Torque-Based Electronic Throttle Control (ETC)

Overview

The torque-based ETC is a hardware and software strategy that delivers an engine output torque (via 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 control the throttle opening and engine torque.

Torque-based ETC enables aggressive automatic transmission shift schedules (earlier upshifts and later downshifts). This is possible by adjusting the throttle angle to achieve the same wheel torque during shifts, and by calculating this desired torque, the system prevents engine lugging (low RPM and low manifold vacuum) while still delivering the performance and torque requested by the driver. It also enables many fuel economy/emission improvement technologies such as variable camshaft timing (VCT), which delivers same torque during transitions.

Torque-based ETC also results in less intrusive vehicle and engine speed limiting, along with smoother traction control.

Other benefits of torque-based ETC are:

- eliminate cruise control actuators
- eliminate idle air control (IAC) valve
- better airflow range
- packaging (no cable)
- more responsive powertrain at altitude and improved shift quality

The ETC system illuminates a powertrain malfunction indicator (wrench) on the instrument cluster when a concern is present. Concerns are accompanied by diagnostic trouble codes (DTCs) and may also illuminate the malfunction indicator lamp (MIL).

Electronic Throttle Body (ETB)

The ETB has the following characteristics:

- The throttle actuator control (TAC) motor is a DC motor controlled by the PCM (requires 2 wires).
- There are two designs: parallel and in-line. The parallel design has the motor under the bore parallel to the plate shaft. The motor housing is integrated into the main housing. The in-line design has a separate motor housing.
- An internal spring is used in both designs to return the throttle plate to a default position. The default position is typically a throttle angle of 7 to 8 degrees from the hard stop angle.
- The closed throttle plate hard stop is used to prevent the throttle from binding in the bore. This hard stop setting is not adjustable and is set to result in less airflow than the minimum engine airflow required at idle.
- The required idle airflow is provided by the plate angle in the throttle body assembly. This plate angle controls idle, idle quality, and eliminates the need for an IAC valve.
- There is one reference voltage and one signal return circuit between the PCM and the ETB. The reference voltage and the signal return circuits are shared with the reference voltage and signal return circuits used by the accelerator pedal position (APP) sensor. There are also two throttle position (TP) signal circuits 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). The TP2 signal reaches a limit of approximately 4.5 volts at approximately 45 degrees of throttle angle.

Accelerator Pedal Position (APP) Sensor

Depending on the application either a 2-track or 3-track APP sensor is used. For additional information on the APP sensor, refer to Engine Control Components in this section.

Electronic Throttle Control (ETC) System Strategy

The torque-based ETC strategy was developed to improve fuel economy and to accommodate variable camshaft timing (VCT). 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 and transmission shift schedules while delivering the requested wheel torque.

The ETC monitor system is distributed across two processors within the PCM: the main powertrain control processor unit (CPU) and a separate monitoring 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, appropriate corrective action is taken.

ETC System with a 3-Track APP Sensor 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. A DTC is set to indicate the component or circuit with the concern.
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 or PCM 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 the position of the accelerator pedal (RPM Guard). If the actual RPM exceeds this limit, spark and fuel are used to bring the RPM below the limit. The powertrain malfunction indicator (wrench) and the MIL illuminate in this mode and a DTC for an ETC-related component is set. EGR, VCT, and IMRC outputs are set to default values.
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. Depending on the concern detected, the throttle plate is either commanded to the default (limp home) position or the motor is disabled and the spring returns the throttle plate to the default (limp home) position. A maximum allowed RPM is determined based on the position of the accelerator pedal (RPM Guard). If the actual RPM exceeds this limit, spark and fuel are used to bring the RPM below the limit. The powertrain malfunction indicator (wrench) and the MIL illuminate in this mode and a DTC P2110 is set. EGR, VCT, and IMRC outputs are set to default values.
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. The powertrain malfunction indicator (wrench) and the MIL illuminate in this mode and a DTC P2104 is set. EGR, VCT, and IMRC outputs are set to default values.
Shutdown	If a significant processor concern is detected, the monitor forces vehicle shutdown by disabling all fuel injectors. The powertrain malfunction indicator (wrench) illuminates in this mode and a DTC P2105 is set.

[a] ETC illuminates or displays a message on the message center immediately; MIL illuminates after 2 driving cycles

ETC System with a 2-Track APP Sensor Failure Mode and Effects Management:

Effect	Failure Mode
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) and the MIL do not illuminate. However, speed control and power take off (PTO) may be disabled. A DTC is set to indicate the component or circuit with the concern.

Delayed APP Sensor Response with Brake Override	This mode is caused by the loss of 1 APP sensor input due to sensor, wiring, or PCM concerns. The system is unable to verify the APP sensor input and driver demand. The throttle plate response to the APP sensor input is delayed as the accelerator pedal is applied. The engine returns to idle RPM whenever the brake pedal is applied. The powertrain malfunction indicator (wrench) illuminates, but the MIL does not illuminate in this mode. An APP sensor related DTC is set.
Time-Based Driver Demand with Brake Override	This mode is caused by the loss of one brake pedal position (BPP) and one APP sensor input or both APP sensor inputs due to sensor, wiring, or PCM concerns. The system is unable to determine driver demand. There is no response when the accelerator pedal is applied. The engine returns to idle RPM whenever the brake pedal is applied. When the brake pedal is released, the PCM slowly increases the APP signal to a fixed value. The powertrain malfunction indicator (wrench) illuminates, but the MIL does not illuminate in this mode. An APP or BPP sensor related DTC is set.
RPM Guard with Pedal Follower	In this mode, torque control is disabled due to the loss of a critical sensor or PCM concern. The throttle is controlled in pedal-follower mode as a function of the APP sensor input only. A maximum allowed RPM is determined based on the position of the accelerator pedal (RPM Guard). If the actual RPM exceeds this limit, spark and fuel are used to bring the RPM below the limit. The powertrain malfunction indicator (wrench) and the MIL illuminate in this mode and a DTC for an ETC-related component is set. EGR, VCT, and IMRC outputs are set to default values and speed control is disabled.
RPM Guard with Default Throttle	In this mode, the throttle plate control is disabled due to the loss of both TP sensor inputs, loss of throttle plate control, stuck throttle plate, significant processor concerns, or other major electronic throttle body concern. The spring returns the throttle plate to the default (limp home) position. A maximum allowed RPM is determined based on the position of the accelerator pedal (RPM Guard). If the actual RPM exceeds this limit, spark and fuel are used to bring the RPM below the limit. The powertrain malfunction indicator (wrench) and the MIL illuminate in this mode and a DTC for an ETC-related component is set. EGR, VCT, and IMRC outputs are set to default values and speed control is disabled.

Electronic Throttle Monitor Operation:

DTCs [a]	
P060X, P061X	PCM processor concern (MIL, powertrain malfunction indicator [wrench])
P2104 (ETC system with a 3-track APP sensor)	ETC FMEM – forced idle, 2 or 3 pedal sensor concerns (MIL, powertrain malfunction indicator [wrench])
P2105 (ETC system with a 3-track APP sensor)	ETC FMEM – forced engine shutdown; PCM concern (MIL, powertrain malfunction indicator [wrench])
P2110 (ETC system with a 3-track APP sensor)	ETC FMEM – forced limited RPM; Concern with both TP sensors; throttle plate position control concern (MIL, powertrain malfunction indicator [wrench])
U0300	ETC software version mismatch between processors internal to the PCM (non-MIL, powertrain malfunction indicator [wrench])

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

APP and TP Sensor Inputs

Accelerator Pedal Position (APP) Sensor Check:

DTCs [a]	
P1575 (ETC system with a 2-track APP sensor)	APP sensor out of self-test range
P2122, P2123, P2127, P2128, P2132, P2133	APP sensor circuit continuity test (powertrain malfunction indicator [wrench], non-MIL)
P2121, P2126, P2131 (ETC system with a 3-track APP sensor)	APP range/performance (powertrain malfunction indicator [wrench], non-MIL)
P2138 (ETC system with a 2-track APP sensor)	APP to APP signal correlation (powertrain malfunction indicator [wrench], non-MIL)

[a] Correlation and range/performance - sensor disagreement between processors internal to the PCM. Monitor execution is continuous. Monitor false detection duration is less than 1 second to register a concern. Refer to Section 4, Diagnostic Trouble Code (DTC) Charts and Descriptions for additional DTC information.

Throttle Position (TP) Sensor Check:

DTCs [a]	
P0122, P0123, P0222, P0223	TP circuit continuity test (MIL, powertrain malfunction indicator [wrench])
P0121, P0221 (ETC system with a 3-track APP sensor)	TP range/performance (non-MIL)
P1124 (ETC system with a 2-track APP sensor)	TP sensor out of self-test range
P2135	TP to TP sensor correlation test (powertrain malfunction indicator [wrench], non-MIL)

[a] Correlation and range/performance - sensor disagreement between processors internal to the PCM, TP inconsistent with requested throttle plate position. Monitor execution is continuous. Monitor false detection duration is less than 1 second to register a concern. Refer to Section 4, Diagnostic Trouble Code (DTC) Charts and Descriptions for additional DTC information.

Electronic Throttle Actuator Control (TAC) Output

Electronic TAC Operation Check:

DTCs [a]	
P115E	Throttle actuator airflow trim at maximum limit (non-MIL)
P2072 (ETC system with a 3-track APP sensor)	Throttle body ice blockage (non-MIL)
P2100 (ETC system with a 3-track APP sensor)	Throttle actuator circuit open, short to power, short to ground (MIL)
P2101	Throttle actuator range/performance test (MIL)
P2107	Processor and TAC motor circuit 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) is on for the concern that caused the FMEM action. Monitor execution is continuous. Monitor false detection duration is less than 5 seconds to register a concern.