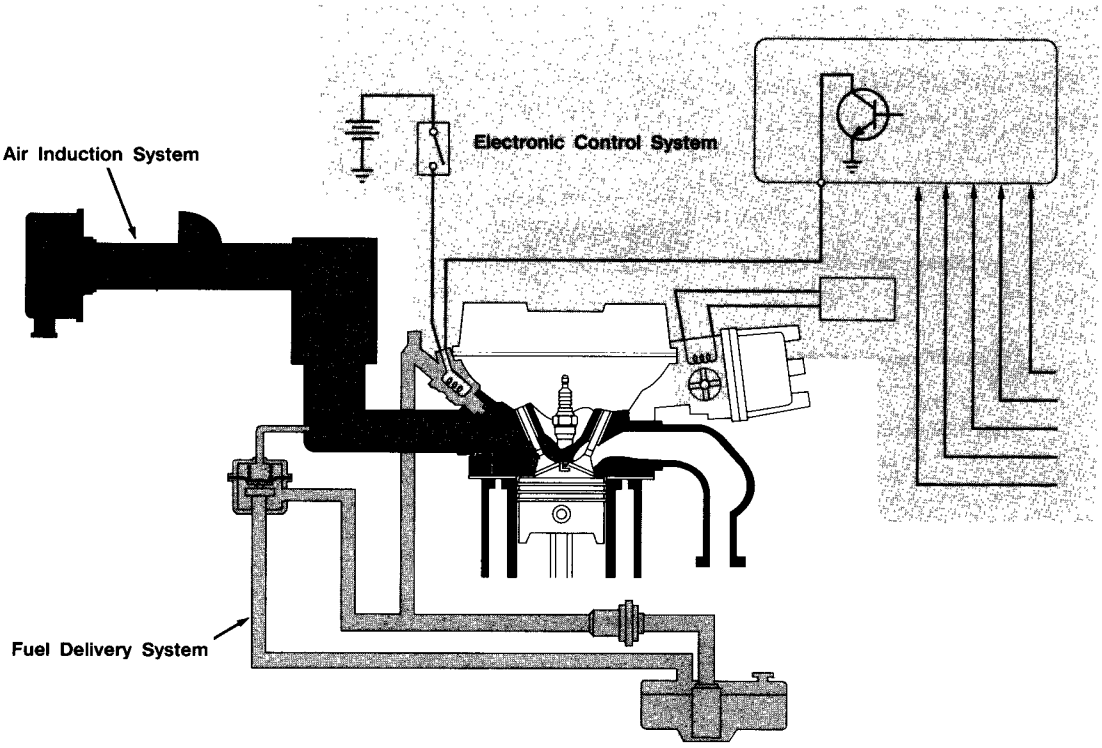
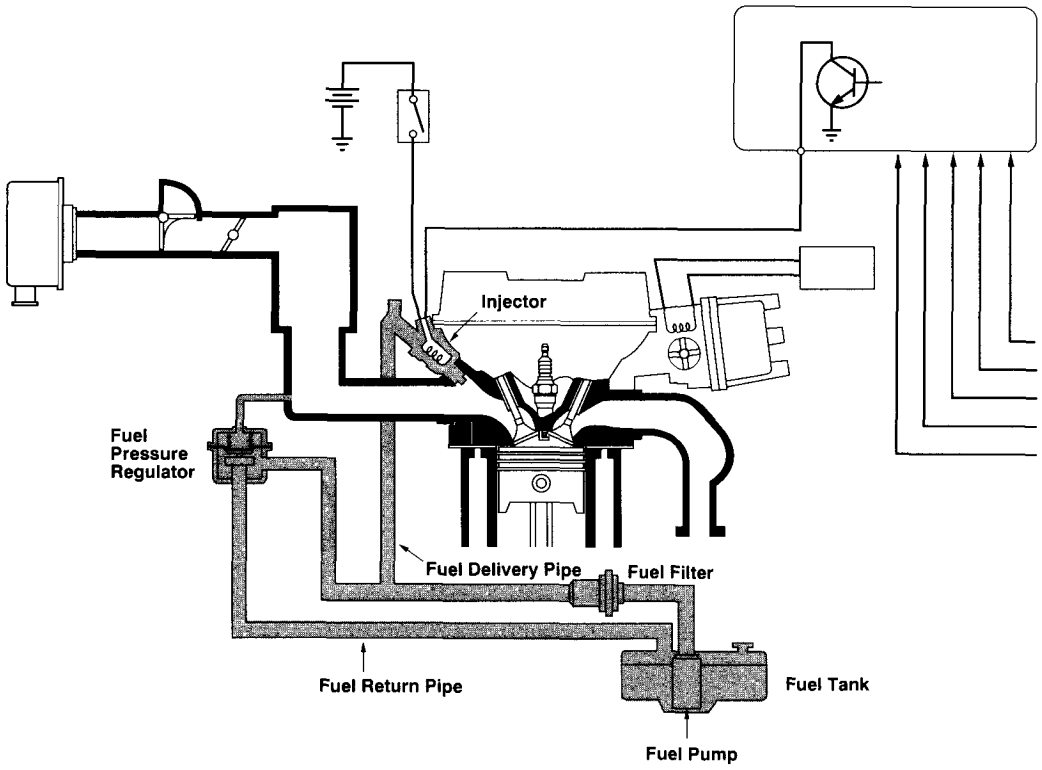
Electronic Fuel Injection Overview



How Electronic Fuel Injection Works

Electronic Fuel injection works on the some very basic principles. The following discussion broadly outlines how a basic or **Convention Electronic Fuel Injection (EFI)** system operates.

The Electronic Fuel Injection system can be divided into three: basic sub-systems. These are the fuel delivery system, air induction system, and the electronic control system.

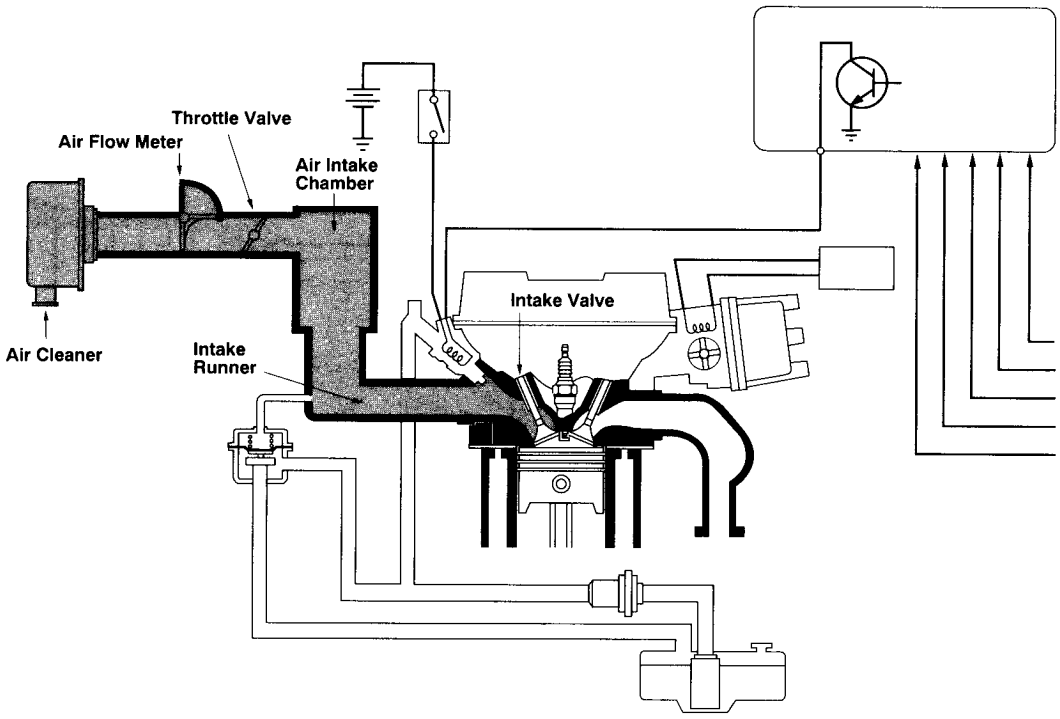


The Fuel Delivery System

- The fuel delivery system consists of the fuel tank, fuel pump, fuel filter, fuel delivery pipe (fuel rail), fuel injector, fuel pressure regulator, and fuel return pipe.

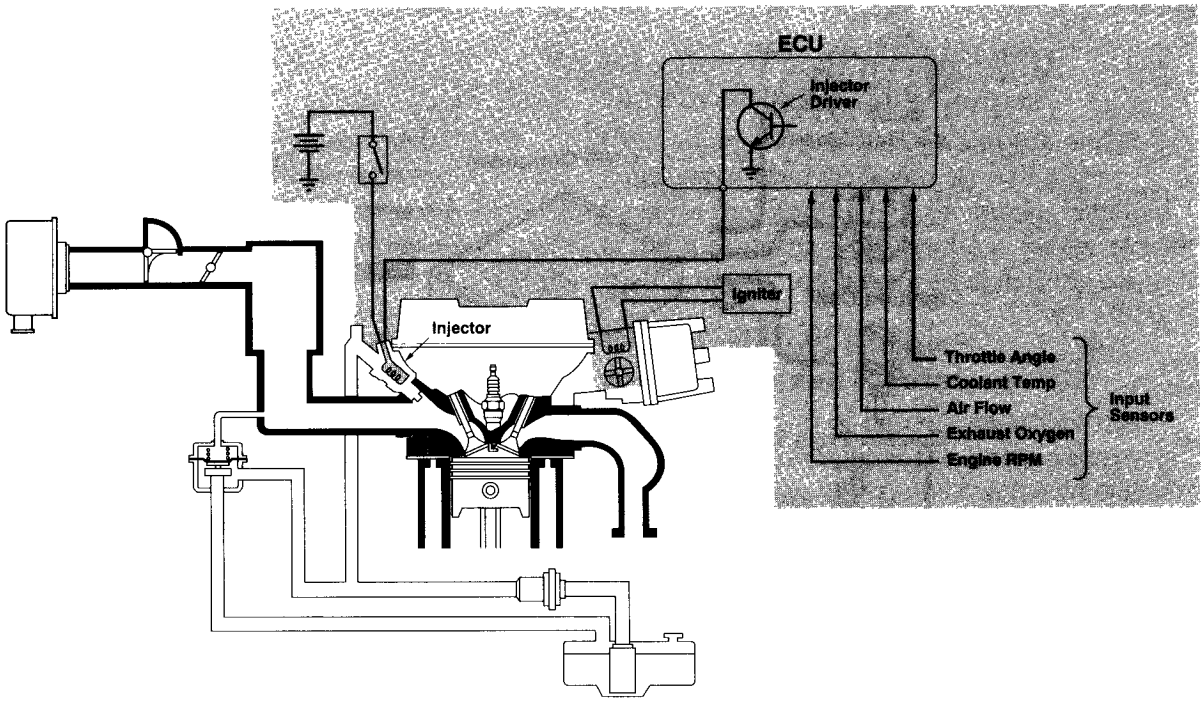
- Fuel is delivered from the tank to the injector by means of an electric fuel pump. The pump is typically located in or near the fuel tank. Contaminants are filtered out by a high capacity in line fuel filter.

- Fuel is maintained at a constant pressure by means of a fuel pressure regulator. Any fuel which is not delivered to the intake manifold by the injector is returned to the tank through a fuel return pipe.



The Air Induction System

- The air induction system consists of the air cleaner, air flow meter, throttle valve, air intake chamber, intake manifold runner, and intake valve.
- When the throttle valve is opened, air flows through the air cleaner, through the air flow meter (on L type systems), past the throttle valve, and through a well tuned intake manifold runner to the intake valve.
- Air delivered to the engine is a function of driver demand. As the throttle valve is opened further, more air is allowed to enter the engine cylinders.
- Toyota engines use two different methods to measure intake air volume. The L type EFI system measures air flow directly by using an air flow meter. The D type EFI system measures air flow indirectly by monitoring the pressure in the intake manifold.

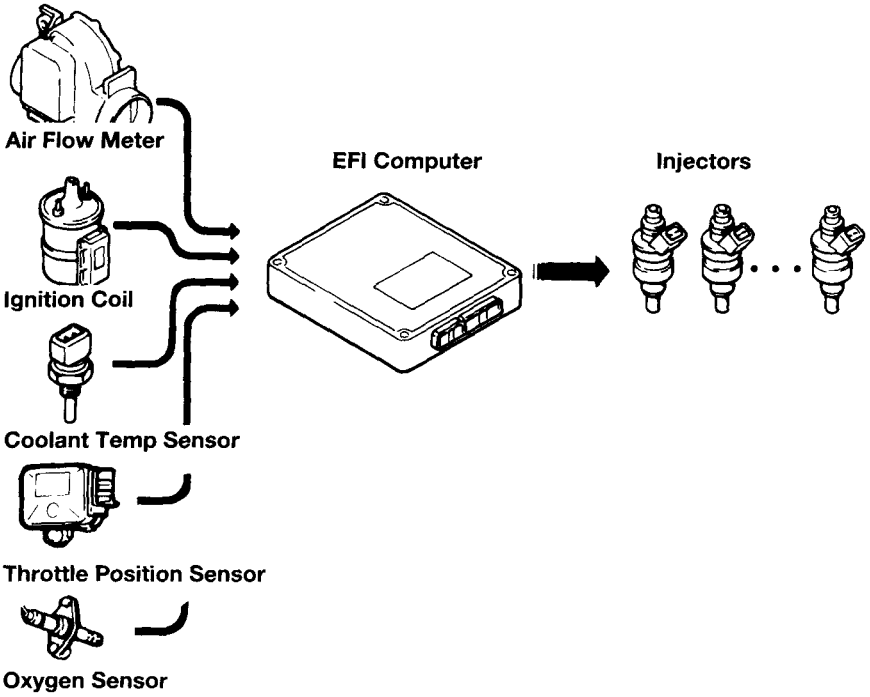


Electronic Control System

- The electronic control system consists of various engine sensors, Electronic Control Unit (ECU), fuel injector assemblies, and related wiring.

- The ECU determines precisely how much fuel needs to be delivered by the injector by monitoring the engine sensors.

- The ECU turns the injectors on for a precise amount of time, referred to as injection pulse width or injection duration, to deliver the proper air/fuel ratio to the engine.



Basic System Operation

- Air enters the engine through the air induction system where it is measured by the air flow meter. As the air flows into the cylinder, fuel is mixed into the air by the fuel injector.
- Fuel injectors are arranged in the intake manifold behind each intake valve. The injectors are electrical solenoids which are operated by the ECU.
- The ECU pulses the injector by switching the injector ground circuit on and off.
- When the injector is turned on, it opens, spraying atomized fuel at the back side of the intake valve.
- As fuel is sprayed into the intake airstream, it mixes with the incoming air and vaporizes due to the low pressures in the intake manifold. The ECU signals the injector to deliver just enough fuel to achieve an ideal air/fuel ratio of 14.7:1, often referred to as stoichiometry.
- The precise amount of fuel delivered to the engine is a function of ECU control.
- The ECU determines the basic injection quantity based upon measured intake air volume and engine rpm.
- Depending on engine operating conditions, injection quantity will vary. The ECU monitors variables such as coolant temperature, engine speed, throttle angle, and exhaust oxygen content and makes injection corrections which determine final injection quantity.

Advantages of EFI

Uniform Air/Fuel Mixture Distribution
Each cylinder has its own injector which delivers fuel directly to the intake valve. This eliminates the need for fuel to travel through the intake manifold, improving cylinder to cylinder distribution.

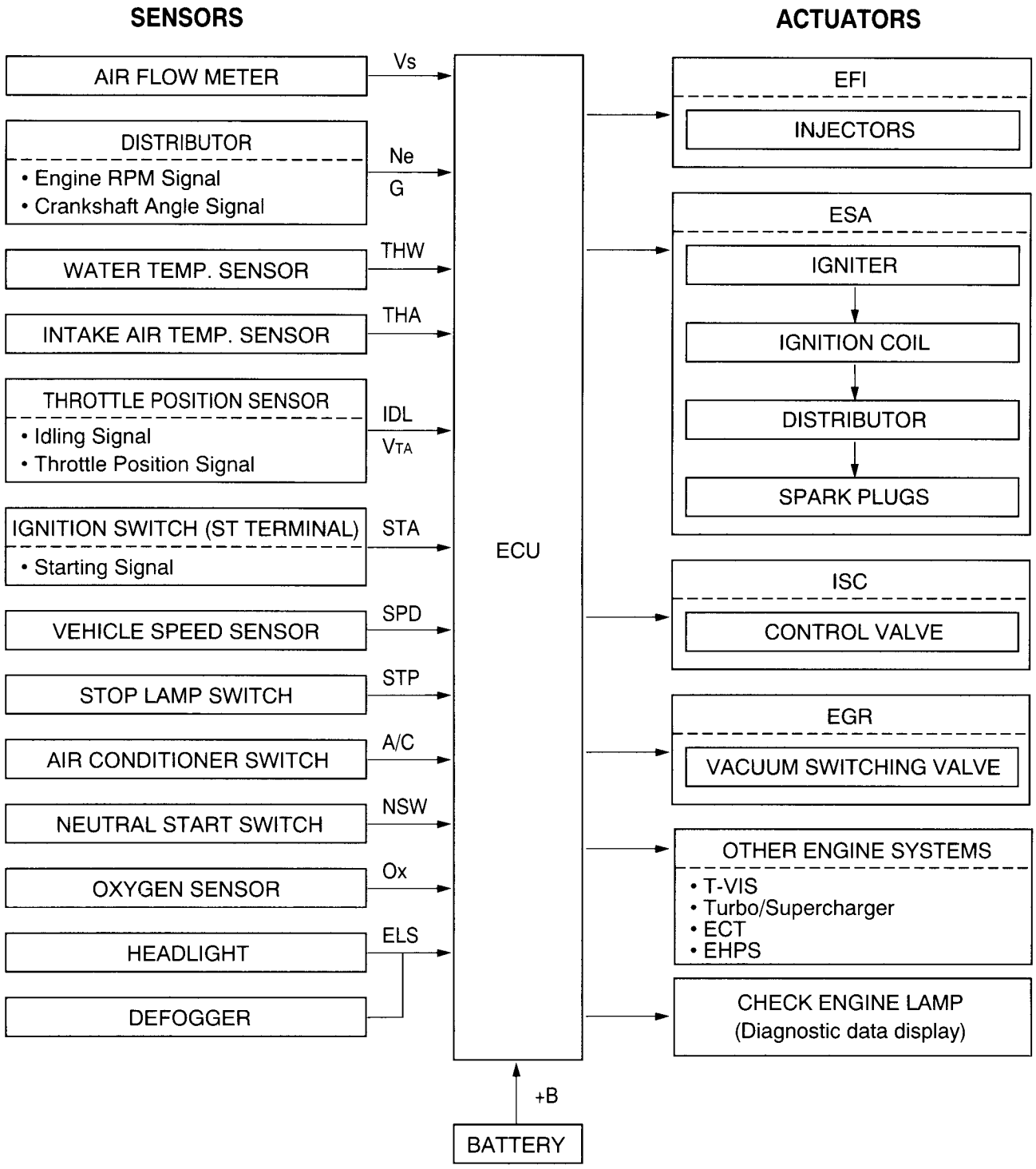
Highly Accurate Air/Fuel Ratio Control Throughout All Engine Operating Conditions
EFI supplies a continuously accurate air/fuel ratio to the engine no matter what operating conditions are encountered. This provides better driveability, fuel economy, and emissions control.

Superior Throttle Response and Power
By delivering fuel directly at the back of the intake valve, the intake manifold design can be optimized to improve air velocity at the intake valve. This improves torque and throttle response.

Excellent Fuel Economy With Improved Emissions Control
Cold engine and wide open throttle enrichment can be reduced with an EFI engine because fuel puddling in the intake manifold is not a problem. This results in better overall fuel economy and improved emissions control.

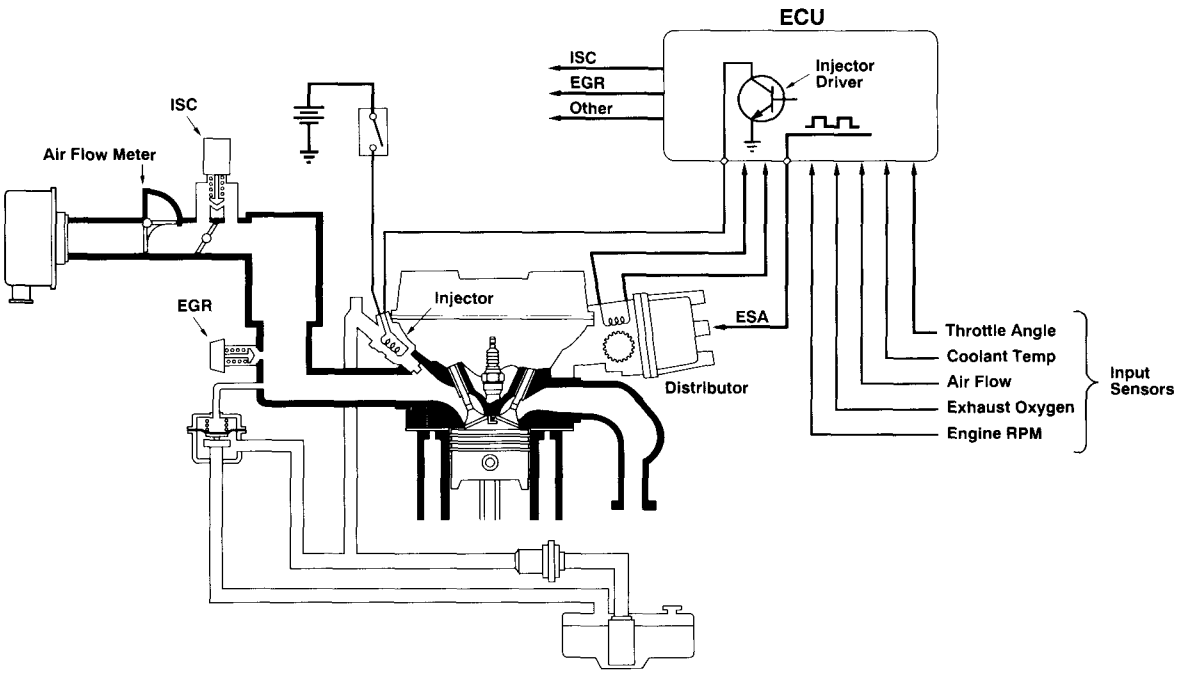
Improved Cold Engine Startability and Operation
The combination of better fuel atomization and injection directly at the intake valve improves ability to start and run a cold engine.

Simpler Mechanics, Reduced Adjustment Sensitivity
The EFI system does not rely on any major adjustments for cold enrichment or fuel metering. Because the system is mechanically simple, maintenance requirements are reduced.



EFI/TCCS System

With the introduction of the Toyota Computer Control System (TCCS), the EFI system went from a simple fuel control system to a fully integrated engine and emissions management system. Although the fuel delivery system operates the same as Conventional EFI, the TCCS Electronic Control Unit (ECU) also controls ignition spark angle. Additionally, TCCS also regulates an Idle Speed Control device, an Exhaust Gas Recirculation (EGR) Vacuum Switching Valve and, depending on application, other engine related systems.

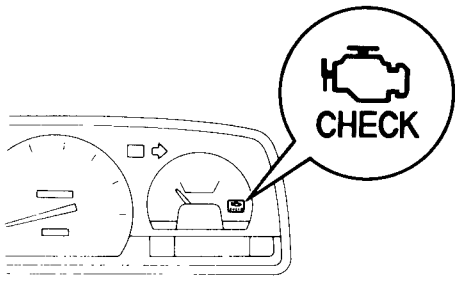


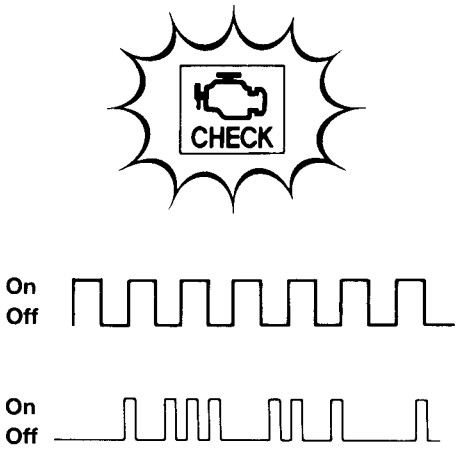
Ignition Spark Management (ESA)
The EFI/'TCCS system regulates spark advance angle by monitoring engine operating conditions, calculating the optimum spark timing, and firing the spark plug at the appropriate time.

Idle Speed Control (ISC)
The EFI/TCCS system regulates engine idle speed by means of several different types of ECU controlled devices. The ECU monitors engine operating conditions to determine which idle speed strategy to use.

Exhaust Gas Recirculation (EGR)
The EFI/TCCS system regulates the periods under which EGR can be introduced to the engine. This control is accomplished through the use of an EGR Vacuum Switching Valve.

Other Engine Related Systems
In addition to the major systems just described, the TCCS ECU often operates an Electronically Controlled Transmission (ECT), a Variable Induction System (T-VIS), the air conditioner compressor clutch, and the turbocharger/supercharger.





Self Diagnosis System

A self diagnosis system is incorporated into all TCCS Electronic Control Units (ECUs) and into some Conventional EFI system ECUs. A Conventional EFI engine equipped with self diagnostics is a P7/EFI system. This diagnostic system uses a check engine warning lamp in the combination meter which is capable of warning the driver when specific faults are detected in the engine control system. The check engine light is also capable of flashing a series of diagnosis codes to assist the technician in troubleshooting these faults.

Summary

The Electronic Fuel Injection system consists of three basic subsystems.

- The electronic control system determines basic injection quantity based upon electrical signals from the air flow meter and engine rpm.

- The fuel delivery system maintains a constant fuel pressure on the injector. This allows the ECU to control the fuel injection duration and deliver the appropriate amount of fuel for engine operating conditions.

- The air induction system delivers air to the engine based on driver demand. The air/fuel mixture is formed in the intake manifold as air moves through the intake runners.

The EFI system allows for improved engine performance, better fuel economy, and improved emissions control. Although technologically advanced, the EFI system is mechanically simpler than other fuel metering systems and requires very little maintenance or periodic adjustment.

- The Conventional EFI system only controls fuel delivery and injection quantity. 'Me introduction of EFI/TCCS added control Of Electronic Spark Advance, idle speed, EGR, and other related engine systems.

- Most of Toyota's late model EFI systems are equipped with some type of on board diagnosis system. All TCCS systems are equipped with an advanced self diagnosis system capable of monitoring many important engine electrical circuits. Only some of the later production Conventional(P7) EFI engines are equipped with a self diagnosis system.

