GENERAL

0000-00

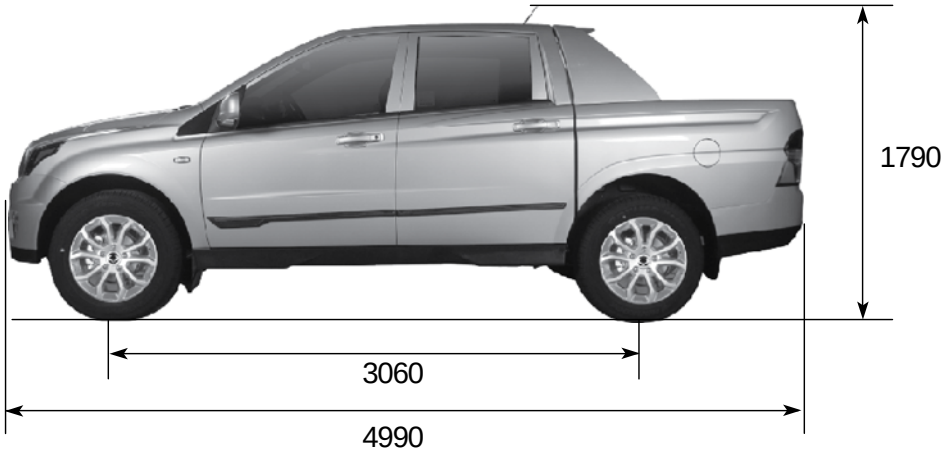
GENERAL INFORMATION

1. DIMENSIONS

Unit: mm

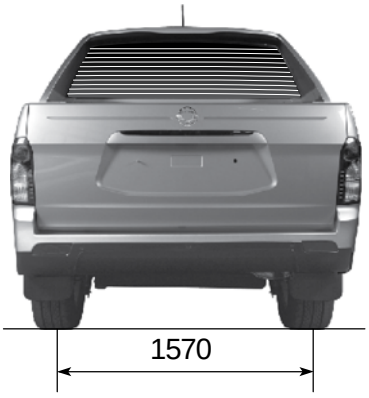
Top view

Side view



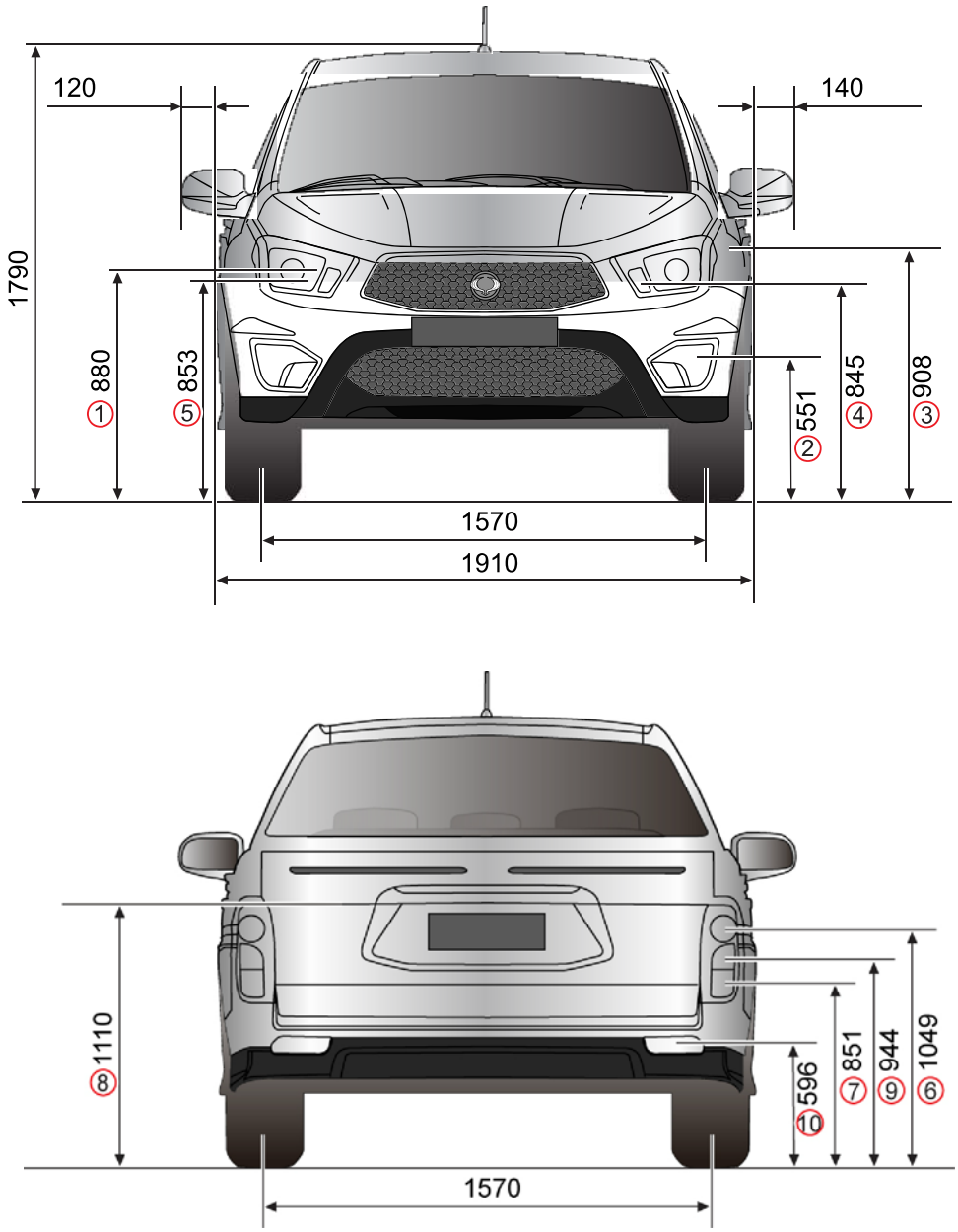
Front view

Rear view



▶ Detailed Dimensions

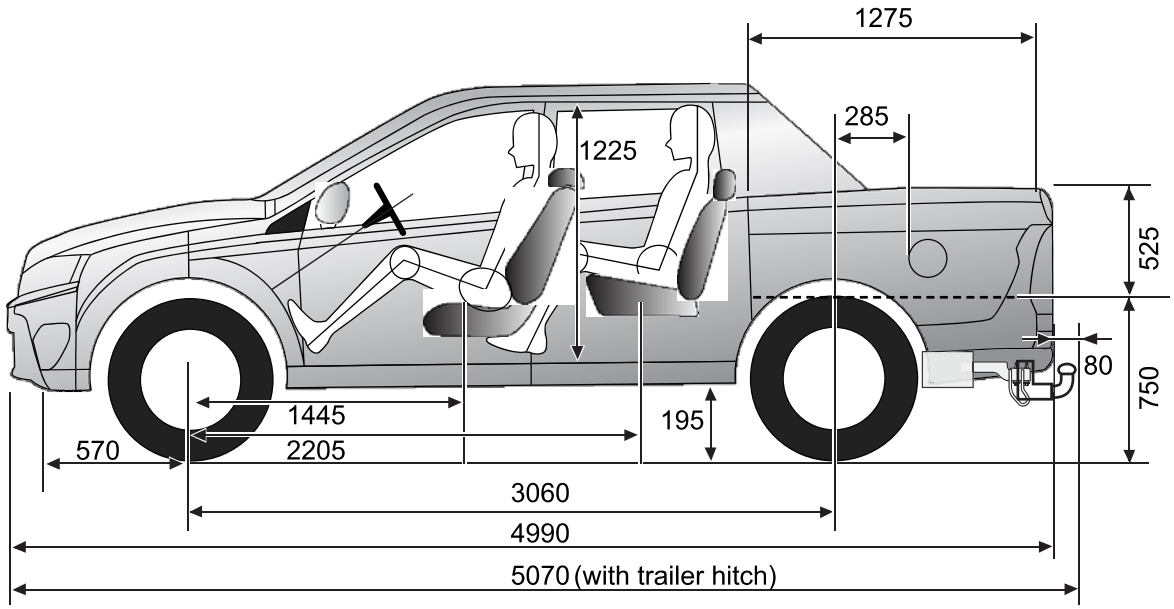
Unit:mm

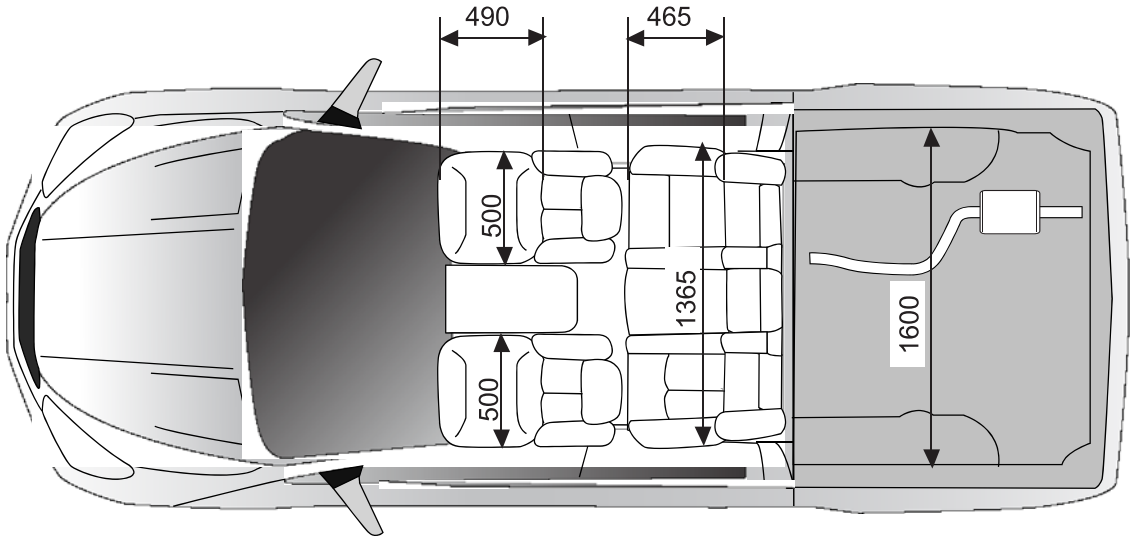


1. Headlamp
2. Front fog lamp
3. Side repeater
4. Tun signal lamp (front)
5. Position lamp
6. Stop/Tail lamp
7. Back-up lamp
8. License plate lamp
9. Turn signal lamp (rear)
10. Reflector

Modification basis	
Application basis	
Affected VIN	

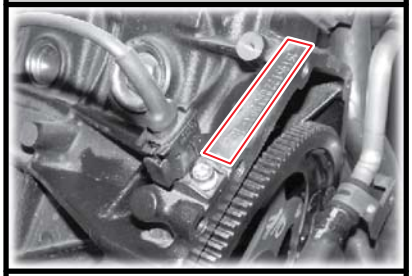
Unit:mm


1275
285
1225
525
80
750
1445
195
570
2205
3060
4990
5070 (with trailer hitch)


490
465
500
1365
1600
500

2) Vehicle Identification

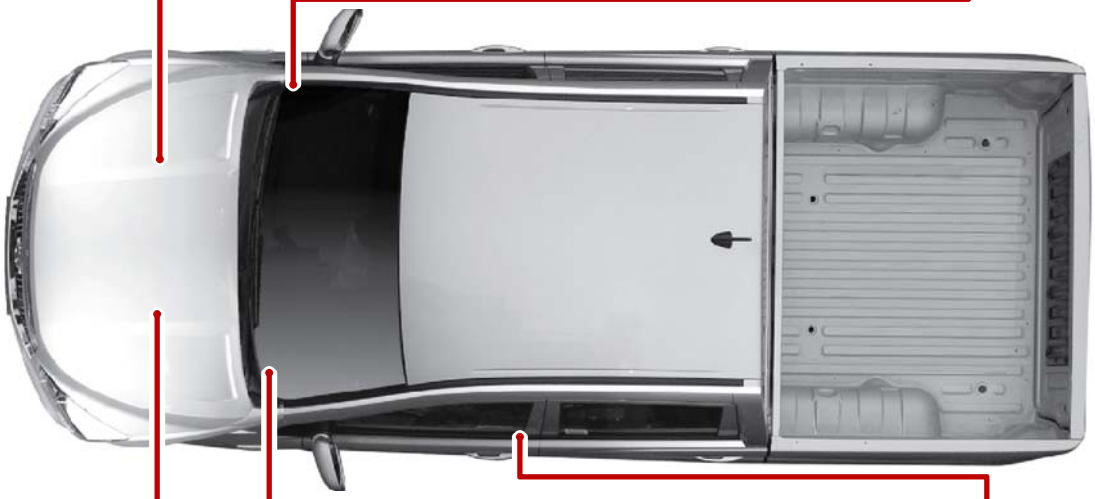
Engine Number (Gasoline Engine)



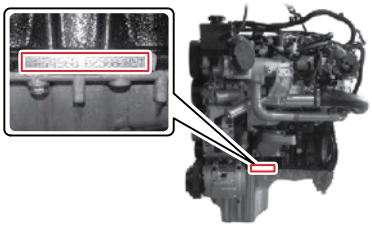
The engine number is stamped on the upper rear left-hand side of the cylinder block.

Chassis Number

The chassis number is stamped on the frame behind the front right tire.



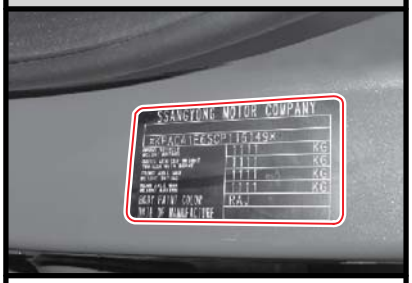
Engine Number (Diesel Engine)



The engine number is stamped on the lower area of cylinder block behind the Intake manifold.

Vin Label

Certification Label



The certification label is located on the driver's door sill.

Modification basis	
Application basis	
Affected VIN	

2. SPECIFICATION

1) Specifications in Unit

- ( ): Optional item
- Vehicle weight and gross vehicle weight may vary according to the options and vehicle types.

Descriptions			D20DTR	G23D
General	Overall length (mm)		4,990	←
	Overall width (mm)		1,910	←
	Overall height (mm)		1,790	←
	Gross vehicle weight (kg)	A/T	2WD: 2,640, 4WD: 2,740	–
		M/T	2WD: 2,640, 4WD: 2,740	2WD: 2,600, 4WD: 2,700
	Curb vehicle weight (kg)	A/T	2WD: 1,895 (1,935) 4WD: 1,995 (2,035)	–
		M/T	2WD: 1,873 (1,913) 4WD: 1,982 (2,022)	2WD: 1,835 (1,898) 4WD: 1,944 (1,984)
	Full load (kg)	A/T	370 (300: with trailer)	–
		M/T	383 (300: with trailer)	381 (300: with trailer)
	Fuel		Diesel	Gasoline
	Fuel tank capacity (ℓ)		75	←
	Min. turning radius (m)		5.58	←
Engine	Numbers of cylinders/ Compression ratio		4 / 16.5:1	4 / 10.0:1
	Total displacement (cc)		1,998	2,295
	Camshaft arrangement		DOHC	←
	Max. power	Normal power	155 ps / 3,400 ~ 4,000 rpm	150 ps / 5,500 rpm
		Low power	149 ps / 4,000 rpm	–
	Max. torque	Normal power	360 Nm / 1,500 ~ 2,800 rpm	214 Nm / 3,500 ~ 4,600 rpm
		Low power	310 Nm / 1,800 ~ 2,700 rpm	–
	Idle speed		750 ± 20 rpm	750 ± 50 rpm
	Cooling system		Water- cooled / forced circulation	←
	Coolant capacity (ℓ)		8.5	10.5 ~ 11.0
	Lubrication type		Gear pump, forced circulation	←
	Max. oil capacity (ℓ) (when shipping)		6.0	7.9
	Turbocharger and cooling type		Turbocharger, air-cooled	–

Descriptions				D20DTR	G23D
Manual Transmission	Operating type			Floor change type	←
	Gear ratio	5-speed	1st	–	4.315
			2nd	–	2.475
			3rd	–	1.536
			4th	–	1.000
			5th	–	0.807
			Reverse	–	3.919
		6-speed	1st	4.489	–
			2nd	2.337	–
			3rd	1.350	–
			4th	1.000	–
			5th	0.784	–
			6th	0.679	–
			Reverse	4.253	–
Automatic Transmission	Model			Electronic, 6-speed	–
	Operating type			Floor change type	–
	Gear ratio		1st	3.536	–
			2nd	2.143	–
			3rd	1.478	–
			4th	1.156	–
			5th	0.866	–
			6th	0.677	–
			Reverse	3.094	–
Transfer Case	Model			Part-time	←
	Type			Planetary gear type	←
	Gear ratio		High (4H)	1.000 : 1	←
			Low (4L)	2.483 : 1	←
Clutch (M/T)	Operating type			Hydraulic type	←
	Disc type			Dry single diaphragm type	←
Power Steering	Type			Rack and pinion	←
	Steering angle		Inner	36.2°	←
			Outer	32.4°	←
Front Axle	Drive shaft type			Ball joint type	←
	Axle housing type			Build-up type	←
Rear Axle	Drive shaft type	Solid axle suspension		Semi-floating type	←
	Axle housing type			Build-up type	←

Modification basis	
Application basis	
Affected VIN	

Descriptions			D20DTR	G23D
Brake	Master cylinder type		Tandem type	←
	Booster type		Vacuum assisted booster type	←
	Brake type	Front wheels	Disc type	←
		Rear wheels	Drum & DISC	←
	Parking brake		Cable type (internal expansion)	←
Suspension	Front suspension		Wishbone + coil spring	←
	Rear suspension	Solid axle suspension	5-link + coil spring	←
Air Conditioner	Refrigerant (capacity)		R-134a (650 ± 30g)	←
Electrical	Battery type / Capacity (V-AH)		MF / 12 - 90	←
	Starter capacity (V-kW)		12 - 2.2	12 - 1.2
	Alternator capacity (V-A)		12 - 120 (140*)	12 - 115
Tire	Regular tire	Front	32 psi	←
		Rear	32 psi (44 psi: when the vehicle is fully laden with luggage)	←
Wiper Blade	Driver side		22 inch	←
	Passenger side		19 inch	←

2) Recommended Fluids and Lubricants

Descriptions			Capacity	Specifications
Engine Oil		D20DTR	≒ 6.0ℓ	Quality class: Ssangyong genuine engine oil (Approved by MB Sheet 229.51 SAE 5W30)
		G23D	≒ 7.5ℓ	Quality class: Ssangyong genuine engine oil (Approved by MB Sheet 229.1 or 229.3 or 229.31 SAE 5W30)
Engine Coolant		D20DTR	≒ 8.5ℓ	Ssangyong genuine coolant Anti-Freeze SYC-1025, Anti-Freeze:Water = 50:50 ORGANIC ACID TYPE, COLOR:BLUE
		G23D	10.5~11.0ℓ	
Automatic Transmission Fluid		6 A/T	≒ 9.5ℓ	Ssangyong genuine oil (FUCHS FES 209 ATF 3292)
Manual Transmission Fluid		6-speed	≒ 2.2ℓ	Ssangyong genuine oil (HD MTF 75W/85 (SHELL) or HK MTF 75W/85(SK))
		5-speed	≒ 3.4ℓ	Ssangyong genuine oil (ATF DEXRON II)
Transfer Case Fluid			≒ 1.4ℓ	Ssangyong genuine oil (ATF DEXRON III)
Axle Oil	Front		≒ 1.4ℓ	Ssangyong genuine oil (SAE 80W/90, API GL-5)
			≒ 1.4ℓ	
	Rear	2WD	≒ 2.0ℓ	Ssangyong genuine oil (SAE 80W/90, API GL-5)
		4WD	≒ 2.0ℓ	
Brake / Clutch Fluid			As required	Ssangyong genuine oil (DOT4)
Power Steering Fluid			≒ 1.0ℓ	Ssangyong genuine oil (S-PSF-3) *TOTAL FLUIDE DA(Extreme cold condition only)
Tailgate Hinge Spring Oil			As required	Heat fluorine resistance grease (PTFE Grease, refer to KS M 2130)

WARNING

- Use only Ssangyong recommended fluids and lubricants.
- Do not mix any different types or brands of oils or fluids. This may cause damages.
- Keep the specified levels when adding or replacing the fluids.

3) Scheduled Maintenance Services (EU) - Diesel Engine

* Use only approved Ssangyong genuine parts.

Maintenance service and record retention are the owner's responsibility. You should retain evidence that proper maintenance has been performed on your vehicle in accordance with the scheduled maintenance service chart.

* EU Countries: Only countries that belong to EU. (It does not apply to all countries in EU.)

MAINTENANCE INTERVAL / MAINTENANCE ITEM	Kilometers (miles) or time in months, whichever comes first							
x1000 km	20	40	60	80	100	120	140	160
x1000 miles	12.5	25	37.5	50	62.5	75	87.5	100
Months	12	24	36	48	60	72	84	96
ENGINE CONTROL SYSTEM								
Drive belt	I	I	I	I	I	I	I	I
* Engine oil & filter *1 (1)* (3)* (4)*	R	R	R	R	R	R	R	R
	Shorten the service interval under severe conditions							
Cooling system hose & connections	I	I	I	I	I	I	I	I
Engine coolant (3)* (4)	Change every 200000 km or 5 years. And, inspect and replenish if necessary.							
Fuel filter (1)*	I	R	I	R	I	R	I	R
	Drain the water from fuel filter: whenever replacing the engine oil							
Fuel line & connections	I	I	I	I	I	I	I	I
Air cleaner (2)*	R	R	R	R	R	R	R	R
	Shorten the service interval under severe conditions							

Chart Symbols:

I - Inspect these items and their related parts. If necessary, correct, clean, replenish, adjust or replace.

*1 Check the engine oil level and leak every 3000 km (2000 miles) or before starting a long trip.

R- Replace or change.

(1)* If vehicle is operated under severe condition:
Shorten the service interval.
- Frequent stop-and-go traffic, extended idling, short driving distance below 6 km, driving distance below 16 km when the outside temperature remains below freezing
- Driving in a hilly or mountainous terrain, sandy, or dusty area
- High load driving such as trailer towing
- Taxi, patrol service or delivery service (extended idling and excessive driving with low speed)

(2)* If vehicle is operated under severe condition, driving in dusty condition or sandy condition, pollutant area or off-road driving, frequently inspect the air cleaner, if necessary, change the air cleaner.

(3)* More frequent maintenance is required if under dusty driving condition.

(4)* Refer to "Recommended fluids, coolant and lubricants".

* EU Countries: Only countries that belong to EU. (It does not apply to all countries in EU.)

MAINTENANCE INTERVAL / MAINTENANCE ITEM	Kilometers (miles) or time in months, whichever comes first								
	x1000 km	20	40	60	80	100	120	140	160
	x1000 miles	12.5	25	37.5	50	62.5	75	87.5	100
	Months	12	24	36	48	60	72	84	96

CHASSIS AND BODY

Exhaust pipes & mountings		I	I	I	I	I	I	I	I
Brake / Clutch fluid (3)*		Change every 2 years (inspect frequently)							
Parking brake / Brake pads (Front & Rear) (4)*		I	I	I	I	I	I	I	I
Brake line & connections (including booster)		I	I	I	I	I	I	I	I
Manual transmission oil (5)*				I			I		
Clutch & brake pedal free play		I	I	I	I	I	I	I	I
Transfer case fluid (3)*		I	I	R	I	I	R	I	I
Axle oil	Front	I	R	I	R	I	R	I	R
	Rear	I	R	I	R	I	R	I	R
Automatic transmission fluid (6)*		I	I	I	I	I	I	I	I
		Change every 60000 km under severe condition							
Chassis & underbody bolts & nuts tight / Secure (6)*		Check frequently and adjust or replace if necessary							
Tire condition & inflation pressure		Check frequently and adjust or replace if necessary							
Wheel alignment (7)*		Inspect when abnormal condition is noted							
Steering wheel & linkage		I	I	I	I	I	I	I	I

Chart Symbols:

I - Inspect these items and their related parts. If necessary, correct, clean, replenish, adjust or replace.

R- Replace or change.

(3)* Refer to “Recommended fluids and lubricants”.

(4)* More frequent maintenance is required if the vehicle is operated under any of the following conditions:
- In heavy city traffic where the outside temperature regularly reaches 32°C (90°F) or higher, or
- In hilly or mountainous terrain, or
- When doing frequent trailer towing, or
- Uses such as found in taxi, police or delivery service.

(5)* Inspect and replenish every 60000 km (or 3 years)
Normal driving condition: Fill for Life
(Severe driving condition: Change every 120000 km)

(6)* If vehicle is operated under severe condition: Shorten the service interval.
- Towing a trailer or off-road driving (Inspect the leak of fluid at any time, occasionally)
- Taxi, patrol service or delivery service (extended idling and excessive driving with low speed)
- Frequent stop-and-go traffic, extended idling, short driving distance
- Driving in a hilly or mountainous terrain, sandy, or dusty area
- Driving frequently at high speed over 170 km/hour
- Driving frequently in area where heavy traffic under the ambient temperature above 32°C

(7)* If necessary, rotate and balance wheels.

Modification basis	
Application basis	
Affected VIN	

* EU Countries: Only countries that belong to EU. (It does not apply to all countries in EU.)

MAINTENANCE INTERVAL / MAINTENANCE ITEM	Kilometers (miles) or time in months, whichever comes first							
	x1000 km	20	40	60	80	100	120	140	160
	x1000 miles	12.5	25	37.5	50	62.5	75	87.5	100
	Months	12	24	36	48	60	72	84	96

CHASSIS AND BODY

Power steering fluid & lines (3)*	I	I	I	I	I	I	I	I
Drive shaft boots (8)*	I	I	I	I	I	I	I	I
Seat belts, buckles & anchors	I	I	I	I	I	I	I	I
Lubricate locks, hinges & bonnet latch	Check frequently and adjust or replace if necessary							
Wheel bearing grease	I	I	I	I	I	I	I	I
Propeller shaft grease - Front / Rear (9)*	I	I	I	I	I	I	I	I
Air conditioner filter (10)*	R	R	R	R	R	R	R	R
	Shorten the service interval under severe conditions							
Tailgate hinge spring	Apply grease when you hear a noise from the tailgate. Maintenance schedule: check the hinge spring at every 20,000 km or 1 year (under severe conditions: check the hinge spring and lubricant frequently)							

Chart Symbols:

I - Inspect these items and their related parts. If necessary, correct, clean, replenish, adjust or replace.

R- Replace or change.

(3)* Refer to “Recommended fluids and lubricants”.

(8)* After completion of off-road operation, the drive shaft boots should be inspected.

(9)* Inspect propeller shaft grease every 5000 km or 3 months if the vehicle is mainly driven under severe condition.

- In off-road or dusty road, or
- In heavy city traffic where the outside temperature regularly reaches 32°C (90°F) or higher, or
- In hilly or mountainous terrain.

(10)* Severe Conditions in Air Conditioner Filter

- Pollutant area or off-road driving, extended air conditioner or heater operation

4) Scheduled Maintenance Services (General) - Diesel Engine

* Use only approved Ssangyong genuine parts.

Maintenance service and record retention are the owner's responsibility. You should retain evidence that proper maintenance has been performed on your vehicle in accordance with the scheduled maintenance service chart.

MAINTENANCE INTERVAL / MAINTENANCE ITEM	Kilometers (miles) or time in months, whichever comes first								
	x1000 km	15	30	45	60	75	90	105	120
	x1000 miles	10	20	30	40	50	60	70	80
	Months	12	24	36	48	60	72	84	96
ENGINE CONTROL SYSTEM									
Drive belt		I	I	I	I	I	I	I	I
* Engine oil & filter *1 (1)* (3)* (4)*		R	R	R	R	R	R	R	R
		Shorten the service interval under severe conditions							
Cooling system hose & connections		I	I	I	I	I	I	I	I
Engine coolant (3)* (4)		Change every 200000 km or 5 years. And, inspect and replenish if necessary.							
Fuel filter (1)*		I	I	R	I	I	R	I	I
		Drain the water from fuel filter: whenever replacing the engine oil							
Fuel line & connections		I	I	I	I	I	I	I	I
Air cleaner (2)*		R	R	R	R	R	R	R	R
		Clean every 7500 km, Shorten the service interval under severe conditions							

Chart Symbols:

I - Inspect these items and their related parts. If necessary, correct, clean, replenish, adjust or replace.
*1 Check the engine oil level and leak every 3000 km (2000 miles) or before starting a long trip.

R- Replace or change.

(1)* If vehicle is operated under severe condition:
Shorten the service interval.
- Frequent stop-and-go traffic, extended idling, short driving distance below 6 km, driving distance below 16 km when the outside temperature remains below freezing
- Driving in a hilly or mountainous terrain, sandy, or dusty area
- High load driving such as trailer towing
- Taxi, patrol service or delivery service (extended idling and excessive driving with low speed)

(2)* If vehicle is operated under severe condition, driving in dusty condition or sandy condition, pollutant area or off-road driving, frequently inspect the air cleaner, if necessary, change the air cleaner.

(3)* More frequent maintenance is required if under dusty driving condition.

(4)* Refer to "Recommended fluids, coolant and lubricants".

Modification basis	
Application basis	
Affected VIN	

MAINTENANCE INTERVAL / MAINTENANCE ITEM	Kilometers (miles) or time in months, whichever comes first								
	x1000 km	15	30	45	60	75	90	105	120
	x1000 miles	10	20	30	40	50	60	70	80
	Months	12	24	36	48	60	72	84	96

CHASSIS AND BODY

Exhaust pipes & mountings		I	I	I	I	I	I	I	I
Brake / Clutch fluid (3)*		Change every 2 years (inspect frequently)							
Parking brake / Brake pads (Front & Rear) (4)*		I	I	I	I	I	I	I	I
Brake line & connections (including booster)		I	I	I	I	I	I	I	I
Manual transmission oil (5)*					I				I
Clutch & brake pedal free play		I	I	I	I	I	I	I	I
Transfer case fluid (3)*		I	I	I	R	I	I	I	R
Axle oil	Front	I	R	I	R	I	R	I	R
	Rear	I	R	I	R	I	R	I	R
Automatic transmission fluid (6)*		Inspect every 30000 km or 12 month (But change every 60000 km under severe condition)							
Chassis & underbody bolts & nuts tight / Secure (6)*		Check frequently and adjust or replace if necessary							
Tire condition & inflation pressure		Check frequently and adjust or replace if necessary							
Wheel alignment (7)*		Inspect when abnormal condition is noted							
Steering wheel & linkage		I	I	I	I	I	I	I	I

Chart Symbols:

I - Inspect these items and their related parts. If necessary, correct, clean, replenish, adjust or replace.

R- Replace or change.

(3)* Refer to “Recommended fluids and lubricants”.

(4)* More frequent maintenance is required if the vehicle is operated under any of the following conditions:
- In heavy city traffic where the outside temperature regularly reaches 32°C (90°F) or higher, or
- In hilly or mountainous terrain, or
- When doing frequent trailer towing, or
- Uses such as found in taxi, police or delivery service.

(5)* Inspect and replenish every 60000 km (or 3 years)
Normal driving condition: Fill for Life
(Severe driving condition: Change every 120000 km)

(6)* If vehicle is operated under severe condition: Shorten the service interval.
- Towing a trailer or off-road driving (Inspect the leak of fluid at any time, occasionally)
- Taxi, patrol service or delivery service (extended idling and excessive driving with low speed)
- Frequent stop-and-go traffic, extended idling, short driving distance
- Driving in a hilly or mountainous terrain, sandy, or dusty area
- Driving frequently at high speed over 170 km/hour
- Driving frequently in area where heavy traffic under the ambient temperature above 32°C

(7)* If necessary, rotate and balance wheels.

MAINTENANCE INTERVAL / MAINTENANCE ITEM	Kilometers (miles) or time in months, whichever comes first							
	x1000 km	15	30	45	60	75	90	105	120
	x1000 miles	10	20	30	40	50	60	70	80
	Months	12	24	36	48	60	72	84	96

CHASSIS AND BODY

Power steering fluid & lines (3)*	I	I	I	I	I	I	I	I
Drive shaft boots (8)*	I	I	I	I	I	I	I	I
Seat belts, buckles & anchors	I	I	I	I	I	I	I	I
Lubricate locks, hinges & bonnet latch	Check frequently and adjust or replace if necessary							
Wheel bearing grease	I	I	I	I	I	I	I	I
Propeller shaft grease - Front / Rear (9)*	I	I	I	I	I	I	I	I
Air conditioner filter (10)*	R	R	R	R	R	R	R	R
	Shorten the service interval under severe conditions							
Tailgate hinge spring	Apply grease when you hear a noise from the tailgate. Maintenance schedule: check the hinge spring at every 20,000 km or 1 year (under severe conditions: check the hinge spring and lubricant frequently)							

Chart Symbols:

I - Inspect these items and their related parts. If necessary, correct, clean, replenish, adjust or replace.

R- Replace or change.

(3)* Refer to “Recommended fluids and lubricants”.

(8)* After completion of off-road operation, the drive shaft boots should be inspected.

(9)* Inspect propeller shaft grease every 5000 km or 3 months if the vehicle is mainly driven under severe condition.

- In off-road or dusty road, or
- In heavy city traffic where the outside temperature regularly reaches 32°C (90°F) or higher, or
- In hilly or mountainous terrain.

(10)* Severe Conditions in Air Conditioner Filter

- Pollutant area or off-road driving, extended air conditioner or heater operation

5) Scheduled Maintenance Services - Gasoline Engine

* Use only approved Ssangyong genuine parts.

Maintenance service and record retention are the owner's responsibility. You should retain evidence that proper maintenance has been performed on your vehicle in accordance with the scheduled maintenance service chart.

* EU Countries: Only countries that belong to EU. (It does not apply to all countries in EU.)

MAINTENANCE INTERVAL / MAINTENANCE ITEM	Kilometers (miles) or time in months, whichever comes first								
	x1000 km	10	20	30	40	50	60	70	80
	x1000 miles	6	12	18	24	30	36	42	48
	Months	12	24	36	48	60	72	84	96
ENGINE CONTROL SYSTEM									
Drive belt		I	I	I	I	I	I	I	I
Engine oil & engine oil filter (1)* (3)* (Initial check: 5,000 km)		R**	R	R	R	R	R	R	R
Cooling system hose & connections		I	I	I	I	I	I	I	I
Engine coolant (3)*		Change every 200,000 km or 5 years. And, inspect replenish if necessary.							
Fuel filter (2)*		Replace every 100,000 km (if using poor quality of fuel, replace every 30,000 km)							
Fuel line & connections		I	I	I	I	I	I	I	I
Air cleaner (2)*		Clean every 10,000 km, change every 60,000 km or 3 years							
		Shorten the service interval under severe conditions							
Ignition timing		I	I	I	I	I	I	I	I
Spark plugs (G23D)		-	-	R	-	-	R	-	-
Charcoal canister & vapor lines		-	-	I	-	-	I	-	-

Chart Symbols:

I - Inspect these items and their related parts. If necessary, correct, clean, replenish, adjust or replace.

R- Replace or change.

**- In order to secure engine long life and effective break-in, first oil (factory filled) would be recommended to drain within 10,000 km.

(1)* If vehicle is operated under severe condition:
Shorten the service interval.
- Frequent stop-and-go traffic, extended idling, short driving distance below 6 km, driving distance below 16 km when the outside temperature remains below freezing
- Driving in a hilly or mountainous terrain, sandy, or dusty area
- High load driving such as trailer towing
- Taxi, patrol service or delivery service (extended idling and excessive driving with low speed)

(2)* If vehicle is operated under severe condition, pollutant area or off-road driving, driving in dusty condition or sandy condition, frequently inspect the air cleaner, if necessary, change the air cleaner.

(3)* Refer to "Recommended fluids and lubricants".

* EU Countries: Only countries that belong to EU. (It does not apply to all countries in EU.)

MAINTENANCE INTERVAL / MAINTENANCE ITEM	Kilometers (miles) or time in months, whichever comes first								
	x1000 km	10	20	30	40	50	60	70	80
	x1000 miles	6	12	18	24	30	36	42	48
	Months	12	24	36	48	60	72	84	96

CHASSIS AND BODY

Exhaust pipes & mountings		I	I	I	I	I	I	I	I
Brake / Clutch fluid (3)*		Change every: 2 years (inspect frequently)							
Parking brake / Brake pads (Front & Rear) (4)*		Periodic check: every 10,000 km, adjust or replace as necessary.							
Brake line & connections (including booster)		Inspect every 10,000 km or 1 years, adjust or replace if necessary							
Manual transmission oil (5)*		I	I	I	I	I	R	I	I
Clutch & brake pedal free play		I	I	I	I	I	I	I	I
Front & Rear differential fluid (3)*	Front	I	I	R	I	I	R	I	I
	Rear	I	I	R	I	I	R	I	I
Transfer case fluid (3)*		Inspect every 10,000 km, change every 60,000 km (Frequent check of oil leak)							

Chart Symbols:

I - Inspect these items and their related parts. If necessary, correct, clean, replenish, adjust or replace.

R- Replace or change.

(3)* Refer to “Recommended fluids and lubricants”.

(4)* More frequent maintenance is required if the vehicle is operated under any of the following conditions:

- In heavy city traffic where the outside temperature regularly reaches 32°C (90°F) or higher, or
- In hilly or mountainous terrain, or
- When doing frequent trailer towing, or
- Uses such as found in taxi, police or delivery service.

(5)* Inspect manual transmission fluid every 10,000 km (Inspect the leak of fluid at any time, occasionally), then change every 60,000 km

Modification basis	
Application basis	
Affected VIN	

* EU Countries: Only countries that belong to EU. (It does not apply to all countries in EU.)

MAINTENANCE INTERVAL / MAINTENANCE ITEM	Kilometers (miles) or time in months, whichever comes first							
x1000 km	10	20	30	40	50	60	70	80
x1000 miles	6	12	18	24	30	36	42	48
Months	12	24	36	48	60	72	84	96

CHASSIS AND BODY

Chassis & underbody bolts & nuts tight / Secure (6)*	Check frequently and adjust or replace if necessary							
Tire condition & inflation pressure	Check frequently and adjust or replace if necessary							
Wheel alignment (7)*	Inspect when abnormal condition is noted							
Steering wheel & linkage	I	I	I	I	I	I	I	I
Power steering fluid & lines (3)*	I	I	I	I	I	I	I	I
Drive shaft boots	I	I	I	I	I	I	I	I
Seat belts, buckles & anchors	I	I	I	I	I	I	I	I
Lubricate locks, hinges & bonnet latch	Check frequently and adjust or replace if necessary							
Wheel bearing grease	I	I	I	I	I	I	I	I
Propeller shaft grease - Front / Rear (8)*	I	I	I	I	I	I	I	I
Air conditioner filter (10)*	R	R	R	R	R	R	R	R
	Shorten the service interval under severe conditions							
Tailgate hinge spring	Apply grease when you hear a noise from the tailgate. Maintenance schedule: check the hinge spring at every 20,000 km or 1 year (under severe conditions: check the hinge spring and lubricant frequently)							

Chart Symbols:

I - Inspect these items and their related parts. If necessary, correct, clean, replenish, adjust or replace.

R- Replace or change.

(3)* Refer to “Recommended fluids and lubricants”.

(6)* After completion of off-road operation, the underbody of the vehicle should be thoroughly inspected. Examine threaded fasteners for looseness.

(7)* If necessary, rotate and balance wheels.

(8)* Inspect propeller shaft grease every 5,000 km or 3 months if the vehicle is mainly driven under severe condition.
- In off-road or dusty road, or
- In heavy city traffic where the outside temperature regularly reaches 32°C (90°F) or higher, or
- In hilly or mountainous terrain.

(10)*Severe Conditions in Air Conditioner Filter
- Pollutant area or off-road driving, extended air conditioner or heater operation

Memo

ENGINE GENERAL

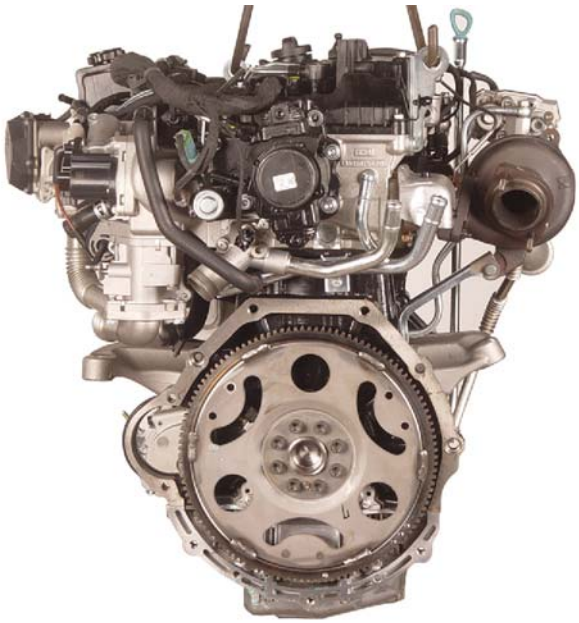
0000-00

GENERAL INFORMATION

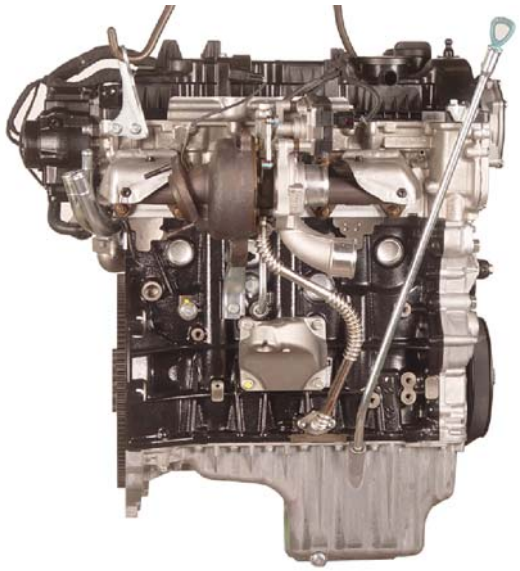
1. ENGINE LAYOUT

Front view

Rear view



Right view

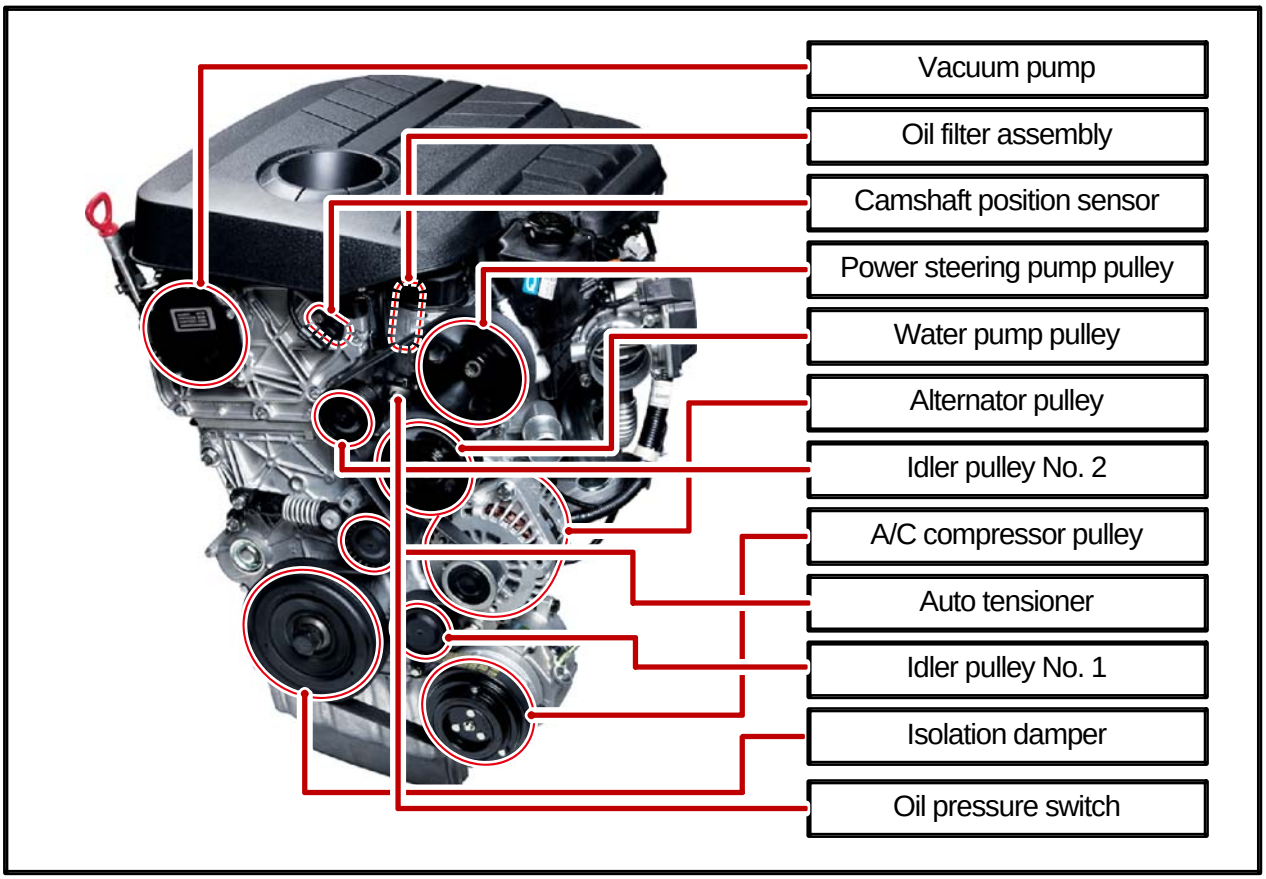


Left view

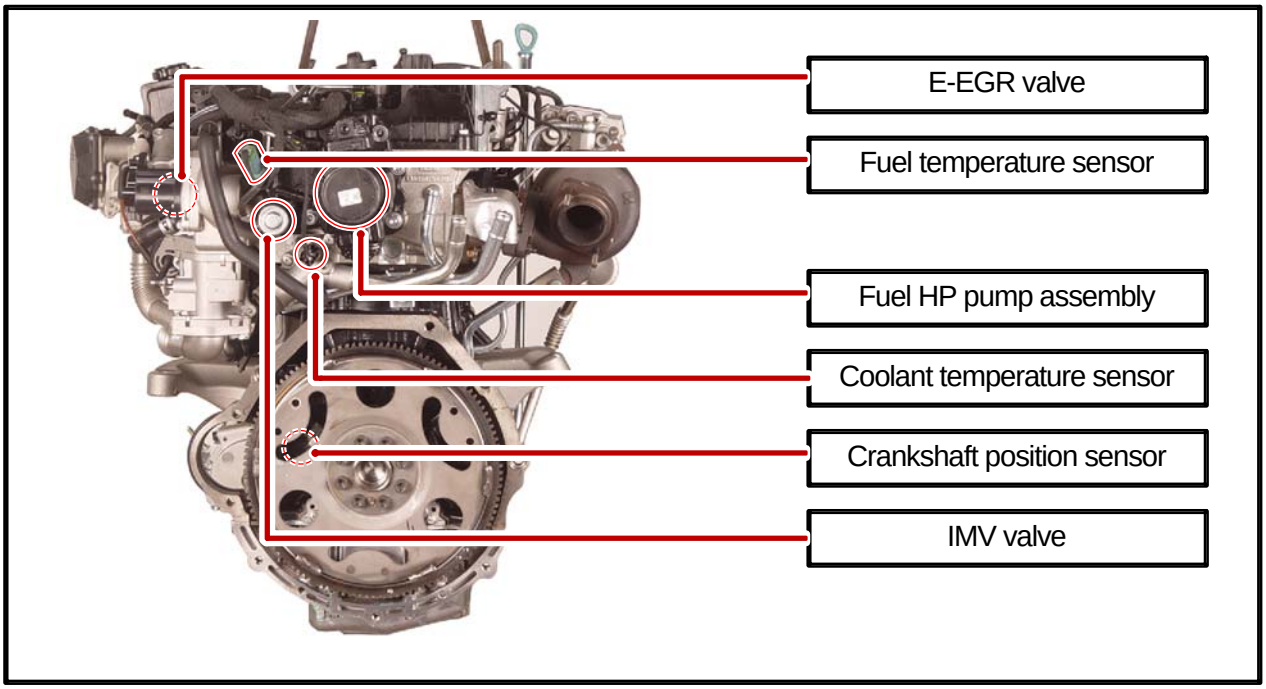
Modification basis	
Application basis	
Affected VIN	

2. MAJOR COMPONENTS

▶ **Front view**

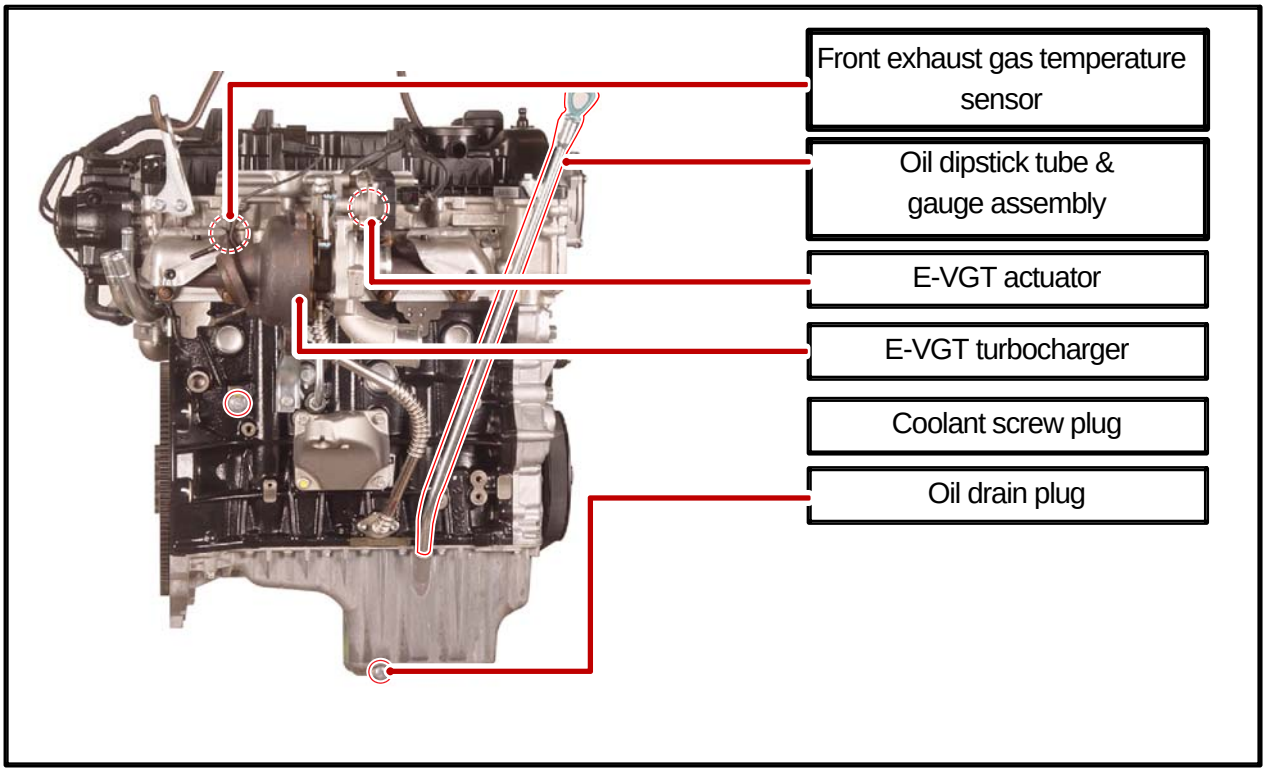


▶ **Rear view**

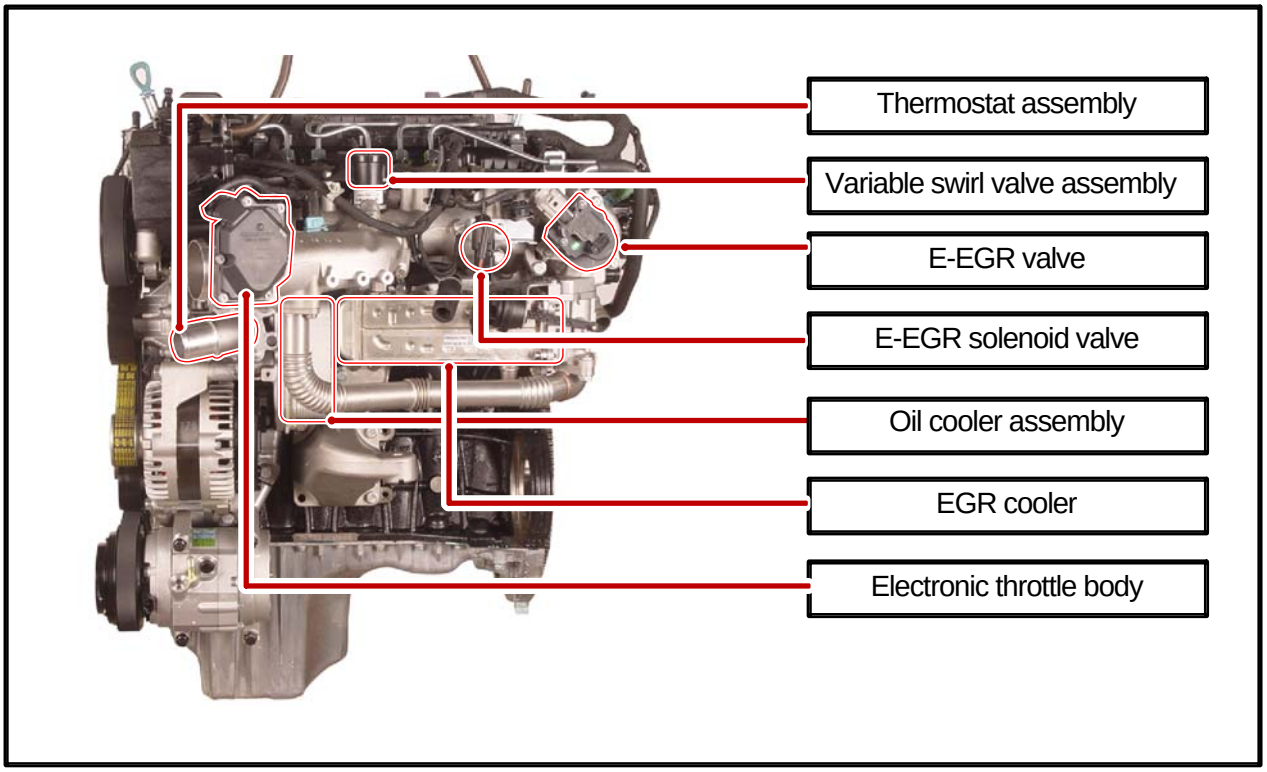


Modification basis	
Application basis	
Affected VIN	

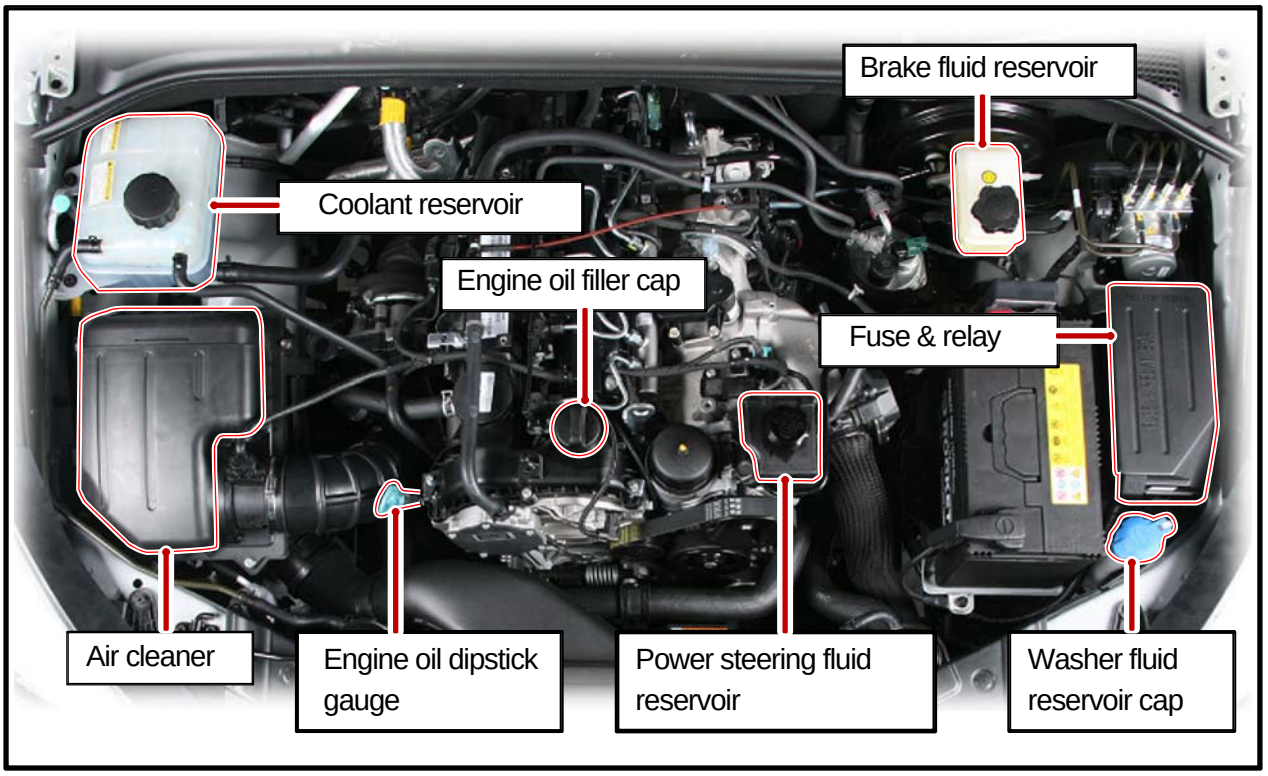
▶ Right view



▶ Left view



3. ENGINE COMPARTMENT LAYOUT



CAUTION

- Do not work on the engine compartment while the engine, radiator, exhaust manifold, muffler or catalytic converter is hot. Always turn the engine off and allow it to cool before starting the maintenance.
- Regularly check the engine oil level and add Ssangyong genuine engine oil if necessary.
- Clean the dipstick with clean cloth so that any foreign materials cannot get into the engine.

WARNING

Operating vehicle with insuffi cient amount of oil can damage the engine. Make sure the engine oil level is correct and add oil if necessary.

Modification basis	
Application basis	
Affected VIN	

1) Service Interval

Description	Daily inspection	Weekly inspection	Service interval		
Engine oil & oil filter	Inspection	-	EU	Change every 20,000 km or 12 months (The service interval should be shortened under severe conditions)	
			General	Change every 15,000 km or 12 months (The service interval should be shortened under severe conditions)	
Coolant	Inspection	-	Change every 200,000 km or 5 years		
Air cleaner element	-	Inspection	Diesel	EU	Change every 20,000 km (The service interval should be shortened under severe conditions)
				General	Clean every 7,500 km, change every 15,000 km (The service interval should be shortened under severe conditions)
			Gasoline	Clean every 15,000 km, replace every 60,000 km (The service interval should be shortened under severe conditions)	
Fuel filter	-	-	EU	Change every 40,000 km (Draining water from fuel filter: whenever replacing the engine oil)	
			General	Change every 45,000 km (Draining water from fuel filter: whenever replacing the engine oil)	

2) Specification and Capacity

Engine oil	Specification	Quality class: Ssangyong genuine engine oil (Total Quartz INEO ECS 5W 30, SK ZIC SY 5W 30) or oil Approved by MB Sheet 229.51
	Capacity	approx. 6.0 litter
Engine coolant	Specification	Ssangyong genuine coolant Anti-Freeze SYC-1025
	Capacity	approx. 8.5 litter

Severe condition

- Frequent stop-and-go traffic, extended idling, short driving distance below 6 km, driving distance below 16 km when the outside temperature remains below freezing
- Driving in a hilly or mountainous terrain, sandy, or dusty area
- High load driving such as trailer towing
- Taxi, patrol service or delivery service (extended idling and excessive driving with low speed)

4. CAUTION WHEN SERVICING THE ENGINE

1) Cleaness

Engine has a lot of precisely machined (grinding, polishing, lapping) surfaces. Thus, there should be great cautions for cleaness when servicing the engine components. Apply the engine oil on the sliding surfaces when assemblying the components. Every component should be disassembled and reassembled in accordance with the correct sequences. Before servicing the engine, the negative cable should be diconnected from the battery. Otherwise, some electric or electronic components could be damaged.

2) Servicing

CAUTION

- Before service work, be sure to disconnect battery negative (-) terminal to prevent damages by bad wire and short.
- To prevent the foreign material from getting into engine cylinder, cover the inlet of air cleaner if the air cleaner has been removed

(1) Lifting up the vehicle

- Always keep the safety precautions.
- To prevent the vehicle from rolling down, put the chocks under the tires (when using a 4-post lift). Make sure to support the correct lifting points (when using a 2-post lift)
-

(2) Exhaust system

- Wear the safety glove when removing the exhaust pipe.
- Make sure that the exhaust pipe is cooled before removing it.

Modification basis	
Application basis	
Affected VIN	

(3) Cautions before service

Scalding hot coolant and steam could be blown out under pressure, which could cause serious injury. Never remove the coolant reservoir cap when the engine and radiator are hot.

(4) Lubrication system

- Prolonged exposure to the engine oil make cause a skin cancer or an irritation.
- Used engine cotains the hazardous material that may cause the skin cancer. Do not allow the used engine to make contact with your skin.
- Make sure to wear the protection gloves and goggle when handling the engine oil. If contact happens, rinse affected areas immediately with plenty of water. Do not wash it with gasoline or solvent. If irritation persists, consult a doctor.
  Improperly disposed engine oil can pollute the environment. Dispose used engine oil in accordance with local environmental regulations.

(5) Tightening the fastener

- Clean the mating surfaces before tightening.
- Place the marks with paint to tighten by angle if the angle wrench is not available.

3) Fuel and Oil System

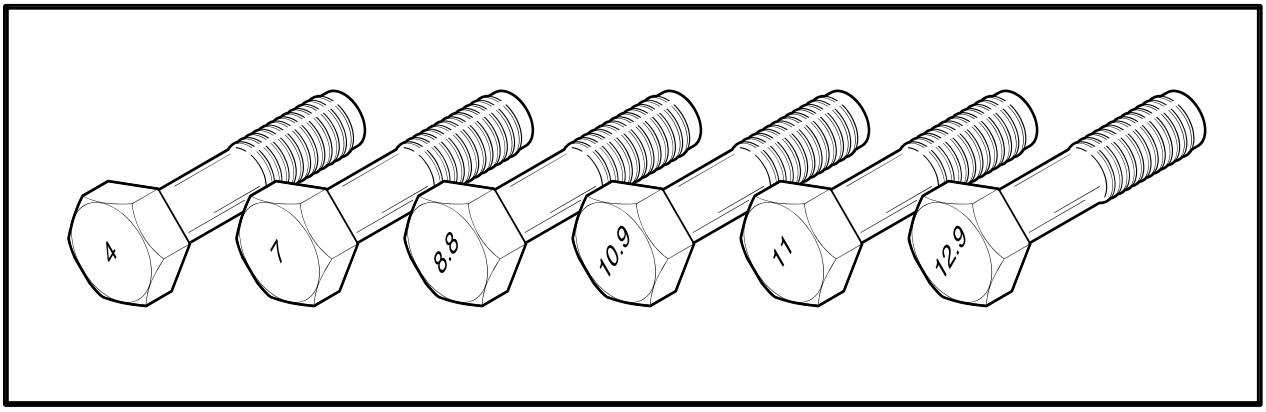
- If work on the fluid system such as fuel and oil, working area should be well ventilated and smoking should be prohibited.
- Gasket or seal on the fuel/lubrication system should be replaced with new ones and bolts and nuts should be tightened as specified.

NOTE

1. If fine dust or foreign material enters into DI engine's fuel system, there can be serious damages between HP pump and injectors. So, be sure to cover removed fuel system components with cap and protect removed parts not to be contaminated with dirt. (Refer to cleanness in this manual while working on DI engine fuel system)
2. When working on the fuel line between priming pump and injector (including return line), always plug the openings with caps to prevent foreign materials or dust from entering to the openings and connections.
3. The HP fuel supply pipe (HP pump to fuel rail) and HP fuel pipe (Fuel rail to injector) should be replaced with new ones when removed.

5. STANDARD BOLTS SPECIFICATIONS

Bolt	Pitch	Tightening torque(kgf.cm)					
		Standard			Limit		
		4T	7T	9T	4T	7T	9T
M3	0.5	5	9	13	7	12	17
M4	0.7	12	20	30	16	27	40
M5	0.8	24	40	57	32	53	77
M6	1.0	41	68	99	55	91	130
M8	1.25	88	160	230	130	210	310
M10	1.25	190	330	470	260	430	620
	1.5	190	310	450	250	420	600
M12	1.25	350	580	840	460	770	1,100
	1.75	330	550	790	440	730	1,000
M14	1.5	550	910	1,300	730	1,200	1,900
M16	1.5	830	1,100	2,000	1,100	1,900	2,700
M18	1.5	1,200	2,000	2,900	1,600	2,700	3,800
M20	1.5	1,700	2,800	4,000	2,200	3,700	5,300
M22	1.5	2,300	3,800	5,400	3,000	5,000	7,200
M24	1.5	2,900	4,900	7,000	3,900	6,500	9,400
	2.0	2,800	4,700	6,800	3,800	6,300	9,100



1) Metric bolt strength is embossed on the head of each bolt. The strength of bolt can be classified as 4T, 7T, 8.8T, 10.9T, 11T and 12.9T in general.
2) Observe standard tightening torque during bolt tightening works and can adjust torque to be proper within 15 % if necessary. Try not to over max. allowable tightening torque if not required to do so.
3) Determine extra proper tightening torque if tightens with washer or packing.
4) If tightens bolts on the below materials, be sure to determine the proper torque.
   - Aluminum alloy: Tighten to 80 % of above torque table.
   - Plastics: Tighten to 20 % of above torque table.

Modification basis	
Application basis	
Affected VIN	

6. TIGHTENING TORQUE

Name	Size	Numbers of fastener	Tightening torque (Nm)	Note (total tightening torque)
Main bearing cap	M12×82	10	55±5Nm, 180°	Not-reusable
Connecting rod cap	M9×52	8	40±5Nm, 90°+10°	50 ~80Nm
Crankshaft rear seal	M6×20	6	10±1Nm	-
Oil pump	M8×35	3	25±2.5Nm	-
Drive plate	M10×22	8	45±5Nm, 90°+10°	Not-reusable
Isolation damper center bolt	M18×50	1	200±20Nm, 180°+20°	660 ~ 720Nm Not-reusable
Oil pan	M6×20	18	10±1Nm	-
	M6×35	2	10±1Nm	-
	M6×85	2	10±1Nm	-
	M6×120	2	10±1Nm	-
	M8×40	2	25±2.5Nm	-
Mounting nut for high pressure pump	M14×1.5-8-1	1	65±5Nm	-
Mounting bolt for high pressure pump	M8×30	3	25±2.5Nm	-
Cylinder head	M13×150	12	85Nm 270°±10°	-
Camshaft cap	M6×30	16	10±1Nm	-
	M8×60	4	25±2.5Nm	-
Exhaust stud bolt		10	15±1.5Nm	-
Exhaust sprocket	M8x16.5	1	25±2.5Nm	-
Chain tensioner screw plug	M8x1.5	1	25±2.5Nm	-
Coolant temperature sensor		1	20±2.0Nm	-
Belt auto tensioner	M8×30(LOW)	1	25±2.5Nm	-
	M10×75(Upper)	1	55±5.5Nm	-
Water pump	M6×25	7	10±1.0Nm	-

Modification basis	
Application basis	
Affected VIN	

Name	Size	Numbers of fastener	Tightening torque (Nm)	Note (total tightening torque)
Hot water inlet pipe	M6×12	2	10±1Nm	-
Alternator	M10×90	1	(LO) 25±2.5Nm	-
	M10×116	1	(HI) 46±4.6Nm	-
Air conditioner compressor	M8×85	4	25Nm	-
Air conditioner bracket	M6×25	4	10±1Nm	-
Intake manifold	M8×35	2	25±2.5Nm	-
	M8×110	6	25±2.5Nm	-
Oil filter module	M8×40	6	25±2.5Nm	-
	M8×80	1	25±2.5Nm	-
	M8×140	2	25±2.5Nm	-
Knock sensor	M8×28	2	20±5Nm	-
Camshaft position sensor	M8×14	1	10~14Nm	-
T-MAP pressure sensor	M6×20	1	10±1Nm	-
Exhaust manifold	M8	10	40±4Nm	-
Turbocharger	M8	3	25±2.5Nm	-
T/C support bolt	M8 x 35	1	25±2.5Nm (Turbo Side)	-
	M8 x 16	1	25±2.5Nm (Block Side)	-
T/C oil supply pipe	M16	1	25±2.5Nm (Fitting Screw)	-
	M10	1	17±2.0Nm (Hollow Bolt)	-
T/C oil return pipe	M6×16(to block)	2	10±1Nm	-
	M6×16 (to turbocharger)	2	10±1Nm	-
EGR valve	M8×30	3	25±2.5Nm	-

Modification basis	
Application basis	
Affected VIN	

Name	Size	Numbers of fastener	Tightening torque (Nm)	Note (total tightening torque)
EGR pipe bolt (to air duct)	M6×16	2	10±1Nm	-
EGR pipe bolt (to EGR cooler)	M8×25	2	25±2.5Nm	-
Idler pulley/tensioner pulley		1	45±4.5Nm	-
Glow plug	M5	4	20±2Nm	-
Vacuum pump	M6×25	3	10±1Nm	-
Timing gear case cover	M6×40	7	10±1Nm	-
	M6×45	1	10±1Nm	-
	M6×50	3	10±1Nm	-
Cylinder head cover	M6×35	21	10±1Nm	-
Oil dipstick gauge cover	M6×16	1	10±1Nm	-
Oil filter cap		1	25±2.5Nm	-
Fuel rail	M8×25	2	25±2.5Nm	-
Injector clamp bolt	M6×44	2	9±1.0Nm 130˚±10˚	-
High pressure pipe (between high pressure pump and fuel rail assembly)	M17	1	30±3Nm	-
High pressure pipe (between fuel rail assembly and injector)	M17	4	30±3Nm	-
Crankshaft position sensor	M5×14	1	8±0.4Nm	-
Main wiring	M6×16	5	10±1Nm	-
Intake duct	M8×25	4	25±2.5Nm	-
Power steering pump	M8×100	3	25±2.5Nm	-
Cylinder head front cover	M6×10	5	10±1Nm	-
Ladder frame	M8×35	5	30±3Nm	-

7. CODING AND INITIALIZATION

1) Engine Variant Coding

Unit	Selection	Description	Remarks
Additional heater	YES	For PTC auxiary heater equipped vehicle, select "YES"	YES
	NO		-
Gear box	5 MT	"DSI 6 AT" is selected automatically.	-
	6 MT		Select
	5 AT(DC 5 AT)		-
	6 AT(DSI 6 AT)		Select
	7 AT(DC 7 AT)		-
Immobilizer	NO	Select "YES" if the vehicle has immobilizer.	-
	YES		YES
Fan	PWM control	Select "PWM"	PWM fan
	Relay		-
Engine level control	NO		
	YES		
SKM key	NO		NO
	YES		-
Glow plug	AQGS (CAN)	Select "AQGS"	AQGS (CAN)
	Relay (K-line)		-
A/C	Refrigerant pressure sensor	Select the appropriate system.	Pressure sensor for A/C refrigerant
	NO		-
Vehicle speed sensor	CAN	Select "CAN" if the vehicle has ABS or ESP	CAN
	WIRE		-
Cruise control	YES	Select "YES" if the vehicle has cruise control.	YES
	NO		-
G-sensor	YES	2WD ABS & Non-ABS: NO 4WD ABS & ESP: YES	Select
	NO		Select

Modification basis	
Application basis	
Affected VIN	

2) Chassis Variant Coding

Unit	Selection	Description
Domestic/Export	Domestic	Select the region.
	GEN. Export	
	EUROPE	
EPB application	YES	Select "NO".
	NO	
Shift lever type	MT	AT: Select "DURA lever (CAN)". MT: Select "MT".
	DC lever (CAN)	
	DURA lever (CAN)	
	DSIH (NO-CAN)	
Electric power steering (EPS)	NO	NO
	YES	
Transper case	P/T	Select "2WD" or "P/T".
	4WD	
	2WD	
	TOD	
	AWD	
Sedan/Limousine	Sedan (RV)	Select "Sedan (RV)".
	Limousine	
Vehicle code (Engine)	Undefined	Select "D20DTR".
	D32DT	
	D27DT	
	D27DTP	
	D20DTR	
EAS	NO	Select "NO".
	ECS	
	EAS2 corner	
	EAS4 corner	
Telematics	NO	Select "NO".
	YES	

Unit	Selection	Description
Brake system	ESP	Select "ABS" or "ESP".
	ABS	
	TCS	
	NO	
SSPS	NO	Select "YES".
	YES	
TPMS	NO	Select "NO".
	YES	
T/M type	MT	Select "M/T" or "DSIH 6 AT".
	DC AT	
	DSIH 6 AT	
Vehicle code	Rodius / Stavic	Select "Rodius".
	Rexton	
	Korando C	
	Actyon sports	
	Kyron	
ECU coding status	ECU not coded	Select "ECU coded".
	ECU coded	
	Signal not valid	
	Not defind	

Modification basis	
Application basis	
Affected VIN	

D20DTR ENGINE ASSEMBLY

0000-00

GENERAL INFORMATION

1. SPECIFICATION

Unit	Description		Specification	Remark
Cylinder head	Height		131.9 to 132.1 mm	-
	Flatness		below 0.1 mm	-
	Valve recess	Intake valve	0.6 to 1.0 mm	-
		Exhaust valve	0.6 to 1.0 mm	-
	Flatness on manifold side	Intake manifold	0.08 mm	-
		Exhaust manifold	0.08 mm	-
Connecting rod	End play		0.05 to 0.31 mm	-
Camshaft	Axial end play	Intake	0.1 to 0.35 mm	-
		Exhaust	0.1 to 0.35 mm	-
Camshaft position sensor	Distance between Camshaft position sensor and sprocket		0.20 to 1.80 mm	-
Valve	Clearance between valve and piston	Intake	1.12 mm	-
		Exhaust	1.09 mm	-
Cylinder block	Piston protrusion		0.475 to 0.745mm	-
Piston ring	TOP ring end gap		0.20 to 0.40 mm	-
	2nd ring end gap		0.35 to 0.50 mm	-
	3rd ring end gap		0.2 to 0.40 mm	-
	Offset		0.3 mm	-
Head gasket	Piston protrusion	0.475~0.540	1.2t	-
		0.541 to 0.649	1.3t	-
		0.650 to 0.745	1.4t	-

2. TIGHTENING TORQUE

Component	Size	Bolt Quantity	Specified torque (Nm)	Remark (Total torque)
Main bearing cap	M12×82	10	55±5Nm, 180°	Not re-usable
Connecting rod cap	M9×52	8	40±5Nm, 90°+10°	50 to 80 Nm
Rear cover	M6×20	6	10 ± 1 Nm	-
Oil pump	M8×35SOC	3	25 ± 2.5 Nm	-
Drive plate	M10×22	8	45 ± 5 Nm, 90°+10°	Not re-usable
Crankshaft center bolt	M20×85	1	200 ± 20 Nm, 180°+20°	660 to 720 Nm Not re-usable
Oil pan	M6×20	18	10 ± 1 Nm	-
	M6×35	2	10 ± 1 Nm	-
	M6×85	2	10 ± 1 Nm	-
	M6×120	2	10 ± 1 Nm	-
	M8×40	2	25 ± 2.5 Nm	-
HP pump main nut	M14×1.5-8-1	1	65 ± 5 Nm	-
HP pump bolt	M8×55	3	25 ± 2.5 Nm	-
Cylinder head	M13×150	12	85Nm 270°±10°	-
Camshaft cap	M6×30	16	10 ± 1 Nm	-
	M8×60	4	25 ± 2.5 Nm	-
Exhaust stud bolt		10	15±1.5Nm	-
Exhaust sprocket bolt	M8 x 16.5	1	25±2.5Nm	-
Chain tensioner screw bolt	M8 x 1.5	1	25±2.5Nm	-
Coolant temperature sensor		1	20±2.0Nm	-
Auto tensioner	M8×30(LOW)	1	25±2.5Nm	-
	M10×75(Upper)	1	55±5.5Nm	-
Coolant pump	M6×50	1	10±1.0Nm	-

Modification basis	
Application basis	
Affected VIN	

Component	Size	Bolt Quantity	Specified torque (Nm)	Remark (Total torque)
Hot water inlet pipe	M6×16	2	10±1Nm	-
Alternator	M10×90	1	25±2.5Nm	-
	M10×116	1	46±4.6Nm	-
A/C bracket	M8×25	4	7.8~11.8Nm	-
A/C sub bracket	M6×25	4	10±1Nm	-
Intake manifold	M8×35	2	25±2.5Nm	-
	M8×110	6	25±2.5Nm	-
Oil filter module	M8×40	6	25±2.5Nm	-
	M8×20	1	25±2.5Nm	-
	M8×140	2	25±2.5Nm	-
Knock sensor	M8×28	2	20±5Nm	-
Cam position sensor	M8×14	1	10~14Nm	-
Booster pressure sensor	M6×20	2	10±1Nm	-
Exhaust manifold	M8	10	40±4Nm	-
Turbocharger	M8	3	25±2.5Nm	-
Support bolt	M8×35	1	25±2.5Nm (Turbo Side)	-
	M8×16	1	25±2.5Nm (Block Side)	-
Support nut	M8	1	25±2.5Nm	-
T/C oil supply pipe	M16	1	25±2.5Nm (Fitting Screw)	-
	M10	1	17±2Nm (Hollow Bolt)	-
T/C oil return pipe	M6×16(turbo side)	2	10±1Nm	-
	M6×16(block side)	2	10±1Nm	-
EGR valve	M8×30	3	25±2.5Nm	-
EGR pipe bolt (Intake side)	M6×16	2	10±1Nm	-
EGR pipe bolt (EGR cooler side)	M8×25	2	25±2.5Nm	-

Component	Size	Bolt Quantity	Specified torque (Nm)	Remark (Total torque)
EGR Cooler MTG Bolt	M8×16	2	25±2.5Nm	-
	M8×70	2	25±2.5Nm	-
Idle pulley/Tensioner pulley		1	45±4.5Nm	-
Glow plug	M5	4	20±2Nm	-
Vacuum pump	M6×25	3	10±1Nm	-
Timing gear case cover	M12×55	3	85±8.5Nm	-
	M6×25	7	10±1Nm	-
	M6×45	1	10±1Nm	-
	M6×50	3	10±1Nm	-
Cylinder head cover	M6×35	21	10±1Nm	-
Oil gauge tube	M6×16	1	10±1Nm	-
Oil filter cap		1	25±2.5Nm	-
Fuel rail	M8×35SOC	2	25±2.5Nm	-
Injector clamp bolt	M6×60	2	10±1Nm, 120°+10°	-
High pressure pipe (between HP pump and fuel rail)	M17	1	30±3Nm	-
High pressure pipe (between fuel rail and injector)	M17	4	30±3Nm	-
Crank position sensor	M5×14	1	5±1.0Nm	-
Main wiring	M6×16	5	10±1Nm	-
Intake duct	M8x25	4	25±2.5Nm	-
Power steering pump	M8×100	3	25±2.5Nm	-
Cylinder head front cover	M6×10	5	10±1Nm	-
Ladder frame	M8×16	5	30±3Nm	-
Oil pump	M8×35	3	25±2.5Nm	-

Modification basis	
Application basis	
Affected VIN	

3. CHECK AND INSPECTION

1) Cylinder

(1) Compression pressure test

▶ **Specified value**

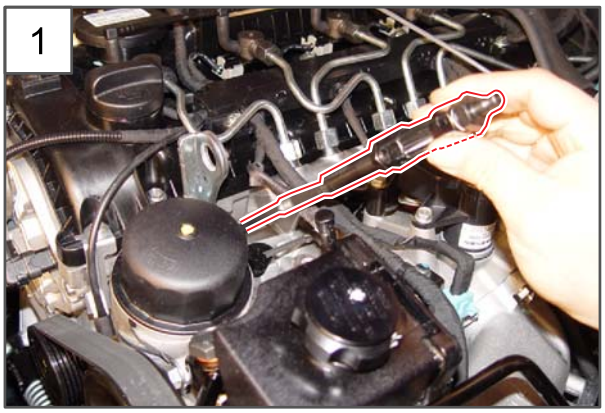
Compression ratio		16.5 : 1
Test condition		at normal operating temperature (80°C)
Compression pressure	**Standard**	32 bar
	Minimum	18 bar
Differential limit between cylinders		Maximum 3 bar

The compression pressure test is to check the conditions of internal components (piston, piston ring, intake and exhaust vale, cylinder head gasket). This test provides current engine operating status.

CAUTION
- Before cranking the engine, make sure that the test wiring, tools and persons are keeping away from moving components of engine (e.g., belt and cooling fan).
- Park the vehicle on the level ground and apply the parking brake.
- Do not allow anybody to be in front of the vehicle.

▶ **Measurement**

- Warm the engine up to normal operating temperature (80°C).
- Disconnect the fuel rail pressure sensor connector to cut off the fuel injection.
- Remove the air cleaner duct and glow plugs.

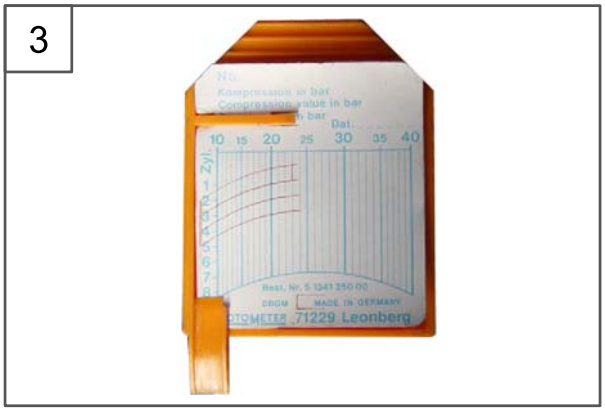


1. Place the diagram sheet to compression pressure tester and install it into the plug hole.

2

2. Crank the engine for approx. 10 seconds by using the start motor.

3



3. Record the test result and measure the compression pressure of other cylinders with same manner.

4. If the measured value is out of specified value, perform the cylinder pressure leakage test.

(2) Cylinder pressure leakage test

▶ **Specified value**

Test condition: normal engine operating temperature (80°C)	**Specified value**
Whole engine	below 25%
at valve and cylinder head gasket	below 10%
at piston ring	below 20%

If the measured value of the compression pressure test is not within the specifications, perform the cylinder pressure leakage test.

CAUTION

- Perform this test in the sequence of firing order.
- Do not test the cylinder pressure leakage with wet type test procedure. (do not inject the engine oil into the combustion chamber)

Modification basis	
Application basis	
Affected VIN	

(3) Piston protrusion check

Position the piston at TDC and measure the piston protrusion from crank case mating surface.

Specified value	0.475~0.745mm

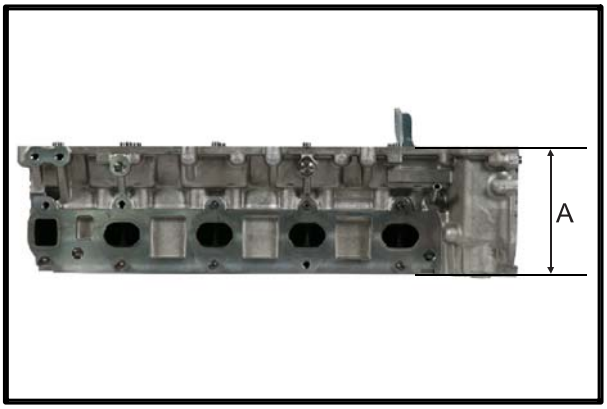
CAUTION
- Measure it at both ends of crankshaft.

2) Cylinder Head

(1) Cylinder head mating surface check

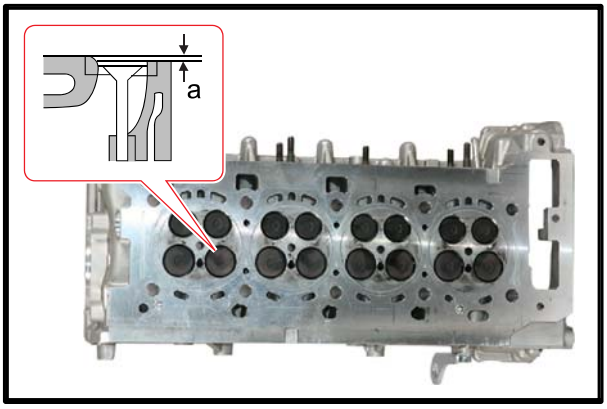
▶ **Specified value**

Total height "A"		131.9 to 132.1 mm
Minimum height after machining		131.9 mm
Flatness		below 0.1 (150 mm)
		below 0.15 (Total)
Parallel deviation of cylinder head		below 0.1 mm
Peak-to valley of surface		Rmax 7 Rz 6.3
valve recess "a"	**Intake valve**	0.6 to 1.0 mm
	Exhaust valve	0.6 to 1.0 mm



1. Measure the cylinder head height "A".

CAUTION
- If the height is less than the limit, the cylinder head must be replaced.



2. Insert the valves into the valve guides and measure the recesses.

Valve recess “a	0.6 to 1.0mm

CAUTION
- If the measured value is out of the specified range, machine the valve seat as much as necessary until the specified value is achieved.

(2) Cylinder head pressure Leak test

Immerse the cylinder head with the pressure plate into warm water (approx. 60°C) and pressurize with compressed air to 2 bar.

Modification basis	
Application basis	
Affected VIN	

4. GUIDELINES ON ENGINE SERVICE

To prevent personal injuries and vehicle damages that can be caused by mistakes during engine and unit inspection/repair and to secure optimum engine performance and safety after service works, basic cautions and service work guidelines that can be easily forgotten during engine service works are described in.

▶ **Cautions before service works**

- For safe and correct works, you must observe the working procedures and instructions in this manual. And, use the designated tools as follow:
  Engine stand / Heavy duty engine jack
- To prevent the engine from starting abruptly, do not allow anybody to get in the vehicle while servicing in engine compartment.
- Before work on engine and each electrical equipment, be sure to disconnect battery negative (-) terminal.
- Before service works, be sure to prepare the works by cleaning and aligning work areas.
- Do not allow the foreign material get into the fuel injection system.
- When removing the engine, use only the safety hook on engine and engine hanger. Do not support the bottom of oil pan with a jack.

▶ **Engine and accessories**

- Completely drain the engine oil, coolant and fuel from engine before removal.
- Before disassembling/assembling the engine components, carefully read the working procedures in this manual.
- Make sure to keep the specified tightening torques during installation.
- Clean and properly lubricate the parts before reassembly.
- Carefully check that there are not any interference while servicing.

▶ Fuel and lubrication system

- Do not allow the fluid and engine oil to make contact with the body paintwork and hoses.
- If work on the fluid system such as fuel and oil, working area should be well ventilated and smoking should be prohibited.
- Gasket or seal on the fuel/lubrication system should be replaced with new ones and bolts and nuts should be tightened as specified.
- After removal/installation works, be sure to check whether there is leak on the connecting section.

If fine dust or foreign material enters into DI engine's fuel system, there can be serious damages in HP pump and injectors. Thus, be sure to plug the inlets of removed fuel line components with cap and protect removed parts not to be contaminated with dirt. (Refer to cleanness in this manual while working on DI engine fuel system)

▶ Electrical equipment

Electric devices should be handled more carefully.
Currently, the engine has a lot of electric devices. there could be poor engine performance, incomplete combustion and other abnormal symptoms due to short circuit or poor contact.

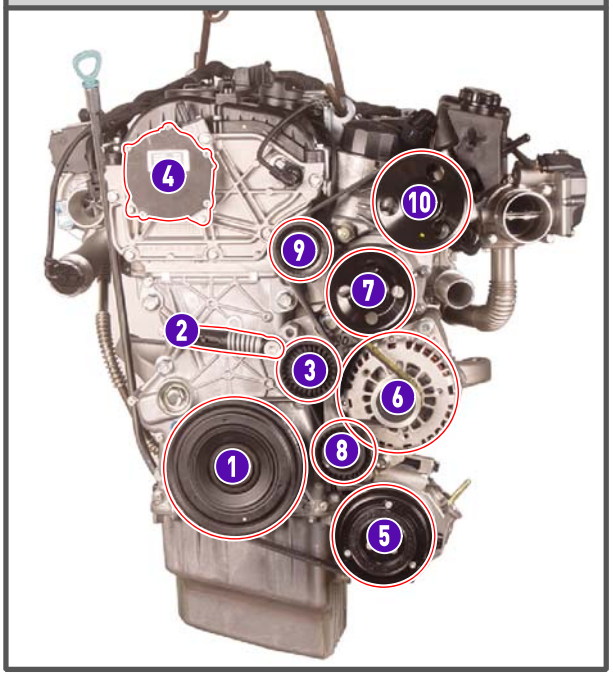
- Before work on engine and each electrical equipment, be sure to disconnect battery negative (-) terminal.
- When replacing the electric device, use only genuine part and check the conditions of connections and grounds. Loosened connection or ground make cause a fire and personal injury.

OVERVIEW AND OPERATING PROCESS

1. BELT LAYOUT

It is single drive type and uses FEAD (Front End Accessories Drive) design to make a compact layout.

▶ **Components**

D20DTR Engine


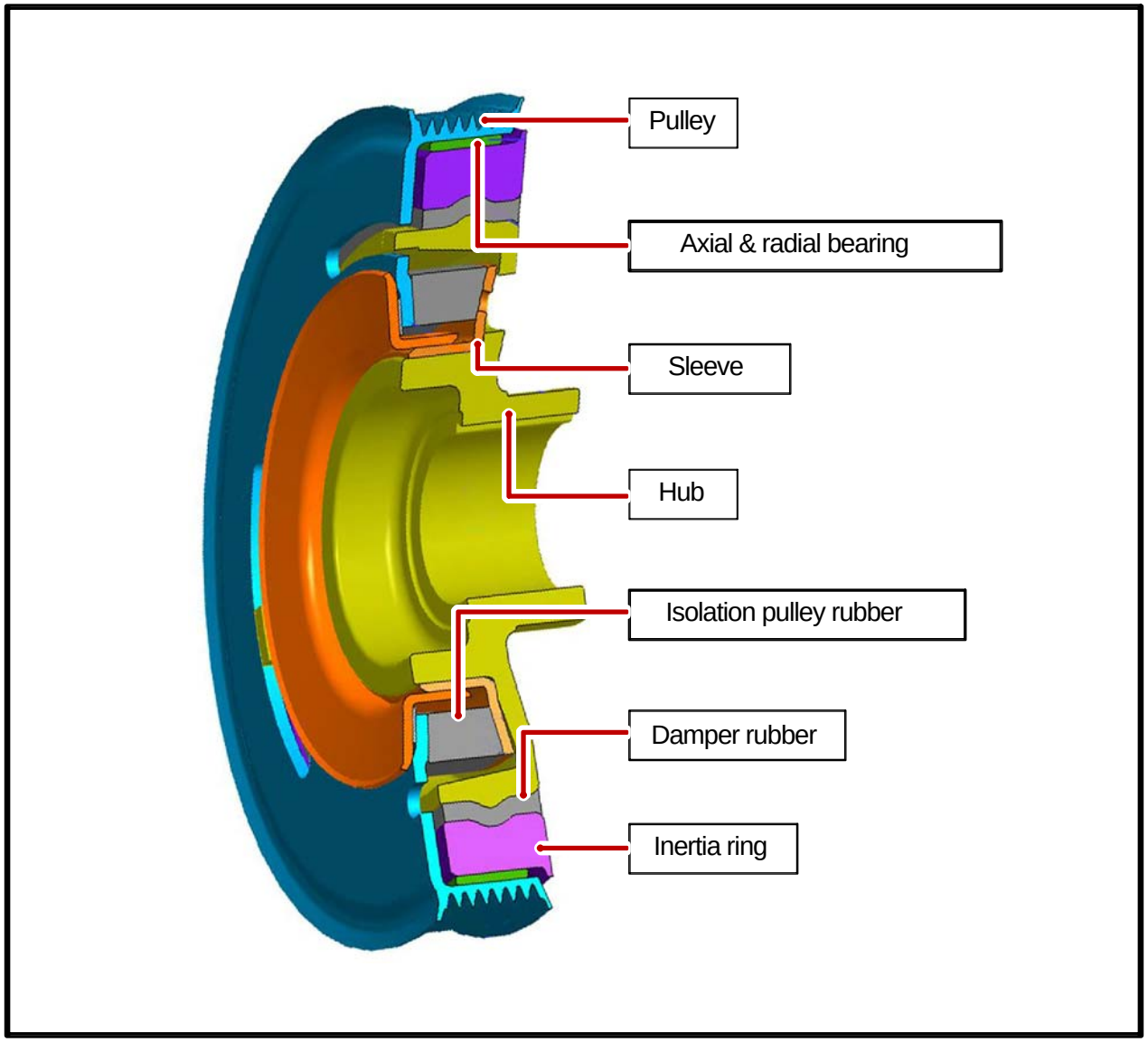
	HPS (Hydraulic Power Steering)
1	Crankshaft pulley (DDU)
2	Auto tensioner
3	Tensioner pulley
4	Vacuum pump
5	A/C compressor pulley
6	Alternator pulley
7	Water pump pulley
8	Idle pulley #1
9	Idle pulley #2
10	Power steering pump pulley

1) Crankshaft Pulley (Isolation Damper)

(1) Overview

The strut type tensioner automatically adjusts the belt tension to provide the reliability and durability for the system. And, the belt tension is decreased to minimize the friction loss and improve the belt operating noise.

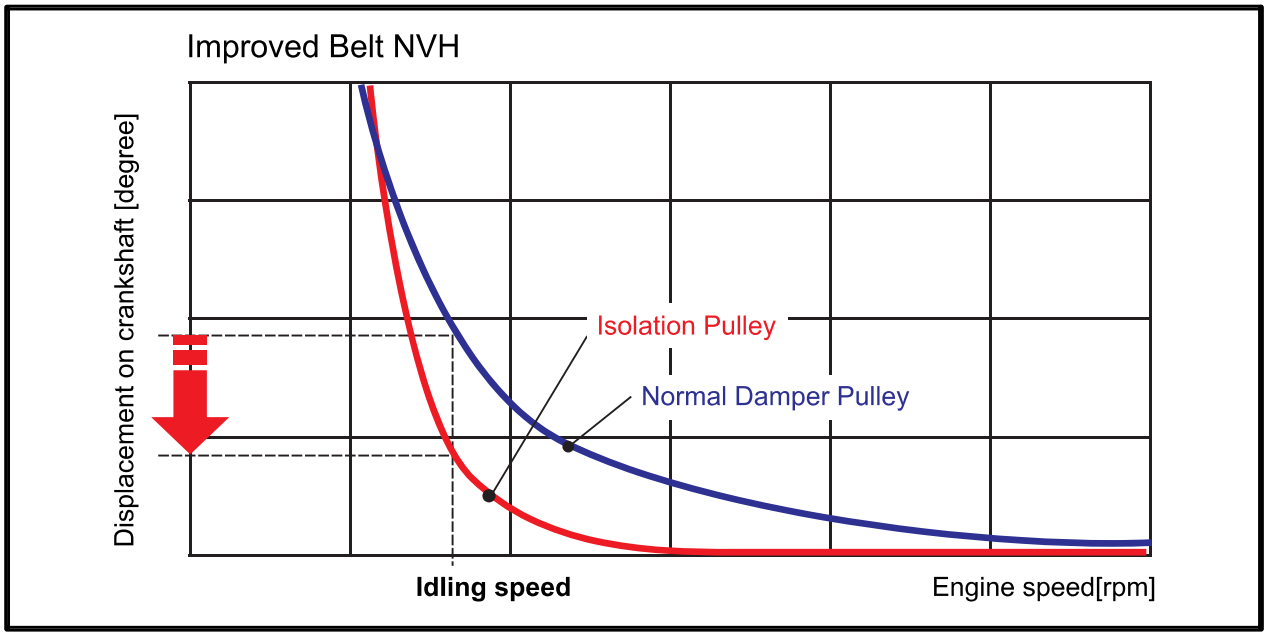
(2) Sectional drawing



Modification basis	
Application basis	
Affected VIN	

(3) Features

1. Rubber damper: Decrease crankshaft torsion
2. Improve belt NHV: Reduce unbalance speed to crankshaft due to irregular combustion
3. Minimize noise: Anti-vibration from crankshaft and belt
4. Post bonded type rubber damper: Improve durability of rubber damper

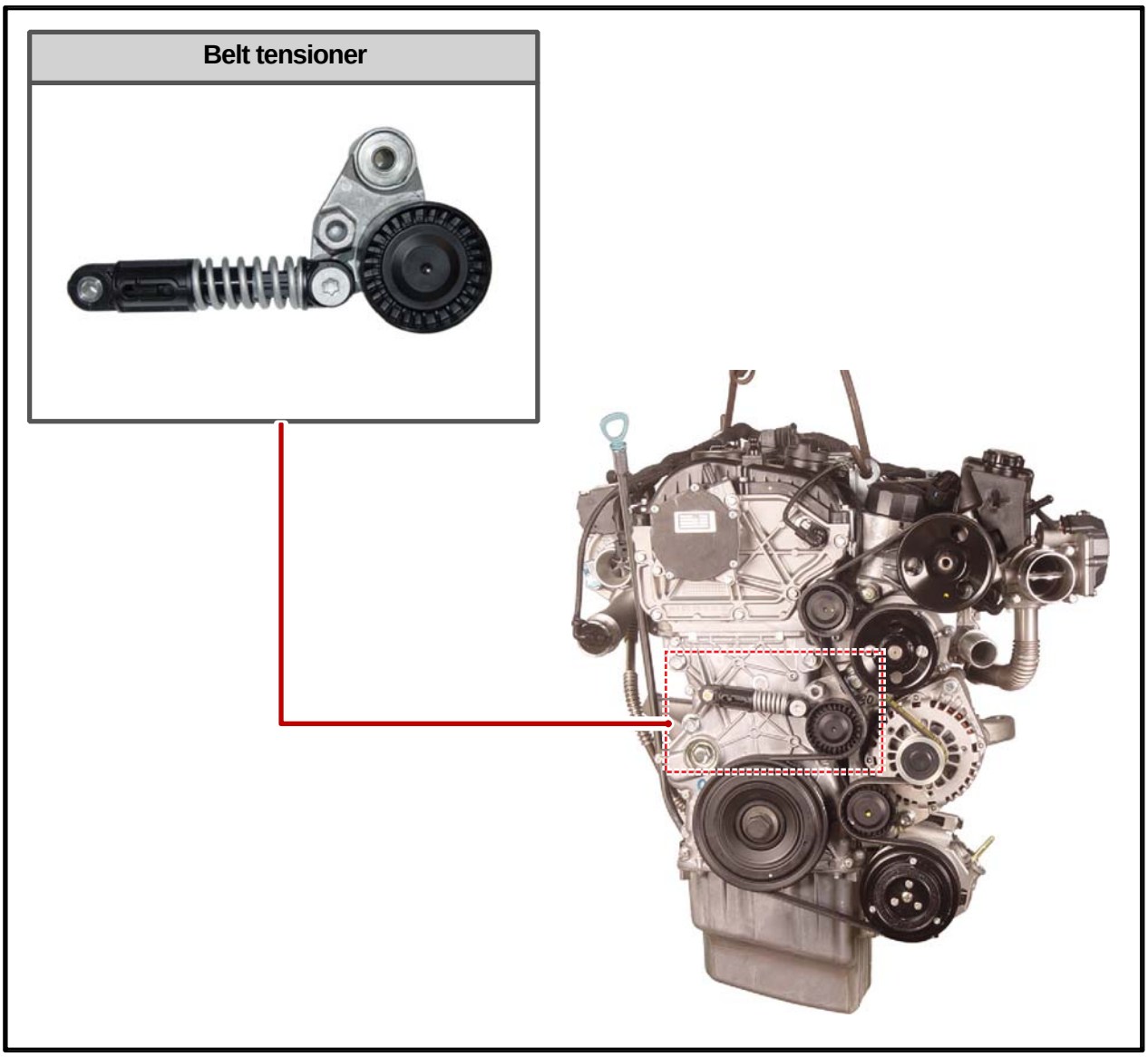


2) Belt Tensioner

(1) Overview

The torque deviation from crankshaft affects the components in belt drive system and the belt movement. The auto tensioner system is to adjust this deviation automatically.
In D20DTR engine, one of the mechanical tensioner, pivot damped tensioner is used to keep the damping force, system reliability and durability. The single belt drive system needs to use the automatic belt tensioning device to transfer the power to pulleys effectively. To get this, the tensioner uses the spring and damping unit.

(2) Location



Modification basis	
Application basis	
Affected VIN	

2. VACUUM PUMP

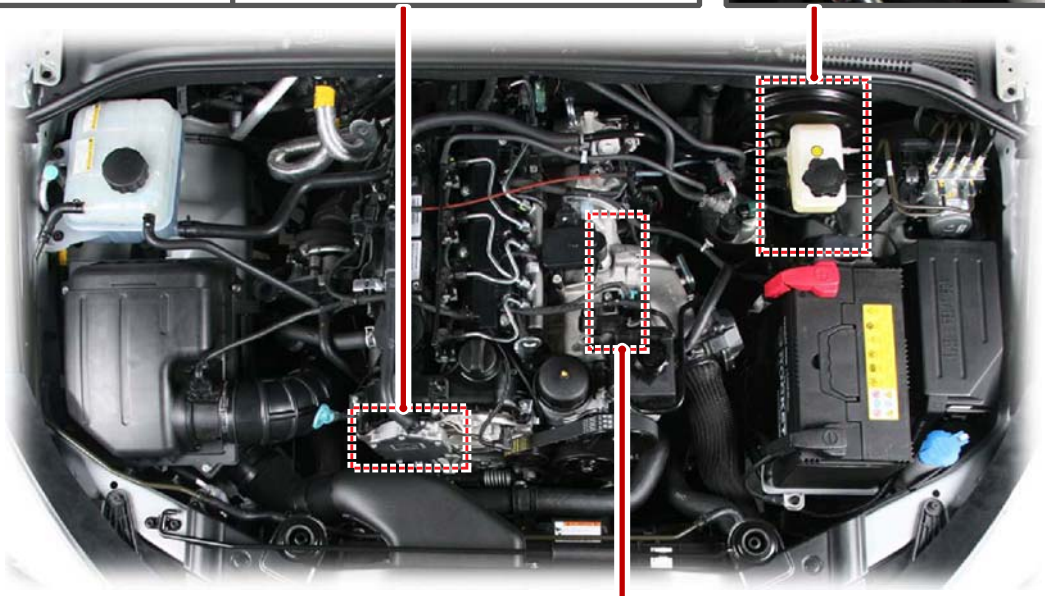
Vacuum pump generates the vacuum pressure and supplies it to EGR cooler bypass solenoid. This pump is single vane type and displacement is 210 cc/rev. The lubrication oil is supplied through the hole in hollow shaft.

▶ Components

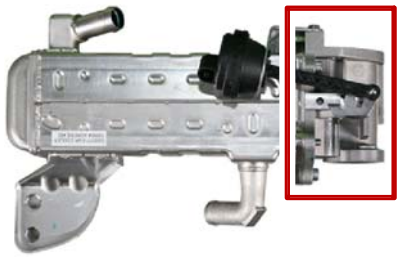
Vacuum pump

Pump capacity: 210 cc/rev
Camshaft speed: 375 to 3,000 rpm
Lubrication temperature: -40 to 155°C
Oil: 5W30
Drive type: Driven by exhaust Camshaft sprocket

Brake booster and naster cylinder

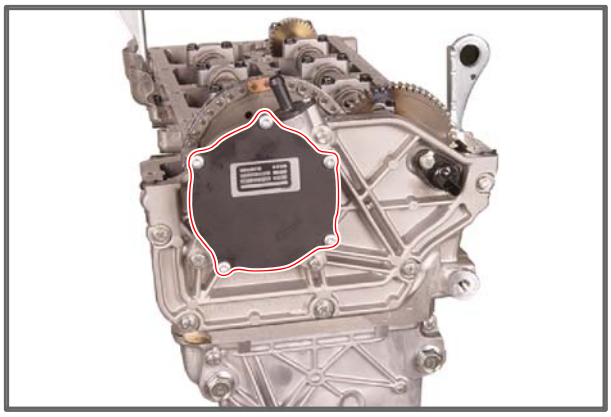


EGR cooler bypass valve



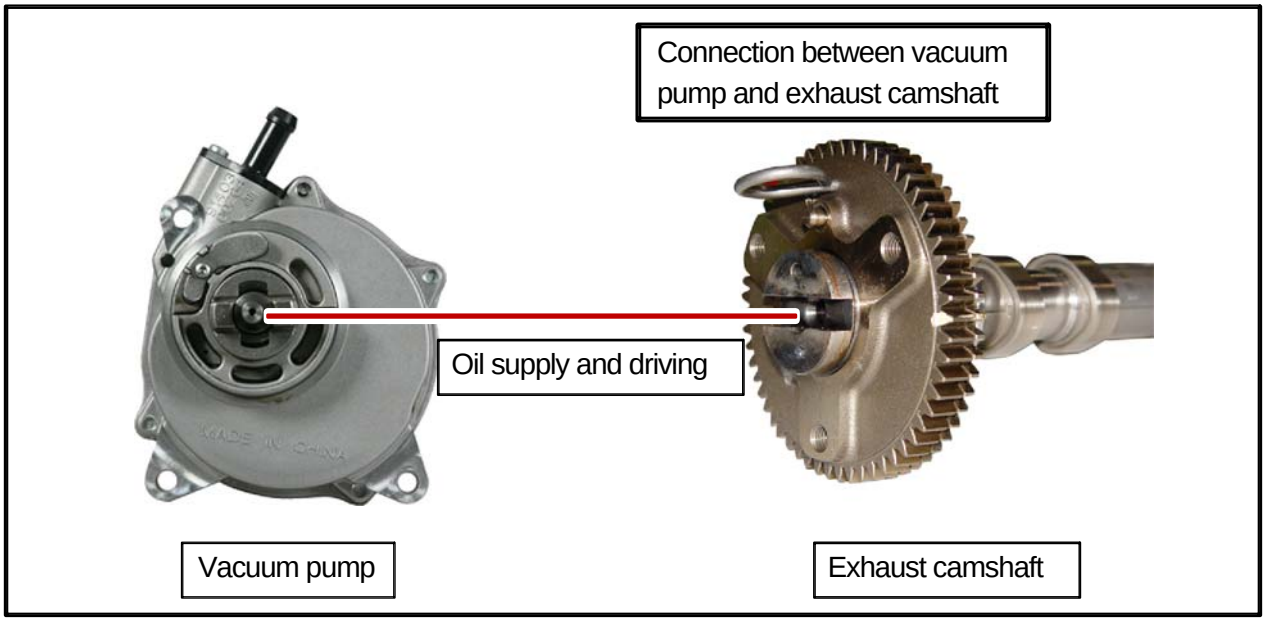
This valve is controlled by ECU. When the engine is cooled, the exhaust gas goes to combustion chamber without passing through EGR cooler because the valve is closed by vacuum pressure.

1) Location



2) Operation

The vacuum pump is engaged to the exhaust camshaft.



Modification basis	
Application basis	
Affected VIN	

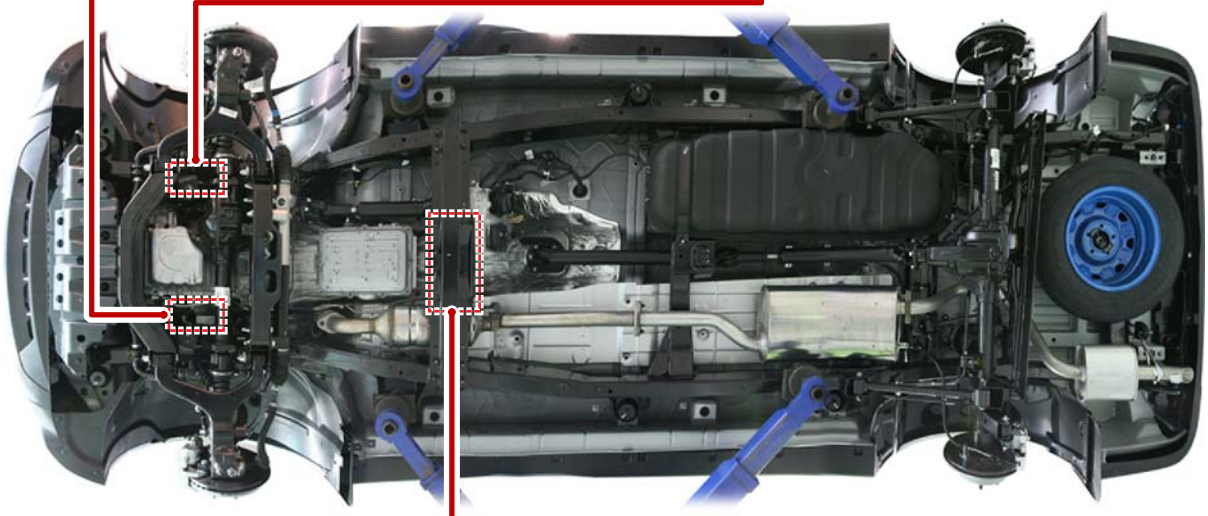
3. ENGINE MOUNTING

D20DTR engine uses 3-point mounting type that supports the engine and transmission simultaneously.

▶ **Components**

Front mounting insulator (Right side)	
Location	Insulator
	

Front mounting insulator (Left side)	
Location	Insulator
	



Rear mounting insulator			
2WD		4WD	
A/T	M/T	A/T	M/T
			

1) Functions

Appearance	Type and function
Front mounting insulator (Right side) 	Type: Rubber mounting Function: Supports the torque reaction
Front mounting insulator (Left side) 	Type: Rubber mounting Function: Supports the torque reaction
Rear mounting insulato 	Type: Rubber mounting Function: Supports the powertrain rod

Modification basis	
Application basis	
Affected VIN	

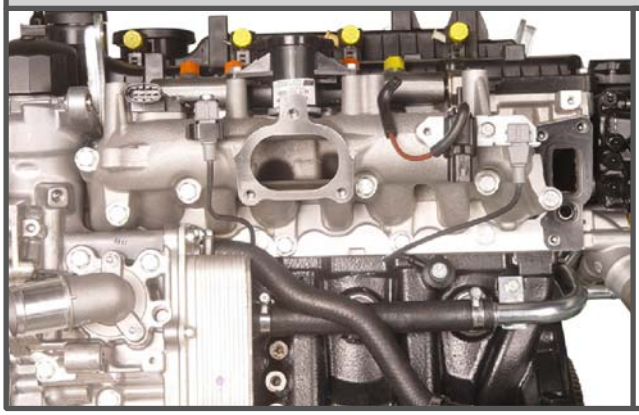
4. INTAKE/EXHAUST MANIFOLD

1) Intake Manifold

Intake manifold is installed on the cylinder head with 8 bolts. The variable swirl valve is introduced to improve the EGR gas mixture and turbulence in combustion chamber and to decrease the exhaust gas.

▶ **Components**

Intake manifold



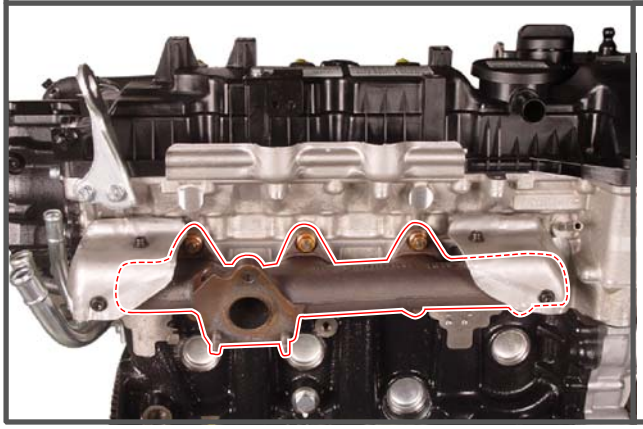
* For detailes, refer to Chapter "Intake System".

2) Exhaust Manifold

Exhaust manifold is installed on the cylinder head with 10 stud bolts and nuts. EGR port is integrated in cylinder head.

▶ **Components**

Exhaust manifold



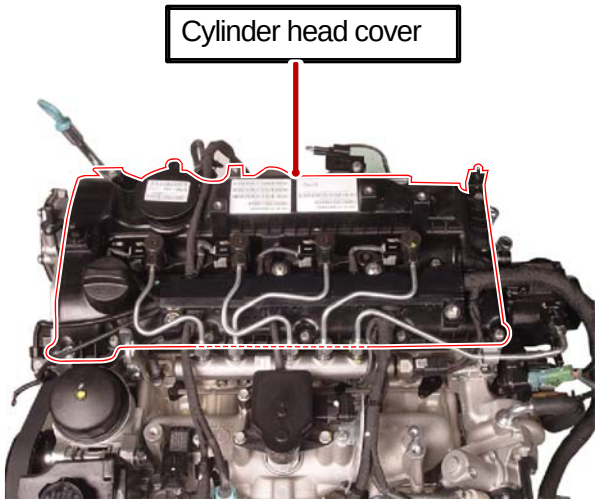
* For detailes, refer to Chapter "Exhaust System".

5. CYLINDER HEAD COVER AND OIL SEPARATOR

1) Cylinder Head Cover

The cylinder head cover is made by high strength plastic to reduce the weight. The multi twist type oil separator improves the oil consumption.

▶ **Components**



Front view

Rear view

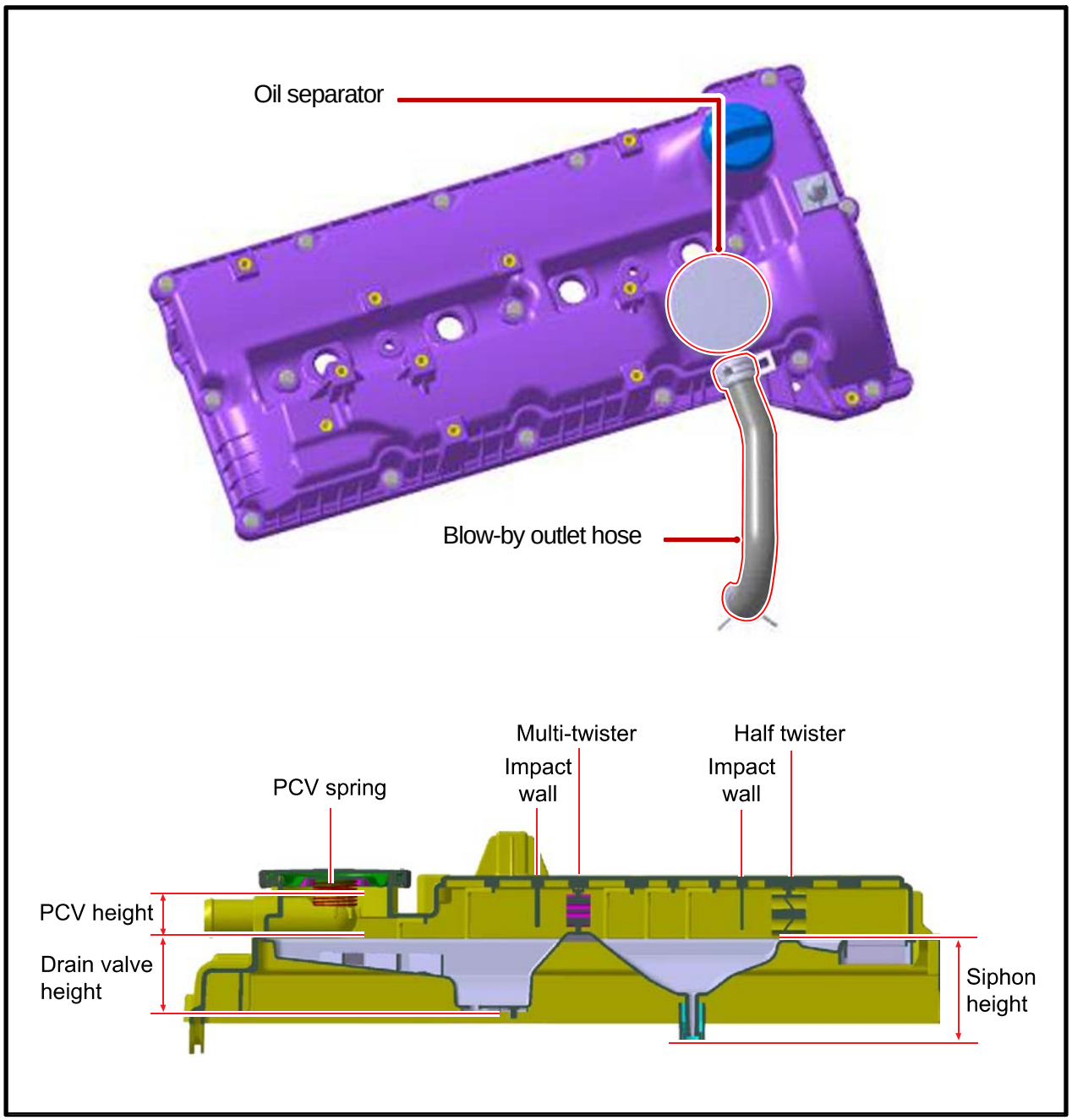
Modification basis	
Application basis	
Affected VIN	

2) Oil Separator

(1) Overview

Oil separator separates the particle in blow-by gas to minimize the engine oil consumption and reduces the inflow oil from intake system into the combustion chamber. The separated oil returns to oil pan through cylinder head.

(2) Layout



6. CYLINDER HEAD

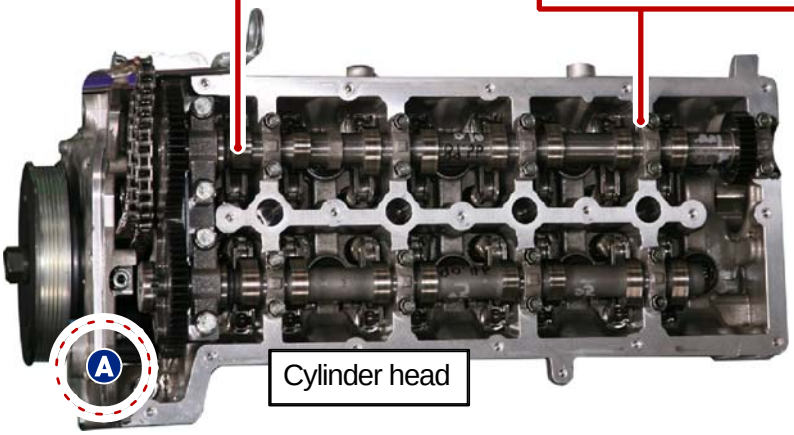
Cylinder head contains cam position sensor, vacuum pump, intake manifold, exhaust manifold and valve assembly. Vacuum pump and the high pressure (HP) pump are driven by Camshaft and valves are install in vertical direction. This enables the compact layout in cylinder head assembly.

▶ **Components**

Finger follower & HLA

Intake/exhaust Camshafts

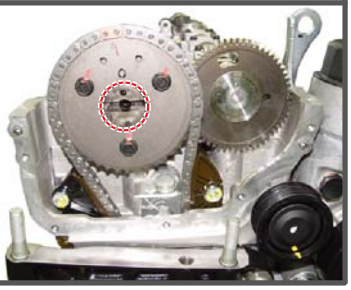
Camshaft sprocket



Camshaft position sensor

HP pump drive gear

Vacuum pump drive



Cylinder head gasket

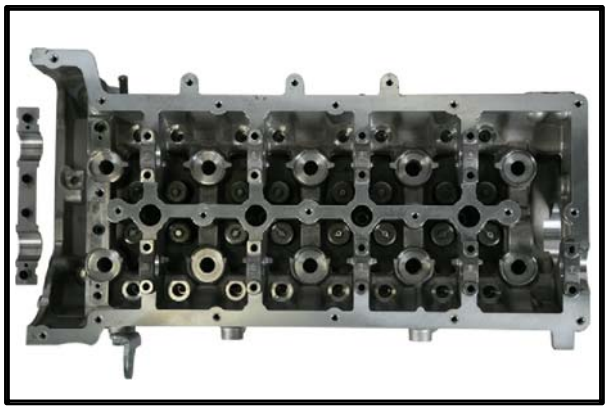
Modification basis	
Application basis	
Affected VIN	

1) Cylinder Head

(1) Overview

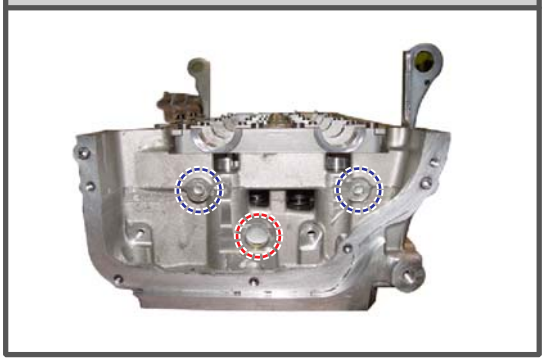
The cylinder is made by gravity casting and the water jacket is integrated type.
The cylinder oil passage is drilled and sealed by cap.
The Camshaft bearing cap is also made by casting and installed on the cylinder head.

(2) Features

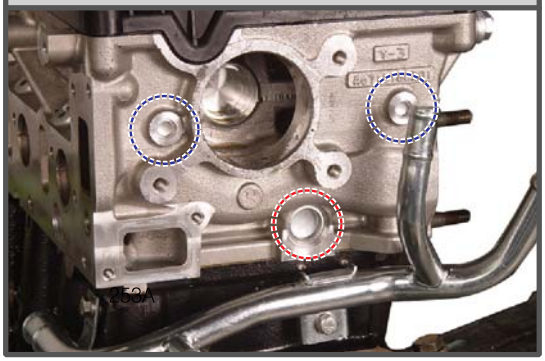


Location of Expansion Plugs

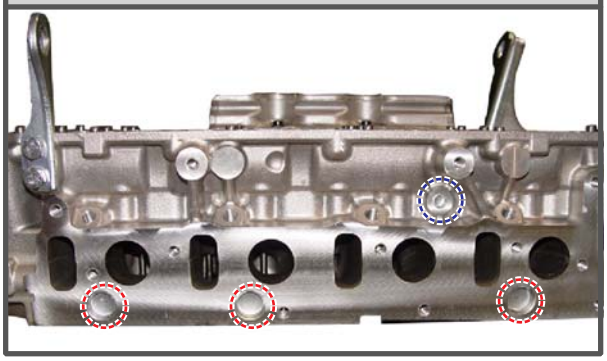
Front



Rear

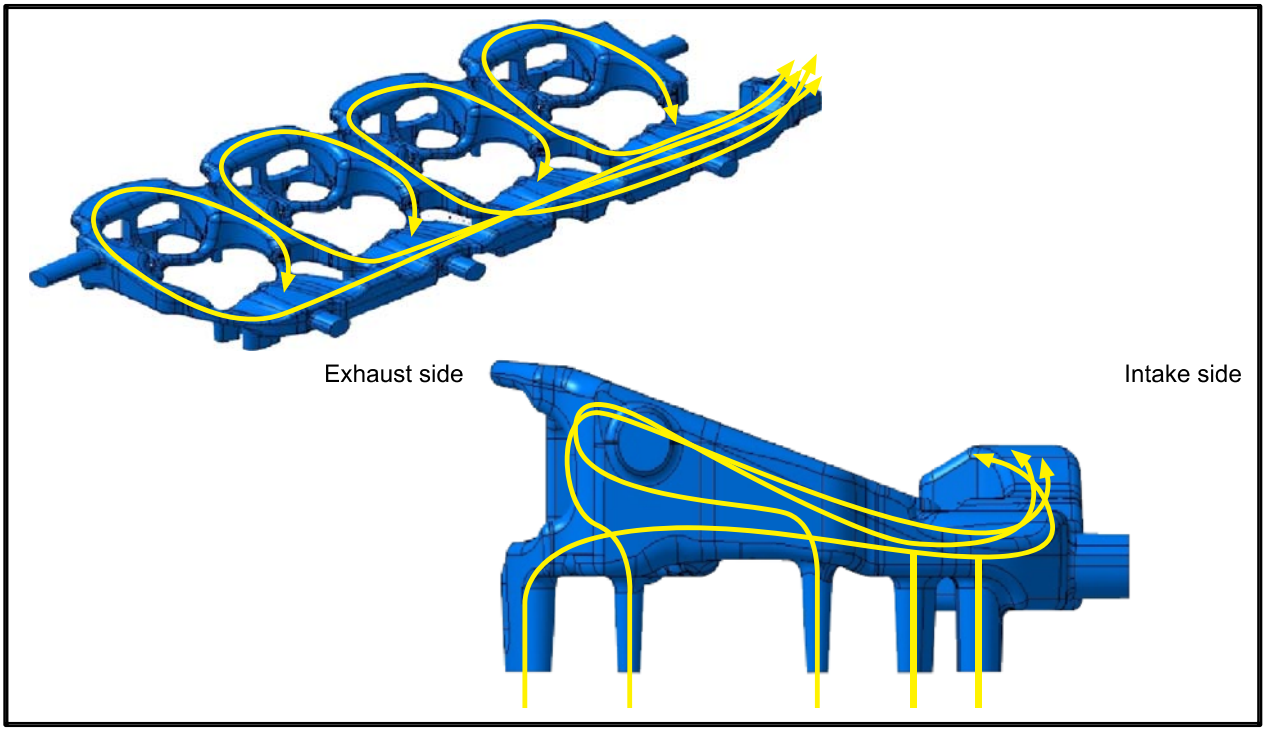


Intake side



Coolant expansion plug (M21)
Oil gallery expansion plug (M10)

▶ **Cross flow type water jacket (improving cooling performance)**



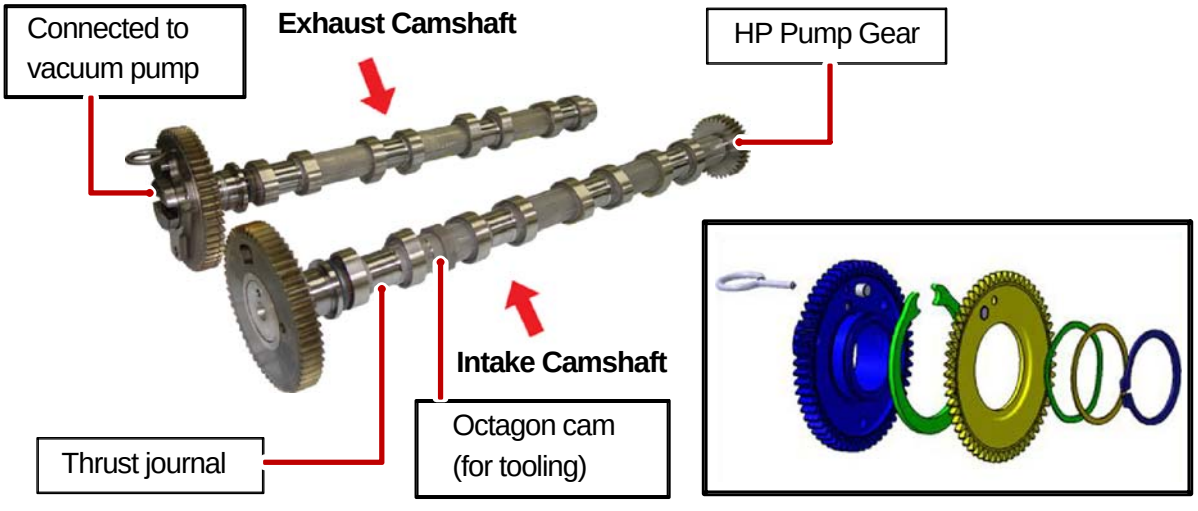
2) Camshaft

(1) Overview

Hollow type camshaft contains cam, octagon cam, HP pump gear and intake/exhaust gears. Camshaft operates the intake/exhaust valves, vacuum pump and HP pump, and transfers the engine oil to vacuum pump through the internal oil passage.

(2) Location

Intake/Exhaust Camshafts



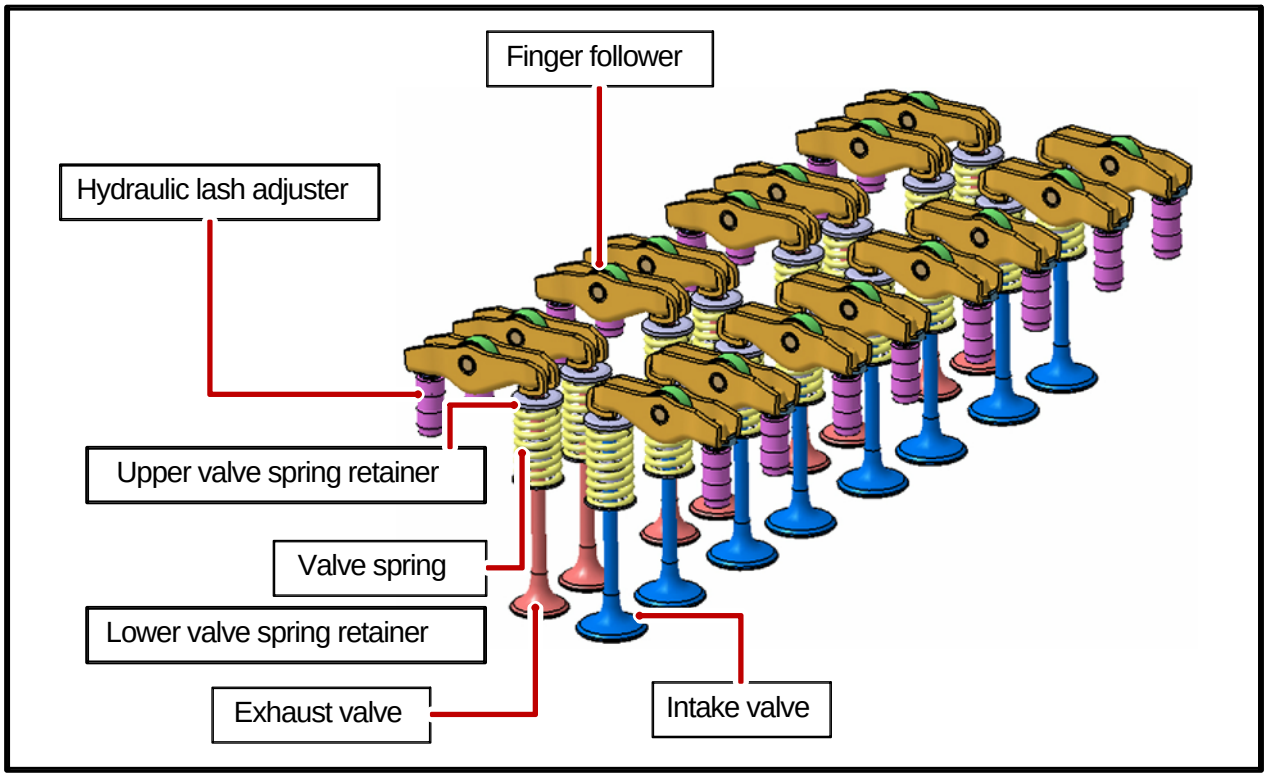
Modification basis	
Application basis	
Affected VIN	

3) Valve Assembly (Installed in Cylinder Head)

(1) Features

1. Automatic valve clearance adjuster by hydraulic pressure (Maintenance Free) - Hydraulic lash
2. Optimized adjustment of valve clearance reduces the valve noise.
3. Roller type finger follower reduces the friction loss.
4. Vertical installation.
5. Simple and compact design reduces the moving operation (improving valve following and fuel consumption at high speed)

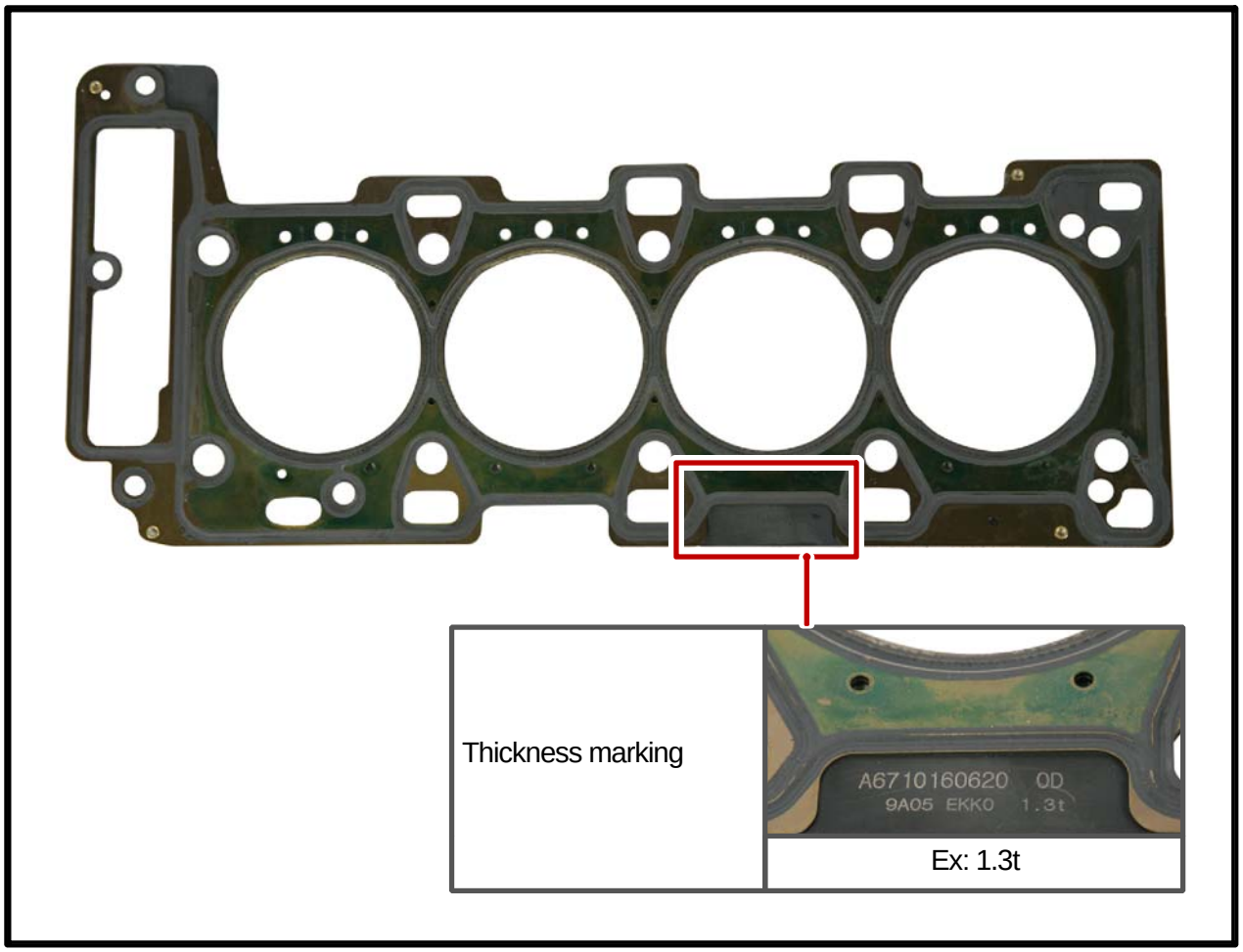
(2) Arrangement



4) Cylinder Head Gasket

(1) Features

1. Sealing the cylinder gas pressure - Peak pressure: 190 bar
2. Minimizing the distortion of engine structure (cylinder head, block): profile stopper, backland stopper
3. Material: MLS (Multi Layer Steel), Gasket (3 layers)
4. Thickness of gasket: 3 types (1.2 /1.3 /1.4 mm)



(2) Thickness of cylinder head gasket

There are three types of gasket to managing the compression ratio.

▶ **Piston protrusion**

Piston protrusion	Thickness
0.475 to 0.540 mm	1.2t
0.541 to 0.649 mm	1.3t
0.650 to 0.745 mm	1.4t

Modification basis	
Application basis	
Affected VIN	

7. CHAIN AND GEAR DRIVE SYSTEM

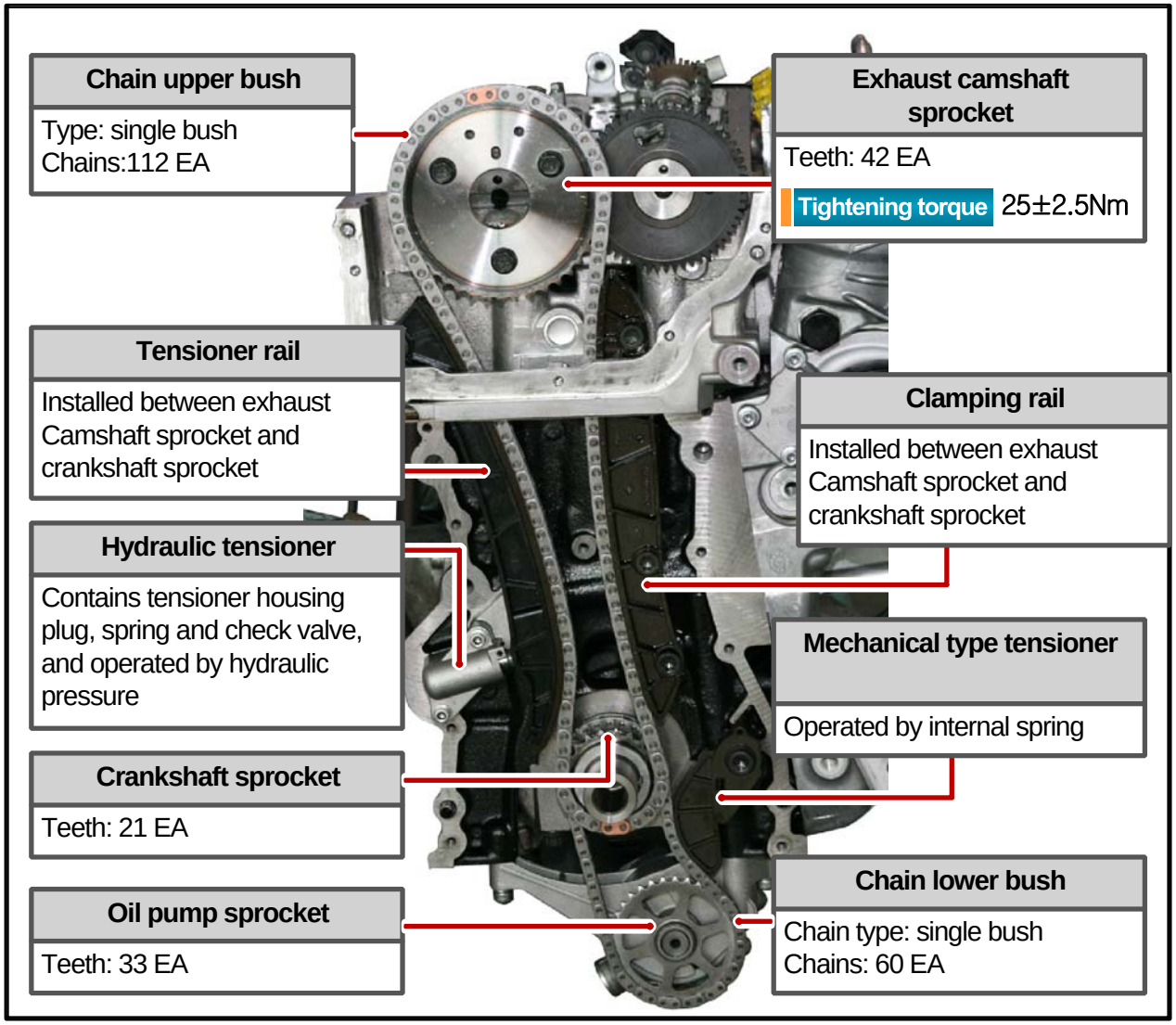
D20DTR engine uses single stage chain drive system. Timing chain drives the exhaust side and gear drive the intake side. Timing chain is single bush type. Upper chain drives HP pump connected to intake Camshaft by driving exhaust camshaft sprocket, and lower chain drives oil pump to lubricate the engine.

1) Chain Drive

(1) Overview

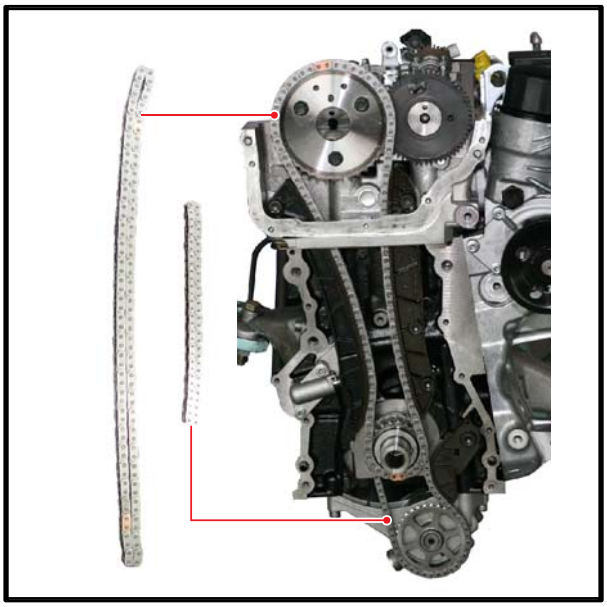
The drive chain is single chain drive system with simple design and variable performance, and it utilizes the hydraulic tensioner to reduce the wave impact generated by the chain. This chain is light weight and has high durability through single bush chain. Shoulder bolts are used for better NVH.

(2) Layout



2) Timing Chain and Gear

(1) Timing chain



- Simple layout: optimized timing, enhanced NVH
- Single stage layout: minimized chain load

Chain upper bush
- Single bush type (112 EA)

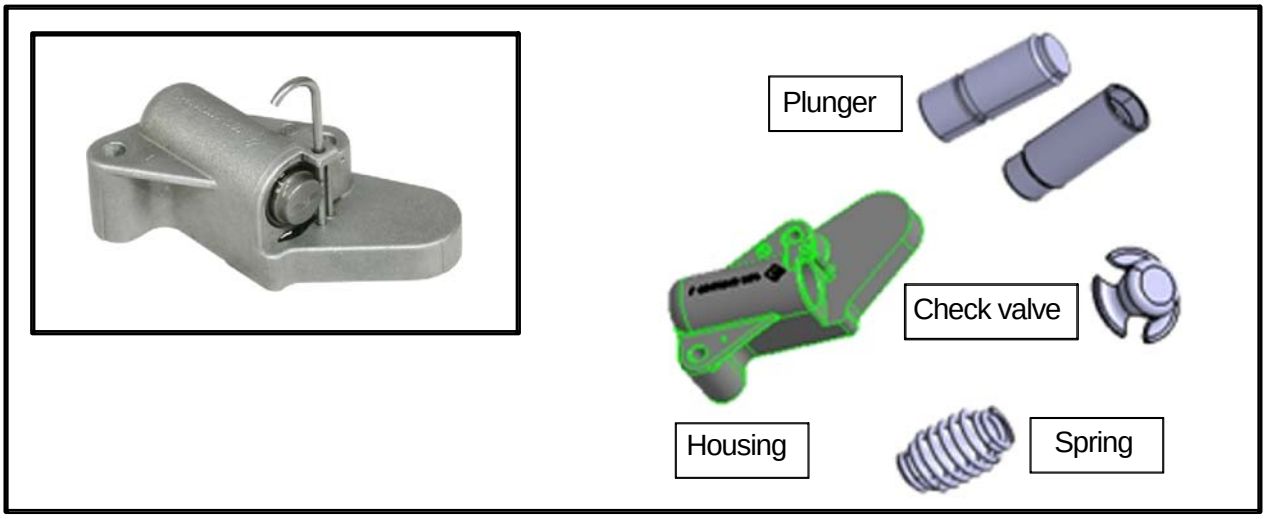
Chain lower bush
- Single bush type (60 EA)

(2) Tensioner

Tensioner adjusts the chain tension to keep it tight during engine running. This reduces the wear in guide rail and spoke.

▶ **Hydraulic tensioner assembly**

1. Operating principle
   - Use the spring tension in tensioner and hydraulic pressure
2. Tensioner type
   - Compensation and impact absorbing
3. Static and dynamic force
   - Spring + Hydraulic pressure



Modification basis	
Application basis	
Affected VIN	

(3) Mechanical Tensioner Assembly

Operating principle
- Use only spring tension

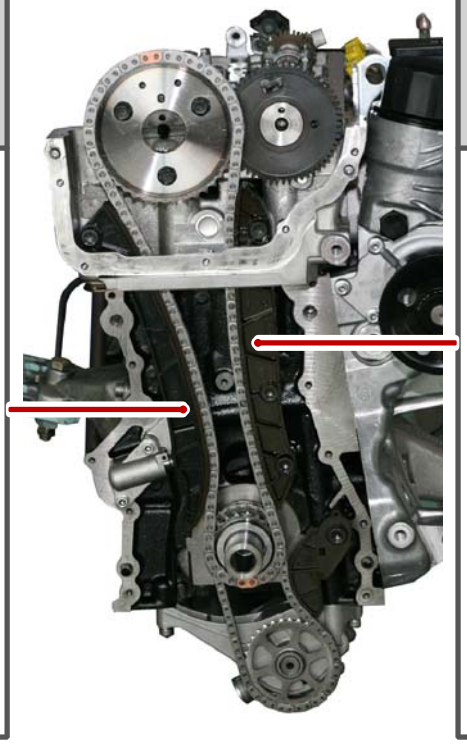
Tensioner type
- Compensation and impact absorbing

Static and dynamic force
- Spring

(4) Guide rail

The guide rail is used for optimizing the movement of chain drive system. And it also prevents the chain from contacting each other when the chain is loose, and reduces the chain wear.
The guide rail is made of plastic, nylon, Teflon, etc. The guide rail is specially required when the distance between two spokes is too great. It pushes the chain with constant force so that the chain can work smoothly. The guide rail is fitted by pins.

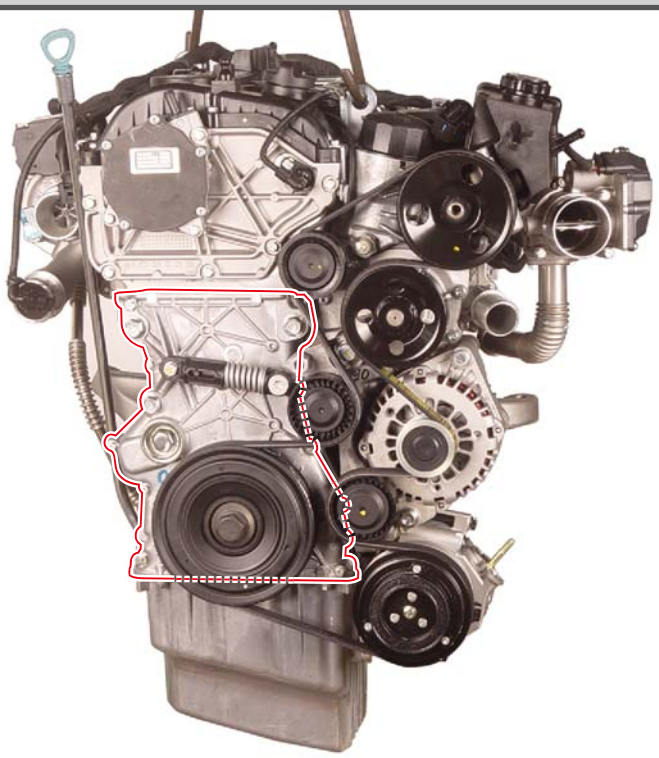
Tensioner guide rail
Installed between exhaust Camshaft sprocket and crankshaft sprocket



Clamping guide rail
Installed between exhaust Camshaft sprocket and crankshaft sprocket

(5) Timing gear case cover

Timing gear case cover (TGCC)



Timing gear case cover

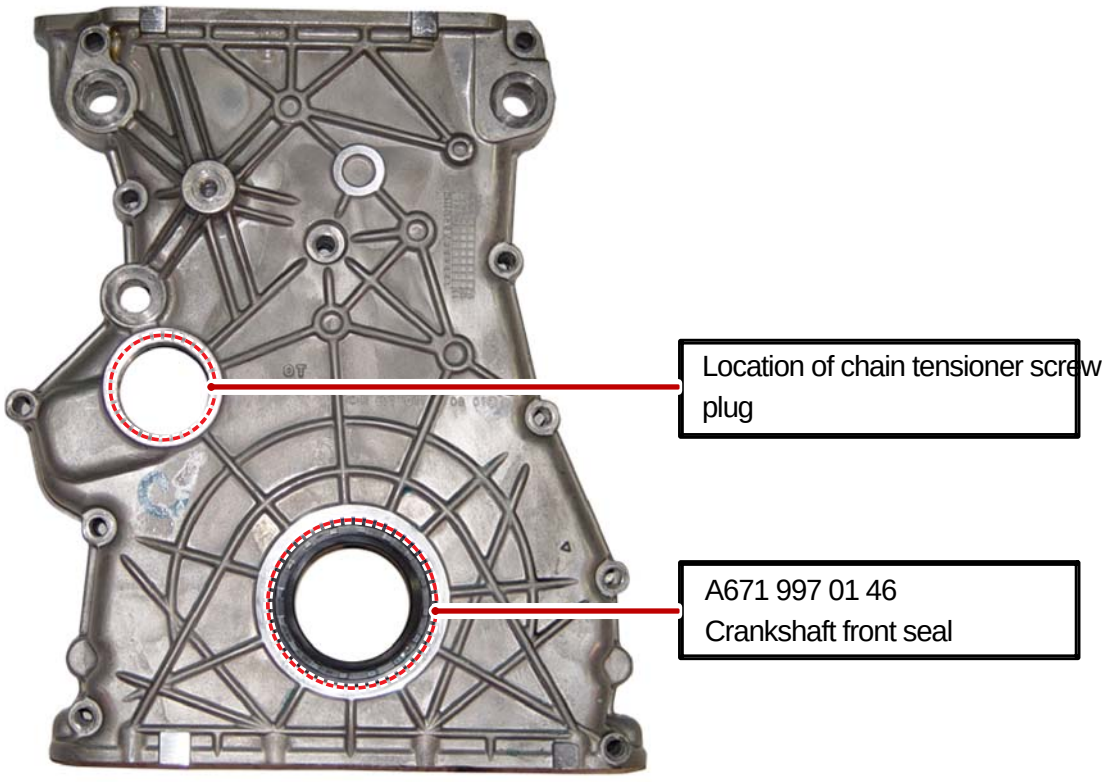
Oil seal

Screw plug

Modification basis	
Application basis	
Affected VIN	

▶ Features

- Major function: Protecting the chain drive system, minor function: Shielding the chain noise.
- Install crankshaft front seal and screw plug on the timing gear case cover.



CAUTION

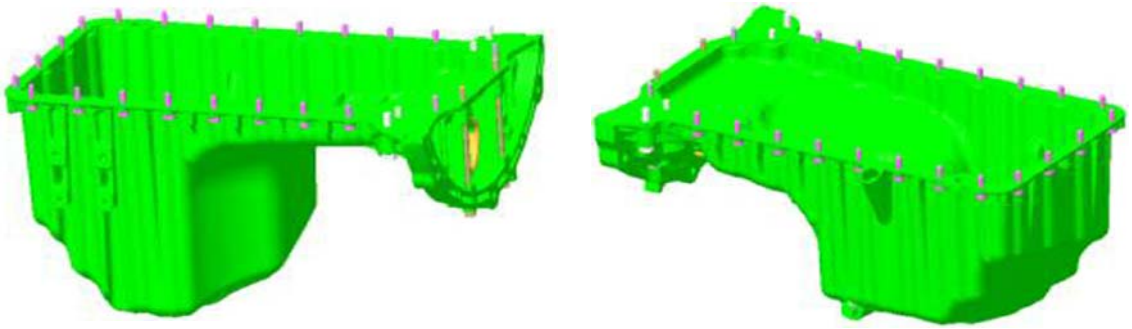
- Do not touch the inner lip of crankshaft front seal.
- Be careful not to damage the screw thread when removing the lock pin to release the chain tensioner.
- Be careful not to damage the O-ring when installing the screw plug.

8. OIL PAN

The oil pan in D20DTR engine improves the NVH. Especially, the oil draining is much easier than before.

▶ **Components**

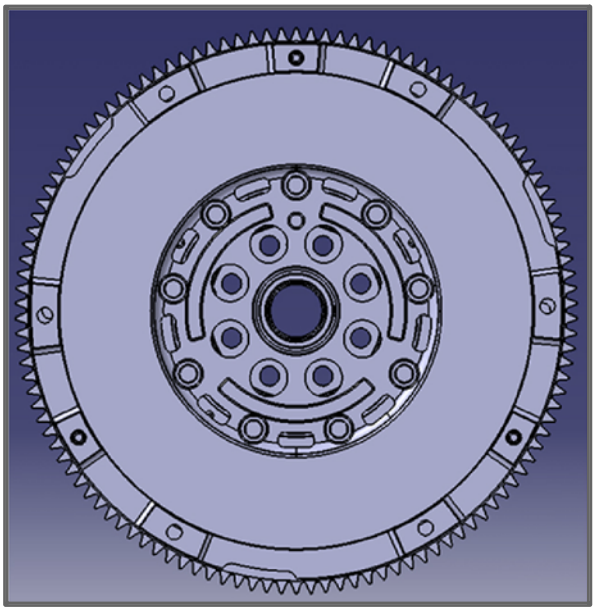
Oil pan sassembly



Modification basis	
Application basis	
Affected VIN	

9. DUAL MASS FLYWHEEL (DMF) & DRIVE PLATE

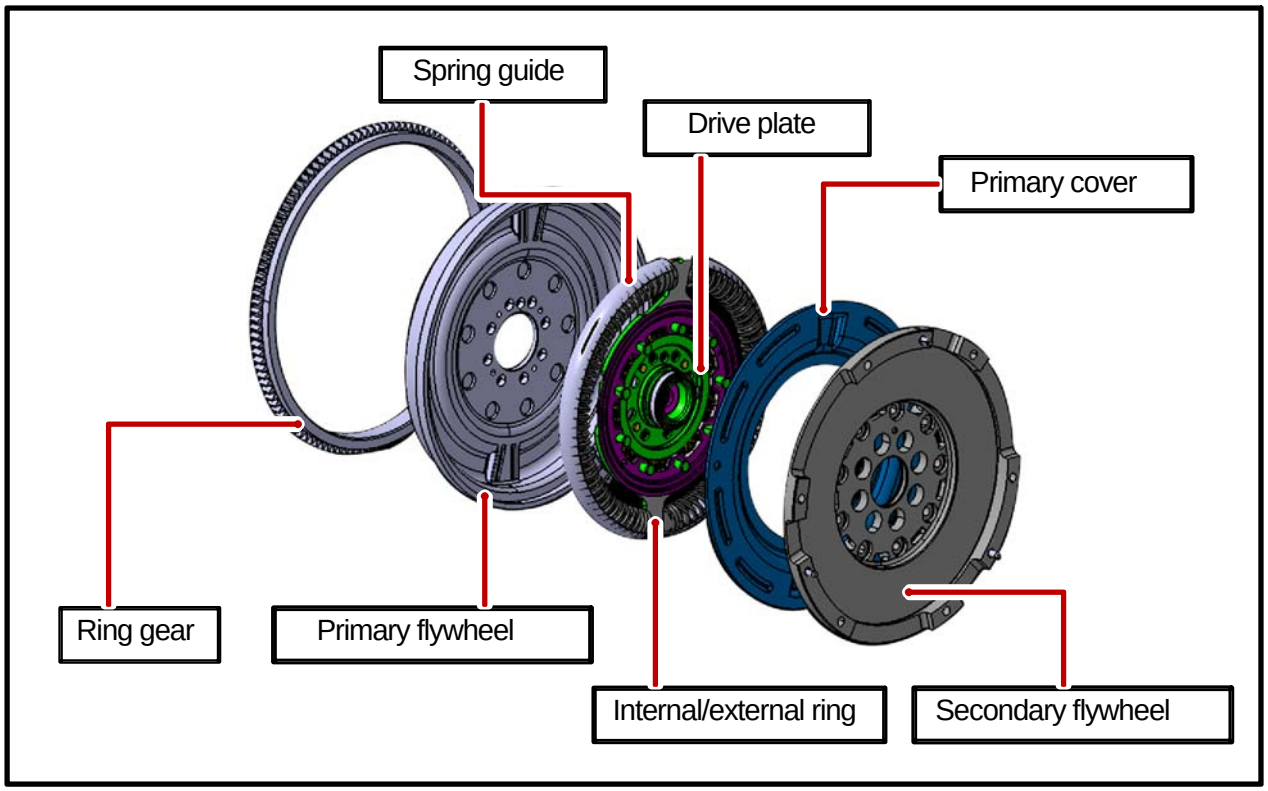
1) Overview



Flywheel is installed on crankshaft. When starting the engine, this functions as follows:

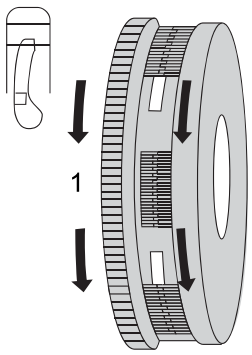
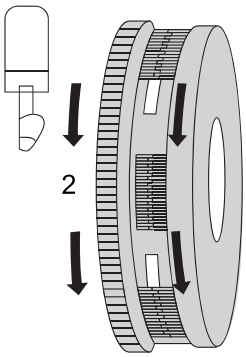
- Reducing the irregular speed of crankshaft due to unbalanced combustion -> Improving the power train NVH, Improving the driving performance
- Reducing the clutch noise by using ball bearing
- Improving the durability of DMF by using strong arch spring

2) Layout

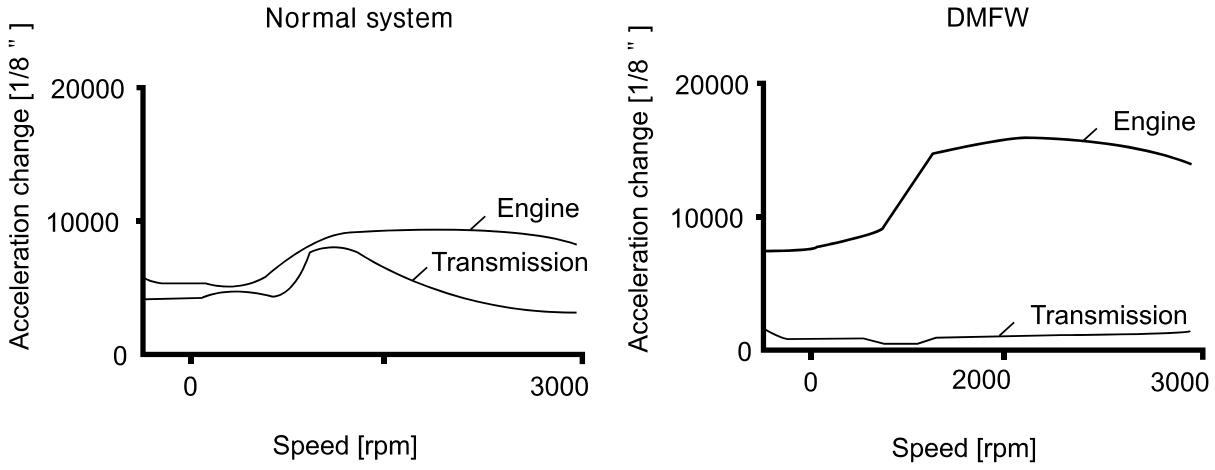


3) Operation

- Compensating the irregular operation of engine: The secondary flywheel operates almost evenly so does not cause gear noises
- The mass of the primary flywheel is less than conventional flywheel so the engine irregularity increases more (less pulsation absorbing effect).
- Transaxle protection function: Reduces the torsional vibration to powertrain (transaxle) by reducing the irregularity of engine.

Compression stroke	Combustion stroke
	
Small changes from engine (k): Damper increases the torque changes to clutch	**Large changes from engine (j):** Damper decreases the torque changes to transaxle by absorbing the impact

Torque change curve of engine and drive shaft



Modification basis	
Application basis	
Affected VIN	

4) Features

- Reduced vibration noise from the powertrain by blocking the torsional vibrations
- Enhanced vehicle silence and riding comforts: reduced engine torque fluctuation
- Reduced shifting shocks
- Smooth acceleration and deceleration

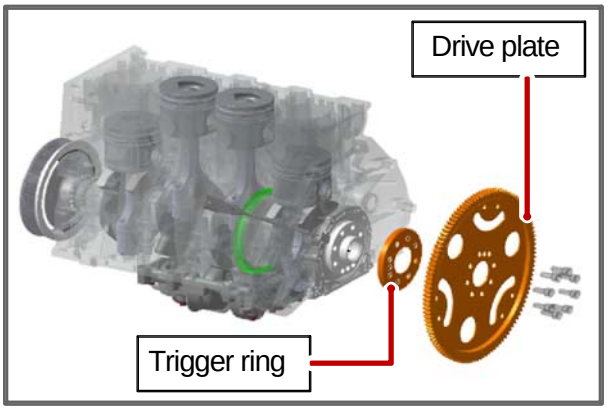
5) Advantages

- Improved torque response by using 3-stage type spring: Strengthens the torque response in all ranges (low, medium, and high speed) by applying respective spring constant at each range.
  Stable revolution of the primary and secondary wheel by using planetary gear: Works as auxiliary
- damper against spring changes
  Less heat generation due to no direct friction against spring surface: Plastic material is covered on
- the spring outer surface
  Increased durability by using plastic bushing (extends the lifetime of grease)
-

6) Drive Plate

Drive plate receives the power from the start motor when starting the engine. With this, the drive plate initially drives the power train system. And, it is connected to the torque converter to transfer the engine torque to the power train system.

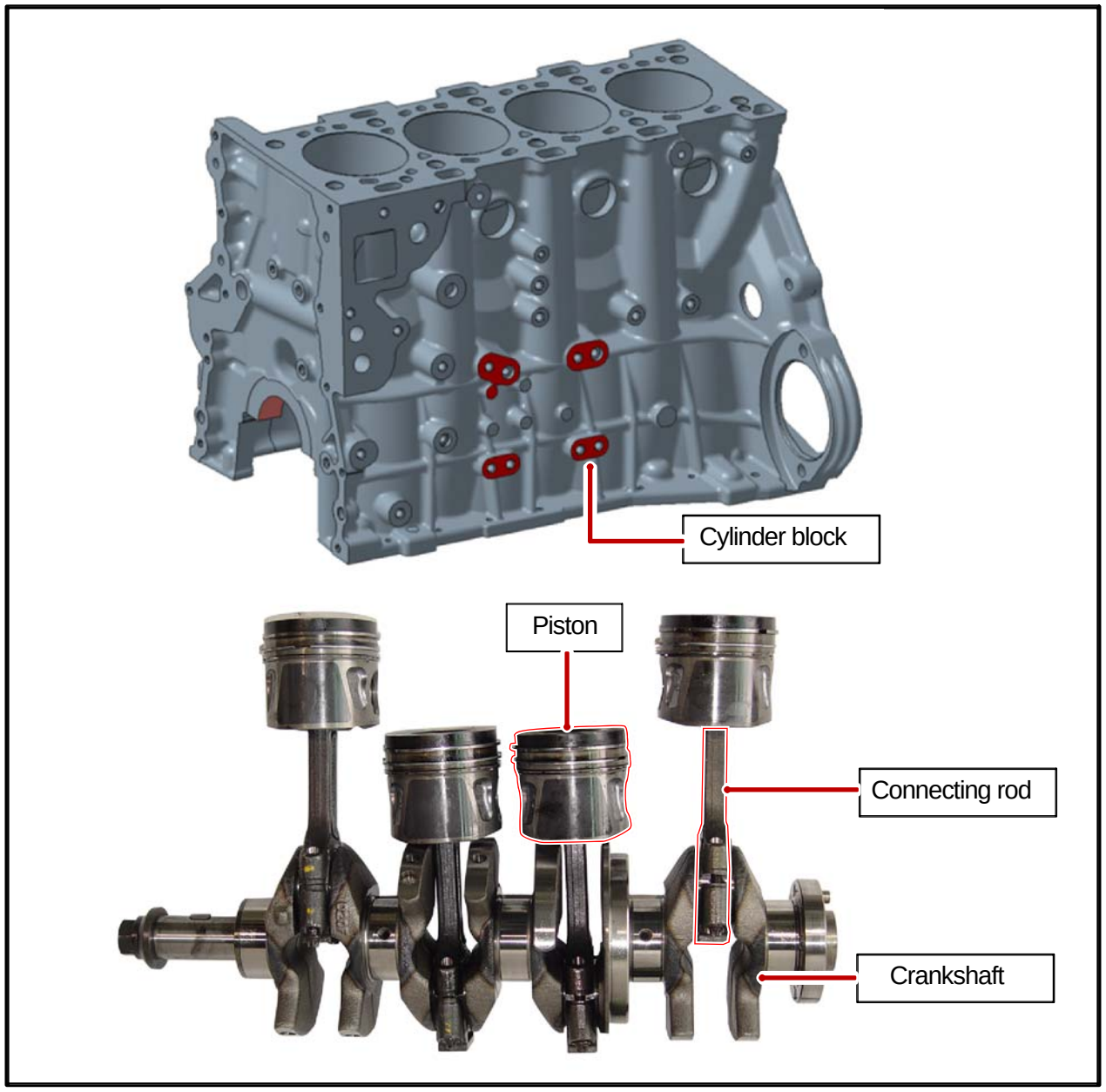
▶ **Components**



10. PISTON/CRANKSHAFT/CYLINDER BLOCK

The crankshaft and the cylinder block convert the compression pressure to the rotating energy.

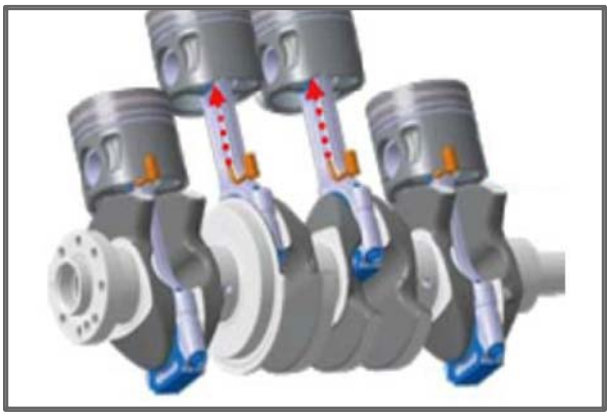
▶ **Components**



Modification basis	
Application basis	
Affected VIN	

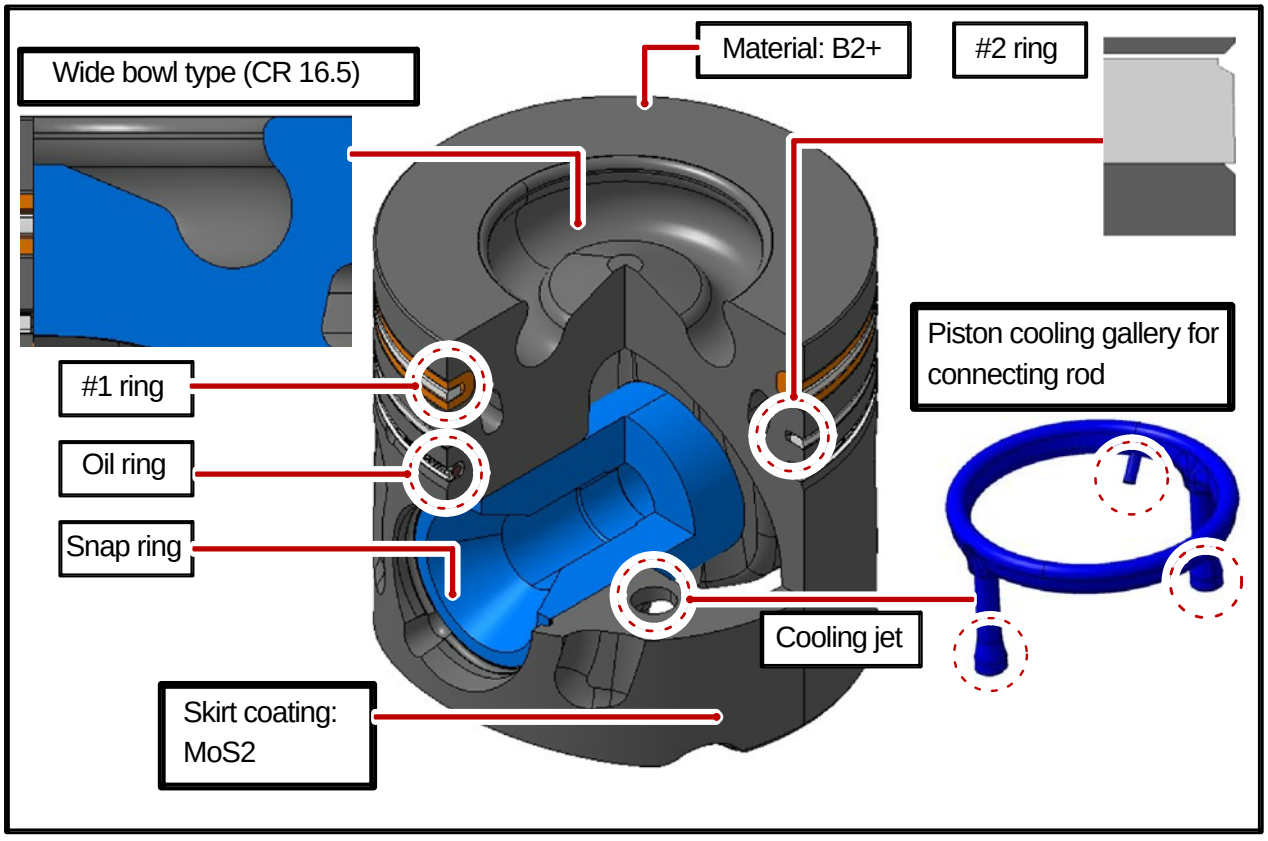
1) Piston

(1) Overview



Piston assembly contains piston, #1 ring, #2 ring, oil ring, piston pin and snap ring. The expansion energy from engine is transferred to the crankshaft through connecting rod to convert the linear movement to rotating energy.

(2) Layout



(3) Functions

Piston transfers the combustion energy from engine to connecting rod. Especially in the direct injection engine such as D20DTR, it provides the combustion space and largely effects to the engine performance and exhaust gas.

▶ **Piston ring**

- #1 ring (Top ring) : Prevents the high pressurized combustion gas from leaking into crank chamber, and prevents the engine oil getting into combustion chamber.
- #2 ring: Scrapes the engine oil on the cylinder bore, and prevents the leaked combustion gas from #1 ring from leaking into the crank chamber.
- Oil ring: Scrapes the engine oil on the cylinder bore.

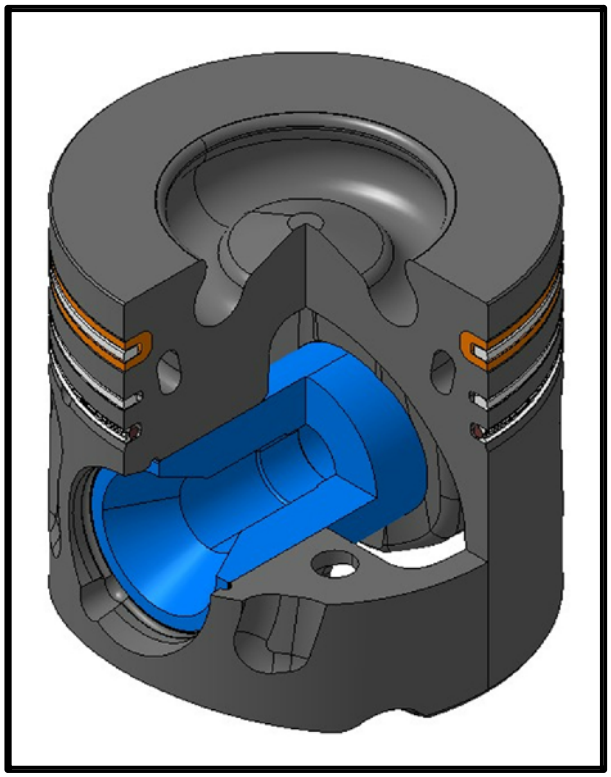
▶ **Piston pin**

- Connects the piston the connecting rod, and transfers the linear movement of piston to connecting rod to convert it to rotating energy

▶ **Snap ring**

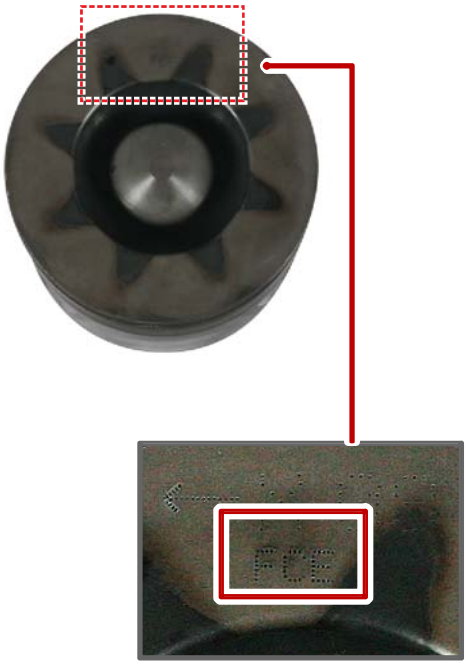
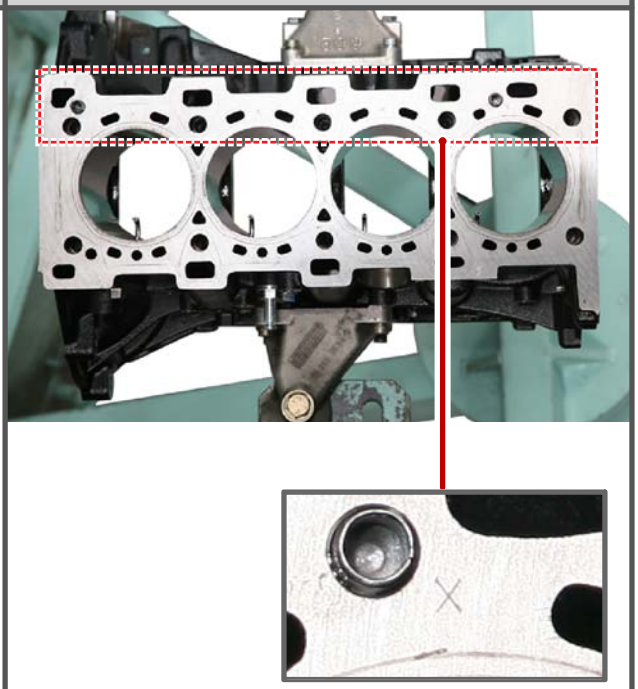
- Locks the piston pin.

(4) Assembling the piston



1. Install the piston rings with the "Y" mark on the ring facing upwards.
2. Position the end gap of #1 ring at 180˚ away from the end gap of #1 ring.
3. Position the end gap of oil ring at 180˚ away from the end gap of coil spring, and position the end gap of oil ring at 90˚ away from the end gap of #2 ring.

Modification basis	
Application basis	
Affected VIN	

Selecting piston oversize	
Top of piston	Top of cylinder block
	

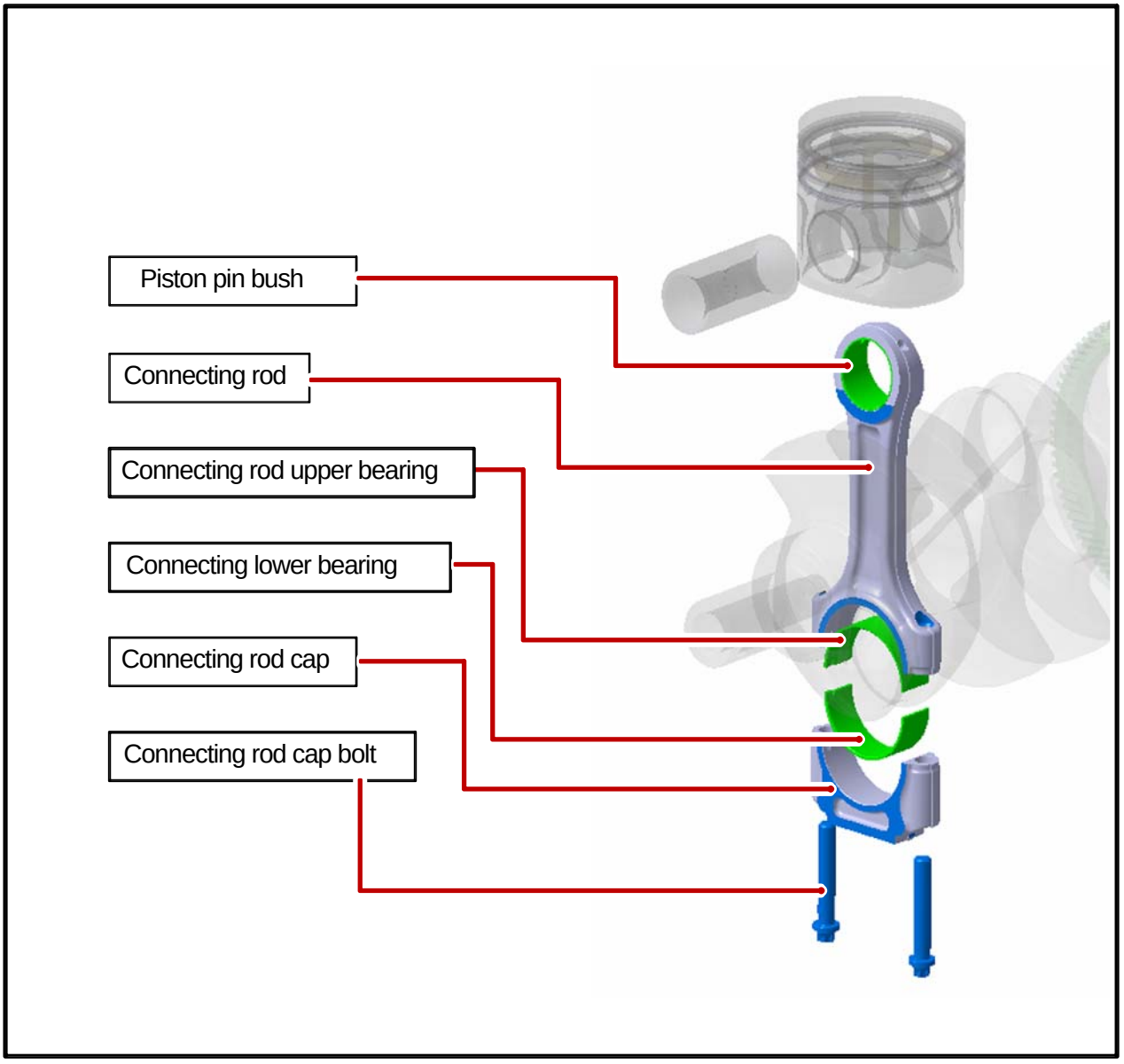
Engine	Piston		Cylinder bore
	Part NO	Marking NO.	-
D20DTR	671 030 06 17	-	-
	671 037 07 01	A	A
	671 037 08 01	X	X
	671 037 09 01	B	B
	671 037 10 01	+5	-
	671 037 11 01	+10	-

2) Connecting Rod

(1) Overview

Connecting rod converts the reciprocating movement of piston to the rotating movement of crankshaft. The big end is connected to connecting rod bearing and the crank pin journal, and the small end is connected to the piston pin.

(2) Components



Modification basis	
Application basis	
Affected VIN	

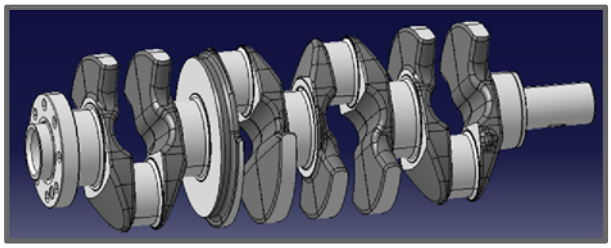
(3) Selection of crankshaft pin journal bearing

- The connecting rod bearing contains 3 sets of 3 grades in upper and lower sections.
- Three sets in the table below have nearly same oil clearance (0.015~0.063 mm) of bearing.
- Identification: Coloe mark on bearing side surface

No	Connecting rod/ Bore diameter in big end	Upper bearing		Lower bearing		Journal diameter of crank pin	Oil clearance of bearing
		Grade	Bearing thickness	Grade	Bearing thickness		
1	54.600	R	1.804	B	1.812	50.935	0.017
			1.808		1.815		0.063
2		Y	1.808	Y	1.809		0.016
	54.614		1.812		1.812	50.960	0.062
3		B	1.812	R	1.806		0.015
			1.816		1.809		0.061
Oil clearance of connecting rod bearing						Min.	0.015
						Max.	0.063

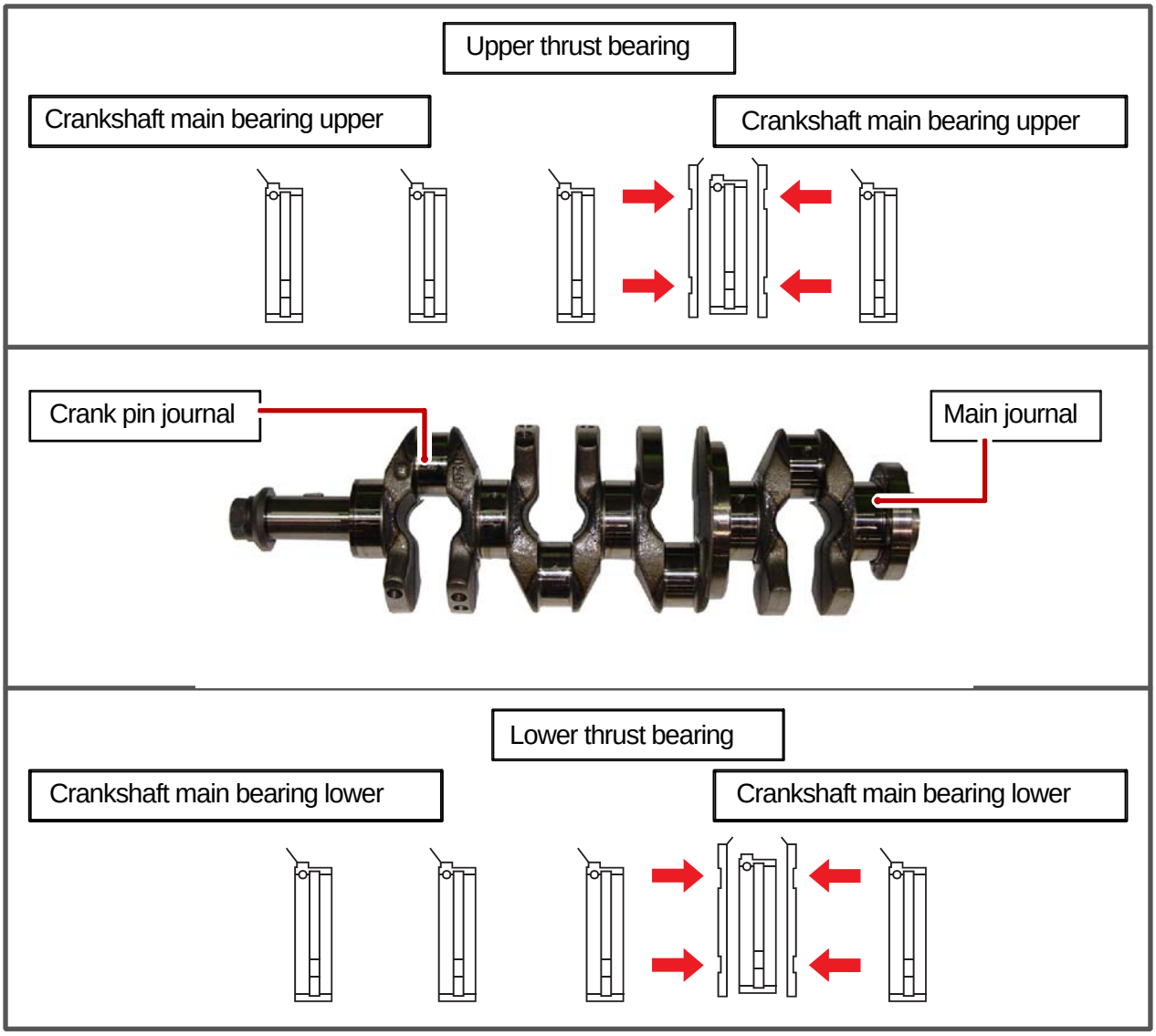
3) Crankshaft

(1) Overview



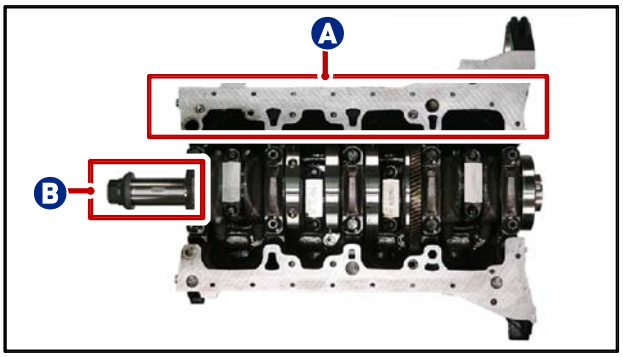
Crankshaft is installed on the cylinder block.

(2) Arrangement

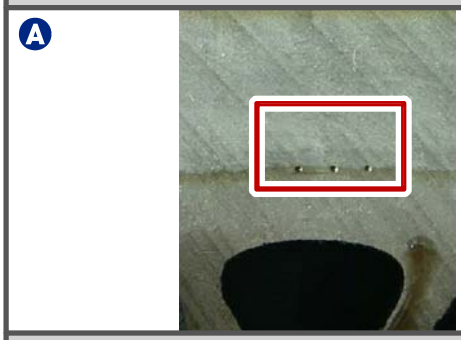


Modification basis	
Application basis	
Affected VIN	

(3) Selection of crankshaft main bearing



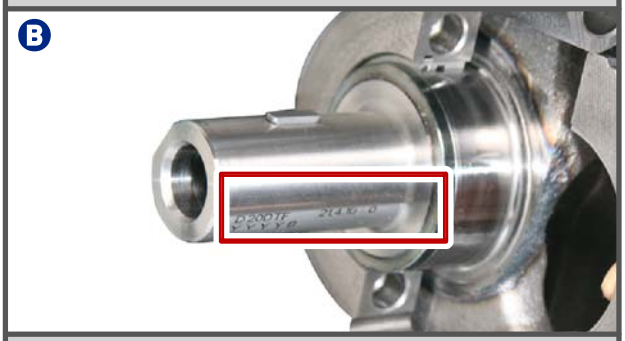
Bottom of cylinder block



Selection of upper main bearing

Selection of bearing according to pin punch & color		
Mark	Color	Thickness of main bearing
*	Blue	66.500~66.506
**	Yellow	66.506~66.513
***	Red	66.513~66.519

Mating surface of crankshaft sprocket



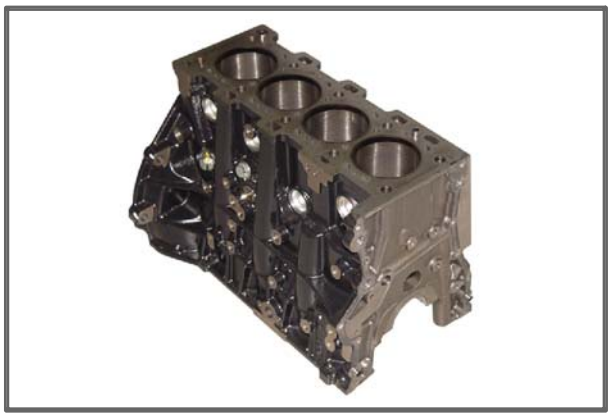
Selection of lower main bearing

Engine name	D	2	0	D	T	F
Main journal bearing	Y	Y	Y	Y	B	
	1	2	3	4	5	

Mark	Color	Thickness of main bearing (mm)
V	Violet	2.25 +0.030 +0.025
W	White	2.25 +0.025 +0.020
R	Red	2.25 +0.020 +0.015
Y	Yellow	2.25 +0.015 +0.010
B	Blue	2.25 +0.010 +0.005

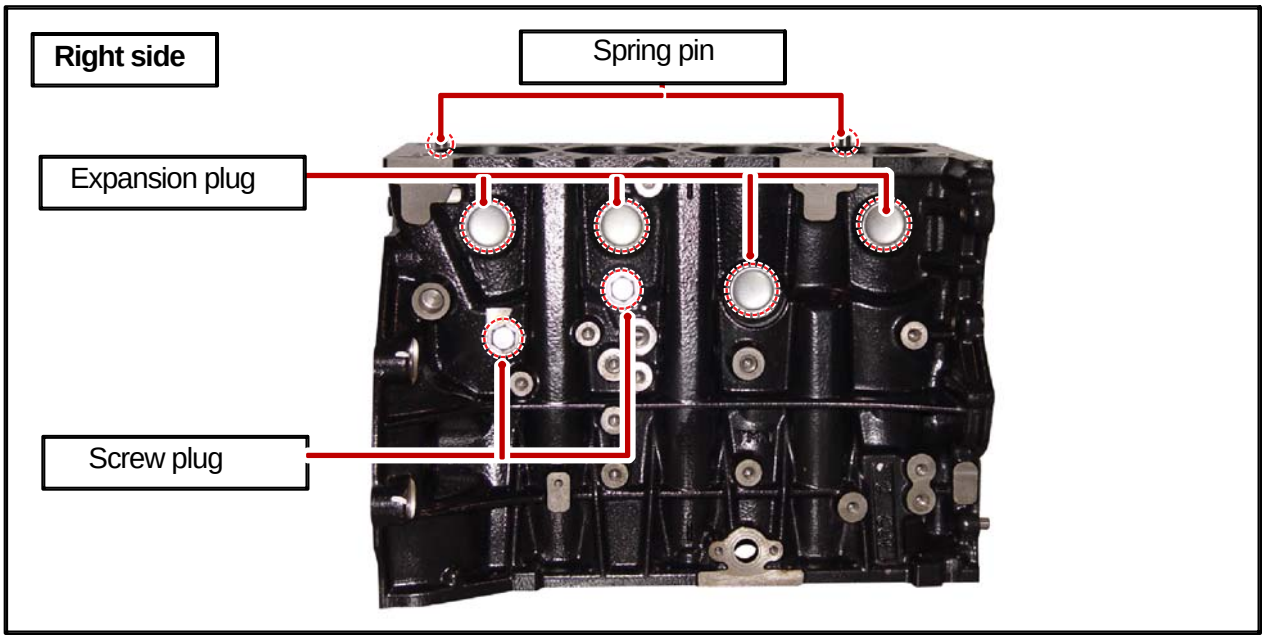
4) Cylinder Block

(1) Overview

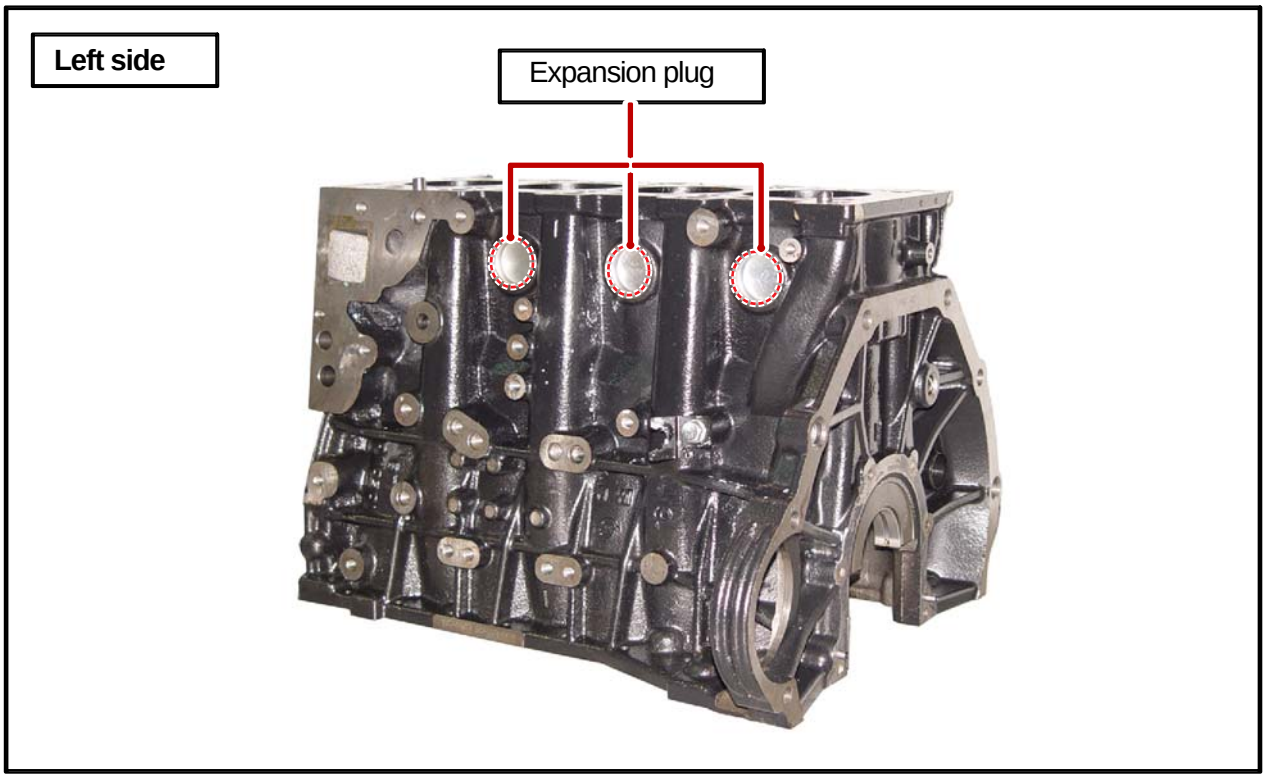


The major dimensions in D20DTR are similar to D20DTR engine. It has two mounting bosses for knock sensor and meets the requirements for EURO5 regulation.

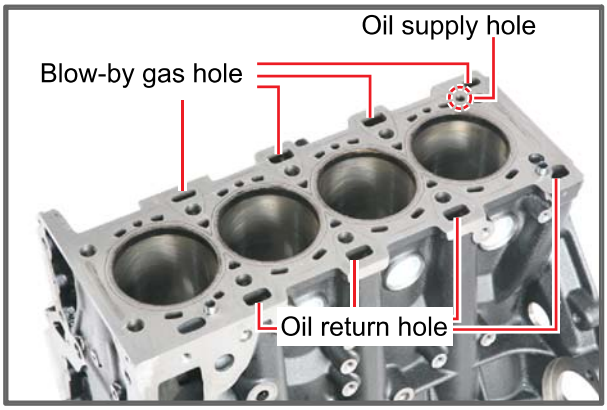
(2) Layout



Modification basis	
Application basis	
Affected VIN	



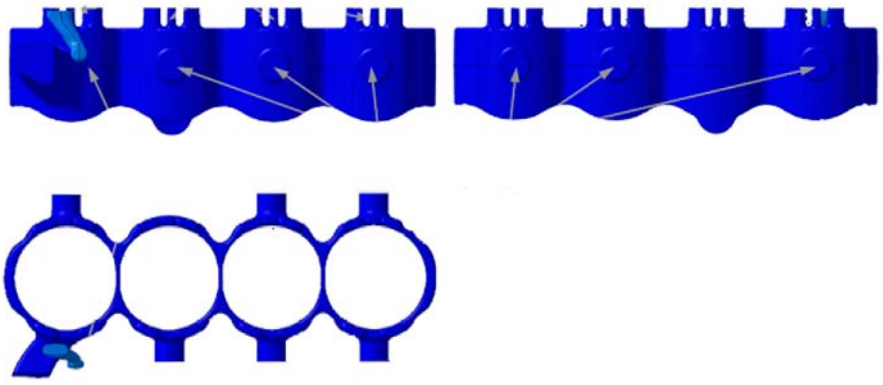
(3) Features



For simple manufacturing, the crankcase blow-by gas passage and the oil return hole are made by casting on the cylinder block.

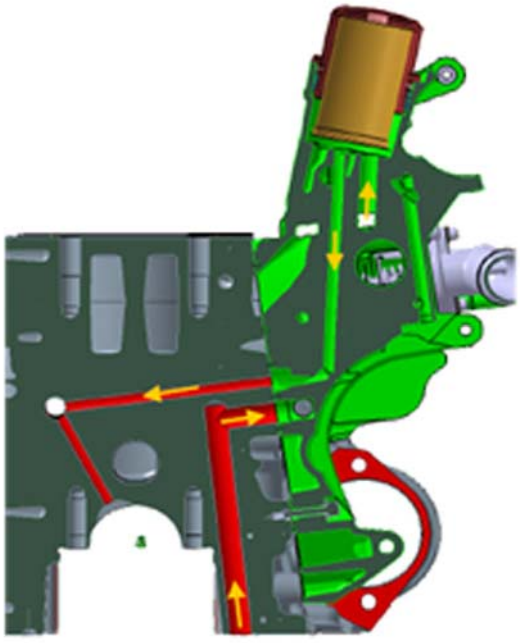
The bottom side of water jacket is desgined as sine wave to strengthen the structure of crankcase. The main flow of coolant starts from outlet port of water pump and goes along the longitudinal direction of engine. The coolant passage from cylinder head to inlet port of water pump is integrated in cylinder head.

Water jacket core



The engine oil from oil pump is supplied to the main oil gallery through oil channel, oil filter module and cross bore in cylinder block without using external pipes. This oil is supplied to main bearing, cylinder head and MBU. And, it is sprayed to the chain through the chain tensioner connected to cross bore.

Crankcase cross bore for oil supply



Modification basis	
Application basis	
Affected VIN	

FUEL SYSTEM

2210-01

GENERAL INFORMATION

1. SPECIFICATION

Description			Specification
Fuel			Diesel
Fuel filter	Type		Fuel heater + priming pump + water separator integrated type
	Filter type		Changeable filter element type
	Change interval	EU	every 40,000 km
		GEN	every 45,000 km
	Water separation interval	EU	every 20,000 km
		GEN	every 15,000 km
	Water accumulating capacity		200 cc
	Heater capacity		250W 13.5V
Injector	System pressure		1800 bar
High pressure fuel pump	Type		Eccentric cam/Plunger type
	Operating type		Gear driven type
	Normal operating temperature		−40 ~ 125°C
	Operating pressure		1800 bar
	Operating temperature		−30 ~ 120°C
Low pressure fuel pump	Type		Vane type
	Gear ratio (pump/engine)		0.5 : 1
	Pressure		6 bar
Fuel tank	Capacity		75 L
	Material		Steel
	Fuel sender		Single sender type

2. MAINTENANCE AND INSPECTION

1) Maintenance Procedures for DI Engine Fuel System

1. Always keep the workshop and lift clean (especially, from dust).
2. Always keep the tools clean (from oil or foreign materials).
3. Wear a clean vinyl apron to prevent the fuzz, dust and foreign materials from getting into fuel system. Wash your hands and do not wear working gloves.

NOTE

Follow the below procedures before starting service works for fuel system.

Carefully listen the symptoms and problems from customer.

↓

Visually check the leaks and vehicle appearance on the wiring harnesses and connectors in engine compartment.

↓

Perform the diagnosis proceee with SCAN tool

↓

Locate the fault. If the cause is from fuel system (from priming pump to injector, including return line), follow the step 1 through step 3 above.

↓

4. If the problem is from HP pump, fuel supply line or injector, prepare the clean special tools and sealing caps to perform the diagnosis for DI engine fuel system in this manual. At this point, thoroughly clean the related area in engine compartment.

CAUTION

Clean the engine compartment before starting service works.

Tool kit for high pressure line	Took kit for low pressure line
	

Modification basis	
Application basis	
Affected VIN	

5. Follow the job procedures. If you find a defective component, replace it with new one.

Disconnect the negative battery cable.

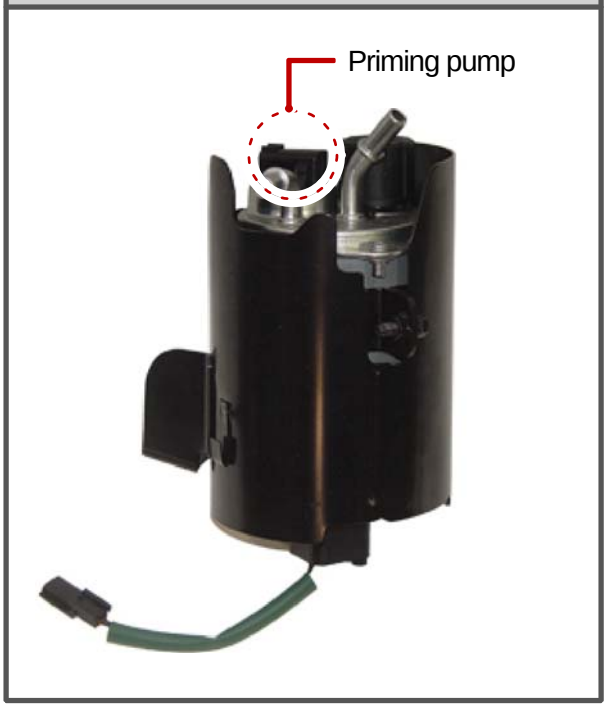
Use special tools and torque wrench to perform the correct works.

Once disconnected, the fuel pipes between HP pump and fuel rail and between fuel rail and each injector should be replaced with new ones. The pipes should be tightened tospecified tightening torques during installation. Over or under torques out of specified range may cause damages and leaks at connections. Once installed, the pipes have been deformed according to the force during installation, therefore they are not reusable. The copper washer on injector should be replaced with new one. The injector holder bolt should be tightened to specified tightening torque as well. If not, the injection point may be deviated from correct position, and it may cause engine disorder.

Plug the disconnected parts with sealing caps, and remove the caps immediately before replacing the components.

6. Plug the removed components with clean and undamaged sealing caps and store it into the box to keep the conditions when it was installed.

Fuel filter assembly



7. To supply the fuel to transfer line of HP pump press the priming pump until it becomes hard.

Priming pump cap

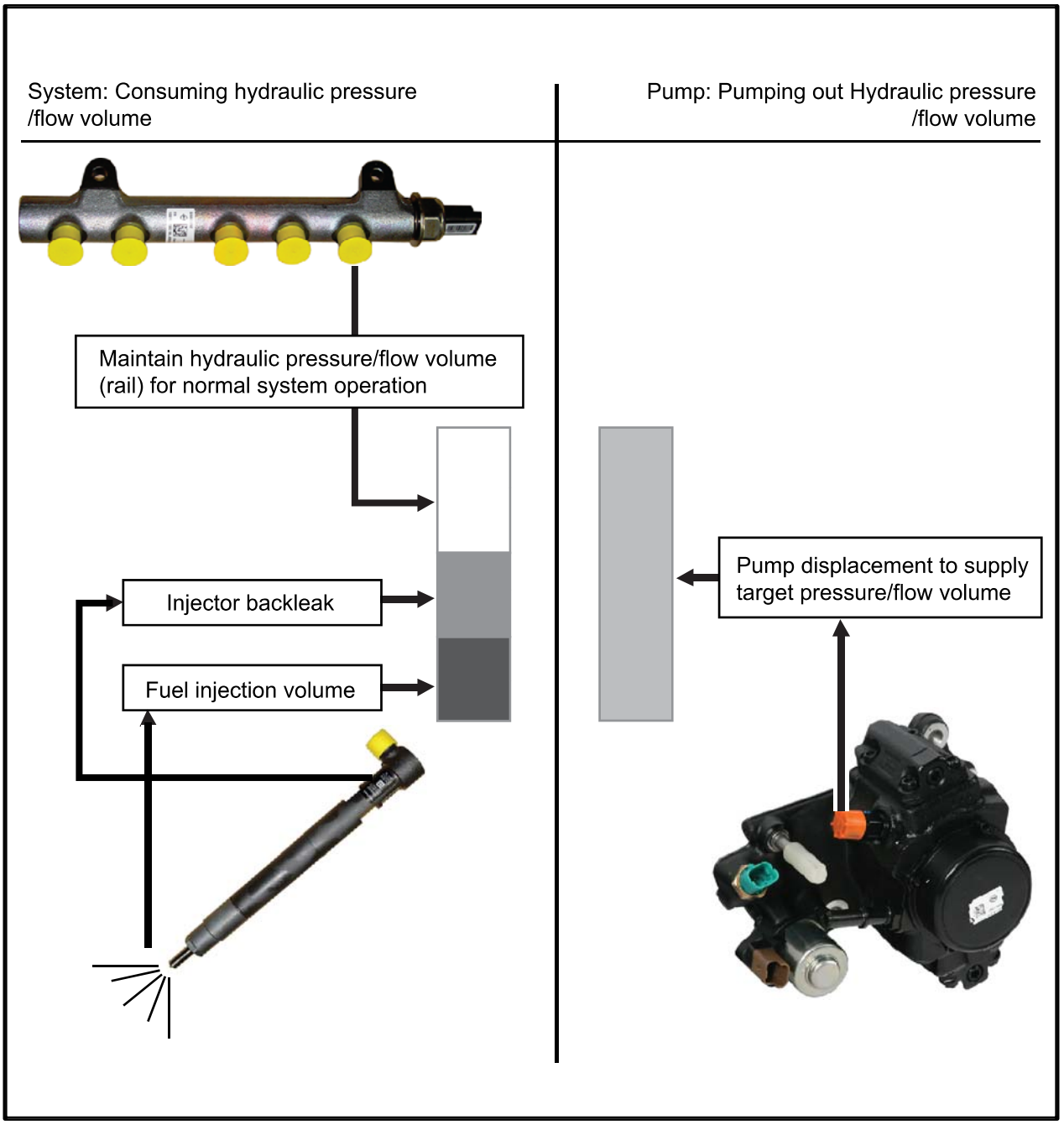
8. Check the installed components again and connect the negative battery cable. Start the engine and check the operating status.
9. With Scan Tool, check if there are current faults and erase the history faults.

2) Diagnostic Test for Engine Fuel System

(1) Overview

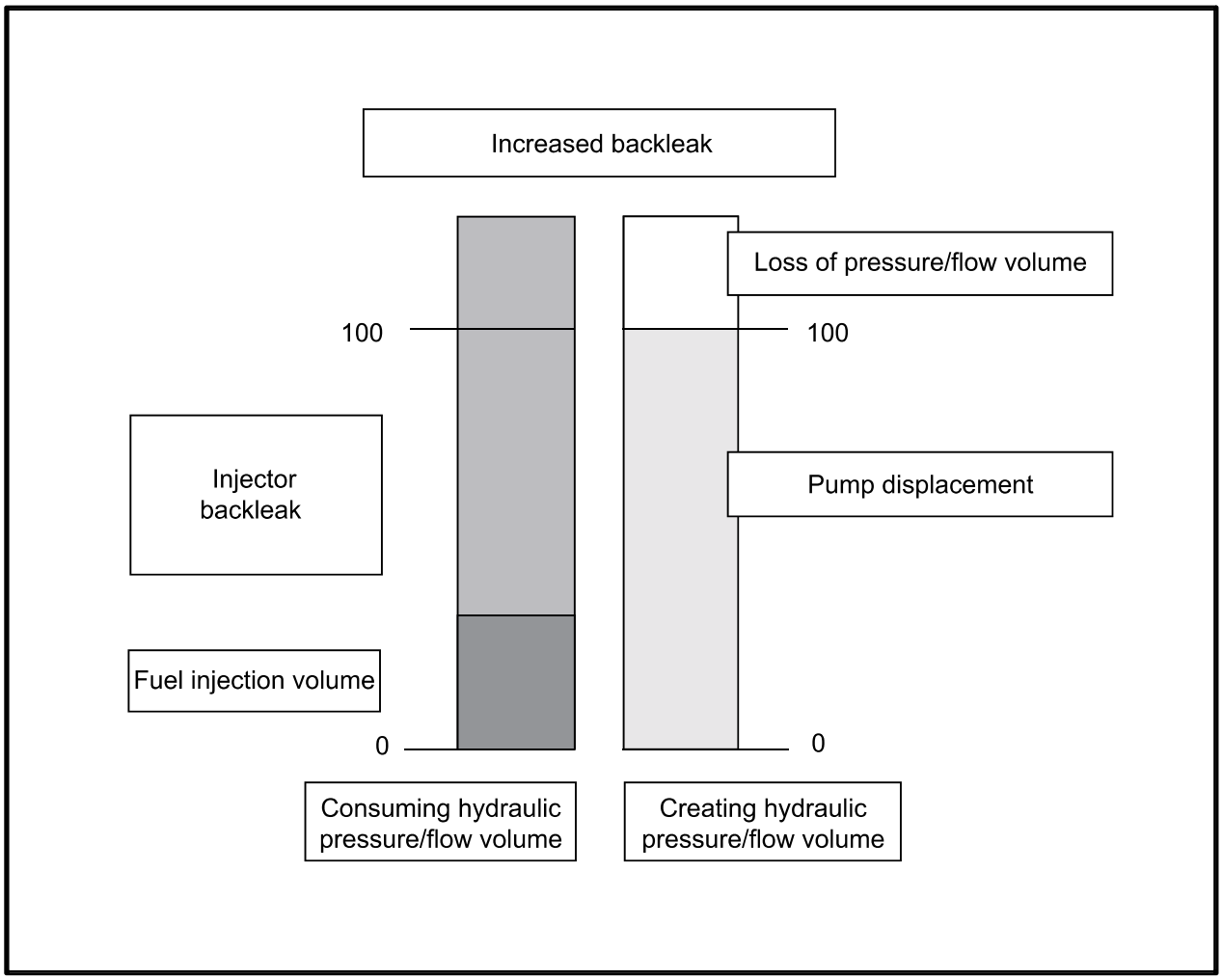
If a DTC is displayed on the diagnostic device, check the low pressure- and high pressure fuel systems before removing the components.
To run the system properly, the electric system must be intact but for the DI engine, the fuel pressure should be measured also when there is a malfunction even after the diagnostic test with a diagnostic device.

(2) Hydraulic system



Modification basis	
Application basis	
Affected VIN	

(3) Excessive backleak of injector



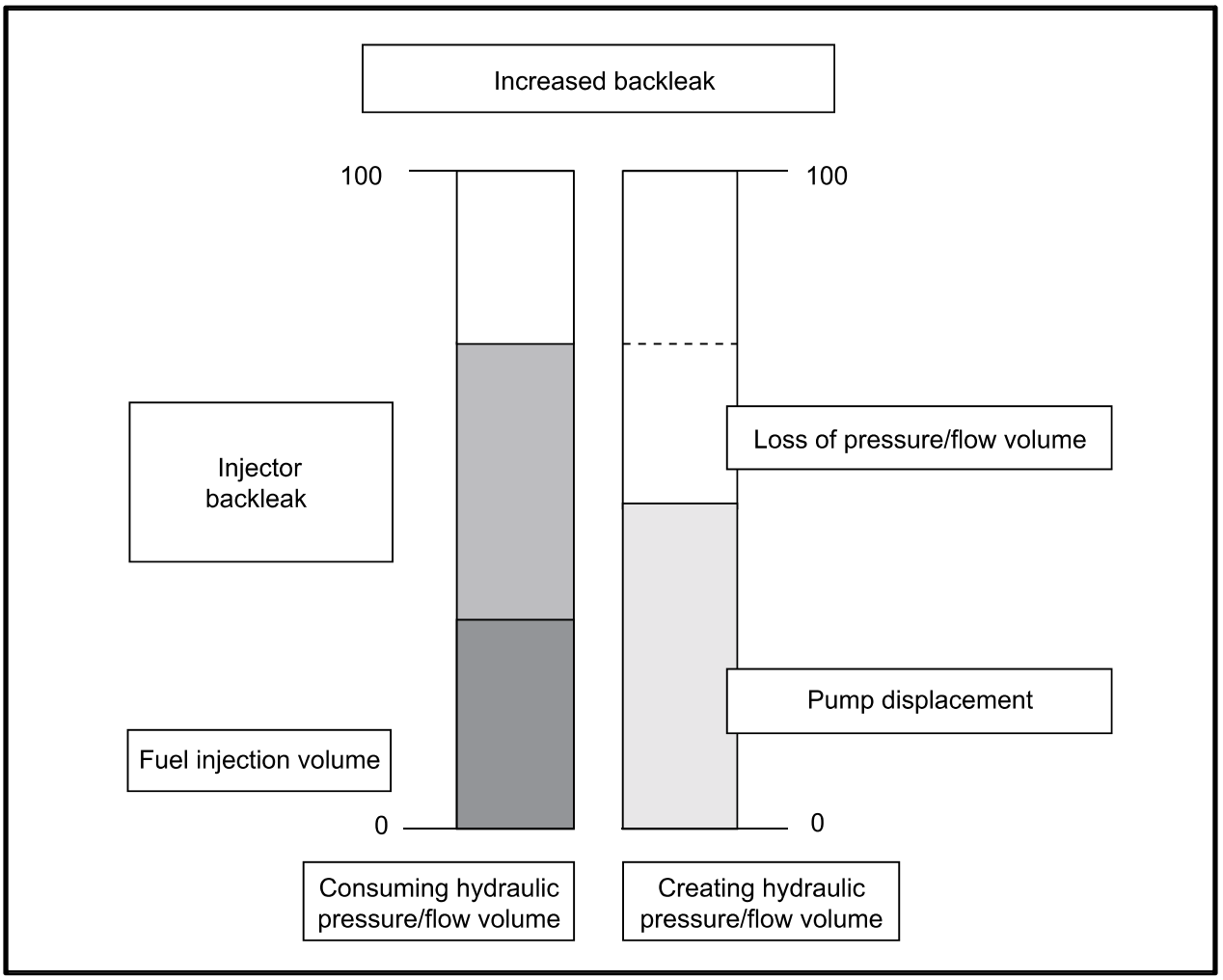
▶ **Excessive injector backleak**

Occurs when the injector control valve is not sealed due to the entry of the foreign materials.

▶ **Example:**

- Entry of foreign materials
- Burned out and worn HP pump
- Mechanical damage inside the injector

(4) Loss of pump pressure/flow



▶ **Loss of HP pump pressure/flow**

Faulty fuel supply line, or damaged or worn pump causes the lack of flow pressure and flow volume

▶ **Example:**

- Air in fuel supply line
- Excessive load on fuel supply line (←400 mBar)
- Burned out and mechanical worn pump
- High temperature of fuel supply (> 85℃)

Modification basis	
Application basis	
Affected VIN	

3) DI Engine Fuel System Pressure Test

(1) Test device (Tool kit)

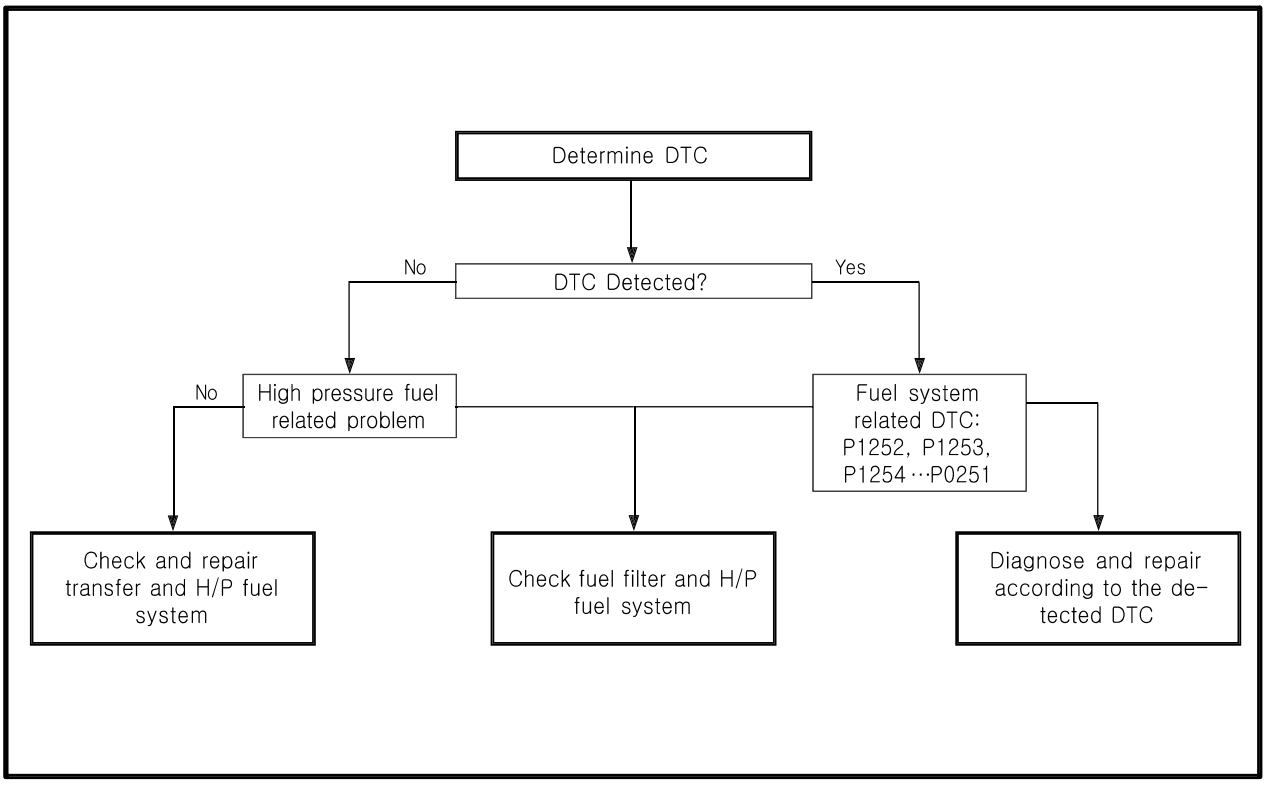
Device for high pressure

Device for low pressure


(2) Pre-check

- Check-tighten fuel supply line
- Check fuel level in fuel tank
- Check air in fuel supply line (bubble in fuel supply line or fuel)
- Check fuel supply line for leaks (low pressure and high pressure)
- Check that specified fuel is used
- Check fuel filter for contamination

(3) DI Engine Fuel System Check Procedure

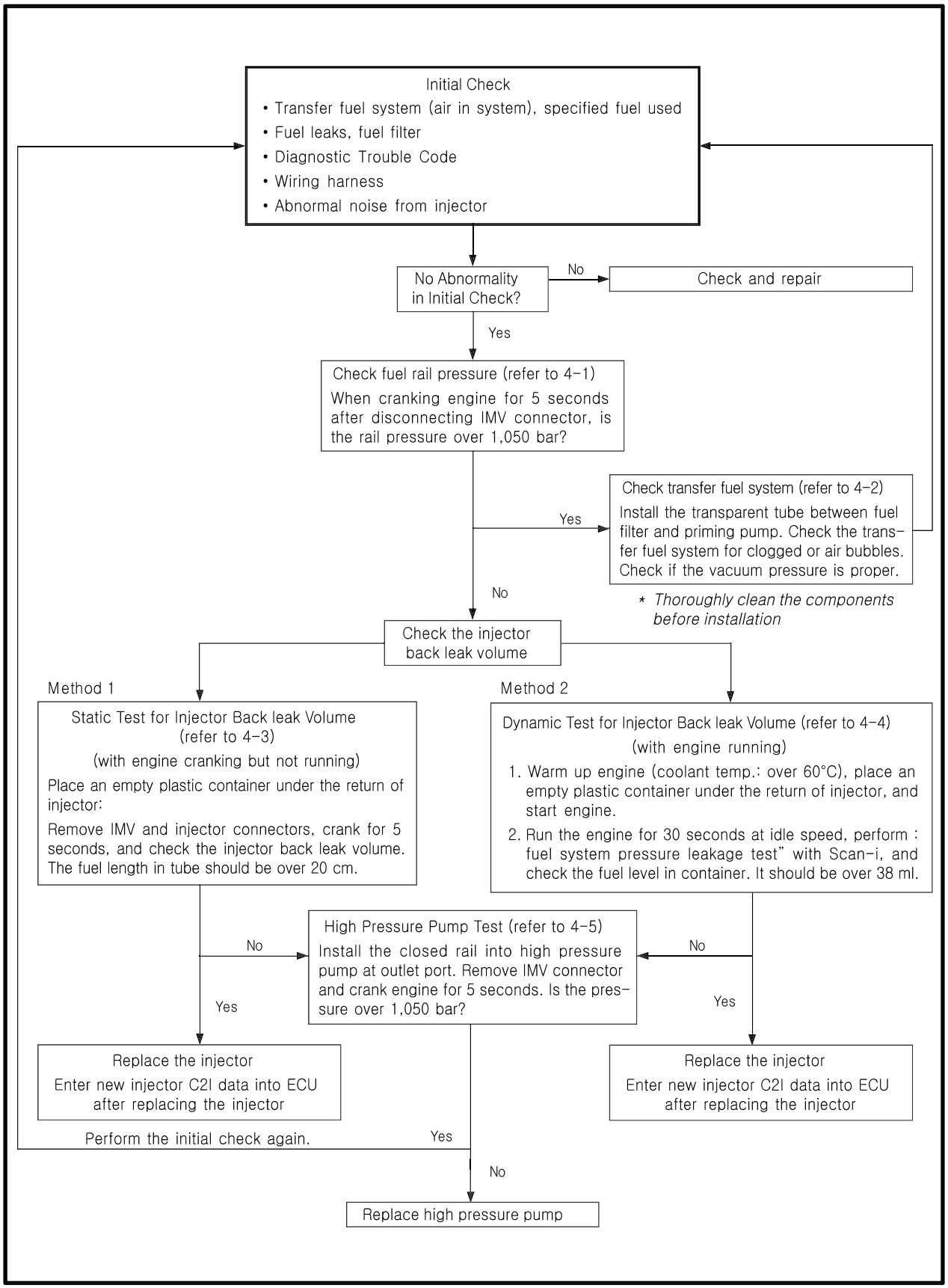


CAUTION

If several DTCs are output simultaneously, check the electric wiring for open or short circuit.
Check the low pressure fuel system and fuel filter and confirm that there are no abnormalities. Carry out the high pressure fuel system check.

Modification basis	
Application basis	
Affected VIN	

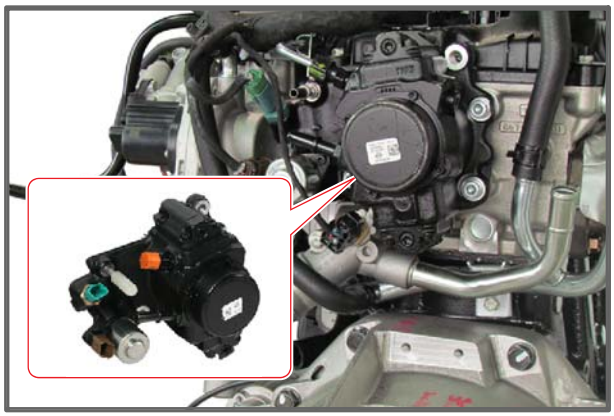
(4) Fuel System Check Procedure



Modification basis	
Application basis	
Affected VIN	

(5) High Pressure System Pressure Test

▶ **Fuel rail pressure test**



1. Disconnect the fuel rail pressure sensor connector and then IMV connector.

2. Connect the pressure tester to the fuel rail pressure sensor connector.

3. Crank the engine 2 times for 5 seconds.
   - Read the highest pressure value displayed on the tester display.
   - If the highest pressure value is 1,050 bar or less, refer to the section "Fuel System Check Process".

Modification basis	
Application basis	
Affected VIN	

▶ How To Use Pressure Tester

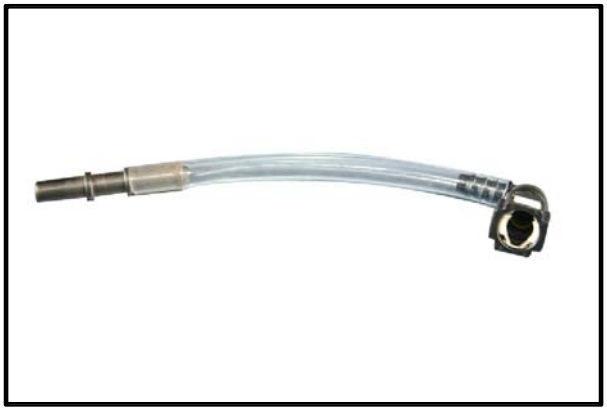
1. Press the "TEST" button on the tester to check if the message "TEST?" is displayed. If the button is pressed again at 4 seconds
2. after starting engine cranking, the highest pressure is displayed on the tester.

NOTE

The fuel rail pressure value can be checked using a diagnostic device.

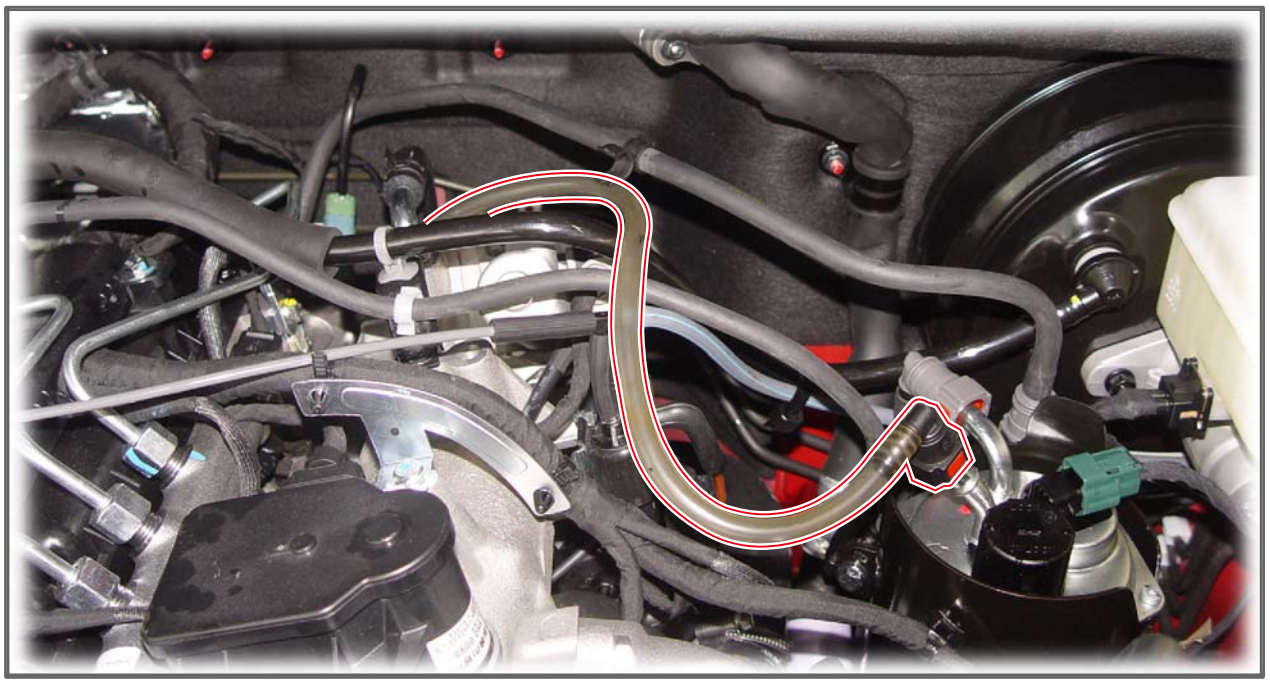
(6) Low Pressure System Pressure Test

▶ **Inspection procedure**



1. All wirings/connectors and fuel lines should be connected and the engine should work properly.
2. Prepare a special tool for low pressure test and clean it thoroughly to prevent foreign materials from entering.

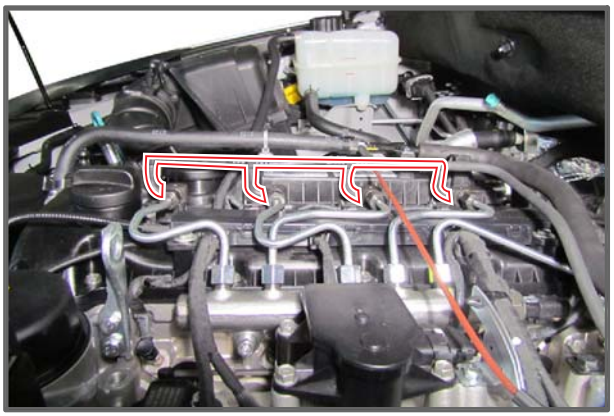
3. Disconnect the key connector for fuel filter connection, and connect both connectors to the fuel filter and hose.



4. Start the engine and check visually for clogged low pressure fuel system, excessive air or air entry. If the fuel flow is not sufficient or air is in the fuel, repair the leak area.
5.

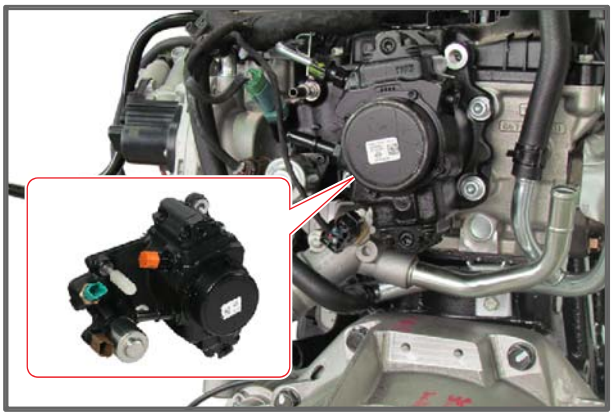
Modification basis	
Application basis	
Affected VIN	

▶ Static test for backleak of injector



1. Disconnect the injector return hose and cover the openings with caps shaped screw (included in the special tool).

2. Connect the hose of the container for measuring backleak to the return nipple of the injector.
   (prevent air entry to the low pressure line)



3. Disconnect the IMV connector of the high pressure pump and then fuel pressure sensor connector.

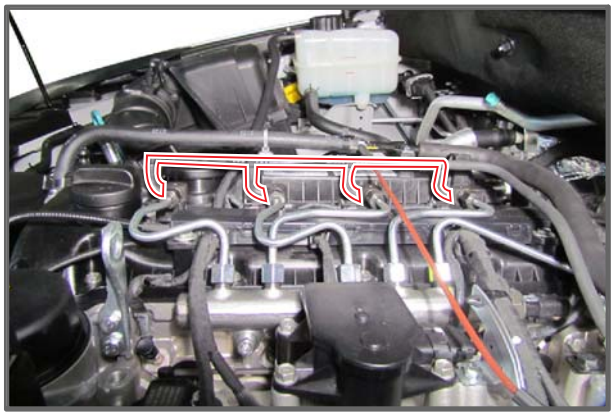
CAUTION
The connector of the injector can be easily contaminated. Always keep it clean.

4. Crank the engine 2 times for 5 seconds.
5. Check the time for flow if injector backleak and confirm that it is within the specified range.

Specification	Below 20 sec.

NOTE
If the value is out of the specified range, replace the injector.

▶ Dynamic test for backleak of injector



1. Warm up the engine so that the engine coolant temperature be over 80℃ and star the engine again.
2. Disconnect the injector return hose and cover the openings with caps shaped screw (included in the special tool)..

3. Connect the hose of the container for measuring backleak to the return nipple of the injector.
4. Start the engine again and let the engine idle for 30 seconds.
5. Perform backleak test of fuel system with a diagnostic device after 30 seconds.

This test consists of 4 cycles, and the engine rpm reaches 3,500 rpm for 18 seconds in each cycle.

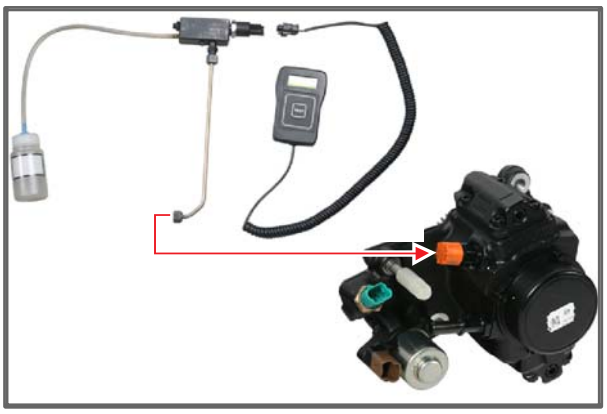
6. Check the amount of backleak collected into the container and confirm that it is within the specified range.

Specification	38 ml or less

Modification basis	
Application basis	
Affected VIN	

▶ HP pump pressure test

1. Prepare a special tool for high pressure test and clean it thoroughly to prevent foreign materials from entering.



2. Disconnect the high pressure fuel supply pipe on the HP pump and install the close rail in the tool kit.

Tightening torque 30Nm

3. Connect the other end of the close rail to the fuel rail for test.

Tightening torque 30Nm

4. Disconnect the return hose for HP pump and connect the clear hose and connect its the other end to the return port of the fuel rail for test.

5. Connect the digital tester connector to the sensor connector of the fuel rail for test.
6. Crank the engine 2 times for 5 seconds after removing the IMV connector and fuel rail pressure sensor connector.
7. Read the pressure value displayed on the tester display is within the specified

Specification	1,050 bar or more

3. CAUTIONS FOR DI ENGINE

1) Cautions for DI Engine

This chapter describes the cautions for DI engine equipped vehicle. This includes the water separation from engine, warning lights, symptoms when engine malfunctioning, causes and actions.

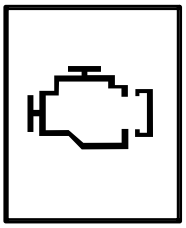
1. DI Engine

Comparatively conventional diesel engines, DI engine controls the fuel injection and timing electrically, delivers high power and reduces less emission..

2. System Safety Mode

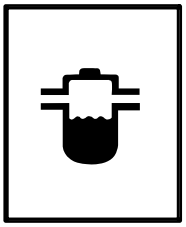
When a severe failure has been occurred in a vehicle, the system safety mode is activated to protect the system. It reduces the driving force, restricts the engine speed (rpm) and stops engine operation. Refer to "Diagnosis" section in this manual.

3. Engine CHECK Warning Lamp



The Engine CHECK warning lamp on the instrument cluster comes on when the fuel or major electronic systems of the engine are not working properly. As a result, the engine's power output may decrease or the engine may stall.

4. Water Separator Warning Lamp



When the water level inside water separator in fuel filter exceeds a certain level (approx. 45 cc), this warning light comes on and buzzer sounds.
Also, the driving force of the vehicle decreases (torque reduction). If these conditions occur, immediately drain the water from fuel filter.

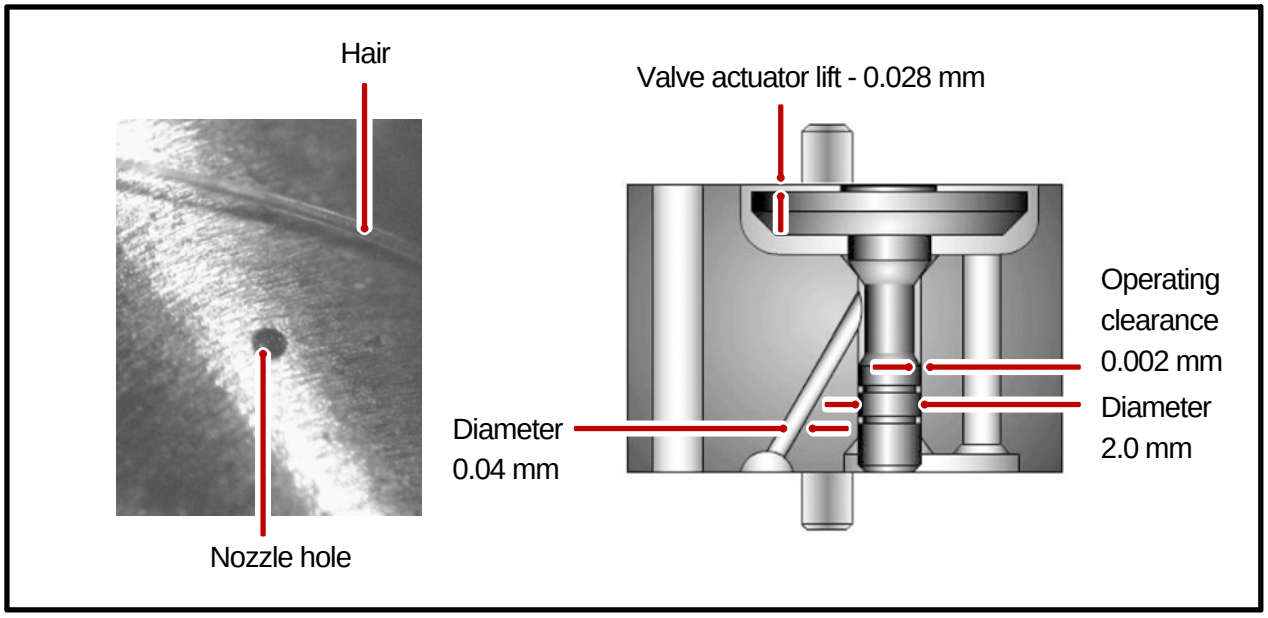
Modification basis	
Application basis	
Affected VIN	

2) Cleanness

(1) Cleanness of DI engine fuel system

▶ Cleanness of DI engine fuel system and service procedures

The fuel system for DI engine consists of transfer (low pressure) line and high pressure line.
Its highest pressure reaches over 1,800 bar.
Some components in injector and HP pump are machined at the micrometer 100 μm of preciseness.
The pressure regulation and injector operation are done by electric source from engine ECU.
Accordingly, if the internal valve is stuck due to foreign materials, injector remains open.
Even in this case, the HP pump still operates to supply high pressurized fuel. This increases the pressure to combustion chamber (over 250 bar) and may cause fatal damage to engine.
You can compare the thickness of injector nozzle hole and hair as shown in below figure (left side). The below figure shows the clearance between internal operating elements.



The core elements of fuel system has very high preciseness that is easily affected by dust or very small foreign material. Therefore, make sure to keep the preliminary works and job procedures in next pages.
If not, lots of system problems and claims may arise.

(2) Di engine and its expected problems and remedies can be caused by water in fuel

▶ System supplement against paraffin separation

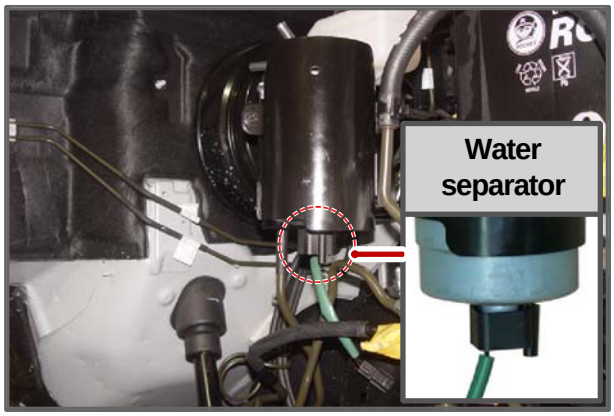
In case of Diesel fuel, paraffin, one of the elements, can be separated from fuel during winter and then can stick on the fuel filter blocking fuel flow and causing difficult starting finally. Oil companies supply summer fuel and winter fuel by differentiating mixing ratio of kerosene and other elements by region and season. However, above phenomenon can be happened if stations have poor facilities or sell improper fuel for the season. In case of DI engine, purity of fuel is very important factor to keep internal preciseness of HP pump and injector.
Accordingly, more dense mesh than conventional fuel filter is used. To prevent fuel filter internal clogging due to paraffin separation, SYMC is using fuel line that high pressure and temperature fuel injected by injector returns through fuel filter to have an effect of built-in heater (see fuel system).

▶ System supplement and remedy against water in fuel

As mentioned above, some gas stations supply fuel with excessive than specified water. In the conventional IDI engine, excessive water in the fuel only causes dropping engine power or engine hunting. However, fuel system in the DI engine consists of precise components so water in the fuel can cause malfunctions of HP pump due to poor lubrication of pump caused by poor coating film during high speed pumping and bacterization (under long period parking). To prevent problems can be caused by excessive water in fuel, water separator is installed inside of fuel filter. When fuel is passing filter, water that has relatively bigger specific gravity is accumulated on the bottom of the filter.

▶ Water drain from water separator

If water in the separator on the fuel filter exceeds a certain level, it will be supplied to HP pump with fuel, so the engine ECU turns on warning lamp on the meter cluster and buzzer if water level is higher than a certain level.
Due to engine layout, a customer cannot easily drain water from fuel filter directly, so if a customer checks in to change engine oil, be sure to perform water drain from fuel filter.



NOTE
To separate the water from the fuel filter, remove the fuel filter assembly first.

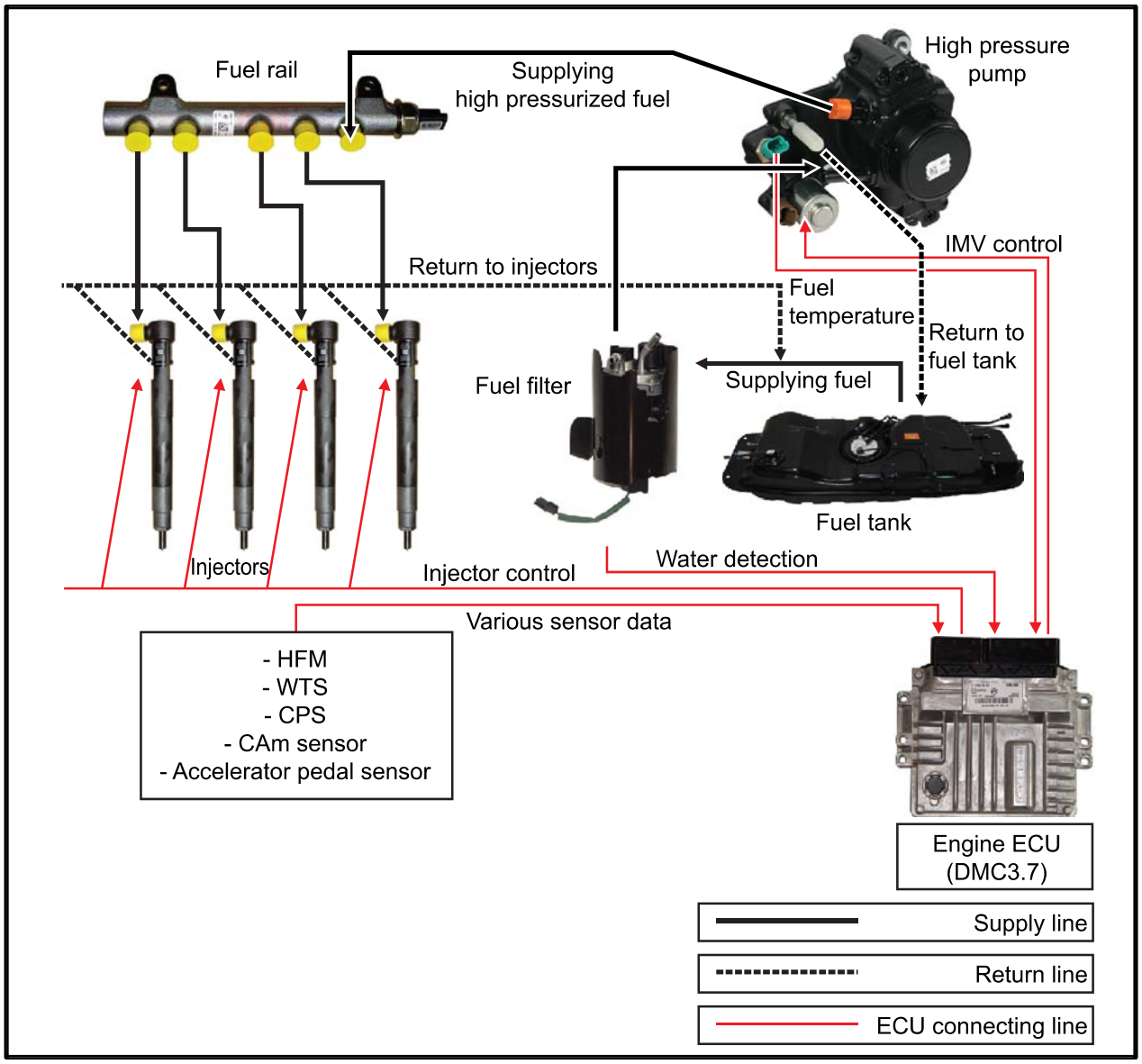
Modification basis	
Application basis	
Affected VIN	

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

The components in fuel system supply the fuel and generate the high pressure to inject the fuel to each injector. They are controlled by the engine ECU.
The common rail fuel injection system consists of fuel tank, fuel line, low pressure line which supplies low pressure fuel to the low pressure pump (including high pressure pump), common rail which distributes and accumulates the high pressurized fuel from the fuel pump, high pressure line which connected to the injector, and the engine control unit (ECU) which calculates the accelerator pedal position and controls the overall performance of vehicle based on the input signals from various sensors.

1) Fuel Flow Diagram



2. SYSTEM LAYOUT AND OPERATION

1) Layout

NOTE

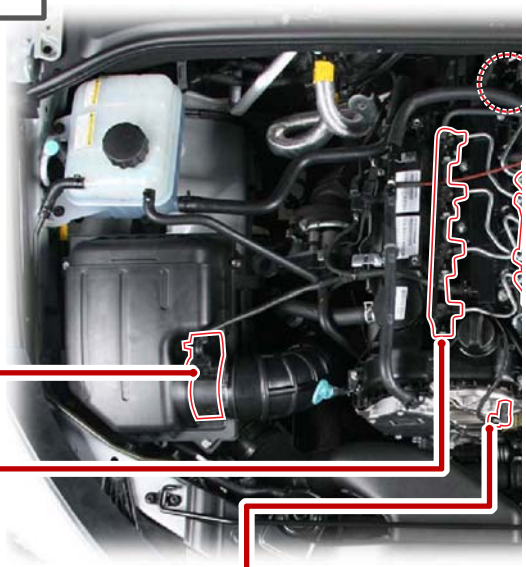
For sensor and actuator control logic, refer to Chapter "Engine Control".

Engine ECU (D20DTR)

Engine control by various signals

Fuel tank

Fuel metering by sender



HFM sensor

Measuring intake air mass and temperature

Crankshaft position sensor

Measuring engine rpm

Injector (C3I)

Pre-injection, main injection, after-injection by signals from ECU

Camshaft position sensor

Determining injection order

Modification basis	
Application basis	
Affected VIN	

High pressure pump

Plunger type HP pump (1,800 bar)

Vane type LP pump (6 bar)

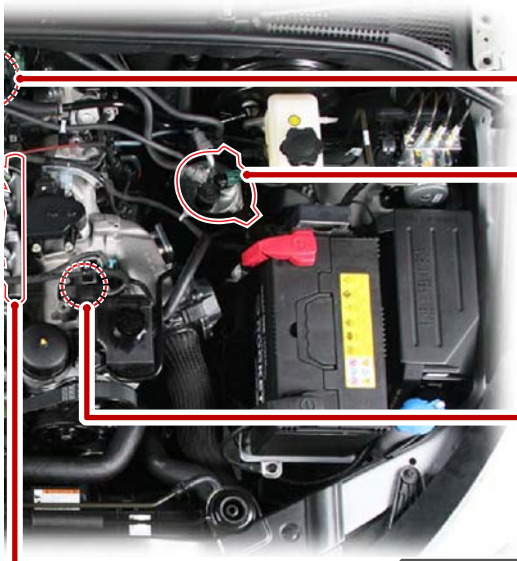
Generating high pressurized fuel and supplying it according to engine rpm, required volume, required pressure

Accelerator pedal position sensor

Detecting driver's intention for speed up/down

Fuel filter assembly

Supplying clean fuel/fuel heating/water separation by priming pump



Fuel rail assembly

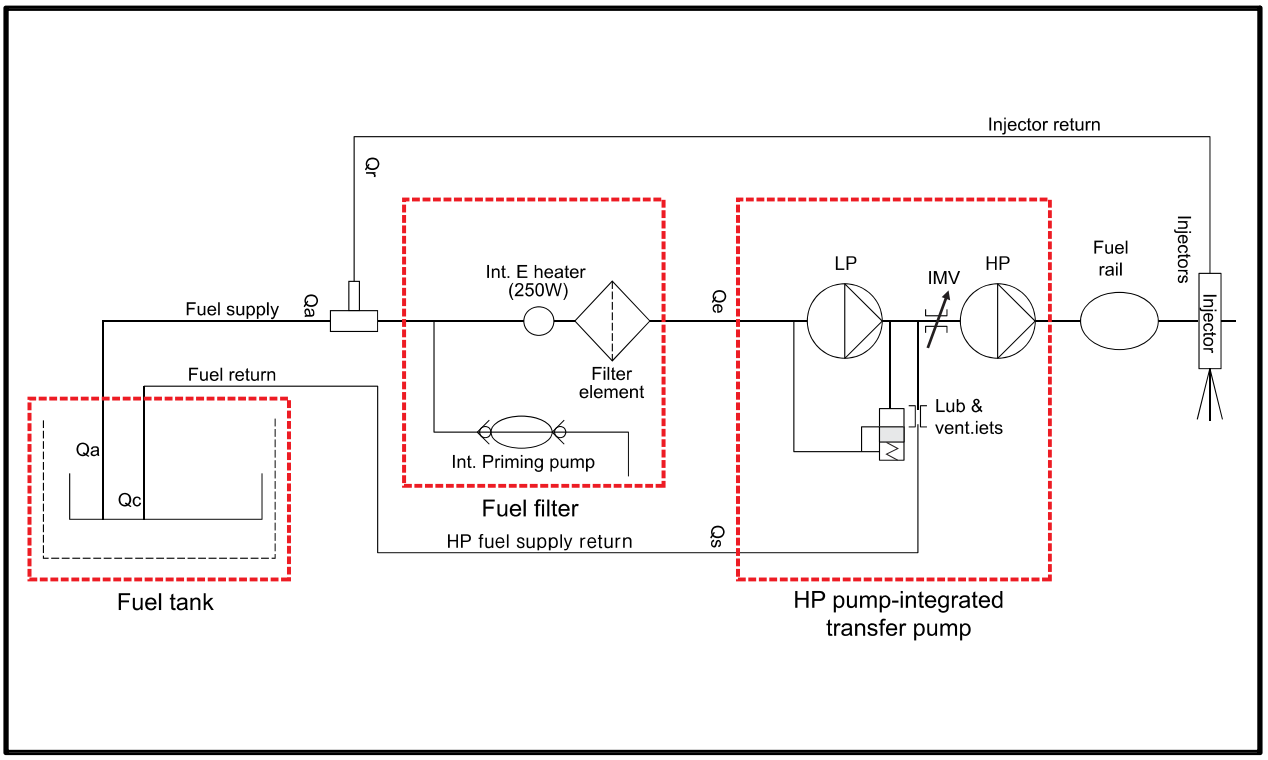
Relieving the pulsation.
Measuring the fuel pressure.
Distributing the fuel to injectors.

T-MAP sensor

Measuring booster pressure and temperature

Modification basis	
Application basis	
Affected VIN	

2) Fuel System Flow Diagram



The fuel from the fuel tank is supplied to the fuel heater of fuel filter/priming pump and then low pressure generated by the low pressure pump (built into HP pump) is transmitted to the HP pump.
The fuel pressure at the HP pump is controlled by the IMV valve, and the maximum allowed pressure is 1,800 bar. The compressed fuel at the fuel pump is delivered to the rail, and injected by the injectors according to the injection signals. The injection method is the same with the conventional method; Fuel return by backleak which operates the needle valve.
The major difference is that the fuel return line is connected to the fuel filter inlet port, not the HP pump venturi.
The pressure from the high pressure pump is increased to 1,800 bar from 1,600 bar, and the pump is now installed to the cylinder head (cylinder block for previous model). The fuel pressure is generated by the operation of intake camshaft and gears. The specifications for the IMV valve and the fuel temperature sensor are not changed.

Modification basis	
Application basis	
Affected VIN	

3) Input/Output devices

Input	Control	Output
Main Map		
Crankshaft position sensor  → Engine rpm (Engine load)	D20DTR ECU	Fuel volume feedback control → IMV (Inter metering valve) 
Cam position sensor  → Injection sequence (Engine rpm)		
HFM (Intake air flow)  → Required flow volume Required rail pressure		
Accelerator pedal  → Driver's will for acceleration Requested rail pressure		
Fuel rail pressure sensor  → Measured rail pressure		Air-fuel ratio control Fuel volume injection volume → Injector 
Sub Map		
Fuel temperature center  → Fuel temperature measured		
Coolant temperature  → Compensation by coolant temperature		
T-MAP  → Boost pressure/ temperature (Air volume calibration)		

* Refer to Chapter "Engine Control".

Modification basis	
Application basis	
Affected VIN	

The engine ECU calculates the accelerator pedal based on the input signals from various sensors, and controls the overall operation of the vehicle.
The ECU receives the signals from various sensor through data line, and performs effective air-fuel ratio control based on these signals.
The crankshaft speed (position) sensor measures the engine speed, and the camshaft speed (position) sensor determines the order of injections, and the ECU detects the amount of the accelerator pedal depressed (driver's will) by receiving the electrical signals from the accelerator pedal sensor.
The mass air flow sensor detects the volume of intake air and sends the value to the ECU.
The major function of the ECU is controlling air-fuel ratio to reduce the emission level (EGR valve control) by detecting instantaneous air flow change with the signals from the mass air flow sensor.
Also, the ECU uses the signals from the coolant temperature & air temperature sensors, booster pressure sensor, atmospheric pressure sensor to: a) determine injection starting point and set value for pilot injection, and b) deal with various operations and variable conditions.

Modification basis	
Application basis	
Affected VIN	

INTAKE SYSTEM

1719-00

GENERAL INFORMATION

1. SPECIFICATION

Unit	Description	Specification
Air cleaner element	Filter type	Dry, filter element
	Initial resistance	Max. 300 mmAq
	Service interval	EU; Clean or change every 20,000 km
		GEN: Clean or change every 15,000 km
Air cleaner assembly	Operating temperature	−30 ~ 100˚C
Intercooler	Core material	Aluminum
	Core size	614W x 192H x 30T
	Tank material	Plastic (Molding)
	Efficiency	80%

* Shorten the service interval under severe conditions such as driving on a dusty road or offroad.

2. INSPECTION

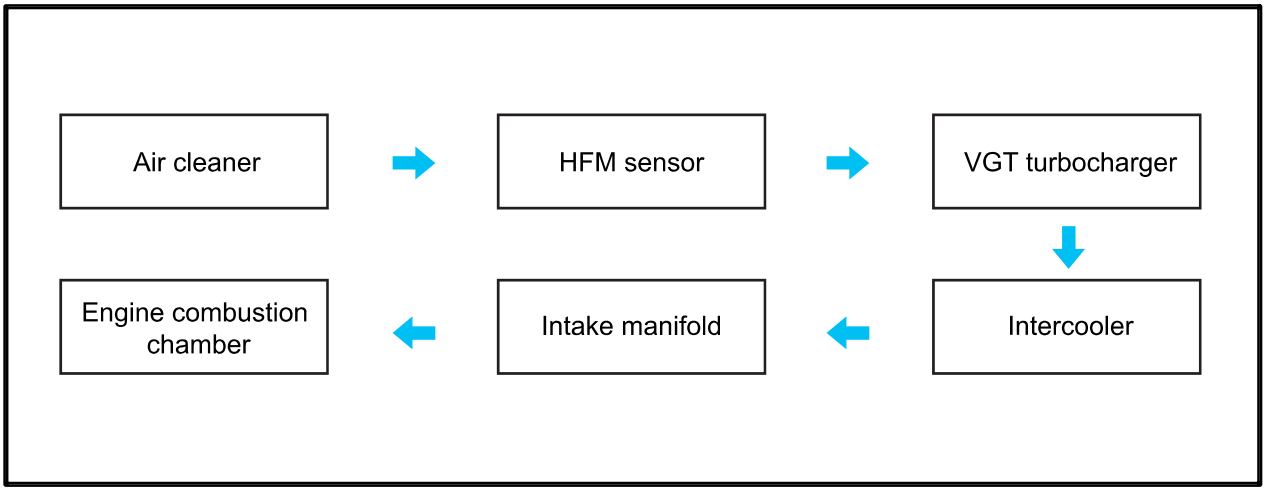
1) Troubleshooting

▶ **When Abnormal Noises are Heard from the Engine Room**

CAUTION

For the vehicle equipped with DI engine, if a learning noise occurs in each range or other noises occur, the major cause of it is a faulty turbocharger assembly. But an interference issue, poor tightness or loose in the intake and exhaust system also can cause those noises. This is mainly because the operator didn't follow the instruction exactly when reconnecting the intake hoses and pipes which were disconnected to check the system or replace the air cleaner. If the intake system is free of any faults, check the EGR and PCV oil separator connected to the intake system.
The figure may be different from the actual engine. Therefore, read thoroughly below before replacing the parts.

2) Abnormal Noise Caused by Poor Tightness of Intake System



When the DI engine is running, the air entered into the engine flows in the sequence as shown above. If high intake pressure is applied to the loose or damaged part, a whistling noise may occur, the intake air volume is measured incorrectly or the engine power is derated.

Modification basis	
Application basis	
Affected VIN	

3) Troubleshooting Sequence

The basic checks for intake system are as follows:

▶ Basic Checks for Intake System

Check if any abnormal noise occurs in each range while the vehicle is driven.

↓

Check if the engine warning lamp is illuminated or any DTC is displayed on the diagnostic device.

↓

Check the hoses for loose connections, or the clamps for deformation.

↓

Check tightness of the air cleaner housing by shaking it.

↓

Check the turbocharger and the intake/exhaust system for interferences in each range.

↓

Check the vacuum system and the hoses connected.

Make sure to replace or clean the air cleaner element periodically. Otherwise, engine will be derated or work abnormally because of low intake air volume.
Unlike the fuel system, which is a closed circuit, the intake system is an open circuit system. Therefore any malfunction may occur due to dust and dirt.
Most of the connections consist of hoses so the system cannot withstand high temperature and pressure. Also it can be deformed or loosened easily because it is a clamp mounting system. Thus, when checking the engine, basic inspections, such as tightened status check and visual inspection for hose, etc., should be carried out in advance.

▶ Other Checks for Intake System

Check the EGR system (vacuum circuit, electrical circuit of modulator, mechanical movements of EGR valve).

↓

Check the PCV oil separator.

If the intake system is free of any faults, check for EGR and PCV oil separator.

OVERVIEW AND OPERATING PROCESS

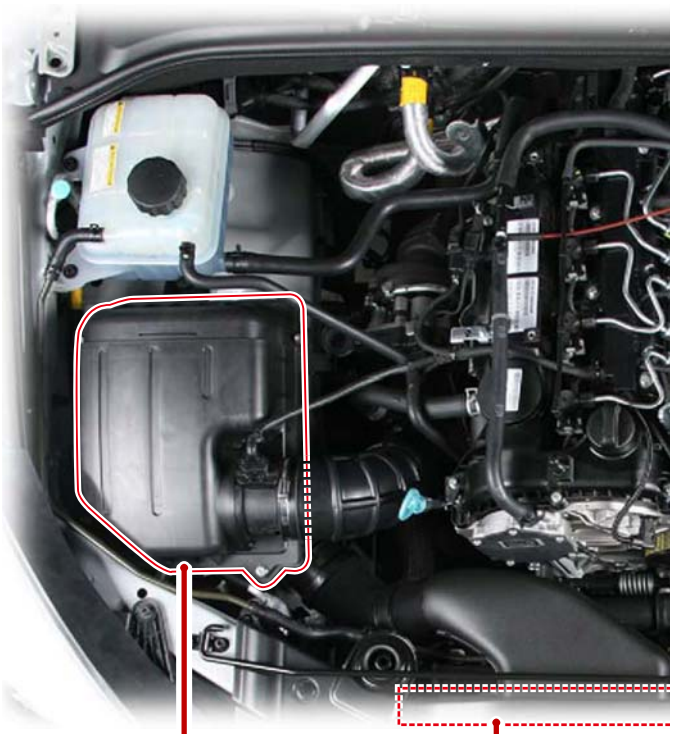
1. OVERVIEW

The intake system for D20DTR engine is equipped with a throttle body which includes a flap. This flap is controlled by an electrical signal to cut off the intake air entering to the engine when the ignition switch is turned off. Because of this, the shape of the intake manifold has been changed and improved HFM sensor is newly adopted to control the intake air volume more precisely.

2. COMPONENT

2313-15	HFM sensor

HFM sensor, version 6
*For more information, refer to Chapter "Engine Control".



2313-01	Air cleaner assembly

2330-01	Intercooler assembly

Modification basis	
Application basis	
Affected VIN	

1719-02	Swirl control valve

Operating variably in accordance with the engine load and rpm.* For more information, refer to Chapter "Engine Control".

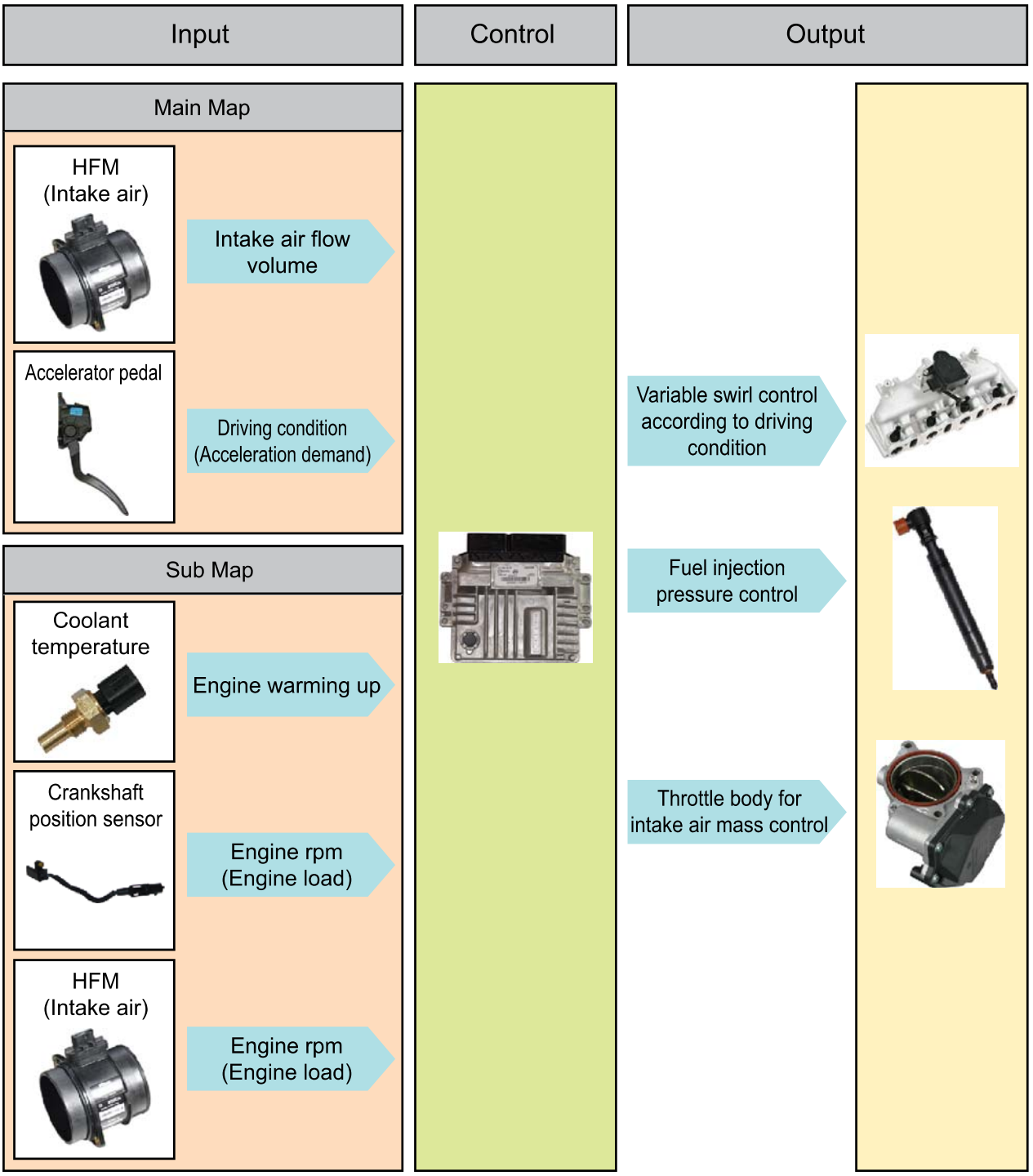
1719-01	Intake manifold

Passage for variable swirl valve and for intake air

1719-16	Electric throttle body

* For more information, refer to Chapter "Engine Control".

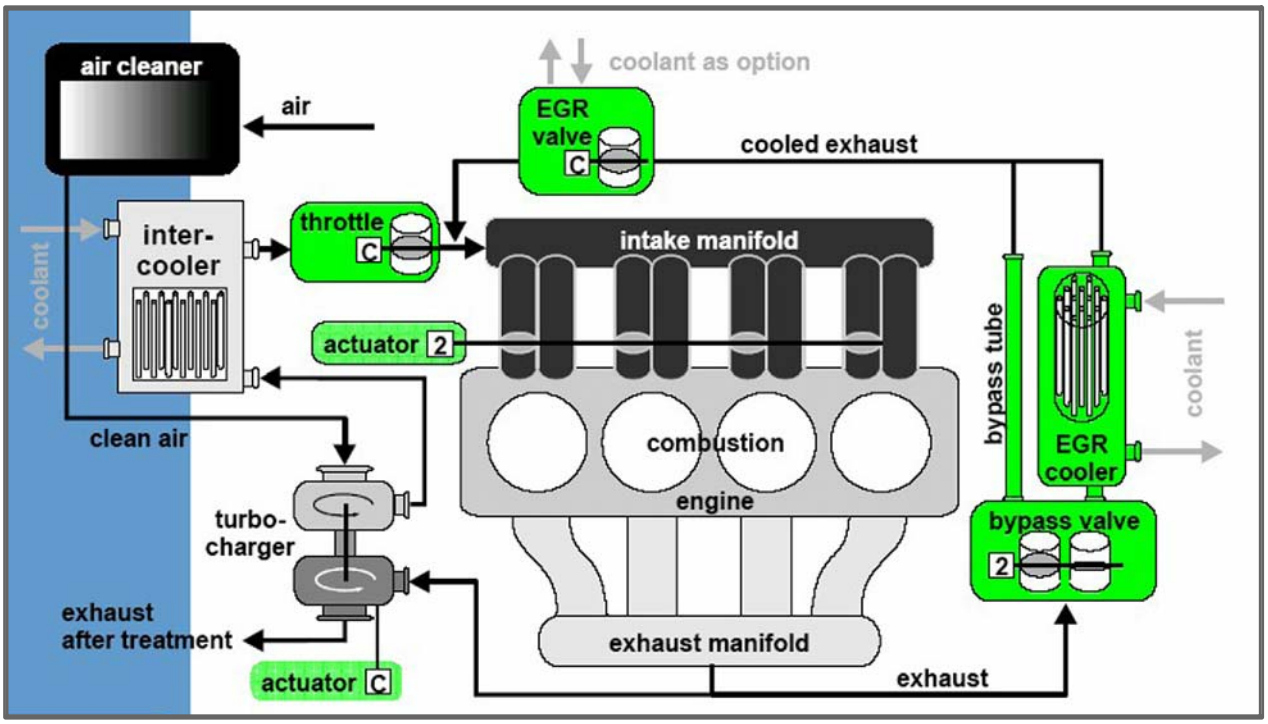
3. INPUT/OUTPUT OF INTAKE SYSTEM



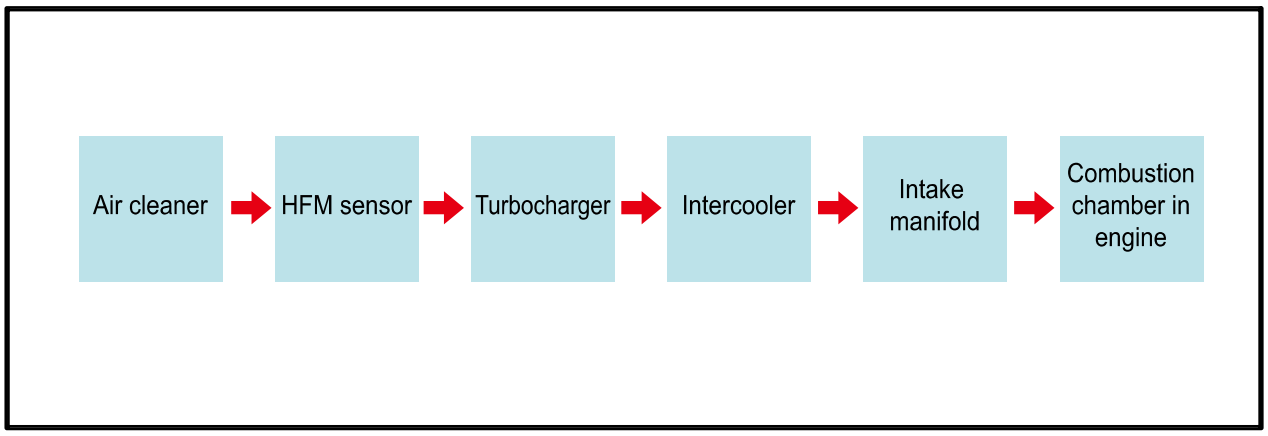
* For more information, refer to Chapter " Engine Control".

Modification basis	
Application basis	
Affected VIN	

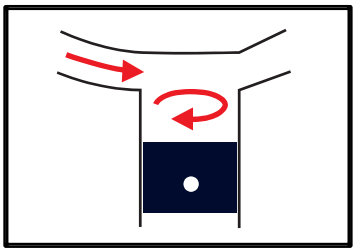
4. OPERATING PROCESS



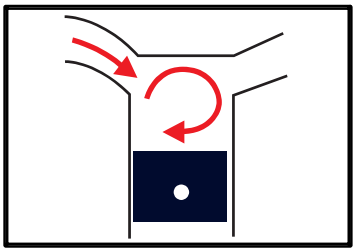
▶ **Work Flow**



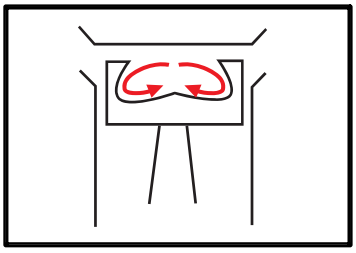
1) Types of swirl



Swirl: One cylinder has two intake air ports, one is set horizontally and the other one is set vertically. Swirl is the horizontal air flows in cylinder due to the horizontal intake air ports.



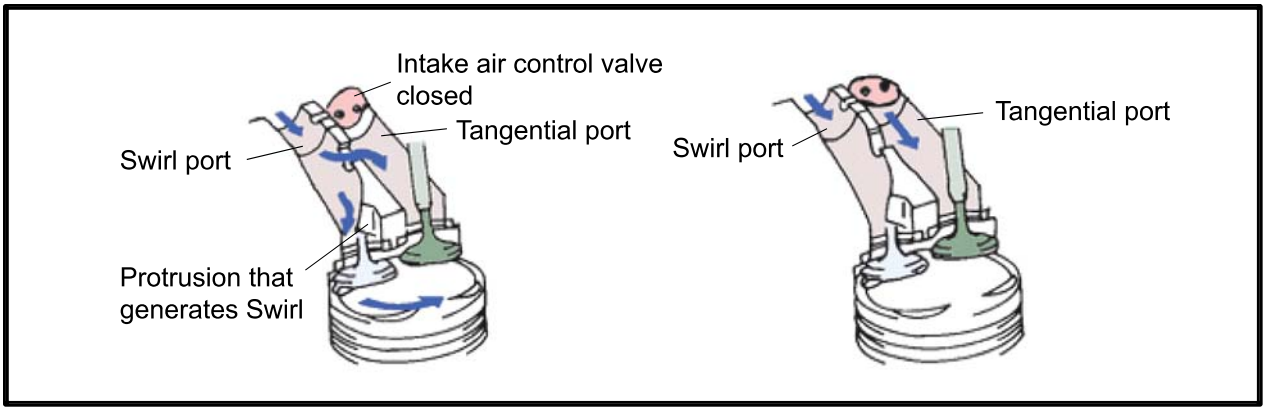
Tumble: Tumble is the vertical air flows in cylinder due to the vertical intake air port



Squish: Squish is the air flows due to the piston head. Normally, this is appears at the final process of compression. In CRDi engine, the piston head creates the bowl type squish.

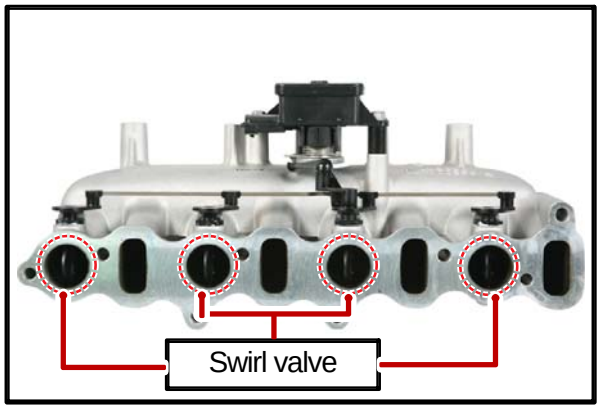
2) Swirl control

In DI type diesel engine, the liquefied fuel is injected into the cylinder directly. If the fuel is evenly distributed in short period, the combustion efficiency could be improved. To get this, there should be good air flow in cylinder. In general, there are two intake ports, swirl port and tangential port, in each cylinder. The swirl port generates the horizontal flow and the tangential port generates the longitudinal flow. In low/mid load range, the tabgential port is closed to increase the horizontal flow. Fast flow decreases the PM during combustion and increases the EGR ratio by better combustion efficiency.

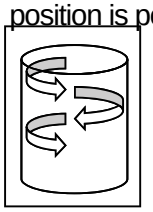


Modification basis	
Application basis	
Affected VIN	

Load	Engine speed	Swirl valve	Amount of swirl	Remarks
Low speed, Low load	below 3,000 rpm	Closed	Heavy	Increased EGR ratio, better air-fuel mixture (reduce exhaust gas)
High speed, High load	over 3,000 rpm	Open	Light	Increase charge efficiency, higher engine power



The variable swirl valve actuator operates when turning the ignition switch ON/OFF position to open/close the swirl valve. In this period, the soot will be removed and the learning for swirl valve position is performed.



NOTE

Swirl: This is the twisted (radial) air flow along the cylinder wall during the intake stroke. This stabilizes the combustion even in lean air-fuel mixture condition.

3) Features

- Swirl and air intake efficiency
  To generate the swirl, the intake port should be serpentine design. This makes the resistance in air flow. The resistance in air flow in engine high speed decreases the intake efficiency. Eventually, the engine power is also decreased, Thus, the swirl operation is deactivated in high speed range to increase the intake efficiency.
- Relationship between swirl and EGR
  To reduce Nox, it is essential to increase EGR ratio. However, if EGR ratio is too high, the PM also could be very higher. And, the exhaust gas should be evenly mixed with newly aspired air. Otherwise, PM and CO are dramatically increased in highly concentrated exhaust gas range and EGR ratio could not be increased beyond a certain limit. If the swirl valve operates in this moment, the limit of EGR ratio will be higher.

4) Relationship between swirl and fuel injection pressure

The injector for DI engine uses the multi hole design. For this vehicle, there are 8 holes in injector. If the swirl is too strong, the injection angles might be overlapped and may cause the increased PM and insufficient engine power. Also, if the injection pressure is too high during strong swirl, the injection angles might be overlapped. Therefore, the system may decreases the fuel injection pressure when the swirl is too strong.

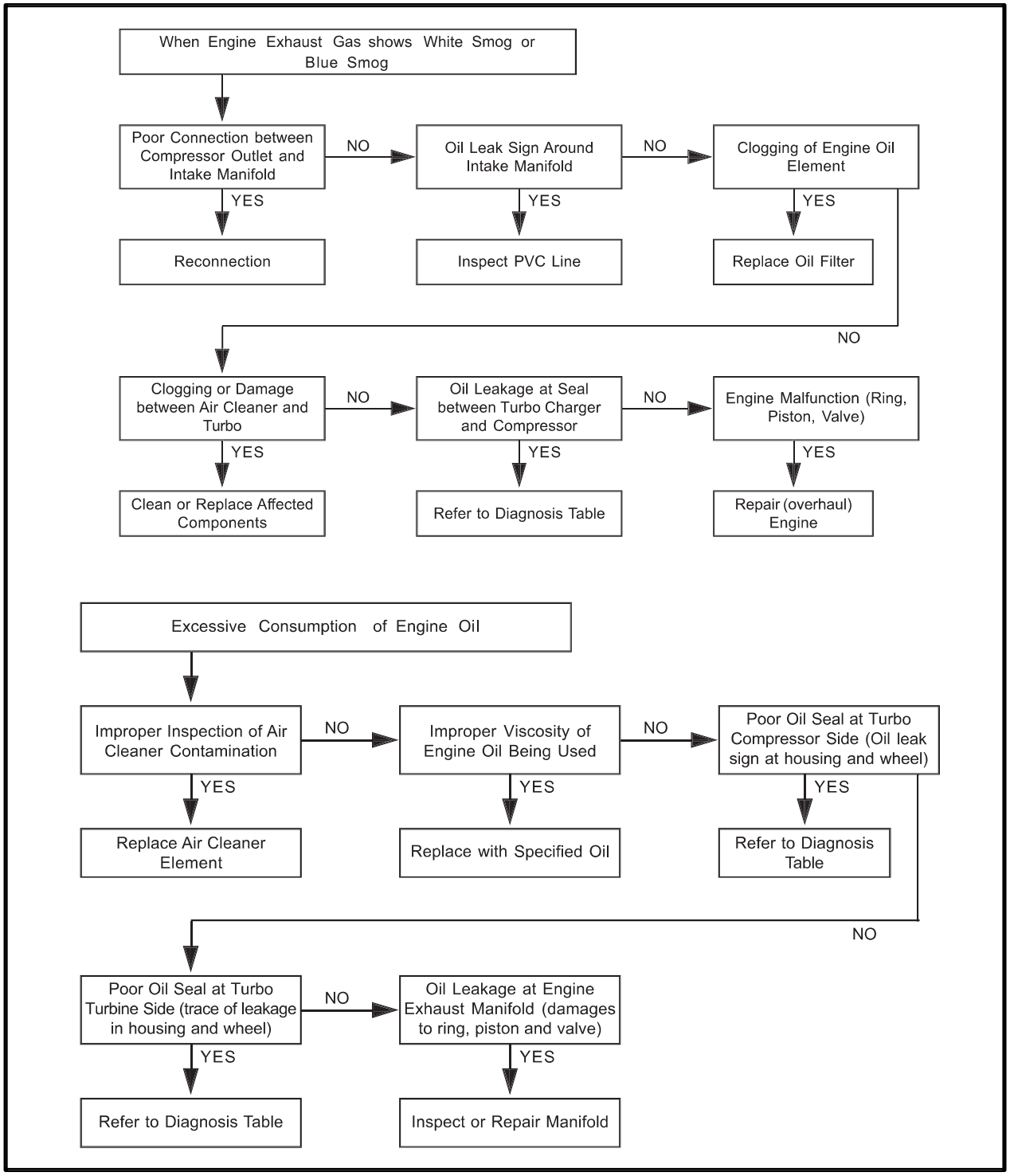
ENGINE EXHAUST SYSTEM

1729-01

GENERAL INFORMATION

1. TROUBLESHOOTING

1) Work Flow



2. CAUTIONS

- Do not park the vehicle on flammable materials, such as grass, leaves and carpet.
- Do not touch the catalyst or the exhaust gas ignition system when the engine is running.
- If a misfire occurs in the combustion chamber or the emission of pollutant exceeds the specified level, the catalyst can be damaged.
- When servicing or replacing components of the exhaust system, makes sure that the components are positioned at regular intervals from all other parts of the under body.
- Be careful not to damage the exhaust system when lifting the vehicle from its side.
- All components and body parts of the engine exhaust system should be inspected for crack, damage, air hole, part loss and incorrect mounting location. Also check for any deformation which can result in exhaust gas drawn into the vehicle.
- Make sure that the exhaust pipe is cooled down sufficiently before working on it because it is still hot right after the engine is stopped.
- Wear protective gloves when removing the exhaust pipe.

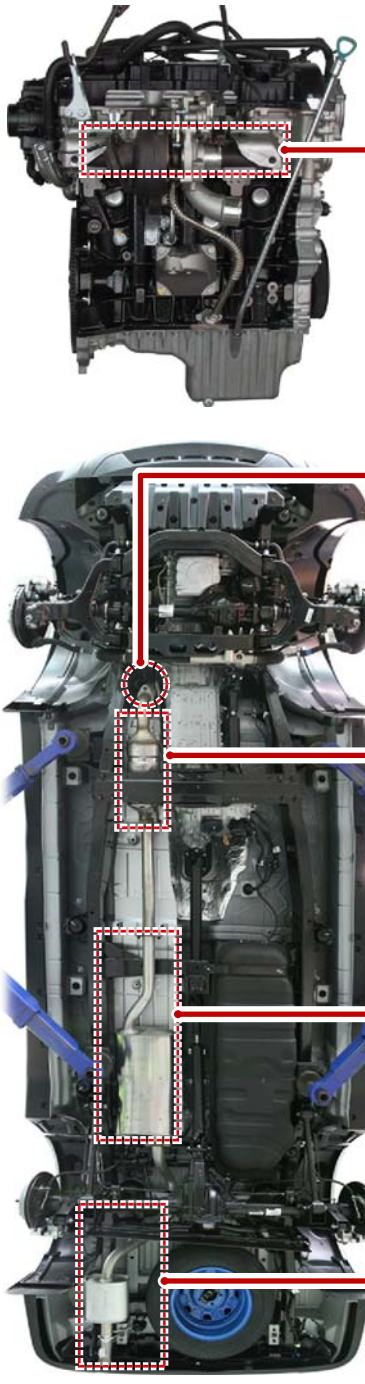
Modification basis	
Application basis	
Affected VIN	

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

This system purifies the exhaust gas generated by the combustion in the engine to reduce the pollutants and noise during that arise during combustion.

2. LAYOUT



Exhaust manifold assembly

Exhaust front pipe assembly

CDPF assembly

* For more information, refer to Chapter "Engine Control".

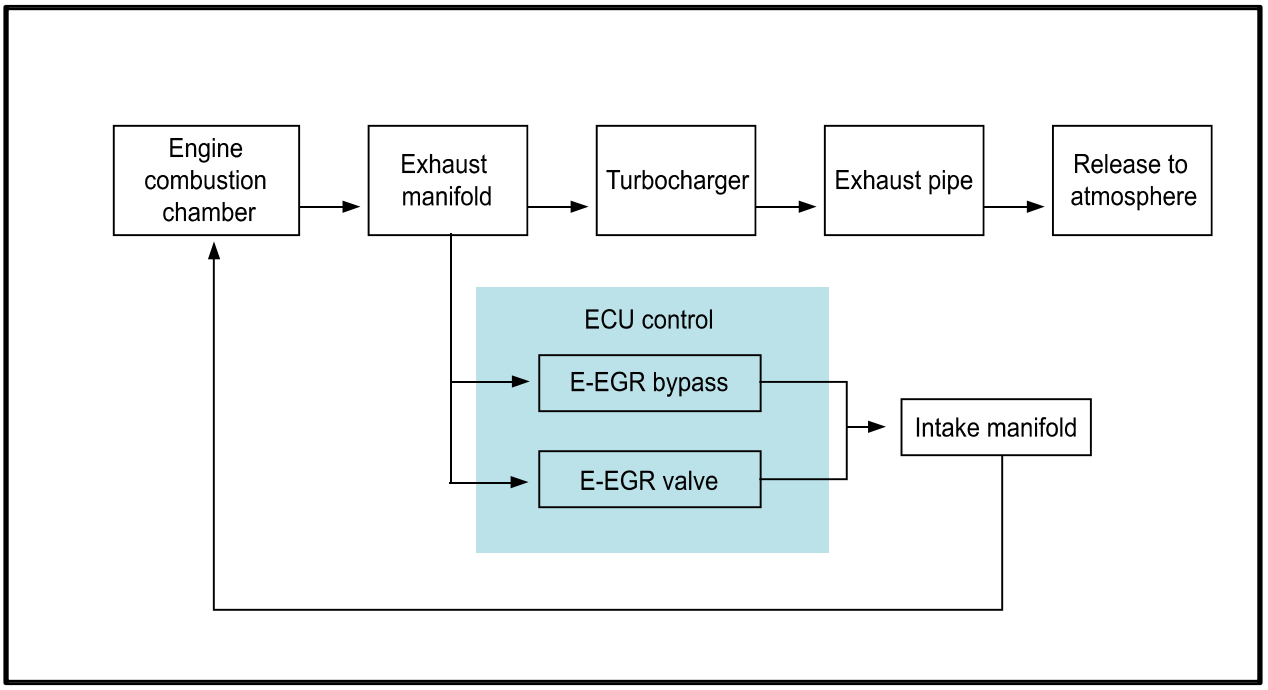
Muffler assembly

Exhaust tail pipe assembly

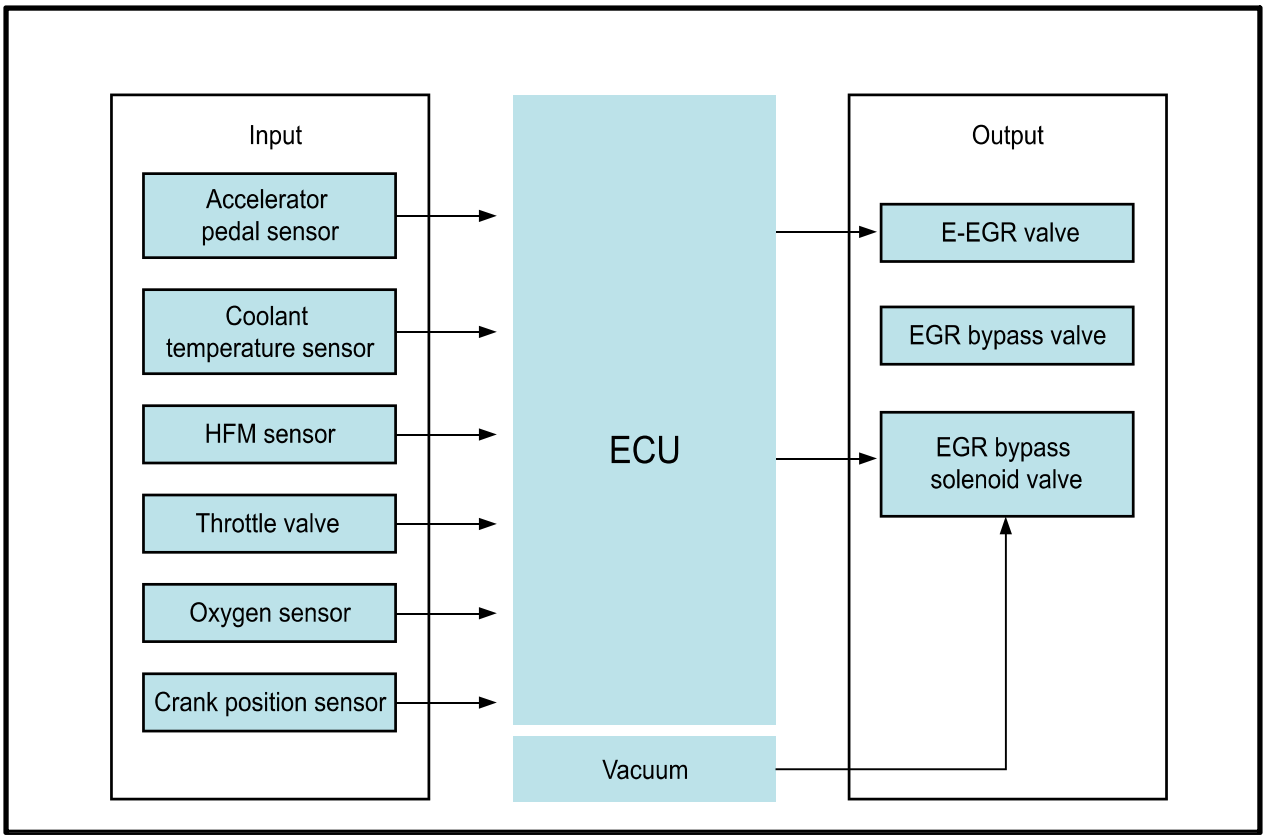
Modification basis	
Application basis	
Affected VIN	

3. OPERATING PROCESS

1) Exhaust Gas Flow



2) Input & Output Devices



Modification basis	
Application basis	
Affected VIN	

TURBOCHARGER

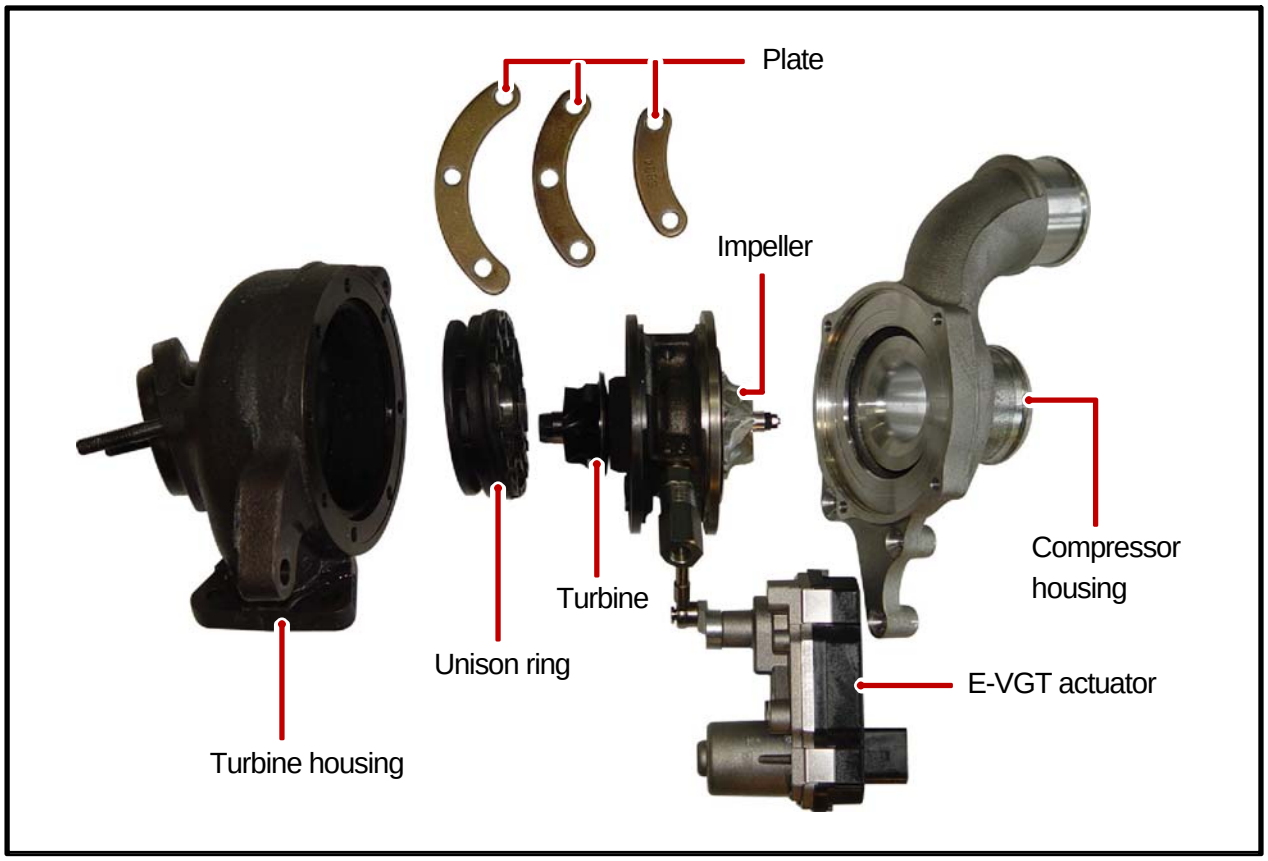
1914-01

GENERAL INFORMATION

1. SPECIFICATION

Unit	Description	Specification
Turbocharger	Max. expansion coefficient	4.0
	Max. turbine speed	226,000rpm
	Max. temperature of turbine housing	790 ℃
	Weight	6.5kg
E-VGT actuator	Operation duty cycle	250Hz

▶ **E-VGT turbocharger**



2. INSPECTION

1) Cautions During Driving

The following lists cautions to take during test drive and on the turbocharger vehicle, which must be considered during the operation.

1. It's important not to drastically increase the engine rpm starting the engine. It could make rotation at excessive speed even before the journal bearing is lubricated and when the turbocharger rotates in poor oil supply condition, it could cause damage of bearing seizure within few seconds.
   If the engine is running radically after replacing the engine oil or oil filter brings poor oil supply
2. condition. To avoid this, it's necessary to start off after idling the engine for about 1 minute allowing oil to circulate to the turbocharger after the replacement.
   When the engine is stopped abruptly after driving at high speed, the turbocharger continues to rotate
3. in condition where the oil pressure is at '0'. In such condition, an oil film between the journal bearing and the housing shaft journal section gets broken and this causes abrasion of the journal bearing due to the rapid contact. The repeat of such condition significantly reduces life of the turbocharger. Therefore, the engine should be stopped possibly in the idle condition.

CAUTION

After string for long period of time during winter season or in the low temperature condition where the fluidity of engine oil declines, the engine, before being started, should be cranked to circulate oil and must drive after checking the oil pressure is in normal condition by idling the engine for few minutes.

Modification basis	
Application basis	
Affected VIN	

2) Inspection of Turbocharger

When problem occurs with the turbocharger, it could cause engine power decline, excessive discharge of exhaust gas, outbreak of abnormal noise and excessive consumption of oil.

1. On-board Inspection

- Check the bolts and nuts foe looseness or missing
- Check the intake and exhaust manifold for looseness or damage
- Check the oil supply pipe and drain pipe for damages
- Check the housing for crack and deterioration

2. Inspection of turbine

Remove the exhaust pipe at the opening of the turbine and check, with a lamp, the existence of interference of housing and wheel, oil leakage and contamination (at blade edge) of foreign materials.

- Interference: In case where the oil leak sign exists, even the small traces of interferences on the turbine wheel mean, most of times, that abrasion has occurred on the journal bearing. Must inspect after overhauling the turbocharger.
- Oil Leakage: Followings are the reasons for oil leakage condition
  * Problems in engine: In case where the oil is smeared on inner wall section of the exhaust gas opening.
  * Problems in turbocharger: In case where the oil is smeared on only at the exhaust gas outlet section.

CAUTION

Idling for long period of time can cause oil leakage to the turbine side due to low pressure of exhaust gas and the rotation speed of turbine wheel. Please note this is not a turbocharger problem.

- Oil Drain Pipe Defect
  In case where oil flow from the turbocharger sensor housing to the crank case is not smooth would become the reason for leakage as oil builds up within the center housing. Also, oil thickens (sludge) at high temperature and becomes the indirect reason of wheel hub section. In such case, clogging and damage of the oil drain pipe and the pressure of blow-by gas within the crank case must be inspected.
  Damages due to Foreign Materials
- When the foreign materials get into the system, it could induce inner damage as rotating balance of the turbocharger gets out of alignment.

3) Inspection of Turbine

Thoroughly check the followings.

CAUTION

Must absolutely not operate the turbocharger with the compressor outlet and inlet opened as it could damage the turbocharger or be hazardous during inspection.

- Interference: In case where is trace of interference or smallest damage on the compressor wheel means, most of times, that abrasion has occurred on the journal bearing. Must inspect after the overhaul.
- Oil Leakage: The reason for oil leakage at the compressor section is the air cleaner, clogged by substances such as dust, causes the compressor inlet negative pressure.

  a. Rotating in high speed at no-load for extended period of time can cause oil leakage to the compressor section as oil pressure within the center housing gets higher than pressure within the compressor housing.
  b. Overuse of engine break (especially in low gear) in down hill makes significantly low exhaust gas energy compared to the time where great amount of air is required during idling conditions of the engine. Therefore, amount of air in the compressor inlet increases but the turbocharge pressure is not high, which makes negative

CAUTION

No problem will occur with the turbocharger if above conditions are found in early stage but oil leaked over long period of time will solidify at each section causing to breakout secondary defects.

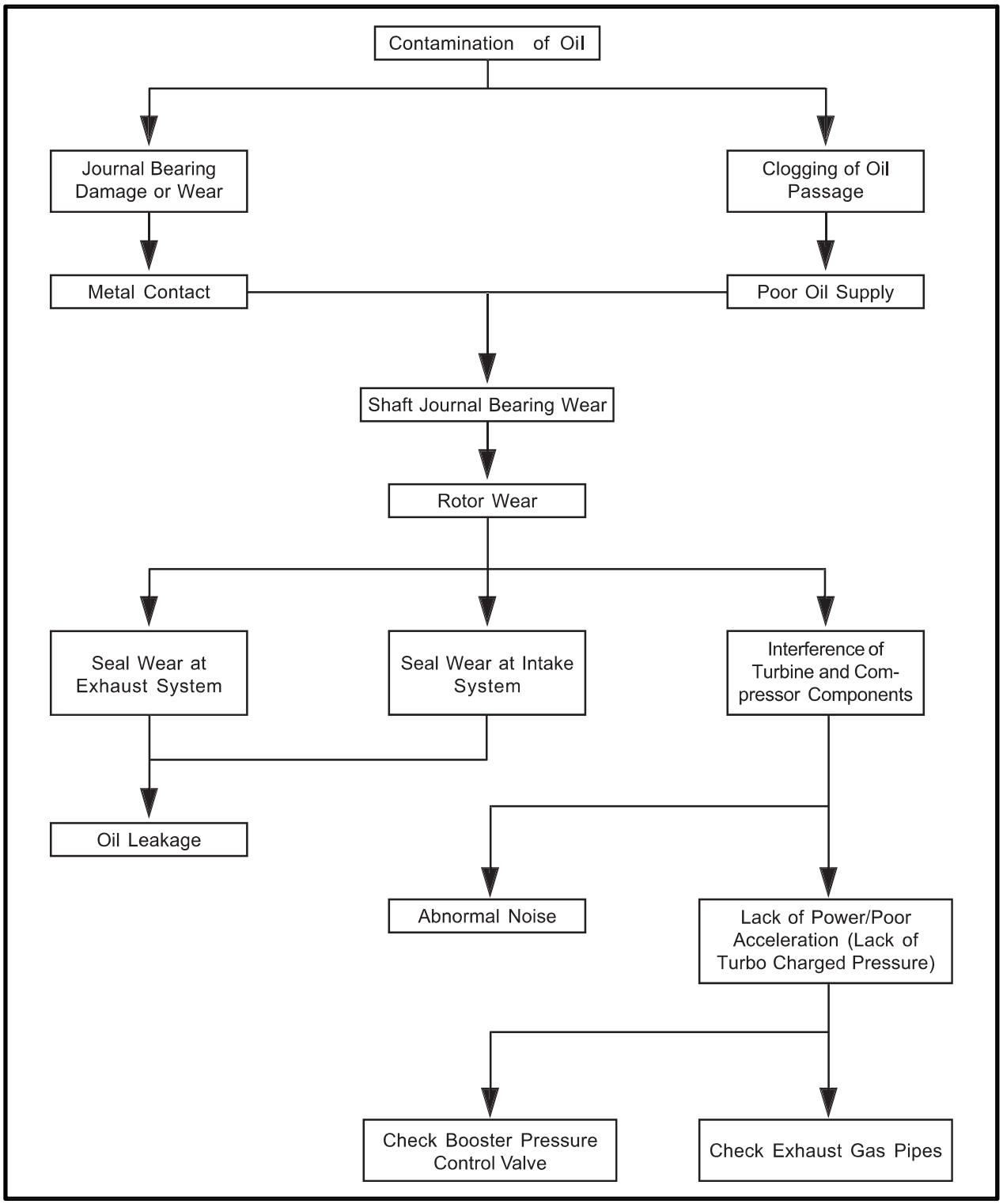
Damages by foreign materials: In case where the compressor wheel is damaged by foreign materials requires having an overhaul. At this time, it's necessary to check whether the foreign materials have contaminated intake/exhaust manifold or inside of engine.

Modification basis	
Application basis	
Affected VIN	

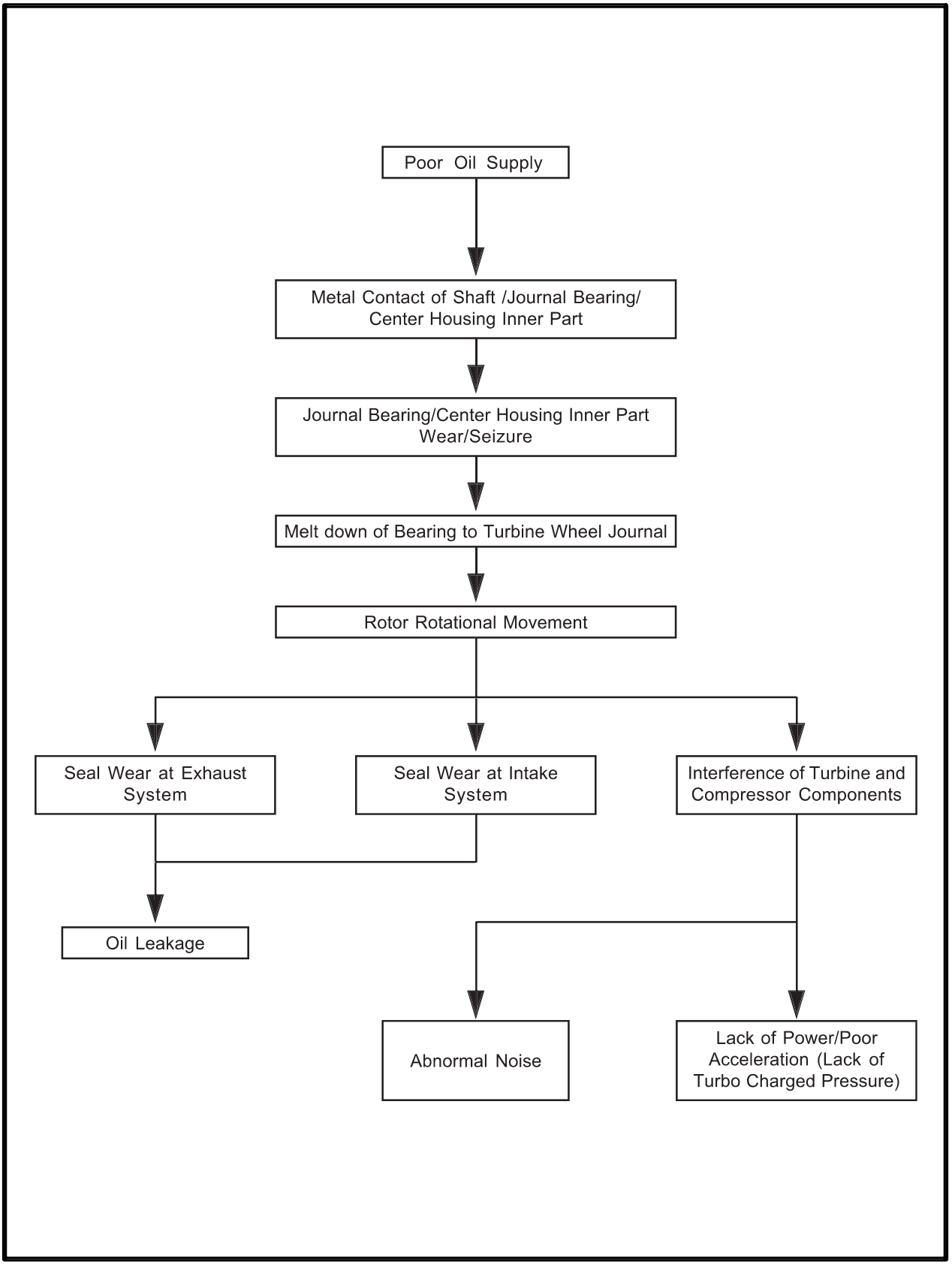
4) Possible Causes of Defect

The following tries to understand the defects that can occur with vehicle installed with the turbocharger and to manage the reasons of such defects.

1. In case where oil pan/oil pipe has been contaminated, oil filter is defected and where adhesive of gaskets has been contaminated into the oil line.

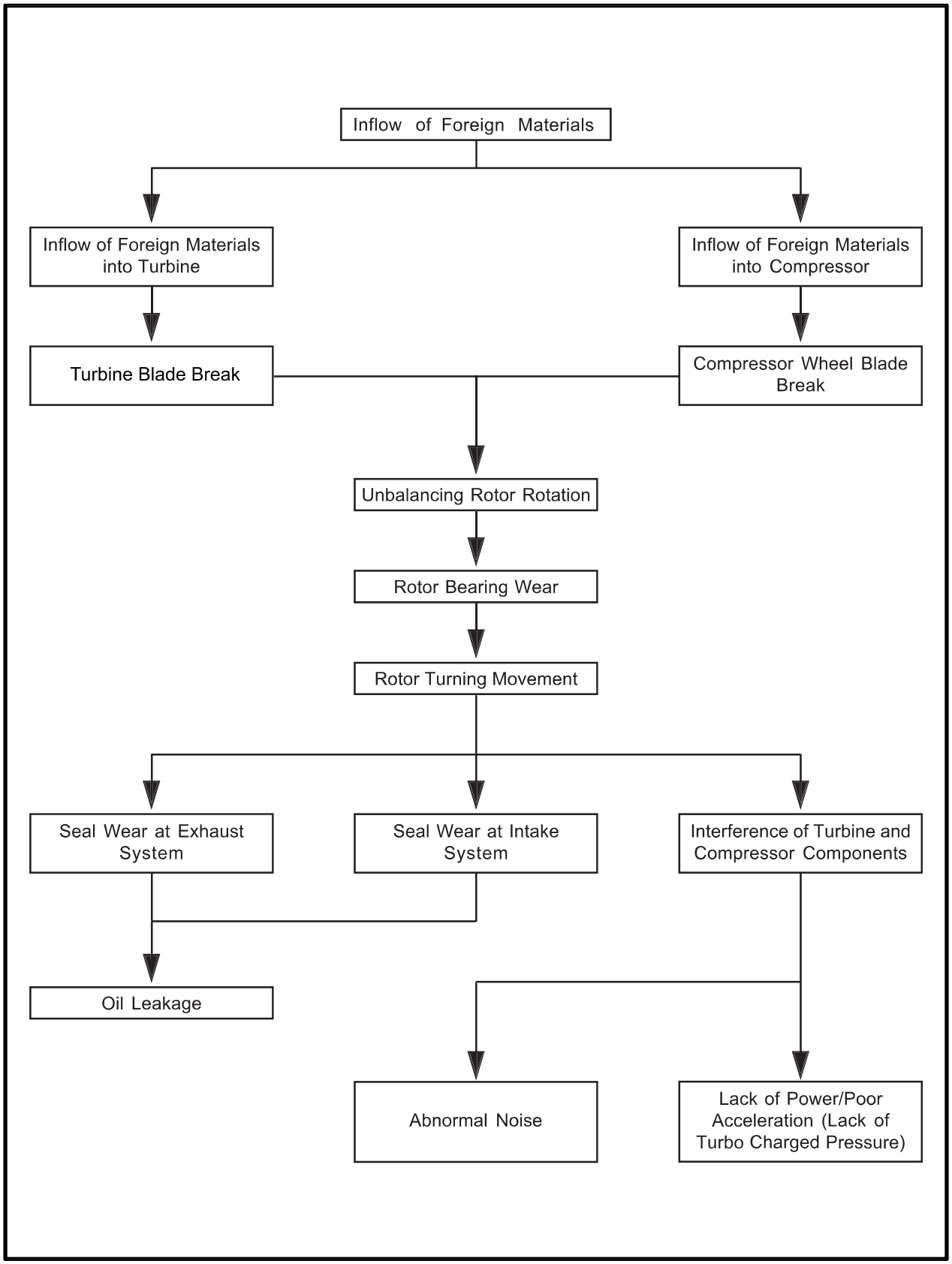


2. Oil Pump Defect: Rapid over-loaded driving after replacing oil filter and oil and clogging of oil line.

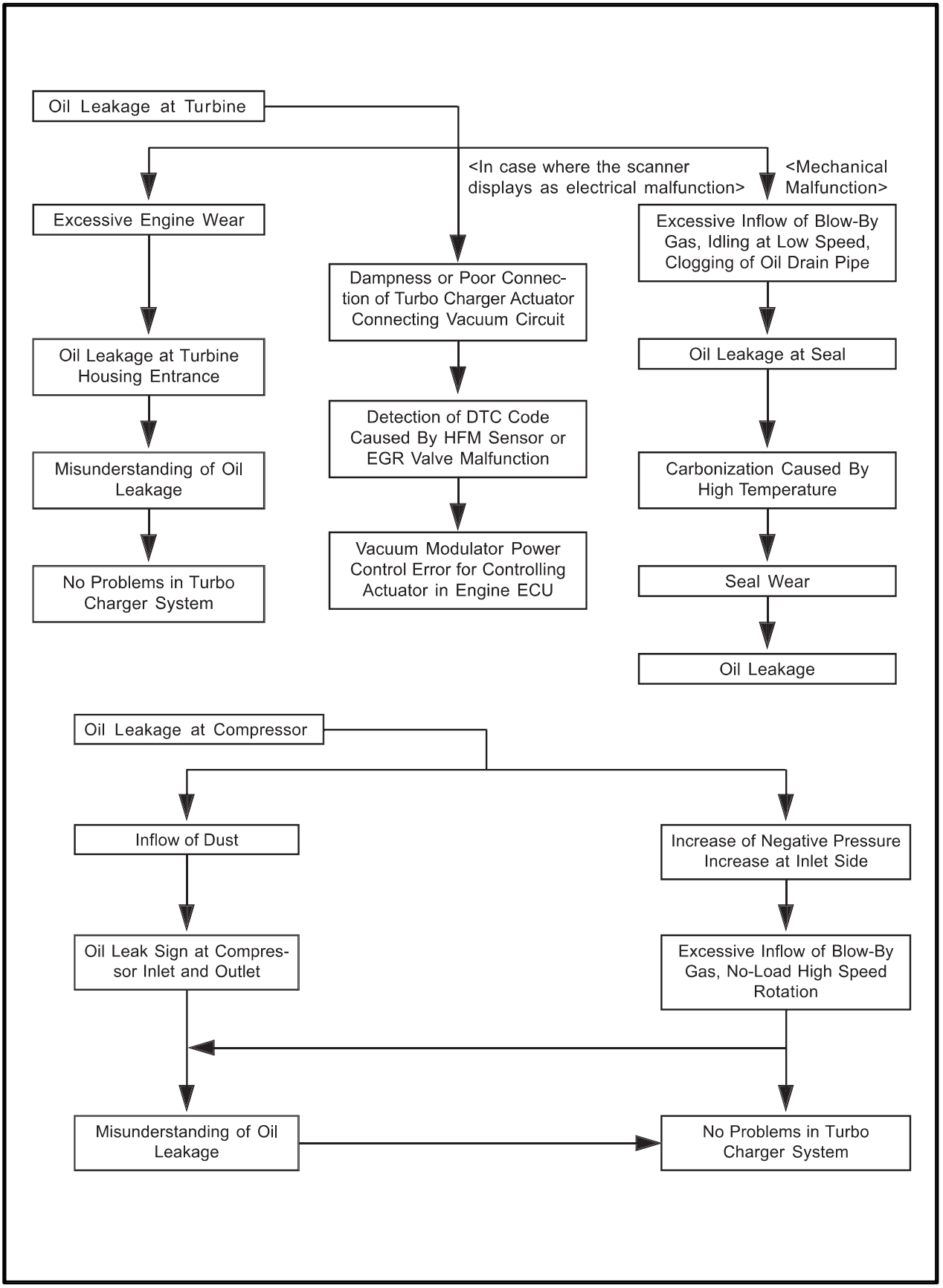


Modification basis	
Application basis	
Affected VIN	

3. Turbine Side: Inflow of foreign materials from engine
   Compressor Side: such as air filter, muffler and nut



4. Defects caused by reasons other than that of the turbocharger.



Modification basis	
Application basis	
Affected VIN	

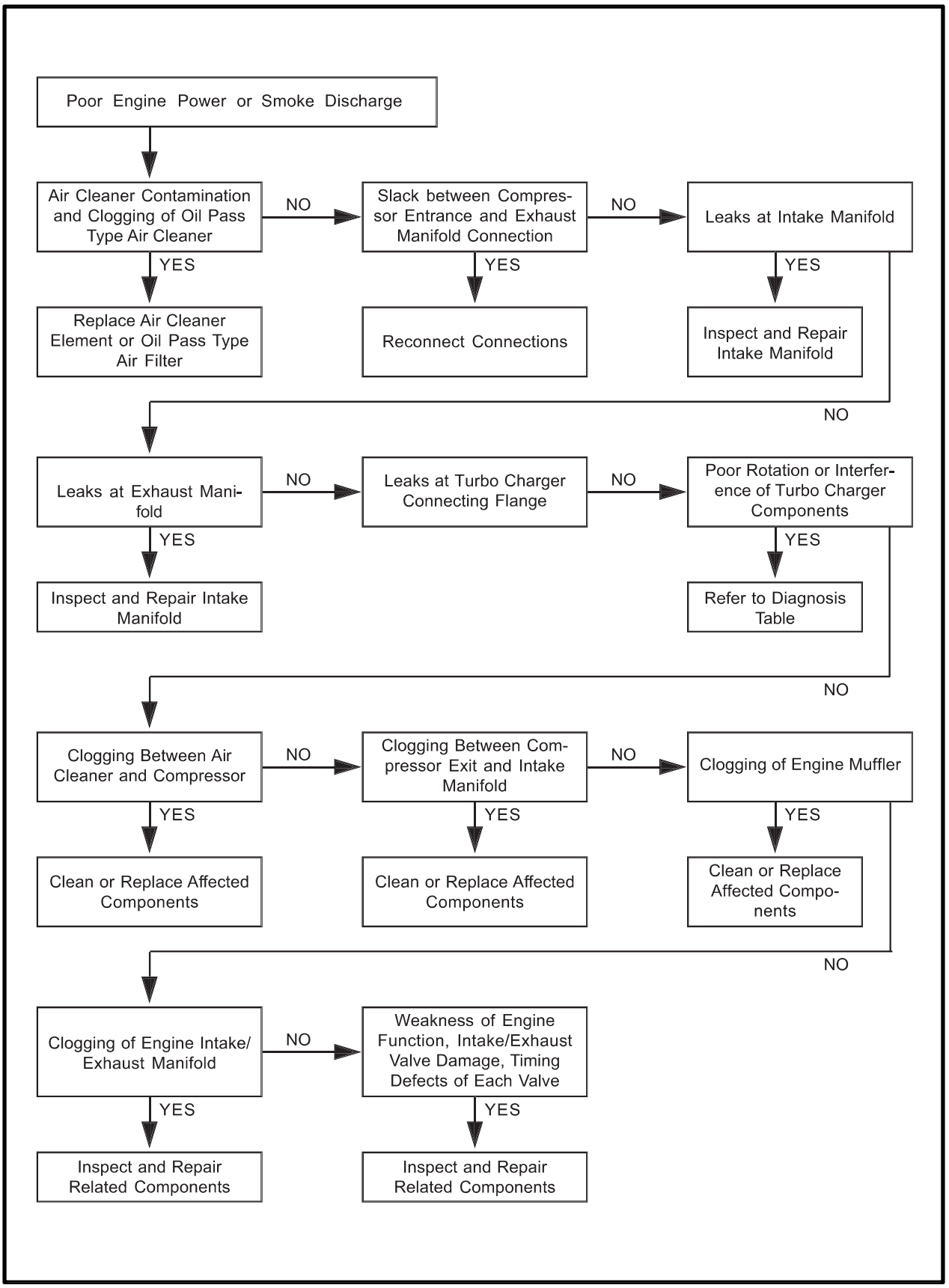
3. TROUBLESHOOTING

The followings are cautions to take in handling defects of turbocharger, which must be fully aware of.

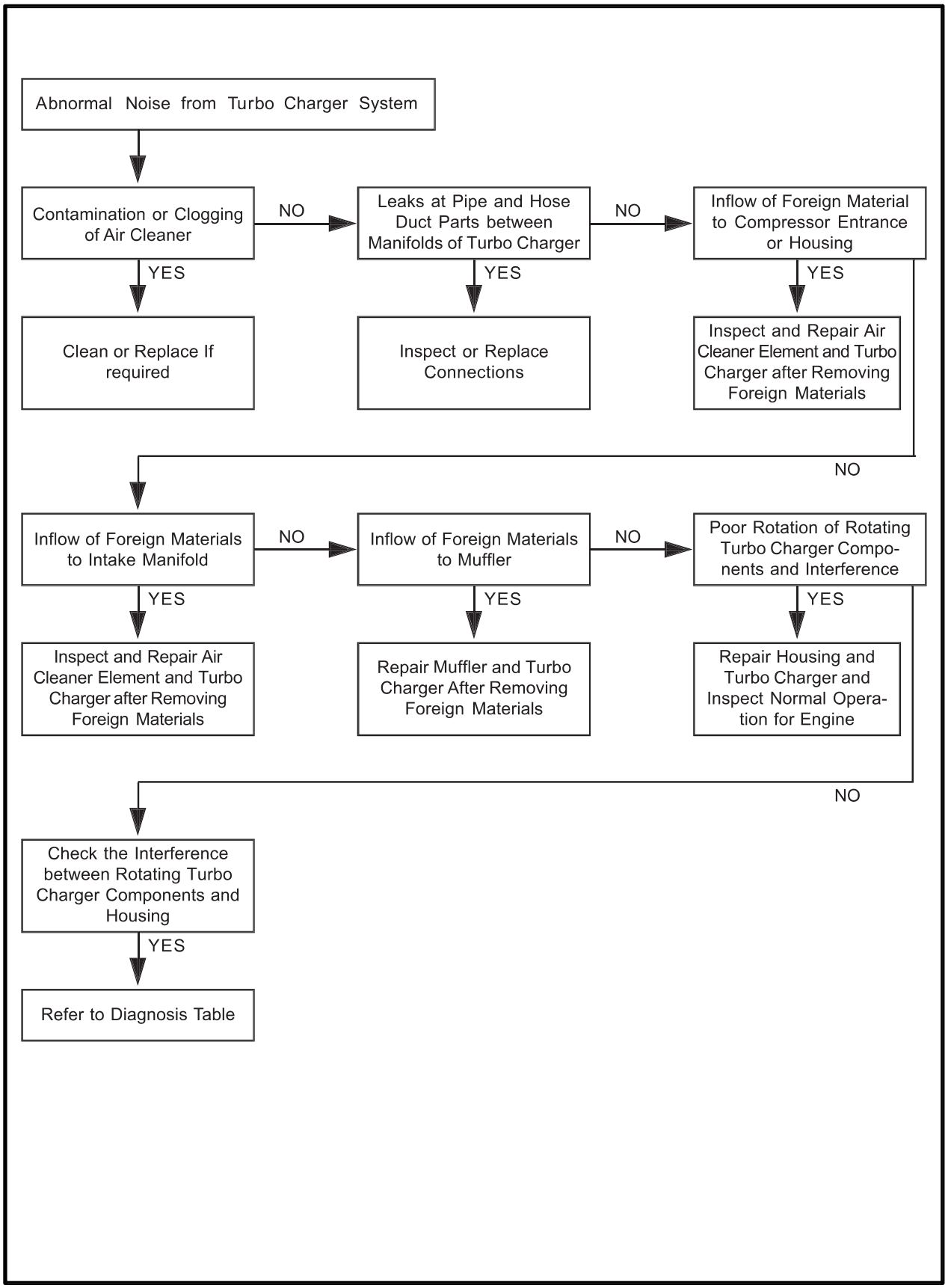
1) Cautions

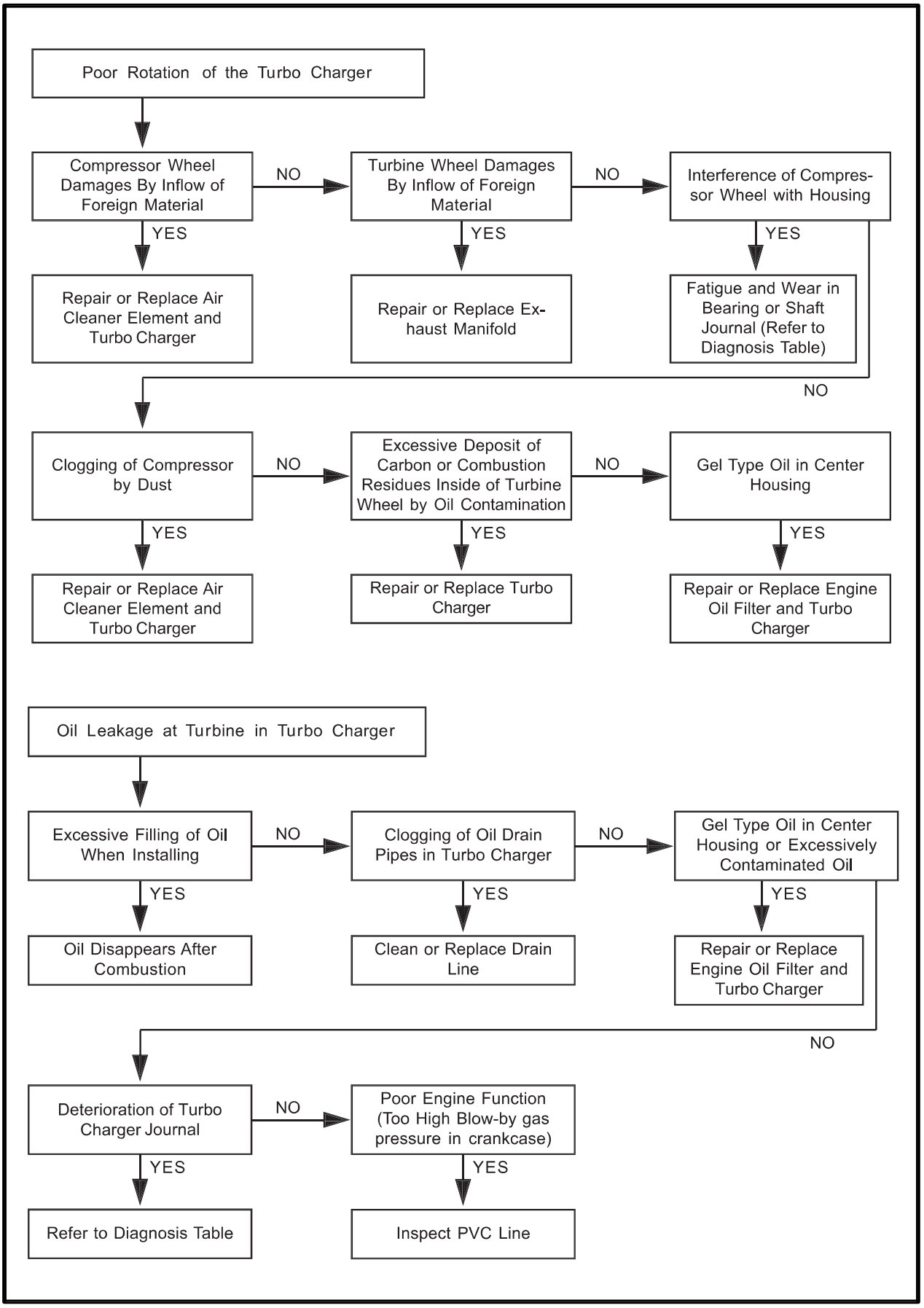
1. After stopping the engine, check whether the bolts on pipe connecting section are loose as well as the connecting condition of vacuum port and modulator, which is connected to the actuator.
2. During idling of the engine, check for leakage in the connecting section of pipe (hoses and pipes, duct connections, after the turbocharger) by applying soap water. The leakage condition in the engine block and turbine housing opening can be determined by the occurrence of abnormal noise of exhaust.
3. By running the engine at idle speed, abnormal vibration and noise can be checked. Immediately stop the engine when abnormal vibration and noise is detected and make thorough inspection whether the turbocharger shaft wheel has any damages as well as checking the condition of connections between pipes.
4. In case where the noise of engine is louder than usual, there is possibility of dampness in the areas related with air cleaner and engine or engine block and turbocharger. And it could affect the smooth supply of engine oil and discharge.
5. Check for damp condition in exhaust gas when there is sign of thermal discoloration or discharge of carbon in connecting area of the duct.
6. When the engine rotates or in case where there is change in noise level, check for clogging of air cleaner or air cleaner duct or if there is any significant amount of dust in the compressor housing.
7. During the inspection of center housing, inspect inside of the housing by removing the oil drain pipe to check for sludge generation and its attachment condition at shaft area or turbine side.
8. Inspect or replace the air cleaner when the compressor wheel is damaged by inflow of foreign materials.
9. Inspect both side of the turbocharger wheel after removing inlet and outlet pipe of the turbocharger.

2) Work Flow for Troubleshooting

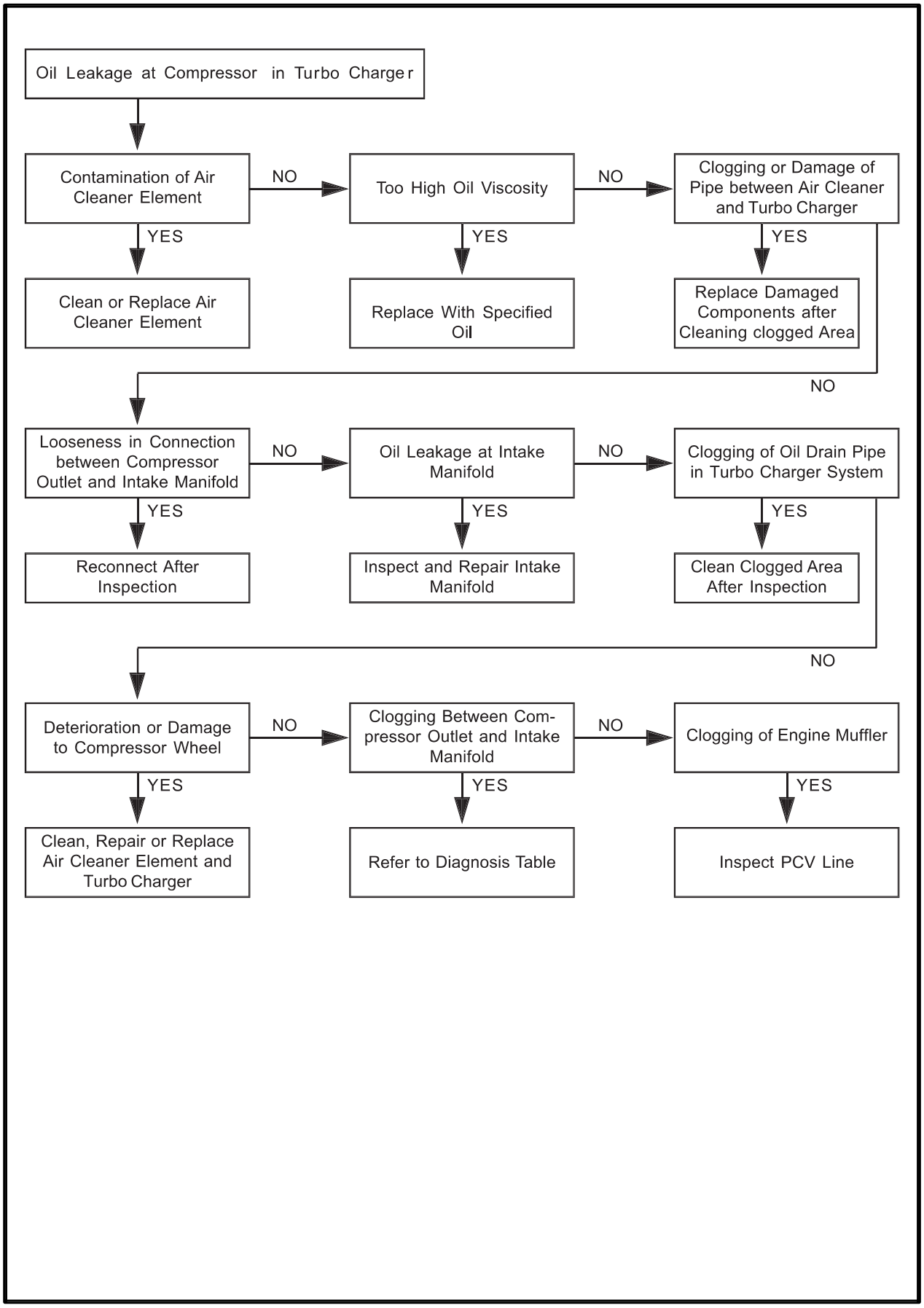


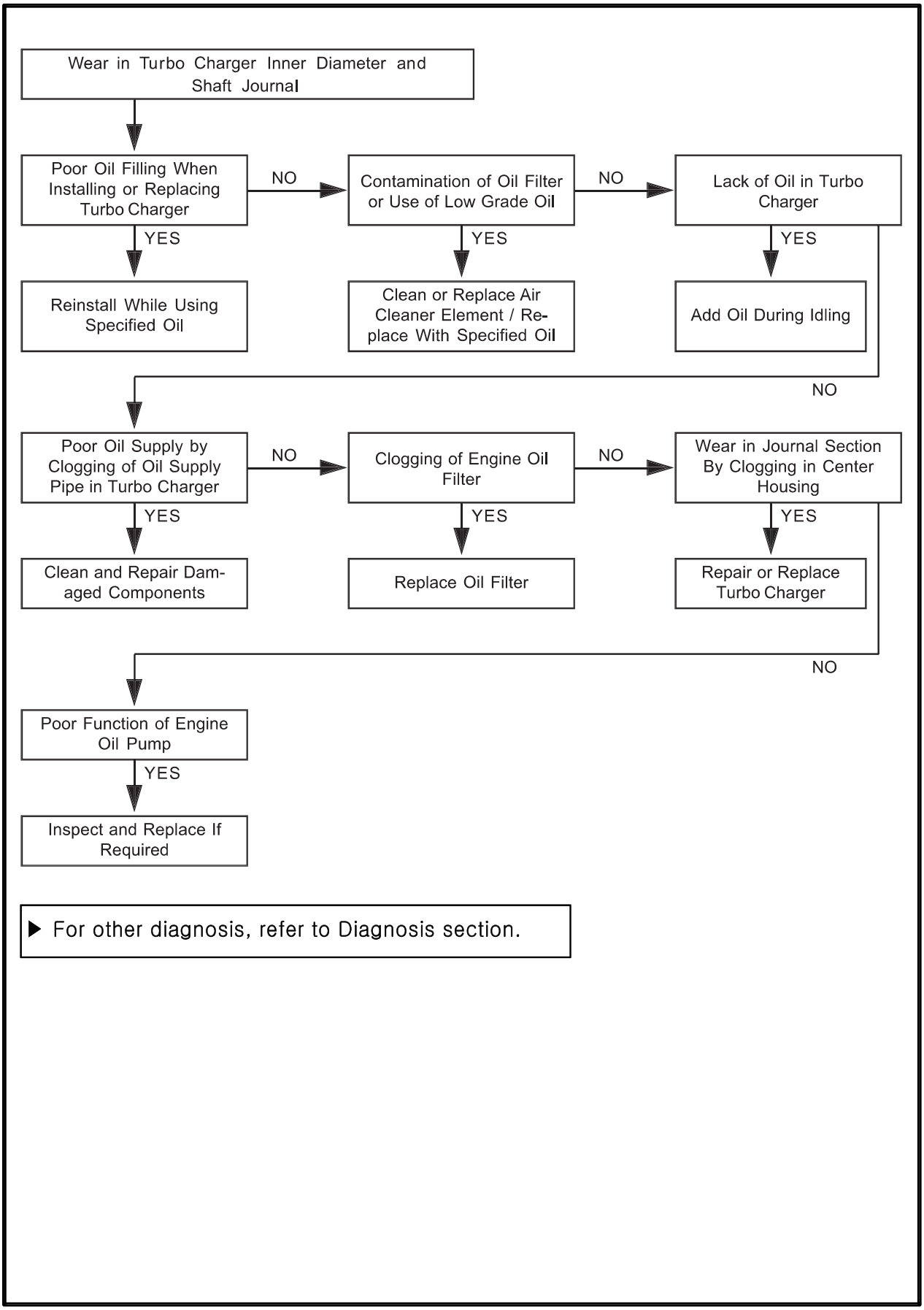
Modification basis	
Application basis	
Affected VIN	


Abnormal Noise from Turbo Charger System
Contamination or Clogging of Air Cleaner
NO
Leaks at Pipe and Hose Duct Parts between Manifolds of Turbo Charger
NO
Inflow of Foreign Material to Compressor Entrance or Housing
YES
YES
YES
Clean or Replace If required
Inspect or Replace Connections
Inspect and Repair Air Cleaner Element and Turbo Charger after Removing Foreign Materials
NO
Inflow of Foreign Materials to Intake Manifold
NO
Inflow of Foreign Materials to Muffler
NO
Poor Rotation of Rotating Turbo Charger Compo-nents and Interference
YES
YES
YES
Inspect and Repair Air Cleaner Element and Turbo Charger after Removing Foreign Materials
Repair Muffler and Turbo Charger After Removing Foreign Materials
Repair Housing and Turbo Charger and Inspect Normal Opera-tion for Engine
NO
Check the Interference between Rotating Turbo Charger Components and Housing
YES
Refer to Diagnosis Table



Modification basis	
Application basis	
Affected VIN	


Oil Leakage at Compressor in Turbo Charger
Contamination of Air Cleaner Element
NO
Too High Oil Viscosity
NO
Clogging or Damage of Pipe between Air Cleaner and Turbo Charger
YES
YES
YES
Clean or Replace Air Cleaner Element
Replace With Specified Oil
Replace Damaged Components after Cleaning clogged Area
NO
Looseness in Connection between Compressor Outlet and Intake Manifold
NO
Oil Leakage at Intake Manifold
NO
Clogging of Oil Drain Pipe in Turbo Charger System
YES
YES
YES
Reconnect After Inspection
Inspect and Repair Intake Manifold
Clean Clogged Area After Inspection
NO
Deterioration or Damage to Compressor Wheel
NO
Clogging Between Compressor Outlet and Intake Manifold
NO
Clogging of Engine Muffler
YES
YES
YES
Clean, Repair or Replace Air Cleaner Element and Turbo Charger
Refer to Diagnosis Table
Inspect PCV Line



Modification basis	
Application basis	
Affected VIN	

OVERVIEW AND OPERATING PROCESS

1. SYSTEM DESCRIPTION OF E-VGT (Electric-Variable Geometry Turbine)

1) Overview

The E-VGT turbocharger has one shaft where at each ends are installed with two turbines having different angles to connect one end of housing to the intake manifold and the other end to the exhaust manifold. As the turbine, at exhaust end, is rotated by exhaust gas pressure the impeller, at intake end, gets rotated to send air around center of the impeller, being circumferentially accelerated by the centrifugal force, into the diffuser. The air, which has been introduced to the diffuser having a passage with big surface, transforms its speed energy into the pressure energy while being supplied to the cylinder improving the volume efficiency. Also, the exhaust efficiency improves as the exhaust turbine rotates. The turbocharger is often referred to as the exhaust turbine turbocharger.

Diffuser: With the meaning of spreading out it is a device that transforms fluid's speed energy into the pressure energy by enlarging the fluid's passage to slow down the flow.
The E-VGT system installed to the D20DTR engine variably controls the passages of the turbine housing to regulate the flow rate of the exhaust gas. The actuator of E-VGT is a DC motor actuator (E-Actuator) which controls more quickly and precisely than the previous vacuum type actuator.

The engine ECU controls the E-Actuator electronically as follows:

- At low speed: Narrows the flow passage for the exhaust gas, resulting in increasing the flow speed of the exhaust gas and running the turbine quickly and powerfully.
- At high speed: Expands the flow passage for the exhaust gas, resulting in increasing the mass flow of the exhaust gas and running the turbine more powerfully.

2) Features

(1) Performance (for EURO V)

1. Enhanced emmission control: By temperature control with CDPF system
   - Target temperature and airflow control

(2) E-VGT Actuator (Electric-Actuator)

1. Optimizes the exhaust gas flow rate by controlling the vanes inside the turbine housing with the E-Actuator.
- Maximizes the intake air charging efficiency (Approx. 15%)

2. Has a faster response time than the conventional vacuum actuator.
- Improved low speed torque, high speed power and fuel economy.
- Improved acceleration performance with rapid response time of vane.

Features
- Folding and unfolding of the vane is controlled electrically
- Easy to get low speed air volume Rapid response time
- Electric control
-

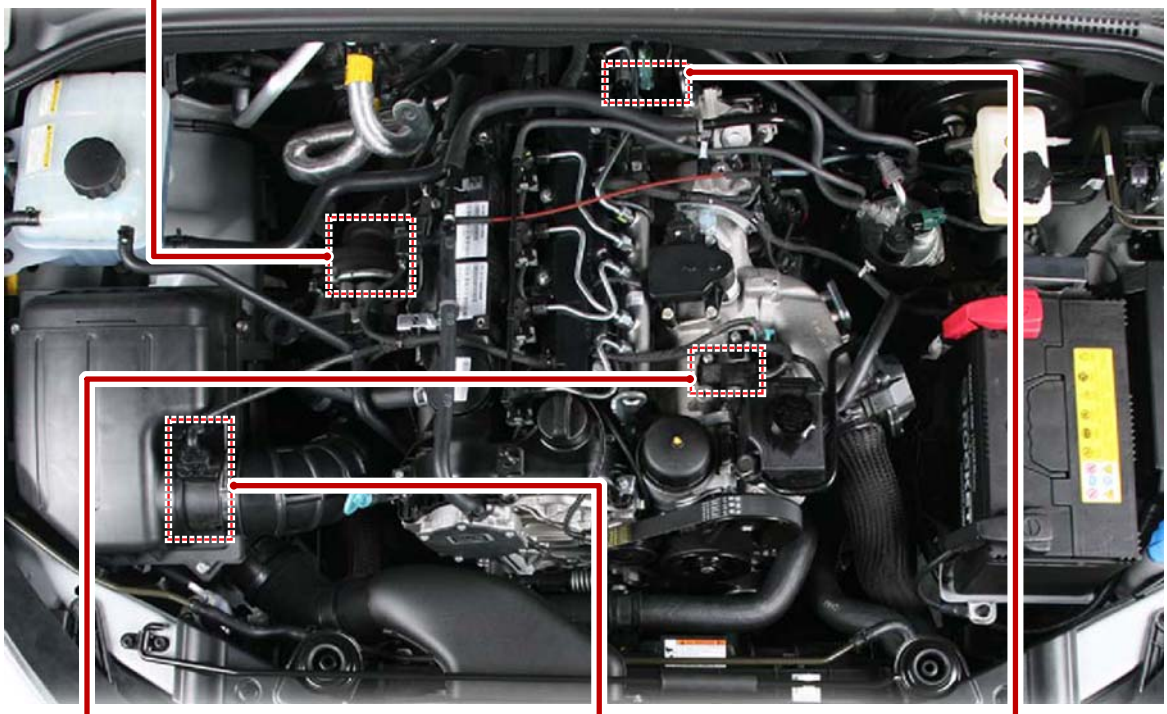
Benefits
- Improved low speed torque and power
- Reduced exhaust gas
- Improved fuel consumption
- Improved acceleration performance

Modification basis	
Application basis	
Affected VIN	

2. COMPONENTS

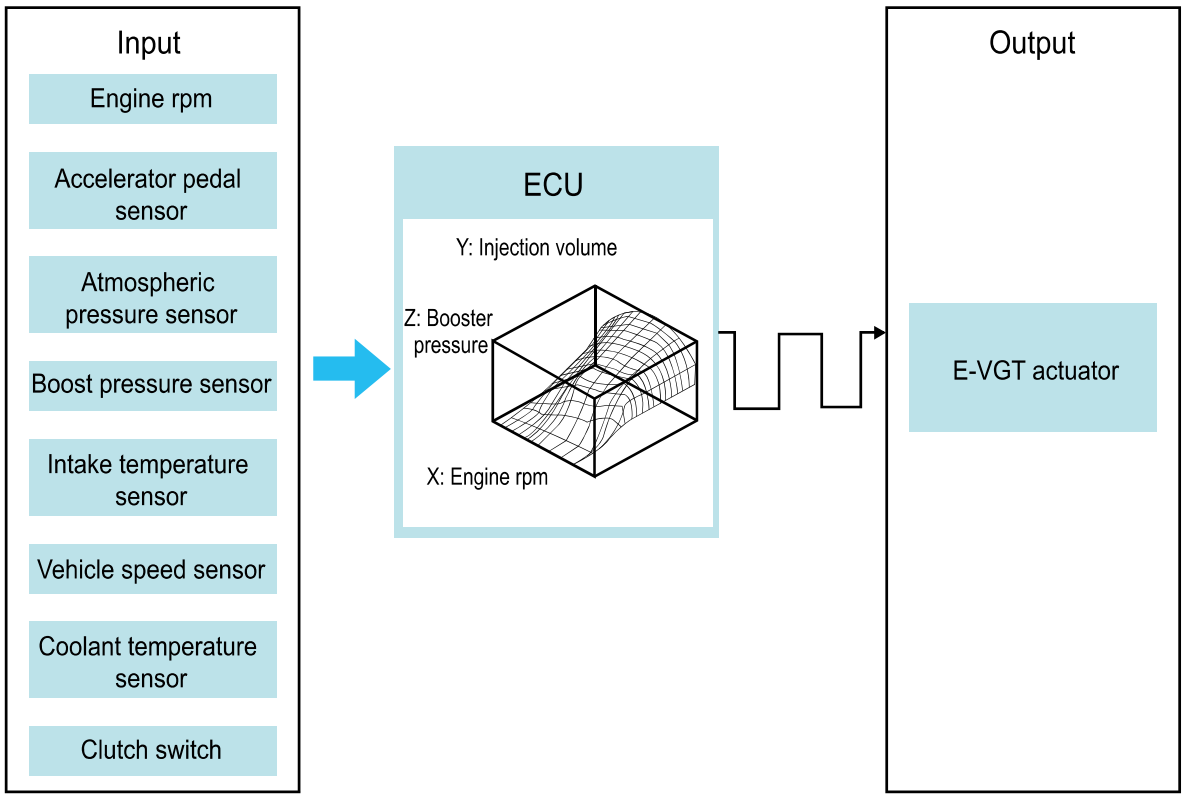
* For details about control logic, refer to Chapter "Engine Control".

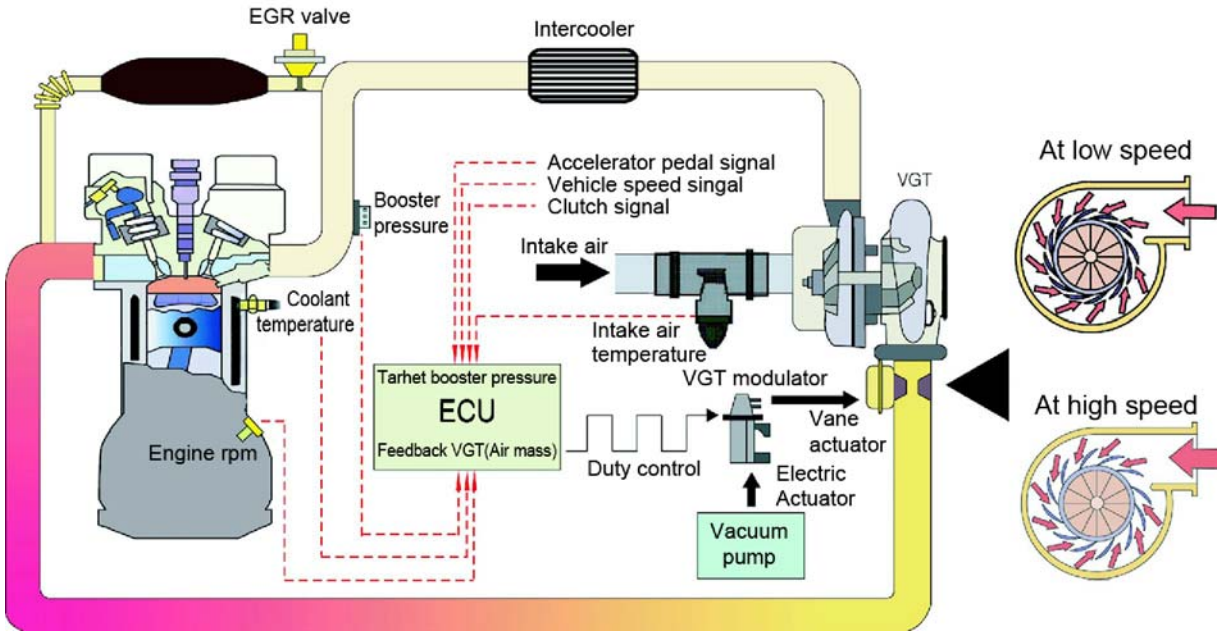
E-VGT turbocharger	Engine ECU (D20DTR)	Accelerator pedal position sensor
	 Atmospheric pressure, RPM signal	
Improves engine power	E-VGT duty control	Transfers driver's will to accelerate to ECU



T-MAP sensor	HFM sensor	Coolant temperature sensor
		
Booster pressure and temperature	Improves the engine power	Operates the VGT according to engine warm-up

3. INPUT/OUTPUT DEVICES





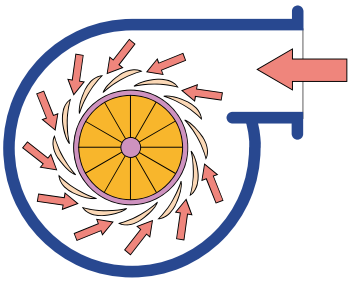
Modification basis	
Application basis	
Affected VIN	

4. OPERATING PRINCIPLES

The E-VGT is designed to get more improved engine power in all ranges by controlling the turbine as follows:

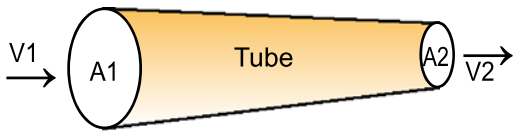
1) How it Works at Low Speed

Normal turbocharger cannot get the turbo effect because the amount of exhaust gas is not enough and the flow speed is slow in a low speed zone, but VGT allows the flow passage of exhaust to narrow, resulting in increasing the flow speed of exhaust gas and running the turbine quickly and powerfully. Therefore, as VGT can intake more air than normal turbocharger, it can give the benefit of the increased output even in a low speed zone.

Control range	Turbocharger driving mechanism	Control method	Effect	Improved performance
At low speed		Narrows the flow passage for the exhaust gas by folding the vanes	The flow rate is increased as the exhaust gas passes the narrow passage → Increased turbine & impeller speed, Increased compressive force	Improved low speed torque

※ **Basic principle at low speed**

At low speed, it utilizes the principle of venturi. For example, when air flows through the venturi tube, the flow speed is faster and the pressure is lower at the point "A". In this case, if the inner diameter of venturi is more narrowed, the flow speed is so much faster (refer to the equation).



V1 x A1 = V2 x A2 = Constant

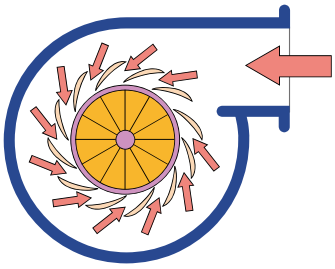
NOTE

Turbocharger lag

The turbocharger is at idle speed when there is no load or it is in the normal driving condition. During this period, the amount of exhaust gas passing through the turbine is not enough to turn the compressor wheel (impeller) fast. Therefore, the intake air is not compressed as needed. Because of this, it takes time for turbocharger to supply the additional power after the accelerator pedal is depressed. This is called "turbocharger lag".

2) How it Works at High Speed

In a high speed zone, the amount of exhaust gas increases and it is accompanied with a great force. Therefore, if the inner diameter of venturi is more widened, the turbine in the turbocharger by the releasing force of abundant exhaust gas can deliver a more increased energy to the compressor. The output will increase in submission to the increase of intake air volume.

Control range	Turbocharger driving mechanism	Control method	Effect	Improved performance
At high speed		Expands the flow passage for the exhaust gas by unfolding the vanes	The flow rate is increased due to the expanded passage→ Increased turbine & impeller speed, Increased compressive force	Improved maximum power

Modification basis	
Application basis	
Affected VIN	

LUBRICATION SYSTEM

1543-00

GENERAL INFORMATION

1. SPECIFICATION

Unit			Specification
Oil pump	Lubrication system		Gear pump, forced circulation
	Type		Inscribed gear
	Capacity		63L@4,000 rpm
	Relief pressure		5.8 bar ± 0.3 bar
Oil filter	Type		Full flow/Paper element
Engine oil	Specified oil		SAE 5W30 (approved by MB SHEET 229.51)
	Capacity (L)		Min.: 4.5 L Max.: 6.0 L
	Service interval	EU	Change every 20,000 km or 12 months (The service interval should be shortened under severe conditions)
		General	Change every 15,000 km or 12 months (The service interval should be shortened under severe conditions)
Oil injection nozzle	Type		Piston
	Operating pressure		1.5bar
	Closing pressure		1.0bar
	Oil flow		4 L/min
Oil pressure switch	Permissible pressure		10bar

CAUTION

The engine oil filter element should be changed at the same time with the engine oil.

- Regularly check the engine oil level and add the engine oil if necessary.
- Remember to check the engine oil level and shorten the cycle to replace the engine oil under severe driving conditions.

Severe Driving Condition

- Frequent stop-and-go traffic, extended idling, short driving distance below 6 km, driving distance below 16 km when the outside temperature remains below freezing
- Driving in a hilly or mountainous terrain, sandy, or dusty area
- High load driving such as trailer towing
- Taxi, patrol service or delivery service (extended idling and excessive driving with low speed)

2. MAINTENANCE

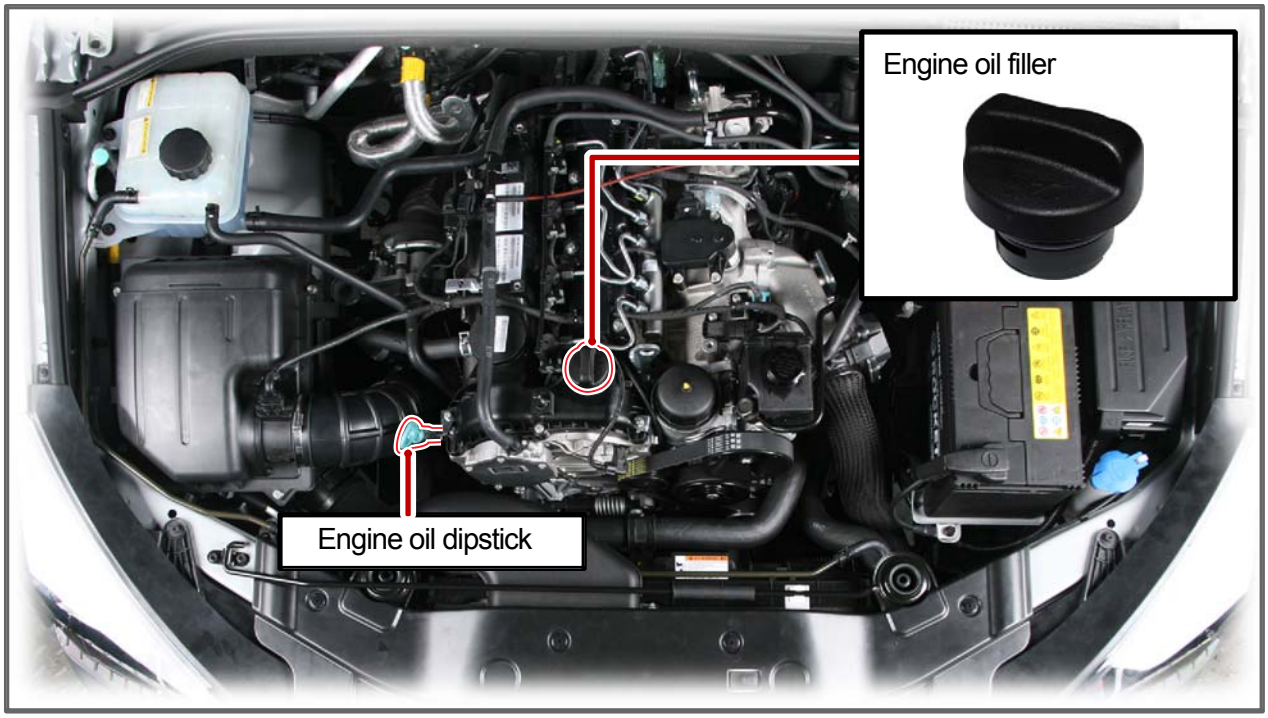
1) Level Check

Park the vehicle on a level ground and apply the parking brake. Stop the engine and wait more than 5 minutes.

- Pull out the dipstick and wipe it with a clean cloth. Reinsert it all the way.
- Pull out it again and check the oil level.
- The oil level should be between the maximum (Max) mark and minimum (Min) mark on the oil dipstick. Oil should be replenished before the level goes below the minimum mark.

WARNING

Operating vehicle with insufficient amount of oil can damage the engine. Make sure the engine oil level is correct and add oil if necessary.



2) Replenishment

If the level gets to the lower point, open the filler cap on top of the cylinder block and add the genuine oil without exceeding the level of the upper mark.
Recheck the oil level after 5 minutes.

CAUTION

- Regularly check the engine oil level and add Ssangyong genuine engine oil if necessary.
- Clean the dipstick with clean cloth so that any foreign materials cannot get into the engine.
- The oil should not go above the upper mark on the dipstick.
- The engine oil may be consumed more if the engine is new.

Modification basis	
Application basis	
Affected VIN	

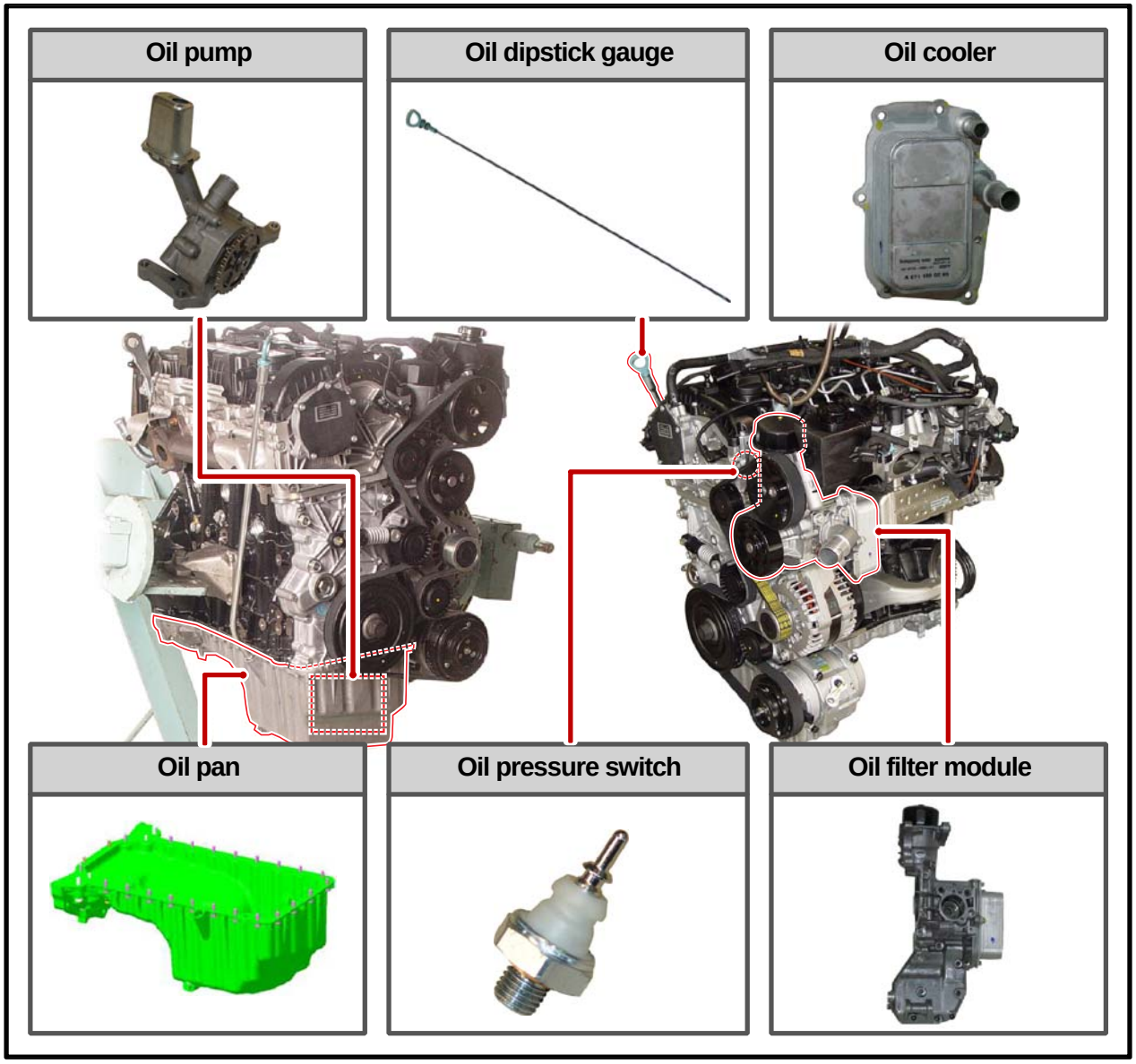
OVERVIEW AND OPERATING PROCESS

1. SYSTEM DESCRIPTION

1) Overview

The lubrication system supplies oil to each lubrication section to prevent friction and wear and to remove heat from the friction part. As the engine runs, frictional heat is generated on each lubrication section. If this condition persists, the bearing can be burned and stuck.
In other words, it creates an oil film on each sliding surface to convert solid friction to liquid friction in order to minimize wear and prevent temperature increasing on the friction part.
For the D20DTF engine with no oil pressure switch, the engine ECU receives the low engine oil level signal from the oil level sensor and communicates with the instrument cluster through the CAN communication to turn on the warning lamp.

2) Components



2. FUNCTIONS OF LUBRICATION

1) Lubrication

It creates a viscous barrier between moving parts that reduces friction, which means less heat and longer life for those parts. As a lubricant, oil must maintain a protective film to prevent metal-to-metal contact. It must be fluid enough to allow easy starting and to circulate quickly through the engine, yet remain thick enough at higher operating temperatures and speeds to provide adequate lubrication.

2) Cooling

Combustion heat and friction energy must be removed from the engine in order to prevent its overheating. Most of heat energy is taken by the engine oil.
Clean oil passages, proper viscosity and low contamination provide sufficient flow rate of the engine oil and effective cooling.

3) Sealing

It helps to seal the space between the pistons and the cylinder walls so that compression is more effective and power is not lost during combustion.

4) Anti-corrosion

As a corrosion inhibitor, oil coats internal engine parts to prevent surface rust on the inside of the engine which can be caused by blow-by products and water formed in combustion. It must also be capable of neutralizing the acids that are formed by combustion blow-by and oil oxidation at high temperatures.

5) Cleaning

The small particles of dirt or other contaminants are suspended in oil and carried away to be filtered out. As a detergent, engine oil must be able to gather and suspend dirt and other contaminants until the oil can leave them as it passes through the filter and returns to the internal engine environment.

Modification basis	
Application basis	
Affected VIN	

COOLING SYSTEM

1520-00

GENERAL INFORMATION

1. SPECIFICATION

Unit	Description	Specification
Cooling system	Type	Water cooling, forced circulation
Coolant	Capacity	approx. 8.5 L
Radiator	Core size	555W x 582.4H x 27T (over 326,250mm2)
	Flow type	Cross flow
	Min. cooling capacity	over 68,000 kcal/h
Antifreeze	Type	SYC1025 (Long life coolant)
	Mixing ratio (water:antifreeze)	50 : 50
Cooling fan module	Type	Electric
	Capacity	Ø472 x 400W x 5B
	Control type	PWM type
Coolant reservoir	Capacity	over 1.5 L
	Circulation	Closed roof type
	Pressure cap	Screw type, 1.4bar
	Vacuum valve	Screw type, 1.4bar
Thermostat	Type	Wax pallet type
	Opening temperature	90˚C
	Fully open temperature	100˚C
	Valve lift	8 mm

2. INSPECTION

Problem	Possible Cause	Action
Coolant level is too low	- Leak from the radiator - Leak from the coolant auxiliary tank - Leak from the heater core	- Change the radiator - Change the coolant auxiliary tank - Change the heater
	- Leak from the coolant hose connections - Damaged coolant hose	- Reconnect the hose or replace the clamp - Change the hose
	- Leak from the water pump gasket - Leak from the water pump internal seal	- Change the gasket - Change the water pump
	- Leak from the water inlet cap - Leak from the thermostat housing	- Change the water inlet cap gasket - Change the thermostat sealing
	- Incorrect tightening torque of the cylinder head bolts - Damaged cylinder head gasket	- Tighten the bolts to the specified torque - Change the cylinder head gasket
Coolant temperature is too high	- Coolant leakage (Coolant level is low) - Improper coolant mixture ratio - Kinked coolant hose	- Add coolant - Check the coolant concentration (Anti-freeze) - Repair or replace the hose
	- Defective thermostat - Defective water pump - Defective radiator - Defective coolant auxiliary tank or tank cap	- Change the thermostat - Change the water pump - Change the radiator - Change the coolant auxiliary tank or tank cap
	- Cracks on the cylinder block or cylinder head - Clogged coolant passages in the cylinder block or cylinder head	- Change cylinder block or cylinder head - Clean the coolant passage
	- Clogged radiator core	- Clean the radiator core
	- Improper operation of cooling fan	- Replace the cooling fan or repair the related circuit
	- Defective temperature sensor or faulty wiring	- Replace the sensor or repair the related wiring
Coolant temperature is too low	- Thermostat is stuck open	- Change the thermostat
	- Improper operation of cooling fan	- Replace the cooling fan or repair the related circuit
	- Defective temperature sensor or faulty wiring	- Replace the sensor or repair the related wiring

Modification basis	
Application basis	
Affected VIN	

1) Coolant Level Check

1. Park the vehicle on level ground and apply the parking brake. Stop the engine and wait until it is cooled down.
2. The coolant level should be between the MAX and MIN mark on the coolant reservoir.
   Check the coolant level. If the level is below the "MIN" mark, immediately add coolant.

CAUTION

- Scalding hot coolant and steam could be blown out under pressure, which could cause serious injury. Never remove the coolant reservoir cap when the engine and radiator are hot.
- Avoid any direct contact of the coolant to the painted body of the vehicle.

2) Leak Test

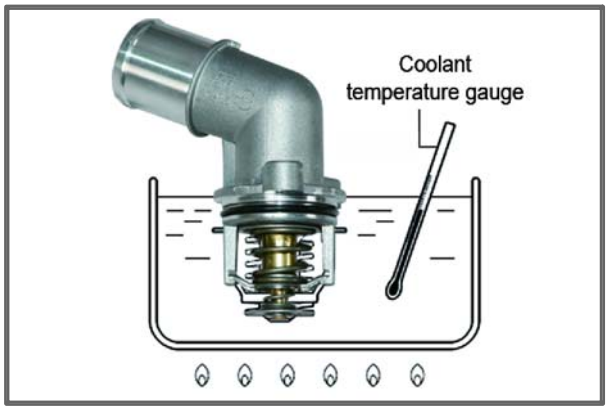
1. Release the pressure in the system by loosening the pressure cap of the coolant reservoir slightly. Then, remove the pressure cap completely.

CAUTION

Never open the cap until the coolant temperature becomes under 90℃ to prevent any burn.

2. Add the coolant so that the coolant level is between MAX and MIN mark on the coolant auxiliary tank.
3. Connect the tester to the tank filler and apply pressure (1.4 bar).
4. Check all the coolant hoses, pipes and connections for leaks when the pressure of the tester drops, and replace or tighten, if necessary.

3) Thermostat



Immerse the thermostat into the water. Heat the water and check the valve opening temperature.

Valve opening temperature	90±2℃

Modification basis	
Application basis	
Affected VIN	

3. CAUTIONS

CAUTION

- If 100% of anti-freeze is added, the water pump vane can be damaged and thermal conductivity can be decreased resulting in poor circulation in the cooling system which leads to overheated engine.
- Use of non-recommended coolant could cause damage to the cooling system and overheating of the engine.
- Opening the coolant reservoir cap while the engine is running or hot can cause burns by hot steam or water.
- To open the coolant reservoir cap, wrap the cap with a wet towel or thick cloth after the engine is cooled down sufficiently.
- If cool water is added to the heated engine, the engine or radiator can be deformed.
- The anti-freeze in the coolant can damage the painted surface, so avoid the contact of the coolant to the painted body.
- The anti-freeze and water should be mixed in proper mixture ratio. Never add only water when adding coolant.
- If the anti-freeze content is too low, the coolant can be frozen while the engine can be overheated if anti-freeze content is too high.

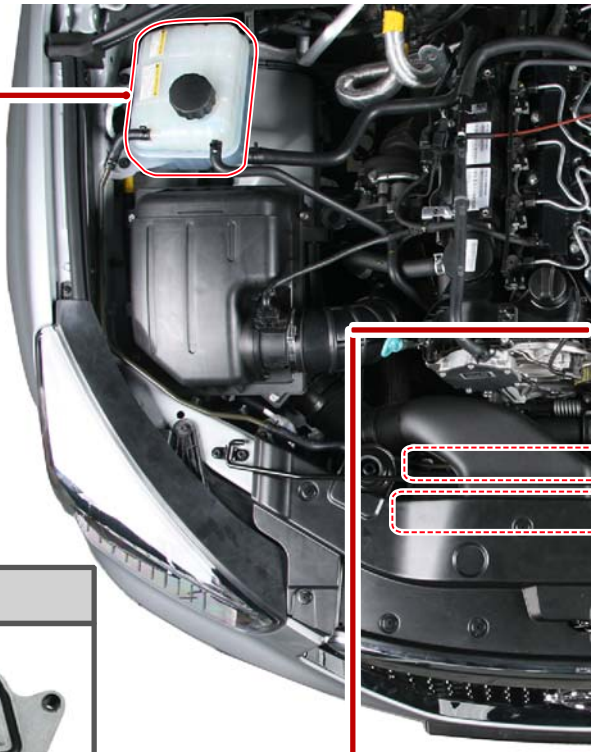
OVERVIEW AND OPERATING PROCESS

1. SYSTEM DESCRIPTION

1) Overview

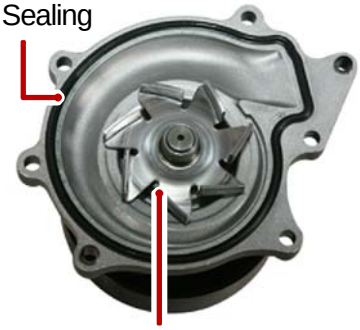
Coolant reservoir

Long life coolant is used.



Water pump

Water pump

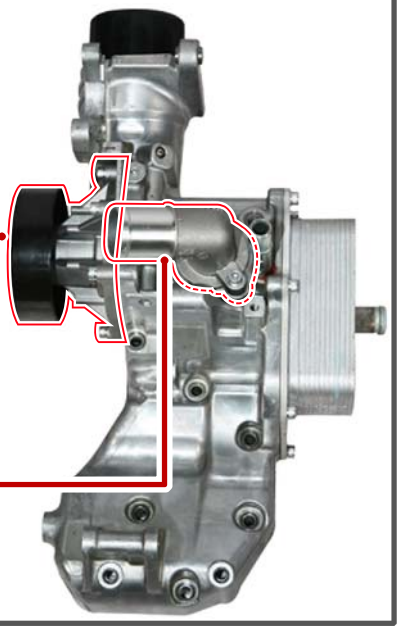


The water pump is driven by the engine drive belt and supplies the coolant to each area of the engine.

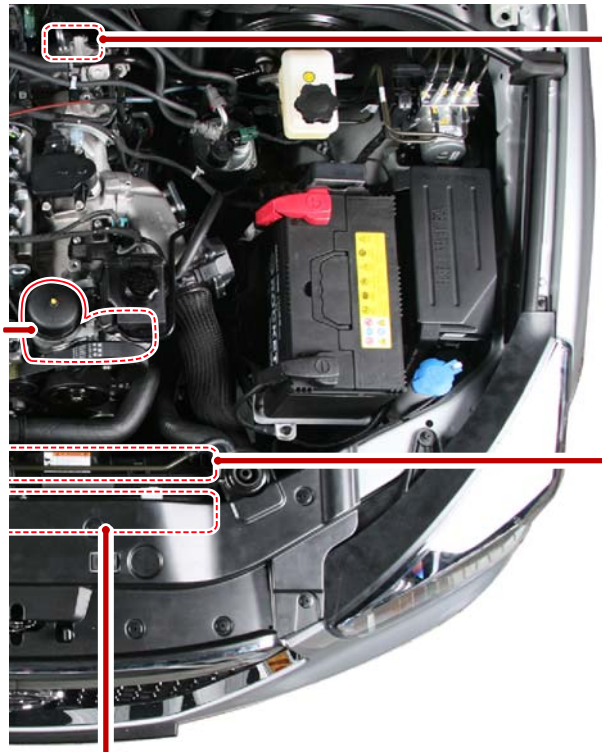
Thermostat

When the engine coolant reaches 90℃, the thermostat starts to open (fully open at 100℃) and lets the coolant flow to the radiator to maintain the engine temperature.

Oil filter module



Modification basis	
Application basis	
Affected VIN	



Coolant temperature sensor

Measures the coolant temperature and sends the result to the engine ECU.

Electric fan

Circulates the fresh air forcibly to exchange heat with the radiator core fin.

Radiator

Releases heat through fins and cools down the hot coolant as the coolant passes through the tube of the radiator core.

Modification basis	
Application basis	
Affected VIN	

CHARGING SYSTEM

1451-01

GENERAL INFORMATION

1. SPECIFICATION

Unit	Description		Specification
Alternator	Crankshaft pulley : Alternator pulley		1 : 2.94
	Normal output (idling/2200 rpm)		70/120 A
	Regulator voltage		14.6 V
	Brush	Length	12.5 mm
		Wear limit	7 mm
Battery	Type		MF
	Capacity		90 AH

2. INSPECTION

1) Alternator Output Test

Item	How to check	DTC set value / Action
Output current	1. Disconnect the cable connected to the B terminal on the alternator. Connect one end of the ammeter to the B terminal and the other end to the cable connected to the B terminal. 2. Measure the maximum output value. (Maintain the engine speed between 2,500 and 3,000 rpm.) (Turn the headlamp and all the electrical switches on.)	- Pass: If the measured current is 45 A or higher. - Fail: If the measured current is less than 45 A. - Check the current of the B terminal.
B terminal current	1. Move the gear selector lever to the neutral position. 2. Maintain the engine speed at 2,500 rpm with the vehicle unloaded. (Turn all the electrical switches off.)	- Open circuit: If the measured current is 5 A or higher.
Rotor coil resistance	1. Disconnect the negative cable from the battery. 2. Remove the B terminal and turn off the ignition switch. 3. Measure the resistance between the L and F terminals with an ohmmeter.	- Pass: If the measured resistance is between 3 and 6 Ω. - Faulty rotor coil or slip ring: If the measured resistance is less than 3 Ω or greater than 6 Ω.
L terminal voltage	1. Connect the B terminal wiring. 2. Measure the voltage with the engine running.	- Specification: 12.5 V to 14.5 V - Faulty IC regulator or field coil: If the measured voltage is 14.5 V or higher.

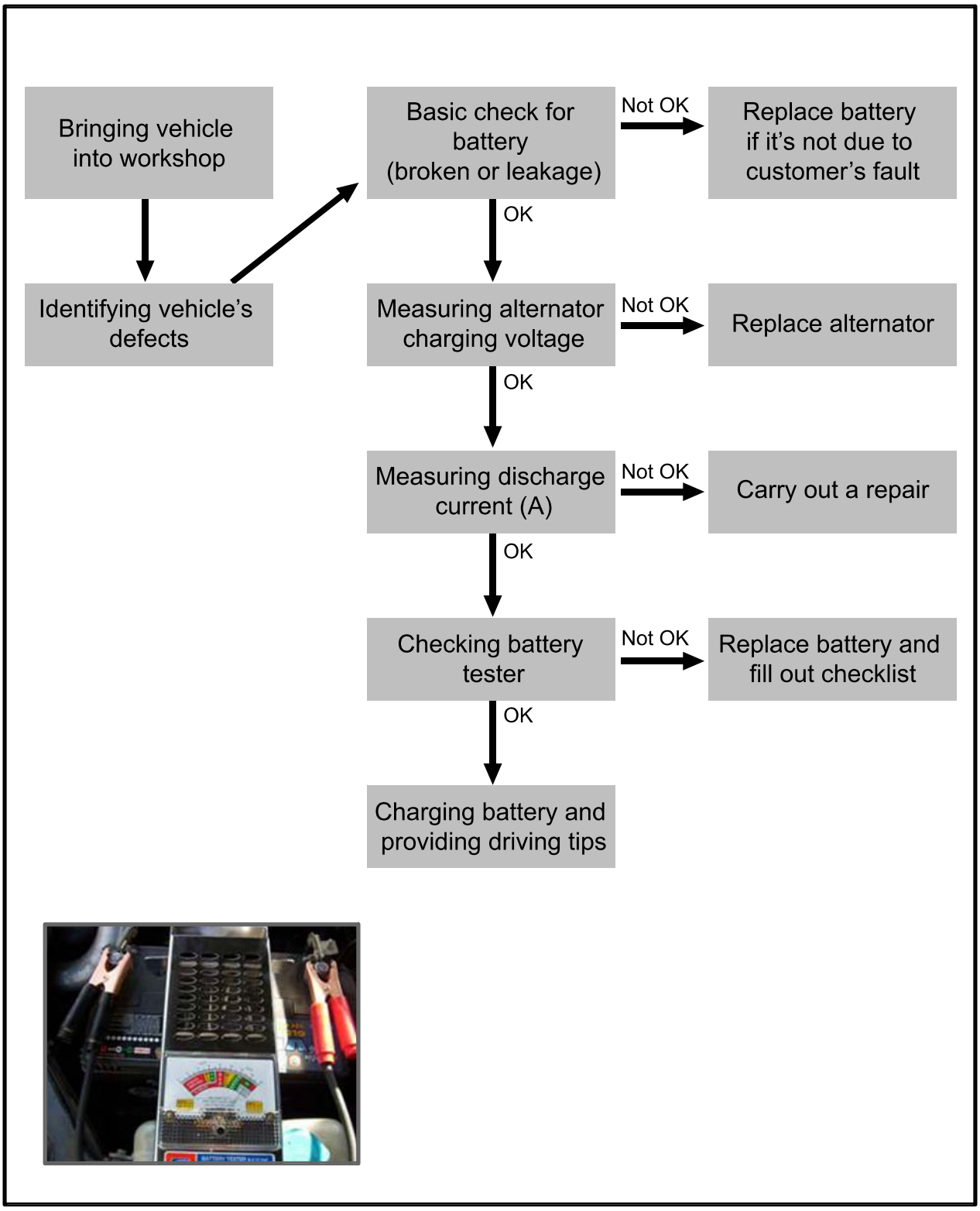
CAUTION
- Disconnect the negative battery cable.
- Connect the negative cable again after connecting the ammeter.

Modification basis	
Application basis	
Affected VIN	

2) Troubleshooting for Alternator

Item	Cause	Action
Overcharged battery	Defective alternator voltage regulator	Replace the alternator
	Defective voltage detection wiring	Repair or replace
	Loose alternator drive belt	Adjust the belt tension or replace
Discharged battery	Poor connection of related circuit or open circuit	Retighten the loose connection or repair open circuit
	Defective alternator voltage regulator	Replace the alternator
	Defective alternator voltage regulator	Replace the alternator
	Terminated battery	Replace the battery
	Defective ground	Repair
Charge warning lamp does not come on when turning on ignition switch with engine stopped	Defective alternator voltage regulator	Replace the alternator
	Open circuit in charge warning lamp, fuse or wiring	Replace or repair the charge warning lamp or fuse
	Defective ignition switch	Replace the ignition switch
	Defective ground of alternator circuit	Repair
Charge warning lamp is not turned off after starting engine	Defective alternator voltage regulator	Replace the alternator
	Corroded or worn battery cable	Repair or replace the battery cable
	Loose alternator drive bel	Replace the batteryAdjust the belt tension or replace the belt
	Defective wiring harness	Repair or replace

3) Checking Battery



Modification basis	
Application basis	
Affected VIN	

(1) Checking

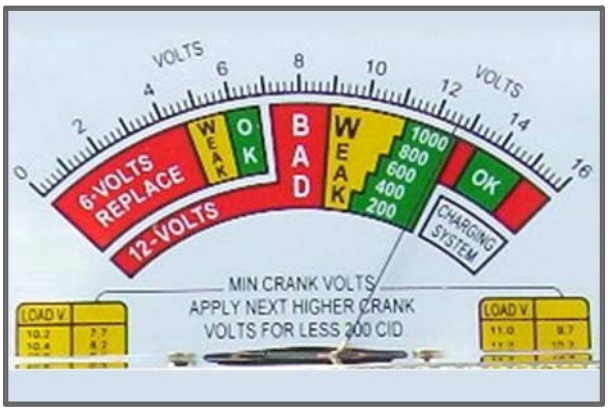
▶ **Using battery tester**

- PASS (11.0 V or more): Explain to the customer that the battery is reusable.
- Need to be charged (9.0 to 11.0 V): Charge the battery with a charger and reinstall it. Explain it to the customer.
- Need to be replaced (9.0 V or more): The battery should be replaced due to overdischarging.

(2) How to use battery tester

▶ **How it works and How to use it**

- Determine battery capacity by fixing current (load capacity) and time and varying voltage. Determine battery capacity based on the
- amount of voltage drop when discharging a fixed load capacity (120 A) for 5 seconds. Connect the tester to the battery and read the display while applying a load for 5 seconds.
-



▶ **How to read display**

- Red area (①): overdischarge or faulty battery
- Yellow area (②): Need to be charged (using a vehicle alternator and a battery charger) Green area (③): Normal
- Red area on the left-hand side of OK (④):
- Impossible to charge with an alternator Green area with OK (⑤): Normally charged
- Red area on the right-hand side of OK (⑥): Overcharged by an alternator태
-

(3) Starting with jumper cable

If the battery is weak or terminated, the battery from another vehicle can be used with jumper cables to start the engine.

▶ Connecting order

1. The positive (+) terminal of the discharged battery
2. The positive (+) terminal of the booster battery
3. The negative (-) terminal of the booster battery
4. Connect one end of the other jumper cable to the body of the discharged vehicle, such as the engine block or a front towing hook.

▶ Starting

1. Prepare a set of jumper cables.
2. Place another vehicle that has the same 12 V of power near to the discharged vehicle.
3. Switch off all electrical accessories for the discharged vehicle.
4. Apply the parking brake and shift the transaxle to the P position (automatic transaxle) or neutral (N) position (manual transaxle).
5. Connect the jumper cables.
6. Try to start the discharged vehicle while accelerating the engine rpm in the booster vehicle.
7. Attempt to start the engine with the discharged battery.
8. After starting the engine, carefully disconnect the jumper cables in the reverse sequence of connection.

Modification basis	
Application basis	
Affected VIN	

(4) Maintenance

If the charge warning lamp ( ) on the instrument cluster comes on while driving, there is a malfunction in the charge system including the battery. Therefore, carrying out the system check is needed.

- Make sure that the battery cables are firmly connected.
- If the terminals are corroded, clean them with a wire brush or sandpapers.
- Always disconnect the battery cables with the ignition key removed. When disconnecting the battery cables with the ignition key turned to ON or ACC position, several electric units can be damaged due to sudden voltage change.
- Check the battery for crack, damage or fluid leaks. Replace it if necessary.
  Wipe out the battery fluid on the battery surface using a rubber glove and a clean cloth wetted with soapy water.

OVERVIEW AND OPERATING PROCESS

1. SYSTEM DESCRIPTION

1) Overview

The charge system is designed to supply electrical energy to the vehicle while driving, and supplies a constant direct current voltage by converting mechanical rotational movement to electrical energy.
The voltage regulator on the back of the alternator controls the generated voltage in all rotating ranges and adjusts the system voltage according to the electric load and ambient temperature change.

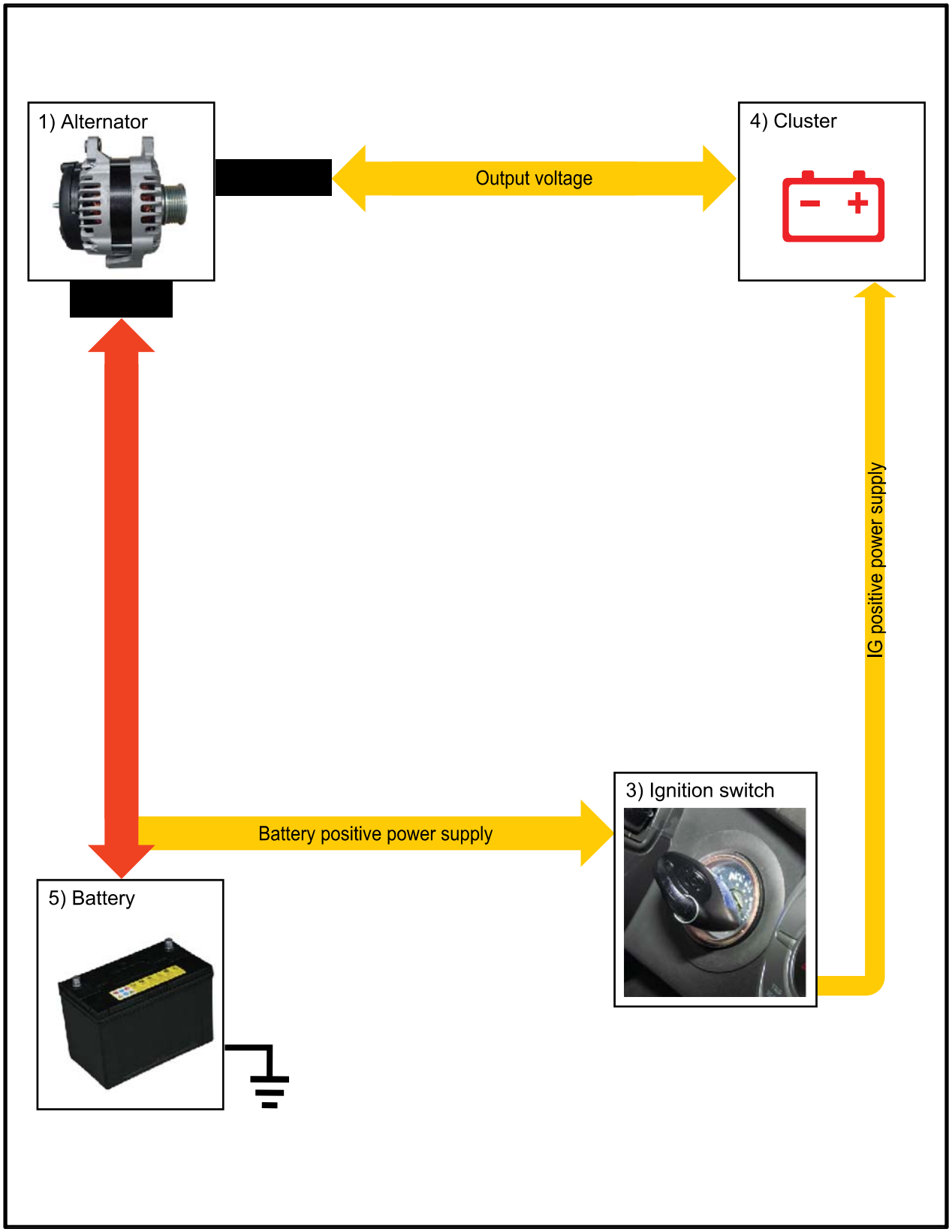
2) System Layout (Locations)

Alternator	Battery
	
The alternator charges the battery and supplies power to each electric unit by converting the mechanical energy to the electrical energy.	It converts the chemical energy to the electrical energy and supplies power to the corresponding electric units when starting the engine.

Modification basis	
Application basis	
Affected VIN	

2. OPERATING PROCESS

1) Charging Flow



2) Charging

The alternator uses a new regulator which has three diodes. It consists of the delta stator, rectifier bridge, slip ring and brush.

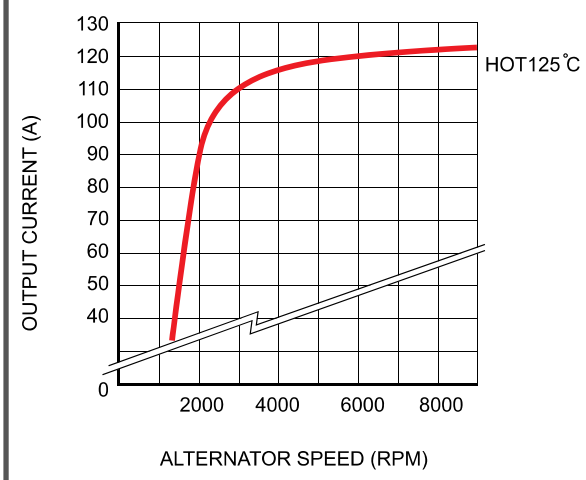
▶ **Charging time according to vehicle conditions and environment**

Specification: Charging a fully depleted high-capacity battery takes twice or more as long as charging a fully depleted battery for small vehicles.
Temperature: The lower the temperature is, the longer the time taken to charge the battery. When connecting the battery charger to the cold battery, the amount of current the battery can accept initially is very small. As the battery gets warmer, it can accept more current.

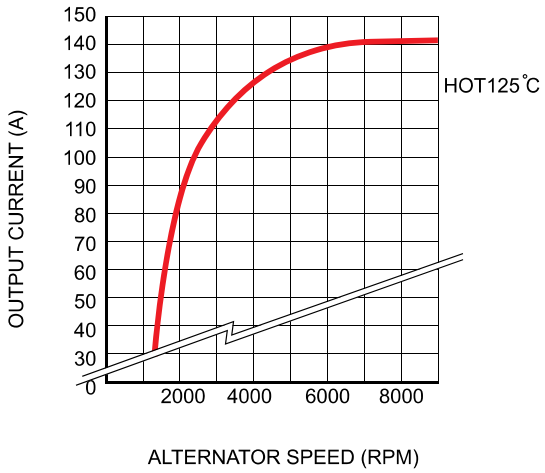
Charging capacity: Charging a battery with a low-capacity charger takes longer time than charging with a high-capacity charger.
Charging status: Charging a fully depleted battery takes twice or more as long as charging a half-depleted battery. Since the electrolyte in a fully depleted battery consists of nearly pure water and conductor, only a very small amount of current can be accepted by the battery initially. The charging current increases as the amount of acids in the electrolyte is increased by the charging current.

3) Output Characteristics

Alternator (120 A)

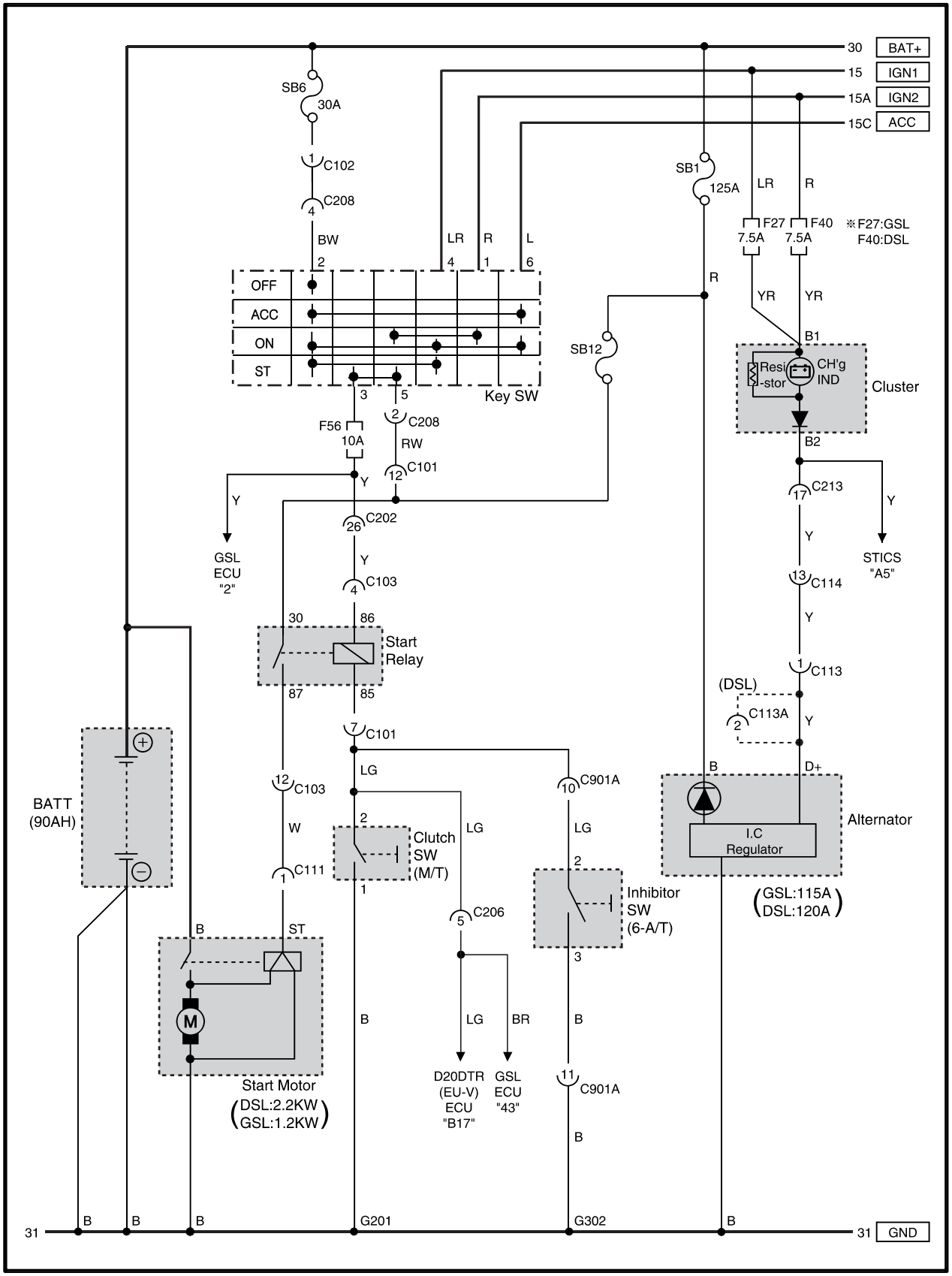


Alternator (140 A)



Modification basis	
Application basis	
Affected VIN	

3. CIRCUIT DIAGRAM



Modification basis	
Application basis	
Affected VIN	

D20DTR PRE-HEATING

1413-00

GENERAL INFORMATION

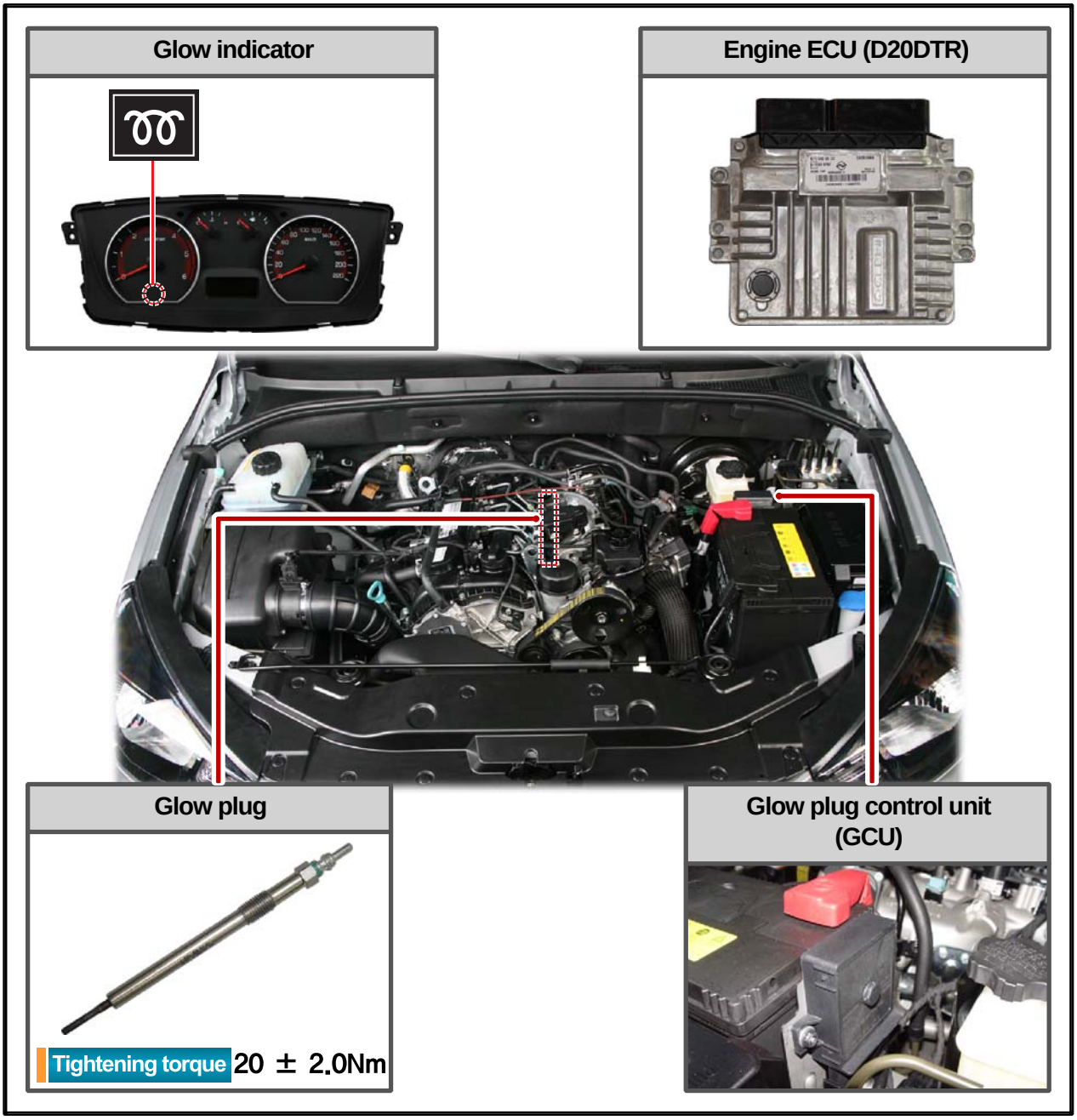
1. SPECIFICATION

Description		Specification
Glow plug	Rated voltage	4.4 V
	Maximum temperature	1100°C
	Operating temperature	1080 ~ 1100°C
Glow plug control unit	EMS operating voltage	6 ~ 16 V
	Operating temperature	−40°C ~ 110°C
	Dark current	Max. 1 mA

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

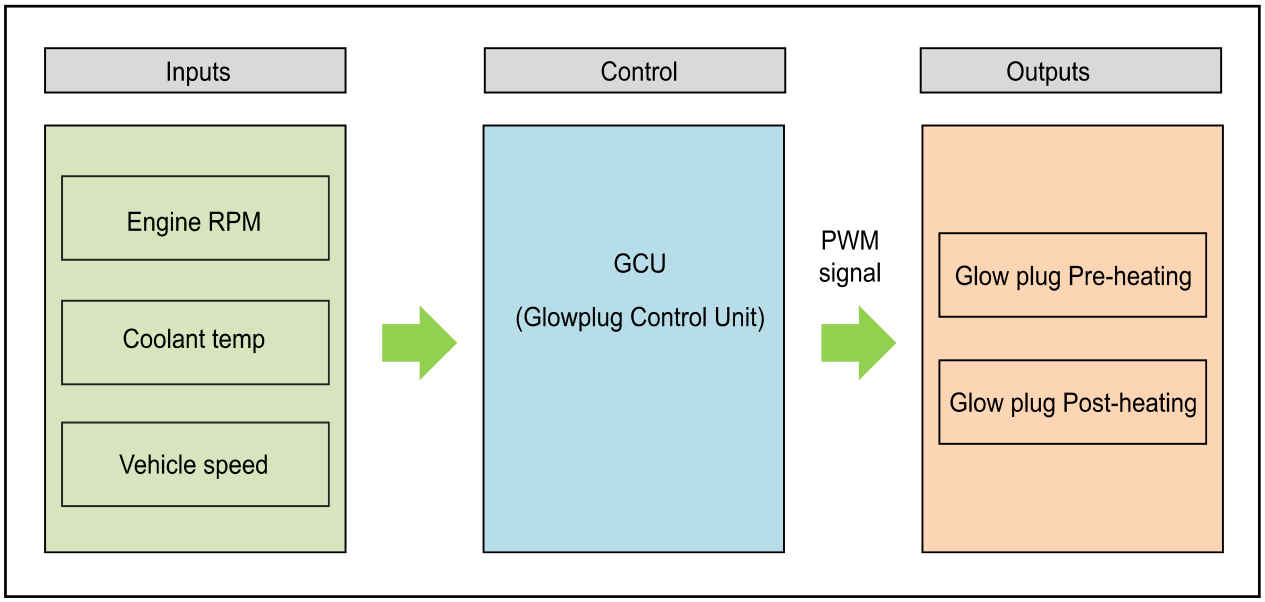
The pre-heating system for D20DTR engine has the glow plug to the cylinder head (combustion chamber), and improves the cold start performance and reduces the emission level.
The pre-heating resistor (air heater) is used to heat the intake air.
This enables the diesel fuel to be ignited in low temperature condition.
The ECU receives the information such as, engine rpm, coolant temperature, engine torque, etc., through CAN communication during pre-heating process; and the pre-heating control unit controls the pre-heating, heating during cranking and post-heating by the PWM control.



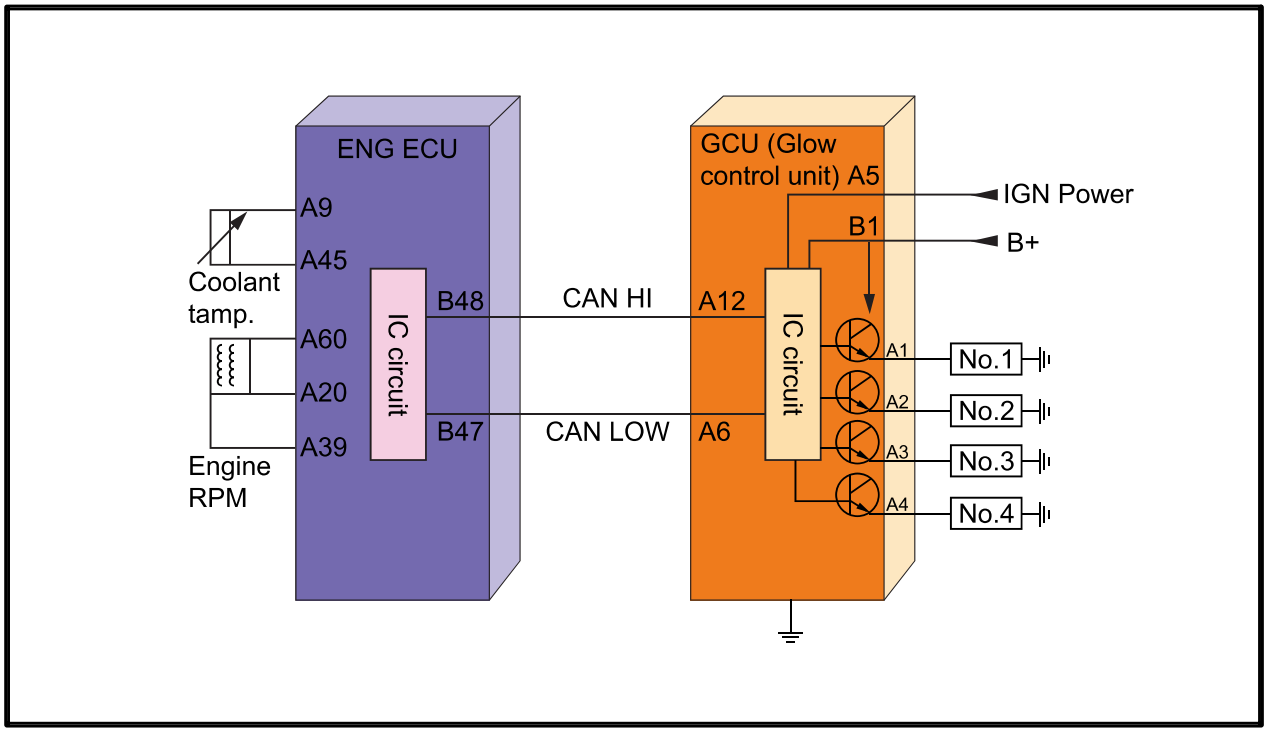
Modification basis	
Application basis	
Affected VIN	

2. SYSTEM OPERATION

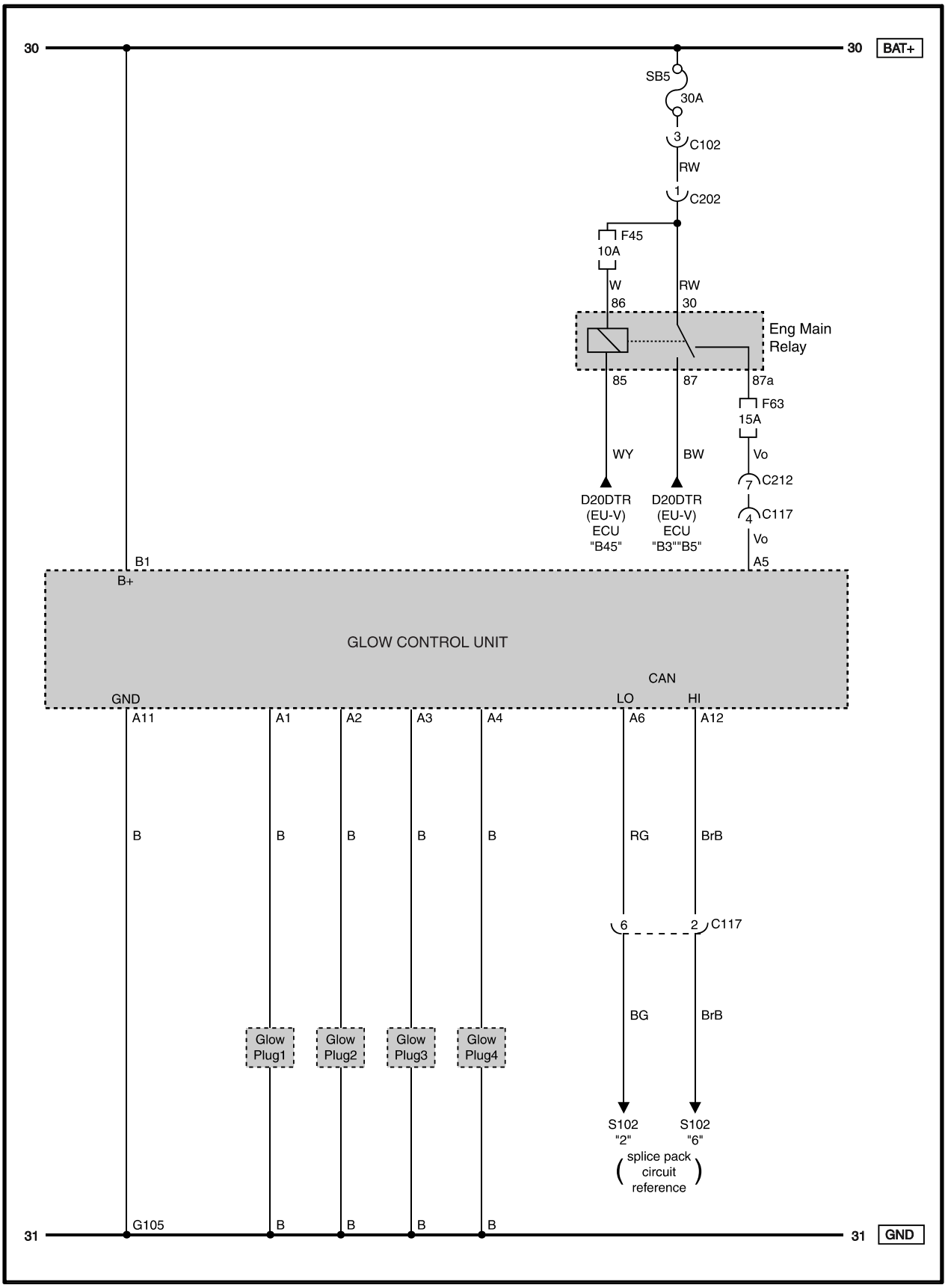
1) Input/Output Diagram of Glow Plug Control Unit



2) System Diagram



3) Circuit Diagram



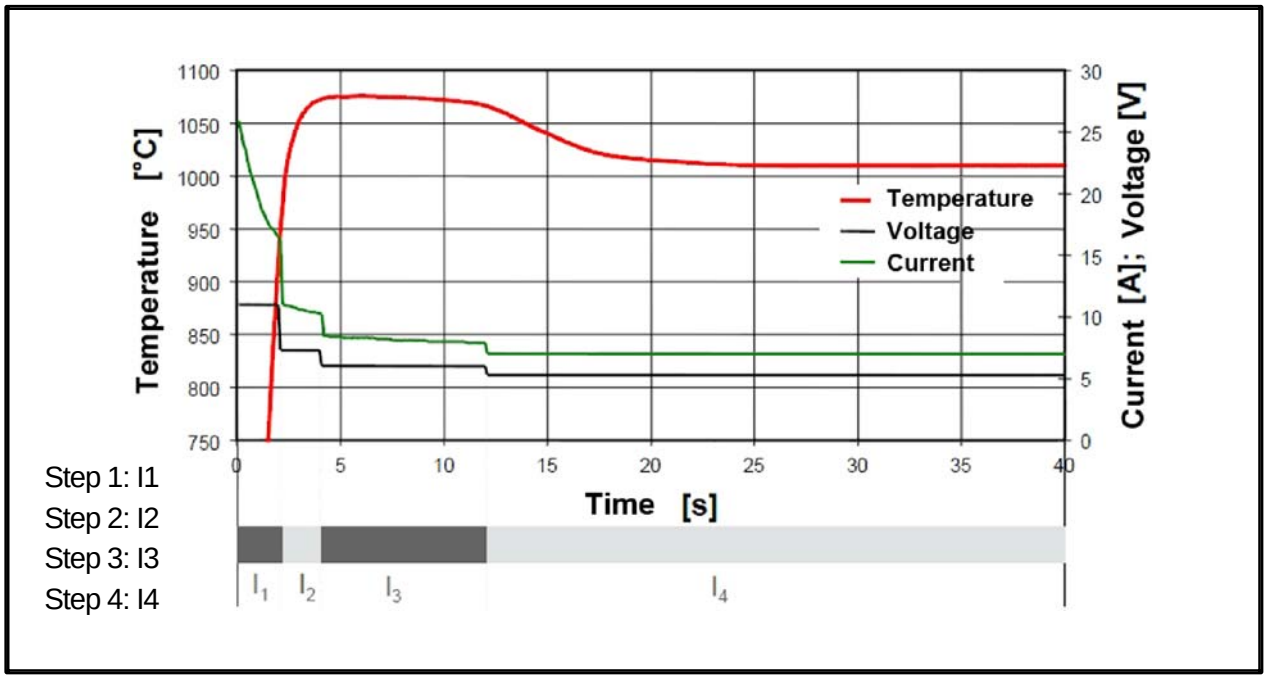
Modification basis	
Application basis	
Affected VIN	

4) Operation

Glow plug is installed in the cylinder head. It enhances the cold starting performance and reduces the exhaust gas during cold starting.
ECU receives the data (engine rpm, coolant temperature, vehicle speed) through CAN lines. Based on the data, GCU controls the pre-glow, cranking and post-glow. It also checks the glow plugs, and sends the result to ECU.

(1) Temperature/Current Properties of GCU

Step 1: GCU increases the temperature of glow plug very rapidly (approx. 2 seconds up to 10C
FETs (similar to transistor) for each cylinder are integrated in GCU. During the pre-glow
Step 2 & 3: period, battery voltage is supplied to the glow plugs directly to heat them rapidly.
After getting the desired temperature by pre-glowing, the temperature is controlled by duty ratio.
Step 4:

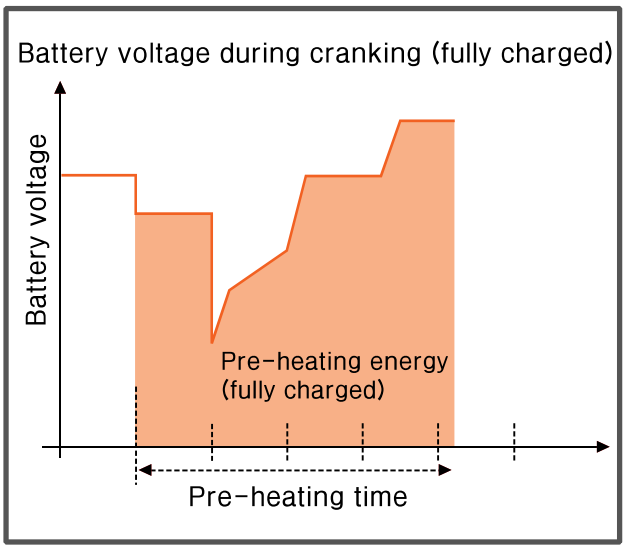


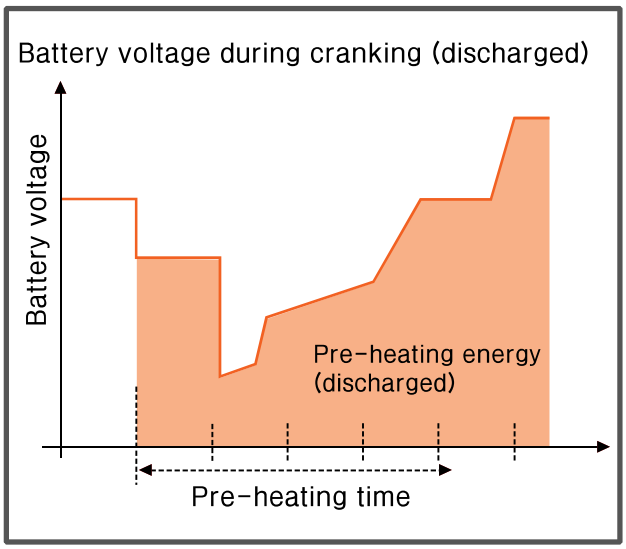
Step 1: I1
Step 2: I2
Step 3: I3
Step 4: I4

- This shows the supplying voltage and time by GCU in each step. The step 4 is the period to keep the temperature.

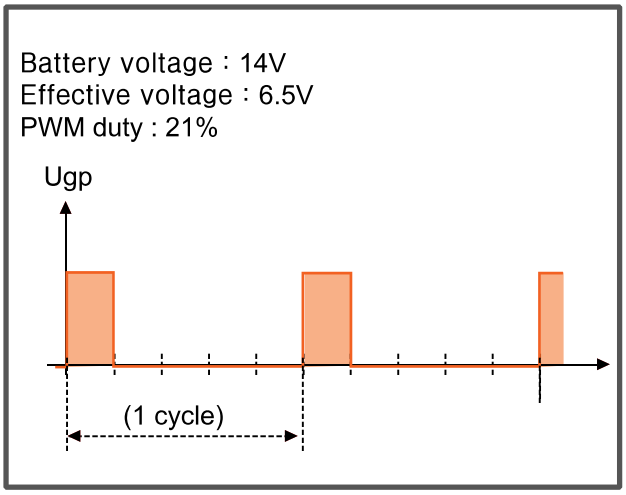
(2) Pre-heating time control based on battery voltage

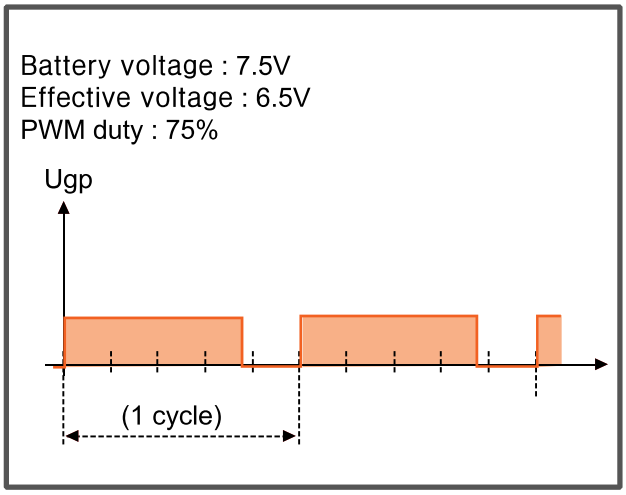
- GCU monitors the battery voltage. If it is low, GCU extends the pre-heating time.
- GCU monitors the energy to glow plugs (the amount of pre-heating energy is always same).





- GCU monitors the battery voltage. If it is low, GCU extends the pre-heating time to get enough energy.



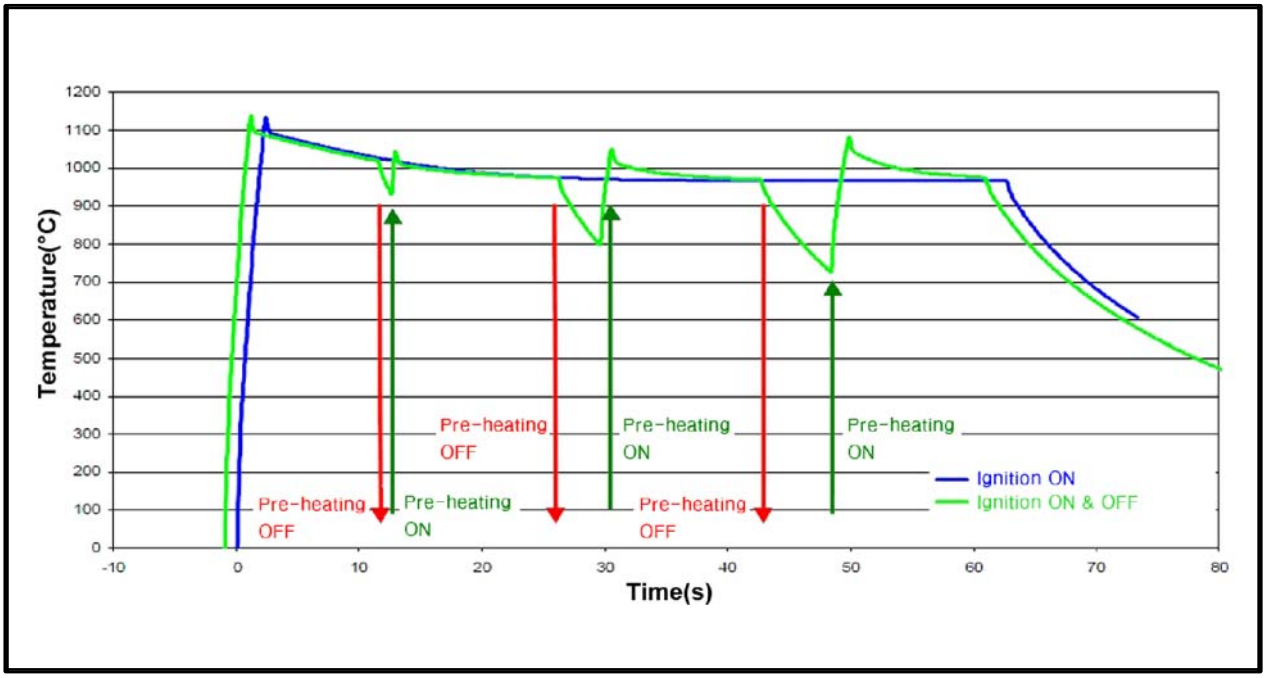


- GCU monitors the battery voltage. If it is low, GCU increases PWM duty..

Modification basis	
Application basis	
Affected VIN	

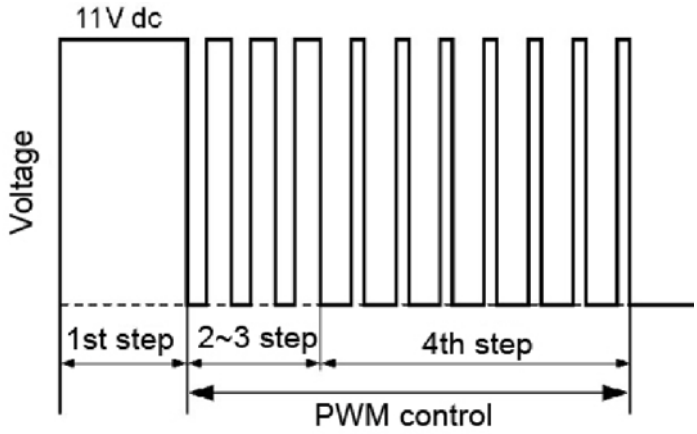
(3) Power control

- GCU estimates the temperature of glow plug for pre-heating. To avoid the power loss and overheat, GCU supplies the lowest power for getting target temperature when turning ON the ignition from OFF.



(4) Operation

GCU PWM control

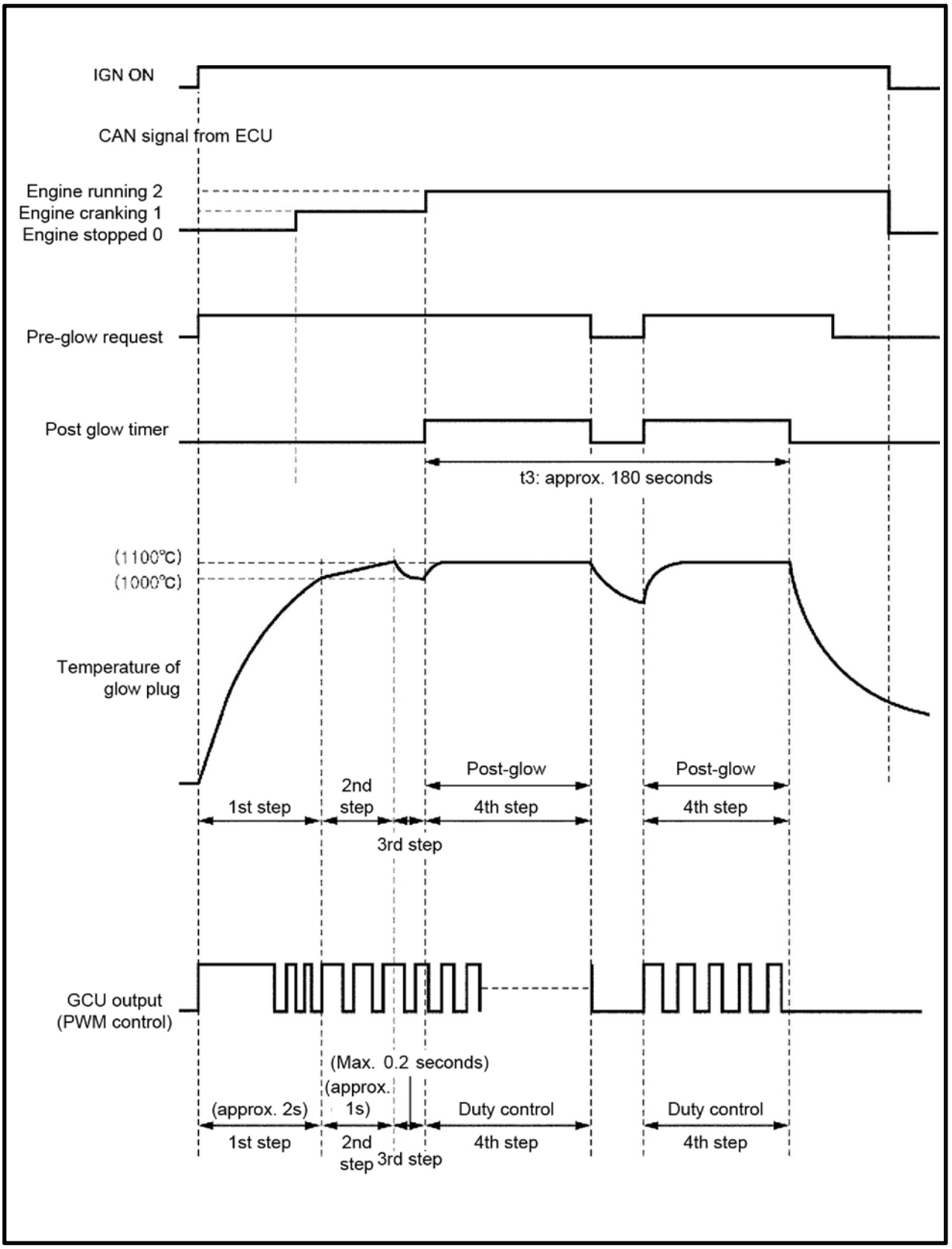


Frequency: 20~33Hz
PWM control duty ratio
- 1st step: 100%
- 2~3 step: 35%
- 4th step: 23%

- This describes the voltage supplying types to glow plugs.

(5) Pre-glow and Post-glow

This shows the pre-glow and post-glow step as a chart.



Modification basis	
Application basis	
Affected VIN	

STARTING SYSTEM

1461-01

GENERAL INFORMATION

1. SPECIFICATION

Description	Specification
Capacity	12 V, 2.2 kW
Engagement	Meshed type
Rotating direction	Clockwise
Pinion gear manufacturing	Cooled forging
Solenoid operating voltage	Max. 8 V
Weight	2.5 kg
Bracket manufacturing	Aluminum die casting

2. TROUBLESHOOTING

Problem	Possible Cause	Action
Engine will not crank	Low battery voltage	Charge or replace
	Loose, corroded or damaged battery cable	Repair or replace
	Faulty starter or open circuit	
	Faulty ignition switch or blown fuse	Repair or replace
	Poor engine ground	Repair
Engine cranks too slow	Low battery voltage	Charge or replace
	Loose, corroded or damaged battery cable	Repair or replace
	Faulty starter	
Starter does not stop	Faulty starter	
	Faulty ignition switch	Replace
Engine cranks normally, but does not start	Broken pinion gear or faulty starter	Replace the starter
	Broken flywheel ring gear	Replace
	Open circuit	Repair

Modification basis	
Application basis	
Affected VIN	

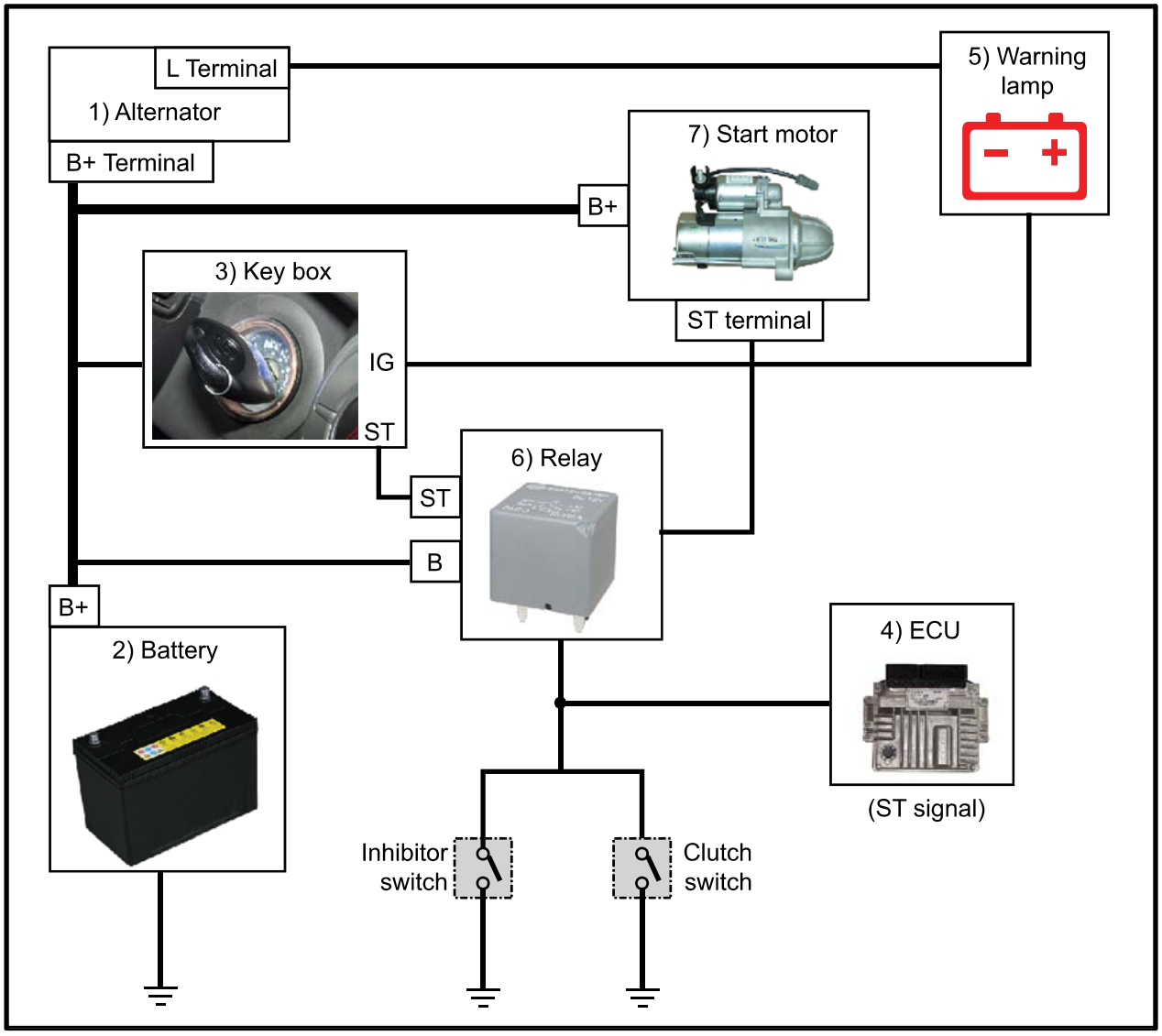
OVERVIEW AND OPERATING PROCESS

1. SYSTEM DESCRIPTION

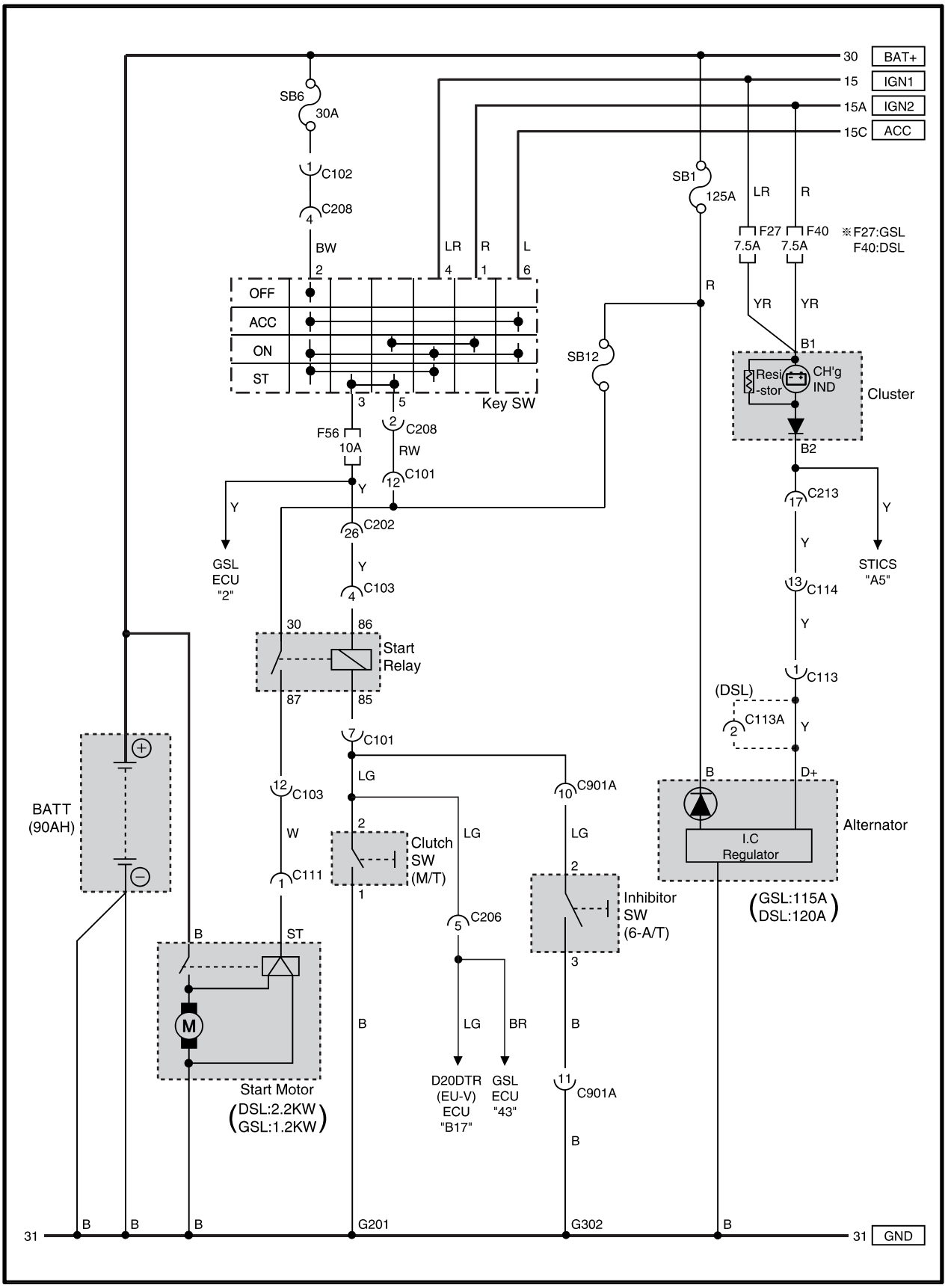
The starter (start motor) starts the engine with rotational power by converting the electric energy to the mechanical energy.
When the engine is cranking, the pinion gear meshes with the ring gear. If the ring gear overruns, the pinion gear clutch overruns to protect the pinion gear.

2. OPERATING PROCESS

1) System Layout



2) Circuit Diagram



Modification basis	
Application basis	
Affected VIN	

CRUISE CONTROL 8510-23

OVERVIEW AND OPERATING PROCESS

1. SYSTEM DESCRIPTION

1) System Description

The cruise control is an automatic speed control system that maintains a desired driving speed without using the accelerator pedal.
The vehicle speed must be greater than 38 km/h to engage the cruise control. This feature is especially useful for motorway driving.

CAUTION
The cruise control system is a supplementary system, which helps the driver to drive the vehicle at a desired speed without using the accelerator pedal under the traffic condition where the vehicle-to-vehicle distance meets the legal requirement.

2) Traffic Conditions for Using Cruise Control

Use the cruise control system only when the traffic is not jammed, driving on motorways or highways where there is no sudden change in the driving condition due to traffic lights, pedestrian, etc.

WARNING

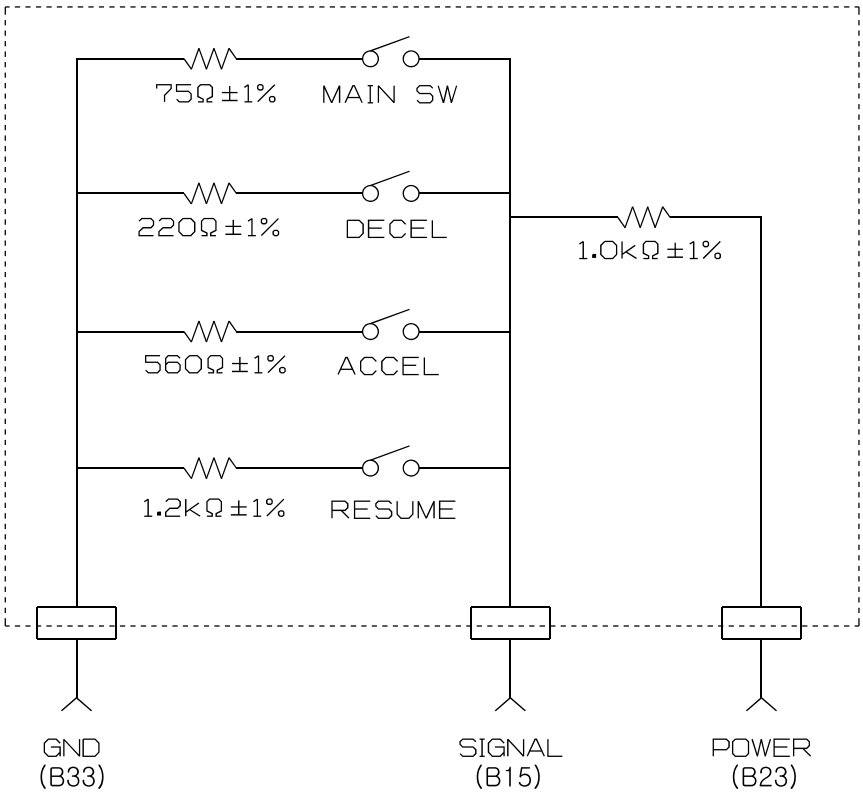
Improper use of the cruise control could be dangerous.
- Do not use on winding roadsyy .
- Do not use in heavy traffic.
- Do not use on slippery, wet roads.

This could result in a loss of control, collision, and/or personal injuries.

Modification basis	
Application basis	
Affected VIN	

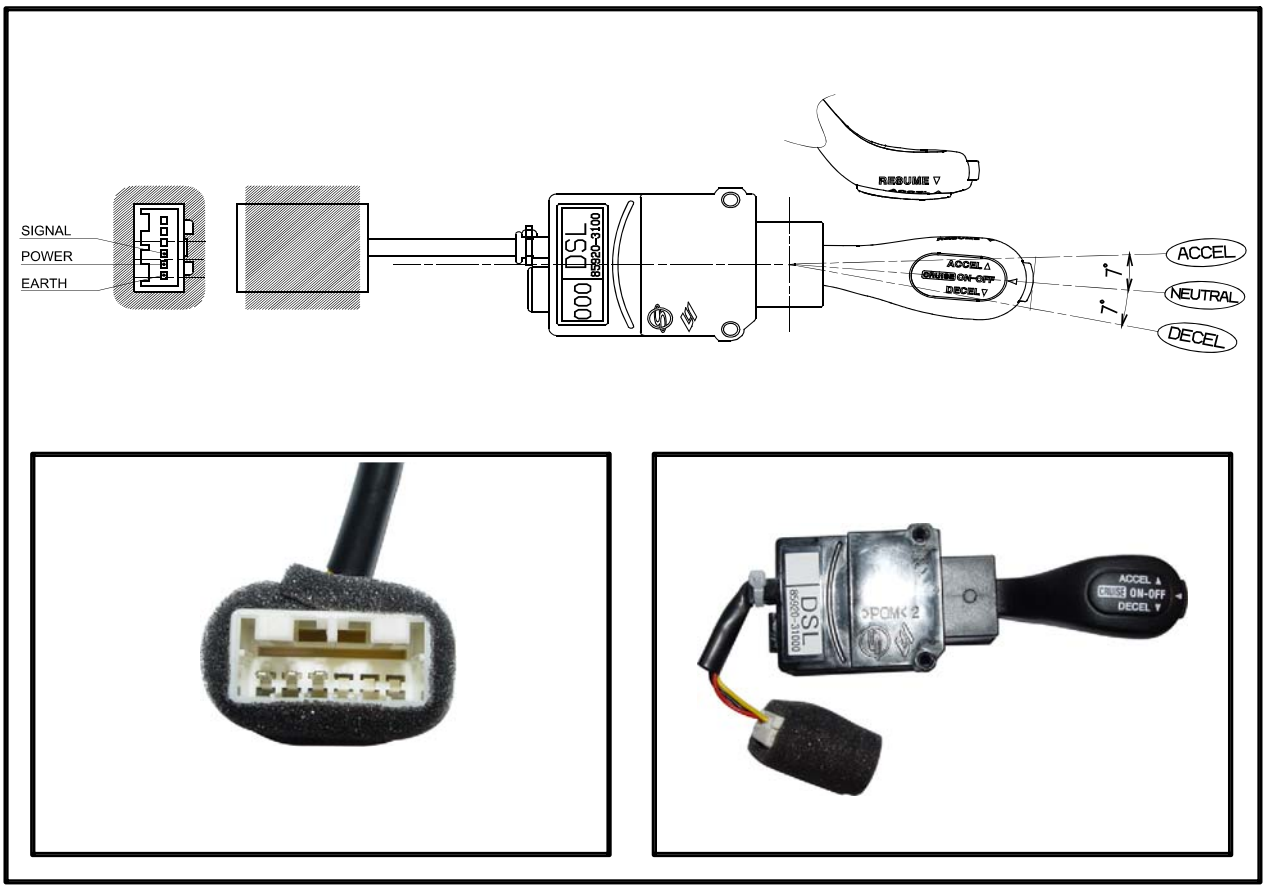
2. CONFIGURATION

1) Circuit Diagram



The engine ECU detects the operating conditions of cruise control system, and monitors the braking performance, vehicle speed, road conditions and ESP system operation. If the engine ECU determines that there are not any problem to drive in cruise control mode, the vehicle can be operated by cruise switch signals (decelerating, accelerating, cruising).

2) Configuration



Modification basis	
Application basis	
Affected VIN	

3. OPERATION

1) Setting a Desired Speed

1. To operate the cruise control, accelerate to the desired speed, which must be more than 36 km/h and less than 150 km/h.
2. When the desired speed is reached, push up the ACCEL switch of the cruise control lever or push down the DECEL switch for 1 second per one switching and then release the accelerator pedal slowly. Now, the vehicle is cruised by this system with the set speed. You don't need to use the accelerator
3. pedal.
   Refer to the following pages for details of operation.
4.

CAUTION

Never use the cruise control system until you get used to it.
Improper use or not fully aware of this function could result in collision and/or personal injuries.

2) Accelerating with the Cruise Control System

(1) While the cruise control system is running

1. Push up the ACCEL switch of the cruise control lever and hold it until the desired speed is reached without an accelerator pedal intervention.
2. When the desired speed is reached, release the lever.

(2) When the cruise control system is not running

To increase the speed with the cruise control system while the system is not running, follow the procedures below.

1. Accelerate using the accelerator pedal over 36 km/h.
2. Push up the ACCEL switch of the cruise control lever and hold it. And then release the accelerator pedal slowly.
3. When the desired speed is reached, release the lever.

(3) Tap-up while the cruise control system is running

To increase the vehicle speed in stages while the cruise control system is running, follow the procedures below.

1. Push up the ACCEL switch of the cruise control lever less than 0.5 second per one switching while the cruise control system is running. This is a tap-up switching. When you operate a tap-up switching, the vehicle is accelerated for 1.3 km/h over the previous set speed.
2. If you want to accelerate for 13 km/h, operate the tap-up switching ten times without accelerating with the cruise control system.

Modification basis	
Application basis	
Affected VIN	

3) Decelerating with the Cruise Control System

(1) While the cruise control system is running

1. Push down the DECEL switch of the cruise control lever and hold it until the desired speed is reached without a brake pedal intervention. But the cruise control system cannot maintain the cruise function at less than 34 km/h.
2. When the desired speed is reached, release the lever.

(2) When the cruise control system is not running

To decrease the vehicle speed with the cruise control system when the system is not running, follow the procedures below.

1. Push down the cruise control switch lever to DECEL side and hold it until the desired speed is reached while the vehicle speed is over 36 km/h.
2. And then release the accelerator pedal slowly.
3. When the desired speed is reached, release the lever. But the cruise control system cannot maintain the cruise function at less than 34 km/h.

(3) Tap-down while the cruise control system is running

To decrease the vehicle speed in stages while the cruise control system is running, follow the procedures below.

1. Push down the DECEL switch of the cruise control lever less than 0.5 second per one switching while the cruise control system is running. This is a tap-down switching. When you operate a tap-down switching, the vehicle is decelerated for 1.0 km/h below the previous set speed.
   If you want to decelerate for 10 km/h, operate the tap-down switching ten times without the brake pedal
2. intervention.

4) Recovery of Set Speed (RESUME)

Even if the cruise control is cancelled, the previous set cruise speed can be recovered by pulling up the cruise control lever when the current vehicle speed is over 36 km/h without an acceleration intervention. But if you turn off the ignition switch, the memorized set speed is cleared and you cannot recover the previous set speed.

CAUTION

But the driver should know the previous set speed to react to the changed vehicle speed properly. If the vehicle speed increases abruptly, depress the brake pedal to adjust the vehicle speed properly.

Modification basis	
Application basis	
Affected VIN	

5) Normal Cancellation of the Cruise Control

The cruise control system will be canceled when one or more items of the following conditions are applied;

1. When the brake pedal is depressed or When ESP is activated.
2. When the cruising speed is downed less than 34 km/h
3. When applying the parking brake during driving.
4. When using the clutch in order to shift (M/T only).

CAUTION

Keep the main cruise control switch in the neutral position when not using the cruise control.

(1) Abnormal Cancellation of the Cruise Control

1. When the rapid deceleration is applied without braking.
   When the rapid acceleration is applied without acceleration pedal intervention.
2. When the cruise control lever is faulty.
3. When the brake switch and the brake light switch input signal are implausible.

When the cruise control function is cancelled abnormally or intermittent problems occur, stop the vehicle and turn off the ignition switch and remove the key to reset the system. After a while, turn on the ignition switch again to operate the cruise control system.

CAUTION

1. Do not move the shift lever to Neutral position while driving with the cruise control turned on. Otherwise, it may result in system malfunction or accidents.
2. Always be prepared to use the brake or accelerator pedal for safe driving while the cruise control system is running.
3. The actual speed can be different from the set speed momentarily when driving on a uphill or downhill. So, it is recommended to disable the cruise control function on a uphill or downhill. hen driving on a steep hill use the engine brake and foot brake properly to protect the vehicle system and for a safe driving.
4. Ensure that the safe distance is maintained and use the brake pedal if needed.

Modification basis	
Application basis	
Affected VIN	

E-EGR SYSTEM

1793-00

GENERAL INFORMATION

1. SPECIFICATION

Item			Specification
E-EGR valve	Motor	EGR response time	50 ms
		Driven by	DC motor
	Valve	EGR gas flow rate	120 kg/h
E-EGR cooler		Cooling capacity	8.3 kW or more
		Cooling fin type	Wavy fin
		Cooler type	U-shaped
E-EGR bypass valve	Solenoid valve	Drivien by	Vacuum (Solenoid valve)

OVERVIEW AND OPERATING PROCESS

1. SYSTEM DESCRIPTION

1) Overview

The EGR (Electric-Exhaust Gas Recirculation) valve reduces the NOx emission level by recirculating some of the exhaust gas to the intake system.
To meet Euro-V regulation, the capacity and response rate of E-EGR valve in D20DTR engine have been greatly improved. The EGR cooler with high capacity reduces the Nox, and the bypass valve reduces the CO and HC due to EGR gas before warming up.
Also, the engine ECU adjusts the E-EGR opening by using the air mass signal through HFM sensor. If the exhaust gas gets into the intake manifold when the EGR valve is open, the amount of fresh air through HFM sensor should be decresed.

▶ **Benefits of E-EGR valve**

- Improved accuracy and response through electric control
- Feedback function (Potentiometer)
- Preventing chattering of EGR valve and improved durability
- Self-cleaning function

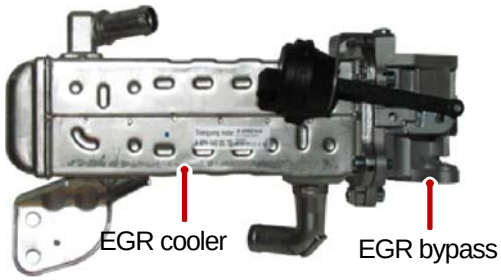
Modification basis	
Application basis	
Affected VIN	

2) Location and Components

HFM sensor

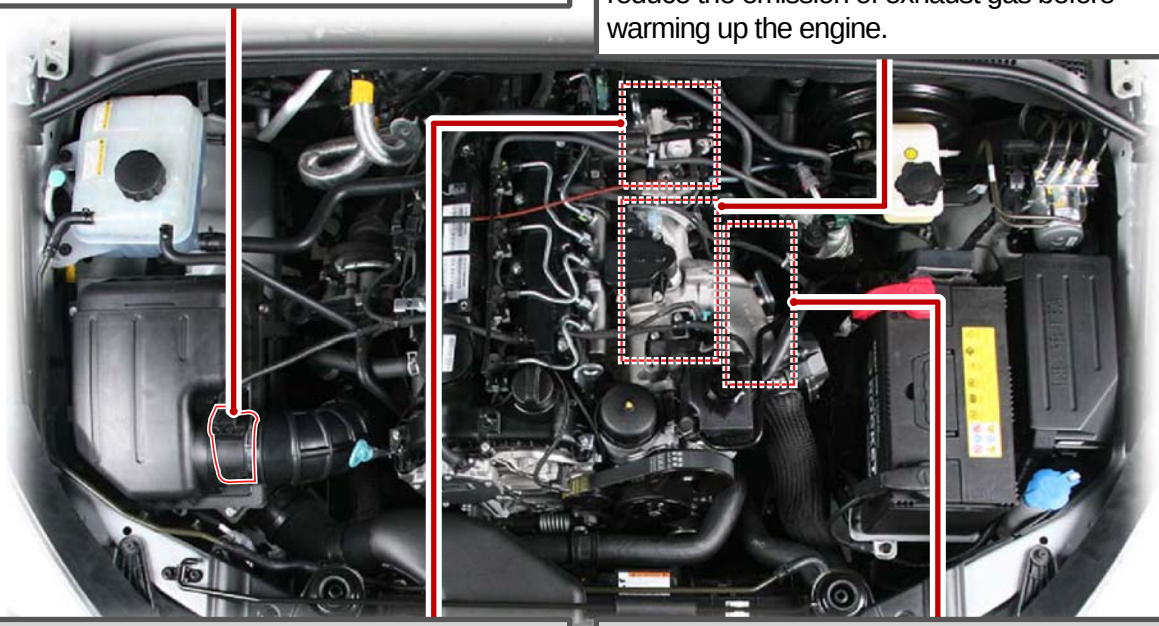
Used as a main map value to control the EGR. The coolant temperature, engine rpm, engine load, intake air temperature (HFM: decreased at 60˚C or more), atmospheric pressure (atmospheric pressure sensor: altitude compensation) are used as auxiliary map values.

E-EGR cooler and bypass valve



See the section "Engine control" for E-EGR valve control logic.

The cooler lowers the high temperature of the exhaust gas and the bypass valve directly supplies the exhaust gas to the intake duct without passing through the EGR cooler to reduce the emission of exhaust gas before warming up the engine.



E-EGR valve

Receives the electric signal from the ECU to control the valve.

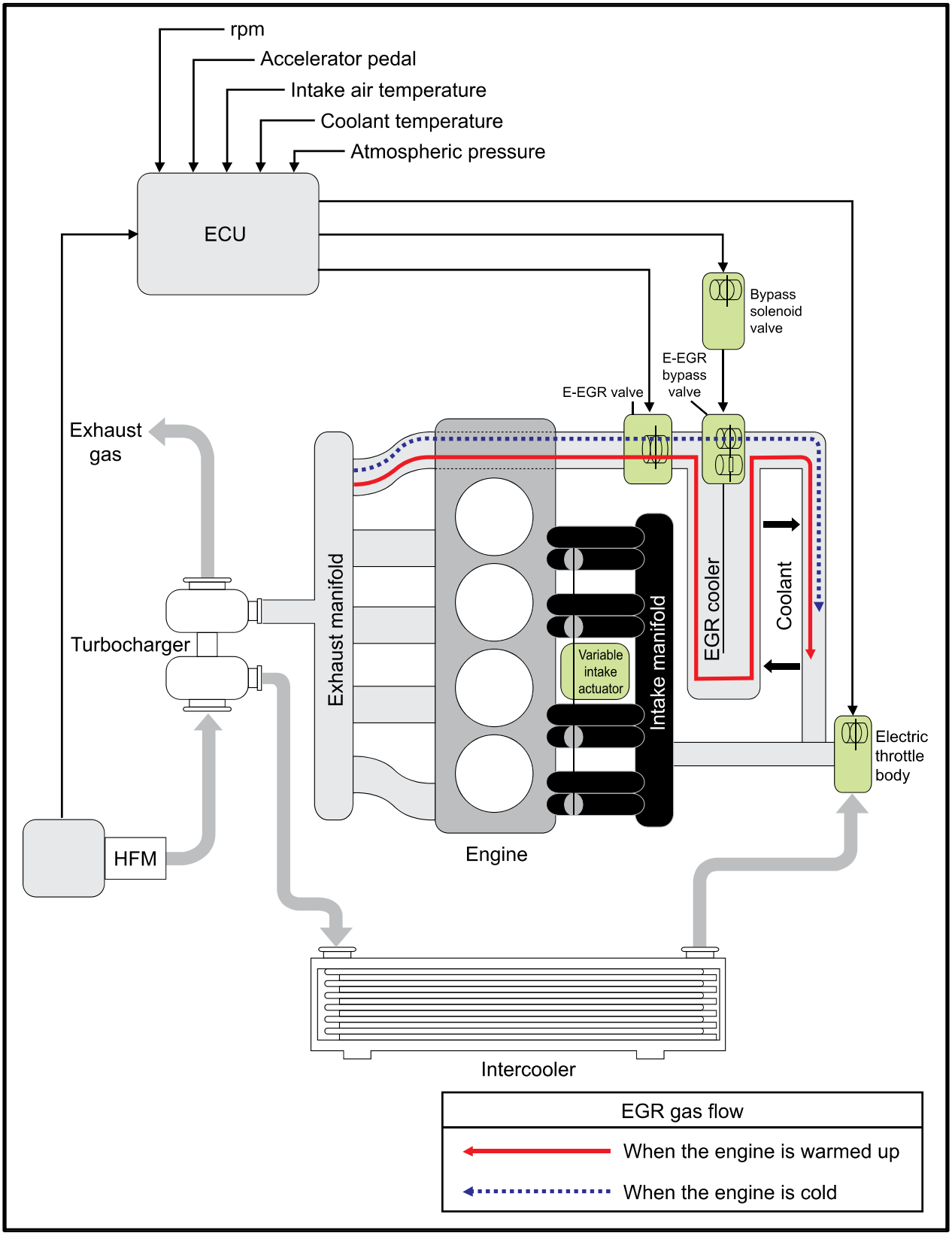
EGR pipe

Transports the exhaust gas from the EGR cooler and EGR bypass valve to the intake duct.

* For details, see the section "Engine control".

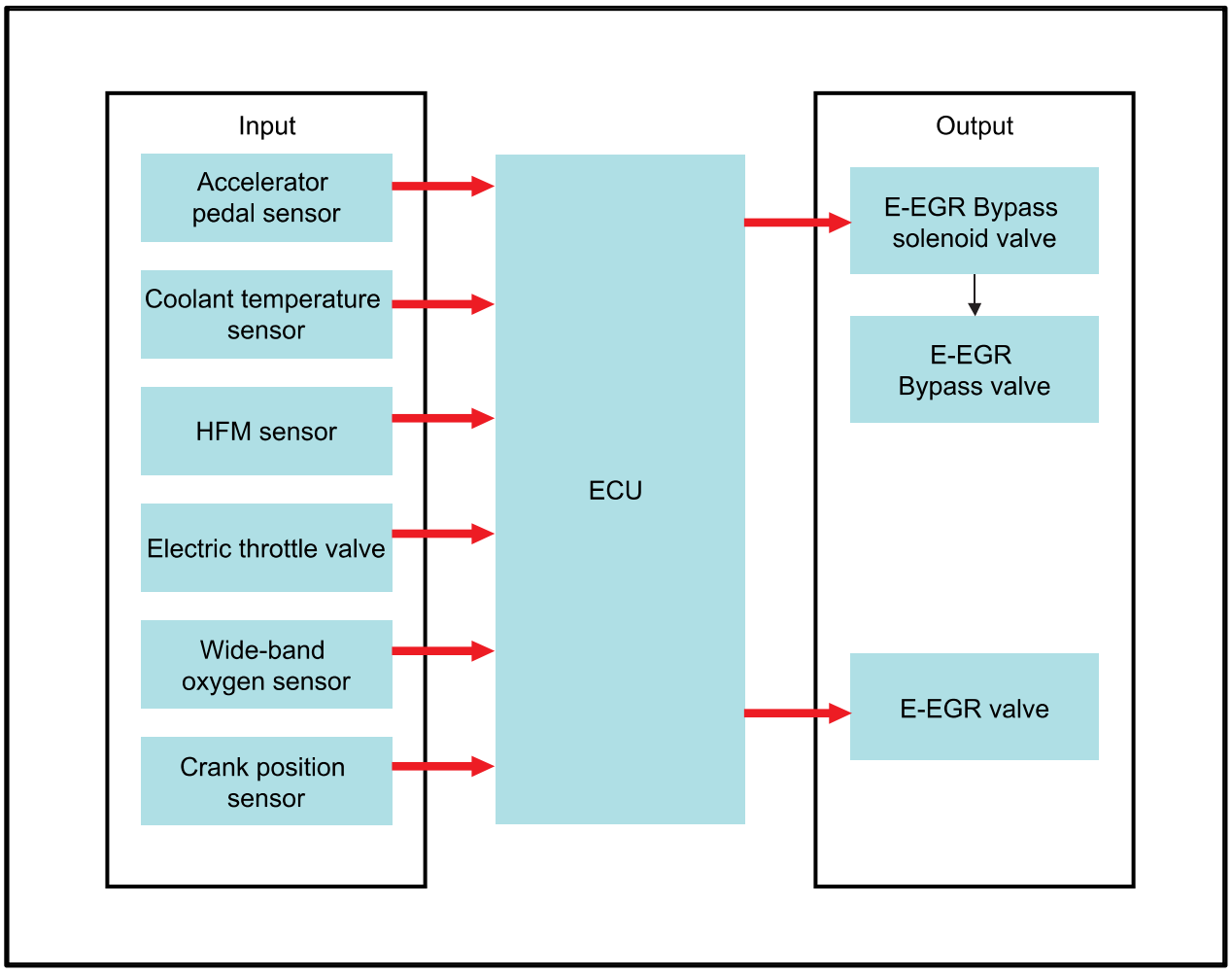
2. OPERATING PROCESS

1) Schematic Diagram



Modification basis	
Application basis	
Affected VIN	

2) Input/Output Devices



3) Control Logic

The EGR system controls the EGR amount based on the map values shown below:

※ Main map value: Intake air volume

※ Auxiliary map value:

- Compensation by the coolant temperature
- Compensation by the atmospheric pressure: Altitude compensation
- Compensation by the boost pressure deviation (the difference between the requested value and the measured value of boost pressure)
- Compensation by the engine load: During sudden acceleration
- Compensation by the intake air temperature

The engine ECU calculates the EGR amount by adding main map value (intake air volume) and auxiliary map value and directly drives the solenoid valve in the E-EGR to regulate the opening extent of the EGR valve and sends the feedback to the potentiometer.

(1) Operating conditions

- Intake air temperature: between −10 and 50℃
- Atmospheric pressure: 0.92 bar or more
- Engine coolant temperature: between 0 and 100°C
- When there is no fault code related to EGR

(2) Shut off conditions

- Abrupt acceleration: with engine speed of 2600 rpm or more
- When the engine is idling for more than 1 minute
- Vehicle speed: 100 km/h or more
- Engine torque: 380 Nm or more

Modification basis	
Application basis	
Affected VIN	

CDPF SYSTEM

2412-02

GENERAL INFORMATION

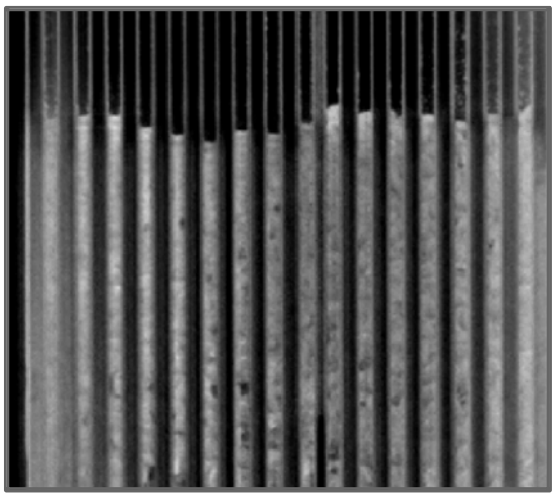
1. SPECIFICATION

Emission Regulation		Euro-V
Front Area		154.06㎠
Size	DOC	158 X 124 X 78L
	DPF	158 X 124 X 194L
CDPF Case	Shell	SUS430J1L X 1.5t
	End Cone	SUS430J1L X 2.0t
CDPF	Catalyst Capacity	4.2L
	Material of Filter	AT

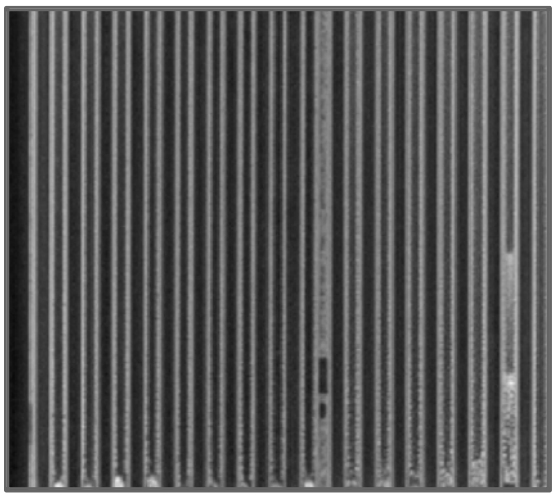
2. CAUTIONS

1) Standard pattern of soot accumulation

▶ **Abnormal Soot Accumulation**



▶ **Normal Soot Combustion**



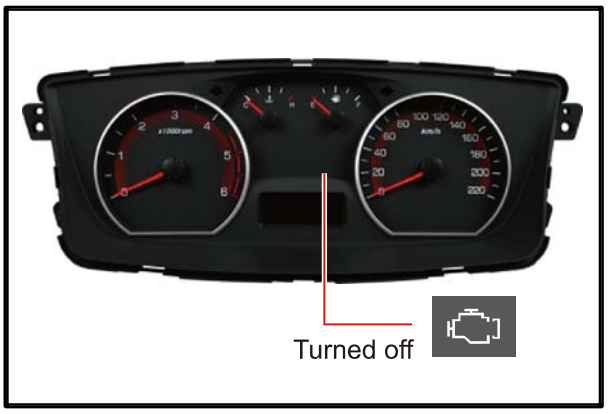
▶ **Cautions to protect the catalyst filter**

- Use the designated fuel only.
- Observe the recommended service intervals of engine oil.
- Check the engine oil level frequently and add if necessary.
- Do not idle the vehicle unnecessarily.
- Do not turn off the engine while the vehicle is running.
- Do not shift the gear selector lever to neutral when going downhill.
- Do not use improper engine oil or fuel additives.
- Do not drive for a long time when the warning lamp is illuminated.
- Make sure no flammable material, such as dry grass or tissue paper, contacts with the catalyst filter while the vehicle is parked.
- For the vehicles used in urban traffic, driving on the expressways for more than 1 hour at least once per week is needed so that the PM inside CDPF isn't collected to one side only.

Modification basis	
Application basis	
Affected VIN	

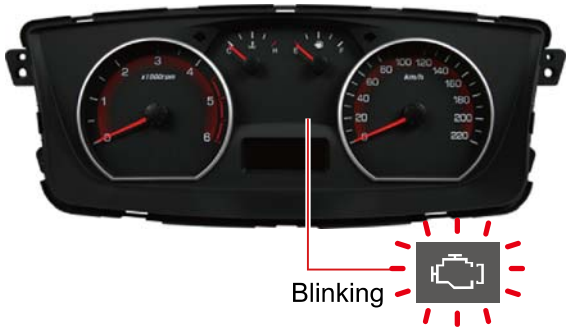
2) Warning Lamp Related to CDPF

▶ **CDPF regeneration process (warning lamp NOT illuminated)**



The CDPF system enters the regeneration mode when the driving distance becomes approx. 600 to 1,200 km (may differ by the driving condition and driving style). Then, the engine ECU performs the CDPF regeneration operation. However, the driver is not informed with this operation by any engine warning lamp or vehicle signal, so he/she may not detect this operation. The control logic at the post-injection dur-ing the regeneration process is to increase the fuel injection volume and control the intake air volume (by the throttle body) in order to increase the temperature of the exhaust gas. The driver may not feel any particular difference from the vehicle.

Overload of CDPF (warning lamp blinking)



1. If the CDPF cannot reach the regeneration temperature due to low speed driving or other reason during the regeneration process, the soot is continuously accumulated in the CDPF. When this
2. condition continues and the CDPF is overloaded with soot, the engine warning lamp blinks to inform this situation to the driver.
   In order to solve this problem, drive the vehicle at a speed of approx. 80 km/h for 15 to 20 minutes to perform the CDPF regeneration process.
3. If the engine warning lamp on the instrument cluster blinks, the CDPF is overloaded. In this case, perform the step 2.

Excessive overload of CDPF (warning lamp illuminated)

1. If the vehicle is driven at a speed of 5 to 10 km/h for an extended period of time, the soot accumulated in the CDPF cannot be burned as the CDPF cannot reach the regeneration temperature. Then, an excessive amount of soot can be accumulated in the CDPF.
2. This case is much worse than the simple over-load of the CDPF. To inform this to the driver, the engine warning lamp comes on and the engine power is decreased to protect the system.
   To solve this problem, blow soot between the engine and exhaust system several times and erase
3. the related DTC. Then, check if the same DTC is regenerated again. If so, check the DTC related to the differential pressure sensor.

Modification basis	
Application basis	
Affected VIN	

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

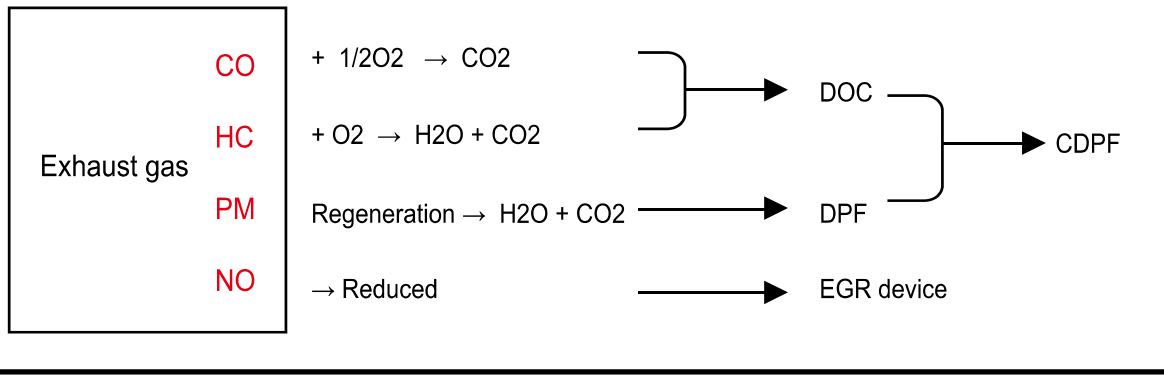
The low emission vehicle is being sold increasingly in the market as a countermeasure for complying with the environment regulations such as a special act on Seoul metropolitan air quality improvement and for reducing the PM (Particulate Material) from the diesel-powered vehicle. For the CDPF system, the DOC (two-way catalytic converter or catalytic combustion system) fitted to the conventional diesel engine has the high purification rate for HC or CO but not have a high reduction rate for the PM. For this reason, a necessity has been raised in order to consider a countermeasure to reduce the PM since the existing DOC can't meet the regulation, which is getting tighter.
This results in a development of the CDPF (Catalyst & Diesel Particulate Filter) that is combination of the existing DOC (Diesel Oxydation Catalyst) and DPF (Diesel Particulate Filter). While the DOC converts the CO and HC into the CO2 and H2O - unharmful to human body - using a oxidation reaction, the DPF collects the PF (Particulate Material) for regeneration of it. However, each of these devices can only reduce a part of the exhaust gas. This evoked the necessity of the CDPF with both features. The DOC capacity is more on the manual transmission than the automatic transmission.

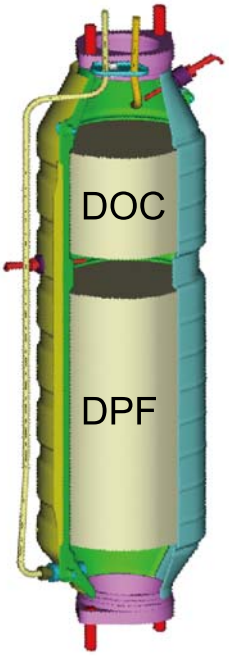
▶ DOC(Diesel Oxidation Catalyst)

It is called as a oxidation catalyst, which purifies CO and HC in exhaust gas. The three-way catalyst is used for the gasoline vehicle. But, the diesel engine oxidates CO and HC excepting NOx into H2O and CO2 in order to purify the exhaust gas since the exhaust gas has a rich oxygen at all times.

▶ DPF(Diesel Particulate Filter)

It consists of mainly the aluminum and titanium and there is a porous thin film, which emits the exhaust gas but does not emit the PM in it. It emits the exhaust gas generated during combustion and filters the PM which is a byproduct of combustion to burn it when a certain amount of it is collected in the filter. When a certain amount of the PM builds up, exposure to high exhaust gas causes carbon, the fundamental ingredient in PM, to burn and release into the atmosphere in form of CO2.





DOC [Diesel Oxidation Catalyst]
CO + 1/2O2 -Oxidation → CO2
HC + O2 -Oxidation → H2O + CO2

DPF [Diesel Particulate Filter]
Collecting PM → Regeneration →
H2O + CO2

CDPF [Catalyst &
Diesel Particulate Filter]

Modification basis	
Application basis	
Affected VIN	

2. COMPONENT

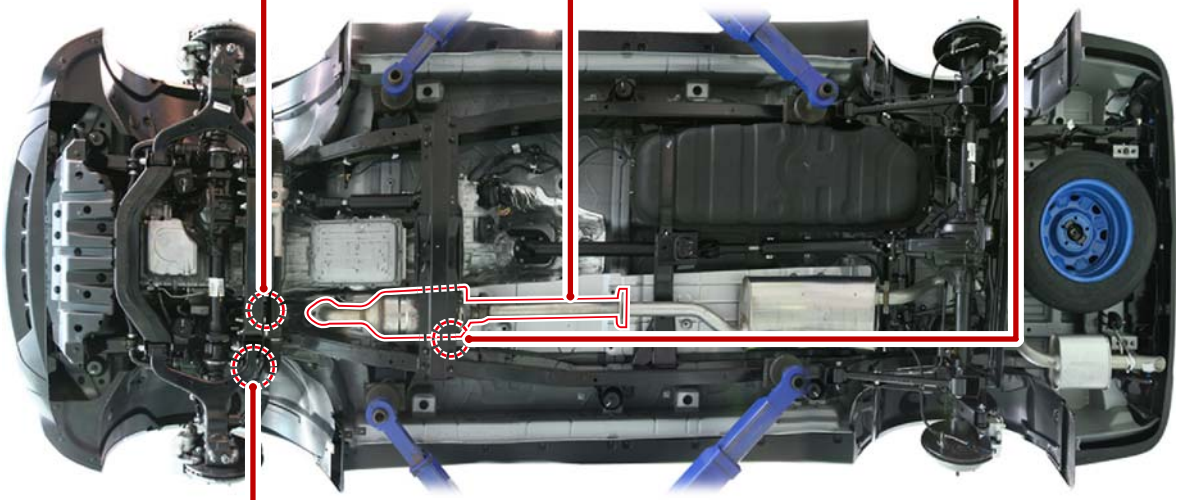
Front temperature sensor

Protects the turbocharger.

CDPF DOC+DPF

Rear temperature sensor

Measures the temperature of fuel combustion.



Differential pressure sensor

Calculates the amount of PM collected by reading the pressure difference between before and after the CDPF.

Engine ECU DCM 3.7

Post-injection

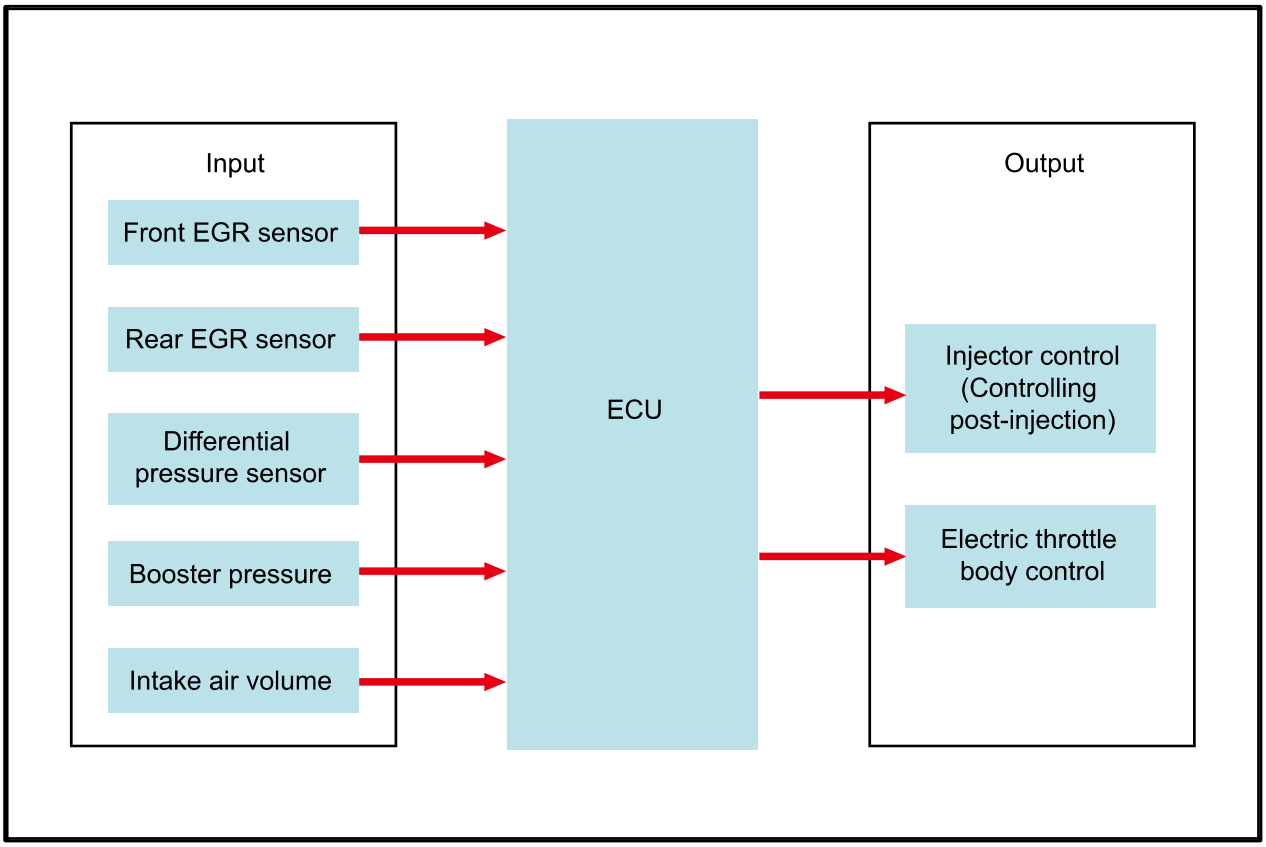
Throttle valve

Regulates the rate of air intake.

* For details, refer to section "Engine Control".

Modification basis	
Application basis	
Affected VIN	

3. INPUT/OUTPUT DEVICES



1. Front temperature sensor: This sensor is installed at the inlet of DOC and detects whether the DOC can burn (oxidize) the post-injected fuel or not.
2. Rear temperature sensor: This sensor is installed at the inlet of DPF and monitors that the temperature of the exhaust gas is kept at 600℃.

- If the temperature exceeds 600℃, the life of CDPF can be reduced. So the amount of fuel post-injection is decreased.
- If the temperature drops under 600℃, the rate of regeneration can be decreased. So the amount of fuel post-injection is increased.

3. Differential pressure sensor: This sensor checks the amount of PM collected by calculating the pressure difference between before and after the CDPF.
4. Electric throttle valve: This valve reduces the intake air flow to raise the temperature of the exhaust gas when the CDPF is operating during idling.

Modification basis	
Application basis	
Affected VIN	

4. POST-INJECTION AND AIR MASS CONTROL

A DPS (Differential Pressure Sensor) measures the pressure difference between before and after the CDPF and detects whether the soot is collected in the CDPF or not. If PM is collected in the CDPF (In this case the pressure difference between before and after the CDPF exceeds the specified value. Normally, the system sends the signal when the driving distance becomes approx. 600 to 1,200 km), the temperature of exhaust gas is increased and the post-injection is started for regeneration. The amount of fuel post-injection is controlled by the exhaust gas temperature measured by the rear temperature sensor. If the temperature is less than 600℃, the amount of post-injection is increased to increase the regeneration temperature. Otherwise, the fuel injection amount is decreased or the fuel is not injected.

When the engine is running with low load, the intake air amount is also controlled as well as fuel injection amount. This function is used to increaser the combustion temperature by increasing the amount of fuel post-injection with the lowest air amount within the specified control logic.

Front temperature sensor

Measures the temperature of exhaust gas.

This sensor is located at the rear side of exhaust manifold and monitors the temperature of combusted gas to prevent the exhaust system from overheating. When the temperature gets higher, this sensor cuts off the fuel delivery and controls the EGR to lower the temperature.

Differential pressure sensor

Measures the difference between inlet and outlet pressures of CDPF.

If the difference is higher than the specified value when collecting the PM, this makes the post injection for forced recycling of PM.

HFM sensor

Intake air mass

Engine ECU (D20DTR)

Measures the excessive amount of PM.

Wide band oxygen sensor

Boost pressure/ temperature

T-MAP sensor

Rear temperature sensor

Measure the outlet temperature of DOC.

This sensor is located at the rear side of DOC and monitors the overheating of CDPF and post injection volume.

Injector (C31)

Controls the post injection.

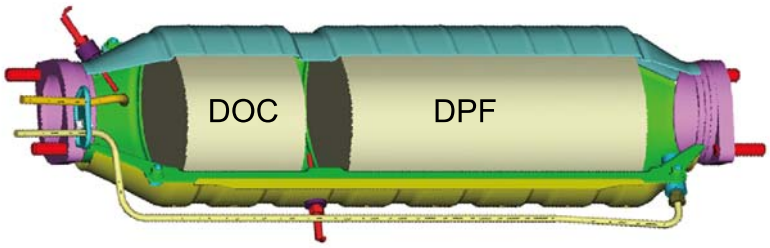
Electric throttle body

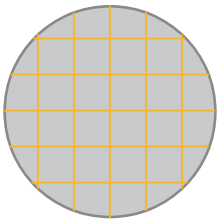
Controls the intake air mass.

Modification basis	
Application basis	
Affected VIN	

5. OPERATING PROCESS

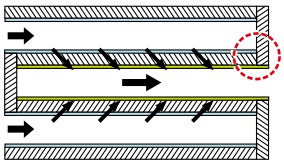
[Configuration and principle of operation]





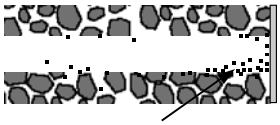
The exhaust gas passed through the exhaust manifold enters into the CDPF assembly (at approx 250℃).

Oxidation (DOC)



When the exhaust gas enters into the CDPF assembly, its CO, HC and PM are reduced by the redox reaction of the DOC. The remaining PM is filtered and collected in CDPF, and the temperature of the exhaust gas is increased to between 450 and 500°C.

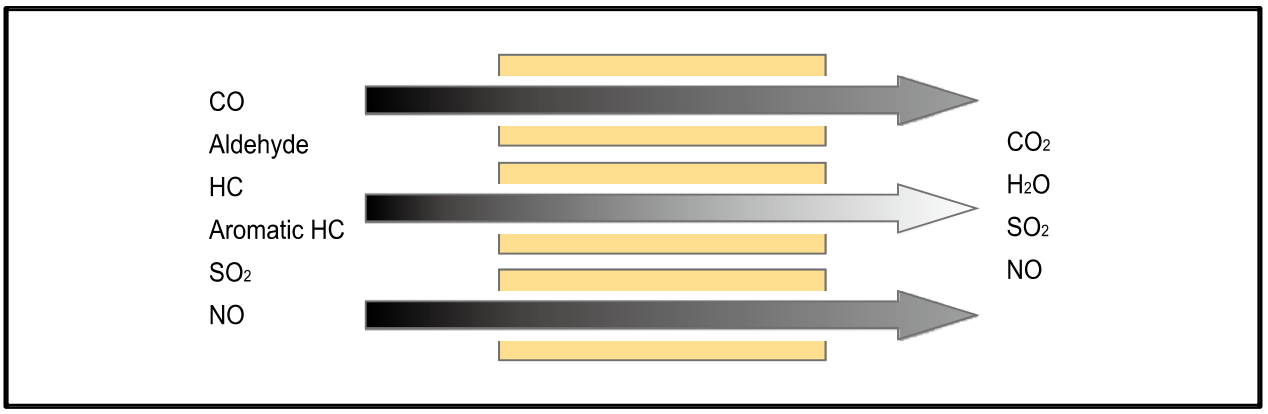
Collecting PM
→ Regeneration



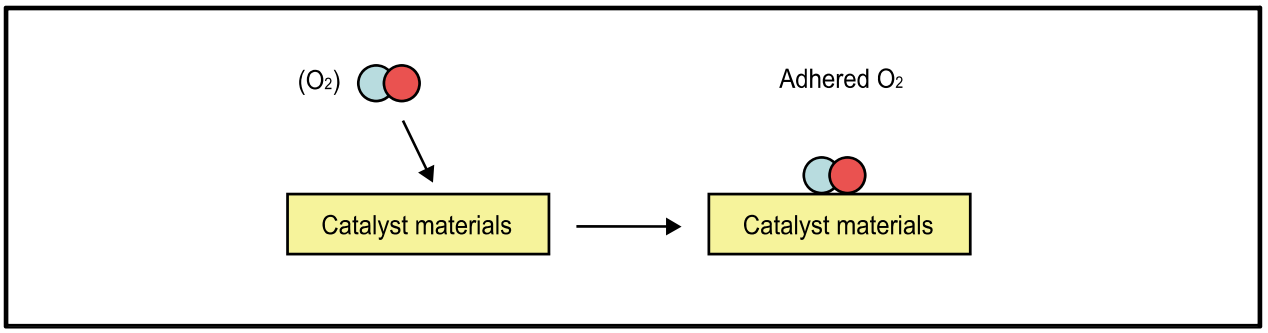
The engine ECU detects the amount of PM collected by the information from the temperature sensors and differential pressure sensor. When the soot is accumulated, the engine ECU performs post-injection to increase the exhaust gas temperature and burns the collected PM at approx. 600°C.

1) Oxidation of DOC

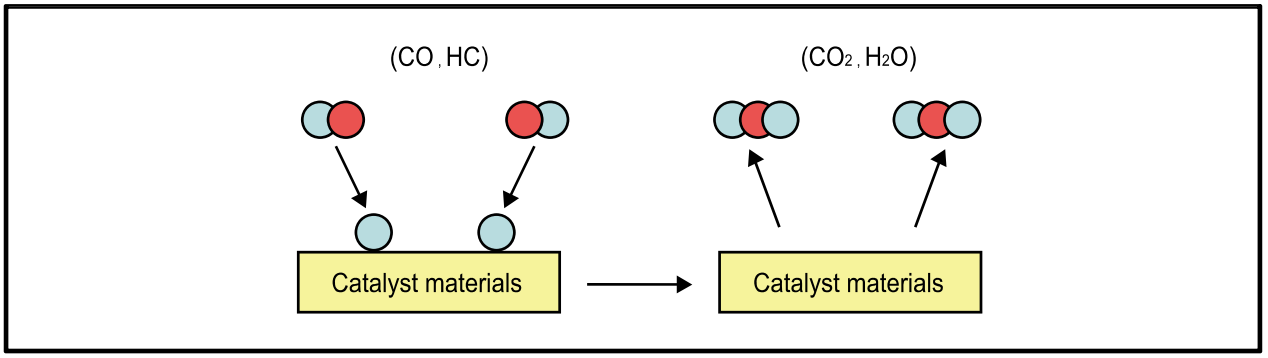
The DOC oxidizes HC and CO of the exhaust gas in the two-way catalytic converter at 180℃ or more, and performs best at the temperature between 400 and 500℃. The front EGT sensor detects whether the DOC can burn (oxidize) the post-injected fuel or not, and sends the signal to the ECU to maintain the DOC operating temperature between 300 and 500℃. The DOC reduces CO and HC of the exhaust gas by redox reaction and also reduces small amount of PM.



1. Oxygen adheres to the catalyst materials: Less than 180℃



2. CO and HC are oxidized by the catalyst materials: More than 180℃

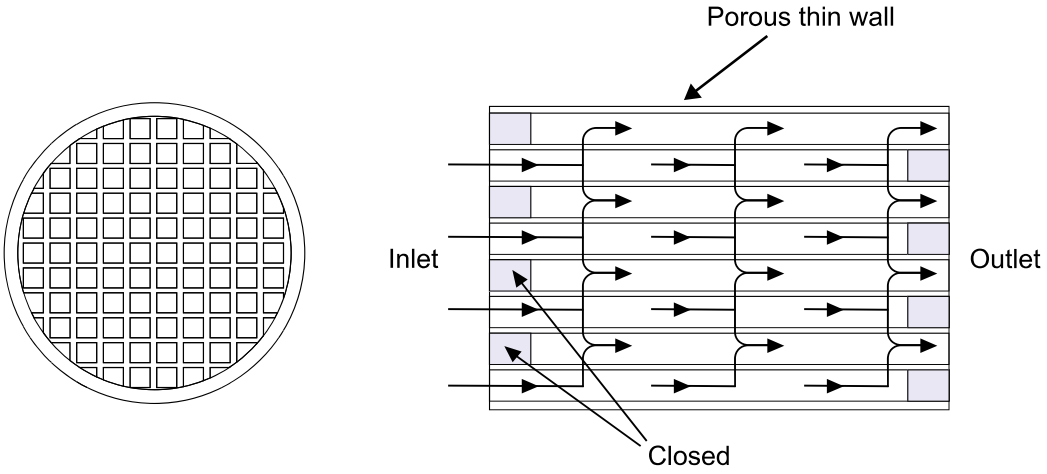


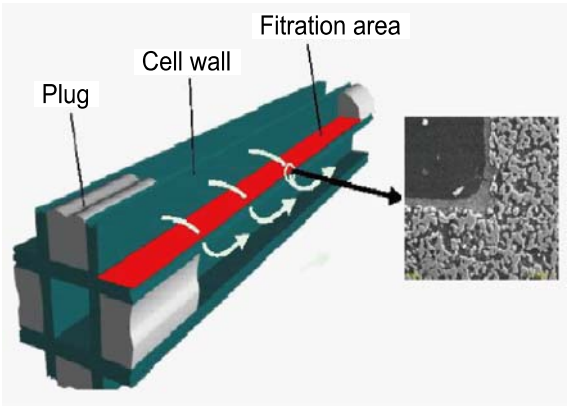
Modification basis	
Application basis	
Affected VIN	

2) Collecting PM of DPF

There is a filter installed in the DPF and the PM filtered by this filter is burned (regeneration) when the temperature of exhaust gas is increased due to post-injection. The filter has a honeycomb-like structure to capture the particulate matter and the inlet and outlet of each channel are closed alternatively. Once the exhaust gas enters to the inlet of a channel, it is released from the outlet of the adjacent channel through the porous wall because of the closed outlet of the first channel, and the PM is collected in the first channel.

[Collecting PM of CDPF]





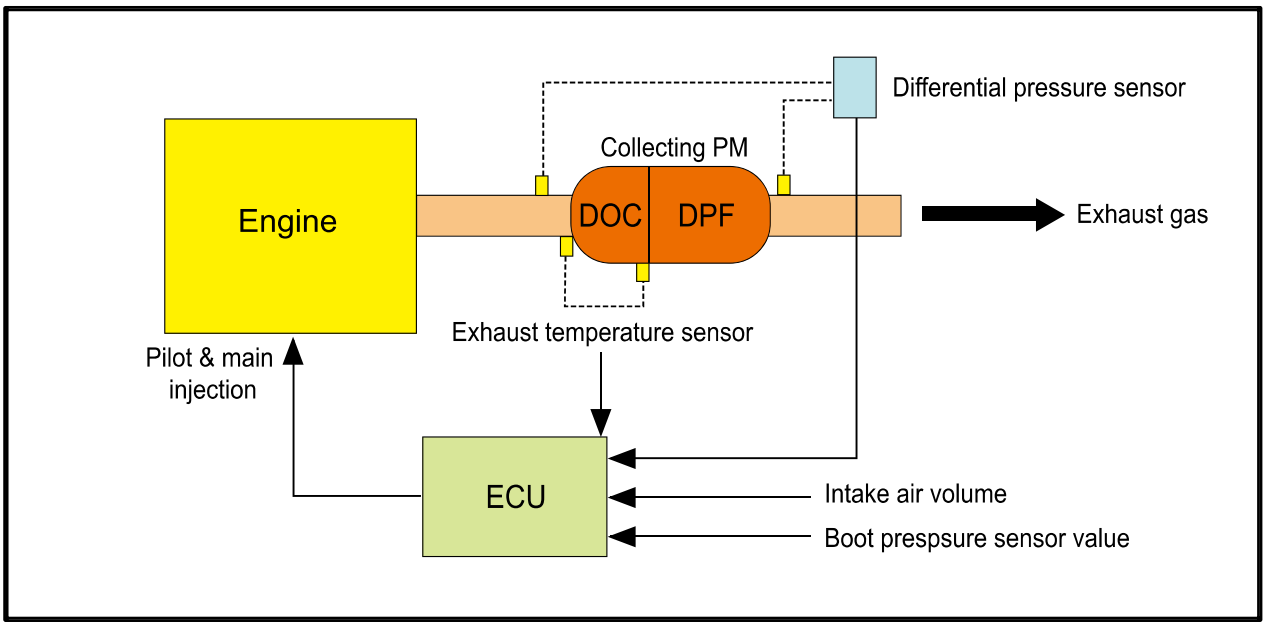
NOTE

Normally, when the driving distance becomes approx. 600 to 1,200 km, enough amount of soot to be burned is filtered and accumulated in the CDPF. The ECU increases the amount of fuel post-injection to increase the temperature of the exhaust gas up to 600°C, so that the soot is burned. The soot is burned for 15 to 20 minutes (may differ by conditions).

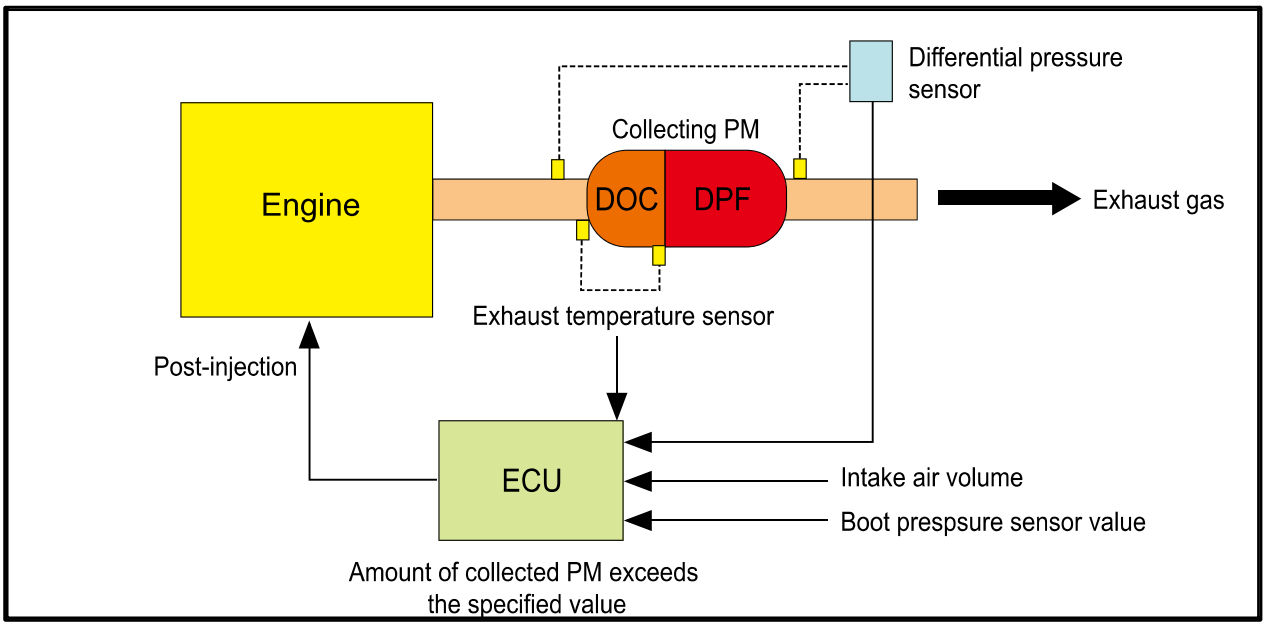
3) PM Regeneration of DPF

The differential pressure sensor installed in the DPF measures the pressure values of inlet and outlet of CDPF. And the amount of the PM collected in the filter is calculated based on the exhaust temperature, intake air mass flow, booster pressure, etc.
The regeneration is started when the amount of the collected PM is 28 g or more.
The ECU commands post-injection to increase the temperature of CDPF to 600℃.

1. When the amount of the collected PM is not enough: The DPF works as a filter.

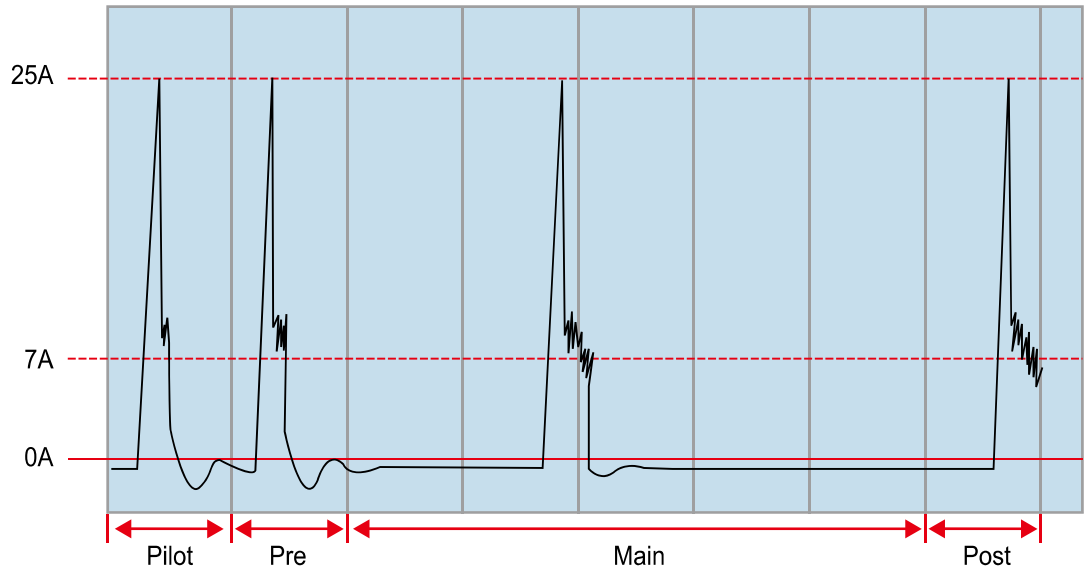


2. When enough amount of PM is collected: The ECU commands post-injection and increase the exhaust gas temperature to start regeneration.



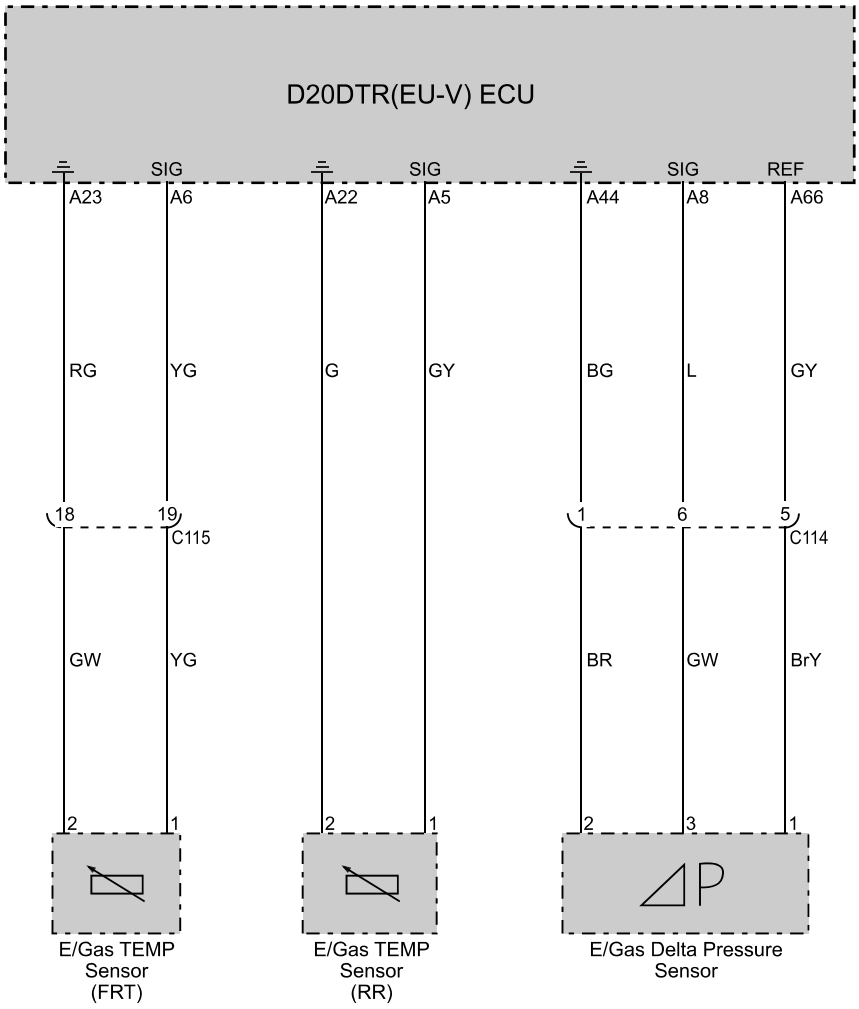
Modification basis	
Application basis	
Affected VIN	

4) Fuel Injection During CDPF Regeneration



Injection	Effect
Pilot injection	Decrease of PM by fuel mixture Decrease of noise from engine combustion
Pre-injection	Decrease of NOx by shortening main injection delay due to flammability Decrease of noise from engine combustion
Main injection	Main power source
Post-injection	Activation of CDPF by increasing exhaust gas temperature and supplying reduction material

6. ELECTRIC CIRCUIT DIAGRAM



Modification basis	
Application basis	
Affected VIN	

ENGINE CONTROL

0000-00

GENERAL INFORMATION

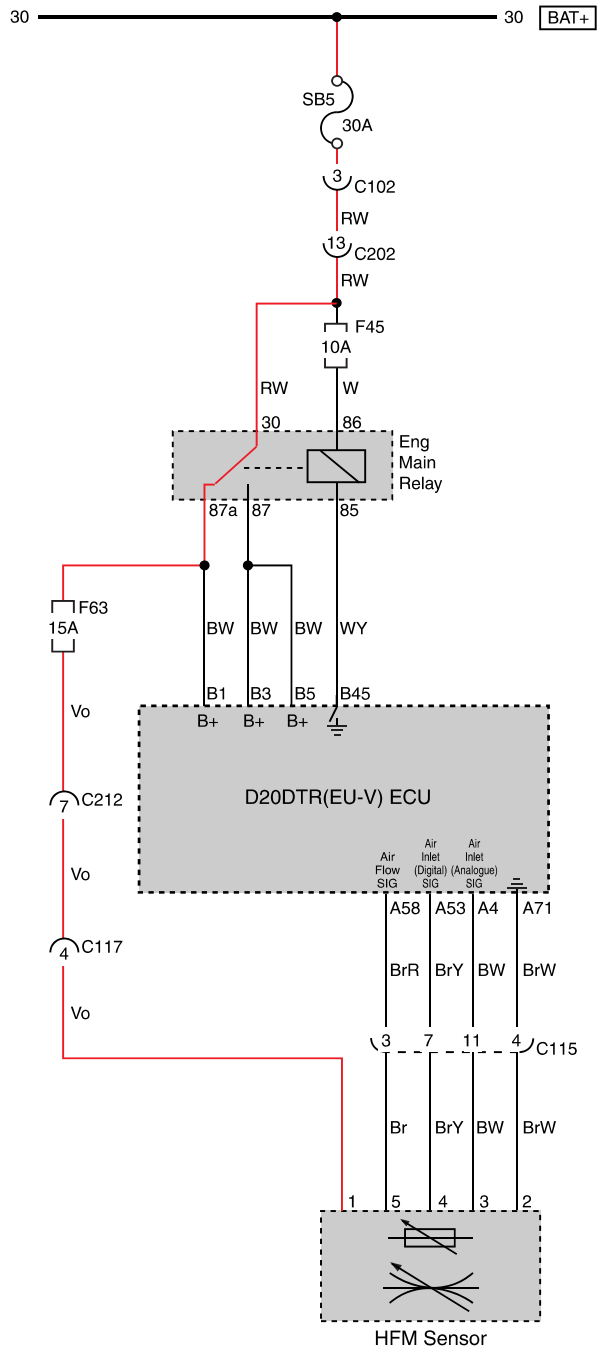
1. ENGINE DATA LIST

Data	Unit	Value
Coolant temperature	℃	0.436 V (130℃) to 4.896 V (−40℃)
Intake air temperature	℃	−40 to 130℃ (varies by ambient air temperature or engine mode)
Idle speed	rpm	750 ± 20
Engine load	%	18~25%
Mass air flow	kg/h	16 to 25 kg/h
Throttle position angle	°TA	0° (Full Open) to 78° (Close)
Engine torque	Nm	varies by engine conditions
Injection time	ms	3 to 5ms
Battery voltage	V	13.5 V to 14.1 V
Accelerator pedal position 1	V	0.4. to 4.8V
Accelerator pedal position 2	V	0.2 to 2.4 V
Throttle position 1	V	0.3 to 4.6 V
Throttle position 2	V	0.3 to 4.6 V
Oxygen sensor	mV	0 to 5 V
A/C compressor switch	1=ON / 0=OFF	-
Full load	1=ON / 0=OFF	-
Gear selection (A/T)	1=ON / 0=OFF	-
Knocking control	1=ON / 0=OFF	-
Brake switch	1=ON / 0=OFF	-
Cruise control	1=ON / 0=OFF	-

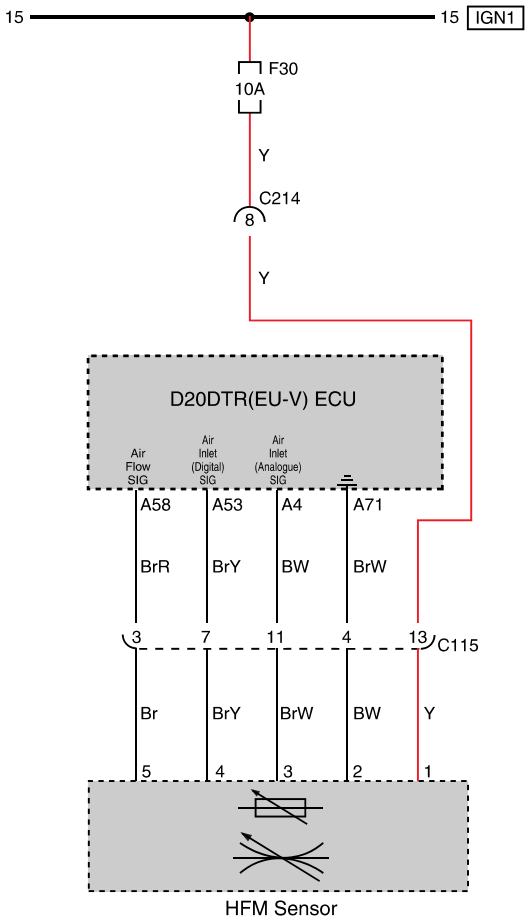
2. CHANGES IN ENGINE CONTROL

Power supply line to HFM sensor (Hot Film Air-Mass Sensor) changed

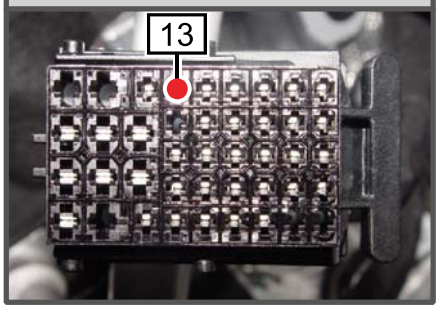
Old



New



Engine control wiring (C115)



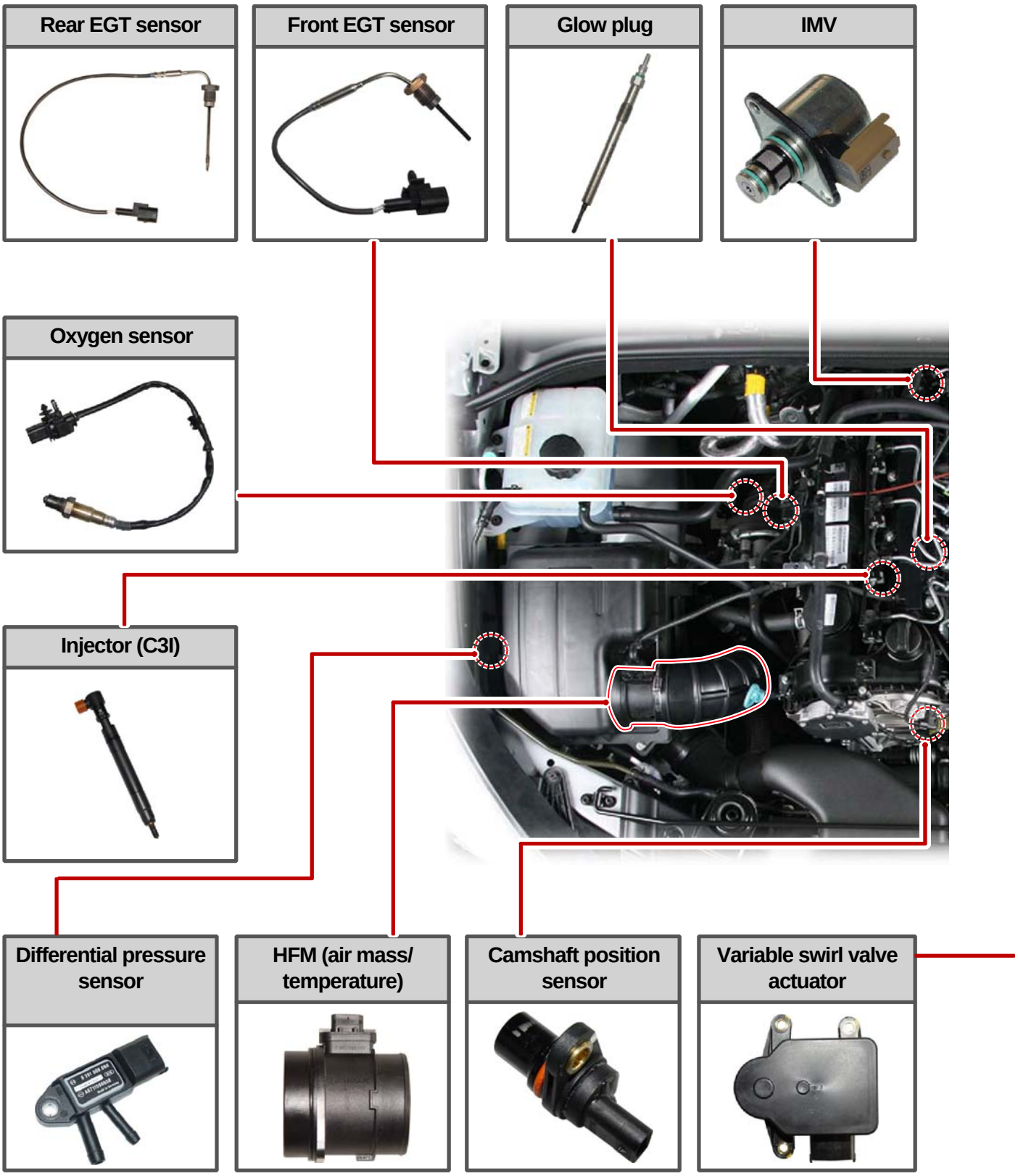
Power supply line to HFM sensor changed from power supply line to rear end of the engine main relay controlled by the ECU to IGN1+ power supply line (engine control wiring C115 No. 13 terminal added)

Modification basis	
Application basis	
Affected VIN	

Memo

OVERVIEW AND OPERATINF PROCESS

1. MAJOR COMPONENTS



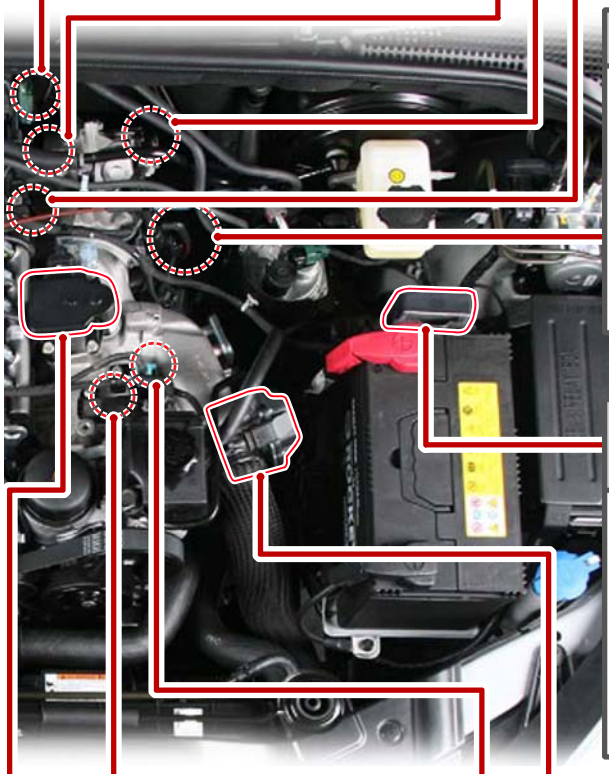
Modification basis	
Application basis	
Affected VIN	

Coolant temperature sensor

Fuel temperature sensor

EGR valve

Fuel rail pressure sensor



E-EGR bypass valve

E-VGT actuator

GCU (Preglow control unit)

Water sensor

T-MAP sensor

Knock sensor (2 ea)

Electric throttle body

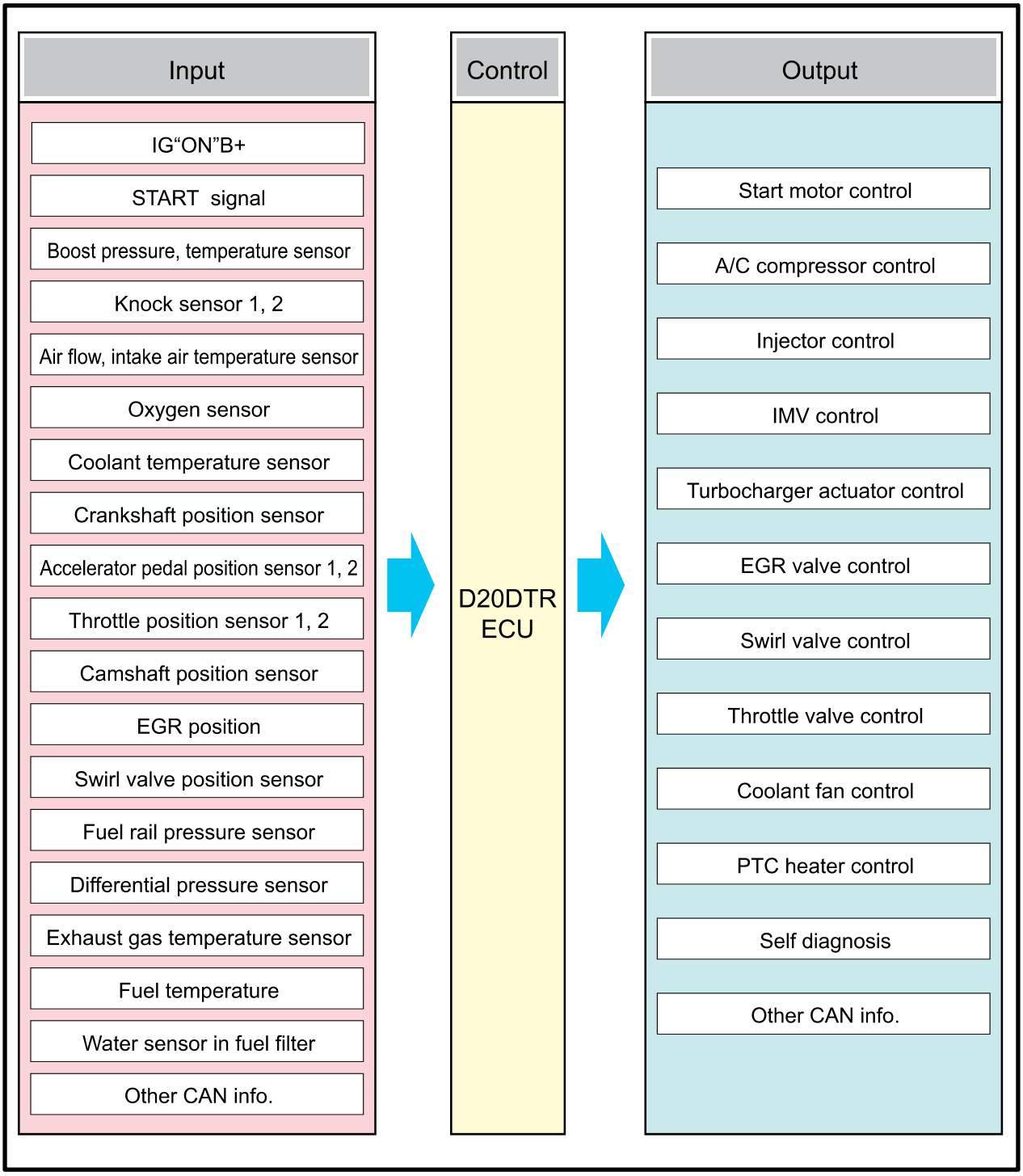
D20DTR ECU

Modification basis	
Application basis	
Affected VIN	

2. SYSTEM OPERATION

1) Input/Output of ECU

(1) ECU Block diagram



Modification basis	
Application basis	
Affected VIN	

(2) Components for ECU Input

-Auto cruise switch
- Rear right wheel speed (without ABS)
- Refrigerant pressure sensor
- Clutch pedal signal
- Blower switch signal
- Brake pedal signal

Crankshaft position sensor 	**Accelerator pedal sensor** 	**Throttle position sensor** 	**Knock sensor** 
Exhaust gas temperature sensor 	**HFM sensor** 	**T-MAP sensor** 	**Oxygen sensor** 
Differential pressure sensor 	**E-EGR valve position sensor** 	**Camshaft position sensor** 	**Coolant temperature sensor** 
Fuel rail pressure sensor 	**Swirl valve position sensor** 	**Water sensor** 	**CAN** - ABS & ESP - GCU - Instrument cluster - TCU

(3) Components for ECU Output

E-EGR valve	A/C compressor	Injector	Throttle position sensor
			

E-EGR cooler bypass valve	Variable swirl valve	E-VGT actuator	IMV valve
			

PTC heater	Cooling fan
	

CAN	
- Glow plug unit	- Instrument cluster
- ABS & ESP unit	- TCU
- GCU	- Self diagnosis

Modification basis	
Application basis	
Affected VIN	

2) ECU Control

(1) Function

a. ECU Function

ECU receives and analyzes signals from various sensors and then modifies those signals into permissible voltage levels and analyzes to control respective actuators.
ECU microprocessor calculates injection period and injection timing proper for engine piston speed and crankshaft angle based on input data and stored specific map to control the engine power and emission gas.
Output signal of the ECU microprocessor drives pressure control valve to control the rail pressure and activates injector solenoid valve to control the fuel injection period and injection timing; so controls various actuators in response to engine changes. Auxiliary function of ECU has adopted to reduce emission gas, improve fuel economy and enhance safety, comforts and conveniences. For example, there are EGR, booster pressure control, autocruise (export only) and immobilizer and adopted CAN communication to exchange data among electrical systems (automatic T/M and brake system) in the vehicle fluently. And Scanner can be used to diagnose vehicle status and defectives.
Operating temperature range of ECU is normally −40 to +85°C and protected from factors like oil, water and electromagnetism and there should be no mechanical shocks.
To control the fuel volume precisely under repeated injections, high current should be applied instantly so there is injector drive circuit in the ECU to generate necessary current during injector drive stages. Current control circuit divides current applying time (injection time) into full-in-current-phase and hold-current-phase and then the injectors should work very correctly under every working condition.

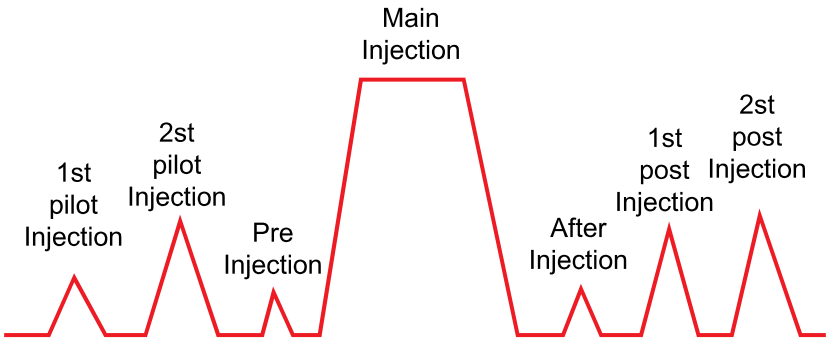
b. Control Function

- Controls by operating stages
  To make optimum combustion under every operating stage, ECU should calculate proper injection volume in each stage by considering various factors.
- Starting injection volume control
  During initial starting, injecting fuel volume will be calculated by function of temperature and engine cranking speed. Starting injection continues from when the ignition switch is turned to ignition position to till the engine reaches to allowable minimum speed.
- Driving mode control
  If the vehicle runs normally, fuel injection volume will be calculated by accelerator pedal travel and engine rpm and the drive map will be used to match the drivers inputs with optimum engine power.

(2) Fuel injection control

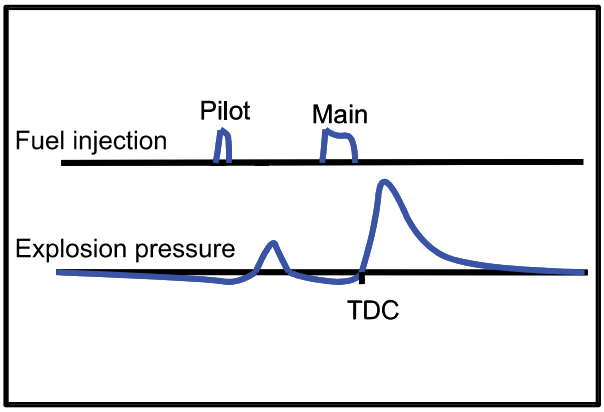
a. Multi injection

Fuel injection process consists of 3 steps: Main Injection, Pilot Injection, Post Injection

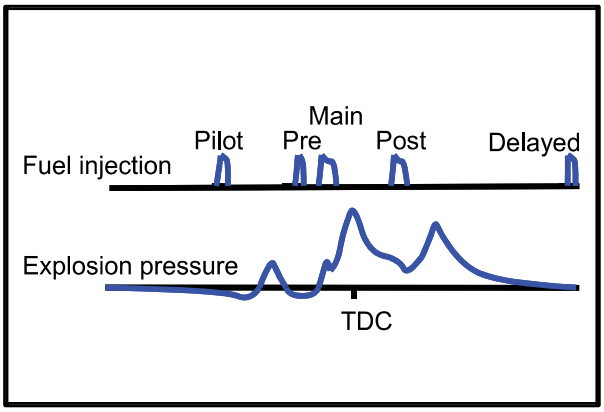


Injection	Function	Main	Produces engine power
Pilot 1	Reduces PM by injecting before main injection.	**After**	PM control
Pilot 2	Reduces NOx and noise by shortening main injection delay due to flammability	**Post 1**	Reduces PM by enabling fuel activation.
Pre	Controls NOx emission level, Combustion noise and Stable idle	**Post 2**	Activates CDPF by increasing exhaust gas temperature and supplying reduction material

▶ **Pilot injection**



▶ **Multi injection**



Modification basis	
Application basis	
Affected VIN	

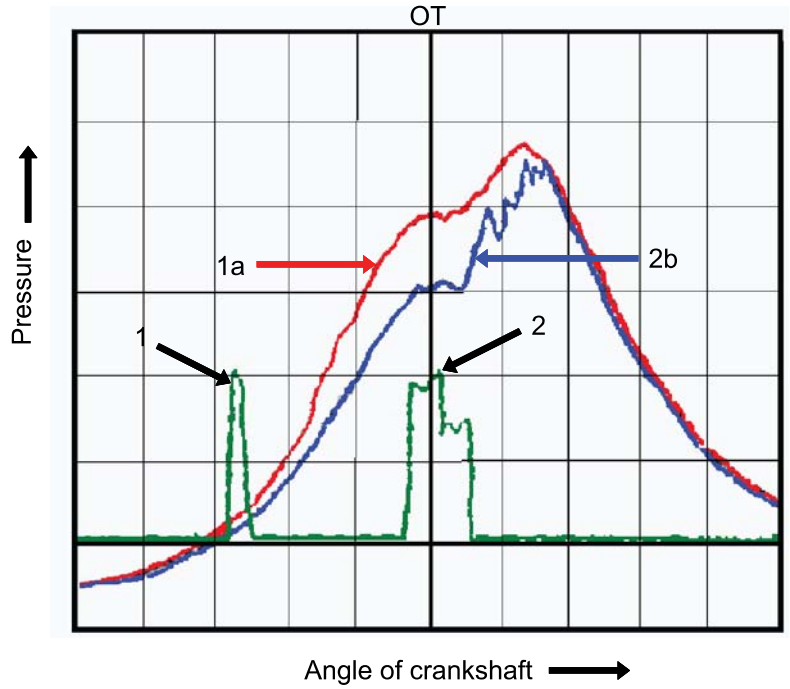
b. Pilot Injection

Injection before main injection. Consists of 1st and 2nd pilot injection, and Pre-injection
Inject a small amount of fuel before main injection to make the combustion smooth. Also, called as preliminary injection or ignition injection. This helps to reduce Nox, engine noise and vibration, and to stabilize the idling.
The injected fuel volume is changed and stopped according to the coolant temperature and intake air volume.

Stop conditions

- Pilot injection is much earlier than main injection due to higher engine rpm
- Too small injection volume (insufficient injection pressure, insufficient fuel injection volume in main injection, engine braking)
- System failure (fuel system, engine control system)

▶ **Combustion pressure characteristic curve for pilot injection**



1. Pilot injection
2. Main injection

1a.Combustion pressure with pilot injection
2b.Combustion pressure without pilot injection

c. Main Injection

The power of the vehicle is determined by the main fuel injection volume.
Main injection calculates the fuel volume based on pilot injection. The calculation uses the value for accelerator pedal position, engine rpm, coolant temperature, intake air temperature, boost pressure, boost temperature and atmospheric pressure etc.

d. Post Injection

Injection after main injection. Consists of After injection, Post 1, Post 2 injection.
Post injection reduces PM and smoke from exhaust gas. No actual output is generated during these injections, instead, fuel is injected to the unburned gas after main injection to enable fuel activation. The PM amount in the emission and smoke can be reduced through these processes.
Only up to 5 types of injections can be performed within 1 cycle. If these 7 injections are all performed, fuel economy and emission performance becomes poor.

Modification basis	
Application basis	
Affected VIN	

(3) Fuel Pressure Control

▶ Fuel Pressure

Fuel pressure is controlled by IMV opening according to the calculated value by ECU.

▶ Pressure in the fuel rail is determined according to engine speed and load on the engine.

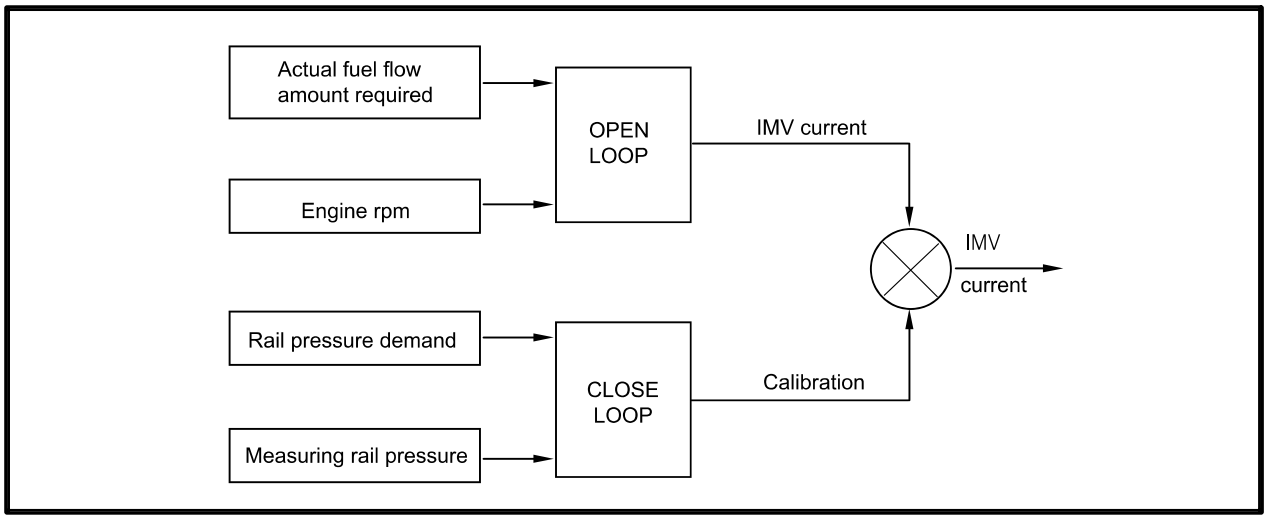
- When engine speed and load are high
  The degree of turbulence is very great and the fuel can be injected at very high pressure in order to optimize combustion.
- When engine speed and load are low
  The degree of turbulence is low. If injection pressure is too high, the nozzle's penetration will be excessive and part of the fuel will be sprayed directly onto the sides of the cylinder, causing incomplete combustion. So there occurs smoke and damages engine durability.

Fuel pressure is corrected according to air temperature, coolant temperature and atmospheric pressure and to take account of the added ignition time caused by cold running or by high altitude driving. A special pressure demand is necessary in order to obtain the additional flow required during starts. This demand is determined according to injected fuel and coolant temperature.

▶ Open loop determines the current which needs to be sent to the actuator in order to obtain the flow demanded by the ECU.

▶ Closed loop will correct the current value depending on the difference between the pressure demand and the pressure measured.

- If the pressure is lower than the demand, current is reduced so that the fuel sent to the high pressure pump is increased.
- If the pressure is higher than the demand, current is increased so that the fuel sent to the high pressure pump is reduced.



(4) Injection Timing Control

▶ **Injection timing is determined by the conditions below.**

1. Coolant temperature
   Hot engine - Retarded to reduce Nox
   Cold engine - Advanced to optimize the combustion
2. Atmospheric pressure
   Advanced according to the altitude
3. Warming up
   Advanced during warming up in cold engine
4. Rail pressure
   Retarded to prevent knocking when the rail pressure is high
5. EEGR ratio
   Advanced to decrease the cylinder temperature when EGR ratio increases

▶ **Pilot injection timing control**

The pilot injection timing is determined as a function of the engine speed and of the total flow.
The elements are:

- A first correction is made according to the air and coolant temperatures. This correction allows the pilot injection timing to be adapted to the operating temperature of the engine.
- A second correction is made according to the atmospheric pressure. This correction is used to adapt the pilot injection timing as a function of the atmospheric pressure and therefore the altitude.

▶ **Main injection timing control**

The pulse necessary for the main injection is determined as a function of the engine speed and of the injected flow.
The elements are:

- A first correction is made according to the air and coolant temperatures.
  This correction makes it possible to adapt the timing to the operating temperature of the engine. When the engine is warm, the timing can be retarded to reduce the combustion temperature and polluting emissions (NOx). When the engine is cold, the timing advance must be sufficient to allow the combustion to begin correctly.
- A second correction is made according to the atmospheric pressure.
  This correction is used to adapt the timing advance as a function of the atmospheric pressure and therefore the altitude.
- A third correction is made according to the coolant temperature and the time which has passed since starting.
  This correction allows the injection timing advance to be increased while the engine is warming up (initial 30 seconds). The purpose of this correction is to reduce the misfiring and instabilities which are liable to occur after a cold start.

Modification basis	
Application basis	
Affected VIN	

- A fourth correction is made according to the pressure error.
  This correction is used to reduce the injection timing advance when the pressure in the rail is higher than the pressure demand.
  A fifth correction is made according to the rate of EGR.
- This correction is used to correct the injection timing advance as a function of the rate of exhaust gas recirculation.

When the EGR rate increases, the injection timing advance must in fact be increased in order to compensate for the fall in termperature in the cylinder.

(5) Fuel Control

A. Main Flow Control

The main flow represents the amount of fuel injected into the cylinder during the main injection. The pilot flow represents the amount of fuel injected during the pilot injection.

The total fuel injected during 1 cycle (main flow + pilot flow) is determined in the following manner.

- When the driver depress the pedal, it is his demand which is taken into account by the system in order to determine the fuel injected.
- When the driver release the pedal, the idle speed controller takes over to determine the minimum fuel which must be injected into the cylinder to prevent the enigne from stalling.

It is therefore the greater of these 2 values which is retained by the system. This value is then compared with the lower flow limit determined by the ESP system.

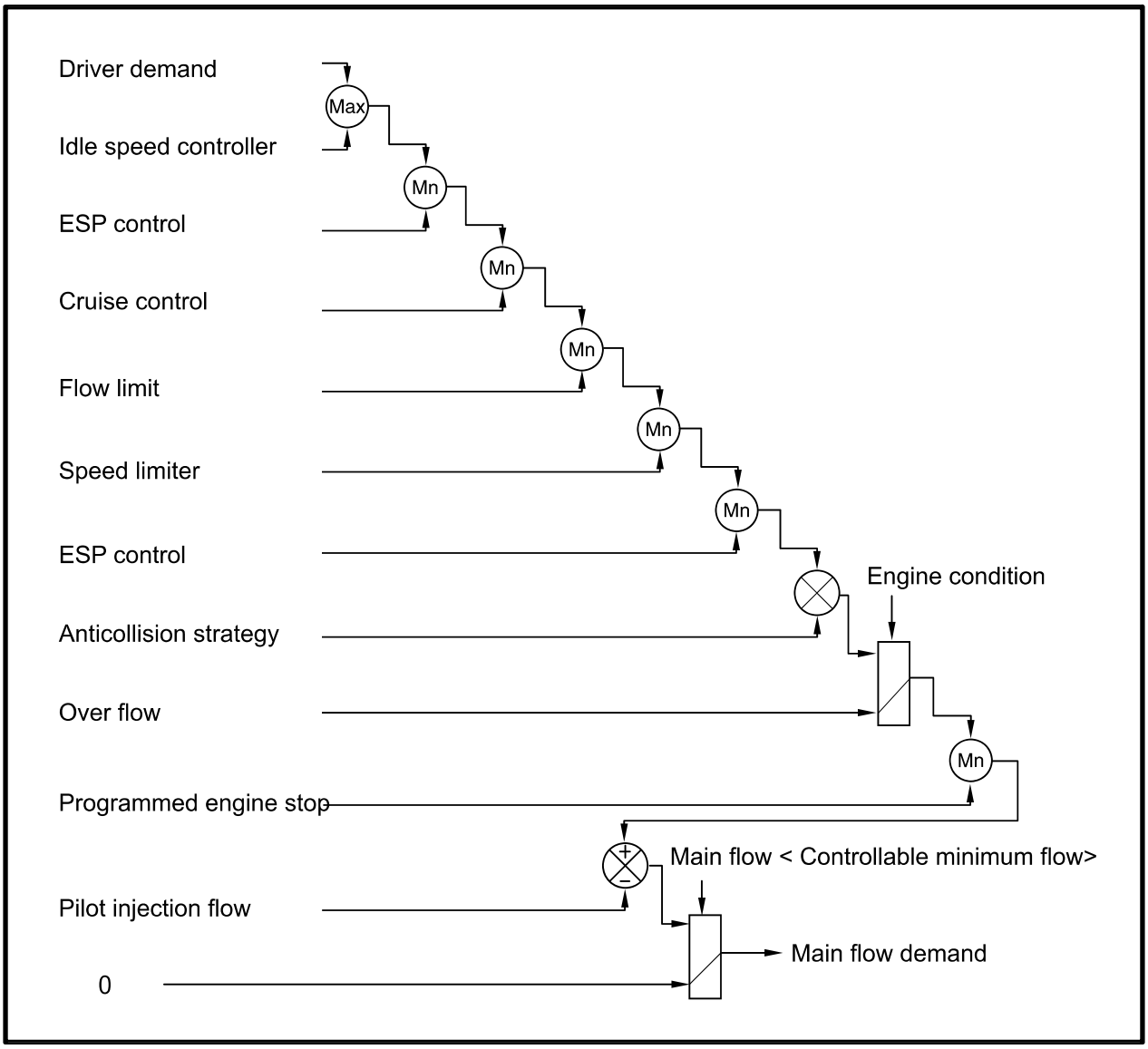
As soon as the injected fuel becomes lower than the flow limit determined by the ESP system, the antagonistic torque (engine brake) transmitted to the drive wheels exceeds the adherence capacity of the vehicle and there is therefore a risk of the drive wheels locking.
The system thus chooses the greater of these 2 values (main flow & pilot flow) in order to prevent any loss of control of the vehicle during a sharp deceleration.

As soon as the injected fuel becomes higher than the fuel limit determined by the ASR trajectory control system, the engine torque transmitted to the wheels exceeds the adhesion capacity of the vehicle and there is a risk of the drive wheels skidding. The system therefore chooses the smaller of the two values in order to avoid any loss of control of the vehicle during accelerations.
The anti-oscillation strategy makes it possible to compensate for fluctuations in engine speed during transient conditions. This strategy leads to a fuel correction which is added to the total fuel of each cylinder.

A switch makes it possible to change over from the supercharge fuel to the total fuel according to the state of the engine.

- Until the stating phase has finished, the system uses the supercharged fuel.
- Once the engine changes to normal operation, the system uses the total fuel.

The main fuel is obtained by subtracting the pilot injection fuel from the total fuel.
A mapping determines the minimum fuel which can control an injector as a function of the rail pressure.
As soon as the main fuel falls below this value, the fuel demand changes to 0 because in any case the injector is not capable of injecting the quantity demand.



B. Driver Demand

The driver demand is the translation of the pedal position into the fuel demand. It is calculated as a function of the pedal position and of the engine speed. The driver demand is filtered in order to limit the hesitations caused by rapid changes of the pedal position. A mapping determines the maximum fuel which can be injected as a function of the driver demand and the rail pressure. Since the flow is proportional to the injection time and to the square root of the injection pressure, it is necessary to limit the flow according to the pressure in order to avoid extending the injection for too long into the engine cycle. The system compares the driver demand with this limit and chooses the smaller of the 2 values. The driver demand is then corrected according to the coolant temperature. This correction is added to the driver demand.

Modification basis	
Application basis	
Affected VIN	

C. Idle Speed Controller

The idle speed controller consists of 2 principal modules:

- The first module determines the required idle speed according to:
  * The operating conditions of the engine (coolant temperature, gear engaged)
  * Any activation of the electrical consumers (power steering, air conditioning, others)
  * The battery voltage
  * The presence of any faults liable to interface with the rail pressure control or the injection control. In this case, increase the idle speed to prevent the engine from stalling.
- The second module is responsible for providing closed loop control of the engine's idle speed by adapting the minimum fuel according to the difference between the required idle speed and the engine speed.

D. Flow Limitation

The flow limitation strategy is based on the following strategies:

- The flow limitation depending on the filling of the engine with air is determined according to the engine speed and the air flow. This limitation allows smoke emissions to be reduced during stabilized running.
- The flow limitation depending on the atmospheric pressure is determined according to the engine speed and the atmospheric pressure. It allows smoke emissions to be reduced when driving at altitude.
- The full load flow curve is determined according to the gear engaged and the engine speed. It allows the maximum torque delivered by the engine to be limited.
- A performance limitation is introduced if faults liable to upset the rail pressure control or the injection control are detected by the system. In this case, and depending on the gravity of the fault, the system activates:

Reduced fuel logic 1: Guarantees 75 % of the performance without limiting the engine speed.
Reduced fuel logic 2: Guarantees 50 % of the performance with the engine speed limited to 3,000 rpm.
Reduce fuel logic 3: Limits the engine speed to 2,000 rpm.

The system chooses the lowest of all values.
A correction depending on the coolant temperature is added to the flow limitation. This correction makes it possible to reduce the mechanical stresses while the engine is warming up.
The correction is determined according to the coolant temperature, the engine speed and the time which has passed since starting.

E. Superchager Flow Demand

The supercharge flow is calculated according to the engine speed and the coolant temperature. A correction depending on the air temperature and the atmospheric pressure is made in order to increase the supercharge flow during cold starts. It is possible to alter the supercharge flow value by adding a flow offset with the aid of the diagnostic tool

F. Pilot Flow Control

The pilot flow represents the amount of fuel injected into the cylinder during the pilot injection. This amount is determined according to the engine speed and the total flow.

- A first correction is made according to the air and water temperature.
  This correction allows the pilot flow to be adapted to the operating temperature of the engine. When the engine is warm, the ignition time decreases because the end-of-compression temperature is higher. The pilot flow can therefore be reduced because there is obviously less combustion noise when the engine is warm.
- A second correction is made according to the atmospheric pressure.

During starting, the pilot flow is determined on the basis of the engine speed and the coolant temperature.

G. Cylinder Balancing Strategy

▶ Balancing of the point to point flows

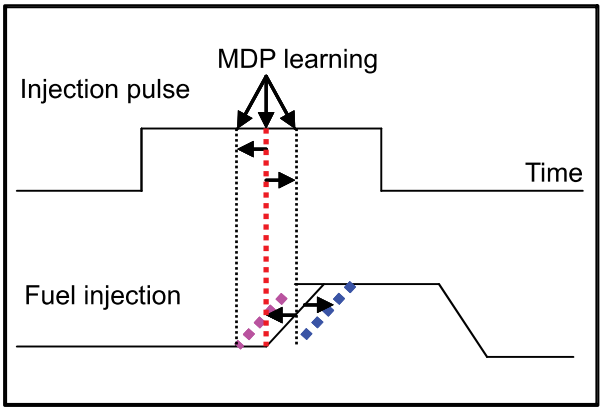
The pulse of each injector is corrected according to the difference in instantaneous speed measured between 2 successive injectors.

The instantaneous speeds on two successive injections are first calculated.
The difference between these two instantaneous speeds is then calculated.
Finally, the time to be added to the main injection pulse for the different injectors is determined.
For each injector, this time is calculated according to the initial offset of the injector and the instantaneous speed difference.

▶ Detection of an injector which has stuck closed

The cylinder balancing strategy also allows the detection of an injector which has stuck closed. The difference in instantaneous speed between 2 successive injections then exceeds a predefined threshold. In this case, a fault is signaled by the system.

(6) MDP Learning Control



MDP (Minimum Drive Pulse) refers to the minimum power supply pulse for injection which the injector can perform. It is possible to control the fuel volume for each injector accurately through correct learning for the MDP value. The basic process of MDP learning is that the pulse slightly higher than MDP is supplied and then (b) the vibration generated from the cylinder is detected. The knock sensor detects the vibration from the engine after a small volume of fuel is injected. And the time interval between the points of injection and vibration is measured so that MDP can be learned. MDP learning is helpful to prevent engine vibration, high emission and power reduction through performing calibration for the old injectors. During MDP learning, a little vibration and noise can be occur for a while. This is because the fuel pressure is increased instantaneously and the exact injection value is not input, so that the exact engine vibration timing can be detected.

A. MDP Learning

When the pulse value that the injector starts injection is measured, it is called minimum drive pulse (MDP). Through MDP controls, can correct pilot injections effectively. Pilot injection volume is very small, 1 to 2 mm/str, so precise control of the injector can be difficult if it gets old. So there needs MDP learning to control the very small volume precisely through learning according to getting older injectors.

B. Purpose of MDP learning

The system measures the pulse at initial injection to reduce the engine vibration.

- Control the fuel injection volume precisely by MDP learning even for the old injector.
- ECU corrects the pilot injection effectively by MDP control.
- MDP learning is performed by the signal from knock sensor.

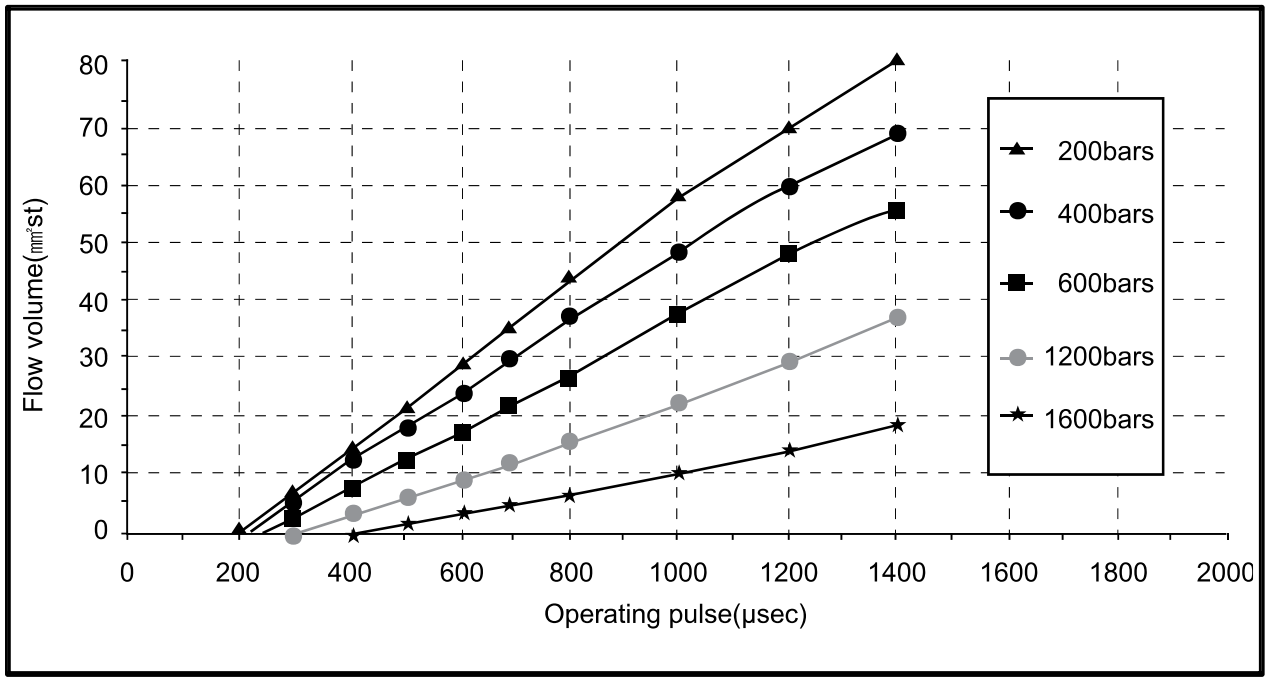
C. Learning Conditions

	Idle MDP learning	Drive MDP learning
Coolant temperature	over 60℃	over 60℃
Vehicle speed	Idling	over 50km/h (over 5 seconds)
Engine rpm		2,000 to 2,500 rpm
Fuel temperature	0 < Fuel temperature < 80℃	
Learning	2 times for each cylinder (every 5 seconds)	2 times for each cylinder (every 5 seconds)

CAUTION

- If MDP learning is not properly performed, engine vibration and injection could be occurred.
- MDP learning should be performed after replacing ECU, reprogramming and replacing injector.

D. Injector characteristic curve for rail pressure



Modification basis	
Application basis	
Affected VIN	

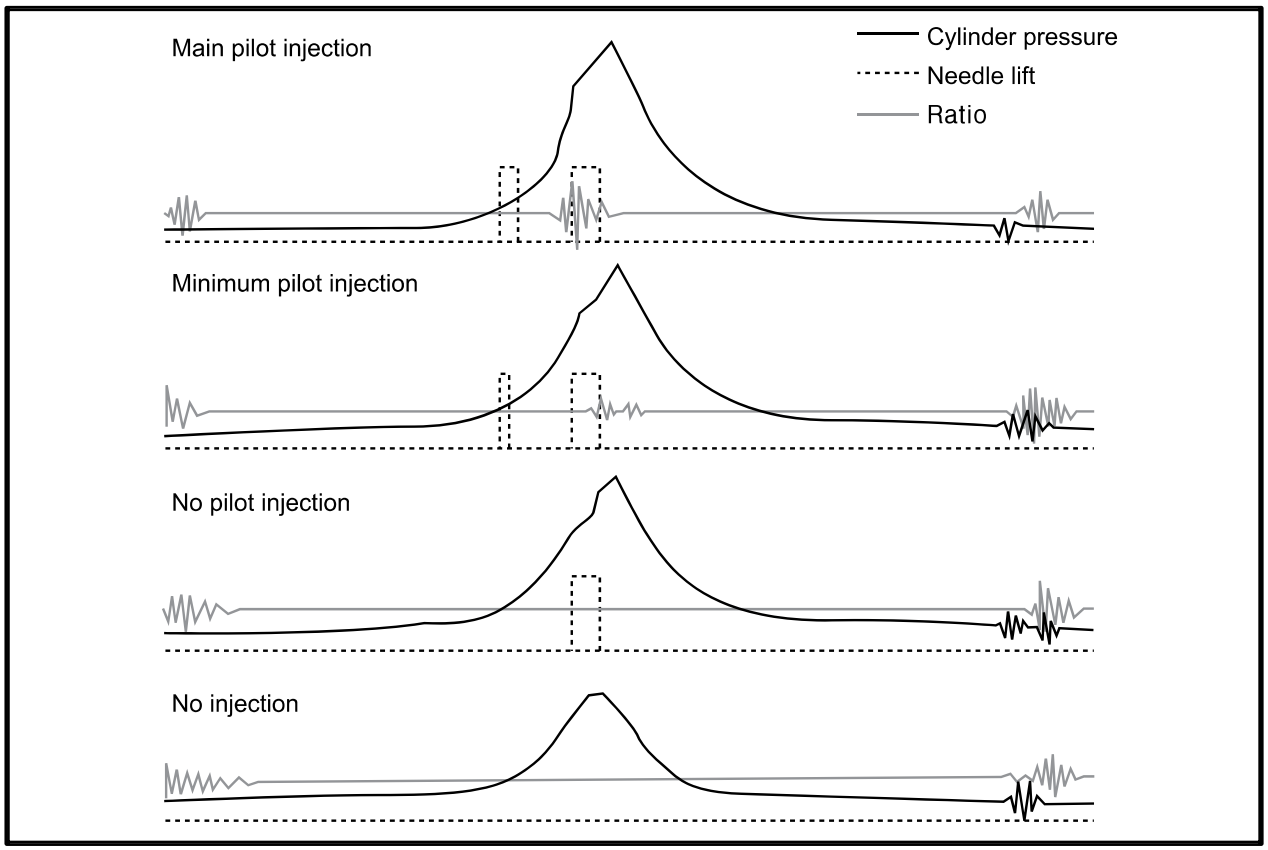
(7) Knocking Control

A. Resetting the pilot injection

The knocking control is used to reset the pilot injection flow in closed loop for each injector. This method allows the correction of any injector deviations over a period of time. The principle of use of the knocking control is based on the detection of the combustion noises.
The sensor is positioned in such a way as to receive the maximum signal for all the cylinders. The raw signals from the knock sensor are processed to obtain a variable which quantifies the intensity of the combustion. This variable, known as the ratio, consists of the ratio between the intensity of the background noise and the combustion noise.

1. A first window is used to establish the background noise level of the knocking control signal for each cylinder. This window must therefore be positioned at a moment when there cannot be any combustion.
2. The second window is used to measure the intensity of the pilot combustion. Its position is such that only the combustion noises produced by the pilot injection are measured . It is therefore placed just before the main injection.

The knock sensor does not allow any evaluation of the quantity injected. However, the pulse value will be measured when the injector starts injection and this pulse value is called the MDP (Minimum Drive Pulse). On the basis of this information, it is possible to efficiently correct the pilot flows. The pilot injection resetting principle therefore consists of determining the MDP, in other words the pulse corresponding to the start of the increase in value of the ratio (increase of vibration due to fuel combustion).



This is done periodically under certain operating conditions. When the resetting is finished, the new minimum pulse value replaces the value obtained during the previous resetting. The first MDP value is provided by the C3I. Each resetting then allows the closed loop of the MDP to be updated according to the deviation of the injector.

B. Detection of leaks in the cylinders

The accelerometer is also used to detect any injector which may have stuck open. The detection principle is based on monitoring the ratio. If there is a leak in the cylinder, the accumulated fuel self-ignites as soon as the temperature and pressure conditions are favorable (high engine speed, high load and small leak).
This combustion is set off at about 20 degrees before TDC and before main injection.
The ratio therefore increases considerably in the detection window. It is this increase which allows the leaks to be detected. The threshold beyond which a fault is signaled is a percentage of the maximum possible value of the ratio.
Because of the severity of the recovery process (engine shut-down), the etection must be extremely robust.
An increase in the ratio can be the consequence of various causes:

- Pilot injection too much
- Main combustion offset
- Fuel leak in the cylinder

If the ratio becomes too high, the strategy initially restricts the pilot injection flow and retards the main injection. If the ratio remains high despite these interventions, this shows that a real leak is present, a fault is signaled and the engine is shut down.

C. Detection of an accelerometer fault

This strategy permits the detection of a fault in the sensor or in the wiring loom connecting the sensor to the ECU.
It is based on detection of the combustion. When the engine is idling, the detection window is set too low for the combustion caused by the main injection. If the ratio increases, this shows that the knock sensor is working properly, but otherwise a fault is signaled to indicate a sensor failure. The recovery modes associated with this fault consist of inhibition of the pilot injection and discharge through the injectors.

Modification basis	
Application basis	
Affected VIN	

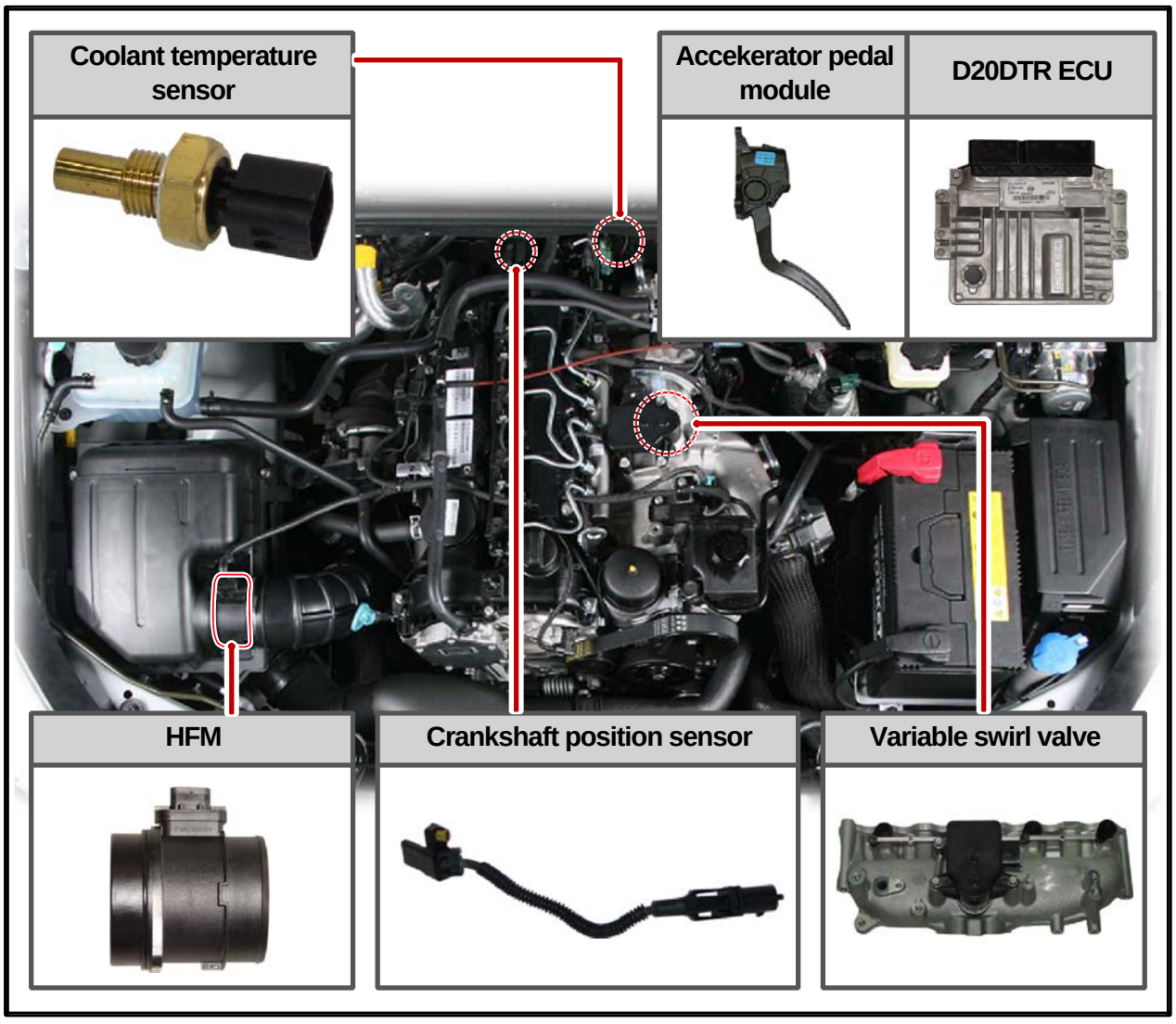
(8) Swirl control

A. Overview

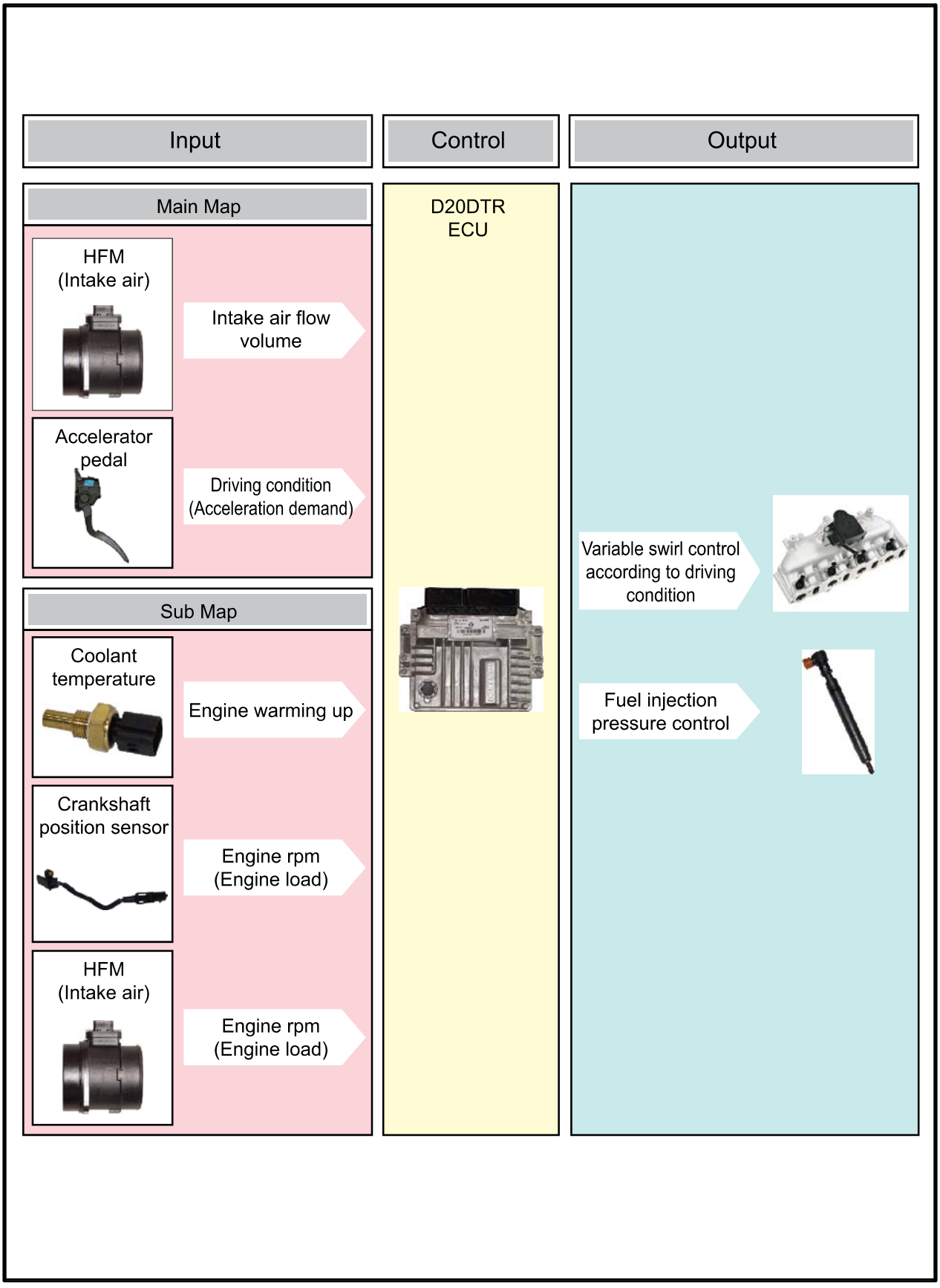
▶ Variable swirl valve

The strong swirl caused by intake air is important element for anti-locking function in diesel engine. The swirl control valve partially closes the intake port to generate the swirl according to the engine conditions. When the engine load is in low or medium range, the swirl could not be generated because the air flow is slow. To generate strong swirl, there are two passages in intake manifold, and one of them has the valve to open and close the passage. When the valve closes the passage, the air flow through the another passage will be faster, and the strong swirl will be generated by the internal structure of the passage. This swirl makes the better mixture of air and fuel, eventually the combustion efficiency in combustion chamber could be improved. This provides the enhanced fuel consumption, power and EGR ratio.

▶ Components

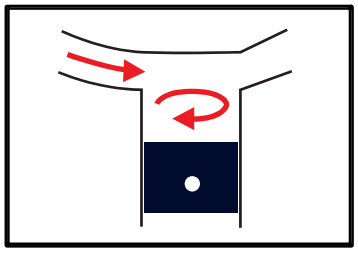


B. Input/Output for variable swirl valve

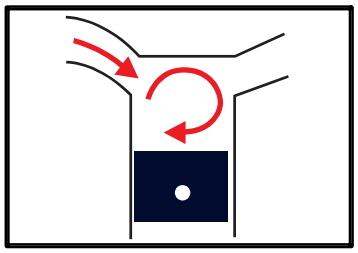


Modification basis	
Application basis	
Affected VIN	

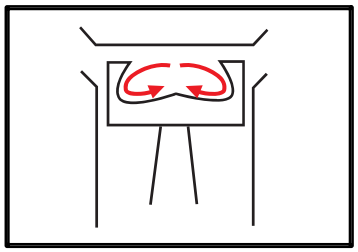
C. Types of swirl



Swirl: One cylinder has two intake air ports, one is set horizontally and the other one is set vertically. Swirl is the horizontal air flows in cylinder due to the horizontal intake air ports.



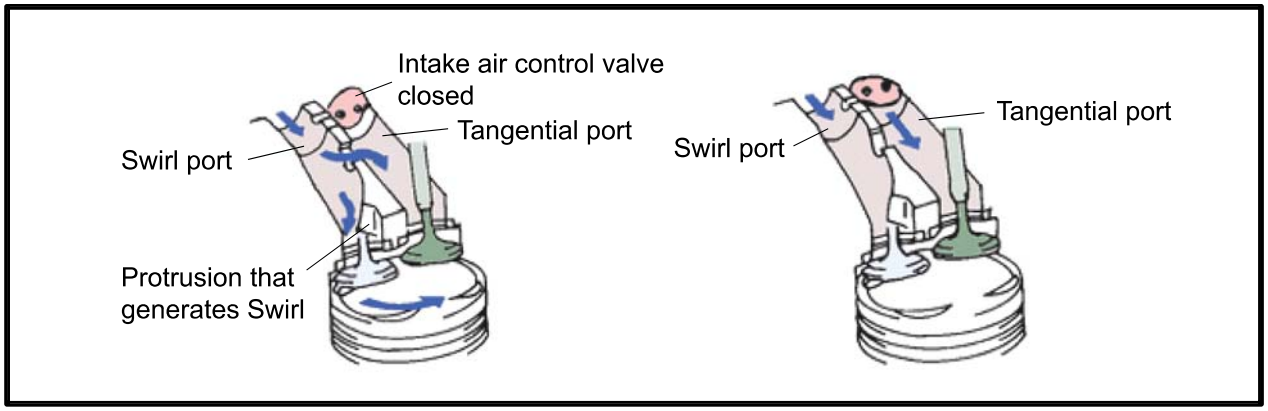
Tumble: Tumble is the vertical air flows in cylinder due to the vertical intake air port



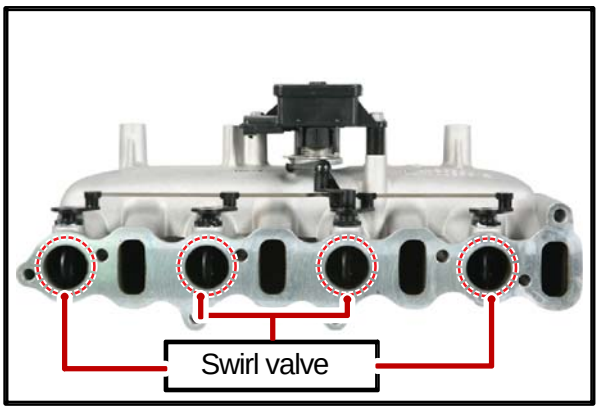
Tumble: Tumble is the vertical air flows in cylinder due to the vertical intake air port

D. Swirl control

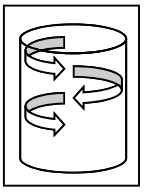
In DI type diesel engine, the liquefied fuel is injected into the cylinder directly. If the fuel is evenly distributed in short period, the combustion efficiency could be improved. To get this, there should be good air flow in cylinder. In general, there are two intake ports, swirl port and tangential port, in each cylinder. The swirl port generates the horizontal flow and the tangential port generates the longitudinal flow. In low/mid load range, the tabgential port is closed to increase the horizontal flow. Fast flow decreases the PM during combustion and increases the EGR ratio by better combustion efficiency.



Load	Engine speed	Swirl valve	Amount of swirl	Remarks
Low speed, Low load	below 3,000 rpm	Closed	Heavy	Increased EGR ratio, better air-fuel mixture (reduce exhaust gas)
High speed, High load	over 3,000 rpm	Open	Light	Increase charge efficiency, higher engine power



The variable swirl valve actuator operates when turning the ignition switch ON/OFF position to open/close the swirl valve. In this period, the soot will be removed and the learning for swirl valve position is performed.



NOTE

Swirl: This is the twisted (radial) air flow along the cylinder wall during the intake stroke. This stabilizes the combustion even in lean air-fuel mixture condition.

E. Features

- Swirl and air intake efficiency
  To generate the swirl, the intake port should be serpentine design. This makes the resistance in air flow. The resistance in air flow in engine high speed decreases the intake efficiency. Eventually, the engine power is also decreased, Thus, the swirl operation is deactivated in high speed range to increase the intake efficiency.
- Relationship between swirl and EGR
  To reduce Nox, it is essential to increase EGR ratio. However, if EGR ratio is too high, the PM also could be very higher. And, the exhaust gas should be evenly mixed with newly aspired air. Otherwise, PM and CO are dramatically increased in highly concentrated exhaust gas range and EGR ratio could not be increased beyond a certain limit. If the swirl valve operates in this moment, the limit of EGR ratio will be higher.

F. Relationship between swirl and fuel injection pressure

The injector for DI engine uses the multi hole design. For this vehicle, there are 8 holes in injector. If the swirl is too strong, the injection angles might be overlapped and may cause the increased PM and insufficient engine power. Also, if the injection pressure is too high during strong swirl, the injection angles might be overlapped. Therefore, the system may decreases the fuel injection pressure when the swirl is too strong.

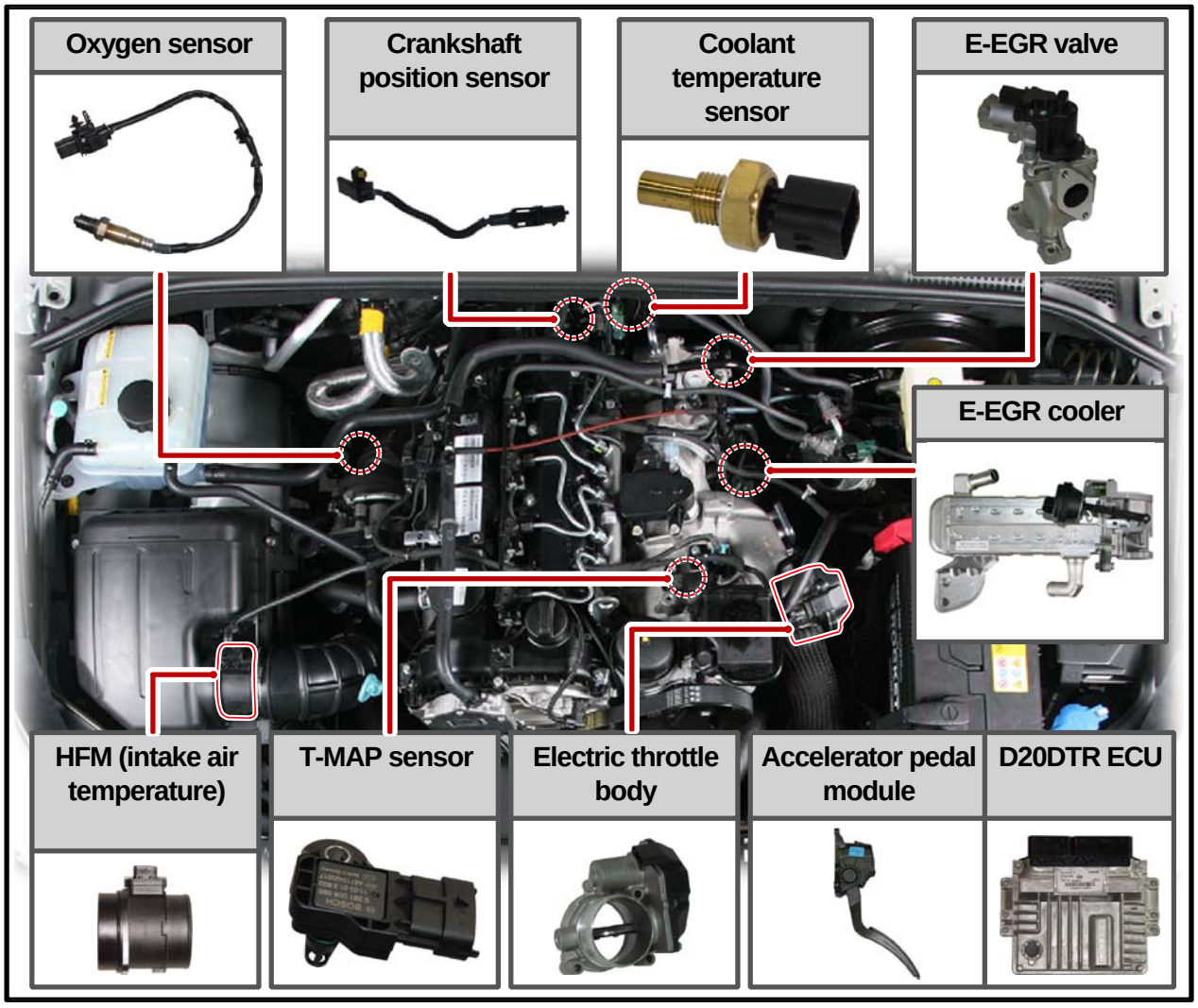
Modification basis	
Application basis	
Affected VIN	

(9) EGR control

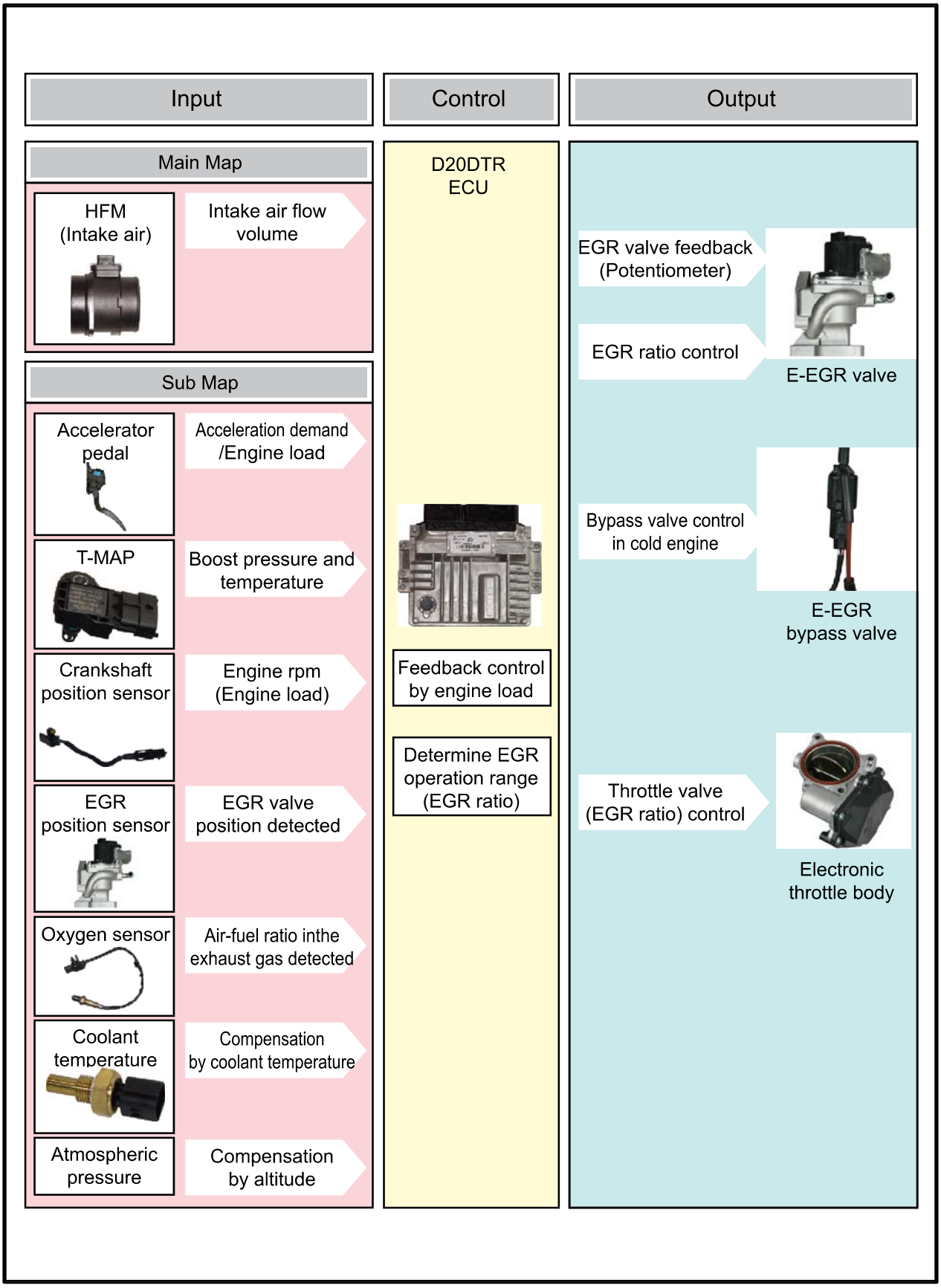
A. Overview

The EGR (Electric-Exhaust Gas Recirculation) valve reduces the NOx emission level by recirculating some of the exhaust gas to the intake system.
To meet Euro-V regulation, the capacity and response rate of E-EGR valve in D20DTR engine have been greatly improved. The EGR cooler with high capacity reduces the Nox, and the bypass valve reduces the CO and HC due to EGR gas before warming up.
Also, the engine ECU adjusts the E-EGR opening by using the air mass signal through HFM sensor. If the exhaust gas gets into the intake manifold when the EGR valve is open, the amount of fresh air through HFM sensor should be decresed.

B. Components



C. Input/Output of E-EGR system

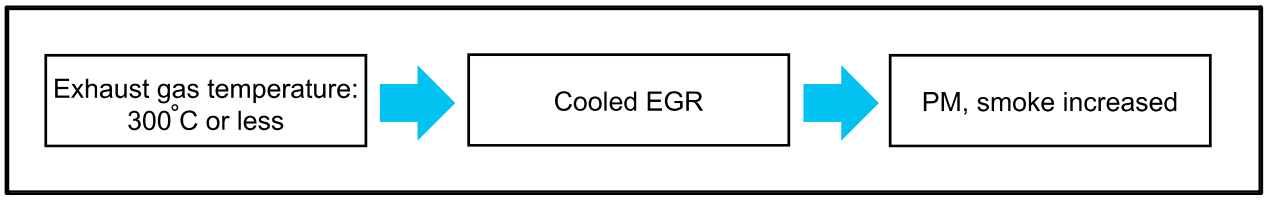


Modification basis	
Application basis	
Affected VIN	

D. Bypass control for EGR cooler

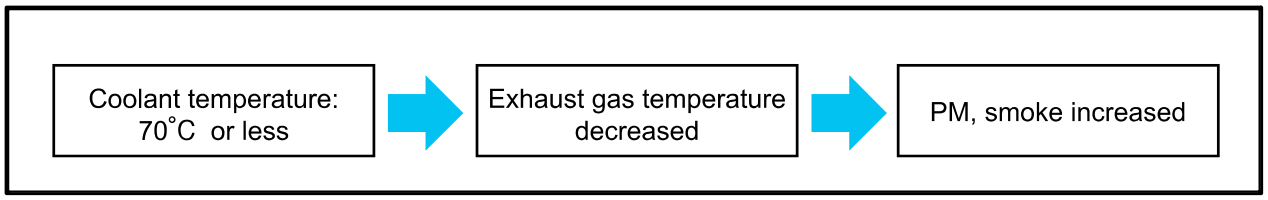
▶ Cooler temperature

When the coolant temperature is below 70℃, the exhaust gas is bypassed the EGR cooler.



▶ Exhaust gas temperature

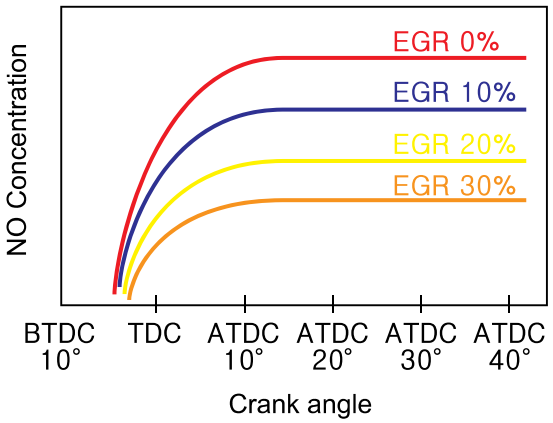
When the exhaust gas temperature is below 300℃, the exhaust gas is bypassed the EGR cooler. Otherwise, PM could be increased due to too low exhaust gas temperature.



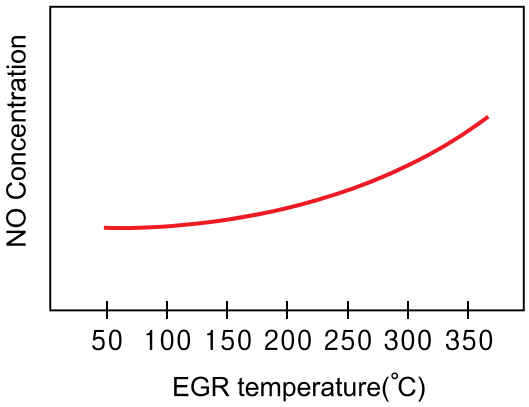
E. Control elements for EGR system

- Accelerator pedal (engine load) - Indicates the driver's intention and engine load. If the load goes up, the EGR ratio is decreased.
- T-MAP (boost pressure map stored in ECU) - Compensates the difference in boost pressure by adjusting EGR ratio.
- Engine rpm - Used as the signal for determining EGR operating range.
- Coolant temperature - When the coolant temperature is low, NOx is decreased but PM could be increased. So, to reduce PM, decrease EGR ratio when the coolant temperature is low.
  Intake air mass and temperature - HFM sensor measures the intake air mass to calculate the actual EGR volume. If the air mass is larger than programmed value in map, EGR ratio will be higher.
  EGR position sensor - Detects the actual opening angle of EGR valve and performs feedback
- function according to PWM control by ECU.
  Wide band oxygen sensor - Detects the oxygen volume in exhaust gas to check if the EGR ratio is
- proper.
  Electronic throttle body - Keeps EGR ratio to optimized level by controlling the throttle body in EGR
- operating range (decreasing pressure in intake manifold).

F. Features



As EGR ratio goes up, smoke volume will be higher. But, this lowers the combustion chamber temperature and accordingly the concentration of NOx is decreased. The point with highest NOx is immediately after TDC.



As EGR temperature goes up, the concentration of NOx will be higher. Thus, it is necessary to cool down the exhaust gas. However, during engine cooled, it may cause large amount of PM. To prevent this, the exhaust gas is bypassed the EGR cooler.

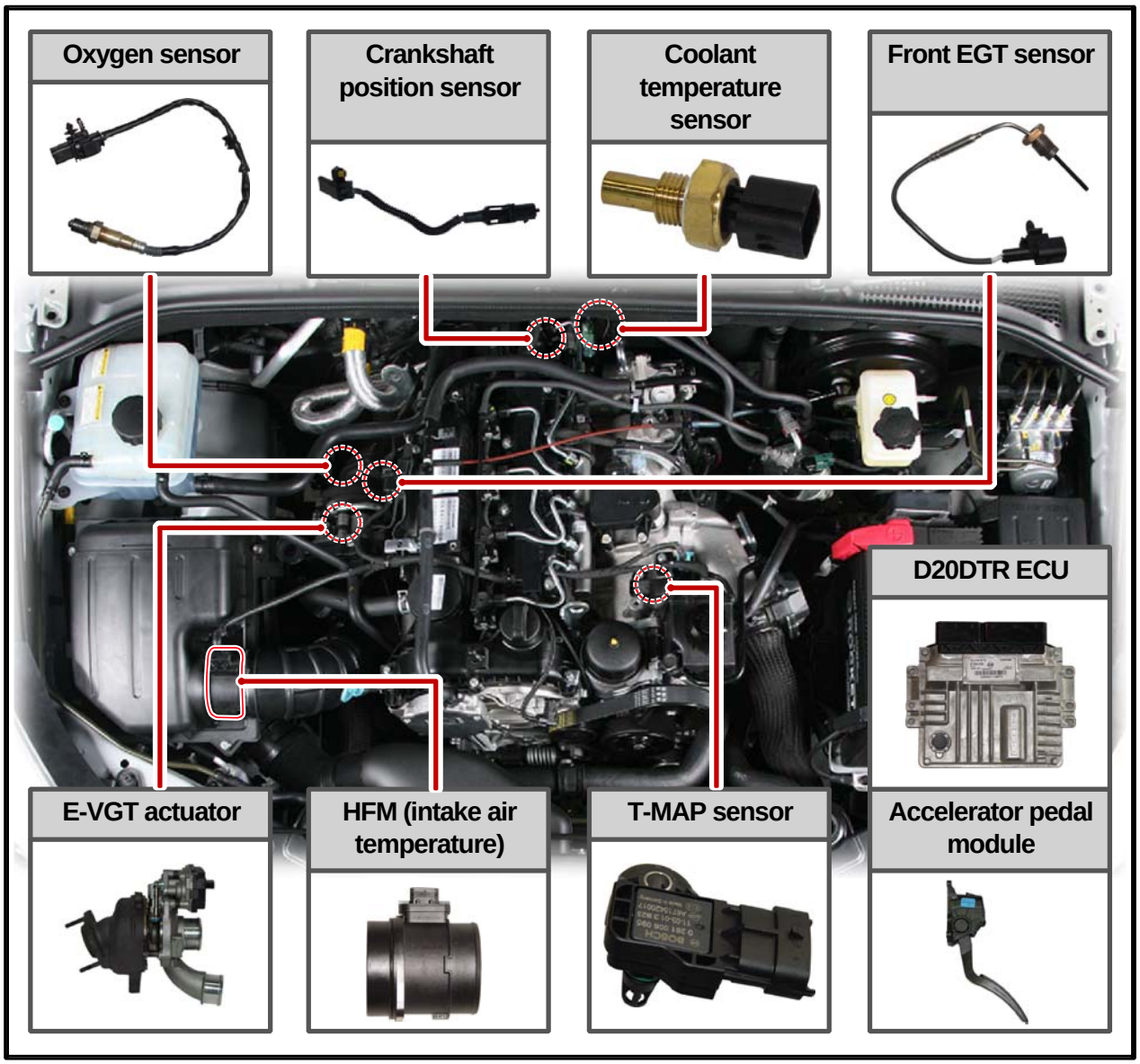
Modification basis	
Application basis	
Affected VIN	

(10) E-VGT control

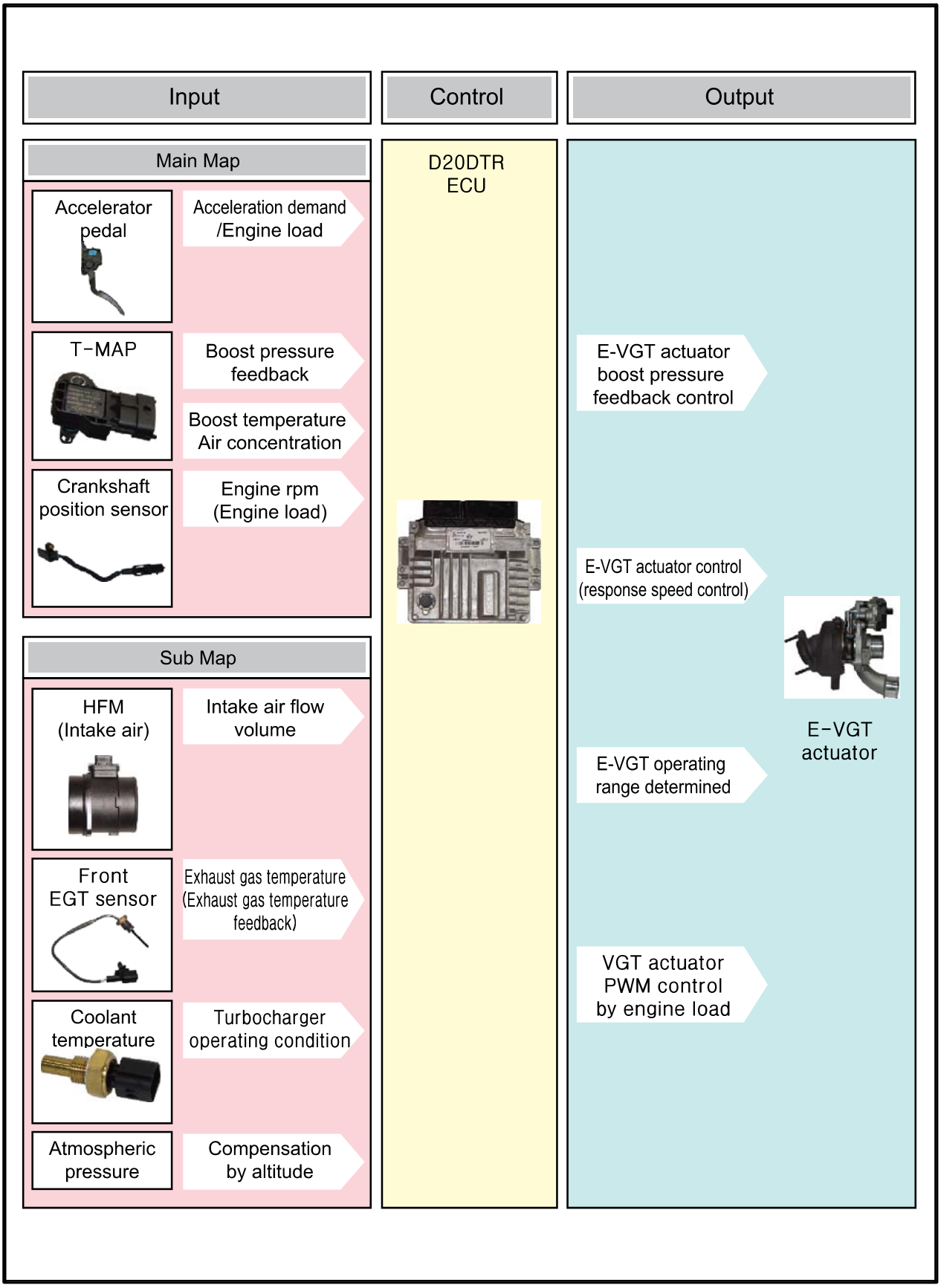
A. Overview

E-VGT (Electric-Variable Geometry Turbine) turbocharger system in D20DTF engine uses the venturi effect that controls the flow rate of exhaust gas by adjusting the passage in turbine housing. The newly adopted DC motor actuator (E-actuator) controls the E-VGT system more precisely and faster. To get the high operating power from turbine, the ECU reduces the exhaust gas passage In low speed range and increases it in high speed range.

B. Components



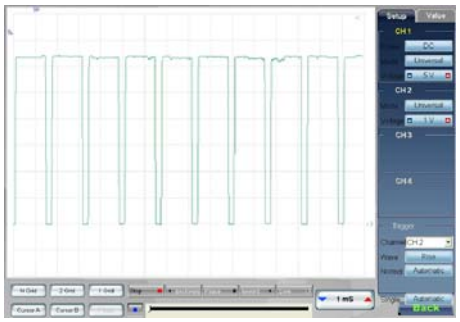
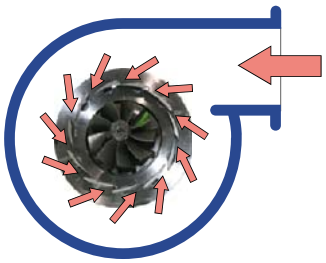
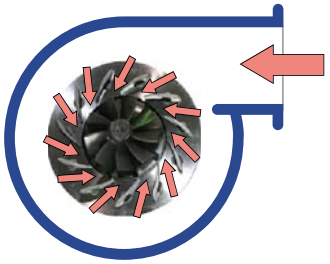
C. Input/Output for E-VGT system



Modification basis	
Application basis	
Affected VIN	

D. E-VGT system control

Turbocharger system operates the E-VGT actuator according to the signals for engine epm, accelerator pedal position, atmospheric pressure, T-MAP, coolant temperature and intake air temperature.
Turbocharger actuator is performed PWM control by ECU.
In general, the boost pressure feedbacks the turbocharger operation and the boost temperature is used for calculating the precise density.
E-VGT provides higher engine power with faster reaction speed compared to conventional VGT.

	Operating wave	Vane	Control
Low speed range			In low speed range: retract the vane to increase boost pressure. The vane has low (-) duty, and the unison ring moves to retract the vane in weak PWM signal.
High speed range			The unison ring moves to extend the vane in strong PWM signal. Maximum pressure is 3 bar and the system controls it according to the input signals.

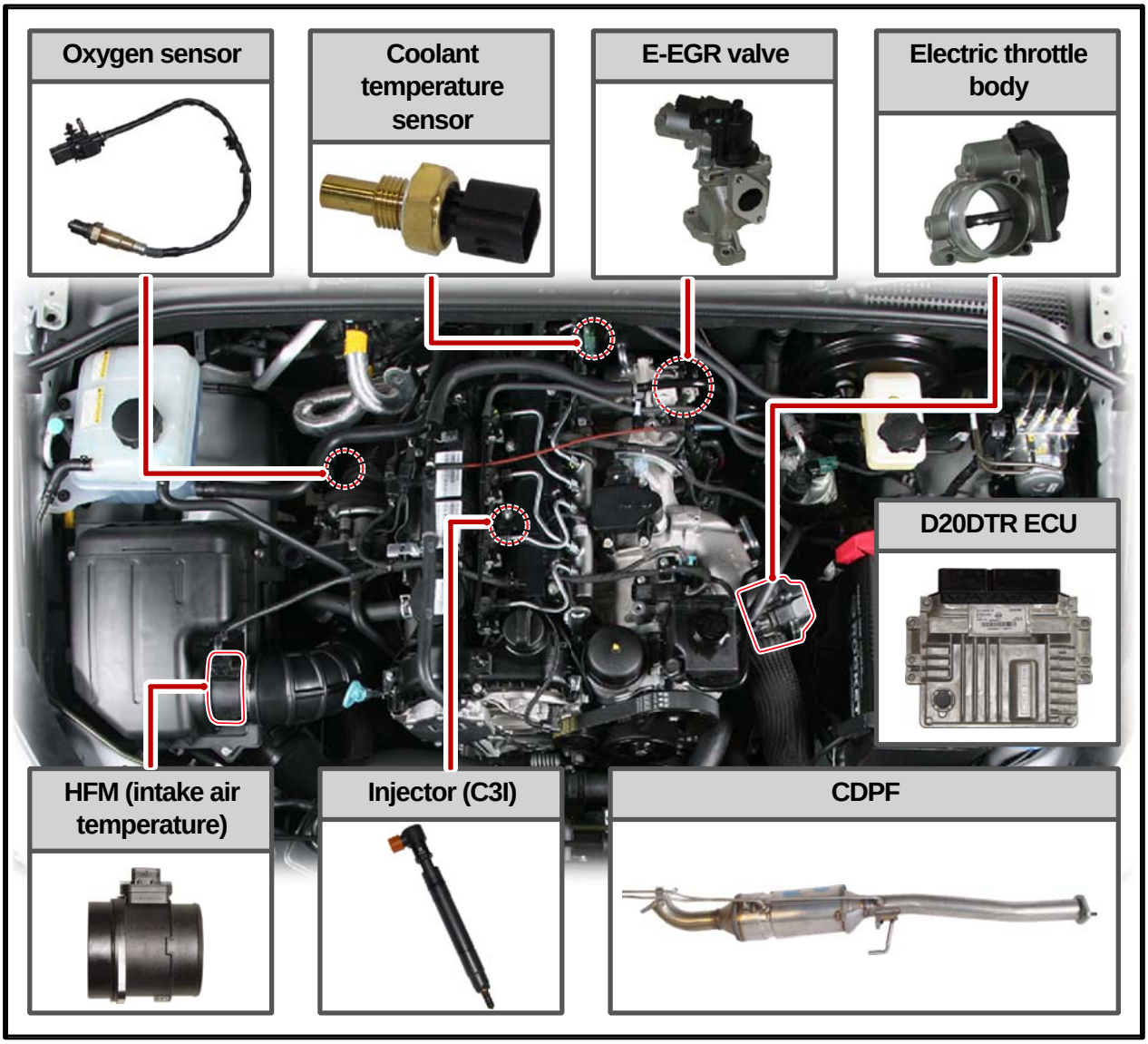
(11) Wide band oxygen sensor control

A. Overview

For diesel engine, combustion is not performed at the optimum (theoretically correct) air-fuel ratio and the oxygen concentration is thin in most cases. So the wide-band oxygen sensor is used for this kind of engine, and this sensor is a little different from the one that used for gasoline engine. The combustion in diesel engine is controlled by fuel injection volume. Therefore, the wide band oxygen sensor should be used in diesel engine. This sensor measures the air-fuel ratio in very wide range, and is also called full range oxygen sensor.

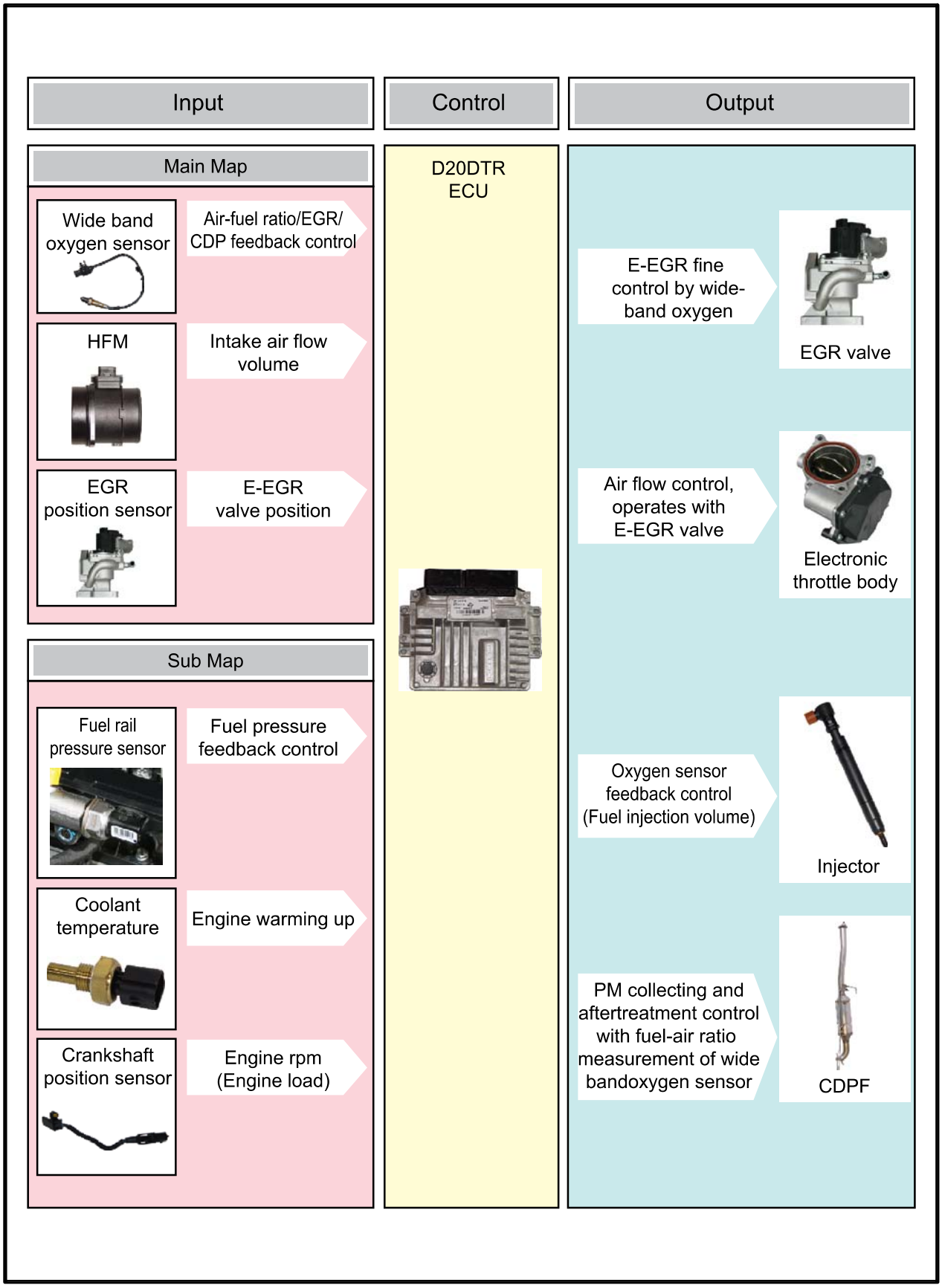
- The wide band oxygen sensor measures the oxygen density in exhaust gas and sends it to ECU to control the EGR more precisely.

B. Components



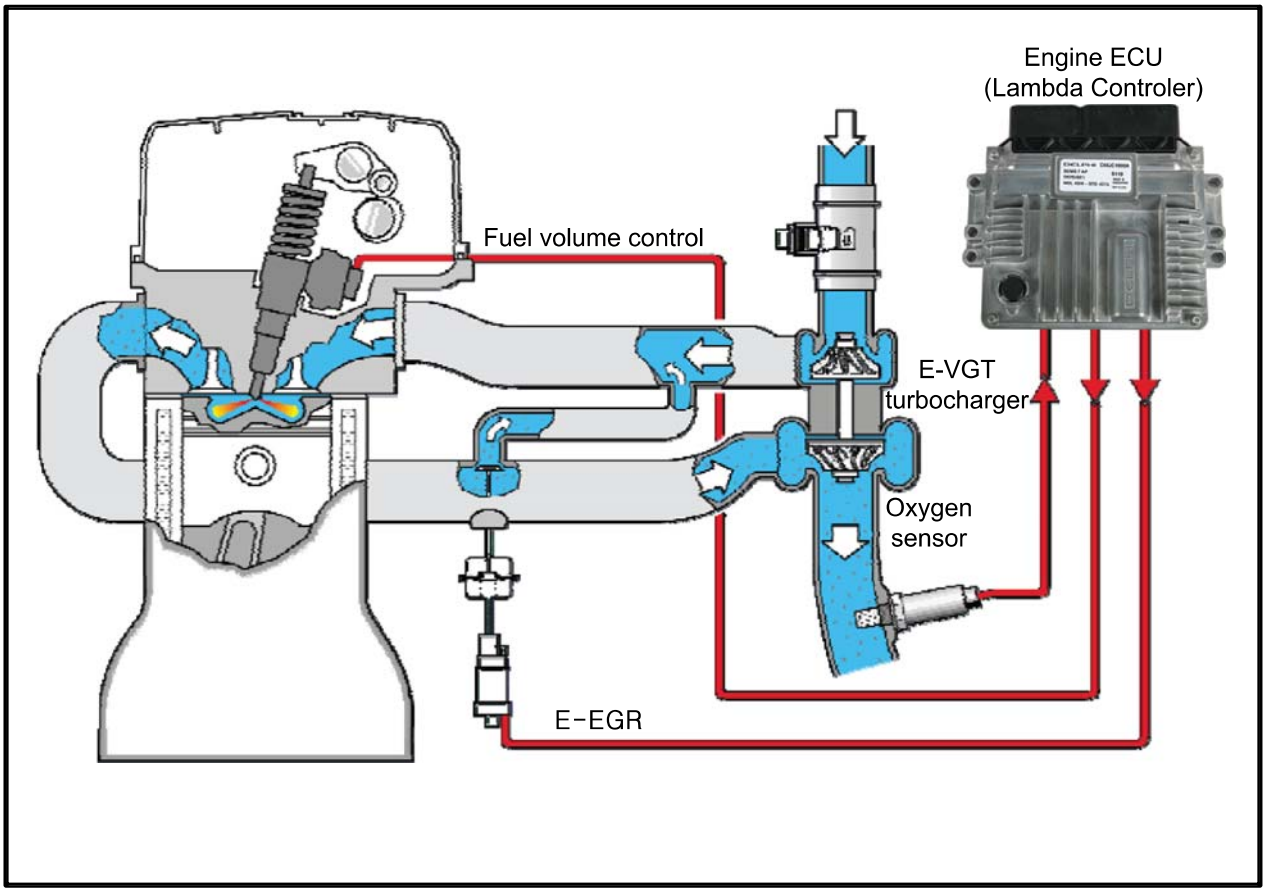
Modification basis	
Application basis	
Affected VIN	

C. Input/Output for oxygen sensor



D. Oxygen sensor control

The wide band oxygen sensor uses ZnO2. It produces the voltage by movement of oxygen ions when there is oxygen concentration difference between exhaust gas and atmosphere.
If a certain voltage is applied to the sensor, the movement of oxygen ions occurs regardless of the oxygen density. The current generated through this flow of ions, is called pumping current (IP), and the oxygen sensor measures this value.



Modification basis	
Application basis	
Affected VIN	

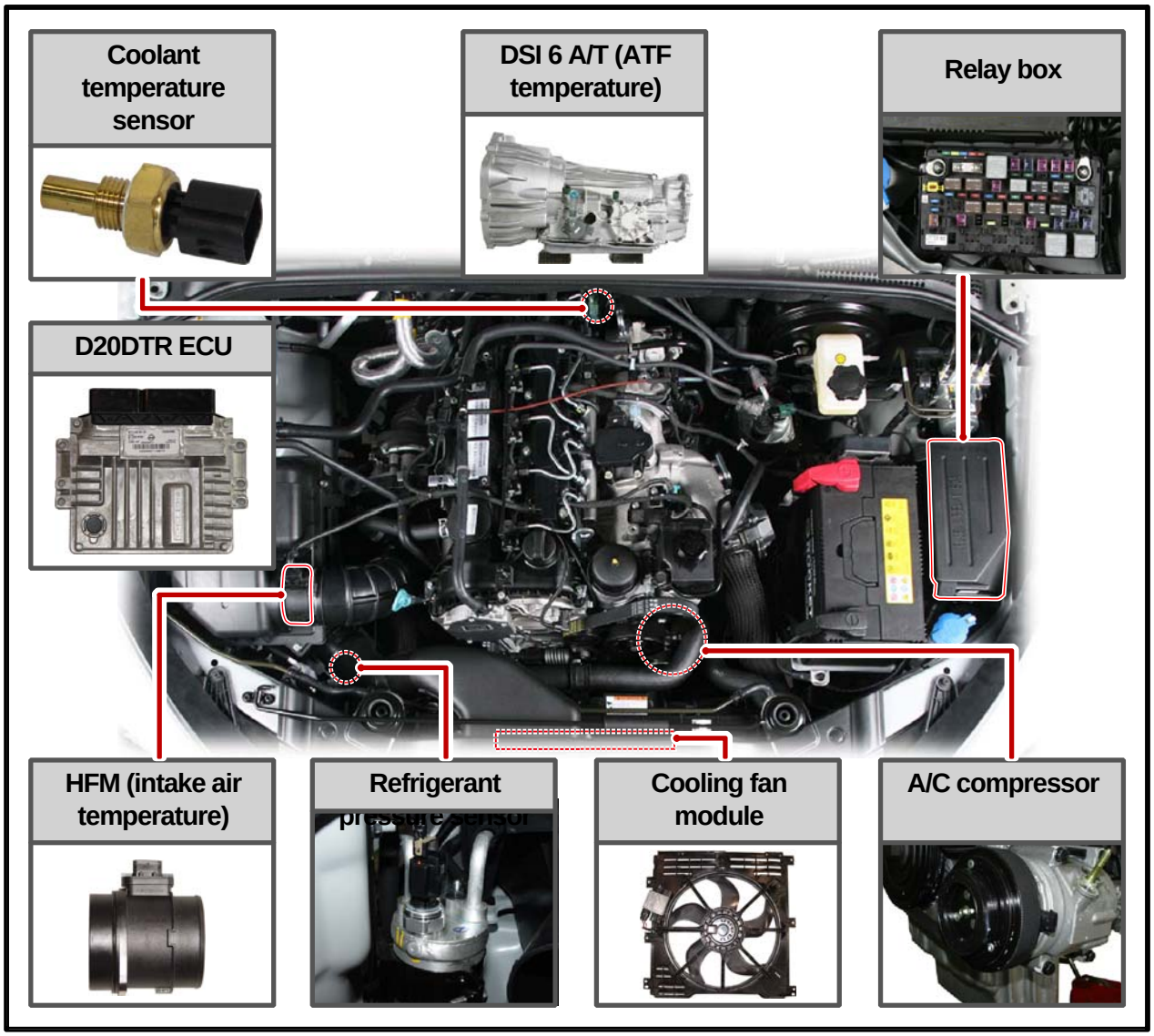
(12) Cooling fan control

A. Overview of cooling fan and A/C compressor

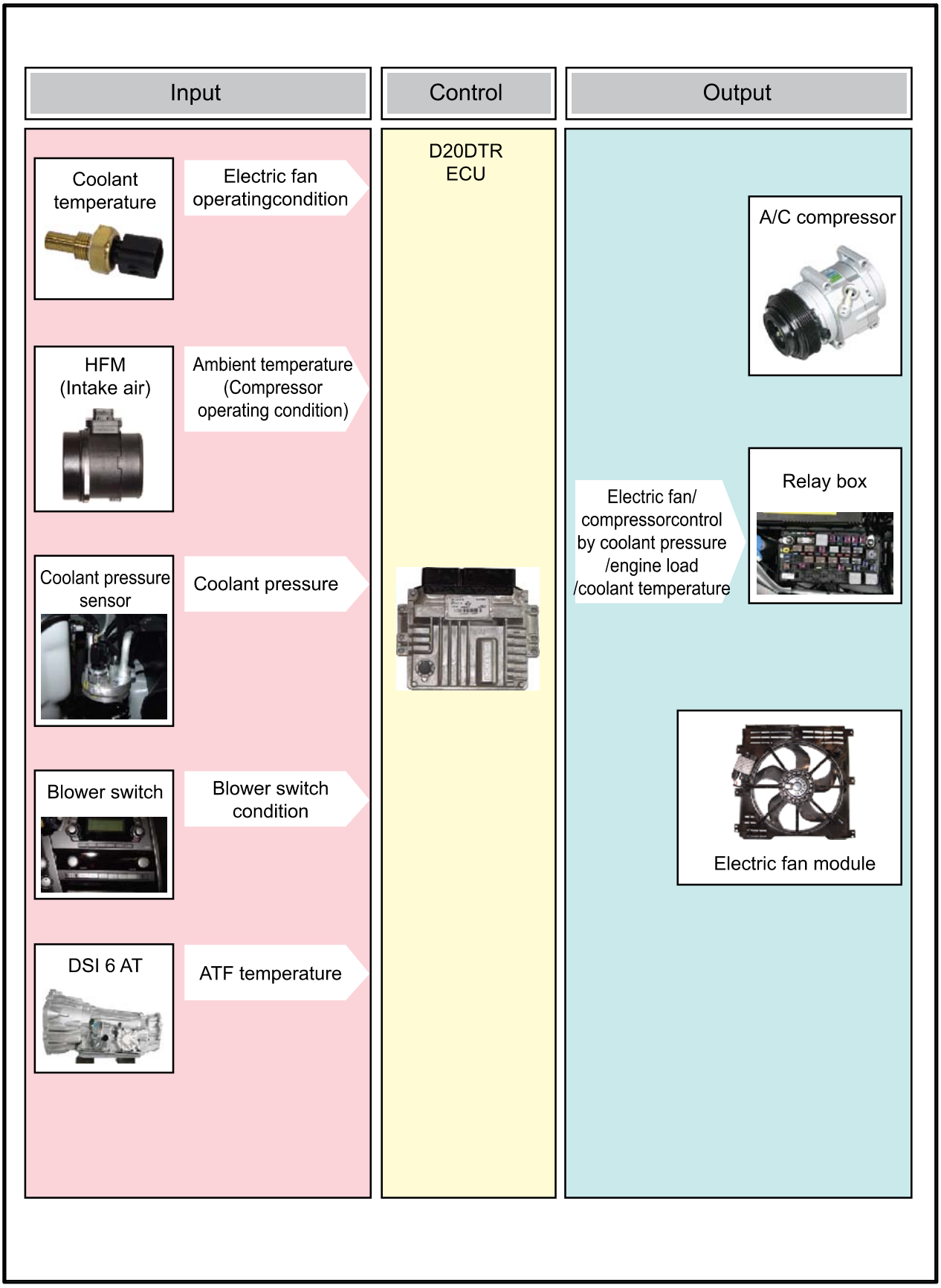
The cooling system maintains the engine temperature at an efficient level during all engine operating conditions. The water pump draws the coolant from the radiator. The coolant then circulates through water jackets in the engine block, the intake manifold, and the cylinder head. When the coolant reaches the operating temperature of the thermostat, the thermostat opens. The coolant then goes back to the radiator where it cools. The heat from automatic transmission is also cooled down through the radiator by circulating the oil through the oil pump. ECU controls the electric cooling fans with three cooling fan relays to improve the engine torque and air conditioning performance.

reference For detailed information, refer to Chapter "Air Conditioning System".

B. Components



C. Input/Output for cooling fan and A/C compressor



Modification basis	
Application basis	
Affected VIN	

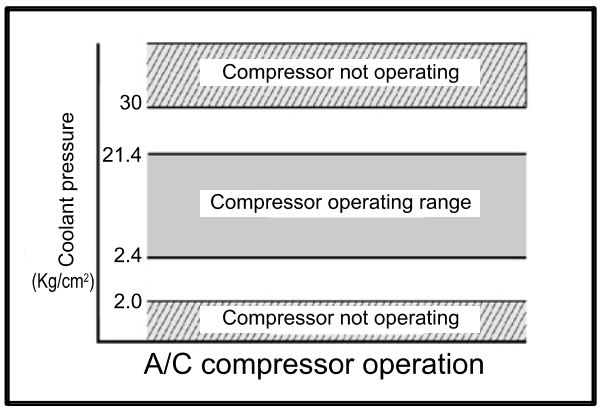
D. Cooling fan and A/C compressor control

▶ Conditions for cooling fan

The cooling fan module controls the cooling fan relay, high speed relay and low speed relay. The cooling fan is controlled by the series and parallel circuits.

A/C switch	Cooling fan	Coolant temperature	Refrigerant pressure	A/C compressor
OFF	OFF	Coolant temp. < 90℃	-	
	LO	90℃ ≤ Coolant temp. < 105℃	-	
	HI	105℃ ≤ Coolant temp.	-	
ON	LO	Coolant temp. < 105℃	Refrigerant pressure < 18 bar	ON
	HI		18 bar ≤ Refrigerant pressure	
	HI	105℃ ≤ Coolant temp. < 115℃	-	
	HI	115℃ ≤ Coolant temp.	-	OFF (cut)

▶ A/C compressor OFF conditions



A/C compressor operation

- Coolant temperature: below −20℃ or over 115℃
- Approx. 4 seconds after starting the engine
- Engine rpm: below 650 rpm or over 4500 rpm
- When abrupt acceleration
- Refrigerant pressure:
  * OFF below 2.0 kg/㎠, then ON over 2.4 kg/㎠
  * OFF over 30 kg/㎠, then ON below 21.4 kg/㎠

▶ Output voltage according to refrigerant pressure

The output voltage from refrigerant pressure sensor is 1.7 V to 3.5 V when the refrigerant pressure is 10 to 24 kgf/㎠ with A/C "ON".

▶ Cooling fan controls according to ATF

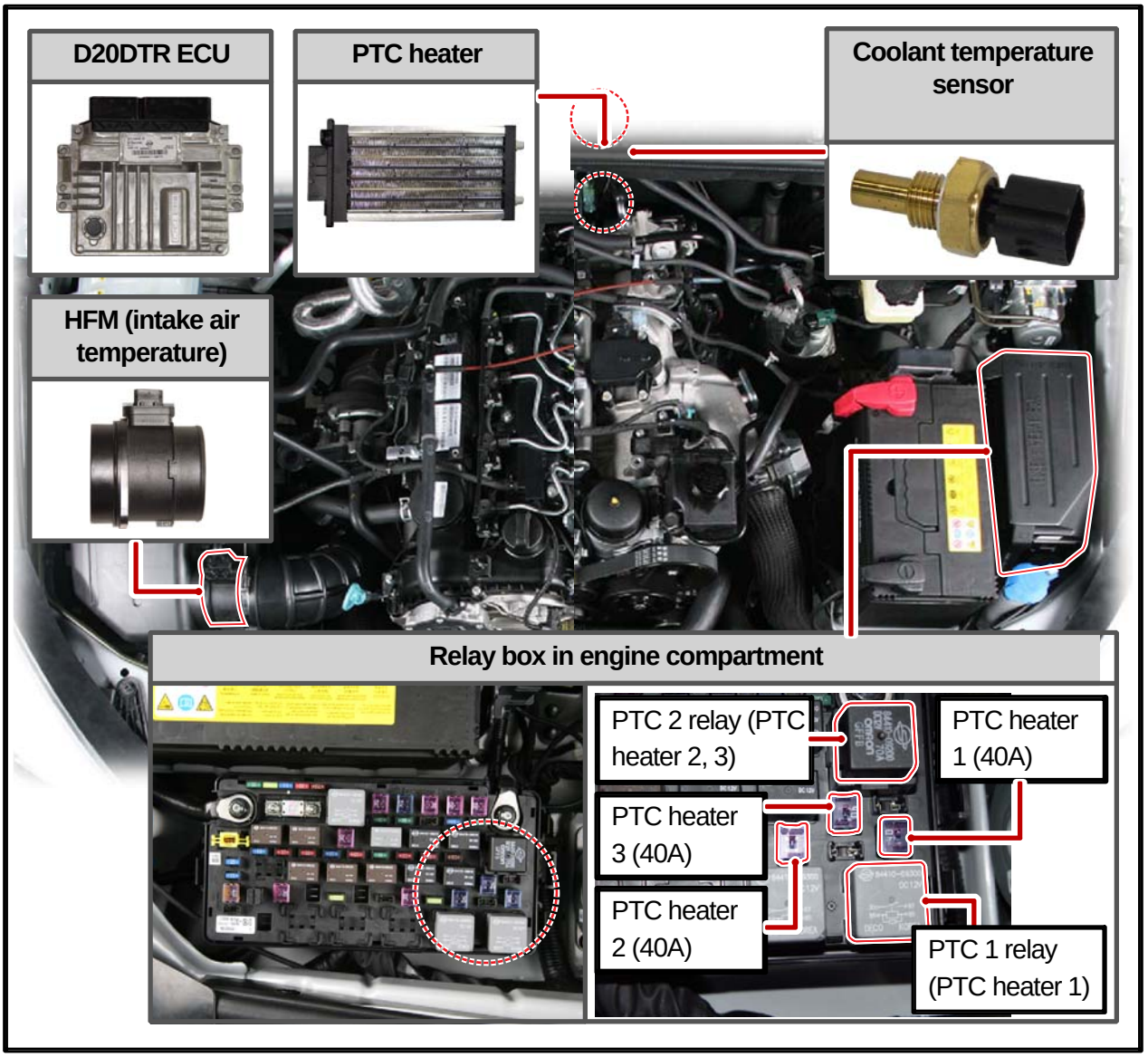
ATF temperature	Fan condition	Remark
Over 110˚C	High speed	-

(13) PTC heater control

A. Overview

The supplementary electrical heater is installed in DI engine equipped vehicle as a basic equipment. The PTC system is operated according to two temperature values measured at the coolant temperature sensor and HFM sensor. This device is mounted in the heater air outlet and increase the temperature of air to the passenger compartment. Because PTC system is heated by electrical power, high capacity alternator is required. PTC does not operate during engine cranking, while the battery voltage is lower than 11 V or during preheating process of glow plugs.

B. Components

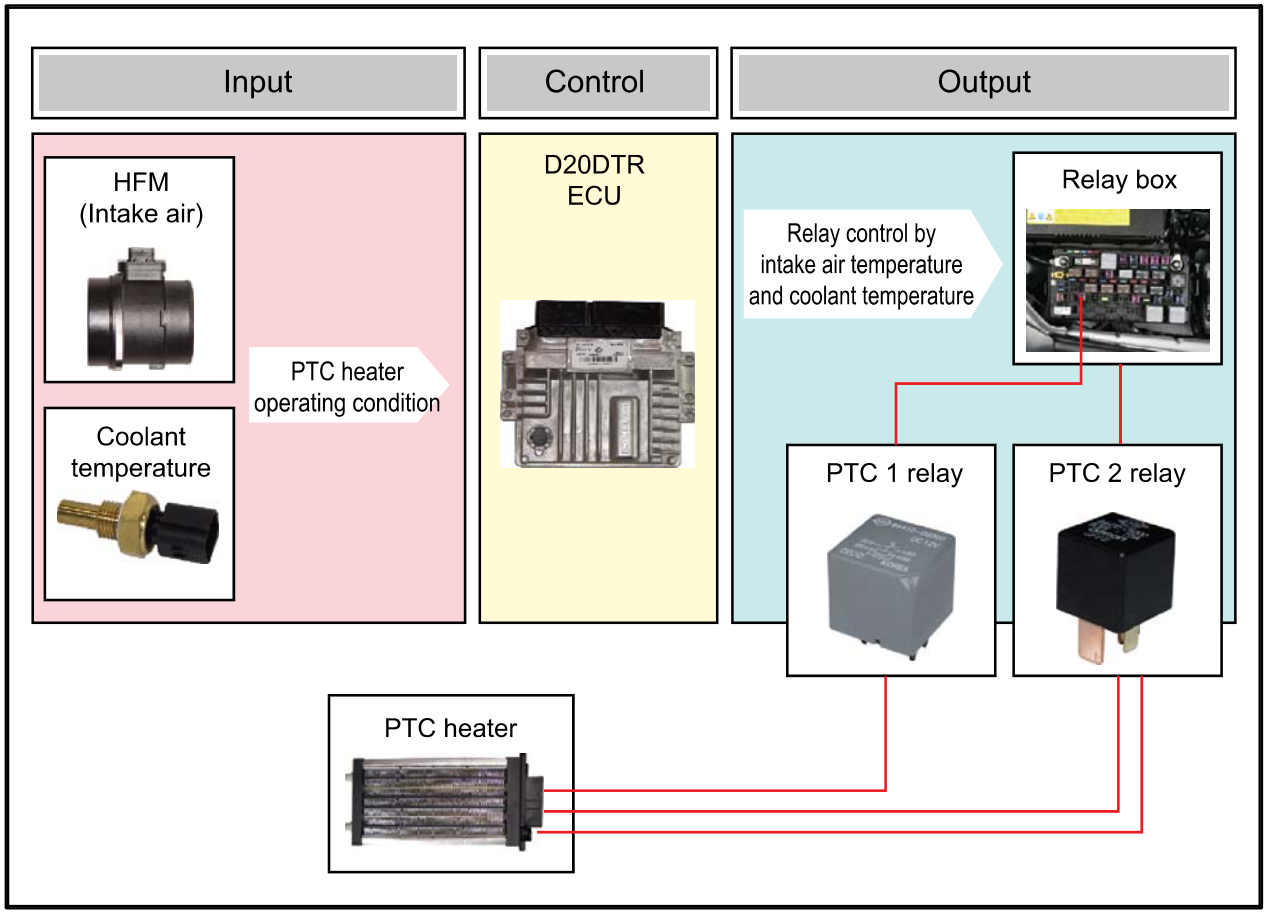


Modification basis	
Application basis	
Affected VIN	

C. Operation process

The ceramic PTC has a feature that the resistance goes up very high at a certain temperature. There are three circuits in PTC heater. Only one circuit is connected when PTC1 relay is ON, and two circuits are connected when PTC2 relay is ON.

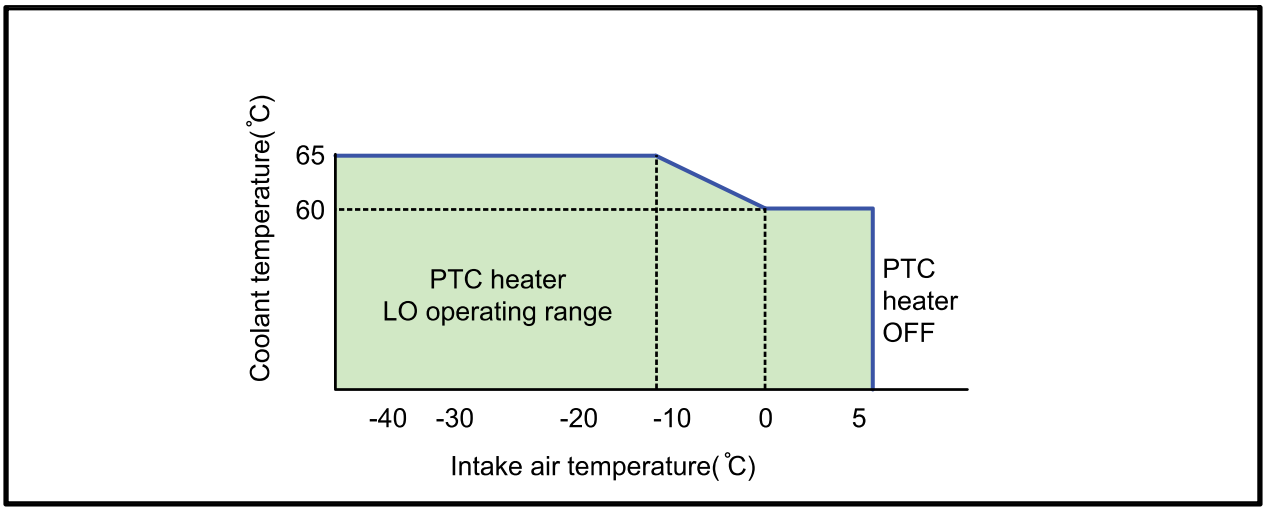
Operation process: reaches at a certain temperature→high resistance→low current→less heat radiation→temperature down→high resistance→high current→temperature up



D. Control conditions

Operation	Operating condition	PTC Heater
HI (PTC2)	- Coolant temperature < 15℃	PTC HI ON
LO (PTC1)	- Coolant temperature 15℃ ≤ 65℃, intake air temperature ≤ −10℃ - Coolant temperature 15℃ < 65 to 60℃, intake air temperature <−10℃ to 0℃ - Coolant temperature 15℃ ≤ 60℃, intake air temperature ≤ 0℃ to 5℃	PTC LO ON
Stop	- A/C blower switch OFF - Defective ambient air temperature sensor (including open or short circuit) - Engine cranking - Low battery voltage (below 11V) - During pre-glow process (glow indicator ON)	

▶ **Operation diagram for PTC heater LO (step 2)**



Modification basis	
Application basis	
Affected VIN	

(14) Immobilizer control

A. Overview

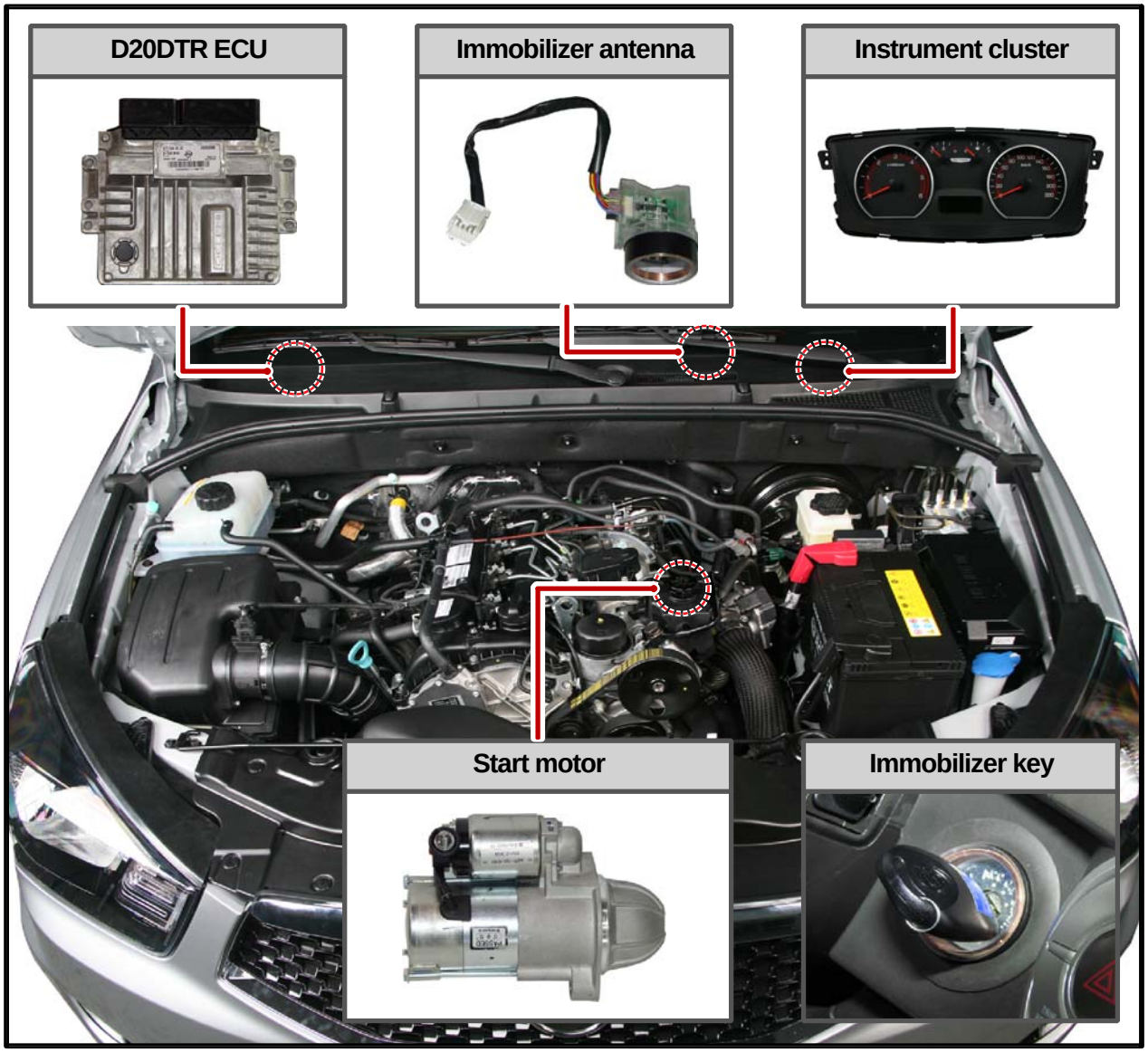
The Immobilizer System provides an additional theft deterrent to the vehicle in which it is installed and prevents it from being started by unauthorized persons. The transponder integrated in the key and the engine control unit have the same code. When the ignition key with the integrated transponder is turned to the ON position, the ECU (Engine Control Unit) checks the crypto code of the key and, if correct, allows the vehicle to start the engine.

NOTE

For details, refer to Chapter "Immobilizer".

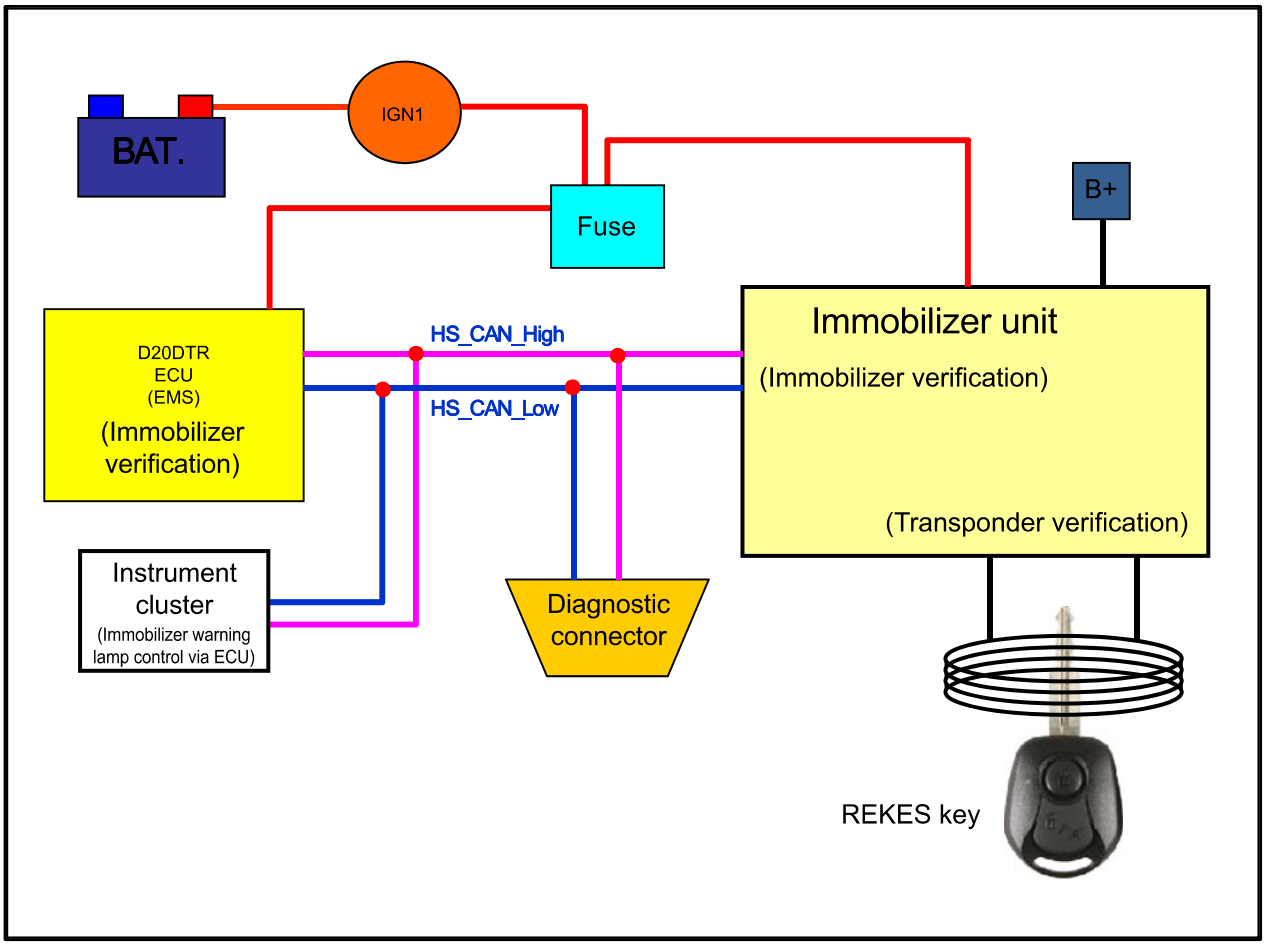
B. Components

▶ **Basic components (ignition key system)**



▶ Key approval process

When turning the ignition switch to ON position, the power is supplied to BCM and ECU. ECU communicate with the immobilizer key to check if it is valid crypto code. If it is valid, ECU start to control the engine when turning the ignition switch to START position. The system has 10 seconds of valid time-out period. If the engine does not start in this period, the key approval process should be done again.



Modification basis	
Application basis	
Affected VIN	

(15) CDPF control

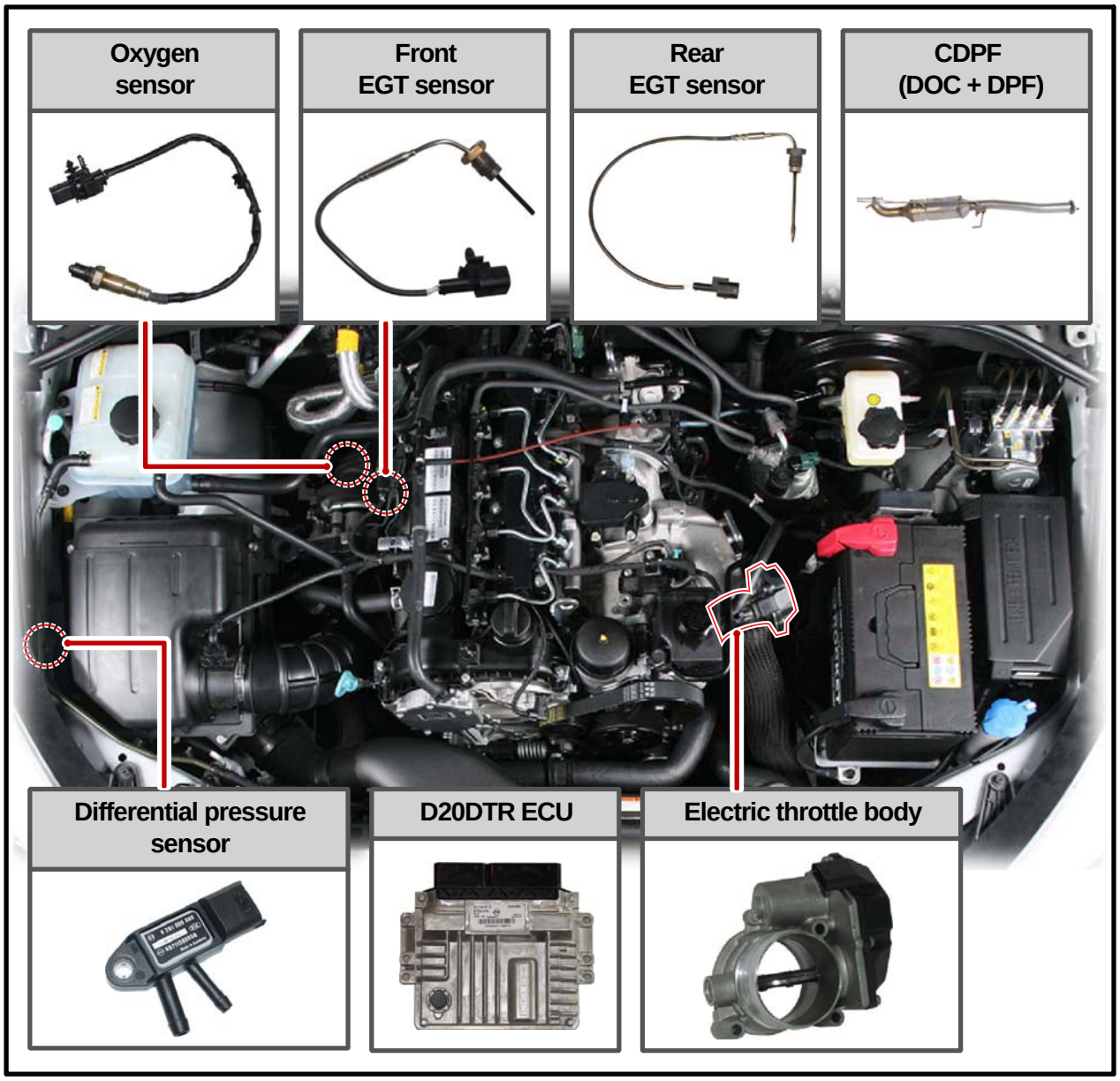
A. Overview

As the solution for environmental regulations and PM Particle Material) of diesel engine, the low emission vehicle is getting popular. This vehicle is equipped with an extra filter to collect the soot and burn it again so that the amount of PM in the exhaust gas passed through the DOC (Diesel Oxidation Catalyst) is reduced. The CDPF (Catalyst & Diesel Particulate Filter) is an integrated filter including DOC (Diesel Oxidation Catalyst) and DPF (Diesel Particulate Filter).

NOTE

For details, refer to Chapter "CDPF".

B. Components



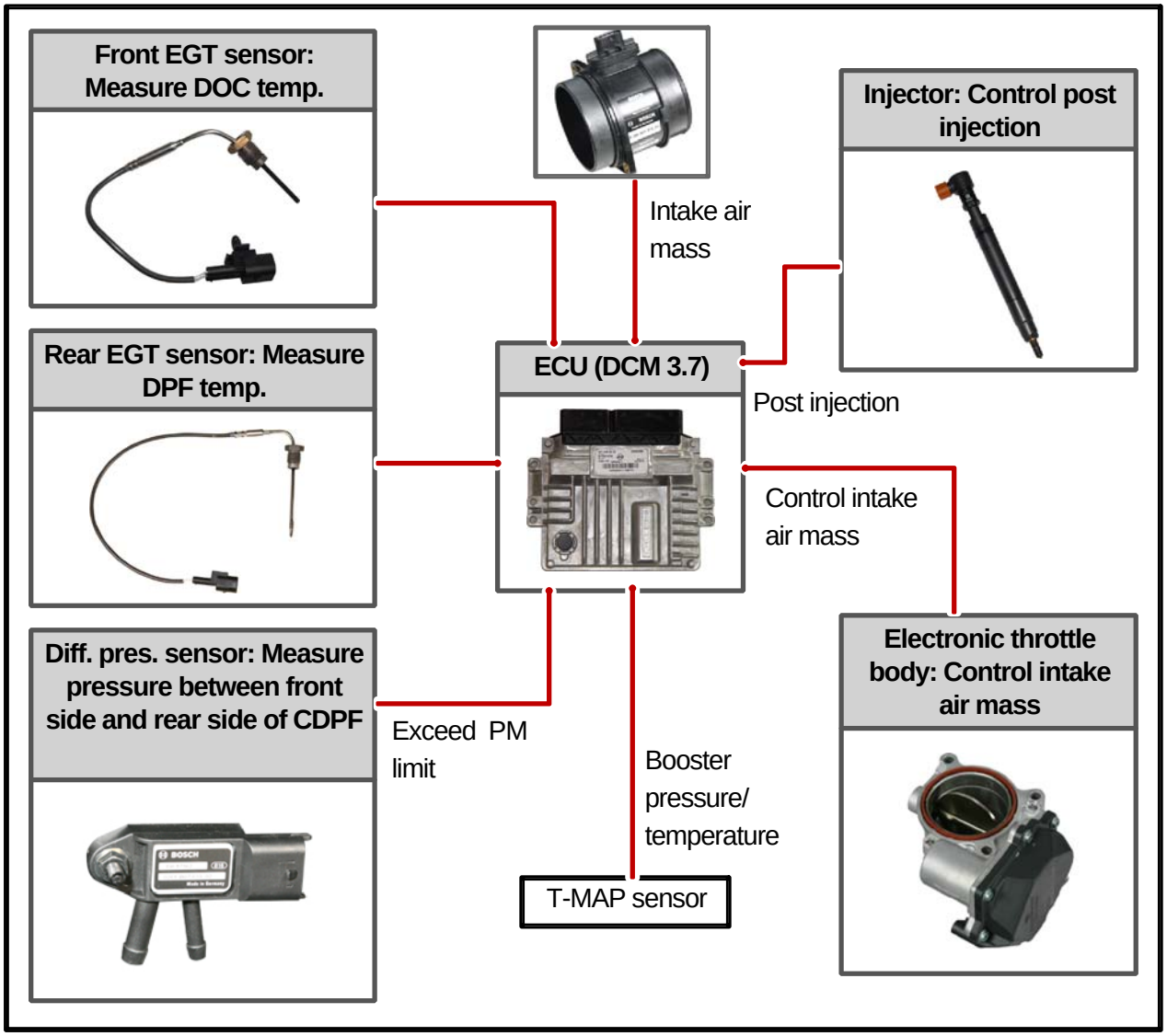
C. Input/Output for CDPF control

Input	Control	Output
Differential pressure sensor  → Pressure difference between before and after CDPF detected	D20DTR ECU 	Injection volume control (Post-injection control) → Injector 
Wide band oxygen sensor  → Air-fuel ratio during EGR/CDPF operation (feedback control)		
Front EGT  → Combustion temperature value of engine (Preventing High temperature combustion)		Air intake ratio control → Electronic throttle body 
Rear EGT sensor  → CDPF temperature value (Protecting CDPF)		
HFM (Intake air temperature)  → Intake air flow volume		CO/HC->CO_2/H_2O PMCollecting ->Combustion → CDPF 

Modification basis	
Application basis	
Affected VIN	

D. Operation process

When the differential pressure sensor detects the pressure difference between the front and the rear side of CDPF, the sensor sends signal indicating the soot is accumulated and the post injection is performed to raise the temperature of exhaust gas. The amount of fuel injected is determined according to the temperature of exhaust gas detected by the rear temperature sensor. If the temperature is below 600°C, the amount of fuel injected is increased to raise the temperature. If the temperature is over 600°C, the amount of fuel injected is decreased or not controlled. When the engine is running in low load range, the amount of post injection and the amount of intake air are controlled. It is to raise the temperature by increasing the amount of fuel while decreasing the amount of intake air.



E. Cautions

- Use only specified Engine Oil (approved by MB Sheet 229.51) for CDPF.

▶ Use only specified engine oil (Low Ash Oil)

- The vehicle equipped with CDPF should use specific engine oil to improve the engine performance and fuel economy, and ensure the service life of CDPF.

▶ Issue with normal engine oil

- Sulfur, one of the contents of engine oil is burned and generates soot that is not regenerated by the DPF. This remains on the filter as ashes and keeps accumulating. Eventually, this ashes will block the filter.

▶ Benefit for specified engine oil

- Minimized the sulfur content of engine oil which reduces the service life.
- Improved fuel economy and emission level of CO2 with high performance and low viscosity.
- Increased service life of engine oil with high resistance to temperature.

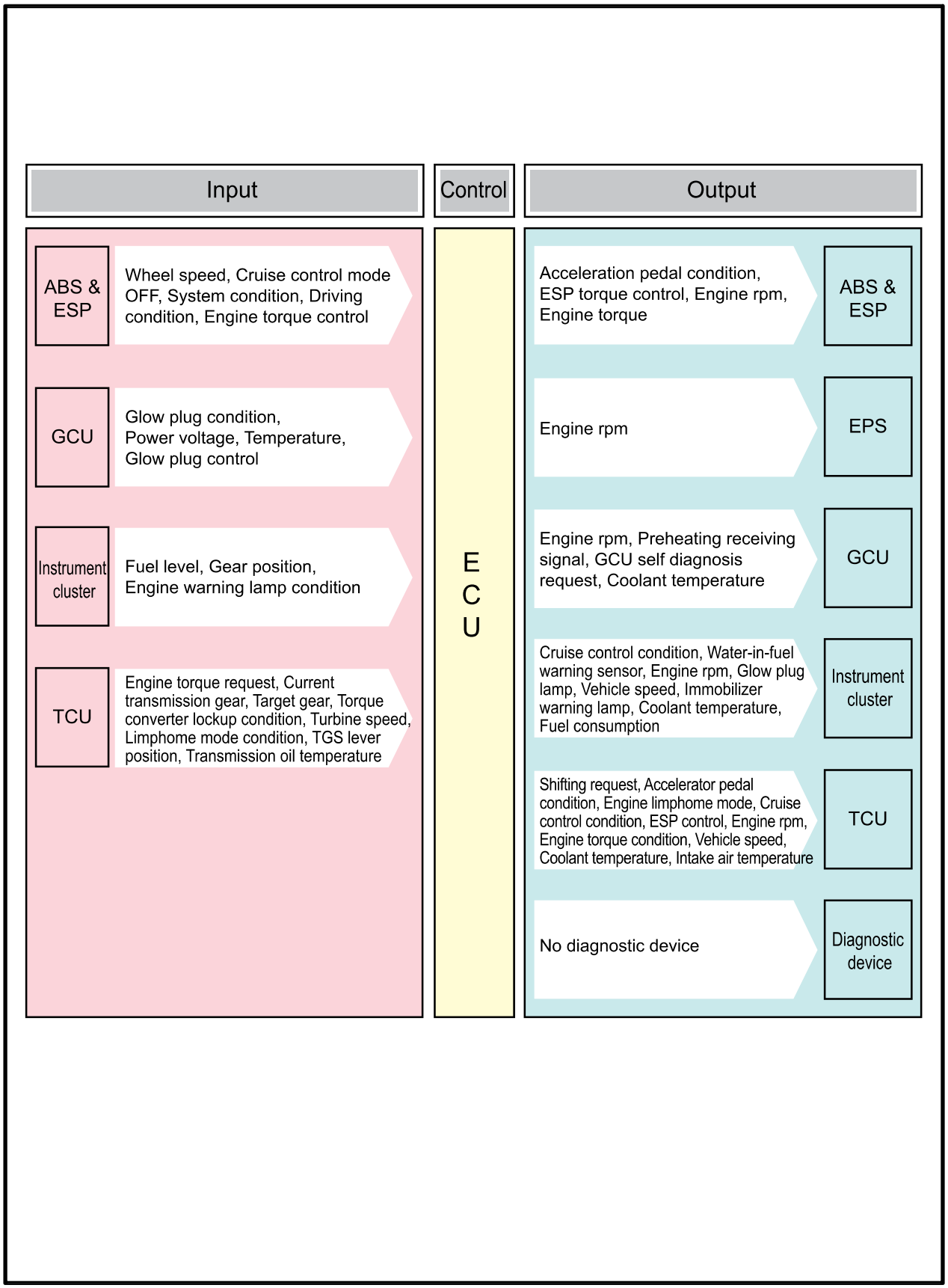
▶ Problems when using unspecified engine oil

- The service life of filter may be reduced by 30% or more by the ashes accumulated on the filter.
  The fuel economy may be reduced because of engine rolling resistance, frequent regeneration of
- DPF.

* These problems are also caused by oil with high sulfur content, such as tax exemption oil and heating oil, etc.

Modification basis	
Application basis	
Affected VIN	

3) Input/Output for CAN communication



ENGINE ASSEMBLY

1113-01

GENERAL

1. DESCRIPTION AND OPERATION

1) Cleanliness and Care

An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in the ten-thousanths of an inch.

When any internal engine parts are serviced, care and cleanliness are important.

A liberal coating of enigne oil should be applied to friction areas during assembly, to protect and lubricate the surfaces on initial operation. Proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure.

This is considered standard shop practice even if not specifically stated.

Whenever valve train components are removed for service, they should be kept in order. They should be installed in the same locations, and with the same mating surfaces, as when they were removed.

Battery cables should be disconnected before any major work is performed on the engine. Failure to disconnect cables may result in damage to wire harness or other electrical parts.

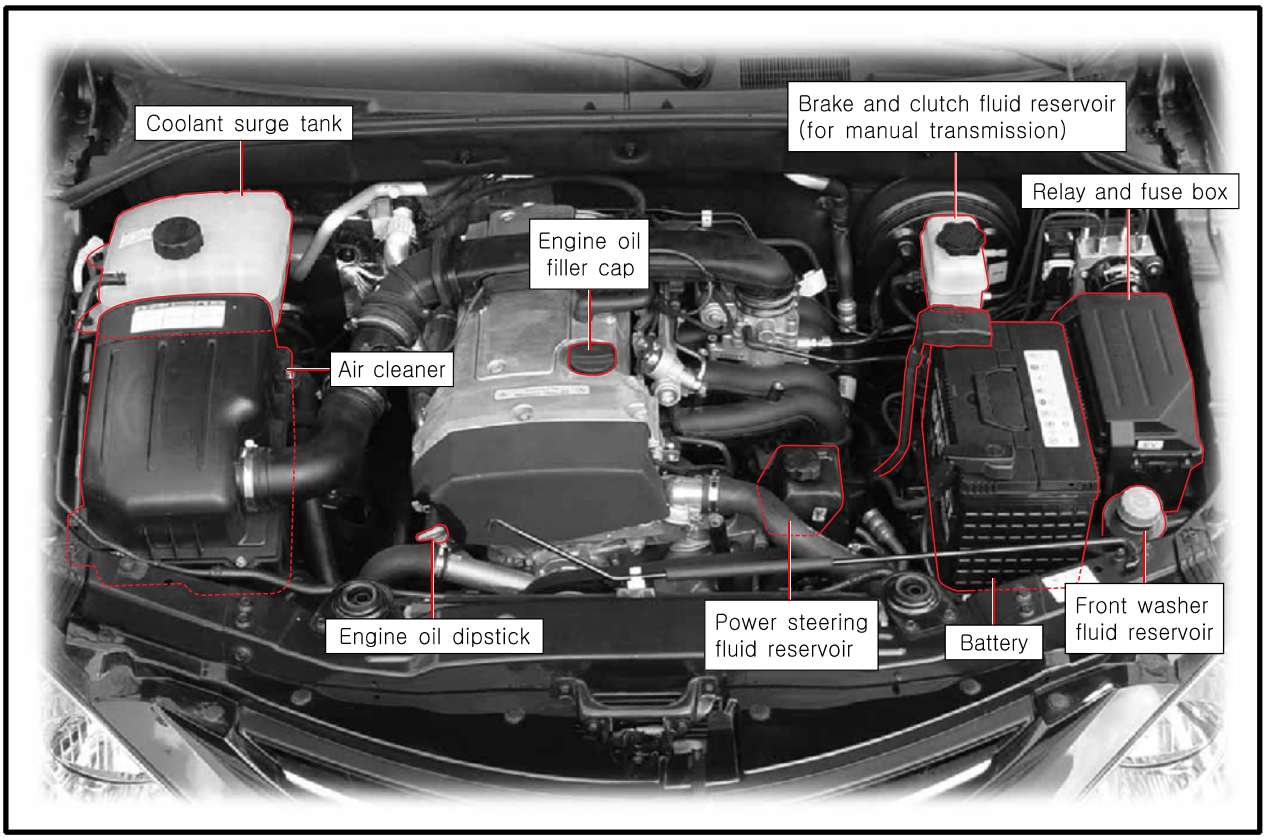
2) On-engine Service

CAUTION

- Disconnect the negative battery cable before removing or installing any electrical unit, or when a tool or equipment could easily come in contact with exposed electrical terminals.
  Disconnecting this cable will help prevent personal injury and damage to the vehicle. The ignition must also be in LOCK unless otherwise noted.

CAUTION

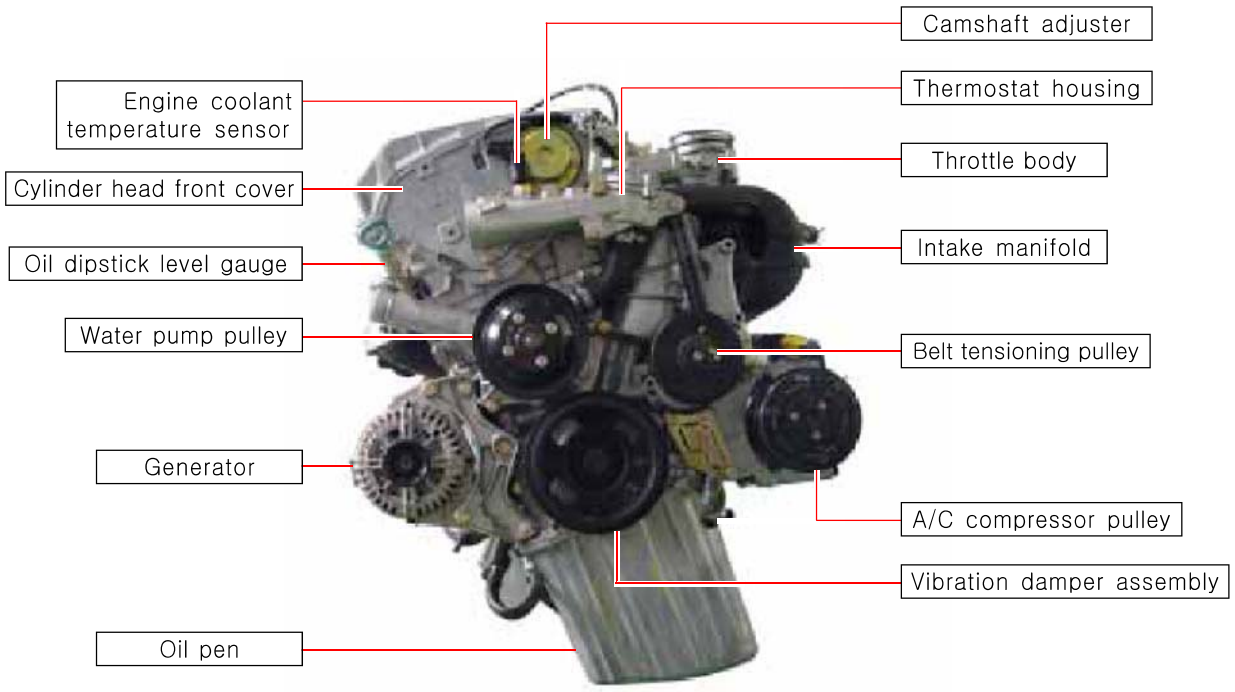
- Any time the air cleaner is removed, the intake opening should be covered. This will protect against accidental entrance of foreign material, which could follow the intake passage into the cylinder and cause extensive damage when the engine is started.



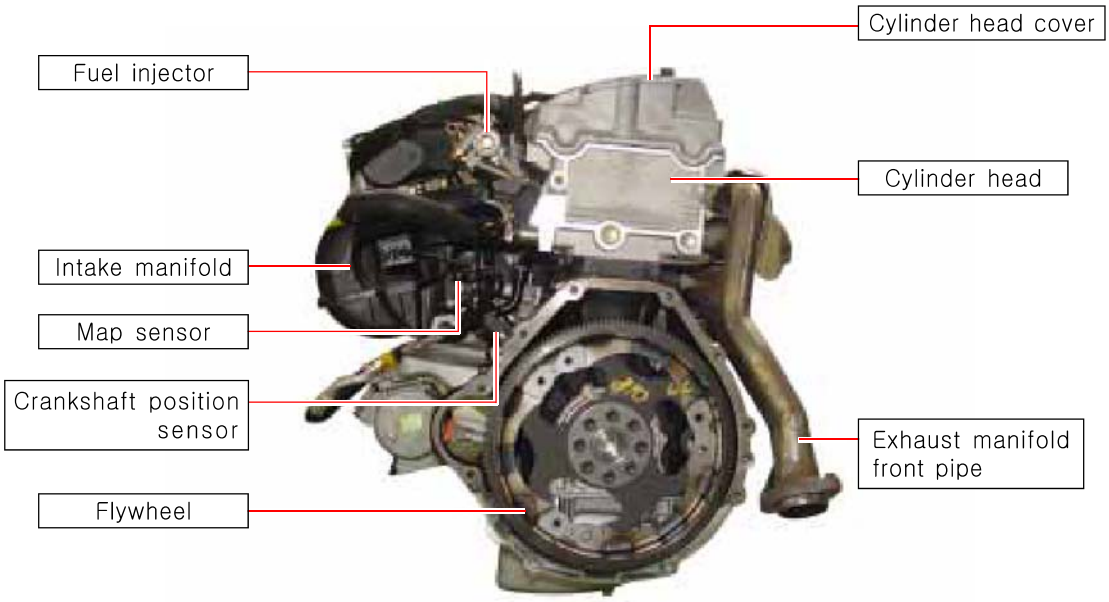
Modification basis	
Application basis	
Affected VIN	

2. G23D ENGINE ASSEMBLY

Front View

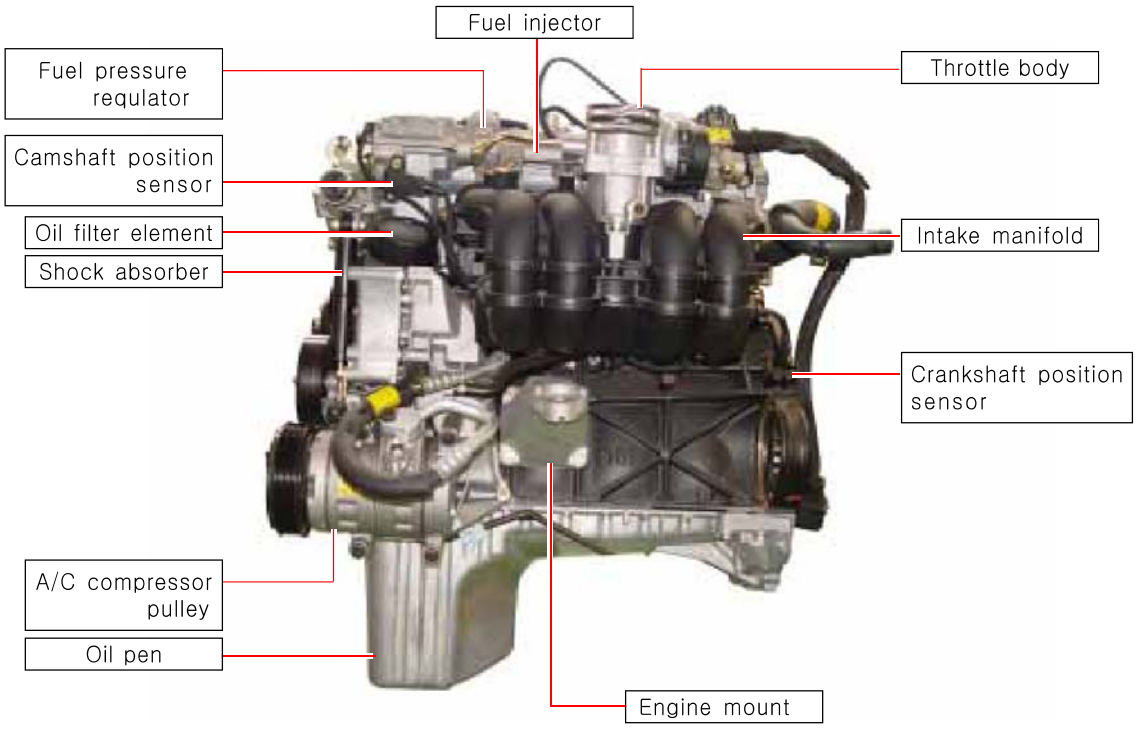


Rear View

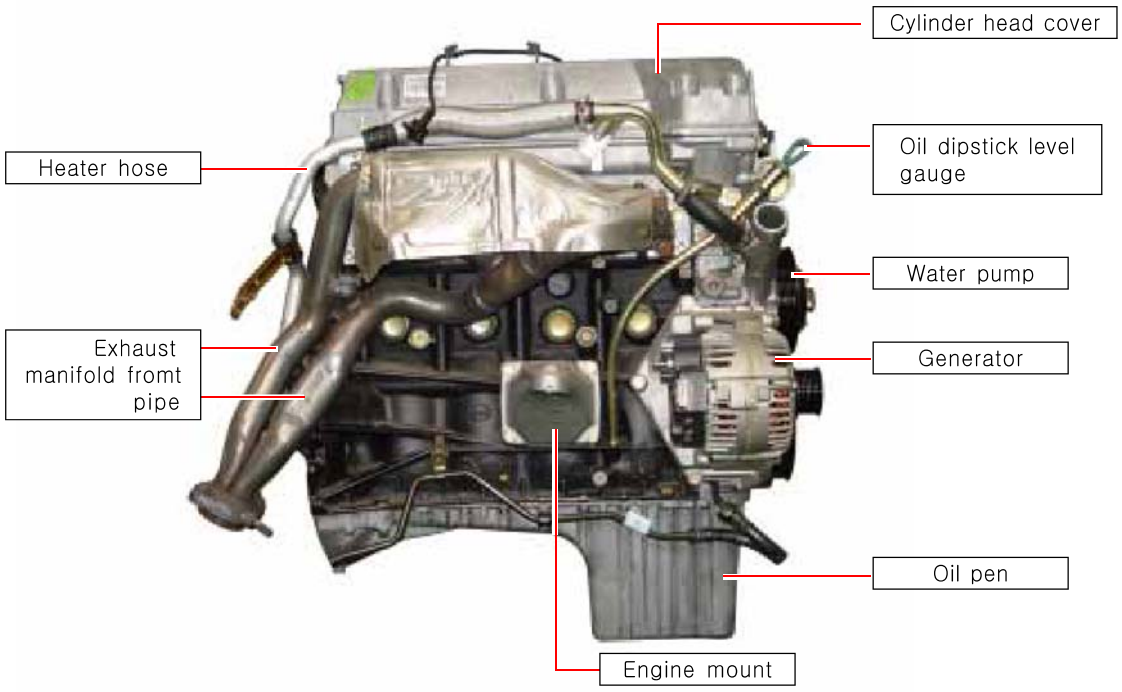


Modification basis	
Application basis	
Affected VIN	

LH Side View



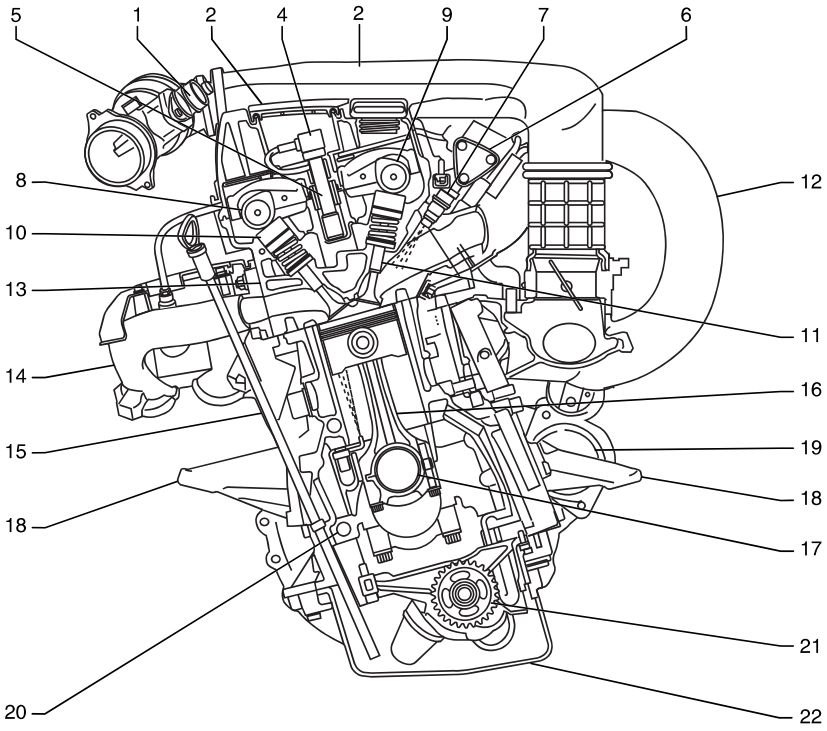
RH Side View



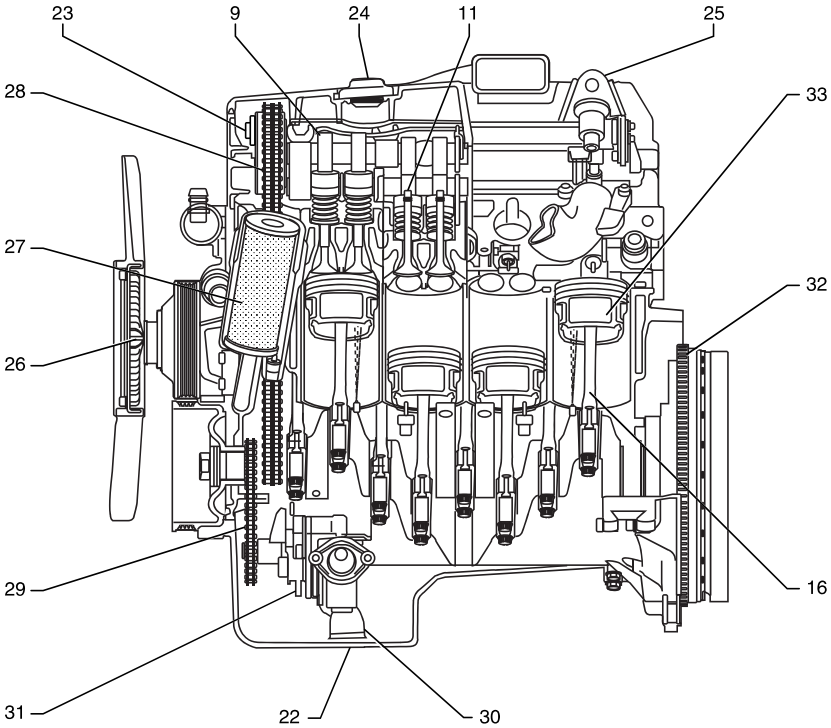
Modification basis	
Application basis	
Affected VIN	

3. G23D ENGINE STRUCTURE

Front View



Side View



Modification basis	
Application basis	
Affected VIN	

▶ **Front View**

NO.	FUNCTION	NO.	FUNCTION
1	HFM Sensor	12	Intake Manifold
2	Intake Air Duct	13	Cylinder Head
3	Cylinder Head Cover	14	Exhaust Manifold
4	Ignition Coi	15	Dipstick Guide Tube and Gauge
5	Spark Plug Connector	16	Connecting Rod
6	Fuel Distributor	17	Crankshaft
7	Injector	18	Engine Mounting Bracket
8	Exhaust Camshaft	19	Starter
9	Intake Camshaft	20	Crankcase
10	Valve Tappet	21	Oil Pump Sprocket
11	Intake Valve	22	Oil Pan

▶ **Side View**

NO.	FUNCTION	NO.	FUNCTION
23	Camshaft Adjuster	29	Oil Pump Drive Chain
24	Oil Filler Cap	30	Oil Strainer
25	Engine Hanger Bracket	31	Oil Pump
26	Cooling Fan and Viscous Clutch	32	Ring Gear and Flywheel of Drive Plate
27	Oil Filter	33	Piston
28	Timing Chain		

Modification basis	
Application basis	
Affected VIN	

4. DIAGNOSTIC INFORMATION AND PROCEDURE

1) Oil Leak Diagnosis

Most fluid oil leaks are easily located and repaired by visually finding the leak and replacing or repairing the necessary parts. On some occasions a fluid leak may be difficult to locate or repair. The following procedures may help you in locating and repairing most leaks.

▶ **Finding the Leak**

- Identify the fluid. Determine whether it is engine oil, automatic transmission fluid, power steering fluid, etc.
- Identify where the fluid is leaking from.
  · After running the vehicle at normal operating temperature, park the vehicle over a large sheet of paper.
  · Wait a few minutes.
  · You should be able to find the approximate location of the leak by the drippings on the paper.

- Visually check around the suspected component.
  Check around all the gasket mating surfaces for leaks. A mirror is useful for finding leaks in areas that are hard to reach.
- If the leak still cannot be found, it may be necessary to clean the suspected area with a degreaser, steam or spray solvent.
  · Clean the area well.
  · Dry the area.
  · Operate the vehicle for several miles at normal operating temperature and varying speeds. After operating the vehicle, visually check the suspected component.
  · If you still cannot locate the leak, try using the powder or black light and dye method.
  ·

▶ **Powder Method**

- Clean the suspected area.
- Apply an aerosol-type powder (such as foot powder) to the suspected area.
- Operate the vehicle under normal operating conditoins.
- Visually inspect the suspected component. You should be able to trace the leak path over the white powder surface to the source.

▶ Black Light and Dye Method

A dye and light kit is available for finding leaks, Refer to the manufacturer's directions when using the kit.

- Pour the specified amount of dye into the engine oil fill tube.
- Operate the vehicle normal operating conditions as directed in the kit.
- Direct the light toward the suspected area. The dyed fluid will appear as a yellow path leading to the source.

▶ Repairing the Leak

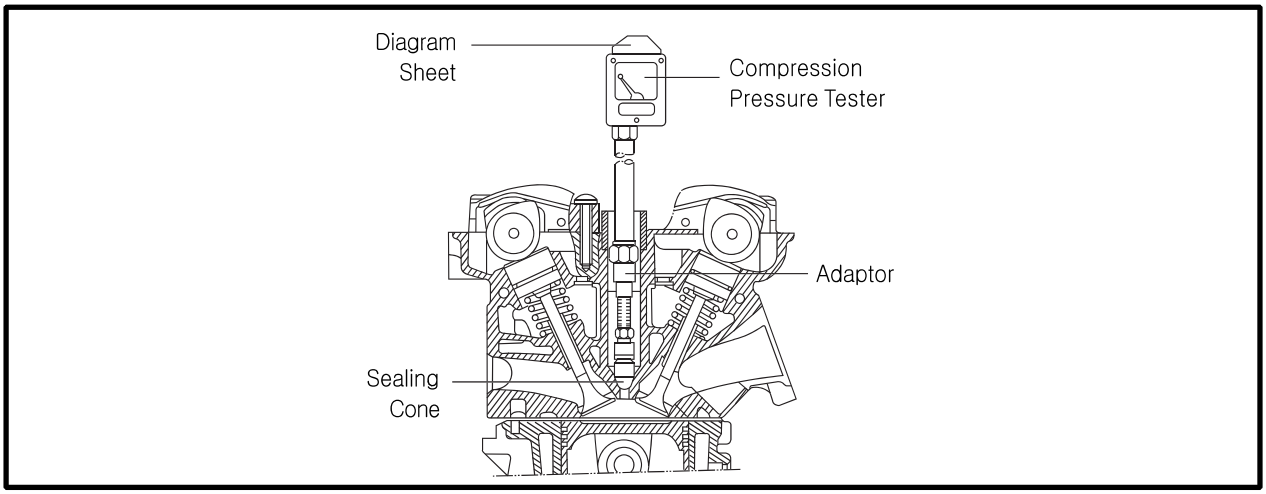
Once the origin of the leak has been pinpointed and traced back to its source, the cause of the leak must be determined in order for it to be repaired properly.

If a gasket is replaced, but the sealing flange is bent, the new gasket will not repair the leak. The bent flange must be repaired also. Before attempting to repair a leak, check for the following conditions and correct them as they may cause a leak.

▶ Gaskets

- The fluid level/pressure is too high.
- The crankcase ventilation system is malfunctioning.
- The seal bore is damaged (scratched, burred or nicked).
- The seal is damaged or worn.
- Improper installation is evident.
- There are cracks in the components.
- The shaft surface is scratched, nicked or damaged.
- A loose or worn bearing is causing excess seal wear.

2) Compression Pressure Test



▶ Standard Service Data

Application	G23D Engine
Compression Ratio	10.4 : 1
Normal Engine Temperature	←
Normal Compression Pressure	Min. 11 bar, Max. 15 bar
Permissible Pressure Difference Between Individual C ylinders	←

CAUTION

- A9912 0012B (001 589 76 21 00) Compression Pressure Tester

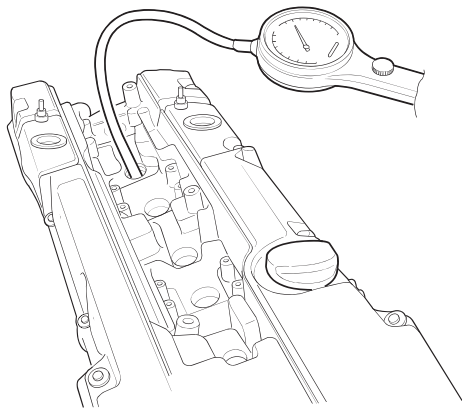
▶ Measuring Procedure

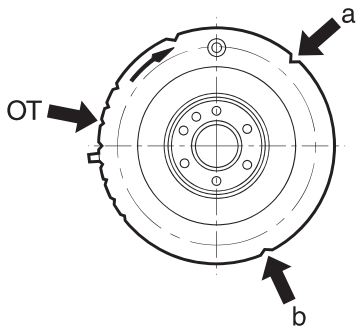
- Warm the engine up to normal operating temperature.
- Remove the spark plugs using the spark plug wrench.
- Place the diagram sheet to compression pressure tester A9912 0012B (001 589 76 21 00).
  Connect the adaptor to compression pressure tester A9912 0012B (001 589 76 21 00) and
- install it into the spark plug hole.
  Crank the engine approx. eight revolutions by using the start motor.
- Compare the measurements of compression pressure tester A9912 0012B (001 589 76 21 00)
- with the specifications.
  Measure the compression pressure of the other cylinders in the same way.
- If measured value is not within the specifications, perform the cylinder pressure leakage test.
-

CAUTION

- Discharge the combustion residues in the cylinders before testing the compression pressure.
  Apply the parking brake before cranking the engine.
-

3) Cylinder Pressure LeakageTest





▶ **Permissible Pressure Leakage**

At Whole Engine	Max. 25 %
At Valve and Cylinder Head Gasket	Max. 10 %
At Piston and Piston Ring	Max. 20 %

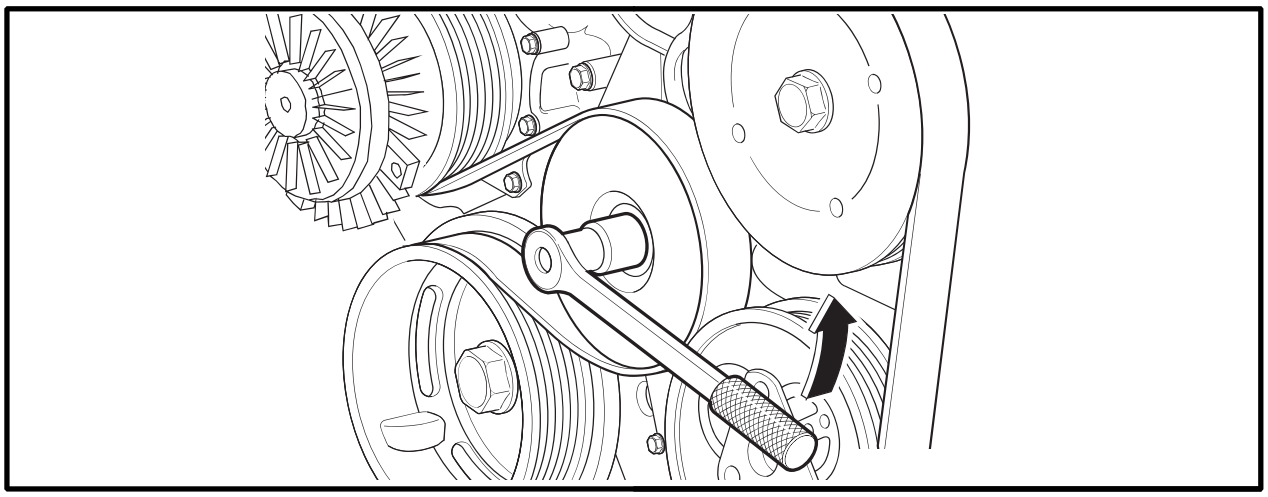
▶ **Cylinder Number**

OT (TDC)	1, 4
UT (BDC 180 °)	2, 3

▶ **Cylinder Number**

Cylinder Pressure Leakage Tester	Bosch, EFAW210A Sun, CLT 228

Modification basis	
Application basis	
Affected VIN	



▶ **Leakage Test**

- Warm the engine up to normal operating temperature.
- Disconnect the negative battery cable.
- Remove the spark plugs.
- Check the coolant level by opening the coolant reservoir cap and replenish if insufficient.
- Open the engine oil filler cap.
- Connect the tester to air pressure line and adjust the scale of tester.
- Install the connecting hose to spark plug hole.
- Position the piston of No.1 cylinder at TDC by rotating the crankshaft.
- Connect the connecting hose to tester and measure the leakage volume after blowing up 5 bar of compressed air.

CAUTION

- Measure the leakage volume in the completely opening condition of throttle valve by pulling the acceleration cable.

- Perform the pressure test according to the firing order.

CAUTION

- Firing Order: 1 - 3 - 4 - 2

- Compare the leakage pressure with the specifications.

5. GENERAL DIAGNOSIS

Condition		Probable Cause	Correction
Hard starting (With normal cranking)	Malfunction of immobilizer system	• Faulty immoblilzer system	• Check (Antenna, Immobilizer transponder) • Replace (Antenna, Immobilizer transponder)
	Malfunction of ignition system	• Faulty fuse	• Replace the fuse.
		• Faulty spark plug.	• Clean, adjust the plug gap or replace.
		• Electric leakage at the high tension cable.	• Replace the cable.
		• Poor connection of the high tension cable or lead wires.	• Replace the cable or wires.
		• Faulty ignition coil.	• Replace the ignition coil.
	Malfunction of fuel system	• Empty of fuel in the fuel tank.	• Feed the fuel.
		• Dirty or clogged fuel filter.	• Replace the filter.
		• Clogged fuel pipe.	• Clean the fuel pipe.
		• Malfunction of the fuel pump.	• Replace the fuel pump.
		• Malfunction of the fuel injector.	• Replace the injector.
		• The foreign material in the fuel tank.	• Clean the fuel tank.
	Decline of compression pressure	• Poor tightening spark plug.	• Tighten to the specified torque. Compression
		• Cracked cylinder head gasket.	• Replace the gasket.
		• Inadequate the valve clearance.	• Adjust the clearance.
		• Leakage of the valve clearance.	• Repair the valve.
		• Interference of the valve stem.	• Replace the valve or the valve guide.
		• Low elasticity or damage of the valve spring.	• Replace the valve spring.
		• Abnormal interference of pistons and cylinders.	• Replace the piston ring.
		• Excessive wear of pistons, rings, or cylinders.	• Replace the ring or the piston and boring or replace the cylinder.
	Others	• Broken timing belt.	• Replace the belt.
		• Loosening, damage or leakage of the vacuum hose.	• Connect the hose correctly or replace it.
		• Leakage of intake system.	• Replace intake system.
Lack of engine power	Decline of compression pressure	• Refer to above in this page.	• Refer to above in this page.
	Malfunction of ignition system	• Faulty spark plug.	• Adjust or replace the spark plug.
		• Electric leakage or poor connection of the high tension cable.	• Connect the cable correctly or replace it.

Modification basis	
Application basis	
Affected VIN	

▶ General Diagnosis (Cont'd)

Condition		Probable Cause	Correction
Lack of engine power	Malfunction of fuel system	• Clogged fuel pipe.	• Clean the pipe.
		• Clogged or contaminated fuel filter.	• Replace the filter.
	Others	• Clogged exhaust system.	• Check and repair the system.
		• Clogged or contaminated air cleaner element.	• Clean or replace the air cleaner element.
		• Leak of the intake manifold gasket.	• Replace the gasket.
		• Dragging brakes.	• Repair or replace the brakes.
Rough engine idling	Malfunction of fuel system	• Clogged fuel pipe.	• Clean the pipe.
		• Clogged or contaminated fuel filter.	• Replace the filter.
		• Malfunction of the fuel pressure regulator.	• Replace the regulator.
	Malfunction of ignition system	• Malfunction of the spark plug.	• Adjust or replace the spark plug.
		• Electric leakage or poor connection of the high tension cable.	• Connect the cable correctly or replace it.
		• Malfunction of the ignition coil.	• Replace the ignition coil.
	Others	• Clogged or contaminated air cleaner element.	• Clean or replace the air cleaner element.
		• Leak of the intake manifold gasket.	• Replace the gasket.
		• Poor connection or damage or leakage of the vacuum hose.	• Connect the hose correctly or replace it.
Engine hesitate (Upon pressing accelerating pedal, the engine makes delayed response This situation is remarkable when cruising or starting.)	Malfunction of ignition system	• Poor spark plug or Poor adjustment of the plug gap.	• Replace the plug or adjust the gap.
		• Electric leakage or poor connection of the high tension cable.	• Connect the cable correctly or replace it.
	Others	• Malfunction of the air cleaner system.	• Clean or replace the air cleaner system.
		• Leak of the intake manifold gasket.	• Replace the gasket.

▶ General Diagnosis (Cont'd)

Condition		Probable Cause	Correction
Engine surging (Engine power makes fluctuation in a fixed speed and speed changes without operating the accelerating pedal.)	Malfunction of fuel system	• Clogged fuel pipe.	• Clean the pipe.
		• Clogged or contaminated fuel filter.	• Replace the filter.
		• Malfunction of the fuel pressure regulator.	• Replace the fuel pressure regulator.
	Malfunction of ignition system	• Malfunction of the spark plug.	• Adjust or replace the spark plug.
		• Electric leakage or poor connection of the high tension cable.	• Connect the cable correctly or replace it.
		• Poor ignition timing.	• Adjust the ignition timing.
	Others	• Leak of the intake manifold gasket.	• Clean or replace the gasket.
		• Leakage of the vacuum hose.	• Connect the hose correctly or replace it.
Excessive detonation (According to the opening range of Malfunction of metallic is made with abnormal explosion)	Malfunction of fuel system	• Abnormal spark plug.	• Replace the spark plug.
		• Electric leakage or poor connection of the high tension cable.	• Connect the cable correctly or replace it.
	Malfunction of ignition system	• Clogged or contaminated fuel filter and fuel pipe.	• Clean or replace the fuel filter and the fuel pipe.
	Others	• Leak of the intake manifold gasket.	• Replace the gasket.
		• Excessive carbon deposit due to abnormal combustion.	• Remove the carbon.
Overheat	Malfunction of cooling system	• Lack of coolant.	• Refill coolant.
		• Malfunction of the thermostat.	• Replace the thermostat.
		• Malfunction of the cooling fan.	• Check or replace the cooling fan.
		• Poor water pump performance.	• Replace the pump.
		• Clogged or leaky radiator.	• Clean, repair or replace the radiator.
	Malfunction of lubrication system	• Poor engine oil.	• Replace engine oil with the specified one.
		• Blocking oil filter or strainer.	• Clean or repair the oil filter or the strainer.
		• Lack of engine oil.	• Refill oil.
		• Poor oil pump performance.	• Replace or repair the pump.
	Other	• Leakage of oil	• Repair.
		• Damaged cylinder head gasket.	• Replace the gasket.

Modification basis	
Application basis	
Affected VIN	

▶ General Diagnosis (Cont'd)

Condition		Probable Cause	Correction
Poor fuel consumption	Malfunction of fuel system	• Leakage of the fuel tank or the fuel pipe.	• Repair or replace the fuel tank or the fuel pipe
	Malfunction of ignition system	• Abnormal spark plug (Excessive carbon deposit, inadequate gap, burnt electrode).	• Replace the plug.
		• Electric leakage or poor connection of the high tension cable.	• Connect the cable normally or replace it.
	Malfunction of cooling system	• Malfunction of the thermostat.	• Repair the thermostat.
	Others	• Improperly installed valve.	• Repair or replace the valve.
		• Low pressure of tires.	• Adjust the pressure of tires.
Excessive consumption of engine oil	Leakage of engine oil	• Loosened oil drain plug.	• Tighten the plug.
		• Loosened oil pan bolt.	• Tighten the bolt. Engine Oil
		• Loosened oil filter.	• Tighten the filter.
		• Loosened oil pressure switch.	• Tighten the switch.
		• Leakage of camshaft front oil seal.	• Replace the seal.
		• Leakage of crankshaft front oil seal.	• Replace the seal.
		• Leakage at the cylinder head cover gasket.	• Replace the gasket.
		• Damage of the cylinder head gasket.	• Replace the gasket.
	Oil mixing in combustion chamber	• Stuck piston ring.	• Remove carbon and replace the ring.
		• Worn piston or cylinder.	• Replace the piston or the cylinder.
		• Worn piston ring or ring groove.	• Replace the piston or ring.
		• Inadequate position of the piston ring cutting part.	• Adjust the position.
		• Abrasion or damage of the valve system.	• Replace the valve system.
Low oil pressure	Malfunction of lubrication system	• Inadequate oil viscosity.	• Replace with the specified one.
		• Loosening of the oil pressure switch.	• Tighten the switch.
		• Lack of engine oil.	• Refill oil.
		• Blocking oil strainer.	• Clean the strainer.
		• Lowered function of the oil pump.	• Replace the pump.
		• Abrasion or damage of the oil pump relief valve.	• Replace the valve.

▶ General Diagnosis (Cont'd)

Condition		Probable Cause	Correction
Engine noise	Valve noise	• Inadequate valve clearance	• Adjust the valve clearance.
		• Abrasion of valve stem or guide.	• Replace the valve stem or the guide.
		• Weak valve spring.	• Replace the spring.
	Piston, ring, cylinder noise	• Abrasion of the piston, the ring or the cylinder.	• Boring the cylinder or replace the piston, the ring or the cylinder.
	Connecting rod noise	• Abrasion of the connecting rod bearing.	• Replace the bearing.
		• Loosened the connecting rod nut.	• Tighten to the specified torque
	Crankshaft noise	• Abrasion of the crankshaft bearing.	• Replace the bearing.
		• Abrasion of the crankshaft journal.	• Grind or replace the crankshaft journal.
		• Loosened bearing cap bolt.	• Tighten to the specified torque.
		• Excessive clearance of the crankshaft thrust bearing.	• Adjust or replace.

6. SPECIFICATIONS

1) Engine Specifications

Application			G23D Engine	Remarks
Engine Model			M161.970	
Displacement			2295 cc	
Cylinder (Bore x Stroke)			90.9 x 88.4 mm	
Fuel Injection / Ignition System			MSE 3.53D	
Compression Ratio			10.4 : 1	
Number of Cylinders			4	
Camshaft Valve Arrangement			DOHC	
Camshaft Drive Type			Chain-Driven	
Max. Output			150 ps / 5500 rpm	
Max. Torque			214 Nm / 3,500 ~ 4,000 rpm	
Firing Order			1 - 3 - 4 - 2	
Ignition Type			Distributor less double ignition	
Ignition Timing			BTDC 6° ± 2°	
Valve Timing	Intake	Open/Close	ATDC 19.25° / ABDC 28.76°	
	Exhaust	Open/Close	BBDC 20.62° / BTDC 15.08°	
Valve Clearance Adjustment			←	
Idle Speed			750 ± 50 rpm	
Fuel Injection Pressure			3.2 - 4.2 kg/cm²	
Oil Capacity			7.9 ℓ	
Lubrication Type			Forced by gear pump	
Oil Filter Type			Full flow with paper filter	
Fuel			Unleaded gasoline	

MSE : Engine Control Module

3.53D : 4 Cylinder Version

2) Fastener Tightening Specifications

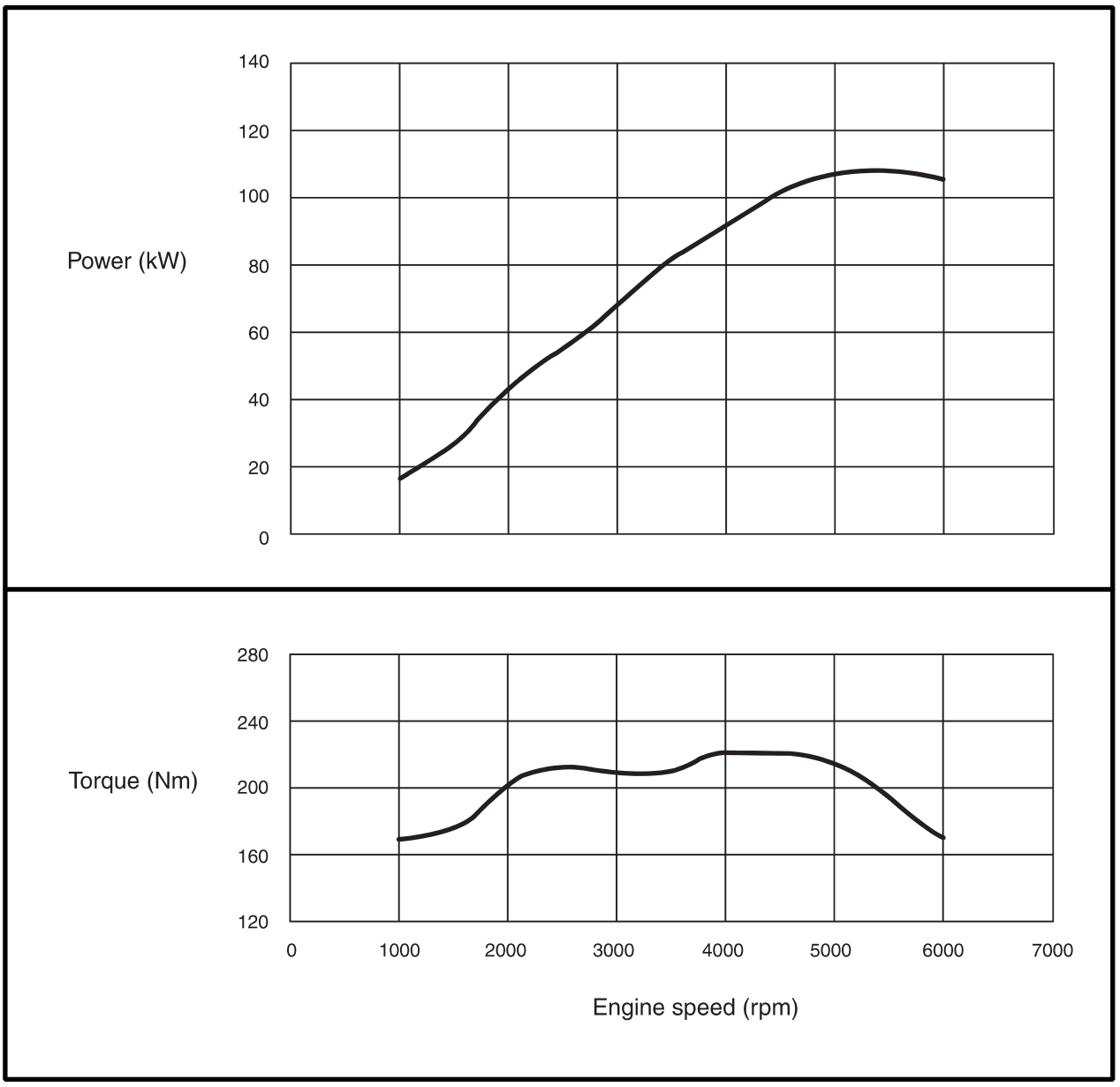
Application		N•m	Lb-Ft	Lb-In
Fuel Feed and Return Line		21 ~ 25	15 ~ 18	-
Exhaust Manifold and Pipe		30	22	-
Engine Mounting Nuts		70	52	-
Generator Carrier Bolts		25	18	-
Tensioning Pulley Bolt		40.5 ~ 49.5	29.9 ~ 36.5	-
Steering Pump Bolts		22.5 ~ 27.5	16.6 ~ 20.3	-
A/C Braket Bolts		22.5 ~ 27.5	16.6 ~ 20.3	-
Intake Air Duct Mounting Nuts		9 ~ 11	-	80 ~ 97
Spark Plug Cover Bolts		9 ~ 11	-	80 ~ 97
Cylinder Head Cover Bolts		9 ~ 11	-	80 ~ 97
Magnetic Assembly Bolt		9 ~ 11	-	80 ~ 97
Cylinder Head Front Cover Bolts	M8	22.5 ~ 27.5	16.6 ~ 20.3	-
	M6	9 ~ 11	-	80 ~ 97
Cylinder Head Bolts		55 +90° +90°	41 +90° +90°	- - 80 ~ 97
Timing Gear Case Cover Bolts		22.5 - 27.5	16.6 ~ 20.3	-
Crankshaft Sealing Rear Cover Mounting Bolts		9 ~ 11	-	-
Vibration Damper Center Bolts		200 + 20 +90° + 10°	148 + 15 +90° + 10°	- -
Flywheel Mounting Bolt		45+5 90°+10°	33.1+3.7 90°+10°	- -
Amarture Bolt in Flywheel		45 + 5	33 + 3.7	-
Camshaft Adjuster Flange Bolts		+90° + 10° 35	+90° + 10° 26	- -
Intake Flange Shaft Bolts		18 ~ 22 60° ± 5°	13 ~ 16 60° ± 5°	- -
Exhaust Camshaft Sprocket Bolts		18 ~ 22 60° ± 5°	13 ~ 16 60° ± 5°	- -
Intake Flange Shaft Bolts		18 ~ 22	13 ~ 16	-
Exhaust Camshaft Sprocket Bolts		60° ± 5°	60° ± 5°	-
Camshaft Bearing Cap Bolts		22.5 ~ 27.5	16.6 ~ 20.3	-
Chain Tensioner Screw Plug		40	30	-
Chain Tension Assembly		72 ~ 88	53 ~ 65	-
Oil Pump Sprocket Bolt		29 ~ 35	21 ~ 26	-
Tensioning Device Bolts		26 ~ 32	19 ~ 24	-
Water Pump Pulley		22.5 ~ 27.5	16.6 ~ 20.3	-
Upper Intake Manifold Bolt		22.5 ~ 27.5	16.6 ~ 20.3	-
Lower Intake Mainfold Bolt		22.5 ~ 27.5	16.6 ~ 20.3	-
Flange Bolt to Exhaust Mainfold		30	22	-
Bolt-connecting rod		40+5 90°+10°	33.1+3.7 90°+10°	-

Modification basis	
Application basis	
Affected VIN	

▶ Fastener Tightening Specifications (Cont'd)

Application	N•m	Lb-Ft	Lb-In
Exhaust Mainfold Nut to Stud Bolt	26 ~ 34	19 ~ 25	-
Oil Drain Plug	25	18	-
Oil Filter Cover	25	18	-
Oil Filter Bolt	22.5 ~ 27.5	16.6 ~ 20.3	-
Oil Pump Drive Sprocket Bolt	29 ~ 35	21 ~ 26	-
Oil Pump Mounting Bolt	22.5 ~ 27.5	16.6 ~ 20.3	-
Oil Strainer Bracket Bolt	9 ~ 11	-	80 ~ 97
Oil Pressure Relief Valve Screw Plug	50	37	-
Oil Dipstick Guide Tube Bolt	9 ~ 11	-	80 ~ 97
Oil Gallery Screw Plug	15	11	-
Shock Absorber Bolts	22.5 ~ 27.5	16.6 ~ 20.3	-
Crankshaft Bearing Cap Bolts	55/+90°	41/+90°	-
Torque Converter Mounting Bracket Bolts	42	31	-

2) Performance Curve



Modification basis	
Application basis	
Affected VIN	

FUEL SYSTEM

2211-06

GENERAL

1. FUEL SYSTEM SPECIFICATION

▶ Use Only Unleaded Fuel Rated at 89 Octane or Higher

Fuel quality and additives contained in fuel have a significant effect on power output, drivability, and life of the engine.

Fuel with too low an octane number can cause engine knock.

Caution: Use of fuel with an octane number lower than 89 may damage engine and exhaust system.

CAUTION

- To prevent accidental use of leaded fuel, the nozzles for leaded fuel are larger, and will not fit the fuel filler neck of your vehicle.

▶ Do Not Use Methanol

Fuels containing methanol (wood alcohol) should not be used in vehicle.

This type of fuel can reduce vehicle performance and damage components of the fuel system.

CAUTION

- Use of methanol may damage the fuel system.

▶ Vehicle Fueling from Drums or Storage Containers

For safety reasons (particularly when using noncommercial fueling systems) fuel containers, pumps and hoses must be properly earthed.

Static electricity build up can occur under certain atmospheric and fuel flow conditions if unearthed hoses, particularly plastic, are fitted to the fuel-dispensing pump.

It is therefore recommended that earthed pumps with integrally earthed hoses be used, and that storage containers be properly earthed during all noncommercial fueling operations.

▶ Temperature VS Resistance

°C	°F	ECT sensor	IAT sensor
		ohms ( )	
Temperature vs Resistance Values (Approximate)			
130	266	88	102
120	248	111.6	127
110	230	143	159
100	212	202	202
90	194	261	261
80	176	340	340
70	158	452	452
60	140	609	609
50	122	835	835
40	113	1166	1166
30	86	1662	1662
20	68	2420	2420
10	50	3604	3604
0	32	5499	5499
-10	14	8609	8609
-20	-4	13850	13850
-30	-22	22960	22960
-40	-40	39260	39260

Modification basis	
Application basis	
Affected VIN	

OVERVIEW AND OPERATION PROCESS

1. FUEL SYSTEM

The function of the fuel metering system is to deliver the correct amount of fuel to the engine under all operating conditions.
The fuel is delivered to the engine by the individual fuel injectors mounted into the intake manifold near each cylinder.
The main fuel control sensors are the Mass Air Flow (MAF) sensor and the oxygen (O2) sensors.
The MAF sensor monitors the mass flow of the air being drawn into the engine. An electrically heated element is mounted in the intake air stream, where it is cooled by the flow of incoming air. Engine Control Module (ECM) modulates the flow of heating current to maintain the temperature differential between the heated film and the intake air at a constant level. The amount of heating current required to maintain the temperature thus provides an index for the mass air flow. This
concept automatically compensates for variations in air density, as this is one of the factors that determines the amount of warmth that the surrounding air absorbs from the heated element. MAF sensor is located between the air filter and the throttle valve.
Under high fuel demands, the MAF sensor reads a high mass flow condition, such as wide open throttle. The ECM uses this information to enrich the mixture, thus increasing the fuel injector on-time, to provide the correct amount of fuel. When decelerating, the mass flow decreases. This mass flow change is sensed by the MAF sensor and read by the ECM, which then decreases the fuel injector on-time due to the low fuel demand conditions.
The O2 sensors are located in the exhaust pipe before catalytic converter. The O2 sensors indicate to the ECM the amount of oxygen in the exhaust gas, and the ECM changes the air/fuel ratio to the engine by controlling the fuel injectors. The best air/fuel ratio to minimize exhaust emissions is 14.7 to 1, which allows the catalytic converter to operate most efficiently. Because
of the constant measuring and adjusting of the air/fuel ratio, the fuel injection system is called a "closed loop" system.
The ECM uses voltage inputs from several sensors to determine how much fuel to provide to the engine. The fuel is delivered under one of several conditions, called "modes".

1) Starting Mode

When the ignition is turned ON, the ECM turns the fuel pump relay on for 1 second. The fuel pump then builds fuel pressure. The ECM also checks the Engine Coolant Temperature (ECT) sensor and the Throttle Position (TP) sensor and determines the proper air/fuel ratio for starting the engine. This ranges from1.5 to 1 at -36 ℃ (-33 ℉) coolant temperature to 14.7 to 1 at 94 ℃ (201 ℉) coolant temperature. The ECM controls the amountof fuel delivered in the starting mode by changing how long the fuel injector is turned on and off. This is done by "pulsing" the fuel injectors for very short times.

2) Run Mode

The run mode has two conditions called "open loop" and "closed loop".

3) Open Loop

When the engine is first started and it is above 690 rpm, the system goes into "open loop" operation. In "open loop", the ECM ignores the signal from the HO2S and calculates the air/fuel ratio based on inputs from the ECT sensor and the MAF sensor. The ECM stays in "open loop" until the following conditions are met:

- The O2 has a varying voltage output, showing that it is hot enough to operate properly.
- The ECT sensor is above a specified temperature (22.5 ℃).
- A specific amount of time has elapsed after starting the engine.

4) Closed Loop

The specific values for the above conditions vary with different engines and are stored in the Electronically Erasable Programmable Read-Only Memory (EEPROM).
When these conditions are met, the system goes into "closed loop" operation. In "closed loop", the ECM calculates the air/fuel ratio (fuel injector on- time) based on the signals from the O2 sensors. This allows the air/fuel ratio to stay very close to 14.7 to 1.

5) Acceleration Mode

The ECM responds to rapid changes in throttle position and airflow and provides extra fuel.

6) Deceleration Mode

The ECM responds to changes in throttle position and airflow and reduces the amount of fuel. When deceleration is very fast, the ECM can cut off fuel completely for short periods of time.

Modification basis	
Application basis	
Affected VIN	

7) Battery Voltage Correction Mode

When battery voltage is low, the ECM can compensate for a weak spark delivered by the ignition module by using the following methods:

- Increasing the fuel injector pulse width.
- Increasing the idle speed rpm.
- Increasing the ignition dwell time.

8) Fuel Cut-Off Mode

No fuel is delivered by the fuel injectors when the ignition is off. This prevents dieseling or engine runon. Also, the fuel is not delivered if there are no reference pulses received from the CKP sensor. This prevents flooding.

ENGINE INTAKE SYSTEM

0000-00

GENERAL

1. SPECIFICATIONS

(1) Fastener Tightening Specifications

Application	N•m	Lb-Ft	Lb-In
DOC to Muffler Nut	28 - 47	21 - 35	-
Exhaust Manifold to Front Exhaust Pipe Nut	15 - 28	11 - 21	-
Front Exhaust Pipe to DOC Nut	28 - 47	21 - 35	-
Front Exhaust Pipe to Muffler Nut	28 - 47	21 - 35	-
Intake Air Duct Mounting Bolt	22.5 - 27.5	16.6 - 20.3	-
Intake Manifold Mounting Bolt	22.5 - 27.5	16.6 - 20.3	-
Muffler to Tail Exhaust Pipe Nut	28 - 47	21 - 35	-
Resonance Flap Mounting Bolt	9 - 11	-	80 - 97

ENGINE EXHAUST SYSTEM

2420-01

GENERAL

1. SPECIFICATION

(1) Fastener Tightening Specifications

Application	N•m	Lb-Ft	Lb-In
DOC to Muffler Nut	28 - 47	21 - 35	-
Exhaust Manifold to Front Exhaust Pipe Nut	15 - 28	11 - 21	-
Front Exhaust Pipe to DOC Nut	28 - 47	21 - 35	-
Front Exhaust Pipe to Muffler Nut	28 - 47	21 - 35	-
Intake Air Duct Mounting Bolt	22.5 - 27.5	16.6 - 20.3	-
Intake Manifold Mounting Bolt	22.5 - 27.5	16.6 - 20.3	-
Muffler to Tail Exhaust Pipe Nut	28 - 47	21 - 35	-
Resonance Flap Mounting Bolt	9 - 11	-	80 - 97

OVERVIEW AND OPERATION PROCESS

1. DESCRIPTION AND OPERATION

1) Exhaust System

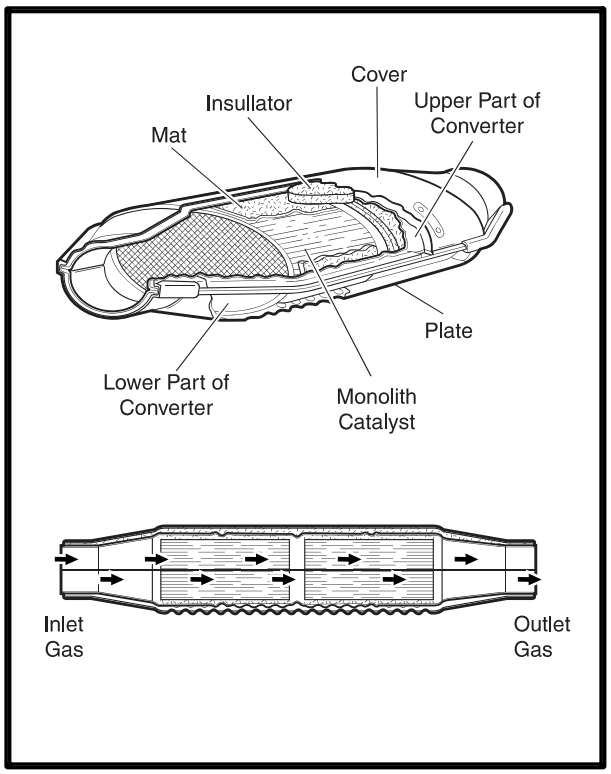
CAUTION

When you are inspecting or replacing exhaust system components, make sure there is adequate clearance from all points on the underbody to avoid possible
overheating of the floor panel and possible damage to the passenger compartment insulation and trim materials.
Check the complete exhaust system and the nearby body areas and trunk lid for broken, damaged, missing or mispositioned parts, open seams, holes, loose connections, or other deterioration which could permit exhaust fumes to seep into the trunk may be an indication of a problem in one of these areas. Any defects should be corrected immediately.

2) Catalytic Converter (Gasoline Engine)

1. When jacking or lifting the vehicle from the body side rails, be certain that the lift pads do not contact the catalytic converter, as this could damage the catalytic converter.
2. Use of anything other than unleaded fuel will damage the catalyst in the catalytic converter.

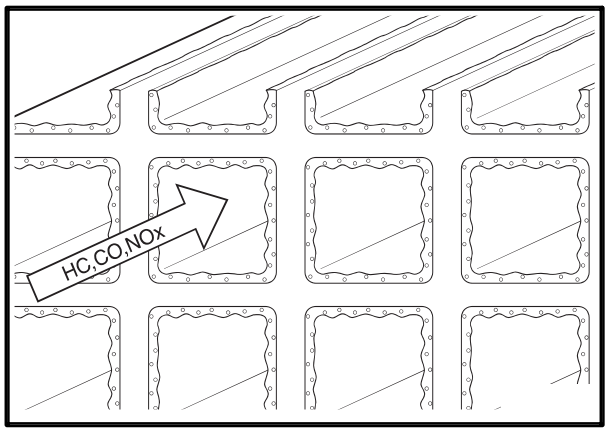
▶ **Catalytic Converter Structure**



The Catalytic converter of monolith type consists of 2 walled metal bodies which is made of Cordierite. The principal element of converter consists of the materials like Alumina or oxidized Serume in order to apply to Ceramic Monolith. Washer coat operates first, and catalytic metal elements (Pt, Pd, Rh) operates to washer coat next.
Monolith type is lighter than other types, easy to manufacture and quickly approaches to proper temperature. Washer coat is used to make a contact surface with exhaust gas bigger by adhering closely to small holes
of inner layer. If a lead compound or phosphorus adheres to the surface and the temperature rises, its surface is decreased. The total area of general monolith converter is about 45, 000~500,000ft3. (10 times of a football field) Generally Alumina (AL2 O3) is used as a raw materialand its 7 phases of gamma, delta, theta have big areas and high stability for the temperature, and nowadays gamma Alumina is used usually.

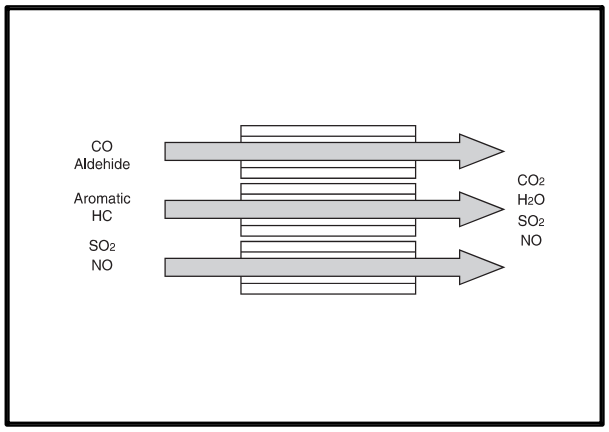
Modification basis	
Application basis	
Affected VIN	

▶ Catalytic Converter and Temperature

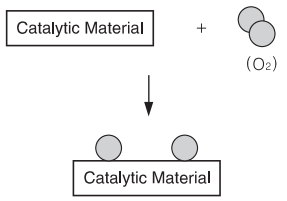
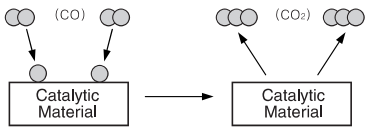
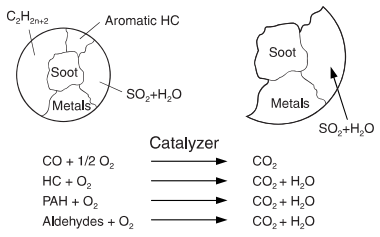


Catalytic converter has the normal function of purification at a range of the temperature.
Because it has a weak point of decreasing of the purification rate in the condition of continuous high temperature, it should keep the temperature range of 400 to 500°C for normal condition.
HC purification rate becomes better according to the increase of temperature in the normal range of temperature. CO purification rate becomes the best near the temperature of 450°C, and NOx does so near the temperature of 400 to 500°C.

▶ Purification of Catalytic Converter



- Adhesion of soluble organic fraction (SOF) below 180°C
- Purification of soluble organic fraction (SOF) over 180°C
  Chemical reaction formula
  SOF(HC)+O2 → CO2+H2O
  2CO+O2 → 2CO2
  2C2H6+7O2 → 4CO2+6H20
- By catalytic action of two primary catalytic converter, oxidation occurs in order to decrease HC and CO.

Oxygen adheres to catalytic material : below 180°C	Catalytic material supplies each CO and HC with O2 for their oxidation : above 180°C	Catalytic material conversion process by DOC
		

▶ Method for Reduction of NOx

NOx is generated a great deal in case that combustion temperature and excess air factor are high. EGR valve can decrease NOx (30 to 35% decrease) by making temperature of combustion chamber fall by means of exhaust gas re-circulation.

- EGR valve is installed on the diesel engine of Musso, Korando, Istana and Rexton.
  And micro switch is installed together to control EGR valve.
- The setting method of micro switch is identical with the existing one.

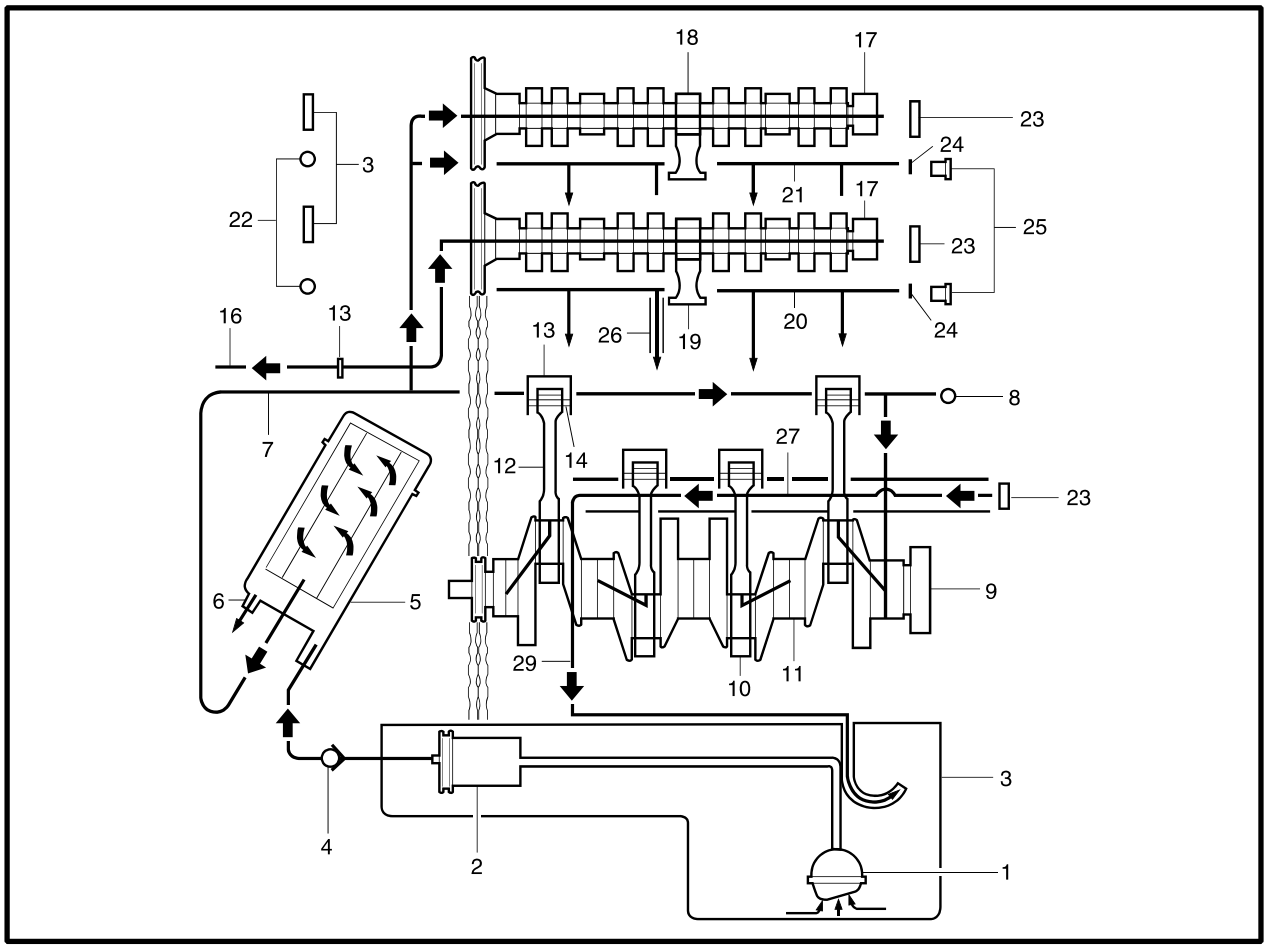
Modification basis	
Application basis	
Affected VIN	

LUBRICATION SYSTEM

1531-24

OVERVIEW AND OPERATION PROCESS

1. OIL CIRCULATION



1 Oil Strainer
2 Oil Pump
3 Oil Pan
4 Oil Non-Return Valve
5 Oil Filter
6 Oil Filter Bypass Valve
7 Main Oil Gallery
8 Closing Ball (ϕ 15 mm)
9 Crankshaft
10 Connecting Rod Bearing
11 Crankshaft Bearing
12 Connecting Rod
13 Piston
14 Oil Spray (Piston Crown Area)
15 Non-Return Valve (Crankcase)
16 Oil Supply (To Chain Tensioner)
17 Camshaft
18 Cam Bearing
19 Valve
20 Oil Gallery (Supply Oil to Intake Tappet)
21 Oil Gallery (Supply Oil to Exhaust Tappet)
22 Ball (ϕ 8 mm)
23 Camshaft Plug
24 Seal
25 Screw Plug
26 Oil Return Gallery (Cylinder Head and Crankcase)
27 Oil Return Gallery (Crankcase)
28 End Cover (ϕ 20 mm)
29 Oil Return Pipe

ENGINE COOLING SYSTEM

2110-01

GENERAL

1. GENERAL SPECIFICATIONS

Application		Gasoline engine
Cooling system	Type	Water cooling forced circulation
Coolant	Capacity	11.3L
Thermostat	Type	Wax Pellet Type
	Initial Opening Temp.	87℃(188.6°F)
	Fully Opening Temp.	102℃(215.6°F)
	Fully Closing Temp.	85℃(187°F)
	Stroke	7mm
Cooling fan module	Type	Electric
	Capacity	Φ472 x 400W x 5B
	Control type	PWM type
Coolant reservoir	Capacity	over 1.5L
	Circulation	Closed roof type
	Pressure cap	Screw type, 1.4bar
	Vacuum valve	Screw type, 1.4bar
Water pump	Type	Turbo centrifugal
	Impeller diameter	65mm
	Impeller blades	8
Radiator	Core size	555W x 582.4H x 27T (over 326,250mm²)
	Flow type	Cross flow
	Min. cooling capacity	over 68,000kcal/h
Coolant temperature gauge	Minimum radiation capability	45,000kcal/h
	Resistance(50℃(122°F))	185.2Ω
	Resistance(80℃(176°F))	47.4Ω
	Resistance(105℃(221°F))	28.2Ω

Application		Gasoline engine
Engine coolant temperature sensor	Resistance(20℃(68°F))	3.33 - 37.8kΩ
	Resistance(80℃(176°F))	0.32 - 0.35kΩ
Anti-freeze agent	Type	ALUTEC-P78
	Mixture of water and good quality ethylene glycol-base anti-freeze	50 : 50

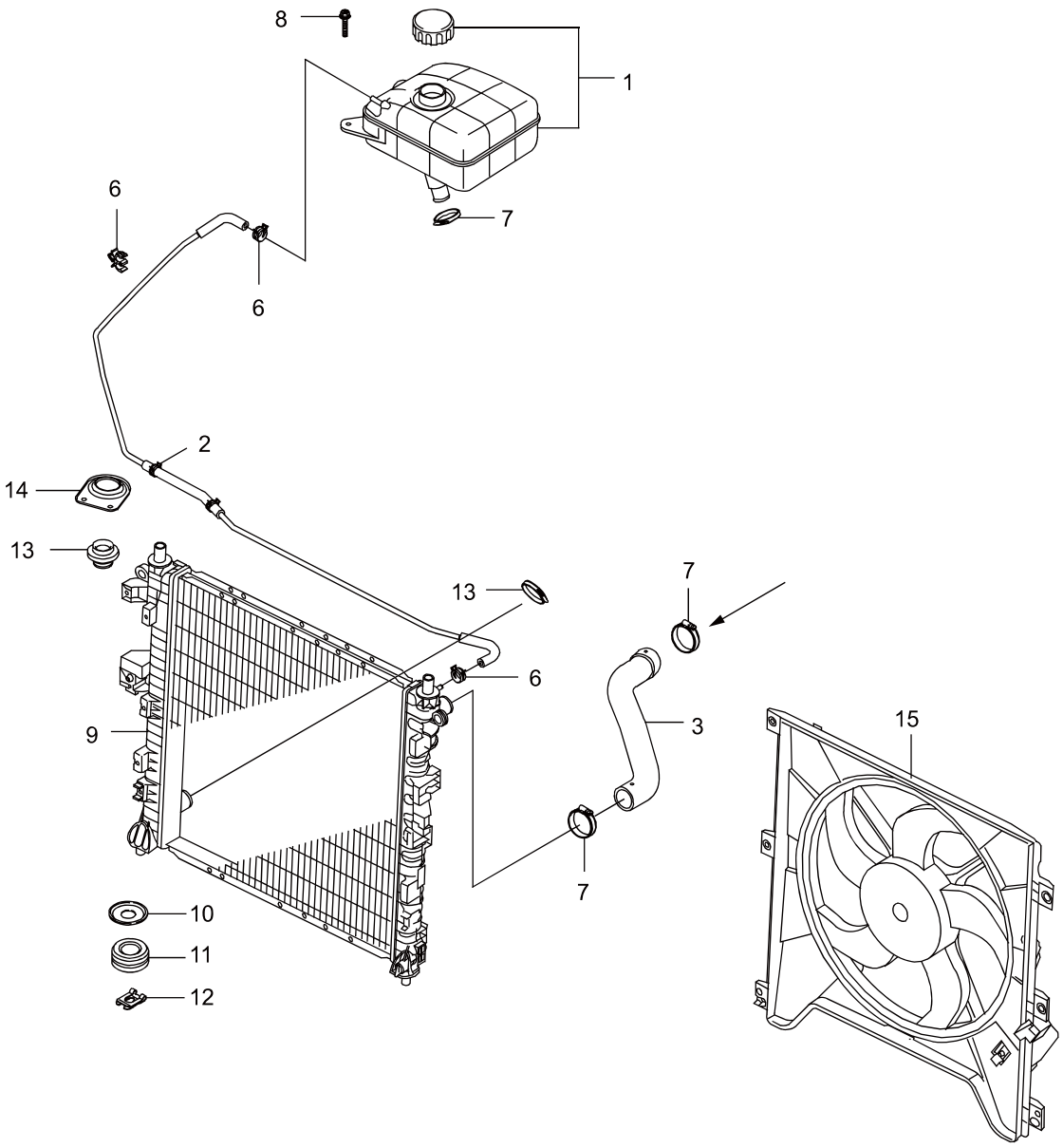
2. FASTENER TIGHTENING SPECIFICATIONS

Application		Nm	Lb-Ft	Lb-In
Automatic Transmission Oil Cooler Pipe		20	15	-
Automatic Transmission Oil Cooler Pipe Mounting Bolt		3 - 7	-	27 - 62
Coolant Drain Plug		30	22	-
Cooling Fan Bolt		9 - 11	-	80 - 97
Cooling Fan Shroud Bolt		3 - 7	-	27 - 62
Oil Cooler Pipe Line Bolt		9 - 11	-	80 - 97
Radiator Mounting Bracket Bolt		3 - 7	-	27 - 62
Tensioning Device Shock Absorber Bolt		22.5 - 27.5	16.6 - 20.3	-
Thermostat Cover Bolt		9 - 11	-	80 - 97
Thermostat Housing Bolt	M6	9 - 11	-	80 - 97
	M8	22.5 - 27.5	16.6 - 20.3	-
Viscous Clutch Mounting Bolt		40.5 - 49.5	29.8 - 36.5	-
Water Pump Housing Bolt	M6	9 - 11	-	80 - 97
	M8	22.5 - 27.5	16.6 - 20.3	-
Water Pump Pulley Bolt		9 - 11	-	80 - 97

Modification basis	
Application basis	
Affected VIN	

OVERVIEW AND OPERATION PROCESS

1. COMPONENT LOCATOR



1. Reserver Tank
2. Deaeration Tube
3. Inlet Hose
6. Clamp
7. Clamp
8. Bolt (M6, 2 piece)
9. Radiator
10. Lower Radiator Insulator
11. Plate
12. Clip
13. Upper Radiator Insulator
14. Bracket
15. PWM Electric Fan

2. DESCRIPTION AND OPERATION

1) General Description

The cooling system maintains the engine temperature at an efficient level during all engine operating conditions.
When the engine is cold, the cooling system cools the engine slowly or not at all. This slow cooling of the engine allows the engine to warm up quickly.
The cooling system includes a radiator and recovery subsystem, cooling fans, a thermostat and housing, a water pump, and a water pump drive belt. The timing belt drives the water pump.
All components must function properly for the cooling system to operation. The water pump draws the coolant from the radiator. The coolant then circulates through water jackets in the engine block, the intake manifold, and the cylinder head. When the coolant reaches the operating
temperature of the thermostat, the thermostat opens. The coolant then goes back to the radiator where it cools.
This system directs some coolant through the hoses to the heat core. This provides for heating and defrosting.
The coolant reservoir is connected to the radiator to recover the coolant displaced by expansion from the high temperatures. The coolant reservoir maintains the correct coolant level.
The cooling system for this vehicle has no radiator cap or filler neck. The coolant is added to the cooling system through the coolant reservoir.

2) Radiator

This vehicle has a lightweight tube-and-fin aluminum radiator. Plastic tanks are mounted on the upper and the lower sides of the radiator core.
On vehicles equipped with automatic transaxles, the transaxle fluid cooler lines run through the radiator tank.
A radiator drain plug is on this radiator.
To drain the cooling system, open the drain plug.

3) Coolant Reservoir

The coolant reservoir is a transparent plastic reservoir, similar to the windshield washer reservoir.
The coolant reservoir is connected to the radiator by a hose and to the engine cooling system by another hose.
As the vehicle is driven, the engine coolant heats and expands. The portion of the engine coolant displaced by this expansion flows from the radiator and the engine into the coolant reservoir. The air trapped in the radiator and the engine is degassed into the coolant reservoir.
When the engine stops, the engine coolant cools and contracts. The displaced engine coolant is then drawn back into the radiator and the engine. This keeps the radiator filled with the coolant to the desired level at all times and increases the cooling efficiency.
Maintain the coolant level between the MIN and MAX marks on the coolant reservoir when the system is cold.

Modification basis	
Application basis	
Affected VIN	

4) Water Pump

The belt-driven centrifugal water pump consists of an impeller, a drive shaft, and a belt pulley.
The impeller is supported by a completely sealed bearing.
The water pump is serviced as an assembly and, therefore, cannot be disassembled.

5) Thermostat

A wax pellet-type thermostat controls the flow of the engine coolant through the engine cooling system. The thermostat is mounted in the thermostat housing to the front of the cylinder head.
The thermostat stops the flow of the engine coolant from the engine to the radiator to provide faster warm-up, and to regulate the coolant temperature. The thermostat remains closed while the engine coolant is cold, preventing circulation of the engine coolant through the radiator. At this point, the engine coolant is allowed to circulate only throughout the heater core to warm it quickly and evenly.
As the engine warms, the thermostat opens. This allows the engine coolant to flow through the radiator wherethe heat is dissipated. This opening and closing of the thermostat permits enough engine coolant to enter the radiator to keep the engine within proper engine temperature operating limits.
The wax pellet in the thermostat is hermetically sealed in a metal case. The wax element of the thermostat expands when it is heated and contracts when it is cooled.
As the vehicle is driven and the engine warms, the engine coolant temperature increases. When the engine coolant reaches a specified temperature, the wax pellet element in the thermostat expands and exerts pressure against the metal case, forcing the valve open. This allows the engine coolant to flow through the engine cooling system and cool the engine.
As the wax pellet cools, the contraction allows a spring to close the valve.
The thermostat begins to open at 87°C(188.6 °F) and is fully open at 102°C(215.6°F). The thermostat closes at 85°C (187°F).

6) Electric Cooling Fan

CAUTION

- Keep hands, tools, and clothing away from the engine cooling fans to help prevent personal injury. This fan is electric and can turn on even when the engine is not running.

CAUTION

- If a fan blade is bent or damaged in any way, no attempt should be made to repair or reuse the damaged part. A bent or damaged fan assembly should always be replaced with a new one to prevent possible injury.

The cooling fans are mounted behind the radiator in the engine compartment. The electric cooling fans increase the flow of air across the radiator fins and across the condenser on air conditioned (A/C)-equipped vehicles.
This helps to speed cooling when the vehicle is at idle or moving at low speeds.
All models have two fans. The main fan is 320 mm (12. 6 inches) in diameter with seven blades to aid the airflow through the radiator and the condenser. An electric motor attached to the radiator support drives the fan.
The auxiliary fan is 320 mm (12.6 inches) in diameter.

▶ **A/C Off or Non-AC Model**

- The cooling fans are actuated by the engine control module (ECM) using a low-speed cooling fan relay, a high-speed cooling fan relay and a cooling fan motor relay.
- The ECM will turn the cooling fans on at low speed when the coolant temperature reaches 95°C(203°F) and at high speed when the coolant temperature reaches 105°C(221°F).
  The ECM will change the cooling fans from high peed to low speed at 100°C(212°F) and
- will turn the cooling fans off at 90°C (194°F).

▶ **A/C On**

- The ECM will turn the cooling fans on at low speed when the A/C system is on. The ECM will change to high speed when the high side A/C pressure reaches 1860 kPa (269.8 psi).
  The cooling fans will return to low speed when the high side A/C pressure reaches 1378 kPa
- (199.8 psi).

7) Engine Coolant Temperature Sensor

The Engine Coolant Temperature (ECT) sensor uses a temperature to control the signal voltage to the Engine Control Module (ECM).

8) Coolant Temperature Gauge

The coolant temperature gauge controls the instrument panel temperature indicator. The coolant temperature gauge is located with ECT sensor.

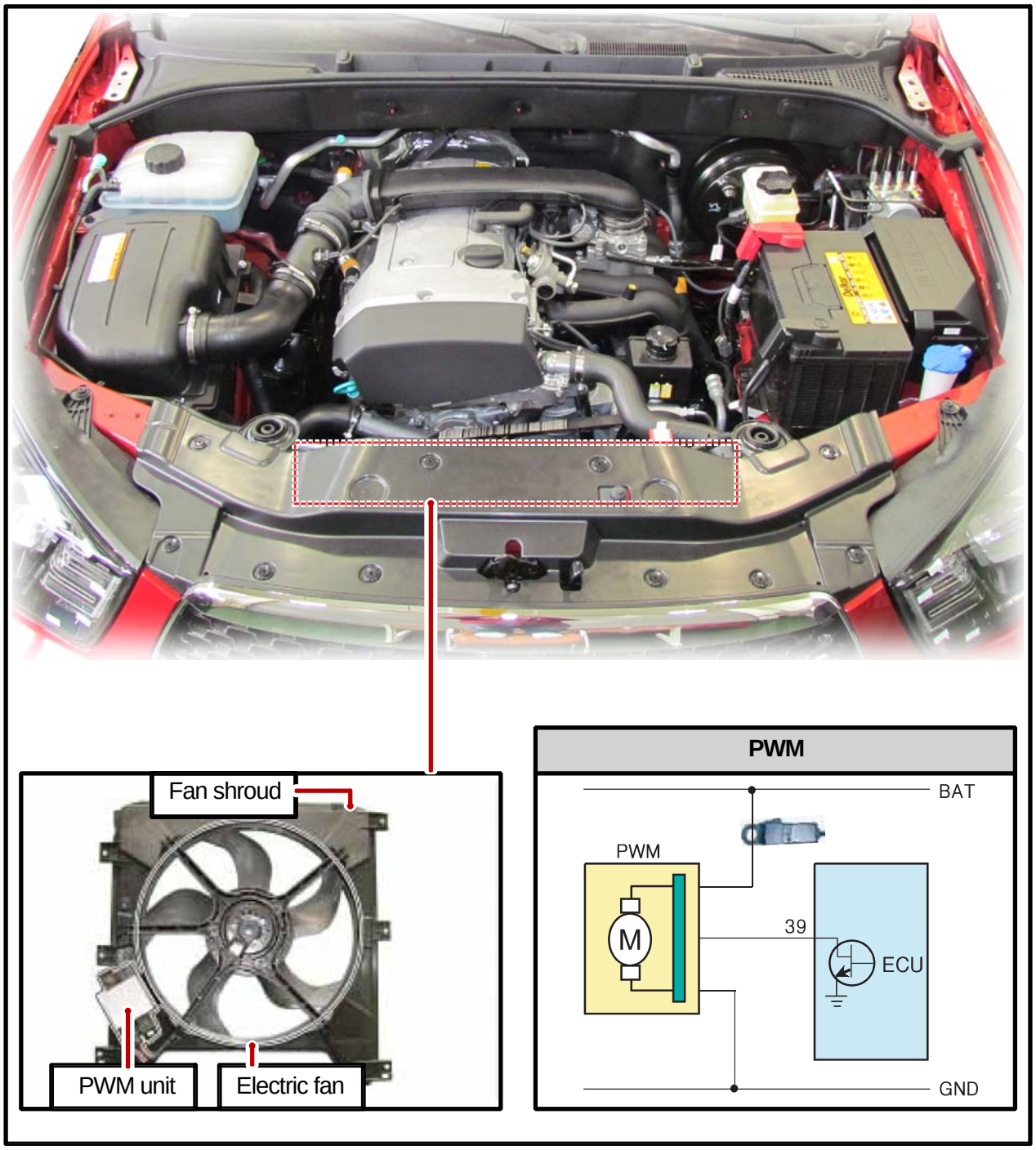
Modification basis	
Application basis	
Affected VIN	

3. PWM (PULSE WIDTH MODULATION) ELECTRIC FAN OPERATION

1) Function

The PWM (Pulse Width Modulation) high capacity electric fan is installed instead of electric condenser fan to enhance the durability and controllability and reduce noise.

2) Mounting Location



3) PWM Electric Fan

(1) Advantages and Disadvantages of the PWM Electric Fan

▶ **Advantages**

- Enhanced A/C performance: at low speed, at idling, driving in city
- Reduction of vibration/noise: fan activated by PWM only when necessary
- Reduction of engine consuming power (V/Fan driving force) by 4 Hp - Cost saving

▶ **Disadvantage**

- Poor engine cooling perfomance at low and high rpm

4) PWM (Pulse Width Modulation) Unit

It controls the time of the output voltage to control the fan motor speed independently.

▶ **Internal functions**

- Motor power shutting-off function when overcurrent is applied
- Adverse voltage prevention function
- Detection function for the motor lock
- Temperature detecting function: The electric fan operates at FULL speed to cool down the PWM unit when the interior temperature of PWM unit is over 120~150°C.
- Communication function when failing: The fail signal is transmitted to the ECU when the PWM unit is malfunctioning.
- Soft start function: The motor speed is gradually increased when the motor is initially operated.

Modification basis	
Application basis	
Affected VIN	

5) Shutting-off Condition of the A/C Compressor

▶ **Coolant temperature**

- When coolant temperature is below 20°C or over 115°C, engine speed is below 650 rpm or over 4500 rpm for 4 seconds after engine starting, abrupt acceleration and A/C refrigerant pressure sensor detecting the followings
- A/C compressor is turned off when the refrigerant pressure is below 2.0 kg/cm2 and then is turned on when the refrigerant pressure is over 2.4 kg/cm2.
- A/C compressor is turned off when the refrigerant pressure is over 30 kg/cm2 and then is turned on when the refrigerant pressure is below 21.4 kg/cm2.

ENGINE ELECTRIC DEVICES

0000-00

GENERAL

1. DIAGNOSTIC INFORMATION AND PROCEDURE

1) Ignition System

Condition	Probable Cause	Correction
No Crank	• Low battery voltage.	• Charging the battery or Replace the battery.
	• Battery cable is loose, corroded, or damaged.	• Repair or Replace the battery cable.
	• Faulty starter motor or starter motor circuit is open.	• Repair or Replace the starter motor/starter motor circuit.
	• Faulty ignition switch.	• Replace the ignition switch.
	• Ground short.	• Repair the ground short.
Crank OK, But Too Slow	• Low battery voltage.	• Charging the battery or Replace the battery.
	• Battery. • Battery cables are loose, corroded, or damaged.	• Repair or Replace the battery cable.
	• Faulty starter motor.	• Repair or Replace the starter motor.
Starter Motor Does Not Stop	• Faulty starter motor.	• Repair or Replace the starter motor.
	• Faulty ignition switch.	• Replace the ignition switch.
Starter Motor Running, But Not Cranking	• Broken the clutch pinion gear or faulty starter motor.	• Replace the starter motor.
	• Broken the flywheel ring gear.	• Replace the flywheel.
	• Connected circuit is open.	• Repair the open circuit.
Battery Discharge	• Loosen the generator drive belt.	• Adjust the belt tension or Replace the belt.
	• The circuit is open or a short.	• Repair the open or a short circuit.
	• Battery run down.	• Replace the battery.
	• Open ground circuit.	• Repair the open ground circuit.
Charging Indicator Lamp Does Not Work When the Ignition Switch ON (Engine Does Not Work)	• Charging indicator lamp is blown or fuse is blown.	• Repair or Replace the charging indicator lamp/fuse.
	• Faulty ignition switch.	• Replace the ignition switch.
	• Generator ground circuit is open or a short.	• Repair the circuit.
Charging Indicator Lamp Does Not Put Out Lights After Starting the Engine	• Battery cable is corroded or damaged.	• Repair or Replace the battery cable.
	• Loosen the generator drive belt.	• Adjust the belt tension or Replace the belt.
	• Faulty wiring harness.	• Repair the wiring harness.
Battery Over Charging	• Generator Voltage Regulator Faulty	• Replace Generator
	• Voltage detecfing wiring faulty	• Repair Wiring

2) Ignition System (Cont'd)

Condition	Probable Cause	Correction
Hard Engine Starting	• Ignition coil faulty	• Replace ignition coil
	• Distributor (including optical sensor) faulty	• Replace distribator (or sensor)
	• Spark plug malfuntion	• Replace spark plug or adjust clearance
	• Ignition timing faulty (spark plug light is normal)	• Resetting valve timing
Unstable Engine Idling	• Spark plug malfunction	• Replace spark plug or adjust clearance
	• Ignition coil faulty	• Replace ignition coil
	• Ignition timing faulty	• Resetting valve timing
Enging Acceralation Malfunction	• Ignition timing faulty	• Resetting valve timing

Modification basis	
Application basis	
Affected VIN	

OVERVIEW AND OPERATION PROCESS

1. DESCRIPTION AND OPERATION

1) Battey

The sealed battery is standard on all cars. There are no vent plugs in the cover.
The battery is completely sealed, except for two small vent holes in the sides.
These vent holes allow the small amount of gas produced in the battery to escape.
The battery has the following advantages over conventional batteries:

- No water addition for the life of the battery.
- Overcharge protection. If too much voltage is applied to the battery, it will not accept as much current as a conventional battery.
  In a conventional battery, the excess voltage will still try to charge the battery, leading to gassing, which causes liquid loss.
- Not as liable to self-discharge as a conventional battery. This is particularly important when a battery is left standing for long periods of time.
- More power available in a lighter, smaller case.

The battery has three major functions in the electrical system.
First, the battery provides a source of energy for cranking the engine.
Second, the battery acts as a voltage stabilizer for the electrical system. Finally, the battery can, for a limited time, provide energy when the electrical demand exceeds the output of the generator.

2) Ratings

▶ A battery has two ratings: (1) a reserve capacity rating designated at 27°C(80°F), which is the time a fully charged battery will provide 25 amperes of current flow at or above 10.5 volts (2) a cold cranking amp rating determined under testing at -18°C(0°F), which indicates the cranking load capacity.

(1)Reserve Capacity

The reserve capacity (RC) is the maximum length of time it is possible to travel at night with the minimum electrical load and no generator output. Expressed in minutes, the RC rating is the time required for a fully charged battery, at a temperature of 27°C(80°F) and being discharged at a current of 25 amperes, to reach a terminal voltage of 10.5 volts.

(2) Cold Cranking Amperage

The cold cranking amperage test is expressed at a battery temperature of −18°C(0°F).
The current rating is the minimum amperage, which must be maintained by the battery for 30 seconds at the specified temperature, while meeting a minimum voltage requirement of 7.2 volts.
This rating is a measure of cold cranking capacity.
The battery is not designed to last indefinitely. However, with proper care, the battery will provide many years of service. If the battery tests well, but fails to perform satisfactorily in service for no apparent reason, the following factors may point to the cause of the trouble:

- Vehicle accessories are left on overnight.
- Slow average driving speeds are used for short periods.
- The vehicle's electrical load is more than the generator output, particularly with the addition of aftermarket equipment.
- Defects in the charging system, such as electrical shorts, a slipping generator belt, a faulty generator, or a faulty voltage regulator.
- Battery abuse, including failure to keep the battery cable terminals clean and tight or a loose battery hold-down clamp.
- Mechanical problems in the electrical system, such as shorted or pinched wires.

3) Charging Time Required

The time required to charge a battery will vary depending upon the following factors:

▶ Size of Battery - A Completely discharged large heavy-duty battery required more than twice the recharging time as a completely discharged small passenger car battery.

▶ Temperature − A longer time will be needed to charge any battery at −18°C(0°F) than at 27°C(80°F).
When a fast charger is connected to a cold battery, the current accepted by the battery will be very low at first.
The battery will accept a higher current rate as the battery warms.

▶ Charger Capacity - A charger which can supply only 5 amperes will require a much longer charging period than a charger that can supply 30 amperes or more.

▶ State-of-Charge - A completely discharged battery requires more than twice as much charge as a onehalf charged battery.
Because the electrolyte is nearly pure water and a poor conductor in a completely discharged battery, the current accepted by the battery is very low at first. Later, as the charging current causes the electrolyte acid content to increase, the charging current will likewise increase.

Modification basis	
Application basis	
Affected VIN	

4) Charging a Completely Discharged Battery (Off the Vehicle)

Unless this procedure is properly followed, a perfectly good battery may be needlessly replaced.
The following procedure should be used to recharge a completely discharged battery:

1. Measure the voltage at the battery terminals with an accurate voltmeter.
   If the reading is below 10 volts, the charge current will be very low, and it could take some time before the battery accepts the current in excess of a few milliamperes.
   Refer to "Charging Time Required" in this section, which focuses on the factors affecting both the charging time required. Such low current may not be detectable on ammeters available in the field.
   Set the battery charger on the high setting.
2.

CAUTION

Some chargers feature polarity protection circuitry, which prevents charger unless the charger leads are correctly connected to the battery terminals.
A completely discharged battery may not have enough voltage to activate this circuitry, even though the leads are connected properly, making it appear that the battery will not accept charging current.
Therefore, follow the specific charger manufacturer's instruction for by passing or overriding the circuitry so that the charger will turn on and charge a low-voltage battery.

3. Continue to charge the battery until the charge current is measurable. Battery chargers vary in the amount of voltage and current provided. The time required for the battery to accept a measurable charger current at various voltages may be as follows:

Voltage	Hours
16.0 or more	Up to 4 hours
14.0 - 15.9	Up to 8 hours
13.9 or less	Up to 16 hours

- If the charge current is not measurable at the end of the above charging times, the battery should be replaced.
- If the charge current is measurable during the charging time, the battery is good, and charging should be completed in the normal manner.

CAUTION

It is important to remember that a completely discharged battery must be recharged for a sufficient number of ampere hours (AH) to restore the battery to a usable state.

- If the charge current is still not measurable after using the charging time calculated by the above method, the battery should be replaced.

5) Jump Starting Procedure

1. Position the vehicle with the charged battery so that the jumper cables will reach from the charged battery to the battery that requires charging.
2. Turn off the ignition, all the lights, and all the electrical loads in both vehicles.
3. Leave the hazard flasher on if jump starting where there may be other traffic and any other lights needed for the work area.
4. Apply the parking brake firmly in both vehicles.

CAUTION
In order to avoid damaging the vehicle make sure the cables are not on or near pulleys, fans, or other parts that will move when the engine starts.

5. Shift an automatic transmission to PARK.

CAUTION
In order to avoid injury, do not use cables that have loose or missing insulation.

6. Clamp one end of the first jumper cable to the positive terminal on the booster battery. Make sure it does not touch any other metal parts.
7. Clamp the other end of the same cable to the positive terminal on the discharged battery. Never connect the other end to the negative terminal of the discharged battery.

CAUTION
Do not attach the cable directly to the neg-ative terminal of the discharged battery. Doing so could cause sparks and possible battery explosion.

8. Clamp one end of the second cable to the negative terminal of the booster battery.
9. Make the final connection to a solid engine ground, such as the engine lift bracket at least 450 millimeters (18 inches) from the discharged battery.
10. Start the engine of the vehicle with the good battery.
    Run the engine at a moderate speed for several minutes.
11. Then start the engine of the vehicle with the discharged battery.
12. Remove the jumper cables by reversing the above sequence exactly, removing the negative cable from the vehicle with the discharged battery first.
    While removing each clamp, take care that it does not touch any other metal while the other end remains attached.

Modification basis	
Application basis	
Affected VIN	

6) Alternator

Alternators are equipped with internal regulators.
Unlike three-wire generators, the alternator may be used with only two connections: battery positive and an "D+" terminal to the charge indicator lamp.
As with other charging systems, the charge indicator lamp lights when the ignition switch is turned to RUN, and goes out when the engine is running.
If the charge idicator is on with the engine running, a charging system defect is indicated. This indicator light will glow at full brilliance for several kinds of defects as well as when the system voltage is too high or too low.
The regulator voltage setting varies with temperature and limits the system voltage by controlling rotor field current.
Achieve correct average field current for proper system voltage control by varying the on-off time. At high speeds, the on-time may be 10 percent and the off-time 90 percent.
At low speeds, with high electrical loads, the on-time may be 90 percent and the off-time 10 percent.

7) Charging System

Generators use a new type of regulator that incorporates a diode trio.
A Delta stator, a rectifier bridge, and a rotor with slip rings and brushes are electrically similar to earlier generators.
A conventional pulley and fan are used.
There is no test hole.

8) Starter

Wound field starter motors have pole pieces, arranged around the armature, which are energized by wound field coils.
Enclosed shift lever cranking motors have the shift lever mechanism and the solenoid plunger enclosed in the drive housing, protecting them from exposure to dirt, icy conditions, and splashes.
In the basic circuit, solenoid windings are energized when the switch is closed.
The resulting plunger and shift lever movement causes the pinion to engage the engine flywheel ring gear.
The solenoid main contacts close. Cranking then takes place.
When the engine starts, pinion overrun protects the armature from excessive speed until the switch is opened, at which time the return spring causes the pinion to disengage.
To prevent excessive overrun, the switch should be released immediately after the engine starts.

9) Starting System

The engine electrical system includes the battery, the ignition, the starter, the generator, and all the related wiring.

Diagnostic tables will aid in troubleshooting system faults. When a fault is traced to a particular component, refer to that component section of the service manual.

The starting system circuit consists of the battery, the starter motor, the ignition switch, and all the related electrical wiring.

All of these components are connected electrically.

Modification basis	
Application basis	
Affected VIN	

ENGINE CONTROL SYSTEM

1521-01

GENERAL

1. ENGINE DATA DISPLAY TABLE

Parameter	Unit	Value
Engine coolant temp.	℃	greater than 95℃ after warm up
Intake air temp.	℃	-40 ~ 130℃ (varies with ambient temp. or engine mode)
Engine rpm	rpm	700 ± 50 (P/N), 600 ± 50 (D)
Regular rpm	rpm	700 ± 50 (P/N), 600 ± 50 (D)
Engine load	%	18 ~ 25 %
Mass air flow meter	Kg/h	16 ~ 25 Kg/h
Throttle position angle	°TA	0°TA (up to 100°TA at the wide open throttle)
Spark advance	°CA	°CA (6 ~ 9°CA)
Indicated engine torque	Nm	Varies with engine condition
Injection time	ms	3 ~ 5 ms
Battery voltage	V	13.5 ~ 14.1V (engine running)
Front axle speed	Km/h	0 ~ 265 Km/h
Rear axle speed	Km/h	0 ~ 265 Km/h
Accel. Pedal position 1	V	0.4 ~ 4.8 V
Accel. Pedal position 2	V	0.2 ~ 2.4 V
Throttle position 1	V	0.3 ~ 4.6 V
Throttle position 2	V	0.3 ~ 4.6 V
Fuel integrator		0.8 ~ 1.2
Oxygen sensor	mv	100 ~ 900 mv
A/c s/w condition	1=ON/0=OFF	-
Full load state	1=ON/0=OFF	-
Shift gear state (A/T)	1=ON/0=OFF	-
A/c control state	1=ON/0=OFF	-
Clutch switch (M/T)	1=ON/0=OFF	-
Cam actuator state	1=ON/0=OFF	-
Knocking control	1=ON/0=OFF	-
Protect mission	1=ON/0=OFF	-
Purge control valve	1=ON/0=OFF	-
Lambda function	1=ON/0=OFF	-
Catalyst heating	1=ON/0=OFF	-
Overrun fuel cut	1=ON/0=OFF	-
Full fuel cut	1=ON/0=OFF	-
Brake switch	1=ON/0=OFF	-
Cruise control status	1=ON/0=OFF	-

* Condition: Warmed up, idle, P/N or neutral

1) TEMPERATURE VS RESISTANCE

℃	°F	ECT Sensor	IAT Sensor
		ohms (Ω)	
Temperature vs Resistance Values (Approximate)			
130	266	88	102
120	248	111.6	127
110	230	143	159
100	212	202	202
90	194	261	261
80	176	340	340
70	158	452	452
60	140	609	609
50	122	835	835
40	113	1166	1166
30	86	1662	1662
20	68	2420	2420
10	50	3604	3604
0	32	5499	5499
-10	14	8609	8609
-20	-4	13850	13850
-30	-22	22960	22960
-40	-40	39260	39260

2. FASTENER TIGHTENING SPECIFICATIONS

Application	Nm	Lb-Ft	Lb-In
Camshaft position sensor retaining bolts	10	-	89
Canister mounting bolts	6	-	53
Coolant temperature sensor	30	22	-
Crankshaft position sensor retaining bolt	10	-	89
Engine Control Module (ECM) mounting bracket nuts	10	-	89
Fuel filter mounting bracket bolt	6	-	53
Fuel filter lines	28	21	-
Fuel pressure test connector	25	18	-
Fuel rail assembly bolts	25	18	-
Fuel return and supply lines	23	17	-
Fuel tank retaining nuts	38	28	-
Intake air duct mounting bolts	9	-	80
Knock sensor mounting bolt	25	18	-
Oxygen sensor	55	41	-
Pedal position censor mounting bolts and nut	6	-	53
Throttle body bolts	12	-	106

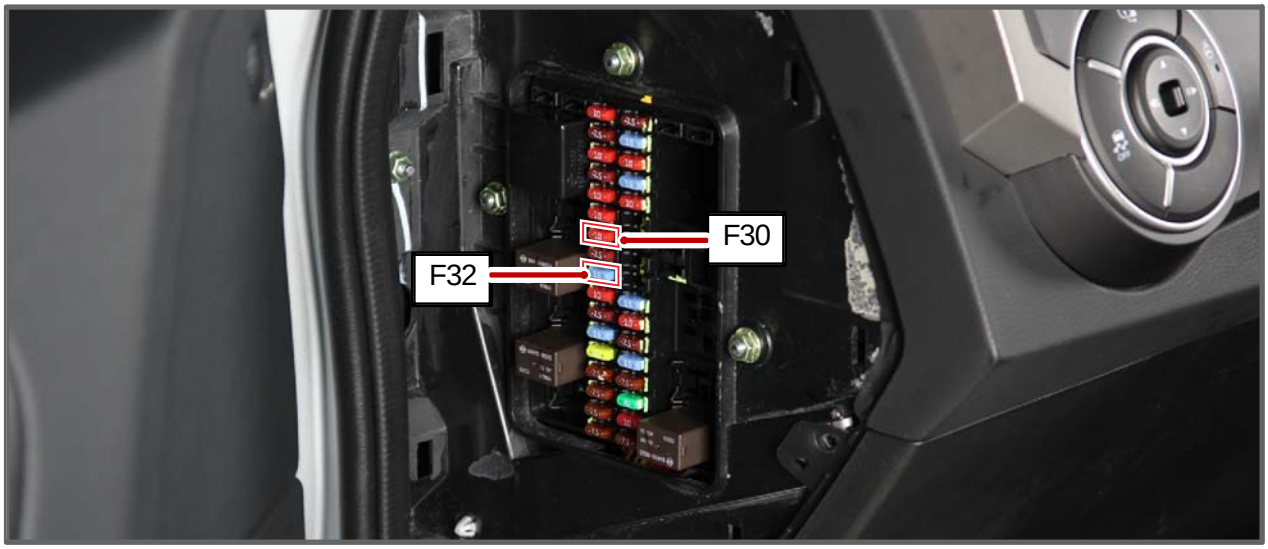
FUSE AND REALY

8410-02

GENERAL INFORMATION

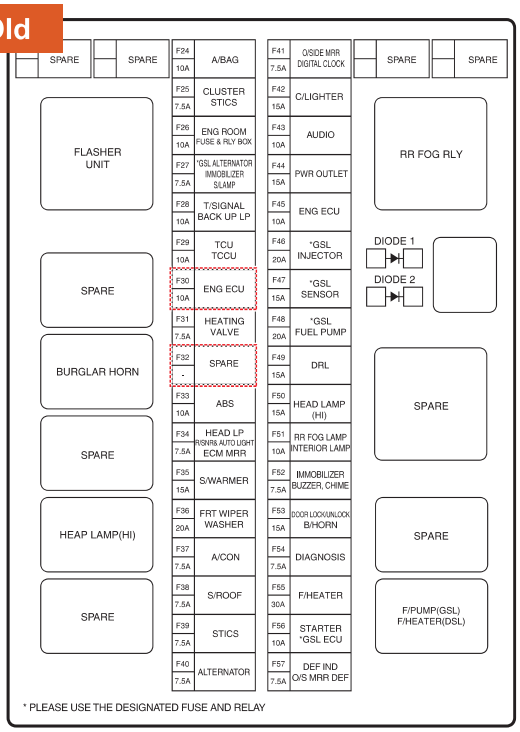
1. MAJOR CHANGES

▶ Driver's interior fuse and relay box assembly changed

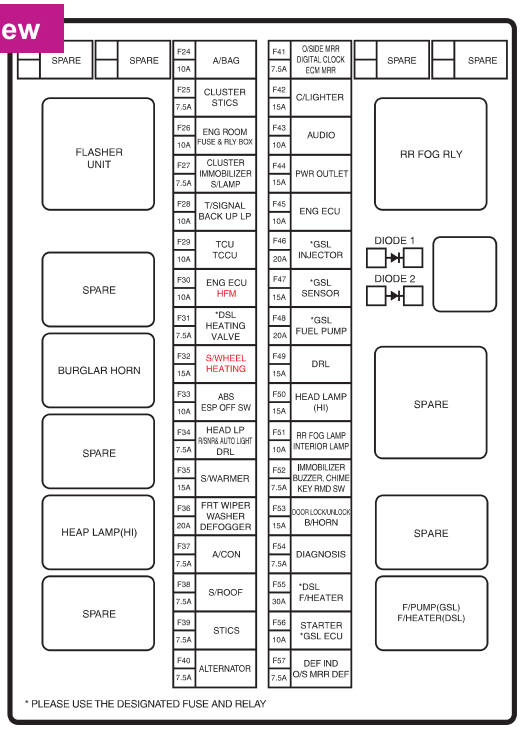


I/P - LH FUSE / RELAY BOX

Old



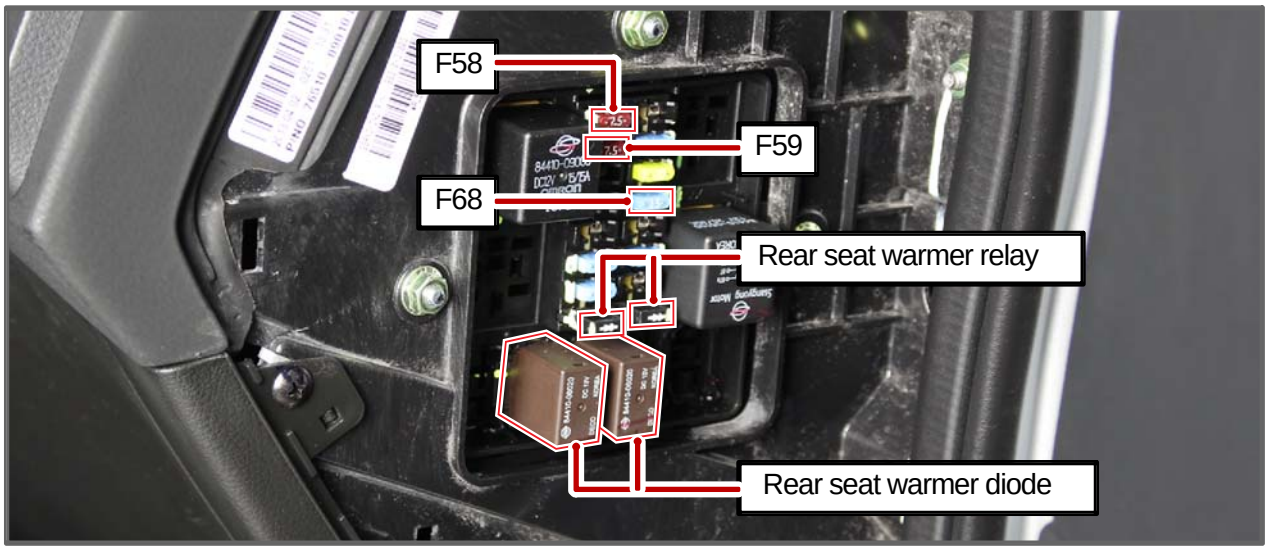
New



- Power supply circuit for HFM sensor added (F30)
- Fuse for heated steering wheel added (F32)

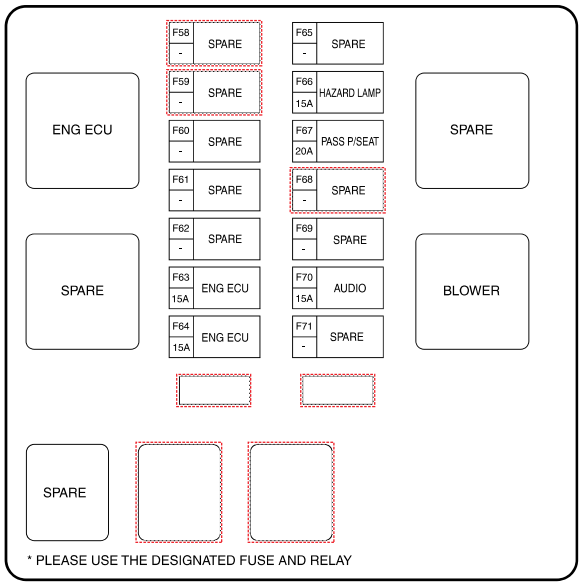
Modification basis	
Application basis	
Affected VIN	

▶ Passenger's interior fuse and relay box assembly changed

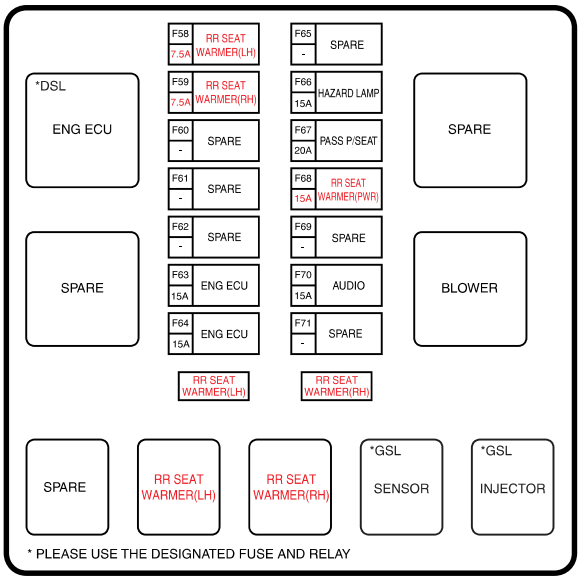


I/P - RH FUSE / RELAY BOX

Old



New



Fuse, relay and diode for rear seat warmer added
- F58: Rear LH seat warmer fuse
- F59: Rear RH seat warmer fuse
- F68: Rear seat warmer power fuse
- 2 rear seat warmer diodes (LH & RH)
- 2 rear seat warmer relays (LH & RH)

Modification basis	
Application basis	
Affected VIN	

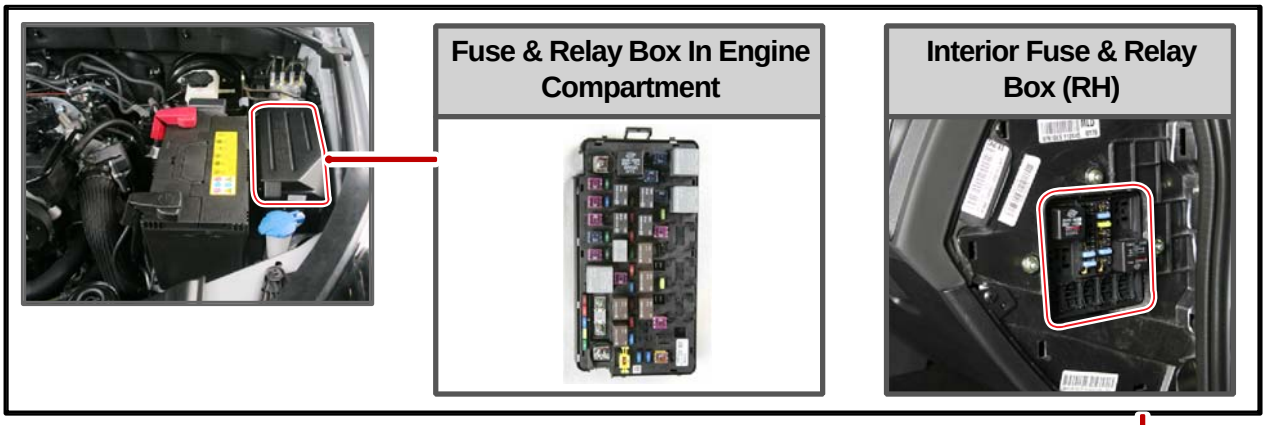
OVERVIEW AND OPERATION PROCESS

1. OVERVIEW

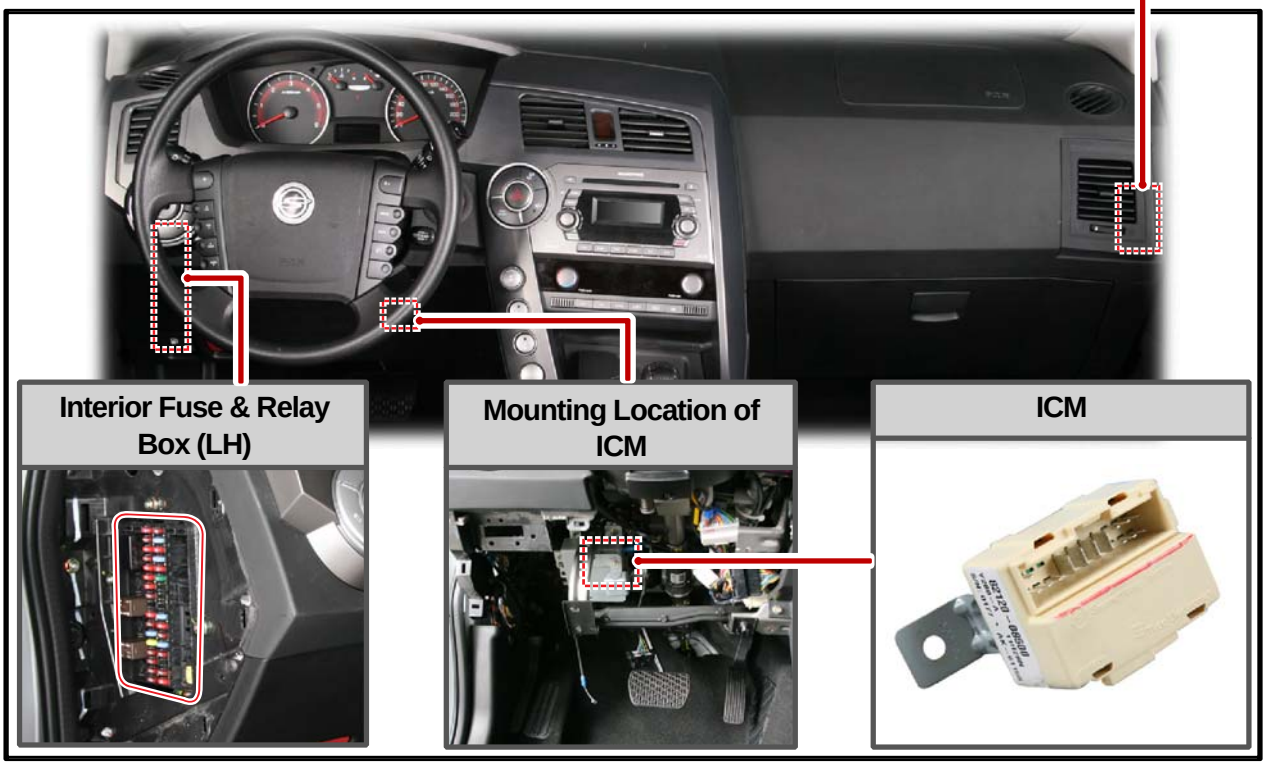
The ICM (Integrated Control Module) mounted to the back of the STICS is integrated with the door lock/unlock relay, windshield de-icer relay and turn signal lamp relay. There are four fuse & relay units.

2. MOUNTING LOCATION

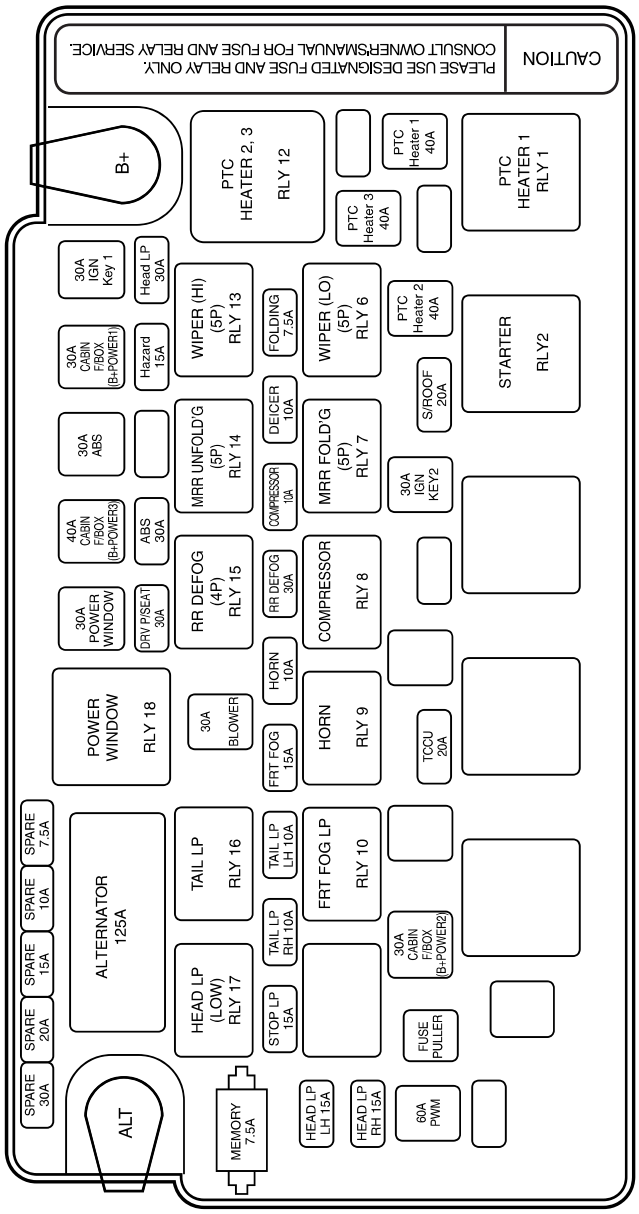
▶ **In engine compartment**



▶ **In vehicle**



3. CAPACITY AND NAME OF FUSE AND RELAY IN ENGINE COMPARTMENT



* The label attached on each fuse box indicates only major fuses and relays. Therefore, there are more fuses and relays than indicated. For details about the connection of fuses and relays, refer to the power distribution circuit diagram on the following pages.

Modification basis	
Application basis	
Affected VIN	

4. CAPACITY AND NAME OF INTERIOR FUSE AND RELAY

1) Interior Fuse and Relay Box on Driver Side

SPARE	SPARE	F24 10A	A/BAG	F41 7.5A	O/SIDE MRR DIGITAL CLOCK ECM MRR	SPARE	SPARE
FLASHER UNIT		F25 7.5A	CLUSTER STICS	F42 15A	C/LIGHTER	RR FOG RLY	
		F26 10A	ENG ROOM FUSE & RLY BOX	F43 10A	AUDIO		
		F27 7.5A	CLUSTER IMMOBILIZER S/LAMP	F44 15A	PWR OUTLET		
		F28 10A	T/SIGNAL BACK UP LP	F45 10A	ENG ECU		
SPARE		F29 10A	TCU TCCU	F46 20A	*GSL INJECTOR	DIODE 1	
		F30 10A	ENG ECU	F47 15A	*GSL SENSOR	DIODE 2	
		F31 7.5A	*DSL HEATING VALVE	F48 20A	*GSL FUEL PUMP		
BURGLAR HORN		F32 15A	S/WHEEL HEATING	F49 15A	DRL	SPARE	
		F33 10A	ABS ESP OFF SW	F50 15A	HEAD LAMP (HI)		
SPARE		F34 7.5A	HEAD LP R/SNR& AUTO LIGHT DRL	F51 10A	RR FOG LAMP INTERIOR LAMP		
		F35 15A	S/WARMER	F52 7.5A	IMMOBILIZER BUZZER, CHIME KEY RMD SW		
HEAP LAMP(HI)		F36 20A	FRT WIPER WASHER DEFOGGER	F53 15A	DOOR LOCK/UNLOCK B/HORN	SPARE	
		F37 7.5A	A/CON	F54 7.5A	DIAGNOSIS		
SPARE		F38 7.5A	S/ROOF	F55 30A	*DSL F/HEATER	F/PUMP(GSL) F/HEATER(DSL)	
		F39 7.5A	STICS	F56 10A	STARTER *GSL ECU		
		F40 7.5A	ALTERNATOR	F57 7.5A	DEF IND O/S MRR DEF		

* PLEASE USE THE DESIGNATED FUSE AND RELAY

Modification basis	
Application basis	
Affected VIN	

2) Interior Fuse and Relay Box on Passenger Side

		F58 7.5A RR SEAT WARMER(LH)	F65 - SPARE		
*DSL ENG ECU		F59 7.5A RR SEAT WARMER(RH)	F66 15A HAZARD LAMP	SPARE	
		F60 - SPARE	F67 20A PASS P/SEAT		
		F61 - SPARE	F68 15A RR SEAT WARMER(PWR)		
SPARE		F62 - SPARE	F69 - SPARE	BLOWER	
		F63 15A ENG ECU	F70 15A AUDIO		
		F64 15A ENG ECU	F71 - SPARE		
		RR SEAT WARMER(LH)	RR SEAT WARMER(RH)		

SPARE	RR SEAT WARMER(LH)	RR SEAT WARMER(RH)	*GSL SENSOR	*GSL INJECTOR

* PLEASE USE THE DESIGNATED FUSE AND RELAY

Modification basis	
Application basis	
Affected VIN	

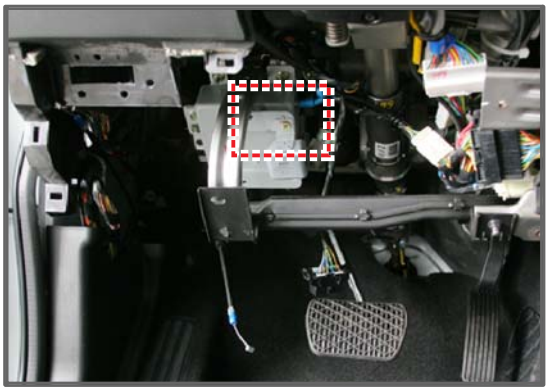
5. OPERATING PROCESS OF ICM BOX

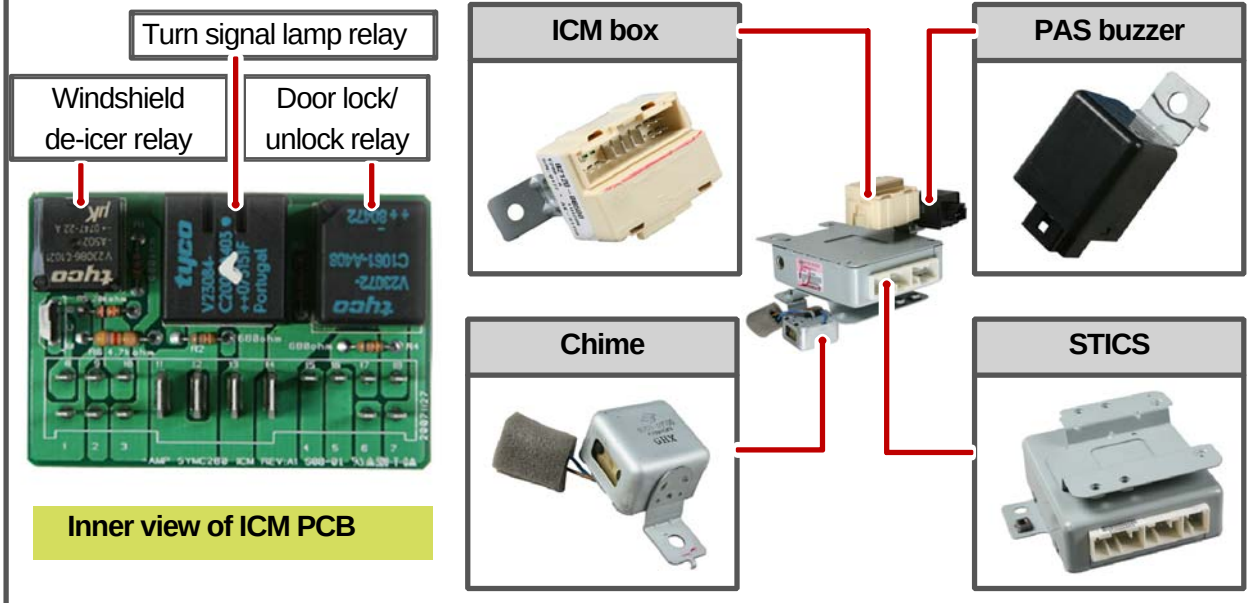
1) Overview

The following relays are integrated into the ICM (Integrated Control Module) box.

- **Door lock/unlock relay**
- **Windshield de-icer relay**
- **Turn signal lamp relay**

2) Mounting Location





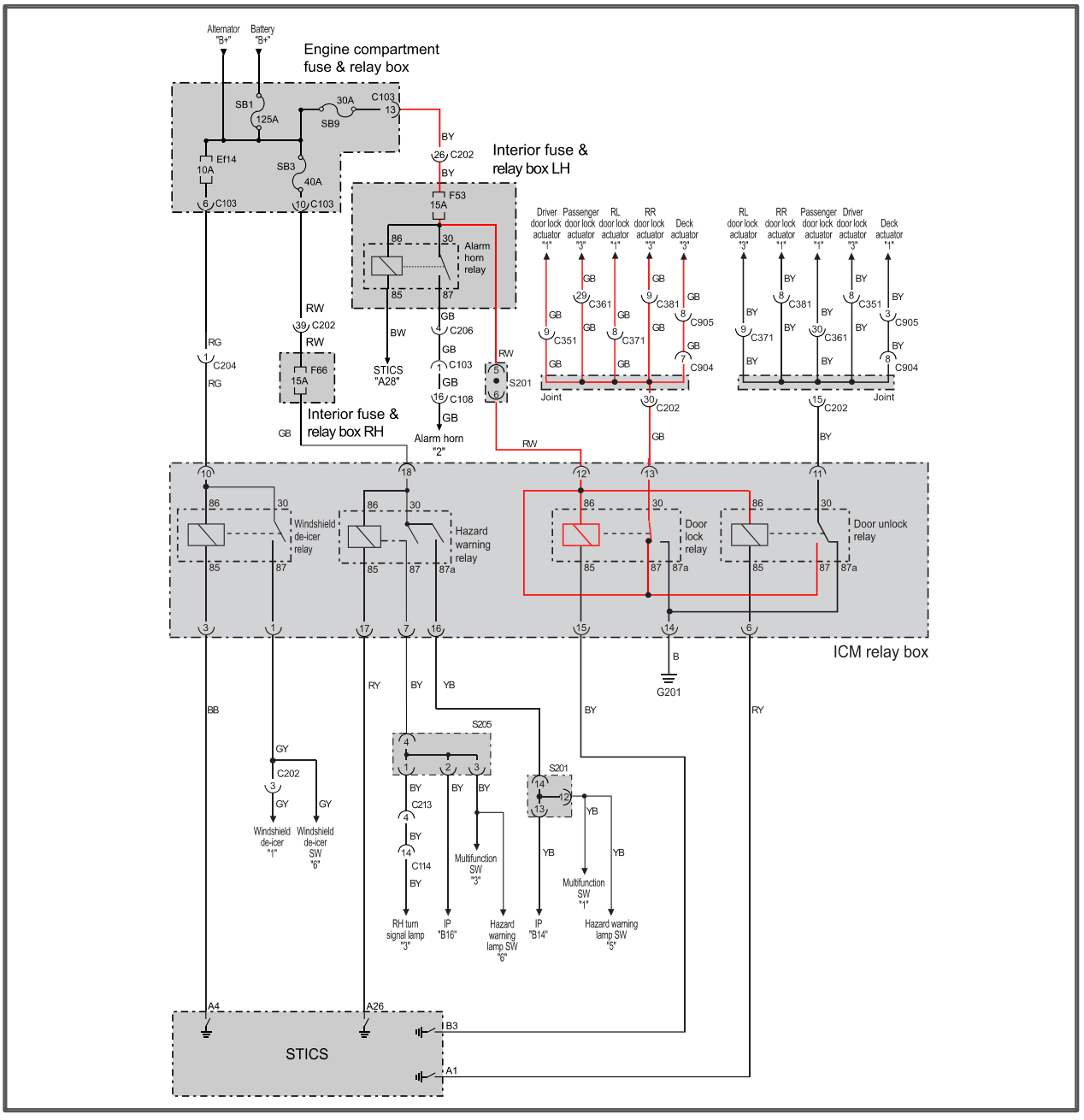
Inner view of ICM PCB

NOTE

The relays in the ICM box cannot be replaced respectively; so if the any of the components on the PCB are defective, they should be replaced as an assembly.

3) Operating Process by Power Supply of ICM Box

(1) Door lock relay

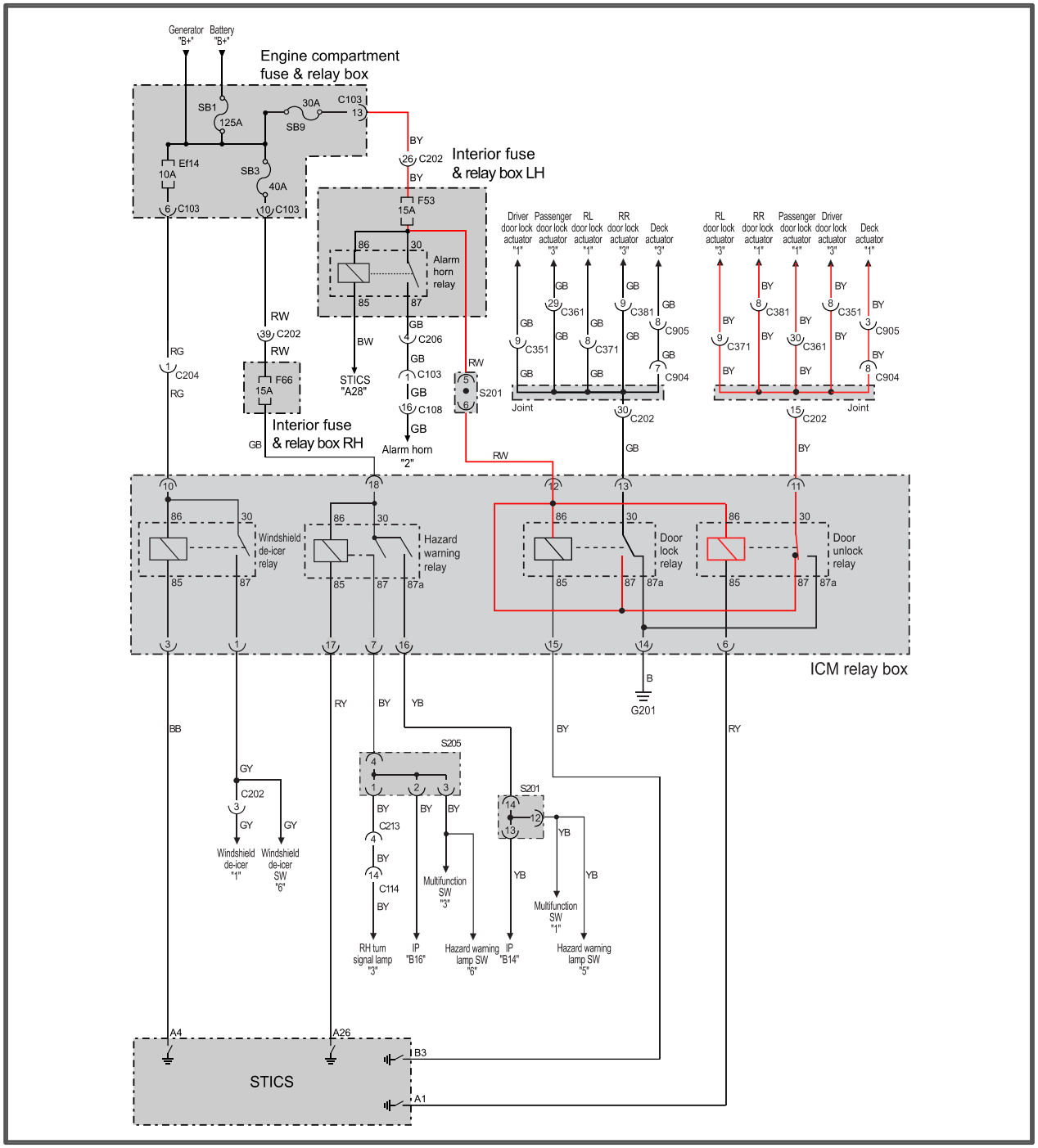


The power supplied through the No. F53 interior fuse on the left-hand of the engine compartment is on standby on the No. 86 and 87 door lock relay terminals and No. 86 and 87 door unlock relay terminals via the ICM No. 12 terminal. The STICS activates and/or controls the door lock relay connected to the ICM No. 15 terminal using the STICS No. B3 terminal depending on the operating conditions. The activated door lock relay supplies the No. 30 terminal with the B+ power, which is standby on the No. 87 terminal and supplies each door actuator with the B+ power.

The supplied power flows to the G201 ground connected to the ICM No. 14 terminal via the No. 30 and 87a door unlock relays for corresponding load.

Modification basis	
Application basis	
Affected VIN	

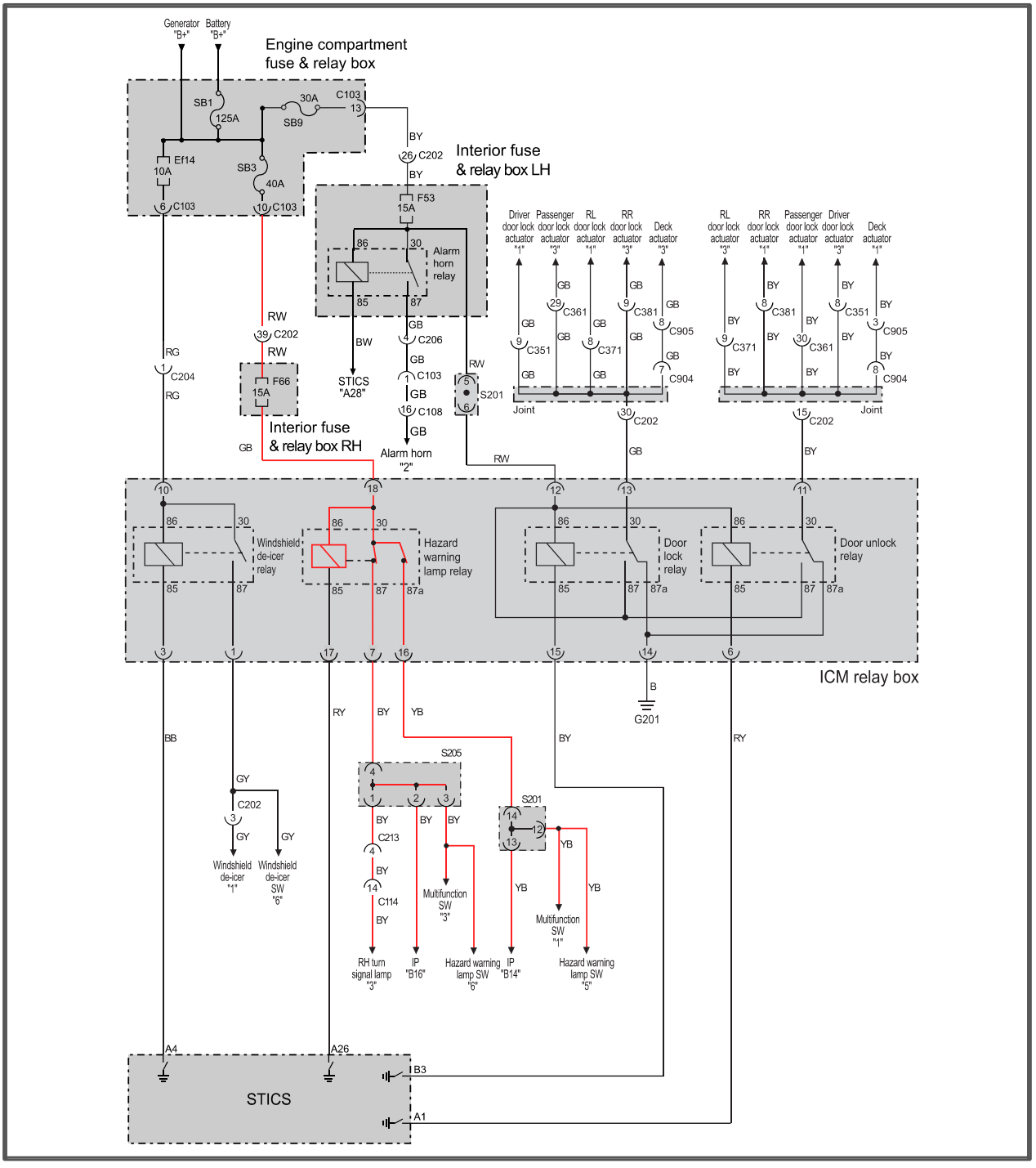
(2) Door unlock relay



The supply power is on standby in the same way as the door lock relay, and the STICS activates and/or controls the door unlock relay connected to the ICM No. 6 terminal using the STICS No. A1 terminal depending on the operating conditions. The activated door unlock relay supplies the No. 30 terminal with the B+ power, which is standby on the No. 87 terminal and supplies each door actuator with the B+ power.

The supplied power flows to the G201 ground connected to the ICM No. 14 terminal via the No. 30 and 87a door lock relays for corresponding load.

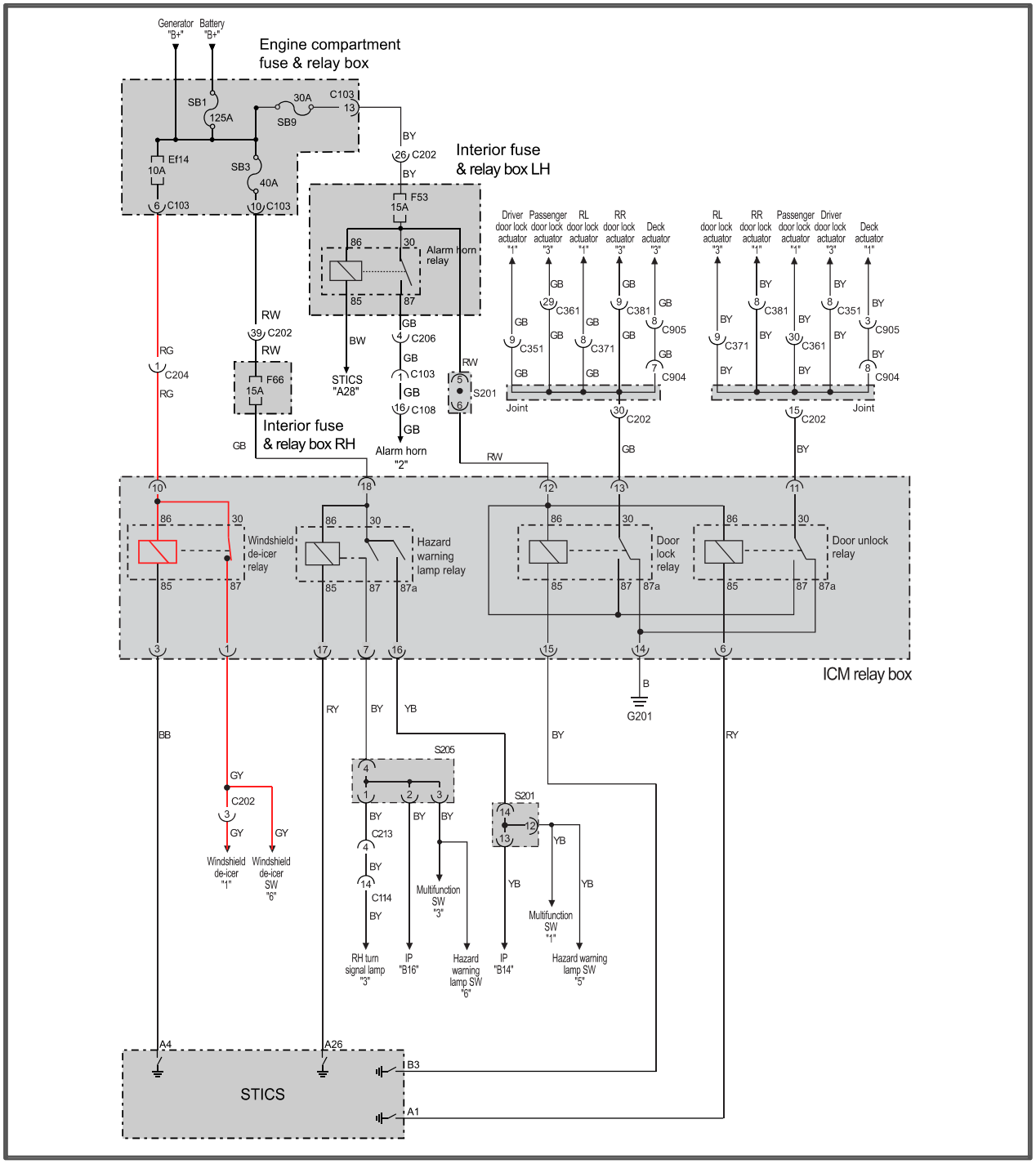
(3) Turn signal lamp (Hazard warning lamp operation)



The B+ power supplied through the No. F66 interior fuse on the right-hand of the engine compartment is on standby on the No. 30 and 86 hazard warning lamp relay terminals via the ICM No. 18 terminal.
The STICS activates and/or controls the hazard warning lamp relay using the No. A26 terminal depending on the operating conditions. The activated relay supplies the No. 87 and 87a terminals with the power, which is on standby on the No. 30 hazard warning lamp relay terminal.
The supplied power flows to the corresponding circuit via the No. 7 and 16 ICM terminals.

Modification basis	
Application basis	
Affected VIN	

(4) Windshield de-icer operation



The B+ power supplied through the No. Ef14 fuse and relay box in the engine compartment is on standby on the No. 30 and 86 windshield de-icer relay terminals via the ICM No. 10 terminal.
The STICS activates and/or controls the windshield de-icer relay using the No. A4 terminal depending on the operating conditions. The activated relay supplies the No. 87 terminal with the power, which is on standby on the No. 30 windshield de-icer lamp relay terminal.
The supplied power flows to the windshield de-icer circuit via the No. 1 ICM terminal.

STICS

8710-01

GENERAL

1. PERFORMANCE AND SPECIFICATIONS

1) Rated Load & Input Signals

▶ **Rated Load**

NO.	Item	Rated Load
1	Chime bell / Buzzer	DC 12V 350 mA (Inductive load)
2	Front room lamp	DC 12V 16W (Lamp load)
3	Rear room lamp	DC 12V 8W (Lamp load)
4	Ignition key illumination	DC 12V 1.2W (Lamp load)
5	Seat belt indicator	DC 12V 1.2W (Lamp load)
6	Parking brake warning lamp	DC 12V 1.2W (Lamp load)
7	Door ajar warning lamp	DC 12V 1.2W (Lamp load)
8	Door lock relay	DC 12V 200 mA (Inductive load)
9	Door unlock relay	DC 12V 200 mA (Inductive load)
10	Horn relay	DC 12V 260 mA
11	Tail lamp relay	DC 12V 200 mA (Inductive load)
12	Hazard warning lamp relay	DC 12V 200 mA (Inductive load)
13	Power window relay	DC 12V 200 mA (Inductive load)
14	Rear defogger relay	DC 12V 200 mA (Inductive load)
15	Wiper LOW relay	DC 12V 200 mA (Inductive load)
16	Wiper HIGH relay	DC 12V 200 mA (Inductive load)
17	Front washer motor	DC 12V 1.5A
18	Head lamp relay	DC 12V 750 mA (Inductive load)
19	Front defogger relay	DC 12V 200 mA (Inductive load)
20	Mirror lock relay	DC 12V 200 mA (Inductive load)
21	Mirror unlock relay	DC 12V 200 mA (Inductive load)

▶ **Input Signals**

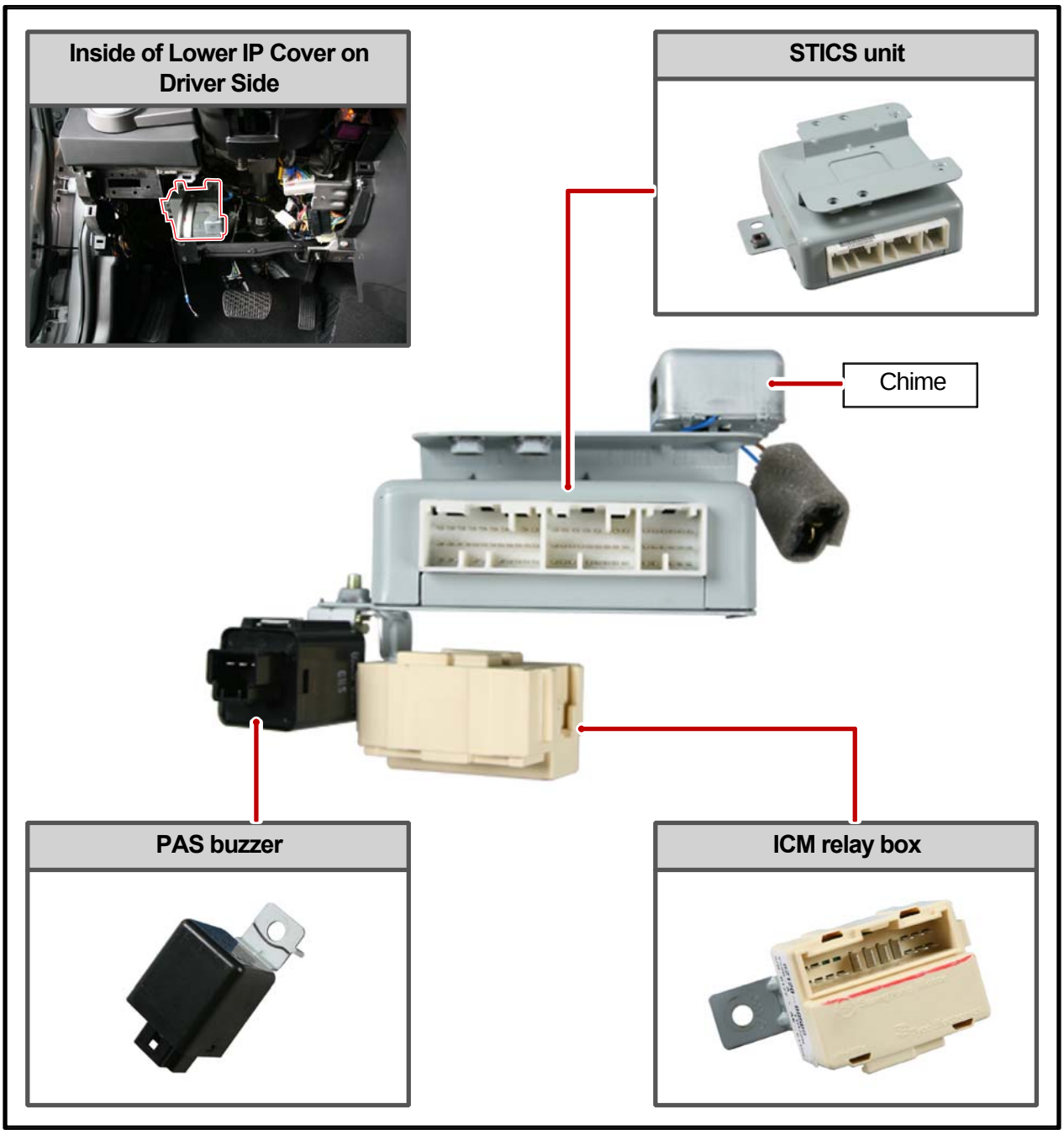
NO.	Input Signal Name	Logic Status
1	IGN1	ON = BAT (IGN ON or START)
2	IGN2	ON = BAT (IGN ON)
3	ALT_D	ON = BAT (engine started)
4	Key reminder switch	IN = BAT (key in)
5	Driver's door switch	OPEN = GND, CLOSE = OPEN
6	Passenger's door switch	OPEN = GND, CLOSE = OPEN
7	Rear door switch	- OPEN (one of rear doors) = GND - CLOSE (all rear doors) = OPEN
8	Hood switch	OPEN = GND, CLOSE = OPEN
9	Driver's door lock/unlock switch	LOCK = OPEN, UNLOCK = GND
10	Passenger's door lock/unlock switch	LOCK = OPEN, UNLOCK = GND
11	Rear door lock/unlock switch	- UNLOCK (one of rear doors) = GND - LOCK (all rear doors) = OPEN
12	Tailgate lock/unlock switch	LOCK = OPEN, UNLOCK = GND
13	Rear defogger switch	ON = GND, OFF = OPEN
14	Seat belt switch	Unfastened = GND, Fastened = OPEN
15	Sunroof open switch	ON = GND, OFF = OPEN
16	Parking brake switch	ON = GND, OFF = OPEN
17	Air bag collision sensor	ON = 200 ms output (LOW), OFF = OPEN
18	Wiper motor (parking) switch	STOP = BAT VOLTAGE, ROTATING = GND
19	Washer switch	ON = BAT, OFF = OPEN
20	INT-AUTO switch	ON = BAT, OFF = OPEN
21	Auto washer switch	ON = BAT, OFF = OPEN
22	Intermittent resistance	0W ~ 51KW (for intermittent wiper)
23	Speed sensor	ON = GND (PWM), OFF = OPEN
24	Mirror lock/unlock switch	ON = GND, OFF = OPEN
25	Front defogger switch	ON = GND, OFF = OPEN
26	Auto hazard switch	ON = GND, OFF = OPEN

NO.	Input Signal Name	Logic Status
27	Central door lock switch	ON = GND, OFF = OPEN
28	Multifunction auto light switch	ON = GND, OFF = OPEN
29	Turn signal lamp switch	ON = BAT/GND, OFF = OPEN (approx. 5.1 V ~ 9.2 V)
30	Rain sensor	ON = GND (DATA), OFF = BAT
31	Telematics	ON = GND (DATA), OFF = BAT
32	Diagnosis	ON = GND (DATA), OFF = BAT (KWP2000)

OVERVIEW AND OPERATING PROCESS

1. GENERAL

STICS of KORANDO SPORTS, called as RKSTICS (REKES + STICS (Super Time & Integrated Control System)), is almost the same as that of ACTYON SPORTS in terms of its function and role.



Modification basis	
Application basis	
Affected VIN	

1) Wiper and Washer Operations

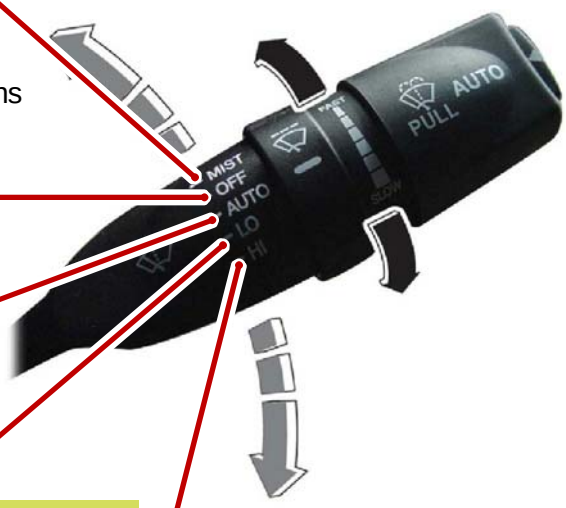
Front Wiping Speed Control Switch
FAST: Fast interval
SLOW: Slow interval

MIST
When pulling up the lever, the wiper operates once and the wiper lever returns to the "OFF" position.

OFF
Stop the operation.

AUTO
Operates automatically according to the vehicle speed or the amount of rain.

LO
Continuous wipe, slow operation.



HI
Continuous wipe, fast operation

Front Auto Washer Switch (AFW)
When the front wiper switch is off and this switch is pressed, washer fluid will be sprayed and the wiper will automatically operate 4 times. Then, the fluid will be sprayed again and the wiper will automatically operate 3 times.

Previous model
Pressing the switch makes washer fluid to be sprayed for 2 sec. with four wiping, after having delay of 0.6 sec., washer fluid to be sprayed for 1.5 sec. with three wiping

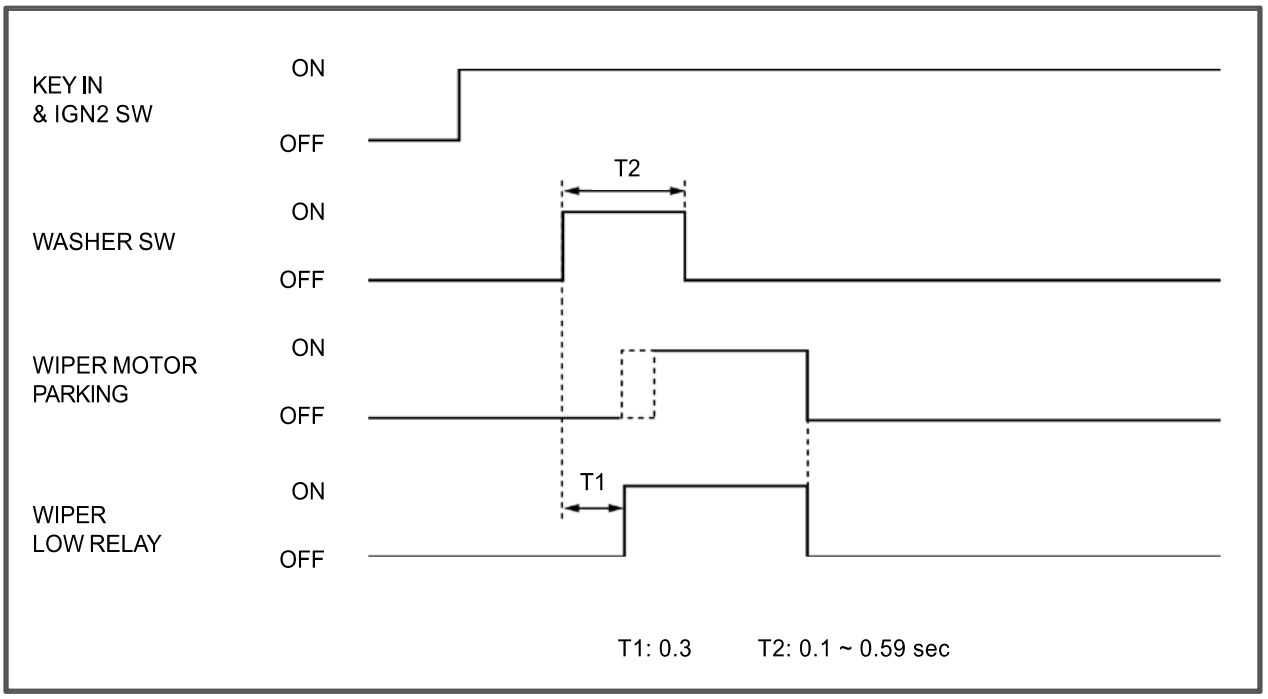
New model
Pressing the switch makes washer fluid to be sprayed for 2 sec. with four wiping, and washer fluid to be sprayed for 1.5 sec. with three wiping, with no delay of time

Front Wiper and Washer Coupled Operation
Pull the lever briefly (below 0.6 seconds):
One wiping cycle without washer spray
Pull and hold the lever for more than 0.6 seconds:
Three wiping cycles with washer spray

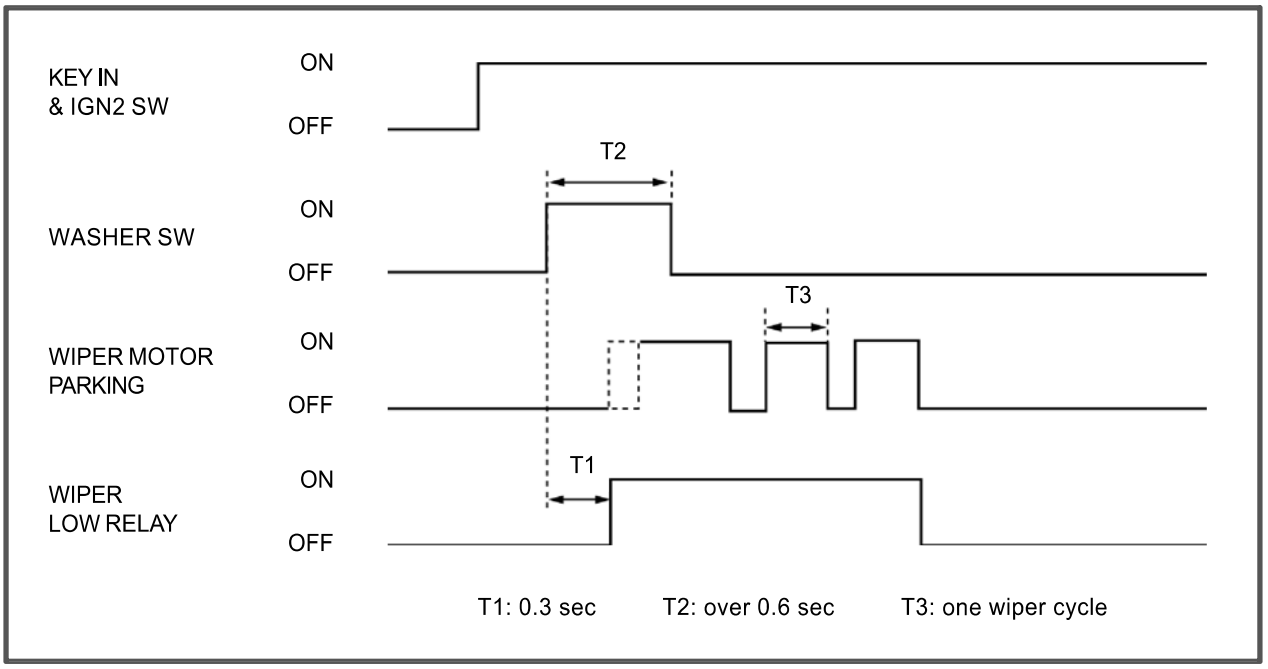
2) Operation Logic

▶Wiper MIST and Front Washer Coupled Wiper

- The wiper relay is turned on at 0.3 seconds after from the time when the washer switch is turned on for 0.1 to 0.59 seconds with the ignition switch "ON".If the wiper parking terminal gets off, the wiper relay is turned off.

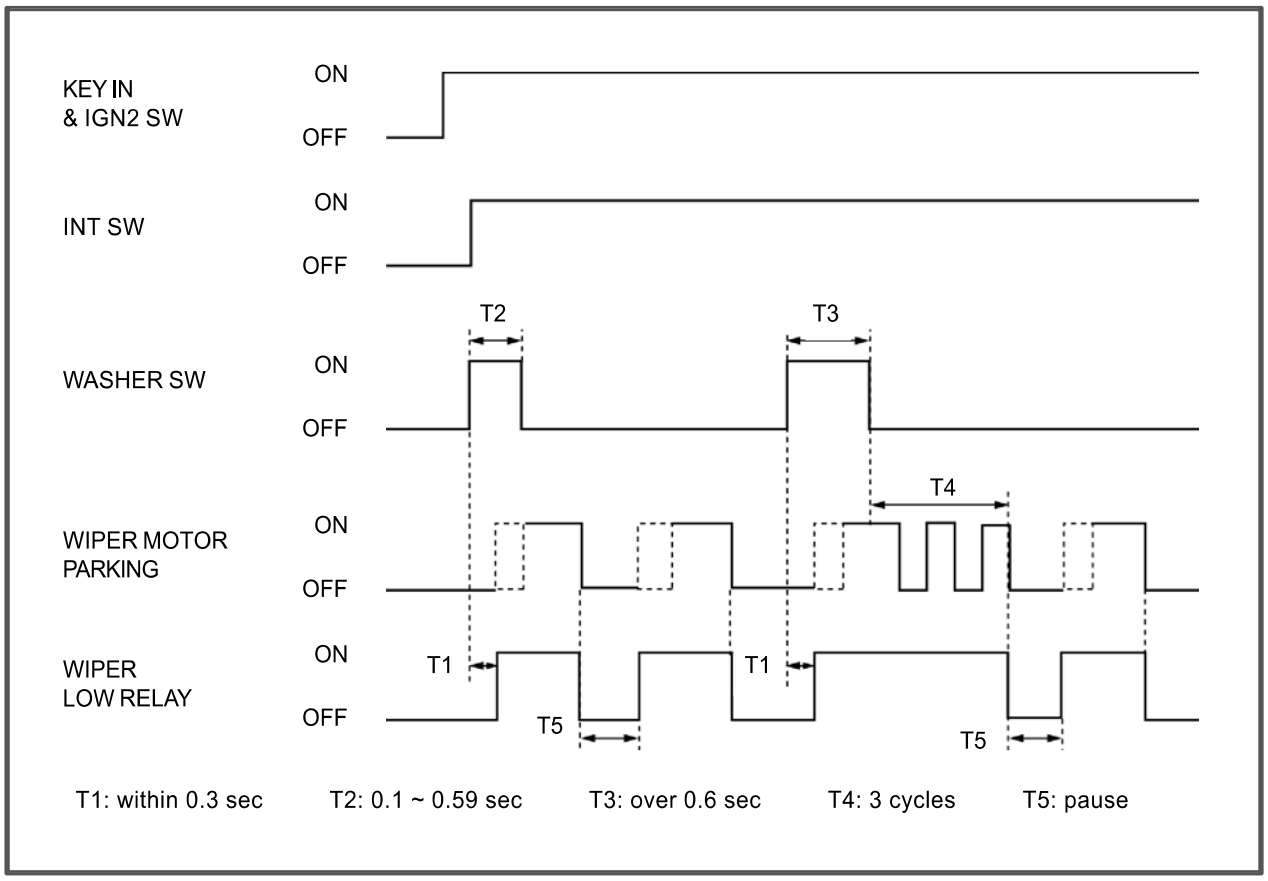


- The wiper relay is turned on at 0.3 seconds after from the time when the washer switch is turned on for more than 0.6 seconds with the ignition switch "ON". The wiper relay gets on 3 times immediately after turning off the washer switch.



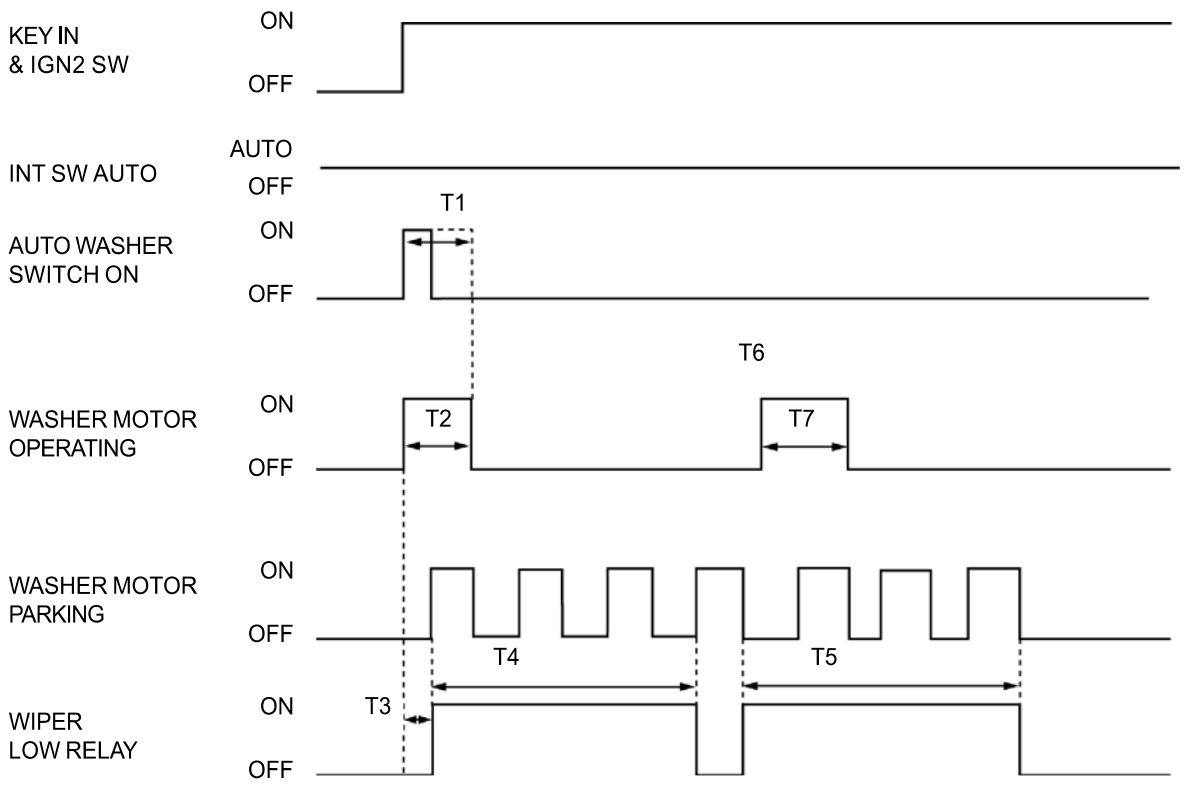
Modification basis	
Application basis	
Affected VIN	

- When the washer switch is turned on for more than 0.6 seconds during the wiper operation by INT switch, the operation in step (2) is performed.
  When it is turned on for a certain period of time (0.1 to 0.59 seconds), the operation in step (1) is performed.



▶Auto Washer and Wiper Switch (AFW)

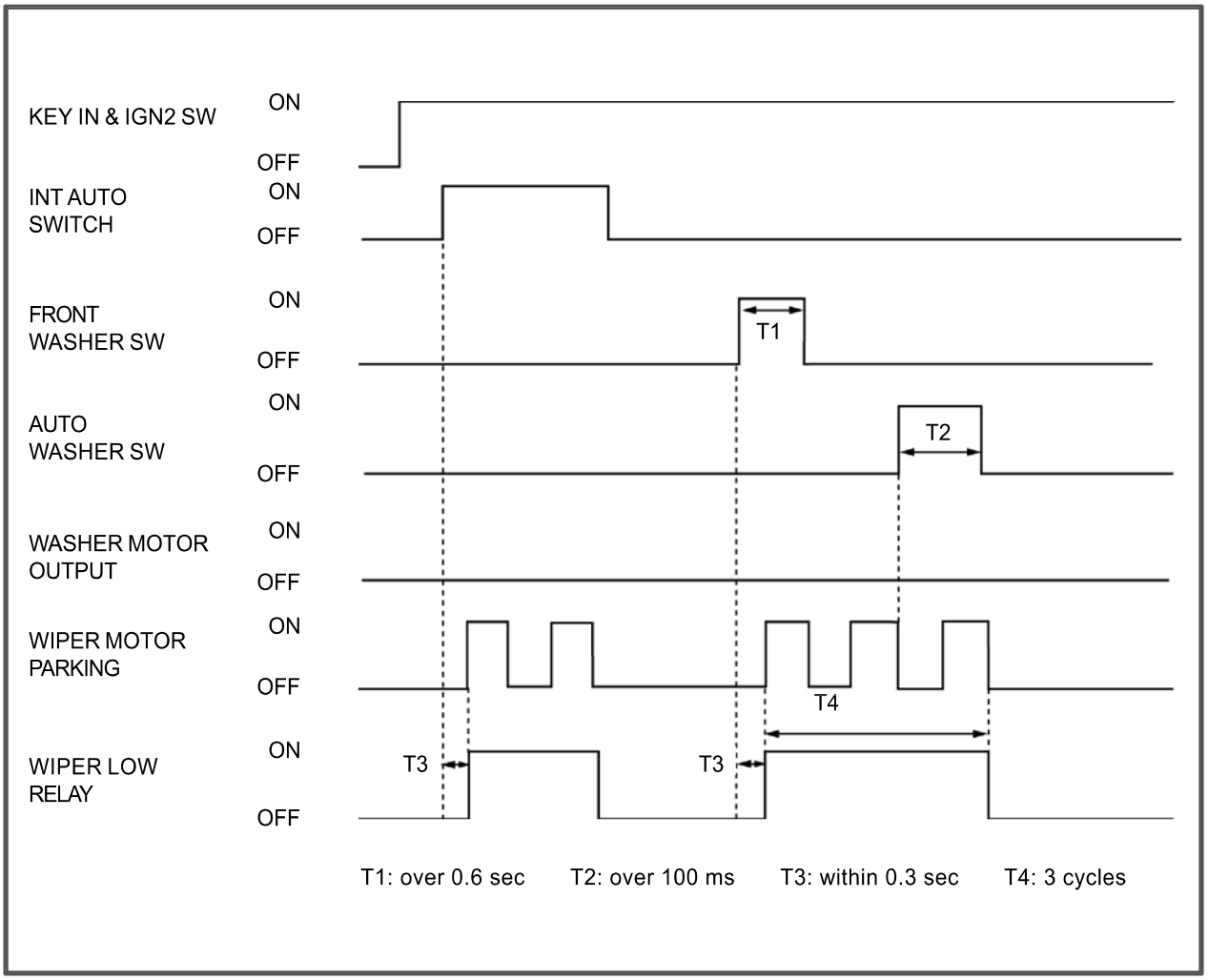
- When the auto washer switch is turned on with the ignition switch "ON" and the INT switch "OFF", the washer motor output gets ON for 1 second. If the system recognizes the output signal, the wiper relay output gets ON during 4 cycles and the washer motor output gets ON for 1 second. Then, the wiper relay output gets OFF after 3 cycles.



T1: Operates for more than 0.1 sec T2: 2.0 ± 0.1 sec T3: 0.6 ± 0.1 sec T4: 4 cycles
T5: 3 cycles T6: 0.6 sec T7: 1.5 ± 0.1 sec

Modification basis	
Application basis	
Affected VIN	

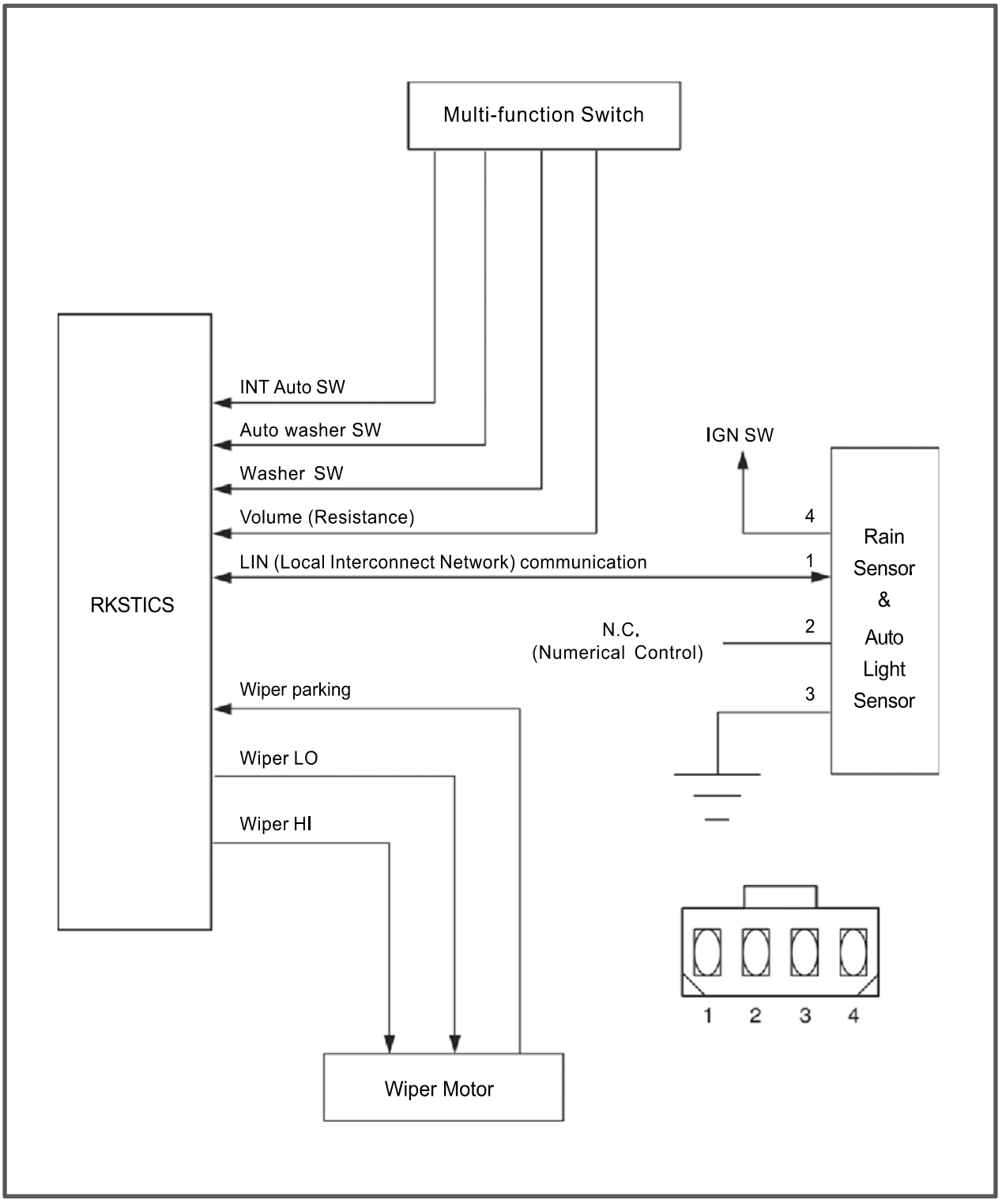
- The auto washer switch input is overridden during the washer coupled wiper operation.
- The auto washer switch input is overridden during the auto washer coupled wiper operation.
- The auto washer switch input is overridden during the rain sensor coupled wiper or vehicle speed sensitive INT wiper operation.
- When the auto INT switch input is received during the auto washer operation, the auto washer operation stops and the auto INT operation is activated.



▶Rain Sensor Coupled Wiper and Auto Light Control

- If equipped with RKSTICS rain sensor, it has following operation system.

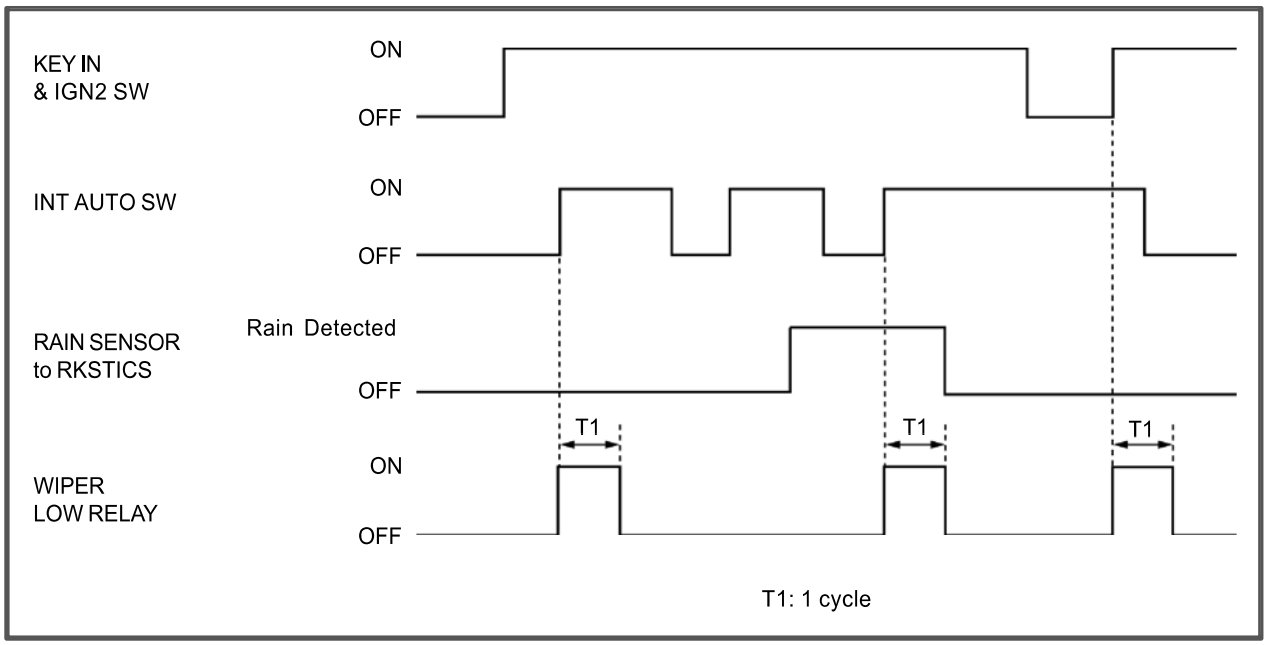
▶System layout



Modification basis	
Application basis	
Affected VIN	

▶INT Switch Auto Position Reminder (Power-Up Reminder Wiper)

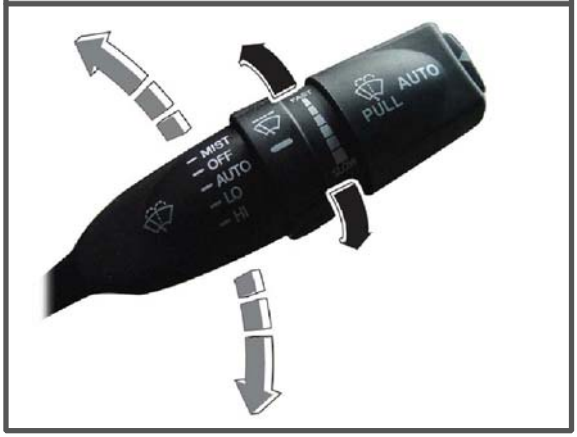
- When turning off and on the auto INT switch, the system drives the wiper motor through LOW relay regardless of communication with rain sensor.
- When turning the INT-AUTO switch from the "OFF" to "ON" position with the ignition switch in the "ON" mode, the LOW relay operates to drive the wiper motor for 1 cycle, regardless of the rain sensor communication.
  After that, when turning the INT-AUTO switch from the "OFF" to "ON" position, the LOW relay operates to drive the wiper motor for 1 cycle only if data from the rain sensor indicates rain drops.



Rain sensing unit (AUTO light integrated type)

A sensor that emits infrared rays through LED and then detects the amount of rain drops by receiving reflected rays against sensing section (rain sensor mounting section on the windshield) with photodiode (auto light sensor integrated type)

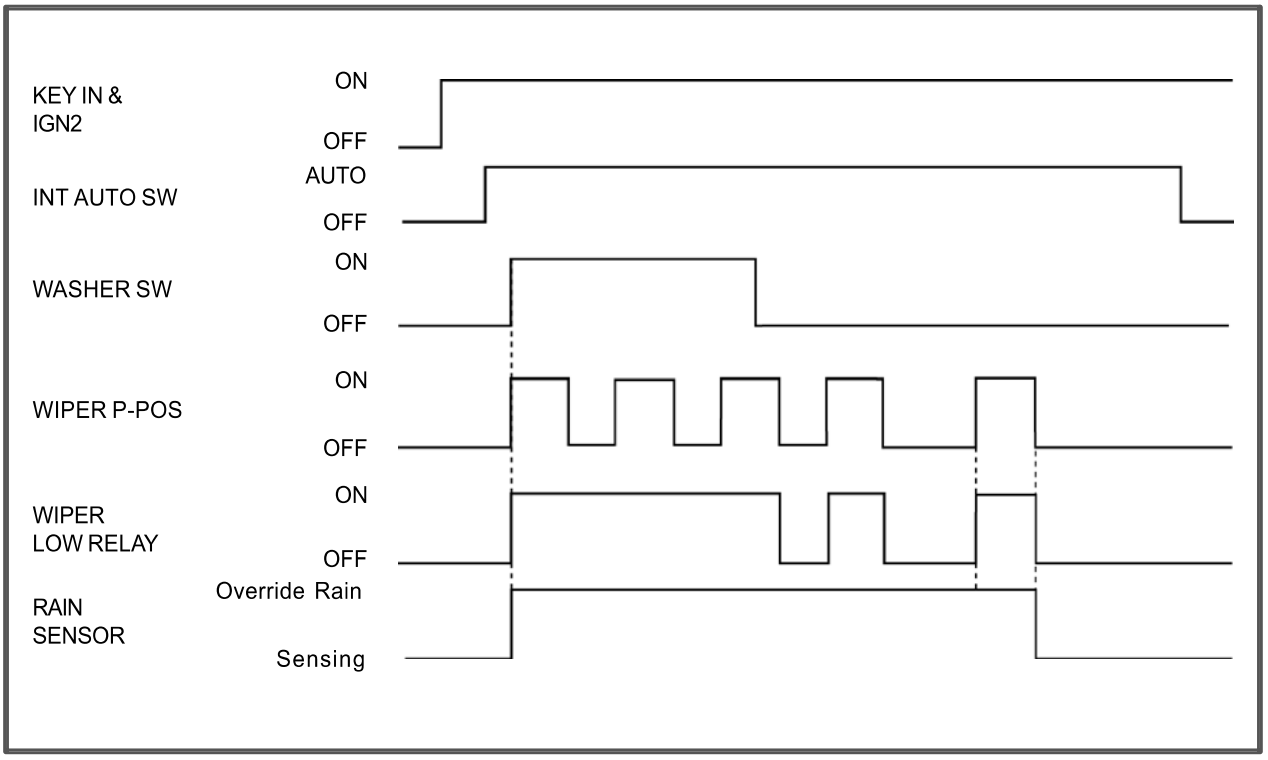
Multifunction wiper switch: AUTO and sensitivity control



AUTO: Wiper operates automatically by rain sensor
FAST↔SLOW: Auto delay/Auto speed control. A position that can control sensitivity against rains on the windshield and transmits wiping demand signal accordingly

▶Washer Coupled Wiper in Rain Sensing Mode

- The washer coupled wiper is operated when receiving the washer switch input with the ignition switch and the INT-AUTO switch "ON" in the rain sensing mode. At this moment, the communication with the rain sensor is overridden. However, a washer input is overridden if there is an output for continuous operation.
- The operation data is sent to the rain sensor even during the washer coupled wiper's operation.

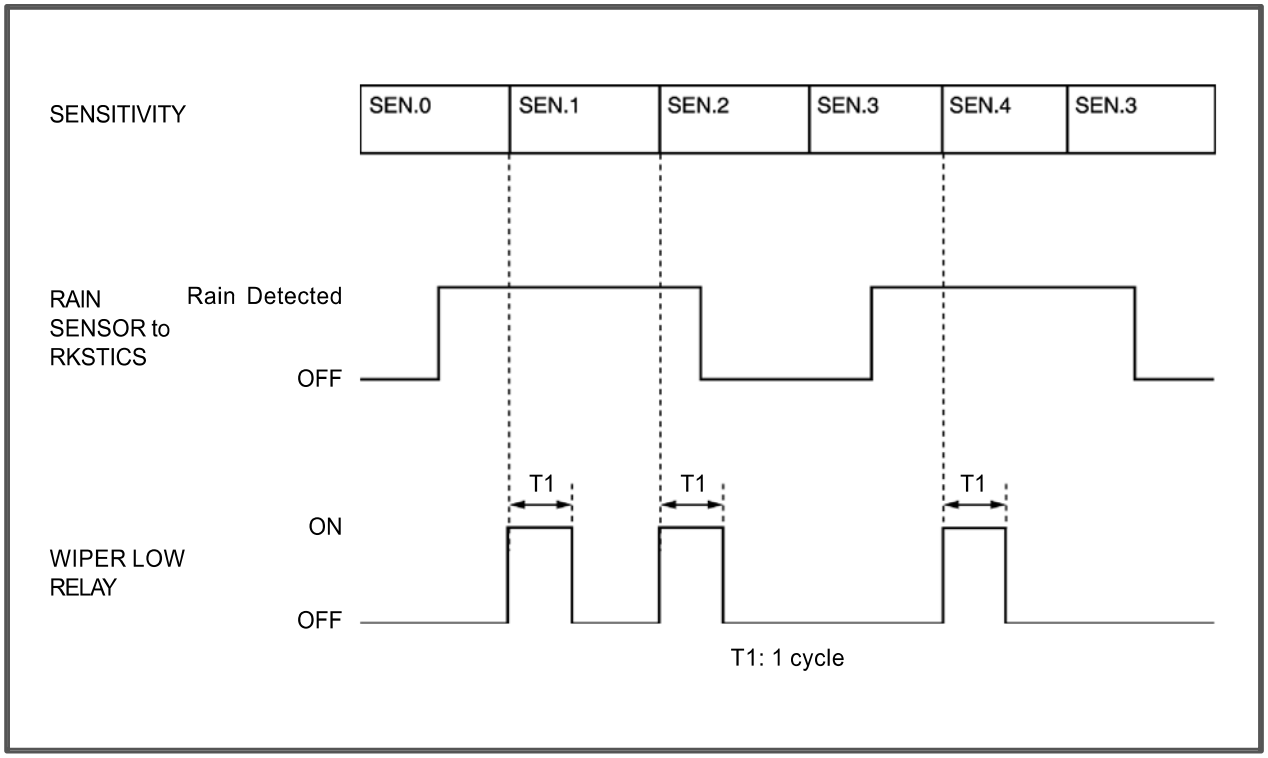


Modification basis	
Application basis	
Affected VIN	

▶Sensitivity Control

- The wiper LOW relay is turned on and the wiper motor runs one cycle when the volume sensitivity is increased (ex: sensitivity 0 ⇒ 1) while the ignition switch and the INT switch is in the "ON" position, and the wiper motor is in "Parked" position). However, the wiper motor can be operated only when the rain sensor detects the "Rain Detected" signal.

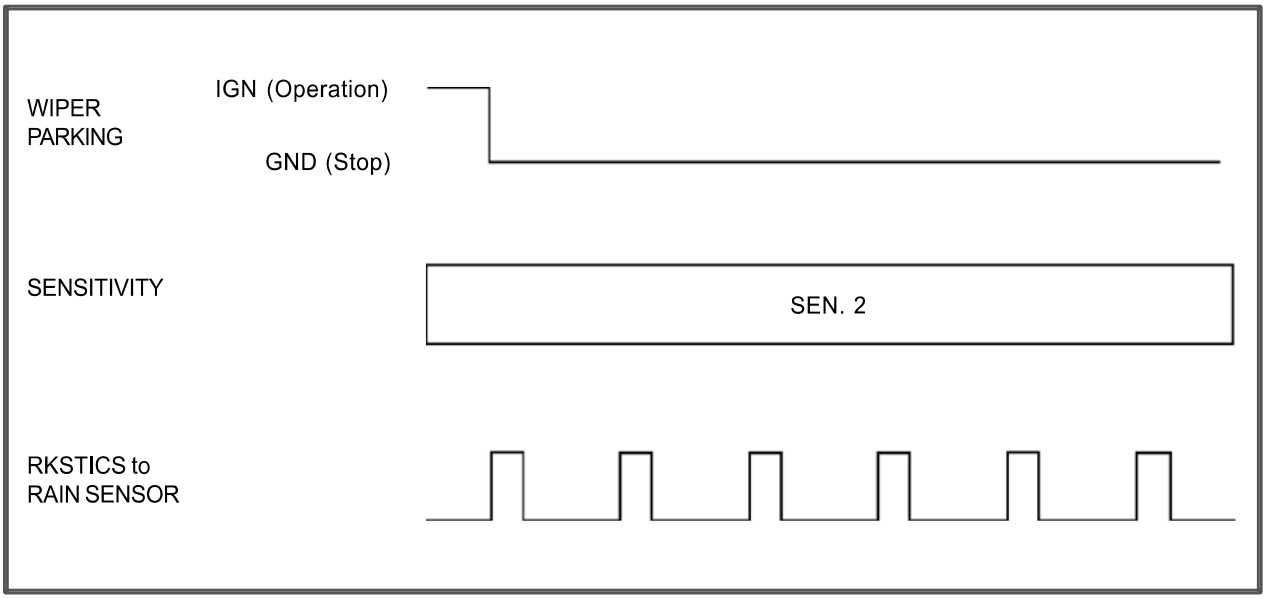
※ If the volume sensitivity is changed more than 2 stages within 2 seconds, the wiper motor runs only one cycle.



▶When the Wiper Parking Signal is abnormal

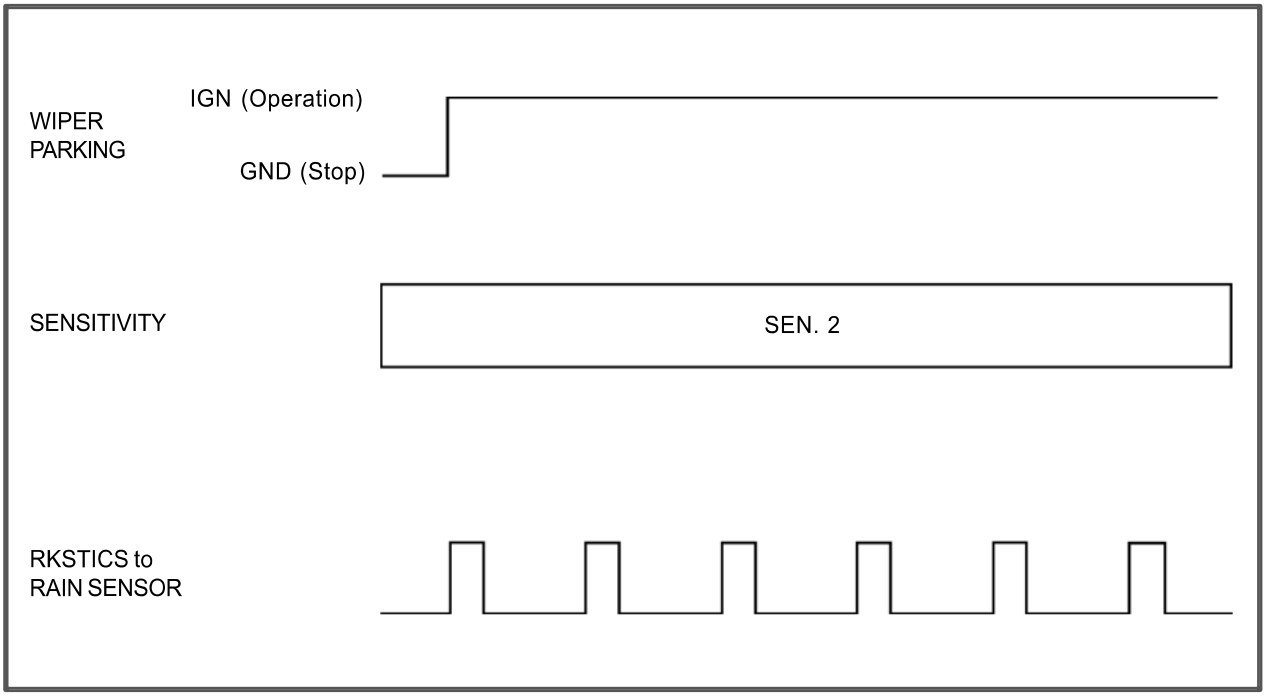
- The wiper system continuously outputs the wiper parking signal when the wiper parking terminal is grounded, while the ignition switch is in "ON" position and the INT switch is in "ON" position.

※The wiper motor runs only when the rain sensor requires the wiper operation.



- When the parking terminal is fixed to IGN, the wiper system outputs the wiper operating signal for 2 seconds, then continuously outputs the wiper parking signal.

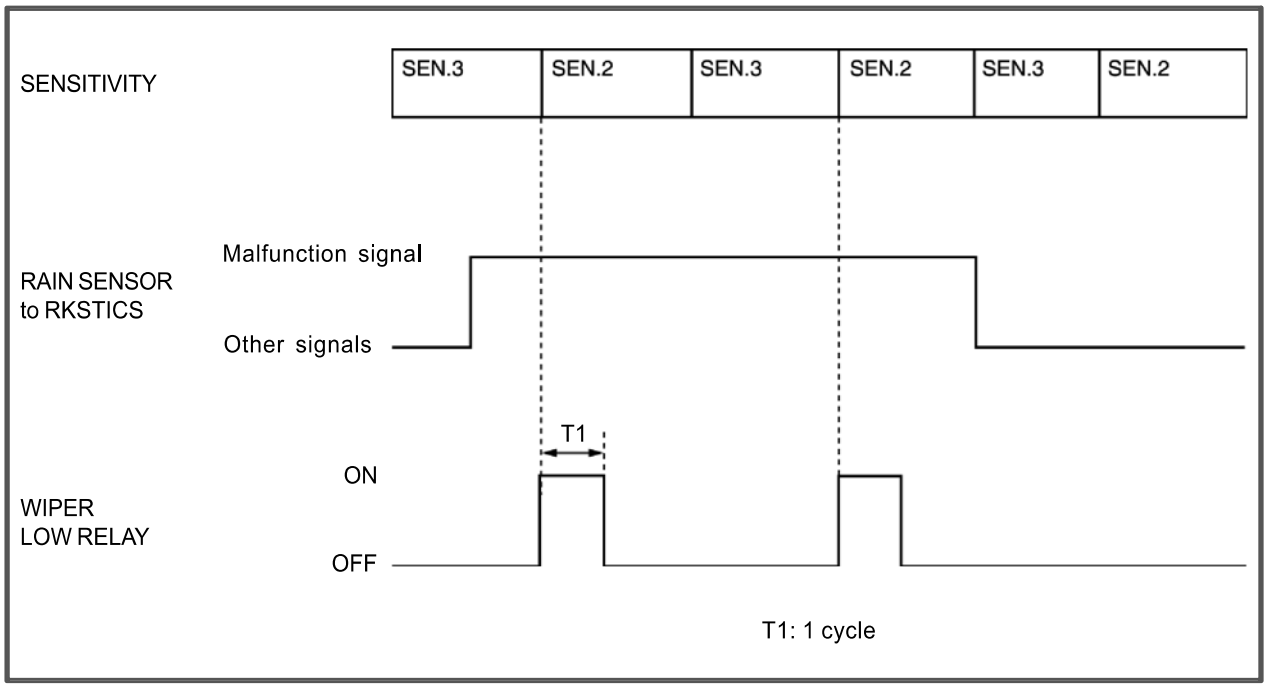
※The wiper motor runs only when the rain sensor requires the wiper operation.



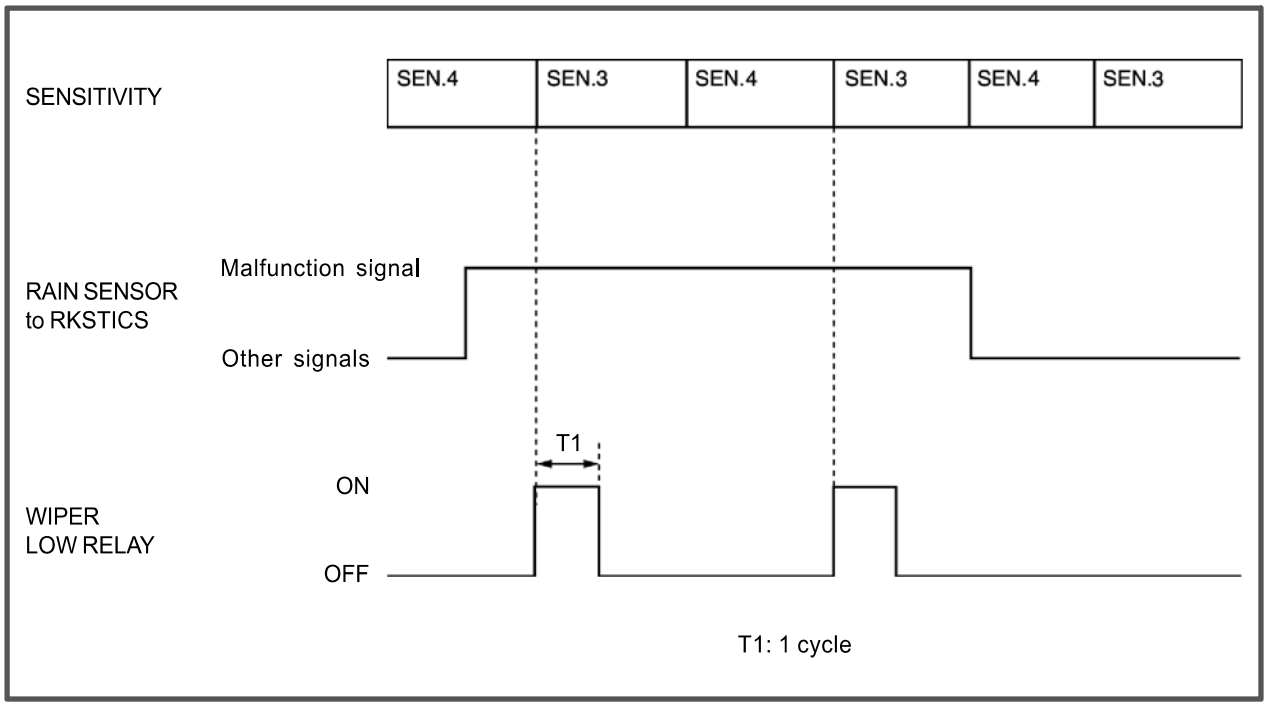
Modification basis	
Application basis	
Affected VIN	

▶Defective Rain Sensor

- The wiper relay (LOW) is turned on and the wiper motor runs one cycle when the volume sensitivity is changed to 2 from 3 during receiving the malfunction signal from the rain sensor, while the ignition key is in "ON" position and the wiper switch is in "ON" position.



- The wiper relay (LOW) is turned on and the wiper motor runs one cycle when the volume sensitivity is changed to 3 from 4 during receiving the malfunction signal from the rain sensor, while the ignition key is in "ON" position and the wiper switch is in "ON" position.



NOTE

▶ TROUBLE SHOOTING

Symptom 1. The wiper does not operate one cy cle when turning the multifunction wiper switch to the "AUTO" from the "OFF" position or starting the engine while the wiper switch is in the "AUTO" position.

1) When starting the engine with the multifunction wiper switch in the "AUTO" position, the wiper operates one cycle to remind a driver that the wiper switch is in the "AUTO" position. When the multifunction wiper switch is turned to "AUTO" from "OFF", the wiper operates
2) one cycle.
   It always operates one cycle for the initial operation, however, the wiper does not operate afterwards to prevent the wiper blade wear if not raining when turning the wiper switch to "AUTO" from "OFF". However, the wiper operates up to 5 minutes after rain stops. If this function does not occur, check No. 8 pin. If the pin is normal, check the wiper relay related terminals.

Symptom 2. It rains but the system does not work in "AUTO" position.

1) Check whether the multifunction wiper switch is in the "AUTO" position.
2) Check the power to the sensor. Check the conditions of the pin 3 (Ground) and the pin 4 (IGN).
3) Check the wiper relay for defective.

Symptom 3. The wiper operates 3 or 4 times at high speed abruptly.

Check whether the variable resistance knob on the multifunction wiper switch is set in "FAST". The "FAST" is the highest stage of sensitivity and very sensitive to small amount of rain drops. Therefore, change the knob to low sensitivity.

Symptom 4. The wiper operates continuoulsy even on the dry windshield glass.

1) Check the wiper blade for wear. If the wiper blade cannot wipe the glass uniformly and clearly, this problem could be occurred. In this case, replace the wiper blade with new one.
   Check whether the variable resistance knob on the multifunction wiper switch is set in
2) "FAST" The "FAST" is the highest stage of sensitivity and very sensitive to small amount of rain drops. Therefore, change the knob to low sensitivity.

Modification basis	
Application basis	
Affected VIN	

NOTE

Symptom 5. The wiper does not operate at high speed even in heavy rain.

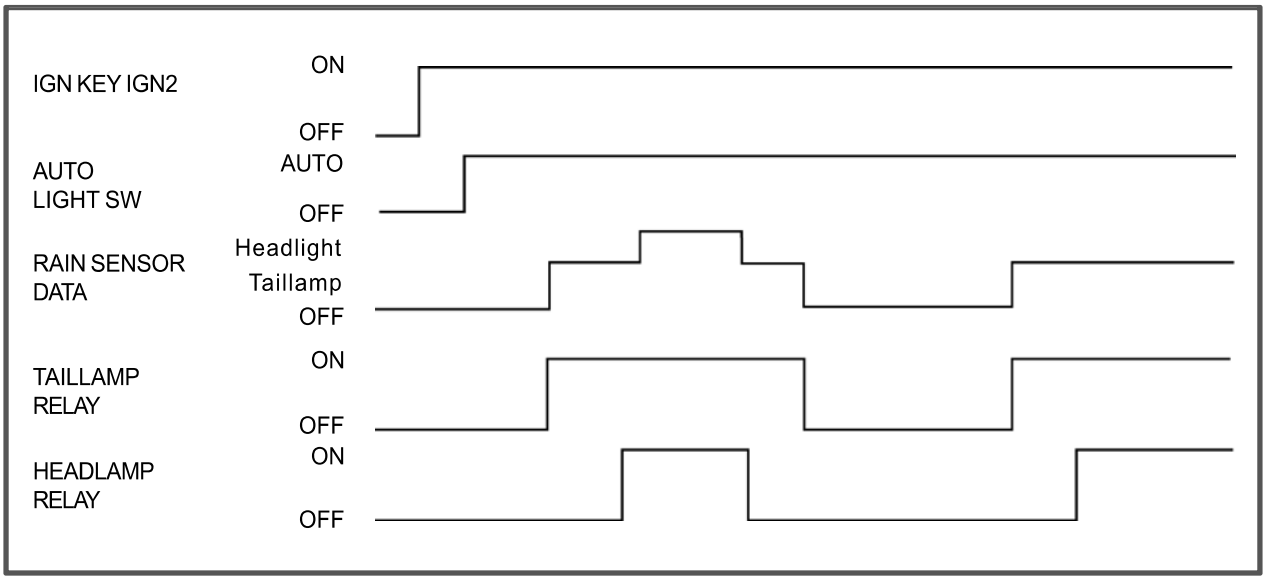
If the wiper does not operate at high speed even in heavy rain, check the pins 1 and 2.
In other words, the wiper should operate at high speed when grounding the pins 1 and 2.

Symptom 6. The wiper responses are too fast or slow.

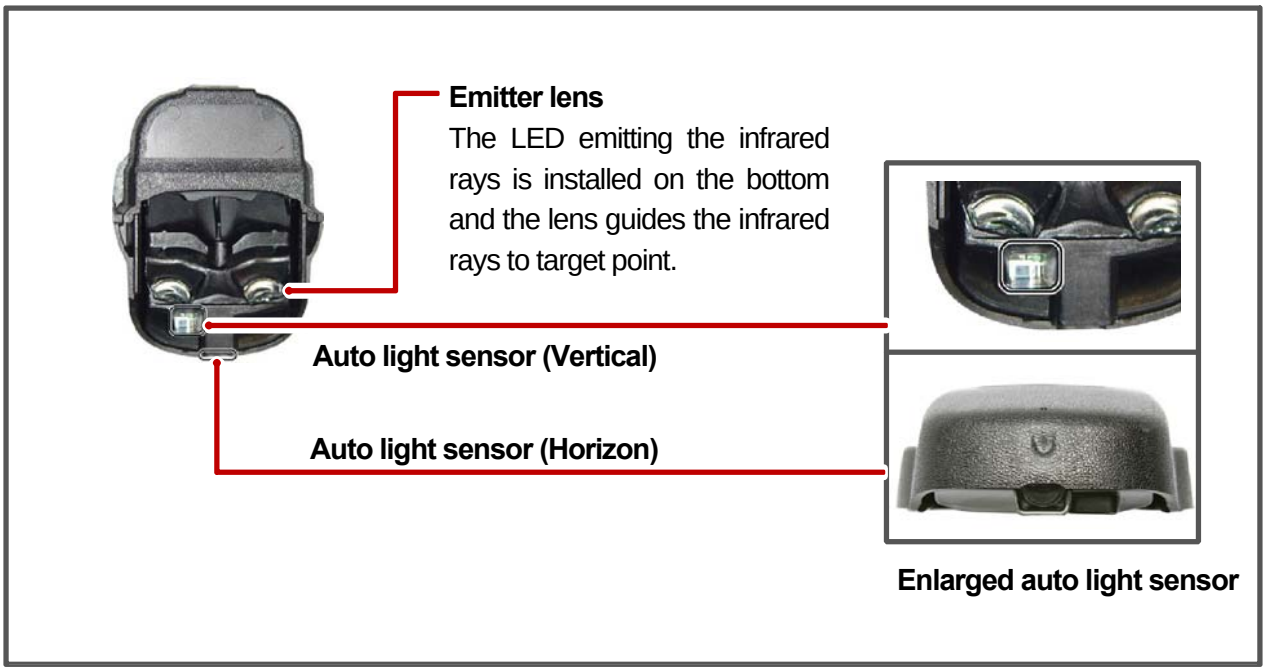
Check whether the variable resistance knob on the multifunction wiper switch is set in "FAST" or "SLOW".
Notify that the customer can select the sensitivity by selecting the variable resistance value. And, select a proper stage.

▶Auto Light Control

- The tail lamps and headlamps can be controlled by the communication with the rain sensor only when the auto light switch is in "AUTO" position with the ignition switch "ON".



- Rain detected headlamp: If it rains heavy which requires the highest INT speed (almost LOW), the headlamps are turned on automatically.
- Night detected wiping: When the auto light control turns on the headlamps and the rain sensor detects the rain, the wiper sensitivity is automatically increased by one level in comparison with daytime.
  (i.e. the AUTO wiper switch is at the 3rd level, but the wiper operates at the 4th level.)



Modification basis	
Application basis	
Affected VIN	

▶Volume Sensitive INT (Intermittent) Wiper

For RKSTICS without the rain sensor, perform the following operation:

- Controls the wiper intermittent operation by the values from the vehicle speed and the volume (resistance).
  - Calculates and converts the Intermittent interval automatically by obtaining the INT VOLUME when the ignition switch and the INT switch is in the "ON" position.
  - The wipers are operated in vehicle speed sensitive mode when turning the INT switch to the "ON" position with the engine running or starting the engine with the INT switch positioned to "ON".
  - Intermittent interval (at 0 km/h): 3 ± 0.5 ~ 19 ± 2 seconds
- Vehicle speed calculation

[Input the vehicle speed]
It is calculated by the numbers of input pulses for one second.

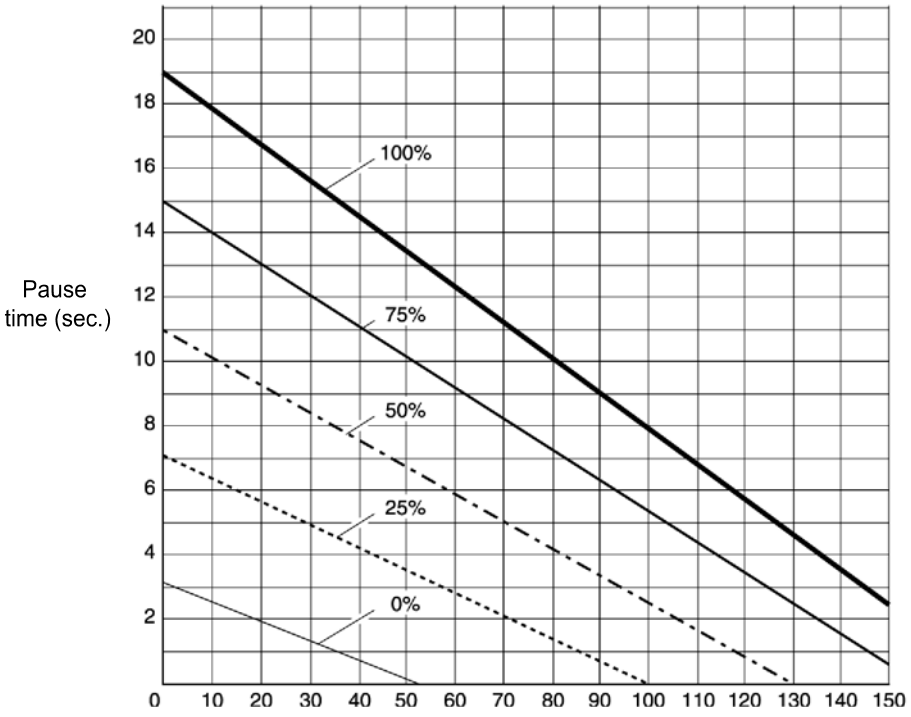
$$1\ [\text{PULSE/SEC}] = \frac{60\ [\text{km/h}] \times 60\ [\text{sec}]}{637 \times 4\ \text{PULSE}} \fallingdotseq 1.41\ [\text{km/h}]$$

- VOLUME calculation
  - The pause time of the vehicle speed sensitive INT wiper is calculated by the INT volume (input voltage). Each level has the hysteresis.
- Pause time calculation
  - Pause time means the duration that wipers are stopped at parking position.
  - Elapsed time means the duration after the wiper motor started to operate from parking position.
  - The pause time is calculated by the vehicle speed and the VOLUME.
    ※If the pause time is below 1.0 second, the wipers operate without pause.
    ※If the pause time is over 1.5 seconds, the wipers operate intermittently.

[Pause time of vehicle speed sensitive INT wiper]

Vehicle Speed / Resistance	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
100%	19.00	17.90	16.80	15.70	14.60	13.50	12.40	11.30	10.20	9.10	8.00	6.90	5.80	4.70	3.60	2.50
75%	15.00	14.03	13.06	12.09	11.13	10.16	9.19	8.22	7.26	6.29	5.32	4.35	3.39	2.42	1.45	0.45
50%	11.0	10.16	9.33	8.49	7.66	6.82	5.99	5.15	4.32	3.48	2.65	1.81	0.98	0.14	0.00	0.00
25%	7.00	6.29	5.59	4.89	4.19	3.48	2.78	2.08	1.38	0.67	0.02	0.00	0.00	0.00	0.00	0.00
0%	3.0	2.43	1.86	1.29	0.72	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Pause time against vehicle speed



CAUTION

Cautions for wiper control

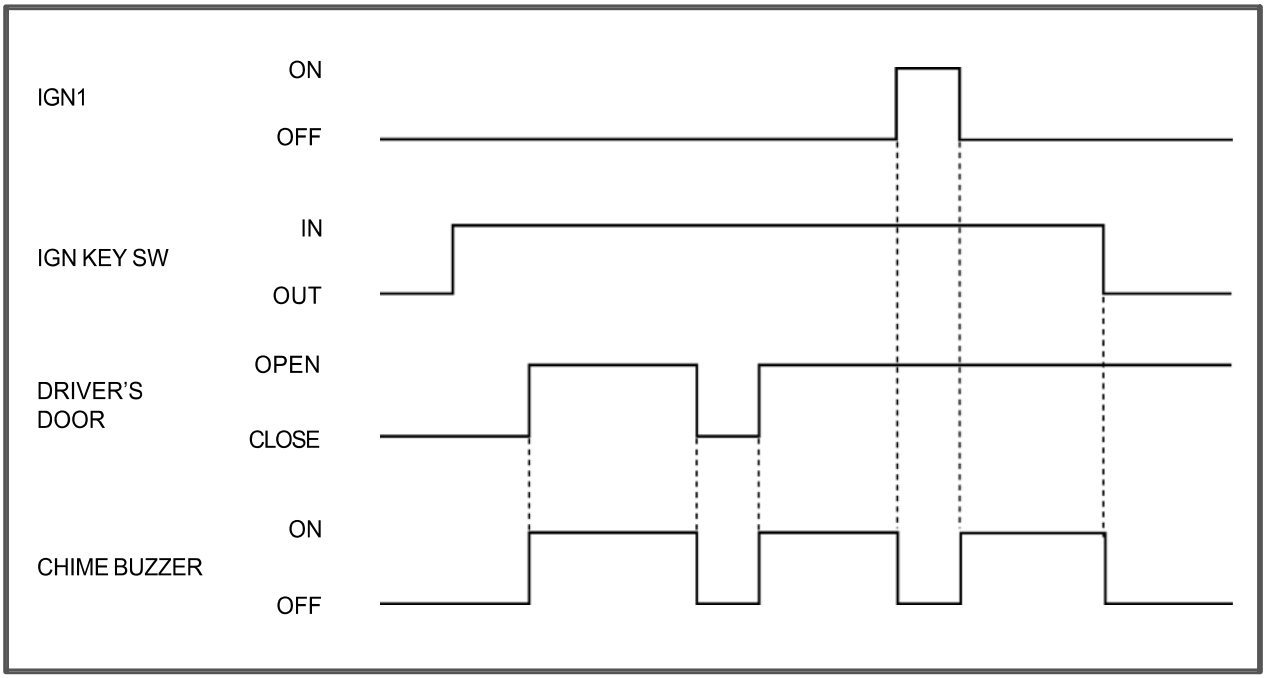
1. Speed sensitive INT (intermittent) wiper
   1) The wiper relay continues to output for remaining "ON" time even when the INT switch is turned off during its operation.
   2) IGN switch "ON", INT switch "OFF": Resume the intermittent time when turning "ON"
   3) IGN switch "OFF", INT switch "ON": Resume the intermittent time when turning "ON"
2. Controls when the wiper motor parking is defective
   - The wiper relay continues to output when the parking terminal is fixed at the ground or IGN while the wiper relay is "ON" (INT switch = ON or washer switch = ON)
     (The output stops immediately after turning off the switch)

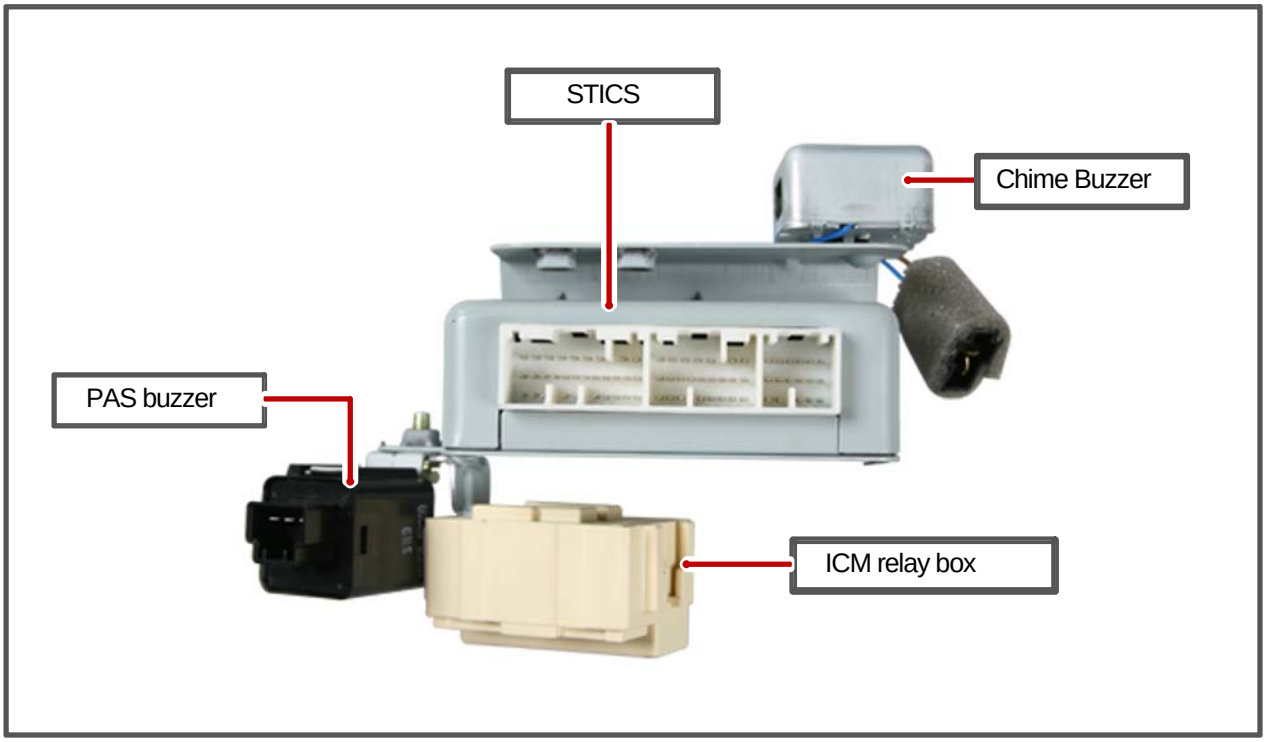
Modification basis	
Application basis	
Affected VIN	

▶Ignition Key Reminder Warning

(The function has priority over the "TAILLAMP ON WARNING".)

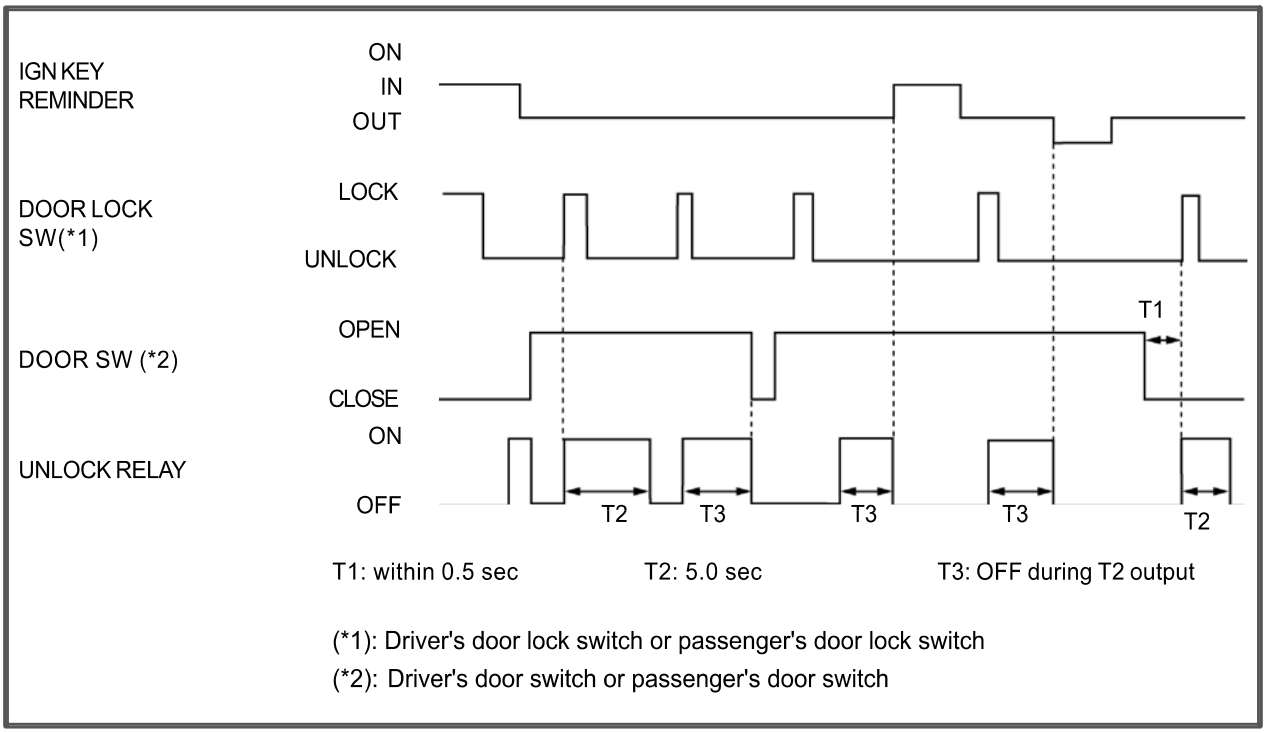
- The chime buzzer sounds continuously when opening the driver's door while the ignition key is in ignition switch.
- When removing the ignition key or closing the driver's door during chime buzzer operation, the buzzer stops.
- This function does not work when the IGN1 switch is in "ON" position.





▶Ignition Key Reminder

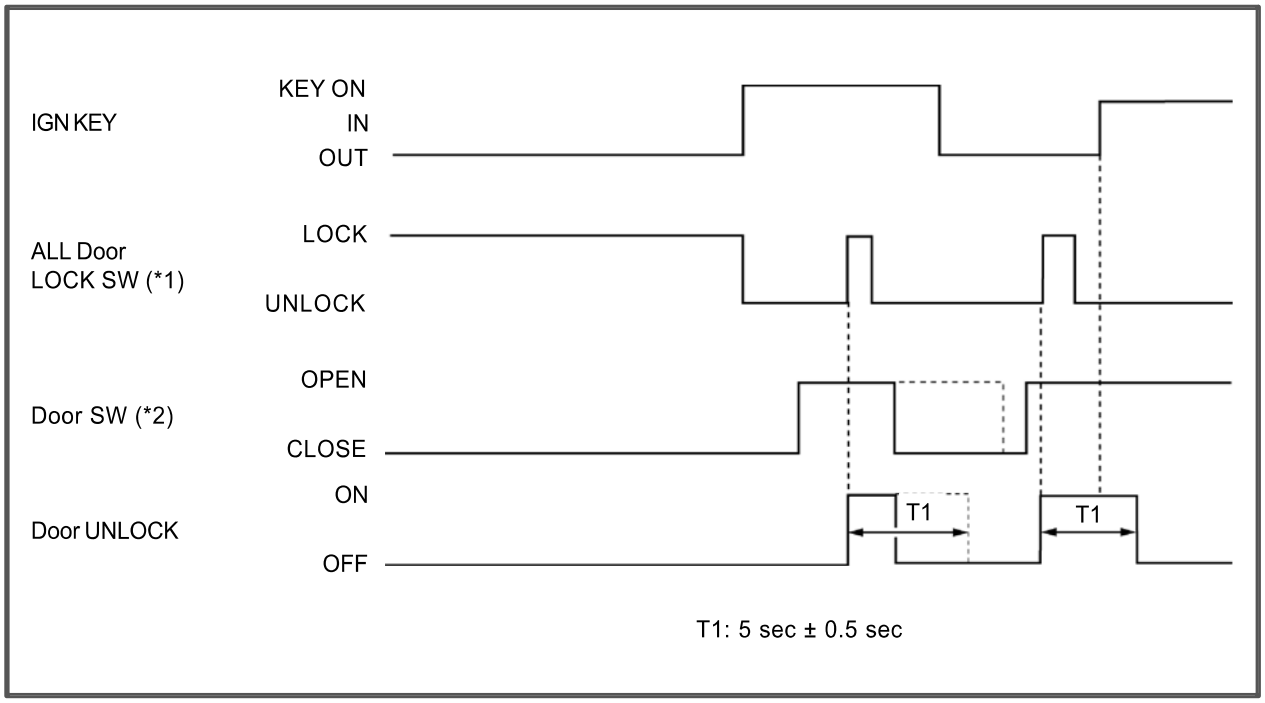
- The system outputs "UNLOCK" signal for 5 seconds after the driver's door is opened and the door lock switch is changed to "LOCK" (while the ignition key is in ignition switch).
- The system outputs "UNLOCK" signal for 5 seconds when the door lock switch is changed to "LOCK" from "UNLOCK" and the driver's door is closed within 0.5 seconds (while the ignition key is in the ignition switch).
- If the "UNLOCK" conditions are met, the system outputs "UNLOCK" signal unconditionally. However, if the ignition key is removed after the door lock switch is changed from "UNLOCK" to "LOCK", the system does not output "UNLOCK" signal.



Modification basis	
Application basis	
Affected VIN	

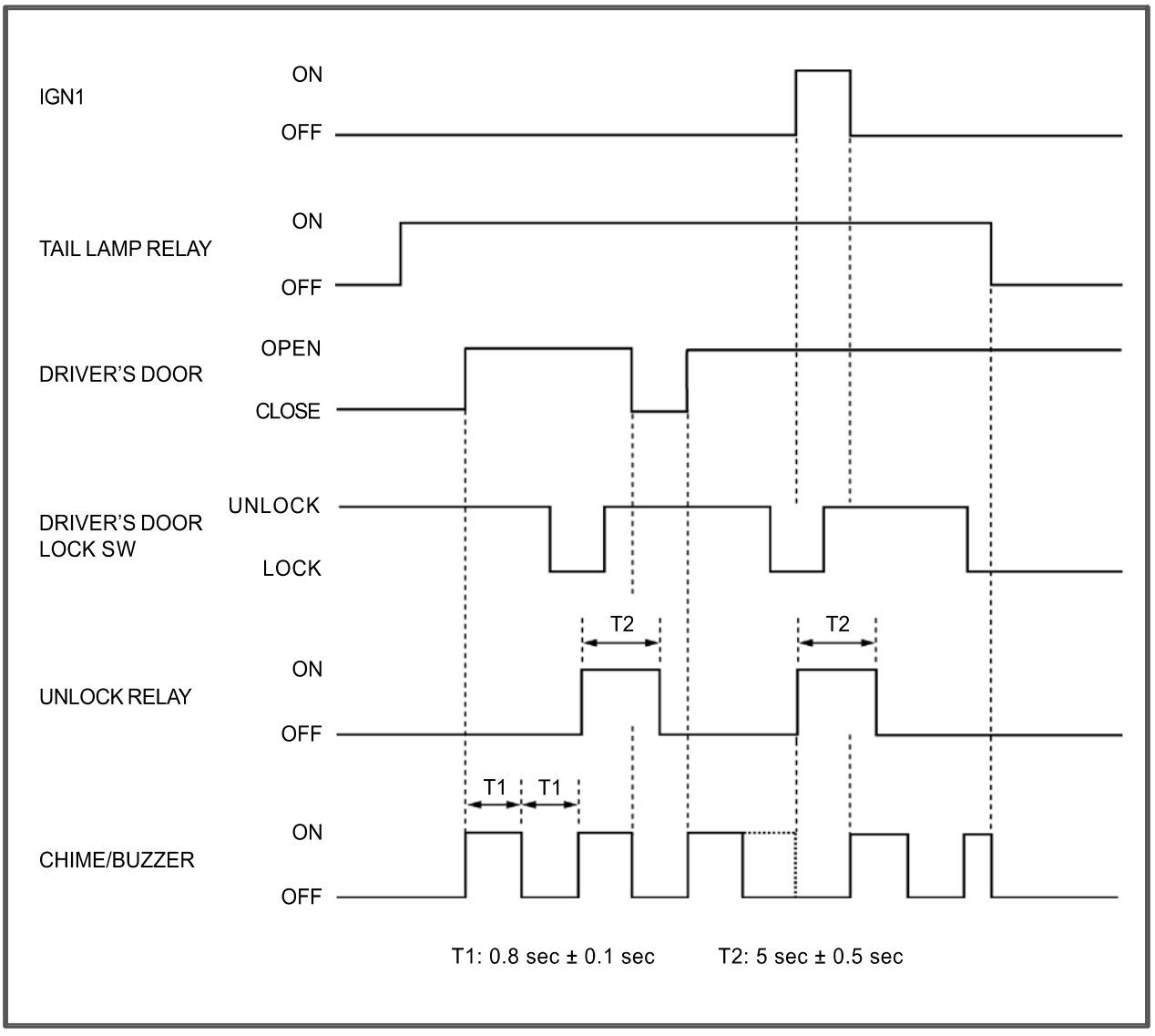
▶All Door Lock Prevention Function when a Door is Open

- All doors, except the tailgate and hood, output "UNLOCK" signal for 5 seconds when the "LOCK" signal is inputted (while the ignition key is removed and one of any doors is open).
- When the door is closed during the UNLOCK output for approx. 5 seconds, the UNLOCK output stops immediately.
- When the ignition key is inserted during the 5 seconds output, the output continues for approx. 5 seconds.
- If the ignition switch is in the "ON" position or the ignition switch is removed, the above steps are performed. If the key is in the key cylinder, the ignition key reminder function is activated.
  This function does not work if the vehicle speed is over 10 km/h.
-



▶Tail Lamp Left On Warning

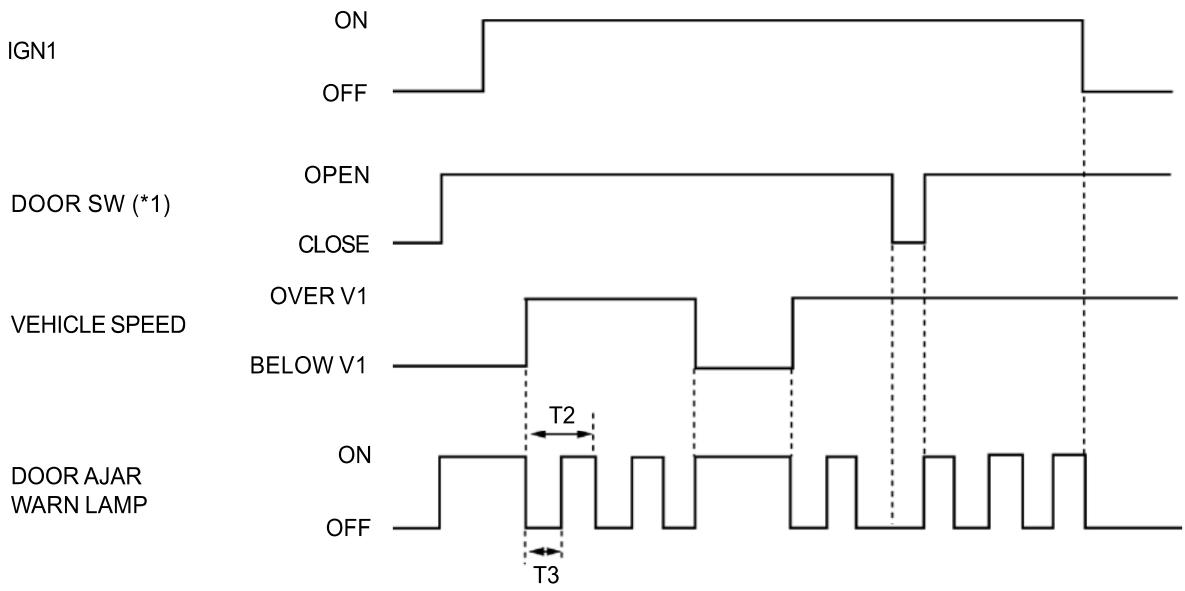
- The chime buzzer sounds with the interval of 0.8 second when opening the driver's door while the tail lamp is turned on and the ignition key is removed.
- The c/buzzer output stops when turning off the tail lamp and closing the driver's door.
- The system outputs "UNLOCK" signal for 5 seconds when the driver's and passenger's door lock switch is locked (while the tail lamp is turned on and the driver's door is open).
- This function does not work when the IGN1 switch is in "ON" position.



Modification basis	
Application basis	
Affected VIN	

▶Door Ajar Warning

1. The warning light comes on when opening any door while the vehicle speed is below 10 km/h.
   The warning light goes off when closing the door under step (1).
2. The warning light blinks when the vehicle speed is over 10 km/h while the warning light is turned
3. on.
   The warning light blinks when a door is open while the vehicle speed is over 10 km/h.
4. The warning light goes off when closing the door under step (3).
5. The warning light comes on when the vehicle speed goes below 10 km/h under step (3).
6.



T2: 0.6 sec T3: 0.3 sec V1 = 10 Km/h

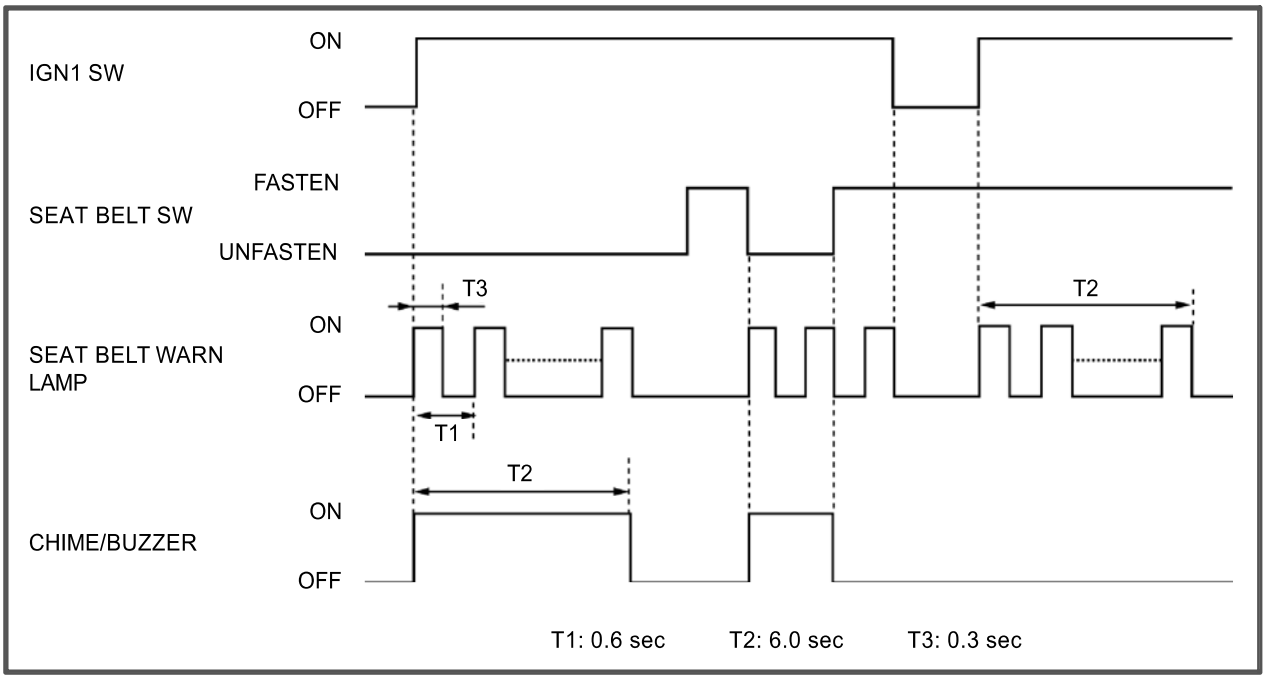
(*1) DOOR OPEN: Open any doors including tailgate
CLOSE: Close the opened door

CAUTION

Since the luggage room tailgate does not have the door switch, the door ajar warning light does not come on when it is open.

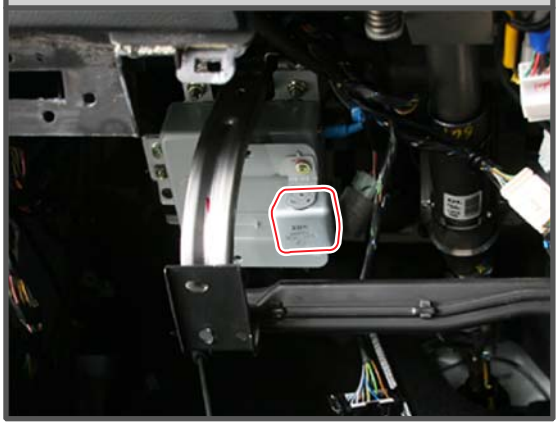
▶Seat Belt Warning

1. The seat belt warning light comes on and the chime buzzer sounds for 6 seconds when turning the ignition key to "ON" from "OFF".
   If the seat belt is fastened before turning the ignition key to the the "ON" position, the warning light blinks, however, the chime buzzer does not sound.
2. The seat belt warning light goes off and the chime buzzer stops when turning the ignition switch to the "OFF" position during the warning operation.
3. The chime buzzer stops and the seat belt warning light stays on for the remainig time when fastening the seat belt.
4. The seat belt warning light comes on and the chime buzzer sounds for 6 seconds again when unfastening the seat belt during fastening operation while the ignition key is "ON" position.



Seat Belt Warning Light

Chime Buzzer

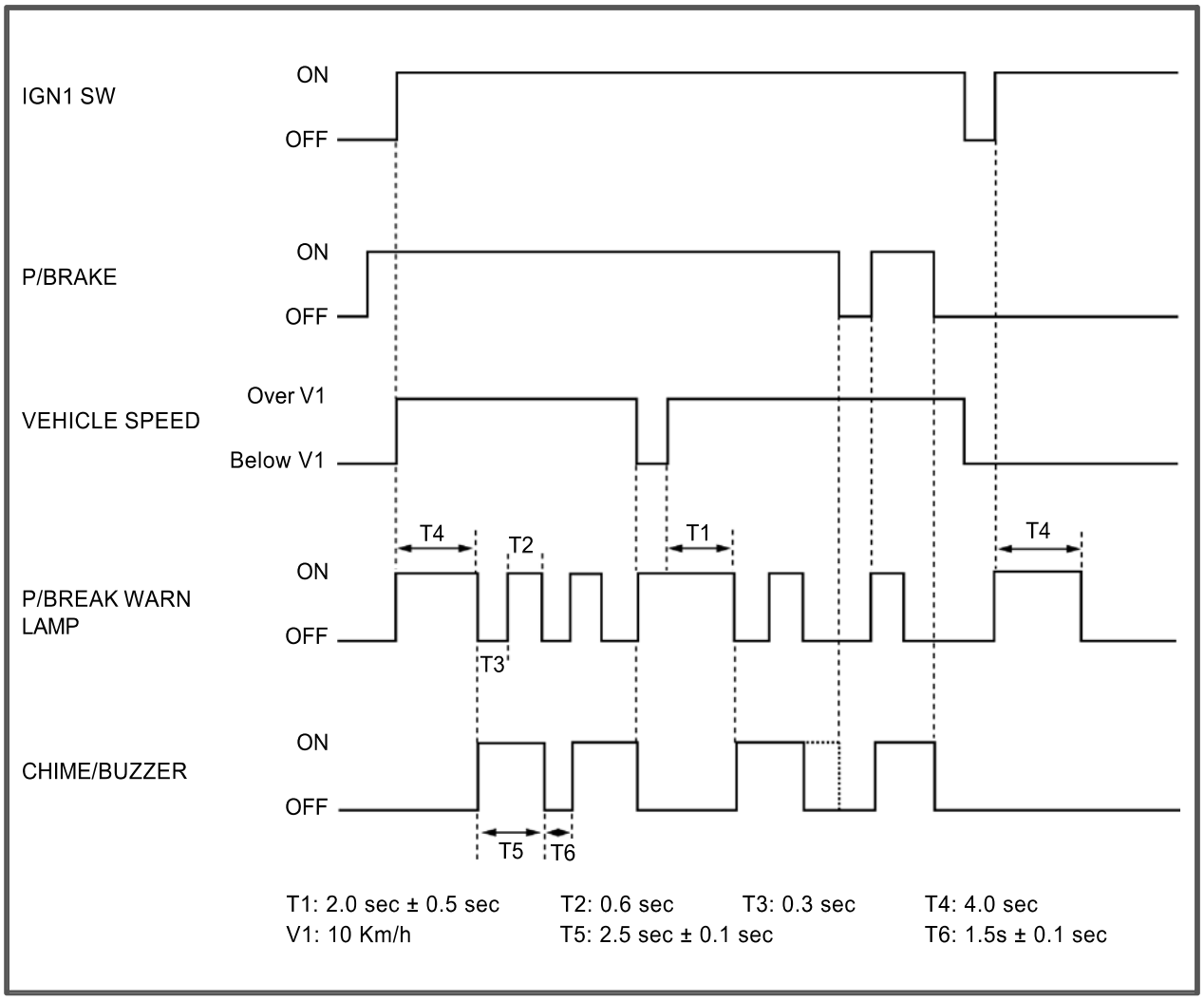


The seat belt warning light blinks and the chime buzzer sounds for 6 seconds when turning the ignition key to "ON" without fastening the seat belt. After fastening the seat belt, the chime buzzer stops.

Modification basis	
Application basis	
Affected VIN	

▶Parking Brake Warning

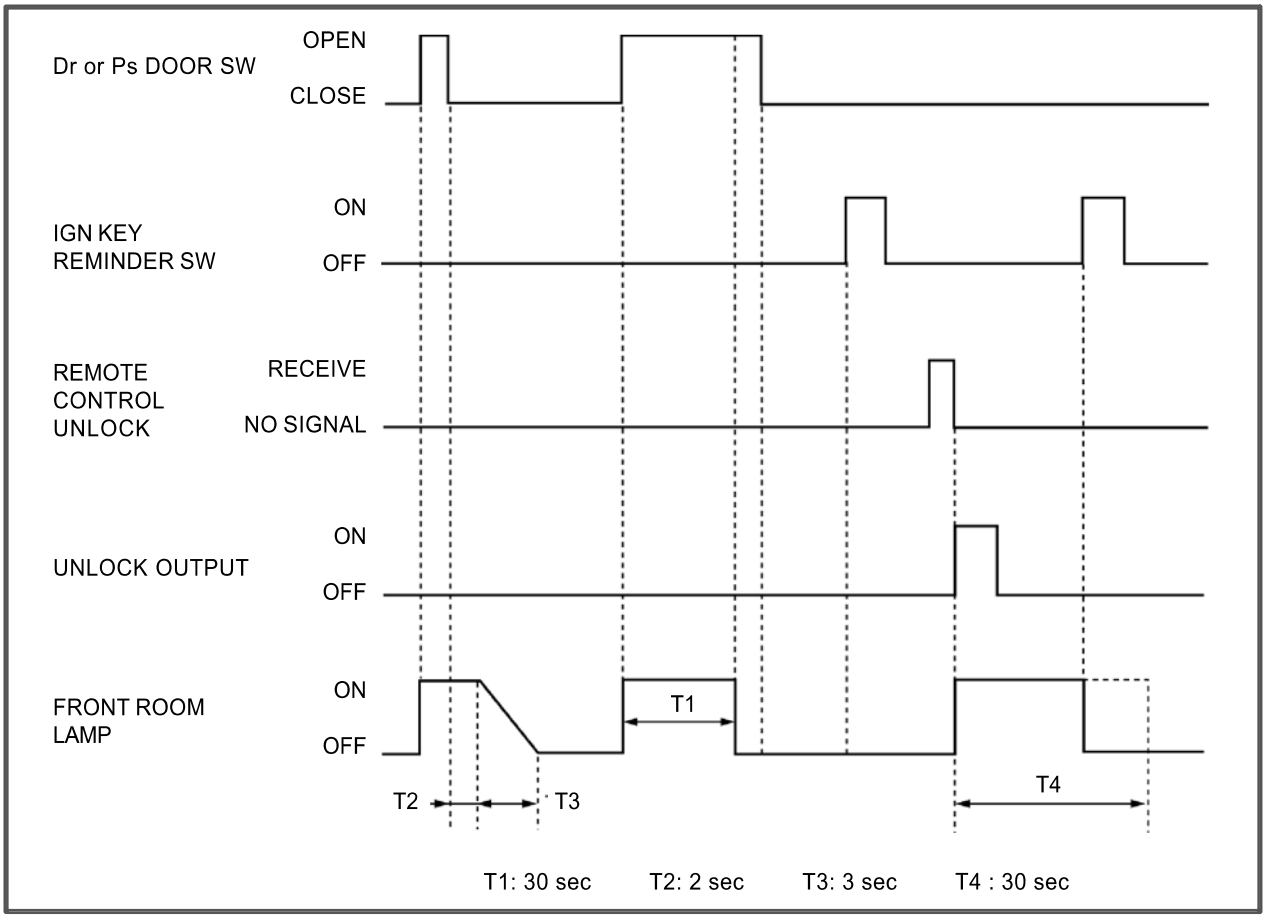
1. The parking brake warning light comes on for approx. 4 seconds when turning the ignition key from the "OFF" to the "ON" position regardless of the vehicle speed and the parking brake switch position. After this 4 seconds, the warning light comes on, goes off or blinks according to the vehicle speed and the parking brake switch position.
2. The warning light comes on when the parking brake is applied and the vehicle speed is below 10 km/h.
3. The warning light goes off when releasing the parking brake under step (2).
4. The warning light blinks and the chime buzzer sounds for 2.5 seconds and stops for 1.5 seconds when the vehicle speed is over 10 km/h for more than 2 seconds while the parking brake is applied.
5. The warning light goes off and the chime buzzer stops when releasing the parking brake under step (4).
6. The warning light comes on and the chime buzzer stops when the vehicle speed goes down below 10 km/h under step (4).
7. This function does not work when the ignition switch is in "OFF" position.



▶Center Room Lamp Control

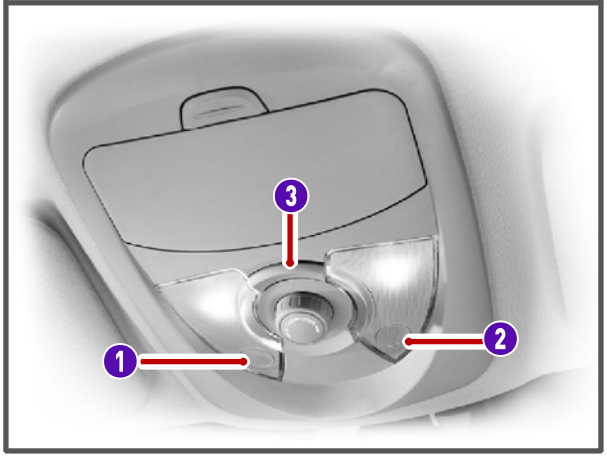
The overhead console lamp (front room lamp) and the center room lamp come on at 100% when opening the door (driver's/passenger's/rear) while the center room lamp switch is at the door coupled/tailgate coupled operating position and the key reminder switch is "OFF".

1. When the door (driver's/passenger's/rear) is opened, the front and center room lamps come on at 100% and automatically go off after 30 seconds.
2. The room lamp stays on for 2 seconds and then dims through 3 seconds when closing the doors within 30 seconds.
3. The dimming operation must have greater than 32 steps per one second.
4. The room lamp output should stop immediately after turning on the ignition key during the dimming operation.
5. The front room lamp and the center room lamp come on for 30 seconds when receiving the unlock signal from the remote control key while the doors are closed.
6. The front room lamp and the center room lamp output period is extended by 30 seconds when receiving the unlock signal from the remote control key again during output under step (5). (The lamp stays on when unlocked by the remote control key.)
7. When a door is opened during its extended period, the lamp stays on. If closed, operates as in step (2).
8. The room lamp output stops immediately after receiving the lock signal from door lock switches while all doors are closed or entering into the anti-theft mode by pushing LOCK button on the remote control key.



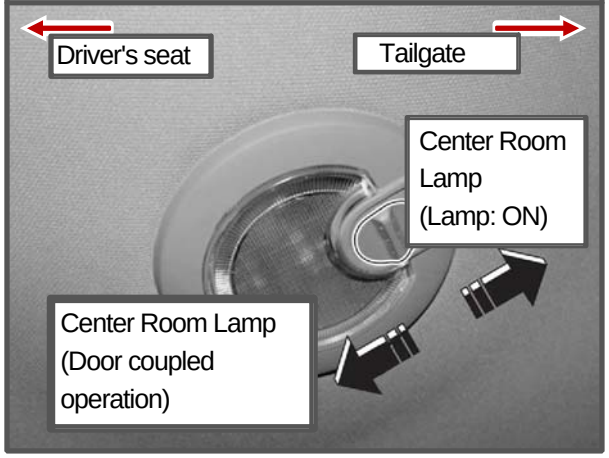
Modification basis	
Application basis	
Affected VIN	

Front Room Lamp: 12V / 8W - 2 EA



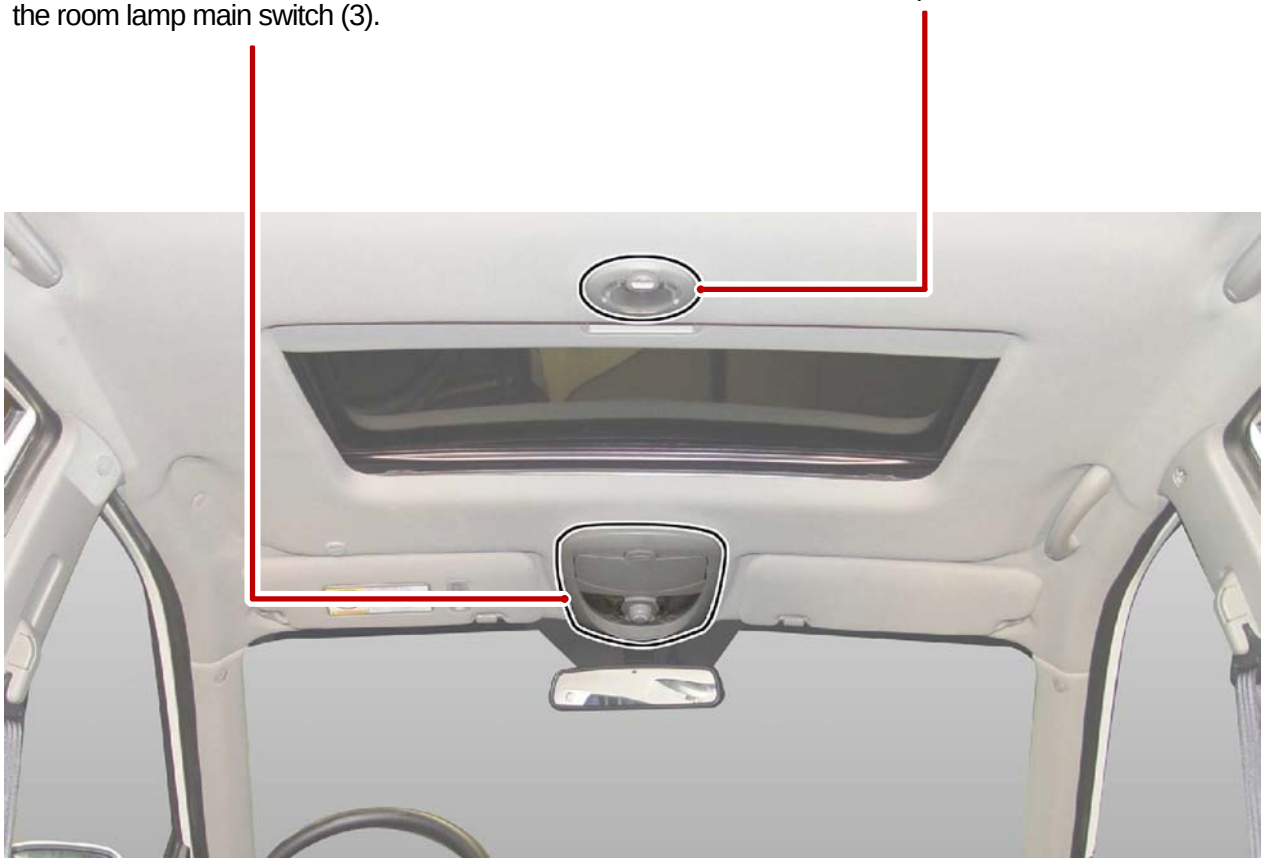
Front room lamp (driver's or passenger's) is turned on and off when pressing the switch (1 or 2). However, it comes on when a door is opened and goes off when the door is closed. The front and center room lamps come on when pressing the room lamp main switch (3).

Center Room Lamp: 12V / 8W - 1 EA



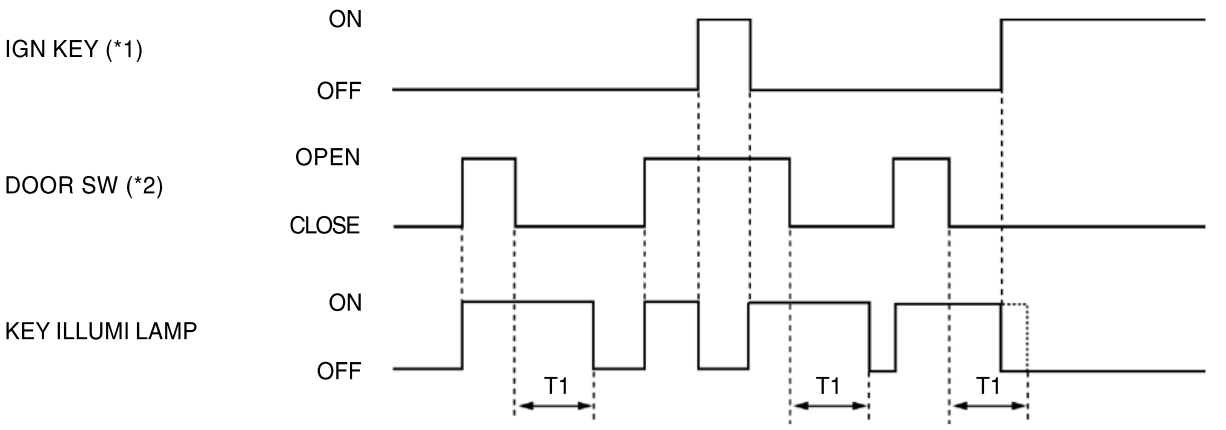
Center Room Lamp

If the switch is at the door coupled position, the center room lamp comes on whenever a door is opened. The lamp always comes on while the switch is at the other position.



▶Ignition Key Hole Illumination

1. The ignition key hole illumination comes on when opening the driver's door or passenger's door while the ignition key is removed.
2. The ignition key hole illumination stays on for 10 seconds when closing the door after step (1). The output stops when the ignition key is turned to the "ON" position.
3. The output stops when receiving the lock signal from the remote control key and entering armed
4. mode.

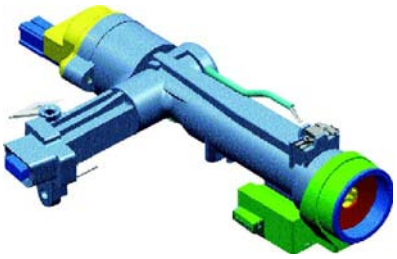
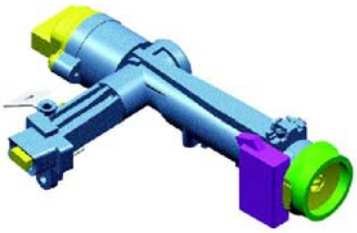


T1 : 10 sec

(*1) ON : IGN KEY = ON
OFF : IGN KEY = OFF

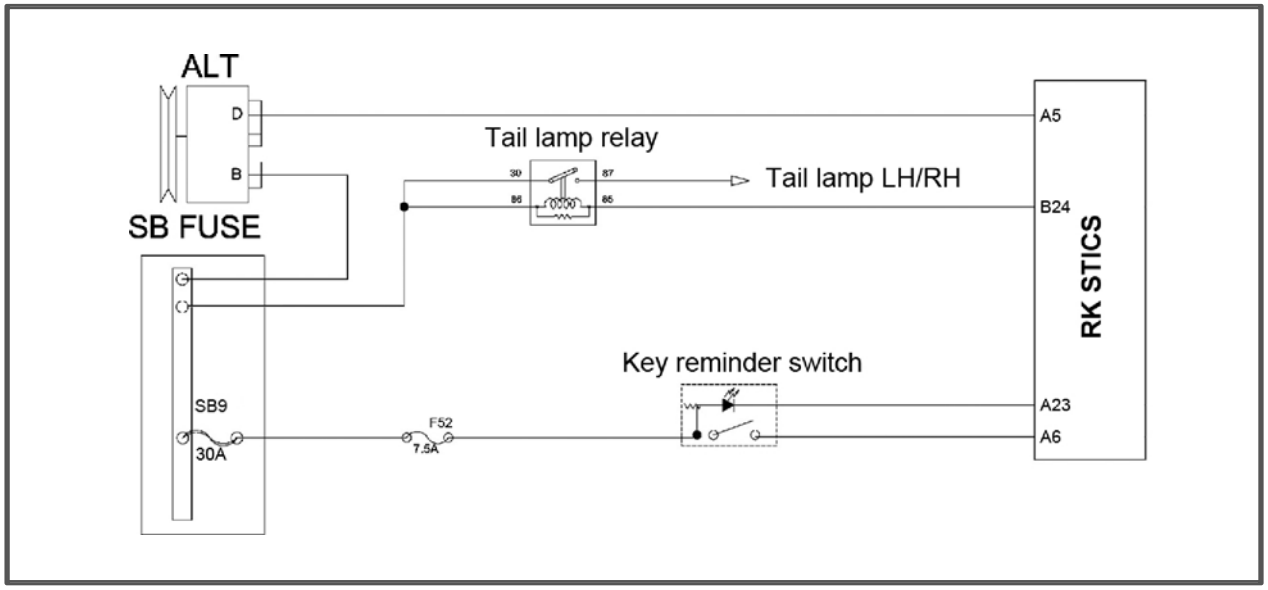
(*2) OPEN : Driver's or Passenger's door = OPEN
CLOSE : Driver's and Passenger's = CLOSE

▶Key cylinder with key hole illumination

With diesel and gasoline engine	With diesel engine	With gasoline engine
		
Without immobilizer →With key hole illumination	With immobilizer →With key hole illumination	With immobilizer →Without key hole illumination function

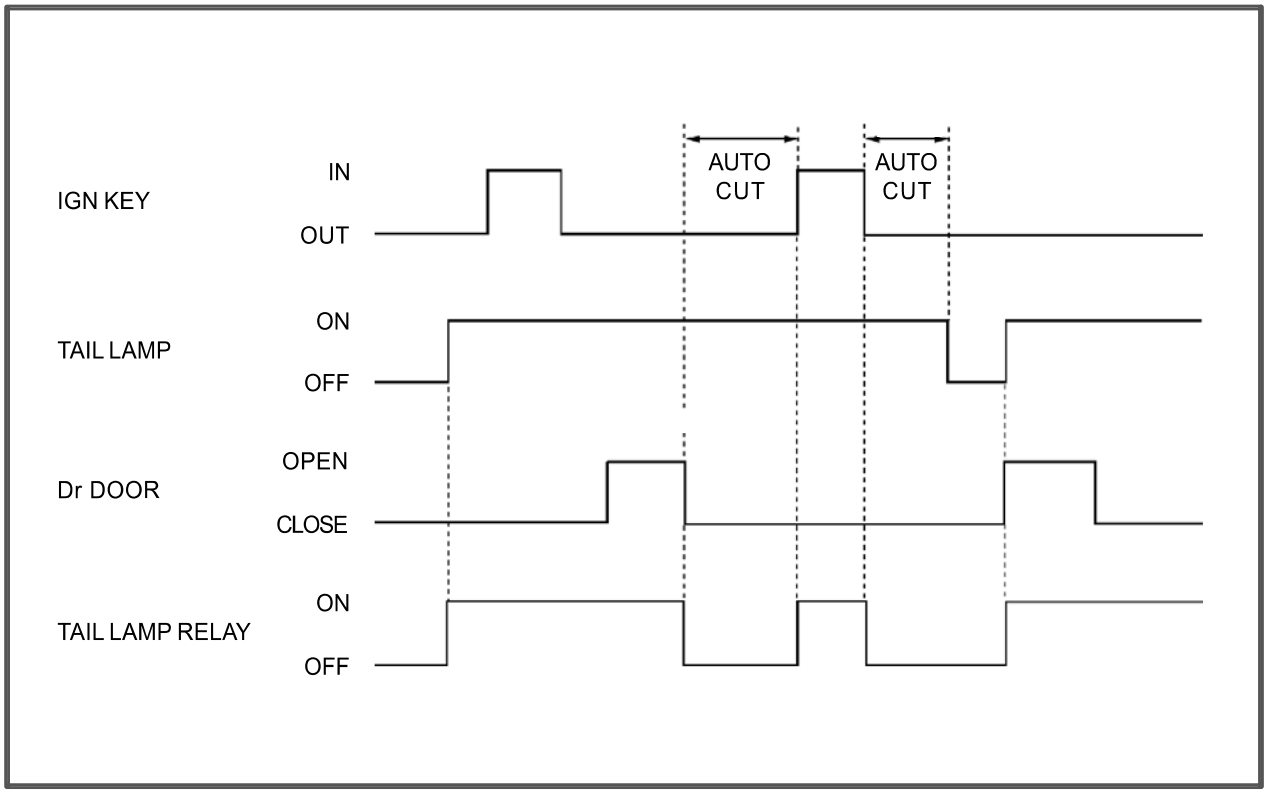
Modification basis	
Application basis	
Affected VIN	

▶STICS Circuit for Tail Lamp Auto Cut (Battery Saver)

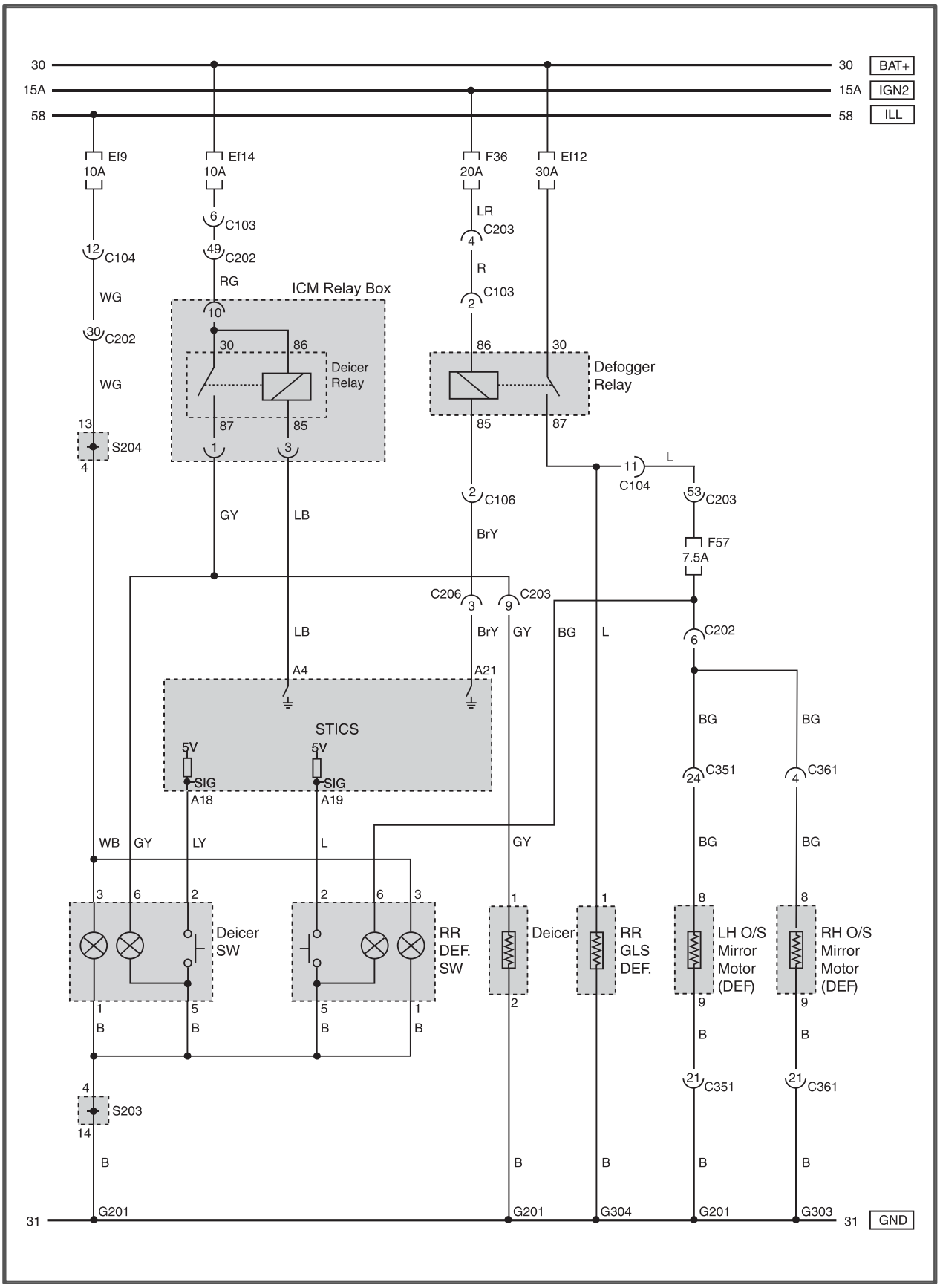


▶Tail Lamp Auto Cut (Battery Saver)

1. The tail lamp is turn on or off according to the operations of the tail lamp switch.
2. The tail lamp relay is turned off (auto cut) when opening and closing the driver's door after removing the ignition key without turning off the tail lamp.
3. The tail lamp relay is turned on when inserting the ignition key into the ignition switch.
4. The tail lamp relay is turned off (auto cut) when opening and closing the driver's door while the ignition key is removed and the tail lamp is turned on.



▶STICS Circuit for Front/Rear Defogger Timer



Modification basis	
Application basis	
Affected VIN	

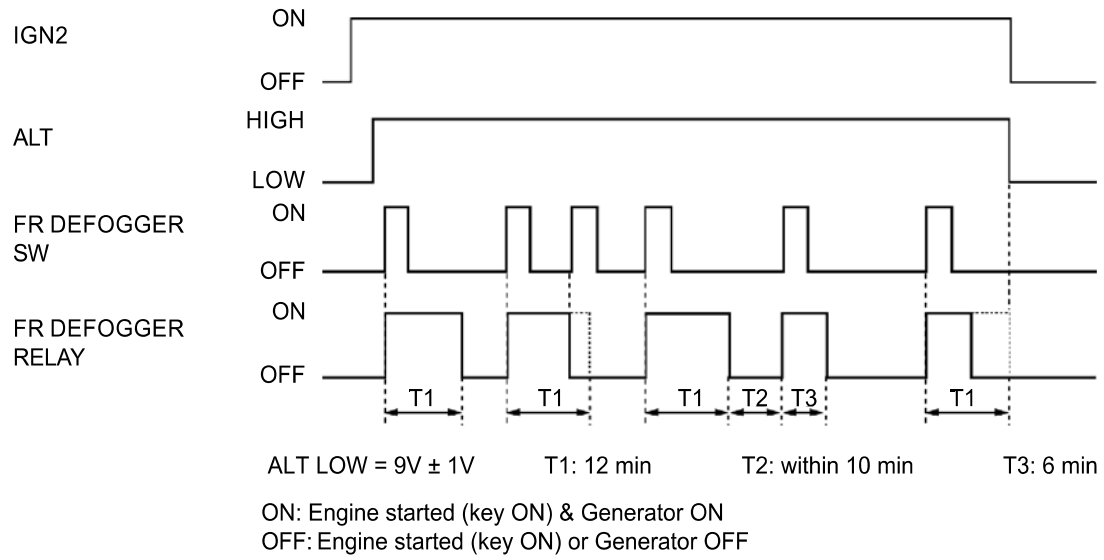
The defogger system uses the heated glass to remove the moisture and frost on the windows, which can disturb safe driving.
The defogger (including de-icer) activates the corresponding switch and the STICS controls the operating time.

Tailgate and outside rearview mirror heated glass switch
Pressing switch activates tailgate and outside rearview mirror heated glass for approx. 12 minutes

Windshield heated glass (de-icer) switch
Pressing switch activates windshield heated glass for approx. 12 minutes

▶Front Defogger Timer

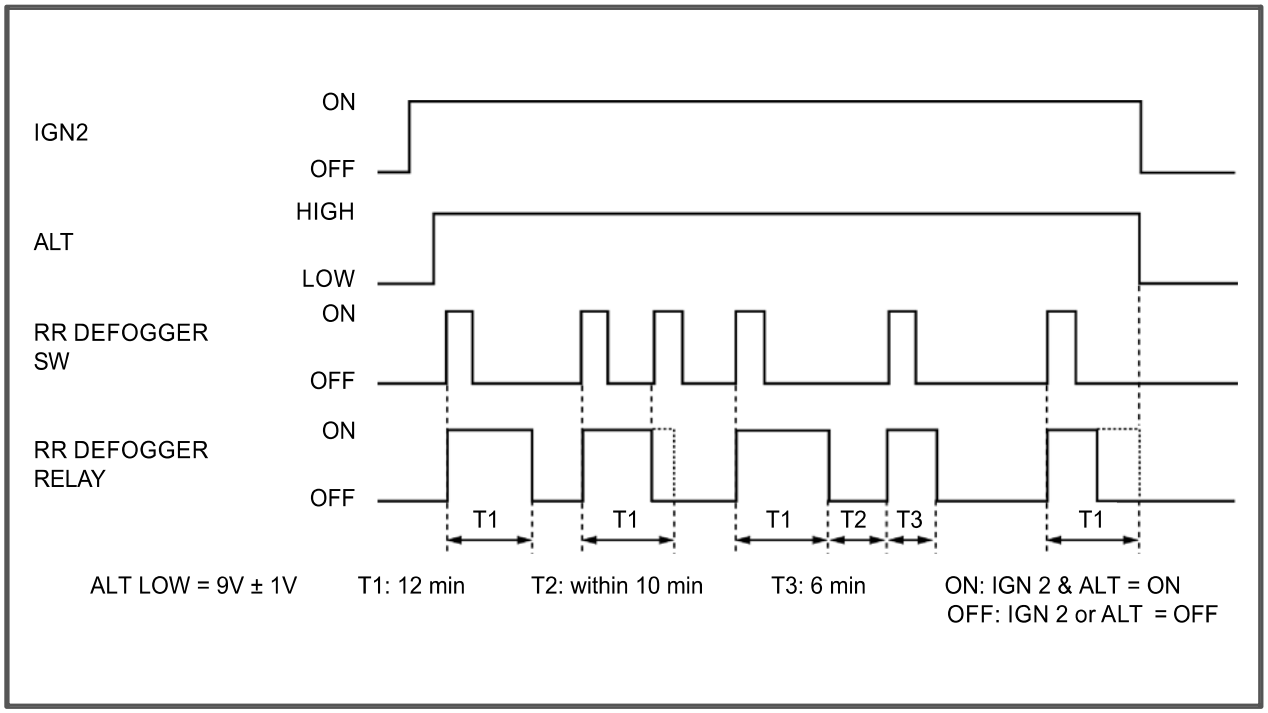
1. The front defogger output is "ON" when turning on the front defogger switch with the engine started (IGN ON)
2. The output stops when turning on the front defogger switch again during its operation.
3. The output is "ON" only for 6 minutes when turning on the front defogger switch within 10
4. minutes after completion of output for 12 minutes. This can be done only once.
   The output is "OFF" when the ignition switch is "OFF".



Modification basis	
Application basis	
Affected VIN	

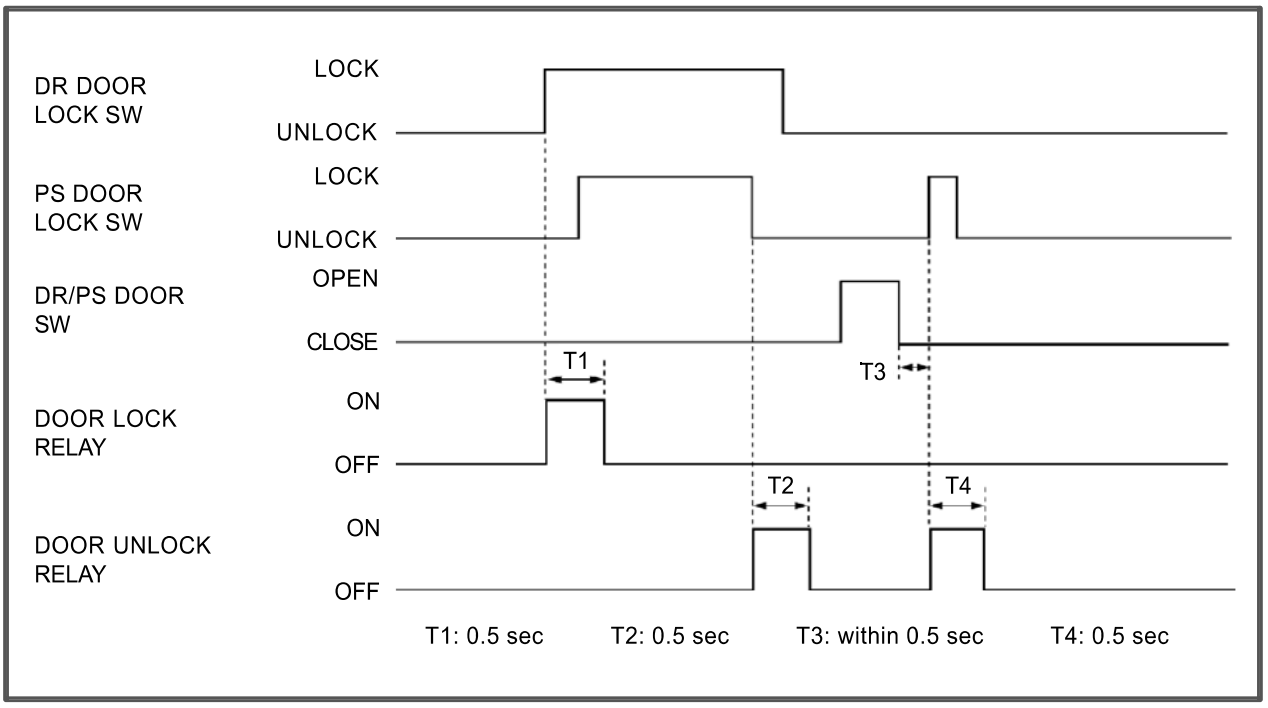
▶Rear Defogger Timer

1. The rear defogger output is "ON" when turning on the rear defogger switch with the engine started (IGN ON)
2. The output stops when turning on the rear defogger switch again during its operation.
3. The output is "ON" only for 6 minutes when turning on the rear defogger switch within 10 minutes after completion of output for 12 minutes. This can be done only once.
4. The output is "OFF" when the ignition switch is "OFF".



▶Door Lock/Unlock Control by Door Lock Switch

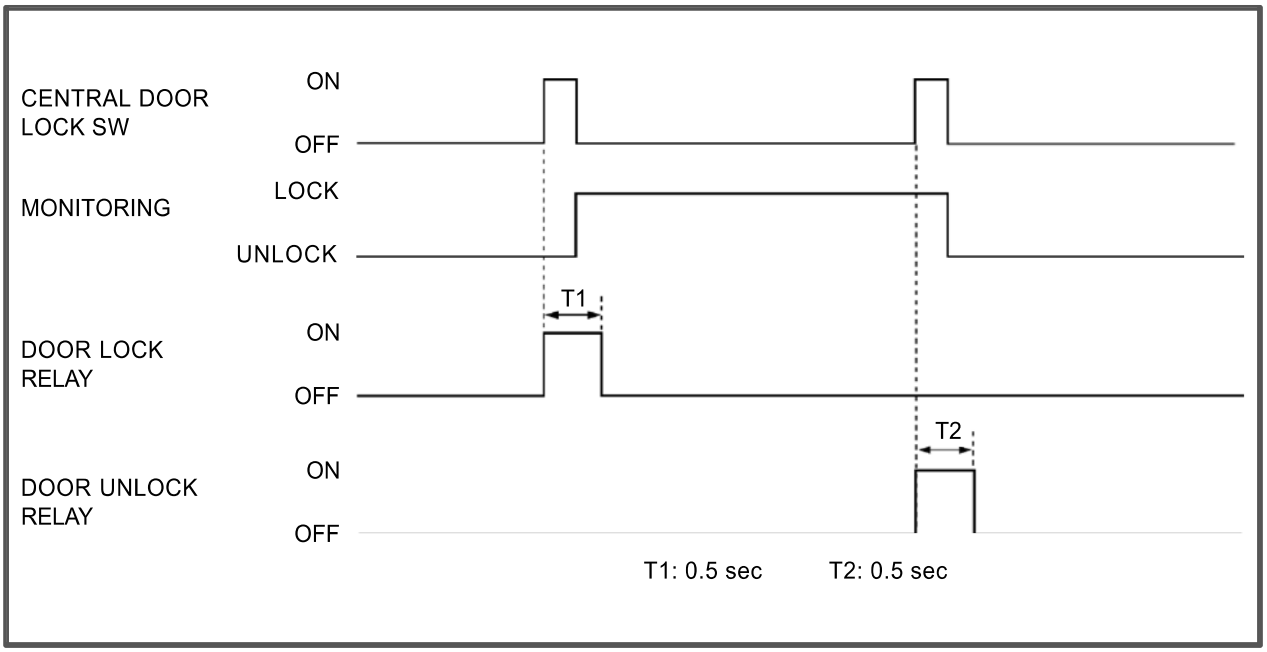
1. The door lock system outputs "LOCK" signal for 0.5 seconds when positioning the driver's or passenger's door lock knob to the lock from unlock position.
2. The door lock system outputs "UNLOCK" signal for 0.5 seconds when positioning the driver's or passenger's door lock knob to the unlock from lock position.
3. "LOCK" or "UNLOCK" by the door lock switch is ignored when outputting the "LOCK" or "UNLOCK" signal by other functions.
4. All door lock signals are "UNLOCK" for 0.5 seconds just for once when receiving the "LOCK" signal within 0.5 seconds after closing the driver's or passenger's door while the ignition key is removed.



Modification basis	
Application basis	
Affected VIN	

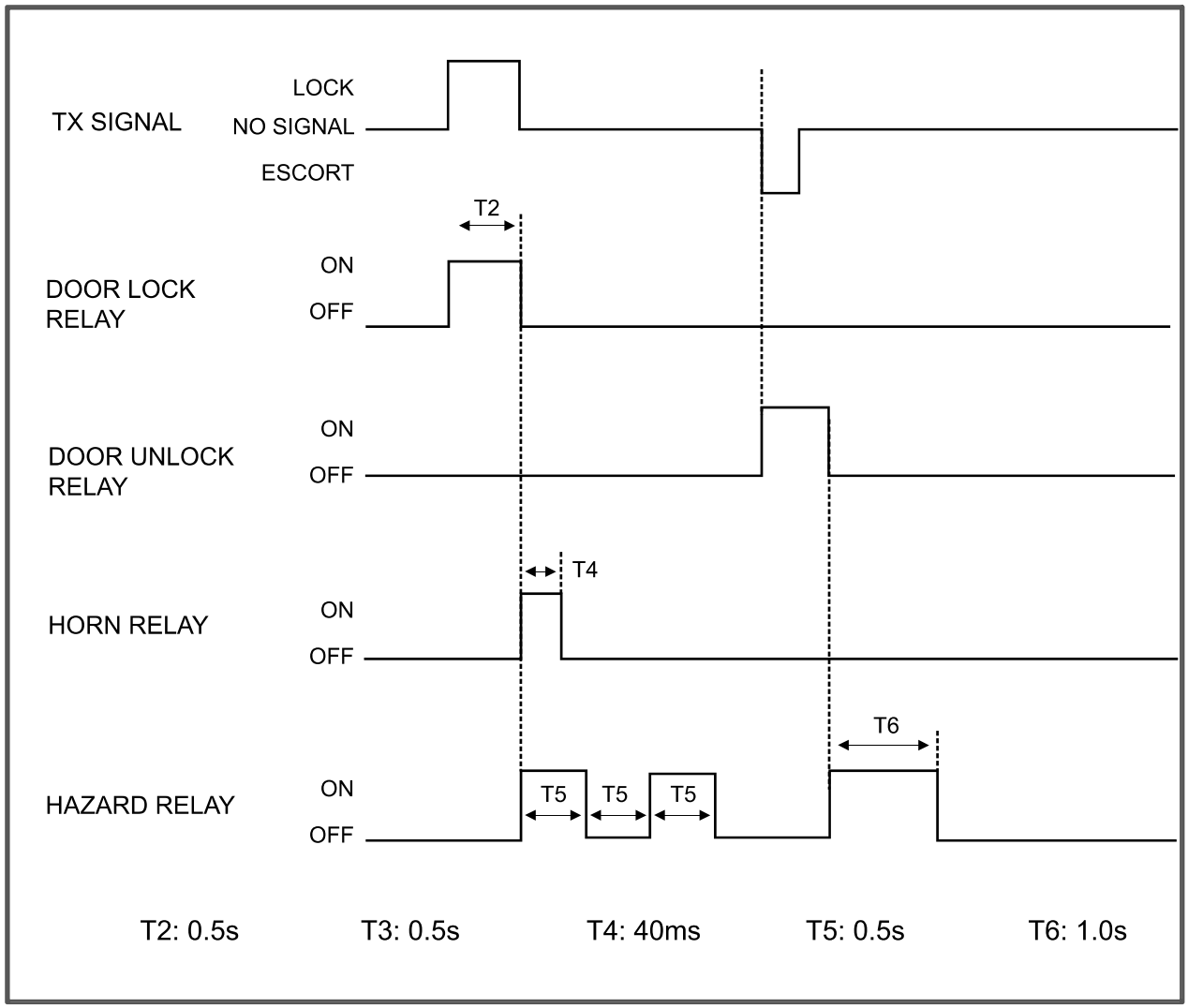
▶Door Lock/Unlock Control by Central Door Lock Switch

1. When the central door lock switch is activated, LOCK/UNLOCK output is performed. (However, if the driver's/passenger's lock switch is previously locked, UNLOCK output is performed and if the driver's/passenger's lock switch is unlocked, LOCK output is performed.)
2. The input of the central door lock switch is overridden in armed mode.



▶Door Lock/Unlock Control by Remote Control Key

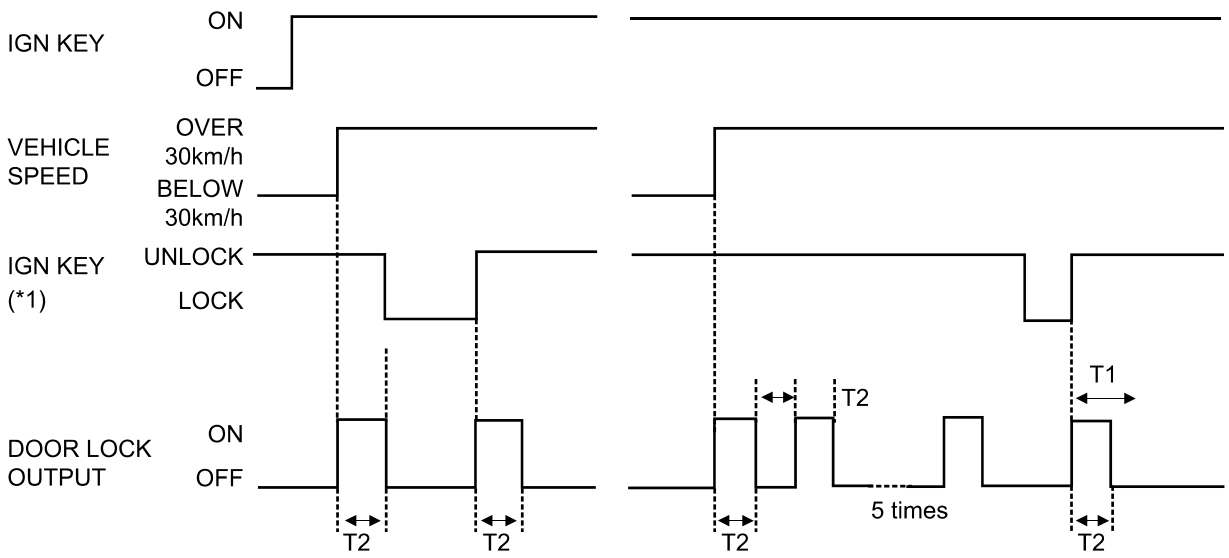
1. The door lock relay output is "ON" for 0.5 seconds when receiving the lock signal from the remote control key.
2. The door unlock relay output is "ON" for 0.5 seconds when receiving the unlock signal from the remote control key.



Modification basis	
Application basis	
Affected VIN	

▶Auto Door Lock

1. The door lock system outputs "LOCK" when the vehicle speed maintains over 30 km/h. However, it doesn't output "LOCK" when all doors are locked or failed.
2. If any of doors is unlocked after outputting "LOCK" in step 1, outputs "LOCK" up to 5 times (except step (1)) at the interval of one second.
3. If any of doors is unlocked after 5 times of "LOCK" outputs, the door (driver's/passenger's/rear) is regarded as "FAIL".
4. If the door that was regarded as fail is changed (UNLOCK to LOCK), it will be recognized as a normal one.
5. If any door is regarded as FAIL, the auto door lock function does not work. (if it is occurred when the vehicle speed is over 30 km/h, the auto door lock output does not occur even if the vehicle speed falls below 30 km/h and accelerates again to over 30 km/h.) Nonetheless, the central
6. door lock function works properly.
   When the system receives "UNLOCK" signal from a door switch, it outputs "LOCK" signals 5 times. If additional "LOCK" signal from another door switch is detected during the period, the system outputs five "LOCK" signals 5 times for the switch.
7. The door lock system outputs "UNLOCK" automatically if the "LOCK" output conditions are established by this function or the key is cycled (IGN=OFF) (even when there is no "LOCK" output while the vehicle speed maintains over 30 km/h under lock condition).
   (If the LOCK condition is established with the ignition switch ON, the system outputs UNLOCK signal unconditionally when turning the ignition switch to OFF position.)
   However, when the ignition key is turned to "OFF" position, the lock output conditions will be cancelled.
8. The "FAIL" condition of the door will be erased when the ignition key is turned to "OFF" position.

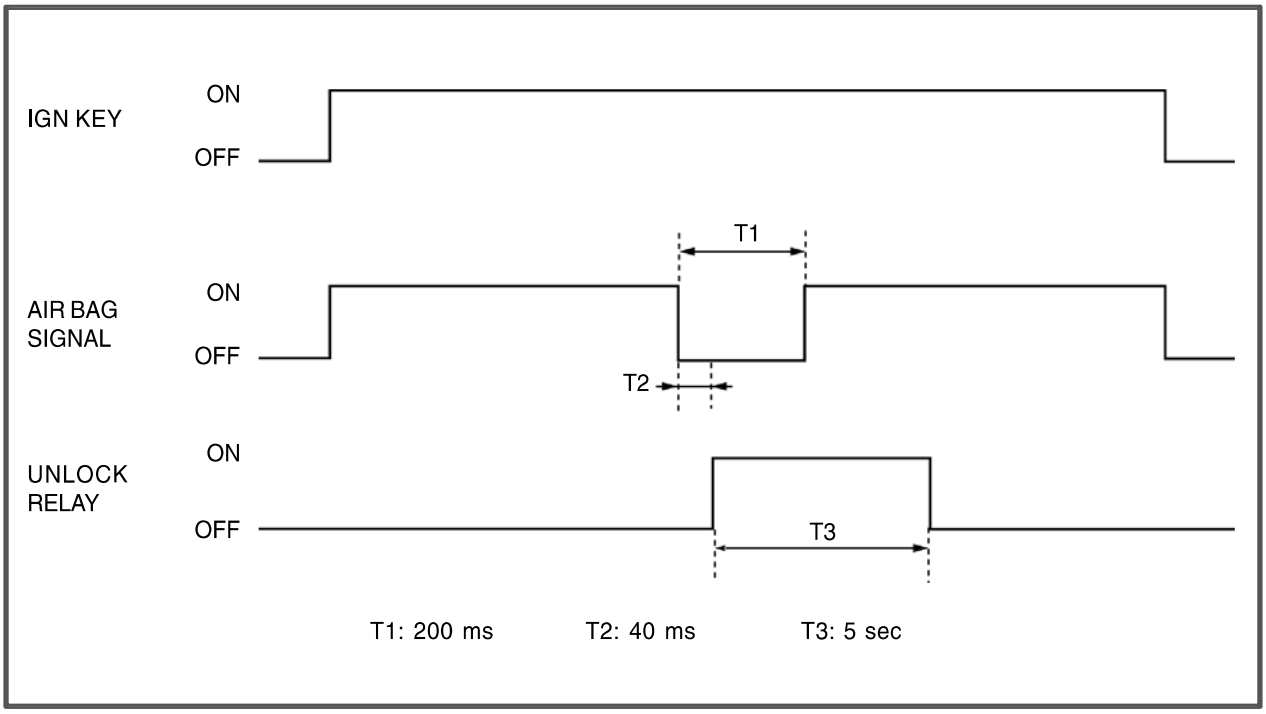


T2: 0.5 s

(*1) LOCK: Driver's & Passenger's & Rear door & = Lock

▶Auto Door Unlock (Crash Unlock: Automatic Door Unlock in Collision)

1. The air bag collision signal input cannot be accepted within 7 seconds after turning the ignition key to "ON" position.
2. After this period, the door lock system outputs "UNLOCK" for all doors for 5 seconds from 40 ms after receiving the air bag collision signal.
3. Even though the key is turned to "OFF" position during the output of "UNLOCK", the output continues on for remaining period.
4. The function is erased when turning "OFF" the ignition switch.



CAUTION

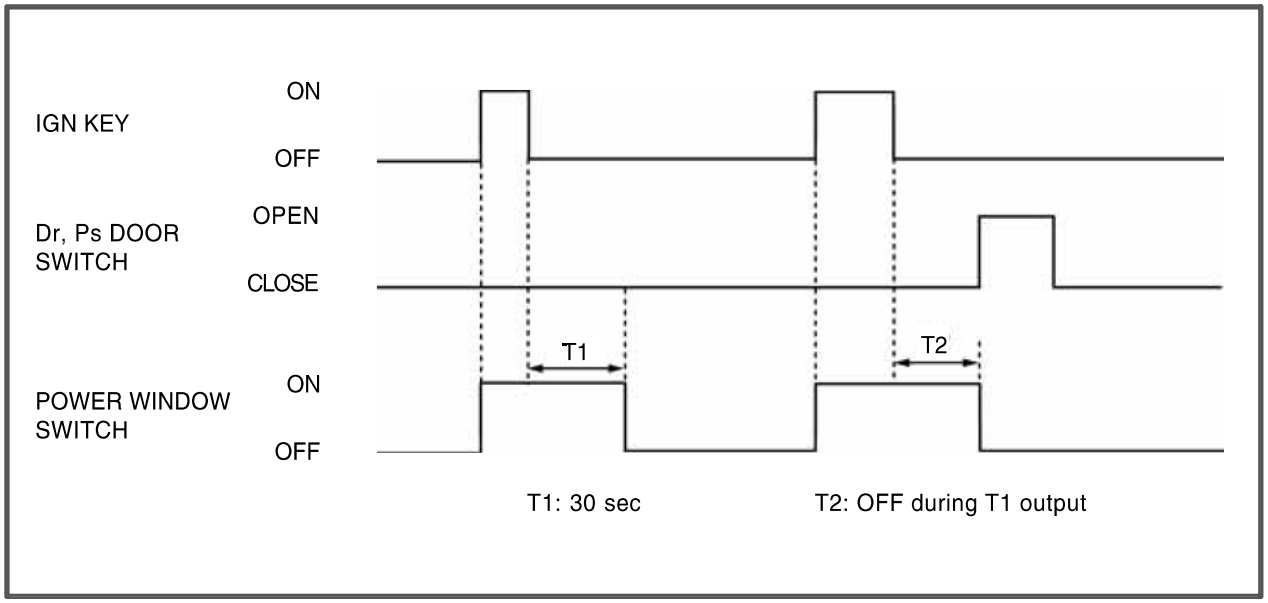
Cautions for door lock/unlock control

1. The "Unlock" control by air bag signal prevails over any "LOCK" or "UNLOCK" control by other functions.
2. The "LOCK/UNLOCK" request by other functions will be ignored after/during the output of "UNLOCK" by the air bag.
3. However, the door lock is controlled by other functions when the ignition switch is "OFF".
   "LOCK" (or "UNLOCK") output is ignored if "LOCK" (or "UNLOCK") output is required while
4. performing the output of "LOCK" (or "UNLOCK").
   (However, UNLOCK by air bag signal and operation by the remote control key are valid.)
   If the door lock system outputs "LOCK" and "UNLOCK" simultaneously, only the "LOCK" output can be activated.

Modification basis	
Application basis	
Affected VIN	

▶Time Lag Power Window Control

1. The power window relay output is "ON" when turning on the ignition switch.
2. The power window relay output is "ON" for 30 seconds when turning off the ignition switch.
   The power window relay output is "OFF" when opening the driver's door or the passenger's door.
   The power window relay is turned "OFF" when receiving the remote control key lock signal
3. (armed mode) during its extended operation period of 30 seconds.



2. STICS CONTROL REGARDING THEFT WARNING ALARM

1) Armed mode

- The followings are definition of DOOR OPEN/CLOSE and DOOR LOCK/UNLOCK in respect of theft deterrent system.

DOOR OPEN and DOOR CLOSE

- DOOR OPEN: Any of all door switches (including engine hood, driver's door, passenger's door or rear door) is in "OPEN" position.
- DOOR CLOSE: All door switches (including engine hood, driver's door, passenger's door, rear door and tailgate) are in "CLOSE" position.

CAUTION

- The door lock/unlock operation does not affect the engine hood.
- OPEN/CLOSE of the dech tailgate does not affect entering the armed mode.
  In other words, when the hood and front/rear door are closed even if the dech tailgate is open, the vehicle can enter the armed mode.

DOOR LOCK & DOOR UNLOCK

- DOOR LOCK: Indicates that driver's, passenger's and rear door and tailgate lock switches are in LOCK positions.
- DOOR UNLOCK: Indicates that driver's, passenger's or rear door or tailgate lock switches are in UNLOCK positions.

Engine hood open warning lamp

The warning lamp comes on when the engine hood is open.

CAUTION

Since the luggage room tailgate does not have the door switch, the door ajar warning light does not come on when it is open.

Modification basis	
Application basis	
Affected VIN	

2) Description of Theft Deterrent Function

(1) Armed mode activation requirements

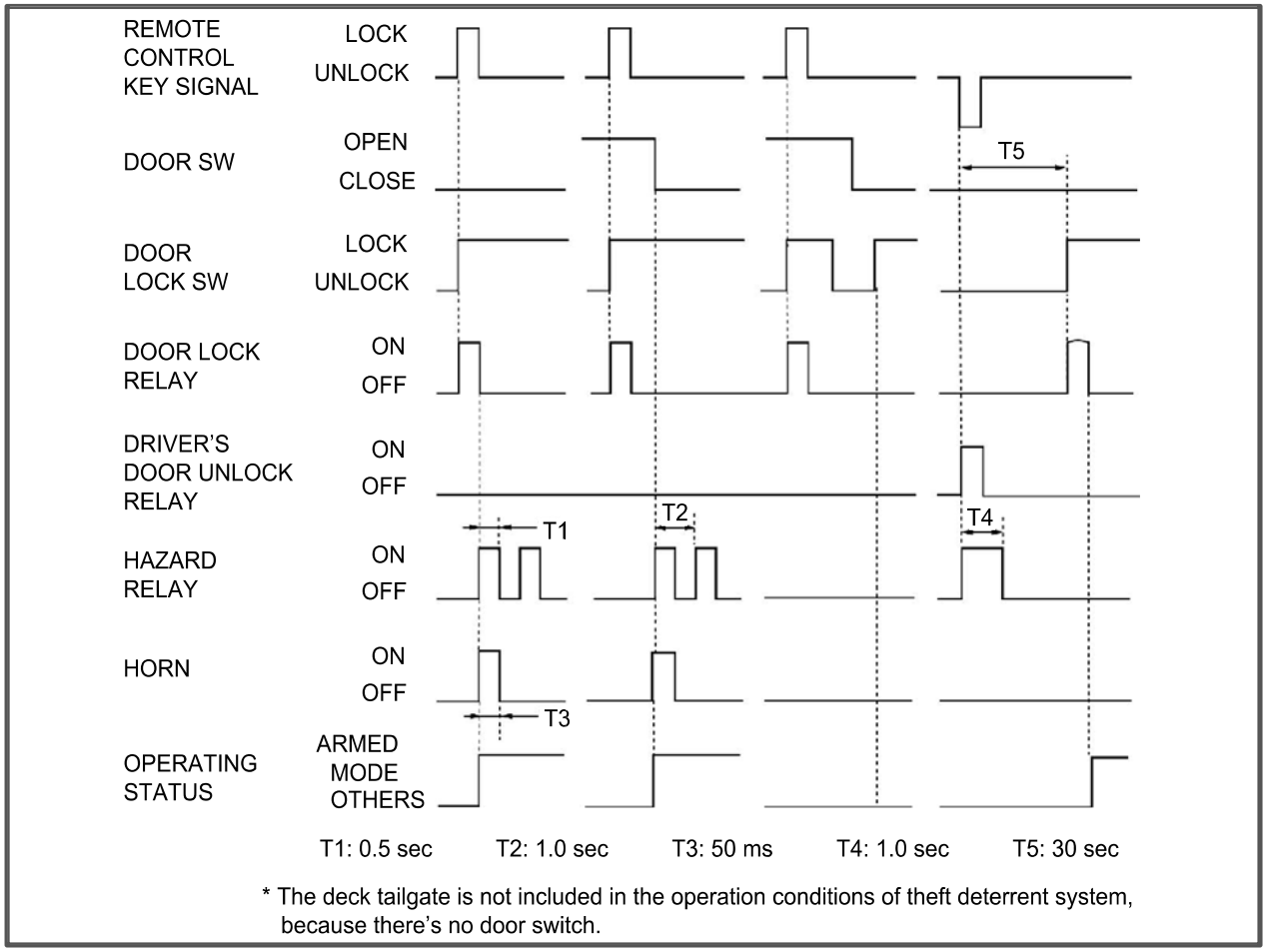
a. The "LOCK" output is "ON" when the "LOCK" signal is received from transmitter while the ignition key is removed and all doors are closed.
The armed mode is activated when the door lock switch is locked (hazard warning flasher blink twice).

b. The armed mode is still activated and the hazard warning flasher blink twice when the "LOCK" signal is received from the remote control key again in armed mode.

c. When the "LOCK" signal is received from the remote control key while any of doors is not closed, only the "LOCK" output can be done and then activates the armed ready mode (without theft deterrent horn and hazard warning flasher). At this moment, if the ignition key is inserted or the door lock switch is unlocked, it cancels the armed mode and activates the normal mode.

d. When the door is opened or the ignition key is not inserted into ignition switch within 30 seconds after receiving "UNLOCK" signal from the remote control key, it outputs "LOCK" and then activates armed mode (RELOCK operation). Also, at this moment, the system blinks hazard warning flasher twice.

e. The armed mode will not be activated except above conditions.
Ex) The armed mode will not be activated when the door is locked by the ignition key.



* The deck tailgate is not included in the operation conditions of theft deterrent system, because there's no door switch.

(2) Armed mode cancellation requirements

a. Receiving UNLOCK signal from the remote control key or starting the engine.

(3) Warning operation requirements

a. When opening the door in armed mode
b. When unlocking the door lock switch in armed mode by other than the remote control key
c. When closing and then opening the door after completion of warning (27 seconds)

(4) Warning operation

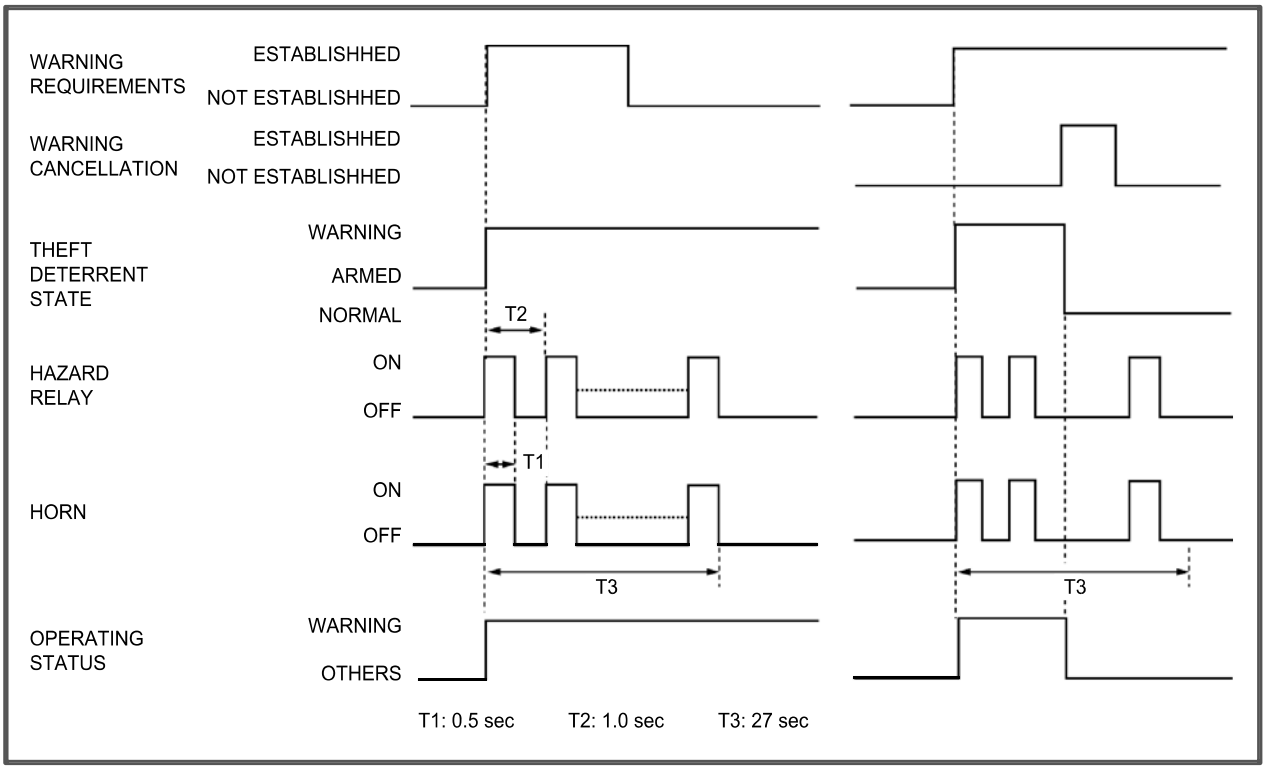
a. The theft deterrent horn and hazard warning flasher output is "ON" for 27 seconds at the interval of 1 second.

(5) Warning cancellation requirements

a. Cancels warning by using any signal from the remote control key (LOCK, UNLOCK, PANIC) during warning operation.
b. Cancels warning after 27 seconds (remaining time) while the ignition key is turned to "ON" position.
c. If the ignition switch is turned to ON position when the warning is activated in armed mode, the warning is cancelled immediately and the warning buzzer stops after 27 seconds (remaining time).

(6) Operation when warning is cancelled

a. The theft deterrent horn and hazard warning flasher outputs are "OFF".



Modification basis	
Application basis	
Affected VIN	

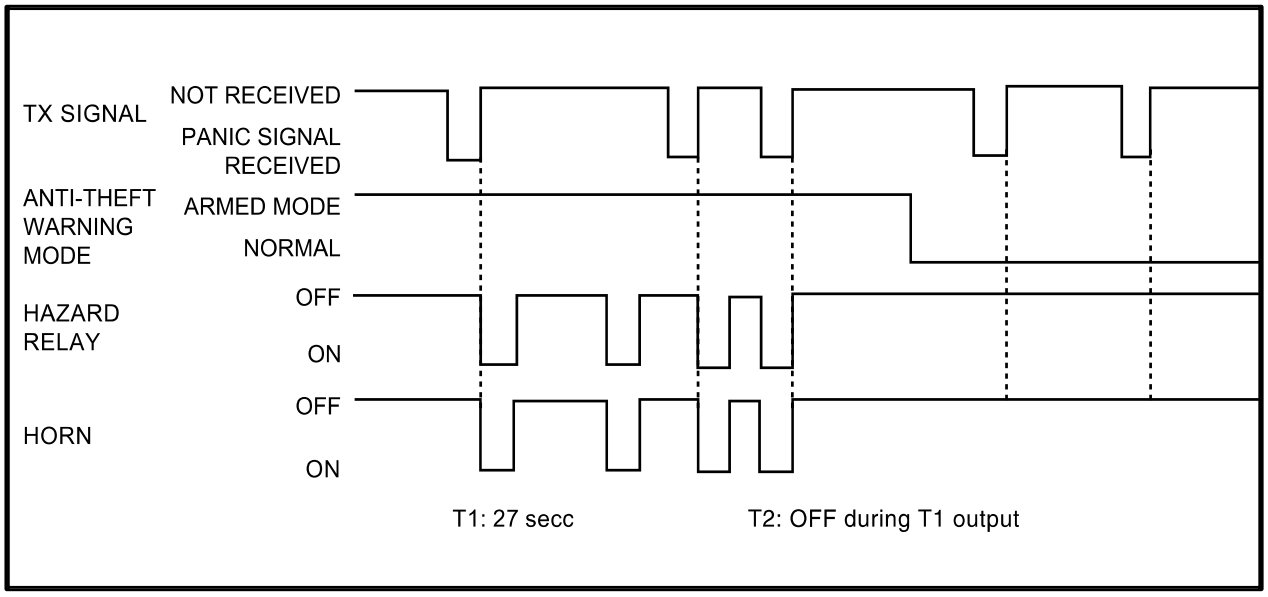
(7) Operation when warning is cancelled

Removed \ Installed	Normal	Armed	Warning	Remark
Normal	O			**RELOCK operation:** When the door is not opened or the ignition key is not inserted into ignition switch for 30 seconds after receiving "UNLOCK" signal, outputs "LOCK" and then activates armed mode
Armed Ready	O			
Armed		O		
Warning			O	
Warning Completion	O	O	O	
RELOCK Ready	O			

The theft deterrent horn and hazard warning flasher is activated when fitting the battery in armed mode. (The same operation as when alarm condition is met in armed mode is performed.)

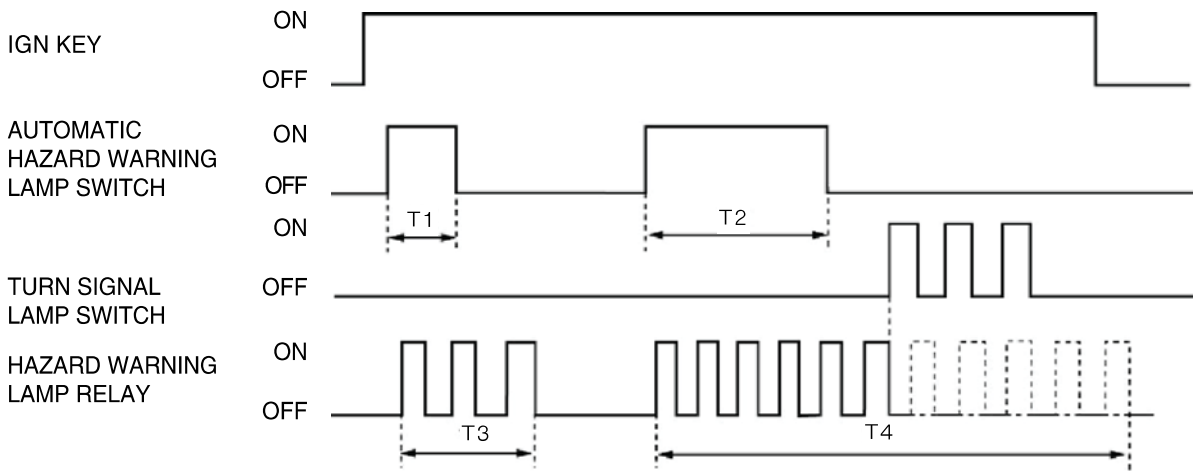
▶ **PANIC Warning**

1. The PANIC warning output is "ON" for 27 seconds using the horn and hazard warning flasher, when receiving the PANIC signal from the remote control key.
2. The PANIC warning output is "OFF" when pressing any button on the remote control key during PANIC warning.
3. The followings are about the theft deterrent warnings.
   a. The theft deterrent warning is deactivated when receiving PANIC signal from the remote control key during theft deterrent warning.
   b. The theft deterrent warning output is "ON" when the theft deterrent conditions are established during PANIC warning (PANIC output is "OFF").
   c. The PANIC warning output is "ON" when receiving the PANIC signal from the remote control key in Armed Ready / Armed / Warning Completion / Relock Ready mode (maintaining the theft deterrent mode).
4. This function operates only in armed mode.



▶ Automatic Hazard Warning Lamp Switch (SHP: Safety Hazard Protection)

1. When the automatic hazard warning lamp switch is pressed for approx. 0.1 to 0.59 seconds, the hazard warning lamp blinks 3 times at an interval of 0.35 seconds.
2. When the automatic hazard warning lamp switch is pressed for approx. 0.6 seconds or longer, the hazard warning lamp blinks 10 times at an interval of 0.35 seconds.
3. This function is only available when the ignition key is in the "ON" position.
4. If the ignition key is turned to the "OFF" position during this function is activated, this function is immediately deactivated.
5. If the system receives signals for the turn signal lamp operation during this function is activated, this function is immediately deactivated.
6. While the turn signal lamp signals are already inputted, pressing the automatic hazard warning lamp switch does not activate the automatic hazard warning lamp function.



T1: 0.1 ~ 0.59 sec T2: over 0.6 sec T3: Turn on and off 3 times
T4: Deactivated while turning on and off 10 times

▶ Automatic hazard warning lamp switch

- Press briefly (0.1 ~ 0.59 seconds): The hazard warning lamp blinks three times.
- Press and hold (more than 0.6 seconds): The hazard warning lamp blinks ten times.

Modification basis	
Application basis	
Affected VIN	

▶Specifications of Remote Control Key

When any of switches on remote control key is pressed, the integrated CPU in remote control key sends the coded control message to the CPU in receiver to control the vehicle.

Door Unlock and Panic Function

Breifly press (below 0.5 sec): Door unlock and theft deterrent mode is deactivated
Press and hold (over 2 sec): Panic function

1. Door unlock (Briefly press)
   - If you send the door unlock signal using the remote control key, with all the doors locked, the door will be opened and the theft deterrent mode will be deactivated. If the door coupled switch of front room lamp is pressed, the lamp will come on for 30 seconds. It will turn off immediately after the lock button of the remote control is pressed.

2. Panic function: activated in the theft deterrent mode
   - If you press and hold the door unlock and panic buttons, the buzzer will sound for 27 seconds and the hazard warning flasher blinks.
   - The function is inactivated if any button of remote control is pressed.
     * For the previous model, only the theft deterrent horn has been activated.

LED flasher
Briefly press: blink once
Press and hold: blink twice

Door Lock Function

Breifly press (below 0.5 sec): Door lock and theft deterrent mode is activated

1. Door unlock (Briefly press)
   - Pressing this button locks all doors and activates the theft deterrent mode.

Battery Replacement

Key type	REKES key
Specification	CR2032
Amount	1 EA

Modification basis	
Application basis	
Affected VIN	

▶ Specification of Receiver

1. Operating requirements

   - You should remove the ignition key.

2. Code registration requirement

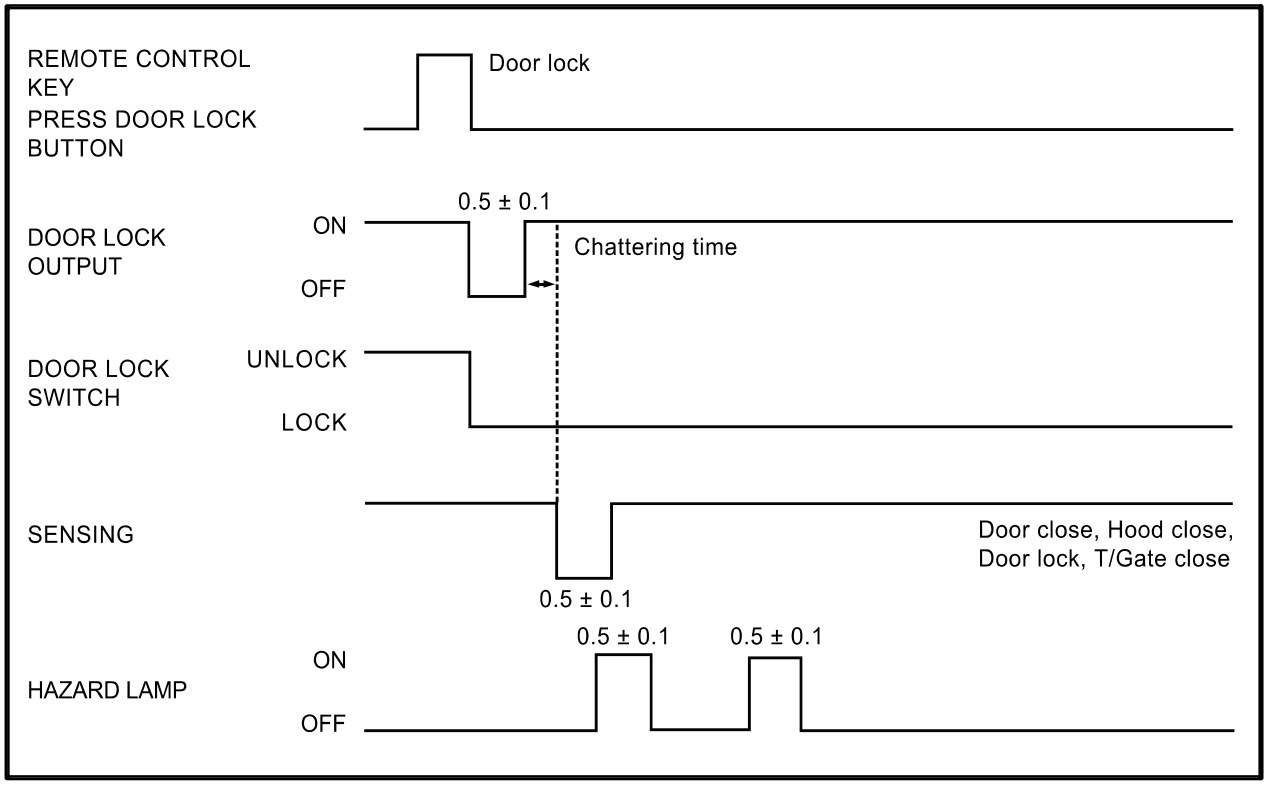
   - You can register the code only using the diagnostic device.

3. Transmitter code registration

   a. You can register up to 5 transmission codes to the remote control key.
   b. The receiver does not output the received code during registration.
   c. Connect the device to the diagnostic terminal.
   The code can be registered only by the panic signal from the transmitter.
   (Other switches (LOCK/UNLOCK) can't code.)

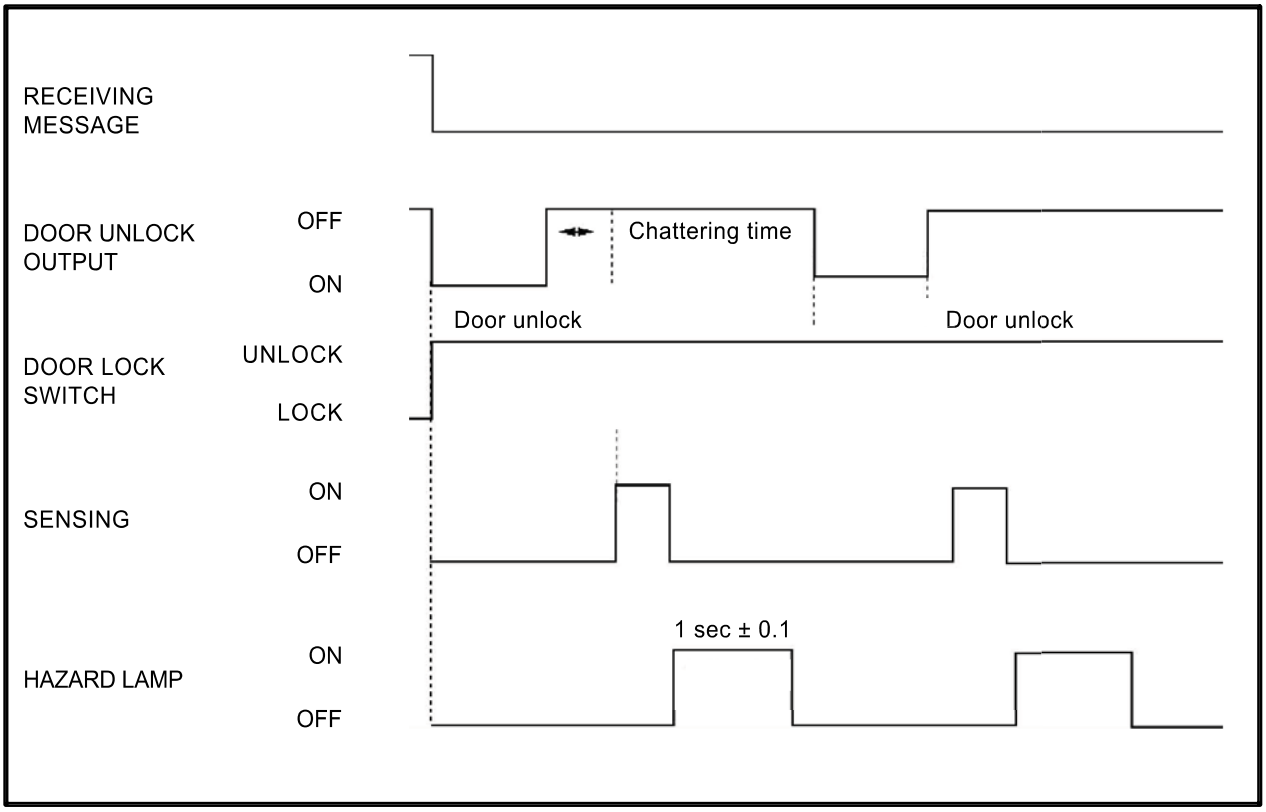
▶ Remote Door Lock

1. All doors are locked when briefly pressing the door LOCK burron on remote control key (less than 0.5 seconds).
2. The system outputs LOCK signal immediately after receiving the door lock message from the remote control key. The system activates the theft deterrent mode when all doors are locked while they are fully closed (the hazard warning lamps blink twice.).



▶ Door Unlock

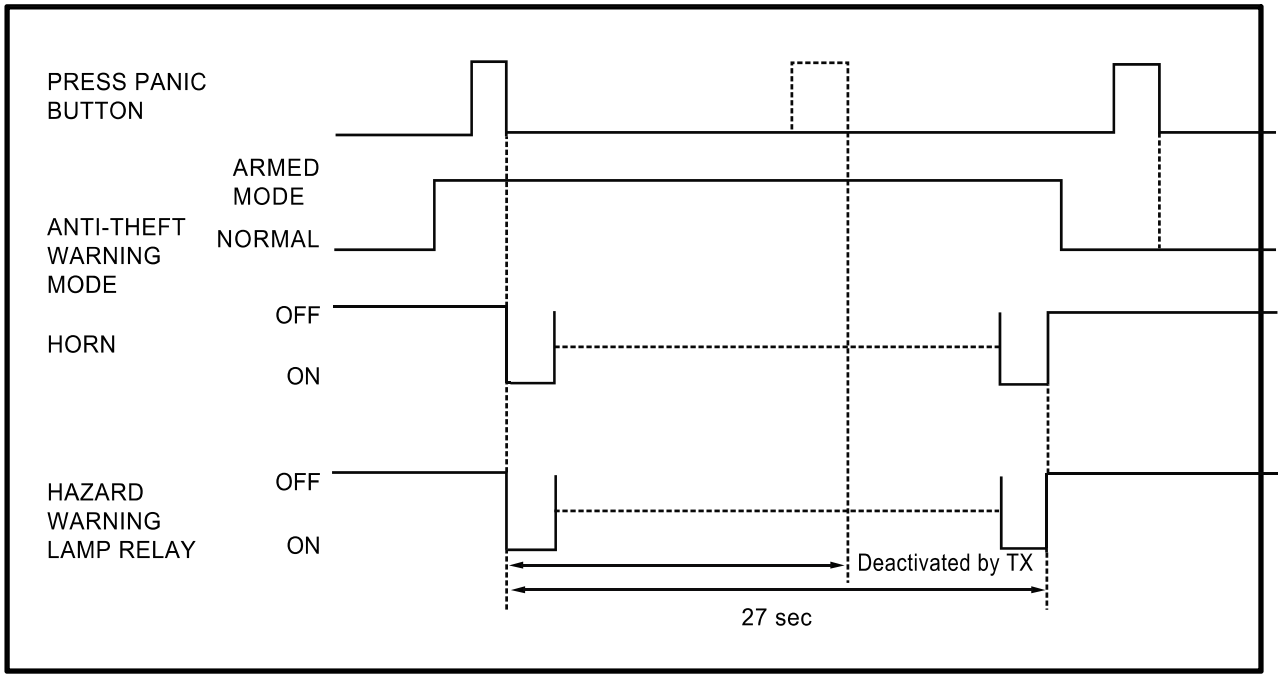
1. The door unlock operates when pressing the door switch on the remote control key for longer than 0.5 seconds.
2. The door unlock relay is "ON" for 0.5 seconds when receiving the door unlock message from the remote control key.
3. The hazard warning lamps blink once only when all the doors unlocked successfuly.



Modification basis	
Application basis	
Affected VIN	

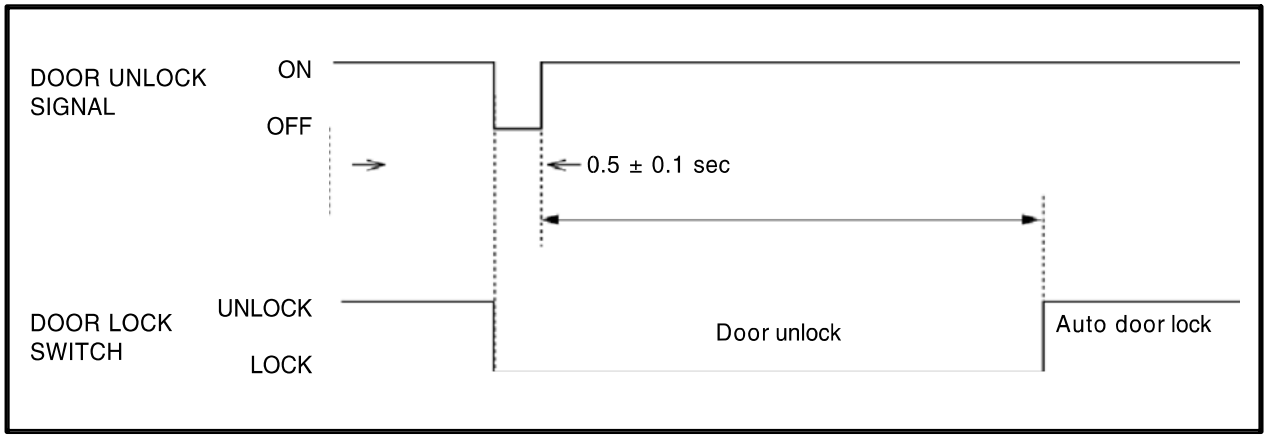
▶ Remote Panic

1. If you press and hold the door UNLOCK and PANIC button (more than 2 seconds) on the remote control key, the panic function is activated.
2. The vehicle activates the panic alarm by using the horn and hazard warning lamp for 27 seconds when receiving the panic message from the remote control key.



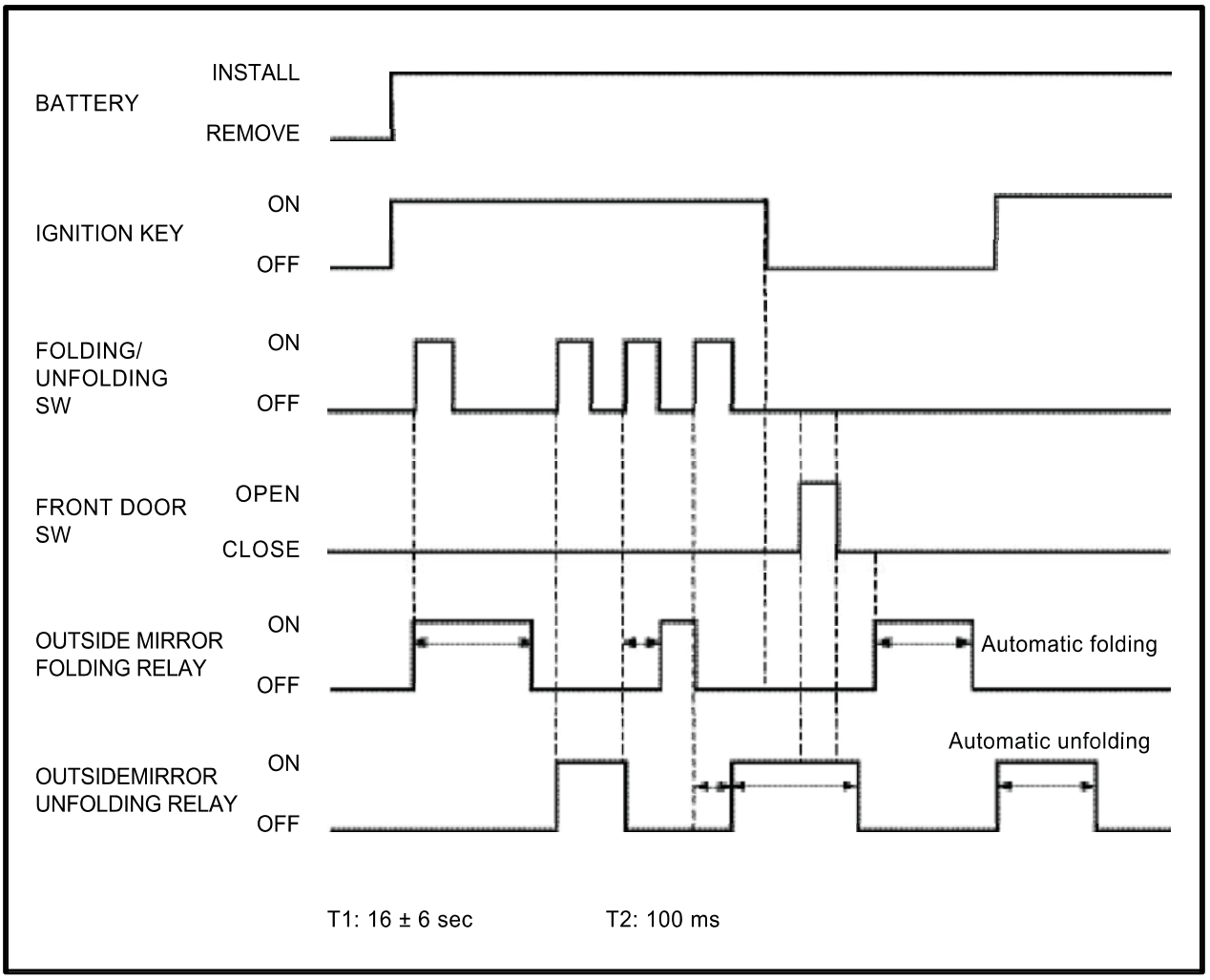
▶ Auto Door Lock in 30 Seconds after Pressing Door Unlock Button

1. If no door is opened for 30 seconds after inputting remote door unlock, the doors are automatically locked and the armed mode of anti-theft system is activated again (RELOCK function).



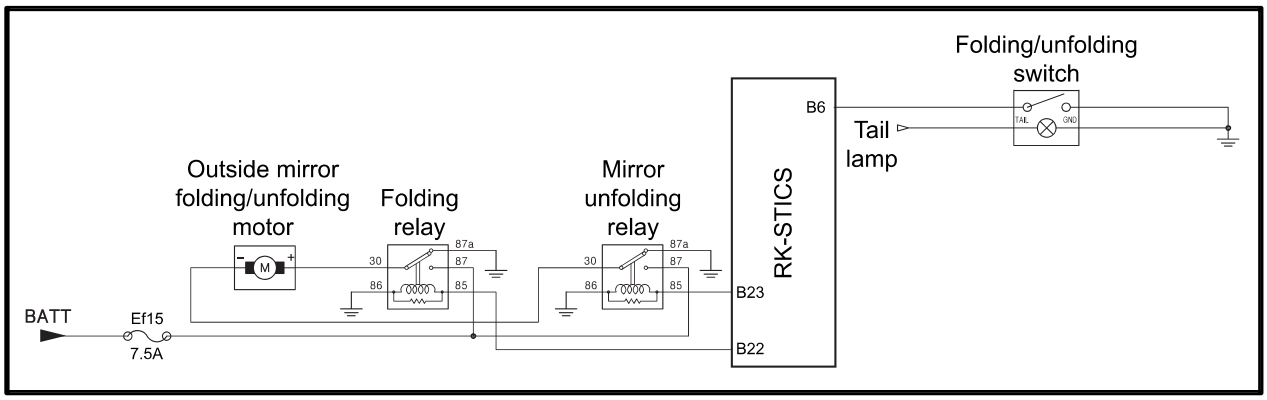
▶ Outside rearview mirror folding/unfolding control

1. If you press the folding/unfoling switch with the ignition switch in "ON" position, the outside rearview mirror is folded or unfolded depending on the previous status. At this time, folding/unfolding outputs are maintained for about 15 to 17 seconds.
2. Even though the ignition switch is turned to "OFF" position during folding/unfolding output, the output continues on for remaining time.
3. When removing and refitting the battery, the first switch input folds the mirror.
4. If you turn the ignition switch to the "OFF" from "ON" position, operating time is extended by 60 seconds. Unlikely the previous model, opening the front door does not affect the extension time. (i.e., opening/closing the front door is irrelevant)
5. If the unfolding input is received from the switch during folding output or the folding input is received during unfolding output, the existing output stops and new output is activated after the delay time of about 0.1 second.
6. When the vehilce speed is above 50 km/h with the mirror unfolded, even though the folding signal is received it is overridden.
   (folding is possible only at vehicle speed of less than 50 km/h)



Modification basis	
Application basis	
Affected VIN	

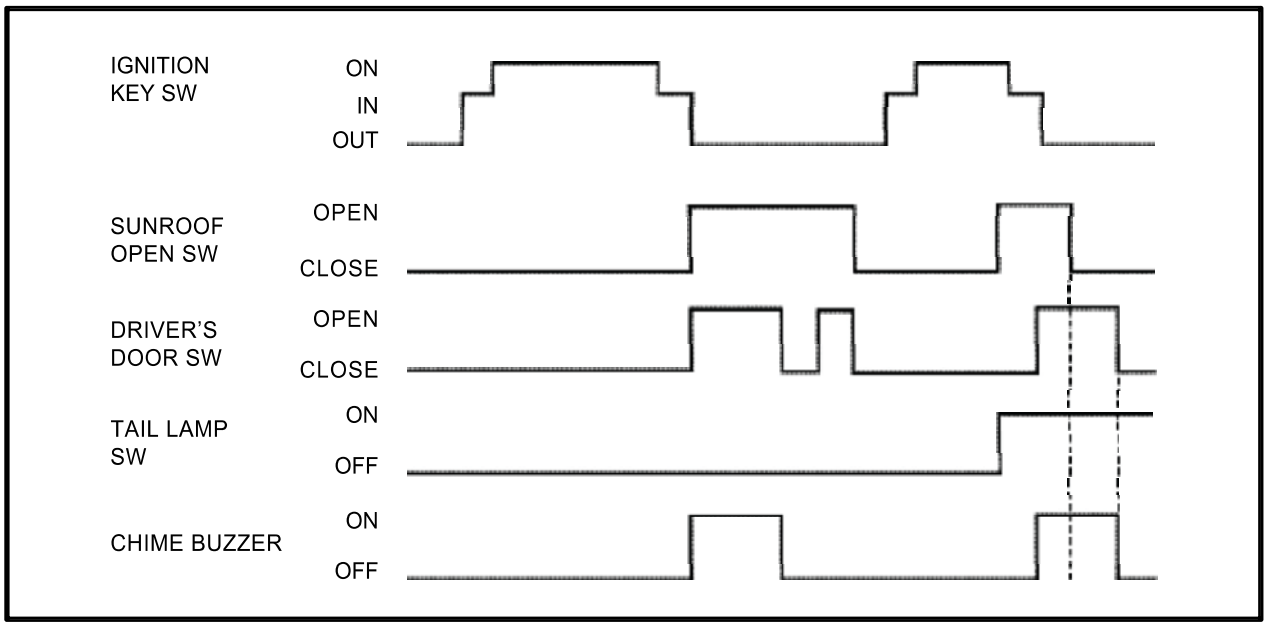
▶ STICS Outside Rearview Mirror Folding/Unfolding Control Circuit

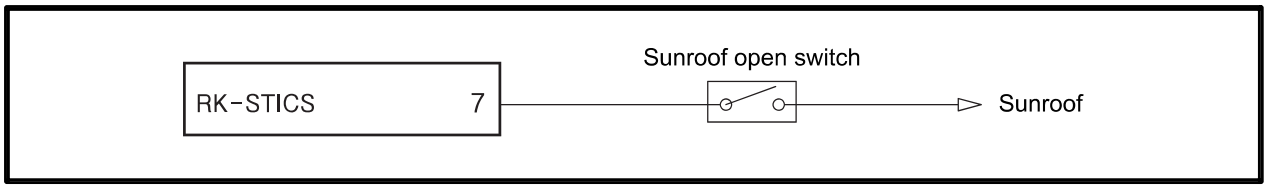


▶ Sunroof open warning

In order to prevent the driver from getting off the vehicle with the sunroof open, the reminder function for the driver is added. This function is activated as follows:

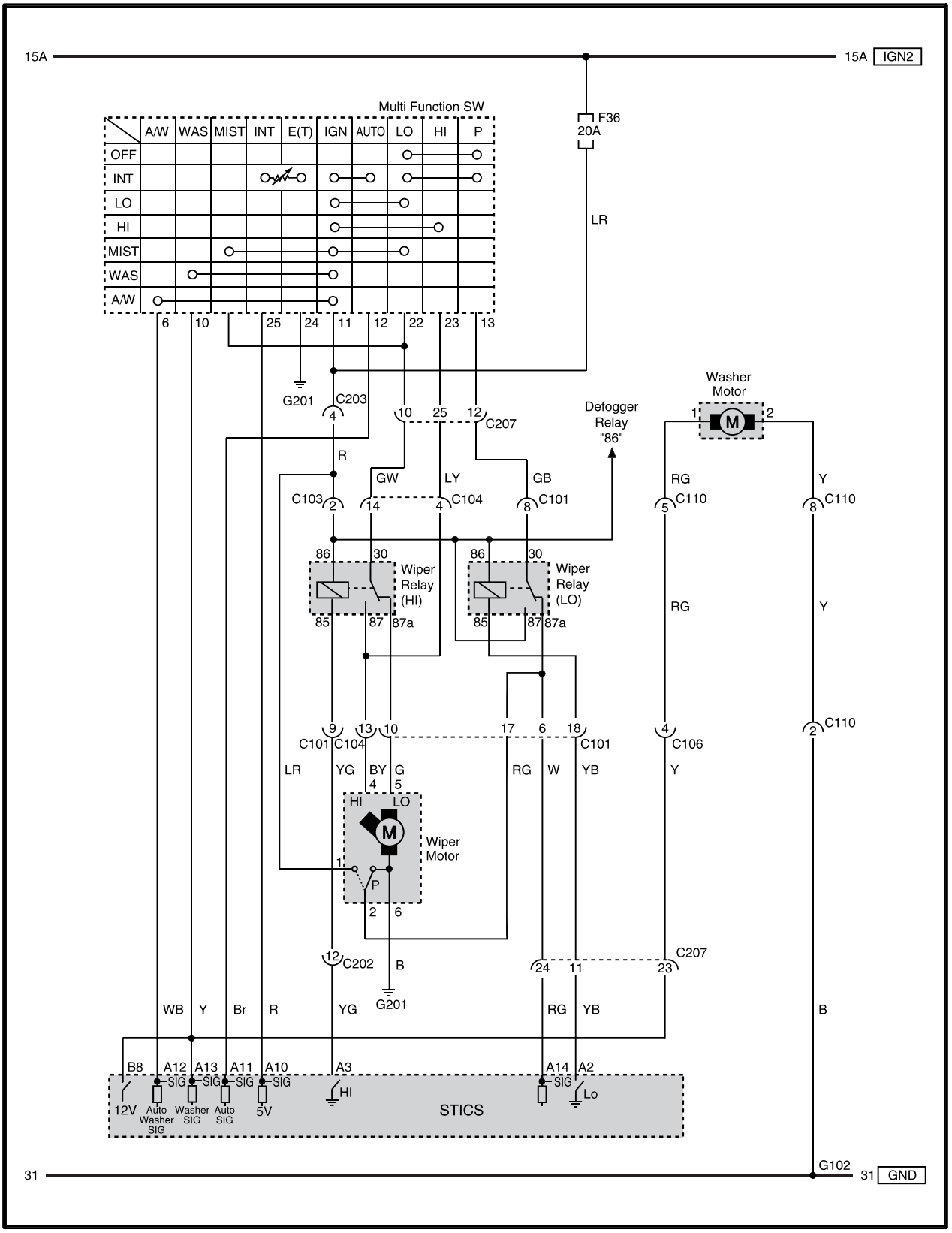
1. If you remove the ignition switch and open the driver's door with the sunroof open, the chime buzzer sounds.
2. As soon as you close the driver's door or the sunrooof, the chime buzzer output stops.
3. However, when operating conditions in step (1) are met after the operation in step (2), the chime buzzer will not sound again. If you turn the ignition swtich to the "ON" position again and the operating contions in step (1) are met, the chime buzzer sounds again.
4. If the operating condtions for door ajar warning and sunroof open warning are met at the same time, the sunroof open warning is activated preferentially.





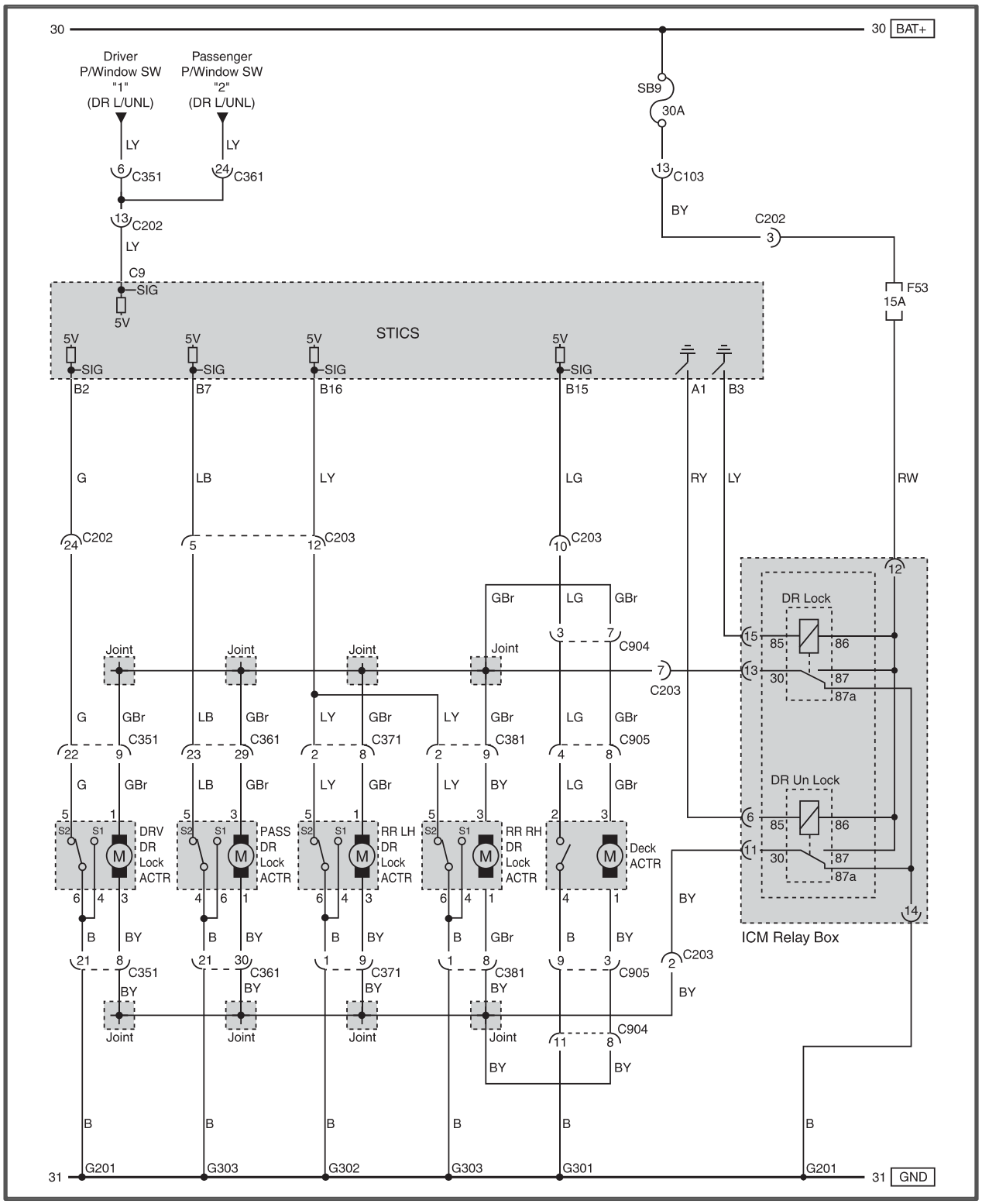
3. CIRCUIT DIAGRAM

▶ FRT wiper / washer



Modification basis	
Application basis	
Affected VIN	

▶ Central Door Lock Circuit



NOTE

The door ajar warning lamp in the instrument cluster does not come on even though the tailgate is opened.

4. REKES Key Coding

1) Operating requirements

You should remove the ignition key.

2) Code registration requirement

You can register the code only using the diagnostic device.

3) Transmitter code registration

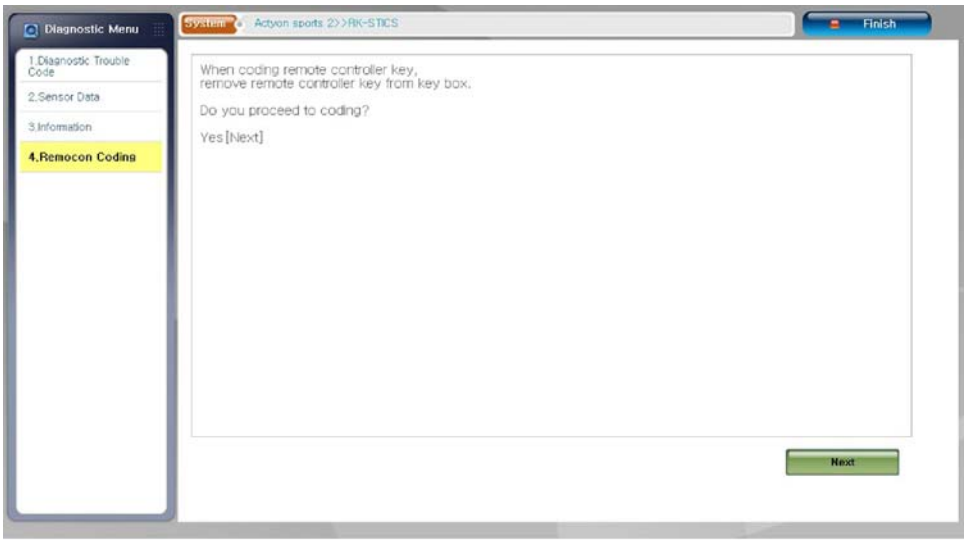
a. You can register up to 2 transmission codes to the remote control key.
b. The receiver does not output the received code during registration.
c. The remote control key should be coded using the diagnostic device.

Modification basis	
Application basis	
Affected VIN	

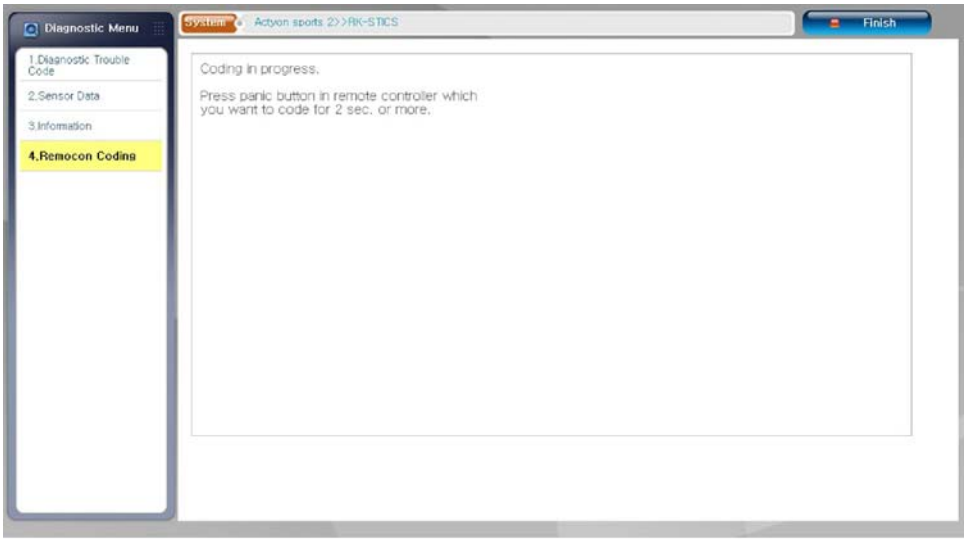
4) How to Code REKES Key

If you replace the REKES key or immobilizer key to new one, you should code the REKES key using the diagnostic device. (maximum 5)

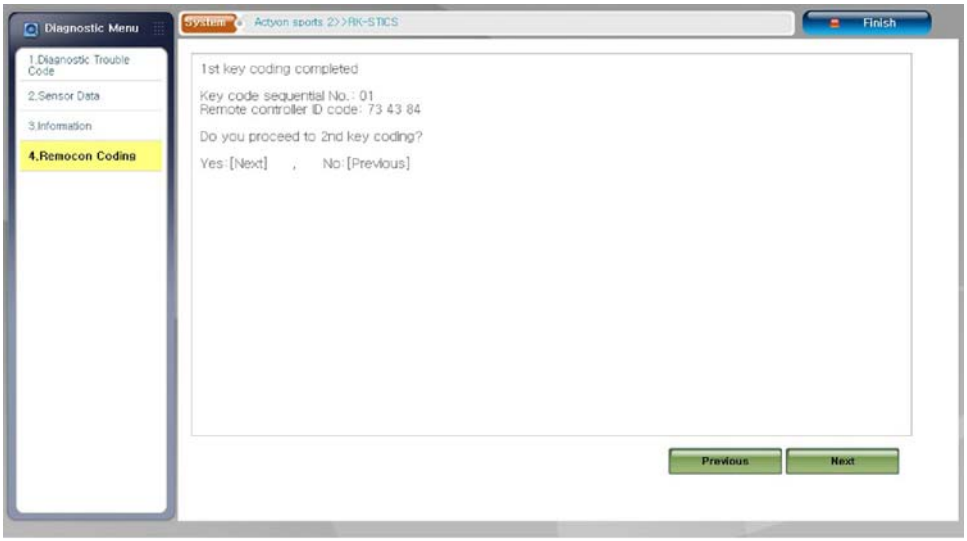
1. Connect the diagnostic device to the vehilce and select the vehicle type and system (RK-STICS). When the following screen is displayed, select 'REMOCON CODING'.



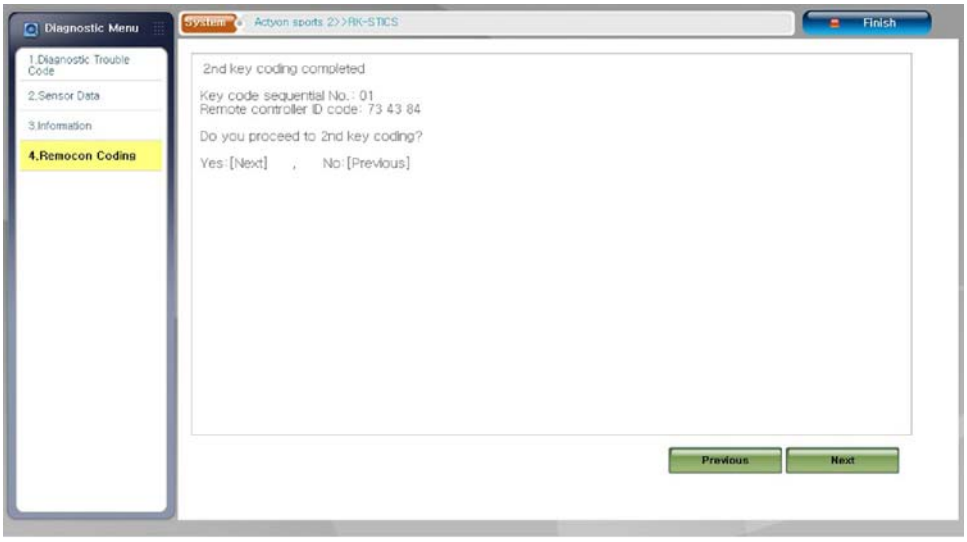
2. Remove the remote control key from the ignition key box and press 'Next'. Press the door UNLOCK (PANIC) button on the remote control key once (for approx. 2 seconds or longer).



3.The first key coding completion screen is displayed with beep sound as follows: Press 'Next' and perform the second remote control key coding in the same way.



4.When the second key coding is completed, the following screen is displayed. Finish the remote control key coding by pressing 'Previous'.



5.Exit the diagnostic screen, remove the device from the diagnostic connector and perform the function test for the remote control key. If it does not work well, perform the above procedures again.

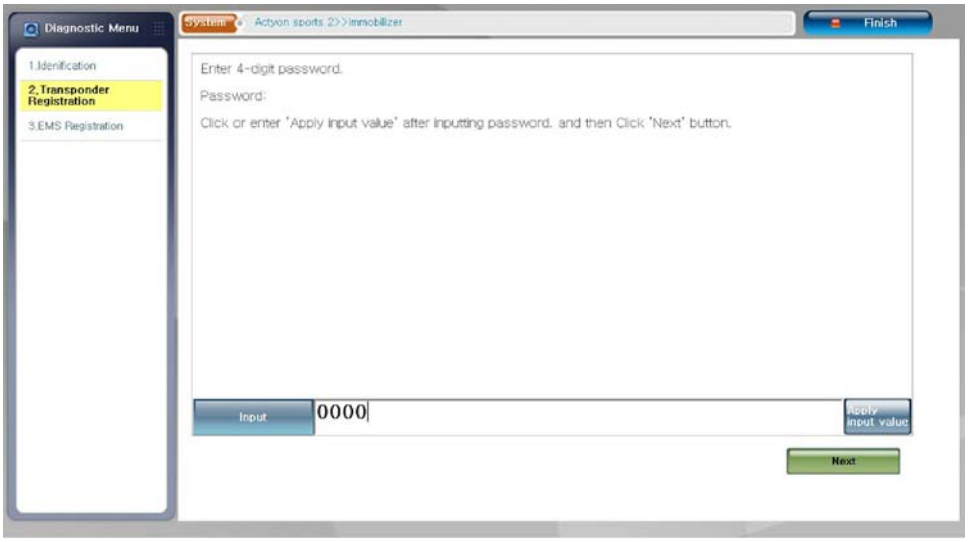
CAUTION

When you code newly purchased remote control key:

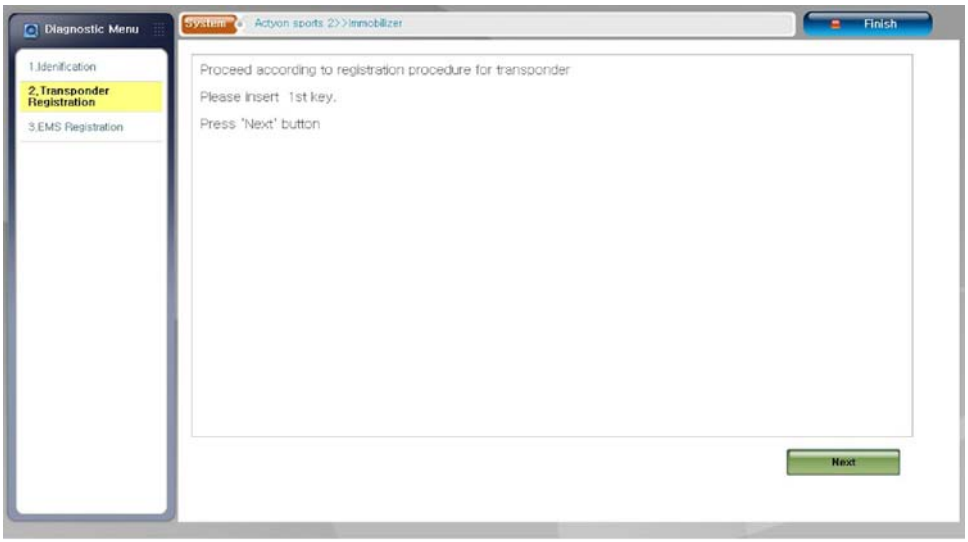
- When you lost the remote control key and purchase a new one, if you code only the newly purchased one, the existing remote control key becomes unavailable. You must code the newly purchased remote control key together with the existing one.

5) How to Register Transponder

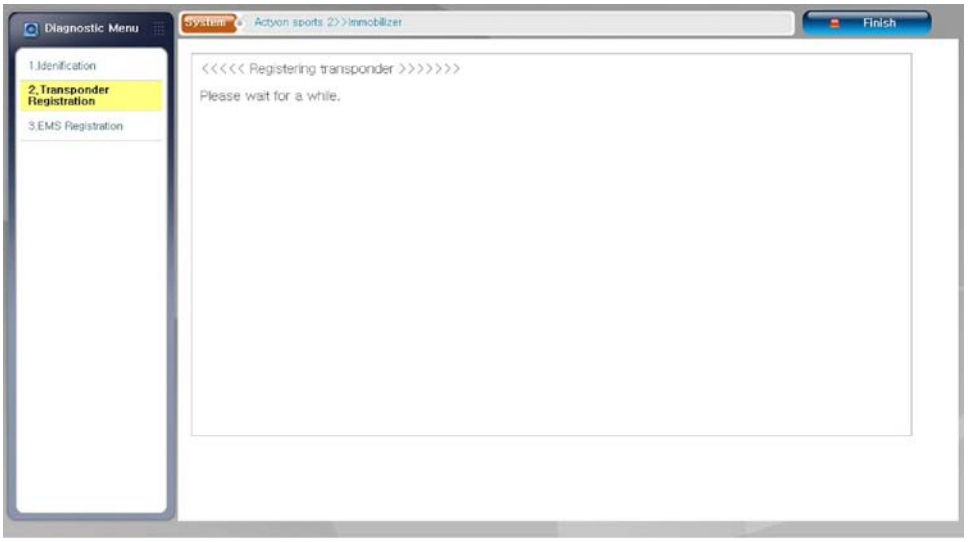
1. Insert the ignition key into the key cylinder and turn it to the "ON" position.
2. Select the vehicle type and system (immobilizer) on the diagnosis program.
3. Select the Transponder registration menu and enter the password. (initial value is "0000") Select "Next".



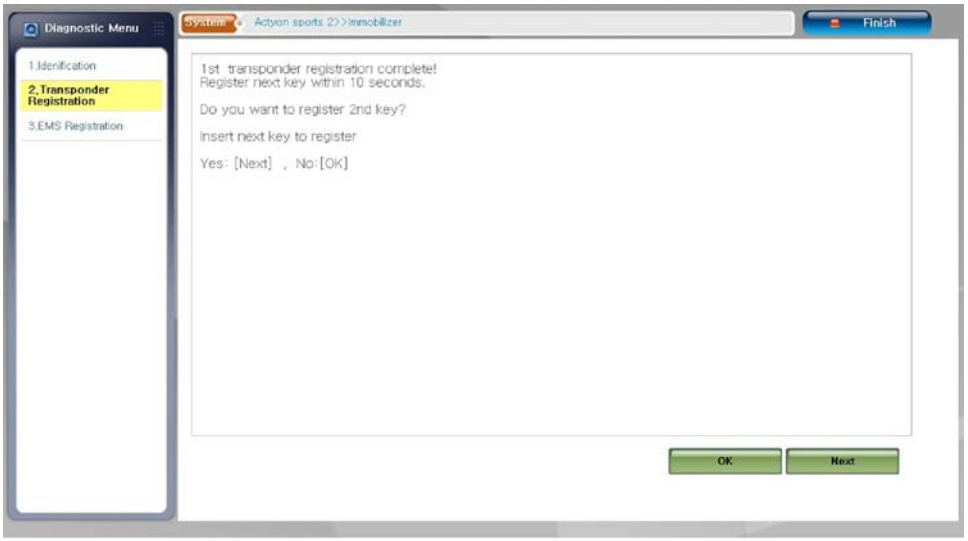
4. Press "Next" with the first key in key box.



5. Check the progress.



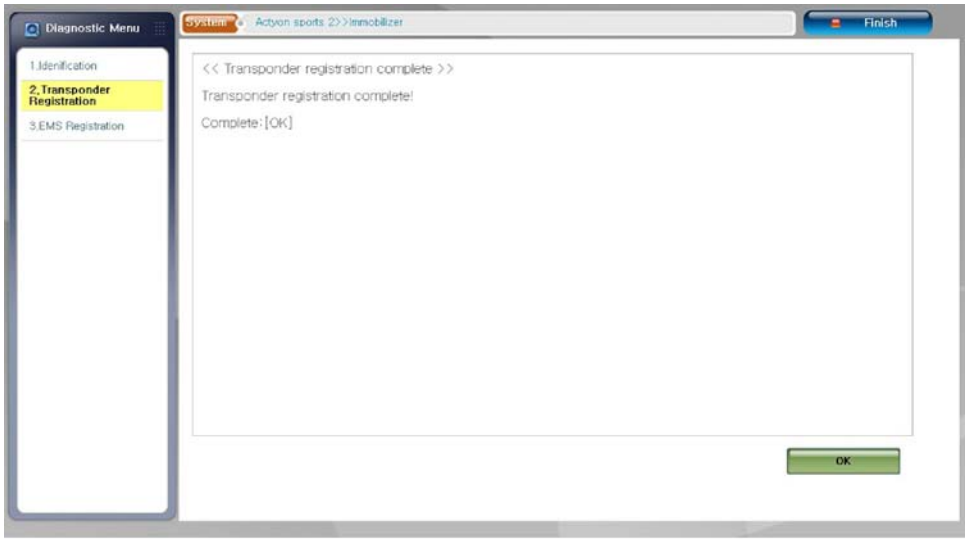
6. If another key should be registered additionally, insert the second key into the key cylinder and press "Next" within 10 seconds since the first transponder coding is complete.



7. Press "OK" button when the registration is complete.

NOTE

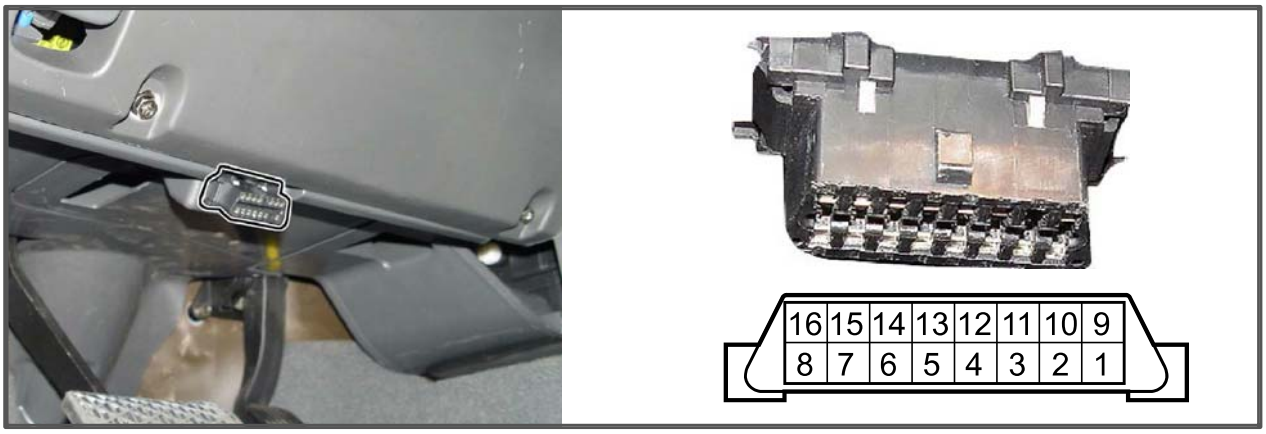
If the registration fails, press "Previous" button and perform the registration procedures again.



6) Pin Arrangement of Diagnostic Connector

Diagnosis connector is installed at the lower driver side instrument panel and it consists of 16 pins.

REKES key coding should be done using the diagnostic device.



▶Fuction For Each Terminal

Pin No.	Function	Pin No.	Function
1	-	9	Air bag
2	-	10	-
3	STICS "C1"	11	TCU(6AT)
4	Ground	12	SSPS Unit
5	Signal ground	13	TCCU
6	CAN - HIGH	14	CAN - LOW
7	GSL ECU	15	STICS "B21"
8	-	16	Battery +

CAUTION

The REKES key coding is not performed by connecting the REKES coding terminal (No. 15) of the diagnostic connector to the jump wire between the ground terminals.
(possible only diagnostic device)

Modification basis	
Application basis	
Affected VIN	

IMMOBILIZER AND RECHARGEABLE KEY

7010-06

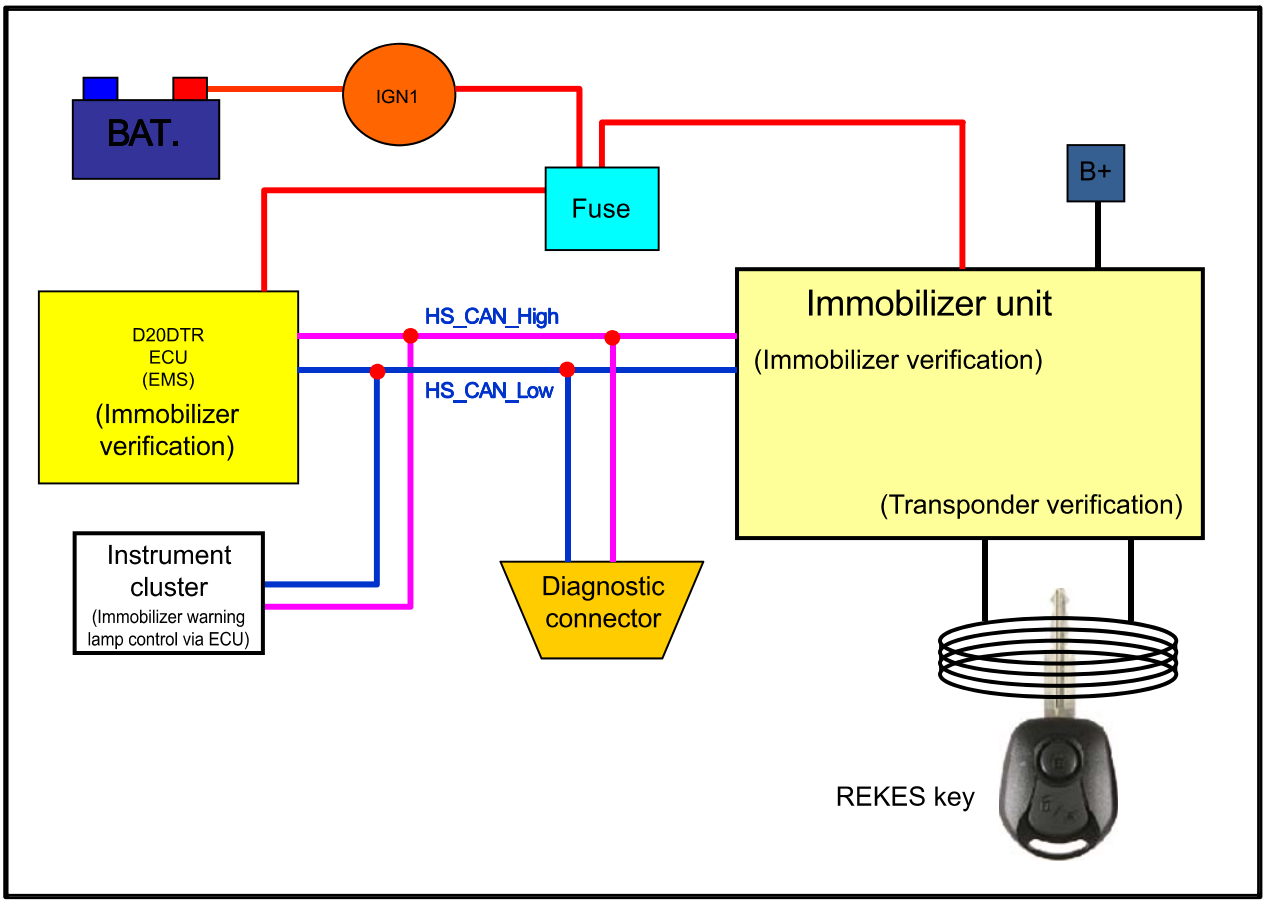
OVERVIEW AND OPERATING PROCESS

1. SYSTEM CONFIGURATION

1) Components and Locations

Modification basis	
Application basis	
Affected VIN	

2) System Diagram



The certification for the immobilizer is performed when turning the ignition switch to the "ON" position after the CAN communication between the ECU and immobilizer is established.

Modification basis	
Application basis	
Affected VIN	

2. OVERVIEW

The Immobilizer System provides an additional theft deterrent to the vehicle in which it is installed and prevents it from being started by unauthorized persons. The transponder integrated in the key and the engine control unit has the same code. When the ignition key with the integrated transponder is turned to the ON position, the ECU (Engine Control Unit) checks the crypto code of the key and, if correct, allows your vehicle to start the engine.

▶ **RKSTICS Key**

Item	Front view	Rear view	Internal structure
RKSTICS key			

3. FUNCTIONS OF IMMOBILIZER

The functions of the immobilizer are similar to that of the normal REKES key. But, there are the immobilizer function that permits the engine to start only after confirming the encrypted coding. The followings are common functions of the normal REKES key and the immobilizer.

Door Unlock and Panic Function

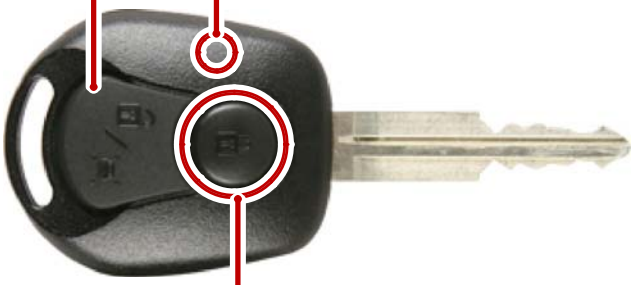
Breifly press (below 0.5 sec): Door unlock and theft deterrent mode deactivated

Press and hold (over 2 sec): Panic function

LED flasher

Briefly press: blink once

Press and hold: blink twice



1. Door unlock (Briefly press)

If you send the door unlock signal using the remote control key, with all the doors locked, the door will be opened and the theft deterrent mode will be deactivated. If the door coupled switch of front room lamp is pressed, the lamp will come on for 30 seconds. It will turn off immediately after the lock button of the remote control is pressed.

2. Panic function: activated in the theft deterrent mode

- When pressing the door UNLOCK and PANIC button for approx. 2 seconds or longer, the warning alarm sounds and the hazard warning lamp blinks for approx. 27 seconds.
- The function is inactivated if any button of remote control is pressed.

Door Lock

Breifly press (below 0.5 sec): Door lock and theft deterrent mode is activated

1. Door unlock (Briefly press)

If you press this button briefly, all doors and the tailgate are locked and the theft deterrent mode is activated.When the theft deterrent mode is activated, the hazard warning flashers blink twice.

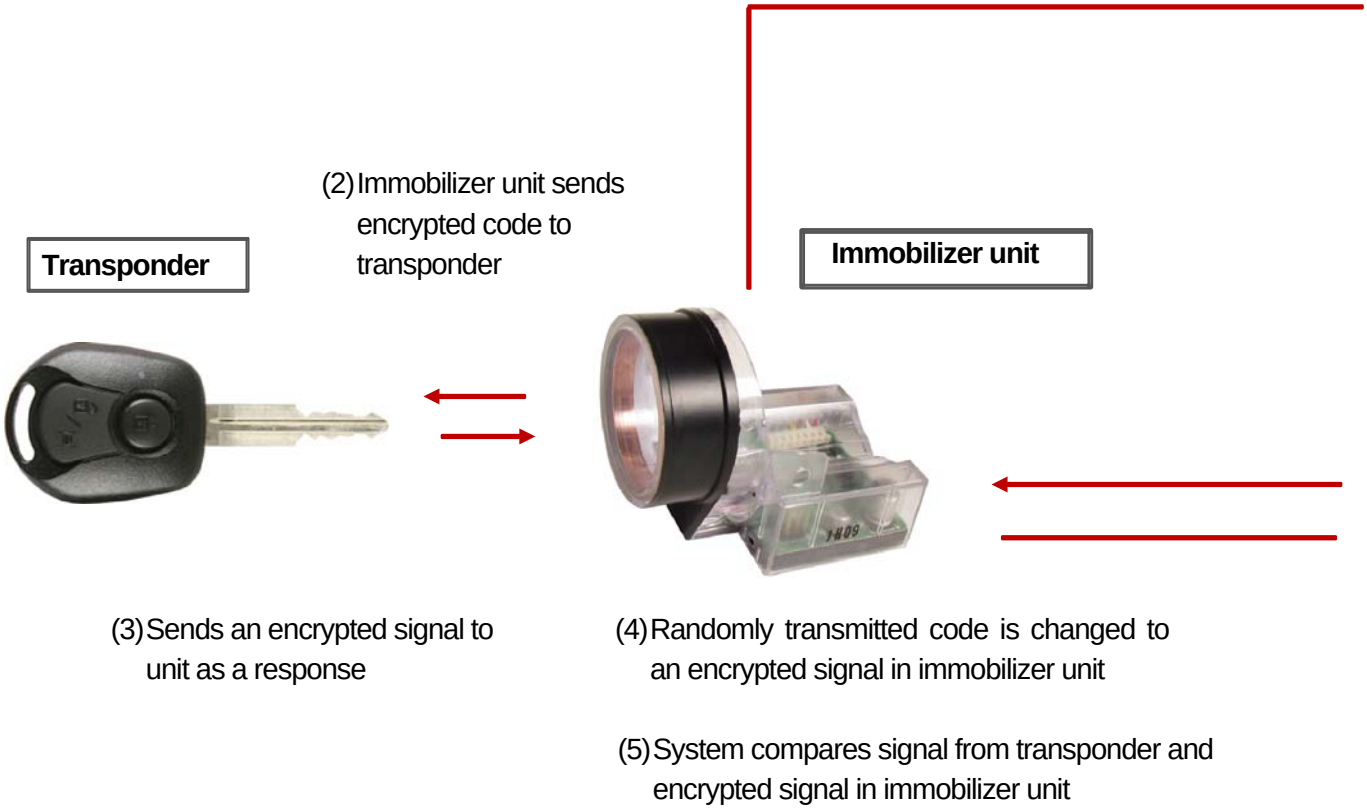
Modification basis	
Application basis	
Affected VIN	

Memo

4. START FUNCTION

1) Immobilizer Function

The immobilizer system prevents the vehicle theft by allowing only the authorized key to start the engine. The transponder inside the key communicates with the immobilizer installed in the key box, and the system permits the engine to start after confirming the encrypted coding from the engine ECU.



CAUTION

For the vehicle with the immobilizer, there can be a problem in starting the vehicle or the system error:

a. When two or more immobilizer keys come into contact with (each) other(s).
b. When the key is close to any device sending or receiving electromagnetic fields or waves other than Ssangyong products.
c. When the key is close to any electronic or electric devices such as lighting equipment, security keys or security cards.
d. When the key is close to a magnetic or metal object or a battery.

Modification basis	
Application basis	
Affected VIN	

▶ Immobilizer and Warning Lamp

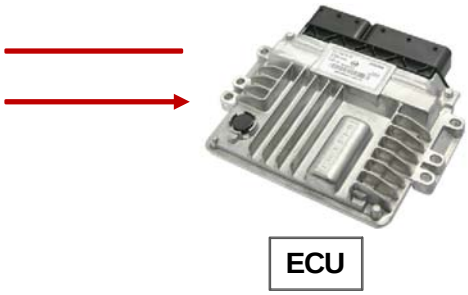
(1) When turning the ignition key to the "ON" position, the ECU (engine control unit) transmits the challenge message to the immobilizer unit. (This is to verify whether the key is valid. If the verification fails, it transmits re-verification signals 3 times for 2 seconds. If three re-verifications fail, it stops verification and starts re-verification after 10 seconds.)

This indicator comes on when the ignition key is communicating with the engine control unit (during engine starting) and goes out after starting the engine.

ON: In communication

Blinks twice at one second intervals: Immobilizer system fault
Blinks once at 2 second intervals: Immobilizer unit not coded

CAUTION
The immobilizer indicator does not come on if the communication time between immobilizer key and ECU is too short.

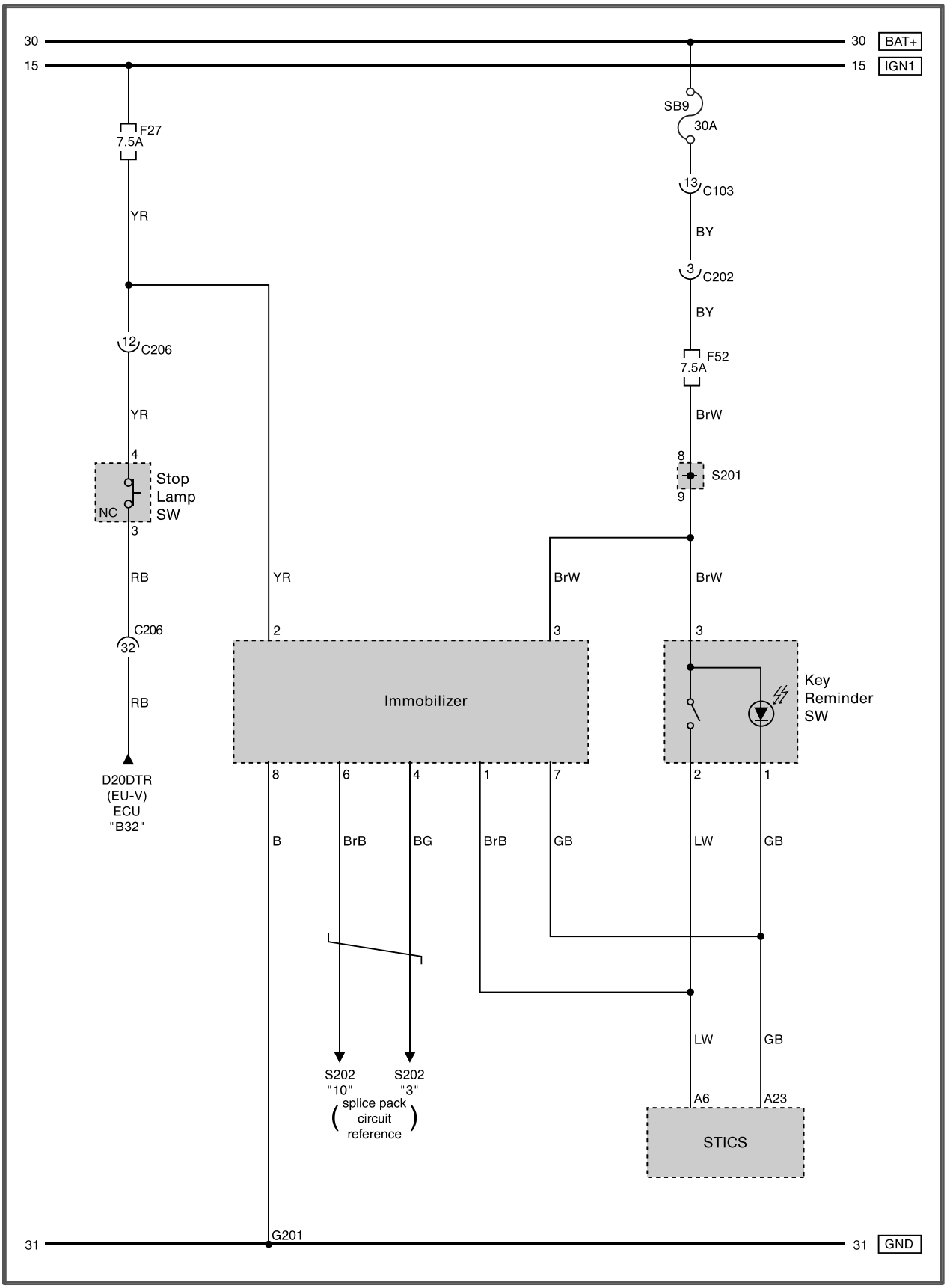


(6) Only when the two signals are identical, it recognizes the key as the authorized one and transmits the positive message to the ECU.

(7) The ECU enable the engine to be started.

CAUTION
- Do not drop or shock to the transponder in the key as it may be damaged.
- With a damaged transponder, the engine cannot be started.
- When you erase the code or register an extra key, please attend on the site.
- In any cases, the immobilizer system can not be removed from the vehicle. If you attempt to remove it and damage the system, starting will be impossible, so never attempt to remove, damage or modify it.
- The remote engine starter cannot be installed to the vehicle equipped with the immobilizer system.

3) Circuit Diagram

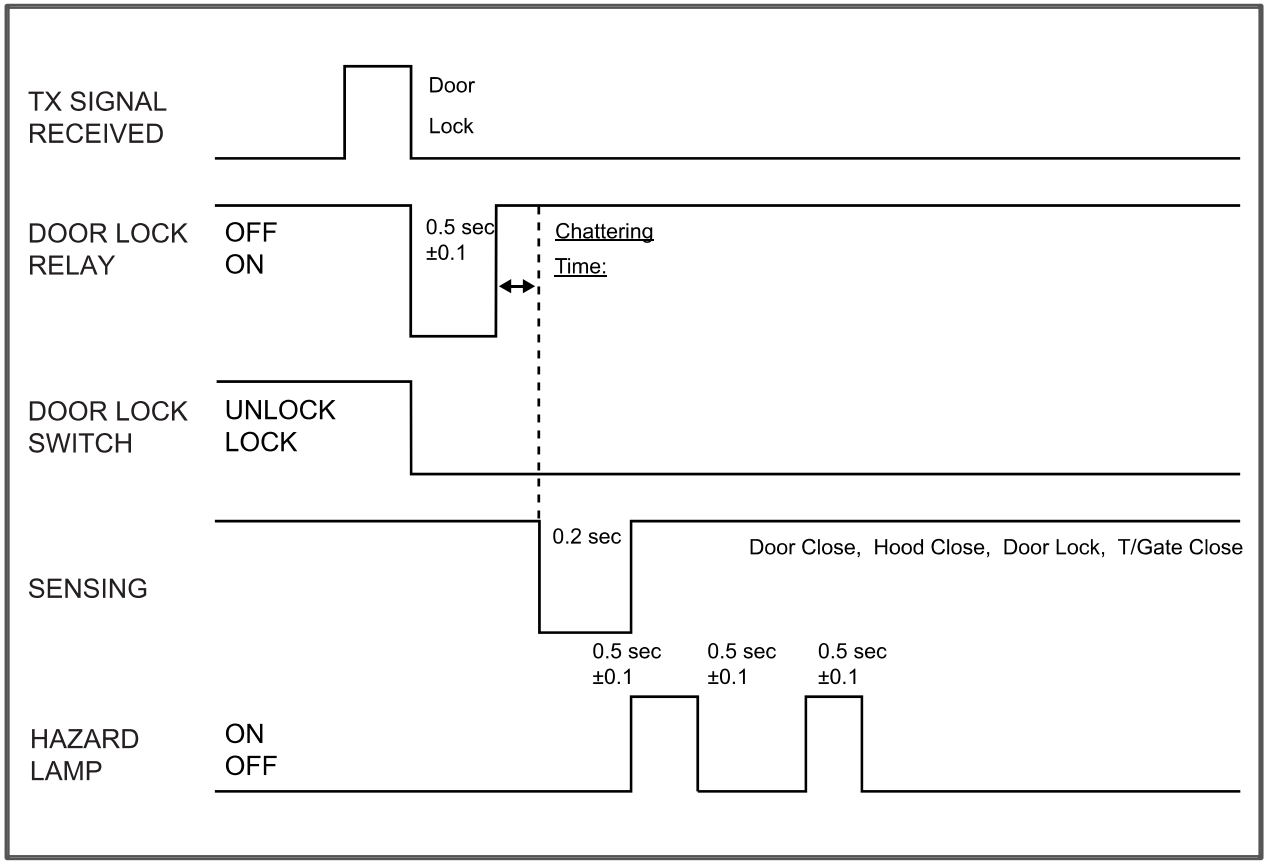


Modification basis	
Application basis	
Affected VIN	

5. REKES OPERATION LOGIC

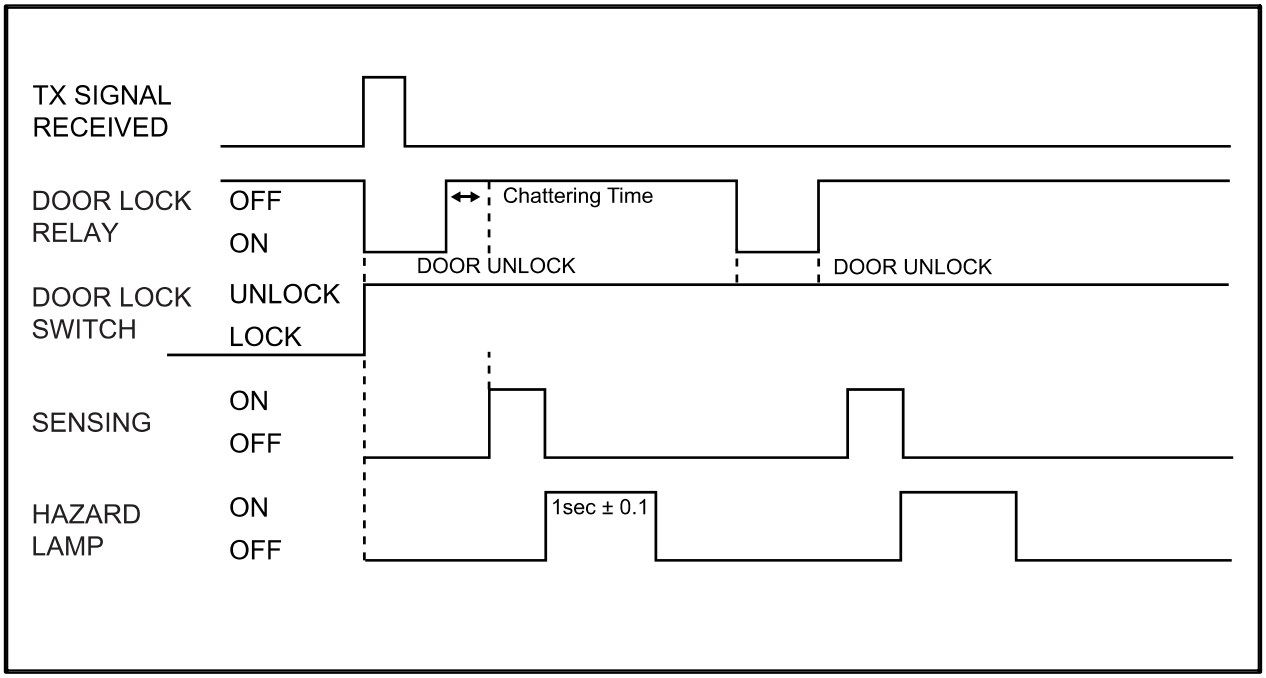
1) Remote Door Lock

1. When briefly pressing the door lock switch on the remote control key for less than 0.5 seconds, all doors are locked.
2. The system outputs the "LOCK" signal immediately after receiving the door lock message from the remote control key. If the vehicle is locked while all doors including engine hood are closed, the theft deterrent mode is activated (hazard warning lamps are blinking twice).



2) Door Unlock

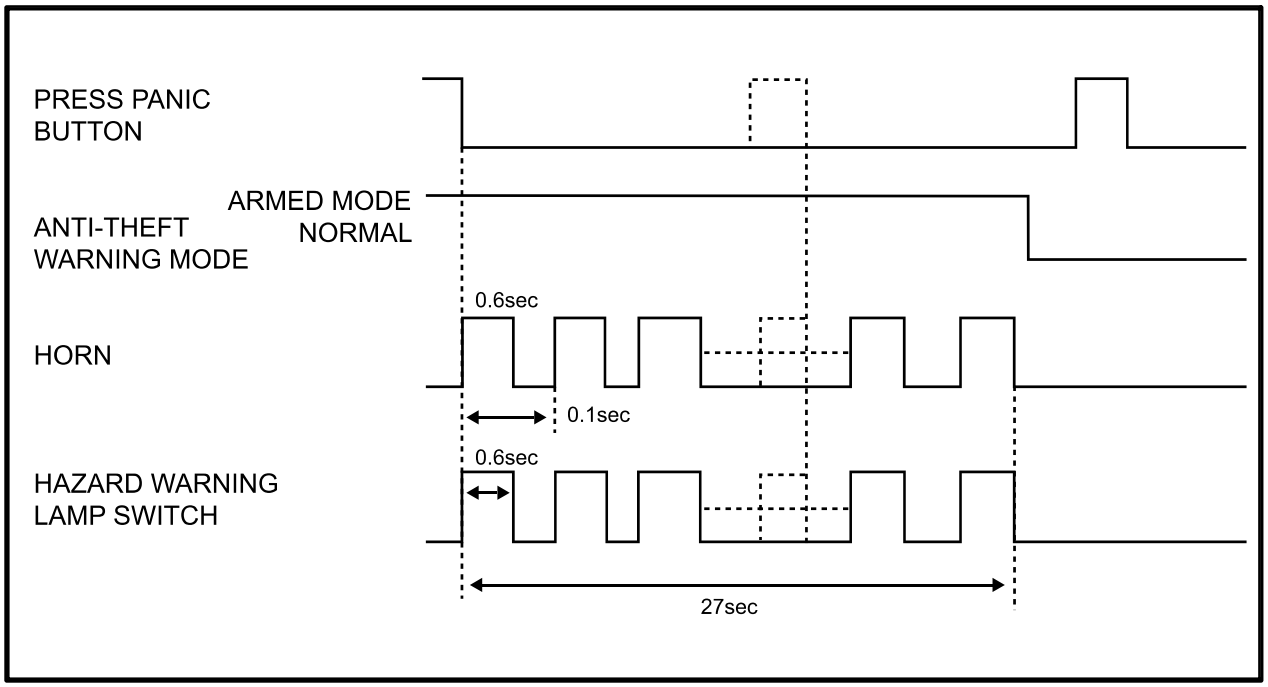
1. When briefly pressing the door unlock switch on the remote control key for less than 0.5 seconds, all doors are unlocked.
2. When receiving the DOOR UNLOCK message from the remote control key, the door unlock relay is turned on for 0.5 seconds.
3. The hazard warning lamps blink once only when all the doors unlocked successfuly.



Modification basis	
Application basis	
Affected VIN	

3) Remote Panic

1. When pressing and holding the PANIC button on the remote control key for more than 2 seconds, the panic function is activated.
2. The vehicle activates the panic alarm by using the horn for 27 seconds when receiving the panic message from the remote control key.



CLUSTER

8010-01

GENERAL INFORMATION

1. SPECIFICATIONS

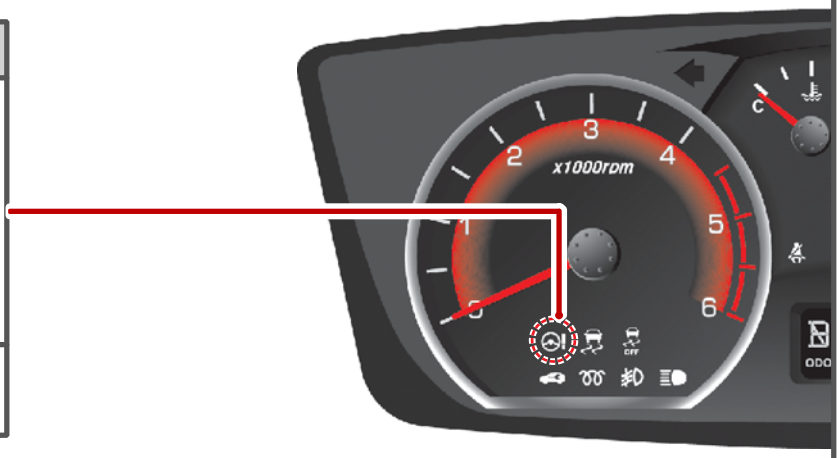
Item		Specification
Rated voltage		DC 13.5 V
Operating voltage		DC 9 V ~ 16 V
Checking voltage		DC 13.5 V
Operating temperature		−30℃ ~ +80℃
Storage temperature		−40℃ ~ +85℃
Illumination color	Dial	White
	Pointer	Red
	LCD	Red
Displays on Instrument Cluster	Warning and indicator lamp	1 blue indicator
		13 red indicators
		7 green indicators
		8 yellow indicators
	Gauge	Vehicle speed
		Fuel level
		Engine coolant temperature
		Engine speed (rpm)
	LCD display	Driving distance
		Trip meter
		Gear position display
Gear position display in A/T(Left hand of LCD display)	A/T vehicle	P, R, N, D, 1, 2, 3, 4, 5, 6
	M/T vehicle	R

2. MAJOR CHANGES

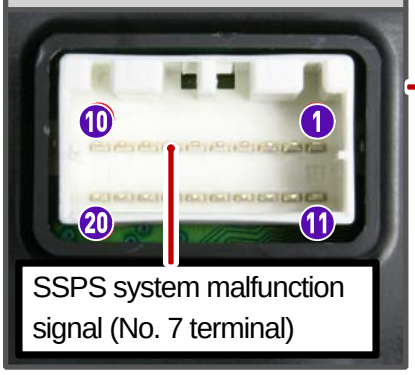
SSPS system-specific information reflected to instrument cluster

SSPS warning lamp

Comes on when fault occurs in SSPS system



Sub-connector



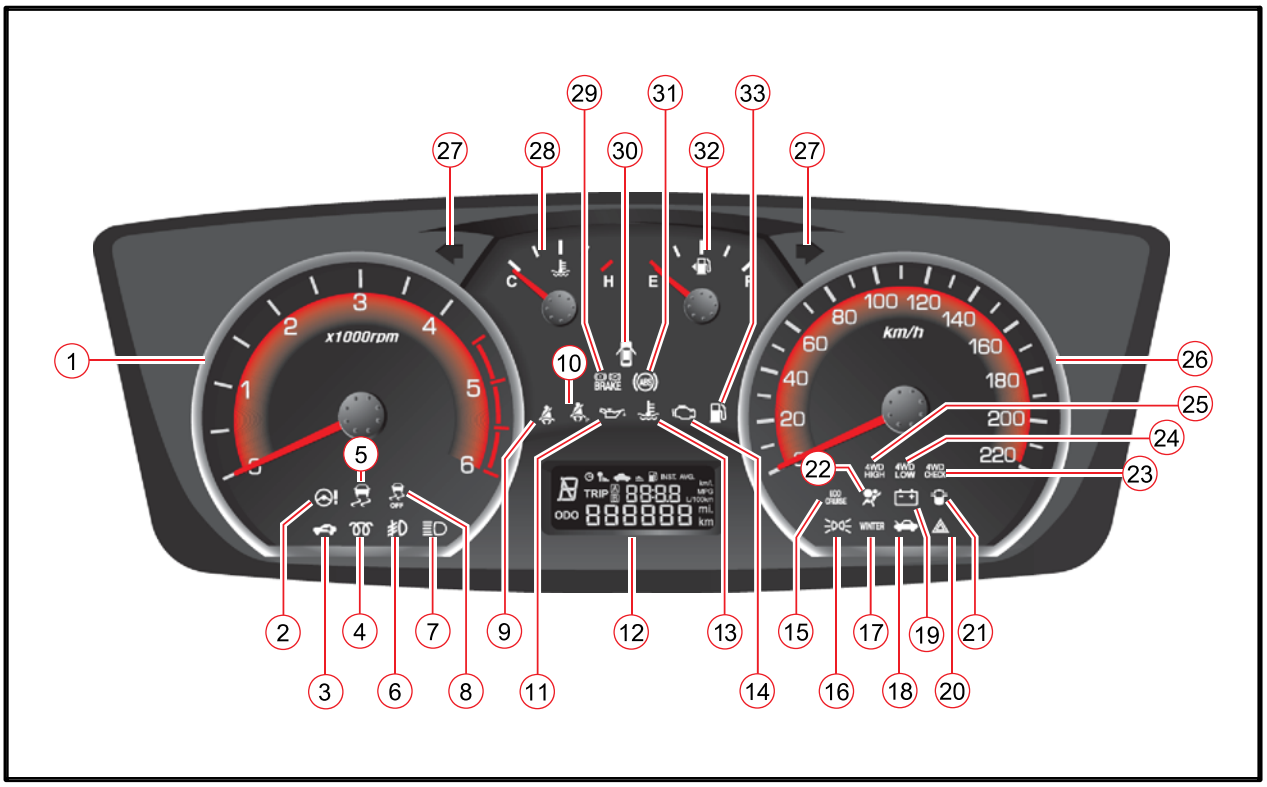
- SSPS warning lamp (red) added to lower left corner of the instrument cluster due to introducing of SSPS (Speed Sensing Power Steering) system
- No. 7 terminal (SSPS system malfunction signal) added to sub-connector at rear of instrument cluster

Modification basis	
Application basis	
Affected VIN	

OVERVIEW AND OPERATING PROCESS

1. DESCRIPTIONS OF INDICATOR DISPLAY

It sends and receives information to/from each unit through CAN communication line. The LCD display and separate ESP ON/OFF indicator are newly added.



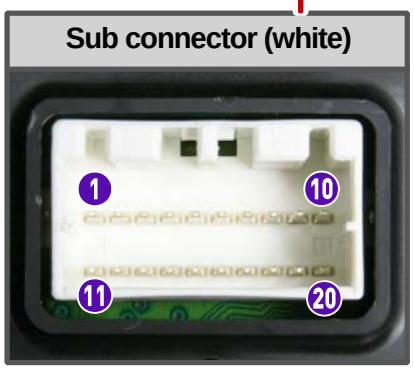
1. Tachometer
2. SSPS warning light
3. Immobilizer indicator
4. Glow indicator
5. ESP indicator/warning light
6. Front fog light indicator
7. High beam indicator
8. ESP OFF indicator
9. Seat belt reminder (driver's seat)
10. Seat belt reminder (passenger's seat)
11. Engine oil pressure warning light
12. LCD Display
13. Engine overheat warning light
14. Engine check warning light
15. Auto cruise indicator
16. Light indicator
17. Winter mode indicator
18. Engine hood open warning light
19. Battery charge warning light
20. Hazard Indicator
21. Water separator warning light
22. Air bag warning light
23. 4WD CHECK warning light
24. 4WD LOW indicator
25. 4WD HIGH indicator
26. Speedometer
27. Turn signal indicator
28. Coolant temperature gauge
29. Brake warning light
30. Door ajar warning light
31. ABS warning light
32. Fuel gauge
33. Low fuel level warning light

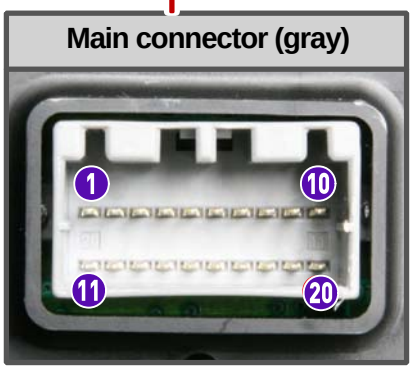
Modification basis	
Application basis	
Affected VIN	

▶ System Layout

Front view

Rear view



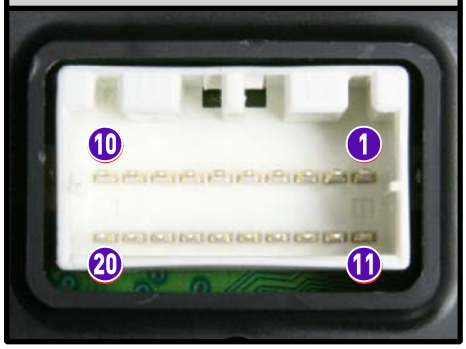


Modification basis	
Application basis	
Affected VIN	

▶ Connector Pin Arrangement

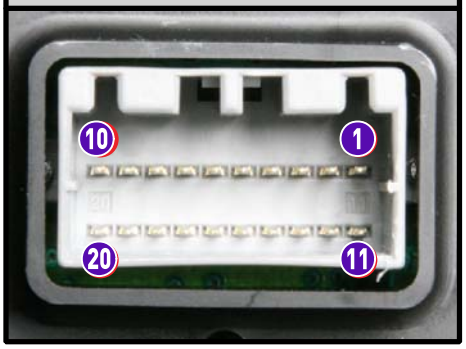
The connector pin sections illustrated below are viewed from the front of the instrument cluster. The arrangement of the pins is the same for both the main connector and the sub connector.

Sub connector - 20-pin (white)



1. IGN2+
2. CHARGE(ALT)
3. -
4. HAZARD
5. FRONT FOG
6. -
7. SSPS
8. PASSENGER SEATBELT
9. HOOD OPEN
10. -
11. -
12. PARKING BRAKE INPUT
13. OIL PRESSURE
14. TURN LEFT
15. HIGH BEAM+
16. TURN RIGHT
17. HIGH BEAM-
18. DRIVER SEATBELT
19. AIRBAG
20. -

Main connector - 20-pin (gray)



1. B+
2. -
3. DOOR OPEN
4. CHECK ENGIN (GSL ONLY)
5. -
6. ILL+
7. BUZZER OUTPUT
8. 4P OUTPUT
9. -
10. -
11. IGN1+
12. GND
13. FUEL GND
14. CAN HIGH
15. CAN LOW
16. MT R INPUT
17. MT N INPUT
18. RESET/MODE SW
19. FUEL INPUT
20. -

▶ **Indicators on Instrument Cluster**

No.	Symbol	Item	Power	Turning ON condition
1		Turn signal lamp-L	Multifunction switch	When activating switch
2		Turn signal lamp-R	Multifunction switch	When activating switch
3		4WD HIGH indicator	IGN	IGN ON/ CAN signal input
4		Winter mode indicator	IGN	IGN ON/ CAN signal input
5		Front fog lamp indicator	Fog lamp relay	When activating switch
6		Cruise control indicator	IGN	IGN ON/ CAN signal input
7		Light illumination indicator	BATT	Tail lamp ON
8		High beam indicator	Headlamp high beam relay	When activating switch
9		ABS warning lamp	IGN	IGN ON/ CAN signal input (ABS, EBD)
10		Glow indicator	IGN	IGN ON/ CAN signal input
11		Immobilizer indicator	IGN	IGN ON/ CAN signal input
12		Low fuel level warnig light	IGN	When analog inputting fuel level

Modification basis	
Application basis	
Affected VIN	

No.	Symbol	Item	Power	Turning ON condition
13		Engine check warning lamp	IGN	IGN ON/ CAN signal input
14		4WD LOW indicator	IGN	IGN ON/ CAN signal input
15		ESP indicator/ warning light	IGN	IGN ON/ CAN signal input (ESP & buzzer activated)
16		ESP OFF indicator	IGN	IGN ON/ CAN signal input
17		Brake warning light	IGN	IGN ON, CAN signal input (EBD)
18		4WD CHECK indicator	IGN	IGN ON/ CAN signal input
19		Air bag warning lamp	IGN	Signal input
20		Door ajar waning light	BATT	When door opened
21		Charge warning lamp	IGN	Charge system fault
22		Seat belt warning light (driver)	IGN	Switch input
23		Seat belt warning light (passenger)	IGN	Switch input

No.	Symbol	Item	Power	Turning ON condition
24		Engine oil pressure warning lamp	IGN	Signal input
25		Water separator warning light	IGN	IGN ON/ CAN signal input
26		Engine coolant overheat warning light	IGN	IGN ON/ CAN signal input
27		Engine hood open warning lamp	IGN	Switch ground
28		EBD warning light	IGN	CAN signal input
29		SSPS warning lamp	IGN	Digital input
30		Hazard warning lamp	IGN	Switch to High

Modification basis	
Application basis	
Affected VIN	

2. CONFIGURATION

1) RPM Gauge

The tachometer indicates engine speed in revolutions per minute. Multiply 1,000 to the current number, then it will be the current number of engine revolutions.

Under the normal engine operating temperature, the proper idling speed is 700 ~ 800 rpm. The red zone (danger rpm range) starts from 4,500 rpm.

1. Connect the tachometer for tune-up test and start the engine.
2. Eliminate the hysteresis by tapping the tachometer.
3. Compare the values on the tester and tachometer and replace the tachometer if the tolerance is excessive.

Description		Specification (VIN=13.5 ± 0.1V, Temperature: 25°C)							
Engine speed (rpm)		750	1000	2000	3000	4000	5000	6000	7000
Tolerance (rpm)	DSL	+50 -100	±100	±100	±100	±100	±100	-	-
	GSL	+50 -100	±100	±100	±100	±100	±100	±100	±100

Check Method

If the tachometer (engine rpm gauge) pointer vibrates or stops moving at a certain range, or abnormal noises are heard from the tachometer, the tachometer may have a malfunction. If you have reason to suspect that the reading from the tachometer differs from the actual engine speed (rpm), connect a diagnostic device and compare the value on tachometer with the reading from the diagnostic device.

2) Speedometer Gauge

The speedometer indicates the vehicle speed by calculating the signals from the rear left and rear right wheel speed sensors through ABS or ESP unit. (For the vehicle without ABS or ESP, the signals are received from the EMS)

If the speedometer gauge vibrates, stops at a certain range or makes an abnormal noise, there could be defectives in speedometer. **However, these symptoms also could be occured when the tire has uneven wear, different tire inflation pressures or different tire specifications.**

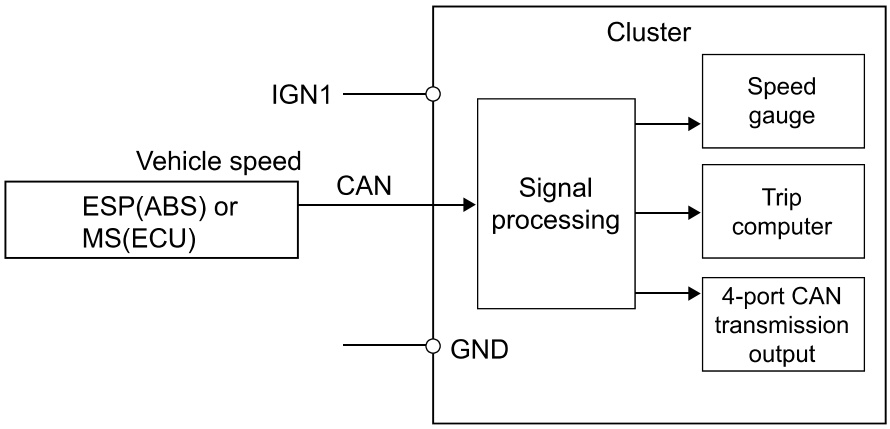
Perform the speedometer test regarding the tolerance as described. However, it is not similar simple work in field due to lack of measuring conditions such as test equipment and preciseness.

1. Check the allowable tolerance of the speedometer and operations of the trip odometer by using a tester.
2. Check if the speedometer pointer is shaking and the abnormal noise sounds.
3. Eliminate the hysteresis by tapping the speedometer.

Description	Specification (VIN=13.5 ± 0.1V, Temperature: 25°C)										
Engine speed (rpm)	20	40	(60)	80	100	120	140	(160)	(180)	200	220
Tolerance (rpm)	+4	+4	+7	+9	+10.5	+12.5	+14.5	+16	+18	+18	-
	0	0	+2.5	+3.5	+4	+6	+7.5	+8.5	+10	+10	-
Tolerance (mph)	+3.0	+4.5	+6.5	+8.0	+9.5	+11.0	-				
	+0.5	+1.0	+2.0	+3.0	+4.0	+5.0	-				

Modification basis	
Application basis	
Affected VIN	

▶ Speed Input from ESP(ABS) or MS(ECU)

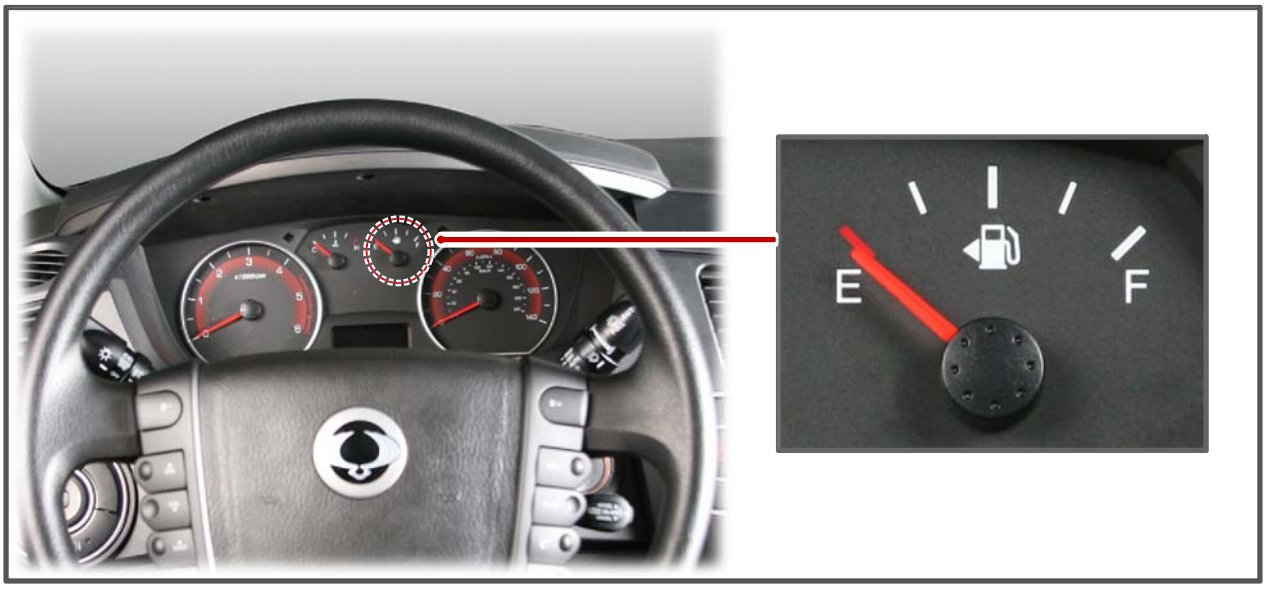


Input/Output Diagram

CAUTION

The allowable tolerance increases when the tires are worn or the tire pressure is out of specified range.

3) Fuel Level Gauge



The fuel level gauge displays the resistance value of the float on the fuel sender in the fuel tank through a pointer. Note that this vehicle doesn't have a service hole for checking the fuel sender connector in the fuel tank.

The fuel sender and its connector can be checked and replaced only when the fuel tank is removed. The power supply and resistance value should be measured at the connector in front of the fuel sender (refer to wiring diagram).

When the power supply and output resistance are normal, the float operation by fuel level may be defective; if so, replace the fuel sender.

Item	Tolerance and resistance value by indicating angle (VIN = 13.5 ± 0.1 V, temperature: 25°C)								
Scale	Full	Full (Gauge)	(3/4)	1/2	(1/4)	LFW		Empty (Gauge)	Empty
						GSL	DSL		
Indicating angle (°)	-	90	67.5	45	22.5	3.0	3.0	0	-
Tolerance (°)	-	+4, 0	-	±5	-	-	-	0, -4.0	-
Resistance (Ω)	38	43	67	99.5	150	260	268	276.3	283
Fuel (ℓ)	75.0	73.0	56.0	39.0	22.0	11.5	9.0	5.0	4.0

CAUTION

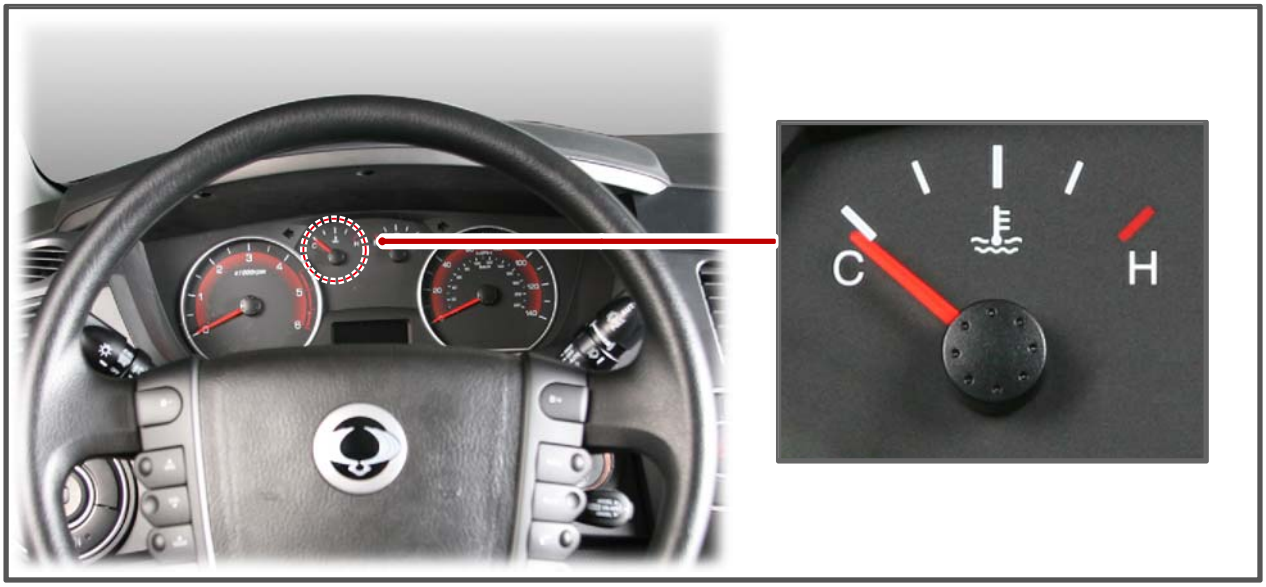
This table shows the tolerance and resistance value changes by fuel level in normal conditions. Therefore, the differences that can be occurred by the road conditions and fuel fluctuations are ignored.

Low fuel warning lamp comes on when:

The fuel level drops to 9 L or less. The lamp goes off if the fuel level reaches 9.5 L or more.

Modification basis	
Application basis	
Affected VIN	

4) Coolant Temperature Gauge



The coolant temperature gauge displays the coolant temperature with a pointer. The angle of pointer that changes by coolant temperature is as shown below.

Item		Specification (VIN=13.5 ± 0.1V, Temperature: 25°C)				
Coolant temperature	Less than 40°C	DSL	GSL	110°C	120°C	Over 125°C
		70°C	80°C			
Indicating angle (°)	-	45			90	-
Tolerance	+0°C -4°C	+0°C -4°C			-	+4°C +0°C

Measurement of coolant temperature sensor resistance

Measure the resistance between the terminal and the ground with an ohmmeter and replace if the resistance is out of specified range.

Temperature (ºC)	20	60	80	100	120
Resistance (Ω)	2449Ω ± 5%	589.4kΩ ± 5%	321Ω ± 5%	185.7kΩ ± 5%	112.9kΩ ± 5%
Voltage (V)	3.615	1.910	1.259	0.819	0.536

CAUTION

When the resistance value by coolant temperature is within the specified range, check thermostat, water pump, radiator related coolant circuit for normal operation. Also, check the wiring harnesses and connectors for proper connection.

5) Description for LCD Display

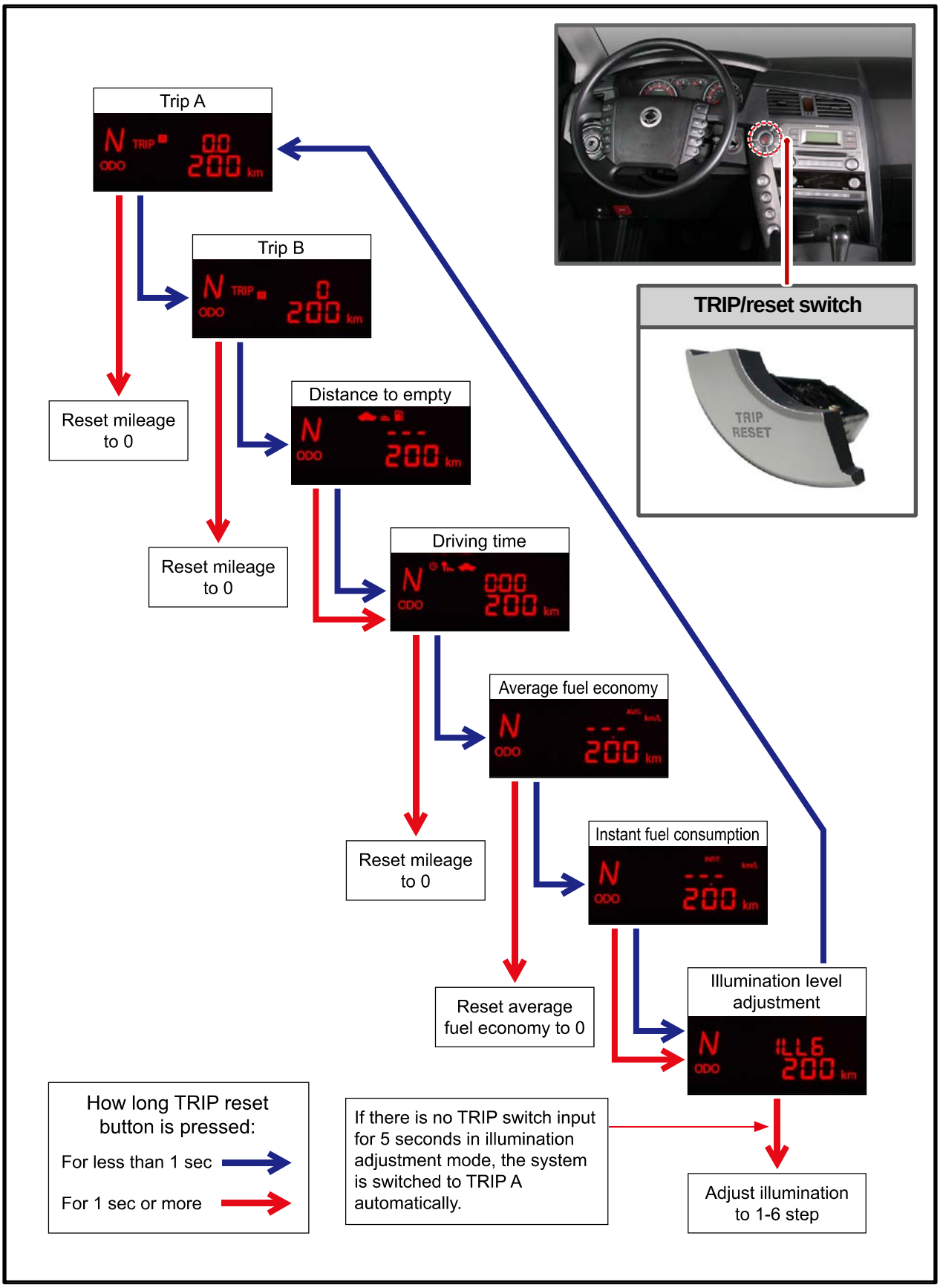
▶ **Mode Description**

Change Order	Mode	LCD Display	Description
1	TRIP A		The maximum distance value that can be displayed is 999.9 km with increments of 0.1 km. The trip meter is reset to 0.0 km when the value reaches above 999.9 km. When measuring a trip distance, reset the distance value in the mode you want to use by pressing the TRIP switch for 1 sec. or more.
2	TRIP B		The maximum distance value that can be displayed is 6,213.09 mi with increments of 0.62mi. The trip meter is reset to 0.0 km when the value reaches above 999.9 km. When measuring a trip distance, reset the distance value in the mode you want to use by pressing the TRIP switch for 1 sec. or more.
3	Distance to empty		The estimated distance that can be traveled is calculated based on the current fuel level. If the DTE is less than 50 km, "---" flashes on the display.
4	Driving time		The driving time from resetting the value (0:00) until now is displayed. The value displayed is accumulated while the engine is running even if the vehicle is not driven. The display range is 00:00 to 99:59. When measuring the driving time, press the TRIP switch for 1 sec. or more to reset the value.
5	Average fuel economy		The average fuel economy from resetting the value (--.-) until now is displayed. The value displayed is accumulated while the engine is running even if the vehicle is not driven. The display range is 0.0 to 99.9 km/h. When measuring the average fuel economy, press the TRIP switch for 1 sec. or more to reset the value. "--.-" is displayed on the screen when resetting. The value is reset automatically whenever the vehicle is fuelled.

Modification basis	
Application basis	
Affected VIN	

Change Order	Mode	LCD Display	Description
6	Instant fuel consumption		The fuel range is calculated based on the distance driven and fuel consumed every 2 seconds. If the vehicle speed is below 10 km/h or the engine rpm is 200 rpm or less, the instant fuel economy is not displayed. The display range is 0.0 to 99.9 km/.
7	Brightness adjustment		The brightness of the illumination can be adjusted in 6 steps by pressing the TRIP switch briefly (less than 1 sec.). The display is changed from ILL1 to ILL6 every time the switch is pressed. If you select one level within the range and press and hold the TRIP switch, the brightness level is memorized. If there is no TRIP switch input for 5 seconds or more, the mode is switched to TRIP A mode automatically. When the battery is reinstalled, the brightness level is reset to level 4.

▶ Shifting Mode



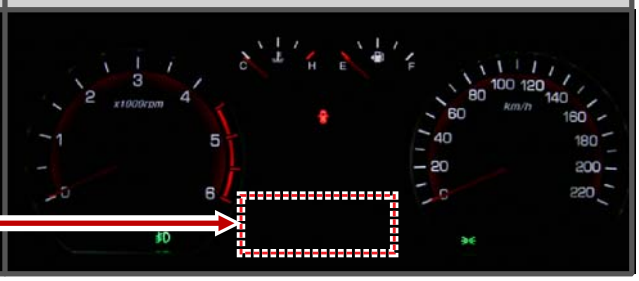
Modification basis	
Application basis	
Affected VIN	

▶ Brightness of LCD display when turning ON/OFF tail lamp

Sequence	Level	Tail lamp OFF		Tail lamp ON	
		Display brightness	Brightness ratio	Display brightness	Brightness ratio
1	ILL1		25%		5%
2	ILL2		40%		9% (LCD: 12%)
3	ILL3		55%		13% (LCD: 19%)
4	ILL4		70%		17% (LCD: 26%)
5	ILL5		85%		21% (LCD: 33%)
6	ILL6		100%		25% (LCD: 40%)

▶ Illumination conditions of LCD display when turning ON/OFF tail lamp

The illumination for the LCD display comes on when turning on the tail lamp and is adjustable only when the ignition is ON. When turning on the tail lamp switch with the ignition OFF, the tail lamp comes on but the LCD display is not illuminated. Refer to the illustration below.

IGN ON (Comes on regardless of whether the tail lamp switch is turned ON or OFF)	Tail lamp comes on with IGN OFF (Tail lamp comes on but the illumination for LCD display is not turned on)
	

3. WARNING LIGHTS AND INDICATORS

Seat belt warning lamp

The seat belt warning light comes on and the seat belt warning chime sounds for 6 seconds when the ignition switch is turned to "ON" position unless the driver's seat belt is securely fastened. This reminding operation stops when the driver fastens the seat belt.

Brake warning light

This warning light comes on and warning buzzer sounds when the parking brake is applied and/or the brake fluid level is lower than specified level.

Door ajar warning light

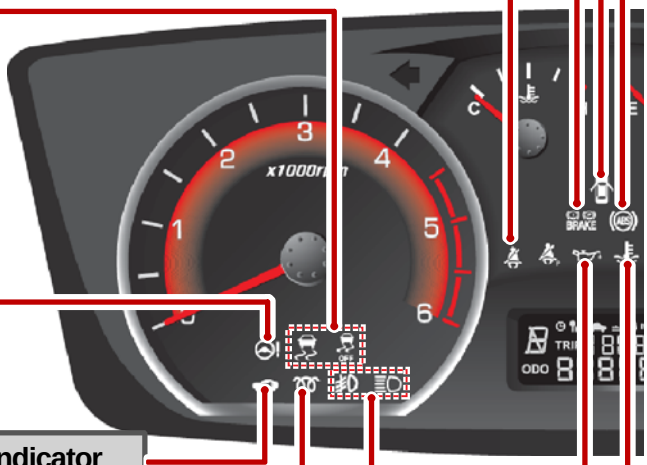
This light comes on when a door or tailgate is either opened or not closed completely.

ESP OFF Indicator

This lamp comes on when pressing the "ESP OFF" switch or the ESP system is defective. When the ESP system is activated, this lamp blinks and a chime sounds.

SSPS warning light

This warning light comes on when the SSPS system is defective. When this warning light comes on, the steerability becomes heavier.



Glow Indicator

When the ignition key is turned ON, this indicator lamp comes on and the combustion chamber is warmed up. In the vehicle equipped with direct injection type engine, this indicator may come on very shortly or may not come on.

Immobilizer Indicator

This indicator comes on when the ignition key is communicating with the engine control unit for approx. 0.5 seconds.

Fog Lamp / Headlamp High Beam Indicator

This lamp comes on when the fog lamp or high beam headlamp operates to indicate the operating status.

Engine Oil Pressure Warning Light

This lamp comes on if there is any fault in the engine oil system and goes off when a certain amount of time has elapsed after turning ON the ignition switch.

Engine Coolant Overheat Warning Light

When the coolant temperature is abnormally hot (over 120℃), this warning light blinks and a warning buzzer sounds at 1 Hz. (check cooling system)

Modification basis	
Application basis	
Affected VIN	

ABS Warning Light

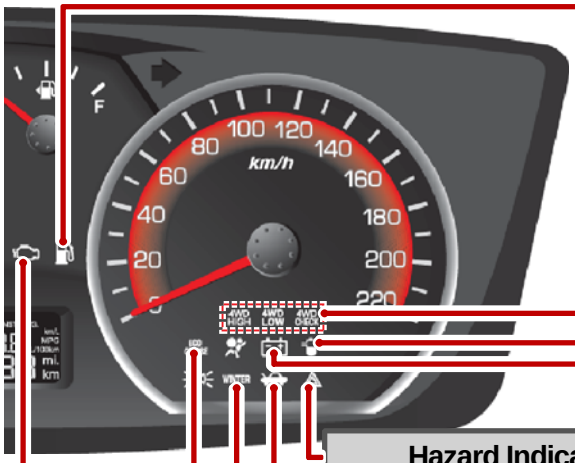
This warning light comes on when the ignition switch is turned to "ON" position and should go out if the system is normal.
The vehicle with ABS performs self-diagnosis. During this diagnosis, brake pedal vibration and noise may be apparent when the driving motors discharges the hydraulic pressure from the internal hydraulic device.

Low Fuel Level Warnig Light

This warning light comes on when the fuel will soon be exhausted. The time it takes turn on, however, varies according to the gradient of the vehicle.

4WD Indicator

- 4WD HIGH Indicator
- The lamp blinks momentarily during the change of driving mode.
- 4WD LOW Indicator
  The lamp blinks momentarily during the change of driving mode.
  4WD CHECK Warning Light
  This indicates that there is something wrong in the transfer case system. (check the system)



Water Separator Warning Light

This lamp comes on to warn the driver of water in the fuel tank which causes the loss of engine power. When a certain amount of water is accumulated, the lamp comes on and a chime sounds.

Charge Warning Light

This warning light comes on when the ignition switch is turned on and go off when the engine is started.
If this light doesn't go off after engine starting, it means there is a malfunction in the system.

Hazard Indicator

This indicator blinks when the hazard warning flashers are switched on.

Engine Hood Open Warning Light

When the engine hood is open, this light comes on to inform the driver.

Engine CHECK Warning Light

This warning light comes on when the ignition switch is turned to "ON" position and should go out if the system related to engine control is normal.
This comes on when different sensors and devices related to engine control are defective.

Auto Cruise Control Indicator

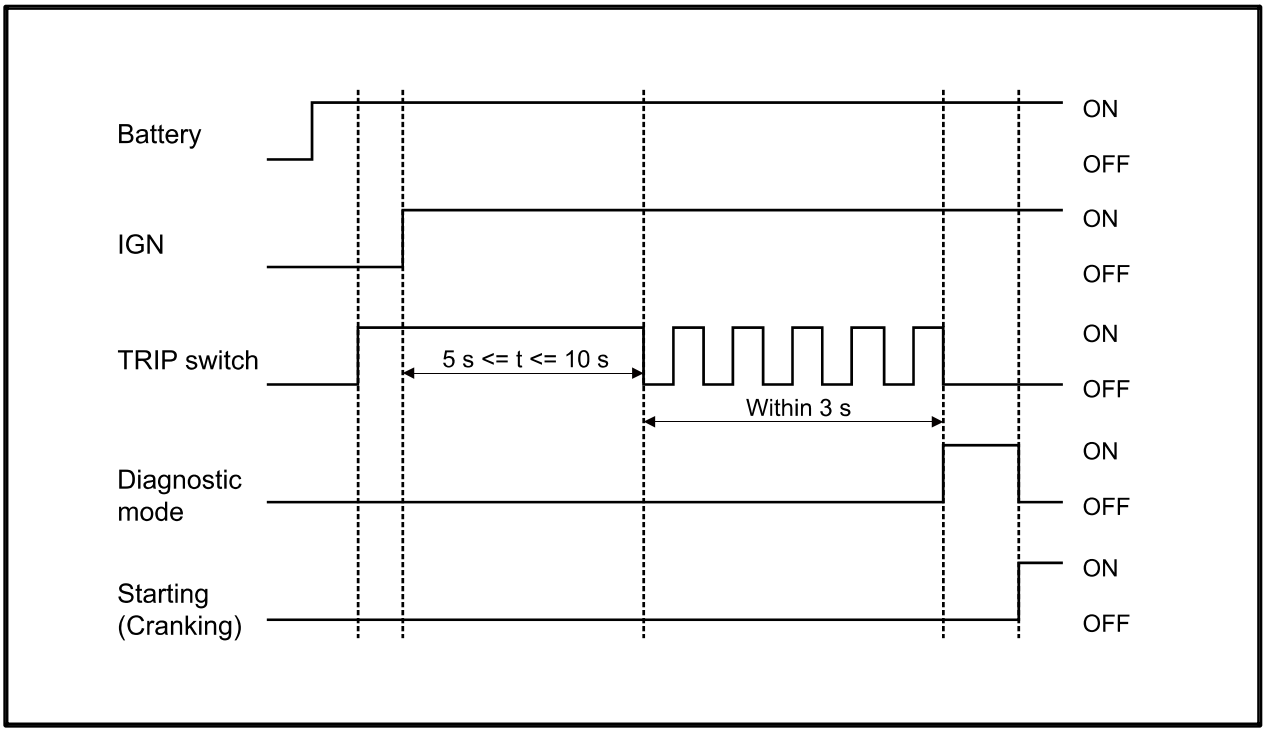
Operating the cruise control switch turns on the indicator lamp to indicate the cruise control system is activated.

Winter Mode Indicator

Pressing the "W" side of the automatic transmission mode selector switch switches the driving mode to winter mode and turns on the indicator lamp.
Use this mode to drive off smoothly on icy and slippery roads.

4. SELF-DIAGNOSIS CHECK

▶ **How to enter self-diagnosis mode**



1. Turn the ignition ON with the TRIP switch pressed.
2. Press and hold the TRIP switch for 5 to 10 sec. with the ignition ON.
3. Press and hold the TRIP switch for less than 10 sec. and then cycle the switch between ON and OFF 5 times within 3 sec.
4. Confirm that the self-diagnosis mode is activated through the instrument cluster.

▶ **Self-diagnosis OFF**

If the engine speed increases to 396 rpm or more while the engine is cranking or the ignition key is turned OFF in self-diagnosis mode, the self-diagnosis mode is turned OFF automatically.

▶ **Operating process**

1. Speed gauge: changes from 0 to 220 km
2. RPM gauge: changes from 0 to 6,000 rpm
3. Fuel gauge: changes from E to F
4. Temperature gauge: changes from C to H
5. Warning/Indicator lamps: All indicator/warning lamps controlled by MICOM are turned ON.
6. Dimming: Illuminates at the highest lighting level.
7. LCD display: All elements are activated.

Modification basis	
Application basis	
Affected VIN	

5. BUZZER OUTPUT

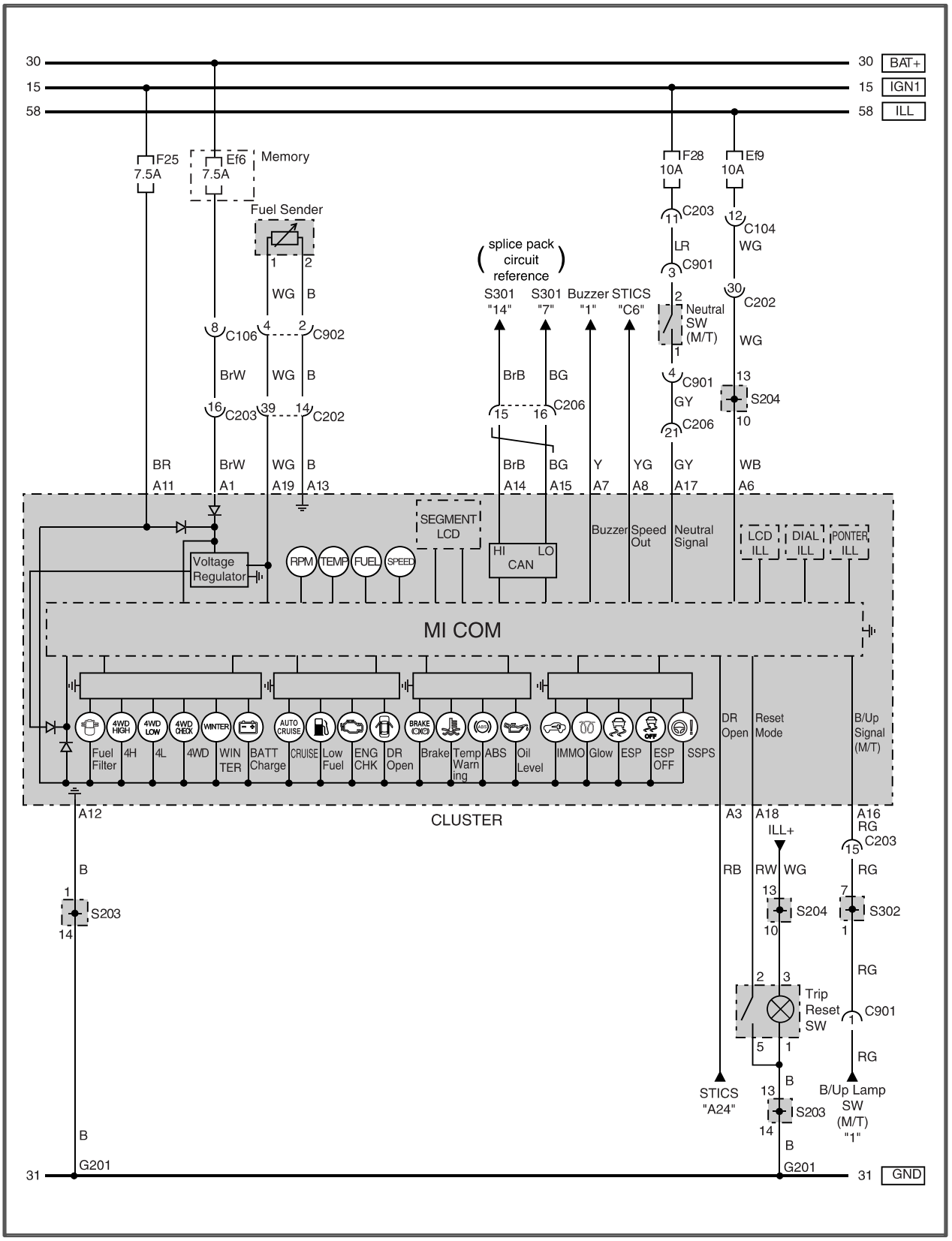
Priority	Item	Buzzer output time		Operating condition
		ON	OFF	
1	"R" PAS buzzer output	75ms	610ms	610msec delay and then generate 75ms buzzer output
2	Overspeed warning	500ms	200ms	Buzzer on when dial indication speed exceeds 120km/h
3	ESP buzzer output	100ms	100ms	Interior buzzer (PAS buzzer) ON
4	TEMP warning output	500ms	500ms	Engine overheats
5	Fuel filter	500ms	500ms	Water separator warning light ON with IGN ON

NOTE

- If the signal with higher priority is activated during the operation of signal with lower priority, the current operation should be completed before starting the operation with higher priority.
- If there are multiple signals at a time, the operation should be completed in order of priority.

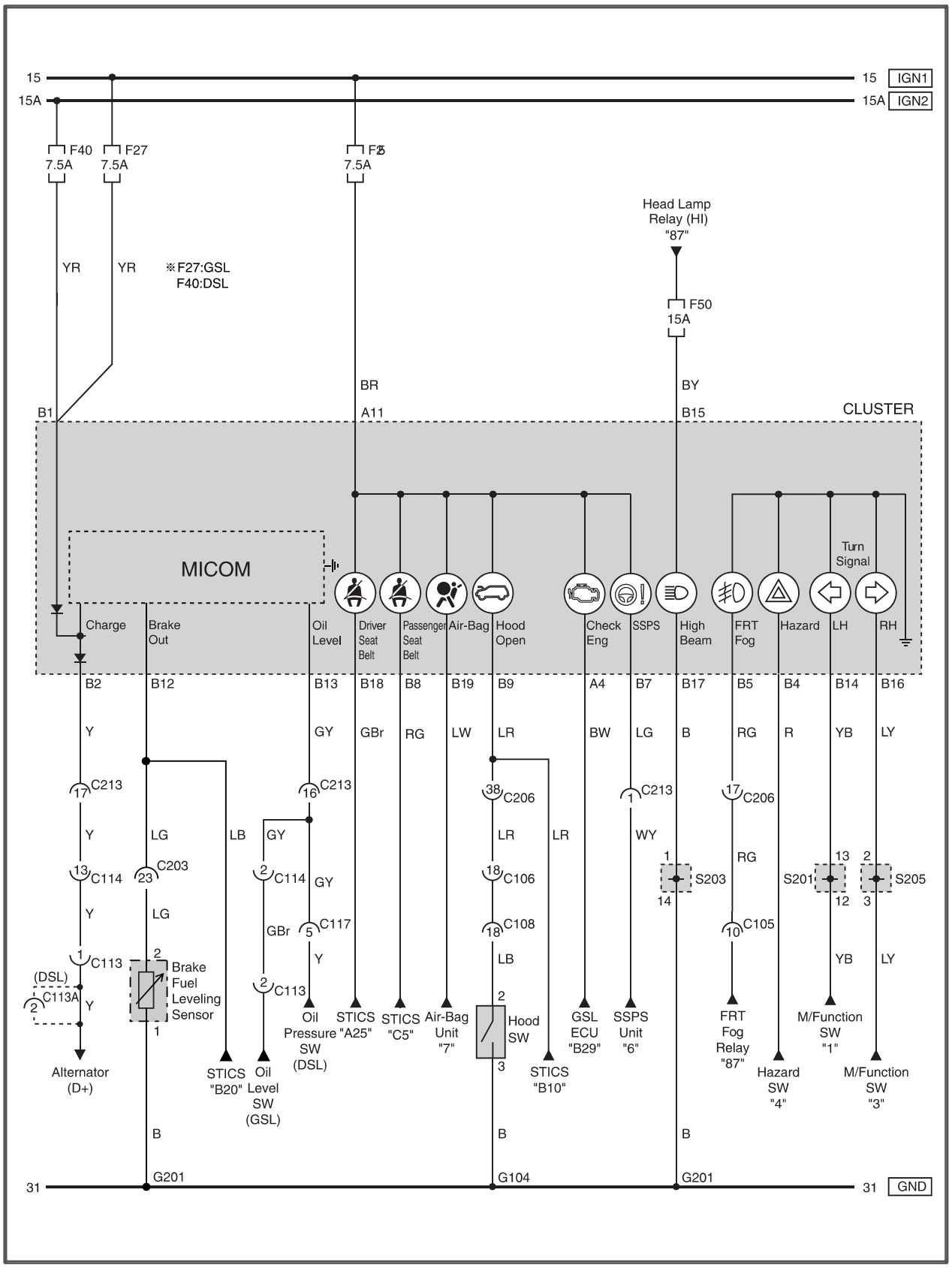
6. CIRCUIT DIAGRAM

▶ GAUGE (SPEED, RPM, FUEL, TEMP), WARNING LAMP (FUEL, FUEL FILTER, ABS, BRAKE, 4WD)



Modification basis	
Application basis	
Affected VIN	

▶ WARNING LAMP (BATT CHARGE, OIL, HOOD, DOOR, ENG CHECK, AIR BAG, SEAT BELT), TURN SIGNAL, FOG LAMP, HAZARD



Modification basis	
Application basis	
Affected VIN	

LAMP

0000-00

GENERAL

1. SPECIFICATIONS

Description			Amount	Specification	
				EU	General
Exterior lamp	Headlamp	Low beam / High beam	2	H4(60W) / H4(55W)	←
		Turn signal lamp	2	PY21W	←
		Position lamp	2	W5W	←
	Front fog light		2	H27W	←
	DRL		2	P21W	←
	Side repeater		2	LED	←
	Rear combination lamp	Stop (tail) lamp	2	P21W(5W)	←
		Turn signal lamp	2	PY21W	←
		Back-up lamp	1/2	P21W/1	P21W/2
	Rear fog light		1	P21W	-
	License plate lamp		2	W5W	←
Interior lamp	Front room lamp		2	8W	←
	Glove box lamp		1	5W	←
	Center room lamp		2	10W	←
	Door courtesy lamp		2	5W	←

NOTE

The surface of lamps can get foggy when raining or washing the vehicle. This is normal and is a result of the temperature difference between inner and outer surface of lamp cover. However, if water gets into the lamp, have the system checked at Ssangyong Authorized Service Center.

SWITCH

8610-08

GENERAL

1. SPECIFICATIONS

▶ **Multifunction switch**

Item	Rated load	Voltage drop
Light	0.1 A (Relay load)	Max. 0.25 V
Dimmer & passing	High beam: 0.3 A / Low beam: 0.3 A / Passing: 0.3 A (Relay load)	Max. 0.25 V
Turn signal lamp switch	6.6±0.5 A (Lamp load)	Max. 0.25 V
Hazard warning flasher switch	0.1 A	-
Fog lamp	0.1 A (Relay load)	-
Wiper	LOW: 5 A (motor load) HI: 7 A (motor load) AUTO: 0.22 ± 0.05A (relay load) LOCK: Max. 28 A (motor load)	Max. 0.25 V
Auto washer	0.1 A (Signal load)	-
Washer	4 A (motor load) 20 A (Lock/Min)	Max. 0.8 V
Variable Int Volume	Max. 25 mA	-
MIST SW	5 A (motor load)	Max. 0.25 V

▶ **Hazard warning flasher bezel switch**

Item	Rated load
Hazard warning flasher switch	12 V-10 A
Rear heated glass switch	12 V-0.1 A
Windshield heated glass switch	12 V-0.1 A
TRIP switch	12 V-0.1 A

▶ **Outside rearview mirror control bezel switch**

Item	Rated load
Outside rearview mirror switch	12 V-2 A
ESP OFF switch	12 V-0.1 A
Mirror folding switch	12 V-0.1 A
Steering wheel heating switch	12 V-0.1 A
Rear Fog Lamp Switch	12 V-0.1 A

▶ **CTR fascia switch bezel**

Item	Rated load
4WD control switch	12 V-0.1 A (signal load)
Driver's heated seat switch	12 V-5 A (relay load)
Passenger's heated seat switch	12 V-5 A (relay load)
Head Lamp Leveling Switch	12 V-1 A (inductive load)

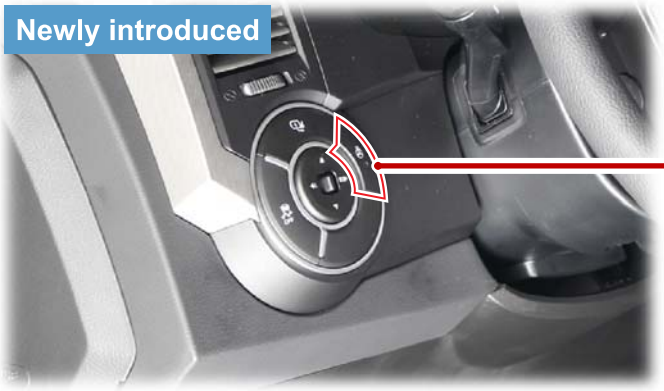
▶ **Rear heated seat switch**

Item	Rated load
Rear heated seat switch	12 V-0.1 A

2. MAJOR CHANGES

8510-60	Heated steering wheel switch

Newly introduced



- Heated steering wheel switch added to outside mirror switch bezel

8510-10	Rear seat warmer switch

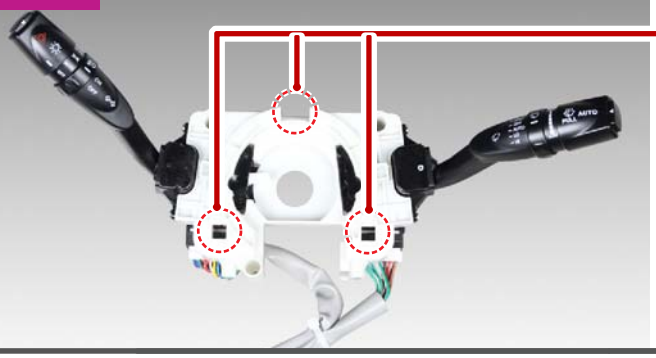
Newly introduced

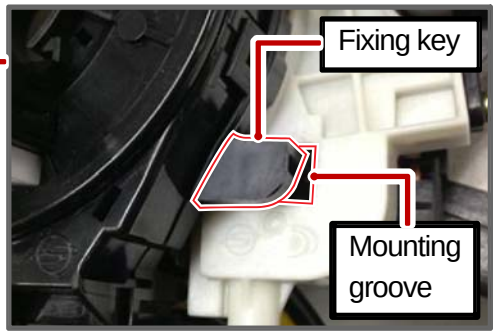
- Adopt rear seat warmer switches to rear door LH/RH

8510-72	Multifunction switch

Old

New





- Connector pin and layout changed due to heated steering wheel system adopted
- Mounting appearance changed due to changed steering wheel angle sensor (wiring route changed) and contact coil (fixing key)

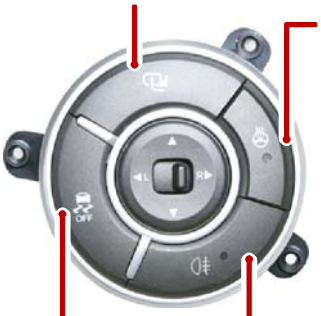
Modification basis	
Application basis	
Affected VIN	

Memo

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

Outside rearview mirror folding/unfolding switch
Press the FOLD/UNFOLD switch to fold the outside rearview mirror and press the switch again to unfold the mirror.



Steering Wheel Heating Switch
To heat the steering wheel, press this switch. To stop the heating, press it again. The indicator on the instrument cluster comes on when heating and goes off when turning off. The heating function stops when stopping the engine.

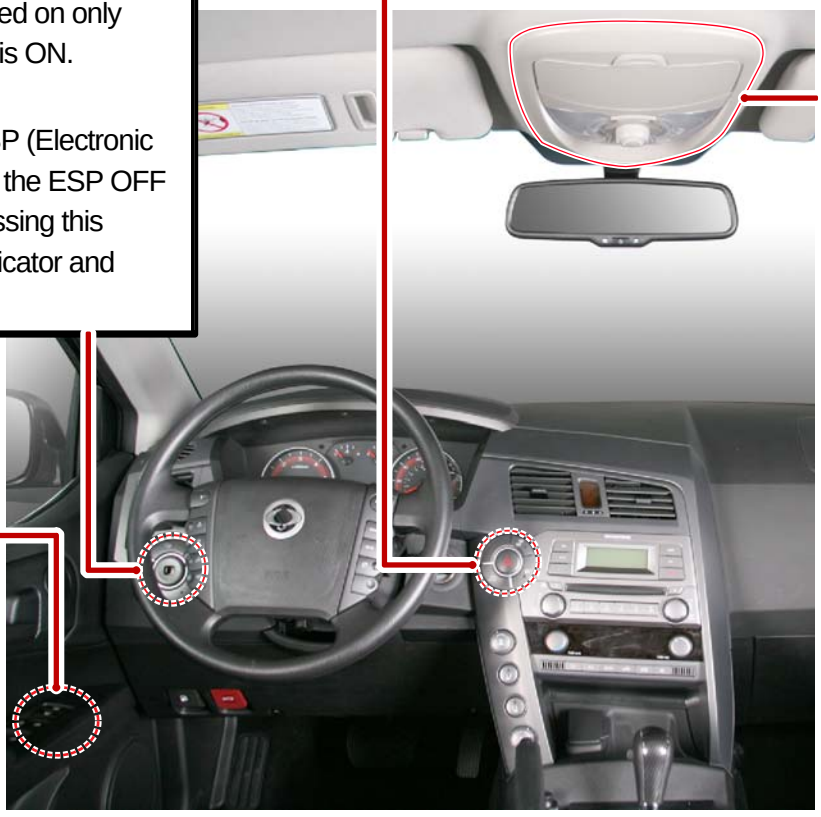
Rear Fog Lamp Switch
The rear fog lamp comes on when the rear fog lamp is turned on only while the front fog lamp is ON.

ESP ON/OFF switch
Pressing this switch deactivates the ESP (Electronic Stability Program) system and turns on the ESP OFF indicator on the instrument cluster. Pressing this switch again turns off the ESP OFF indicator and activates the ESP system.

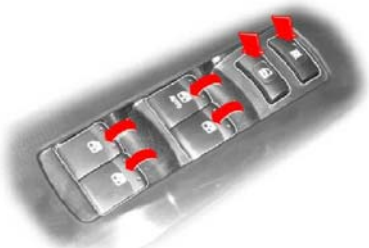
Tailgate and outside rearview mirror heated glass switch
Pressing switch activates tailgate and outside rearview mirror heated glass for approx. 12 minutes

Windshield de-icer switch
Pressing switch activates windshield heated glass for approx. 12 minutes

TRIP/RESET Switch
The mode is changed each time this button is pressed as follows: TRIP A -> TRIP B -> DTE -> Driving time -> Average fuel economy -> Instant fuel consumption -> Tail lamp illumination level.



Driver power window switch



The main switch which allows the driver to control all door windows, door lock and window lock from the driver seat.

Modification basis	
Application basis	
Affected VIN	

Major Functions of Multifunction Switch (Added functions)

Automatic hazard warning flasher switch

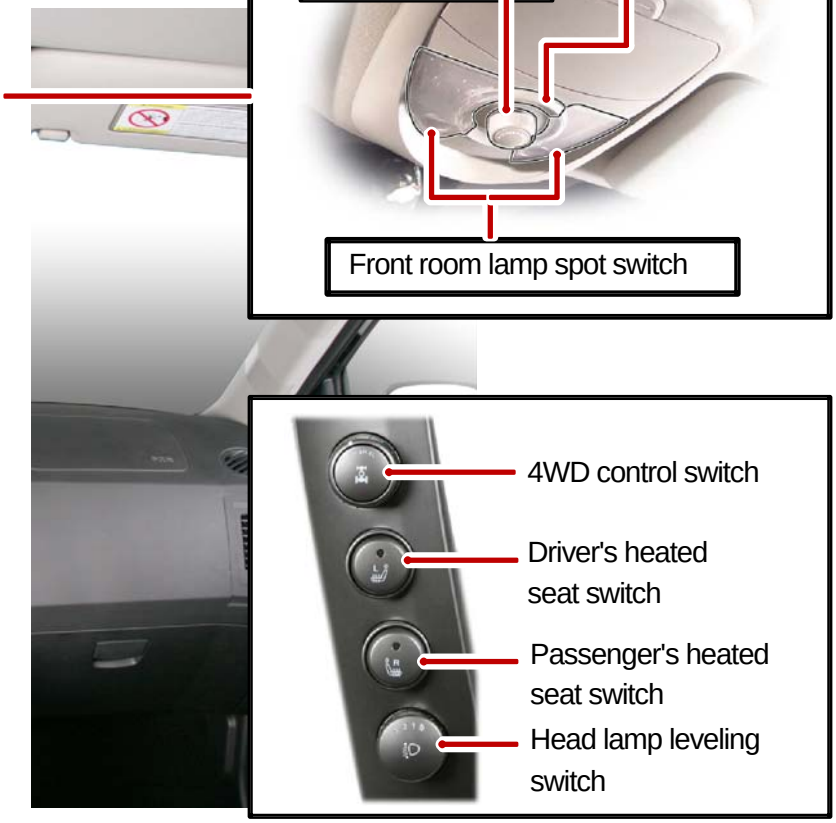
- Briefly press: Hazard warning flasher blinks three times.
- Press and hold: Hazard warning flasher blinks ten times.

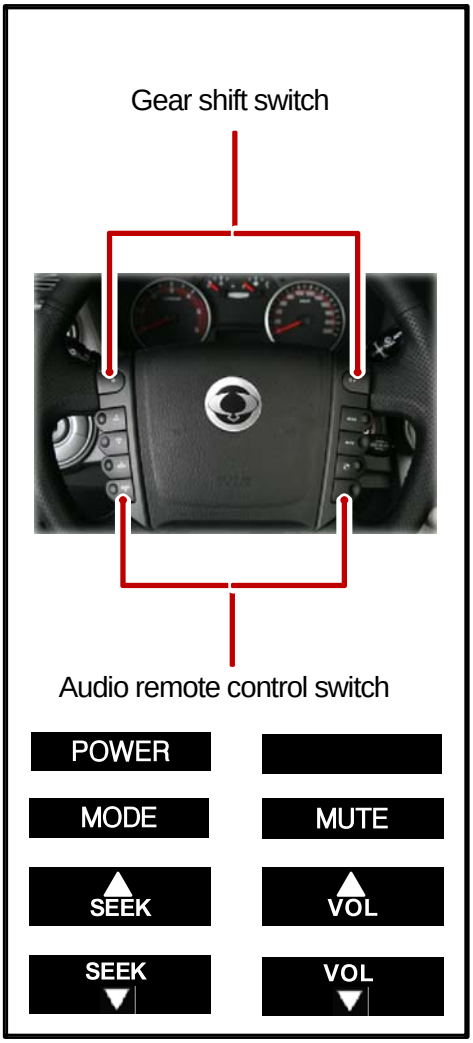
Auto light switch

Auto washer switch
Washer fluid is sprayed on the windshield and the wiper sweeps off 4 times. Then, the fluid will be sprayed again and the wiper will automatically operate 3 times.

Front wiper operation range
(move the wiper lever up/down)

Front wiper and washer coupled operation
Pull the lever briefly (below 0.6 seconds):
Wiping without washer spray
Pull and hold the lever for more than 0.6 seconds:
Three wiping cycles with washer spray





WIPER

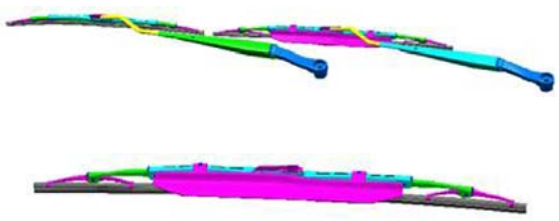
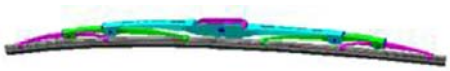
0000-00

GENERAL INFORMATION

1. SPECIFICATIONS

Unit	Item		Specification
Wiper motor	Rated voltage		DC 12 V
	Operating voltage		DC 10 to 15 V
	Lowest operating voltage		DC 8 V or less
	Low revolutions		46 ± 5 RPM
	High revolutions		70 ± 9 RPM
Wiper arm and blade	Wiper arm length	Driver	508 mm
		Passenger	537 mm
	Wiper blade length	Driver	550 mm
		Passenger	475 mm
Rain sensor	Operating voltage		DC 9 to 16 V
	Load		Max. 200 mA (relay load)
	Operating temperature		−30˚C to 85˚C
	Mounting location		Top center of inner side of windshield glass
Washer reservoir tank	Volume		3.0 L

2. MAJOR CHANGES

Wiper blade	
Old  Driver: 550 mm (22 inches)  Passenger: 475 mm (19 inches)	**New**  Driver: 550 mm (22 inches)  Passenger: 475 mm (19 inches)
- Changed from conventional type to aero blade type - No change in wiper blade dimension and wiper arm	

Modification basis	
Application basis	
Affected VIN	

3. CAUTIONS ON RAIN SENSOR

- When the wiper switch is in the AUTO position, the wiper will operate for 1 cycle if the initial engine start is made. This may cause the wiper blades to wear prematurely. Therefore, other than rainy days, set the switch to the OFF position. Especially during the winter time, check if the wiper blades are not frozen to the windshield.
- Operating the wiper with the blades frozen can damage the wiper motor.
  If you operate the wipers when the windshield is dry without spraying washer fluid, the windshield can be scratched and the wiper blades can wear prematurely. Use the wiper with the washer fluid when the windshield is dry.
- When it does not rain, turn the wiper switch to the OFF position.
- Turn the wiper switch to the OFF position before any car wash to avoid unwanted operation of the wipers.

WARNING

When cleaning the windshield over the sensor with damp clothes, the wiper may operate suddenly. It could cause serious injury. Make sure to place the wiper switch to the OFF position and ignition switch OFF when not in use.

▶ **Irregular operation (abrupt operation)**

- Check if the sensor is off the position.
- Check if the rain sensor cover is securely installed.
- Check if the customer is familiar to how to control the wiper sensitivity.
  Check if the wiper sensitivity control is set to the FAST side (step 5).
  Check the wiper blade for wear.
- If the wiper blade cannot wipe the glass uniformly and clearly, it may cause the rain sensor to work irregularly. Therefore, in this case, replace the wiper blade with a new one.

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

The wiper & rain sensor system consists of the multifunction wiper switch, windshield wiper motor and linkage, wiper arm and blade, rain sensor, wiper relay (LO/HI) and washer tank. The rain sensor does not directly operate the rain sensing wiper and it sends only the data of the rainfall to the STICS. The basic operation of the wiper and washer is controlled by the STICS according to the signal regarding the multifunction switch operation modes (MIST, AUTO, LO/HI, washer, sensitivity adjustment).

▶ **Layout**

Windshield wiper motor & linkage

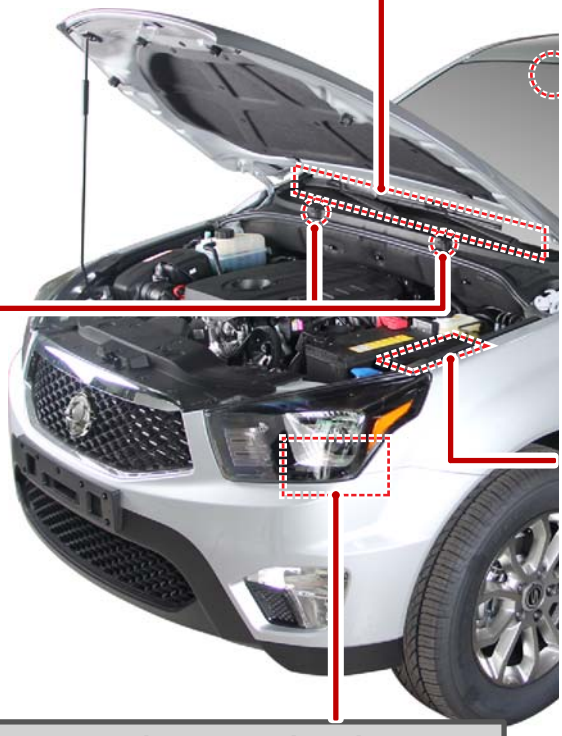
When the driver operates the switch so that the wiper motor is activated, the linkage converts the rotary motion to reciprocating motion and transfers it to the wiper arm.

Windshield wiper arm & blade

It receives the power from the wiper linkage and does a reciprocating motion (left to right).

Washer nozzle

Installed on both sides of the cowl grille assembly (one on each side). Sprays washer fluid in fan-shape to cover the windshield area as much as possible.



Washer reservoir tank

Tank that supplies washer fluid to front washer system.

Modification basis	
Application basis	
Affected VIN	

Rain sensor unit

Emitter lens
The LED which is located at bottom emits the infrared rays and the lens guides the infrared rays to target point.

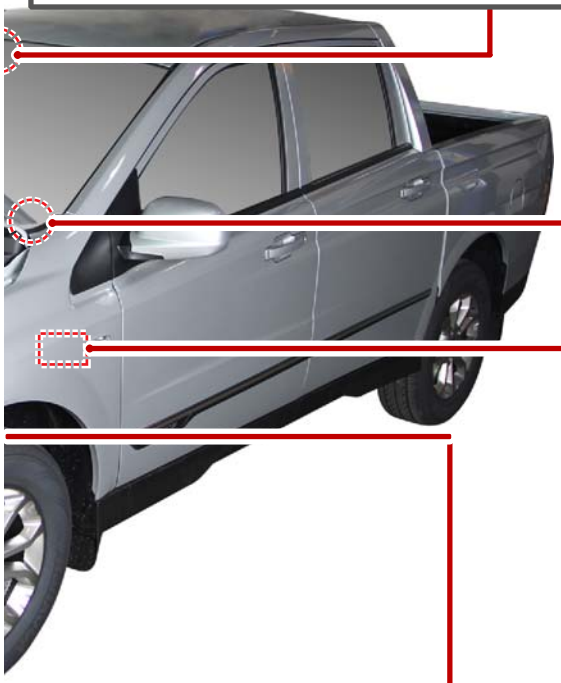
Auto light sensor (Vertical)

Auto light sensor (Horizon)

Auto light sensor

Enlarged auto light sensor section

Integrated into the auto light sensor. Detects and sends amount of rain drops to STICS



Multifunction wiper switches

AUTO: Wiper operates automatically by rain sensor
FAST to SLOW: Auto delay/auto speed control. A position that can control sensitivity against rains on the windshield and transmits wiping demand signal accordingly.

Wiper (HI, LO) relays

Wiper relay (HI)

Wiper relay (LO)

Used 3-way relay consisting of 5-pin

STICS

It receives the signals regarding the rain sensor, multifunction wiper switch and vehicle speed to control the wiper system with the various functions.

Modification basis	
Application basis	
Affected VIN	

2. FUNCTIONS

1) Wiper and Washer Fluid Switch Operation

MIST The wiper operates for 1 cycle when pushing up the lever. The lever will return to the "OFF" position when released.

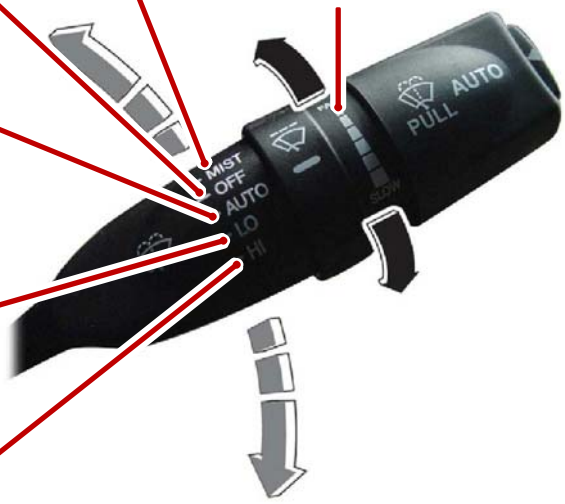
OFF Stop the operation.

AUTO Operates automatically according to the vehicle speed or amount of rain.

LO Continuous wipe, slow operation

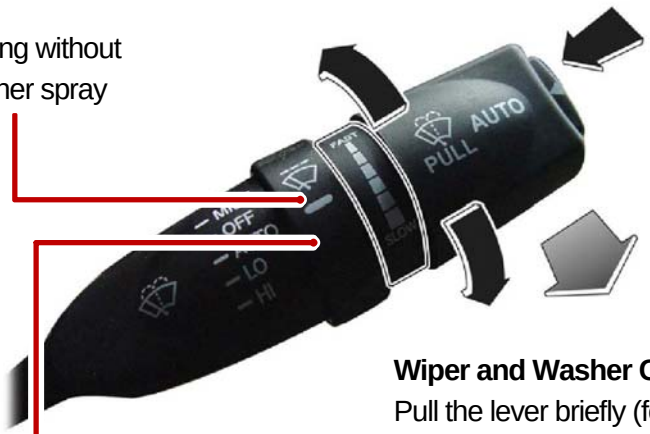
HI Continuous wipe, fast operation

Front Automatic Wiping Speed Control Switch
Fast: Fast interval
Slow: Slow interval



Wiping without washer spray

Wiping stops



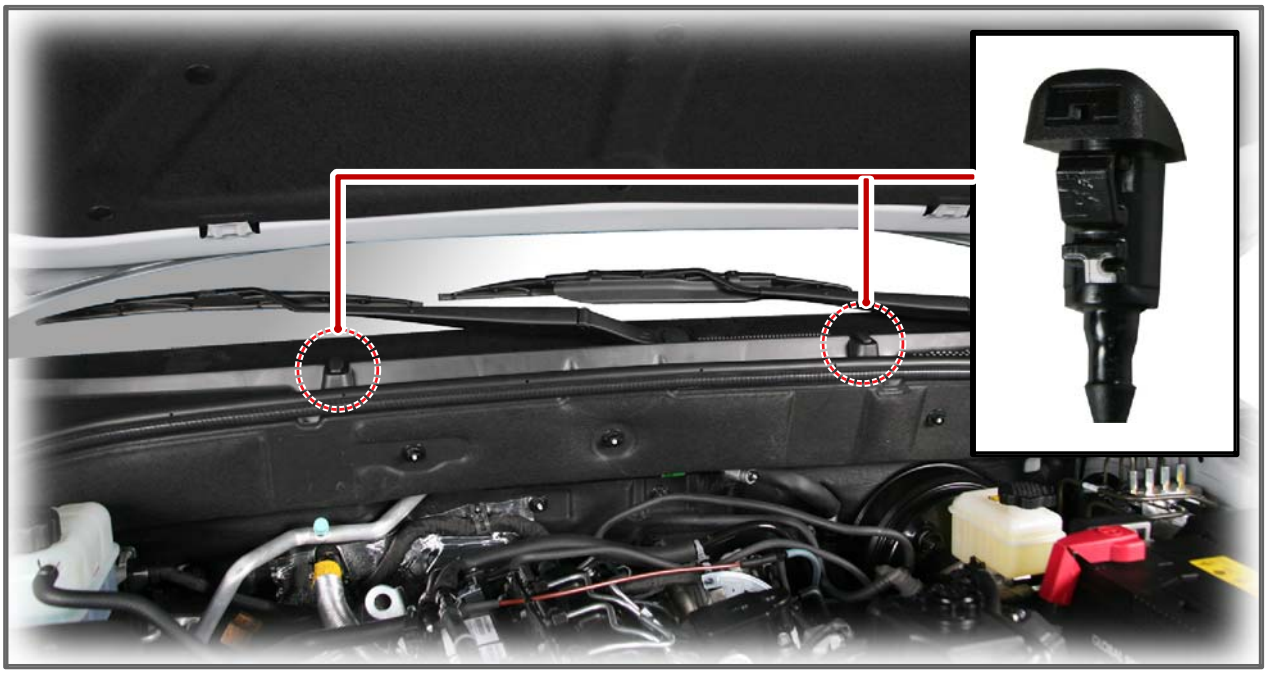
Front Auto Washer Switch (AFW)
When the front wiper switch is off and this switch is pressed, washer fluid will be sprayed and the wiper will automatically operate 4 times. Then, the fluid will be sprayed again and the wiper will automatically operate 3 times.

Wiper and Washer Coupled Operation
Pull the lever briefly (for less than 0.6 seconds): One wiping cycle with washer spray Pull and hold the lever for more than 0.6 seconds: Three wiping cycles with washer spray

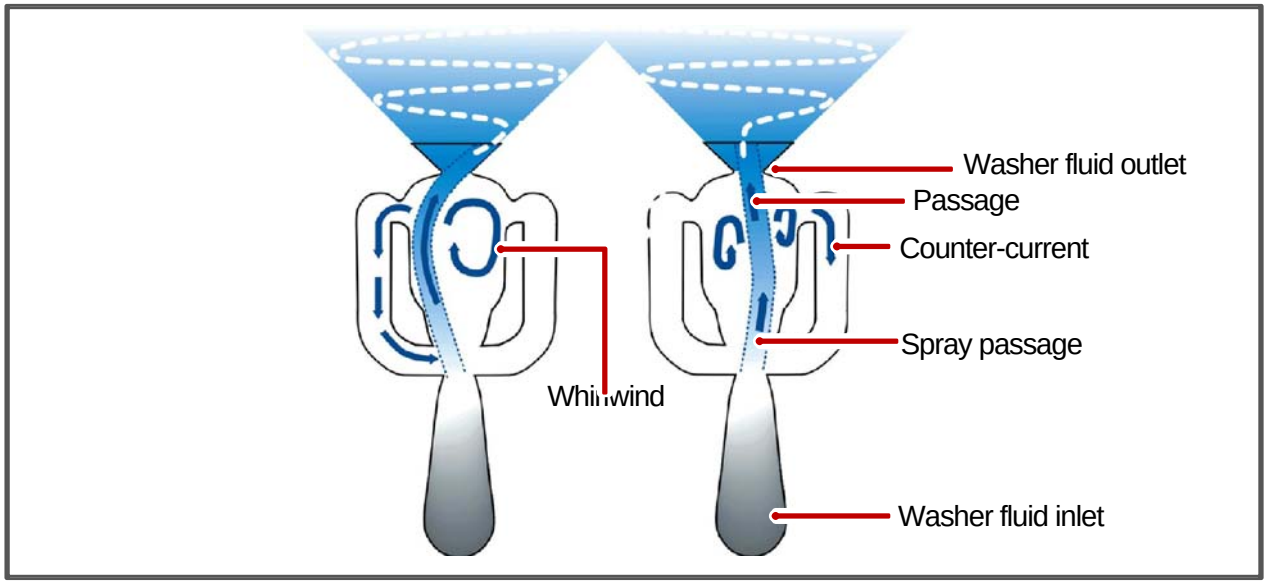
Modification basis	
Application basis	
Affected VIN	

2) Fluidic Washer Nozzle

Fluidic Washer Nozzle is applied to the front washer spray system in this vehicle. The inside of nozzle is designed to utilize the fluidic movement.



This is a shape of the inside of nozzle. It is designed to change the spraying direction continuously according to the spraying time (fan-shape). The figure below shows the changes of spraying direction according to the spraying time.

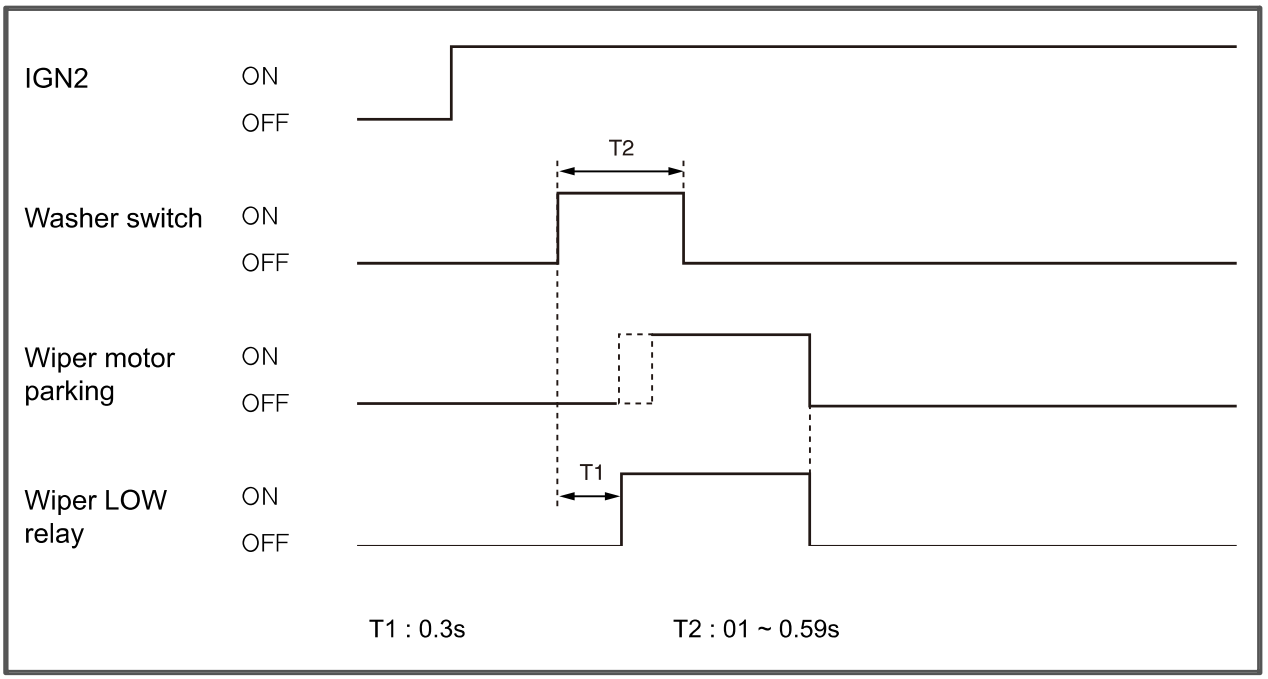


It is designed to be changed spraying direction using the whirlwind and backflow generated in nozzle.

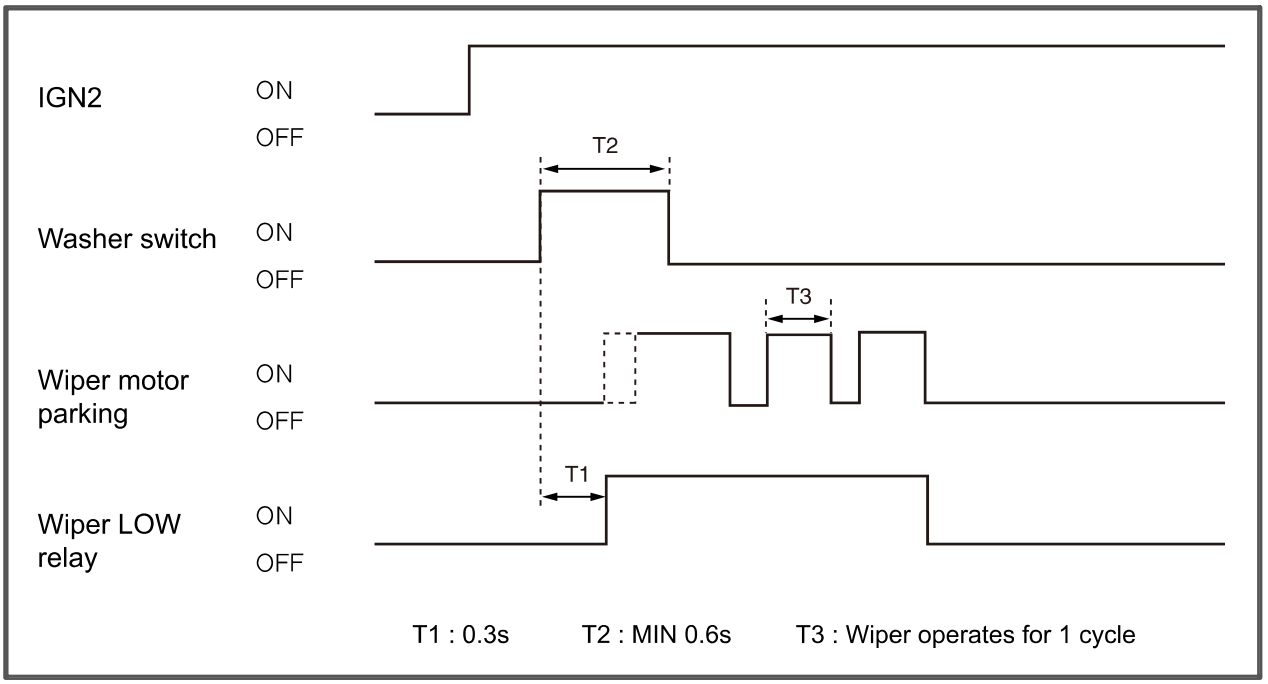
3) STICS Control Logic Related to Wiper and Washer

▶ **Wiper MIST and Front Washer Coupled Wiper**

1. The wiper relay is turned on 0.3 seconds after turning "ON" the washer switch for 0.1 ~ 0.59 seconds with the ignition key "ON", and it is turned off when the parking terminal is turned off.

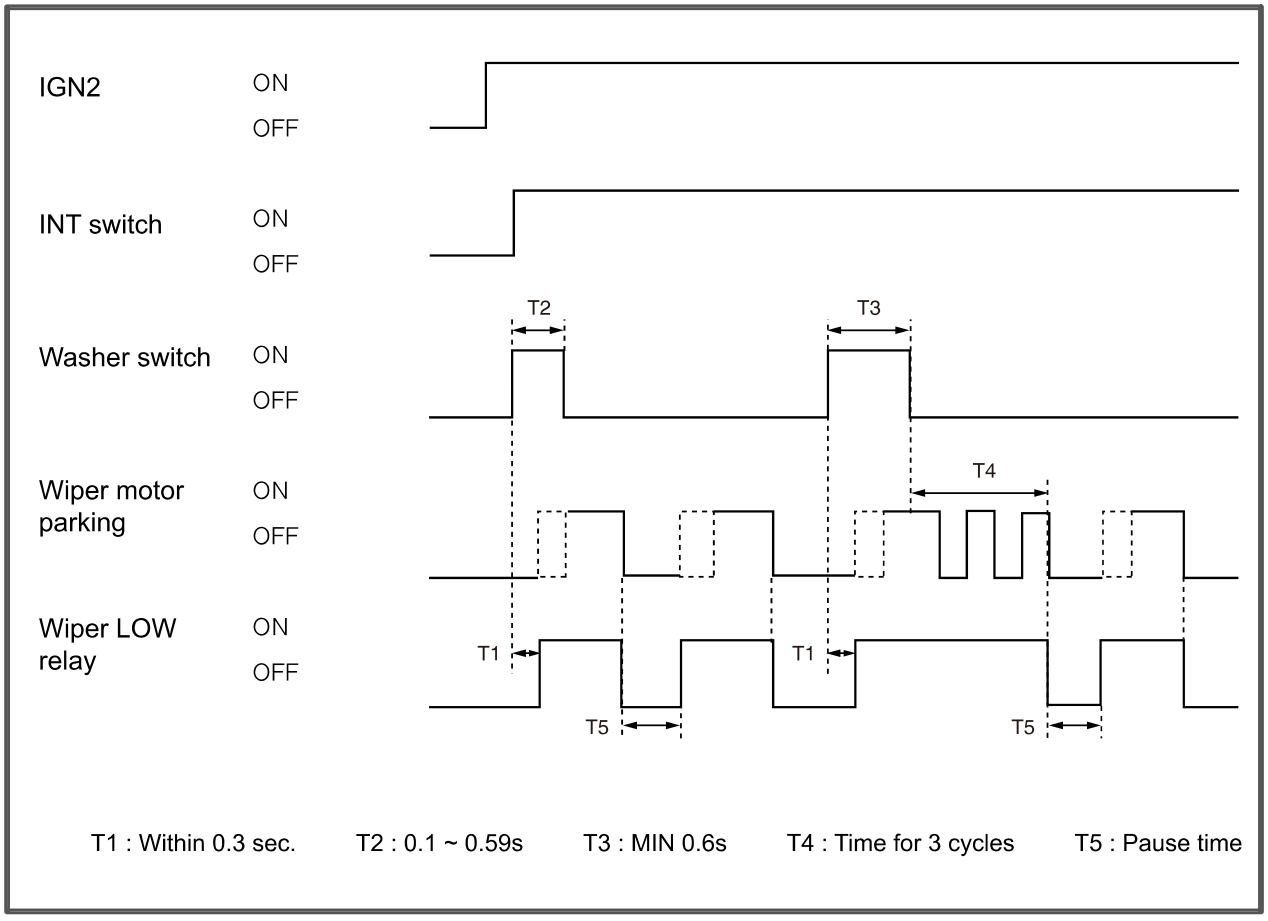


2. The wiper relay is turned on at 0.3 seconds after from the time when the washer switch is turned on for more than 0.6 seconds with the ignition switch "ON". The wiper relay gets on 3 times immediately after turning off the washer switch.

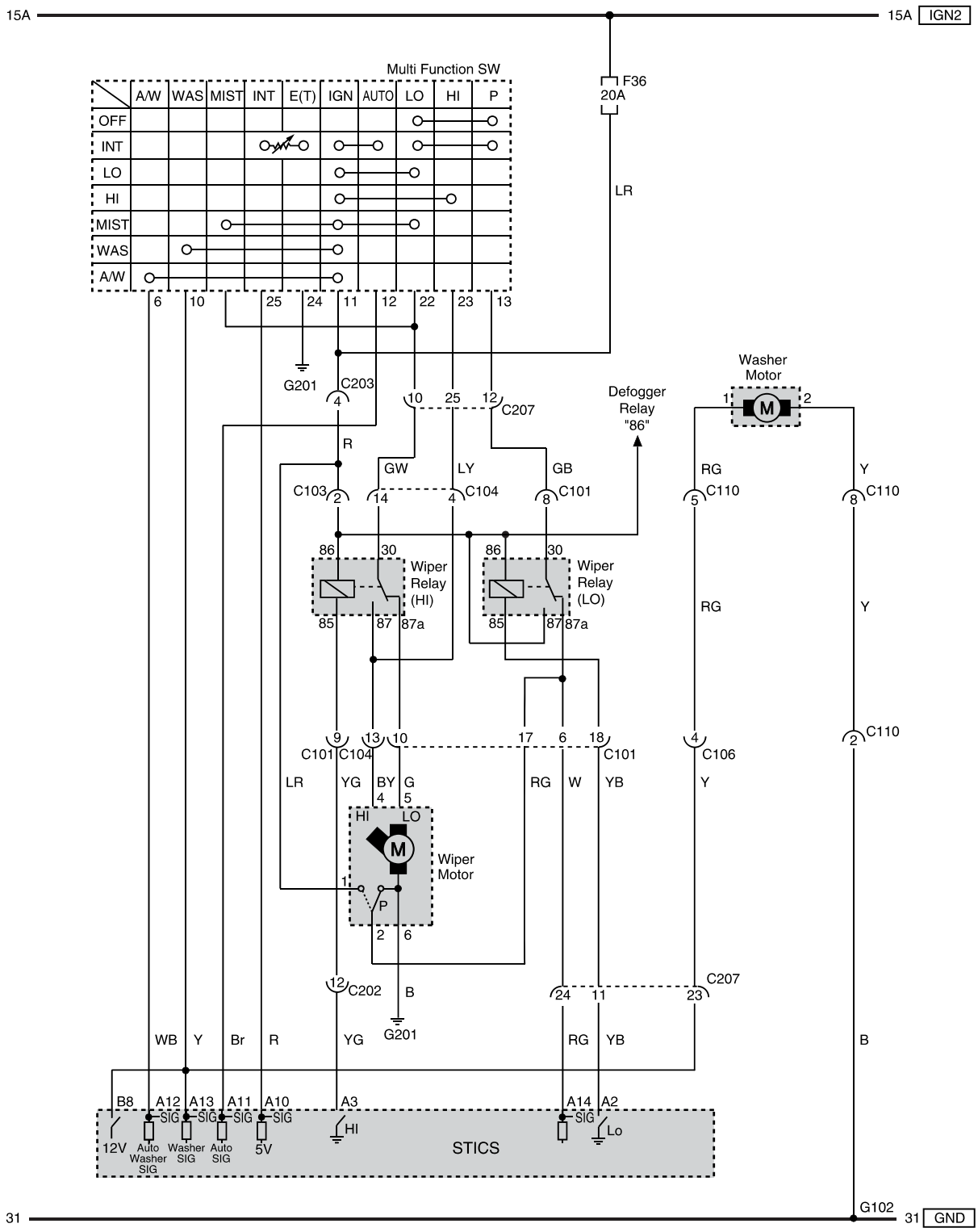


Modification basis	
Application basis	
Affected VIN	

3. When the washer switch is turned on for more than 0.6 seconds during the wiper operation by INT switch, the operation in step (2) is performed.
4. When it is turned on for a certain period of time (0.1 to 0.59 seconds), the operation in step (1) is performed.



3. CIRCUIT DIAGRAM



Modification basis	
Application basis	
Affected VIN	

RAIN SENSING UNIT

8610-09

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

The rain sensing wiper unit system doesn't control the wiper directly. The rain sensing unit detects the amount of rain drops and sends the operating signal to STICS, and STICS drives the wiper directly.

Rain Sensing Unit (AUTO Light Sensor Integrated Type)

A sensor that emits infrared rays through LED and then detects the amount of rain drops by receiving reflected rays against sensing section (rain sensor mounting section on the windshield) with photodiode. The auto light sensor is Integrated into the rain sensor (refer to the below picture).

Multifunction Wiper Switch: AUTO and Sensitivity Control

AUTO: Wiper operates automatically by rain sensor
FAST SLOW: Auto delay/auto speed control. A position that can control sensitivity against rains on the windshield and transmits wiping demand signal accordingly.

Emitter lens
The LED which is located at bottom emits the infrared rays and the lens guides the infrared rays to target point.

Auto light sensor(Vertical)

Auto light sensor (Horizon)

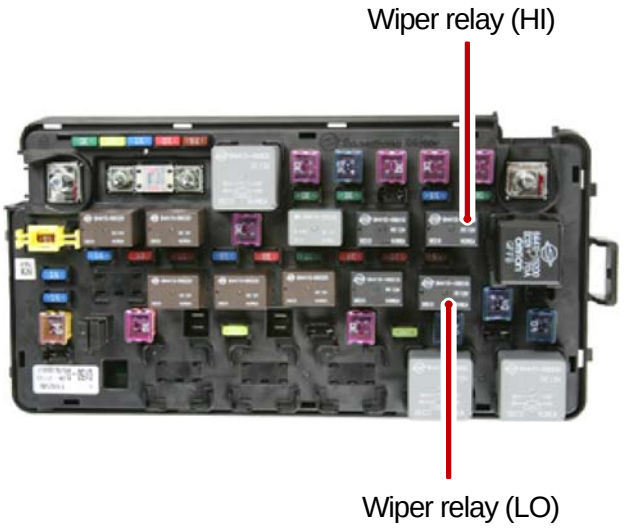
Auto light sensor

Enlarged auto light sensor section

Modification basis	
Application basis	
Affected VIN	

▶ STICS

The rain sensing unit detects the amount of rain drops and sends the operating signal to STICS, and STICS drives the wiper directly. At this moment, STICS determines the wiper operation mode (washer, MIST, AUTO), then sends the information to the rain sensor.

STICS	Engine Compartment Fuse Box
	

▶ Auto Light Sensor and Rain Sensor Coupled Control

- Rain detected headlamp: If it rains heavy which requires the highest INT speed (almost LOW), the headlamps are turned on automatically.
- Night detected wiping: When the auto light control turns on the headlamps and the rain sensor detects the rain, the wiper sensitivity is automatically increased by one level in comparison with daytime.
  (i.e. the AUTO wiper switch is at the 3rd level, but the wiper operates at the 4th level.)

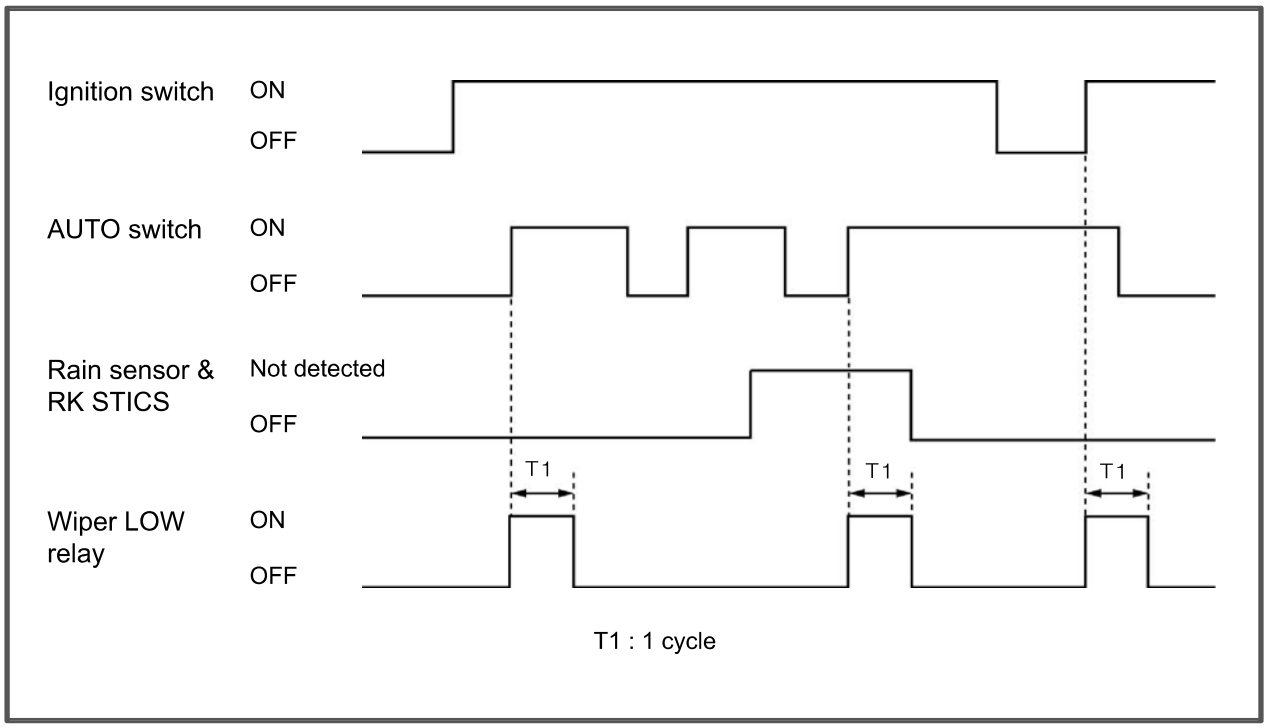
Modification basis	
Application basis	
Affected VIN	

2. FUNCTIONS OF RAIN SENSING WIPER

1) Power-up Reminder Wiper Function

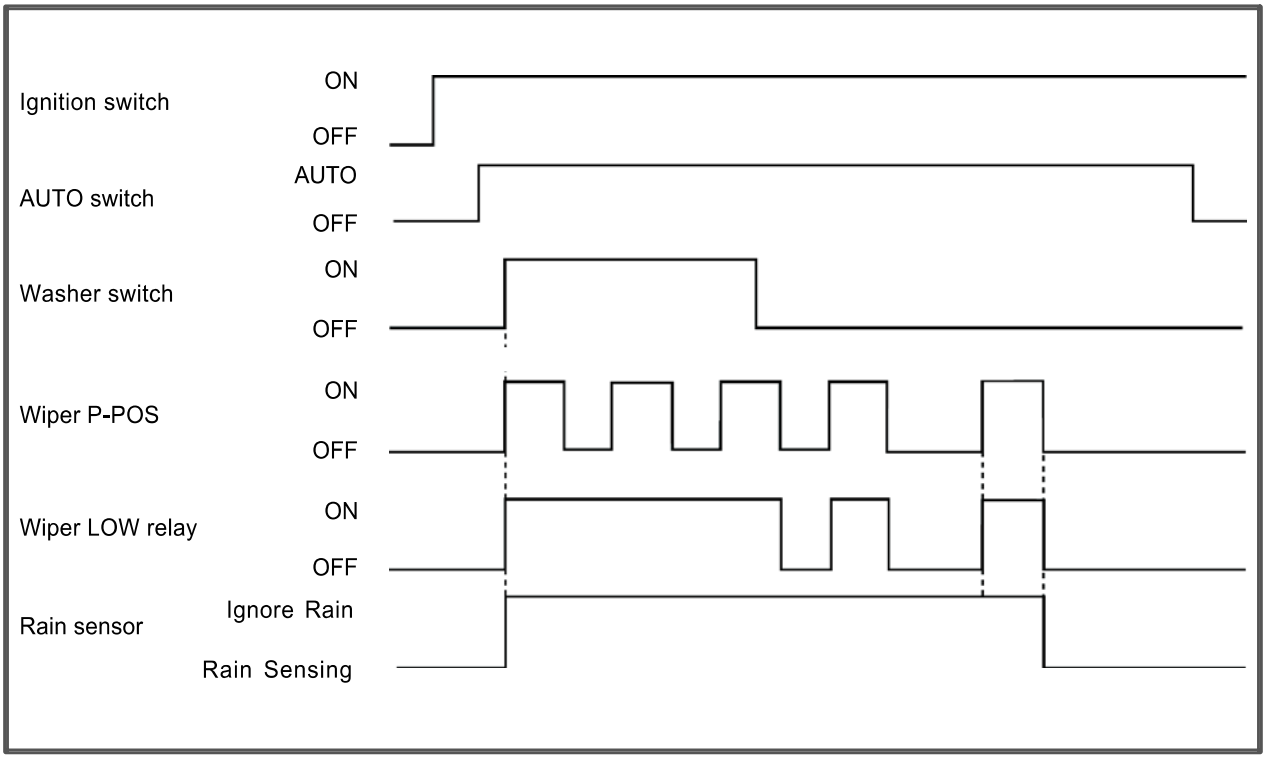
1. When turning off and on the auto INT switch, the system drives the wiper motor through LOW relay regardless of communication with rain sensor.

2. When turning the INT-AUTO switch from the "OFF" to "ON" position with the ignition switch in the "ON" mode, the LOW relay operates to drive the wiper motor for 1 cycle, regardless of the rain sensor communication.
   After that, when turning the INT-AUTO switch from the "OFF" to "ON" position, the LOW relay operates to drive the wiper motor for 1 cycle only if data from the rain sensor indicates rain drops.



2) Washer Coupled Wiper in Rain Sensing Mode

1. The washer coupled wiper is operated when receiving the washer switch input with the ignition switch "ON" and the auto INT switch "ON" in rain sensing mode. At this moment, the communication with the rain sensor is overridden. However, a washer input is overridden if there is an output for continuous operation.
2. The operation data is sent to the rain sensor even during the washer coupled wiper's operation.



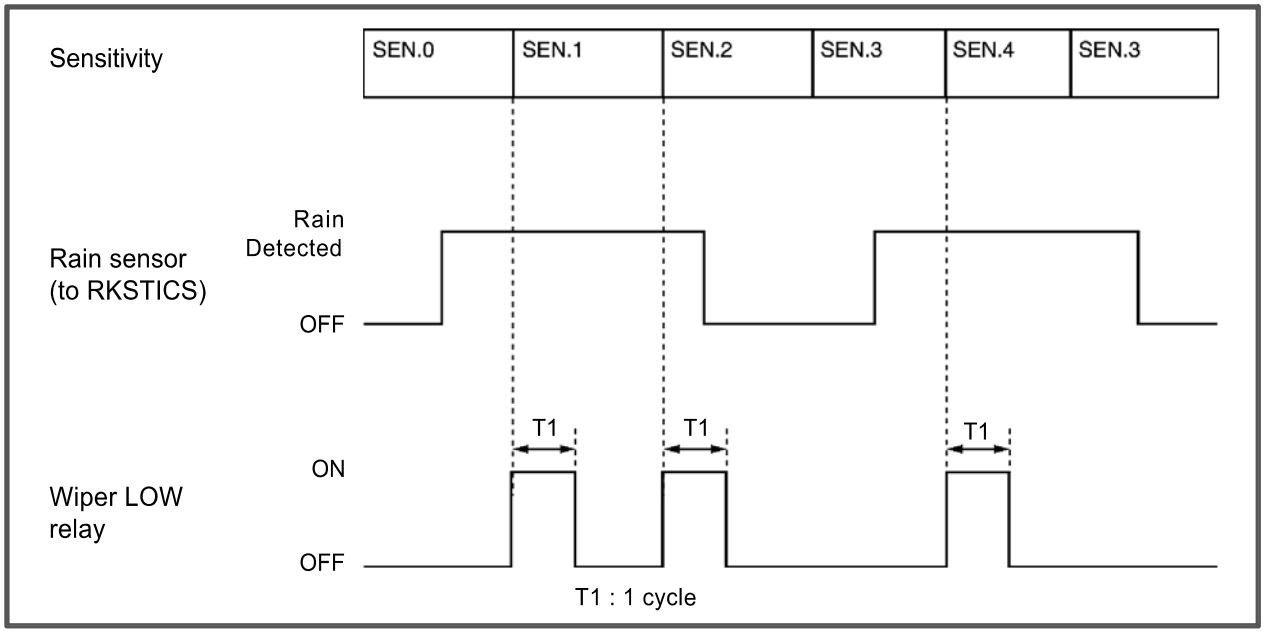
Modification basis	
Application basis	
Affected VIN	

3) Sensitivity Control

1. The wiper LOW relay is turned on and the wiper motor runs one cycle when the volume sensitivity is increased (ex: sensitivity 0 ⇒ 1) while the ignition switch and the INT switch is in the "ON" position, and the wiper motor is in "Parked" position). However, the wiper motor can be operated only when the rain sensor detects the "Rain Detected" signal.

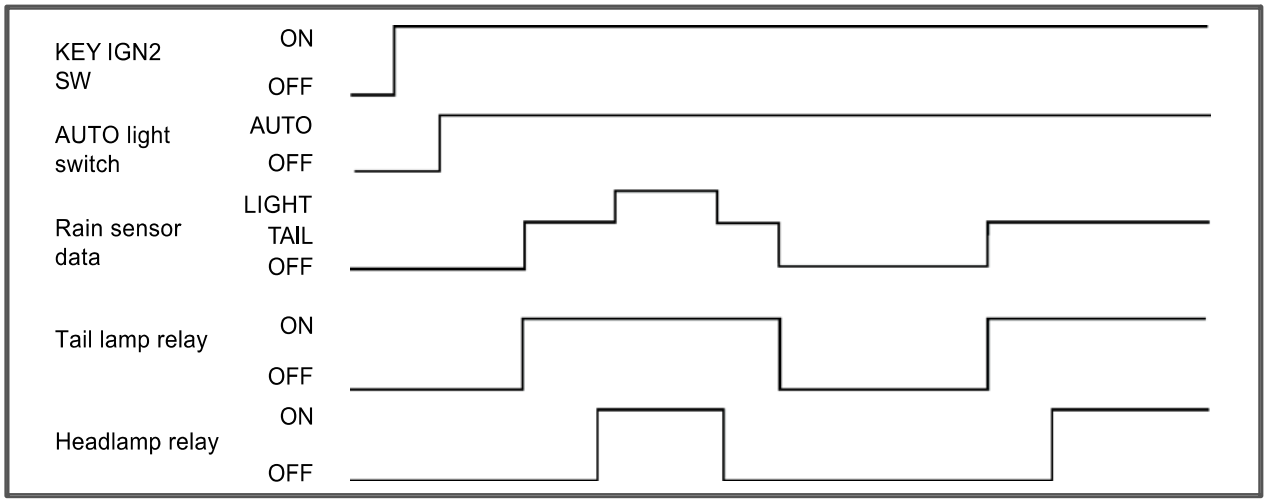
NOTE

If the volume sensitivity is changed more than 1 stage within 2 seconds, the wiper motor runs only one cycle.



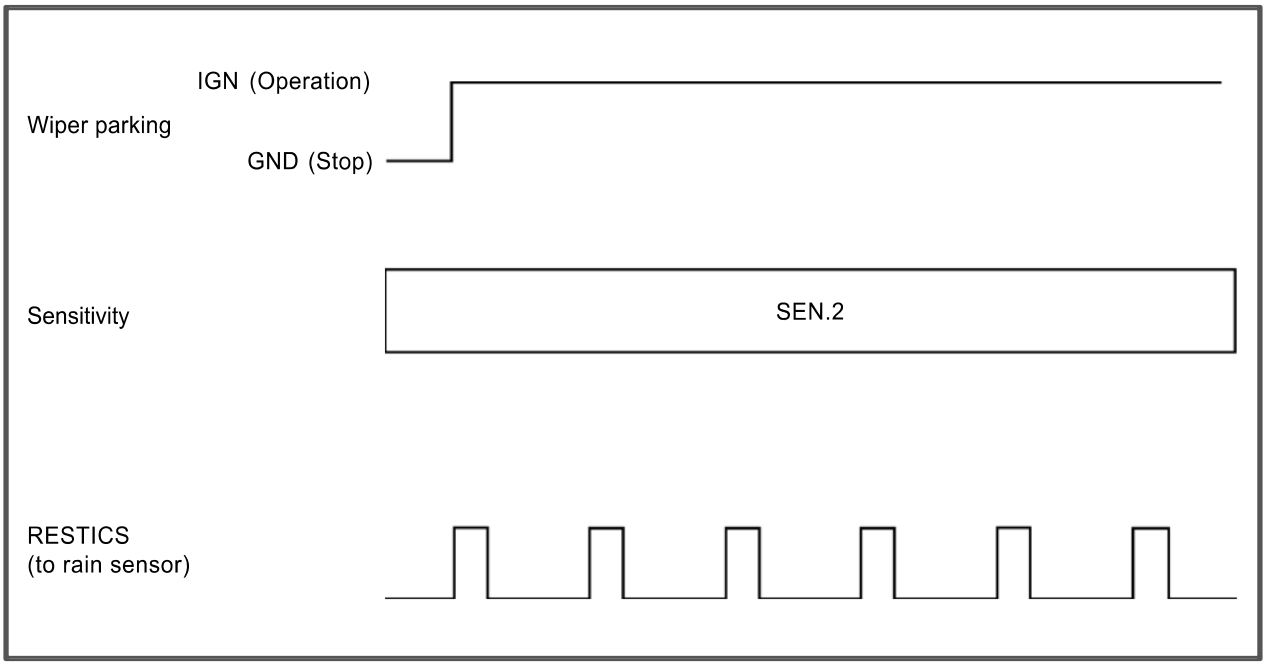
4) Auto Light Control

1. Only when the auto light switch is in "AUTO" position, it controls the tail lamp and headlamp by communicating with the rain sensor (while the ignition key is in "ON" position).

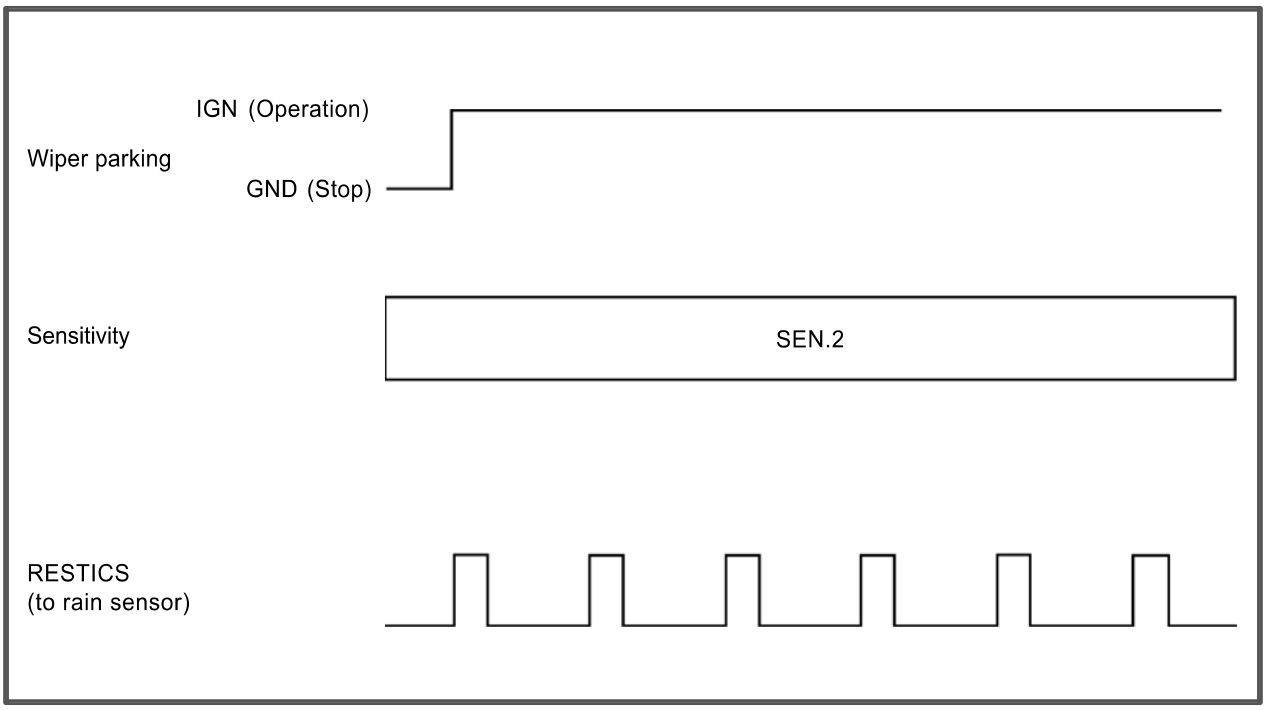


5) When Wiper Parking Signal is Abnormal

1. The wiper system continuously outputs the parking signal of current sensitivity when the parking terminal is grounded (while the ignition key is in "ON" position and the INT switch is in "ON" position).



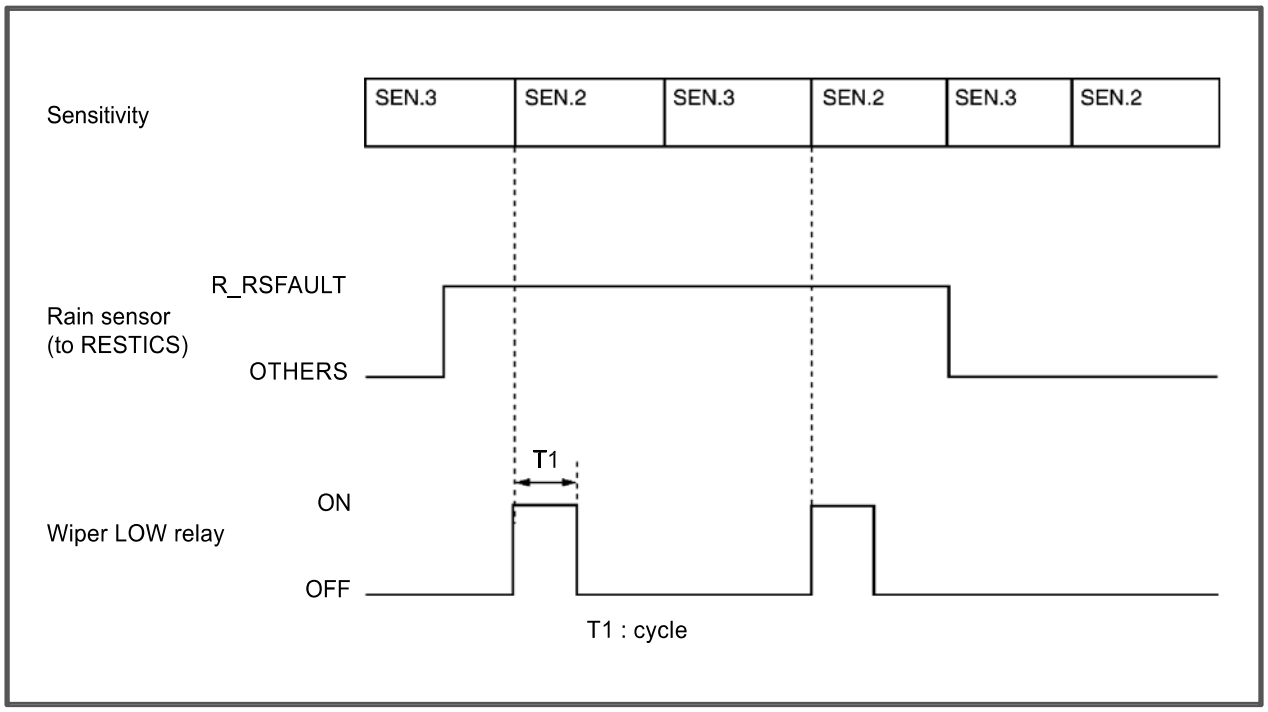
2. When the parking terminal is fixed to IGN, the wiper system outputs the wiper operating signal for 2 seconds, then continuously outputs the wiper parking signal.
   ※ The wiper motor runs only when the rain sensor requires the wiper operation.



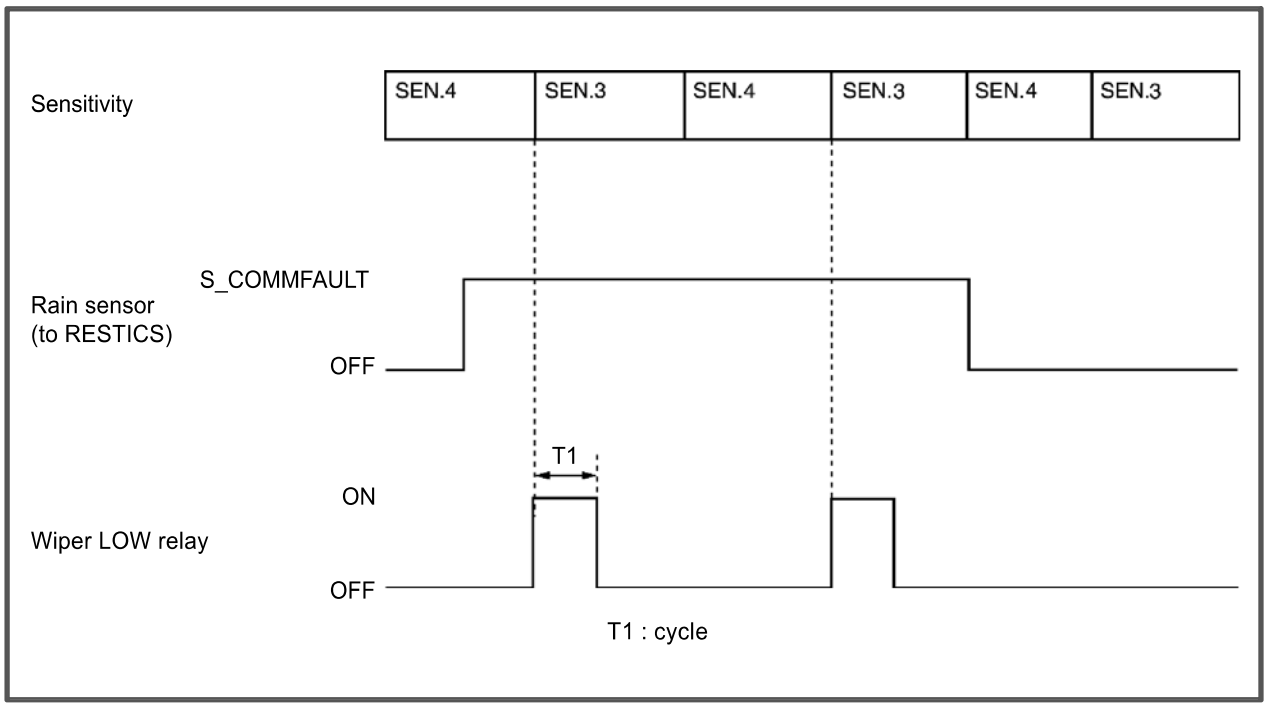
Modification basis	
Application basis	
Affected VIN	

6) Defective Rain Sensor

1. The wiper relay (LOW) is turned on and the wiper motor runs one cycle when the volume sensitivity is changed to 2 from 3 during receiving the malfunction signal from the rain sensor, while the ignition key is in "ON" position and the wiper switch is in "ON" position.



2. The wiper relay (LOW) is turned on and the wiper motor runs one cycle when the volume sensitivity is changed to 3 from 4 during receiving the malfunction signal from the rain sensor, while the ignition key is in "ON" position and the wiper switch is in "ON" position.

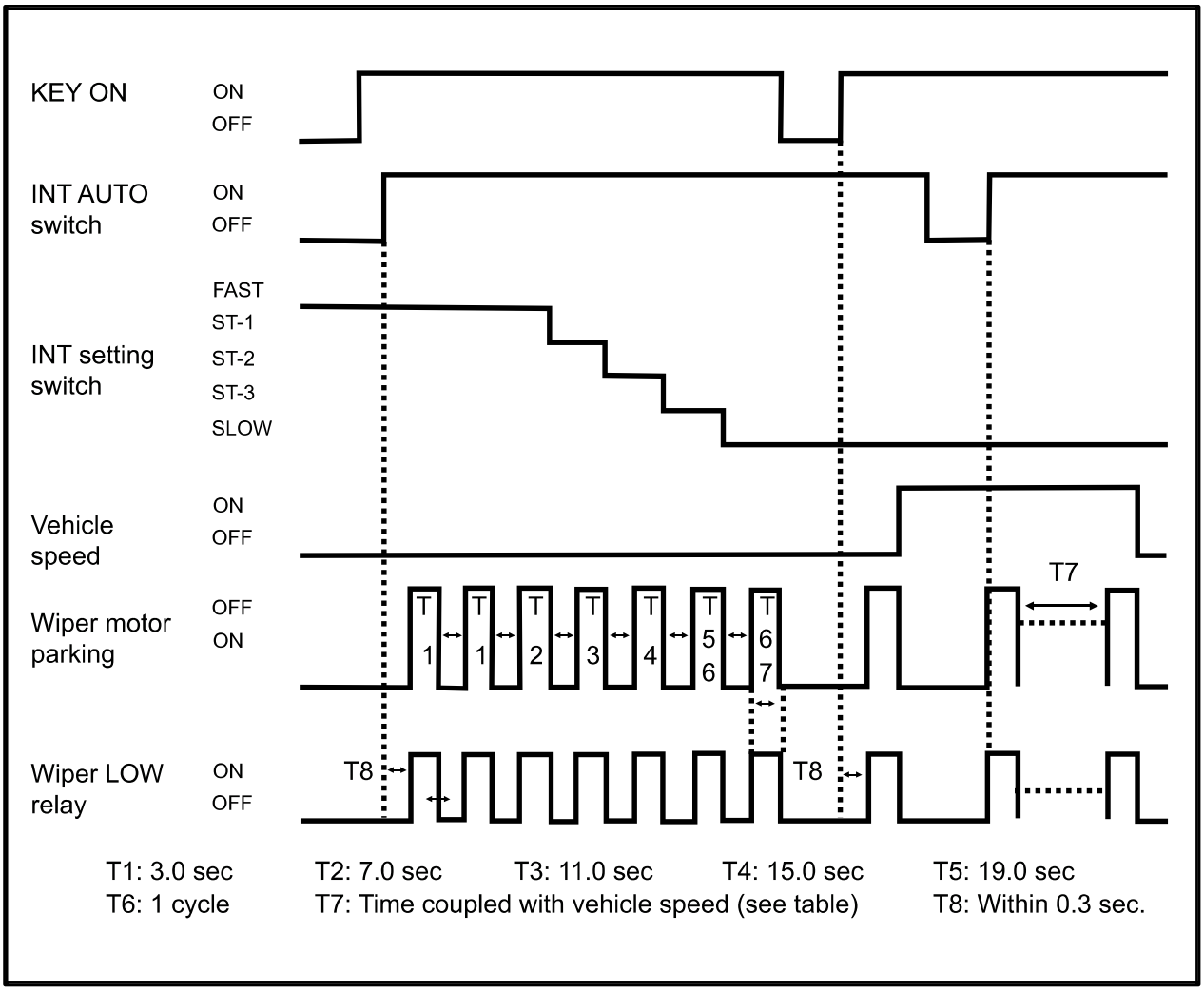


7) Speed Sensitive INT Wiper

Controls the wiper intermittent operation by the values from the vehicle speed and the setting value.

- Calculates and converts the Intermittent interval automatically by obtaining the INT VOLUME when the ignition switch and the INT switch is in the "ON" position.
- The wipers are operated in vehicle speed sensitive mode as soon as turning the INT auto switch to the "ON" position with the ignition key ON or turning the ignition key to the "ON" position with the INT auto switch ON.

※ This applies to the vehicle without the rain sensor.

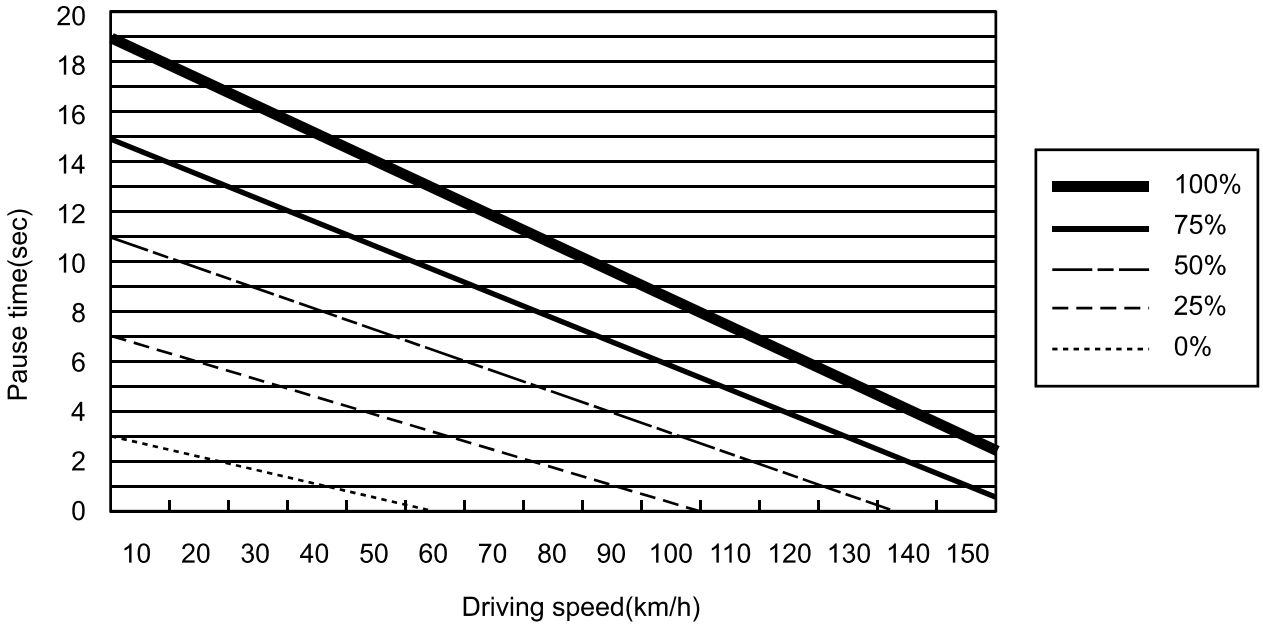


Modification basis	
Application basis	
Affected VIN	

▶ Pause Time Table of Vehicle Speed Coupled INT Wiper

Vehicle speed / (Resistance)	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
100 %	19.00	17.90	16.80	15.70	14.60	13.50	12.40	11.30	10.20	9.10	8.00	6.90	5.80	4.70	3.60	2.50
75 %	15.00	14.3	13.06	12.09	11.13	10.16	9.19	8.22	7.26	6.29	5.32	4.35	3.39	2.42	1.45	0.45
50 %	11.0	10.16	9.33	8.49	7.66	6.82	5.99	5.15	4.32	3.48	2.65	1.81	0.98	0.14	0.00	0.00
25 %	7.00	6.29	5.59	4.89	4.19	3.48	2.78	2.08	1.38	0.67	0.02	0.00	0.00	0.00	0.00	0.00
0 %	3.0	2.43	1.86	1.29	0.72	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

▶ Pause time against vehicle speed



※ Cautions for wiper control

1. Speed sensitive INT (intermittent) wiper
   - The wiper relay continues to output for remaining "ON" time even when the INT switch is turned off during its operation.
   - IGN switch "ON", INT switch "OFF": Resume the intermittent time when turning "ON".
   - IGN switch "ON", INT switch "ON": Resume the intermittent time when turning "ON".
2. Controls when the wiper motor parking is defective
   - The wiper relay continues to output when the parking terminal is fixed at the ground or IGN while the wiper relay is "ON" i.e., with the INT switch ON or washer switch ON. (The output stops immediately after turning off the switch)

3. OPERATION MODE OF RAIN SENSING WIPER SYSTEM

Driver switch positions		Operation mode
MIST (transmits the manual operation mode signal to sensor)		As long as the switch is in MIST position, the wiper motor operates in low speed. The wiper blade returns to parking position if the switch returns to the original position. The rain sensor ignores inputs during parking signal periods.
OFF (transmits the manual operation mode signal to sensor)		The wiper motor rotates in low speed until it returns to parking position. When the system is in manual mode, the sensitivity of sensor will be set to 2(AUTO 2) internally. By doing so, immediate wiping with proper intervals is possible when a driver sets the system from OFF to AUTO.
AUTO 1 (low sensitivity)	**SLOW** ▲	Auto delay/auto speed control. Low sensitivity against rains on windshield. When the switch is in AUTo position, the sensor transmits the wiping request signal to STICS.
AUTO 2 (low/med sensitivity)		Auto delay/auto speed control. Low/medium sensitivity against rains on windshield.
AUTO 3 (medium sensitivity)		Auto delay/auto speed control. Medium sensitivity against rains on windshield.
AUTO 4 (med/hi sensitivity)		Auto delay/auto speed control. Medium/high sensitivity against rains on windshield.
AUTO 5 (high sensitivity)	▼ **FAST**	Auto delay/auto speed control. High sensitivity against rains on windshield.
LOW SPEED (transmits the manual operation mode signal to sensor)		The wiper motor rotates continuously in low speed of approx. 45 rev./minute(in the normal battery voltage). The rain sensor operations are same as in MIST.
HI SPEED (transmits the manual operation mode signal to sensor)		The wiper motor rotates continuously in high speed of approx. 70 rev./minute(in the normal battery voltage). The rain sensor operations are same as in MIST.

1. Rain detected headlamp: If it rains heavy which requires the highest INT speed (almost LOW), the headlamps are turned on automatically.

2. Night detected wiping: When the auto light control turns on the headlamps and the rain sensor detects the rain, the wiper sensitivity is automatically increased by one level in comparison with daytime.
   (i.e. the AUTO wiper switch is at the 3rd level, but the wiper operates at the 4th level.)

PARKING AID SYSTEM

8790-01

GENERAL

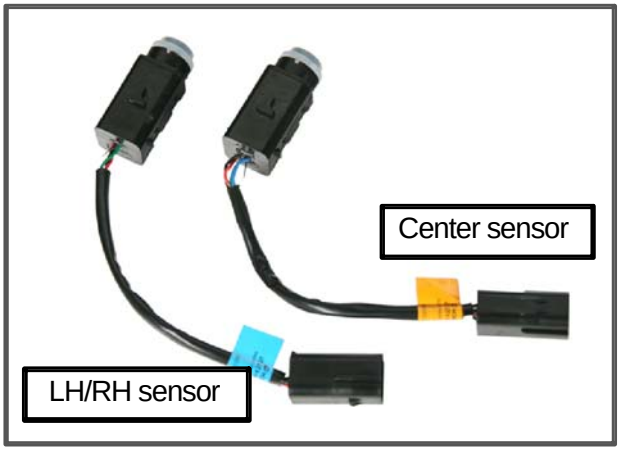
1. COMPONENT SPECIFICATIONS

The PAS (parking aid system) emits the ultrasonic wave signals from the sensors on the rear bumper at a specific interval
and detects the reflected signals from obstacles when reversing. The alarm interval increases as the obstacle approaches.
This supplementary system is useful to measure the distance when parking.

Item		Value	Item		Value
Rated voltage		DC 12 V	Operating temperature		−30˚C ~ +80˚C
Operating voltage		DC 9 V ~ 16 V	Storage temperature		−40˚C ~ +85˚C
Current consumption	Unit	100 mA or less	Relative humidity		95% RH max
	Sensor	20 mA or less (each)	Weight	Unit	72 ± 10 g
				Sensor	40 ± 5 g

▶ **Parking Aid Unit**

▶ **Parking Aid Sensor**



- Detecting type: Ultrasonic wave (Piezo ceramic element)
  Calculates the distance between the sensor and the object by calculating the return time of the emitted the ultrasonic wave
  Frequency used: 50 KHz ± 1 KHz
- Detection distance: 30 cm ~ 120 cm
- (based on lineal distance between sensor and obstacle)
  Tolerance: ± 10 cm
- Sensor detection range (at -6 dB)
-

2. CAUTIONS

- Note that the display does not show everything in the rear area. Always check nobody, especially animals and children, is behind the vehicle when parking or reversing.
- If you can not properly check the vehicle behind, get out of the vehicle and then visually check it. The parking aid system is just a supplemental device to help your parking.
- Always keep the safety precautions.
- Do not press or shock the sensors by hitting or using a high-pressure water gun while washing,
- since it may damage the sensors.
  If the system is in normal operating condition, a short beep sounds when the shift lever is moved into
- "R" position with the ignition key "ON".

▶ **The parking aid system will not work or improperly work under following cases:**

1. Certain obstacles that sensors can not detect
   - Thin and narrow objects, such as wires, ropes, chains
   - Cotton, sponge, clothes, snow; that absorb ultrasonic waves
   - Obstacles lower than the bumper (ex. drain ditch or mud puddle)

2. Not defective but improperly working
   - When the sensing portion is frozen (operates normally after thawed)
   - When the sensing portion is covered by rain, water drops, snow or mud (operates normally after cleaned)
   - When receiving other ultrasonic signals (metal sound or air braking noises from heavy commercial vehicles)
   - When a high-power radio is turned on

3. Narrowed sensing area
   - When the sensing portion is partially covered by snow or mud (operates normally after cleaned)
     Surrounding temperature of sensor is too high (approx. over 80°C) or too low (approx.
   - below −30°C)

4. Not defective but may cause malfunction
   - When driving on the rough roads, gravel road, hill and grass
   - When the bumper height is changed due to heavy load
   - When the sensing portion is frozen
   - When the sensing portion is covered by rain, water drops, snow or mud
   - When receiving other ultrasonic signals (metal sound or air braking noises from heavy commercial vehicles)
   - When a high-power radio is turned on
   - When some accessories are attached in detecting ranges

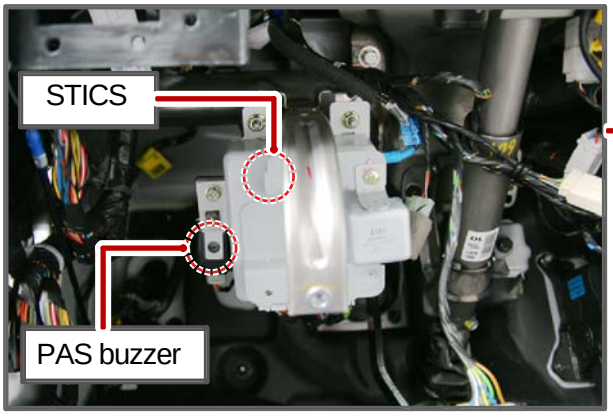
Modification basis	
Application basis	
Affected VIN	

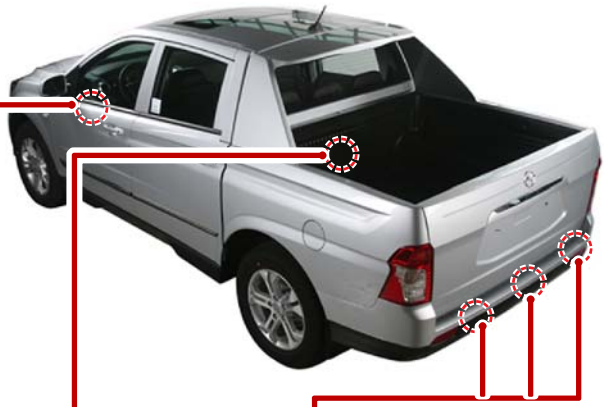
OVERVIEW AND OPERATING PROCESS

1. GENERAL INFORMATION

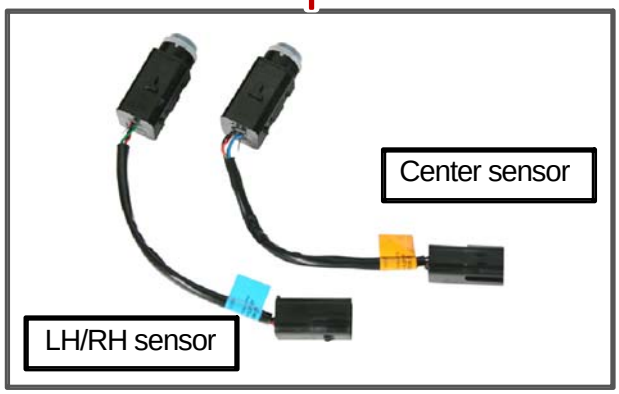
1) Components and Function

The parking aid system uses three piezoelectric ceramic sensors inside the rear bumper to measure the vertical and horizontal distances to the obstacles. The parking aid system has a separate unit that sends signal to the buzzer when reverse parking to notify the driver of the distance to obstacle. When placing the gear selector lever to "R" position, this unit activates the sensor to measure the distance between the object and the bumper. The existing PAS unit displays the malfunctions using the LED when there are any defects in sending/receiving signal or the open circuit to sensor. On the other hand, the PAS unit of KORANDO SPORTS informs the malfunction of the relevant sensor using a buzzer.





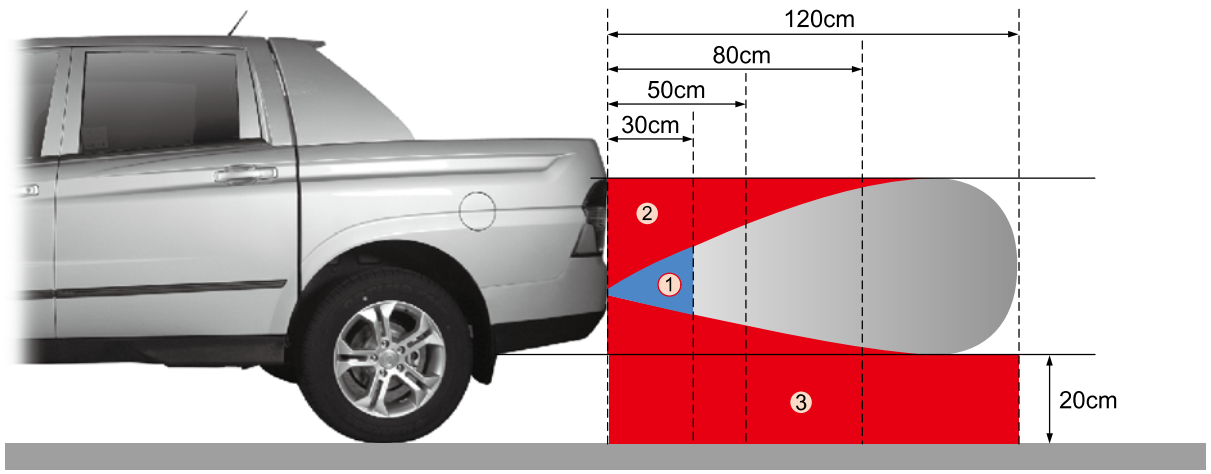
Parking Aid Unit



2. ALARM INTERVAL

1) Sensing Distance and Range

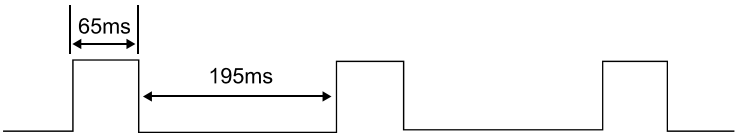
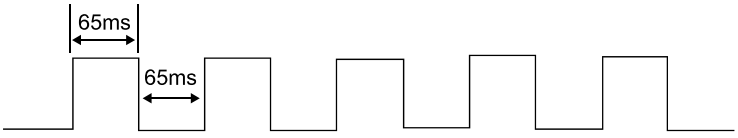
Sensor detection range



NOTE

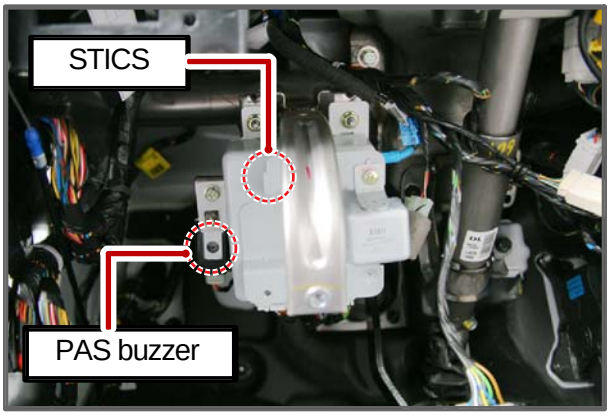
- Within 20 cm from the ground (Intrinsically, supersonic wave sensors may not detect obstacles within 20 cm from the ground)(Area 1)
- Obstacles may not be detected within 80 cm from the sensor(Area 2)
- Sensor may not detect zone within 30 cm from the rear bumper (Area 3)

While reversing, if obstacles are within stage 1, the warning beep sounds with long intervals. If within stage 2, the warning beep sounds with short intervals and if within stage 3, the warning beep sounds continuously.

Stage	L, R, C	Alarm interval
Stage 1	80 ~ 120cm	
Stage 2	50 ~ 80cm	
Stage 3	30 ~ 50cm	
Tolerance	± 10cm	

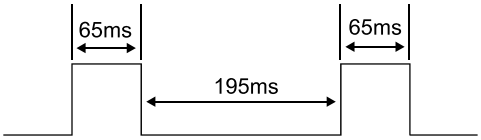
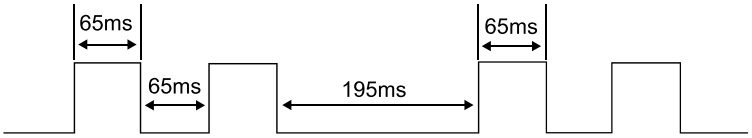
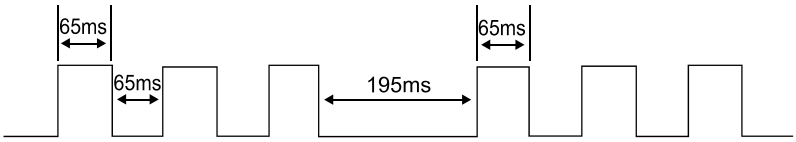
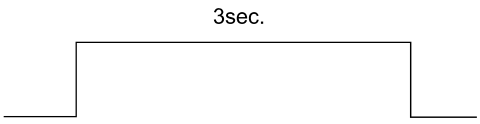
Modification basis	
Application basis	
Affected VIN	

2) Troubleshooting



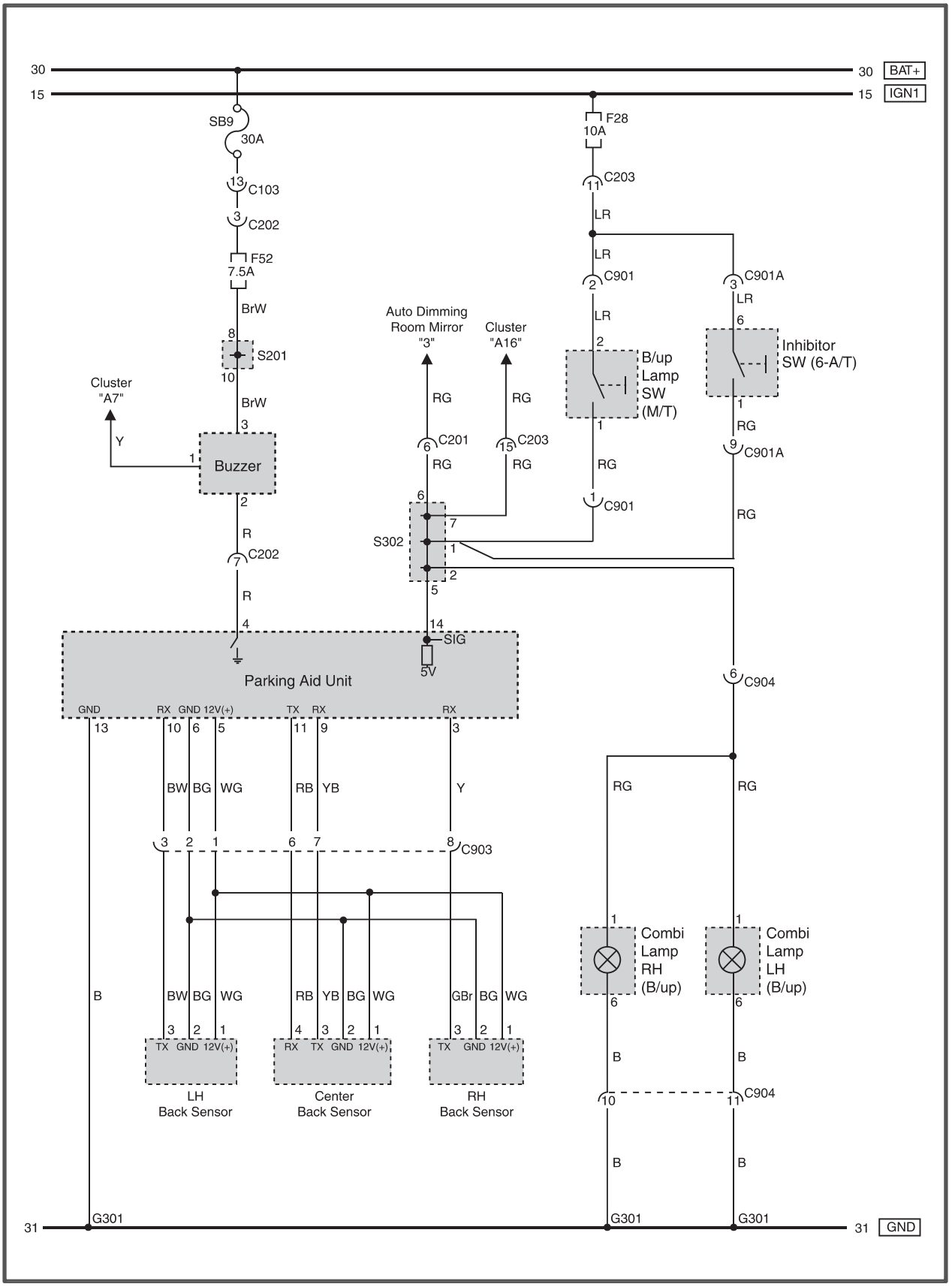
When the ignition switch is in IGN1 position (shift lever is in "R" position), the sensor will be diagnosed once. If any malfunction due to an open circuit in sensor or an error in sending/receiving signals, the system warns the driver with audible buzzer sound. If it is normal, the warning buzzer sounds for 65 ms.

※ When the sensor failed in self-diagnostics

Malfunction mode	Buzzer sound interval	Remark
L		
C		
R		
2 or more sensors faulty		

Modification basis	
Application basis	
Affected VIN	

3. CIRCUIT DIAGRAM



Modification basis	
Application basis	
Affected VIN	

AUDIO SYSTEM

0000-00

GENERAL INFORMATION

1. SPECIFICATION

Unit	Description	Specification
General	Rated voltage	DC 14.4 V
	Operating voltage	10.8 ~ 16.0 V
	Operating temperature	−20˚C ~ 70˚C
	Storage temperature	−40˚C ~ 80˚C
Radio	Frequency range	FM: 87.5 ~ 108 MHz (50 kHz STEP) MW: 522 ~ 1620 kHZ (9 kHz STEP) LW: 144 ~ 290 kHz (1 kHz STEP)
	Channels	FM1: 6, FM2: 6, MW: 6, LW: 6
Performance	Speaker output	45 W/CH (4Ω)
	Speaket impedence	4Ω
	Current consumption	below 5 A, max. 10 A
	Parasitic current	below 3 mA
Bluetooth	Performance	HFP A2DP.AVRCP
	Configuration	MD-5XR
	Technology	Bluetooth 2.0 + EDR
LCD	Operating voltage	9.0 V
	Operating temperature	−30˚C ~ 75˚C
	Storage temperature	−40˚C ~ 80˚C
	DOT	132 x 36
Micro-pole antenna	Operating current	up to 150 mA
	Operating voltage	DC 10.5 ~ 16.0 V
	Operating temperature	−30˚C ~ 60˚C
	Storage temperature	−40˚C ~ 80˚C
	Input/output impedence	75Ω (FM)

2. CAUTIONS AND WARNING FOR SAFETY

CAUTION

- Ssangyong is not liable for any personal injury and material damage, caused by violation of traffic regulations or neglect of observing actual traffic and driving situations.
- Colors on display figures in this manual may differ from actual display due to publication concerns.

WARNING

- Do not disassemble or modify this system.
  If doing so, it may cause an accident, fire or electric shock.
- Do not use the system if it is malfunctioning (sound or video output problem).
  Doing so may lead to an accident or electric shock.
  Please contact a Ssangyong service dealer immediately.
- The system should be used only when the engine is started.
  Using the system for an extended period of the with the engine off may discharge the battery.
  Do not leave beverages or foreign materials around the system.
- If they enter the system, they may cause a fire.
  The system may break down if a disc not supported by this system is inserted.
- Do not apply impact to or drop this system.
- It might cause malfunction.
- Never leave the system in a hot or cold place for an extended period of time. Therefore, do not park the vehicle in a hot or cold place. The ambient temperature should be −30℃ ~ +80℃ for proper operation.

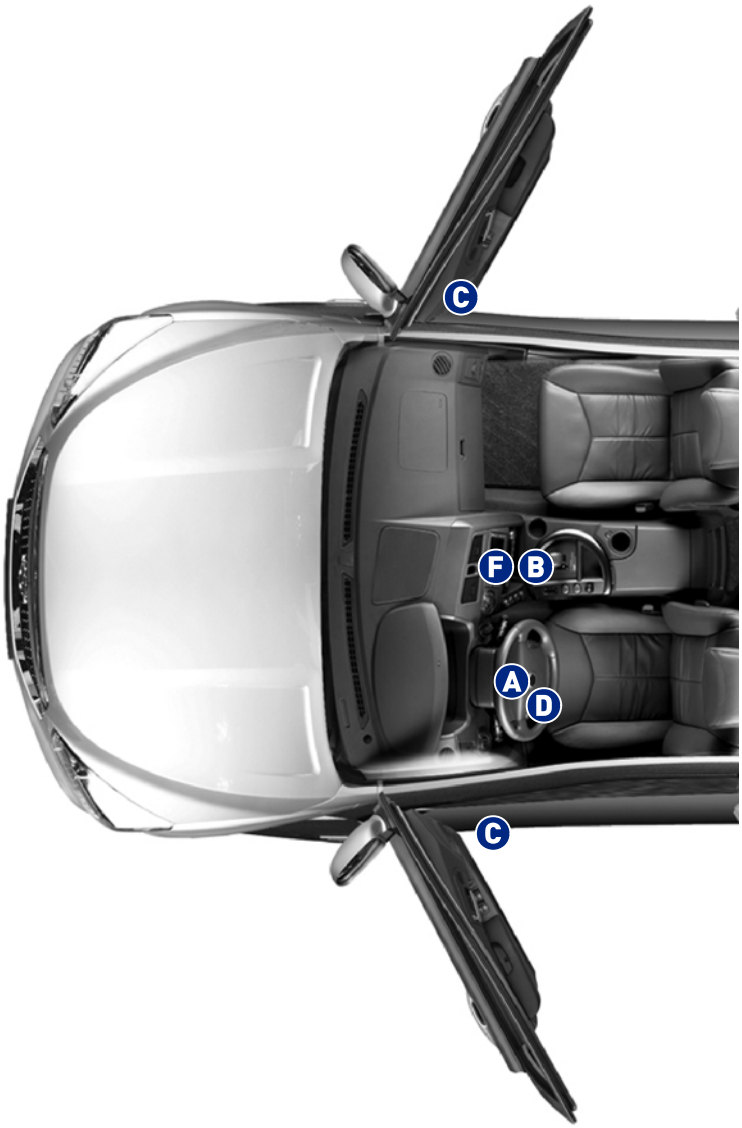
Modification basis	
Application basis	
Affected VIN	

Memo

OVERVIEW AND OPERATING PROCESS

1. LAYOUT

A Remote contro switches on steering wheel



B USB & AUX module

C Front door speaker

D Handsfree microphone

Modification basis	
Application basis	
Affected VIN	

H Micro-pole antanna

G Rear door speaker

F Audio

2. SWITCH

No.	Name and Function
1	RDS setup
2	AF/TA selection
3	Start call
4	USB, AUX, CD selection
5	Power (ON/OFF), Mute, Volume
6	Preset key #1, Intro SCAN
7	Preset key #2, RPT
8	Preset key #3, Random
9	Preset key #4, folder down
10	Preset key #5, folder up
11	Preset key #6, File guide
12	AST, SCAN, TUNE UP/DOWN
13	Eject
14	End call
15	Set
16	Band
17	LCD window

Modification basis	
Application basis	
Affected VIN	

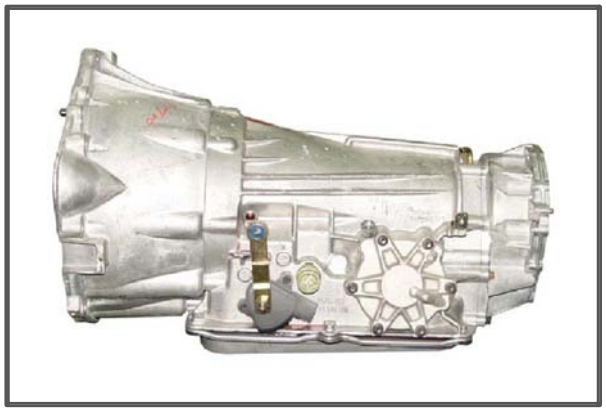
DSI 6 A/T

3680-01

GENERAL

1. GENERAL INFORMATION

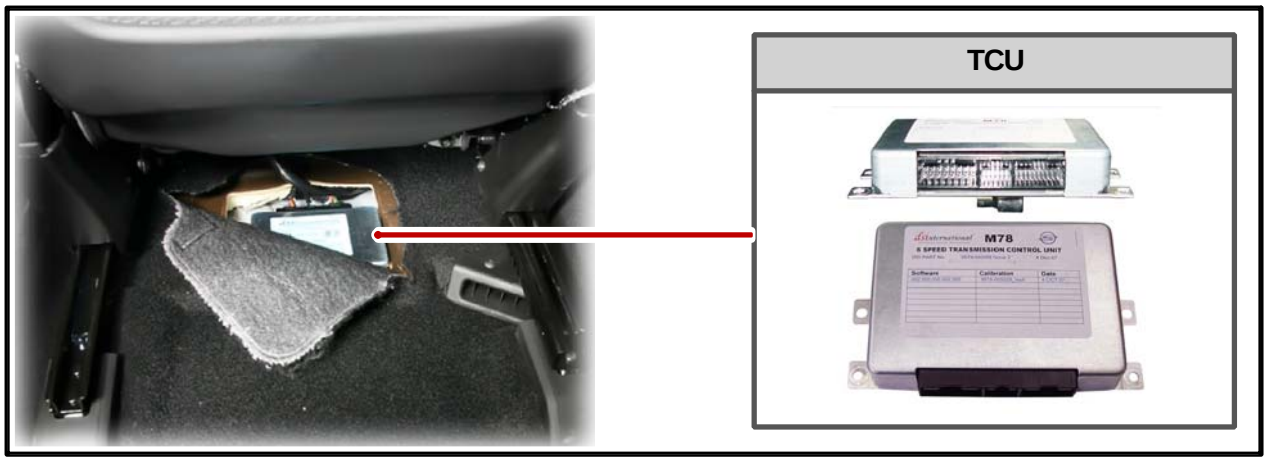
▶ **Automatic transaxle (DSI M78)**



- Six forward speeds
- One reverse gear
- A toruqe converter with an integral converter lock-up clutch
- Electronic shift and pressure controls
- A single planetary gear-set
- A double planetary gear-set
- Two hydraulically controlled brake bands
- Three multi-plate clutches
- All hydraulic functions are directed by electronic solenoids to control

▶ **TCU**

TCU is located under the driver's seat and controls the operations of transmission.
TCU receives the ignition voltage and has three connectors (16-pin, 12-pin, 20-pin).
TCU receives input signals from certain transmission-related sensors, gear select lever and inhibitor switch. TCU also uses these signals when determining transmission operating strategy. TCU uses PCAN to communicate with other units. And, TCU communicates with engine ECU, ESP unit, TCCU and instrument cluster through CAN lines to control the gear shifting and to recognize the current gear position.



▶ Tip switch on steering wheel

Driving gear can be adjusted by operating the tip switch after moving the gear select lever in "M" position.

Shift down	Shift up

▶ Gear position display on instrument cluster

This indicator shows the current position of the gear.
In normal mode: P, R, N, D
Gear indication in "M" mode: 1, 2, 3, 4, 5, 6

Positions of gear select lever
P : Parking
R : Reverse
N : Neutral
D : Drive

▶ Gear select lever

Tip Switch in "M" Position (Manual Gear Shift)
The shiftable gear can be adjusted by moving this switch to forward and rearward when the gear select lever is in "M" position.

Mode Switch
W : Winter mode
S : Standard mode (Use the standard mode in normal driving conditions.)

Selection of Manual/ Automatic Shift Function
D : Automatic shift according to the driving condition
M : Manual shift

Shift Lock Release Button Hole when Locked in the "P" Position
If you cannot move the gear select lever from the "P" position, try to move the lever while pushing down here with a sharp object such as a ballpoint pen. For your safety, turn off the engine and depress the brake pedal before the attempt.

Modification basis	
Application basis	
Affected VIN	

2. FEATURES AND SPECIFICATIONS

1) Specifications

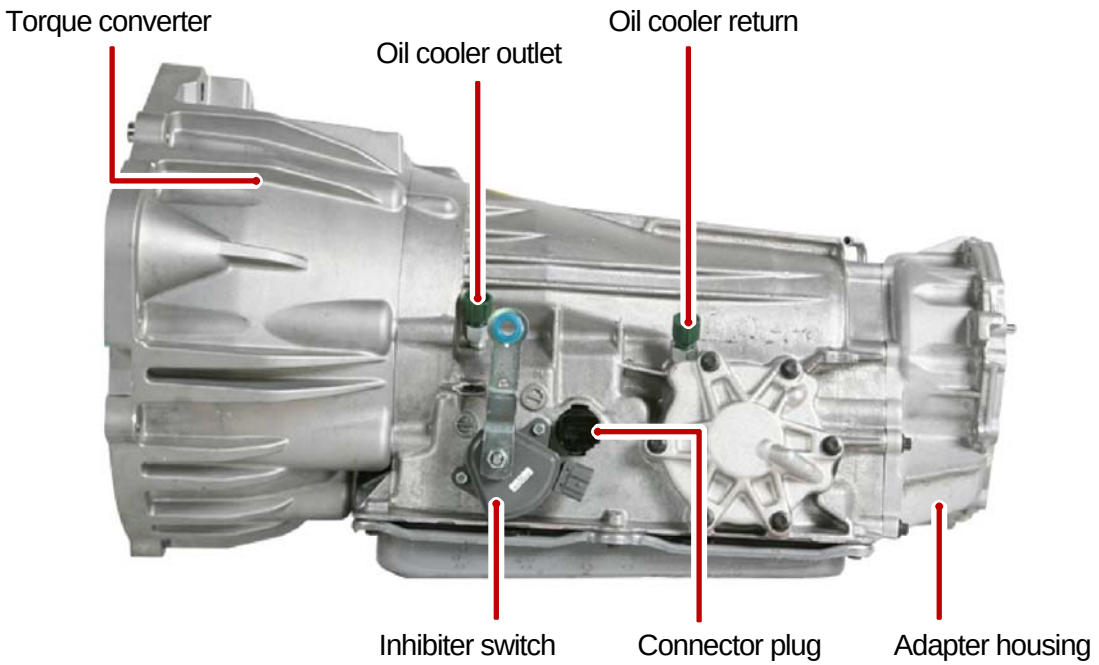
Description		DSI M78 (6-speed)	Remarks
Gear ratio	1st	3.53:1	
	2nd	2.14:1	
	3rd	1.48:1	
	4th	1.16:1	
	5th	0.87:1	
	6th	0.68:1	
	Reverse	3.09:1	
Transmission fluid	Fluid	Fuchs ATF 3292	
	Capacity	Approx. 9.5 L	
	Change interval	Check the fluid at every 30,000 km or 1 year, and change it if necessary.	Under the severe driving conditions, change the fluid at every 60,000 km.
Resistance of oil temperature sensor	-20	430.7 ~ 533.9 kΩ	
	0	146.8 ~ 175.7 kΩ	
	20	56.74 ~ 65.86 kΩ	
	100	3.201 ~ 3.399 kΩ	
Gear position sensor	1	-	
	2	-	
	3	-	
	D	2.686 kΩ ± 8%	
	N	5.036 kΩ ± 8%	
	R	8.953 kΩ ± 8%	
	P	16.786 kΩ ± 8%	

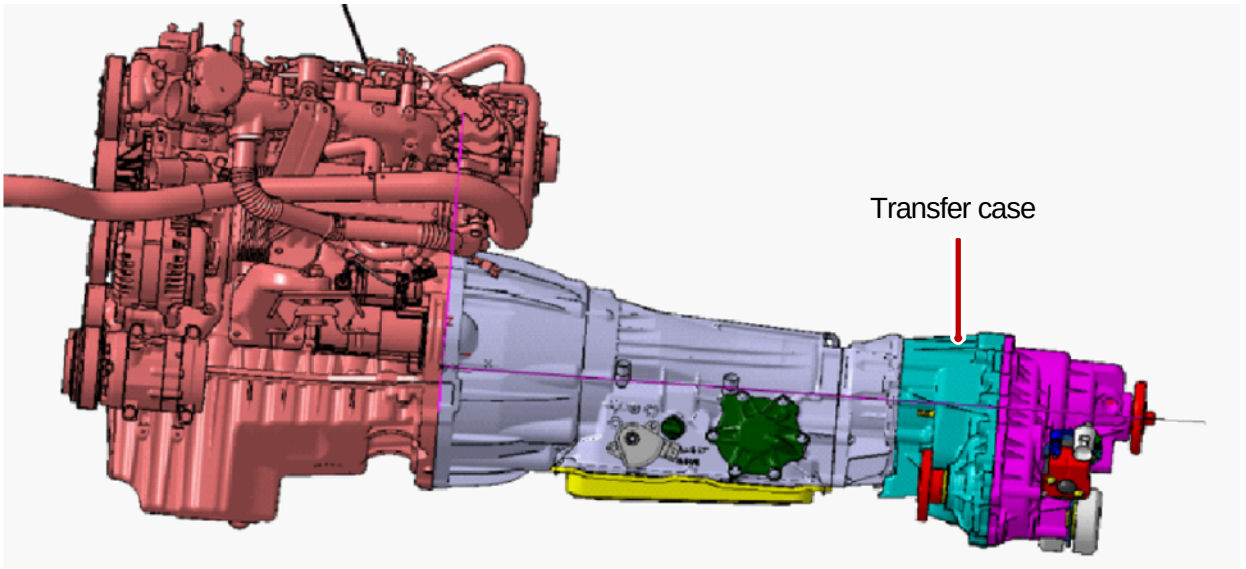
* **Severe driving conditions?**

- Towing a trailer or off-road driving (Inspect the leak of fl uid at any time, occasionlly)
- Taxi, patrol service or delivery service (extended idling and excessive driving with low speed) Frequent stop-and-go traffi c, extended idling,
- short driving distance
- Driving in a hilly or mountainous terrain, sandy, or dusty area
- Driving frequently at high speed over 170 km/hour
- Driving frequently in area where heavy traffi c under the ambient temperature above 32°C

2) Appearance

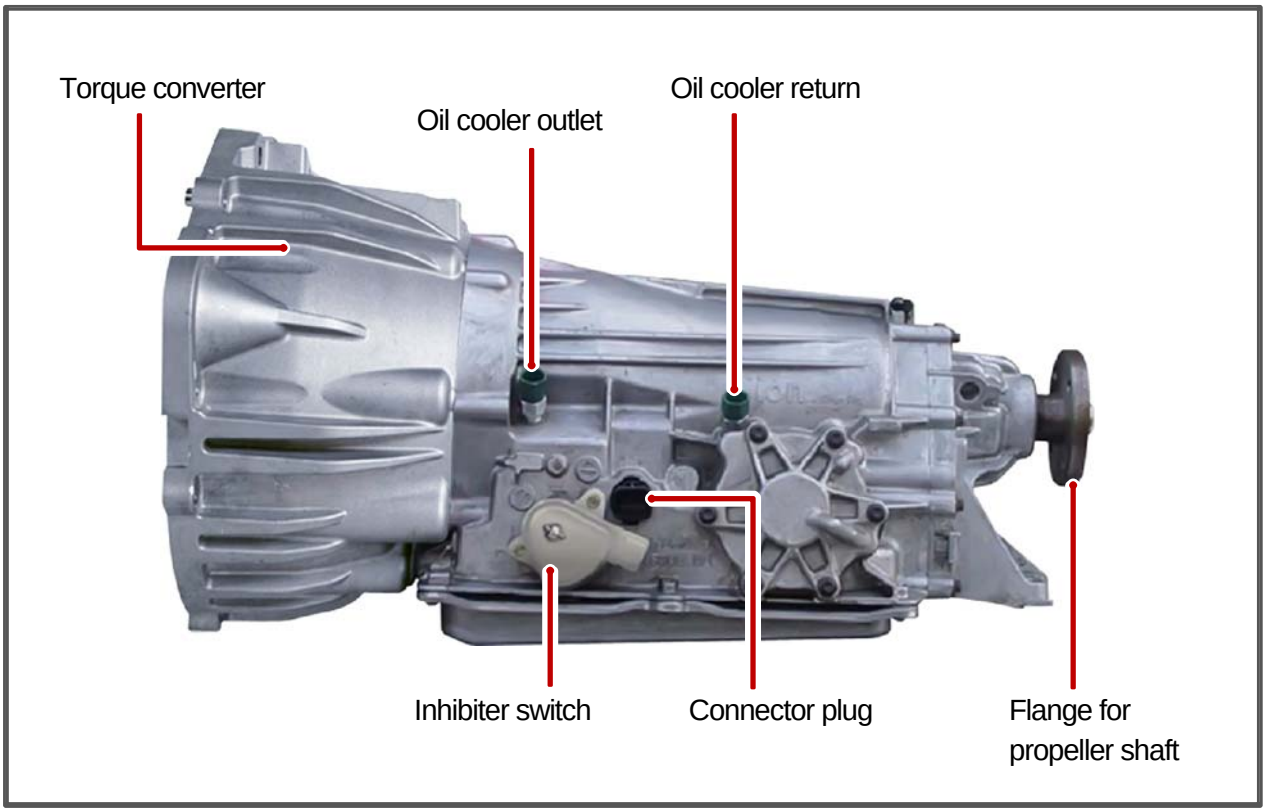
▶ **4WD Automatic Transmission**

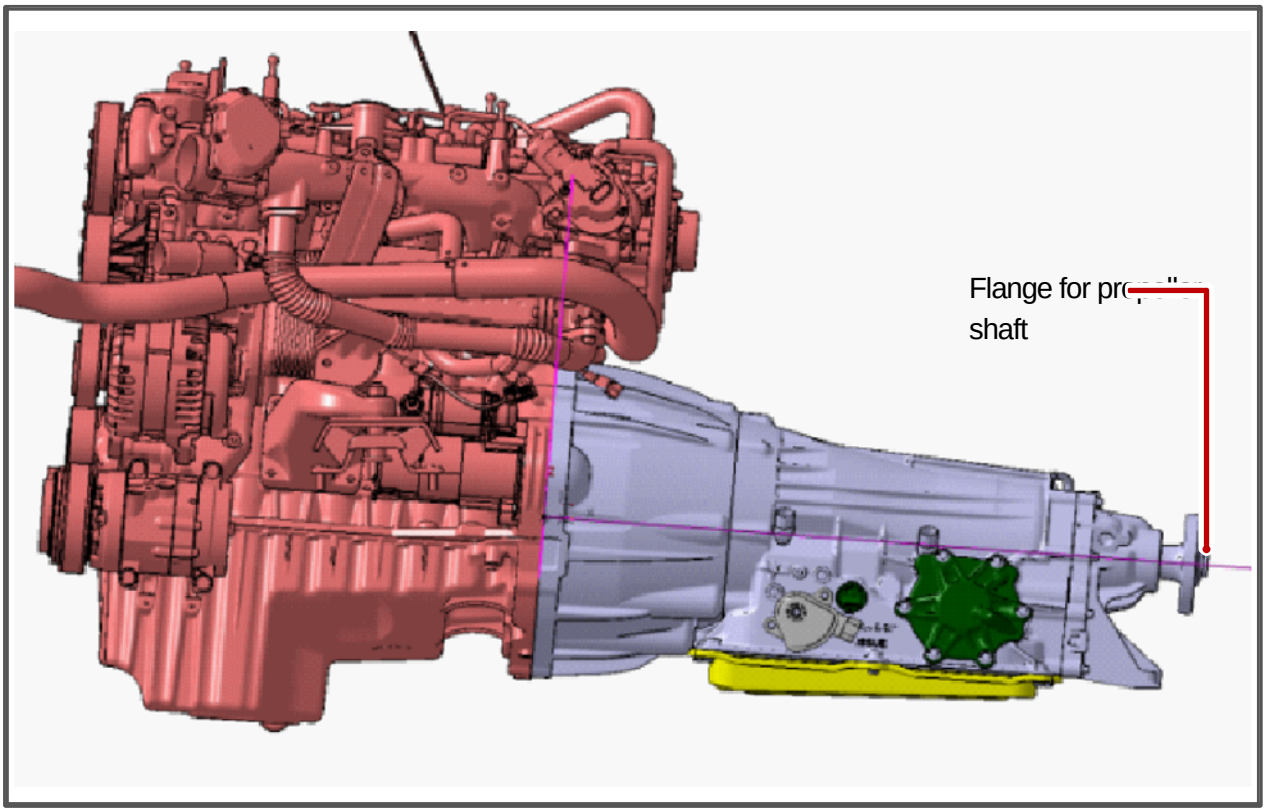




Modification basis	
Application basis	
Affected VIN	

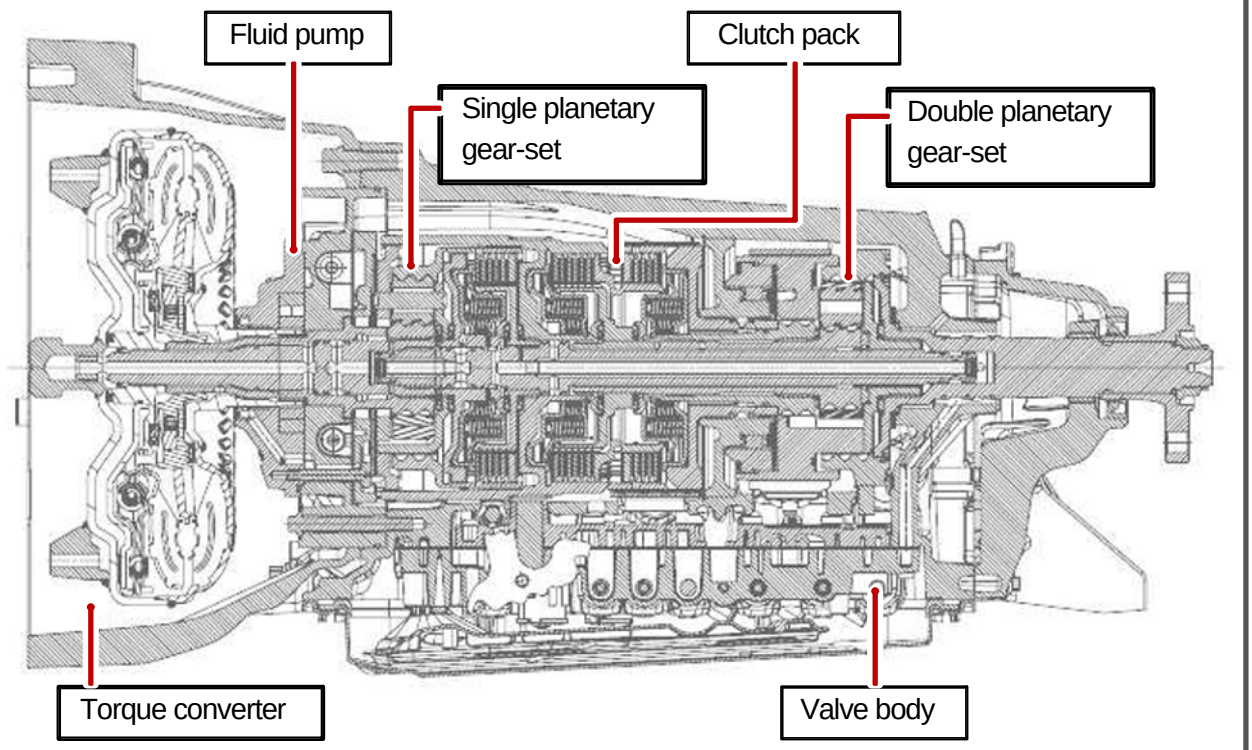
▶ 2WD Automatic Transmission



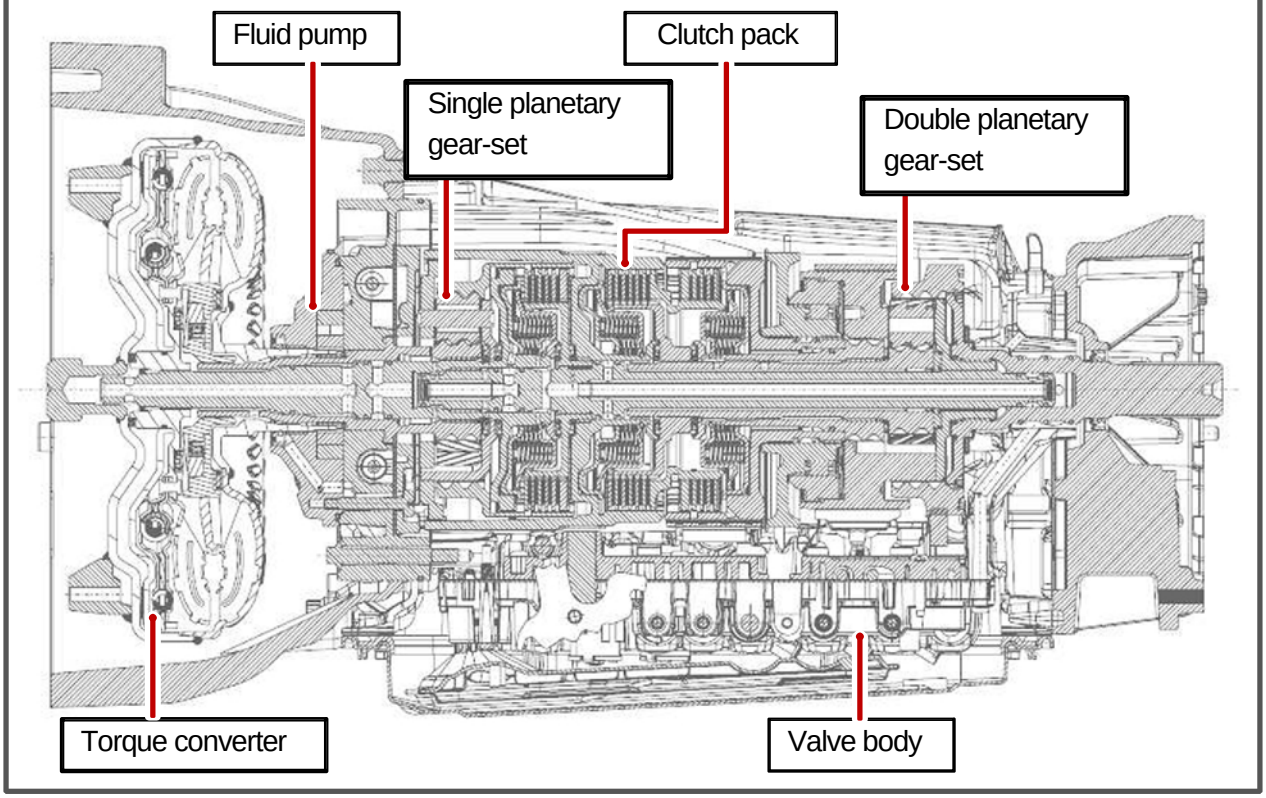


3) Sectional Diagram

4WD



2WD

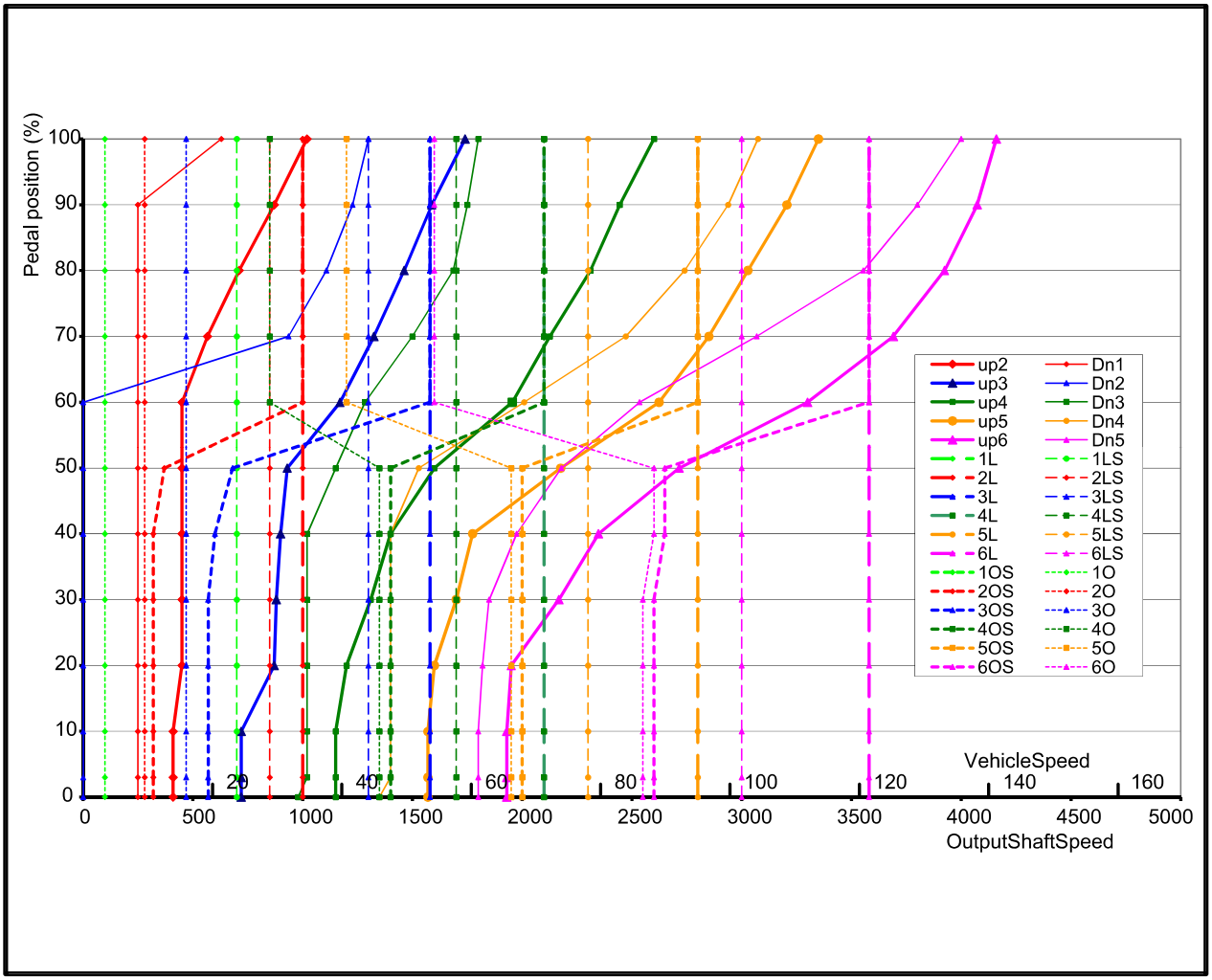


Modification basis	
Application basis	
Affected VIN	

3. TIGHTENING TORQUE

Description	Size x Numbers	Tightening torque
Transfer case housing	M12 x 32	54 ~ 68
Etension housing	M12 x 32	54 ~ 68
Oil pan	M6 x 16	4 ~ 6
Valve body to transmission housing	M6 x 26	8 ~ 13
Valve body to transmission housing	M6 x 45	8 ~ 13
Center support to transmission housing	M10 x 34	20 ~ 27
Output shaft locking nut	M24 x 15	100 ~ 110
Pump cover to oil pump	M8 x 55	24 ~ 27
Pump cover to transmission housing	M8 x 40	24 ~ 34
Pump cover to transmission housing	M8 x 58	24 ~ 34
Upper valve body to lower valve body	M6 x 30	15 ~ 17
Detent spring	M8 x 16	20 ~ 25
Variable bleed solenoid and speed sensor	M4 x 12	2.8 ~ 3.2
Transmission oil level plug		30 ~ 35
Front cooling lines to transmission cooler		25 ~ 35
Rear cooling lines to transmission cooler		25 ~ 35
Drive plate to torque converter		40 ~ 42
Gear select lever to shaft rod		14 ~ 20

4. SHIFT PATTERN DIAGRAM



Modification basis	
Application basis	
Affected VIN	

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

The six speed automatic (M78) transmission is available in two variants: four wheel drive and two wheel drive.
The transmission has the following features:

- Six Forward Speeds
- One reverse gear
- A torque converter with an integral converter lock-up clutch
- Electronic shift and pressure controls
- A single planetary gear-set
- A double planetary gear-set
- Two hydraulically controlled brake bands
- Three multi-plate clutches
- All hydraulic functions are directed by electronic solenoids to control:
  - Engagement feel
  - Shift feel
  - Shift scheduling
  - Modulated torque converter clutch applications

The transmission contains fully synthetic automatic transmission fluid (ATF) and is filled for life; therefore it does not require periodic servicing.
Engine power reaches the transmission via a torque converter with integral converter lock-up clutch. The six forward gears and one reverse gear are obtained from a single planetary set, followed by a double planetary set. This type of gear-set arrangement is commonly known as Lepelletier type gear-set.
The automatic transmission is electronically controlled. The control system is comprised of the following elements:

- External transmission control unit (TCU)
- Internal embedded memory module (EMM)
- Input and output speed sensors
- Valve body unit comprised of four on/off solenoid valves and six variable bleed solenoids
- Torque converter

2. FEATURES

1) Features

▶ Early Downshifts with Hard Braking and Skip Shifts

When heavy braking is detected, the transmission downshifts early and skips gears to provide increased engine braking to provide gear selection for tip-in.

▶ Gear Hold on Uphill/Downhill

If the accelerator pedal is released when travelling uphill, upshifts are prevented to reduce busyness on grades. If the accelerator pedal is released when travelling downhill, upshifts are prevented to enhance engine braking.

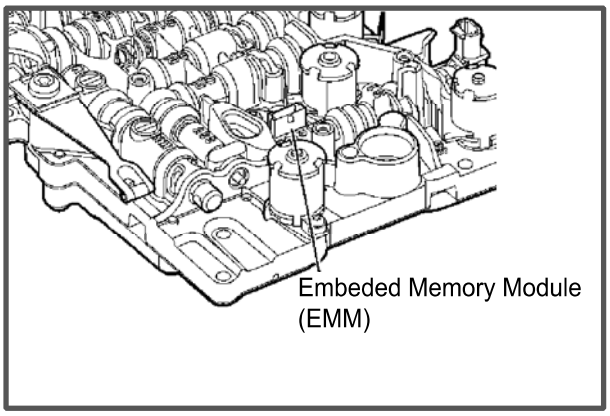
▶ Soft Engagement when Shifting to "D" and "R" Position

A soft engagement feature avoids harsh take up of drive when selecting Drive or Reverse. This is achieved by limiting engine speed and engine torque which results in a rapid, but progressive engagement of either Drive or Reverse when moving from the Park or Neutral positions. There is no drive engagement prevention strategy implemented on the transmission system as there is sufficient engine strategy to protect the system. However, reverse gear engagement is prevented until engine speed is less than 1400 rpm and the accelerator pedal position is less than 12% and vehicle speed is less than 10 km/h.

▶ Converter Clutch Lock-Up In All Gears

The transmission features converter clutch lock-up in all gears. This feature provides improved fuel economy and vehicle performance. It also improves transmission cooling efficiency when towing heavy loads at low speeds, e.g. in city driving or hill terrain.

▶ Embeded Memory Module (EMM)



The embedded memory module (EMM) is matched to the transmission's valve bodies during transmission assembly to ensure refined shift quality. The EMM is integrated into the input speed sensor which is mounted on the valve body in the transmission. The EMM is used to store data such as valve body calibration data and valve body serial number. Upon installation, the TCU will download the data from the EMM and utilise this data in the operation of the transmission.

Modification basis	
Application basis	
Affected VIN	

2) Cooling System

The transmission cooling system ensures rapid warm-up and constant operating temperature resulting in reduced fuel consumption and refined shift quality.
It also includes a cooler by-pass within the hydraulic system to allow sufficient cooling and lubrication to the transmission drivetrain in the event of a blockage in the transmission cooler.

3) Shift Strategy

▶ Gear Shift

Transmission gear change is controlled by the TCU. The TCU receives inputs from various engine and vehicle sensors to select shift schedules and to control the shift feel and torque converter clutch (TCC) operation at each gear change

▶ Coastdown

Coastdown downshifts occur at 0% accelerator pedal when the vehicle is coasting down to a stop. To reduce the shift shock and to improve the shift feeling during downshift, TCU electronically controls the transmission.

▶ Torque Demand

Torque demand downshifts occur (automatically) when the driver demand for torque is greater than the engine can provide at that gear ratio. If applied, the transmission will disengage the TCC to provide added acceleration.

3. MODE DESCRIPTIONS

1) Functions

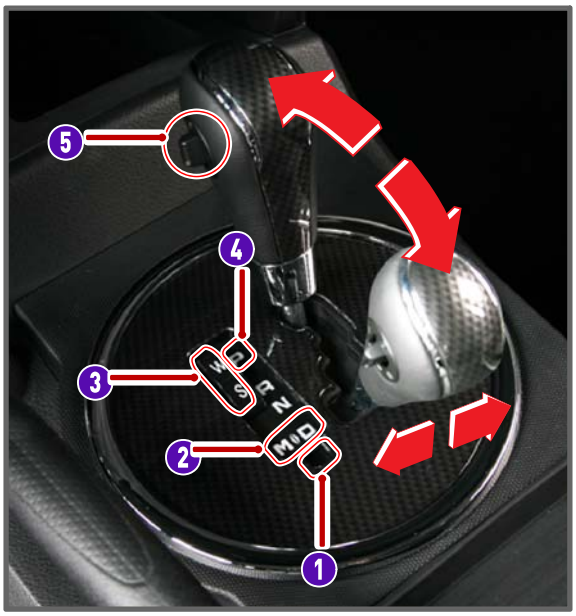
1. **Shift Lock Release Button Hole when Locked in the "P" Position (1)**
   If you cannot move the gear select lever from the "P" position, try to move the lever while pushing down here with a sharp object such as a ballpoint pen. For your safety, turn off the engine and depress the brake pedal before the attempt.

2. Selection of Manual/Automatic Shift Function (M↔D) (2)
   D : Automatic shift according to the driving condition
   M : Manual shift

3. **Mode Switch (3)**
   W : Winter mode (Start off the vehicle in 2nd gear)
   S : Standard mode (Use the standard mode in normal driving conditions.)

4. **Gear Position (4)**
   P : Park
   R : Reverse
   N : Neutral
   D : Drive

5. Tip Switch in "M" Position (Manual Gear Shift) (5)
   The shiftable gear can be adjusted by moving this switch to forward and rearward when the gear select lever is in "M" position.



Modification basis	
Application basis	
Affected VIN	

2) Mode “M” (Manual Shift Mode)

This allows the driver to define the highest possible gear by selecting "+" or "-" on the gear selector when the lever is in the "M" position. When the lever is first moved to the manual "M" position the transmission will select the lowest possible gear.
When maximum engine rpm is reached the transmission will upshift automatically regardless of the driver selected limit. 4WD models with low range will not automatically upshift when low range is selected.

NOTE

Kickdown Function
If you need to accelerate rapidly, depress the accelerator pedal completely to the floor.
Then, a one- or two-lever gear will automatically be engaged. This is called the Kickdown function.

▶ **1st gear position**

- Use on a rugged road, mountain path and steep hill. Engine braking effect on steep hill is available.

▶ **2nd gear position**

- Use on a long and gentle slope. 2-1 automatic kickdown shift is available. Engine braking effect is available.

▶ **3st gear position**

- Use on a long and gentle slope. 3-2 and 2-1 automatic kickdown shift is available. Engine braking effect is available.

▶ **4th gear position**

- Use on a long and gentle slope. 4-3, 4-2 and 4-1 automatic kickdown shift is available.

▶ **5th gear position**

- 5-4 and 5-3 automatic kickdown shift is available.

▶ **6th gear position**

- 6-5 and 6-4 automatic kickdown shift is available.

4. LIMP HOME MODE

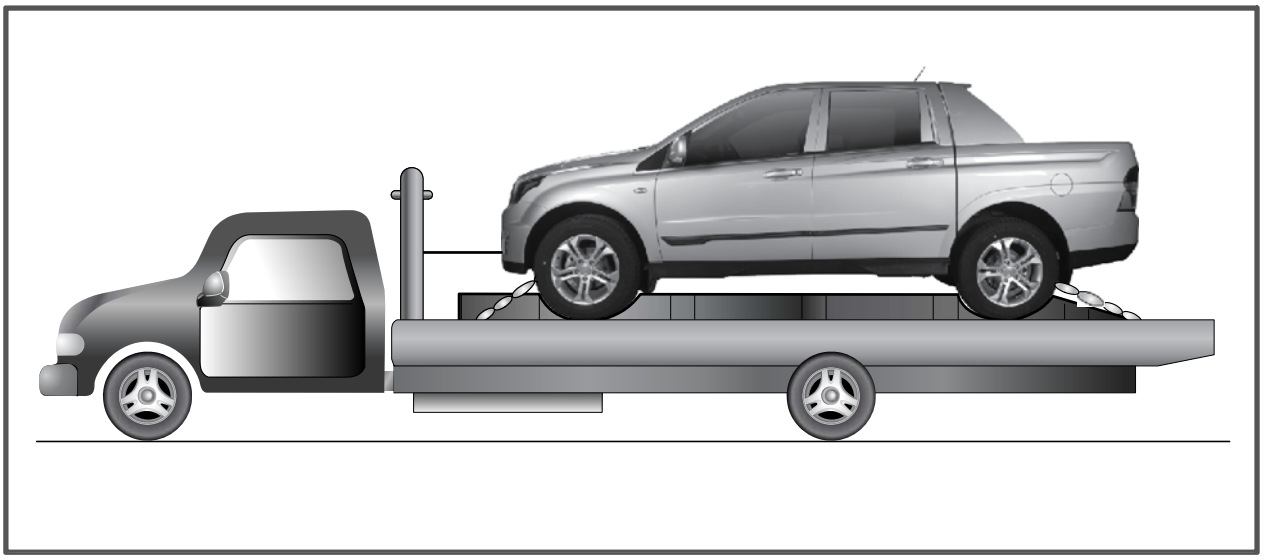
▶ In case of transmission malfunction

1. If a serious fault occurs in the automatic transmission, the TCU enters the limp home mode to secure safe driving and protect the automatic transmission.
2. As power is no longer supplied to the solenoid, the current basic function (P, R, N, D) is maintained and the 4th gear can be maintained only by the operation of the hydraulic system without electrical operation.
3. The ECU communicates with other electric modules with CAN. If a serious fault occurs, the transmission automatically enters the limp home mode for service.
4. The TCU monitors all factors which can affect to the performance of the transmission and diagnose the system according to OBD II regulation.

▶ In case of overheated transmission

1. The TCU enters the limp home mode when the batter voltage drops below 8 V.
2. If the transmission is overheated, the shift pattern is changed to the hot mode to cool the transmission more efficiently.
3. While the transmission is overheated, the selector lever symbol and engine temperature warning lamp on the instrument cluster blink until the transmission is cooled down to the normal operation temperature. If the transmission is excessively overheated, the gear cannot be shifted but remains in the neutral position.

▶ Towing the vehicle with A/T



CAUTION

The best way to transport the vehicle is to load it to a truck and transport it, especially if the vehicle is 4WD.

- If towing the vehicle with the propeller shaft connected, the transmission or oil pump of transfer case may malfunction, resulting in internal damage due to poor lubrication.

Modification basis	
Application basis	
Affected VIN	

5. ELECTRONIC CONTROL SYSTEM

1) Overview

The transmission control unit (TCU) and its input/output networks control the operations of transmission:

- Shift timing
- Line pressure
- Clutch pressure (shift feel)
- Torque converter clutch

In addition, the TCU receives input signals from certain transmission-related sensors and switches. The TCU also uses these signals when determining transmission operating strategy. Using all of these input signals, the TCU can determine when the time and conditions are right for a shift, or when to apply or release the torque converter clutch. It will also determine the pressure needed to optimise shift feel. To accomplish this, the TCU operates six variable bleed control solenoids and four ON/OFF solenoids to control the operations of transmission.

2) Transmission Control Unit (TCU)

The transmission control unit (TCU) is mounted under the driver's seat and controls the operation of the transmission.
TCU processes the analog information from the internal sensors and the digital information through CAN communication lines. TCU monitors all the input and output signals. If there is any failure, TCU changes the system to "Limp Home Mode" and alerts to the driver through the warning lamp on the instrument cluster.

(1) Hard-wired (Analog) Input/Output

▶ **Input/Output Data between TGS Lever and TCU**

- Position and conditions of gear select lever
- Driving moded (Winter or Standard)

▶ **Input/Output Data between Inhibitor and TCU**

- Position of inhibitor switch

▶ **Input/Output Data between Automatic Transmission and TCU**

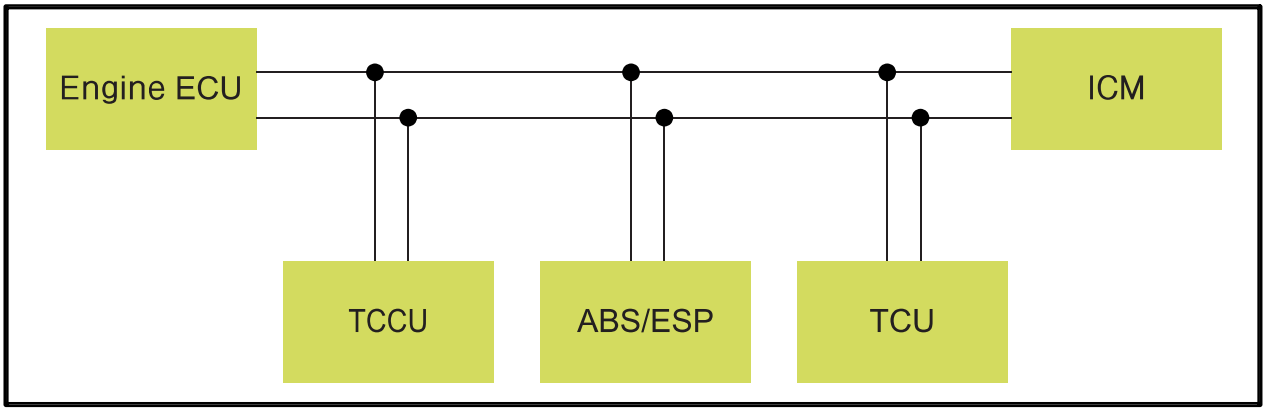
- 6 control signals for variable bleed solenoid
- 4 control signals for ON/OFF solenoid
- Transmission input speed
- Transmission output speed
- Transmission oil temperature
- EMM (Embeded Memory Module)

▶ **Input/Output Data between Self Diagnostic Connector and TCU**

- Various DTC codes and TCU information

(2) CAN Input/Output

TCU receives and sends the data among the units through P-CAN communication.

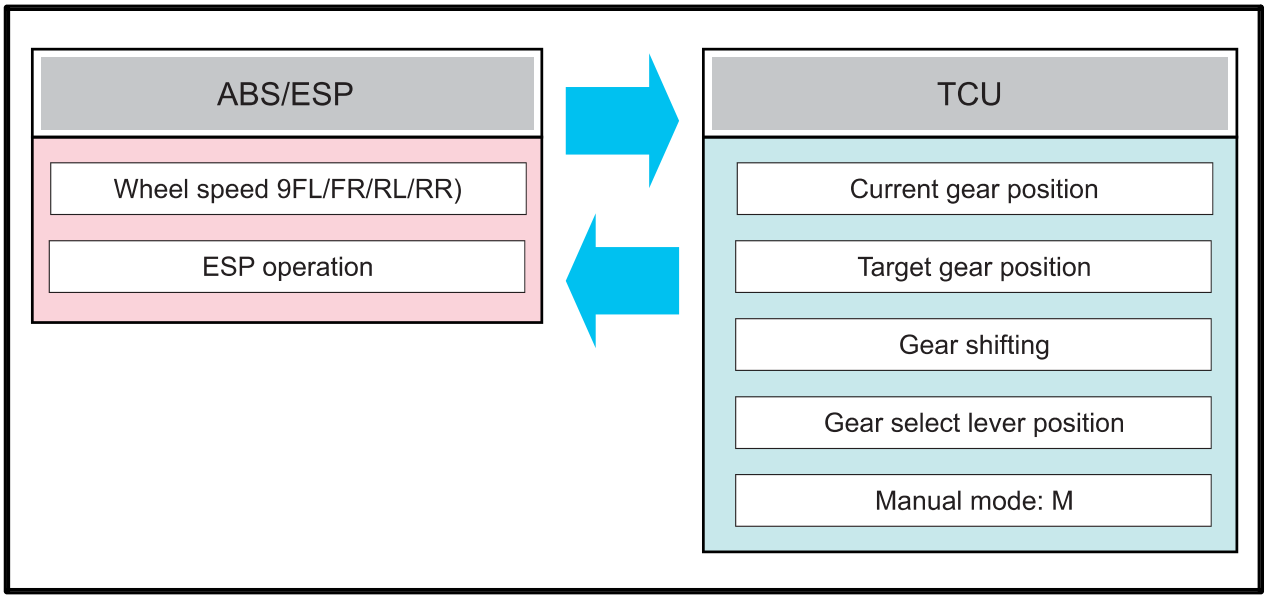


▶ **CAN Input/Output Data between Engine ECU and TCU**

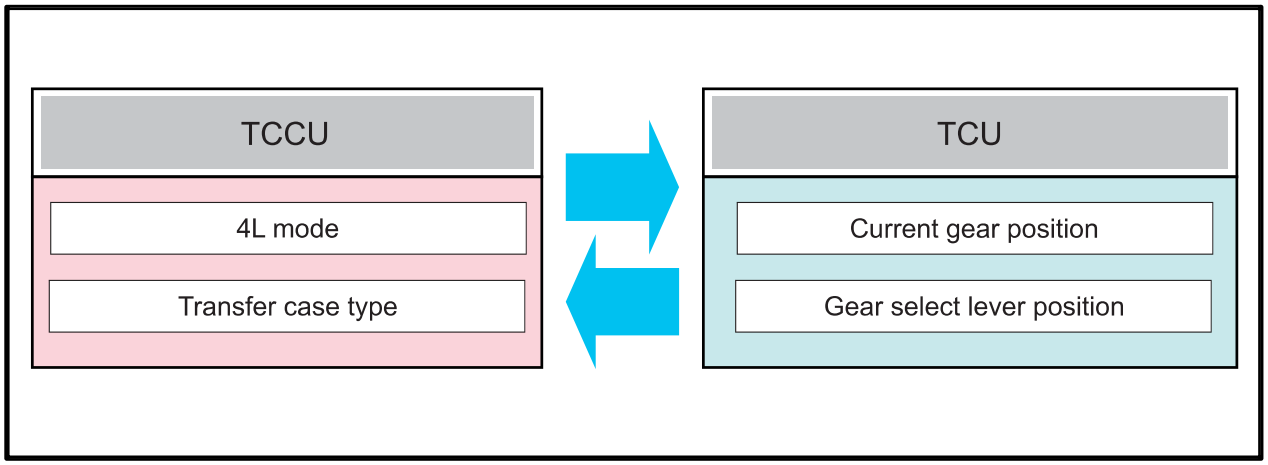
Engine ECU	TCU
Accelerator pedal position	Engine torque (including max/min)
Shift level request	Current gear position
Engine limp home mode	Target gear position
Accelerator pedal sensor error	Torque converter lock up
Cruise control ON	Gear shifting
Requested torque from ESP	Torque request in safety mode
Engine rpm	Engine torque control
Engine torque (including max/min)	Software calibration ID and gear select lever position
Vehicle speed	Failure and error
Stop lamp ON/OFF	Turbine speed of torque converter
Engine coolant temperature	Drive position
Intake air temperature	Driving mode program (Winter or Standatd)
	Transmission oil temperature

Modification basis	
Application basis	
Affected VIN	

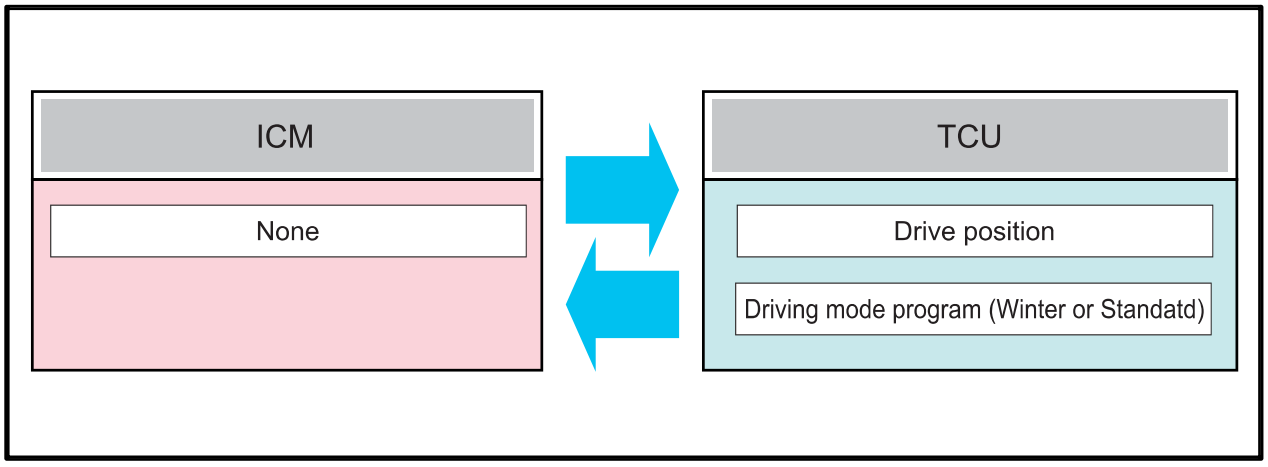
▶ CAN Input/Output Data between ABS/ESP and TCU



▶ CAN Input/Output Data between TCCU and TCU



▶ CAN Input/Output Data between ICM and TCU



3) Transmission Control Monitoring System

TCU monitors all input and output signals to identify possible failures. If a fault is detected, TCU activates the safety mode to keep the driver's safety and the life span of transmission.

▶ Monitoring the Supply Voltage

If the battery voltage is too high or too low, the TCU sets the DTC.

▶ Monitoring the Supply Voltage to Solenoid

TCU monitors the circuits for open or short to ground or supply. The monitoring function evaluates the voltage characteristics while the switch is ON.

▶ Monitoring the Gear Ratio

TCU monitors the gear is engaged properly in the allowed time.

▶ Monitoring the Torque Converter

TCU checks if the torque converter can be locked up properly. If it is failed, TCU releases the torque converter clutch to activate the fail-safe operation.

4) Shift Energy Management

This function involves reducing or increasing the engine output torque during shifting. This reduces the energy which is dissipated in the friction elements of the transmission during up-shift. This is done by reducing the engine torque during the gear ratio change without interrupting the tractive drive.
This function is used for:

- Increasing the life span of transmission by shortening the slipping time
- Improving the shift comfort by reducing the step changes due to gearshift
- Transferring a higher engine power

Real-time control of engine torque is required to maintain the proper shift operations and the durability of transmission. TCU controls the engine torque during the gearshift by synchronizing the operation of transmission clutches.

▶ **Pressure Modulation**

To provide a higher level of shift comfort and durability, the hydraulic pressure in the shift related friction elements of the transmission must be matched accurately to the input torque to transmission. This hydraulic pressure is composed of a hydraulically pre-set basic pressure and a control pressure which is set by one of the variable bleed solenoids.

The transmission input torque can be directly calculated from the following operating parameters:

- engine torque signals
- engine speed or any signal transmitted from ECU through CAN lines
- converter slip

Separate pressure characteristics for each gear change make it possible to adapt precisely to the particular shift operation.

5) Shift Mode Selection by TCU

The driver can select Standard (S) or Winter mode (W) with the mode switch. TCU automatically changes the shift mode according to the transmission oil temperature, uphill or downhill gradient, and altitude to keep the good driving conditions.

▶ **Standard Mode (S)**

Standard Mode is selected when setting the mode switch in Standard (S) position with the gear select lever in "D" and the transmission oil temperature in normal operating range. Proper shift timing provides the optimized fuel economy and good driving conditions.

▶ **Uphii and Downhill Mode**

In this mode, the operating points of torque converter lock-up clutch and the shifting points are adjusted according to the vehicle weight.

▶ **Altitude Mode**

In this mode, the shifting points are automatically adjusted according to the altitude to compensate the engine torque changes due to barometric pressure and temperature.

▶ Winter Mode (W)

When the Winter mode is selected, the second gear is engaged to start off the vehicle easily to prevent wheel spin on slippery surfaces and WINTER mode indicator comes ON. The first gear is not available in this mode.

▶ Low Range Driving Mode

When the vehicle is in 4L driving mode, the transmission uses a different shift mode to optimize the low range driving. Similar to Winter mode, the first gear is not available.

▶ Warm Up Mode

This mode is normally used when the transmission oil temperature is below 20°C.
The torque converter cannot be locked-up below 20°C to provide the warming up process of transmission.

▶ Hot Mode

If the transmission oil temperature is between 110°C and 145°C, the system provides the cooling and reduces the load to the transmission. This is called Hot Mode.

- Above 110°C: PWM fan ON
- Above 130°C: the engine torque is reduced and WINTER indicator is blinking
- Above 145°C: the transmission is held in Neutral (N) gear until the oil temperature falls below 120°C (Final protection)

In Hot Mode, any of shift mode is not available.

▶ Cruise Control

When the cruise control is activated, the engine ECU requests the downshift to increase the engine brake effect.

Modification basis	
Application basis	
Affected VIN	

6. POWER FLOW

Power flows in gears:

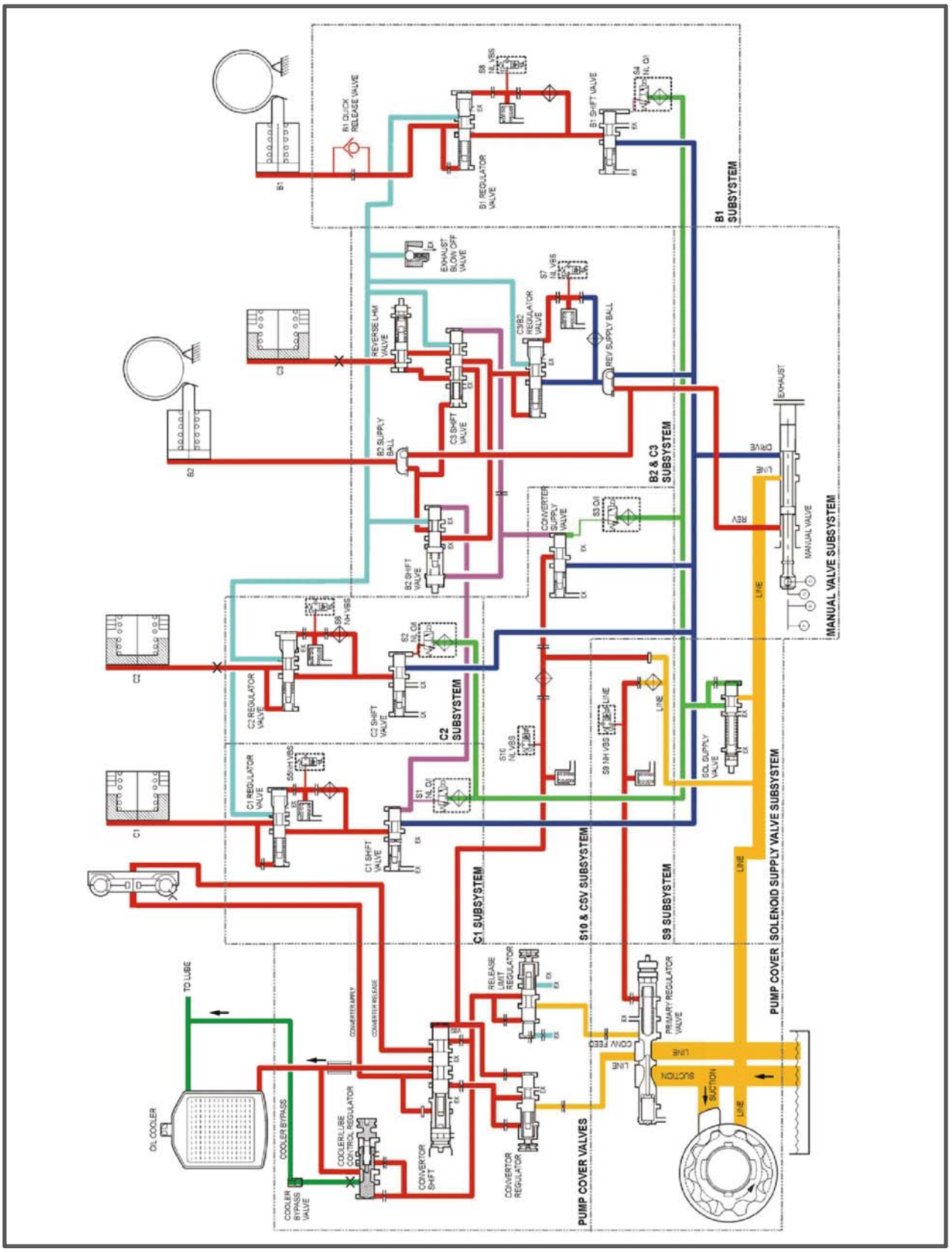
- Power flow - 1st gear (M)
- Power flow - 1st gear (D)
- Power flow - 2nd gear (D)
- Power flow - 2nd gear (D) ? lockup (D)
- Power flow - 3rd gear (D)
- Power flow - 4th gear (D) - 4th gear (D) in Limp home mode
- Power flow - 5th gear (D)
- Power flow - 6th gear (D)

▶ Gear Selection and Engaged Element

Gear	Gear ratio	Engaged element (clutch & band)					
		C1	C2	C3	B1	B2	1-2OWC
M1	3.53		ON			ON	
1st	3.53		ON				ON
2nd	2.14		ON		ON		
3rd	1.48		ON	ON			
4th	1.16	ON	ON				
5th	0.87	ON		ON			
6th	0.68	ON			ON		
Reverse	-3.09			ON		ON	

Gear	ON/OFF solenoid valve				Variable bleed solenoid valve - VBS					
	S1	S2	S3	S4	S5(A)	S6(A)	S7(A)	S8(A)	S9(A)	S10(A)
M1	ON				1	0	1			
1st	ON				1	0			0-1	
2nd	ON			ON	1	0		1	0-1	
3rd	ON		ON		1	0	1		0-1	
4th					0	0			0-1	
5th		ON			0	1	1		0-1	
6th		ON		ON	0	1		1	0-1	
Reverse	ON	ON	ON		1	1	1		0-1	

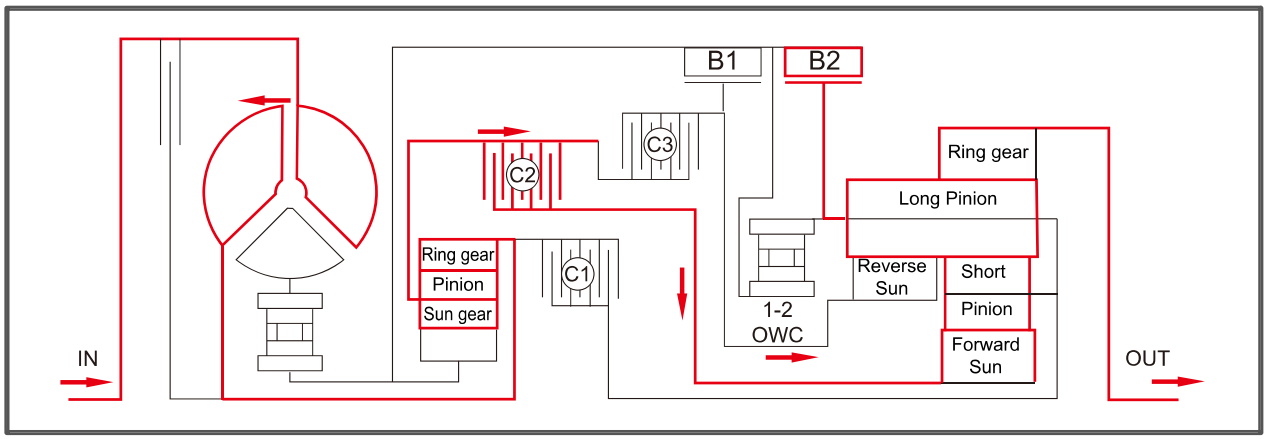
▶ Hydraulic Circuit Diagram



Modification basis	
Application basis	
Affected VIN	

1) Power Flow - Manual (M Position)

▶ Power Flow Diagram



▶ Functioning elements

- C2 applied, FSG (Forward Sun Gear) driven
- B2 applied to hold Rear Planet Carrier stationary
- Provides engine breake effect

CAUTION

Manual 1st gear is not engaged even when moving the manual valve to a certain position. This gear state is obtained electronically by solenoids S1 and S7.

▶ Control

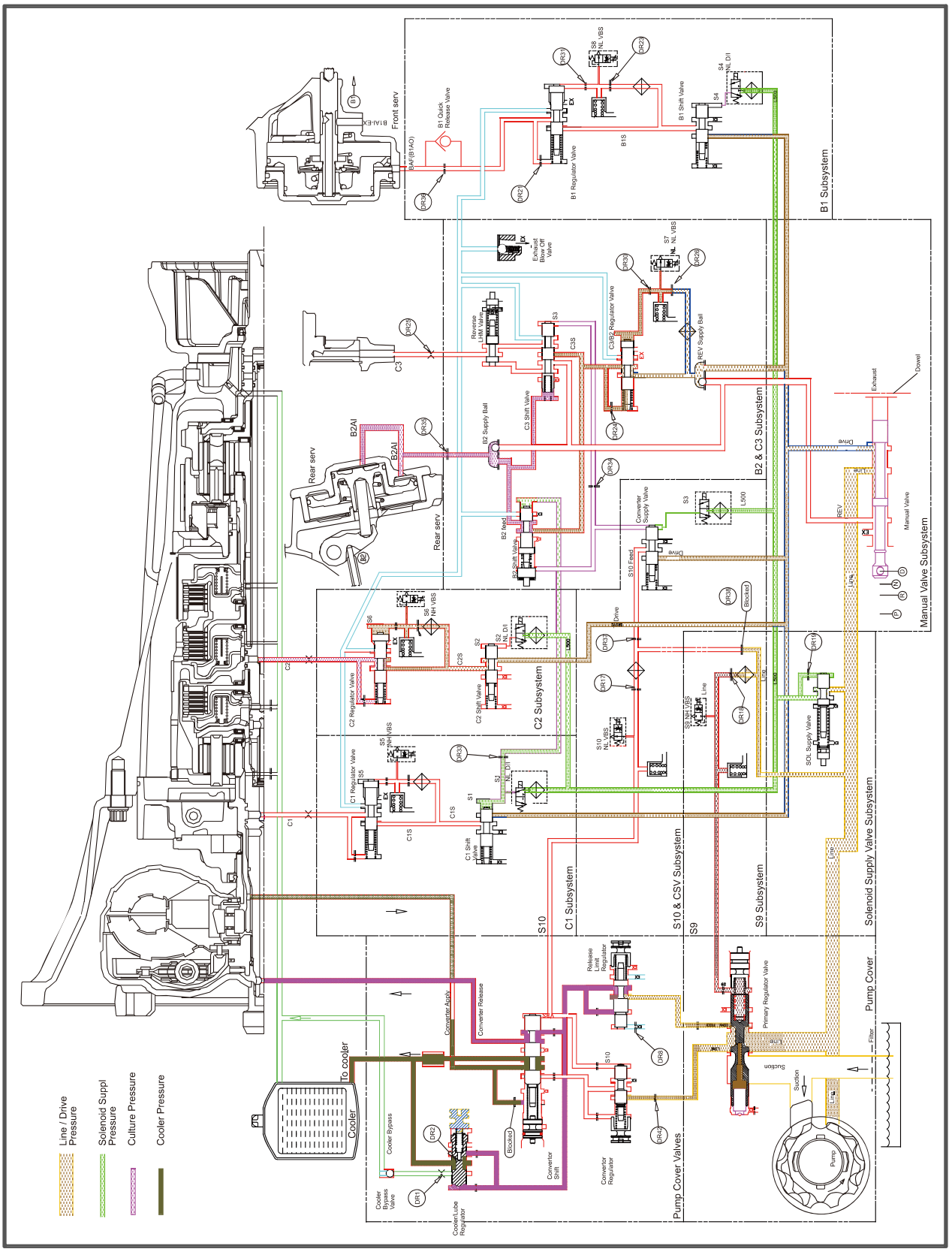
- S1 ON, C1 shift valve moved to the left end, C1 clutch not engaged
- S1 ON, B2 shift valve moved to the left end, B2 band operated (S7 should be ON)
- C2 shift valve open (S2 OFF), C2 clutch engaged by drive oil
- Drive oil (for C2 clutch engagement) is regulated by VBS S6

▶ Connecting Components

Gear ratio	Engaged element									
	C1	C2	C3	B1			B2		OWC	Lock-up clutch
				AO	AI	R	AO	AI		
3.53	ON						ON	ON		

Gear ratio	ON / OFF solenoids				Variable pressure sol. valve-VBS					
	S1	S2	S3	S4	S5(A)	S6(A)	S7(A)	S8(A)	S9(A)	S10(A)
3.53	ON				1	0	1		0-1	

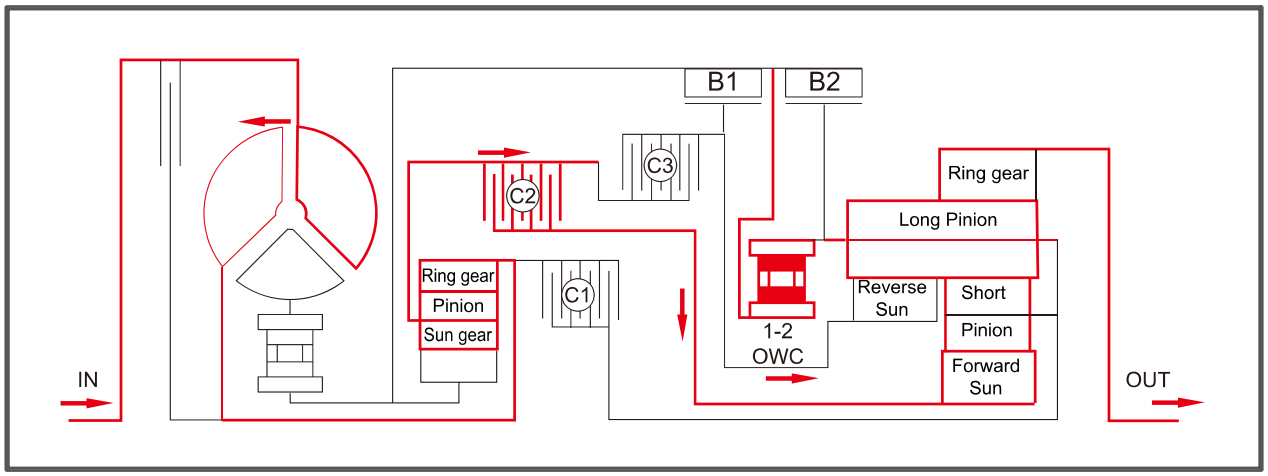
▶ 1st Gear (M) (3.53:1)



Modification basis	
Application basis	
Affected VIN	

2) Power Flow - 1st Gear (D)

▶ Power Flow Diagram



▶ Functioning elements

- C2 applied, FSG (Forward Sun Gear) driven
- 1-2 OWC (One-Way Clutch) operated to hold Rear Planet Carrier stationary

▶ Control

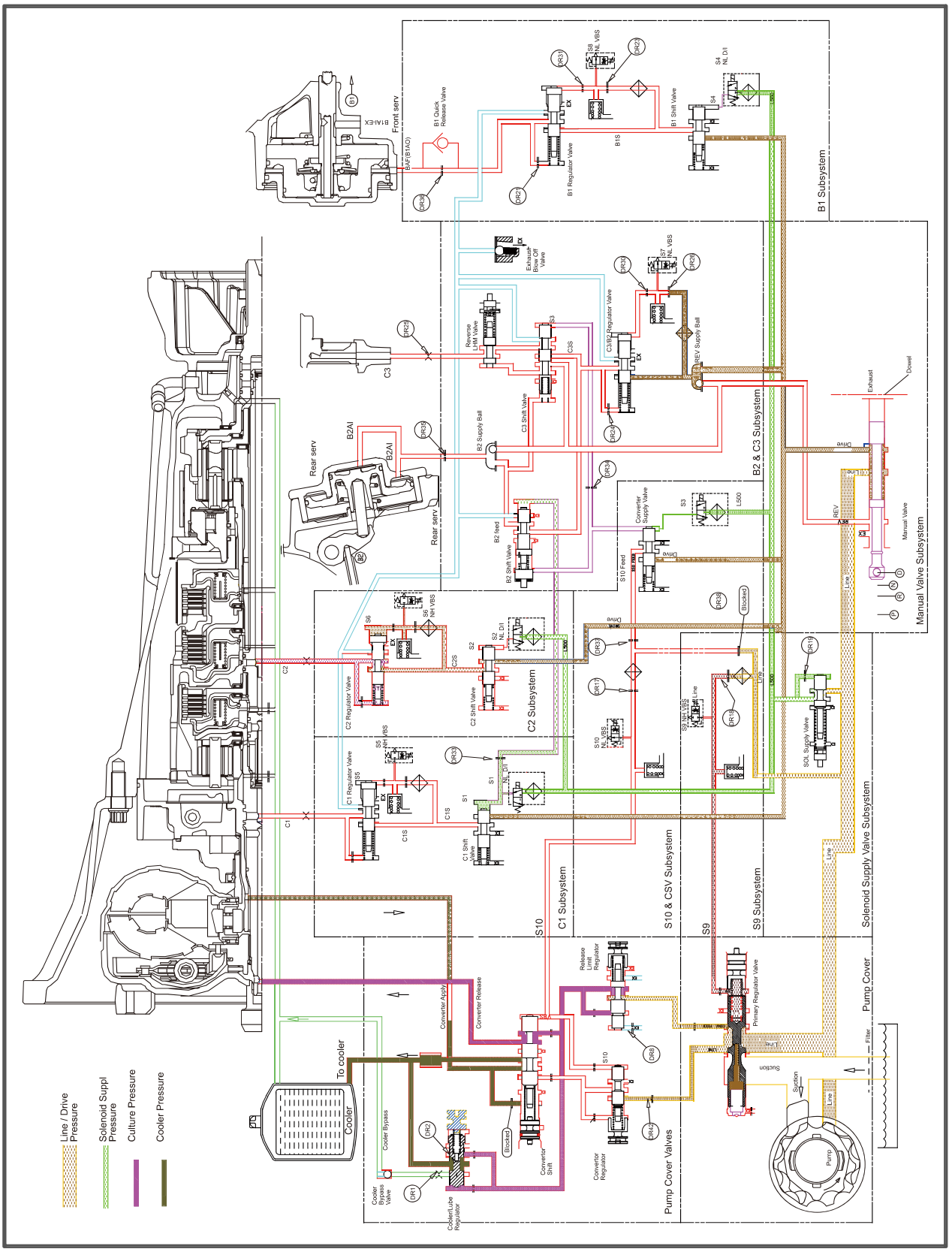
- S1 ON, S2 OFF
- S1 ON, C1 shift valve moved to the left end, C1 clutch not engaged
- C2 shift valve open (S2 OFF), C2 clutch engaged by drive oil
- Drive oil (for C2 clutch engagement) is regulated by VBS S6

▶ Connecting Components

Gear ratio	Engaged element									
	C1	C2	C3	B1			B2		OWC	Lock-up clutch
				AO	AI	R	AO	AI		
3.53		ON							ON	

Gear ratio	ON / OFF solenoids				Variable pressure sol. valve-VBS					
	S1	S2	S3	S4	S5(A)	S6(A)	S7(A)	S8(A)	S9(A)	S10(A)
3.53	ON				1	0			0-1	

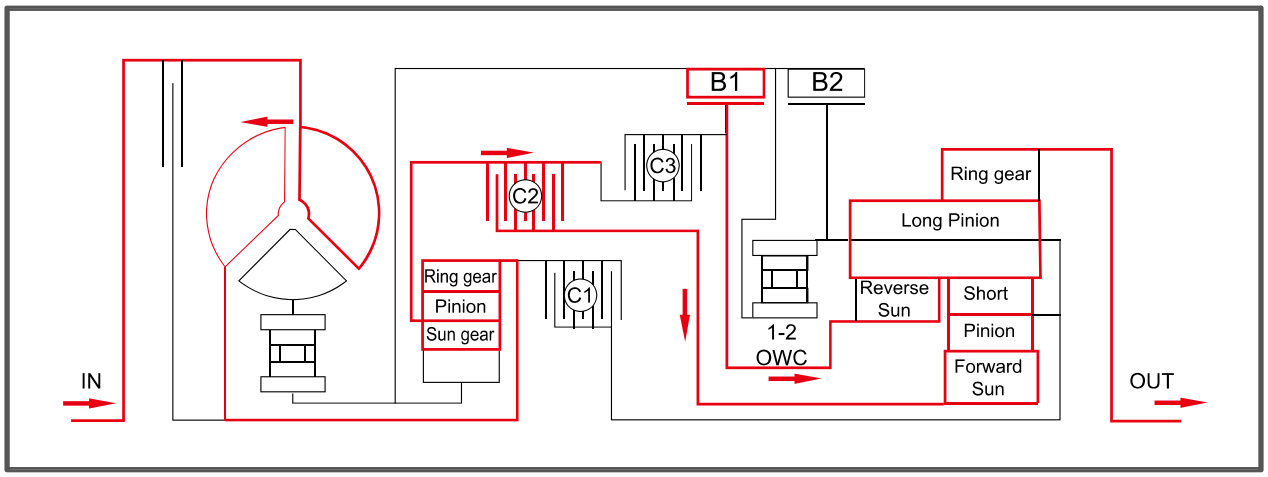
▶ 1st Gear (D) (3.53:1)



Modification basis	
Application basis	
Affected VIN	

3) Power Flow - 2nd Gear (D)

▶ Power Flow Diagram



▶ Functioning elements

- C2 applied, FSG (Forward Sun Gear) driven
- B1 applied to hold Rear Planet Carrier stationary

▶ Control

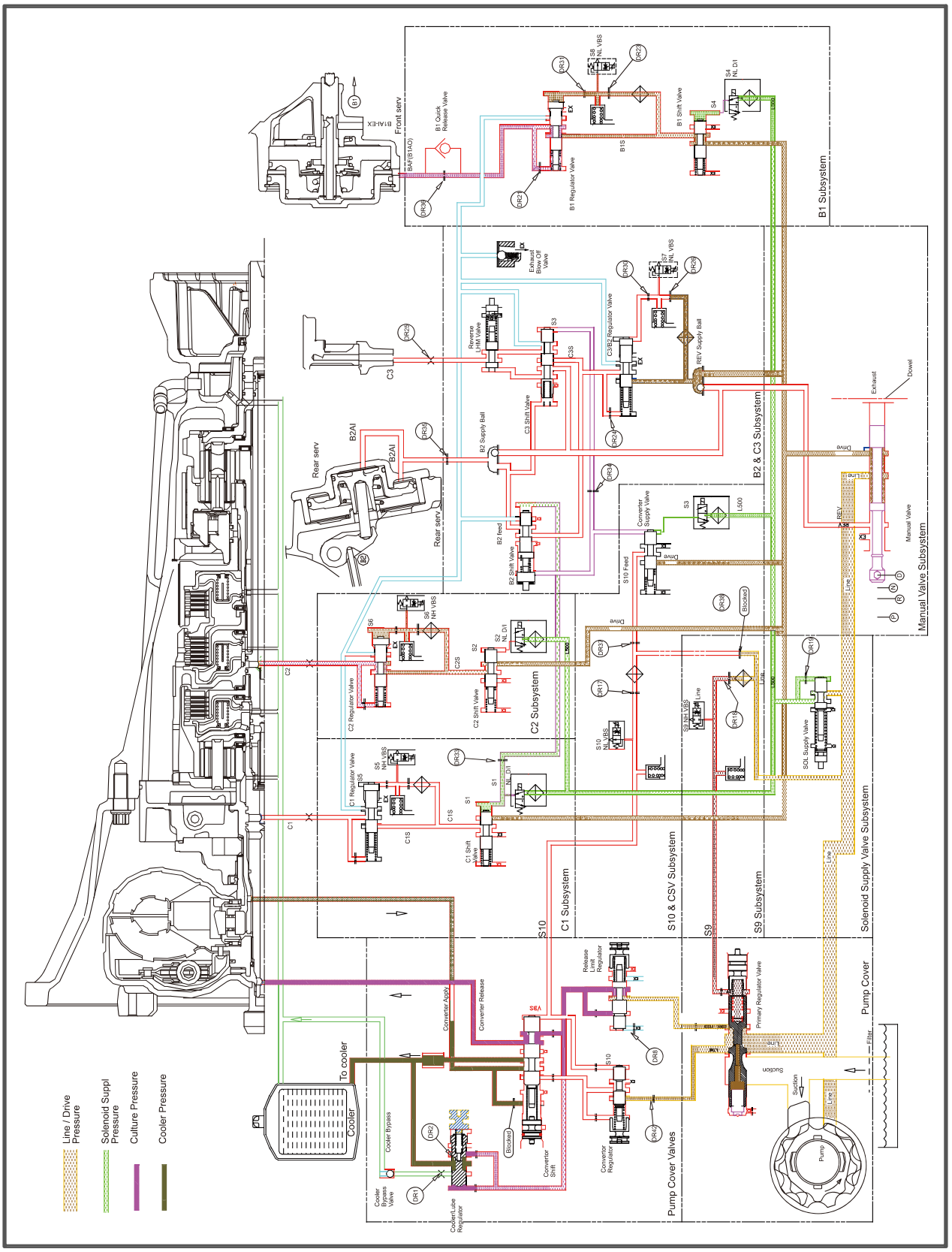
- S1 ON, S4 ON, S2 OFF
- S1 ON, C1 shift valve moved to the left end, C1 clutch not engaged
- C2 shift valve open (S2 OFF), C2 clutch engaged by drive oil
- Drive oil (for C2 clutch engagement) is regulated by VBS S6
- S4 ON, B1 shift valve moved to the left end, B1 band operated
- Drive oil (for B1 band engagement) is regulated by VBS S6

▶ Connecting Components

Gear ratio	Engaged element									
	C1	C2	C3	B1			B2		OWC	Lock-up clutch
				AO	AI	R	AO	AI		
2.14		ON		ON						

Gear ratio	ON / OFF solenoids				Variable pressure sol. valve-VBS					
	S1	S2	S3	S4	S5(A)	S6(A)	S7(A)	S8(A)	S9(A)	S10(A)
2.14	ON			ON	1	0		1	0-1	

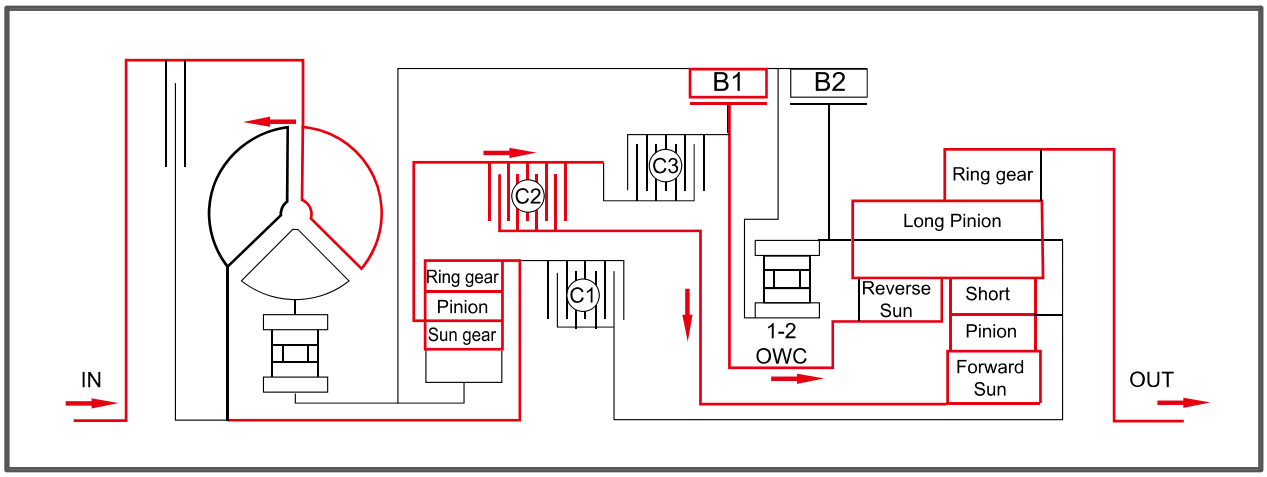
▶ 2nd Gear (D) (2.14:1)



Modification basis	
Application basis	
Affected VIN	

4) Power Flow - 2nd Gear (D) Lock-Up

▶ Power Flow Diagram

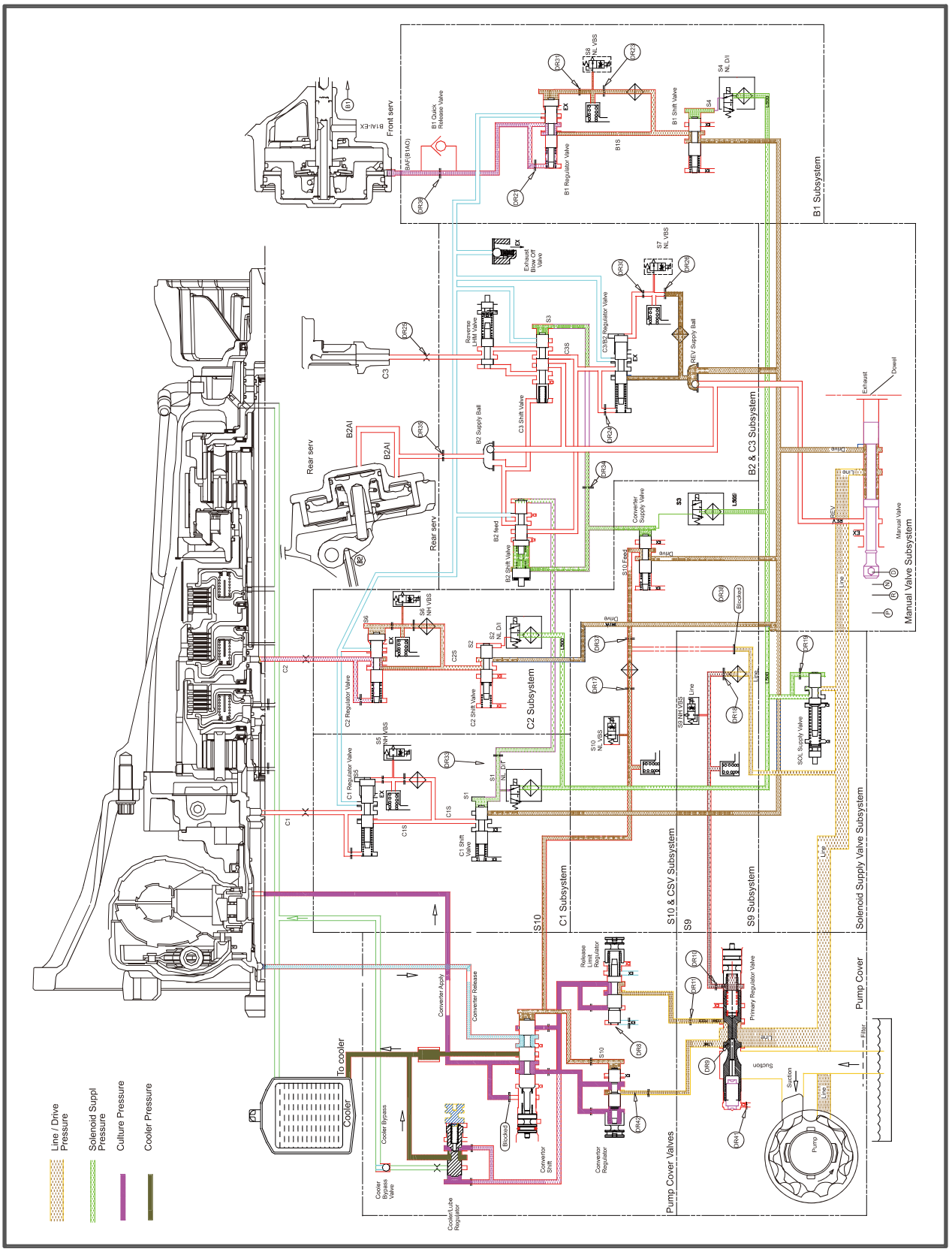


▶ Connecting Components

Gear ratio	Engaged element									
	C1	C2	C3	B1			B2		OWC	Lock-up clutch
				AO	AI	R	AO	AI		
2.14		ON		ON						

Gear ratio	ON / OFF solenoids				Variable pressure sol. valve-VBS					
	S1	S2	S3	S4	S5(A)	S6(A)	S7(A)	S8(A)	S9(A)	S10(A)
2.14	ON		ON	ON	1	0	0	1	0-1	1

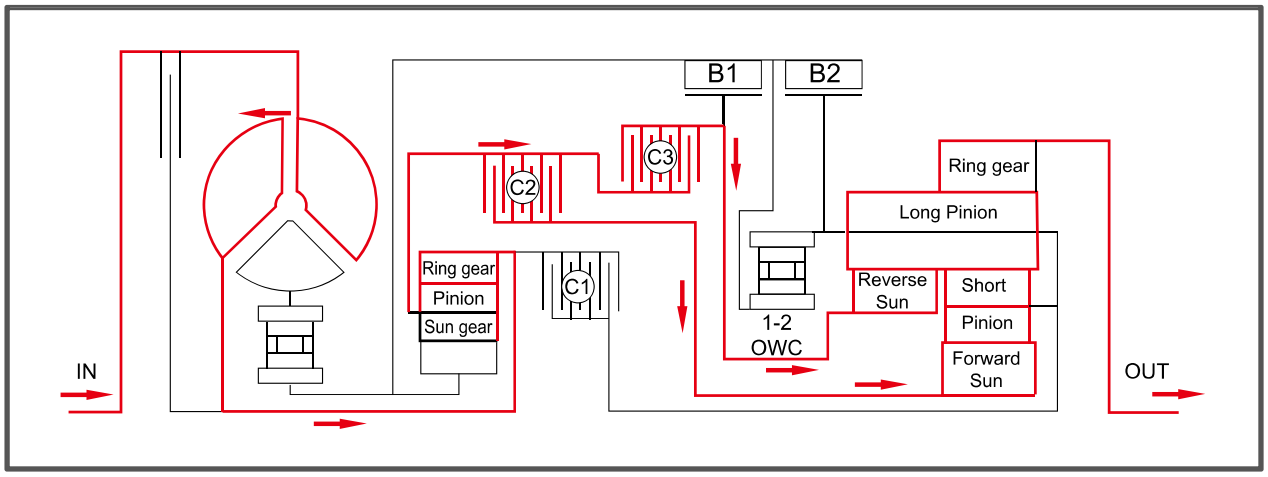
▶ 2nd Gear (D) Lock-Up



Modification basis	
Application basis	
Affected VIN	

5) Power Flow - 3rd Gear (D)

▶ Power Flow Diagram



▶ Functioning elements

- C2 applied, FSG (Forward Sun Gear) driven
- C3 applied, Rear Planet Carrier driven
- Rear Planet Gear Set is locked and its output has the same gear ratio with Front Gear Set.

CAUTION

C3 clutch cannot be engaged if S7 is OFF and the oil pressure is not supplied to C3 regulator valve.

▶ Control

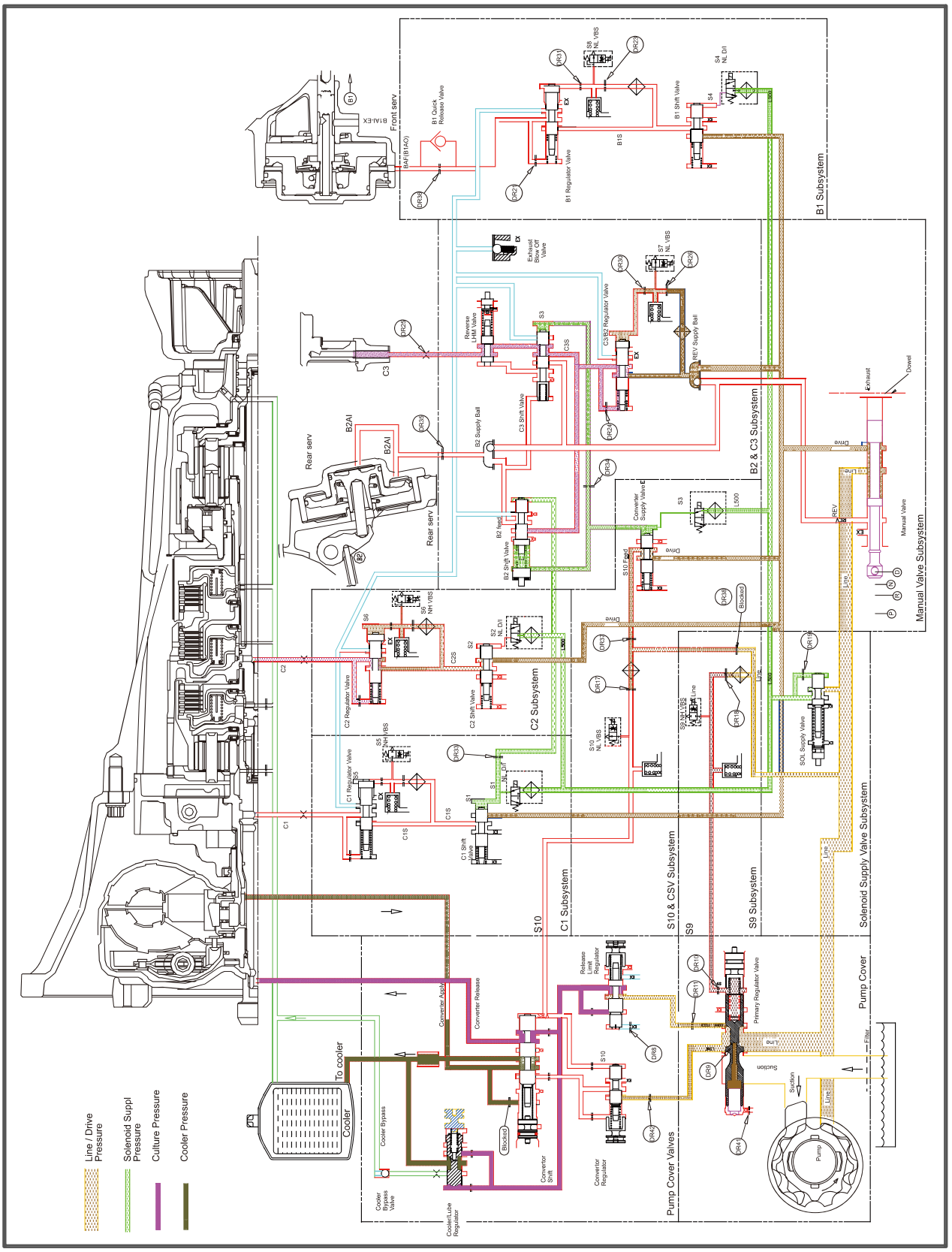
- S1 ON, C1 shift valve moved to the left end, C1 clutch not engaged
- C2 shift valve open (S2 OFF), C2 clutch engaged by drive oil
- S3 and S7 ON, C3 shift valve moved to the left end, C3 clutch engaged

▶ Connecting Components

Gear ratio	Engaged element									
	C1	C2	C3	B1			B2		OWC	Lock-up clutch
				AO	AI	R	AO	AI		
1.48		ON	ON							

Gear ratio	ON / OFF solenoids				Variable pressure sol. valve-VBS					
	S1	S2	S3	S4	S5(A)	S6(A)	S7(A)	S8(A)	S9(A)	S10(A)
1.48	ON		ON		1	0	1		0-1	

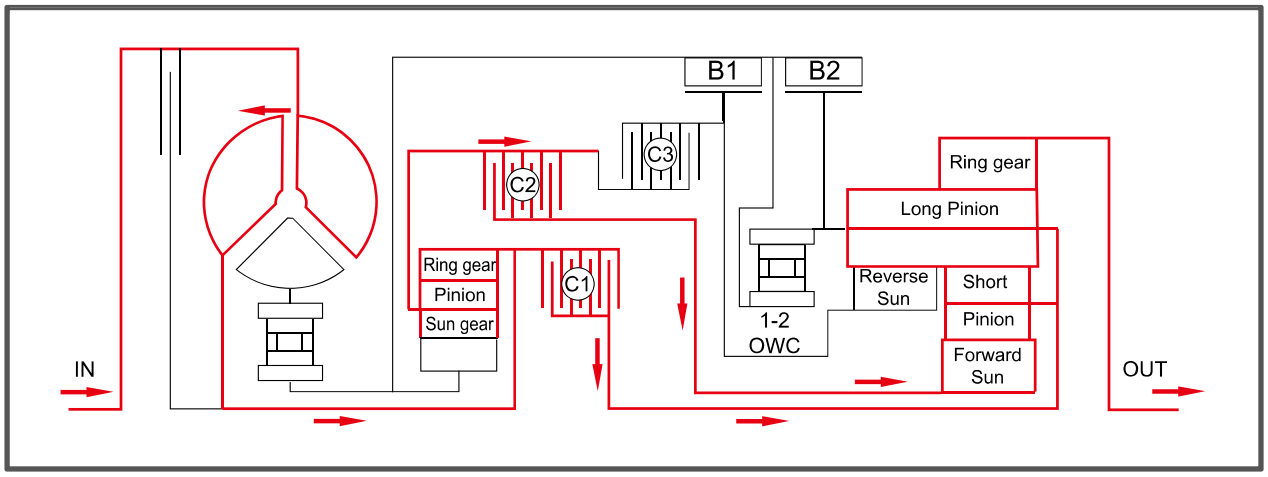
▶ 3rd Gear (D) (1.48:1)



Modification basis	
Application basis	
Affected VIN	

6) Power Flow - 4th Gear (D) & 4th Gear (D) in Limp Home Mode

▶ Power Flow Diagram



▶ Functioning elements

- C2 applied, FSG (Forward Sun Gear) driven
- C1 applied, Rear Planet Carrier driven

CAUTION
4th gear is used as Limp Home Mode.

▶ Control

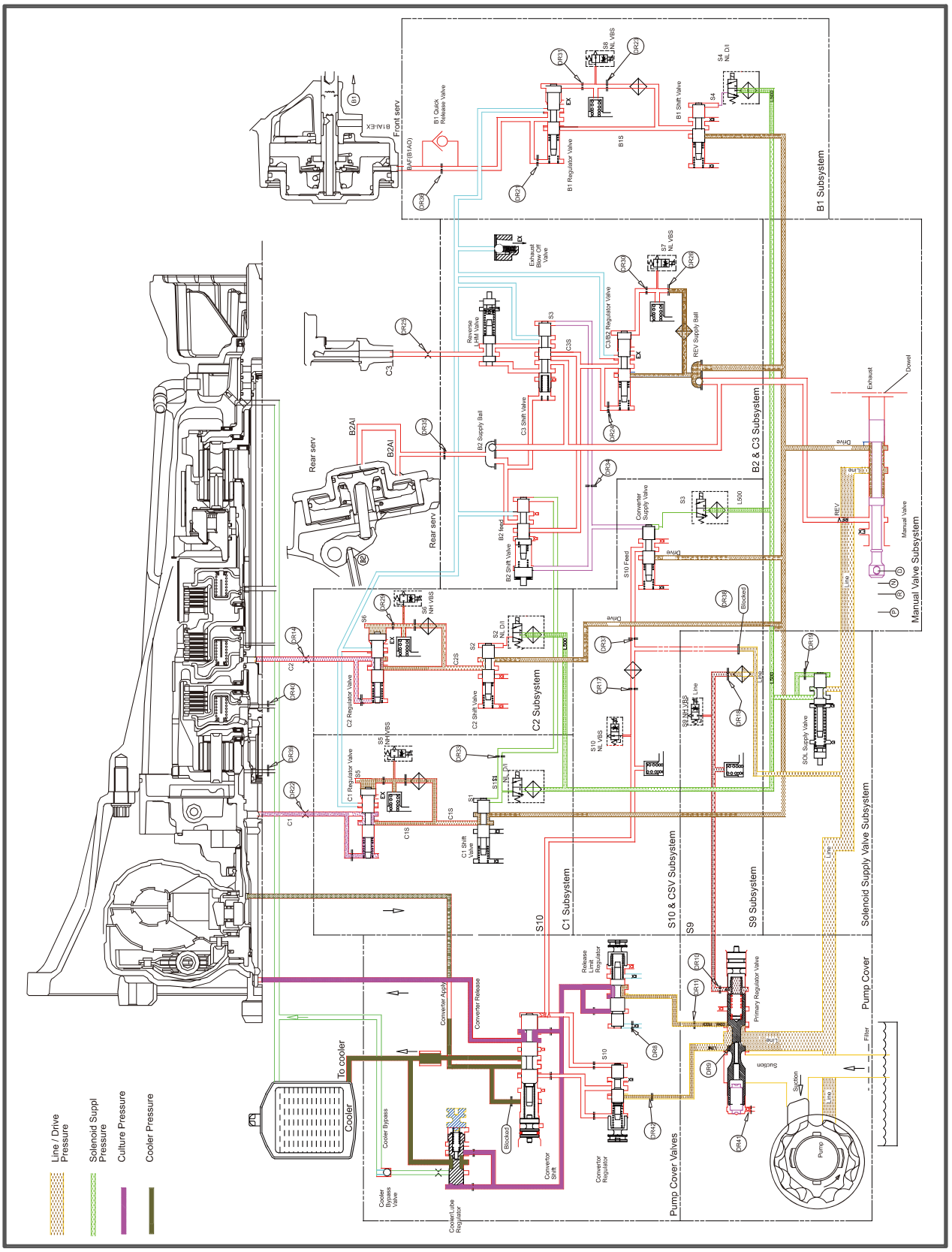
- S1 and S2 ON
- C1 shift valve open (S1 OFF), C1 clutch engaged by drive oil
- C2 shift valve open (S2 OFF), C2 clutch engaged by drive oil
- Drive oil (for C1 and C2 engagement) is regulated by VBS S6 and S6

▶ Connecting Components

Gear ratio	Engaged element									
	C1	C2	C3	B1			B2		OWC	Lock-up clutch
				AO	AI	R	AO	AI		
1.16	ON	ON								

Gear ratio	ON / OFF solenoids				Variable pressure sol. valve-VBS					
	S1	S2	S3	S4	S5(A)	S6(A)	S7(A)	S8(A)	S9(A)	S10(A)
1.16					0	0			0-1	

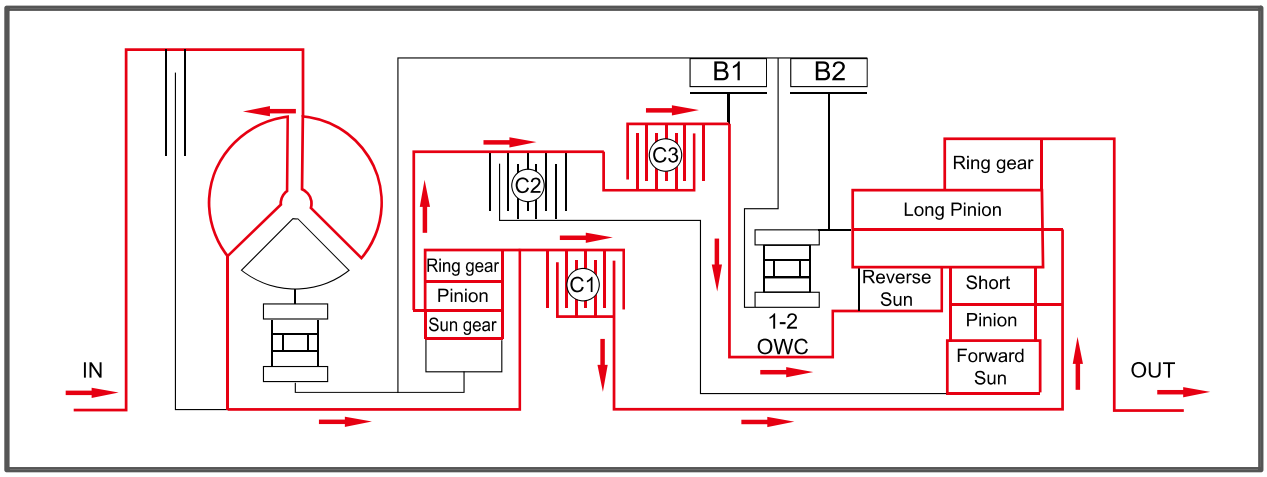
▶ 4th gear (D) & 4th gear (D) in Limp home mode (1.16:1)



Modification basis	
Application basis	
Affected VIN	

7) Power Flow - 5th Gear (D)

▶ Power Flow Diagram



▶ Functioning elements

- C1 applied, Rear Planet Carrier driven
- C3 applied, RSG (Rear Sun Gera) driven

▶ Control

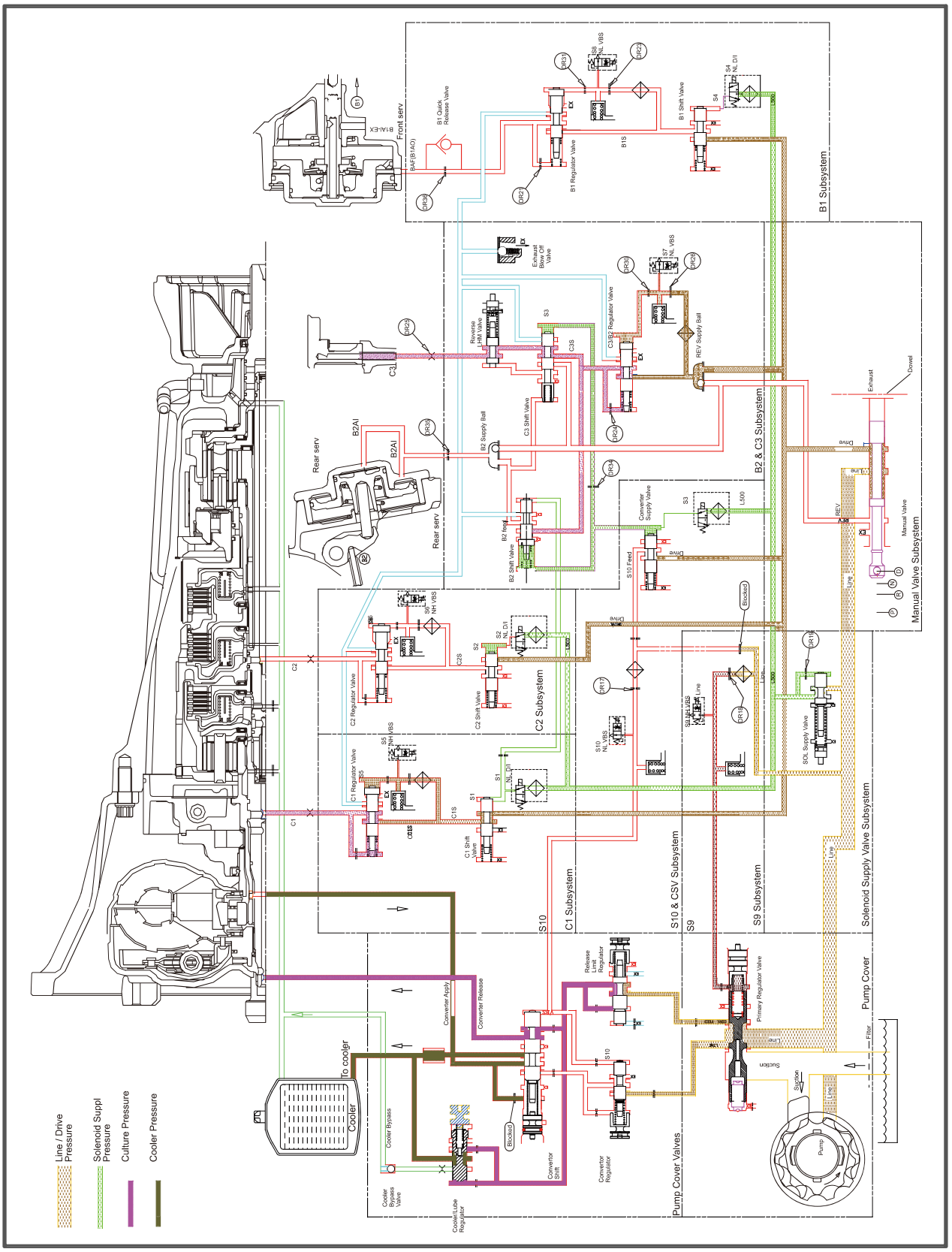
- S1 OFF, S2 and S3 ON
- S2 ON, C2 shift valve moved to the left end, C2 clutch not engaged
- C1 shift valve open (S1 OFF), C1 clutch engaged by drive oil
- S3 and S7 ON, C3 shift valve moved to the left end, C3 clutch engaged

▶ Connecting Components

Gear ratio	Engaged element									
	C1	C2	C3	B1			B2		OWC	Lock-up clutch
				AO	AI	R	AO	AI		
0.87	ON		ON							

Gear ratio	ON / OFF solenoids				Variable pressure sol. valve-VBS					
	S1	S2	S3	S4	S5(A)	S6(A)	S7(A)	S8(A)	S9(A)	S10(A)
0.87		ON	ON		0	1	1		0-1	

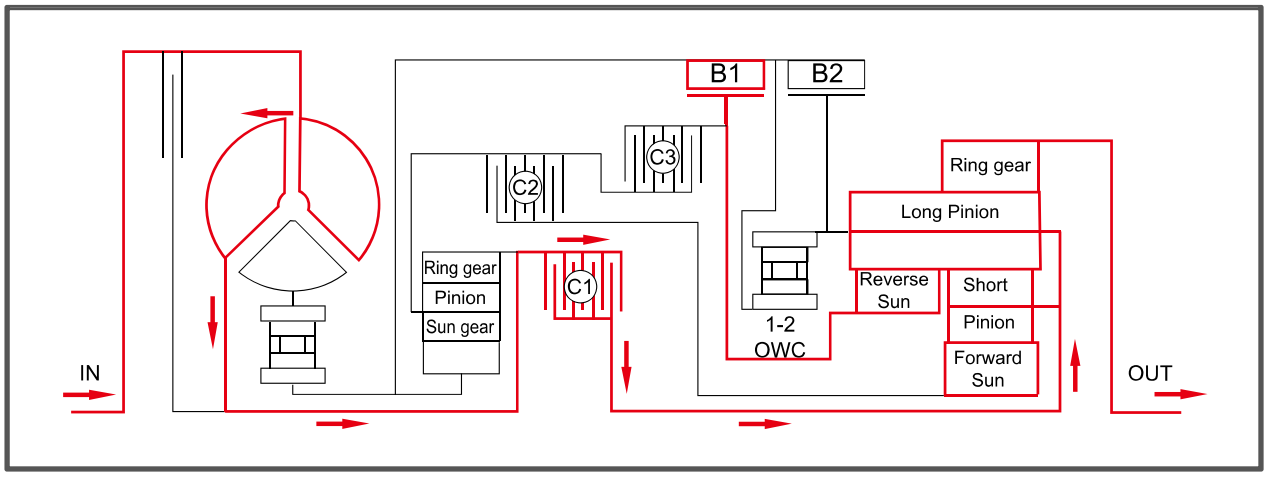
▶ 5th gear (D) (0.87:1)



Modification basis	
Application basis	
Affected VIN	

8) Power flow - 6th gear (D)

▶ Power Flow Diagram



▶ Functioning elements

- C1 applied, Rear Planet Carrier driven
- B1 applied, RSG (Rear Sun Gera) locked

▶ Control

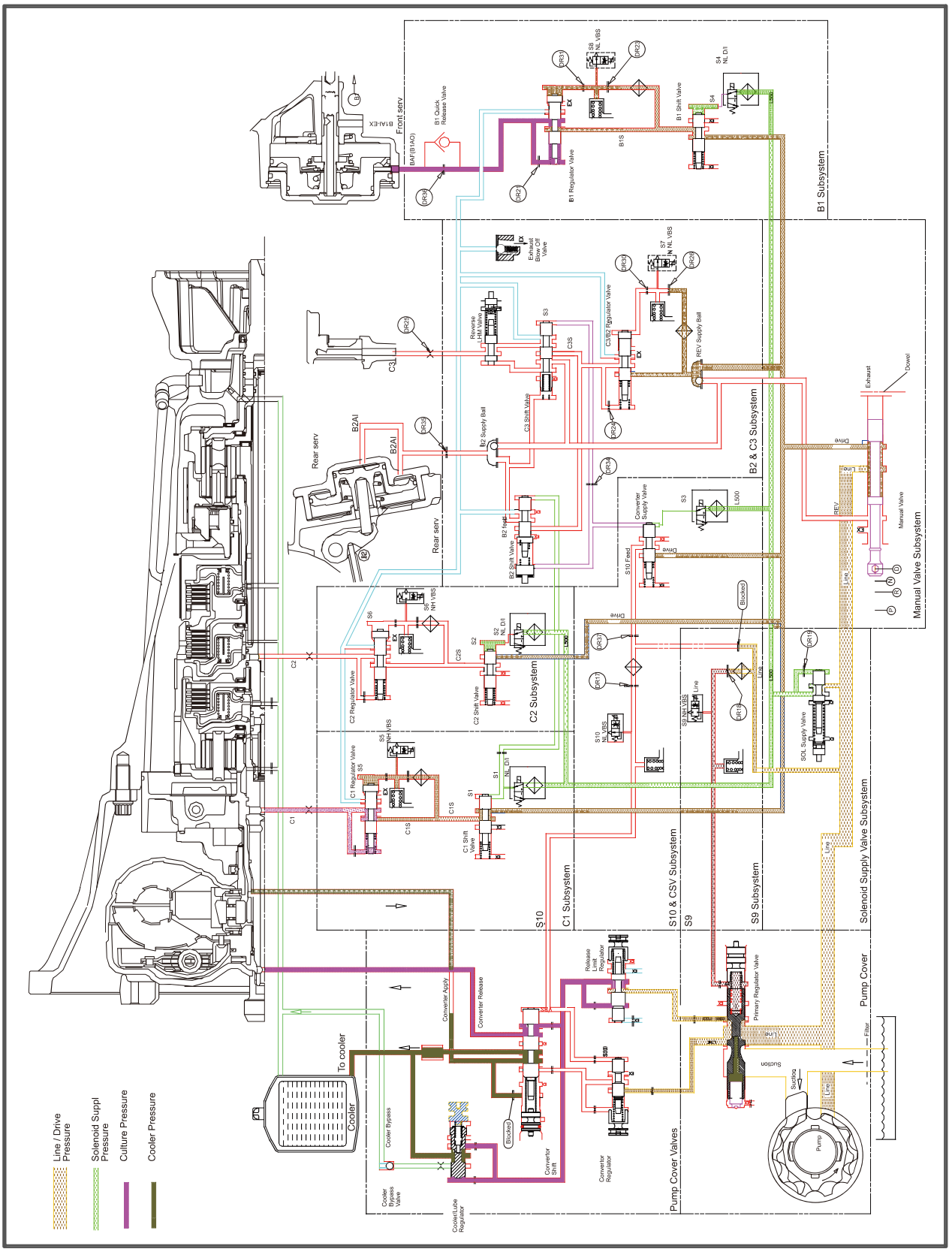
- S1 OFF, S2 and S4 ON
- S3 ON, C2 shift valve moved to the left end, C2 clutch not engaged
- C1 shift valve open (S1 OFF), C1 clutch engaged by drive oil
- S4 ON, B1 shift valve moved to the left end, B1 Band engaged

▶ Connecting Components

Gear ratio	Engaged element									
	C1	C2	C3	B1			B2		OWC	Lock-up clutch
				AO	AI	R	AO	AI		
0.68	ON			ON						

Gear ratio	ON / OFF solenoids				Variable pressure sol. valve-VBS					
	S1	S2	S3	S4	S5(A)	S6(A)	S7(A)	S8(A)	S9(A)	S10(A)
0.68		ON		ON	0	1		1	0-1	

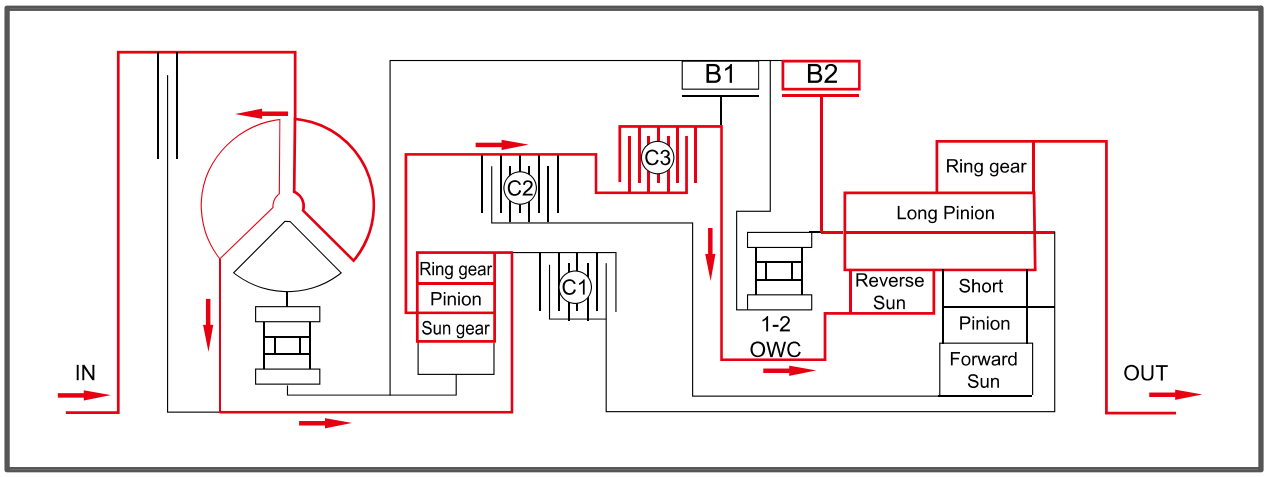
▶ 6th gear (D) (0.68:1)



Modification basis	
Application basis	
Affected VIN	

9) Power flow - Reverse (R)

▶ Power Flow Diagram



▶ Functioning elements

- C3 applied, RSG (Rear Sun Gera) locked
- B2 applied, Rear Planet Carrier locked

▶ Control

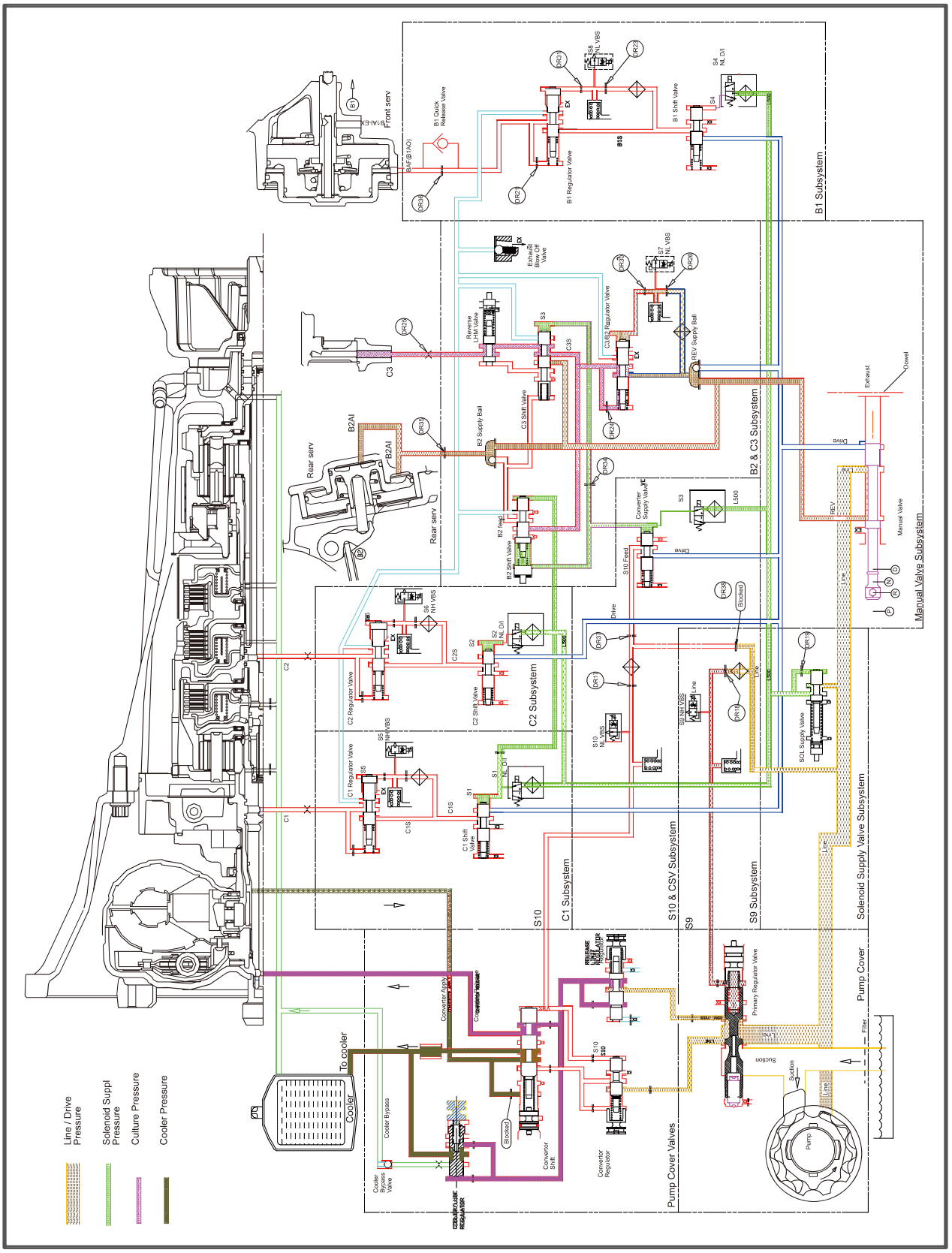
- S1, S2 and S3 ON
- Line pressure applied to B2 Band directly through manual valve
- S3 ON, Pressure to C3 increased or regulated
- S1 and S2 ON, C1 not engaged in any case

▶ Connecting Components

Gear ratio	Engaged element									
	C1	C2	C3	B1			B2		OWC	Lock-up clutch
				AO	AI	R	AO	AI		
3.09			ON				ON	ON		

Gear ratio	ON / OFF solenoids				Variable pressure sol. valve-VBS					
	S1	S2	S3	S4	S5(A)	S6(A)	S7(A)	S8(A)	S9(A)	S10(A)
3.09	ON	ON	ON		1	1	1		0-1	

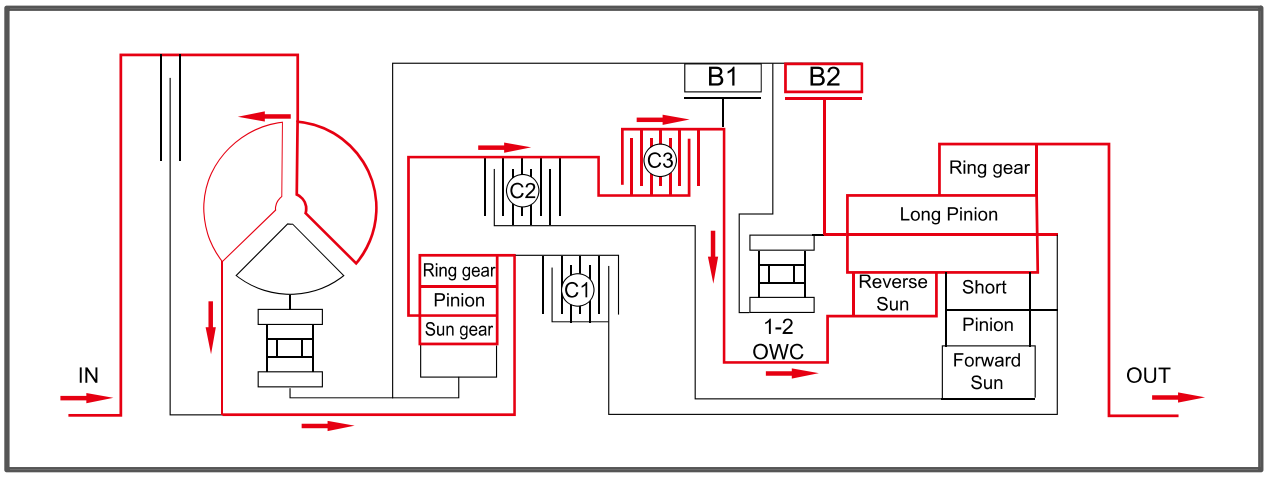
▶ Reverse gear (R) (3.09:1)



Modification basis	
Application basis	
Affected VIN	

10) Power Flow - Reverse (R) Limp Home Mode

▶ Power Flow Diagram

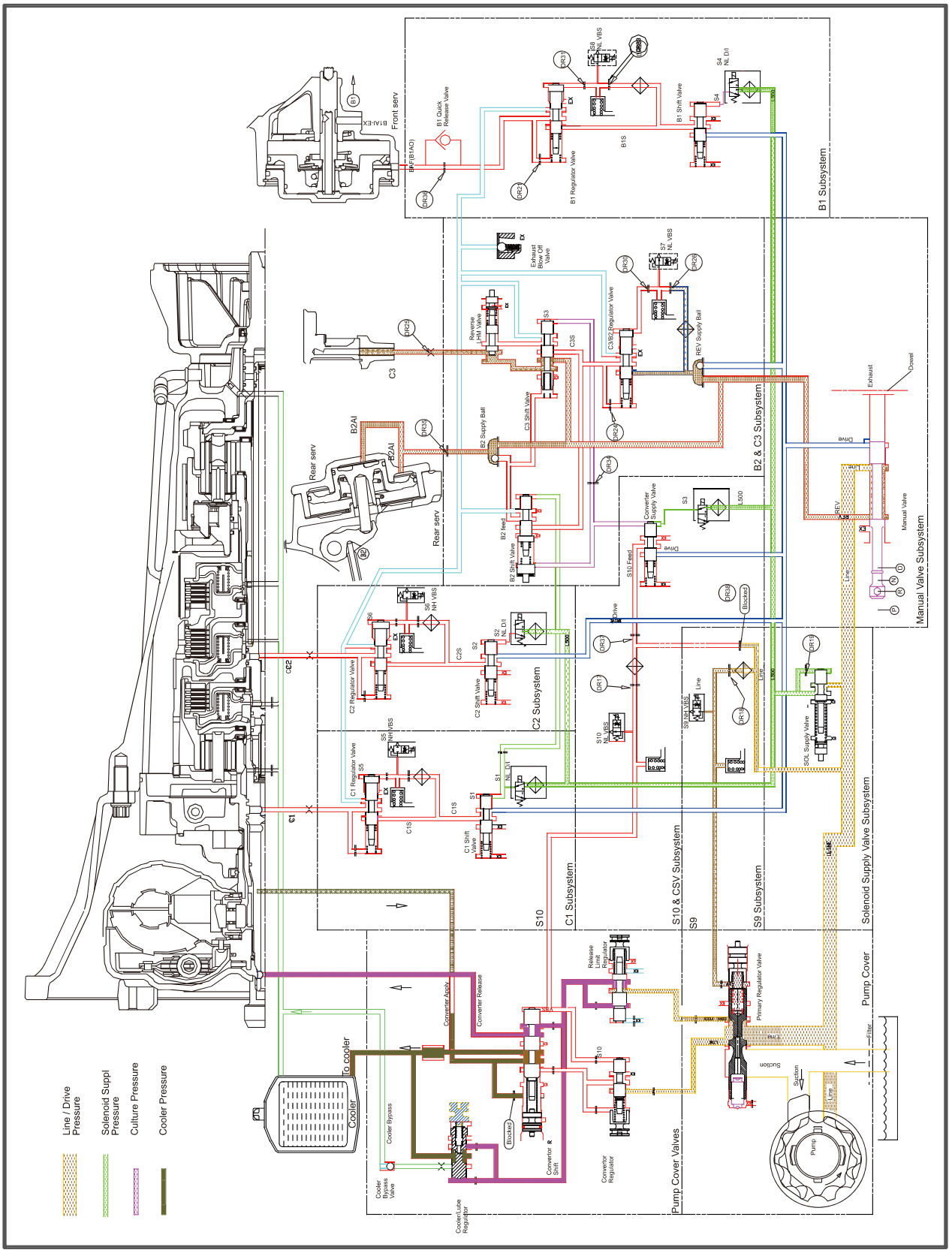


▶ Connecting Components

Gear ratio	Engaged element									
	C1	C2	C3	B1			B2		OWC	Lock-up clutch
				AO	AI	R	AO	AI		
3.09			ON				ON	ON		

Gear ratio	ON / OFF solenoids				Variable pressure sol. valve-VBS					
	S1	S2	S3	S4	S5(A)	S6(A)	S7(A)	S8(A)	S9(A)	S10(A)
3.09					0	0	0	0	0	0

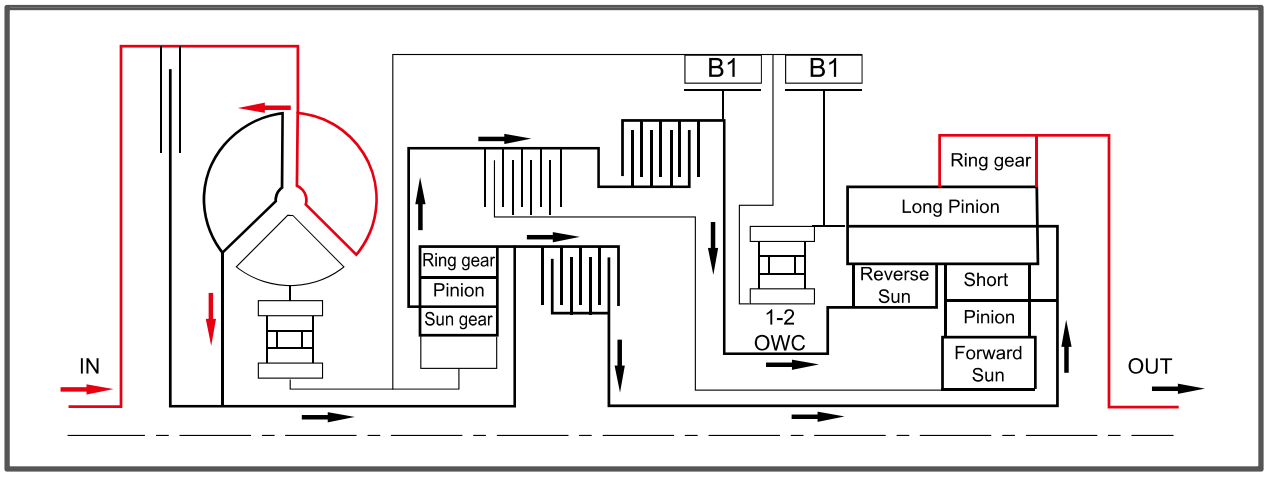
▶ Reverse (R) Limp Home Mode



Modification basis	
Application basis	
Affected VIN	

11) Power flow - Park (P)

▶ Power Flow Diagram

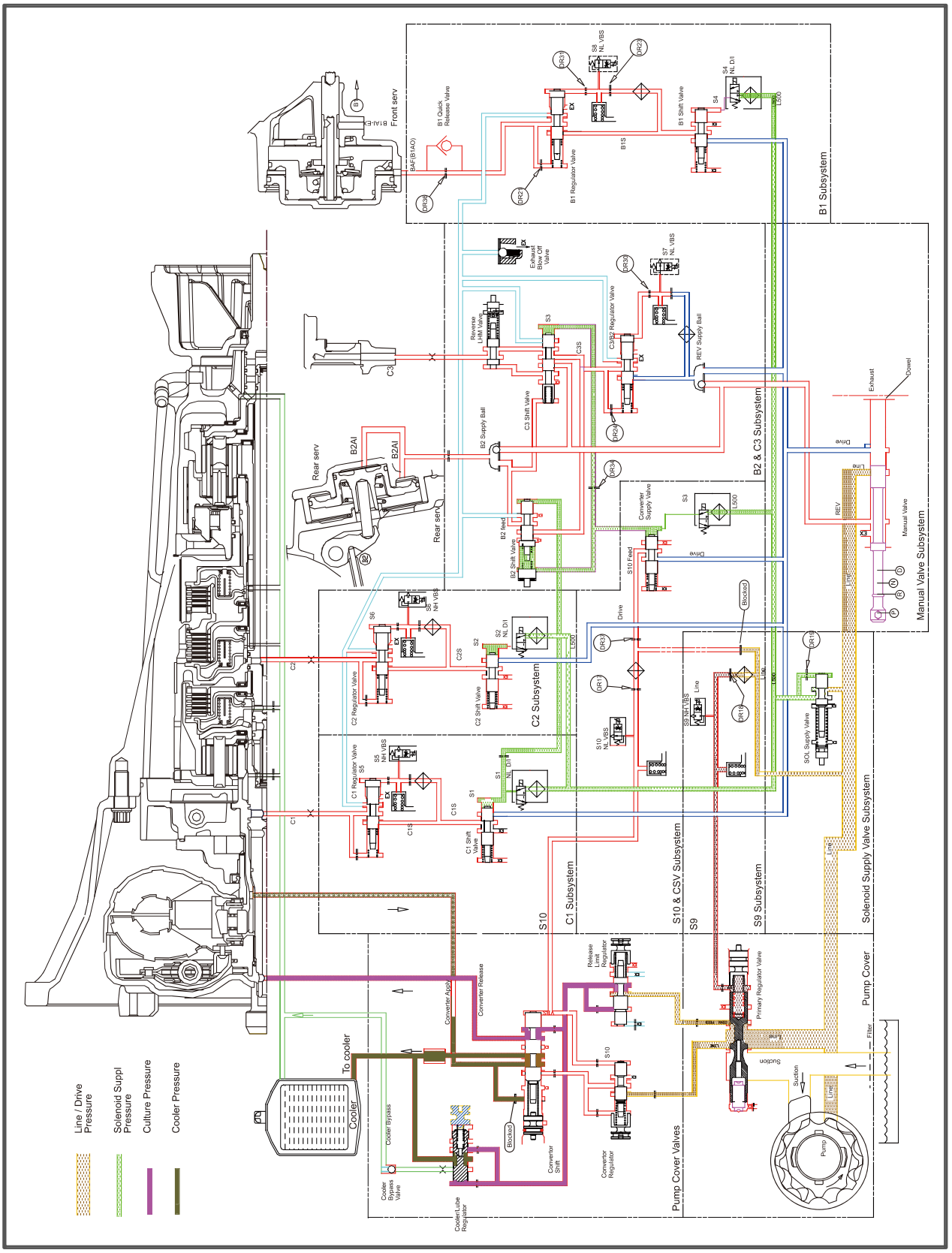


▶ Connecting Components

Gear ratio	Engaged element									
	C1	C2	C3	B1			B2		OWC	Lock-up clutch
				AO	AI	R	AO	AI		
N/A										

Gear ratio	ON / OFF solenoids				Variable pressure sol. valve-VBS					
	S1	S2	S3	S4	S5(A)	S6(A)	S7(A)	S8(A)	S9(A)	S10(A)
N/A	ON	ON	ON							

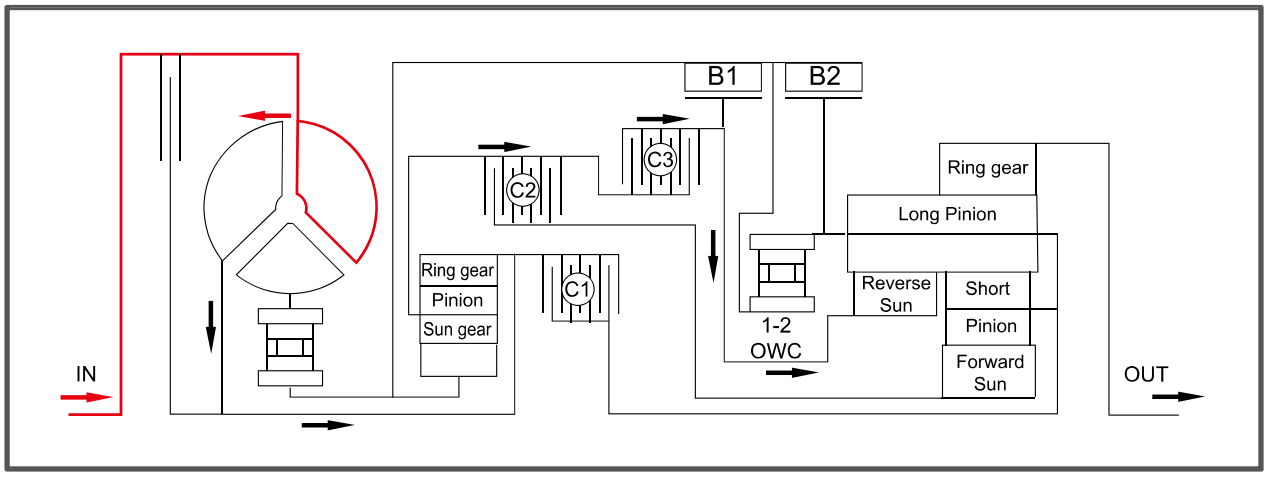
▶ Park



Modification basis	
Application basis	
Affected VIN	

12) Neutral (N)

▶ Power Flow Diagram

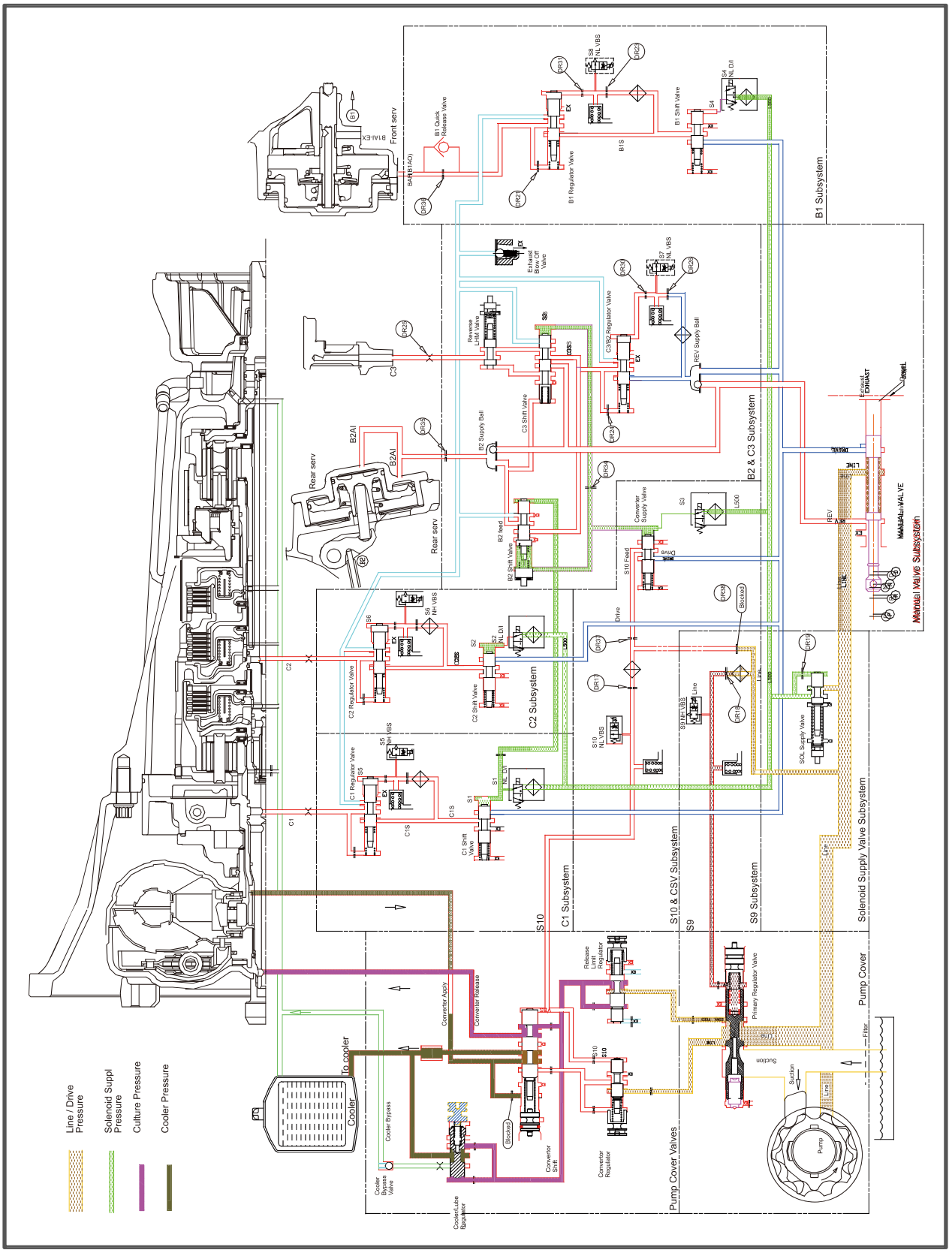


▶ Connecting Components

Gear ratio	Engaged element									
	C1	C2	C3	B1			B2		OWC	Lock-up clutch
				AO	AI	R	AO	AI		
N/A										

Gear ratio	ON / OFF solenoids				Variable pressure sol. valve-VBS					
	S1	S2	S3	S4	S5(A)	S6(A)	S7(A)	S8(A)	S9(A)	S10(A)
N/A	ON	ON	ON						0-1	

▶ Neutral



Modification basis	
Application basis	
Affected VIN	

MANUAL TRANSMISSION 3170-01

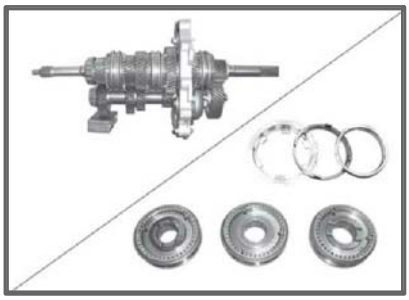
GENERAL

1. OVERVIEW AND CHARACTERISTICS OF MANUAL TRANSMISSION

1) System Components

Inside

Front View



(1) Features

1. All gears use the helical type and high strength materials.

CAUTION
- The helical type gear prevents the axial gear missing and provides less noise.

2. The semi-remote control type gear shift mechanism is used to prevent incorrect shifting.
3. To improve the shifting performance, 3-piece triple cone is used for 1/2 shift.

CAUTION
- TSM54/52 transmission uses the inertia lock type key to make smooth gear engagement and to provide silent gear engagement.

4. The synchronizing devices are installed in 1/2, 3/4, 5/R gears. To prevent the double engagement, the independent interlock devices are installed.
5. The clutch release system is available to use CSC (Concentric Slave Cylinder) or Fork type according to the vehicle model.

2. SPECIFICATIONS AND TIGHTENING TORQUE OF MANUAL TRANSMISSION

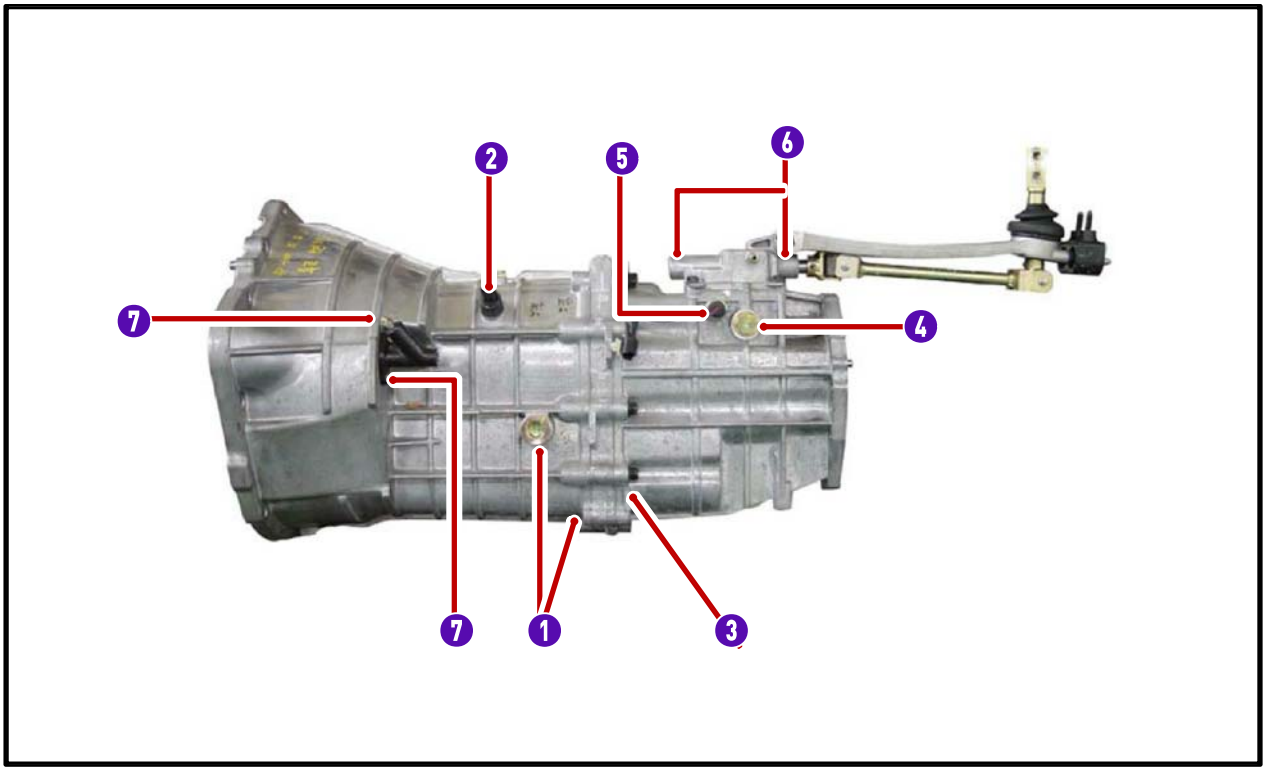
1) Specifications

Description		Specifications (G23D)
Length (mm)		628.3 mm
Distance between shafts (mm)		81 mm
Input torque (kg-m)		34.7 kg-m (340 Nm)
Transmission control type		Semi-remote
Weight (kg) - not including transmission fluid		44 kgm
Gear ratio/Gear teeth (input gear: main gear)	1st gear	4.315
	2nd gear	2.475
	3rd gear	1.536
	4th gear	1.000
	5th gear	0.807
	Reverse gear	3.919
Transmission fluid	Specification	ATF DEXRON II
	Capacity (ℓ)	3.6 / 3.4 ℓ (4WD / 2WD)
	Change interval	Inspect at every 10,000 km, replace at every 60,000 km (add or replace if necessary)

Modification basis	
Application basis	
Affected VIN	

2) Tightening Torque

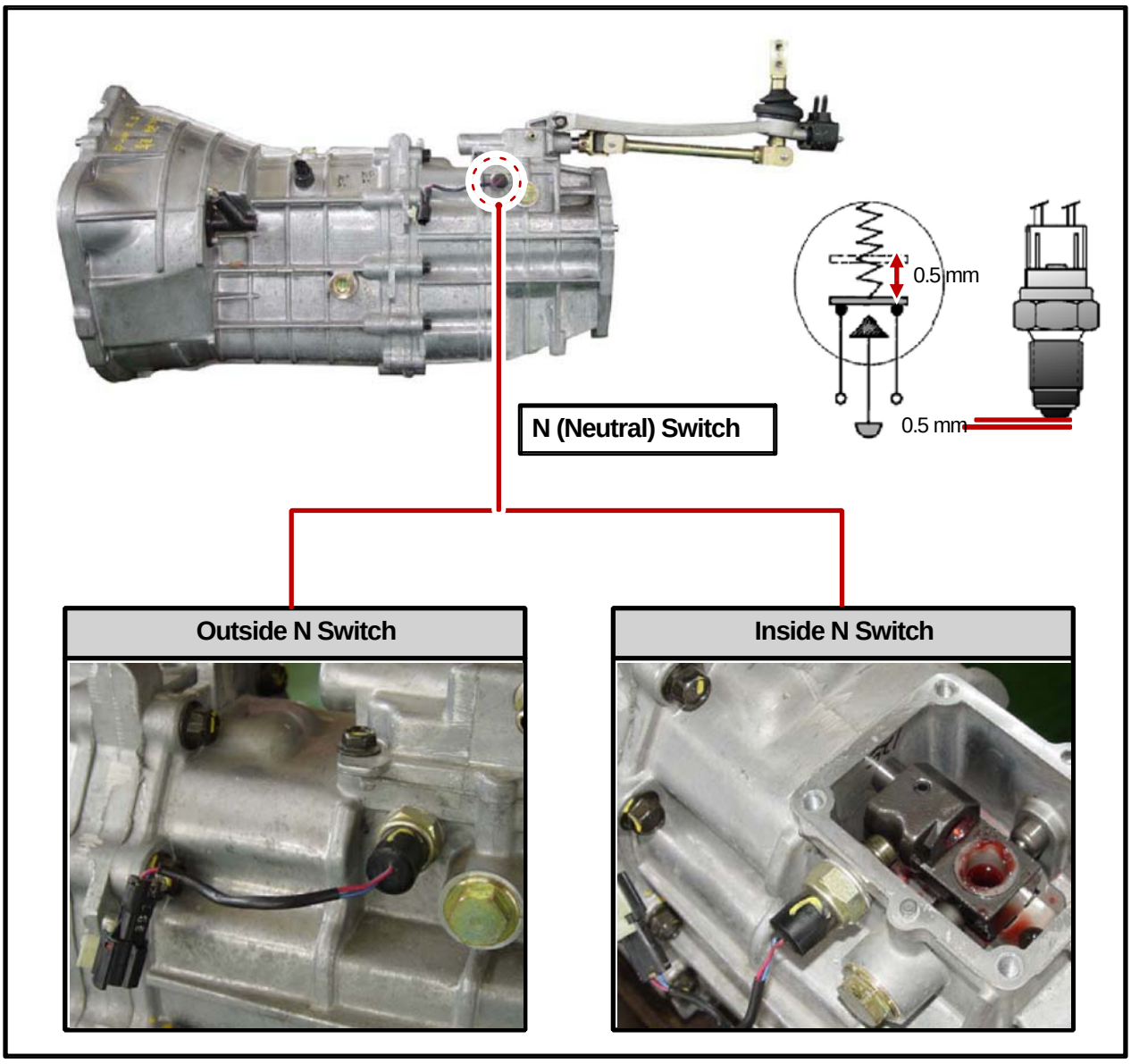
Descriptio n	Tightening Torque
1. Oil drain plug & filler plug	40 ~ 50 Nm
2. Backup lamp switch (24 mm)	30 ~ 40 Nm
3. Extension housing bolt (14 mm)	42 ~ 57 Nm
4. Extension housing spring plug (27 mm)	70 ~ 100 Nm
5. Neutral switch	30 ~ 40 Nm
6. Shift top cover bolt (12 mm)	17 ~ 26 Nm
7. Concentric slave cylinder adapter bolt	10 ~ 16 Nm



OVERVIEW AND OPERATION PROCESS

1. MANUAL TRANSMISSION SYSTEM

1) Neutral Switch



Modification basis	
Application basis	
Affected VIN	

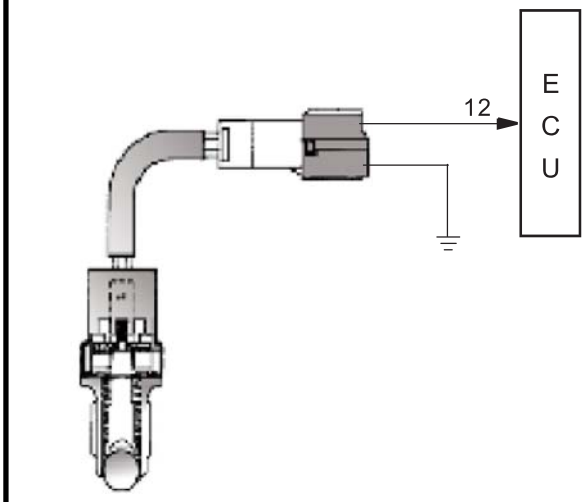
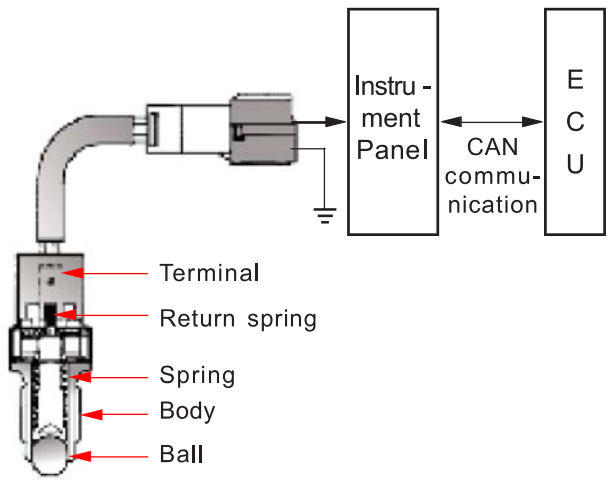
2) Function of N Switch

(1) Aids a smooth start of the vehicle by raising the RPM during the gear shifting when the engine is cold.

When the vehicle is trying to start from the stopped state (vehicle speed below 3 km/h), the N switch determines the shifting timing by using the clutch switch and the N switch. It raises the engine RPM (100 ~ 200 rpm). Operation conditions are as follows.

- The vehicle speed is at the stopped state (Vehicle speed below 3km/h detection).
- While depressing the clutch (Clutch switch detection).
- The gear lever is at a position other than neutral (N switch detection).
- Start the vehicle while depressing the clutch pedal (Clutch switch detection).
- The RPM increases in accordance with the temperature of the engine coolant (Engine coolant temperature sensor detection).
  - · appx. 100 rpm increase
  - · appx. 100 ~ 170 rpm increase
  - · appx. 80°C (normal temperature of the engine coolant): around 200 rpm
- When the gear has been smoothly shifted and the vehicle speed exceeds 3km/h, it returns to the previous operation interval of the engine RPM.

In case of Actyon, the N switch signal is transmitted to the instrument panel, and then the instrument panel transmits it to the engine ECU through the CAN communication.

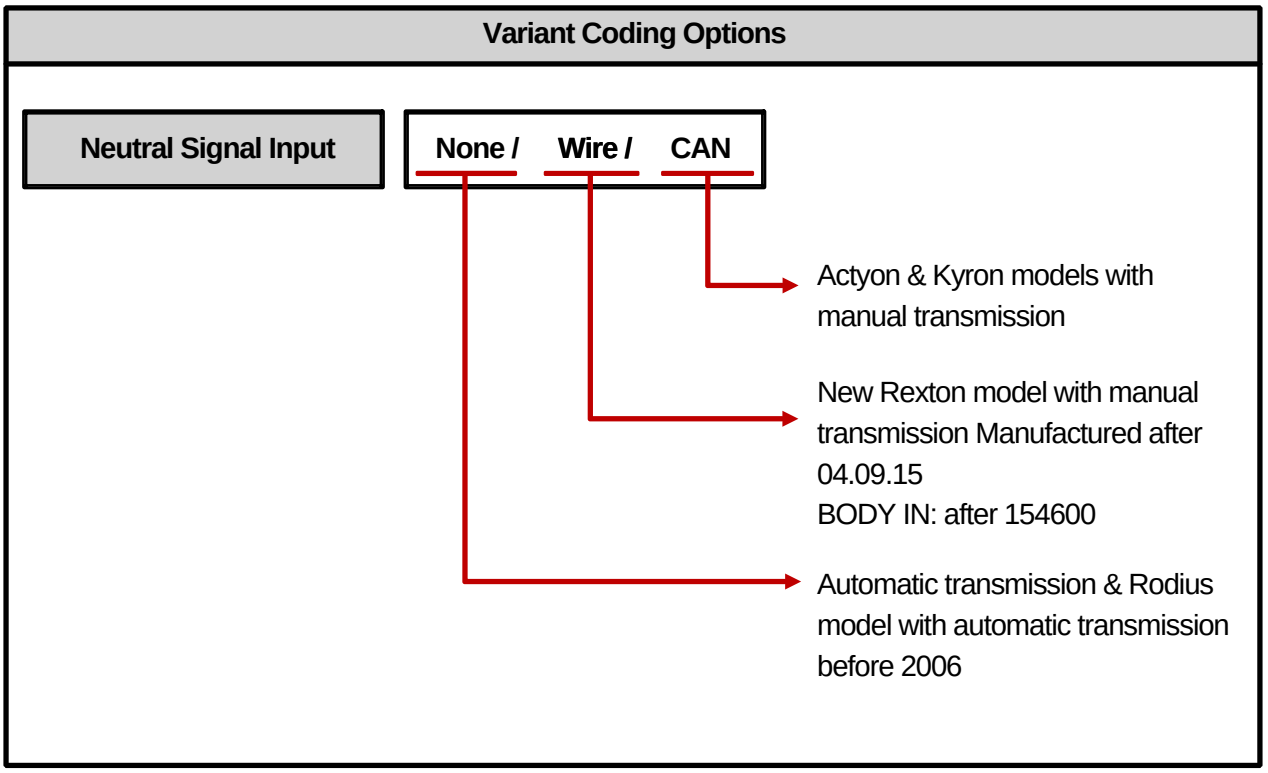
Vehicle Made After 04.09.15	Actyon
	

(2) Detects the position of the shifting lever for the HDC operation among ABS functions.

The HDC function operates only if the M/T shift lever is in forward or reverse position. Please refer to the ABS section for the specific information related to the HDC.

▶ Variant Coding Related to N Switch

The N switch transmits information to the ECU through the CAN communication while New Rexton is connected to the ECU through wires. Thus, if you set the variant coding in the engine ECU, you must do it differently, and you must set the variant coding differently according to the vehicle category and specification as below.



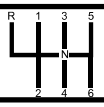
Modification basis	
Application basis	
Affected VIN	

M/T

3170-01

GENERAL INFORMATION

1. SPECIFICATION

Description		Specification
Gear ratio	1st	4.489 : 1
	2nd	2.337 : 1
	3rd	1.350 : 1
	4th	1.000 : 1
	5th	0.784 : 1
	6th	0.679 : 1
	Reverse	4.253 : 1
Synchronizer ring type	1st	T: Triple-cone
	2nd	T: Triple-cone
	3rd	T: Triple-cone
	4th	S: Single-cone
	5th	D: Double-cone
	6th	S: Single-cone
	Reverse	T: Triple-cone
Shifting	Type	Floor change type
	Gear selector lever position	 Reversing: High-force type
Transmission fluid	Type	HD MTF 75W/85 (SHELL) or HK MTF 75W/85(SK)
	Capacity	≒2.2ℓ
	Sercive interval	Inspect and replenish every 60000 km or 3 years (under severe driving conditions, change every 120,000 km)

NOTE What's the severe conditions?

- Towing a trailer or off-road driving (Inspect the leak of fluid at any time, occasionlly)
- Taxi, patrol service or delivery service (extended idling and excessive driving with low speed)
- Frequent stop-and-go traffic, extended idling, short driving distance
- Driving in a hilly or mountainous terrain, sandy, or dusty area
- Driving frequently at high speed over 170 km/hour
- Driving frequently in area where heavy traffic under the ambient temperature above 30°C

Modification basis	
Application basis	
Affected VIN	

2. SPECIAL SERVICE TOOLS

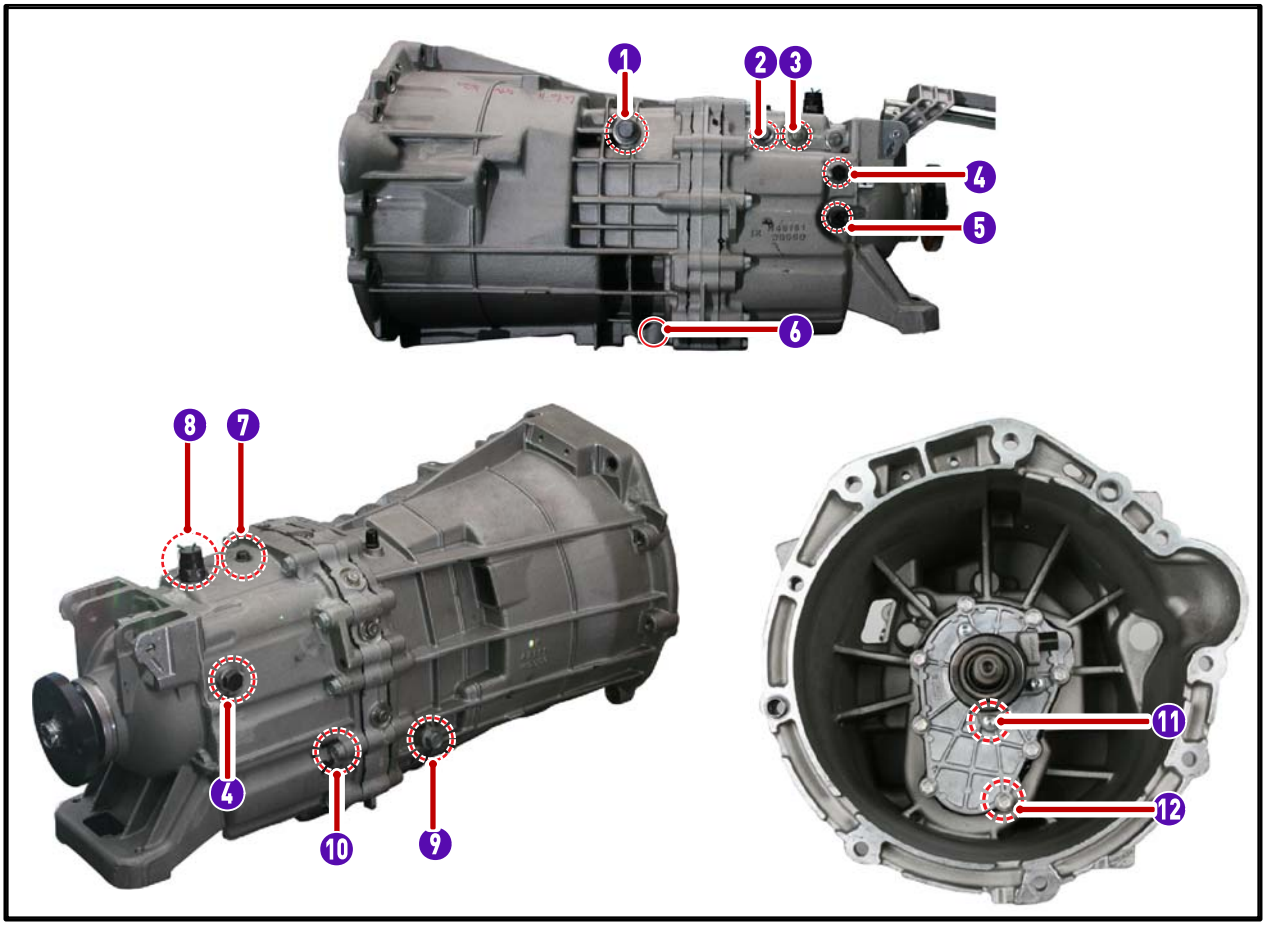
Part No. & Name	Appearance	Description
Part No.: SSM00203-005 **Name**: Main shaft 1st sleeve installer		- Install the main shaft 1st gear sleeve - Install the drive pinion assembly front ball bearing - Install the main shaft double angular ball bearing
Part No.: SSM00203-006 **Name**: Main shaft reverse sleeve installer		- Install the main shaft reverse sleeve and bearing - Install the main drive pinion assembly front ball bearing - Install the main shaft double angular ball bearing - Install the 3rd & 4th synchronizer hub - Install the main shaft 5th gear - Install the main shaft 6th gear
Part No.: SSM00203-002 **Name**: Main shaft 5th sleeve installer		- Install the main shaft 5th gear sleeve - Install the counter shaft 6th gear sleeve - Install the counter shaft reverse gear - Install the main shaft ball bearing
Part No.: SSM00203-003 **Name:** Oil seal installer		Install the extension housing oil seal
Part No.: SSM00203-004 **Name:** Oil seal installer		Install the control shaft oil seal

Modification basis	
Application basis	
Affected VIN	

Part No. & Name	Appearance	Description
Part No.: SSM00203-001 **Name:** **Counter shaft bearing installer**		Install the counter shaft front roller bearing
Part No.: T88310011A-9 **Name:** Bearing support		Support the counter shaft when removing the roller bearing with a puller

* Special service tool Supplier: Tool & Tech

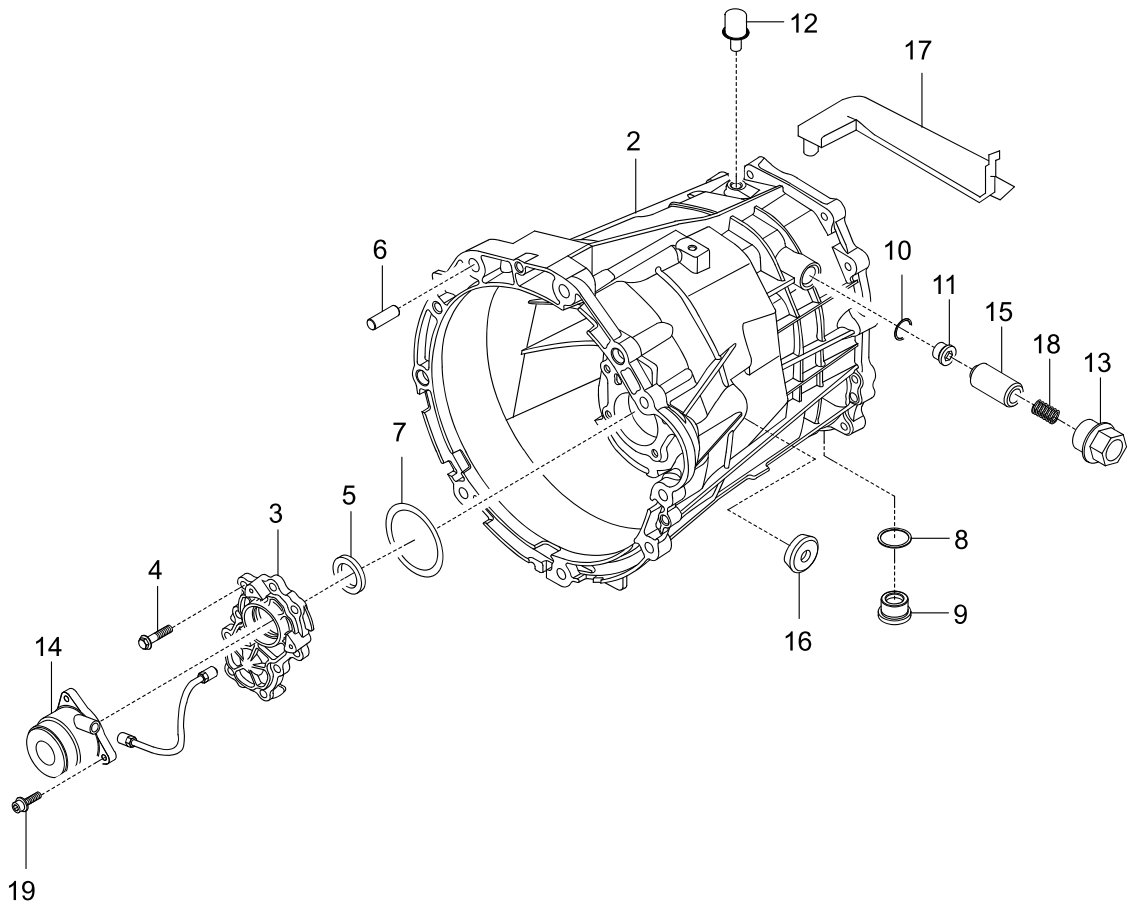
3. TIGHTENING TORQUE



Part name	Tightening torque (Nm)	Numbers	Adhesive
1. Seal bolt (rolling plunger and guide spring)	53.9~67.6	1EA	Loctite
2. Guide bolt	14.7~21.5	1EA	Loctite
3. Pocket ball bearing bolt	29.4~41.1	1EA	Loctite
4. Reverse shift fork retainer bolt	53.9~67.6	2EA	Loctite
5. Backup lamp switch	29.4~34.3	1EA	Loctite
6. Oil drain plug	58.8~78.4	1EA	Loctite
7. Interlock bolt	14.7~21.5	1EA	-
8. Neutral switch	29.4~34.3	1EA	Loctite
9. Oil filler plug	58.8~78.4	1EA	Loctite
10. Extension housing bolt	42.1~53.9	12EA	-
11. Concentric slave cylinder bolt	9.8~15.6	3EA	-
12. Front bearing retainer bolt	19.6~24.5	8EA	Loctite

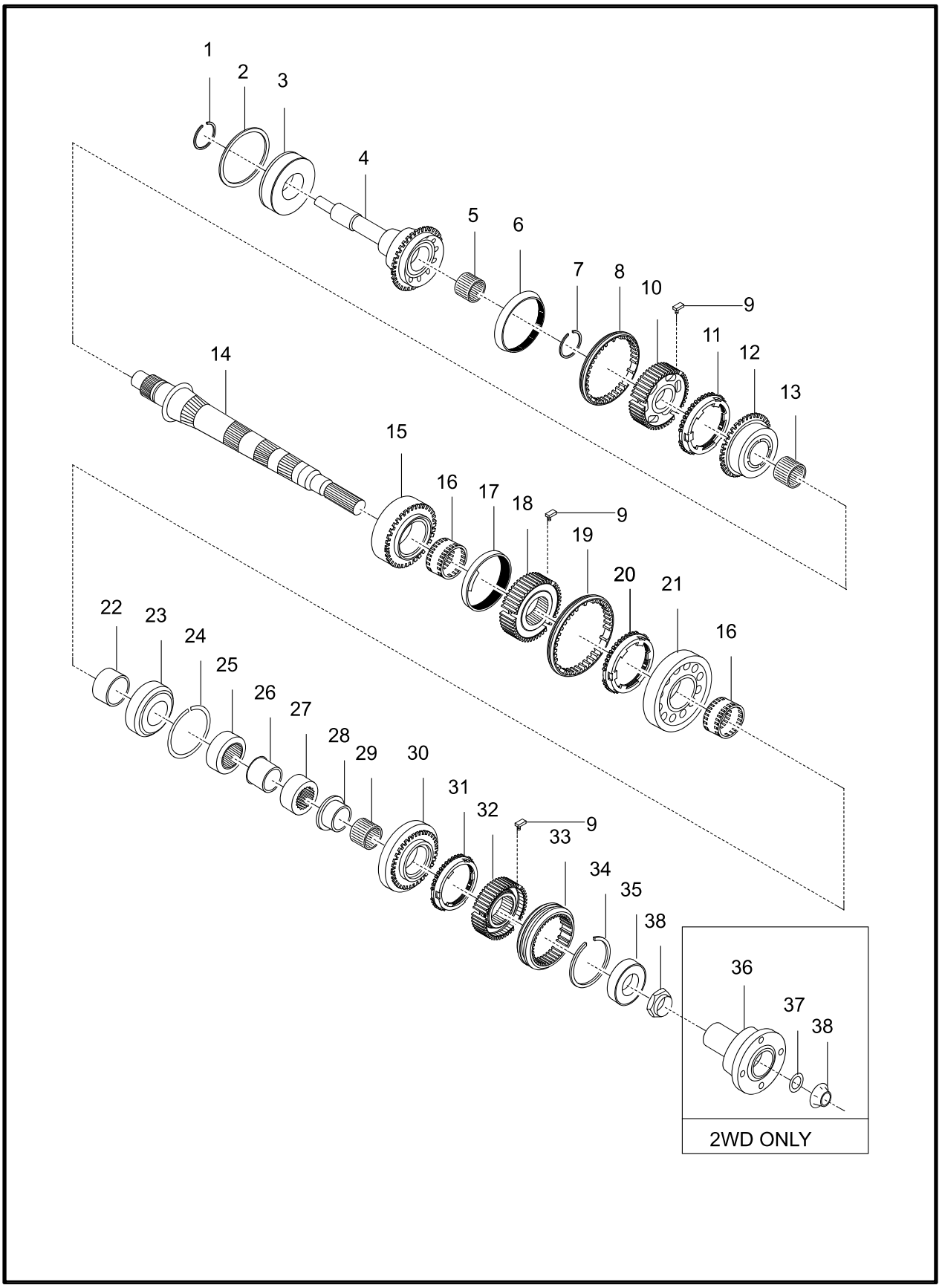
Modification basis	
Application basis	
Affected VIN	

▶ 3163161-00 Housing



2. Case - Transmission
3. Retainer - Bearing
4. Bolt - Seal (19.6 ~ 24.5 Nm)
5. Seal - Oil
6. Bushing
7. Spacer
8. Gasket
9. Plug (58.8 ~ 78.4 Nm)
10. Gasket
11. Plug
12. Breather - Air
13. Pulg - Seal (53.9 ~ 67.6 Nm)
14. Cylinder assembly - Concentric slave
15. Plunger - Rolling
16. Boot
17. Guide - Oil
18. Spring - Guide
19. Bolt - Flange (42.1 ~ 53.9 Nm)

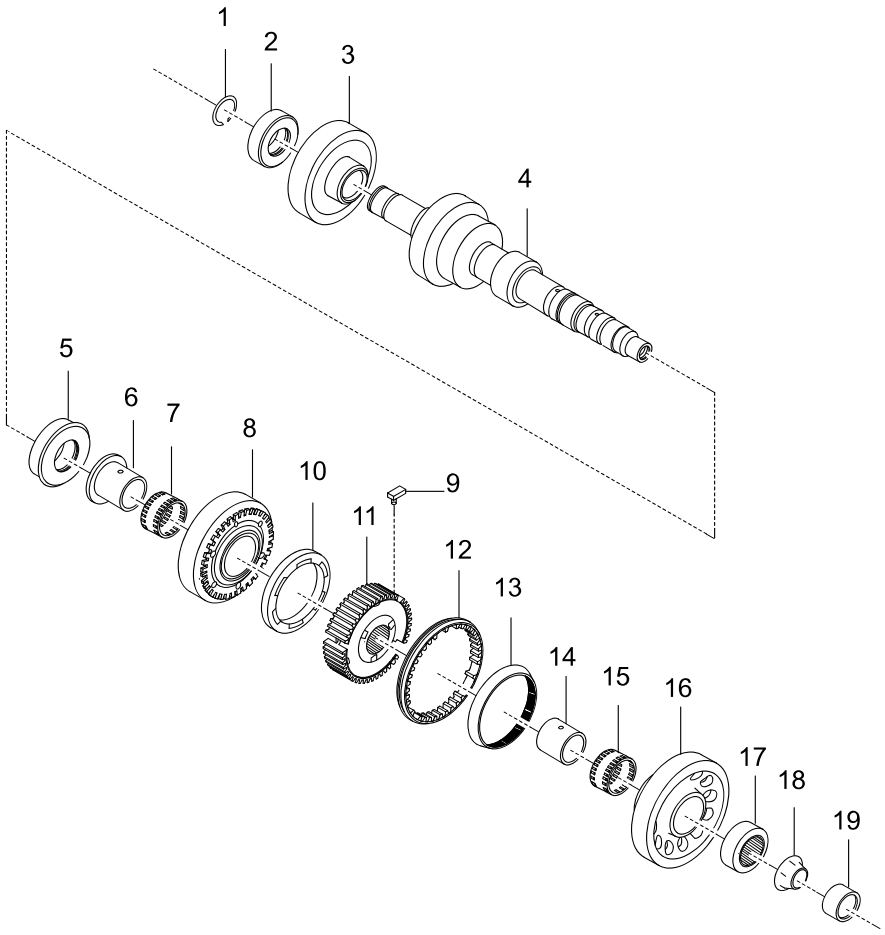
▶ 3162-00 Main shaft



Modification basis	
Application basis	
Affected VIN	

1. Ring - Snap
2. Ring - Snap
3. Bearing - Ball
4. Pinion assembly - Main drive
5. Bearing - Needle roller
6. Ring - Synchronizer
7. Ring - Snap
8. Sleeve - Synchronizer
9. Key assembly - Synchronizer
10. Hub - Synchronizer
11. Ring assembly - Triple cone
12. Gear assembly - 3rd speed
13. Bearing - Needle roller
14. Shaft - Main
15. Gear assembly - 2nd speed
16. Bearing - Needle roller
17. Ring assembly - Triple cone
18. Hub - Synchronizer
19. Sleeve - Synchronizer
20. Ring assembly - Triple cone
21. Gear assembly - 1st speed
22. Sleeve - 1st gear
23. Bearing - Double angular ball
24. Ring - Snap
25. Gear - Main shaft 5th
26. Spacer
27. Gear - Main shaft 6th
28. Sleeve - Reverse gear
29. Bearing - Needle roller
30. Gear assembly - Reverse speed
31. Ring assembly - Triple cone
32. Hub - Synchronizer
33. Sleeve - Synchronizer
34. Stopper - Synchronizer key
35. Bearing - Ball
36. Flange assembly - Companion
37. O-ring
38. Nut - Locking (4WD: 245.1 ~ 264.7 Nm, 2WD: 117.6 ~ 137.2 Nm)

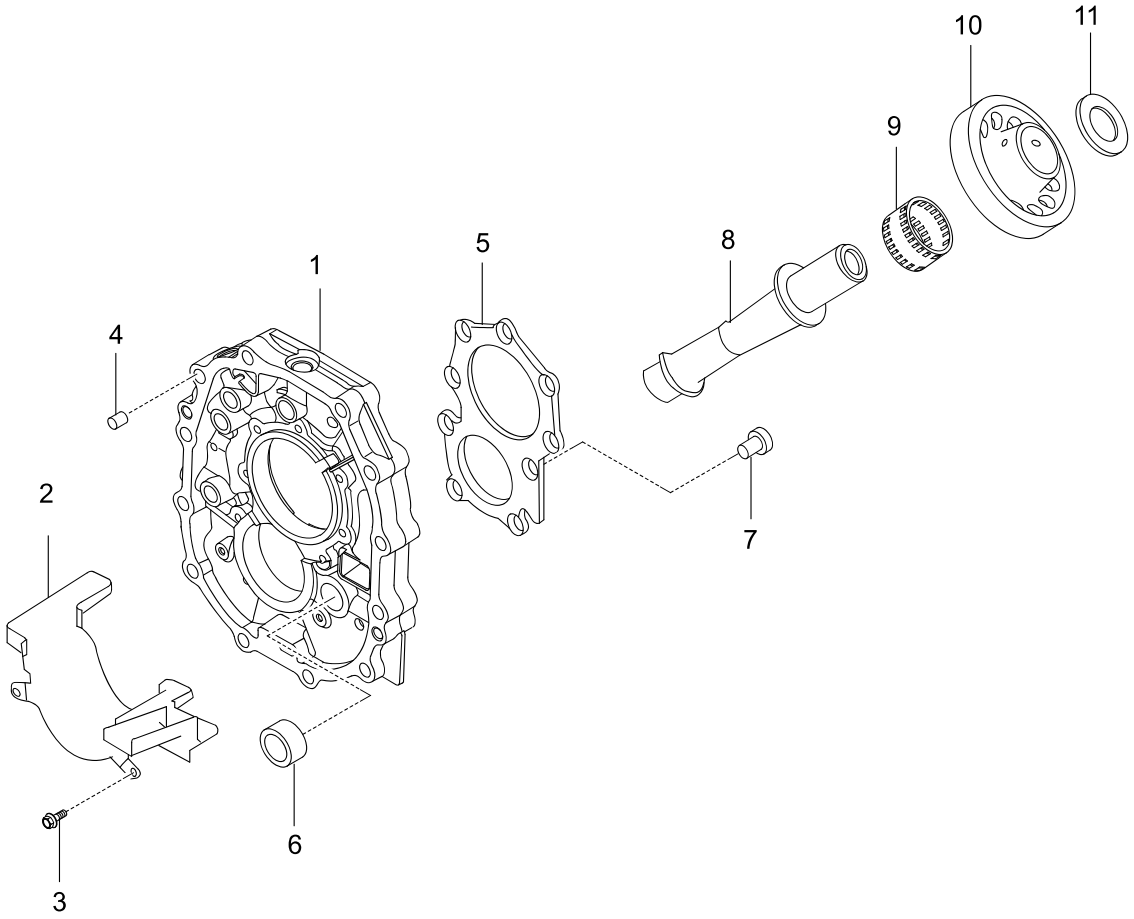
▶ 33163-00 Counter shaft



1. Ring - Snap
2. Bearing - Roller
3. Gear - Counter shaft
4. Gear - Counter shaft cluster
5. Bearing - Roller
6. Sleeve - Speed gear
7. Bearing - Needle roller
8. Gear assembly - 5th speed
9. Key assembly - Synchronizer
10. Ring assembly - Triple cone
11. Hub - Synchronizer
12. Sleeve - Synchronizer
13. Ring - Synchronizer
14. Sleeve - Speed gear
15. Bearing - Needle roller
16. Gear assembly - 6th speed
17. Gear - Counter shaft
18. Nut - Locking (156.9 ~ 186.3 Nm)
19. Bearing - Needle roller

Modification basis	
Application basis	
Affected VIN	

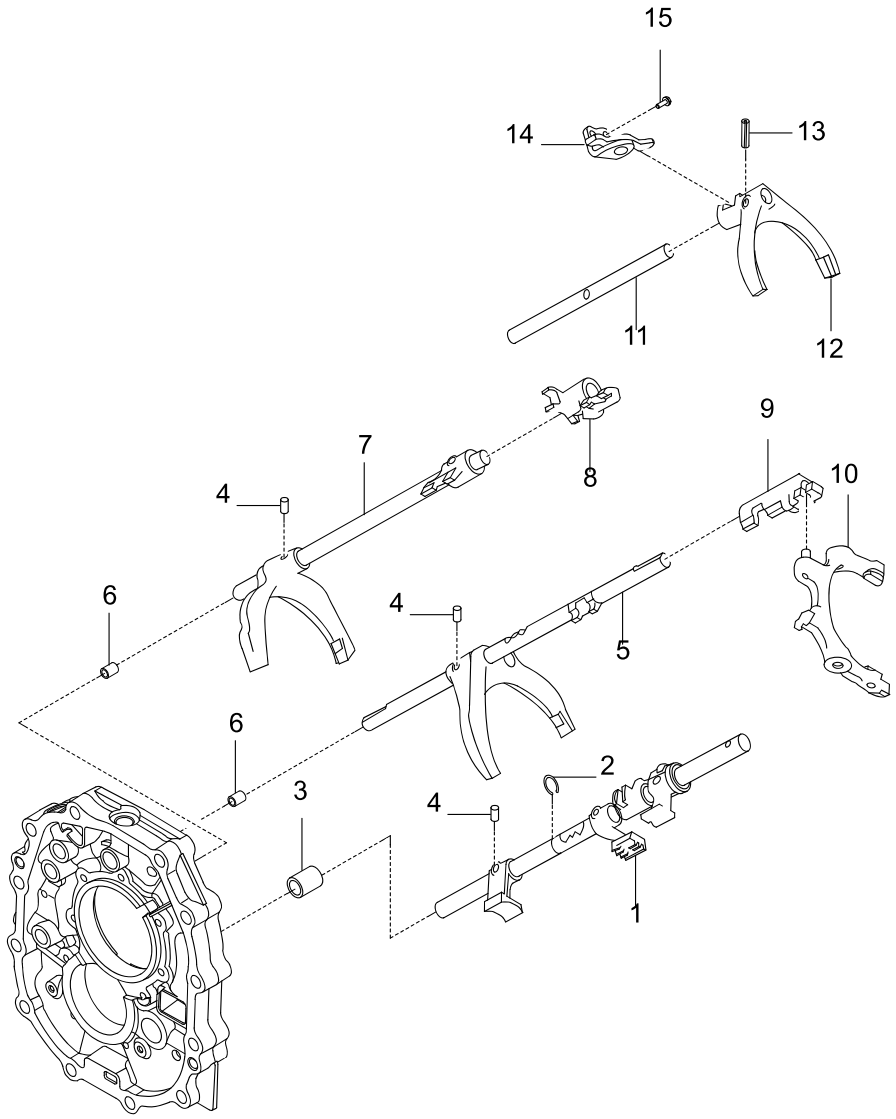
▶ 3164-00 Adapter assembly



1. Plate - Intermediate
2. Guide - Oil
3. Bolt (7.8 ~ 9.8 Nm)
4. Pin - Dowel
5. Retainer - Bearing
6. Magnet
7. Bolt - Seal (19.6 ~ 26.4 Nm)
8. Shaft - Reverse idler gear
9. Bearing - Needle roller
10. Gear - Reverse idler
11. Spacer - Reverse

Modification basis	
Application basis	
Affected VIN	

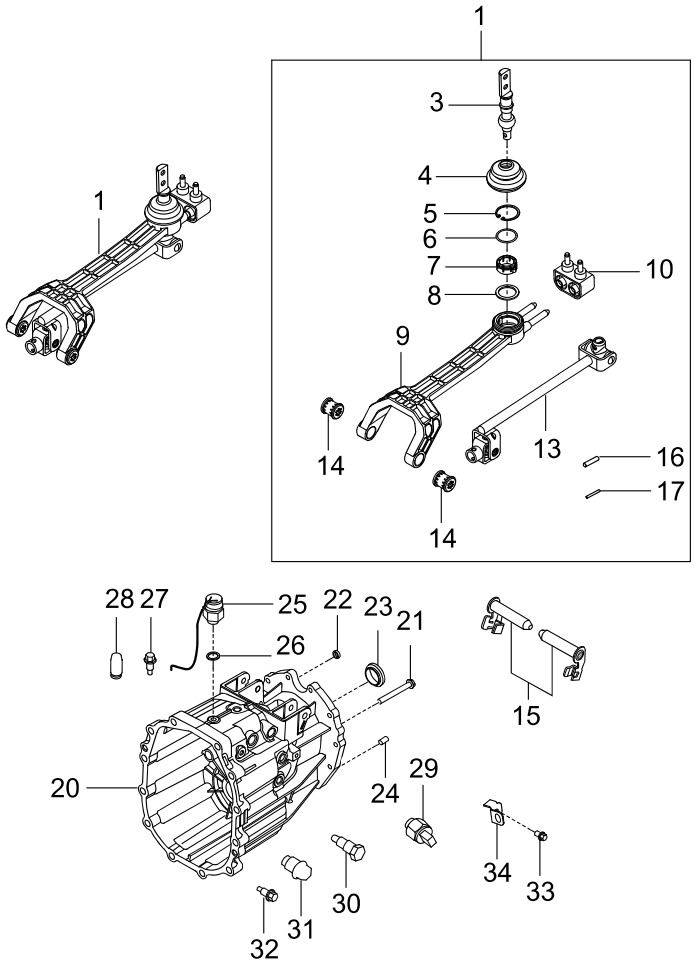
▶ 3165-00 Rail and shift fork



1. Shaft assembly - Control
2. Ring - Retainer
3. Bearing - Retainer ball
4. Pin - Spring
5. Rail sub assembly - Shaft 1st & 2nd
6. Bushing
7. Rail sub assembly - Shaft 3rd & 4th
8. Lug - Shaft 5th & 6th
9. Lug _ Reverse shaft
10. Fork - Reverse shaft
11. Rail - Shaft 5th & 6th
12. Fork - Shaft 5th & 6th
13. Pin - Spring
14. Lever assembly - Shaft 5th & 6th
15. Bolt - Flange (14.7 ~ 21.5 Nm)

Modification basis	
Application basis	
Affected VIN	

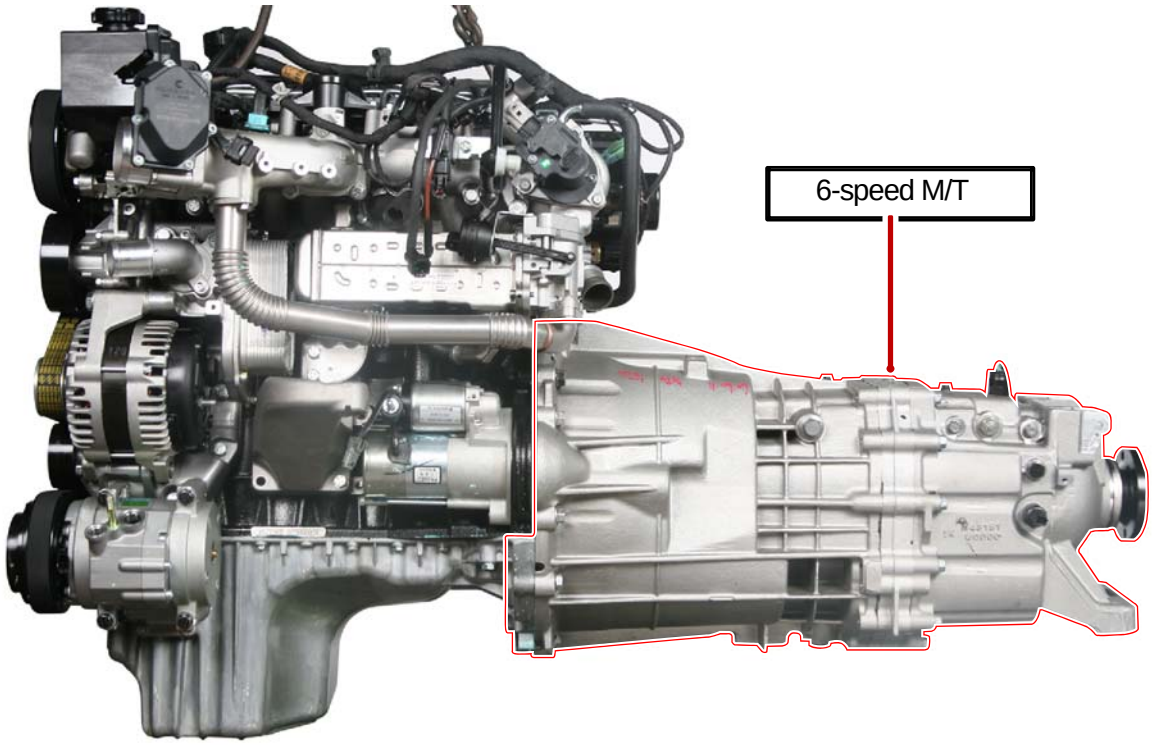
▶ 3166-00 Extension housing



1. Lever assembly - Semi remote
3. Lever - Shift
4. Boot - Rubber
5. Ring - Retainer
6. O-ring
7. Bearing
8. Shim
9. Arm - Control
10. Damper assembly
13. Rod assembly
14. Bushing assembly - TGS mounting
15. Pin - TGS mounting
16. Pin - Spring
17. Pin - Spring
20. Adapter - Case
21. Bolt - Flange (42.1 ~ 53.9 Nm)
22. Seal - Oil
23. Seal - Oil
24. Pin - Dowel
25. Switch - Neutral (29.4 ~ 34.3 Nm)
26. Gasket
27. Bolt - Interlock (14.7 ~ 21.5 Nm)
28. Pin - Detent
29. Switch - Backup lamp (29.4 ~ 34.3 Nm)
30. Bolt - Fork hinge (53.9 ~ 67.6 Nm)
31. Bearing - Poppet ball (29.4 ~ 41.1 Nm)
32. Bolt - Guide (14.7 ~ 21.5 Nm)
33. Bolt (2.9 ~ 4.9 Nm)
34. Bracket - Wiring

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW



Front view

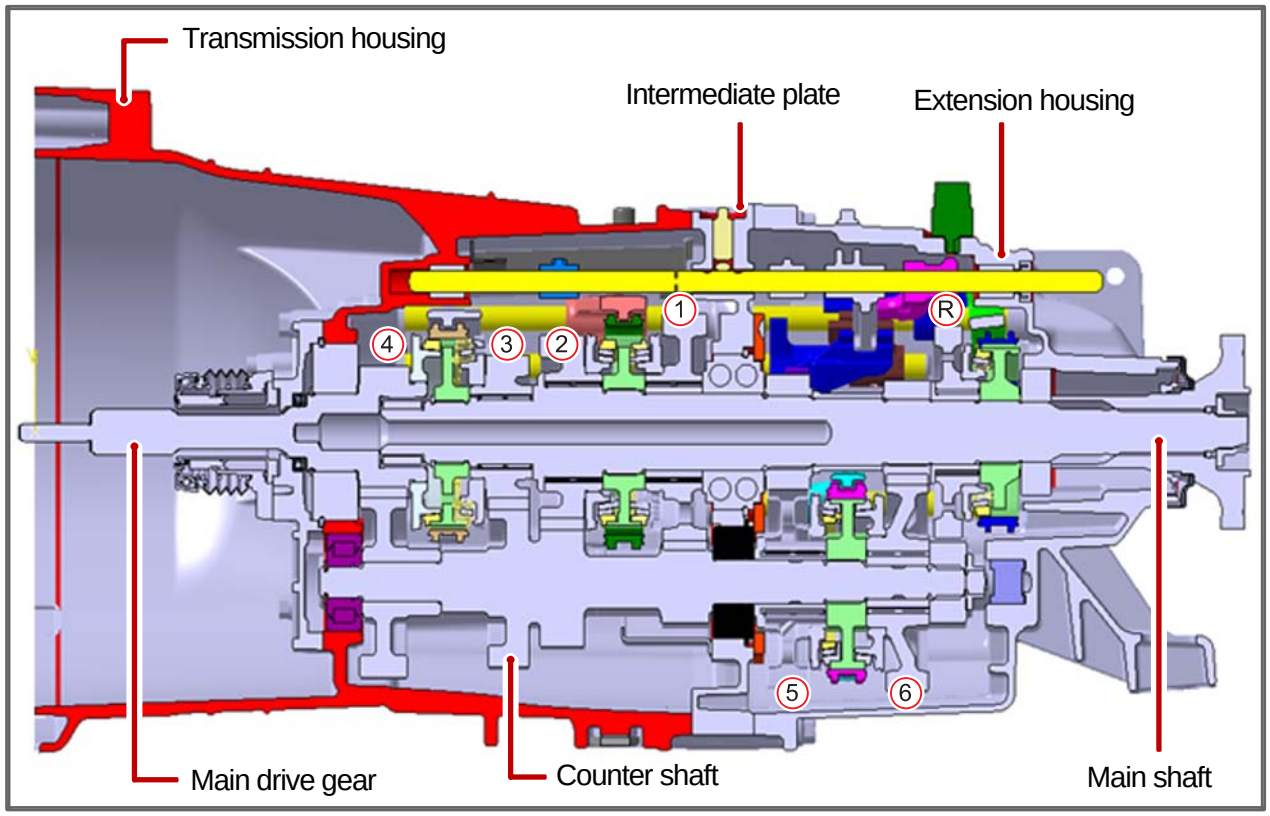
Sectional view

1) Characteristics of Transmission

- Forward and Reverse gears are helical gear.
- The clutch is operated by concentric slave cylinder (CSC).
- To prevent the improper gear shift, semi-remote control system has been introduced.
- To prevent the gears from engaging improperly, the synchronizer mechanisms and independent interlock systems are installed on 1/2 gears, 3/4 gears, 5/6 gears and reverse gear.
  The High-Force system for reverse gear shift has been introduced.
- The synchronizer has three types: Triple (1, 2, 3, R), Double (5), Single (4, 6)
-

Modification basis	
Application basis	
Affected VIN	

2) Sectional Diagram

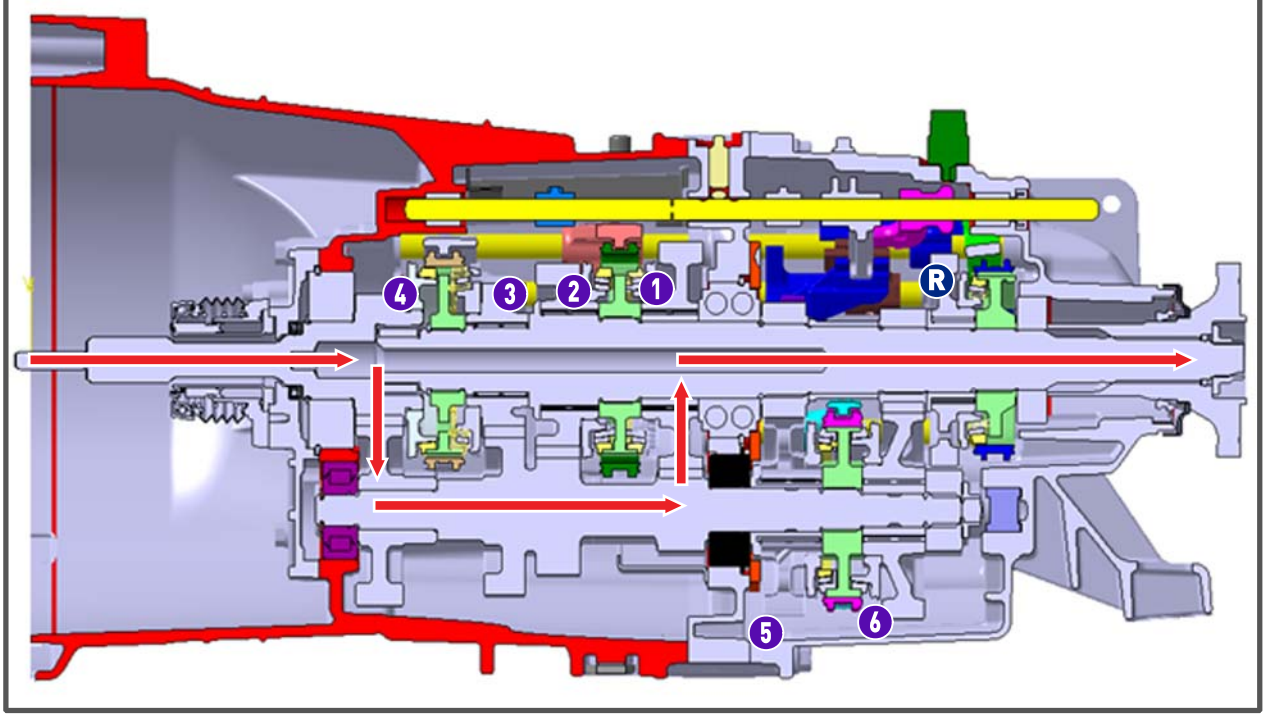


3) Gear Ratio

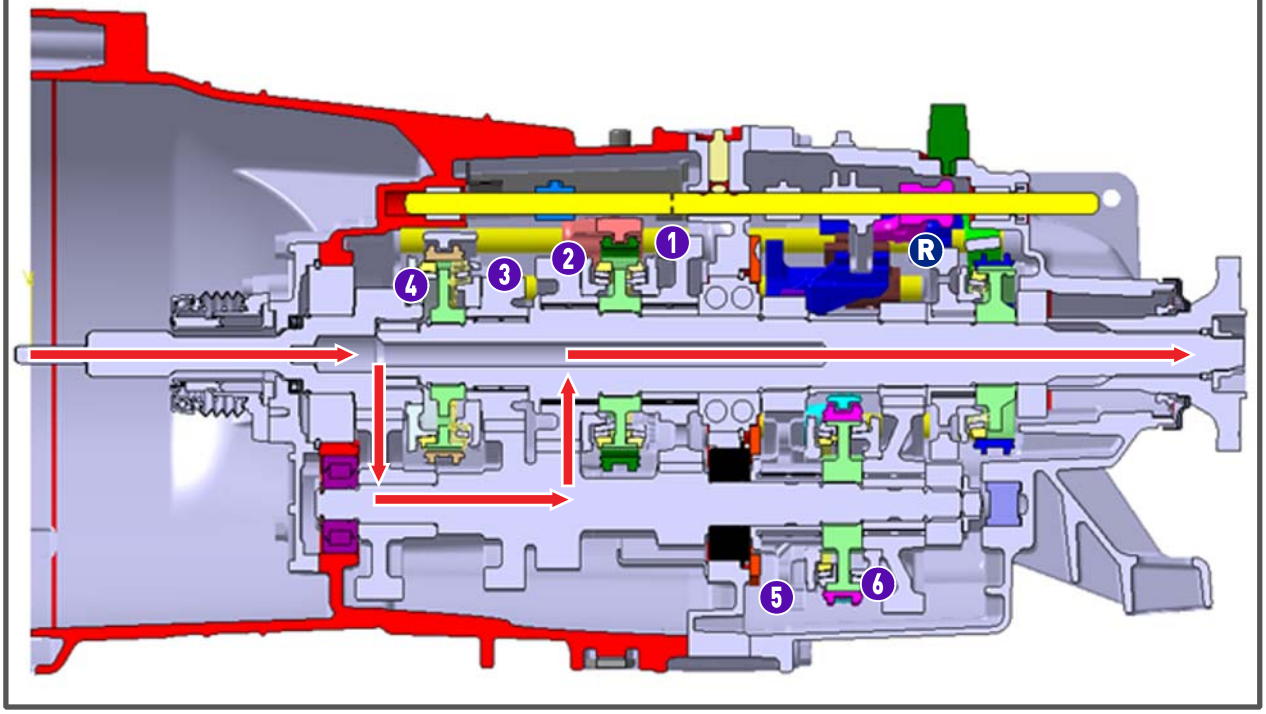
Gear	Teeth		Final gear ratio
	Input	Output	
1st	13	38	4.489
2nd	23	35	2.337
3rd	33	29	1.350
4th	28	43	1.000
5th	47	24	0.784
6th	52	23	0.679
R	13	36	4.253
	Idle: 25		

2. POWER FLOW

1st speed

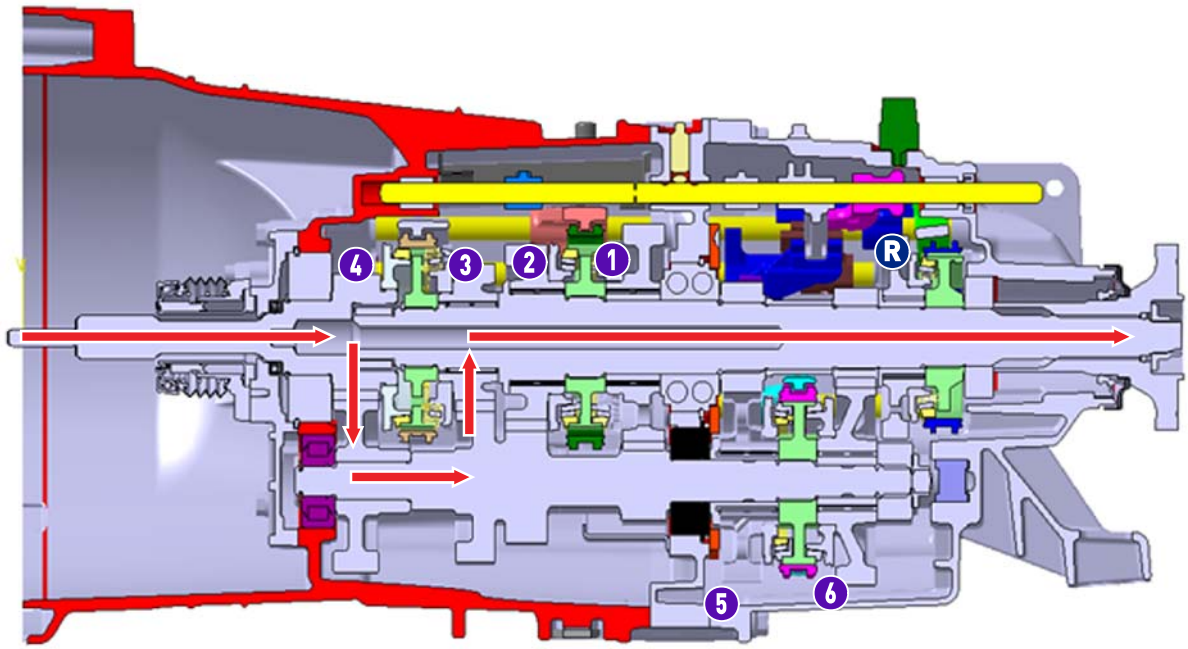


2nd speed

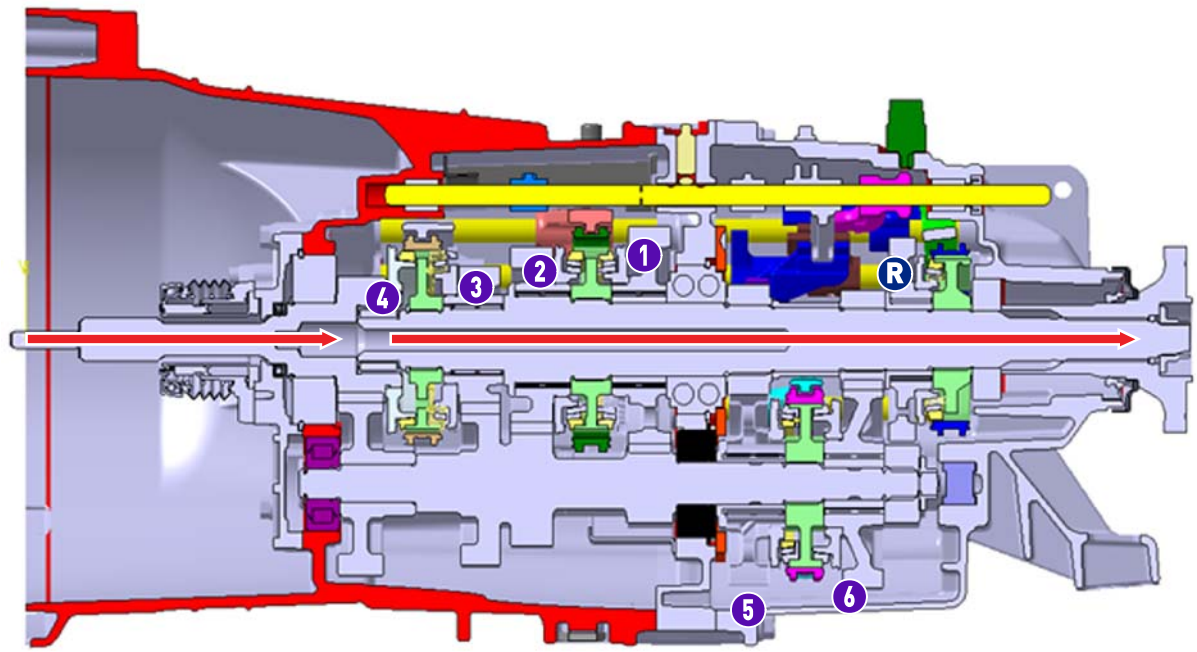


Modification basis	
Application basis	
Affected VIN	

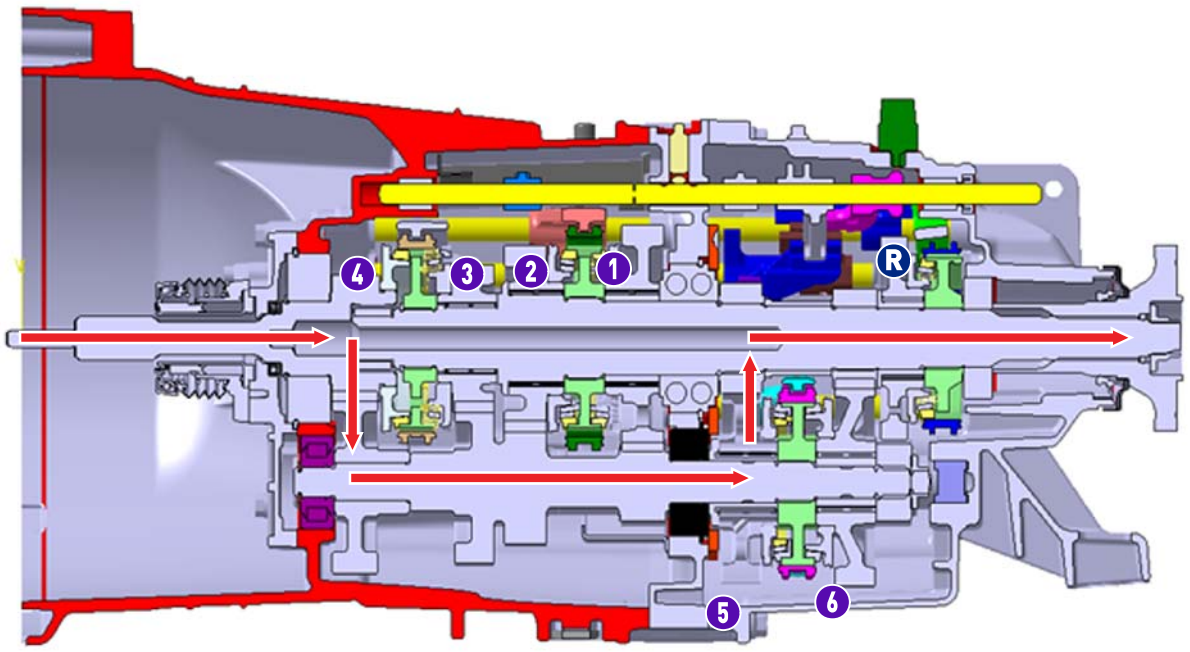
3rd speed



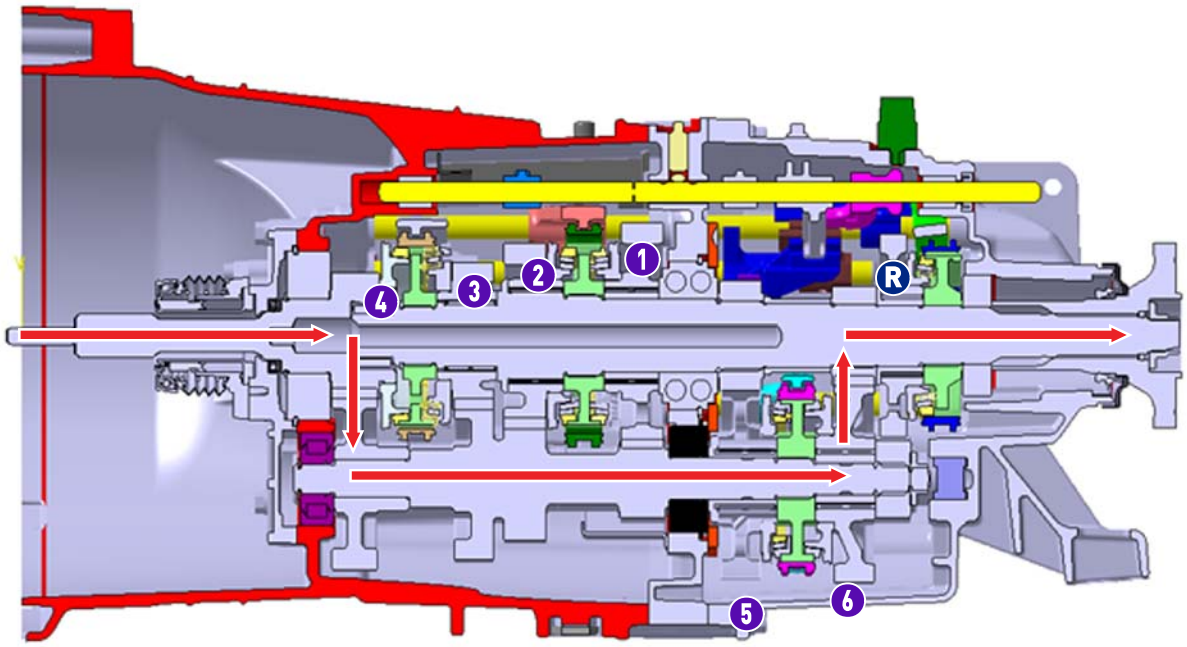
4th speed



5th speed

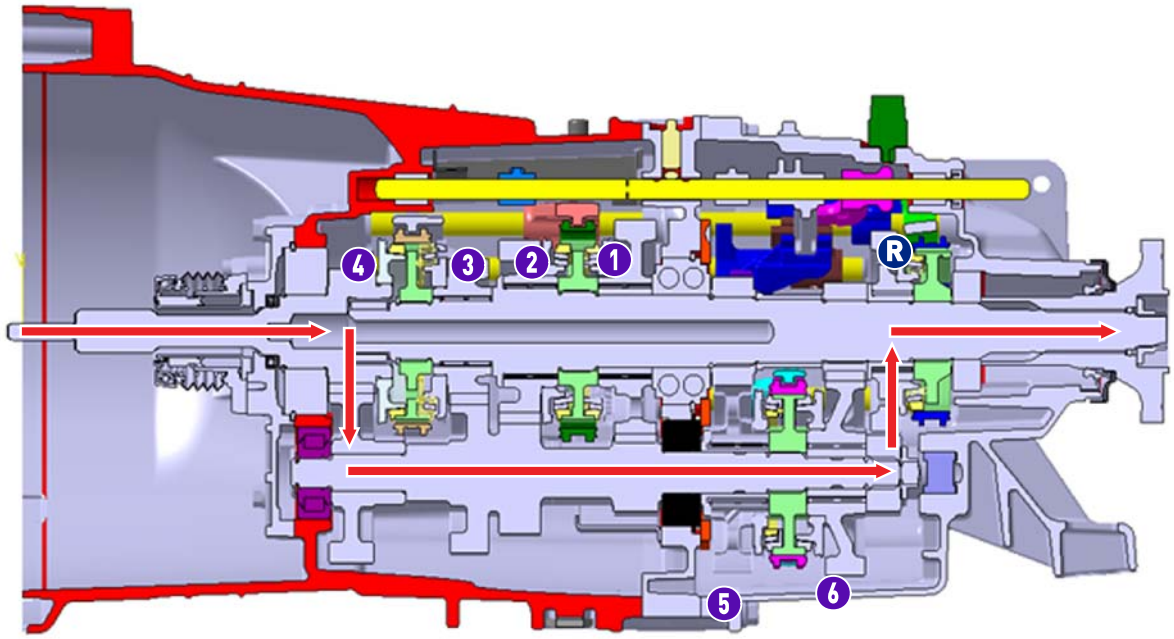


6th speed

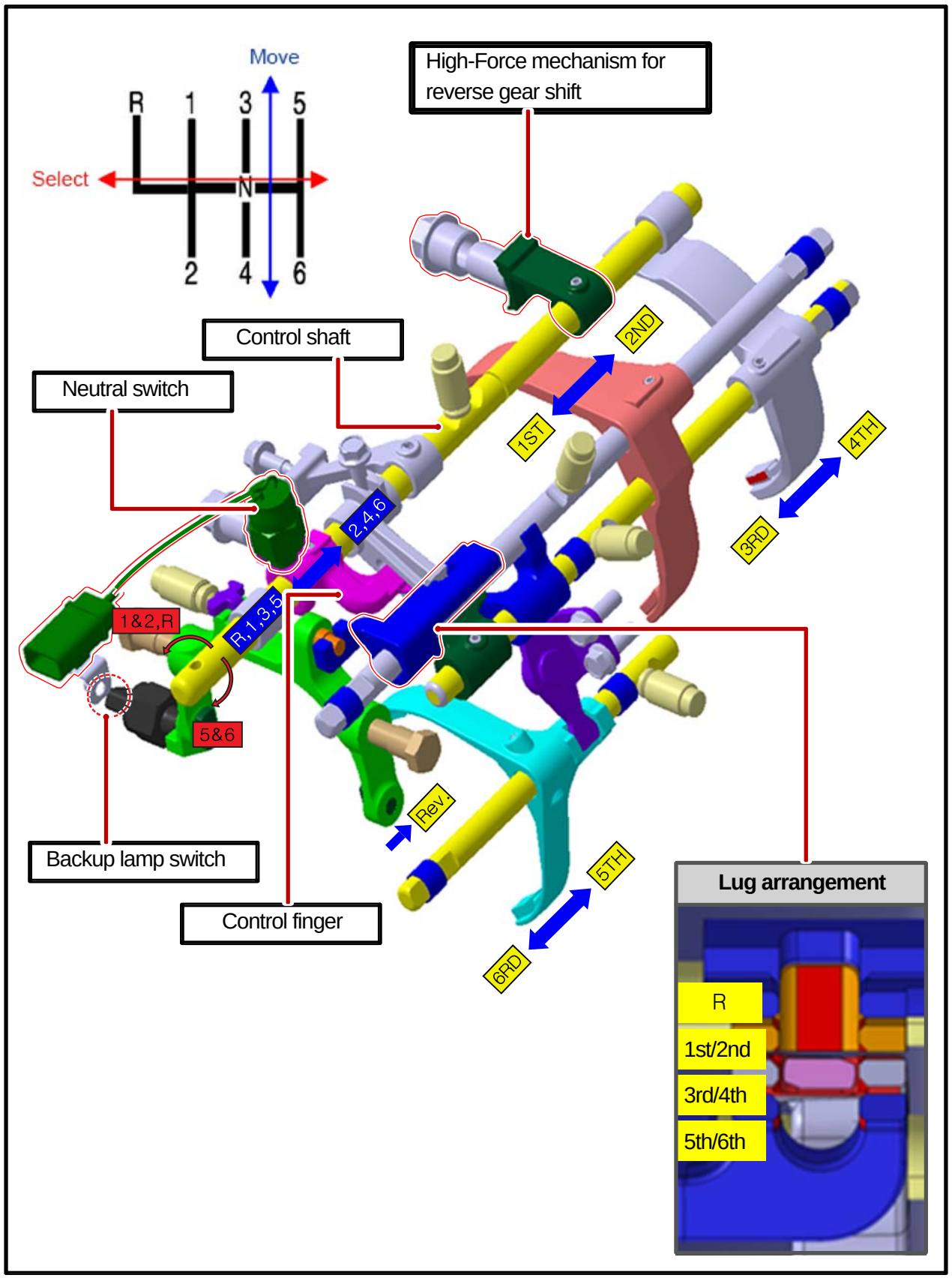


Modification basis	
Application basis	
Affected VIN	

Reverse gear



3. SHIFTING MECHANISM



Modification basis	
Application basis	
Affected VIN	

CLUTCH

3010-00

GENERAL INFORMATION

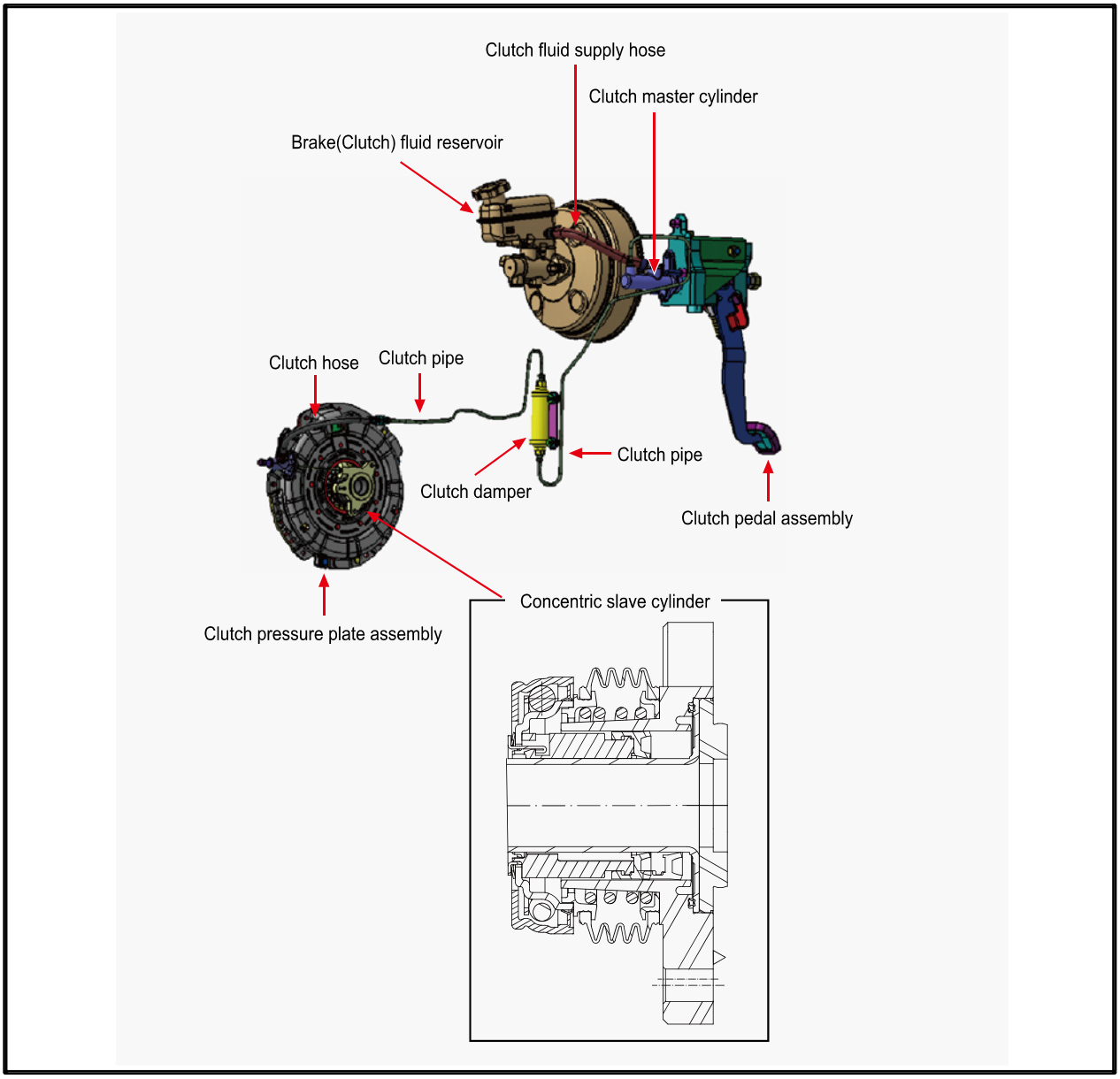
1. SPECIFICATION

Description			Specification
Operating type			Hydraulic type
Clutch pedal	Type		Suspended type
	Max. operating travel		145 mm
	Pedal free play (Longitudinal)		159 ± 5 mm
	Pedal free play (Transverse)		5 ~ 15 mm
Clutch disc	Type		Dry type single diaphragm
	Diameter of facing		Outer: Ø250 mm Inner: Ø160 mm
	Numbers of disc		2
	Thickness of disc		Free: 8.7 ± 0.3 mm When loaded: 8.0 ± 0.2 mm
Setting load of clutch cover assembly			At least 7,800 N
Clutch master cylinder	Stroke	5MT	30mm
		6MT	27mm
	Inner diameter		Ø17.46 mm
Concentric slave cylinder	Maximum operating travel		Max. 20 mm
	Operating pressure		Max. 2,200 N
Clutch fluid	Type		DOT 4
	Capacity		As required

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

The hydraulic clutch transmits the force required to operate the clutch pedal to the concentric slave cylinder fitted to the clutch housing as a hydraulic pressure.
(The hydraulic pressure is transmitted in the following order: Clutch pedal - Clutch master cylinder - Clutch pipe - Clutch damper - Clutch pipe and hose - Concentric slave cylinder - Pressure plate - Flywheel.)
If a driver depress the clutch pedal, the hydraulic pressure is generated in the master cylinder. It is transmitted to the concentric slave cylinder through the pipe, resulting in the cylinder being forced out. At this time, the clutch disc is forced against the cylinder by pushing the cover. This, in turn, remove the flywheel from the pressure plate. As a consequence, the power from the engine will be cut off and the gear change can be carried out.



Modification basis	
Application basis	
Affected VIN	

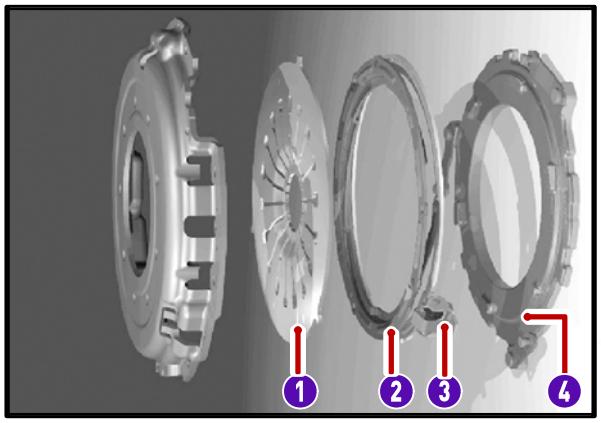
2. SATIC (SELF ADJUSTING TECHNOLOGY WITH INTEGRATED CASSETTE)

1) System Description

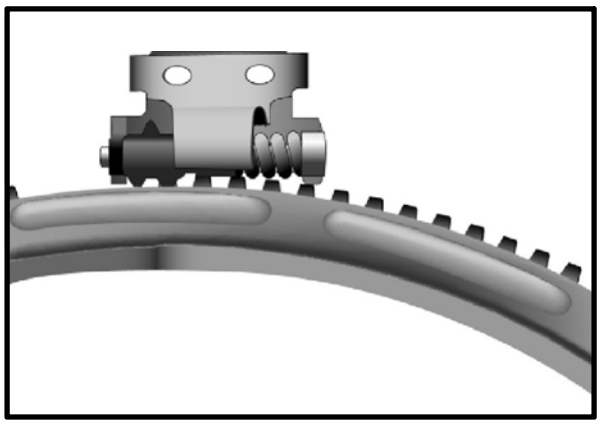
▶ Function

On the conventional clutch, the pedal force tends to increase in proportion to the degree of disc run-out. However, the SATIC clutch has the adjusting function which activates the cassette system inserted to the clutch cover to maintain a constant pedal force and clearance when the disc runs out. (Unlike SAT type, SATIC type does not need SST for clutch cover removal.)

▶ Operation



Diaphragm spring rotates the adjusting equipment as clutch disc is wearing and so, pressure plate is pushed to clutch disc side at the amount of wear.
Disc wear (Free play) → Diaphragm spring (1) → Adjusting equipment (2, 3) → Pressure plate (4)



2) Overview

▶ Driving elements

The driving elements consist of two flat surfaces machined to a smooth finish.
One of these is the rear face of the engine flywheel and the other is the clutch pressure plate. The clutch pressure plate is fitted into a clutch steel cover, which is bolted to the flywheel.

▶ Driven elements

The driven element is the clutch disc with a splined hub which is free to slide lengthwise along the splines of the input shaft.
The driving and driven elements are held in contact by spring pressure. This pressure is exerted by a diaphragm spring in the clutch cover pressure plate assembly.

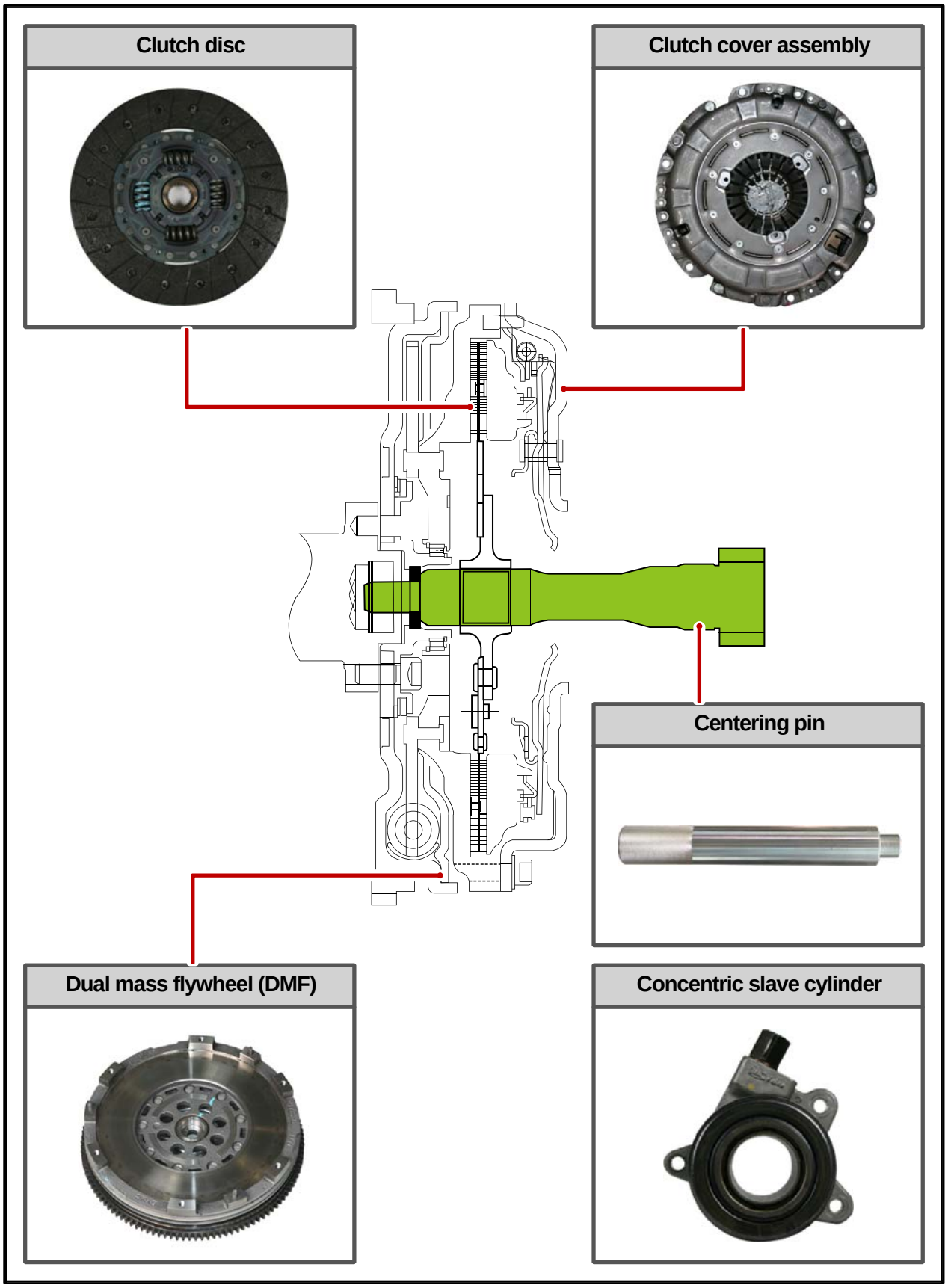
▶ Operating Elements

The clutch "release" system consists of the clutch pedal and clutch release cylinder.
This system directly releases the clutch by using hydraulic pressure while the conventional clutch system releases the clutch by using release lever and release fork. This system provides higher efficiency than conventional clutch system, and its durability is superior.

- Clutch master cylinder (mounted on clutch pedal)
- Concentric slave cylinder pipe (mounted inside of transmission)

Modification basis	
Application basis	
Affected VIN	

3) Layout



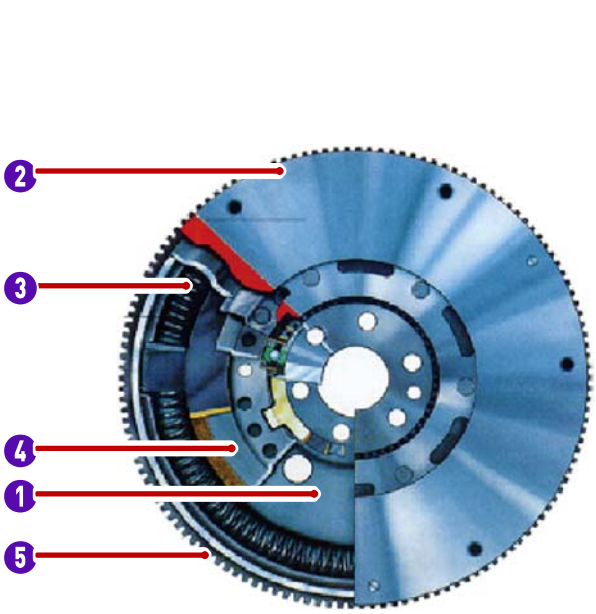
Modification basis	
Application basis	
Affected VIN	

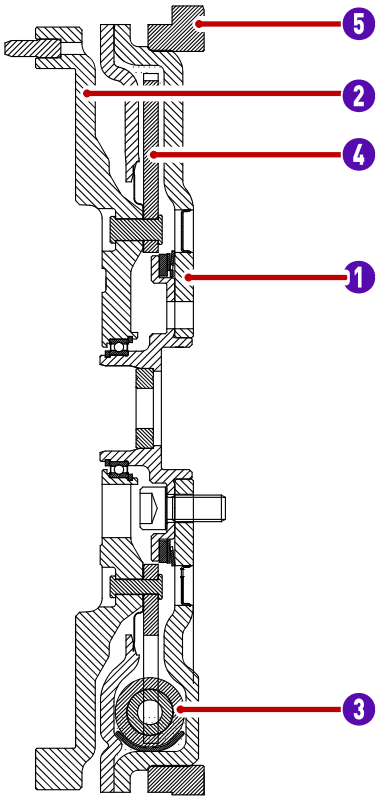
3. DUAL MASS FLYWHEEL (DMF)

The dual mass flywheel (DMF) is of having a mass divided into two halves.
While one mass is connected to the engine crankshaft, which is affected by the mass moment of inertia of the engine, the other mass is affected by one of the transmission.
The divided dual masses are connected to the coil spring and damping system internally.

▶ **The DMF has the following benefits:**

- Reducing fuel consumption by lowering engine speed
- Reducing rattling noise and vehicle vibration in all driving ranges
- Reducing synchronization wear
- Facilitating gear change
- Protecting power train parts by preventing excessive load from being delivered





1. Primary flywheel
2. Secondary flywheel
3. Arc damper spring
4. Torque limiter
5. Ring gear

Modification basis	
Application basis	
Affected VIN	

PROPELLER SHAFT

3310-00

GENERAL INFORMATION

1. SPECIFICATION

Description			Specification
Structure			Universal joint with yoke arm and spider
Number of spiders	Front	Part time T/C	Two
	Rear		Three
Runout			Max. 0.3mm
Unbalance			Max. 18 g.cm / 4,500 rpm
Dimension of front propeller shaft (Length x Dia.) (mm)	A/T		552.3*Φ63.5 (Compressed)
	M/T		603.8*Φ63.5 (Compressed)
Dimension of front propeller shaft (Length x Dia.) (mm)	2WD	Front	1136.0*Φ63.5
		Rear	743.*Φ63.5(Compressed)
	4WD(M/T)	Front	785.1*Φ63.5
		Rear	743.*Φ63.5(Compressed)
	4WD(A/T)	Front	836.8*Φ63.5
		Rear	743.*Φ63.5(Compressed)

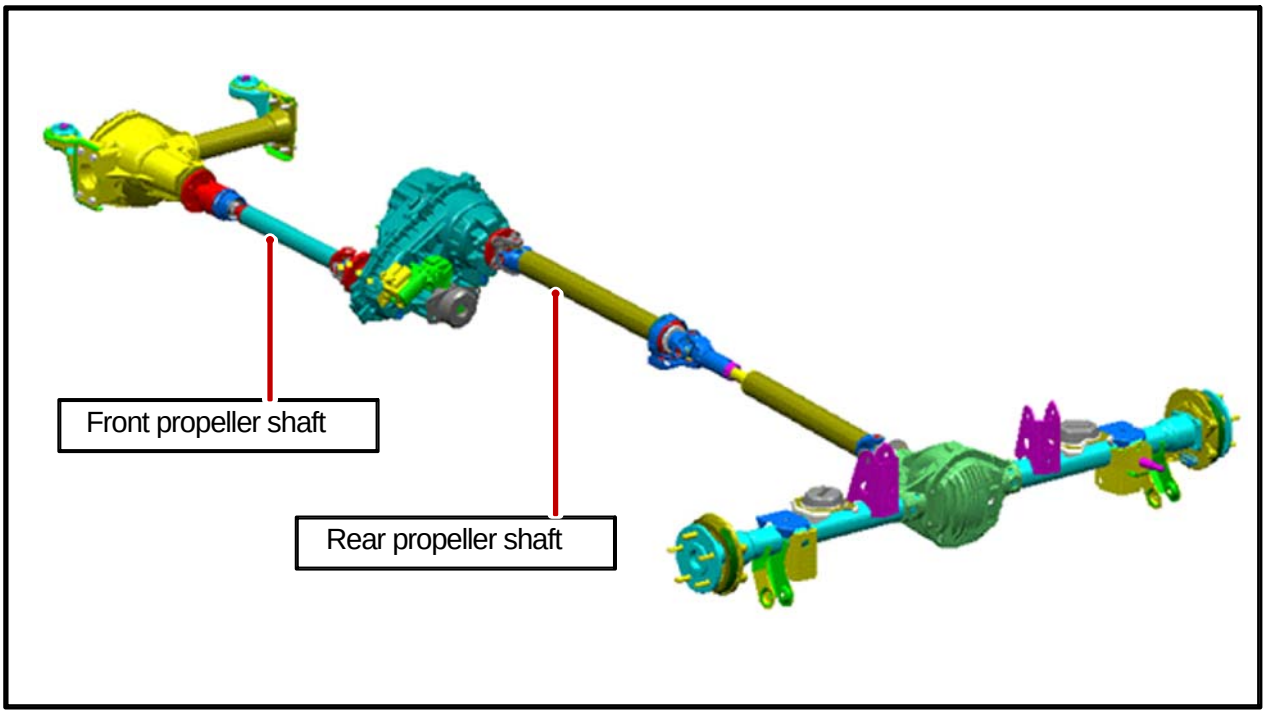
2. TIGHTENING TORQUE

Fastener	Tightening torque
Mounting bolts for front/rear axle	66.7 ~ 73.5Nm
Mounting bolts for T/M and T/C	79.4 ~ 87.2Nm
Mounting bolts for center bearing	78.4 ~93.1Nm

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

The propeller shaft transfers the power through the transmission and transfer case to the front/rear axle differential carrier (final reduction gear).
It is manufactured by a thin rounded steel pipe to have the strong resisting force against the torsion and bending.
Both ends of propeller shaft are connected to the spider and the center of propeller shaft is connected to the spline to accommodate the changes of the height and length.
The rubber bushing that covers the intermediate bearing keeps the balance of rear propeller shaft and absorbs its vibration.



▶ **Function of propeller shaft**

- Transmits driving torque.
- Compensates the angle change (universal joint / CV joint).
- Compensates the axial length change (splines for the slip joint).

Modification basis	
Application basis	
Affected VIN	

AXLE

4120-01

GENERAL INFORMATION

1. SPECIFICATIONS

Location		Front Axle		Rear Axle	
Specification		M/T	A/T	M/T	A/T
Gear ratio		4.55R(5MT DSL) 4.89R(5MT GSL)	3.54(5AT DSL) 3.91(6AT DSL)	4.55R(5MT DSL) 4.89R(5MT GSL)	3.54(5AT DSL) 3.91(6AT DSL)
Gear	Type	Hypoid	←	←	←
	Size	Ø182.8 mm	←	Ø228.6 mm	←
	Offset	28.58 mm (DYMOS) 35 mm(Tongil)	←	30 mm	-
Housing		Steel	←	Steel casting	←
Oil	Type	SAE 80W/90, API GL-5	←	SAE 80W/90, API GL-5	←
	Capacity	1.4 L	←	2.0L	←
Length		448.0 mm	←	469.0 mm	←
Witdh		681.9 mm	←	1,717.7 mm	←
Weight		45 kg	←	90 kg	←

Modification basis	
Application basis	
Affected VIN	

TRANSFER CASE

3240-01

GENERAL INFORMATION

1. SPECIFICATIONS

Description		Specifications
Type		Part-time transfer case
Total length		343 mm
Mating surface of front flange		40 mm
Weight		32.4 kg (including oil)
Oil capacity		1.4 L
Oil type		ATF DEXRON III
Location		Transfer case
Major element	Housing	Part-time & TOD
	Bolt	11 ea, M8 x 1.25
	Input shaft	A/T: outer spline M/T: inner spline

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

By using the planetary gear sets, two-gears shift type part time transfer case achieves direct connection when selecting 4WD "HIGH" and 2.48 of reduction gear ratio when selecting 4WD "LOW". The silent chain in transfer case transfers the output power to front wheels.
The simple operation of switches on instrument panel allows to shift between "2H" and "4H" easily while driving (for 4L: stop vehicle first). The warning lamp warns the driver when the system is defective.

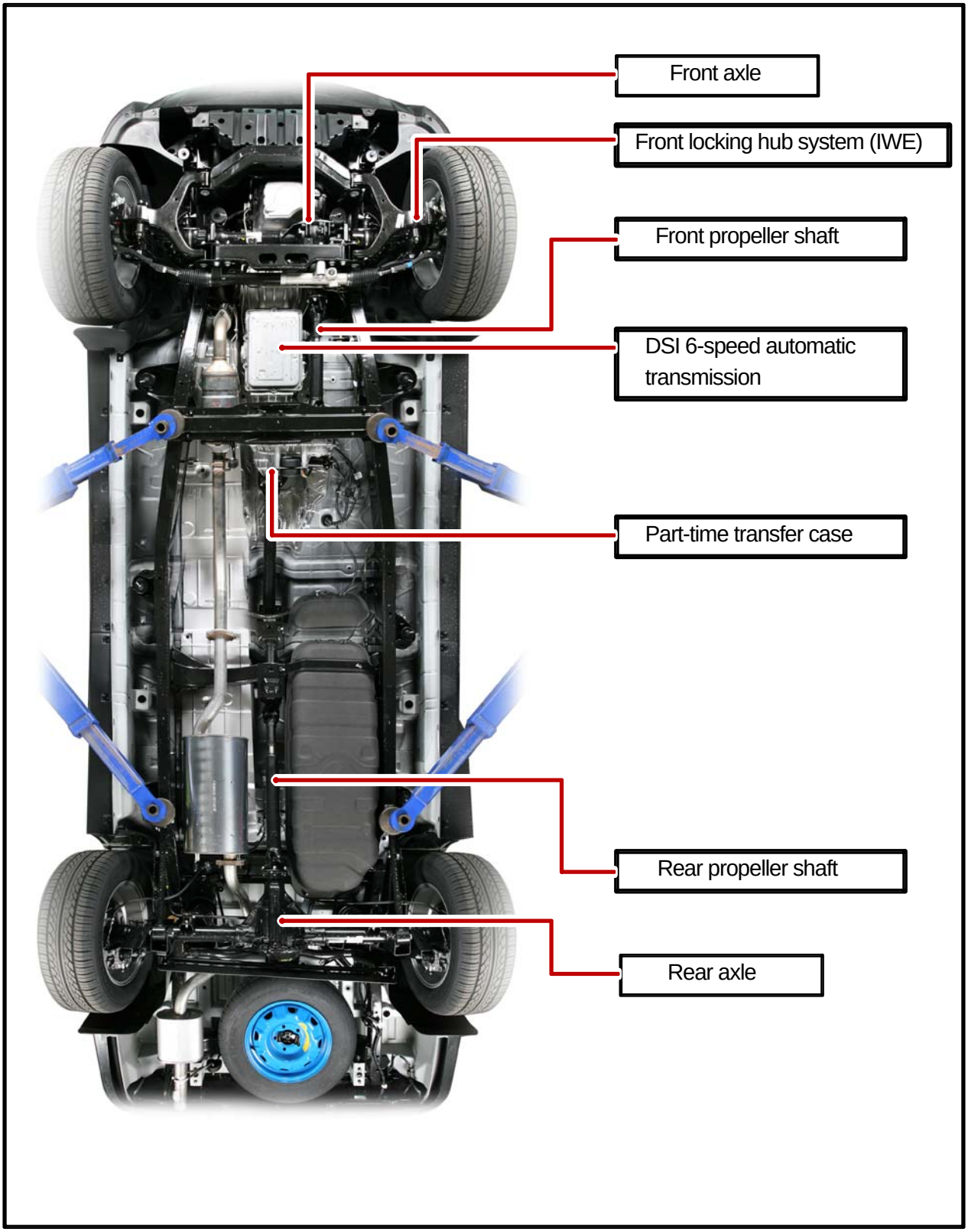
Side View	Rear View
	

Modification basis	
Application basis	
Affected VIN	

▶ Operation

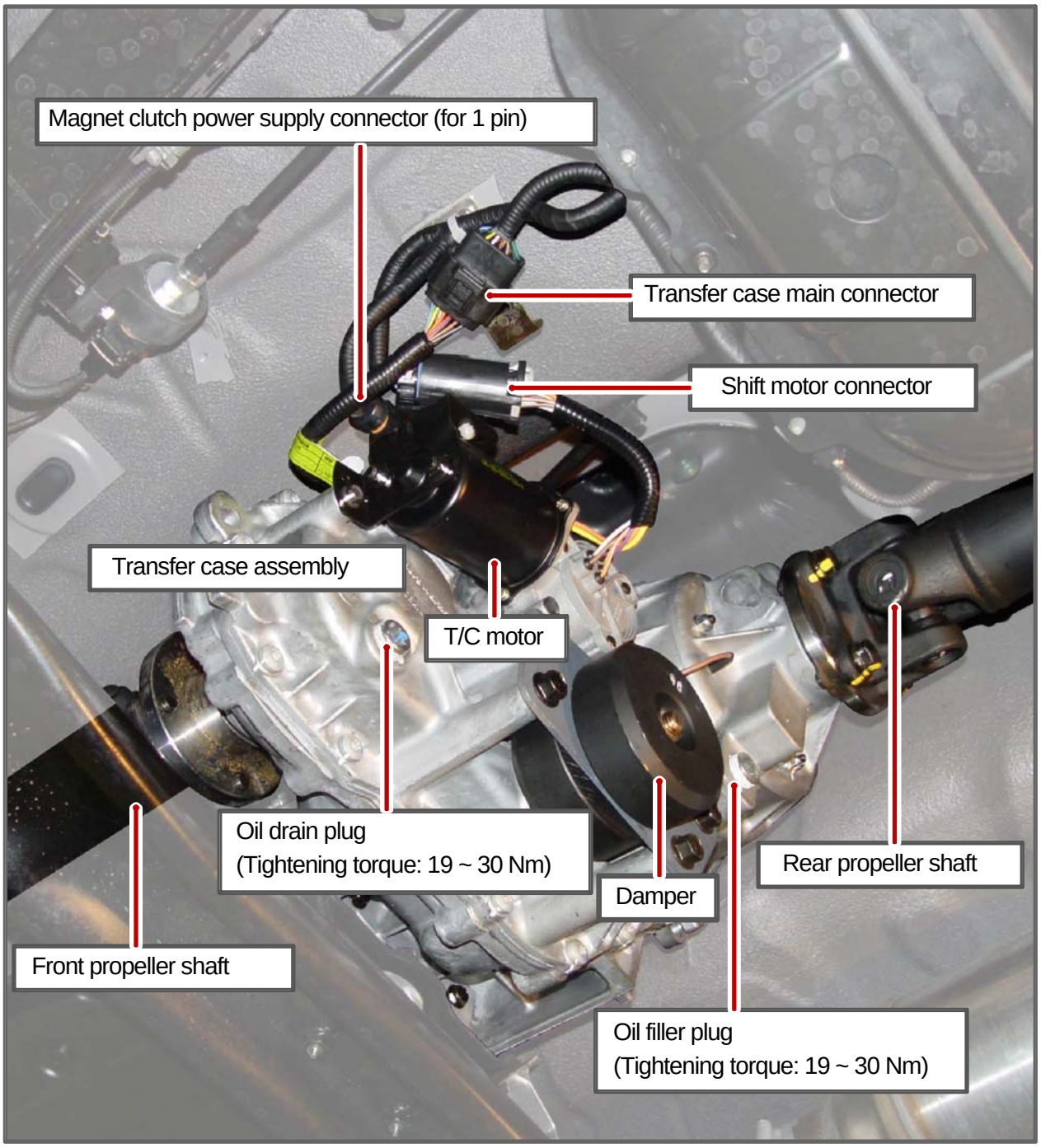
Description	Mode		Conditions
Driving mode	2H	2 Wheel drive (rear wheel)	Rear-wheel drive mode. This is used under normal or high-speed driving conditions on public roads or highways.
	4H	4 Wheel drive (high speed)	This is used under sandy, muddy or snow-covered road conditions
	4L	4 Wheel drive (low speed)	This is used for maximum traction. When cornering with low speed in 4WD condition, there could be tire dragging, some mechanical shocks and resistances in vehicle's drive train. These are normal conditions due to internal resistance in the drive train when the 4WD system is properly working
Mode change	2H←4H	2 Wheel drive ↔4 Wheel drive	Shifting is possible while driving at the speed of 70 km/h or less
	2H, 4H↔4L	2 Wheel drive, 4 Wheel drive (high speed) ↔4 Wheel drive (low speed)	**For Automatic Transmission:** · Stop the vehicle on level ground and move the gear selector lever into the "N" position. Turn the switch to the desired position. **For Manual Transmission:** · Stop the vehicle on level ground and move the gear selector lever into the "N" position. Then turn the switch to the desired position while depressing the clutch pedal. **NOTE** To make the mode change easily, stop the vehicle on level ground and turn the mode switch to the desired position and move the shift lever to "N"-"R"-"N" while depressing the brake pedal.

2. LAYOUT



Modification basis	
Application basis	
Affected VIN	

1) Components Location



3. SYSTEM LAYOUT

▶ **4WD mode switch**

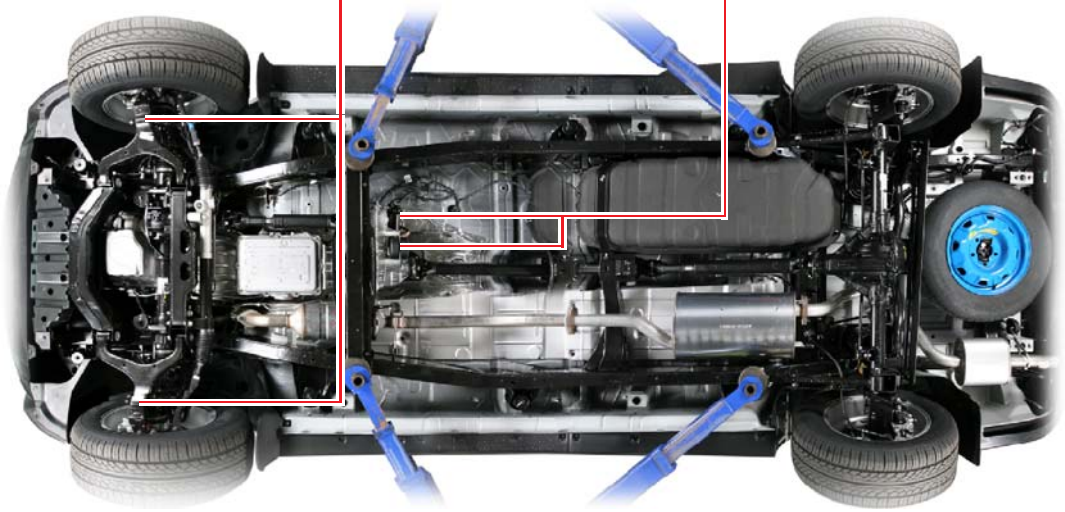
4H: 4 Wheel drive, high speed
4L: 4 Wheel drive, low speed
2H: 2 Wheel drive

▶ **Indicators**

4H: 4WD HIGH indicator ON
4L: 4WD LOW indicator ON
2H: Indicator OFF
System failure: 4WD CHECK warning lamp ON

TCCU

Solenoid valve

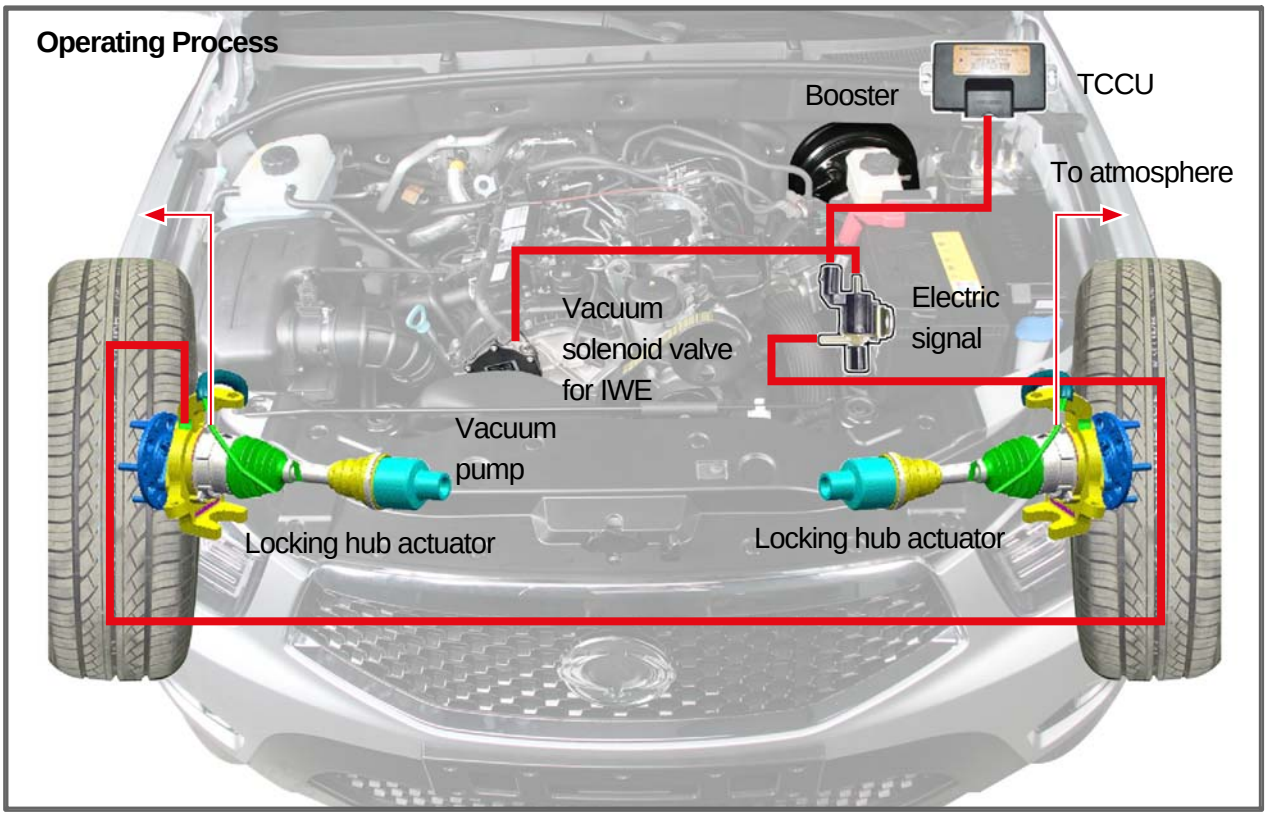


Modification basis	
Application basis	
Affected VIN	

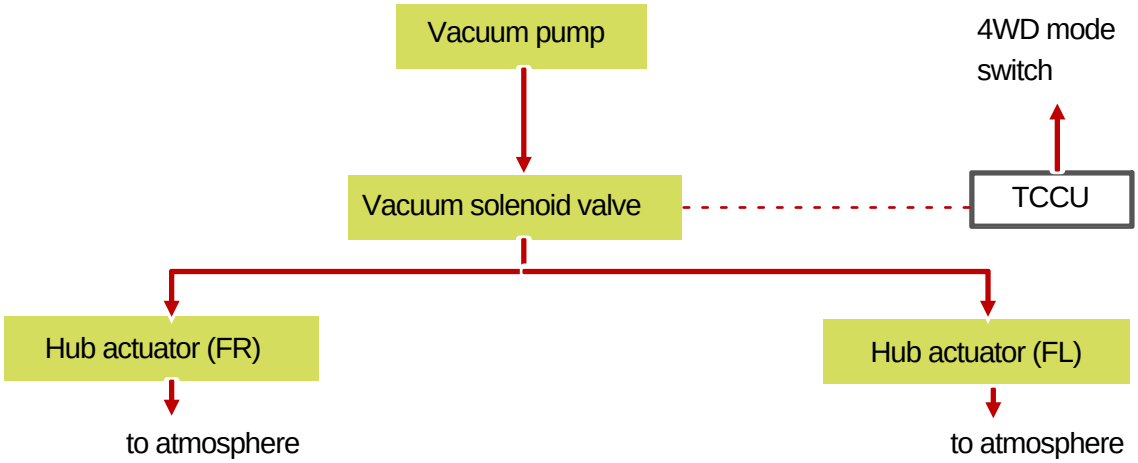
4. IWE LOCKING HUB SYSTEM

1) Overview

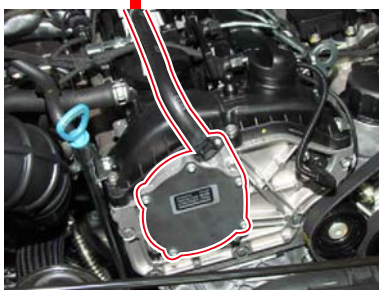
The vacuum locking hub uses the IWE (Integrated Wheel End) system, and in this system, the vacuum is generated only within the hub actuator.
It is structured to transmit power to the front section after the actuator hub is engaged following the release of vacuum from the drive shaft end gear and the hub end gear



Vacuum generation process in front hub actuator

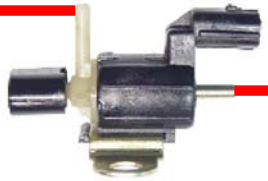


2) Vacuum System Related to 4WD



During 2WD mode, the vacuum pressure from vacuum pump is continuously transmitted to the locking hub system.
This vacuum pressure pulls in the locking hub actuator so that it will not be engaged with the front end hub gear.

In 4WD mode, the TCCU blocks the transferring of vacuum pressure from vacuum pump to locking hub by supplying the power to solenoid valve.



Hub actuator (RH)

Hub actuator (LH)

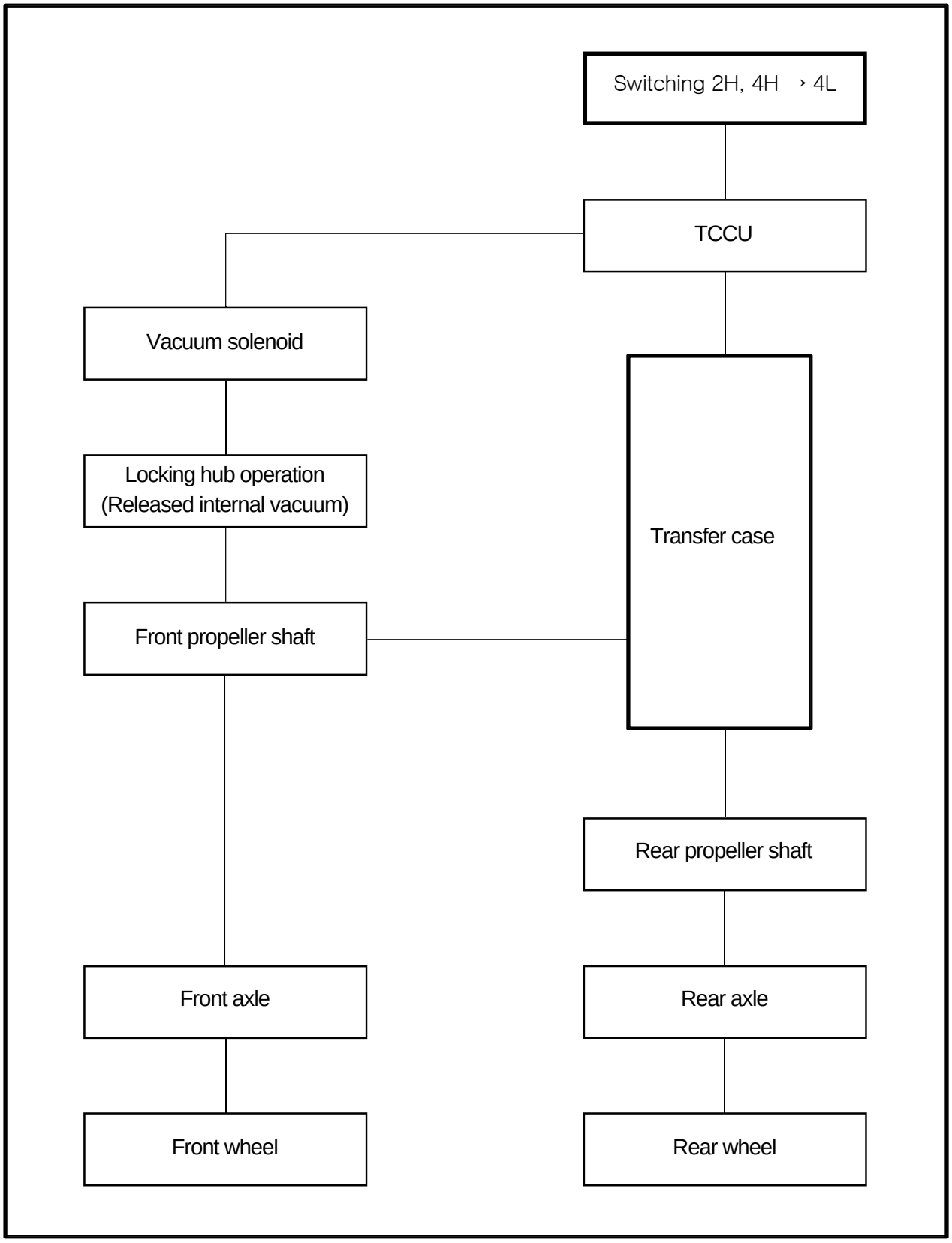
tmosphere (in 4WD mode)

The vacuum pressure is released from the hub actuator. At this time, the front hub end gear is engaged.

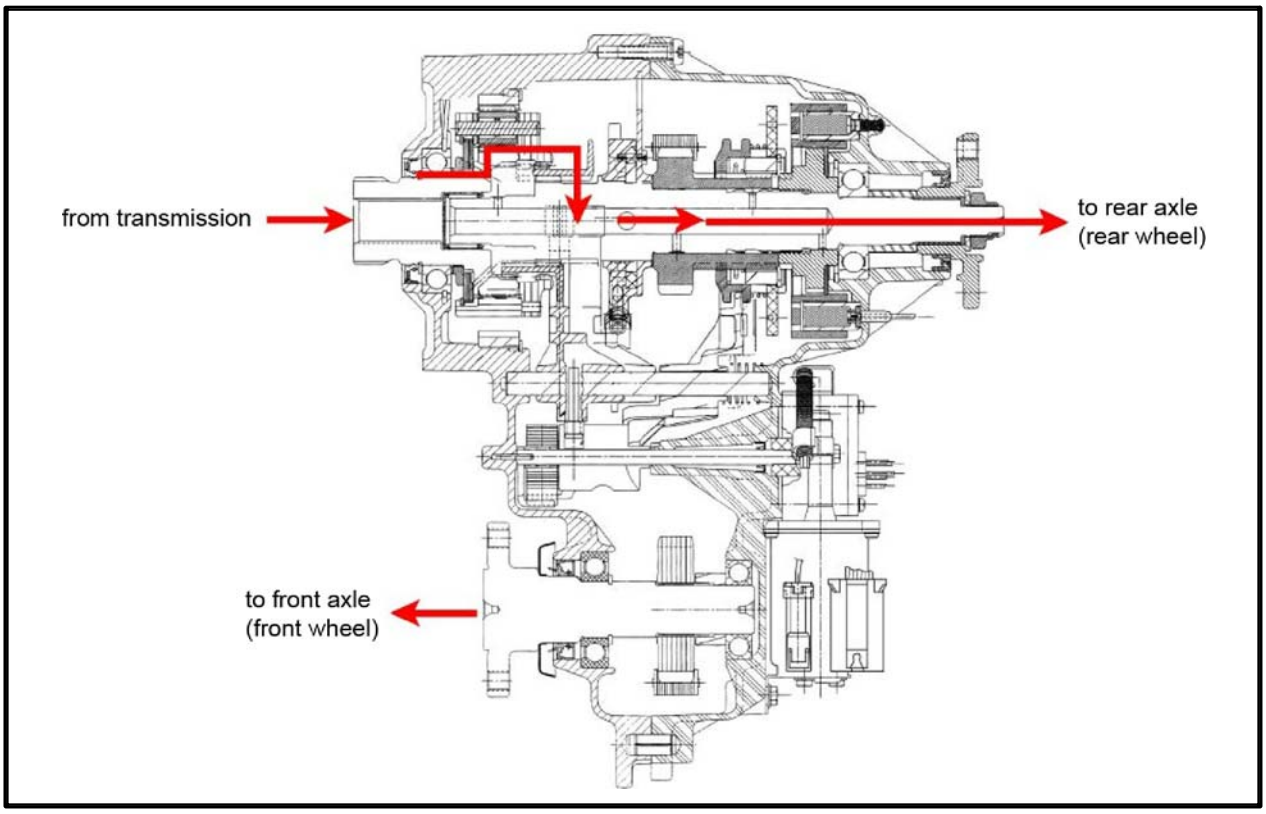
22WD (applying vacuum pressure to hub actuator) The vacuum pressure pulls in the locking hub actuator so that it will not be engaged with the front end hub gear.

Modification basis	
Application basis	
Affected VIN	

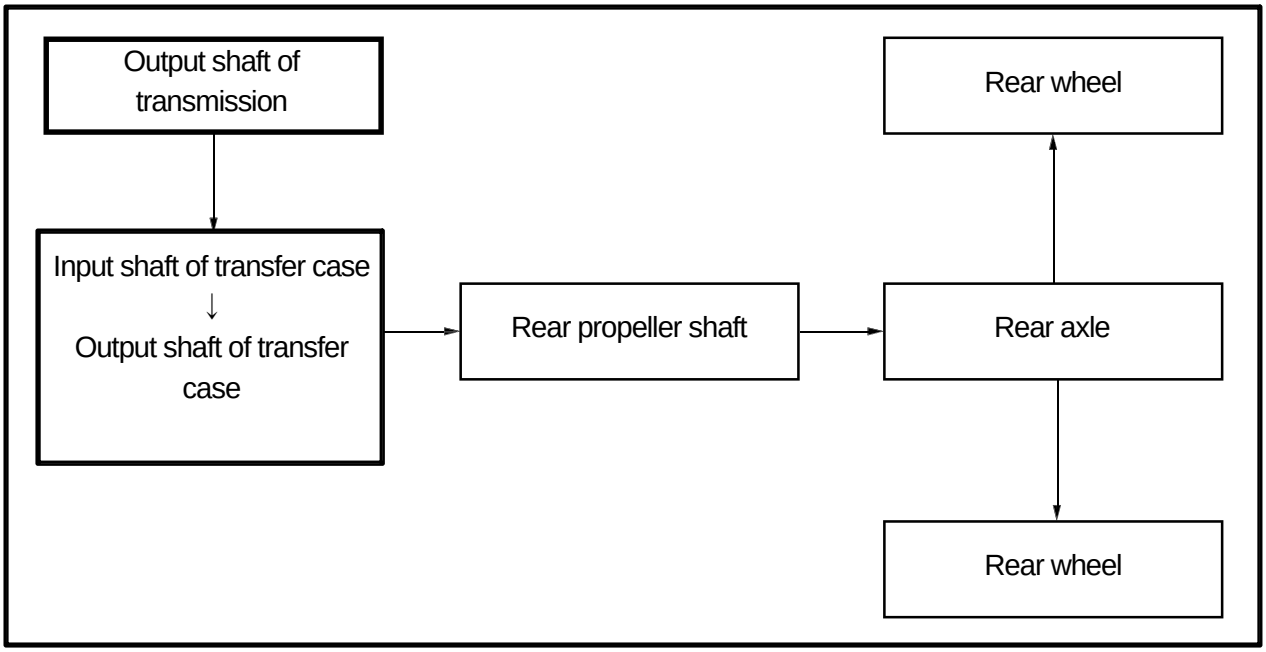
5. POWER FLOW


Switching 2H, 4H → 4L
TCCU
Vacuum solenoid
Locking hub operation
(Released internal vacuum)
Front propeller shaft
Transfer case
Rear propeller shaft
Front axle
Rear axle
Front wheel
Rear wheel

1) 2H Mode (2 Wheel Drive)



▶ **Power Flow**

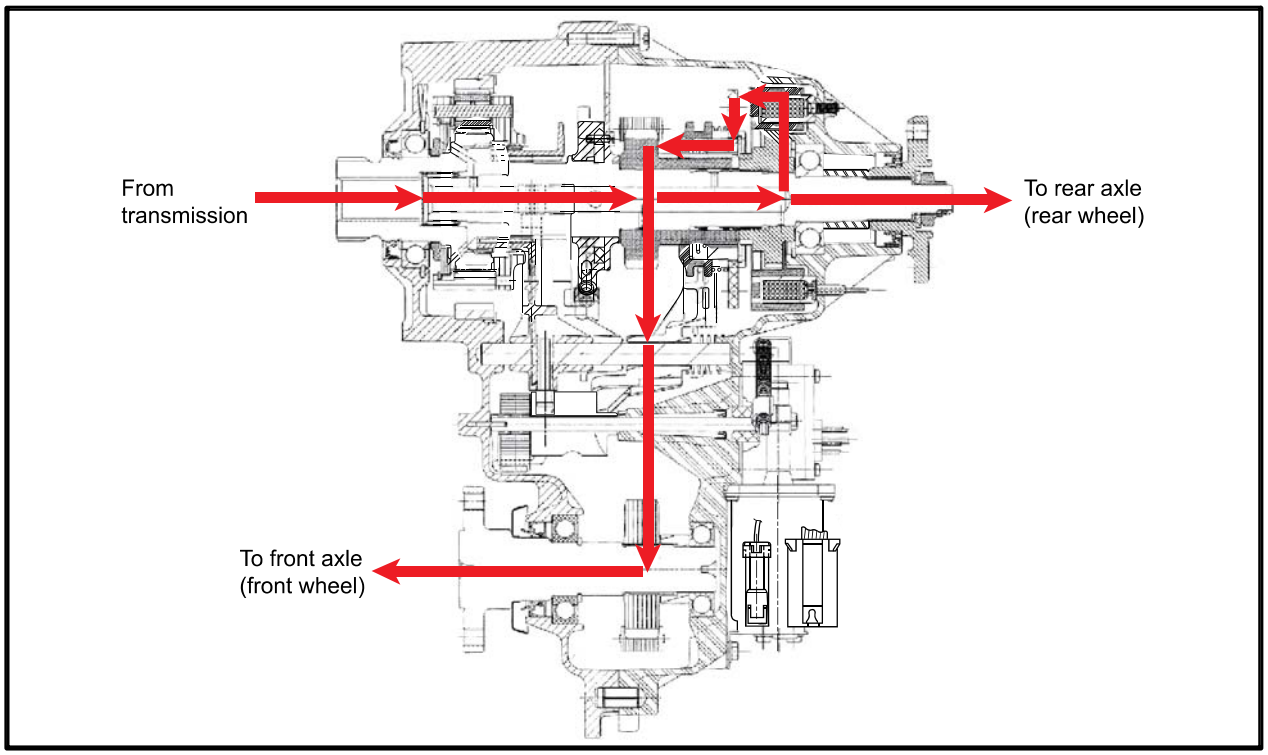


NOTE

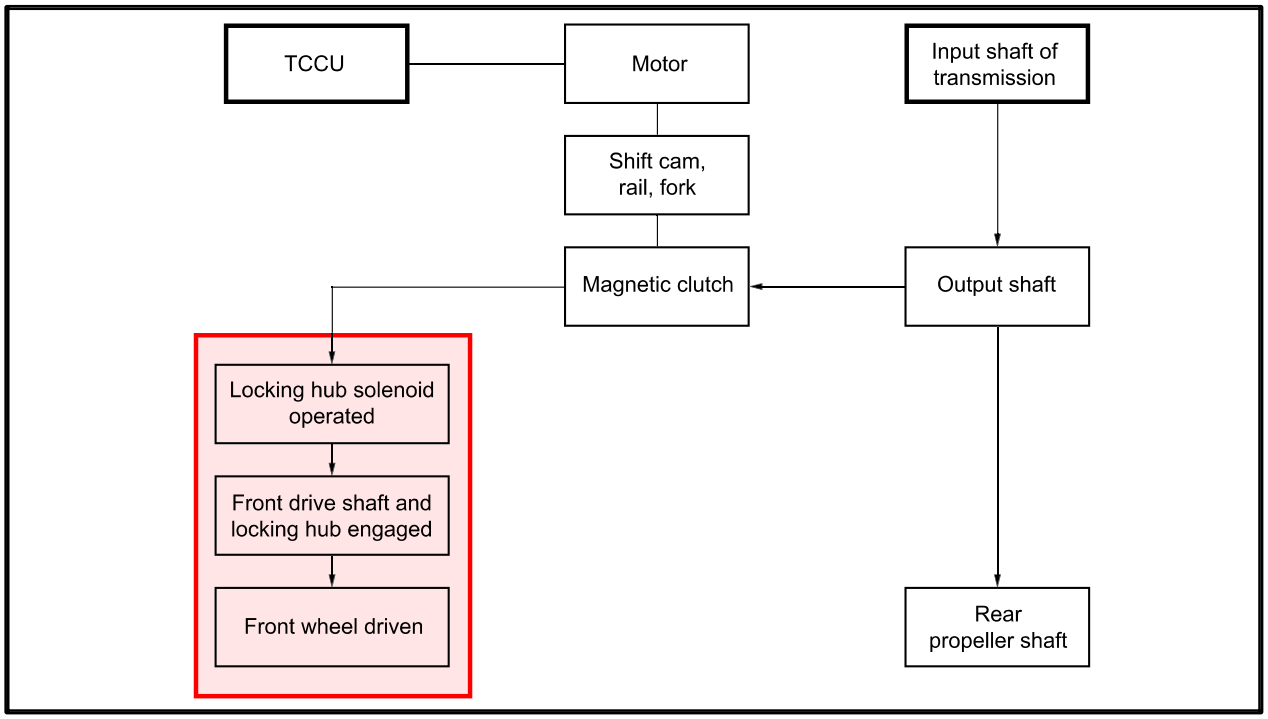
The driving force is directly engaged(1:1) to rear axle and is transferred only to the rear wheels.

Modification basis	
Application basis	
Affected VIN	

2) 4H Mode (4 Wheel Drive - High Speed)



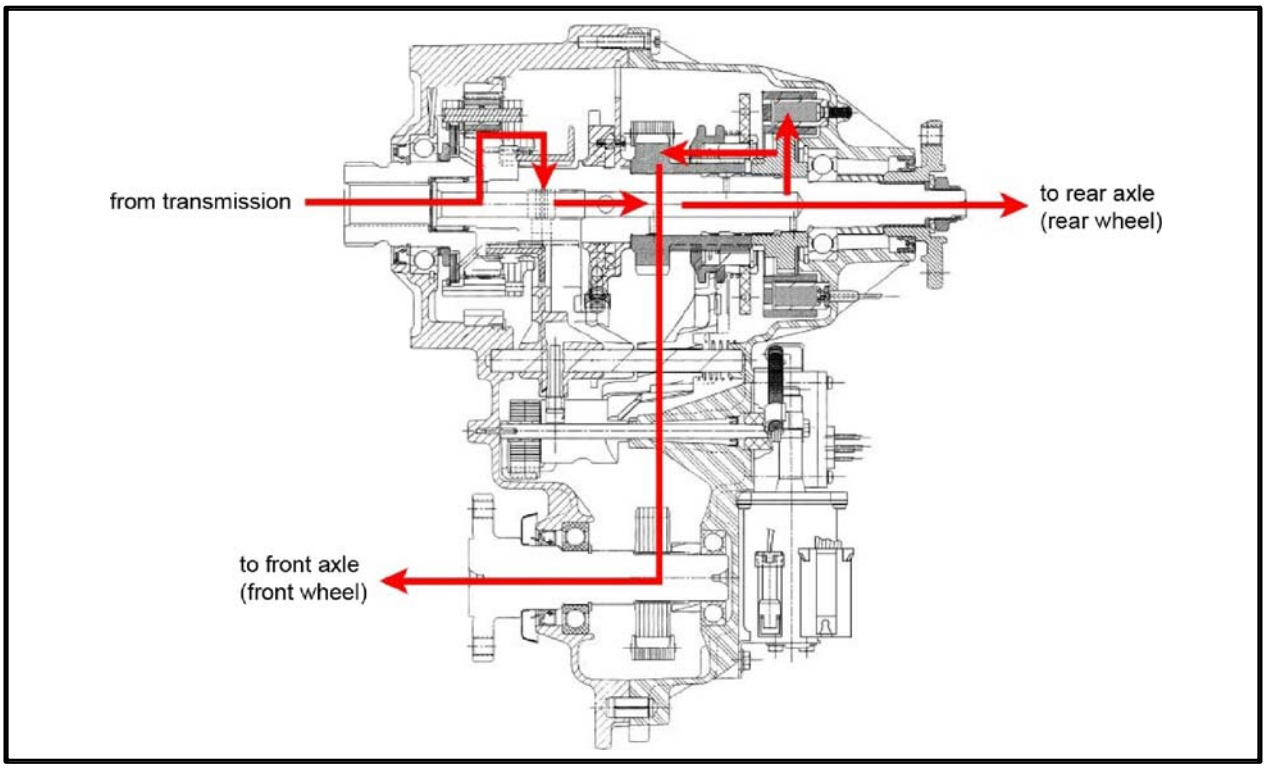
▶ Power Flow



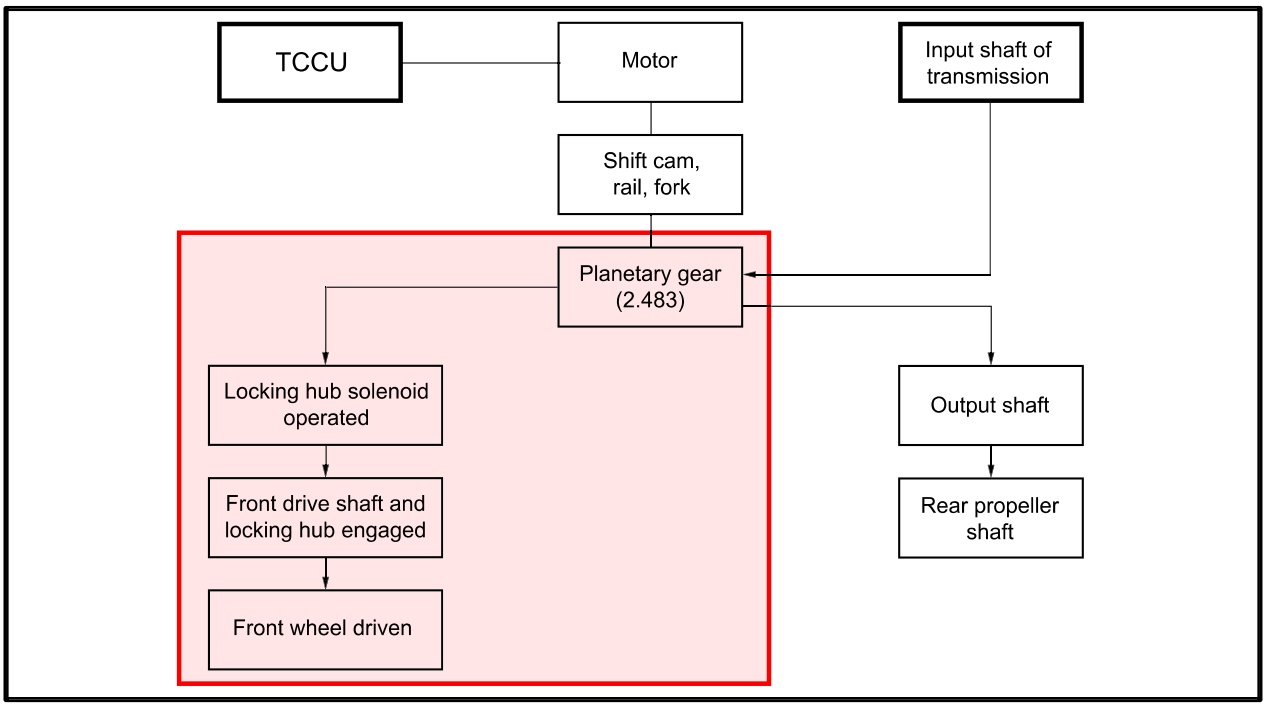
NOTE

The driving force is pass through 4WD High magnetic clutch in transfer case and is distributed on front wheels and rear wheels (50;50).

3) 4L Mode (4 Wheel Drive - Low Speed)



▶ **Power Flow**



NOTE

The gear ratio is reduced to 2.48;1 while passing through 4WD Low range and planetary gear set in transfer case and the driving force is distributed on front wheels and rear wheels(50;50).

Modification basis	
Application basis	
Affected VIN	

SUSPENSION

4411-01

GENERAL INFORMATION

1. SPECIFICATIONS

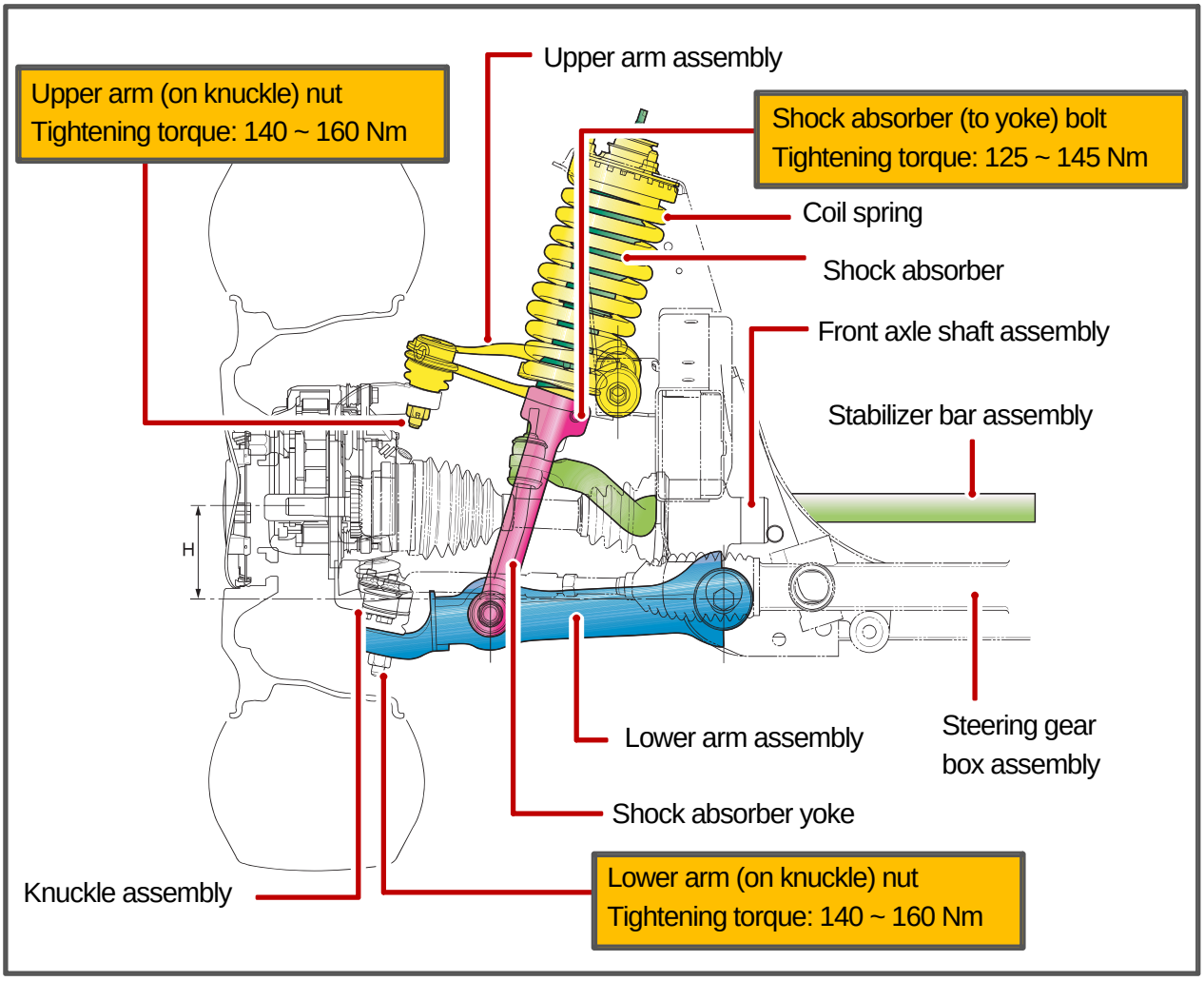
	Description	Specification
Front Suspension	Suspension type	Double wishbone
	Spring type	Coil spring
	Shock absorber type	Reciprocating cylindrical type (gas type)
	Stabilizer bar type	Torsion bar type
Rear Suspension	Suspension type	5-link type
	Spring type	Coil spring
	Shock absorber type	Reciprocating cylindrical type (gas type)
	Stabilizer bar type	Torsion bar type

2. WHEEL ALIGNMENT

Front Wheel Alignment	TOE	Unilateral : 0.10 ± 0.16° Total : 0.20 ± 0.13°
	Camber	−0.5 ± 0.25°
	Caster	4.6 ± 0.4°

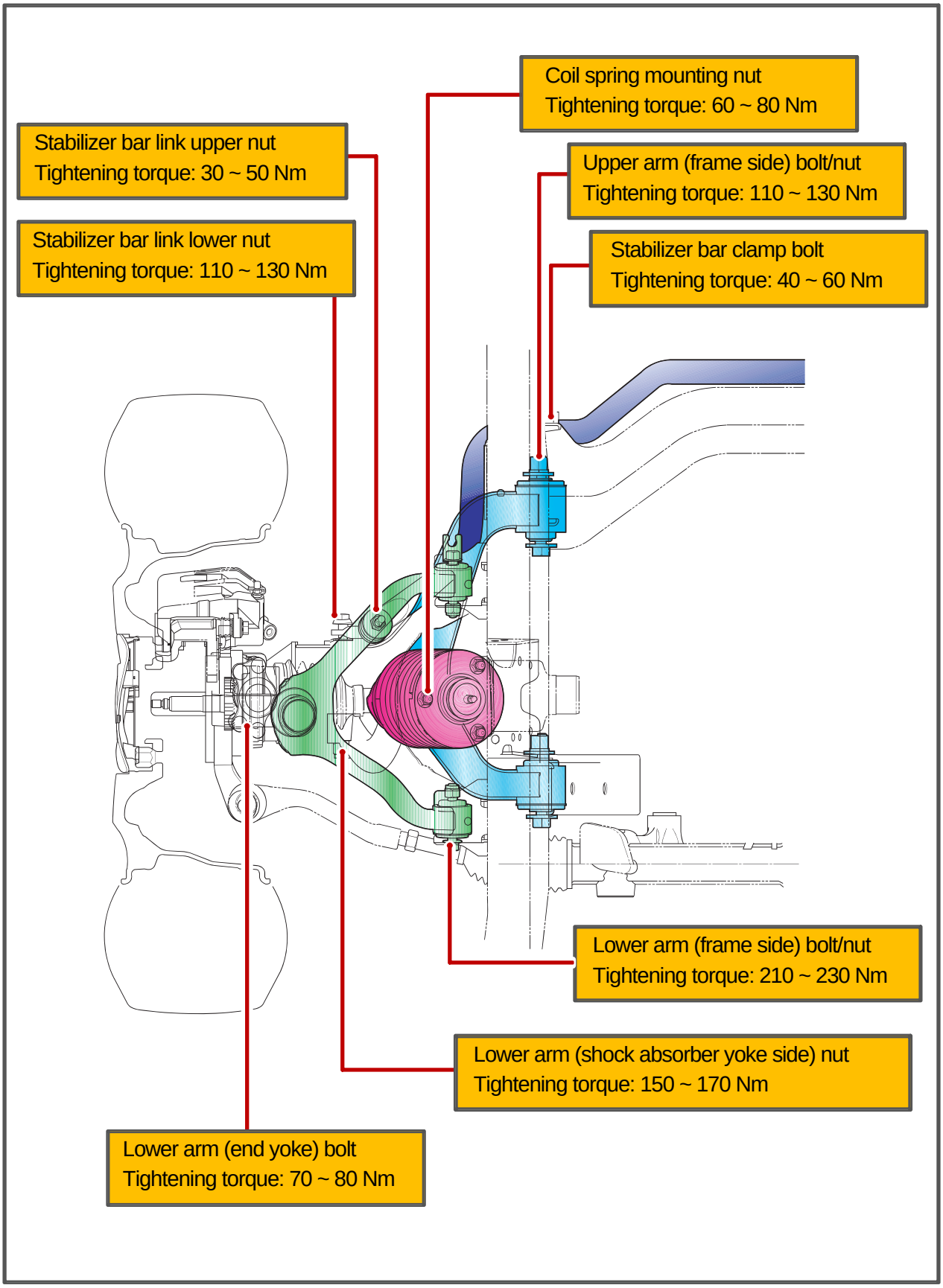
3. SYSTEM LAYOUT AND TIGHTENING TORQUE OF FRONT SUSPENSION

▶ **Front View**



Modification basis	
Application basis	
Affected VIN	

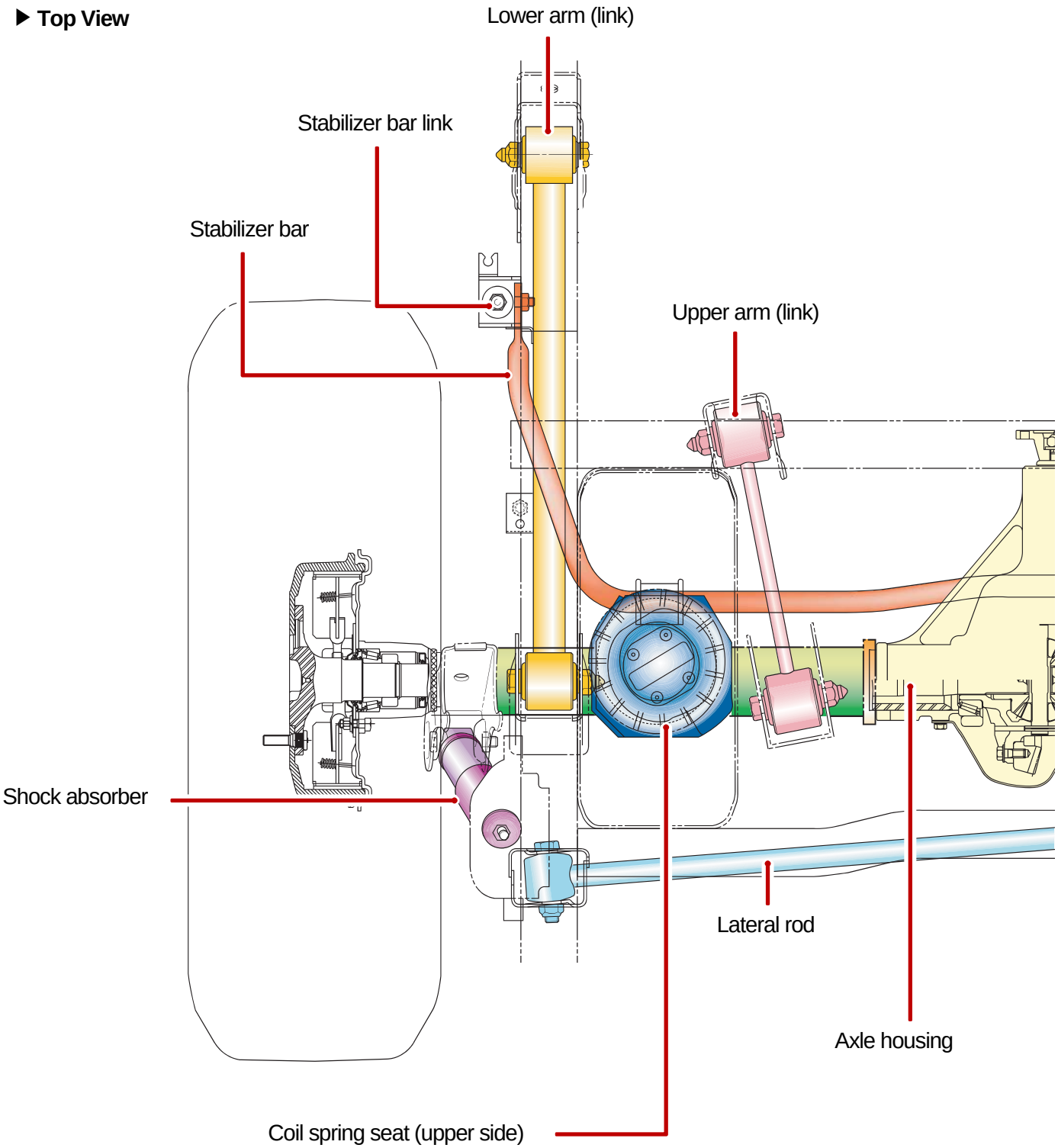
▶ **Top View**



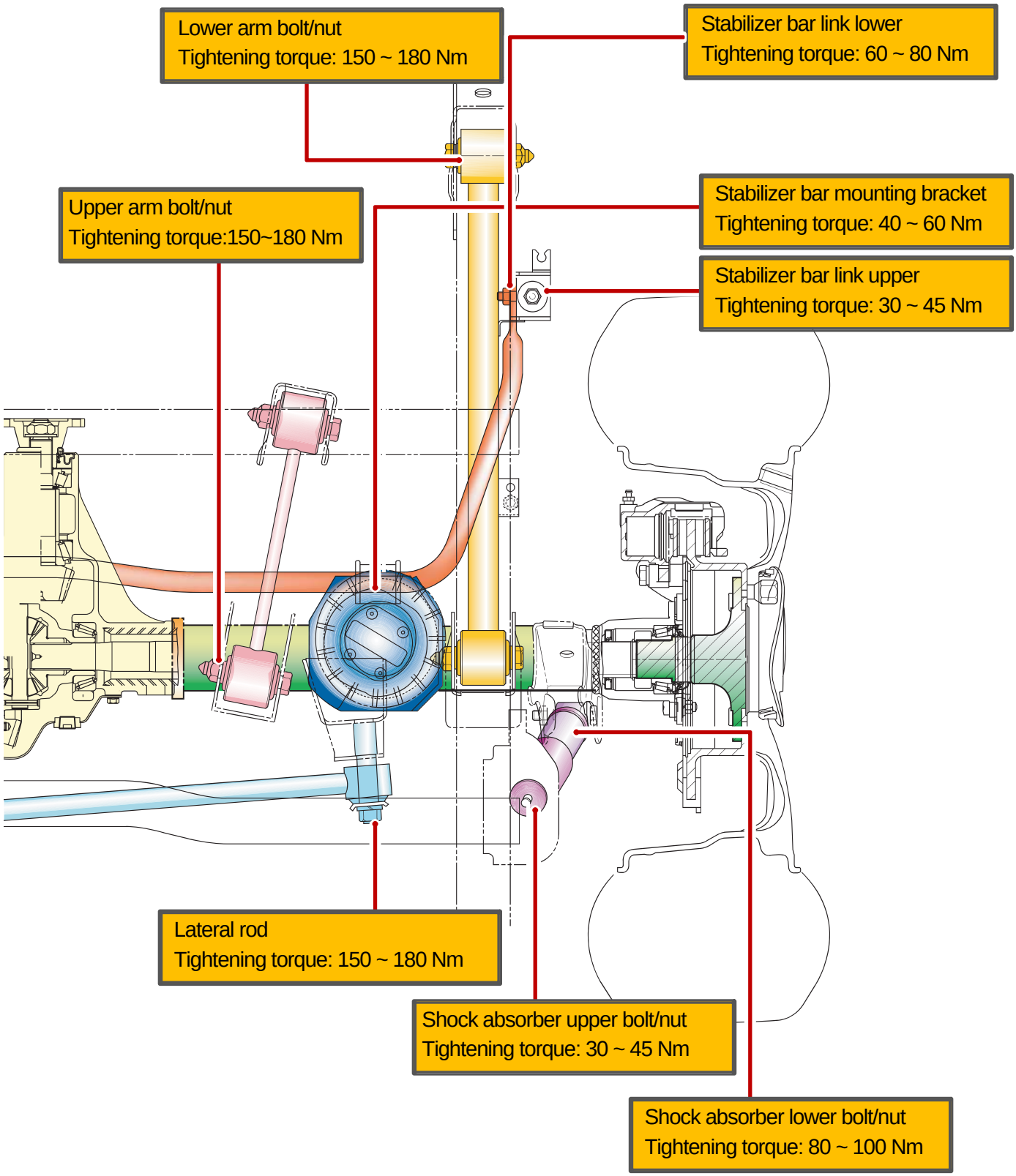
Modification basis	
Application basis	
Affected VIN	

4. SYSTEM LAYOUT AND TIGHTENING TORQUE OF REAR SUSPENSION

▶ **Top View**



Modification basis	
Application basis	
Affected VIN	


Lower arm bolt/nut
Tightening torque: 150 ~ 180 Nm
Stabilizer bar link lower
Tightening torque: 60 ~ 80 Nm
Upper arm bolt/nut
Tightening torque:150~180 Nm
Stabilizer bar mounting bracket
Tightening torque: 40 ~ 60 Nm
Stabilizer bar link upper
Tightening torque: 30 ~ 45 Nm
Lateral rod
Tightening torque: 150 ~ 180 Nm
Shock absorber upper bolt/nut
Tightening torque: 30 ~ 45 Nm
Shock absorber lower bolt/nut
Tightening torque: 80 ~ 100 Nm

5. TROUBLESHOOTING

Problem	Cause	Action
Vehicle rolling	Broken stabilizer bar	Replace
	Faulty shock absorber	Replace
Abnormal noise.	Loosening mounting	Retighten
	Damaged or worn wheel bearing	Replace
	Damaged shock absorber	Replace
	Damaged tire	Replace
Poor riding	Over inflated tire	Adjust pressure
	Faulty shock absorber	Replace
	Loosened wheel nut	Tighten as specified torque
	Bent or broken coil spring	Replace
	Damaged tire	Replace
	Worn bushing	Replace
Vehicle pulls to one side	Deformed arm assembly	Replace
	Worn bushing	Replace
	Bent or broken coil spring	Replace
Hard steering	Excessive resistance of lower arm ball joint	Replace
	Insufficient tire pressure	Replace
	Faulty power steering	Replace
Unstable steering	Worn or loosened lower arm bushing	Retighten or replace
Vehicle bottoming	Worn or broken coil spring	Replace
Vehicle height lowered	Over loaded on the vehicle	-
	Defective shock absorber	Replace
	Defective coil spring	Replace

Modification basis	
Application basis	
Affected VIN	

OVERVIEW AND OPERATING PROCESS

1. SUSPENSION

The suspension is the device to connect the axle and vehicle. It absorbs the vibrations and impacts from road surface, which enhances the comforts, driving force, braking force and drivability.

Under View (4WD, Automatic Transmission)

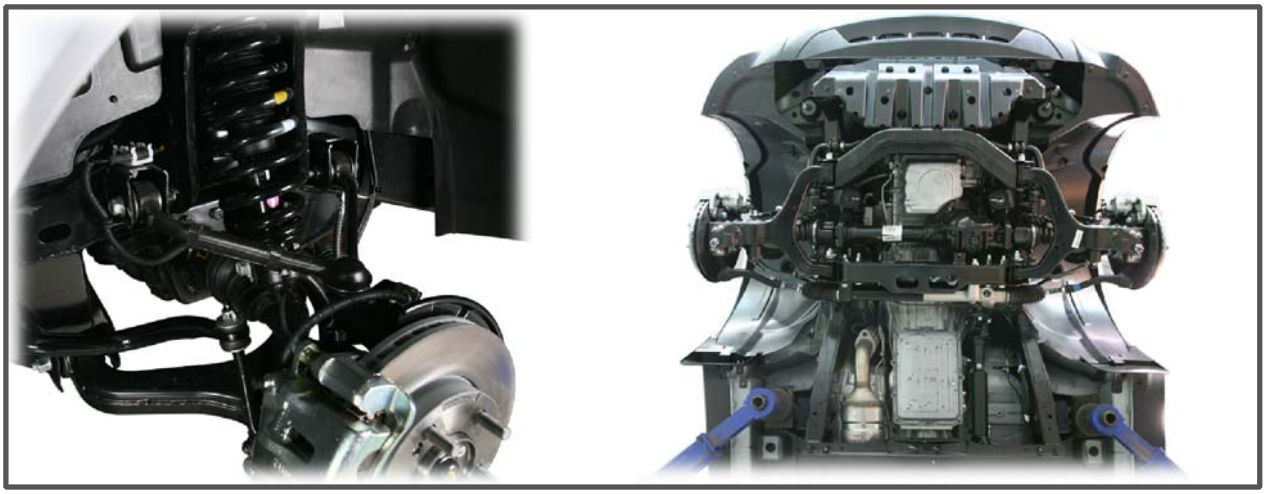
Front suspension

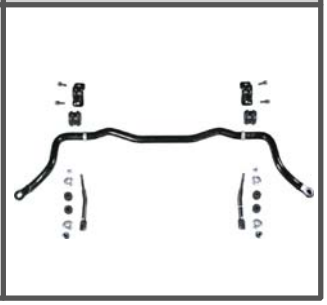
Rear suspension

Modification basis	
Application basis	
Affected VIN	

2. FRONT SUSPENSION (DOUBLE WISHBONE)

Double wishbone suspension is an independent suspension design using two (occasionally parallel) wishbone-shaped arms to locate the wheel. Each wishbone or arm has two mounting points to the chassis and one joint at the knuckle. The shock absorber and coil spring mount to the wishbones to control vertical movement. Double wishbone designs allow the engineer to carefully control the motion of the wheel throughout suspension travel, controlling such parameters as camber angle, caster angle, toe pattern, roll center height, scrub radius, scuff and more.



Lower arm	Upper arm	Shock absorber	Stabilizer
			

▶ **Advantage**

1. The advantage of a double wishbone suspension is that it is fairly easy to work out the effect of moving each joint, so the kinematics of the suspension can be tuned easily and wheel motion can be optimized.
2. It is also easy to work out the loads that different parts will be subjected to which allows more optimized lightweight parts to be designed.
3. They also provide increasing negative camber gain all the way to full jounce travel unlike the MacPherson strut which provides negative camber gain only at the beginning of jounce travel and then reverses into positive camber gain at high jounce amounts.

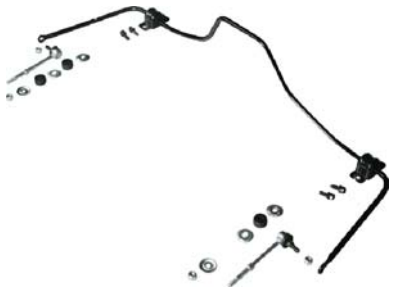
▶ **Disadvantage**

1. The disadvantage is that it is slightly more complex than other systems like a MacPherson strut. Due to
2. the increased number of components within the suspension setup it takes much longer to service and is heavier than an equivalent MacPherson design.

Modification basis	
Application basis	
Affected VIN	

3. REAR SUSPENSION (MULTI LINK TYPE)

Multi-link (5-Link) type suspension is the independent suspension. It provides good ride comfort and drivability by reducing the coil spring weight. Also, it increases the space for passenger compartment by lowering the floor. This type of suspension consists of multiple links such as coil spring, shock absorber, upper and lower arms, lateral rod and stabilizer bar.

Shock absorber	Stabilizer bar	Rear coil spring
		

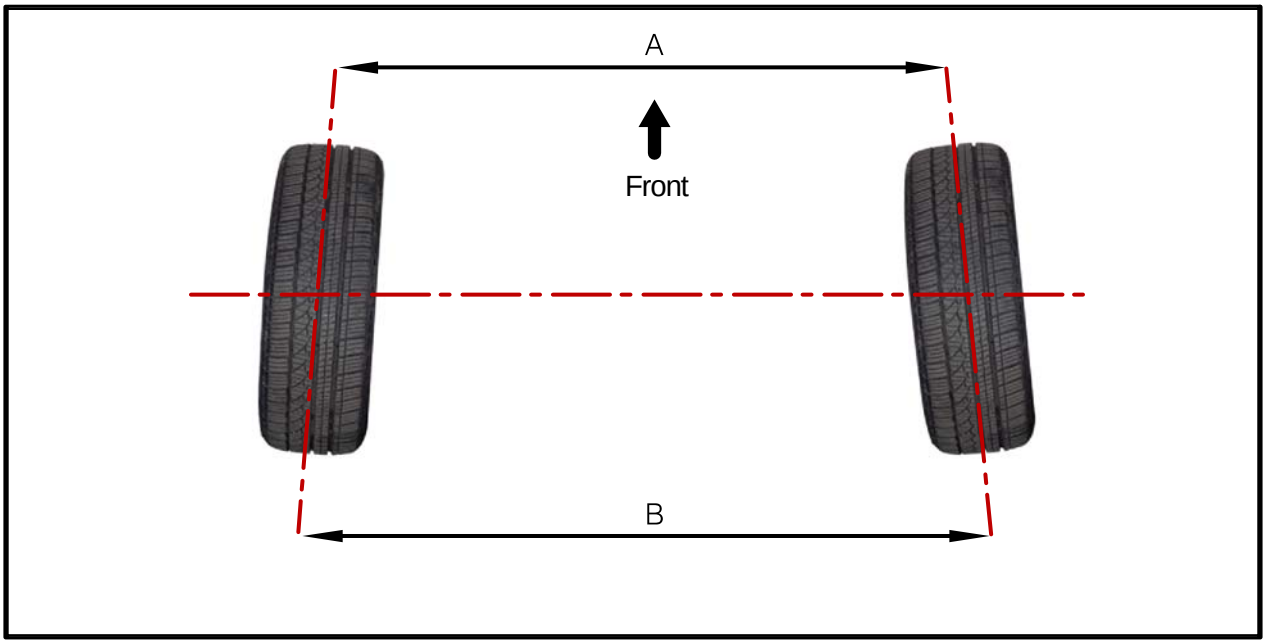
Lower arm	Upper arm	Lateral rod
		

4. WHEEL ALIGNMENT

The front wheels have specific angle to allow control of the steering wheel with less effort, ensure driving stability, improve steering wheel restoration and steering performance, and minimize the tires wear.

1) Toe-in

The difference of measured distances between the front ends of the tires (A) and the rear ends of the tires (B) along the same axle when viewed the wheels from the top



TOE	Unilateral : 0.10 ± 0.16° Total : 0.20 ± 0.13°

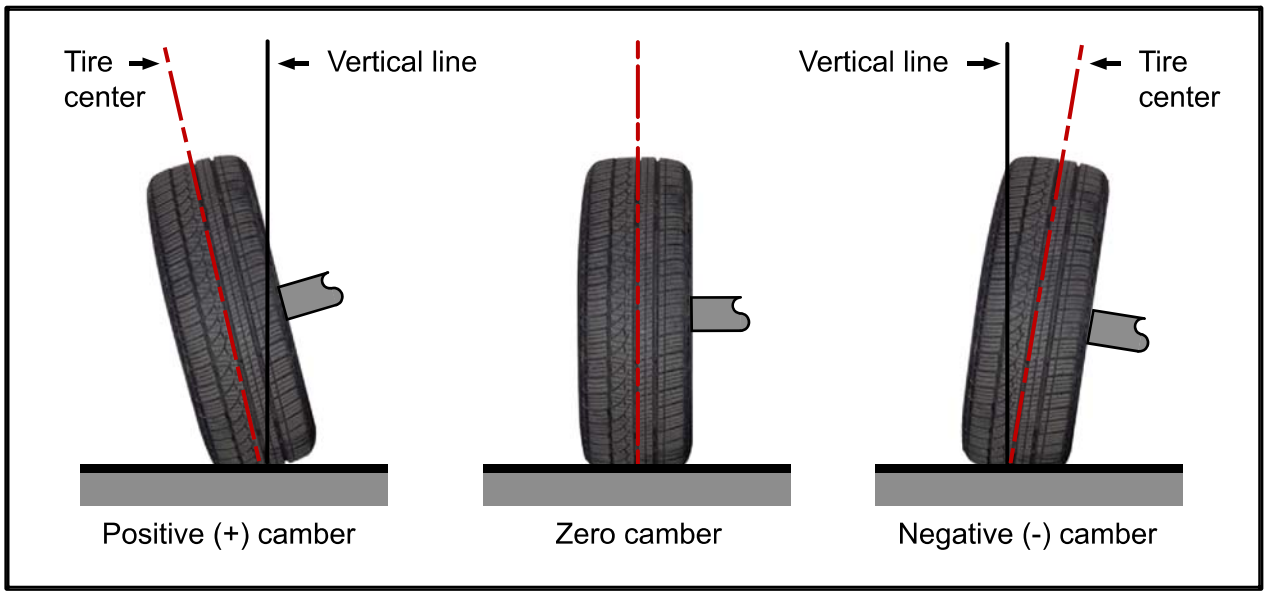
▶ **When viewed from the top, the distance between the tire centers is smaller in the front than in the rear.**

- Side slip protection
- Parallel front wheels rotation (straight ahead driving is ensured by toe-in to prevent the wheels from tilting outwards by the camber while driving)
- Prevention of uneven (outward) tire wear
- Prevention of toe-out from wearing of steering linkage

Modification basis	
Application basis	
Affected VIN	

2) Camber

The angle between the center line of the tire and the vertical line when viewed from the front of the vehicle



Camber	−0.5 ± 0.25°

▶ **Positive camber: Top of the tire is tilted outward**

Advantages:
- The axle is not bent when it is loaded.
- The force required to operate the steering wheel is reduced due to smaller contact area (or load area) of the tire.
- Restoring force of the steering wheel is gained (when turning the steering wheel, the tire circles and the force to lift the frame is applied. In this case, the shock absorber contracts and the restoration force is applied to the steering wheel.)

Disadvantages:
- Cornering force decreases as the positive camber increases when the vehicle makes turn.
- The hub bearing is worn unevenly if camber is excessive.

▶ **Zero camber: When the tire center line is perpendicular to the ground level**

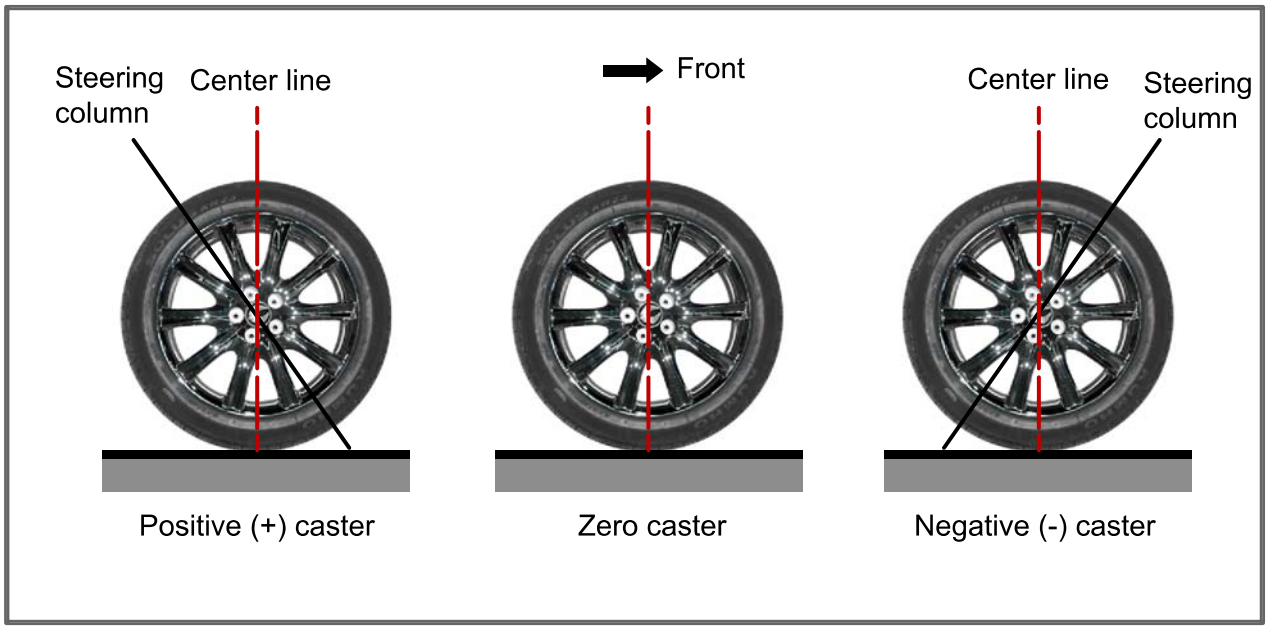
▶ **Negative camber**

Advantages:
- Better traction force due to wide load area (applicable for off-road vehicle)
- Better corner driving when the vehicle makes turn as the cornering force increases (applicable for high-speed F1 vehicle)

Disadvantages:
- he axle is easy to be bent or deviated in the negative camber than in the positive camber when load is applied on the axle.
- Difficult to control due to wide load area.

3) Caster

The angle between the vertical line and king pin, which fixes the steering knuckle and front axle, (steering column which connects the top and bottom ball joints in the independent axle type) when viewed the tires from the side.



Caster	4.6 ± 0.4°

▶ **Caster:** With considering the height difference between the wheel centers of the front and rear wheels. (Under standard condition that the vehicle is on a level ground)

▶ **Positive caster:** Top of the king pin is tilted backward from the vertical line of the wheel center when viewed the tires from the side

Advantages:
- Directional force to go straight (following control)
- Restoring force of the wheel (restored to the straight ahead direction)
- Prevention of wheel shimmy (wheels wobble left and right)

▶ **Negative caster:** Top of the king pin is tilted forward from the vertical line of the wheel center when viewed the tires from the side

Advantages:
- Smaller turning radius

Disadvantages:
- Impact from the road is transferred to the steering wheel (steering wheel turns) Poor straightness
-

Modification basis	
Application basis	
Affected VIN	

BRAKE SYSTEM 4850-01

GENERAL INFORMATION

1. SPECIFICATION

Unit	Description	Specification
Front brake	Type	Ventilated disc
	Outer diameter of disc	Ø294 mm
	Inner diameter of caliper cylinder	Ø43.0 x 2 mm
	Thickness of disc	28 mm (wear limit: 25.4 mm)
	Area of brake pad	Above 60 cm2
	Pad wear indicator	Mechanical type
Rear brake	Type	Solid disc
	Outer diameter of disc	Ø299 m
	Thickness of disc	10.4 mm (wear limit: 8.5 mm)
	Area of brake pad	Above 28.8 cm2
	Pad wear indicator	Mechanical type
Brake booster	Type	Vacuum assist type
	Size	8” + 9” (Tandem)
Master cylinder	Type	Tandem type(integrated level sensor)
	Inner diameter of cylinder	Ø26.99 mm
Brake pedal	Maximum operating stroke	150 mm
	Pedal ratio	4 : 1
	Free play	3 to 10 mm
Parking brake	Type	Mechanically expanded rear lining
	Operating type	Hand operated type
	Inner diameter of drum	Ø190 mm
Brake oil	Specification	DOT 4
	Capacity	As required

NOTE

Service Interval: Change the brake oil at every 2 years

DOT?

It is the quality grade of brake fluid established by US Department of Transportation.

2. SYSTEM OVERVIEW

1) Terms and Definition

- CBS: Conventional Brake System
- ABS: Anti-Lock Brake System
- EBD: Electronic brake-Force Distribution
- ESP: Electronic Stability Program
- ABD: Automatic Braking Differential
- ASR: Acceleration Slip Regulation
- AYC: Active Yaw Control (Understeer and Oversteer Control)
- HBA: Hydraulic Brake Assistant
- ARP: Active Rollover Protection
- HSA: Hill Start Assistant
- Brake pad: Brake pad is a component of disk brakes used in automotive and other applications. Brake pad is steel backing plates with friction material bound to the surface that faces the brake disc.
- Brake disc: The brake disc is a device for slowing or stopping the rotation of a wheel while it is in motion.
- Brake caliper: To stop the wheel, friction material in the form of brake pads (mounted on a device called a brake caliper) is forced hydraulically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop.
- Brake master cylinder: The brake master cylinder is a control device that converts non-hydraulic pressure (commonly from a driver's foot) into hydraulic pressure, in order to move other device(s) which are located at the other end of the hydraulic system, such as one or more slave cylinders. As piston(s) move along the bore of the master cylinder, this movement is transferred through the hydraulic fluid, to result in a movement of the slave cylinder(s). The hydraulic pressure created by moving a piston (inside the bore of the master cylinder) toward the slave cylinder(s) compresses the fluid evenly, but by varying the comparative surface-area of the master cylinder and/or each slave cylinder, one will vary the amount of force and displacement applied to each slave cylinder (relative to the amount of force and displacement that was applied to the master cylinder).

2) Functions

<table>
<tr><th>Function</th><th>Vehicle with CBS</th><th>Vehicle with ABS/EBD</th><th>Vehicle with ESP</th></tr>
<tr><td>ABS</td><td rowspan="7">Not applied</td><td>Applied</td><td rowspan="7">Applied</td></tr>
<tr><td>EBD</td><td>Applied</td></tr>
<tr><td>ABD</td><td rowspan="6">Not applied</td></tr>
<tr><td>ASR</td></tr>
<tr><td>AYC</td></tr>
<tr><td>HBA</td></tr>
<tr><td>ARP</td></tr>
</table>

Modification basis	
Application basis	
Affected VIN	

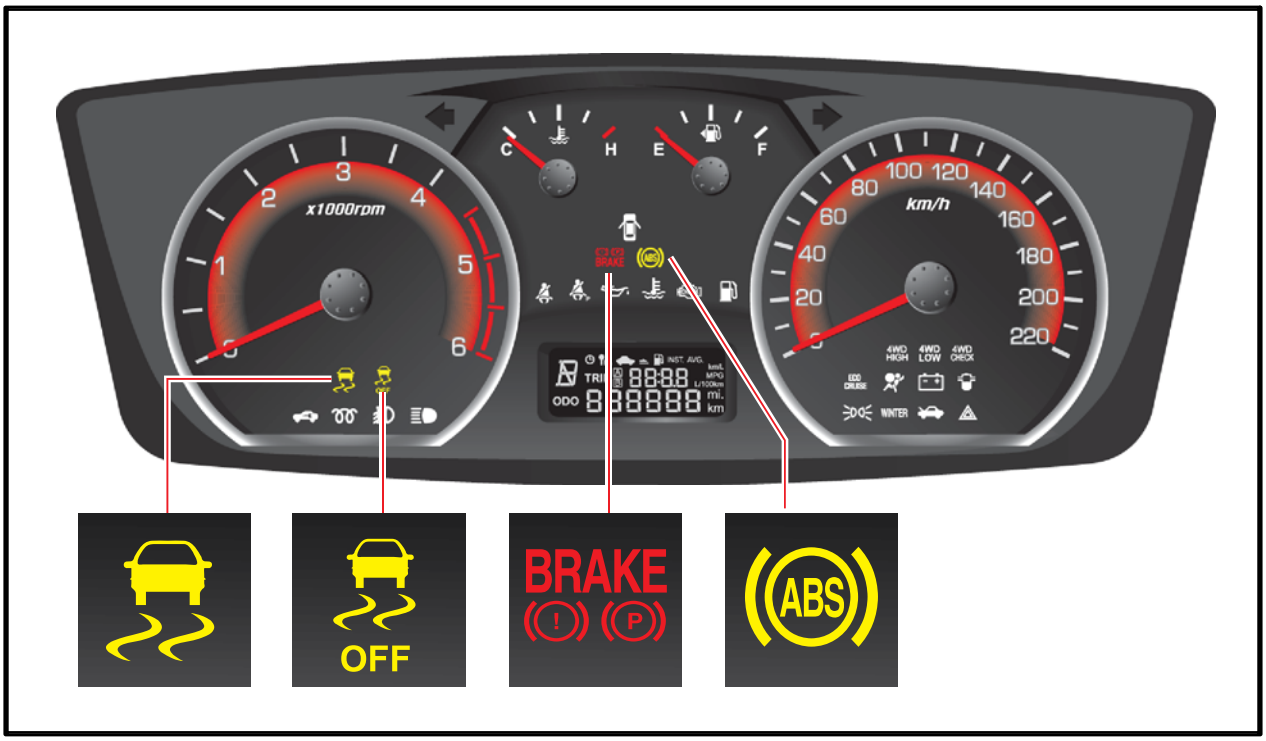
3) Parts Arrangement

Part name	Vehicle with CBS	Vehicle with ABS/EBD	Vehicle with ESP
HECU	Not applied	Applied	Applied
Front wheel speed sensor			
Rear wheel speed sensor			
ABS warning lamp			
EBD indicator			
Longitudinal G sensor		2WD: N/A, 4WD: Applied	Not applied
Sensor cluster (Yaw rate sensor, lateral/longitudinal G sensor)		Not applied	Applied
ESP indicator			
ESP OFF switch and warning lamp			
Steering wheel angle sensor			

4) Components

	ABS		ESP+ARP	
	2WD	4WD	2WD	4WD
Whhel speed sensor	4	4	4	4
Sensor cluster	N/A	N/A	Applied	Applied
G-sensor	N/A	Applied	N/A	N/A
2H G-sensor	-	Operating	-	-
4H G-sensor	-	Operating	-	-
4L G-sensor	-	Operating	-	-
2H sensor cluster	-	-	Operating	Operating
4H sensor cluster	-	-	Operating	Operating
4L sensor cluster	-	-	Operating	Operating

5) Indicators and Warning Lamps for ABS/ESP



Lamp	Indicator/Warning Lamp	Description
EBD warning lamp		ON when EBD function is failed
ABS warning lamp		ON when ABS function is failed
ESP indicator		Blinking when ESP function is operating
ESP OFF indicator		ON when the ESP OFF switch is pressed
ESP warning lamp		ON when ESP function is failed
ESP buzzer		Sound when ESP function is operating

Modification basis	
Application basis	
Affected VIN	

3. TROUBLESHOOTING

Problem	Possible Cause	Action
Noise or vehicle vibration when applied	Incorrectly mounted back plate or caliper	Repair
	Loosened bolt of back plate or caliper	Retighten
	Uneven wear of brake disc	Replace
	Brake pad contamination	Clean or replace
	Sticking brake pad on contact surface	Replace
	Wear or hardening of brake pad	Replace
	Excessive clearance between caliper and pad	Repair
	Uneven contact of pad	Repair
	Lack of lubrication in sliding parts	Lubricate
	Improper operation of caliper	Replace
	Dust cover missing	Repair
	Loosened suspension mounting bolt	Retighten
Pulls to one side when braking	Unbalanced tire pressure between left and right	Adjust
	Poor contact of brake pad	Repair
	Oil or grease on brake pad	Replace
	Scratch, uneven wear, distortion of brake disc	Replace
	Improperly installed brake caliper	Repair
	Improper operation of auto adjuster	Repair
	Crack or distortion of brake pad	Replace
Poor braking	Oil leak or contamination	Repair or replace
	Air in brake line	Bleed air
	Improper operation of brake booster	Repair
	Poor contact of brake pad	Repair
	Oil or grease on brake pad	Replace
	Improper operation of auto adjuster	Repair
	Clogged brake line	Repair
	Improper operation of proportioning valve	Repair

Problem	Possible Cause	Action
Increased pedal stroke	Air in brake line	Bleed air
	Oil leak	Repair
	Worn brake pad	Replace
	Excessive clearance between push rod and master cylinder	Adjust
	Worn or damaged piston seal	Replace
Brake dragging	Parking brake is not fully released	Release
	Incorrect adjustment of parking brake	Adjust
	Incorrectly adjusted clearance of parking brake shoe	Adjust
	Faulty brake pedal return spring	Replace
	Incorrectly adjusted free play of brake pedal	Adjust
	Faulty master cylinder	Replace
	Lack of lubrication in sliding parts	Lubricate
	Faulty brake booster (vacuum leak)	Repair
Poor parking brake	Wear, hardening or poor contact of brake pad	Replace
	Oil or water on lining	Repair or replace
	Fixed or broken parking brake cable	Replace
	Excessive stroke of brake lever	Adjust notch
	Faulty auto clearance adjuster	Repair
Increased stroke of parking brake lever	Loosened parking brake cable	Adjust or replace
	Incorrectly adjusted parking brake cable	Adjus
	Defective automatic lining clearance adjuster	Repair or replace
	Worn brake lining	Replace

Modification basis	
Application basis	
Affected VIN	

Problem	Cause	Action
Burning smell around tire	Too frequent braking in high driving speed	Reduce the use of foot brake/use engine brake properly
	Used only foot brake during downhill driving	
	Driving with foot on brake pedal	Get off the foot from pedal
	Foreign materials such as dirt or sand in brake system	Replace: caliper, wheel cylinder, master cylinder, return spring
	Broken return spring in shoe assembly	Replace
	Incorrectly adjusted parking brake cable	Adjust
	Incorrect wheel or wheel cover (generating the heat)	Replace

▶ BRAKE OPERATION AND NOISE

This section describes the noise phenomena occurred possibly in the brake system operation. Distinguish between the information given below and the actual problems and then, inspect the vehicle and take appropriate measures.

- **Noise symptoms and Causes**

Symptom 1. If depressing the brake pedal when the engine is cold, "screeching" sound always occurs and, after driving for a while, the sound disappears..

This usually occurs in the morning. When the temperature goes down, the dew condensation phenomenon sets moisture on the brake disc as the window frost forms. Due to this moisture, the iron within the brake disc and pad oxidizes, forming undetectable micro-rusts on the disc surface. When starting the engine under this condition, noise may sound due to the friction of micro-rusts. When operating the brake several times, the disc temperature goes up and the micro-rusts come off and the noise goes away. Depending on the driving conditions, noise gets louder when slightly depressing the brake pedal and oppositely, noise is smaller when deeply depressing the brake pedal. This is simply a physical phenomenon, called "morning effect" in professional terms, and does not imply any problems with the brake system.

Symptom 2. Slip or screech after the brake pad replacement.

This usually occurs when the bed-in is not made between the disc and the pad's friction material. The bed-in is a state that the brake system normally works and gives no noise out, when, after about 300 km city driving, the contact area of the pad friction material is enlarged and the disk is in complete contact with the pad's friction material. Therefore, for some time after the brake disk/pad replacement, the brake system poorly operates or noise (abnormal sound) occurs due to the partial contact.

Symptom 3. "Groaning" sound occurs in the automatic transmission vehicle when slightly taking the foot off the brake pedal to slowly start after waiting for the signal, or slightly depressing the brake pedal.

This is the noise "Creep groan" that occurs when, in both the automatic and manual transmission, slightly releasing the brake pedal in the neutral gear at downhill roads.
It frequently occurs at the low braking power and low speed, through the following process. When operating the brake system at low speed and low pressure, adhesion and slip repeatedly take place between the brake disk and the friction material, and this makes the braking power inconstant, instantly increasing or decreasing, and gives out the brake noise.
It is also a physical phenomenon and has no relation with the brake performance.

Modification basis	
Application basis	
Affected VIN	

4. AIR BLEEDING

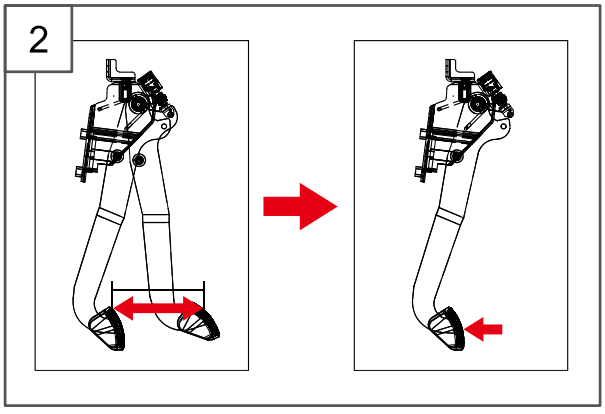
CAUTION

- Never reuse the used brake fluid.
- Use only specifies brake fluid (DOT 4). Add brake fluid between MAX and MIN lines on the reservoir (0.7 to 0.8 liters).
- Be careful not to splash the brake fluid on painted area or body.
- Make sure that any foreign material does not get into brake line.
- Always work with another staff.

1

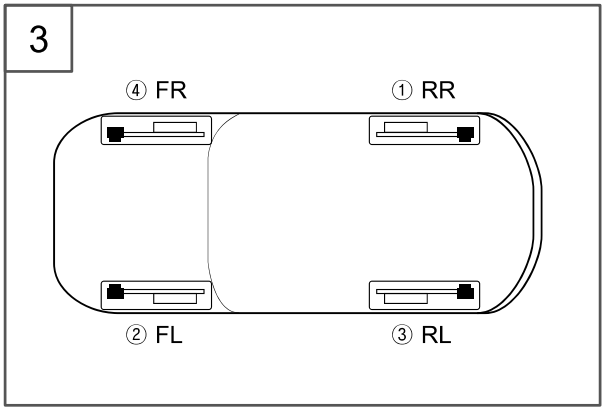
1. Fill up the brake fluid up to "MAX" line on the reservoir.

2



2. Fill the reservoir with brake fluid and pump the brake pedal several times. Then keep it depressed.

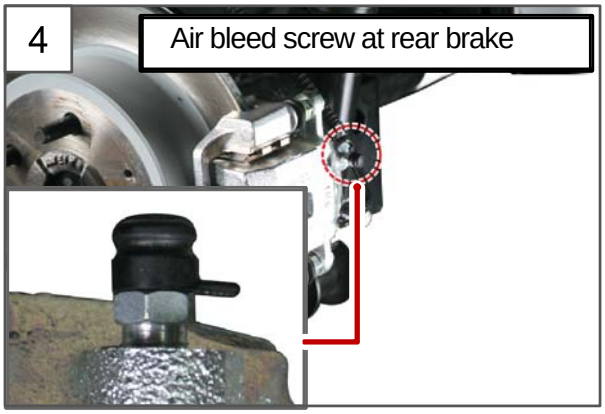
3



3. Loosen the bleed screw and collect the bleeding brake fluid from the brake line with the order in the figure.

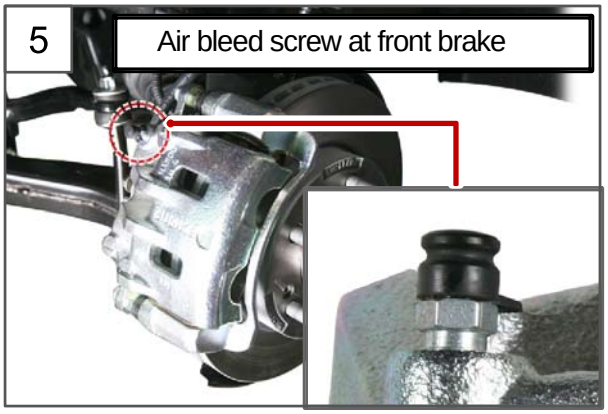
CAUTION

Fill the reservoir with the brake fluid as much as it bleeded, and continue to bleeding operation.



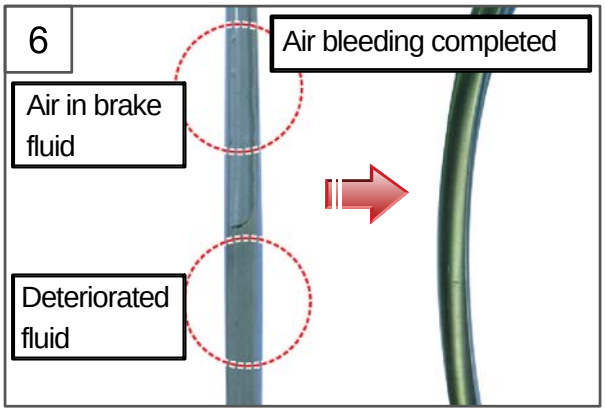
4. Air bleed screw at rear brake

Tightening torque 9.8 ~ 11.2Nm



5. Air bleed screw at front brake

Tightening torque 9.8 ~ 11.2Nm



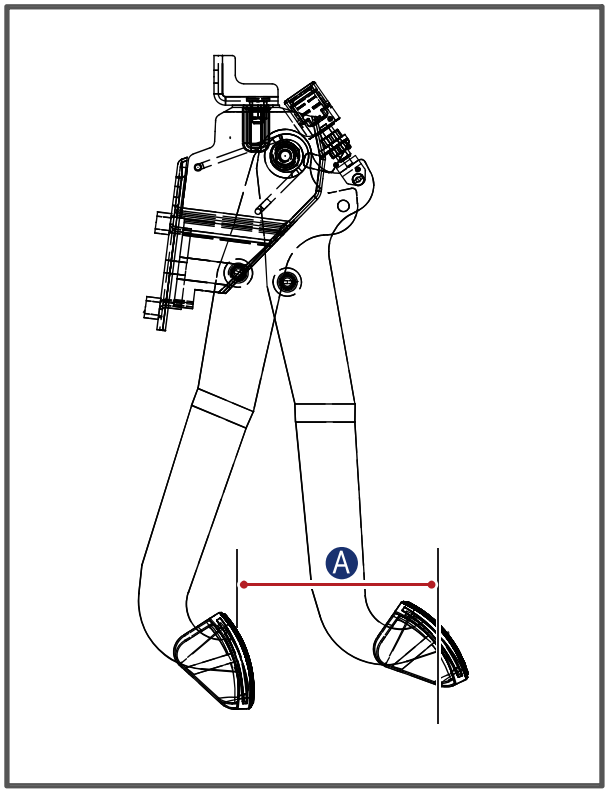
6. Repeat the air bleeding procedures until clear brake fluid comes out of air bleed screw.

7. Check for oil leaks from the brake lines.

Modification basis	
Application basis	
Affected VIN	

5. BRAKE SYSTEM CHECK

▶ **Maximum Stroke of Brake Pedal**



- Check the brake pedal with below procedures:

1. Start the engine.
2. Pump the brake pedal around 3 times.
3. Depress the brake pedal with approx. 30 kg and measure the distance (A) between the upper surface of pedal pad and the lower dash panel.
4. If the measured value is out of the specified value, adjust the length.

Specified value (A)	150mm

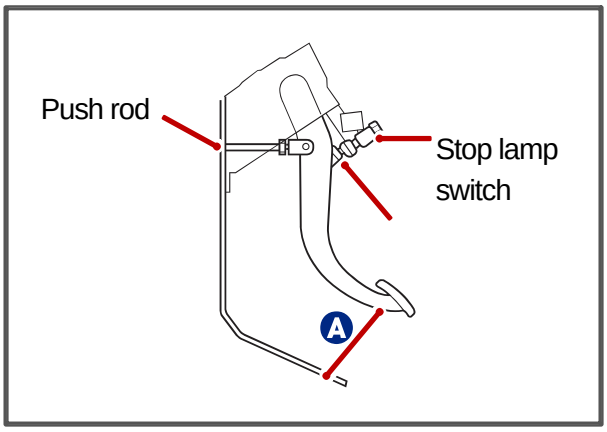
Over the specified value

Cause	Action
Worn brake pad	Replace
Worn brake shoe	Replace
Improper stroke of hand brake	Adjust
Air in brake line	Air bleeding
Oil leak	Repair or replace
Brake booster push rod	Replace or adjust
Improperly adjusted stopper bolt	Adjust

Below the specified value

Cause	Action
Brake booster push rod	Replace or adjust
Air in brake fluid	Replace
Improperly adjusted stopper bolt	Adjust

▶ Pedal Height



- Check the pedal height with below procedures:

1. Start the engine and measure the length (A) between floor mat and pedal.
2. If the measured value is out of the specified value, adjust the length.

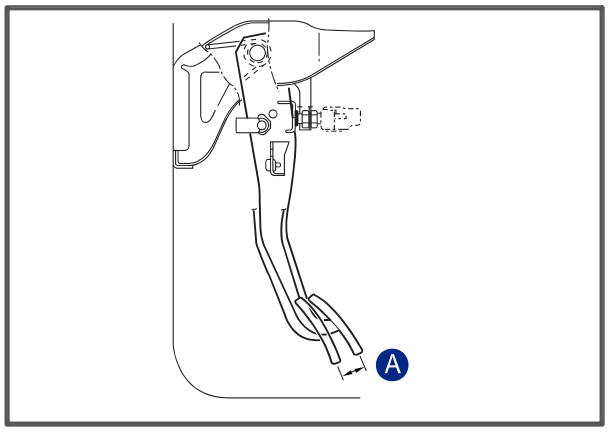
Specified value (B)	155mm

- Adjust the pedal height with below procedures:

1. Disconnect the stop lamp switch connector.
   Unscrew the lock nut and remove the stop
2. lamp switch assembly.
   Loosen the lock nut on the pedal push rod.
3. Turn the pedal push rod to adjust the pedal
4. height.
   Tighten the lock nut.
5. Install the stop lamp switch assembly.
6. Connect the stop lamp switch connector.
7. Check if the stop lamps come on when
8. pressing the brake pedal around 5 mm.
   If the stop lamp dpes not come on, adjust the
9. stop lamp switch assembly again.
   If the stop lamps come on, tighten the lock nut
10. and measure the pedal height again.

Modification basis	
Application basis	
Affected VIN	

▶ Pedal Free Play



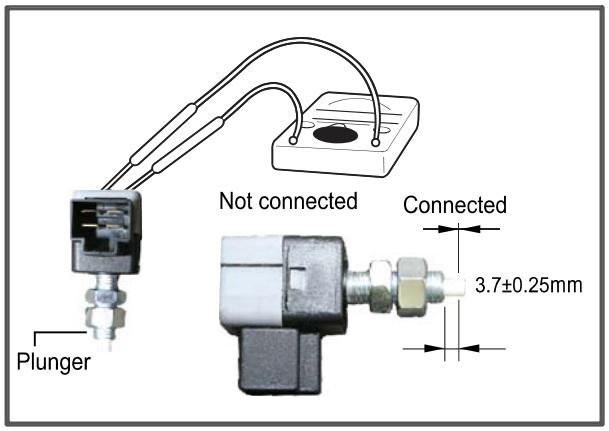
- Check the pedal free play with below procedures:

1. Stop the engine.
2. Depress the brake pedal several times to discharge the vacuum pressure of the brake booster.
3. Depress the brake pedal until you feel the resistance, and measure the movement (A).

Specified value (A)	3 ~ 10mm

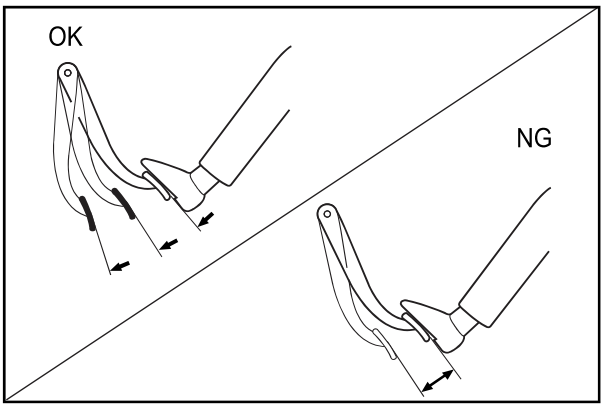
- Below the specified value: Check if the distance between the outer case of stop lamp switch and the brake pedal.
- Over the specified value: It may be caused by bigger clearance between the clevis pin and the brake pedal arm. Replace the components if necessary.

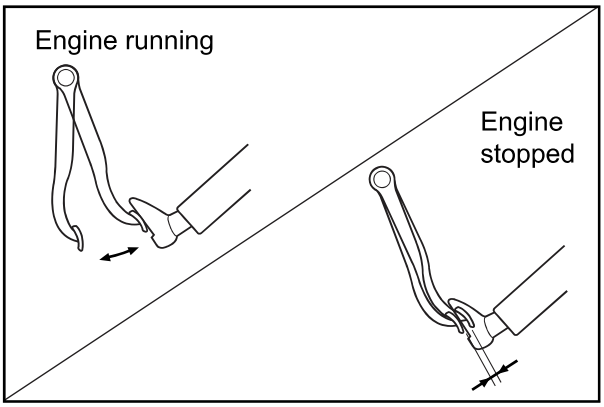
▶ Stop Lamp Switch



- Connect the multimeter to stop lamp switch connector and check if the continuity exists when pushing in the plunger. If the continuity doesn't exist, the stop lamp switch is normal.

▶ Brake Booster





1. Let the engine run for 1 to 2 minutes and stop it. If the brake pedal stroke is shortened as pumping the brake pedal, the system is normal. If not, the system is defective.
2. Depress the brake pedal several times with engine off. If the brake goes down when starting engine with pedal depressed, the system is normal. If not, the system is defective.
3. Depress the brake pedal when the engine is running. If the pedal height is not changed for 30 seconds after stopping the engine, the system is normal. If not, the system is defective.

If the above three checks are OK, the system is normal. If any condition is not met, check the valve, vacuum hose and brake booster.

Modification basis	
Application basis	
Affected VIN	

▶ Brake Fluid

1. Color
   - Ligh gold (New oil) → Brown → Black

2. Service Interval/Type
   - Change: every 2 years, Type: DOT4
     The water in the brake fluid has an adverse effect to the brake system. If the fluid contains around 3% of water, the boiling point of the brake fluid goes down by 25%. It will cause the vapor lock frequently.
     Water content in fluid: around 3% after 18 months, around 7~10% after few years
     The water ib fluid makes the corrosion in the brake lines, deforms and deteriorates the rubber components, brake calipers and pistons.

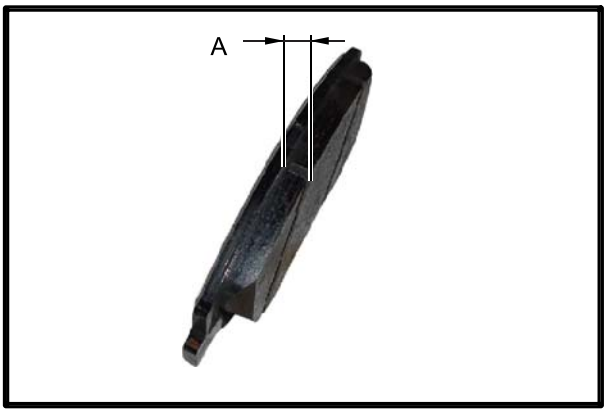
▶ Brake Fluid Type

DOT4: Brake fluid for premium vehicle. Lower water absorbing rate AND higher boiling point than DOT3

▶ Brake Fluid Level Check

The brake fluid level should be between "MAX" and "MIN" on the reservoir. If it is below "MIN" mark, check for oil leaks and refill the reservoir with the specified fluid.

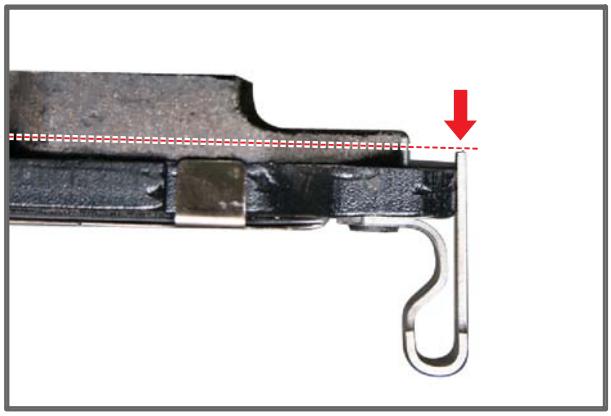
▶ Front Brake



1. Pad Thickness

- Measure the pad thickness and replace it if it is below the wear limit.

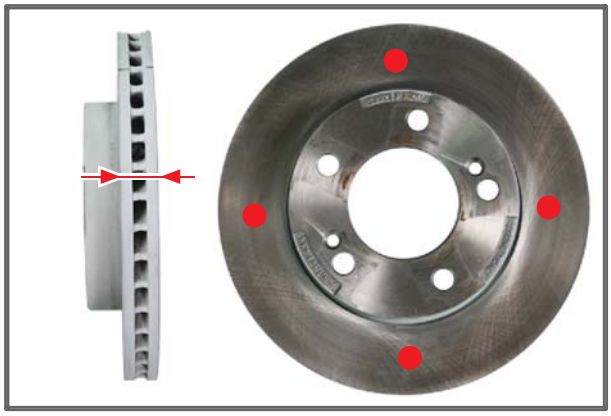
New pad	Wear limit
10.5 mm	2 mm



- Wera limit point

2. Disc Thickness

- Measure the disc thickness at over four points.
- If any of measured points is below the wear limit, replace the brake disc with new one.



New disc	Wear limit
28 mm	25.4 mm

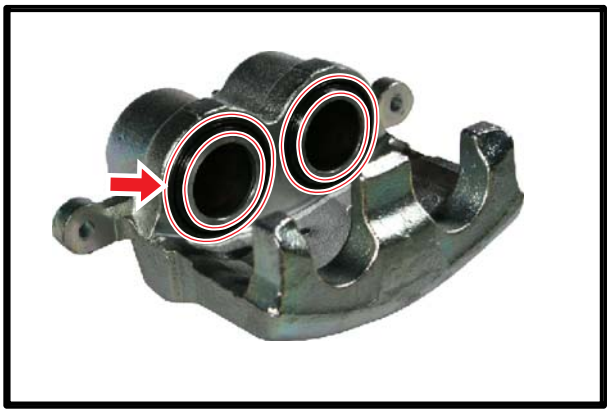
3. Disc Run-Out

- Install the dial gauge on the side of brake disc and measure the run-out while rotating the brake disc.
- If the measured value exceeds the limit, replace the brake disc with new one. Otherwise, it may cause the pedal vibration and shimmy when braking.

Limit	0.03 mm (before installation)
	0.07 mm (when installed)

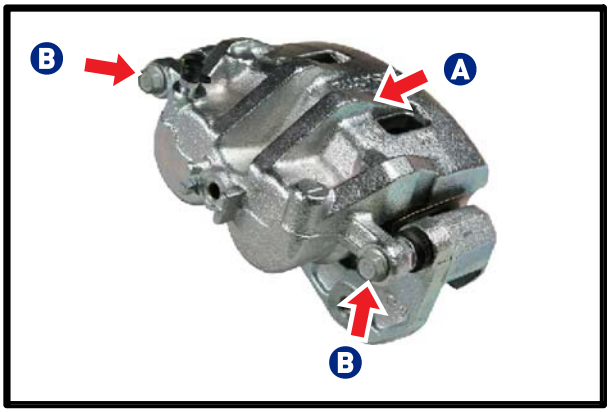
Modification basis	
Application basis	
Affected VIN	

Clean the dissembled components and visually check the followings:



4. Damage and tear on boot

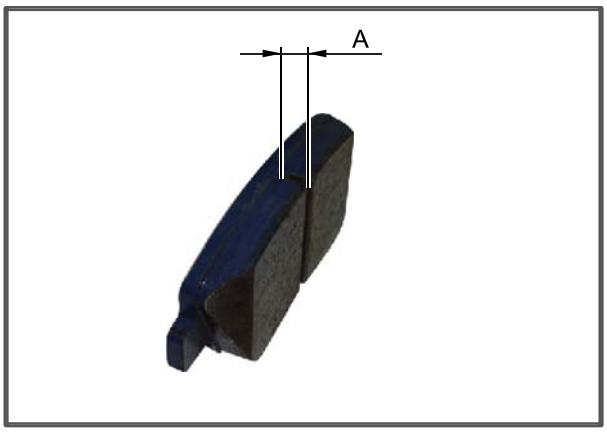
5. Uneven wear and oil contamination



6. Damage, crack and wear on cylinder body (A) and guide pin (B)

7. Wear, rust and damage on the cylinder and piston
8. Scratch and bending on disc plate

▶ Rear Brake



Pad Thickness

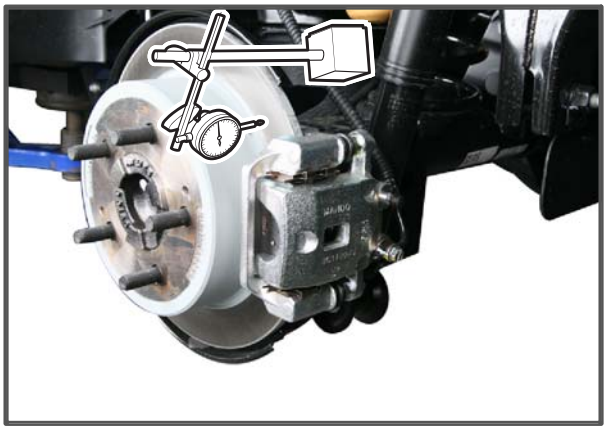
1. Remove the front tire.
2. 2. Measure the pad thickness and replace it if it is below the wear limit.

New pad	Wear limit
10 mm	2mm

Disc thickness

1. Measure the disc thickness at over four points.
2. If any of measured points is below the wear limit, replace the brake disc with new one.

New disc	Wear limit
10.4mm	8.5mm

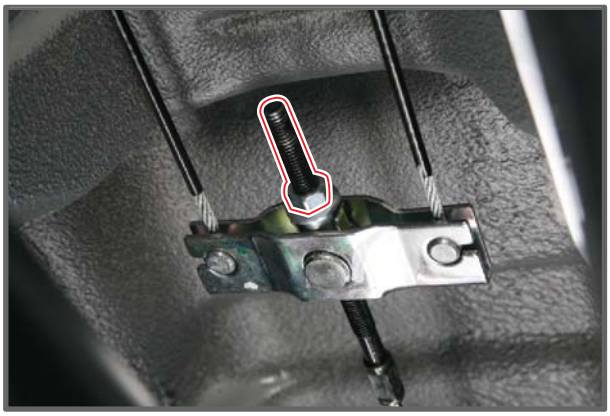


Disc Run-Out

1. Install the dial gauge on the side of brake disc and measure the run-out while rotating the brake disc.
2. If the measured value exceeds the limit, replace the brake disc with new one. Otherwise, it may cause the pedal vibration and shimmy when braking.

Limit	0.03 mm (before installation)
	0.07 mm (when installed)

▶ Parking Brake



Check the brake force with below procedures:

1. Count the number of the clicks (notches) when pulling up the parking brake with 19 kg of force.

Specified notches	5

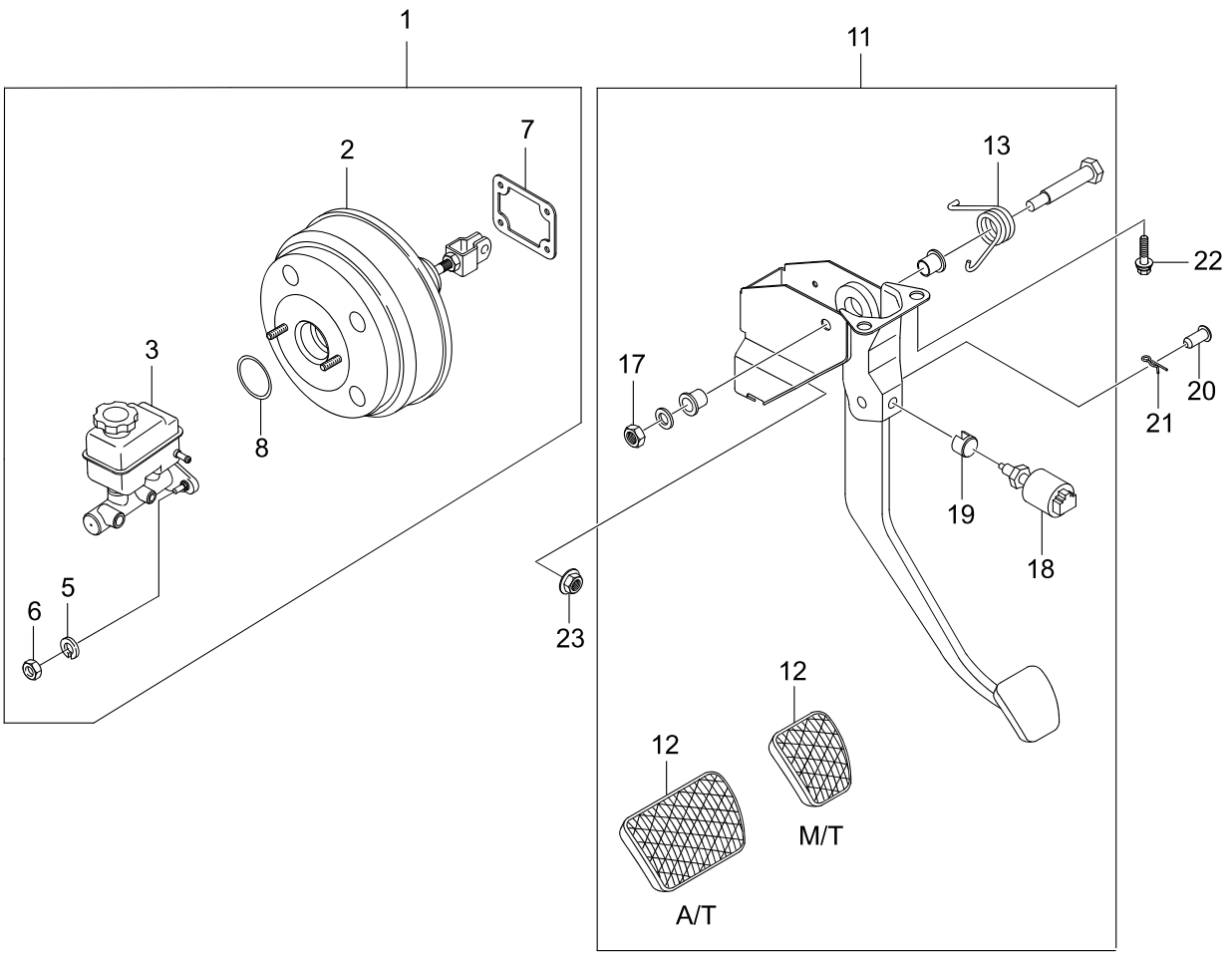
2. If the clicks are over or below the specified value, adjust the clicks to the specified value with the parking brake adjusting nut.
3. Check the parking brake force after adjustment.
4. If the parking brake force is not enough, check the parking brake lever and cable. Replace the components if needed.

CAUTION

Never park the vehicle only with the parking brake on the stiff hill. It may cause roll down of the vehicle due to release of the parking brake. Place the wheel chocks under the wheels.

6. COMPONENTS

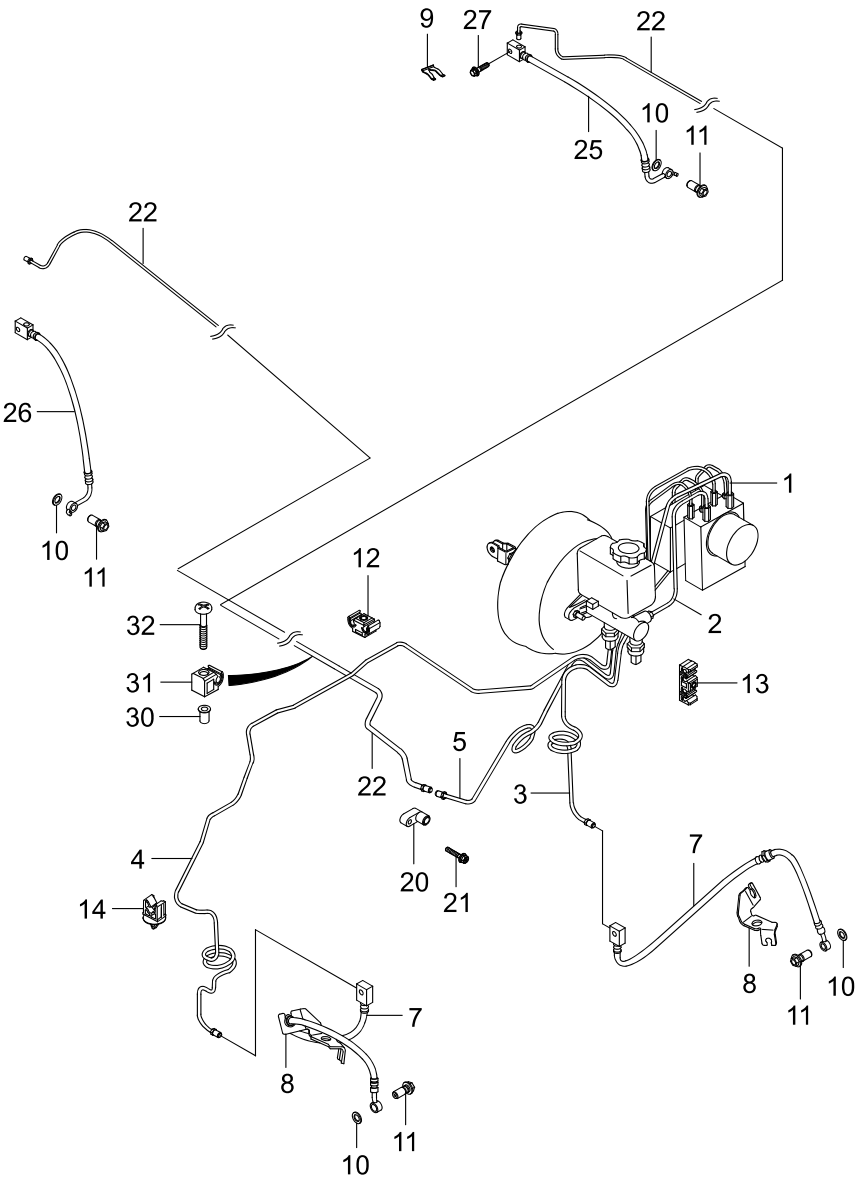
▶ **Brake Pedal, Master Cylinder and Booster**



1. Brake master cylinder assembly
2. Brake booster assembly
3. Brake master cylinder
6. Nut (12.8~16.7 Nm)
7. Booster mounting seal
8. O-ring
11. Brake pedal assembly
12. Brake pedal
13. Brake pedal return spring
17. Nut - Brake pedal
18. Stop lamp switch
19. Stopper
20. Clevis pin
21. Snap pin
22. Bolt - Brake pedal assembly (17.6~21.6 Nm)
23. Nut - Brake booster (17.6~21.6 Nm)

Modification basis	
Application basis	
Affected VIN	

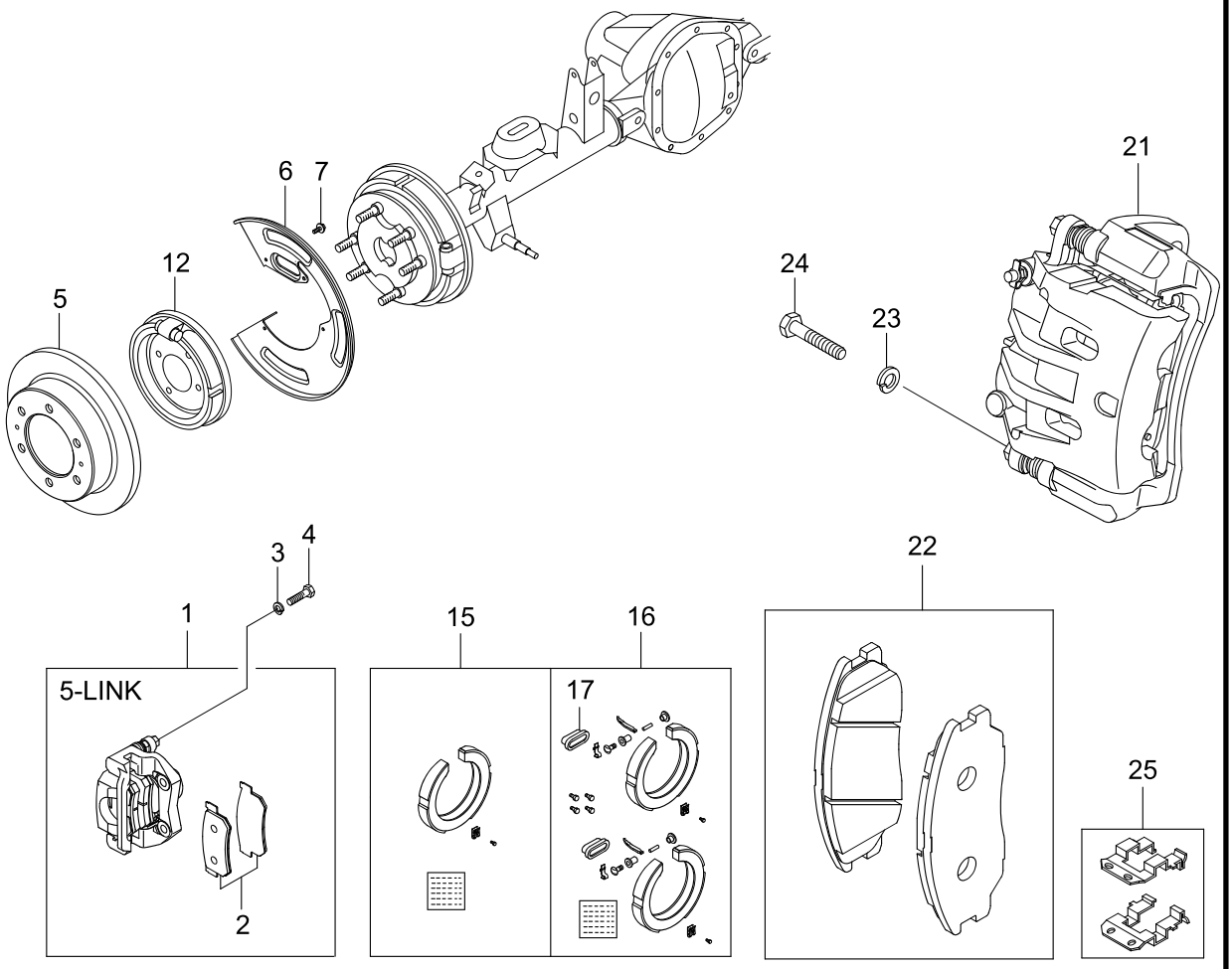
▶ Brake Pipe



1. Master cylinder primary tube assembly
2. Master cylinder secondary tube assembly
3. Front tube assembly
4. Front tube assembly
5. 2-way connector tube assembly
7. Front brake hose assembly
8. Front brake hose mounting holder
9. Flexible hose clip
11. Caliper eye bolt (19.6~29.4 Nm)
12. Brake tube mounting clip
13. Brake tube mounting clip
14. Brake tube mounting holder
20. Brake tube 2-way connector
21. Screw
22. Rear hose 2-way connector
24. 3-way connector hose tube assembly
25. Rear brake hose assembly
26. Rear brake hose assembly
27. Bolt (9.8~11.8 Nm)

Modification basis	
Application basis	
Affected VIN	

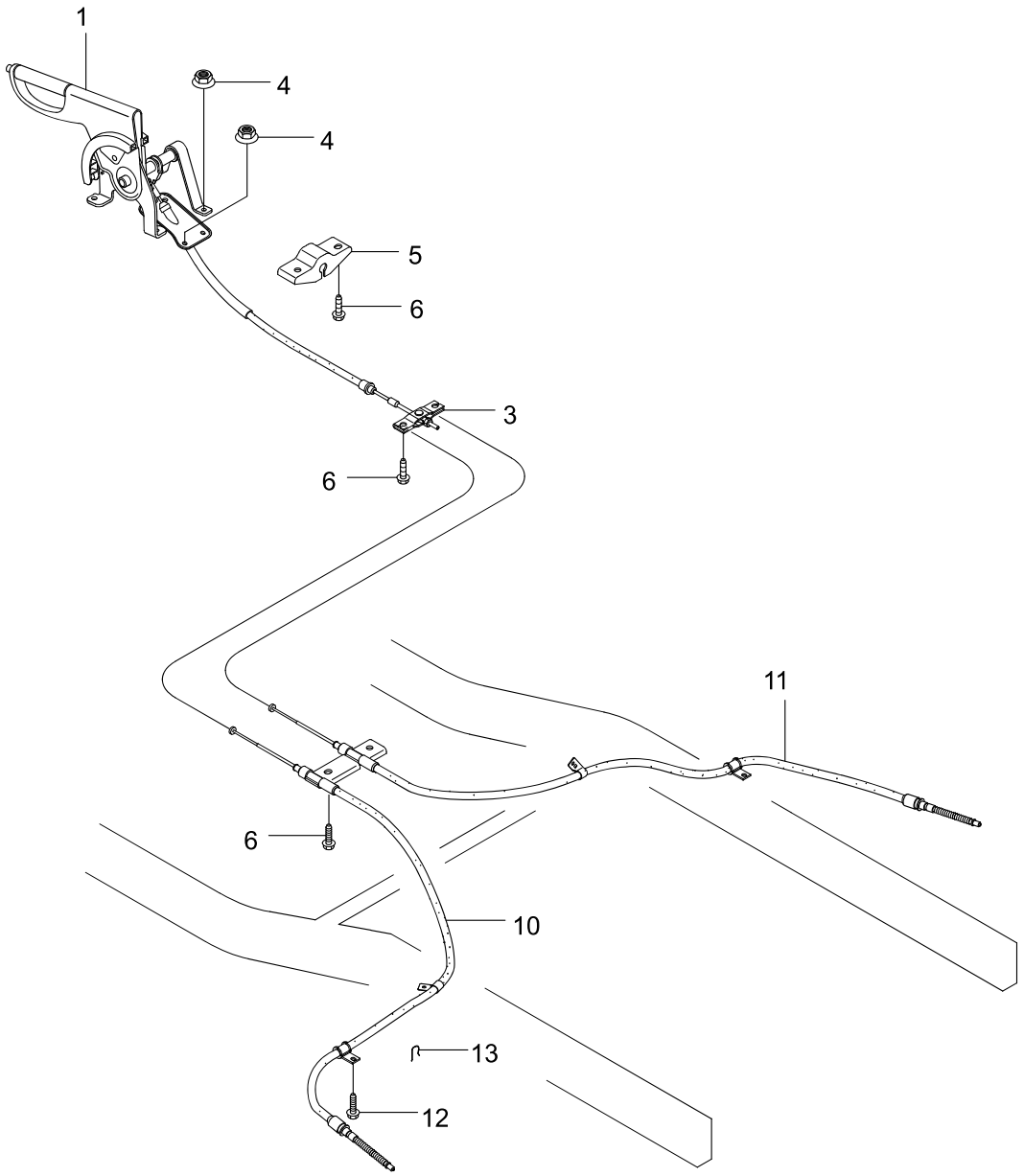
▶ Front/Rear Brake Assembly



1. Rear brake caliper assembly
2. Rear brake pad
3. Washer
4. Bolt (52.9~63.7 Nm)
5. Rear brake disc
6. Rear disc brake dust shield
7. Bolt
12. Rear drum brake assembly
15. Parking brake shoe
16. Parking brake repair kit
17. Rear axle shaft grommet
21. Front brake caliper assembly
22. Front brake pad
23. Washer
24. Front caliper mounting bolt (25.5~30.4 Nm)
25. Caliper clip set

Modification basis	
Application basis	
Affected VIN	

▶ Parking Brake



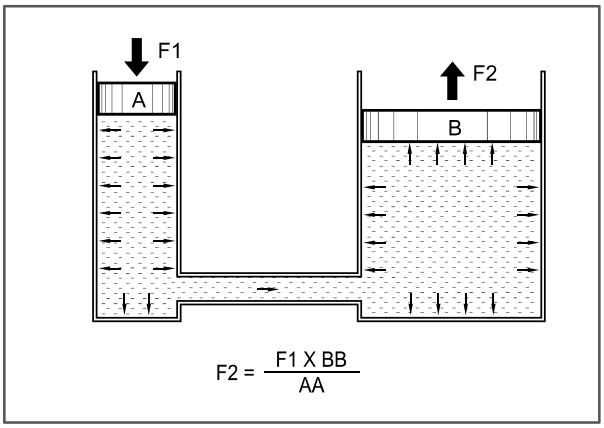
1. Parking brake lever assembly
3. Equalizer
4. Nut (9.8~12.7 Nm)
5. Front brake mounting bracket
6. Bolt
10. Parking brake rear cable assembly
11. Parking brake rear cable assembly
12. Bolt (9.8~12.7 Nm)
13. Parking brake cable retaining ring

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

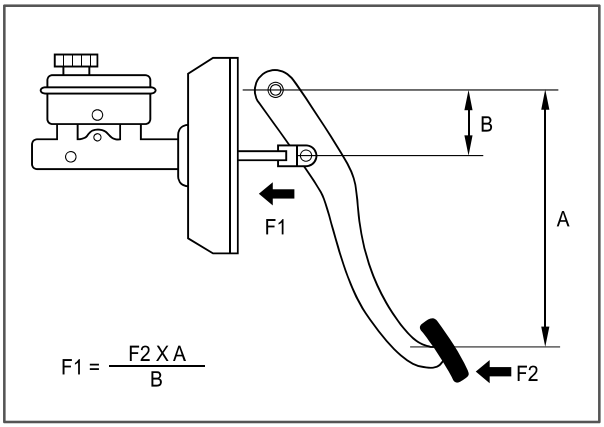
Even though a driver cuts off the power, while driving, the vehicle continues to move due to the law of inertia. Therefore, a braking device is needed to stop the vehicle. The brake system normally uses the frictional discs that converts the kinetic energy to the thermal energy by frictional operation. The brake system consists of the brake disc (front wheel), brake disc or drum (rear wheel), parking brake (mechanical type), master cylinder, booster, pedal and supply lines (pipes and hoses).

▶ Hydraulic Brake



This system uses the leverage effect and Pascal's principle. When depressing the brake pedal, the pedal pressure is increased by booster and is delivered to master cylinder to generate hydraulic pressure. The hydraulic pressure generated by the master cylinder is delivered to the brake caliper through the brake pipes or hoses. This hydraulic pressure pushes the brake calipers, accordingly the caliper pads are contacted to brake disc to generate the braking force.

▶ Brake Pedal



Brake pedal uses the leverage effect to apply bigger force to the brake master cylinder.

Modification basis	
Application basis	
Affected VIN	

▶ Braking distance & stopping distance

Stopping distance = free running distance + braking distance

What is stopping distance?

A certain distance (free running distance + braking distance) is needed from the moment an obstacle appears ahead until you bring your vehicle to a complete stop. This is called as stopping distance.
What is braking distance?
Tire slip occurs until the vehicle stops completely when the the brake is applied.
This slip is what we call a braking distance.

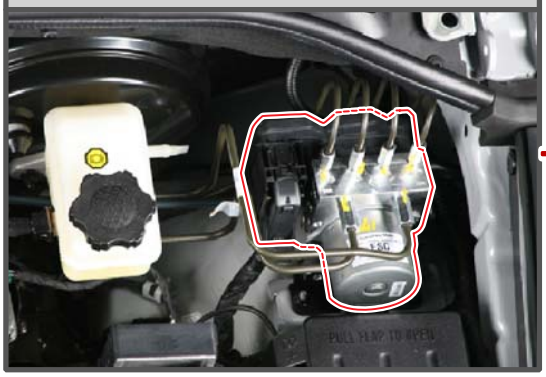
What is free running distance?

The free running distance is the time from the driver sees the obstacles and begins to prepare for depressing the brake pedal until the moment the brake pedal is depressed.

2. SYSTEM LAYOUT

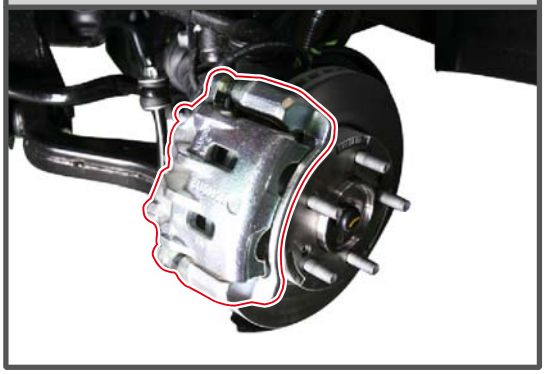
Master Cylinder and Booster

HECU



Brake Pedal

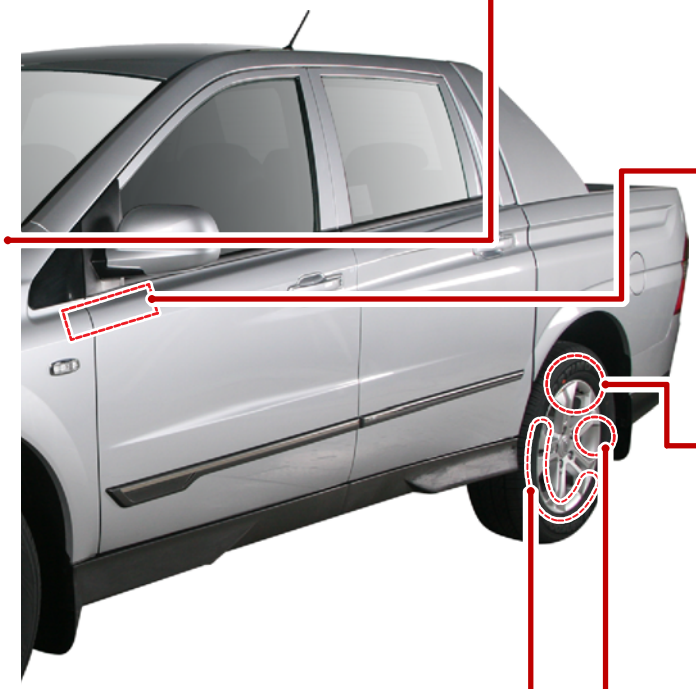
Front Brake Assembly



Front Wheel Speed Sensor (4WD)

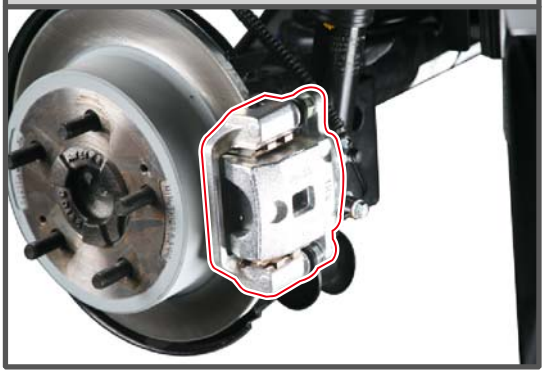
Modification basis	
Application basis	
Affected VIN	

ABS/EBD Indicators



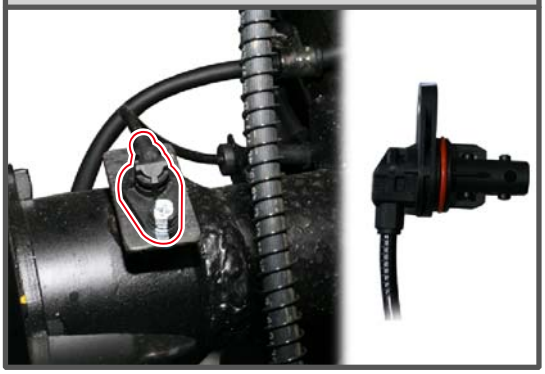
Parking Brake Lever

Rear Brake Assembly



Parking Brake

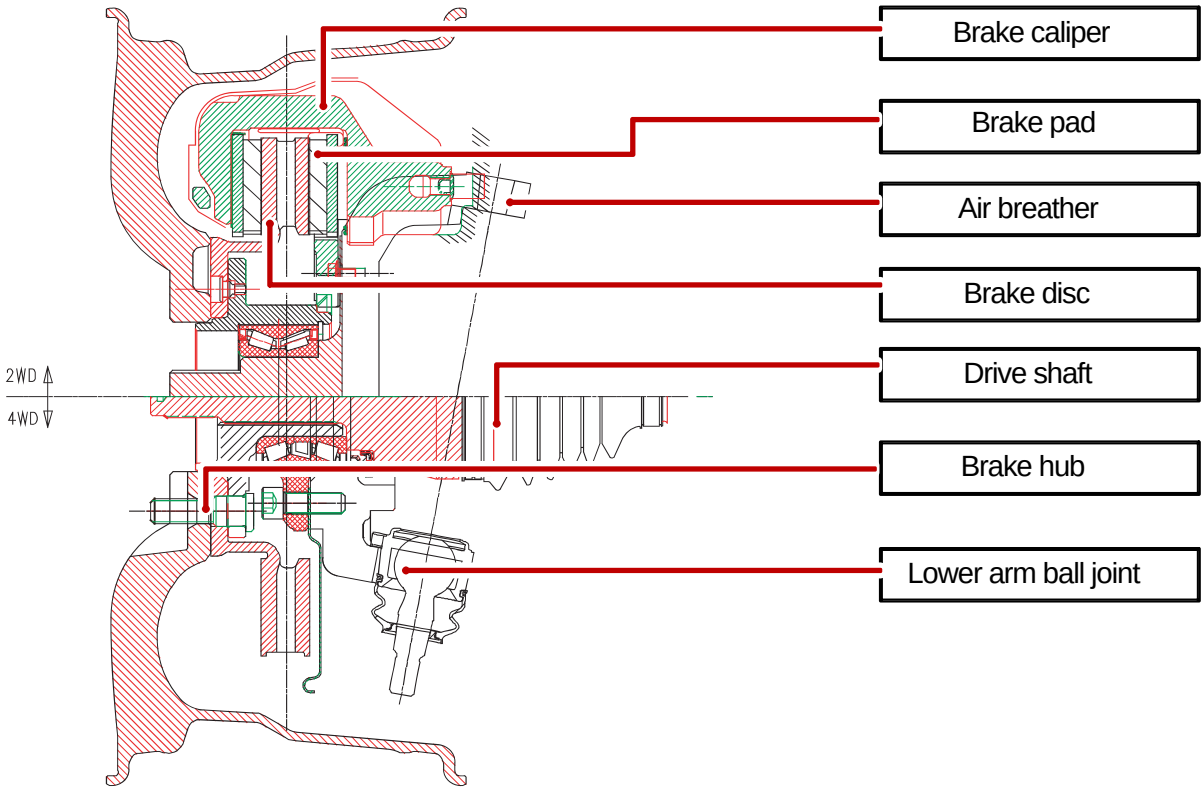
Rear Wheel Speed Sensor (4WD)

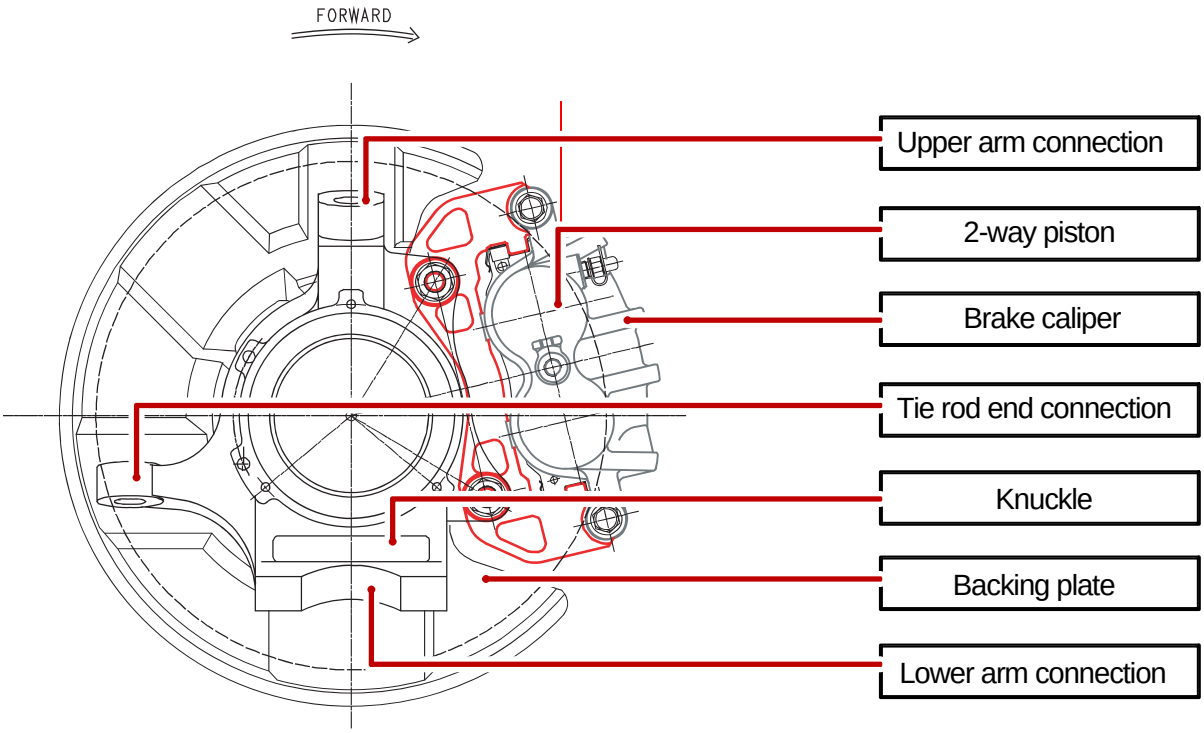


Modification basis	
Application basis	
Affected VIN	

3. PARKING BRAKE

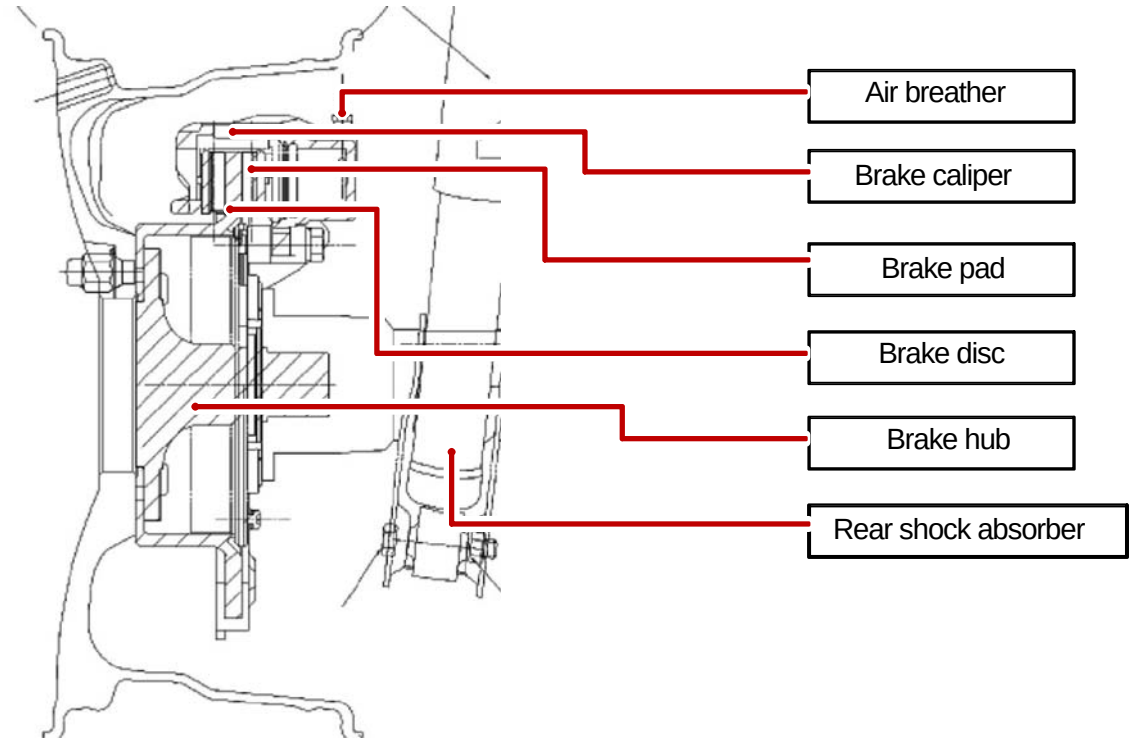
▶ Front Disc Brake

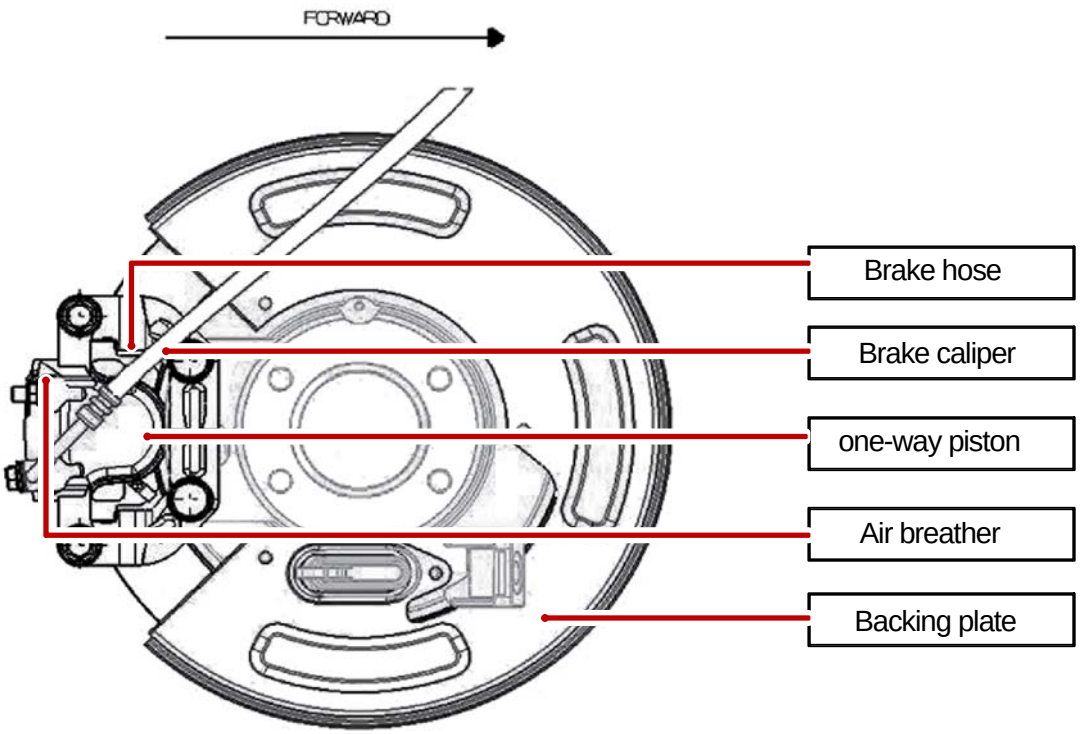




Modification basis	
Application basis	
Affected VIN	

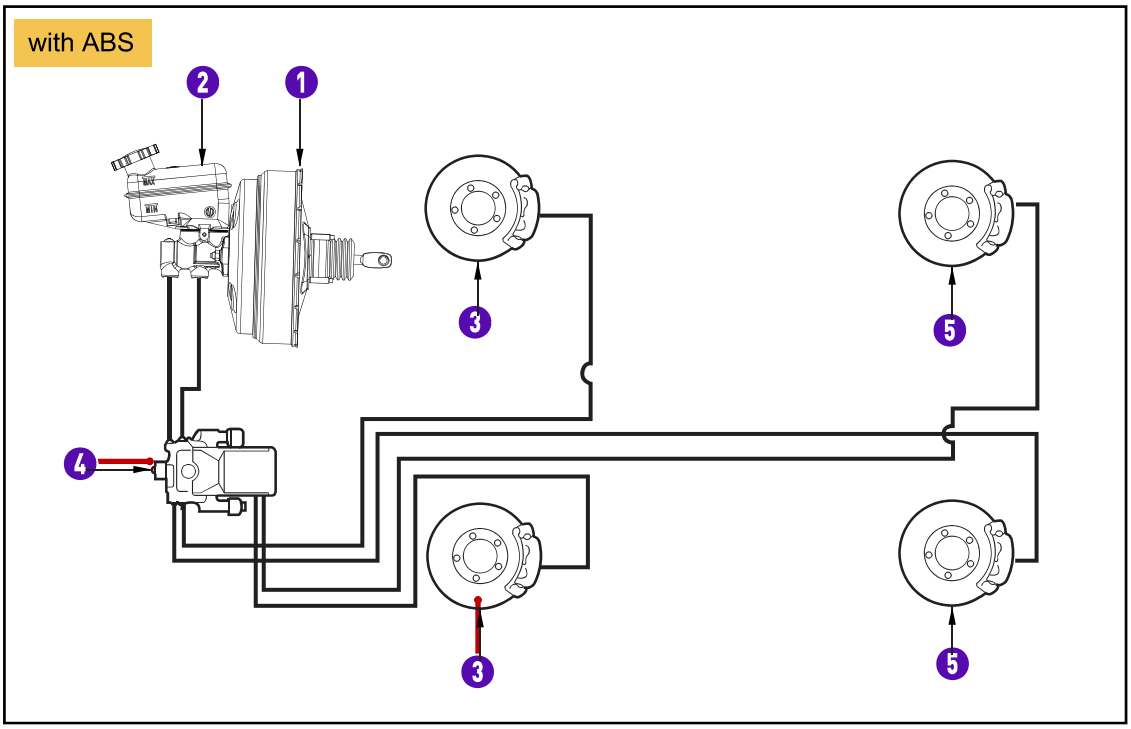
▶ Rear Disc Brake





Modification basis	
Application basis	
Affected VIN	

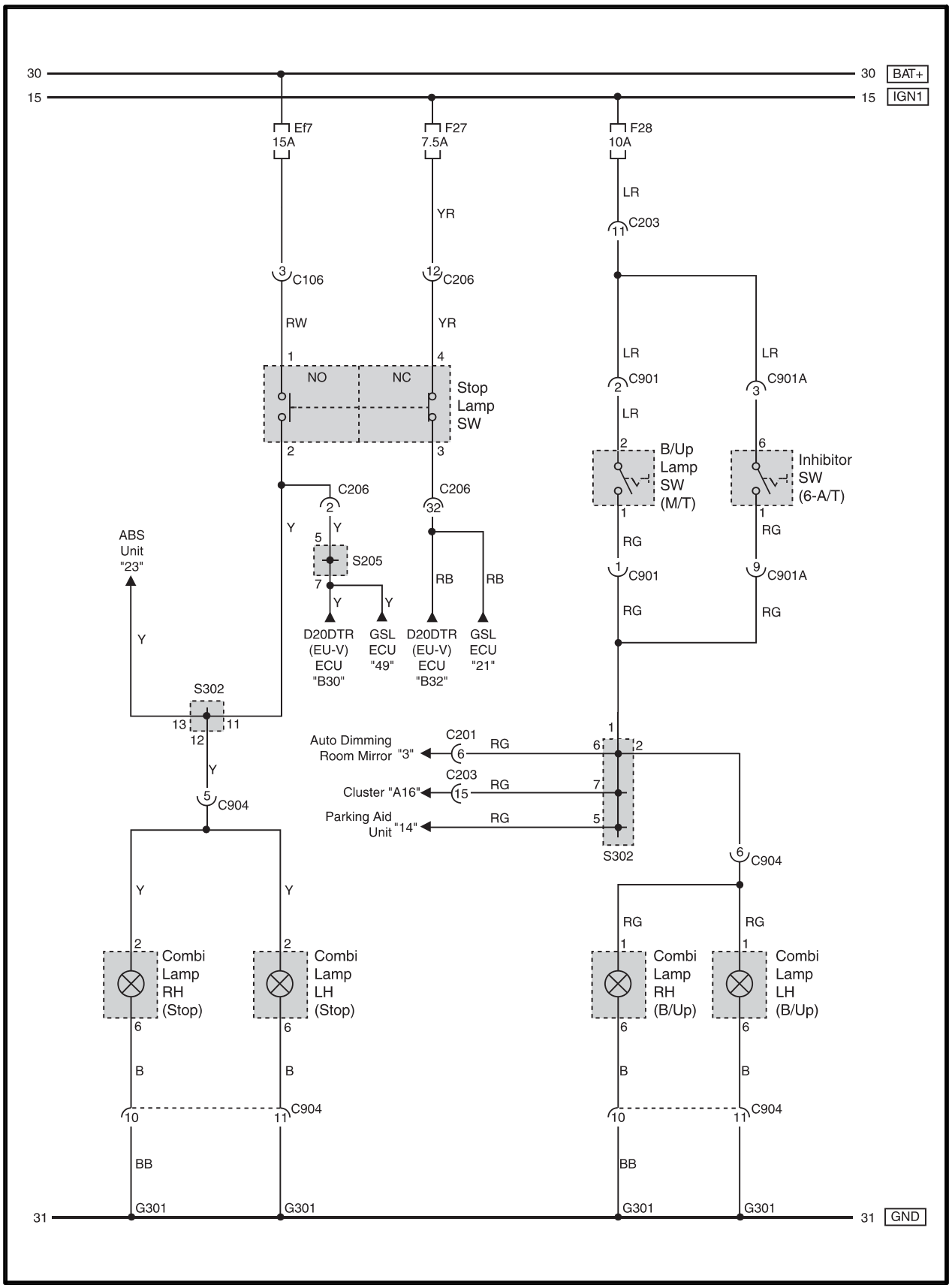
4. HYDRAULIC CIRCUIT



1. Brake booster
2. Brake fluid reservoir and master cylinder
3. Front disc brake and caliper
4. HECU (Hydraulic & Electric Control Unit)
5. Rear disc brake and caliper

Modification basis	
Application basis	
Affected VIN	

5. CIRCUIT DIAGRAM OF STOP LAMP



Modification basis	
Application basis	
Affected VIN	

ABS

4892-01

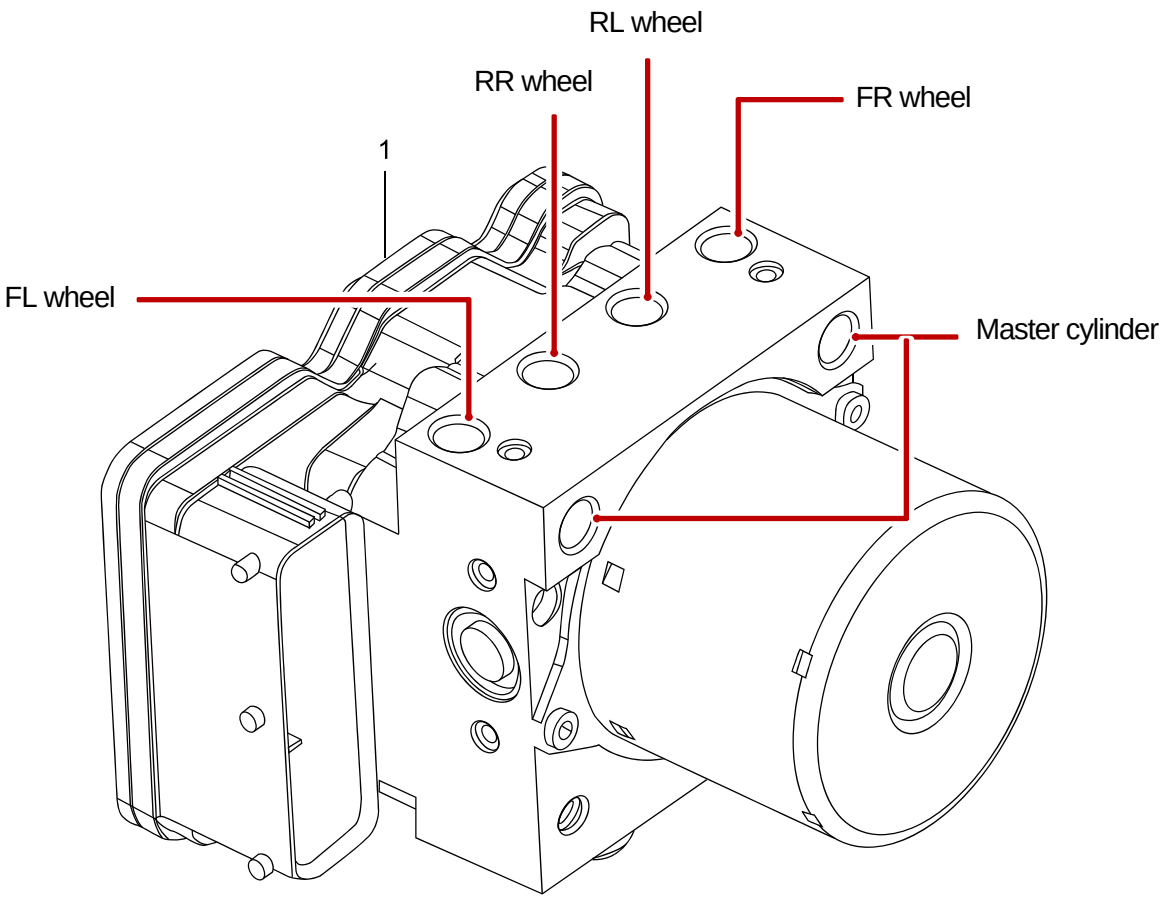
GENERAL INFORMATION

1. SPECIFICATION

Unit	Description	Specification		Remark
		ABS	ESP	
HECU	Clock frequency	32MHz	50MHz	
	Memory	128KB	256KB	
S-sensor	Operating voltage	4.75~5.25V	None (functions in sensor cluster)	Installed in IP panel behind audio (only for 4WD)
	Operating temperature	−30 ~ 85℃		
	Operating range	-1.5 ~ 1.5g		
	Output voltage	0.5 ~ 4.5V		
Wheel speed sensor	Supplying voltage	4.5 ~ 16V	←	
	Output current (approx. 2.7 km/h of vehicle speed)	7mA(Lo) ~ 14mA +20%	←	
	Operating temperature	−40 ~ 150℃	←	
	Operating frequency	1~2500Hz	←	

2. OPERATING FREQUENCY

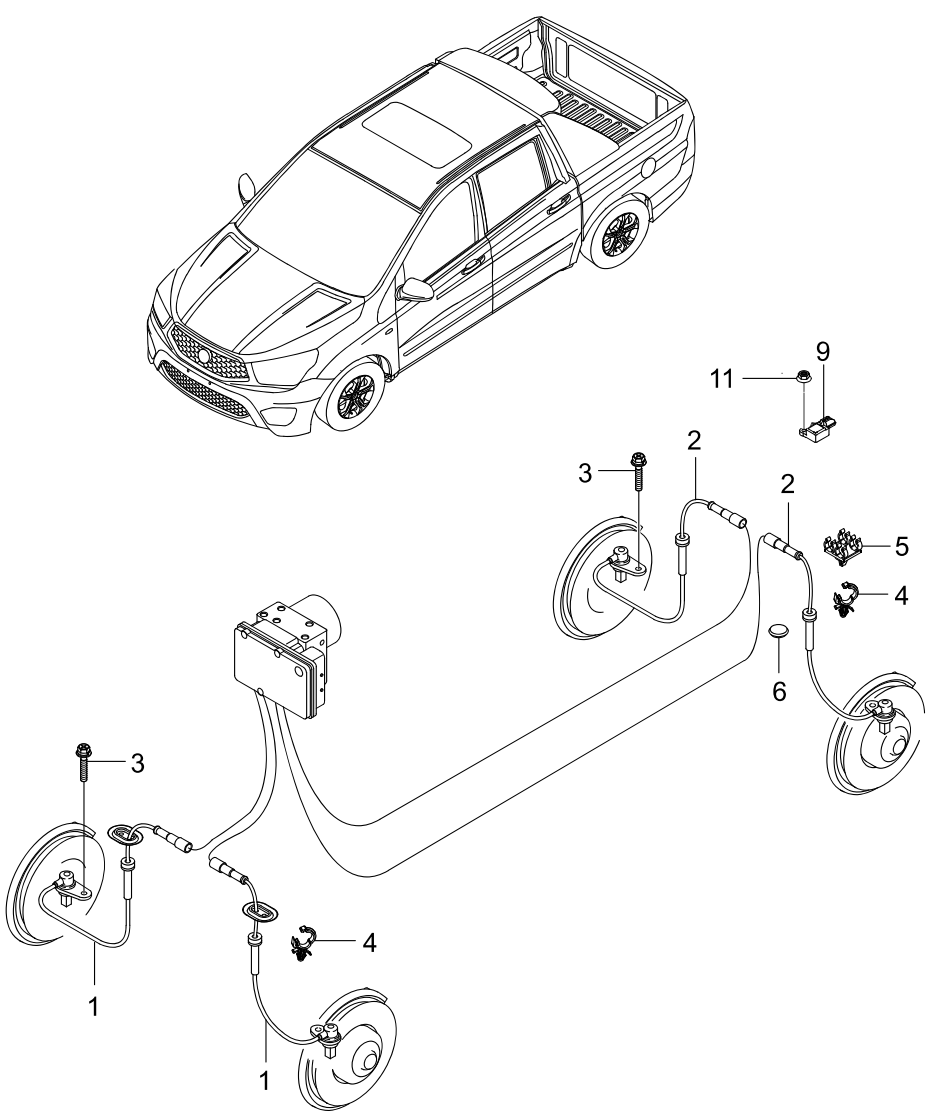
1) Hydraulic and Electronic Control Unit (HECU)



1. Hydraulic and Electronic Control Unit (HECU)

Modification basis	
Application basis	
Affected VIN	

2) ABS System



1. Sensor - front wheel speed
2. Sensor - rear wheel speed
3. Screw (7.8~11.8 Nm)
4. Clip - cable holder
5. Clip - sensor cable mounting, rear
6. Plug - blind
9. G-sensor
11. Nut (9.8~10.8 Nm)

OVERVIEW AND OPERATING PROCESS

1. SYSTEM OVERVIEW

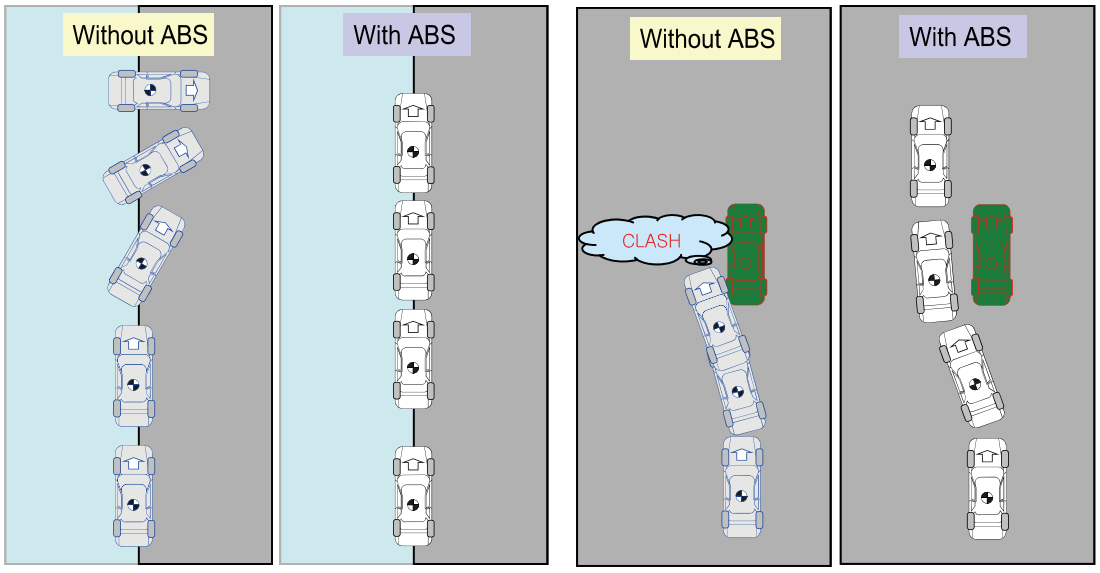
1) What is ABS?

When braking suddenly or braking on slippery roads, the vehicle keeps moving forward but the wheels are locking and not rotating. If these happen, the vehicle may lose stability or rotate resulting in an accident. ABS helps to maintain directional stability and control of the vehicle. ABS is designed to secure more safety and increase the control of steering wheel during emergency braking situation. But, ABS does not guarantee perfect safety beyond its physical limit. ABS in this vehicle contains EBD function. In normal driving conditions, the brake system operates without ABS function.

2) What is EBD (Electronic Brake-force Distribution)?

EBD is an automobile brake technology that automatically varies the amount of force applied to each of a vehicle's brakes, based on road conditions, speed, loading, etc. Always coupled with anti-lock braking systems, EBD can apply more or less braking pressure to each wheel in order to maximize stopping power whilst maintaining vehicular control. EBD does not operate when ABS is working.

▶ **ABS effect according to braking conditions**



Braking on split road **Maneuvering while braking**

Modification basis	
Application basis	
Affected VIN	

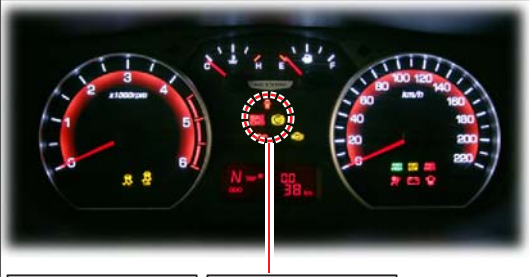
Memo

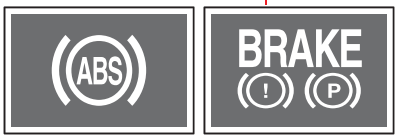
2. COMPONENT

G-sensor

Located on the floor under center fascia.

ABS warning lamp

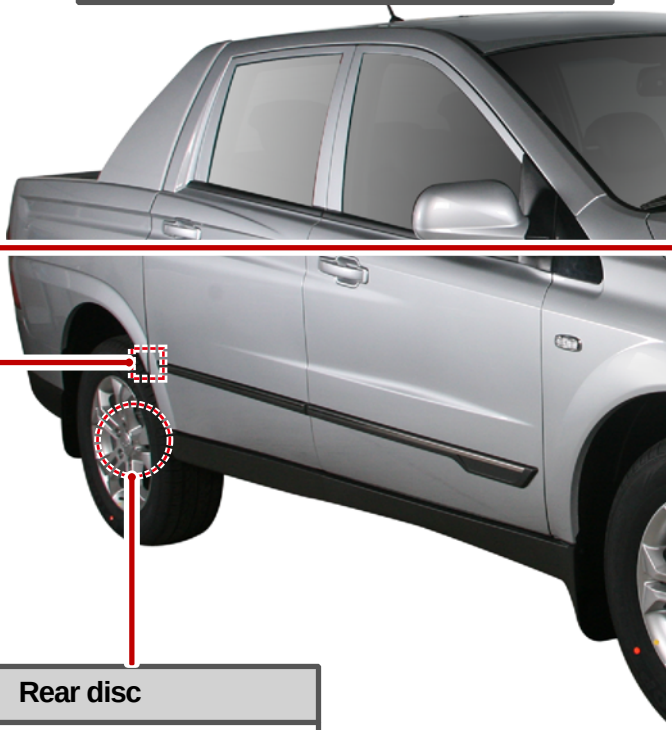




EBD warning lamp
(two indicators come on)

Rear wheel speed sensor (4WD)

Located at both ends of rear axle.



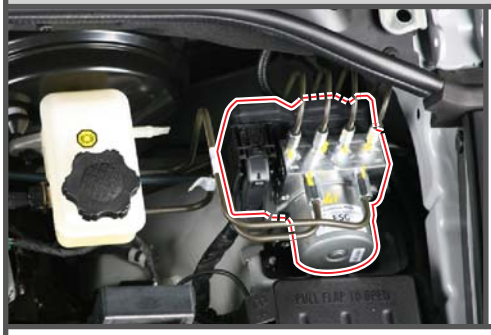
Rear caliper assembly (2WD/4WD)

Located on the knuckle.

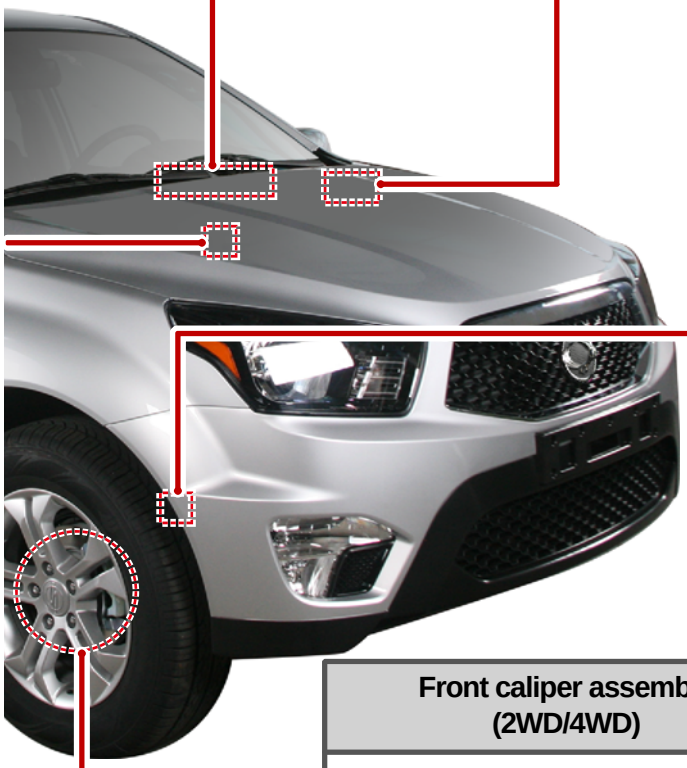
Rear disc

Modification basis	
Application basis	
Affected VIN	

ABS hydraulic device and control unit



Located near the brake booster in engine compartment.



Front wheel speed sensor (4WD)

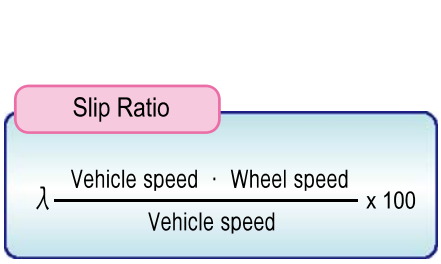
Located on the hub assembly.

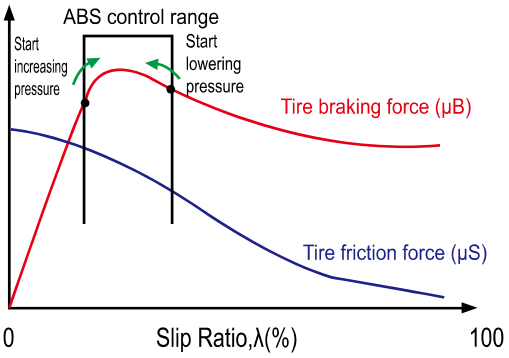
Front caliper assembly (2WD/4WD)

Located on the knuckle.

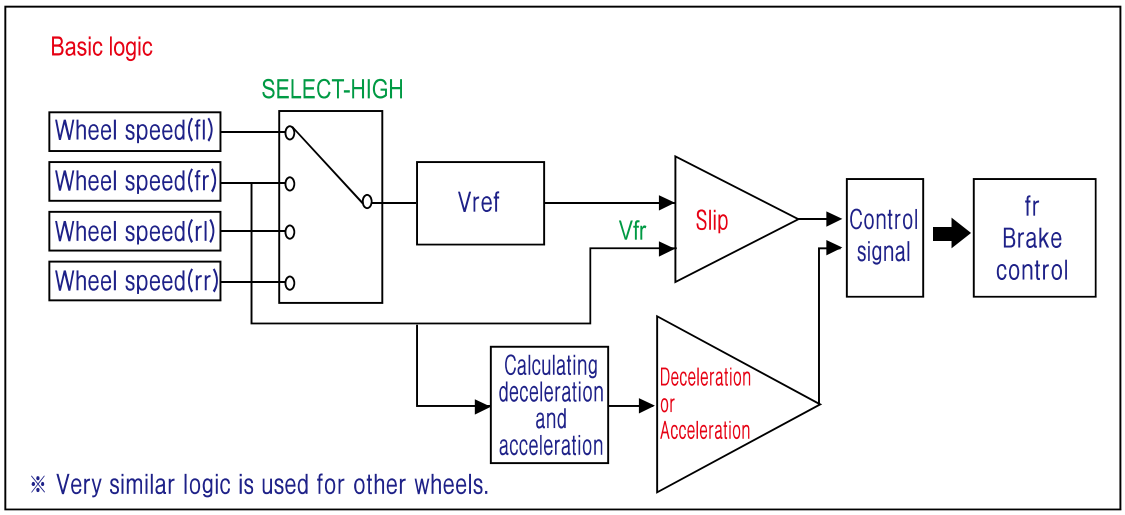
Front disc

3. ABS CONTROL LOGIC





λ=0% : Brake not in operation λ=100% : Wheel fully locked



The principal ABS control logic is the determination of the reference speed by choosing one wheel meeting a certain condition, while sensing the speed information from 4 wheel speed sensors when the vehicle is being driven.

For example, when the comparison of the reference speed with front right wheel speed shows a slip, the control signal is determined according to whether it's deceleration or acceleration. If the control conditions are met, the brake for the front right wheel will be got under control.

Modification basis	
Application basis	
Affected VIN	

4. WARNING LAMPS

(1) Brake warning lamp
(EBD warning lamp: two indicators come on simultaneously)

(2) ABS warning lamp

1) ABS Warning Lamp

ABS warning lamp module indicates the self diagnosis and malfunction.
ABS warning lamp ON:

A. When turning the ignition switch to ON position, ABS warning lamp comes on for 3 seconds for self diagnosis and goes off if the system is OK (initialization mode).
B. When the system is defective, the warning lamp comes on.
C. When disengaging the connector, the warning lamp comes on.
D. ABS is not available during lamp ON. In this condition, Only the conventional brake system without ABS function is available.
E. When the communication between warning lamp CAN modules in meter cluster is failed, the warning lamp comes on.

2) EBD (Electronic Brake-force Distribution) Warning Lamp

EBD warning lamps (brake warning lamp and ABS warning lamp) come on when the system performs the self diagnosis and when it detects the malfunction of EBD system. However, the brake warning lamp comes on regardless of EBD system when the parking brake is applied.
EBD warning lamp ON:

A. When turning the ignition switch to ON position, ABS warning lamp and the brake warning lamp comes on for 3 seconds for self diagnosis and goes off if the system is OK (initialization mode). When applying the parking brake, the brake warning lamp comes on.
B. When the brake fluid is not sufficient, the brake warning lamp comes on.
C. When disengaging the connector, the warning lamp comes on.
D. When the system is defective, ABS warning lamp and the brake warning lamp come on
E. simultaneously.

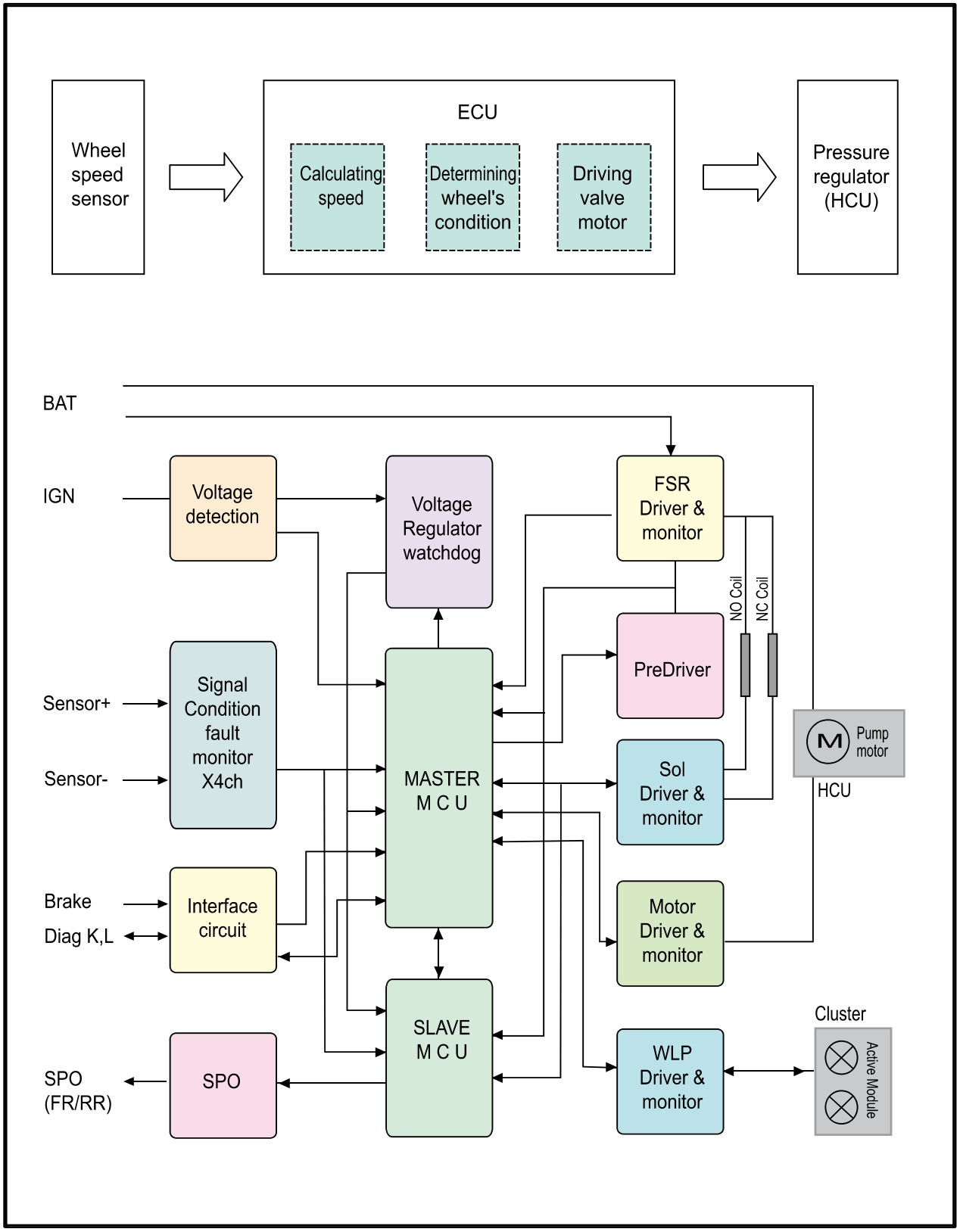
a. When the solenoid valve is defective
b. When one or more wheel sensors are defective
c. When ABS HECU is defective
d. When the voltage is abnormal
e. When valve relay is defective

F. When the communication between warning lamp CAN modules in meter cluster is failed, the warning lamp comes on.

Modification basis	
Application basis	
Affected VIN	

5. SYSTEM OPERATION

1) Block Diagram of ABS HECU



Modification basis	
Application basis	
Affected VIN	

2) Basic Theory of ABS Function

To give you a better understanding of the tasks and functions of ABS, we will first look at the physics principles.

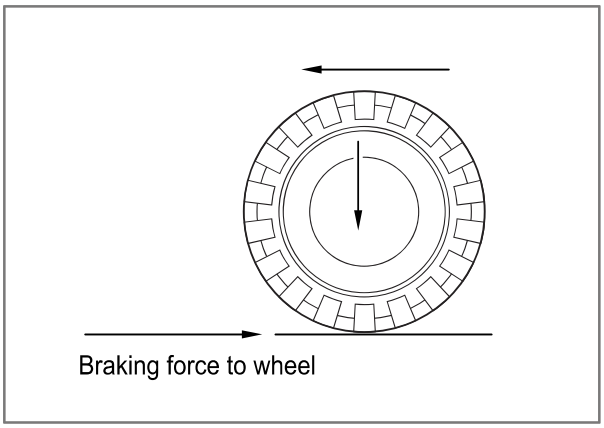
(1) Stopping distance

The stopping distance depends on the vehicle weight and initial speed when braking starts. This also applies for vehicle with ABS, where ABS always tries to set an optimum brake force on each wheel. As great forces are exerted between the tires and the carriageway when braking, even with ABS the wheels may scream and rubber is left on the road. With an ABS skid mark one may be able to clearly recognize the tire profile. The skid mark of an ABS vehicle does not however leave any hint of the speed of the vehicle in the case of an accident, as it can only be clearly drawn at the start of braking.

(2) Brake force on a wheel

The maximum possible brake force on a wheel depends on the wheel load and the adhesion coefficient between tire and carriageway. With a low adhesion coefficient the brake force, which can be obtained is very low. You are bound to know the result already from driving on winter roads. With a high adhesion coefficient on a dry road, the brake force, which can be obtained, is considerably higher. The brake force, which can be obtained, can be calculated from below formula:

▶ **Maximum brake force**



FBmax = wheel load FR x coefficient of frictionMh

The braking process cannot be described sufficiently accurately with the brake forces calculated. The values calculated only apply if the wheel is not locked. In the case of a locking wheel, the static friction turns into lower sliding friction, with the result that the stopping distance is increased. This loss of friction is termed "slip" in specialist literature.

Modification basis	
Application basis	
Affected VIN	

▶ Slip

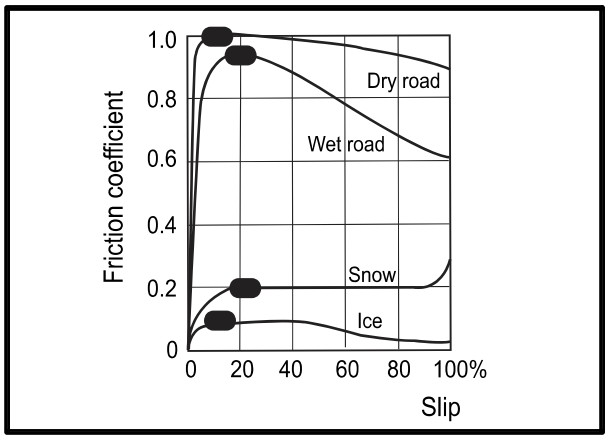
The brake slip is the difference between the vehicle speed and the wheel circumference speed. If the wheel locks, the slip is greatest, that is 100 %. If the wheel is running freely and un-braked, the slip is the lowest, equal to 0 %. Slip can be calculated from the vehicle speed Vveh and the wheel speed Vw. The equation for this is:

Ex) Vveh = 100 km/h, Vw = 70 km/h

$$\text{Slip ratio (S)} = \frac{\text{Vveh - Vw}}{\text{Vveh}} \text{ X } 100\%$$

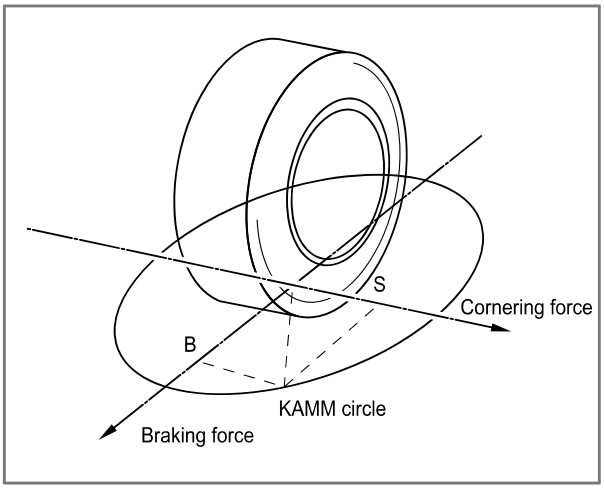
S = 30%

▶ Typical Slip Curves



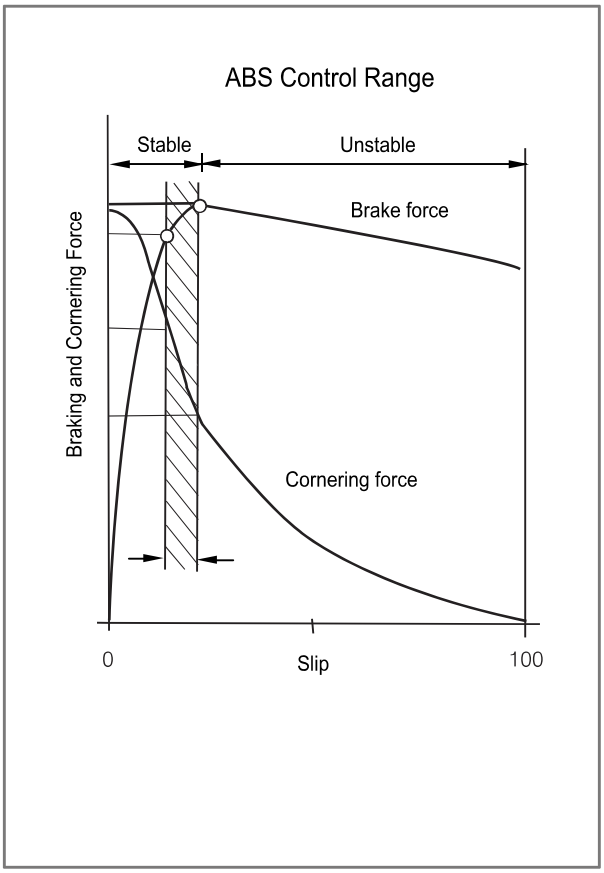
For the various road conditions, the friction coefficients were plotted. The typical course of the curves is always the same. The only special feature is shown by the curve for freshly fallen snow, for this curve increases at 100 % slip. In a vehicle without ABS, the wheel locks on braking and therefore pushes a wedge before it. This wedge of loose surface or freshly fallen snow means and increased resistance and as a result the stopping distance is shorter. This reduction in stopping distance is not possible with a vehicle with ABS, as the wheel does not lock. On these surfaces the stopping distance with ABS is longer than without ABS. The reason for this is based in physics and not in the Anti-Lock System.
However, as mentioned before, ABS is not about the stopping distance, but maneuverability and driving stability, for the vehicle with locking wheels without ABS cannot be steered.

▶ KAMM circle



Before we go into the Kamm circle, you should know that a tire offers a maximum of 100 % transmissibility. It is all the same for the tire whether we require 100 % in the direction of braking or in the direction of the acting lateral force, e.g. when driving round curves. If we drive into a curve too fast and the tire requires 100 % transmissibility as cornering force, the tire cannot transmit any additional brake force. In spite of the ABS the car is carried out of the curve. The relationship between brake force B and cornering force S is shown very clearly in the Kamm circle. If we put a vehicle wheel in this circle, the relationship becomes even clearer. In this relationship: as long as the acting forces and the resulting force remain within the circle, the vehicle is stable to drive. If a force exceeds the circle, the vehicle leaves the road.

▶ Brake and cornering force

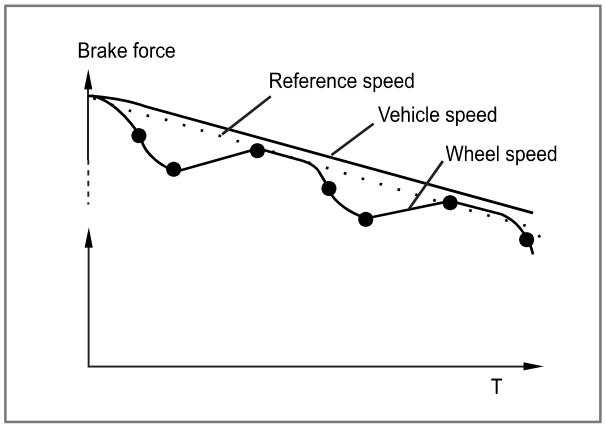


- Brake force
  When depressing the brake pedal the brake force increases to the maximum, then the brake force decreases until the wheel locks.
  Cornering force
- The cornering force is a maximum when the wheel is turning freely with zero slip. When braking the cornering force falls to zero if the wheel locks (slip 100 %).
  ABS operating range
- The operating range starts just before the maximum brake force and ends in maximum, for the unstable range then begins, in which no further modulation is possible. The ABS controls the regulation of the brake pressure so that the brake force only becomes great enough for a sufficient proportion of cornering force to remain. With ABS we remain in the Kamm circle as long as the car is driving sensibly. We will leave driving physics with these statements and turn to the braking systems with and without ABS.

Modification basis	
Application basis	
Affected VIN	

3) Basic ABS Control

▶ Operation of ABS control unit



Applications of the ABS control unit The signals produced by the wheel sensors are evaluated in the electronic control unit. From the information received, the control unit must first compute the following variables:

- Wheel speed
- Reference speed
- Deceleration
- Slip

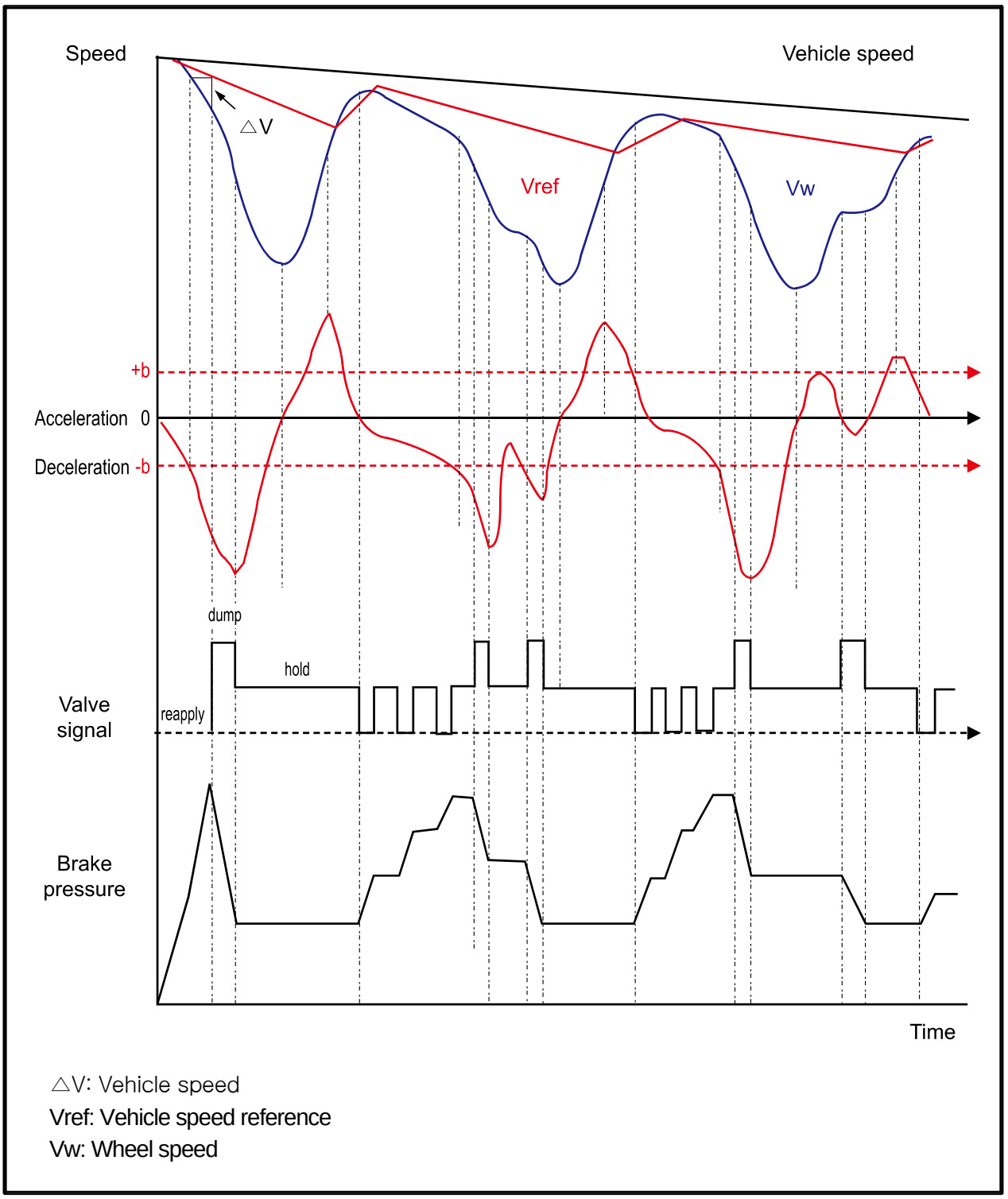
▶ Reference speed

The reference speed is the mean, I.e. average speed of all wheel speeds determined by simple approximation.

▶ Simplified ABS control

If, during braking, one wheel speed deviates from the reference speed, the ABS control unit attempts to correct that wheel speed by modulating the brake pressure until it again matches the reference speed. When all four wheels tend to lock, all four wheels speeds suddenly deviate from the previously determined reference speed. In that case, the control cycle is initiated again in order to again correct the wheel speed by modulating the brake pressure.

4) ABS Control Pattern



The ABS control is performed by comparing the reference speed with each wheel speed. Firstly, it is determined whether the vehicle is in the deceleration or acceleration state using the wheel speed change ratio. Then, a signal is transmitted to the valve.
Finally, the brake pressure is adjusted via the signal.

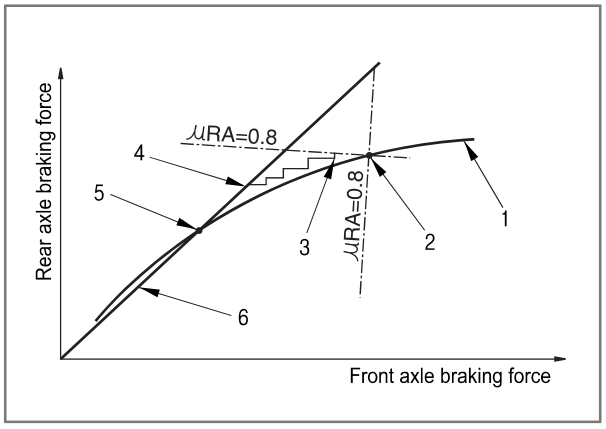
Modification basis	
Application basis	
Affected VIN	

5) EBD (Electronic Brake Force Distribution) System

▶ System description

As an add-on logic to the ABS base algorithm, EBD works in a range in which the intervention thresholds for ABS control are not reached yet.
EBD ensures that the rear wheels are sensitively monitored for slip with respect to the front axle. If slip is detected, the inlet valves for the rear wheels are switched to pressure hold to prevent a further increase in pressure at the rear-wheel breaks, thus electronically reproducing
a pressure-reduction function at the rear-wheel brakes.
ABS features an enhanced algorithm which includes control of the brake force distribution between the front and rear axles. This is called Electronic Brake Distribution. In an unloading car condition the brake efficiency is comparable to the conventional system but for a fully loaded vehicle the efficiency of the EBD system is higher due to the better use of rear axle braking capability.

▶ Advantages



1. Ideal distribution
2. EBD start point
3. Cut-in point
4. Fixed distribution

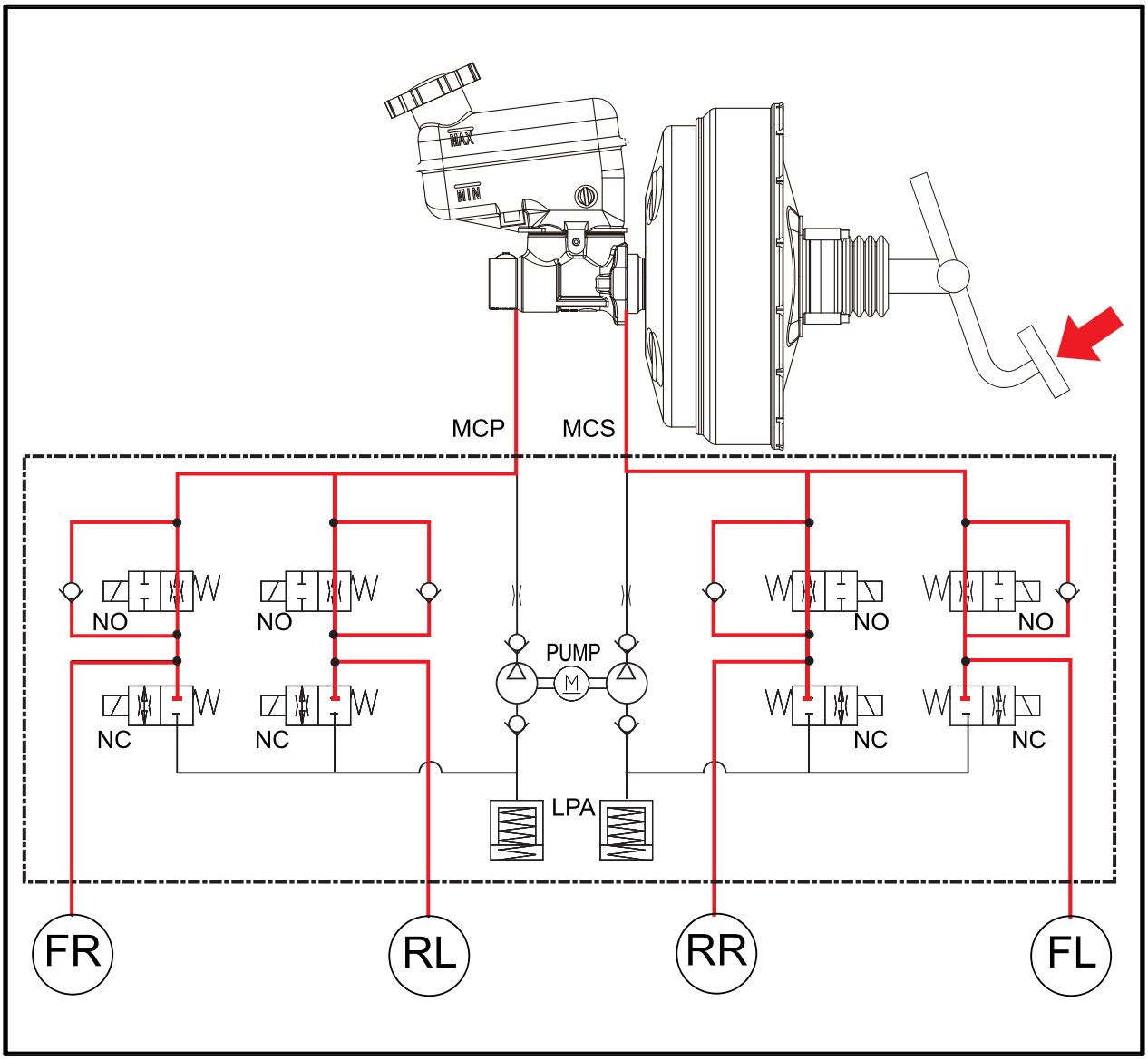
- Elimination of conventional proportioning valve
- EBD utilizes the existing rear axle wheel speed sensor to monitor rear wheel slip.
  Based on many variables in algorithm a
- pressure hold, increase and/or decrease pulsetrain may be triggered at the rear wheels insuring vehicle stability.
- Vehicle approaches the ideal brake force distribution (front to rear).
- Constant brake force distribution during vehicle lifetime.
  EBD function is monitored via ABS safety logic (conventional proportioning valves are not monitorable).

6. HYDRAULIC CIRCUIT OF ABS

1) Normal Brake Operation (ABS is not working) Mode

If the driver depress the brake pedal so that the ABS does not operate, the hydraulic pressure in the master cylinder increases through the vacuum booster and it is delivered to the wheel via the normal open inlet valve. At this moment, the normally-closed outlet valve is closed The speed of the wheel that hydraulic pressure is delivered reduces gradually.

Solenoid valve	Valve Open/Close	Pump motor
Inlet valve - Normal open (NO) valve	Open	OFF
Outlet valve - Normal close (NC) valve	Close	

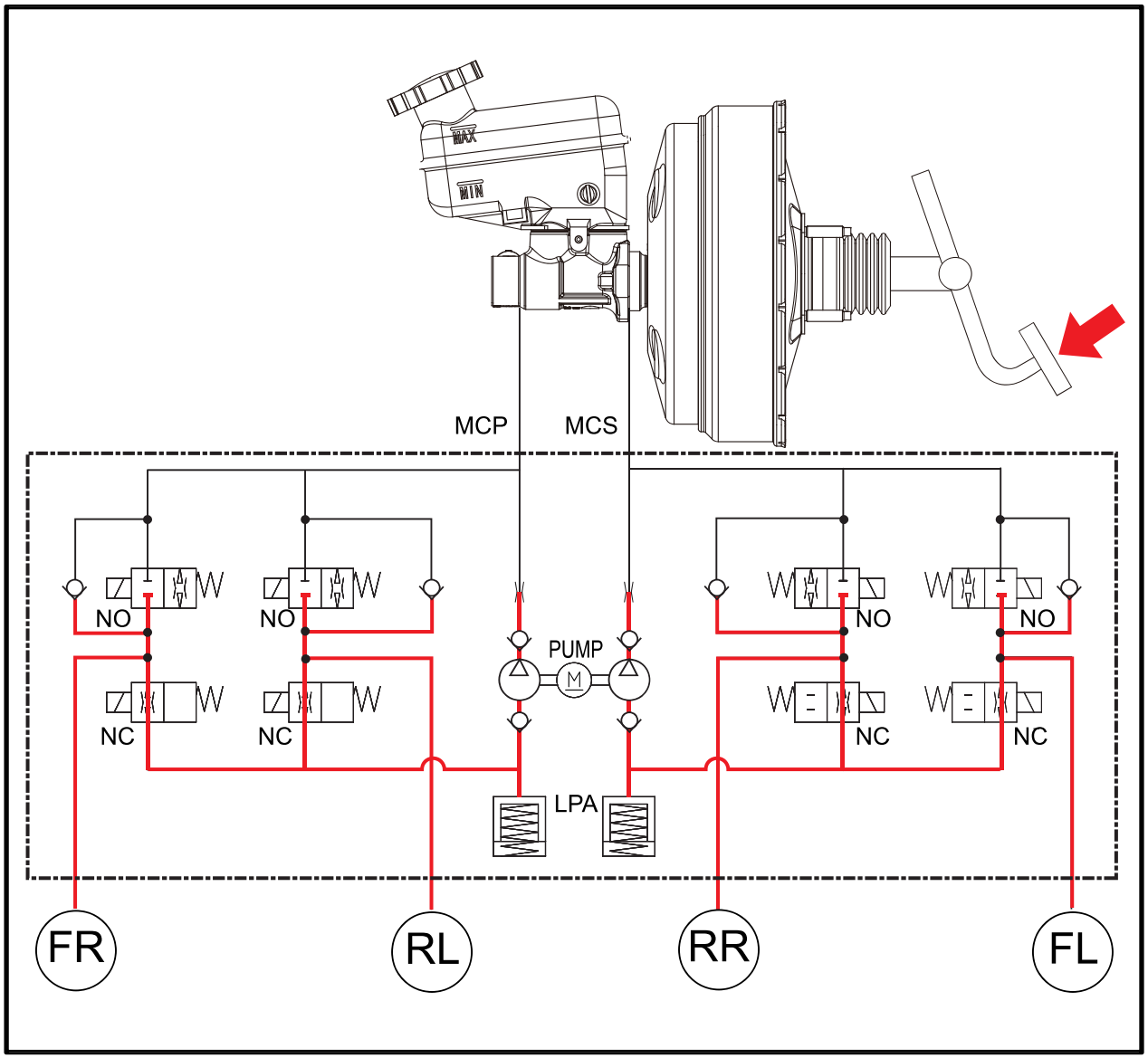


Modification basis	
Application basis	
Affected VIN	

2) DUMP (ABS is working) Mode

Even when the hydraulic pressure on each circuit is constant, the wheel can be locked as the wheel speed decreases. This is when the ABS HECU detects the wheel speed and the vehicle speed and gives the optimized braking without locking the wheels. In order to prevent the hydraulic pressure from increasing, the inlet valve will be closed, the outlet valve will be opened and the oil will flow into the low pressure chamber. In addition, the ABS HECU operates the pump to circulate the oil in the low pressure chamber to the master cylinder. This may make the driver to feel the brake pedal vibration and some

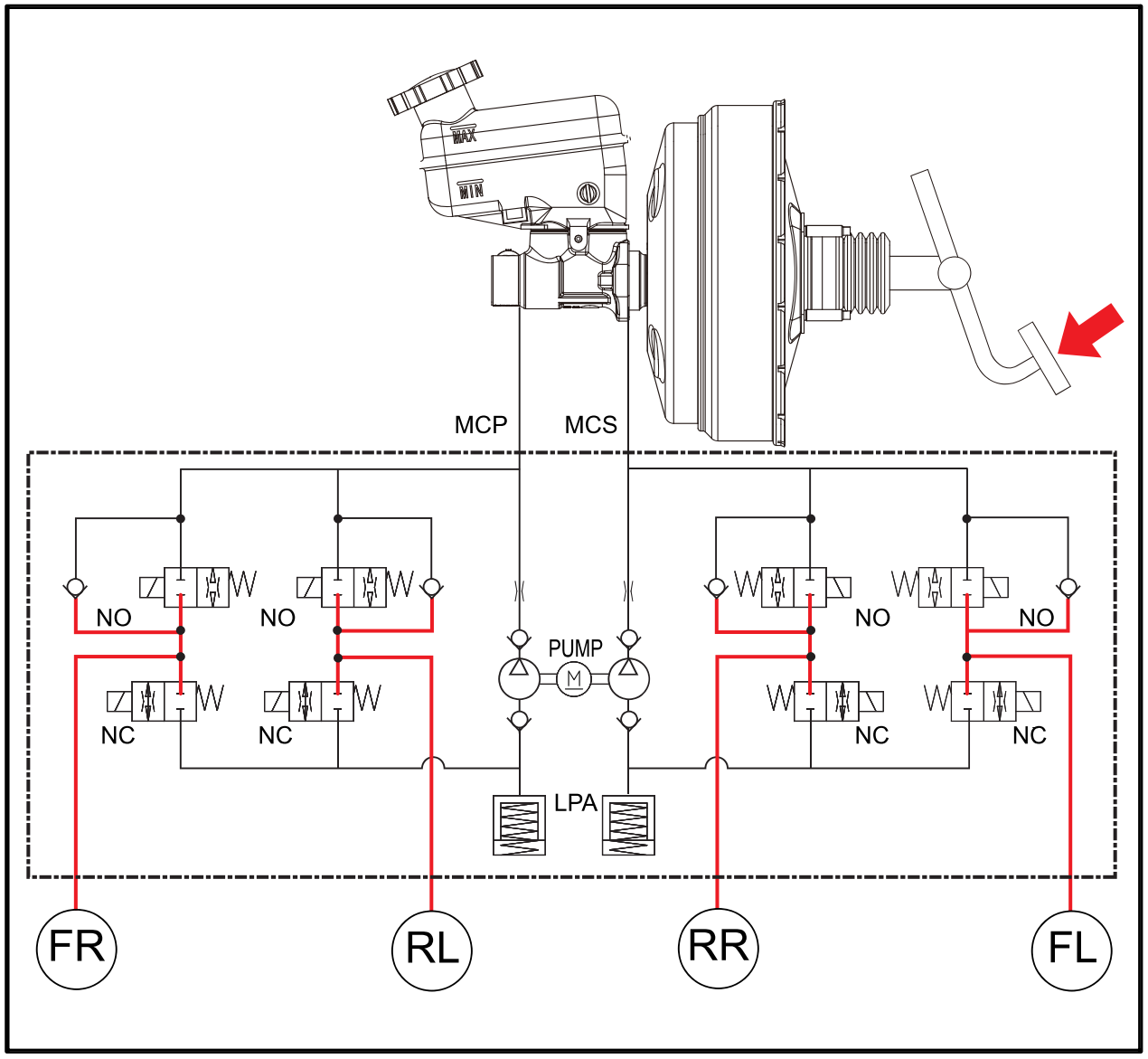
Solenoid valve	Valve Open/Close	Pump motor
Inlet valve - Normal open (NO) valve	Close	ON
Outlet valve - Normal close (NC) valve	Open	



3) HOLD (ABS is working) Mode

As hydraulic pressure on each wheel increases, the wheel tends to lock. In order to prevent the wheel from locking, the hydraulic valve modulator operates the inlet valve control solenoid to stop increasing the hydraulic pressure by closing the inlet valve. At this moment, the outlet valve is closed. This procedure helps the wheel to maintain a constant hydraulic pressure.

Solenoid valve	Valve Open/Close	Pump motor
Inlet valve - Normal open (NO) valve	Close	OFF
Outlet valve - Normal close (NC) valve	Close	

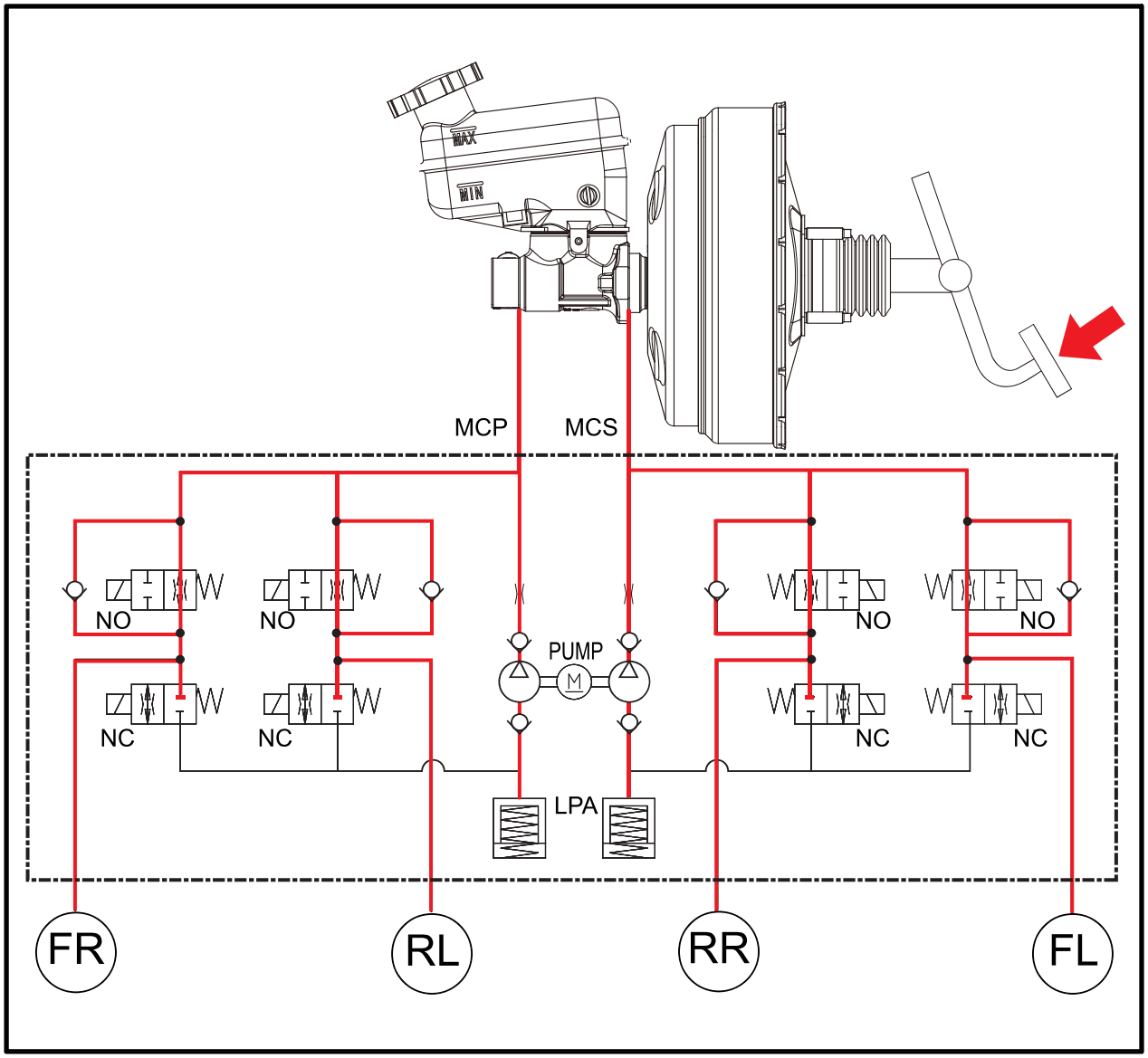


Modification basis	
Application basis	
Affected VIN	

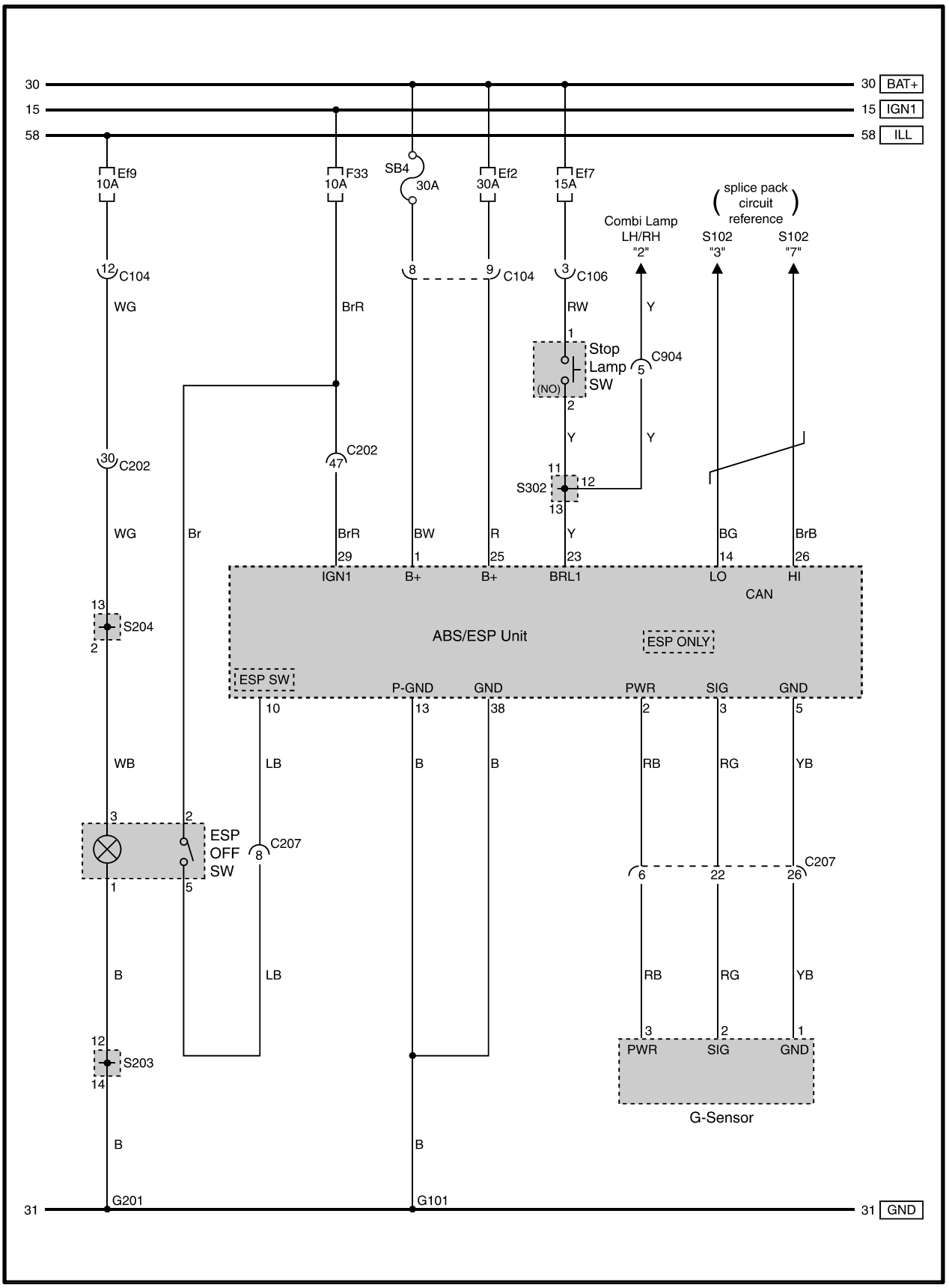
4) RISE (ABS is working) Mode

As the wheel speed increases, the inlet valve opens and the wheel's pressure increases due to the master cylinder pressure. In addition, the pump circulates the oil in the low pressure chamber to the wheel. As the hydraulic pressure to the wheel increases, the wheel speed will reduce. This operation continues repetitively until there are no signs that the ABS HECU tends to lock the wheels. Since the ABS hydraulic pressure control process takes place repeatedly for a short time, there may be some vibration and noises at the brake pedal.

Solenoid valve	Valve Open/Close	Pump motor
Inlet valve - Normal open (NO) valve	Open	ON
Outlet valve - Normal close (NC) valve	Close	



7. CIRCUIT DIAGRAM



Modification basis	
Application basis	
Affected VIN	

ESP

4890-10

GENERAL INFORMATION

1. SPECIFICATION

Unit	Description		Specification
	ABS	ESP	
HECU	Clock frequency: 32 MHz	Clock frequency: 50 MHz	
	Memory: 128 KB	Memory: 256 KB	
Wheel speed sensor	Active type	Active type	Output: 7~14 mA
Steering wheel angle sensor	None	Max. detection angle speed: 1500 °/Sec	Pulse duty: 50±10%
		Operating voltage: 9 to 12 V	
Sensor cluster	None	Yaw rate sensor + lateral G sensor + longitudinal G sensor (4WD)	Mounting direction should be kept (CAN communcation)
Longitudinal G sensor	4WD only	None	
Pressure sensor	None	HECU integrated	

1) Specification of Active Wheel Sensor

Description	Specification	Remark
Supplying voltage	4.5 ~ 16.0V	
Output current (at 2.75 km/h of vehicle speed)	7mA(Lo) ~ 14mA(Hi)	
Tightening torque	Front: 7.8 to 11.8 Nm	
	Rear: 7.8 to 11.8 Nm	
Operating temperature	−40 ~ 150℃	
Operating frequency	1 ~ 2,500Hz	

2) Specification of Steering Wheel Angle Sensor

Description	Specification
Operating voltage	9 to 16 V
Maximum output current	10 mA
Maximum detection angle speed	±100°/Sec
Operating temperature	−30 to 75 ℃
Supplying voltage	9 to 16 V (battery voltage)
Output voltage (HI)	approx. 3.50 V (3.0 to 4.1 V)
Output voltage (LO)	approx. 1.50 V (1.3 to 2.0 V)
Pulses/rev	45 pulses/rev

3) Specification of Sensor Cluster

Description	Specification	
Supplying voltage	approx. 12 V (8 to 16 V)	
Current consumption	below 250 mA	-
Operating range	Yaw rate sensor	± 75 °/Sec
	Lateral/longitudinal sensor	± 14.7m/Sec²

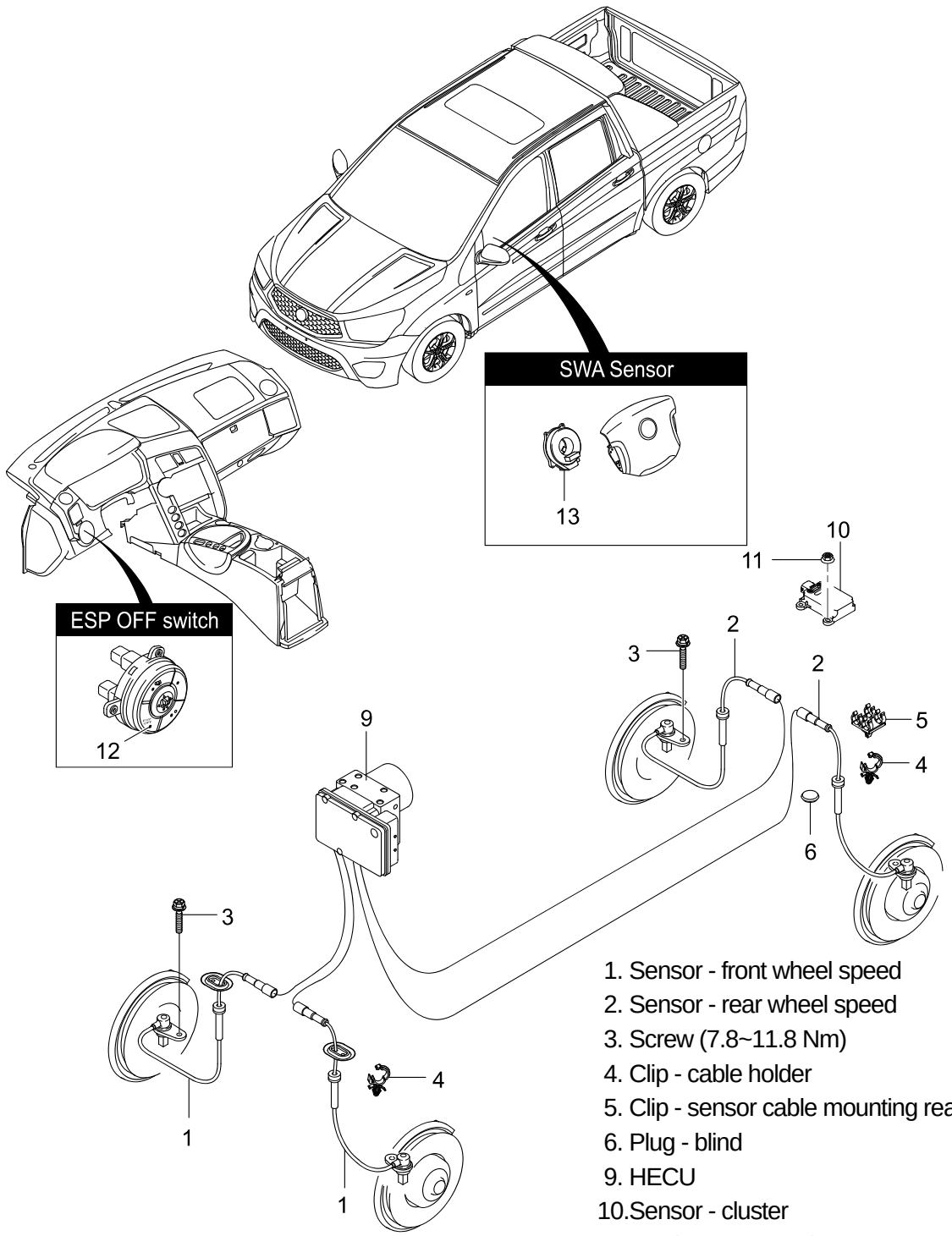
Modification basis	
Application basis	
Affected VIN	

2. MAJOR CHANGES

Steering wheel angle sensor	
Old 	New 
– Steering wheel angle sensor's appearance and wiring route changed	

3. SYSTEM LAYOUT

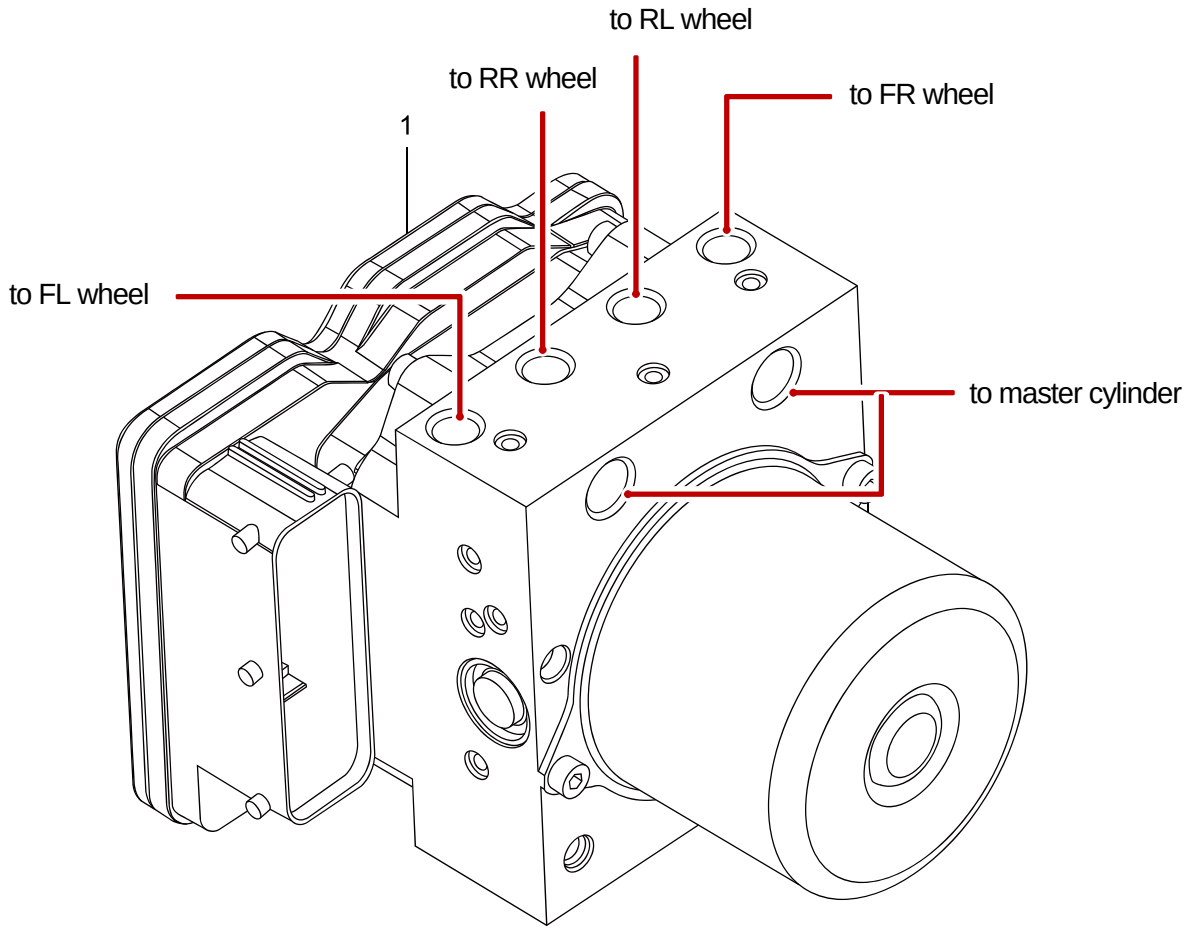
▶ **ESP System**



1. Sensor - front wheel speed
2. Sensor - rear wheel speed
3. Screw (7.8~11.8 Nm)
4. Clip - cable holder
5. Clip - sensor cable mounting rear
6. Plug - blind
9. HECU
10. Sensor - cluster
11. Nut (9.8~10.8 Nm)
12. ESP OFF switch
13. Steering wheel sensor

Modification basis	
Application basis	
Affected VIN	

▶ HECU (Hydraulic & Electronic Control Unit)

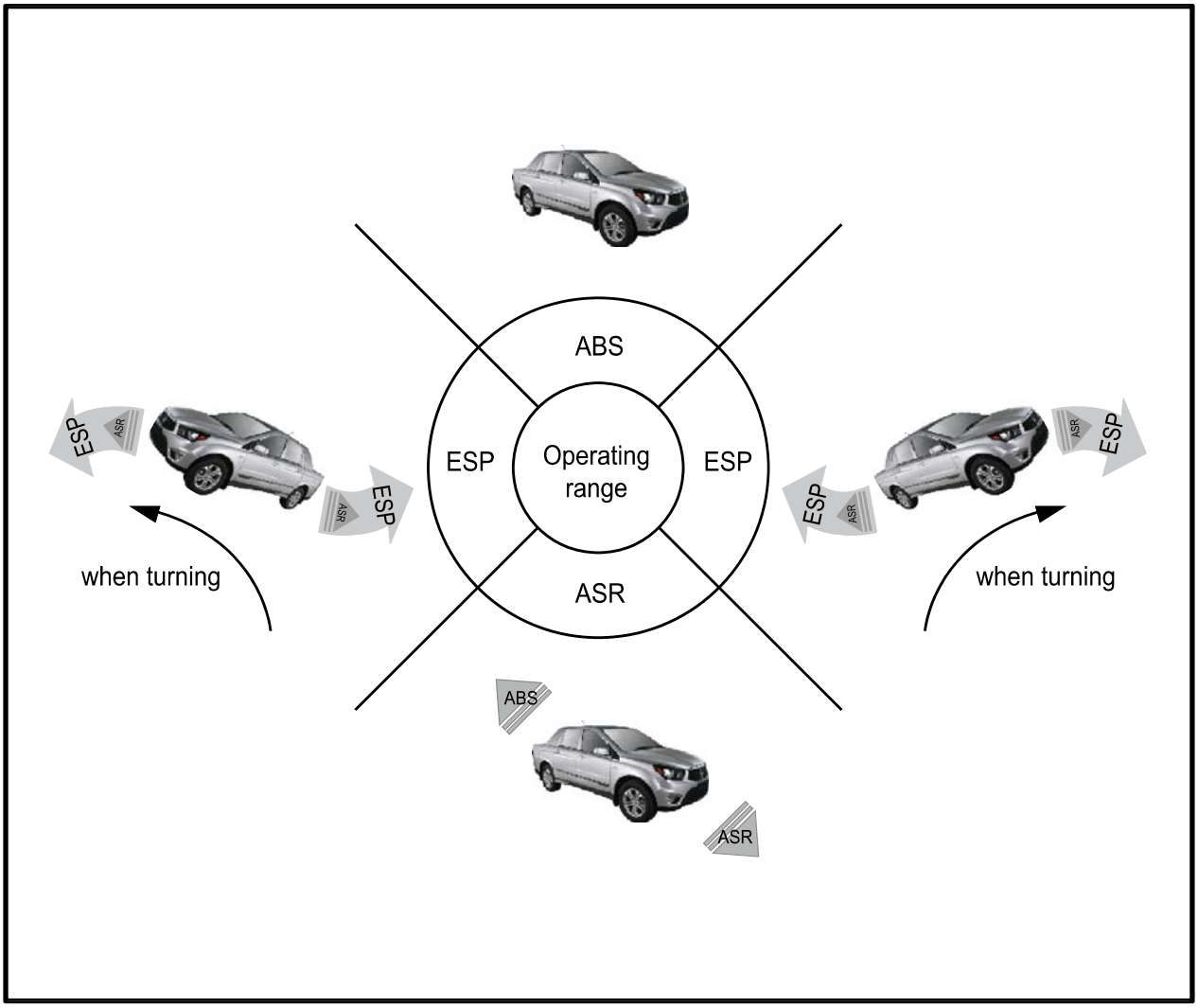


1. Hydraulic & Electronic Control Unit (HECU)

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

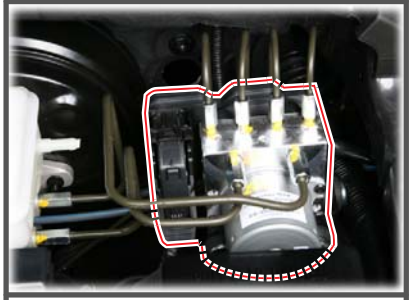
The ESP (Electronic Stability Program) has been developed to help a driver avoid danger of losing control of the vehicle stability due to understeer or oversteer during cornering. The yaw rate sensor, lateral sensor and longitudinal sensor in the sensor cluster and the steering wheel angle sensor under the steering column detect the vehicle conditions when the inner or outer wheels are spinning during oversteer, understeer or cornering. The ESP ECU controls against oversteer or understeer during cornering by controlling the vehicle stability using input values from these sensors and applying the braking force to the corresponding wheels independently. The system also controls the engine power right before the wheel spin synchronized to decelerate the vehicle automatically in order to maintain the vehicle stable during cornering.



Modification basis	
Application basis	
Affected VIN	

2. COMPONENTS

HECU assembly



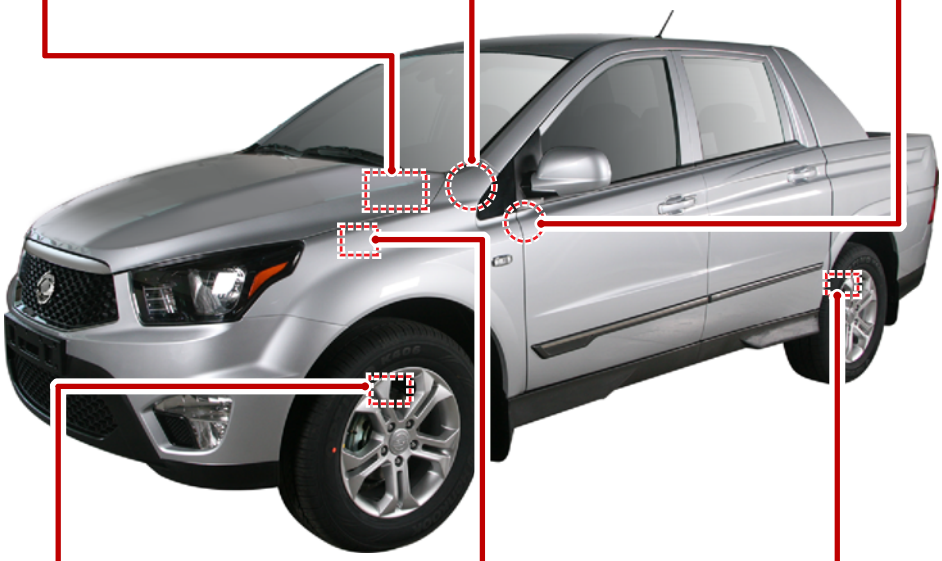
Located near the brake booster in engine compartment and contains the pressure sensor.

Steering wheel angle sensor

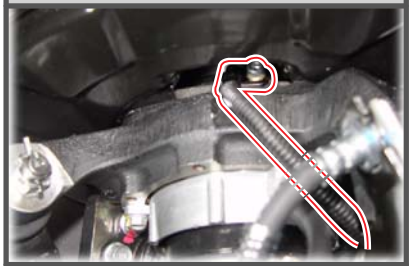
Located on column shaft with contact coil.

ESP OFF switch

Located on the left side of instrument panel.



Front wheel speed sensor

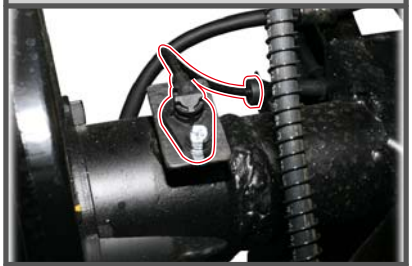


Located on the hub assembly.

Sensor cluster

Located at the bottom of center fascia panel.

Rear wheel speed sensor



Located on the both ends of rear axle.

Modification basis	
Application basis	
Affected VIN	

3. FUNCTION

1) Term Definition

▶ ABS: Anti-Lock Brake System

When the brake pedal is abruptly depressed, the HECU calculates the slip ratio of each wheel based on information received from the wheel speed sensors and controls the hydraulic module data quickly and precisely in order to maintain the friction between the road surface and tire optimal (static friction). Therefore, by keeping the friction between the road surface and tire optimal, it is possible to obtain following effects: Enhanced steering stability, improved direction stability, reduced stopping distance and etc.

▶ EBD: Electronic brake-Force Distribution

This is to detect the tire speed from the wheel speed sensor in order to supply the braking pressure to the rear tires individually. In other words, the HECU measures the tire deceleration speed continuously and controls the rear inlet valve on the hydraulic modulator to obtain optimal braking force as much as possible. Thereby, stopping distance, braking effect and straight stability are improved.

▶ ESP: Electronic Stability Program

This is used to make the vehicle stabilized to recognize the emergency driving conditions, and to control the brake for each wheels and the engine power when the brake system or acceleration will not work any more in dangerous circumstances.

▶ TCS: Traction Control System

When the wheel is slipping due to an excessive engine torque while starting off or driving, this controls the driving force (braking force + engine torque) in order to prevent the wheel from slipping through the engine or brake control.

▶ AYC: Active Yaw Control

This has been developed to help a driver avoid danger of losing control of the vehicle stability due to understeer or oversteer during cornering, which is a part of the ESP function.

▶ HBA: Hydraulic Brake Assistant

Developed based on the fact that elderly drivers depress the brake pedal too soft even when hard braking is necessary, this an assist system to operate the HECU drive motor immediately and apply high braking force to the wheels when the brake pedal is depressed softly and the vehicle should be braked in emergency.

▶ ARP: Active Rollover Protection

This is a supplementary device for safety in ESP system and can help minimize the rollover accidents by detecting a potential rollover situation through the brake and engine control when making sudden lane change or turning sharply by adding only the software, without any separate device or switch.

Modification basis	
Application basis	
Affected VIN	

2) Component Overview By System

Function	Vehicle with ABS	Vehicle with ESP
ABS	Yes	Yes
EBD	Yes	
HBA	No	
ARP		

3) Part Overview By System

Part	Vehicle with ABS	Vehicle with ESP
HECU	Yes	Yes
Front wheel speed sensor		
Rear wheel speed sensor		
ABS warning lamp		
EBD indicator lamp		
G sensor (integrated in HECU)	4WD: Yes, 2WD: No	No
Sensor cluster (Yaw rate sensor + lateral sensor+ G sensor)	No	Yes
ESP operation indicator lamp and warning lamp		
ESP OFF switch and indicator		
Steering wheel angle sensor		

4. PRECAUTIONS

CAUTION

The warning lamp flashes and warning beep sounds when the ESP is operating

When the ESP operates during vehicle movement, the ESP warning lamp on the instrument panel flashes and beep comes on every 0.1 second. The ESP system is only a supplementary device for comfortable driving. When the vehicle exceeds its physical limits, it cannot be controlled.
Do not rely on the system. Keep on the safe driving.

Feeling when ESP is working

When the ESP system activates, the feeling can be different depending on vehicle driving conditions.
For example, you will feel differently when the ESP system is activated during the ABS is operating with the brakes applied and when the brakes are not applied on a curve.
If the ESP system operates when the brake is applied, the brake pressure will be increased on the corresponding wheel which already has braking pressure for the ESP controls.

ARP Operation

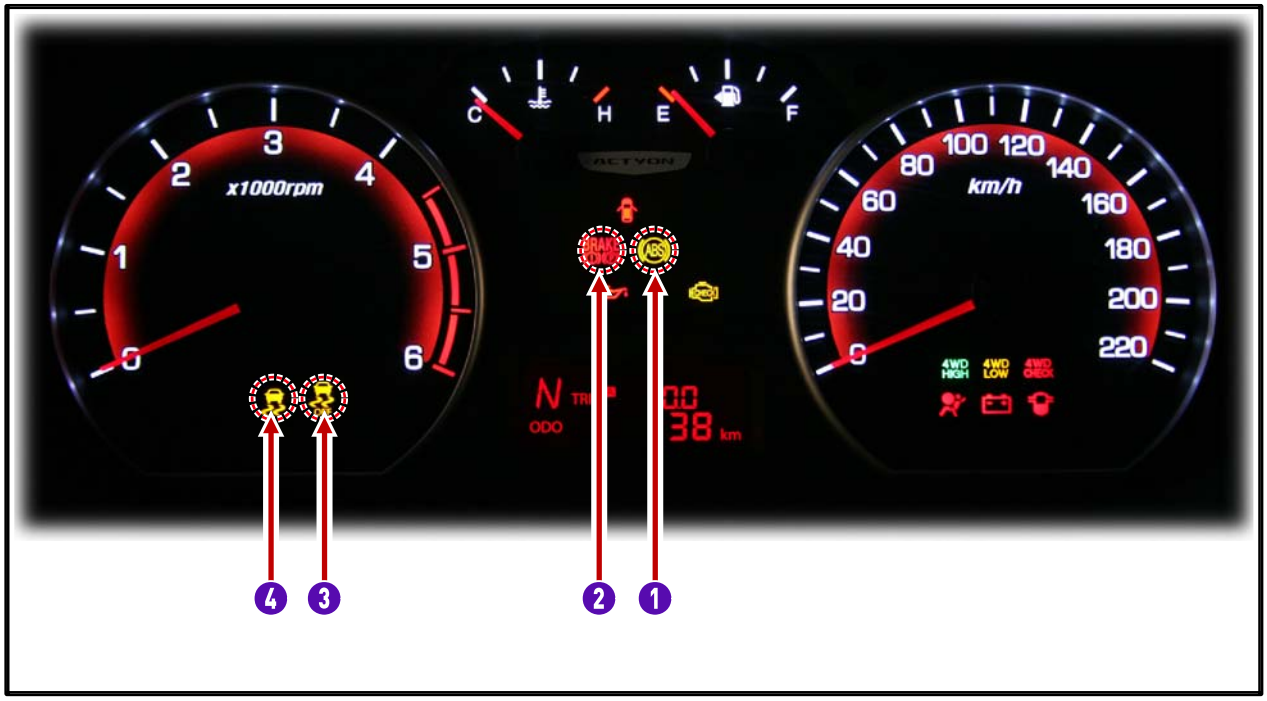
During the ARP operation, vehicle safety (rollover prevention) takes the first priority and thus, stronger engine control is in effect. Consequently, the vehicle speed decreases rapidly, so the driver must take caution for the vehicle may drift away from the lane.

Noise and vibration that driver feels when ESP system is operating

The ESP system may transfer noise and vibration to the driver due to the pressure changes caused by the motor and valve operations in a very short period of time. And, keep in mind that the output and vehicle speed could be decreased without rpm increase due to the ASR function that controls the engine power.

Modification basis	
Application basis	
Affected VIN	

5. WARNING LAMPS



1. ABS warning lamp
2. Brake warning lamp
3. ESP OFF indicator
4. ESP warning lamp/indicator
5. EBD warning lamp

1) ABS Warning Lamp

ABS warning lamp module indicates the self diagnosis and malfunction.
ABS warning lamp ON:

1. When turning the ignition switch to ON position, ABS warning lamp comes on for 3 seconds for self diagnosis and goes off if the system is OK (initialization mode).
2. When the system is defective, the warning lamp comes on.
3. When disengaging the connector, the warning lamp comes on.
4. ABS is not available during lamp ON. In this condition, Only normal brake system without ABS function is available.
5. When the communication between warning lamp CAN module in meter cluster, the warning lamp comes on.

2) EBD (Electronic Brake-force Distribution) Warning Lamp (Brake Warning Lamp)

EBD warning lamp when the system perform the self diagnosis and when it detects the malfunction of EBD system. However, the brake warning lamp comes on regardless of EBD when the parking brake is applied.

EBD warning lamp ON:

1. When turning the ignition switch to ON position, ABS warning lamp and the brake warning lamp comes on for 3 seconds for self diagnosis and goes off if the system is OK (initialization mode). When applying the parking brake, the brake warning lamp comes on.
2. When the brake fluid is not sufficient, the brake warning lamp comes on.
3. When disengaging the connector, the warning lamp comes on.
4. When the system is defective, ABS warning lamp and the brake warning lamp come on
5. simultaneously.

    a. When the solenoid valve is defective
    b. When one or more wheel sensors are defective
    c. When ABS HECU is defective
    d. When the voltage is abnormal
    e. When valve relay is defective

6. When the communication between warning lamp CAN module in meter cluster, the warning lamp comes on.

3) ESP OFF Indicator

ESP OFF indicator ON:

1. When turning the ignition switch to ON position, ESP warning lamp comes on for 3 seconds for self diagnosis and goes off if the system is OK (initialization mode).
2. When the ESP OFF switch is pressed to turn off ESP function, ESP OFF indicator comes on.

4) ESP Warning Lamp

1. ESP warning lamp ON:
2. When turning the ignition switch to ON position, ESP warning lamp comes on for 3 seconds for self diagnosis and goes off if the system is OK (initialization mode).
3. When the system is defective, the warning lamp comes on.
4. When the ESP function is activated, ESP warning lamp blinks with the interval of 2 Hz.
5. When the communication between warning lamp CAN module in meter cluster, the warning lamp comes on.

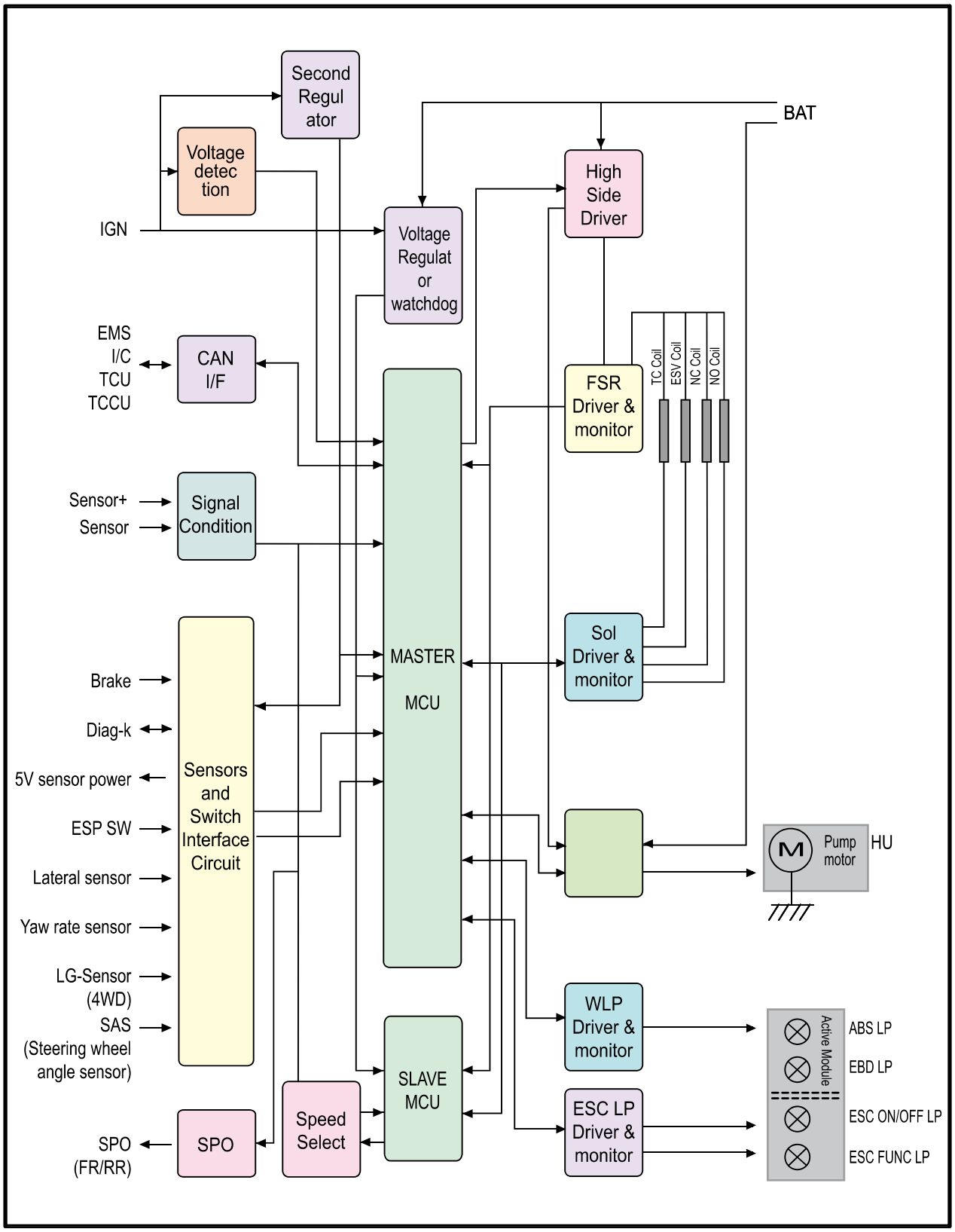
5) ESP OFF Switch

If ESP OFF switch is pressed, ESP function is deactivated and the ESP OFF indicator in the instrument cluster comes on.

To resume the ESP function, press the switch again. At this time, ESP OFF indicator goes out.

6. SYSTEM DESCRIPTION

1) Block Diagram of ESP HECU

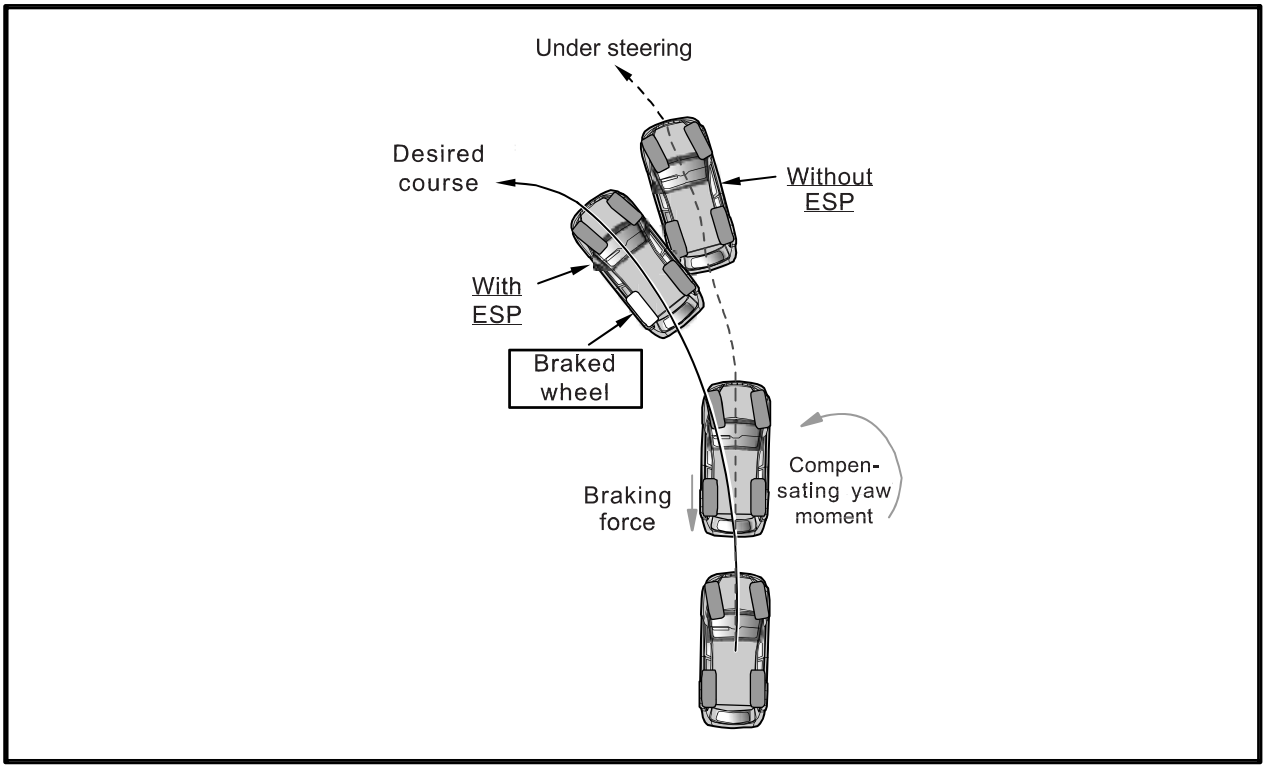


Modification basis	
Application basis	
Affected VIN	

2) Operation of ESP System

The ESP (Electronic Stability Program) has been developed to help a driver avoid danger of losing control of the vehicle stability due to understeer or oversteer during cornering. The yaw rate sensor, lateral sensor and longitudinal sensor in the sensor cluster and the steering wheel angle sensor under the steering column detect the vehicle conditions when the inner or outer wheels are spinning during oversteer, understeer or cornering. The ESP ECU controls against oversteer or understeer during cornering by controlling the vehicle stability using input values from these sensors and applying the braking force to the corresponding wheels independently. The system also controls the engine power right before the wheel spin synchronized with the ASR function to decelerate the vehicle automatically in order to maintain the vehicle stable during cornering.

(1) Under steering



▶ **What is understeering?**

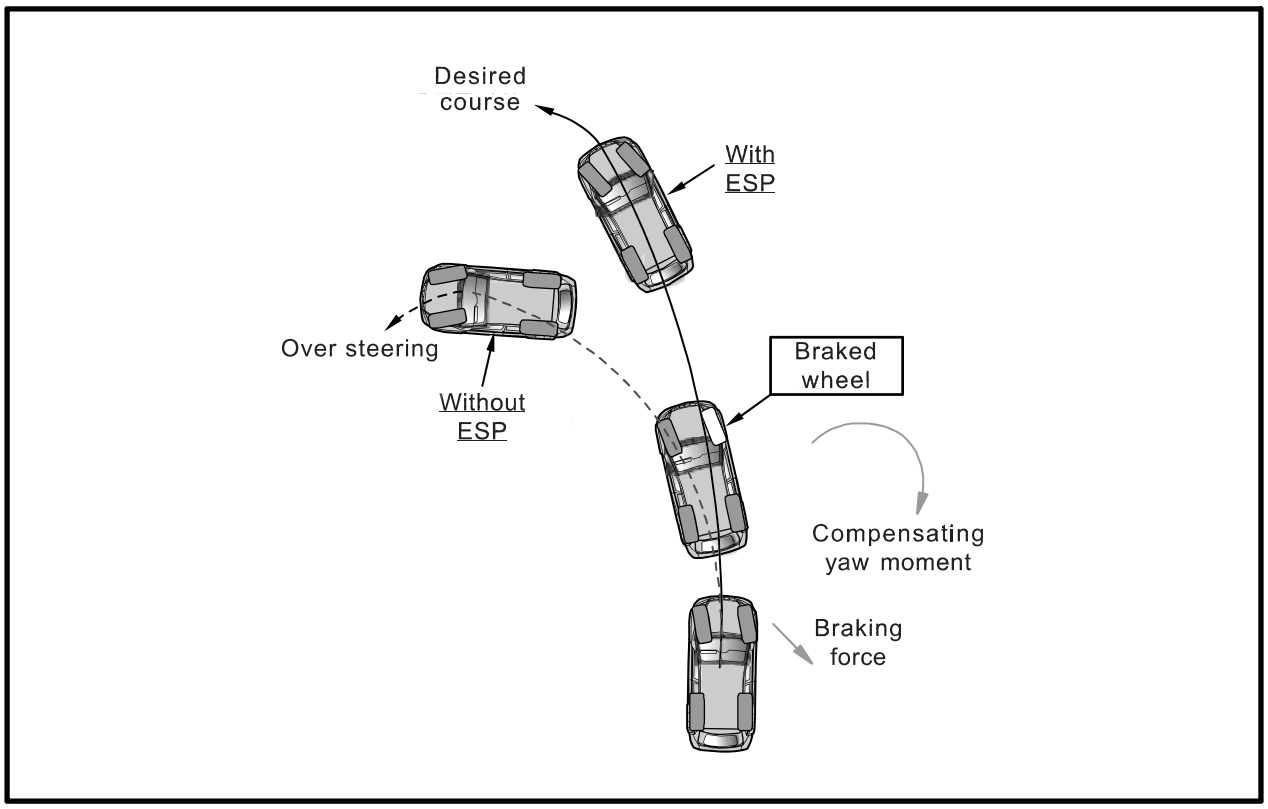
Understeer is a term for a condition in which the steering wheel is steered to a certain angle during driving and the front tires slip toward the reverse direction of the desired direction. Generally, vehicles are designed to have understeer. It is because that the vehicle can return back to inside of cornering line when the steering wheel is steered toward the inside even when the front wheels are slipped outward. As the centrifugal force increases, the tires can easily lose the traction and the vehicle tends to slip outward when the curve angle gets bigger and the speed increases.

Modification basis	
Application basis	
Affected VIN	

▶ ESP controls during understeer

The ESP system recognizes the directional angle with the steering wheel angle sensor and senses the slipping route that occurs reversely against the vehicle cornering direction during understeer with the yaw rate sensor and lateral sensor. Then, the ESP system applies the braking force to the rear inner wheel to compensate the yaw moment value. In this way, the vehicle does not lose its driving direction and the driver can steer the vehicle as intended.

(2) Over steering



▶ What is oversteering?

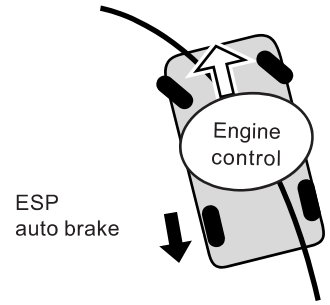
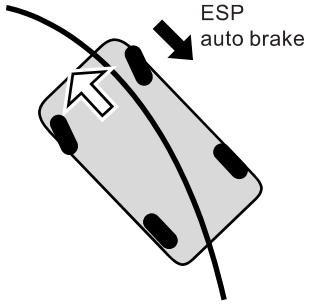
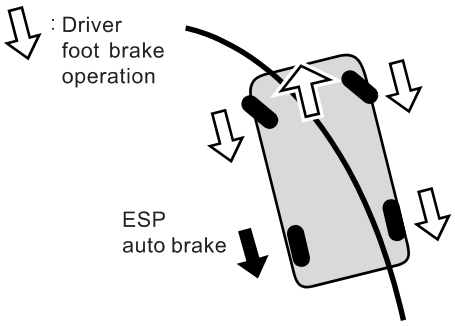
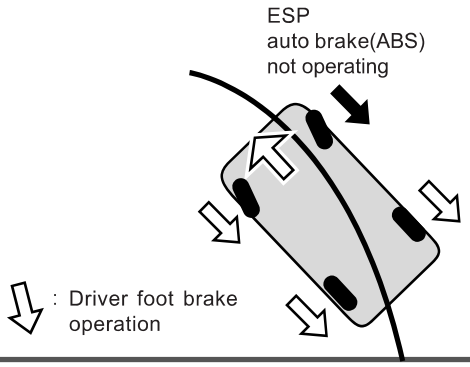
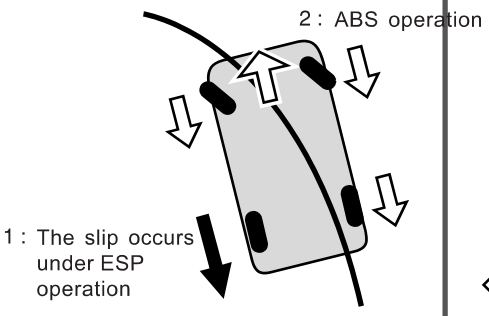
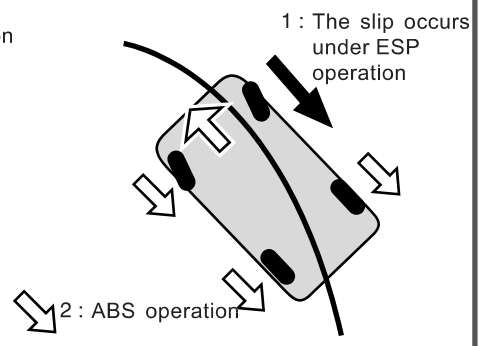
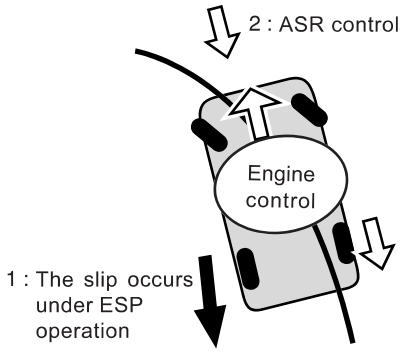
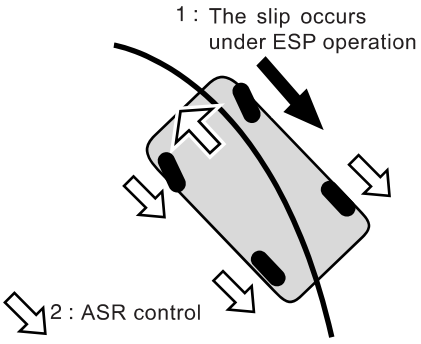
Oversteer is a term of a condition in which the steering wheel is steered to a certain angle during driving and the rear tires slip outward losing traction.
Compared to understeering vehicles, it is hard to control the vehicle during cornering and the vehicle can spin due to rear wheel moment when the rear tires lose traction and the vehicle speed increases.

▶ ESP controls during oversteer

The ESP system recognizes the directional angle with the steering wheel angle sensor and senses the slipping route that occurs towards the vehicle cornering direction during oversteer with the yaw rate sensor and lateral sensor. Then the ESP system applies the braking force to the front outer wheel to compensate the yaw moment value. In this way, the vehicle does not lose its driving direction and the driver can steer the vehicle as intended.

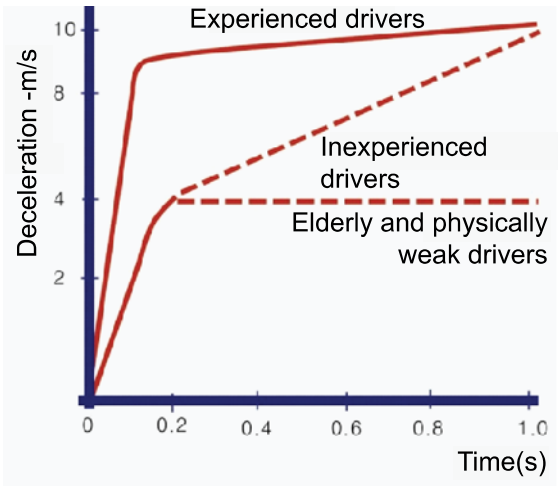
3) Vehicle Control During Cornering

The figure below shows the vehicle controls by the ESP system under various situations such as when the brake pedal is depressed or not depressed during cornering, when the ABS is operating and when braking without the ABS. It also includes the vehicle conditions when the TCS, a part of the ESP system, is operating.

Condition	Understeer control	Oversteer control
Only ESP in operation No braking by driver		
ESP + Normal braking (no ABS operation)		
ESP + ABS brake		
ESP + ASR		

Modification basis	
Application basis	
Affected VIN	

4) HBA (Hydraulic Brake Assist System)



(1) Purpose

HBA (Hydraulic Brake Assist) system helps in an emergency braking situation when the driver applies the brake fast, but not with sufficient pressure, which leads to dangerously long braking distance. ECU recognizes the attempt at full braking and transmits the signal calling for full brake pressure from the hydraulic booster. An inexperienced, elderly or physically weak driver may suffer from the accident by not fully pressing the brake pedal when hard braking is required under emergency. The HBA System increases the braking force under urgent situations to enhance the inputted braking force from the driver. Based on the fact that some drivers depress the brake pedal too soft even under when hard braking is necessary, the HECU system is a safety supplementary system that builds high braking force during initial braking according to pressure value of the brake pressure sensor and the pressure changes of the pressure sensor intervals. When the system is designed to apply high braking force when brake pedal is depressed softly by an elderly or physically weak driver, the vehicle will make abrupt stopping under normal braking situation due to high braking pressure at each wheels.

(2) Operation

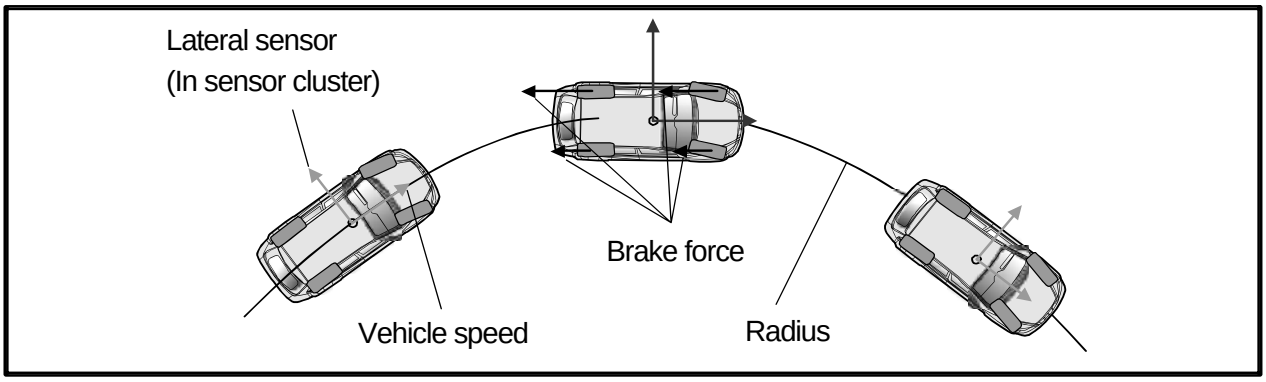
The brake pressure value and the changed value of the pressure sensor are the conditions in which the HBA System operates. There are 2 pressure sensors under the master cylinder. When the ESP ECU system determines that emergency braking is present, the pump operates, the brake fluid in the master cylinder is sent to the pump and the braking pressure is delivered to the wheels via the inlet valves . If the drive depress the brake pedal slowly, the pressure change is not high. In this case, only the conventional brake system with booster is activated.

(3) Operating conditions

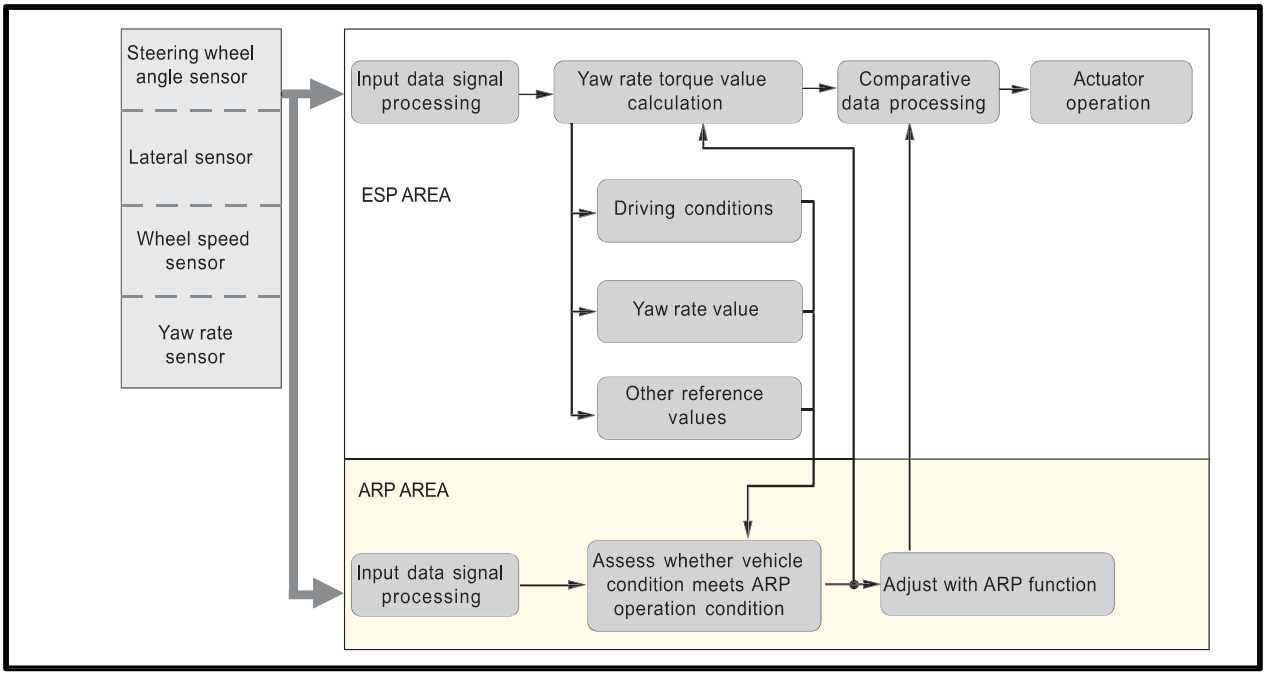
- Sensor pressure: over 40 bar
- Pressure changes: over 850 bar/sec
- Vehicle speed: over 30 km/h

5) ARP (Active Roll-Over Protection

The ARP (Active Roll-over Protection) system is a safety assistant device that minimizes, by controlling brakes and the engine, the physical tendency of the vehicle rollover during sharp lane changes or U-turns. For the system, software is added to the existing ESP system and no additional device or switch is needed. One must note that the ARP system, just as general assistant devices including the ABS, is only a safety assistant device using the ESP system and its function is useless when the situation overcomes the physical power. Following picture shows how the ARP compensates the vehicle position by varying each wheel's braking power to overcome the physical tendency of the vehicle rollover during sharp turns.



The vehicle driving condition is controlled by the internally programmed logic according to the input signals from wheel speed sensor, steering angle sensor and lateral sensor.

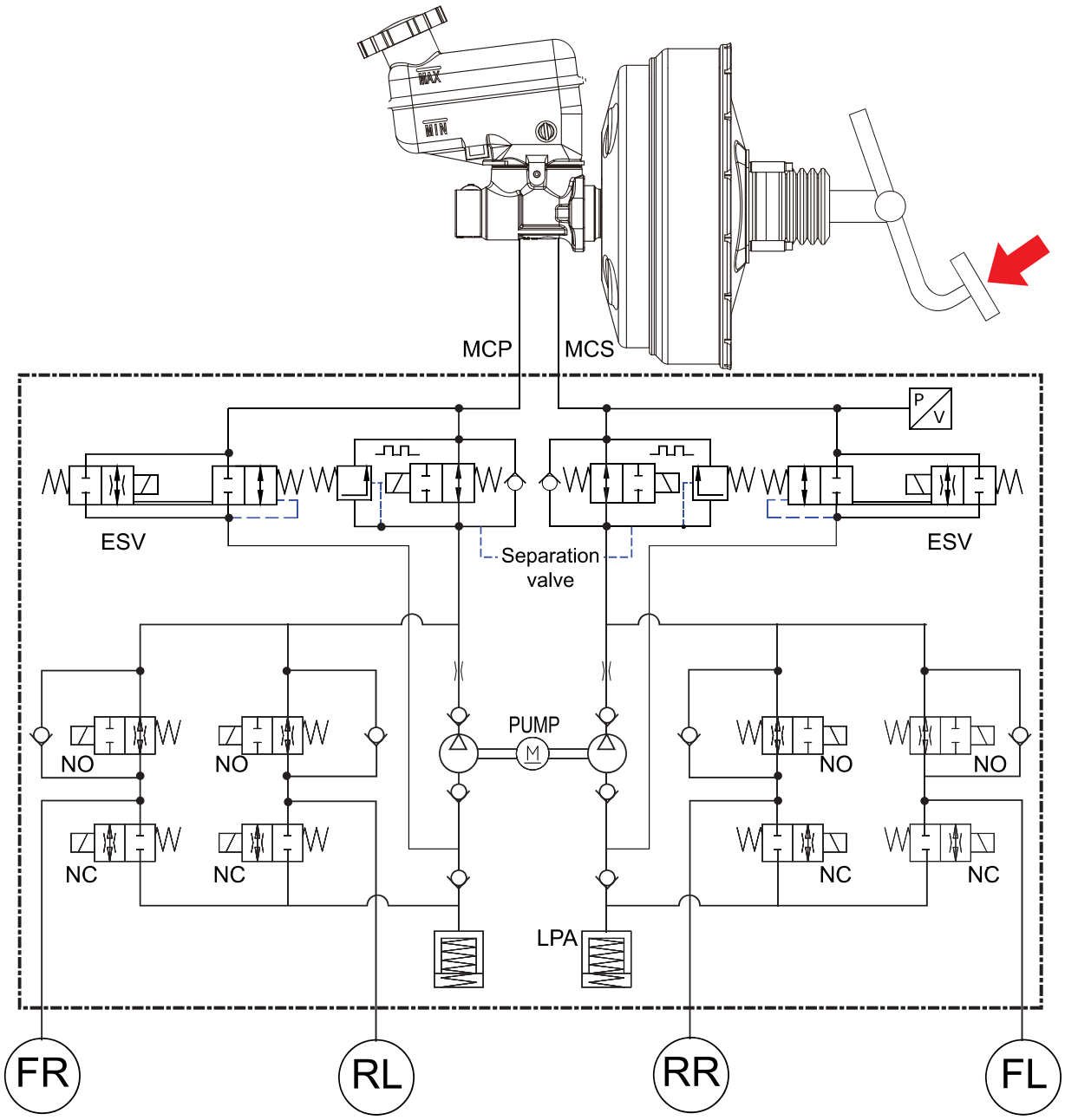


CAUTION

During the ARP operation, vehicle safety (rollover prevention) takes the first priority and thus, stronger engine control is in effect. Consequently, the vehicle speed decreases rapidly, so the driver must take caution for the vehicle may drift away from the lane.

Modification basis	
Application basis	
Affected VIN	

7. HYDRAULIC CIRCUIT OF ESP



MCP: Master Cylinder Primary
MCS: Master Cylinder Secondary
ESV: Electric Shuttle Valve
NO: Normal Open
NC: Normal Close
LPA: Low Pressure Accumulator

Modification basis	
Application basis	
Affected VIN	

▶ Circuit description

When compared to the vehicle equipped with ABS/EBD only, the internal hydraulic circuit has a normally-open separation valve and a shuttle valve in primary circuit and in secondary circuit.
When the vehicle brakes are not applied during engine running or when applying the non-ABS operating brakes, the normally-open separation valve and the inlet valve are open, whereas the normally-closed shuttle valve and the outlet valve are closed.
When the ESP system is operating, the normally-open separation valve will be closed by the solenoid valve operation and the hydraulic circuit will be established by the shuttle valve. Then, the inlet and outlet valves will be closed or open depending on the braking pressure RISE, HOLD or DUMP conditions.

▶ Flashing warning lamp and warning sound during ESP operation

When the ESP operates while the vehicle is moving, the ESP warning lamp on the instrument panel flickers and the buzzer sounds at every 0.1 second. The ESP lamp operation is to inform a driver that the vehicle is extremely unstable.
The ESP system is just a supplementary system for the vehicle and it cannot control the vehicle over the physical limit. Do not solely rely on the system but be advised to drive the vehicle safely.

▶ Drive feeling during ESP operation

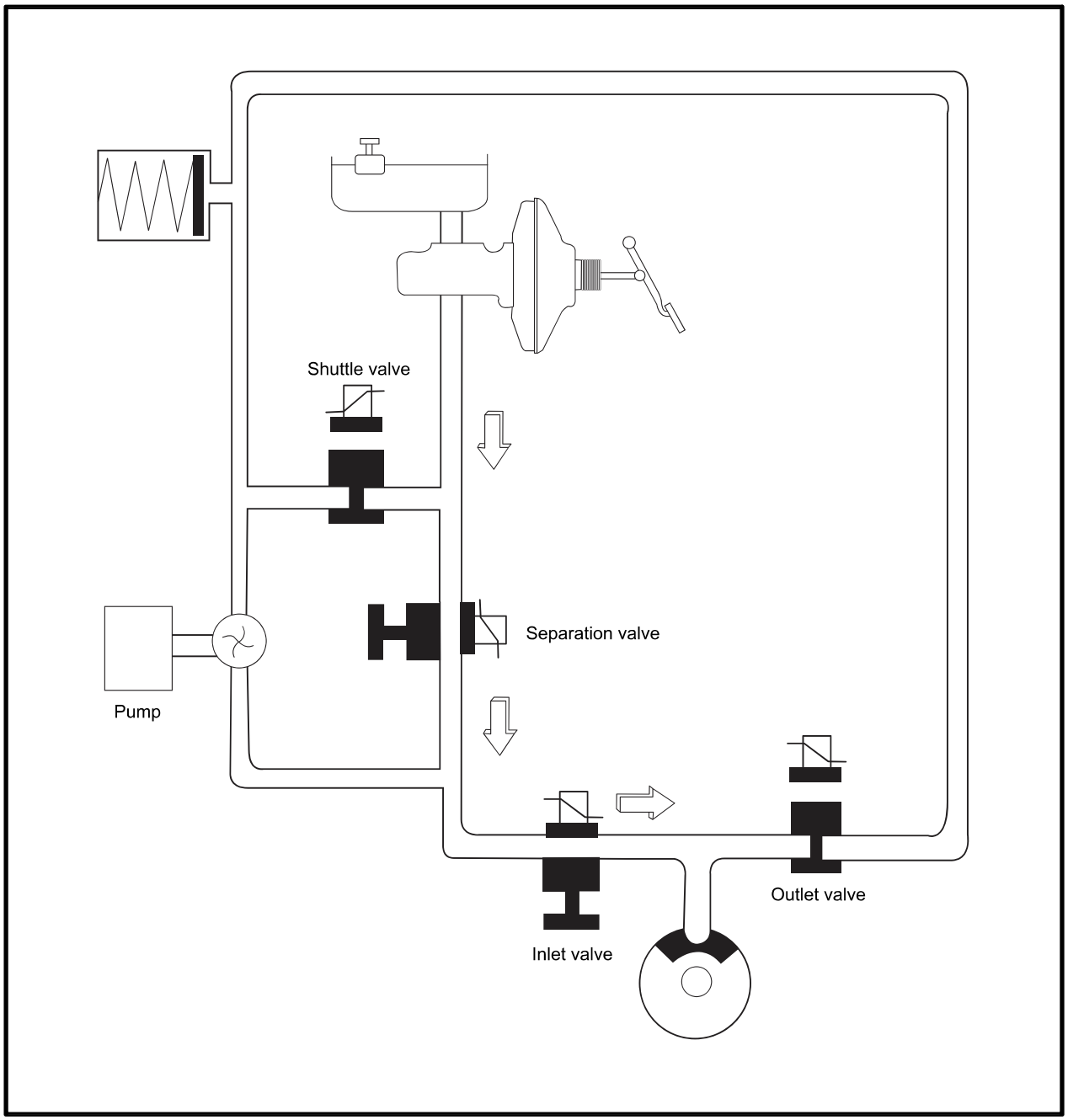
When the ESP system activates, the driving feeling can be different depending on vehicle driving conditions. For example, it will feel different when the ESP system is activated while the ABS is operated by depressing the brake pedal and when the ESP system is in control without the brake pedal depressed on the same curve.
If the ESP system operates with the brake applied, the brake pressure will be increased on the corresponding wheel which already has braking pressure for the ESP controls. In other words, the ESP system would make the driver feel more abruptly braked compared to the situation that the braking pressure is applied to wheel which had no braking force.

▶ Noise and vibration that driver senses during ESP operation

The ESP system may transfer noise and vibration to a driver due to the pressure changes caused by the motor and valve operations in a very short period of time.
Extreme cornering will trigger the ESP operation and this will make the driver sense noise and vibration due to sudden brake application.
Also, the ESP system controls the engine power. Therefore, the driver may notice the engine power decreases even when the accelerator pedal is depressed.

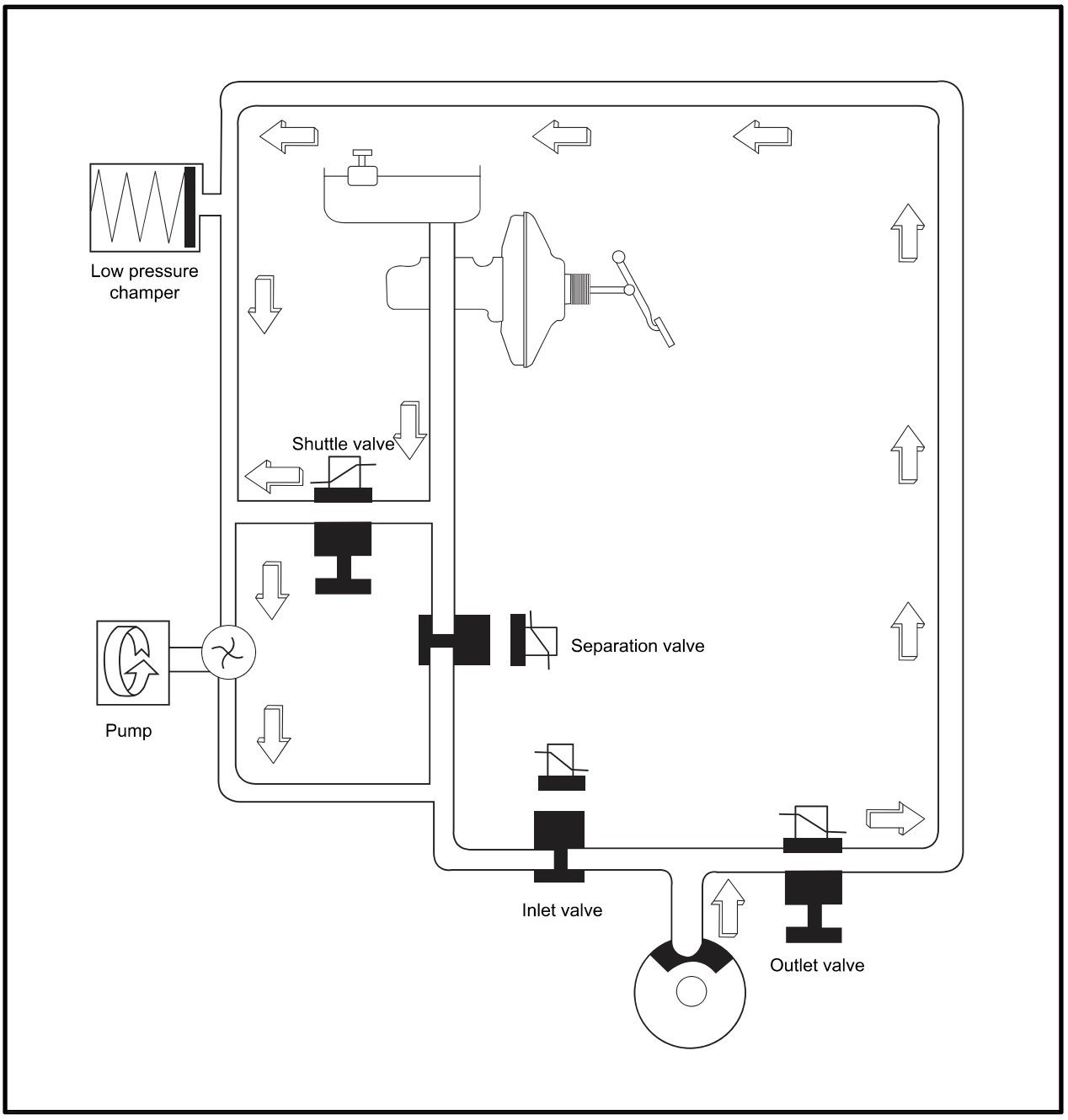
Modification basis	
Application basis	
Affected VIN	

1) Idling and Normal Braking Condition



In this position, the separation valve and the inlet valve are open (normal open), the electrically operated shuttle valve and the outlet valve are closed.
When the brake is applied under these conditions, the brake fluid will be sent to each wheel via the separation valve and inlet valve.

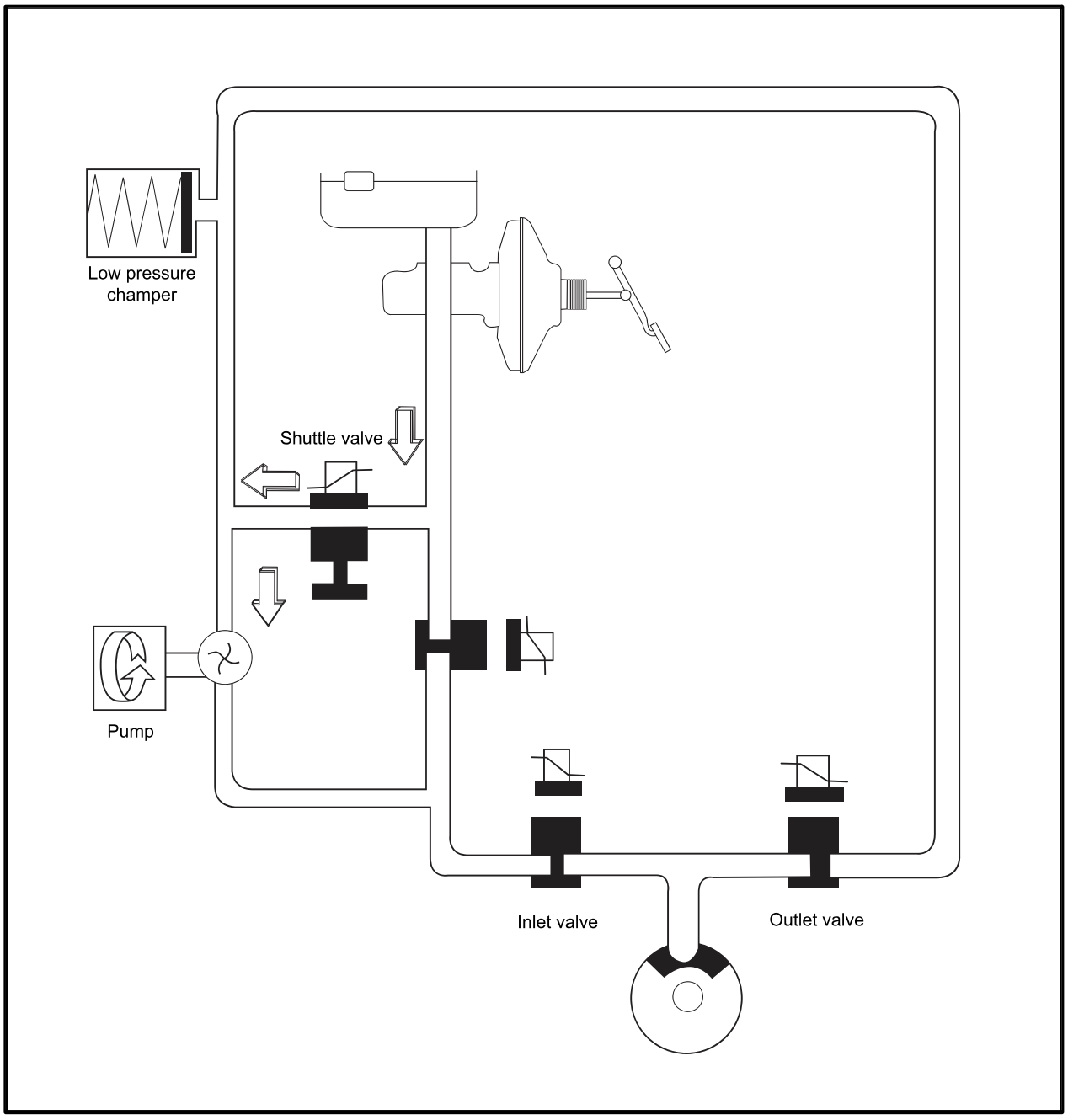
2) DUMP (ESP is working) Mode



The pressure decreases just before the wheel speed drops and the wheels are locked.
The inlet valve closes and the outlet valve opens as in the ABS HECU and the oil is gathered at the low pressure chamber while no additional oil is being supplied. Then the pump operates to allow fast oil drainage. The shuttle valve and the separation valve do not operate while decompression.

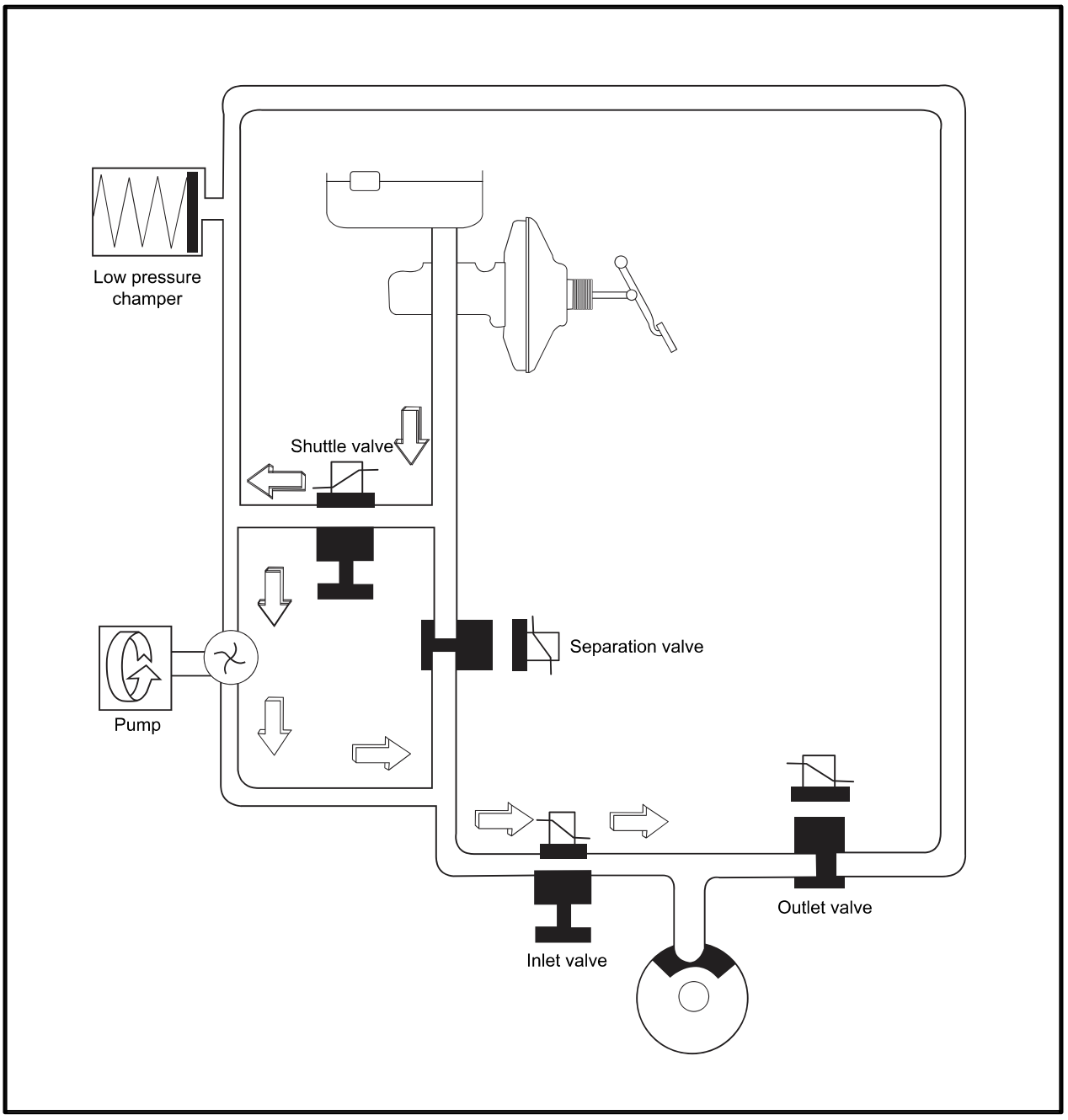
Modification basis	
Application basis	
Affected VIN	

3) HOLD (ESP is working) Mode



The Inlet valve and outlet valve will be closed to maintain the pressure in the hydraulic circuit applied at the wheels. By closing the valves, the hydraulic pressure at the wheels will not be lost or supplied any more. During ESP operation, the separation valve closes and only the shuttle valve at the pump opens.

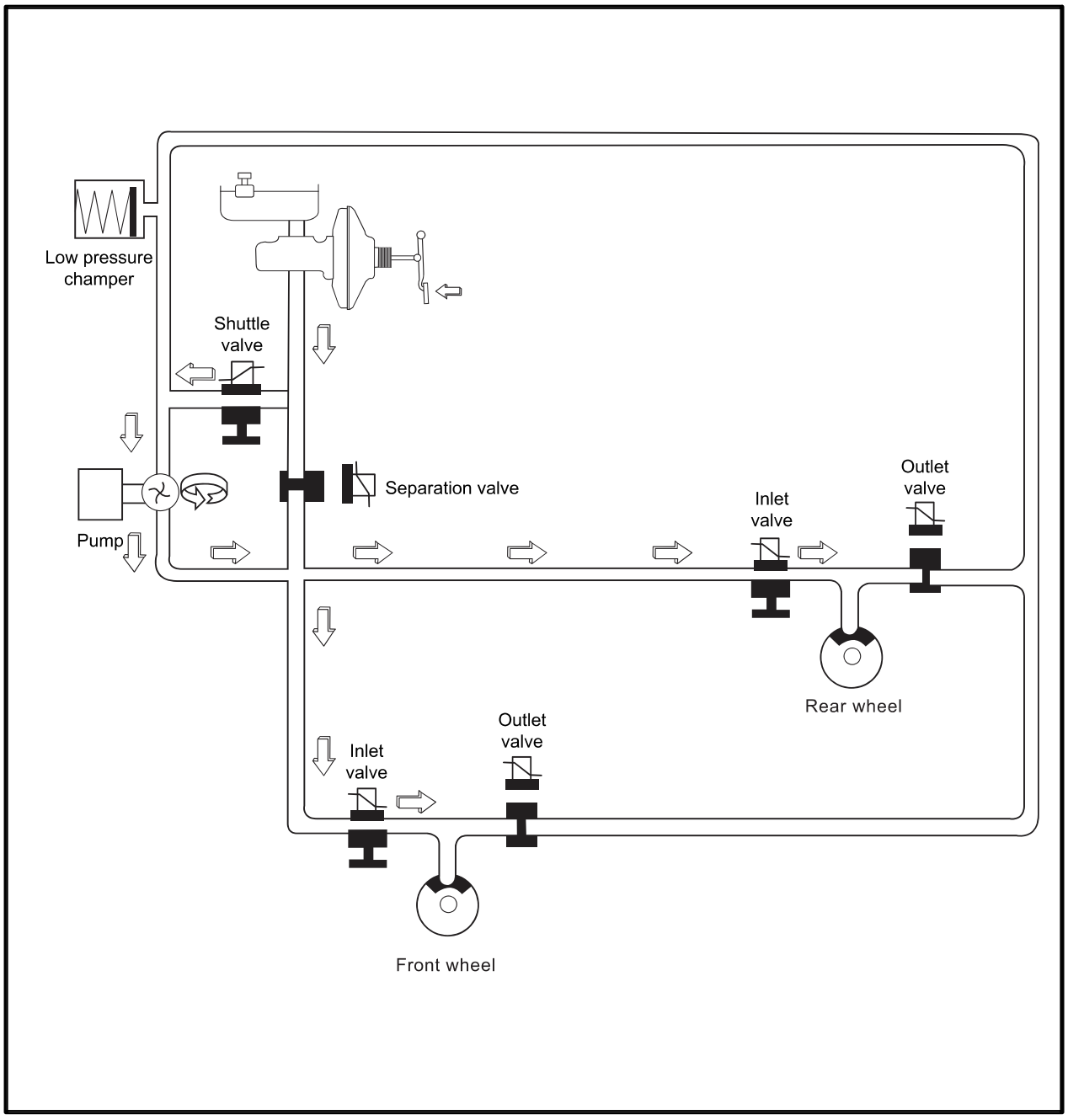
4) RISE (ESP is working) Mode



The shuttle valve and inlet valve will be open and the separation valve and outlet valve will be closed. Then, the pump is operated. When ESP operates while the ABS is operating, the pressure will be increased continuously until just before the corresponding wheel gets locked.

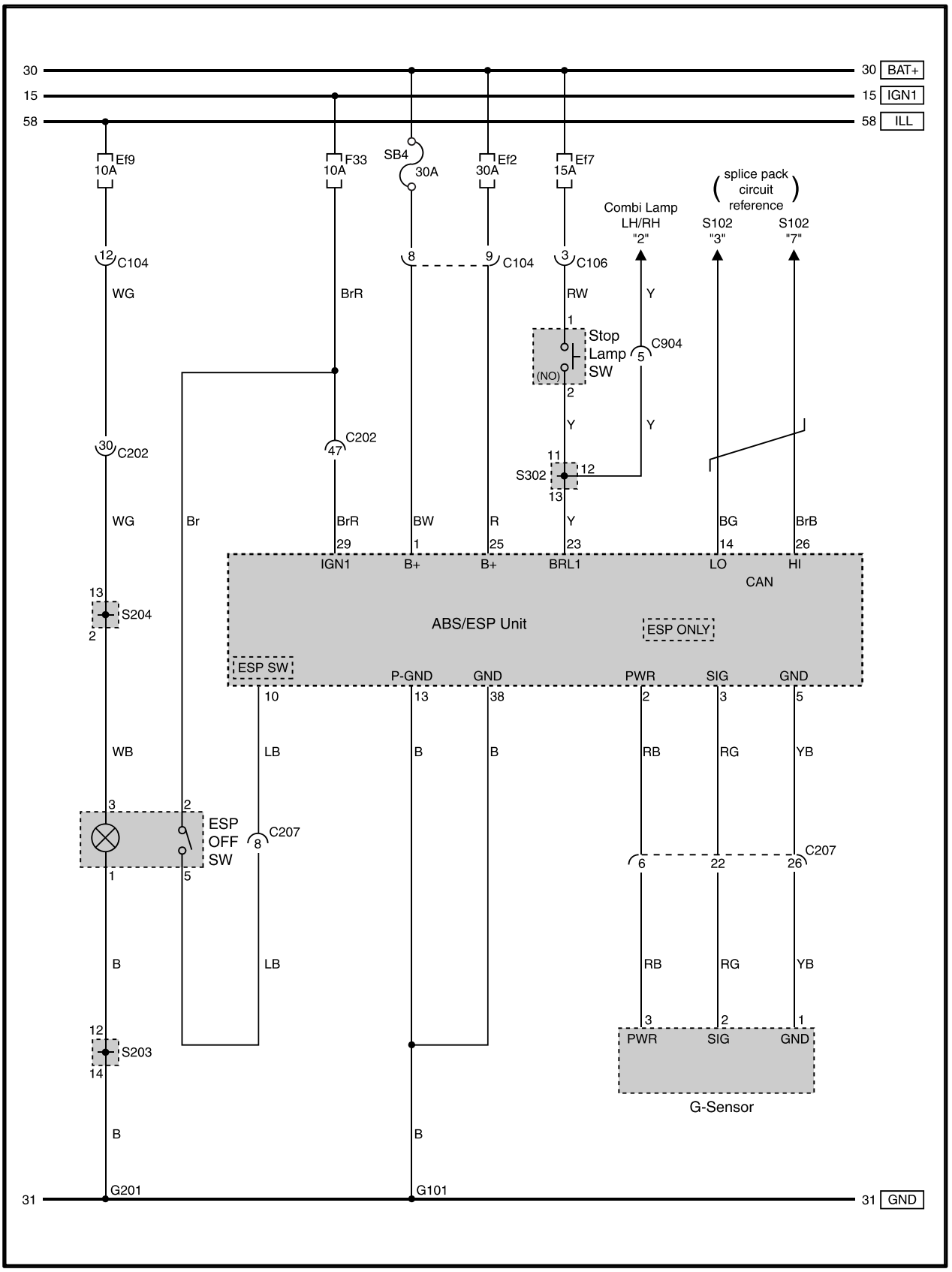
Modification basis	
Application basis	
Affected VIN	

5) Hydraulic Circuit of HBA

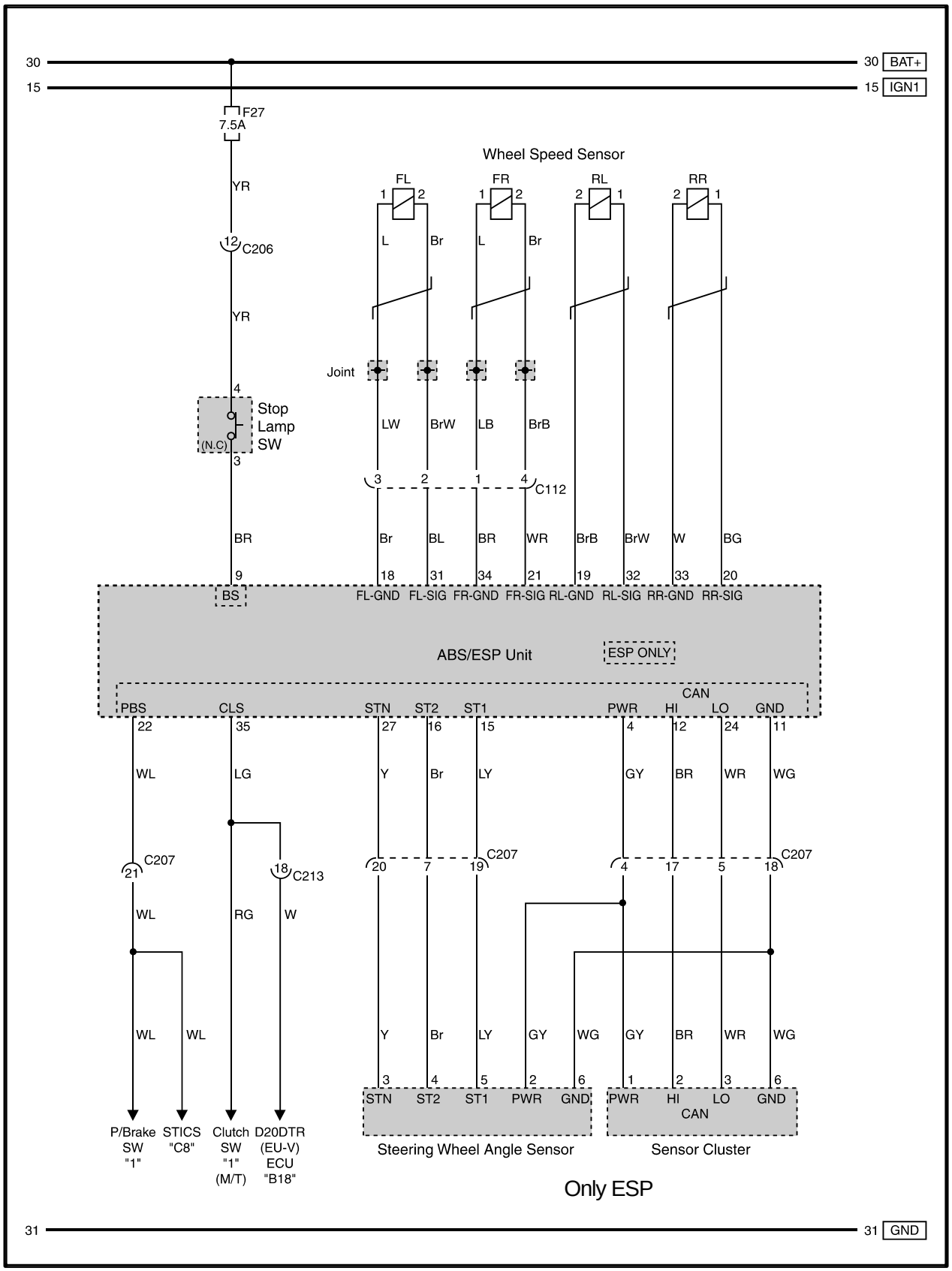


The above figure shows one front and one rear wheel and the same hydraulic circuit forms as in the ESP operation. When HECU recognizes that it is an emergency and it is required for hard braking, depending on the pressure value of the brake pressure sensor and pressure changes caused by the pressure sensor timing, it operates the pump immediately to apply the brake pressure at the wheels. Then, the pressure in the pump increases until just before the corresponding wheel gets locked. The motor still keeps rotating and the outlet valve and the separation valve will stay closed. When the wheel starts to lock, the HBA function cancels and switches to ABS operation.

8. CIRCUIT DIAGRAM



Modification basis	
Application basis	
Affected VIN	



Modification basis	
Application basis	
Affected VIN	

STEERING

4610-01

GENERAL INFORMATION

1. SPECIFICATIONS

Description			Specification
Steering wheel	Type		4-spoke type
Gear box (HPS)	Type		Rack and pinion type
	Gear ratio		40.245
	Steering angle	Inner	36.2˚
		Outer	32.4˚
Oil pump (HPS)	Type		Vane type
	Maximum pressure (kgf/cm2)		90 ± 3
	Pulley size (mm)		Ø115
	Operating temperature		−40℃~150℃
Minimum turning radius	(m)		5.8
Steering oil	Type		S-PSF-3
	Capacity (L)		Approx. 1.0
	Service interval		Daily check and add if necessary.
Steering column shaft	Tilting angle		−4.0/ 0° /+4.0° / +8.0°

NOTE

This section describes the power steering pump and gear box based on the HPS (Hydraulic Power Steering) system. For the information of the SSPS (Speed Sensing Power Steering) system, refer to SSPS section under CHASSIS.

2. MAJOR CHANGES

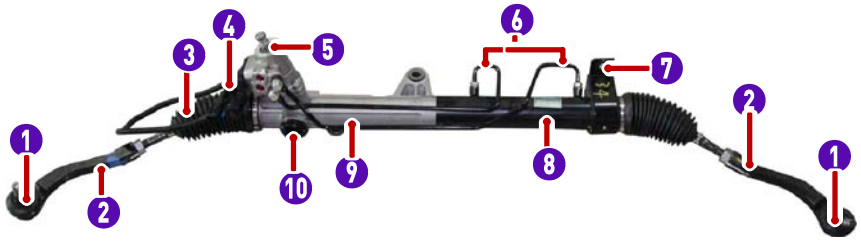
▶ **SSPS (Speed Sensing Power Steering) system adopted**

SSPS control unit

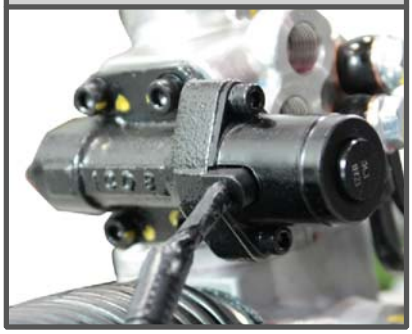
Installed view	Unit components
	

It is installed at the bottom of the ECU inside the passenger's floor mat foot protector cover and receives data related to the vehicle speed and throttle position through the CAN communication and controls the solenoid valves to obtain optimal steering force.

Power steering gearbox & solenoid valve for SSPS model



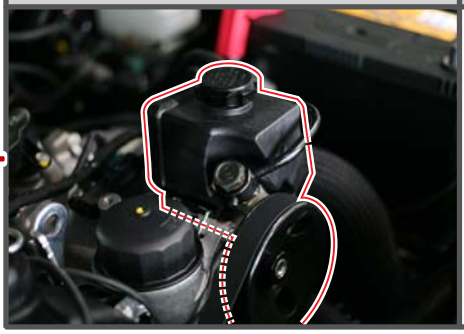
SSPS Solenoid Valve

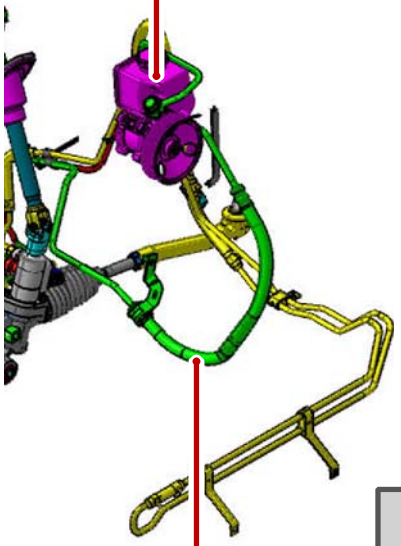


1. Tie Rod End
2. Tie Rod
3. Bellows
4. SSPS Solenoid Valve
5. Valve Assembly
6. Feed Tube
7. Mounting Bracket
8. Cylinder Tube
9. Rack Housing
10. Adjusting Plug

Modification basis	
Application basis	
Affected VIN	

Power steering pump with SSPS

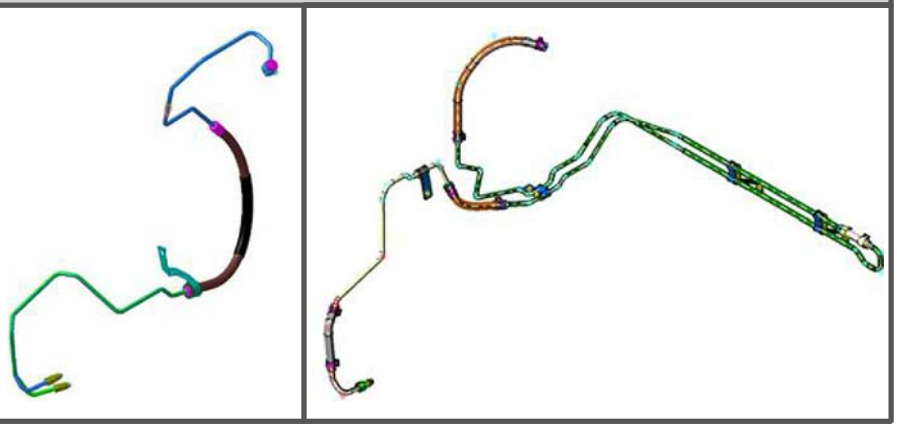
Installed view	Pump components
	



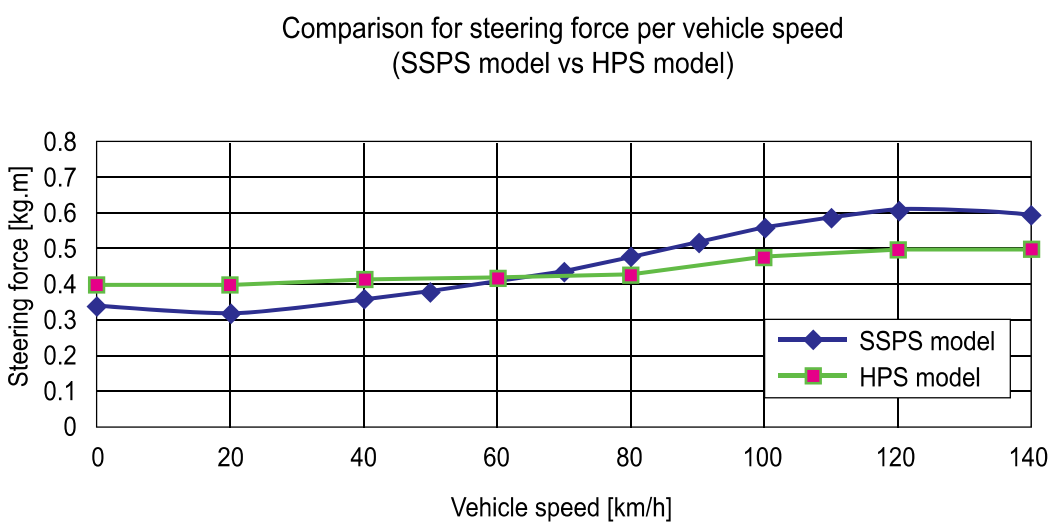
SSPS warning lamp

Comes on when SSPS system has a fault

Power steering supply hose and return hose for SSPS model



Modification basis	
Application basis	
Affected VIN	



* The SSPS system provides an extensive steering force range at high and low speeds, compared with the general HPS system.

Modification basis	
Application basis	
Affected VIN	

▶ Heated Steering Wheel Adopted

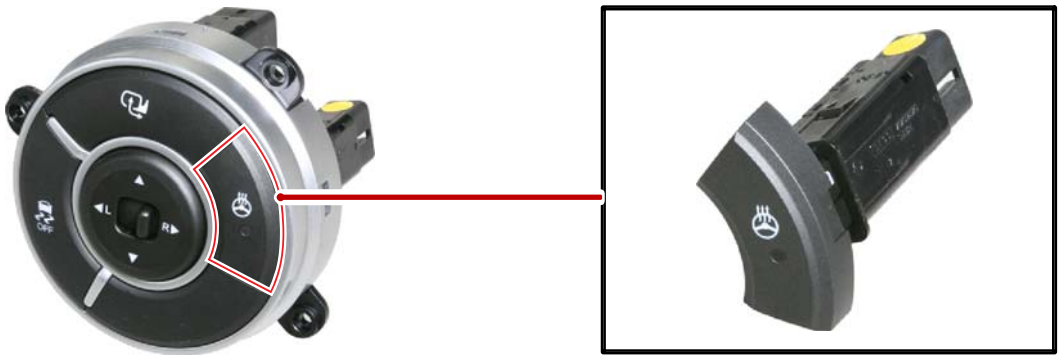
Steering Wheel Body & Heated Wire Controller

Old

New

Heated pad and controller added to steering wheel body

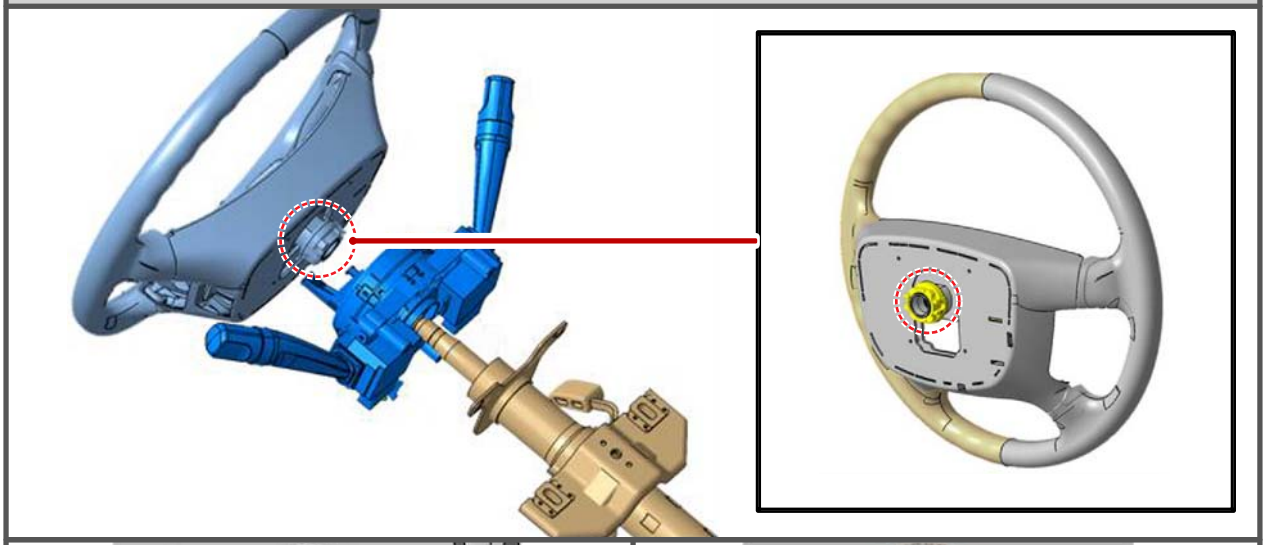
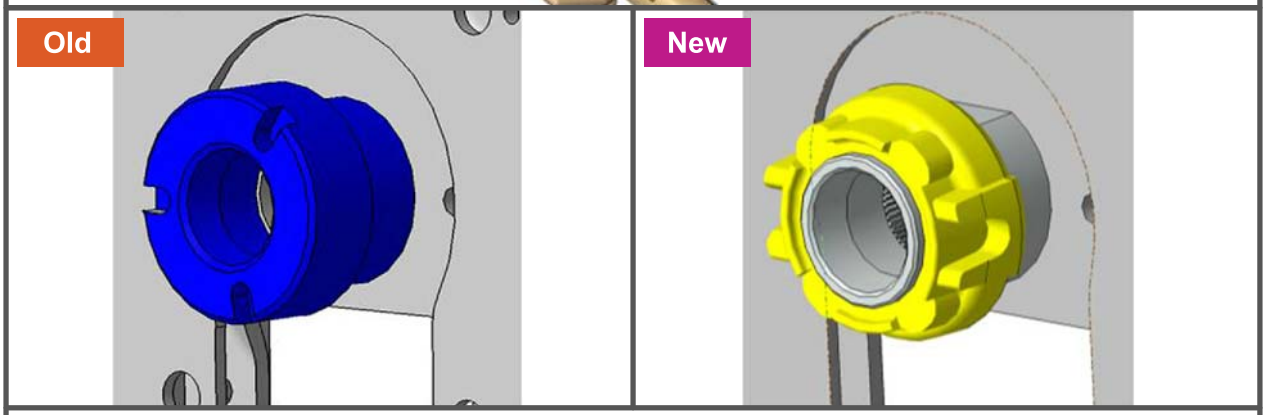
HEATED STEERING WHEEL SWITCH



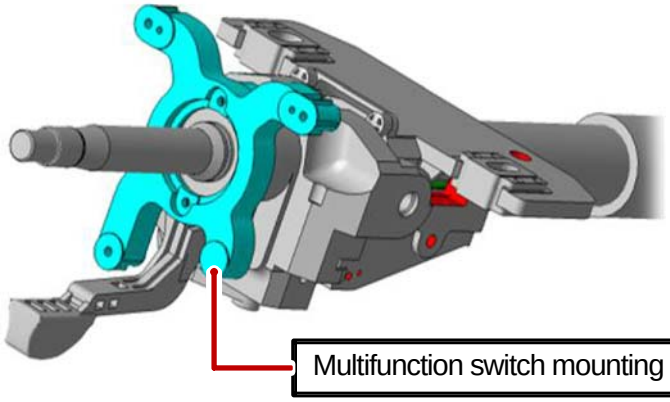
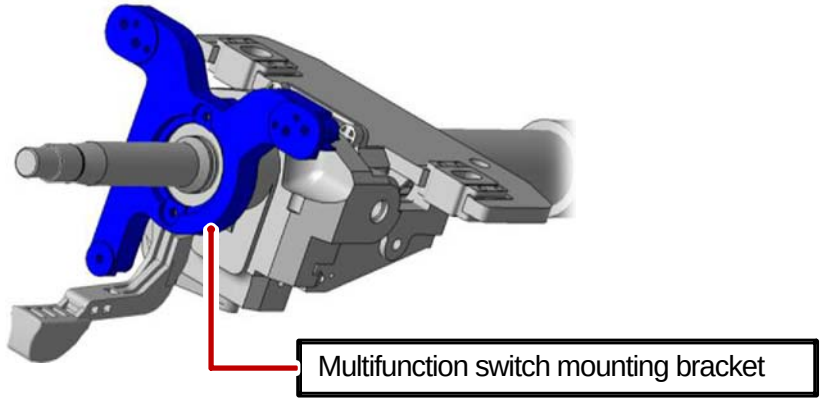
Heated steering wheel switch added to cluster fascia panel switch assembly

Modification basis	
Application basis	
Affected VIN	

▶ Change of Steering Wheel & Steering Column Shaft

Steering wheel assembly boss part


Appearance of steering wheel boss part changed

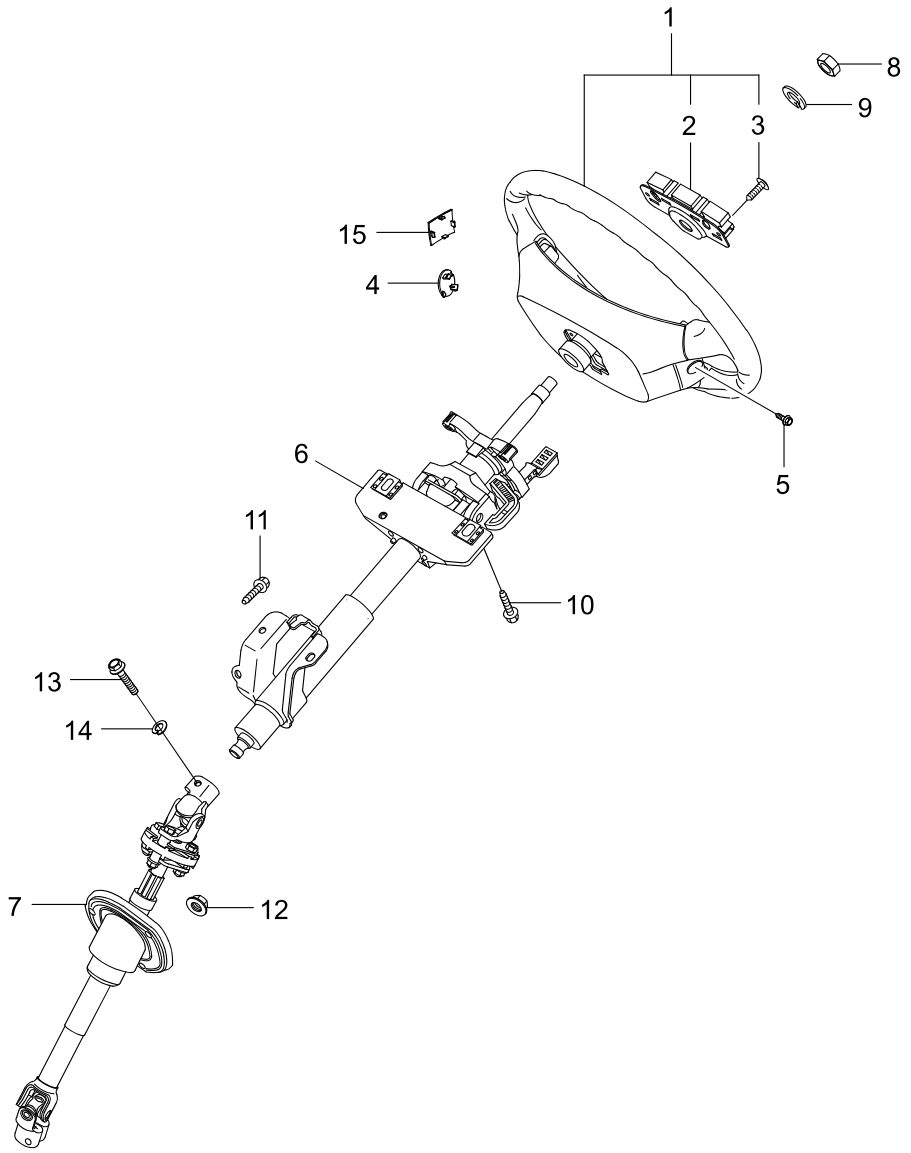
Modification basis	
Application basis	
Affected VIN	

Steering column shaft
Old 
New 
Steering column shaft upper multifunction switch mounting bracket changed due to change of multifunction switch

Modification basis	
Application basis	
Affected VIN	

3. SYSTEM LAYOUT

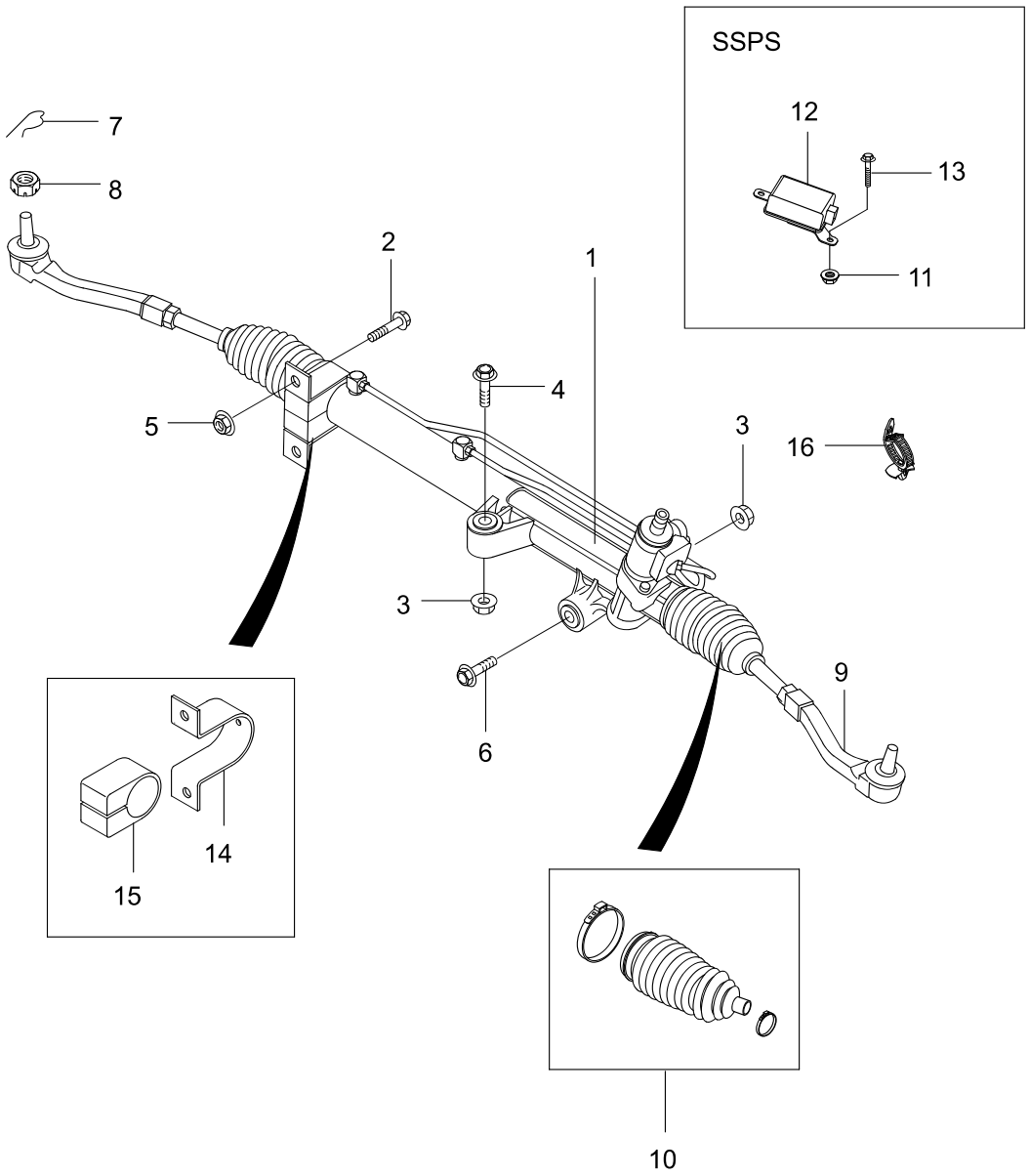
1) Steering Wheel and Column



1. Body assembly - steering wheel
2. Damper - steering wheel
3. Screw
4. Lid
5. Bolt
6. Column & shaft assembly - tilt
7. Shaft assembly - lower
8. Nut (39.2~58.5 Nm)
9. Washer
10. Bolt (19.6 ~ 24.5 Nm)
11. Bolt (19.6 ~ 24.5 Nm)
12. Nut
13. Bolt - joint (17.6~24.5 Nm)
14. Washer
15. Blanking cover - cruise switch

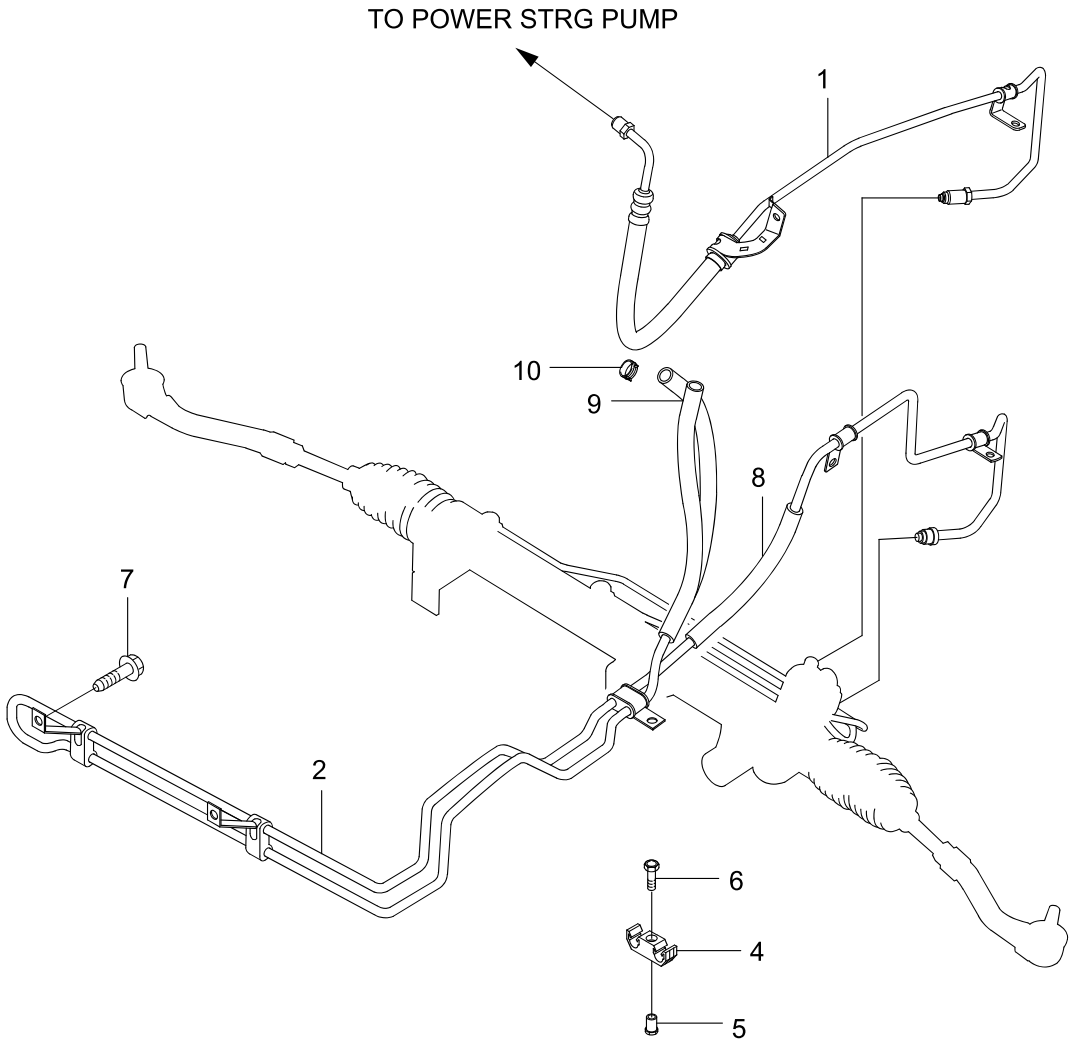
Modification basis	
Application basis	
Affected VIN	

2) Steering Gear Linkage



1. Linkage assembly - gear & operation ball
2. joint
3. Bolt (100 ~ 130 Nm)
4. Nut (100~130 Nm)
5. Bolt (100 ~ 130 Nm)
6. Nut (100~130 Nm)
7. Bolt (100 ~ 130 Nm)
   Pin
8. Nut
9. End assembly - tie rod
10. Boot kit - power steering gear box
11. Nut
12. SSPS module
14. Clamp - mounting
15. Rubber - MTG

3) Pipe Lines



1. Hose assembly - pump to gear
2. Tube & hose assembly - return
4. Clamp - pipe
5. Nut - well
6. Screw
7. Bolt
8. Hose - return
9. Hose - return
10. Clamp - hose return

Modification basis	
Application basis	
Affected VIN	

4. TROUBLESHOOTING

Problem	Possible Cause	Action
Movements of steering feels heavy	Irregular wear or binding of steering ball joint due to lack of lubrication or foreign material insertion	Lubricate or replace
	Damaged or defective steering gear	Replace the steering gear assembly
	Incorrect steering pinion preload	Adjust
	Defective steering shaft joint	Replace
	leakage of steering fluid	Repair or replace
	Insufficient steering fluid or air insertion	Fill up fluid or bleed air
	Defective steering oil pump	Replace
	Damaged or loosened pump drive belt	Adjust or replace
	Clogging of fluid line	Repair or replace
	Damaged wheel or tire	Repair or replace
	Defective suspension	Repair or replace
Steering wheel pulls to one side	Damaged steering linkage	Replace
	Damaged wheel or tire	Repair or replace
	Defective suspension	Repair or replace
	Defective brake system	Repair or replace
Excessive free play of steering wheel	Worn steering gear	Replace the steering gear assembly
	Worn or damaged steering ball joint	Replace
	Looseness of steering gear box	Retighten
Poor returning of steering wheel	Broken or binding of steering ball joint	Replace
	Improper correct steering pinion preload	Replace the steering gear assembly
	Damaged wheel or tire	Repair or replace
	Defective suspension	Repair or replace

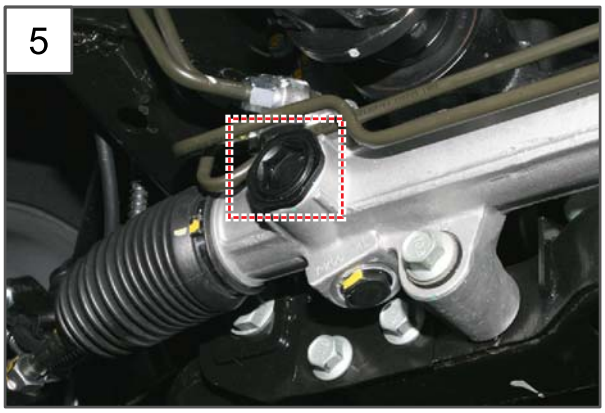
Problem	Possible Cause	Action
Excessive vibration of steering wheel (shimming)	Broken steering linkage	Replace
	Looseness of steering gear box	Retighten
	Broken or binding of steering ball joint	Replace
	Worn or damaged front wheel bearing	Replace
	Damaged wheel or tire	Repair or replace
	Defective suspension	Repair or replace
Abnormal noise from steering system	Looseness of steering gear box	Retighten
	Defective steering gear	Replace the gear assembly
	Interference between steering column and parts	Repair
	Looseness of steering linkage	Retighten
	Loosened or damaged oil pump drive belt	Adjust or replace
	Looseness of oil pump bracket	Replace
	Looseness of oil pump	Replace
	Air insertion into system	Bleed air
	Defective oil pump	Replace
Abnormal noise when turning steering wheel	Looseness of steering column	Retighten
	Worn or damaged steering shaft bearing	Replace the steering column
	Looseness of intermediate shaft	Retighten
Too heavy steering wheel	Worn or damaged steering shaft bearing	Replace the steering column

5. INSPECTION AND MAINTENANCE

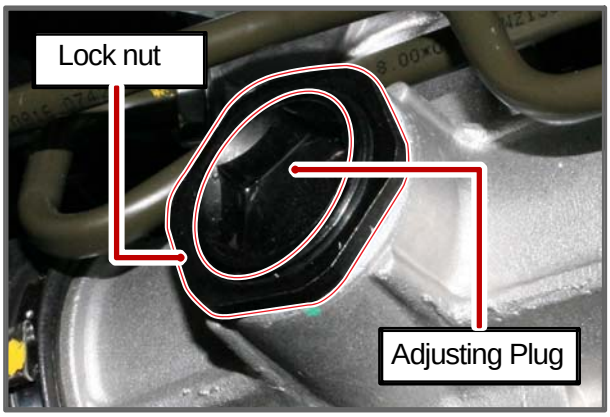
▶ Gear Preload Check

Preload is the term used in mechanical engineering to describe the load applied to a fastener merely as a result of being fastened (and before any external loads are applied)

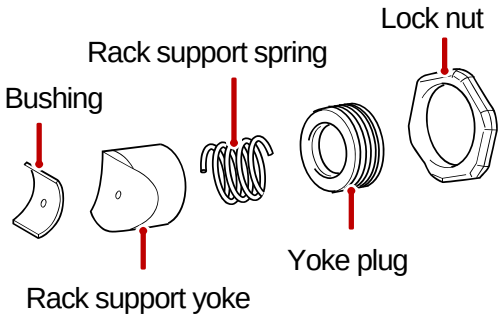
1. Place the wheels at straight ahead direction.
2. Lift up the vehicle with a lift.
3. Unscrew the adjusting plug lock nut.
4. Measure the torque of the adjusting plug.



5. If the torque is excessive or too low, adjust to the specified torque.
   - Place the rack gear to the center position.
   - Tighten the adjusting plug to 10.2 Nm.
   - Turn the pinion gear so that the rack gear is turned to lock to lock 5 times.
   - Unscrew the adjusting plug.
   - Tighten the adjusting plug to 4.6 to 5.6 Nm.
   - Unscrew the adjusting plug to 67.5°.



Adjusting Plug



▶ Free Play Check

1. Start the engine and place the wheels at straight ahead direction.
2. Turn the steering wheel until the tires starts to move and measure the distance on the circumference of the steering wheel.

Free play	30 mm

CAUTION

If the free play is out of the specified value, check the free play in steering column shaft connection and steering linkage. Replace or repair if necessary.

▶ Steering Effort Check

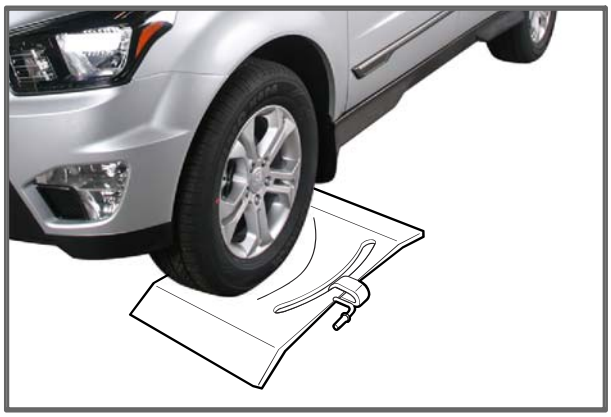
1. Park the vehicle on a paved and flat ground and place the front wheels at straight ahead direction.
2. Start the engine and let it run around 1,000 rpm.
3. Install the spring scale on the circumference of the steering wheel and measure the steering effort in both directions.

Steering effort in standstill	2.2 kgf

CAUTION

The difference between both sides should be within 0.6 kg.

▶ Steering Angle Check



1. Place the front wheel on a turning radius measuring tool.
2. Turn the steering wheel to the its both ends and measure the maximum steering angle.

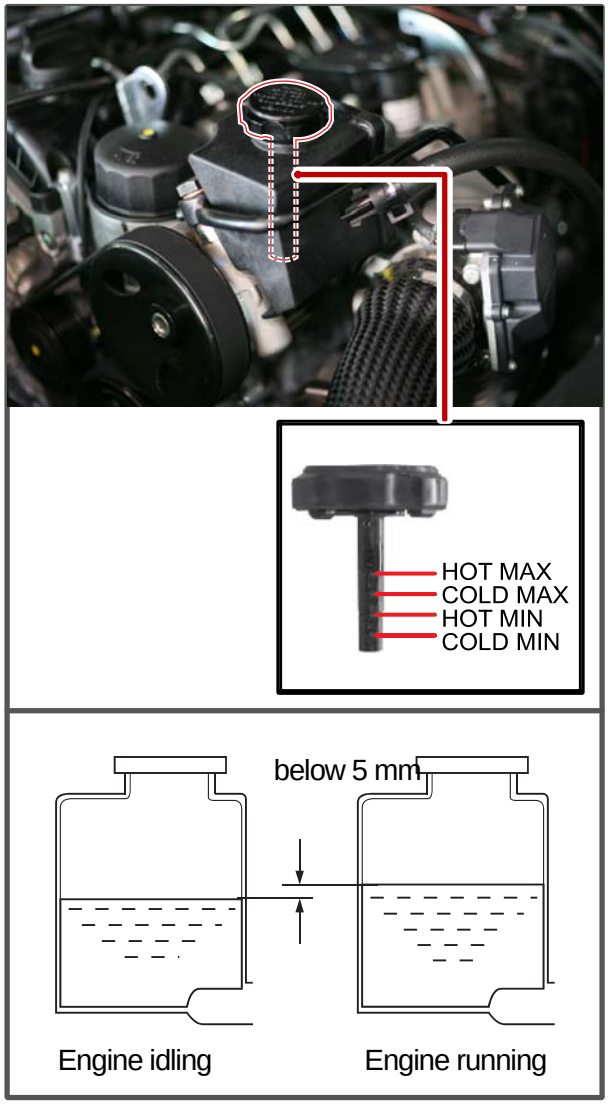
Steering angle	Inner	36.2˚
	Outer	32.4˚

CAUTION

If the steering angle is out of the specified value, check and adjust the toe-in.

Modification basis	
Application basis	
Affected VIN	

▶ Oil Level Check



Check the fluid level on a level ground with the engine turned off. The fluid level should be between the MIN and MAX marks on the reservoir cap gauge.

1. Place the vehicle on a level ground and start the engine and let it run at idle speed.
2. Turn the steering wheel several times so that the oil temperature reaches to normal operating level (75~85°C).
3. Place the steering wheel at straight ahead direction.
4. Check the oil level in the power steering oil reservoir. Adjust the oil level between MAX and MIN.

CAUTION

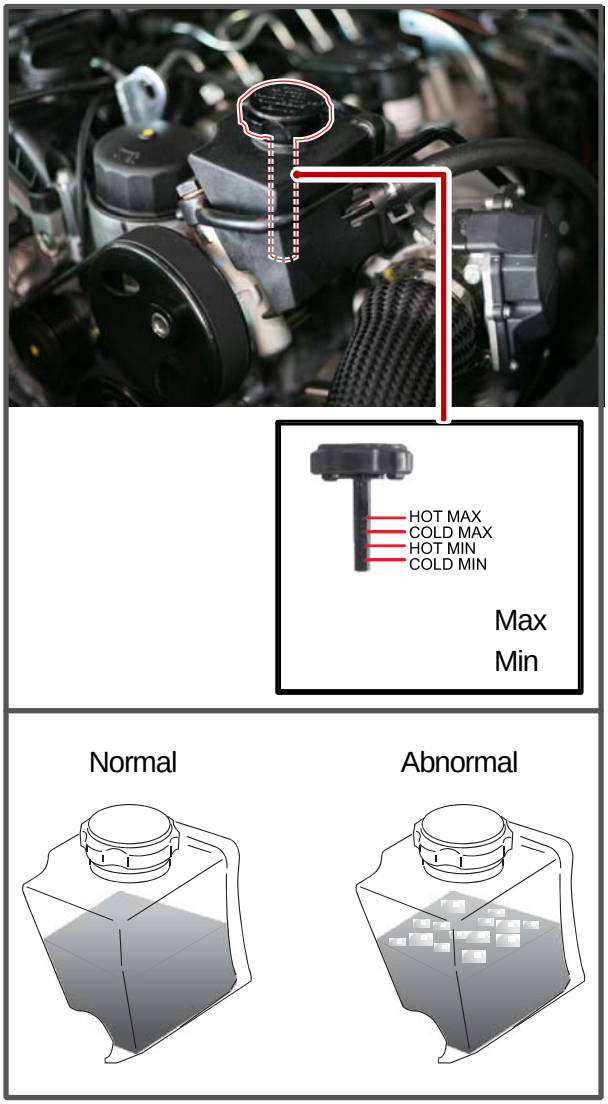
If the difference between two measurements is below 5 mm and the level is between MAX and MIN level, it's normal. If it is over 5 mm, bleed air from the system.

▶ Oil Change

1. Open the power fluid reservoir cap and drain the fluid completely with oil suction device. To make it easy, turn the steering wheel to its both ends several times.
2. Fill up the specified fluid into fluid reservoir and bleed air from the steering system.

Oil type	S-PSF-3
Capacity	approx. 1ℓ (including reservoir)

▶ Air Bleeding



The air bleeding should be done after servicing the power steering system and when the difference between two measurements (cooled and normal temperature) is prominent.

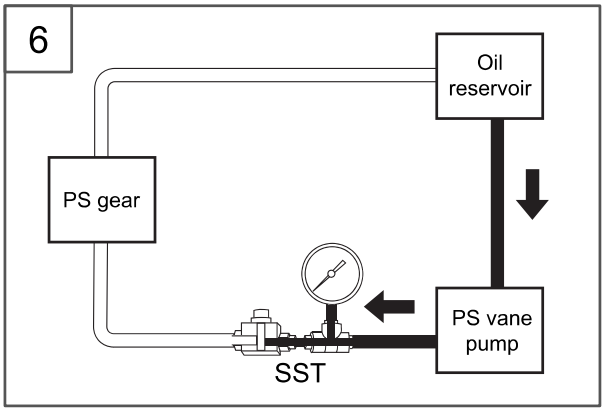
1. Lift up the vehicle very carefully.
2. Turn the steering wheel to its both ends several times and add the oil up to MAX line in the steering oil reservoir.
3. Periodically crank the starting motor and turn the steering wheel to its both ends without any interruption.
4. Check the oil level again. If the oil level is fluctuated, repeat the procedures from step 3 to step 5.
5. Start the engine.
6. Turn the steering wheel to its both ends until any bubble can be found in the steering oil reservoir.
7. Perform the test drive and check the steering wheel for normal operation and noise.
   If the oil level abruptly goes up, bleed the air
8. from the system again.

CAUTION

- If the air bleeding is not properly performed, the life span of the power steering pump may be shortened.

Modification basis	
Application basis	
Affected VIN	

▶ Oil Pump Pressure Check



Check the oil pump pressure to locate any defect in oil pump.

CAUTION

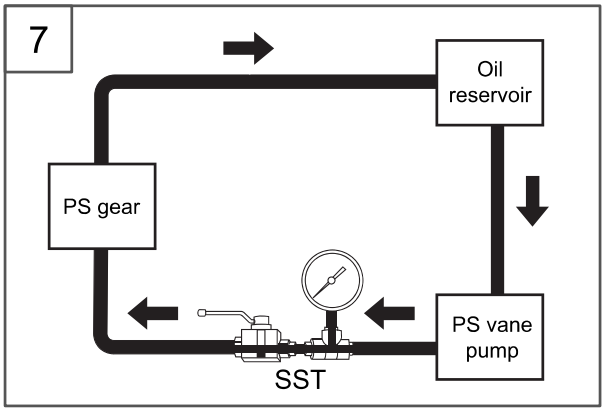
Before checking the pressure, check the oil level and belt tension. Prepare the empty container to collect the spilled oil during the service.

1. Unscrew the pressure line fitting in power steering pump.
2. Install the pressure gauge between the power steering pump and the power steering oil pressure line.
3. Place the shift lever to neutral position. Apply the parking brake.
4. Open the valve in pressure gauge. Start the engine and let it run at idle speed.
5. Turn the steering wheel several times so that the oil temperature reaches to normal operating level.
6. Fully close the valve in pressure gauge and measure the oil pressure.

CAUTION

- To prevent internal damage, do not close the gauge valve over 10 seconds.
- Keep the oil temperature at proper range.

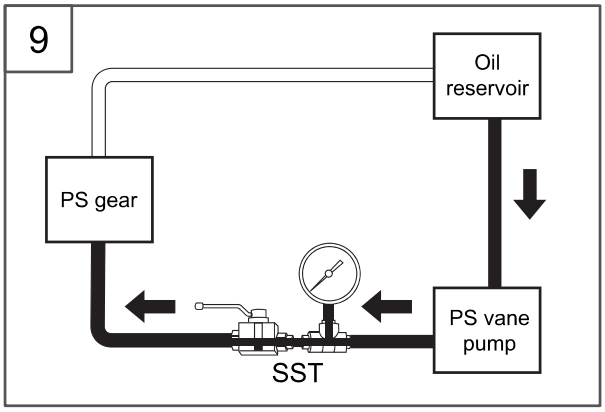
Relief pressure	90 ± 3 bar



7. Measure the oil pressure with the gauge valve fully open.

Pressure at no load	3 to 5 bar

8. If the pump pressure is in specified range, the pump is normal. If not, replace the power steering pump



9. Turn the steering wheel right or left until it stops with the engine idling and valve fully open.

Oil pressure	78 to 83 bar

CAUTION

- To prevent the internal damage, do not close the gauge valve for over 10 seconds. Keep the oil temperature at proper range.
-

Modification basis	
Application basis	
Affected VIN	

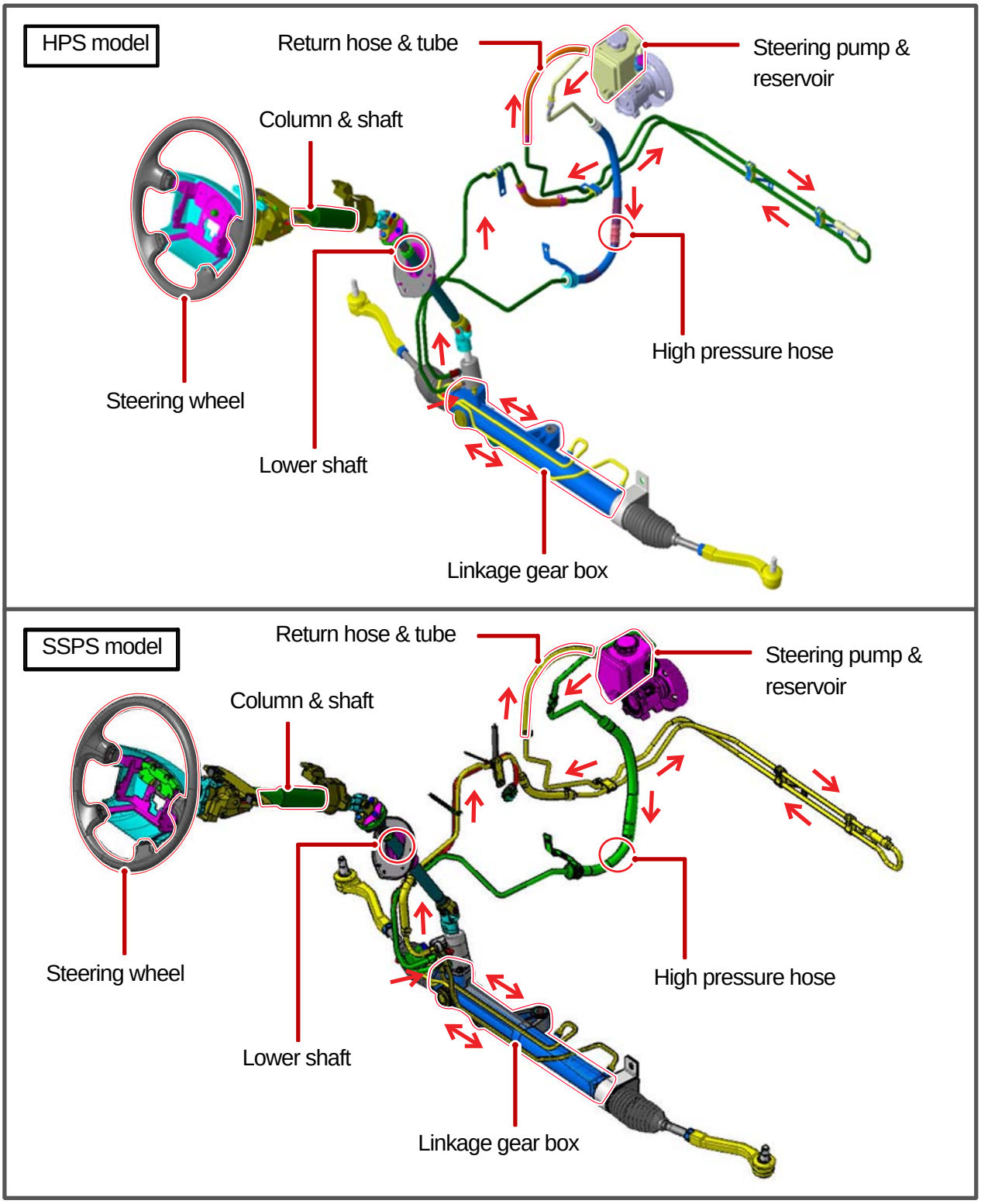
OVERVIEW AND OPERATING PROCESS

1. SYSTEM DESCRIPTION

The power steering has been designed to make the wheel move more easily than in a manual steering system. The hydraulic power assists the process utilizing hydraulic fluid. The fluid increases pressure in the power steering pump and aids the movement of the steering mechanism. The power steering system consists of pump, oil reservoir, rack and gear box. The power steering pump is a vane type and delivers hydraulic pressure to operate the power steering system. The pressure relief valve in the pump controls the discharging pressure. The rotary valve in the rack and the pinion gear directs the oil from the power steering pump to one side of the rack piston. The integrated rack piston converts the hydraulic pressure to linear movement. The operating force of the rack moves the wheels through the tie rod, the tie rod end and the steering knuckle. Even though the hydraulic pressure cannot be generated, a driver can steer the vehicle without power assist but it needs very high steering force. In this case, the operating force of the steering wheel is conveyed to the pinion, and the movement of the pinion moves the rack through the pinion gear combined to the rack gear.

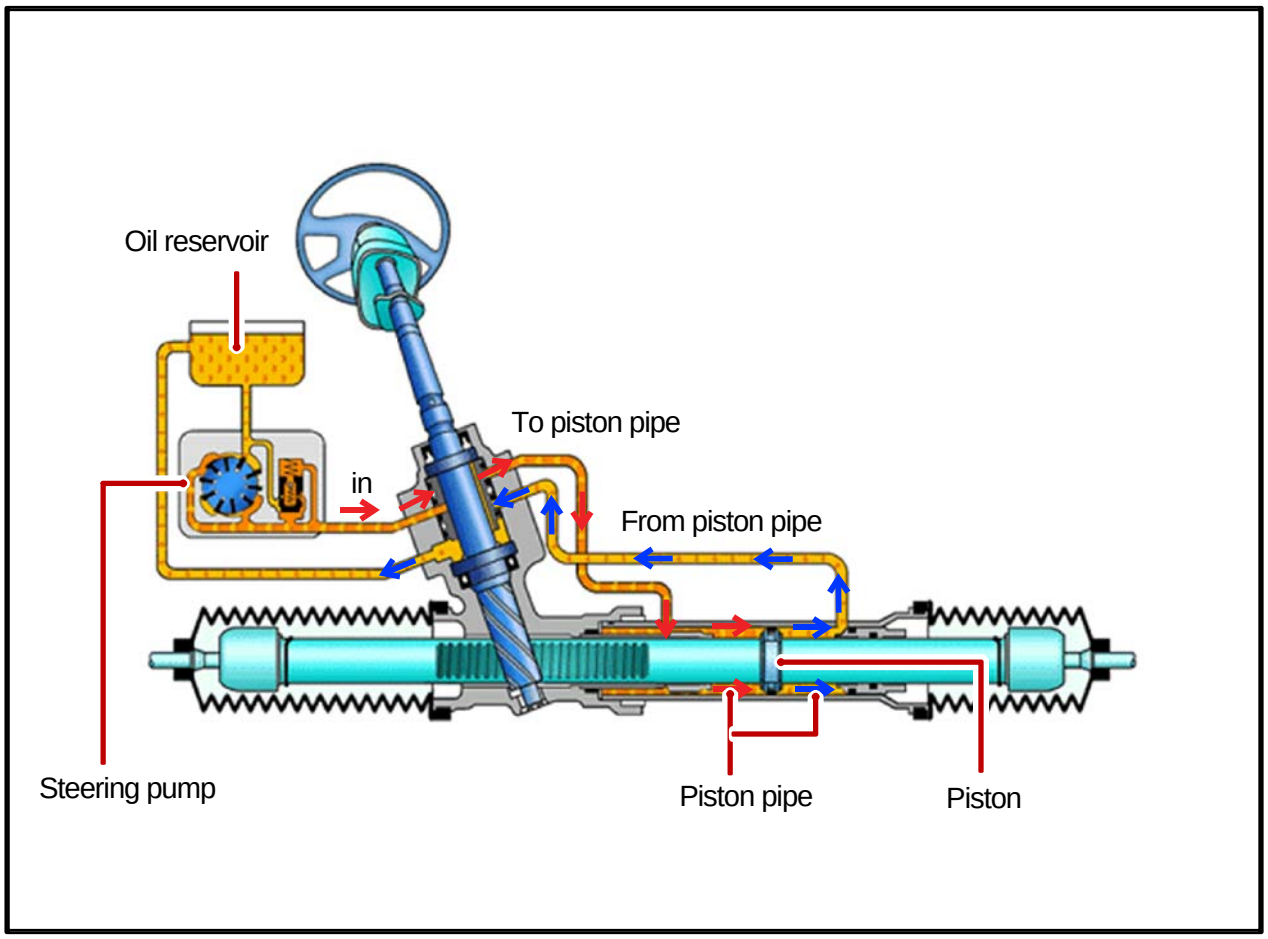
2. SYSTEM LAYOUT

The steering pump is driven by the engine power through a belt. This pump circulates the power steering oil from the reservoir -> steering pump -> oil supply pipe -> steering gear box -> oil return pipe -> reservoir to perform steering operations



Modification basis	
Application basis	
Affected VIN	

▶ Oil Flows during Right Turn



SSPS

4620-01

GENERAL INFORMATION

1. SPECIFICATIONS

Item	Item		Specification
SSPS solenoid valve	Rated voltage		DC 12 V
	Rated voltage		1.0 A
	Resistance		6.7 ±1 Ω
Power steering oil pump (with SSPS)	Operating temperature		−40℃~150℃
	Release pressure		90 bar
	Displacement		9.3 cc/rev
	Flow velocity		9.75~6 l/mn
	Pulley size		Ø115
	Pulley type		6 groove
	Housing material		Aluminium
Power steering fluid reservoir (with SSPS)	Fracture pressure		min 8kgf/㎠
	Air leakage		2 kgf/㎠×min
	Cap open torque		9.8 to 14.2 Nm
	Oil capacity		FULL 550cc
Power steering gear box (with SSPS)	Gear type		Rack & pinion type
	Gear ratio		40.245
	Fixed rack		3.78
	Gear weight		12.800 kg
	Steering angle	Inner	36.2°
		Outer	32.4°

Memo

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

The speed-sensitive power-assisted steering system can automatically adjust the boosts according to the speed changes, automatically induct the high-speed or low-speed status, and relatively adjust the reasonable steering boosts, enhance the operation precision, reduce the driving pressure of drivers. No matter for steering, parking or reversing, it becomes much easier. The adjustable safety steering column attached possesses the functions of electrically adjusting height and transverse position, has brought much more abundant and comfortable spaces for legs, and has provided the great convenience to get in or out the car.

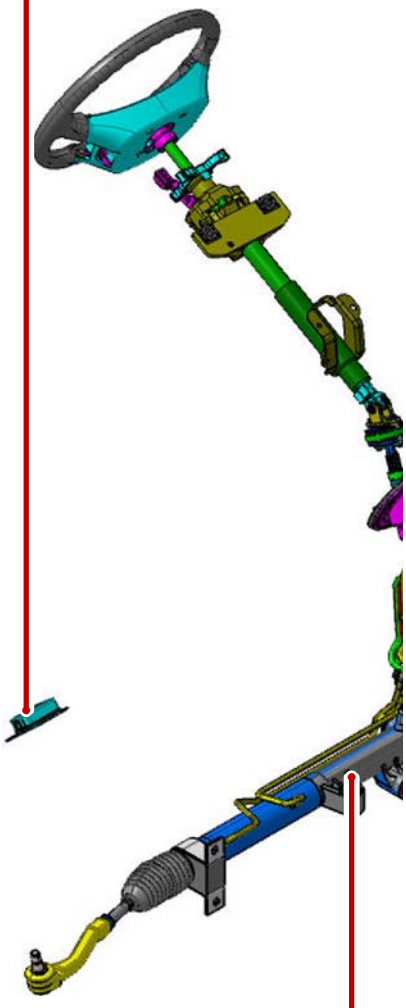
The Speed Sensitive Power Steering (SSPS) unit controls the SSPS solenoid vale in steering gear box to get proper power steering force.

2. LAYOUT

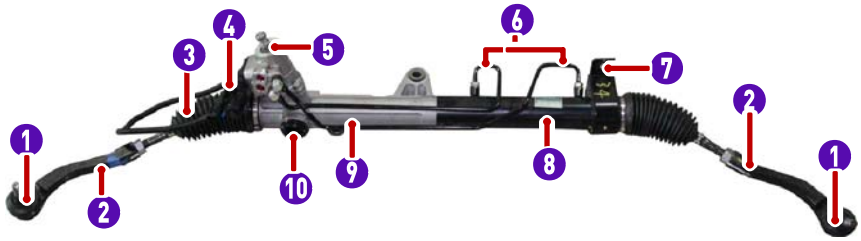
SSPS control unit

Installed view	Unit components
	

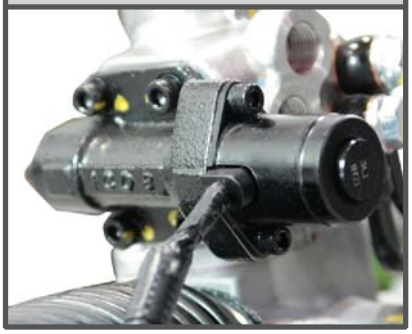
It is installed at the bottom of the ECU inside the passenger's floor mat foot protector cover and receives data related to the vehicle speed and throttle position through the CAN communication and controls the solenoid valves to obtain optimal steering force.



Power steering gearbox & solenoid valve for SSPS model



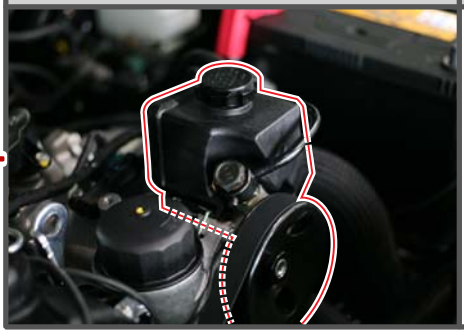
SSPS Solenoid Valve

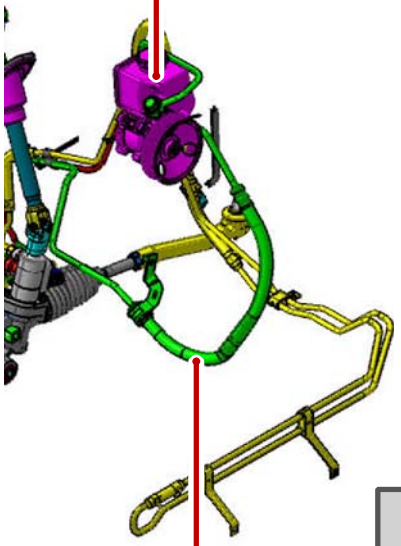


1. Tie Rod End
2. Tie Rod
3. Bellows
4. SSPS Solenoid Valve
5. Valve Assembly
6. Feed Tube
7. Mounting Bracket
8. Cylinder Tube
9. Rack Housing
10. Adjusting Plug

Modification basis	
Application basis	
Affected VIN	

Power steering pump with SSPS

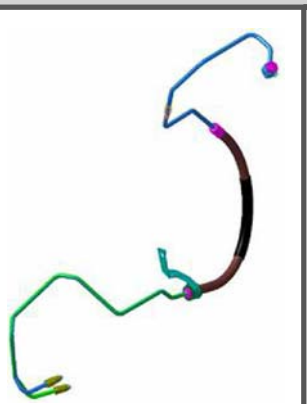
Installed view	Pump components
	

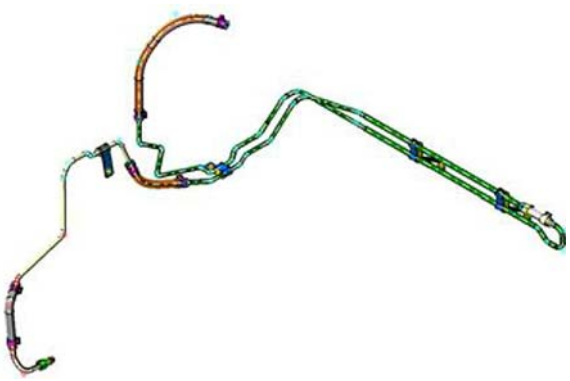


SSPS warning lamp

Comes on when SSPS system has a fault

Power steering supply hose and return hose for SSPS model

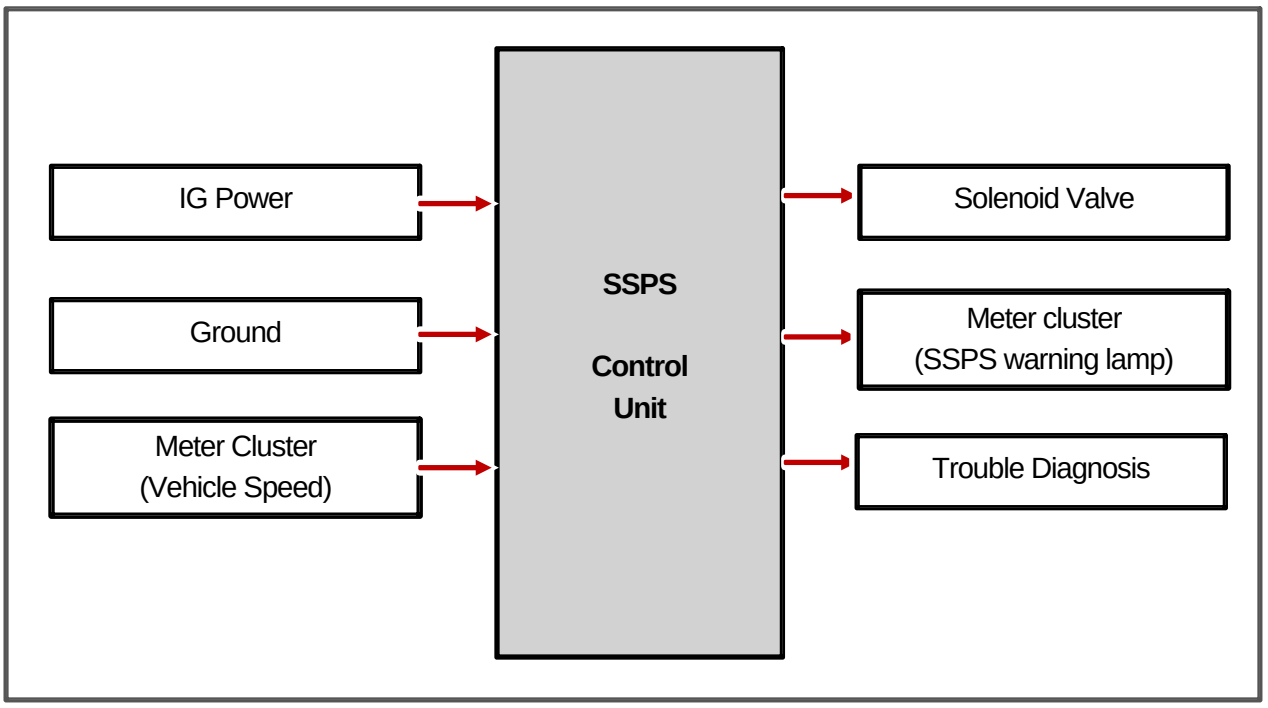




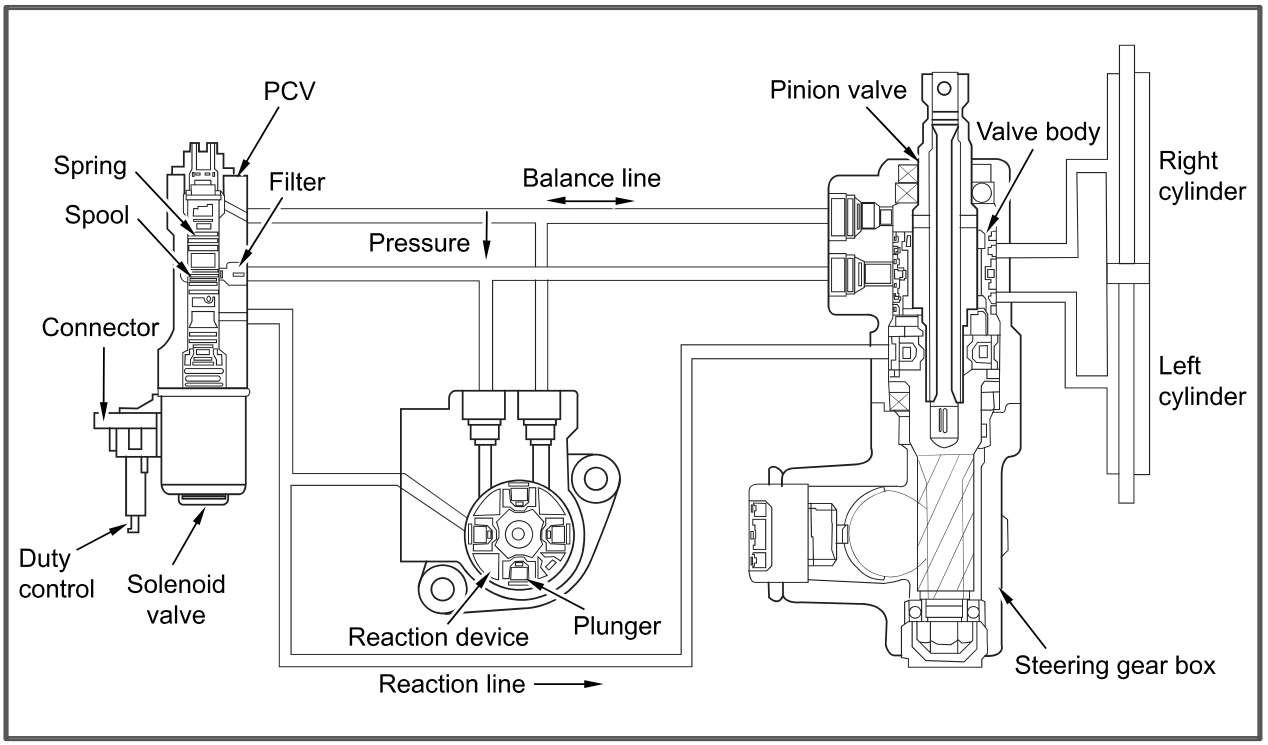
Modification basis	
Application basis	
Affected VIN	

3. HOW TO OPERATE

1) Input/Output of SSPS Control Unit



2) SSPS Configuration



Modification basis	
Application basis	
Affected VIN	

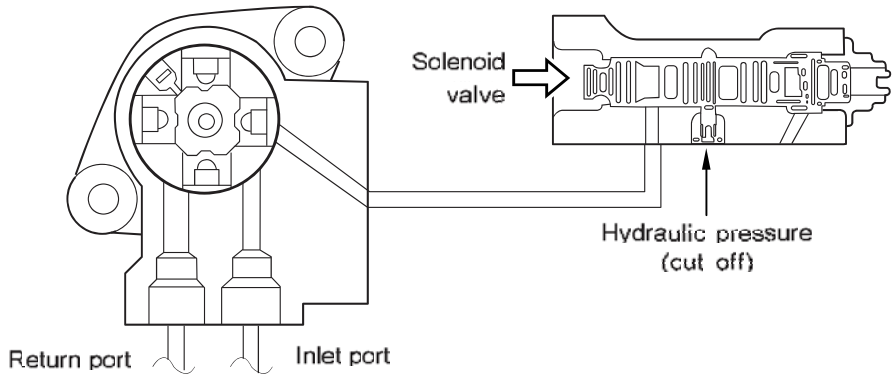
▶Components

1. **PCV (Pressure Control Valve)**
   This valve controls the hydraulic pressure supplied to reaction device by moving the spool valve according to the changes of solenoid valve.
2. **Reaction device**
   This device increases the steerability effect by binding the input shaft with supplied hydraulic pressure from PCV.
3. **Solenoid valve**
   This valve determines the valve spool position in PCV with the electric current supplied from ECPS control unit.

3) Operation of Solenoid Valve

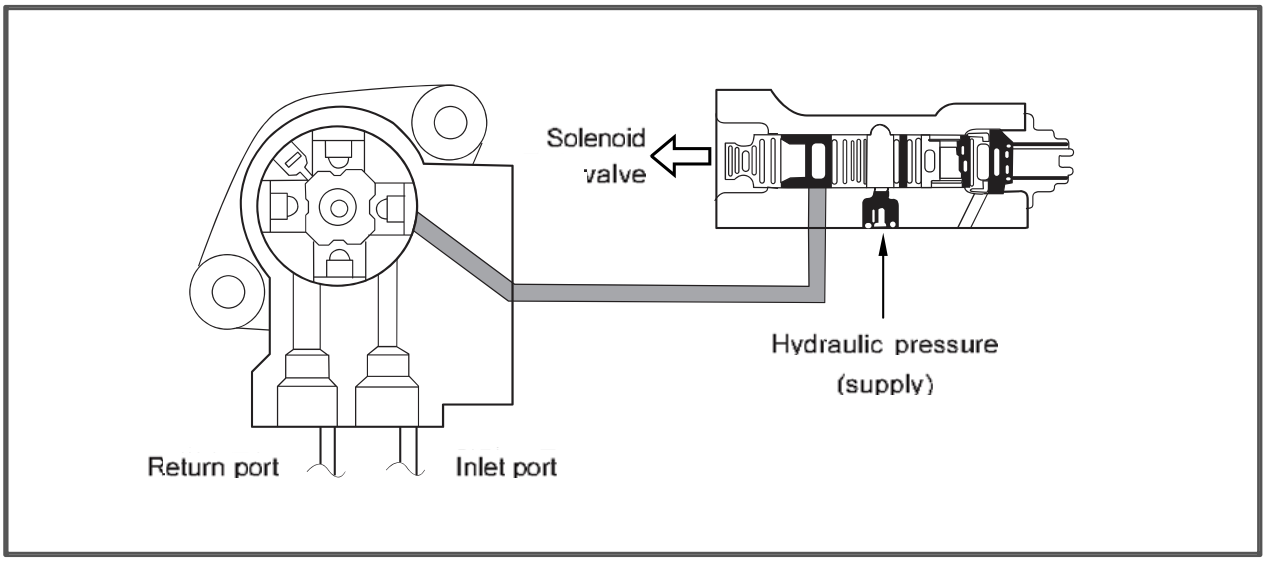
SSPS control unit controls the current to solenoid valve according to the vehicle speed. Based on this current, the solenoid valve changes the position of valve spool to control the hydraulic pressure to the reaction plunger. Accordingly, the SSPS system can get the desired steering force according to the vehicle speed.

▶During parking and low speed driving



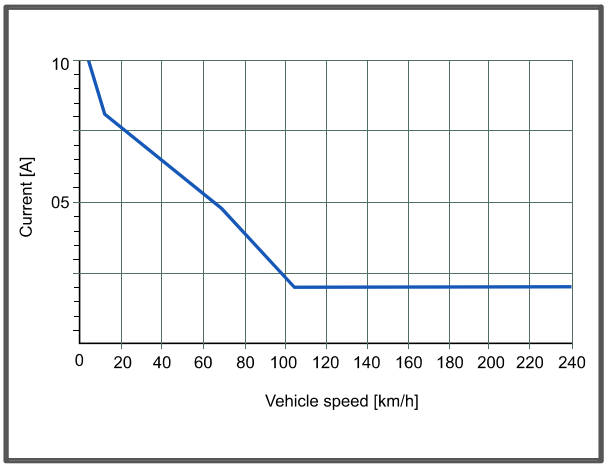
1. SSPS control unit outputs nearly maximum electrical current.
2. The solenoid rod pushes PCV spool to right side.
3. The hydraulic pressure coming from pump is not supplied to the reaction device as the spool orifice is cut off.
4. The hydraulic pressure is cut off and the manipulation of steering wheel becomes lighter.

▶ In medium and high speed driving



1. The shaft operation force of solenoid rod is reduced due to the reduction of output current from SSPS control unit.
2. The coil spring pulls the PCV spool toward solenoid valve to open it.
3. The hydraulic pressure from pump flows to pinion reaction area through orifice and applies reaction force to reaction plunger.
4. At this time, the reaction plunger transmits the reaction force to V-groove in input shaft to provide heavy steerability.

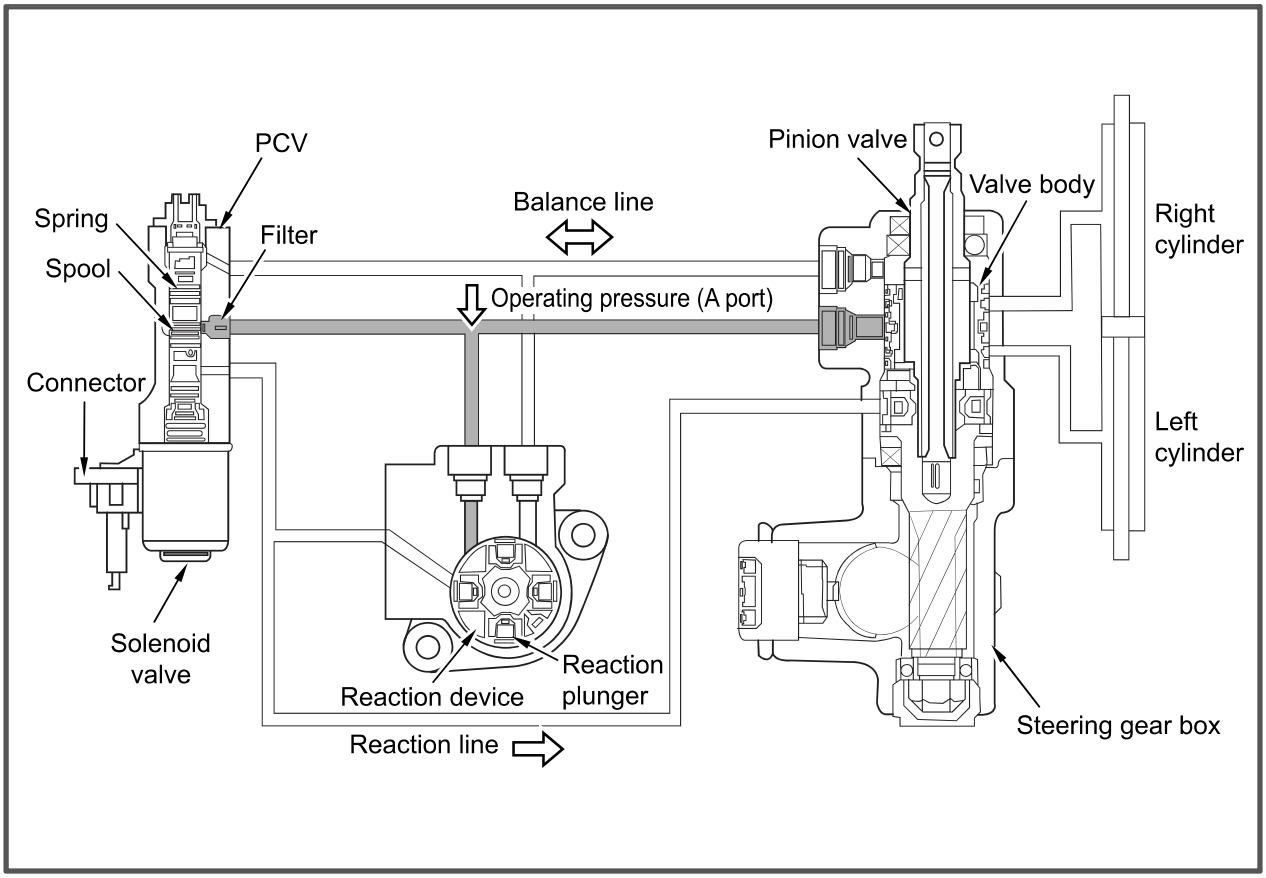
4) System Control



ECPS system, according to the vehicle speed, enables to achieve proper steering characteristics by controlling hydraulic pressure to reaction plunger located in input shaft of power steering gear box. In other words, ECPS control unit enhances the parking conveniences by controlling duty type current control. It provides heavy steerability with low current as the vehicle speed increases. And, it provides light steerability with high current as the vehicle speed decreases.

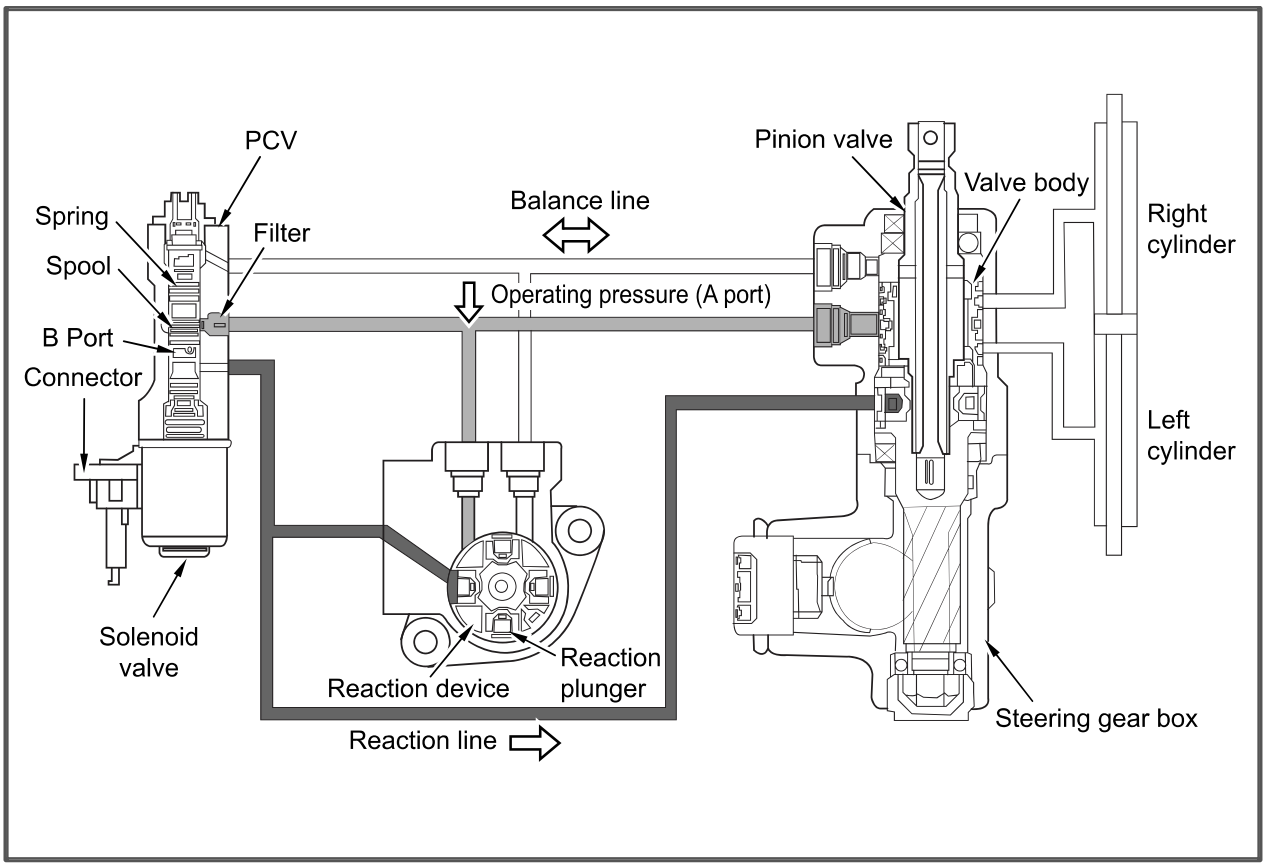
▶During parking and low speed driving

During parking and driving in low speed, the control unit supplies approx. 1 A of electric current to solenoid valve. Then, the spool located in PCV compresses the upper spring and elevates upward and, the working pressure from oil pump (A port) is not able to flow to the reaction plunger (C port). As a result, the pressing force from reaction plunger disappears and the steerability enhances.



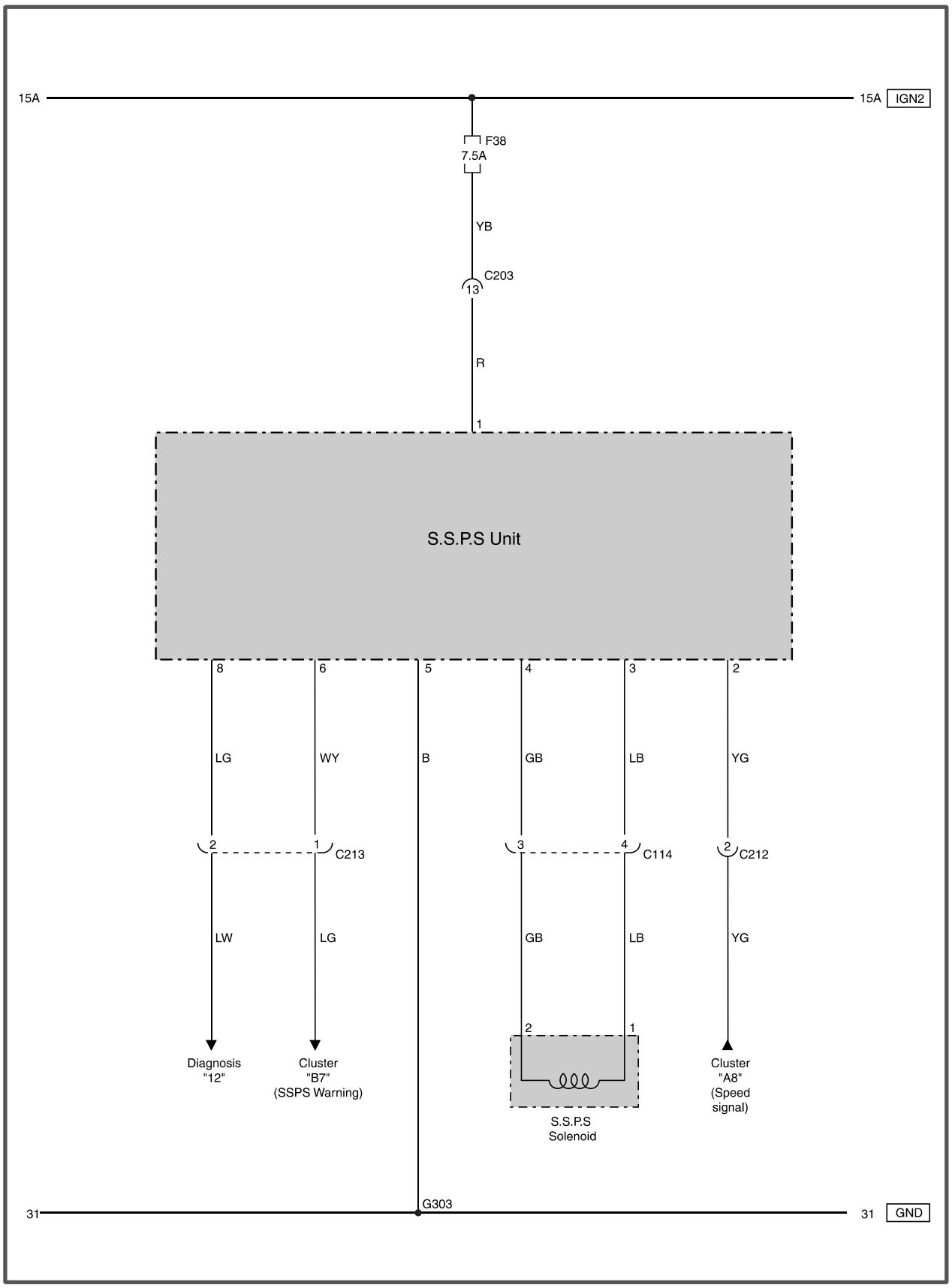
▶During high speed driving

During high speed driving, the control unit supplies weak electric current to solenoid valve. Then, the spool located PCV moves from top to bottom, and the working pressure (A port) from oil pump is applied to reaction plunger (C port) through B port. As a result, the pressing force from reaction plunger against input shaft is increased and the steerability becomes heavier.



Modification basis	
Application basis	
Affected VIN	

4. S.S.P.S (SPEED SENSITIVE POWER STEERING)



WHEEL TIRE

4170-01

GENERAL INFORMATION

1. SPECIFICATIONS

Description		Specification
Tire	16 inch	225/75R 16
	18 inch	255/60R 18
Tire inflation pressure		Front: 32 psi Rear: 32 psi (44 psi: when the vehicle is fully laden with luggage)
Wheel	16 inch	6.5J x 16
	18 inch	7.5J x 18
Balance weight	16 inch	Inner: Attachment type Outer: Clip type
	18 inch	Inner: Attachment type Outer: Attachment type
Tightening torquse of wheel bolt		127.4 ~ 156.8 Nm

2. MAJOR CHANGES

Wheel assembly		
Existing specifications		New specifications
16-inches silver	18-inches silver	18-inches hyper silver
PN: 41730-32000	PN: 41730-32200	PN: 41730-32300
		
- Added 18-inches hyper silver to wheel assembly - Wheel offset and tire size are identical with existing specifications		

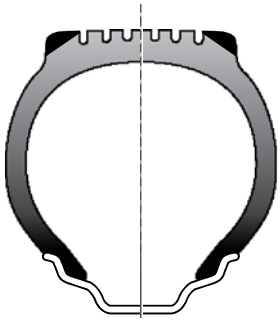
3. TROUBLE DIAGNOSIS

Problem	Possible Cause	Action
Uneven tire wear	Incorrect tire pressure	Adjust
	Unbalanced wheel	Adjust
	Improper location change of tire	Change tire location in specified interval
	Incorrect toe adjustmen	Adjust
	Incorrect wheel bearing preload adjustment	Adjust
	Malfunction of brake syste	Adjust
Tire squeal, vibration	Too low tire pressure	Adjust
	Unbalanced wheel or tire	Adjust
	Heavy vibration of wheel or tire	Uneven tire wear
	Uneven tire wear	Check and adjust
Premature tire wear	Too high tire pressure	Adjust
	Fast driving with low pressure tire	Adjust
	Overload	Adjust

Modification basis	
Application basis	
Affected VIN	

4. INSPECTION

1) Appearance Check

Symptom		Possible Cause
Wear at tread edge 		Insufficient tire inflation pressure or overload
Wear at tread center 		Excessive tire inflation pressure
Excessive wear in the outer side of the tread than in the inner side 		Excessive camber or deflection of knuckle arm
Excessive wear in the inner side of the tread than in the outer side 		Insufficient camber or deflection of knuckle arm

Symptom		Possible Cause
Blade type wear from outer side toward inner side of the tread 		Excessive toe-in, Deflection of knuckle arm, Difference in tie rod length between left and right sides
Blade type wear from inner side toward outer side of the tread 		Excessive toe-in, Deflection of knuckle arm, Difference in tie rod length between left and right sides
Corrugation wear of tread 		Poor wheel balance, Loose wheel bearing, poor wheel alignment

Modification basis	
Application basis	
Affected VIN	

2) Typical Inspection

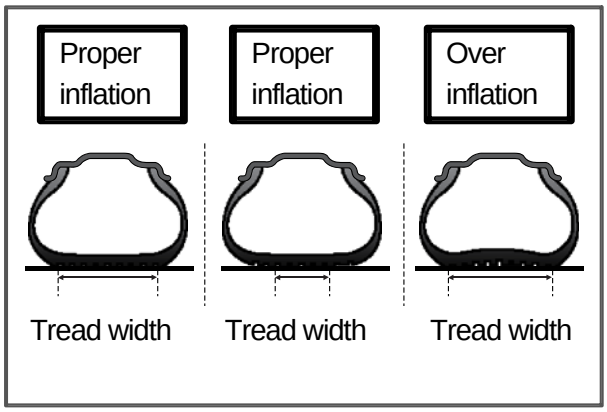
1. **Tread**
   Inspect the tread condition on the tire surface and various damages resulting from the foreign materials, crack, stone or nail etc. If there is any damage in the tire, repair or replace it.

2. **Wear limit**
   - Measure the depth of the tire tread. If the depth of the tread is below the specified value, replace the tire

Wear limit	1.6 mm

- You can see the protruded part in the groove at the point with mark "▲", which is the indicator of the tread wear limit.
- The limit of the tread wear for all season tires are 1.6 mm, which is the same as the general tires, but the wear limit mark is indicated as '↓'.

CAUTION
- Higher than recommended pressure can cause hard ride, tire bruising or damage and rapid tread wear at the center of the tire.
- Excessive tire wear over the limit of the tread wear (1.6 mm) can cause lower sliding friction due to longer braking distance, easy tire burst by foreign materials, tire hydroplaning, and tough brake and steering wheel handling.



3. **Tire inflation pressure**

- Tire inflation pressure

Specified value	32 psi

- Check the tire inflation pressure by inspecting the tread width.

CAUTION

Maintaining the specified tire ressure is essential for comfortable riding, driving safety, and long tire life. Incorrect inflation pressures will increase tire wear and will impair safety, vehicle handling, comfortable driving and fuel economy. Always make sure that the tire inflation pressure is correct.

4. **Wheel runout**

If wheel runout or tire runout is excessive, it could result in abnormal wear of the tire. Measure the runout with a dial gauge.

- Measure the dial runout and lateral runout on both the inboard and outboard rim flanges.

Specified value	2.66 mm

- Measure free radial runout on the tire tread.

Specified value	2.03 mm

CAUTION

- If any measurement exceeds the above specifications, replace the applicable tires or wheels

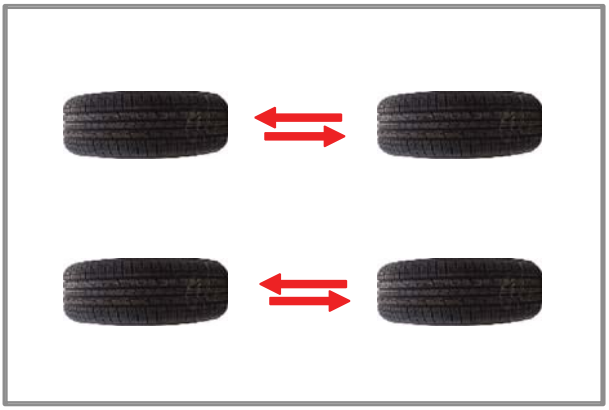
Modification basis	
Application basis	
Affected VIN	

5. **Wheel balance**

- Check the wheel balance when the wheel is unbalanced or the tire is repaired.
  The total weight of the wheel weight
- should not exceed 150 g.
  Ensure that the balance weight installed is
- not projected over 3mm from the wheel surface.
  Use the specified aluminum wheel balance
- weights for aluminum wheels.
  Weight balance can be added by 5 g.
- There are two types of weight balance,
- tape type and adhesion type.

NOTE

- Make sure to read the manual of the manufacturer thoroughly before using wheel balance tester.



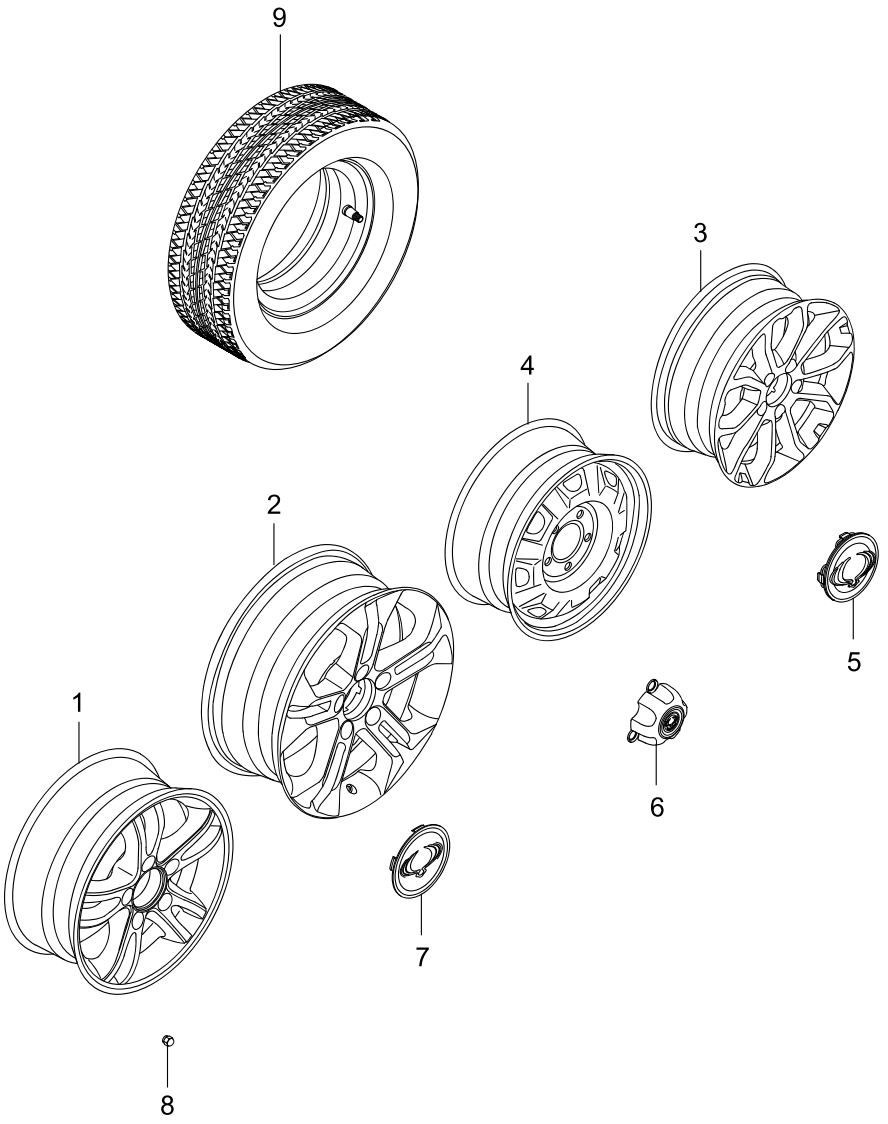
6. **Change tire location**

To avoid uneven wear of tires and to prolong tire life, inspect and rotate your tires every 5,000 km.

CAUTION

- Mixing tires could cause to lose control while driving. Be sure to use the same size and type tires of the same manufacturer on all wheels.

5. COMPONENTS



1. Alloy wheel
2. Alloy wheel
3. Alloy wheel
4. Wheel-steel
5. Cap ASSY-wheel
6. Cap ASSY-wheel
7. Cap ASSY-wheel
8. Nut

Modification basis	
Application basis	
Affected VIN	

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

A radial tire uses a cord angle of 90 degrees. That is, the cord material runs in a radial or direct line from one bead to the other across the tread. In addition, a radial tire has a belt overwrap under the tread surface to provide greater structural stability. The belt overwrap of a radial tire distortion while the radial structure enables high speed driving.

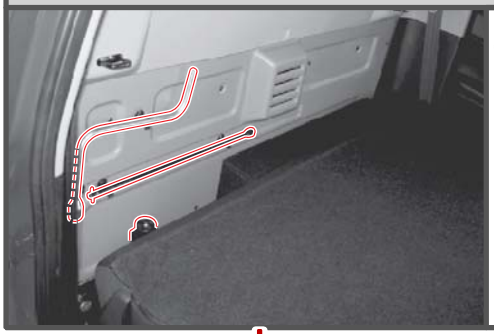
Tire supports the weight of the vehicle, reduces the impact from the road and at the same time, transmits the power to propel, brake and steer on the road. It also functions to maintain a vehicle's movement. In order to complete such tasks, a tire must be structured to be a resilient vessel of air.

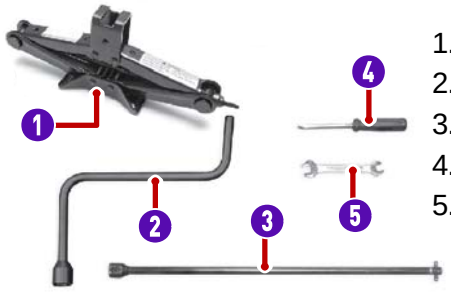
There is wear limit mark on the tire, which protrudes as a strip shape located approximately 1.6 mm from the groove bottom. This wear limit mark is not seen from the outside so there is additional "▲" mark on the shoulder to let the driver find the wear mark easily. To measure the tire groove depth, measure at any point other than the point which has a wear limit mark.

The tire is worn unevenly according to the driver's driving habit, improper servicing, low tire inflation pressure, changed tire location, etc.

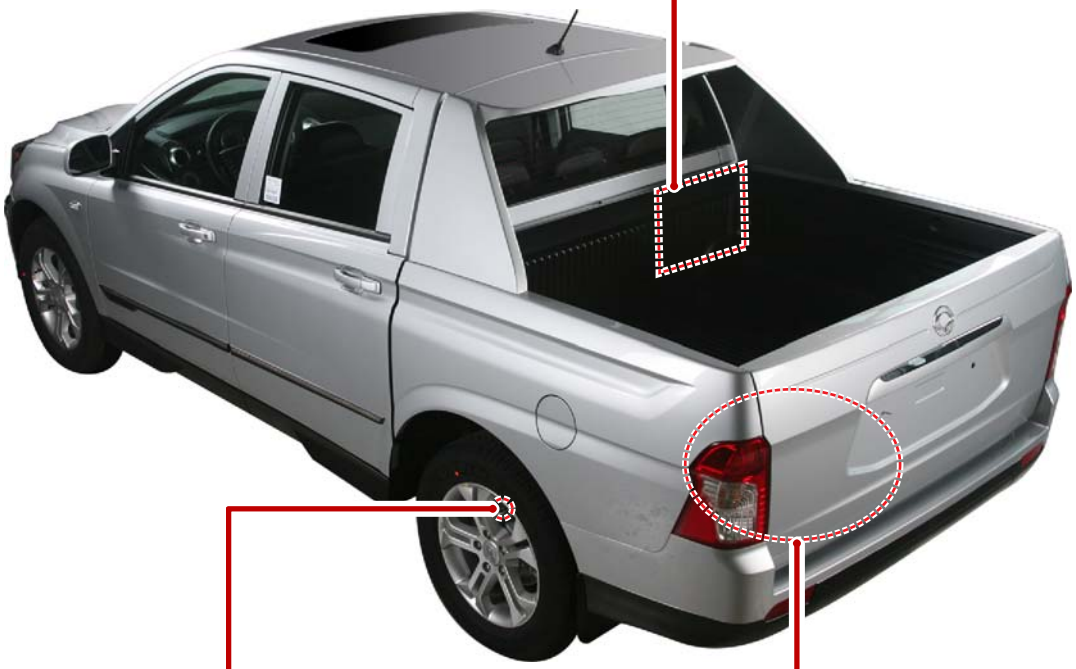
▶ Location

OVM Tools



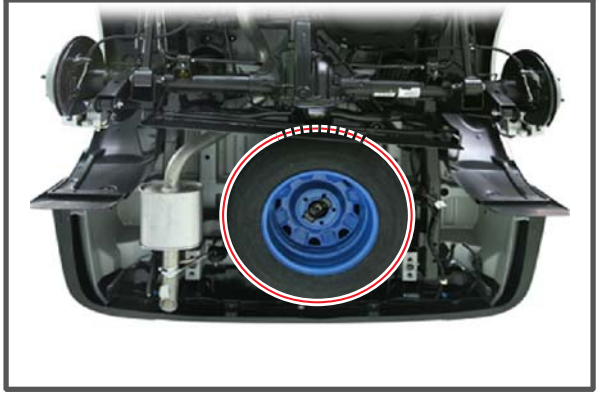


1. Jack (pantograph jack)
2. Wheel wrench
3. Jack connection
4. Driver (+, -)
5. Spanner



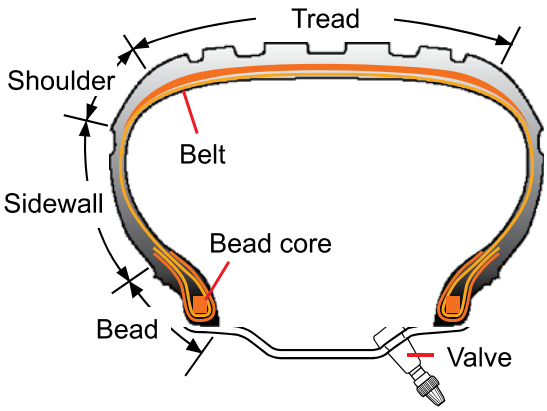
Valve insert

Spare tire



Modification basis	
Application basis	
Affected VIN	

▶ Structure of Tire



Tread

This thick layer of rubber provides the interface between the tire and the road. Wear-resistant rubber is used to protect the carcass and belt against fractures and impacts and to deliver a long driving life.

Shoulder

Located between the tread and sidewall, the shoulder rubber is the thickest so that the design must allow for the easy diffusion of heat generated within the tire while driving.

Sidewall

The part between the shoulder and bead, the flexible sidewall protects the carcass and enhances the ride. A tire's type, size, structure, pattern, manufacturing company, product name and various characters are indicated here.

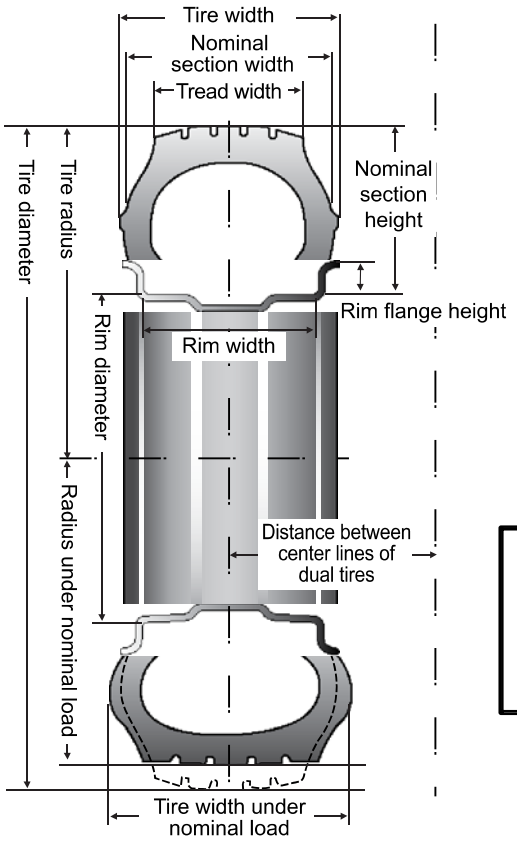
Bead

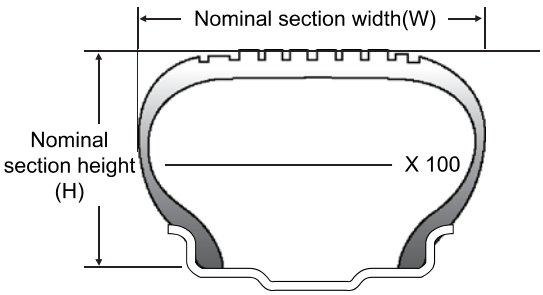
The bead attaches the tire to the rim and wraps the end of the cord fabric. Comprised of the bead wire, core, flipper and other parts, the bead is generally designed to be slightly tight around the rim so that in the case of a sudden drop in inflation pressure, the tire will not fall off the rim.

Carcass

As the most important framework of a tire, the entire inner layer of cord fabric is called the carcass. The carcass acts to support air pressure, vertical load and absorb shocks.

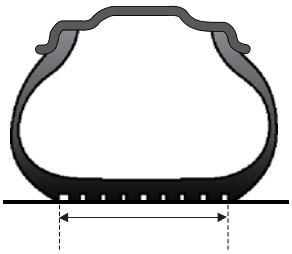
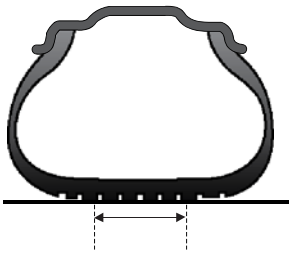
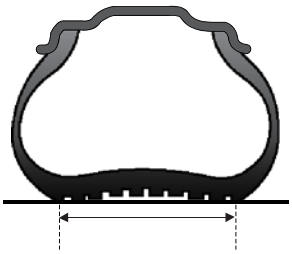
▶ Tire Unit Indication





Aspect ratio (%)
= Nominal section height (H) / Nominal section width (W)
X 100

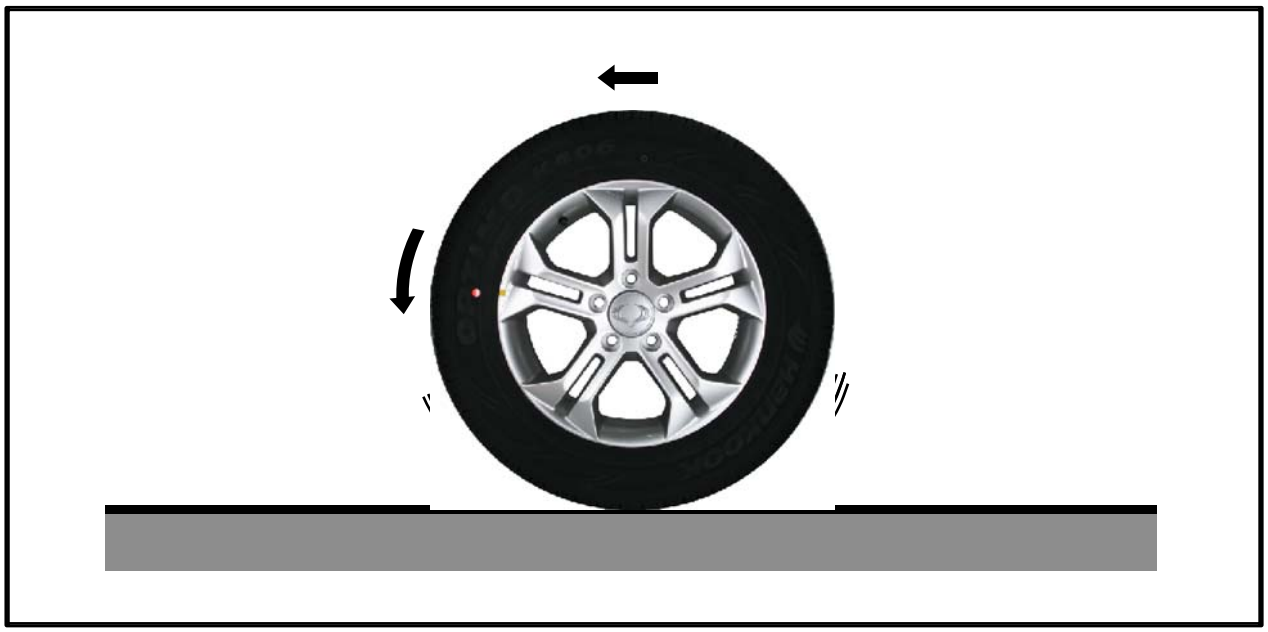
▶ Tire Inflation Pressure (32 psi)

Proper inflation pressure	Excessive inflation pressure	Low inflation pressure
 Tread width	 Tread width	 Tread width
The contact area between the ground and tire faces the tread layer completely. Thus the driving force and the braking force are optimized, and the tire is worn out evenly resulting in increased life.	The contact area between the ground and tire is not enough, so the tire is worn out unevenly and the tire is vulnerability to outside influence.	The contact area between the ground and tire is excessive, so a lot of heat is generated and the tire is worn out unevenly and abnormally.

Modification basis	
Application basis	
Affected VIN	

2. ABNORMAL TIRE SYMPTOM

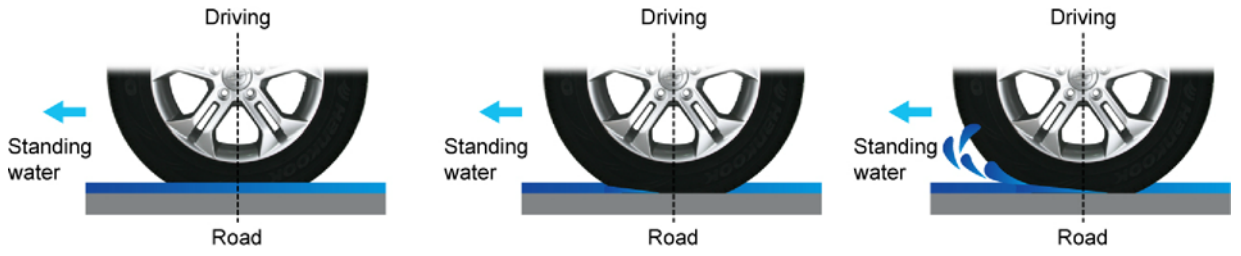
▶ **Standing Wave**



Specified tire inflation pressure	32psi

During driving, the rotating tire repeats deformation and restoring movement in is tread. This happens when the tire pressure is low in high speed driving.
However, when the wheel rotating speed is fast, the tire is deformed even before it is restored to its original shape and the trembling wave appears on the tread portion. If this symptom lasts for an extended period of time, the tire can be blown out in a short period of time.
If the standing wave symptom occurs on the tire, rubber on the tread comes off and eventually the tire can be blown out which is very dangerous. When driving at high speed, the inflation pressure should be increased to decrease heat generation due to extension and contraction motion, to decrease hydroplaning and to prevent standing wave.
To prevent this symptom, it is recommended to increase the tire pressure 10 ~ 30 % higher than the specified pressure value in high speed driving.

▶ Hydro Planing



Vehicle speed ≤ 60 km/h	Vehicle speed = 80 km/h	Vehicle speed ≥ 100 km/h
No Hydro planning	Partial Hydro planning	Full Hydro planing

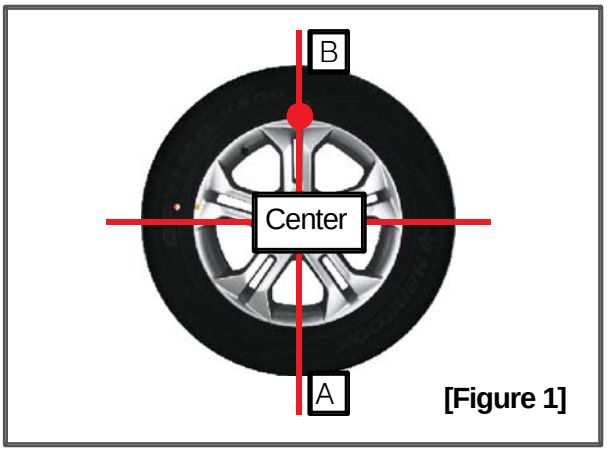
When the vehicle is driven on a road surface covered with water at high speed, tires do not contact with the road surface but rotate floating on a thin film of water.
It causes brake failure, lower traction force and losing the steering performance.
To prevent this, increase the tire inflation pressure, use tires with leaf shape tread which is not worn.
However, it is a best measure to drive slowly.

Modification basis	
Application basis	
Affected VIN	

3. WHEEL BALANCE

If weight is not equally distributed around the wheel, unbalance centrifugal force by the wheel rotation produces vibration. As the centrifugal force is produced proportional to the square of the rotating speed, the wheel weight should be balanced even at high speed. There are two types of the tire and wheel balancing: static and dynamic. Abnormal vibration may also occur due to unbalanced rigidity or size of tires.

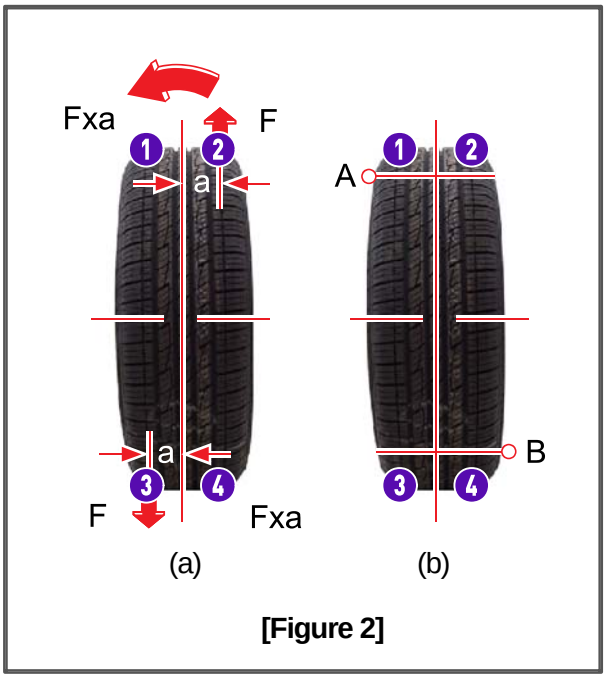
▶ Static Balance



[Figure 1]

When the free rotation of the wheel is allowed, the heavier part is stopped on the bottom if the wheel weight is unbalanced and this is called "Static Unbalance". Also, the state at which tire's stop position is not same is called "Static Balance" when the wheel is rotated again. If the part A is heavier as shown in the figure 1, add the balance weight of a weight corresponding to unbalanced weight from B to A to maintain the static balance. If the static balance is not maintained, tramping, up and down vibration of the wheels, occurs.

▶ Dynamic Balance



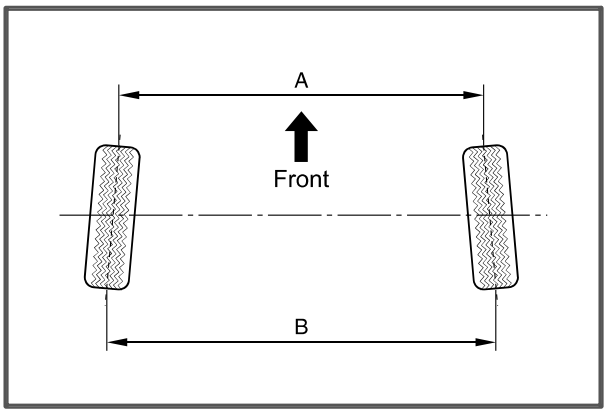
[Figure 2]

The static unbalance of the wheel creates the vibration in the vertical direction, but the dynamic unbalance creates the vibration in the lateral direction. As shown in the figure 2 (a), if two parts, (2) and (3), are heavier when the wheels are under the static balance condition, dynamic unbalance is created, resulting in shimmy, left and right vibration of the wheels, and the torque Fxa is applied in the axial direction. To correct the dynamic unbalance, add the balance weight of a same weight for two points of the circumference of the rim, A and B, as shown in the figure 2 (b), and apply the torque in the opposite direction to the torque Fxa to offset in order to ensure smooth rotation of the wheel.

4. WHEEL ALIGNMENT

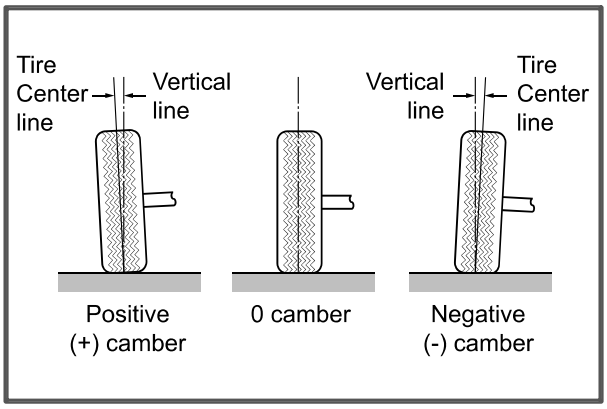
Wheel alignment consists of adjusting the angles of the wheels so that they are parallel to each other and perpendicular to the ground, thus maximizing tire life and ensures straight and true tracking along a straight and level road.

▶Toe-in



In automotive engineering, toe, also known as tracking, is the symmetric angle that each wheel makes with the longitudinal axis of the vehicle, as a function of static geometry, and kinematic and compliant effects. This can be contrasted with steer, which is the anti-symmetric angle, i.e. both wheels point to the left or right, in parallel (roughly). Positive toe, or toe in, is the front of the wheel pointing in towards the center line of the vehicle. Negative toe, or toe out, is the front of the wheel pointing away from the center line of the vehicle. Toe can be measured in linear units, at the front of the tire, or as an angular deflection.

▶Camber

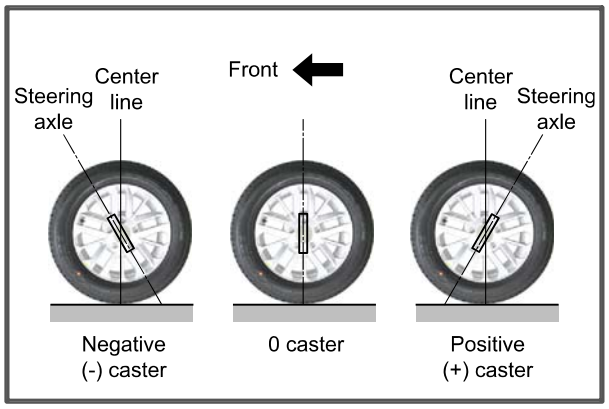


Camber is the angle made by the wheels of a vehicle; specifically, it is the angle between the vertical axis of the wheels used for steering and the vertical axis of the vehicle when viewed from the front or rear. It is used in the design of steering and suspension. If the top of the wheel is farther out than the bottom (that is, away from the axle), it is called positive camber; if the bottom of the wheel is farther out than the top, it is called negative camber.

Camber angle alters the handling qualities of a particular suspension design; in particular, negative camber improves grip when cornering. This is because it places the tire at a better angle to the road, transmitting the forces through the vertical plane of the tire rather than through a shear force across it. Another reason for negative camber is that a rubber tire tends to roll on itself while cornering. Negative camber can also be caused by excessive weight on the front wheels. This is commonly seen on modified cars with larger engines than standard; the weight of the modified engine can make the wheels negatively camber. The inside edge of the contact patch would begin to lift off of the ground if the tire had zero camber, reducing the area of the contact patch. This effect is compensated for by applying negative camber, maximizing the contact patch area. Note that this is only true for the outside tire during the turn; the inside tire would benefit most from positive camber.

Modification basis	
Application basis	
Affected VIN	

▶Caster

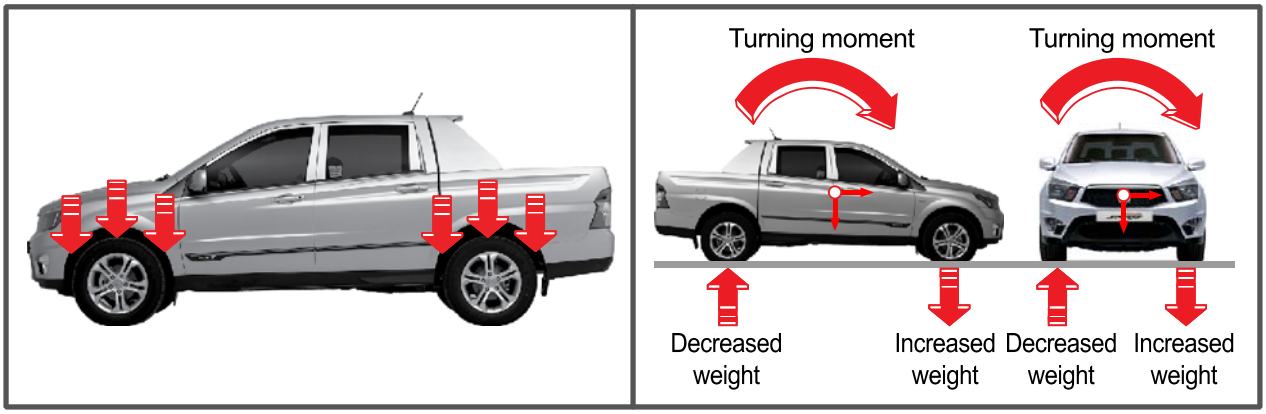


Caster is the angle to which the steering pivot axis is tilted forward or rearward from vertical, as viewed from the side. If the pivot axis is tilted backward (that is, the top pivot is positioned farther rearward than the bottom pivot), then the caster is positive; if it's tilted forward, then the caster is negative.

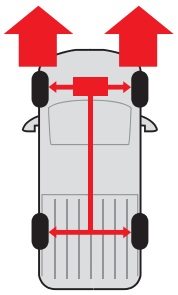
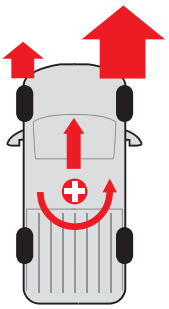
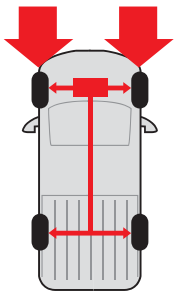
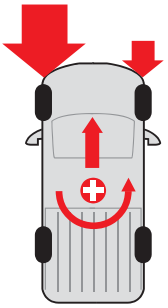
Positive caster tends to straighten the wheel when the vehicle is traveling forward, and thus is used to enhance straight-line stability. The mechanism that causes this tendency is clearly illustrated by the castering front wheels of a vehicle. The steering axis of a vehicle wheel is set forward of where the wheel contacts the ground. As the vehicle is driving forward, the steering axis pulls the wheel along, and since the wheel drags along the ground, it falls directly in line behind the steering axis. The force that causes the wheel to follow the steering axis is proportional to the distance between the steering axis and the wheel-to-ground contact patch-the greater the distance, the greater the force. This distance is referred to as "trail."

5. FUNCTIONS OF TIRE

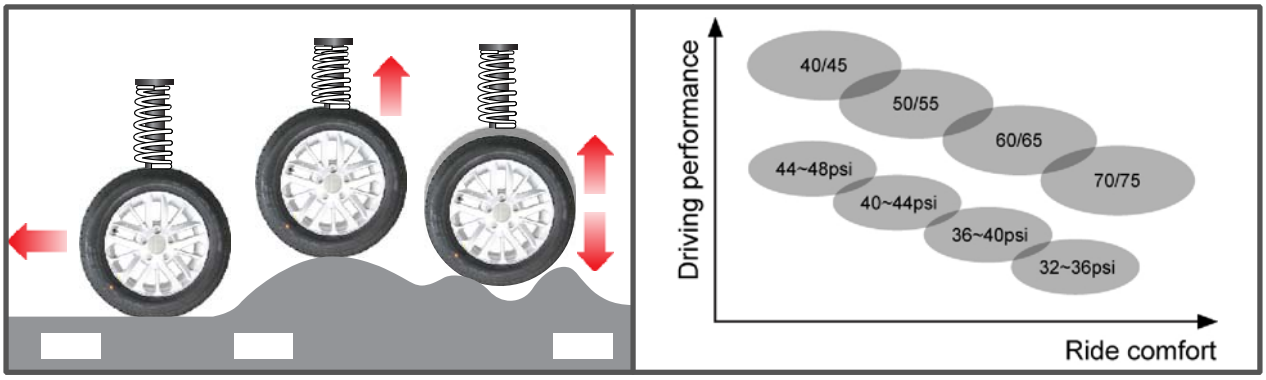
▶ Supporting the Vehicle Weight



▶ Transferring the Driving Force & Braking Force to Road

	Even friction coefficient road	Uneven friction coefficient road
Driving Force		
Braking Force		

▶ Supporting the Vehicle Weight



Modification basis	
Application basis	
Affected VIN	

A/C ASSEMBLY

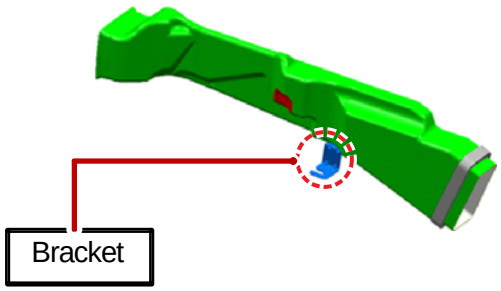
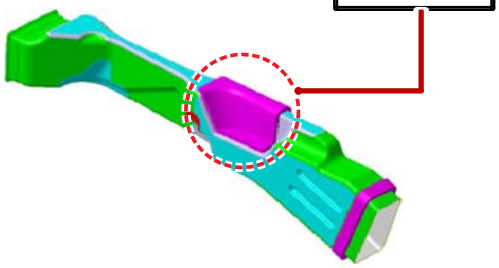
6810-01

GENERAL INFORMATION

1. SPECIFICATIONS

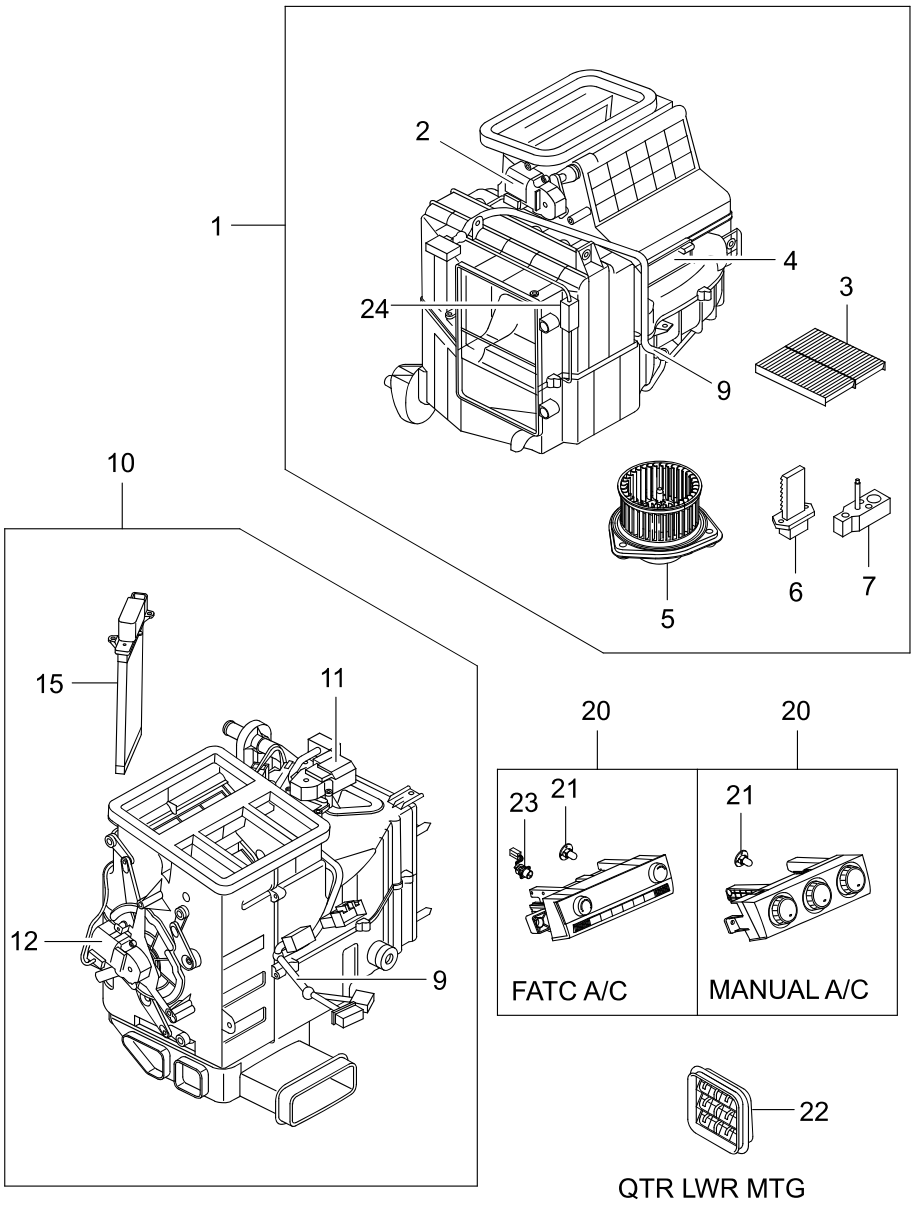
Description			Specification
Heater	Core size (mm²)		200 x 165.5 x 25
	Capacity (kcal/h)		4,700
Evaporator	Core size (mm²)		254.8 x 196.7 x 60
	Capacity (kcal/h)		4,700
Blower	Supplied power (W)		240 + 10% Max (at12V)
	Fan speed (rpm)		2900 ± 200
	Supply voltage (V)		12.0
PTC	Supply power (W)		900~1,050
Compressor	Capacity (cc/rev)		170
	Diameter of pulley (mm)		120
	Max. speed (rpm)		8,000
	Supply voltage (V)		12.0
	Power consumption (A)		2.2
	Discharge pressure (kgf/cm²G)		8~10
Power transistor	Supply voltage (V)		12.0
	Operating temperature (℃)		-30℃~60℃
	Resistance	Hi-Low (Ω)	2.0 Ω ± 10%
		Hi-ML (Ω)	0.9 Ω ± 10%
		Hi-MH (Ω)	0.4 Ω ± 10%

2. MAJOR CHANGES

Console rear duct	
Old  	New 
Console rear duct bracket removed and upper part's appearance changed due to changed cup holder/poam pad used	

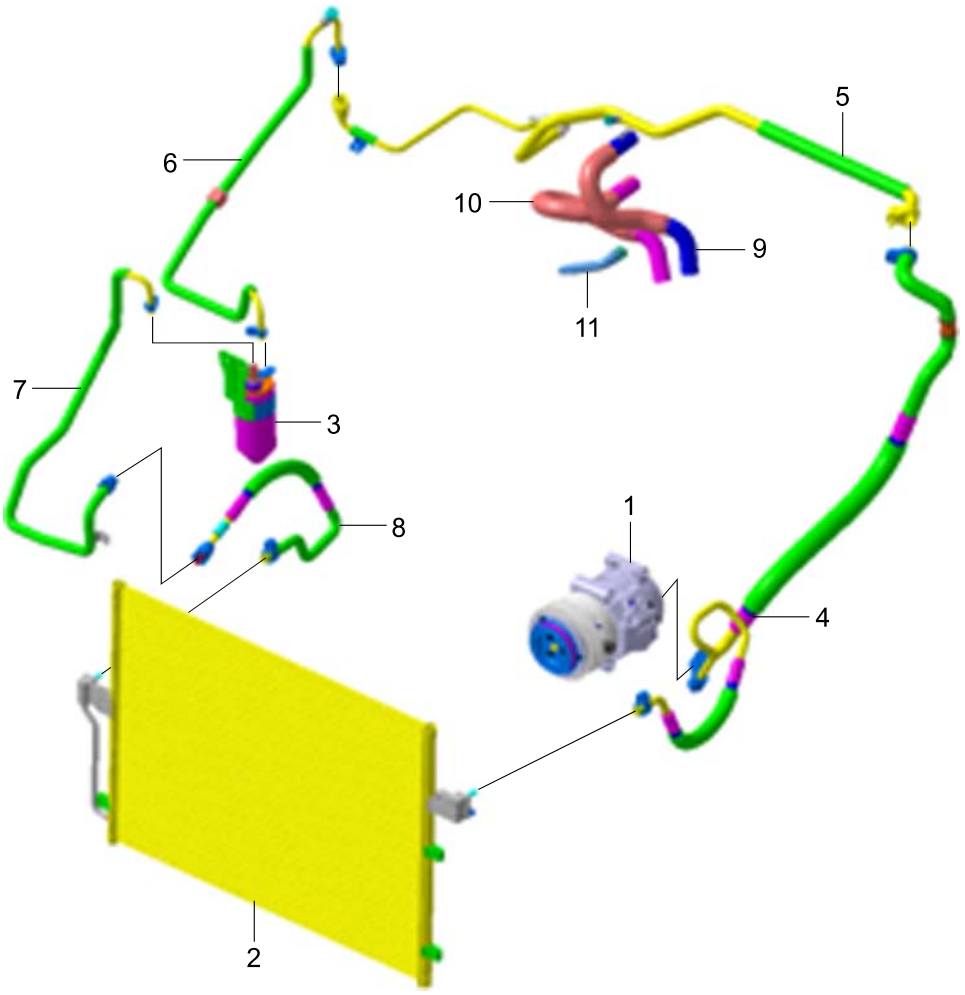
Modification basis	
Application basis	
Affected VIN	

3. COMPONENTS



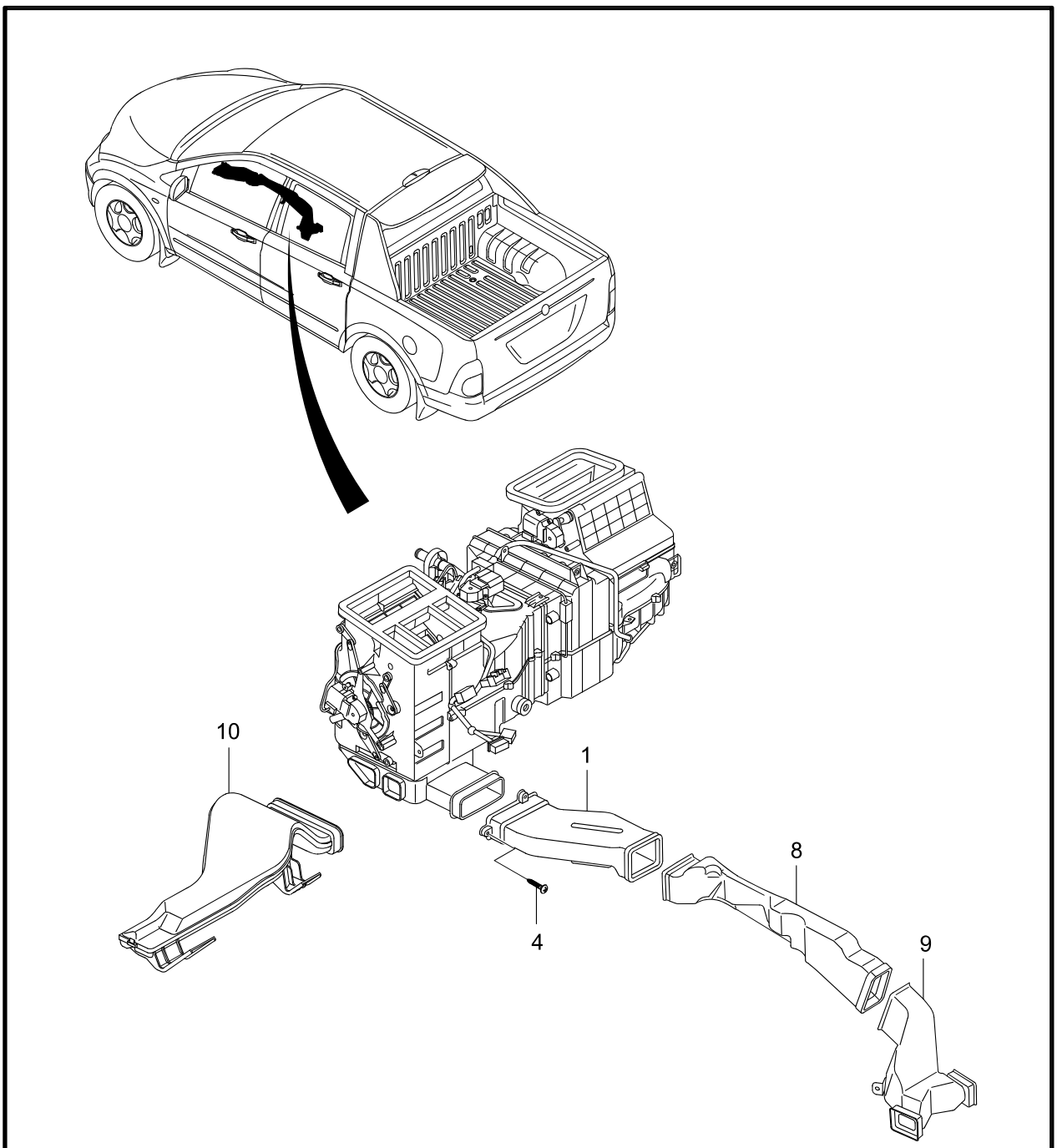
1. Blower and evaporator assembly
2. Actuator assembly - Intake
3. Air filter assembly
4. Cover - Air filter
5. Blower motor assembly
6. Resistor
7. Expansion valve assembly
9. Wiring assembly - Heater & evaporator
10. Heater assembly
11. Actuator assembly - Temperature
12. Actuator assembly - Mode
15. Heater assembly - PTC
20. Control assembly - Heater and A/C control
21. Bulb
22. Insert assembly - Ventilation
23. Sensor assembly - Humid and Incar
24. Sensor assembly - Intake

Modification basis	
Application basis	
Affected VIN	



1. Compressor Assy-A/CON
2. Condenser Assy
3. Receiver Drier & Brkt Assy
4. Hose Assy-Discharge & Suction
5. Pipe Assy-Joint
6. Pipe Assy-Liquid No1
7. Pipe Assy-Liguid No2
8. Hose Assy-Liguid
9. Hose Assy-Heater Inlet
10. Hose Assy-Heater Outlet
11. Hose-Drain

Modification basis	
Application basis	
Affected VIN	



1. Duct assembly - Console front
4. Screw
8. Duct assembly - Console rear
9. Duct assembly - Console foot
10. Duct assembly - Foot

Modification basis	
Application basis	
Affected VIN	

4. TROUBLESHOOTING

1) Overview

The FATC has a self-diagnosis function that can diagnose the system by itself. Before checking a component, be sure to check the fault code by using the self-diagnosis function. The self-diagnosis consists of 6 steps. The temperature control dial (step 2 to 5) and fan speed dial (step 6) are used to enter each step of the self-diagnosis. The 6 steps of the self-diagnosis are:

▶ Step 1

- The VFD and all LED segments are checked for proper illumination.

▶ Step 2

- The sensors and air mix door are checked for proper operation.

Code	Malfunction	Remark	Code	Malfunction	Remark
0	VDF segments are OK		5	Defective sun sensor	
1	Defective ambient temperature sensor		6	Check air mix door	
2	Defective interior temperature sensor		7	-	
3	Defective water temperature sensor		8	-	
4	Defective intake sensor		9	-	

▶ Step 3

- The position and condition of the air source door and mode door are checked.

Code	Malfunction	Remark	Code	Malfunction	Remark
1	VENT		6	DEF	
2	B/L		7	FRE	
3	Mix Cool		8	20% FRE	
4	FOOT		9	REC	
5	D/F		0	All door OK	

▶ Step 4

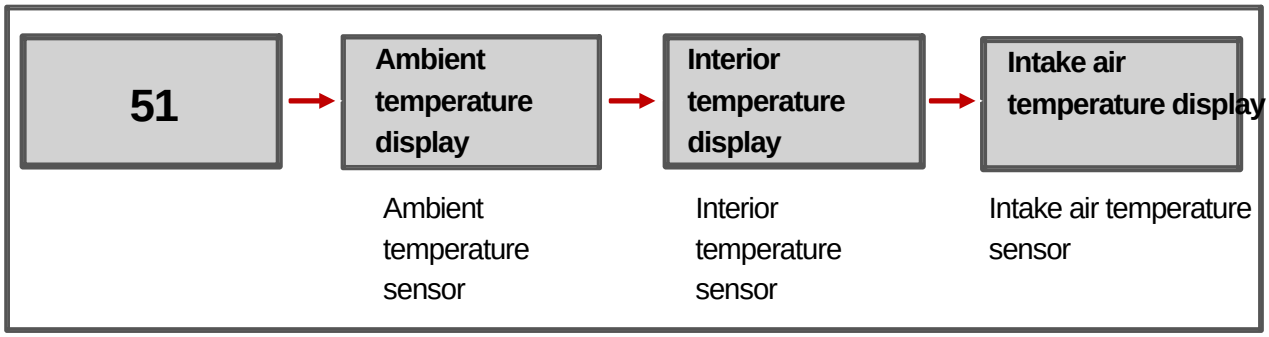
- The actuator door position, fan speed and compressor operation are checked. Pressing the defroster switch after entering step 4 changes the diagnosis mode as follows: 41 -> 42 -> 43 -> 44 -> 45 -> 46 -> 41.

Displayed Number	41	42	43	44	45	46
Mode door	VENT	B/L	B/L	FOOT	D/F	DEF
Interior/Ambient door	REC	REC	20%FRE	FRE	FRE	FRE
Air mix door	F/COOL	F/COOL	F/HOT	F/HOT	F/HOT	F/HOT
Blower	4.5 V	10.5 V	8.5 V	8.5 V	8.5 V	MAX
Compressor	ON	ON	OFF	OFF	ON	ON

Modification basis	
Application basis	
Affected VIN	

▶ Step 5

- You can check that the temperature value from each temperature sensor is displayed properly in this step. Pressing the defroster switch changes the temperature value that appears on the display in the order as follows:



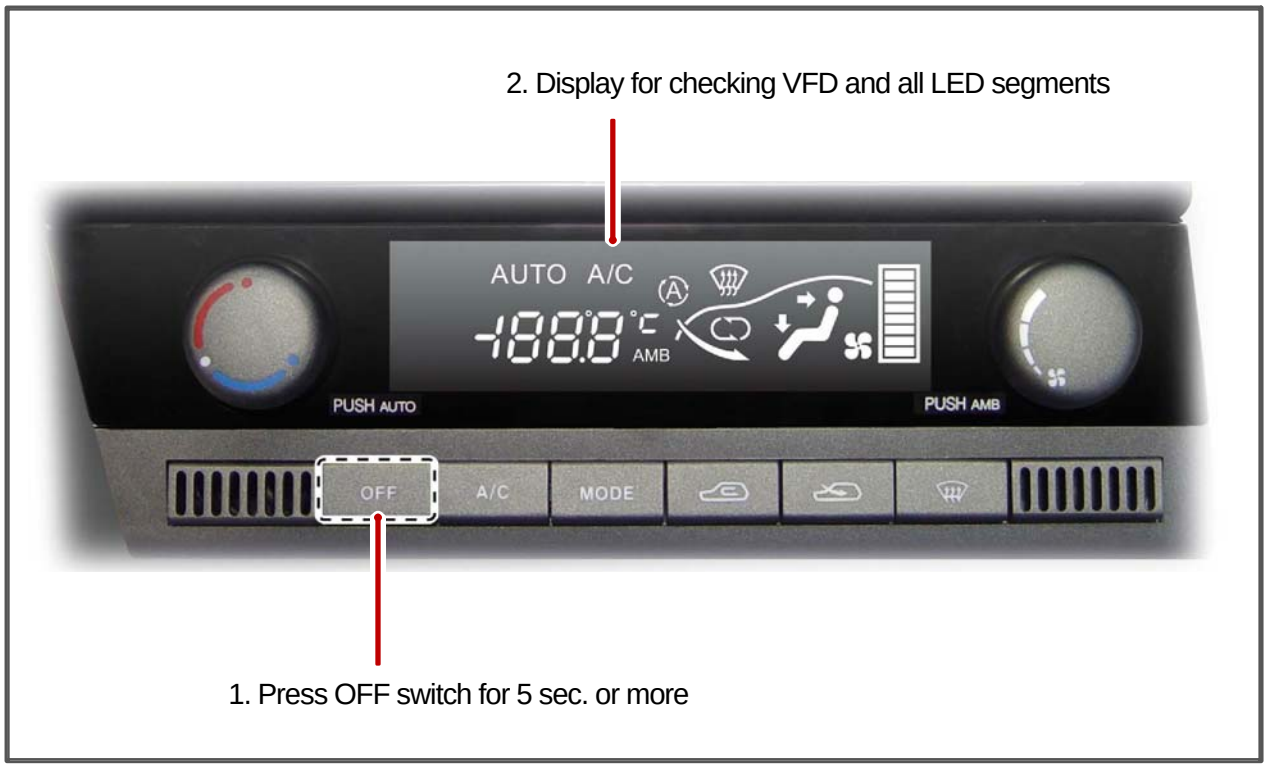
▶ Step 6

- To enter the step 6 from 5, turn the fan speed dial lightly toward the right not using the temperature control dial. In this step, you can decrease or increase by up to 3 degrees from the temperature set on the A/C controller.

2) Self-diagnosis step

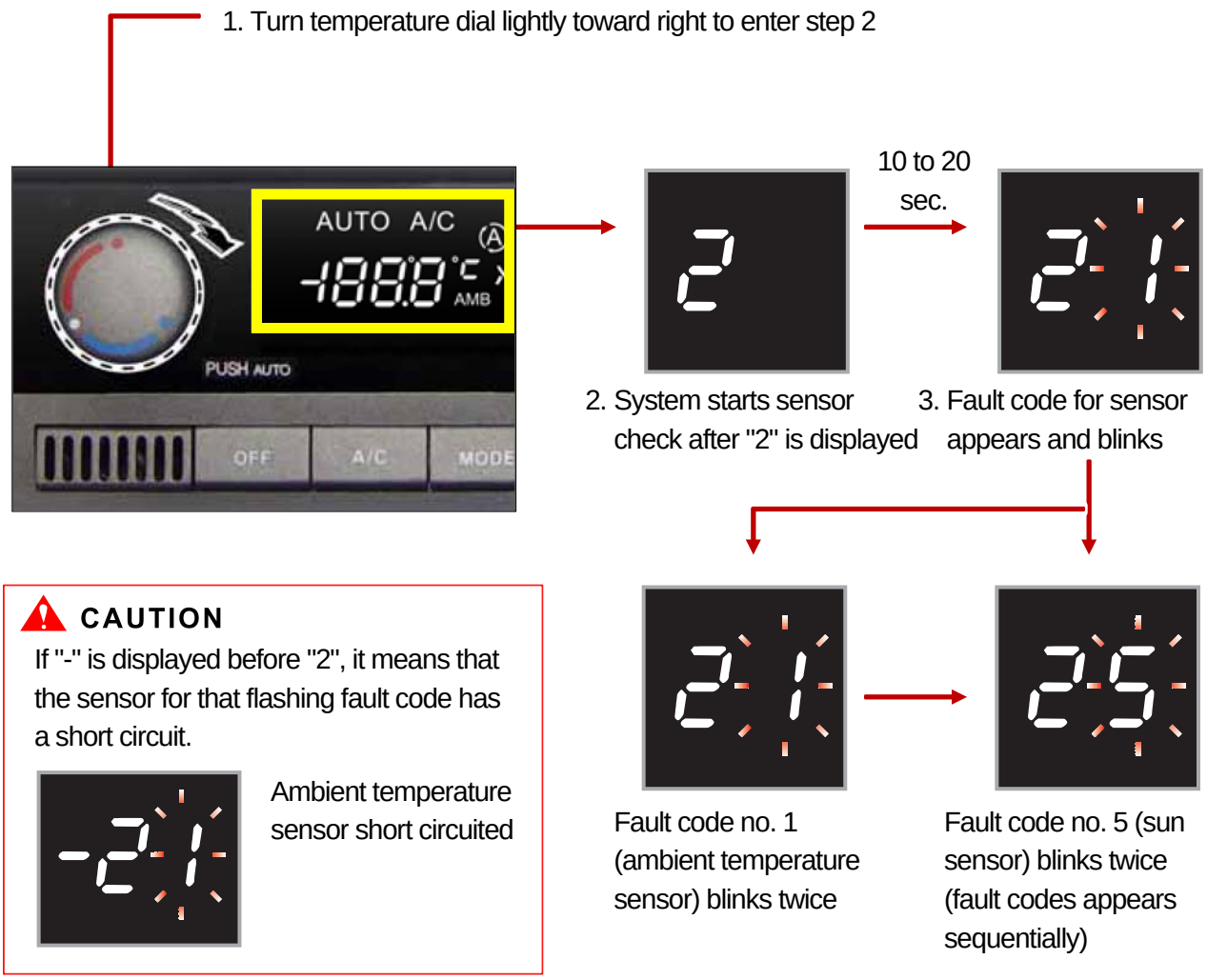
(1) Step 1

Turn the ignition ON and press the OFF switch for 5 sec. or more within 10 sec.
Then the first step of the self-diagnosis is started as shown in the below figure.



(2) Step 2

The sensors and air mix door are checked for proper operation in this step. When the step 2 is started, the number "2", which indicates that the system is in the step 2, apprears on the display and the check for sensors is performed. Once the check is done (for 10 to 20 sec.), the one digit number between 0 and 8 is added behind "2". "20" means there is no fault code. For the meaning of the rest of the numbers, refer to the description below.



CAUTION

If "-" is displayed before "2", it means that the sensor for that flashing fault code has a short circuit.

Ambient temperature sensor short circuited

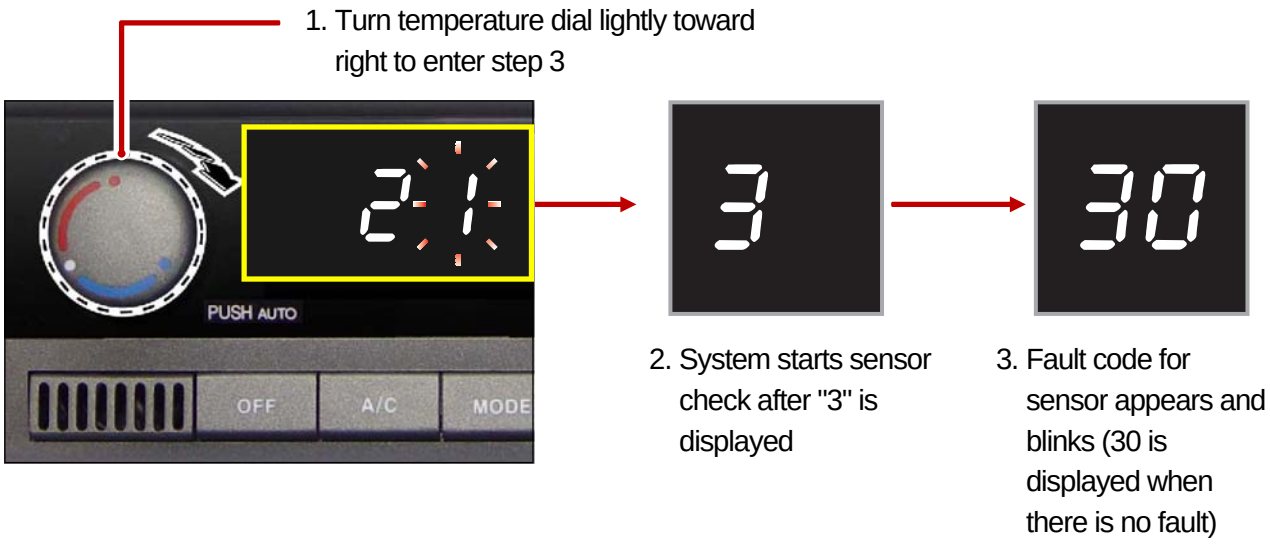
Refer to the following table for the meaning of the fault code.

Code	Malfunction	Remark	Code	Malfunction	Remark
0	VDF segments are OK		5	Defective sun sensor	
1	Defective ambient temperature sensor		6	Check Air mix door	
2	Defective interior temperature sensor		7	-	
3	Defective water temperature sensor		8	-	
4	Defective intake sensor		9	-	

Modification basis	
Application basis	
Affected VIN	

(3) Step 3

In this step, you can check the position and condition of the air source door and mode door. To start step 3, turn the temperature control dial lightly toward the right and confirm that the number 3 appears on the display. It takes several tens of seconds to finish the check. If there is no fault code, "30" is displayed. And if there is a malfunction, the corresponding fault code is added as described in the step 2.

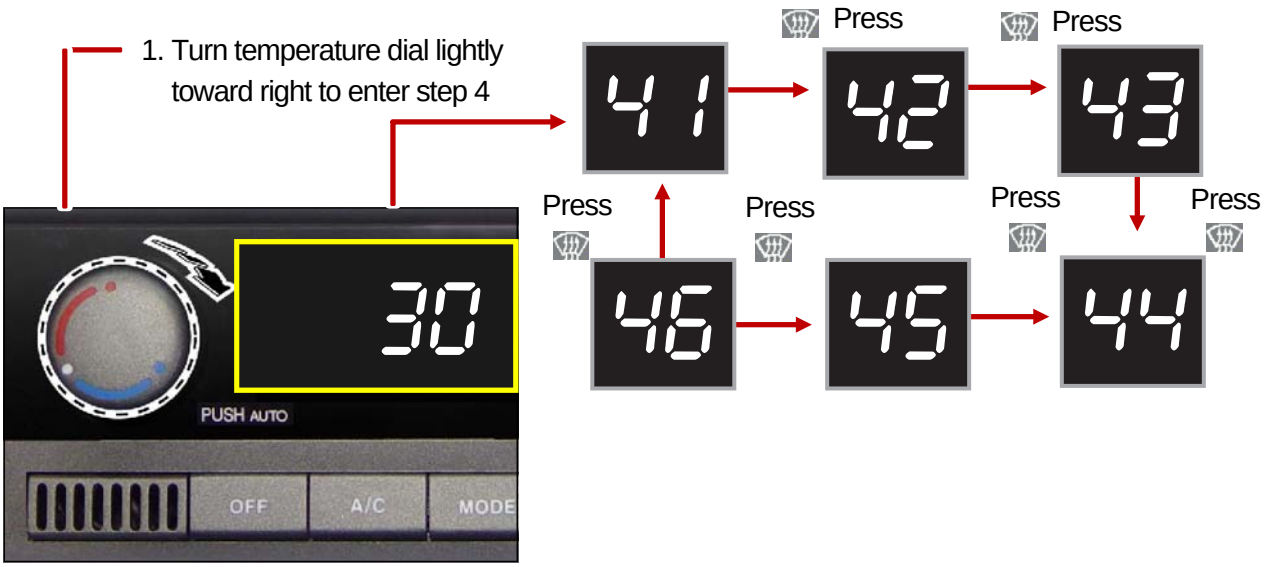


Refer to the following table for the meaning of the fault code.

Code	Malfunction	Remark	Code	Malfunction	Remark
1	Defective VENT		6	DEF	
2	Defective B/L		7	FRE	
3	Mix Cool		8	20% FRE	
4	FOOT		9	REC	
5	D/F		0	All door OK	

(4) Step 4

In this step, the door position of each actuator, fan speed and operation of the compressor are checked. To enter this step, turn the temperature dial to the right in the step 3. The number, "41", appears on the display as soon as the step 4 is started. Press the defroster switch to change the diagnosis mode.



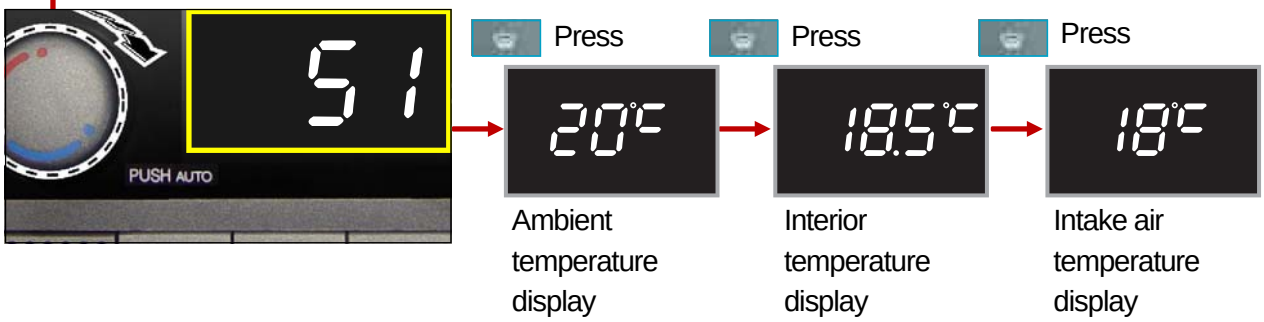
Below table describes the detailed diagnosis items performed for each number. Check the corresponding component for proper operation according to the table. The voltage values listed in the table are the output voltage to operate the blower motor. The higher the voltage, the faster the fan speed is.

Displayed Number	41	42	43	44	45	46
Mode door	VENT	B/L	B/L	FOOT	D/F	DEF
Interior/Ambient door	REC	REC	20%FRE	FRE	FRE	FRE
Air mix door	F/COOL	F/COOL	F/HOT	F/HOT	F/HOT	F/HOT
Blower	4.5 V	10.5 V	8.5 V	8.5 V	8.5 V	MAX
Compressor	ON	ON	OFF	OFF	ON	ON

Modification basis	
Application basis	
Affected VIN	

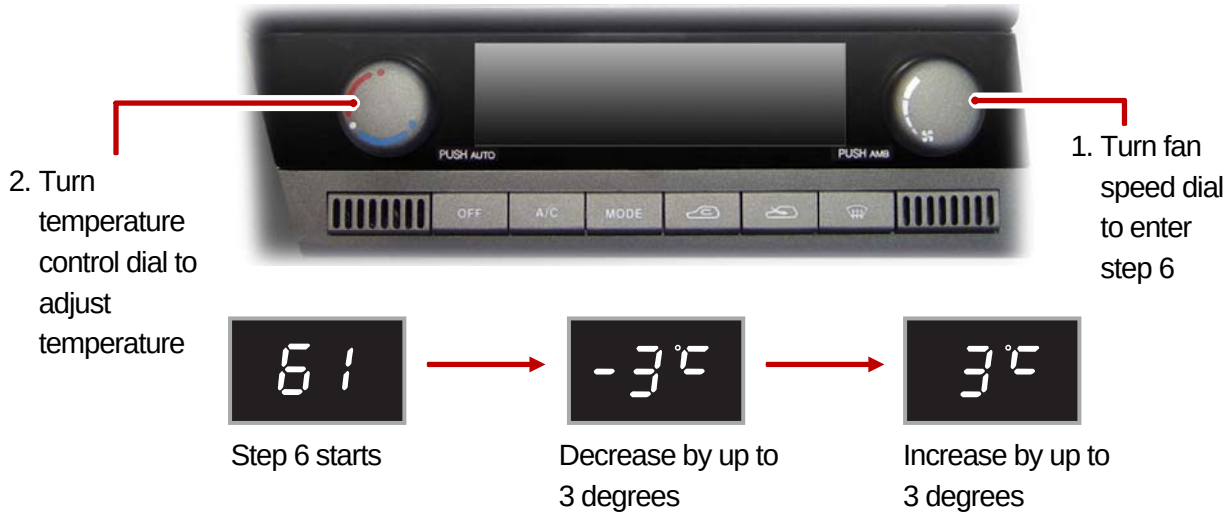
(5) Step 5

In this step, the system checks the temperature sensors used to control the A/C. To enter this step, turn the temperature dial to the right in the step 4. The ambient temperature appears on the display first and the interior temperature appears next and the intake air temperature last. The display changes the temperature value each time the defroster switch is pressed.



(6) Step 6

You can increase or decrease by up to 3 degrees from the set temperature. When entering the step 6 from 5, turn the fan speed dial.



(7) How to end self-diagnosis

Turn the AUTO switch ON or turn OFF the ignition key.

(8) When A/C system is faulty (Initial auto-diagnosis)

The fault code for the faulty sensor is not displayed. Therefore you should start the self-diagnosis to check the system.

Modification basis	
Application basis	
Affected VIN	

3) Trouble Diagnosis

(1) Duct Temperature Sensor

If the fault code for the duct temperature sensor (DTC 3) appears on the display, check the sensor as follows:

A. Remove the duct temperature sensor and measure the resistance between the terminals of the connector (specification: approx. 2.2 kW at 25℃). If the resistance value is extremely high or low, replace the duct temperature sensor.
B. If the result is not as specified, replace the duct temperature sensor. If the result is as specified, proceed to the next step.
C. Turn the ignition switch to ON position and measure the voltage between the connector of the FATC controller and the duct temperature sensor (specification: approx. 2 V at 25℃).
D. If the voltage cannot be measured, check the wiring for open circuit. If the result is as specified, replace the FATC controller.

(2) Power Transistor

If the fault code for the power transistor (DTC 6) is displayed, check as follows:

A. Turn the ignition switch to ON position.
B. Measure the voltage between the terminals of the blower motor while changing the fan speed from the lowest level to the highest level.
C. The specified voltage value in each stage:

Stage	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7	Stage 8
Voltage (V)	4 ~ 4.75 V	5 ~ 5.75 V	6 ~ 6.75 V	7 ~ 7.75 V	8 ~ 8.75 V	9 ~ 9.75 V	10 ~ 10.75 V	11~Battery voltage

D. If the voltage is out of specified value, check the wiring for open circuit. If the wiring is intact, replace the power transistor.

(3) Thermo AMP Sensor (Intake Air Sensor)

If the A/C is not turned on, check as follows:

A. Remove the thermo AMP and measure the voltage between the terminals no. 1 and 2 of the connector.
B. Check if the voltage is approx. 12 V when the output is ON and 0 V when the output is OFF.
C. If the voltage value is not as specified, replace the thermo AMP. If the value is as specified, proceed to the next step.
D. Turn the ignition switch to ON position and turn on the A/C by pressing the A/C button. And measure the voltage between the terminals A12 and A11 of the FATC controller connector (specification: approx. 12 V).
E. If the voltage cannot be measured, check the wiring for open circuit. If the result is not as specified, replace the thermo AMP.

(4) Sun-load sensor

A. Remove the sun-load sensor and measure the current between the terminals with the sensor exposed to direct sunlight.
B. Measure the current again in the shade. If this value is lower than the measured value in the sunlight, the sensor is intact.
C. Turn the ignition switch to the "ON" position.
D. Measure the voltage between the terminals of the sun sensor at the FATC connector. (approx. 2.5 V under sunlight and approx. 4.8 V under shade)
E. If the voltage cannot be measured, check the wiring for open circuit. If the result is not as specified, replace the FATC controller.

Modification basis	
Application basis	
Affected VIN	

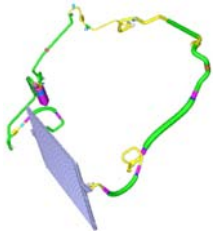
OVERVIEW AND OPERATING PROCESS

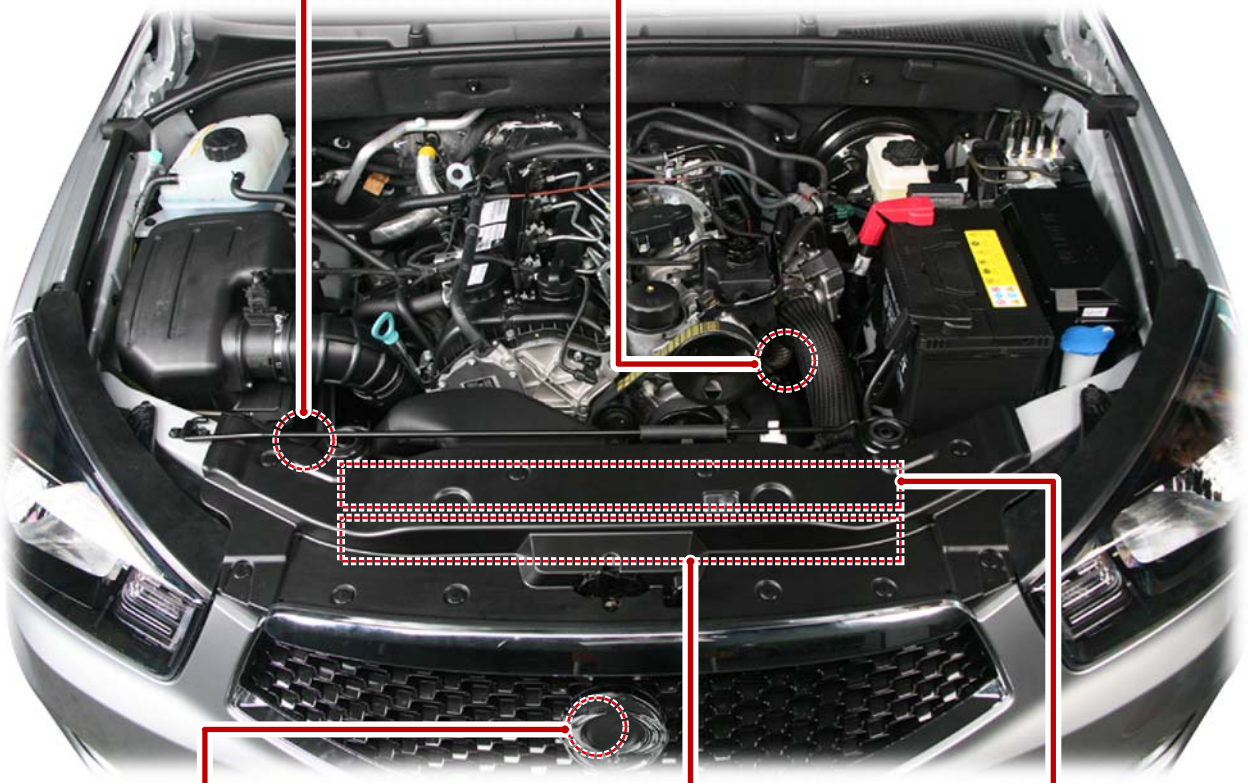
1. SYSTEM LAYOUT (EXTERIOR)

Receiver drier

A/C compressor

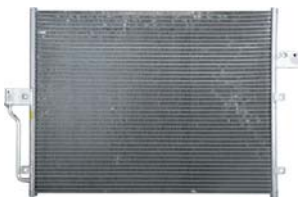
Line and port





Ambient temperature sensor

A/C condenser



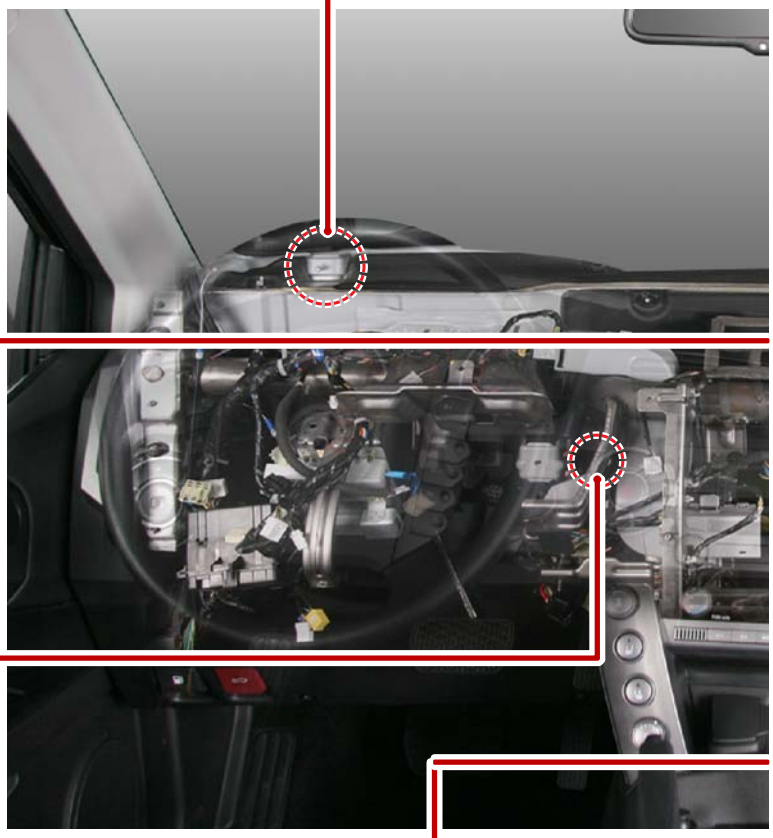
Electric fan

Modification basis	
Application basis	
Affected VIN	

2. SYSTEM LAYOUT (INTERIOR)

Sun-load sensor

A/C controller



A/C Module assembly

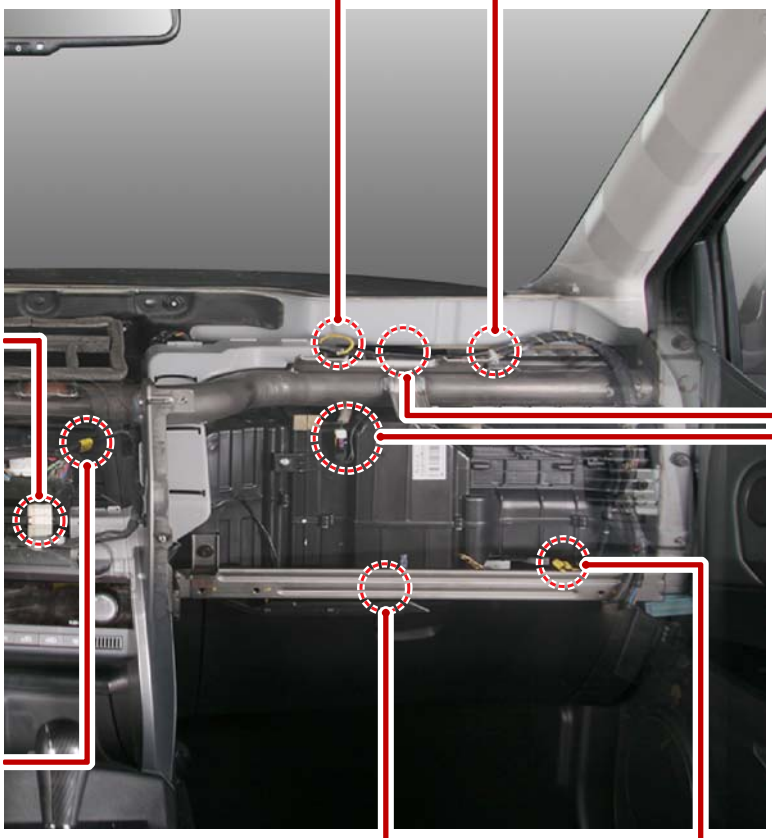
Mode door actuator

Air mix door actuator

Modification basis	
Application basis	
Affected VIN	

PTC

Air source mode actuator



Duct temperature sensor

Thermo AMP

Power transistor

Blower motor assembly

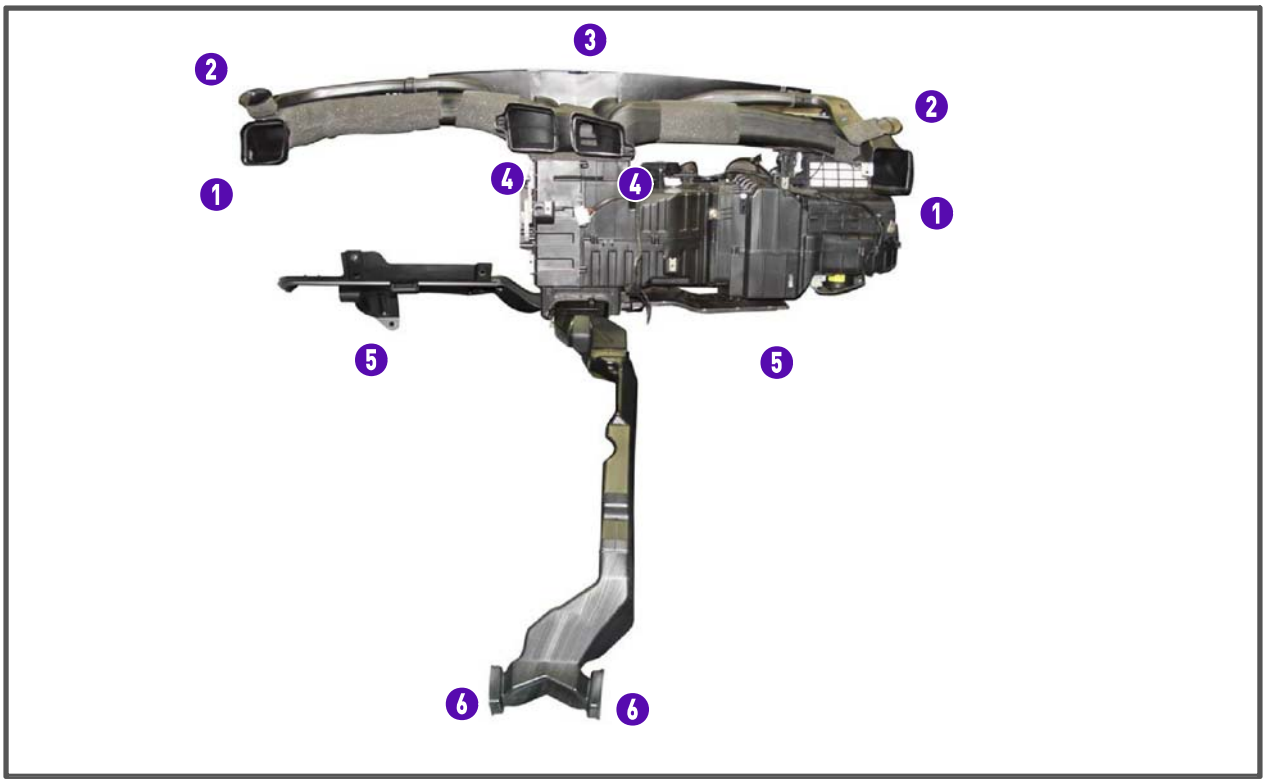
A/C filter

Modification basis	
Application basis	
Affected VIN	

3. VENTILATION SYSTEM

1) Vent Ports Location - Interior

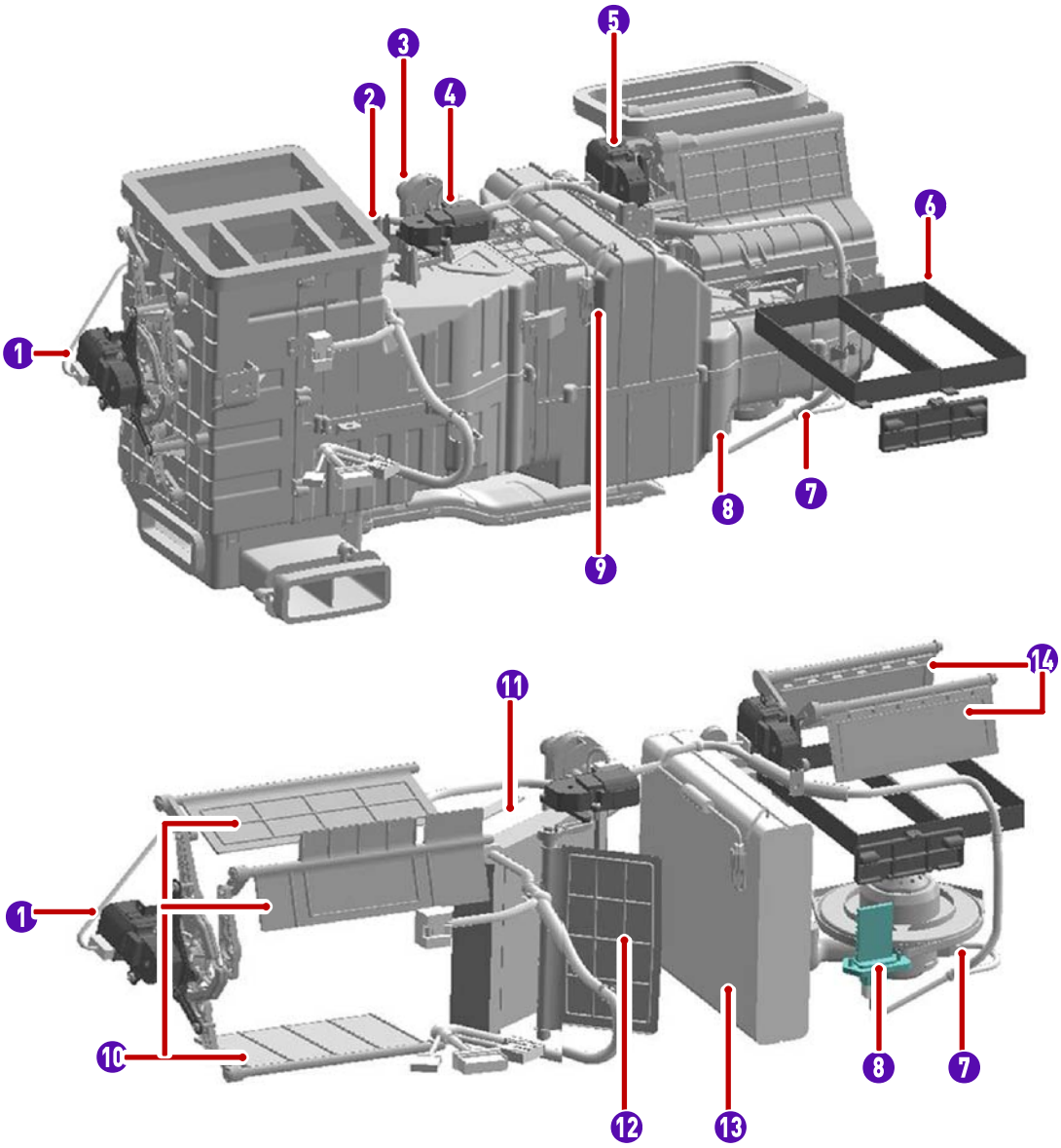
2) Configuration of Air Duct



Modification basis	
Application basis	
Affected VIN	

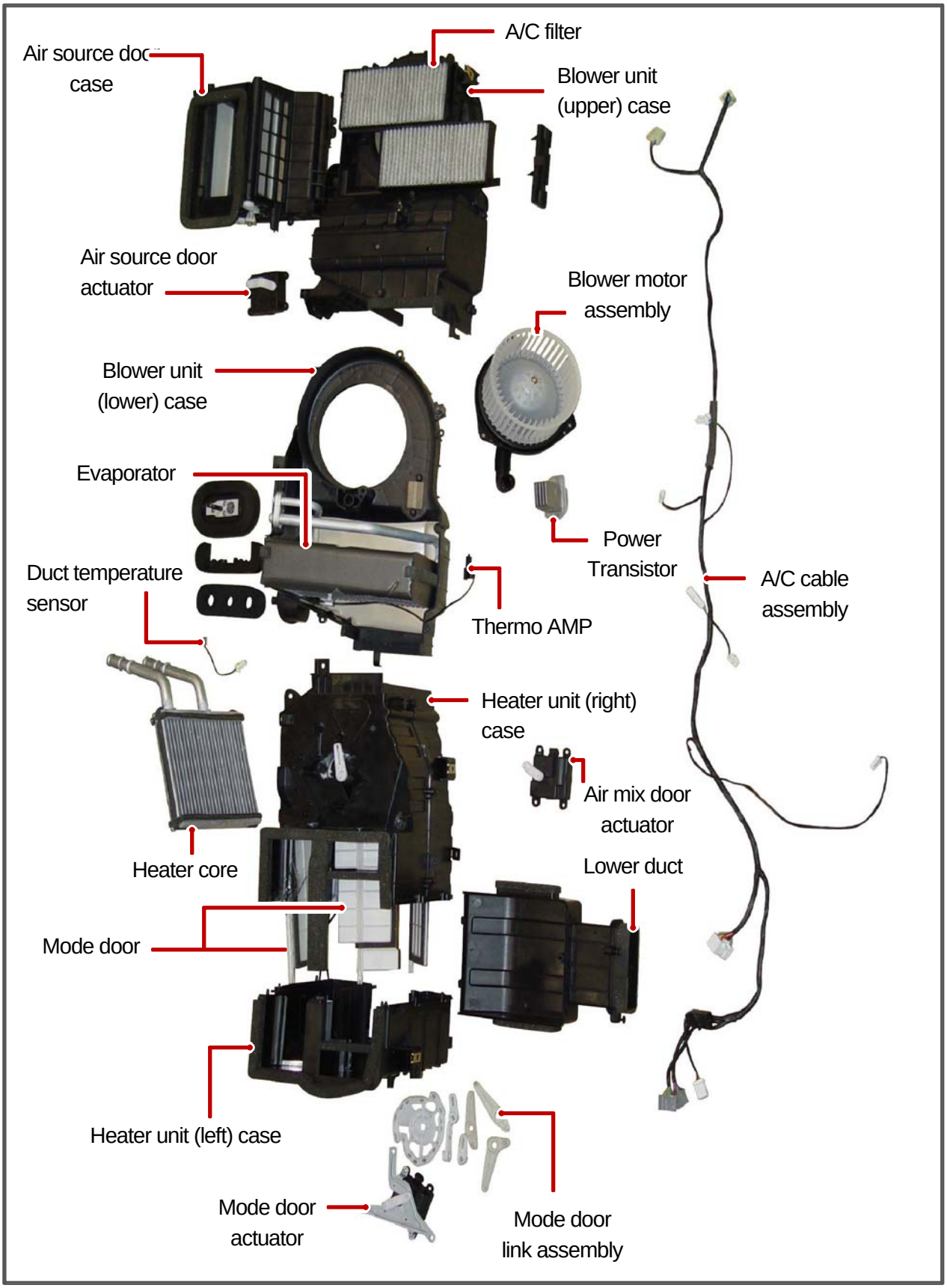
4. A/C MODULE

1) Components



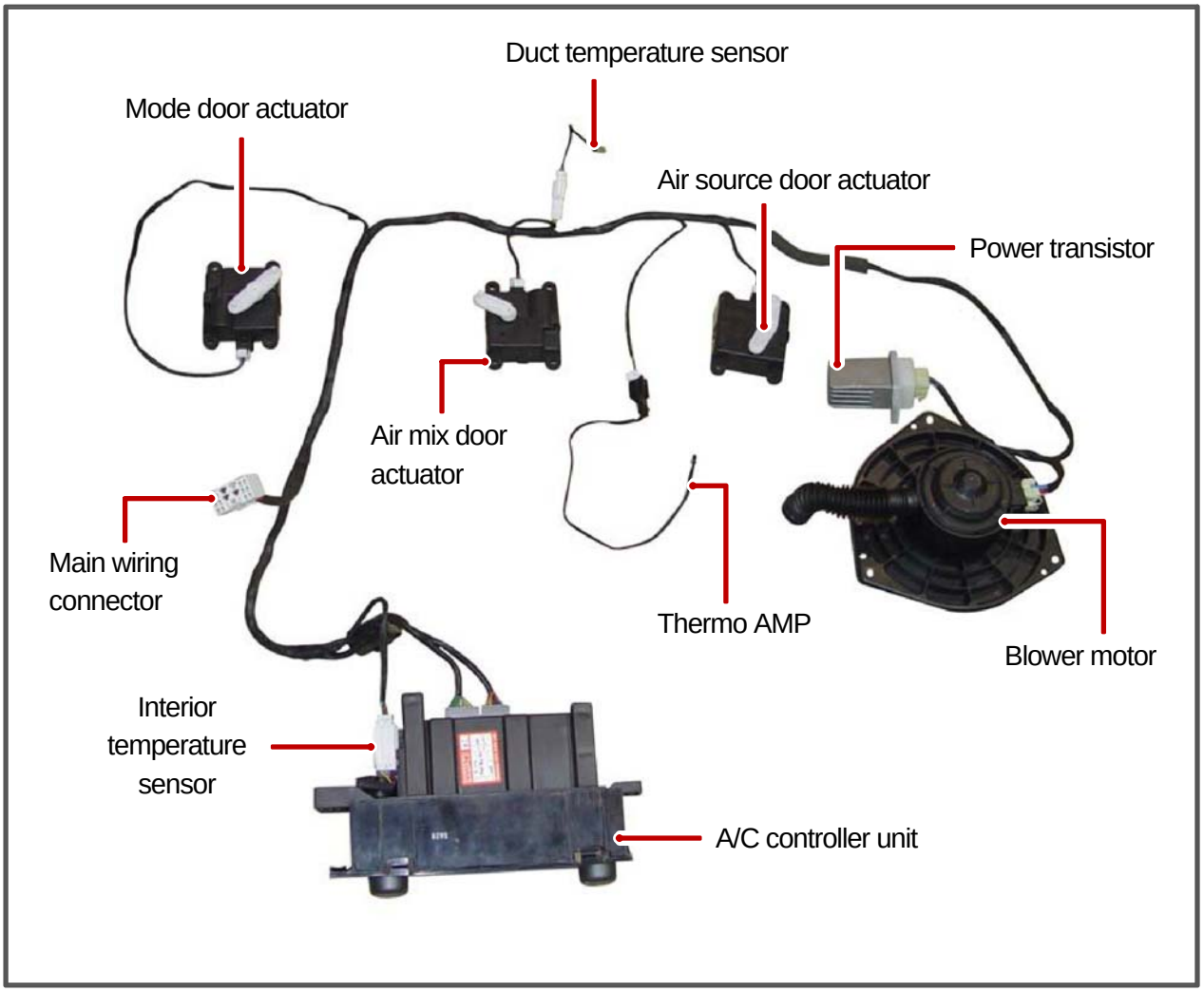
1. Mode door actuator
2. PTC heater assembly
3. Duct temperature sensor
4. Air mix door actuator
5. Air source door actuator
6. A/C antibacterial filter
7. Blower motor
8. Power transistor
9. Thermo AMP
10. Mode door
11. Heater core
12. Air mix door
13. Evaporator
14. Air source door

2) Configuration



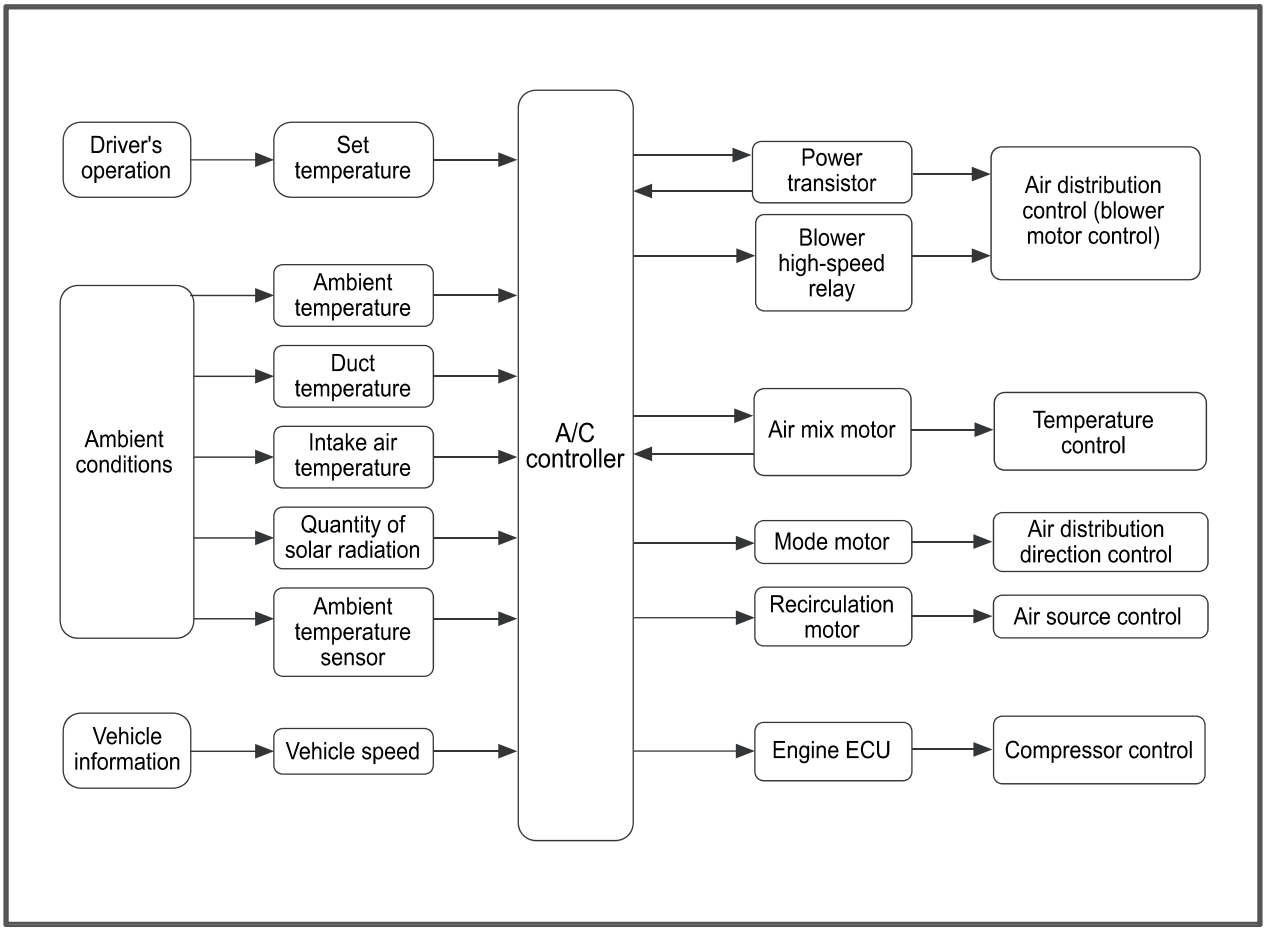
Modification basis	
Application basis	
Affected VIN	

3) Wiring Layout



5. A/C INPUT/OUTPUT DIAGRAM

Below diagram shows the input/output mapping between the components of FATC A/C and A/C controller briefly.



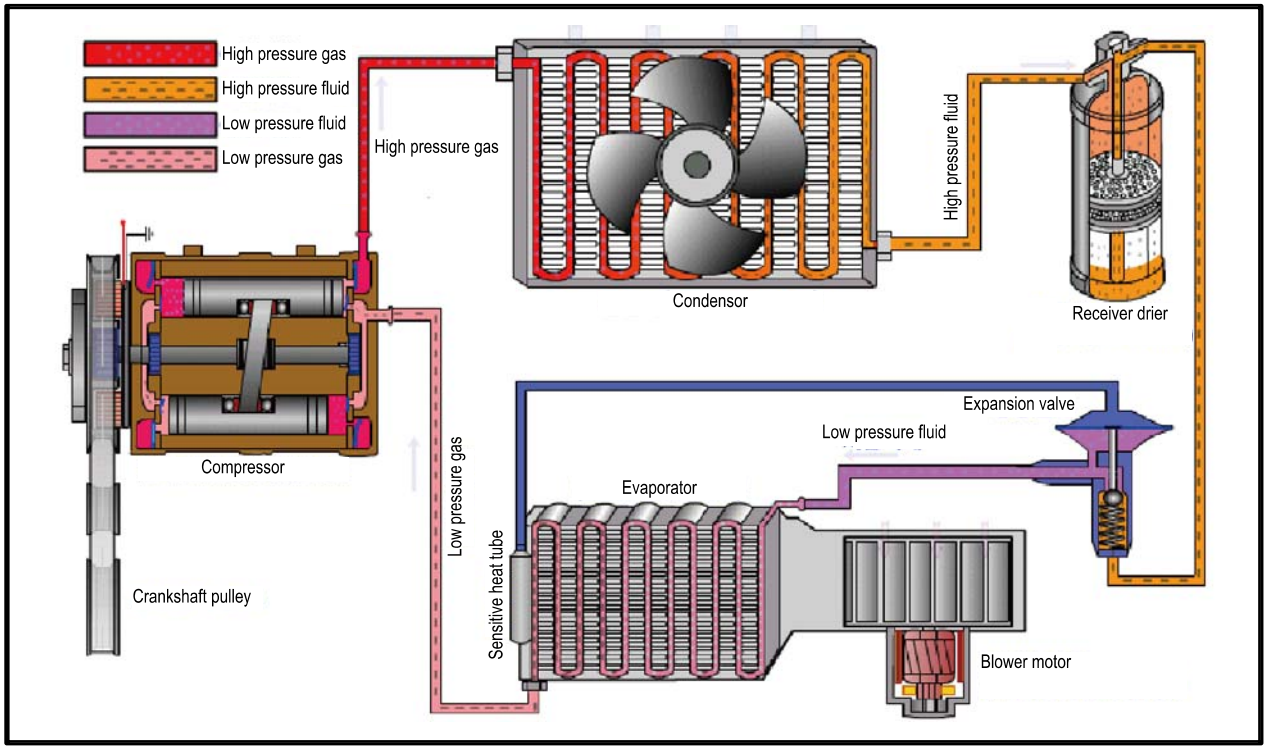
▶ A/C compressor control by engine ECU

In case of current vehicle models, the system turns ON or OFF the compressor switch according to the refrigerant pressure, ambient temperature and condenser temperature to protect the A/C circuits. However, for the vehicles equipped with DI engine, the engine ECU turns off the A/C compressor under below conditions, including those above.

1. Coolant temperature: 20℃ or less
2. Coolant temperature: 115℃ or more
3. For approx. 4 sec. after starting the engine
4. Engine speed: 650 rpm or less
5. Engine speed: 4,500 rpm or more
6. During abrupt acceleration for the vehicle equipped with manual transmission

Modification basis	
Application basis	
Affected VIN	

6. A/C COOLING CYCLE



1) System Flow

- "Compression -> Condensation -> Expansion -> Evaporation"

2) Functions

(1) Compressor

- Condition: Gas
- Function: Circulates the refrigerant and increases the pressure and temperature for easier evaporation.

(2) Condenser

- Condition: Gas/Liquid
- Function: Cools and condenses the refrigerant by using ambient air to liquefy it under high pressure.

(3) Receiver drier

- Condition: Gas/Liquid
- Function: Keeps the refrigerant free from moisture by separating/collecting the moisture from it.

(4) Expansion valve

- Condition: Liquid/Liquefied gas
- Function: Performs adiabatic expansion and flow control for easier evaporation.

(5) Evaporator

- Condition: Liquefied gas/Gas
- Function: Cools the air by absorbing the heat from the air around the evaporator.

3) Description for Each Cycle

(1) Compression

- The evaporated refrigerant in the evaporator enters to the compressor. And the refrigerant gas is compressed until it can be liquefied at ambient temperature.
- Thus, the low refrigerant pressure is maintained so that the liquid refrigerant can be evaporated actively at low temperature (around 0 ℃).

(2) Condensation

- The high pressure and high temperature gas (refrigerant) from the compressor is cooled down by the fresh air entered into the condenser. Then, this gas is converted to liquid and collected in the receiver drier.
  The heat generated from the high pressure refrigerant is dissipated to the ambient air, and it is called "heat of condensation".
- The heat of condensation is the summation of the heat of vaporization (heat that the refrigerant absorbs from the inside of the vehicle) and the calorific value converted from the amount of work which is needed to compress.

(3) Expansion

- The liquid refrigerant lowers the pressure making its evaporation easily accomplished.
  This process (lowering the pressure to the level at which evaporation easily takes place before the liquid refrigerant is sent to the evaporator) is called
  "Adiabatic Expansion".
- During adiabatic expansion, the expansion valve lowers the pressure of the refrigerant and determines the correct amount of refrigerant going into the air conditioning evaporator.
  That is, the amount of heat, which is needed to stop the evaporation, is determined according to the cooling load.
  The expansion valve detects this and regulates the amount of the refrigerant exactly.

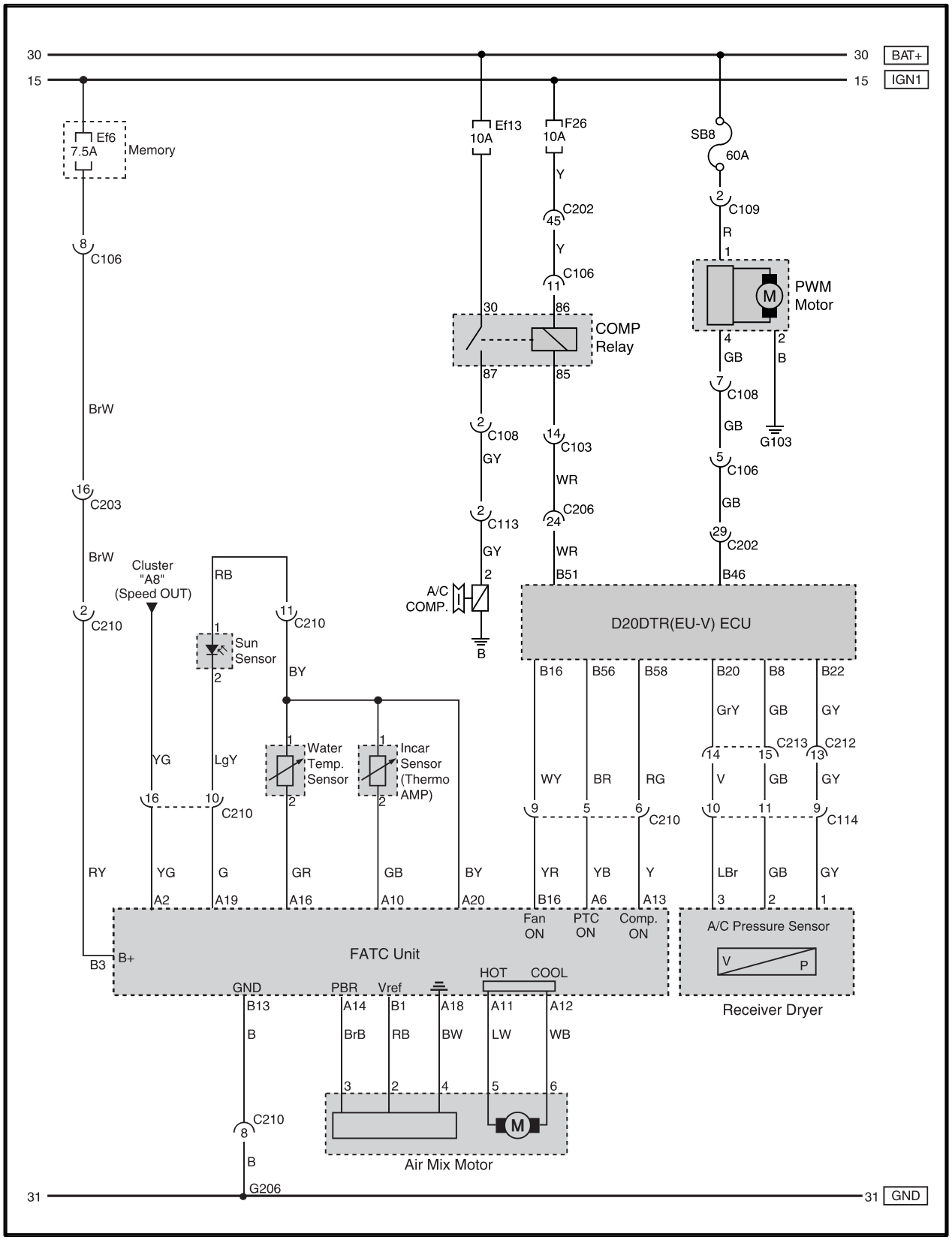
(4) Evaporator

- The refrigerant is converted from liquid to gas in the evaporator.
  (The refrigerant in the form of fog in the evaporator is vaporized actively)
- At this time the refrigerant, in the form of liquid, absorbs the heat in the air which is need for evaporation (latent heat) and is cooled down. Then the blower blows the cooled air inside the vehicle to lower the temperature.
- There are liquid refrigerant from the expansion valve and evaporated refrigerant in the evaporator.
  The evaporation temperature can be predicted from the evaporation pressure (i.e. relationship
- between saturation pressure and saturation temperature).
  It is important to keep the pressure inside the evaporator low, so that the refrigerant is evaporated at
- low temperature to make sure the completely evaporated refrigerant is entered into the compressor.

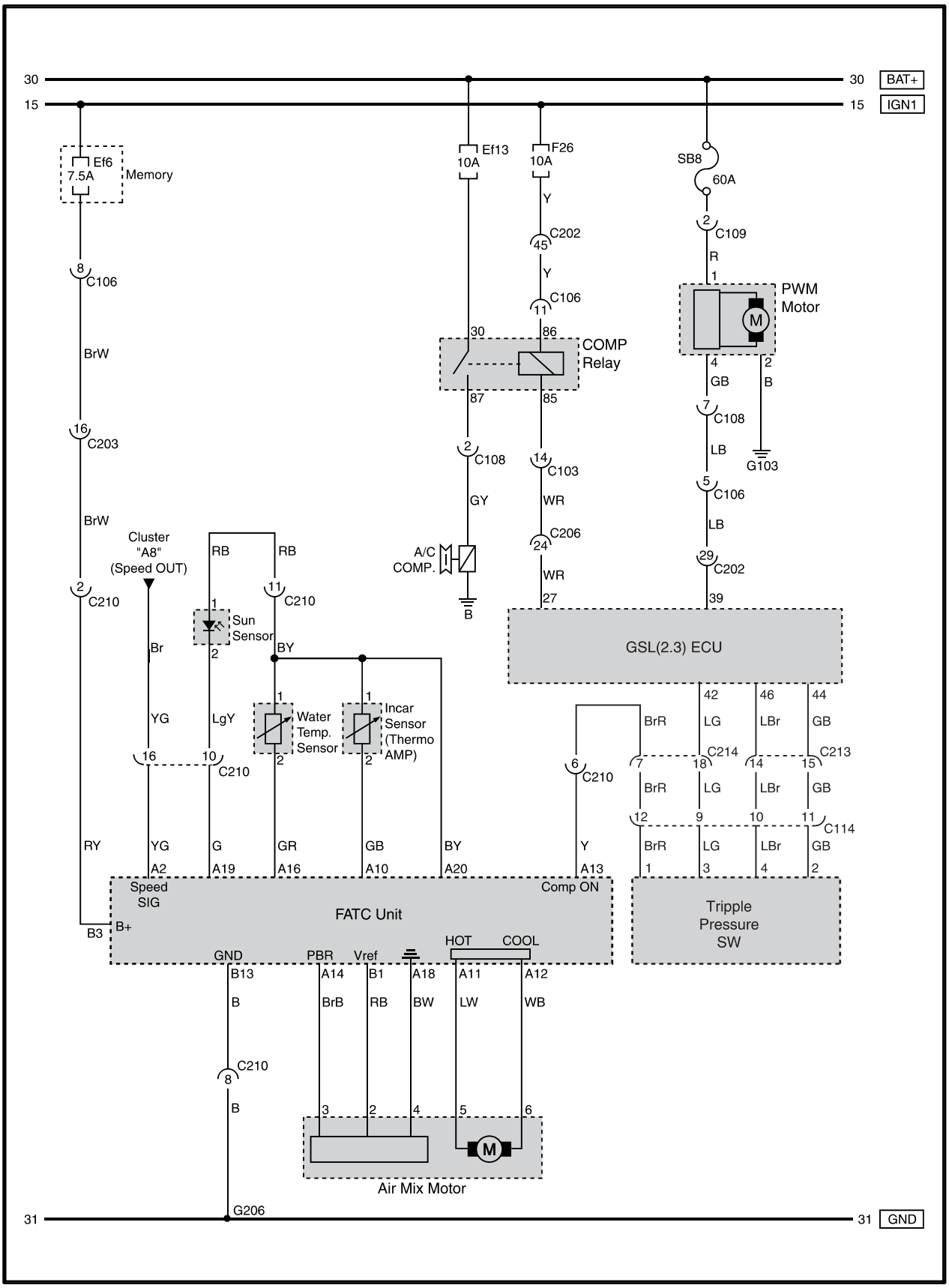
Modification basis	
Application basis	
Affected VIN	

7. FATC (FULL AUTO TEMP. CONTROL) CIRCUIT

1) PWM Motor, Compressor, Air Mix Motor, Sun Sensor

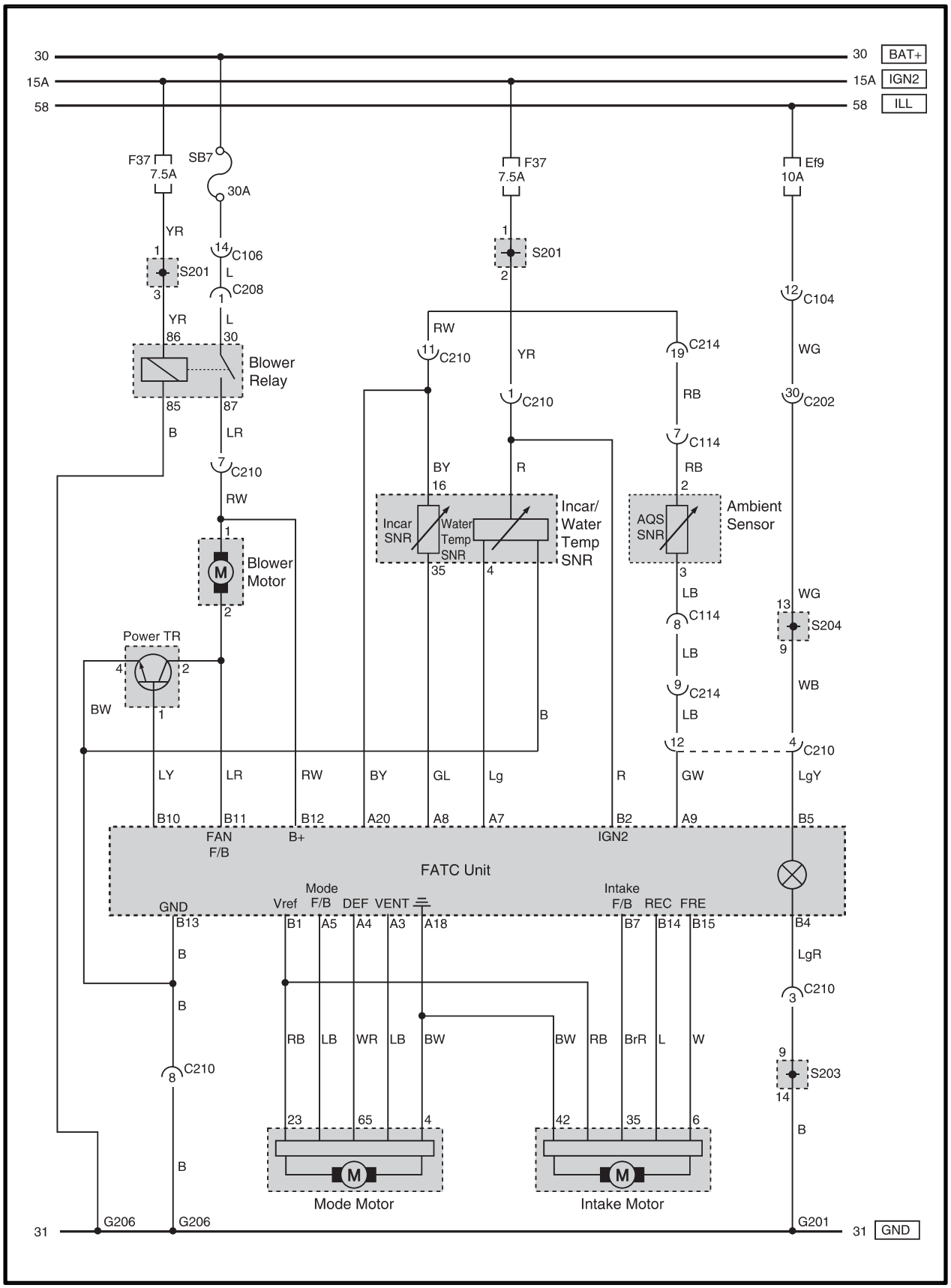


2) PWM Motor, Air Mix Motor(GSL 2.3)



Modification basis	
Application basis	
Affected VIN	

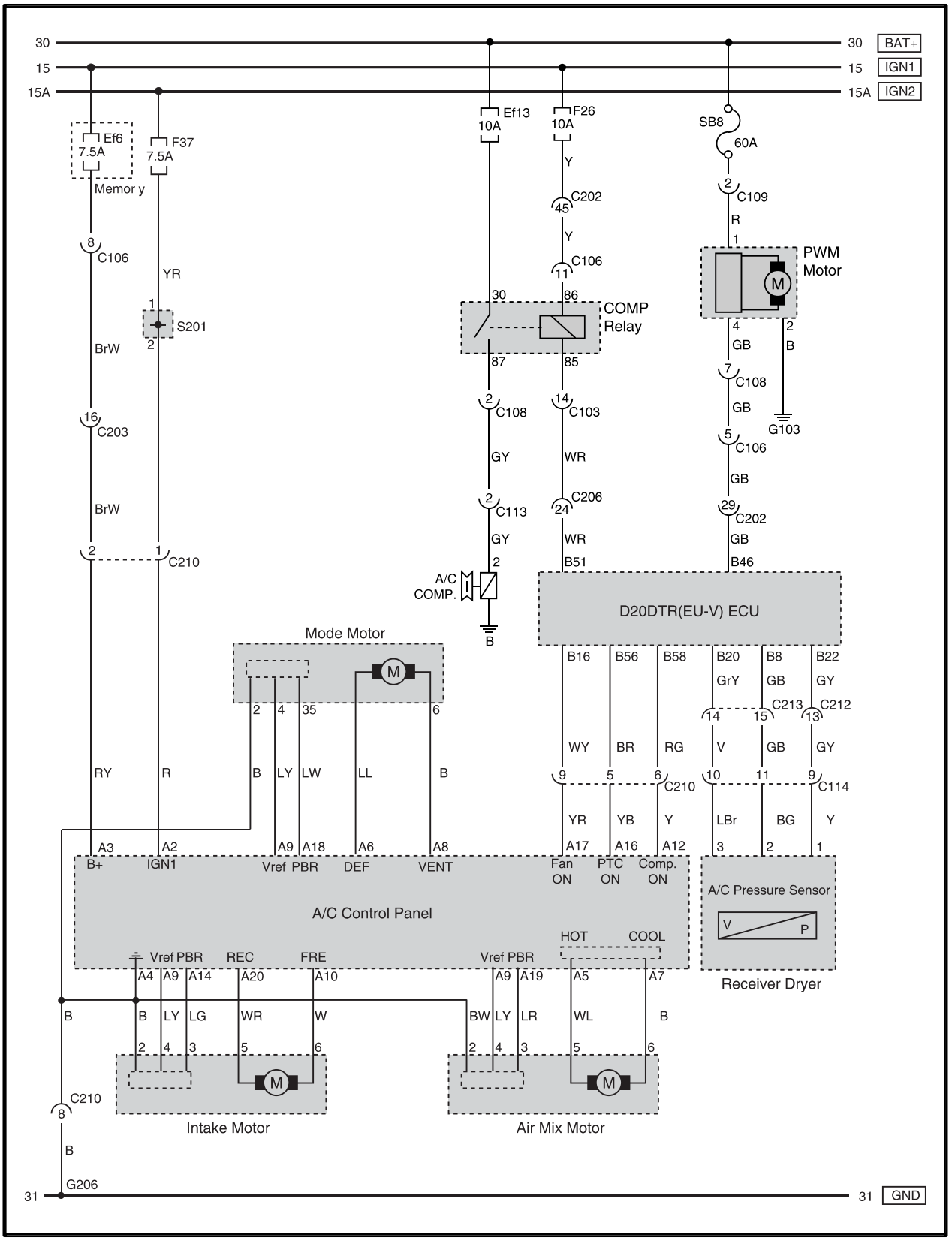
3) Blower, Actuator (Mode, Intake), AMBI Sensor



Modification basis	
Application basis	
Affected VIN	

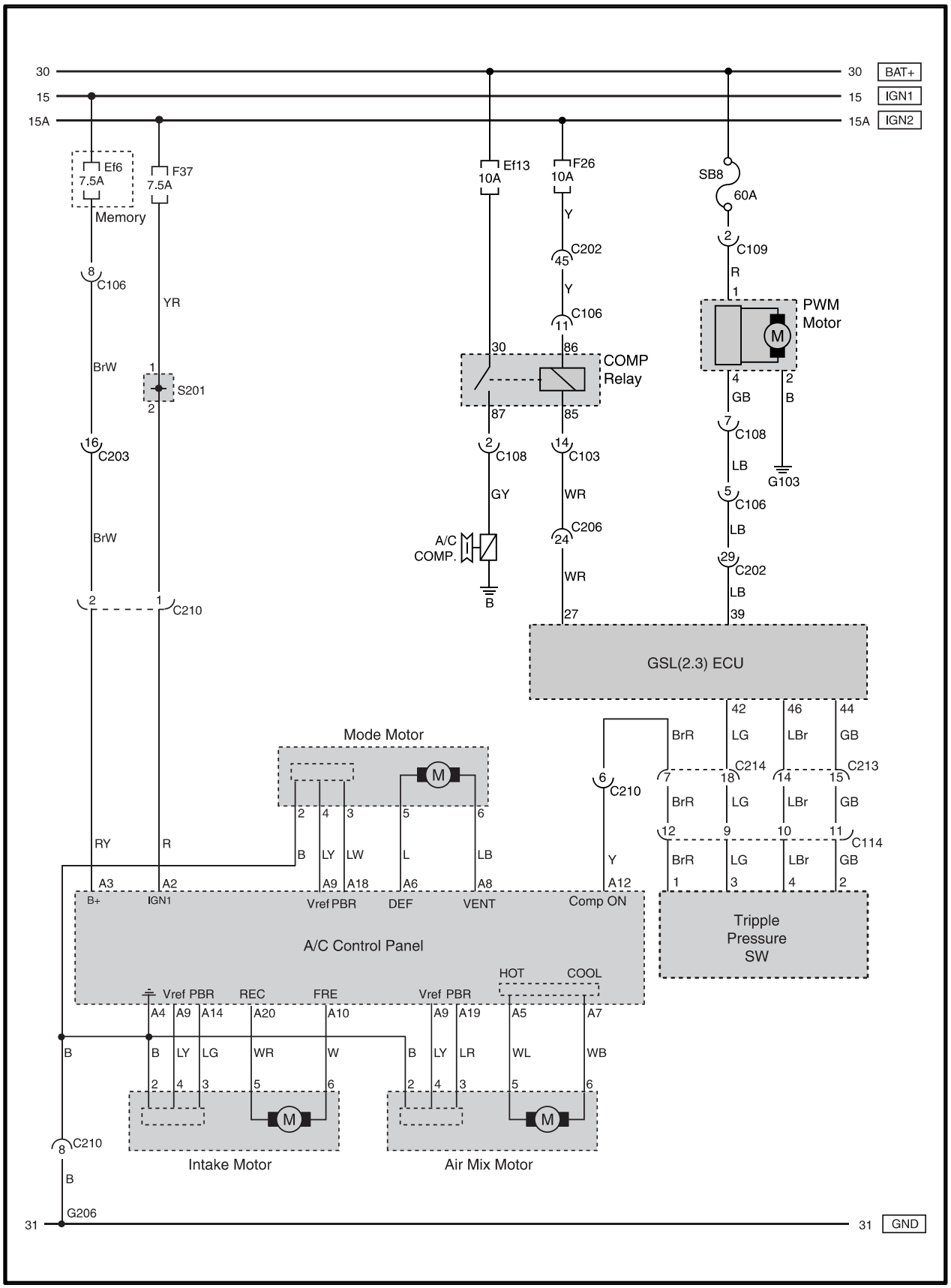
8. AIR-CON (MANUAL) CIRCUIT

1) PWM Motor, Compressor, Motor (Mode, Intake, Air Mix)



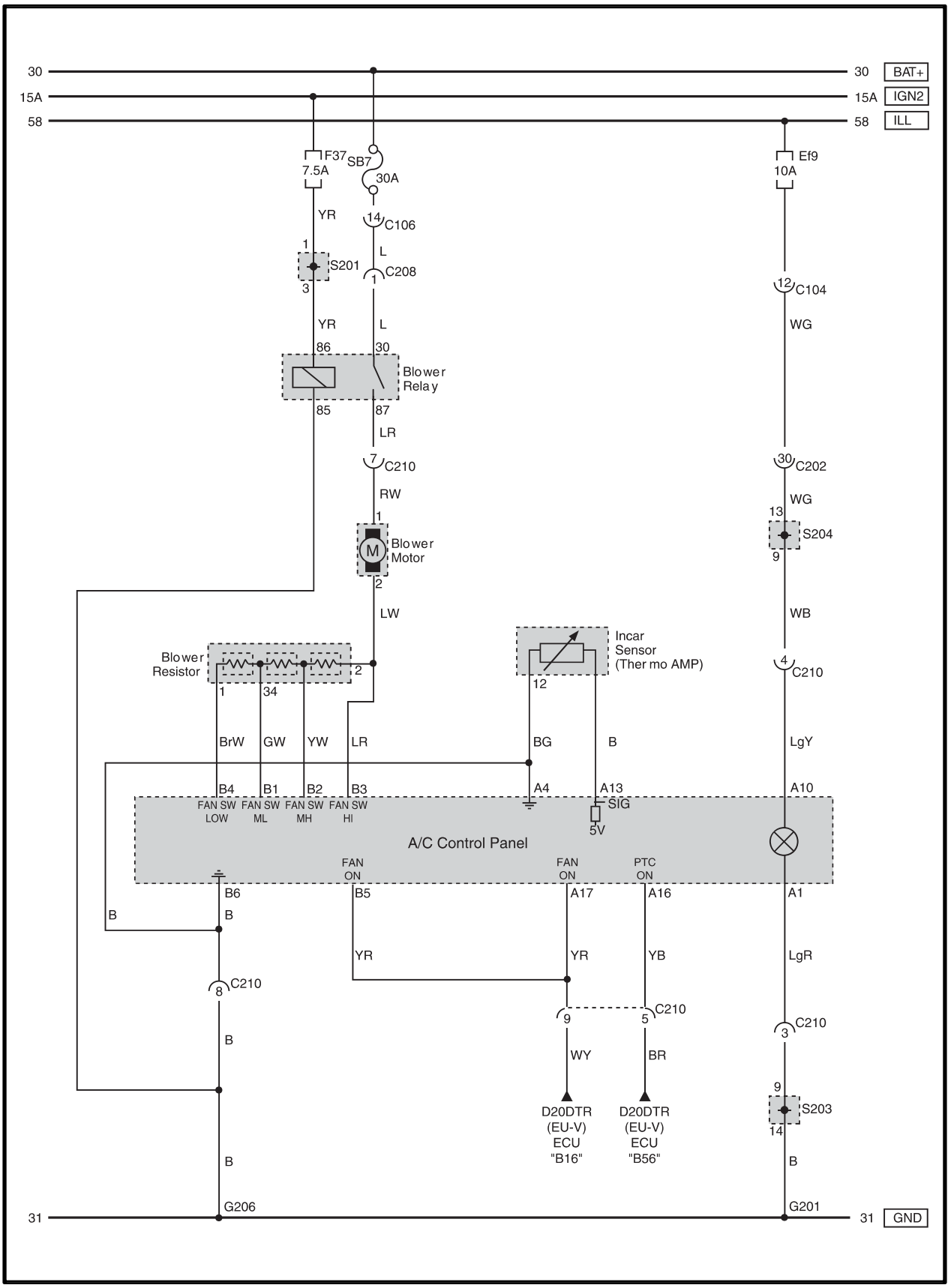
Modification basis	
Application basis	
Affected VIN	

2) PWM Motor, Motor(GSL 2.3)



Modification basis	
Application basis	
Affected VIN	

3) Blower



Modification basis	
Application basis	
Affected VIN	

AIR BAG SYSTEM 8810-01

GENERAL INFORMATION

1. CAUTIONS FOR AIR BAG OPERATION

CAUTION

1. When there is any deployed air bag (including seat belt pretensioner), the air bag unit should be replaced. Any DTC (Diagnostic Trouble Code) in the air bag unit should not be cleared since the unit has data for status when the air bag was deployed as well as information related to the air bag deployment.
2. Note that the used components related to the air bag, especially the air bag unit, should be packaged in an air tight container to prevent any damage.
3. Do not connect a tester to any connector or component to check supply voltage or resistance of air bag related components. The detonator may explode due to a sudden extra power supplied by the tester.
4. Before removing or installing any air bag related components, disconnect the negative battery cable.

Collision sensors, a kind of impact G (acceleration) sensor, detect the lateral and longitudinal collisions and determine whether or not to deploy air bags. The roles of each collision sensor are as follows:

Front G sensors (inside the air bag unit)
Send signals to the front air bags (driver and passenger air bags) and the driver's and front passenger's seat belt pretensioners. When the front collision G sensor sends out only the air bag deployment signal, the signal deploys the two front air bags and activates their seat belt pretensioners.

Once an air bag deploys, its repair parts vary according to the deployment situation and damage to the vehicle from collision. Needed repairs also slightly vary between the front air bags and the curtain air bags. The following are the differences:

Replacement parts when the front air bags deploy:
Air bag unit and its wiring (including connector), seat belt pretensioner and its wiring (including connector), whole front air bags, instrument panel (IP)

2. OPERATING RANGE

▶ **In the event of the collision, the air bag will be deployed when the G value detected by the G sensor in the SDM is beyond the impact limit.**

Seat Belt Status	Air Bag Operation	Seat Belt Pretensioner Operation
Fastened	Over reference speed	Below reference speed
Unfastened	Below reference speed	Inoperative
Failure, during initial diagnosis	Below reference speed	Below reference speed
No sensor	Below reference speed	Below reference speed

* This is based on frontal collision and reference speed is between approx. 4 and 24 km/h.

▶ **The air bag is deployed in the event of frontal collisions while drving.**
But, there are exceptional cases as follows:

Situation	Condition
May operate or not	- Underbody impact from the road surface, impact against the curb at a very high speed, or dropping impact onto the road surface with a large angle occurs. - The vehicle rolls over or tips over sideward by severe impact.
Never operate	- The vehicle is stationary or a front collision occurs with low speed. - A rear collision occurs. - A minor collision occurs.
Seldom oeprate	- A collision with oblique impact to the front seat direction or a front collision to the diagonal direction occurs. - A front/rear collision occurs. - The vehicle rolls over or tips over sideward with minor impact. - The air bag warning lamp is on.

Modification basis	
Application basis	
Affected VIN	

3. GENERAL WARNINGS

- Do not diagnose the circuit with a circuit tester or attempt to modify any air bag components including the steering wheel, air bag mounting area and harness.
- Incorrect inspection could cause a problem with an air bag and seat belt pretensioner, and they cannot protect occupants properly. Inspection and repair service should be done only by a qualified technician.
- An infant or a child should not be seated on the front seat alone or on an adult's lap. An infant or a child could be severely injured by air bag deployed.
- A child restraint system should be placed on the rear seat which has the 3-point type seat belt.
- Never install a child restraint system on the front seat. Impact by the air bag inflation might cause severe injury or even death.
- When an occupant fastens the seat belt with unstable or inclined posture, the air bag cannot protect the occupant properly. Moreover, the occupant may be injured by the air bag.
- Do not incline toward the steering wheel while driving. If you hit the air bag before it is fully inflated, brain or neck injury, or even death can occur.
- Be careful not to strike the steering wheel, air bag mounting area, any air bag related component (including wiring) and seat belt pretensioner. You might get severely injured by sudden deployment of the air bag.
- The air bag contains explosive materials, so handle it carefully when disposing or replacing it.
- The air bag components will be very hot immediately after deployment. Do not touch them until they cool down.
- Once the air bag/seat belt pretentioner is triggered, it will not deploy again even if an additional impact is applied to it. Once triggered air bag/seat belt pretensioner related components cannot be reused, so they should be removed from the vehicle and the whole system should be replaced with a new one.
- Do not place any object or sticker on the air bag mounting area for correct and safe activation of the air bag.
- Do not bang the door. Otherwise, an air bag might operate erroneously.
- Hold the outer rim of the steering so that the air bag can inflate without any hindrance.
- Do not incline toward the steering wheel or hold the steering wheel with your hands crossed. It will cause a problem with the air bag activation or severe injury when the air bag inflates.
- Never put your hands or feet on the dash board. You can severely injured when the air bag inflates.
- It is normal that a loud noise, dust and smoke occur when the air bag and seat belt pretensioner operate.
- The gas come out of air bag/seat belt pretensioner activation is non-toxic nitrogen gas. However, if this gas occurs irritation to your skin, eyes, nose, and so on, wash it out with clean water. Seek medical help if symptoms develop.

- The windshield or windows can be broken due to impact from driver or passenger air bag inflation.
- When any repairs are needed to the air bag mounting area or its surrounding area, or when an accident has occurred without the air bag deployment, have the air bag system/seat belt pretensioner checked for safety.
- The air bag is a unit to save an occupant's life from sudden accident and it inflates at a very fast speed by gas with high temperature, which might cause injury, such as an abrasion, bruise and burn depending on the accident conditions.
- Normal inflation of the air bag could make a loud noise and smoke (non-toxic gas).
- A minor collision, which occupants can be protected only by seat belts, will not activate the air bag system. It is because that air bag inflation at a minor collision could cause more injury such as an abrasion, bruise and burn.
- Check the air bag system even though there is no fault in the air bag system when 10 years have passed after air bag installation.

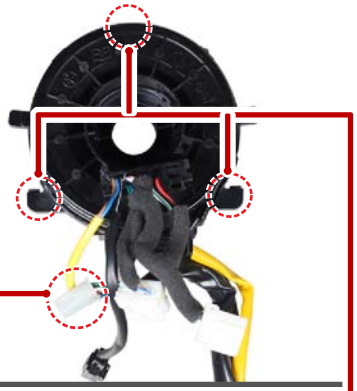
Modification basis	
Application basis	
Affected VIN	

4. MAJOR CHANGES

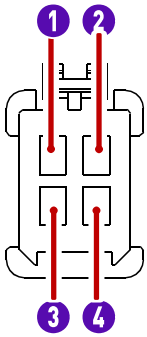
Contact coil

Old

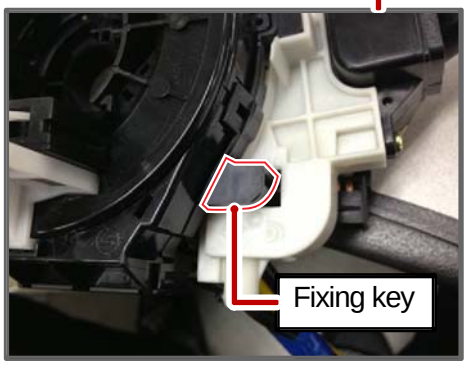
New



Heated steering wheel connector (to contact coil)



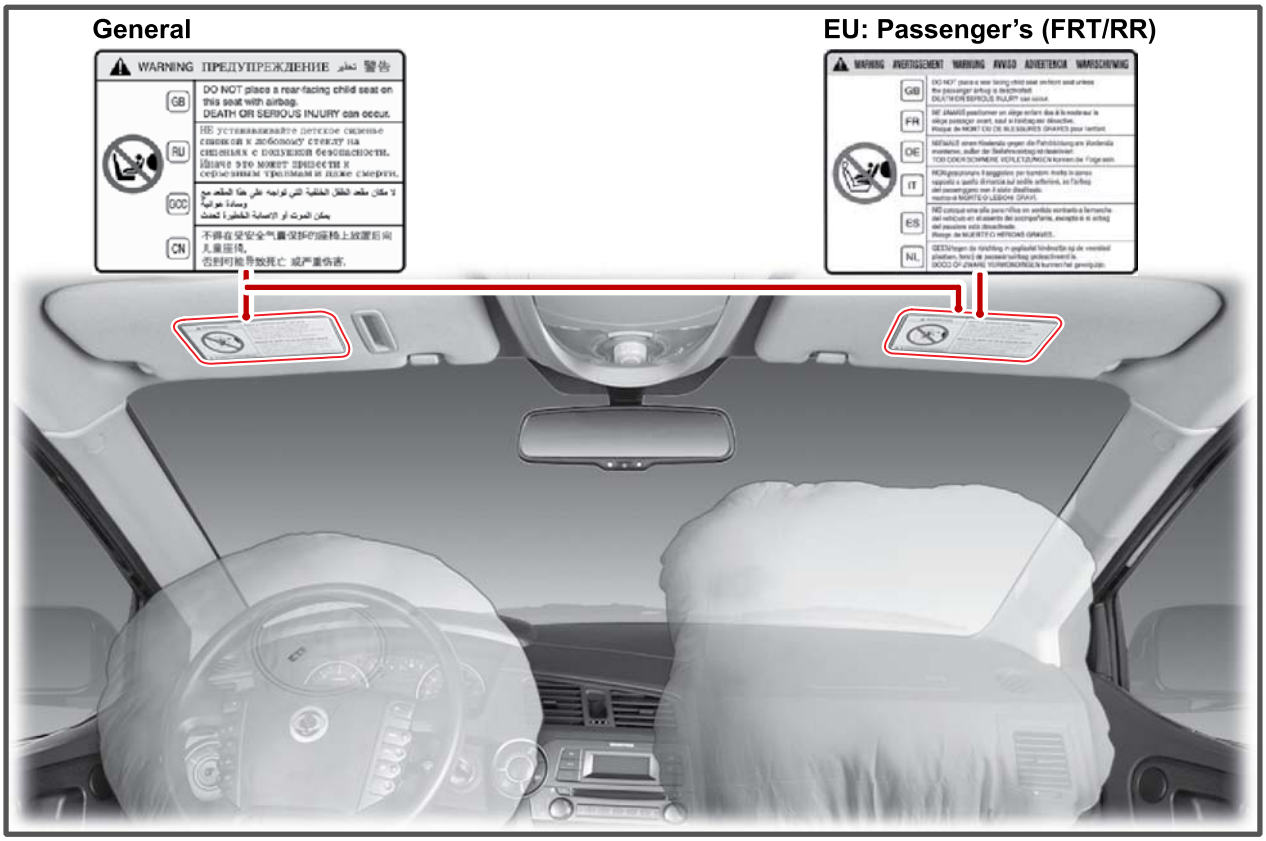
Pin No.	Name
1	Ground
2	IGN
3	Heated steering wheel switch ON/OFF
4	Heated steering wheel switch signal



- Heated steering wheel connector adopted and its appearance changed
- Fixing keys (3 off) for engaging with multifunction switch

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW



For the air bag system in KORANDO SPORTS, the seat belt pretensioners on both sides as well as the driver/passenter air bags are deplyed when the front air bag is deployed like as they did.

Collision sensors, a kind of impact G (acceleration) sensor, detect the lateral and longitudinal collisions and determine whether or not to deploy air bags. The roles of each collision sensor are as follows:

Front G sensors (inside the air bag unit))
Send signals to the front air bags (driver and passenger air bags) and the driver's and front passenger's seat belt pretensioners. When the front collision G sensor sends out only the air bag deployment signal, the signal deploys the two front air bags and activates their seat belt pretensioners.

Once an air bag deploys, its repair parts vary according to the deployment situation and damage to the vehicle from collision. Needed repairs also slightly vary between the front air bags and the curtain air bags. The following are the differences:

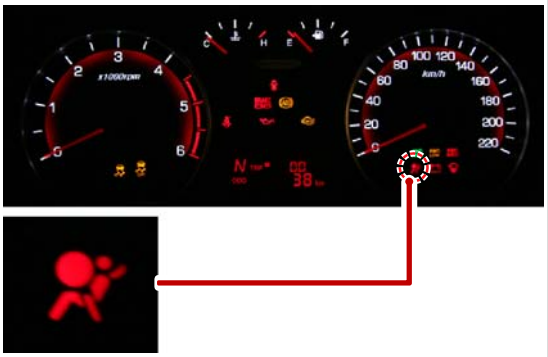
Replacement parts when the front air bags deploy:
Air bag unit and its wiring (including connector), seat belt pretensioner and its wiring (including connector), whole front air bags, instrument panel (for vehicle with passenger air bag)

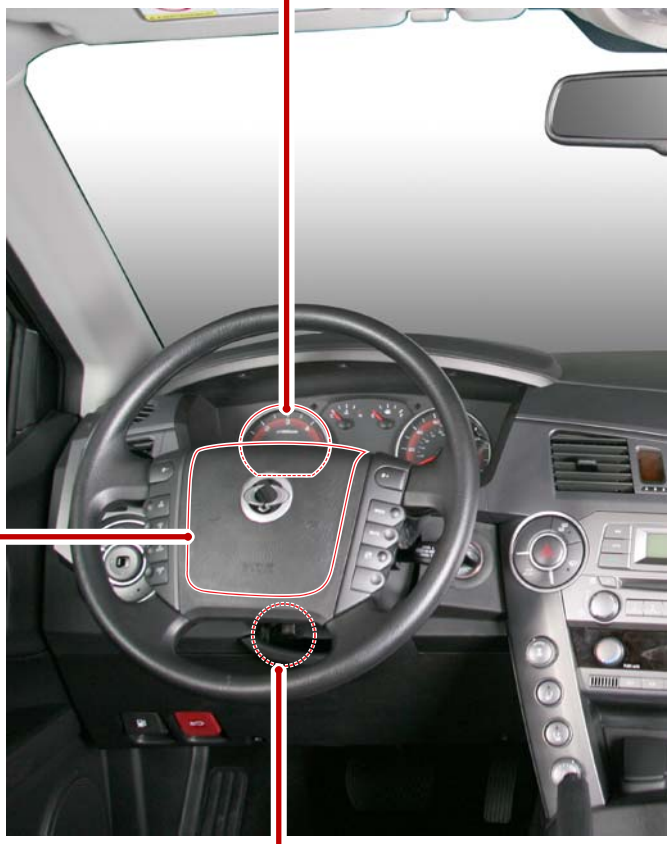
Modification basis	
Application basis	
Affected VIN	

Memo

2. CONFIGURATION

Air Bag Warning Lamp





Driver Air Bag (DAB)

Driver side (pretensioner)

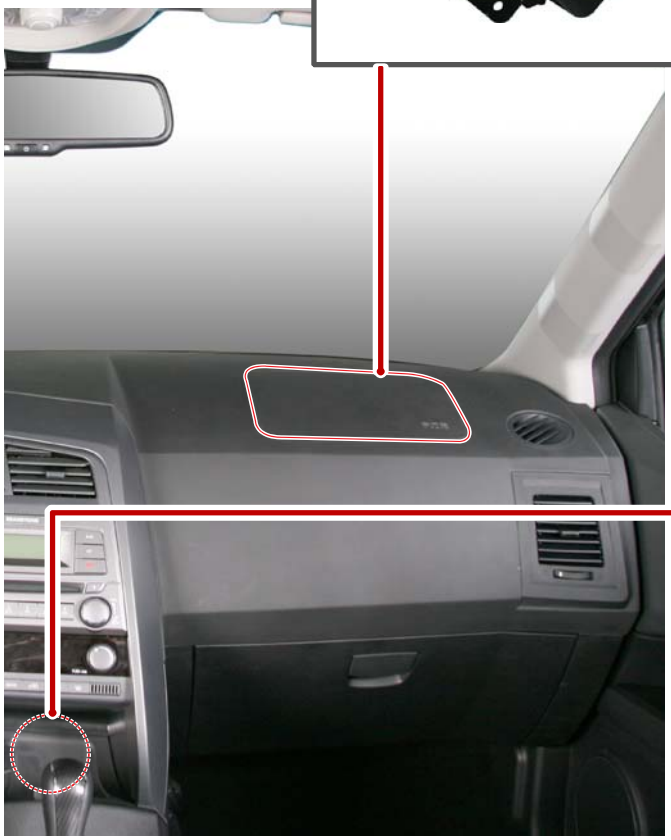
STICS

40 ms after receiving the air bag deployment signal at the vehicle speed 3 km/h or higher, it sends out the door UNLOCK signal for 5 seconds.

Modification basis	
Application basis	
Affected VIN	

Passenger Air Bag

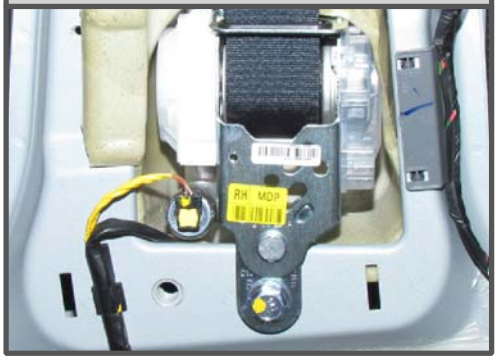
Upper side	Lower side
	



Air Bag Unit (SDM)

The collision G sensor is installed inside this. And it sends out signals to deploy the front air bags (driver and passenger air bags) and/or the driver and passenger seat belt retensioners. When the front collision G sensor sends out only the air bag deployment signal, the signal deploys the two front air bags and activates their seat belt pretensioners.

Passenger pretensioner

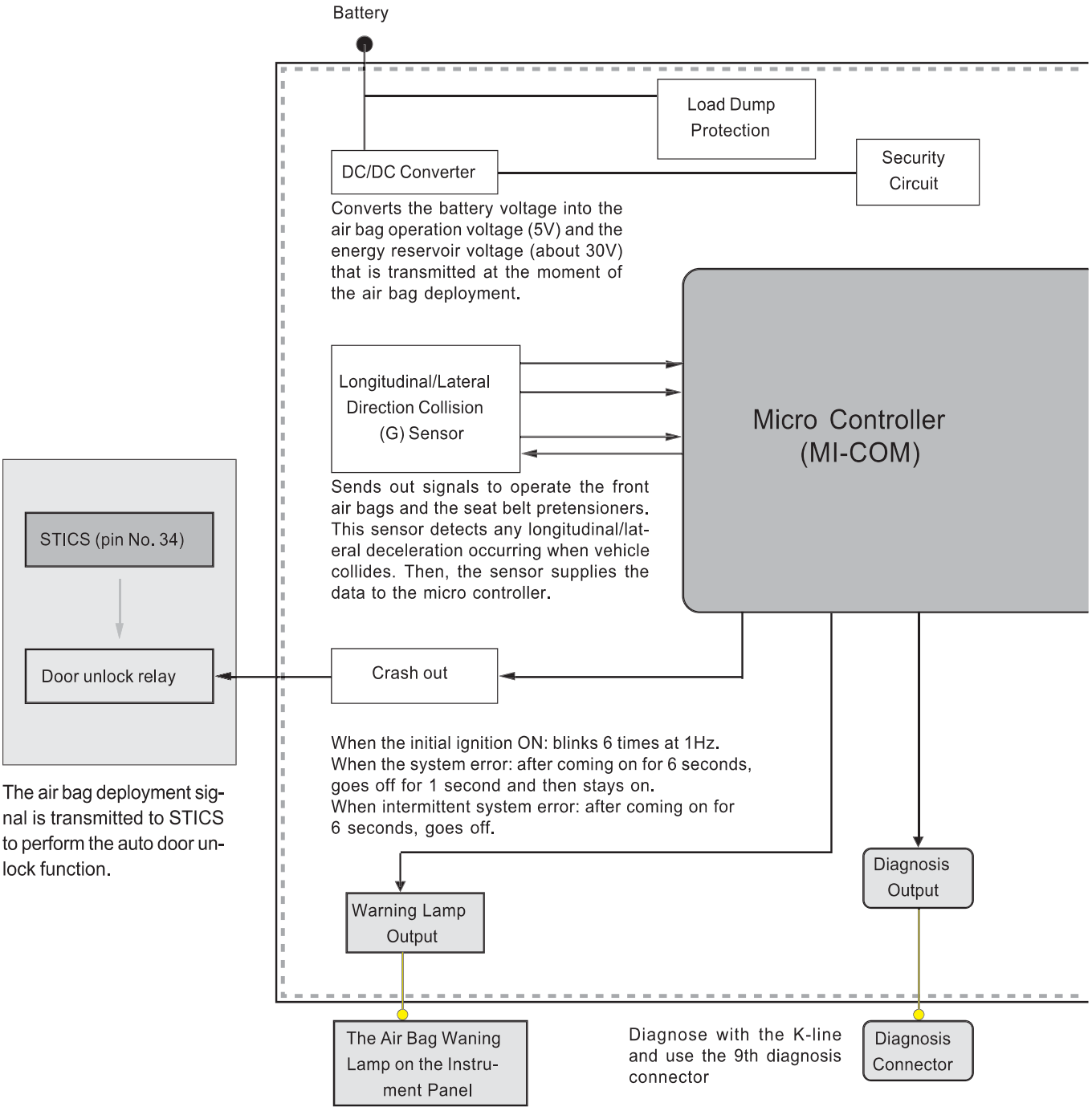


Modification basis	
Application basis	
Affected VIN	

3. OPERATION PROCESS

The overall air bag operation process and its functions and roles are broadly explained in this block diagram. This diagram summarizes and highlights the functions adopted by Ssangyoung Motors.

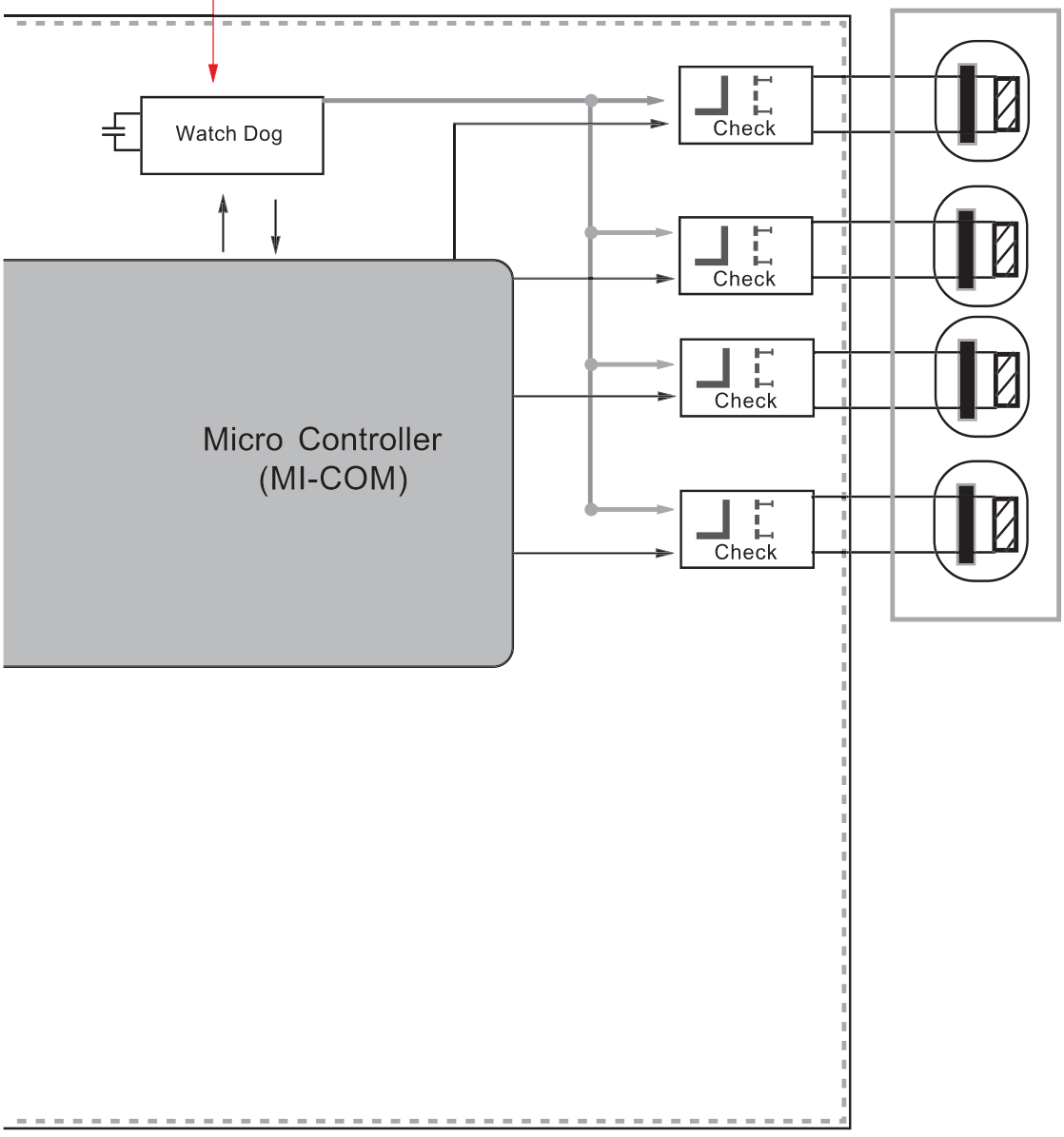
1) Air Bag System Block Diagram



Modification basis	
Application basis	
Affected VIN	

The watch dog monitors the micro controller, the air bags, and the seat belt pretensioners in the air bag unit. When any error occurs, it turns on the air bag warning lamp.

When the front air bags deploy, the driver's air bag and the front passenger's air bag deploy simultaneously and their seat belt pretensioners also simultaneously retract their seat belts.
The air bag unit monitors conditions of the air bags and the seat belt pretensioners. When any error occurs, it stores the failure diagnostic code or turns on the air bag warning lamp on the instrument panel.



Modification basis	
Application basis	
Affected VIN	

4. DEPLOYMENT

1) Air Bag System Deployment (Firing Loop)

According to the collision deceleration rate that each collision G sensor reads, the air bag unit sends out about 2~4 or higher Amp current. This current generates some heat, which fires the detonator in the inflator.
The table shows the basic inner resistance of the air bag related module and the basic instant current necessary for firing.

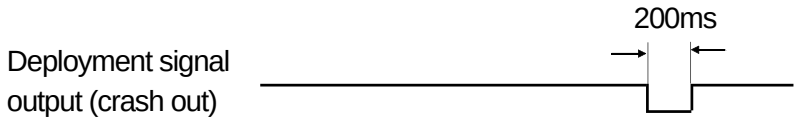
Air bag module	DAB /PAB	Seat belt pretensioner(BPA)
Resistance (at −30 ~ 85˚C)	2 ±0.3 Ω	2.15 ±0.35 Ω
Firing current	1.2 Amps	0.8 Amps

CAUTION

- Please do not connect a tester to any air bag connector or single item to measure the supplied power or resistance. The detonator may explode due to a sudden extra power supplied by the tester.
- Before removing or installing any air bag related components, disconnect the negative battery cable.

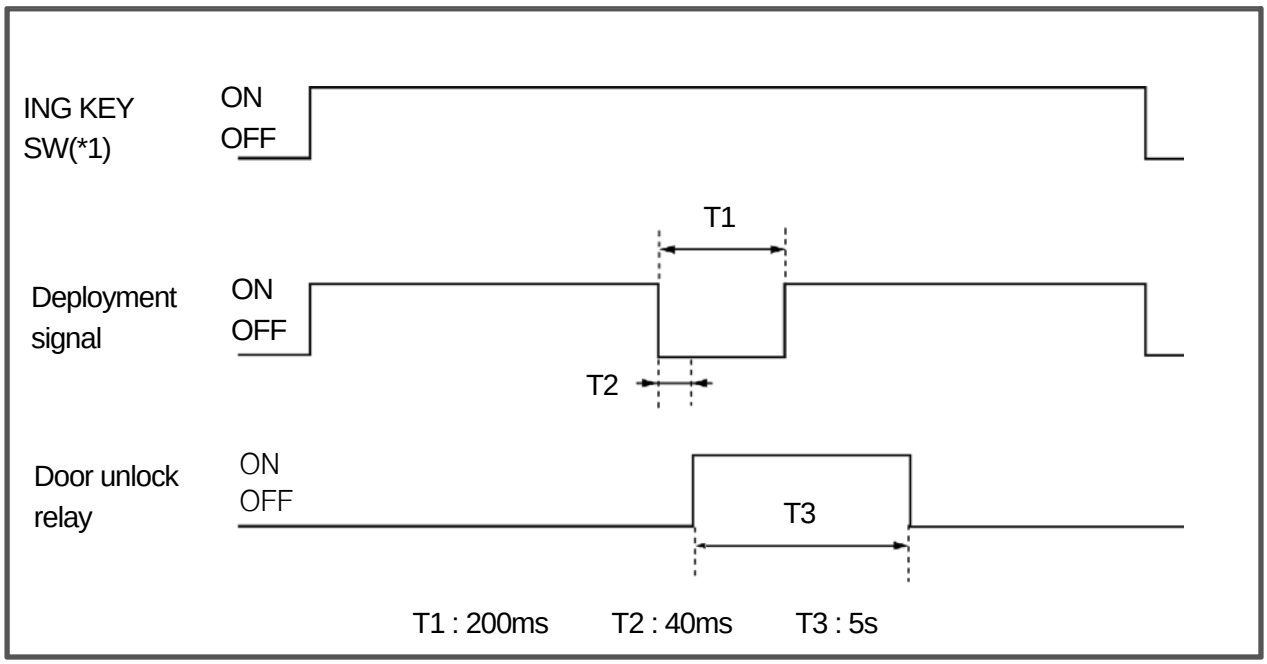
2) Air Bag Deployment Signal Output (Crash Out)

When the air bag deploys, the signal is sent to STICS to perform the basic security operation which is the automatic door unlock function that release the automatic door lock mode.



▶ Automatic Door Unlock (Crash unlock: unlock when colliding)

1. The air bag collision signal input cannot be accepted within 7 seconds after turning the ignition key to "ON" position.
2. After this period, the door lock system outputs "UNLOCK" for all doors for 5 seconds from 40 ms after receiving the air bag collision signal.
3. Even though the key is turned to "OFF" position during the output of "UNLOCK", the output continues on for remaining period.
4. The function is erased when turning "OFF" the ignition switch.



CAUTION

▶ Cautions for Door Lock/Unlock Control

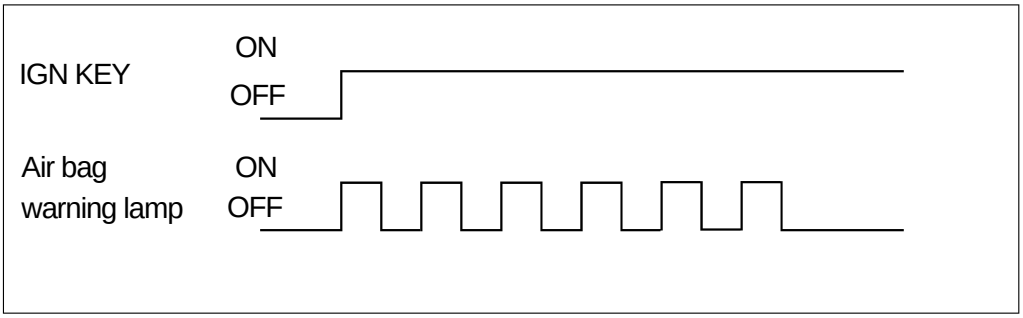
1. The "Unlock" control by air bag signal prevails over any "LOCK" or "UNLOCK" control by other functions.
2. The "LOCK/UNLOCK" request by other functions will be ignored after/during the output of "UNLOCK" by the air bag.
   However, the door lock is controlled by other functions when the ignition switch is "OFF".
3. "LOCK" (or "UNLOCK") output is ignored if "LOCK" (or "UNLOCK") output is required while performing the output of "LOCK" (or "UNLOCK").
   However, UNLOCK by air bag signal and operation by the remote control key are valid.
4. If the door lock system outputs "LOCK" and "UNLOCK" simultaneously, only the "LOCK" output can be activated.

5. AIR BAG WARNING LAMP OPERATIONAL CONDITIONS

The air bag warning lamp on the instrument panel has a few operational conditions. The following are the conditions:

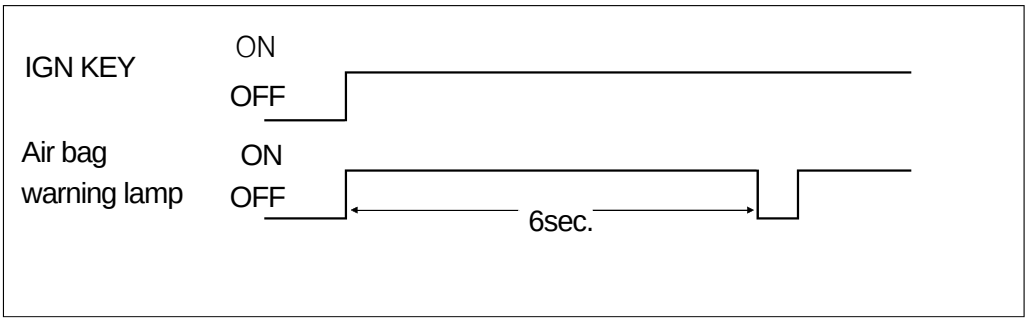
▶ When Turning the Ignition Switch to ON Position Initially

The air bag unit performs a turn-on test when the ignition is turned on initially. The air bag unit flashes the air bag warning lamp 6 times at 1 Hz interval. After that, the air bag warning lamp will go off if no malfunction have been detected.



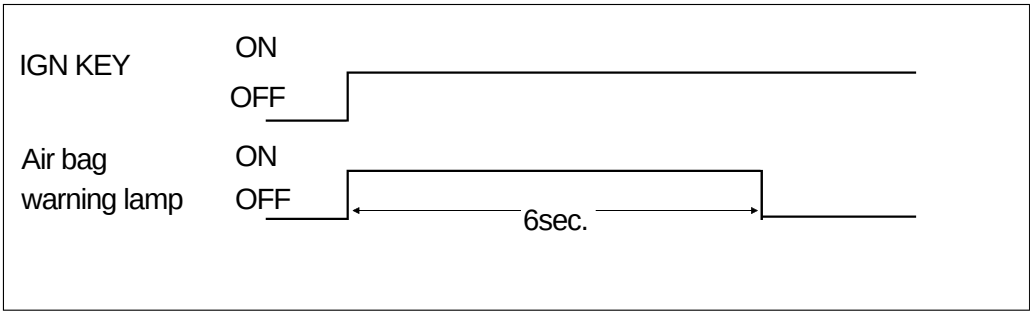
▶ When the Air Bag Unit Detects Any Malfunctions in Unit

When it is recorded as a system failure in the air bag unit, the air bag warning lamp on the instrument panel comes on for about 6 seconds and goes off for 1 second. Then the waning lamp stays on.



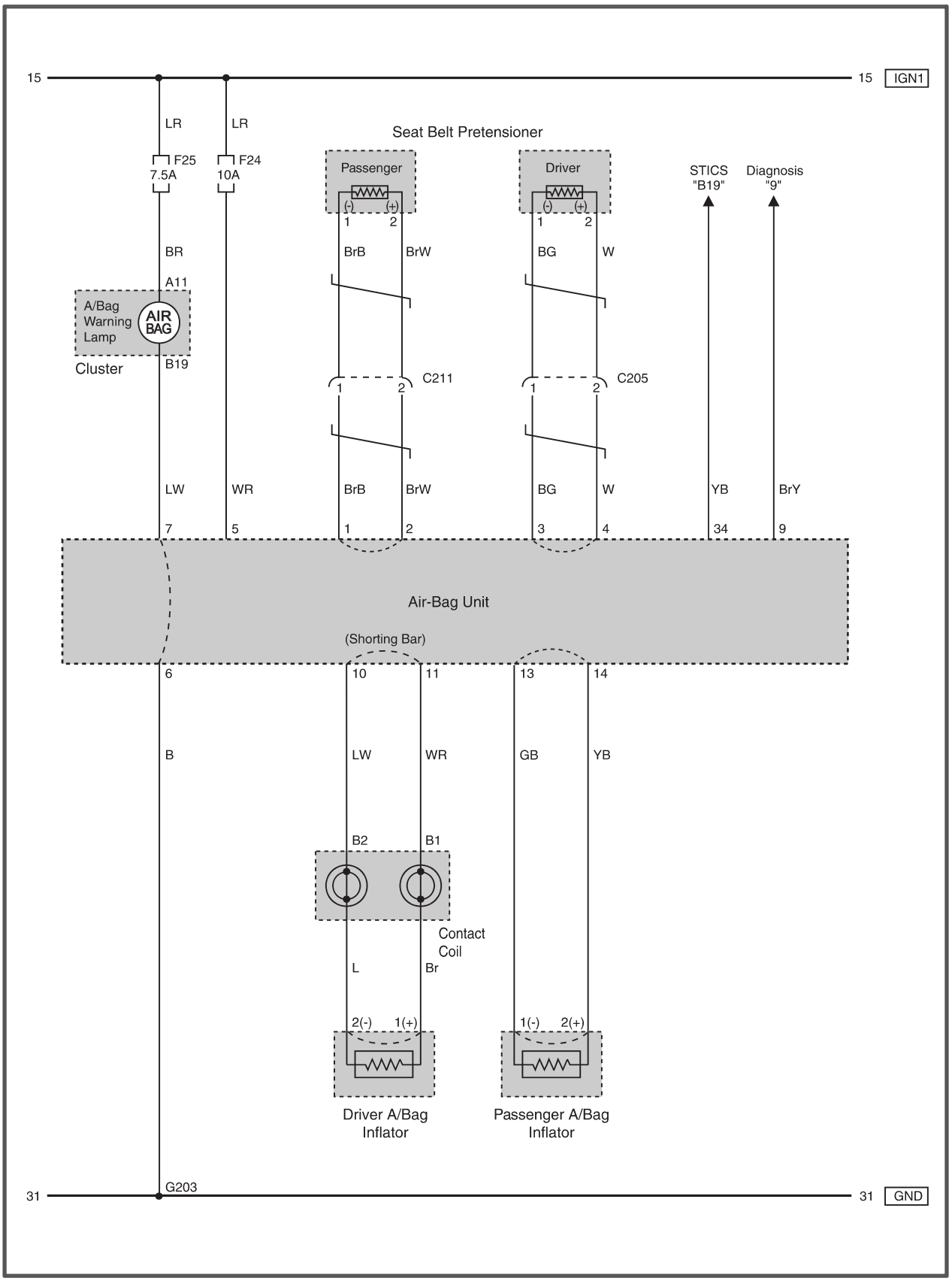
▶ When the Air Bag Unit Detects Any Intermittent Failure

When, due to an error from outside the system, the intermittent failure signal is received 5 times or less, the air bag warning lamp comes on for about 6 seconds and then, goes off.



Modification basis	
Application basis	
Affected VIN	

6. CIRCUIT DIAGRAM



SEAT/SEAT BELT

0000-00

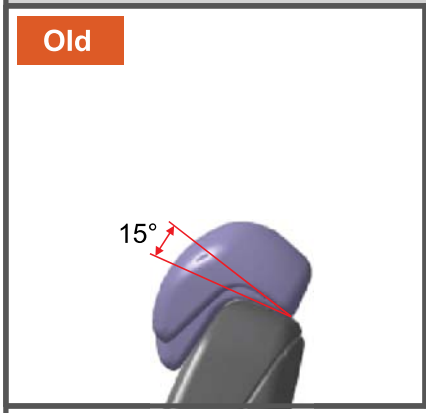
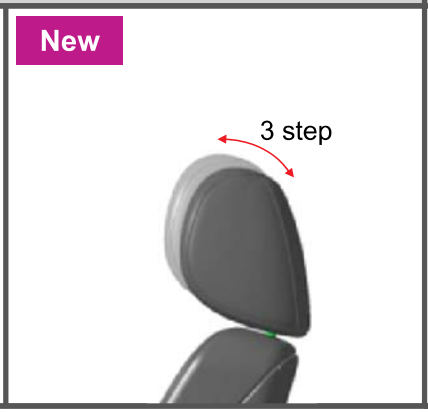
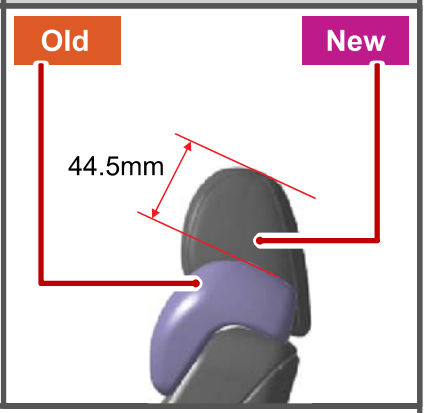
GENERAL INFORMATION

1. SPECIFICATION

Item		Front seat	Rear seat	Remark
Headrest	Type	Slide	Helm	
	Up/down	90 mm (15 mm X 6)	100 mm (100 mm X 1)	
Seat	Recliner	20° (foremost position)+ 64°(2° X 32)	-	
	Folding	-	O	
	Height adjustment	± 15 mm	-	
	Sliding	192 mm (12 mm X 16)	-	
	Driver lumbar support	60° (30° X 2)	-	
Seat adjusting motor	Slide/height adjustment operating voltage	10 to 15 V	-	
	Recliner Operating voltage	9.6 to 14.4 V	-	
	Slide operating voltage	7 A	-	13.5 V (based on 75 KG)
	Height adjust operating current	8 A	-	
	Recliner operating current	7 A	-	13.5 V, Unloaded
Heated seat	Rated voltage	12 V	←	
	Operating voltage	10 ~ 16V	←	
	Power consumption	60W±10%	←	
	Heated wire temperature	ON: 35±4°C OFF: 45±3°C	ON: 35±4°C OFF: 45±3°C	Temperature measured at seat surface

2. MAJOR CHANGES

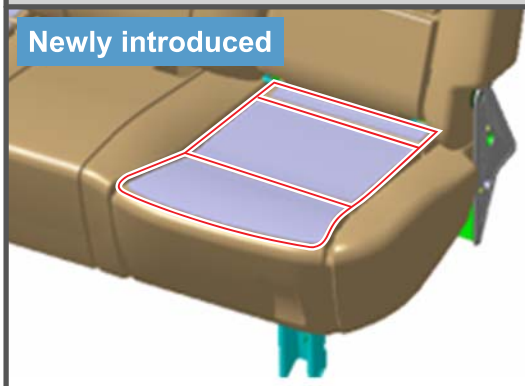
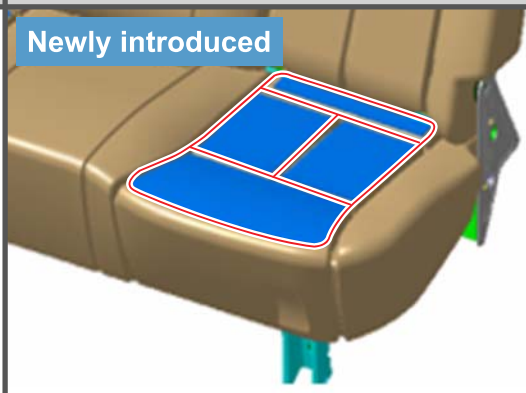
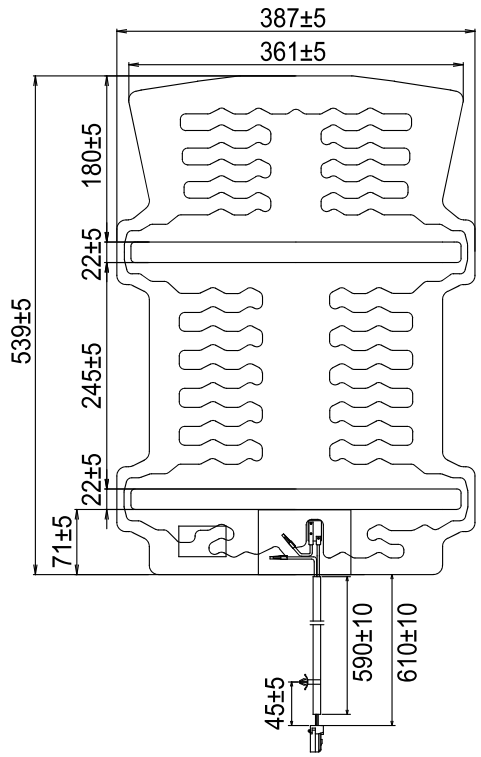
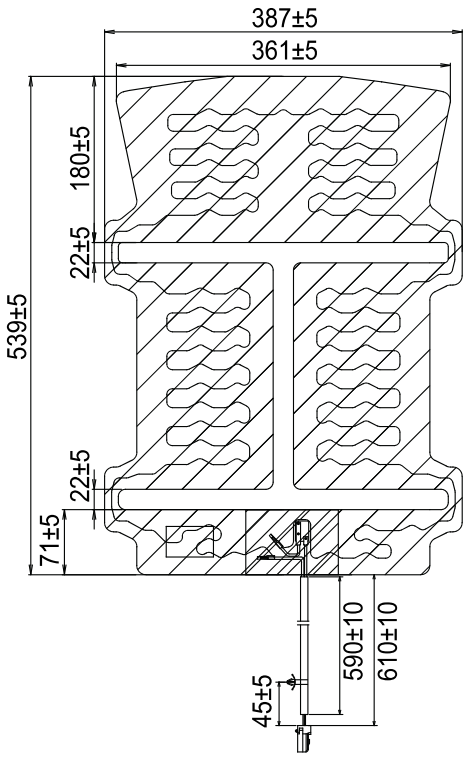
1) Front Seat

<table>
<tr><th colspan="3">Front headrest</th></tr>
<tr><th colspan="2">Headrest tilting</th><th>Headrest height</th></tr>
<tr><td>Old
 
</td><td>New
 
</td><td>Old New
 
</td></tr>
<tr><td colspan="3">– Chnaged headrest type (Helm → Slide)
- Changed from swing tilting adjusmtment to sliding tilting adjustment
- Improved safety by increasing headrest height (44.5 mm) in case of rear impact</td></tr>
</table>

2) Rear Seat

<table>
<tr><th colspan="2">Rear seat headrest</th></tr>
<tr><td>Newly introduced
  </td><td>Headrest warning label
  </td></tr>
<tr><td colspan="2">- Warning label affixed to side of rear seat headrest</td></tr>
</table>

Modification basis	
Application basis	
Affected VIN	

Rear RH seat	
Fabric seat	Leather seat
	
	
- 2 different heating wires according to fabric and leather specification	

3. WARNINGS FOR POWER SEAT

1. Adjust the driver's seat before driving.
2. Make sure that the seat is firmly secured after adjusting.
3. Never drive the vehicle with the head restraint removed or lowered excessively. Otherwise, your neck, spine or other parts of the body can be severely injured in the event of an accident.
4. If you recline the seatback excessively, you could slide under the seat belt and be injured severely in a collision.
5. Do not put any object that could damage the seat on the seat.
6. The front and rear seats are equipped with the heated wire (seat warmer) system. Using the seat warmer system excessively may cause minor burns. The following occupants should exercise special care when using the heated wire seat.
   - Infant, child, old or handicapped person
   - Person with sensitive skin
   - Exhausted person
   - Persons who is drunk or took medicine which causes drowsiness such as sleeping pills, cold tablets, etc.
7. Do not place anything on the seat that insulates against the heat, such as a blanket or cushion.
5. Make sure that the head restraints are in place and secured properly. Never drive the vehicle with the head restraint removed.
9. To minimize the injuries in a collision or an abrupt stop, make sure the seatback is in the upright position before driving. If the seatback is reclined too much, the occupant could slide under the seat belt in a collision or an abrupt stop and cannot be protected properly by the airbag system.

4. CAUTIONS FOR POWER SEAT

1. You can operate the power seat with the ignition switch OFF. However, frequent operation of the seat switch with the engine stopped can result in battery becoming discharged.
2. Operating more than one seat adjustment switch at the same time can cause damage to the seat motor. Therefore, operate the seat switch only one at a time.
3. Do not use organic solvents such as benzene, thinner, alcohol or gasoline to prevent the seat cover from being damaged while cleaning.
4. Do not operate the seat position adjustment switch forcefully when the seat does not move or it contacts an object.
5. If the power seat is not operated, check and correct the problem before driving off.

Modification basis	
Application basis	
Affected VIN	

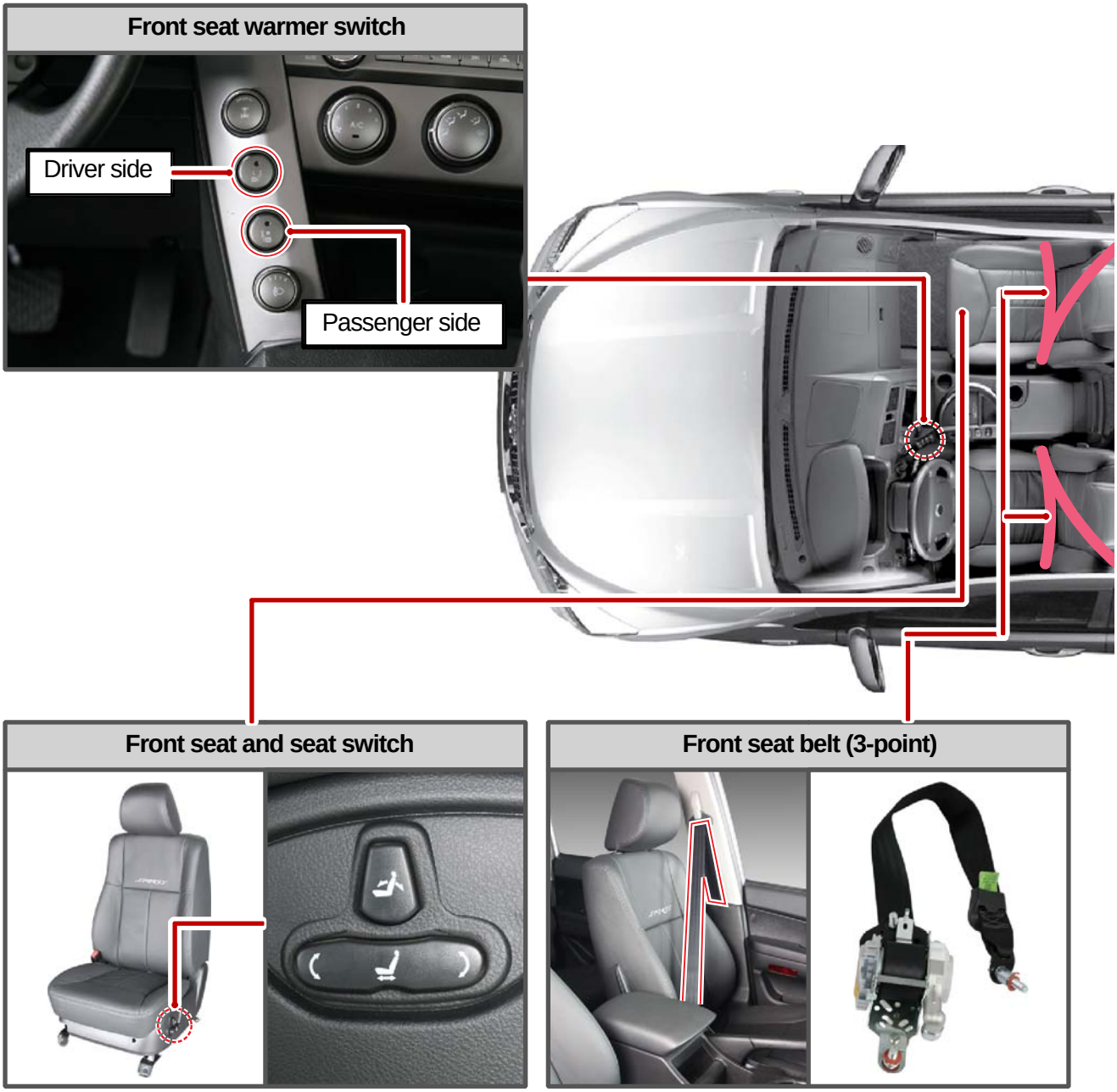
Memo

OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

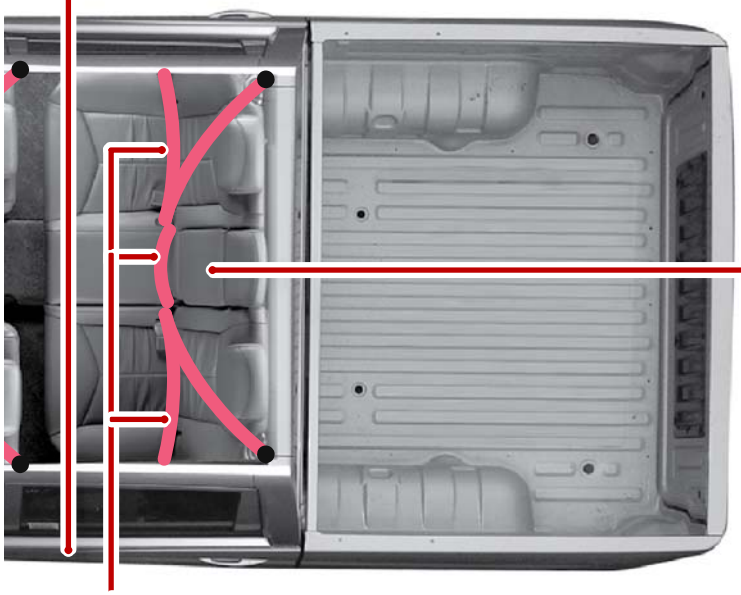
The seat consists of the front seats (driver and front passenger) and rear seats.
The heated wires are inserted into the seat cushion and seatback for front seat and is inserted into the seat cushion for rear seat.
While the front and rear LH/RH seats have 3-point seat belt, rear center seat has 2-point seat belt.

2. SEAT/SEAT BELT LAYOUT



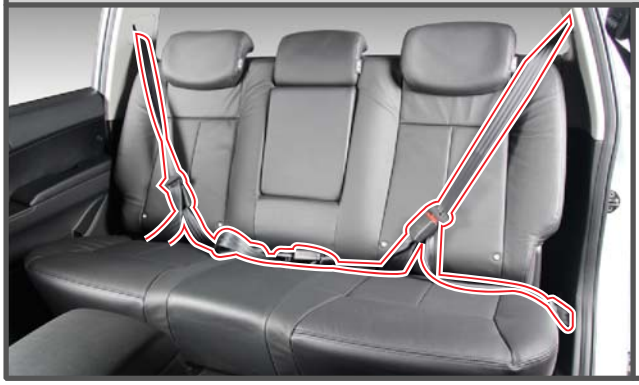
Modification basis	
Application basis	
Affected VIN	

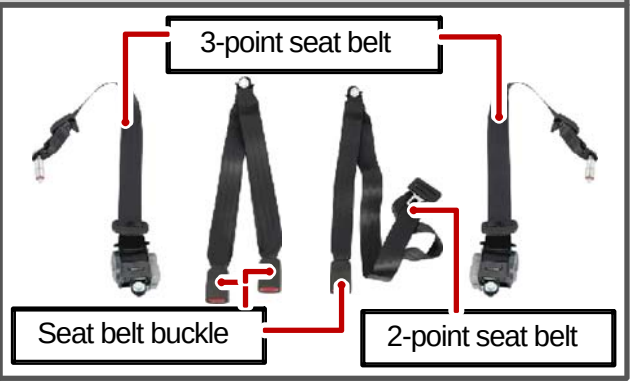
Rear seat warmer switch



Rear seat

Rear seat belts (3-point and 2-point)





3. HOW TO ADJUST AND OPERATE SEAT

1) Front Seat

There are two types of front seats: the power seat which uses the electric motor to adjust the seat movement, seatback and seat cushion and
the manual seat which adjusts them by pulling the lever by hand.
For both power seat and manual seat, the driver can adjust the headrest and driver lumbar support by hand.
The heated wires are inserted into the seatback and the seat cushion, which are operated by the front seat warmer switch located to the center fascia.

▶ **To adjust headrest**

To adjust headrest height

To adjust the height of the headrest, raise or lower it while pressing the headrest sleeve (A).

To adjust headrest tilting

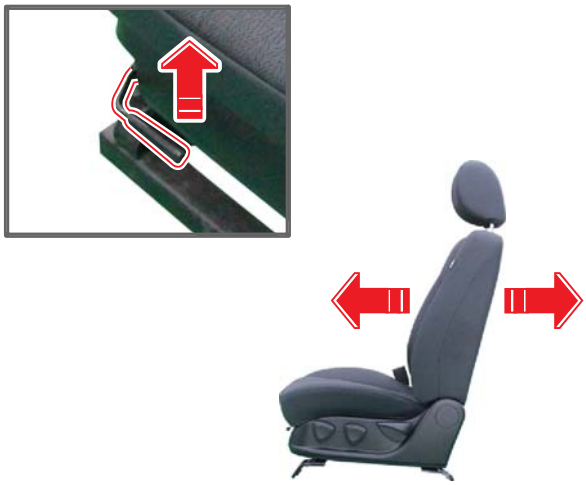
Pull the headrest forwards and release to adjust its tilting angle in 3 steps.

Modification basis	
Application basis	
Affected VIN	

▶ To adjust seatback

Power Seat
To adjust seat slide

Moving the slide knob forward and rearward activates the slide motor to move the seat forward and rearward.

Manual seat
To adjust seat slide

To move the seat forward or backward, pull and hold the seat slide lever up and move the seat as desired. Then, release the lever.

To adjust seat back angle

When moving the upper part of the recline knob forward/backward, the seatback angle is adjusted as the recline motor rotates the rail.

To adjust seat back angle

To change the seatback angle, lean forward slightly and raise the lever. Then, lean back to the desired angle and release the lever. After adjusting, make sure the lever is returned to its original position and the seatback is locked.

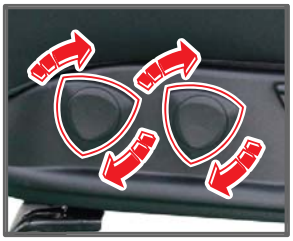
Power Seat

To adjust seat cushion angle

When moving the slide switch forward/backward, the front and rear up/down motors rotate the rails to move the front and rear side of the cushion up/down.

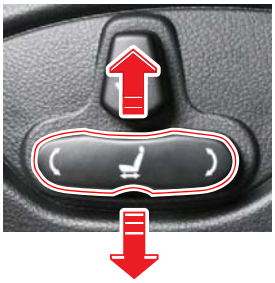
Manual seat

To adjust seat cushion angle and height



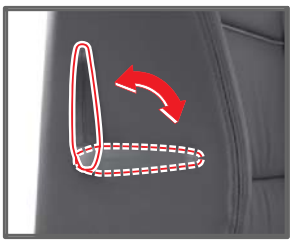
You can adjust the angle and height of the front or rear section of the seat cushion by rotating the adjustment knob on the side of the seat clockwise or counterclockwise.

To adjust seat cushion height



When moving the slide switch up/down, the front rear up/down motor rotates the rail to move the whole seat cushion up/down.

To adjust driver seat lumbar support



When you raise and lower the lumbar support lever on the power and manual seats, the lumbar support goes in and out of the seat.

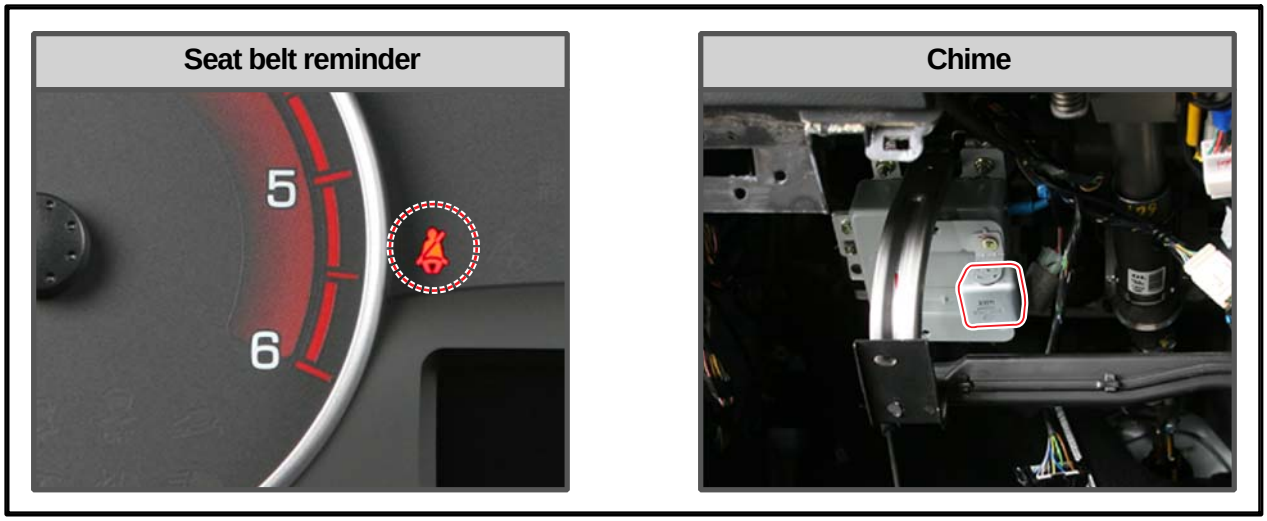
Modification basis	
Application basis	
Affected VIN	

2) Seat Belt Reminder & Pretensioner

In addition to securing the occupants to the seat, the seat belt has the seat belt reminder and the pretensioner which retracts the seat belts while the air bags are deployed and the load limiter which protects the seat belt from being retracted excessively.

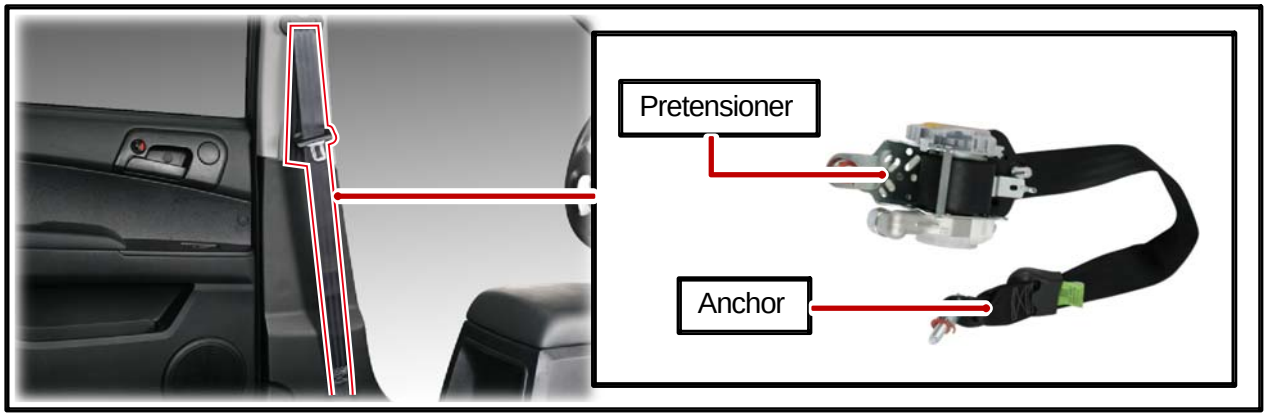
▶ Driver's seat belt reminder

The STICS detects if the seat belt is fastened or not using a signal from the driver's seat belt switch. The seat belt reminder flashes and the chime sounds when the seat belt is not fastened.
The seat belt reminder stops its operation as soon as the seat belt is fastened.



▶ Pretensioner

It is installed on the driver and passenger LH/RH B-pillar and the pretensioner is installed in it, which retracts the seat belt when the air bag is deployed in case of the front impact to secure the occupant to the seat.



SUNROOF

7340-00

GENERAL

1. SPECIFICATIONS

Operating voltage	9 ~ 16 V
Operating current (open & close)	Max. 6 A
At no load	Max. 2 A
Leakage current	Max. 1 mA or less
Roof motor operating speed (at opening and closing)	1.2 ± 0.5 sec./100 mm
Motor overload stop conditions	Current for up to 26 A and torque (load) for up to 8.3 Nm
Opening amount	230 ± 3
Vertical/horizontal tolerance for sunroof glass panel	± 2 mm/± 2.5 mm

2. CAUTIONS WHEN WORKING

1. Wear clean work clothes and gloves.
2. Replace and wash the gloves frequently.
3. Any unauthorized modification or operational test is not allowed since the sunroof motor and control unit are preset at the factory.
4. Take care not to drop the sunroof assembly when removing it and do not keep it right up.

3. CAUTIONS FOR OPERATION

- Even though the sunroof can be operated when the engine is not running, operating the sunroof repeatedly with the engine turned off will run down the battery. Operate the sunroof while the engine is running.
- When the sunroof operation is completed, release the switch. Keeping pressing the switch can result in malfunction.
  Especially in winter, never operate the sunroof if operation areas are iced. Wait until melted.
- Make sure that the sunroof is completely closed when leaving the vehicle. Leaving the vehicle with the sunroof open result in a theft. In addition, rain or snow can get into the vehicle through the open sunroof.
- When the sunroof is fully open, wind buffeting symptom can be worse. In this case, try to adjust the sunroof position manually or open the sunroof until the wind buffeting is disappeared
  Parts of the body can be trapped in the sunroof and can be struck by passing objects. Do not stick
- hands, head or anything else out of the openings.
  Remove any dirt and foreign material stuck on the edge of the sunroof glass periodically.
- Noise can occur due to friction when operating the sunroof.

OVERVIEW AND OPERATING PROCESS

1. SYSTEM LAYOUT

OPEN

TILT

Sunroof switch

1

Sunroof assembly

2

Sunroof motor & control unit

3

Modification basis	
Application basis	
Affected VIN	

2. OPERATING PROCESS

1) Sunroof Switch

▶ Sunroof operation switch

The sunroof switches are included in the overhead console switches and consists of the TILT, CLOSE and OPEN switches.

▷ **CLOSE**

Closes the sunroof.

▷ **OPEN**

Opens the sunroof.

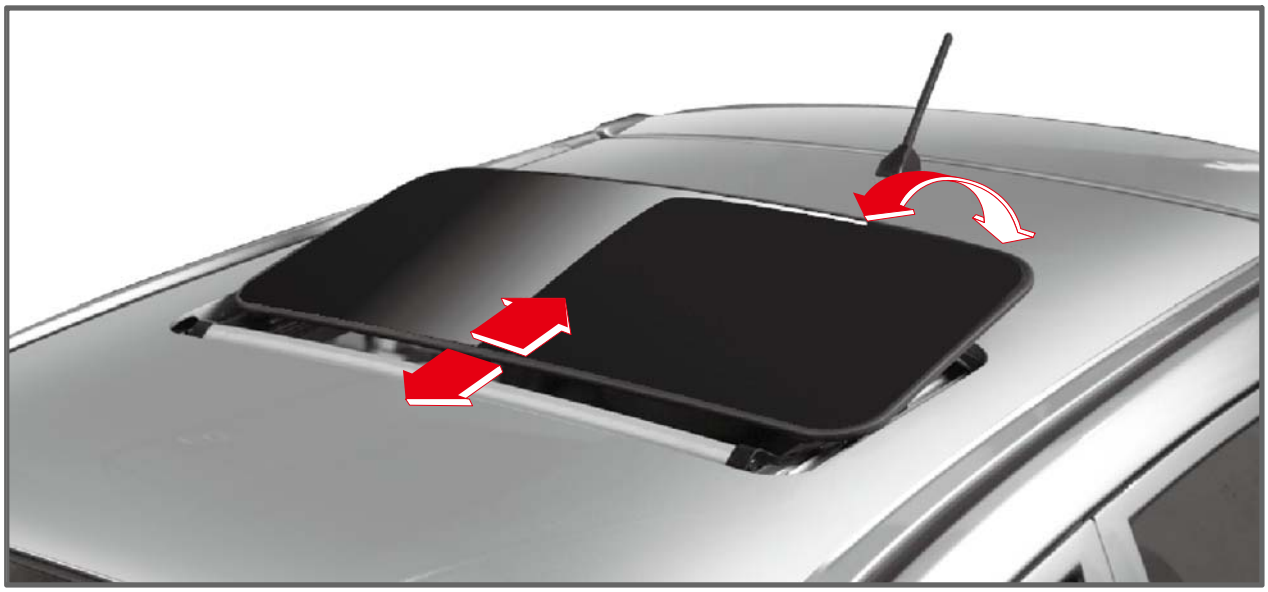
▶ Sunroof glass

The sunroof glass can be open automatically and can be tilted by the switch operation.

▶ Roller blind

This can be closed or open manually to block sunlight when the sunroof function is not in use.

2) Sunroof Sliding Opening/Closing



▶ **Opening sunroof (Sliding open)**

Auto open

When turing the switch to the "OPEN" position briefly, the sunroof is tilted up and opened automatically until it stops. The sunroof operation stops if you operate the switch during its operation.

Manual open

- 1st step (tilt up): When making a long turn of the switch to the "OPEN" position with the sunroof closed, it is tilted up.
- 2nd step (opens by itself from tilted up condition): When making a long turn of the switch to the "OPEN" position with the sunroof tilted up, it opens only whilst turning the switch.

▶ **Closing sunroof (Sliding close)**

Manual close

While turning the switch to the "CLOSE" position, the sunroof is closed. Release the switch at the desired position.

CAUTION

Since the sunshade blind does not operate together with the sunroof, you should open and close it manually.

Modification basis	
Application basis	
Affected VIN	

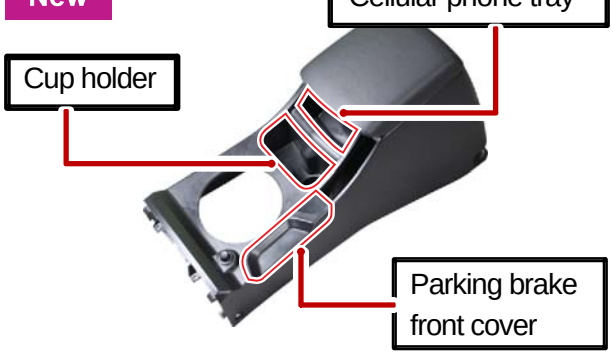
BODY INTERIOR

7710-06

GENERAL INFORMATION

1. MAJOR CHANGES

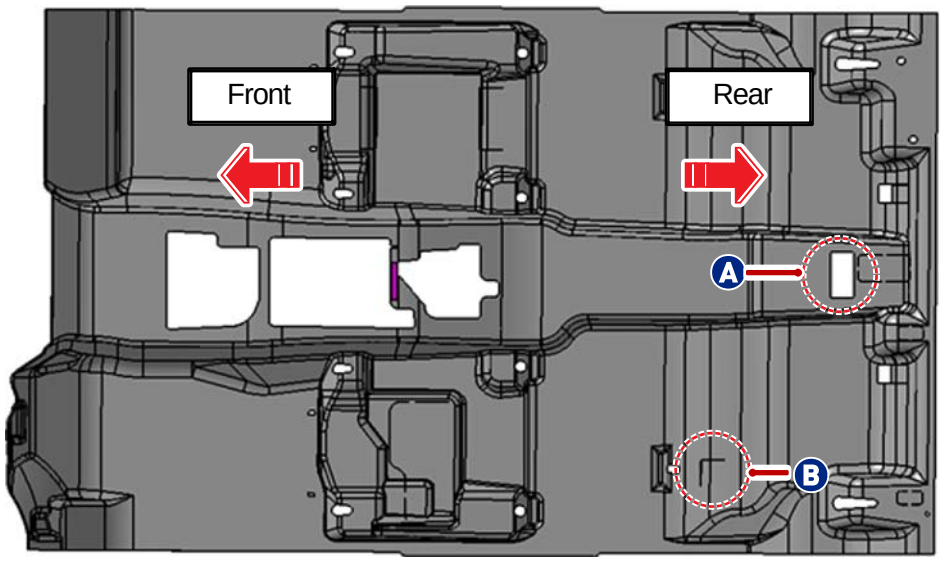
1) Front Console

Front console	
Old 	New 
- Parking brake front cover and its mounting appearances changed - Cup holder shutter removed and cellular phone tray adopted	

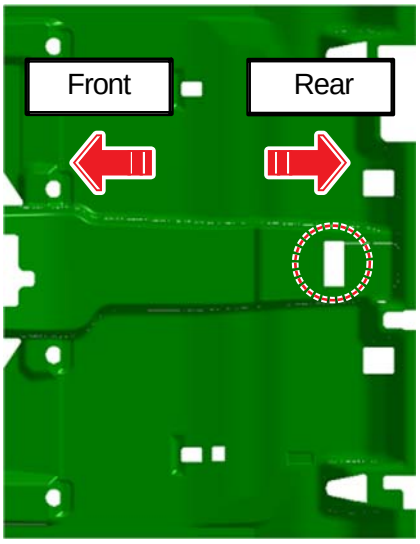
2) Dash Inner Insulator

Dash inner insulator	
Old 	New 
- Hole added and appearance changed	

3) Floor Mat

Floor mat
New 
A. Hole added and appearance changed B. Silt line added and appearance changed due to heated rear seat adoption

4) Floor Rear Insulator

Floor rear insulator
New 
- Hole added and appearance changed

Modification basis	
Application basis	
Affected VIN	

BODY REPAIR

4110-01

GENERAL INFORMATION

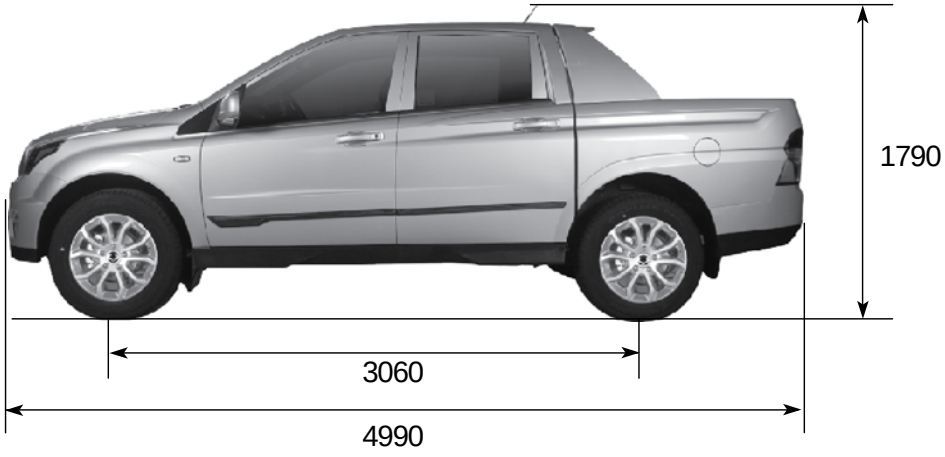
1. DIMENSIONS

▶ **Major Dimensions**

Unit: mm

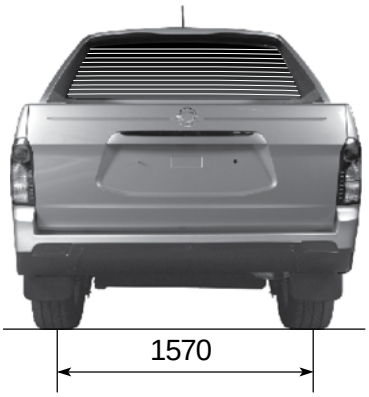
Top view

Side view



Front view

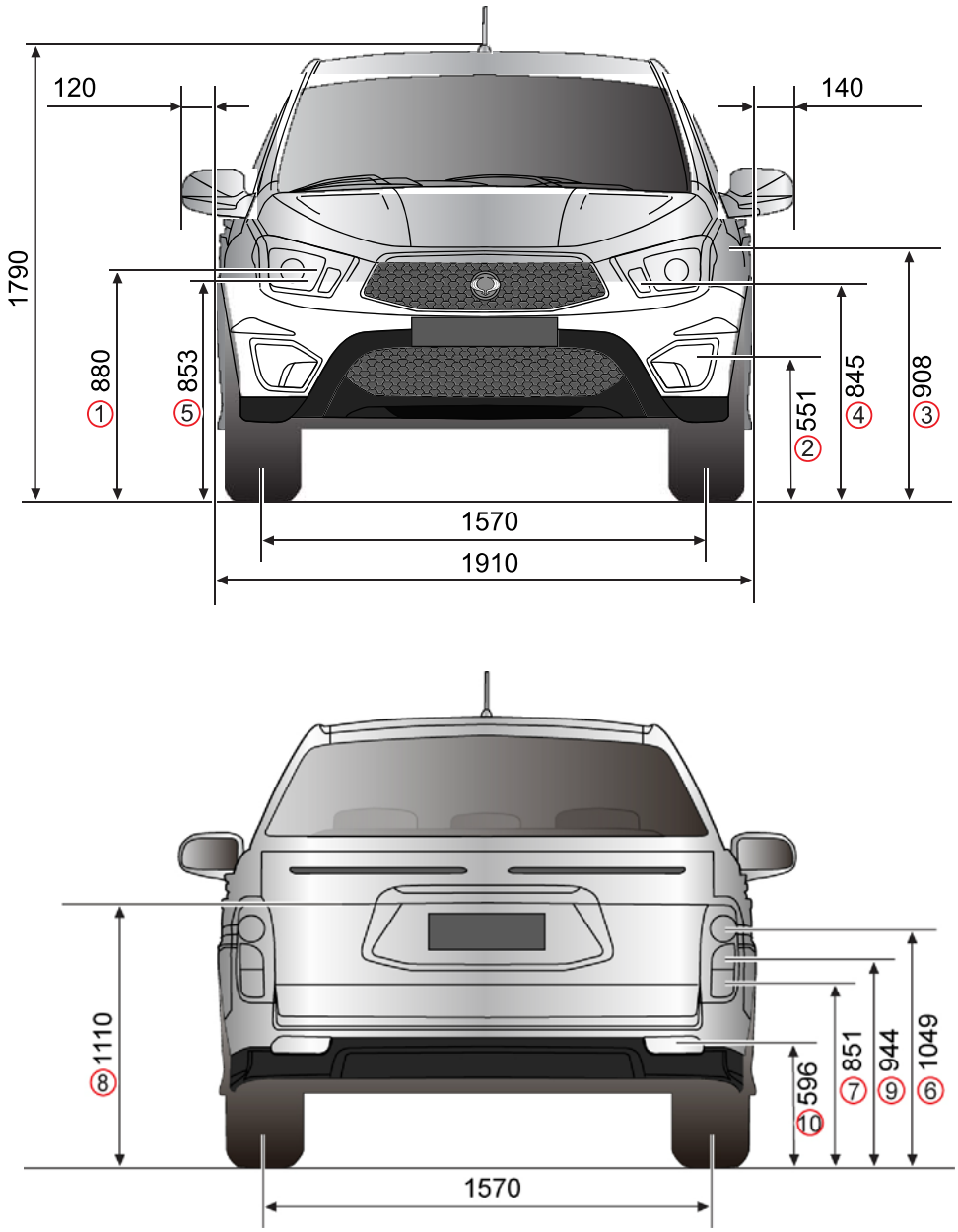
Rear view



Modification basis	
Application basis	
Affected VIN	

▶ Detailed Dimensions

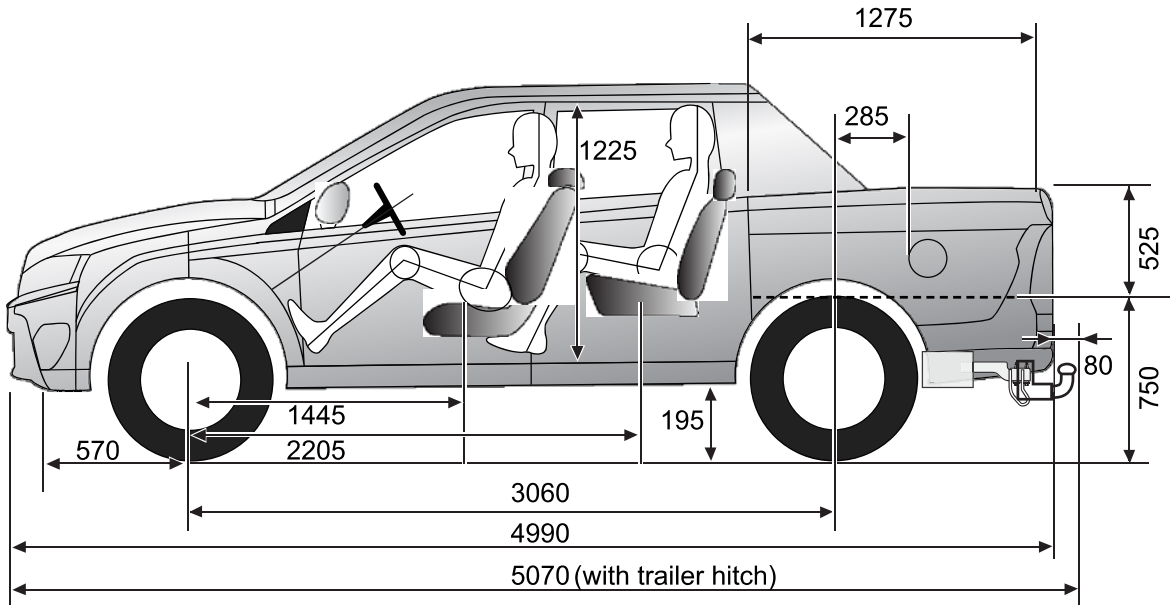
Unit: mm

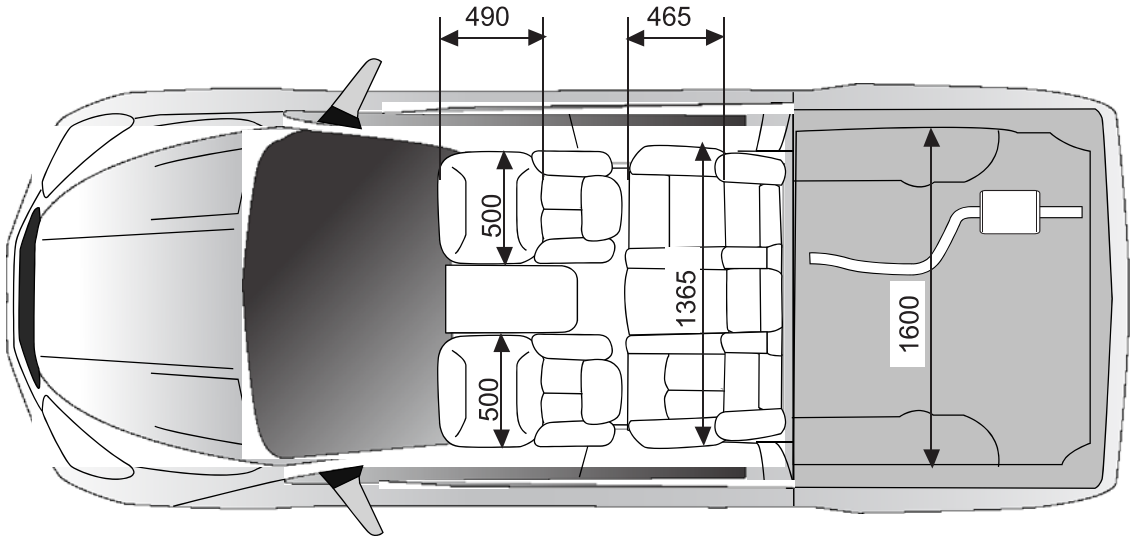


1. Headlamp
2. Front fog lamp
3. Side repeater
4. Front turn signal lamp
5. Position lamp
6. Stop/Tail lamp
7. Back-up lamp
8. License plate lamp
9. Rear turn signal lamp
10. Reflector

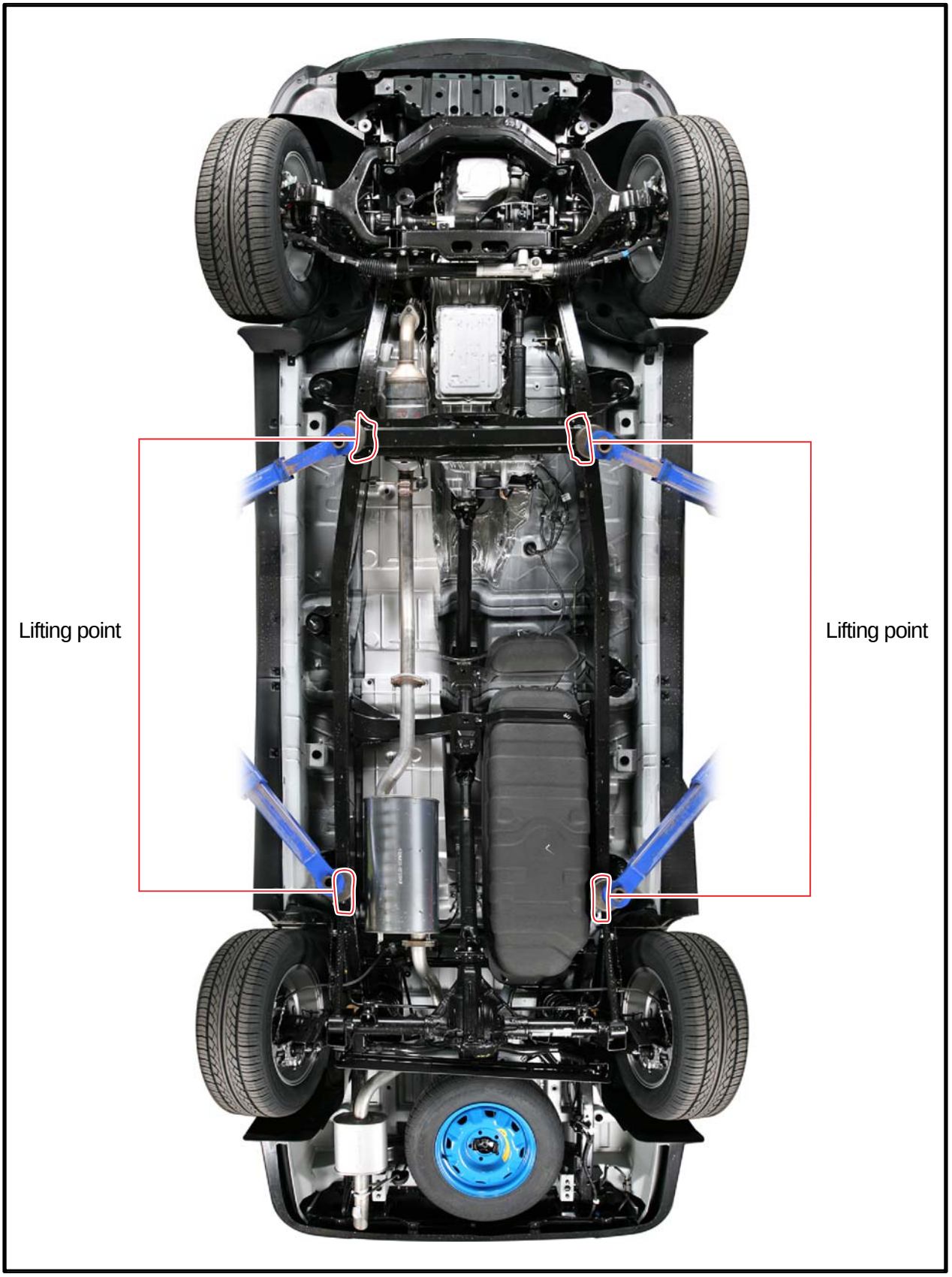
Modification basis	
Application basis	
Affected VIN	

Unit: mm


1275
285
1225
525
80
750
195
1445
2205
570
3060
4990
5070 (with trailer hitch)


490
465
500
1365
1600
500

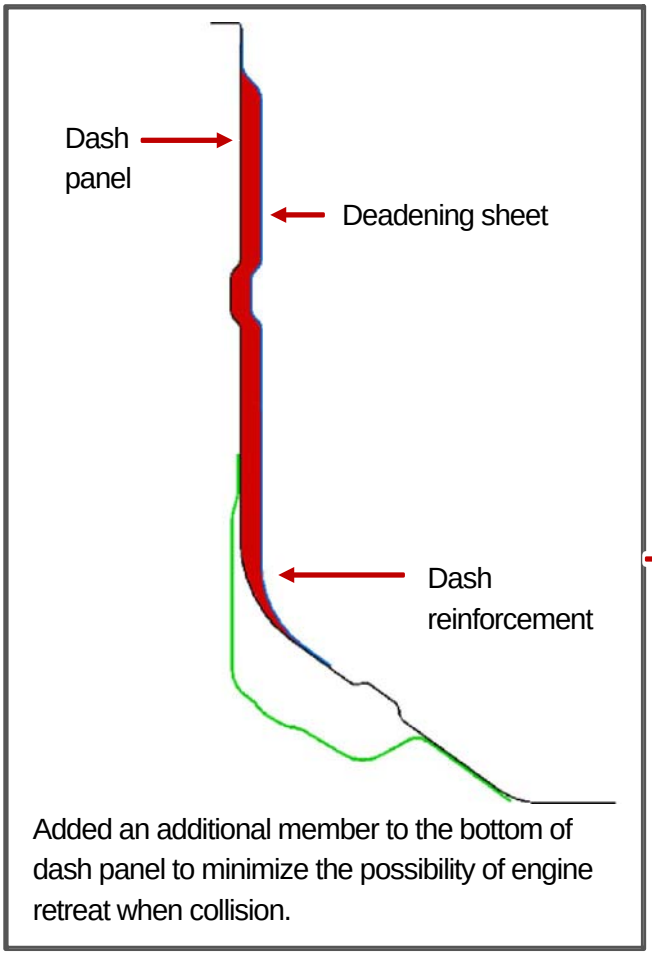
2. LIFTING POINTS



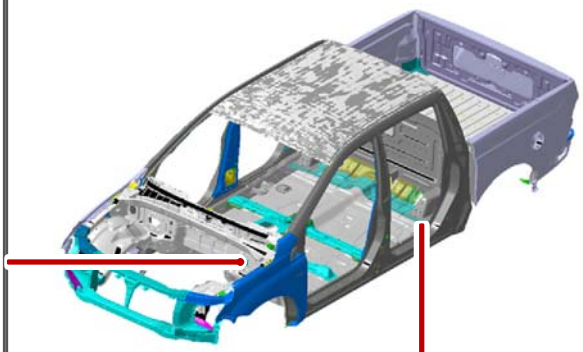
Modification basis	
Application basis	
Affected VIN	

3. DESIGN FOR IMPROVING NVH

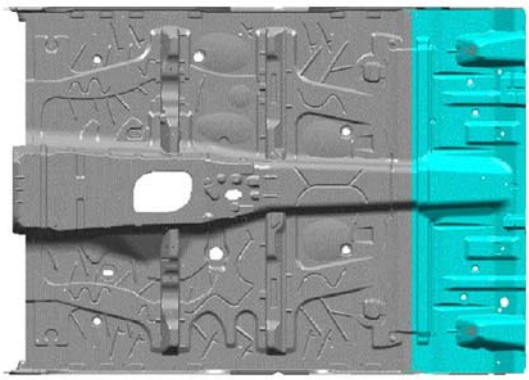
1) Dual Type Dash Panel and Engine Tunnel with Foaming Pad



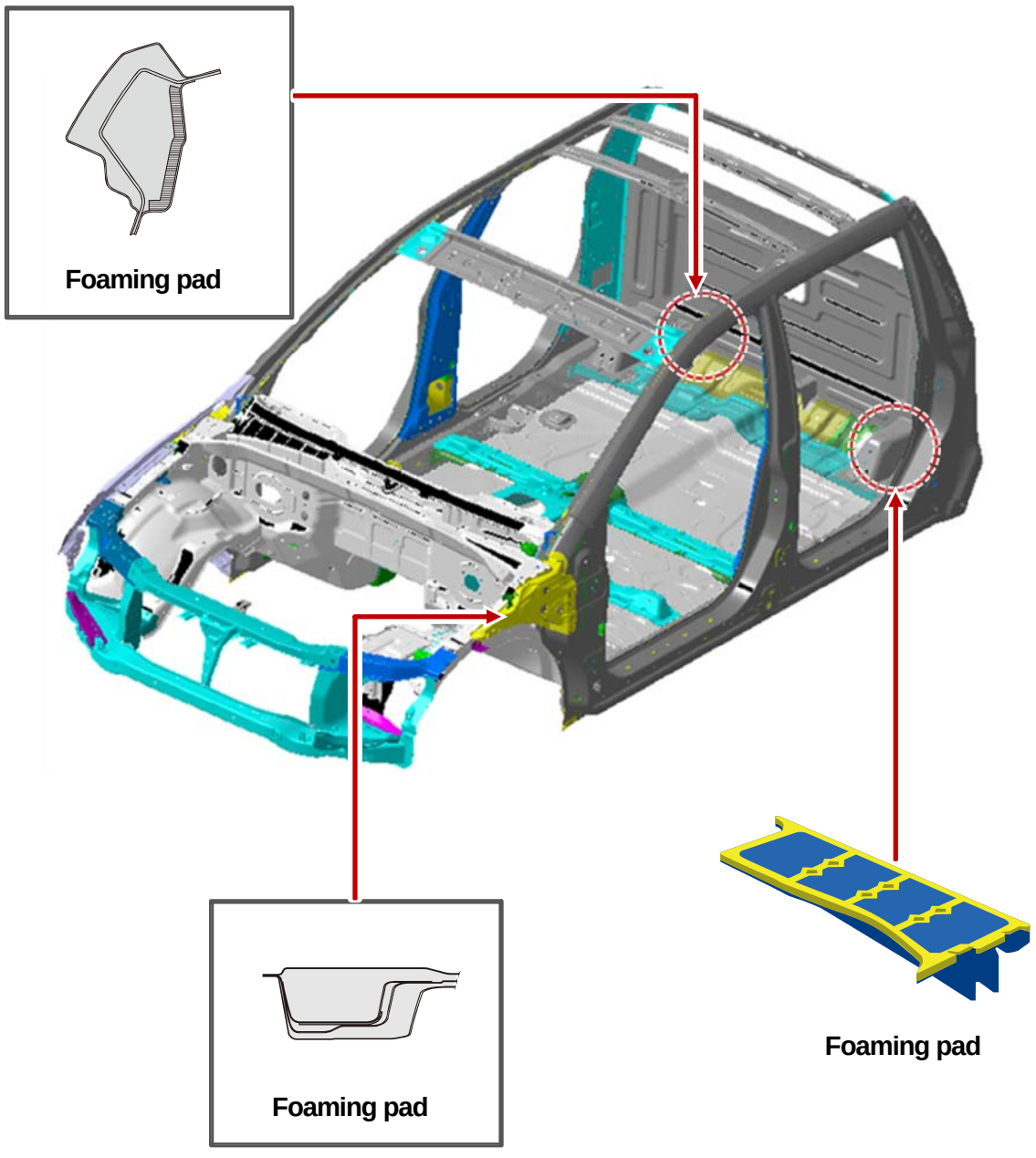
Added an additional member to the bottom of dash panel to minimize the possibility of engine retreat when collision.



▶ **Reinforcement for Front Floor and Rear Floor**

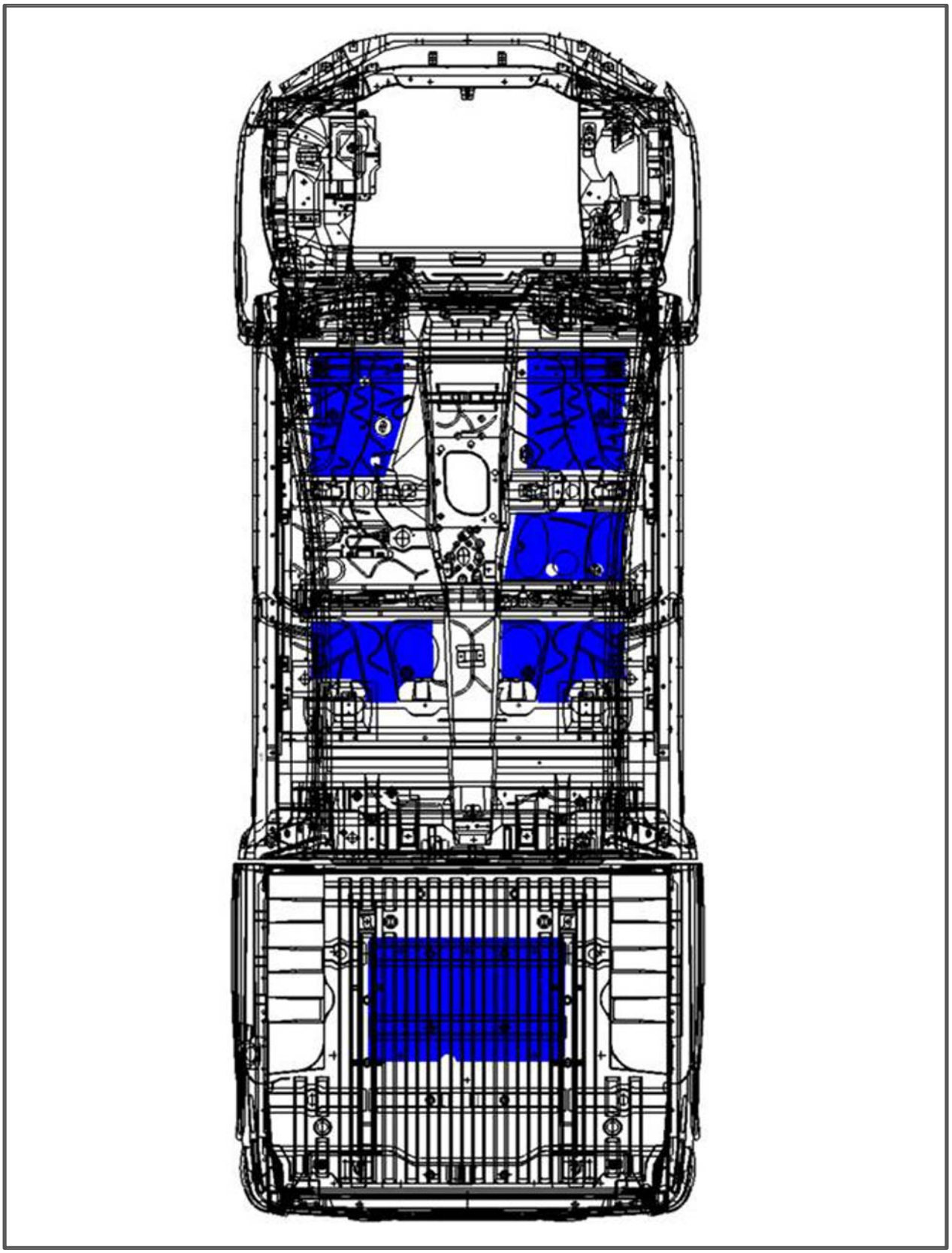


2) Applied BPR (Body Panel Reinforcement) Sealer to the Door Outer Panel



Modification basis	
Application basis	
Affected VIN	

3) Applying the Asphalt Sheet to the Body Panel (Improved Anti-Vibration)



Modification basis	
Application basis	
Affected VIN	