E - THEORY/OPERATION

1993 Toyota Celica

1993 ENGINE PERFORMANCE
Toyota Theory & Operation

Celica

INTRODUCTION

This article covers basic description and operation of engine performance-related systems and components. Read this article before diagnosing vehicles or systems with which you are not completely familiar.

AIR INDUCTION SYSTEM

INTAKE AIR CONTROL VALVE SYSTEM

NOTE: Intake air control valve system may also be referred to as Acoustic Control Induction System (ACIS).

VARIABLE INDUCTION SYSTEM

Turbo

Each intake manifold cylinder runner is divided into 2 parts. An intake air control valve is installed in one passage on each cylinder runner. Opening and closing of intake air control valve provides best possible airflow to prevent low-speed performance loss and improved fuel economy.

On Engine Control Module (ECM) uses input RPM signal from distributor pick-up coil, throttle position signal and coolant temperature signal for determining intake air control valve operation.

NOTE: The T-VIS Vacuum Switching Valve (VSV) may also be referred to as variable induction system VSV.

ECM controls ground circuit on T-VIS VSV, which provides vacuum to a vacuum chamber for intake air control valve operation.

TURBOCHARGERS

Turbo

All systems are equipped with Charge Air Cooler (CAC) to cool turbocharger intake air, and a wastegate system to control maximum boost pressure. Cooling of turbocharger intake air increases air density, resulting in increased engine output.

Maximum boost pressure is controlled by Engine Control Module (ECM) and wastegate actuator. Turbocharging pressure sensor delivers an input signal to ECM, indicating boost pressure. The ECM controls a turbocharging pressure Vacuum Switching Valve (VSV) which operates wastegate actuator for controlling boost pressure.

COMPUTERIZED ENGINE CONTROLS

TOYOTA COMPUTER CONTROL SYSTEM (TCCS)

The TCCS is a computerized emission, ignition and fuel injection control system. The TCCS lowers exhaust emissions while maintaining good fuel economy and driveability. System consists of

various sensors, switches and control units. See Figs. 1-4.

An Engine Control Module (ECM) controls the TCCS based on input signals received from various input devices. The ECM contains preprogrammed data to maintain optimum engine performance under all operating conditions.

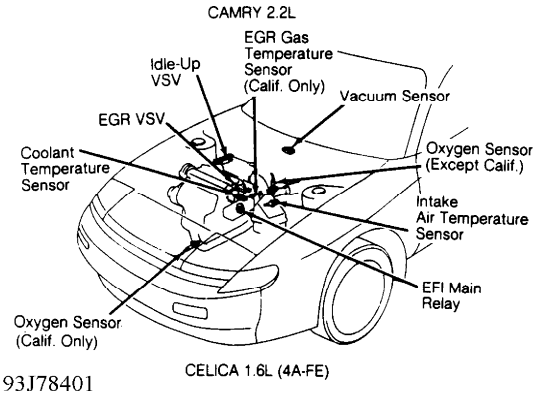

Fig. 1: Locating TCCS Components (1.6L - 4A-FE)
Courtesy of Toyota Motor Sales, U.S.A., Inc.

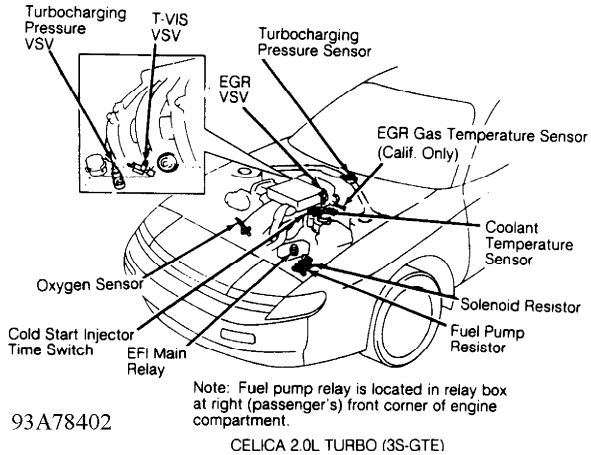

Fig. 2: Locating TCCS Components (2.0L Turbo - 3S-GTE)
Courtesy of Toyota Motor Sales, U.S.A., Inc.

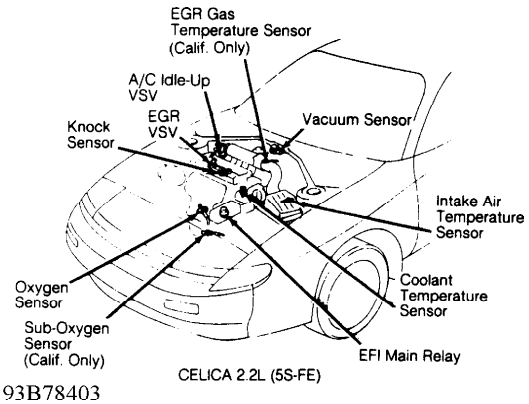

Fig. 3: Locating TCCS Components (2.2L - 5S-FE)
Courtesy of Toyota Motor Sales, U.S.A., Inc.

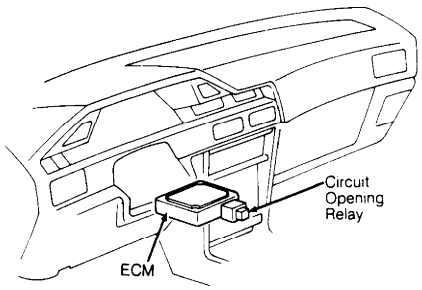

Fig. 4: Locating TCCS Components (All Models)
Courtesy of Toyota Motor Sales, U.S.A., Inc.

ENGINE CONTROL MODULE

The Engine Control Module (ECM) microprocessor receives input signals from various sensors, switches, and ignition and starting system components. The ECM uses this information for controlling various functions. See OUTPUT SIGNALS under COMPUTERIZED ENGINE CONTROLS. The ECM has constant battery voltage at BATT terminal. The EFI main relay provides battery voltage to +B and +B1 terminals of ECM when ignition is turned on.

The ECM contains a fail-safe function, used in case of sensor or switch failure. Fail-safe function uses preprogrammed values to provide a limp-in mode for minimal driveability. If a failure exists, ECM will inform the driver by turning on Malfunction Indicator Light (MIL) on the instrument panel.

NOTE: The MIL light may also be referred to as the CHECK ENGINE light.

The ECM is equipped with a self-diagnostic function. Diagnostic trouble codes may be set by the malfunction of various engine sensors, switches or circuits, and stored in the ECM memory. When diagnostic trouble code is stored, Malfunction Indicator Light (MIL) on instrument panel will come on.

ECM LOCATION TABLE

Model	Location
Celica ...	Bottom Center Of Dash, In Front Of Console

NOTE: Components are grouped into 2 categories. First category is INPUT DEVICES, which covers components that control or produce voltage signals monitored by the Engine Control Module (ECM). Second category is OUTPUT SIGNALS, which are components controlled by the ECM.

INPUT DEVICES

Vehicles are equipped with different combinations of input devices. Not all devices are used on all models. To determine input device usage on a specific model, see appropriate wiring diagram in L - WIRING DIAGRAMS article. Available input signals include the following:

A/C Switch

When A/C is turned on, an input signal is delivered to the Engine Control Module (ECM). The ECM uses input signal to control

engine idle speed during A/C operation.

Airflow Sensor (Except 1.6L 4A-FE & 2.2L 5S-FE)

Airflow sensor is located in airflow meter and measures intake airflow volume. Airflow meter converts intake air readings into a voltage signal by means of a variable resistor (potentiometer). On all models, input signal is sent to Engine Control Module (ECM) for controlling fuel injection system operation and ignition timing (spark advance).

NOTE: Airflow meter may be referred to as Volume Airflow (VAF) meter or Mass Airflow (MAS) meter.

Battery Signal

Battery voltage is always present at BATT terminal of Engine Control Module (ECM). When ignition is turned on, voltage for ECM operation is applied through EFI main relay to +B and +B1 terminals.

Brakelight Signal (Turbo)

Brakelight switch delivers an input signal to STP terminal of Engine Control Module (ECM) to indicate when brakes are applied.

Coolant Temperature Sensor (CTS)

The CTS contains a built-in thermistor in which resistance varies according to engine coolant temperature. The CTS delivers an input signal to THW terminal of Engine Control Module (ECM). The ECM uses input signal for controlling Pulsed Secondary Air Injection (PAIR) system (if equipped), fuel injection system, overdrive operation on electronically controlled transaxles/transmissions, ignition timing (spark advance), idle speed control system, fuel pressure control system (if equipped), heated oxygen sensor system (if equipped) and EGR system.

NOTE: Coolant temperature sensor may be referred to as Engine Coolant Temperature (ECT) sensor.

Electrical Load Signal (Turbo & 2.2L 5S-FE)

An input signal is delivered to ELS terminal of Engine Control Module (ECM) to indicate when high electrical output is required. This signal is delivered when items such as rear window defroster, headlights, etc. are turned on. The ECM uses input signal to maintain proper idle speed.

Engine Cranking Signal

While engine is cranking, voltage applied to the starter is also delivered to STA terminal of Engine Control Module (ECM).

NOTE: The EGR gas temperature sensor may be referred to as EGR function sensor.

EGR Gas Temperature Sensor

EGR gas temperature sensor monitors EGR gas temperature and delivers an input signal to Engine Control Module (ECM).

Intake Air Temperature Sensor

An intake air temperature sensor is mounted in either airflow meter or air filter housing. Intake air temperature sensor measures incoming intake air temperature and delivers an input signal to THA terminal of Engine Control Module (ECM) to control fuel injection system. Input signal is also used to control fuel pressure control and heated oxygen sensor systems (if equipped).

Knock Sensor (Turbo & 2.2L)

Knock sensor monitors ignition knock conditions and delivers an input signal to KNK or KNK1 and KNK2 terminals of Engine Control Module (ECM). The ECM uses input signal to determine ignition timing (spark advance) and control fuel injection system.

Oxygen (O2) Sensor

O2 sensor monitors exhaust gas oxygen content and delivers an input signal to Engine Control Module (ECM). The ECM uses input signal to determine fuel injection system operation. Some models may be equipped with more than one oxygen sensor and a sub-oxygen sensor. Some models may contain a heater to warm the oxygen sensor.

Park/Neutral Switch (A/T Models)

On some models, neutral/start switch delivers an input signal to NSW terminal of Engine Control Module (ECM), indicating gear position. The ECM uses information to control engine idle and fuel injection system.

RPM Signal

Crankshaft position and engine RPM are detected by pick-up coils in the distributor. The Engine Control Module (ECM) uses input signal for controlling Pulsed Secondary Air Injection (PAIR) system (if equipped), fuel injection system, ignition timing (spark advance), idle speed control system, fuel pressure control system (if equipped), EGR system, A/C-cut control system (if equipped) and heated oxygen sensor system (if equipped).

Crankshaft position input signal is delivered to G, G+ or G1 (and G2 on some models) terminal of ECM, and engine RPM input signal is delivered to NE or NE+ terminal of ECM.

Sub-Oxygen Sensor

Sub-oxygen sensor is used in conjunction with the oxygen sensor. Sub-oxygen sensor monitors exhaust gas oxygen content and delivers an input signal to Engine Control Module (ECM). The ECM uses input signal to determine fuel injection system operation.

Throttle Position Sensor (TPS)

The TPS, mounted on throttle body, delivers an input signal indicating throttle valve position to the Engine Control Module (ECM). The ECM uses input signal for controlling Pulsed Secondary Air Injection (PAIR) system (if equipped), fuel injection system, ignition timing (spark advance), idle speed control system, fuel pressure control system (if equipped), A/C-cut control system (if equipped), EGR system (if equipped) and automatic transmissions/transaxles (some models).

Turbocharging Pressure Sensor (Turbo)

Turbocharging pressure sensor delivers an input signal to Engine Control Module (ECM), indicating boost pressure. The ECM uses this signal to control turbo boost pressure.

Vacuum Sensor (1.6L & 2.2L)

Vacuum sensor may also be referred to as Manifold Absolute Pressure (MAP) sensor. Vacuum sensor monitors intake manifold intake air volume and delivers an input signal to Engine Control Module (ECM). The ECM uses input signal for controlling fuel injection system and ignition timing (spark advance).

Vehicle Speed Sensor

Vehicle speed sensor monitors vehicle speed and delivers an input signal to Engine Control Module (ECM). The ECM uses input signal for controlling fuel injection system and electronic control of automatic transmission/transaxle (some models). Vehicle speed sensor

is mounted on instrument cluster.

OUTPUT SIGNALS

NOTE: Vehicles are equipped with various combinations of computer-controlled components. Not all components listed are used on every vehicle. For theory and operation on each output component, refer to system indicated after component.

The Engine Control Module (ECM) receives input from data sensors and switches, depending on model application, to control following components and sub-systems:

A/C-Cut Control System
See IDLE SPEED under FUEL SYSTEM.

A/C Idle-Up System
See IDLE SPEED under FUEL SYSTEM.

Circuit Opening Relay
See FUEL DELIVERY under FUEL SYSTEM.

Electronic Spark Advance
See ELECTRONIC IGNITION SYSTEM under IGNITION SYSTEM.

EGR System Vacuum Switching Valve (VSV)
See EXHAUST GAS RECIRCULATION (EGR) SYSTEM under EMISSION SYSTEMS.

Electronically Controlled Transmission/Transaxle (ECT)
See TRANSMISSION/TRANSAXLE CONTROLS under MISCELLANEOUS CONTROLS.

EVAP Vacuum Switching Valve (VSV)
See EVAPORATIVE EMISSION (EVAP) SYSTEM under EMISSION SYSTEMS.

Exhaust By-Pass Valve Vacuum Switching Valve (VSV)
See TURBOCHARGERS under AIR INDUCTION SYSTEM.

Exhaust Gas Control Valve Vacuum Switching Valve (VSV)
See TURBOCHARGERS under AIR INDUCTION SYSTEM.

Fuel Pressure Control System Vacuum Switching Valve (VSV)
See FUEL DELIVERY under FUEL SYSTEM.

Fuel Pump
See FUEL DELIVERY under FUEL SYSTEM.

Idle Speed Control System
See IDLE SPEED under FUEL SYSTEM.

Idle-Up System
See IDLE SPEED under FUEL SYSTEM.

Intake Air Control Valve System
See INTAKE AIR CONTROL VALVE SYSTEM under AIR INDUCTION SYSTEM.

Oxygen Sensor Heater
See FUEL CONTROL under FUEL SYSTEM.

Pulsed Secondary Air Injection (PAIR) System Vacuum Switching

Valve (VSV)
See PULSED SECONDARY AIR INJECTION (PAIR) SYSTEM under EMISSION SYSTEMS.

Self-Diagnostic System
See SELF-DIAGNOSTIC SYSTEM.

Throttle Opener Vacuum Switching Valve (VSV)
See IDLE SPEED under FUEL SYSTEM.

Turbocharging Vacuum Switching Valve (VSV)
See TURBOCHARGERS under AIR INDUCTION SYSTEM.

Variable Induction System Vacuum Switching Valve (VSV)
See VARIABLE INDUCTION SYSTEM under AIR INDUCTION SYSTEM.

Wastegate Vacuum Switching Valve (VSV)
See TURBOCHARGERS under AIR INDUCTION SYSTEM.

FUEL SYSTEM

FUEL DELIVERY

Vehicles are equipped with different combinations of fuel system electrical components. For complete wiring circuit of electrical components on a specific model, see appropriate wiring diagram in L - WIRING DIAGRAMS article.

NOTE: EFI main relay may be also be referred to as MFI main relay, MPI main relay or SFI main relay.

EFI Main Relay
The EFI fuse supplies constant battery voltage to EFI main relay. EFI main relay provides battery voltage to +B terminal of circuit opening relay (some models) and data link connector. Depending on model, EFI main relay may either be turned on directly by ignition switch or by M-REL terminal of Engine Control Module (ECM). The EFI main relay may also provide battery voltage to +B and +B1 terminals of ECM when ignition is turned on. The EFI main relay is located in engine compartment relay box. See Figs. 1-4.

NOTE: Circuit opening relay is used on all models.

Circuit Opening Relay
Circuit opening relay controls fuel pump circuit. The Engine Control Module (ECM) receives an input signal at STA terminal when engine is cranking. Starter signal is also applied to terminal STA of circuit opening relay.
Starter signal energizes circuit opening relay during cranking. Circuit opening relay then provides voltage to fuel pump or fuel pump relay. Fuel pump relay is used on Turbo only.
Circuit opening relay is grounded by the ECM through the FC terminal. On all other models, fuel pump switch in airflow meter provides ground for circuit opening relay. Circuit opening relay and fuel pump relay are located in different locations. See Figs. 1-4.

Fuel Pump Relay & Fuel Pump Resistor (Turbo)
Fuel pump relay receives voltage from circuit opening relay to operate the fuel pump. Fuel pump operating speed may be varied by the Engine Control Module (ECM). When ECM grounds fuel pump relay, relay contacts close and voltage is supplied through fuel pump resistor to the fuel pump. This changes the fuel pump operating speed.

Fuel pump relay and fuel pump resistor are located in different locations. See Figs. 1-4.

Fuel Pump

Fuel pump is mounted in the fuel tank and contains an internal check valve. Fuel pump can be operated with ignition off by installing jumper wire between +B and FP terminals of data link connector. On Turbo fuel pump operating speed may be varied by use of fuel pump relay and fuel pump resistor.

Fuel Pressure Regulator

Mounted on fuel rail, vacuum-operated fuel pressure regulator maintains constant fuel pressure to fuel injectors. As throttle is depressed and manifold vacuum decreases, fuel pressure regulator increases fuel pressure to maintain a constant fuel flow to fuel injectors.

NOTE: Fuel pressure control system may also be referred to as fuel pressure-up system.

Fuel Pulsation Damper

Some models use a fuel pulsation damper mounted on fuel delivery pipe to eliminate fuel line pressure surges caused by fuel injector operation.

FUEL CONTROL

Cold Start Injector (Turbo)

Cold start injector delivers additional fuel during cold engine starts. Cold start injector receives voltage from ignition switch during engine cranking. Ground circuit for cold start injector is controlled by cold start injector time switch.

Cold Start Injector Time Switch (Turbo)

Cold start injector time switch determines cold start injector on time for cold engine starting. Cold start injector ground circuit is controlled by cold start injector time switch, located in an engine coolant passage. See Figs. 1-4.

Fuel-Cut System

Controlled through input from throttle position sensor, Engine Control Module (ECM) will cut fuel delivery during closed throttle deceleration.

Fuel Injectors

Fuel injectors are ECM-actuated electric solenoids which deliver fuel to individual cylinders. The ECM controls fuel injector duration based on various input signals to determine air/fuel mixture.

NOTE: Solenoid resistor may also be referred to as injector resistor.

Solenoid Resistor (Turbo)

Solenoid resistor reduces current flow to fuel injectors. Solenoid resistor is located in engine compartment. See Figs. 1-4.

Oxygen Sensor Heater (1.6L 4A-FE & Turbo)

Oxygen sensor is equipped with a heating element. The Engine Control Module (ECM) activates oxygen sensor heater when intake air volume and coolant temperature are low, warming the oxygen sensor for improved performance.

IDLE SPEED

A/C-Cut Control System (1.6L & 2.2L)

The A/C-cut control system interrupts A/C compressor operation for a fixed period of time when vehicle accelerates from low engine speed.

On 2.2L Engine Control Module (ECM) uses vehicle speed and throttle valve angle input signals to determine A/C-cut control system operation. On 1.6L, ECM uses vehicle speed, throttle valve angle, vacuum sensor and park/neutral switch input signals to determine A/C-cut control system operation.

A/C Idle-Up System (2.2L 5S-FE)

The A/C idle-up system provides a stable idle speed when A/C is operating. Engine Control Module (ECM) controls A/C idle-up Vacuum Switching Valve (VSV). The A/C idle-up VSV allows extra intake air to by-pass throttle valve for increased idle speed. The A/C idle-up VSV is located in engine compartment. See Figs. 1-4.

NOTE: Auxiliary air valve may also be referred to as the air valve.

Auxiliary Air Valve (1.6L 4A-FE)

Auxiliary air valve provides additional air to intake manifold when engine is cold for increased idle speed. Auxiliary air valve is mounted on throttle body and determines engine temperature by engine coolant being routed around auxiliary air valve.

NOTE: Idle speed control system may also be referred to as idle air control system.

Idle Speed Control System (Turbo & 2.2L 5S-FE)

Engine Control Module (ECM) is programmed with engine idle speed values. Idle air control system provides a stable idle speed when engine is cold and idle speed decreases due to electrical load.

An input signal is delivered to ECM, indicating when high electrical output is required. Input signal is delivered when items such as rear window defroster, headlights, etc. are turned on. The ECM uses input signal along with other various input signals to maintain proper idle speed by controlling Idle Air Control (IAC) valve located on air intake system.

IGNITION SYSTEM

ELECTRONIC IGNITION SYSTEM

NOTE: The electronic ignition system may be referred to as Electronic Spark Advance (ESA).

The electronic ignition system uses the Engine Control Module (ECM) for determining ignition timing (spark advance). The ECM determines ignition timing (spark advance) based on various input signals. Following input signals may be used: coolant temperature sensor, oxygen sensor, engine RPM, vehicle speed sensor, A/C switch, airflow meter, knock sensor, vacuum sensor and cranking (starter) signal. Input signals may vary on model application. Integrated (ignition coil on distributor) and remote ignition coil designs are used depending on model.

Crankshaft position and engine RPM input signals are delivered to the ECM by 2 pick-up coils in the distributor. Crankshaft position input signal is delivered to G, G+ or G1 (and G2 on some models) terminal of ECM, and engine RPM input signal is delivered to NE or NE+ terminal of ECM. See Fig. 5.

On all models, ECM uses pick-up coil input signals to switch

primary ignition circuit on and off. Primary circuit is turned off when ECM delivers a signal to ignitor on the IGT wire, causing ignition coil to fire the spark plug. After delivering a command to turn off primary circuit on the IGT wire, the ECM monitors IGF circuit to ensure primary switching occurred. See Fig. 5.

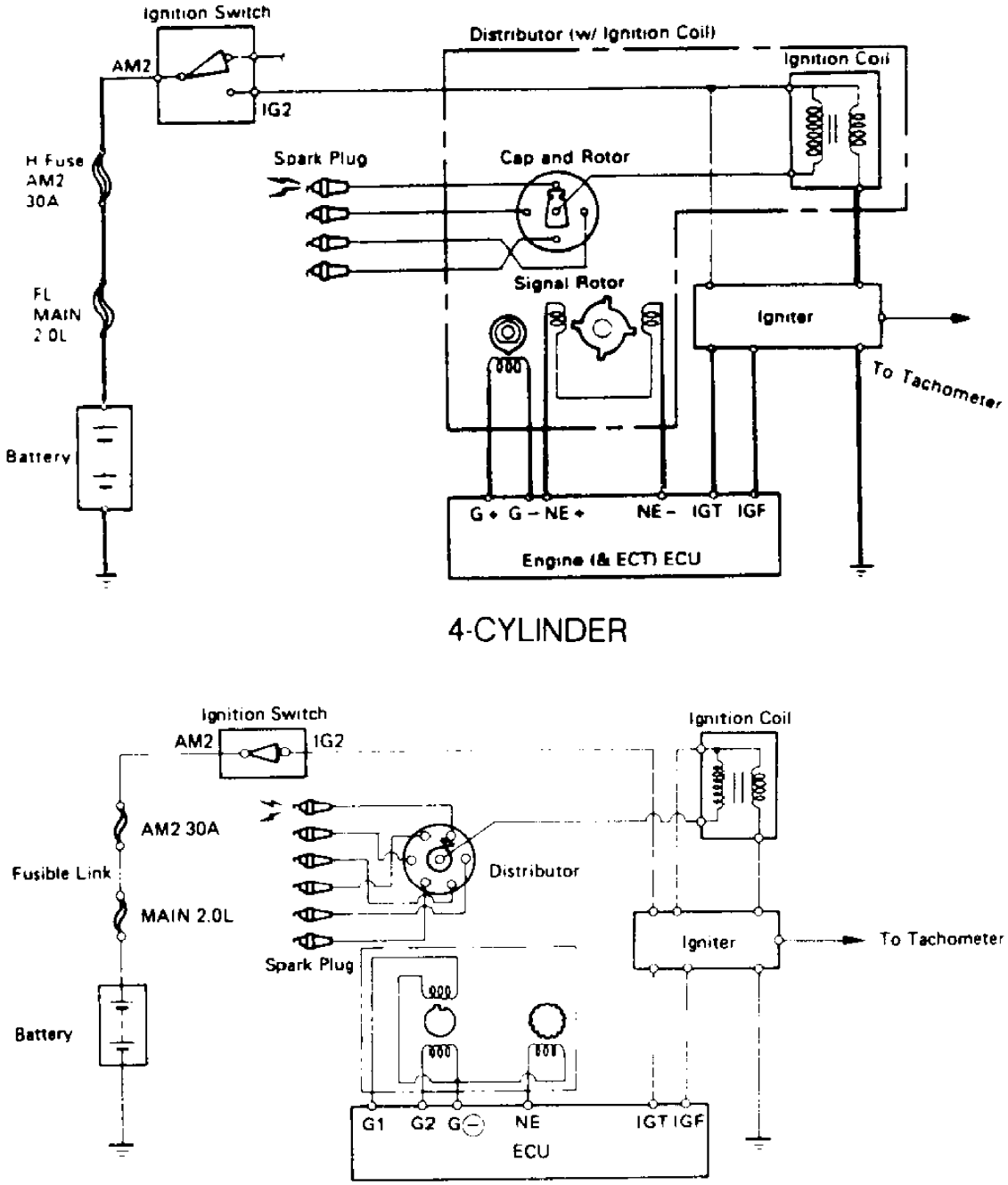

Fig. 5: Typical Electronic Ignition System Schematic
Courtesy of Toyota Motor Sales, U.S.A. Inc.

EMISSION SYSTEMS

CRANKCASE VENTILATION

The Positive Crankcase Ventilation (PCV) system prevents crankcase hydrocarbon (HC) vapors from escaping into the atmosphere. Crankcase vapors are routed from crankcase through a vacuum-controlled PCV valve, into the intake manifold. In the intake manifold, crankcase vapors are mixed with air/fuel mixture and delivered into the cylinders. See Fig. 6.

The PCV system provides primary control of crankcase blow-by vapors, according to manifold vacuum. When manifold vacuum is high (at idle), PCV restricts vapor flow to maintain a smooth idle condition.

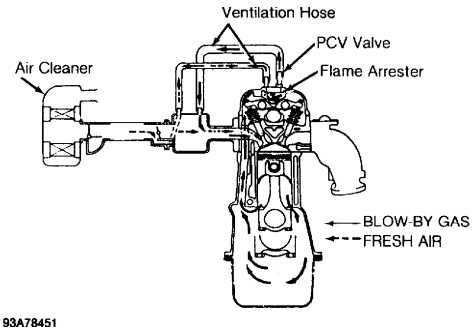

Fig. 6: Identifying PCV System (Typical)
Courtesy of Toyota Motor Sales, U.S.A., Inc.

EXHAUST GAS RECIRCULATION (EGR) SYSTEM

The EGR system reduces oxides of nitrogen (NOx) emissions by lowering combustion temperatures. Combustion temperatures are lowered by recycling metered amount of exhaust gases back into the intake system.

The EGR system contains a vacuum-operated EGR valve and a vacuum modulator. See Fig. 7. A check valve, EGR cooler and EGR Vacuum Switching Valve (VSV) may also be used. Vacuum modulator regulates exhaust backpressure and balances atmospheric pressure and vacuum to allow EGR operation at heavy throttle.

Engine Control Module (ECM) controls the EGR VSV for EGR operation. This system is referred to as EGR-cut control system. The ECM uses input signals such as coolant temperature, engine RPM, throttle position, brakelight switch, intake air volume and vehicle speed for controlling the EGR VSV. Input signals may vary by vehicle application. Various model and engine types will have different EGR system components and operating parameters. For specific EGR operating parameters and testing of system or components on various models, see EXHAUST GAS RECIRCULATION (EGR) under EMISSION SYSTEMS & SUB-SYSTEMS in I - SYSTEM/COMPONENT TESTS article.

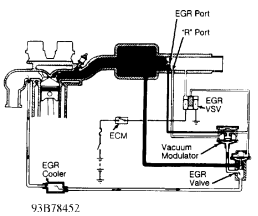

Fig. 7: Identifying Typical EGR System Components
Courtesy of Toyota Motor Sales, U.S.A., Inc.

EVAPORATIVE EMISSION (EVAP) SYSTEM

NOTE: The EVAP may also be referred to as fuel evaporation.

The EVAP system prevents fuel tank gasoline vapors from escaping into the atmosphere. Fuel tank gasoline vapors are routed through charcoal canister into intake manifold for combustion in the cylinders. See Fig. 8. All models use a Bimetallic Vacuum Switching (BVSV) to control EVAP system in relation to engine coolant temperature. BVSV is mounted in the engine coolant passage.

NOTE: The BVSV may be referred to as a Thermal Vacuum Valve (TVV).

Various model and engine types will have different evaporative emission system components and operating parameters. For specific EVAP system operating parameters and system and component testing, see FUEL EVAPORATION under EMISSION SYSTEMS & SUB-SYSTEMS in I - SYSTEM/COMPONENT TESTS article.

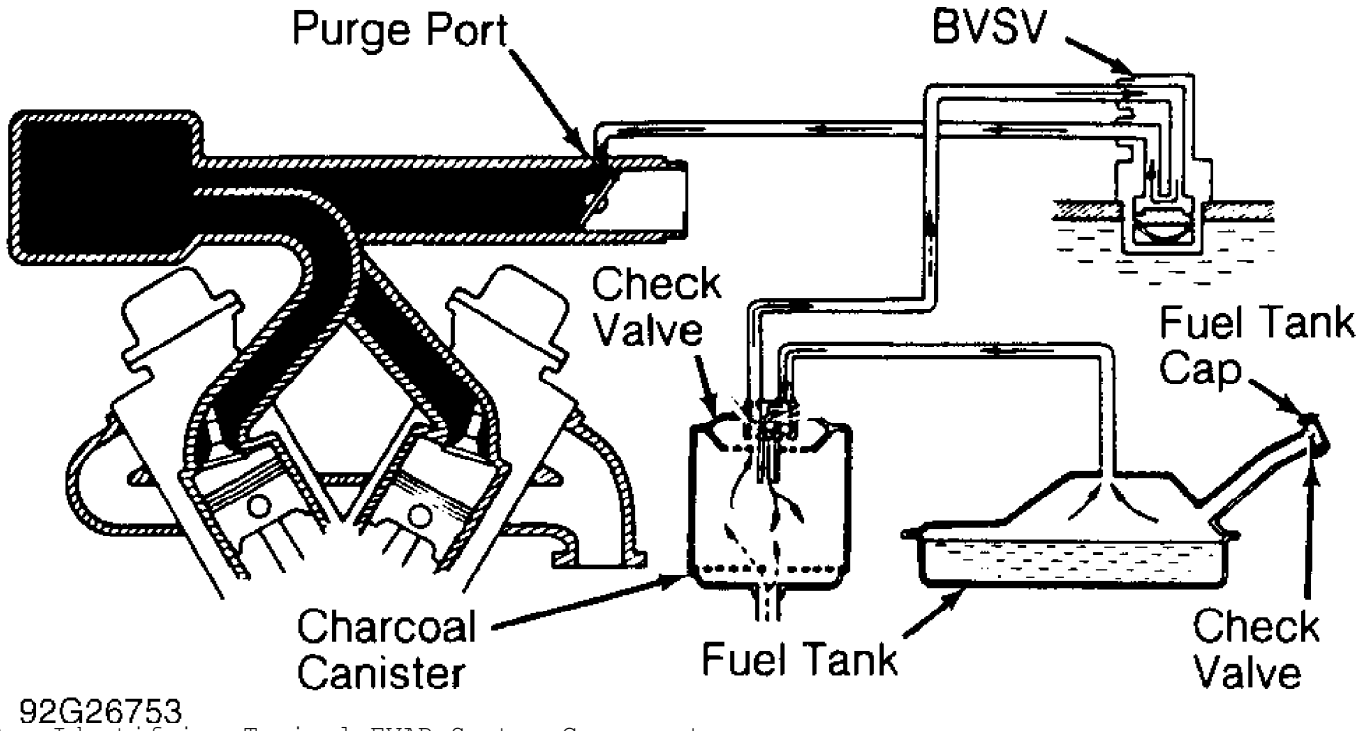

Fig. 8: Identifying Typical EVAP System Components
Courtesy of Toyota Motor Sales, U.S.A., Inc.

SELF-DIAGNOSTIC SYSTEM

The Engine Control Module (ECM) is equipped with self-diagnostic system. By analyzing various input signals, ECM detects system malfunctions related to various operating parameters. When malfunction occurs, ECM will inform the driver by turning on Malfunction Indicator Light (MIL) on the instrument panel.

NOTE: The MIL may be referred to as the CHECK ENGINE light.

Diagnostic Trouble Codes (DTC) may be set by malfunction of various engine sensors, switches or circuits. DTC is stored in ECM memory. When diagnostic trouble code is stored, MIL on instrument panel will come on. Diagnostic trouble code can be retrieved for system diagnosis. For additional information on self-diagnostic

system, see G - TESTS W/CODES article.

MISCELLANEOUS CONTROLS

TRANSMISSION/TRANSAXLE CONTROLS

NOTE: Only electronically controlled transmissions/transaxles are covered. Some models have transmissions and transaxles that are not electronically controlled.

Electronically Controlled Transmission/Transaxle (ECT)
ECM uses input signals for controlling transmission/transaxle operation.