Signature and ISX CM870 Electronics
System Description

General Information
The Signature and ISX CM870 engine control system is an electronically operated fuel control system that also provides many operator and vehicle features.

The base functions of the control system include fueling and timing control, limiting the engine speed operating range between the low and high idle set points and reducing exhaust emissions while optimizing engine performance. The system also controls the engine brakes.

The control system uses inputs from the operator and its sensors to determine the fueling and timing required to operate at the desired engine speed at the required emissions level.

ECM Inputs
The electronic control module (ECM) is the control center of the system. It processes all of the inputs and sends commands to the fuel system, vehicle and engine control devices.

The ECM performs diagnostic tests on most of its circuits and will activate a fault code if a problem is detected in one of these circuits. Along with the fault code identifying the problem, a snapshot of engine operating parameters at the time of fault activation is also stored in memory.

Active fault codes will cause a diagnostic lamp to activate to signal the driver.

The ECM can communicate with service tools and some other vehicle controllers (such as transmissions, ABS, ASR, electronic dash displays and so on) through the SAE J1939 data link or the SAE J1708 data link.

Some vehicles and equipment will have SAE J1939 networks on them that link many of the “smart” controllers together. Vehicle control devices can temporarily command engine speed or torque to perform one of its functions (that is, transmission shifting, anti-lock braking and so on).
The Signature, ISX engines with EGR use separate wiring harnesses to control the engine and some vehicle operations. There are three connectors for the wiring harnesses. In the picture shown, the following harnesses connect to the ECM from left to right:

1. ECM power harness
2. Engine harness
3. OEM harness.

The control system utilizes a number of sensors to provide information on engine operating parameters. These sensors include:

1. Intake manifold pressure sensor
2. Intake manifold air temperature sensor
3. Engine and camshaft position sensor
4. Engine coolant temperature sensor
5. Fuel shutoff solenoid.

6. Engine oil temperature sensor
7. Engine oil pressure sensor
8. Wet tank pressure sensor
9. Water-in-fuel sensor
10. Turbocharger speed sensor
11. Rail fuel pressure sensor.

12. EGR differential pressure sensor
13. Exhaust pressure sensor
14. EGR temperature sensor
15. EGR valve position sensor
16. EGR valve motor
17. Fuel lift pump
18. Fuel temperature sensor
19. Timing actuators
20. Fueling actuators.
• Engine coolant temperature sensor

The engine coolant temperature sensor is used by the electronic control module (ECM) to monitor the engine coolant temperature. The ECM monitors the voltage on the signal pin and converts this to a temperature value. The engine coolant temperature value is used by the ECM for the engine protection system and engine emissions control.

• Intake manifold pressure sensor

The intake manifold pressure sensor monitors intake manifold pressure and passes information to the electronic control module (ECM) through the engine harness. If intake manifold pressure becomes too low, it will cause a derate condition.

• Intake manifold air temperature sensor

The intake manifold air temperature sensor monitors intake manifold air temperature and passes information to the electronic control module (ECM) through the engine harness.

• Engine oil pressure sensor

The engine oil pressure sensor is used by the electronic control module (ECM) to monitor the lubricating oil pressure. The ECM monitors the voltage on the signal pin and converts this to a pressure value. The oil pressure value is used by the ECM for the engine protection system.
• Engine oil temperature sensor

The engine oil temperature sensor is used by the electronic control module (ECM) to monitor engine oil temperature. The ECM monitors the voltage on the signal pin and converts this to a temperature value. The oil temperature value is used by the ECM for the engine protection system and engine emissions control.

• Engine speed sensor

The engine speed sensor monitors engine speed and position then passes this information to the electronic control module (ECM) through the engine harness.

• Camshaft position sensor

The camshaft position sensor monitors camshaft position then passes this information to the electronic control module (ECM) through the engine harness.

• Barometric pressure sensor

The barometric pressure sensor is used by the electronic control module (ECM) to monitor the barometric pressure. This value is one of many inputs used by the ECM to maintain the correct air to fuel ratio for proper engine operation.
• Rail fuel pressure sensor

The rail fuel pressure sensor is used by the electronic control module (ECM) to monitor fuel pressure at the fuel rail inside the IFSM.

• Water-in-fuel sensor

The water-in-fuel sensor monitors fuel for the presence of water and passes this information to the electronic control module (ECM) through the engine harness. The water-in-fuel sensor is located in the pre-filter (OEM supplied).

• EGR valve position sensor

The EGR valve position sensor outputs a voltage signal to the ECM. The ECM converts this signal into a percentage value from 0 to 100 indicating valve position. A fully open valve is equivalent to 100 percent. The engine harness is connected to the EGR valve by an EGR valve extension harness. This extension harness contains five wires, three for the EGR valve position sensor and two for the EGR valve motor.

• EGR temperature sensor

The EGR temperature sensor is used to measure the temperature of the exhaust gas that exits the EGR cooler. The ECM uses this temperature to control emission levels of the engine.
• Exhaust gas pressure sensor

The exhaust gas pressure sensor is used to measure exhaust gas pressure in the exhaust manifold. This information is used by the ECM to control emissions and EGR valve operation.

• EGR differential pressure sensor

The EGR differential pressure sensor measures the exhaust gas pressure drop across the EGR differential pressure orifice. This pressure drop is used to calculate the amount of EGR flow into the intake manifold.

• Turbocharger speed sensor

The turbocharger speed sensor is a variable reluctance speed sensor. It consists of a coil of wire and an iron core. A signal is generated as the turbocharger shaft spins. The target on the turbocharger shaft is a ground flat in the center of the shaft.

• Turbocharger compressor inlet air temperature sensor

The turbocharger compressor inlet temperature sensor is used by the electronic control module (ECM) to monitor the air temperature entering the turbocharger. The ECM monitors the voltage on the signal pin and converts this to a temperature value. The temperature is one of many inputs used by the ECM to control engine operation and emissions.
• Turbocharger control shutoff valve

The turbocharger control shutoff valve prevents the bleed off of air from the vehicle brake air tanks when the engine is shut down.

• Turbocharger control valve

The ECM controls the turbocharger nozzle ring position with the turbocharger control valve. The turbocharger control valve routes vehicle brake air to the turbocharger VGT actuator when commanded by the ECM. This is a PWM signal.

• Real-Time clock battery

Under ordinary operating conditions, the real-time clock in the ECM is powered by the vehicle's batteries. If battery power to the ECM is lost, then the real-time clock will be powered by a battery in the engine harness (if equipped).

• Engine fuel temperature sensor

The engine fuel temperature sensor is used by the electronic control module (ECM) to monitor engine fuel temperature. The ECM monitors the voltage on the signal pin and converts this to a temperature value. Fuel temperature is used by the ECM to adjust fuel delivery to the injectors.
• Fuel shutoff valve

The ECM supplies voltage for the fuel shutoff valve to open.

• Fueling (metering) actuators

The fueling actuators are commanded by the ECM to control fuel metering. Each actuator is normally closed, and it is only opened by an electrical pulse from the ECM.

• Timing actuators

The timing actuators are commanded by the ECM to control fuel timing. Each actuator is normally closed, and it is only opened by an electrical pulse from the ECM.

• Fuel lift pump

The fuel lift pump provides a positive flow of fuel to the IFSM each time the engine is started. The ECM shuts off the fuel lift pump after two minutes of operation.
• OEM wiring harness

The OEM harness is supplied and installed by the vehicle manufacturer. Follow the vehicle manufacturer's procedures, if replacement is necessary. Refer to the vehicle manufacturer's troubleshooting and repair manual.

There is no traditional 31-pin connector. The ECM connects to the OEM components directly from the OEM harness and OEM port on the ECM (50-pin).

• Key switch battery supply circuit

The vehicle key switch supplies an input signal to the ECM which turns the ECM on or off.

• Unswitched battery supply circuit

The ECM receives constant voltage from the batteries through the ECM battery supply positive (+) wire that is connected directly to the positive (+) battery post. There is one in-line 30-amp fuse in the ECM supply wire to protect the ECM. The ECM battery supply negative (-) wire is connected directly to the negative (-) battery post.

• Brake pedal position switch

The brake pedal position switch detects the position of the service brake pedal. Certain features such as cruise control and PTO respond to the state of the brake pedal position switch and disengage when the brakes are applied. The circuit has a normally-closed switch, switch return wire, and brake pedal position switch signal wire of the OEM harness.

The brake pedal position switch is mounted in the low pressure side of the vehicle pneumatic brake system. When the vehicle brakes are applied, the normally-closed switch opens and disables the cruise control operation.
• Engine brake on/off switch and Engine brake level switch

The engine brake ON/OFF switch circuit signals the system that the operator is requesting the engine brake system to be activated. The engine brake level switch determines what percentage of engine braking power will be used for engine braking. Three inputs to the ECM from the engine brake level switch are used to communicate the setting to the ECM. Engine brake selector number 1 signal, engine brake selector number 2 signal, and engine brake selector number 3 signal in the OEM connector are used. Various combinations of the three wires are used to represent the six switch positions.

After the ECM receives the signal from the engine brake ON/OFF switch and all other engine braking preconditions are met (engine RPM and road speed limits), the ECM will supply 12 VDC to the appropriate engine brake solenoids depending on how the 3 or 6 position engine brake level switch is set.

• Fan control circuit

The Signature and ISX control system can control the fan clutch activation. The ECM energizes the air valve solenoid which in turn controls the fan clutch.

• Accelerator pedal position sensor and Idle validation switch

The accelerator pedal position sensor is attached to the accelerator pedal. The accelerator pedal position sensor sends a signal to the electronic control module (ECM) indicating pedal position.

The idle validation switch, on the accelerator pedal assembly, is used to detect when the accelerator pedal is at idle.
• Coolant level sensor

The engine coolant level sensor monitors the engine coolant level within the coolant system and passes information to the electronic control module (ECM) through the OEM harness.

• Clutch pedal position switch

The clutch pedal position switch circuit is used to disable the PTO and cruise control features. When the clutch pedal position switch is installed and adjusted, the contact points are held closed. When the clutch pedal is depressed, the clutch pedal position switch is in its normally open position. This will disable the PTO or cruise control operation.

• On/Off switch (type)

Will enable the following: (OEM dependant for each)
- Remote accelerator
- Remote PTO
- Cruise control/PTO
- Diagnostic

• Cruise control or PTO set/resume select switch

The cruise control/PTO set/resume select switch has two positions: SET/COAST and RESUME/ACCEL.

The switch can be used for: Cruise Control SET/COAST and RESUME/ACCEL, PTO INCREASE/DECREASE, Idle INCREASE/DECREASE, Road Speed Governor INCREASE/DECREASE, Diagnostic Fault Code INCREASE/DECREASE.
• Vehicle speed sensor

The vehicle speed sensor senses the speed of the output shaft of the transmission. The vehicle’s road speed is computed from this data by the ECM. The ECM uses programmed gearing and tire size data to compute the road speed.

• Fuse, Harness in-line

A 30 amp fuse is used in the unswitched battery supply circuit to the ECM and a 10 amp fuse is used in the fuel lift pump supply circuit.

• Engine protection override switch

The engine protection override switch is an OEM installed switch that allows a driver to abort a pending engine protection shutdown. The switch is only active when it is properly wired by the OEM and the engine protection shutdown override feature is enabled in the calibration.

• Engine torque limit switch

The engine torque limit switch allows the operator to switch to a different torque output limit by the engine. This is desirable in applications where auxiliary equipment can not handle full engine torque.

Activating this switch protects the equipment by limiting the maximum output torque of the engine. This maximum torque value can be entered through the electronic service tool under the powertrain protection feature.
• Governor type switch

The governor type switch selects between variable speed (VS) and automotive accelerator governors. Governor selection often occurs while changing operation modes, for example between cab accelerator and remote accelerator. When the OEM enables the switchable accelerator type feature, the automotive or VS governing feature uses the governor type switch.

• Fan control switch

The fan control switch circuit signals the system that the operator is requesting the engine fan to be engaged. The fan on and off circuit consists of the fan control switch signal, the switch return, and the OEM cab-mounted toggle switch. This circuit is considered “fail safe”, meaning when the circuit is open, the engine fan will be engaged by the ECM.

**NOTE:** This is only valid if the fan control switch is wired through the ECM and the feature manual fan switch is enabled in the ECM. If the fan control switch is wired in series with the fan control relay, the ECM could log fan circuit errors during normal operation.

• Maximum engine speed switch

The maximum engine speed switch is an OEM installed switch that allows a driver to select a lower, programmable maximum engine speed. Certain applications such as one that uses a hydraulic system may need to be protected from an overspeed condition. The operator may toggle this switch and limit the maximum engine RPM to a lower value that is safe for the hydraulic system to operate in.

**NOTE:** The switch is now programmable, meaning the speed limit and normal positions can either be open or closed depending on the configuration.
Diagnostic Fault Codes
The electronic engine control system can display and record certain detectable fault conditions. These failures are displayed as fault codes, which make troubleshooting easier. The fault codes are retained in the ECM.

There are two types of diagnostic codes:
1. Engine electronic control system fault codes are to inform the operator that there is a problem with the control system that will require troubleshooting.
2. Information and engine protection fault codes are to inform the operator that the control system has detected an engine condition outside the normal operating range.

All fault codes recorded will either be active (fault code is currently active on the engine) or inactive (fault code was active at some time, but is not currently active). The “Stop” light is red and indicates the need to stop the engine as soon as it can be safely done. The engine must remain shutdown until the fault can be repaired. The “Warning” light is amber and indicates the need to repair the fault at the first available opportunity. Maintenance type fault codes, such as water-in-fuel, and maintenance monitor oil change interval, will flash the amber Warning light for 30 seconds after the keyswitch is turned to the ON position.

NOTE: The names and colors of these lamps can vary with equipment manufacturer.

Fault codes can be accessed in at least two different ways; using the electronic service tool, or fault code flash out. To check for active engine electronic fuel system and engine protection system fault codes, turn the keyswitch OFF and move the diagnostic switch to the ON position.

Turn the vehicle keyswitch to the ON position. If no active fault codes are recorded, both lights will come on and stay on. If active fault codes are recorded, both lights will come on momentarily then begin to flash the code of the recorded faults.
The fault code will flash in the following sequence:
- First, a WARNING (amber) light will flash.
- Then there will be a short one or two second pause after which the number of the recorded fault code will flash in STOP (red).
- There will be a one or two second pause between each number.
- When the number has finished flashing in red, an amber light will appear again.

The lights flash each fault code out three times before advancing to the next code. To skip to the next fault code, move the Increment/Decrement switch (if equipped) momentarily to the increment (+) position. You can go back to the previous fault code by momentarily moving the Increment/Decrement switch (if equipped) to the decrement (-) position. If only one active fault is recorded, the same fault code will continuously be displayed when either (+) or (-) switch is depressed.

When **not** using the diagnostic system, turn off the diagnostic switch.

**Fault Code Snapshot Data**
When a diagnostic fault code is recorded in the ECM, the ECM input and output data is recorded from all sensors and switches. Snapshot data allows the relationships between ECM inputs and outputs to be viewed and used during troubleshooting.

Fault code snapshot data can only be viewed using INSITE™.
INSITE™ Description
INSITE™ is a service tool for the electronic engine control system. Use INSITE™ to:
- Program customer specified information into the ECM (parameter and features)
- Aid in troubleshooting the engine
- Change the engine power or rated speed calibration
- Transfer new or update calibration files to the electronic engine control system ECM
- Create and view trip reports, etc.

INSITE™ Monitor Mode
The INSITE™ monitor mode is a useful troubleshooting aid that displays the key ECM inputs and outputs. This feature can be used to spot constant or abnormally fluctuating values.