
Torque Based Electronic Throttle Control (ETC)

Overview

The torque based ETC is a hardware and software strategy that delivers an engine output torque (through throttle angle) based on driver demand (pedal position). It uses an electronic throttle body, the powertrain control module (PCM), and an accelerator pedal assembly to the control throttle opening and engine torque. The ETC system replaces the standard cable operated accelerator pedal, idle air control (IAC) valve, 3-wire throttle position (TP) sensor, and mechanical throttle body.

Electronic Throttle Body (ETB)

The ETB has the following characteristics:

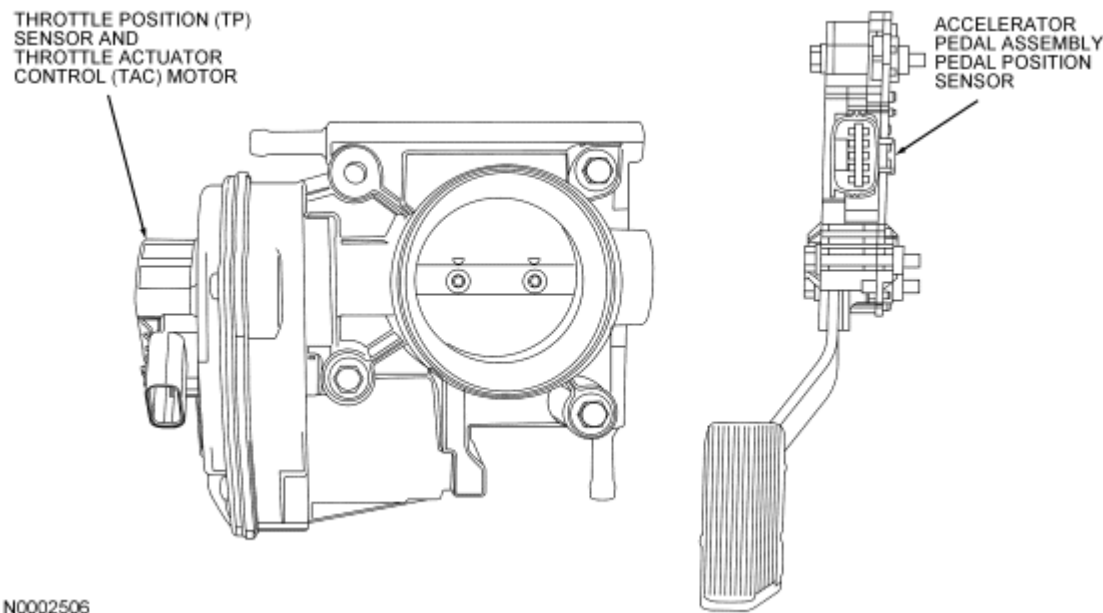
1. The throttle actuator control (TAC) motor is a DC motor controlled by the PCM (requires 2-wires). The gear ratio from the motor to the throttle plate shaft is 17:1.
2. Two springs are used: one is used to close the throttle (main spring) and the other is in a plunger assembly that results in a default angle with no power applied. This is for limp-home reasons (the force of the plunger spring is 2 times stronger than the main spring). The default angle is usually set to result in a top vehicle speed of 48 km/h (30 mph). Typically this throttle angle is 7 to 8 degrees from the hard-stop angle.
3. The closed throttle plate hard stop is used to prevent the throttle from binding in the bore (~0.75 degree). This hard stop setting is non-adjustable and is set to result in less airflow than the minimum engine airflow required at idle.
4. Unlike cable type throttle bodies, the intent for the ETB is to not have a hole in the throttle plate or to use plate sealant. The hole is not required in the ETB because the required idle airflow is provided by the plate angle in the throttle body assembly. This plate angle controls idle and idle quality and eliminates the need for an IAC valve.
5. The TP sensor has 2 signal circuits in the sensor for redundancy. The redundant TP signals are required for increased monitoring reasons. The first TP signal (TP1) has a negative slope (increasing angle, decreasing voltage) and the second signal (TP2) has a positive slope (increasing angle, increasing voltage). During normal operation the negative slope TP signal (TP1) is used by the control strategy as the indication of throttle position. The TP sensor assembly requires 4 circuits:
 - 5-volt reference voltage
 - Signal return
 - TP1 voltage with negative voltage slope (5-0 volts)
 - TP2 voltage with positive voltage slope (0-5 volts)

Accelerator Pedal Position (APP) Sensors

The ETC strategy uses pedal position as an input to determine the driver demand.

1. There are 3 pedal position sensors required for system monitoring. The APP1 has a negative slope (increasing angle, decreasing voltage) and APP2 and APP3 both have a positive slope (increasing angle, increasing voltage). During normal operation APP1 is used as the indication of pedal position by the strategy.

2. There are 2 voltage reference (VREF) circuits, 2 signal return circuits, and 3 signal circuits between the PCM and APP assembly.
 - 2 reference voltage circuits (5 volts)
 - 2 signal return (ground) circuits
 - APP1 voltage with negative voltage slope (5-0 volts)
 - APP2 voltage with positive voltage slope (0-5 volts)
 - APP3 voltage with positive voltage slope (0-5 volts)
3. The pedal position signal is converted to pedal travel degrees (rotary angle) by the PCM. The software then converts these degrees to counts, which is the input to the torque based strategy.
4. The 3 pedal position signals make sure the PCM receives a correct input even if a signal has a concern. The PCM determines if a signal is incorrect by calculating where it should be, inferred from the other signals. A value is substituted for an incorrect signal if 2 of the 3 signals are incorrect.

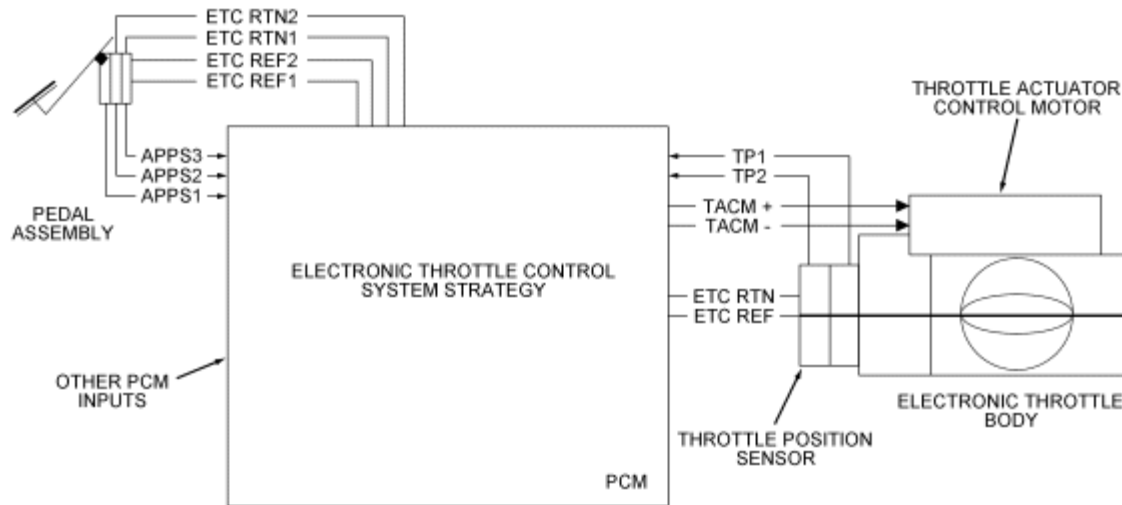


Electronic Throttle Body (ETB) and Accelerator Pedal Assembly

Electronic Throttle Control (ETC) System Strategy

The torque based ETC strategy was developed to improve fuel economy. This is possible by not coupling the throttle angle to the driver pedal position. Uncoupling the throttle angle (produce engine torque) from the pedal position (driver demand) allows the powertrain control strategy to optimize fuel control while delivering the requested torque.

The ETC monitor system is distributed across 2 processors within the PCM: the main powertrain central processing unit (CPU) and a monitoring processor called an enhanced quizzer (E-Quizzer) processor. The primary monitoring function is carried out by the independent plausibility check (IPC) software, which resides on the main processor. It is responsible for determining the driver-demanded torque and comparing it to an estimate of the actual torque delivered. If the generated torque exceeds driver demand by a specified amount, the IPC takes the appropriate corrective action.



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ETC System

Since the IPC and the main controller share the same processor, they are subject to a number of potential, common failure modes. Therefore, the E-Quizzer processor was added to redundantly monitor selected PCM inputs and to act as an intelligent watchdog and monitor the performance of the IPC and the main processor. If the E-Quizzer determines that the IPC function is impaired in any way, it takes appropriate failure mode and effects management (FMEM) actions.

ETC System Failure Mode and Effects Management

Effect	Failure Mode ^a
No Effect on Driveability	A loss of redundancy or loss of a non-critical input could result in a concern that does not affect driveability. The powertrain malfunction indicator (wrench) illuminates, but the throttle control and torque control systems function normally.
Disable Speed Control	If certain concerns are detected, speed control is disabled. Throttle control and torque control continue to function normally.
RPM guard with Pedal Follower	In this mode, torque control is disabled due to the loss of a critical sensor, PCM, or hybrid system concern. The throttle is controlled in pedal follower mode as a function of the pedal position sensor input only. A maximum allowed RPM is determined based on pedal position (RPM guard.) If the actual RPM exceeds this limit, spark and fuel are used to bring the RPM below the limit.
RPM guard with Default Throttle	In this mode, the throttle plate control is disabled due to the loss of throttle position, the throttle plate position controller, or other major electronic throttle body concern. A default command is sent to the TPPC, or the H-bridge is disabled. Depending on the concern detected, the throttle plate is controlled or springs to the default (limp home) position. A maximum allowed RPM is determined based on pedal position (RPM guard.) If the actual RPM exceeds this limit, spark and fuel are used to bring the RPM below the limit.
RPM guard with High Forced Idle	This mode is caused by the loss of 2 or 3 pedal position sensor inputs due to sensor, wiring, or PCM concerns. The system is unable to determine driver demand, and the throttle is controlled to a fixed high idle airflow. There is no response to the driver input. The maximum allowed RPM is a fixed value (RPM guard). If the actual RPM exceeds this

	limit, spark and fuel are used to bring the RPM below the limit.
Shutdown	If a significant processor concern is detected, the monitor forces vehicle shutdown by disabling all fuel injectors.

^a Powertrain malfunction indicator (wrench) illuminates or displays a message on the message center immediately, MIL illuminates after 2 driving cycles

Electronic Throttle Monitor Operation

DTCs ^a	Description (Indicator Lamp)
P2104	ETC FMEM – forced idle, 2 or 3 pedal sensors failed (MIL, powertrain malfunction indicator [wrench])
P2105	ETC FMEM – forced engine shutdown; E-Quizzer detected concern (MIL, powertrain malfunction indicator [wrench])
P2110	ETC FMEM – forced limited RPM; 2 TPs failed; TPPC detected concern (MIL, powertrain malfunction indicator [wrench])

^a Monitor execution is continuous. Monitor false detection duration is less than 1 second to register a concern.

Accelerator Pedal Position (APP) and Throttle Position (TP) Sensor Inputs

APP Sensor Check

DTCs ^a	Description (Indicator Lamp)
P2122, P2123, P2127, P2128, P2132, P2133	APP sensor circuit continuity test (powertrain malfunction indicator [wrench], non-MIL).
P2121, P2126, P2131	APP range/performance (powertrain malfunction indicator [wrench], non-MIL).
P2138, P2140, P2139	APP to APP sensor correlation (powertrain malfunction indicator [wrench], non-MIL).

^a Correlation and range/performance - sensor disagreement between processors (PCM and E-Quizzer). Monitor execution is continuous. Monitor false detection duration is less than 1 second to register a concern. For additional DTC information, refer to Section 4, [Diagnostic Trouble Code \(DTC\) Charts and Descriptions](#).

TP Sensor Check

DTCs ^a	Description (Indicator Lamp)
P0122, P0123, P0222, P0223	TP circuit continuity test (MIL, powertrain malfunction indicator [wrench]).
P2135	TP to TP sensor correlation test (powertrain malfunction indicator [wrench], non-MIL).

^a Correlation and range/performance - sensor disagreement between processors (PCM and E-Quizzer), TP inconsistent with TPPC throttle plate position. Monitor execution is continuous. Monitor false detection duration is less than 1 second to register a concern. For additional DTC information, refer to Section 4, [Diagnostic Trouble Code \(DTC\) Charts and Descriptions](#).

Throttle Plate Position Controller (TPPC) Outputs

The purpose of the TPPC is to control the throttle position to the desired throttle angle. It is a separate chip embedded in the PCM. The desired angle is communicated from the main CPU over a 312.5 Hz duty cycle signal. The TPPC interprets the duty cycle signal as follows:

- Less than 5% - Out of range, limp-home default position.
- Greater than or equal to 5% but less than 6% - Commanded default position, closed.
- Greater than or equal to 6% but less than 7% - Commanded default position. Used for key ON, engine OFF.
- Greater than or equal to 7% but less than 10% - Closed against hard-stop. Used to learn zero throttle angle position (hard-stop) after key-up.
- Greater than or equal to 10% but less than or equal to 92% - Normal operation, between 0 degrees (hard-stop) and 82 degrees, 10% duty cycle equals 0 degrees throttle angle, 92% duty cycle equals 82 degrees throttle angle.
- Greater than 92% but less than or equal to 96% - Wide open throttle (WOT), 82 to 86 degrees throttle angle.
- Greater than 96% but less than or equal to 100% - Out of range, limp-home default position.

The desired angle is relative to the hard-stop angle. The hard-stop angle is learned during each key-up process before the main CPU requests the throttle plate to be closed against the hard-stop. The output of the TPPC is a voltage request to the H-driver (also in PCM). The H-driver is capable of providing a positive or negative voltage to the electronic throttle body motor.

Throttle Plate Controller Check Operation

DTCs ^a	Description (Indicator Lamp)
P2100	Throttle actuator circuit open, short to power, short to ground (MIL).
P2101	Throttle actuator range/performance test (MIL).
P2107	Processor test (MIL).
P2111	Throttle actuator system stuck open (MIL).
P2112	Throttle actuator system stuck closed (MIL).

^a Note: For all DTCs, in addition to the MIL, the powertrain malfunction indicator [wrench] illuminates for the concern that caused the FMEM action. Monitor execution is continuous. Monitor false detection duration is less than 5 second to register a concern.
