

Overview

The AJ16 Engine Management System (EMS) is controlled through a digital Electronic Control Module (ECM) containing a microprocessor. The system maintains optimum performance over the engine operating range by precisely controlling all fuel injection, ignition and emission control functions. In addition, the ECM provides various interface outputs and incorporates an on-board diagnostic facility.

The AJ16 EMS complies with OBD II (on-board diagnostics II), the second generation environmental legislative regulations that set the acceptable maximum level of motor vehicle exhaust emission and the required engine control systems self diagnosis capabilities.

The previous EMS used on the AJ6 4.0 litre engine complied with OBD I, which required that the following performance and diagnostic standards be met:

OBD I (AJ6 EMS 1990 – 94 MY)

- Exhaust emission level
- Monitoring and diagnosis of electrical fuel system faults
- Monitoring of both open and closed circuit faults
- Visual warning to driver: MIL (CHECK ENGINE)
- Fault code provided to technician: Diagnostic Trouble Code – DTC (Fuel Fail Code – FF)

OBD II requires lower exhaust emission levels, standardized diagnostics and failure prediction.

OBD II (AJ16 EMS)

- Exhaust emission level reduced
- Industry standardized DTCs
- Generic (after-market) scan tool capable of DTC retrieval
- Expanded self diagnostics to include monitoring and diagnosis of any power train system fault that will likely cause exhaust emission to exceed 1.5 times the standard level.
- Failure prediction of subsystems by performance observation over the life of the power train including: catalyst efficiency, engine misfire, exhaust gas recirculation, and secondary air injection.

Engine Control Module (ECM)

GEMS 6 Engine Control Module

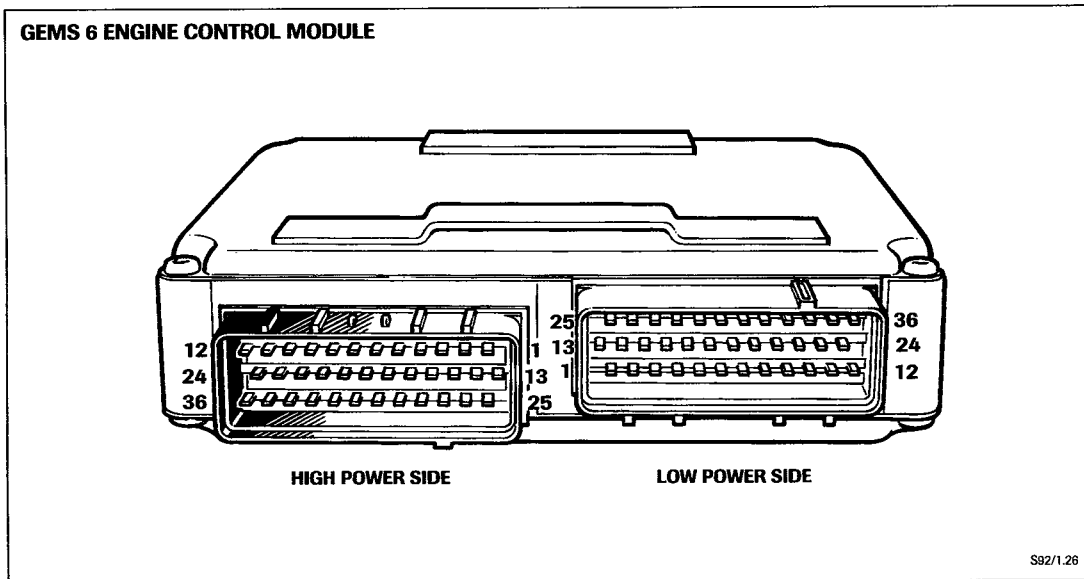
The AJ16 EMS is microprocessor based using a Sagem / Lucas GEMS 6 ECM as the heart of the system. The ECM has a 1.5 megabyte memory with a microprocessor running at a clock speed of 12/24 MHz. The ECM uses discrete components plus analog-to-digital circuits to interface between the microprocessor and the input sensors and output devices. Software is programmed into two EPROMs and one EEPROM. The EPROMs are used for control and data. The EEPROM is used for On-Board Diagnostics and adaptive functions. The ECM has nonvolatile memory so that on-board diagnosis and adaptive information is maintained if the vehicle battery is disconnected. Market specific variants are achieved through PECUS (programmable electronic control units) during manufacturing. The VIN is recorded in the ECM memory.

⚠ CAUTION: Because fuel metering and idle air adaptations cannot be reprogrammed using PDU, ECMs must not be switched from one vehicle to another.

The ECM contains two double sided printed circuit boards. One is a low power board and the other is a high power board. The red and black 36-way connectors are therefore referred to as the low and high power connectors respectively. Most of the input signals from engine mounted sensors, and interfaces with other systems are located on the low power (red) connector. The high power connector (black), mainly serves outputs such as fuel injector drive, ignition coil drive, and relay activation.

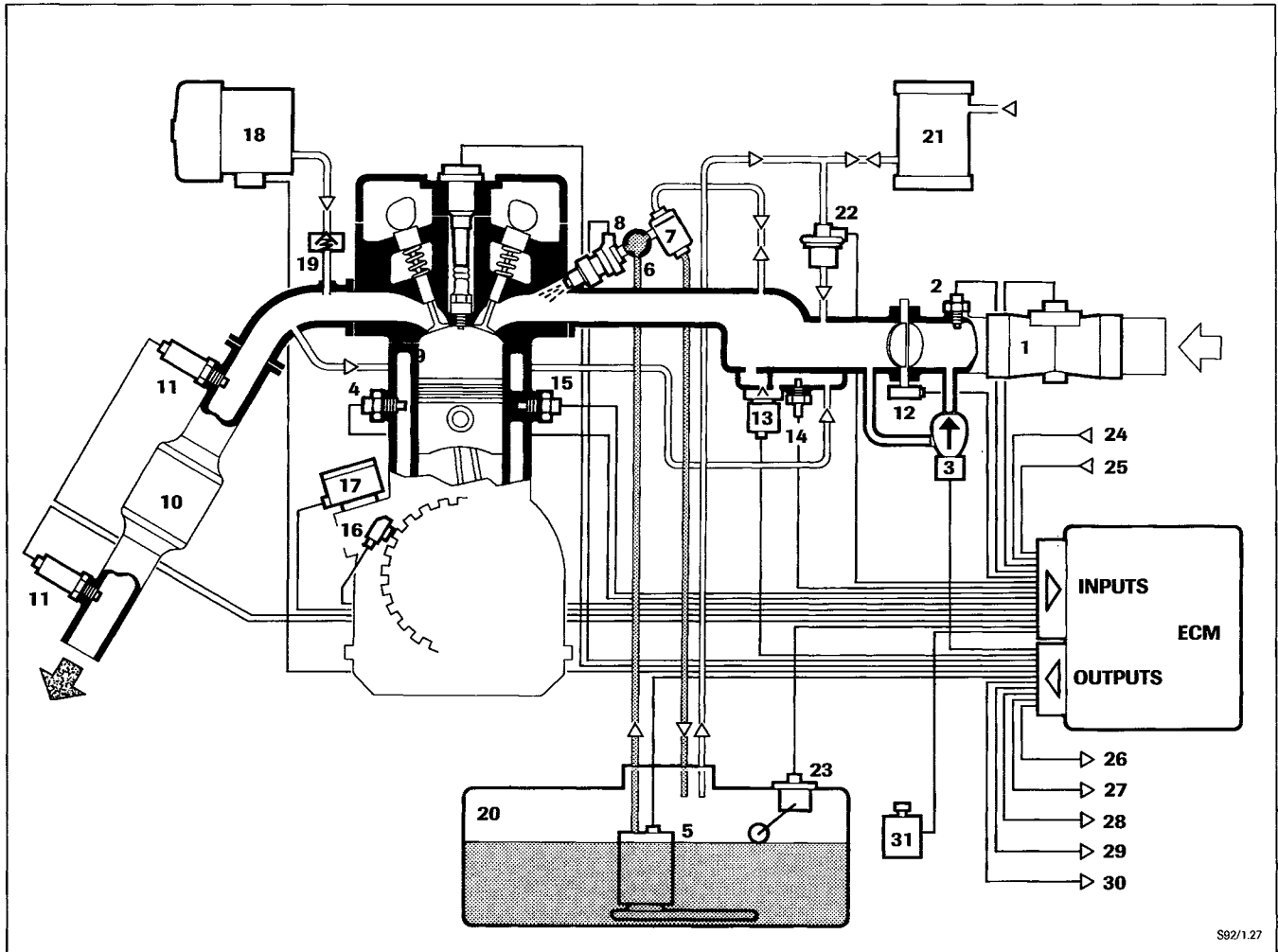
The expanded capacity of the ECM is used for stored emission control strategies, diagnostics, semi-sequential fuel injection, and direct ignition. Sixty percent of the ECM software is used for OBD II diagnostics.

An ECM controlled relay remains energized for approximately 15 seconds after power-down. This enables the ECM to perform idle air control valve positioning and other initializing functions, yet allows for reduced quiescent drain after switch-off.



Engine Control Module (ECM) (continued)

Engine Management Logic



S92/1.27

Key to Diagram

- | | |
|--|---|
| 1 Mass air flow sensor (MAFS) | 17 Camshaft position sensor (CMPS) |
| 2 Intake air temperature sensor (IATS) | 18 Secondary air injection pump (AIRP) |
| 3 Idle air control valve (IACV) | 19 Secondary air injection check valve (AIRC) |
| 4 Engine coolant temperature sensor (ECTS) | 20 Fuel tank |
| 5 Fuel pump (FP) | 21 Evaporative (charcoal) canister |
| 6 Fuel rail | 22 Evaporative emission control (purge) valve (EVAPP) |
| 7 Fuel pressure regulator | 23 Fuel level sensor |
| 8 Fuel injector (FI) | 24 Park / neutral switch |
| 9 Spark plug with integral coil | 25 Ignition ON |
| 10 Catalyst | 26 Instrument pack (road speed) |
| 11 Heated oxygen sensors (HO2S) | 27 Trip computer |
| 12 Throttle position sensor (TPS) | 28 Malfunction Indicator Lamp (MIL) |
| 13 EGR valve (EGRV) | 29 Serial communication |
| 14 EGR temperature sensor (EGRT Sensor) | 30 Transmission control module (torque control) |
| 15 Knock sensor (KS) | 31 Inertia switch |
| 16 Crankshaft position sensor (CKPS) | |

ECM Inputs, Outputs and Pin Information

ECM Black Connector A (High Power)

Pin LI 189 -

- 1 Power ground - input
- 2 Fuel injector 1 - output
- 3 Idle speed control 1 - output
- 4 Oxygen sensor heaters, downstream - output
- 5 Ignition coil 4 - output
- 6 Ignition coil 3 - output
- 7 Air pump - output
- 8 Ignition coil 2 - output
- 9 Ignition coil 5 - output
- 10 Ignition coil 1 - output

- 11 Ignition coil 6 - output
- 12 Power ground - input
- 13 Fuel injector 4 - output
- 14 Fuel injector 3 - output
- 15 Fuel injector 2 - output
- 16 Idle air control 2 - output
- 17 Fuel used - output
- 18 ECM controlled relay - output
- 19 Fuel pump - output
- 20 MIL - output
- 21 A/C compressor relay - output
- 22 Engine speed - output
- 23 Crankshaft position sensor positive - input
- 24 ECM controlled relay - input

- 25 Fuel injector 6 - output
- 26 Crankshaft position sensor negative - input
- 27 Fuel injector 5 - output
- 28 Idle speed control 3 - input
- 29 Idle speed control 4 - output
- 30 Oxygen sensor heaters, upstream - output
- 31 Not used
- 32 Throttle position (transmission) - output
- 33 Engine torque - output
- 34 Evaporative emission control valve - output
- 35 EGR valve - output
- 36 Power ground - input

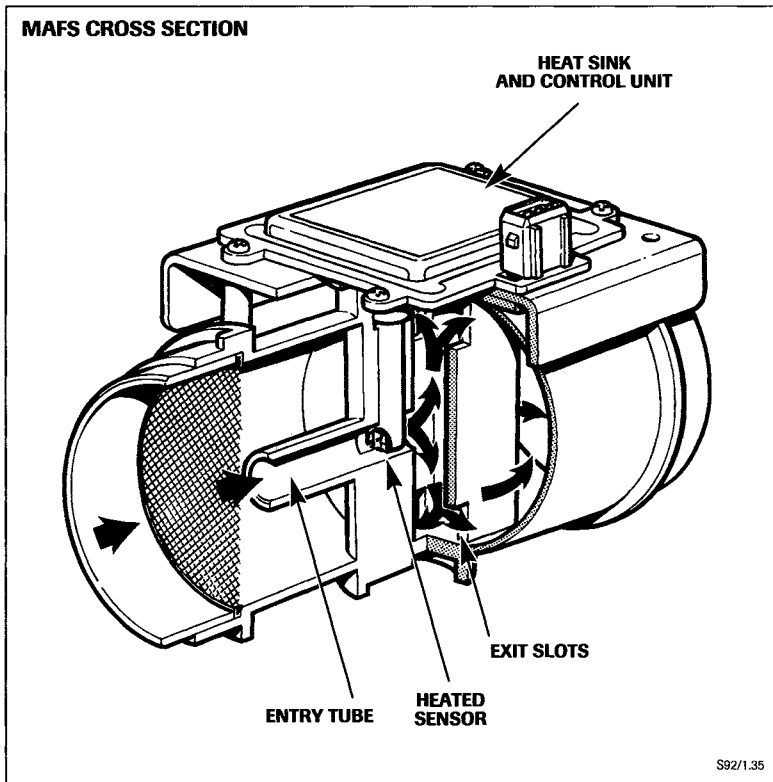
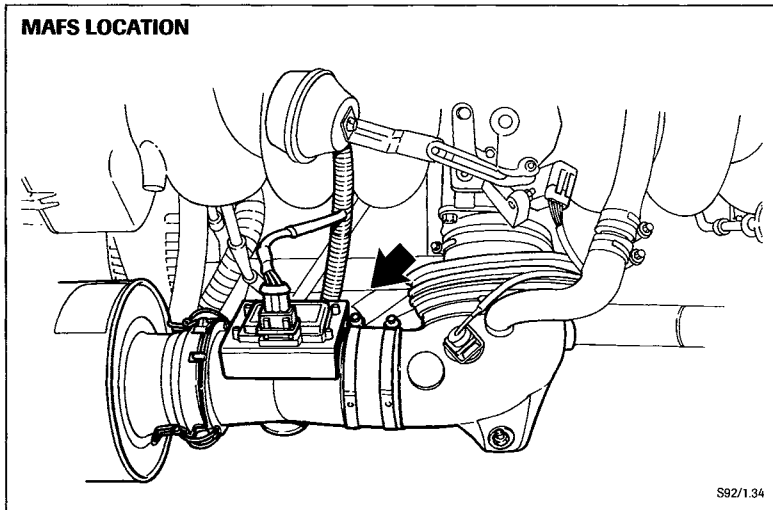
ECM Red Connector B (Low Power)

Pin LI 190 -

- 1 Intake air temperature - input
- 2 Not used
- 3 EGR valve function - input
- 4 Mass air flow (load) - input
- 5 Not used
- 6 Oxygen sensor 3 - input
- 7 Sensor 5v ground - input
- 8 Oxygen sensor signal ground - input
- 9 Knock sensor ground - input
- 10 Bidirectional serial communication - input / output
- 11 Sensor 5v supply - output
- 12 Throttle position - input
- 13 Not used
- 14 Engine coolant temperature - input
- 15 EGR valve position - input
- 16 Oxygen sensor 1 - input
- 17 Battery voltage common supply - input
- 18 Oxygen sensor 2 - input
- 19 Oxygen sensor 4 - input
- 20 Fuel tank level - input
- 21 Knock sensor A - input
- 22 Not used
- 23 Not used
- 24 Camshaft position sensor 12v supply - output
- 25 Not used
- 26 Transmission ignition control - input
- 27 Park / neutral position - input
- 28 Road speed - input
- 29 Mass air flow sensor ground - input
- 30 Small signal ground - input
- 31 Engine coolant temperature sensor ground - input
- 32 Knock sensor B - input
- 33 Ignition ON - input
- 34 Camshaft position - input
- 35 Not used
- 36 Air conditioning ON request

EMS Main Sensing Components

The inputs provided by the engine management system main sensing components are used by the ECM to control a variety of subsystems and functions.



Engine Load

Mass air flow sensor (MAFS)

The new MAFS has an improved and simplified design with revised calibrations for the GEM 6 EMS.

The model 20 AM mass air flow sensor (MAFS) is a hot wire type that measures air flow volume by the cooling effect of air passing over a heated platinum 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 heated wire sensor is located in the central column that is an integral part of the casting. The column has a central tube entry and four exit slots. A small portion of the intake air flows through the entry tube and passes over the heated wire sensor before returning to the main air flow through the four exit slots. The heated sensor is an integral part of the heat sink and control unit mounted on the main casting. The intake screen stabilizes the air flow through the MAFS and protects the sensor from debris in the air stream.

Engine Speed and Crankshaft Position

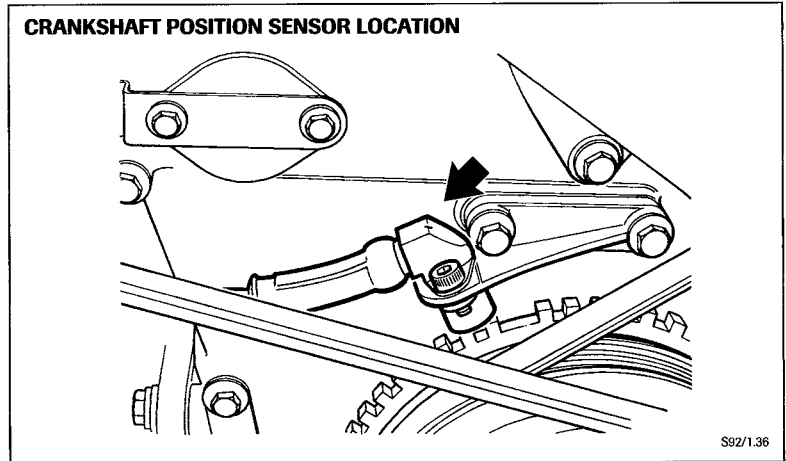
Crankshaft position sensor (CKPS)

The sensor portion of the crankshaft position sensor is identical to the AJ6 sensor with a revised electrical lead and bracket.

The CKPS provides the primary input to the ECM for engine speed and engine position. The sensor is a variable reluctance device, consisting of a bobbin coil with a magnetic core. The steel teeth on the crankshaft timing ring form a rotor. As the rotor teeth pass by the crankshaft position sensor, pulses are generated.

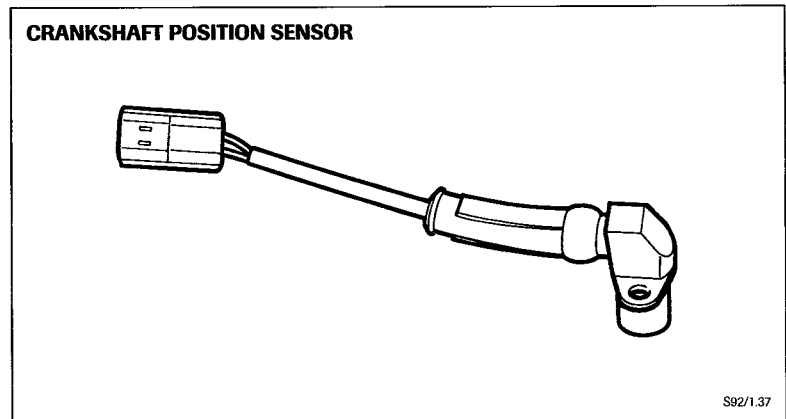
The rotor has 60 tooth positions set at 6° intervals with one tooth missing. The gap identifies the TDC position of cylinders 1 and 6. The rotor thus provides both engine speed and crankshaft position information to the ECM. Each tooth pulse represents 6° of crankshaft rotation. Thus the frequency of the toothed pulses are a measure of engine speed. The sensor is mounted to the timing cover on the front of the engine. The air gap between the sensor and the rotor should be 0.020 - 0.040 in.

CRANKSHAFT POSITION SENSOR LOCATION



S92/1.36

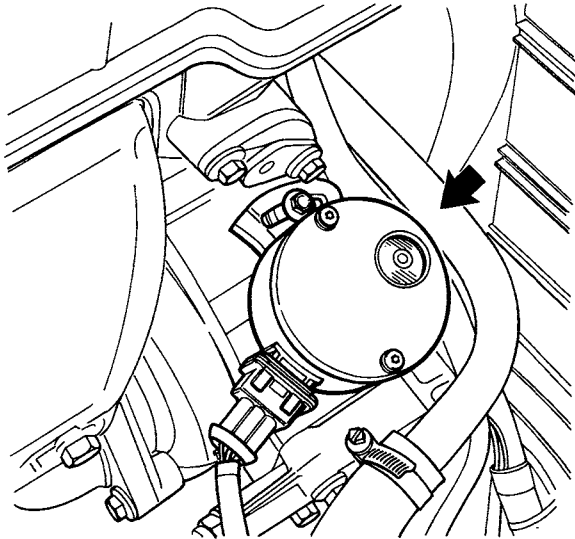
CRANKSHAFT POSITION SENSOR



S92/1.37

EMS Main Sensing Components (continued)

CAMSHAFT POSITION SENSOR LOCATION



S92/1.38

Initial Cylinder Synchronization for Engine Starting

Camshaft position sensor (CMPS)

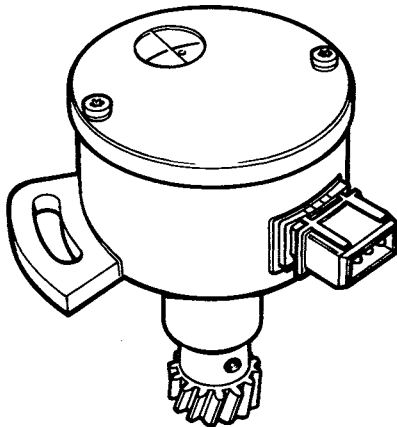
The camshaft position sensor is a Hall-effect sensor which provides the ECM with a sequencing input so that correct ignition and fuel injection will begin with two-thirds of an engine revolution at engine start. The CMPS rotor has six "windows" of different width to positively identify each cylinder. As a window passes the sensor, the ECM is able to identify the cylinder (1 through 6).

The CMPS is necessary because the crankshaft position sensor (CKPS) gap identifies TDC position for *both* cylinders 1 and 6. Without the CMPS sequencing input, the ECM would attempt engine start by trial and error, firing each cylinder in sequence; several engine revolutions might be required for successful engine start. CMPS input is not required by the ECM once the engine is started.

CMPS installation procedure

With the engine at cylinder 1 compression TDC, the dot on the CMPS rotor should align with the circle in the inspection window.

CAMSHAFT POSITION SENSOR



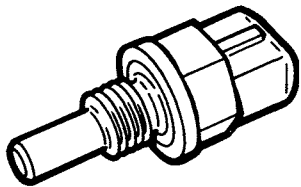
S92/1.39

Engine Coolant Temperature

Engine coolant temperature sensor (ECTS)

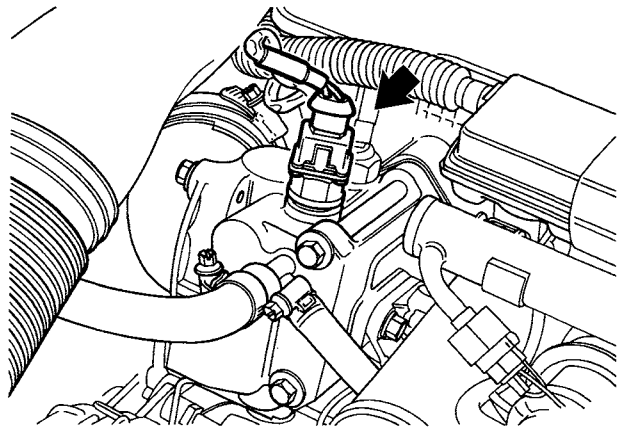
The model 8 TT engine coolant temperature sensor is a negative temperature coefficient (NTC) thermistor. It is identical to the sensor used in AJ6 engine management systems, however, the connector and leads are revised. Engine coolant temperature is determined by the ECM by a change in resistance within the sensor. The ECM applies 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance.

ENGINE COOLANT TEMPERATURE SENSOR



S92/1.40

ENGINE COOLANT TEMPERATURE SENSOR LOCATION



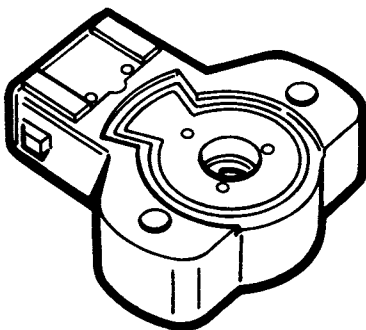
S92/1.41

Throttle Position

Throttle position sensor (TPS)

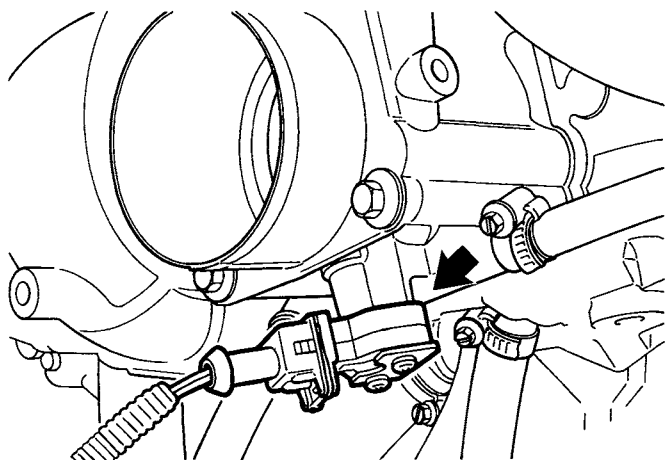
The model CTS 518 throttle position sensor is a nonadjustable single-track potentiometer connected to the spindle on the throttle shaft. The ECM adapts to the TPS idle position to compensate for aging and component wear. The ECM applies 5 volts to the sensor and monitors the voltage across the pins to determine throttle position: low voltage – closed throttle, high voltage – opened throttle.

THROTTLE POSITION SENSOR



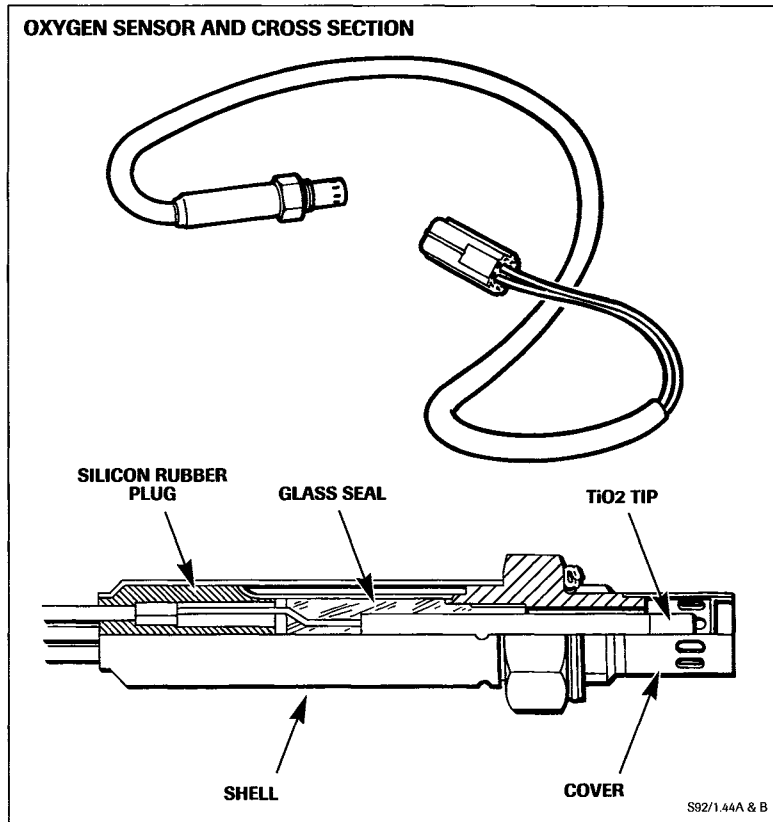
S92/1.42

THROTTLE POSITION SENSOR LOCATION



S92/1.43

EMS Main Sensing Components (continued)



Exhaust Gas Oxygen Content

Heated oxygen sensors (HO2S)

The AJ16 EMS uses four new redesigned heated oxygen sensors that provide improved heater temperature control and reduced warm-up time.

The model TO 19 heated oxygen sensors are of the Titanium Dioxide type that have a tip composed of an alumina substrate with a thick film titanium dioxide element. This type of sensor does not require reference air to detect the oxygen content of the exhaust so wetting or contamination of the sensor exterior will not affect sensor performance. The resistance of the sensor element varies greatly with the partial presence of oxygen in the exhaust gas. The change in resistance is converted to a voltage output to the ECM via a constant voltage source and reference resistance. Whenever the fuel / air mixture ratio passes 14.7:1 (Lambda = 1), the sensor delivers a voltage swing:

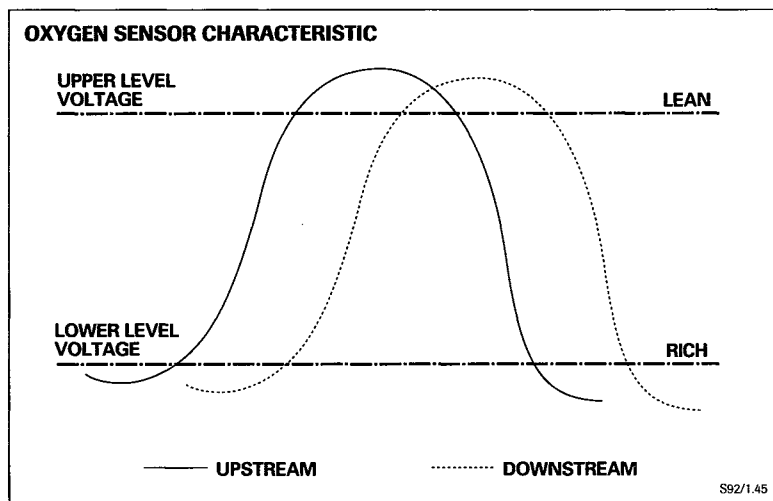
Fuel / air mixture **leaner** than 14.7:1
reference voltage **high** (maximum 4.89 v)

Fuel / air mixture **richer** than 14.7:1 -
reference voltage **low** (minimum 0.015 v)

The heater is used to bring the sensor to the active temperature of approximately 500°C in approximately 20 seconds after engine start.

If the oxygen sensors are to be removed or the exhaust system replaced, the sensors and harness side connectors must be labeled to ensure reinstallation in their original locations.

NOTE: If the sensors and connectors are not reinstalled in their original locations, the ECM can be reprogrammed using PDU to match the sensor locations to the ECM. When new sensors are installed or the wiring harness is changed, the ECM must be reprogrammed using PDU.



Fuel Injection

Fuel metering is obtained by controlling the injector pulse duration during each engine cycle (two crankshaft rotations). The pulse duration is varied by the engine control module (ECM) according to several sensor inputs. The sensed control inputs form two groups – primary and secondary. Primary control inputs are intake mass air flow (engine load) and engine speed; secondary control inputs consist of engine coolant temperature, cranking signal, throttle movement and position and exhaust oxygen content. The injector pulse is then corrected for actual battery voltage. The injectors are pulsed semi-sequentially, twice per engine cycle (once per engine revolution) in the engine firing order.

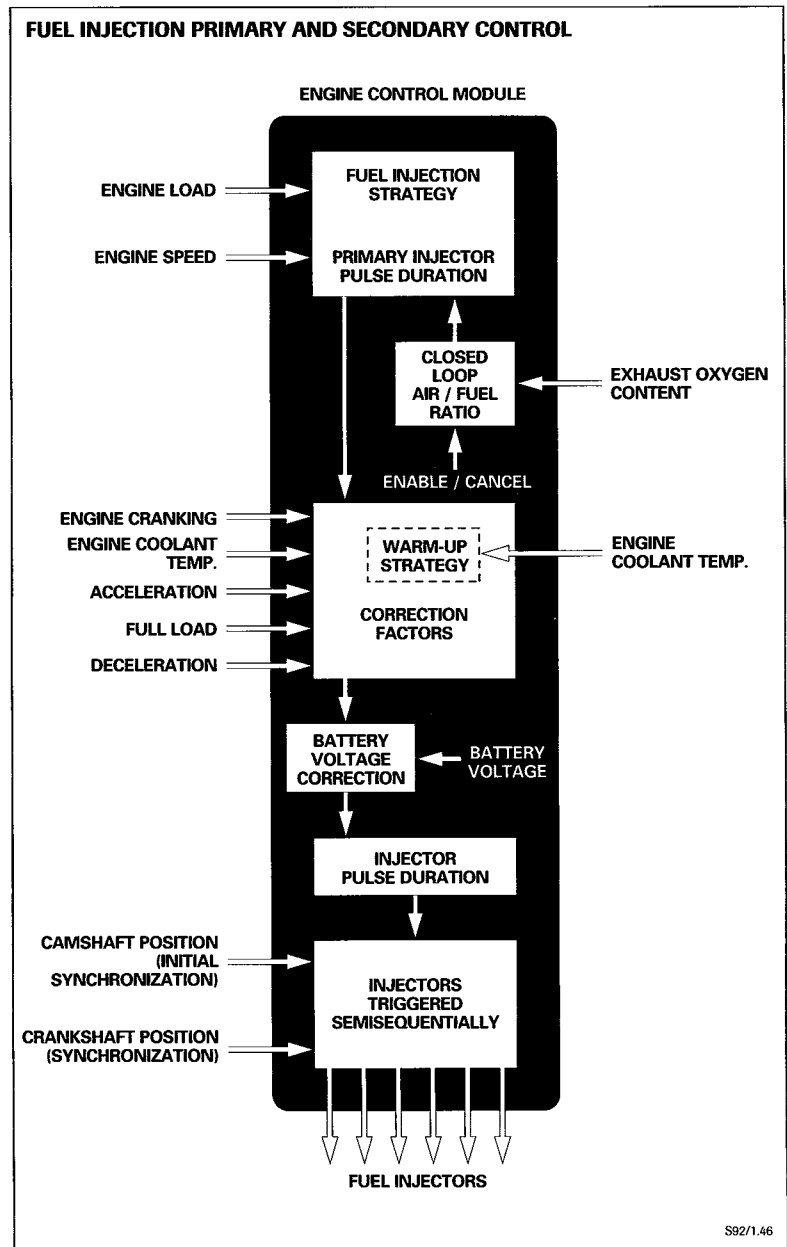
Fuel metering strategies are held in memory (EPROM) in the ECM and form an engine load versus engine speed matrix. The load and speed range of the engine is divided into 16 loads and 16 speeds (256 memory sites). Digital numbers representing injector pulse duration in milliseconds fill each site and cover the entire engine load and speed range. Fuel metering correction is applied for all six cylinders simultaneously – not for individual cylinders.

Fuel injector sequential pulsing in the engine firing order is ECM controlled. The ECM “learns” the compression stroke synchronization at each engine start from the camshaft position sensor (CMPS) and crankshaft position sensor (CKPS) inputs. After the firing synchronization is learned, the ECM uses the CKPS input for engine speed and position. Refer to the CMPS description on page 26 and the CKPS description on page 25.

Additional fuel injection controls are used for overrun fuel cutoff, engine overspeed prevention and fuel cutoff during wide-open-throttle cranking.

Fuel Injection Primary Control

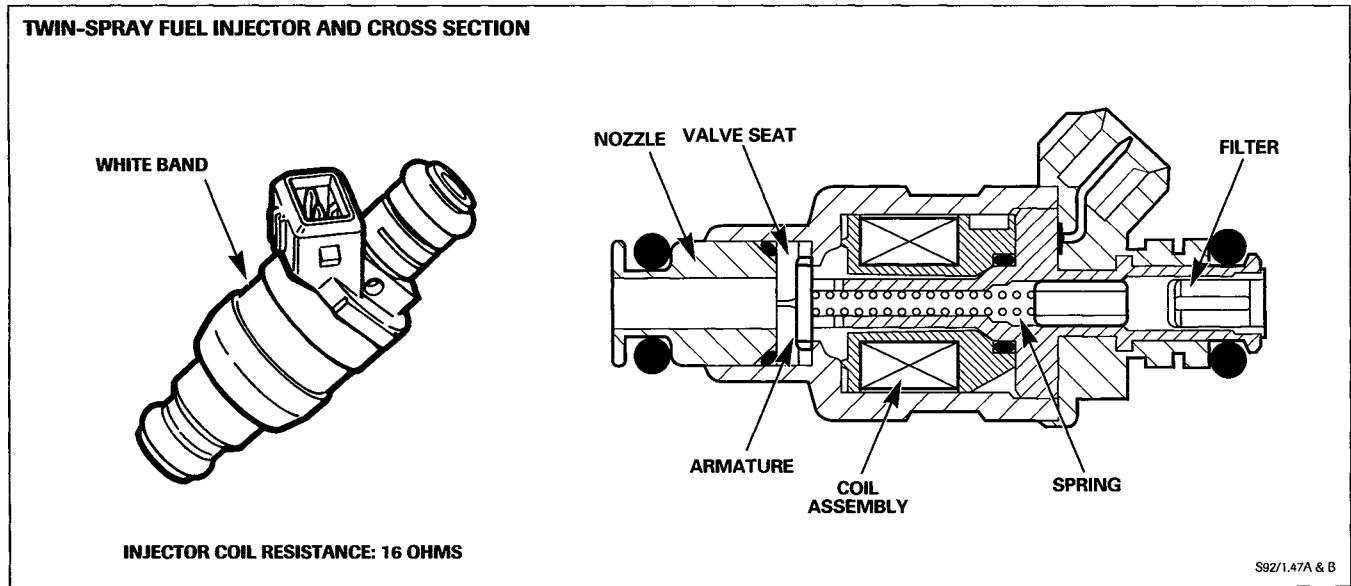
Fuel metering is controlled primarily as a function of engine load and speed. Engine load is sensed by a mass air flow sensor (MAFS) located in the engine air intake before the throttle housing. Engine speed is sensed by a crankshaft position sensor (CKPS) located behind the engine damper. The ECM processes the input from the MAFS and the CKPS to access pulse duration from the fuel metering strategy.



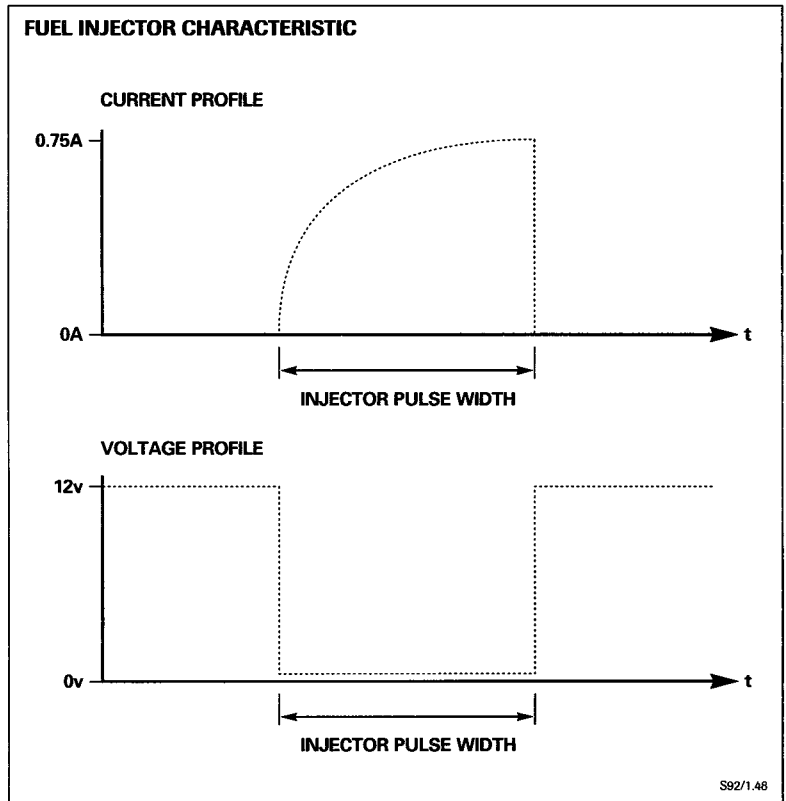
Fuel Injection (continued)

Fuel Injectors

The fuel injectors are plate-type, twin-spray injectors as used on the 1993 / 94 model year AJ6 engine, but with revised flow rates. The plate-type, twin-spray injector design has several benefits: it aims a fuel spray at each intake valve throat, it is quieter in operation, and the tip is less prone to contamination. The injectors are secured to the fuel rail with custom clips that ensure the twin jets of fuel are directed to the intake valve throats. AJ16 injectors are identified by a white band around the injector body.



The AJ16 injector drive signal is a single-width modulated pulse. (The AJ6 injector has a large opening pulse followed by a series of hold-on pulses.)



Fuel Injection (continued)

Fuel Injection Secondary Control

Secondary fuel metering control adjusts for engine coolant temperature, cranking signal, throttle movement and position, exhaust oxygen content and battery voltage.

Cranking and after-start enrichment

The ECM provides fuel metering enrichment for cranking and after-start conditions by increasing the injector pulse duration. The injector pulse duration, and the rate at which the enrichment is decreased back to the warm-up phase, are dependent upon engine coolant temperature.

Warm-up

The programmed warm-up enrichment provides extra fuel during engine warm-up based on the engine temperature measured by the coolant temperature sensor.

Acceleration enrichment

When the ECM senses that the throttle is opening (throttle position sensor input), the injector pulse duration is lengthened by an amount dependent upon the rate at which the throttle is opened and on engine coolant temperature.

Full load enrichment

If the ECM senses a full throttle input from the throttle position sensor, full load enrichment is applied and closed loop operation is temporarily canceled.

Deceleration leaning

When the ECM senses that the throttle is closing (throttle position sensor input), the injector pulse duration is shortened dependent on the rate at which the throttle closed. This prevents a momentary rich condition.

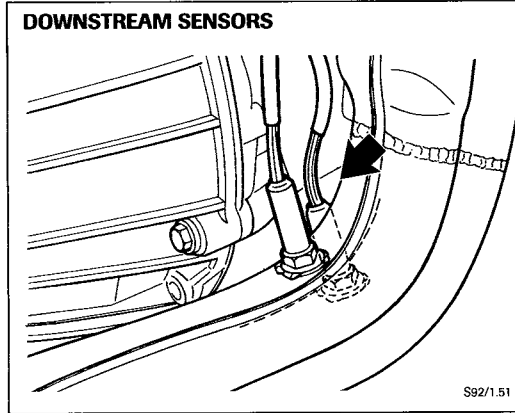
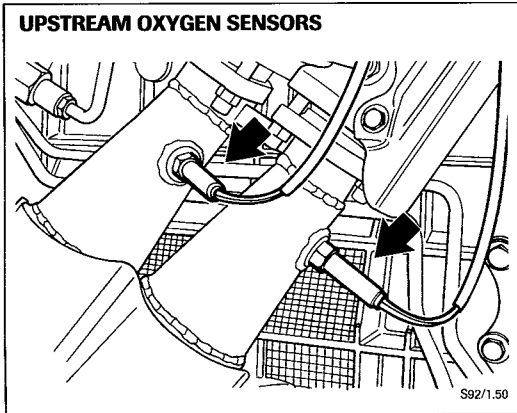
Battery voltage correction

Because the time to achieve full lift of the injector plate decreases as voltage increases, the amount of fuel delivered by the injector for a given pulse duration is dependent upon the injector operating voltage. The ECM is programmed with a voltage correction strategy. The supply voltage is monitored by a software routine and the correction applied to the pulse duration.

Closed loop fuel metering

In order to significantly reduce exhaust emission, the exhaust system incorporates two primary and one secondary 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 is used to maintain an optimum air / fuel ratio as close to 14.7 : 1 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 baseline injector pulse duration.

Four oxygen sensors are installed on the exhaust system, two upstream and two downstream of the primary catalyts. The two downstream sensor voltage swings are used by the ECM for closed loop fuel metering correction. The upstream sensors are used for OBD catalyst monitoring. Refer to Catalytic Converters on page 44.



The oxygen sensor voltage swings abruptly at an air / fuel ratio of 14.7 : 1 ($\text{Lambda} = 1$). The new sensors used in the AJ16 EMS have different characteristics than sensors used in previous Jaguar systems. Refer to Heated Oxygen Sensors on page 28 for more information.

Additional Fuel Injection Controls

Overrun fuel cutoff

In order to improve fuel economy and aid in controlling exhaust emission, the ECM cancels fuel injection during engine overrun conditions. The ECM determines overrun conditions from inputs received from the throttle position sensor (TPS), crankshaft position sensor (CKPS) and engine coolant temperature sensor (ECTS).

Engine overspeed control

An engine overspeed control function limits the maximum engine speed by canceling fuel injection.

Wide-open-throttle during cranking

If the ECM senses that the throttle is wide open (throttle position sensor input) during cranking, fuel injection is canceled to help clear a flooded engine.

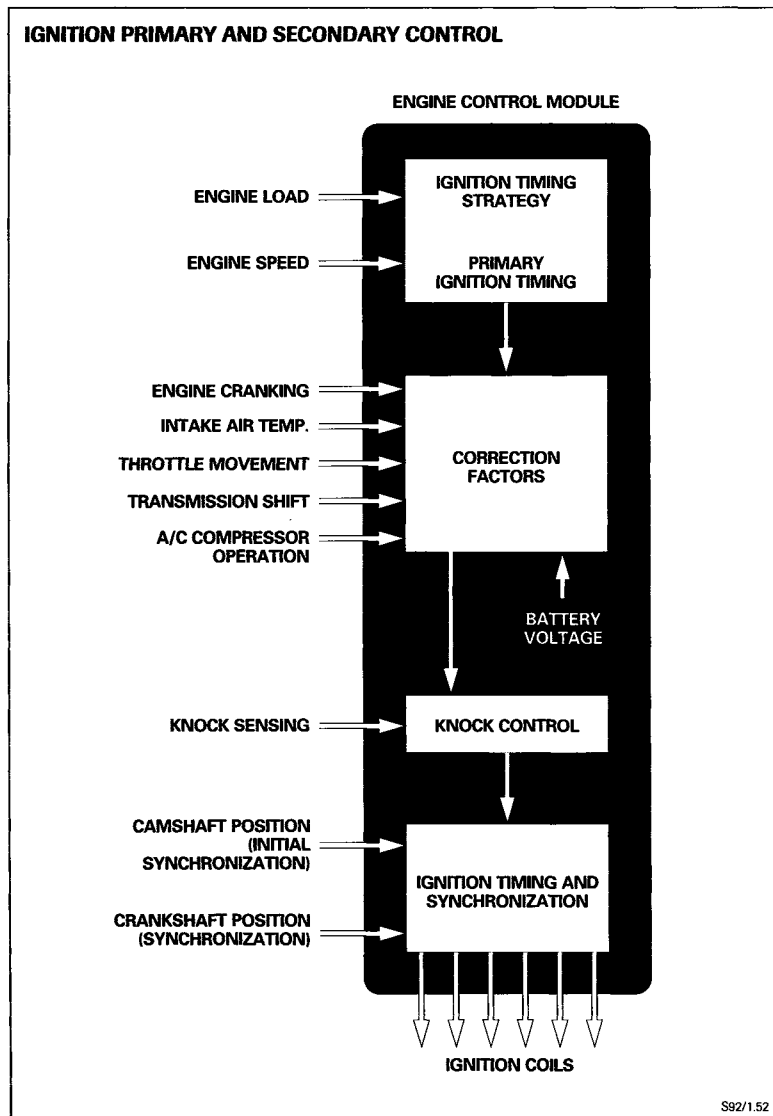
Ignition Control

Ignition Timing and Spark Distribution

Ignition timing and spark distribution are controlled by the engine control module (ECM) according to sensor inputs. As with fuel injection, the sensed control inputs form two groups: primary and secondary. Primary control inputs are intake mass air flow (engine load) and engine speed; secondary control inputs consist of engine coolant temperature, intake air temperature, throttle movement and position, transmission upshift and knock control.

Ignition timing strategies are held in memory (EPROM) in the ECM and form an engine load versus engine speed matrix. The load and speed range of the engine is divided into 16 loads and 16 speeds (256 memory sites). Digital numbers representing ignition timing values fill each site. The resulting 256 ignition timing values cover the entire engine load and speed range. Ignition timing is then calculated from the ignition timing strategy according to secondary input correction factors.

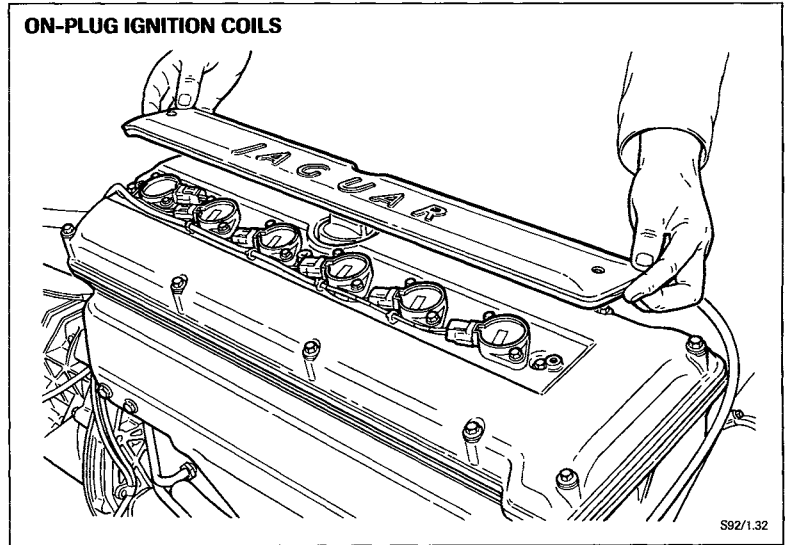
Spark distribution, in the engine firing order, is ECM controlled. The ECM "learns" the compression stroke synchronization at each engine start from the camshaft position sensor (CMPS) input. After starting the ECM uses the crankshaft position sensor (CKPS) input for spark timing. Refer to the CMPS description on page 26 and the CKPS description on page 25.



Ignition Primary Control

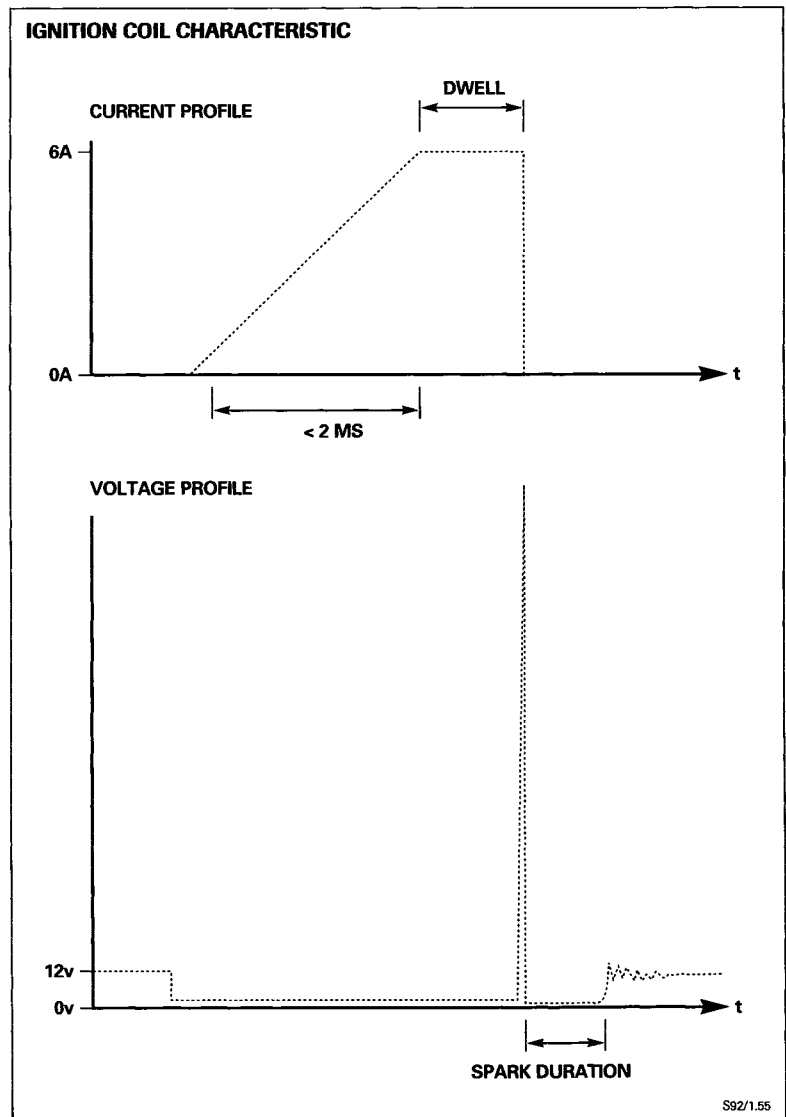
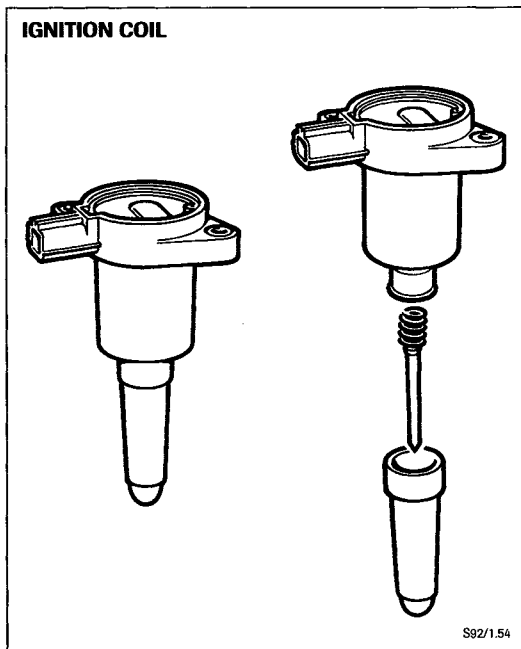
Ignition timing is controlled primarily as a function of engine load and speed. Engine load is sensed by the mass air flow sensor (MAFS) located in the engine air intake before the throttle housing. Engine speed is sensed by a crankshaft position sensor (CKPS) located behind the engine damper. The ECM processes the inputs from the MAFS and the CKPS and accesses ignition timing from the ignition timing strategy.

Six individual "on-plug" ignition coils are located above each spark plug. The ECM incorporates the primary circuit for each coil and provides switching for each primary circuit. The correct firing sequence and timing of the six individual on-plug ignition coils is determined by the ECM from the cylinder synchronization input provided by the camshaft position sensor (CMPS) (initial learning at engine start) and the crankshaft position sensor (CKPS). Refer to the CMPS description on page 26 and the CKPS description on page 25.



Ignition Coils

Each ignition coil assembly is made up of a coil body with an integral two-pin connector plug (for connection to the ECM), a central electrode and an extension housing.



Ignition Control (continued)

Ignition Secondary Control

Secondary ignition timing control inputs consist of battery voltage, engine coolant temperature, intake air temperature, throttle movement and position, transmission upshift, and knock control.

Dwell control

The dwell angle and peak coil current are ECM controlled to maintain the required spark energy required throughout the operating range of the engine while keeping dwell to a minimum to avoid overheating of the ignition coils.

Engine coolant temperature correction

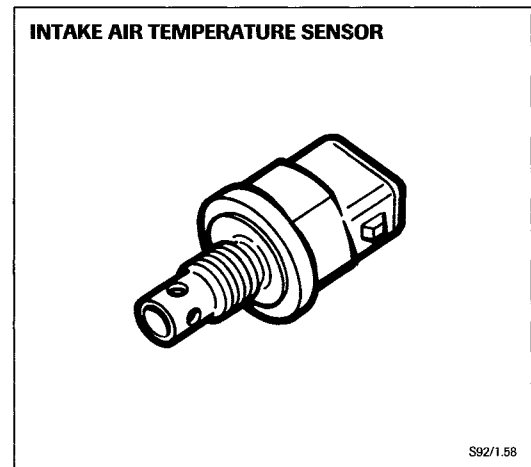
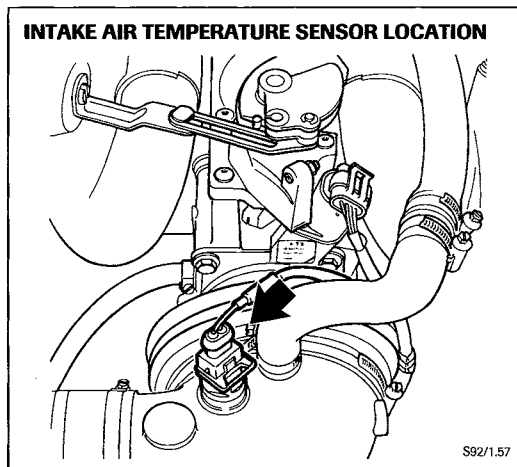
Ignition timing is corrected for engine coolant temperature by the ECM.

Intake air temperature correction

Ignition timing is corrected by the ECM for engine intake air temperature measured by the air temperature sensor mounted in the air inlet elbow.

Intake air temperature sensor (IATS)

The model 10 TT intake air temperature sensor (IATS) is a negative temperature coefficient (NTC) thermistor identical to the sensor used in AJ6 engine management systems, however, the connector and leads are revised. 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 across the pins to detect the varying resistance.



Closed throttle / idle correction

Separate closed throttle idle ignition strategies for gear positions Neutral and Drive are used. Refer to Idle Control, page 38.

Full load correction

The ECM corrects ignition timing to compensate for full load conditions.

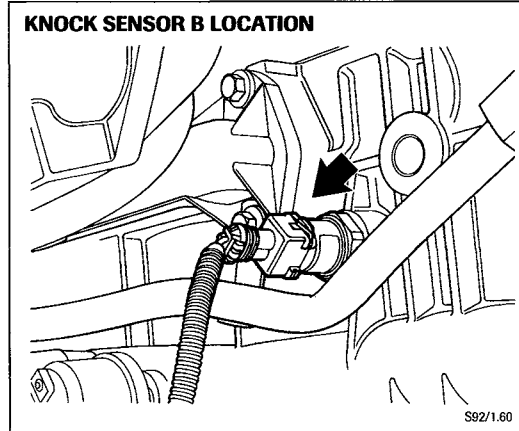
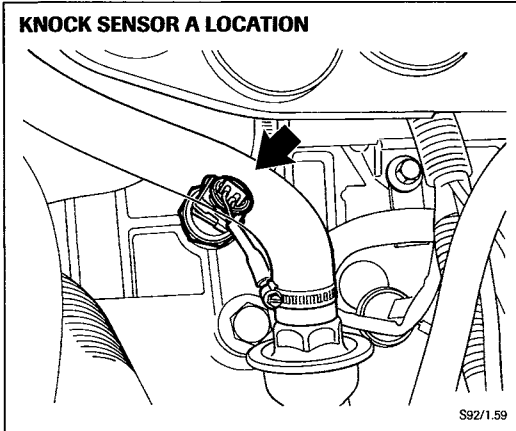
Torque-based transmission shifting

Transmission shift quality is enhanced by "torque-based shifting". The ECM continuously provides the transmission control module (TCM) with a pulse width modulated (PWM) signal that represents the amount of torque the engine is producing. This signal is generated by the ECM based on the injector pulse duration.

When a shift is to occur, the TCM calculates the necessary torque reduction and provides a PWM torque reduction signal to the ECM. The torque reduction signal will vary between 20% and 90%. The actual amount of retard is applied to the ignition advance angle after other corrections are applied.

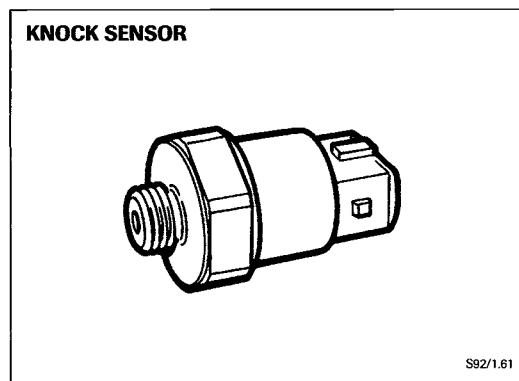
Knock control

Individual, cylinder specific ignition retard to control knock and optimize engine power is provided through ECM control. Two knock sensors (KS) are positioned on the cylinder block at the number 2 and number 5 cylinder locations to sense engine combustion knocks. Each knock sensor has a piezo electric sensing element to detect broad band (2–20 kHz) engine accelerations.



If a knock occurs, the ECM determines which cylinder is firing from the camshaft position sensor (CMPS) input, and retards the ignition timing for that cylinder only. If, on the next firing of that cylinder, the knock reoccurs, the ECM will further retard the ignition timing; if the knock does not reoccur on the next firing, the ECM will advance the ignition timing to the normal running ignition timing.

The knock sensing ignition retard / advance process can continue for a particular cylinder up to a maximum retard of 9 degrees. The ECM will advance the ignition timing incrementally after each firing of the cylinder.



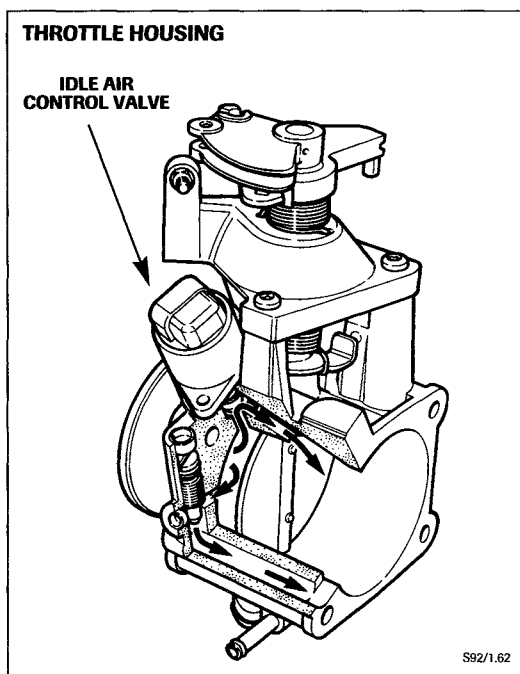
Idle Control

Idle is regulated by idle air control and ignition timing.

The idle air control valve (IACV) is driven by the ECM. The ECM uses inputs received from ignition ON, the crankshaft position sensor (CKPS), engine coolant temperature sensor (ECTS) and throttle position sensor (TPS) as well as inputs for gear position, air conditioning compressor operation and road speed to control idle.

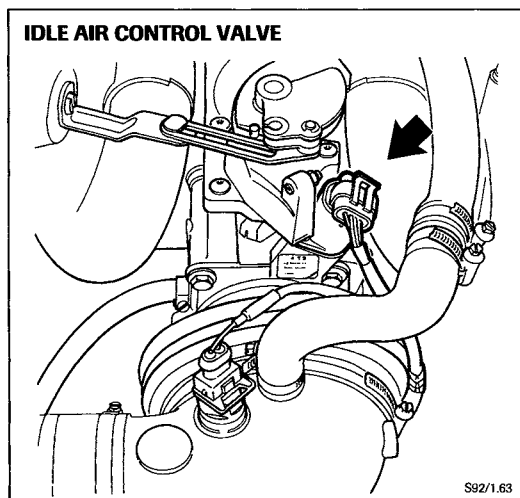
Throttle Body and Idle Air Control Valve (IACV)

The throttle body assembly incorporates the engine throttle, a fixed idle air bypass, an idle air control valve (IACV), and a fixed single track throttle position sensor (TPS). The throttle body is heated by engine coolant to prevent ice formation around the throttle area.



The nonadjustable fixed idle air bypass provides a base idle setting. The ECM-driven IACV provides a variable idle air bypass enabling ECM idle air control. The nonadjustable throttle position sensor provides the ECM with a throttle position input. Refer to page 27. The throttle valve will not require setting during service.

The IACV regulates a variable bypass passage. The flow of bypass air through the variable passage is regulated by a stepper motor connected to a conical valve. The stepper motor has two coils that are pulsed by the ECM. The pulses are phased 90° apart. The order in which the coils are pulsed determines the direction of stepper motor travel. The stepper motor has a total travel from fully opened to fully closed of approximately 230 steps.



ECM Idle Control

ECM idle speed control occurs at closed throttle when road speed is less than 3 mph. The programmed idle speed accounts for engine temperature and the loads placed on the engine by the transmission (gear position N, D, etc.), and air conditioning compressor clutch operation.

Target stable idle speeds: Park / Neutral – 700 rpm
(normal operating temperature) Drive / R, D 2, D 3 – 580 rpm

Idle speed \pm 30 rpm when coolant temperature is less than 86°F (30°C)

Idle speed \pm 20 rpm when coolant temperature is 86°F or higher

An ECM adaption function allows for a correction to the idle speed “base line” as the engine base idle changes with age. The adaption values are held in nonvolatile memory (EEPROM) and will be retained or updated even if the battery is disconnected.

NOTE: At road speeds above 3 mph, the idle air control valve (IACV) is opened to limit overrun intake manifold pressure. The amount that the valve is opened is based on engine speed, engine temperature and throttle opening.

Engine start-up

ECM idle speed control begins shortly after the engine is started, provided the throttle is closed (throttle position sensor at idle) and the road speed is less than 3 mph. The stepper motor in the control valve is closed in stages until the target idle speed is reached.

Gear position

When the gear selector is in Park or Neutral, the engine management ECM receives a ground signal from the transmission rotary switch. The ECM then closes the idle air control valve a predetermined number of steps in anticipation of the reduced engine load. At idle, the ECM applies ignition timing from separate closed throttle ignition strategies for gear positions Neutral and Drive.

Air conditioning compressor clutch operation

When the air conditioning compressor clutch is energized, a parallel circuit inputs battery voltage to the engine management ECM. The ECM opens the idle air control valve a predetermined number of steps and advances the ignition timing to adjust for the change in engine load.

Ignition switched OFF

When the ignition is switched OFF, the idle air control valve indexes to a known parked position. The reference is from the fully closed position approximately 10 seconds after the ignition is switched OFF.

Adaptive Idle Fuel Metering

Adaptive idle fuel metering is used to allow for minor engine mechanical variability and engine aging.

The ECM contains an adaptive idle fuel metering software function that automatically makes a baseline correction to the idle fuel metering strategy throughout the life of the vehicle. The adaption values are held in nonvolatile memory (EEPROM) and will be retained or updated even if the battery is disconnected.

Secondary Air Injection

Secondary air injection is employed to reduce catalyst "light off" to a minimum. "Light off" is the term used to describe the time taken to bring the catalyst to the ideal operation temperature. After engine start, the fuel / air mixture is initially rich. The exhaust from this rich mixture is still burning when it enters the catalyst. Air is delivered to the exhaust system to prolong the catalyst burning time and therefore raise the catalyst operating temperature to the ideal temperature level as soon as possible.

Secondary air injection operates immediately after start-up for a period mapped against engine coolant temperature and is enabled only when the engine coolant temperature is below 16°C (61°F).

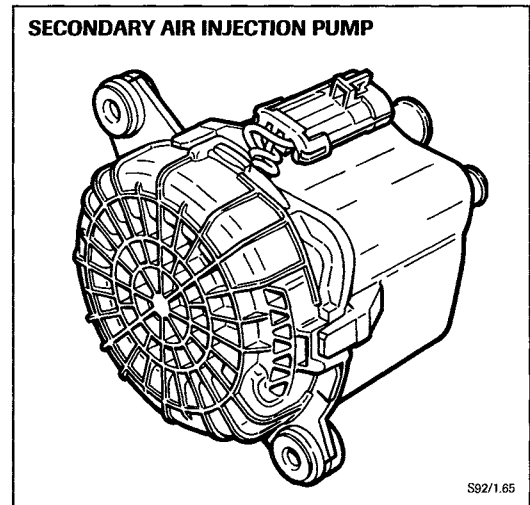
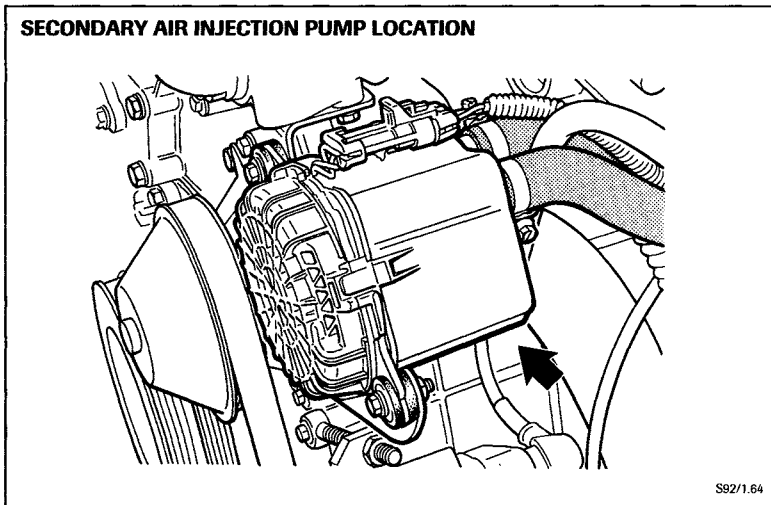
The ECM activates air injection after engine start for 15 seconds, or until the engine coolant temperature reaches 16°C (61°F). Operation occurs for a maximum of 4 minutes.

Secondary Air Injection Monitoring for OBD II

Secondary air injection is monitored for decreased flow. The ECM can determine the air injection flow volume by monitoring the drift in oxygen sensor swing levels.

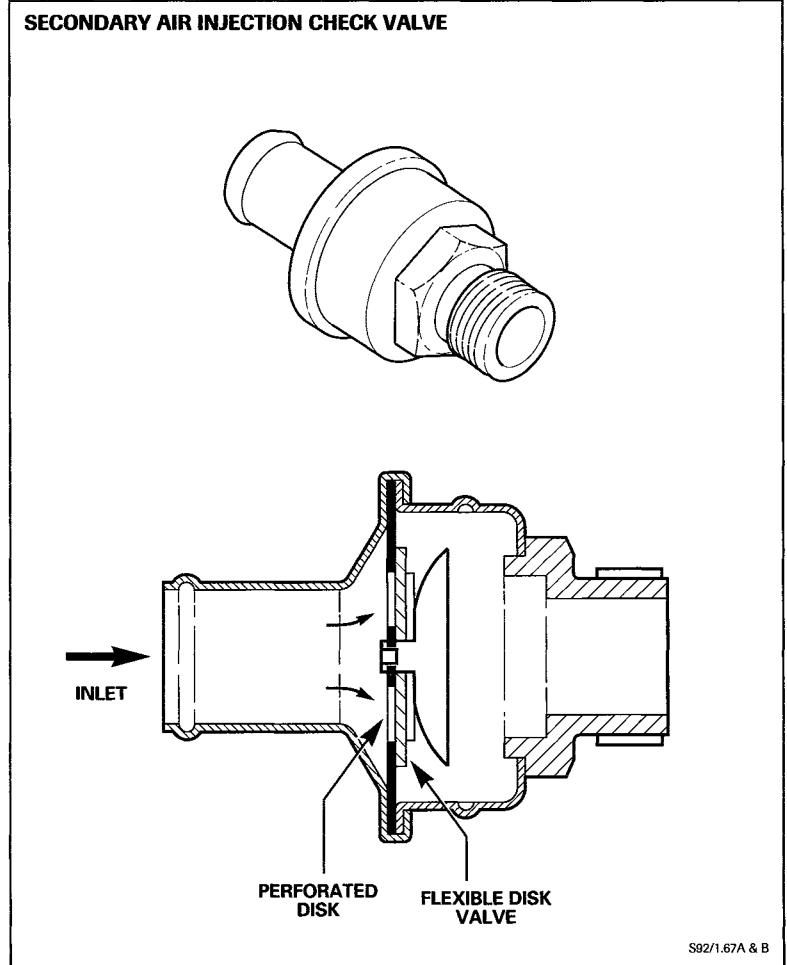
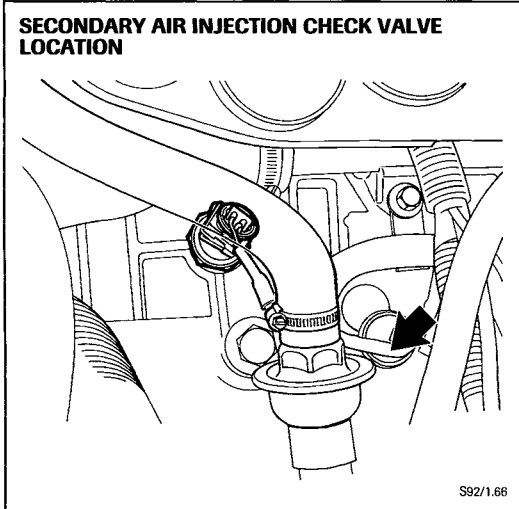
Secondary Air Injection Pump (AIRP)

The secondary air injection pump is an electrically powered regenerative turbine-type pump that is permanently lubricated and requires no periodic maintenance. The AIRP incorporates an integral solenoid operated stop valve, which is activated to open when the pump operates to allow air flow to the exhaust manifolds. The stop valve closes when current is switched off to prevent air flow through the pump. The pump and stop valve are controlled by the ECM via the air injection relay.



Secondary Air Injection Check Valve (AIRC)

The secondary air injection check valve, located in the delivery tube behind the air pump, prevents the back-flow of exhaust gas to the air pump.



Exhaust Gas Recirculation

EGR is employed to lower the combustion temperature, which in turn aids in the reduction of NOx exhaust emission. If the EGR valve is seized closed, the uncontrolled production of NOx will result; if the EGRV is seized open, the combustion temperature will lower resulting in high HC and CO exhaust emission and poor engine performance.

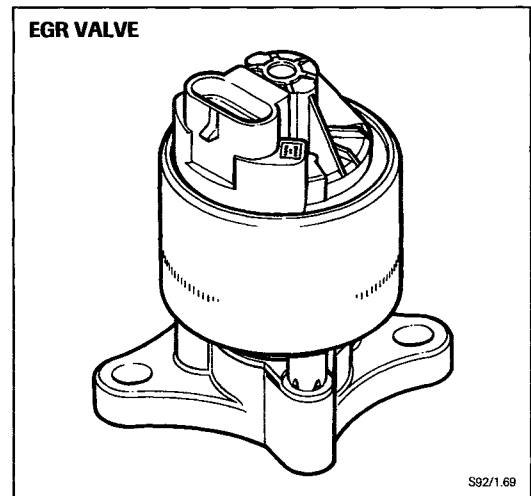
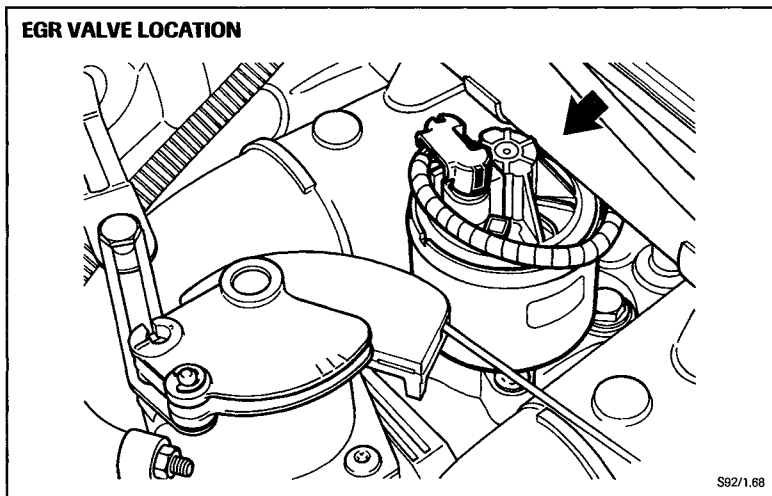
EGR operation is mapped against engine load and speed, throttle position, and coolant temperature.

EGR Monitoring for OBD II

EGR operation is monitored by the ECM via the EGR temperature sensor. When EGR is enabled, the ECM monitors EGR temperature and compares it with the expected temperature for a given EGR valve opening. The valve opening is determined by feedback from the EGR valve.

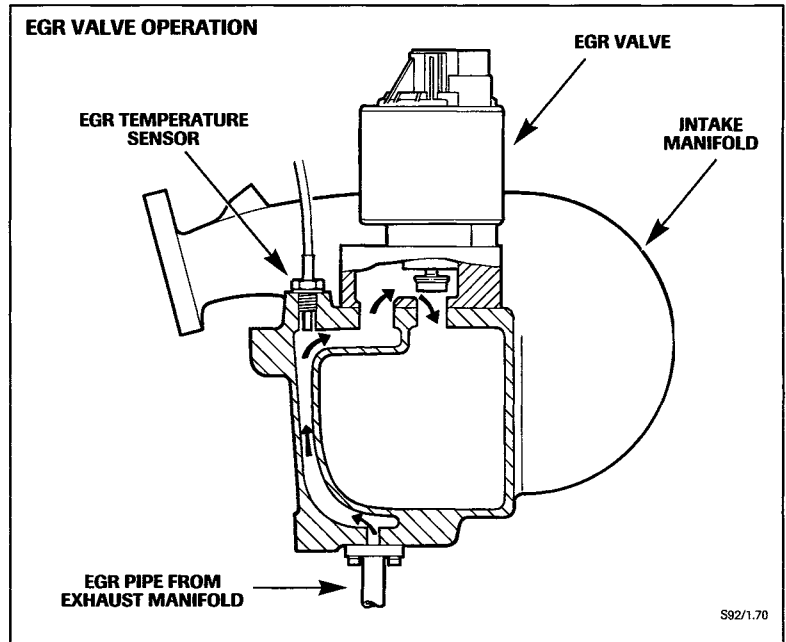
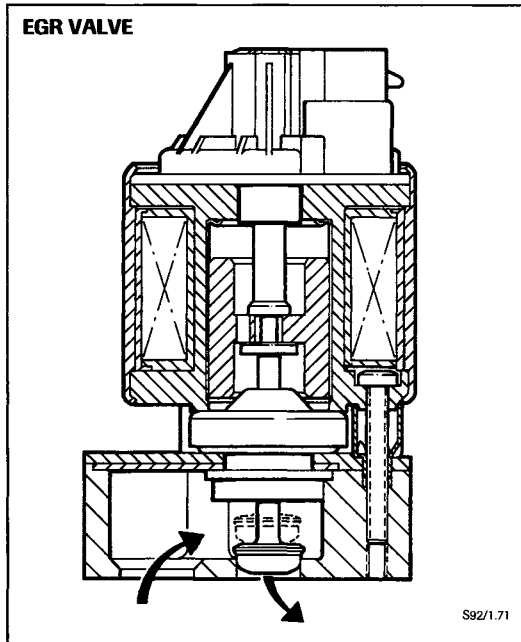
EGR Valve (EGRV)

The electronically operated and controlled independent EGR valve is located on the intake manifold.



The EGRV consists of three main parts: the solenoid, the pintle and seat, and the pintle position sensor. When energized by the ECM, the solenoid pulls the pintle away from the seat to allow exhaust gas flow into the intake manifold. Movement of the armature and pintle is resisted by three forces: the pressure drop across the pintle and seat area, gravity, and the spring load from the pintle position sensor.

The ECM is able to continuously vary the flow of exhaust gas into the intake manifold by the pintle position sensor providing feedback to the ECM for closed loop control. In addition to closed loop EGR control, the ECM uses the pintle position feedback to calculate fuel metering and ignition corrections.

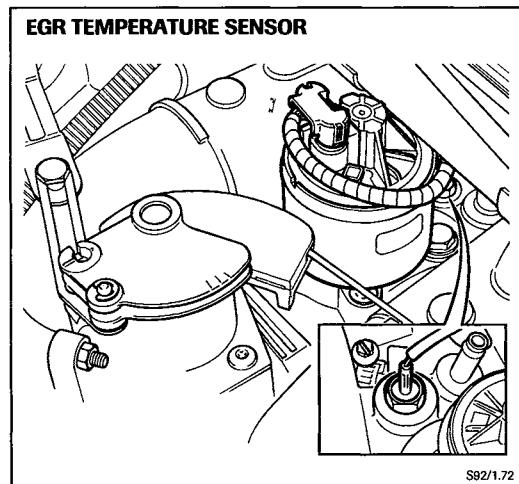


EGR Temperature Sensor (EGRT Sensor)

The EGR temperature sensor is a negative temperature coefficient (NTC) thermistor. It is identical to the EGR temperature sensor used in AJ6 engine management systems, however, the connector and leads are revised. The ECM applies 5 volts to pin 1 of the sensor and monitors the voltage across the sensor pin to ground. The theoretical full voltage range is from 5 to 0 volts representing maximum cold to maximum hot.

EGR temperature sensor – temperature versus resistance

EGR temperature		Resistance
F	°C	(kilo ohms)
122	50	600
212	100	90
302	150	11
392	200	5
482	250	2
572	300	0.8
662	350	0.3
752	400	0.1

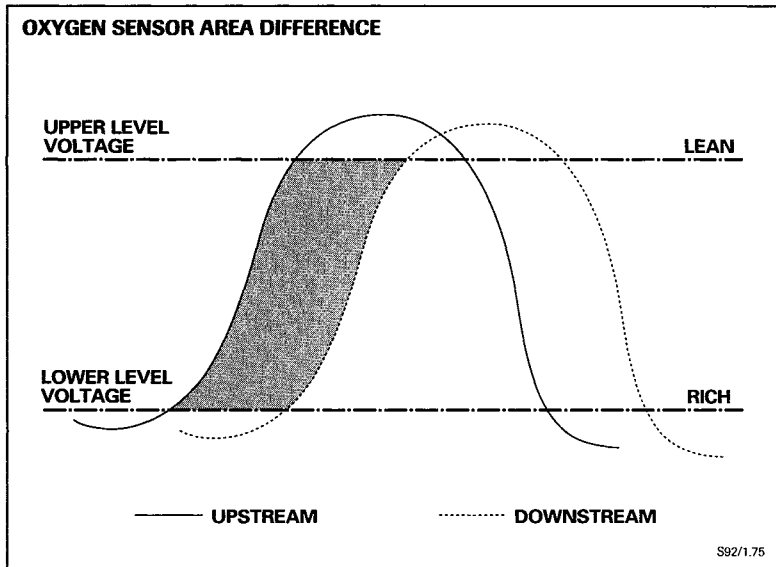
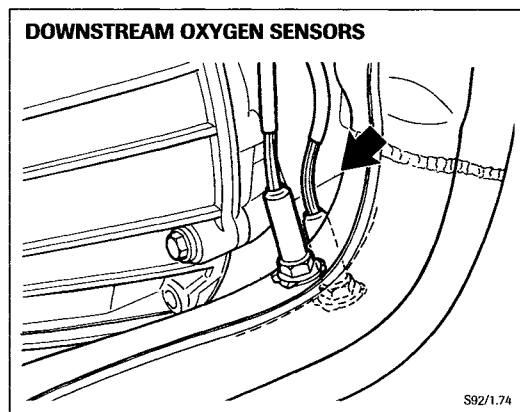
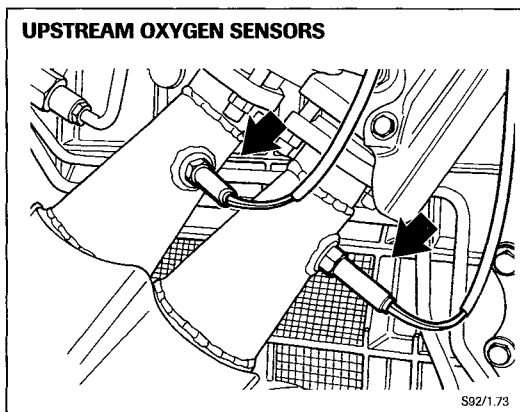


Catalytic Converters

Catalyst Monitoring for OBD II

Deterioration of catalytic conversion efficiency will create higher than acceptable HC, CO and NOx exhaust emission.

The efficiency of the primary catalytic converters is monitored and any deterioration in efficiency is flagged as a fault by the ECM. Monitoring for catalyst efficiency is achieved by sampling both the incoming and outgoing exhaust at the primary catalyts. Two oxygen sensors are positioned in each exhaust down pipe assembly – one upstream of the primary catalyst and one down stream of the primary catalyst.



By comparing the voltage swings of each set of sensors, the ECM can detect when catalyst efficiency drops off. An "area difference" technique is used to compare successive oxygen sensor swing measurements.

NOTE: The CHECK ENGINE MIL will not be activated for catalyst monitoring faults on 1995 model year vehicles.

Engine Misfire

Misfire Monitoring for OBD II

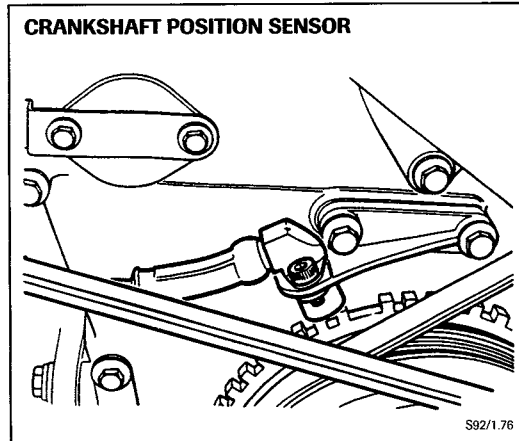
Engine misfire may cause catalytic converter damage and/or cause a vehicle to fail an emission inspection.

The ECM monitors the engine for misfire via the crankshaft position sensor (CKPS). The steel teeth on the crankshaft timing ring are used as a rotor for the sensor. The rotor has 60 tooth positions set at 6 degree intervals with one tooth missing. The gap identifies the TDC position of cylinders 1 and 6 during one complete engine cycle (two crankshaft revolutions). The ECM uses the gap as a position reference.

At each cylinder firing, the crankshaft momentarily accelerates. The ECM records and compares the time intervals between cylinder firings and the rotor gap to detect a misfire.

If a persistent misfire occurs, the ECM will identify the cylinder and switch off the fuel injector.

NOTE: The CHECK ENGINE MIL will not be activated for misfire monitoring faults on 1995 model year vehicles.



Vehicle Systems Interfaces

The engine management system interfaces with the instrument pack, the air conditioning compressor clutch circuit, and the transmission control module to provide data and sensor input, and operational control.

Instrument Pack

Vehicle road speed

The instrument pack outputs a road speed signal (pulsed signal) to the ECM. The ECM uses the signal to determine idle speed control functions.

Low fuel level

The instrument pack outputs a fuel level voltage signal to the ECM. When the voltage drops below a specified value, fuel metering diagnostics (OBD) are canceled. Canceling the fuel metering diagnostics prevents the ECM from flagging DTCs caused by the vehicle running out of fuel.

Engine speed

The ECM provides an engine speed signal (pulsed signal) to the instrument pack for operation of the tachometer.

CHECK ENGINE MIL

If the OBD system detects a fault, the ECM outputs a warning signal (ground) to the instrument pack for operation of the CHECK ENGINE MIL. Refer to On-Board Diagnostic Facility, page 47.

Climate Control / Air Conditioning

The ECM controls air conditioning compressor clutch operation from a request made by the climate control module. When an air conditioning compressor ON request (12 volt signal) is received from the climate control module, the ECM switches ON the compressor (via the air conditioning compressor relay). The ECM cancels (or does not switch ON) air conditioning during a full throttle demand, and when high engine coolant temperatures occur.

Automatic Transmission

Throttle position

The ECM processes the throttle position input signal from the single track throttle position sensor (TPS) and supplies the TCM with a pulse width modulated signal to indicate throttle position.

Gear selector position

The transmission control module (TCM) outputs gear position signals to the ECM. When the gear selector is in R, D, 2 or 3, the signal is 5 volts; when the gear selector is in P or N, the signal is ground or 0 volts. The ECM uses the gear position inputs to control idle speed. Refer to Ignition Control, page 34 – 37, and Idle Control, page 38 – 39, for a detailed explanation.

Engine speed and torque

The ECM supplies the TCM with engine speed and torque signals. Speed is supplied as a pulsed voltage signal that decreases as rpm increases; torque (derived from injector pulse duration) is supplied as a pulse width modulated (PWM) signal that.

Serial Communication

Serial communication between the engine management system and PDU takes place via the serial communication data link. Only one bidirectional serial line connects to the ECM. Serial communication is used for engine setup, accessing stored DTCs, fault diagnosis and erasing DTCs.

On-Board Diagnostic Facility

The OBD facility has greatly expanded diagnostic capability, as described previously in this section. The OBD facility continuously monitors the operation of the engine management sensors and components. In addition the OBD facility predicts failure of subsystems by performance observation. If a fault is detected by OBD monitoring or testing, a fault is registered and reported to the Diagnostic Status Manager (DSM) (ECM internal software). The DSM decides whether to flag a DTC and activate the CHECK ENGINE MIL. Except in cases where EMS system operation would be impaired, a fault must be detected on two consecutive trips (ignition ON cycles) before being is flagged by the DSM.

If, after the MIL is activated, three sequential trips are made with no recurrence of the fault(s) and no occurrence of additional fault(s), the MIL will extinguish on the next trip. The fault(s) will remain stored in memory. The DSM will erase any fault code that has not recurred in 40 consecutive engine warm-up cycles.

Faults stored in the ECM memory can only retrieved through serial communication via the data link. Refer to page 55. DTCs are held in nonvolatile memory (EEPROM) so that disconnecting the battery does not erase stored codes.

Limp Home Default

In order to allow vehicle operation if a malfunction occurs, "limp home" default values are incorporated as an ECM facility. If a sensor fault is detected by OBD, the ECM will substitute a nominal value for the missing input(s).

Diagnostic Trouble Codes

The number of possible diagnostic trouble codes (DTCs) has been greatly increased. Each DTC is a five place standard SAE (Society of Automotive Engineers) code that describes a subsystem and the specific fault. Refer to the Service Manual for a complete DTC listing.

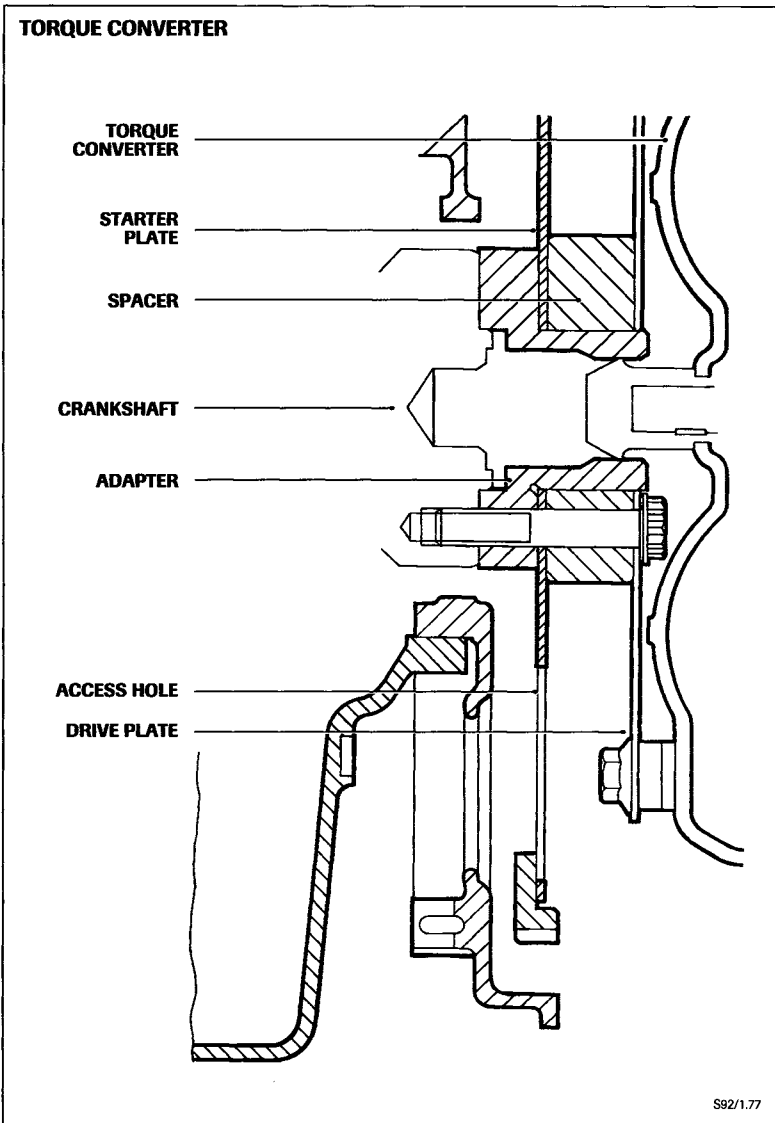
DTCs are arranged in seven major groups as follows.

PX1XX	Fuel and air metering
PX2XX	Fuel and air metering
PX3XX	Ignition system or misfire
PX4XX	Auxiliary emission controls
PX5XX	Vehicle speed; idles control; auxiliary inputs
PX6XX	Computer and auxiliary inputs
PX7XX	Transmission control

Fault diagnostics

The Service Manual contains a Diagnostics section for OBD II specific fault finding and repair.

Automatic Transmission Mechanical



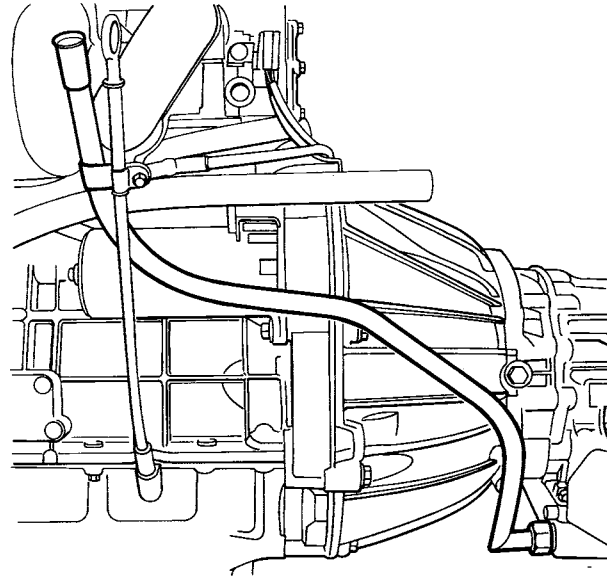
Torque Converter

A new torque converter with reduced mass improves engine response. The depth of the converter has been reduced by 1.18 in. (30 mm). In order to allow the use of the existing torque converter housing (bell housing), a spacer and drive plate have been added between the crankshaft and the torque converter. The torque converter attaches to the drive plate. Six holes in the starter plate allow access to the drive plate-to-torque converter attaching hardware.

Fill Tube and Dipstick

With the introduction of the new torque converter, the expansion tank on the fill tube is no longer required. To improve fluid level reading accuracy, the new simplified fill tube positions the end of the dipstick adjacent to the transmission sump.

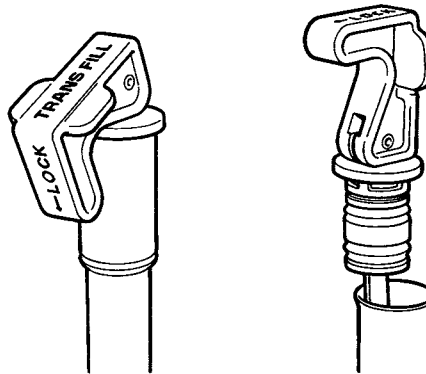
FILL TUBE



S92/1.78

The dipstick has a "flip-top" handle that compresses the fill tube seal when moved to the lock position. The dipstick handle is color keyed silver to indicate the XJS (AJ16) fill level specification.

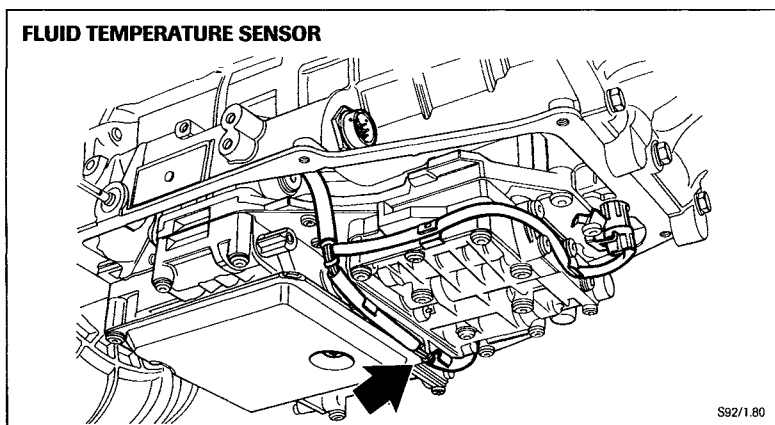
"FLIP-TOP" DIPSTICK HANDLE



S92/1.79

Automatic Transmission Control

The transmission control system and the transmission control module (TCM) have been revised to suit the characteristics of the AJ16 engine and conform to OBD II. In addition, a fluid temperature sensor has been added to the system.



Fluid Temperature Sensor

The positive temperature coefficient (PTC) fluid temperature sensor, located in the transmission internal electrical harness, provides the TCM with a sump fluid temperature signal. The TCM uses the signal input to calculate and adjust line pressure. This adjustment refines gear shift quality at low fluid temperature.

Transmission Control Module

The revised TCM incorporates control revisions for the AJ16 engine operating characteristics and the introduction of the fluid temperature sensor. The TCM also has revised

sensor and interface inputs from the engine management system, expanded and enhanced shift quality control and OBD fault monitoring.

Throttle position input

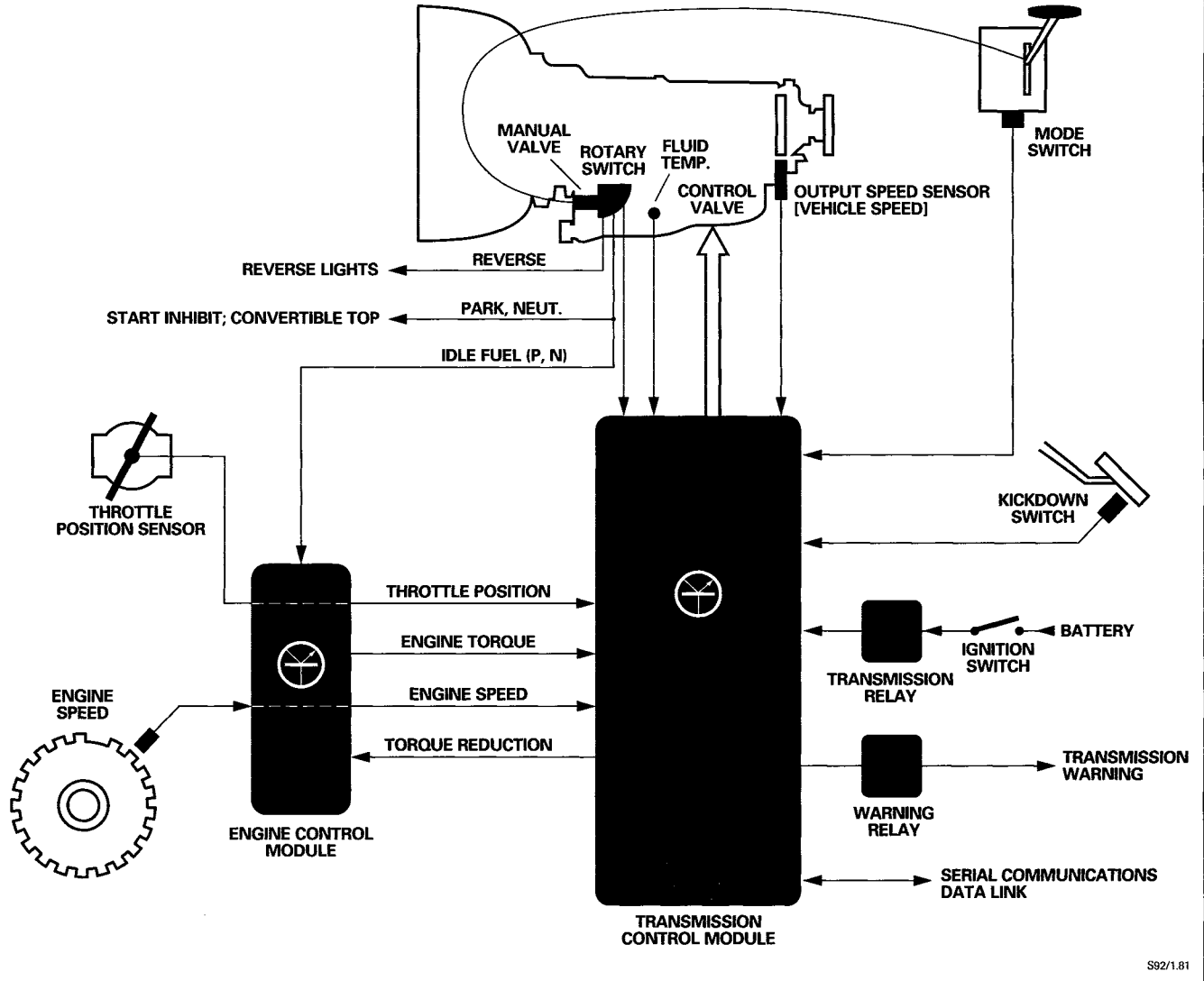
The TCM receives a throttle position signal from the engine management ECM. The ECM processes the single track throttle position sensor (TPS) input and supplies the TCM with a pulse width modulated (PWM) signal to indicate throttle position.

Torque-based shifting

Transmission shift quality is enhanced by "torque-based shifting". The ECM continuously provides the transmission control module (TCM) with a pulse width modulated (PWM) signal that represents the amount of torque the engine is producing. This signal is generated by the ECM based on the injector pulse duration.

When a shift is to occur, the TCM calculates the necessary torque reduction and provides a PWM torque reduction signal to the ECM. The torque reduction signal will vary between 20% and 90%. The actual amount of retard is applied to the ignition advance angle after other corrections are applied.

AJ16 AUTOMATIC TRANSMISSION CONTROL



Automatic Transmission Control (continued)

On-Board Diagnostic Facility

The transmission control OBD facility has expanded diagnostic capability for fluid temperature and to conform to OBD II. The OBD facility continuously monitors the operation of the transmission sensors and components.

Before a fault is flagged by the TCM, the fault must be detected on two consecutive trips (ignition ON cycles). If a fault is detected on two consecutive trips, the OBD system will activate the Malfunction Indicator Lamp (MIL) (TRANSMISSION FAULT) warning in the instrument pack and flag a diagnostic trouble code (DTC) in the TCM memory. DTCs are held in nonvolatile memory so that disconnecting the battery does not erase stored codes. The TCM can be interrogated only through serial communication via the data link. Refer to page 55.

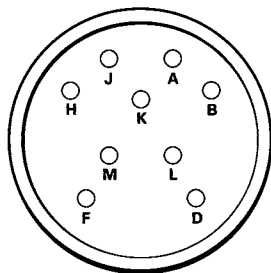
Fault Diagnostics

The Service Manual contains a Diagnostics section for OBD II specific fault finding and repair.

Serial Communication

Serial communication between the transmission control system and PDU takes place via the serial communication data link. Both serial lines (input and output) connect to the ECM. Serial communication is used for accessing stored DTCs, fault diagnosis and erasing DTCs.

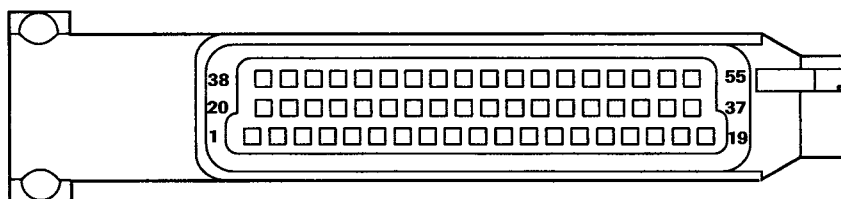
TRANSMISSION HARNESS CONNECTOR PINS



- A Road Speed (-)
- B Fluid pressure regulator control
- D Fluid temperature sensor
- F Road speed (+)
- H Solenoid valve 1 control
- J Fluid temperature ground
- K Solenoid valve 2 control
- L Solenoid valve 3 control
- M Solenoids supply

S92/1.82

TRANSMISSION CONTROL MODULE PIN-OUT INFORMATION

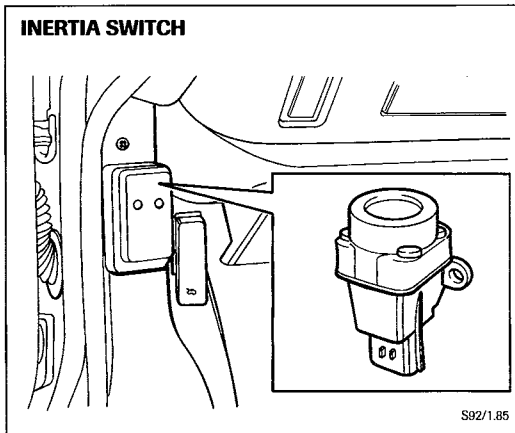


- | | | |
|--------------------------------------|----------------------------------|----------------------------------|
| 1 Power supply | 19 Solenoids supply | 38 Road speed (-) |
| 2 Road speed (+) | 20 Not used | 39 Not used |
| 3 Engine speed | 21 Engine torque signal | 40 Not used |
| 4 Mode selector input B | 22 Not used | 41 Kickdown switch |
| 5 Solenoid valve 1 control | 23 Not used | 42 Solenoid valve 3 control |
| 6 Fluid pressure regulator control | 24 Solenoid valve 2 control | 43 Not used |
| 7 Digital ground | 25 Not used | 44 Fluid temperature ground |
| 8 Not used | 26 Power ground | 45 Not used |
| 9 Not used | 27 Not used | 46 Fluid temperature sensor |
| 10 Not used | 28 Not used | 47 Throttle position |
| 11 Not used | 29 Mode selector input A | 48 Not used |
| 12 Not used | 30 Not used | 49 Sport mode indicator |
| 13 First gear inhibit mode indicator | 31 Not used | 50 Gear selector position code X |
| 14 Gear selector position code Y | 32 Engine torque reduction | 51 Serial output |
| 15 Serial input | 33 Gear selector position code Z | 52 Not used |
| 16 Gearbox fault warning | 34 Not used | 53 Not used |
| 17 Not used | 35 Not used | 54 Not used |
| 18 Not used | 36 Not used | 55 Not used |
| | 37 Not used | |

S92/1.83

Wiring Harness and Components

Minor harness and component revisions have been made for incorporation of the AJ16 engine management system and improvements to systems and circuits. The tables and charts, included in the Reference Section, include all current component locations and service specifications.

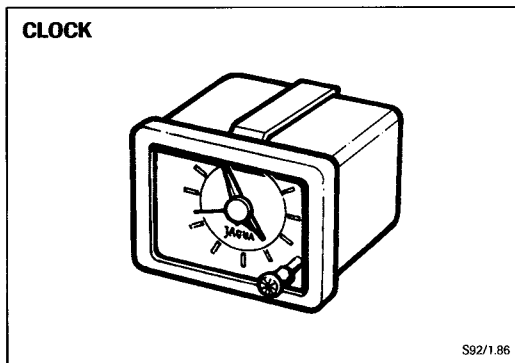


Inertia Switch

A new type inertia switch is installed in the same location as previous models.

Window Lift Circuit

The window lift thermal breaker has been deleted and replaced by a 30-amp fuse.



Clock: XJS (4.0L)

A new analog clock replaces the previous trip computer / LCD display on XJS (4.0L) models. The trip computer has been deleted and is no longer available.

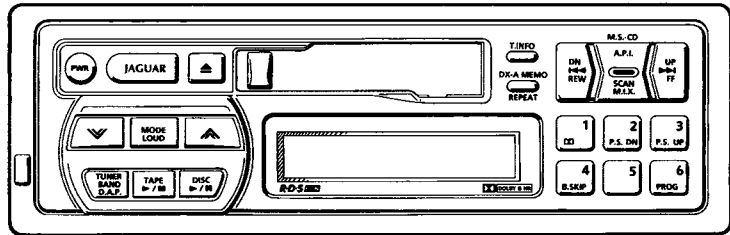
In-Car Entertainment

A new radio cassette unit allows custom operation to suit individual taste. The optional trunk-mounted CD player remains unchanged.

Theft deterrent control panel

The theft deterrent control panel can be removed simply by pressing the release button and hinging the panel out from the left. All programmable functions are stored in nonvolatile memory so that reprogramming is not required after reinstallation. "Coding" has been deleted.

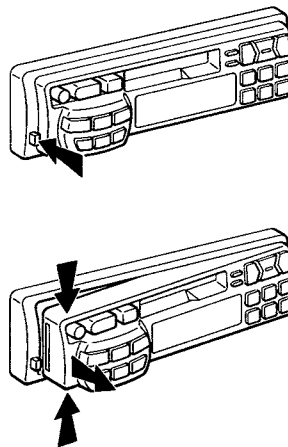
RADIO CASSETTE CONTROL PANEL



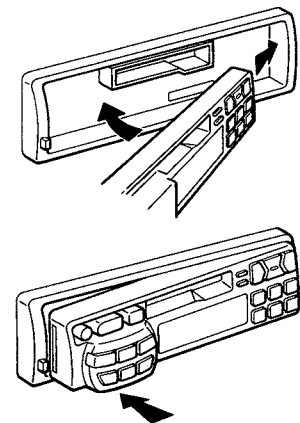
S92/1.87

CONTROL PANEL REMOVAL AND REPLACEMENT

TO REMOVE:



TO REPLACE:

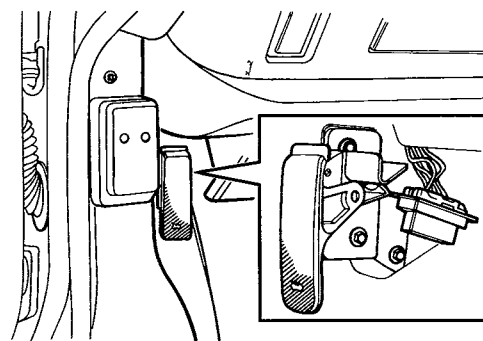


S92/1.88A - D

Serial Communication

A new serial communication Data Link Connector that conforms to OBD II is located behind the hood release lever. The control modules on the data link remain unchanged from previous models.

DATA LINK CONNECTOR



S92/1.89

Fuse Identification and Location**Left fuse panel**

Number	Color	Value	Circuit
1	Lt. Blue	15A	Driver's seat movement - fore, aft, lumbar
2	Tan	5A	Cruise control
3	Yellow	20A	Left blower
4	Red	10A	Radio memory
5	Red	10A	Radio power
6	Tan	5A	Interior lights; serial communications data link
7 *	Tan	5A	Climate control (ECM and control circuit)
7 **	—	—	Not used
8	Red	10A	Windshield washer pump
9	Red	10A	Driver's seat heater
10	—	—	Not used
11	Red	10A	Trunk lighting
12	Yellow	20A	Driver's seat movement - recline
13 *	Tan	5A	Clock; gear shift interlock; climate control panel
13 **	Tan	5A	Trip computer memory; gear shift interlock; climate control panel
14	Tan	5A	Power mirrors; door switch packs; seat memory
15	Tan	5A	Heated washer jets
16	Tan	5A	Speed interface; gear shift interlock; serial communications data link
17	Lt. Green	30A	Power windows
18	Orange	7.5A	Locate lighting; instrument pack lighting
19	Red	10A	Hazard warning; seat belt logic
20	—	—	Not used
21	—	—	Not used
22	Lt. Blue	15A	Heated rear window

Right fuse panel

Number	Color	Value	Circuit
1	Lt. Blue	15A	Passenger's seat movement - fore, aft, lumbar
2	Red	10A	Central locking; multi-function unit
3	Yellow	20A	Right blower
4 *	Tan	5A	Air conditioning compressor relay
4 **	Red	10A	Air conditioning compressor relay; supplementary air valve
5	Lt. Blue	15A	Horns
6	Brown	7.5A	Turn signals
7 *	Red	10A	EMS power relay; transmission relay
7 **	Lt. Blue	15A	Fuel injection main relay; ignition system power
8	Lt. Blue	15A	Windshield wash/wipers (logic module)
9	Red	10A	Passenger's seat heater
10 *	Tan	5A	ECM controlled power
10 **	Tan	5A	Transmission memory
11	Lt. Green	30A	Brake (ABS) control module
12	Yellow	20A	Passenger's seat movement - recline
13 *	—	—	Not used
13 **	Red	10A	EVAPP valves; secondary air injection; hot start
14 *	Tan	5A	ECM controlled relay
14 **	Tan	5A	Fuel injection memory

* XJS 4.0L

** XJS V12

Fuse Identification and Location

Right fuse panel (continued)

Number	Color	Value	Circuit
15 *	—	—	Not used
15 **	Tan	5A	Climate control (ECM and control circuit)
16 *	Red	20A	Cigar lighter
16 **	Yellow	20A	Cigar lighter
17	Lt. Green	30A	Headlight power wash
18	Lt. Blue	15A	Accessory connector
19	Lt. Blue	15A	Stop lights
20 *	Yellow	20A	Engine management system power
20 **	Tan	5A	Transmission (shift solenoids) power
21 *	Red	10A	Transmission power
21 **	Tan	5A	Transmission control module power
22	Lt. Green	30A	ABS Pump

Front fuse panel

Number	Color	Value	Circuit
1	Lt. Blue	15A	Not used – USA; daytime running lights – Canada
2	Lt. Blue	15A	Front fog lights
3	—	—	Not used
4 *	Lt. Blue	15A	Auxiliary cooling fan
4 **	Lt. Green	30A	Auxiliary cooling fan
5	Red	10A	Left headlight high beam
6	Red	10A	Right headlight high beam
7	Tan	5A	Left front side lights
8	Tan	5A	Right front side lights
9	Brown	7.5A	Left headlight low beam
10	Brown	7.5A	Right headlight low beam
11	—	—	Not used
12	Tan	5A	Not used

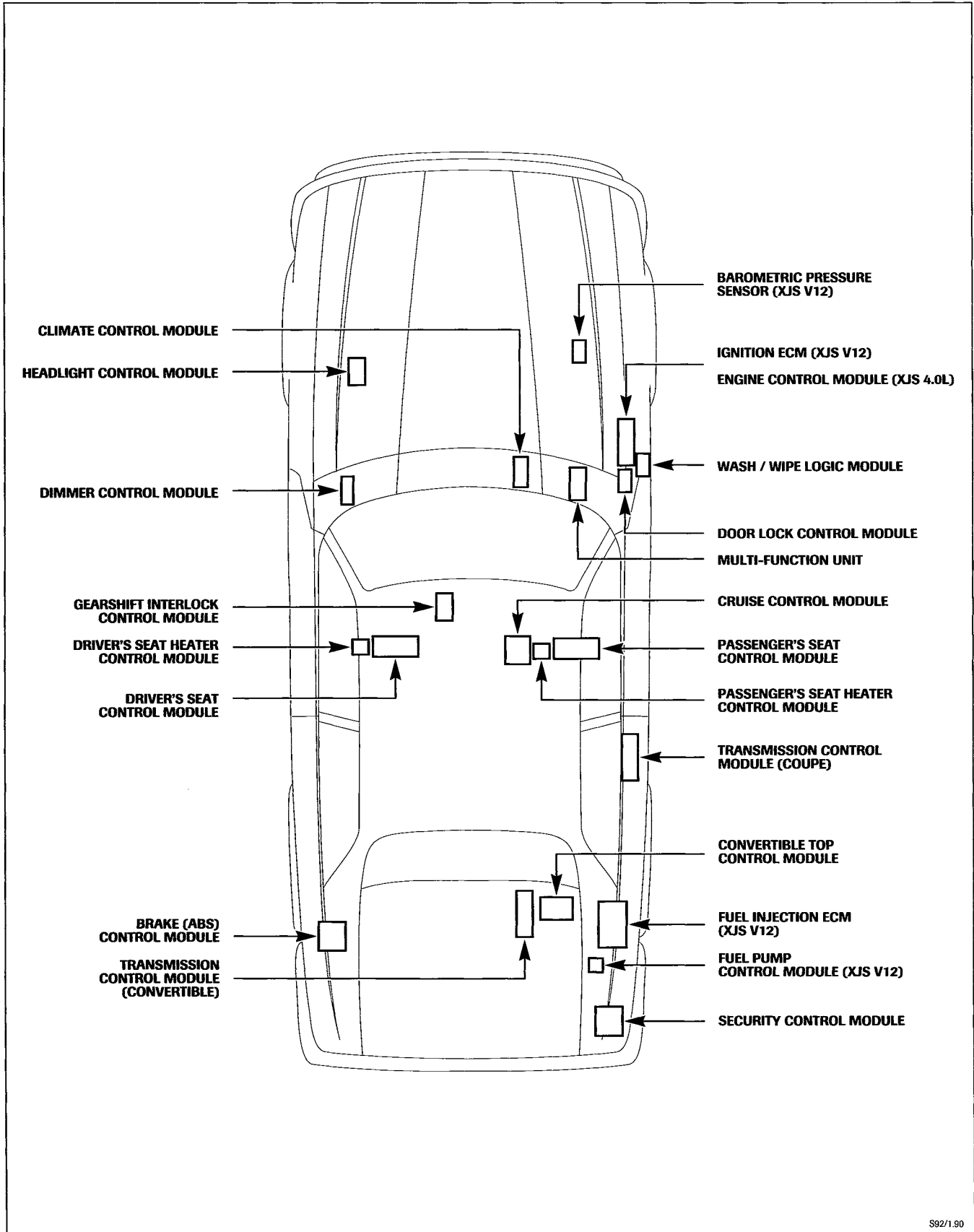
Rear fuse panel

Number	Color	Value	Circuit
1	Tan	5A	Cellular telephone power
2 *	Yellow	20A	Not used
2 **	Yellow	20A	Fuel pump 2
3 *	—	—	Not used
3 **	Yellow	20A	Fuel injection power
4	Tan	5A	Right tail, right license plate lighting
5	Red	10A	Rear fog lights; antenna
6	Tan	5A	Cellular phone memory
7	Tan	5A	Reverse lights
8	Tan	5A	Left tail; left license plate lighting
9	Tan	5A	Trailer right tail lighting
10	Tan	5A	Trailer left tail lighting
11	Orange	7.5A	Security system
12 *	Yellow	20A	Fuel pump
12 **	Yellow	20A	Fuel pump 1

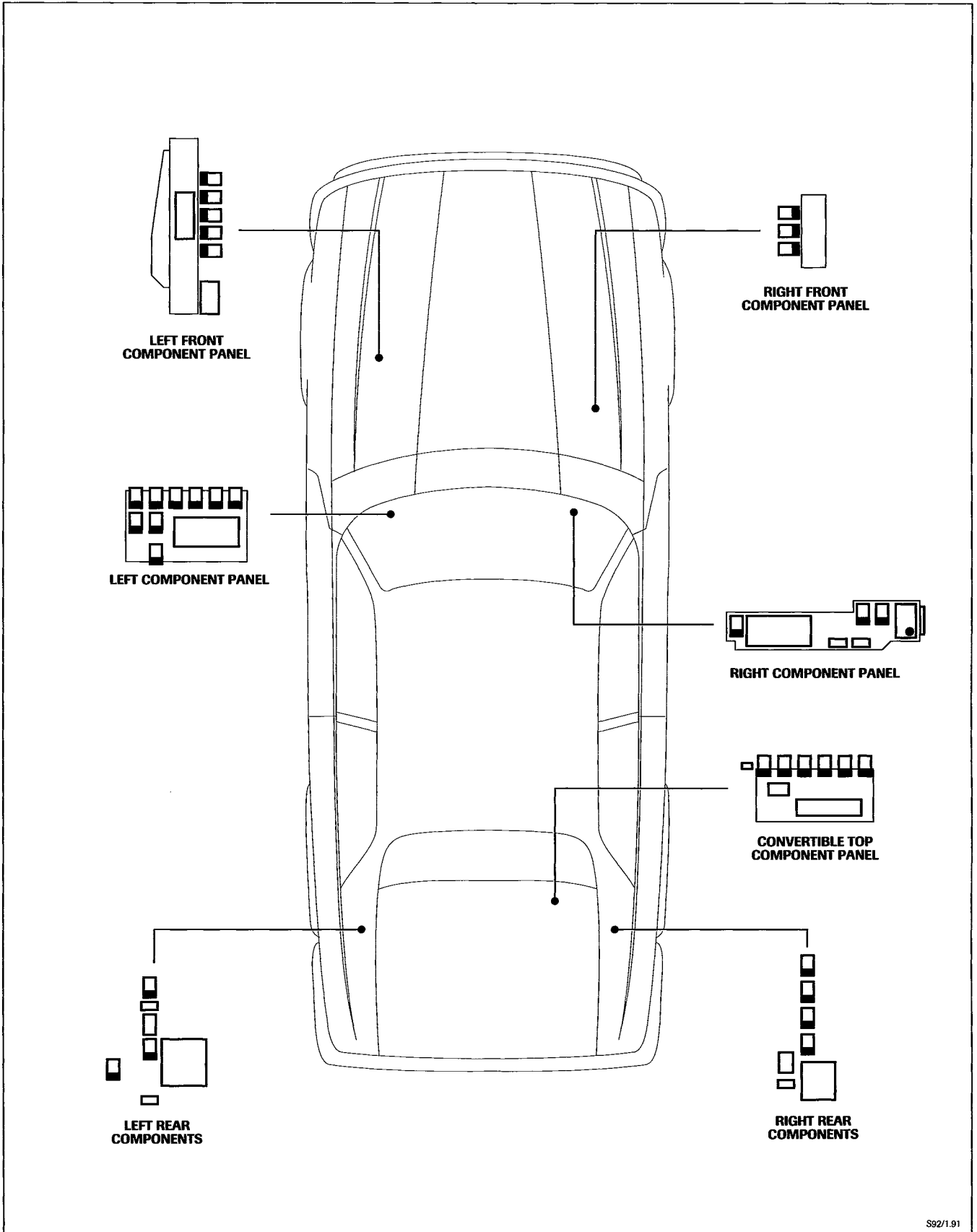
* XJS 4.0L

** XJS V12

Vehicle Control Module Identification and Location

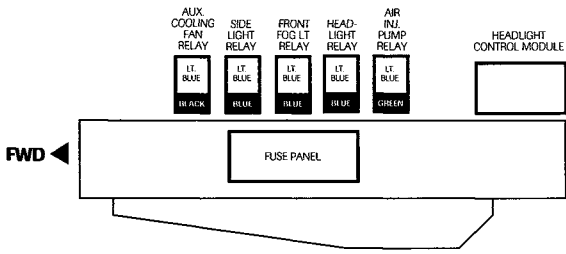


Component Panel Location – see pages 62 - 63 for detailed relay identification

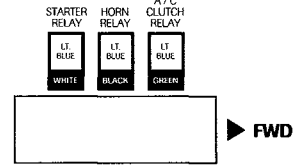


S92/1.91

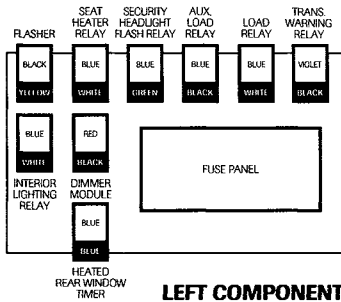
Relay Identification and Location: XJS 4.0L



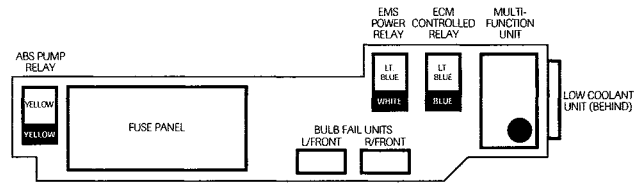
LEFT FRONT COMPONENT PANEL



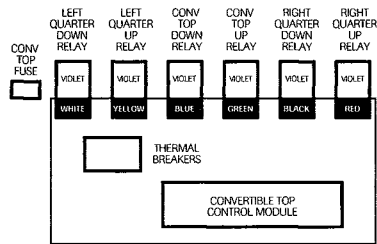
RIGHT FRONT COMPONENT PANEL



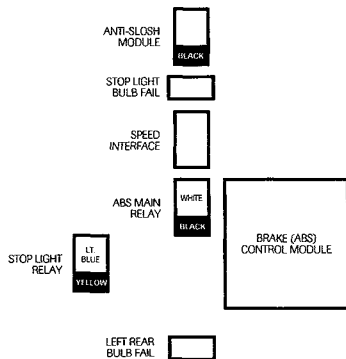
LEFT COMPONENT PANEL



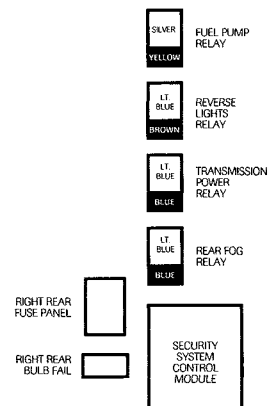
RIGHT COMPONENT PANEL



CONVERTIBLE TOP COMPONENT PANEL



LEFT REAR COMPONENTS



RIGHT REAR COMPONENTS

Relay Identification and Location: XJS V12

