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Modern Automotive Technology

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Presentations for PowerPoint

Modern Automotive Technology



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Chapter 41

Gasoline Injection Fundamentals

Objectives

After studying this chapter, you will be able to:

- List some of the advantages of direct fuel injection systems.
- Describe the major assemblies of a modern gasoline injection system.
- Compare the operation of indirect gasoline injection to direct electronic gasoline injection.

Objectives

- Summarize the operating voltages, current levels, and other values of sensors and injectors that are important to technicians.
- Summarize the operation of oxygen sensors to control an engine air-fuel ratio.
- Correctly answer ASE certification test questions on gasoline injection systems.

Gasoline Injection Fundamentals

- Gasoline injection system
 - Uses pressure from electric or mechanical fuel pump to spray fuel into engine's intake manifold
 - Multiport or manifold injection
 - Combustion chambers
 - Direct injection

Gasoline Injection Fundamentals (Cont.)

Electronic fuel injection systems have five subsystems

- Fuel delivery system
- Air induction system
- Sensor system
- Computer control system
- Fuel metering system

Gasoline Injection Fundamentals (Cont.)

- Fuel delivery system
 - Feeds clean, liquid gas from storage tank to engine
- Air induction system
 - Filters, routes, and controls outside air flowing into cylinders

Gasoline Injection Fundamentals (Cont.)

- Sensor system
 - Measures pressure, temperature, engine speed, and exhaust cleanliness for engine control module (ECM)
- Computer control system
 - ECM responds to sensor signals to control fuel injector and meter precise amount of fuel

Gasoline Injection Fundamentals (Cont.)

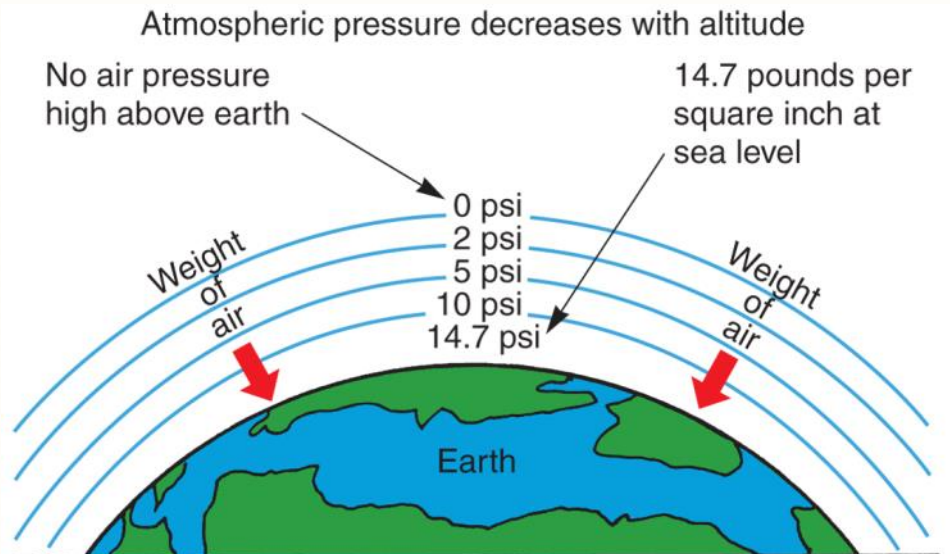
- Fuel metering system
 - Controls amount of fuel injected into engine

Gasoline Injection Fundamentals (Cont.)

- Fuel delivery system of modern direct electronic fuel injection (DEFI) system
 - Electric fuel pump
 - Mechanical fuel pump
 - Fuel filter
 - Pressure regulator solenoid
 - Electronic fuel injectors
 - Fuel flow control valves
 - Connecting fuel lines

Atmospheric Pressure

- Pressure formed by air surrounding earth
- At sea level, atmosphere exerts 14.7 psi
- At higher altitudes, air pressure and air density drop
 - Lowers amount of fuel injected into engine



Vacuum

- Vacuum
 - Pressure lower than atmospheric pressure formed in enclosed area
- Many sealed parts in and on engine contain vacuum pressure
- Vacuum measured in units of negative psi, inches of mercury, Pascals, or bars compared to outside atmospheric pressure

Differences in Pressure Cause Flow

- Difference in pressure between two areas used to cause flow
- Engine acts as vacuum pump, producing low-pressure area in intake manifold and cylinders
 - This pulls air into engine to support combustion

Engine Throttle Valve

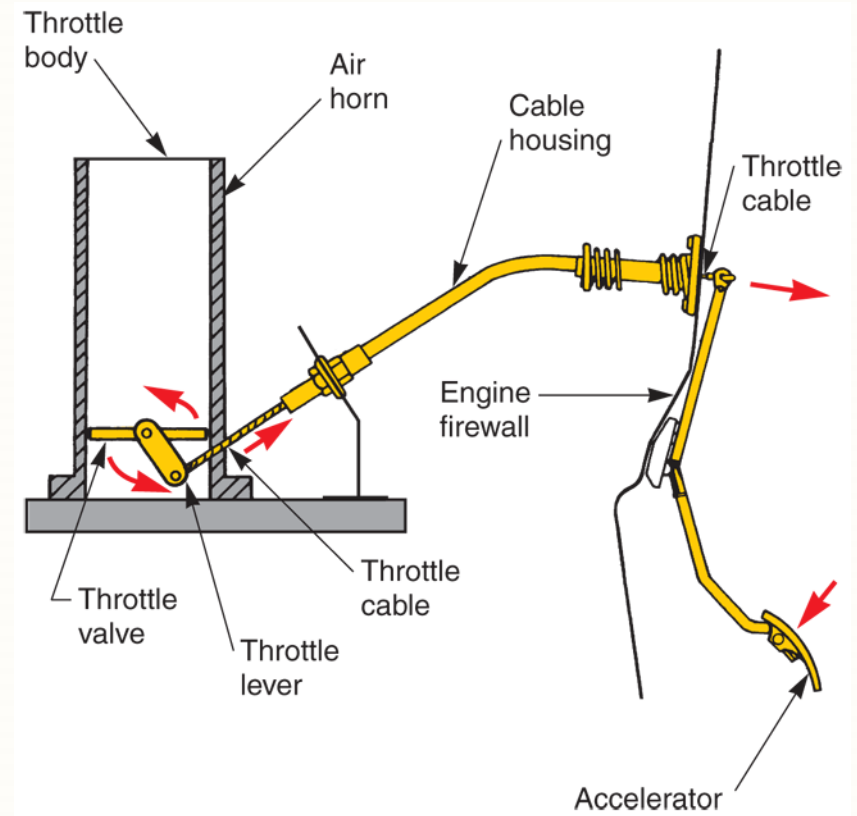
- Engine throttle valve
 - “Butterfly” or flap-type valve in throttle body assembly that controls airflow and engine power output
- When closed, throttle valve restricts flow of air and fuel
 - Keeps engine speed and power low for idling at low rpms

Engine Throttle Valve (Cont.)

- Engine sensors
 - Detect changes and adjust fuel flow through injectors
- Engine idle speed
 - Operating speed of engine when vehicle is in Park or Neutral

Engine Throttle Valve (Cont.)

- When driver presses accelerator
 - Throttle cable slides inside its housing and swings throttle valve open
 - Atmospheric pressure pushes more air into engine intake manifold

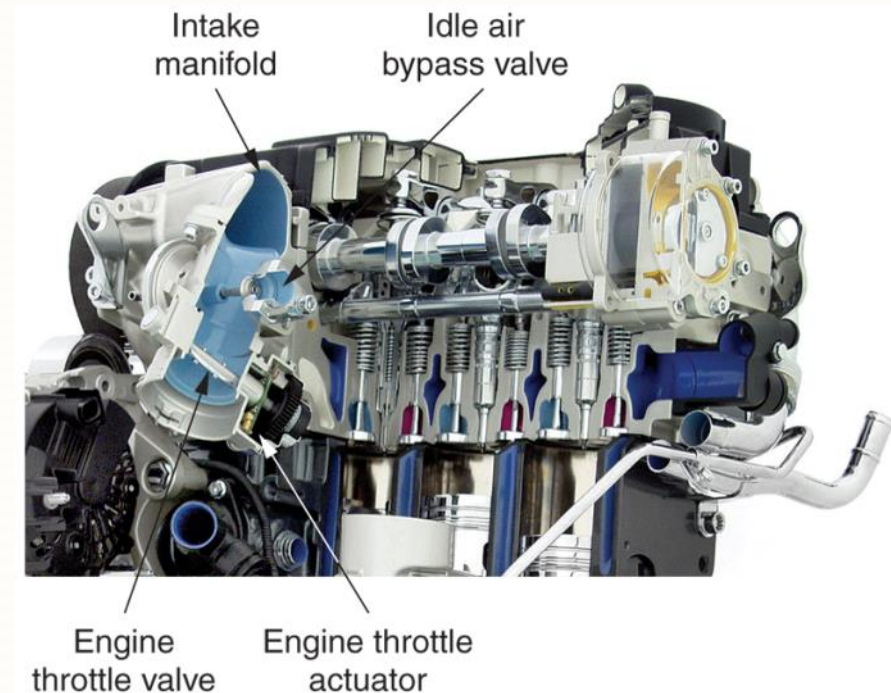


Throttle-by-Wire Systems

- Throttle-by-wire or drive-by-wire systems
 - Moves throttle valves electronically instead of using mechanical linkage from accelerator pedal
- Accelerator pedal sensor
 - Feeds electric signal to ECM corresponding to pedal position
 - ECM sends control current to servo motor actuator that opens and closes throttle valve

Throttle-by-Wire Systems (Cont.)

- Engine throttle actuator
 - Small, reversible servo motor with emergency release
- Throttle safety release
 - Used to return engine to idle even if engine throttle actuator fails



Gasoline Injection Timing

- Older fuel injection systems
 - Continuous fuel injection
 - Injectors spray fuel whenever engine is running
 - Intermittent fuel injection
 - Injectors open and close regardless of intake valve positions
- Timed injection system
 - Sprays fuel during intake or compression strokes, in relation to piston and valve action

Injector Pulse Width

- Injector pulse width
 - Indicates amount of time each injector is energized and kept open
- ECM controls injector pulse width and amount of fuel sprayed into engine
 - Using all power train sensors

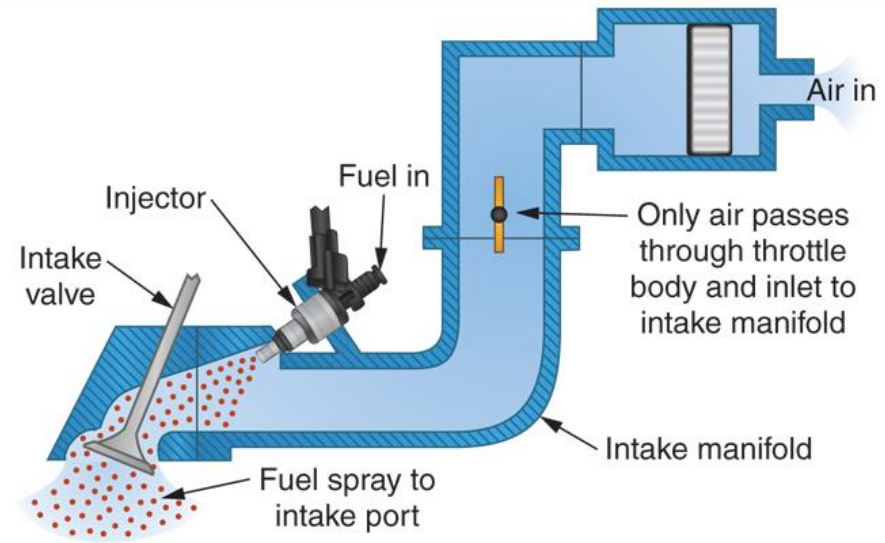
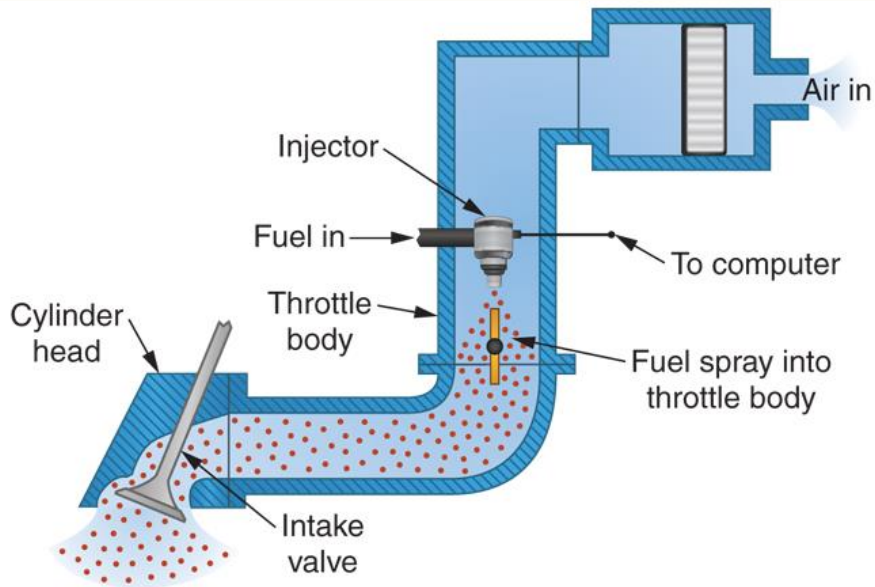
Direct and Indirect Injection

- Fuel injection systems
 - Gasoline injection system often classified by where it injects fuel into engine
- Indirect injection system
 - Sprays fuel into engine intake manifold
- Direct injection system
 - Sprays high-pressure fuel into engine's combustion chambers

Indirect Injection Systems

- Throttle body injection system (TBI), or single point injection
 - Injector nozzles mounted in throttle body assembly located on top of engine
- Multiport injection system
 - Has fuel injectors in intake ports
- Cold-start fuel injector
 - Used in early designs to richen fuel mixture for cold engine startup

Indirect Injection Systems (Cont.)



Direct Fuel Injection

- Direct fuel injection (DFI) systems
 - Inject fuel directly into engine combustion chambers
- Direct electronic fuel injection (DEFI)
 - Uses electric fuel pump, mechanical fuel pump, and high-pressure injectors to spray fuel straight into combustion chambers

Direct Fuel Injection (Cont.)

- Stratified charge mode
 - Ultra-lean burn mode where small charge of fuel injects into combustion chambers during end of compression stroke
- Stoichiometric mode
 - Produces theoretically homogenous mixture of fuel and air
 - Equally mixed and dispersed

Direct Fuel Injection (Cont.)

- Full power charge mode
 - Produces homogeneous, rich mixture that generates more combustion pressure and power
 - Needed when engine accelerates quickly

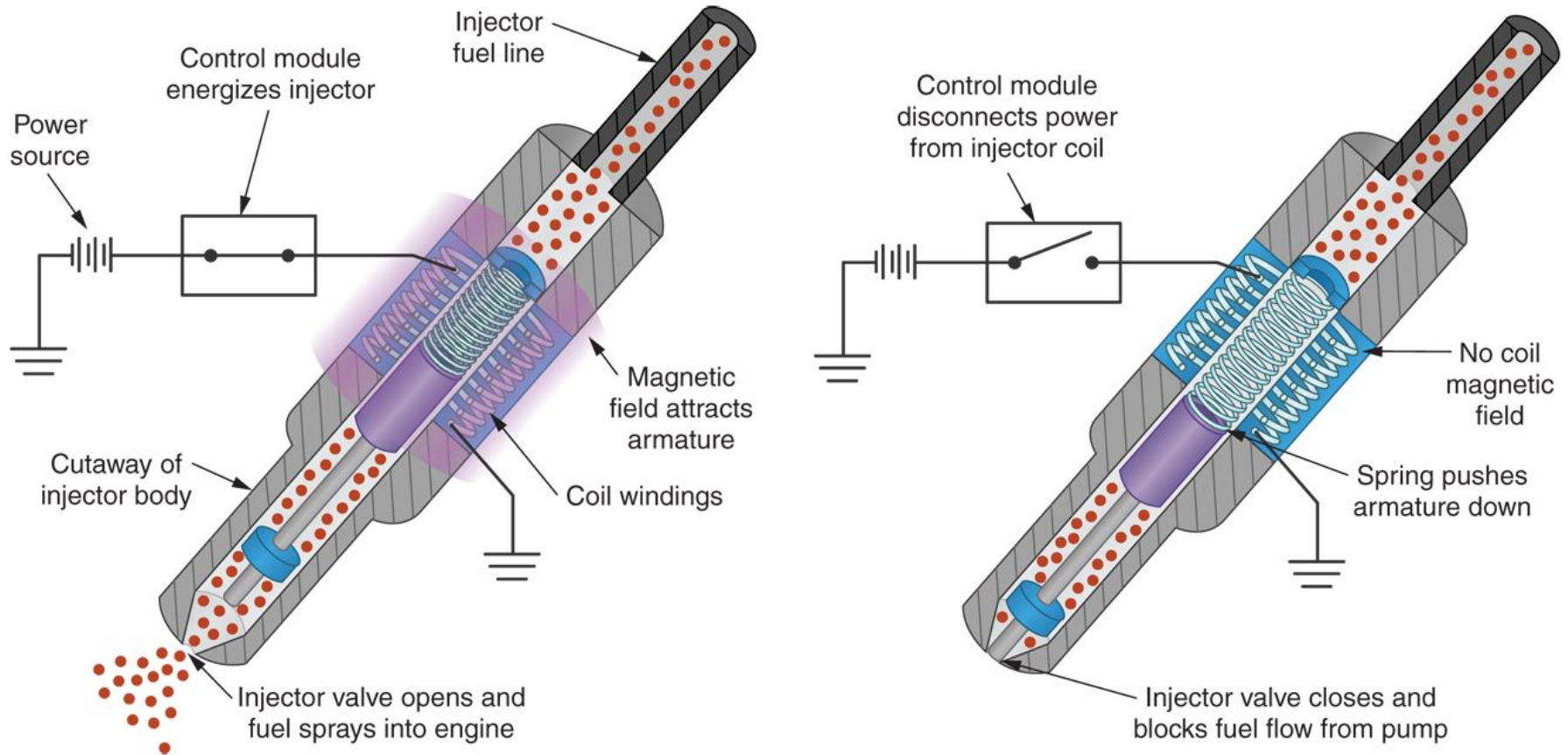
Electronic Fuel Injector Types

- Two common types of electronic fuel injectors
 - Solenoid fuel injectors
 - Electric current energized electromagnet pulls fuel valve open
 - Piezo fuel injectors
 - Electric current energized crystal expands to push fuel valve open

Solenoid Fuel Injectors

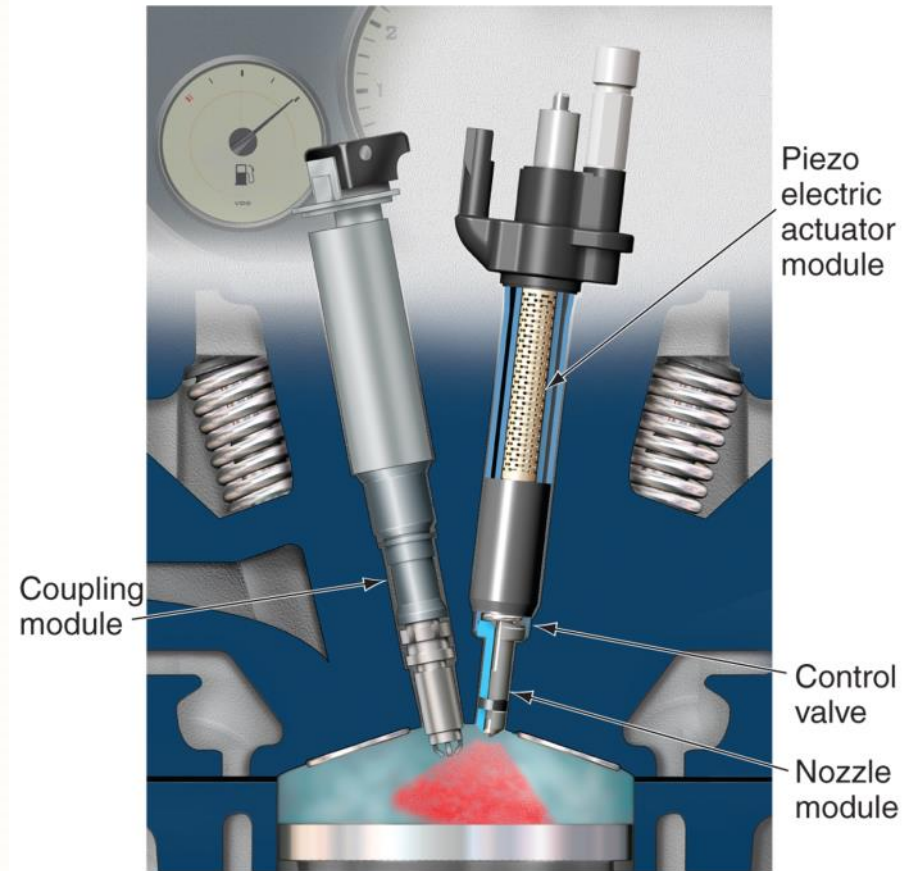
- Used in multiport system
- Typically consists of
 - Electric terminals
 - Injector solenoid
 - Inlet screen
 - Needle valve
 - Needle seat
 - Return spring
 - O-ring seal
 - Injector nozzle

Solenoid Fuel Injectors (Cont.)



Piezo Fuel Injectors

- Uses crystalline ceramic material instead of electromagnet to open injector valve
- Converts electrical energy directly into motion
- More precise

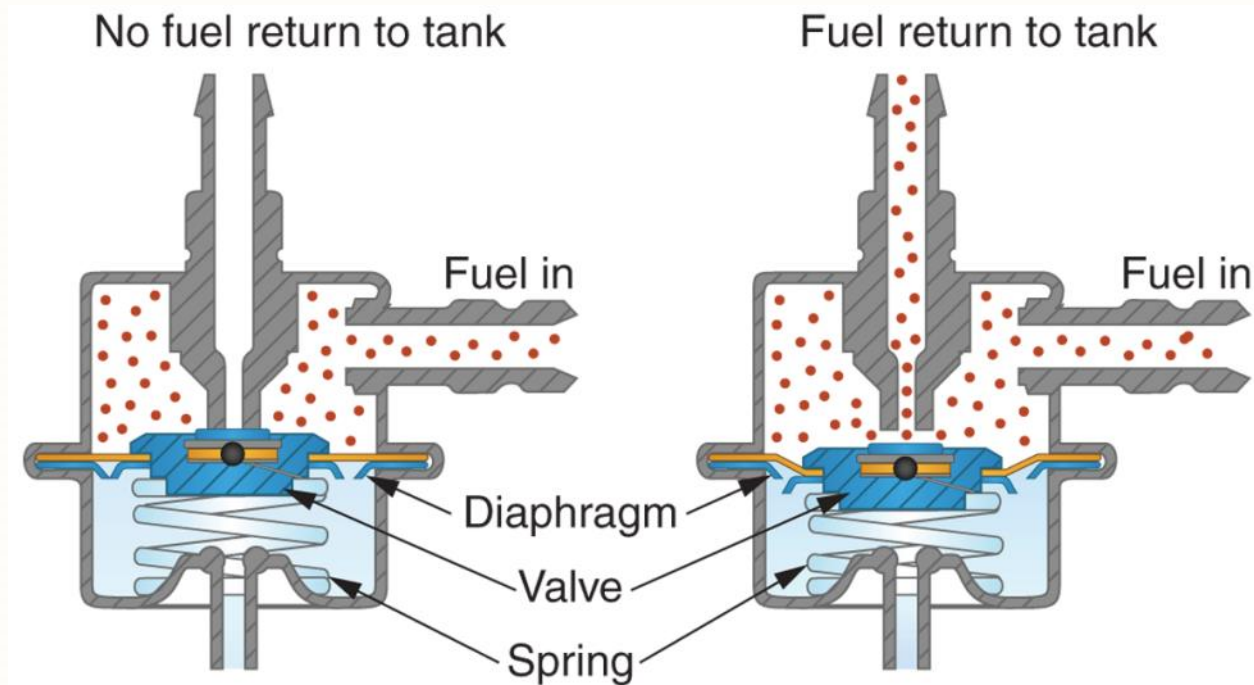


Fuel Pressure Regulator

- Fuel pressure regulator
 - Controls amount of fuel pressure in fuel rail
- DEFI fuel pressure regulator
 - Uses electric solenoid to bypass excess fuel pressure back to low pressure side of system

Fuel Pressure Regulator (Cont.)

- EFI fuel pressure regulator
- Engine vacuum, not ECM, controls fuel pressure in multiport fuel injection systems



Fuel Rail

- Fuel rail or fuel log
 - Large diameter steel tube feeds gasoline to inlet fittings of fuel injectors
- Fuel system service fitting
 - Often provided on low-pressure EFI systems for releasing and measuring fuel pressure

DEFI Amplifier Module

- DEFI amplifier
 - Increases voltage and current signal sent from ECM to operate high-pressure direct injectors
- DEFI systems often require up to 100 volts dc for proper solenoid operation

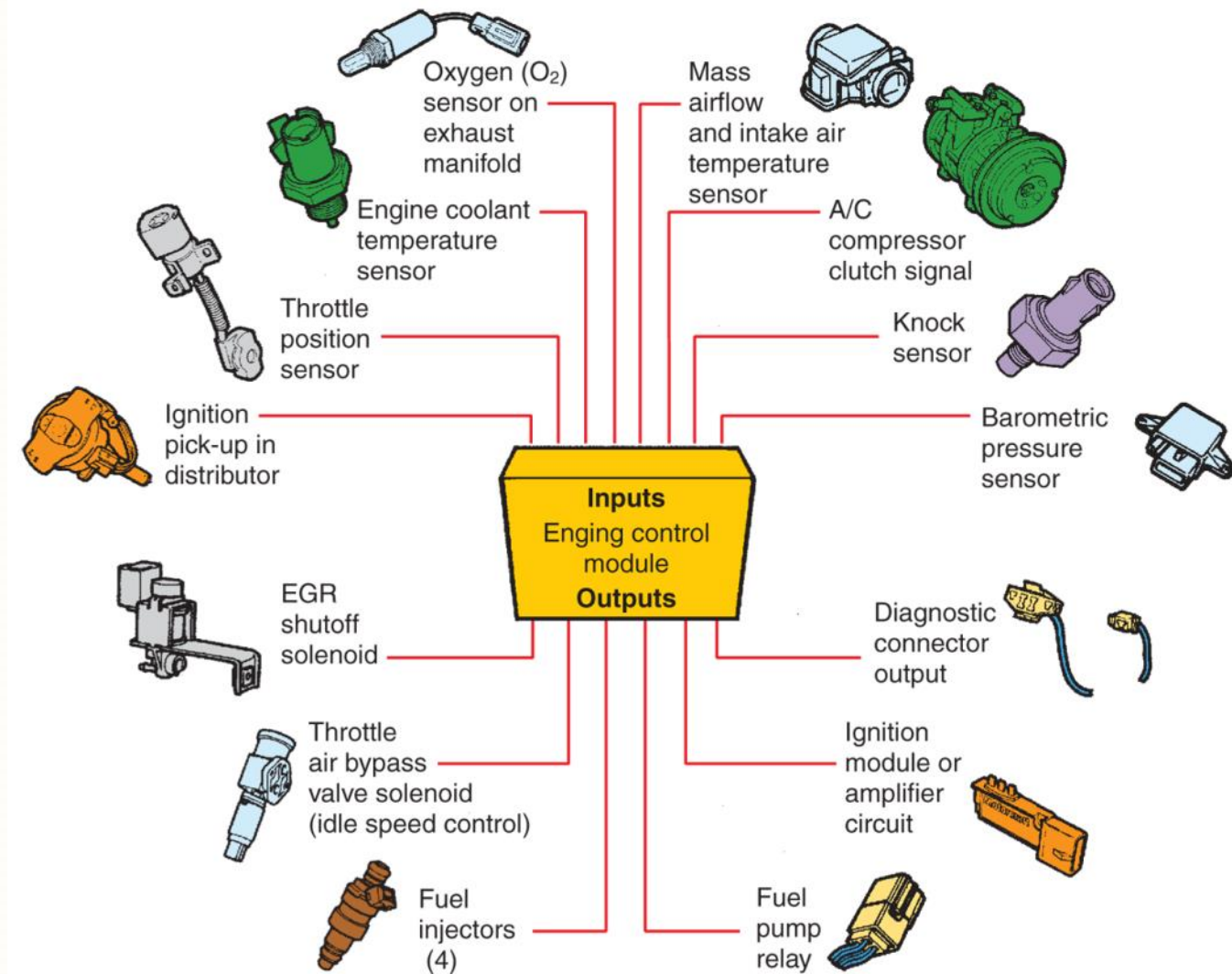
Fuel Control Sensors

- Oxygen
- Manifold absolute pressure (MAP)
- Throttle position
- Accelerator pedal
- Engine coolant temperature
- Airflow
- Intake air temperature
- Crankshaft position
- Camshaft position
- High fuel-pressure

Fuel Control Sensors (Cont.)

- Low fuel-pressure
- Fuel tank temperature
- Fuel temperature
- Vehicle speed
- Brake pedal switch
- Hybrid control module
- Traction control module

Fuel Control Sensors (Cont.)



(Ford)

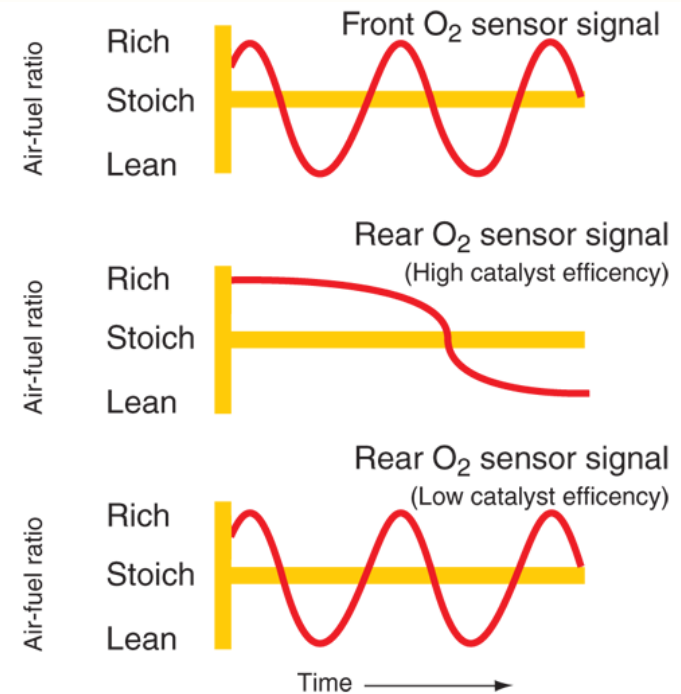
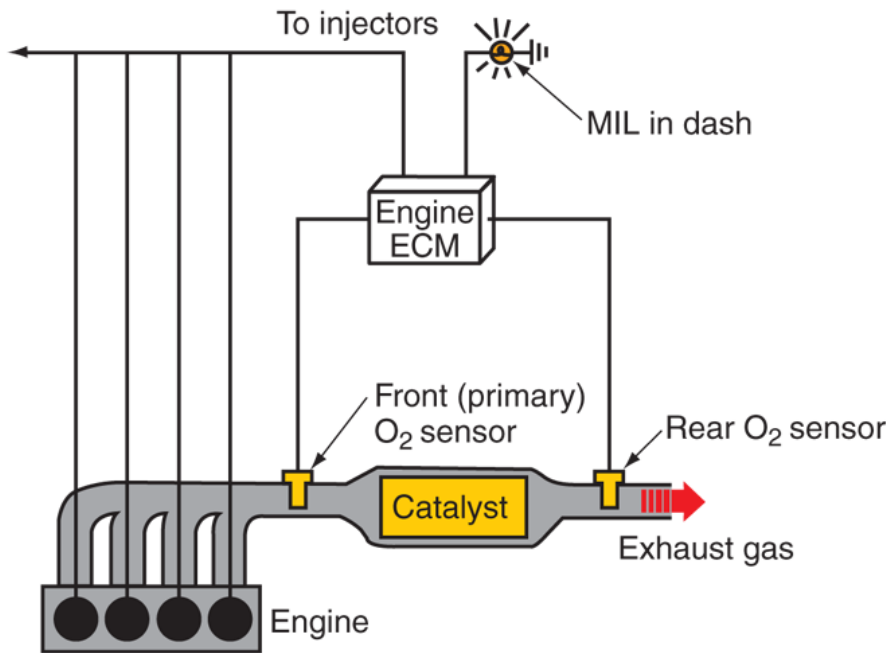
Oxygen Sensor

- Oxygen sensor, exhaust gas, or O₂ sensor
 - Measures oxygen content in exhaust gases to check combustion efficiency
- Primary oxygen sensor or front O₂ sensor
 - Monitors oxygen in exhaust gases as it leaves engine

Oxygen Sensor (Cont.)

- Secondary oxygen sensor or rear O₂ sensor
 - Mounted downstream in exhaust system
 - Primarily monitors catalytic converter
- Catalyst monitor
 - Any O₂ sensor mounted after catalytic converter

Oxygen Sensor (Cont.)



Oxygen Sensor Positions

- Oxygen sensor position
 - Assigned number by its location and order in relation to engine's banks
 - Sensor closest to number one cylinder denoted as Oxygen Sensor, Bank 1, Sensor 1

Open Loop and Closed Loop

- Open loop
 - Electronic fuel injection system does not use engine exhaust gas content as main indicator of air-fuel mixture
- Closed loop
 - Computer using information from oxygen sensor and other sensors
 - Forms imaginary loop from ECM, through fuel system, into exhaust system, and back to ECM

Narrow Band Oxygen Sensors

- Narrow band oxygen sensors
 - Can only measure combustion efficiency near stoichiometric
 - Chemically correct
- Zirconia oxygen sensors
 - Use zirconia and platinum to produce voltage output that represents oxygen in exhaust gases

Narrow Band Oxygen Sensors

(Cont.)

- Planar zirconia oxygen sensors
 - Similar to conventional zirconia sensors
 - Zirconia element, electrodes, and heater combined in flat, laminated strip
- Lean burn oxygen sensor
 - Measures oxygen content in exhaust of lean-burn engines

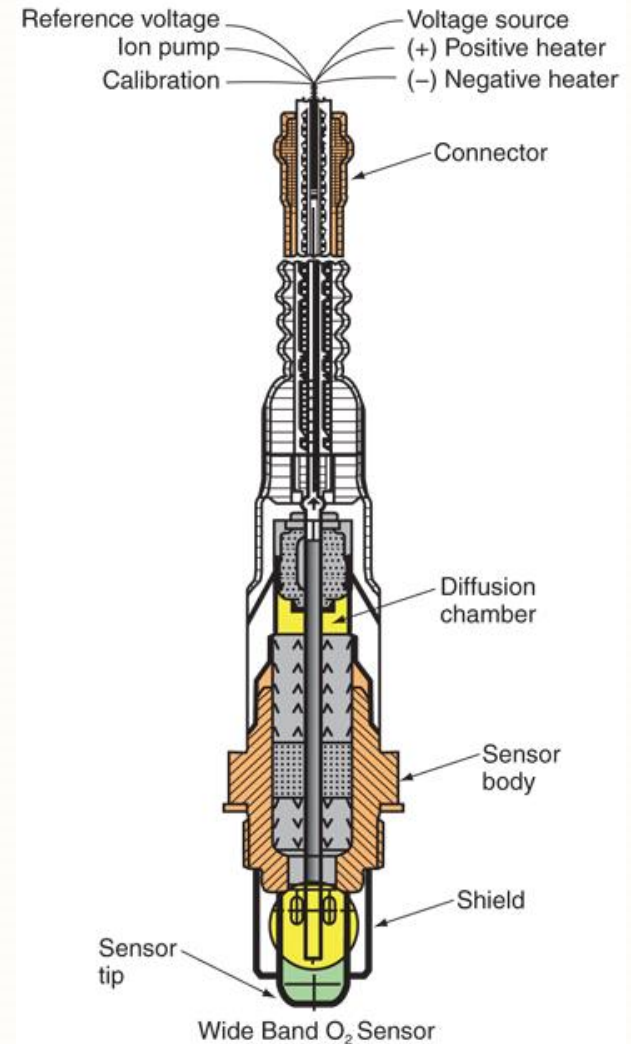
Narrow Band Oxygen Sensors

(Cont.)

- Titania oxygen sensor
 - Uses thick film of titania to detect amount of oxygen present in exhaust gases
 - Varies its internal resistance to signal ECM

Wide Band Oxygen Sensors

- Can change its output gradually and in direct proportion to oxygen content of exhaust gases
- Produces small O_2 sensor pump current representing oxygen content



Manifold Absolute Pressure Sensor

- Manifold absolute pressure (MAP) sensor
 - Measures pressure, or vacuum, inside engine intake manifold
- Excellent indicator of engine load
- Varies resistance with changes in engine load
 - Data is used by computer to alter fuel mixture

Throttle Position Sensor

- Throttle position sensor
 - Variable resistor connected to throttle plate shaft
- Different current levels produced for different throttle positions

Engine Coolant Temperature Sensor

- Engine coolant temperature sensor
 - Monitors operating temperature of engine
- Mounted so exposed to engine coolant
- When engine warms, sensor's resistance changes so ECM knows to make mixture leaner

Sensors

- Airflow sensor
 - Used in many EFI systems to measure amount of outside air entering engine
- Intake air temperature sensor
 - Measures temperature of air entering engine
- Crankshaft position sensor
 - Used to detect engine speed

Sensors (Cont.)

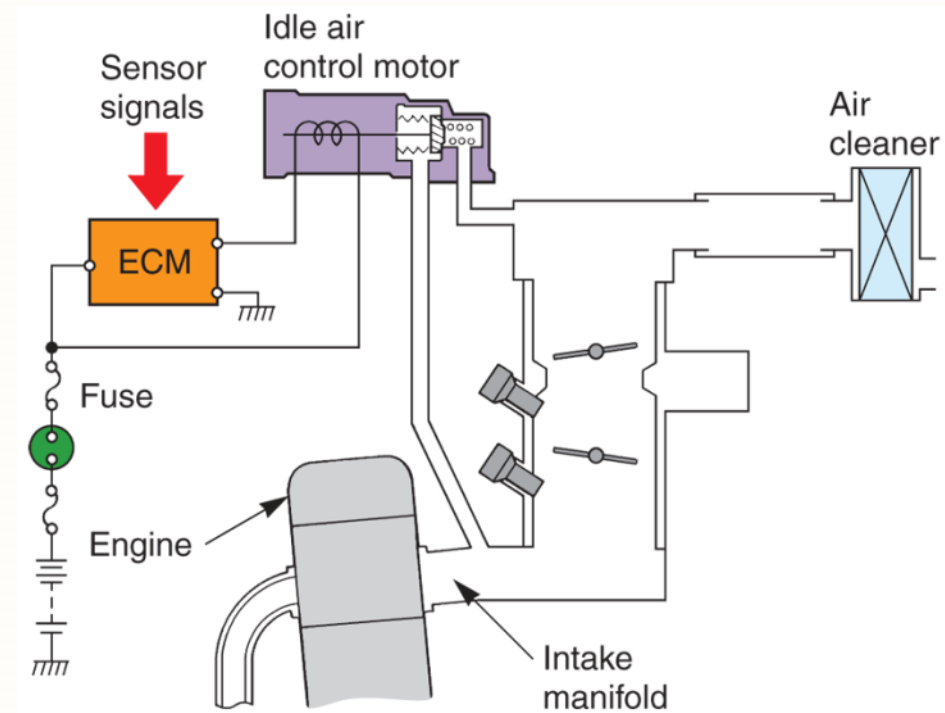
- Fuel pressure sensor
 - Mounts on fuel rail
 - Sends electronic signal, proportional to pressure inside rail
- Fuel temperature sensor
 - Monitors temperature of fuel in fuel rail

Other Sensors

- Other sensors affect fuel injection system operation
 - A/C compressor sensor
 - Transmission sensors
 - EGR sensor
 - Engine knock sensor
- Provide additional data about operating conditions affecting engine fuel needs

Engine Idle Speed Control

- Idle air control motor
 - Solenoid, or servo motor-operated air bypass valve
 - Used to help control engine idle speed
- Works like thermo or temperature-sensitive mechanical valve but ECM controlled



(Honda)