Task: Electronic Throttle Control System (Toyota)

Required material:

- Personal Computer with the 'Toyota Electronic Throttle' program

Introduction

An Electronic Throttle Control System (ETCS-i) is used by Toyota and provides throttle control in all the operating ranges. There is no accelerator cable - an accelerator pedal position sensor is integrated in the accelerator pedal.

In the conventional throttle body, the throttle valve opening is determined by the amount of pressure put on the accelerator pedal. The ETCS system, on the other hand, uses the engine ECU to calculate the optimal throttle valve opening appropriate for the respective driving condition. It uses a throttle control motor to control the opening.

The ETCS also regulates the idle speed control, the traction control, the vehicle stability control and cruise control system, where available. If there are abnormal conditions, this system switches to the 'limp-home' mode. On certain models, the different ECUs communicate through the CAN-bus (fig.1).

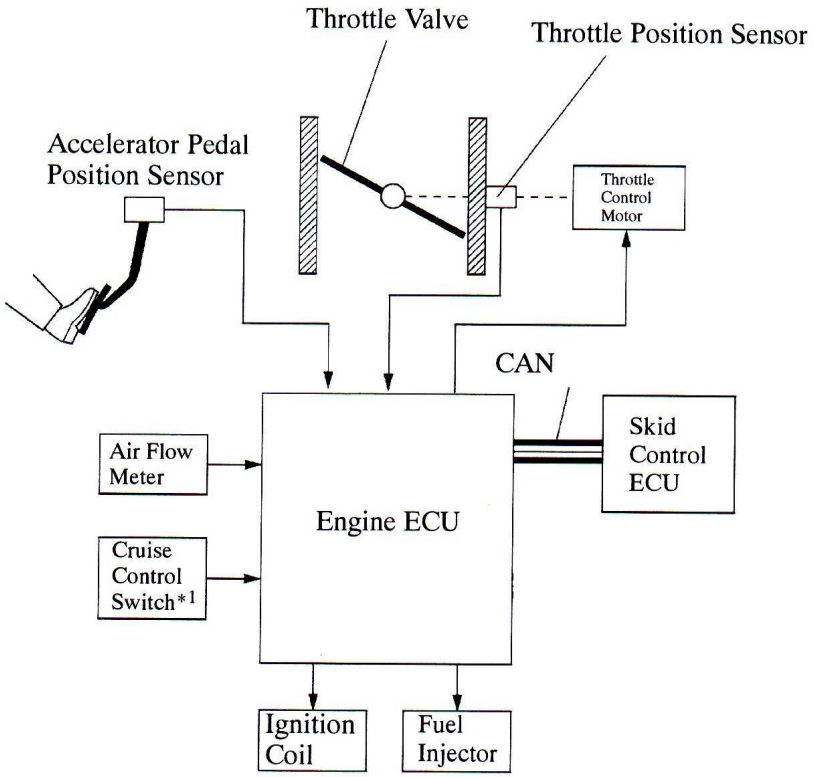

Fig. 1 Toyota's ETCS-i system

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Operation
The engine ECU drives the throttle control motor by determining the target throttle valve opening in accordance with the respective operating condition. The most common conditions are:

- Non-Linear Control (a cable system is called linear)
- Idle Speed Control
- Cruise Control

Non-Linear Control
The engine ECU controls the throttle to an optimal throttle valve opening appropriate for the driving condition. See figure 2 for examples of the driving conditions acceleration and deceleration.

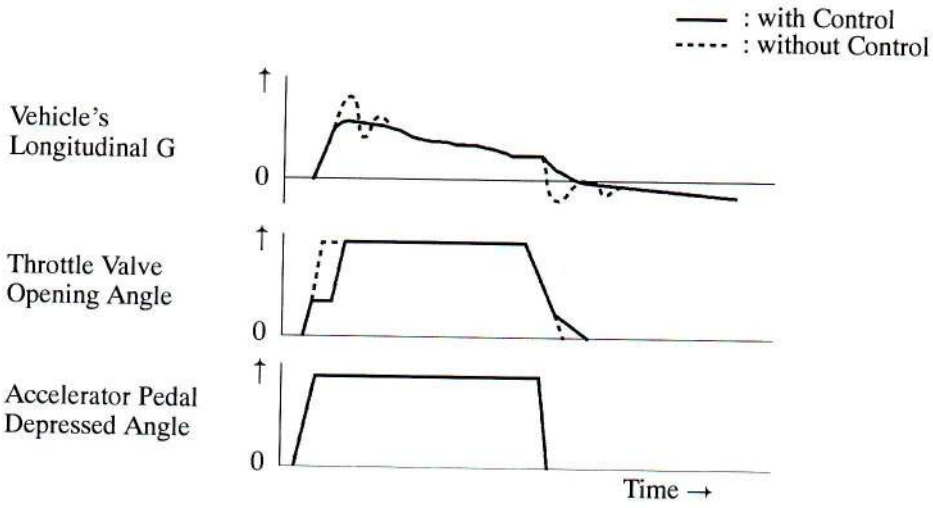

Fig. 2 Control examples during acceleration and deceleration

Idle speed control
The engine ECU controls the throttle valve in order to constantly maintain an optimal idle speed.

Cruise control
An engine ECU with an integrated cruise control ECU actuates the throttle valve directly for cruise control operation.

Models with Traction Control System
As part of the TRC system, the throttle valve is closed by a request signal from the TRC control ECU when an excessive amount of wheel spin is detected on a driven wheel.

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Accelerator Pedal Position Sensor Fail-safe
The accelerator pedal position sensor is comprised of two sensor circuits. If a malfunction occurs in either one of the sensor circuits, the engine ECU detects the abnormal signal voltage difference between these two sensor circuits and switches to the 'limp-home' mode. The 'limp-home' mode operates by calculating the angle of the depressed accelerator pedal.

If both circuits have a malfunction, the engine ECU detects the abnormal signal voltage from these two sensor circuits and stops the throttle control. At this time, the vehicle can be driven within idling range.

Throttle Position Sensor Fail-safe
The throttle position sensor is comprised of two sensor circuits. If a malfunction occurs in either or both of the sensor circuits, the engine ECU detects the abnormal signal voltage difference between these two sensor circuits. It cuts off the current to the throttle control motor and switches to the 'limp-home' mode. The force of the return spring causes the throttle valve to return and stay at the prescribed opening angle. At this time, the engine output is regulated through the control of the fuel injection (intermittent fuel-cut) and ignition timing.

The same control as above is activated if the engine ECU detects a malfunction in the throttle control motor system (fig. 3).

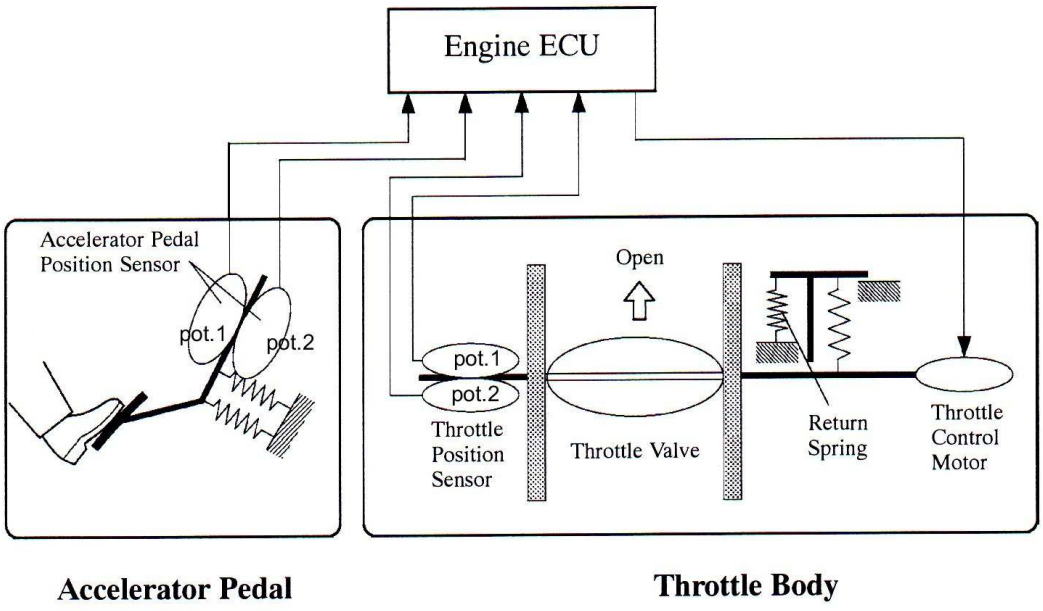

Fig. 3 Two accelerator position sensors and two throttle valve position sensors are used for fail safe purposes.

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Constructions

Accelerator pedal position sensor
The non-contact type accelerator pedal position sensor uses a Hall IC. The magnetic yoke that is mounted on the accelerator pedal arm rotates around the Hall IC in accordance with the amount of pressure that is applied to the accelerator pedal. The Hall IC converts the changes in the magnetic flux that occur at that time into electrical signals, and outputs them as accelerator pedal pressure to the engine ECU. The Hall IC contains circuits for the main and sub-signals. It converts the angle of the depressed accelerator pedal into electric signals with two differing characteristics and outputs them to the engine ECU (fig. 4)

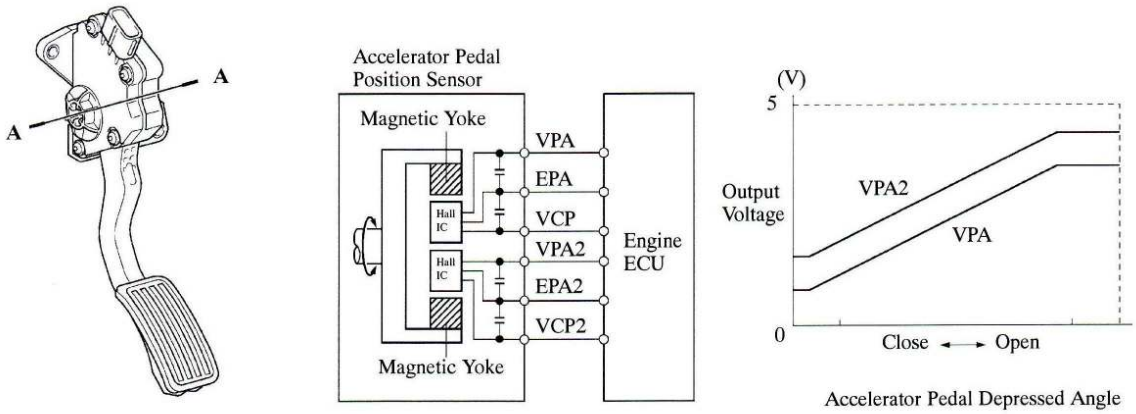

Fig. 4
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Throttle valve position sensor
The throttle valve position sensor is mounted on the throttle body to detect the opening angle of the throttle valve. Non-contact type throttle valve position sensors are used. The sensors use Hall ICs which are mounted on the throttle body.
The Hall ICs are surrounded by magnetic yokes. The Hall ICs convert the changes that occur in the magnetic flux into electrical signals The Hall ICs contain circuits for the main and sub-signals. They convert the throttle valve opening angles into electric signals with two different characteristics and output them to the engine ECU (fig. 5).

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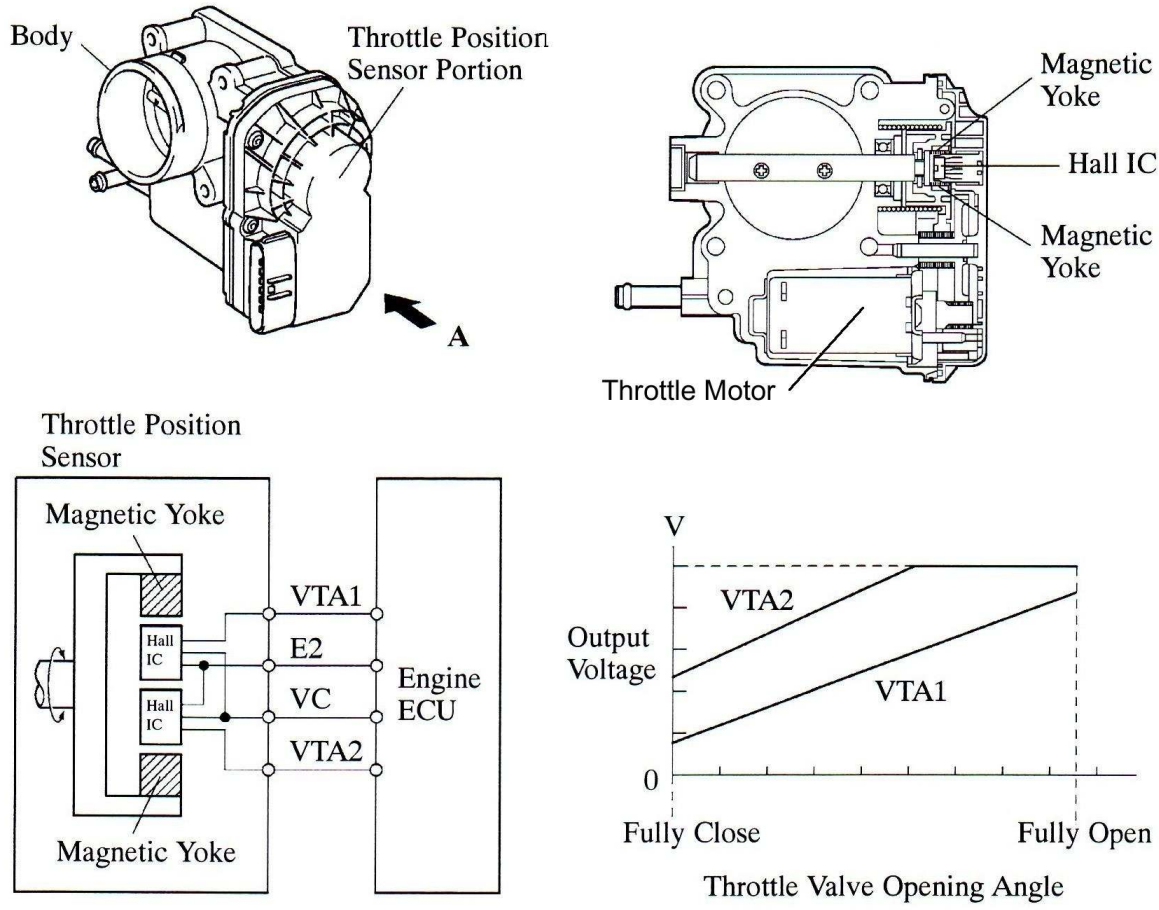

Fig. 5

Throttle Control Motor
A DC motor is used for the throttle control motor. The engine ECU performs the duty ratio control of the direction and the amperage of the current flow in order to regulate the opening of the throttle valve.

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On board Diagnoses
Toyota uses its intelligent tester for testing the electronic Throttle Control System (fig. 6). The tester is connected to the 16-pin OBD connector in the car. With the intelligent tester we can record an engine datalist. The amount of data we can record depends on the type of car but is a considerable amount. For testing the ETCS system we have to make a selection from the available data.

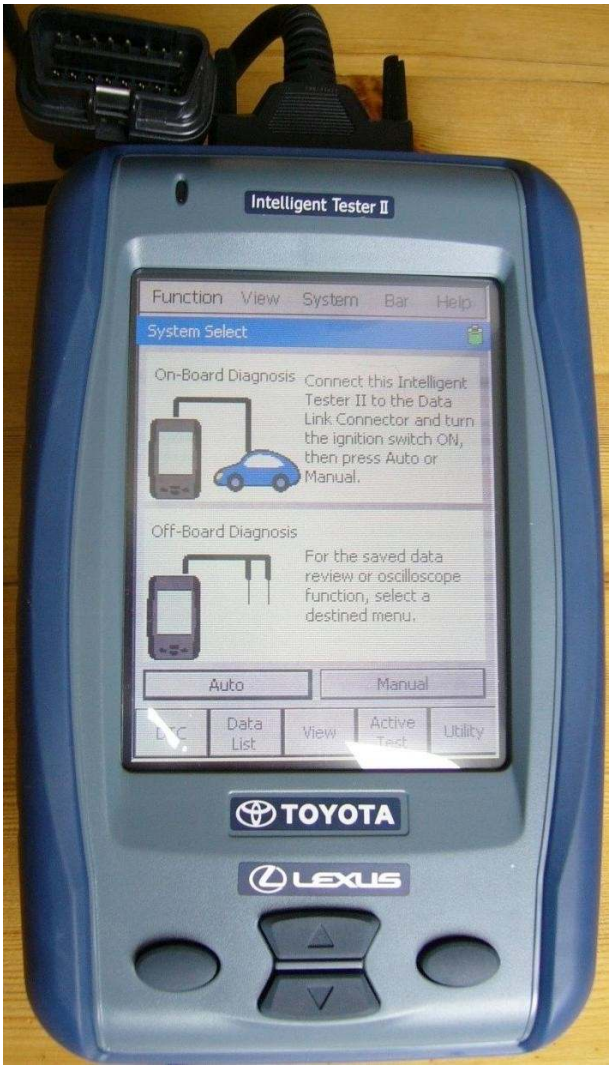

Fig. 6 The Toyota intelligent tester

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The most important available data concerning the ETCS system (from a Toyota Auris) are:

Tester display	**Measurement / range**	**normal condition**	
engine speed	min. 0 rpm max. 16384 rpm (0-4000 hex)	Idling: 600 to 700 rpm	
accelerator position no.1	min. 0% , max. 100%	10 to 22% pedal released 52 to 90% pedal fully depressed	
accelerator position no.2	min. 0% , max. 100%	24 to 40% pedal released 68 to100% pedal fully depressed	
accelerator position no.1	min. 0 V, max .5 V	0.5 to 1.1 V pedal released 2.6 to 4.5 V pedal fully depressed	
accelerator position no.2	min. 0 V, max .5 V	1.2 to 2.0 V pedal released 3.4 to 5.0 V pedal fully depressed	
accelelerator idle position	on / off	on: idling	
throttle fully closed (learned value)	valve fully closed (learned value) min. 0 V, max. 5 V	0.4 to 0.8 V	
fail-safe drive	on / off	on: ETCS system failed	
throttle position	throttle position sensor : min. 0% , max. 100%	8% to 20% throttle fully closed 64% to 96% throttle fully open	
throttle idle position	on or off	on: idling	
throttle required position	min. 0 V, max. 5 V	0.5 to 1.0 V idling	
throttle sensor position 1	min. 0% , max. 100%	0% throttle fully closed 50 to 80% throttle fully open	
throttle sensor position 2	min. 0% , max .100%	42% to 62% throttle fully closed 92% to 100% throttle fully open	
throttle sensor position 1	min. 0 V, max. 5 V	0.5 to 1.1 V throttle fully closed 3.2 to 4.9 V throttle fully open	
throttle sensor position 2	min. 0 V, max.. 5 V	2.1 to 3.1 V throttle fully closed 4.5 to 5.0 V throttle fully open	
throttle position command	value min. 0 V, max. 4.98 V	0.5 to 4.9 V	
throttle motor	on or off	on: idling	
throttle motor current	min. 0 A, max. 8 A	0 to 3.0 A idling	
throttle motor actuator	min. 0% , max. 100%	Idling (warmed up) 30 to 50%	
throttle motor duty open / closed	duty ratio 0% to 100%	0 to 40% idling	

Fig. 7 Table Toyota motor management data

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We selected and saved the following data from the intelligent tester while the engine was running idle. Then we used the following data in the educational program called 'ToyotaEtcsystem'

-engine speed
-accelerator position
-throttle position sensor output
-throttle motor duty

Fig. 7 shows us the printscreen of the program.

Now, go to the Timloto site (www.timloto.org) choose 'English' and 'Lesson grids' followed by 'Engine Control System' and select 'ToyotaEtcsystem' from the 'on site educational programs' and start up the ToyotaEtcsystem program. Examine the program by moving the cursor while studying the data.

Fig. 7 Printscreen from the ETCS educational program

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Please answer the following questions:

1) Put the cursor on the zero position, study the data on the screen and compare the data with the table (fig.7). Is accelerator postion sensor 1 or 2 used in the program? Explain your answer.

2) How many Amps of current correspond with a duty cycle of the throttle motor of 14.9% ?
Use the table in fig.7. Explain your answer.

3) At which cursor position do we find the maximum throttle motor duty cycle? How much current do you think will flow through the motor? Use the table in fig. 7.

4) Study the data of the 'throttle position' and the 'throttle motor duty' cycle. The values are quite close but not always the same. Can you explain why?

5) When we press down the accelerator pedal, in which order will the data of the the sensors and actuators change?

6) Can you explain why the highest points of the 'accelerator pos', the 'throttle position' and the 'throttle motor duty' cycle correspond with the lowest positions of the engine speed line?

7) Give a possible cause for the accelerator position sensor line not corresponding with the throttle position sensor line.

8) Find the position of the cursor at which the accelerator pos. data is 3.3 V.
In that situation, what is the 'throttle position' and the 'throttle motor duty' cycle?

9) If there is a situation in which the accelelerator pos. data is 3.3 V and the corresponding throttle position is 15%, does that mean there is a technical defect?

10) How do you assess an 'accelerator pos.' data of 3.3 V, a 'throttle motor duty' cycle of 56% and a throttle position of 25%?

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