Throttle-by-wire

MasterCraft Technical Training
Vonore, Tennessee USA

A MasterCraft Technical Services Publication
Engine Control Module (ECM)

The Engine Control Module (ECM), located on the engine, is the control center of the fuel injection system. It controls the following:

- Fuel metering system
- Ignition timing
- Idle speed
- On-board diagnostics for engine functions
- Boat speed
- Throttle position

It constantly looks at the information from various sensors, and controls the systems that affect engine performance. The ECM also performs the diagnostic function of the system. It can recognize operational problems, alert the driver through the Malfunction Indicator Lamp (MIL) and store diagnostic trouble codes which identify the problem areas to aid the technician in making repairs.

Electronic Throttle Control (ETC) Components

The Electronic Throttle Control (ETC) system uses the boat electronics and components in order to calculate and control the position of the throttle blade. This system eliminates the need for a mechanical cable attachment from the Throttle-Shift Control (T-SC) to the electronic throttle body assembly.

The ETC system components include the following:

- The ECM
- The Throttle Position Sensor (TPS) is located in a sealed housing, which is mounted to the side of the electronic throttle body assembly.
- The Throttle Actuator Control (TAC) motor is located within the same sealed housing as the TPS.
- The Pedal Position Sensor (PPS) is located within a sealed housing mounted to the Throttle-Shift Control (T-SC).

Each of these components interface together in order to ensure accurate calculations, and in order to control the throttle position.
ECM Function

The ECM supplies either 5 or 12 volts to power various sensors or switches. This is done through resistance in the ECM which is so high in value that a test light will not illuminate when connected to the circuit. In some cases, an ordinary voltmeter will not give an accurate reading because its resistance is too low. Therefore, a digital voltmeter with at least 10 megohms input impedance is required to ensure accurate voltage readings. Tool J 39978, Fluke 78 or Fluke 87 meets this requirement. The ECM controls output circuits such as the injectors, relays, etc by controlling the ground or power feed circuit.

The ECM also controls the Electronic Throttle Control (ETC). The ECM monitors the commanded throttle position and compares the commanded position to the actual throttle position. This is accomplished by monitoring the Pedal Position Sensors (PPS) (located on the Throttle-Shift Control [T-SC]) and the Throttle Position Sensors (TPS). These two values must be within a calibrated value of each other. The ECM also monitors each individual circuit of the TPSs, and of the PPSs to verify proper operation (the Pedal Position Sensor reads the degree of movement of the Throttle-Shift Control from 0 degrees at locked neutral, to 120 degrees at Wide Open Throttle [WOT]).

Electronic Throttle Body Assembly

![Sealed Housing (TAC motor & Throttle Position Sensors 1 & 2)](image)

The Electronic Throttle Body Assembly consists of the electronic throttle body, the Throttle Position Sensors (2), and the Throttle Actuation Control (TAC) motor. The throttle body has a sealed housing mounted to the side of it, which contains the two Throttle Position Sensors (TPS) and the Throttle Actuation Control (TAC) motor. The electronic throttle body assembly is connected to the ECM by a single 6 pin connector to the wiring harness.

Throttle Position Sensor (TPS)

The Throttle Position Sensor (TPS) and the Throttle Actuation Control (TAC) motor are contained within a sealed housing mounted onto the side of the electronic throttle body assembly. If one of these components should become defective the electronic throttle body assembly must be replaced as a complete unit.

The TPS is actually two individual sensors within the above mentioned sealed housing. The TPSs use two separate signal circuits; however the two sensors share one low reference circuit and one, 5 volt reference circuit.

The TPS signal voltage is pulled up to the reference voltage as the throttle opens, from ~0.6 volts at closed throttle to ~4.3 volts at wide open throttle (WOT). The TPS 2 signal voltage is pulled down to the reference voltage as the throttle opens, from ~4.3 volts at closed throttle to ~0.6 volts at WOT.

TPS 1 and Pedal Position Sensor (PPS) 1 share a 5 volt reference circuit that is connected within the ECM. TPS 2 and Pedal Position Sensor (PPS) 2 also share a 5 volt reference circuit that is connected within the ECM.

The PPS 1 signal voltage is pulled up to the reference voltage as the throttle opens, from ~0.45 volts at closed throttle to ~4.18 volts at wide open throttle (WOT). The PPS 2 signal voltage is pulled down to the reference voltage as the throttle opens, from ~4.55 volts at closed throttle to ~0.82 volts at WOT.

Throttle Actuation Control (TAC) Motor

The Throttle Actuation Control (TAC) motor and the TPSs are located within one sealed housing mounted onto the side of the electronic throttle body. If one of these components should become defective, the electronic throttle body assembly must be replaced as a complete unit. The unit is connected to the ECM by one 6 pin connector.

The TAC motor is used to control the throttle position instead of a mechanical cable. This system eliminates the need for a mechanical cable. This system eliminates the need for a mechanical cable attachment from the T-SC to the electronic throttle body assembly. The TAC motor also controls the throttle opening for idle and cold start/fast idle functions, thereby eliminating the need for an Idle Air Control (AC) valve.
Pedal Position Sensor

The Pedal Position Sensor (PPS) is mounted on the T-SC. The PPS is actually two individual position sensors within one housing. The PPSs use two separate signal circuits, two low references, and two 5 volt reference circuits to connect the PPSs to the ECM.

Note: The two PPSs operate in slightly different voltage ranges. Some variation in voltage above or below the normal calibration is acceptable, however more than approximately 0.15 volts will set a PPS 1-2 Correlation Fault.

The PPS 1 voltage should increase from below 1 volt at closed throttle to above 3.75 volts at WOT.

The PPS 2 voltage should decrease from below 5 volts at closed throttle to above 1 volt at WOT.

Remote Mount Pedal Position Sensor (Typical)

Throttle Cable Interconnect

The production Throttle-Shift Control (T-SC) unit is set up for dual function in a single lever. It controls both shifting and throttle by a mechanical cable and by electronic throttle movement. Added features include a neutral interlock to help prevent accidental shifting and crisp positive detents. Also, the control has a push button clutch disengagement feature for warm-up and start-up adjustments for increased throttle. The throttle control is designed with neutral as the center location and is in gear when the lever is moved forward to crisp positive detent thirty degrees. The transmission cable is pulled with a one-to-one ratio as the lever rotates for the thirty degrees while the throttle blade is in the closed position. After the first thirty-five degrees, the throttle blade will begin to move and the transmission cable will stay at the thirty degree location. Maximum throttle is approximately one hundred twenty-five degrees. Reverse works in the same manner.
Electronic Throttle Control (ETC) Basics

Function: Replaces the mechanical cable link from the Throttle-Shift Control (T-SC) to electronic throttle body assembly with a system of sensors and computer controlled throttle.

Components:

Throttle Position Sensor (TPS 1 & 2): These two individual sensors are housed together with one Throttle Actuation Control (TAC) motor within one sealed compartment. That sealed compartment is permanently mounted to the side of the electronic throttle body. There is one, 6 wire, connector plug leading from the electronic throttle body to the main wiring harness and eventually to the ECM.

Pedal Position Sensor (PPS 1 & 2): These two individual sensors are housed together in one sealed compartment. That compartment is permanently attached to the aft end of the T-SC. There is one, six wire, connector plug leading directly from the T-SC to the ECM.

ECM: The ECM is the control center for the Electronic Throttle Control (ETC) system as well as the rest of the engine electronics. It communicates between the different sensors and the TAC motor. It constantly monitors the sensor readings.

The ECM continuously compares the voltage readings between TPS 1 and TPS 2. It looks for any variance from their normal operating voltage ranges. If variance is found a **TPS1-2 Correlation** fault is set.

The ECM also monitors both TPS 1 and TPS 2 in case of a disconnected condition. If one of these sensors should become disconnected, then a **TPS 1 Out of Range** or a **TPS 2 Out of Range** fault will set. An ETC Limited Authority will also set (see Diagnosing the ETC system below for explanation). If this occurs the engine goes to idle.

Additionally, the ECM continuously compares the voltage readings between PPS 1 and PPS 2. It watches for any variance from their normal operating voltage ranges. If variance is found a **PPS 1-2 Correlation** fault will set.

The ECM also monitors both PPS 1 and PPS 2 in case of a disconnected condition. If one of these sensors becomes disconnected, then either a **PPS 1 Out of Range** or a **PPS 2 Out of Range** fault will set. An ETC Limited Authority will also set (see Diagnosing the ETC system below for explanation). If this occurs the engine goes into power reduction mode.

The ECM compares the predicted throttle position and the actual throttle position. The predicted throttle position is the amount of throttle called for by the pedal position sensor, which indicates how much throttle the driver wants. The actual throttle position is the current location (angle) of the throttle blade in the throttle body.

The ECM continuously compares the commanded throttle position and the actual throttle position. The commanded throttle position is the amount of throttle (degree of angle the throttle blade is set at) called for by the location of the Throttle-Shift Control (T-SC) from neutral to Wide Open Throttle (WOT). The actual throttle position is the current exact location or angle of the throttle blade.

The ECM continuously tests the integrity of the data within itself. If there is a loss of integrity in the ECM data, or an inability to write or read data to and from the RAM, or an inability to correctly read data from the flash memory, or an internal ECM processor fault, then an **ETC Process** fault sets.