JAGUAR

TRAINING PROGRAM

JAGUAR ENGINE MANAGEMENT SYSTEMS AND ADVANCED EMS DIAGNOSTICS - BOOK B

PUBLICATION CODE – 870B

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OBJECTIVE

- Locate and identify all components of the V6 and V8 engine management systems
- Identify relevant technical information to diagnose emissions, drivability and DTC related complaints.
- Recognize possible failure modes and default operation for subsystems.
- Assess the condition of engine management system components

PROGRAM CONTENT

1. INTRODUCTION
2. PTEC EMS
3. DENSO 32-BIT EMS
4. ADVANCED EMS DIAGNOSTICS
5. ENGINE MANAGEMENT REFERENCE

DISCLAIMER

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Jaguar Cars North America Service Training Department

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PTEC OVERVIEW

The PTEC (PowerTrain Electronic Control) system is a comprehensive 32 bit combined engine and transmission control system. The system is used on both the 3 liter AJ60 and the 4 liter AJ28 V8 engines installed on the S-TYPE 2000 – 2002 MY.

There are detail sensor and control differences between V6 and V8, however the majority of the system is identical in its functions.

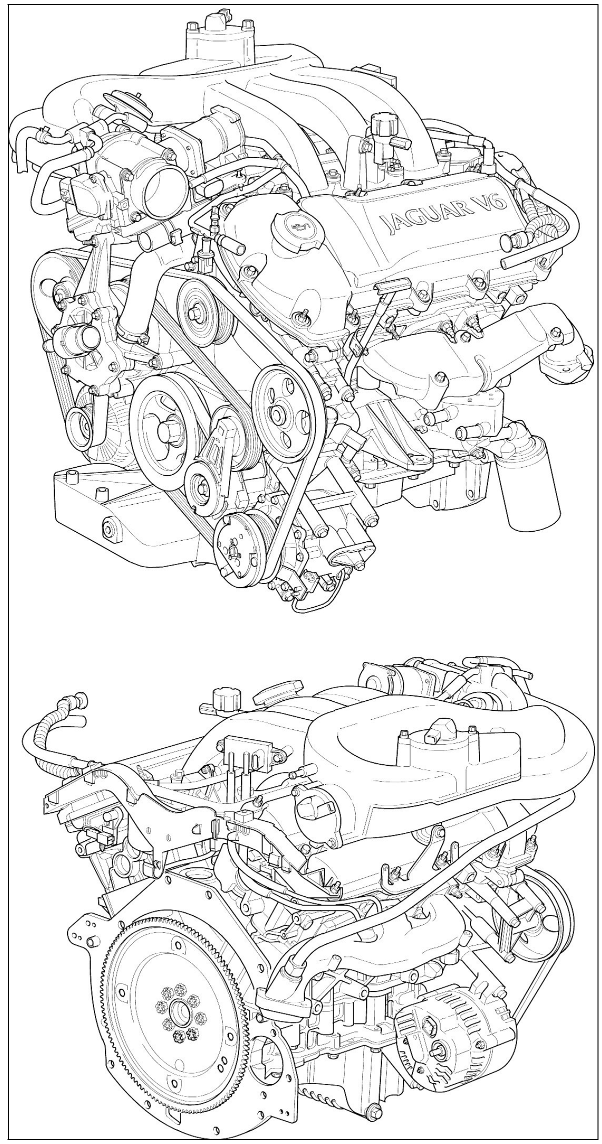

Fig. 1 AJ60 V6 ENGINE

PTEC Highlights

Single control module

A single Powertrain Control Module (PCM) performs both engine and transmission control functions. This Student Guide covers only the engine management portion of the PTEC system.

SCP Network

PTEC communicates only on the vehicle SCP (Standard Corporate Protocol) multiplex network.

Returnless fuel system

The fuel delivery system is a supply only system with no provision for returning unused fuel from the fuel rail to the fuel tank.

Full authority throttle

PTEC employs a full authority electronic throttle assembly with no cable connection between the accelerator pedal and the throttle. The throttle assembly incorporates a separate control module with diagnostic capabilities.

Variable intake system (V6)

V6 engines are equipped with a variable length air intake manifold that optimizes engine torque across the entire speed/load range.

Fail safe cooling (V6)

V6 engines have a PCM “fail safe cooling” strategy that allows for limited engine operation with low or no coolant to prevent a catastrophic engine failure.

PTEC CONTROL SUMMARY

The engine management systems for the 3.0 liter AJ60 engine and the 4.0 liter AJ28 V8 engine vehicles are virtually identical in function with differences in the control module parameters and the location of some components.

The major differences between the two systems are as follows:

AJ-V6

- Two position VVT (variable valve timing)
- Variable air intake system
- EGR (exhaust gas recirculation) – 2000 MY only

AJ28 V8

- Continuously variable VVT (variable valve timing)
- AAI (air assisted injection)

PTEC Functions

The PTEC powertrain control module (PCM) directly governs the following functions:

- Air assisted fuel injection (V8 only)
- Air conditioning compressor
- Automatic transmission
- Cooling system radiator fan
- Cruise control
- Default operating modes
- Engine power limiting
- Engine speed limiting
- Engine torque reduction control
- Evaporative emission control
- Exhaust emission control
- Exhaust gas recirculation (V6 only)
- Fail safe engine cooling
- Fuel delivery and injection (fuel pump via RECM)
- Fuel system leak check
- Full authority electronic throttle (via Throttle Actuator Control Module)
- Idle speed
- Ignition
- OBD II diagnostics
- Variable intake manifold tuning (V6 only)
- Variable intake valve timing
- Vehicle speed limiting

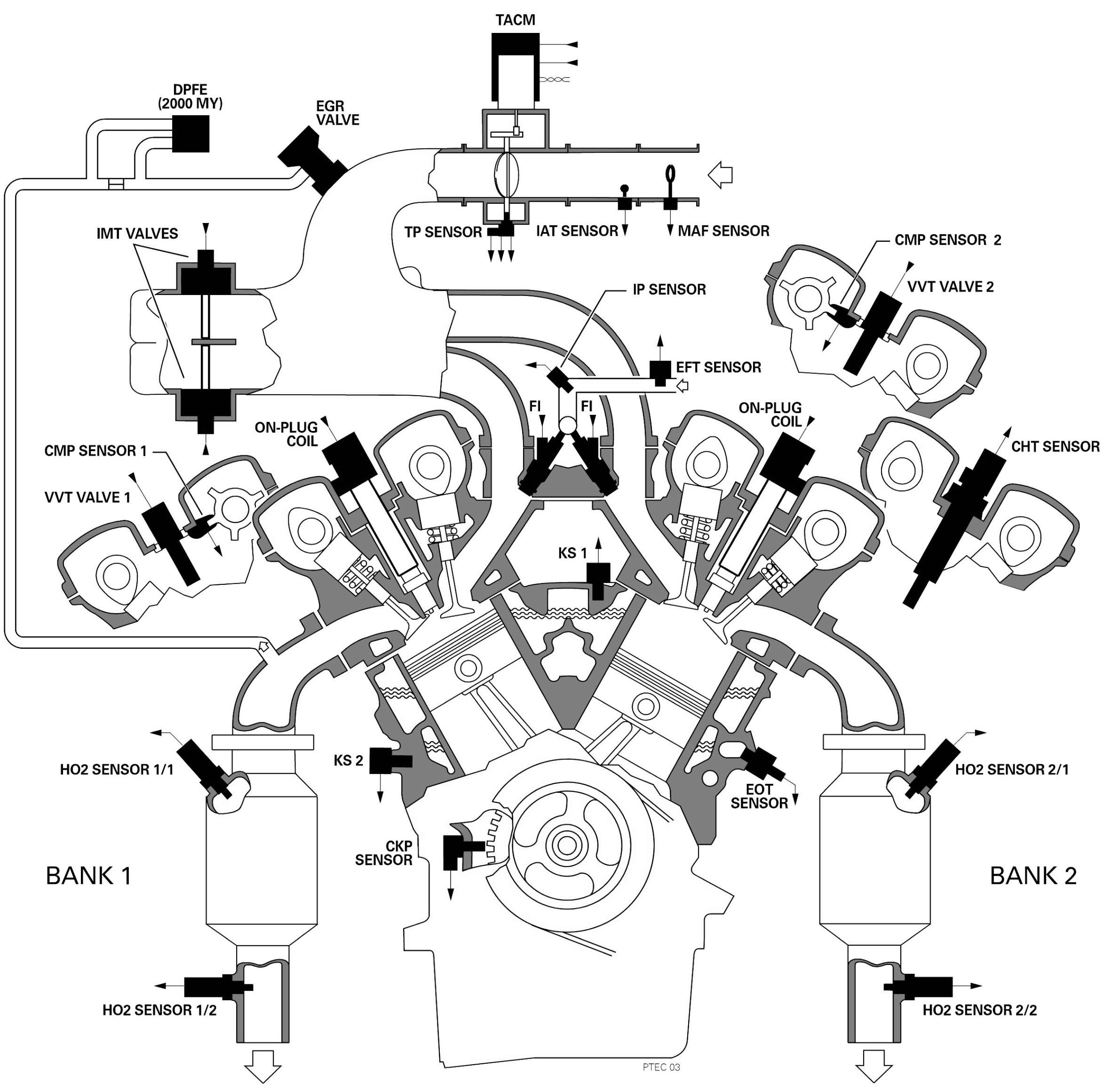

Fig. 2 V6 ENGINE MANAGEMENT COMPONENTS

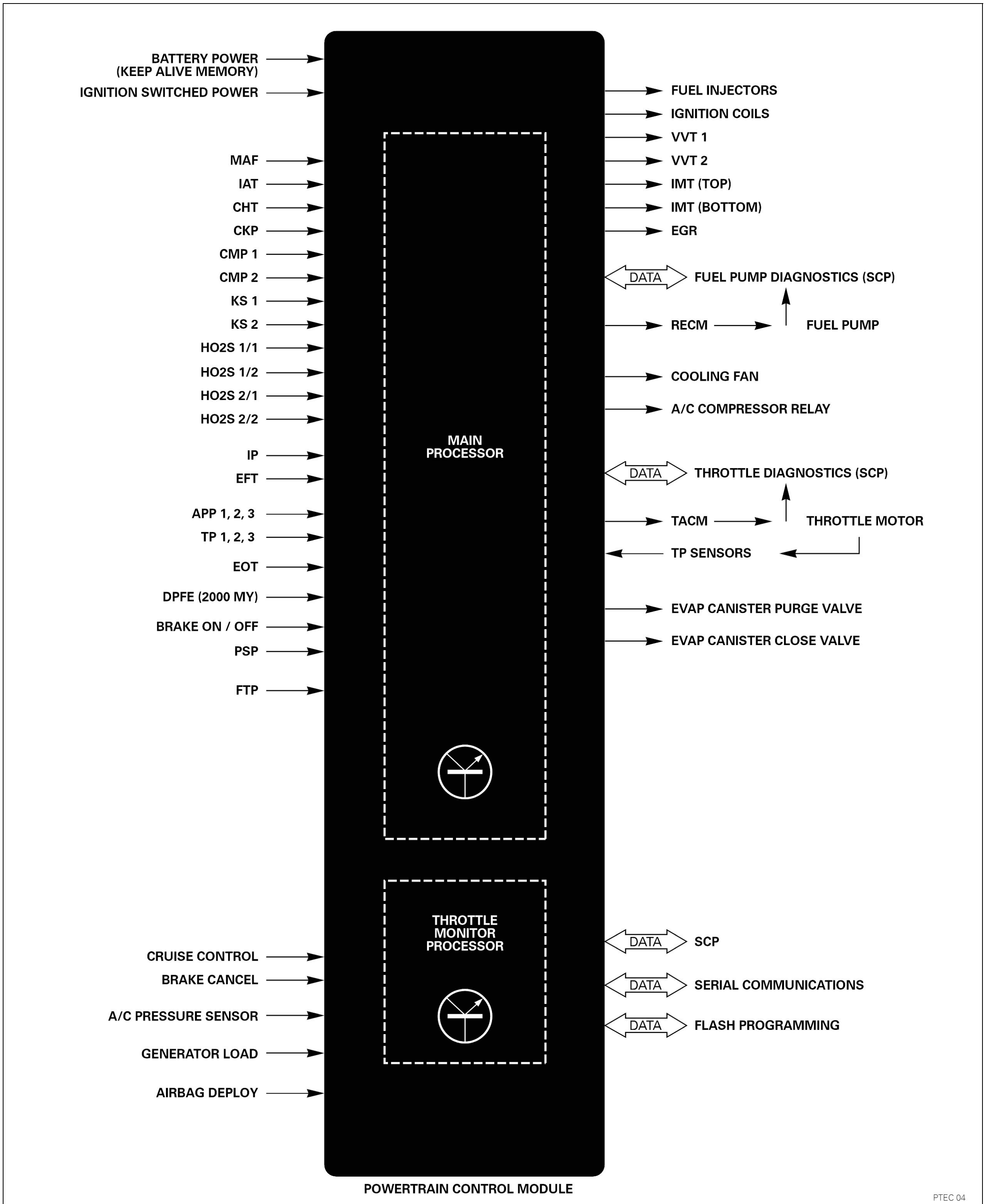

Fig. 3 V6 PCM ENGINE MANAGEMENT INPUTS AND OUTPUTS

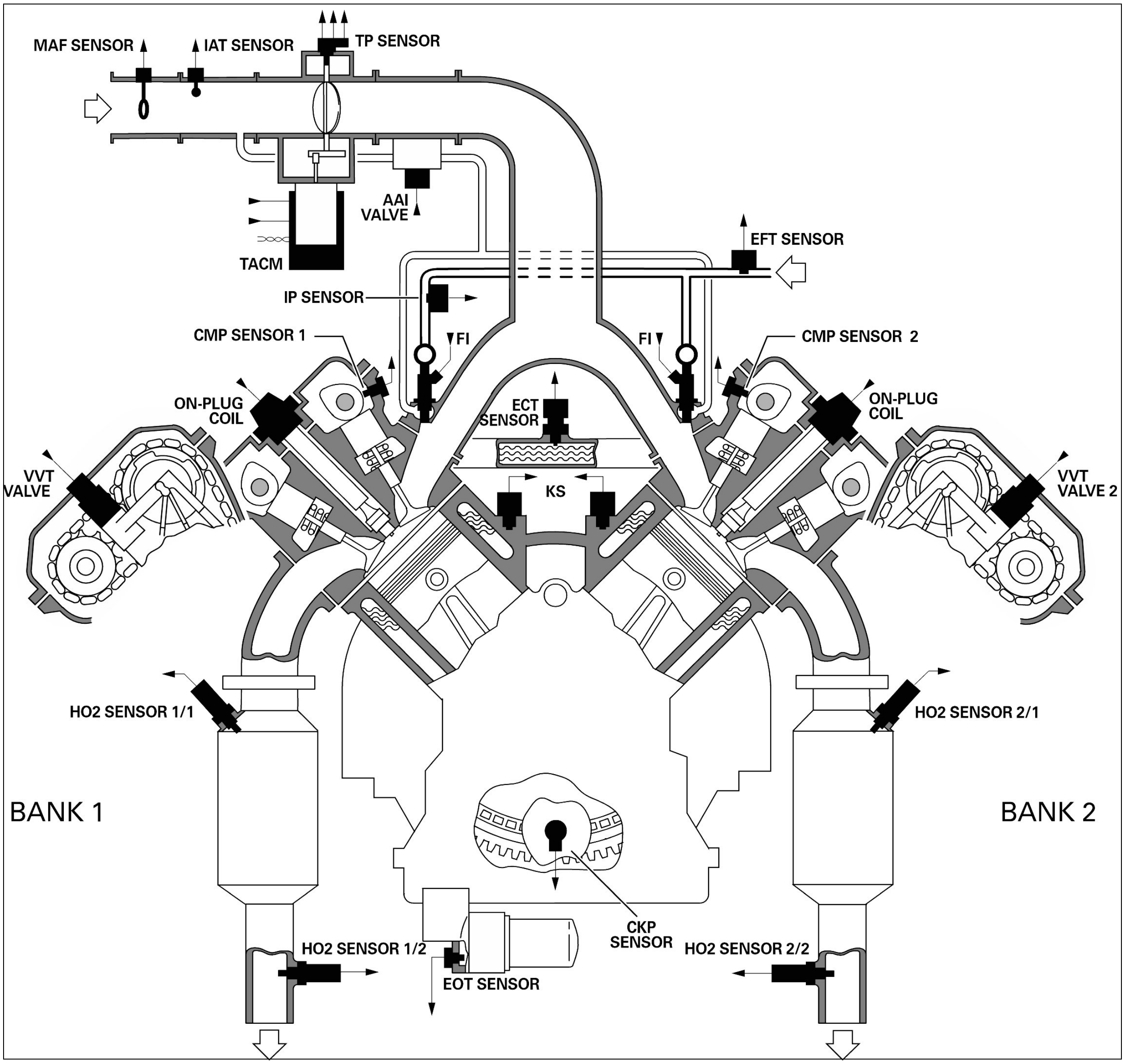

Fig. 4 V8 ENGINE MANAGEMENT COMPONENTS

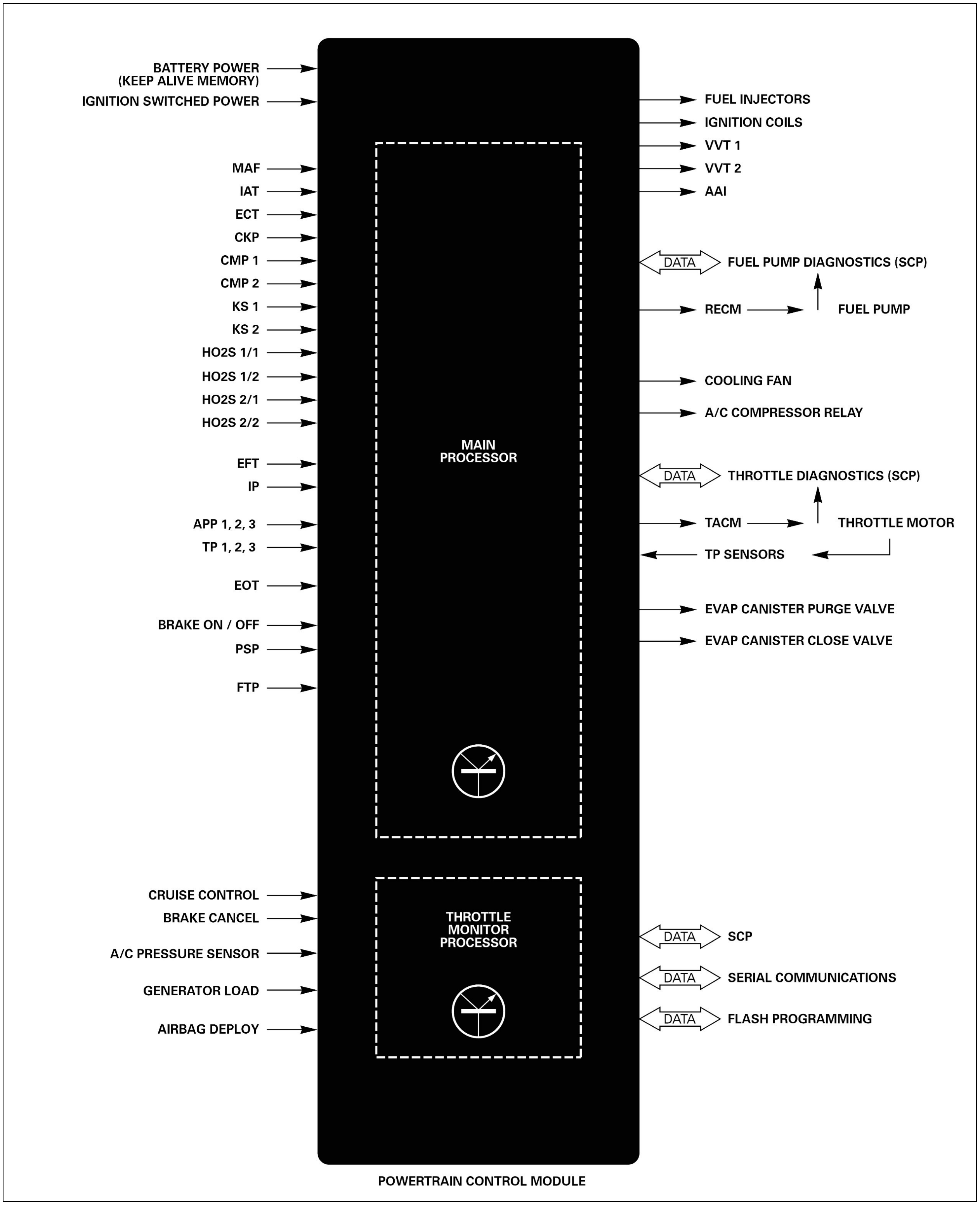

Fig. 5 V8 PCM ENGINE MANAGEMENT INPUTS AND OUTPUTS

POWERTRAIN CONTROL MODULE (PCM)

Overview

The PCMs for all 2000–2002MY S-TYPE Jaguars are almost identical but with unique programming for the characteristics of the various powertrain combinations.

Also, some minor differences are required in the interface circuits to accommodate the sensors and actuators used on AJ60 or AJ28 engines.

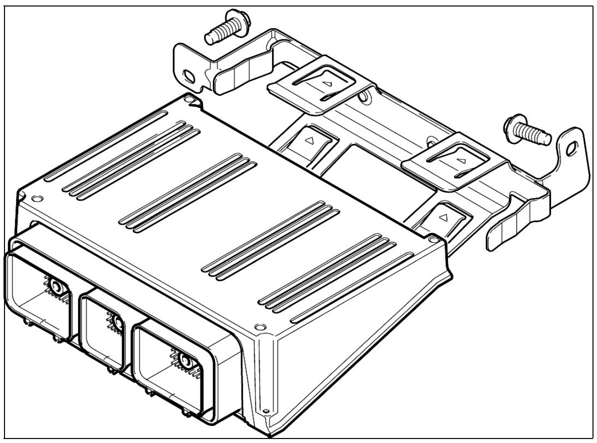

Fig. 6 POWERTRAIN CONTROL MODULE (PCM)

The vehicle powertrain configuration information and the vehicle identification number (VIN) are flash programmed into the PCM during vehicle production.

If the vehicle battery is disconnected, stored DTCs and adaptive values will be lost. The PCM will "relearn" adaptive values during the next driving cycle.

NOTE:

If the PCM or Instrument Pack are replaced, WDS must be used to match the control modules before the vehicle is operated.

CAUTION:

The PCM must not be switched from one vehicle to another; the VIN will be mismatched and the powertrain configuration information may be incorrect for the vehicle.

PCM Power Supply

The PCM power supply flows through a 40 Amp fuse to powertrain control relay 1. Powertrain control relay 2 supplies power to the A/C compressor clutch, generator, HO2S heaters, and coil-on plug ignition coils.

Both relays are located in the front power distribution board and are powered by the same fuse. 5 Amp fused B+ voltage activates the relays directly from the ignition switch when it is in positions II (RUN) and III (START). The PCM is located on the passenger side of the cabin below the climate control blower unit.

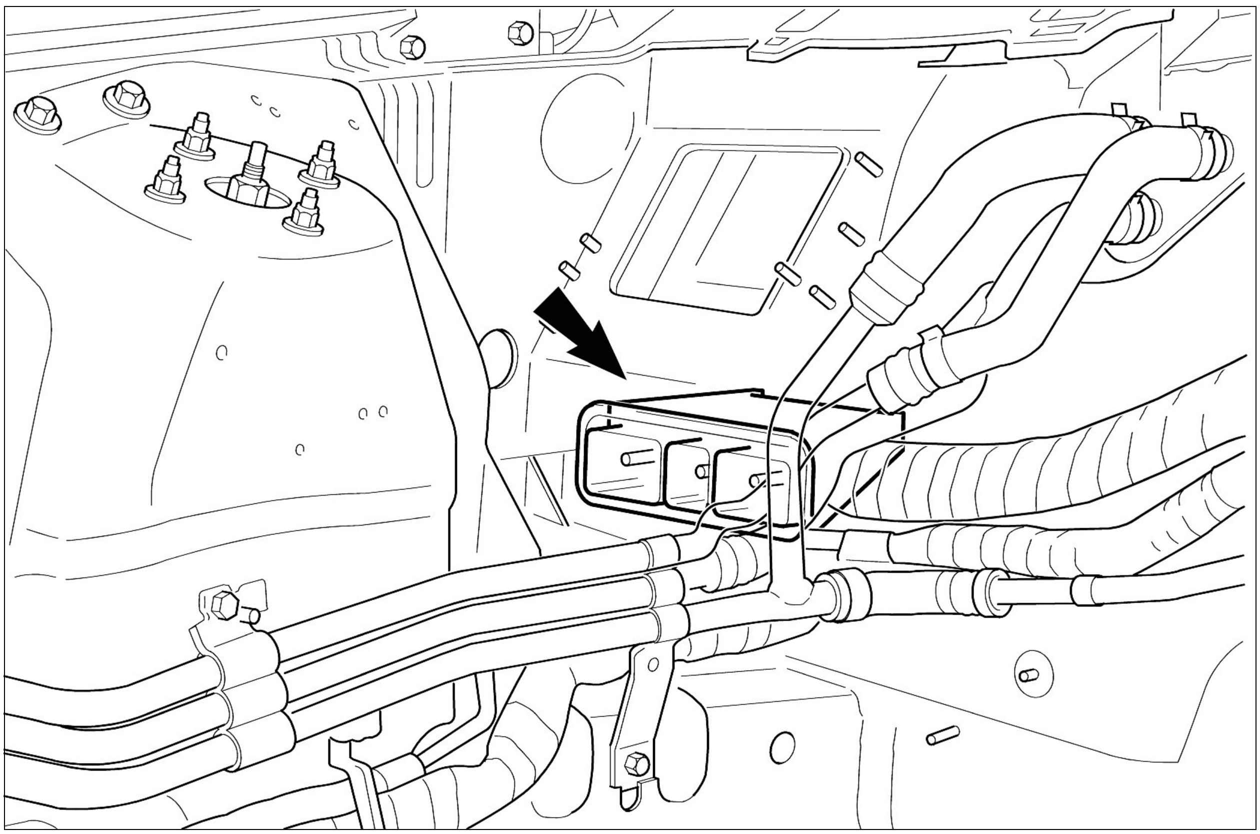

Fig. 7 POWERTRAIN CONTROL MODULE LOCATION

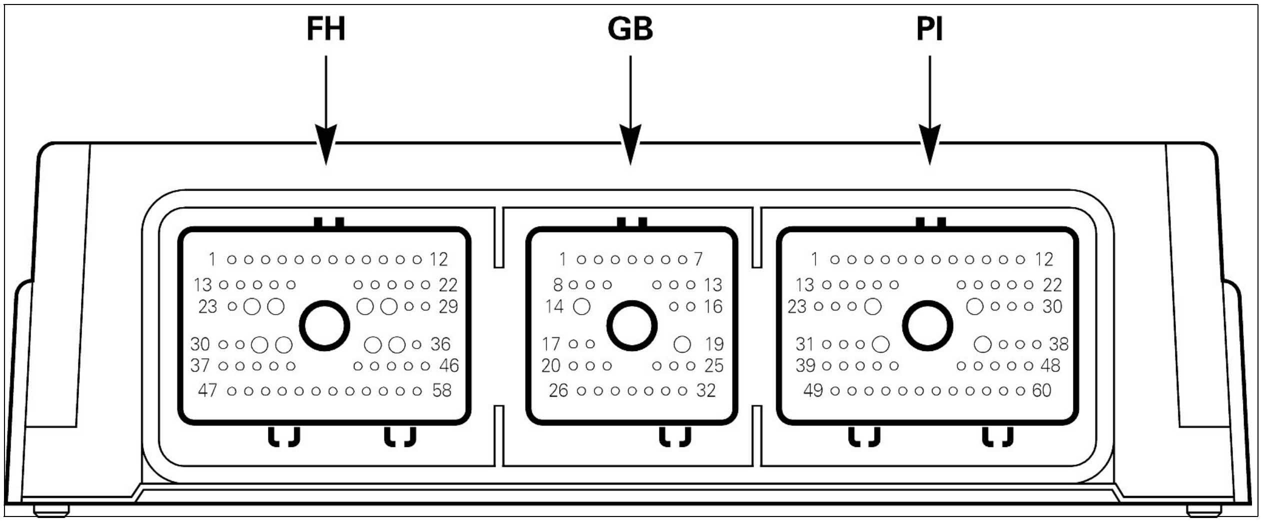

Fig. 8 POWERTRAIN CONTROL MODULE FACE

The 32-way socket connects to the transmission harness (GB). The 58-way socket connects to the vehicle forward harness (FH). The 60-way socket connects to the engine harness (PI).

The 150-way three-pocket connector housing protrudes through the bulkhead to accept the matching connectors from the engine bay side harnesses.

PCM Configuration

After a PCM is replaced and the battery reconnected, connect WDS. Select Guided Diagnostics from the Main Menu followed by Vehicle Set Up and Vehicle CM Set Up / Configuration. WDS will perform the configuration during which you will be prompted to enter the Vehicle Identification Number.

During configuration WDS writes vehicle identification information into a section of the PCM memory called the VID Block (Vehicle Identification Block). Once the VID Block space is occupied, it cannot be overwritten. The VID Block stores data pertaining to certain other vehicle control modules. For example, the instrument pack identification data.

NOTE:

Once a PCM is configured to a vehicle, it cannot be re configured to another vehicle.

The VID Block has no effect on vehicle operation and is accessible in the future via WDS. The intent of the VID Block is to give Jaguar technicians information on the programmed status of control modules, in the event of a problem.

NOTE:

The PCM must be configured to the instrument pack as part of the security system set up. If this is not carried out, the engine will not start.

Barometric Pressure

The PCM does not incorporate a barometric pressure sensor. Instead, it calculates barometric pressure based on input signals received from the mass air flow sensor and the throttle position sensor. If the PCM cannot calculate barometric pressure (failure mode), it defaults to an atmospheric pressure of 27 in. Hg. (902 mBar).

PCM Multiplex and Serial Data Communications

The PCM is part of the SCP vehicle multiplex data network that operates at 41.6 kb per second. In addition to the SCP network, the PCM is connected to the Serial Data Link, and has a dedicated flash programming circuit. All three circuits are accessed at the Data Link Connector (DLC) for DTC retrieval, system diagnostics and monitoring, and PCM EPROM flash programming.

Idle Speed Adaptations

If the vehicle battery is disconnected, idle speed adaptations will be lost. After battery re-connection, operate the vehicle as follows to restore the idle speed adaptations:

- Start the engine and warm to >82 °C (180 °F)
- Switch off the engine; restart the engine
- Idle in Neutral for two (2) minutes
- Depress and hold brake pedal; select Drive; idle for two (2) minutes

Diagnostic monitoring

The PCM continuously performs diagnostic monitoring for OBD II and non-OBD II functions. Diagnostics include: self-test routines, engine and transmission function monitoring, individual sensor circuit, signal, function and integrity monitoring, and critical sensors input signal validation. Detected faults are logged in the PCM memory as DTCs.

In most instances of detected sensor and/or component failure, the PCM takes default action. Specific default actions, messages and warnings are contained in the DTC Summaries.

PCM SENSING COMPONENTS – ENGINE

Mass Air Flow (MAF) Sensor

The MAF sensor measures the mass of air entering the intake system, the measurement being based on the constant temperature hot wire principle. A hot wire probe and an air temperature probe are Suspended in the air intake tract.

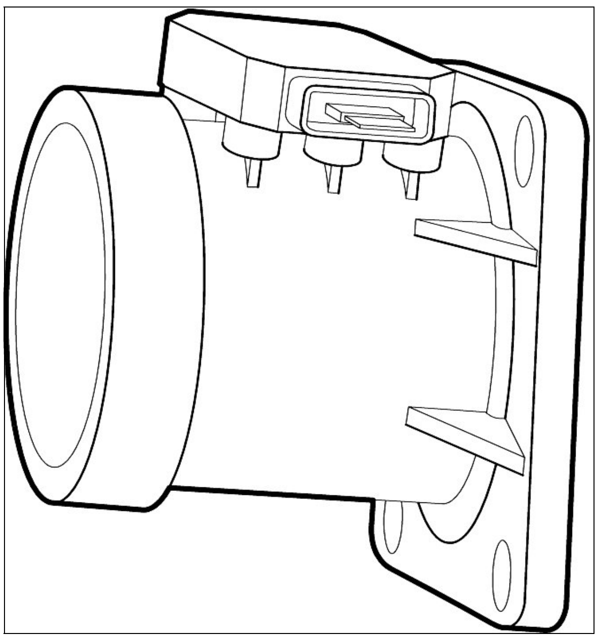

Fig. 9 MAF SENSOR

Intake Air Temperature (IAT) Sensor

The IAT sensor, located in the air induction duct, is a thermistor which has a negative temperature coefficient (NTC).

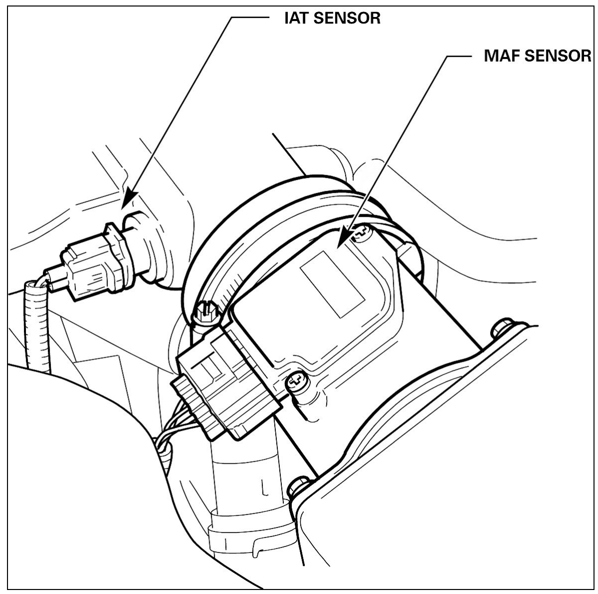

Fig. 10 MAF AND IAT SENSOR LOCATION

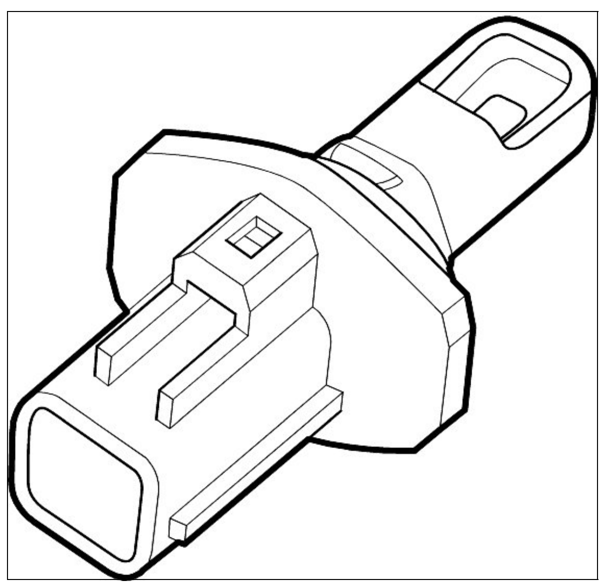

Fig. 11 IAT SENSOR

Crankshaft Position (CKP) Sensor

The CKP sensor is an inductive pulse generator, which provides the PCM with an engine speed and position signal.

The reluctor is located on the crankshaft at different locations in the V6 and V8.

- V6 sensor is located on the front timing cover.
- V8 sensor is located on the rear of the engine structural sump as in previous V8 engines.

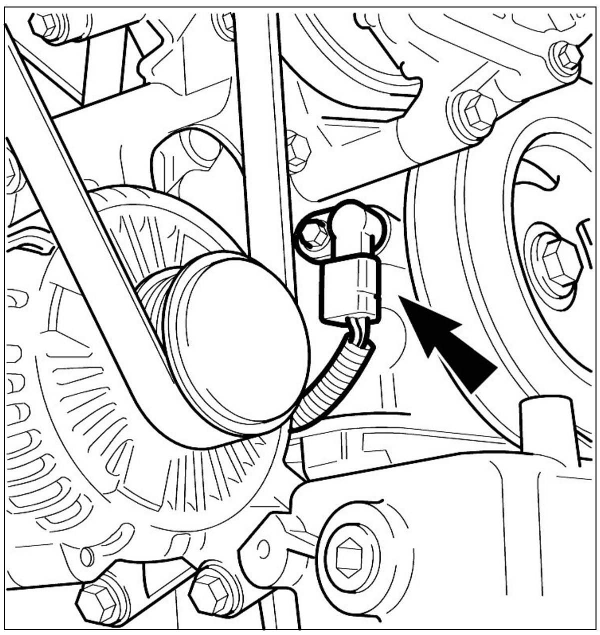

Fig. 12 CKP SENSOR – V6

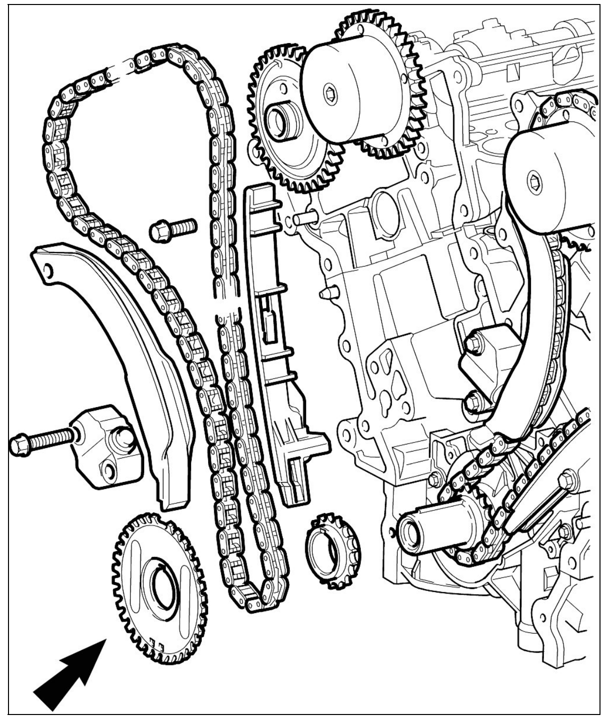

Fig. 13 CKP SENSOR RELUCTOR – V6

The missing tooth gap provides a PCM reference for crankshaft position.

- V6 gap is located at 60° BTDC cylinder 1/1.
- V8 gap is located at 50° BTDC cylinder 1/1.

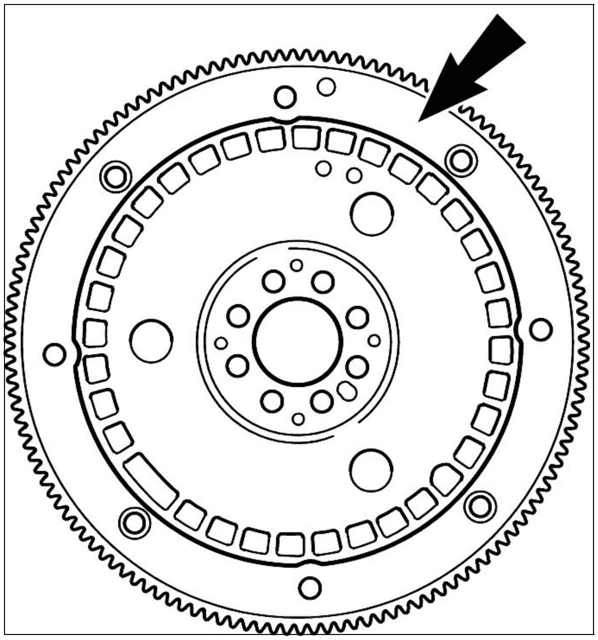

Fig. 14 CKP SENSOR RELUCTOR – V8

Camshaft Position (CMP) sensors

The CMP reluctors are located on the inlet camshafts at the rear of the cylinder heads.

- V6 reluctors have four teeth (three are equally spaced)
- V8 reluctors have five teeth (four are equally spaced).

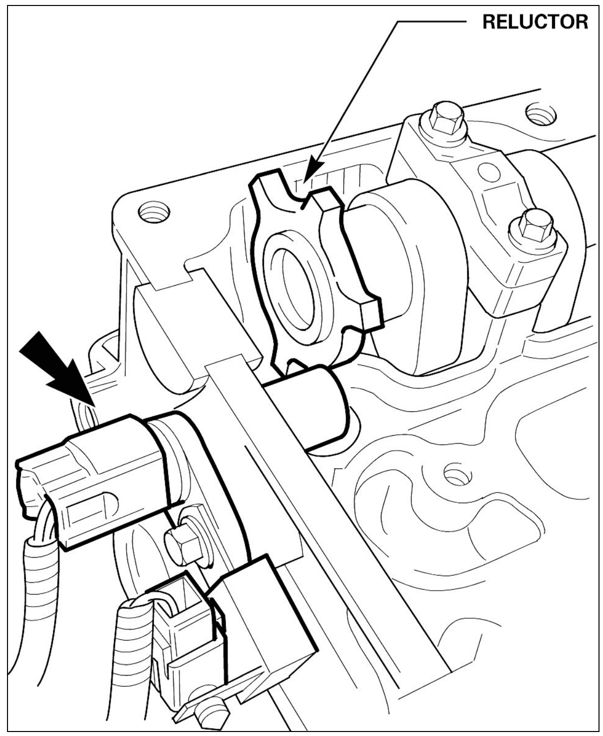

Fig. 15 CMP SENSOR AND RELUCTOR – V6

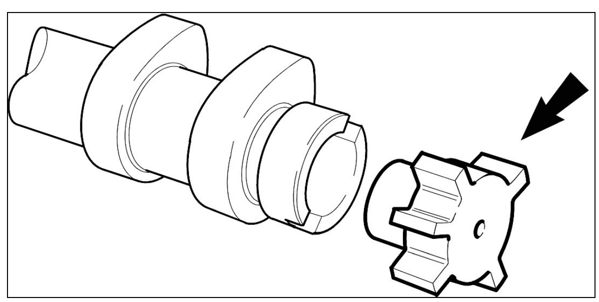

Fig. 16 CMP SENSOR RELUCTOR – V8

Engine Coolant Temperature (ECT) Sensor (V8)

The V8 ECT sensor, located on the coolant outlet elbow between the cylinder banks, is a thermistor which has a negative temperature coefficient (NTC). Engine coolant temperature is determined by the PCM by the change in the sensor resistance.

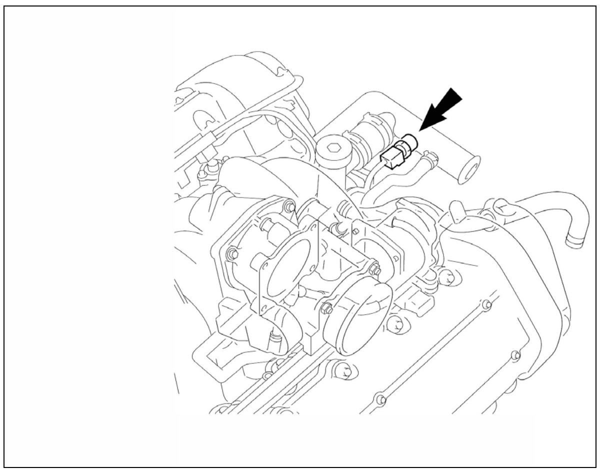

Fig. 17 ECT SENSOR (V8)

PTEC Temperature Sensors

The following Temperature / Resistance / Voltage chart applies to all of the PTEC Temperature Sensors except for the Cylinder Head Temperature (CHT) Sensor:

- Engine Coolant Temperature (ECT) Sensor
- Engine Fuel Temperature (EFT) Sensor
- Engine Oil Temperature (EOT) Sensor
- Intake Air Temperature (IAT) Sensor
- Transmission Fluid Temperature (TFT) Sensor

Table 1 PTEC Temperature Sensor Chart

Temperature		Nominal Resistance	Nominal voltage Voltage at PCM
C	F	(kΩ)	Volts
0	32	95.851	3.88
10	50	59.016	3.52
20	68	37.352	3.09
30	86	24.239	2.62
40	104	16.043	2.226
50	122	10.908	1.72
60	140	7.556	1.34
70	158	5.337	1.04
80	176	3.837	0.79
90	194	2.840	.61
100	212	2.080	.47
110	230	1.564	.36
120	248	1.191	.28
130	266	.715	.17
140	284	.563	.14
150	302	.542	.132

Cylinder Head Temperature (CHT) Sensor (V6)

The CHT sensor, located between the two rear coil-on-plug units in the bank 2 cylinder head, is a thermistor which has a negative temperature coefficient (NTC).

The sensor directly monitors the metal temperature of the cylinder head. This method of engine heat sensing is used in place of an engine coolant temperature sensor to enable the V6 fail safe cooling strategy to operate. The use of a metal temperature sensor allows cylinder head temperature to be measured even if coolant has been lost.

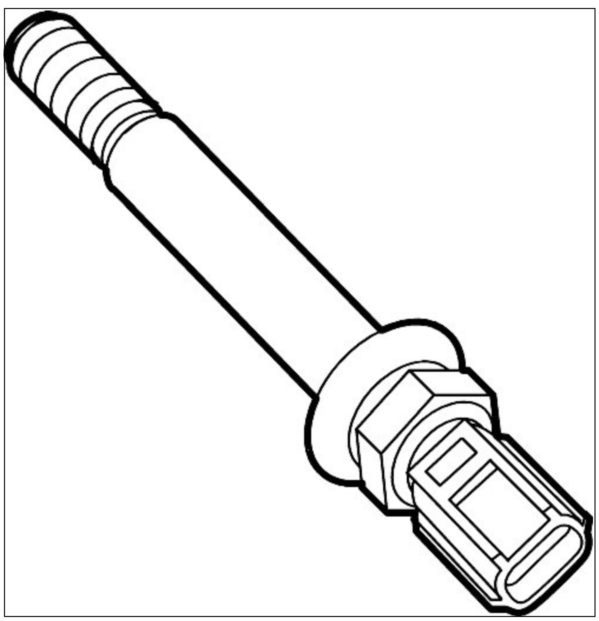

Fig. 18 CHT SENSOR (V6)

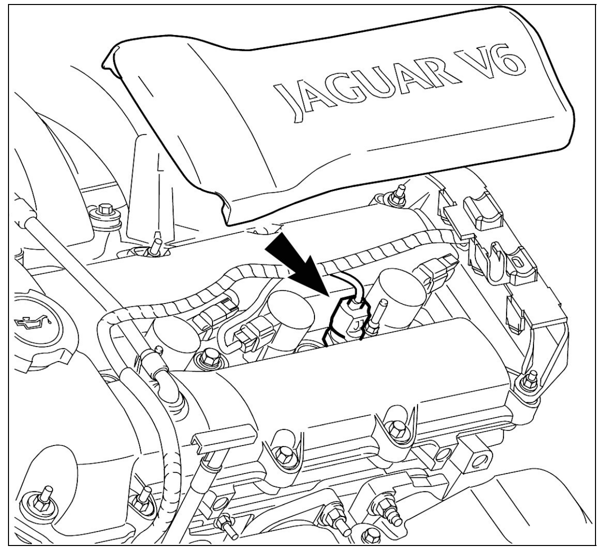

Fig. 19 CHT SENSOR LOCATION (V6)

Cylinder head temperature is determined by the PCM by the change in the sensor resistance. The PCM applies 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance.

Table 2 V6 Cylinder Head Temperature Sensor

Coolant temperature		Nominal Resistance	Nominal Voltage at PCM
C	F	(kΩ)	Volts
0	32	96.248	4.140
10	50	59.173	3.737
20	68	37.387	3.257
30	86	24.216	2.738
40	104	16.043	2.226
50	122	10.851	1.759
60	140	7.487	1.362
70	158	5.269	1.043
80	176	3.775	0.794
90	194	2.750	.604
100	212	2.038	.462
110	230	1.523	.0354
120	248	1.155	.273
130	266	.887	.212
140	284	.689	.167
150	302	.542	.132
160	320	.430	.105
170	320	.345	.085

Engine Oil Temperature (EOT) Sensor

Engine oil temperature is determined by the PCM by the change in the sensor resistance. The V6 and V8 sensors are fitted to the engine lubrication system in different locations:

- V6 EOT sensor is located on the left hand side of the cylinder block in the oil return channel from the oil cooler
- V8 EOT sensor is located on the oil cooler / filter adapter.

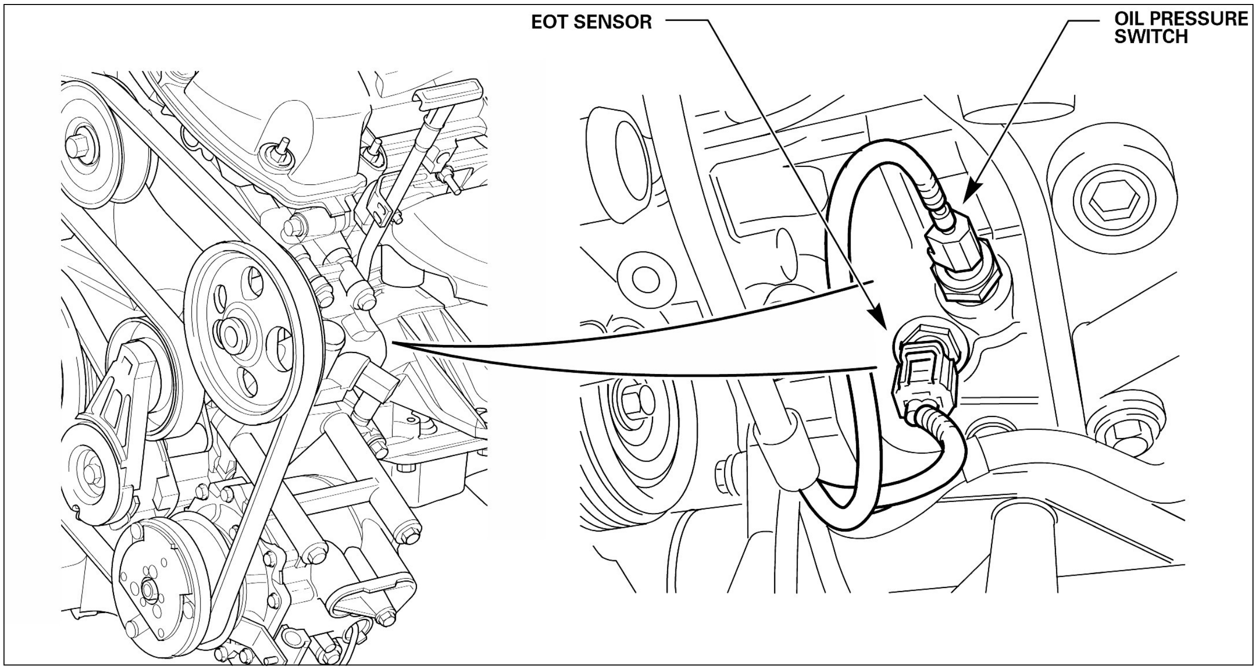

Fig. 20 EOT SENSOR – V6

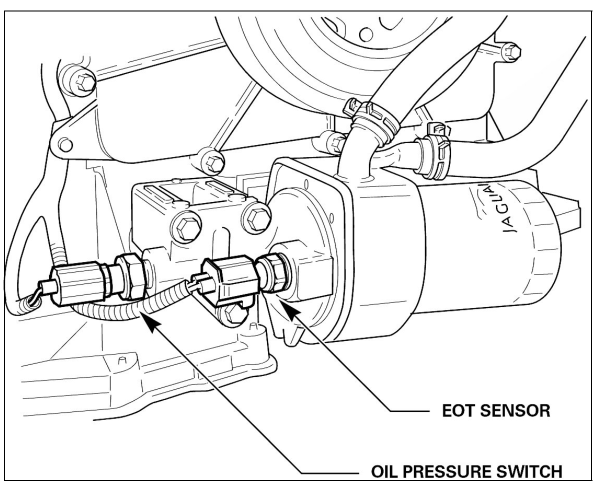

Fig. 21 EOT SENSOR – V8

Power Steering Pressure (PSP) Switch

The PCM uses the input from the PSP switch to compensate for the additional accessory drive load on the engine by adjusting the engine idle speed and preventing engine stall during parking maneuvers.

The PSP switch, located on the PAS pump outlet pipe, monitors the hydraulic pressure on the high pressure side of the power steering system. The switch is a normally open switch that closes when the hydraulic pressure reaches 24.13 ± 3.45 Bar (350 ± 50 psi).

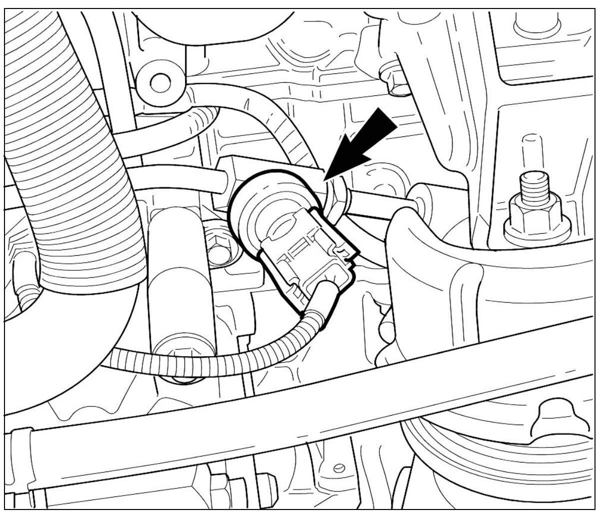

Fig. 22 PSP SWITCH – V6 SHOWN

Brake Switches

The PCM receives input signals from two brake pedal position switches:

- Brake switch (B+ voltage / normally open)
- Brake cancel switch

Two switches provide signal plausibility.

- The switch inputs to the PCM are used for cruise control cancel and multiple vehicle functions (via SCP).

NOTE:

On DSC equipped vehicles, the brake switch is hard wired to the DSC control module.

The DSC system uses an active brake booster, which when activated by the DSC CM, will cause the brake pedal to drop with the subsequent activation of the brake switches. During the DSC self test when the vehicle first moves off, the booster is momentarily activated by the DSC CM causing the brake pedal to drop.

When the DSC CM is performing the self test, it does not broadcast an SCP BRAKES APPLIED message, which prevents erroneous brake light activation.

INDUCTION AIR AND THROTTLE CONTROL

Air Induction Systems

The V6 and V8 engines have air induction systems that are similar from the air cleaner inlet through the throttle body. The systems consist of the normal components with the MAF sensor located in the air cleaner outlet and the IAT sensor located in the air intake duct just downstream of the MAF sensor.

Resonator chambers are fitted to the intake ducting to control intake air reverberation at certain throttle openings.

After exiting the throttle body, the V6 and V8 induction air systems differ greatly.

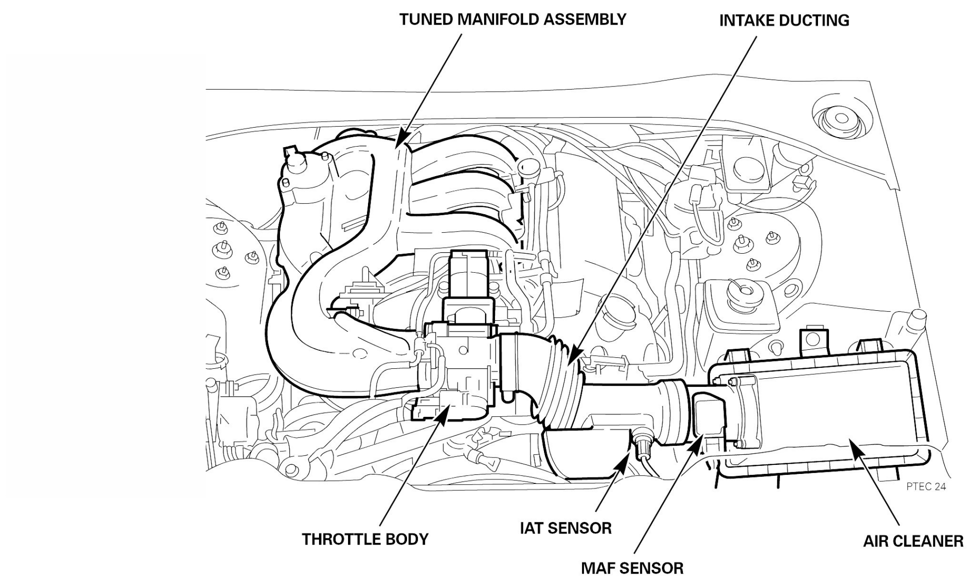

Fig. 23 AIR INDUCTION: V6

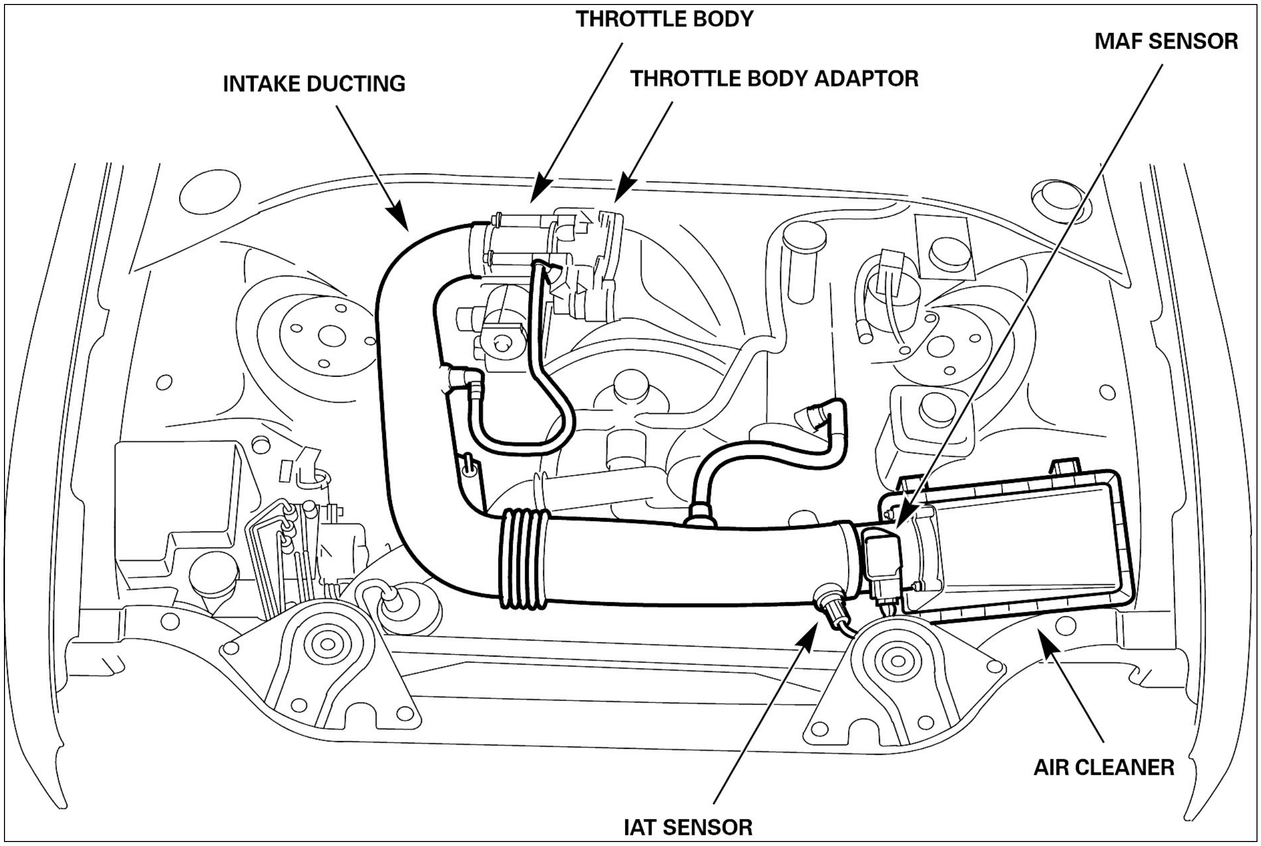

Fig. 24 AIR INDUCTION: V8

Air Intake – V8

Induction air flows into the manifold through a centrally located inlet. The manifold incorporates the air rails for air assisted fuel injection. The heated (engine coolant) throttle adapter connects the throttle body to the manifold and provides EVAP, and vacuum source connections.

The air assist injection valve is located on the throttle adapter. A noise isolation pad locates between the induction manifold and the engine vee.

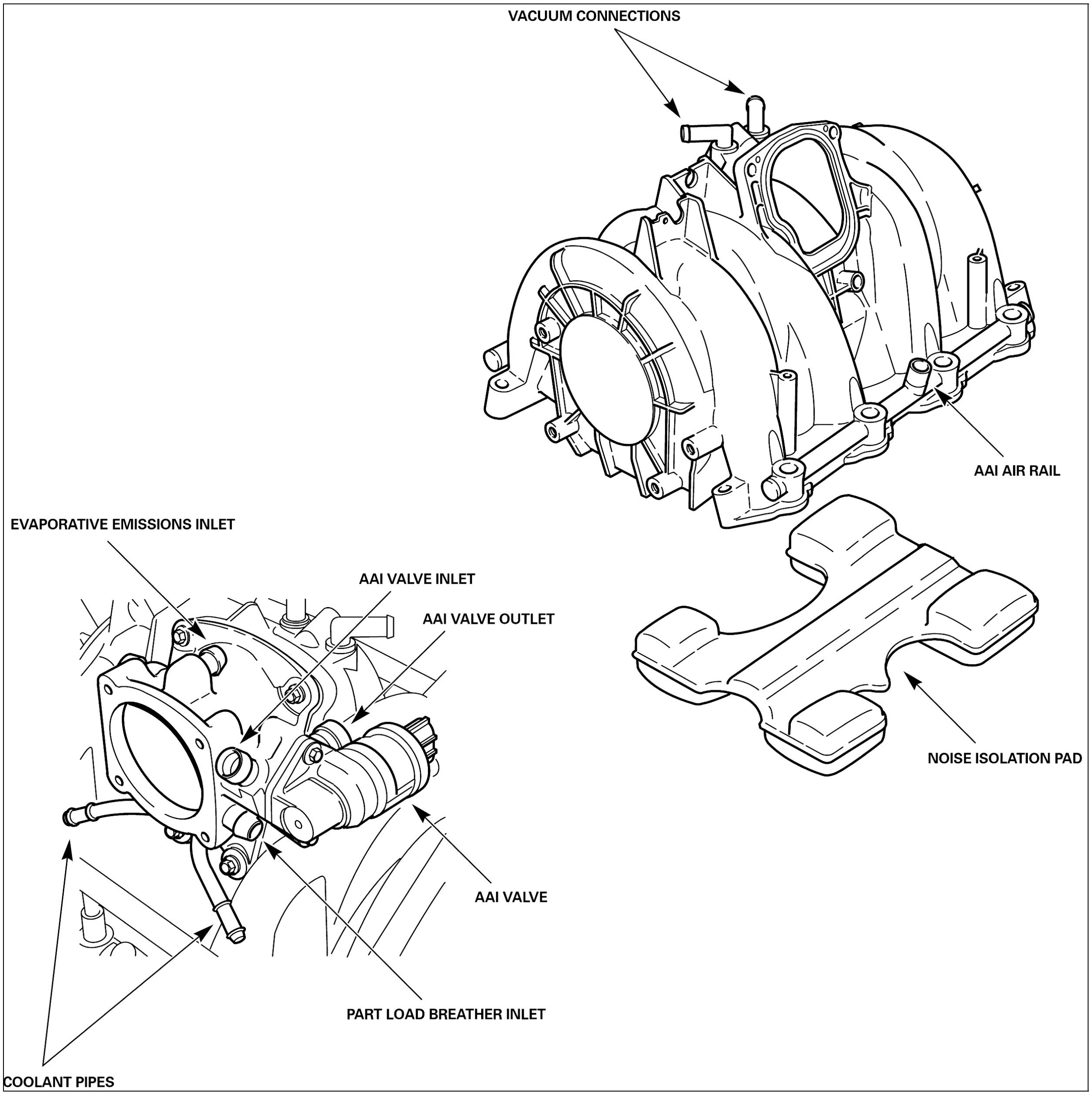

Fig. 25 INTAKE MANIFOLD, THROTTLE ADAPTOR AND ISOLATION PAD – V8

Full Authority Throttle Control

The electronic throttle control system used in the PTEC engine management systems is designed with no mechanical connection between the vehicle accelerator pedal and the throttle valve. The PCM has full authority over throttle valve movement.

The PCM calculates a required throttle position from the APP input signals and applies engine speed, cruise control status, engine torque reduction requirements, and other applicable data to generate duplicate 256 Hz PWM throttle command signals.

The PCM issues redundant PWM throttle position command signals via hard wired connections to the throttle actuator control module (TACM), which is located on the throttle body assembly. The TACM drives the throttle valve to the desired position via the throttle drive motor.

Throttle position sensors communicate actual throttle angle feedback to the PCM via hard wires to provide closed loop control. The TACM communicates calculated throttle position to the PCM via hard wire connection as a crosscheck.

The throttle control system uses multiple accelerator pedal position sensors, throttle position sensors, and multiple hard wired signals that allow the PCM to monitor individual signal validity. Two separate, dedicated, twisted pair (B+ around ground) provide supply power and ground to the TACM.

A dedicated electronic throttle monitor microprocessor, within the PCM, constantly monitors overall operation of the throttle control system. The throttle monitor microprocessor interfaces internally with the PCM main microprocessor logic and software.

In the event of a software or component failure, the system alerts the driver and, depending on the failure, adopts a default action to ensure driver safety. Refer to the DTC Summaries.

Operation of the system is designed to be totally transparent to the driver with a total delay of less than 70 ms between pedal actuation and throttle movement.

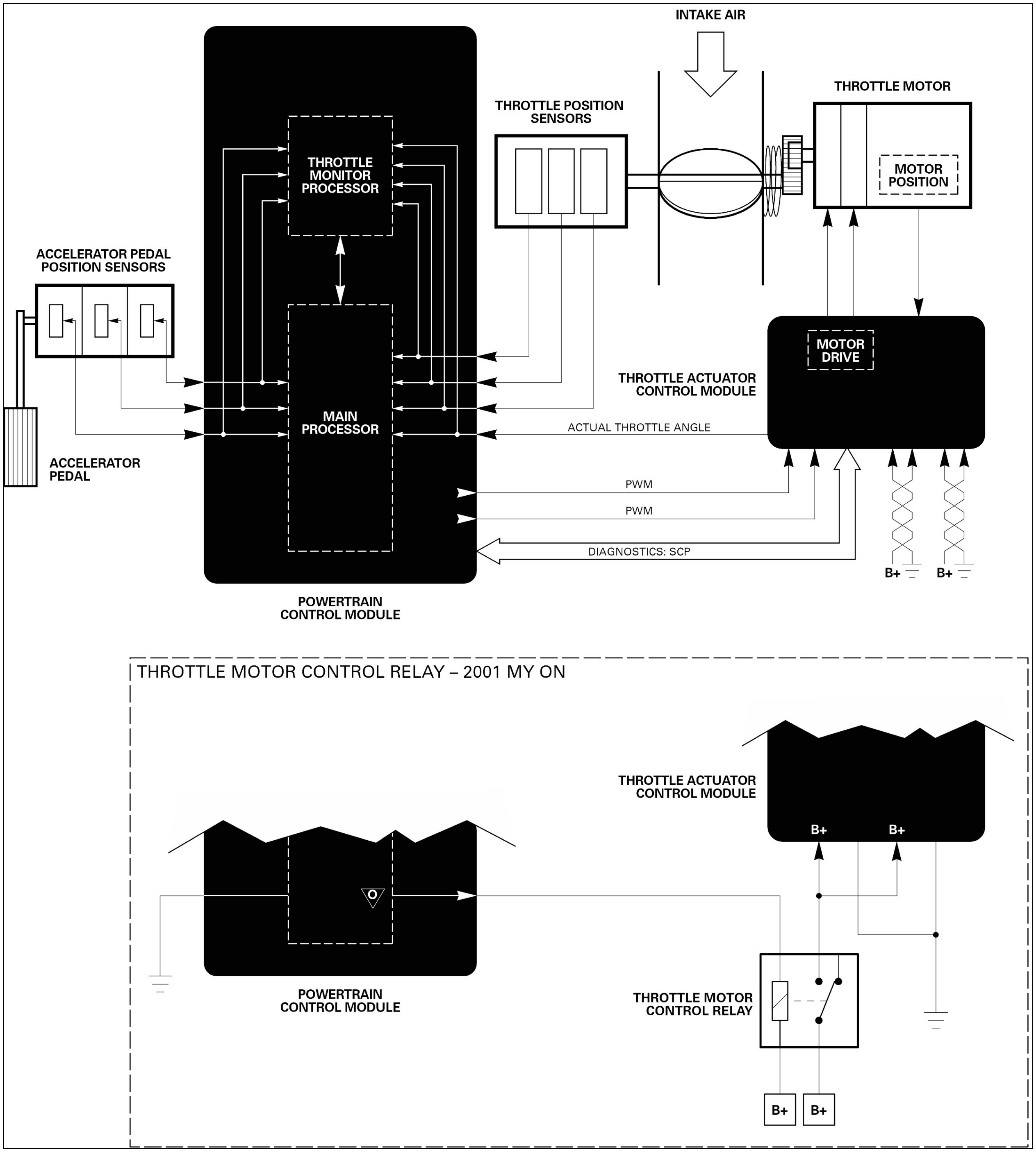

Fig. 26 THROTTLE CONTROL LOGIC

Throttle Data Recorder

The PCM throttle monitor processor incorporates a throttle data recorder. If the throttle data recorder is stopped by an airbag deployed input, the current throttle data is retained in memory and the PCM main processor flags DTC P1582.

The throttle data recorder will not function again until 100 ignition key cycles have been completed. The logged DTC P1582 will require an additional 40 key cycles to clear, or the DTC can be cleared using WDS.

Throttle Motor Control Relay, 2001 Model Year ON

2001 Model Year ON PTEC systems have a PCM internal timer circuit to control a throttle motor control relay. This circuit allows the PCM to open the throttle, via the relay, after engine OFF to prevent exhaust gas from building-up in the intake manifold and creating difficult hot start conditions.

Throttle Body Assembly

The throttle body assembly consists of the following sub components:

- Throttle body with valve and shaft
- Throttle actuator control module (TACM)
- Drive motor unit
- Throttle position (TP) sensor assembly

Because each throttle assembly is calibrated during assembly, no adjustments to the assembly or its components are required or permitted. The throttle body must not be disassembled. The only serviceable component is the TP sensor assembly.

The throttle body is an aluminum casting with a 70 mm (2.75 in.) intake bore. The throttle valve and shaft rotate on ball bearings with an internal tooth quadrant gear and two throttle return springs on the drive end of the shaft. Factory adjusted and sealed stop screws set the throttle closed and full open positions.

The throttle drive motor unit consists of the motor and an integral position encoder. If the motor fails, the throttle return springs return the throttle valve to the closed position.

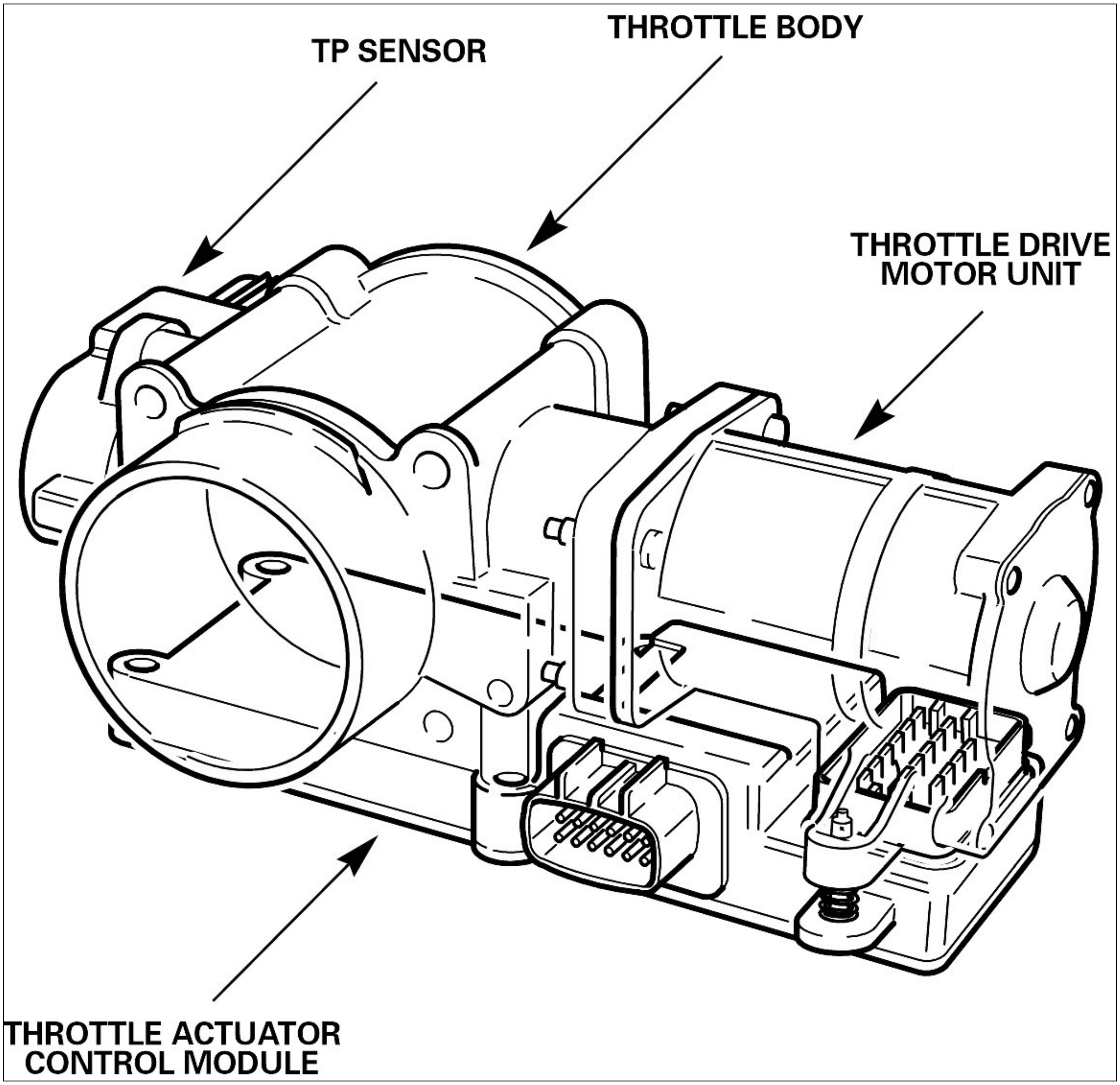

Fig. 27 THROTTLE BODY ASSEMBLY

WARNING:

DO NOT PUT YOUR FINGERS IN THE THROTTLE BODY BORE. THEY COULD BE INJURED IF TRAPPED BY THE THROTTLE PLATE.

CAUTION:

Do not attempt to clean the throttle housing or remove any sealant from the assembly. Any air leakage will disturb the idle speed calibration.

Throttle Position sensor (TP) Assembly

The throttle position sensor assembly consists of three Hall effect sensing elements with conditioning circuits that are directly driven by the throttle valve shaft.

Each sensing element has separate reference voltage and reference ground circuits hard-wired to the PCM; each provides its unique throttle position signal (via hard-wire connection) directly to the PCM. The unique characteristics of each signal are used for identification, similar to the APP Sensor signals.

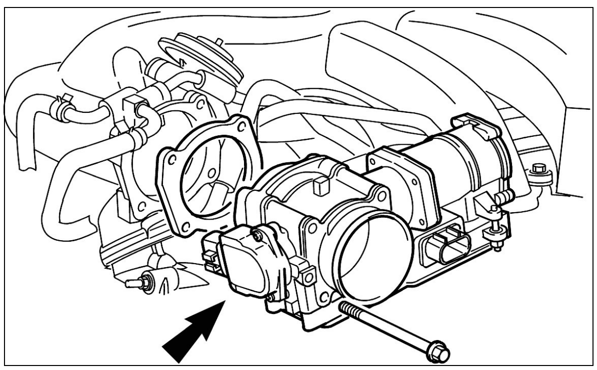

Fig. 28 TP SENSOR

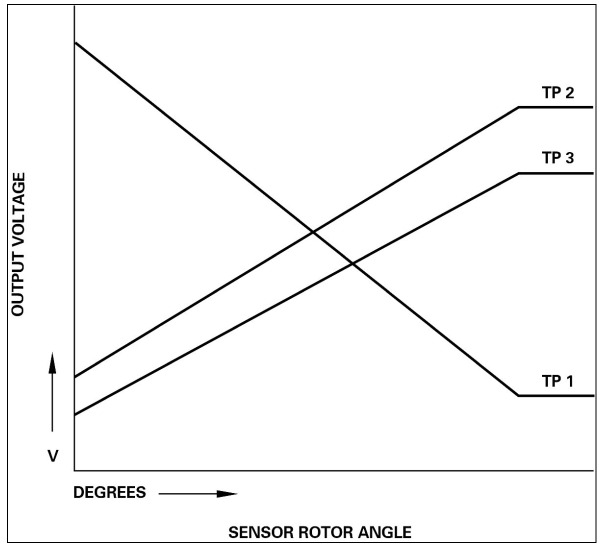

Fig. 29 TP SENSORS GENERAL CHARACTERISTICS

Throttle Actuator Control Module (TACM)

The TACM has two connectors and mounts to the throttle body and motor assembly. One connector plugs directly into the throttle motor. The second connector is the main interface with the PCM and also carries the twisted pair B+ voltage and ground supplies for TACM and throttle motor drive power. The two separate B+ voltage supplies from the front power distribution boxes are switched by powertrain relay 1 and the two separate ground supplies share the main ground stud used by the PCM.

The TACM processes the two throttle command PWM signals from the PCM and drives the throttle motor to the required position. The motor's position feedback to the TACM provides closed loop control and enables the TACM to maintain the desired throttle valve position. The PCM monitors actual throttle valve angle via the three-element TP sensor signals.

In addition to motor drive and positioning, the TACM also performs the following functions:

- Self diagnostics
- PCM throttle command signals validity comparison
- Requested throttle angle to actual throttle angle comparison
- Drive motor circuit operational comparison
- Failed throttle return spring detection
- Drive motor internal circuit continuity monitoring
- Inductive position encoder failure and out of range signals monitoring
- SCP transmission of diagnostic data to the PCM

Accelerator Pedal Position (APP) Sensor Assembly

The APP Sensor is a part of the accelerator pedal assembly, as shown in the figure. The accelerator pedal uses two return springs to provide a positive return if one should fail, and to simulate the feel of a conventional accelerator pedal.

Three individual rotary potentiometers comprise the APP sensor assembly located at the top of the accelerator pedal.

The potentiometers are driven by the accelerator pedal pivot shaft and provide separate analog voltage signals to the PCM proportional to accelerator pedal movement and position.

Each potentiometer has separate reference voltage and reference ground circuits hard-wired to the PCM; each provides its unique pedal position signal (via hard-wire connection) directly to the PCM. The PCM detects faults by comparing each pedal position signal to expected values as shown in the chart below.

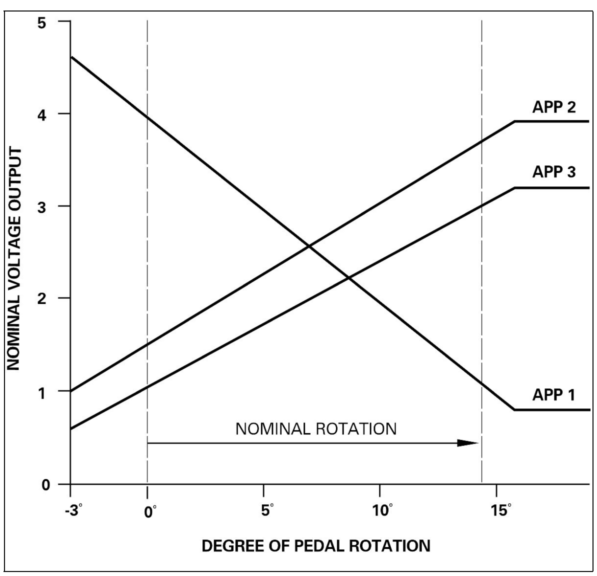

Fig. 30 APP SENSOR CHARACTERISTIC

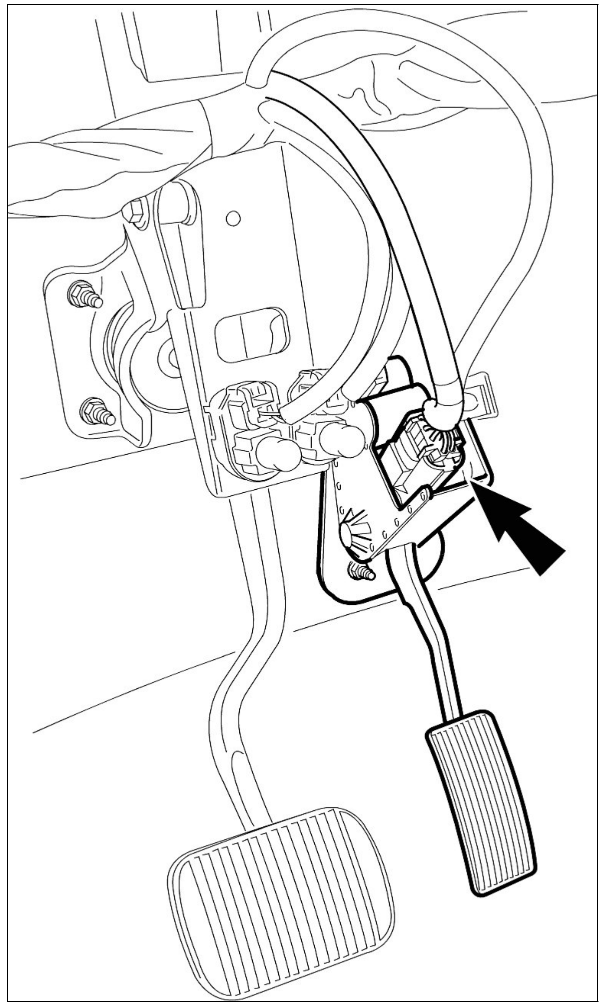

Fig. 31 APP SENSOR

Cruise Control

The cruise control system is fully integrated within PTEC. The PCM maintains the driver selected vehicle speed to within ±1 m.p.h. (1.5 km/h) via the normal throttle control and other engine and transmission control functions.

The system uses inputs from illuminated steering wheel mounted ON / OFF, SET / ACCEL, COAST, CANCEL, and RESUME switches, the two brake pedal switches (normally open Brake Switch, normally closed Brake Cancel Switch), and vehicle speed. Cruise control is operational between 25 – 130 m.p.h. (40 – 209 km/h).

The cruise control strategy within the PCM uses engine control to provide smooth acceleration and deceleration. In cases such as driving downhill, where the vehicle tends to exceed the cruise control set speed, the PCM uses an engine braking strategy and transmission downshifts to help maintain the desired speed.

Cruise control switch functions

- ON / OFF — When the system is switched ON or OFF, the PCM broadcasts an SCP VEHICLE SPEED CONTROL ON/OFF message. A SPEED CONTROL ON or OFF message is displayed in the message center for 4 seconds accompanied by a single audible chime. The PCM also broadcasts an SCP VEHICLE SPEED CONTROL SET SPEED ENABLE/DISABLE message whenever the Speed Control Set lamp in the instrument pack should be switched ON or OFF.
- SET / ACCEL — Touching the SET / ACCEL switch with the cruise control switched ON and vehicle speed in the operating range puts the system into SET mode. The current vehicle speed is memorized and maintained. If the switch is held in the active position the vehicle will accelerate smoothly until the switch is released. If the switch is touched momentarily (less than 640 ms), the vehicle speed increases by 1 m.p.h. Pressing the accelerator pedal will accelerate the vehicle higher than the memorized speed without disengaging cruise control. When the pedal is released, the vehicle smoothly decelerates to the memorized speed.
- COAST — Touching the COAST switch momentarily (less than 640 ms) decelerates the vehicle 1 m.p.h. Holding the switch allows the vehicle to decelerate until the switch is released. When the switch is released, the vehicle will maintain the current speed.
- CANCEL — Touching the CANCEL switch or applying the brakes puts the system into STANDBY mode and allows the vehicle to decelerate until either the SET / ACCEL or the RESUME switch is activated.
- RESUME — When the system is STANDBY mode, touching the RESUME switch accelerates the vehicle to the memorized set speed. Resume will not function if the system has been switched OFF, the ignition has been switched OFF, or the vehicle is below the minimum operational speed.

FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

Fuel tank

The plastic blow-molded fuel tank is a saddle shape tank with LH and RH fuel compartments. The tank is located below the rear passenger seat with the drive shaft and exhaust running through the arch of the tank. The underside of the tank is protected by a heat shield. The tank assembly is retained by two metal straps which are fixed to the underbody at the front by removable hinge pins and at the rear by bolts.

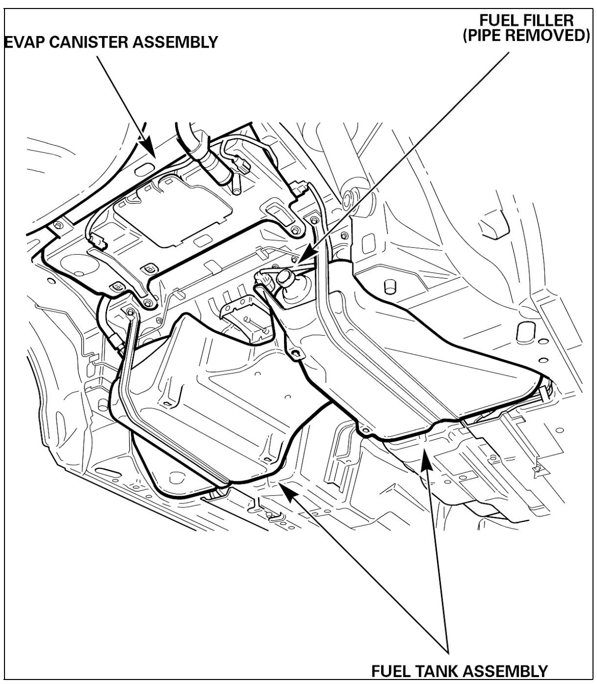

Fig. 32 FUEL TANK AND EVAP CANISTERS (UNDER FLOOR)

Refueling is via a separate filler pipe and connecting hose to a stub pipe on the RH fuel compartment.

A variable speed fuel pump is located in the RH compartment. Jet pumps are located in both compartments with external crossover pipes for fuel transfer between the compartments. The crossover pipes and electrical connectors exit the fuel tank through top plates which are secured in the tank using screw-on closure rings. The components on the top of the fuel tank are accessible from inside the vehicle via two access holes in the floor panel, below the rear seat.

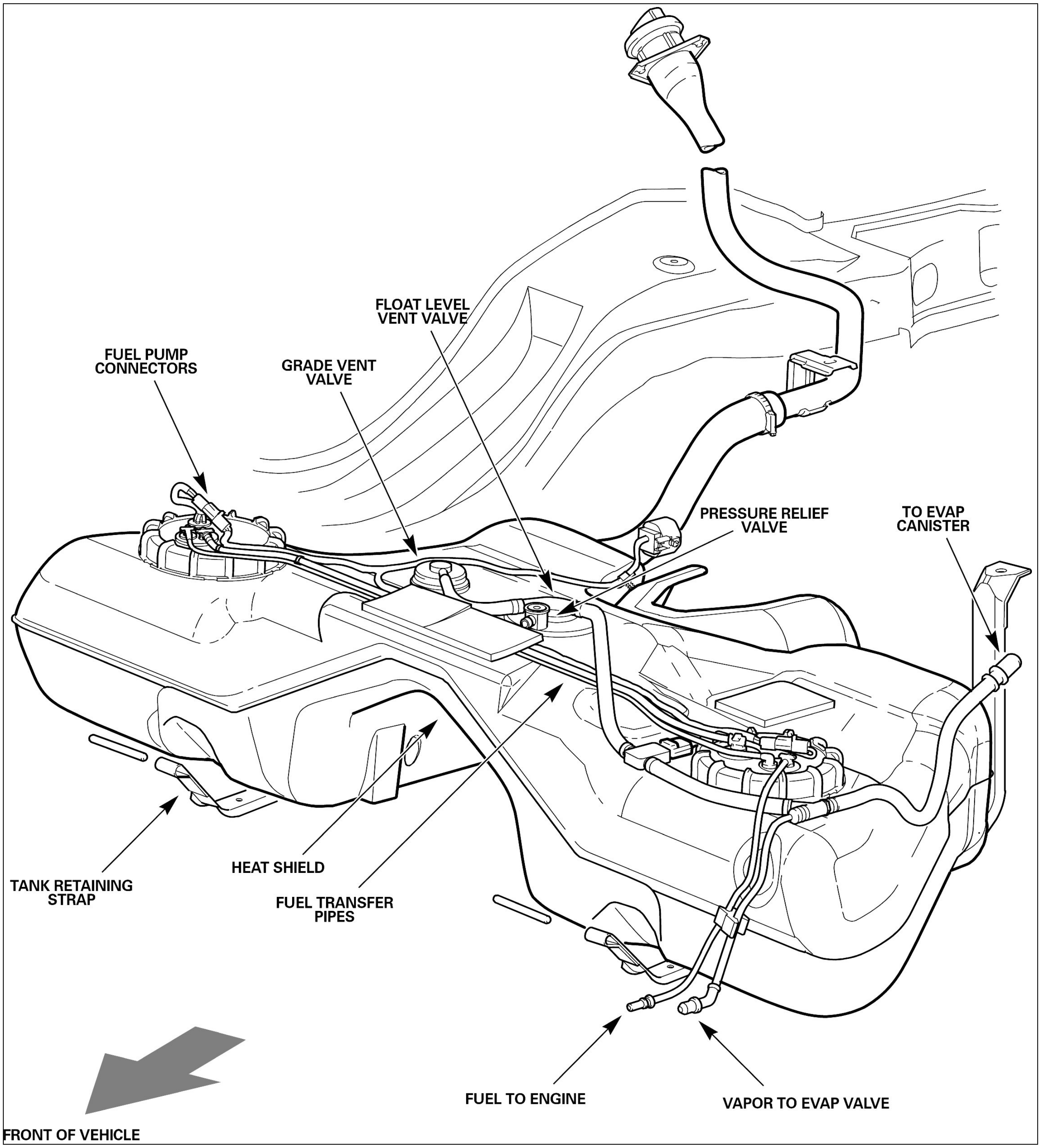

Fig. 33 FUEL TANK ASSEMBLY

Fuel filter

The replaceable in-line fuel filter is located in the back of the left wheel well. All fuel supply lines use quick-fit connections.

Fuel flow

The variable speed fuel pump is contained in a fuel reservoir in the RH compartment. Fuel is pumped from the reservoir through an external crossover pipe to the LH compartment where it flows via a 'T' junction to the parallel pressure relief valve and then out to the engine fuel rail.

The reservoir fuel level is maintained by the continual flow of fuel supplied by jet pumps in the LH and RH compartments.

Parallel pressure relief valve

The parallel pressure relief valve assembly contains two spring-loaded valves, which operate in opposite directions:

- The supply valve opens to allow fuel flow at approximately 0.014 Bar (0.2 psi) during normal operation.
- The fuel rail pressure relief valve opens at approximately 4.14 – 4.48 Bar (60 – 65 psi) to relieve excessive fuel rail pressure.

The main functions of the parallel pressure relief valve assembly are:

- To ensure fast engine starting by "checking" fuel in the supply lines and rail.
- To limit rail pressure due to temporary vapor increase during hot soak conditions (temperature and thus pressure drop after approximately 20 minutes.)
- To prevent siphoning from the tank in the even of the fuel line being severed with the pump inactive.

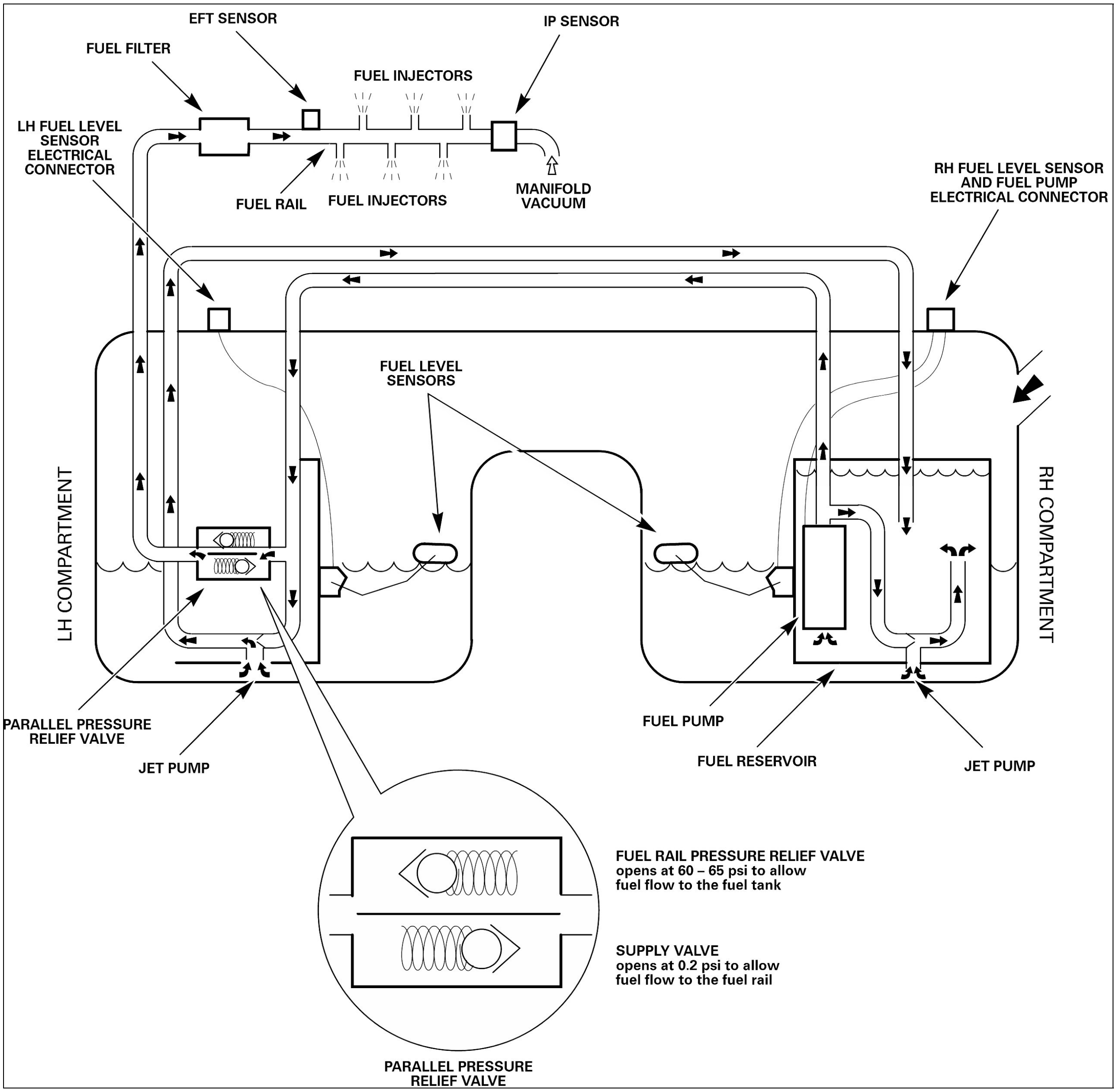

Fig. 34 ELECTRONIC RETURNLESS FUEL SYSTEM

Fuel System Sensors

The fuel pump delivers fuel through a single fuel supply line to the closed-ended fuel rail. Two sensors feedback fuel rail pressure and temperature to the PCM.

The IP (injector pressure) sensor is located at the end of the fuel rail, the EFT (engine fuel temperature) sensor is located at the supply end of the fuel rail.

Fuel injection pressure (IP) sensor

The IP sensor, located on the fuel rail, is a pressure transducer device with a diaphragm separating the pressure transducer from direct contact with the fuel.

A pipe connects the sensor to the intake manifold for sensing manifold depression (manifold vacuum). The voltage signal from the transducer is “conditioned” within the sensor.

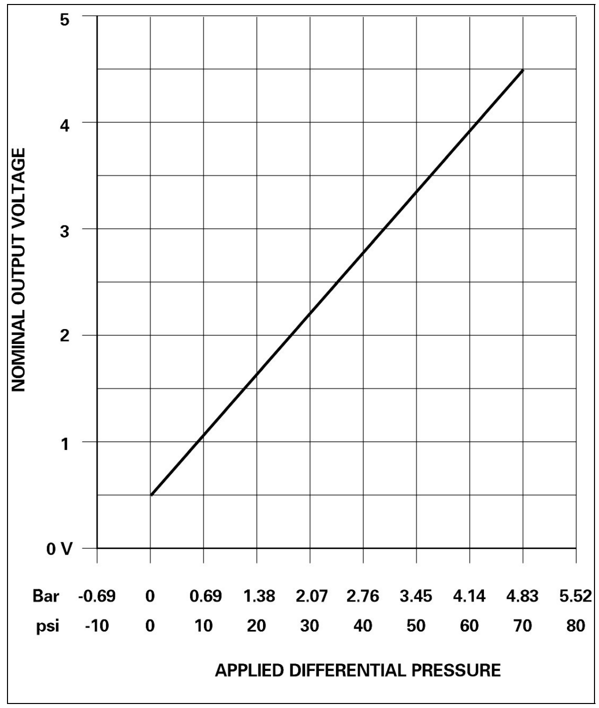

Fig. 35 IP SENSOR OUTPUT VOLTAGE vs. APPLIED DIFFERENTIAL PRESSURE

Engine fuel temperature (EFT) sensor

The EFT sensor, located on the fuel rail, is a thermistor which has a negative temperature coefficient (NTC). Fuel temperature is determined by the PCM by the change in the sensor resistance.

The PCM applies 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance. The PCM uses the EFT signal to prevent fuel vaporization and ensure adequate fuel supply to the injectors.

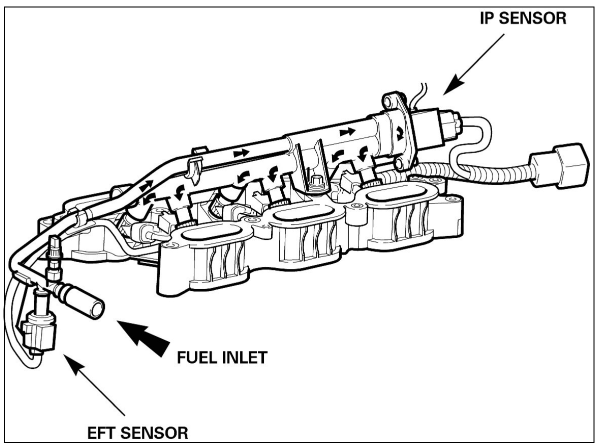

Fig. 36 FUEL RAIL – V6

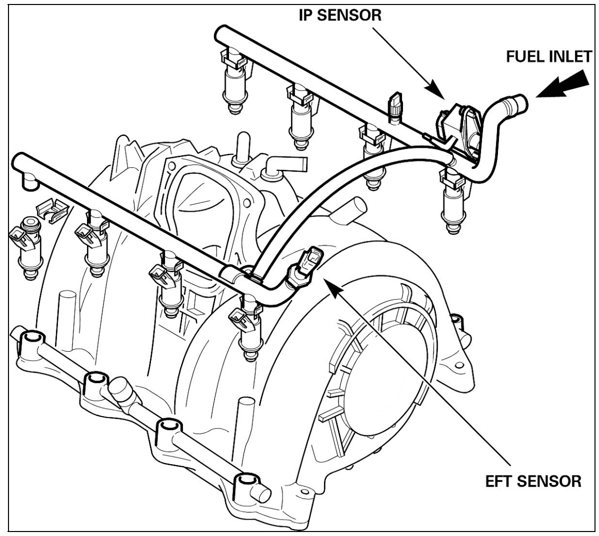

Fig. 37 FUEL RAIL – V8

Fuel pump control and operation

The fuel pump relay, located in the rear power distribution box, supplies power to the RECM to operate the fuel pump. The relay is activated by ignition switched B+ voltage via the inertia switch.

The PCM calculates engine fuel requirements using:

- engine load
- speed
- air flow
- engine temperatures:
  - cylinder head (V6)
  - engine coolant (V8)
  - intake air
- current fuel rail environment from the IP and EFT sensors.

The PCM communicates the fuel flow demand to the RECM as a pulse width modulated (PWM) signal over a single line at a frequency of approximately 256 Hz and a duty cycle of 0-50%.

The RECM amplifies this signal by increasing the frequency and doubling the duty cycle, thus providing the variable high current drive for the fuel pump.

When the ignition switch is turned from OFF to RUN or START, the PCM primes the system by running the pump for 1 second. After prime, the pump is switched ON when the CKP signal is received. The pump is switched OFF 1 second after the engine is stopped. During all hot fuel conditions, fuel pressure is increased to prevent vapor lock.

Fuel pump drive status is monitored by the RECM and communicated to the PCM via the SCP network. In the event of a vehicle impact, the inertia switch switches open deactivating the fuel pump relay and causing the RECM to cancel fuel pump drive.

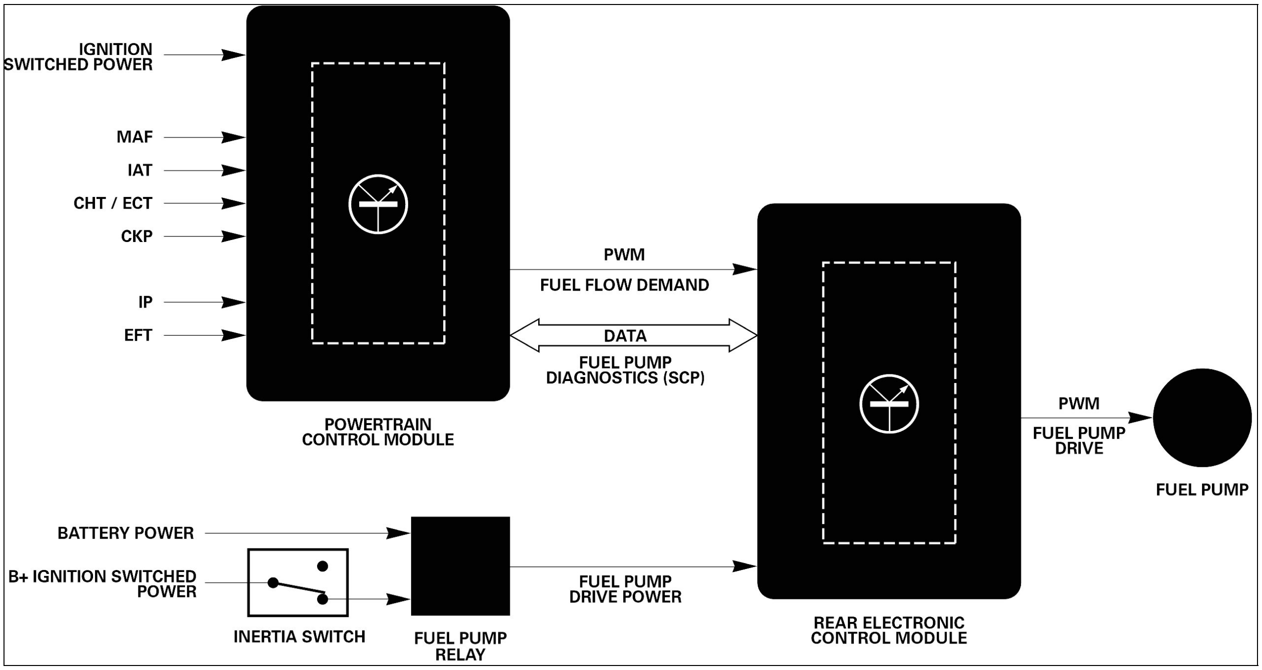

Fig. 38 FUEL PUMP CONTROL

Fuel level sensors

Outputs from the fuel level sensors are connected by independent wires to the RECM, which communicates the LH and RH sensor data independently to the instrument pack and the PCM via the SCP network.

Inertia switch

The inertia switch is located behind the trim on the left side of the vehicle, forward of the front door post and below the fascia. A finger access hole in the trim allows the switch to be reset.

If the inertia switch is tripped, it interrupts the ignition switched B+ voltage supply circuit to the fuel pump relay coil. The direct B+ voltage fuel pump supply to the RECM is interrupted and the pump immediately stops.

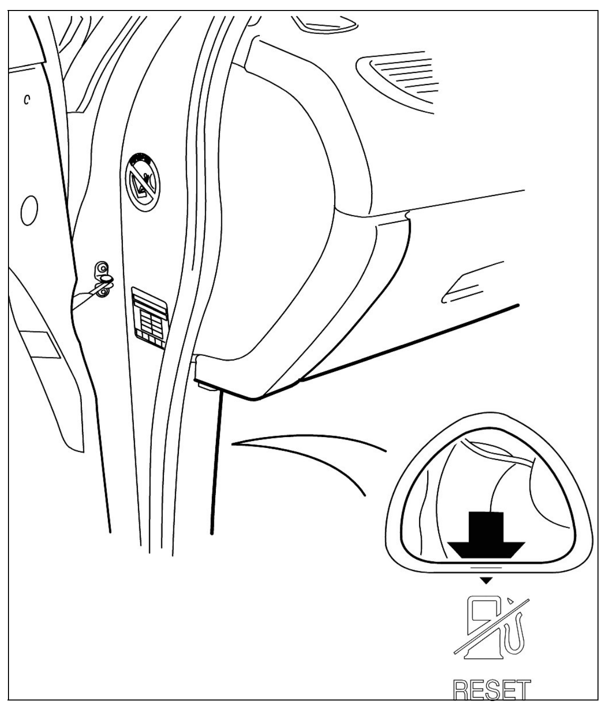

Fig. 39 INERTIA SWITCH

EVAP fuel tank components

To meet ORVR evaporative emission requirements, the tank and associated components are designed to minimize vapor losses. During refueling, the narrowed fuel filler tube below the nozzle region provides a liquid seal against the escape of vapor and a check valve in the tank inlet pipe opens to incoming fuel only to prevent splash back. As the tank fills, vapor escapes through the fuel level float valve, at the top of the tank, and passes through the evaporative canisters to atmosphere.

When the rising fuel level closes the float valve, the resulting back pressure causes refuelling cutoff. While the float valve is closed, any further rise in vapor pressure is relieved by the grade vent valve which connects to the canisters via the outlet of the float valve. At less than full tank level, the float valve is always open, providing an unrestricted vapor outlet to the canisters.

If the tank is over filled (e.g. a fault in the delivery system) an integral pressure relief valve in the float valve assembly opens to provide a direct vent to atmosphere.

The float level vent valve/pressure relief valve assembly and the grade valve are welded to the tank top and are non-serviceable. Note that both valve assemblies incorporate roll-over protection.

The fuel filler cap uses a 1/8 turn action and is tethered to the body. The filler cap assembly incorporates both pressure relief and vacuum relief valves.

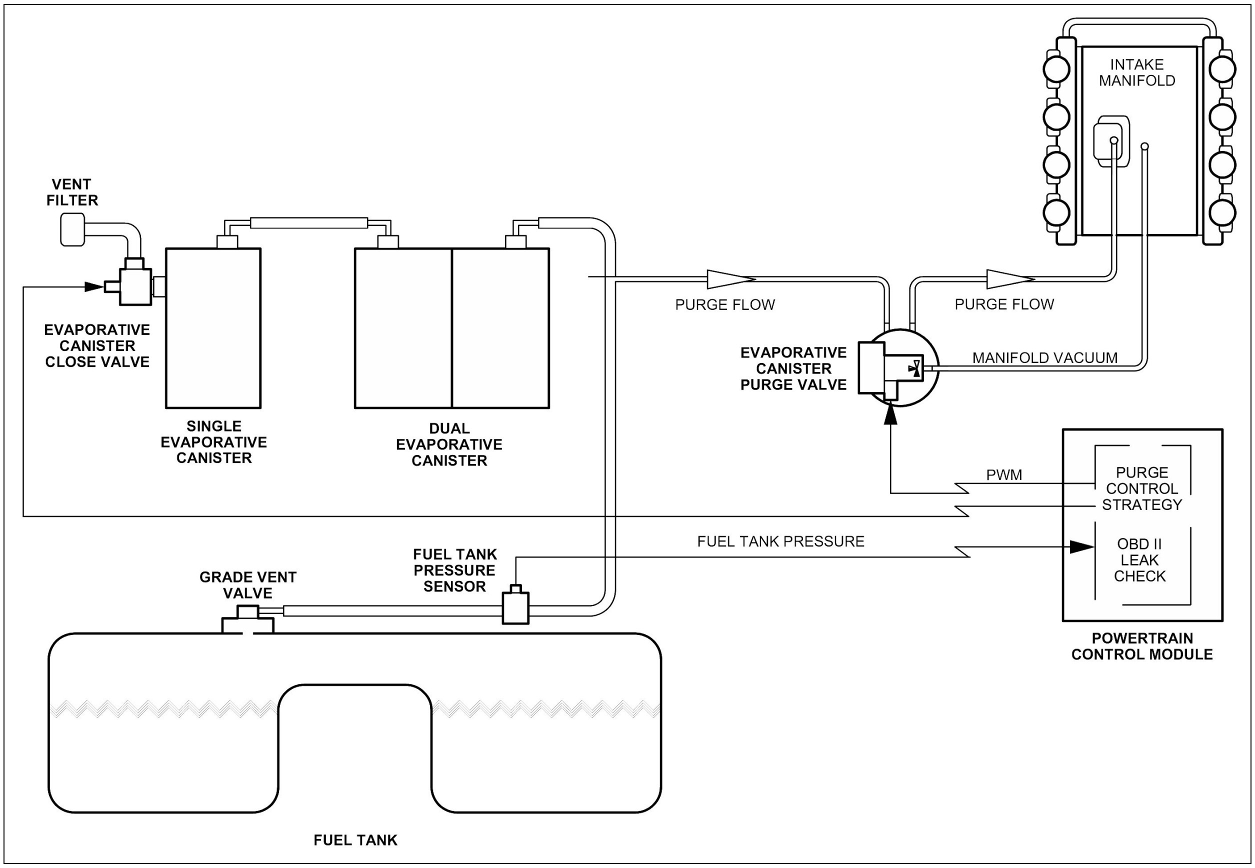

Fig. 40 EVAPORATIVE EMISSION CONTROL SYSTEM

EVAP canister assembly

Three series connected EVAP carbon canisters (one single, one dual) are used for vapor storage and are mounted on a plastic bracket fixed to the underbody above the rear axle.

The EVAP canister close valve and fuel tank pressure sensor are components used by the PCM for leak check monitoring. The EVAP canister close valve is mounted on the canister bracket. The fuel tank pressure sensor is fitted to the vapor pipe.

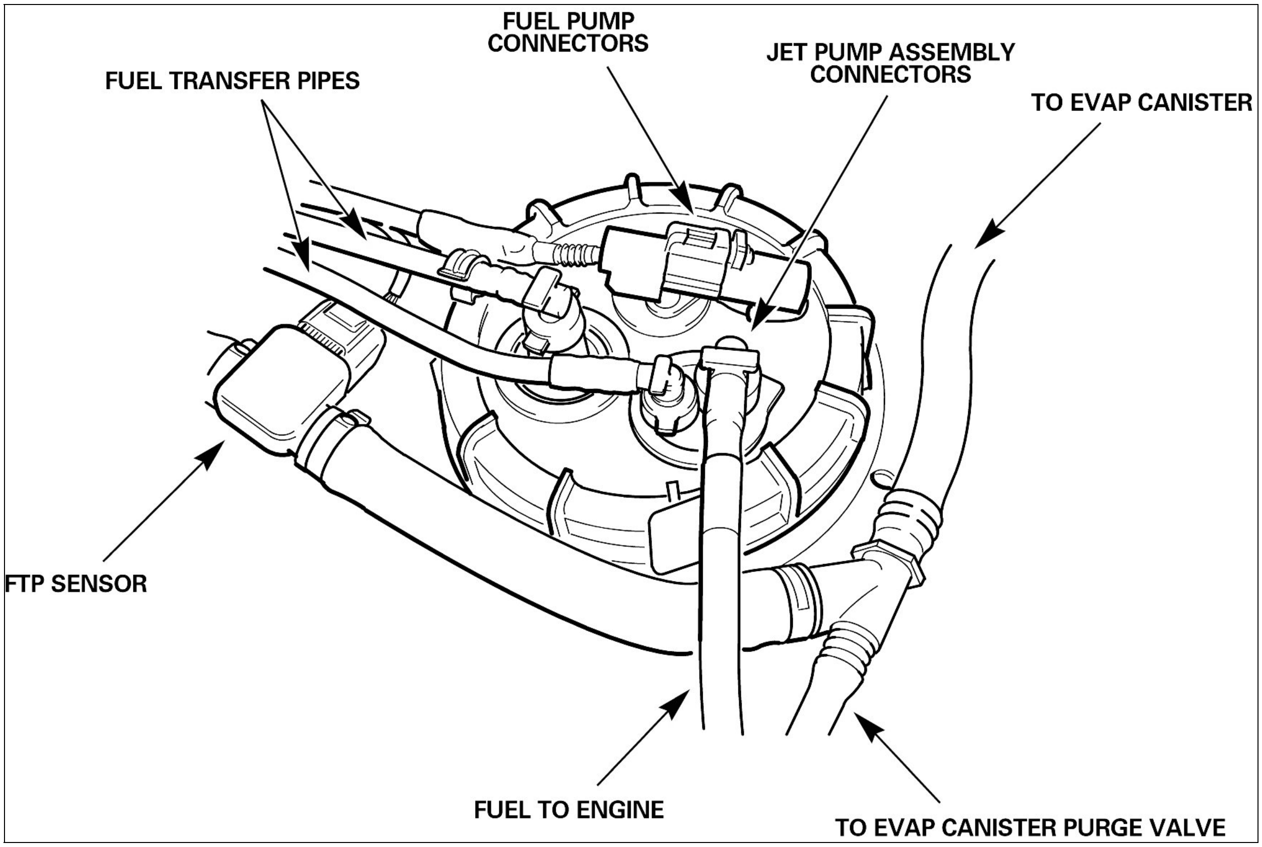

Fig. 41 EVAP FUEL TANK COMPONENTS

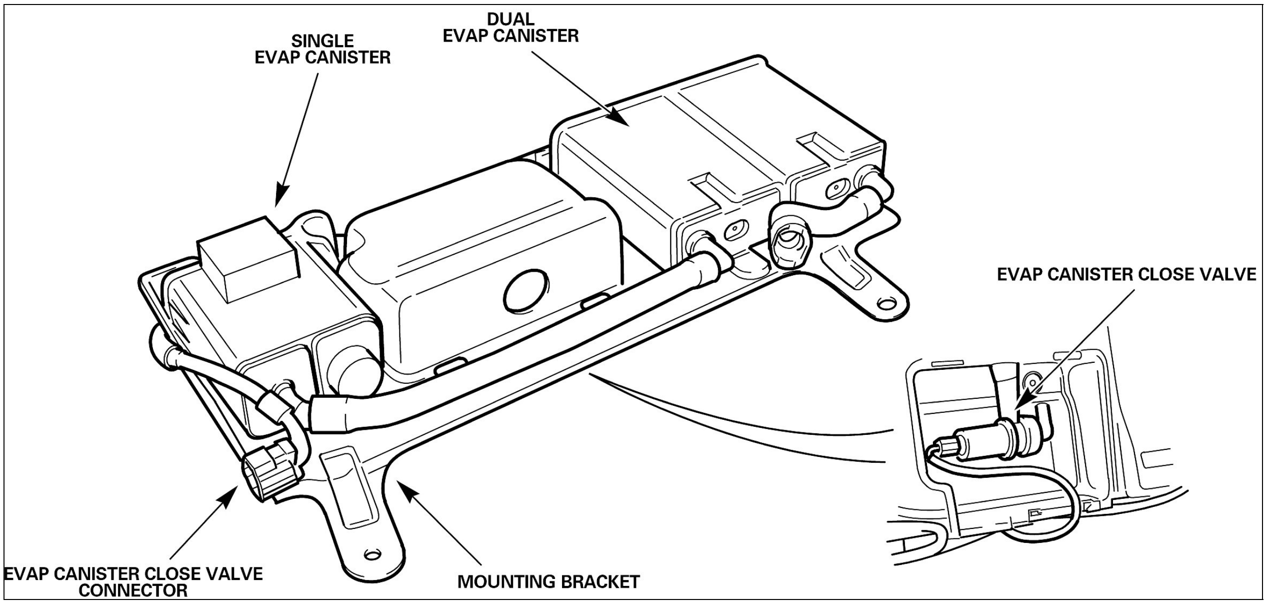

Fig. 42 EVAP CANISTER ASSEMBLY

EVAP canister close valve

The EVAP canister close valve is a solenoid valve that closes the canister vent outlet when driven by the PCM. By closing the vent, the system can be monitored for leaks.

Fuel tank pressure (FTP) sensor

The FTP sensor is a pressure transducer device. The voltage signal from the transducer is "conditioned" within the sensor. The PCM receives the conditioned voltage signal, which is proportional to the vapor pressure in the fuel tank.

EVAP canister purge valve

The EVAP canister purge valve is mounted on the rear left hand side of the engine bay. The valve is controlled by the PCM with a PWM signal driving a solenoid valve, which in turn applies manifold vacuum to actuate the valve.

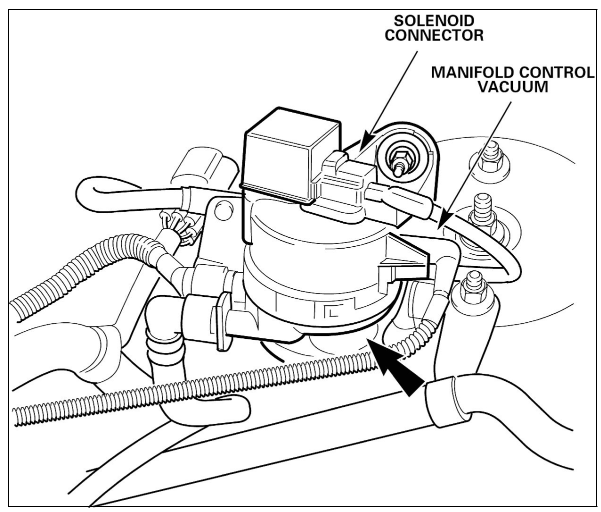

Fig. 43 EVAP CANISTER PURGE VALVE

Crankcase Ventilation System: V6

The closed and part throttle crankcase ventilation system consists of an oil separator, externally mounted to the cylinder block between the cylinder banks, a spring loaded in-line positive crankcase ventilation (PCV) valve, and a hose to the intake manifold. The intake manifold hose connection is downstream of the throttle valve and is warmed by engine coolant to prevent icing.

During closed and part throttle conditions, high manifold vacuum opens the spring loaded PCV valve allowing crankcase vapors to be drawn through the oil separator to the intake manifold. Any oil in the vapors is trapped by the separator and returns to the crankcase. As throttle opening increases, intake manifold vacuum decreases and the PCV valve closes in proportion to the manifold vacuum decrease.

The full load crankcase ventilation system consists of breather outlets on each camshaft cover connected to the intake duct via hoses and a tee connection. At full and near full load engine operation, intake duct pressure decreases drawing crankcase vapor to the intake via the hoses and tee connection.

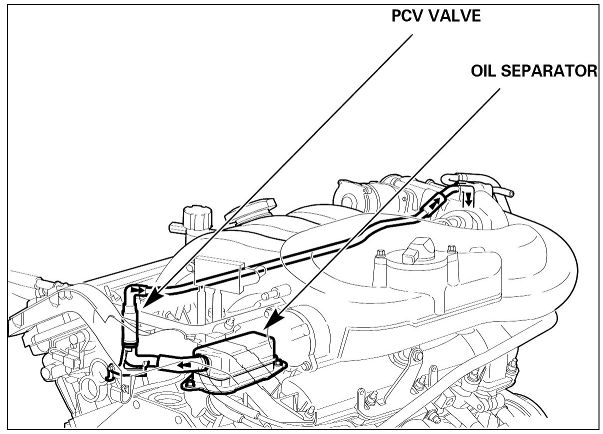

Fig. 44 POSITIVE CRANKCASE VENTILATION: V6

Crankcase Ventilation System: V8

The V8 full load and part load breather pipes are reconfigured in the S-TYPE to accommodate the induction manifold, camshaft covers and the engine installation.

During idle and part load operation, crankcase vapors are drawn through the bank 1 camshaft cover oil separator to the heated intake manifold connection downstream of the throttle valve. During full load operation the vapors flow through the bank 2 camshaft cover oil separator to the intake duct.

Vacuum connections for the EVAP system and the IP Sensor are also shown in the illustration.

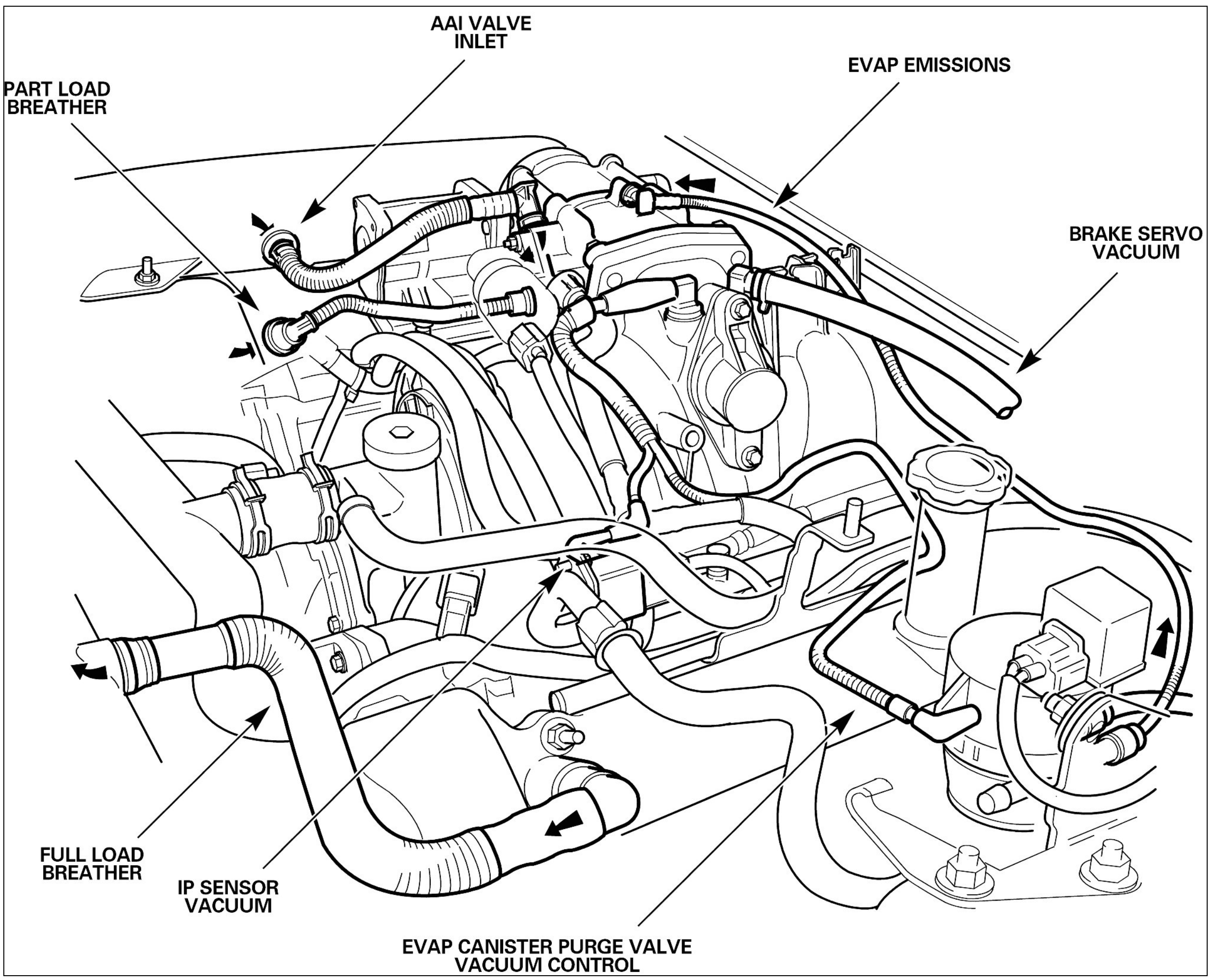

Fig. 45 CRANKCASE VENTILATION AND VACUUM CONNECTIONS: V8

FUEL INJECTION

Fuel injectors

The fuel injectors for the 3.0 liter are of the multi-hole design. The injectors for each engine have unique flow rates. The V8 injectors are constructed with a shroud to accommodate the air assisted injection (AAI) system.

Fuel injectors are identified by engine bank and cylinder position (bank/position) as follows:

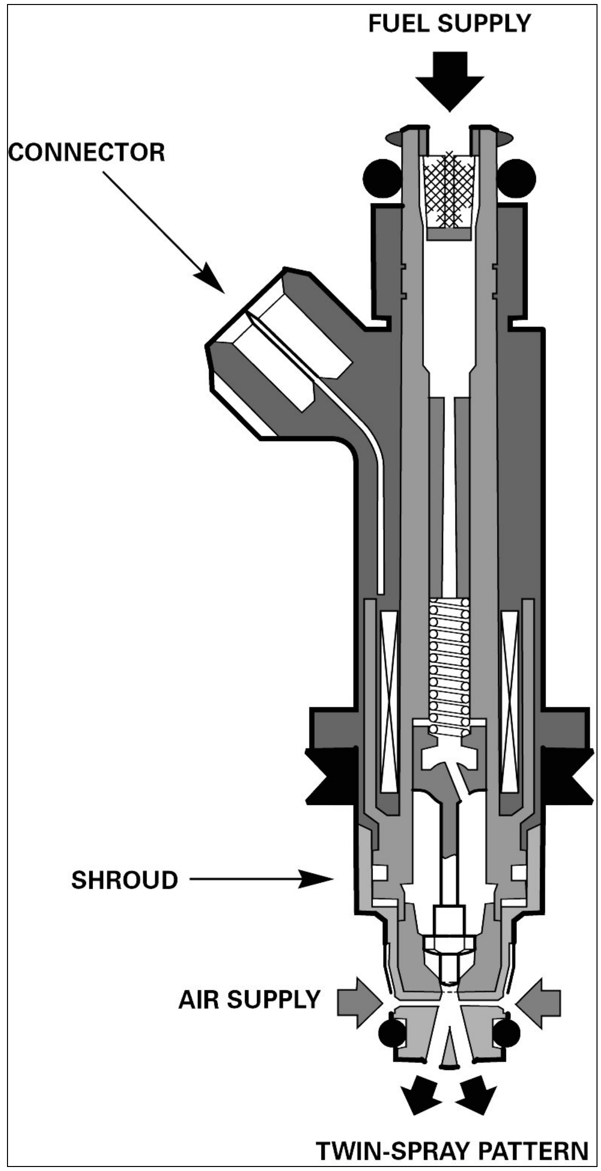

Fig. 46 AAI FUEL INJECTOR CROSS-SECTION – AJ28

Table 3

BANK	V6	V8
Right hand bank	1 / 1, 1 / 2, 1 / 3	1 / 1, 1 / 2, 1 / 3, 1 / 4
Left hand bank	2 / 1, 2 / 2, 2 / 3	2 / 1, 2 / 2, 2 / 3, 2 / 4

Fuel injector resistance

- V8 12 Ohms
- V6 14 Ohms

Air Assisted Fuel Injection (V8)

Air assisted injection decreases the formation of hydrocarbons and improves combustion stability during cold engine starts by admitting a metered amount of air to the base of each fuel injector to help atomize the fuel.

The amount of air admitted reduces progressively as engine temperature increases. The PCM controlled AAI valve is attached to the throttle body adapter.

The valve controls the air flow volume through the hoses to the air rails and fuel injectors. The air rails are part of each bank of the intake manifold.

The difference between intake manifold pressure and atmospheric pressure causes the air to flow through the valve.

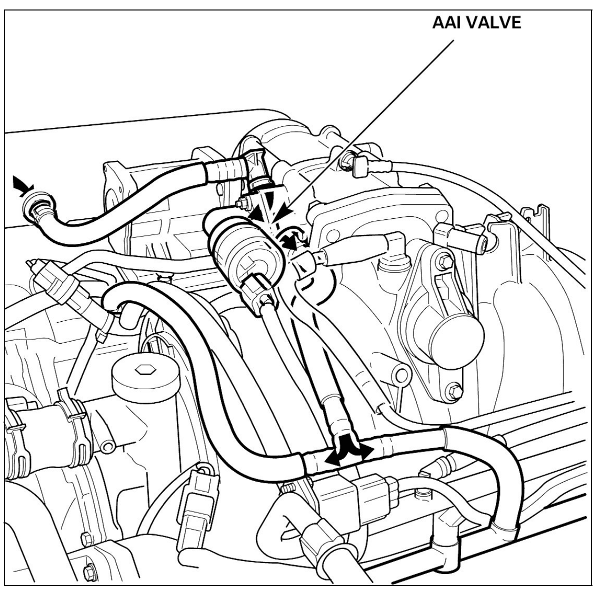

Fig. 47 AAI VALVE AND AIR DISTRIBUTION

Heated Oxygen (HO2) Sensors

Both the V6 and V8 engines use two conventional zirconium dioxide heated oxygen sensors for each cylinder bank.

One sensor is located upstream and one is located downstream of each catalytic converter. The upstream sensors are used by the ECM for closed loop fuel metering correction. The downstream sensors are used to monitor catalyst efficiency.

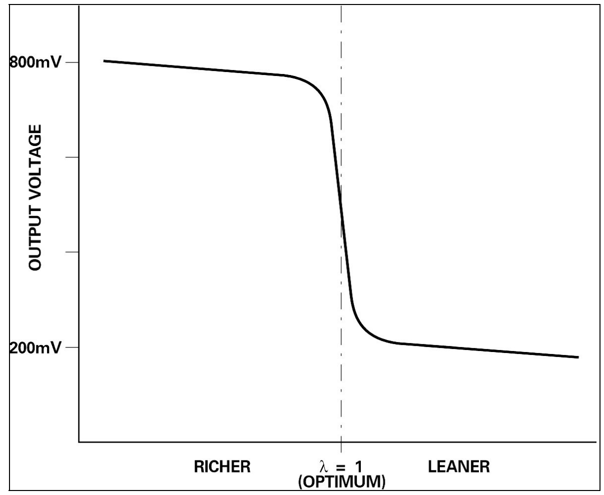

Fig. 48 HO2 SENSOR CHARACTERISTIC

HO2 sensors are identified by engine bank and exhaust position (bank/position) as follows:

Table 4

BANK	Upstream	Downstream
Right hand bank	HO2 sensor 1 / 1	HO2 sensor 1 / 2
Left hand bank	HO2 sensor 2 / 1	HO2 sensor 2 / 2

The HO2 sensor internal electric heaters reduce the time needed to bring the sensors up to operating temperature and maintain sensor temperature when the exhaust gasses are cool. B+ voltage is supplied to all four heaters from powertrain relay 2. Each heater has a separate ground circuit to the PCM for control and diagnostics.

- Upstream HO2 Sensor heater resistance 3.3
- Downstream HO2 Sensor heater resistance 5.0

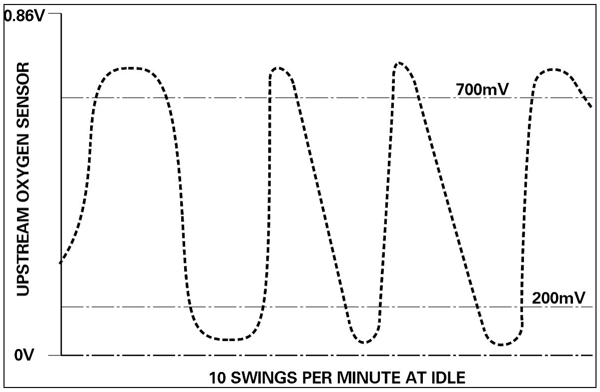

Fig. 49 HO2 SENSOR VOLTAGE SWING TRACE (UPSTREAM)

The PCM switches the upstream heaters ON at 100% for about 10 seconds during engine cranking, then controls the voltage to maintain sensor temperature above 350 °C (662 °F). This action provides fast "light off". The downstream HO2 sensors operate in the cooler exhaust gas exiting from the catalytic converter and are always ON while the engine is running.

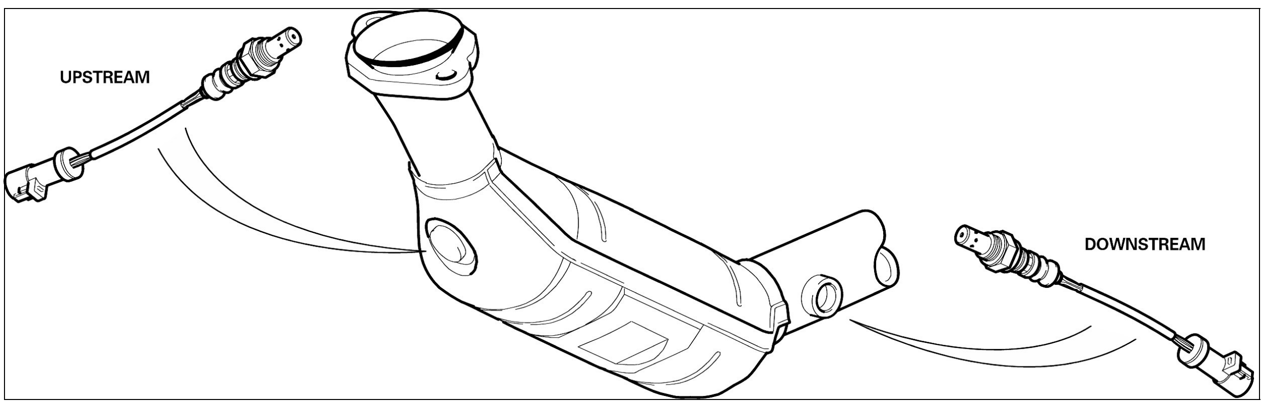

Fig. 50 HO2 SENSORS

NOTE:

The upstream sensors connect to the engine (PI) harness and the downstream sensors connect to the transmission (GB) harness. THE UPSTREAM AND DOWNSTREAM SENSORS ARE NOT INTERCHANGEABLE.

Catalytic Converters

Each two-element catalytic converter is attached to its exhaust manifold with a two-bolt self sealing flange. The resonator and muffler assemblies connect to the converter outlets with Torca clamps. The entire exhaust system can be serviced from under the vehicle.

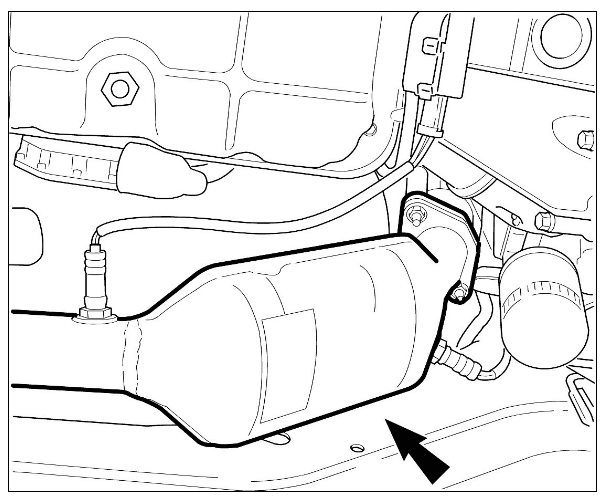

Fig. 51 CATALYTIC CONVERTER

IGNITION

Ignition Coils

The spark plug for each cylinder is fired by an on-plug ignition coil. The primary current side of each coil is supplied with ignition switched B+ power. The ground side of each coil is switched directly by the PCM with no additional ignition amplifiers required.

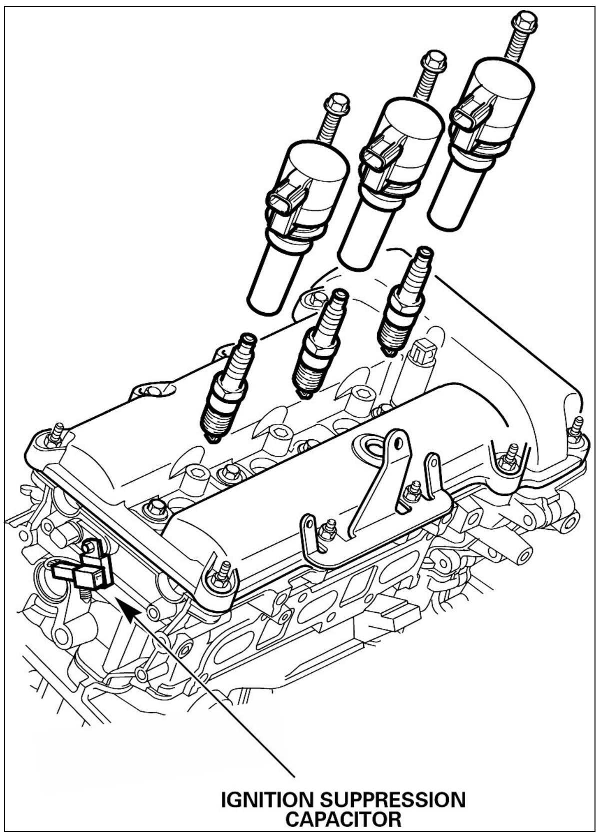

Fig. 52 ON-PLUG IGNITION COILS – V6

The primary coil switching duration is limited by the PCM to manage the voltage at 9.0v through the coils. Damage to the coils will result if the PCM switched circuit is short circuited to ground.

The ignition suppression capacitors in the B+ supply circuit, fitted to the rear of each cylinder head, prevent radio interference.

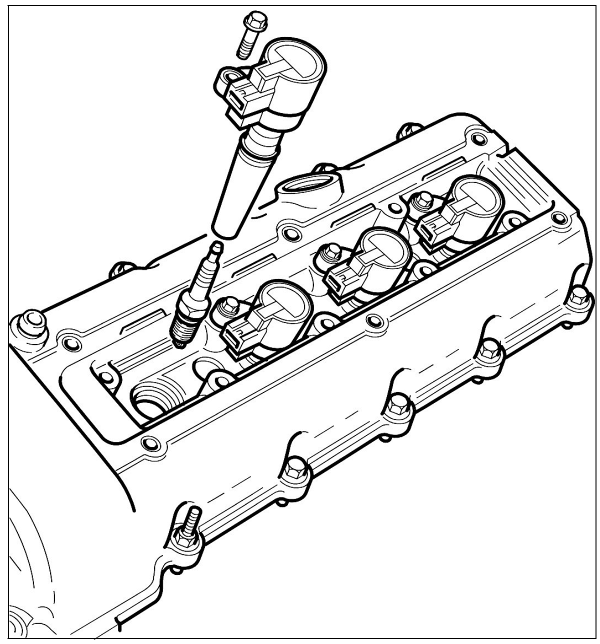

Fig. 53 ON-PLUG IGNITION COILS – V8

CAUTION:

The ignition coils are rated at approximately 9 volts. Testing a coil by applying B+ voltage will cause permanent damage and may destroy the unit.

Knock Sensor (detonation) Control

The ECM retards ignition timing to individual cylinders to control ignition knock (detonation) and optimize engine power. Two knock sensors (KS) are positioned on the cylinder block to sense engine detonation. One KS is positioned on bank 1 and the other on bank 2.

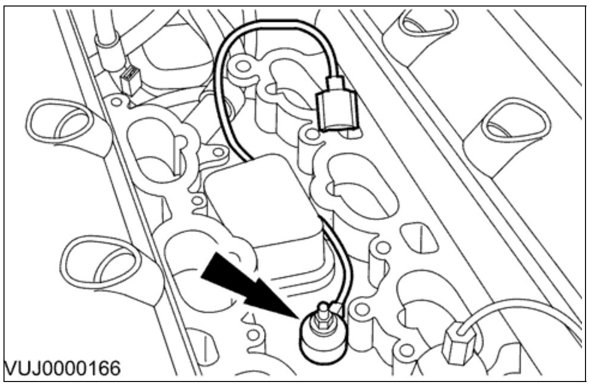

Fig. 54 KNOCK SENSOR 1 — V6

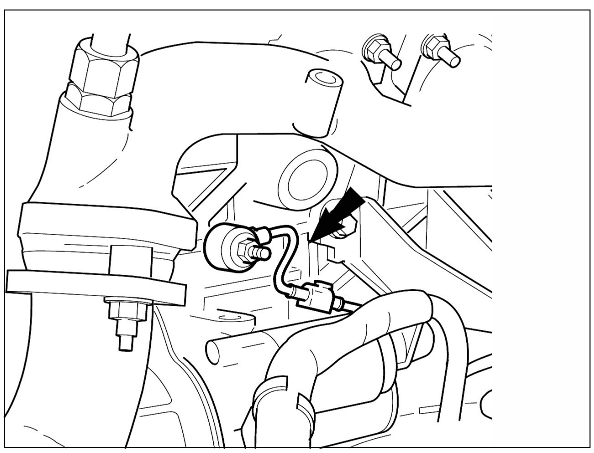

Fig. 55 KNOCK SENSOR 2 – V6

V6 knock sensors are attached to the engine bank in different locations.

- knock sensor 1, with the long flying lead, is located near the oil separator on the top of the bank 2 cylinder block.
- knock sensor 2, with the short flying lead, is located on the right side of bank 1 of the engine block above the starter motor

V8 knock sensors are unchanged from previous Jaguar V8 engines. Each knock sensor has a piezo electric sensing element to detect broad band (2 – 20 kHz) engine accelerations.

If detonation is detected, the PCM determines which cylinder is firing, and retards the ignition timing for that cylinder only. If, on the next firing of that cylinder, the detonation reoccurs, the PCM will further retard the ignition timing.

If the detonation does not reoccur on the next firing, the PCM will advance the ignition timing incrementally with each firing. The knock sensing ignition retard / advance process can continue for a particular cylinder up to a specified maximum retard measured in degrees of crankshaft rotation.

During acceleration at critical engine speeds, the PCM retards the ignition timing to prevent the onset of detonation. This action occurs independent of input from the knock sensors

VARIABLE VALVE TIMING / VARIABLE INTAKE

Variable Valve Timing (VVT) – V6

A VVT system is used to allow the phasing of the inlet valve opening to be changed relative to the fixed timing of the exhaust valves. Two positions are used, 30 degrees apart, with the advanced position occurring at 30 degrees BTDC and overlapping with the exhaust opening.

The operating strategy is controlled by the engine management system in conjunction with the variable geometry induction system so as to optimize torque characteristics over the engine speed/load range. The VVT system also provides increased amounts of 'internal' EGR under certain speed/load operating conditions.

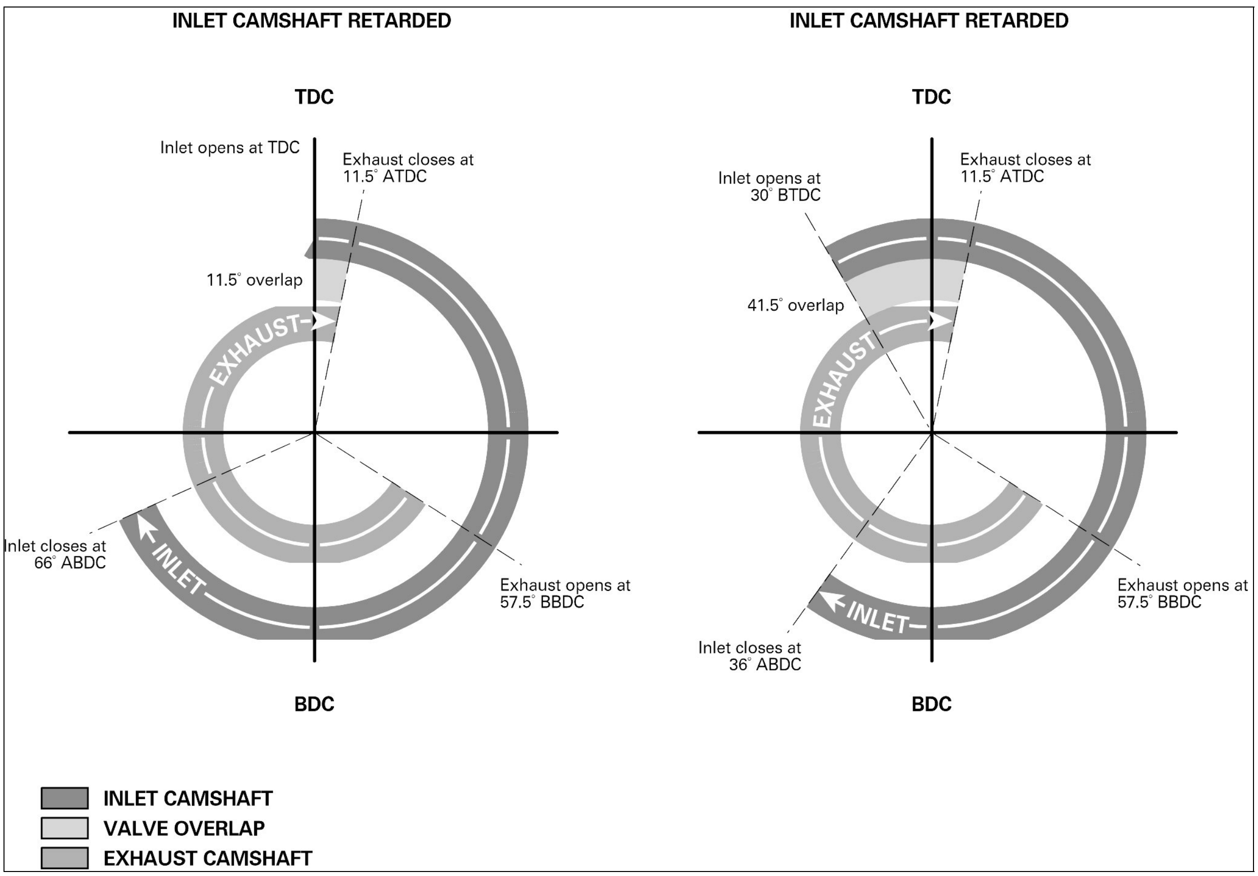

Fig. 56 TWO-STAGE VVT TIMING – V6 (CRANKSHAFT ROTATION SHOWN)

V6 VVT Oil Feed

The VVT/sprocket unit is fixed on the nose of each inlet camshaft via a locating pin and hollow bolt and is driven directly by the timing chain.

The oil feed to each VVT unit is supplied via fixed oilways in the cylinder heads. The oil feed is controlled by the VVT solenoid operated oil control valves, which are bolted directly to each cylinder head.

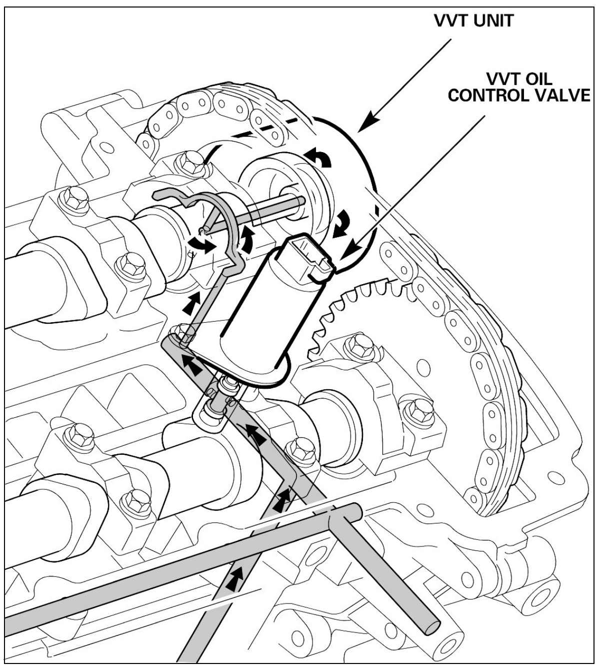

Fig. 57 VVT OIL FEED – V6

V6 VVT Operation

From the oil control valve, the flow is via the thrust bearing cap, through drillings in the camshaft and then through the hollow fixing bolt which secures the VVT unit. Drain holes are provided at the rear (camside) face of the VVT unit for any residual oil which has seeped past the piston.

With the oil control valve open, oil pressure on the helical drive piston is increased, rotating the cams to the advanced position. When the valve closes, oil pressure reduces and the return spring pushes the piston back to the fully retarded position.

The oil control valve is controlled by a 300Hz PWM signal from the PCM which sets it to either the fully open or fully closed position.

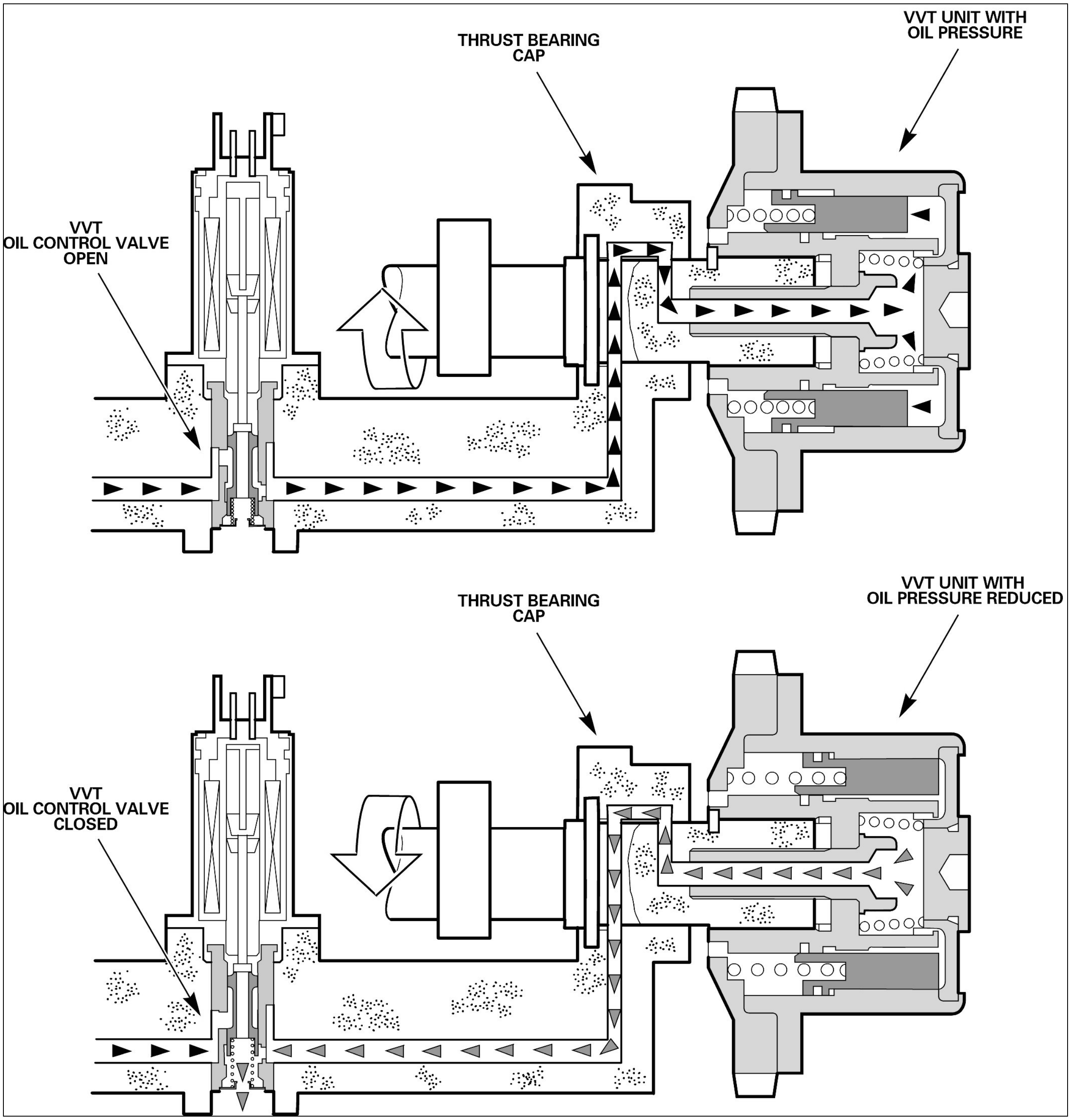

Fig. 58 TWO-STAGE VVT OPERATION – V6

Variable Valve Timing – V8

The V8 variable valve timing (VVT) system is the same as the linear VVT system used on AJ27 V8 engines. The system provides continuously variable inlet valve timing over a crankshaft range of 48° ±2°.

Depending on driver demand, engine speed/load conditions and Powertrain Control requirements, the inlet valve timing is advanced or retarded to the optimum angle within this range.

Compared to the two position system on the AJ26, the inlet valve opening angle is advanced by an extra 8°, providing greater overlap and increasing the internal EGR effect (exhaust gases mixing with air in the inlet port).

See 16–BIT AJ-27 VVT system for more information.

Variable Intake System (V6)

V6 engines use a variable intake system designed to optimize engine torque across the engine speed / load range. Variable intake combined with variable valve timing provides an optimized engine torque curve throughout the engine operating range.

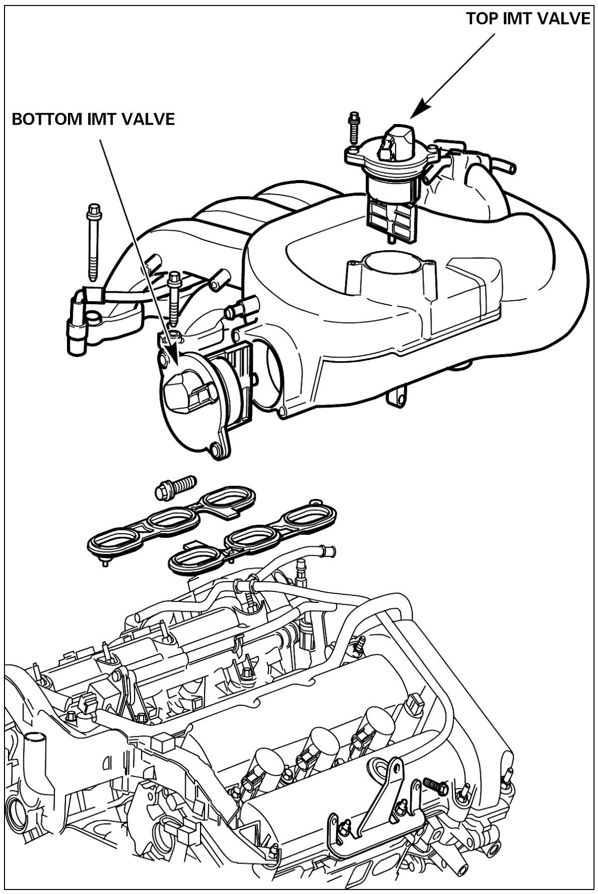

Fig. 59 VARIABLE INTAKE SYSTEM MANIFOLD (V6)

Variable Intake Components

The throttle body connects directly to the induction manifold assembly, which is constructed of aluminum alloy. The manifold mounts to the cylinder heads with the lower intake manifold assembly "sandwiched" between.

The manifold plenum chamber is split into upper and lower compartments with two interconnecting holes. Two identical Intake Manifold Tuning (IMT) Valves are located at the interconnecting holes.

The IMT valves are solenoid operated gate valves, which rotate 90° for open / close. B+ voltage is separately supplied to each IMT valve via powertrain control relay 1 in the front power distribution box.

The PCM switches the ground side of the valves via separate hard wires to activate the solenoids.

The plenum chamber volume and the length of the intake air path are tuned by the positions of the IMT valve gates to assure that the natural charge air pressure waves or pulses are maximized for the ever changing engine speed and load conditions.

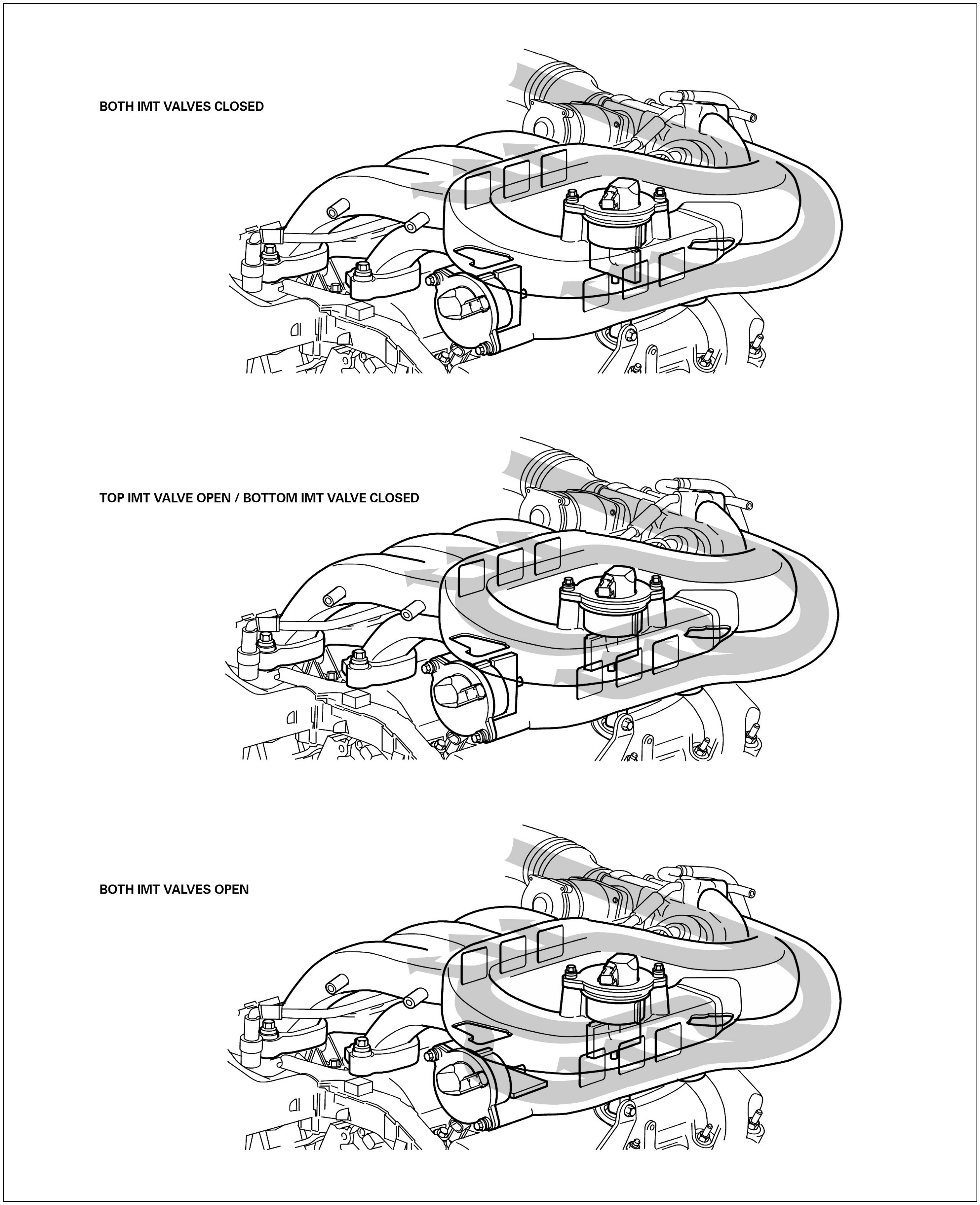

Fig. 60   VARIABLE INTAKE SYSTEM OPERATION (V6)

The plenum chamber volume and manifold geometry can be set to three different configurations based on the specific engine speed / load range:

- short pipe — Both IMT valves closed provides the minimum plenum volume and the shortest intake air path to the cylinders.
- medium-length pipe— With the top valve open and the bottom valve closed, plenum volume and the effective length of the intake air path are both increased.
- long pipe — With both valves open, the plenum volume and the air intake path effective length are at their maximum.

The two IMT valves, controlled by the PCM are set in combination to provide the three manifold configurations. The PCM calculates the required valve positions using the following data:

- Engine speed from CKP sensor
- Throttle position from TP sensors
- Engine temperature from CHT sensor
- Charge air temperature from IAT sensor

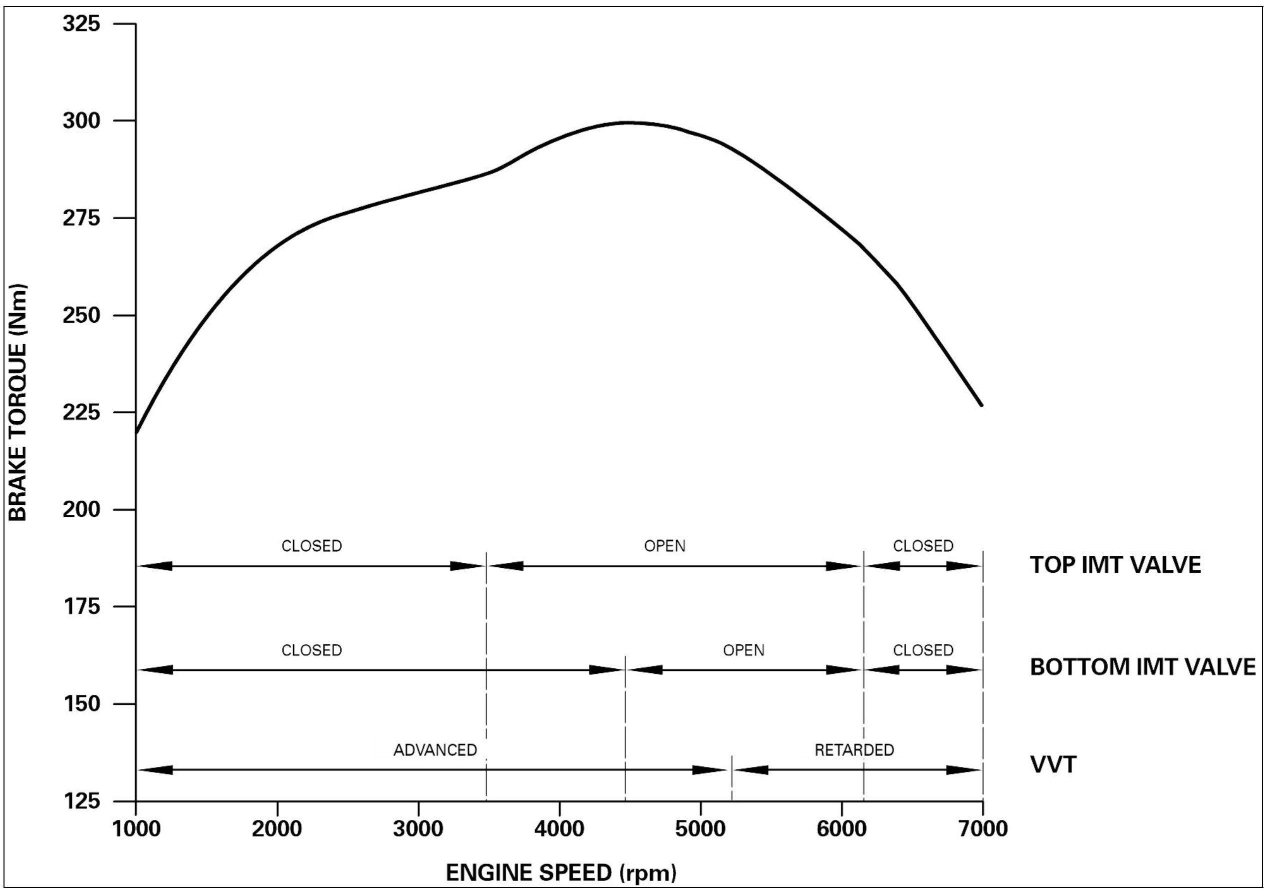

Fig. 61 ENGINE TORQUE CHARACTERISTICS

EXHAUST GAS RECIRCULATION (EGR): 2000MY V6 ONLY

System Overview

The EGR system is only fitted to V6 engines and comprises the following components:

- EGR vacuum regulator valve
- EGR valve
- Differential pressure feedback EGR sensor
- Exhaust gas transfer pipe with internal orifice

Exhaust gas is recirculated back to the engine intake in proportion to a measured pressure differential in the feedback pipe. The amount of gas recirculated varies primarily with engine speed and load but is also modified by the PCM to allow for other factors, e.g. coolant temperature, and also to achieve optimum emissions and fuel economy.

The recirculated exhaust gas is taken from the bank 1 exhaust manifold and fed into the engine via the EGR valve. The transfer pipe contains an internal tube with a small diameter orifice that creates a pressure differential in the transfer pipe. Two small pipes, connected to the transfer pipe each side of the orifice, transmit the pressure differential to the differential pressure feedback EGR sensor.

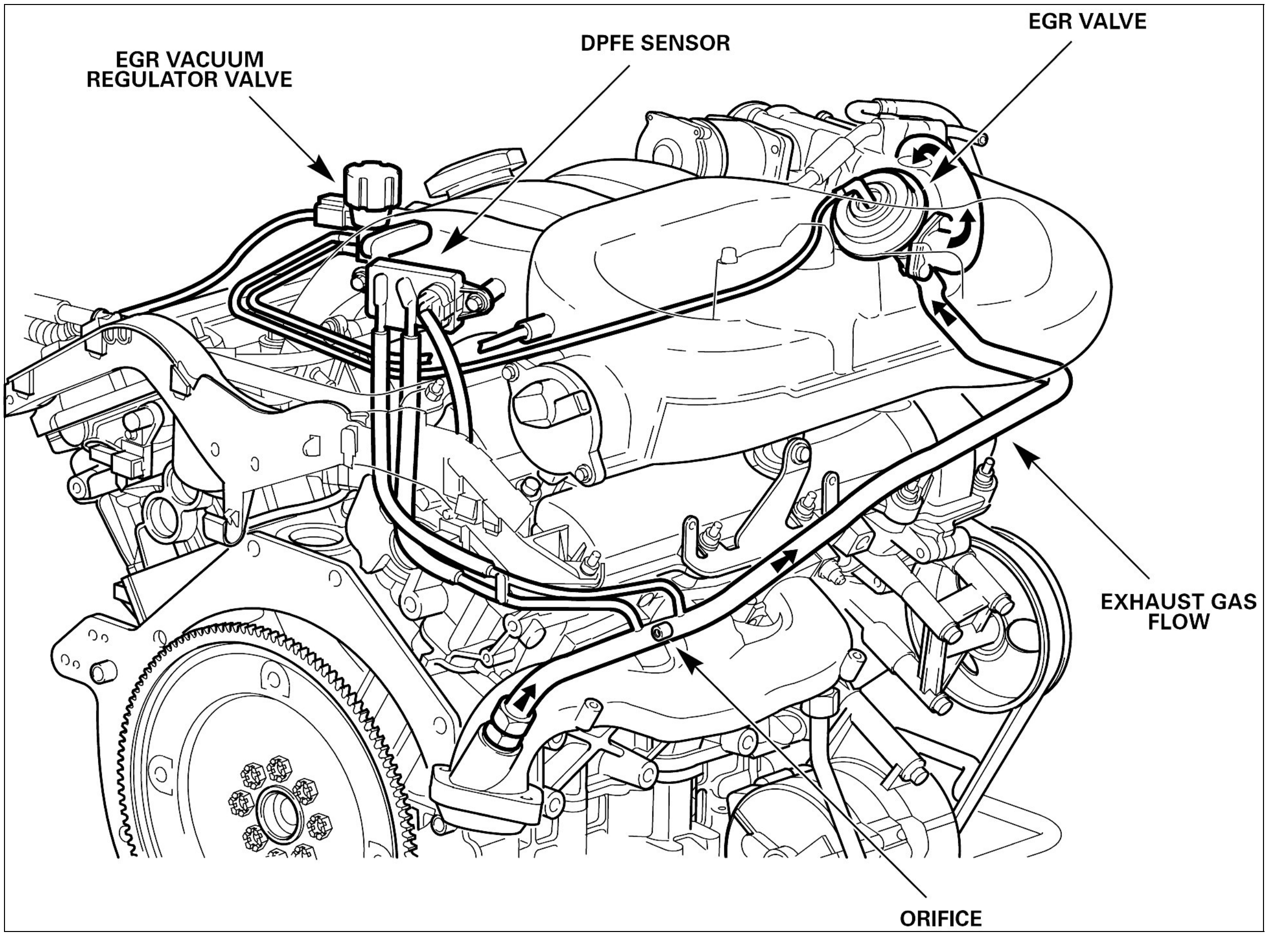

Fig. 62 EGR SYSTEM (V6)

Differential pressure feedback EGR (DPFE) sensor

The PCM receives an EGR flow feedback signal from the DPFE sensor. The sensor consists of a delta pressure transducer which measures the pressure drop across an orifice in the EGR tansfer pipe, and converts the input pressure / vacuum value to a corresponding analogue voltage signal. The DPFE sensor has a linear response to EGR mass flow rate, and the variations in exhaust pressure produce a signal voltage in the range of 1V – 3.5V dc.

The EGR vacuum regulator valve and the EGR valve comprise the actuating components of the control loop. The EGR vacuum regulator valve has a vacuum input from the manifold distribution pipes, a vacuum output to the EGR valve, and receives a pulse width modulated (PWM) signal from the PCM.

The PWM signal switches the vacuum control output to the EGR valve according to input demand from the differential pressure feedback EGR sensor or in response to override conditions determined by the engine management system.

The EGR valve is a vacuum operated diaphragm valve with no electrical connections, which opens the EGR transfer pipe to the induction manifold under the EGR vacuum regulator control.

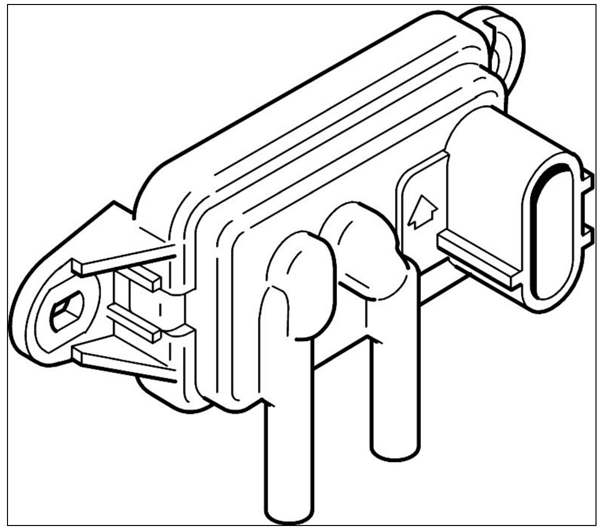

Fig. 63 DPFE SENSOR (V6)

EGR Control Conditions

EGR operates over most of the engine speed/load range but is disabled by the engine management system under certain conditions:

- During engine cranking
- Until normal operating temperature is reached
- When the diagnostic system registers a failure which affects the EGR system (e.g. a faulty sensor)
- During idling to avoid unstable or erratic running
- During wide open throttle operation
- When traction control is operative.

While the main control loop is based on feedback from the differential pressure feedback EGR sensor, the EGR rate is also modified by other engine conditions; coolant, ambient and charge air temperatures, barometric pressure, VVT cam position and charge air mass. Note also that the EGR rate increases gradually after it is enabled during each driving period.

OTHER PCM ENGINE CONTROL AND INTERFACE FUNCTIONS

Radiator Cooling Fan and Air Conditioning Compressor Control

The S-TYPE radiator cooling fan is driven by a variable speed 500W electric motor. An electronic cooling fan module, located under the radiator cooling pack, drives the fan motor.

The cooling fan module is supplied with:

- ignition switched 20 Amp fused B+ power supply from powertrain relay 1 for the control circuit
- battery direct B+ power supply via the 80 Amp fuse adjacent to the front power distribution box for fan motor drive.

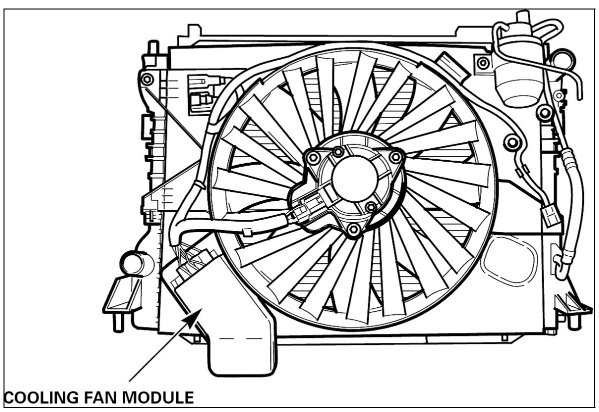

Fig. 64 S-TYPE RADIATOR COOLING FAN ASSEMBLY

When the engine is running, the cooling fan module receives a PWM control signal proportional to the engine cooling requirements from the PCM. In response to the PCM control signal, the cooling fan module switches the fan motor ON and OFF and varies fan speed between 300 rpm to 2900 rpm using PWM drive voltage.

As the engine is switched off, the A/CCM notes the engine coolant (V8) or cylinder head (V6) temperature (SCP MESSAGE) and provides a control signal to the cooling fan control module for a fixed period of time to operate the fan motor. The engine off fan operational time period is determined by the A/CCM based on the SCP temperature message.

In addition to radiator cooling fan control, the PCM controls the operation of the air conditioning compressor clutch. The PCM receives the air conditioning compressor operation request from the A/CCM via the SCP network.

The PCM calculates the engine cooling requirement from signal inputs received from the following sources:

- ECT sensor (V8)
- CHT sensor (V6)
- Air conditioning pressure sensor
- Air conditioning compressor status
- Transmission fluid temperature

Air Conditioning Pressure Sensor

The air conditioning pressure sensor, located in the A/C “high side” is a pressure transducer sensing refrigerant system high side pressure. The feedback voltage from the transducer supplies the PCM with a signal proportional to refrigerant pressure. The PCM uses the refrigerant pressure signal for coolant fan requirement and compressor clutch control.

Fail Safe Engine Cooling (V6)

V6 PCMs are programmed with a function that monitors engine temperature and performs actions that prolong safe engine operation by controlling engine temperature. This "fail safe engine cooling" strategy is fully controlled by the PCM. Fail safe engine cooling strategy on V6 engines is made possible by monitoring the engine temperature with a cylinder head temperature (CHT) sensor (metal contact) instead of a ECT sensor (coolant).

If the PCM detects excessively high engine temperature, it switches off the fuel injector(s) of one or more cylinders. With no fuel being injected, ambient air is pumped through the cylinder cooling the piston and valvetrain for that particular cylinder. By switching individual injectors off for a period of time and in a sequence determined by the PCM, engine temperature can be controlled to allow the vehicle to be driven for a short distance.

The overall engine cooling strategy can be divided into five stages. The fail safe engine cooling (FSC) strategy operates in the three bottom stages as explained in the following chart.

Table 5 Engine cooling strategy

Stage	Temperature	Warnings	Action
Normal	82 °C (180 °F) – 118 °C (245 °F	Coolant temp gauge	Normal cooling fan control
Above normal	> 118 °C (245 °F) – <121 °C (250 °F)	Coolant temp gauge in RED zone ENGINE OVERTEMP warning light CHECK ENGINE TEMP message Single chime	Cooling fan maximum
FSC Stage 1 Reduced power	> 121 °C (250 °F) – < 149 °C (300 °F)	Coolant temp gauge in RED zone ENGINE OVERTEMP warning light REDUCED ENGINE POWER message CHECK ENGINE MIL	Cooling fan maximum PCM begins selectively and alternately shutting off the fuel injectors Engine speed limited
FSC Stage 2 Stop engine safely	> 149 °C (300 °F) – < 166 °C (330 °F)	Coolant temp gauge in RED zone Flashing ENGINE OVERTEMP warning light STOP ENGINE SAFELY message CHECK ENGINE MIL Five chimes	Cooling fan maximum PCM begins selectively and alternately shutting off the fuel injectors Engine speed limited
FSC Stage 3 Engine shut down	166 °C (330 °F)	Coolant temp gauge in RED zone ENGINE OVERTEMP warning light CHECK ENGINE MIL	Cooling fan max PCM shuts down engine

Generator

The PCM is responsible for issuing SCP commands directing the instrument pack to switch the generator warning light OFF or ON. Each time the ignition is switched ON to position II, the instrument pack initiates its bulb check cycle. The generator warning light will remain active until the instrument pack receives an SCP LOW VOLTAGE TELLTALE (OFF) message from the PCM.

The PCM receives generator charging voltage information via a hard wire from generator pin marked ALTLMP on the generator. If the charging system is functioning correctly, the PCM transmits the SCP LOW VOLTAGE TELLTALE (OFF) message. If the PCM detects an out of range voltage (high or low) during normal operation, it transmits an SCP LOW VOLTAGE TELLTALE (ON) message signaling the instrument pack to activate the generator warning light.

If the generator detects an internal fault it holds the ALTLMP signal at zero volts. After 15 seconds at zero volts the PCM transmits the SCP LOW VOLTAGE TELLTALE (ON) message and triggers a non OBD II DTC.

The PCM receives generator load information via a hard wire from the generator pin marked FRI. This circuit communicates a PWM signal proportional to generator field load. When the vehicle battery is fully charged and electrical demands are low, generator output can drop to zero resulting in a B+ voltage signal.

As generator output increases to supply increased electrical demands the PWM duty cycle increases. At full generator output the duty cycle is 100% resulting in a continuous zero voltage signal. The PCM increases throttle valve opening at idle to compensate for the increased generator load.

TRAINING PROGRAM

JAGUAR ENGINE MANAGEMENT SYSTEMS AND ADVANCED EMS DIAGNOSTICS - BOOK B

PUBLICATION CODE – 870B

OVERVIEW AND CONTROL SUMMARY

Overview

The Jaguar / Denso 32 Bit EMS is designed as a generic Jaguar system that is applicable to all V6, V8 normally aspirated and V8 supercharged engines across the model ranges.

The system was first introduced in the X-TYPE V6 engine and has now been applied to the remainder of the Jaguar model ranges.

Application is as follows:

Table 6 System Application

Vehicle Range	Model Year	Emission Control
X-TYPE (AJ61)	2002 (2004MY)	LEV (LEV-2)
S-TYPE (AJ62/AJ33)	2003	LEV–2
XK (AJ34)	2003	LEV–2
XJ (AJ33)	2004	LEV-2

The system is built around a two-microprocessor based 32-bit Engine Control Module (ECM). One microprocessor is dedicated to throttle control and diagnostics; the other microprocessor handles all other ECM functions, controls and diagnostics.

The ECM is linked to and communicates with other powertrain control modules via the Controller Area Network (CAN). Communication with other vehicle control modules is carried out via the CAN / SCP gateway, internal to the instrument cluster.

The ECM governs all engine operating functions including:

- Throttle control (full authority)
- Fuel delivery
- Fuel pressure
- Sequential fuel injection
- Ignition via on-plug ignition coils
- Idle speed control
- Exhaust emission control
- Enhanced evaporative emission control
- Intake valve timing
- Intake manifold tuning (V6 only)
- Exhaust gas recirculation (certain variants only)
- Cooling system radiator fan control
- Air conditioning compressor control (XJ via CAN)
- Vehicle speed (cruise) control
- Engine speed limiting
- Vehicle speed limiting
- Engine torque control
- EMS and OBD II diagnostics
- Default operating modes including engine speed and throttle limits
- Vehicle electrical load control (XJ only)

Engine Cylinder Numbering

Jaguar has adopted the SAE standard for cylinder numbering. This standard uses the engine driveplate (flywheel) as a datum point.

Cylinder 1 is the greatest distance away from the datum point; cylinder 2 the next greatest distance away, continuing through six or eight cylinders.

Using this standard, Jaguar engines are numbered cylinders 1, 3, 5, 7 on the RH bank (bank 1) and 2, 4, 6, 8 on the LH bank (bank 2).

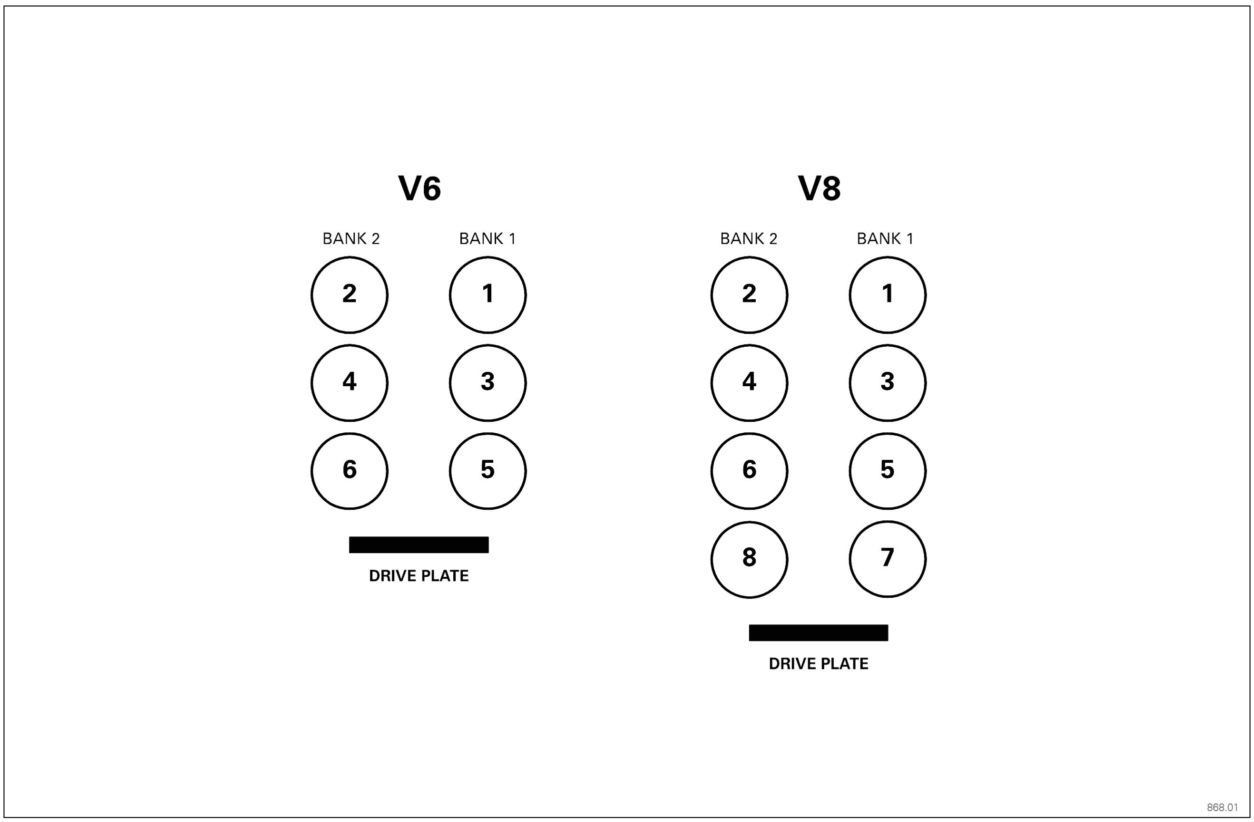

Fig. 65 ENGINE CYLINDER NUMBERING

ENGINE CONTROL SUMMARIES

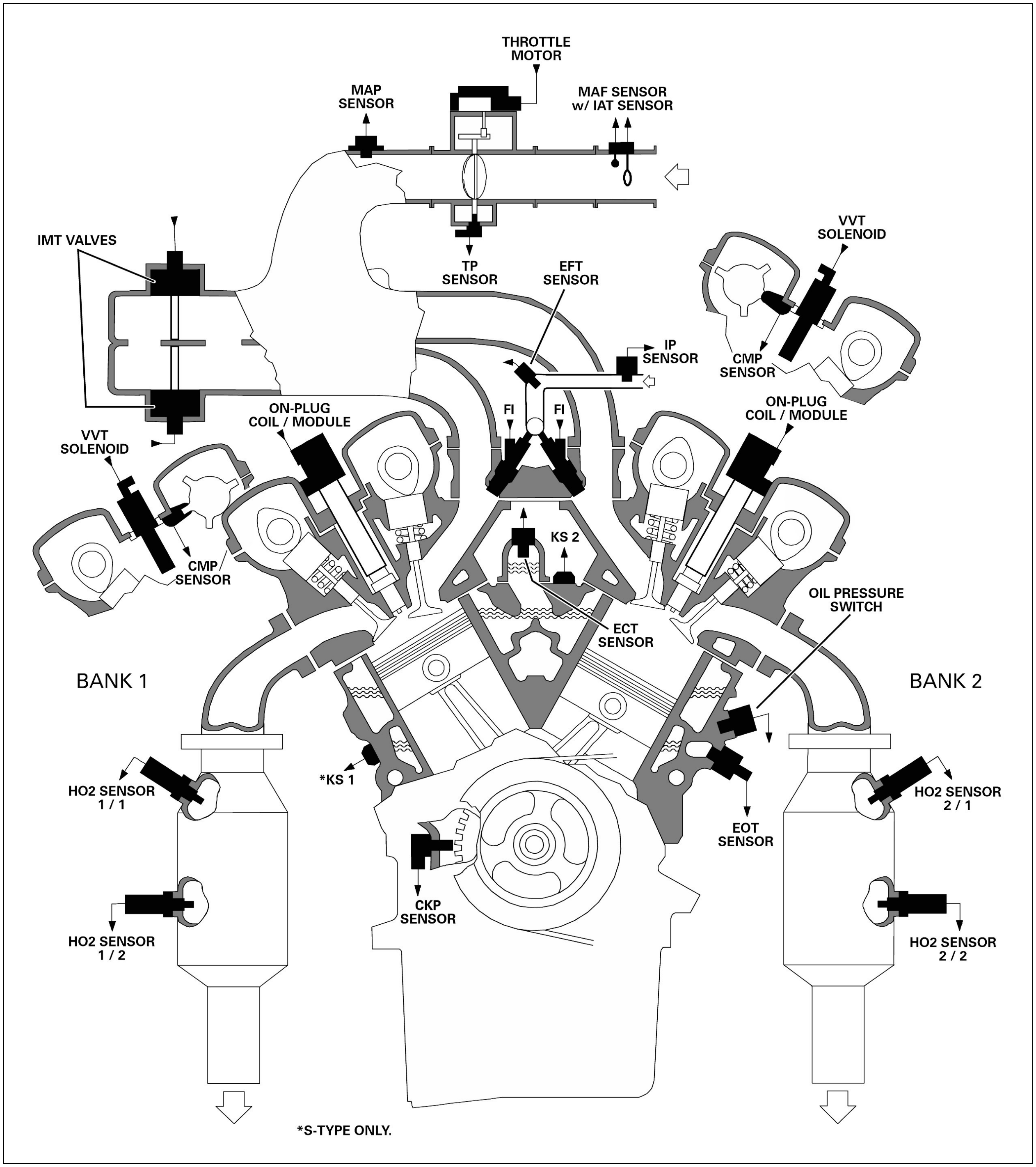

Fig. 66 AJ61/62 ENGINE MANAGEMENT COMPONENTS

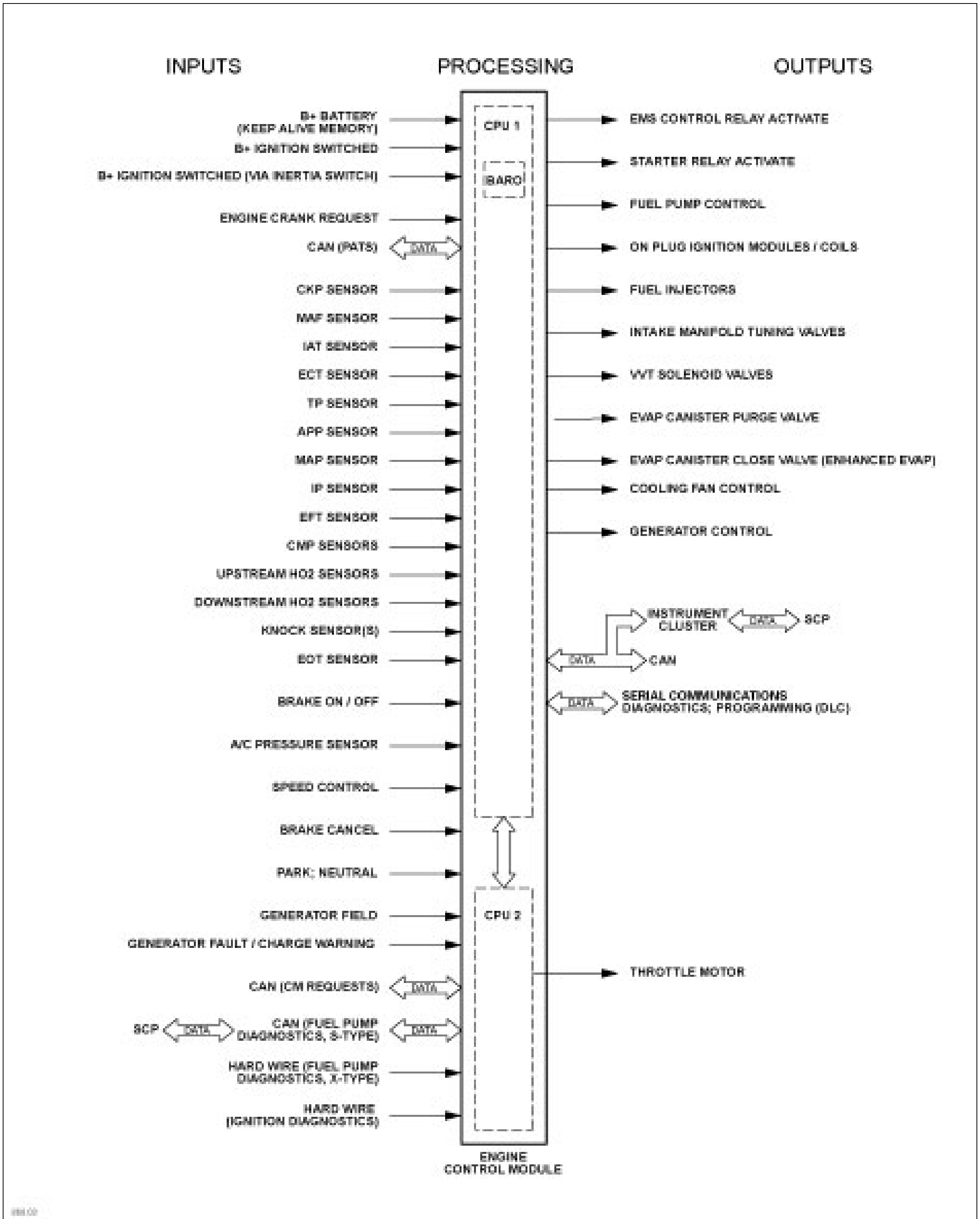

Fig. 67 AJ61/62 ENGINE MANAGEMENT INPUTS / OUTPUTS

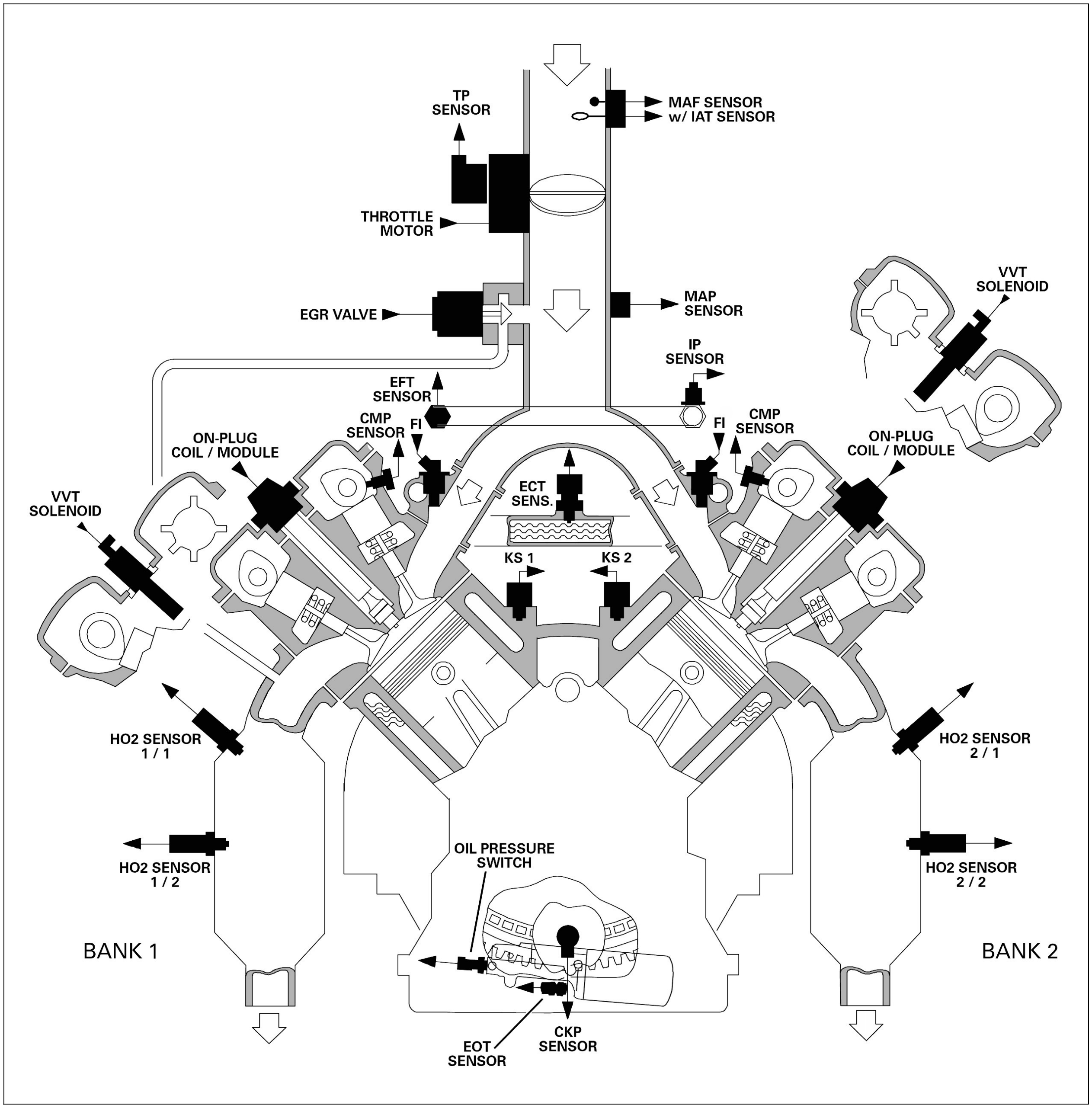

Fig. 68 AJ33/34 N/A ENGINE MANAGEMENT COMPONENTS

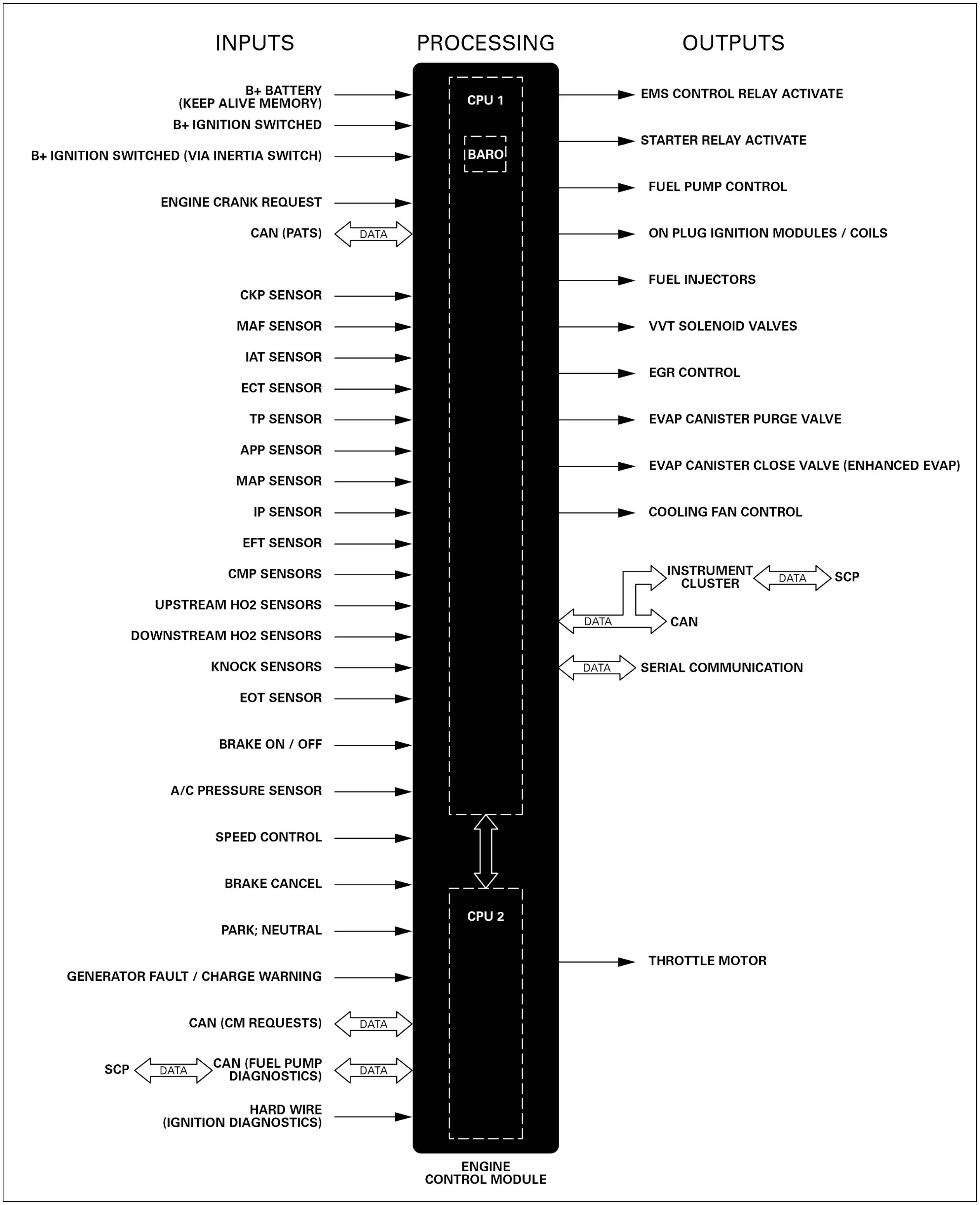

Fig. 69 AJ33/34 N/A ENGINE MANAGEMENT INPUTS / OUTPUTS

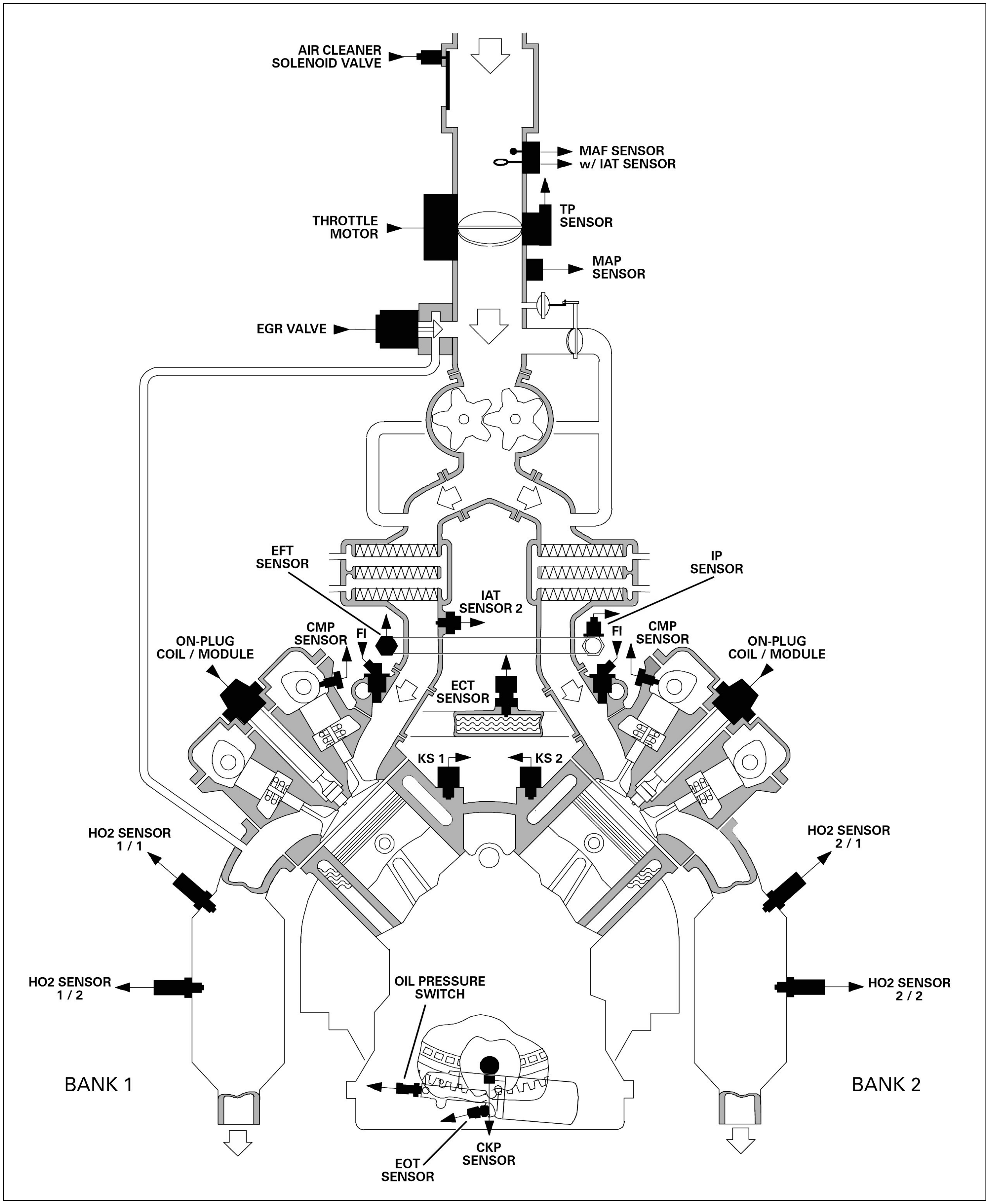

Fig. 70 AJ33/34 SC ENGINE MANAGEMENT COMPONENTS

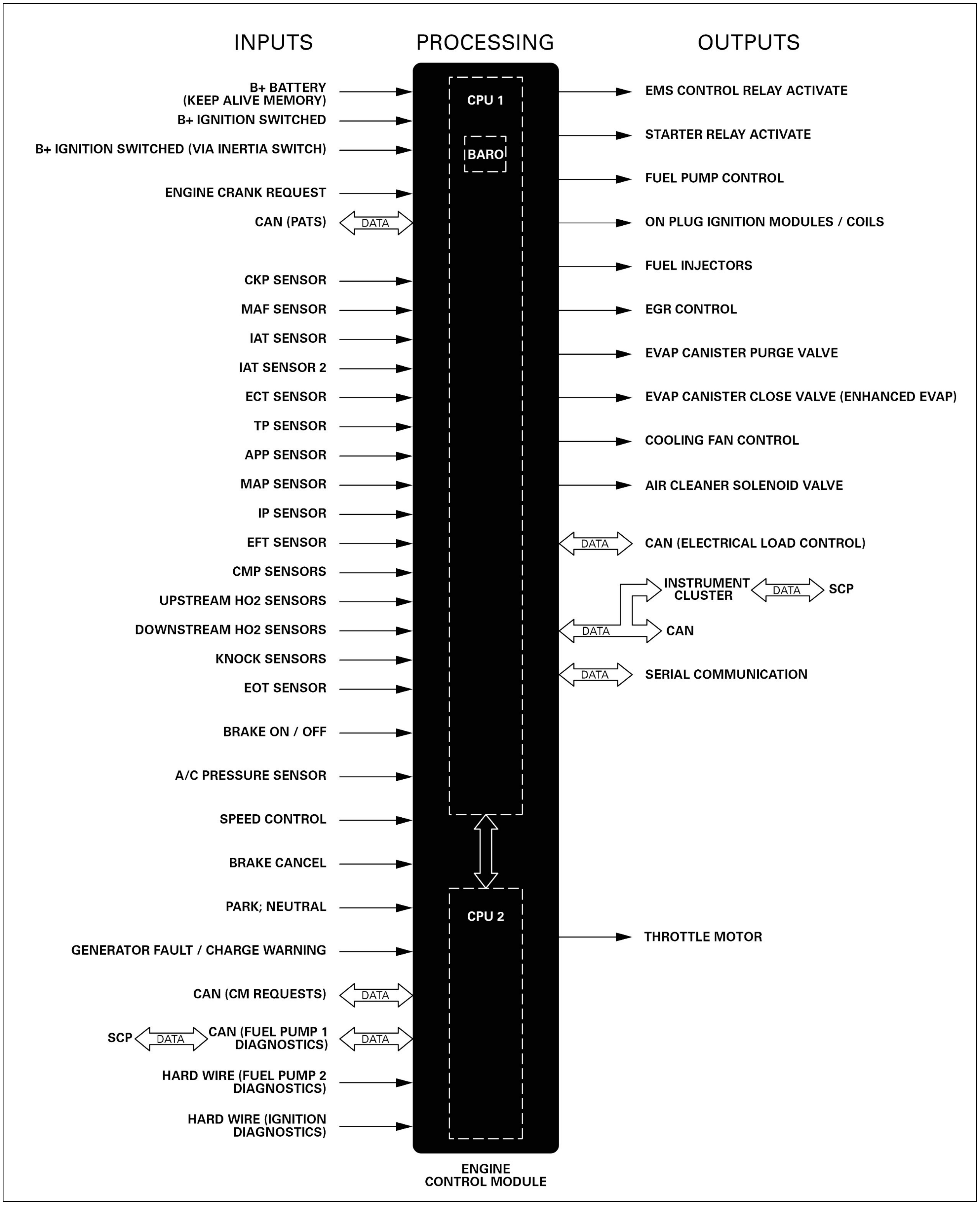

Fig. 71 AJ33/34 SC ENGINE MANAGEMENT INPUT / OUTPUTS

ENGINE CONTROL MODULE (ECM)

Hardware

Jaguar / Denso 32 Bit ECMs share a common construction with unique installation hardware for each vehicle application. X-TYPE, 2003MY S-TYPE and 2004MY XJ vehicles have the ECM located through the front bulkhead on the right hand side. XK vehicles have the ECM located in the right hand side control module enclosure. A single 134- pin connector is common to all ECMs.

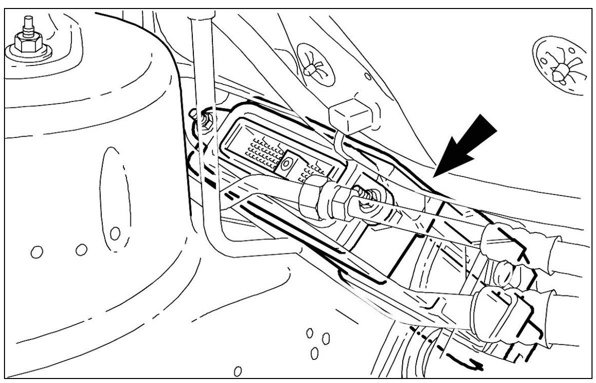

Fig. 72 X-TYPE ENGINE CONTROL MODULE

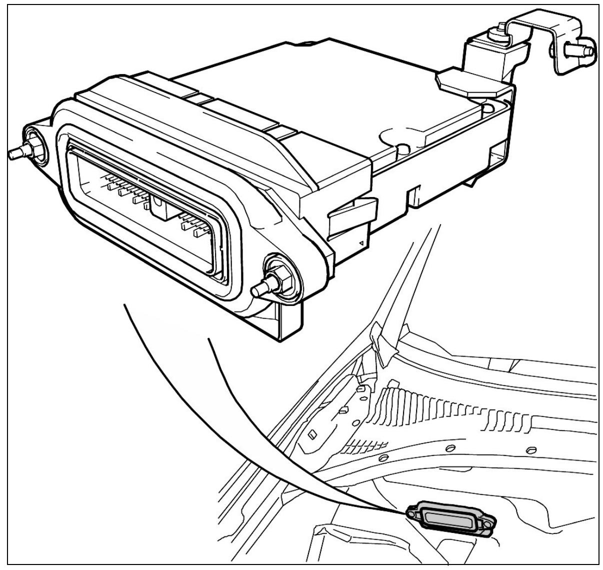

Fig. 73 S-TYPE ENGINE CONTROL MODULE

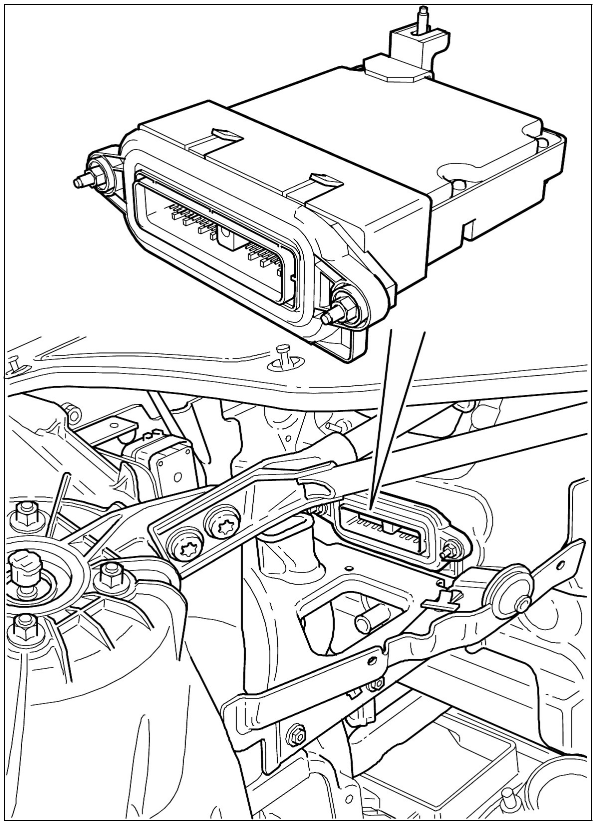

Fig. 74 XJ ENGINE CONTROL MODULE

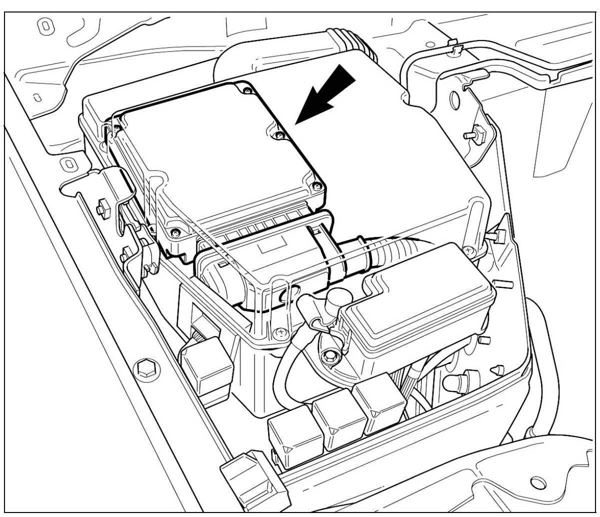

Fig. 75 XK ENGINE CONTROL MODULE

ECM Power Supplies

The ECM has three power supplies:

- Battery power supply pin 022 — This circuit supplies continuous battery power to maintain the volatile memory where diagnostic and adaptive value data is stored.
- Ignition switched power supply pin 007 — This circuit signals the ECM that the ignition switch has been moved to the II (RUN) position.
- Ignition switched power supply (via inertia switch) pin 010 — This circuit is used to signal the ECM that the inertia switch has been tripped in the event of a vehicle impact. If the inertia switch is tripped, all EMS components will be deactivated. Fuel pump drive(s) from the Rear Electronic Module (S-TYPE, XJ), Fuel Pump Module (X-TYPE, XK), and supercharged second Fuel Pump Module (S-TYPE, XJ) are also deactivated when the inertia switch is tripped.

NOTE:

Due to the “ignition switched ground supply” electrical architecture, XK vehicles apply a ground signal to pin 010 if the inertia switch is tripped.

When the ECM receives the ignition switched signal, it performs internal initialization and PATS functions. Once these are complete, the ECM activates the EMS Control Relay and the Throttle Motor Relay to power the EMS sensors and components, and the throttle motor.

Depending on the vehicle, all EMS components (excluding the throttle) are either powered via the EMS control relay or use additional relays for specific components.

Refer to the applicable Electrical Guide for circuit details.

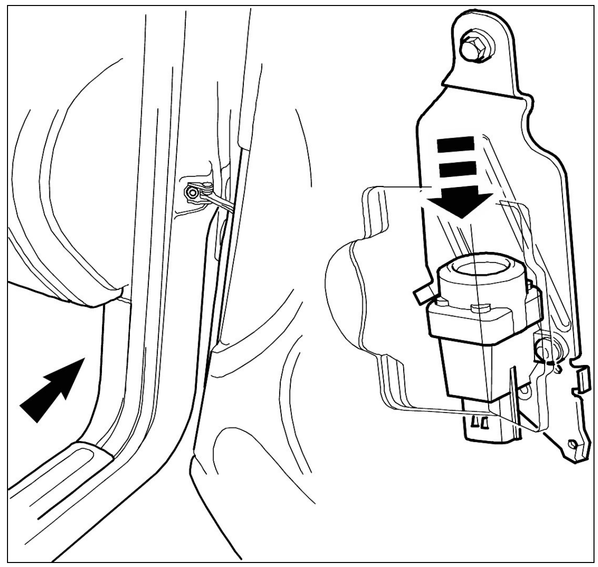

Fig. 76 X-TYPE INERTIA SWITCH

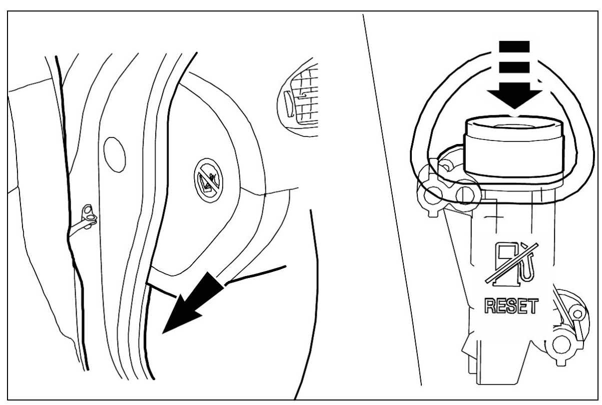

Fig. 77 S-TYPE INERTIA SWITCH

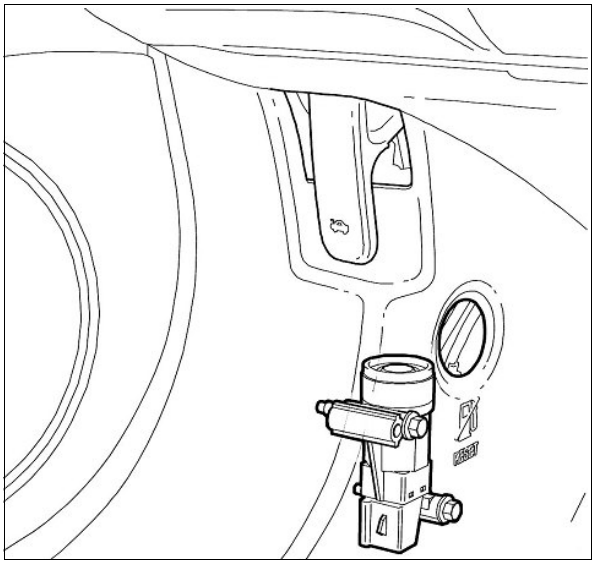

Fig. 78 2004 XJ INERTIA SWITCH

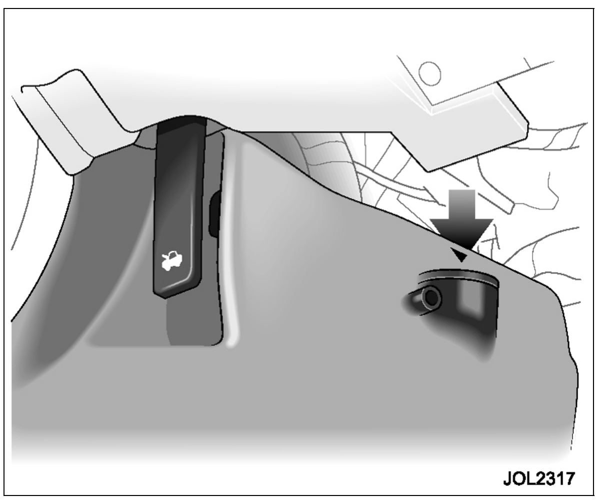

Fig. 79 2003 XK INERTIA SWITCH

ECM Data Recorder (32–BIT Systems)

The flight data recorder captures vehicle data in the event of an incident in the field. This data may be used for problem diagnosis and displayed using WDS.

The ECM will utilize an area of its RAM to provide a 10 second rolling buffer for a number of parameters defined by Jaguar. The data in the rolling RAM buffer will be refreshed every 256 milliseconds by the ECM CPU and will be transferred to an area of EEPROM once a trigger condition has been met.

The data storage area in EEPROM is divided into two areas (Area A and Area B) and the data transferred into these areas from RAM will depend on the trigger condition that has been detected. The data in these areas will represent events over a calibrated time prior to the trigger event followed by the remaining portion of the 10-second buffer after the trigger event.

Area A will only store data associated with the Area A trigger condition and likewise Area B will only store data associated with the Area B trigger conditions. The Data stored in area A will be overwritten with new data every time a trigger condition occurs.

The data stored in area B will be overwritten depending on the priority of the triggered data. The trigger priorities are as follows:

Highest priority A fuel pump cut off by the inertia switch being tripped will trigger data rated as the highest priority. This data will overwrite all other data and can only be cleared using WDS.

Medium priority A throttle default will trigger data rated at a medium priority. This data will overwrite any lower priority data. It will not overwrite medium or highest priority data.

Lowest priority An engine that fails to start or an engine that starts and stumbles will trigger data rated as the lowest priority. It will not overwrite high or medium priority data.

Whenever data is captured in EEPROM memory, the odometer reading and stored DTCs are also written to the EEPROM. DTC P1582 (Flight Recorder Information Available) will be logged whenever data is stored in either Area A or Area B.

To access the recorded information you can choose to read DTCs from the vehicle, and select the DTC (P1582) that indicates that ECM recorded data is available. The user may choose to investigate the DTC by pressing the DTC pinpoint button. This causes the application sub-tab to appear within DTC Monitor. This is consistent with existing methods of DTC investigation. The existing functionality of DTC Monitor will allow user help and the required DTC clearing operations to be performed as with any other DTC.

Or, the user can select Vehicle Configuration, then Special Applications, then select the ECM Data Recorder application from the Special Applications menu.

Table 7 Trigger Conditions for Data Storage

Condition	Trigger	Storage Area	Trigger Mode
Engine Stalls	Engine speed held above a calibrated threshold for more than a calibrated period of time, and then dropping below a calibrated threshold.	A	1
Engine fails to start	Engine speed remaining below a calibrated threshold for longer than a calibrated period of time while the engine is being cranked.	B	2
Engine starts and stumbles	Engine speed exceeding a calibrated threshold and then dropping below a calibrated threshold without meeting the conditions for "engine stall"	B	2
Throttle default	Entry into throttle default mode	B	4
Fuel pump cut off by inertia switch	Inertia switch going open circuit	B	5

ECM Data Recorder Parameters

- Throttle position
- Driver demand
- Engine speed
- Vehicle speed
- Fuel pulse width
- Ignition
- MAF volts
- Coolant temperature
- Air temperature
- PATS status
- CAN traction status
- Gear position selected
- Gear position actual
- Brake switch status
- Cruise control mode
- Fuel intervention
- Throttle failure flag
- Ignition angle
- Fuel pressure
- Battery voltage

Start Time Monitor The start time monitor is another feature within the data recorder function. This will display the length of time taken to start the vehicle in milliseconds for each of the last 50 engine starts. The ECM considers the engine to have started when the engine speed exceeds 700 RPM.

The display will also indicate the engine coolant temperature for each of the 50 starts as either low, medium or high. The following parameters are used:

- Low: < 15° C (59° F) –> 25 starts
- Medium: 15° – 70° C (59° — 158° F) –> 10 starts
- High: > 70° C (158° F) –> 15 starts

WDS will also display the total number of times the engine has been started and the average length of time taken. This data will be reset if the vehicle battery is disconnected.

Controller Area Network (CAN) and Serial Data Communications

The ECM is part of the controller area network that allows high-speed data transmission between powertrain control modules. The Instrument Cluster provides a “gateway” to the SCP network to allow communication with other vehicle control modules.

In addition to the CAN network, the ECM is connected to the Serial Data Link. The networks are accessed at the Data Link Connector (DLC) for DTC retrieval, system diagnostics and monitoring, and EEPROM flash programming.

Refer to the applicable Electrical Guide Appendix for a listing of CAN messages, sources and receivers.

CAN Network Diagnostic Monitoring

The CAN Network is continuously monitored by the ECM for EMS related data faults. If a failure occurs, no default action is taken.

EMS SENSING COMPONENTS

Mass Air Flow (MAF Sensor)

The MAF Sensor, located between the air cleaner and the air intake duct, provides the ECM with an engine load voltage signal. The MAF sensor is a hot wire anemometer. Mass air flow is determined by the ECM as proportional to the square of the voltage output from the MAF internal circuitry. The ECM supplies 5 volts (nominal) to the sensor and monitors the voltage on a separate signal return wire. The MAF Sensor and IAT Sensor are combined in an integral, plug-in unit, secured by two screws to the intake duct.

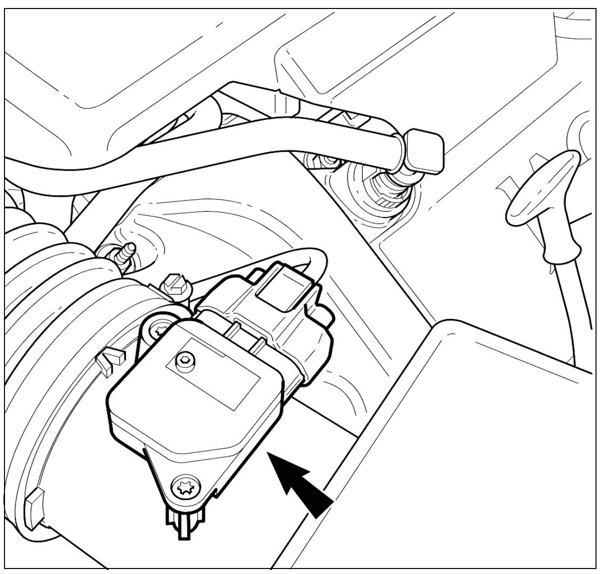

Fig. 80 MAF SENSOR (S/C SHOWN)

MAF Sensor Diagnostic Monitoring

The MAF Sensor circuits are continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for:

- Range / performance (actual mass airflow as compared to expected mass airflow)
- Signal circuit low voltage
- Signal circuit high voltage
- Ground circuit fault

If a fault is detected, the ECM will institute the following default actions:

- Default air mass used
- Adaptive fuel metering inhibited
- Catalyst warm up ignition retard inhibited
- Canister purge inhibited
- Maximum engine speed reduced

Intake Air Temperature (IAT Sensor)

The IAT Sensor provides the ECM with an intake air temperature voltage signal.

The IAT Sensor is a negative temperature coefficient (NTC) thermistor. Intake air temperature is determined by the ECM by a change in resistance within the sensor. The ECM applies 5 volts (nominal) to the sensor and monitors the voltage drop through the thermistor. The IAT Sensor is not serviceable separately from the MAF Sensor.

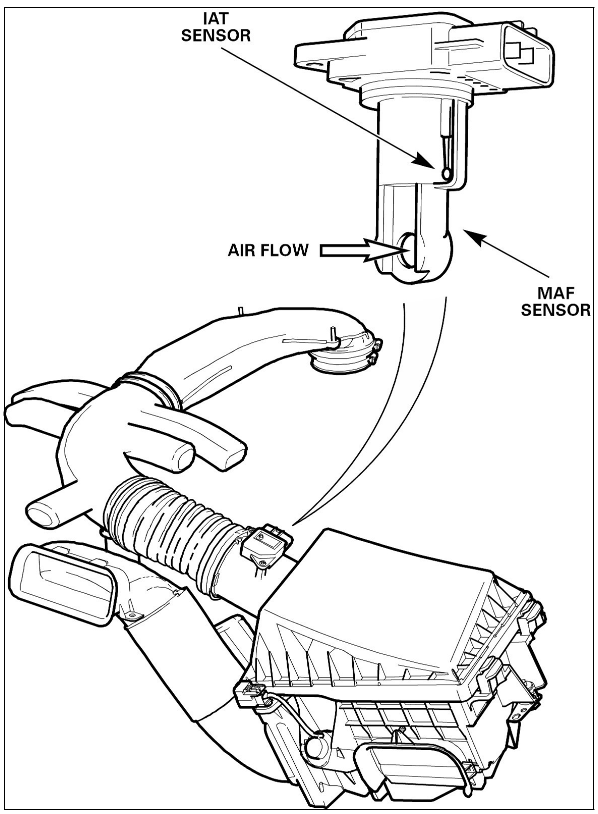

Fig. 81 IAT SENSOR

IAT Sensor Diagnostic Monitoring

The IAT Sensor circuit is continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for:

- Range / performance (actual intake air temperature as compared to expected intake air temperature)
- Signal circuit low voltage (high intake air temperature)
- Signal circuit high voltage (low intake air temperature)
- Sensor ground circuit fault (collective sensor ground circuit)

If a fault is detected, the ECM will substitute a value of 50 °C (122 °F).

Manifold Absolute Pressure (MAP Sensor)

Located at the rear of the intake manifold, the MAP Sensor provides the ECM with an additional engine load voltage signal. The sensor incorporates a pressure sensor capsule connected to a resistive element. Manifold absolute pressure changes (throttle valve opening / closing) act on the pressure capsule, which in turn acts on the resistive element to alter resistance.

The MAP is supplied with 5 volts (nominal) from the ECM and outputs a voltage to the ECM that is directly proportional to manifold absolute pressure.

Because the MAF Sensor is located so far from the intake valves, the MAF measurement may be inaccurate when the throttle is suddenly opened / closed, or at engine startup. During these throttle transition periods, the MAP Sensor signal is used for detecting the manifold absolute pressure change, which corresponds to the air charge as if measured right at the intake valves. Additionally, the MAP Sensor signal is used to monitor EGR flow on engines so equipped.

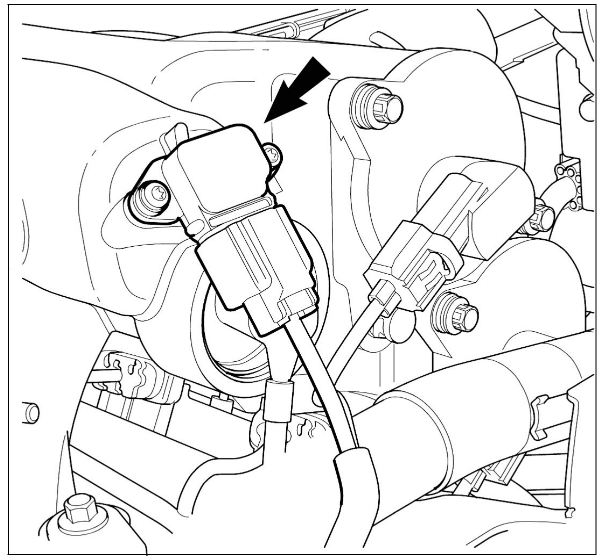

Fig. 82 V6 MAP SENSOR

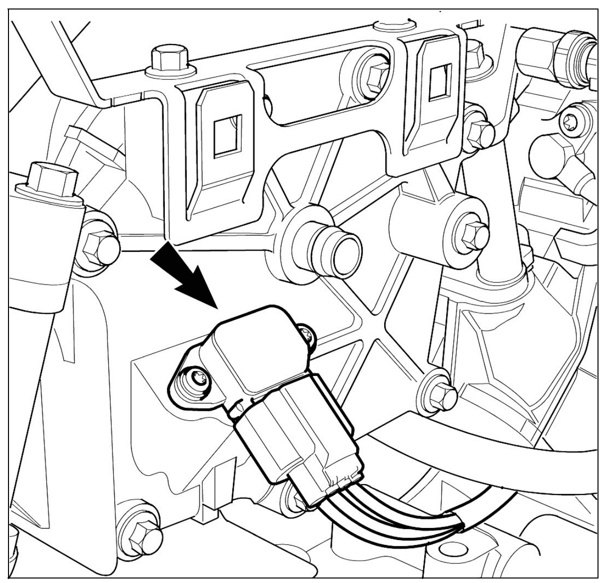

Fig. 83 V8 N/A MAP SENSOR

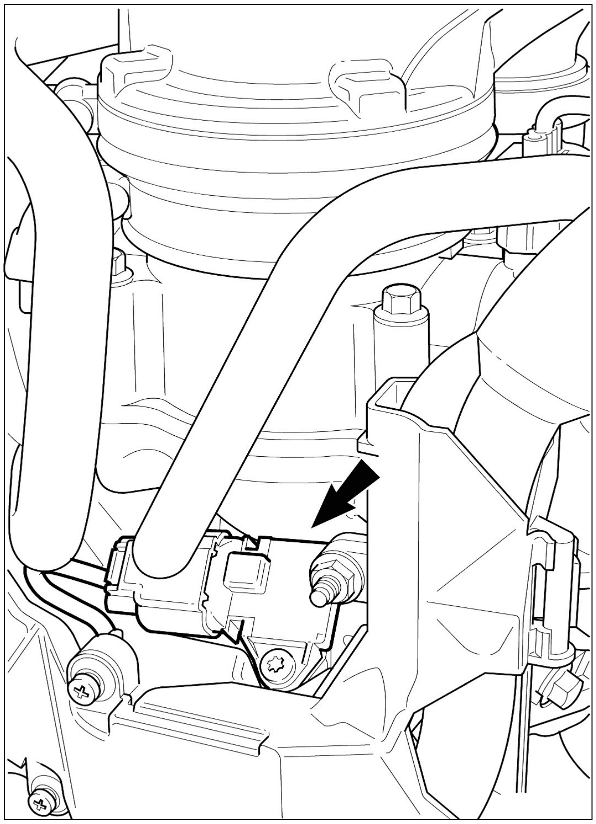

Fig. 84 V8 SC MAP SENSOR

MAP Sensor Diagnostic Monitoring

The MAP Sensor circuits are continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for:

- Signal circuit malfunction
- Signal circuit low voltage
- Signal circuit high voltage
- Sensor supply and ground circuit fault (collective sensor supply and ground circuits)

If a signal circuit fault is detected, the ECM will substitute a default value of 1 BAR.

Barometric Pressure

A barometric pressure sensor (BARO Sensor) is incorporated into the ECM. The BARO input is used for fuel metering barometric (atmospheric) pressure correction. In addition, certain diagnostic monitoring is inhibited at high elevation. The BARO cannot be replaced separately.

BARO Sensor Diagnostic Monitoring

The BARO Sensor circuits are continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for:

- Range / performance (actual barometric pressure as compared to expected barometric pressure)
- Signal circuit low voltage
- Signal circuit high voltage

If a BARO Sensor failure occurs, the ECM defaults to a value of 1 BAR.

Engine Coolant Temperature (ECT Sensor)

The ECT Sensor, located on the coolant outlet elbow, supplies the ECM with a voltage signal representing engine coolant temperature.

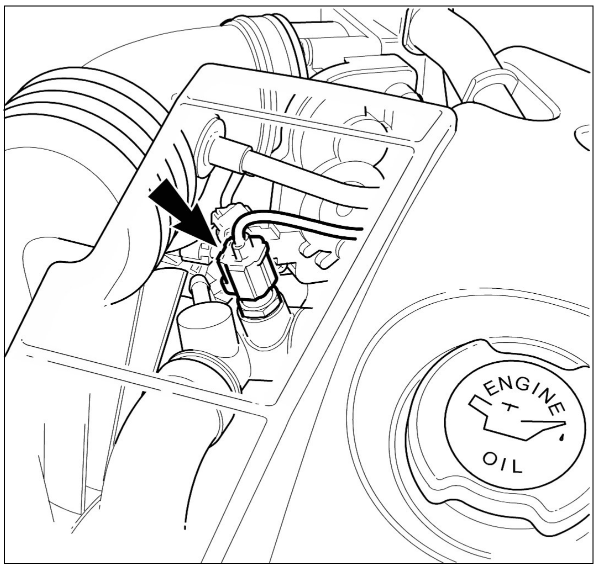

Fig. 85 V6 ECT SENSOR

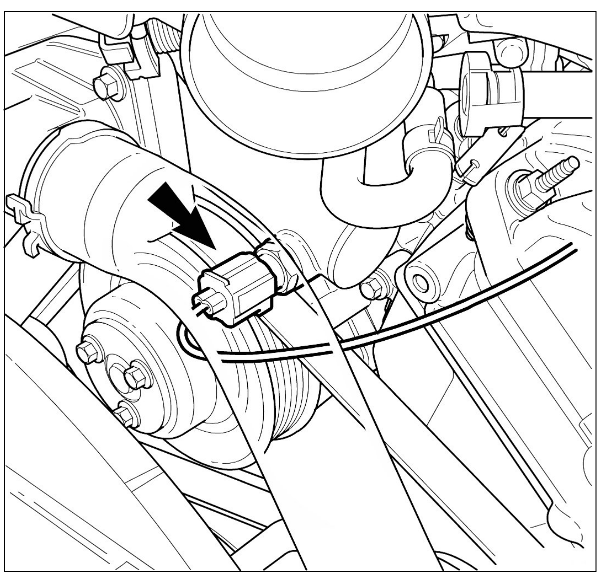

Fig. 86 V8 N/A ECT SENSOR

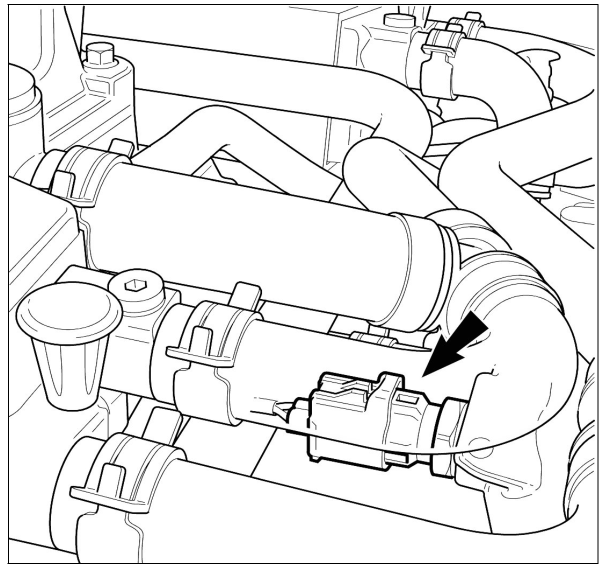

Fig. 87 V8 SC ECT SENSOR

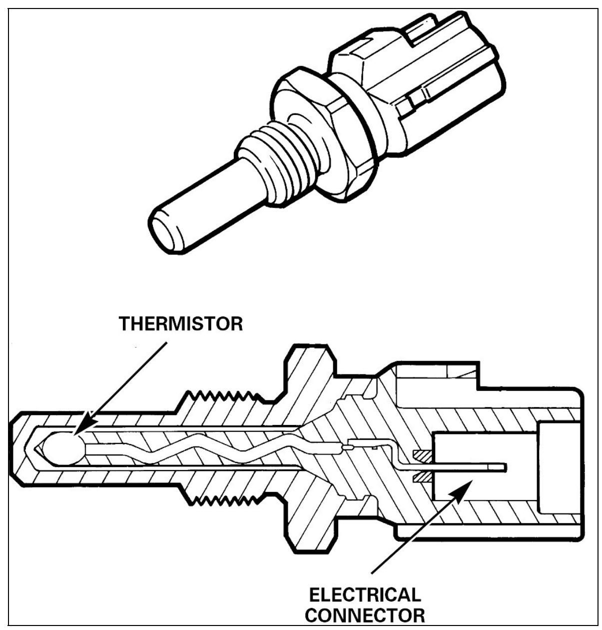

Fig. 88 ECT SENSOR DETAIL

ECT Sensor Diagnostic Monitoring

The ECT Sensor circuit is continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for:

- Range / performance (actual coolant temperature as compared to expected coolant temperature)
- Signal circuit low voltage (high coolant temperature)
- Signal circuit high voltage (low coolant temperature)
- Sensor ground circuit fault (collective sensor ground circuit)
- Sensor response (coolant thermostat monitor)
- Thermostat range / performance

If a fault is detected, the ECM will substitute the EOT value (but not greater than 95 °C (203 °F) and institute the default actions as follows:

- Closed loop fuel metering inhibited
- Adaptive fuel metering inhibited
- Catalyst warm-up ignition retard inhibited
- Canister purge inhibited
- Maximum engine speed reduced

Engine Oil Temperature (EOT Sensor)

The EOT Sensor located on the left hand side of the cylinder block, supplies the ECM with a voltage signal representing engine oil temperature. The EOT Sensor is a negative temperature coefficient (NTC) thermistor (the sensor resistance decreases as the engine oil temperature increases).

Engine oil temperature is determined by the ECM by the change in the sensor resistance. The ECM applies 5 volts (nominal) to the sensor and monitors the voltage across the pins to detect the varying resistance.

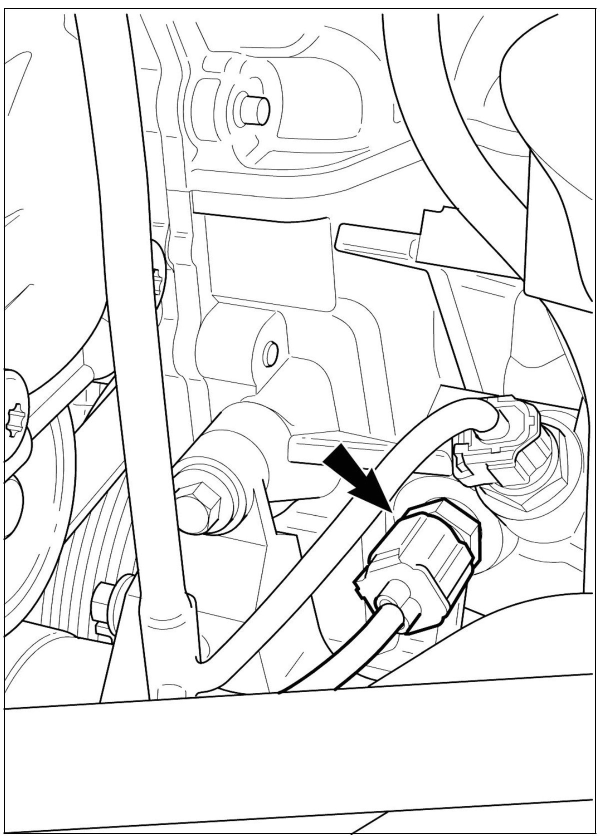

Fig. 89 V6 EOT SENSOR

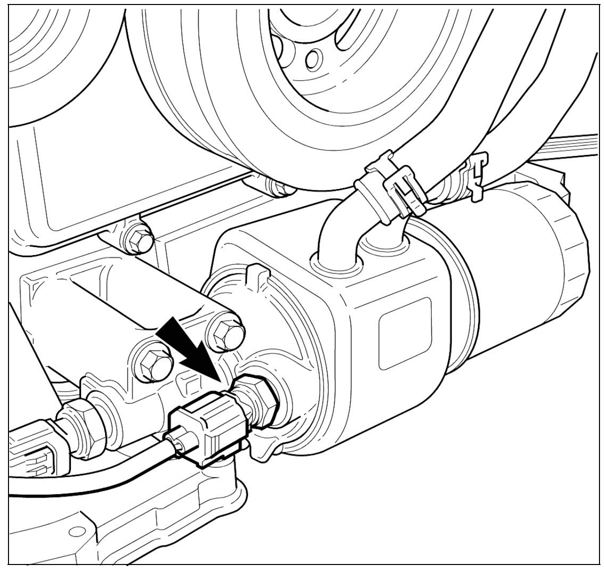

Fig. 90 V8 N/A and SC EOT SENSOR

EOT Sensor Diagnostic Monitoring

The EOT Sensor circuit is continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for:

- Range / performance (actual engine oil temperature as compared to engine coolant temperature)
- Signal circuit low voltage (high oil temperature)
- Signal circuit high voltage (low oil temperature)
- Sensor ground circuit fault (collective sensor ground circuit)

If a fault is detected, the ECM will substitute the ECT value.

Crankshaft Position Sensor (CKP Sensor)

A 35-tooth reluctor is located on the crankshaft at different locations in the V6 and V8 engines:

- V6 sensor is located in the front timing cover
- V8 sensor is located at the rear of the engine structural sump as in previous V8 engines.

The sensor "teeth" are spaced at 10° (crankshaft rotation) intervals with the missing tooth providing a 20° interval. The missing tooth 20° interval provides a ECM reference for crankshaft position.

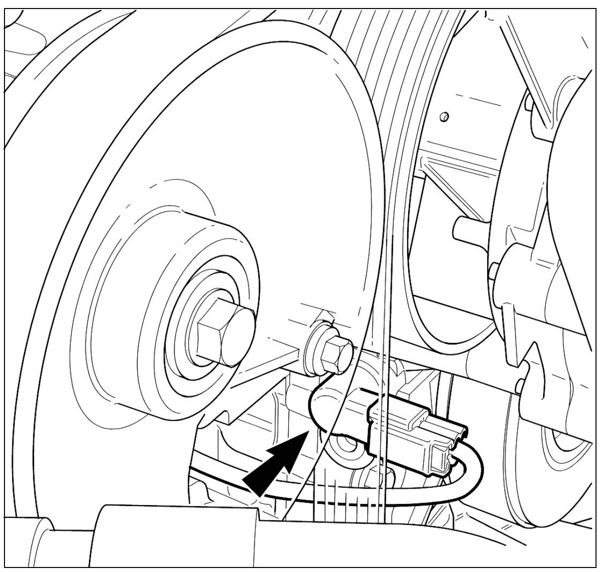

Fig. 91 V6 CKP SENSOR

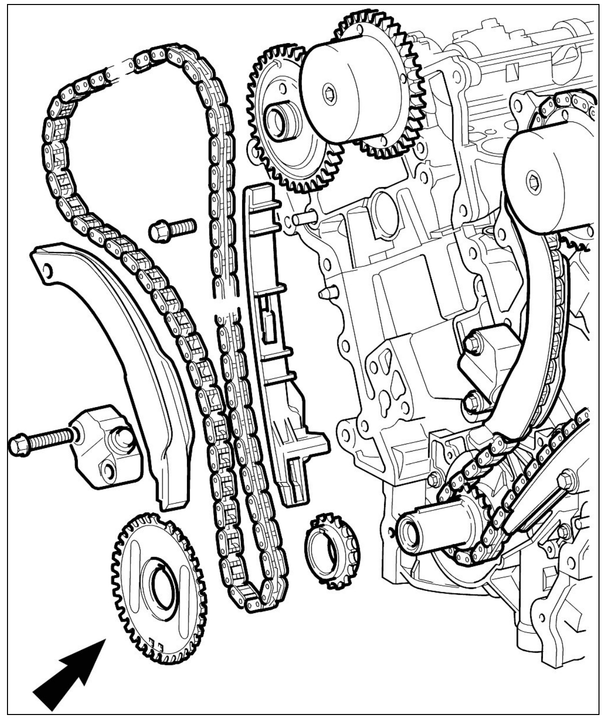

Fig. 92 V6 CKP SENSOR RELUCTOR

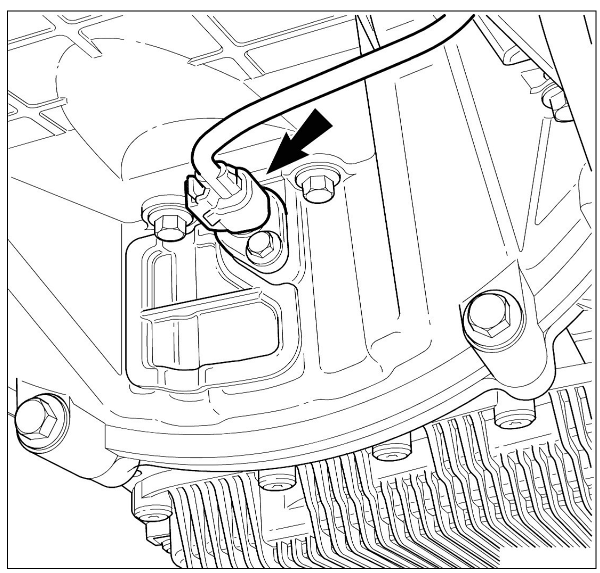

Fig. 93 V8 CKP SENSOR

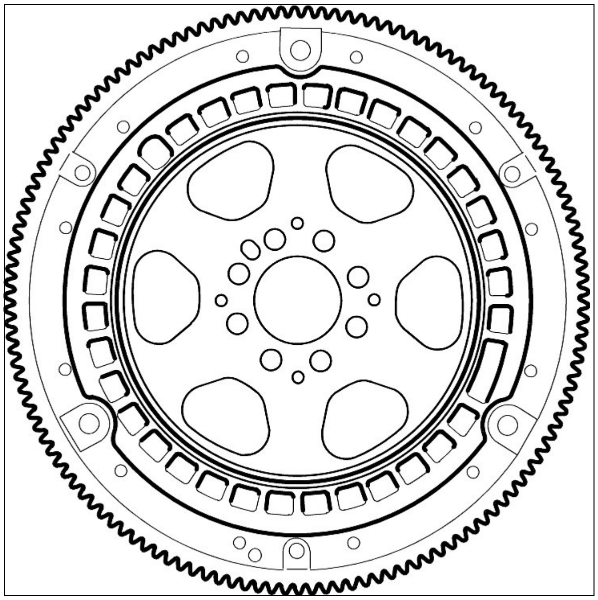

Fig. 94 V8 CKP SENSOR RELUCTOR

CKP Sensor Diagnostic Monitoring

The CKP Sensor circuit is continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for:

- Range / performance (engine running, CKP signal not received or signal does not represent an expected reasonable engine speed for a normally operating engine)
- Signal and / or ground circuit malfunction

If a fault is detected, the ECM will reduce maximum engine speed, and (for circuit malfunction only) will use cylinder bank 1 CMP signal for cylinder synchronization.

Camshaft Position (CMP Sensor)

The ECM uses the CMP signals (one for each cylinder bank) for:

- Cylinder identification to control starting
- Fuel injection sequential operation
- Ignition timing
- Variable valve timing operation and diagnostics.

The CMP reluctors are located on the inlet camshafts at the front of the V6 cylinder heads, and at the rear of the V8 heads. V6 reluctors have four teeth (three are equally spaced); V8 reluctors have five teeth (four are equally spaced).

The use of multi-tooth sensor rings also improves starting by providing additional reference points for the ECM to determine camshaft position.

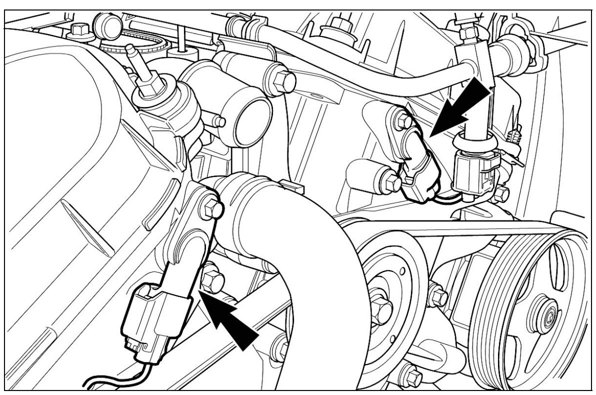

Fig. 95 V6 CMP SENSOR

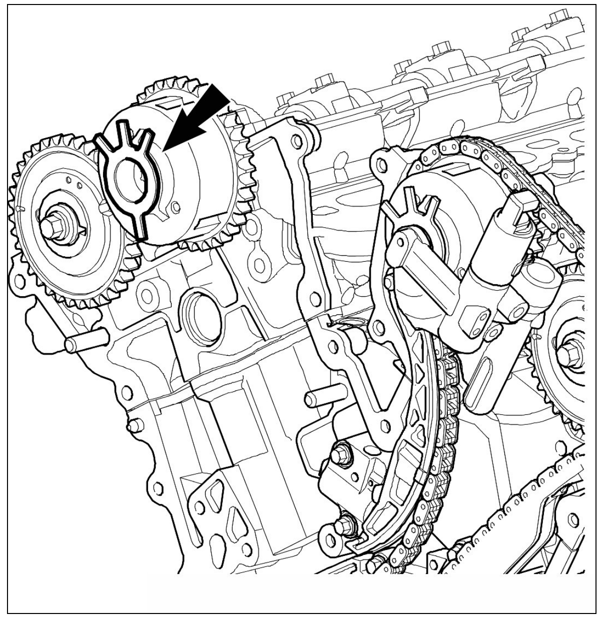

Fig. 96 V6 CMP SENSOR RELUCTOR

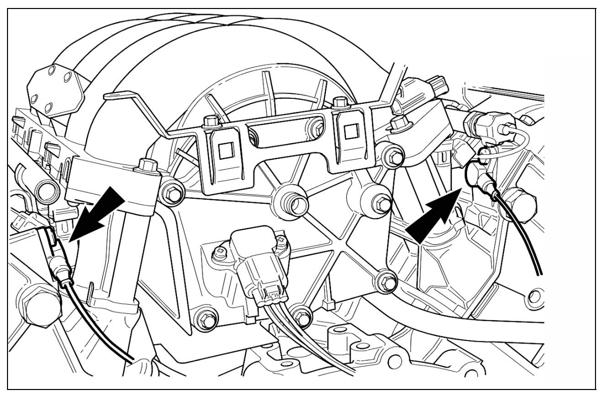

Fig. 97 V8 CMP SENSOR

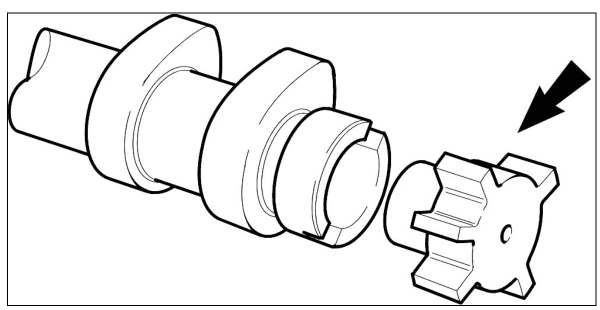

Fig. 98 V8 CMP SENSOR RELUCTOR

CMP Sensor Diagnostic Monitoring

The CMP Sensor circuit is continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for:

- Range / performance (CKP signal as compared to CKP signal)
- Signal and / or ground circuit malfunction

Accelerator Pedal Position Sensor (APP Sensor)

The APP Sensor consists of two pair of mated resistance tracks and contact points (potentiometers). The contact point moves on the resistance track in accordance with throttle valve position. A nominal voltage of 5V is connected to one end of the resistance track, therefore voltage at the contact point varies in accordance with the position of the contact points. The ECM uses one track and contact point, (APP1) for detection of the accelerator pedal position. The output from the other track and the contact point (APP2) is used for the sensor diagnostic monitoring. The ECM monitors the difference between the output of the two tracks for that purpose.

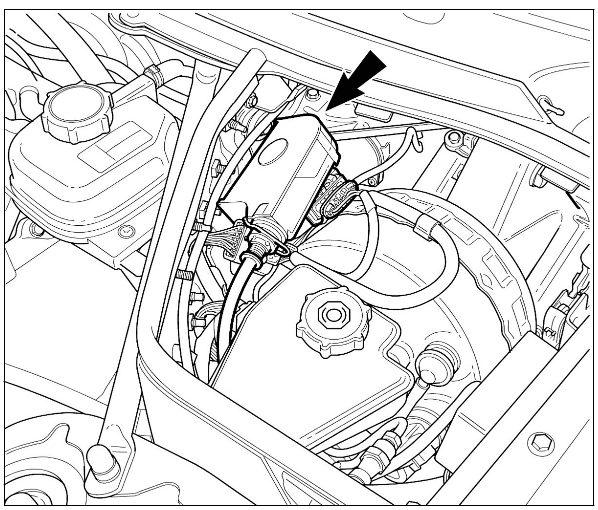

Fig. 99 XK APP SENSOR

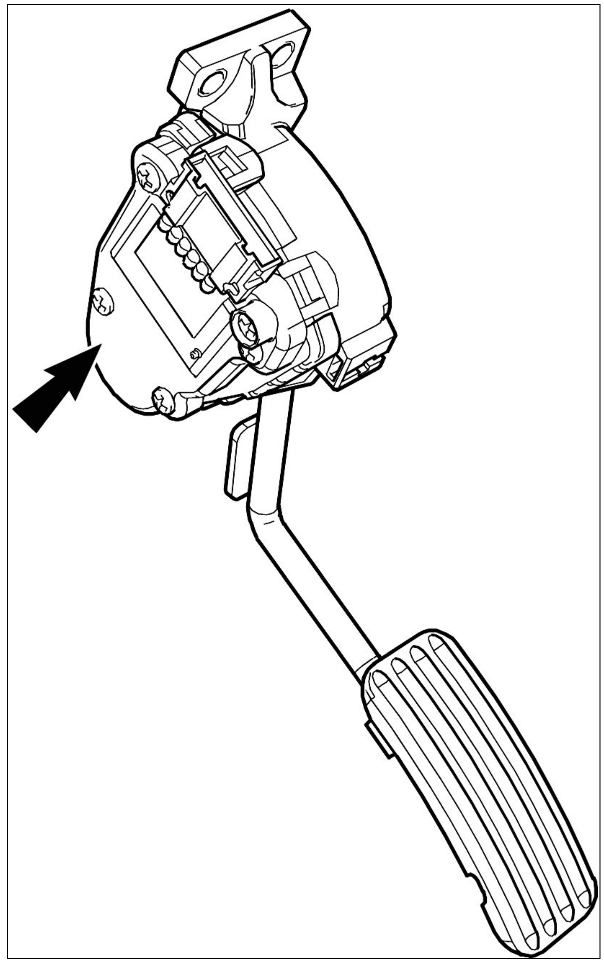

Fig. 100 X-TYPE / S-TYPE / XJ APP SENSOR

Due to a lack of package space in the footwell area, XK (X103) models have the APP sensor mounted remotely from the accelerator pedal assembly. The X103 APP sensor is located in the left hand side control module housing, and is actuated by a short throttle cable linked to the traditional accelerator pedal.

Organ Throttle Pedal (X404)

The organ throttle pedal supplements the driver lower air bag module by providing a consistent driver's heel point, independent of seat position. In addition, the 'Organ' style pedal offers a more refined pedal feel over the former pendulum pedal. The organ throttle pedal comprises:

- Throttle sensor mounting bracket with pedal stop
- Throttle sensor
- Organ pad
- Organ pedal mounting bracket

The throttle sensor's control arm engages with the organ pad and slides freely in a slot in the pedal side when the organ pad articulates from its 'live' hinge.

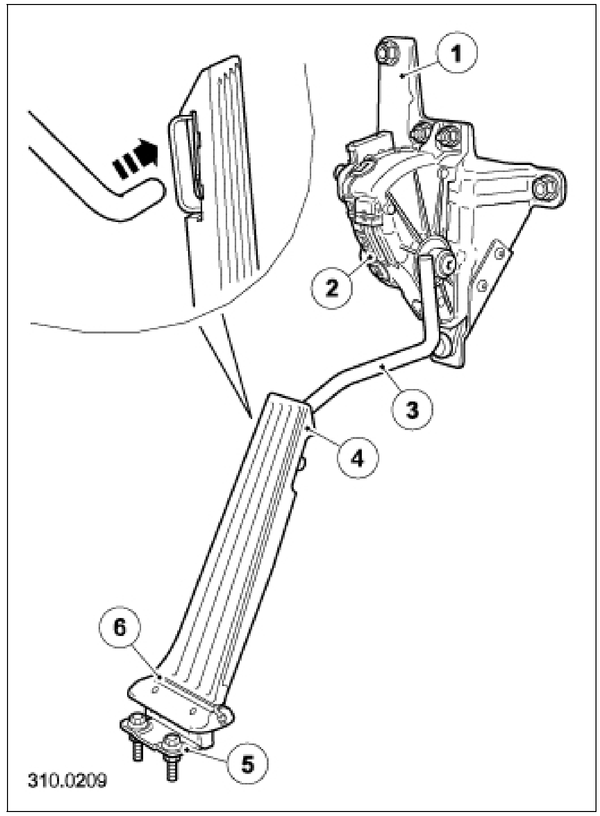

Fig. 101 - X404 ORGAN THROTTLE PEDAL

1. Throttle sensor mounting bracket with pedal stop
2. Throttle sensors
3. Sensor control arm
4. Organ pad
5. Organ pedal mounting bracket
6. Live hinge

APP Sensor Diagnostic Monitoring

The APP Sensor circuits are continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for:

- APP1 and / or APP2 circuit(s) low voltage
- APP1 and / or APP2 circuit(s) high voltage
- Range / performance (APP1 compared to APP2)
- Sensor supply circuit fault (collective sensor supply circuit)
- Sensor ground circuit fault (collective sensor ground circuit)

If a fault is detected, the ECM will institute default actions as follows:

- APP angle default value used
- Speed control inhibited
- APP adaptations (wear, variance) inhibited

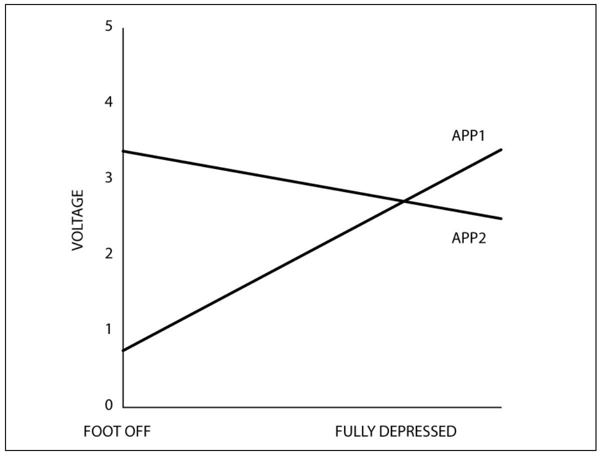

Fig. 102 APP SENSOR CHARACTERISTIC

Throttle Position Sensor (TP Sensor)

The twin track TP Sensor detects the actual throttle valve position and provides the ECM with two voltage signals. Using the throttle position signal, the ECM controls the throttle valve position to the target throttle valve position.

The ECM uses one track and contact point, (TP1) for detection of the throttle valve opening for throttle valve position control. The output from the other track and the contact point (TP2) is used for the sensor diagnostic monitoring. The ECM monitors the difference between the output of the two tracks for that purpose.

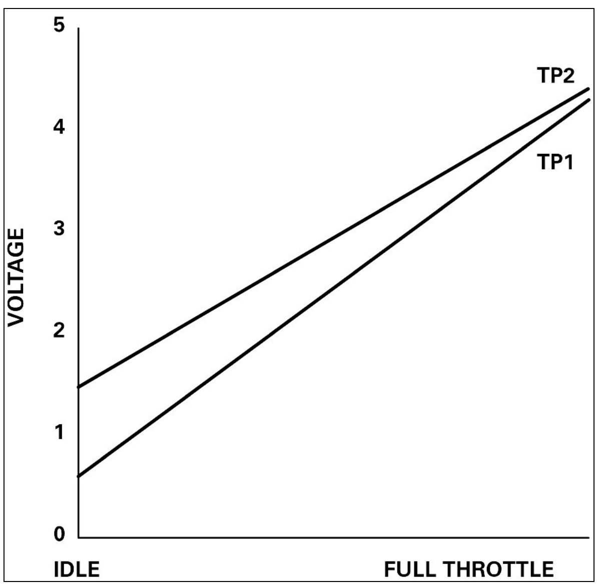

Fig. 103 TP SENSOR CHARACTERISTIC

TP Sensor Diagnostic Monitoring

The TP Sensor circuits are continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for:

- TP1 and / or TP2 circuit(s) low voltage
- TP1 and / or TP2 circuit(s) high voltage
- Range / performance (TP1 compared to TP2)
- Sensor supply circuit fault (collective sensor supply circuit)
- Sensor ground circuit fault (collective sensor ground circuit)

If a fault is detected, the ECM will institute default actions as follows:

- Throttle motor and throttle motor relay disabled
- Throttle valve opening set to default value
- Idle speed controlled by fuel injection intervention
- Idle speed adaptation inhibited

Brake Switches

The ECM receives input signals from two brake pedal position switches:

- Brake ON / OFF switch (B+ voltage / normally open)
- Brake cancel switch (B+ voltage / normally closed)

The two switches provide signal plausibility. The switch inputs to the ECM are used for speed control cancel and multiple vehicle functions (via CAN).

Due to the ignition switched ground electrical architecture of the XK vehicles, the Brake ON / OFF switch signal inputs to the ECM via the Stop Lamp Relay.

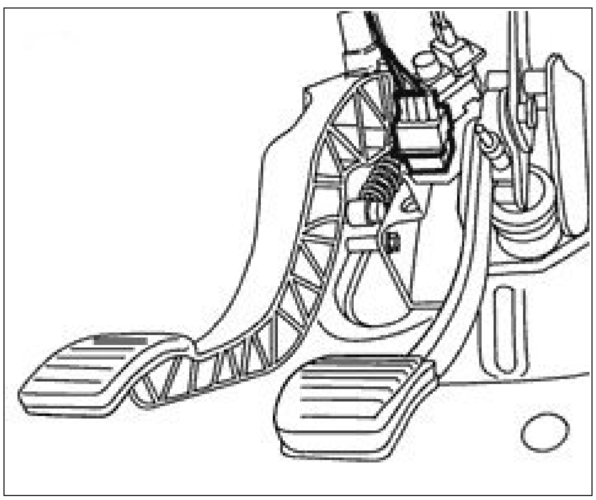

Fig. 104 X-TYPE brake switch

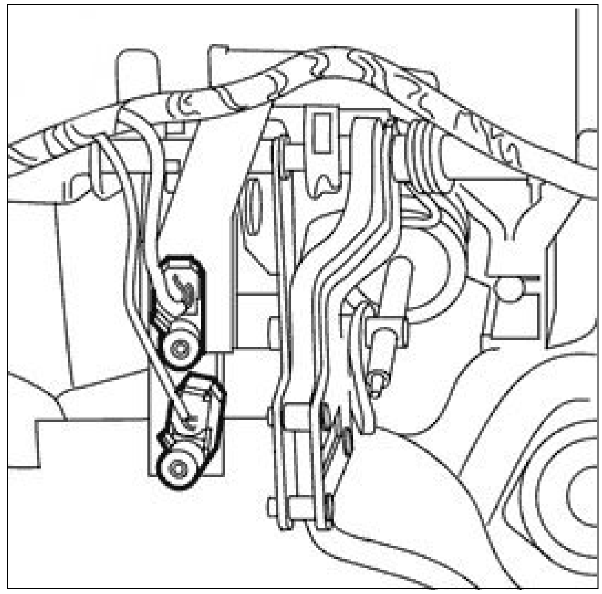

Fig. 105 S-TYPE brake switch

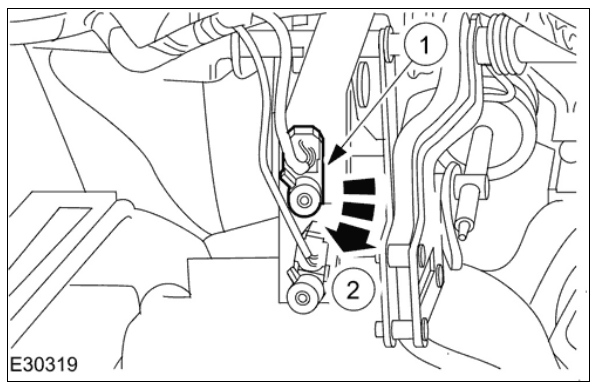

Fig. 106 XJ brake switch

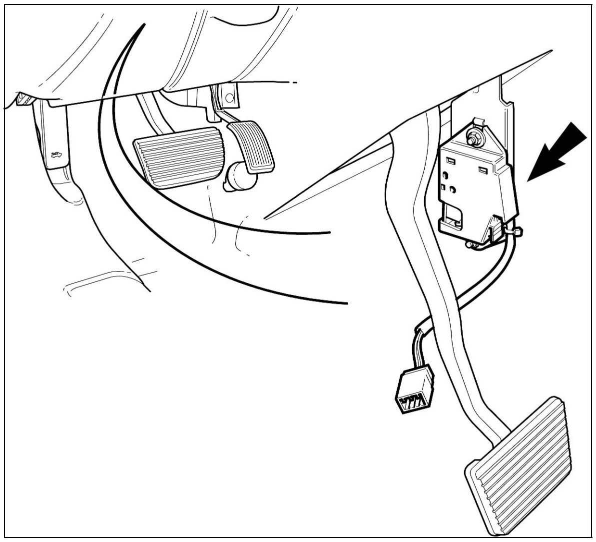

Fig. 107 XK brake switch

Brake ON / OFF and Brake Cancel Switches Diagnostic Monitoring

Both brake switches signals are continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for switch malfunctions.

If a fault is detected, the ECM will inhibit vehicle Speed Control and reduce maximum engine speed.

Air Conditioning Pressure Sensor

The Air Conditioning Pressure Sensor, located in the A/C “high side” is a pressure transducer that senses refrigerant system high side pressure. The signal voltage from the transducer supplies the ECM with a signal proportional to refrigerant pressure. The ECM uses the refrigerant pressure signal for cooling fan operation (in addition to ECT) and A/C compressor clutch control.

On XJ vehicles, the Air Conditioning Pressure Sensor signal is transmitted by the ECM to the Climate Control Module, which directly controls the A/C compressor variable output.

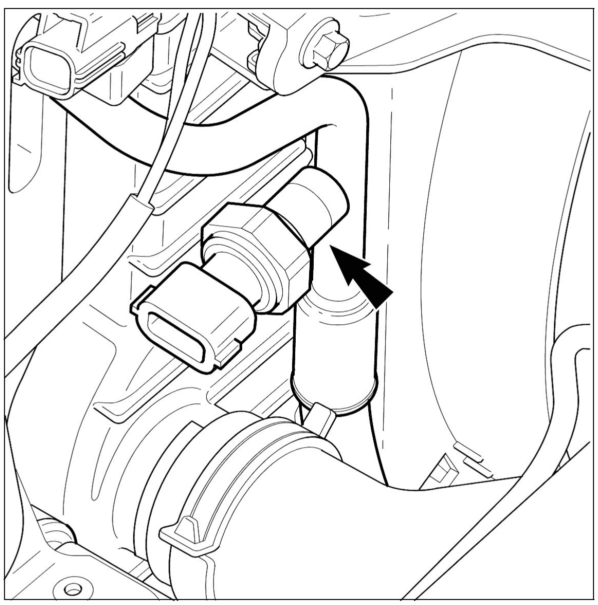

Fig. 108 AIR CONDITIONING PRESSURE SENSOR

Intake Air Temperature 2 (IAT Sensor 2, Supercharged V8 only)

Supercharged engines have an additional IAT Sensor to monitor the intake manifold charge air temperature.

The IAT Sensor 2, located on the rear of the bank 1 intake manifold, provides the ECM with a charge air temperature voltage signal.

The IAT Sensor 2 is a negative temperature coefficient (NTC) thermistor. Charge air temperature is determined by the ECM by a change in resistance within the sensor. The ECM applies 5 volts (nominal) to the sensor and monitors the voltage drop through the thermistor.

IAT Sensor 2 Diagnostic Monitoring

The IAT Sensor 2 circuit is continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for:

- Range / performance (actual charge air temperature as compared to expected charge air temperature)
- Signal circuit low voltage (high charge air temperature)
- Signal circuit high voltage (low charge air temperature)
- Sensor ground circuit fault (collective sensor ground circuit)

If a fault is detected, the ECM will substitute a default a value of 70 °C (158 °F).

INDUCTION AIR AND THROTTLE CONTROL

Air Induction Systems

The V6, V8, and V8 Supercharged engines have air induction systems that are similar from the air cleaner inlet through the throttle body. The systems consist of the normal components with the MAF Sensor and IAT Sensor module located in the air cleaner outlet.

Resonator chambers are fitted to the intake ducting to control intake air reverberation at certain throttle openings. After exiting the throttle body, the V6 and V8 induction air systems differ greatly.

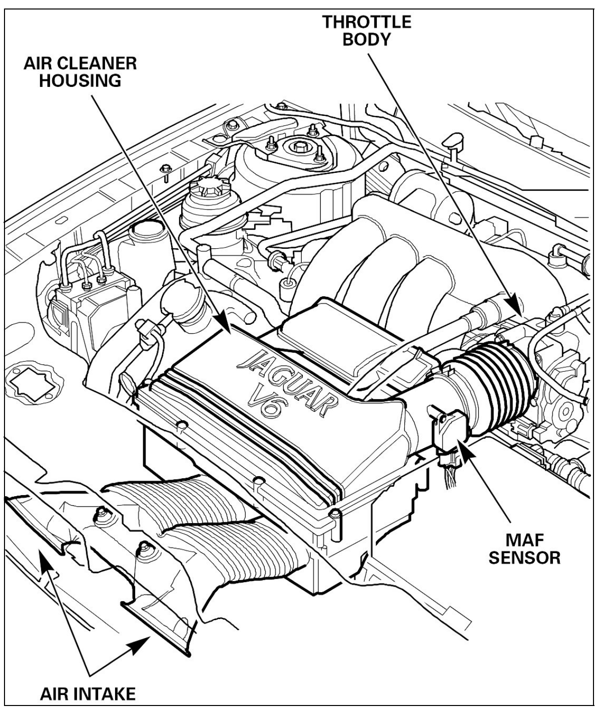

Fig. 109 X-TYPE V6 AIR INTAKE

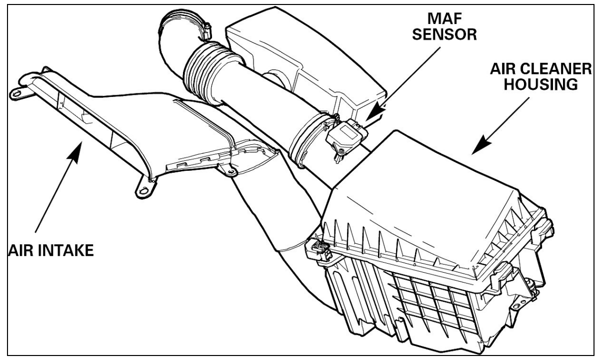

Fig. 110 S-TYPE V6 AIR INTAKE

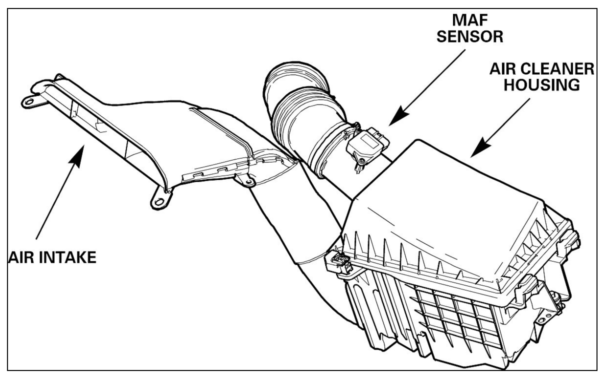

Fig. 111 V8 N/A AIR INTAKE

V8 SC Air Cleaner V8

Supercharged engines require an additional air intake opening into the air cleaner during periods of high engine speed and load. A solenoid operated flap, controlled by the ECM, is opened or closed as engine charge air increases / decreases.

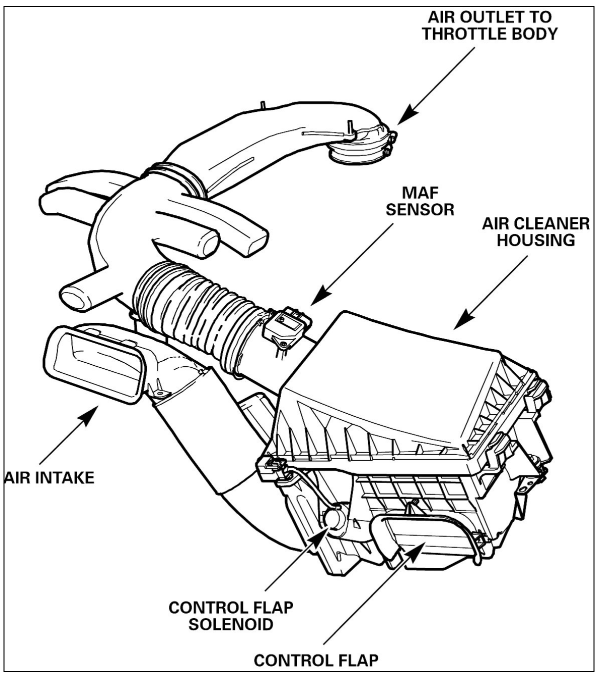

Fig. 112 V8 S/C AIR INTAKE

Air Cleaner Solenoid Valve Diagnostic Monitoring

The Air Cleaner Solenoid Valve drive circuit is continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for circuit faults. If a fault is detected, the ECM takes no default action.

Air Intake: V6

V6 Engines use a variable intake system designed to optimize engine torque across the engine speed / load range. Variable intake combined with variable valve timing provides an optimized engine torque curve throughout the engine operating range.

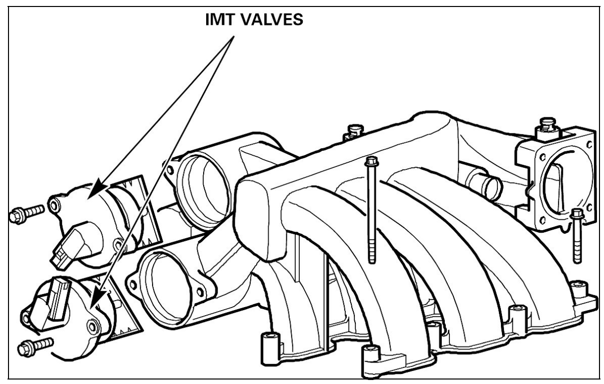

Fig. 113 X—TYPE INTAKE MANIFOLD

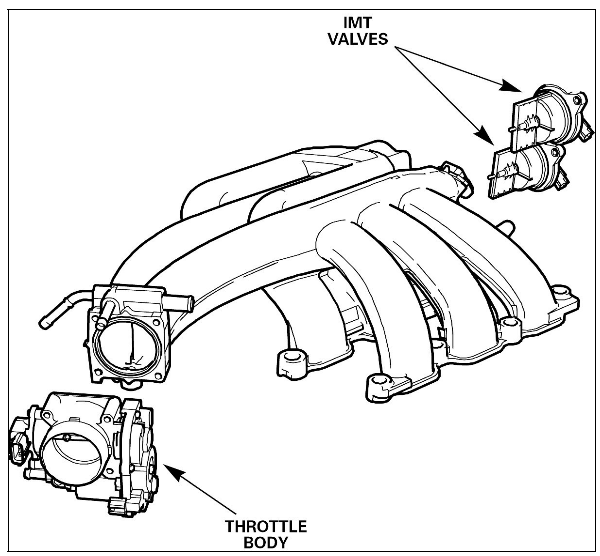

Fig. 114 S—TYPE INTAKE MANIFOLD

Variable Intake

The throttle body connects directly to the induction manifold assembly. The manifold mounts to the cylinder heads with the lower intake manifold assembly “sandwiched” between.

The manifold plenum chamber is split into upper and lower compartments with two interconnecting holes. Two identical Intake Manifold Tuning (IMT) Valves are located at the interconnecting holes. The IMT valves are solenoid operated gate valves, which rotate 90° for open / close.

B+ Voltage is separately supplied to each IMT valve via EMS control relay. The ECM switches the ground side of the valves via separate drive circuits to activate the solenoids.

The plenum chamber volume and the length of the intake air path are tuned by the positions of the IMT valve gates to assure that the natural charge air pressure waves or pulses are maximized for the ever changing engine speed and load conditions. The plenum chamber volume and manifold geometry can be set to three different configurations based on the specific engine speed / load range:

- Short pipe
- Medium-length pipe
- Long pipe

The two IMT valves, controlled by the ECM are set in combination to provide the three manifold configurations.

Both valves closed (Short Pipe) — Both IMT valves closed provides the minimum plenum volume and the shortest intake air path to the cylinders.

Top valve open / bottom valve closed (Medium Pipe) — With the top valve open and the bottom valve closed, plenum volume and the effective length of the intake air path are both increased.

Both valves open (Long Pipe) — With both valves open, the plenum volume and the air intake path effective length are at their maximum.

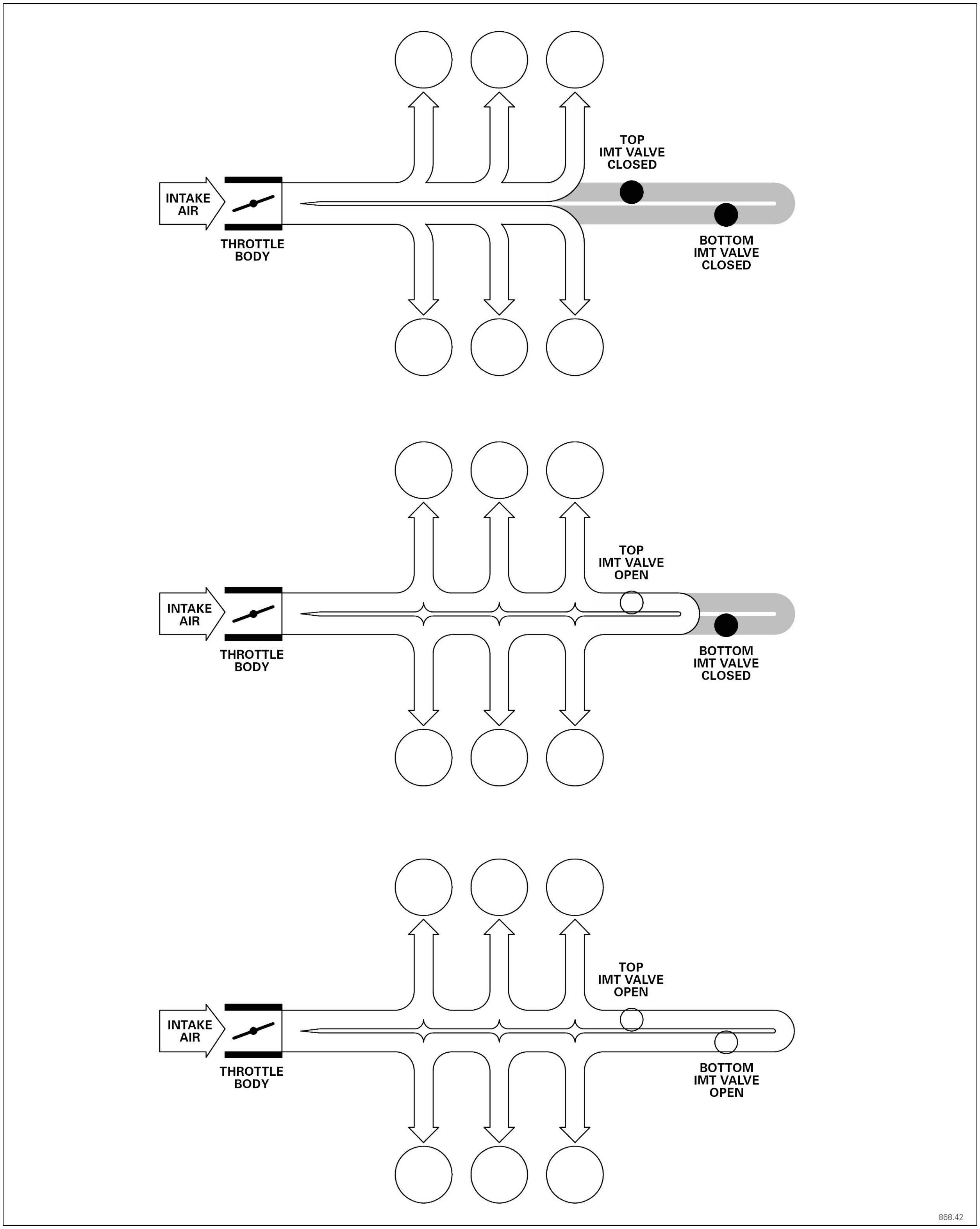

Fig. 115 VARIABLE INTAKE OPERATION STAGES

The ECM calculates the required valve positions using the following data:

- Engine speed – CKP Sensor
- Throttle position – TP Sensor
- Engine coolant temperature – ECT sensor
- Intake air temperature – IAT sensor

The graph shows how the ECM control of variable intake system optimizes the engine torque curve.

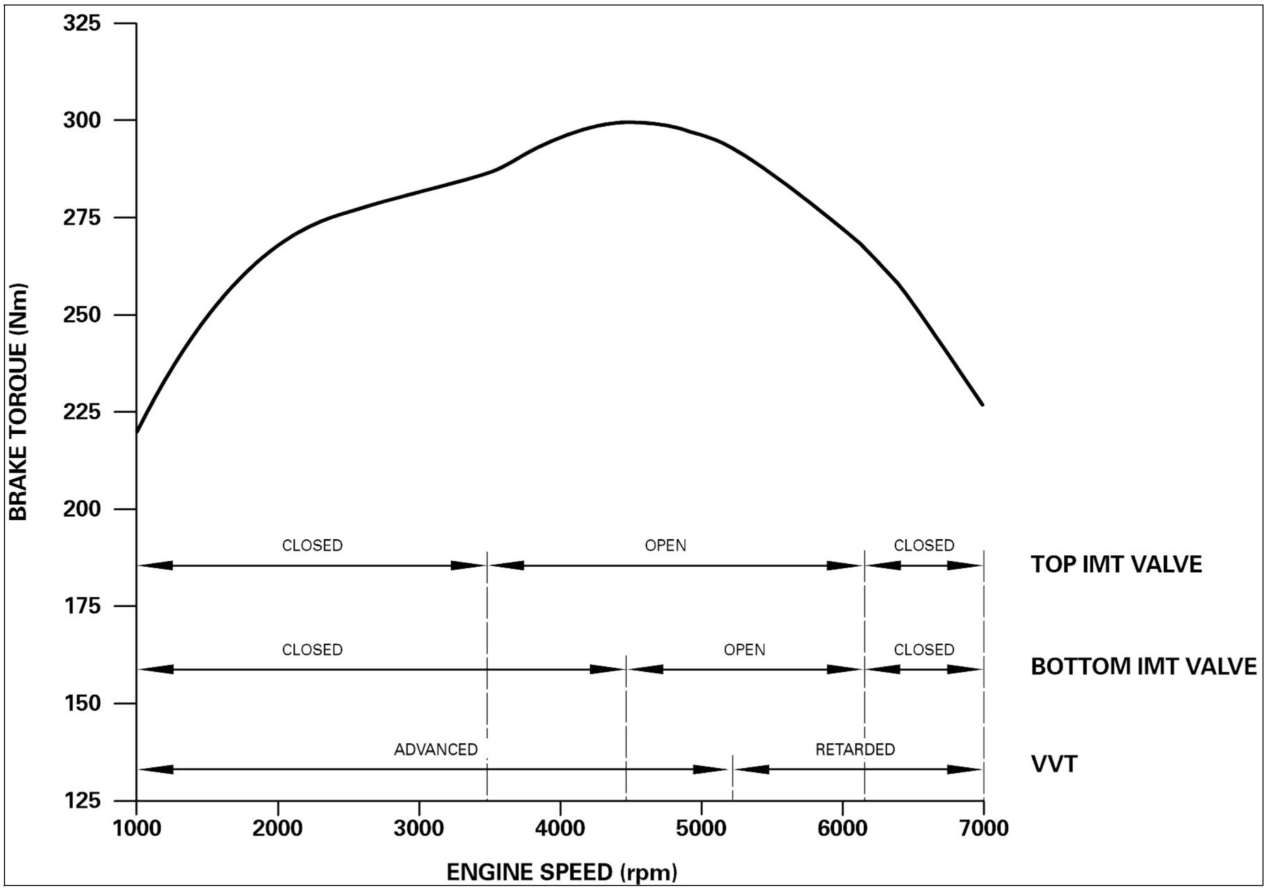

Fig. 116 ENGINE TORQUE CHARACTERISTICS (3.0L X204)

IMT Solenoid Valve Diagnostic Monitoring

The IMT Solenoid Valve drive circuits is continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for circuit faults. If a fault is detected, the ECM disables the applicable IMT Solenoid Valve.

Air Intake: V8 Naturally Aspirated

Induction air flows from the front mounted throttle body into the intake manifold through a front inlet adaptor. The manifold is made up of three components: the manifold “runner” assembly and the LH and RH lower manifolds, which accept the fuel injectors.

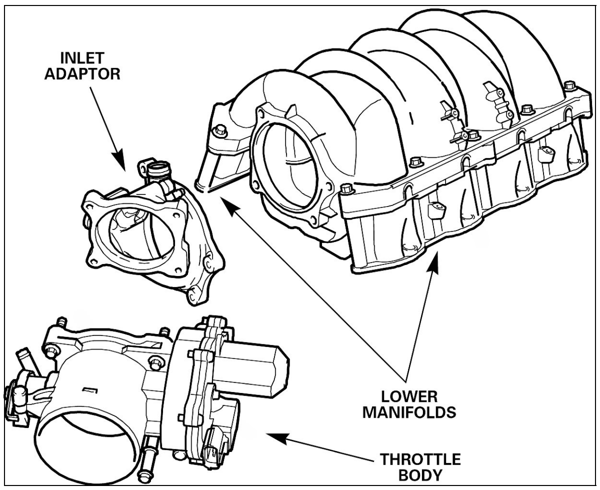

Fig. 117 V8 N/A INTAKE MANIFOLD

Air Intake: V8 Supercharged

Induction air flows from the rear mounted throttle body into the supercharger body. Compressed charge air exits the supercharger and flows through adaptors to the LH and RH intercooler / manifold units, through the intercoolers and the fuel rail adaptors to the cylinders.

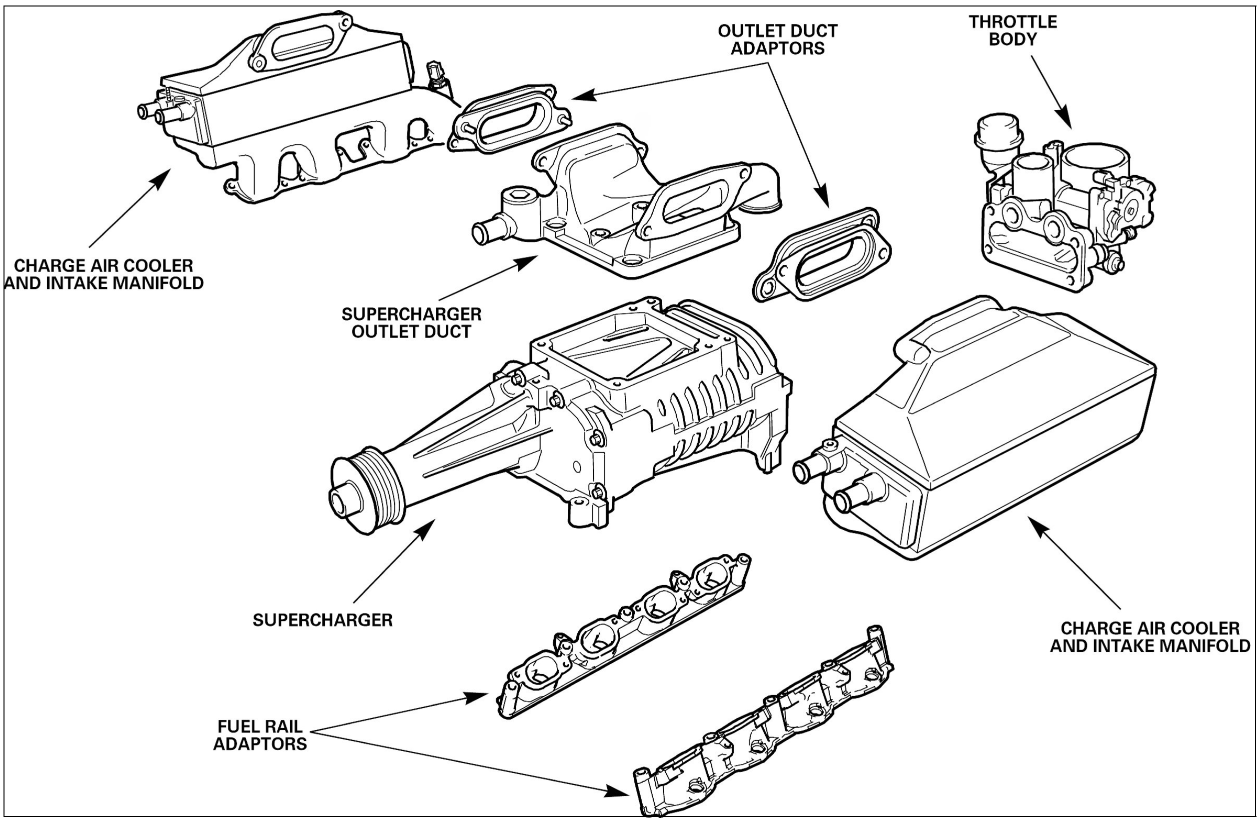

Fig. 118 V8 S/C INTAKE MANIFOLD

The intercoolers are air-to-liquid coolers with cooling liquid provided by the engine cooling system. A dedicated intercooler coolant pump operates continuously when the ignition is switched ON to ensure maximum charge air cooling efficiency. Unlike the AJ27, the 32 bit ECM does not control the intercooler coolant pump. Instead, the pump is powered by hardwire from the ignition relay.

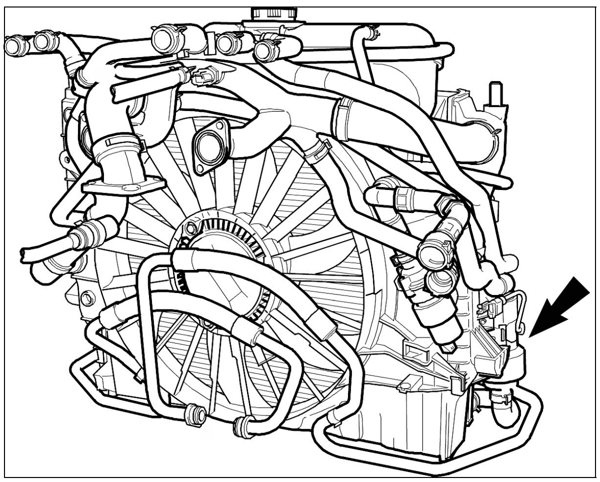

Fig. 119 V8 SC INTERCOOLER COOLANT PUMP

Full Authority Electronic Throttle Body

The electronic throttle body system consists of the following components:

- Throttle valve
- Motor reduction drive gears
- Throttle return spring and “limp home” spring
- Throttle position sensor
- Accelerator pedal position sensor (mounted on accelerator pedal assembly*)
- Throttle motor relay

NOTE:

* except XK, which has a remote pedal position sensor, located in the LH underhood relay enclosure

According to the accelerator pedal position sensor signal, driving mode, demand from the speed control and other vehicle systems, the ECM calculates the target throttle valve position. By comparing the throttle position sensor signal, which shows the actual valve position with the target position, the ECM outputs a drive signal to the motor to control the actual valve position to the target position.

The ECM contains a second CPU dedicated to throttle control and monitoring. B+ Power to drive the throttle motor is provided via the ECM controlled Throttle Motor Relay.

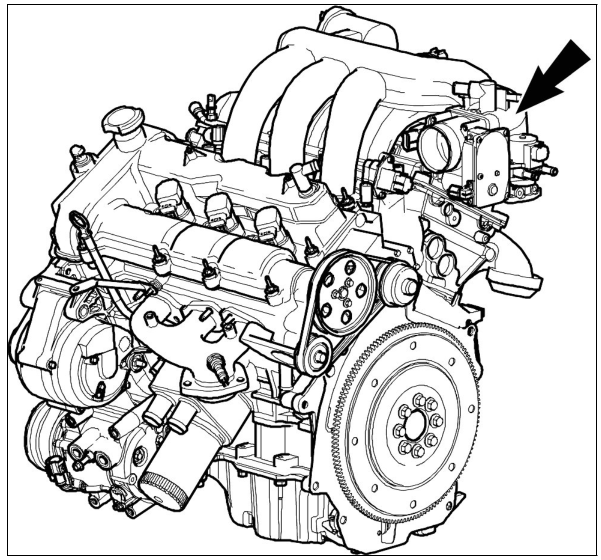

Fig. 120 X-TYPE THROTTLE BODY

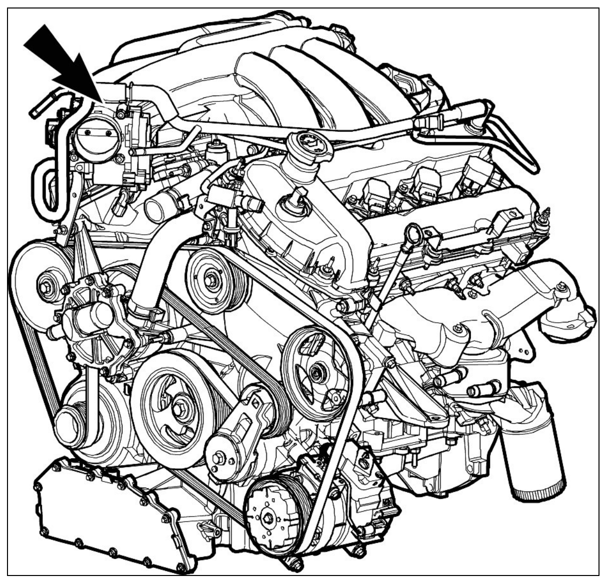

Fig. 121 S-TYPE V6 THROTTLE BODY

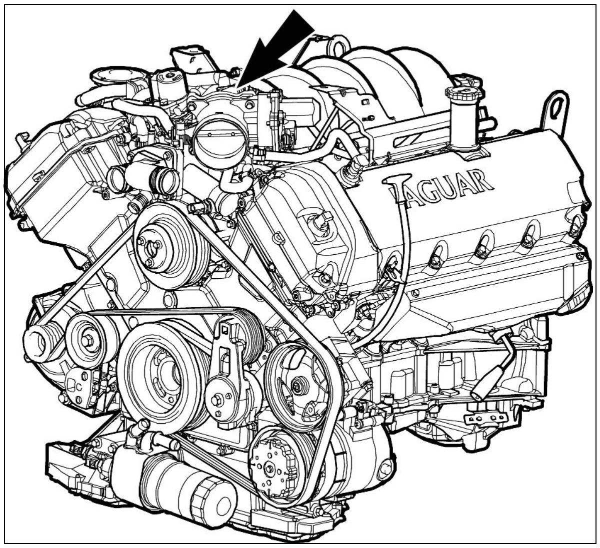

Fig. 122 V8 N/A THROTTLE BODY

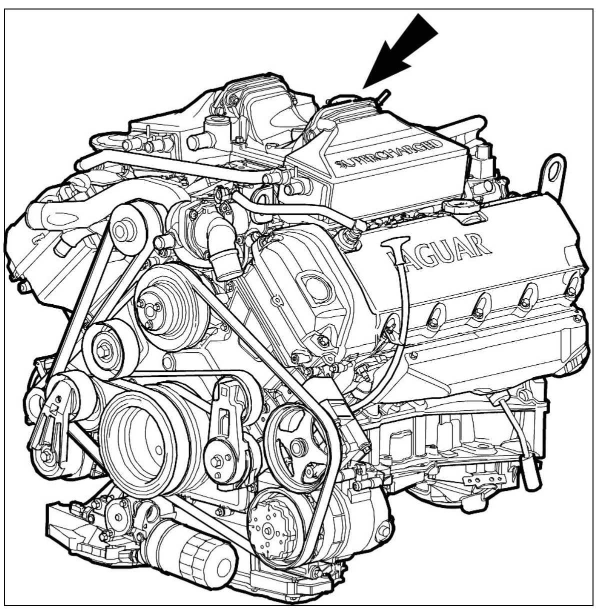

Fig. 123 V8 S/C THROTTLE BODY

Throttle Motor Drive

To control the throttle motor, the ECM determines the deviation between the target throttle position and the calculated throttle position. The calculated throttle position is derived from the APP Sensor and TP Sensor signals. After determining the deviation, the ECM specifies a motor control value.

The motor control value is converted into a PWM duty cycle at a fixed frequency, which is passed to the ECM motor drive circuit. The motor drive circuit subsequently applies a current, proportional to the duty cycle, through the motor. The direction of rotation of the motor is determined by switching combinations of the four switches in the ECM throttle motor drive circuit Open/Closed.

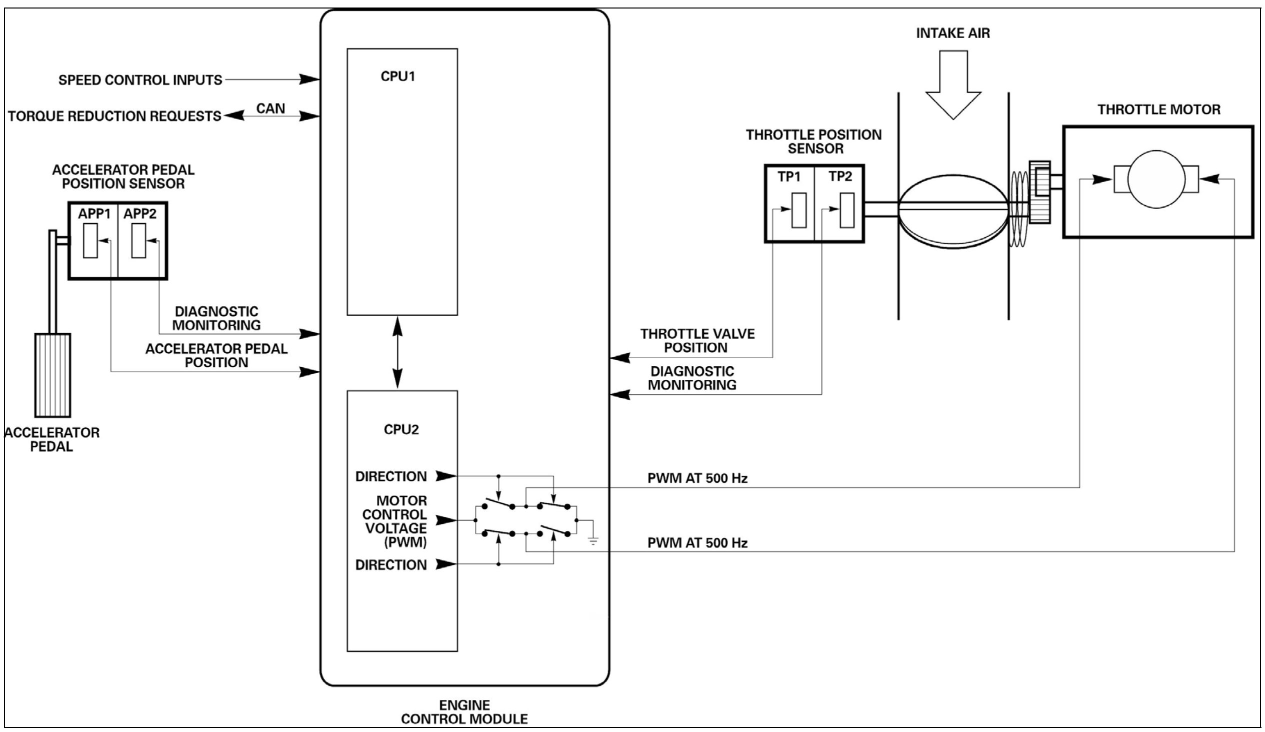

Fig. 124 THROTTLE MOTOR DRIVE

Throttle Body: V8 Supercharged

Supercharged engines require a system for relieving excess compressed charge air during low load engine operating modes such as deceleration and low load cruise conditions. The supercharged throttle body incorporates a vacuum actuated circuit for control of excess compressed charge air.

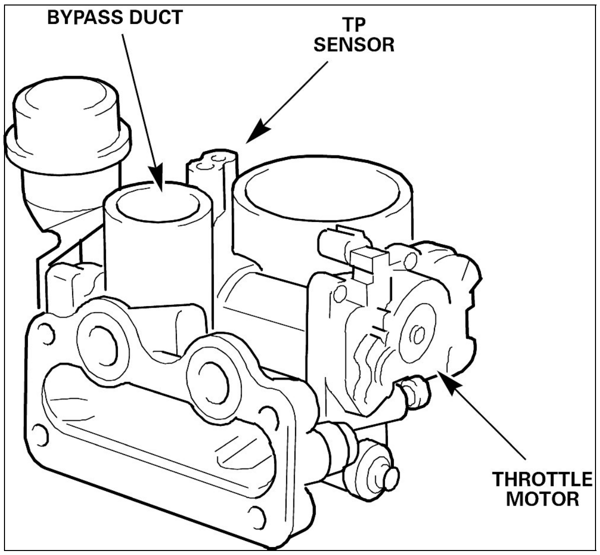

Fig. 125 V8 SC THROTTLE BODY

Bypass Duct and Valve

A bypass duct returns air to the throttle body from the supercharger outlet duct. The bypass valve consists of a butterfly valve installed in the bypass circuit within the throttle body. A bypass valve actuator and a spring are attached to the spindle of the valve.

Bypass Operation

With a closed or partially open throttle, the vacuum actuator overcomes spring pressure to hold the bypass valve fully open, allowing excess compressed charge air to flow through the throttle body (downstream from the throttle valve) back to the supercharger intake. As the throttle opens, manifold vacuum decreases, and the spring progressively overcomes the pull of the vacuum actuator to close the valve, increasing the pressure of the charge air supplied to the intercoolers.

Throttle Fail Safe Modes

All throttle system components are continuously monitored for correct operation. If a failure occurs, the ECM takes default action(s) appropriate for safe vehicle operation. The complete range of throttle fail safe modes is shown in the following table.

NOTE:

In addition to the throttle fail safe modes, the ECM takes additional default actions depending on the specific fault. Refer to the “Powertrain DTC Summaries”.

Table 8 Throttle fail safe modes

Fail Safe Mode	Message Display	Fail Safe Action	Warning	Failure(s)
Engine shut down	Engine system fault	Fuel injection canceled	Red Amber CHECK ENGINE	• Throttle valve stuck open • Limp home failure • Limp home unavailable failure
Limp home	Engine system fault	• Throttle motor disabled • Speed control inhibited • Idle speed controlled by fuel injection intervention	Red Amber CHECK ENGINE	• Throttle motor failure • Throttle motor relay failure • ECM throttle motor relay drive circuit failure • ECM hardware fault
High idle	Engine system fault	• Fixed throttle valve angle • Speed control inhibited	Red CHECK ENGINE	APP Sensor failure
Limp home unavailable	Restricted performance	• Engine power limited • Speed control inhibited	Red CHECK ENGINE	Throttle limp home spring or return spring failure

Fail Safe Mode	Message Display	Fail Safe Action	Warning	Failure(s)
Safety redundancy	Restricted performance (Cruise unavailable on X-Type)	• Engine power limited • Speed control inhibited	Red CHECK ENGINE	• Throttle motor relay failure • ECM throttle motor relay drive circuit failure • ECM internal failure
Speed control inhibit	Cruise unavailable	Speed control inhibited	Red CHECK ENGINE	• Speed control switch(es) failure • Brake / clutch switches failure • P/N ECM input signal failure • TCM failure • CAN failure
Redundancy	None	TP Sensor signal ignored	Amber CHECK ENGINE	ECM internal TP Sensor amplifier failure

Throttle Diagnostic Monitoring

Throttle operation is continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for:

- Throttle control position error
- Throttle motor drive circuit malfunction
- Throttle valve return spring malfunction
- Throttle “limp home” spring malfunction
- Throttle “watch dog” circuit malfunction
- Throttle motor relay ON / OFF failures

If a fault is detected, the ECM will institute the default actions as listed in the “Powertrain DTC Summaries”.

Adaptive Cruise Control (ACC)

The adaptive cruise control (ACC) is an enhancement of conventional cruise control, which helps the driver to maintain a constant gap to the vehicle in front.

The driver inputs a desired cruising speed and engages the system, in the same way as he would for conventional cruise control.

The system will then cruise at this set speed until another slower moving vehicle is detected in front. In this situation the system will operate the throttle and brakes to maintain a constant time based gap (headway) to the vehicle in front.

Adaptive cruise control was introduced on the X103, was available for 2004MY as an option on XJR and S-TYPE R models, and is available as an option on all 2005MY X204, X105 and X350 vehicles.

Adaptive cruise control (ACC) system uses a high-performance long-range radar sensor to help the driver detect objects in the vehicle's path (up to 150 m/402 ft). If the lane ahead is clear, the system will maintain the cruising speed set by the driver. When slower traffic is detected, the system will maintain a driver-selected time gap—using throttle control and limited braking.

ACC is most useful on freeways and other multi-lane roads, and two-lane rural roads, but can be used effectively at speeds as low as 20 m.p.h. The IC message center displays communicate set speed and driver-selectable gap.

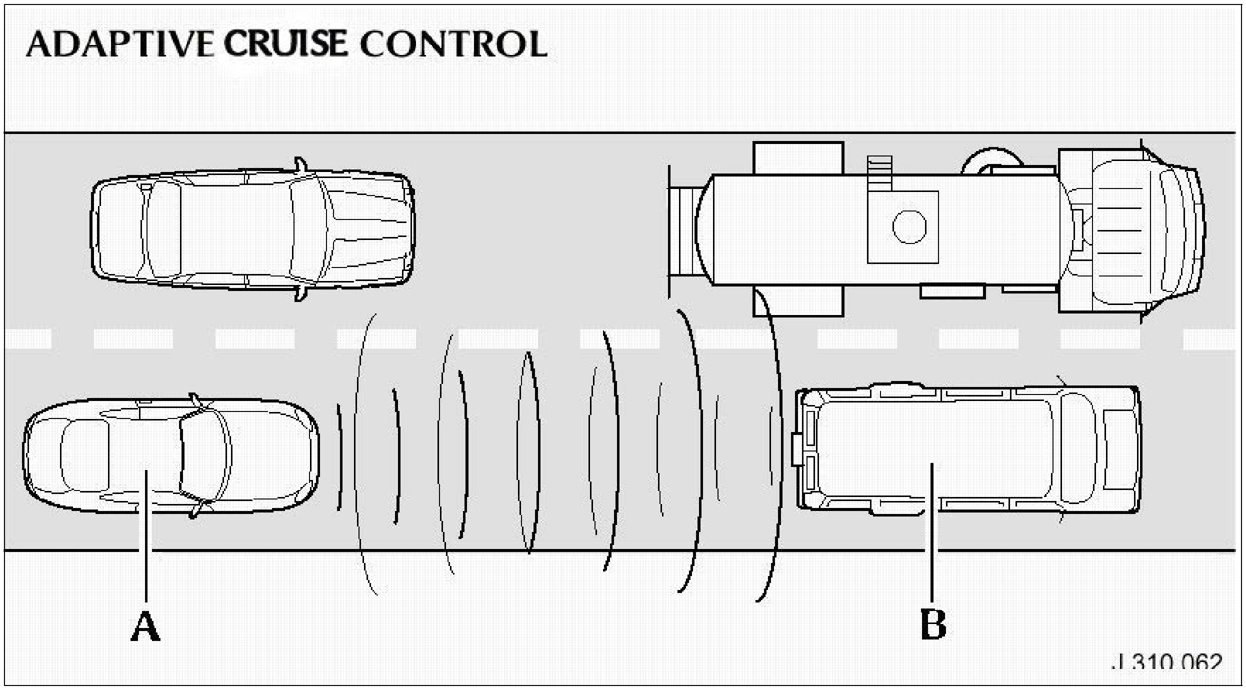

Fig. 126

A. Vehicle with ACC active
B. System maintaining gap with vehicle in front

The system has the following features:

- Completely hidden sensor
- Maintains awareness of vehicle ahead through curves – Enabled by integrated yaw sensor
- All-weather performance— detects objects in fog and rain
- Blockage detection—notifies driver when ACC is unavailable/ sensor is blocked with excess mud, snow, or ice
- Resume inhibit
- Forward alert

The system will detect obstructions but will ignore them if they are not in the path of the vehicle. The ACC module incorporates its own yaw rate sensor which will inform the system which path the vehicle is taking. Stationary objects will be detected but the system will ignore them. If a moving object in the path of the vehicle slows down or a moving object comes into the path of the vehicle the system will take action to prevent a collision.

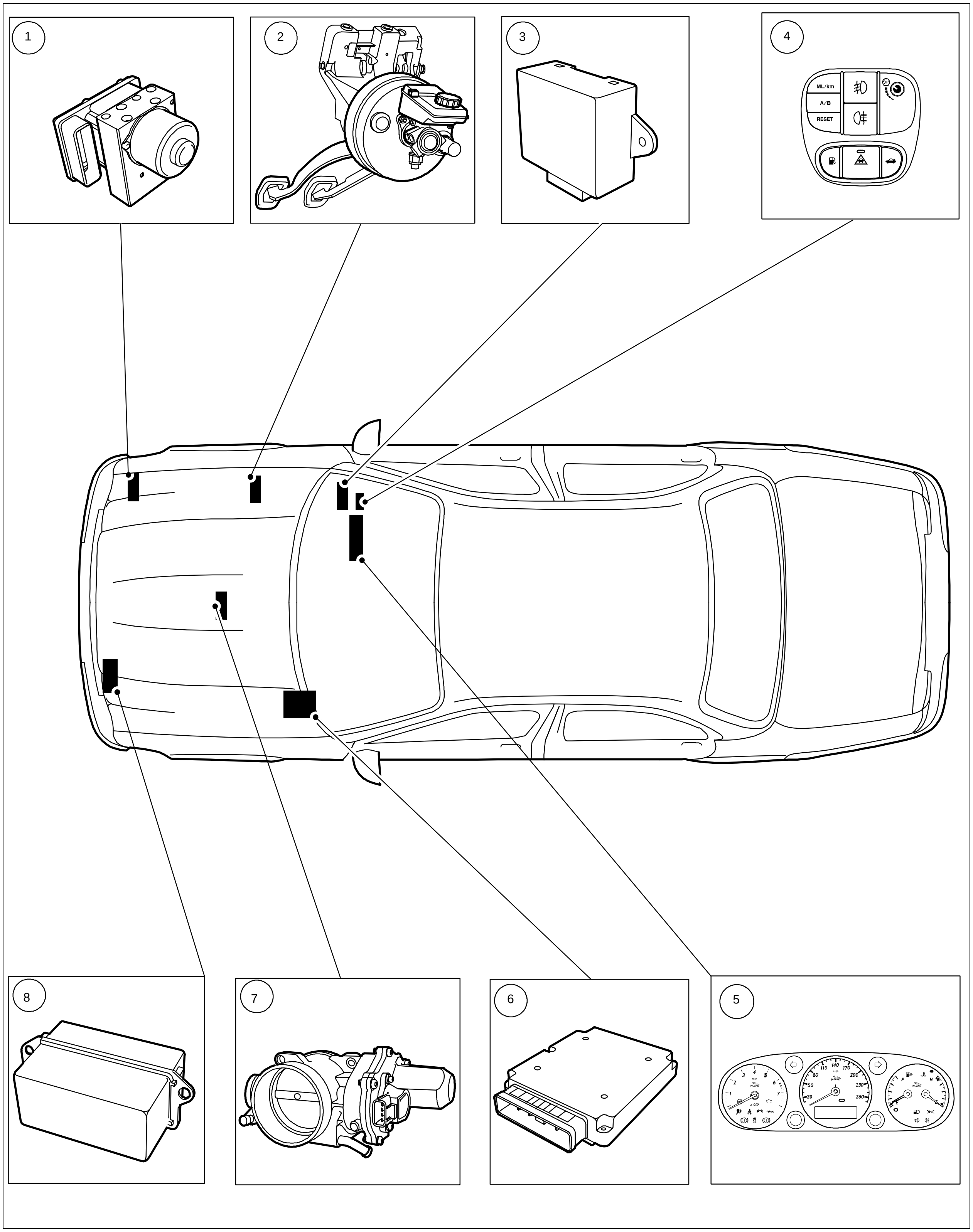

Fig. 127 ACC component locations (2004 XJ RHD shown)

1. ABS
2. Brake master cylinder and booster
3. Chime module
4. Forward alert inhibit switch
5. IC
6. ECM
7. Throttle housing
8. ACC module

This automatic target acquisition, adaptive cruise control system, operates in the following manner:

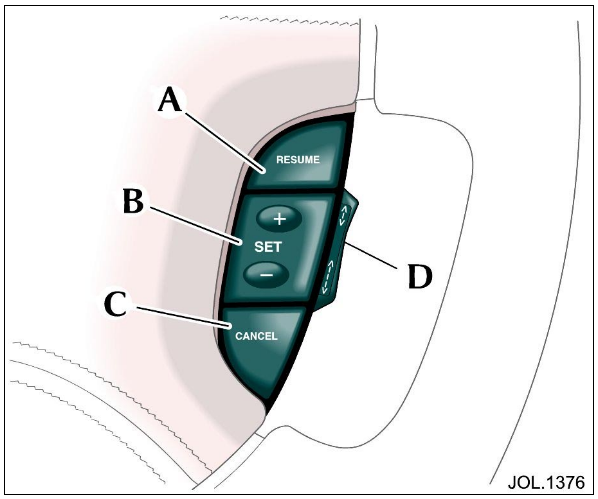

Fig. 128 XJ Series ACC Control switches

A. RESUME
B. SET
C. CANCEL
D. GAP

- The driver inputs a desired cruising speed and engages the system, in the same way as he would for conventional cruise control except for the gap increase decrease button as shown on the illustration below.
- The system will then cruise at this set speed until another slower moving vehicle is detected in the path of the vehicle. In this situation the system will operate the throttle and brakes to maintain a constant time based gap (headway) to the vehicle in front.
- When using ACC a chime will sound during circumstances when the driver is required to intervene. These circumstances may require the driver to apply more braking pressure than ACC is capable of. ACC sounds the chime based on the range of the followed vehicle and the rate at which the host vehicle is approaching.
- The XJ, the 2003MY XKR, and S-TYPE R systems all recognize stationary targets and sound the chime with the warning message accordingly.
- Forward alert is a feature that allows the ACC module to continue to monitor the road and invoke the ‘Driver Intervene’ chime and warning message independent to the ACC functionality. The chime will sound when the driver selected threshold for stationary targets is exceeded. The ‘Forward Alert’ switch enables the user to have this feature switched on or off.

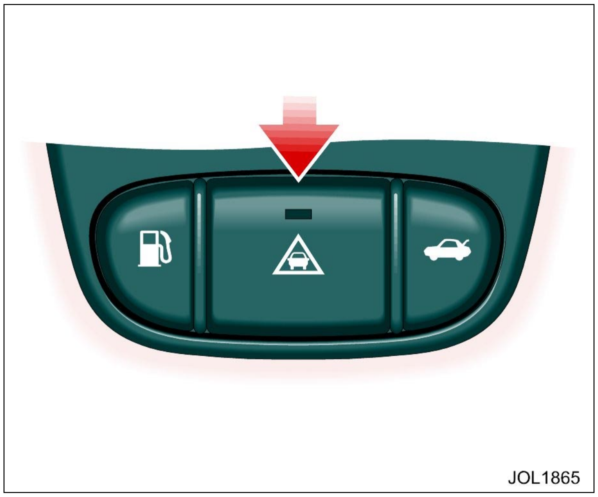

Fig. 129 Forward Alert Switch

- If the ACC is performing a resume while following a slower vehicle and a stationary target is in its path the resume is inhibited. This feature is intended for multi lane highways etc.

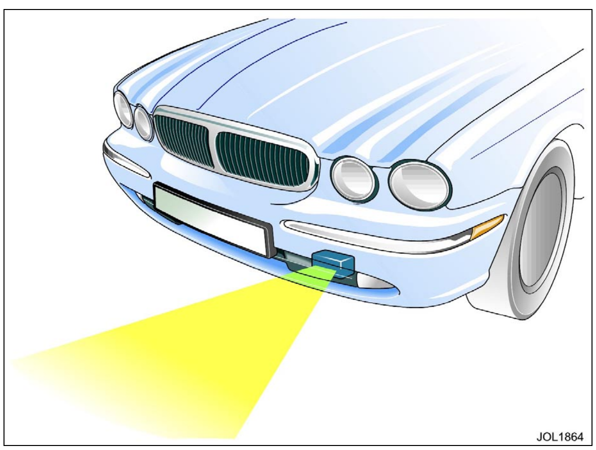

Fig. 130 X350 ACC module location

If the module is replaced or disturbed then it must be correctly aligned to the vehicle. This is done by setting the front face of the module vertical using the electronic spirit level from the beam alignment kit (X200) and the adjusting screw of the fixing bracket.

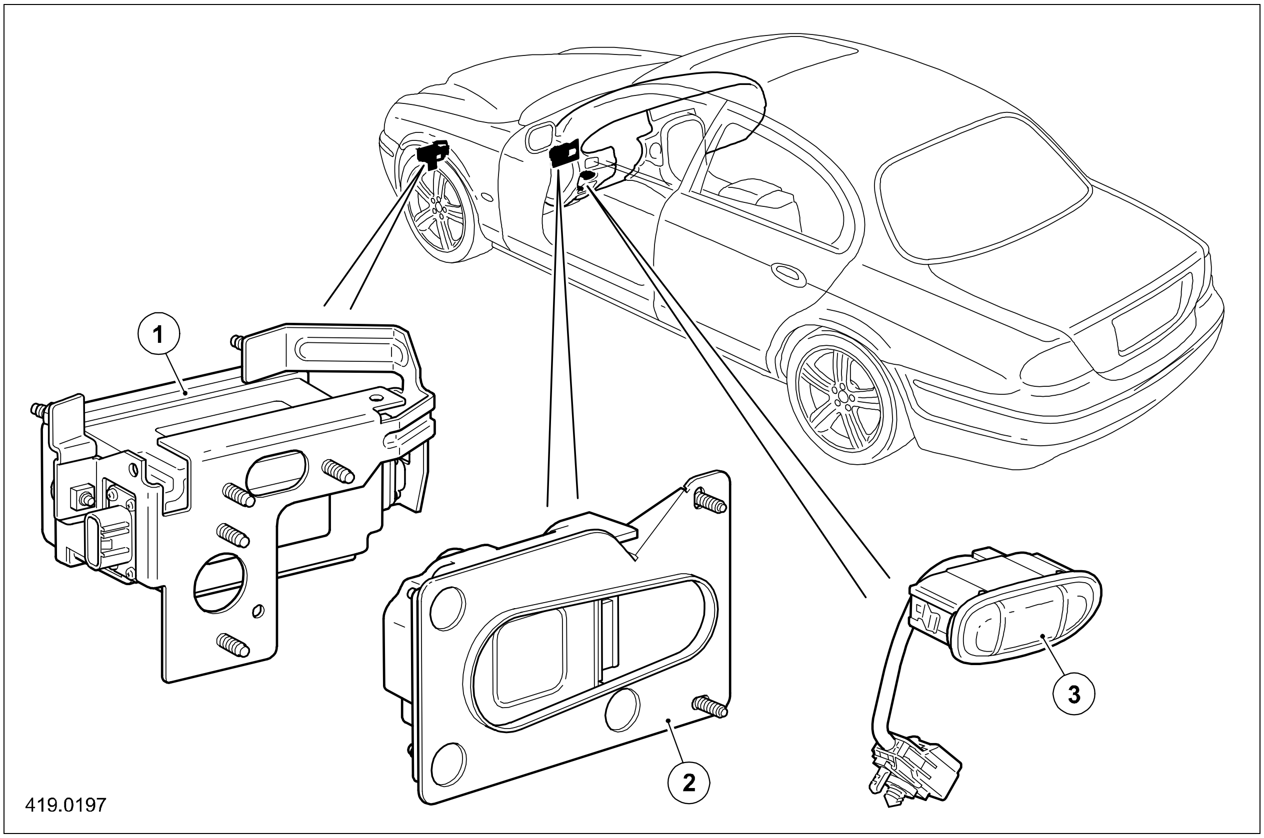

Fig. 131 X204 ACC component locations

The 2005 ACC system is updated from the 2004 version (ACC-2) to version ACC-3 but functions in the same way. The ACC-2 version had the radar sensor and the control module as a single package mounted behind the bumper cover cooling aperture to provide a clear view forward for the radar beam. The ACC-3 version retains the location for the radar sensor but has a separate control module, located underhood in the powertrain control module PCM cool box, next to the bulkhead. The ACC control module is secured with self-adhesive Velcro.

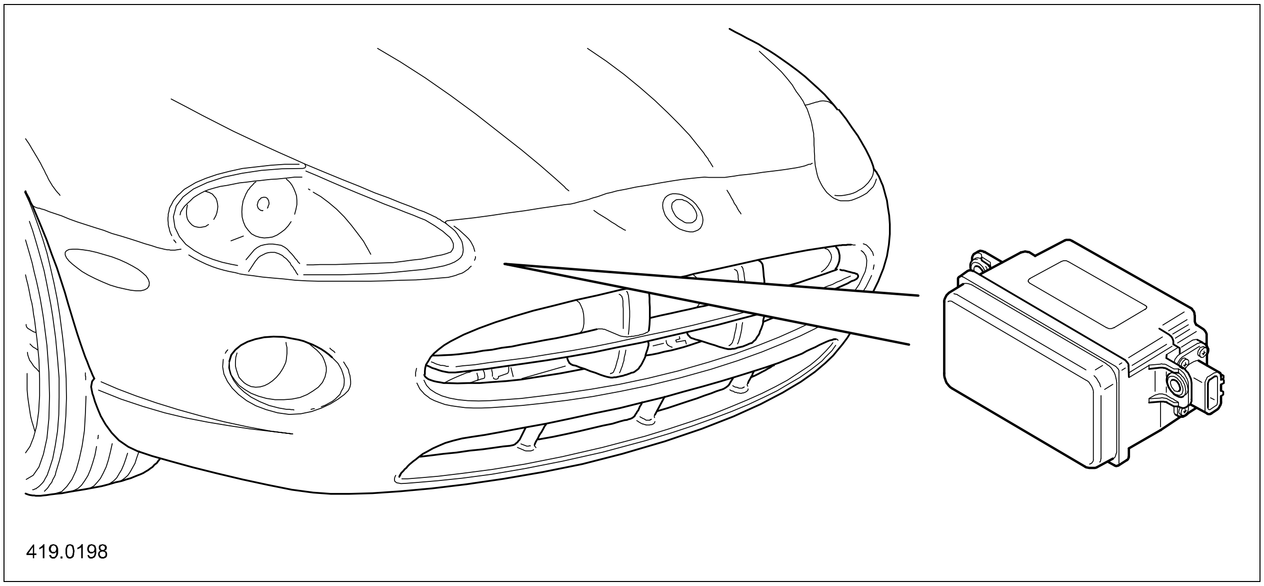

Fig. 132 2005 X105 ACC radar sensor location

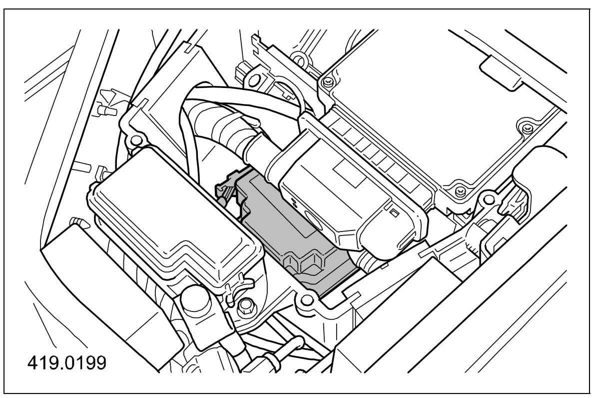

Fig. 133 2005 X105 ACC module location

If a new ACC module is fitted the new unit has to be configured (after alignment) on the vehicle using the WDS with the following information:

- Vehicle market
- Engine variant
- Tire size (for calculation of vehicle speed)
- Pecus programmed (to indicate whether Instrument cluster and ABS is configured for ACC)

The module will have to enter the ‘Service alignment mode’ via the WDS and driven for a short period of time in order to align the radar. The flashing yellow "Follow" Icon in the Instrument Pack will extinquish once alignment period completes.

Table 9 Adaptive Cruise Control Instrument Cluster Messages

MESSAGE CENTER	MEANING
CRUISE OFF	Cruise control has been switched off.
CRUISE ON	Cruise control has been switched on.
CRUISE NOT AVAILABLE	Vehicle performance not affected. Adaptive Cruise Control will not function.
SETSPEED xxx MPHSETSPEED xxx km/h	Displayed when any of the following conditions apply: - the cruise control is resuming to the speed displayed - the car's speed has been captured as the cruise control's set speed - the cruise control set speed is being adjusted with the set + or - buttons
CRUISE CANCELLED	Cruise control has been cancelled either by pressing the cancel button or pressing the brake pedal. Note that when Adaptive Cruise Control (ACC) has been cancelled it will no longer brake when approaching other vehicles on the road.
GAP <-------> GAP <-----> GAP <---> GAP <->	Displayed when either of the following conditions apply: - the car's speed has been reduced to follow a vehicle in front at the distance indicated - the intended gap to the vehicle ahead is adjusted with the steering wheel buttons (ACC only)
DRIVER INTERVENE	The driver must take control of vehicle braking and speed control. Displayed when any of the following conditions apply: - the driver must apply the brakes in order to avoid the vehicle in front (this may happen if the vehicle in front brakes harder than the ACC system is capable of braking) - ACC has been cancelled because the vehicle speed has fallen below the lower limit for ACC (this may happen in traffic when the vehicle in front slows down) - there is a fault with the ACC system causing it to be switched off

Automatic Speed Limiter

The automatic speed limiter (ASL) can be used by the driver to select a maximum vehicle speed limit between the range of 30 km/h (18 mile/h) to 240 km/h (150 mile/h) that is not to be exceeded. This is an additional feature that is interlocked with the cruise (speed) control system. The switch on the "J" gate surround allows the driver to switch between the cruise control (or adaptive cruise control, where fitted) system and the automatic speed limiter system.

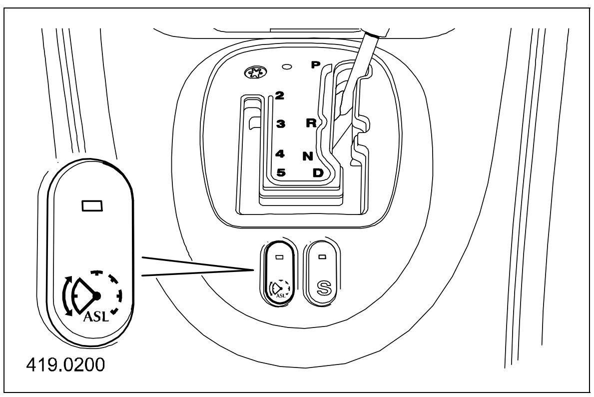

Fig. 134

It is advisable to set the speed limit while the vehicle is stationary but with the engine running. When the ASL system is switched on, the tell-tail status light will illuminate and the ASL function will be selected. In the alternative switch position, the light will be extinguished and the cruise control system will be selected.

When the ASL has been set, the engine will respond to the driver's accelerator pedal demand until the set limit is reached. At this point, provided that the accelerator pedal position is sustained, the vehicle will maintain the limit speed. The ASL system controls the vehicle speed through engine throttle control to match the limit speed.

If the accelerator pedal is depressed further, the vehicle will not increase speed but the automatic speed limiter will hold the vehicle to the limit speed. The ASL system can be cancelled either by switching to cruise control or applying kickdown on the accelerator pedal or by pressing the CANCEL button on the steering wheel.

The application by the driver of the brakes will not deactivate the ASL system. The system is deactivated and the limit speed memory deleted, each time the ignition is switched off.

When ASL is selected, the message center will display one of the following:

- Limiter set
- Limiter cancelled
- Limiter not available
- Too fast to resume limit
- Over limit

LINEAR VARIABLE VALVE TIMING

VVT Continually variable system

The VVT system provides continuously variable inlet valve timing over a crankshaft range of 48°.

Depending on driver demand, engine speed/load conditions and powertrain control requirements, the inlet valve timing is advanced or retarded to the optimum angle within this range.

The linear VVT system provides a number of advantages:

- Improves internal EGR, further reducing NOx (Oxides of nitrogen) emissions and eliminating the need for an external EGR system
- Optimises torque over the engine speed range without the compromise of the two position system: note that specified torque and power figures are unchanged
- Improves idle quality: the inlet valve opens 10° later, reducing valve overlap and thus the internal EGR effect (undesirable at idle speed)
- Faster VVT response time
- VVT operates at lower oil pressure

Linear VVT Components

Each cylinder bank has a VVT unit, bush carrier and solenoid operated oil control valve which are all unique to the linear VVT system. The VVT unit consists of an integral control mechanism with bolted on drive sprockets, the complete assembly being non serviceable. The unit is fixed to the front end of the inlet camshaft via a hollow bolt and rotates about the oil feed bush on the bush carrier casting.

The oil valve fits into the bush carrier to which it is secured by a single screw. The solenoid connector at the top of the valve protrudes through a hole in the camshaft cover but the cover must first be removed to take out the valve.

Engine oil enters the lower oil-way in the bush carrier (via a filter) and is forced up through the oil control valve shuttle spools to either the advance or retard oil-way and through the bush to the VVT unit. Oil is also returned from the VVT unit via these oil-ways and the control valve shuttle spools, exiting through the bush carrier drain holes.

Note that only the bush carriers are left and right handed.

Linear VVT operation — V6

Although the principle function of the V6 VVT is the same as that used on the AJ-27 V8 engine the internal operating components of this VVT are different. Instead of a helical gear construction the unit uses a vane device to control the camshaft angle.

The VVT unit is driven by the timing chain and rotates relative to the exhaust camshaft sprocket. When the ECM requests the camshaft timing advance, the oil control solenoid is energised moving the shuttle valve to a relevant position to allow the engine oil pressure, via a filter, into the VVT unit's advance chamber. When the camshaft timing is requested to retard, the shuttle valve moves position to allow oil pressure to exit the advance chamber, while simultaneously routing the oil pressure into the retard chambers.

When directed by the ECM the VVT unit will be set to the optimal position between full advance and retard for a particular engine speed and load. This is achieved by the ECM rapidly pulsing the energising signal to the oil control solenoid. Due to this rapid pulsing the shuttle valve assumes a position between the limits of it's travel and is continuously controlled by the ECM to maintain the requested camshaft angle. The actual position of the inlet camshaft is monitored by the camshaft position sensors which transmits signals to the ECM.

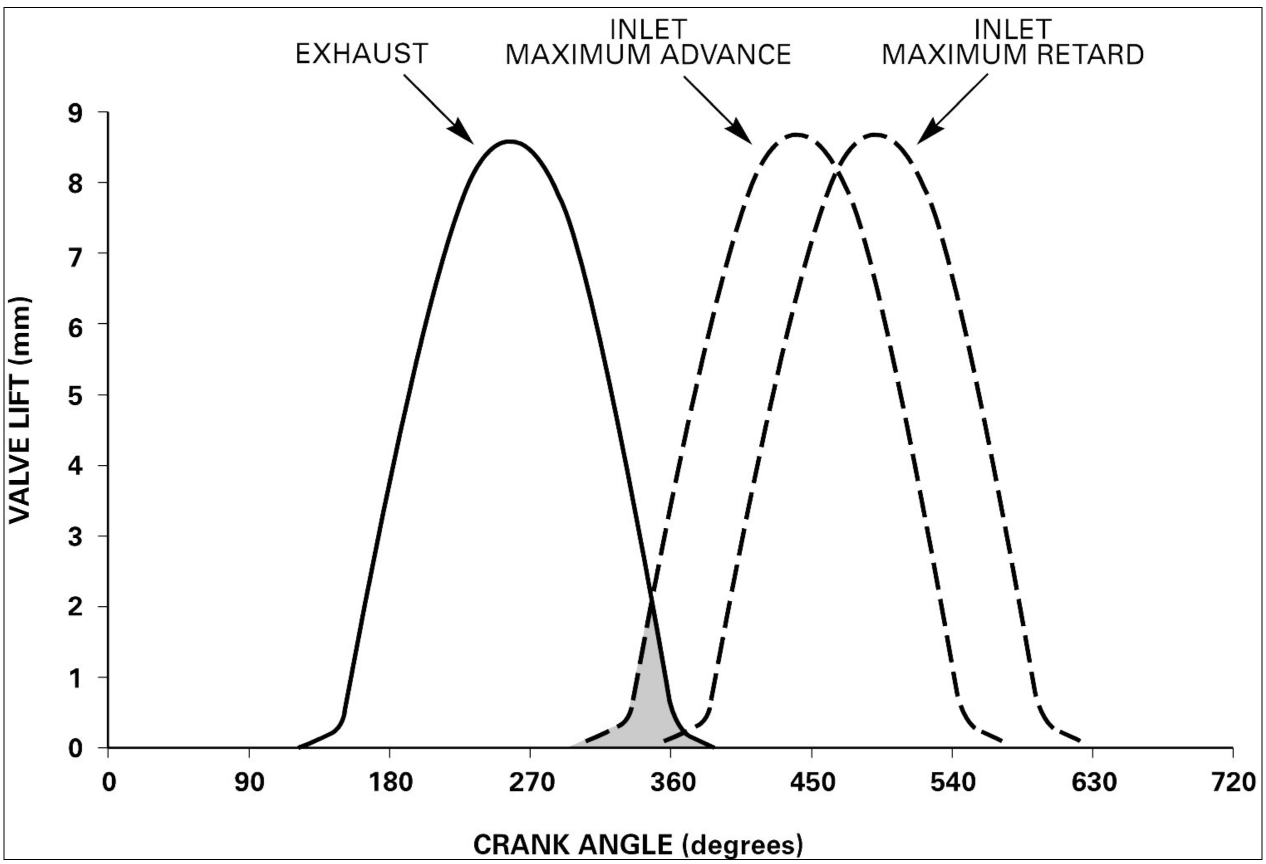

Fig. 135 LINEAR VVT

Linear VVT - ECM Closed Loop Control

Normally, continuously variable timing requires the VVT piston to be set to the optimal position between full advance and retard for a particular engine speed and load. The ECM positions the shuttle valve using PWM control signal operating at a frequency of 300 Hz. The shuttle valve assumes a position between the limits of travel proportional to the "duty cycle" of the signal. An increasing duty cycle causes an increase in timing advance.

The shuttle valve is continuously controlled by the ECM to maintain a given cam angle. The actual position of the camshaft is monitored by a variable reluctance sensor which generates pulses from the toothed sensor ring keyed on to the end of the camshaft and transmits them to the ECM. If a difference is sensed between the actual and demanded positions, the ECM will attempt to correct it. The cam sensor fitted to each bank allows each bank to have its own feedback loop. The four tooth cam sensor rings increase the cam position feedback frequency, providing the enhanced control required by the VVT system. The use of four tooth sensor rings also improves starting.

Variable valve timing (VVT) AJ-33 and AJ-34

Faster engine response at all speeds is available due to inlet camshaft timing that is continuously varied according to demands and conditions. The V8 VVT system uses principles similar to that used on the AJ-V6 3.0 litre engine. The V8 uses a three vane unit in lieu of the four vane unit on the V6 variants.

Although principle function of this VVT system is the same as that used on the V8 (AJ-27) engine, the internal operating components of this VVT unit are different. Instead of a helical gear construction this VVT unit uses a vane device to control the camshaft angle. The system operates over a 48 degrees and is advanced or retarded to the optimum angle within this range.

This system also has the added benefits of operating at a lower oil pressure and faster response time.

The VVT unit is a hydraulic actuator mounted on the end of the intake camshaft, which advances or retards the intake camshaft timing and thereby alters the camshaft to crankshaft phasing. The oil control solenoid, controlled by the ECM, routes oil pressure to either the advance or retard chambers located either side of the three vanes interspersed within the machined housing of the unit.

The actual position of the intake camshaft is monitored by the camshaft position sensor, which transmits signals to the ECM.

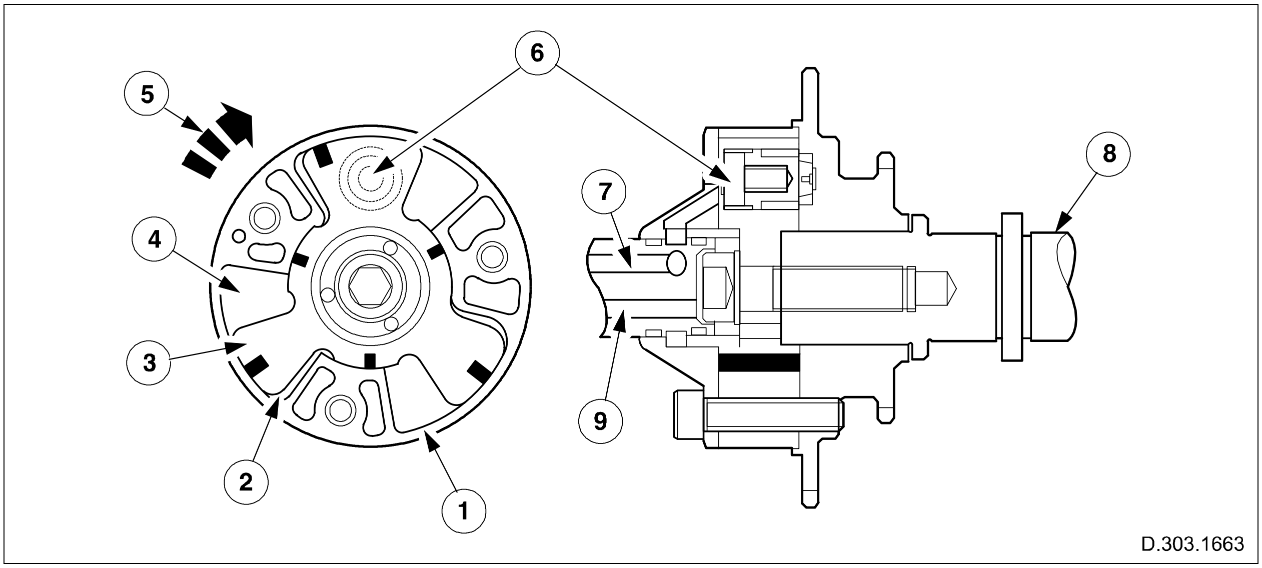

Fig. 136 VVT unit

1. Vane unit
2. Advance chamber
3. Vane shaft
4. Retard chamber
5. Rotation direction
6. Stopper pin
7. Advance chamber oil-channel
8. Intake camshaft
9. Retard chamber oil-channel

FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL

Electronic Returnless Fuel System Overview

The electronic returnless fuel system provides pressurized fuel at the fuel injectors and does not require a return line with its associated hardware. Due to the design of the system, it is possible to achieve more precise evaporative emission control. Additional benefits of the system include:

- Precise fuel pressure control
- Reduced fuel temperature and fuel tank vapor caused by constant fuel recirculation
- Reduced electrical system load
- Fuel pressure boost to prevent fuel vapor lock
- Reduce hot start cranking time

Fuel delivery volume and pressure from the single in-tank fuel pump are controlled by the ECM in a closed loop. The actual fuel pump "drive" is supplied and controlled by either the Rear Electronic Module (S-TYPE, XJ) or Fuel Pump Module (X-TYPE, XK), which receives fuel pump control input from the ECM.

NOTE:

S-TYPE and XJ supercharged engines have a separate fuel pump module to drive a second fuel pump.

The system delivers the correct amount of fuel to the engine under all conditions and at a constant pressure differential with respect to manifold absolute pressure, without the need for a return line to the tank.Instead, the injection pressure sensor measures the pressure difference electronically, and the REM or fuel pump module increases/decreases the fuel flow from the pump accordingly.

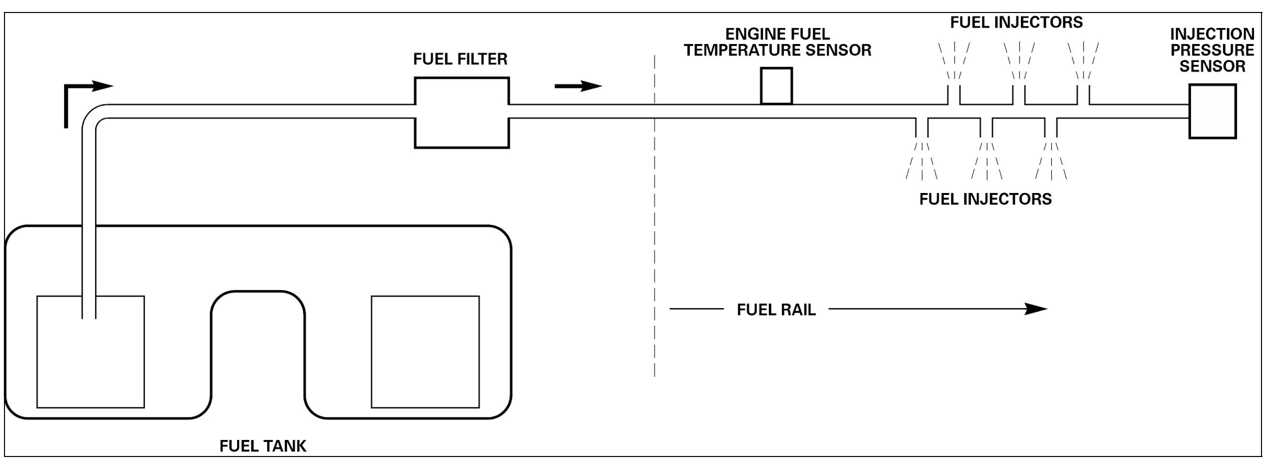

Fig. 137 ELECTRONIC RETURNLESS FUEL SYSTEM

Fuel Tank and Components: X-TYPE, S-TYPE, XJ

The plastic blow-molded fuel tank is a saddle shape tank with LH and RH fuel compartments. The tank is located below the rear passenger seat with the drive shaft and exhaust running through the arch of the tank. The underside of the tank is protected by a heat shield.

Refueling is via a separate filler pipe and connecting hose to a stub pipe on the RH fuel compartment.

A variable speed fuel pump is located in the RH compartment (normally aspirated engines). Jet pumps are located in both compartments with internal crossover pipes for fuel transfer between the compartments. The crossover pipes and electrical connectors exit the fuel tank through top plates which are secured in the tank using screw-on closure rings. The components on the top of the fuel tank are accessible from inside the vehicle via two access holes in the floor panel, below the rear seat.

NOTE:

The fuel tank on the X-TYPE is only accessible by removing it from the vehicle.

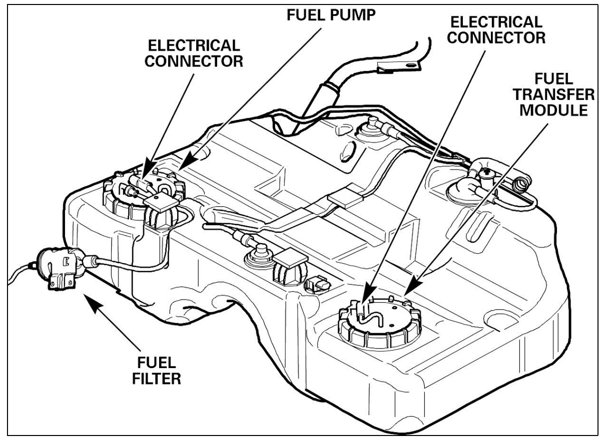

Fig. 138 2001–2003MY (X400) X-TYPE FUEL TANK

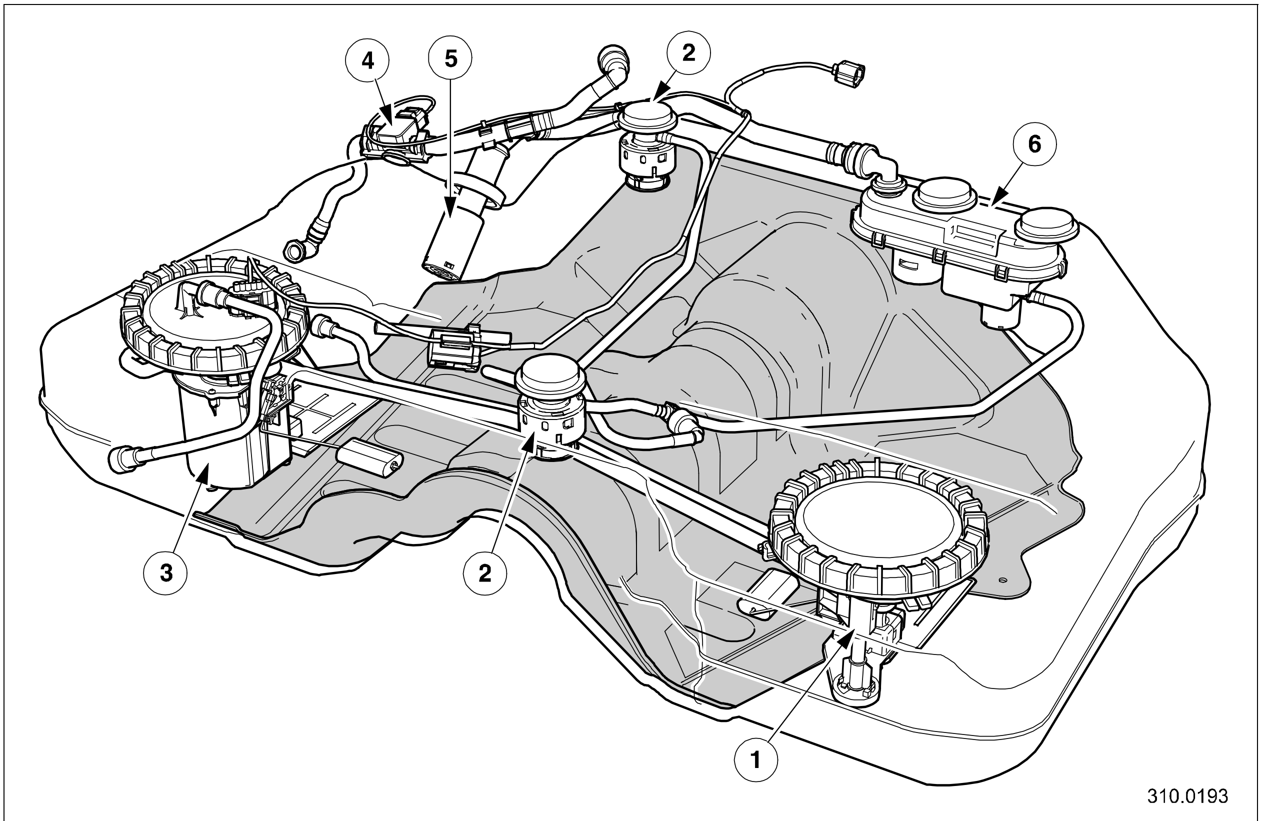

Fig. 139 2004MY (X404) X-TYPE Fuel tank

1. Sender and fuel transfer module
2. Roll-over valve
3. Sender and pump assembly
4. Pressure transducer
5. Inlet check valve
6. Fuel delivery shut-off valve

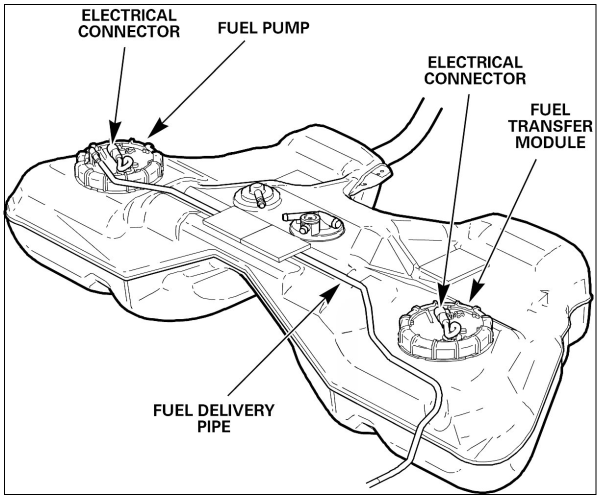

Fig. 140 S-TYPE FUEL TANK (N/A ENGINES)

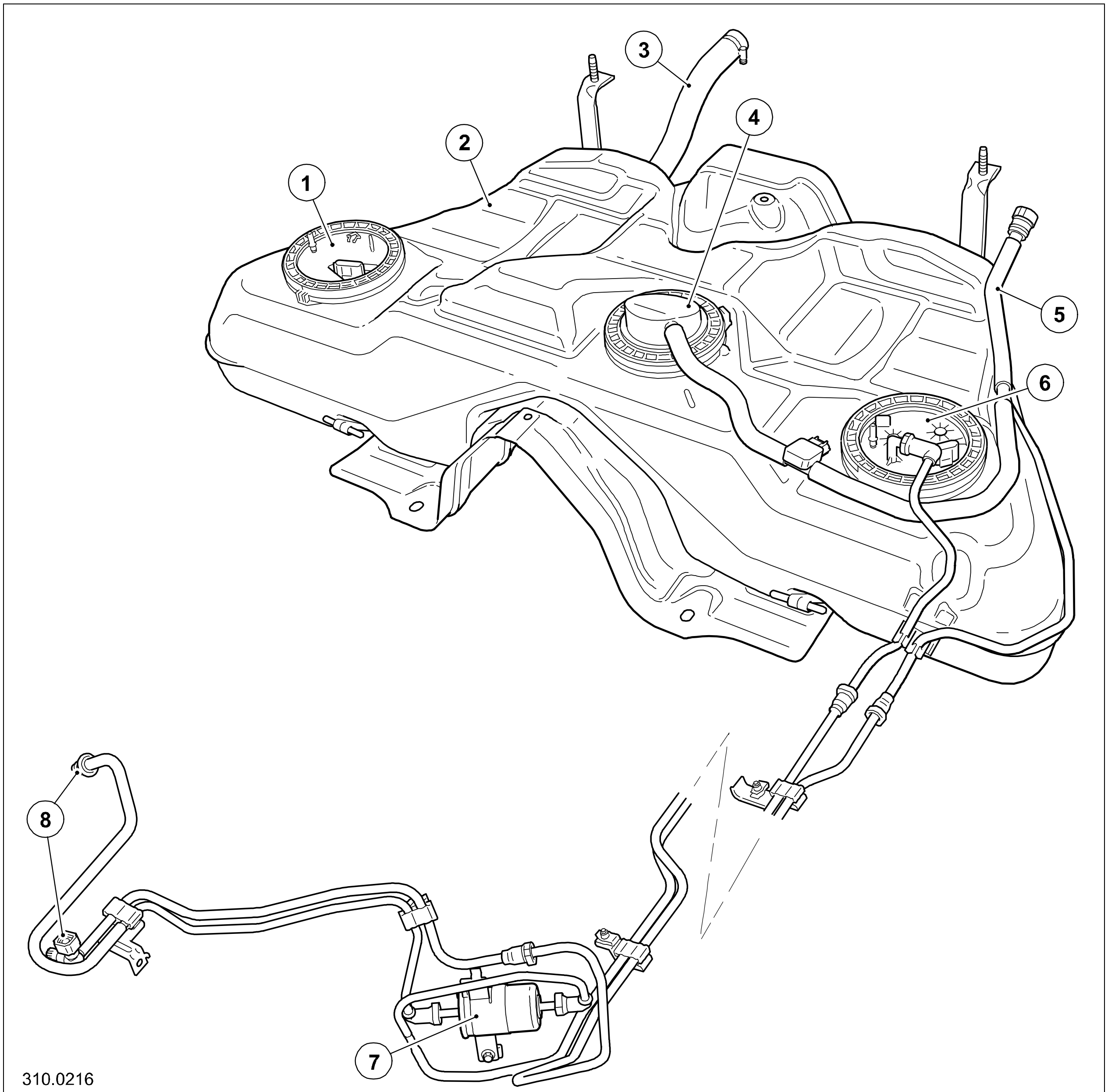

Fig. 141 S-TYPE (X204) FUEL TANK (S/C ENGINES)

1. Fuel pump and sender unit
2. Fuel tank
3. Hose to filler neck
4. Pressure control valve
5. Pipe to carbon can
6. Fuel pump and sender unit
7. Fuel filter
8. Fuel pipes to engine

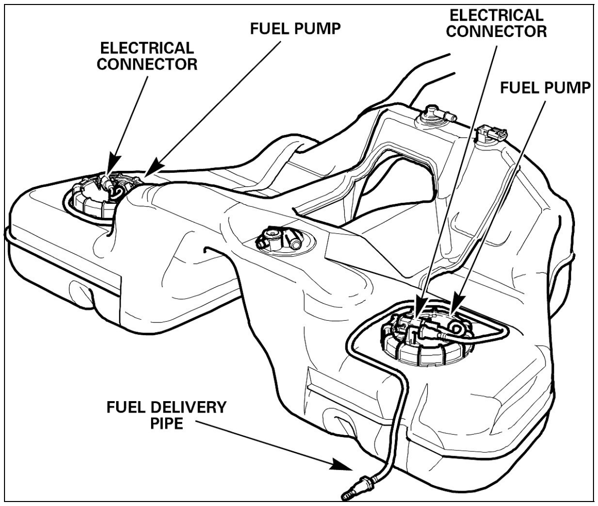

Fig. 142 XJ (X350) FUEL TANK (SC ENGINES)

Supercharged engines have a second fuel pump (not XKR) located in the LH compartment to supply the additional fuel necessary to achieve high engine loads and speeds. The internal fuel tank components are unique to the supercharged variants.

Fuel Tank and Components: XK

XK vehicles use a formed steel fuel tank located in the trunk above the rear axle. A common internal fuel pump is used for both normally aspirated and supercharged engines. Vent lines and electrical connections are made via the centrally located evaporative flange located at the top of the fuel tank. The fuel level sensor locates into the tank via a flange at the rear of the tank.

Starting with the 2003MY, XKR models use only one fuel pump instead of 2 as on the XJR and S-TYPE R.

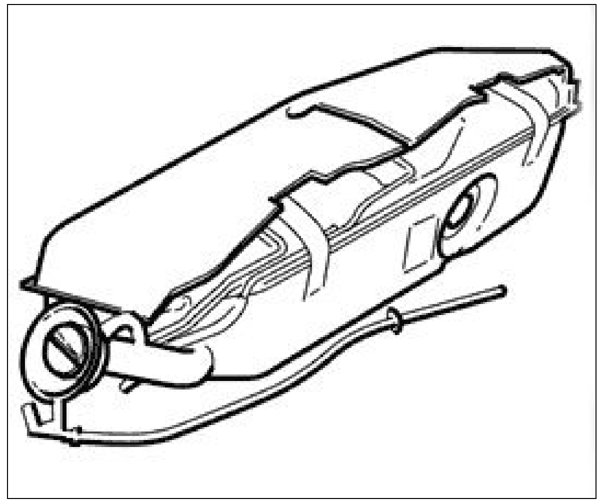

Fig. 143 XK Tank

2005MY S-TYPE (X204) LEV II Fuel Filler neck features

- Stainless steel construction.
- New fixing arrangement to accommodate the new filler bowl.
- New low permeation hose, filler neck to tank.
- New filler cap (as X-TYPE Level II).
- New vapor line to eliminate joints in the wheel arch area.

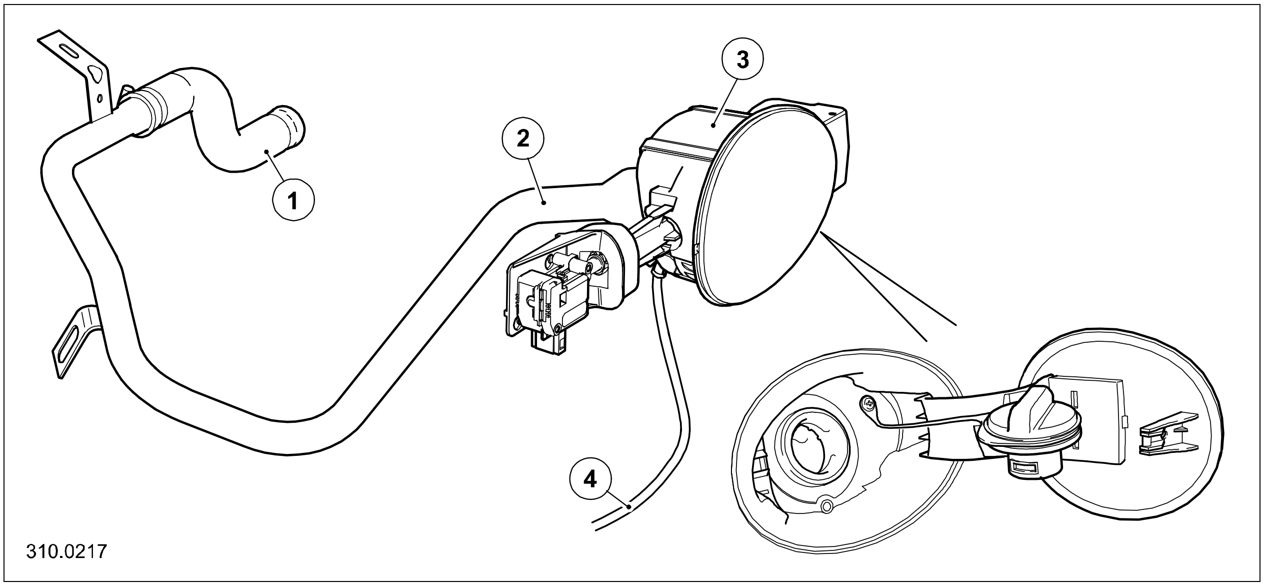

Fig. 144 2005MY X204 LEV II Fuel filler neck

1. Hoes to fuel tank
2. Stainless steel filler neck
3. Filler neck bowl
4. Vapor pipe

Fuel Filter

A replaceable in-line fuel filter is located in the fuel delivery line. All fuel supply lines use quick-fit connections that require a Jaguar service tool.

On-Board Refueling Vapor Recovery: X-TYPE, S-TYPE, XJ

To meet on-board refueling vapor recovery (ORVR) requirements, the fuel tank and associated components are designed to minimize fuel vapor loss by preventing fuel vapor from the fuel tank venting directly to the atmosphere. Fuel vapor therefore, is vented into the evaporative emission canister (EVAP canister) where it is stored before being purged at intervals determined by the ECM to the engine's intake manifold.

During refueling the narrow fuel-filler-tube below the fuel-dispenser nozzle region, provides a liquid seal against the escape of vapor. A check valve also located in the filler-tube opens to incoming fuel to prevent splash back. As the fuel tank fills, fuel vapor is routed through the open float-level vent-valve located in the top of the tank. The fuel vapors then flow through to the EVAP canister where hydrocarbons are removed from the vapor to meet emission regulations. The purified air passes to atmosphere through the vent pipe. The remaining hydrocarbons are stored in the EVAP canister, before being purged at intervals determined by the ECM to the engine's intake manifold. The rising fuel-level in the fuel tank closes the float-level vent-valve when the fuel tank reaches full, and the resulting back-pressure causes refueling to stop automatically. While the float-level vent valve is closed, any further rise in vapor pressure is vented to the EVAP canister via the grade vent-valve.

NOTE:

The float-level vent valve is always open when the fuel-tank level is below full, providing an unrestricted vapor outlet to the EVAP canister.

If a malfunction occurs in the fuel tank delivery system and the tank overfills, an integral pressure relief valve in the float-level valve opens, to provide a direct vent to the atmosphere.

The ORVR system incorporates the following safety devices:

- The fuel-filler cap incorporates both pressure and vacuum relief valves.
- Both the float-level vent valve and the grade vent valve incorporate protection against leakage in the event of a vehicle rollover.

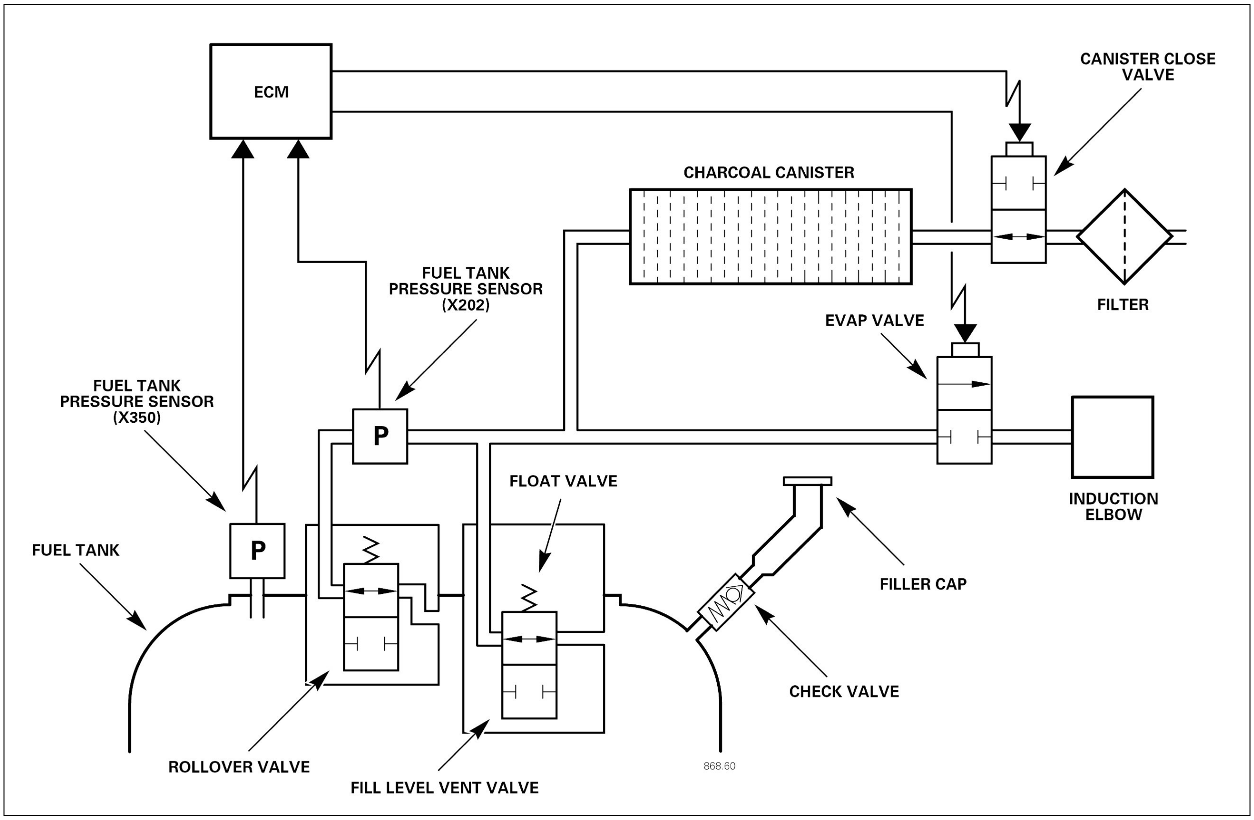

Fig. 145 ORVR System S-TYPE (X202), XJ (X350)

Upgrades to Fuel Tank and Lines (X204) to meet LEV II Evap

Modifications and improvements to the fuel system have been incorporated, mainly, but not only, to conform to the latest NAS requirements.

It is a NAS requirement that vehicles must comply to the improved Level II evaporative emissions requirements by 2005 MY.

Introduction by Jaguar is required by January 2004.

Requirements are that the system should have reduced emissions (Jaguar target 330 mg) and 15 years/150,000 mile durability.

Changes to the fuel system, based on the information given above, are as follows:

- New fuel tank with improved sealing systems.
- New carbon can assembly with bleed trap.
- New stainless steel filler neck to satisfy 15 year durability requirement.
- New fuel lines with reduced number of joints.

2005MY S-TYPE (X204) Carbon Can updates for LEV2 Standards

- New brackets front and rear to suit the Level ll mounting system.
- New bleed can.
- No items are serviceable separately.

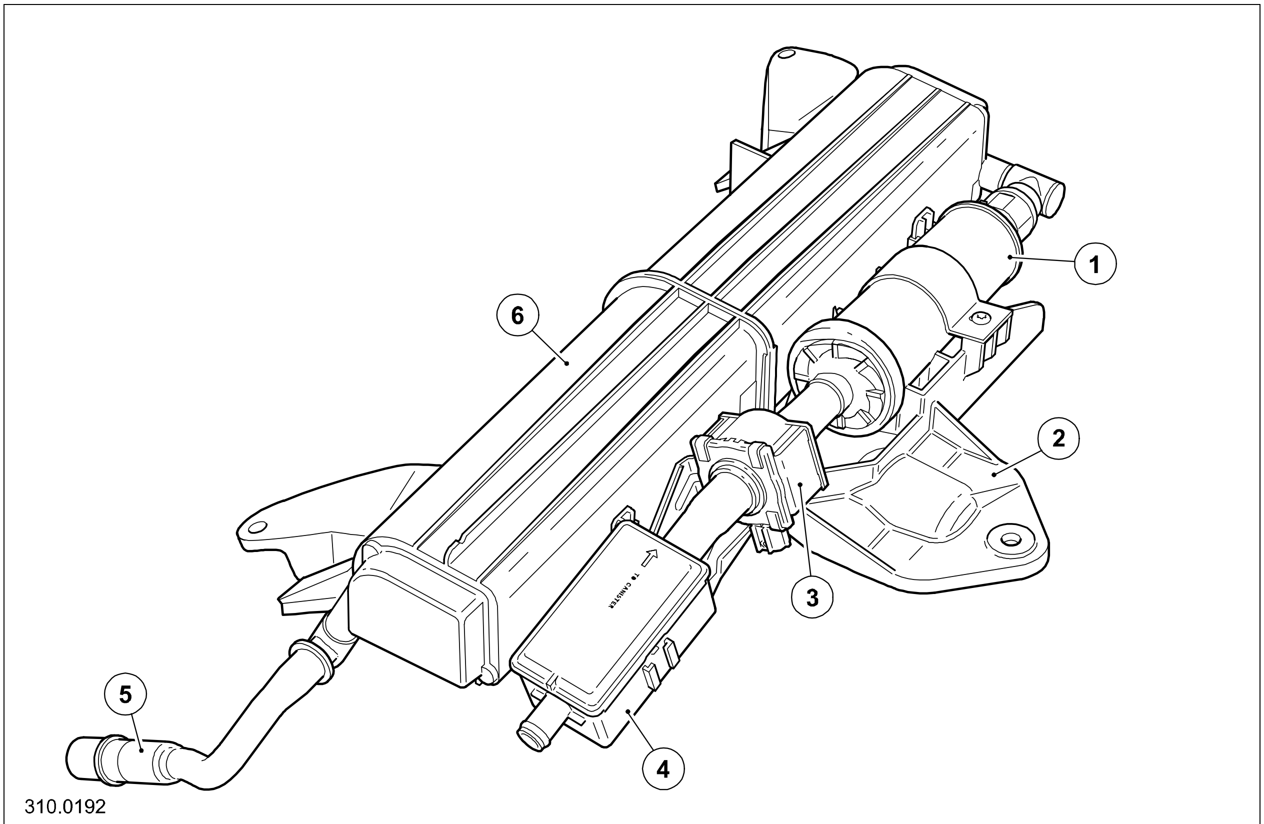

Fig. 146 X204 carbon can

1. Bleed Can
2. Mounting bracket
3. Canister close valve
4. Dust box
5. Pipe to fuel tank
6. Carbon can

Fuel Delivery

The fuel pump is a variable-speed rotary-vane type, which operates in a fuel module located in the RH fuel tank compartment. A fuel transfer module is located in the left-hand compartment. Both components are secured by screw-on plastic closure rings and have integral top plates for external line-work and electrical connectors. The fuel delivery line connects to the tank module on the RH side (X-TYPE, S-TYPE) or LH side of the tank (XJ).

Fuel is maintained between the fuel tank compartments by circulating the fuel through internal crossover lines via suction jet-pumps. High-pressure fuel from the fuel pump is directed through the jet-pump's orifice, creating a low-pressure area to be formed around the orifice. Fuel is drawn into this low-pressure area and directed into the crossover line to the opposing module. On XK vehicles, a common internal fuel pump is used for both normally aspirated and supercharged engines. Starting with the 2003MY, XKR models use only one fuel pump instead of 2 as on the XJR and S-TYPE R

Fuel is pumped from the fuel pump to the fuel rail via the parallel pressure relief valve and fuel filter. The parallel pressure relief valve contains two spring-loaded valves, which operate in opposite directions. The function of the valve is to:

- Assist engine starting by retaining a pre-set fuel pressure in the fuel delivery line and fuel rail whenever the ignition is turned off, and hence the fuel pump is not energized.
- Limit fuel-rail pressure due to temporary vapor increase in hot conditions while the ignition is off.
- Prevent leakage from the tank in the event that the fuel delivery line is severed.

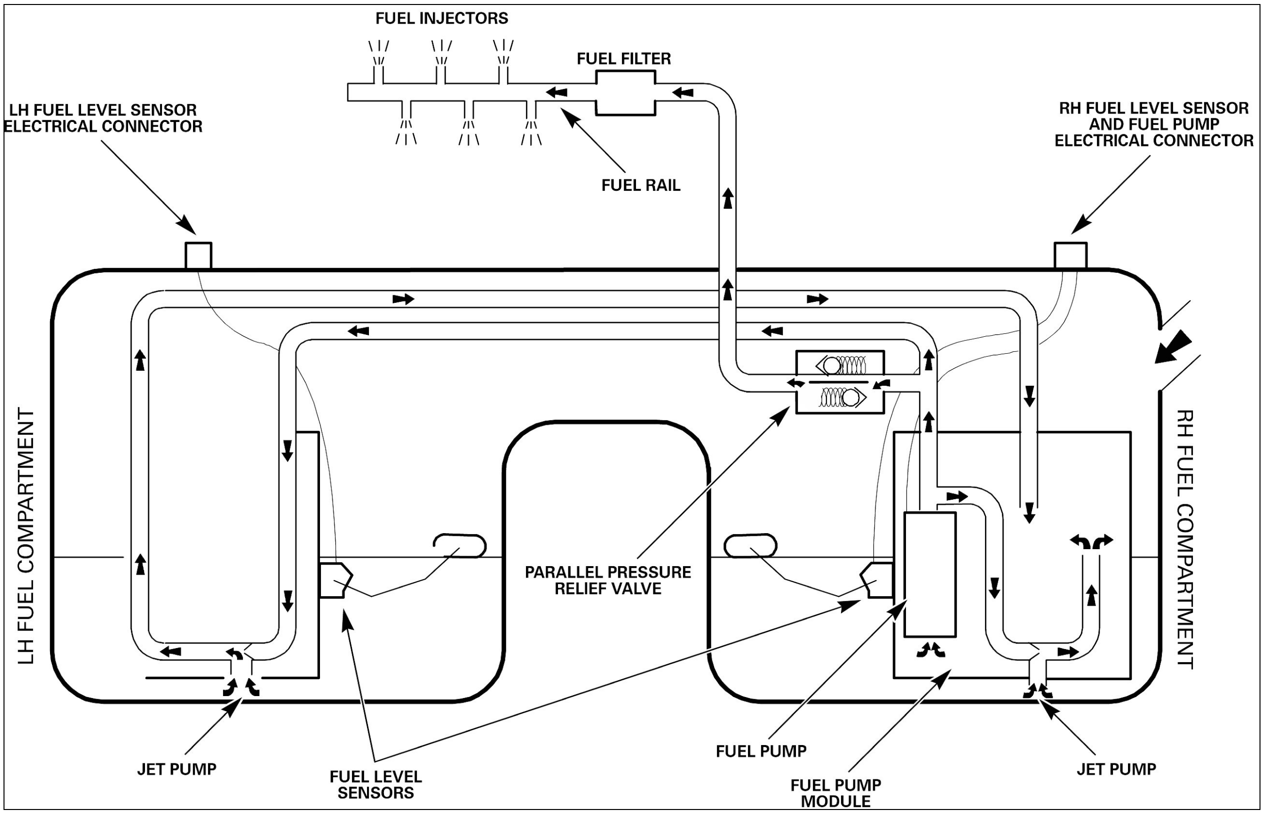

Fig. 147 X-TYPE FUEL FLOW DIAGRAM

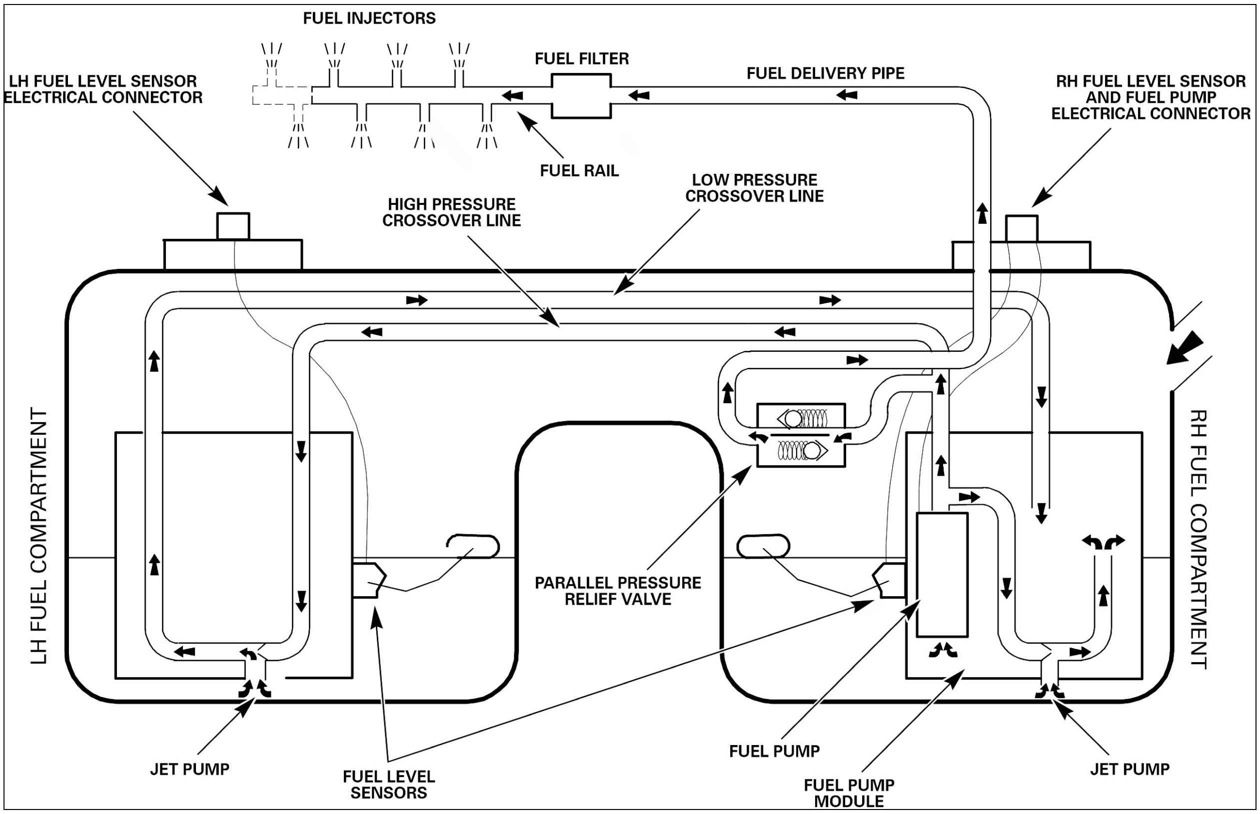

Fig. 148 S-TYPE / XJ FUEL FLOW DIAGRAM

Supercharged Engines

The twin fuel pumps (not XKR) are high-performance variable-speed types, with each pump operating in a fuel module located in each fuel tank compartment. The pumps are secured by screw-on plastic closure rings and have integral top plates for external line-work and electrical connectors. The fuel delivery line connects to the RH module.

The operating principles are the same as the single fuel pump tanks. Note that each fuel pump outlet has a parallel pressure relief valve before the lines merge into one.

Both pumps run simultaneously

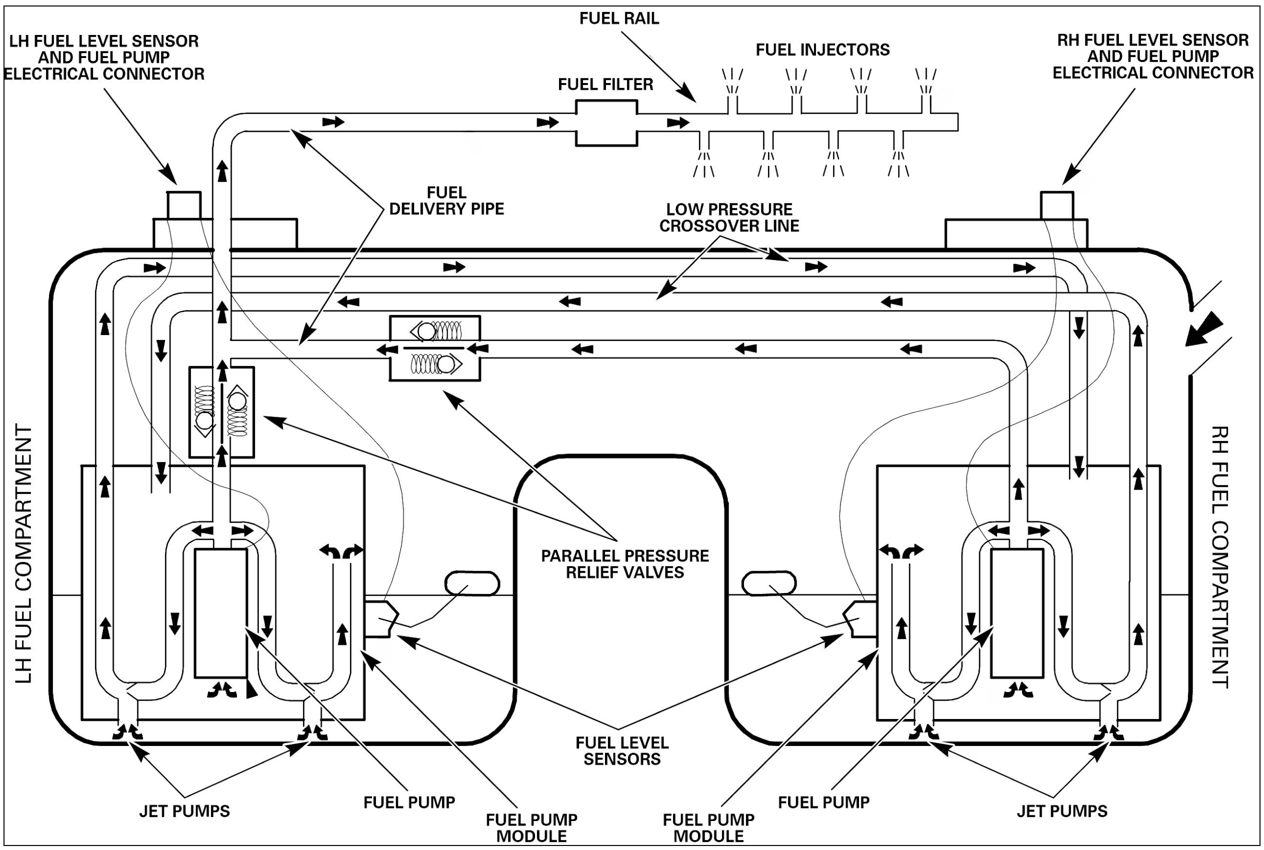

Fig. 149 XJ SUPERCHARGED FUEL FLOW DIAGRAM

Fuel Level Sensors

The fuel level sensors produce a fuel level signal by a moving contact (wiper) passing along a resistance track. One end of the resistance track is connected to the control module to provide a constant resistance signal (signal ground). A moving contact that moves with the fuel level provides a variable resistance signal to the control module.

- X-TYPE — The fuel level sensors provide their signals directly to the Instrument Cluster where they are processed and averaged. The Instrument Cluster uses the averaged signal for fuel level display and trip computer fuel calculations. Both the “averaged” and the “raw” fuel level messages are broadcast on the CAN Network. The ECM receives the CAN fuel level messages for EMS use.
- S-TYPE, XJ — Two fuel level sensors are fitted, one for each fuel tank compartment. The fuel level signals are transmitted to the Rear Electronic Module (REM) where they are processed and averaged. The REM broadcasts both the “averaged” and the “raw” fuel level messages on the SCP Network. The Instrument Cluster receives the SCP fuel level messages for fuel level display, trip computer fuel calculations, and broadcast on the CAN Network. The ECM receives the CAN fuel level messages for EMS use.
- XK — A single fuel level sensor is fitted which provides its’ signal directly to the Instrument Cluster. The Instrument Cluster uses the signal for fuel level display, trip computer fuel calculations, and broadcast on the CAN Network. The ECM receives the CAN fuel level messages for EMS use.

Fuel Level Sensor Diagnostic Monitoring

The fuel level signal is continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for range / performance (actual fuel level as compared to expected fuel level). If a fault is detected, the ECM takes no default action.

In addition to ECM monitoring, the fuel level sensor circuits are monitored for faults by the REM (S-TYPE, XJ) or IC (X-TYPE, XK) and reported as BODY DTCs. Further SCP fuel level message monitoring is carried out for S-TYPE and XJ vehicles. Faults are as BODY DTCs.

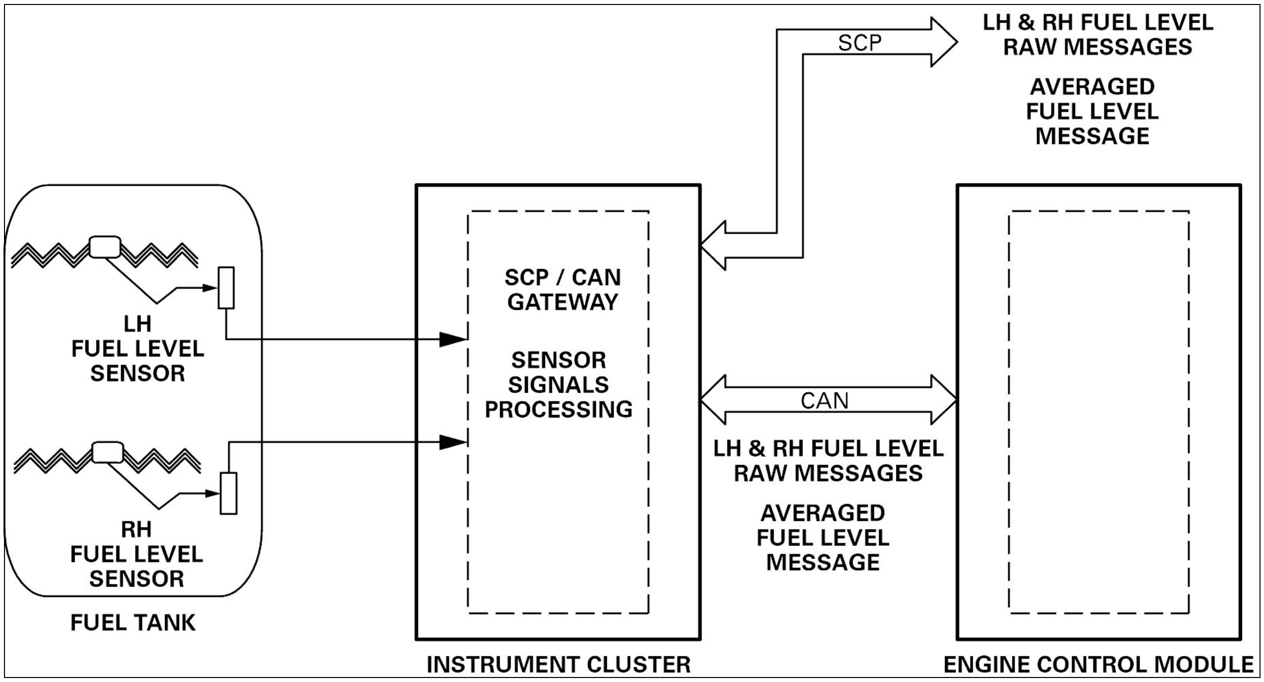

Fig. 150 X-TYPE FUEL LEVEL SENSOR DIAGRAM

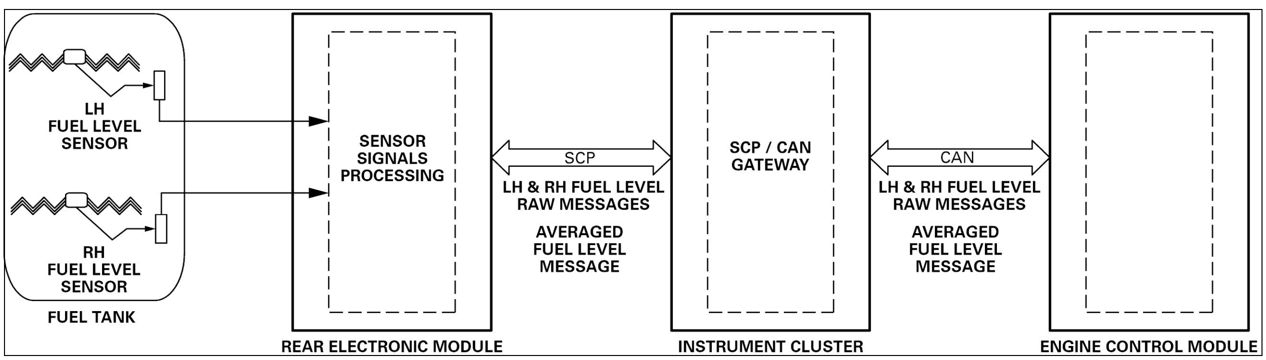

Fig. 151 S-TYPE / XJ FUEL LEVEL SENSOR DIAGRAM

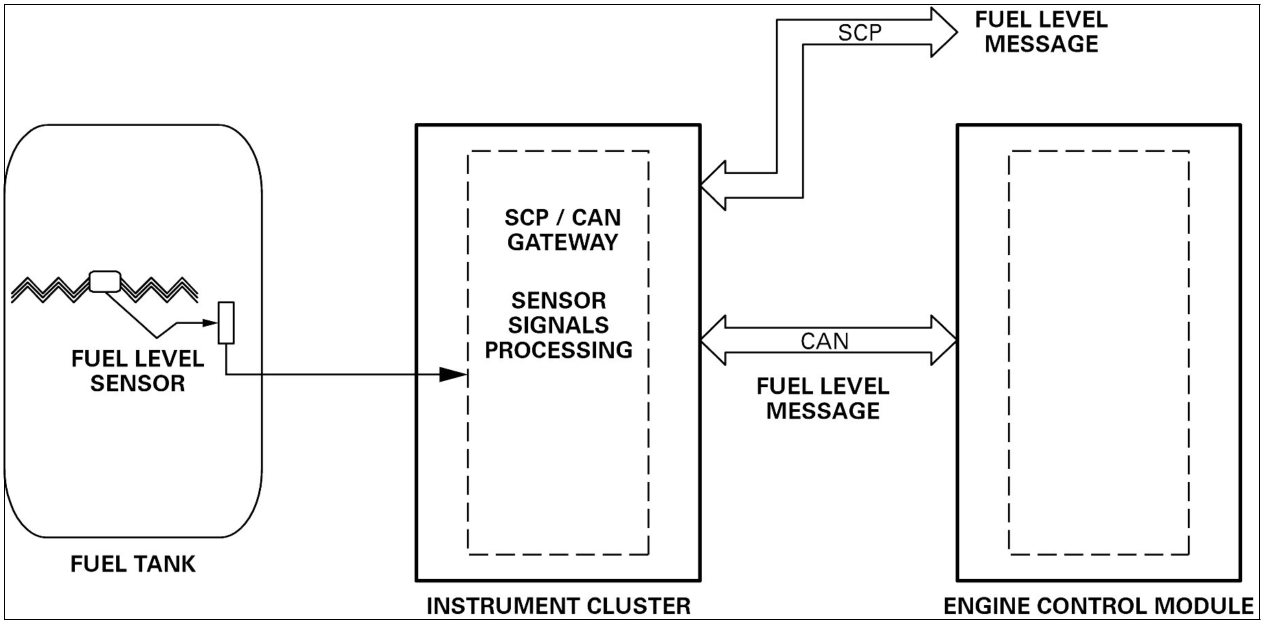

Fig. 152 XK FUEL LEVEL SENSOR DIAGRAM

Returnless Fuel System Sensors

The fuel pump(s) delivers fuel through a single fuel supply line to the closed-ended fuel rail. Two sensors located on the fuel rail, the Fuel Injection Pressure Sensor and the Engine Fuel Temperature Sensor, signal differential fuel rail pressure, and fuel temperature to the ECM.

Fuel Injection Pressure Sensor (IP Sensor)

The IP sensor is a pressure transducer device with a diaphragm separating the pressure transducer from direct contact with the fuel. A pipe connects the sensor to the intake manifold for sensing manifold depression (manifold vacuum). The sensor is supplied with nominal 5 volts and signal ground. The voltage signal from the transducer signal circuit is "conditioned" within the sensor.

The ECM receives the conditioned voltage signal, which is proportional to differential fuel pressure in the rail.

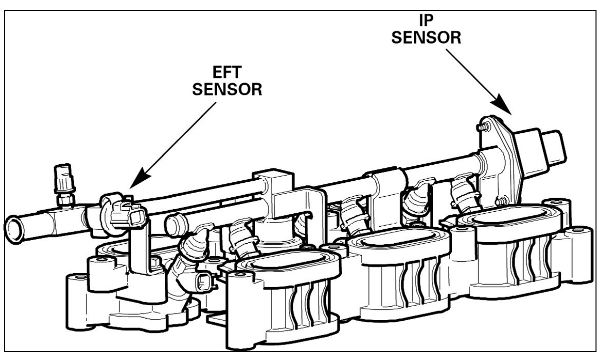

Fig. 153 X-TYPE V6 FUEL RAIL

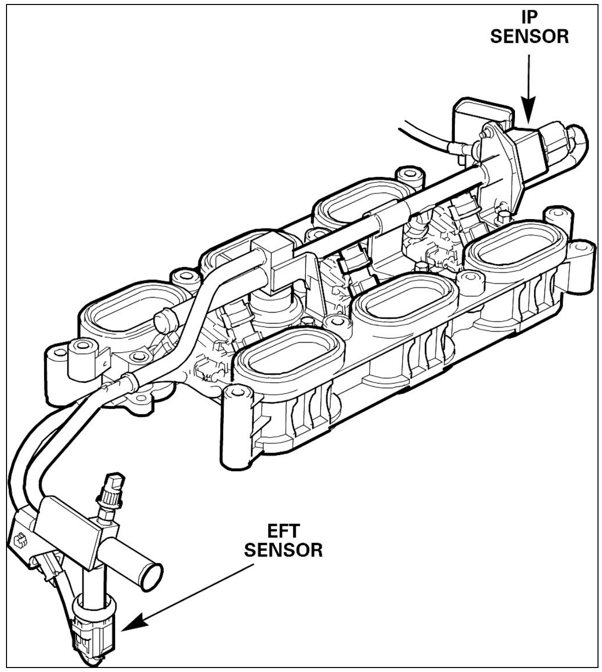

Fig. 154 S-TYPE V6 FUEL RAIL

IP Sensor Diagnostic Monitoring

The IP Sensor circuits are continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for:

- Range / performance (actual pressure as compared to expected pressure)
- IP Sensor signal circuit low voltage (low pressure)
- IP Sensor signal circuit high voltage (high pressure)
- Sensor supply circuit fault (collective sensor supply circuit)
- Sensor ground circuit fault (collective sensor ground circuit)

If a fault is detected, the ECM will substitute the default value of 3.80 BAR (55.11 psi) and inhibit fuel pump feedback control.

Engine Fuel Temperature Sensor (EFT Sensor)

The EFT sensor is a thermistor which has a negative temperature coefficient (NTC). Fuel temperature is determined by the ECM by the change in the sensor resistance. The ECM applies 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance.

The ECM uses the EFT signal to adjust fuel pump pressure to prevent fuel vaporization and ensure adequate fuel supply to the injectors.

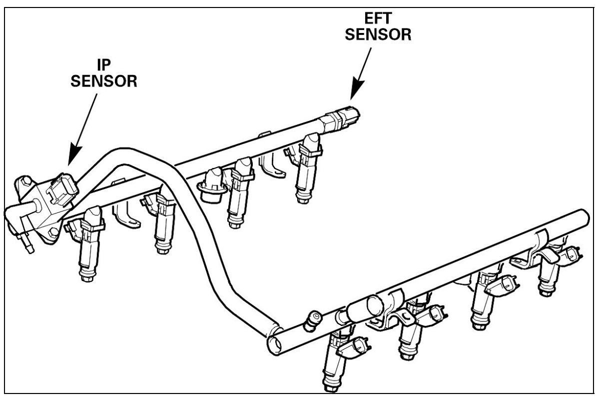

Fig. 155 V8 N/A FUEL RAIL

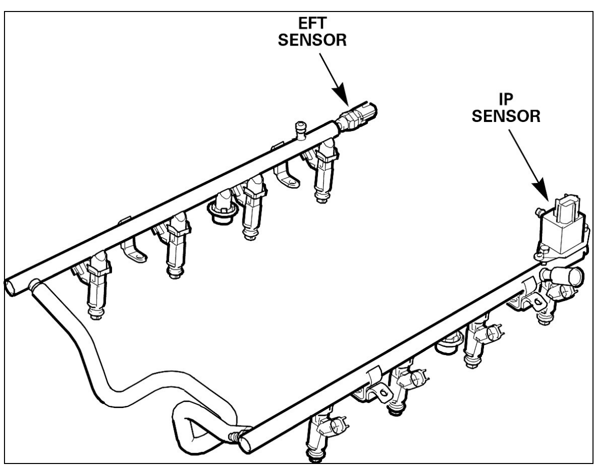

Fig. 156 V8 S/C FUEL RAIL

EFT Sensor Diagnostic Monitoring

The EFT Sensor circuits are continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for:

- Range / performance (actual pressure as compared to expected temperature)
- IP Sensor signal circuit low voltage (high temperature)
- IP Sensor signal circuit high voltage (low temperature)

If a fault is detected, the ECM will substitute the default value of 25 °C (77 °F).

X-TYPE, XK Fuel Pump Operation and Control

X-TYPE and XK vehicles use a Fuel Pump Module to drive the fuel pump. XK vehicles use a single high-output fuel pump and module for both normally aspirated and supercharged engines. Power supply to the module comes directly from an inertia switch, which receives its power from an ignition switched B+ power supply. No fuel pump relay is fitted.

The ECM communicates the fuel flow demand to the Fuel Pump Module as a pulse width modulated (PWM) signal over a single line at a frequency of approximately 150 Hz and a duty cycle range of 4 - 51%. The Fuel Pump Module amplifies this signal by increasing the frequency and doubling the duty cycle, thus providing the variable high current drive for the fuel pump.

Fuel pump drive status (feedback control) is monitored directly by the ECM via a hard wired circuit that transmits a PWM feedback signal from the Fuel Pump Module.

In the event of a vehicle impact, the inertia switch trips, deactivating the Fuel Pump Module and signaling the ECM to cancel fuel pump drive.

Fuel Pump Diagnostic Monitoring

The fuel pump PWM drive circuit to the Fuel Pump Module and the Fuel Pump Module to fuel pump drive circuits are continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for faults. Diagnostic monitoring takes place via the hard wired monitoring circuit. If a fault is detected, the ECM will inhibit fuel pump feedback control.

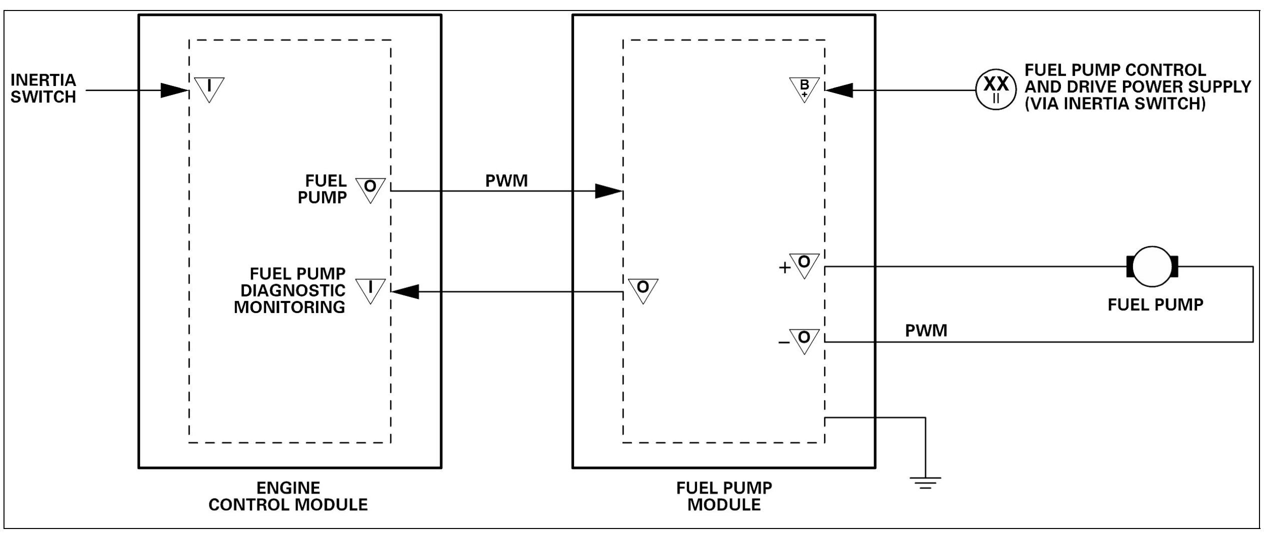

Fig. 157 X-TYPE / XK FUEL PUMP CONTROL

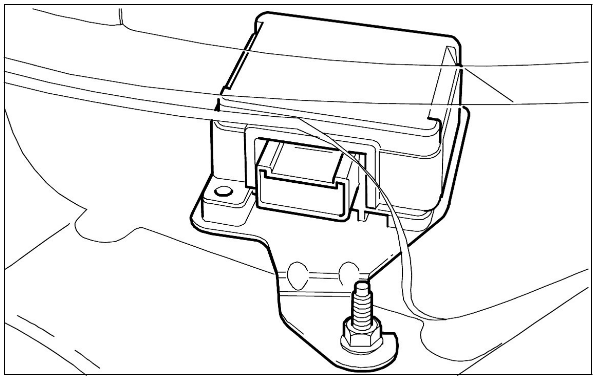

Fig. 158 X-TYPE FUEL PUMP MODULE

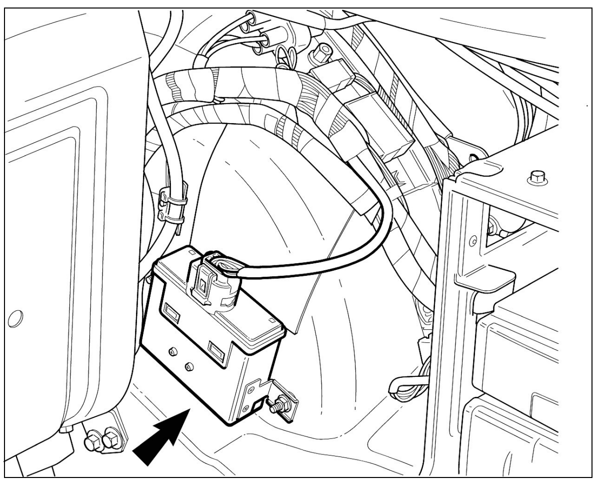

Fig. 159 XK FUEL PUMP MODULE

S-TYPE / XJ: Normally Aspirated Engines Fuel Pump Operation and Control

The fuel pump relay supplies power to the Rear Electronic Module to operate the fuel pump. The relay is activated by ignition switched B+ voltage via the inertia switch.

- The ECM calculates engine fuel requirements using:
- Engine load
- Engine speed
- Mass air flow and manifold absolute pressure
- Engine temperature
- Intake air and charge air (supercharged) temperature
- Current fuel rail environment from the IP and EFT Sensors
- Barometric pressure
- Battery voltage
- After start time

The ECM communicates the fuel flow demand to the REM as a pulse width modulated (PWM) signal over a single line at a frequency of approximately 150 Hz and a duty cycle range of 4 - 51%. The REM amplifies this signal by increasing the frequency and doubling the duty cycle, thus providing the variable high current drive for the fuel pump.

When the ignition switch is turned from “0” (OFF) to “II” (RUN) or “III” (START), the ECM primes the system by momentarily running the pump. After prime, the pump is switched ON when the CKP Sensor signal is received. The pump is switched OFF after the engine is stopped (CKP Sensor signal not received or ignition switch turned OFF). During all hot fuel conditions, fuel pressure is increased to prevent vapor lock. PATS “start inhibit” will, among other actions, disable fuel pump operation.

Fuel pump drive status (feedback control) is monitored by the REM and communicated to the ECM via the SCP and CAN networks.

In the event of a vehicle impact, the inertia switch trips deactivating the fuel pump relay and signaling the REM and the ECM to cancel fuel pump drive.

Fuel Pump Diagnostic Monitoring

The fuel pump PWM drive circuit to the REM and the REM to fuel pump drive circuits are continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for faults. Diagnostic monitoring takes place via the REM, SCP Network / Can Network to the ECM. If a fault is detected, the ECM will inhibit fuel pump feedback control.

XJ vehicles have additional REM recorded fuel pump diagnostic monitoring. DTCs are displayed as P (powertrain) DTCs. REM monitoring duplicates ECM monitoring; however, no default actions are initiated if a fault is recorded.

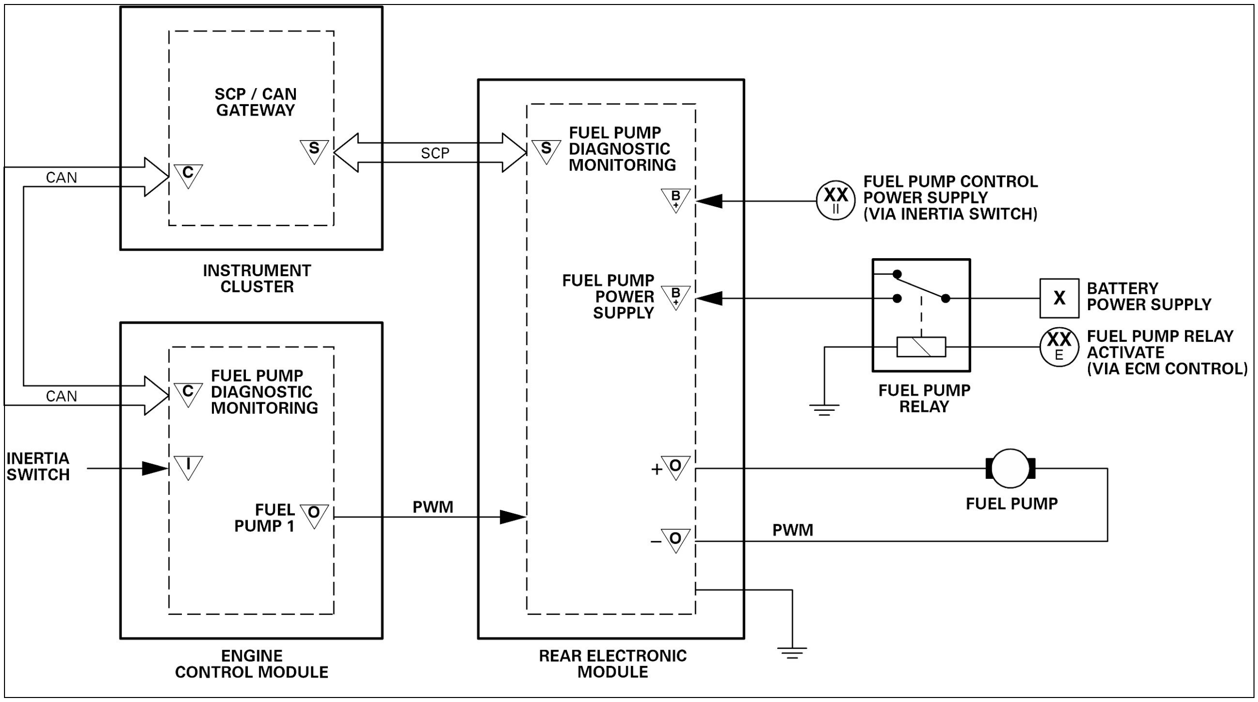

Fig. 160 S-TYPE / XJ N/A ENGINE FUEL PUMP CONTROL

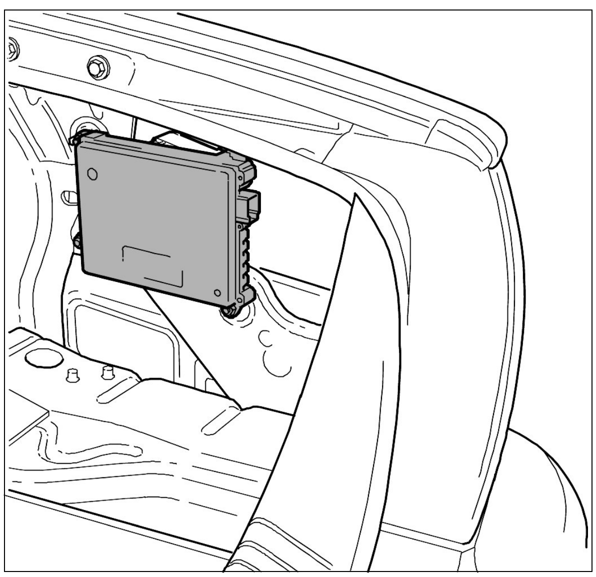

Fig. 161 XJ REAR ELECTRONIC MODULE

S-TYPE, XJ: Supercharged Engines Fuel Pump Operation and Control

In addition to the fuel pump (fuel pump 1) circuit described for normally aspirated engines, supercharged engine S-TYPE and XJ vehicles have a second fuel pump (fuel pump 2) circuit. The second fuel pump is required to meet the higher fuel flow demands of the supercharged engine. A separate fuel pump module is used to drive fuel pump 2.

The fuel pump relay supplies power to the Fuel Pump 2 Module to operate fuel pump 2.

The ECM communicates the fuel flow demand to the Fuel Pump 2 Module as a pulse width modulated (PWM) signal over a single line at a frequency of approximately 150 Hz and a duty cycle range of 4 - 51%. The Fuel Pump 2 Module amplifies this signal by increasing the frequency and doubling the duty cycle, thus providing the variable high current drive for the fuel pump 2.

Fuel pump 2 drive status (feedback control) is monitored directly by the ECM via a hard wired circuit that transmits a PWM feedback signal from the Fuel Pump 2 Module.

In the event of a vehicle impact, the inertia switch trips deactivating the fuel pump relay and signaling the ECM to cancel fuel pump drive.

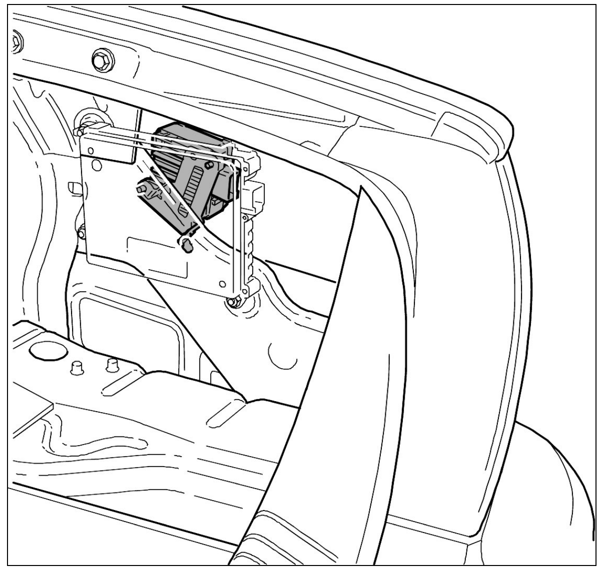

Fig. 162 XJ FUEL PUMP 2 MODULE

Fuel Pump 2 Diagnostic Monitoring

The following signals are continuously monitored by the ECM Comprehensive Component Diagnostic Monitor for faults:

- Fuel pump 2 drive circuit to fuel pump module
- Fuel pump module to fuel pump 2 drive circuits

Diagnostic monitoring takes place via the hard wired monitoring circuit. If a fault is detected, the ECM will inhibit fuel pump 2 feedback control.

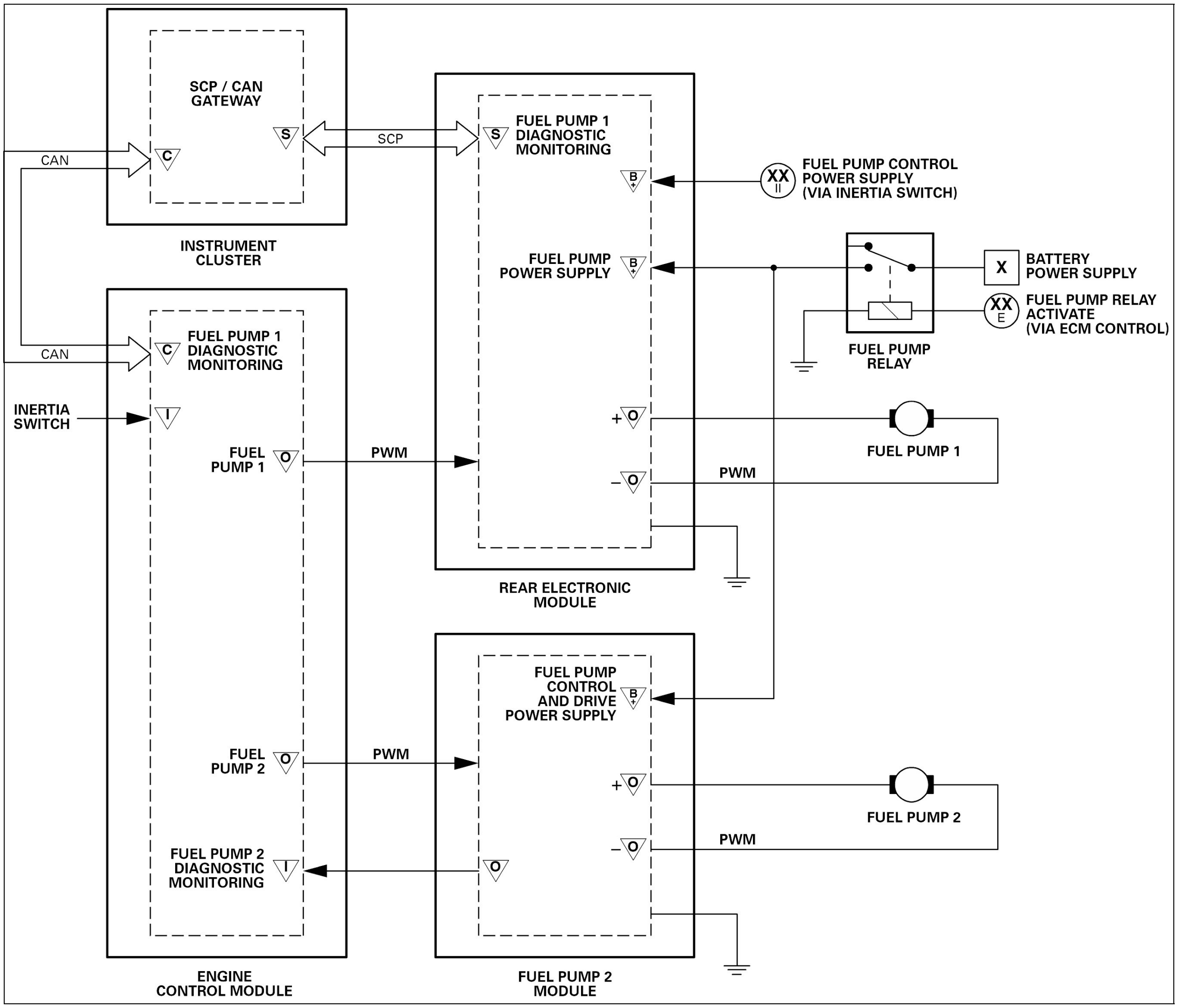

Fig. 163 S-TYPE / XJ SC ENGINE FUEL PUMP CONTROL

Exhaust Gas Recirculation – AJ33/34

Exhaust gas recirculation (EGR) is used on the AJ33 and AJ34 engines Its operation is the same as on the AJ26 and AJ27 engines.

EGR is controlled by the ECM from a map that factors engine operating conditions such as engine load and speed, throttle position, and coolant temperature.

The EGR valve is mounted directly to the intake air induction elbow and connects to the A bank exhaust manifold by a transfer pipe. The EGR valve contains a four-pole stepper motor (60 step), which is driven by the ECM. Engine coolant returning from the throttle assembly is channeled through the valve to provide cooling.

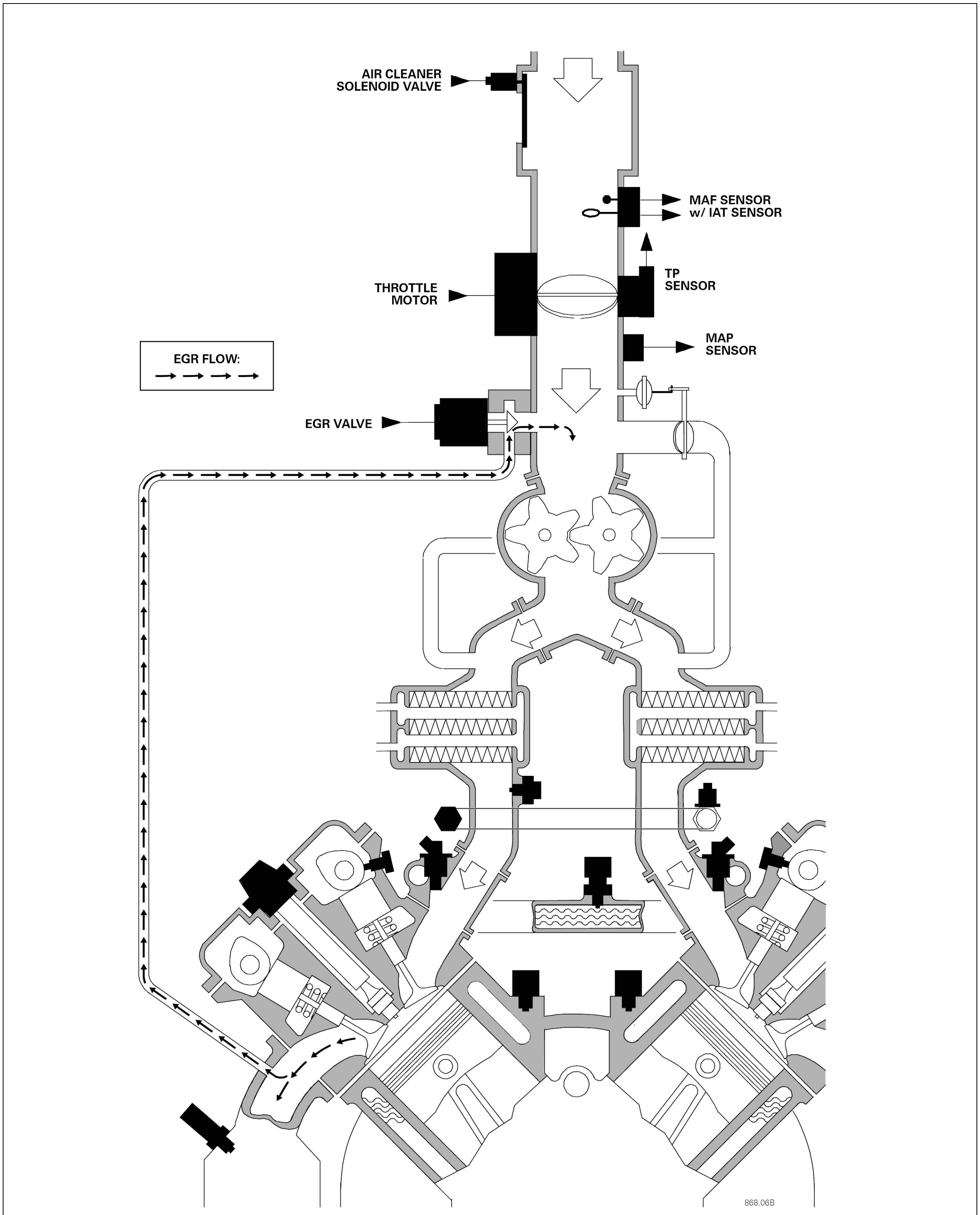

Fig. 164 EGR SYSTEM DIAGRAM – AJ33/34 SC

JAGUAR

TRAINING PROGRAM

JAGUAR ENGINE MANAGEMENT SYSTEMS AND ADVANCED EMS DIAGNOSTICS – BOOK B

PUBLICATION CODE – 870B

DIAGNOSTIC EQUIPMENT

Because sensitive electronic circuits can be damaged by using analog (dial type) meters, test lights and many types of circuit testers, only digital multimeters (DVOM) should be used. Analog meters require too much power to be used in circuits with sensitive digital components. DVOMs require very little power. In addition, DVOMs are more accurate, enabling precise value measurement. By using a DVOM with a combination digital / analog display or a MIN / MAX mode, it can be determined if the measured value is increasing or decreasing during the test.

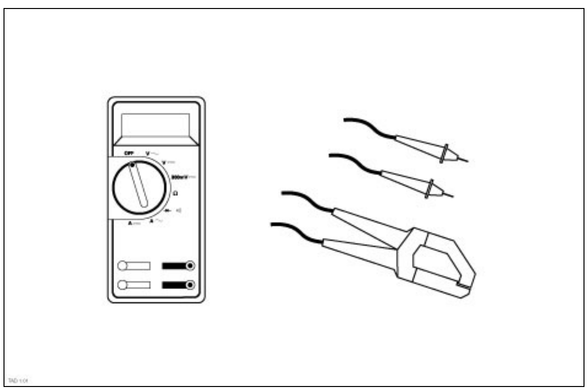

Fig. 165 Digital Multimeter (DVOM) with Leads and Current Probe

WDS has digital multimeter capabilities and can be used for circuit analysis.

When performing electrical tests, refer to the applicable Electrical Guide to determine the circuit construction, associated circuits, wire colors and connector, splice, component and ground locations.

DIAGNOSTIC STRATEGY

Problem diagnosis can be time consuming and sometimes frustrating. However, the job will be easier if you apply a logical approach to the task, called a Diagnostic Strategy. The following outlines a Diagnostic Strategy that will help ensure that none of the information necessary for accurate diagnosis is overlooked.

Step 1: Verify the Complaint

- Check the accuracy and detail of information on the repair order.
- Confirm that the condition is an actual fault and if it is permanent or intermittent.
- Duplicate the condition and note all of the symptoms.

Step 2: Analyze the System(s) and Identify Probable

- Research the Service Manual, Technical Introduction Guides and Service Training material to identify the vehicle systems that are related to the complaint.
- Check Technical Bulletins for issues with related symptoms.
- Use the Electrical Guides to identify circuits or components that could cause the symptoms.
- Trace the circuits from power to ground to find related circuits that could cause the problem.
- Use your previous experience.
- Prioritize possible causes from the most likely and easiest to test, to the least likely and most difficult to test.

Step 3: Inspect, Test and Pinpoint the Fault

- Visually inspect the vehicle and look for obvious faults first.
- Read the Service Manual and check PDU menus for tests that apply to the systems, circuits and components identified in the step 2 analysis.
- Test the circuits and components. Start with those that are the most likely cause and the easiest to test.
- Be aware that intermittent faults or symptoms may require recreating the fault conditions while testing: hot condition, cold condition, or “wiggle” test. The wiggle test technique will be reviewed later in this course.

Step 4: Perform the Repair

- Follow the recommended service procedures.
- To avoid a repeat failure, ensure that wiring, connectors and grounds are in good condition before fitting new components.
- Replace defective components.

Step 5: Evaluate the Results

- Verify that the customer complaint is resolved and that all of the original symptoms have disappeared.
- Confirm that no new conditions were created by performing operational tests of any other systems that were disturbed during the repair or that are related to the complaint.

PROFESSIONAL ELECTRICAL PRACTICES

When testing electrical circuits it is important to access the circuits carefully to avoid damaging insulation, conductors, contacts or components. Measurements should be performed carefully. Ensure that the tester is connected to the correct pins. If measurements are not consistent with the values expected, always double check that the tester is correctly connected.

Here are a list of **"Do Not's"** , which are considered unprofessional practices:

- **DO NOT BACK PROBE sealed electrical connectors.** This malpractice will damage the sealing material an allow moisture or other contaminants to enter the connector causing corrosion.
- **DO NOT PIERCE the insulation of conductors when performing measurements.** This malpractice will damage the conductor, increasing the conductor resistance, and allow moisture or other contaminants to enter the connector causing corrosion.
- **DO NOT use circuit powered or self-powered test lights or circuit testers for component testing.** This malpractice may cause damage to sensitive components. Because of the amount of sensitive components in modern vehicles, the best rule is to use only a high impedance digital multimeter when measuring any electrical circuit in the vehicle.

The following is a list of **"DO's"** which should always be followed:

- **DO calibrate test equipment periodically** and check the resistance of the test leads and adapters to assure that measurements are accurate.
- **DO use the correct testing adapters** when performing measurements. Using incorrect adapters or probing connectors may damage the plating on the contacts, causing corrosion and increased resistance.

SYMPTOM BASED CIRCUIT FAILURE TESTING

Consumer / Function operates intermittently

Because the failure is not always present, intermittent failures can be the most difficult to diagnose. If the system is electronically controlled and its control module is capable of storing DTCs, extract any DTCs as a guide to diagnosis.

It is also vital to gather the following information about any intermittent failure:

- When does the function fail?
- Are any other functions affected?
- Were any other functions in operation at the time of failure?
- Is the failure related to a vibration or bump occurrence?
- Does the failure occur at any specific temperature, time of day, engine or transmission operating condition?

Try to recreate the failure by operating the vehicle under the conditions reported. If the failure can be recreated, follow the general diagnostic procedures.

If the failure cannot be recreated, apply the reported failure conditions to the symptoms in order to determine the probable causes of the failure. Then, carefully examine each of the probable causes. Start with the circuit areas or system components that are the most probable causes of the failure and thoroughly test each one. Apply the "wiggle" test while following the general diagnostic procedures.

"Wiggle" Test

This test method is used to find intermittent circuit faults.

The so called "wiggle" test is important to help identify circuit problems caused by intermittent failures in the wiring, connectors or grounds. With the meter connected, "wiggle" the suspect wires or connectors and look for differences in the meter reading indicating changes in resistance or voltage.

BASIC ELECTRICAL FAULTS

Electrical circuit faults can be categorized as follows:

Open Circuit

An open circuit is a break in the path of current flow. If the circuit is powered, a voltage potential will be present in the portion of the circuit that is still connected to the power source.

With parallel circuits, an open circuit in one branch will stop operation in that branch, but the other branches will continue to operate. An ohmmeter test can determine if a circuit is open (infinite resistance ($\infty \Omega$)).

A voltmeter can also be used to determine an open circuit. By measuring the available voltage at various points or the voltage drop between two points, it is possible to determine the location of the open circuit.

High Resistance

A high resistance circuit is a circuit with more resistance than specified. High resistance reduces the amount of power (current x voltage) available for components connected to the circuit.

High resistance can be caused by loose, dirty or corroded connections. Broken strands of conductor within a wire's insulation or at a connector will also increase circuit resistance.

When diagnosing a circuit for high resistance, disturb the connections as little as possible until the area of high resistance has been found. Disturbing connections may clean any corrosion or dirt, temporarily correcting the problem and making diagnosis difficult.

An ohmmeter test on an unpowered circuit can determine high resistance.

An available voltage or voltage drop test on a powered circuit can also determine areas of high resistance.

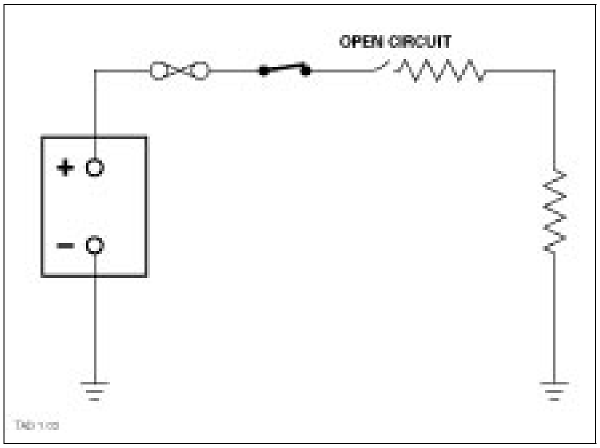

Fig. 166 Open Circuit

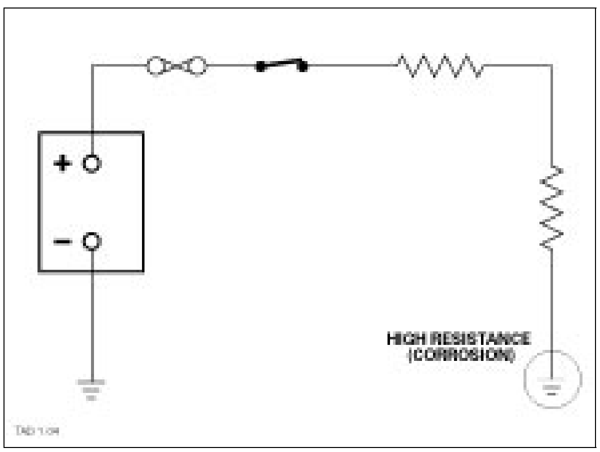

Fig. 167 High Resistance

Short Circuit to Ground

A short circuit to ground occurs when the circuit is grounded or partially grounded where not designed. If the short circuit is located after the load, circuit control may be lost causing operation when it is not wanted.

To diagnose a short circuit to ground in a fused circuit, substitute a voltmeter for the fuse. Systematically disconnecting circuit components until the voltmeter reads 0 V will identify the area of the short circuit.

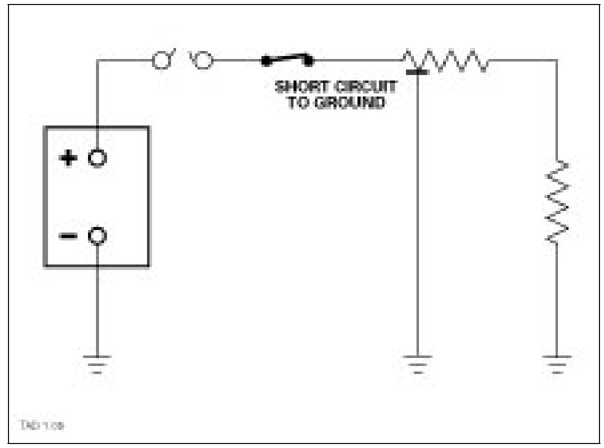

Fig. 168 Short Circuit to Ground

Short Circuit to Voltage

A short circuit to voltage occurs when insulation failure causes a conductor to contact the voltage of another circuit. The circuit (or circuits) will operate improperly.

Carefully observe the symptoms and related symptoms and refer to the Electrical Guide to understand the circuits involved. Remove fuses until the circuit is isolated, then measure resistance and voltage as appropriate to find the problem area.

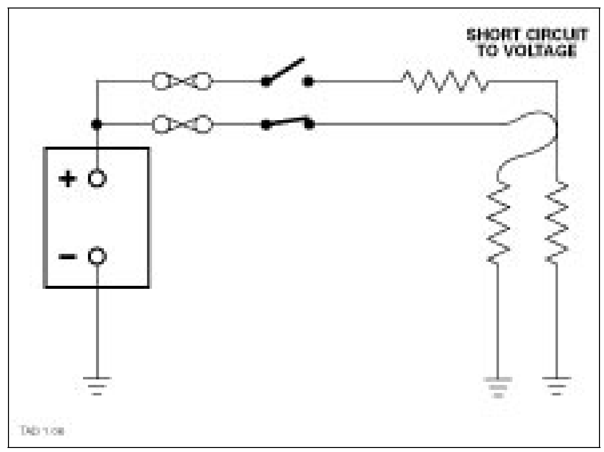

Fig. 169 Short Circuit to Voltage

TEST METHODS

Voltmeter Tests

Voltmeter tests are useful because they measure the voltage potential in the circuit during its operational state.

Available Voltage Test

This check **tests** for power supply availability, open circuits, and short circuits.

The test is performed by **measuring the AMOUNT** of voltage available at that point of the circuit. The circuit must be powered (active). This test is passed if the circuit shows the expected circuit operating voltage (usually B+ voltage).

Voltage Drop Test

This check **tests** for circuit resistance under load.

The test is performed by **measuring the DIFFERENCE** in voltage between two points in the circuit.

Generally, voltage drops should not exceed the following values:

Table 10

Wire or cable	200 mV	Ground Connection	100 mV
Switch	300 mV	Connector	50 mV

NOTE:

The voltage reading depends on the portion of the circuit being tested. The lower the voltage reading, the lower the resistance.

High current circuits such as the starter motor circuit have greater voltage drops.

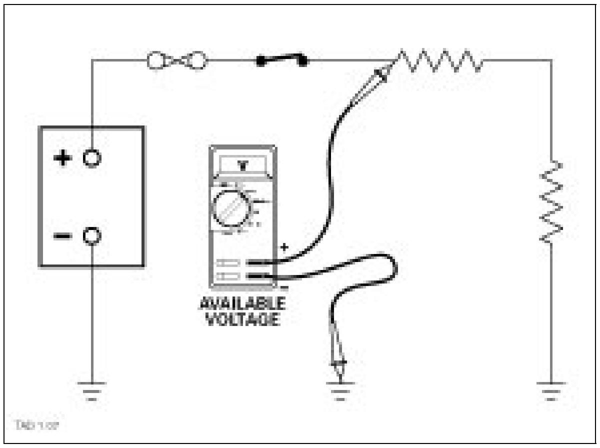

Fig. 170

The relationship between voltage, resistance and current flow, as expressed by Ohm's Law, shows that even a small amount of resistance can have a great affect on the electrical power available in the circuit.

Example: A 12 V starting system drawing 200 Amps will develop 2400 Watts of power (Volts x Amps = Watts). The starter motor will develop 3.22 HP (746 Watts = 1 HP).

A resistance of 0.01 Ω in the starter cable will drop the voltage available at the starter by 2 V (Amps x Ohms = Volts). The 2 V drop caused by the resistance results in only 2000 Watts (83%) of starting power. The starter will develop only 2.68 HP.

Small amounts of resistance are difficult to determine without expensive equipment. In addition, battery power must be disconnected from the circuit to measure resistance. Voltage drop measurements indicate circuit resistance without disconnecting power or disturbing the circuit.

Voltage Drop Test: Ground Side

This check **tests** for ground circuit high resistance, or an open circuit.

The test is performed by **measuring the DIFFERENCE** in voltage between a point in the circuit and ground. The circuit must be powered (active).

Voltage Drop Test: Switch or Connector

This check **tests** for component high resistance, an open circuit, or switch function.

The test is performed by **measuring the DIFFERENCE** in voltage across a switch or connector. The circuit must be powered (active).

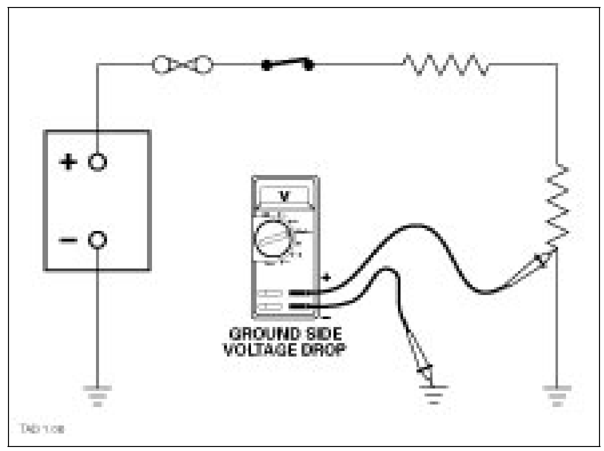

Fig. 171 Voltage Drop Test: Ground Side

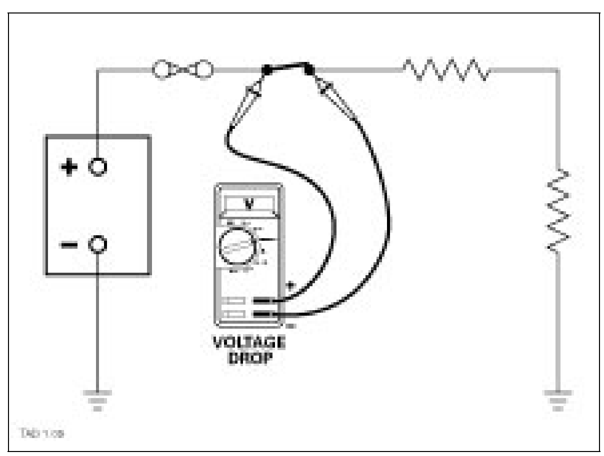

Fig. 172 Voltage Drop Test: Switch

Ohmmeter Tests

NOTE:

Battery power MUST be disconnected from circuits when measuring resistance. The meter provides a small amount of power to measure the circuit resistance.

Circuit Resistance Test

This check **tests** for circuit high resistance, an open circuit, or short circuit.

The test is performed by **measuring the resistance** between the probes. The circuit must be unpowered (inactive).

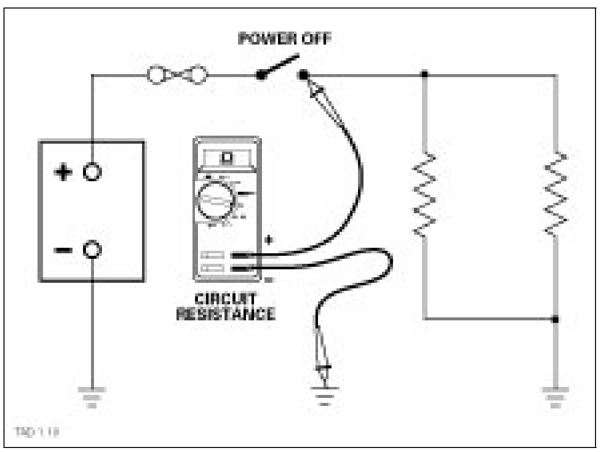

Fig. 173 Circuit Resistance Test

NOTE:

When checking a parallel circuit, the total circuit resistance will be less than the value of the lowest resistance load in the circuit.

Component Resistance Test

This check **tests** for component high resistance, an open circuit, or short circuit.

The test is performed by **measuring the resistance** of individual components. The circuit must be unpowered (inactive).

NOTE:

Disconnect components in parallel circuits when measuring resistance. If connected, the total circuit resistance will be less than the value of the lowest resistance load in the circuit.

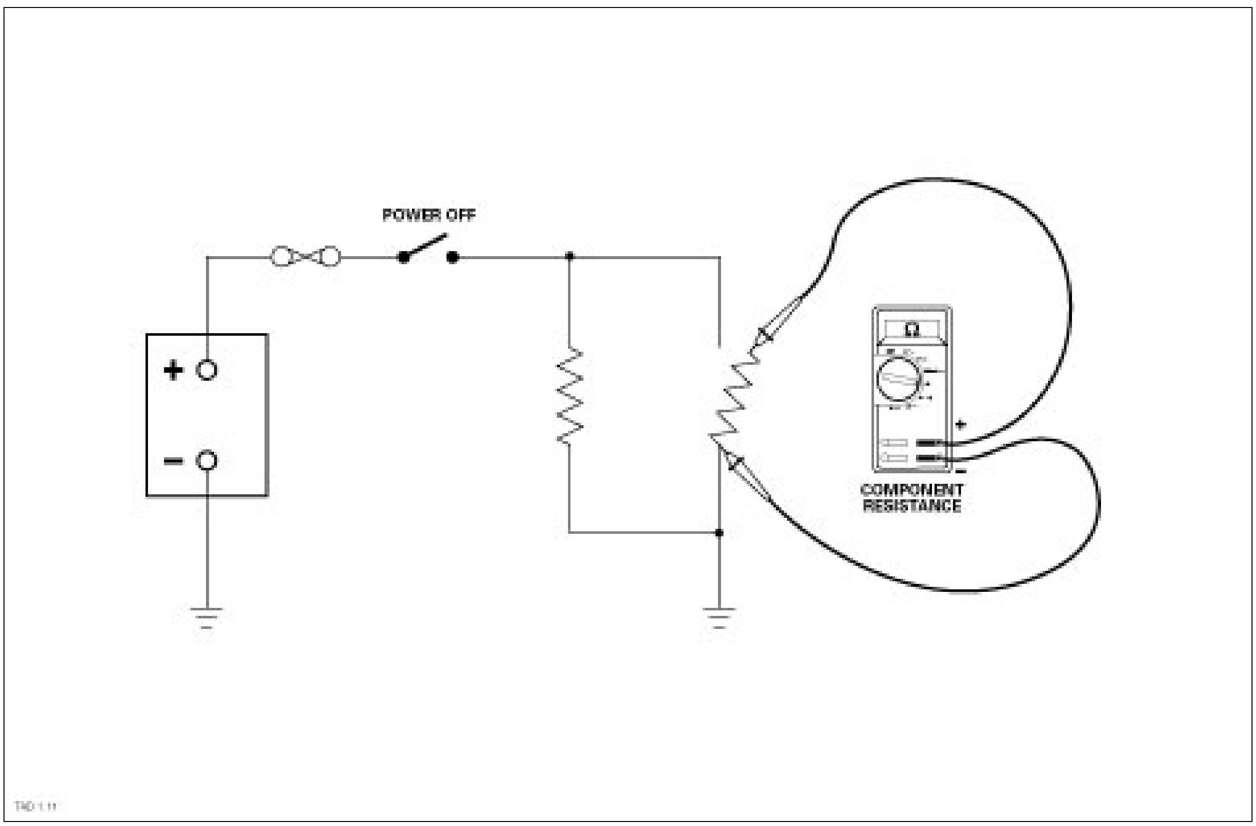

Fig. 174 Component Resistance Test

General Approach to Circuit Testing

There are a number of ways to test a circuit using a DVOM. The test methods chosen depend on the symptoms shown in the circuit, how the circuit functions electrically and its physical layout (accessibility to test points).

Always verify the symptoms to isolate the exact nature of the failure. Refer to the circuit diagram in the Electrical Guide to determine the power supply and ground side portions of the circuit, the type of circuit control (switching) and the most convenient testing points.

The Worldwide Diagnostic System (WDS) functions as a diagnostic aid and a DVOM. WDS will most often help you to pinpoint the cause of the failure. Because WDS diagnostics are software driven, its efficiency in any diagnostic mode depends on the software designer. Most WDS diagnostic modes are excellent. However, a technician with knowledge of the system being tested, using a DVOM and the Electrical Guide, can often diagnose a problem as efficiently as the WDS diagnostic function. WDS is most useful in accessing DTCs, observing the state of electronic components and measuring CM signals. A DVOM can measure voltage, resistance and current flow. Selecting what to measure and where to measure depends on the individual circuit construction and failure symptoms.

When Testing:

Usually, test for available voltage first. Start at the easiest point to determine if the consumer power supply is sufficient.

If the power supply is insufficient, the fault is located somewhere in the “front half” of the circuit, between the test point and the battery.

If there is sufficient power available at the consumer, the fault is probably in the consumer itself or in the ground side of the circuit. Remember, consumers can be controlled on the power side or the ground side.

It is generally most efficient to “split-half test” the faulty circuit. Split-half testing means progressively narrowing down the area of the fault by testing half of each faulty section until the fault location is precisely determined.

Refer to the Electrical Guide to determine the most convenient test points.

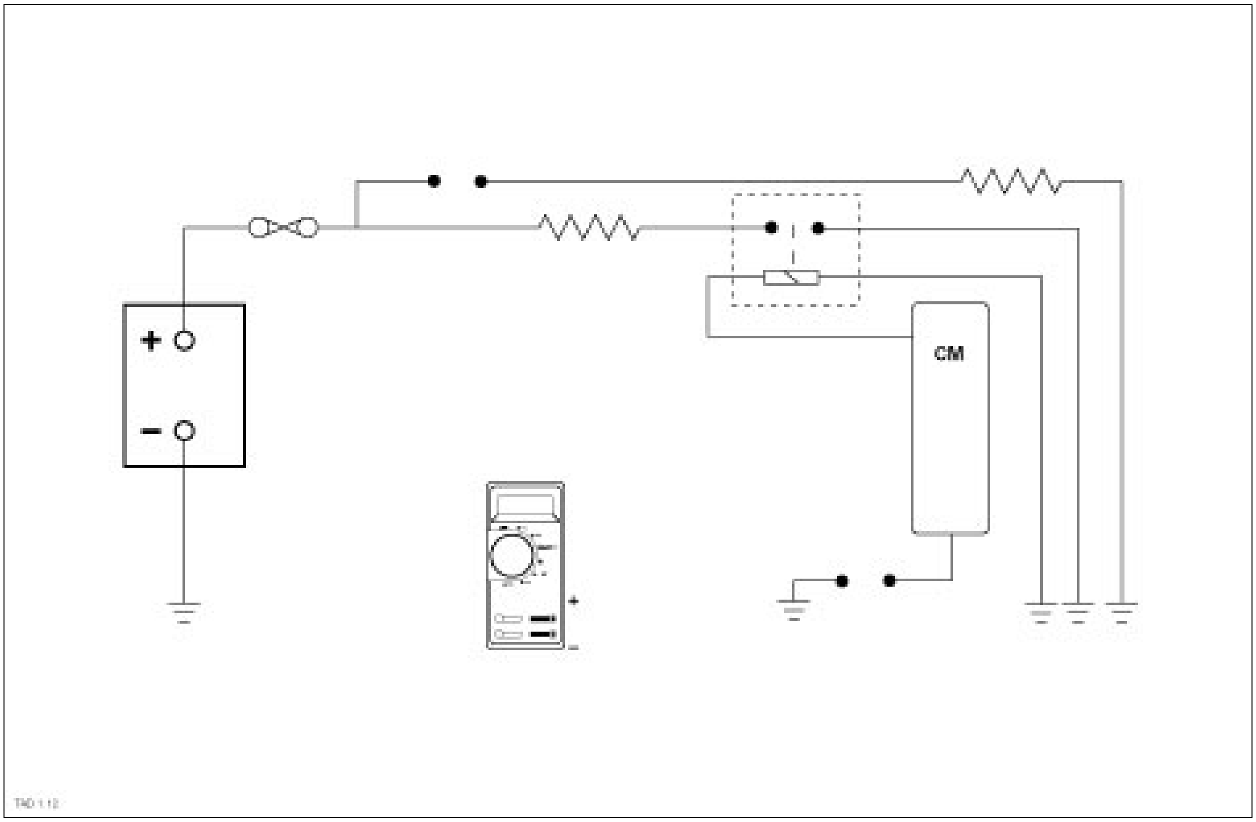

Fig. 175 Split-Half Testing

JAGUAR

TRAINING PROGRAM

JAGUAR ENGINE MANAGEMENT SYSTEMS AND ADVANCED EMS DIAGNOSTICS - BOOK B

PUBLICATION CODE – 870B

EMS SENSING COMPONENTS

Mass Air Flow sensor (MAF)

The MAF is a hot wire type that measures air flow volume by the cooling effect of air passing over a heated wire, altering the electrical resistance of the wire.

The electrical resistance value is converted to an analog output voltage supplied to the ECM as a measure of air flow volume (engine load).

The MAF Sensor signal may be augmented by the MAP Sensor signal to allow the ECM to calculate engine load during transient (sudden open/closed throttle) situations. The engine load signal is used by the ECM for calculation of numerous control outputs.

10% of the engine combustion air volume is routed over the heated wire allowing unrestricted air flow for 90% of the air.

The ECM ensures that the hot wire probe is always 200 °C hotter that the air temperature probe. The hot wire probe is cooled by the air flowing through the intake system and the ECM varies the heating current to maintain the 200 °C temperature difference.

The change in heating current is measured as a voltage drop across a precision resistor and is assigned to a corresponding mass air flow calculation by the ECM.

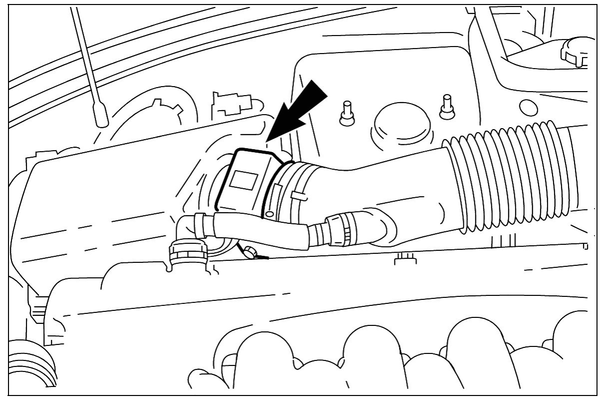

Fig. 176 TYPICAL MAF

Intake Air Temperature sensor (IAT)

The IAT is a negative temperature coefficient (NTC) thermistor. Intake air temperature is determined by the ECM by a change in resistance within the sensor.

The ECM applies 5 volts to the sensor and monitors the voltage drop through the thermistor.

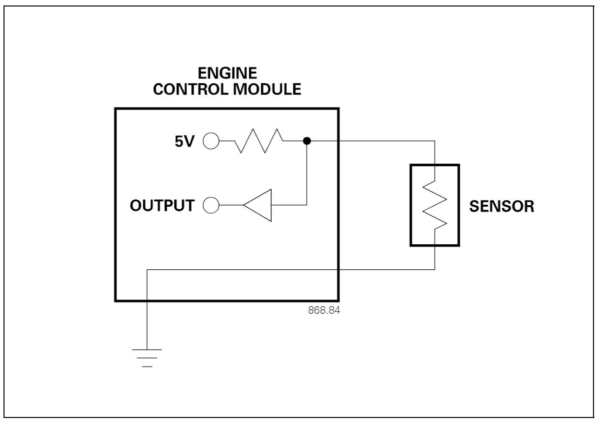

Fig. 177 SAMPLE OF SENSOR CIRCUIT

The IAT signal is used to modify timing strategies

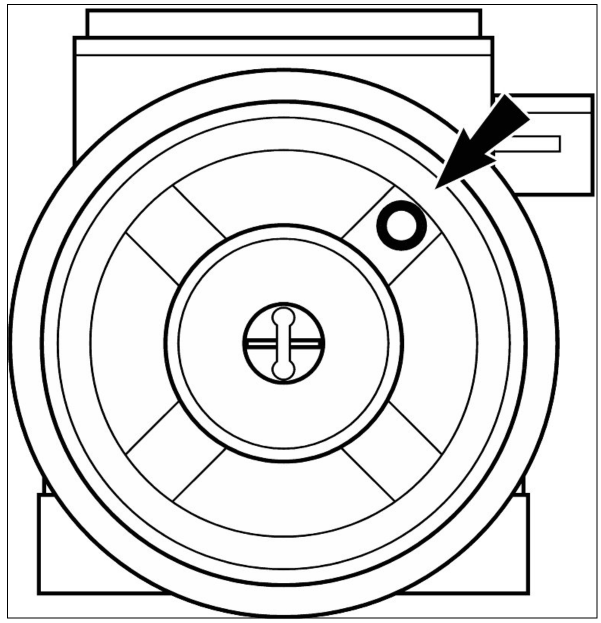

Fig. 178 TYPICAL IAT (IN MAF HOUSING)

Engine Coolant Temperature Sensor (ECT)

The ECT is a negative temperature coefficient (NTC) thermistor.

The ECM applies 5 volts to the sensor and monitors the voltage drop through the thermistor.

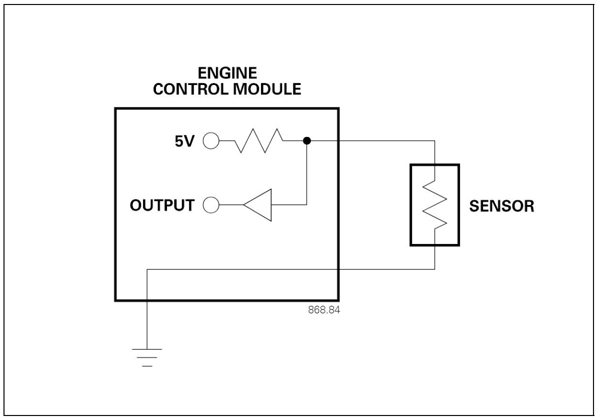

Fig. 179 SAMPLE OF SENSOR CIRCUIT

Engine coolant temperature is determined by the voltage drop.

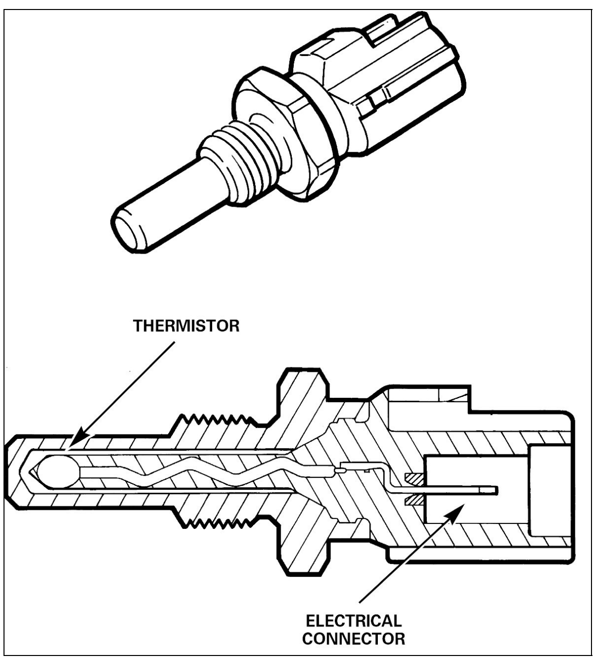

Fig. 180 ECT WITH CROSS-SECTION

Crankshaft Position sensor (CKP)

The CKP provides the ECM with pulsed signals for crankshaft position and engine speed.

The CKP input pulse is used by the ECM for ignition timing and fuel injection timing. In addition, the missing pulses (and the CMP input) are used to identify cylinder 1A, compression stroke for starting synchronization.

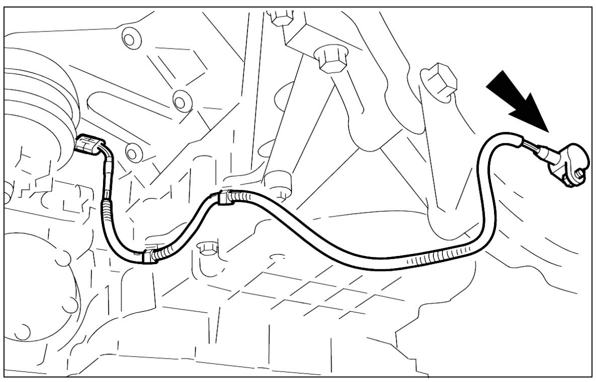

Fig. 181 TYPICAL CKP

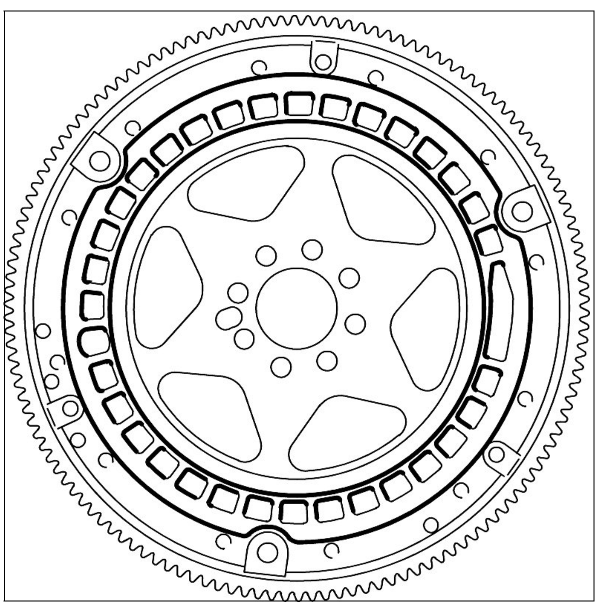

Fig. 182 TYPICAL CKP RELUCTOR

Camshaft Position sensor (CMP)

The variable reluctance CMP sensor provides the ECM with a pulsed signal for cylinder 1 compression stroke identification (one pulse per two crankshaft revolutions).

The pulse is generated by the raised segment of the intake camshaft timing ring as it passes the sensor tip. The CMP input pulse is monitored along with the CKP signal for synchronizing ignition timing and fuel injection timing with engine cycle position.

In addition, the CMP signal is used for variable valve timing (VVT) diagnostic monitoring.

The ECM uses the CMP signals for cylinder identification to control starting, fuel injection sequential operation, ignition timing, and variable valve timing operation and diagnostics.

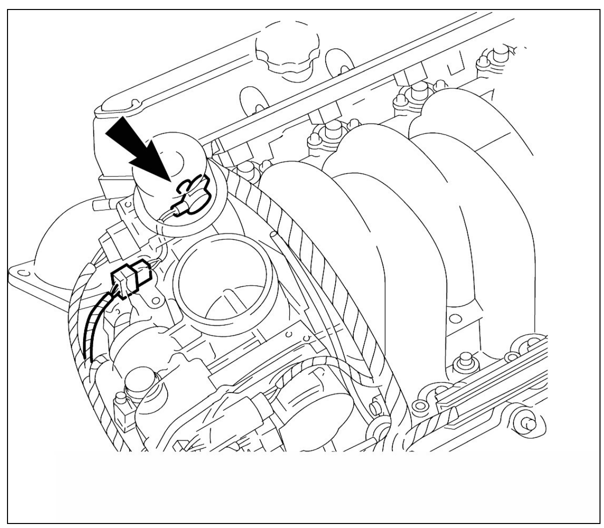

Fig. 183 TYPICAL CMP LOCATION

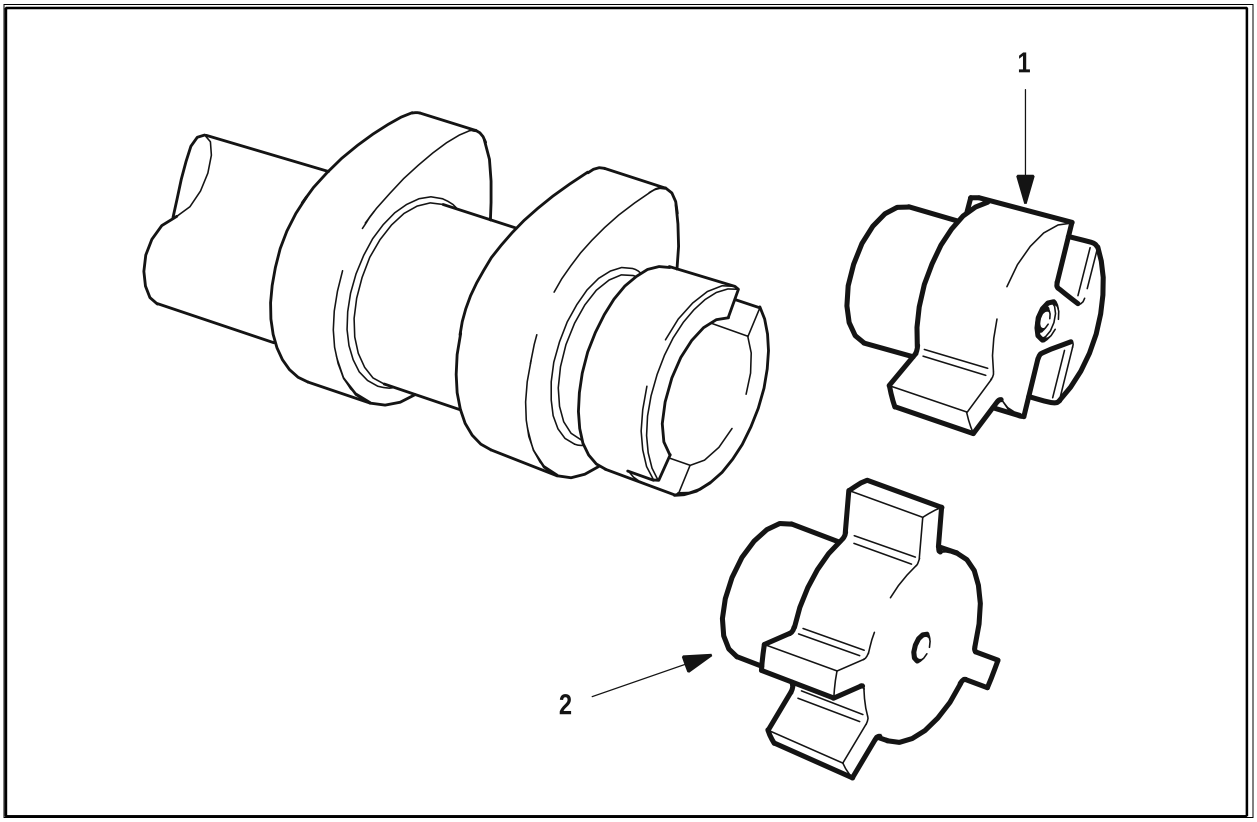

Fig. 184 CAMSHAFT POSITION SENSOR RINGS

1. Non-PTEC Sensor Ring for 2 POS VVT
2. Typical Sensor Ring for LINEAR VVT

Throttle position sensor (TP)

The throttle position sensor assembly consists of rotary sensors (typically potentiometers or Hall Effect) that are directly driven by the throttle valve shaft.

The sensors have common reference voltage and reference ground circuits hard-wired to the ECM; each provides its unique throttle position signal (via hard-wire connection) directly to the ECM.

The unique characteristics of both signals are used for identification, similar to the PPS signals. The ECM detects faults by comparing the throttle position signals to expected values. If the ECM detects a fault, throttle operation defaults to the “limp home” mode (mechanical).

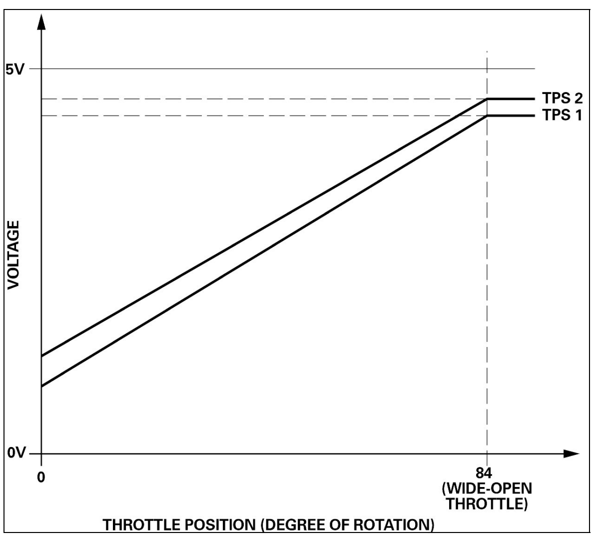

Fig. 185 TYPICAL TP CHARACTERISTIC

Pedal position sensor (PPS)

For non-PTEC applications, the pedal position sensor is a twin track potentiometer, located at the accelerator cable side of the throttle assembly. The throttle input shaft drives the potentiometer wipers to provide the ECM with redundant pedal position voltage signals.

The voltage signals range from approximately 0.5 V at closed to 4.75 V at full throttle. WDS defines the redundant circuits as “A” and “B”. Circuit A is identified as pedal position sensor pin 5; circuit B is identified as pedal position sensor pin 3. Refer to the applicable Electrical Guide.

Two individual rotary potentiometers comprise the PPS assembly typically located at the pedal. The potentiometers are rotated by the throttle cable lever and provide separate analog voltage signals to the ECM proportional to pedal movement and position.

The potentiometers have common reference voltage and reference ground circuits hard-wired to the ECM.

Each potentiometer provides its unique pedal position signal (via hard-wire connection) directly to the ECM. The ECM detects faults by comparing the pedal position signals to expected values.

If the ECM detects a fault, throttle operation defaults to the “limp home” mode (mechanical).

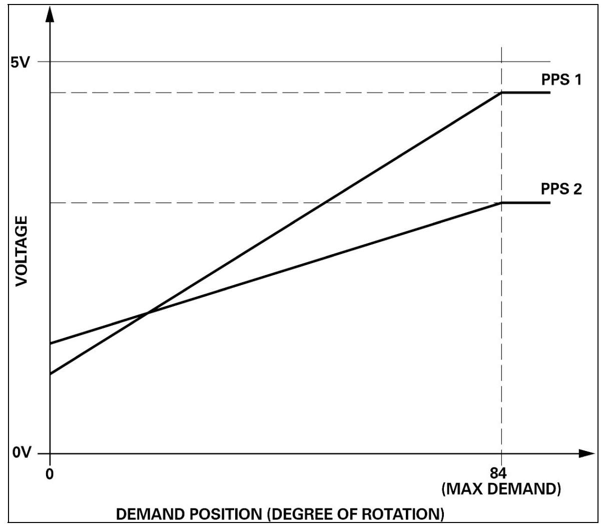

Fig. 186 PPS CHARACTERISTIC – AJ27

Oxygen Sensors (LAMDA)

The two upstream sensors are used by the ECM for closed loop fuel metering correction. The downstream sensors for used for OBD catalyst monitoring. The oxygen sensors produce voltage by conducting oxygen ions at temperatures above 300 °C (572 °F), which then drives current through a sensing circuit. The tip portion of the sensor's ceramic element is in contact with the exhaust gas.

The remaining portion of the ceramic element is in contact with ambient air via a filter through the sensor body. In order to reduce the time and resulting emission needed to bring the upstream sensors up to working temperature, an internal electric heater is used. The heaters are controlled by the ECM.

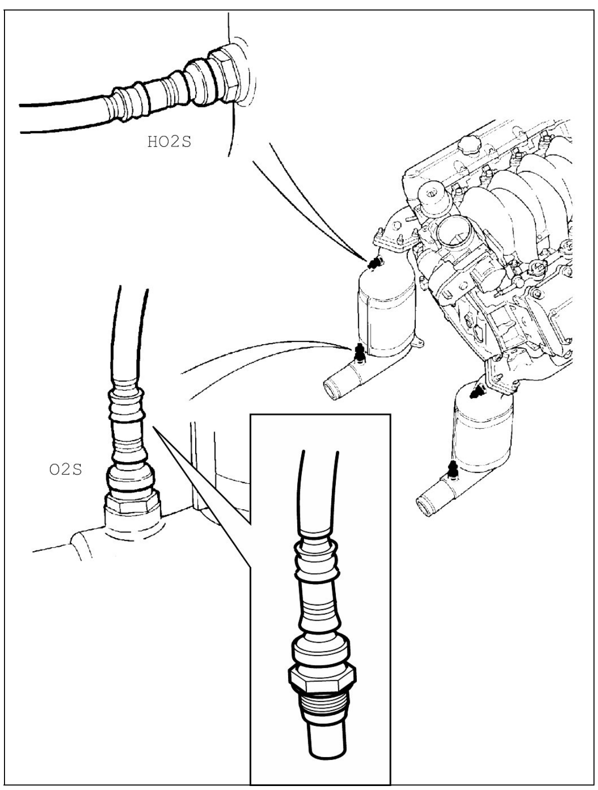

Fig. 187 TYPICAL OXYGEN SENSORS

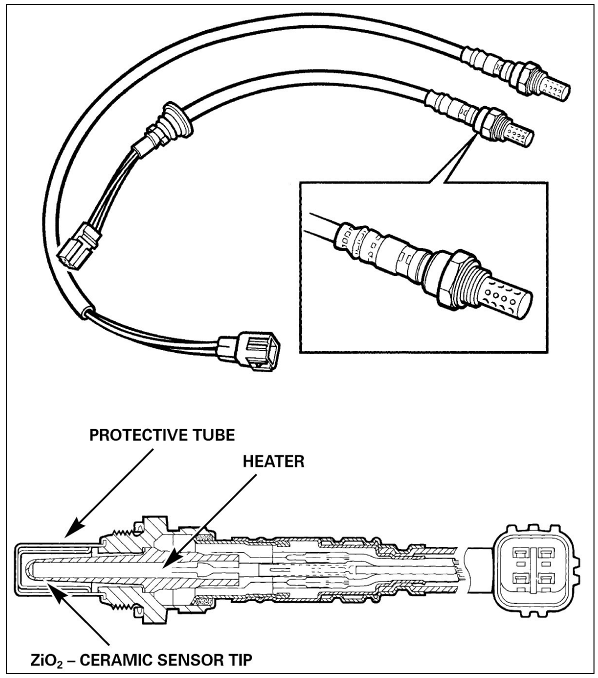

Fig. 188 TYPICAL HEATED OXYGEN SENSOR WITH CROSS-SECTION

Oxygen Sensor Characteristic

The sensor voltage varies between approximately 800 millivolts and 200 millivolts, depending on the oxygen level in the exhaust gas.

When the air : fuel ratio is richer than optimum, there is low oxygen in the exhaust gas and the voltage output is high.

When the air : fuel ratio is leaner than optimum, oxygen in the exhaust is high and the output voltage is low.

Only a very small change in air : fuel ratio is required to swing the oxygen sensor voltage from one extreme to the other, thus enabling precise fuel metering control.

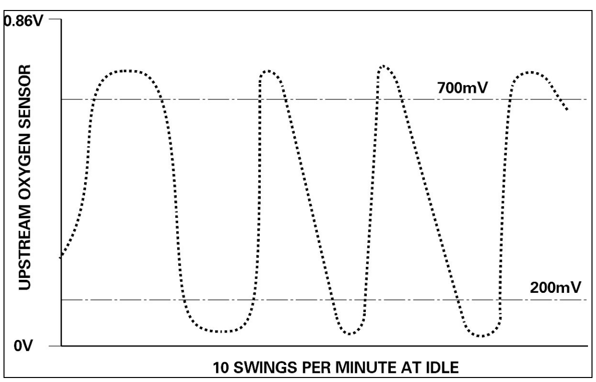

Fig. 189 TYPICAL OXYGEN SENSOR VOLTAGE SWING TRACE

Universal Oxygen Sensors

In order to improve air : fuel ratio (AFR) control under varying engine conditions, a “universal” type heated oxygen sensor was introduced on AJ27 in the upstream position. The universal sensor has varying current response to changes in exhaust gas content.

The AFR can be maintained more precisely within a range from approximately 12:1 to 18:1, not just stoichiometric. Voltage is maintained at approximately 450 mV by applying a current.

The current required to maintain the constant voltage is directly proportional to the AFR. A higher current indicates a leaner condition; a lower current indicates a richer condition.

The current varies with the temperature of the sensor and is therefore difficult to measure for technician diagnostic purposes. The downstream heated oxygen sensors, used for catalyst efficiency monitoring, remain unchanged. However, the location in the exhaust system has changed.

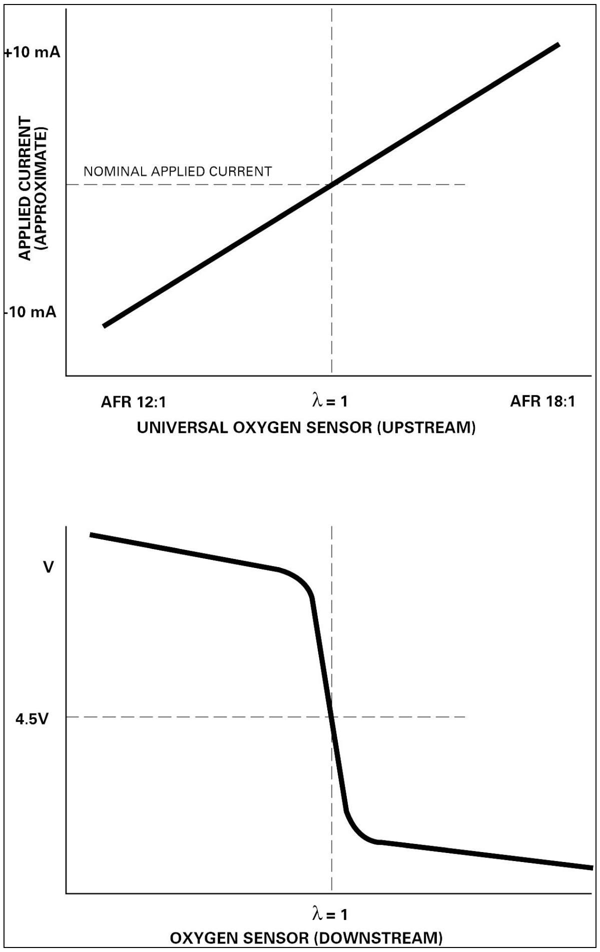

Fig. 190 UNIVERSAL OXYGEN SENSOR CHARACTERISTIC

FUEL CONTROL

Fuel Metering

Fuel metering is controlled by the ECM using a base fuel metering map, which is then corrected for the specific engine operating conditions.

The ECM varies the fuel injector pulse duration and the number of pulses during each engine cycle (two crankshaft rotations) to achieve the necessary fuel metering. The injectors are pulsed sequentially, once per engine cycle (once every two engine revolutions) in the engine firing order, except during starting and acceleration.

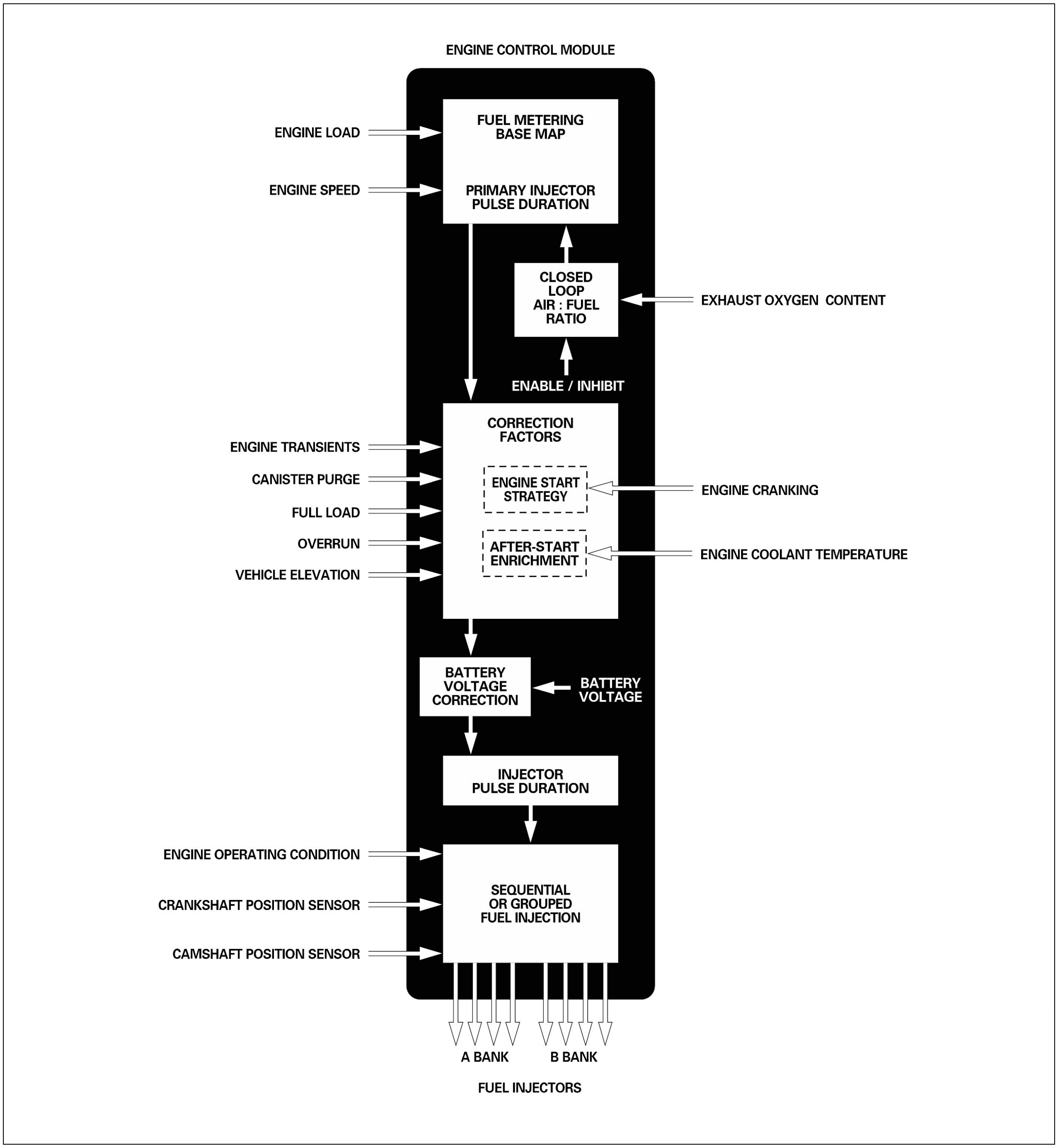

Fig. 191 FUEL METERING STRATEGY

Base Fuel Metering Map

The base fuel metering map sets the base air : fuel ratio for normal engine operation throughout the full range of engine load and speed.

Engine load is determined by measuring intake mass air flow. The MAF supplies the ECM with a mass air flow signal.

The ECM receives an engine speed signal from the CKP. By monitoring the exhaust oxygen content from the HO2S (upstream oxygen sensors), the ECM is able to perform closed loop fuel metering control and adaptive fuel metering.

Closed Loop Fuel Metering

The exhaust system incorporates 3-way catalytic converters that oxidize CO and HC, and reduce NOx. These converters operate efficiently only if engine combustion is as complete as possible.

A closed loop system between fuel injection, ECM control, and exhaust oxygen content feedback maintains an air : fuel ratio as close to stoichiometric as possible.

In response to oxygen sensor voltage swings, the ECM continuously drives the air : fuel ratio rich-lean-rich by adding to, or subtracting from the base fuel metering map. Separate channels within the ECM allow independent control of A and B bank injectors.

Short Term Fuel Trim

Short Term Fuel Trim is a software program in the ECM that adjusts the fuel control system to provide the desired air/fuel ratio.

Oxygen sensors do not indicate the actual air/fuel ratio; the sensors indicate either lean or rich of stoichiometry. Since O2 sensors cannot indicate the actual air/fuel ratio, short term fuel trim must continuously ramp the fuel rich and lean in order to get the O2 sensor to “switch” and operate near stoichiometry. The ECM adjusts the air/fuel ratio in this manner until the short term fuel trim excursions are equal. This indicates that the air/fuel ratio is at stoichiometry.

For example, if the oxygen sensor indicates that the previous combustion results were lean of stoichiometry, the ECM increases the fuel injector pulse width. Increased fuel injector pulse width results in the fuel injectors being open longer.

Fuel will continue to be added until the oxygen sensor switches to indicate rich of stoichiometry. Now that the oxygen sensors indicate conditions that are rich of stoichiometry, the ECM decreases the fuel injector pulse width. Now that the oxygen sensors indicate conditions that are rich of stoichiometry, the ECM decreases the fuel injector pulse width.

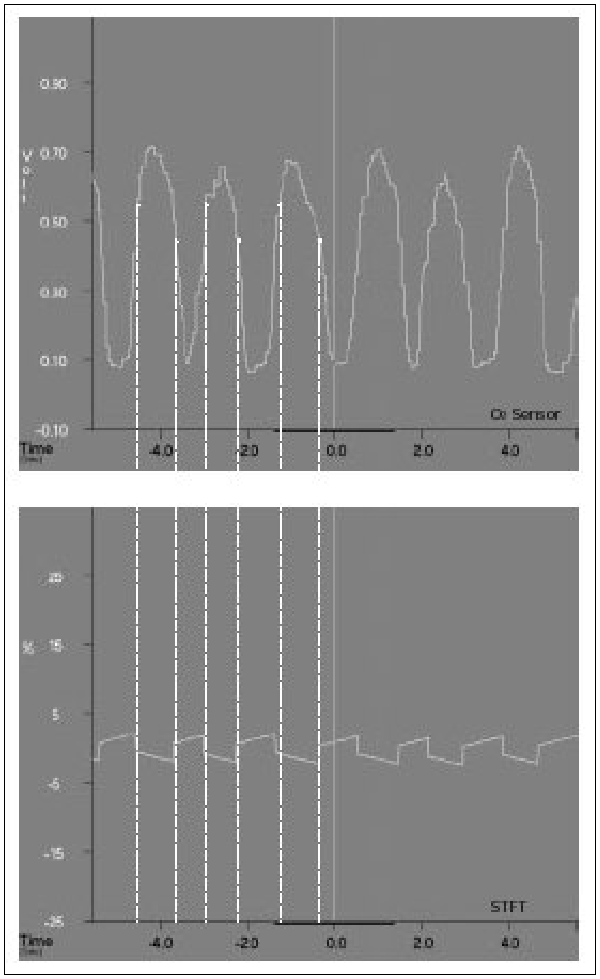

Fig. 192 STFT pattern sample

Long Term Fuel Trim

Long Term Fuel Trim, also known as Adaptive Fuel Strategy, is a software program in the ECM that "learns" the short term fuel trim corrections into tables stored in Keep Alive Memory.

These tables are used to improve both the open loop and closed loop air/fuel ratio control:

- Because long term fuel trim corrections are stored in Keep Alive Memory, short term fuel trim does not have to generate new corrections each time the vehicle goes closed loop.
- Long term fuel trim corrections are used both while in open loop and closed loop modes.

For example, if the fuel injectors clogged over time, the oxygen sensor will indicate a consistently lean condition. Short Term Fuel Trim will be constantly increasing the amount of fuel for every firing event. As the ECM sees this consistent pattern, the ECM will shift the baseline used by the Short Term Fuel Trim.

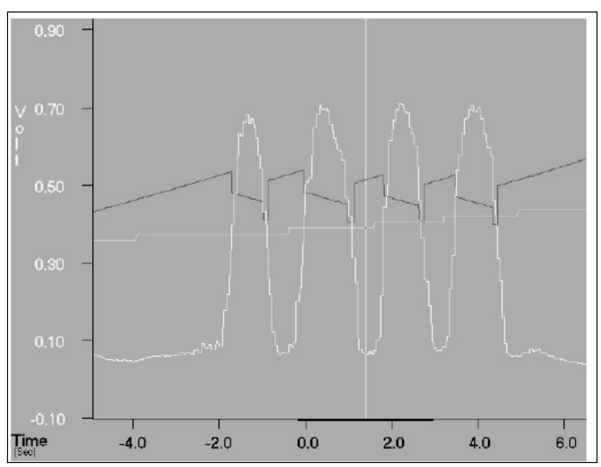

Fig. 193 LTFT pattern sample

Adaptive Fuel Metering

The ECM adapts fuel metering to variations in engine efficiency, subsystem tolerances, and changes caused by engine aging. Adaptations take place at normal operating temperature during engine idle, and at four other points within the engine load / speed range.

While monitoring the HO2S feedback, the ECM centralizes fuel metering within the feedback range. These adaptations can be measured by the WDS Datalogger Long Term Fueling Trim (LTFT) parameter. The ECM retains the adaptations in memory, for use in subsequent drive cycles.

During the next drive cycle, the ECM monitors the adaptations taking place and compares them to the adaptations that took place during the previous drive cycle for diagnostic purposes. If the ECM battery power supply is disconnected, all adaptations will be lost from memory.

After reconnecting the battery power supply and starting the engine, engine operation may be uneven (especially at idle) until the ECM relearns the adaptations.

Full Load Enrichment

The ECM determines full load from the throttle valve angle and the engine speed. At full load, the ECM inhibits closed loop fuel metering control and increases fuel flow to enrich the air : fuel ratio. The amount of enrichment is determined from the engine speed.

Evaporative Canister Purge Flow

During evaporative canister purge flow to the engine, the ECM determines the concentration of fuel vapor being drawn from the evaporative canister and makes a correction to the base fuel metering map.

Overrun Fuel Injection Cutoff

When the throttle is closed during higher engine speeds, the ECM cancels fuel injection. The engine speeds at which fuel injection is canceled and reinstated are mapped against coolant temperature.

On reinstatement, the ECM initially uses a lean air : fuel ratio to provide a smooth transition, then progressively returns to the nominal air : fuel ratio. The nominal air : fuel ratio for reinstatement is derived from throttle valve angle and engine speed. During overrun fuel injection cutoff, closed loop fuel metering control, EVAP and EGR are inhibited.

Engine Overspeed Protection

To protect the engine from overspeed damage, the ECM cancels fuel injection at 7100 rpm. Fuel injection is reinstated at 7050 rpm.

Traction / Stability Control

Fuel injection intervention is used for traction / stability control.

Full Authority Electronic Throttle Body

The full authority electronic throttle body has a motor, which is controlled and driven by the ECM. The motor positions the throttle valve opening.

The electronic throttle body can achieve not only the driver torque demand as does a conventional mechanical throttle body but can also achieve demands from other systems such as dynamic stability control, idle speed control and vehicle speed control. As the throttle is under full control from the ECM, no additional components are required for vehicle speed control.

The electronic throttle body system consists of the following components:

- Throttle valve
- Motor reduction drive gears
- Throttle return spring and “limp home” spring
- Throttle position sensor
- Accelerator pedal position sensor (mounted on accelerator pedal assembly*)
- Throttle motor relay

NOTE:

* except XK

According to the accelerator pedal position sensor signal, driving mode, demand from the speed control and other vehicle systems, the ECM calculates the target throttle valve position. By comparing the throttle position sensor signal, which shows the actual valve position with the target position, the ECM outputs a drive signal to the motor to control the actual valve position to the target position.

The ECM contains a second CPU dedicated to throttle control and monitoring. B+ Power to drive the throttle motor is provided via the ECM controlled Throttle Motor Relay.

Fuel Injectors

Jaguars use solenoid operated fuel injectors which are secured to the fuel rail by cap screws.

The fuel spray from each injector tip is directed toward the adjacent intake valve. Two O-rings seal each injector in the fuel rail bores. B+ voltage is supplied to the injectors via the ignition switch activated (position II, III) fuel injection relay.

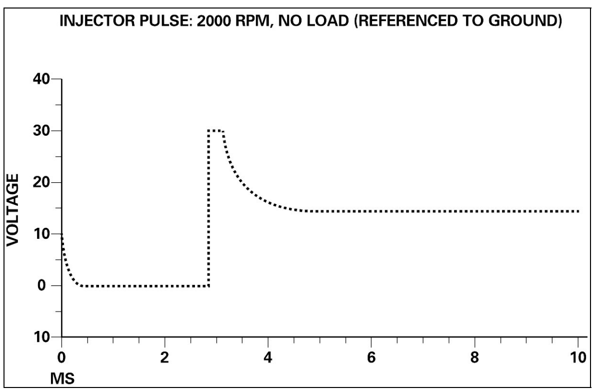

Fig. 194 FUEL INJECTOR CHARACTERISTIC (TYPICAL)

The ECM drives the injectors with a single pulse and modulates the pulse width to control the injector pulse duration.

A special tool is required for injector removal. Refer to JTIS for more information.

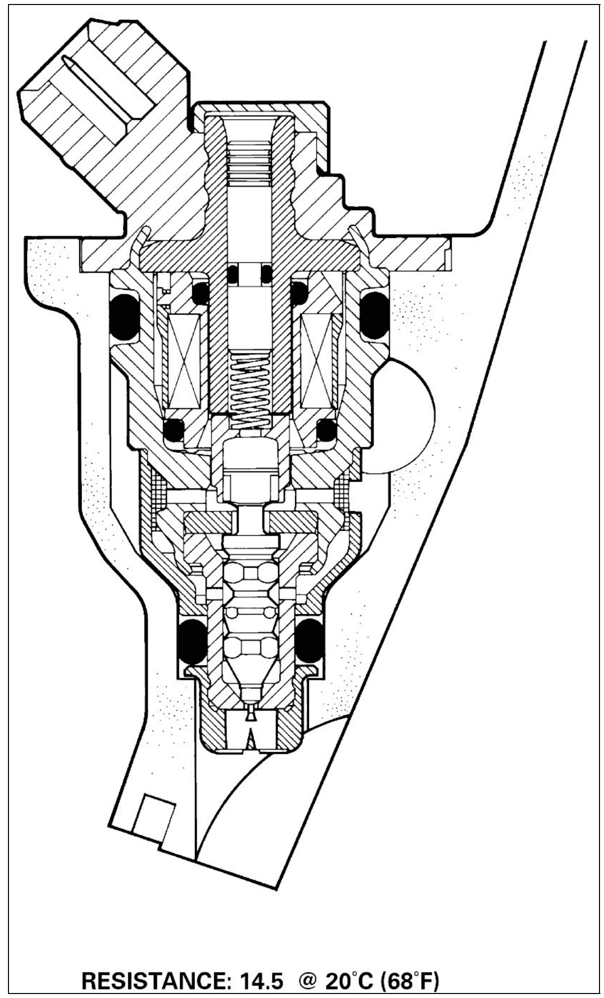

Fig. 195 FUEL INJECTOR CROSS-SECTION – AJ26 N/A

Electronic Returnless Fuel System

The electronic returnless fuel system provides pressurized fuel at the fuel injectors and does not require a return line with its associated hardware. Additional benefits of the system include:

- Precise fuel pressure control
- Reduced fuel temperature and fuel tank vapor caused by constant fuel recirculation
- Reduced electrical system load
- Fuel pressure boost to prevent fuel vapor lock
- Reduce hot start cranking time

Fuel delivery volume and pressure from the single in-tank fuel pump are controlled by the ECM in a closed loop. The actual fuel pump “drive” is supplied and controlled by the Rear Electronic Control Module (RECM), which receives fuel pump control input from the ECM. The ECM / RECM fuel pump control circuit is hard wired.

The system delivers the correct amount of fuel to the engine under all conditions and at a constant pressure differential with respect to manifold absolute pressure, without the need for a return line to the tank or a fuel rail pressure regulator.

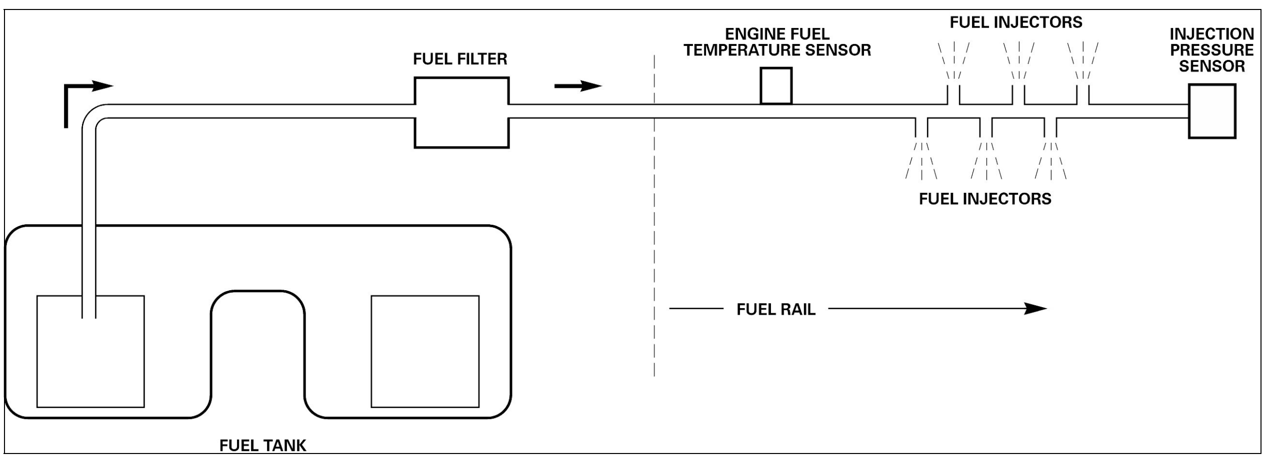

Fig. 196

IGNITION

The Jaguar ignition strategy follows the current standard practice of ECM control from a base ignition map, which is then corrected for the specific engine operating conditions. Ignition is synchronized by the ECM using the input signals from the CKP and CMP sensors.

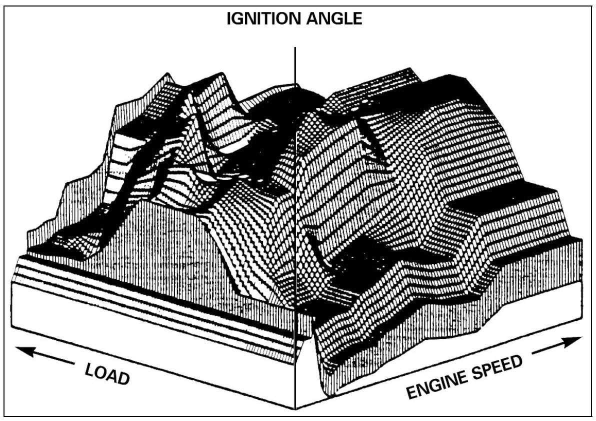

Fig. 197 BASE IGNITION MAP (TYPICAL)

Ignition Timing and Distribution

Ignition timing and spark distribution are controlled by the ECM using a base ignition map, which is then corrected for the specific engine operating conditions.

The spark plug for each cylinder is fired by an on-plug ignition coil. Ignition is synchronized using the input signals from the CKP and CMP.

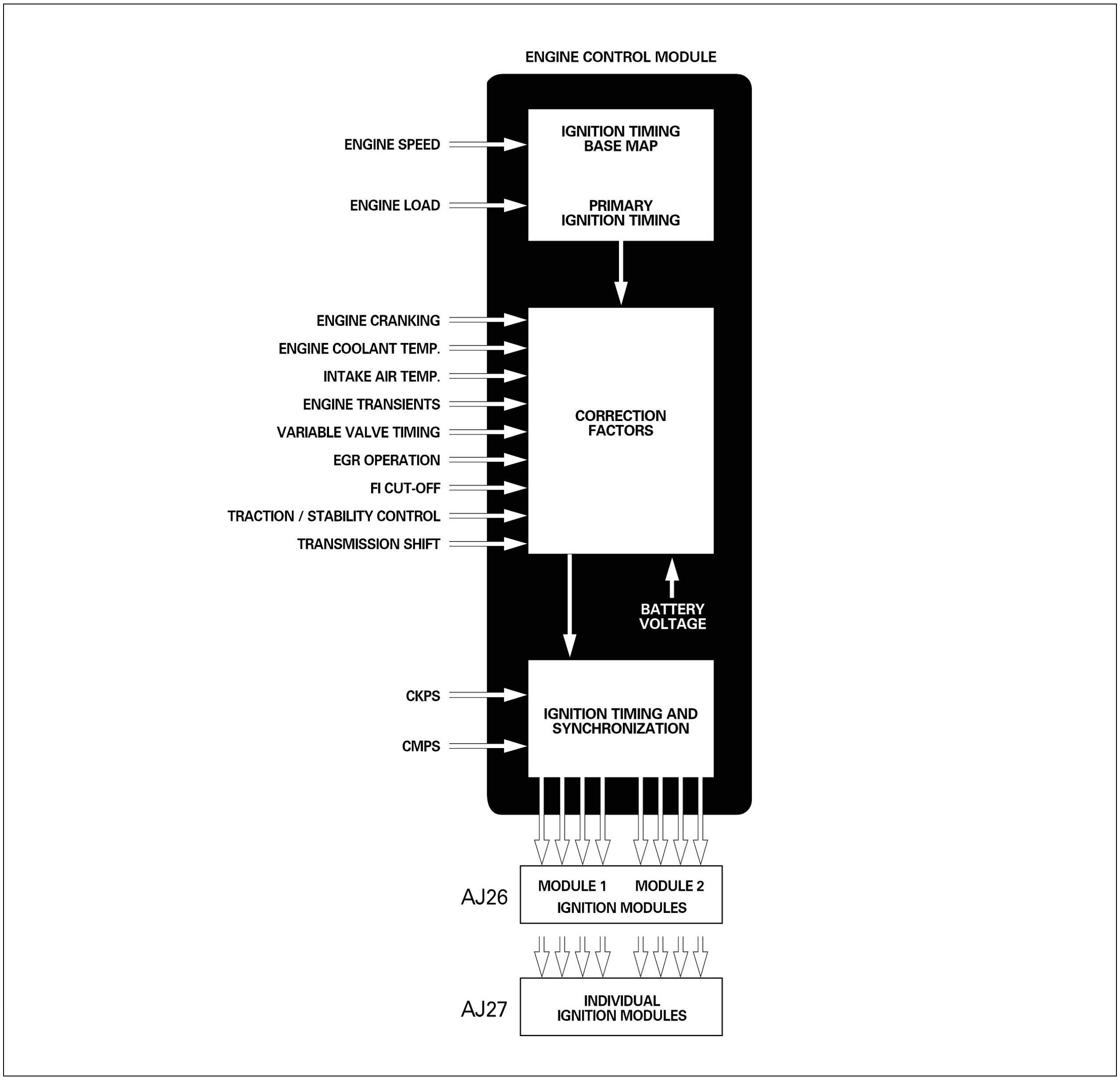

Fig. 198 IGNITION TIMING STRATEGY (TYPICAL)

Base Ignition Map

The base ignition map sets the base ignition timing for the full range of engine load and speed. Engine load is determined by the mass air flow signal .

The ECM receives an engine speed signal from the CKP.

Engine Starting

Ignition timing is fixed at one value for starting when the ECM receives an ENGINE CRANK signal from the BPM.

Temperature Correction

Ignition timing corrections are applied to the ignition map by the ECM to compensate for variations in intake air temperature and engine coolant temperature.

Fuel injection cutoff interaction

Just prior to fuel injection cutoff, the ECM retards the ignition timing to provide a smooth transition between the two operating states.

As fuel injection is reinstated, the ECM progressively returns the ignition timing to nominal.

Transient Interaction

During throttle transients (idle, steady state, acceleration, deceleration), the ECM applies ignition timing correction. The amount of timing correction depends on the throttle valve angle rate of change, and on the direction of throttle valve movement (opening / closing).

Variable Valve Timing Operation

During VVT transition, the ECM retards ignition timing to prevent transient ignition detonation.

EGR Operation (if fitted)

During EGR operation, the ECM advances ignition timing. The diluted combustion chamber charge requires more “burn time” and, therefore, more advanced ignition timing. The degree of ignition advance is proportional to engine load and speed.

Shift Energy Management

Ignition intervention is used for shift energy management.

During shifts, the TCM requests torque reduction. The ECM responds by momentarily retarding ignition timing. The reduced torque results in smoother transmission shifting.

Traction / Stability Control

Ignition intervention is used for traction / stability control.

Misfire Detection / CAN Data

The ECM is able to detect misfire by monitoring crankshaft acceleration (CKP signal). In order to reduce the possibility of false misfire diagnosis, the ECM uses the ABS/TCCM CAN data – left and right rear wheel speeds – to determine if the vehicle is operating on a rough road.

Knock Sensing OBD Monitoring

KS sense circuit out of range (low voltage) — With the ignition switched ON, the ECM monitors the A bank KS signal for low voltage. If the signal voltage is less than 0.6V on the first trip, the ECM takes default action. If the signal voltage is less than 0.6V on two consecutive trips, the ECM flags a KS DTC and the CHECK ENGINE MIL is activated.

Default action: the ECM sets ignition retard to maximum.

KS sense circuit out of range (high voltage) — With the ignition switched ON, the ECM monitors the A bank KS signal for high voltage. If the signal voltage is greater than 4.15V on the first trip, the ECM takes default action. If the signal voltage is greater than 4.15V on two consecutive trips, the ECM flags a KS DTC and the CHECK ENGINE MIL is activated.

Default action: the ECM sets ignition retard to maximum.