ENGINE

CONTENTS

E9BZAG

GENERAL INFORMATION

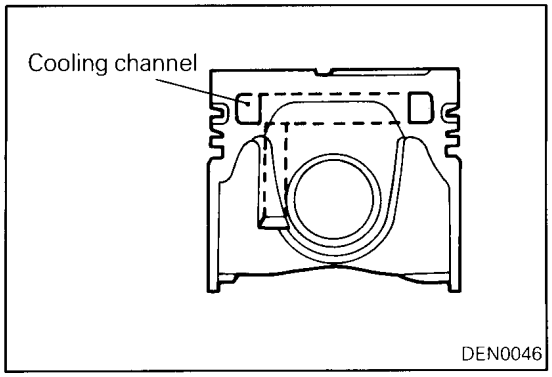
E9BLAAH

There are three versions of engine for the new PAJERO/MONTERO line-up.
The 4G64 petrol engine is the same as that used in the current L300 models. Similarly, the 4G54 and 6G72 petrol engines are the same as those for the current PAJERO/MONTERO models. Conversely the 4D56 turbocharged diesel engine with an inter-cooler has the following improvements:

- The pistons, piston rings and cylinder liners have been improved for higher abrasion resistance and durability.
- The oil pump and oil jets have been improved for better lubrication.
- The turbocharger has been improved for higher operational performance.

Item			4G64	4G54	6G72
Total displacement cm^3 (cu.in.)			2,351 (143.5)	2,555 (155.9)	2,972 (181.4)
Number of cylinders and arrangement			4, in-line type	4, in-line type	6, V-type
Combustion chamber			Compact type	Compact type	Compact type
Number of intake/exhaust valves (per cylinder)			1 each	1 each	1 each
Valve mechanism			Single Overhead Camshaft (SOHC), belt driven	Single Overhead Camshaft (SOHC), chain driven	Single Overhead Camshaft (SOHC), belt driven
Bore x stroke mm (in.)			86.5 x 100.0 (3.406 x 3.937)	91.1 x 98.0 (3.587 x 3.858)	91.1 x 76.0 (3.587 x 2.992)
Compression ratio			8.5	8.8	8.9
Valve timing	Intake valves	Open	20° BTDC	25° BTDC	19° BTDC
		Close	64° ABDC	59° ABDC	59° ABDC
	Exhaust valves	Open	64° BBDC	64° BBDC	59° BBDC
		Close	20° ATDC	20° ATDC	19° ATDC
Supercharging			–	–	–
Intercooler			–	–	–
Fuel system			Electronic control multi-point fuel injection	Carburetor	Electronic control multi-point fuel injection
Ignition system	Ignition distribution		By distributor	By distributor	By distributor
	Ignition timing control		Electronic control	Governor and vacuum control	Electronic control

Item			4D56	4D56 with turbocharger	4D56 with turbocharger and inter-cooler
Total displacement cm³ (cu.in.)			2,477 (151.2)	2,477 (151.2)	2,477 (151.2)
Number of cylinders and arrangement			4, in-line type	4, in-line type	4, in-line type
Combustion chamber			Swirl chamber type	Swirl chamber type	Swirl chamber type
Number of intake/exhaust valves (per cylinder)			1 each	1 each	1 each
Valve mechanism			Single Overhead Camshaft (SOHC), belt driven	Single Overhead Camshaft (SOHC), belt driven	Single Overhead Camshaft (SOHC), belt driven
Bore x stroke mm (in.)			91.1 x 95.0 (3.587 x 3.740)	91.1 x 95.0 (3.587 x 3.740)	91.1 x 95.0 (3.587 x 3.740)
Compression ratio			21.0	21.0	21.0
Valve timing	Intake valves	Open	20° BTDC	20° BTDC	20° BTDC
		Close	48° ABDC	48° ABDC	48° ABDC
	Exhaust valves	Open	54° BBDC	54° BBDC	54° BBDC
		Close	22° ATDC	22° ATDC	22° ATDC
Supercharging			–	Turbocharger	Turbocharger
Intercooler			–	–	Air cooling
Fuel system			Distributor-type injection pump	Distributor-type injection pump	Distributor-type injection pump
Ignition system	Ignition distribution		–	–	–
	Ignition timing control		–	–	–



ENGINE PROPER

E9BBAAG

PISTONS <4D56 WITH TURBOCHARGER AND INTER-COOLER>

A cooling channel has been provided in the pistons for better cooling.

PISTON RINGS <4D56 WITH TURBOCHARGER AND INTER-COOLER>

The surface treatment has been improved for better durability.

CYLINDER BLOCK <4D56>

The cylinder liner material has been improved for greater abrasion resistance.

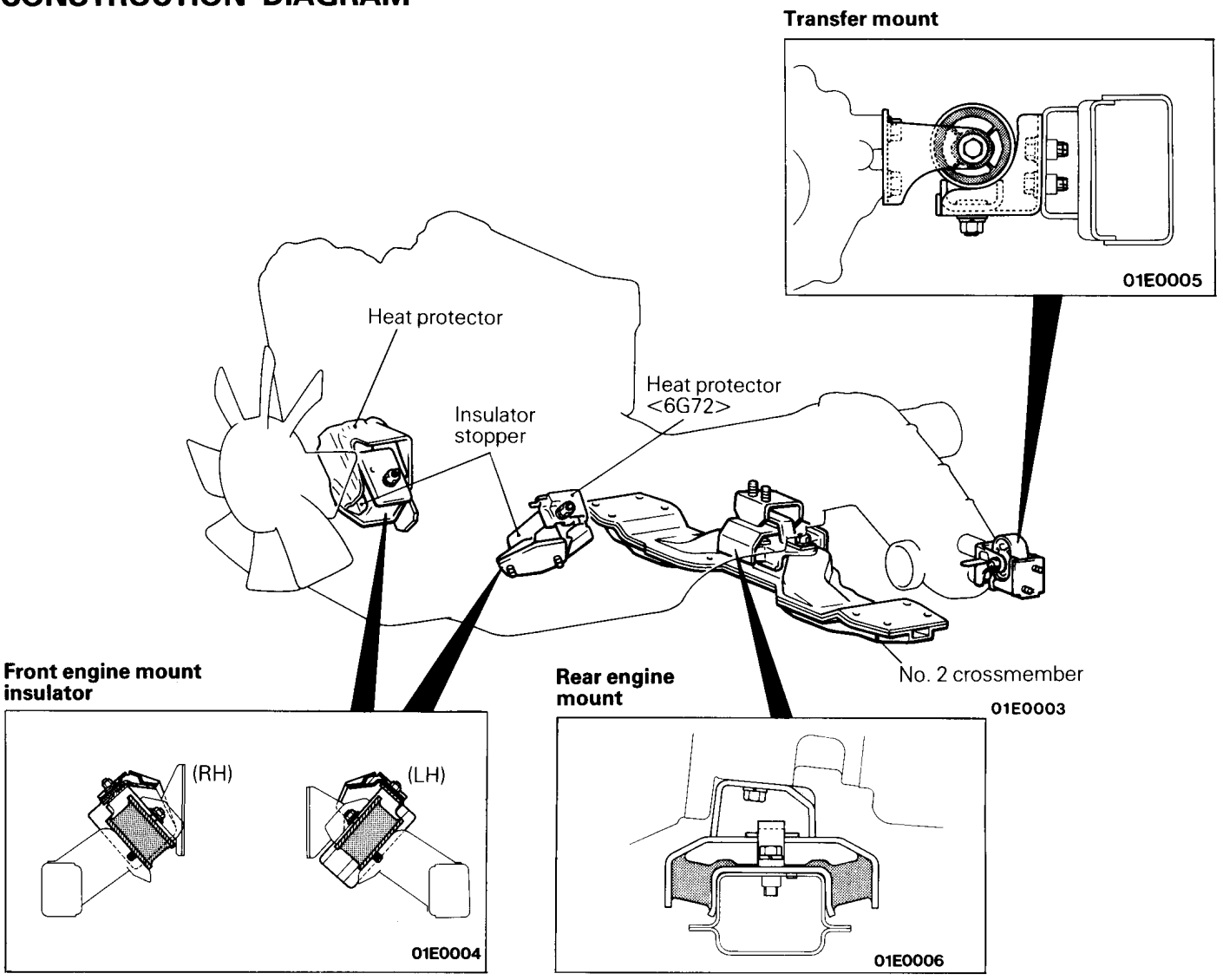
MOUNTS

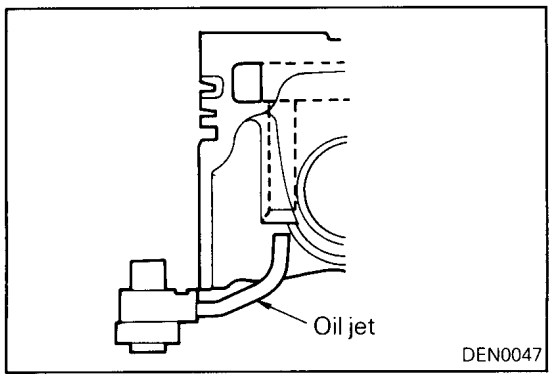
E9BCAAH

The engine and transmission block are supported at four points: at two points below the engine, one below the transmission, and one below the transfer section. This four-point mount configuration is ideal both to minimize engine roll and to reduce vibrations caused by engine rotation:

- The front engine mounts are of the same shear-compression type used in earlier models. A stopper encloses the insulator to ensure greater rigidity.
- The rear engine mount has also adopted the shear-compression type to reduce engine vibration transmission to the vehicle body.
- The transfer mount is a non-contact type which reduces engine roll and effectively insulates the vehicle body from engine vibrations particularly when idling.

CONSTRUCTION DIAGRAM





LUBRICATION SYSTEM

E9BGAAH

OIL PUMP <4D56>

The delivery rate has been increased by the adoption of a multi-tooth trochoidal oil pump.

OIL JETS <4D56 WITH TURBOCHARGER AND INTER-COOLER>

The jet nozzle diameter has been enlarged to increase the oil injection rate.

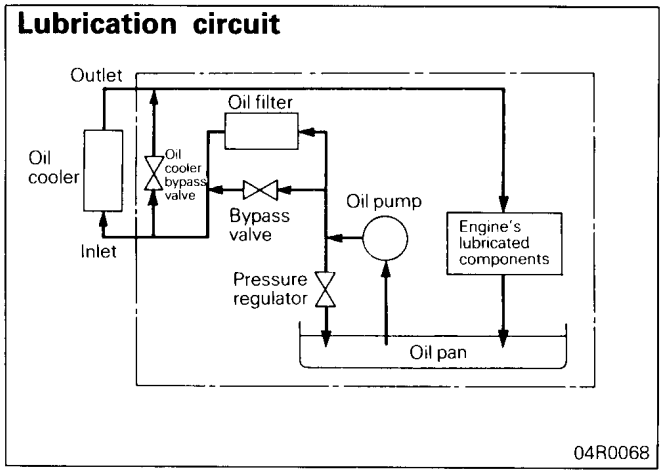
ENGINE OIL COOLER

The engine oil cooler is the corrugated-fin type, and is located at the front of the radiator.
For the lubrication oil circuit, there is a bypass circuit (oil cooler bypass valve) which can lubricate the various parts of the engine even if there is a foreign object clogging the interior of the oil cooler; this bypass circuit is located at the engine side.
This valve detects the temperature of the engine oil, and regulates the circulation of engine oil to the oil cooler, thus improving the engine's warming up characteristics.

SPECIFICATIONS

Items	6G72	4D56
Engine oil cooler Performance J/h (kcal/h, BTU/h)	12,976 X 10^3 (3,100, 12,301)	26,790 x 10^3 (6,400, 25,396)

Lubrication circuit



CONSTRUCTION DIAGRAM

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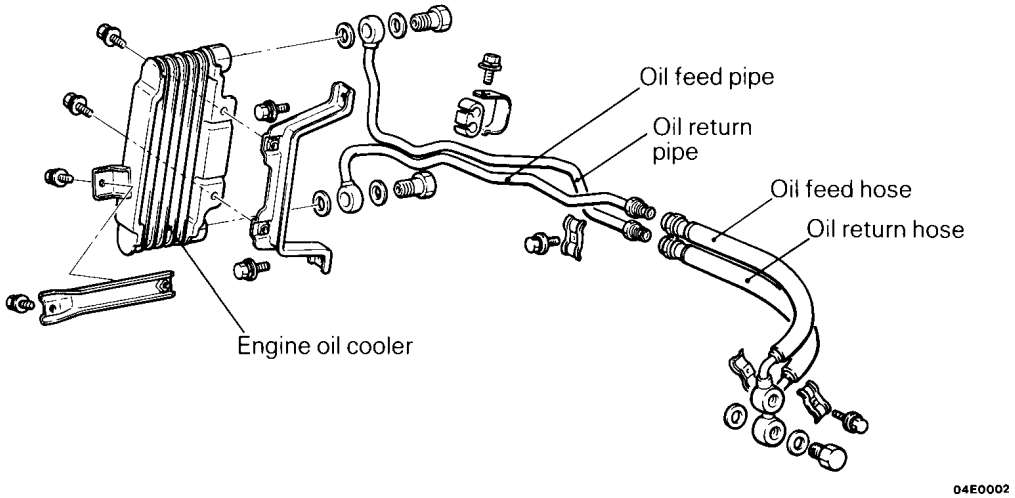

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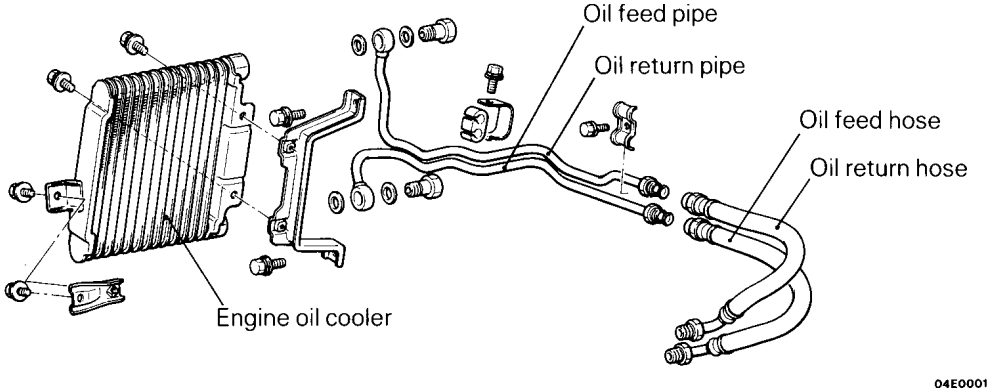


COOLING SYSTEM

E9BFAAJ

The cooling system is of the water-cooled forced circulation type with the following advantageous features:

- The temperature control type fan clutch has been adopted to reduce fan noises and engine output loss.
- The rediator shroud is of the full-shroud type which gives higher cooling performance.
- The automatic transmission oil cooler for vehicles with automatic transmission is of the "double cooling" type which means that both the air cooling system and radiator built-in water cooling system are integrated in the oil cooler.

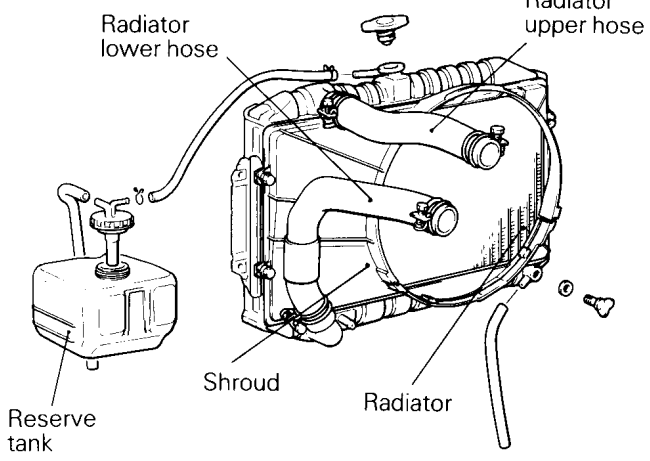
SPECIFICATIONS

Items	Specifications
Cooling method	Water-cooled pressurized, forced circulation
Radiator	
Type	Pressurized corrugated fin type
Performance J/h (kcal/h, BTU/h)	
<6G72 A/T, 4G64, 4G54, 4D56>	193,396 x 10^3 (46,200, 183,333)
<6G72 M/T>	182,093 x 10^3 (43,500, 172,619)
<4D56 T/C>	210,558 x 10^3 (50,300, 199,603)
<4D56 I/C · T/C>	221,861 x 10^3 (53,000, 210,317)
Radiator cap	
High pressure valve opening pressure kPa (kg/cm², psi)	75–105 (0.75–1.05, 11–15)
Vacuum valve opening pressure kPa (kg/cm², psi)	–5 (–0.05, –0.7) or less
Automatic transmission oil cooler <Vehicles with A/T>	
Performance J/h (kcal/h, BTU/h)	
<6G72>	6,195 x 10^3 (1,480, 5,873)
<4G54, 4D56>	4,814 x 10^3 (1,150, 4,563)
Thermostat type	Wax pellet type with jiggle valve
Fan clutch type	Thermo type
Water pump type	Impeller of centrifugal type

NOTE
T/C: With turbocharger
I/C · T/C: With turbocharger and inter-cooler

CONSTRUCTION DIAGRAM

<6G72>



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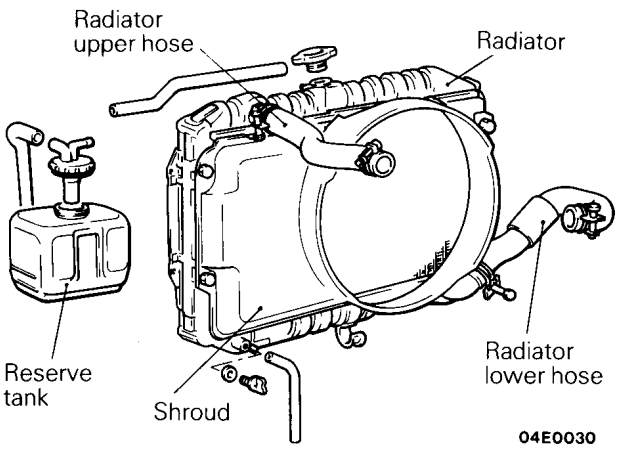

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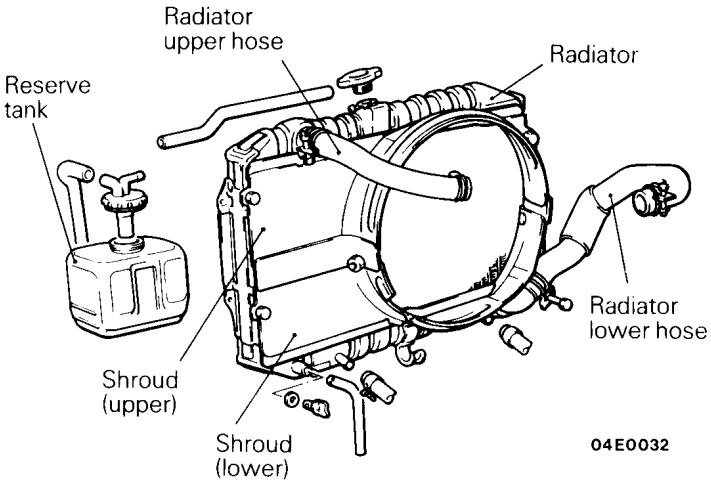

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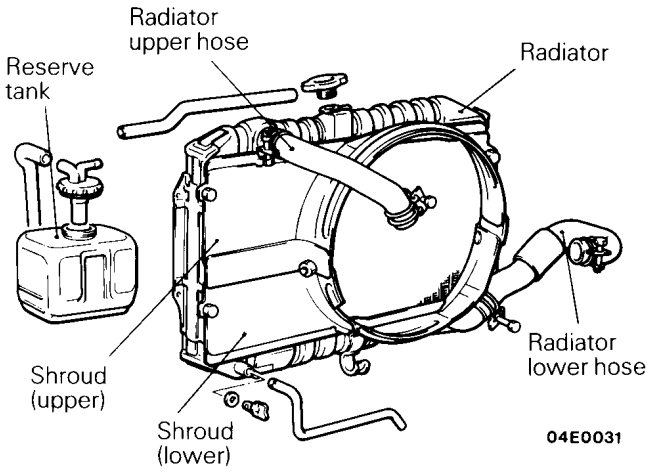
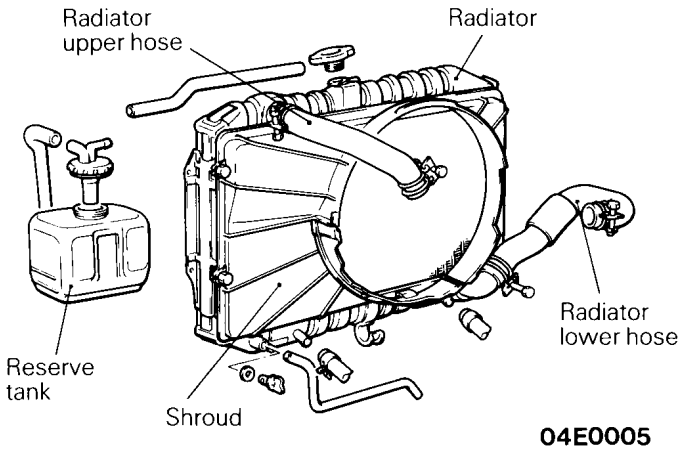
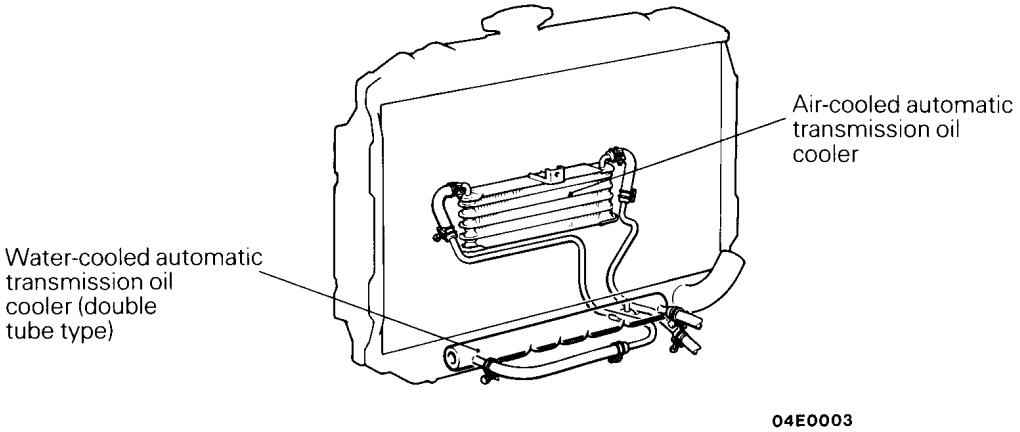
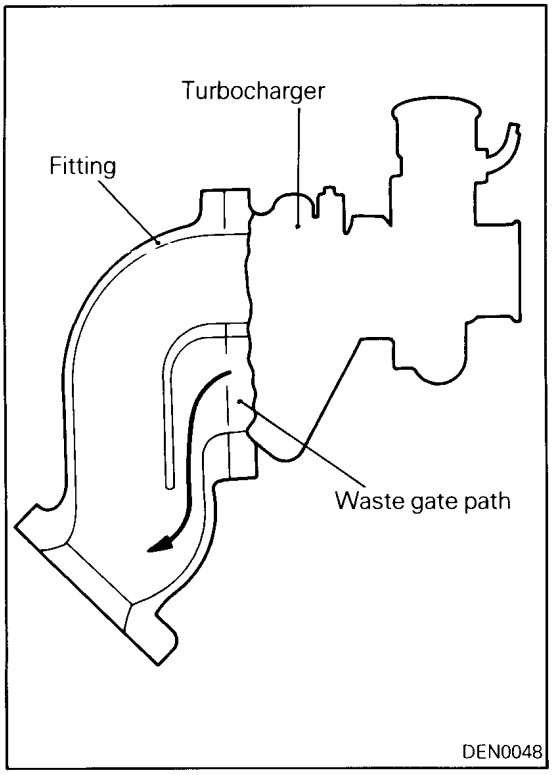


<4D56 with turbocharger and inter-cooler>



<Automatic transmission oil cooler>





INTAKE AND EXHAUST SYSTEM E9BHAAG

TURBOCHARGER <4D56 WITH TURBOCHARGER AND INTER-COOLER>

The shape of compressor wheel blades has been changed to increase the compressor capacity. The waste gate path has also been reshaped to decrease the exhaust resistance.

EXHAUST PIPE

The new exhaust system is designed to assure quiet equivalent to that of passenger vehicles and to make full use of high engine performance. The features are as outlined below:

- Installed to the vehicle body via rubber hangers and suspenders, it reduces vibration transmission from the exhaust system to the body.
- The large-capacity main muffler reduces exhaust noises and reduces power loss.
- The spring type flexible spherical joints reduces vibrations during idling and improves durability and reliability.
- The main muffler is positioned horizontally to provide greater off-road driving clearance.

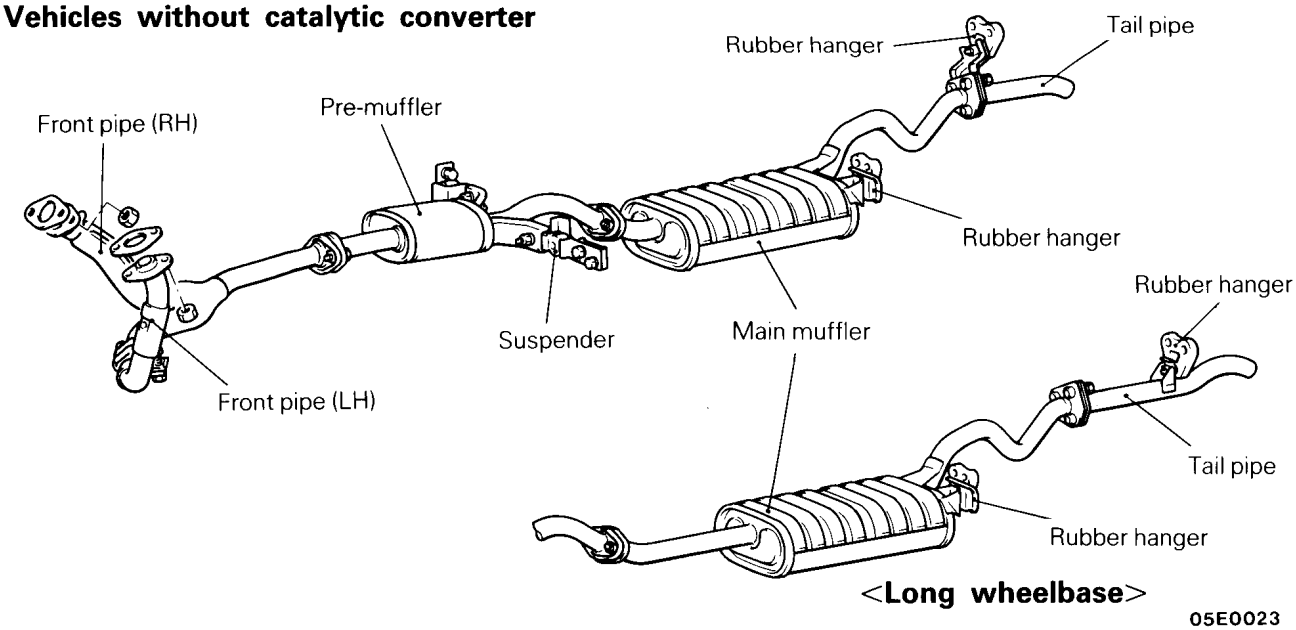
SPECIFICATIONS

Items	Specifications
Exhaust system	
Front exhaust pipe	
<6G72, 4G64, 4G54 – engine for Australia>	Dual type
<4D56, 4G54 – engine for General Export and GCC>	Single type
Muffler	Expansion resonance type
Coupling	Flat coupling and Spherical coupling
Suspension system	Rubber hangers and Rubber suspenders

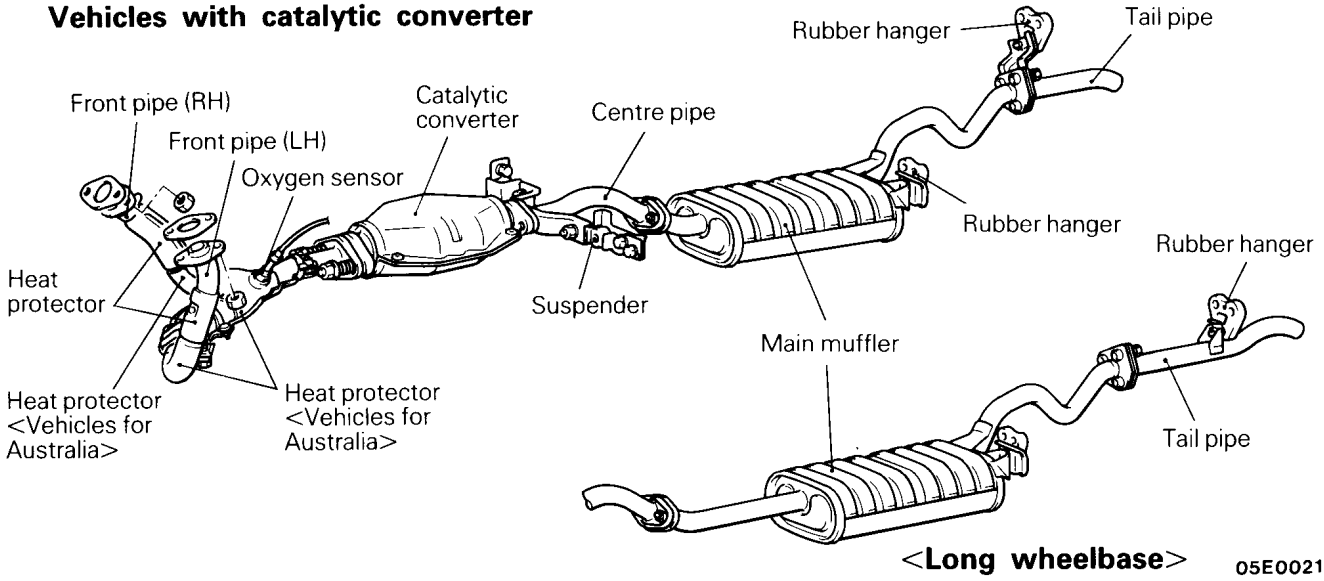
CONSTRUCTION DIAGRAM

<6G72>

Vehicles without catalytic converter



Vehicles with catalytic converter



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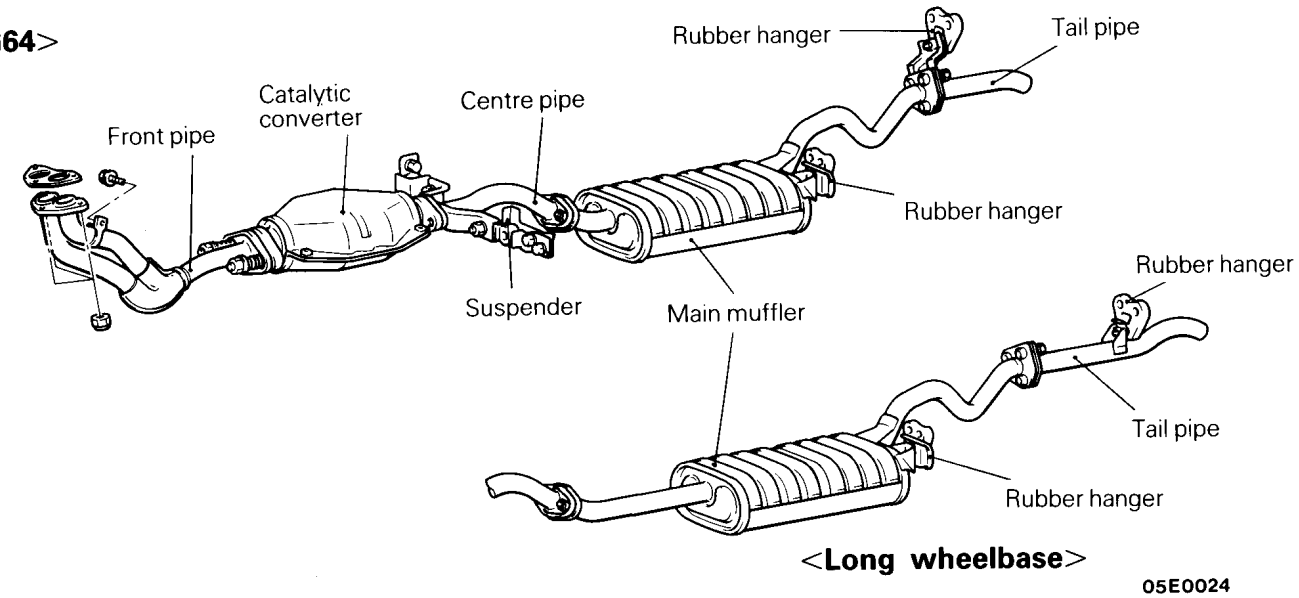

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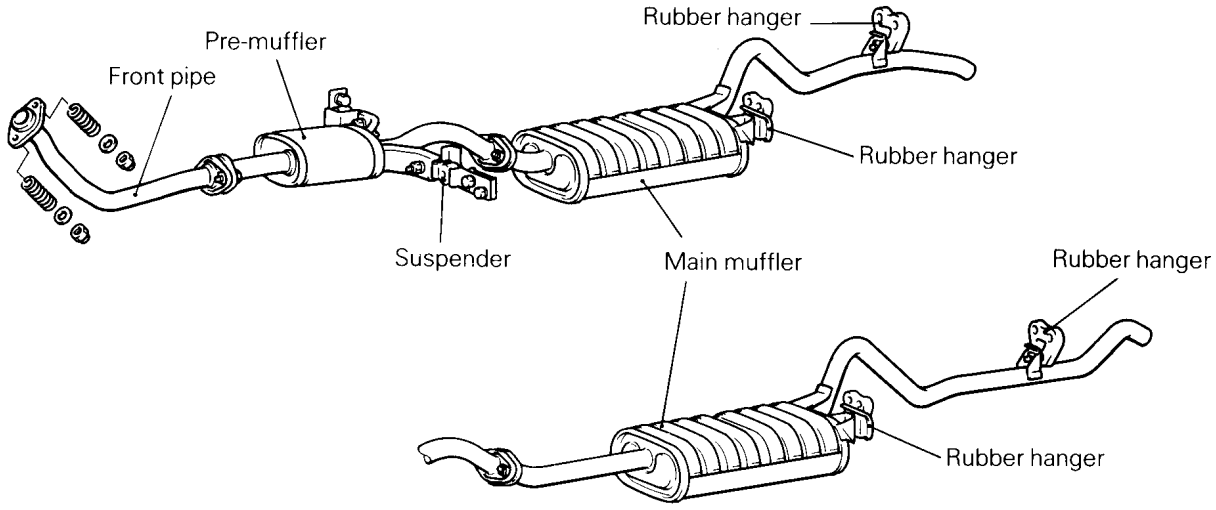
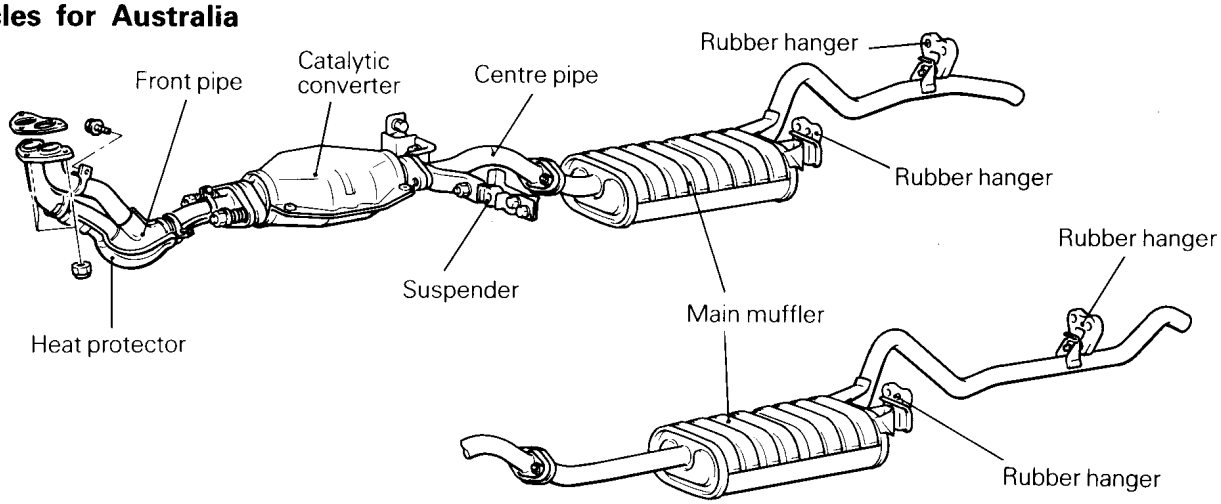
Vehicles for General Export and GCC



<Long wheelbase>

05E0026

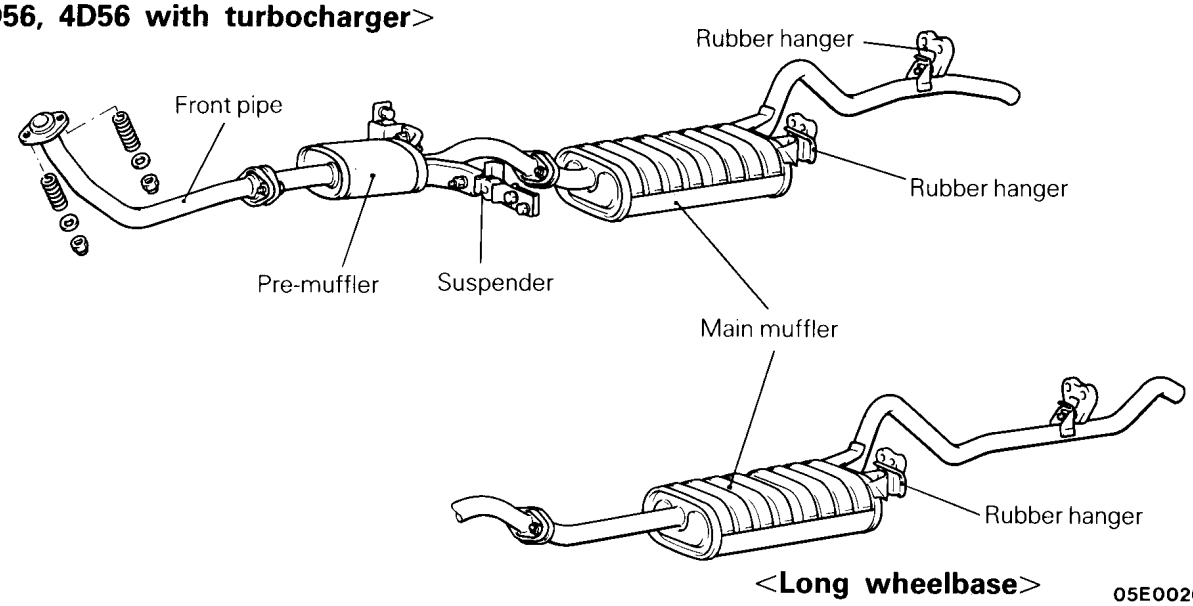
Vehicles for Australia



<Long wheelbase>

05E0025

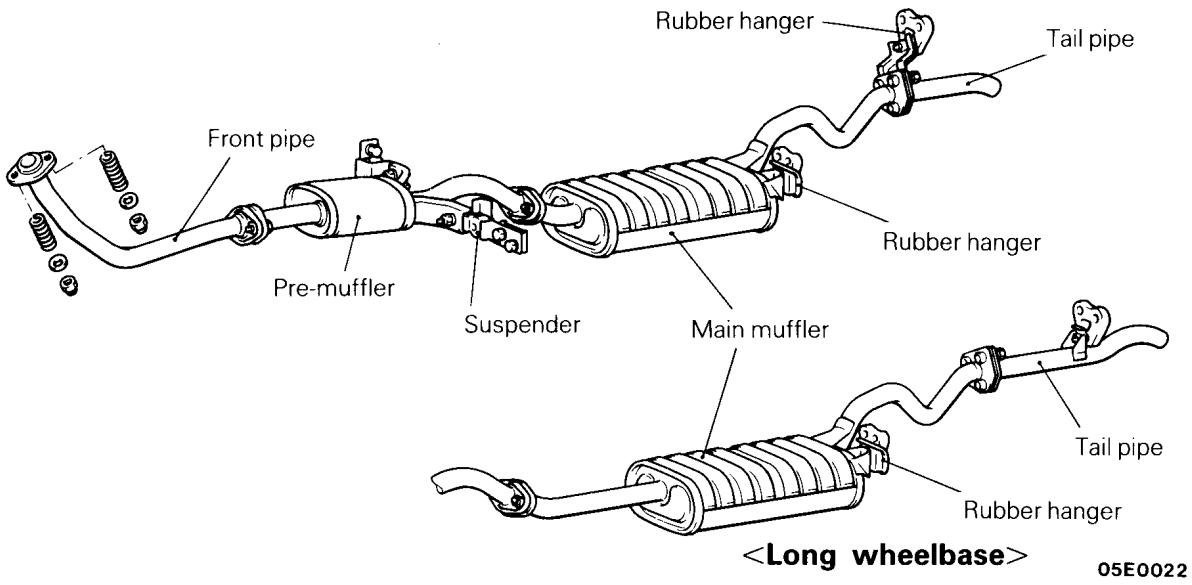
<4D56, 4D56 with turbocharger>



<Long wheelbase>

05E0020

<4D56 with turbocharger and inter-cooler>



FUEL SYSTEM

E9BDFAC

<6G72, 4G64>

The fuel system comprises: an electromagnetic fuel injector; a delivery pipe; a fuel pressure regulator [the control pressure setting is 335 kPa (3.35 kg/cm^2, 47.6 psi)]; an electric motor-driven fuel pump for high pressure fuel supply; an engine control unit to control the engine based on signals from sensors, etc. This system is basically the same as those both for 4G64 engines on current L300 models and for 6G72-SOHC engines on current PAJERO/MONTERO models. It has the following features:

- The fuel filters are located in the fuel tank and on the No. 3 crossmember.
- A check valve is provided to prevent fuel from flowing out if the vehicle overturns. A resin-made screw-in type fuel filler cap is also provided.
- To improve serviceability, a terminal for connecting a power supply to drive the fuel pump is provided in the engine compartment.
- The rear floor has an access hole which allows the fuel pump and fuel gauge unit to be removed without removal of the fuel tank.
- The electronic-controlled fuel injection has adopted the MPI system that injects fuel independently into each air intake port of cylinder. (For the MPI system, see P.1-21 <4G64> and P.1-38 <6G72>.)

SPECIFICATIONS

Items		Standard wheelbase	Long wheelbase
Fuel			
Tank capacity	dm^3 (U.S.gal., Imp.gal.)	75 (19.8, 16.5)	92 (24.3, 20.2)
Return system		Equipped	Equipped
Filter		High pressure type	High pressure type
Fuel pump			
Type		Electrical, in-tank type	Electrical, in-tank type
Driven by		Electric motor	Electric motor

FUEL FLOW DIAGRAM

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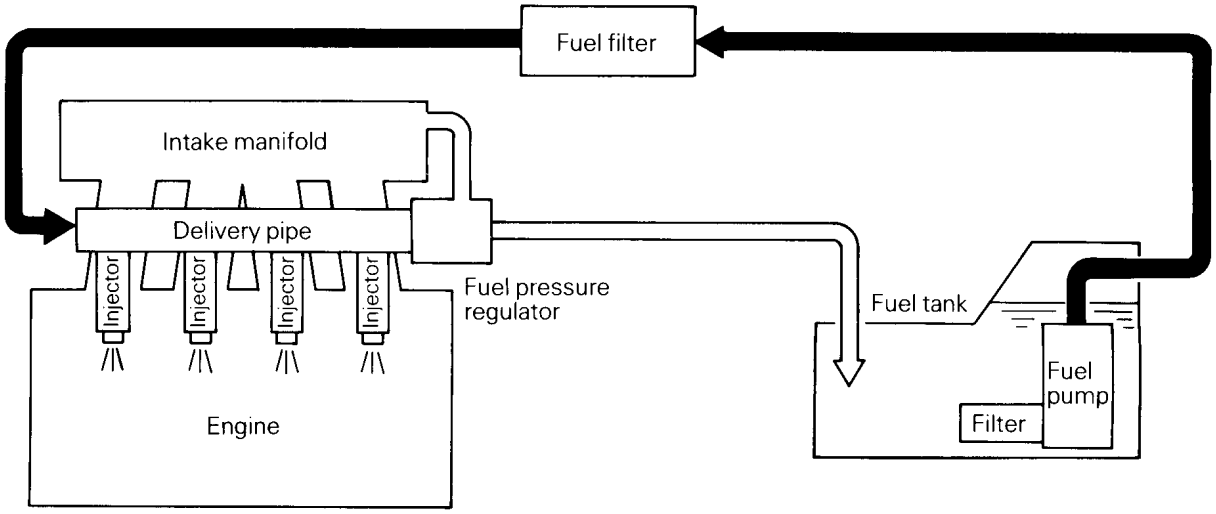

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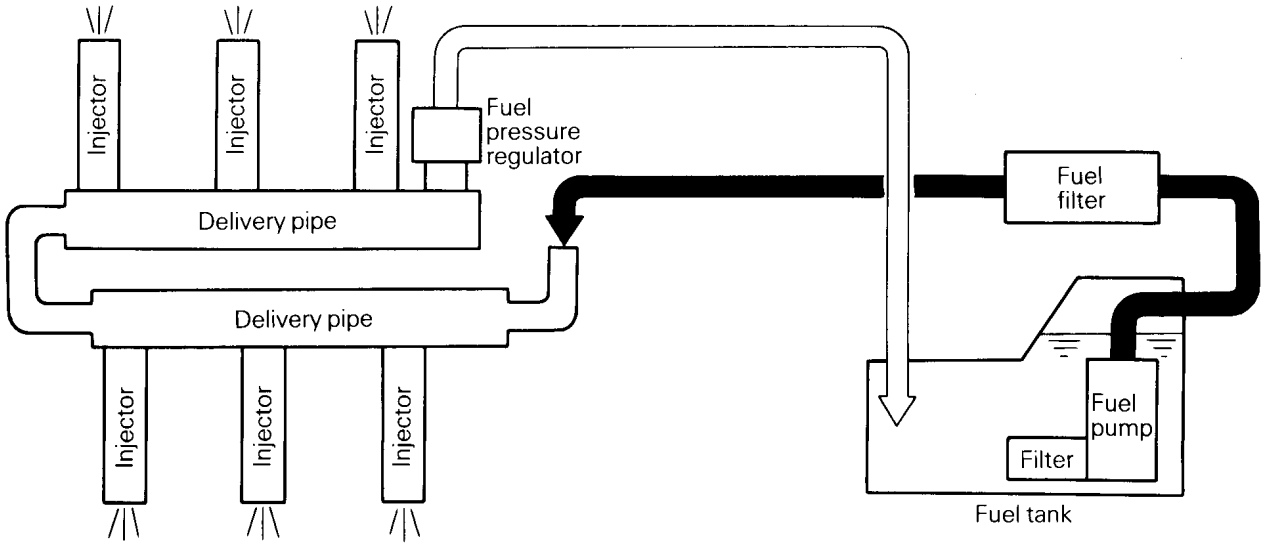

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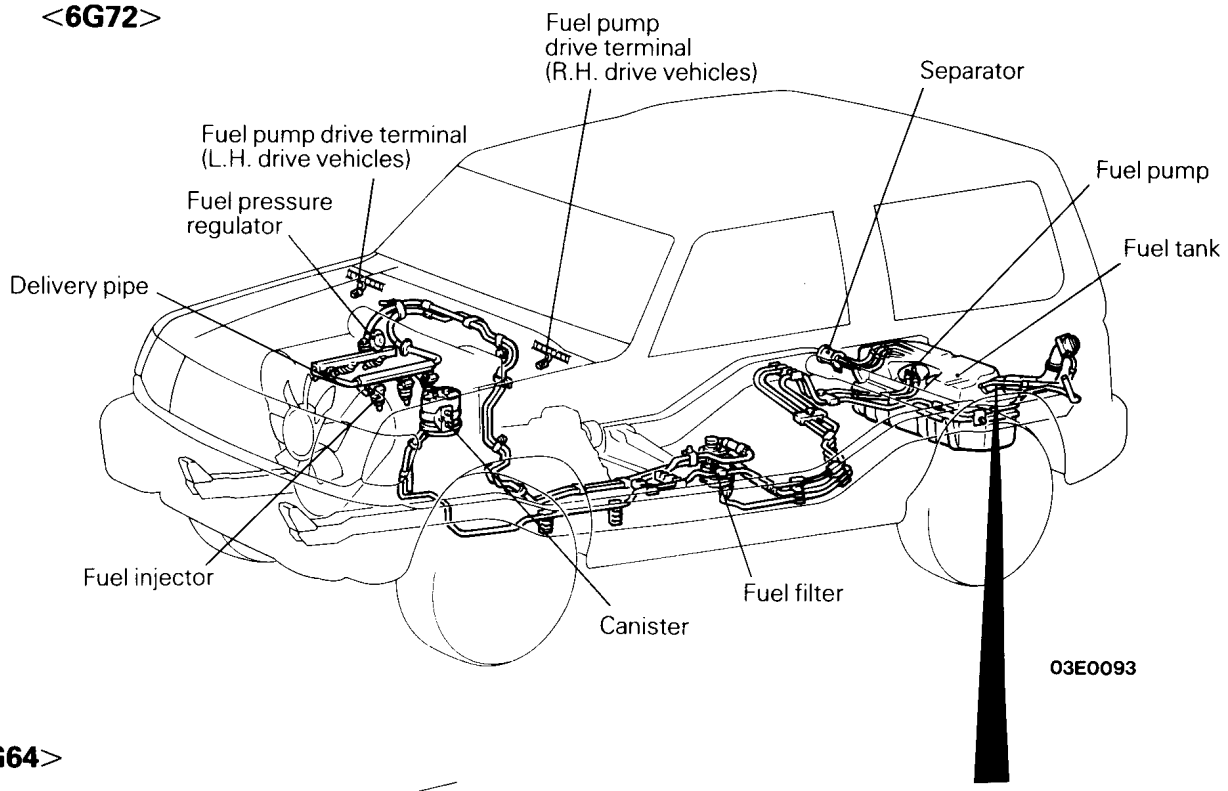
CONSTRUCTION DIAGRAM

<6G72>



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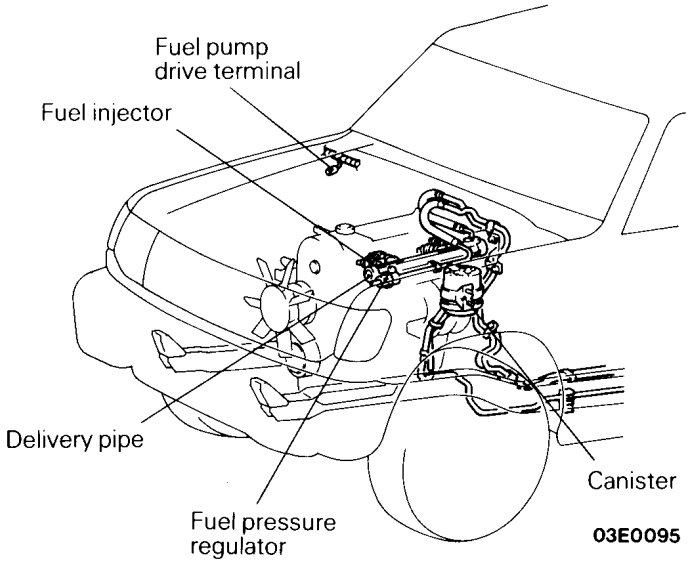
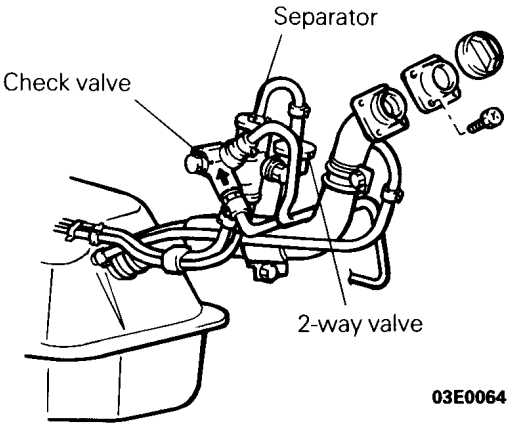




<4G54>

E9BDDAE

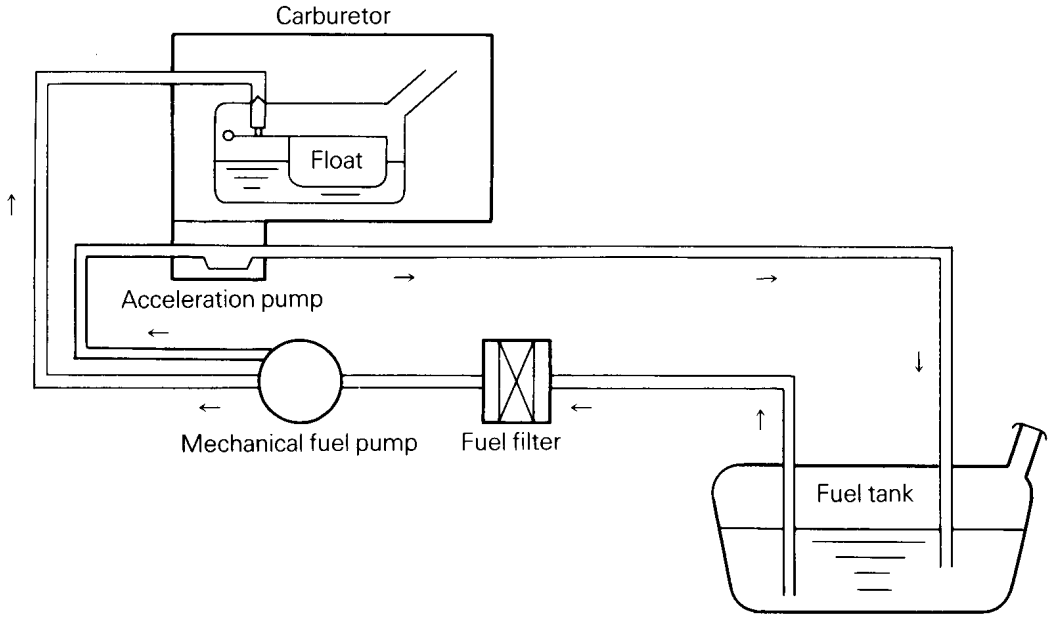
The fuel system comprises a two-barrel down-draft type carburetor, a mechanical (diaphragm type) fuel pump, etc. This system is basically the same as that adopted for the 4G54 engines on current PAJERO/MONTERO models. It has the following features:

- The fuel filters are located in the fuel tank and in the engine compartment.
- A check valve is provided to prevent flow out of fuel if the vehicle turns over. A resin-made screw-in type fuel filler cap is also provided.
- The rear floor has an access hole to allow removal of the fuel gauge unit without need for removal of the fuel tank.

SPECIFICATIONS

Items		Standard wheelbase	Long wheelbase
Fuel			
Tank capacity	dm^3 (U.S.gal., Imp.gal.)	60 (15.9, 13.2)	92 (24.3, 20.2)
Return system		Equipped	Equipped
Filter		Cartridge type	Cartridge type
Fuel pump			
Type		Mechanical diaphragm	Mechanical diaphragm
Driven by		Camshaft	Camshaft
Carburetor			
Type		Down-draft, 2-barrel, conventional	Down-draft, 2-barrel, conventional

FUEL FLOW DIAGRAM



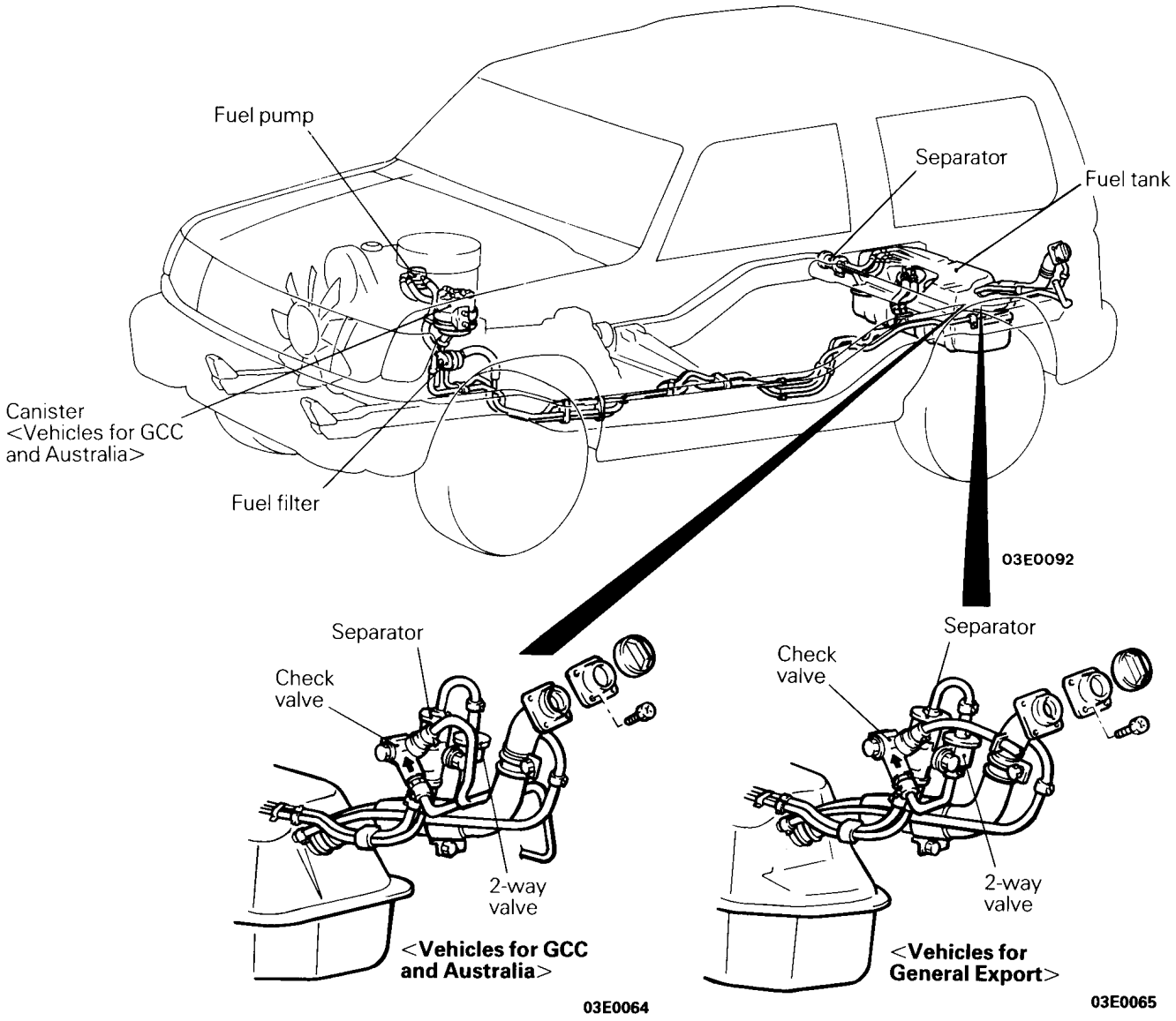
1FU0138

CARBURETOR SPECIFICATIONS

Destination		GCC		General Export		Australia
Engine		4G54		4G54		4G54
Transmission <4WD>		M/T	A/T	M/T	A/T	M/T
Carburetor main body		Resin body		Resin body		Resin body
Throttle bore diameter (primary/secondary) mm (in.)		32 (1.26)/35 (1.38)		32 (1.26)/35 (1.38)		32 (1.26)/35 (1.38)
Venturi diameter (primary/secondary) mm (in.)		24 (0.94)/30 (1.18)		24 (0.94)/30 (1.18)		24 (0.94)/30 (1.18)
Choke mechanism	Choke type	Manual		Manual		Automatic (wax type)
	Choke breaker	Not provided		Not provided		Provided
	Fast idle	Provided		Provided		Provided
	Unloader	Not provided		Not provided		Provided
Devices	Fuel cut solenoid valve	Provided		Provided		Provided
	Dash pot	Not provided		Not provided		Not provided
	Mixture control valve	Not provided		Not provided		Not provided
	Auxiliary accelerator pump	Not provided		Not provided		Provided
	Bowl vent valve	Not provided		Not provided		Provided
	Secondary valve control	Not provided		Not provided		Not provided
Carburetor gasket*		Metallic (rubber-coated)		Metallic (rubber-coated)		Metallic (rubber-coated)

*: Set the carburetor gasket using a guide bar.

CONSTRUCTION DIAGRAM



<4D56>

E9BDEAE

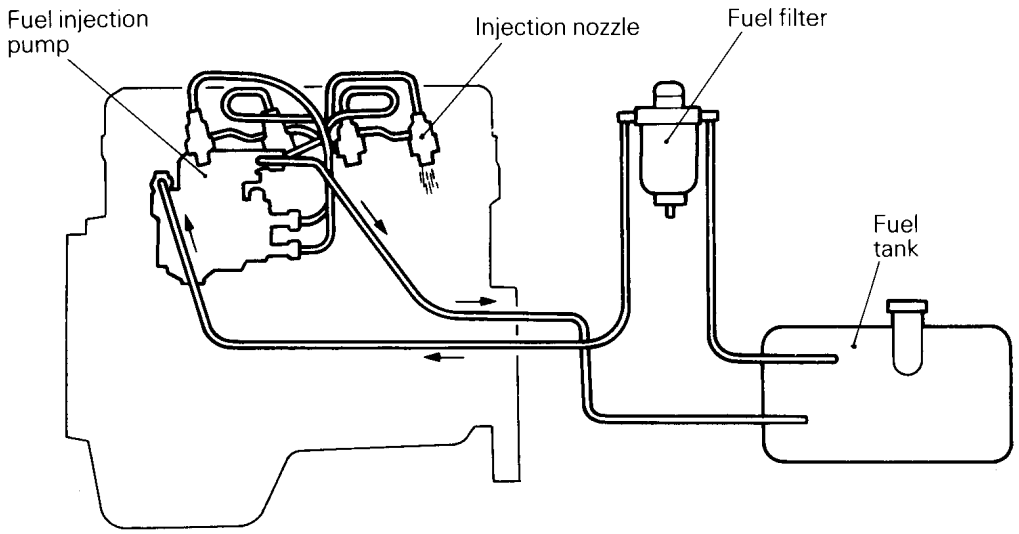
The fuel system comprises: injection nozzles; fuel injection pipes; a fuel injection pump; fuel filters, fuel hoses and pipes; a fuel tank, etc. This system is basically the same as that used for the 4D56 engines in current PAJERO/MONTERO models. It has the following features:

- The fuel filters are located in the fuel tank and in the engine compartment.
- A check valve is provided to prevent fuel from flowing out if the vehicle turns over. A resin-made screw-in type fuel filler cap is also provided.
- The rear floor has an access hole to allow removal of the gauge unit without need for removal of the fuel tank.

SPECIFICATIONS

Items	Standard wheelbase		Long wheelbase
	Vehicles for General Export	Vehicles for Europe and GCC	
Fuel			
Tank capacity dm³ (U.S.gal., Imp.gal.)	60 (15.9, 13.2)	75 (19.8, 16.5)	92 (24.3, 20.2)
Return system	Equipped	Equipped	Equipped
Fuel injection pump			
Type	Distributor-type	Distributor-type	Distributor-type
Injection nozzle			
Nozzle type	Throttling type	Throttling type	Throttling type
Holder type	Screw-in type	Screw-in type	Screw-in type

FUEL FLOW DIAGRAM

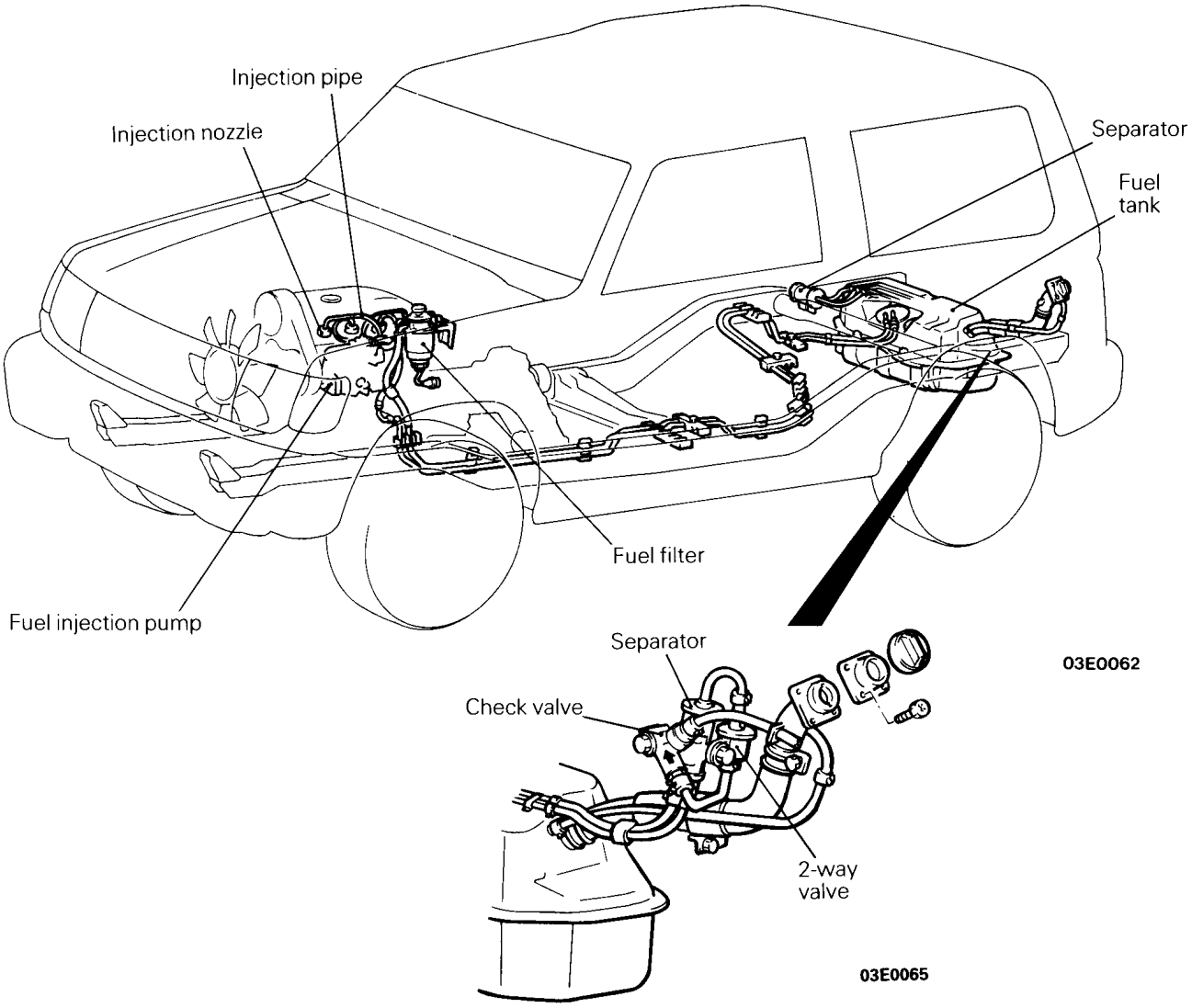


DFU0012

FUEL INJECTION PUMP SPECIFICATIONS

Destination		Europe	GCC	General Export	Australia
Engine: 4D56		Turbocharger with inter-cooler	Turbocharger with inter-cooler	Non-turbocharger, turbocharger with inter-cooler	Turbocharger, turbocharger with inter-cooler
Transmission		M/T, A/T	M/T	M/T	M/T
Injection timing	ATDC	7° [at plunger lift 1 mm (0.0394 in.) point]			
Idle speed	r/min	750			
Injection pump	Type	Distributor pump			
	Plunger diameter mm (in.)	10 (0.39)			
	Injection order	1–3–4–2			
	Injection interval	90°±0.5°			
	Rotation direction	Clockwise as viewed from drive side			
Governor	Type	Centrifugal, half all-speed control			
	Boost compensator	Provided: Turbocharged model only			
Timer (injection timing control unit) type		Hydraulic			
Load timer		Provided			
Fuel feed pump		Vane type			
Fuel cut solenoid valve		Provided			
Accelerator opener		Provided: Vehicles with anti-skid brake system or air-conditioner only			

CONSTRUCTION DIAGRAM



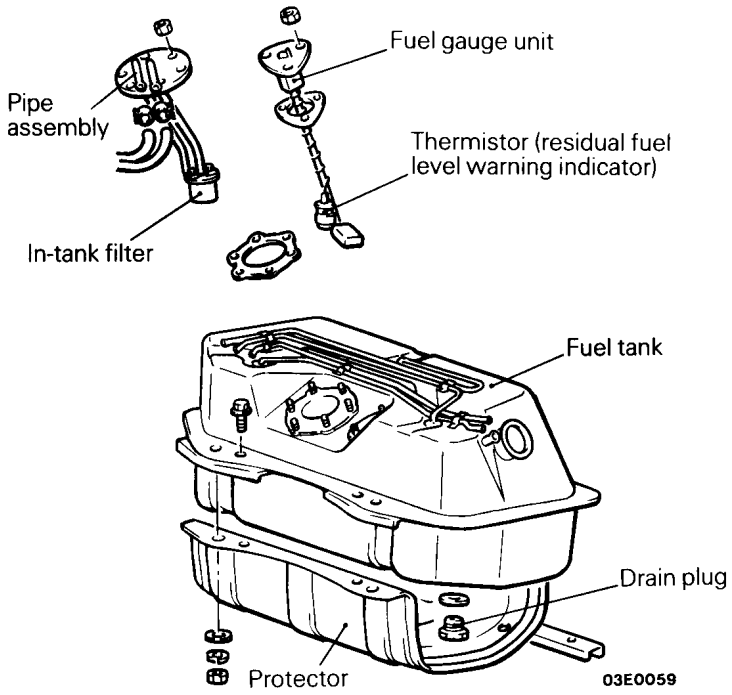
FUEL TANK

Within the fuel tank, there is an electric motor-driven fuel pump <6G72, 4G64>, an in-tank filter and a fuel gauge unit.
The fuel tank has the following features:

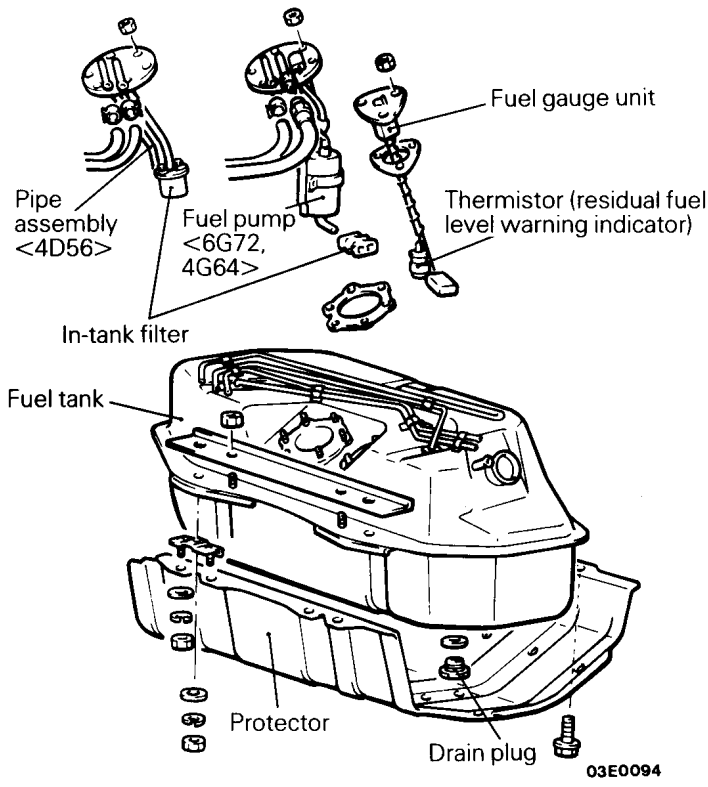
- A rigid crossmember protects the fuel tank from rear collision, improving safety.
- It has a protector that prevents damage to the fuel tank from flying stone chips, bricks, etc.
- A reservoir cup is provided in the fuel tank which secures a smooth fuel supply even a small amount of fuel remains in the tank.*
- The fuel tank drain plug is standard on all vehicles.

*: Exclusing 4G54 and 4D56 engines for standard wheelbase models for General Export.

<Standard wheelbase>
(4G54, 4D56 engine for General Export)



<Standard wheelbase>
(6G72, 4G64, 4D56 engine for Europe and GCC)



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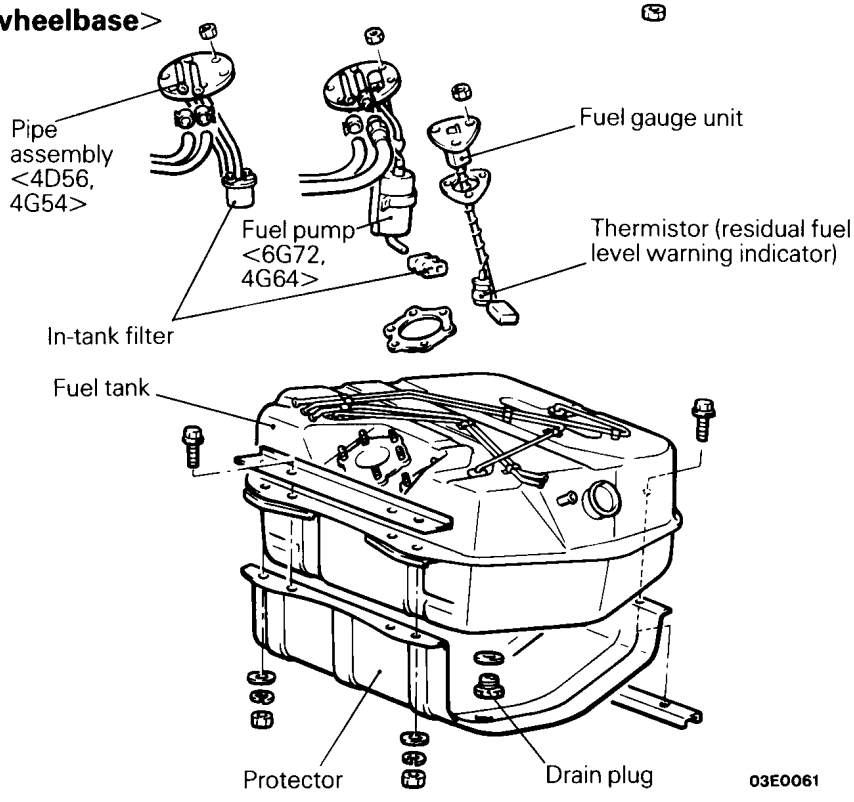

CONTROL SYSTEM <4G64>

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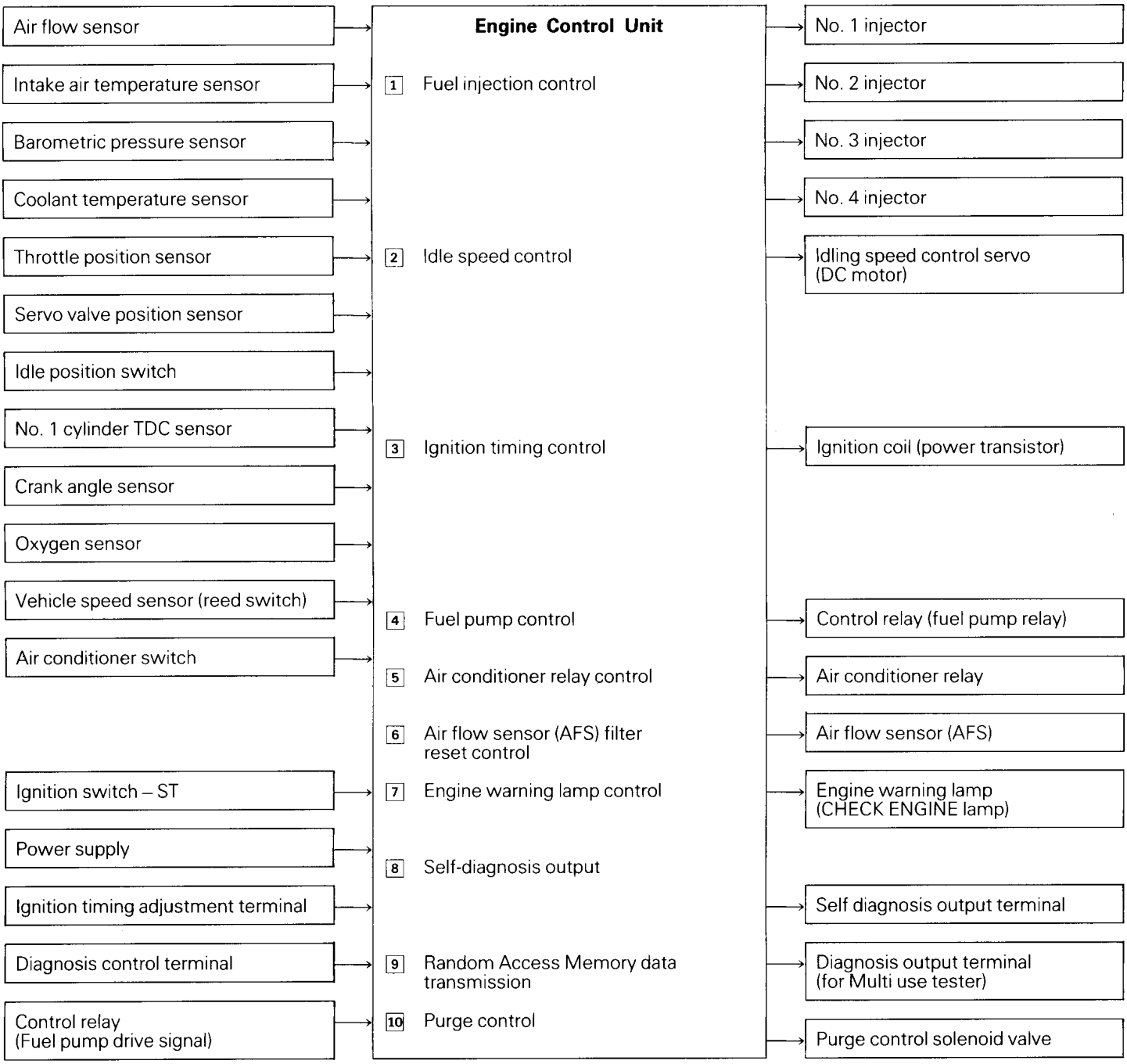
In addition to inheriting the control features of the 4G64 engine which powers the current L300 models, the new 4G64 engine's control system incorporates the following improvements for better driveability and higher engine performance:

Principal improvements/additions	Remarks
New idle speed control (ISC) system	• The new system regulates the throttle valve bypass air volume for idle speed control (same as the 6G7 engine) • A DC motor is used for driving the servo valve. (A stepper motor is used in 6G7 engine.)
Servo valve position sensor	A sensor compatible with the new idle speed control (ISC) system
Pressure sensitive type air flow sensor and smooth flow type air cleaner	• Conventional sensor is an ultrasonic sensitive type • Higher engine output
Air flow sensor filter reset control	• Corresponds to the adoption of the pressure sensitive type air flow sensor • Assures a highly reliable air flow sensor signal
Independent earth lead for oxygen sensor	• Improves oxygen sensor signal reliability • Same as the 4G1 engine
Smaller water temperature sensor temperature sensing section size	• For higher sensor response • Same as the 4G1 engine
Throttle position sensor (TPS) with built-in idle position switch	Same as the 6G7 engine
Oil level alarm system	To improve reliability

SYSTEM BLOCK DIAGRAM

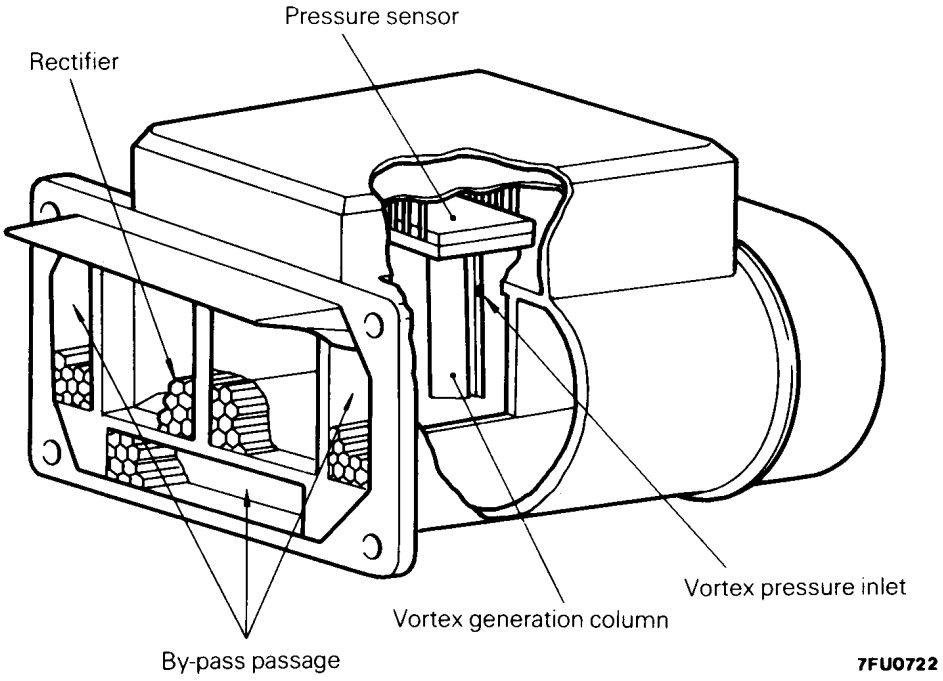


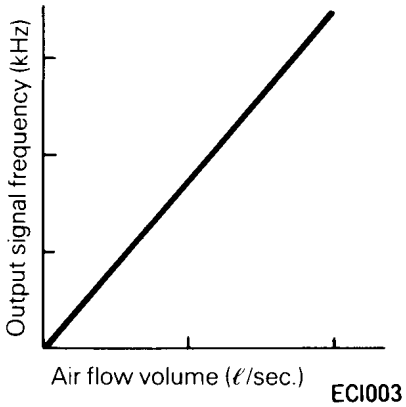
SENSORS

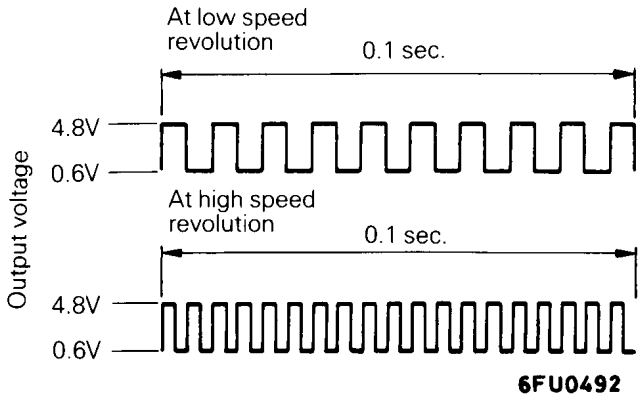
AIR FLOW SENSOR (AFS)

The air flow sensor (AFS) is the sensor that measures the amount of intake air and is mounted on the air cleaner. The AFS uses the Karman vortex phenomenon to detect the amount of intake air passing the air cleaner element and inputs it as a signal for the amount of intake air to the engine control unit.

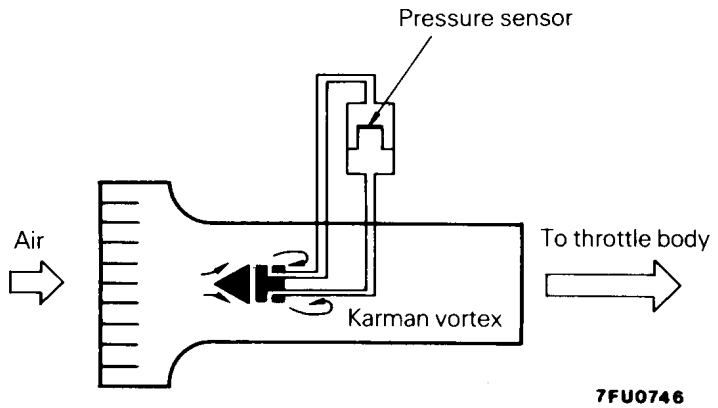
The engine control unit uses this signal for the amount of intake air and the engine speed (rpm) signal (crank angle sensor signal) to calculate and determine the basic injector drive time.
An intake air temperature sensor and barometric pressure sensor are attached to the AFS.



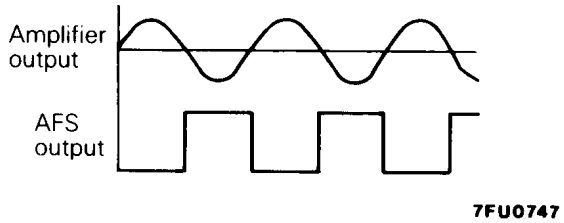




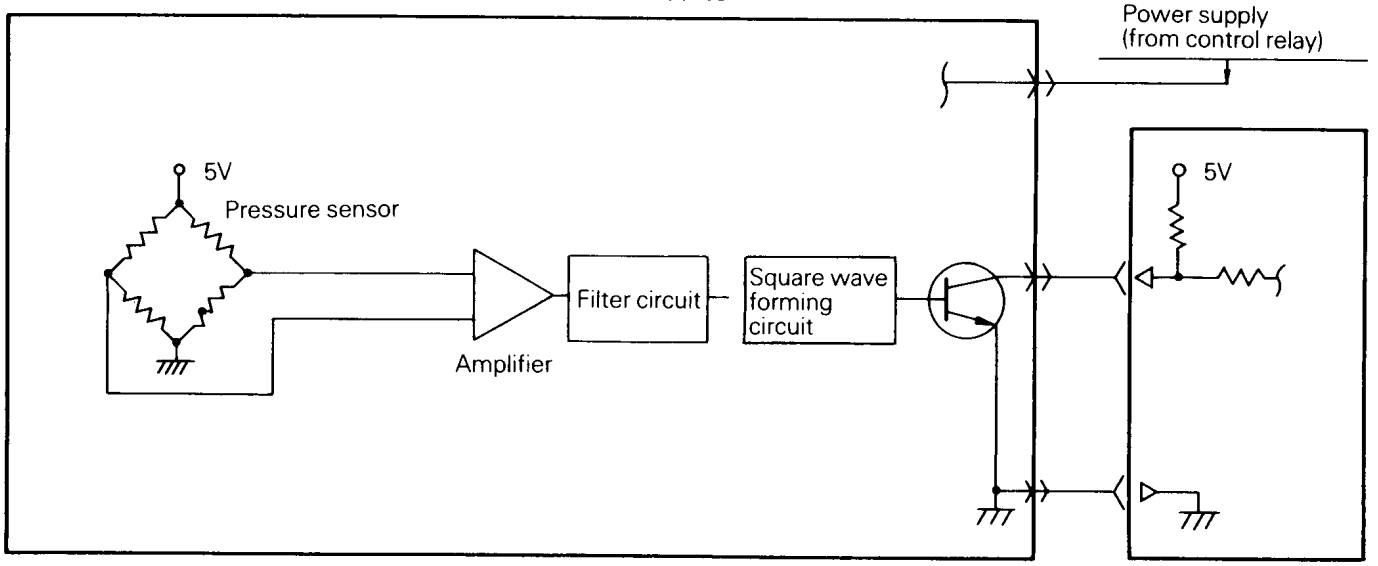
If a vortex generation column is placed in the path of the air flow, regular vortexes are generated downstream alternately. This is called the Karman vortex line and the number of vortexes generated is proportional to the air flow speed, in other words, the amount of air flow.
If a vortex pressure inlet is made downstream of the vortex generating column and the pressure detected, this pressure varies each time the vortex passes the inlet and when the number of vortexes increases, the number of pressure variations also increases in proportion to this. In other words, the frequency of the pressure variations is proportional to the amount of air flow. The pressure detection type AFS is different from the conventional ultrasonic detection type AFS, and it detects the pressure variations due to the Karman vortex using a semiconductor type pressure sensor. The AFS changes the pressure variations to a square wave and inputs it as a pulse signal proportional to the amount of intake air flow to the engine control unit.



7FU0746



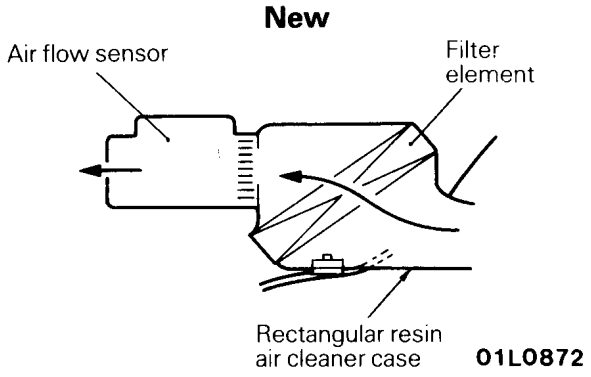
7FU0747

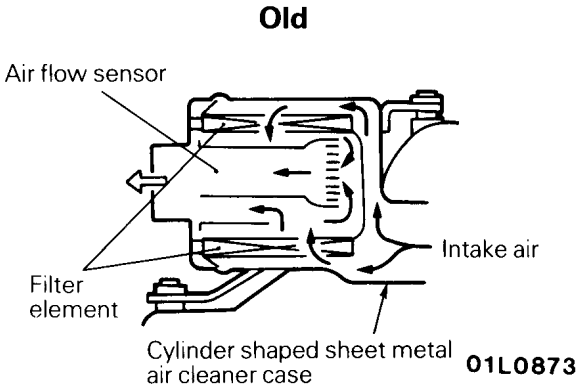


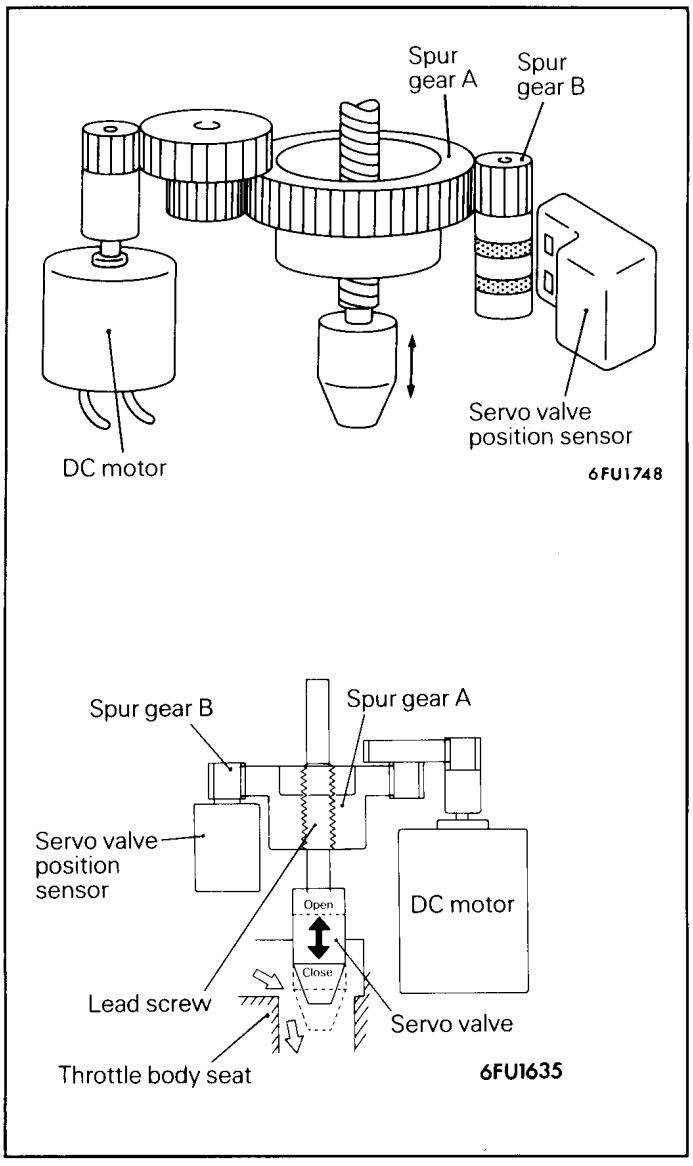
7FU0748

SMOOTH FLOW TYPE AIR CLEANER

The air cleaner case is a resin made rectangular shape which is adapted to the new pressure sensitive type air flow sensor. It assures smooth intake air flow and also features easy removal and installation of the filter element.

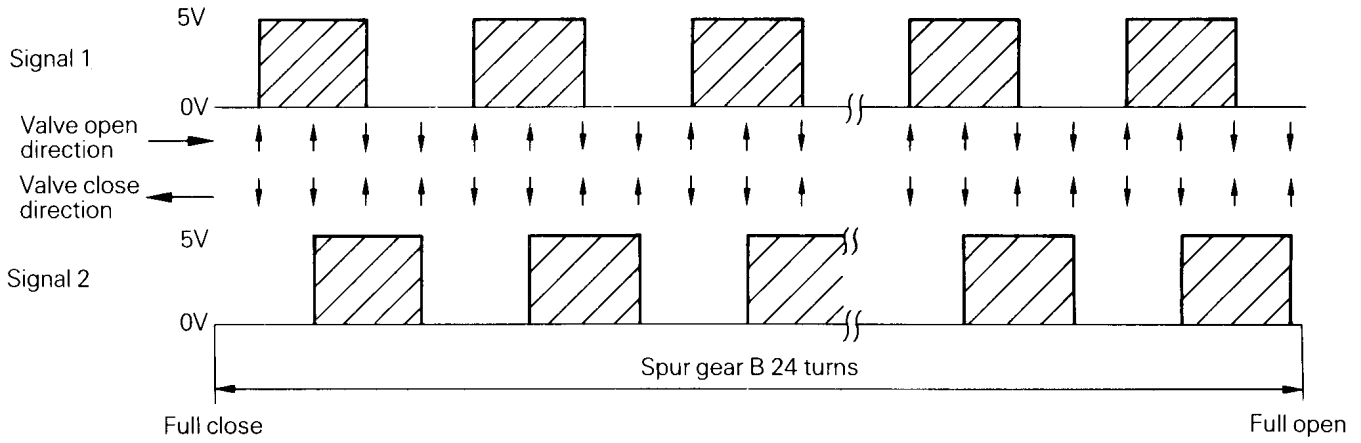






SERVO VALVE POSITION SENSOR

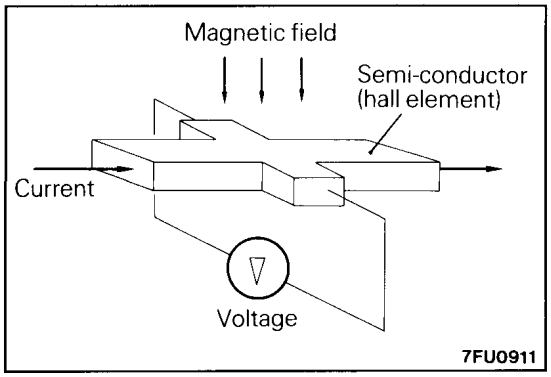
As spur gear A (see figure) is rotated by the DC motor, the servo valve extends or retracts according to the motor's rotating direction. The servo valve position sensor is built into the idle speed control (ISC) servo and it detects the rotation of spur gear A (change of the servo valve position) via the rotation of spur gear B (see figure) and converts it into a pulse signal, which is sent to the engine control unit. The servo valve position sensor outputs one pulse signal (Signal 1) each time spur gear B completes one rotation. To detect spur gear B's rotating direction (or to determine whether the servo valve is extending or retracting), it also outputs another pulse signal (Signal 2) which is same in waveform as Signal 1 but is 90° out of phase from Signal 1. When the ignition switch turned ON, the engine control unit causes the servo valve to move once to the fully closed position (where the valve contacts the stopper) for initializing and then it computes the servo valve position by detecting Signals 1 and 2. The valve position is calculated with the assumption that the servo valve fully closed position is step 0 and the fully open position is step 96.



6FU1633

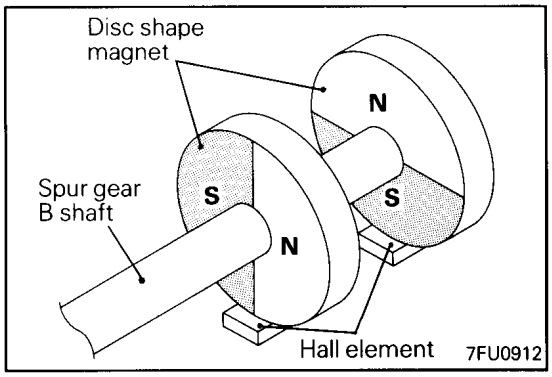
	Valve position increment step				Valve position decrement step			
Signal 1	L → H	H	H → L	L	L	L → H	H	H → L
Signal 2	L	L → H	H	H → L	L → H	H	H → L	L

NOTE H: High, L: Low



7FU0911

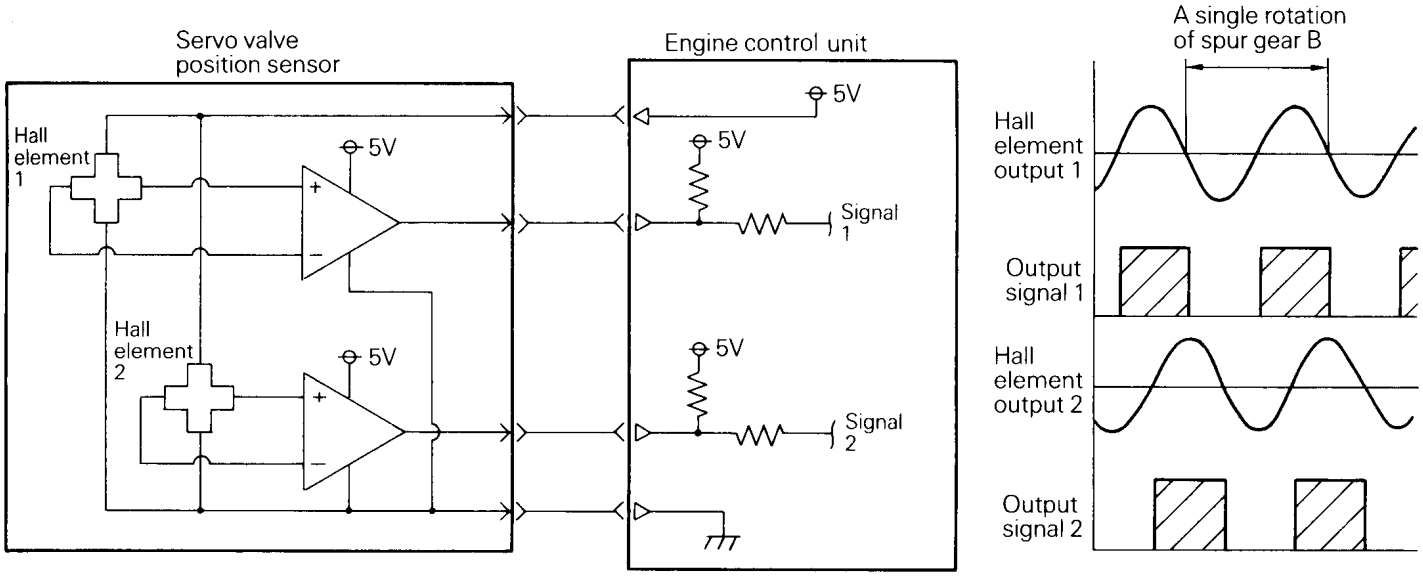
The servo valve position sensor detects the rotation signal of spur gear B as described below.
When a semi-conductor is so positioned in a magnetic field that the current flow through the semi-conductor is perpendicular to the magnetic field, a voltage proportional to the current strength and magnetic flux density develops in a direction perpendicular to both the current flow and the magnetic field (Hall effect).



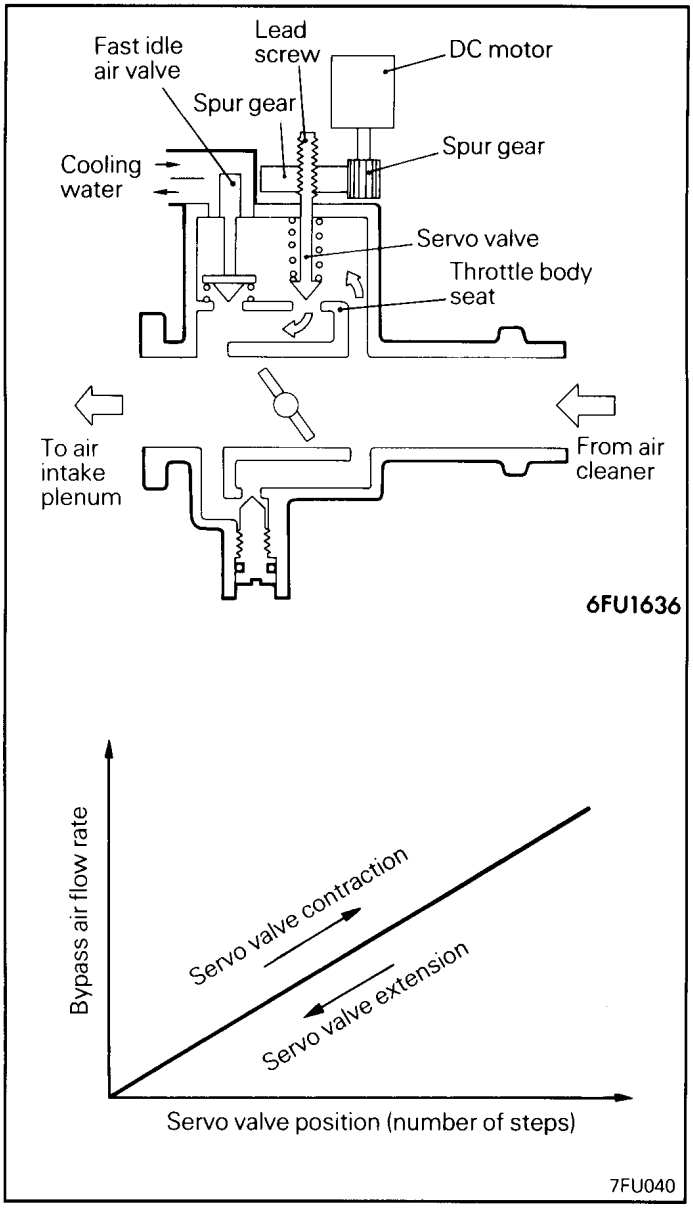
7FU0912

The servo valve position sensor employs this principle and is shown schematically to the left.
The shaft carries two disc magnets with the polarity shifted about 90° to each other. Close to each of these magnets is fitted a Hall element.

As spur gear B rotates, the magnetic field applied to the Hall element changes. If a current is flowing through the Hall element, the voltage generated by the element changes with the gear rotation.
When this voltage is applied to the comparator in the sensor, the comparator output voltage is 5 V when the generated voltage is positive and is 0 V when the voltage is negative. Represented in this manner as a pulse signal, the rotation signal of spur gear B is transmitted from the position sensor to the engine control unit.



7FU0913



ACTUATOR

IDLE SPEED CONTROL (ISC) SERVO

The ISC servo consists of a DC motor, spur gears and a servo valve, and is joined to the throttle body. The spur gear on the lead screw of the servo valve shaft turns when the DC motor is driven by the current from the engine control unit. Consequently, the valve extends or retracts according to the motor rotating direction.

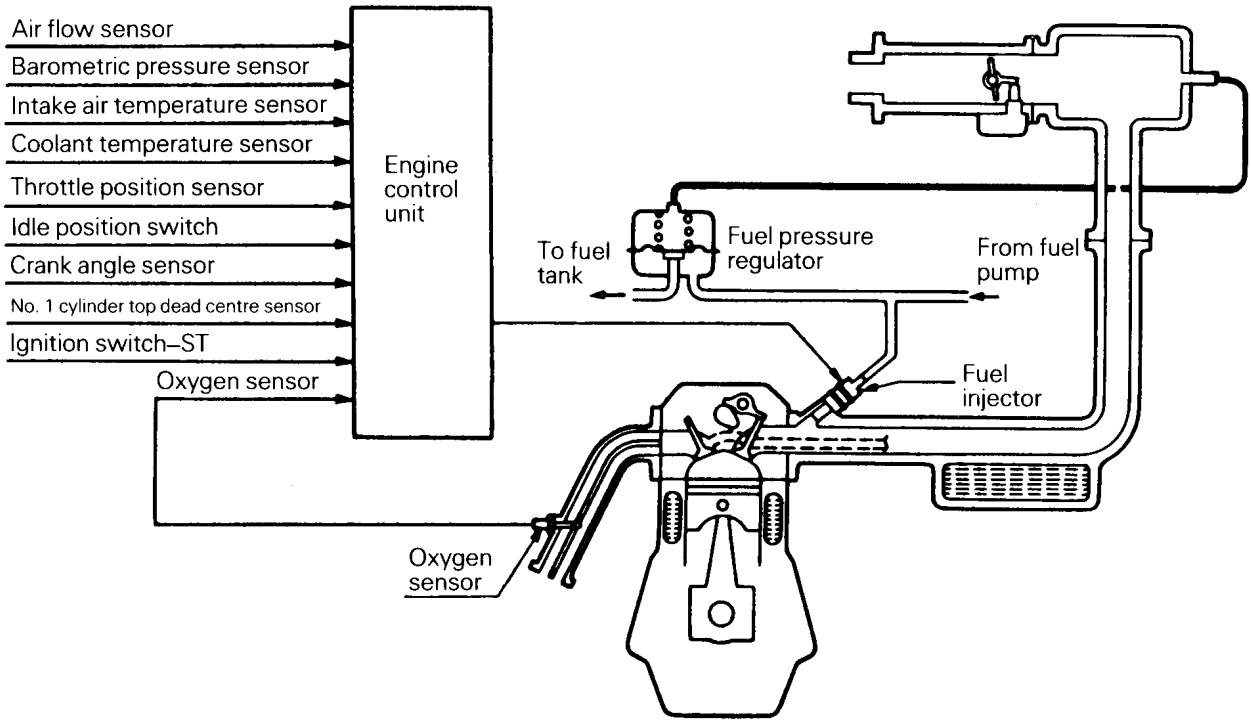
The volume of bypass air that flows bypassing the throttle valve increases when the clearance between the servo valve and the throttle body seat becomes larger and it decreases when this clearance become smaller.

In other words, the bypass air volume changes with the servo valve position (i.e., the gap between the valve and its seat). The servo valve position changes either positively or negatively according to the direction of the DC motor's rotation and the amout of valve's positional change is continuously calculated by the engine control unit.

FUEL INJECTION CONTROL

The fuel injection control system is basically the same configuration as used in the current 4G64 engine.

System Configuration

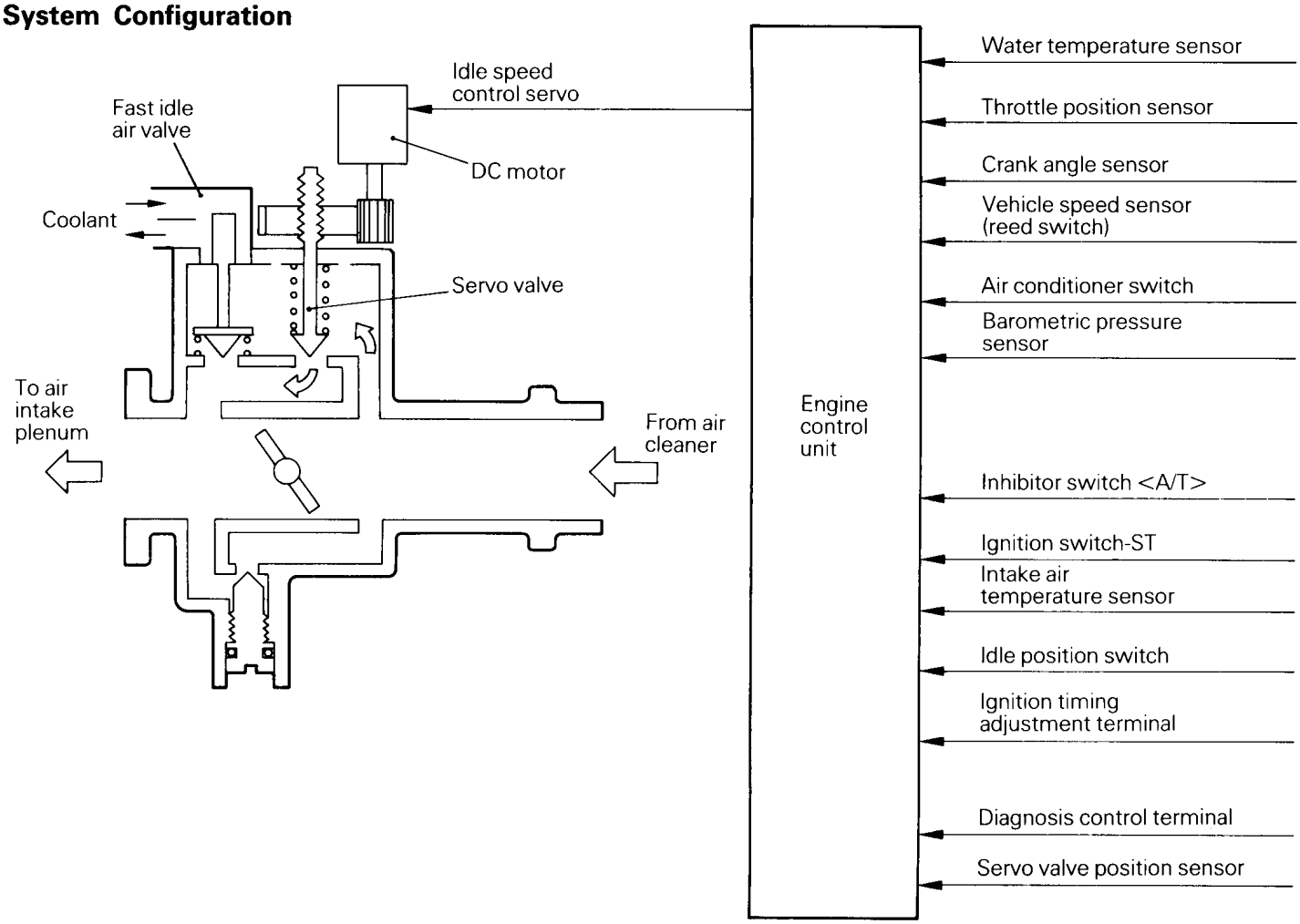


IDLE SPEED CONTROL (ISC)

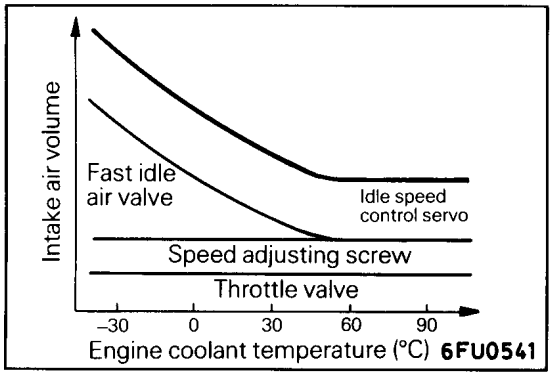
In the new 4G64 engine, the idle speed is controlled by regulating the throttle valve bypass air volume, the same as in the current 6G7 engines and 4G6-DOHC engines.

Therefore, the idle speed control system used in the new engine is basically the same as these engines.

System Configuration



6FU1630



INTAKE AIR VOLUME AT IDLING

The intake air volume at idling is measured at each of the four paths before being supplied to the intake manifold (See figure). This is the same as for an idle speed control which uses a stepper motor.

The status of the throttle body when adjusting the basic idle speed is also basically the same as that of the stepper motor type idle speed control as follows:

- Idle speed control servo: Opened to the nineth step (opened wider at high-altitude)
- Fast idle air valve: Completely closed [engine coolant temperature 80°C (176°F) or higher]
- Throttle valve: Lever touching the fixed SAS

DC MOTOR DRIVE CONTROL

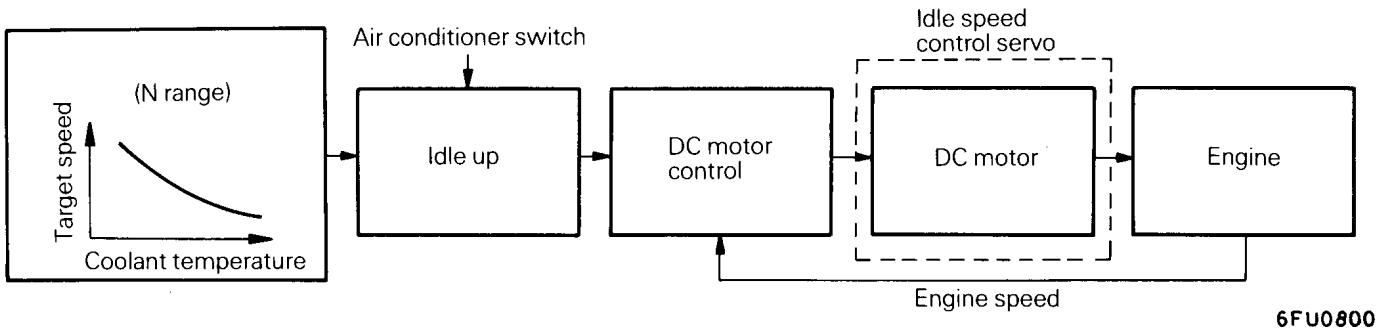
When there is a difference between the target position and the actual position of the servo valve, the engine control unit drives the DC motor to either extend or contract the valve according to the actual difference. When the target is reached, the motor stops.

IDLE SPEED FEEDBACK CONTROL

In order to keep the engine speed at the preset idle target speed when idling, the DC motor is operated to control the bypass air volume.

The feedback control includes basically the same items as those of the stepper motor type idle speed control.

Idle Speed Feedback Control Block Diagram

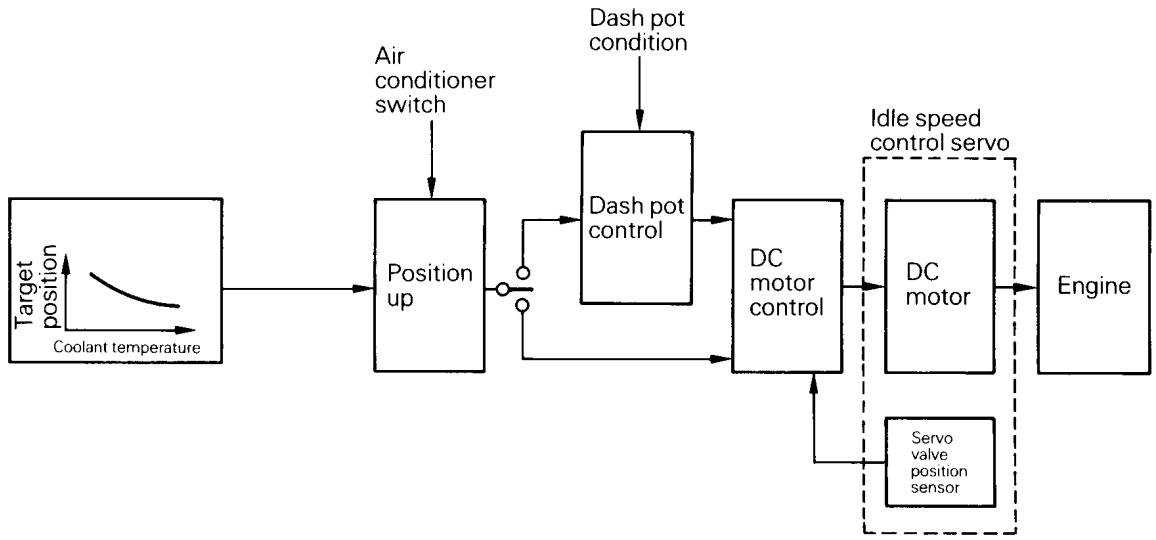


IDLE SPEED CONTROL (ISC) POSITION CONTROL

During idling, the engine speed changes sharply if the air conditioner switch is turned ON or OFF, or any other operation is made which can cause a change of engine load.
Immediately after detection of the load change signal, the engine control unit moves the servo valve to the target position according to the load status after such a change in order to adjust the bypass air volume, thereby limiting the engine speed change.

If the target position cannot be reached even after several DC motor operation attempts during position control, servo valve failure is assumed and the self diagnosis failure code (No. 55) is stored. Also the DC motor stops.
The position control items are basically the same as those of the stepper motor type idle speed control.

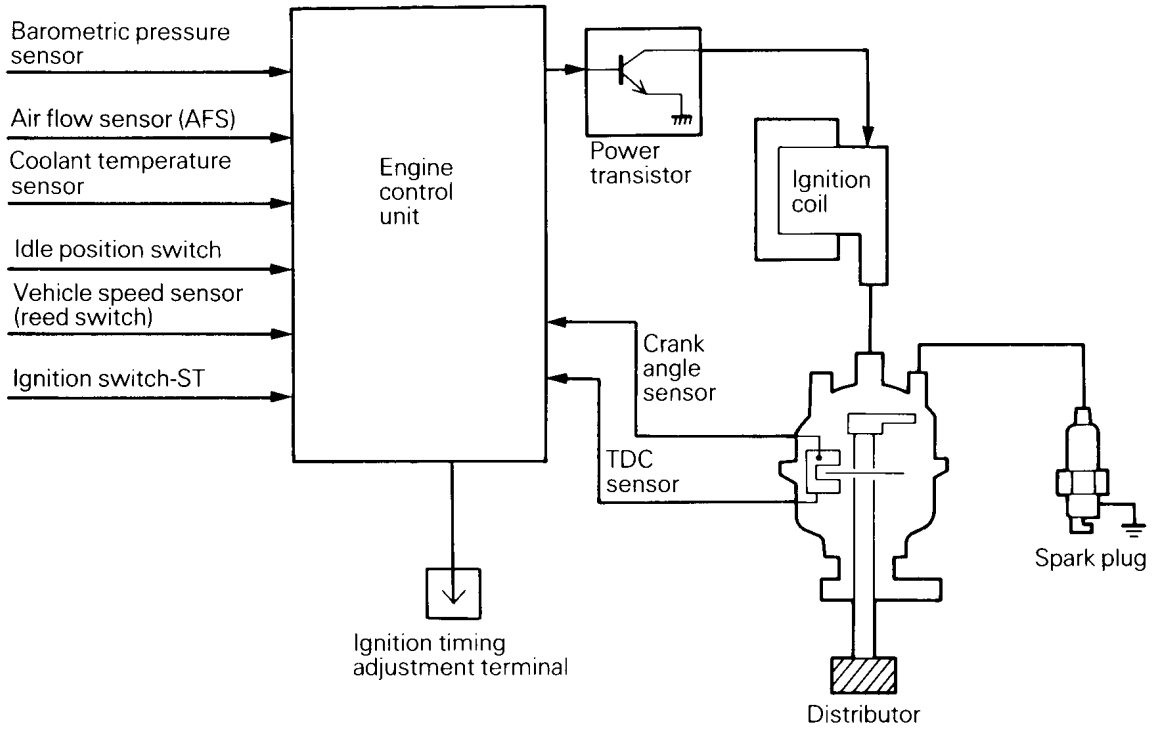
Position Control Block Diagram



6FU1634

IGNITION TIMING AND ENERGIZATION TIME CONTROL

The ignition timing and energization time control is basically the same as that of the current 4G64 engine.

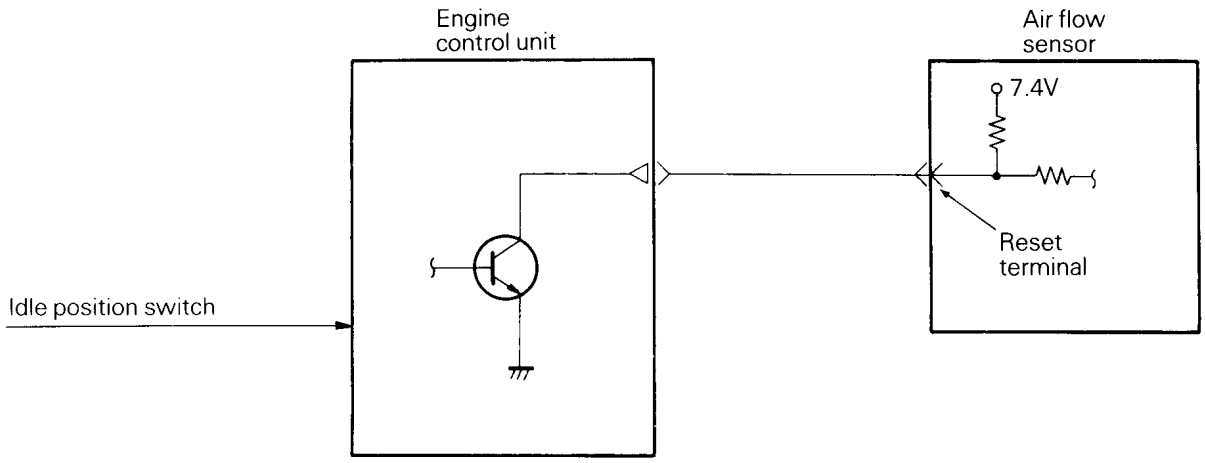


7FU0915

FUEL PUMP CONTROL, AIR CONDITIONER RELAY CONTROL, PURGE CONTROL

These controls are the same as those of the current 4G64 engine.

AIR FLOW SENSOR (AFS) FILTER RESET CONTROL



When the idle position switch is ON, the engine control unit turns on the power transistor, thereby sending the air flow sensor reset signal to the air flow sensor.

After receiving the reset signal, the air flow sensor resets the filter circuit, thereby improving the air volume detecting capacity of the air flow sensor in the operational region of low intake air volume.

SELF DIAGNOSIS SYSTEM

ENGINE WARNING LAMP (CHECK ENGINE LAMP) CONTROL

The components which may cause an engine warning lamp illumination are as listed below:

Oxygen sensor	No. 1 cylinder TDC sensor
Air flow sensor (AFS)	Barometric pressure sensor
Intake air temperature sensor	Ignition timing adjustment signal*
Throttle position sensor	Injector
Coolant temperature sensor	Fuel pump
Crank angle sensor	Engine control unit

*: The engine warning lamp also illuminates if the ignition timing adjustment terminal is shorted to earth when adjusting the ignition timing.

SELF DIAGNOSIS FUNCTION

The diagnosis items are as listed below:

Code No.	Diagnosis item	Major diagnosis points
11	Oxygen sensor	Malfunction of the air/fuel ratio control system Open or short circuit in the oxygen sensor circuit
12	Air flow sensor	Open or short circuit of sensor related circuit
13	Intake air temperature sensor	Open or short circuit of sensor related circuit
14	Throttle position sensor	Abnormal sensor output
21	Water temperature sensor	• Open or short circuit of sensor related circuit • Excessive connector contact resistance
22	Crank angle sensor	Abnormal sensor output
23	No. 1 cylinder TDC sensor	Abnormal sensor output
24	Vehicle speed sensor (reed switch)	Open or short circuit of sensor circuit
25	Barometric pressure sensor	Open or short circuit of sensor related circuit
36*	Ignition timing adjustment signal	Shorted ignition timing adjustment signal cable
41	Injector	Open circuit in injector related circuit
42	Fuel pump	• Open circuit in fuel pump drive circuit • Faulty control relay
55	Idle speed control servo valve position sensor	• Open or short circuit of sensor related circuit • Faulty idle speed control servo
–	Normal	–

*: Failure code No. 36 is not stored.

SERVICE DATA OUTPUT FUNCTIONS

The available service data output items are as listed below:

NOTE
Items added to those contained in the existing system are shown in bold characters.

Item No.	Service data item	Unit
11	Oxygen sensor output	mV
12	Air flow sensor output	Hz
13	Intake air temperature sensor output	°C
14	Throttle position sensor output	mV
16	Battery voltage	V
18	Cranking signal (ignition switch – ST)	ON – OFF
21	Coolant temperature sensor output	°C
22	Crank angle sensor output	RPM
25	Barometric pressure sensor output	mmHg

Item No.	Service data item	Unit
26	Idle position switch	ON – OFF
28	Airconditioner switch	ON – OFF
34	**Air flow sensor reset signal**	**ON – OFF**
36	**Ignition timing adjustment mode**	**ON – OFF**
37	**Volumetric efficiency**	**%**
38	**Crank angle sensor output (readable at 2,000 r/min or less)**	**RPM**
41	Injector drive time	mS
44	Ignition advance angle value	°BTDC, °ATDC
49	Airconditioner relay	ON – OFF
55	**ISC servo position sensor**	**STEP**

ACTUATOR TESTS

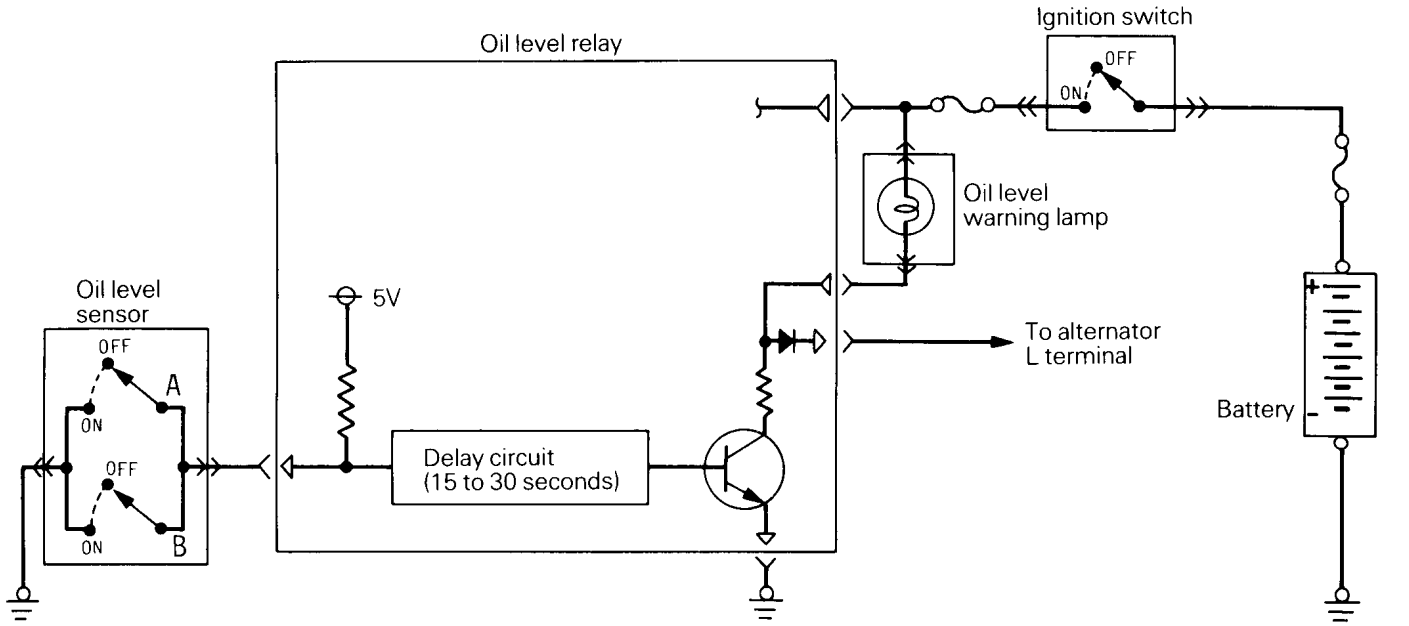
The actuator test items are as listed below:

Item No.	Actuator test item
01	No. 1 injector: OFF
02	No. 2 injector: OFF
03	No. 3 injector: OFF
04	No. 4 injector: OFF
07	Fuel pump: ON
08	Purge control solenoid valve: ON

OIL LEVEL WARNING SYSTEM

When a low engine oil level is detected during engine operation, this system illuminates the oil level warning lamp to warn the driver of low oil level.

If the normal oil level recovers either by replenishment or repair, the oil level warning lamp goes out.



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The oil level warning lamp illuminates under either or both of the following conditions:

(1) When the ignition switch is ON (engine stopped)
- The current from the ignition switch flows through the oil level warning lamp and alternator L terminal to ground. This causes the oil level warning lamp to come on.
- When the engine is started, the alternator L terminal potential goes high so that current stops flowing and the oil level warning lamp goes out.

(2) When low oil level remains for more than about 20 seconds after the engine oil temperature has risen [about 55°C (131°F)].
- If the engine oil temperature is low, oil level sensor switch A (oil temperature switch) is kept ON so that no voltage is applied to the delay circuit.
- If the engine oil temperature has risen and accordingly the oil temperature switch has been turned OFF, but the oil level is normal, oil level sensor switch B (level switch) remains ON so that no voltage is applied to the delay circuit.
- If the engine oil quantity decreases due to leaks or other reasons while the engine is running, the oil level switch is turned OFF and the voltage is applied to the delay circuit. If the level switch remains OFF for more than the predetermined delay time (approximately 20 seconds), the power transistor is turned ON and the oil level warning lamp comes on.
- The delay circuit is provided to prevent the oil level warning lamp from lighting when the level switch is turned OFF temporarily due to vehicle turns or similar causes.

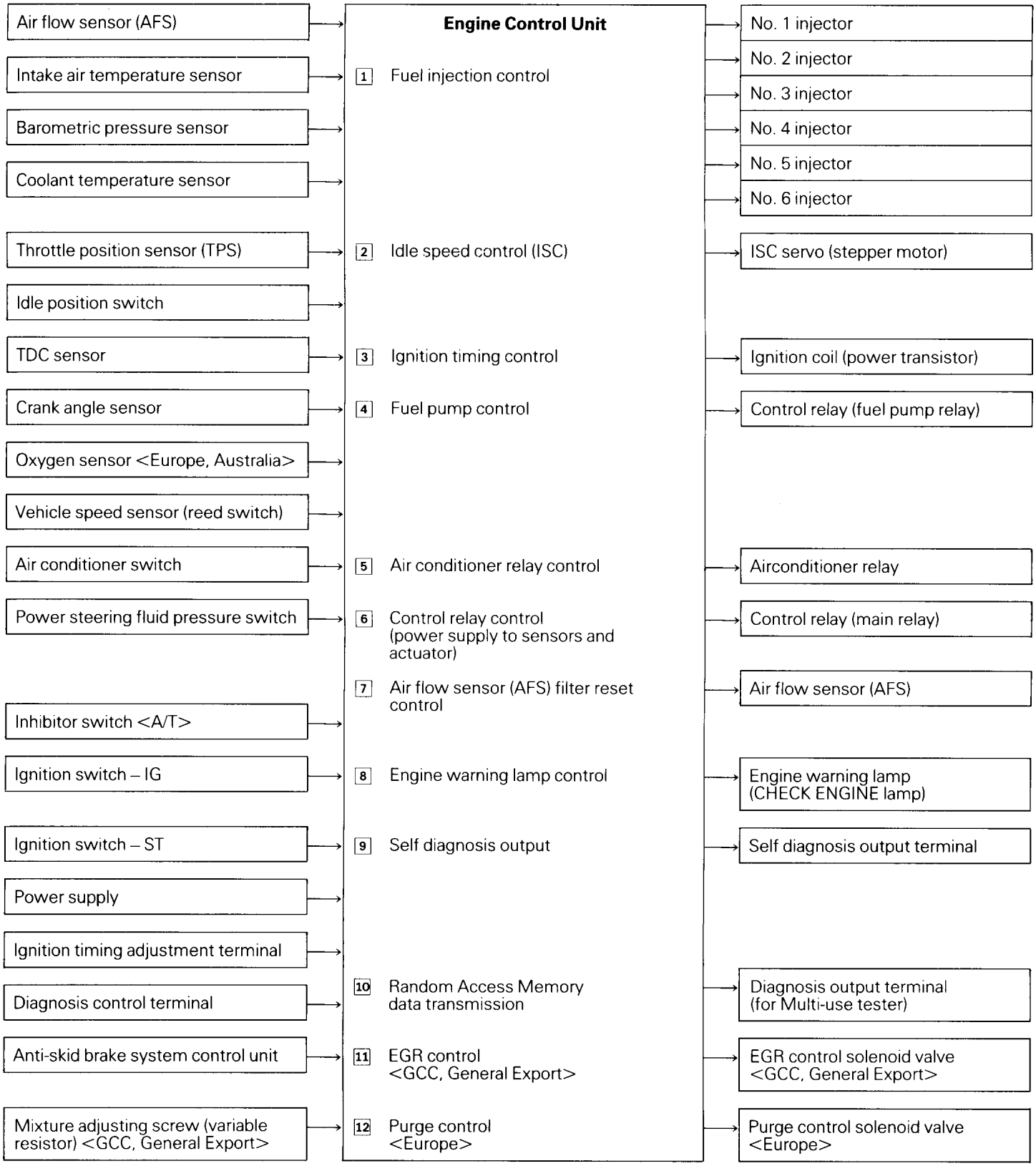
CONTROL SYSTEM <6G72>

E9BMBAF

In addition to the control features derived from the current 6G72-SOHC engine, the new 6G72-SOHC engine's control system features the following improvements for better driveability and higher engine performance:

Principal improvements/additions	Applicable destination			Remarks
	Europe	GCC General Export	Australia	
Pressure sensitive type air flow sensor and smooth flow type air cleaner	X	X	X	• Conventional sensors are the ultrasonic sensitive type. • Higher engine output
Air flow sensor filter reset control	X	X	X	• Corresponds to the adoption of a pressure sensitive type air flow sensor. • Assures a highly reliable air flow sensor signal.
Changed TDC sensor and crank angle sensor signals	X	X	X	For using the signal common to 6G72-DOHC engines.
Oxygen sensor with heater	X	–	X	Highly sensitive to oxygen density ever when the exhaust temperature is low (already adopted for PAJERO/ MONTERO models for Australia)
Independent earth lead for oxygen sensor	X	–	X	Improves of oxygen sensor signal reliability.
Smaller water temperature sensor temperature sensing section size	X	X	X	• For higher sensor response • Same as the 4G1 engine
Stepper motor control for when the anti-skid brake system is operating	X	X	X	• For higher braking performance • Same as the 4G6-DOHC engine
Oil level warning system	X	–	–	For better reliability

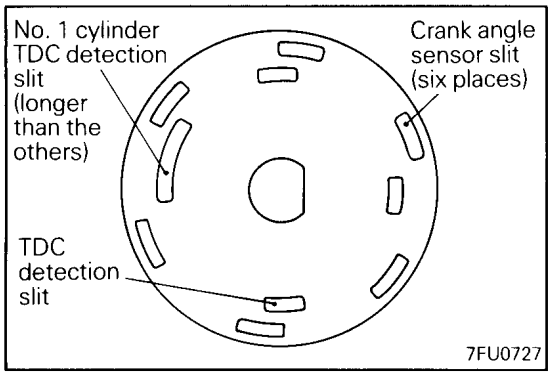
SYSTEM BLOCK DIAGRAM

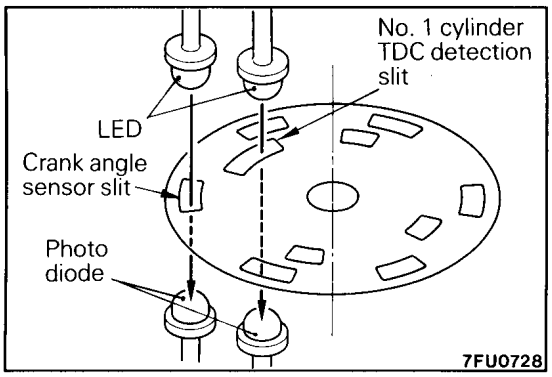


SENSORS

AIR FLOW SENSOR

See the paragraph on 4G64 engine (P.1-23).

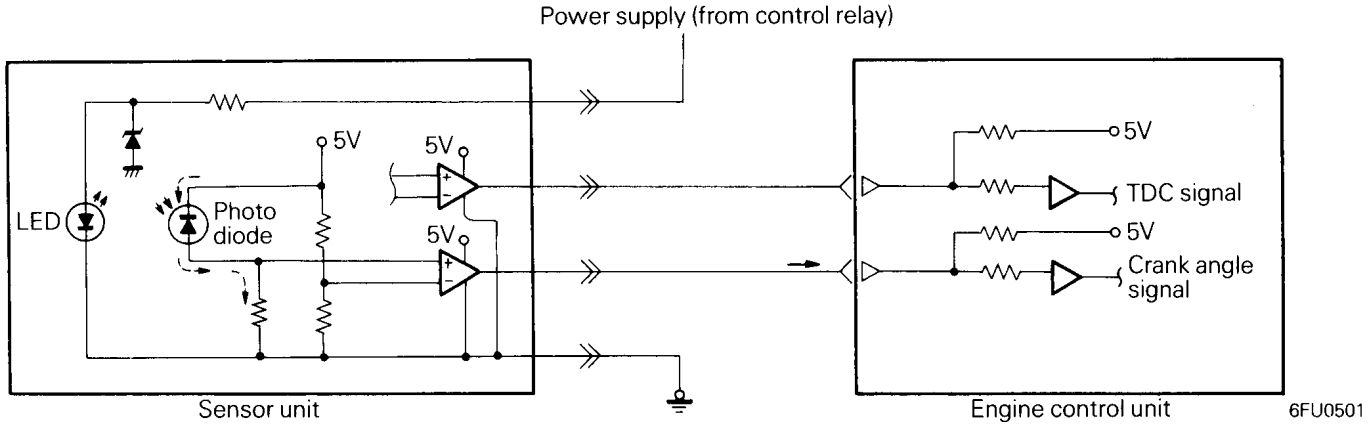


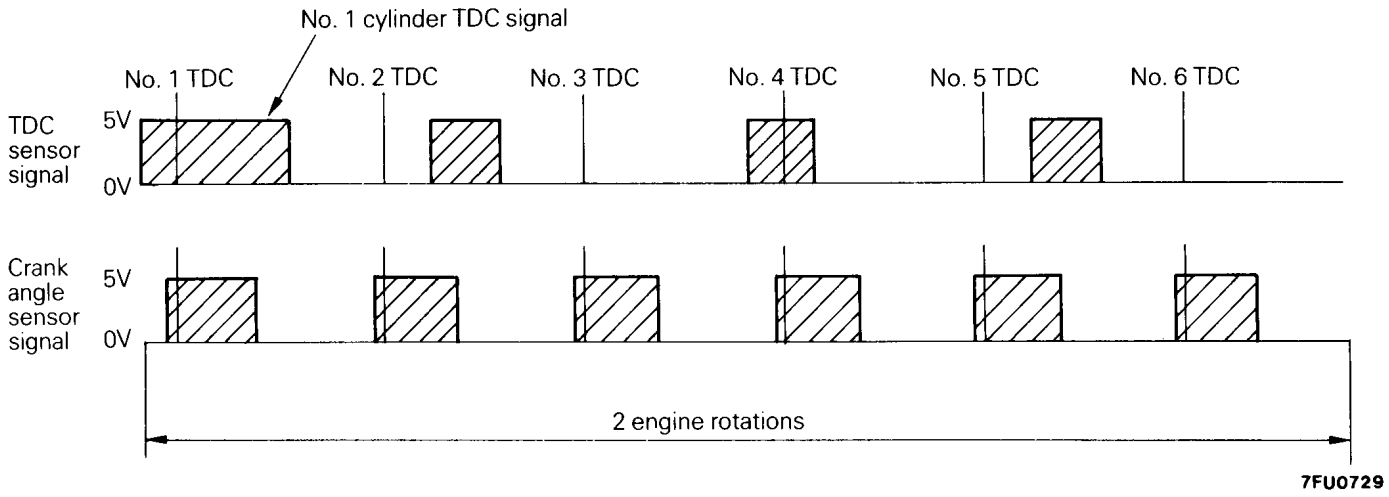


TDC SENSOR AND CRANK ANGLE SENSOR

The TDC sensor and crank angle sensor combination consists of a disc and a sensor unit which are built into the distributor. The disc is a metal disc with six outer slits and four inner slits. The outer slits are arranged at 60 degree intervals.
The inner slits are for the TDC sensor and the outer ones are for the crank angle sensor.
The disc is fixed to the sensor shaft so that when the intake valve side camshaft on the rear bank rotates, the disc also rotates. The light transmitted through the disc slits is read optically by the sensor unit.
The sensor unit has two light emitting diode (LED) and photo diode pairs. One pair is for the outer slits and the other is for the inner slits. The disc rotates in a narrow space between the light emitting diodes and photo diodes.

Light from the LED reaches the photo diode each time a slit passes between them.
The photo diode has a special characteristics meaning that when it receives light, it allows the current to flow in the opposite direction to that of an ordinary diode.
Consequently, the current flows in the direction of dotted line shown below. This sends a voltage of about 5 V to the comparator of the sensor unit so the engine control unit terminal voltage becomes 5 V.
After a slit has passed the LED and photo diode pair, light cannot reach the photo diode so that the current indicated by the dotted line no longer flows. This means that the engine control unit terminal voltage becomes 0 V. Consequently, the output signal from the sensor unit is sent as a pulse signal to the engine control unit.



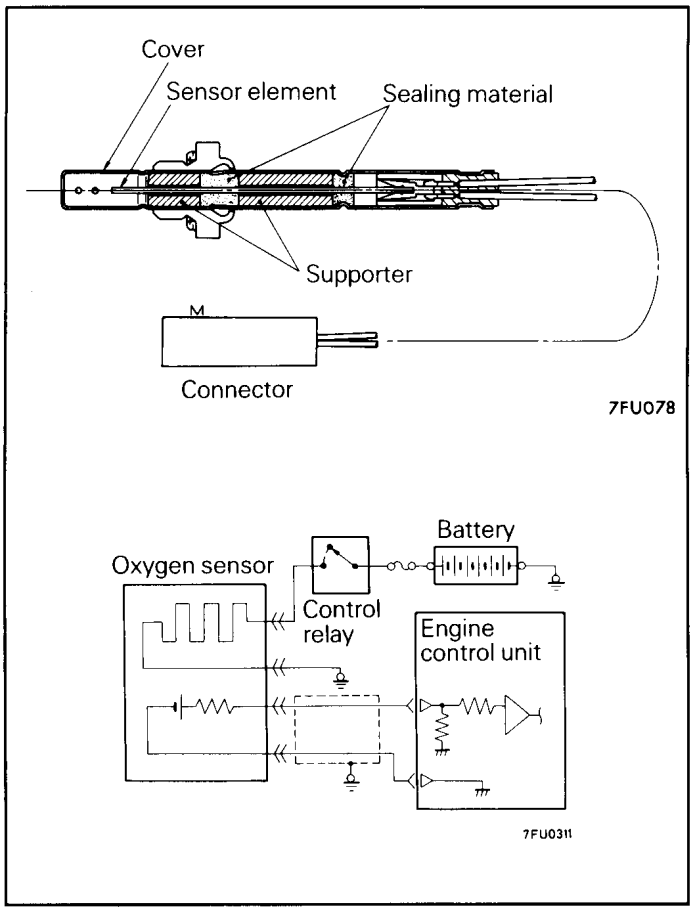


(1) TDC sensor signal

This signal obtained using the four inner slits of the disc is for detecting the top dead centre on compression stroke of each cylinder. Based on this signal, the engine control unit determines both the fuel injection order and which cylinder to ignite.

(2) Crank angle sensor signal

This signal obtained using the six outer slits of the disc is for detecting the crank angle corresponding to each cylinder. The engine control unit determines the engine speed and the intake air volume per stroke based on this signal. It also determines the ignition timing and sends the ignition coil primary current shut off signal to the power transistor unit.



OXYGEN SENSOR

Similarly as the engine for Australia, the oxygen sensor has a platinum heater built in the sensor element.

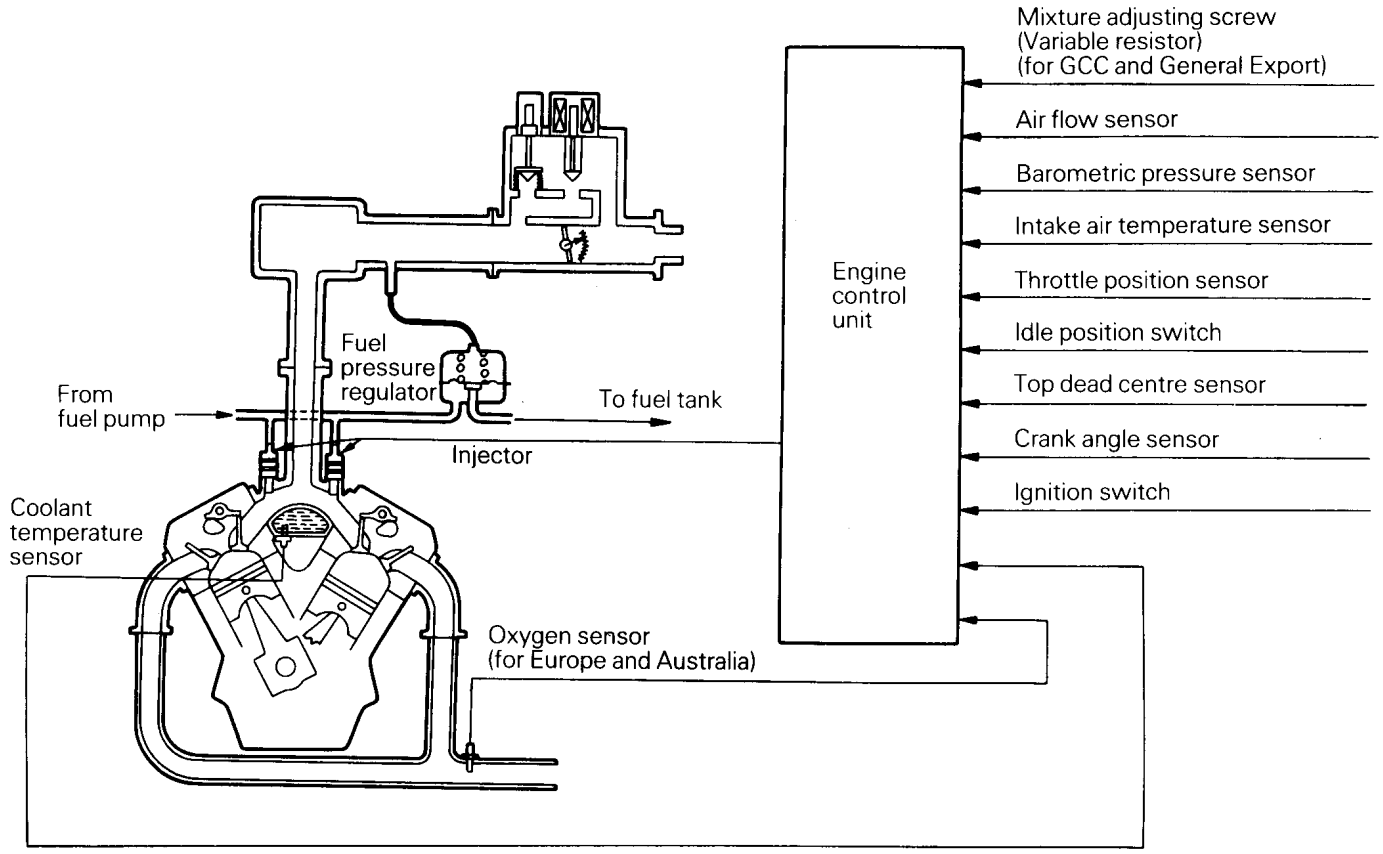
This oxygen sensor with the built-in heater has good oxygen density response even when the exhaust gas temperature is low.

Therefore, quite quickly after engine start up, it can provide feedback control of the air-fuel ratio. This sensor has a dedicated earth lead and is connected directly to the earth within the engine control unit. This makes the oxygen sensor output signal highly reliable, because it is virtually free from the influence of earth level variations in other components.

FUEL INJECTION CONTROL

(1) Along with improvements in the TDC sensor and the crank angle sensor signal, the trigger signal for controlling the fuel injection timing (injector energization timing) has been changed from the TDC sensor signal to the crank angle sensor signal.
(2) Other controls are basically the same as the control system used for the current 6G72-SOHC engines.

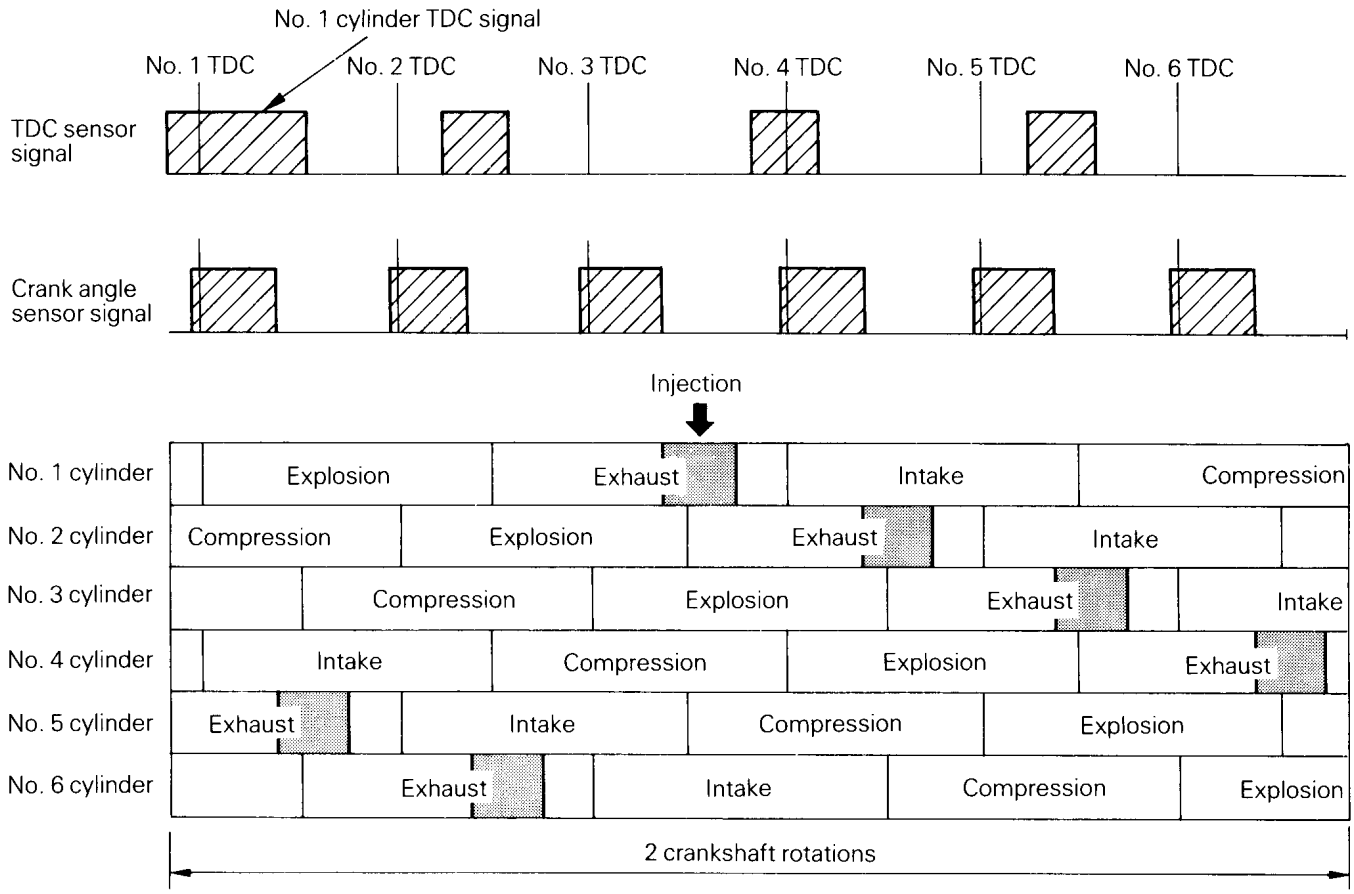
System Configuration Diagram



7FU0312

FUEL INJECTION (INJECTOR DRIVE) TIMING CONTROL

Sequential Injection Timing Diagram



7FU0736

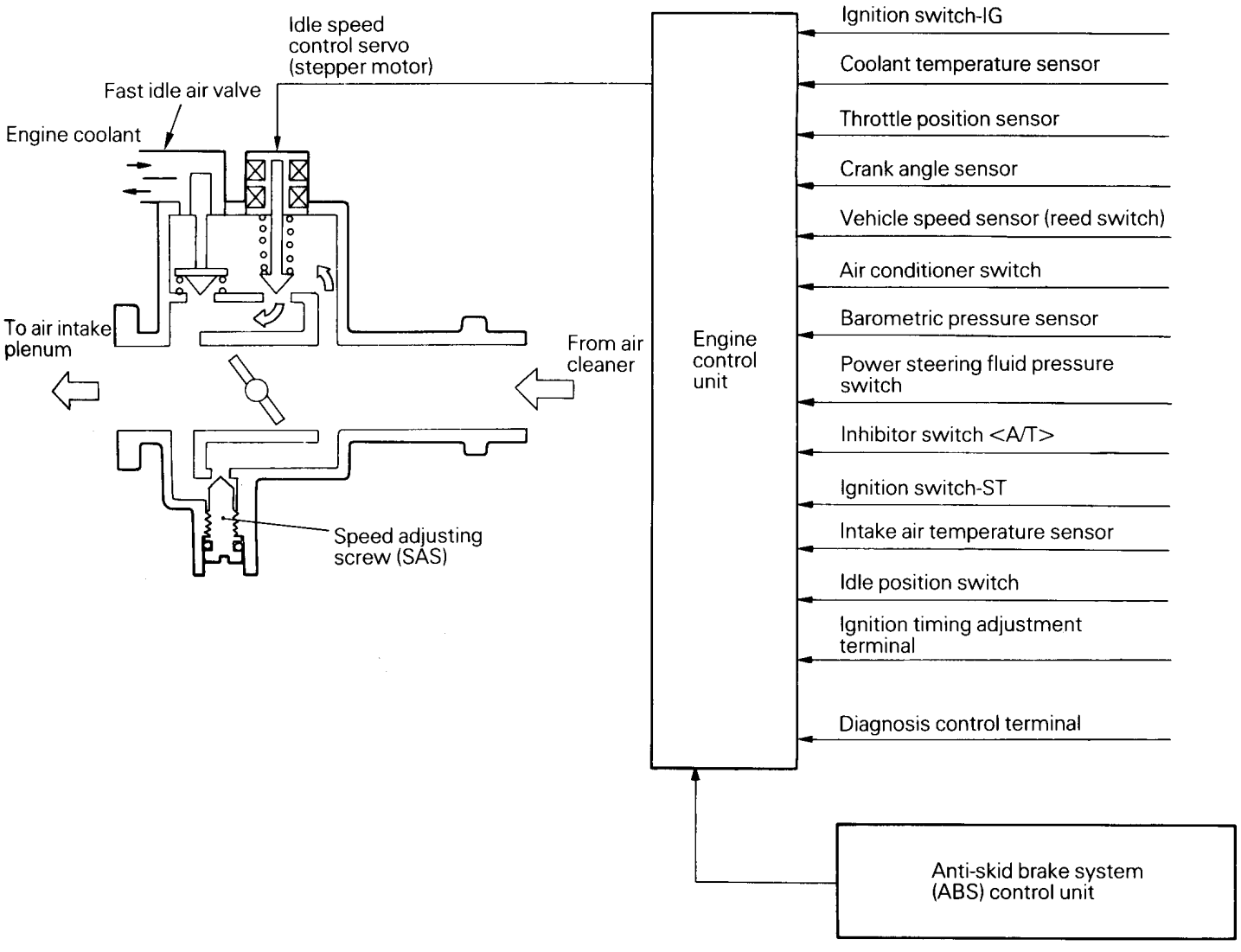
The injector is energized on the exhaust stroke of each cylinder.
The No. 1 cylinder TDC signal is the reference signal of the sequential injection. Upon detection of the compression stroke of No. 1 cylinder from this reference signal, the sequential injection to the cylinders starts in the order of 5-6-1-2-3-4. Injection into each cylinder occurs in sync with the crank angle signal every time the crankshaft rotates two times.

IDLE SPEED CONTROL (ISC)

(1) A stepper motor position control feature has been added for more precise idle speed control when the anti-skid brake system is in operation. This control is basically the same as that used in the current 4G63-DOHC engine.

(2) Other controls are basically the same as those for the current 6G72-SOHC engines.

System Configuration Diagram

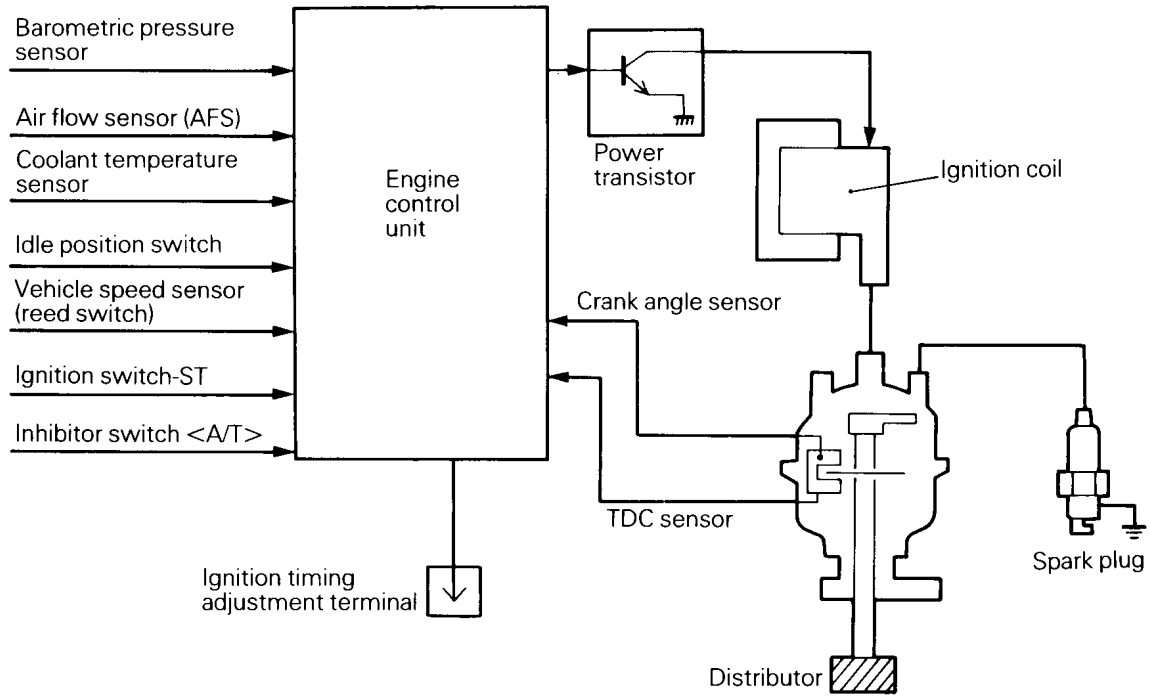


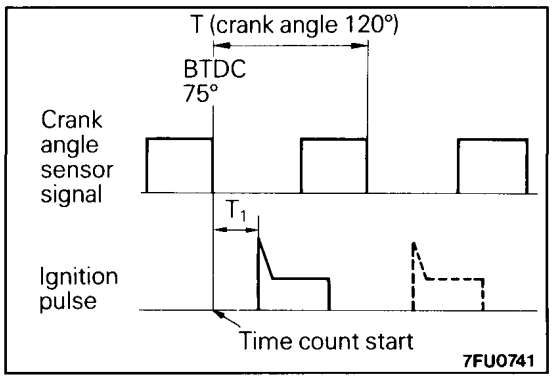
IGNITION TIMING AND ENERGIZATION TIME CONTROL

(1) Along with the improvements of the TDC sensor and crank angle sensor signals, the ignition timing control has been changed to the same control system as the current 4G63 engine.

(2) Other controls are basically the same as those used for the current 6G72-SOHC engine.

System Configuration Diagram





IGNITION TIMING CONTROL

Period T of the crank angle sensor signal is measured and based on this, the time (t) necessary for one degree (1°) of the crankshaft rotation is determined.

$t = T/120$

After determining "t", the ignition timing (T_1) is calculated in reference to the 75° BTDC signal. After T_1 time has lapsed following the 75° BTDC signal input, the ignition coil primary current cut off signal is sent to the power transistor.

$T_1 = t \times (75 - \theta)$

θ: an ignition advance angle as calculated by the engine control unit

FUEL PUMP CONTROL, AIR CONDITIONER RELAY CONTROL, CONTROL RELAY CONTROL, EGR CONTROL <GCC, GENERAL EXPORT>, PURGE CONTROL <EUROPE>

These controls are the same as the current 6G72-SOHC engine.

AIR FLOW SENSOR (AFS) FILTER RESET CONTROL

See the paragraph on the 4G64 engine (P.1-34).

SELF DIAGNOSIS SYSTEM

ENGINE WARNING LAMP (CHECK ENGINE LAMP) CONTROL

The components which may cause an engine warning lamp illumination are as listed below.

Oxygen sensor	TDC sensor
Air flow sensor (AFS)	Barometric pressure sensor
Intake air temperature sensor	Ignition timing adjustment signal*
Throttle position sensor	Injector
Coolant temperature sensor	Engine control unit
Crank angle sensor	–

*: The engine warning lamp also illuminates if the ignition timing adjustment terminal is shorted to earth when adjusting the ignition timing.

SELF DIAGNOSIS FUNCTION

The diagnosis item are as listed below.

Code No.	Diagnosis item	Major diagnosis contents	DIAGNOSIS 2 Mode
11	Oxygen sensor	Malfunction of the air/fuel ratio control system Open or short circuit in the oxygen sensor circuit	–
12	Air flow sensor	Open or short circuit of sensor related circuit	–
13	Intake air temperature sensor	Open or short circuit of sensor related circuit	–
14	Throttle position sensor	Abnormal sensor output	–
21	Coolant temperature sensor	• Open or short circuit of sensor related circuit • Exessive connector contact resistance	–
22	Crank angle sensor	Abnormal sensor output	–
23	TDC sensor	Abnormal sensor output	–
24	Vehicle speed sensor (reed switch)	Open or short circuit of sensor circuit	–
25	Barometric pressure sensor	Open or short circuit of sensor related circuit	–
36*	Ignition timing adjustment signal	Short circuit in ignition timing adjustment signal line	–
41	Injector	Open circuit in injector related circuit	–
–	Normal	–	–

*: Malfunction code No. 36 is not stored.

SERVICE DATA OUTPUT

The available service data output items are as listed below.

NOTE
Items added to those contained in the existing system are shown in bold characters.

Item No.	Service data item	Unit
11	Oxygen sensor output	mV
12	Air flow sensor output	Hz
13	Intake air temperature sensor output	°C
14	Throttle position sensor output	mV
16	Battery voltage	V
17	Mixture adjusting screw (variable resistor) <GCC, General Export>	mV
18	Cranking signal (ignition switch – ST)	ON – OFF
21	Coolant temperature sensor output	°C
22	Crank angle sensor output	RPM
25	Barometric pressure sensor output	mmHg
26	Idle position switch	ON – OFF
27	Power steering fluid pressure switch	ON – OFF
28	Airconditioner switch	ON – OFF
29	Inhibitor switch <A/T>	D2LR – NP
34	**Air flow sensor reset signal**	**ON – OFF**
36	**Ignition timing adjustment mode**	**ON – OFF**
37	**Volumetric efficiency**	**%**
38	**Crank angle sensor output (readable at 2,000 r/min or less)**	**RPM**
41	Injector drive time	mS
44	Ignition advance angle value	°BTDC, °ATDC
45	ISC stepper motor position	STEP
49	Airconditioner relay	ON – OFF

ACTUATOR TESTS

The actuator test items are as listed below.

Item No.	Actuator test item
01	No. 1 injector: OFF
02	No. 2 injector: OFF
03	No. 3 injector: OFF
04	No. 4 injector: OFF
05	No. 5 injector: OFF
06	No. 6 injector: OFF
07	Fuel pump: ON
08	Purge control solenoid valve: ON <Europe>
10	EGR control solenoid valve: ON <GCC, General Export>

OIL LEVEL WARNING SYSTEM <EUROPE>

See the paragraph on the 4G64 engine (P.1-37).

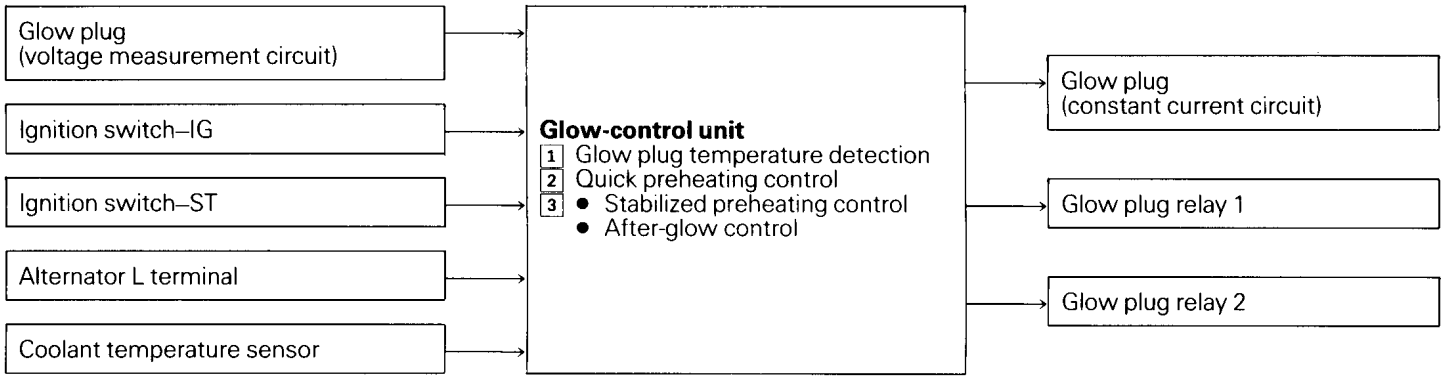
CONTROL SYSTEM <4D56>

E9BMDAC

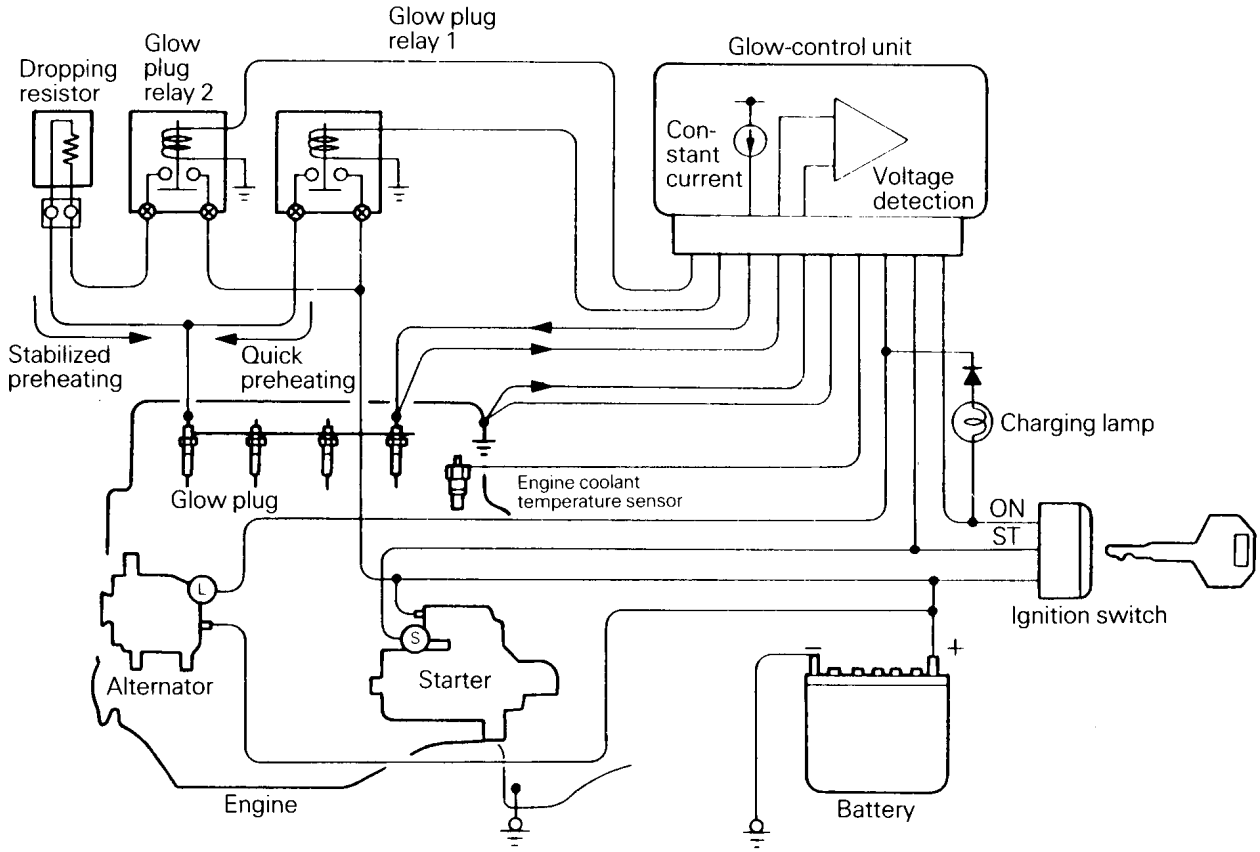
SUPER QUICK GLOW SYSTEM

The new 4D56 engine uses the same super quick glow system as that used in the current 4D56 engine.

SYSTEM BLOCK DIAGRAM



CONTROL SYSTEM DIAGRAM

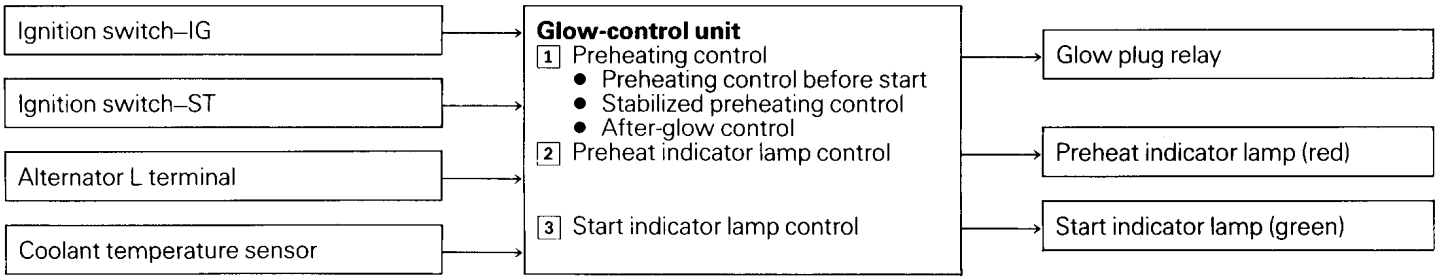


DFU0025

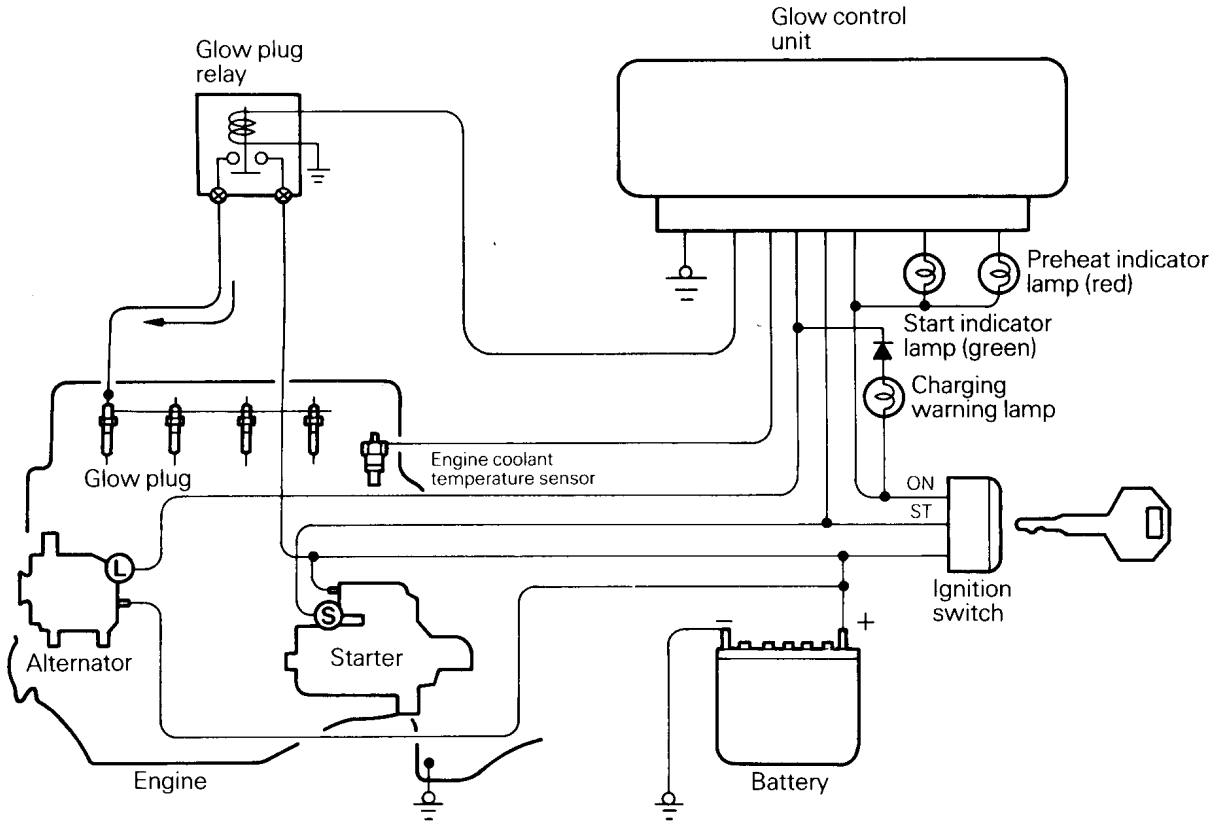
AUTO GLOW SYSTEM

The auto glow system is the same as that used in the current 4D56 engine.

SYSTEM BLOCK DIAGRAM



CONTROL SYSTEM DIAGRAM

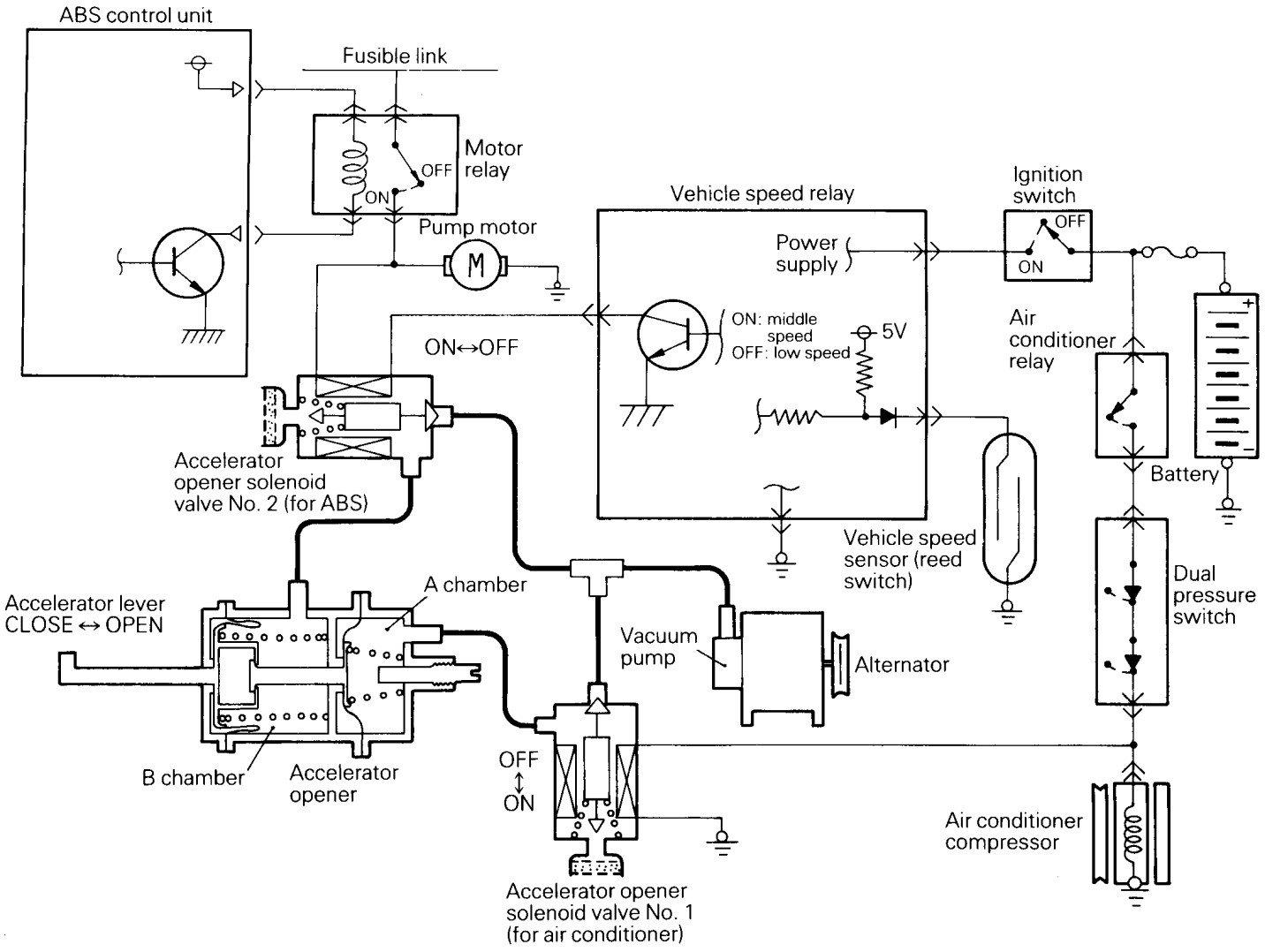


DEL0027

ACCELERATOR LEVER CONTROL WHEN ANTI-SKID BRAKE (ABS) IS IN OPERATION

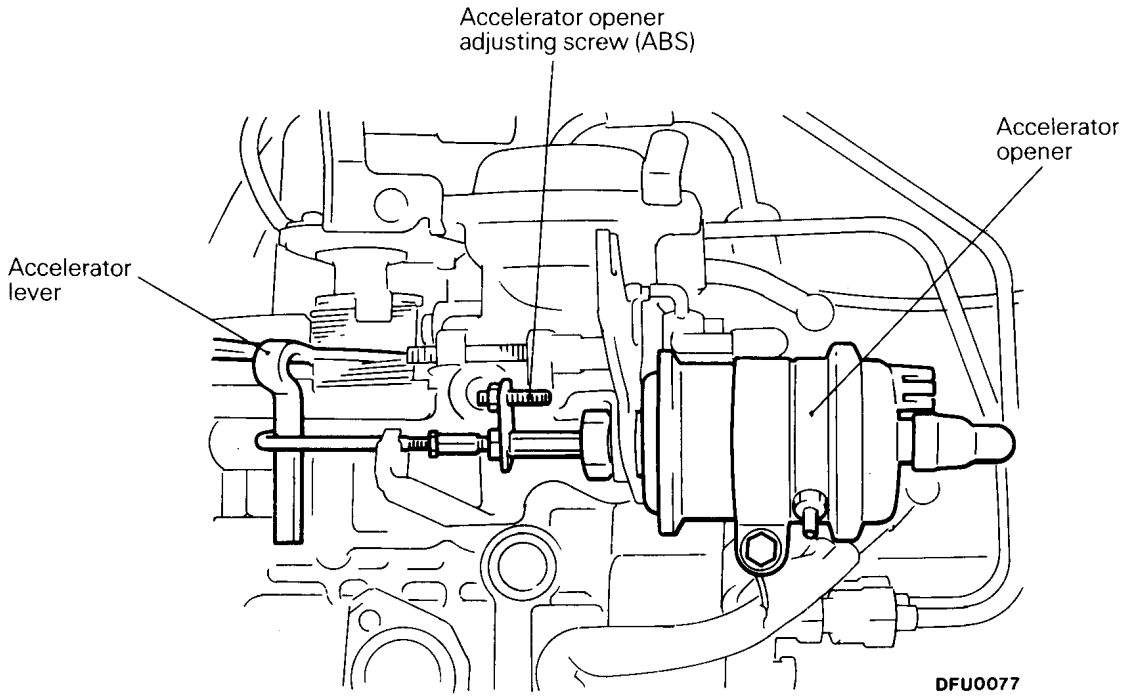
When ABS is operating, this new function controls the accelerator lever, opening it a little to increase the amount of fuel injected (equivalent to that amount injected when the engine runs at 1,900 r/min with no load). This limits wheel lock due to excessive engine braking effects and thereby improving the ABS performance.

CONTROL SYSTEM DIAGRAM



DFU0076

Accelerator Opener External View



The ABS control unit turns ON the motor relay to supply the motor drive power to the pump motor when the ABS is in operation. It also supplies the power to accelerator opener solenoid valve No. 2 (for ABS). The vehicle speed relay has its inside power transistor turned ON only when the vehicle speed as detected by the vehicle speed sensor (reed switch) is at either middle or high speed [approx. 24 km/h (15 mph) or more]. Therefore, when the vehicle is driven at middle or high speeds while the ABS is operating, accelerator opener solenoid valve No. 2 is turned ON to introduce the vacuum produced by the vacuum pump to chamber B of the accelerator opener. This makes the accelerator lever open a little (to the position equivalent to when the engine is running at 1,900 r/min with no load), thereby preventing excessive engine braking effect. In other cases, this valve remains OFF, introducing atmosphere into chamber B of the accelerator opener.

When the air conditioner compressor is operating, accelerator opener solenoid valve No. 1 (for air conditioner) is turned ON, introducing the vacuum into chamber A of the accelerator opener. This makes the accelerator lever open a little (to the position equivalent to when the engine is running at 900 r/min under the compressor load), thereby securing air conditioner performance.

OIL LEVEL WARNING SYSTEM <EUROPE>

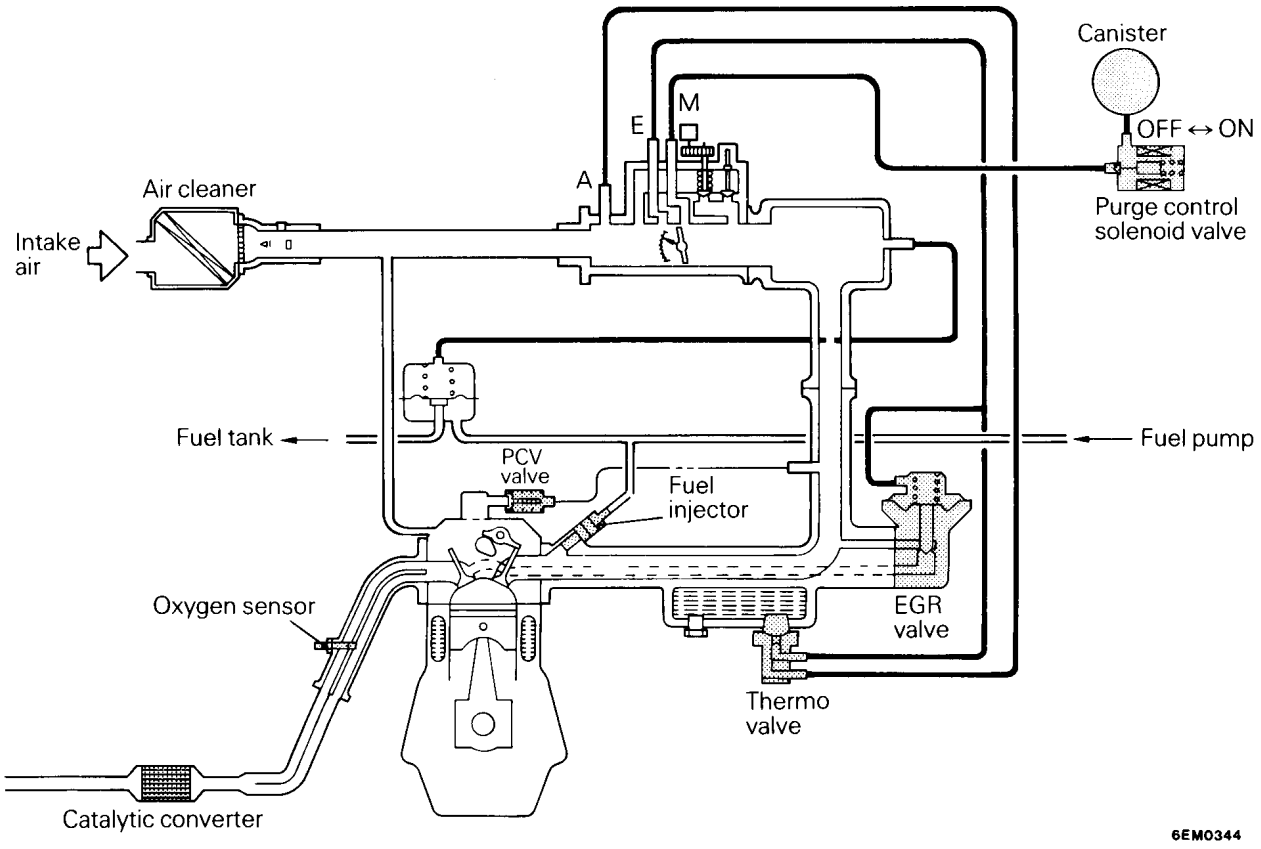
See the paragraph on the 4G64 engine (P.1-37).

EMISSION CONTROL SYSTEM <4G64>

E9BNAAE

The system used is basically the same as one used in the current 4G6 engine.

EMISSION CONTROL SYSTEM DIAGRAM



EMISSION CONTROL SYSTEM <6G72>

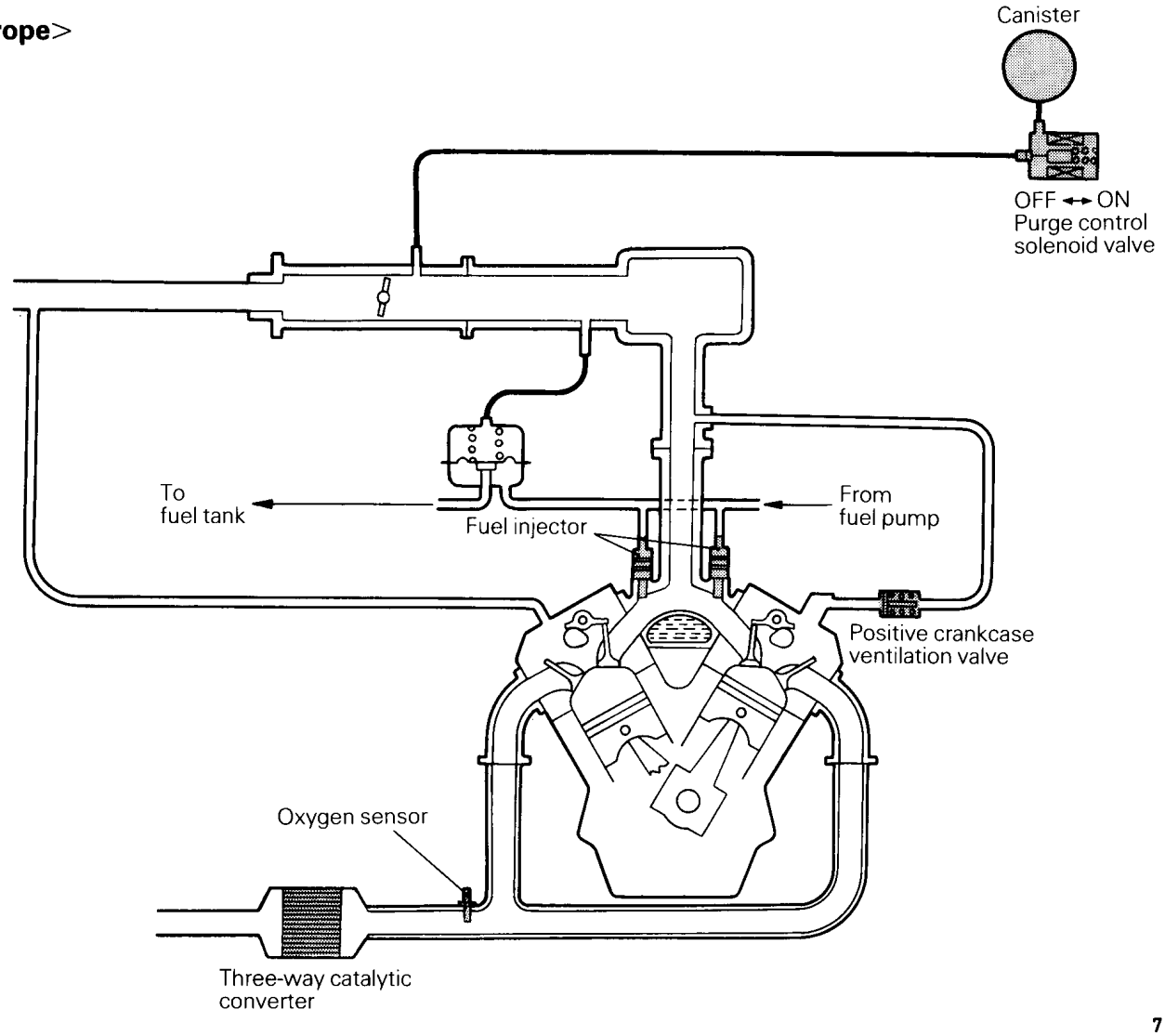
E9BNAAF

The system used is basically the same as one used in the 6G72-SOHC engines in the current PAJERO/ MONTERO models.

System	Applicable destination				Remarks
	Europe	GCC	General Export	Australia	
Crank case ventilation system	X	X	X	X	
Evaporating emission control system	X	X	–	X	Electronic control type <Europe> Vacuum control type <GCC, Australia>
Catalytic converter	X	–	–	X	Three-way catalyst
Air-fuel ratio closed loop control	X	–	–	X	Oxygen sensor signal used
Exhaust gas recirculation system	–	X	X	–	Electronic control type

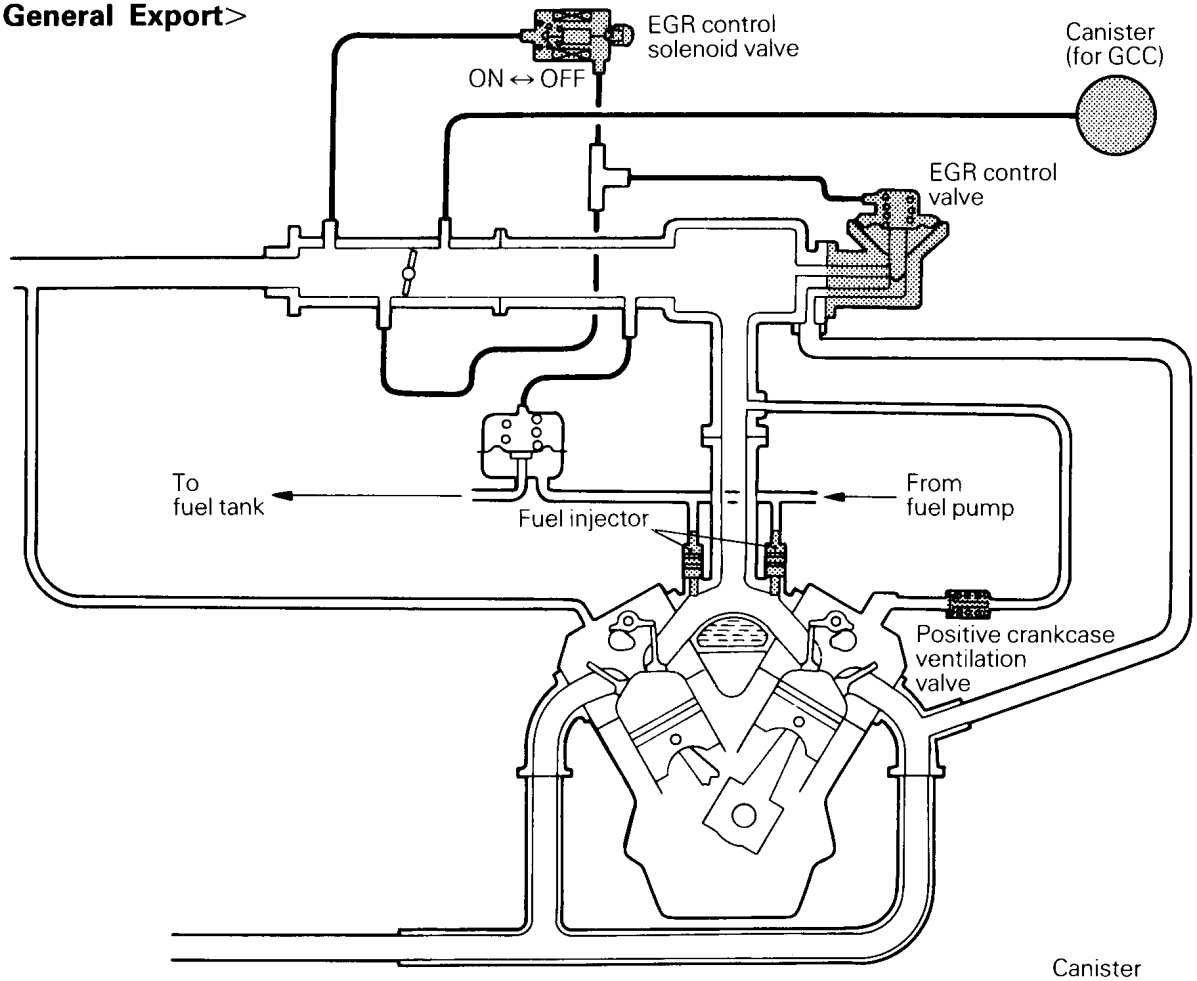
EMISSION CONTROL SYSTEM DIAGRAM

<Europe>



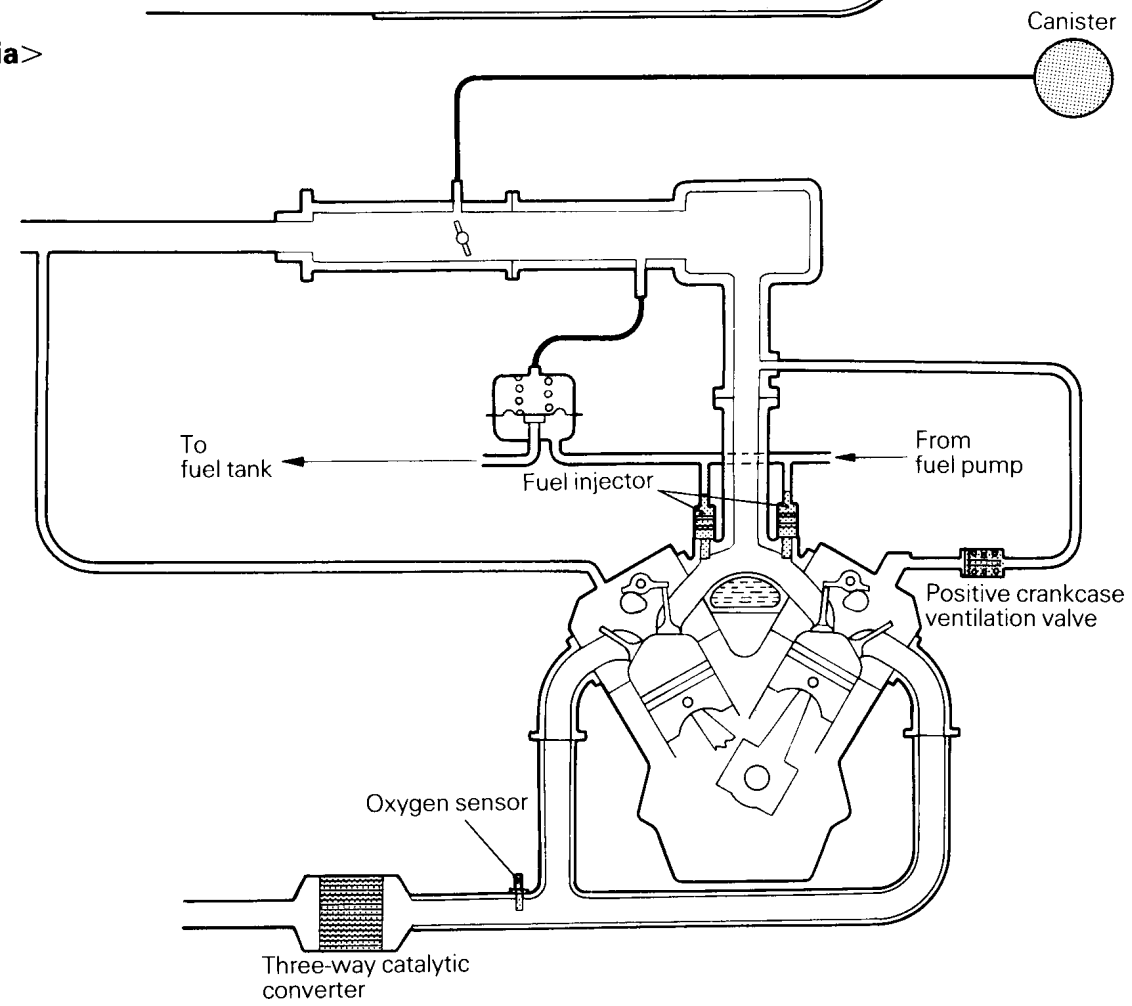
7EM0057

<GCC, General Export>



7EM0174

<Australia>



7EM0217

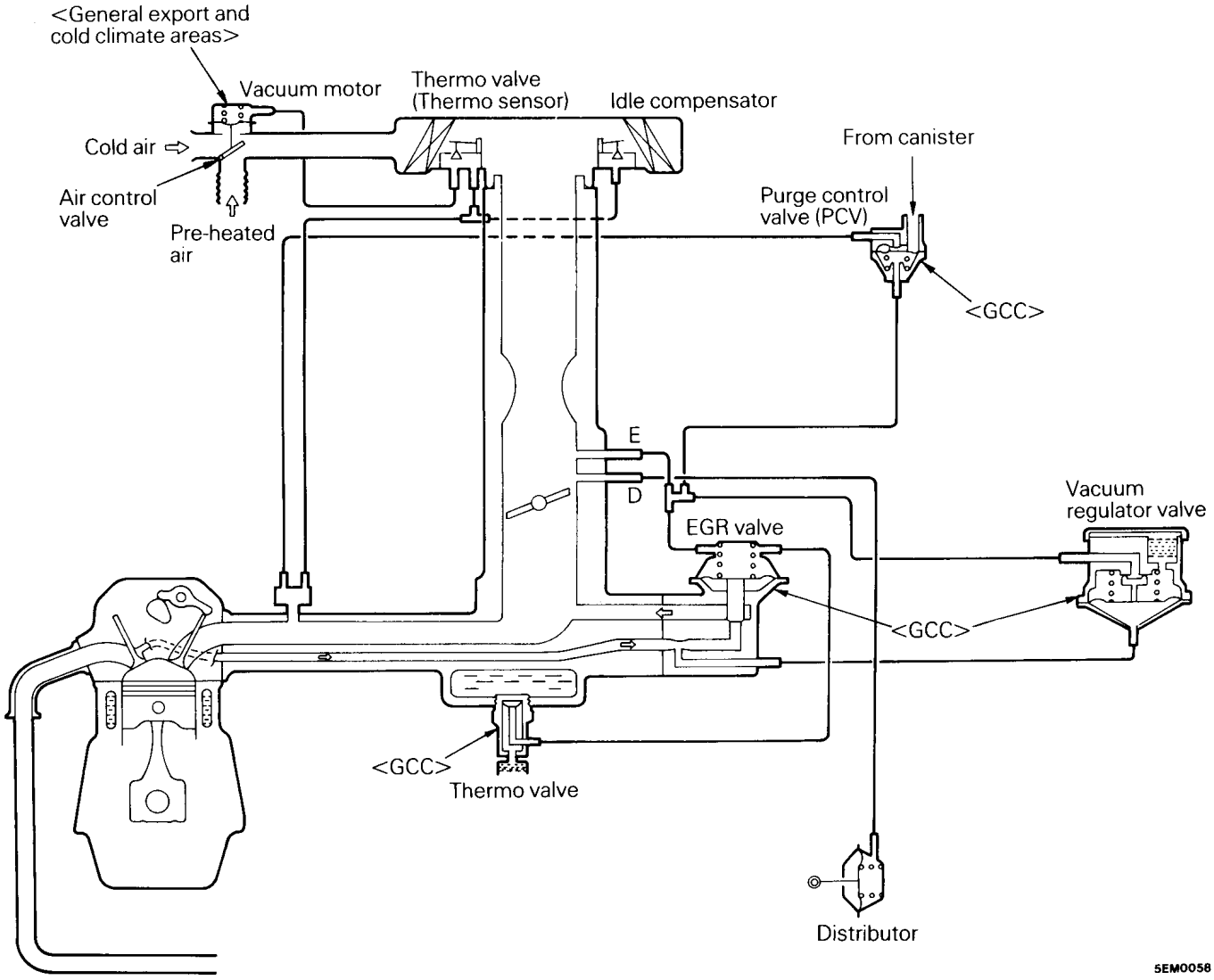
EMISSION CONTROL SYSTEM <4G54>

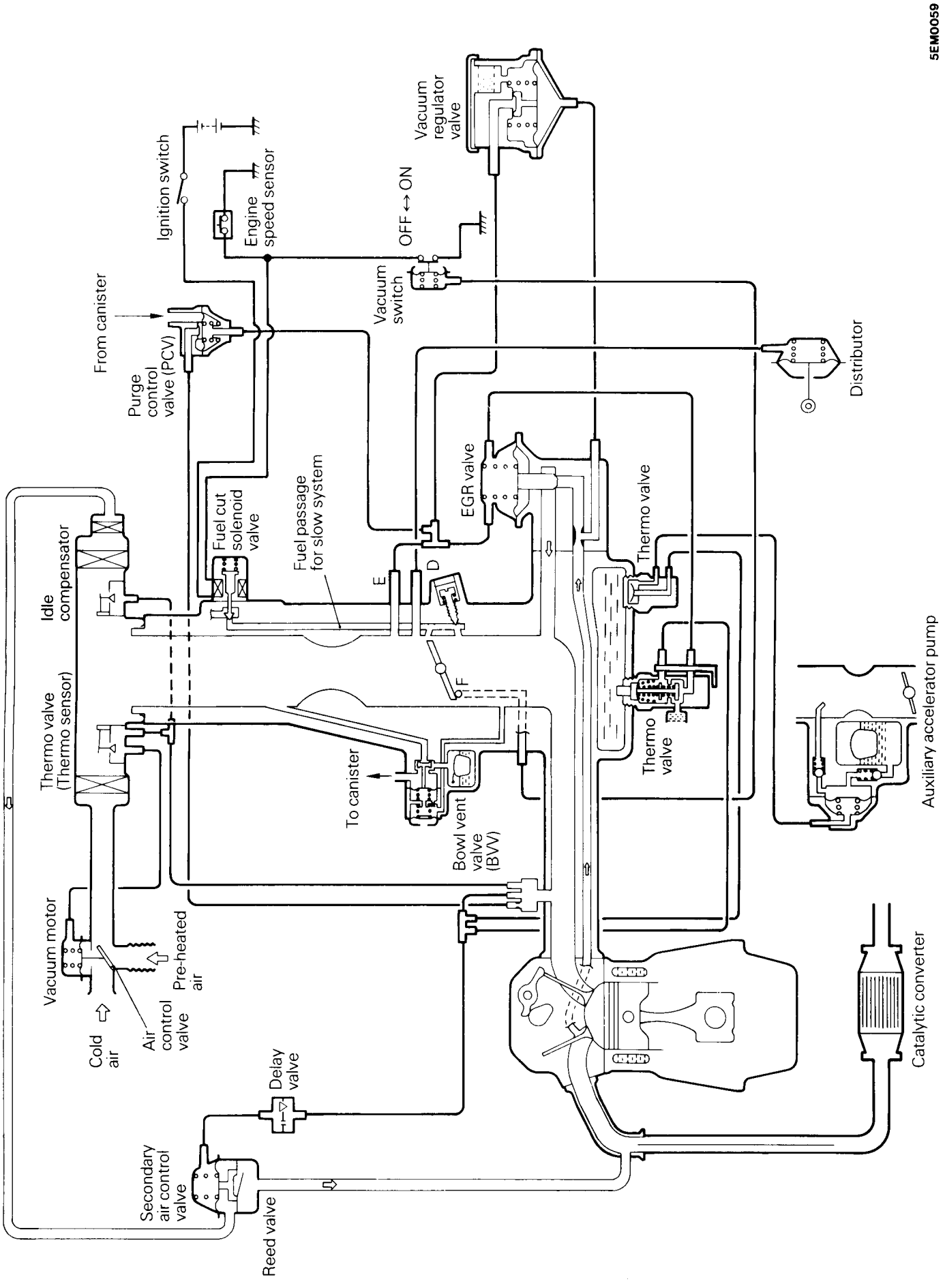
E9BNDAD

The system used is basically the same as one used in the current 4G54 engines.

System	Applicable destination			Remarks
	GCC	General Export	Australia	
Crankcase ventilation system	X	X	X	Closed system
Evaporative emission control system	X	–	X	Purge control valve E vacuum control type
Catalytic converter	–	–	X	Oxidizing catalyst
Secondary air supply system	–	–	X	Reed valve type with control valve
Exhaust gas recirculation (EGR) system	X	–	X	Vacuum regulate type
Fuel shut-off device at deceleration	–	–	X	Controlled by vacuum switch and engine speed sensor
Intake air temperature control system	–	X (Cold climate areas)	X	Vacuum control type
Idle compensator	X	X	X	Bimetal type

EMISSION CONTROL SYSTEM DIAGRAM
<GCC, General Export>




5EM0059
Vacuum regulator valve
Ignition switch
Engine speed sensor
OFF ↔ ON
Vacuum switch
From canister
Purge control valve (PCV)
Distributor
Fuel cut solenoid valve
Fuel passage for slow system
EGR valve
Thermo valve
Idle compensator
Thermo valve (Thermo sensor)
To canister
Bowl vent valve (BVV)
Thermo valve
Auxiliary accelerator pump
Vacuum motor
Pre-heated air
Cold air
Air control valve
Delay valve
Catalytic converter
Secondary air control valve
Reed valve
E
D
F

<Australia>

AUTO-CRUISE CONTROL SYSTEM

E9BKAAF

By using the auto-cruise control, the driver can drive at the speed he likes [in a range of approximately 40 – 200 km/h (25 – 124 mph)] without depressing the accelerator pedal.

Control system

The throttle position sensor (TPS) signal is used in addition to the conventional vehicle speed sensor as the input signal to bring about the following improvements in control.

(1) The amount of actuator control varies according to vehicle speed and throttle opening not only for an expansion of conformity to differences in engine output but also for better response.

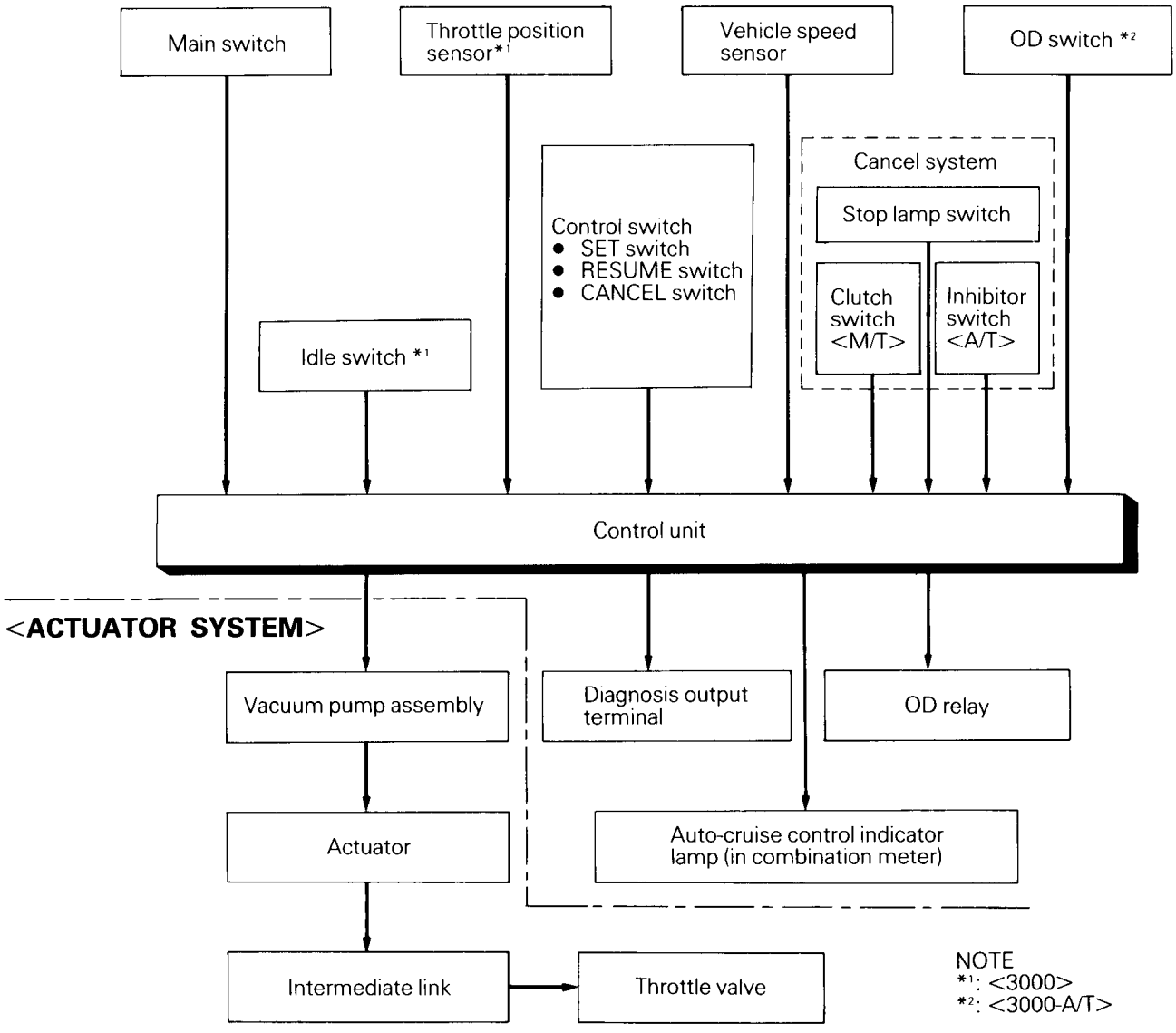
(2) On A/T models, overdrive is released (4-speed → 3-speed) when climbing inclines and the system judges the return time by vehicle speed and throttle opening to prevent hunting between 3-speed and 4-speed.

Actuator system

The actuator system consists of the motor-driven vacuum pump, actuator and intermediate link. The vacuum pump and actuator are in different locations.

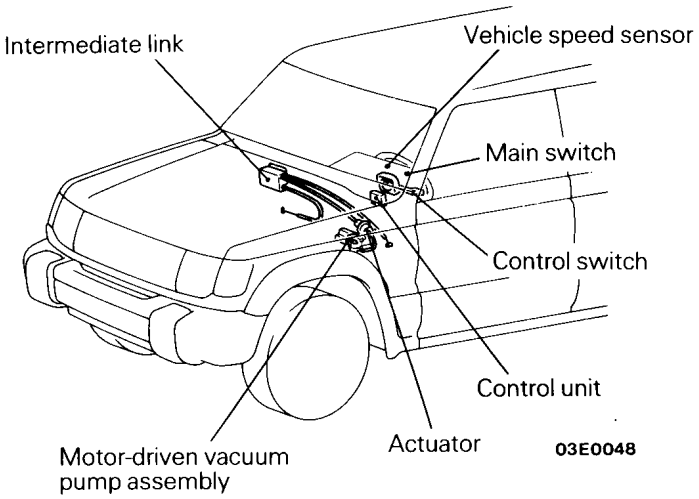
SYSTEM BLOCK DIAGRAM

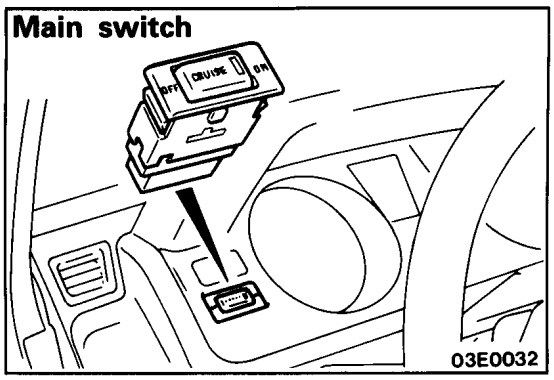
<CONTROL SYSTEM>

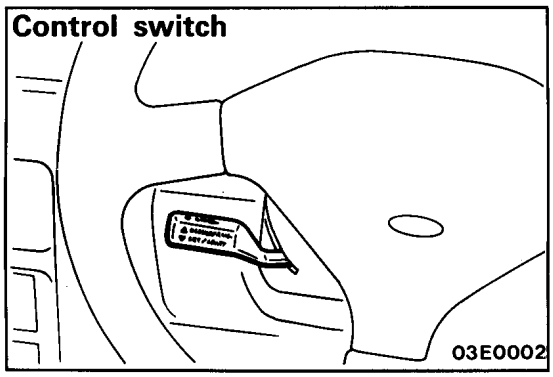


03E0007

COMPONENTS AND FUNCTIONS







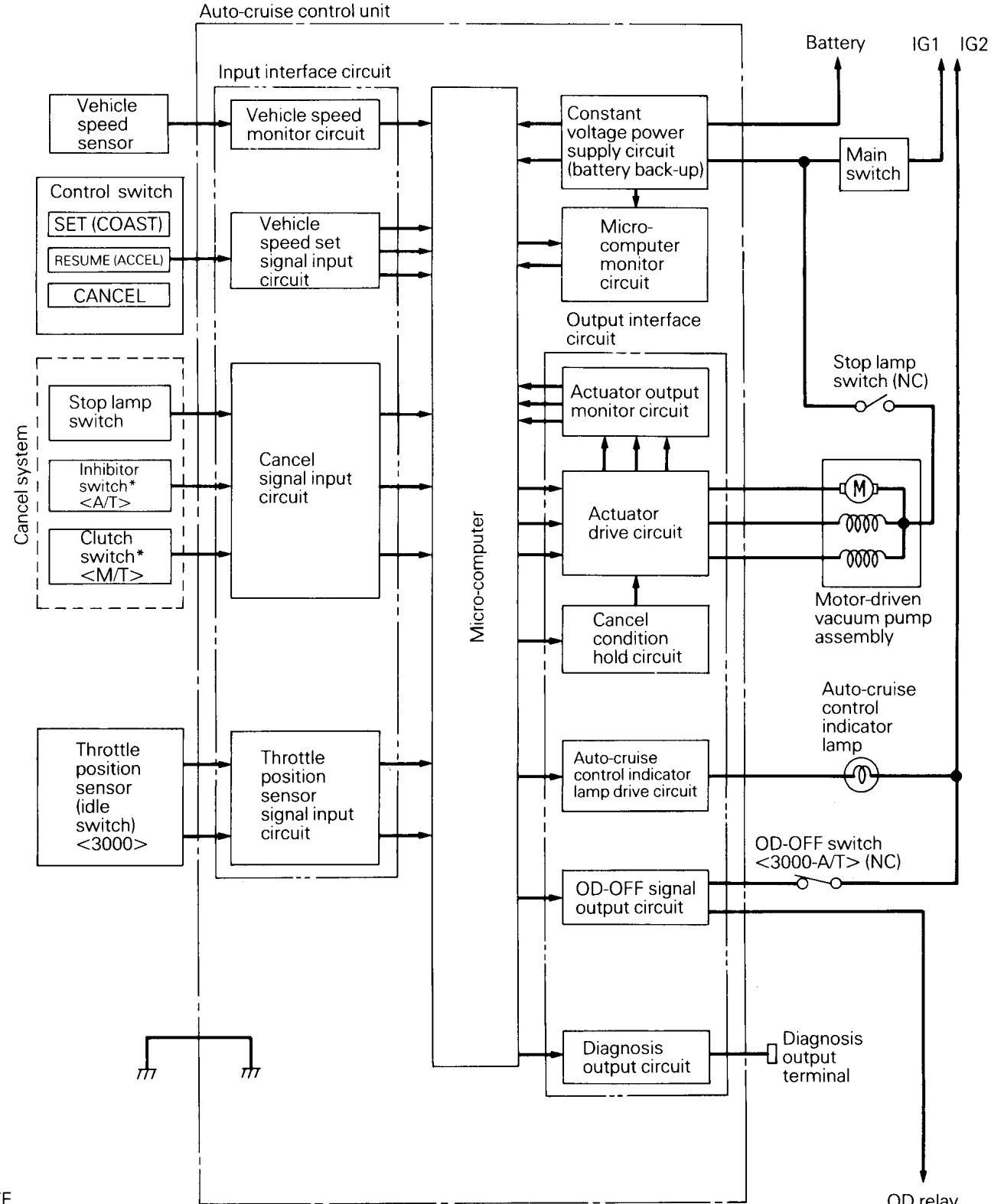
Components		Function
Vehicle speed sensor		It generates a pulse signal proportional to vehicle speed (revolving speed of the transaxle output gear).
Control unit		It receives signals from the vehicle speed sensor and each switch, and uses a micro-computer to control all functions of the auto-cruise control.
Actuator system		It drives the motor-driven vacuum pump according to signals from the control unit and adjusts the throttle valve via the intermediate link to the set opening.
Main switch		Switch for cruise control power.
Control switch	SET (COAST) switch	Vehicle speed is set with the SET (COAST) switch and RESUME (ACCEL) switch.
	RESUME (ACCEL) switch	
	CANCEL switch	It is used to cancel the setting pf the cruise speed.
Cancel system	Stop lamp switch	It outputs a signal to cancel cruise control.
	Clutch switch <M/T>	
	Inhibitor switch <A/T>	
Throttle position sensor (TPS)*		It generates an analog voltage proportional to throttle opening.
Idle switch*		Based on the value of TPS voltage when the idle switch goes from ON to OFF, it varies TPS voltage to compensate for fluctuations.
Diagnosis output terminal		If the multi-use tester or a voltmeter is connected, diagnosis and input check codes from the control unit can be read.
Auto-cruise control indicator lamp		It is in the combination meter and lights up when the auto-cruise control is functioning.

NOTE
*: <3000>

AUTO-CRUISE CONTROL UNIT

The control unit is made up of the input interface circuit, micro-computer, constant voltage power supply circuit, micro-computer monitor circuit and output interface circuit. Signals from the vehicle speed sensor, throttle position sensor <3000> and each switch are input into the control unit. It processes them according to the program in the micro-computer memory and outputs control signals to the actuator. It also outputs system self-diagnosis results and conditions of input signals to the diagnosis output terminal.

CONTROL LOGIC AND BLOCK DIAGRAM



NOTE
* mark indicates the conventional same structure used formerly.
NC: Normally Closed.

03E0008

SET (COAST) SWITCH FUNCTION

SET

When driving within the range of the limit vehicle speed [approximately 40 – 200 km/h (25 – 124 mph)], it makes vehicle speed set when the SET switch is turned from the on-position to the off. After that, it controls the actuator for cruise-controlled driving at that speed. However, if the SET switch is turned from the on-position to the off in the range over the high speed limit speed [approximately 200 km/h (124 mph)], the high speed limit speed is taken as the set speed.

COAST

When the SET switch is turned to the on-position during auto-cruise control the throttle is fully closed while the SET switch is the on-position, the vehicle decelerates due to the engine brake and then the vehicle speed when the SET switch is turned to the off-position is taken as the new set speed for auto-cruise control. The COAST function can decelerate until the low speed limit speed [approximately 40 km/h (25 mph)] is reached but if vehicle speed falls below that, the COAST function is canceled. In such a case, the vehicle speed just before the beginning of COAST function is put into memory as the set speed.

RESUME (ACCEL) SWITCH FUNCTION

RESUME

If the cruise-controlled driving speed is canceled by the cancel system (refer to the item mentioned below) during auto-cruise control, the vehicle speed set before the cancellation resumes when the RESUME switch is turned from the off-position to the on in the speed range over the low speed limit speed [approximately 40 km/h (25 mph)] to control the cruising speed.

ACCEL

When the RESUME switch is turned to the on-position during auto-cruise control, it continues acceleration while the switch is in the on-position, the vehicle speed when the switch is turned to the off-position is taken as the new set speed for auto-cruise control. Vehicle can be accelerated to over the high speed limit speed [approximately 200 km/h (124 mph)] by the ACCEL function but after the RESUME switch is turned to the off-position, it decelerates to the high speed limit speed to control the cruising speed.

CANCEL FUNCTION

When the following signals are input, current to the motor-driven vacuum pump assembly is cut off and the auto-cruise control canceled.

- When CANCEL switch is in on-position.
- When the stop lamp switch is ON.
- When the clutch switch is ON <M/T>.
- When the inhibitor switch is in neutral <A/T>.
- When vehicle speed is below the low speed limit speed [approximately 40 km/h (25 mph)].
- When vehicle speed falls more than 15 km/h (9 mph) from the speed in memory.
- When, during RESUME functioning, vehicle speed again falls more than 15 km/h (9 mph) after resuming to the memorized vehicle speed minus 10 km/h (6 mph) and over.
- When vehicle speed changes suddenly (0.5G or more).
- When the stop lamp switch input wire is broken.

HIGH SPEED LIMIT FUNCTION

Cruise-controlled driving is not possible at vehicle speeds exceeding the high speed limit speed [approximately 200 km/h (124 mph)]. If the SET switch is turned to the on-position when vehicle speed exceeds the high speed limit speed, 200 km/h (124 mph) is put into memory. At this time, when the accelerator pedal is released to decelerate (under high speed limit speed), the cruise control functions to control cruising at 200 km/h (124 mph).

FAIL-SAFE FUNCTION

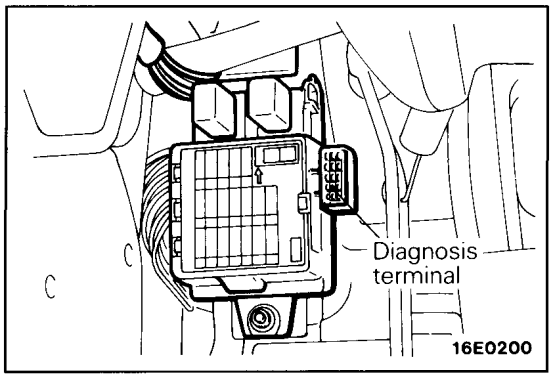
When the following conditions exist, current to the motor-driven vacuum pump assembly is cut off and the cruise control is canceled.

Condition	When only main switch is ON	Driving with auto-cruise control
When SET, RESUME or CANCEL switch is turned to the on-position continuously for 60 seconds or more.	X	X
When there is some abnormality in the hold circuit, system becomes cancel condition	X	X
When a disagreement between the motor-driven vacuum pump drive signal and valve drive signal occurs.	X	X
When there is a failure* in the TPS or idle switch <3000>	X	X
When vehicle speed signal is not input continuously for 0.1 second or more [when vehicle speed exceeds approximately 40 km/h (25 mph)]	–	X

NOTE
The * mark means that the condition in which the TPS output voltage is 1.5V or over with the idle switch ON or 0.2V or less with the idle switch OFF continues for 4 seconds or more.

OVERDRIVE RELEASE FUNCTION <3000-A/T>

When actual vehicle speed falls approximately 7 km/h (4 mph) or more below the set vehicle speed when in overdrive or during cruise driving, overdrive is released for a fixed amount of time to return to the set speed in a short time.



SELF-DIAGNOSIS AND INPUT CHECK FUNCTIONS

SELF-DIAGNOSIS

When the auto-cruise control is canceled without intervention by the driver, the cause can be found out in the following way.

(1) Turn the ignition switch and main switch ON.

NOTE
Contents of diagnosis stay in memory until ie battery terminals are disconnected.

(2) Connect the multi-use tester or a voltmeter to the diagnosis terminal and read the output codes.
(3) By comparing the output codes that are read out with the chart below, it is possible to find the cause of the cancellation in each system.

Diagnosis Code NO.

Output code No.	Contents of trouble
11	Trouble related to actuator drive output
12	Trouble related to vehicle speed signal
15	Control switch trouble
16	Trouble in control unit, etc.
17	TPS or idle switch trouble <3000>

Cancellation of Diagnosis Codes

Diagnosis codes stay in memory until the battery terminals are disconnected but they can be canceled without disconnecting them by going through the following procedures;
(1) Turn the ignition switch ON.
(2) With the SET switch to the on-position, turn the main switch ON and then turn the RESUME switch on within one second. (This makes it ready for input check.)
(3) Turn the SET switch and stop lamp switch to the on-position at the same time and keep them the position for five seconds or more.
(4) Use the multi-use tester or a voltmeter to confirm that the diagnosis codes have been canceled.

INPUT CHECK FUNCTION

The input check function can be used to check whether the input signal is normal when there is some trouble related to the auto-cruise control, such as the auto-cruise control cannot be set.
(1) Connect the multi-use tester or a voltmeter to the diagnosis terminal.
(2) Turn the ignition switch ON.
(3) With the SET switch to the on-position, turn the main switch ON and then turn the RESUME switch on within one second to make input check possible. Perform each input operation and read the codes.

Output code	Input operation	Operation check judgement	Output code	Input operation	Operation check judgement
21	SET switch on	SET switch circuit normal	26	Turn the following switches ON • Clutch switch <M/T> • Inhibitor switch <A/T>	Switch circuit mentioned on left normal
22	RESUME switch on	RESUME switch circuit normal	27	CANCEL switch on	Cancel switch circuit normal
23	Stop lamp switch on	Stop lamp switch circuit mentioned	28	TPS voltage is over 1.5V (Depress accelerator pedal more than half) <3000>	TPS circuit normal
24	Driving at 40 km/h (25 mph) or more	If code No. 24 can be confirmed, vehicle speed sensor is normal.	29	Idle switch OFF (Depress accelerator pedal.) <3000>	Idle switch circuit normal
25	Driving at 40 km/h (25 mph) or lower.	If code No. 25 can be confirmed, vehicle speed sensor is normal.	–	–	–

NOTE
If more than two input operations are performed at the same time, the codes are output, starting with the smallest number.

MOTOR-DRIVEN VACUUM PUMP ASSEMBLY CONSTRUCTION

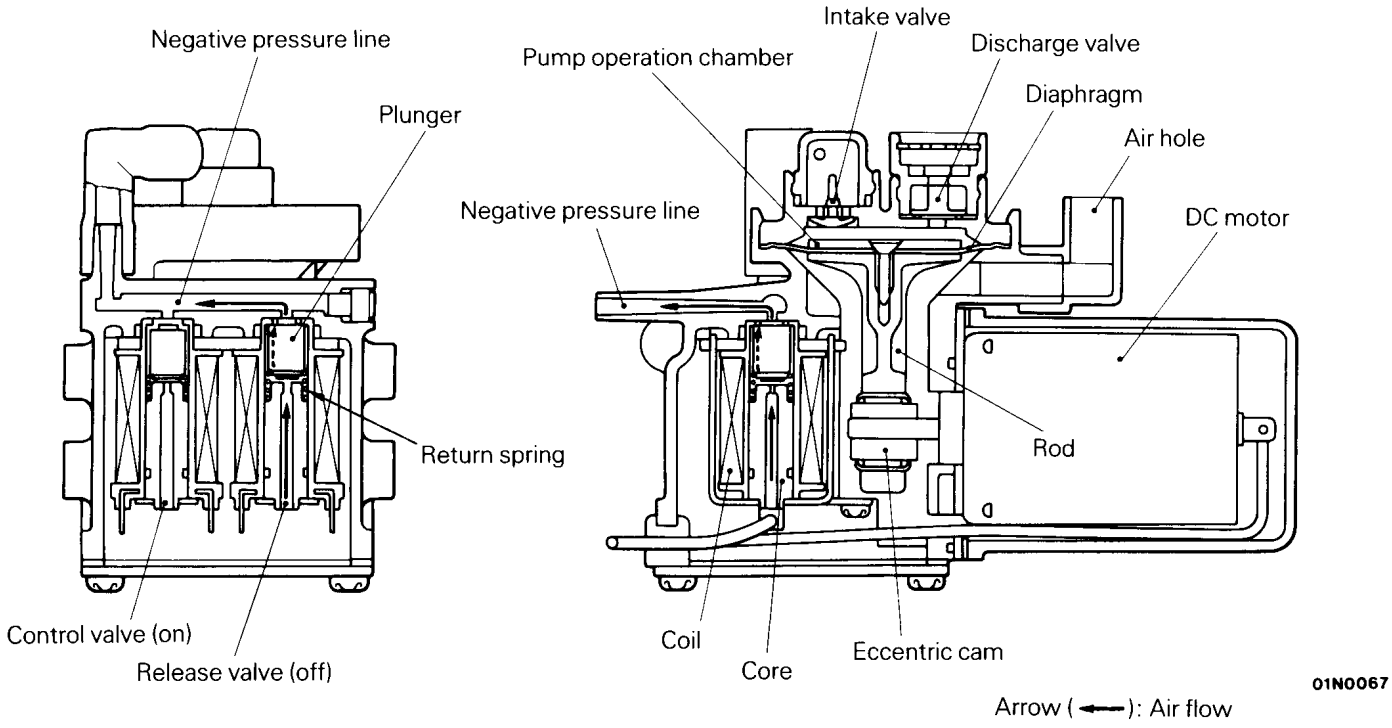
The motor-driven vacuum pump assembly consists of a diaphragm type vacuum pump driven by a DC motor and two solenoid valves (control valve and release valve), and the rotations of the DC motor are varied to the diaphragm back and forth action by the eccentric cam and rod.

When the diaphragm moves in the direction (down in the figure below) to increase the capacity of the pump operating chamber, the intake valve is OPEN and the discharge valve is CLOSED so the air in the negative pressure line is sucked into the pump operating chamber.

Next, when the diaphragm moves in the direction (up in the figure below) to decrease the capacity of the pump operating chamber, the discharge valve is OPEN and the intake valve is CLOSED, releasing the air in the pump operating chamber to the atmosphere. In this way, the negative pressure is generated by sucking the air in the negative pressure line into the pump operating chamber and releasing the air in the pump operating chamber to atmosphere.

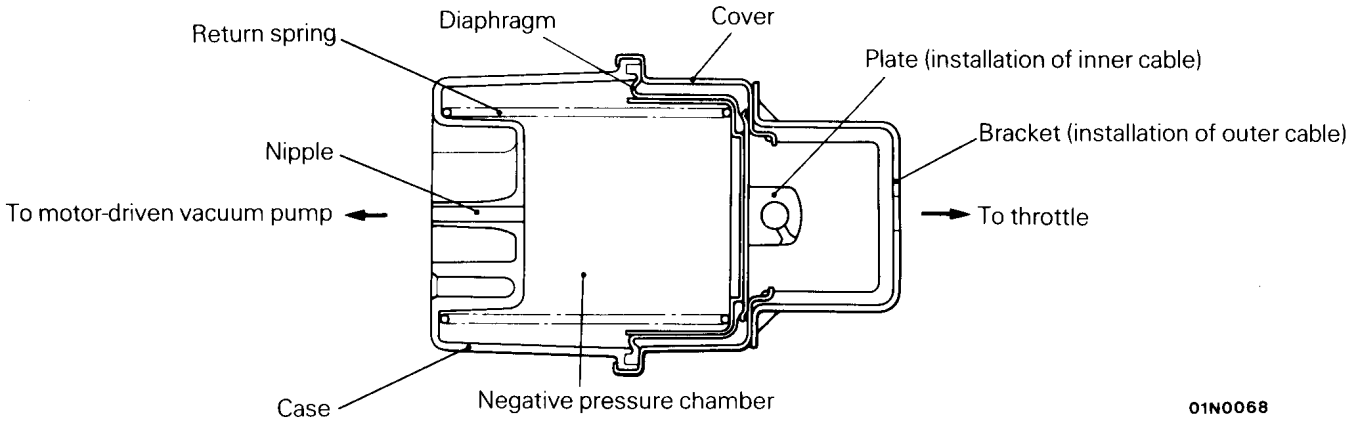
When no current flows in the solenoid coil, the solenoid valve plunger set in the negative pressure line is returned by the return spring, the line hole in the core opens and the negative pressure line is opened to the atmosphere.

When current flows in the solenoid coil, the coil is energized to pull the plunger, the line hole in the core is closed and the negative pressure line is cut off from the atmosphere.



ACTUATOR CONSTRUCTION

The actuator consists of the diaphragm, case, cover and return spring, etc. Negative pressure is used in the negative pressure chamber formed by the diaphragm and case, and the diaphragm moves in the direction to pull the auto-cruise control cable when negative pressure increases. Also, when negative pressure decreases, the diaphragm is moved by the force of the return spring to loosen the auto-cruise control cable. In this way, the throttle valve is opened and closed by the increase and decrease in the negative pressure sent to the negative pressure chamber.



MOTOR-DRIVEN VACUUM PUMP ASSEMBLY ACTUATOR OPERATION

The negative pressure line of the vacuum pump and negative pressure chamber of the actuator are connected by the vacuum hose. The DC motor, control valve and release valve in the motor-driven vacuum pump assembly are turned on or off by the control signal from the control unit and have the following operation modes.

ACCELERATION MODE

Current flows to the DC motor, control valve and release valve. The vacuum pump is operated by the DC motor, the control valve and release valve are closed and the negative line is cut off from the atmosphere. The negative pressure generated by the vacuum pump is used in the negative pressure chamber of the actuator and the diaphragm moved in the direction to pull the auto-cruise control cable to open the throttle valve and accelerate the vehicle.

HOLD MODE

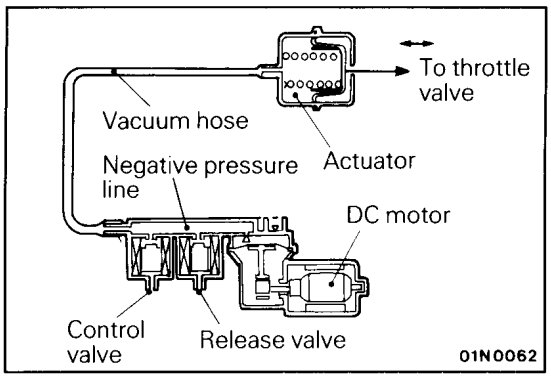
No current flows to the DC motor but current flows to the control valve and release valve. Since the vacuum pump does not operate, no negative pressure is added; since both the control valve and release valve are closed and the negative pressure line is cut off from the atmosphere, negative pressure is not reduced. Consequently, the diaphragm does not function and the throttle valve is held in a fixed position.

DECELERATION MODE

No current flows to the DC motor and control valve but current flows to the release valve. Since the control valve is off, the line hole in the control valve core is open, air flows to the actuator negative pressure chamber and negative pressure is reduced. The diaphragm is returned by the force of the return spring to loosen the auto-cruise control cable to close the throttle valve and decelerate the vehicle speed.

RELEASE MODE

No current flows in the DC motor, control valve and release valve. The line holes in the release valve core and control valve core are open and air flows into the negative pressure chamber of the actuator. As a result, the diaphragm is returned quickly by the force of the return spring to the initial condition, the throttle valve moves in the closing direction and the auto-cruise control is canceled.



Operation modes	DC motor	Solenoid valve	
		Control valve	Release valve
Acceleration	Flow	Closed	Closed
Hold	Not flow	Closed	Closed
Deceleration	Not flow	Open	Closed
Cancel	Not flow	Open	Open

INTERMEDIATE LINK STRUCTURE

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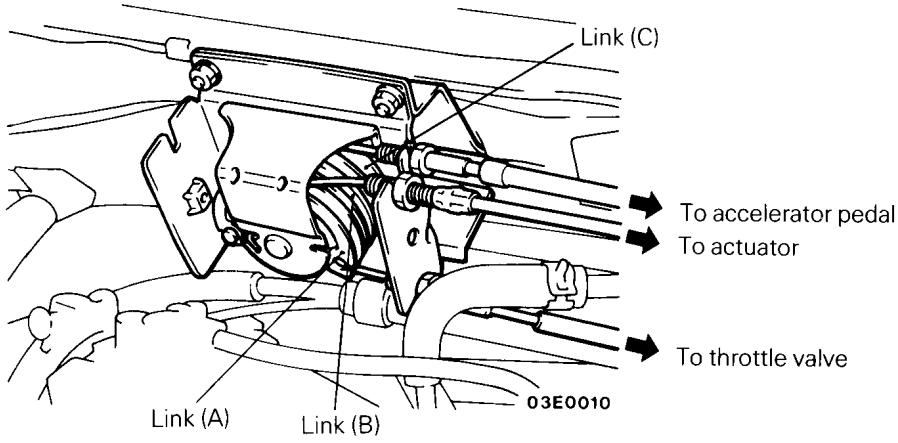

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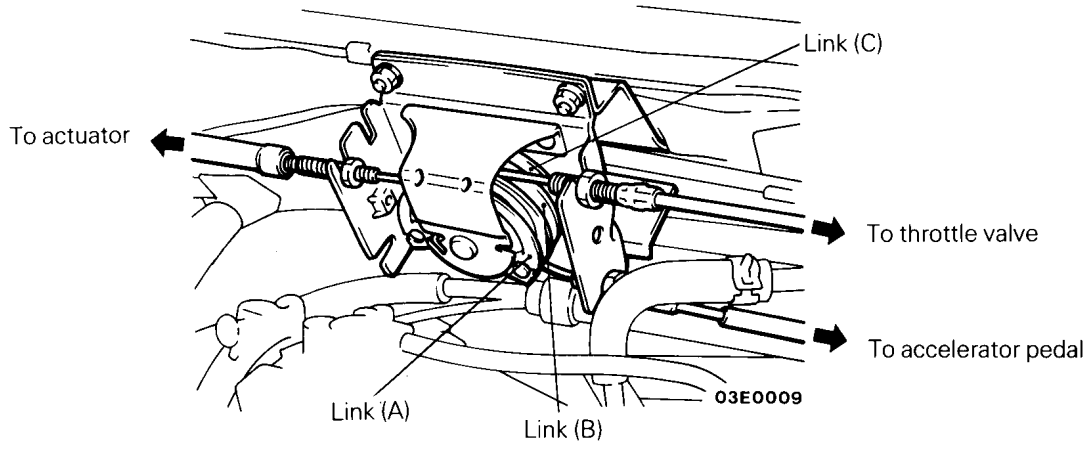

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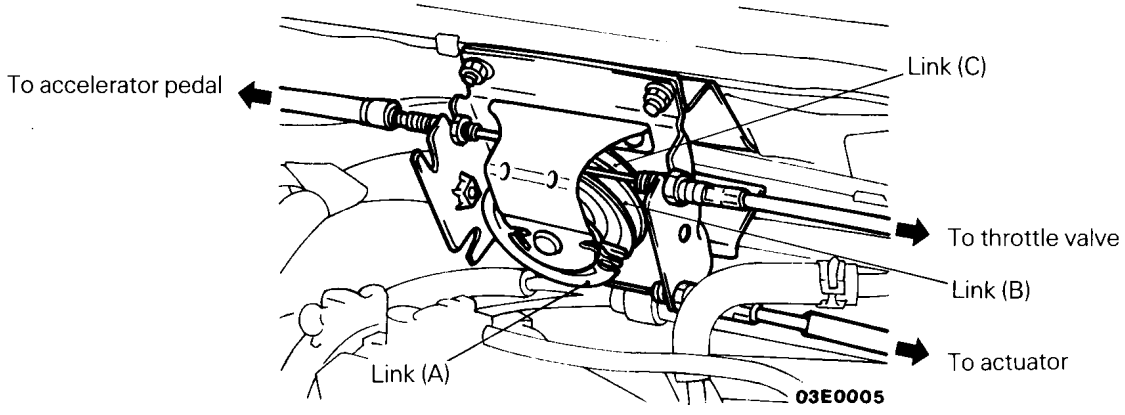

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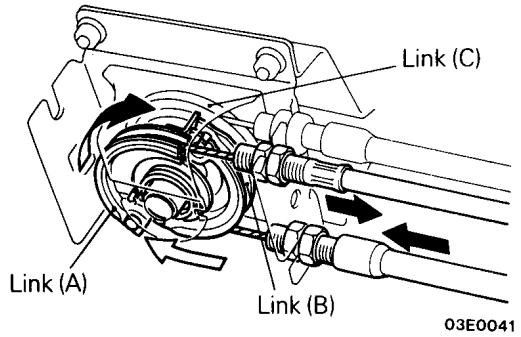

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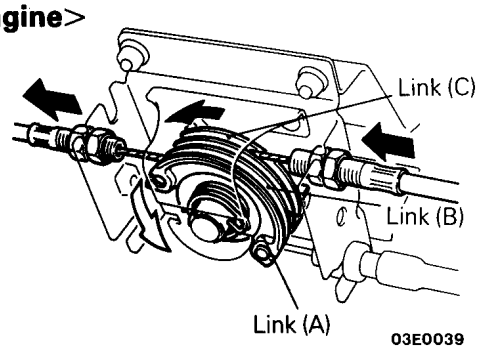

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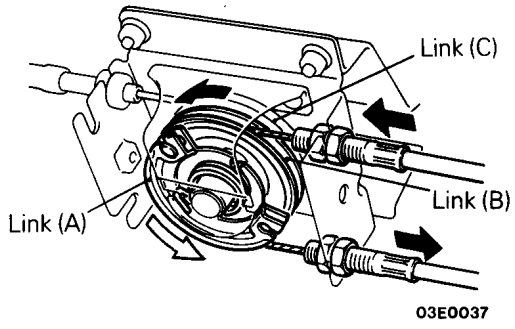

AUTO-CRUISE CONTROL DRIVING

The actuator operates, link (B) on the throttle valve side rotates because of rotation of link (A) on the actuator side to open and close the throttle valve. At this time, link (C) on the accelerator pedal side does not rotate so the accelerator pedal does not move but remains in its usual position.

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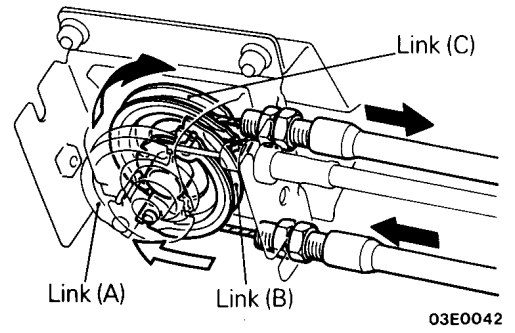

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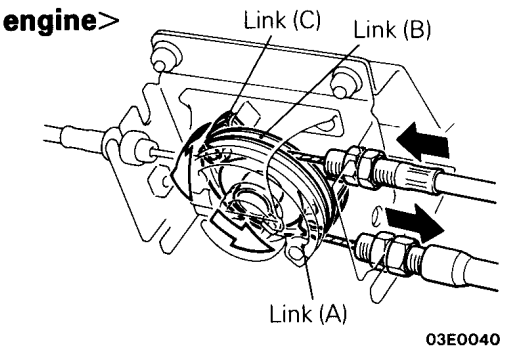
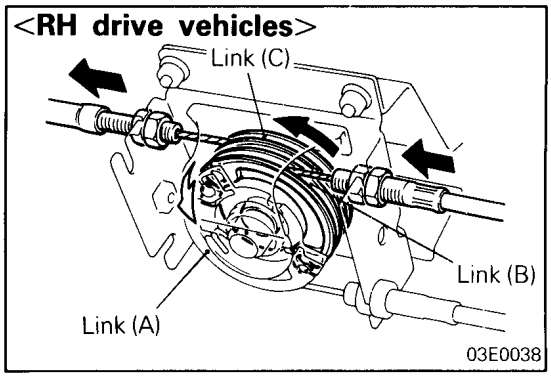
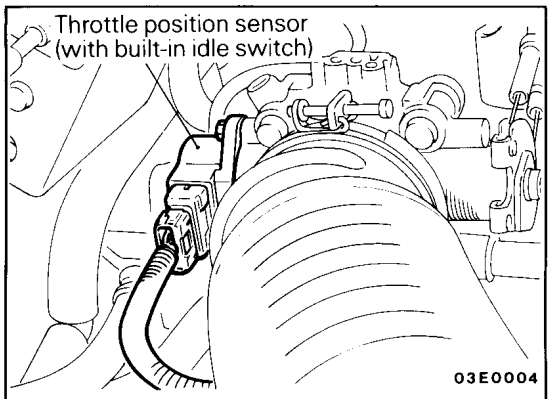
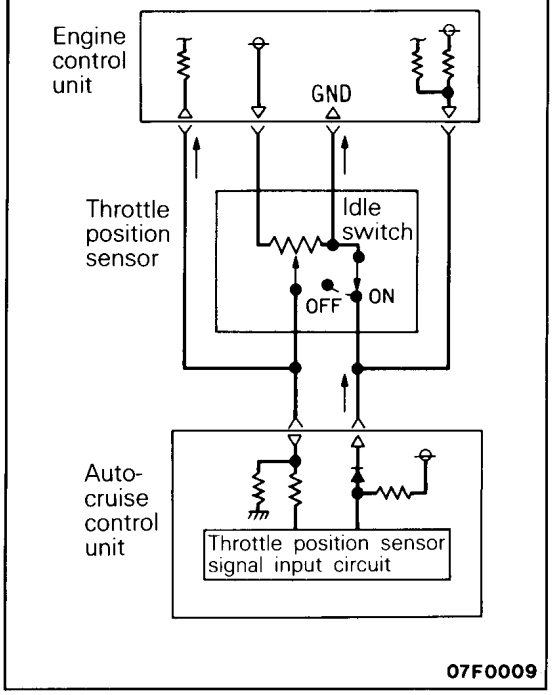


ORDINARY DRIVING

When the accelerator pedal is depressed, its cable is pulled to rotate the link (C). As a result, the link (B) on the throttle valve side rotates, opening/closing the throttle valve. At this time, the link (A) on the actuator side will not rotate.





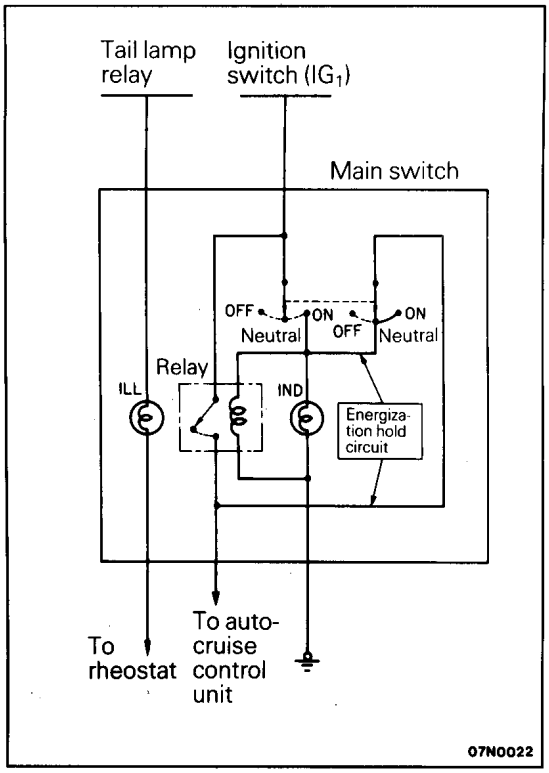


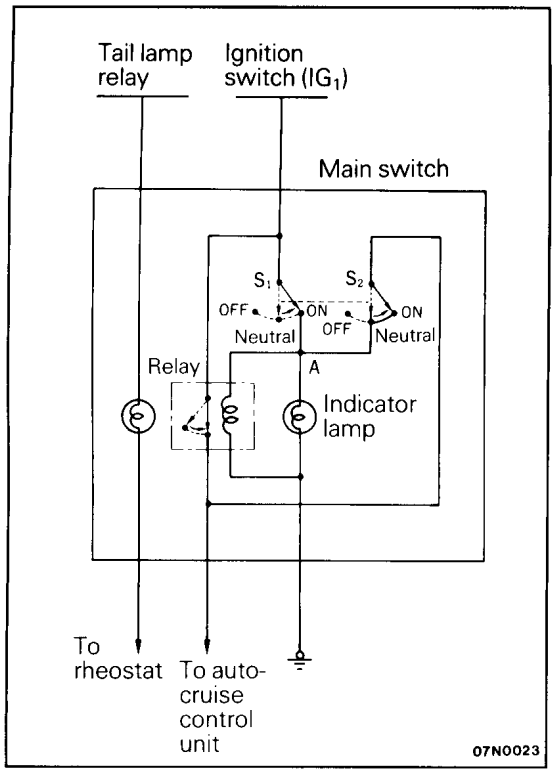
THROTTLE POSITION SENSOR (TPS) <3000>

The throttle position sensor is also used for engine control and it sends the degree of opening of the throttle valve to the control unit as an output voltage.

IDLE SWITCH <3000>

The idle switch is built into the throttle position sensor. Based on the value of the TPS voltage when the idle switch is turned from ON to OFF, the control unit compensates variation and fluctuations of the TPS voltage.





AUTO-CRUISE CONTROL SWITCH

MAIN SWITCH

The main switch is the power switch for the control unit and it uses a system as shown in the figure so it automatically returns to the neutral position. If the ignition switch is turned OFF with the main switch ON (indicator lamp illuminates), the main switch also goes OFF at the same time. In this condition, even if the ignition switch is turned ON again, the main switch remains OFF.

Operation of Main Switch

WHEN THE MAIN SWITCH IS PRESSED TO THE ON SIDE (WHEN IGNITION SWITCH IS ON)

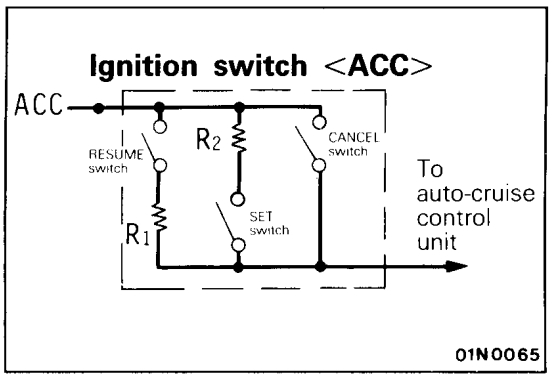
While the main switch is pressed to the ON side, switches S_1 and S_2 both go ON, current flows to ignition switch <IG1>, S_1, relay (coil side), indicator lamp and earth, and the relay inside the main switch is not only turned ON but the indicator lamp also lights up. As a result, power is supplied to <IG1>, relay (contact side) and the control unit. When the main switch is released, the main switch returns to the neutral position and switch S_1 goes OFF but, since switch S_2 is ON, current flows to <IG1>, relay (contact side), switch S_2, relay (coil side), the indicator lamp and earth, the ON condition of the relay is maintained and even if switch S_1 goes OFF, power continues to be fed to the control unit.

WHEN THE MAIN SWITCH IS PRESSED TO THE OFF SIDE (WHEN BOTH THE IGNITION SWITCH AND MAIN SWITCH ARE ON)

If the main switch is pressed to the OFF side, the power is not supplied to the relay coil in the main switch since both S_1 and S_2 switches are OFF, the relay in the main switch goes OFF, and the power supply to the control unit is not only cut off but the indicator lamp also goes out.

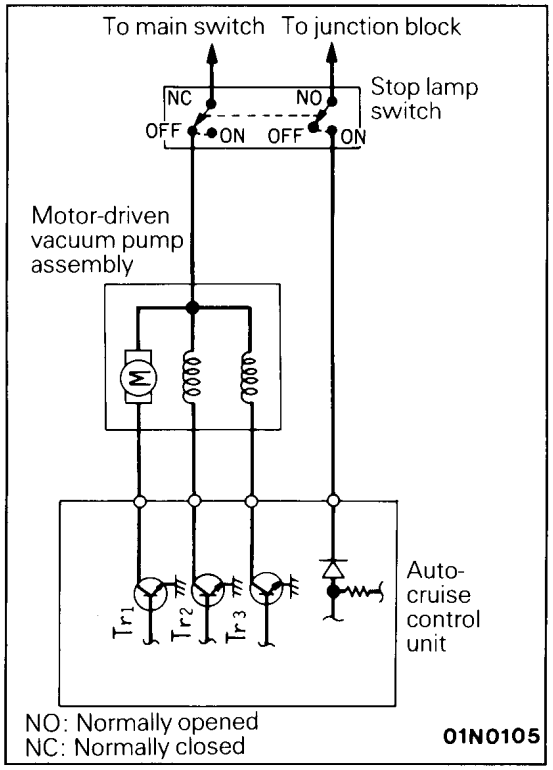
WHEN THE IGNITION SWITCH IS TURNED OFF (WHEN THE MAIN SWITCH IS ON)

If the ignition switch is turned OFF when the main switch is ON, the relay inside the main switch goes OFF and the main switch does not go ON but remains OFF even if the ignition switch is turned ON again.



CONTROL SWITCH

The resistance value inside the switches is varied for each switch and the auto-cruise control is controlled by outputting the different signals to the auto-cruise control unit.



CANCEL SYSTEM

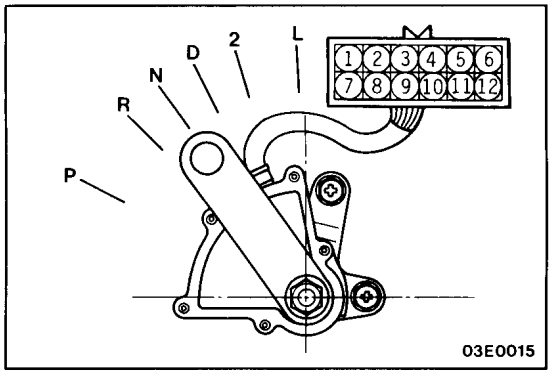
The switches constituting the cancel system are the stop lamp switch, clutch switch <M/T> and inhibitor switch <A/T>. If the contacts of any of these switches close, the auto-cruise control is canceled.

Stop Lamp Switch

A single unit 4-pole type stop lamp switch for the stop lamp (NO) and auto-cruise control (NC) is used for the stop lamp switch to improve the reliability of the cruise control cancel function. When the brake pedal is depressed, the auto-cruise control (NC) contact in the lamp switch is opened, power to the motor-driven vacuum pump assembly is cut off and cruise control driving is canceled. At the same time, the cancel signal stops the power supply to the motor-driven vacuum pump assembly in the control unit because the stop lamp (NO) contact closes and cruise control driving is canceled.

Clutch Switch <M/T>

The construction and operation of this switch are the same as that used in GALANT models.



Inhibitor Switch <A/T>

The starter switch also works as the inhibitor switch. When the selector lever is positioned at "N" during auto-cruise control driving, current flows from the control unit to the inhibitor switch to the starter to earth. As a result, the cancel signal is sent to the microcomputer, cancelling the auto-cruise control driving.