Electronic Throttle Control Module: Description and Operation

TORQUE BASED ELECTRONIC THROTTLE CONTROL (ETC)

Overview

The Generation II (Gen II) torque based electronic throttle control (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 PCM, and an accelerator pedal assembly to control the throttle opening and engine torque. The ETC system replaces the standard cable operated accelerator pedal, idle air control (IAC) valve, 3-wire throttle position sensor (TPS), and mechanical throttle body.

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 cam timing (VCT) (deliver 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 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.

It should be noted that the ETC system includes a warning indicator (wrench light) on the instrument cluster that illuminates when a fault is detected. Faults are accompanied by DTCs and may also illuminate the malfunction indicator lamp (MIL).

Electronic Throttle Body (ETB)

The Gen II 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. There are 2 designs: parallel and in-series. 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-series design has a separate motor housing.
3. 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 when no power is 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.
4. 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 not adjustable and is set to result in less airflow than the minimum engine airflow required at idle.
5. Unlike cable operated throttle bodies, the intent for the ETB is not to 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, idle quality, and eliminates the need for an IAC valve.
6. The throttle position (TP) sensor has 2 signal circuits in the sensor for redundancy. The redundant throttle position 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 (ground).
    - TP1 voltage with negative voltage slope (**5-0 volts**).
    - TP2 voltage with positive voltage slope (**0-5 volts**).

Accelerator Pedal Position (APP) Sensors

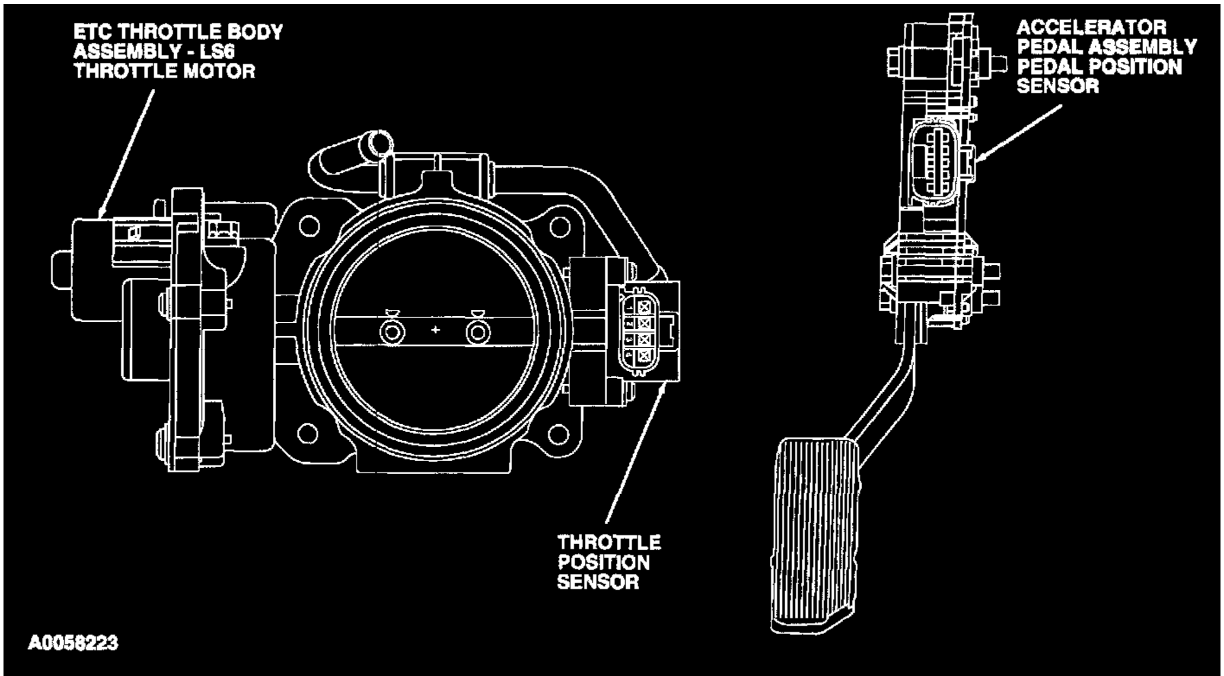

Figure 115: Electronic Throttle Body (ETB) and Accelerator Pedal Assembly

Electronic Throttle Body (ETB) And Accelerator Pedal Assembly

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

1. There are 3 pedal position signals required for system monitoring. 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 VREF circuits, 2 signal return circuits, and 3 signal circuits (a total of 7 circuits and pins) between the PCM and the APP sensor 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 1 signal has a fault. The PCM determines if a signal is incorrect by calculating where it should be, inferred from the other signals. A value will be substituted for an incorrect signal if 2 of the 3 signals are incorrect.

Electronic Throttle Control (ETC) System Strategy

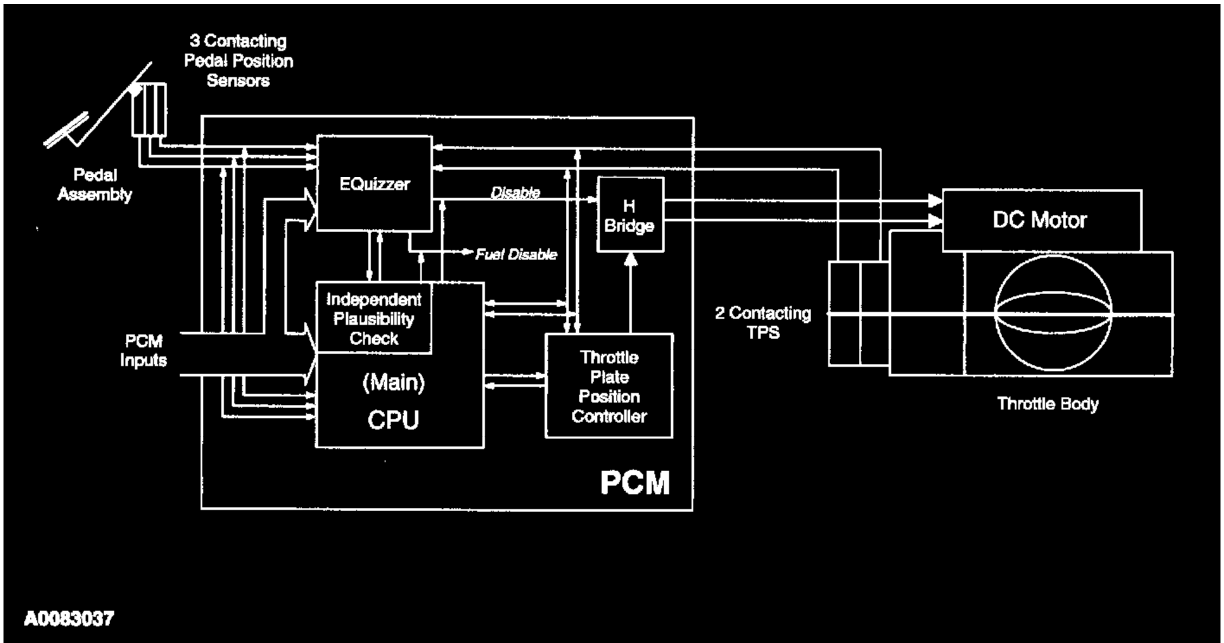

Figure 116: GEN II ETC System

GEN II ETC System

The torque based ETC strategy was developed to improve fuel economy and to accommodate variable cam 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 2 processors within the PCM: the main powertrain control processor 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 appropriate corrective action.

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 fault that does not affect driveability. The ETC lamp illuminates, but the throttle control and torque control systems function normally.
Disable Speed Control	If certain failures are detected, speed control is disabled. Throttle control and torque control continue to function normally.

(Continued)

ETC System Failure Mode And Effects Management (Part 1)

ETC System Failure Mode and Effects Management:

Effect	Failure Mode [a]
RPM Guard with Pedal Follower	In this mode, torque control is disabled due to the loss of a critical sensor or PCM fault. 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. The ETC lamp and the MIL illuminate in this mode and a DTC P2106 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 fault. A default command is sent to the TPPC, or the H-bridge is disabled. Depending on the fault 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. The ETC lamp 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 faults. 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 ETC lamp 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 fault is detected, the monitor will force vehicle shutdown by disabling all fuel injectors. The ETC lamp and the MIL illuminate 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 Failure Mode And Effects Management (Part 2)

Since the IPC and 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 it determines that the IPC function is impaired in any way, it takes appropriate Failure Mode and Effects Management (FMEM) actions.

Electronic Throttle Monitor Operation:

Electronic Throttle Monitor Operation:

DTCs [a]	
P0606, P060X	PCM processor failure (MIL, ETC lamp)
P2106	ETC FMEM forced limited power; sensor fault: MAF, one TP, CKP, TSS, OSS, stuck throttle, throttle actuator circuit fault (MIL, ETC lamp)
P2110	ETC FMEM forced limited RPM; 2 TPs failed; TPPC detected fault (MIL, ETC lamp)
P2104	ETC FMEM forced idle, 2 or 3 pedal sensors failed (MIL, ETC lamp)

(Continued)

Electronic Throttle Monitor Operation (Part 1)

Electronic Throttle Monitor Operation:

DTCs [a]	
P2105	ETC FMEM forced engine shutdown; E-Quizzer detected fault (MIL, ETC lamp)
U0300	ETC software version mismatch, IPC, E-Quizzer or TPPC (non-MIL, ETC lamp)

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

Electronic Throttle Monitor Operation (Part 2)

Accelerator and Throttle Position (TP) Sensor Inputs

Accelerator Pedal Position (APP) Sensor Check:

Accelerator Pedal Position (APP) Sensor Check:

DTCs [a]	
P2122, P2123, P2127, P2128, P2132, P2133	APP sensor circuit continuity test (ETC lamp, non-MIL)
P2121, P2126, P2131	APP range/performance (ETC lamp, non-MIL)
P2138, P2140, P2139	APP to APP sensor correlation (ETC lamp, 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 malfunction. Refer to Diagnostic Trouble Code (DTC) Charts and Descriptions for additional DTC information.

Accelerator Pedal Position (APP) Sensor Check

Throttle Position (TP) Sensor Check:

Throttle Position (TP) Sensor Check:

DTCs [a]	
P0122, P0123, P0222, P0223	TP circuit continuity test (MIL, ETC lamp)
P0121, P0221	TP range/performance (non-MIL)
P2135	TP to TP sensor correlation test (ETC lamp, 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 malfunction. Refer to Diagnostic Trouble Code (DTC) Charts and Descriptions for additional DTC information.

Throttle Position (TP) Sensor Check

Throttle Plate Position Controller (TPPC) Outputs

Throttle Plate Controller Check Operation:

DTCs [a]	
P2107	Processor test (MIL)
P2111	Throttle actuator system stuck open (MIL)
P2112	Throttle actuator system stuck closed (MIL)
P2100	Throttle actuator circuit open, short to power, short to ground (MIL)
P2101	Throttle actuator range/performance test (MIL)
P2072	Throttle body ice blockage (non-MIL)

a Note: For all DTCs, in addition to the MIL, the ETC lamp will be on for the fault that caused the FMEM action. Monitor execution is continuous. Monitor false detection duration is less than 5 second to register a malfunction.

Throttle Plate Controller Check Operation

The purpose of the TPPC is to maintain the throttle position at the desired throttle angle. It is a separate chip embedded in the PCM. The desired angle is communicated from the main CPU via a **312.5 Hz** duty cycle (DC) 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, **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 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 positive or negative voltage to the electronic throttle body motor.