E - THEORY/OPERATION - EFI

1991 Mitsubishi Montero

1990-91 ENGINE PERFORMANCE
Chrysler/Mitsubishi Theory & Operation - Fuel Injection

All Models

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

NON-TURBOCHARGED ENGINES

All Chrysler/Mitsubishi engines with Port Fuel Injection (PFI), called Multi-Point Injection (MPI) by the manufacturer, use the same basic air induction system. Remote air filter (with airflow sensor) is ducted to a plenum-mounted throttle body.

TURBOCHARGED ENGINES

In addition to basic air induction system used on all other models, turbocharging system components include turbocharger, air-to-air intercooler, air by-pass valve, wastegate actuator, wastegate control solenoid valve and intake ducting.

Wastegate Control Solenoid Valve
Engine Control Unit (ECU) energizes solenoid valve, controlling leakage rate of turbocharger pressure to wastegate actuator.

COMPUTERIZED ENGINE CONTROLS

Multi-Point Injection (MPI) is a computerized engine control system which controls fuel injection, ignition timing, idle speed and emission control systems.

ELECTRONIC CONTROL UNIT (ECU)

NOTE: Components are grouped into 2 categories. The first category covers INPUT DEVICES, which control or produce voltage signals monitored by the Engine Control Unit (ECU). The second category covers OUTPUT SIGNALS, which are components controlled by the ECU.

ECU receives and processes signals from input devices. Such operating conditions as cold starting, altitude, acceleration and deceleration affect input device signals. Based upon signals received, ECU sends signals to various components which control fuel injection, ignition timing, idle speed and emission control systems.

INPUT DEVICES

Vehicles are equipped with different combinations of input devices. Not all input devices are used on all models. To determine

input device usage on specific models, see appropriate wiring diagram in M - WIRING DIAGRAMS.

Air Conditioner Switch

When A/C is turned on, signal is sent to ECU. With engine at idle, ECU increases idle speed through Idle Speed Control (ISC) motor.

Airflow Sensor

Incorporated in airflow sensor assembly, airflow sensor is a Karmen Vortex-type sensor which measures intake airflow rate.

Intake air flows through tunnel in airflow sensor assembly. Airflow sensor transmits radio frequency signals across direction of incoming airflow, downstream of vortex. Intake air encounters vortex, causing turbulence in tunnel.

Turbulence disrupts radio frequency, causing variations in transmission. Airflow sensor converts frequency transmitted into a proportionate electrical signal which is sent to ECU.

Airflow Sensor Assembly

Mounted inside air cleaner, incorporates airflow sensor, atmospheric pressure sensor and intake air temperature sensor.

Atmospheric (Barometric) Pressure Sensor

Incorporated in the airflow sensor assembly, converts atmospheric pressure to electrical signal which is sent to ECU. ECU adjusts air/fuel ratio and ignition timing according to altitude.

Coolant Temperature Sensor

Converts coolant temperature to electrical signal for use by ECU. ECU uses coolant temperature information for controlling fuel enrichment when engine is cold.

Crankshaft Angle & TDC Sensor Assembly

Assembly is located in distributor on SOHC engines. On DOHC engines, which use Direct (or Distributorless) Ignition System (DIS), assembly is separate unit mounted in place of distributor. Assembly consists of triggering disc (mounted on shaft) and stationary optical sensing unit. Camshaft drives shaft, triggering optical sensing unit. ECU determines crank angle and TDC based on signals received from optical sensing unit.

Detonation Sensor (Turbo Only)

Located in cylinder block, senses engine vibration during detonation (knock). Sensor converts vibration into electrical signal. ECU retards ignition timing based on this signal.

Engine Speed (Tach Signal)

ECU uses ignition coil tach signal to determine engine speed.

Idle Position Switch

On all DOHC engines and Sigma 3.0L, idle position switch is separate switch mounted on throttle body. On all other models, idle position switch is incorporated in ISC motor or throttle position sensor, depending on vehicle application. When throttle valve is closed, switch is activated. When throttle valve is at any other position, switch is deactivated. This input from idle position switch is used by ECU for controlling fuel delivery time during deceleration.

Ignition Timing Adjustment Terminal

Used for adjusting base ignition timing. When terminal is grounded, ECU timing control function is by-passed, allowing base timing to be adjusted.

Inhibitor Switch (Automatic Transmission Only)
Inhibitor switch senses position of transmission select lever, indicating engine load due to automatic transmission engagement. Based on this signal, ECU commands ISC motor to increase throttle angle, maintaining optimum idle speed.

Intake Air Temperature Sensor
Incorporated in airflow sensor assembly, this resistor-based sensor measures temperature of incoming air and supplies air density information to ECU.

Motor Position Sensor (MPS)
Incorporated in ISC motor (or separate unit on some models), senses ISC motor plunger position and sends electrical signal to ECU.

Oxygen (O2) Sensor
Located in exhaust system, generates an output voltage. Output voltage varies with oxygen content of exhaust gas stream. ECU adjusts air/fuel mixture based on signals from oxygen sensor.

Power Steering Oil Pressure Switch
Detects increase in power steering oil pressure. When power steering oil pressure increases, switch contacts close, signalling ECU. ECU commands ISC motor, raising idle speed to compensate for drop in engine RPM due to power steering load.

TDC Sensor
See CRANKSHAFT ANGLE & TDC SENSOR ASSEMBLY.

Throttle Position Sensor (TPS)
A variable resistor mounted on throttle body. ECU uses voltage signal received from TPS to determine throttle plate angle.

Vehicle Speed Sensor
Located in speedometer in instrument cluster, uses a reed switch to sense speedometer gear revolutions. ECU uses gear revolutions to determine vehicle speed.

OUTPUT SIGNALS

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

CHECK ENGINE Light
See SELF DIAGNOSTIC SYSTEM.

EGR Control Solenoid Valve
See EXHAUST GAS RECIRCULATION (EGR) CONTROL under EMISSION SYSTEMS.

Fuel Injectors
See FUEL CONTROL under FUEL SYSTEM.

Fuel Pressure Control Solenoid Valve (Turbo Only)
See FUEL DELIVERY under FUEL SYSTEM.

Fuel Pressure Regulator
See FUEL DELIVERY under FUEL SYSTEM.

Fuel Pump Relay (MPI Control Relay)

See FUEL DELIVERY under FUEL SYSTEM.

Idle Speed Control Servo
See IDLE SPEED under FUEL SYSTEM.

Power Transistor(s) & Ignition Coils
See IGNITION SYSTEMS.

Purge Control Solenoid Valve
See EVAPORATIVE CONTROL under EMISSION SYSTEMS.

Self-Diagnostic Connector
See SELF-DIAGNOSTIC SYSTEM.

Wastegate Control Solenoid Valve
See TURBOCHARGED ENGINES under AIR INDUCTION SYSTEM.

FUEL SYSTEM

FUEL DELIVERY

Electric fuel pump (located in gas tank) feeds fuel through in-tank fuel filter, external fuel filter (located in engine compartment) and fuel injector rail.

Fuel Pump
Consists of an impeller driven by a motor. Pump has an internal check valve to maintain system pressure and a relief valve to protect the fuel pressure circuit. Pump receives voltage supply from Multi-Point Injection (MPI) control relay.

Fuel Pressure Control Solenoid Valve (Turbo Only)
Prevents rough idle due to fuel percolation. On engine restart, if engine coolant or intake air temperatures reach a preset value, ECU applies voltage to fuel pressure control solenoid valve for 2 minutes after engine re-start. Valve opens, allowing atmospheric pressure to be applied to fuel pressure regulator diaphragm. This allows maximum available fuel pressure at injectors, enriching fuel mixture and maintaining stable idle at high engine temperatures.

Fuel Pressure Regulator
Located on fuel injector rail, this diaphragm-operated relief valve adjusts fuel pressure according to engine manifold vacuum.
As engine manifold vacuum increases (closed throttle), fuel pressure regulator diaphragm opens relief valve, allowing pressure to bleed off through fuel return line, reducing fuel pressure.
As engine manifold vacuum decreases (open throttle), fuel pressure regulator diaphragm closes valve, preventing pressure from bleeding off through fuel return line, increasing fuel pressure.

FUEL CONTROL

Fuel Injectors
Fuel is supplied to engine through electronically pulsed (timed) injector valves located on fuel rail(s). ECU controls amount of fuel metered through injectors based upon information received from sensors.

IDLE SPEED

Air Conditioner Relay
When A/C is turned on with engine at idle, ECU signals ISC

motor to increase idle speed. To prevent A/C compressor from switching on before idle speed has increased, ECU momentarily opens A/C relay circuit.

Idle Speed Control (ISC) Motor

Controls pintle-type air valve (DOHC engines) or throttle plate angle (SOHC engines) to regulate volume of intake air at idle.

During start mode, ECU controls idle intake air volume according to coolant temperature input. After starting, with idle position switch activated (throttle closed), fast idle speed is controlled by ISC motor and fast idle air control valve (if equipped).

When idle switch is deactivated (throttle open), ISC motor moves to a preset position in accordance with coolant temperature input.

When automatic transmission (if equipped) is shifted from Neutral to Drive, A/C is turned on or power steering pressure reaches a preset value, ECU signals ISC motor to increase engine RPM.

Fast Idle Air Control Valve

Some models use a coolant temperature-sensitive fast idle air control valve, located on throttle body, to admit additional intake air volume during engine warm-up. Control valve closes as temperature increases, restricting by-pass airflow rate. At engine warm-up, valve closes completely.

IGNITION SYSTEMS

DIRECT IGNITION SYSTEM (DIS) - DOHC ENGINES

Ignition system is a 2-coil, distributorless ignition system. Crankshaft angle and TDC sensor assembly, mounted in place of distributor, are optically controlled.

Power Transistors & Ignition Coils

Based on crankshaft angle and TDC sensor inputs, ECU controls timing and directly activates each power transistor to fire coils. Power transistor "A" controls primary current of ignition coil "A" to fire spark plugs on cylinders No. 1 and 4 at the same time. Power transistor "B" controls primary current of ignition coil "B" to fire spark plugs on cylinders No. 2 and 3 at the same time.

Although each coil fires 2 plugs at the same time, ignition takes place in only one cylinder since the other cylinder is on its exhaust stroke when plug fires.

ELECTRONIC IGNITION SYSTEM - SOHC ENGINES

Mitsubishi breakerless electronic ignition system uses a disc and optical sensing unit to trigger power transistor.

Power Transistor & Ignition Coil

Power transistor is mounted inside distributor with disc and optical sensing unit. When ignition is on, ignition coil primary circuit is energized. As distributor shaft rotates, disc rotates, triggering optical sensing unit. ECU receives signals from optical sensing unit. Signals are converted and sent to power transistor, interrupting primary current flow and inducing secondary voltage.

IGNITION TIMING CONTROL SYSTEM

Ignition timing is controlled by ECU. ECU adjusts timing based upon various conditions, such as engine temperature, altitude and detonation (turbo vehicles only).

EMISSION SYSTEMS

EXHAUST GAS RECIRCULATION (EGR) CONTROL

Federal (Non-Turbocharged)

To lower oxides of nitrogen (NOx) exhaust emissions, a non-computer controlled exhaust gas recirculation system is used. EGR operation is controlled by throttle body ported vacuum. Vacuum is routed through thermovalve to prevent EGR operation at low engine temperatures.

Spring pressure holds EGR valve closed during low vacuum conditions (engine idling or wide open throttle). When vacuum pressure increases and overcomes EGR spring pressure, EGR valve is lifted and allows exhaust gases to flow into intake manifold for combustion.

California & Turbocharged

ECU controls EGR operation by activating EGR control solenoid valve according to engine load. When engine is cold, ECU signals EGR control solenoid valve to deactivate EGR.

California models are equipped with an EGR temperature sensor. When EGR malfunction occurs, EGR temperature decreases and ECU illuminates CHECK ENGINE (malfunction indicator) light.

EGR Control Solenoid Valve

Denies or allows vacuum supply to EGR valve, based upon ECU commands.

Thermovalve

Denies or allows vacuum supply to EGR valve based on coolant temperature.

EVAPORATIVE CONTROL

Fuel evaporation system prevents fuel vapor from entering atmosphere. System consists of a special fuel tank with vapor separator tanks (if equipped), vacuum relief filler cap, overfill limiter (2-way valve), fuel check valve, thermovalve (if equipped), charcoal canister, purge control valve, purge control solenoid valve and connecting lines and hoses.

Purge Control Solenoid Valve

When engine is off, fuel vapors are vented into charcoal canister. When engine is warmed to normal operating temperature and running above idle, ECU energizes purge control solenoid valve, allowing vacuum to purge valve.

Canister vapors are then drawn through purge valve into intake manifold for burning. Purge control solenoid valve remains closed during idle and engine warm-up to reduce HC and CO emissions.

HIGH ALTITUDE CONTROL (HAC)

This system compensates for variations in altitude. When atmospheric (barometric) pressure sensor determines vehicle is above preset altitude, ECU compensates by adjusting air/fuel mixture and ignition timing. If HAC system is inoperative, there will be an increase in emissions.

PCV VALVE

Positive Crankcase Ventilation (PCV) valve operates in the closed crankcase ventilation system. Closed crankcase ventilation

system consists of PCV valve, oil separator, breather and ventilation hoses.

PCV valve is a one-way check valve, located in valve cover. When engine is running, manifold vacuum pulls PCV valve open, allowing crankcase fumes to enter intake manifold. If engine backfires through intake manifold, PCV valve closes to prevent crankcase combustion.

SELF-DIAGNOSTIC SYSTEM

Self-diagnostic system monitors input and output signals. On all models, codes can be read using analog voltmeter. On some models, scan tool can be used to read codes. For additional information, see G - TESTS W/ CODES article.

CHECK ENGINE Light

Also called Malfunction Indicator Light by manufacturer, comes on when ignition is turned on. Light remains on for several seconds after engine has started. If an abnormal input signal occurs, light comes on and code is stored in memory. If an abnormal input signal returns to normal, ECU turns light off but code remains stored in memory until cleared. If ignition is turned on again, light will not come on until ECU detects malfunction during system operation.

NOTE: ECU diagnostic memory is retained by direct power supply from the battery. Memory is not erased by turning off ignition but is erased if battery or ECU is disconnected.