E - THEORY/OPERATION

1992 Subaru SVX

1992 ENGINE PERFORMANCE
Subaru Theory & Operation

Justy, Legacy, Loyale, SVX

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

TURBOCHARGERS

Legacy uses a water-cooled turbocharger mounted on exhaust crossover pipe. A wastegate assembly is attached to rear of turbine housing. Turbocharger consists of a turbine/compressor assembly, oil supply system, wastegate valve, and wastegate control solenoid valve. Other components include impellers, impeller shaft, bearings and impeller housings.

If intake boost pressure exceeds safe limits, engine damage may result. To prevent excessive intake boost pressure, system uses a pressure-actuated wastegate valve as a limiting device. Wastegate valve opens when intake pressure exceeds a predetermined limit, allowing exhaust gases to by-pass compressor.

Turbocharger operation requires a large quantity of clean oil to prevent bearing failure. Engine oil pressure provides constant lubrication to system.

Wastegate Control Solenoid Valve

Located in pressure line between intake manifold and wastegate valve, this duty solenoid compensates for reduced intake air volume due to high altitude. When Electronic Control Unit (ECU) energizes solenoid, valve closes. This restricts pressure line, eliminating wastegate valve by-pass function. Boost pressure is then unregulated (full volume). This maintains maximum allowable boost under high altitude conditions.

COMPUTERIZED ENGINE CONTROLS

Carbureted

Electronic Fuel Control (EFC) system is a computer-ized fuel, ignition and emission control system designed to maintain fuel economy and reduce vehicle emissions. An Electronic Control Unit (ECU) monitors data from various sensors and controls such functions as carburetor air/fuel mixture ratio, ignition timing and emission control devices.

Port Fuel Injection (PFI)

PFI system is a computerized fuel, ignition and emission control system designed to maintain fuel economy and reduce vehicle emissions. Fuel is metered to intake system through a separate injector, mounted in intake manifold next to intake valve, for each cylinder. An Electronic Control Unit (ECU) monitors data from various sensors and controls such functions as fuel injector pulse width ("on" time), ignition timing and emission control devices.

Throttle Body Injection (TBI)

TBI system is a computerized fuel, ignition and emission control system designed to maintain fuel economy and reduce vehicle emissions. Fuel is metered to intake system through a single fuel injector, mounted to a throttle body on intake manifold. An Electronic Control Unit (ECU) monitors data from various sensors and controls such functions as fuel injector pulse width ("on" time), ignition timing and emission control devices.

ELECTRONIC CONTROL UNIT (ECU)

All Systems

If a system fault (malfunction) occurs, a built-in fail-safe mechanism within ECU controls fuel and ignition system functions according to preprogrammed values. This allows vehicle to be driven, but performance may not be optimal.

A self-diagnostic function allows ECU to store trouble codes in its memory. If a system fault occurs, CHECK ENGINE light will come on to inform driver of system problems and trouble code will be stored. For further self-diagnostic system information, see G - TESTS W/ CODES article in the ENGINE PERFORMANCE Section.

INPUT DEVICES (CARBURETED)

NOTE: Components are grouped into 2 categories. First category covers INPUT DEVICES, which control or produce voltage signals monitored by ECU. Second category covers OUTPUT SIGNALS, which are components controlled by ECU.

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

A/C-On Signal

When A/C is turned on, ECU receives voltage signal and activates idle-up system. See IDLE SPEED under FUEL SYSTEM (CARBURETED).

Coolant Temperature Sensor

ECU applies reference voltage signal to this thermistor. Resistance value of sensor changes with variations in coolant temperature, causing reference voltage to increase or decrease. Sensor is equipped with 2 terminals. One terminal is used for ECU; other terminal is used for temperature gauge.

Crank Angle Sensor (Engine Speed Sensor)

Crank angle sensor is a magnetic pick-up coil sensing mechanism located in distributor. Sensor provides crankshaft angle and engine RPM inputs to ECU.

Electrical Loads

When headlights, heater blower or rear defogger are turned on, ECU receives voltage signal and activates idle-up system. See IDLE SPEED under FUEL SYSTEM (CARBURETED).

Oxygen (O2) Sensor

Sensor generates voltage according to exhaust gas oxygen content. Voltage increases when oxygen content is low (rich), and decreases when oxygen content is high (lean). ECU determines air/fuel ratio based on voltage generated.

Vacuum/Pressure Sensor & Vacuum Line Control (VLC) Solenoid Valve

Detects changes in intake manifold vacuum and atmospheric pressure. Solenoid valve, located in line between intake manifold and vacuum/pressure sensor, receives voltage signal from ECU. With no voltage applied to solenoid valve, sensor monitors intake manifold vacuum. With voltage applied to solenoid valve, sensor monitors atmospheric pressure.

Vehicle Speed Sensor

ECU supplies voltage signal to one side of a tiny reed switch located in speedometer assembly. Speedometer cable revolutions open and close reed switch, providing ECU with continuity/no continuity input. ECU converts this signal to vehicle speed.

OUTPUT SIGNALS (CARBURETED)

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 of each output component, refer to indicated system.

Canister Purge Control Solenoid (CPCS) Valve

See FUEL EVAPORATIVE SYSTEM under EMISSION SYSTEMS.

CHECK ENGINE Light

See SELF-DIAGNOSTICS.

Coasting Fuel Cut (CFC) Solenoid

See FUEL CONTROL under FUEL SYSTEM (CARBURETED).

Duty Solenoid Valve (DSV)

See FUEL CONTROL under FUEL SYSTEM (CARBURETED).

EGR Control Solenoid Valve

See EXHAUST GAS RECIRCULATION (EGR) under EMISSION SYSTEMS.

Float Bowl Vent Solenoid (FBVS)

See FUEL EVAPORATIVE SYSTEM under EMISSION SYSTEMS.

Fuel Pump Relay

See FUEL DELIVERY under FUEL SYSTEM (CARBURETED).

High Altitude Compensator (HAC) Solenoid Valve (Federal)

See FUEL CONTROL under FUEL SYSTEM (CARBURETED).

Idle-Up Control Solenoid Valve (ICSV)

See IDLE SPEED under FUEL SYSTEM (CARBURETED).

Power Transistor

See IGNITION SYSTEMS.

Self-Diagnostics

See SELF-DIAGNOSTICS.

Vacuum/Pressure Sensor & Vacuum Line Control (VLC) Solenoid Valve

See INPUT DEVICES (CARBURETED).

INPUT DEVICES (FUEL INJECTED)

NOTE: Components are grouped into 2 categories. First category is

INPUT DEVICES, which are components than control or produce voltage signals monitored by ECU. Second category is OUTPUT SIGNALS, which are components controlled by ECU.

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

A/C Switch
Signals ECU of A/C operation.

Airflow Meter (Except Justy)
Hot-wire type airflow meter uses heat transfer between incoming air and a heating resistor (located in air intake), to convert air flowing into engine to an electric signal.

Air Temperature Sensor (Justy)
ECU applies reference voltage signal to air-temperature sensitive thermistor installed on air cleaner housing. Reference voltage increases and decreases with variations in air temperature.

Atmospheric Pressure Sensor
Sensor is a component part of ECU. ECU uses this signal to compensate for variations in altitude, which affect air/fuel mixture ratios.

Cam Angle Sensor (Legacy)
Sensor is located on camshaft support, on left cylinder bank. Pick-up coil acts as triggering device. Based on signals received from triggering device, ECU distinguishes No. 1 cylinder from other cylinders. ECU then uses these signals to trigger distributorless ignition system and fuel injectors.

Coolant Temperature Sensor
ECU applies reference voltage signal to thermistor. Resistance value of sensor changes with variations in coolant temperature, causing reference voltage to increase or decrease.

Crank Angle & TDC (Cylinder Identification) Sensor Assembly (Justy & Loyale)
Assembly is located in distributor. On Justy, pick-up coil acts as triggering device. On Loyale, optical sensing unit (light emitting diode) acts as triggering device. Based on signals received from triggering device, ECU determines crankshaft angle and identifies No. 1 cylinder. Based on these signals, ECU triggers ignition system and fuel injector(s).

Crank Angle Sensor (Legacy & SVX)
Sensor is installed on oil pump, at front center of cylinder block. Pick-up coil acts as triggering device. Based on signals received from triggering device, ECU determines crankshaft angle. Based on these signals, ECU triggers distributorless ignition system and fuel injectors.

Detonation (Knock) Sensor
Installed on cylinder block, this sensor responds to cylinder block vibrations resulting from detonation. If detonation occurs, a voltage is generated and sent to ECU. Based on voltage received, ECU retards spark timing until detonation stops.

Idle Switch

Switch signals ECU of closed throttle condition.

Inhibitor Switch (A/T)
Switch signals ECU of transmission gear position.

Neutral & Park Switches
Switch signals ECU of transmission gear position.

Oxygen (O2) Sensor
Sensor generates voltage according to exhaust gas oxygen content. Voltage increases when oxygen content is low (rich), and decreases when oxygen content is high (lean). ECU determines air/fuel ratio based on voltage generated.

Pressure Switch (Turbo)
Mounted in front of body strut mount, this switch closes when intake manifold vacuum reaches about 2 in. Hg. This causes TURBO indicator light to glow, indicating turbocharging operation is in effect.

Throttle Sensor (Except Justy)
Throttle sensor contains a potentiometer (variable resistor) and an idle switch. Throttle position sensor sends ECU a potentiometer output signal corresponding to opening of throttle valve. Idle switch signal occurs when throttle is near idle position. ECU uses these signals to control air/fuel ratio during acceleration, deceleration and idling.

Throttle Switch (Justy)
This switch, attached to end of throttle shaft, informs ECU that throttle valve is closed, wide open (at least 50 degrees), or somewhere in between. This is NOT a variable resistor.

Vehicle Speed Sensor
ECU supplies voltage signal to one side of a tiny reed switch located in speedometer assembly. Speedometer cable revolutions open and close reed switch, providing ECU with continuity/no continuity input. ECU converts this signal to vehicle speed.

OUTPUT SIGNALS (FUEL INJECTED)

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 of each output component, refer to indicated system.

By-Pass Air Control Valve
See IDLE SPEED under FUEL SYSTEM (FUEL INJECTED).

Canister Purge Control (CPC) Solenoid Valve
See FUEL EVAPORATIVE SYSTEM under EMISSION SYSTEMS.

CHECK ENGINE Light
See SELF-DIAGNOSTICS.

Detonation (Knock) Sensor
See IGNITION TIMING CONTROL SYSTEM under IGNITION SYSTEMS.

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

Fast Idle Control Device (FICD) Solenoid Valve
See IDLE SPEED under FUEL SYSTEM (FUEL INJECTED).

Fuel Injector(s)
See FUEL CONTROL (TBI) or FUEL CONTROL (PFI) under FUEL SYSTEM (FUEL INJECTED).

Fuel Pump Relay
See FUEL DELIVERY under FUEL SYSTEM (FUEL INJECTED).

Power Transistor
See IGNITION SYSTEMS.

Self-Diagnostics
See SELF-DIAGNOSTICS.

FUEL SYSTEM (CARBURETED)

FUEL DELIVERY

Fuel Pump
Electric fuel pump is located on crossmember, under center of floor. Flow rate of fuel changes as pressure varies on delivery side. This controls required quantity of fuel delivered.

Fuel Pump Relay
ECU provides power supply and ground for control circuit in fuel pump relay. When ignition is turned on with engine off, ECU energizes fuel pump relay for 3 seconds, activating fuel pump. After 3 seconds, unless ECU receives crank angle signal, ECU will stop energizing fuel pump relay.

FUEL CONTROL

Coasting Fuel Cut (CFC) Solenoid
Located in carburetor, this solenoid responds to voltage signal from ECU to adjust air/fuel mixture through idle circuit during deceleration. This prevents rich air/fuel mixtures during deceleration.

Duty Solenoid Valve (DSV)
Located in carburetor, this ECU-controlled solenoid cycles on and off to control air/fuel mixture ratio entering slow speed and main metering passages.

Electric Choke
When fuel pump relay is energized, voltage is applied to electric choke heater element. Voltage is applied to choke heater under same conditions as fuel pump. See FUEL PUMP RELAY under FUEL DELIVERY under FUEL SYSTEM (CARBURETED).

High Altitude Compensator (HAC) Solenoid Valve (Federal)
To compensate for richer air/fuel mixtures at higher altitudes (26.38 in. Hg or less), HAC admits air into main metering passage. ECU energizes HAC solenoid when vacuum/pressure sensor indicates barometric pressure has reached predetermined specification. This opens valve, admitting more air into main metering passage.

Hot Idle Compensator
Bimetallic heat sensor in air filter housing allows more idle air through idle circuit at high engine temperatures.

IDLE SPEED

Idle-Up Control Solenoid Valve (ICSV)

ICSV compensates for decrease in engine RPM due to cold engine temperatures, increased electrical load (alternator loading) and A/C operation. See INPUT DEVICES (CARBURETED).

When ECU receives input signals indicating engine RPM has dropped, ECU energizes ICSV. ICSV controls vacuum supply to throttle opener diaphragm. When vacuum is applied to throttle opener diaphragm, throttle plate opens to compensate for a decrease in engine RPM.

FUEL SYSTEM (FUEL INJECTED)

FUEL DELIVERY

Fuel Pump

Impeller-type pump is used. On Justy, Legacy and SVX, fuel pump is located in fuel tank. On Loyale, fuel pump is mounted to underbody, near fuel tank.

On all models, fuel pump pressurizes fuel through in-line filter, to fuel injector rail. Fuel pump receives battery power through fuel pump relay.

Fuel Pump Relay

ECU energizes fuel pump relay based on inputs from ignition switch and ignition coil. During cranking, ignition switch cranking circuit supplies current to energize fuel pump relay. After engine starts and key is released to RUN position, ECU provides fuel pump relay ground. This activates fuel pump.

Fuel Pressure Regulator

Regulator maintains constant fuel system pressure by bleeding fuel at injector rail back to fuel tank. Intake manifold vacuum acts on regulator diaphragm to control position of bleed-off valve in regulator.

Fuel Pulsation Damper (Justy)

This device, located on fuel injector rail, absorbs fuel pressure pulsations.

FUEL CONTROL (TBI)

Fuel Injector

Fuel is supplied to engine through a single throttle body injector valve mounted to intake manifold. ECU controls injectors' energized time (pulse width), which affects amount of fuel metered through injectors. ECU triggers injectors based on signals received from crank angle sensor.

FUEL CONTROL (PFI)

Fuel Injectors

Fuel is supplied to engine through injector valves located at intake manifold, near intake valve opening. ECU controls injectors' energized time (pulse width), which affects amount of fuel metered through injectors. ECU triggers injectors based on signals received from crank angle sensor.

IDLE SPEED

By-Pass Air Control Valve (Legacy)

Valve consists of coolant temperature-sensitive bimetallic valve and ECU-controlled duty solenoid. Bimetallic valve compensates for varying engine temperatures. ECU cycles duty solenoid on and off,

regulating amount of air by-passing throttle valve. System compensates for idle speed decreases due to following conditions: cold engine temperatures, A/C operation and electrical loads (alternator loading). System also provides dashpot function to prevent rich air/fuel mixture ratios during deceleration.

By-Pass Air Control Valve (Loyale)

An air passage by-passing throttle valve is provided to control idle air intake volume. ECU cycles duty solenoid on and off, regulating amount of air by-passing throttle valve. System compensates for idle speed changes due to cold engine temperatures, A/C operation, and varying altitude.

Fast Idle Control Device (FICD) Solenoid Valve (Justy)

Valve is located in line between air filter housing and intake manifold. WhenA/C is turned on, ECU energizes solenoid valve. Solenoid valve will open, allowing fresh air to by-pass throttle valve through solenoid valve, into intake manifold.

Idle Speed Control (ISC) Solenoid Valve (Justy)

Valve is mounted on air filter housing, in line between air filter housing and intake manifold. At idle, ECU opens and closes solenoid valve. This allows fresh air to by-pass throttle valve through solenoid valve, into intake manifold.

Thermal Air Valve (Justy)

Coolant temperature-sensitive wax pellet valve allows idle air to by-pass throttle valve. This increases idle RPM during cold engine conditions.

IGNITION SYSTEMS

POWER TRANSISTOR

Power transistor acts as primary current switching device for ignition system. When ECU signals power transistor base, primary current is allowed to flow to ground.

DISTRIBUTOR (MAGNETIC)

Justy

Magnetic pick-up coil sensing mechanism (crank angle sensor) in distributor signals ECU of crankshaft angle, and distinguishes between No. 1 cylinder and other cylinders. Based on these inputs, ECU signals power transistor base, allowing primary current to flow to ground through ignition coil.

On carbureted engines, ignition coil receives battery voltage from ignition switch. On PFI engines, ignition coil receives battery voltage from ignition relay. Ignition relay is energized with ignition switch in ON or START position.

DISTRIBUTOR (OPTICAL)

Loyale

Optical sensing unit (crank angle sensor) in distributor signals ECU of crankshaft angle and identifies No. 1 cylinder. System consists of distributor (crank angle sensor), ignition coil and power transistor.

Based on input from crank angle sensor, ECU signals base of power transistor. This allows primary current flow to ground. Ignition coil receives primary power supply when ignition coil relay is energized.

DISTRIBUTORLESS

Legacy

Distributorless ignition system is controlled by ECU. System consists of 2 ignition coils and a power transistor assembly. Power transistor assembly consists of 2 transistors, which control primary current path to ground for each ignition coil. One transistor controls primary path to ground for ignition coil, which fires cylinders No. 1 and 2. Other transistor controls primary path to ground for ignition coil, which fires cylinders No. 3 and 4.

Although each coil fires 2 plugs simultaneously, ignition takes place in only one cylinder, since other cylinder is on its exhaust stroke when plug fires. Based on input from crankshaft and camshaft angle sensors, ECU signals base of appropriate power transistor. This allows primary current flow to ground. Ignition coils receive primary power supply when ignition coil relay is energized.

SVX

Distributorless ignition system is controlled by ECU. System consists of 6 ignition coils (mounted directly to spark plugs), 2 detonation (knock) sensors and 2 crank angle sensors.

ECU determines ignition timing based on signal from crank angle sensor and sends signal to ignitor to create a spark at cylinder which is judged to be at compression TDC.

IGNITION TIMING CONTROL SYSTEM

Detonation (Knock) Sensor

When engine knock (detonation) is present, a signal is generated by knock sensor and is sent to ECU. ECU retards spark timing until engine knocking stops, then gradually advances spark timing.

Ignition Timing Advance Control

On all models, ignition timing advance is controlled by ECU. Based on sensor input signals, ECU adjusts ignition timing to preprogrammed advance and retard specifications.

EMISSION SYSTEMS

PULSE AIR INJECTION SYSTEM

Justy (Carbureted)

Air injection system reduces exhaust emissions by oxidizing hydrocarbons (HC) and carbon monoxide (CO). System is composed of a one-way air suction valve (pulse air valve), air cleaner, various hoses and tubing.

Negative pressure from exhaust pulsation reaches suction valve through a suction pipe. This causes reeds in suction valve to open. Secondary (fresh) air from air cleaner is drawn into exhaust passages. When positive pressure is present in exhaust, reeds are closed to prevent reverse flow of exhaust gas.

EXHAUST GAS RECIRCULATION (EGR)

Justy (Carbureted), Loyale & SVX

EGR lowers oxides of nitrogen (NOx) exhaust emissions by admitting exhaust gases back into intake system. Exhaust gases lower peak combustion temperatures, which lowers NOx emissions.

EGR Control Solenoid Valve

EGR valve diaphragm receives operating vacuum through EGR

control solenoid valve. ECU controls operation of EGR control solenoid valve.

FUEL EVAPORATIVE SYSTEM

Canister Purge Control Solenoid (CPCS) Valve

On models with Canister Purge Control Valve (CPCV), CPCS valve is located in vacuum signal line between CPCV and ported vacuum source. See CANISTER PURGE CONTROL VALVE (CPCV). Under certain conditions, ECU energizes CPCS valve. This allows ported vacuum signal to CPCV.

On models without CPV, CPC solenoid valve is located in purge line between canister and ported vacuum source. Under certain conditions, ECU energizes CPCS valve, allowing ported vacuum to purge canister.

Canister Purge Control Valve (CPCV)

Located on top of canister, vacuum-controlled valve opens and closes purge line between intake manifold and canister. CPCV valve remains closed at idle because ported vacuum activates its control diaphragm. When vacuum activates control diaphragm, purge line is opened, and stored vapors are free to be drawn into intake manifold.

Fuel Bowl Vent Solenoid (FBVS)

When ignition is off, this solenoid valve remains open to allow float bowl vapor to escape to canister. When ignition switch is in ON or START position, ECU energizes FBVS valve, blocking passage between float bowl and canister.

POSITIVE CRANKCASE VENTILATION (PCV)

PCV system draws crankcase blow-by, vapors and gases into combustion system rather than allowing them to escape into atmosphere. Crankcase gases mix with air/fuel mixture, and are burned in combustion chamber. When engine is running, manifold vacuum pulls PCV valve open, allowing crankcase fumes to enter intake manifold. If engine backfires, PCV valve is forced closed, stopping flow of gases. This prevents ignition of fumes in crankcase.

THERMOSTATIC AIR CLEANER (TAC)

Justy (Carbureted)

TAC reduces exhaust emissions by maintaining a uniform intake air temperature. System consists of an air cleaner housing, air stove on exhaust pipe, and air intake hose between air cleaner and manifold stove. Air cleaner housing contains an air control diaphragm, air control valve, temperature sensor valve, flame arrester, and connecting tubes and hoses.

SELF-DIAGNOSTICS

CHECK ENGINE LIGHT

All vehicles are equipped with a CHECK ENGINE light on instrument panel. Light illuminates when ignition switch is turned to ON position (bulb check), and when system malfunctions occur. For additional information, see G - TESTS W/ CODES article in the ENGINE PERFORMANCE Section.