TEAM21

Technical Education for Automotive Mastery

TOYOTA TECHNICAL TRAINING

training manual

STEP **3** / VOLUME **1**

TCCS (TOYOTA COMPUTER-CONTROLLED SYSTEM)

FOREWORD

This Training Manual has been prepared for the use of technicians employed by Toyota's overseas distributors and dealers. This manual, "TCCS (Toyota Computer-Controlled System)", is Volume 1 of the thirteen Training Manuals which constitute Step 3 of the program of skills which all Toyota New TEAM* technicians should master. It should also be used by the instructor in conjunction with the accompanying Instruction Guide.

The titles of the New TEAM Step 3 Training Manuals are as follows:

VOL.	TRAINING MANUALS
1	TCCS (Toyota Computer-Controlled System)
2	Turbocharger & Supercharger
3	Diesel Injection Pump
4	ECT (Electronically-Controlled Transmission)
5	Full-Time 4WD
6	TEMS & Air Suspension
7	ABS & Traction Control System

VOL.	TRAINING MANUALS
8	NVH (Noise, Vibration & Harshness)
9	Fundamentals of Electronics
10	CCS (Cruise Control System)
11	Car Audio System
12	Automatic Air Conditioning System
13	SRS Airbag & Seat Belt Pretensioner

It is not enough just to "know" or "understand" — you need to master each task so that you can *do* it. For this reason, theory and practice have been combined in this Training Manual. The top of each page is marked either with a symbol to indicate that it is a Theory page or a symbol to indicate that it is a Practice page.

Note that in regards to inspection and other procedures mentioned in the Practice section, this Training Manual contains only the main points to be learned; please refer to the relevant Repair Manual(s) for details.

The following notations often occur in this manual, with the meanings as explained:

CAUTION	A potentially hazardous situation which could result in injury to people may occur if instructions are not followed.
NOTICE	Damage to the vehicle or components may occur if instructions are not followed.
NOTE	Notes or comments not included under the above two headings.
REFERENCE	Information not required to pass the TEAM certification, but which may be useful to instructors and to trainess who wish to gain a deeper knowledge of the subject.

***TEAM: TEAM stands for "Technical Education for Automotive Mastery", which is a training program divided into three steps according to the technician's technical level. This program makes it possible for technicians to receive the appropriate training for their level in a systematic manner so as to help them achieve the skills and efficiency of skilled technicians in the shortest possible time.**

This Training Manual explains the TCCS engine control system based on the 4A-FE engine. However, representative engines other than the 4A-FE engine have sometimes been selected to explain mechanisms not found on the 4A-FE engine. In this way, explanations of as many mechanisms as possible have been included.

All information contained in this manual is the most up-to-date at the time of publication. However, we reserve the right to make changes without prior notice.

TOYOTA MOTOR CORPORATION

TABLE OF CONTENTS

ABBREVIATIONS AND ECU TERMINAL SYMBOLS

ABBREVIATIONS

ABS	Anti-Lock Brake System
ABV	Air Bypass Valve
AC	Alternating Current
A/C	Air Conditioner
ACIS	Acoustic Control Induction System
ACV	Air Control Valve
AI	Air Injection
AS	Air Suction
ASV	Air Switching Valve
A/T	Automatic Transmission
BTDC	Before Top Dead Center
CA	Crankshaft Angle
CALIF.	California
CCS	Cruise Control System
CO	Carbon Monoxide
DIS	Direct Ignition System
DLI	Distributorless Ignition
EC	European Countries
ECT	Electronically-Controlled Transmission
ECU	Electronic Control Unit
EFI	Electronic Fuel Injection
EGR	Exhaust Gas Recirculation
EHPS	Electro-Hydraulic Power Steering
ESA	Electronic Spark Advance
FED.	Federal
GEN.	General Countries
HAC	High-Altitude Compensation
HC	Hydrocarbon
HIC	Hybrid Integrated Circuit
IIA	Integrated Ignition Assembly
ISC	Idle Speed Control
LED	Light Emitting Diode
LS	Lean Mixture Sensor
MRE	Magnetic Resistance Element
M/T	Manual Transmission
NOx	Oxides of Nitrogen
OC	Oxidation Catalyst
OD	Overdrive
O_2	Oxygen
PS	Power Steering
SCV	Swirl Control Valve
SST	Special Service Tool
SW	Switch
TCCS	Toyota Computer-Controlled System
TDC	Top Dead Center
TDCL*1	Toyota Diagnostic Communication Link or Total Diagnostic Communication Link
TEMS	Toyota Electronically-Modulated Suspension
Tr	Transistor
TRC*2	Traction Control
T-VIS	Toyota-Variable Induction System
TWC	Three-Way Catalyst
U.S.	United States
VSV	Vacuum Switching Valve
w/	With
w/o	Without
4WD	4-Wheel-Drive

*1 In vehicles sold at Lexus dealers in the U.S. and Canada, this is called the "Total Diagnostic Communication Link". In Toyotas sold in other countries, and in Toyotas sold at Toyota dealers in the U.S. and Canada, it is called the "Toyota Diagnostic Communication Link". In this manual, it is called the "Toyota Diagnostic Communication Link".

*2 In the U.S. and Canada, this is abbreviated to TRAC.

NOTE

Abbreviations in accordance with SAE terms are used for vehicles sold in the U.S.A. and Canada. Refer to the Repair Manual for differences between SAE terms and Toyota terms.

Example:

ECM Engine Control Module
(= Engine ECU)

ECT Engine Coolant Temperature
(= THW)

ECU TERMINAL SYMBOLS

SYMBOL	MEANING
ABS	Anti-Lock Brake System
ACC1	Acceleration Signal No. 1 (from Throttle Position Sensor)
ACC2	Acceleration Signal No. 2 (from Throttle Position Sensor)
A/C	Air Conditioner
ACMG	Air Conditioner Magnetic Clutch
ACT	Air Conditioner Cut-Off
AI	Air Injection
AS	Air Suction
A/D	Auto Drive (Cruise Control System)
+B	Battery
+B1	Battery No. 1
BATT	Battery
BF	Battery Fail Safe
BRK	Brake
DFG	Defogger
E01	Earth No. 01 (Ground)
E02	Earth No. 02 (Ground)
E1	Earth No. 1 (Ground)
E2	Earth No. 2 (Ground)
ECT	Electronically-Controlled Transmission
ELS	Electrical Load Signal
EGR	Exhaust Gas Recirculation
FC	Fuel Pump Control
FP	Fuel Pump Control Relay
FPU	Fuel Pressure-Up
FS	Fail-Safe Relay
G	Group (Crankshaft Angle Signal)
G1	Group No. 1 (Crankshaft Angle Signal)
G2	Group No. 2 (Crankshaft Angle Signal)
G–	Group Minus (–)
HAC	High-Altitude Compensation
HT	Heater (for Oxygen Sensor or Lean Mixture Sensor)
IDL	Idle Switch (in Throttle Position Sensor)
IGDA	Ignition Distribution Signal A
IGDB	Ignition Distribution Signal B
IGF	Ignition Failure (Confirmation) Signal
IGSW	Ignition Switch
IGT	Ignition Timing Signal

SYMBOL	MEANING
ISC1	Idle Speed Control Signal No. 1
ISC2	Idle Speed Control Signal No. 2
ISC3	Idle Speed Control Signal No. 3
ISC4	Idle Speed Control Signal No. 4
KD	Kick-Down
KNK	Knock Sensor
KS	Karman Signal
L1	Throttle Valve Opening Signal No. 1
L2	Throttle Valve Opening Signal No. 2
L3	Throttle Valve Opening Signal No. 3
LP	Lamp
LS	Lean Mixture Sensor
LSW	Lean Burn Switch
M-REL	EFI Main Relay
N/C	Neutral Clutch Switch
NE	Number of Engine Revolutions Signal
NE–	Number of Engine Revolutions Signal Minus (–)
NEO	Number of Engine Revolutions Signal Output
No.10	(for Injectors)
No.20	(for Injectors)
NSW	Neutral Start Switch
OX	Oxygen Sensor
OX⊕	Oxygen Sensor ⊕
OIL	Oil Pressure
OD	Overdrive
PS	Power Steering
PSW	Power Switch (in Throttle Position Sensor)
PIM	Pressure, Intake Manifold
R-P	Regular or Premium Gasoline Signal
RSC	Rotary Solenoid Valve Closed
RSO	Rotary Solenoid Valve Open
SCV	Swirl Control Valve
SPD	Vehicle Speed
SP2	Vehicle Speed No. 2
SP2–	Vehicle Speed No. 2 Minus (–)
STA	Starter
STJ	Cold Start Injector

SYMBOL	MEANING
STP	Stop Lamp Switch
T	Test Terminal
TE1	Test Terminal, Engine No. 1
TE2	Test Terminal, Engine No. 2
THA	Thermo, Intake Air
THG	Thermo, Exhaust Gas
THW	Thermo, Water
TR	Traction Control
T-VIS	Toyota-Variable Induction System
TSW	Water Temperature Switch
VAF	Voltage, Air-Fuel Ratio Control
VB	Voltage, Battery
VC	Voltage, Constant
VF	Voltage, Feedback
VG	Voltage, Gram Intake Air
V-ISC	VSV Type Idle Speed Control
VS	Voltage, Slide Signal
VSH	Voltage, Sub-Throttle Angle
VTA	Voltage, Throttle Angle
VTH	Voltage, Throttle Angle
W	"CHECK ENGINE" Warning Lamp
WIN	Warning Lamp, Intercooler

MEMO

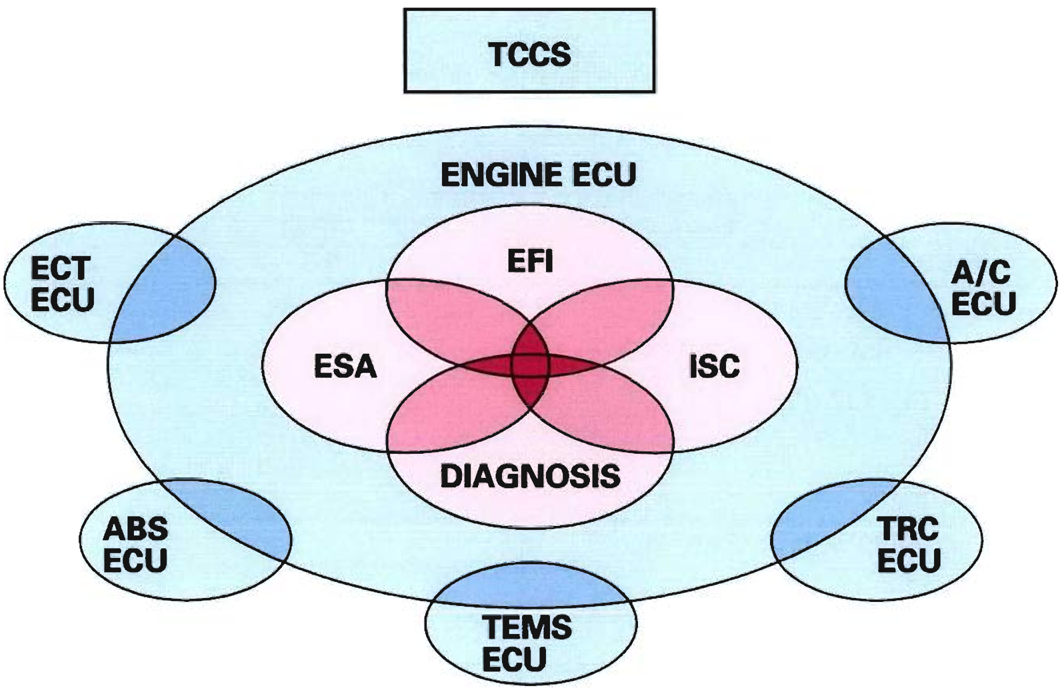
OUTLINE OF TCCS

WHAT IS TCCS?

"TCCS" (Toyota Computer-Controlled System) is the general name for a system which exercises comprehensive and highly precise control of the engine, drive train, brake system, and other systems by means of an ECU* (electronic control unit), at the heart of which is a microcomputer.
Previously, TCCS was used as an engine control system for only EFI (electronic fuel injection), ESA (electronic spark advance), ISC (idle speed control), diagnosis, etc.
Later, control systems utilizing other separate ECUs were developed and adopted for the control of systems other than the engine also.
Currently, the term "TCCS" has come to mean a comprehensive control system which incorporates control systems controlled by various ECUs to ensure basic vehicle performance, not only running, turning and stopping.
*At Toyota, a computer which controls each type of system is called an "ECU".

REFERENCE

On some vehicle models, the ECT has its own ECU, called the "ECT ECU". (The ECU for engine control is called the "Engine ECU" in this case.) On models in which the ECT does not have its own separate ECU, the ECT uses the ECU for engine control, which is then called the "Engine and ECT ECU".



CONCEPTUAL DIAGRAM OF TCCS

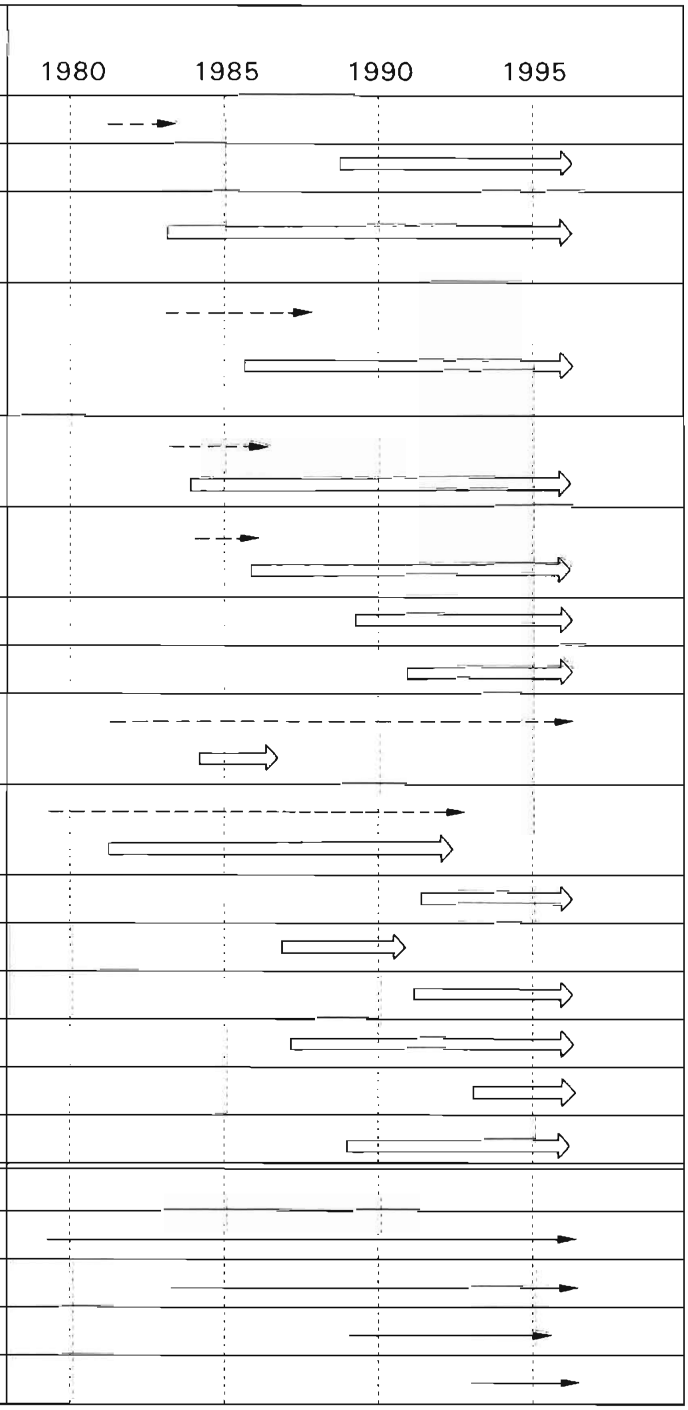
OHP 1

This manual explains the TCCS type engine control system. For details concerning other systems (ECT, ABS, TEMS, etc.), please refer to the training manual for each individual system.
In addition, this manual assumes that you have mastered the contents of the manual for Step 2, vol. 5 (EFI). If you have not, please read that manual carefully before beginning this one.

HISTORY OF TCCS ENGINE CONTROL SYSTEM

The ECU used for conventional EFI in export models beginning in 1979 was the analog circuit type, which controlled the injection volume based on the time required for a capacitor to be charged and discharged.
The microcomputer-controlled type was added beginning in 1981. That was the beginning of the engine control system using TCCS. Now, however, the TCCS engine control system not only controls EFI, but also ESA, which controls ignition timing; ISC, which controls the idle speed, and other such advanced systems; as well as the diagnostic, fail-safe, and back-up functions.

CYL. ARR.	ENGINE MODELS
L4	K series (4K-E)
	E series (3E-E) [2E-E, 4E-FE, 5E-FE]
	A series (4A-GE, 4AG-ZE) [4A-FE, 5A-FE, 7A-FE]
	S series (2S-E) (1S-i, 1S-E, 2S-E) [3S-FE, 5S-FE, 3S-GE, 3S-GTE]
	R series (22R-E) (22R-TE) [22R-E]
	Y series (3Y-E) [4Y-E]
	RZ series [1RZ-E, 2RZ-E, 2RZ-FE, 3RZ-FE]
	TZ series [2TZ-FE, 2TZ-FZE]
L6	G series (1G-E)[1G-FE] (1G-GE)
	M series (4M-E, 5M-E, 5M-GE) (5M-GE, 6M-GE, 7M-GE, 7M-GTE)
	JZ series [2JZ-GE, 2JZ-GTE]
	F series (3F-E)
	FZ series [1FZ-FE]
V6	VZ series (2VZ-FE)[3VZ-E, 3VZ-FE, 5VZ-FE]
	MZ series [1MZ-FE]
V8	UZ series [1UZ-FE]
INTAKE AIR SENSING DEVICES	
Vane type air flow meter	
Manifold pressure (vacuum) sensor	
Optical Karman vortex type air flow meter	
Hot-wire type mass air flow meter	

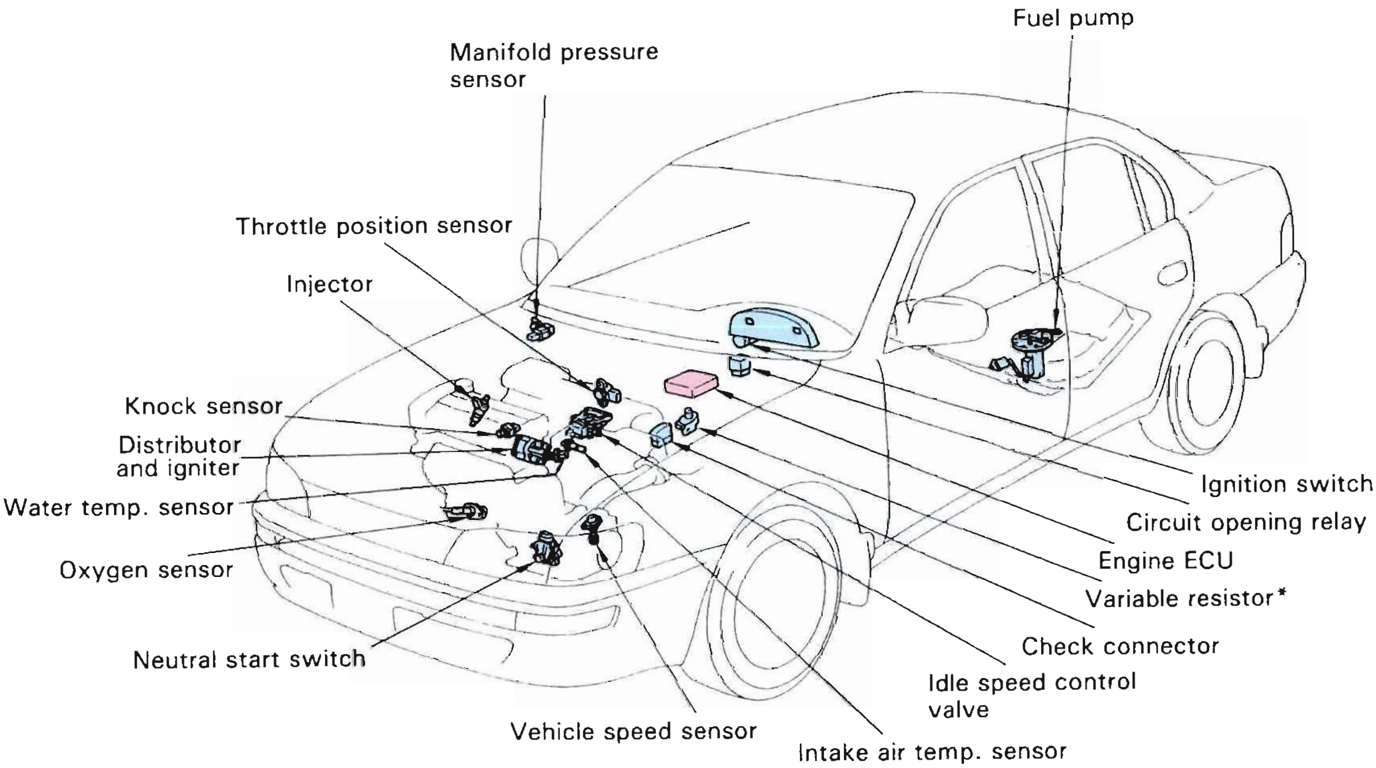


( ): No longer in production models
[ ]: Current product models
- - -►: EFI (EFI control only)
⇨: TCCS (EFI, ESA, ISC, Diagnosis, etc)

SYSTEM DESCRIPTION

The functions of the engine control system include EFI, ESA, and ISC, which control basic engine performance; a diagnostic function, which is useful when repairs are made; and fail-safe and back-up functions, which operate when any of these control systems malfunction.

In addition, there are auxiliary engine control devices on the engine, such as the OD cut-off control system, intake air control system, and others. These functions are all controlled by the Engine ECU.



*Applicable only to General Country specification vehicles without oxygen sensor.

LAYOUT OF ENGINE CONTROL SYSTEM COMPONENTS (COROLLA 4A-FE ENGINE FOR EUROPE Apr., 1992)

1. FUNCTIONS OF ENGINE CONTROL SYSTEM

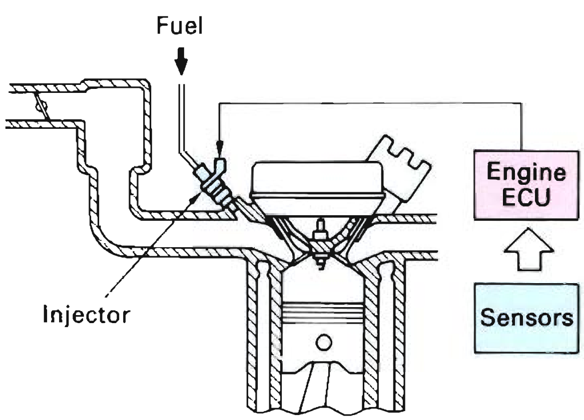
EFI (ELECTRONIC FUEL INJECTION)

An electric fuel pump supplies sufficient fuel, under a constant pressure, to the injectors.
These injectors inject a metered quantity of fuel into the intake manifold in accordance with signals from the Engine ECU.
The Engine ECU receives signals from various sensors indicating changing engine operating conditions such as:

- Manifold pressure (PIM) or intake air volume (VS, KS or VG)
- Crankshaft angle (G)
- Engine speed (NE)
- Acceleration/deceleration (VTA)
- Coolant temperature (THW)
- Intake air temperature (THA)

etc.

These signals are utilized by the Engine ECU to determine the injection duration necessary for the optimal air-fuel ratio to suit the present engine running conditions.



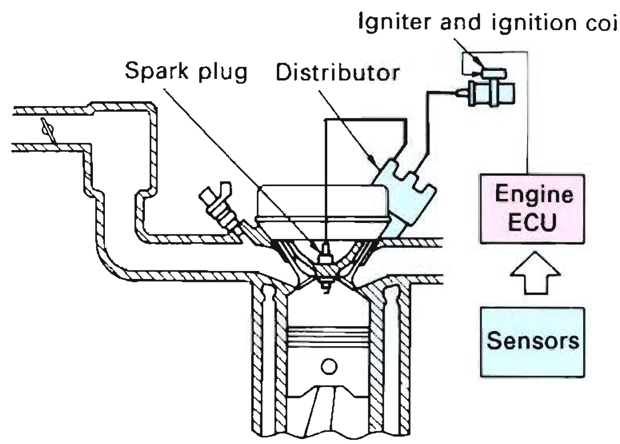
OHP 3

ESA (ELECTRONIC SPARK ADVANCE)

The Engine ECU is programmed with data that will ensure optimal ignition timing under any and all operating conditions. Based on this data, and on data provided by the sensors that monitor various engine operating conditions, such as those shown below, the Engine ECU sends IGT (ignition timing) signals to the igniter to trigger the spark at precisely the right instant.

- Crankshaft angle (G)
- Engine speed (NE)
- Manifold pressure (PIM) or intake air volume (VS, KS or VG)
- Coolant temperature (THW)

etc.



OHP 3

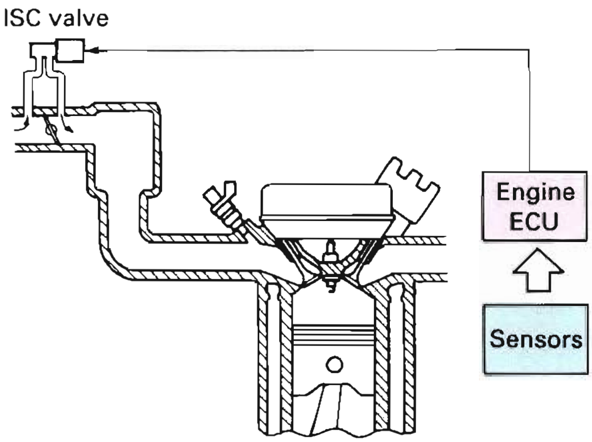
ISC (IDLE SPEED CONTROL)

The Engine ECU is programmed with target engine speed values to respond to different engine conditions such as:

- Coolant temperature (THW)
- Air conditioner on/off (A/C)

etc.

Sensors transmit signals to the Engine ECU, which, by means of the ISC valve, controls the flow of air through the throttle valve bypass and adjusts the idle speed to the target value.

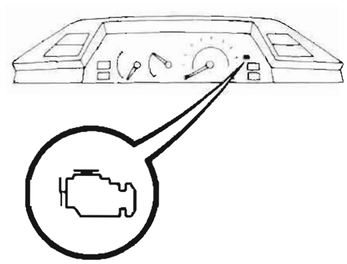


OHP 4

DIAGNOSTIC FUNCTION

The Engine ECU is constantly monitoring the signals that are input to it from the various sensors. If it detects any malfunctions in the input signals, the Engine ECU stores data on the malfunction in its memory and lights the "CHECK ENGINE" lamp. When necessary, it displays the malfunction by lighting the "CHECK ENGINE" lamp, displaying on a tester* or outputting a voltage signal.

* OBD-II scan tool or TOYOTA hand-held tester



"CHECK ENGINE" lamp

OHP 4

FAIL-SAFE FUNCTION

If the signals input to the Engine ECU are abnormal, the Engine ECU switches to standard values stored in its internal memory to control the engine. This makes it possible to control the engine so as to continue more-or-less normal vehicle operation.

BACK-UP FUNCTION

Even if the Engine ECU itself becomes partially inoperative, the back-up function can continue to execute fuel injection and ignition timing control. This makes it possible to control the engine so as to continue more-or-less normal vehicle operation.

OTHER CONTROL SYSTEMS

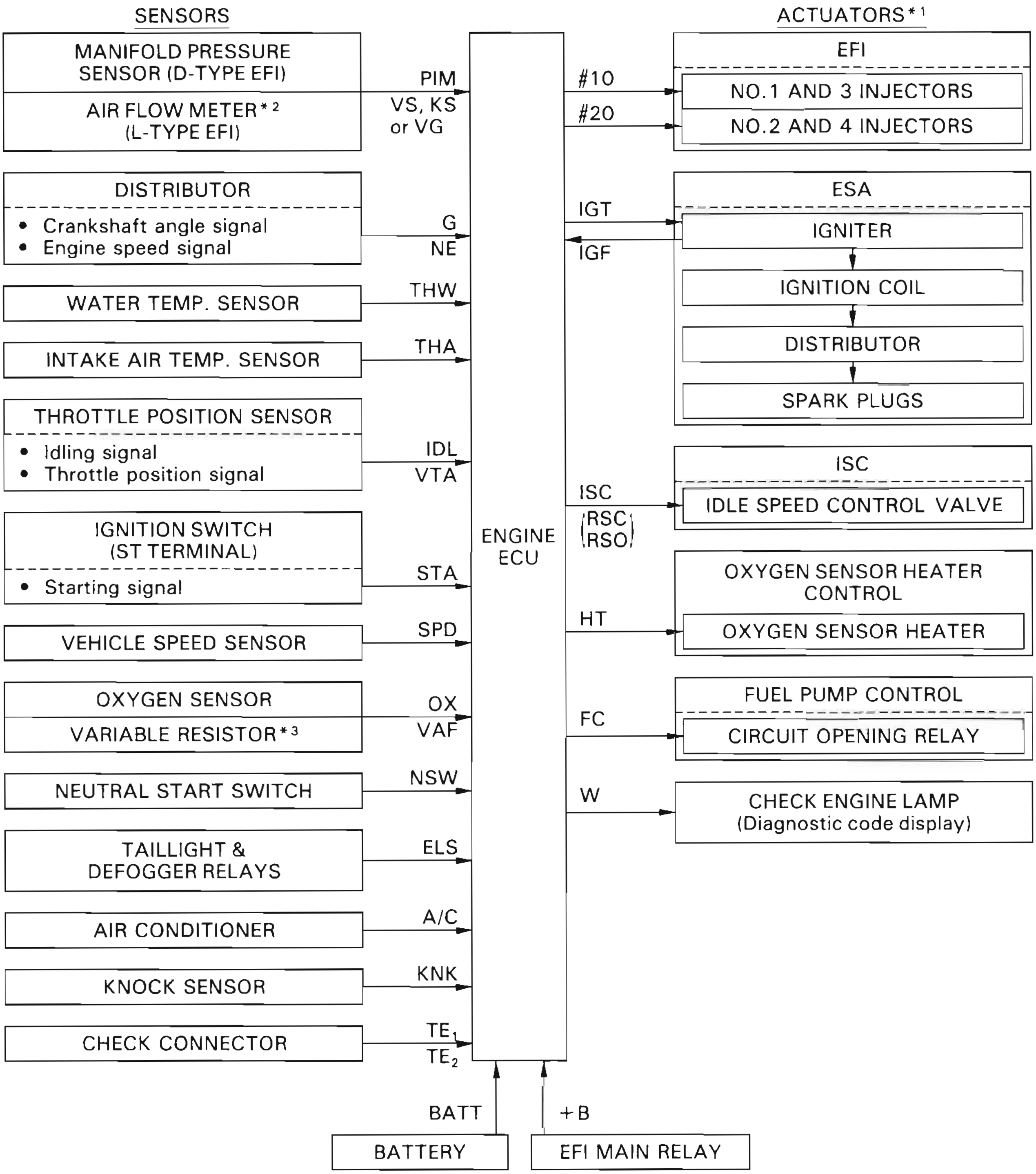
In some engines, the OD cut-off control system, intake air control system, and some other auxiliary systems are also controlled by the Engine ECU.

2. CONSTRUCTION OF ENGINE CONTROL SYSTEM

BLOCK DIAGRAM

The engine control system can be broadly divided into three groups: the sensors, the Engine ECU and the actuators.

The sensors and actuators which form the basis of an engine control system used in an engine with an oxygen sensor are shown below.



*1 Actuators only related profoundly to the engine control are shown here.

*2 Although a D-type EFI is shown in the above figure and a L-type EFI sensor is also shown for reference.

*3 Applicable only to General Country specification vehicles without oxygen sensor.

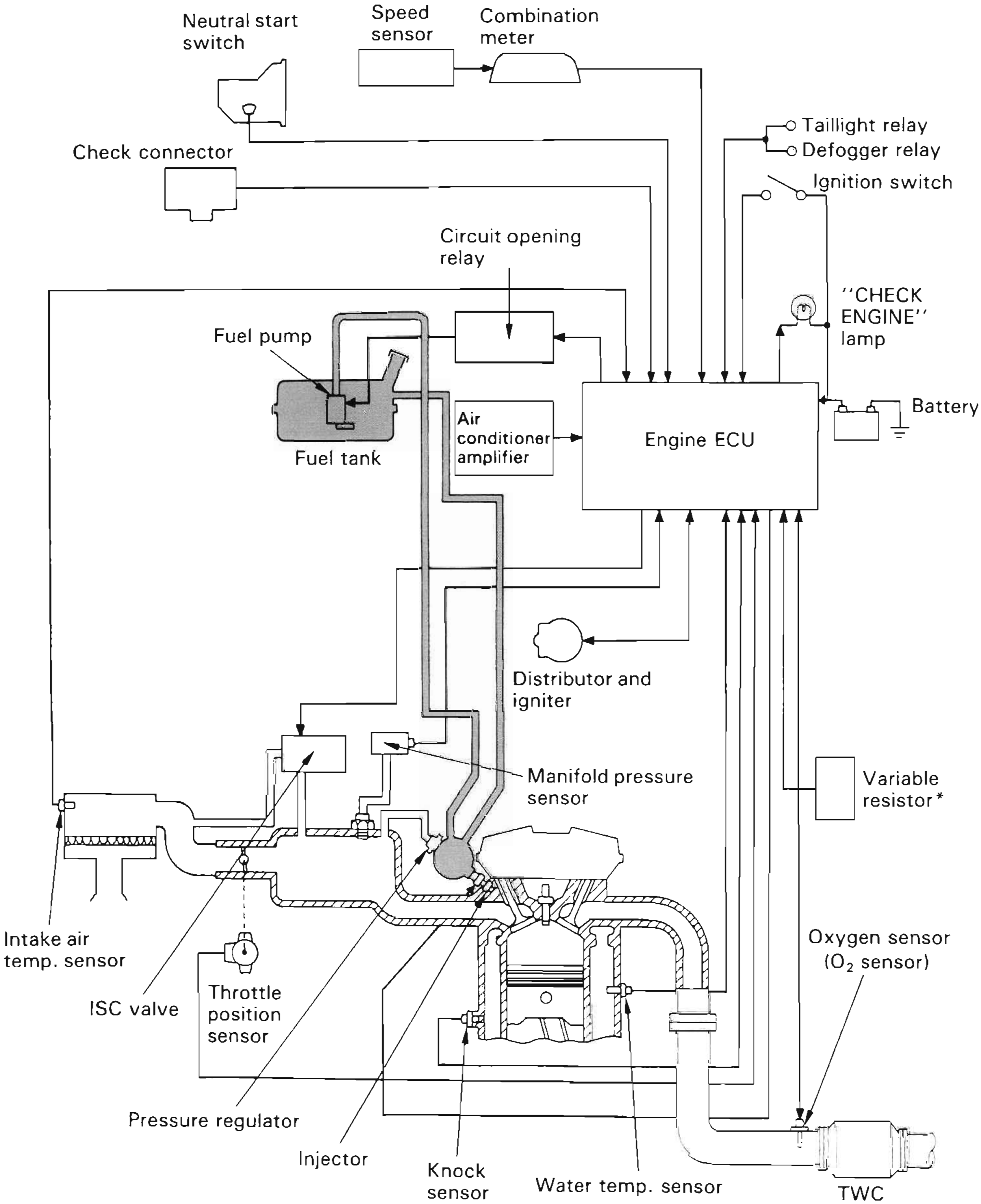
COMPONENTS AND FUNCTIONS

The sensors, Engine ECU, and actuators, which are the basis of the engine control system, are shown in the following table, along with their relationship with the main functions of the engine control system, EFI, ESA and ISC.

REFERENCE
The signals used for each control may differ for some engines.

COMPONENTS		SIG-NALS	FUNCTIONS	EFI	ESA	ISC
Sensors	Manifold pressure sensor (vacuum sensor) (D-type EFI)	PIM	Senses intake manifold pressure.	○	○	
	Air flow meter (L-type EFI)	VS, KS or VG	Senses intake air volume.			
	Distributor	G	Senses crankshaft angle.	○	○	
		NE	Senses engine speed.	○	○	○
	Water temp. sensor	THW	Senses coolant temperature.	○	○	○
	Intake air temp. sensor	THA	Senses intake air temperature.	○		
	Throttle position sensor (on-off type)	IDL	Senses when throttle valve is fully closed.	○	○	○
		PSW	Senses when throttle valve near fully open.	○		
	Throttle position sensor (linear type)	IDL	Senses when throttle valve is fully closed.	○	○	○
		VTA	Senses throttle valve opening angle.	○		
	Ignition switch	STA	Senses when ignition switch is start position.	○	○	○
	Vehicle speed sensor	SPD	Senses vehicle speed.	○		○
	Oxygen sensor (O_2 sensor)	OX	Senses oxygen density in exhaust gas.	○		
	Variable resistor	VAF	It is used to change the air-fuel ratio of the idle mixture.	○		
	Neutral start switch	NSW	Senses whether transmission is in "P" or "N", or in some other gear.			○
	Taillight & defogger relays	ELS	Senses electrical load.			○
	Air conditioner	A/C	Senses whether air conditioner is on or off.		○	○
	Knock sensor	KNK	Senses engine knocking.		○	
Engine ECU			Determines injection duration and timing, ignition timing, idle speed, etc., based upon data from sensors and data stored in memory, and sends appropriate signals to control actuators.	○	○	○
Actuators	Injectors	No.10 No.20	Injects fuel into intake manifold in accordance with signals from Engine ECU.	○		
	Igniter	IGT IGF	When IGT signals from Engine ECU go off, primary current to igniter is interrupted, and sparks are generated by spark plugs. Igniter then sends IGF signals to Engine ECU.		○	
	Idle speed control valve	ISC	Controls idle speed by changing volume of air flowing through throttle valve bypass in accordance with signals from Engine ECU.			○

3. ENGINE CONTROL SYSTEM DIAGRAM



*Applicable only to General Country specification vehicles without oxygen sensor.

COROLLA 4A-FE ENGINE FOR EUROPE (Apr., 1992)

ELECTRONIC CONTROL SYSTEM

GENERAL

The engine control system can be divided into three groups: sensors (and the signals output by them), the ECU, and actuators. This section describes only the sensor (signal) systems.
ECU functions are divided into EFI control, ESA control, ISC control, diagnostic function, fail-safe function, back-up function and others. Each of these functions is covered in a separate section of this manual.
Actuator functions are also covered in a separate section.

The following table shows the specifications for the 4A-FE engine. Information on sensors (and their signals) marked with a circle in the "APPENDIX" column is included in the specifications for each engine in the APPENDIX section (page 188) at the back of this manual.
Sensors (signals) covered in Step 2, vol. 5 (EFI), are covered in outline form only in this manual.
If there is a circle in the "STEP 2 (EFI)" column in the following table, refer to the Step 2, vol. 5 (EFI), for a detailed explanation of the relevant sensors (and their signals).

SENSORS (SIGNALS)		PAGE (THIS MANUAL)	ITEM *	REMARK	APPENDIX	STEP 2 (EFI)
Power circuitry	Engine without stepper motor type ISC valve	15	○			
	Engine with stepper motor type ISC valve	16				
VC circuitry		16	○			
Ground circuitry		16	○			
Manifold pressure sensor (vacuum sensor)		17	○		○	
Air flow meter	Vane type	18			○	○
	Optical Karman vortex type	21			○	
	Hot-wire type	21-1				
Throttle position sensor	On-off type	22			○	○
	Linear type	23	○		○	
G and NE signal generators	In-distributor type	24	○		○	
	Cam position sensor type	27			○	
	Separate type	28			○	
Water temperature sensor		30	○			○
Intake air temperature sensor		30	○			○
Oxygen sensor (O_2 sensor)	Zirconia element type	31	○	With TWC	○	○
	Titania element type	32			○	
Lean mixture sensor		33			○	

* Specifications for Carolla AE101 4A-FE engine (Apr., 1992)

(Continued on next page)

SENSORS (SIGNALS)		PAGE (THIS MANUAL)	ITEM*	REMARK	APPENDIX	STEP 2 (EFI)
Vehicle speed sensor	Reed switch type	34				
	Photocoupler type	34				
	Electromagnetic pickup type	35				
	MRE (magnetic resistance element) type	36	○			
STA (ignition switch) signal		38	○			○
NSW (neutral start switch) signal		38	○			
A/C (air conditioner) signal		39	○			
Electrical load signal		39	○			
Fuel control switch or connector		40				
EGR gas temperature sensor		40	○	California specification models		
Variable resistor		41	○	Except with oxygen sensor		
Kick-down switch		42				
Water temperature switch		42				
Clutch switch		42				
Knock sensor		43	○	With knocking correction for ESA	○	
HAC (high-altitude compensation) sensor		44				
Turbocharging pressure sensor		44				
Stop lamp switch		45				
Oil pressure switch		45				
Communications signals	Throttle opening angle signals	45				
	Throttle opening angle signals for TRC (traction control) system	45				
	Cruise control system communications signal	46				
	TRC system communications signal	46				
	ABS (anti-lock brake system) communications signal	46				
	Intercooler system warning signal	46				
	EHPS (electro-hydraulic power steering) system communications signal	47				
	Engine speed signal	47				
Diagnostic terminal (s)		47	○			

* Specifications for Corolla AE101 4A-FE engine (Apr., 1992)

POWER CIRCUITRY

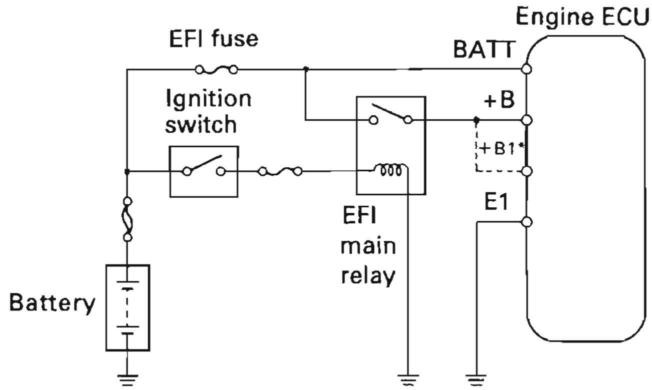
This circuitry supplies power to the Engine ECU, and includes the ignition switch and the EFI main relay. There are two types of this circuitry in use. In one, current flows directly from the ignition switch to the EFI main relay coil to operate the EFI main relay (the type without the stepper motor type ISC valve). In the other, the Engine ECU operates the EFI main relay directly (the type with the stepper motor type ISC valve).

1. ENGINE WITHOUT STEPPER MOTOR TYPE ISC VALVE

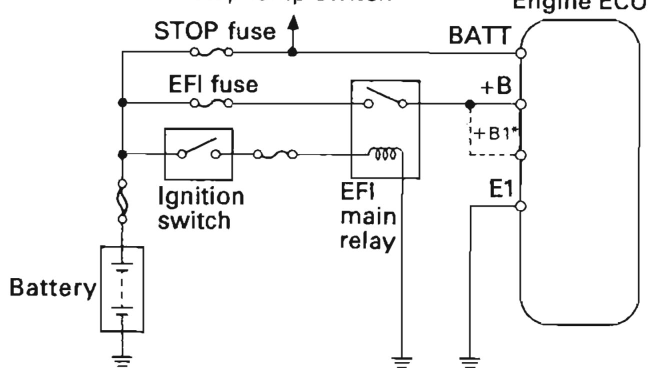
The following diagrams show the type in which the EFI main relay is operated directly from the ignition switch. When the ignition switch is turned on, current flows to the coil of the EFI main relay, causing the contacts to close. This supplies power to the +B and +B1 terminals of the Engine ECU. Battery voltage is supplied at all times to the BATT terminal of the Engine ECU to prevent the diagnostic codes and other data in its memory from being erased when the ignition switch is turned off.

There are two types of circuitry for the type without a stepper motor, depending on the vehicle model.

ELECTRICAL CIRCUITRY



OHP 7



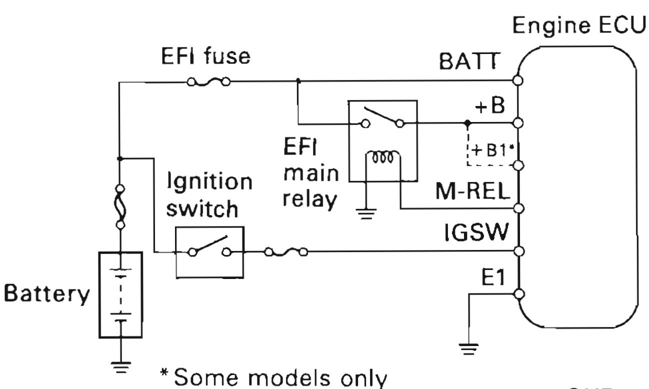
OHP 7

* Some models only

2. ENGINE WITH STEPPER MOTOR TYPE ISC VALVE

The diagram below shows the type in which the EFI main relay is operated from the Engine ECU. In engines with the stepper motor type ISC valve, since initial set control is carried out when the ignition switch is turned off, power is supplied to the Engine ECU for this purpose for approximately 2 seconds after the ignition switch is turned off. (For further details, see page 105.) When the ignition switch is turned on, battery voltage is supplied to the IGSW terminal of the Engine ECU, and the EFI main relay control circuitry in the Engine ECU sends a signal to the M-REL terminal of the Engine ECU, turning on the EFI main relay. This signal causes current to flow to the coil, closing the contacts of the EFI main relay and supplying power to the +B and +B1 terminals of the Engine ECU. Battery voltage is supplied at all times to the BATT terminal of the Engine ECU to prevent the diagnostic codes and other data in its memory from being erased when the ignition switch is turned off.

ELECTRICAL CIRCUITRY

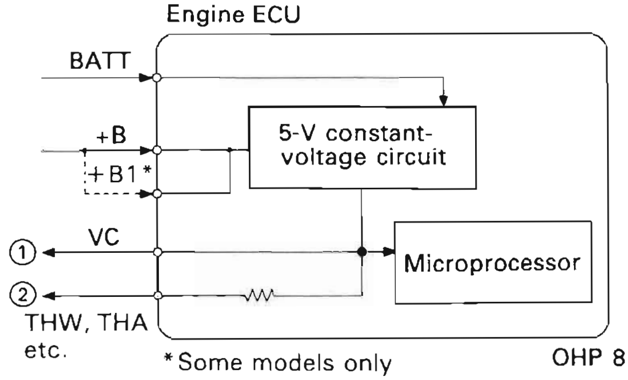


OHP 7

VC CIRCUITRY

The Engine ECU generates a constant 5 volts to power the microprocessor from the battery voltages supplied to the +B and +B1 terminals. The Engine ECU supplies this 5 V of power to the sensors through circuitry like that shown below.

ELECTRICAL CIRCUITRY



OHP 8

① Outputs 5 V from the 5-V constant-voltage circuit.

② Outputs 5 V from the 5-V constant-voltage circuit through a resistor.

NOTE

When the VC circuit is open or shorted, each of the sensors using the 5 V constant voltage of the VC is no longer activated.

In addition, since the microprocessor will no longer be activated when the VC circuit is shorted, the engine ECU will not operate. As a result, the engine will stall.

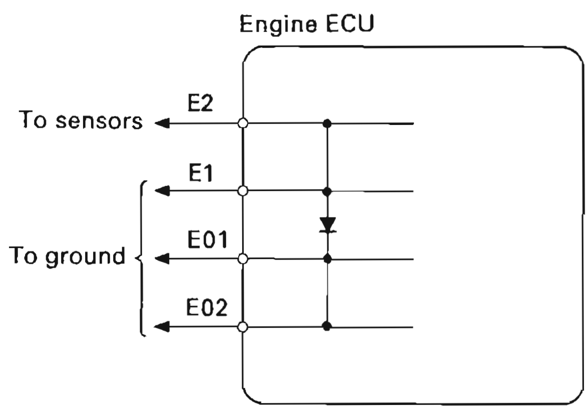
GROUND CIRCUITRY

The Engine ECU has the following three types of basic ground circuitry:

- E1 terminal, which grounds the Engine ECU.
- E2 terminal, which grounds the sensors.
- E01 and E02 terminals, which ground the drive circuits for the injectors or ISC valve, etc.

These ground circuits are connected inside the Engine ECU as shown in the following diagram.

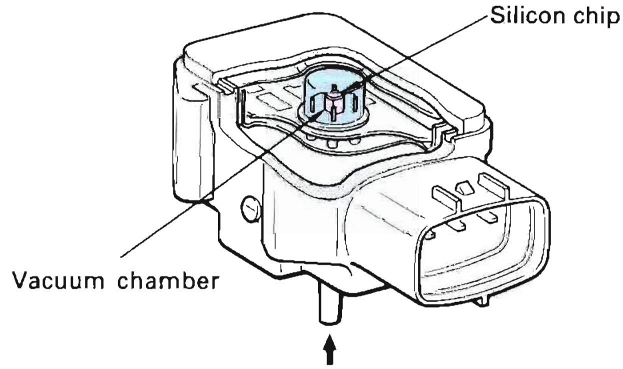
ELECTRICAL CIRCUITRY



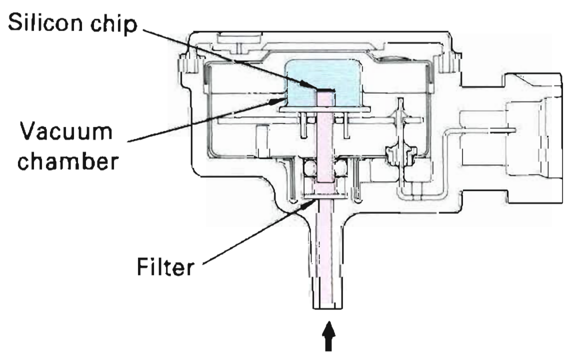
OHP 8

MANIFOLD PRESSURE SENSOR (VACUUM SENSOR)

The manifold pressure sensor is used with D-type EFI for sensing the intake manifold pressure.
This is one of the most important sensors in D-type EFI.
By means of an IC built into this sensor, the manifold pressure sensor senses the intake manifold pressure as a PIM signal. The Engine ECU then determines the basic injection duration and basic ignition advance angle on the basis of this PIM signal.



OHP 9

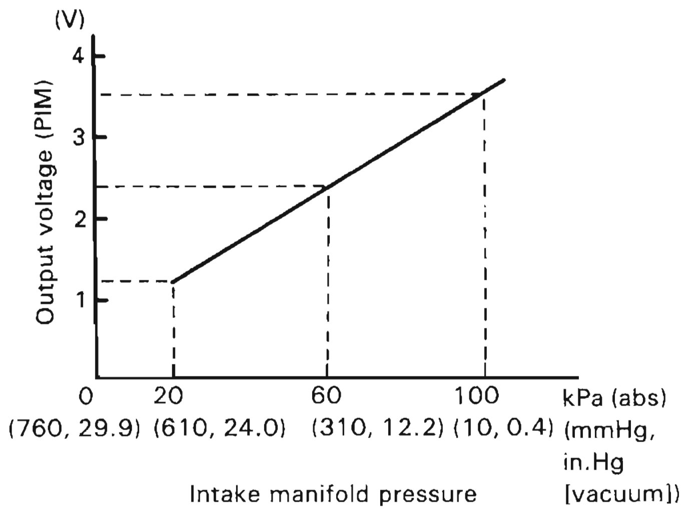


OHP 9

OPERATION AND FUNCTION

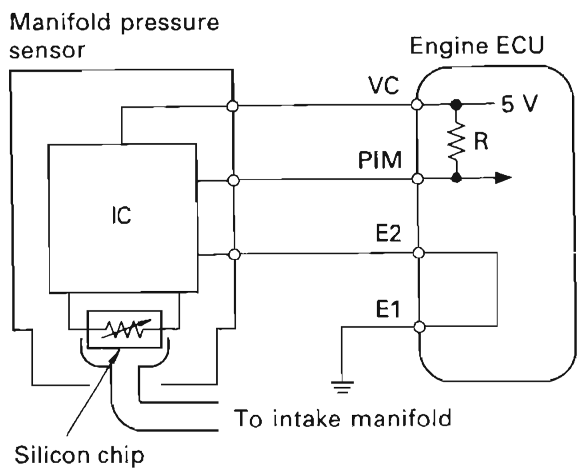
A silicon chip combined with a vacuum chamber maintained at a predetermined vacuum is incorporated into the sensor unit. One side of the chip is exposed to intake manifold pressure and the other side is exposed to the internal vacuum chamber.

A change in the intake manifold pressure causes the shape of the silicon chip to change, and the resistance value of the chip fluctuates in accordance with the degree of deformation.
This fluctuation in the resistance value is converted to a voltage signal by the IC built into the sensor and is then sent to the Engine ECU from the PIM terminal as an intake manifold pressure signal. The VC terminal of the Engine ECU supplies a constant 5 volts as a power source for the IC.



OHP 9

ELECTRICAL CIRCUITRY



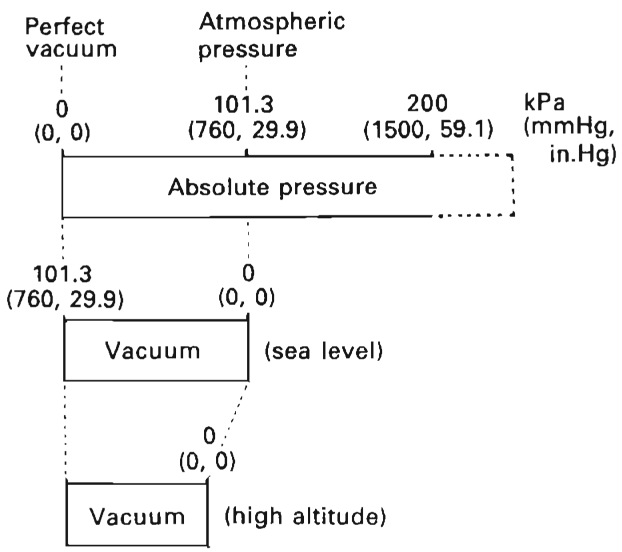
OHP 10

NOTE

The manifold pressure sensor uses the vacuum in the vacuum chamber that is built into it. The vacuum in this chamber is close to a perfect vacuum, and is not influenced by the changes in atmospheric pressure that occur due to changes in altitude.

The manifold pressure sensor compares the intake manifold pressure to this vacuum, and outputs a PIM signal which is not influenced by changes in atmospheric pressure.

This permits the ECU to keep the air-fuel ratio at the optimal level even at high altitudes.



OHP 10

AIR FLOW METER

The air flow meter is used with L-type EFI for sensing the intake air volume.

In L-type EFI, this is one of the most important sensors. The intake air volume signal is used to calculate the basic injection duration and basic ignition advance angle.

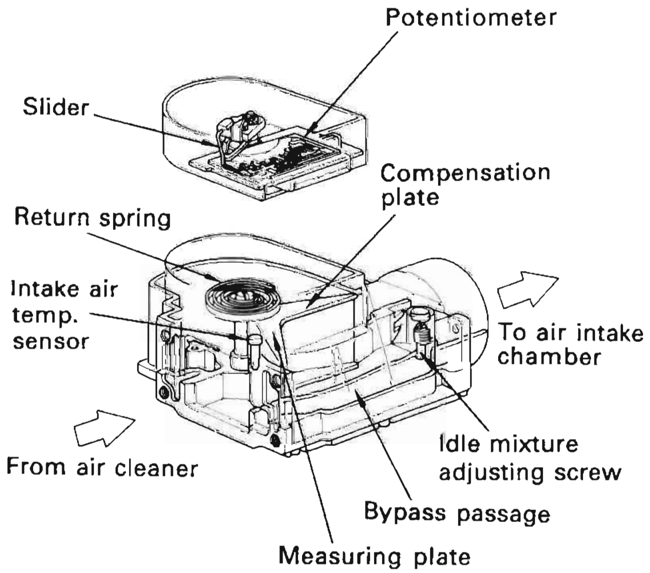
The following three types of air flow meter are used:

- Volume air flow meter
  - Vane type
  - Optical Karman vortex type
- Mass air flow meter
  - Hot-wire type

1. VANE TYPE

There are two types of vane type air flow meter. These differ in the nature of their electrical circuitry, but the components for the two types are the same.

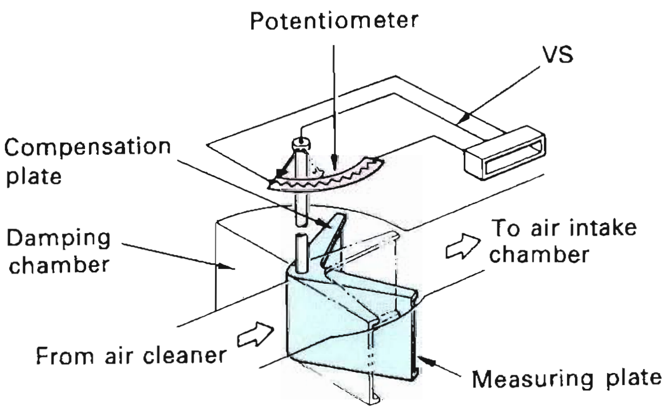
This type of air flow meter is composed of many components, as shown in the following illustration:



OHP 11

OPERATION AND FUNCTION

When air passes through the air flow meter from the air cleaner, it pushes open the measuring plate until the force acting on the measuring plate is in equilibrium with the return spring.
The potentiometer, which is connected coaxially with the measuring plate, converts the intake air volume to a voltage signal (VS signal) which is sent to the Engine ECU. The damping chamber and compensation plate act to prevent the measuring plate from vibrating when the air intake volume changes suddenly.



OHP 11

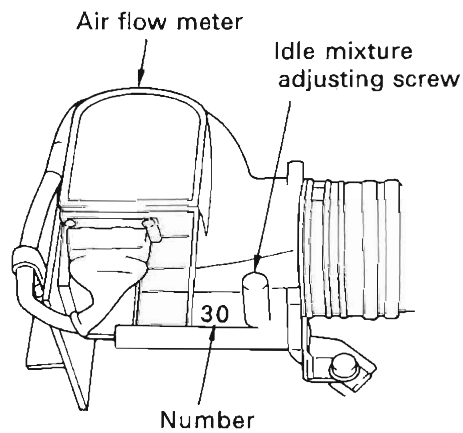
IDLE MIXTURE ADJUSTING SCREW

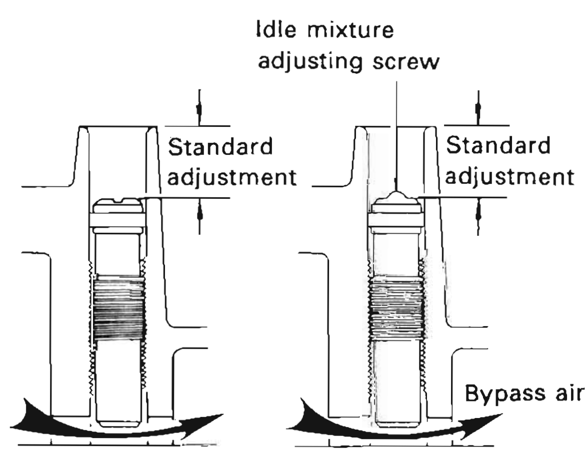
An idle mixture adjusting screw is included in the bypass passage. This screw is used to adjust the volume of intake air which bypasses the measuring plate, and can be used to adjust the idle mixture. (Some engines are equipped with air flow meters which are sealed with an aluminum plug.)

REFERENCE

Standard Adjustment Mark of Idle Mixture Adjusting Screw

As shown in the illustration, a two digit number is stamped on the air flow meter near the idle mixture adjusting screw. This number indicates the distance from the body upper surface to the flat surface of the screw when the VS voltage of the air flow meter is at the standard voltage at the time that the volume of air through the bypass was adjusted during final inspection of the air flow meter at the factory. For example, if the number is "30", it means that the distance was 13.0 mm (0.511 in). If the number is "26", it indicates the distance was 12.6 mm (0.496 in).



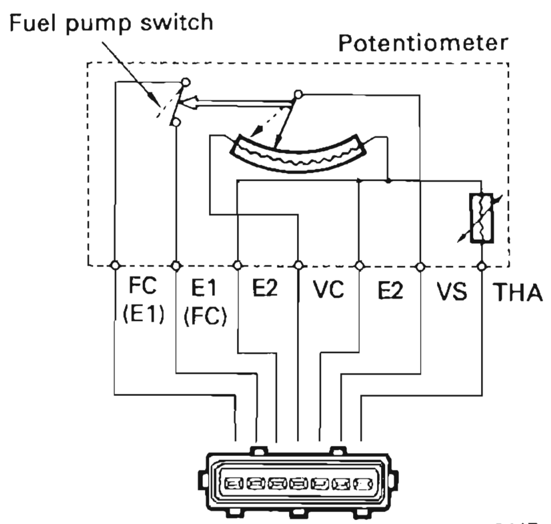


VS SIGNAL

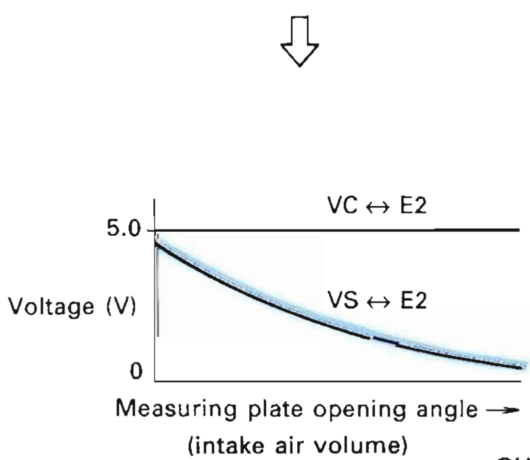
There are two types of vane type air flow meter, which differ in the nature of their electrical circuitry. In one type, the VS voltage falls when the air intake volume becomes large and in the other type, the VS voltage rises when the air intake volume becomes large.

① Type 1

The Engine ECU has a built-in constant-voltage circuit, which supplies a constant 5 V to the VC terminal of the air flow meter. Consequently, the output voltage at the VS terminal will always indicate the exact opening angle of the measuring plate, and therefore, the exact intake air volume.



OHP 12



OHP 12

② Type 2

This type of air flow meter is supplied with battery voltage from the VB terminal.

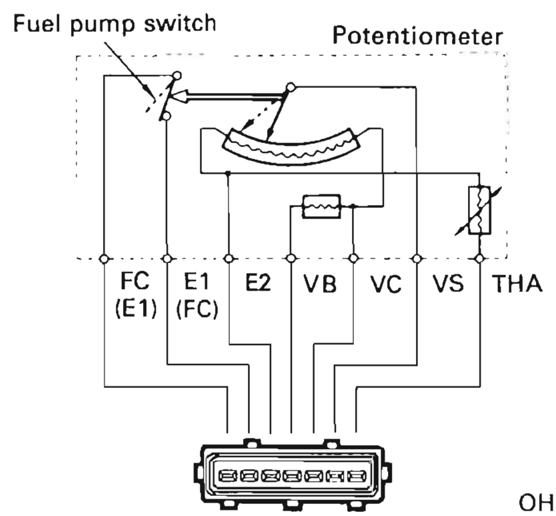
This type of air flow meter does not have a constant voltage (5 V) supplied from the Engine ECU, so the voltage determined by the ratio of the resistances of the resistor between VB and VC and the resistor between VC and E2 is input to the Engine ECU via the VC terminal.

As a result, even when the VS voltage is affected by fluctuations in the battery voltage, the Engine ECU, by executing the following calculation, can detect the intake air volume accurately:

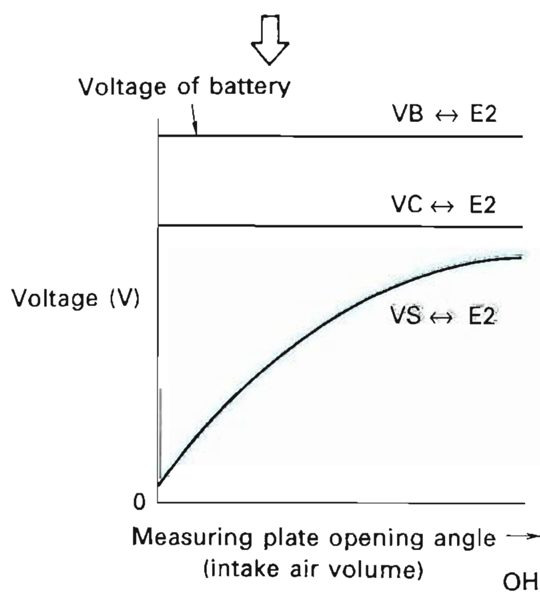
Intake air volume =

$$\frac{VB - E2}{(VC - E2) - (VS - E2)} = \frac{VB - E2}{VC - VS}$$

For further details, see Step 2, vol. 5 (EFI).



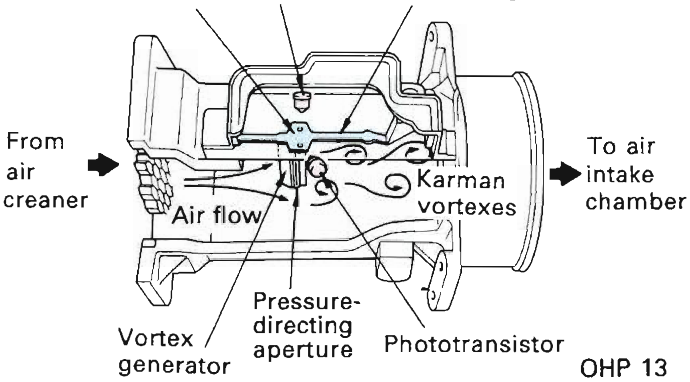
OHP 12



OHP 12

2. OPTICAL KARMAN VORTEX TYPE

This type of air flow meter directly senses the intake air volume optically. Compared to the vane type air flow meter, it can be made smaller and lighter in weight. The simplified construction of the air passage also reduces inlet resistance.
This air flow meter is constructed as shown in the following illustration:



OHP 13

OPERATION AND FUNCTION

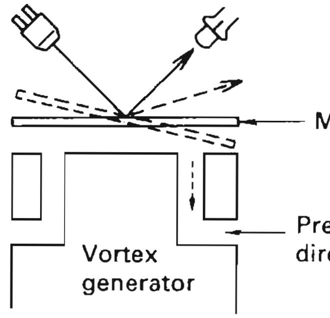
A pillar (called the "vortex generator") placed in the middle of a uniform flow of air generates a vortex called a "Karman vortex" down-stream of the pillar.
The frequency "f" of the Karman vortex thus generated, the velocity of the air "V" and the diameter of the pillar "d" have the following relationship:

$$f = K \times \frac{V}{d}$$

KARMAN VORTEX

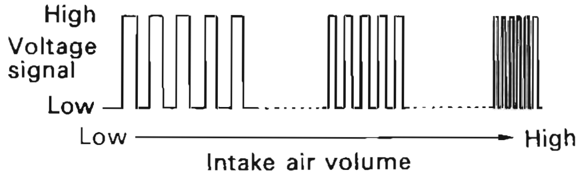
OHP 13

Utilizing this principle, the frequency of the vortexes generated by the vortex generator is measured, making it possible to determine the air flow volume.
Vortexes are detected by subjecting the surface of a piece of thin metal foil (called a "mirror") to the pressure of the vortexes and optically detecting the vibrations of the mirror by means of a photocoupler (an LED combined with a phototransistor).



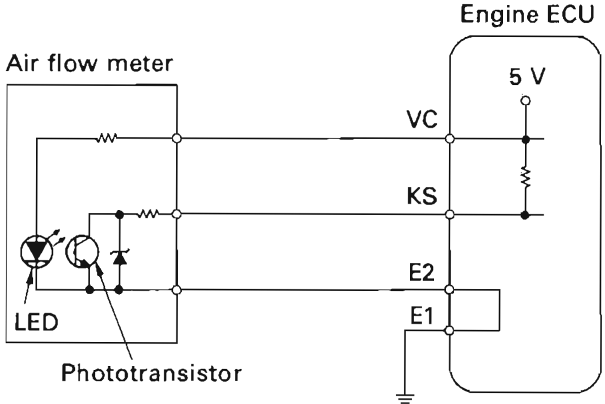
OHP 13

The intake air volume (KS) signal is a pulse signal like that shown below. When the intake air volume is low, this signal has a low frequency. When the intake air volume is high, this signal has a high frequency.



OHP 13

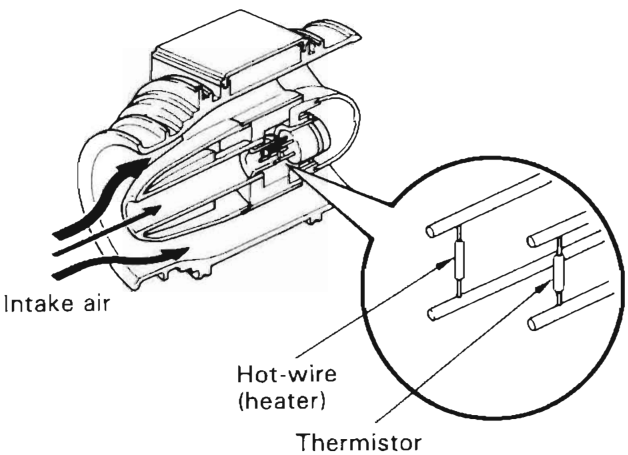
ELECTRICAL CIRCUITRY

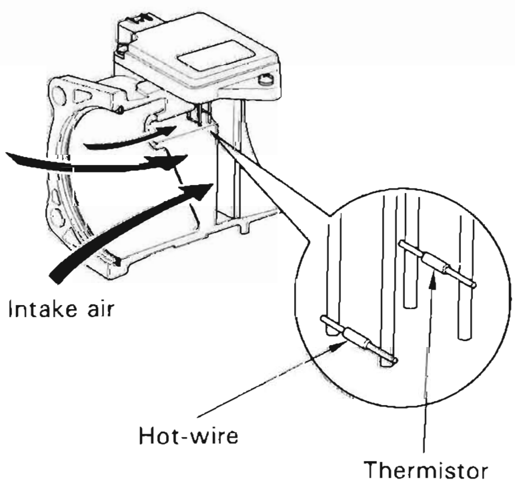


OHP 13

3. HOT-WIRE TYPE

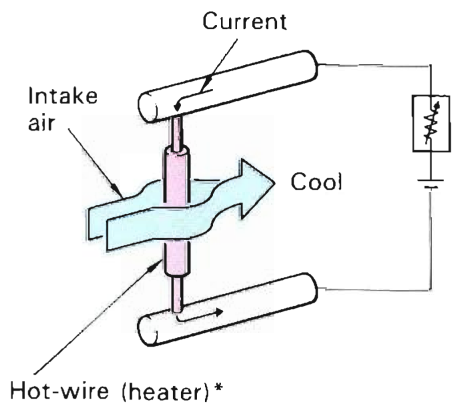
Instead of measuring intake air volume in the manner of other air flow meters, a hot-wire type air flow meter measures intake air mass directly.
The structure is both compact and lightweight. In addition, there is only a low level of intake resistance by the sensor.
Having no mechanical functions it offers a superior durability.



> REFERENCE
> A hot-wire type air flow meter as shown below is used on some models.
>
> 
>

OPERATION AND FUNCTION

Current flows to the hot-wire (heater) causing it to be heated. When air flows through the wire, the hot-wire is cooled corresponding to the intake air mass. By controlling the current flowing to the hot-wire in order to keep the hot-wire temperature constant, that current becomes proportional to intake air mass. Intake air mass can then be measured by detecting that current. In case of hot-wire type air flow meters, this current is converted into a voltage that is then output to the Engine ECU.



*Constant temperature

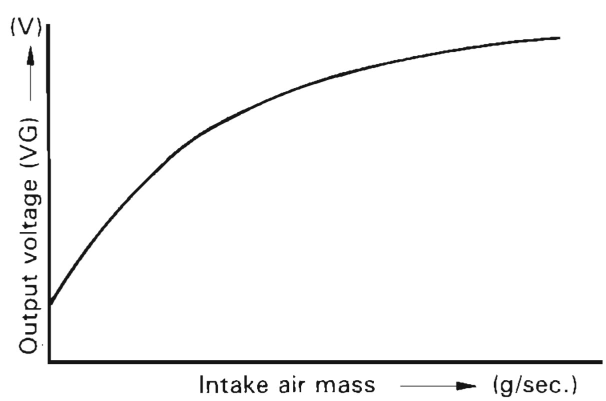
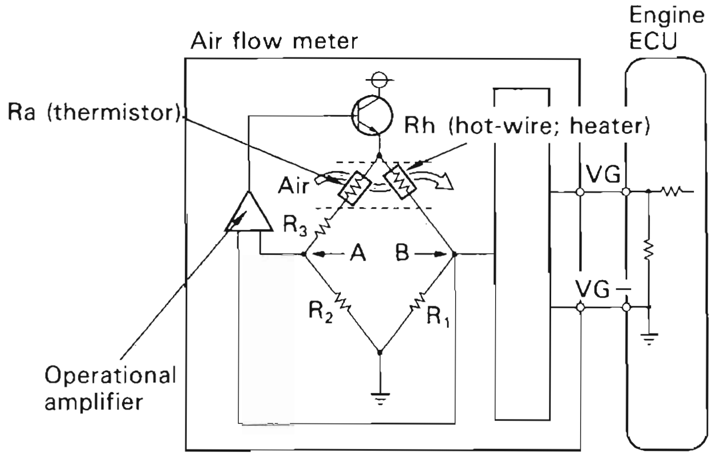


Diagram Indicating Principle of Electrical Circuitry

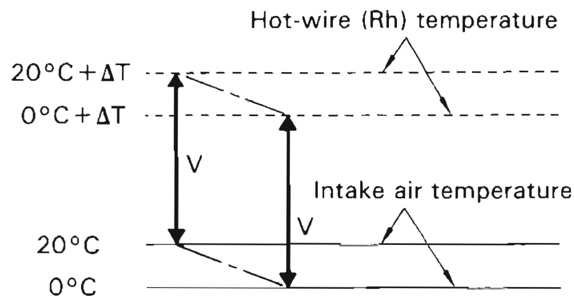


In an actual air flow meter, a hot-wire is incorporated into the bridge circuit. This bridge circuit has the characteristic of the potentials at points A and B being equal when the product of resistance along the diagonal line is equal ([Ra + R3] · R1 = Rh · R2). When the hot-wire (Rh) is cooled by intake air, resistance decreases resulting in the formation of a difference between the potentials of points A and B. An operational amplifier detects this difference and causes a rise in the voltage applied to the circuit (increases the current flowing to the hot-wire (Rh)). When this is done, the temperature of the hot-wire (Rh) again rises resulting in a corresponding increase in resistance until the potentials of points A and B become equal (the voltages of points A and B become higher). By utilizing the properties of this type of bridge circuit, the air flow meter is able to measure intake air mass by detecting the voltage at point B. Moreover, in this system, the temperature of the hot-wire (Rh) is continuously maintained at a constant temperature higher than the temperature of the intake air by using the thermistor (Ra).

Consequently, since intake air mass can be measured accurately even if intake air temperature changes, it is not necessary for the Engine ECU to correct the fuel injection duration for the intake air temperature. In addition, when air density decreases at high altitudes, the cooling capacity of the air decreases in comparison with the same intake air volume at sea level. As a result, the amount of cooling of the hot-wire is reduced. Since the intake air mass detected will also decrease the high-altitude compensation correction is not necessary.

REFERENCE

The voltage (V) required to raise the temperature of the hot-wire (Rh) by the amount of ΔT from the intake air temperature remains constant at all times even if the intake air temperature changes. In addition, the cooling capacity of the air is always proportional to the intake air mass. Consequently, if the intake air mass remains the same, the output of the air flow meter will not change even if there is a change in intake air temperature.



NOTE

An intake air temperature sensor is not required for the measurement of intake air mass due to the properties of a hot-wire type air flow meter. However, since intake air temperature is required for other electronic control systems of the engine, the hot-wire type air flow meter has the built-in intake air temperature sensor.

THROTTLE POSITION SENSOR

The throttle position sensor is mounted on the throttle body. This sensor converts the throttle opening angle to a voltage and sends it to the Engine ECU as the throttle opening angle signal. The IDL signal is used mainly in fuel cut-off control and ignition timing corrections and the VTA or PSW signal is used mainly for increasing the fuel injection volume to increase engine output.

There are two types of throttle position sensor, as follows:

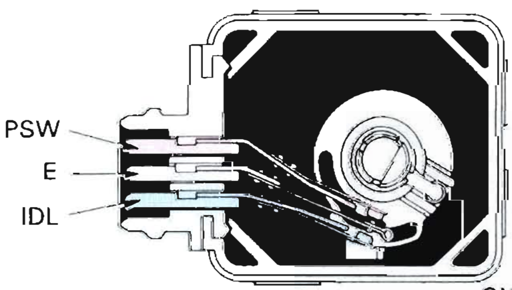
- On-off type
- Linear type

1. ON-OFF TYPE

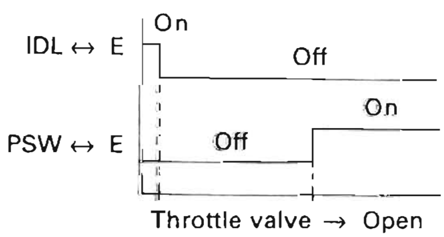
This type of throttle position sensor detects whether the engine is idling or running under a heavy load by means of the idle (IDL) contact or power (PSW) contact.

Other terminals or contacts can also be used to perform other functions, depending on the type of engine. These include: the lean burn switch (LSW) contact, for lean burn correction; the L1, L2, and L3 terminals for control of the ECT; the ACC1 and ACC2 terminals for sensing acceleration; etc. For further details, see Step 2, vol. 5 (EFI).

① 2-contact type

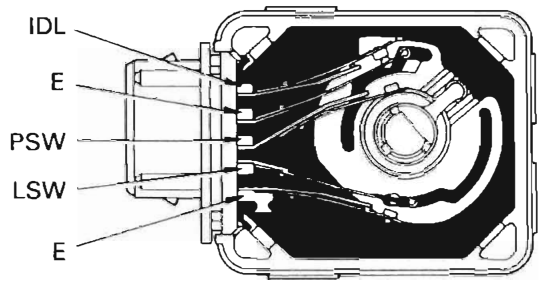


OHP 14

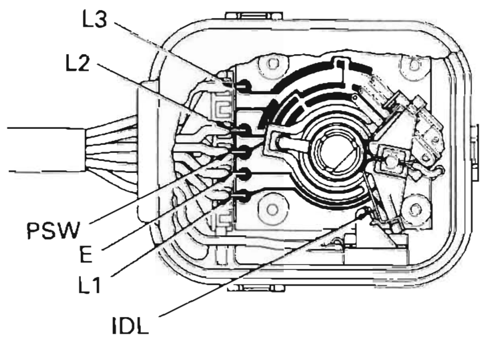


OHP 14

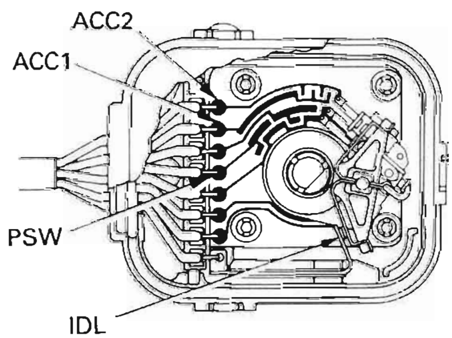
② 3-contact type



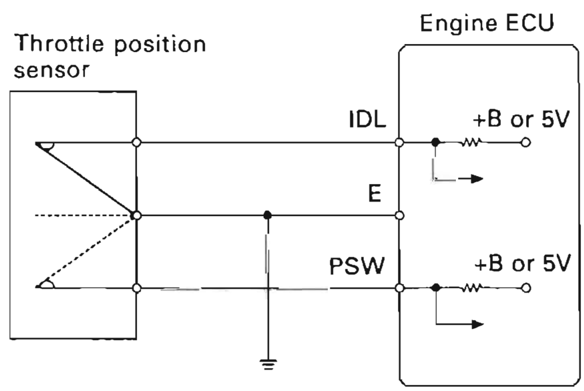
③ With L1, L2 and L3 terminals



④ With ACC1 and ACC2 terminals



ELECTRICAL CIRCUITRY (2-CONTACT TYPE)



OHP 14

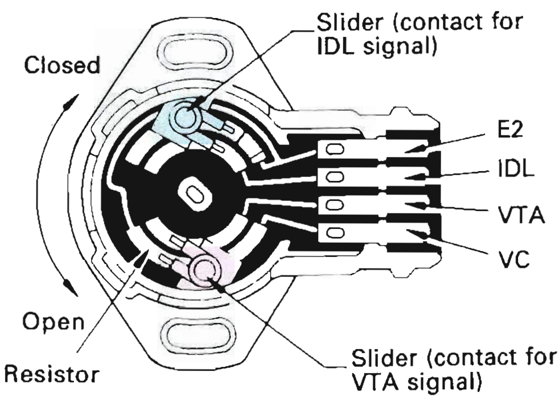
2. LINEAR TYPE

This sensor is composed of two sliders (at the tips of which are mounted the contacts for the IDL and VTA signals, respectively).

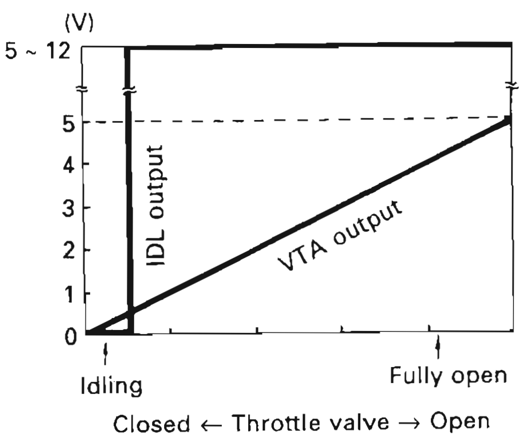
A constant 5 V is applied to the VC terminal from the Engine ECU. As the contact slides along the resistor in accordance with the throttle valve opening angle, a voltage is applied to the VTA terminal in proportion to this angle.

When the throttle valve is closed completely, the contact for the IDL signal connects the IDL and E2 terminals.

The VTA and IDL output signals are as shown in the table below.

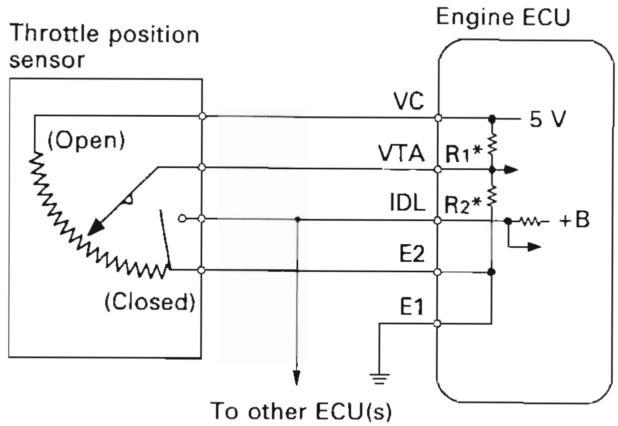


OHP 15



OHP 15

ELECTRICAL CIRCUITRY



OHP 15

*Depending on the model, this circuitry may include both resistors R_1 and R_2, R_1 only, or R_2 only.

NOTE

Recent linear type throttle position sensors include models without an IDL point and the model with an IDL point but its terminal is not connected to the Engine ECU. In these models, the Engine ECU detects idling condition performing learned control by using the VTA signal.

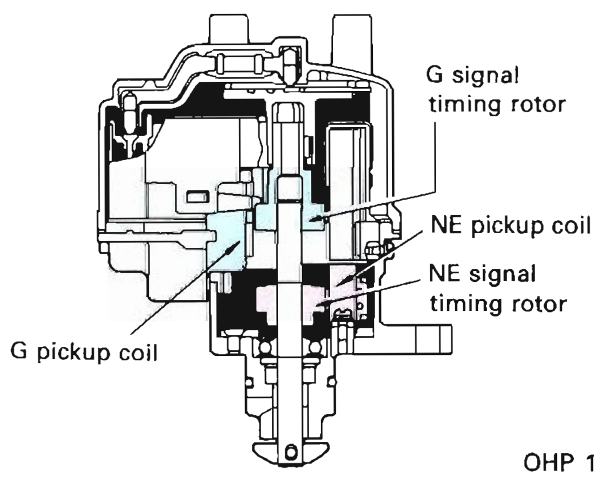
G AND NE SIGNAL GENERATORS

The G and NE signals are generated by the timing rotors or signal plates and the pickup coils. These signals are used by the Engine ECU to detect the crankshaft angle and engine speed. These signals are very important not only for the EFI system but also for the ESA system.
The sensors which generate these signals can be divided into the following three types depending on their installation position, but their basic construction and operation are the same:

- In-distributor type
- Cam position sensor type
- Separate type

1. IN-DISTRIBUTOR TYPE

The conventional governor advance and vacuum advance mechanisms have been eliminated in the distributor used with the TCCS engine control system, since spark advance is controlled electronically by the Engine ECU. The distributor in the engine control system contains the timing rotors and pickup coils for the G and NE signals.



OHP 16

The number of teeth on the rotor and the number of pickup coils differ depending on the engine. Below, we will explain the construction and operation of the G and NE signal generators that use a single pickup coil and a 4-tooth rotor for the G signal, and a single pickup coil and 24-tooth rotor for the NE signal.

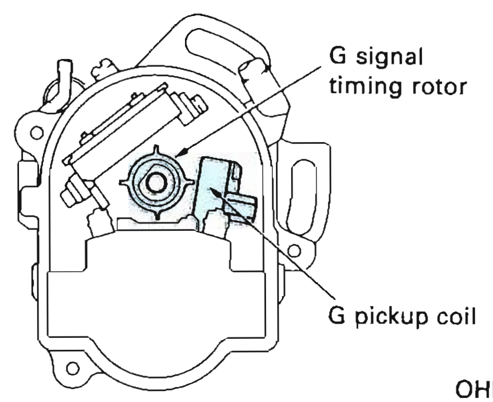
G SIGNAL

The G signal informs the Engine ECU of the standard crankshaft angle, which is used to determine the injection timing and ignition timing in relation to the TDC (top dead center) of each cylinder.
The components of the distributor used to generate these signals are as follows:

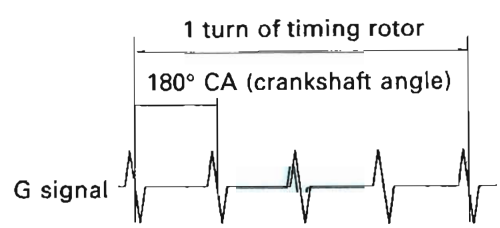
1) The G signal timing rotor, which is fixed to the distributor shaft and turns once for every two rotations of the crankshaft.
2) The G pickup coil, which is mounted on the inside of the distributor housing.

The G signal timing rotor is provided with four teeth which activate the G pickup coil four times per each revolution of the distributor shaft, generating the waveforms shown in the chart shown below. From these signals, the Engine ECU detects when each piston is near TDC (example: BTDC10°CA*).

* Depending on engine models.



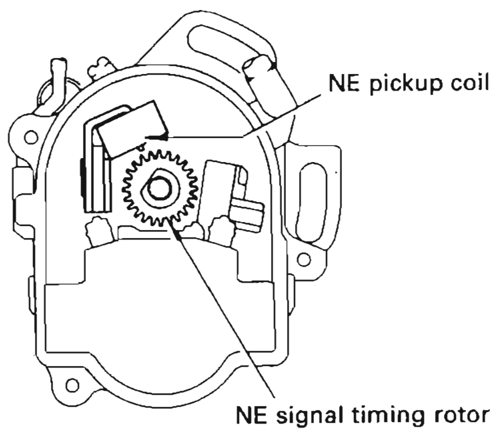
OHP 16



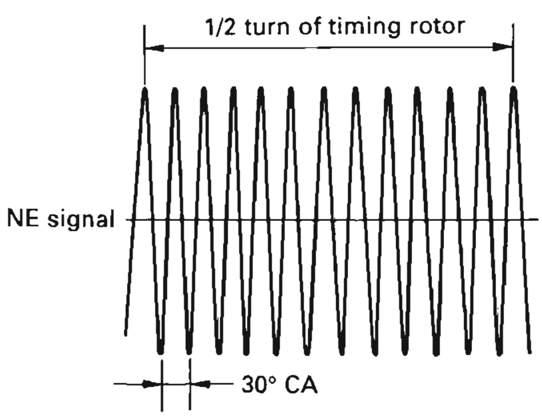
OHP 16

NE SIGNAL

The NE signal is used by the Engine ECU to detect the engine speed. NE signals are generated in the pickup coil by the timing rotor in the same way as with the G signal. The only difference is that the timing rotor for the NE signal has 24 teeth. It activates the NE pickup coil 24 times per each revolution of the distributor shaft, generating the waveforms shown in the chart. From these signals, the Engine ECU detects the engine speed as well as each 30° change in the engine crankshaft angle.



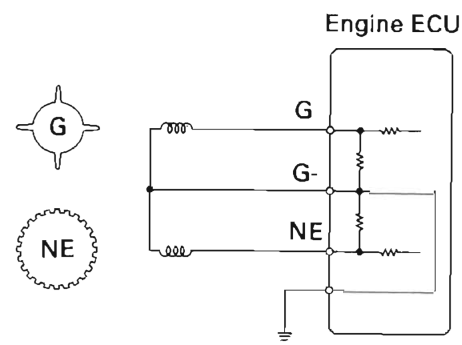
OHP 16



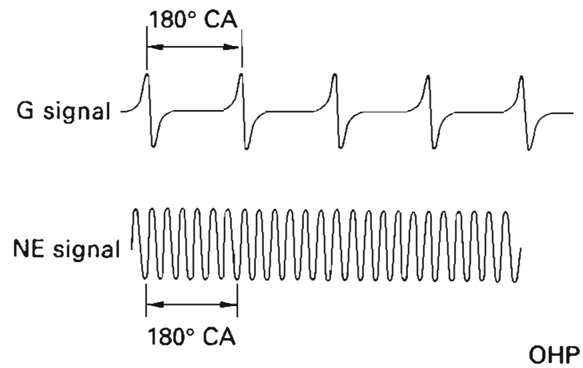
OHP 16

ELECTRICAL CIRCUITRY, AND G AND NE SIGNAL WAVEFORMS

① **G signal (1 pickup coil, 4 teeth)**
NE signal (1 pickup coil, 24 teeth)

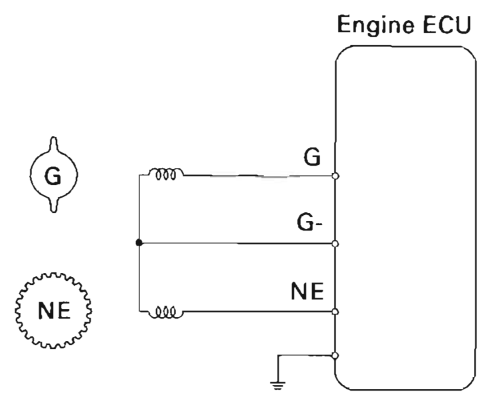


OHP 17

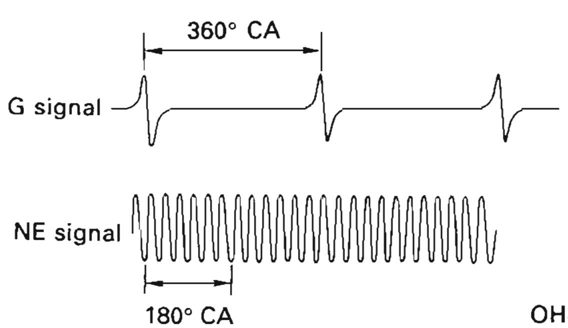


OHP 17

② **G signal (1 pickup coil, 2 teeth)**
NE signal (1 pickup coil, 24 teeth)

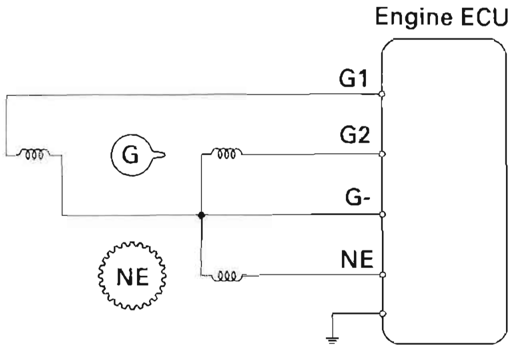


OHP 17

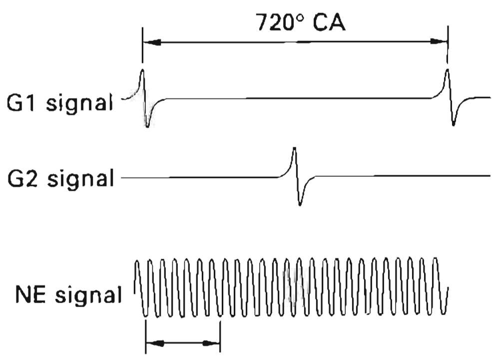


OHP 17

③ G1 and G2 signals (2 pickup coils, 1 tooth)
NE signal (1 pickup coil, 24 teeth)

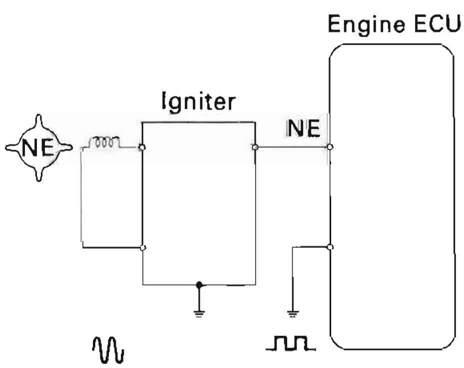


OHP 18

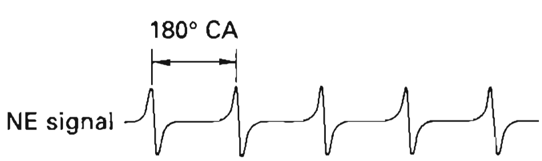


OHP 18

④ NE signal (1 pickup coil, 4 teeth)

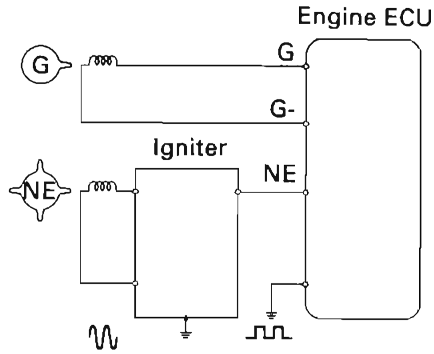


OHP 18

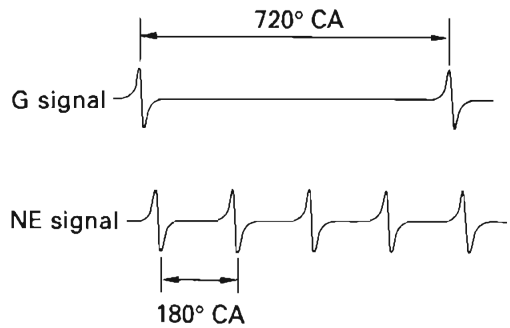


OHP 18

⑤ G signal (1 pickup coil, 1 tooth)
NE signal (1 pickup coil, 4 teeth)

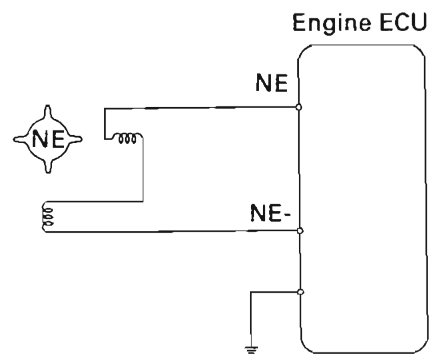


OHP 19

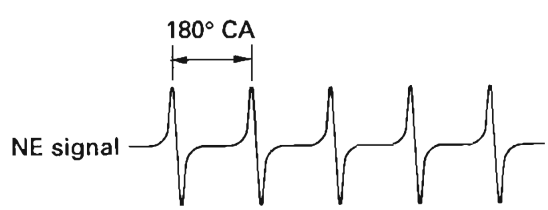


OHP 19

⑥ NE signal (2 pickup coils, 4 teeth)



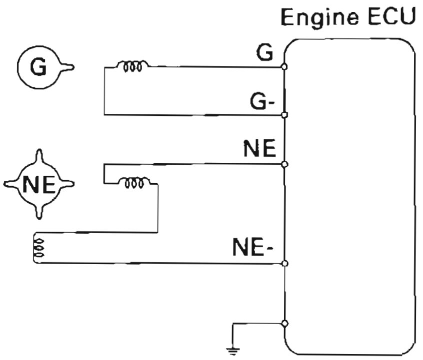
OHP 19



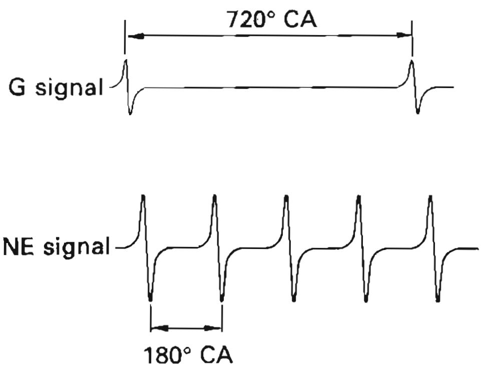
OHP 19

This type of circuit has two NE pickup coils connected in series. This is for the purpose of preventing noise in the NE signal during operation of the ignition coil.

⑦ G signal (1 pickup coil, 1 tooth)
NE signal (2 pickup coils, 4 teeth)



OHP 20

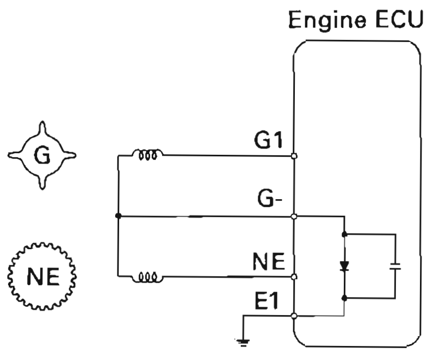


OHP 20

This circuit also has two NE pickup coils for the same purpose as the circuit in ⑥ on the previous page.

NOTE

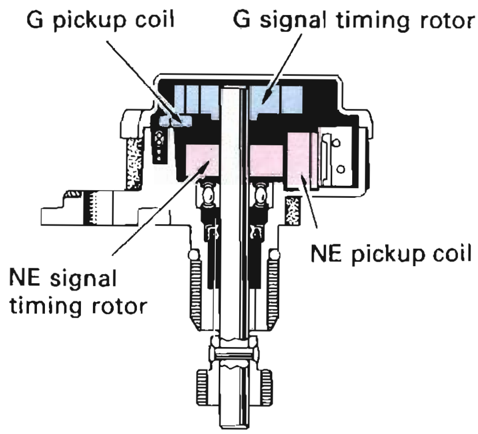
Depending on the engine model, there are also some Engine ECUs in which the G- terminal is grounded through a diode.
When the diode is included in the circuit, a reading of approximately 0.7 V is obtained when measuring the voltage between G- and E1.



OHP 20

2. CAM POSITION SENSOR TYPE

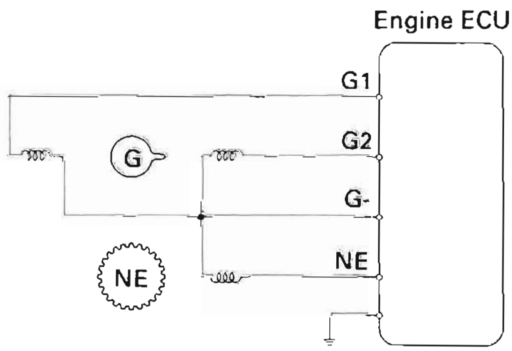
The construction and operation of the cam position sensor is the same as for the in-distributor type, except for the elimination of the voltage distribution system from the distributor.



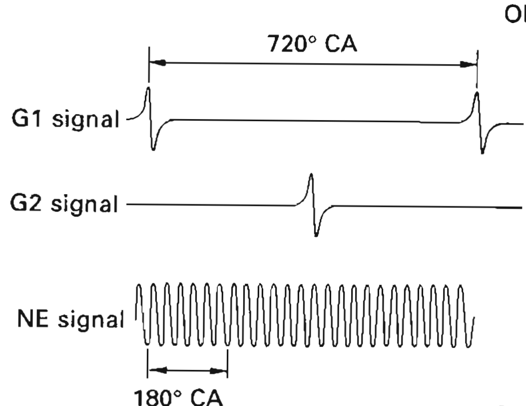
OHP 21

ELECTRICAL CIRCUITRY, AND G AND NE SIGNAL WAVEFORMS

G1 and G2 signals (2 pickup coils, 1 tooth)
NE signal (1 pickup coil, 24 teeth)



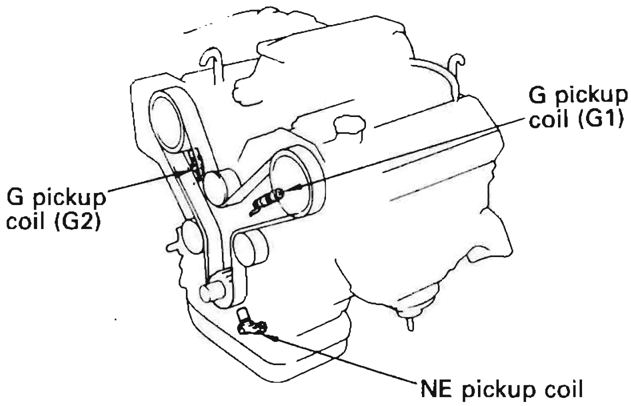
OHP 21



OHP 21

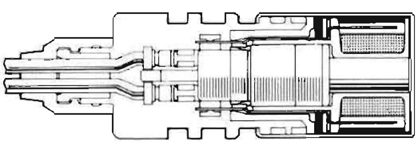
3. SEPARATE TYPE

Compared to the other types, the separate type G and NE signal generator differs in the sensor installation position, as shown in the following illustration. However, the basic function is the same.

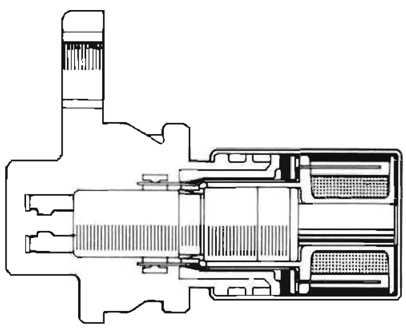


OHP 22

Rotation of the G signal plate on the camshaft and the NE signal plate on the crankshaft alters the air gap between the projection(s) of the plate and the G pickup coil and the NE pickup coil. The change in the gap generates an electromotive force in the pickup coil. This creates the G and NE signals.



G PICKUP COIL



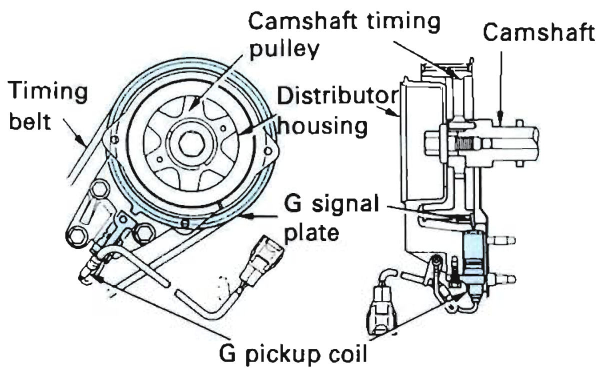
NE PICKUP COIL

G SIGNAL

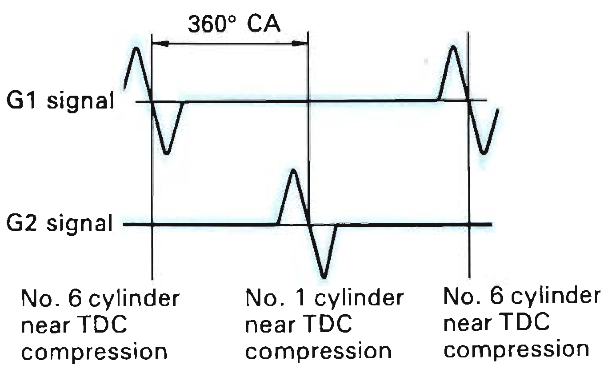
The G1 signal informs the Engine ECU of the standard crankshaft angle, which is used to determine the injection timing and ignition timing in relation to compression TDC of cylinder No. 6. The G2 signal conveys the same information for cylinder No. 1.

The sensors that generate these signals consist of a signal plate, which is fixed to the camshaft timing pulley and turns once per every two rotations of the crankshaft; and a pickup coil for the G signal, which is fitted to the distributor housing.

The G signal plate is provided with a projection which activates the G pickup coil once per each rotation of the camshaft, generating waveforms like those shown in the following chart. From these signals, the Engine ECU detects when the No. 6 and No. 1 pistons are near their compression TDC.



OHP 22

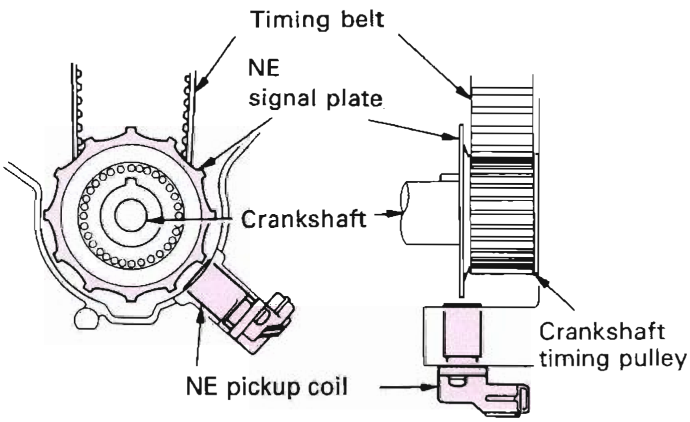


OHP 22

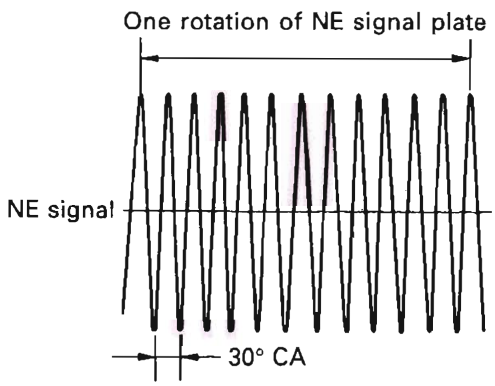
NE SIGNAL

The NE signal is used by the Engine ECU to detect the engine speed. The Engine ECU determines the basic injection duration and basic ignition advance angle by these signals. NE signals are generated in the NE pickup coil by the NE signal plate like the G signals. The only difference is that the signal plate for the NE signal has 12 teeth instead of just one. Therefore, 12 NE signals are generated per each engine revolution.

From these signals, the Engine ECU detects the engine speed as well as each 30° change in the crankshaft angle.



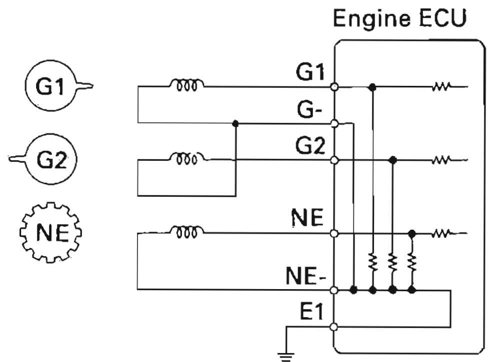
OHP 22



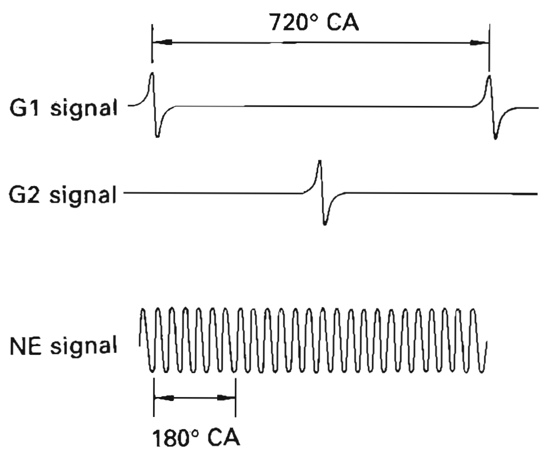
OHP 22

ELECTRICAL CIRCUITRY, AND G AND NE SIGNAL WAVEFORMS

① **G1 signal** **(1 pickup coil, 1 tooth)**
G2 signal **(1 pickup coil, 1 tooth)**
NE signal **(1 pickup coil, 12 teeth)**

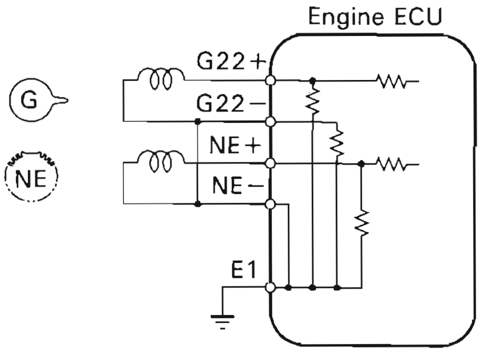


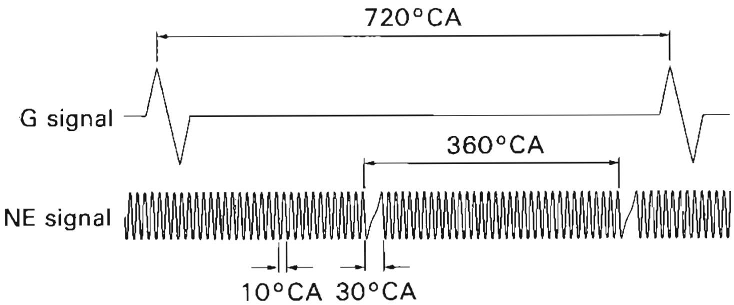
OHP 23



OHP 23

② G signal (1 pickup coil, 1 tooth)
NE signal (1 pickup coil, 36 minus 2 teeth)





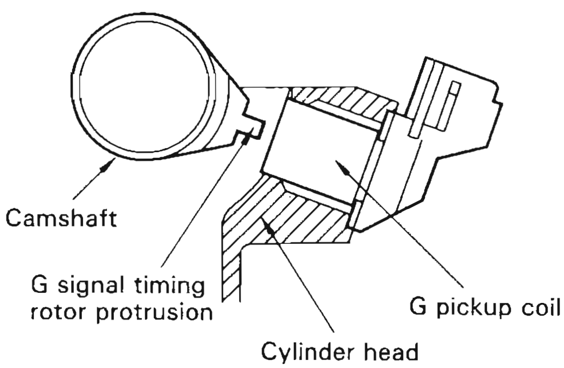
This type of NE signal is able to detect both engine speed and crankshaft angle at the portion of two teeth missing. It is unable, however, to distinguish between the TDC of the compression stroke and that of the exhaust stroke. The G signal is used for this purpose.

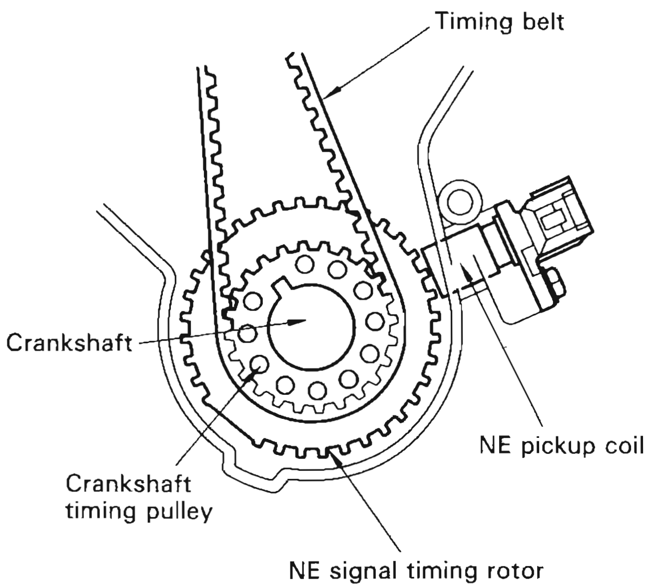
REFERENCE

4A-FE engine which applies the Engine ECU made by Bosch uses G signal generator of the hall element type.
Holl element will generate electromotive force in proportion to the changes of the magnetic flux.

NOTE

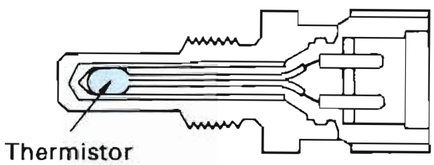
The G signal timing rotor of the above described type in ② is integrated into a single unit with the camshaft, while the NE signal timing rotor is integrated into a single unit with the crankshaft timing pulley. Also, the G signal generator is located in the distributor depending on the engine models.



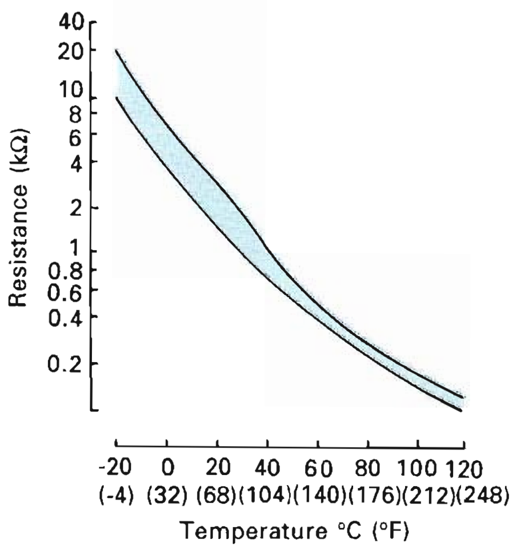


WATER TEMPERATURE SENSOR

This sensor detects the coolant temperature by means of an internal thermistor.

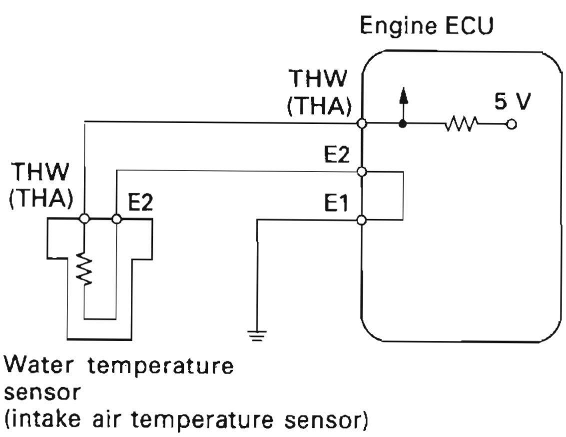


OHP 24



OHP 24

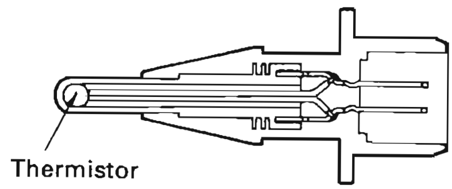
ELECTRICAL CIRCUITRY



OHP 24

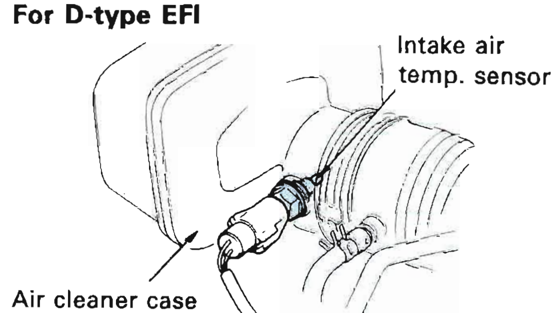
INTAKE AIR TEMPERATURE SENSOR

This sensor detects the temperature of the intake air by means of an internal thermistor.



OHP 25

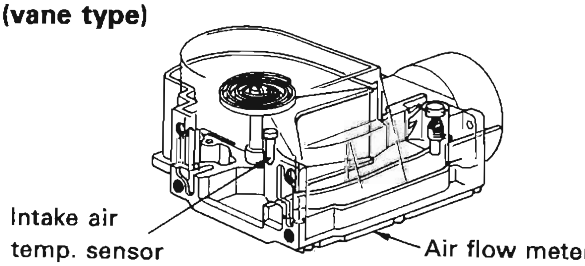
① **For D-type EFI**



OHP 25

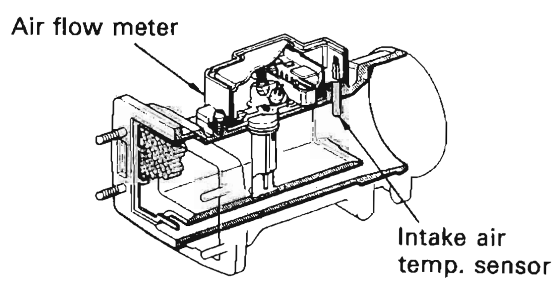
② **For L-type EFI**

(vane type)



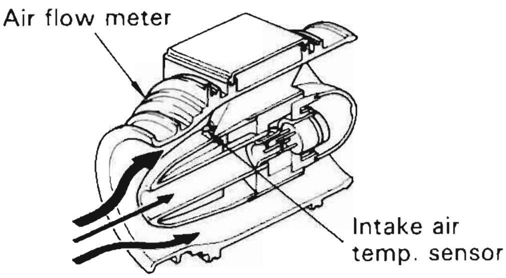
OHP 25

(optical Karman vortex type)



OHP 25

(hot-wire type)



ELECTRICAL CIRCUITRY

The electrical circuitry of the intake air temperature sensor is basically the same as that of the water temperature sensor. See the diagram for the electrical circuitry of the water temperature sensor.

OXYGEN SENSOR (O_2 SENSOR)

In order for engines equipped with the TWC (three-way catalytic converter) to achieve the best purification performance, it is necessary for the air-fuel ratio to be kept within a narrow range near the theoretical (stoichiometric) air-fuel ratio.

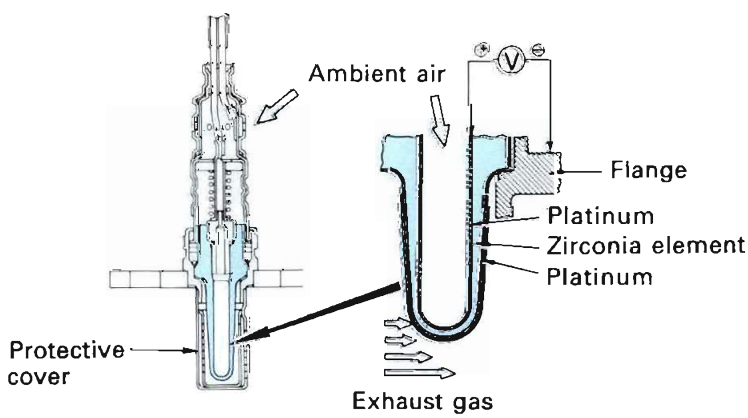
The oxygen sensor senses whether the air-fuel ratio is richer or leaner than the theoretical air-fuel ratio. It is located in the exhaust manifold, in the front exhaust pipe, etc. (This differs depending on the engine model.)

The following types of oxygen sensor are used; they differ mainly in the material used for the element:

- Zirconia element type
- Titania element type

1. ZIRCONIA ELEMENT TYPE

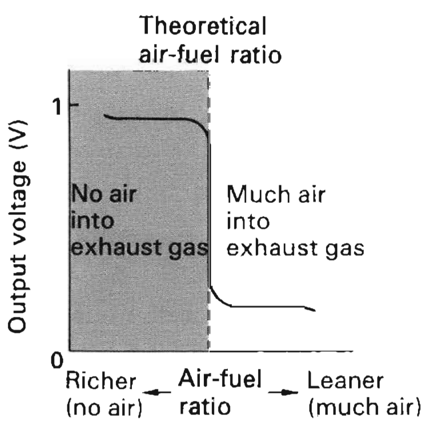
This oxygen sensor consists of a element made of zirconium dioxide (ZrO_2, a kind of ceramic). This element is coated on both the inside and outside with a thin layer of platinum. Ambient air is introduced into the inside of the sensor, and the outside of the sensor is exposed to exhaust gases.



OPERATION

If the oxygen concentration on the inside surface of the zirconia element differs greatly from that on the outside surface at high temperatures (400°C [752°F] or higher), the zirconia element generates a voltage, which acts as an OX signal to the Engine ECU, keeping it informed at all times about the concentration of oxygen in the exhaust gas.

When the air-fuel mixture is lean, there is a lot of oxygen in the exhaust gas, so there is little difference between the oxygen concentration inside and outside the sensor element. For this reason, the voltage generated by the zirconia element is low (close to 0 V). Conversely, if the air-fuel mixture is rich, the oxygen in the exhaust gas almost disappears. This creates a large difference in the oxygen concentrations inside and outside the sensor, so the voltage generated by the zirconia element is comparatively large (approximately 1 V).



OHP 26

The platinum (with which the element is coated) operates as a catalyst, causing the oxygen and the CO (carbon monoxide) in the exhaust gas to react with each other. This decreases the oxygen volume and increases the sensitivity of the sensor.

Based on the signal output by this sensor, the Engine ECU increases or reduces the injection volume to keep the air-fuel ratio at a constant value near the theoretical air-fuel ratio.

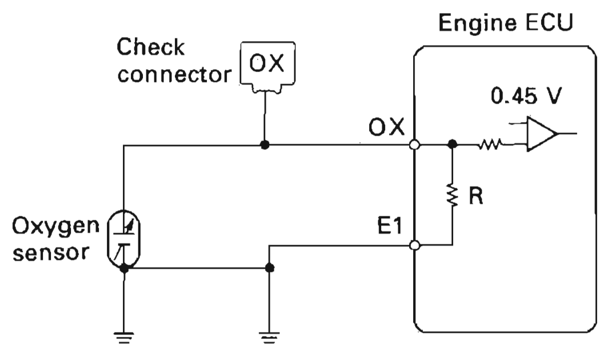
Some zirconia oxygen sensors are provided with a heater which heats the zirconia element. The heater is also controlled by the ECU. When the intake air volume is low (that is, when the temperature of the exhaust gas is low), current flows to the heater to heat the sensor.

For further details, see page 114.

NOTE

Even if the oxygen sensor is normal, if the outside of the oxygen sensor is contaminated with mud, etc., it could prevent outside air from getting into the oxygen sensor. The difference between the oxygen concentrations in the outside air and the exhaust gas will fall, so the oxygen sensor will always be sending a lean signal to the ECU.

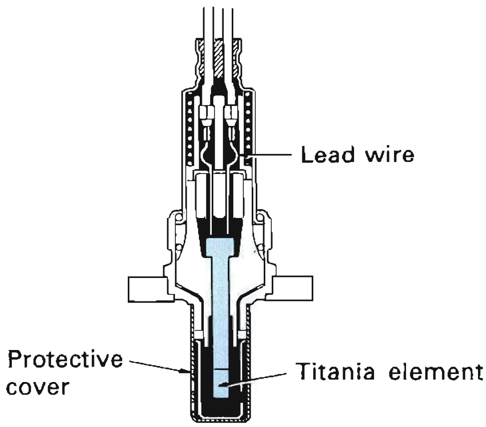
ELECTRICAL CIRCUITRY



OHP 26

2. TITANIA ELEMENT TYPE

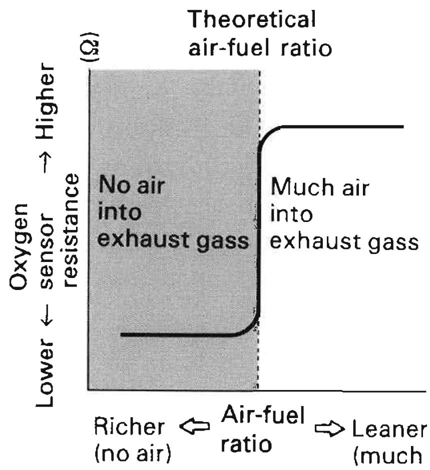
This oxygen sensor consists of a semiconductor element made of titanium dioxide (TiO_2, which is, like ZrO_2, a kind of ceramic). This sensor uses a thick film type titania element formed on the front end of a laminated substrate to detect the oxygen concentration in the exhaust gas.



OHP 27

OPERATION

The properties of titania are such that its resistance changes in accordance with the oxygen concentration of the exhaust gas. This resistance changes abruptly at the boundary between a lean and a rich theoretical air-fuel ratio, as shown in the following graph. The resistance of titania also changes greatly in response to changes in temperature. A heater is therefore built into the laminated substrate to keep the temperature of the element constant.

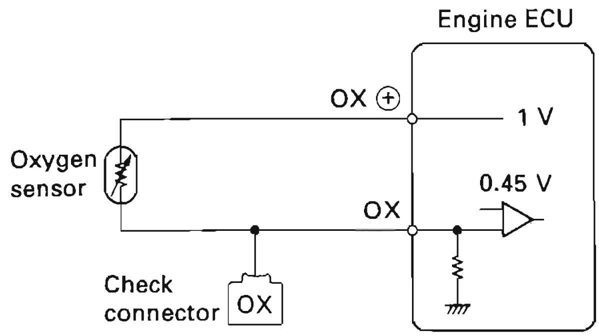


OHP 27

This sensor is connected to the Engine ECU, as shown in the following circuit diagram. A 1V potential is supplied at all times to the OX ⊕ terminal by the Engine ECU. The Engine ECU has a built-in comparator* which compares the voltage drop at the OX terminal (due to the change in resistance of the titania) to a reference voltage (0.45 V). If the result shows that the OX voltage is greater than 0.45 V (that is, if the oxygen sensor resistance is low), the Engine ECU judges that the air-fuel ratio is rich. If the OX voltage is lower than 0.45 V (oxygen sensor resistance high), it judges that the air-fuel ratio is lean.

*See page 37 for details on the comparator.

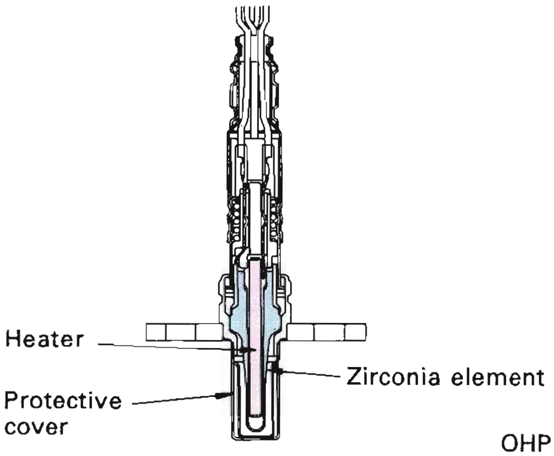
ELECTRICAL CIRCUITRY



OHP 27

LEAN MIXTURE SENSOR

The lean mixture sensor is constructed in basically the same way as the zirconia element type oxygen sensor, but its use differs.



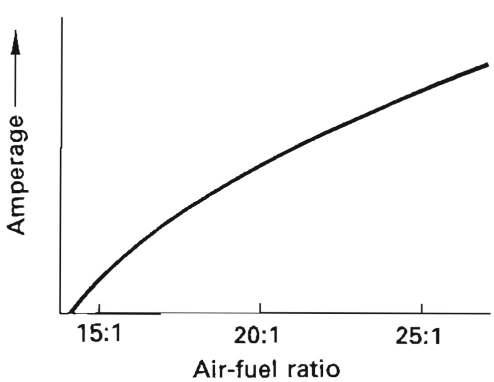
OHP 28

OPERATION

The zirconia element type oxygen sensor operates on the principle that a voltage will be generated if the difference in the oxygen concentration inside and outside the sensor is great.

In the lean mixture sensor, however, a voltage applied to the zirconia element when the temperature is high (650°C [1202°F] or greater), results in a current flow with a value which is proportional to the oxygen concentration in the exhaust gas.

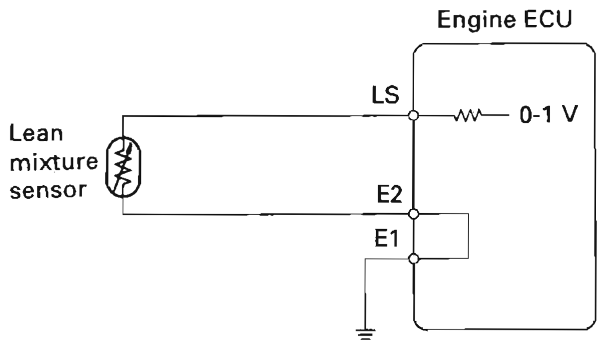
In other words, when the air-fuel mixture is rich, there will be no oxygen in the exhaust gas, so no current will flow through the zirconia element. When the air-fuel mixture is lean, on the other hand, there will be a lot of oxygen in the exhaust gas and the amount of current flowing through the zirconia element will be large, as shown in the following graph.



OHP 28

The lean mixture sensor has been adopted to assure that the air-fuel ratio is kept within a predetermined range, thereby improving fuel economy as well as drivability.
This sensor also comes with a heater to heat the zirconia element. The heater is controlled in the same way as the heater of the oxygen sensor. For further details, see page 114.

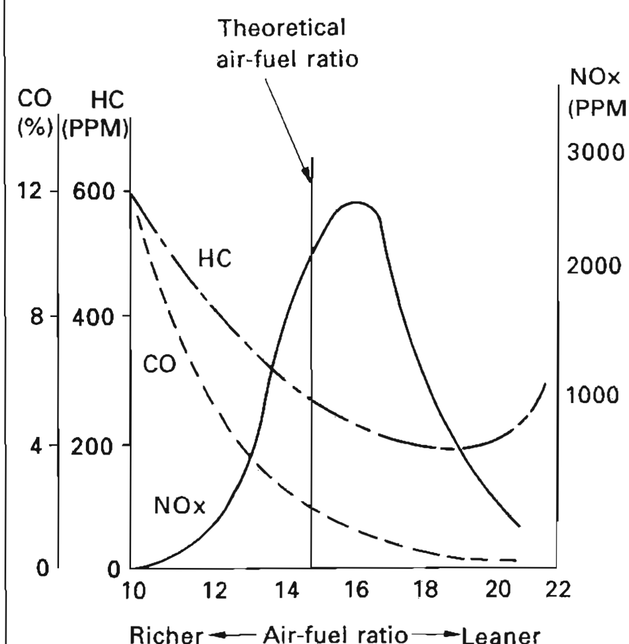
ELECTRICAL CIRCUITRY



OHP 28

REFERENCE

When the air-fuel mixture is extremely lean (about 20:1), combustion will be accompanied by reductions in NOx (oxides of nitrogen), CO, and HC (hydrocarbon gas), as shown in the graph below. This is a good thing up to a point. However, if the air-fuel mixture is too lean, not only will HC concentrations increase, but the engine will lose power and/or misfire.



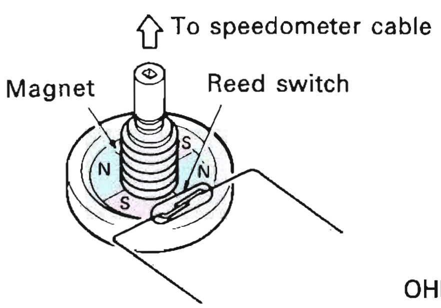
VEHICLE SPEED SENSOR

This sensor senses the actual speed at which the vehicle is traveling. It outputs an SPD signal, which is used mainly to control the ISC system, and to control the air-fuel ratio during acceleration, deceleration, etc.
There are four types of speed sensor:

- Reed switch type
- Photocoupler type
- Electromagnetic pickup type
- MRE (magnetic resistance element) type

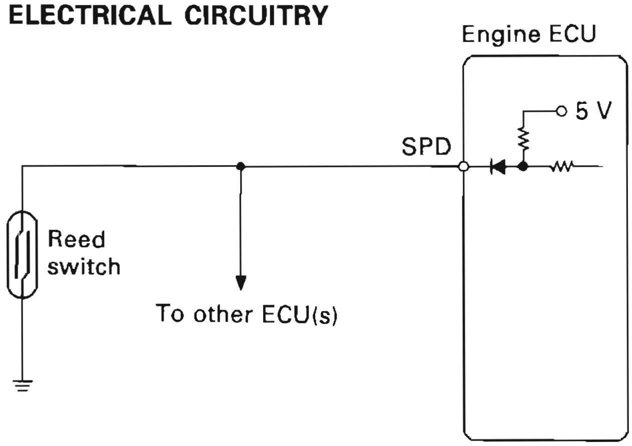
1. REED SWITCH TYPE

This sensor is mounted in the analog combination meter. It contains a magnet which is rotated by the speedometer cable, turning the reed switch on and off. The reed switch goes on and off four times each time the speedometer cable rotates once.
The magnet has the polarities shown in the figure below. The magnetic force at the four areas of transition between the N and S poles of the magnet opens and closes the contacts of the reed switch as the magnet rotates.



OHP 29

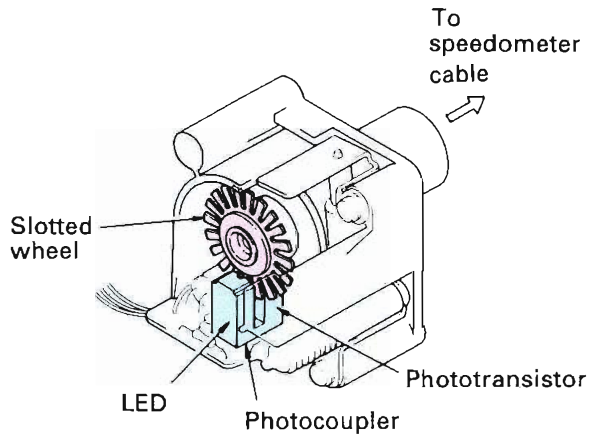
ELECTRICAL CIRCUITRY



OHP 29

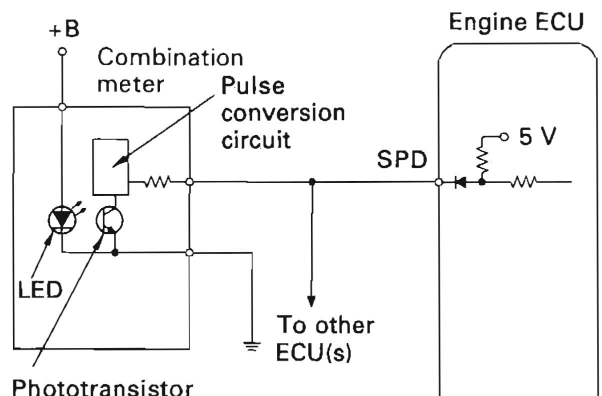
2. PHOTOCOUPLER TYPE

This sensor is mounted in the combination meter. It includes a photocoupler made from an LED, which is aimed at a phototransistor. The LED and phototransistor are separated by a slotted wheel, which is driven by the speedometer cable. The slots in the slotted wheel generate light pulses as the wheel turns, with the light emitted by the LED divided into 20 pulses for each revolution of the cable. These 20 pulses are converted to four pulses by the digital meter computer, then sent as signals to the ECU.



OHP 29

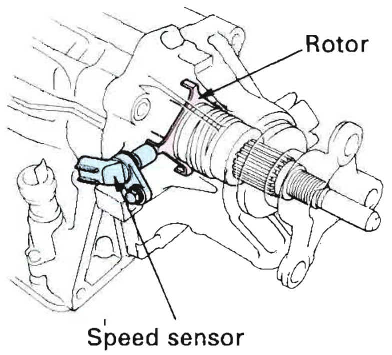
ELECTRICAL CIRCUITRY



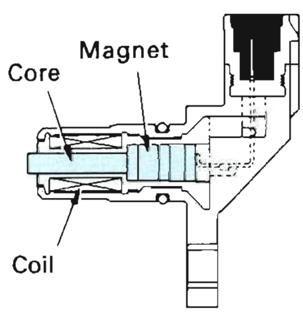
OHP 29

3. ELECTROMAGNETIC PICKUP TYPE

This sensor is fitted to the transmission and detects the rotational speed of the transmission output shaft.
This sensor consists of a permanent magnet, a coil, and a core. A rotor with four teeth is mounted on the transmission output shaft.



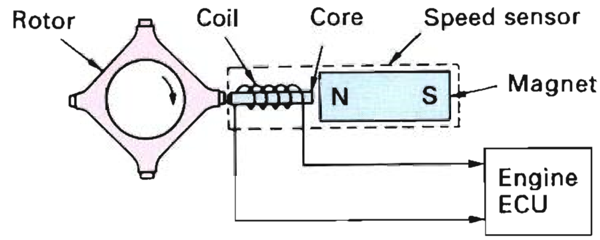
OHP 30



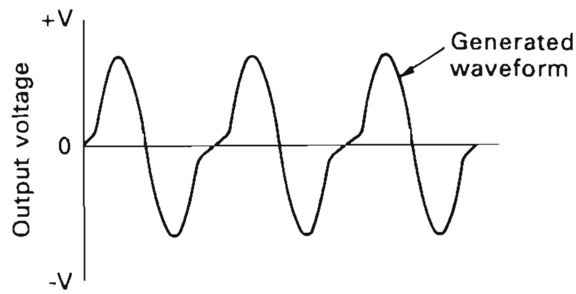
OHP 30

OPERATION

When the transmission output shaft rotates, the distance between the core of the coil and the rotor increases and decreases because of the teeth.
The number of lines of magnetic force passing through the core increases or decreases accordingly, and AC (alternating current) voltage is generated in the coil.
Since the frequency of this AC voltage is proportional to the rotational speed of the rotor, it can be used to detect the vehicle speed.

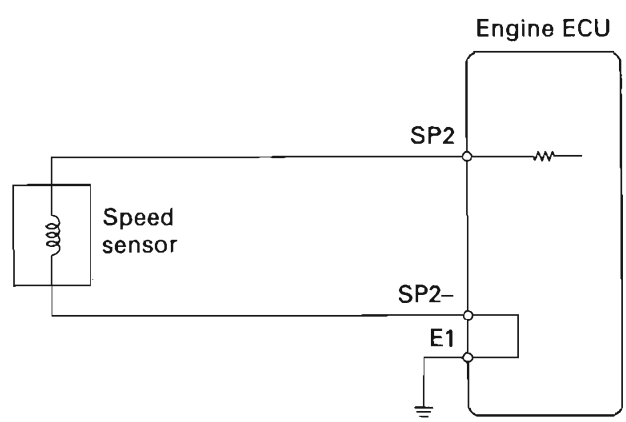


OHP 30



OHP 30

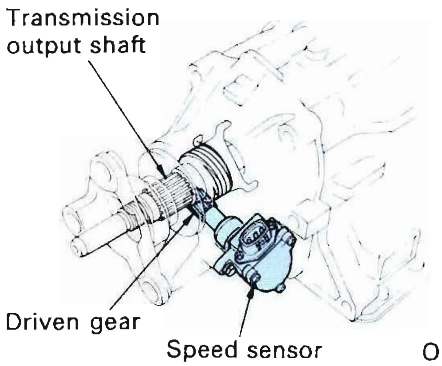
ELECTRICAL CIRCUITRY



OHP 30

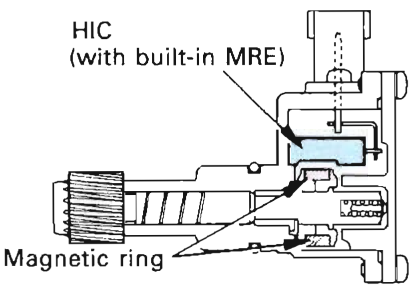
4. MRE (MAGNETIC RESISTANCE ELEMENT) TYPE

This sensor is mounted on the transmission or the transfer and is driven by the drive gear of the output shaft.



OHP 31

This sensor consists of an HIC (hybrid integrated circuit) with a built-in MRE (magnetic resistance element) and a magnetic ring.



OHP 31

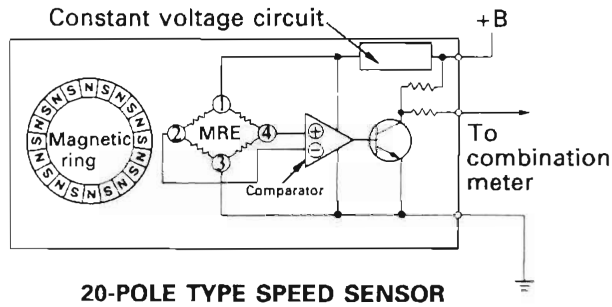
OPERATION

The resistance value of the MRE changes according to the direction of the lines of magnetic force applied to it.

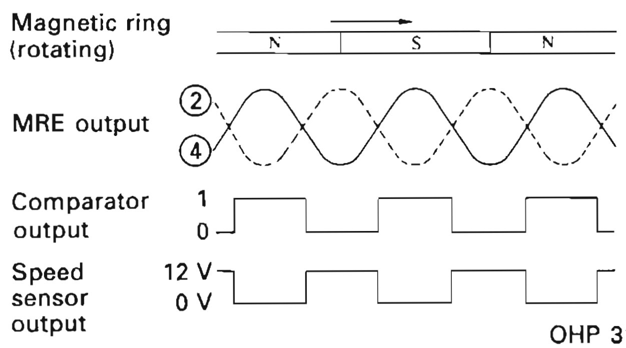
Thus, the direction of the lines of magnetic force is changed by the rotation of the magnet fitted to the magnetic ring with the result that the output of the MRE becomes an alternating waveform as shown in the illustration on the above right.

The comparator in the speed sensor converts the alternating waveform into a digital signal, which is then inverted by the transistor before being sent to the combination meter, as shown in the illustration at right above.

The frequency of the waveform is in accordance with the number of poles of the magnet fitted to the magnetic ring. There are two types of magnetic ring (depending on the vehicle model): the type with twenty magnetic poles, and the type with four magnetic poles. The 20-pole type generates a 20-cycle waveform (i.e., twenty pulses for each rotation of the magnetic ring), while the 4-pole type generates a 4-cycle waveform.



20-POLE TYPE SPEED SENSOR



OHP 31

In the 20-pole type, the frequency of the digital signal is converted from twenty pulses for each revolution of the magnetic ring to four pulses by the pulse conversion circuit in the combination meter, then the signal is sent to the Engine ECU. (See electrical circuitry at right.)

In the case of the 4-pole type, there are two different kinds: in one type, the signal from the speed sensor passes through the combination meter before going to the Engine ECU; in the other type, this signal goes directly to the Engine ECU without passing through the combination meter. (See electrical circuitry at right.)

The output circuitry of the speed sensor differs depending on the vehicle model. As a result, the output signal also differs depending on the model: one type is the output voltage type and the other is the variable resistance type.

The types of MRE-type speed sensor presently used by Toyota are shown in the following table.

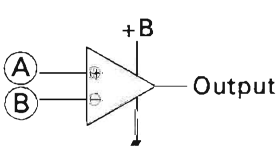
(As of Mar., 1991)

	TYPE OF MAGNETIC RING	TYPE OF SIGNAL
①	20-pole type (20 pulses/rev.)	Output voltage type (0 V ↔ 5 ~ 12 V)
②	4-pole type (4 pulses/rev.)	
③		Variable resistance type (0 Ω ↔ ∞)

REFERENCE

Comparator

The comparator circuit selects either of the two input voltages as the reference voltage and then compares the reference voltage with the other input voltage to judge which is larger or smaller. If input voltage Ⓑ is taken as the reference voltage in the example circuit shown below, the relationship between the input and the output becomes as follows:

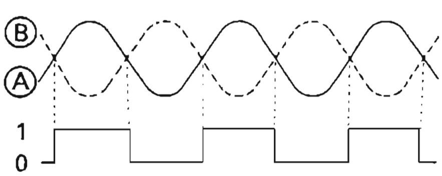


OHP 32

INPUT	OUTPUT
A > B	Hi (1)
A < B	Lo (0)

OHP 32

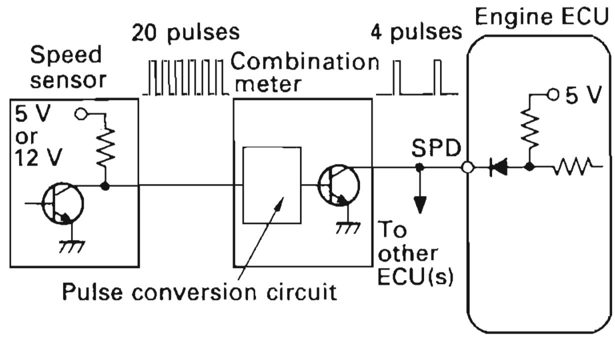
The speed sensor uses this function to convert the alternating waveform into a digital signal:



OHP 32

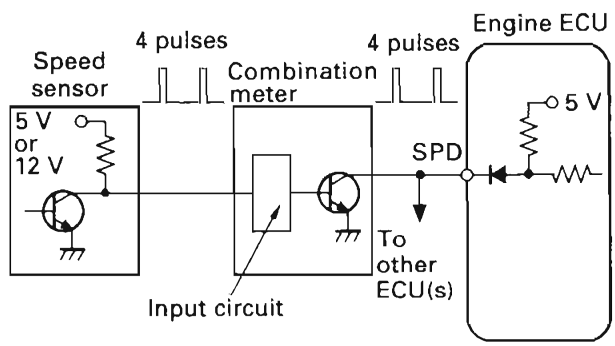
ELECTRICAL CIRCUITRY

① 20-pole type (output voltage type)



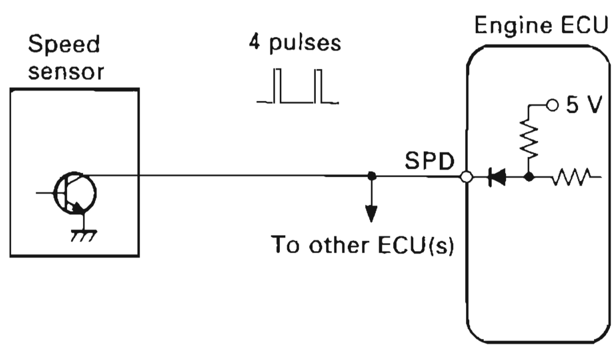
OHP 33

② 4-pole type (output voltage type)



OHP 33

③ 4-pole type (variable resistance type)

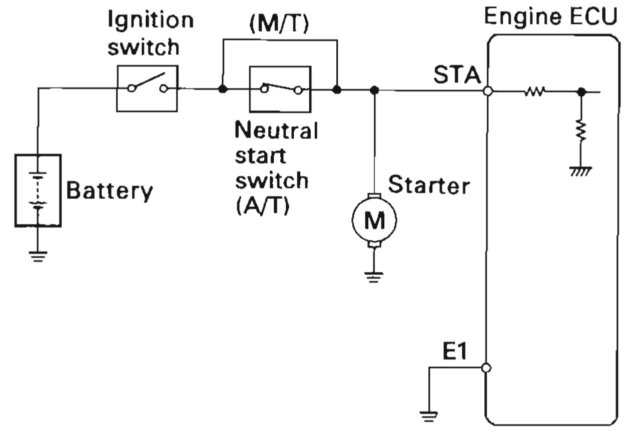


OHP 33

STA (STARTER) SIGNAL

This signal is used to judge if the engine is being cranked. Its main function is to allow the Engine ECU to increase the fuel injection volume during cranking. As can be understood from the figure below, the STA signal is voltage the same voltage as that supplied to the starter motor.

ELECTRICAL CIRCUITRY



OHP 34

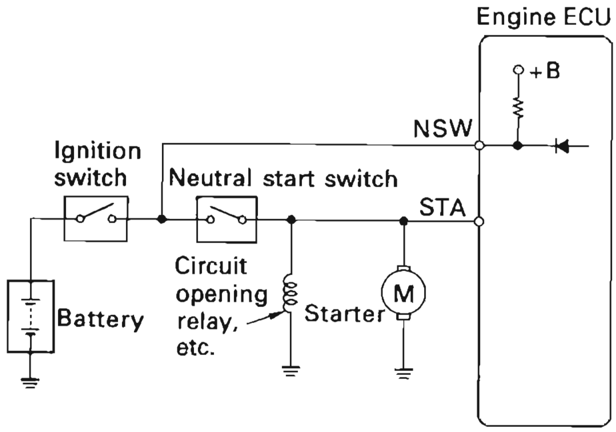
REFERENCE

1. The Engine ECU judges whether the engine is cranking based on the STA signal. There are also engines which use the NE signal to judge the engine running conditions during starting.
2. In some engine models, if the STA signal is input while the engine is running, it could result in the engine stalling.

NSW (NEUTRAL START SWITCH) SIGNAL

In vehicles with an automatic transmission or transaxle, this signal is used by the Engine ECU to determine whether the shift lever is in the "P" or "N" position, or in some other position. The NSW signal is used mainly in controlling the ISC system.

ELECTRICAL CIRCUITRY



OHP 34

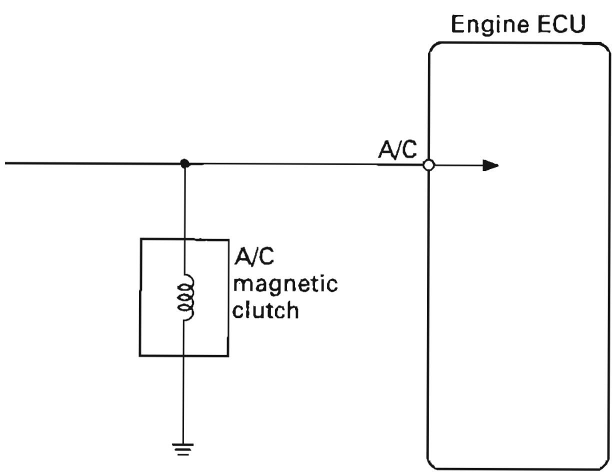
NOTE

1. When the ignition switch is in the START position, battery voltage is supplied to the NSW terminal.
2. When the ignition switch is in a position other than START, and the neutral start switch is open (i.e., the transmission is in "L", "2", "D" or "R"), the voltage at the NSW terminal is high.
3. When the ignition switch is in a position other than START, and the neutral start switch is closed (i.e., the transmission is in "P" or "N"), the voltage at the NSW terminal is low due to the electrical load at the starter motor, etc.

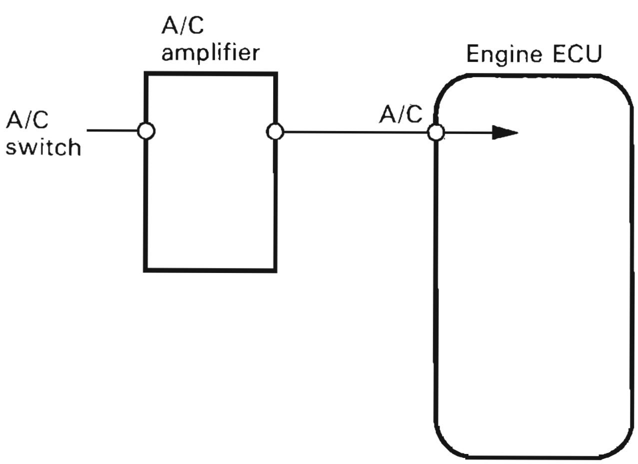
A/C (AIR CONDITIONER) SIGNAL

This signal senses when the air conditioner magnetic clutch is on or air conditioner switch is on.
This signal is used to control the ignition timing during idling, and to control the ISC system, the fuel cut-off speed, and other functions.

ELECTRICAL CIRCUITRY



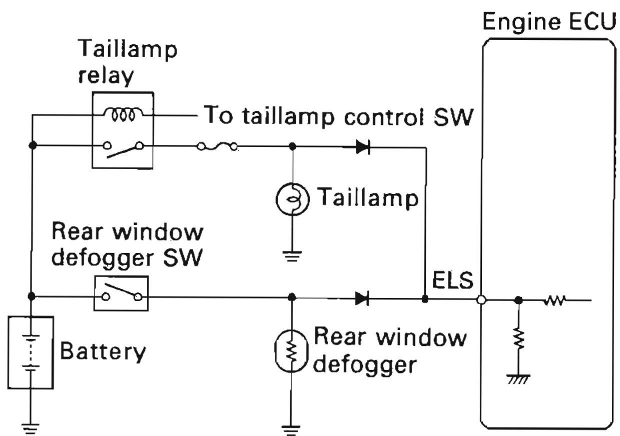
OHP 34



ELECTRICAL LOAD SIGNAL

This signal detects when the head lamps, rear window defogger, etc., are on.
Depending on the vehicle model, the circuitry for this signal can have a number of electrical load signals which are brought together and input into the Engine ECU as a single signal, as shown in the following electrical circuit, or it can have each signal input to the Engine ECU separately.
This signal is used for control of the ISC system.

ELECTRICAL CIRCUITRY



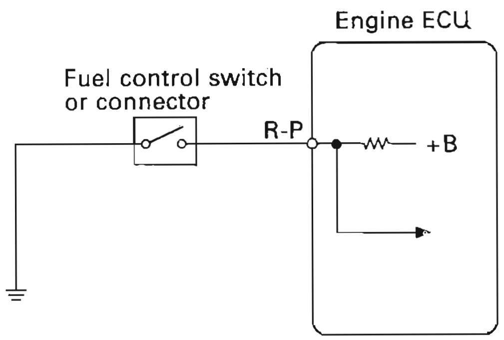
OHP 34

FUEL CONTROL SWITCH OR CONNECTOR

This switch or connector informs the Engine ECU whether the gasoline being used is regular or premium.

This signal is used mainly in controlling the ESA system. The Engine ECU has two sets of advance angle data for different types of gasoline (regular or premium). If the Engine ECU judges that regular gasoline is being used, it uses the data for the smaller angle of advance. If it judges that premium gasoline is being used, it uses the data for the larger angle of advance.

ELECTRICAL CIRCUITRY



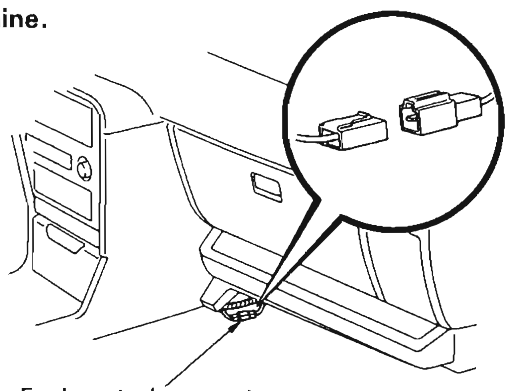
OHP 35

NOTE

Fuel Control Connector

In some vehicle models, this connector should be connected when permium gasoline is used, and disconnected when regular gasoline is used. In other models, the situation is the opposite.

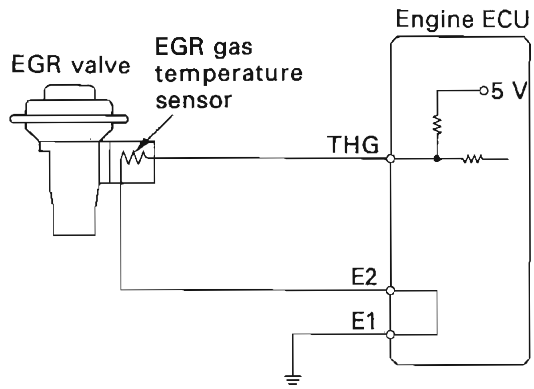
Refer to the owner's manual for the location of the connector and the changeover procedure between regular gasoline and premium gasoline.



EGR GAS TEMPERATURE SENSOR

This sensor is mounted in the EGR valve. It detects the temperature of the EGR gas. This sensor is composed of a thermistor, and it resembles the water temperature sensor or intake air temperature sensor. The signals from this sensor are used in the diagnostic system. When this sensor detects EGR gas temperatures below a predetermined level during EGR system operation, the Engine ECU judges that the EGR system is malfunctioning and lights the "CHECK ENGINE" lamp to inform the driver.

ELECTRICAL CIRCUITRY



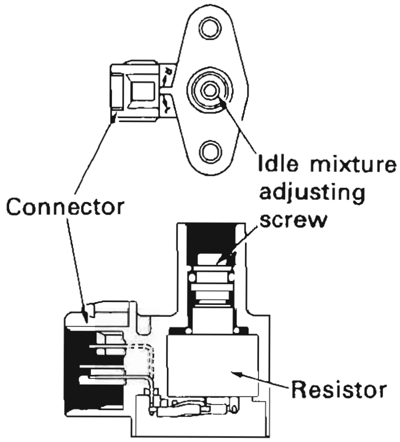
OHP 35

REFERENCE

Some recent D-EFI systems do not use an EGR gas temperature sensor. In these systems, EGR operation is checked by detecting fluctuations in the intake manifold pressure with a manifold pressure sensor (vacuum sensor).

VARIABLE RESISTOR

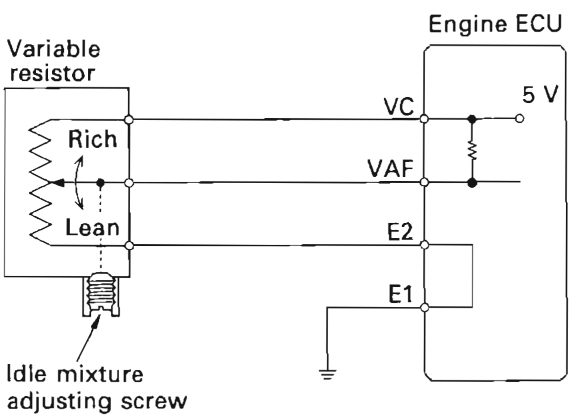
This resistor is provided in D-type EFI systems and L-type EFI with optical Karman vortex type air flow meter or hot-wire type air flow meter which are not equipped with an oxygen sensor. It is used to change the air-fuel ratio of the idle mixture.



OHP 35

Turning the idle mixture adjusting screw clockwise moves the contacts inside the resistor, raising the VAF terminal voltage. Conversely, turning the screw counterclockwise lowers the VAF terminal voltage.
When the VAF terminal voltage rises, the Engine ECU increases the injection volume slightly, making the air-fuel mixture a little richer.

ELECTRICAL CIRCUITRY



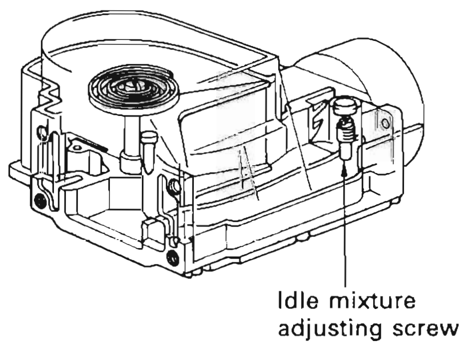
OHP 35

NOTE

It is usually *not* necessary to adjust the idle mixture in most models, provided that the vehicle is in good condition. However, if it does become necessary to do so, always use a CO meter. If a CO meter is not available, it is best *not* to attempt to adjust the idle mixture if at all possible.

REFERENCE

1. In the vane type air flow meter, the idle mixture can be adjusted by turning the idle mixture adjusting screw in the air flow meter. (Some engines are equipped with air flow meters which are sealed with an aluminum plug.)

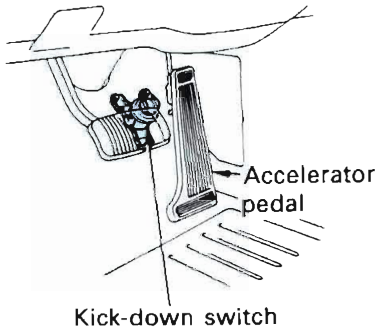


2. In D-type EFI systems and L-type EFI with optical Karman vortex type air flow meter or hot-wire type air flow meter with an oxygen sensor, the ECU uses the signals from the oxygen sensor to correct the air-fuel ratio of the idle muxture, so there is no separate device for adjusting the idle mixture.

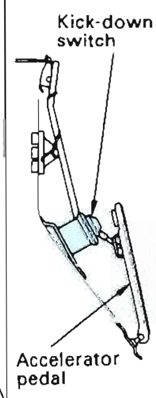
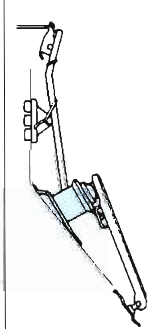
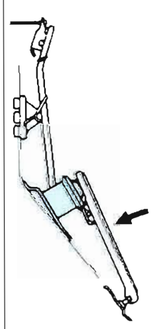
KICK-DOWN SWITCH*

The kick-down switch is fitted to the floor panel directly under the accelerator pedal. When the accelerator pedal is depressed beyond the full throttle opening level, the kick-down switch turns on and sends a KD signal to the ECU. This KD signal is used for power enrichment.

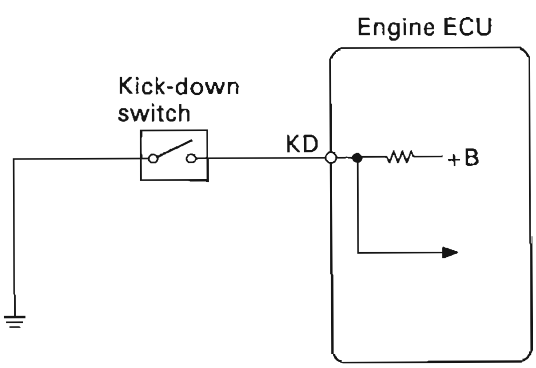
*This switch is also called the "full throttle switch" in other manuals.



OHP 36

ACCELERATOR PEDAL / ITEM			
THROTTLE VALVE	Fully closed	Fully opened	Fully opened
KICK-DOWN SWITCH	Off	Off	On

ELECTRICAL CIRCUITRY

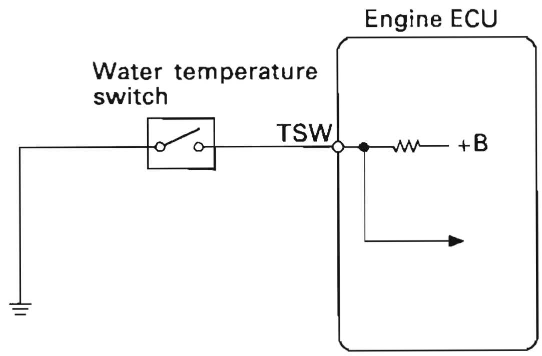


OHP 36

WATER TEMPERATURE SWITCH

This switch sends signals to the Engine ECU when the engine is about to overheat. When the Engine ECU receives this signal, it controls the EFI system and air conditioner cut-off control system in order to lower the fuel combustion temperature.

ELECTRICAL CIRCUITRY

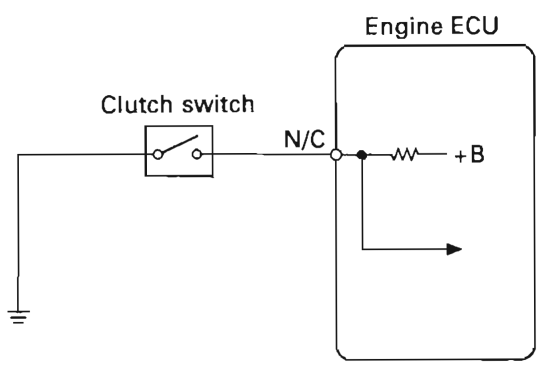


OHP 36

CLUTCH SWITCH

The clutch switch is located under the clutch pedal, and is used to detect whether or not the clutch has been applied. This signal is used mainly to control the fuel cut-off engine speed (See page 78), thereby reducing emissions.

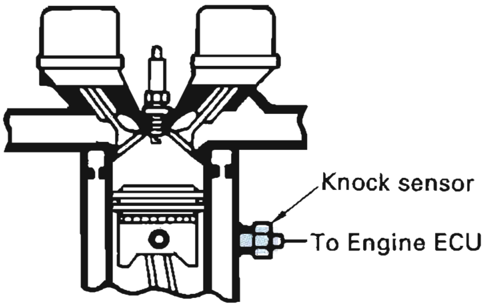
ELECTRICAL CIRCUITRY



OHP 36

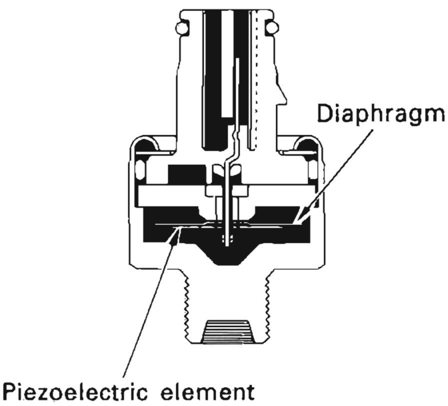
KNOCK SENSOR

The knock sensor is mounted on the cylinder block and detects knocking in the engine.



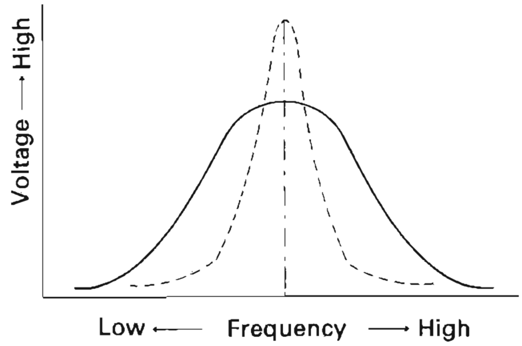
OHP 37

When engine knocking occurs, the Engine ECU uses the KNK signal to retard the ignition timing in order to prevent the knocking.
This sensor contains a piezoelectric element which generates a voltage when it becomes deformed as a result of cylinder block vibration due to knocking.



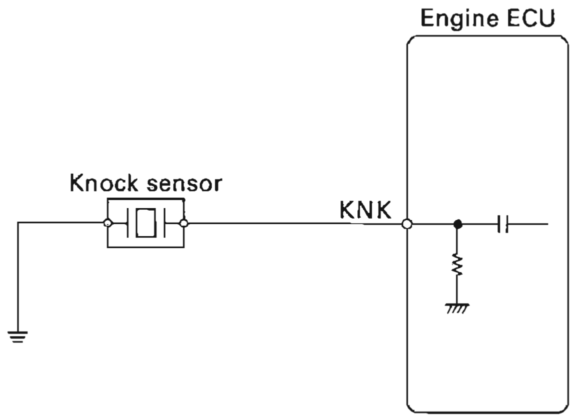
OHP 37

Since the engine knocks at a frequency of approximately 7 kHz, the voltage output by the knock sensor is at its highest level at about that frequency.
There are two types of knock sensor. One type generates high voltages over a narrow range of vibration frequencies, while the other type generates high voltages over a wide range of vibration frequencies.



OHP 37

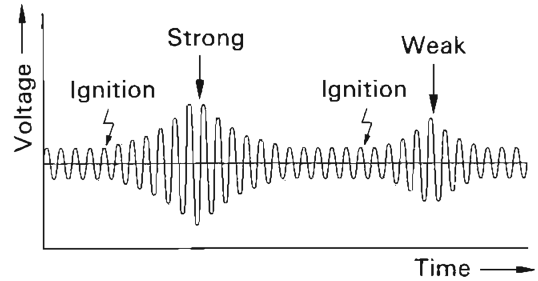
ELECTRICAL CIRCUITRY



OHP 37

REFERENCE

The Engine ECU judges whether the engine is knocking by measuring whether the KNK signal voltage has peaked above a certain voltage level or not. When the Engine ECU judges that the engine is knocking, it retards the ignition timing. When the knocking stops, the ignition timing is advanced again after a predetermined period of time.



KNK SIGNAL

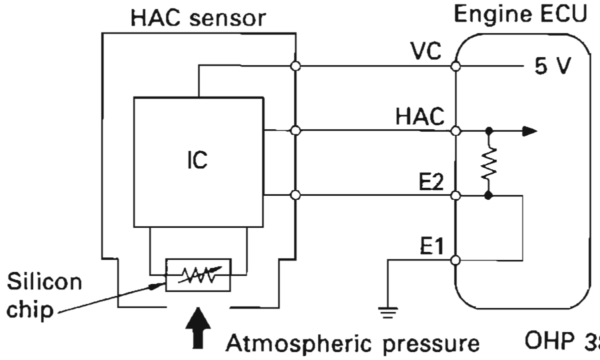
HAC (HIGH-ALTITUDE COMPENSATION) SENSOR

The HAC sensor senses changes in the atmospheric pressure. Its construction and operation are the same as those of the manifold pressure sensor (See page 17).

This sensor can be mounted either in the Engine ECU, or in the passenger compartment separately from the Engine ECU. Currently, the type mounted in the Engine ECU is used the most.

When driving at high altitudes, there is not only a decrease in the atmospheric pressure, but also a drop in the density of the intake air. As a result, the air-fuel ratio deviates toward the rich side in engines with L-type EFI (excluding hot-wire type air flow meters). The HAC sensor corrects for these deviations in the air-fuel ratio.

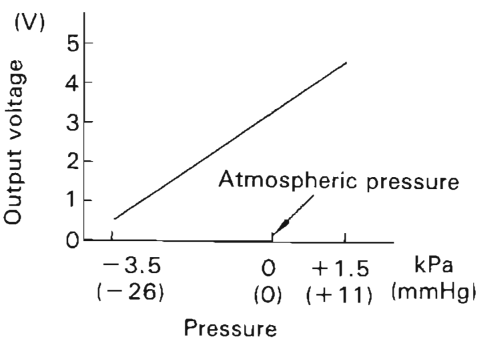
ELECTRICAL CIRCUITRY
(type with sensor mounted separately)



OHP 38

VAPOR PRESSURE SENSOR

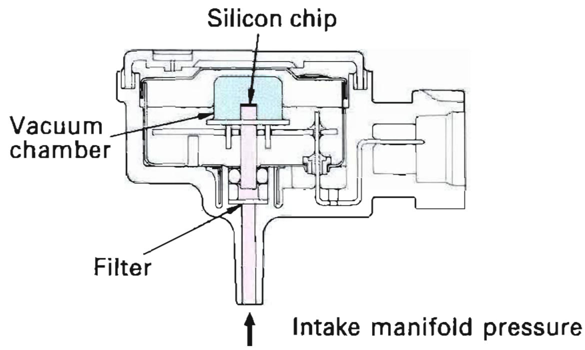
Basic operation and construction is the same as that of a manifold pressure sensor or turbocharging pressure sensor. Output characteristics differ, however, to enable the detection of small changes in vapor pressure.



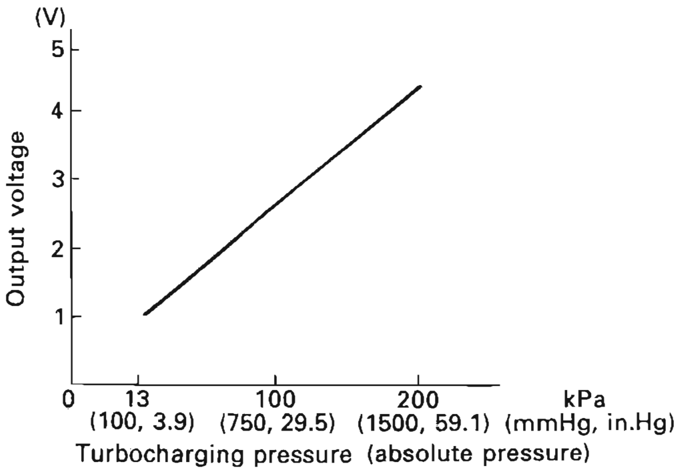
TURBOCHARGING PRESSURE SENSOR

The turbocharging pressure sensor senses the turbocharging pressure (intake manifold pressure). Its construction and operation are the same as those of the manifold pressure sensor (See page 17).

If the turbocharging pressure becomes abnormally high, the Engine ECU cuts off the supply of fuel to protect the engine.

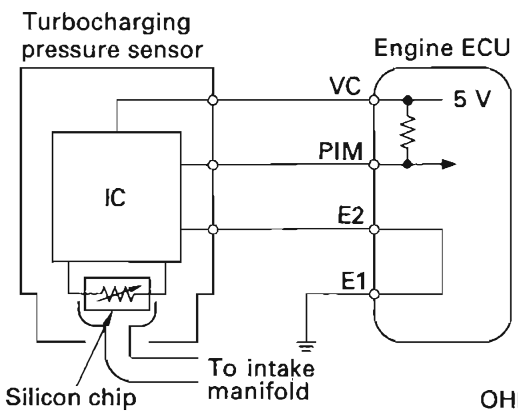


OHP 38



OHP 38

ELECTRICAL CIRCUITRY

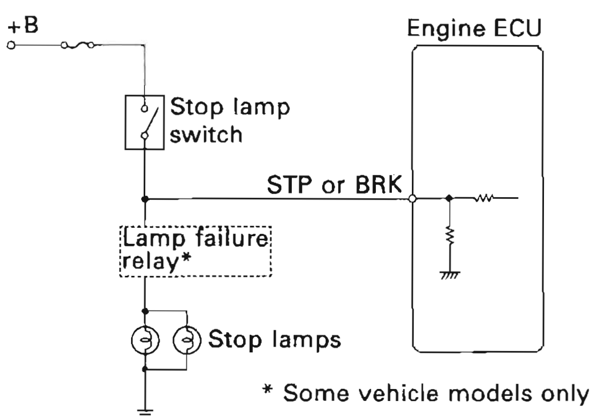


OHP 38

STOP LAMP SWITCH

This signal is used to detect when the brakes have been applied. The STP signal voltage is the same as the voltage supplied to the stop lamps, as seen in the diagram below.
The STP signal is used mainly to control the fuel cut-off engine speed. (The fuel cut-off engine speed is reduced slightly when the vehicle is braking.)

ELECTRICAL CIRCUITRY

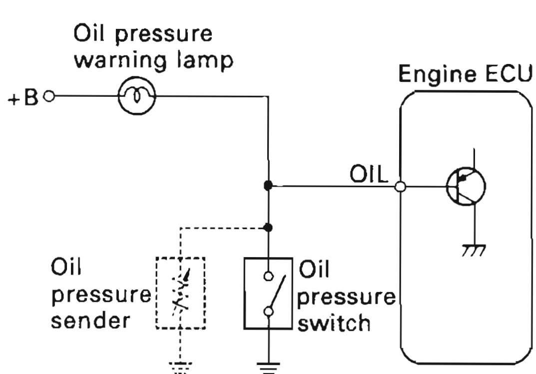


OHP 39

OIL PRESSURE SWITCH

This signal is used to judge whether the engine oil pressure is low or high. The oil pressure signal is used mainly in controlling the ISC system.

ELECTRICAL CIRCUITRY



OHP 39

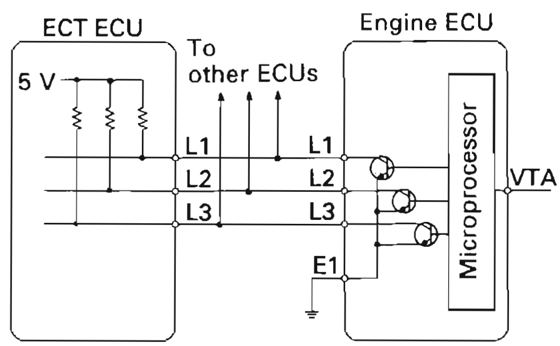
COMMUNICATIONS SIGNALS

Communications signals are signals that are sent between different ECUs to make it possible for them to coordinate their operations.
These communications signals are explained below.

1. THROTTLE OPENING ANGLE SIGNALS

The throttle opening angle (VTA) signal from the throttle position sensor is processed by the Engine ECU, then sent to the ECT ECU, Suspension ECU, etc., as combinations of the L1, L2, and L3 signals.

ELECTRICAL CIRCUITRY

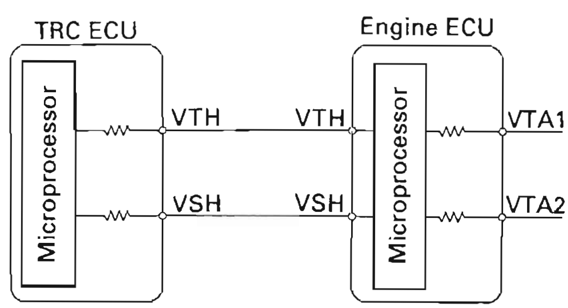


OHP 39

2. THROTTLE OPENING ANGLE SIGNALS FOR TRC (TRACTION CONTROL) SYSTEM

These signals are the throttle opening angle (VTA1 and VTA2) signals which are input from the main and sub throttle position sensors, then passed on by the Engine ECU to the TRC ECU.

ELECTRICAL CIRCUITRY

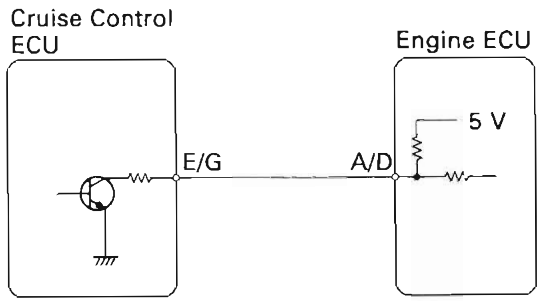


OHP 39

3. CRUISE CONTROL SYSTEM COMMUNICATIONS SIGNAL

This signal is the ignition timing retard request signal that is sent from the Cruise Control ECU to the Engine ECU.

ELECTRICAL CIRCUITRY

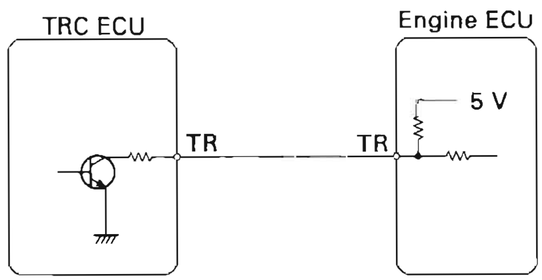


OHP 40

4. TRC SYSTEM COMMUNICATIONS SIGNAL

This signal is sent from the TRC ECU to the Engine ECU to inform it that traction control is in operation. When the TRC ECU outputs the TR signal, the Engine ECU executes various types of corrections related to traction control, such as retarding the ignition timing.

ELECTRICAL CIRCUITRY

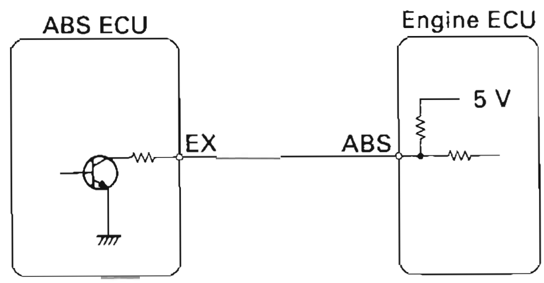


OHP 40

5. ABS (ANTI-LOCK BRAKE SYSTEM) COMMUNICATIONS SIGNAL

This signal detects when the ABS system is operating. It is used in fuel cut-off control to reduce the effectiveness of engine braking as necessary.

ELECTRICAL CIRCUITRY

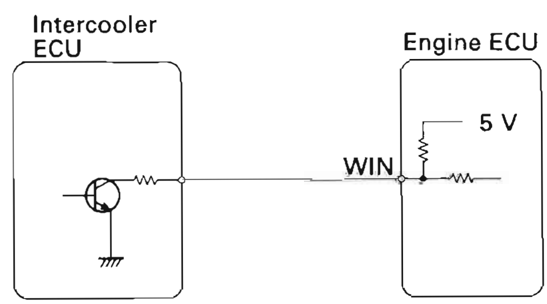


OHP 40

6. INTERCOOLER SYSTEM WARNING SIGNAL

When trouble occurs in the intercooler system in vehicles equipped with a turbocharging system having a water-cooled type intercooler, the Intercooler ECU sends this signal to the Engine ECU, which lights the "CHECK ENGINE" lamp.

ELECTRICAL CIRCUITRY

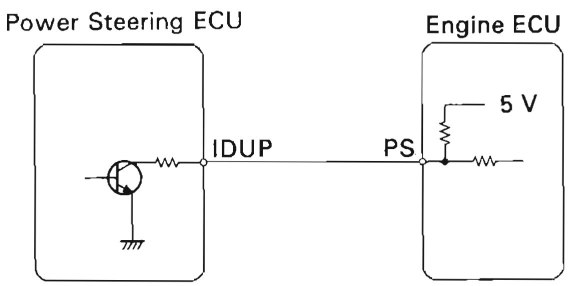


OHP 40

7. EHPS (ELECTRO-HYDRAULIC POWER STEERING) SYSTEM COMMUNICATIONS SIGNAL

When the engine coolant temperature or the engine speed is extremely low, the load on the alternator could become excessive when the vane pump motor of the EHPS is driven.
To prevent this, the Power Steering ECU sends this signal to the Engine ECU, which therefore causes the ISC to increase the engine speed.

ELECTRICAL CIRCUITRY



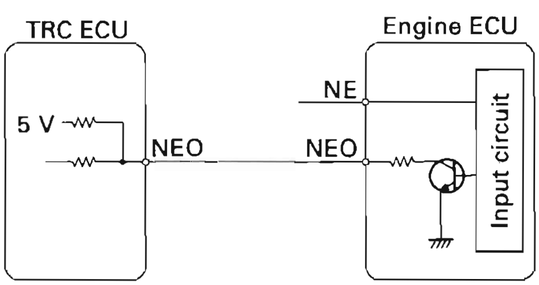
OHP 41

REFERENCE
EHPS is a type of power steering in which the vane pump is driven by an electric motor.

8. ENGINE SPEED SIGNAL

This is the NE signal, which is input to the Engine ECU, then undergoes waveform shaping and is output to the TRC ECU, etc.

ELECTRICAL CIRCUITRY



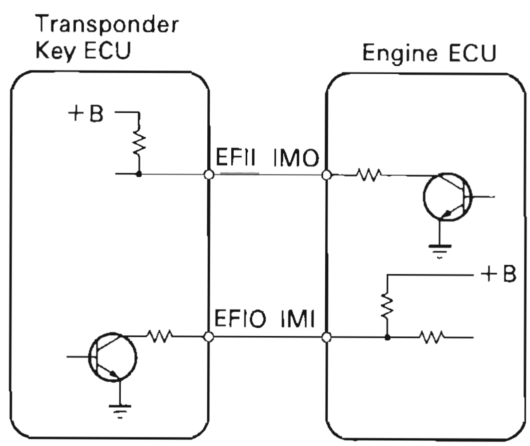
OHP 41

9. ENGINE IMMOBILISER SYSTEM COMMUNICATIONS SIGNAL

The Engine ECU generates a rolling code based on certain parameters, and sends it to the Transponder Key ECU (IMO terminal).

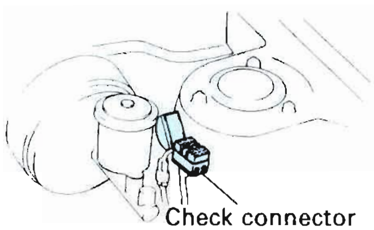
Upon receiving the rolling code from the Engine ECU, the Transponder Key ECU converts the rolling code according to certain parameters, and sends it to the Engine ECU (IMI terminal).
If the correct signal is not sent by the Transponder Key ECU, the Engine ECU will prohibit fuel injection and IGT signal, thus disabling the engine.

ELECTRICAL CIRCUITRY

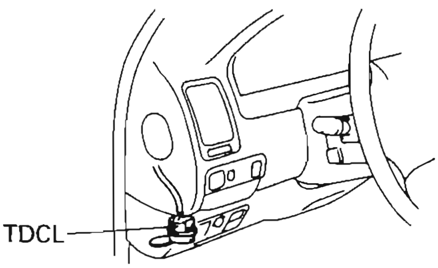


DIAGNOSTIC TERMINAL(S)

The T or TE1 terminal is located in the check connector in the engine compartment and the TE1 and TE2 terminals are located in the TDCL (Toyota diagnostic communication link) in the passenger compartment (located under the instrument panel).



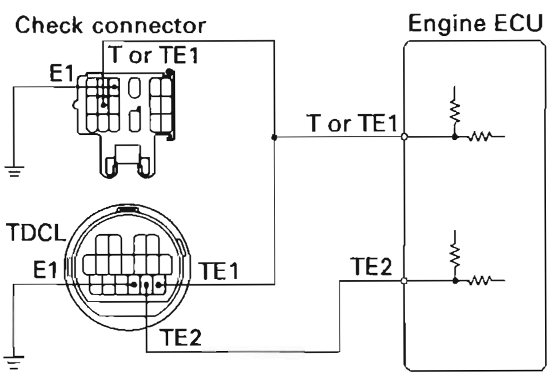
OHP 41



OHP 41

When these terminals are connected with the E1 terminal, diagnostic codes for either the normal mode or the test mode can be read from the blinking of the "CHECK ENGINE" lamp in the combination meter. For further details, see page 159.

ELECTRICAL CIRCUITRY



OHP 41

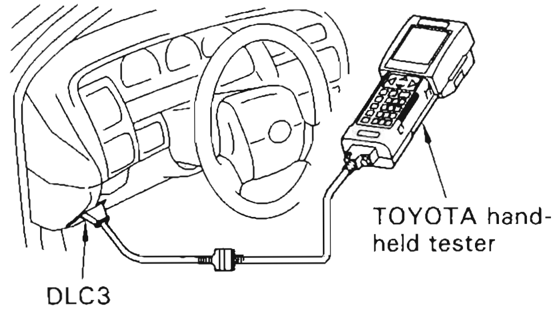
REFERENCE

1. The TDCL is provided in some vehicle models equipped with the TCCS type engine control system.
2. In some vehicle models, the TE2 terminal is located in the check connector.

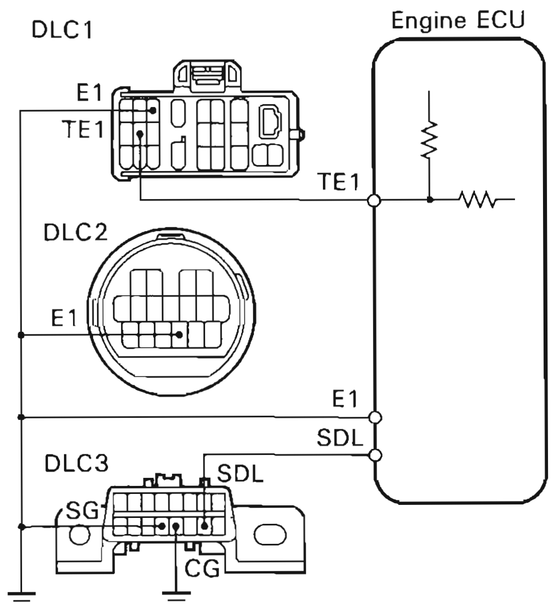
NOTE

OBD-II compatible engines of vehicles sold in the U.S.A. and Canada are equipped with a DLC3 in addition to the check connector (DLC1; Data Link Connector 1) and TDCL (DLC2). Consequently, it does not have a TE2 terminal of DLC1 or TE2 or TE1 terminal of DLC2. In addition, in case of reading diagnostic codes, the tester for exclusive use* must be connected to DLC3.
For further details, see page 137-2.

*** OBD-II scan tool or TOYOTA hand-held tester**



ELECTRICAL CIRCUITRY

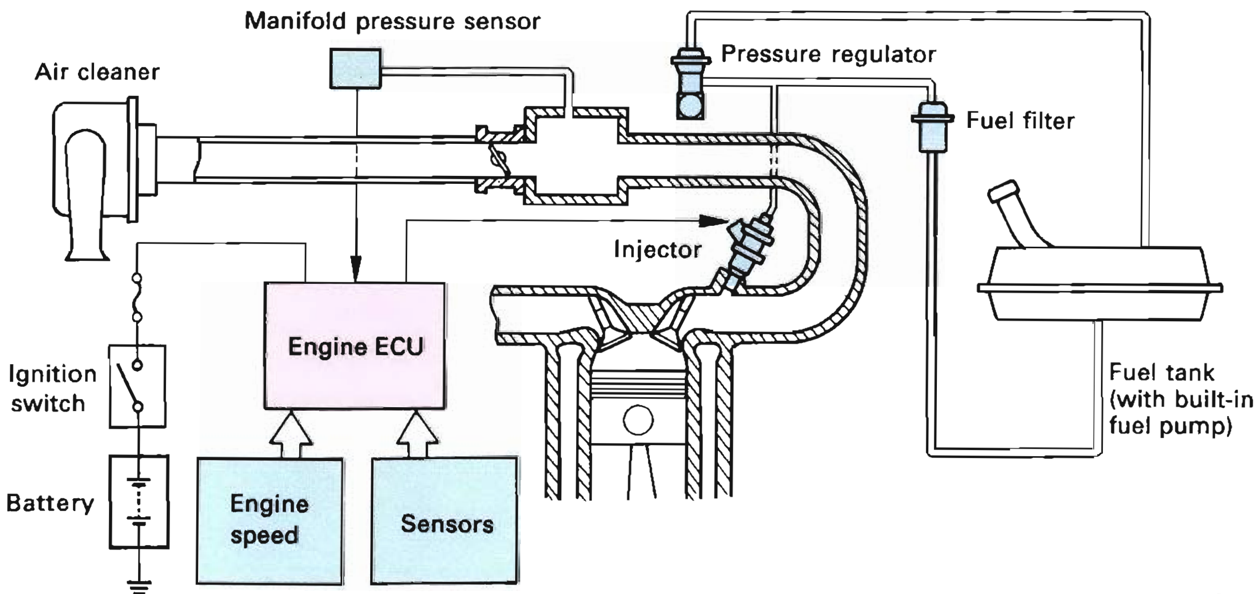


EFI (ELECTRONIC FUEL INJECTION)

GENERAL

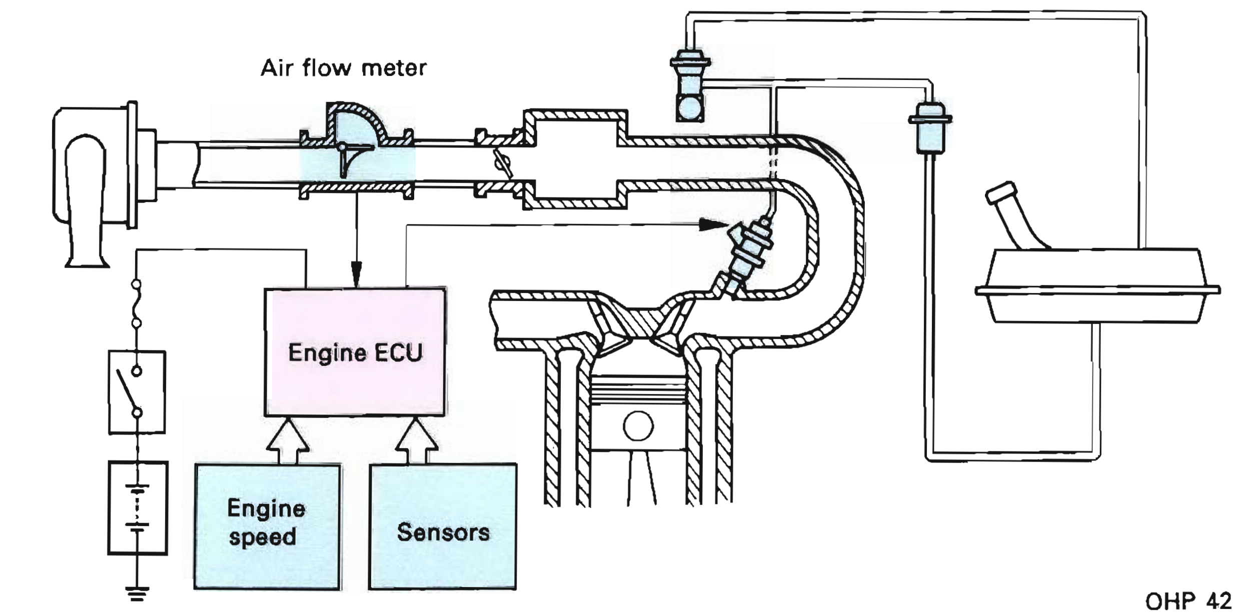
The Engine ECU calculates the basic fuel injection duration in accordance with two signals: 1) the intake manifold pressure signal (in D-type EFI) from the manifold pressure sensor, or the intake air volume signal (in L-type EFI) from the air flow meter, and 2) the engine speed signal. It bases its calculations on a program stored in its memory.

The Engine ECU also determines the optimum fuel injection duration for each engine condition based on signals from various other sensors.



OHP 42

BASIC CONSTRUCTION OF D-TYPE EFI SYSTEM



OHP 42

BASIC CONSTRUCTION OF L-TYPE EFI SYSTEM

The following table shows the specifications for the 4A-FE engine. Items marked with a circle in the "APPENDIX" column are included in the specifications for each engine in the APPENDIX section (page 188) in the back of this manual. Those items covered in Step 2, vol. 5 (EFI), are covered in outline form only in this manual, or their differences only are covered. If there is a circle in the "STEP 2 (EFI)" column in the following table, refer to the Training Manual for Step 2, vol. 5 (EFI), for a detailed explanation for the relevant items.

EFI (ELECTRONIC FUEL INJECTION)				PAGE (THIS MANUAL)	ITEM*	REMARK	APPENDIX	STEP 2 (EFI)
Types of EFI	D-type EFI (manifold pressure control type)			52	○		○	○
	L-type EFI (air flow control type)			52			○	○
Fuel system	Fuel pump	In-tank type		54	○			○
		In-line type		54				○
	Fuel pump control	On-off control (by ECU)		55	○			
		On-off control (by fuel pump switch)		56				○
		On-off control with speed control	By engine ECU with fuel pump control relay and resistor	57				
			By engine ECU with fuel pump ECU	57				
	Fuel filter			58	○			○
	Pulsation damper			58				○
	Pressure regulator	Normal type		58	○			○
		Pressure-up control system		58				
	Injectors			59	○		○	○
	Injector drive method	Voltage-control	High-resistance injectors	60	○		○	○
			Low-resistance injectors	60			○	○
		Current control		61			○	
	Cold start injector			62				○
	Start injector time switch			62				○
	Cold start injector electrical circuitry	Controlled by start injector time switch		63				○
		Controlled by ECU		63				
Air induction system	Throttle body			65	○			○
	Air valve	Wax type		65			○	○
		Bi-metal type		65			○	○

* Specifications for Corolla 4A-FE engine (Apr., 1992)

(Continued on next page)

EFI (ELECTRONIC FUEL INJECTION)						PAGE (THIS MANUAL)	ITEM*	REMARK	APPENDIX	STEP 2 (EFI)
Functions of Engine ECU	Fuel injection methods and injection timing	Simultaneous				66			○	
		2 groups				66	○		○	
		3 groups				67			○	
		4 groups				67			○	
		Independent				67			○	
		For 1S-i				67			○	
	Fuel injection duration control	Start injection control				70	○			
		After-start injection control	Basic injection duration control	For D-type EFI		71	○			
				For L-type EFI		72				○
			Injection corrections	Intake air temp. correction		72	○			○
				After-start enrichment		73	○			○
				Warm-up enrichment		73	○			○
				Power enrichment		74	○			○
				Air-fuel ratio correction during transition	Acceleration enrichment correction	74	○			
					Deceleration lean correction	74				
				Air-fuel ration feedback correction	Oxygen sensor	75	○	With TWC		○
					Lean mixture sensor	75				
				CO emission control correction		76	○	Except with oxygen sensor		
				Idling stability correction		77	○			
				High-altitude compensation correction		77				
				Fuel cut-off	During deceleration	78	○			○
					At high engine speeds	78	○			
					At high vehicle speeds	78				
			Voltage correction			79	○			○

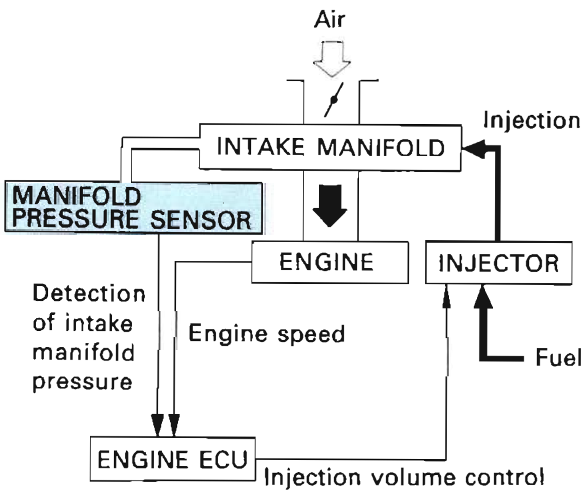
* Specifications for Corolla 4A-FE engine (Apr., 1992)

TYPES OF EFI

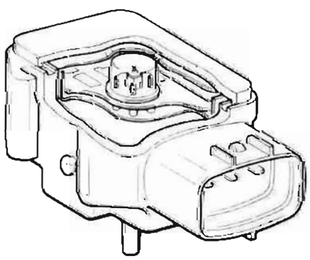
EFI systems can be divided into two types according to the method used to sense the volume of intake air:

1. D-TYPE EFI (MANIFOLD PRESSURE CONTROL TYPE)

This type measures the strength of the vacuum in the intake manifold, thereby sensing the volume of air by its density.



OHP 43

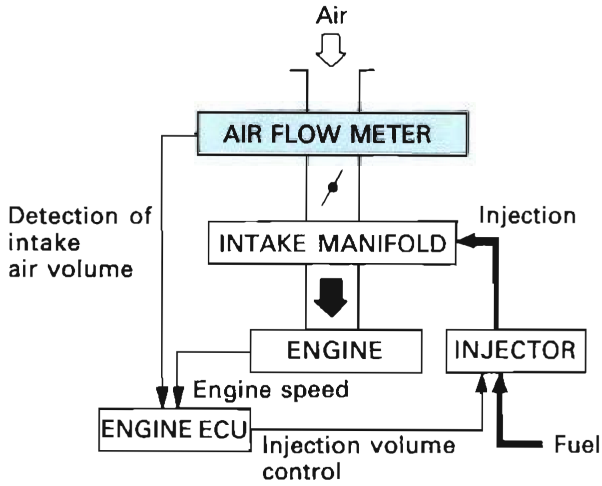


MANIFOLD PRESSURE SENSOR

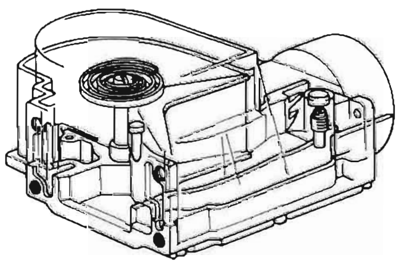
OHP 43

2. L-TYPE EFI (AIR FLOW CONTROL TYPE)

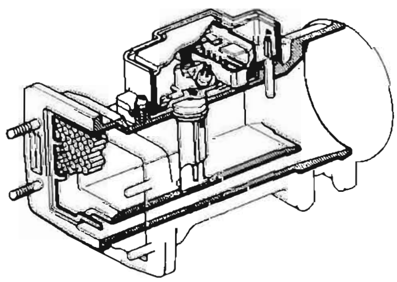
This type directly senses the amount of air flowing into the intake manifold by means of an air flow meter.



OHP 43

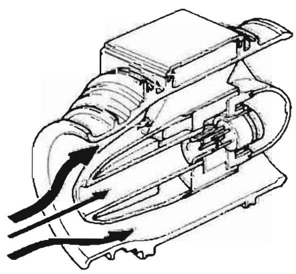


Vane type OHP 43



Optical Karman vortex type

OHP 43



Hot-wire type

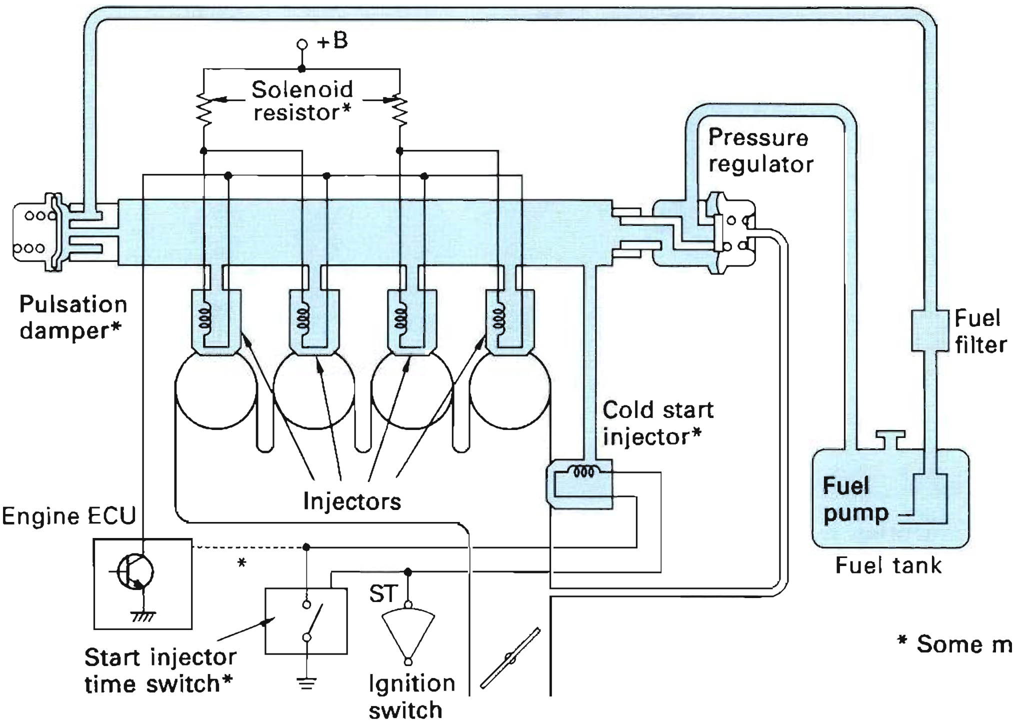
AIR FLOW METER

FUEL SYSTEM

Fuel pumped out of the fuel tank by the fuel pump passes through the fuel filter, then is sent to the injectors. The fuel pressure at the injectors is maintained at a constant high level (285 kPa [2.9 kgf/cm^2; 41.2 psi] or 250 kPa [2.55 kgf/cm^2; 35.5 psi], depending on the engine model), which is greater than the intake manifold pressure. When fuel is injected, the fuel pressure in the fuel line changes slightly. Some engines are equipped with a pulsation damper to prevent this from occurring. One injector is mounted in front of each cylinder (except in the case of the single-point injector for the 1S-i engine), and the amount of fuel injected is controlled by the length of time current is sent to the injectors.

A single cold start injector is also mounted in the intake chamber to improve startability in cold weather. (This system is not included in some engines.)

The injection duration of the cold start injector is controlled by a start injector time switch. (In some engines, it is controlled by both the ECU and the start injector time switch.)

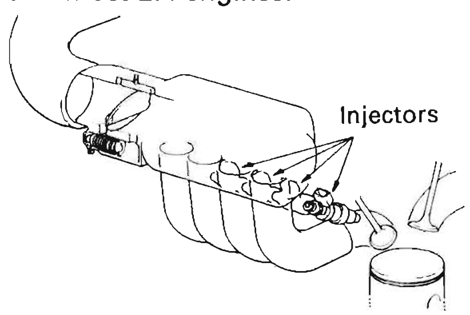


* Some models only.

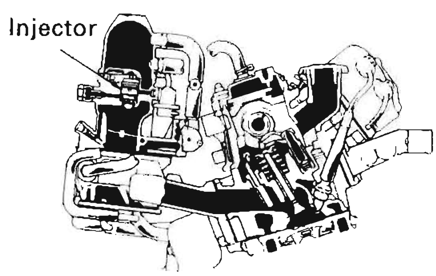
OHP 44

REFERENCE

1. **Multi-point Injection**
   Each cylinder has its own injector, and fuel is injected in front of the intake ports near the cylinders. This is the method used in most EFI engines.



2. **Single-point Injection (Central Injection)**
   The single injector is mounted in the throttle body and fuel is injected at this point into the intake air stream. This method is used in the 1S-i engine only.



1. FUEL PUMP

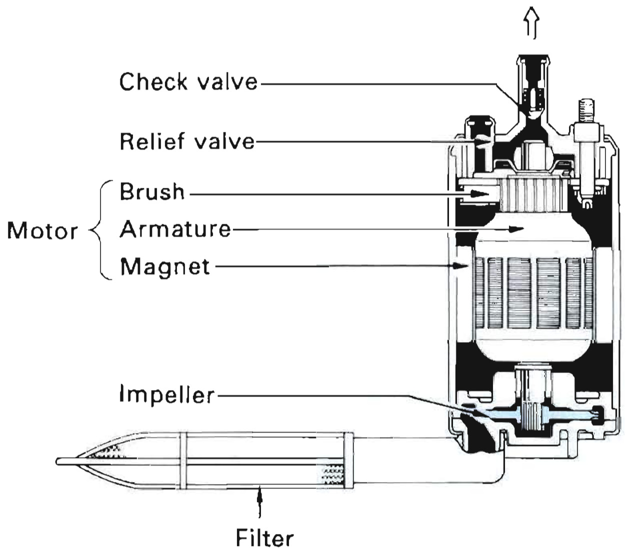
IN-TANK TYPE

This type of fuel pump is mounted inside the fuel tank.

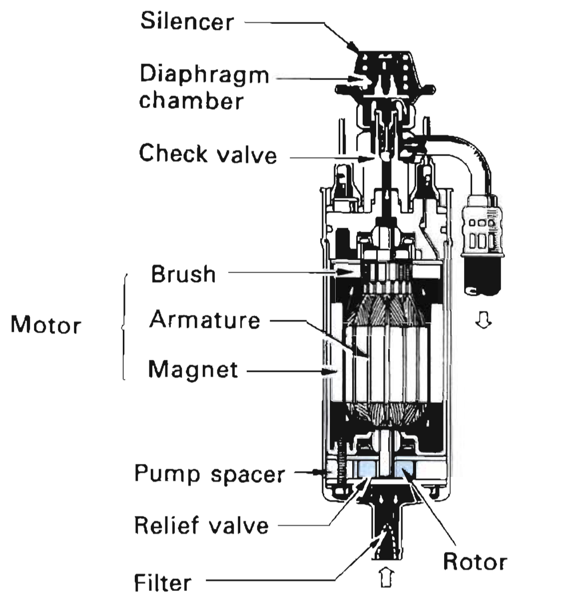
This type produces much less pulsation and noise the in-line type. Currently, only this type is used in Toyota vehicles.

IN-LINE TYPE

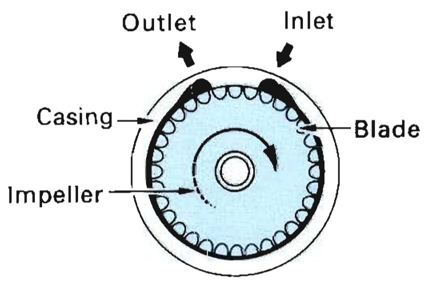
This type of fuel pump is mounted outside the fuel tank. This type is no longer in use at Toyota.



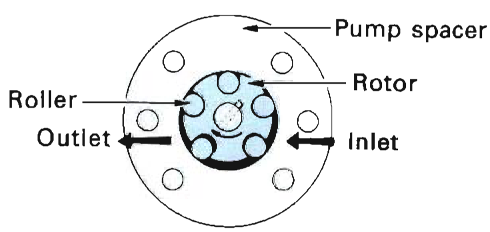
OHP 45



OHP 45



OHP 45



OHP 45

2. FUEL PUMP CONTROL

The fuel pump in a vehicle equipped with an EFI engine operates only when the engine is running. This is to prevent fuel from being pumped to the engine when the ignition switch is on but the engine is stopped.
The following types of fuel pump control are in use at present:

- Fuel pump control method
  - On-off control
    - By Engine ECU
    - By fuel pump switch
  - On-off control with speed control
    - By Engine ECU, fuel pump control relay and resistor
    - By Engine ECU and fuel pump ECU

ON-OFF CONTROL (BY ENGINE ECU)*

① Engine cranking

When the engine is cranking, current flows from the IG terminal of the ignition switch to the L_1 coil of the EFI main relay, turning the relay on. At the same time, current flows from the ST terminal of the ignition switch to the L_3 coil of the circuit-opening relay, turning it on to operate the fuel pump.

The starter operates next and the engine begins to crank, at which point the Engine ECU receives an NE signal. This signal causes the transistor inside the Engine ECU to go on, and current therefore flows to the L_2 coil of the circuit-opening relay.

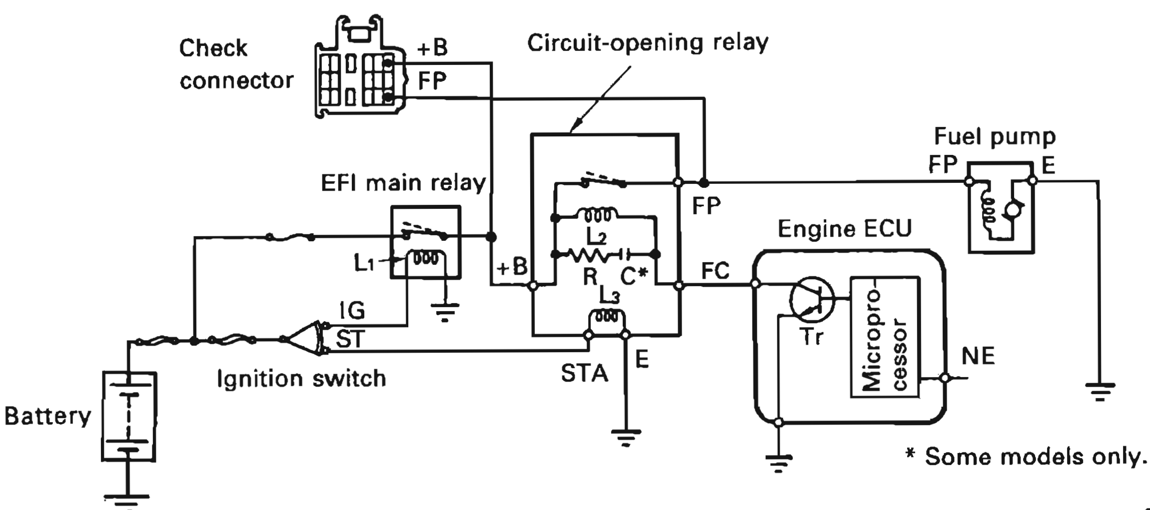
② Engine started

After the engine starts and the ignition switch is returned from the START position (ST terminal) to the ON position (IG terminal), current flowing to the L_3 coil of the circuit-opening relay is cut off. However, current continues to flow to the L_2 coil, while the engine is running, due to the transistor inside the Engine ECU being on. As a result, the circuit-opening relay stays on, allowing the fuel pump to continue operating.

③ Engine stopped

When the engine stops, the NE signal to the Engine ECU stops. This turns off the transistor, thereby cutting off the flow of current to the L_2 coil of the circuit-opening relay. As a result, the circuit-opening relay turns off, turning off the fuel pump.

* D-EFI systems and L-type EFI with optical Karman vortex type air flow meter or hot-wire type air flow meter.



OHP 46

REFERENCE

Circuit-opening Relay

The resistor R and the capacitor C in the circuit-opening relay are for the purpose of preventing the relay contacts from opening when current stops flowing in coil L_2 due to electrical noise (fuel pumps controlled by the ECU) or to sudden drops in the intake air volume (fuel pumps controlled by fuel pump switch).
They also serve to prevent sparks from being generated at the relay contacts.
On some recent models, an L_3 coil is not provided in the circuit-opening relay.

ON-OFF CONTROL (BY FUEL PUMP SWITCH)*

① **Engine cranking**

When the engine is cranking, current flows from the IG terminal of the ignition switch to the L_1 coil of the EFI main relay, turning the relay on. Current also flows from the ST terminal of the ignition switch to the L_3 coil of the circuit-opening relay, turning it on to operate the fuel pump. After the engine starts, the cylinders begin drawing in air, causing the measuring plate inside the air flow meter to open. This turns on the fuel pump switch, which is connected to the measuring plate, and current flows to the L_2 coil of the circuit-opening relay.

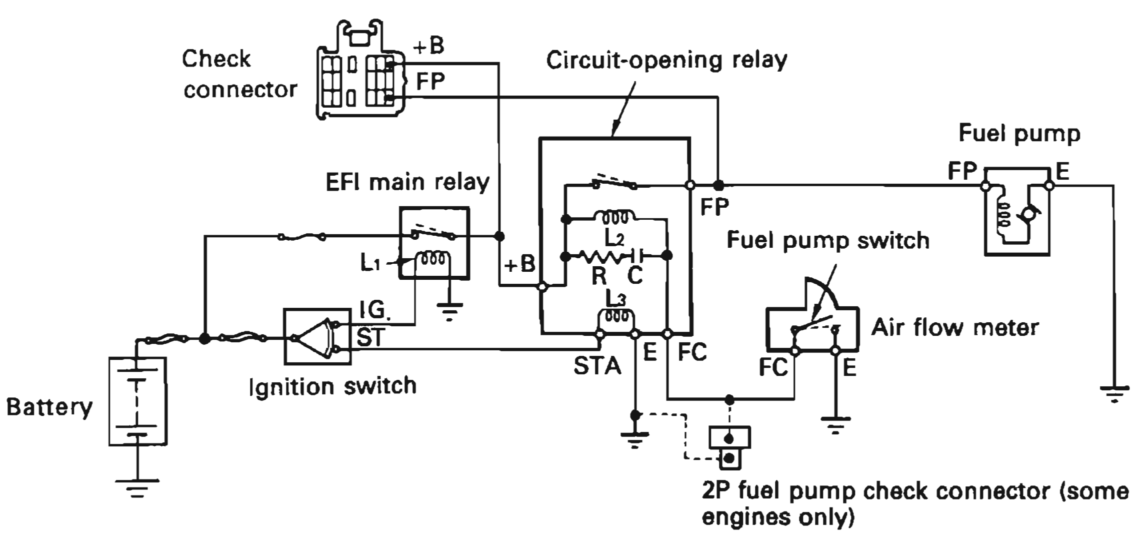
② **Engine started**

After the engine starts and the ignition switch is turned from START back to ON, current flowing to the L_3 coil of the circuit-opening relay is cut off. However, current continues to flow to the L_2 coil, while the engine is running, due to the fuel pump switch inside the air flow meter being on. As a result, the circuit-opening relay stays on, allowing the fuel pump to continue operating.

③ **Engine stopped**

When the engine stops, the measuring plate completely closes and the fuel pump switch is turned off. This cuts off the flow of current to the L_2 coil of the circuit-opening relay. As a result, the circuit-opening relay goes off and the fuel pump stops operating.

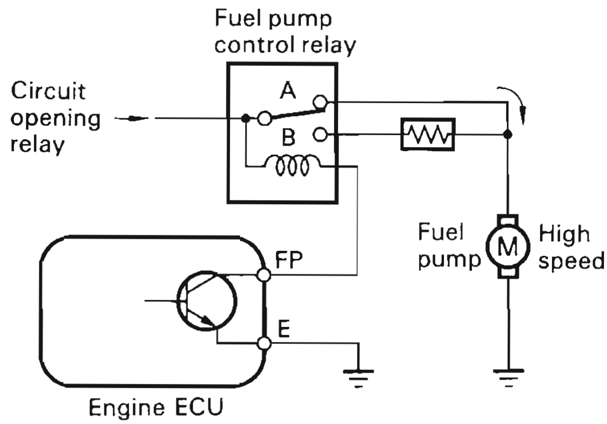
* L-type EFI with vane type air flow meter.



OHP 46

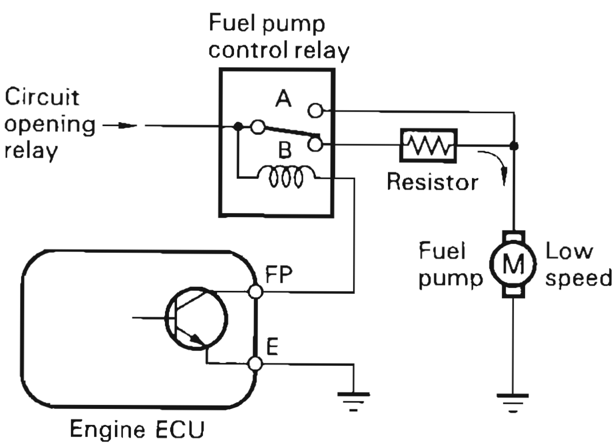
ON-OFF CONTROL WITH SPEED CONTROL (BY ENGINE ECU, FUEL PUMP CONTROL RELAY AND RESISTOR)

The basic operation of this system is the same as that of the previously-mentioned on-off type fuel pump control system, but in this system, the ECU changes the speed of the fuel pump in two stages corresponding to the amount of fuel required by the engine. With this system, electric power consumption is reduced and fuel pump durability is improved.



① At low speeds

When the engine is idling, or under normal driving conditions (that is, when a small amount of fuel is satisfactory), the Engine ECU turns on the fuel pump control relay. The point of this relay contacts contact B, and the current to the fuel pump flows through a resistor, causing the fuel pump to run at low speed.

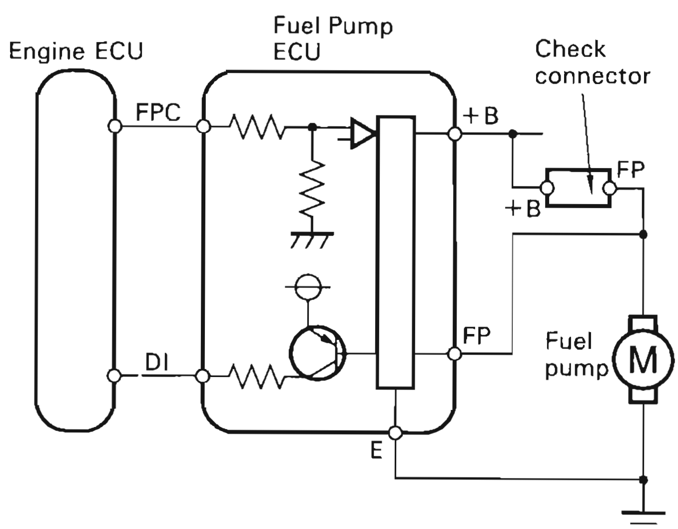


② At high speeds

When the engine is operating at high speeds or under heavy loads, the Engine ECU turns off the fuel pump control relay. The point of this relay contacts contact A, and the current to the fuel pump flows directly to the pump without passing through the resistor, causing the fuel pump to run at high speed.
The fuel pump also runs at high speed while the engine is starting.

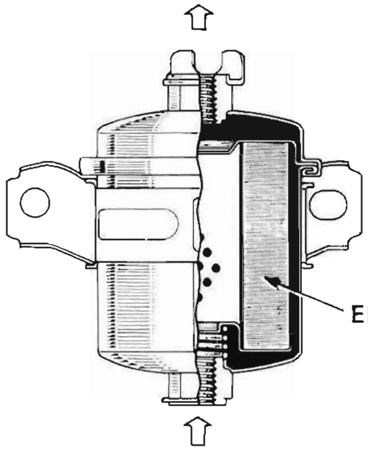
ON-OFF CONTROL WITH SPEED CONTROL (BY ENGINE ECU AND FUEL PUMP ECU)

The basic operation of this system is the same as the types that have been explained thus far. In this system, however, on-off control and speed control of the fuel pump is performed entirely by the Fuel Pump ECU based on the signals from the Engine ECU.
The Fuel Pump ECU is wired as shown in the following diagram. Signals from this ECU are used to switch the fuel pump speed back and forth between 2 steps. In addition, the Fuel Pump ECU is equipped with a fuel pump system diagnosis function. When trouble is detected, signals are sent from the DI terminal to the Engine ECU.



3. FUEL FILTER

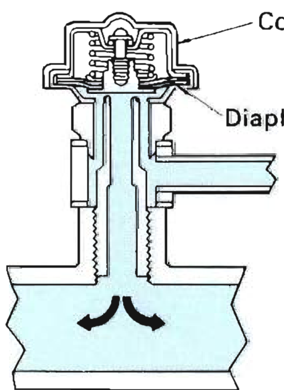
The fuel filter filters out dirt and other foreign particles from the fuel.



OHP 48

4. PULSATION DAMPER

The pulsation damper absorbs variations in fuel line pressure by means of a diaphragm.



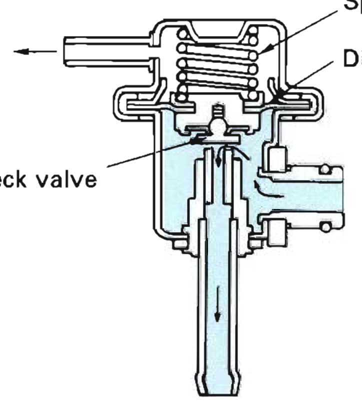
OHP 48

REFERENCE

In the 4A-FE engine and some other engine models, the pulsation damper is no longer necessary because the fuel line has been simplified.

5. PRESSURE REGULATOR

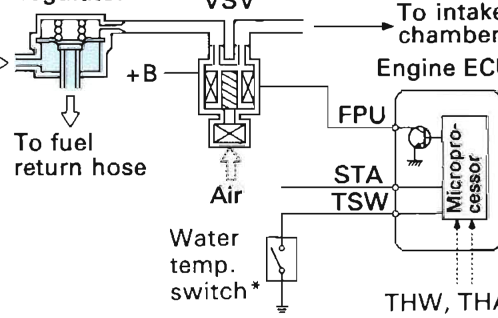
The pressure regulator regulates the fuel pressure to the injectors in accordance with the intake manifold pressure.



OHP 48

PRESSURE-UP CONTROL SYSTEM

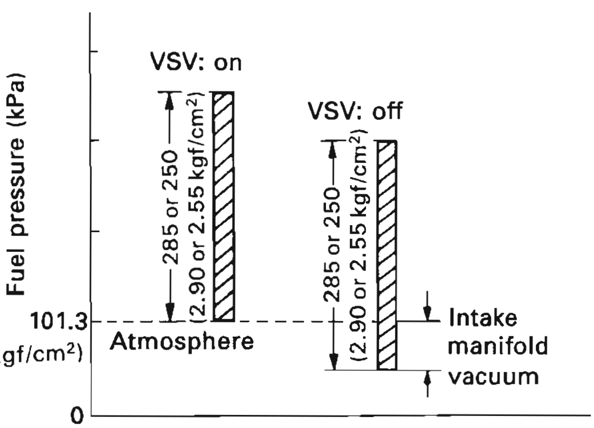
In some engines, the fuel pressure is increased by the Engine ECU when the temperature of the coolant or ambient temperature of the engine is too high during engine cranking. The Engine ECU causes more air to be drawn into the chamber of the pressure regulator to increase the fuel pressure. This prevents vapor lock at high engine temperatures in order to help the engine start when it is warm.



*Some models only

OHP 48

If the engine is cranked when the coolant temperature is 100°C (212°F) or higher, the Engine ECU turns on the VSV (the exact temperature depends on the engine model).
When the VSV goes on, atmospheric air is introduced into the diaphragm chamber of the pressure regulator, causing the fuel pressure to become higher than that under normal engine operating conditions. After the engine is started, the VSV remains on for about two minutes.
There are some engine models in which a water temperature sensor (THW) is used instead of a water temperature switch (TSW).
There are also engines in which other signals besides the coolant temperature are used in pressure-up control. These signals include the intake air temperature (THA) signal, the intake air volume (VS or PIM) signal, and the engine speed (NE) signal.



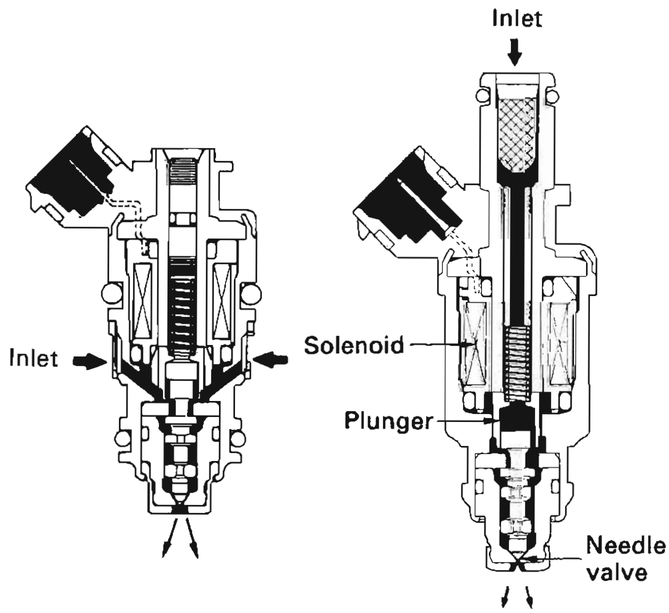
OHP 48

NOTE

1. **On some recent models, intake manifold pressure is not connected to the pressure regulator.**
   Fuel pressure is always maintained at a constant pressure higher than the atmospheric pressure. As a result, changes in injection volume caused by intake manifold pressure are corrected by the Engine ECU.
2. **In addition to the models described in 1 above, there are also models in which the pressure regulator is provided in the fuel tank. Since there is no fuel return pipe, it becomes difficult for air bleed once it has entered the fuel pipe. It is for this reason that more time is required to start the engine after the fuel filter or similar component has been replaced.**

6. INJECTORS

The injector is an electromagnetically-operated nozzle which injects fuel in accordance with signals from the ECU.



SIDE-FEED TYPE TOP-FEED TYPE

OHP 49

NOTE

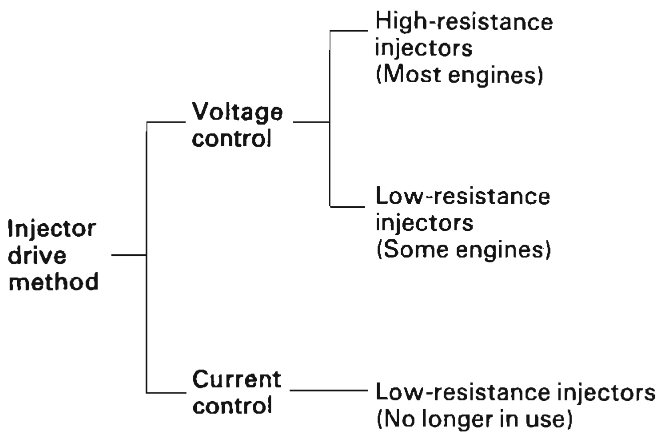
Internal Resistance of Injector

There are two types of injector, which differ in their internal resistance level:

- **High-resistance type: approx. 13.8 Ω**
- **Low-resistance type: approx. 1.5 ~ 3 Ω**

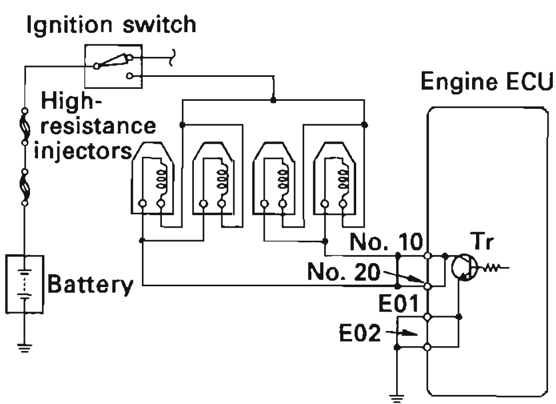
7. INJECTOR DRIVE METHODS

There are two injector drive methods. One is the voltage control method, and the other is the current control method.



VOLTAGE CONTROL METHOD FOR HIGH-RESISTANCE INJECTORS

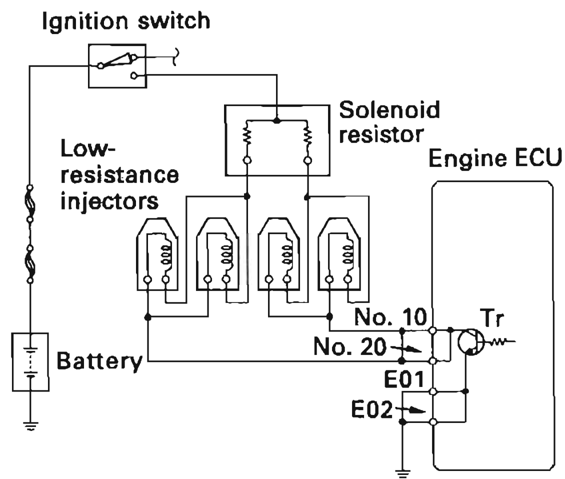
Battery voltage is applied to the injectors directly via the ignition switch.
When the transistor (Tr) in the Engine ECU goes on, current flows from terminals No. 10 and No. 20 to E01 and E02. While the Tr is on, current flows through the injectors and fuel is injected.
The electrical circuitry for simultaneous injection (See page 66) is shown below.



OHP 49

VOLTAGE CONTROL METHOD FOR LOW-RESISTANCE INJECTORS

The electrical circuitry for this type of injector, as well as its operation, are basically the same as for the high-resistance injector, but since a low-resistance injector is used, a solenoid resistor is connected between the ignition switch and the injectors.
The electrical circuitry for simultaneous injection (See page 66) is shown below.



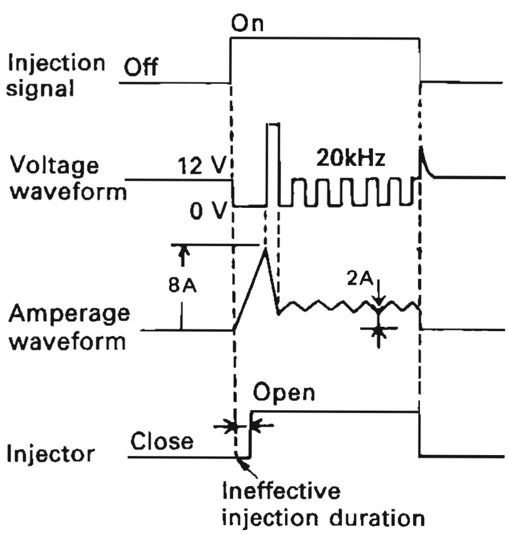
OHP 49

CURRENT CONTROL METHOD (for 4A-GE engine with D-type EFI)

In injectors that use this method, the solenoid resistor is eliminated, and a low-resistance injector is connected directly to the battery. Current flow is controlled by switching a transistor in the Engine ECU on and off.

When the injector plunger is pulled in, a heavy current flows, causing the amperage to rise quickly. This causes the needle valve to open quickly, resulting in improved injection response and reduced ineffective injection duration.

While the plunger is held in, the current is reduced, preventing the injector coil from generating heat, as well as reducing power consumption.



OHP 50

The drive circuitry for this injector is as shown in the figure at the right. Battery voltage is applied to the ignition switch, then to the fail-safe main relay or INJ fuse, then to the injectors, and finally to the Engine ECU.

The fail-safe main relay is connected in such a way that it is grounded through the injector drive circuitry via the FS terminal of the Engine ECU. The relay therefore goes on when the ignition switch is turned on. This turns on Tr_1 in the Engine ECU, letting current flow to the injector solenoids.

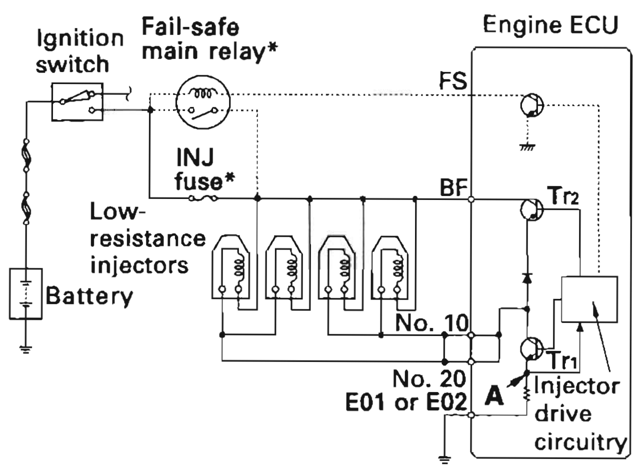
This current builds up until the potential at point "A" reaches a certain value, then the injector drive circuit switches Tr_1 off. The switching on and off of Tr_1 is repeated at a frequency of roughly 20 kHz over the duration of the injection. In this way, the current to the injector solenoid coils is controlled (when the +B voltage is 14 V, the current pulling in the injector plunger is approximately 8 A, while it is about 2 A while the plunger is being held in).

Tr_2 absorbs counter-electromotive force from the injector solenoid coil while Tr_1 is being switched on and off, thus preventing sudden reductions in current.

If an extremely large current flows to the injectors for any reason, the fail-safe main relay goes off, cutting off the flow of current to the injectors.

REFERENCE

The current control method was used in the 4A-GE engine with D-type EFI, which was produced between August, 1983, and May, 1987.

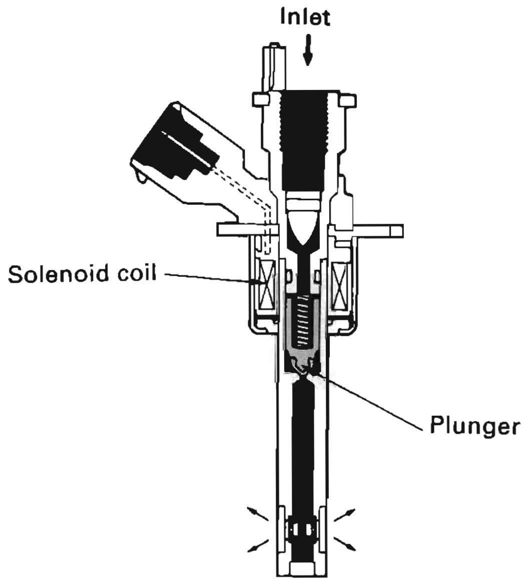


OHP 50

*In vehicles produced between August, 1984, and May, 1987, an INJ fuse was used in place of the fail-safe main relay.

8. COLD START INJECTOR

The function of the cold start injector is to maintain engine startability when it (the engine) is cold. This injector operates only during cranking when the coolant temperature is low.



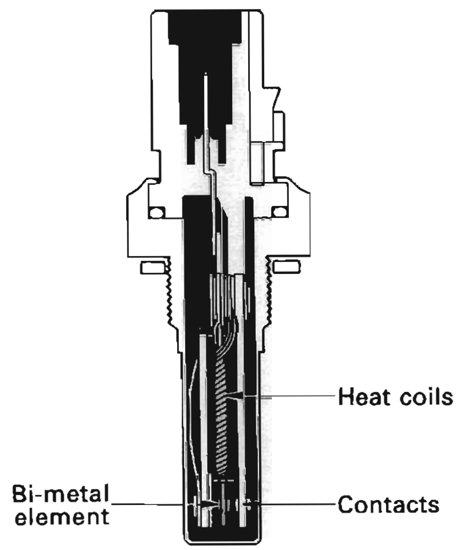
OHP 50

NOTE

On many current engine models, the cold start system has been discontinued. Instead, starting injection control, which is under the control of the Engine ECU, controls the injection of fuel during starting.

9. START INJECTOR TIME SWITCH

The function of the start injector time switch is to control the maximum injection duration of the cold start injector.

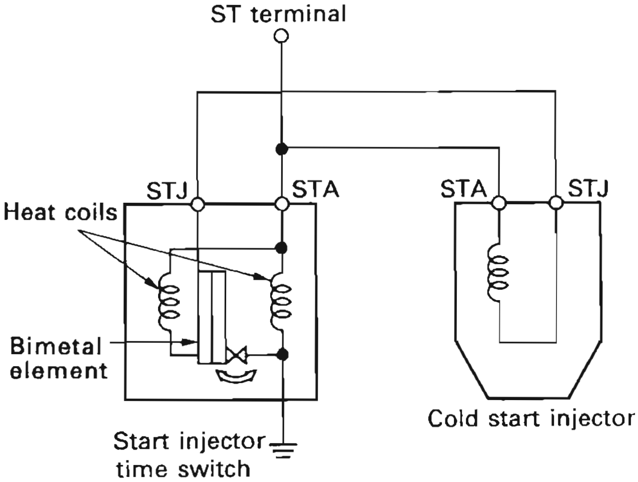


OHP 51

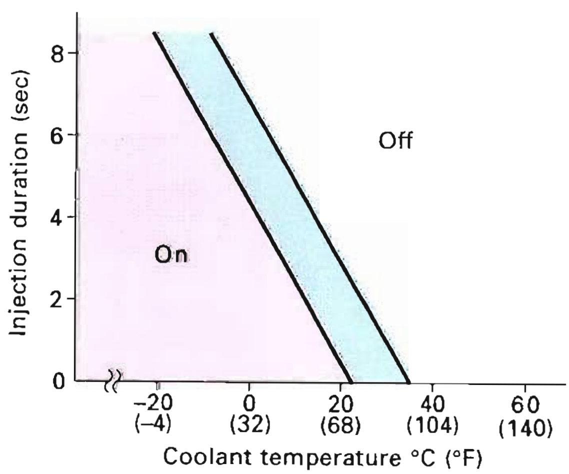
10. COLD START INJECTOR ELECTRICAL CIRCUITRY

CONTROLLED BY START INJECTOR TIME SWITCH

When the engine is cranked while the engine coolant temperature is low, the duration of cold start injector operation is controlled by the start injector time switch.



OHP 51

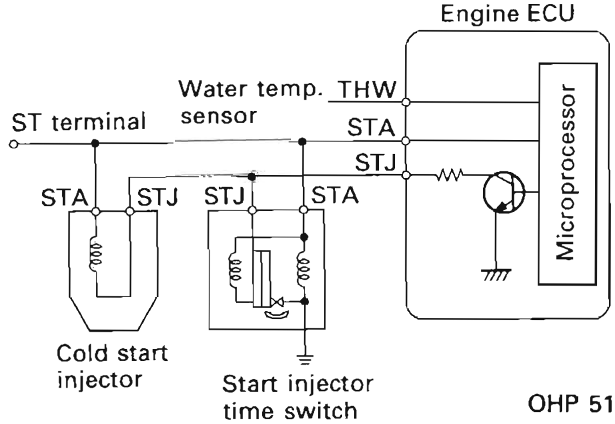


On or off depending on engine model

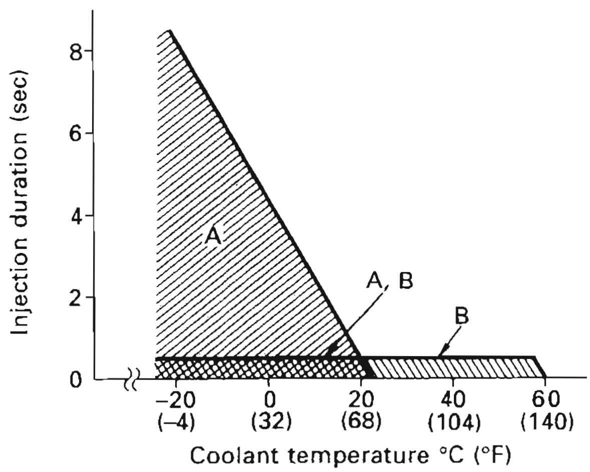
OHP 51

CONTROLLED BY ECU (STJ CONTROL)

In order to improve startability when the engine is cold, the injection duration of the cold start injector is controlled not only by the start injector time switch but also by the Engine ECU in accordance with the coolant temperature.
Control of the injection duration of the cold start injector continues to be carried out by the start injector time switch, as shown by shaded area A in the figure below, but control is also exercised by the Engine ECU, as shown by shaded area B in the figure.



OHP 51



A: Controlled by start injector time switch
B: Controlled by ECU
A, B: Controlled by start injector time switch and ECU

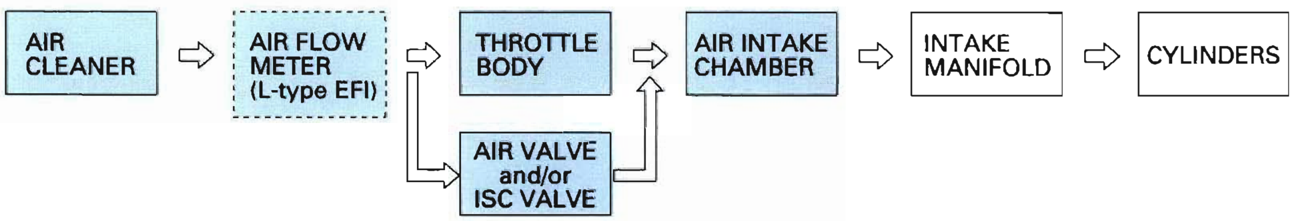
OHP 51

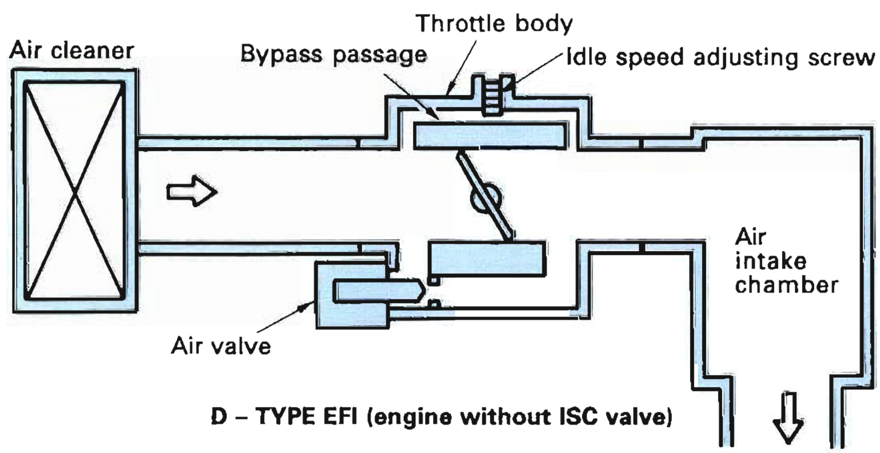
AIR INDUCTION SYSTEM

This system supplies the air necessary for combustion to the cylinders. Air passes through the air cleaner, then through the air flow meter (in L-type EFI only), the throttle body, the air intake chamber, and the intake manifold, then is fed into each cylinder. In an EFI engine, releasing the accelerator pedal closes the throttle valve fully, so during idling or fast idling, air bypasses the throttle valve and is taken directly into the cylinders via the bypass passage in the throttle body or ISC valve.

When the coolant temperature is low, the air valve opens and air passes through it (in addition to passing through the throttle body as usual) and enters the air intake chamber. This extra air raises the idle speed to aid in engine warm-up.

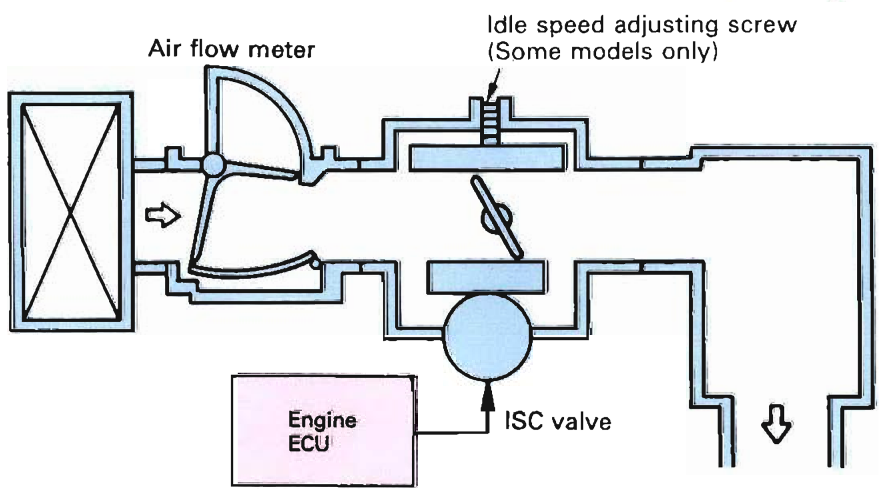
In engines equipped with some types of ISC valves, the above is performed not by an air valve, but by the ISC valve. Please refer to the section on the ISC system (see page 99).





D – TYPE EFI (engine without ISC valve)

OHP 52

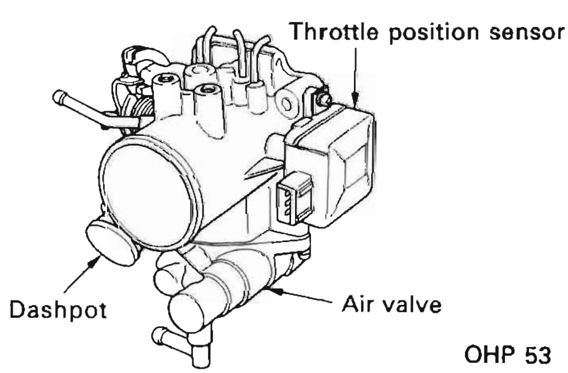


L – TYPE EFI (engine with ISC valve)

OHP 52

1. THROTTLE BODY

The throttle body consists of the throttle valve, which controls the intake air volume during normal engine operation, a bypass passage through which a small volume of air passes during idling, and a throttle position sensor which detects the opening angle of the throttle valve. Some throttle bodies are also equipped with a dashpot which causes the throttle valve to return gradually when it is closed or with a wax type air valve.
During idling, the throttle valve is fully closed. As a result, intake air flows through the bypass passage into the air intake chamber.
The engine speed during idling can be adjusted by the idle speed adjusting screw, which increases or decreases the volume of air passing through the bypass passage. (See the illustration of the wax type air valve at right.)



OHP 53

NOTE

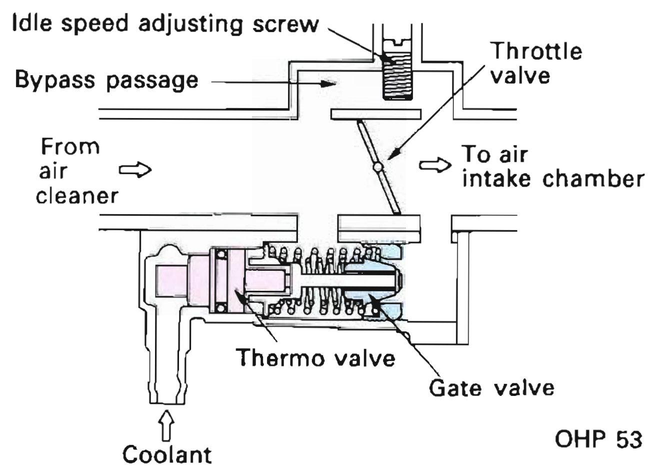
1. **The idle speed adjusting screw adjusts the idle speed, just as the throttle adjusting screw does on a carburetor.**
2. **In engines equipped with a stepper motor type or rotary solenoid type ISC valve, the volume of air flowing through the bypass passage is controlled by the ISC valve. Therefore, in some engines, the idle speed adjusting screw is set to the fully-closed position at the factory, while in others, an idle adjusting screw is not provided.**

2. AIR VALVE

The air valve controls the engine idling speed when the engine is cold.
Some engines equipped with an ISC valve do not use this air valve. (For further details on the ISC valve, see page 99.)

WAX TYPE

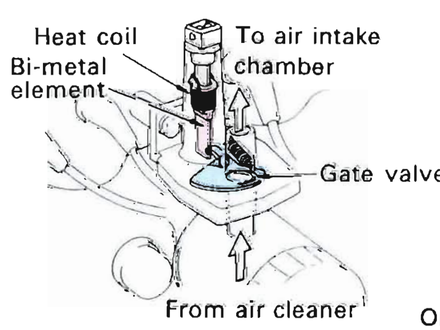
The wax type air valve consists of a thermo valve and a gate valve.
The thermo valve is filled with thermo wax. The volume of this wax changes according to the coolant temperature. The wax type air valve utilizes these characteristics of the thermo wax to open and close the gate valve in order to control the engine idling speed.



OHP 53

BI-METAL TYPE

The bi-metal type air valve consists of a bi-metal element, a heat coil, and a gate valve.
Current flows simultaneously to the heat coil and the fuel pump. This heats the element, causing it to change shape. This in turn causes the gate to close gradually.



OHP 53

FUNCTIONS OF ENGINE ECU

The Engine ECU calculates the basic fuel injection duration in accordance with two signals: 1) the intake manifold pressure signal from the manifold pressure sensor (in D-type EFI), or the intake air volume signal from the air flow meter (in L-type EFI); and 2) the engine speed signal. It bases its calculations on a program stored in its memory.

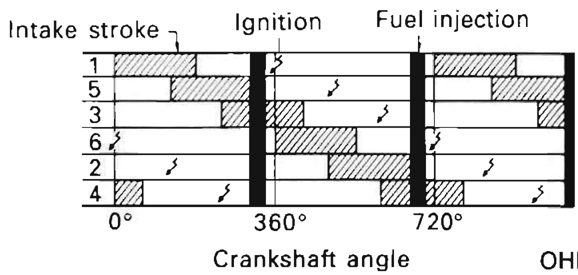
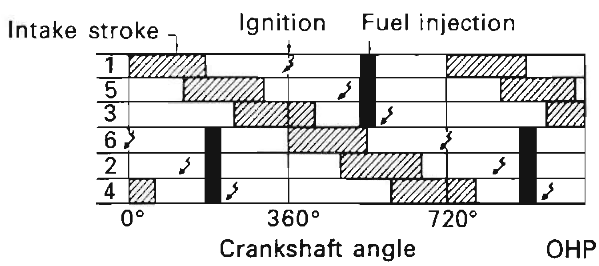
The Engine ECU also determines the optimum fuel injection duration for each engine condition based on signals from various other sensors.

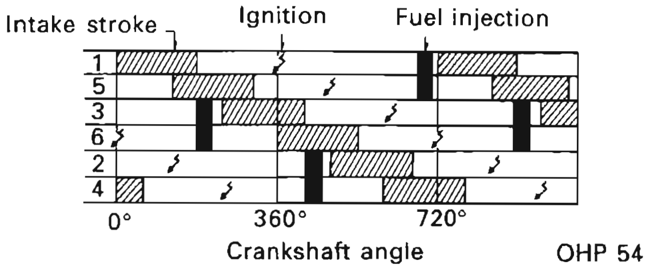
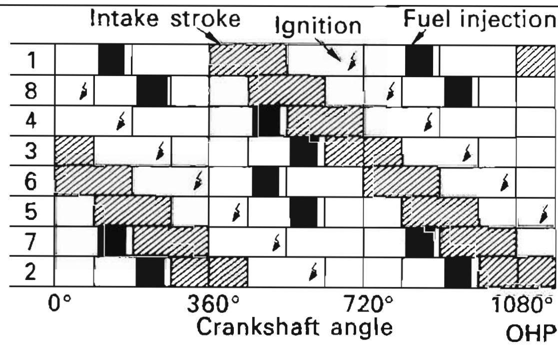
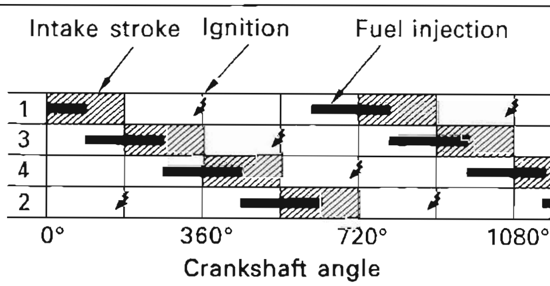
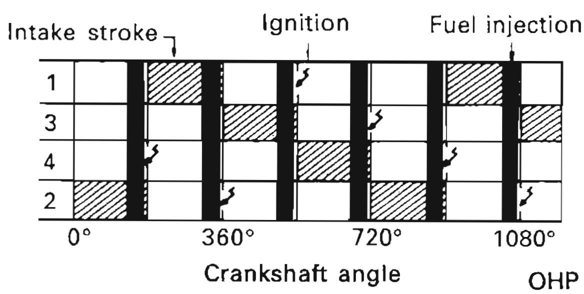
Control by the Engine ECU of the fuel pump, fuel pressure-up function, and cold start injector are covered in the section on the fuel system (See page 53), and control of the oxygen sensor heater is covered in the section on the other control systems (See page 113).

1. FUEL INJECTION METHODS AND INJECTION TIMING

Fuel injection methods include the method in which fuel is injected by the injectors into all cylinders simultaneously, the method in which the cylinders are arranged into several groups and fuel is injected into groups of cylinders in sequence, and the method in which fuel is injected into each cylinder separately. Fuel injection timing can also differ depending on the engine model, with some engines being started at all times with a predetermined timing and other engines being started with an injection timing calculated by the ECU in accordance with the intake air volume, engine speed, etc.

The basic fuel injection methods and injection timing are as follows:

INJECTION METHODS	INJECTION TIMING	ENGINES*[1]
SIMULTANEOUS	 OHP 54 Note: This graph shows the injection timing for the 6M-GE engine.	4A-GE (D-type EFI, 1989 and before) 4A-FE (engines w/o lean mixture sensor) 1S-E, 2S-E, 3S-FE, 5S-FE 5M-GE, 6M-GE 4Y-E 22R-E, 22R-TE 3VZ-E, 3F-E*[2] 2E-E, 3E-E 2RZ-E, 2TZ-FE
2 GROUPS	 OHP 54 Note: This graph shows the injection timing for the 1G-GE engine.	1G-GE 4A-GE (L-type EFI) 4A-GE (D-type EFI, 1989 and after) 4A-GZE

INJECTION METHODS	INJECTION TIMING	ENGINES*[1]
3 GROUPS	 OHP 54 Note: This graph shows the injection timing for the 7M-GE engine.	7M-GE 7M-GTE 2VZ-FE
4 GROUPS	 OHP 54	1UZ-FE
INDEPENDENT (SEQUENTIAL)	 OHP 54	3S-GE 3S-GTE 4A-FE (engines w/lean mixture sensor)
FOR 1S-i	 OHP 54	1S-i

*[1] Applicable engines were manufactured in September 1991.
Refer to the respective engine Repair Manuals or Electrical Wiring Diagrams for later changes and additions.

*[2] The fuel injection volume in the 3F-E engine is controlled separately for the front three cylinders and the rear three cylinders. However, since fuel is injected into the front and rear cylinders once each time the crankshaft turns, injection is simultaneous.

NOTE

There are some engines in which basic fuel injection methods and the injection method employed during starting are different.

2. FUEL INJECTION DURATION CONTROL

The actual fuel injection duration is determined by two things: 1) the basic injection duration, which is, in turn, determined by the intake air volume and the engine speed; and 2) various corrections based on signals from the various sensors. (During engine starting [cranking], however, fuel injection duration is determined differently, because the amount of intake air is not stable during cranking. See page 70 for more details.) Corrections differ depending on the engine model, because each respective engine has its own characteristics to take into consideration.
The following table shows the main controls that make up fuel injection control:

- Fuel injection duration control
  - Starting injection control
    - Basic injection duration control
    - Intake air temp. correction
    - Voltage correction
  - After-start injection control
    - Basic injection duration control
    - Injection corrections
      - Intake air temp. correction
      - After-start enrichment
      - Warm-up enrichment
      - Air-fuel ratio correction during transition
      - Power enrichment
      - Air-fuel ratio feedback correction
      - CO emission control correction
      - Idling stability correction
      - High-altitude compensation correction
      - Fuel cut-off
    - Voltage correction

REFERENCE

Fuel injection duration control consists of synchronous injection, in which injection is performed at a predetermined crankshaft angle as described above as well as asynchronous injection in which injection is performed irrespective of the crankshaft angle.
Asynchronous injection consists of starting injection control in which injection is performed only once during cranking and acceleration injection in which injection is performed only once during acceleration.

- Fuel injection duration control
  - Synchronous injection
    - Starting injection control
    - After-start injection control
  - Asynchronous injection
    - Starting injection control
    - Acceleration injection control

The relationship between fuel injection duration control and the major signals from each sensor is shown in the following table:

REFERENCE
The signals used for each type of control may differ depending on the engine model.

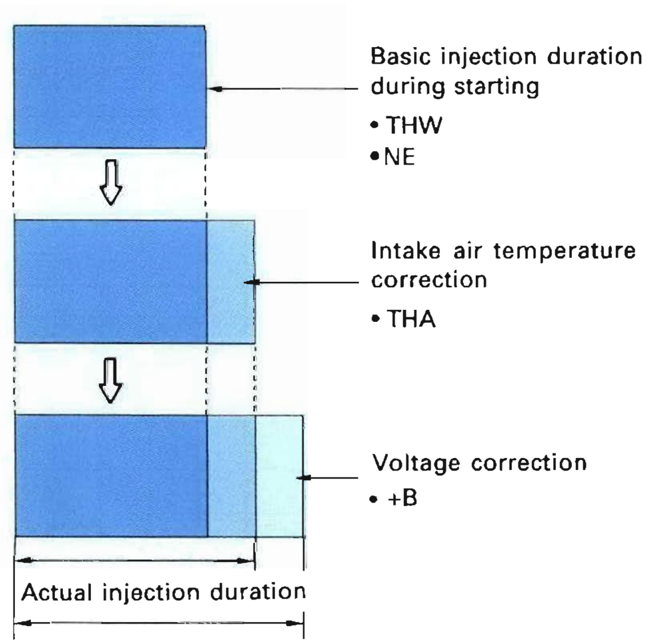
FUEL INJECTION DURATION CONTROL \ SIGNALS				BATTERY VOLTAGE	INTAKE MANIFOLD PRESSURE (D-TYPE EFI)	INTAKE AIR VOLUME (L-TYPE EFI)	THROTTLE POSITION		CRANKSHAFT ANGLE	ENGINE SPEED	COOLANT TEMPERATURE	INTAKE AIR TEMPERATURE	OXYGEN SENSOR	LEAN MIXTURE SENSOR	VEHICLE SPEED	STA (STARTER) SIGNAL	VARIABLE RESISTOR*	HIGH-ALTITUDE COMPENSATION	STOP LAMP SWITCH
				+B	PIM	VS, KS or VG	IDL	PSW or VTA	G	NE	THW	THA	OX	LS	SPD	STA	VAF	HAC	STP
Starting injection control				○					○	○	○	○							
After-start injection control	Basic injection duration control	For D-type EFI			○					○									
		For L-type EFI				○				○									
	Injection corrections	Intake air temp. correction										○							
		After-start enrichment								○	○								
		Warm-up enrichment									○								
		Power enrichment			○	○		○		○									
		Air-fuel ratio correction during transition	Acceleration enrichment correction		○	○		○		○	○				○				
			Deceleration lean correction		○	○	○			○	○				○				
		Air-fuel ratio feedback correction	Oxygen sensor										○						
			Lean mixture sensor											○					
		CO emission control correction*								○							○		
		Idling stability correction					○			○									
		High-altitude compensation correction																○	
		Fuel cut-off	During deceleration				○			○	○								○
			At high engine speeds							○									
			At high vehicle speeds												○				
	Voltage correction			○															

* Only engines without oxygen sensor or lean mixture sensor.

START INJECTION CONTROL

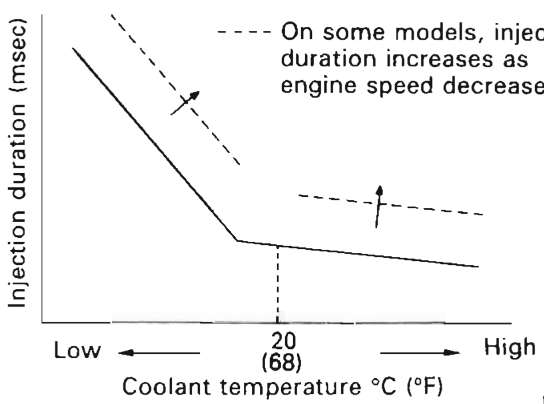
During engine starting, it is difficult for the manifold pressure sensor (for D-type EFI) or the air flow meter (for L-type EFI) to accurately sense the manifold pressure or the amount of air being taken in, due to large fluctuations in engine speed. For this reason, the Engine ECU selects from its memory a basic injection duration that is suitable for the coolant temperature and engine speed, regardless of intake manifold pressure or intake air volume. It then adds to this an intake air temperature correction (See page 72) and a voltage correction (See page 79) to obtain the actual injection duration.

When the weather is cold, the cold start injection system operates in order to improve startability (See page 63).



Injection signal during starting

OHP 55



OHP 55

RELEVANT SIGNALS

- Crankshaft angle (G)
- Engine speed (NE)
- Coolant temperature (THW)
- Intake air temperature (THA)
- Battery voltage (+B)

REFERENCE

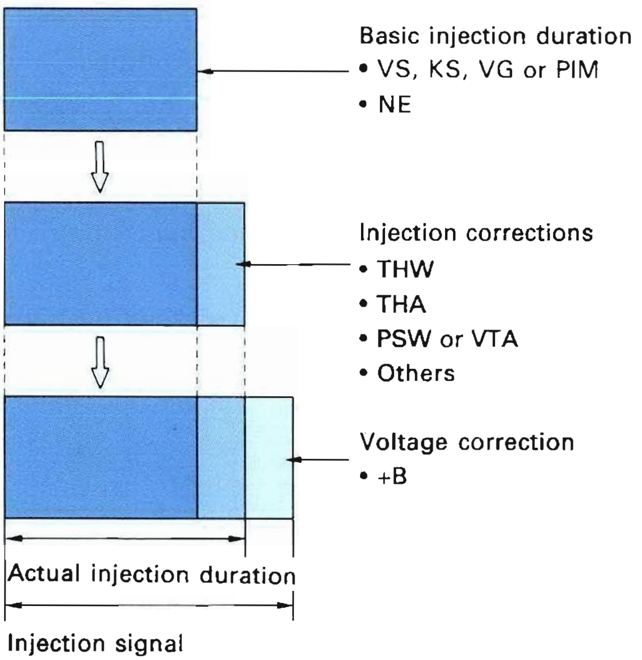
In some engine models, the starter (STA) signal is also used to inform the Engine ECU that the engine is being cranked.

AFTER-START INJECTION CONTROL

When the engine is running at a more-or-less steady speed above a predetermined rpm, the Engine ECU determines the injection signal duration as explained below:

Injection signal duration = basic injection duration × injection correction* + voltage correction

*Injection correction is the sum and product of various correction coefficients.



OHP 55

(1) Basic injection duration

FOR D-TYPE EFI

This is the most basic injection duration, and is determined by the manifold pressure (PIM signal) and the engine speed (NE signal). The internal memory of the Engine ECU contains data on various basic injection durations for various manifold pressures and engine speeds.

RELEVANT SIGNALS

- Intake manifold pressure (PIM)
- Engine speed (NE)

REFERENCE

Since the intake efficiency varies depending on the valve clearance, the intake air volume may vary even if the intake manifold pressure stays the same.
Therefore, in D-type EFI, when the valve clearance varies, the air-fuel ratio of the air-fuel mixture will change slightly.

- Since engines equipped with an oxygen sensor correct injection duration according to the air-fuel ratio feedback correction, the air-fuel ratio is always maintained at the optimal level.
- In engines which are not equipped with an oxygen sensor, the air-fuel ratio is adjusted by a variable resistor (See page 41).

FOR L-TYPE EFI

This is the most basic injection duration, and is determined by the volume of air being taken in (VS, KS or VG signal) and the engine speed (NE signal). The basic injection duration can be expressed as follows:

$$\text{Basic injection duration} = K \times \frac{\text{Intake air volume}}{\text{Engine speed}}$$

where K: correction coefficient

RELEVANT SIGNALS

- Intake air volume (VS, KS or VG)
- Engine speed (NE)

② Injection corrections

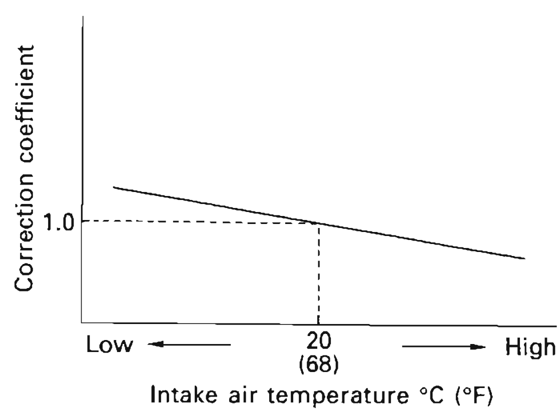
The Engine ECU is kept informed of engine running conditions at each moment by means of signals from various sensors. It then makes various corrections in the basic injection duration based on these signals.

INTAKE AIR TEMPERATURE CORRECTION

The density of the intake air will change depending on its temperature. For this reason, the Engine ECU must be kept accurately informed of the intake air temperature (by means of the intake air temperature sensor) so that it can adjust the injection duration to maintain the air-fuel ratio that is currently required by the engine. For this purpose, the ECU considers 20°C (68°F) to be the "standard temperature" and increases or decreases the amount of fuel injected depending upon whether the intake air temperature falls below or rises above this temperature.
This correction results in an increase or decrease in the injection volume by a maximum of about 10% (for the Karman vortex type air flow meter, this is about 20%).

NOTE

In case of hot-wire type air flow meters, since the air flow meter itself outputs a signal that is corrected by the intake air temperature, the intake air temperature correction is not necessary.



OHP 55

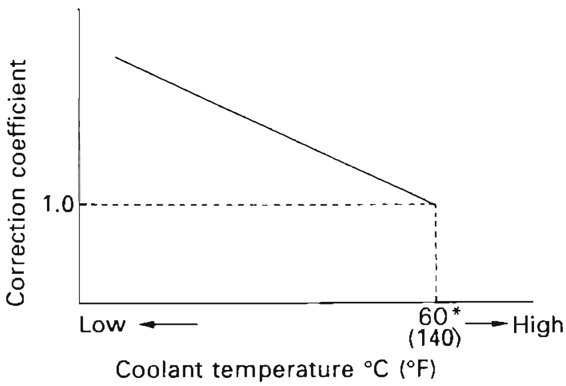
RELEVANT SIGNAL

- Intake air temperature (THA)

AFTER-START ENRICHMENT

Immediately after starting (engine speed above a predetermined rpm), the Engine ECU causes an extra amount of fuel to be supplied for a predetermined period to aid in stabilizing engine operation. The initial after-start enrichment correction is determined by the coolant temperature, and the amount gradually falls thereafter at a certain constant rate.

When the temperature is extremely low, this enrichment roughly doubles the injection volume.



* Depending on the engine models.

OHP 56

RELEVANT SIGNALS

- Engine speed (NE)
- Coolant temperature (THW)

REFERENCE

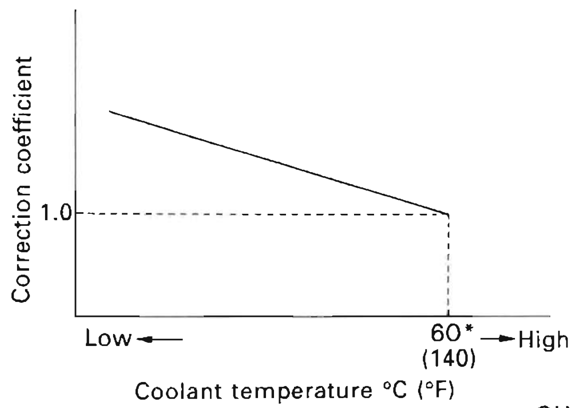
In some engine models, the starter (STA) signal is used as a condition for beginning this correction.

WARM-UP ENRICHMENT

Since fuel vaporization is poor when the engine is cold, the engine will run poorly if a richer fuel mixture is not supplied.

For this reason, when the coolant temperature is low, the water temperature sensor so informs the Engine ECU, which increases the amount of fuel injected to compensate until the coolant temperature reaches the predetermined temperature.

When the temperature is extremely low, this enrichment roughly doubles the injection volume.



OHP 56

* Depending on the engine models.

RELEVANT SIGNAL

- Coolant temperature (THW)

REFERENCE

In some engine models, the amount of this enrichment changes slightly when the IDL signal goes on or off, and it also changes in accordance with the engine speed.

POWER ENRICHMENT

When the engine is operating under a heavy load, the injection volume is increased in accordance with the load in order to ensure proper engine operation.
Methods for sensing whether the engine is operating under a heavy load differ depending on the engine model. In some engines, it is determined by the throttle valve opening angle, while in other engines, it is determined by the intake air volume. This enrichment increases the injection volume by 10 to 30%.

RELEVANT SIGNALS

- Throttle position (PSW or VTA)
- Intake manifold pressure (PIM) or intake air volume (VS, KS or VG)
- Engine speed (NE)

REFERENCE

1. In some engine models, the amount of increase also differs in accordance with the coolant temperature.
2. In some engine models, when the coolant temperature is high, the fuel injection amount is increased to lower the exhaust gas temperature and to prevent the engine from overheating.
3. In some engine models, the kick-down switch (KD) signal is used as a condition for begining this correction.

AIR-FUEL RATIO CORRECTION DURING TRANSITIONS

A "transition" is the moment when the engine rpm changes, either during acceleration or deceleration. During a transition, the injection volume must be increased or decreased to assure proper engine performance.

a. Acceleration Enrichment Correction
   When the Engine ECU detects engine acceleration based on signals from the various sensors, it increases the injection volume to improve acceleration performance.
   The initial correction value is determined by the coolant temperature and the rate of acceleration. The amount gradually decreases from that point.

b. Deceleration Lean Correction
   When the ECU detects engine deceleration, it decreases the injection volume as necessary to prevent over-rich injection during deceleration.

RELEVANT SIGNALS

- Intake manifold pressure (PIM) or intake air volume (VS, KS or VG)
- Engine speed (NE)
- Vehicle speed (SPD)
- Throttle position (IDL, PSW or VTA)
- Coolant temperature (THW)

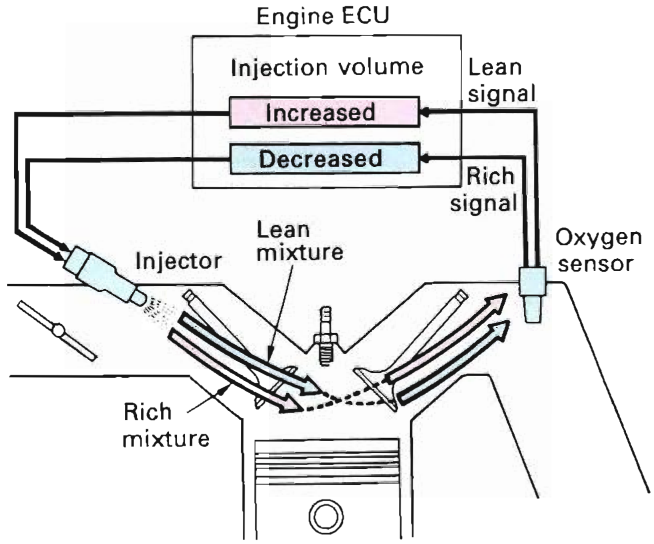
AIR-FUEL RATIO FEEDBACK CORRECTION

a. Oxygen Sensor

The Engine ECU corrects the injection duration based on the signals from the oxygen sensor to keep the air-fuel ratio within a narrow range near the theoretical air-fuel ratio. (This is called a "closed-loop" operation.)

In order to prevent overheating of the catalyst and assure good engine operation, air-fuel ratio feedback does not occur under the following conditions (open-loop operation):

- During engine starting
- During after-start enrichment
- During power enrichment
- When the coolant temperature is below a predetermined level
- When fuel cut-off occurs
- When the lean signal continues longer than a predetermined time

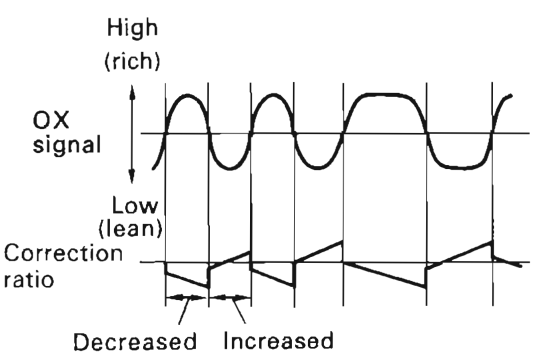


OHP 56

> RELEVANT SIGNAL
> - Oxygen sensor (OX)

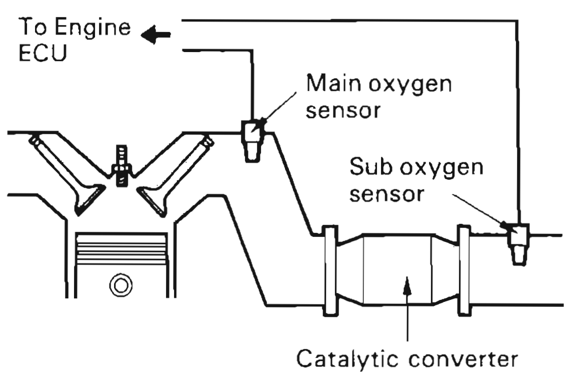
The ECU compares the voltage of the signals sent from the oxygen sensor with a predetermined voltage. If the voltage of a signal is higher than that voltage, it judges the air-fuel ratio to be richer than the theoretical air-fuel ratio and reduces, at a constant rate, the amount of fuel injected. If the voltage of a signal is lower, it judges that the air-fuel ratio is leaner than the theoretical air-fuel ratio, and increases the amount of fuel injected.

The correction coefficient used by the ECU varies over a range of 0.8 to 1.2, and is 1.0 during an open loop operation.



OHP 56

Two oxygen sensors are used on some models. Even if the signal of the main oxygen sensor changes over time, the air-fuel ratio can be maintained within a narrow range near the theoretical air-fuel ratio by using a sub oxygen sensor. In addition, catalyst deterioration can be also detected by comparing the signals of the two oxygen sensors.



NOTE

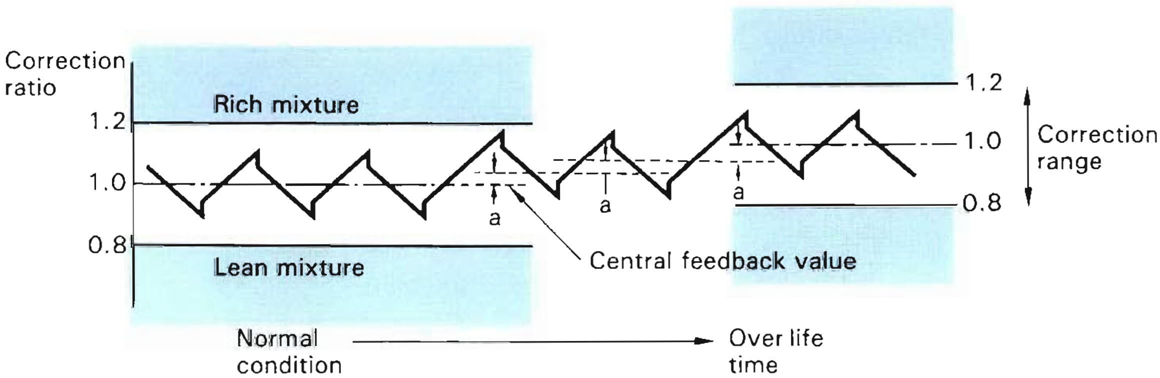
Air-fuel ratio learned control;

When engine condition changes over time, the air-fuel ratio that is created from basic injection duration calculated by the Engine ECU deviates from the theoretical air-fuel ratio. When this happens, time is required for the air-fuel ratio to return to the theoretical air-fuel ratio by air-fuel ratio feedback correction. The deviation may also exceeds the correction range of air-fuel ratio feedback correction.

Consequently, the Engine ECU remembers the central value of the correction ratio and corrects the amount of deviation from the central value (a) for basic injection duration. This function is referred to as air-fuel ratio learned control, and the value remembered by the Engine ECU is referred to as the learned value.

As a result of this learned control, air-fuel feedback correction is constantly able to correct the central value of the correction ratio with a value of 1.0.

This enables the air-fuel ratio to return rapidly within a narrow range near the theoretical air-fuel ratio. Furthermore, learned control is performed when feedback correction is being performed.



b. Lean Mixture Sensor

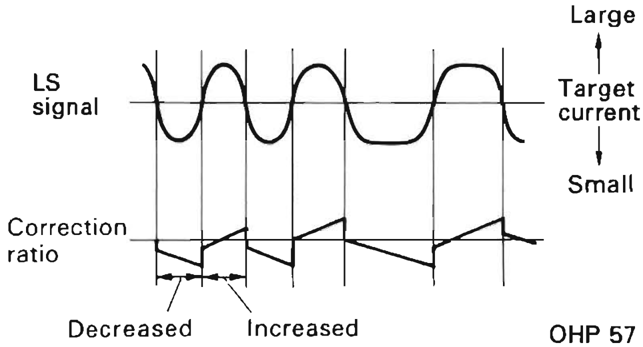
The ECU corrects the injection duration based on signals from the lean mixture sensor to keep the air-fuel ratio within the "lean" range. (This is called a "closed-loop" operation.)

In order to prevent overheating of the catalyst and assure good engine operation, air-fuel ratio feedback does not occur under the following conditions (open-loop operation):

- During engine starting
- During after-start enrichment
- During power enrichment
- When the coolant temperature is below a predetermined level
- When fuel cut-off occurs

The ECU determines the target air-fuel ratio based on signals from the sensors. It then converts this ratio to an electric current and compares this current with the current from the lean mixture sensor. If the current from the lean mixture sensor is larger than the target current, it judges the air-fuel ratio to be leaner than the target air-fuel ratio and increases the amount of fuel injected. If the current from the lean mixture sensor is smaller, it judges that the air-fuel ratio is richer than the target air-fuel ratio, and reduces the amount of fuel injected.

The correction coefficient used by the ECU varies over a range of 0.8 to 1.2, and is 1.0 during an open-loop operation.



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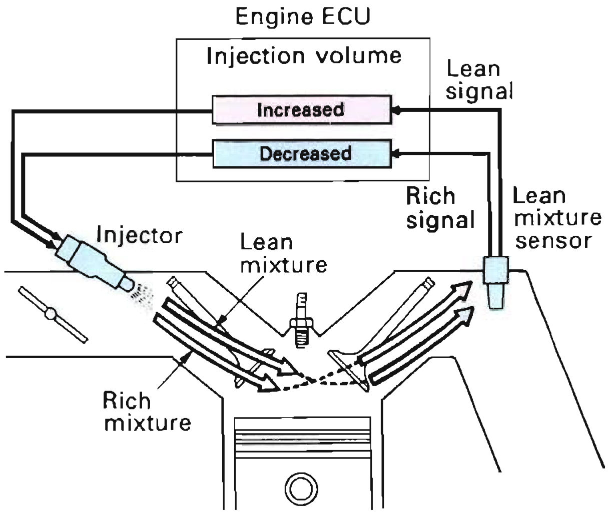


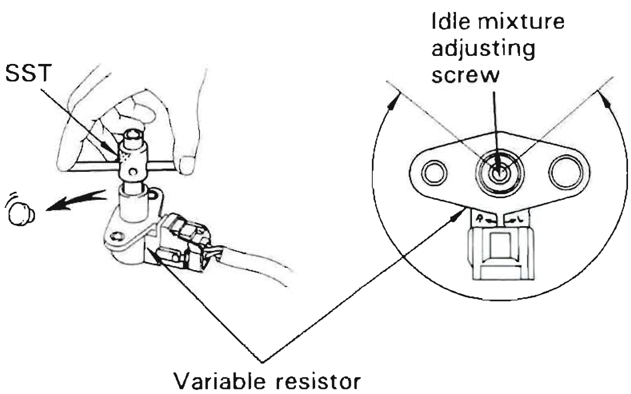
OHP 57

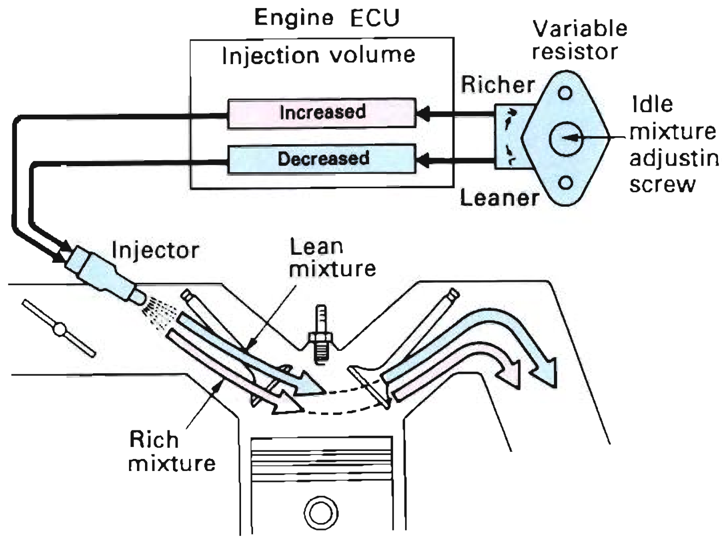
RELEVANT SIGNAL

- Lean mixture sensor (LS)

CO EMISSION CONTROL CORRECTION
(D-type EFI*1 and L-type EFI*2)

The injection volume can be adjusted by manually adjusting the variable resistor (See page 41). This can be used to adjust the volume of CO emissions.





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*1 D-type EFI without oxygen sensor
*2 L-type EFI without oxygen sensor but with optical Karman vortex type air flow meter or hot-wire type air flow meter

The ECU also reduces CO emissions by controlling the injection volume in accordance with the engine speed.

RELEVANT SIGNALS

- Variable resistor (VAF)
- Engine speed (NE)

NOTICE

It is usually *not* necessary to adjust the idle mixture in most models, provided that the vehicle is in good condition. However, if it does become necessary to do so, always use a CO meter. If a CO meter is not available, it is best *not* to attempt to adjust the idle mixture if at all possible.

REFERENCE

When the voltage of the terminal VAF is 0.1 V or less or 4.9 V or more, the Engine ECU discontinues CO emission control correction.

IDLING STABILITY CORRECTION
(D-type EFI only)

The fuel injection volume is increased or decreased in accordance with changes in the engine speed in order to achieve idling stability. In order to do this, the injection volume is increased when the engine speed drops, and is decreased when it rises.

RELEVANT SIGNALS
- Engine speed (NE)
- Throttle position (IDL)

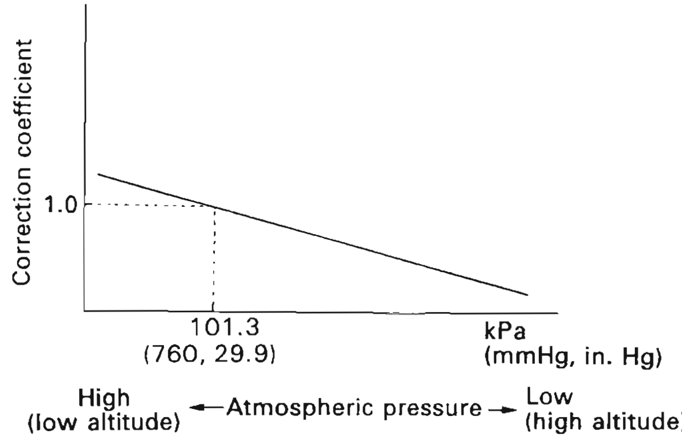
REFERENCE
In some engine models, engine idling is detected by the change of the intake manifold pressure (PIM) signal.

HIGH-ALTITUDE COMPENSATION CORRECTION
(L-type EFI with vane type air flow meter or optical Karman voltex type air flow meter only)

The density of oxygen in the atomosphere is lower at high altitudes. As a result, the amount of intake air flow measured by the air flow meter becomes greater than the amount of oxygen actually being taken into the engine. This means that if the fuel were injected under the same conditions as at sea level, the air-fuel mixture would become richer.

For this reason, the ECU corrects the fuel injection volume based on signals from the high-altitude compensation sensor and the air flow meter.

This correction decreases the injection volume by about 10% at 1000 meters above sea level (for example).



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RELEVANT SIGNAL
- High-altitude compensation (HAC)

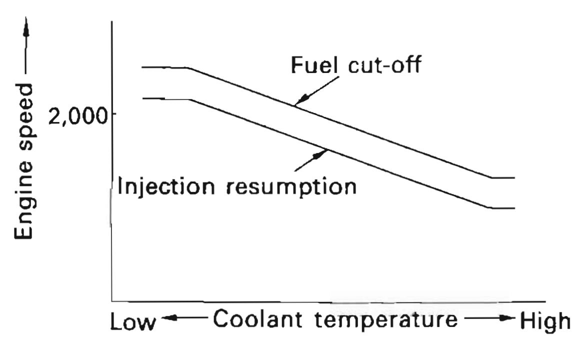
FUEL CUT-OFF

a. Fuel Cut-Off during Deceleration

During deceleration from a high engine speed with the throttle valve completely closed (idle contact on), the ECU halts injection of fuel in order to improve fuel economy and reduce undesirable emissions.

When the engine speed falls below a predetermined level or the throttle valve is opened (idle contact off), fuel injection is resumed.

The fuel cut-off engine speed and the fuel injection resumption engine speed are high when the coolant temperature is low. There are also some engine models in which these engine speeds drop during braking (i.e., when the stop lamp switch is on).



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RELEVANT SIGNALS
- Throttle position (IDL)
- Engine speed (NE)
- Coolant temperature (THW)
- Stop lamp switch (STP)

REFERENCE
1. In some manual transmission models, the clutch switch (N/C) signal is also used as a condition for fuel cut-off.
2. There are some models in which the fuel will be cut off when the injection volume during deceleration falls below the predetermined level even if the throttle valve is not completely closed (idle contact off).

b. Fuel Cut-Off at High Engine Speeds

To prevent engine over-run, fuel injection is halted if the engine speed rises above a predetermined level. Fuel injection is resumed when the engine speed falls below this level.

RELEVANT SIGNAL
- Engine speed (NE)

c. Fuel Cut-Off at High Vehicle Speeds

In some vehicles, fuel injection is halted if the vehicle's speed exceeds a predetermined level. Fuel injection resumes after the speed drops below a predetermined level.

RELEVANT SIGNAL
- Vehicle speed (SPD)

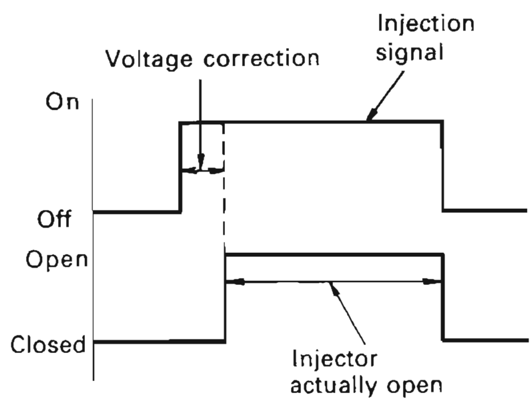
NOTE

The Engine ECU also performs various other corrections in addition to these (page 72 to 79).

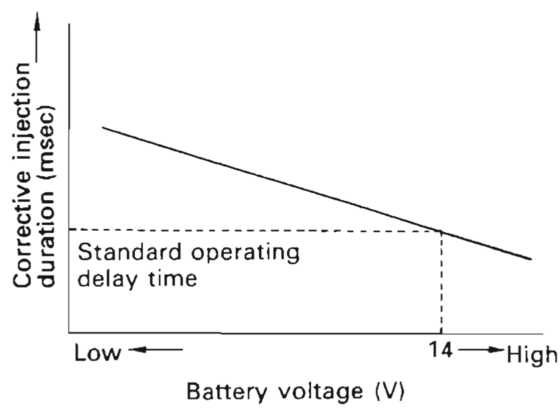
③ Voltage correction

There is a slight delay between the time that the Engine ECU sends an injection signal to the injectors and the time that the injectors actually open. This delay becomes longer the more the voltage of the battery drops. This means that the length of time that the injector valves remain open would become shorter than that calculated by the ECU, causing the actual air-fuel ratio to become higher (i.e., leaner) than that required by the engine, if this were not prevented by voltage correction.

In voltage correction, the ECU compensates for this delay by lengthening the duration of the injection signal by a period corresponding to the length of the delay. This corrects the actual injection period so that it corresponds with that calculated by the ECU. (The amount of this correction value depends on the engine model.)



OHP 58



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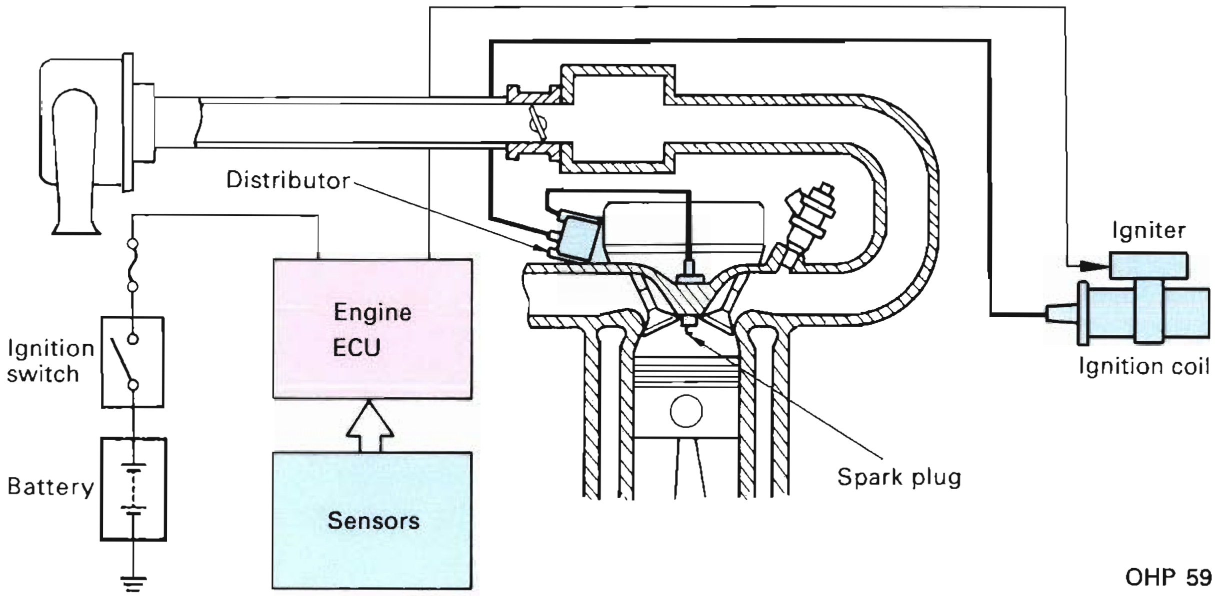
RELEVANT SIGNAL
- Battery voltage (+B)

MEMO

ESA (ELECTRONIC SPARK ADVANCE)

GENERAL

The ESA (electronic spark advance) system is a system in which an ECU (rather than a mechanical advancer) controls the ignition timing of the ignition system.



BASIC CONSTRUCTION OF ESA

1. IGNITION TIMING AND ENGINE RUNNING CONDITIONS

In order to maximize engine output efficiency, the air-fuel mixture must be ignited when the *maximum* combustion pressure occurs; that is, at about 10° after TDC (top dead center).

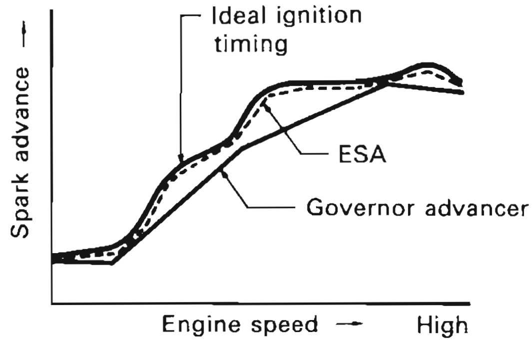
However, the time from ignition of the air-fuel mixture to the development of maximum combustion pressure varies depending on the engine speed and the manifold pressure; ignition must occur *earlier* when the engine speed is *higher* and *later* when it is *lower*. In conventional EFI, the timing is advanced and retarded by a governor advancer in the distributor.

Furthermore, ignition must also be advanced when the manifold pressure is low (i.e., when there is a strong vacuum). In conventional EFI, this is achieved by the vacuum advancer in the distributor.

However, optimal ignition timing is also affected by a number of other factors besides engine speed and intake air volume, such as the shape of the combustion chamber, the temperature inside the combustion chamber, etc. For this reason, governor and vacuum advancers cannot provide ideal ignition timing for the engine. In the ESA system, the engine is provided with nearly ideal ignition timing characteristics.

The ESA works as follows: the ECU determines ignition timing from its internal memory, which contains the optimal ignition timing data for each engine running condition, then sends the appropriate ignition timing signal to the igniter.

Since the ESA always ensures optimal ignition timing, both fuel efficiency and engine power output are maintained at optimal levels.



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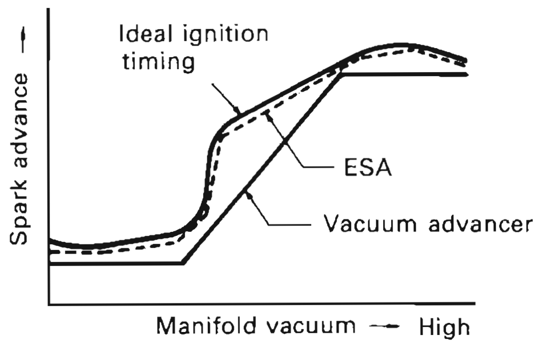
ADVANCING BY ENGINE SPEED



OHP 59

VACUUM ADVANCING

2. IGNITION TIMING AND GASOLINE QUALITY

In some engine models, two ignition timing advance patterns, according to the fuel octane rating (premium or regular), are stored in the ECU. The ignition timing can be changed to match the gasoline being used (premium or regular) by operating the fuel control switch or connector (See page 40).

In some engine models, this is done automatically by the Engine ECU's fuel octane judgement function (See page 116).

The following table shows the specifications for the 4A-FE engine. Items marked with circles in the "APPENDIX" column are included in the specifications for each engine in the APPENDIX section (page 188) in the back of this manual.

In addition, for those items with circle in the "STEP 2 (IGNITION)" column in the following table, refer to the Step 2, vol. 3 (Ignition System) manual for a detailed explanation of the relevant items.

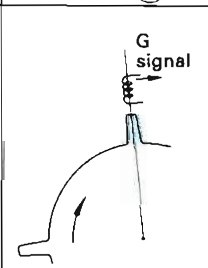
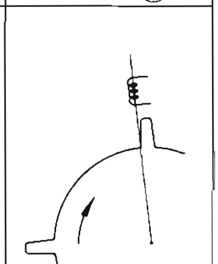
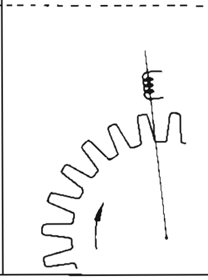
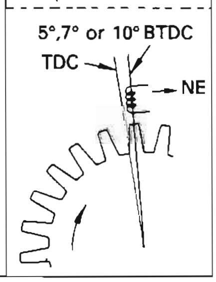
ESA (ELECTRONIC SPARK ADVANCE)	PAGE (THIS MANUAL)	ITEM*	REMARK	APPENDIX	STEP 2 (IGNITION)
Crankshaft angle (initial ignition timing angle) judgement	83	○			
IGT (ignition timing) signal	83	○			
IGF (ignition confirmation) signal	84	○			
Ignition circuitry — Conventional ignition circuitry for TCCS	85	○		○	○
Ignition circuitry — DLI (distributorless ignition) system	86				
Ignition circuitry — DIS (direct ignition system)	88			○	
Functions of Engine ECU — Ignition timing control — Starting ignition control	91	○			
Functions of Engine ECU — Ignition timing control — After-start ignition control — Basic ignition advance angle	92	○			
Functions of Engine ECU — Ignition timing control — After-start ignition control — Corrective ignition advance control — Warm-up correction	93	○			
Functions of Engine ECU — Ignition timing control — After-start ignition control — Corrective ignition advance control — Over-temperature correction	93				
Functions of Engine ECU — Ignition timing control — After-start ignition control — Corrective ignition advance control — Stable idling correction	94	○			
Functions of Engine ECU — Ignition timing control — After-start ignition control — Corrective ignition advance control — EGR correction	94	○	With EGR		
Functions of Engine ECU — Ignition timing control — After-start ignition control — Corrective ignition advance control — Air-fuel ratio feedback correction	95	○	With oxygen sensor		
Functions of Engine ECU — Ignition timing control — After-start ignition control — Corrective ignition advance control — Knocking correction	95	○	With knock sensor		
Functions of Engine ECU — Ignition timing control — After-start ignition control — Corrective ignition advance control — Torque control correction	96				
Functions of Engine ECU — Ignition timing control — After-start ignition control — Corrective ignition advance control — Other corrections — Transition correction	97	○			
Functions of Engine ECU — Ignition timing control — After-start ignition control — Corrective ignition advance control — Other corrections — Cruise control correction	97				
Functions of Engine ECU — Ignition timing control — After-start ignition control — Corrective ignition advance control — Other corrections — Traction control correction	97				
Functions of Engine ECU — Ignition timing control — After-start ignition control — Corrective ignition advance control — Other corrections — ACIS (acoustic control induction system) correction	97				
Functions of Engine ECU — Ignition timing control — After-start ignition control — Corrective ignition advance control — Other corrections — Intercooler failure correction	97				
Functions of Engine ECU — Ignition timing control — After-start ignition control — Maximum and minimum advance angle control	97	○			
Functions of Engine ECU — Ignition timing adjustment	98	○			

*Specifications for Corolla 4A-FE engine (Apr., 1992)

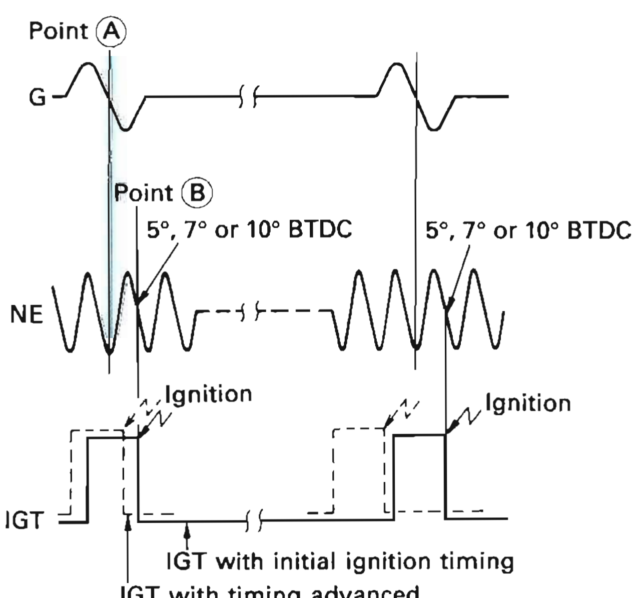
CRANKSHAFT ANGLE (INITIAL IGNITION TIMING ANGLE) JUDGEMENT

The ECU judges that the crankshaft has reached 5°, 7° or 10° BTDC (depending on the engine model) when it receives the first NE signal (point Ⓑ in the illustration below) following a G signal (point Ⓐ).

This angle is known as the "initial ignition timing angle".

TIMING ROTOR	POINT Ⓐ	POINT Ⓑ
G SIGNAL TIMING ROTOR AND G PICKUP COIL		
NE SIGNAL TIMING ROTOR AND NE PICKUP COIL		

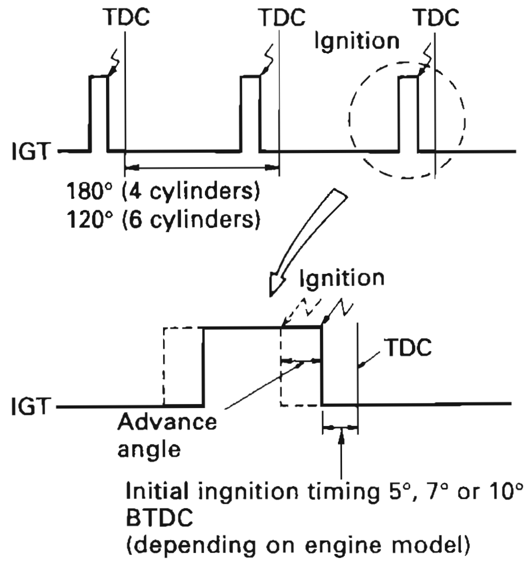
OHP 60



OHP 60

IGT (IGNITION TIMING) SIGNAL

The Engine ECU sends an IGT signal to the igniter based on signals from each sensor so as to achieve the optimal ignition timing. This IGT signal goes on just before the ignition timing calculated by the microprocessor, then goes off. The spark plug fires at the point when this signal goes off.

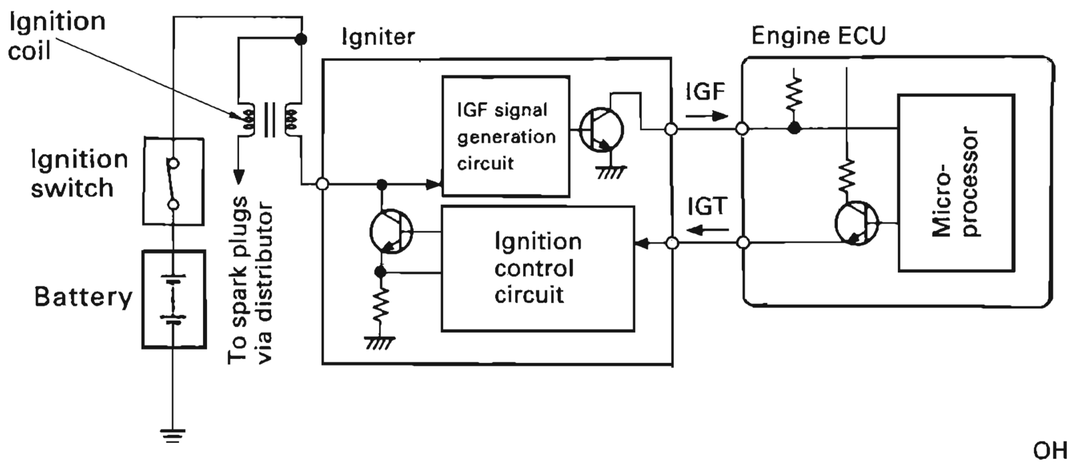


OHP 61

IGF (IGNITION CONFIRMATION) SIGNAL

The counter-electromotive force that is generated when the primary current is interrupted causes this circuit to send an IGF signal to the ECU, which detects by this signal whether ignition actually occurred or not.

This signal is used for diagnosis (See page 131) and the fail-safe function (See page 145).



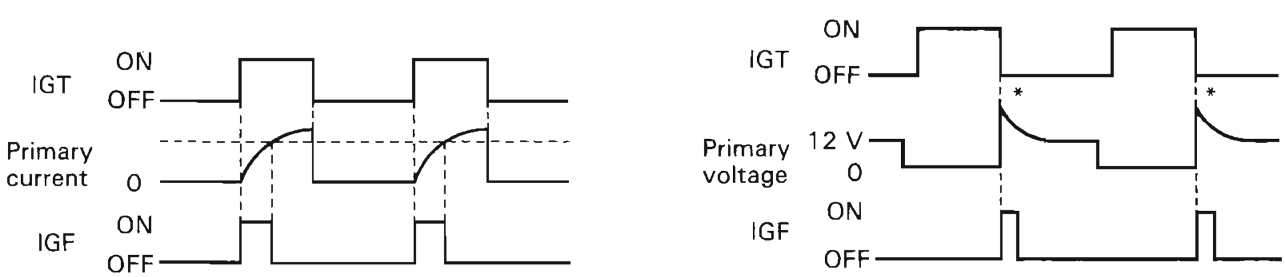
OHP 61

NOTE

In some recent models, the IGF signal is generated according to the primary current value. In these models, IGF is switched on when IGT is on, and IGF is switched off when the primary current exceeds the predetermined value.

FOR RECENT MODELS

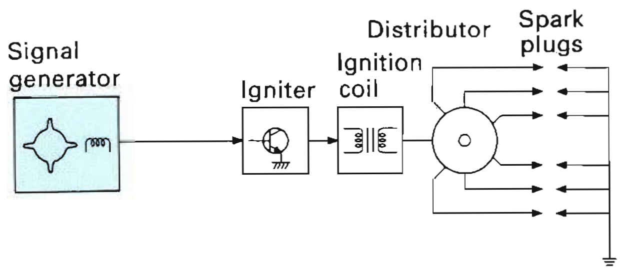
FOR PREVIOUS MODELS



* The counter-electromotive force

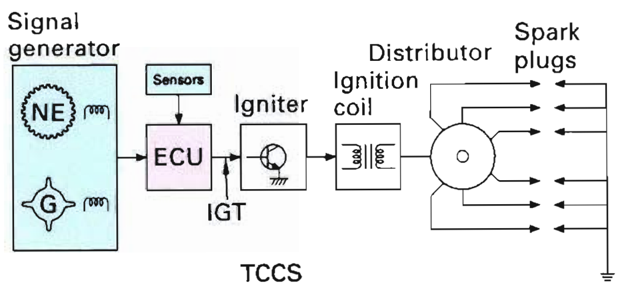
IGNITION CIRCUITRY

The operation of the ignition system in TCCS is basically the same as the operation of the ignition system in conventional EFI, except that the igniter in the latter is turned on and off directly by the signal generator.



CONVENTIONAL EFI

In the TCCS, the signals from the signal generator first pass through the ECU before going to the igniter.



TCCS

The types of ignition system in TCCS can be differentiated by the method used to distribute current to the spark plugs: either the conventional type, in which a distributor is used, or DLI (distributorless ignition) and DIS (direct ignition system), in which no distributor is used.
In this section, we will explain the operation of both the conventional ignition system used in TCCS, and the DLI and DIS. For an explanation of the operation of the ignition system for the conventional EFI, refer to Step 2, vol.3 (Ignition System).

REFERENCE

An igniter is included in the Engine ECU of the 4A-FE engine made by Bosch.

1. CONVENTIONAL IGNITION CIRCUITRY FOR TCCS

The microprocessor in the ECU determines the ignition timing based on the G (G1 and G2) and NE signals, as well as on signals from each sensor. After determining the ignition timing, the ECU sends an IGT signal to the igniter.
When the IGT signal goes off, transistor Tr_2 in the igniter goes off. As a result, the primary current to the ignition coil is interrupted, causing a high voltage (of approx. 20 to 35 kV) to be generated by the secondary coil in the ignition coil. This in turn causes sparks to be generated by the spark plugs.
The igniter incorporates the following circuitry in order to deliver a stable secondary voltage and assure system reliability:

DWELL ANGLE CONTROL CIRCUIT

This circuit controls the length of time during which Tr_2 is on, in order to assure the proper secondary voltage.

> **NOTE**
>
> **A dwell angle control circuit is provided in the Engine ECU in recent engines. The igniter starts the flow of primary current when the IGT signal is on and stops that current when it is off. The Engine ECU lengthens the dwell angle by advancing the timing by which the IGT signal is switched on when engine speed increases.**

IGF SIGNAL GENERATION CIRCUIT

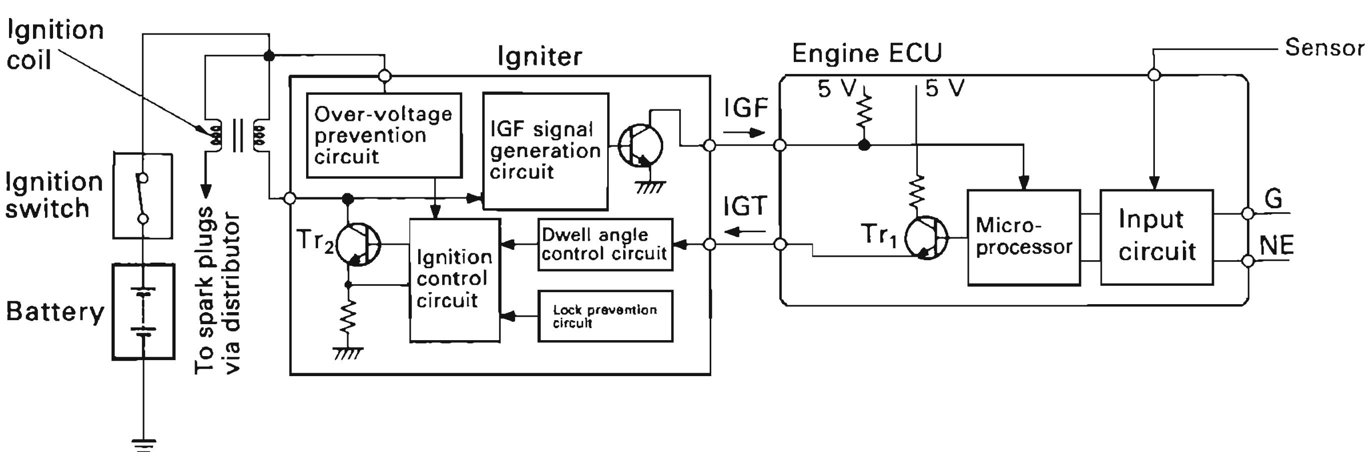
This circuit generates the IGF signal and sends it to the ECU.

LOCK-UP PREVENTION CIRCUIT

This circuit forces Tr_2 to go off if it locks up (that is, if current flows continuously for a period longer than a predetermined period), in order to protect the ignition coil and Tr_2.

OVER-VOLTAGE PREVENTION CIRCUIT

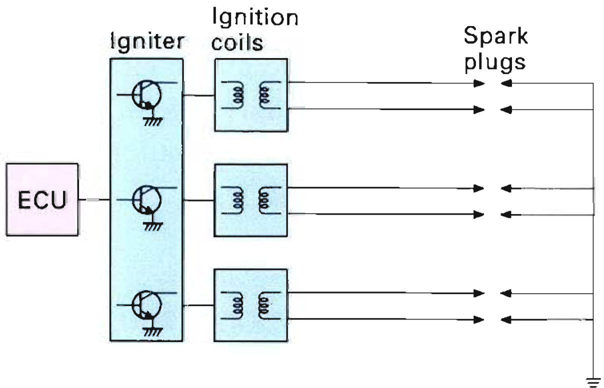
This circuit forces Tr_2 to go off if the power supply voltage becomes too high, in order to protect Tr_2 and the ignition coil.



OHP 62

2. DLI (DISTRIBUTORLESS IGNITION) SYSTEM

DLI is an electronic spark distribution system which distributes high voltages directly from the ignition coils to the spark plugs without the need of a conventional distributor. It differs from the conventional type of ignition system as shown below:



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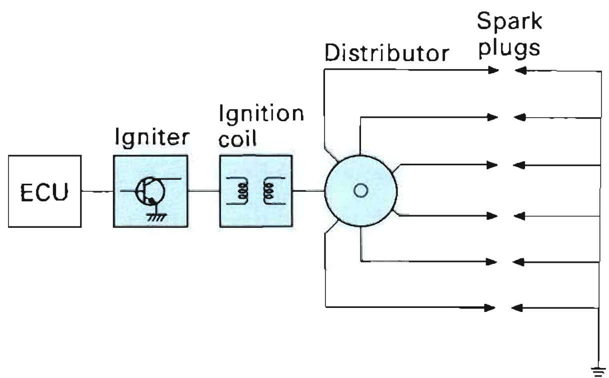
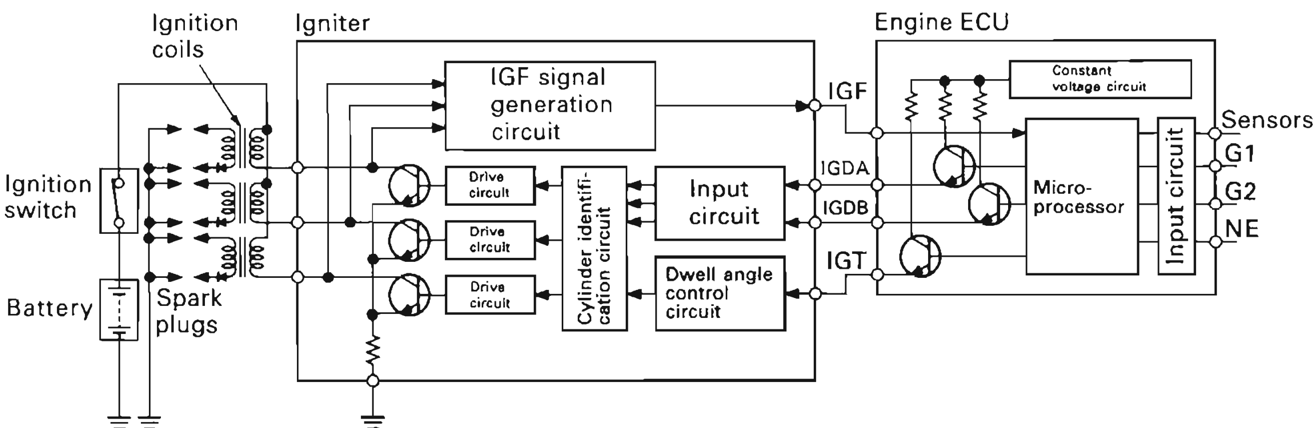
DLI SYSTEM



OHP 63

CONVENTIONAL IGNITION CIRCUITRY FOR TCCS



OHP 63

In the DLI, the igniter is connected to the Engine ECU as shown in the figure above. There are three ignition coils: one for cylinders No. 1 and No. 6, one for cylinders No. 2 and No. 5, and one for cylinders No. 3 and No. 4. The ECU sends cylinder identification signals (IGDA and IGDB) and the IGT signal to the igniter in accordance with the G1, G2 and NE signals from the cam position sensor which detects the crankshaft angle, engine speed and various sensors.

The igniter distributes the primary current to the three ignition coils based on these signals. For this reason, the spark plugs in cylinders No. 1 and No. 6 fire simultaneously, as do those in cylinders No. 2 and No. 5 and cylinders No. 3 and No. 4. In other words, each spark plug is ignited two times in one cycle.

Since the IGT signal from the ECU must be distributed to three coils, the ECU outputs two cylinder identification signals (IGDA and IGDB). The timing of each signal is shown in the chart below.

The microprocessor is informed of when cylinder No. 1 is at 10° BTDC by the next NE signal following the G2 signal, and outputs the IGDA and IGDB signals stored in memory in the combination that corresponds to the order in which the cylinders are fired, as shown in the table to the right above.

The cylinder identification circuit in the igniter distributes the IGT signal to the transistor drive circuit that is connected to the relevant ignition coil, based on the combination of these signals.

Switching of the IGDA and IGDB signals from 1 to 0 and from 0 to 1 is synchronized with the IGT signal. Other circuits are the same as those in the igniter for the conventional type.

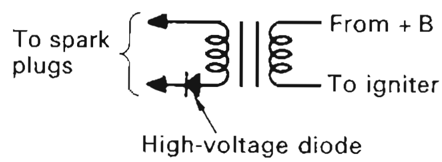
SIGNALS / CYLINDERS	IGDA	IGDB
No. 1 and No. 6	0	1
No. 5 and No. 2	0	0
No. 3 and No. 4	1	0

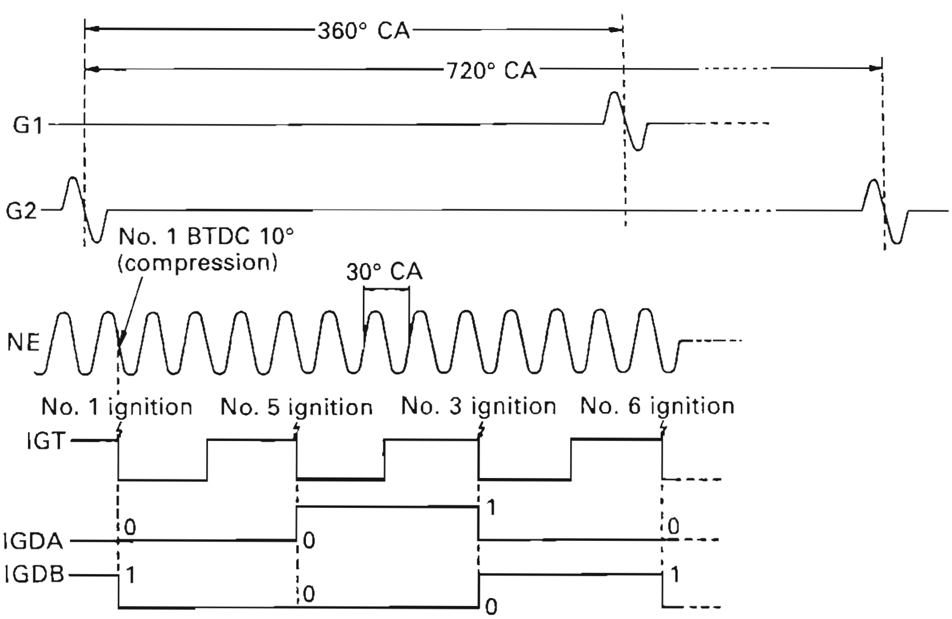
OHP 64

NOTE

High-voltage Diode

On some models, since the ignition coils have high-voltage diodes built into the secondary side, judgment of the continuity cannot be confirmed by using an ordinary ohmmeter.

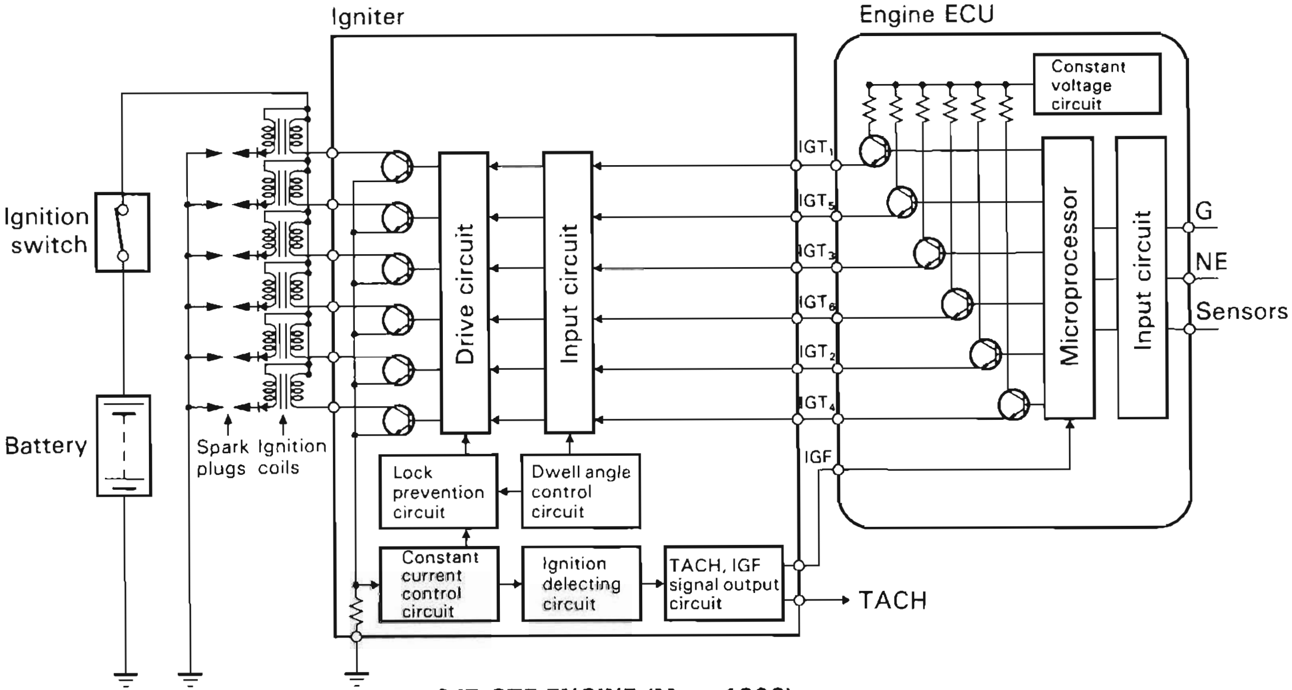




OHP 64

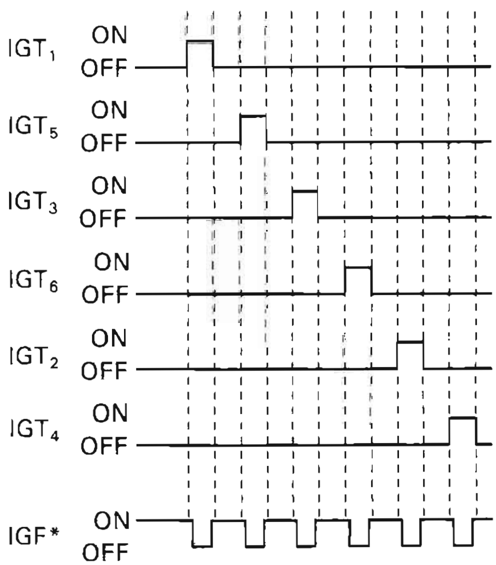
3. DIS (DIRECT IGNITION SYSTEM)

Similar to DLI, DIS is the system to distribute the high voltage directly to the spark plugs from ignition coils without using a distributor. There are various types of current DIS systems, including those in which an ignition coil is provided for each cylinder and those in which an ignition coil is provided for every two cylinders (See Step 2, Vol. 3, ''Ignition System''). The electrical circuitry shown here is for the type in which an ignition coil is provided for each cylinder.



2JZ-GTE ENGINE (May, 1993)

Control by the Engine ECU is basically the same as that of an ordinary ESA. The difference is that the Engine ECU has the same number of IGT signals as the number of ignition coils. IGT signals are then sent to the igniter according to the ignition sequence.



*The IGF signals in DIS is normally HI (ON), and turns to LO (OFF) during ignition.

FUNCTIONS OF ENGINE ECU

1. IGNITION TIMING CONTROL

Ignition timing control consists of two basic controls:

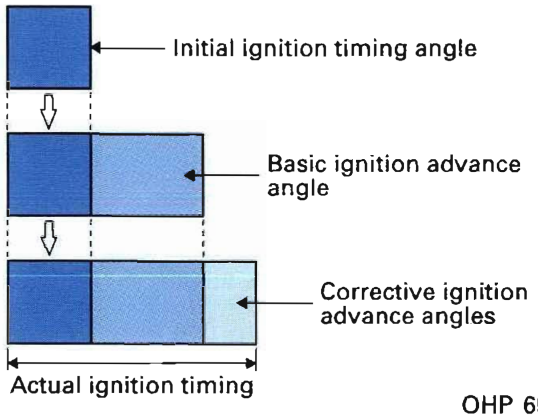
- Starting ignition control

When the engine is cranking, ignition occurs at a certain fixed crankshaft angle, regardless of engine operating conditions. This is called "initial ignition timing angle".

OHP 65

- After-start ignition control

Various corrections are added to the initial ignition timing angle and the basic ignition advance angle during normal operation.



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REFERENCE

Note that, in after-start ignition control, each type of correction differs depending on the engine model.

- Ignition timing control
  - Starting ignition control — Initial ignition timing angle
  - After-start ignition control
    - Initial ignition timing angle
    - Basic ignition advance angle
    - Corrective ignition advance control
      - Warm-up correction
      - Over-temp. correction
      - Stable idling correction
      - EGR correction
      - Air-fuel ratio feedback correction
      - Knocking correction
      - Torque control correction
      - Other correction
      - Maximum and minimum advance angle control

The relationship between the major controls the make up ignition timing control and the major signals from each sensor is shown in the following table.

REFERENCE
The signals used for certain controls may differ depending on the engine.

IGNITION TIMING CONTROL \ SIGNALS			BATTERY VOLTAGE	INTAKE MANIFOLD PRESSURE (D-TYPE EFI)	INTAKE AIR VOLUME (L-TYPE EFI)	THROTTLE POSITION		CRANKSHAFT ANGLE	ENGINE SPEED	COOLANT TEMPERATURE	OXYGEN SENSOR	VEHICLE SPEED	FUEL CONTROL SWITCH OR CONNECTOR	ENGINE KNOCKING
			+B	PIM	VS, KS or VG	IDL	PSW or VTA	G	NE	THW	OX	SPD	R-P	KNK
Starting ignition control								○	○					
After-start ignition control	Basic ignition advance angle			○	○	○			○				○	
	Corrective ignition advance control	Warm-up correction		○	○					○				
		Over-temperature correction								○				
		Stable idling correction				○			○			○		
		EGR correction		○	○	○	○		○					
		Air-fuel ratio feedback correction				○					○	○		
		Knocking correction												○
		Torque control correction*	○				○		○	○				

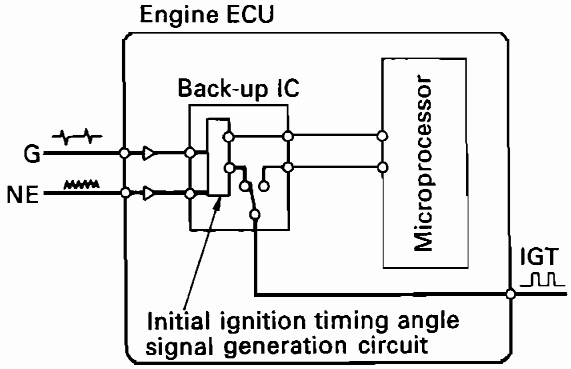
* Torque control correction also uses the vehicle speed (SP2) signal. This signal is used to control the ECT. For further details, see Step 3, vol. 4 (ECT).

STARTING IGNITION CONTROL

Starting ignition control is carried out once immediately after input of the NE signal following the G (G1 or G2) signal. This ignition timing is called "initial ignition timing angle". For further details, see page 83.
During starting, when the engine speed is still below a specified rpm (usually around 500 rpm), since the intake manifold pressure (PIM) signal or the intake air volume (VS, KS or VG) signal is unstable, the ignition timing is fixed at the initial ignition timing (which differs depending on the engine model). This initial ignition timing is set directly by the back-up IC in the Engine ECU.

RELEVANT SIGNALS
- Crankshaft angle (G)
- Engine speed (NE)

REFERENCE
In some engine models, the starter (STA) signal is also used to inform the ECU that the engine is being cranked.



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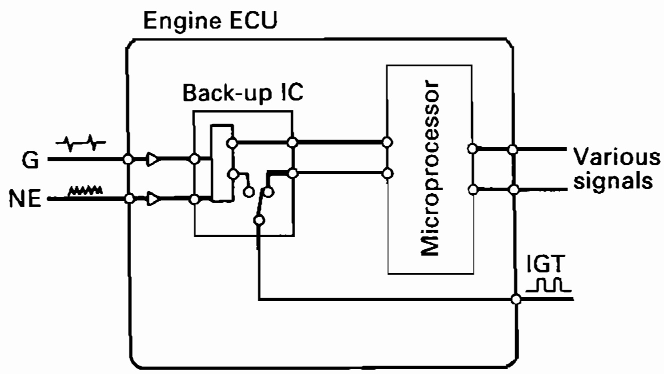
AFTER-START IGNITION CONTROL

After-start ignition control is carried out during normal operation.
The various corrections (which are based on signals from the relevant sensors) are added to the initial ignition timing angle and to the basic ignition advance angle (which is determined by the intake manifold pressure signal or the intake air volume signal, and by engine speed signal):

Ignition timing = initial ignition timing angle
+ basic ignition advance angle
+ corrective ignition advance angle

During normal operation of after-start ignition control, the ignition timing (IGT) signal calculated by the microprocessor is output through the back-up IC.



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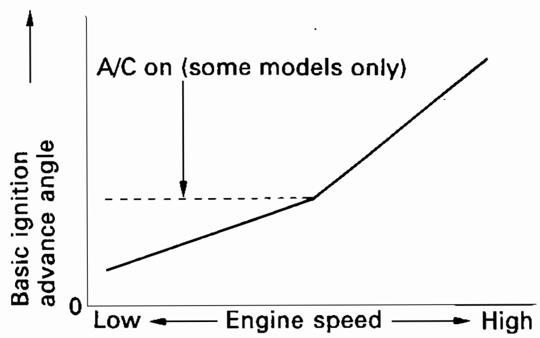
① Basic ignition advance angle

The basic ignition advance angle in the ESA system corresponds to the vacuum advance and governor advance angles in conventional EFI. Data on the optimal basic ignition advance angle (which correspond to the engine speed and intake manifold pressure or intake air volume) are held in the memory of the Engine ECU.

IDLE CONTACT CLOSED (ON)

The ignition timing is advanced in accordance with the engine speed when the idle contact closes.



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RELEVANT SIGNALS
- Throttle position (IDL)
- Engine speed (NE)

REFERENCE

In some engine models, the basic ignition advance angle changes (as shown by the dotted line in the graph above) depending on whether the air conditioner is on or off.
In addition, there are also models in which the advance angle is "0" at the time of the standard idle speed.

IDLE CONTACT OPEN (OFF)

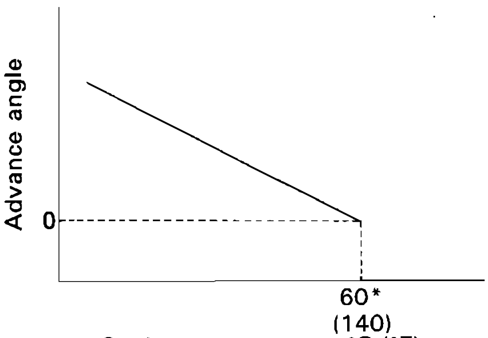
The Engine ECU determines the basic ignition advance angle based on data stored in its memory, and based on the intake manifold pressure (or the intake air volume) and engine speed.
In some engine models, two types of basic ignition advance angle data are stored in memory. One or the other of these two sets of data is then used, depending on the fuel octane rating (premium or regular).
The driver can select the data to be used by setting the fuel control switch or connector to match the octane rating of the gasoline used.
In vehicles equipped with the fuel octane judgment capability, the relevant data are accessed automatically in accordance with the knock (KNK) signal from the knock sensor (See page 116).

RELEVANT SIGNALS
- Intake manifold pressure (PIM) or intake air volume (VS, KS or VG)
- Engine speed (NE)
- Throttle position (IDL)
- Fuel control switch or connector (R-P)
- Engine knocking (KNK)

② Corrective ignition advance control

WARM-UP CORRECTION

The ignition timing is advanced to improve drivability when the coolant temperature is low. In some engine models, this correction changes the advance angle in accordance with the intake manifold pressure or the intake air volume. The ignition timing angle is advanced by approximately 15° by this correction during extremely cold weather.



*Depending on the engine models.

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RELEVANT SIGNALS

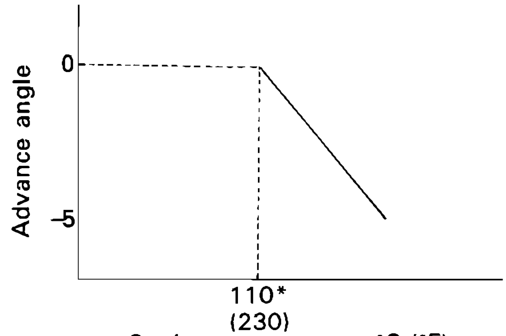
- Coolant temperature (THW)
- Intake manifold pressure (PIM) or intake air volume (VS, KS or VG)

REFERENCE

In some engine models, the throttle position (IDL) signal or the engine speed (NE) signal is used as the relevant signal for this correction.

OVER-TEMPERATURE CORRECTION

To prevent knocking and overheating, the ignition timing is retarded when the coolant temperature is extremely high. The ignition timing angle is retarded a maximum of approximately 5° by this correction.



*Depending on the engine models.

OHP 66

RELEVANT SIGNAL

- Coolant temperature (THW)

REFERENCE

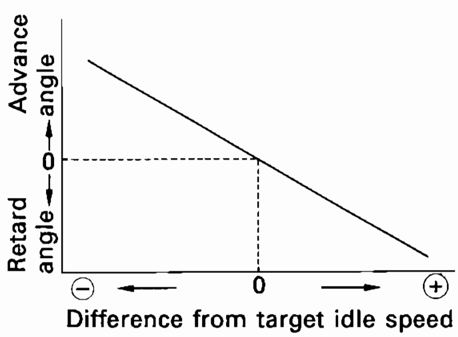
In some engine models, the following signals are also used for this correction.

- Intake manifold pressure (PIM) signal or intake air volume (VS, KS or VG) signal
- Engine speed (NE) signal
- Throttle position (IDL) signal

etc.

STABLE IDLING CORRECTION

When the engine speed during idling has fluctuated from the target idle speed, the Engine ECU adjusts the ignition timing to stabilize the engine speed.
The ECU is constantly calculating the average engine speed. If the engine speed falls below the target speed, the ECU advances the ignition timing by a predetermined angle. If the engine speed rises above the target speed, the ECU retards the ignition timing by a predetermined angle. The ignition timing angle is changed a maximum of approximately ±5° by this correction.
This correction is not executed when the engine exceeds a predetermined speed.



OHP 66

RELEVANT SIGNALS

- Engine speed (NE)
- Throttle position (IDL)
- Vehicle speed (SPD)

REFERENCE

1. In some engine models, the advance angle changes depending on whether the air conditioner is on or off.
2. In some engine models, this correction only operates when the engine speed is below the target engine speed.

EGR CORRECTION

When the EGR is operating and the IDL contact is off, the ignition timing is advanced according to the volume of the intake air and the engine speed to improve drivability.

RELEVANT SIGNALS

- Intake manifold pressure (PIM) or intake air volume (VS, KS or VG)
- Engine speed (NE)
- Throttle position (IDL and PSW or VTA)

AIR-FUEL RATIO FEEDBACK CORRECTION
(engines with oxygen sensor)

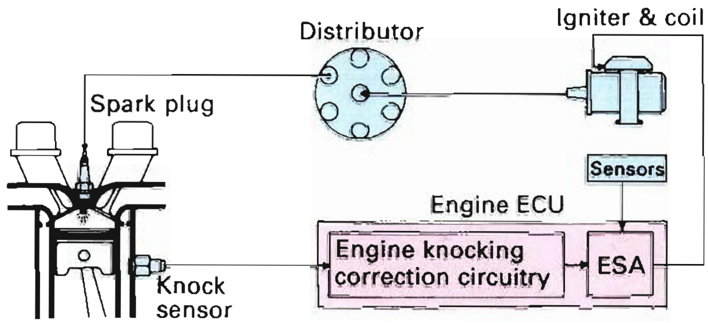
During air-fuel ratio feedback correction, the engine speed varies according to the increase or decrease in the fuel injection volume. The engine is especially sensitive to changes in the air-fuel ratio when it is idling, so stable idling is ensured by advancing the ignition timing at this time in order to match the fuel injection volume of air-fuel ratio feedback correction.
The ignition timing angle is advanced a maximum of approximately 5° by this correction. This correction is not executed while the vehicle is being driven.

RELEVANT SIGNALS

- Oxygen sensor (OX)
- Throttle position (IDL)
- Vehicle speed (SPD)

KNOCKING CORRECTION

If engine knocking occurs, the knock sensor converts the vibrations created by the knocking into voltage signals and sends them to the Engine ECU.



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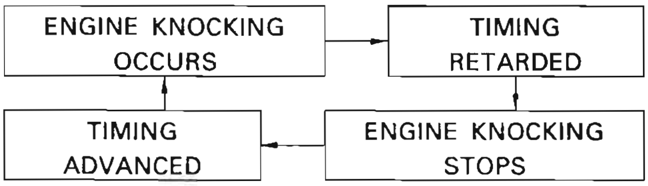
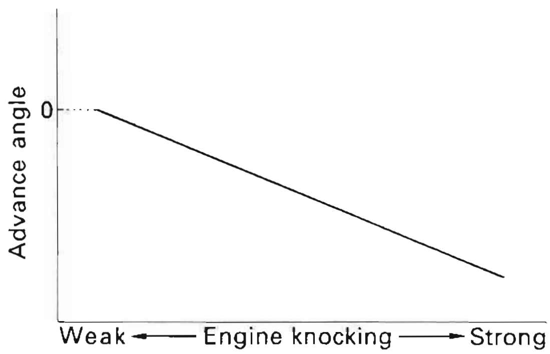
The ECU judges whether the strength of the knocking is at one of three levels, strong, medium or weak, according to the strength of the KNK signals, and changes the corrective ignition retard angle accordingly. In other words, if the knocking is strong, the ignition timing is retarded a lot, while if knocking is weak, it is retarded only a little.
When engine knocking stops, the ECU stops retarding and begins advancing the ignition timing by fixed angles a little at a time.
This ignition timing advance continues until engine knocking recurs, at which point the ignition timing is again retarded.
The ignition timing angle is retarded a maximum of approximately 10° by this correction.
Retarding of the ignition timing during knocking is carried out within the knocking correction range. In some engines, this means when the engine is operating under a heavy load (vacuum below approx. 26.7 kPa [200 mmHg, 7.9 in.Hg]), while in other engines, it covers virtually the full engine load range.

The ECU feeds back signals from the knock sensor to correct the ignition timing as shown below.



OHP 67



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RELEVANT SIGNAL

- Engine knocking (KNK)

TORQUE CONTROL CORRECTION

In the case of vehicles equipped with the ECT (electronically-controlled transmission), each clutch and brake in the planetary gear unit of the transmission or transaxle generates shock to some extent during shifting. In some models, this shock is minimized by delaying the ignition timing when gears are up- or down-shifted.
When gear shifting starts, the Engine ECU retards the engine ignition timing to reduce the engine torque.
As a result, the shock of engagement of the clutches and brakes of the planetary gear unit is reduced and the gear shift change is performed smoothly.
The ignition timing angle is retarded a maximum of approximately 20° by this correction.
This correction is not performed when the coolant temperature or battery voltage is below a predetermined level.

RELEVANT SIGNALS

- Engine speed (NE)
- Throttle position (VTA)
- Coolant temperature (THW)
- Battery voltage (+B)

OTHER CORRECTIONS

Engines have been developed with the following corrections added to the ESA system (in addition to the various corrections explained so far), in order to adjust the ignition timing with extremely fine precision.

a. Transition Correction

During the transition (change) from deceleration to acceleration, the ignition timing is either advanced or retarded temporarily in accordance with the acceleration.

b. Cruise Control Correction

When driving downhill under cruise control, in order to provide smooth cruise control operation and minimize changes in engine torque caused by fuel cut-off due to engine braking, a signal is sent from the Cruise Control ECU to the Engine ECU to retard the ignition timing.

c. Traction Control Correction

This retards the ignition timing, thus lowering the torque output by the engine, when the coolant temperature is above a predetermined temperature and the traction control system is operating.

d. ACIS (Acoustic Control Induction System) Correction

When the engine speed rises above a predetermined level, the ACIS operates. At that time, the Engine ECU advances the ignition timing simultaneously, thus improving output.
See page 120 for details on the ACIS.

e. Intercooler Failure Correction

This correction retards the ignition timing if the intercooler fail signal goes on.

MAXIMUM AND MINIMUM ADVANCE ANGLE CONTROL

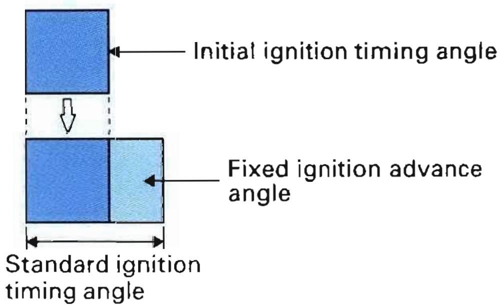
If the ignition timing (initial ignition timing + basic ignition advance angle + corrective ignition advance angle) becomes abnormal, engine operation will be adversely affected.
To prevent this, the Engine ECU controls the actual ignition angle (ignition timing) so that the sum of the basic ignition advance angle and corrective ignition advance angle cannot be greater or less than certain values.
These values are:

MAX. ADVANCE ANGLE	35° ~ 45°
MIN. ADVANCE ANGLE	–10° ~ 0°

Advance angle = Basic ignition advance angle + corrective ignition advance angle

2. IGNITION TIMING ADJUSTMENT

The angle to which the ignition timing is set during ignition timing adjustment is called the "standard ignition timing." It consists of the initial ignition timing (See page 83), plus a fixed ignition advance angle (a value that is stored in the ECU and output during timing adjustment regardless of the corrections, etc., that are used during normal vehicle operation).



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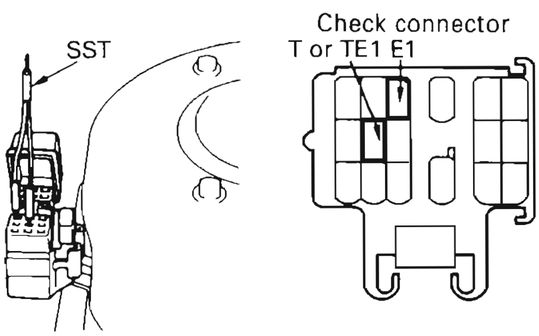
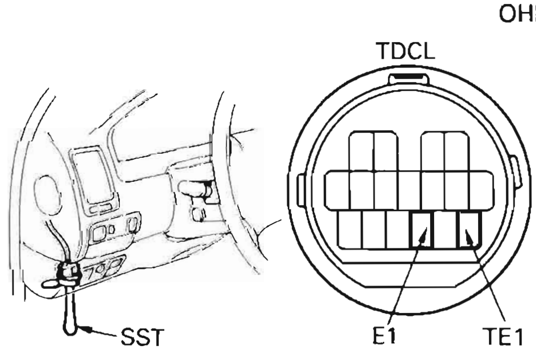
Ignition timing adjustment is carried out as follows:

1) Set the standard ignition timing by connecting terminal T_1 (or TE_1) of the check connector or TDCL with terminal E_1, with the idle contacts on. This will cause the standard ignition timing signal to be output from the back-up IC in the same way as during after-start ignition control (See page 91).



OHP 68



OHP 68

The standard ignition timing differs depending on the engine model, as shown in the following table. When tuning up the engine, refer to the repair manual for the relevant engine.

ENGINE MODEL	INITIAL IGNITION TIMING	FIXED IGNITION ADVANCE ANGLE	STANDARD IGNITION TIMING
Type 1	10° BTDC	0° BTDC	10° BTDC
Type 2	5° BTDC	5° BTDC	10° BTDC
Type 3	7° BTDC	0° BTDC	7° BTDC

OHP 68

2) If the standard ignition timing is not as specified above, adjust it.

NOTE

1. **Even if terminal T1 or TE1 and terminal E1 are connected, the ignition timing will not be fixed at the standard ignition timing unless the idle contacts are on.**
2. **Since the G and NE signal generators are fixed in recent models, there are cases in which ignition timing cannot be adjusted.**

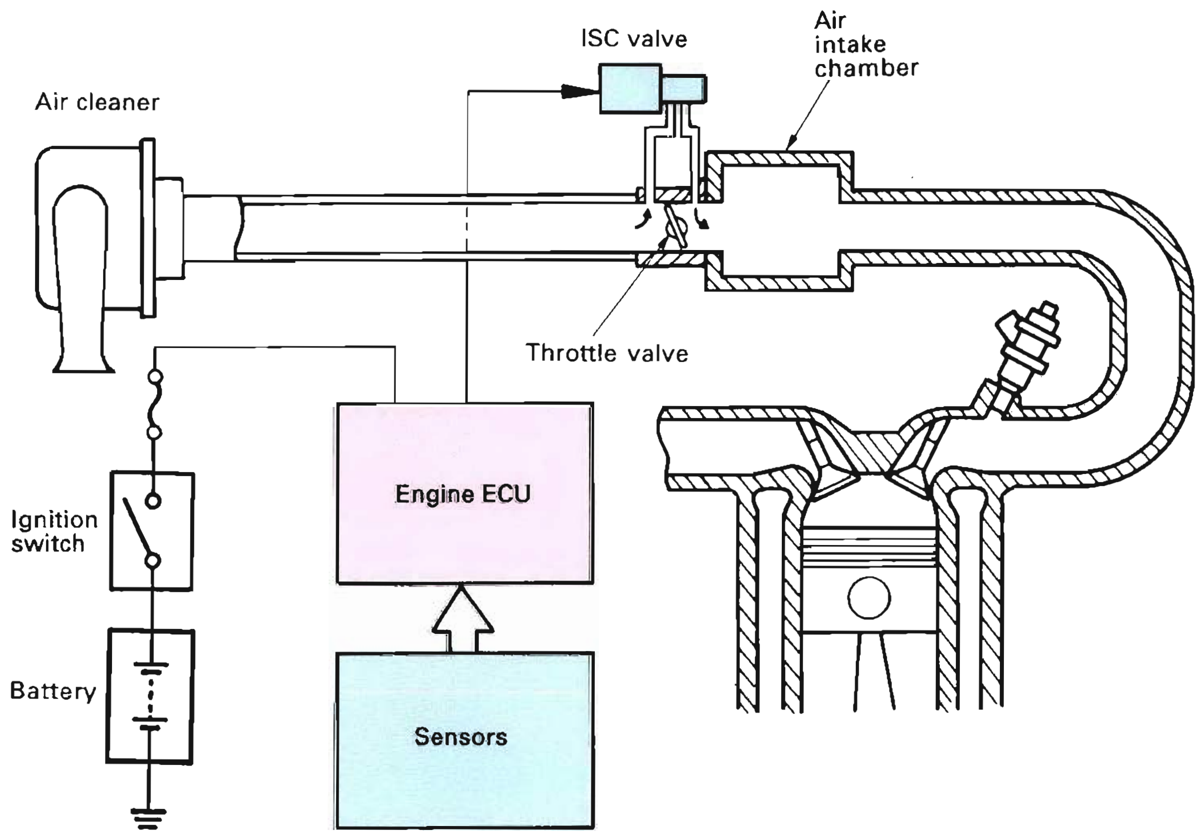
ISC (IDLE SPEED CONTROL)

GENERAL

The ISC system controls the idle speed by means of the ISC valve to change the volume of air flowing through the throttle valve bypass in accordance with signals from the ECU.
There are four types of ISC valve, as follows:

- Stepper motor type
- Rotary solenoid type
- Duty-control ACV (air control valve) type
- On-off control VSV (vacuum switching valve) type

The control functions in the ISC system differ depending on the engine.
The power steering idle-up mechanism is controlled by a separate idle-up device (see Step 2, vol. 11 ["Steering System"] for more details).
Since the volume of air passed through the duty-control ACV type ISC valve and the on-off control VSV type ISC valve is small, a separate air valve for controlling the greater amount of air needed during cold starting is also provided. See page 65 for details on this air valve.



BASIC CONSTRUCTION OF ISC

OHP 69

The following table shows the specifications for the 4A-FE engine. Items with circles in the "APPENDIX" column are included in the specifications for each engine in the APPENDIX section (page 188) at the back of this manual.

ISC (IDLE SPEED CONTROL)			PAGE (THIS MANUAL)	ITEM*	REMARK	APPENDIX
ISC valve		Stepper motor type	101			○
		Rotary solenoid type	102	○		○
		Duty-control ACV type	104			○
		On-Off control VSV type	104			○
Functions of Engine ECU	Stepper motor type ISC valve	Starting set-up	105			
		After-start control	106			
		Warm-up (fast-idle) control	106			
		Feedback control	107			
		Engine speed change estimate control	107			
		Electrical load idle-up control	107			
		Other controls	107			
	Rotary solenoid type ISC valve	Starting control	108	○		
		Warm-up (fast-idle) control	108	○		
		Feedback control	108	○		
		Engine speed change estimate control	109	○		
		Other controls	109	○		
	Duty-control ACV type ISC valve	Starting control	110			
		Feedback control	110			
		Engine speed change estimate control	110			
		Constant duty control	110			
	On-off control VSV type ISC valve		111			

*Specifications for Carolla AE101 4A-FE engine (Apr., 1992)

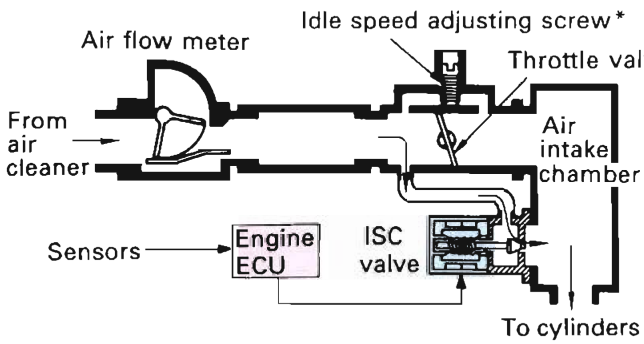
ISC VALVE

1. STEPPER MOTOR TYPE

The ISC valve is mounted on the air intake chamber or throttle body. In order to control the speed at which the engine idles, it increases or decreases (based upon signals from the Engine ECU) the amount of intake air that is allowed to bypass the throttle valve.

The idle speed adjusting screw* is set to the fully closed position at the factory, because the idle speed is controlled by the ISC valve.

* The use of the idle speed adjusting screw has been discontinued in recent models.

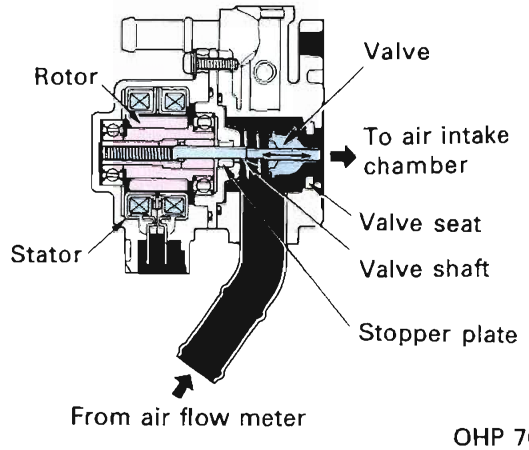


OHP 70

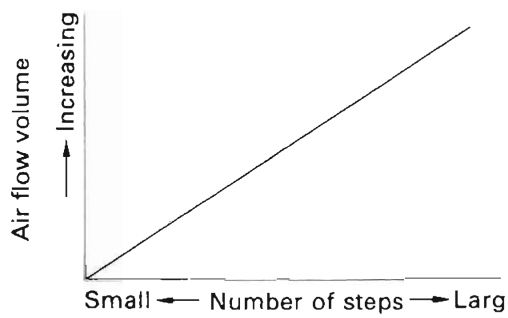
CONSTRUCTION

A stepper motor is built into the ISC valve. This motor rotates the rotor clockwise or counterclockwise, moving the valve in or out. This in turn increases or decreases the clearance between the valve and valve seat, regulating the amount of air that is allowed to pass through. The ISC valve has 125 steps from the fully closed to the fully open position.

Since the air flow capacity of the stepper motor type ISC valve is large, it is also used for controlling fast idle. It is not necessary to use it in combination with an air valve.

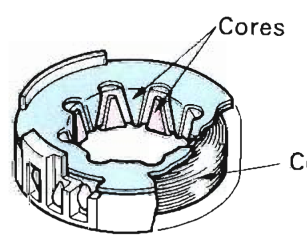


OHP 70



OHP 70

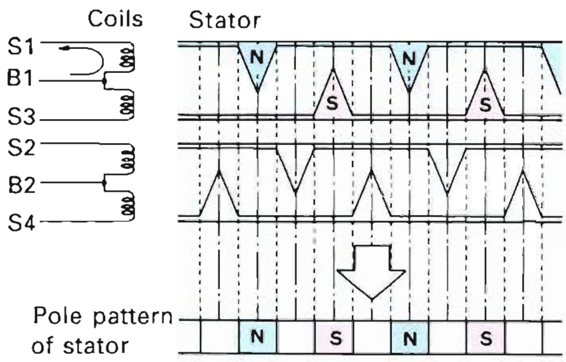
- Rotor... constructed of a 16-pole permanent magnet. (The number of poles differs depending on the engine.)
- Stator... two sets of 16-pole cores, each of which is staggered by half a pitch in relation to the other. Two coils are wound around each core, each coil being wound in opposite directions. (The number of poles differs depending on the engine.)



OHP 70

OPERATION

Current flows through one of the four coils of the stator in turn in accordance with the output from the ECU. The flow of current in coil S1 is as shown in the following illustration:



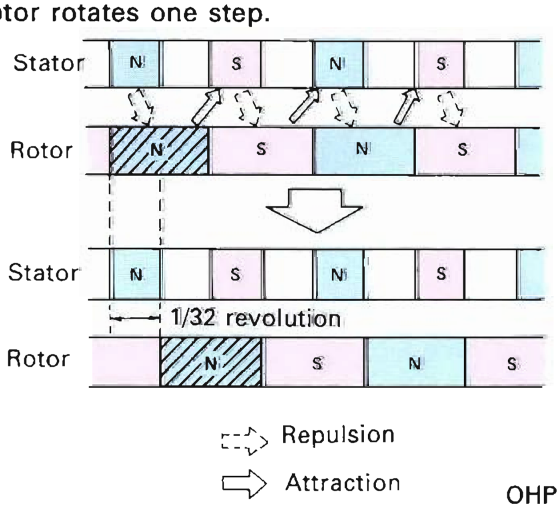
OHP 71

MOVEMENT OF VALVE

The valve shaft is screwed into the rotor. The shaft is prevented from turning by means of a stopper plate, so it moves in and out as the rotor rotates. This controls the clearance between the valve and valve seat, decreasing or increasing it to regulate the amount of air allowed through the bypass.

ROTATION OF ROTOR

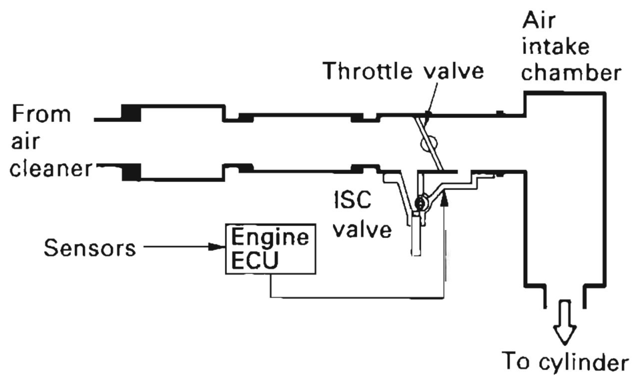
The direction of rotation of the rotor is reversed by changing the order in which current is allowed to pass through the four coils. If the stator and rotor are the 16-pole type, the rotor is rotated about 11° (1/32 of a revolution) each time current passes through the coils.
When the rotor rotates one step, the positional relationship shown in the figure below develops, and the stator coils become excited. Since the N poles tend to be attracted to the S poles in the stator and rotor, and since like poles in the stator and rotor tend to repel each other, the rotor rotates one step.



OHP 71

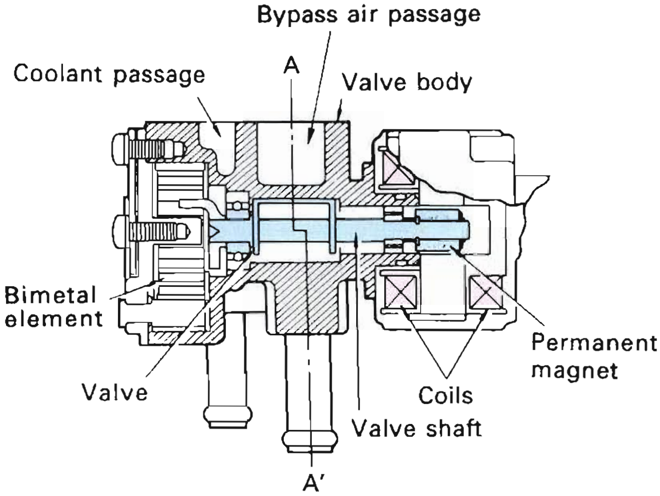
2. ROTARY SOLENOID TYPE

The ISC valve is mounted on the throttle body, and intake air that bypasses the throttle valve passes through it.
The ISC valve is operated by signals from the Engine ECU, and controls the amount of intake air that is allowed to bypass the throttle valve.
Although older models still had an idle speed adjusting screw, its use has been discontinued in recent models.

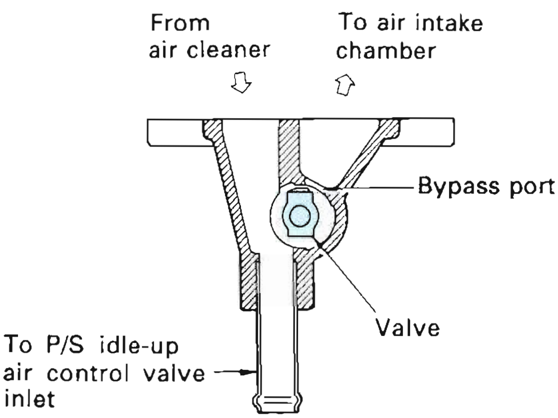


OHP 72

The ISC valve is a small, lightweight rotary solenoid type valve.
Since the air flow capacity of the rotary solenoid type ISC valve is high, it is also used for controlling fast idle. It is not necessary to use it in combination with an air valve.



OHP 72



Cross-section A-A'

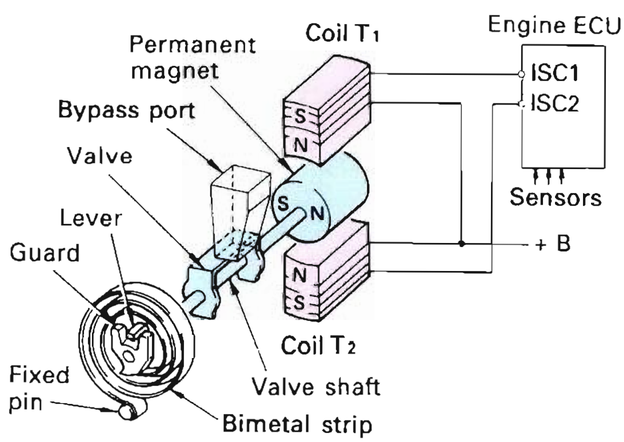
OHP 72

- Permanent magnet
  Located at the end of the valve shaft, the cylindrical permanent magnet rotates when its two poles are repelled by the magnetism exerted by coils T_1 and T_2.

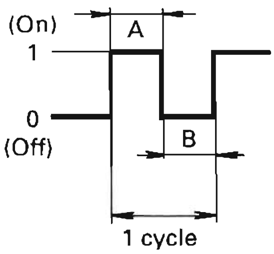
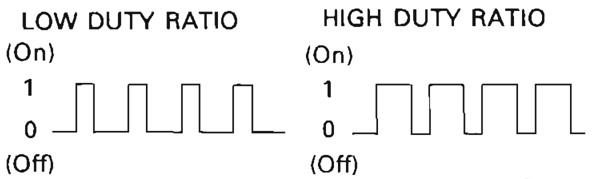
- Valve
  Anchored to the midsection of the valve shaft, the valve controls the amount of air passing through the bypass port, revolving on the shaft together with the permanent magnet.

- Coils (T_1 and T_2)
  Opposing each other and surrounding the permanent magnet, the two coils act as electromagnets that exert north-polarity magnetic force on the sides facing the permanent magnet when the ECU generates a duty signal. The ECU thus causes the permanent magnet to rotate, controlling the magnetic intensity of the field produced by the coils.

- Bimetallic strip assembly
  The bimetallic strip, similar to the one found in a regular carburetor assembly, detects changes in coolant temperature via the valve body.
  The guard attached to one end of the bimetallic strip senses the position of the valve shaft lever running through the notch in the guard: the lever will not trigger bimetallic strip operation as long as the ISC system is operating normally, i.e., as long as the bimetallic strip does not contact the notched section on the guard. This mechanism acts as a fail-safe device that prevents the engine from running at excessively high or low speeds due to a defect in the ISC system's electrical circuitry.

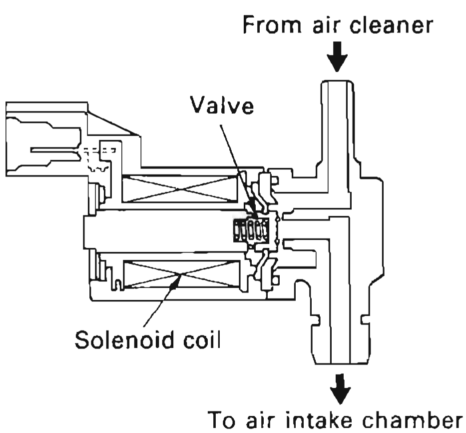


OHP 72

> **NOTE**
>
> **Duty Ratio**
>
> The "duty ratio" is the ratio of the interval during which current flows to the interval during which current does not flow in one cycle of a signal. The figure below shows the time in one cycle during which current flows and does not flow.
>
> A: Current flows (on)
>
> B: Current does not flow (off)
>
> 
>
>
> Duty ratio (%) $= \frac{A}{A + B} \times 100$
>
> 
>
>
> OHP 73

3. DUTY-CONTROL ACV TYPE

The construction of this type of ISC valve is as shown in the following figure. While current flows according to signals from the Engine ECU, the coil becomes excited and the valve moves. This changes the gap between the solenoid valve and the valve body, controlling the idle speed. (Note, however, that the fast-idle speed is controlled using an air valve.)

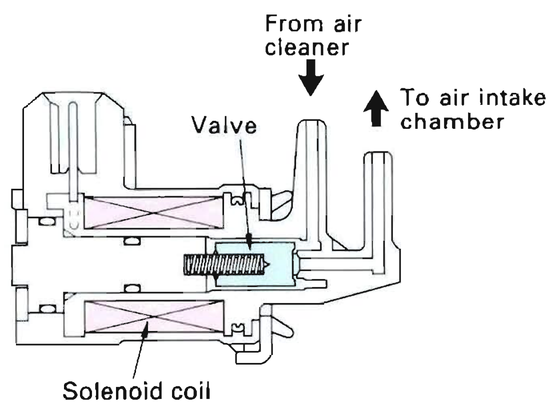


OHP 73

In actual operation, current to the coil is switched on and off each 100 msec., so the position of the solenoid valve is determined by the proportion of time that the signal is on as compared to the time it is off (i.e., by the duty ratio). In other words, the valve opens wider the longer current flows to the coil.

4. ON-OFF CONTROL VSV TYPE

The construction of this type of ISC valve is as shown in the figure below. Signals from the Engine ECU cause current to flow to the coil. This excites the coil, which opens the valve, increasing the idle speed by approximately 100 rpm. (Fast-idle speed is controlled using an air valve.)

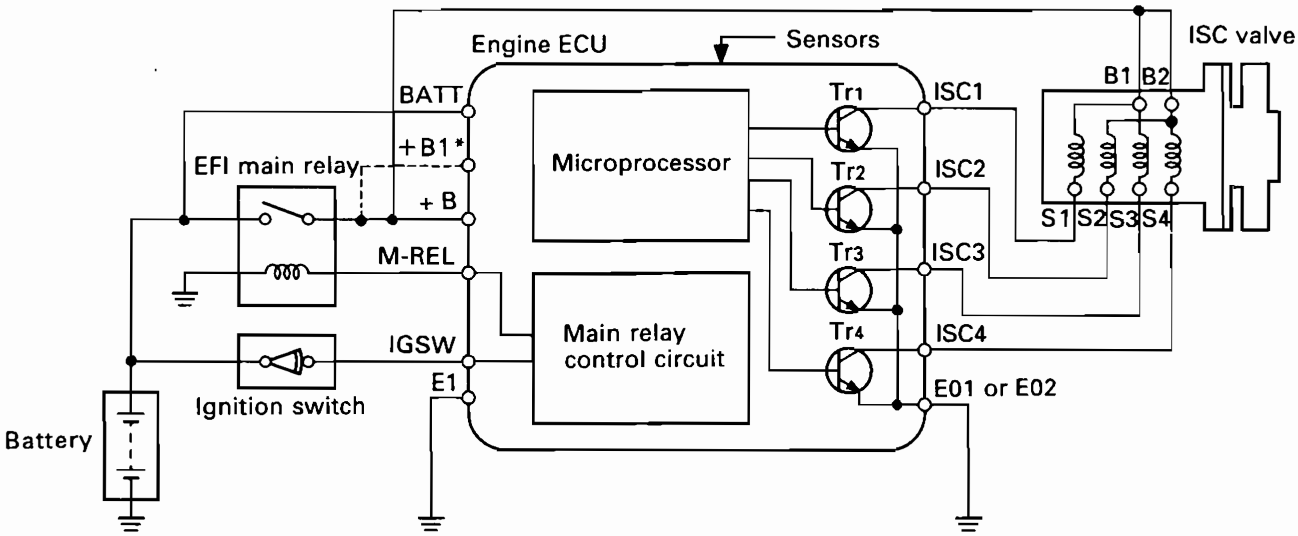


OHP 73

FUNCTIONS OF ENGINE ECU

1. STEPPER MOTOR TYPE ISC VALVE

This type of ISC valve is connected to the Engine ECU as shown in the following diagram. Target idling speeds for each coolant temperature and air conditioner operating state are stored in the ECU's memory.
When the ECU judges from the throttle valve opening angle and vehicle speed signals that the engine is idling, it switches on Tr_1 to Tr_4, in that order, in accordance with the output of those signals. This sends current to the ISC valve coil, until the target idling speed is reached.



* Some models only

OHP 74

STARTING SET-UP

When the engine is stopped (no NE signal to the ECU), the ISC valve opens fully (to the 125th step) to improve startability when the engine is restarted.

- Main Relay (ISC Valve Set-up) Control
  The supply of power to the ECU and ISC valve must be continued for a few moments, even after the ignition switch is turned off, in order to allow the ISC valve to be set up (fully opened) for the next engine start-up.
  Therefore, the ECU outputs 12 V from the M-REL terminal until the ISC valve is set up, in order to keep the main relay on. Once set-up is complete, it cuts off the flow of current to the main relay coil.

CONDITIONS	CURRENT TO MAIN RELAY
Ignition switch on	ON
Ignition switch off (ISC valve set-up is complete)	ON ↓ OFF

RELEVANT SIGNAL

- Engine speed (NE)

NOTE

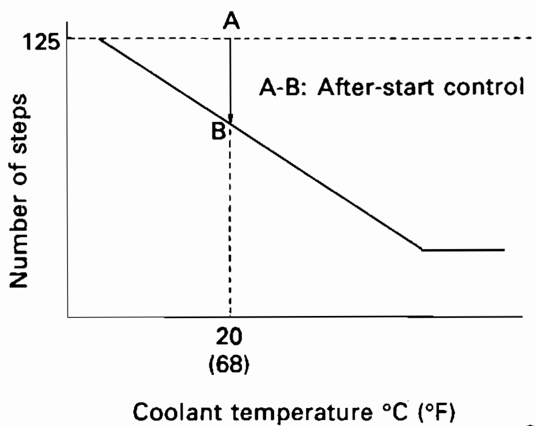
Stepper motor type ISC valves will enter a hold state when the power is interrupted. As a result, they are stopped at the position where they were when the power was interrupted.

AFTER-START CONTROL

Due to the previous set-up of the ISC valve, the amount of air passing through the ISC valve during starting is the maximum amount possible. This allows the engine to start easily.

However, after the engine has started, its speed would rise too high if the ISC valve were kept fully open, so when the engine reaches a certain speed (this speed being determined by the temperature of the coolant) during or after starting, the ECU begins sending signals to the ISC valve, causing it to close from step 125 (fully open) to a point determined by the coolant temperature.

For example, if the coolant temperature is 20°C (68°F) during starting, the ISC valve will gradually close from the fully-open position (step 125, or point A) to point B when engine speed reaches the predetermined level.



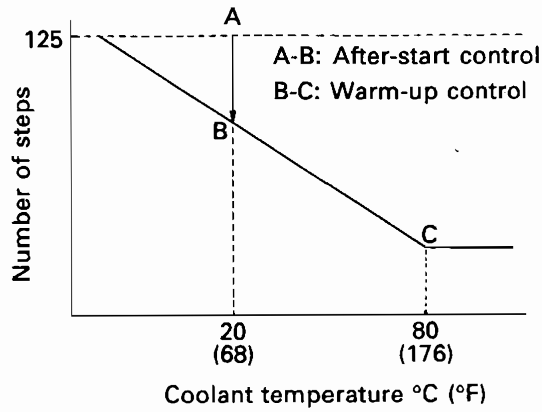
OHP 75

RELEVANT SIGNALS

- Engine speed (NE)
- Coolant temperature (THW)
- Throttle position (IDL)
- Vehicle speed (SPD)

WARM-UP (FAST-IDLE) CONTROL

As the coolant warms up, the ISC valve continues to gradually close from the point to which it closed during starting. When the coolant temperature reaches about 80°C (176°F), fast-idle control by the ISC valve ends.



OHP 75

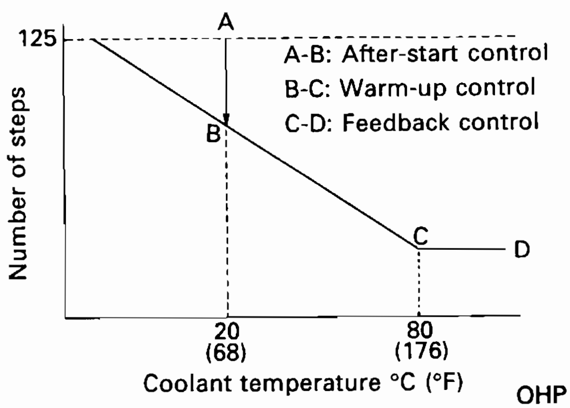
RELEVANT SIGNALS

- Engine speed (NE)
- Coolant temperature (THW)
- Throttle position (IDL)
- Vehicle speed (SPD)

FEEDBACK CONTROL

Feedback control is carried out when the idle contact is on, the vehicle speed is below a predetermined speed, and the coolant temperature is about 80°C (176°F).

If the difference between the actual engine speed and the target speed stored in the memory of the ECU is more than 20 rpm, the ECU sends a signal to the ISC valve, telling it to increase or decrease the volume of air passing through the bypass passage so that the actual engine speed will match the target speed.



OHP 75

Target speeds also differ depending on engine conditions, such as whether the neutral start switch is on or off, and whether the air conditioner switch is on or off.

> **NOTE**
> **Stepper motor type ISC valves also control idle up of the air conditioner.**

RELEVANT SIGNALS

- Engine speed (NE)
- Throttle position (IDL)
- Vehicle speed (SPD)
- Coolant temperature (THW)
- Air conditioner (A/C)
- Neutral start switch (NSW)

ENGINE SPEED CHANGE ESTIMATE CONTROL

Immediately after the neutral start switch or air conditioner switch is operated, the engine load also changes. To prevent the engine speed from changing because of this, the ECU sends signals to the ISC valve to open or close it by a fixed amount *before* changes in the engine speed can occur.

RELEVANT SIGNALS

- Engine speed (NE)
- Neutral start switch (NSW)
- Throttle position (IDL)
- Vehicle speed (SPD)
- Air conditioner (A/C)

ELECTRICAL LOAD IDLE-UP CONTROL

Since the generating capacity of the alternator increases when an electrical load is applied, the Engine ECU opens the step position by a certain number of steps in order to increase the idle speed when there has been a voltage drop at the +B terminal or IGSW terminal or when a signal has been applied to the LP terminal, DFG terminal or ELS terminal.

RELEVANT SIGNALS

- Electrical load (LP, DFG, or ELS)
- Engine speed (NE)
- Throttle position (IDL)
- Vehicle speed (SPD)

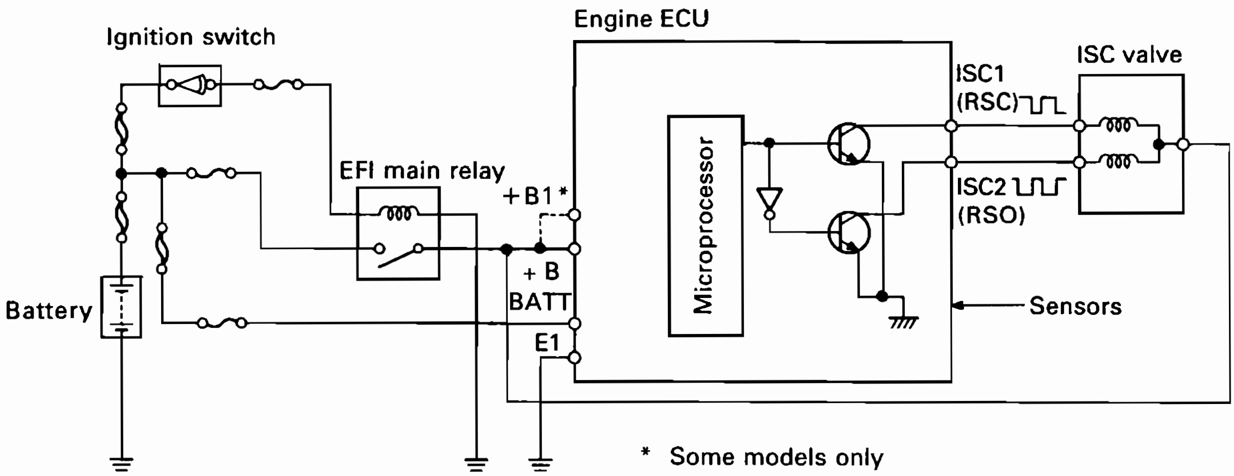
OTHER CONTROLS

In addition to the above controls, some engines are also provided with a control in which the ISC valve operates like a dashpot during deceleration, and a control in which the ISC valve opens slightly when the oil pressure switch goes on.

2. ROTARY SOLENOID TYPE ISC VALVE

This type of ISC valve is connected to the Engine ECU as shown in the diagram below. The ISC valve carries out feedback control through duty control (from a duty ratio of 0 to 100 %) over the full idle speed range, regardless of whether the engine is cold or hot. (Air conditioner idle-up is handled by a separate idle-up device.*)

* In recent models, idle up of the air conditioner is also performed by the ISC valve.



* Some models only

OHP 76

STARTING CONTROL

As the engine is started, the ISC valve is opened in accordance with existing engine operating conditions, based on data stored in the ECU memory. This improves startability.

RELEVANT SIGNALS
• Coolant temperature (THW)
• Engine speed (NE)

WARM-UP (FAST-IDLE) CONTROL

After the engine has started, this function controls the fast idle speed in accordance with the coolant temperature.

Furthermore, the below-mentioned feedback control is carried out to ensure that the engine idle speed matches the target idle speed, the data for which are stored in the ECU.

RELEVANT SIGNALS
• Coolant temperature (THW)
• Engine speed (NE)

FEEDBACK CONTROL

When all feedback control operating conditions have been established after the engine has started, the ECU constantly compares the actual engine speed and the target idling speed stored in its memory. The ECU sends control signals to the ISC valve as necessary in order to adjust the actual engine speed to match the target idling speed.

In other words, when the actual engine speed is lower than the target idling speed, the ECU sends signals to the ISC valve to open it. Conversely, when the actual engine speed is higher than the target idling speed, it sends control signals to the valve to close it.

Target speeds also differ depending on engine running conditions, such as whether the neutral start switch is on or off, whether the electrical load signal is on or off, and whether the air conditioner switch is on or off.

RELEVANT SIGNALS
• Engine speed (NE)
• Throttle position (IDL)
• Vehicle speed (SPD)
• Neutral start switch (NSW)
• Electrical load (LP, DFG, or ELS)
• Air conditioner (A/C)*

* Some models only

ENGINE SPEED CHANGE ESTIMATE CONTROL

Immediately after the neutral start switch, tail lamp relay, defogger relay or air conditioner switch is operated, the engine load also changes. To prevent the engine speed from changing because of this, the ECU sends signals to the ISC valve to open or close it by a fixed amount *before* changes in the engine speed can occur.

RELEVANT SIGNALS

- Neutral start switch (NSW)
- Electrical load (LP, DFG, or ELS)
- Engine speed (NE)
- Air conditioner (A/C)*

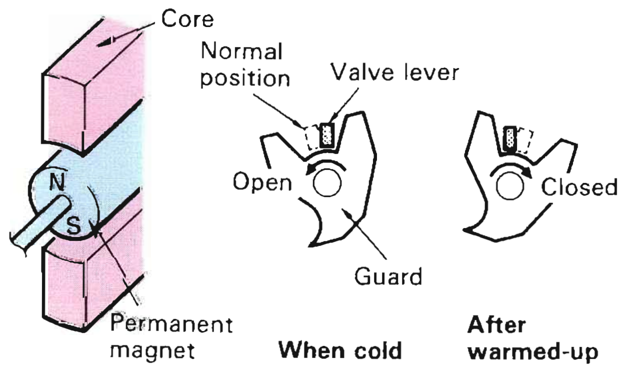
* Some models only

OTHER CONTROLS

Controls other than those described above include dashpot control, which controls the ISC valve so as to prevent a sudden drop due to sudden changes in engine speed when the IDL contact in the throttle position sensor closes.
In some vehicle models equipped with EHPS (electro-hydraulic power steering), the idle speed is also increased whenever the electrical load increases greatly due to the operation of the EHPS.
Another control, used in some turbocharged engines, prevents the turbine from seizing up if the hydraulic pressure should drop too low to provide sufficient turbine lubrication when the idle speed returns to normal following high-speed or high-load operation. It does this by causing the idle speed to drop gradually so that the oil pump will supply a sufficient amount of oil to the turbocharger.

NOTE

1. **When terminal T or TE1 of the check connector or TDCL is connected with terminal E1, the Engine ECU gradually changes the duty ratio of the ISC valve for several seconds and eventually fixed the duty ratio at a constant value.**
   As a result, engine speed returns to the original idle speed after increasing for several seconds.
2. **When the current flowing to the coil is interrupted due to disconnection of the ISC valve connector or other reason, the valve stops at the position at which the S or N pole of the permanent magnet is facing the core of the coil.**
   As a result, idle speed is slightly lower when the engine is cold and slightly higher after the engine has warmed up than during normal operation. (Example: Idle speed after warm-up is approximately 1000 – 1200 rpm.)



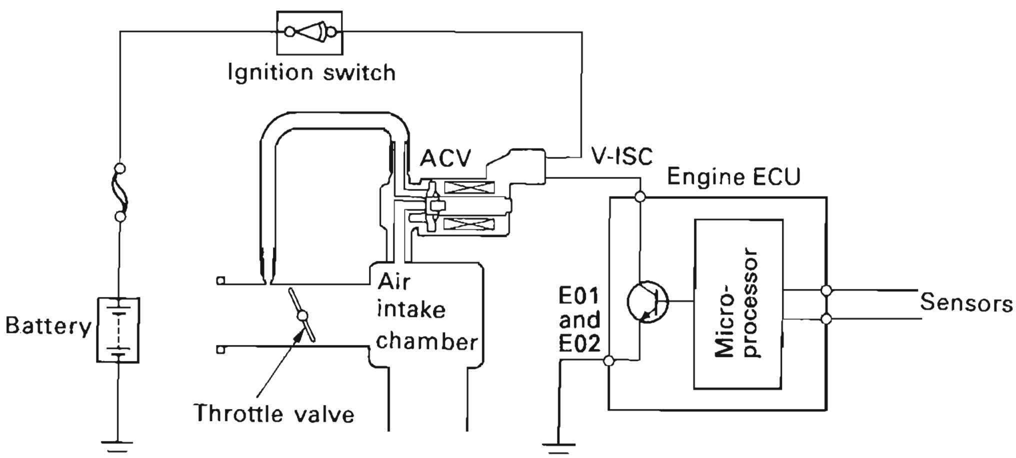
3. DUTY-CONTROL ACV TYPE ISC VALVE

The duty-control ACV controls the volume of air passing through the throttle valve by means of signals (duty signals) from the Engine ECU, and is mounted on the intake manifold. The air flow volume is determined by the ratio of the length of time that the air flow volume signal from the ECU is on to the length of time that it is off.

If the idle speed has dropped due to changes in engine running conditions or changes in the electrical load (as when the air conditioner switch or neutral start switch is operated, etc.), the ACV controls the volume of air bypassing the throttle valve according to signals from the ECU, thus helping to stabilize the idle speed. (During warm-up, the fast-idle speed is controlled by the air valve.) Control is as explained below.

NOTE

Connecting the T (or TE1) terminal to the E1 terminal of the check connector or TDCL causes the ECU to fix the ACV opening angle to a certain value, regardless of engine operating conditions.



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STARTING CONTROL

To improve startability during cranking, STA goes on, causing the ACV to open fully.

RELEVANT SIGNAL
- Ignition starter switch (STA)

FEEDBACK CONTROL

The ECU changes the duty ratio of the V-ISC signal to maintain the idle speed under conditions other than starting control, engine speed change estimate control, and constant duty control.

RELEVANT SIGNAL
- Engine speed (NE)
- Coolant temperature (THW)

ENGINE SPEED CHANGE ESTIMATE CONTROL

The duty ratio changes when the air conditioner switch or neutral start switch is operated. This helps to limit changes in the idle speed.

RELEVANT SIGNALS
- Neutral start switch (NSW)
- Air conditioner (A/C)

CONSTANT DUTY CONTROL

The ECU maintains the ACV at a fixed opening angle when the idle contact is off or the air conditioner switch is on.

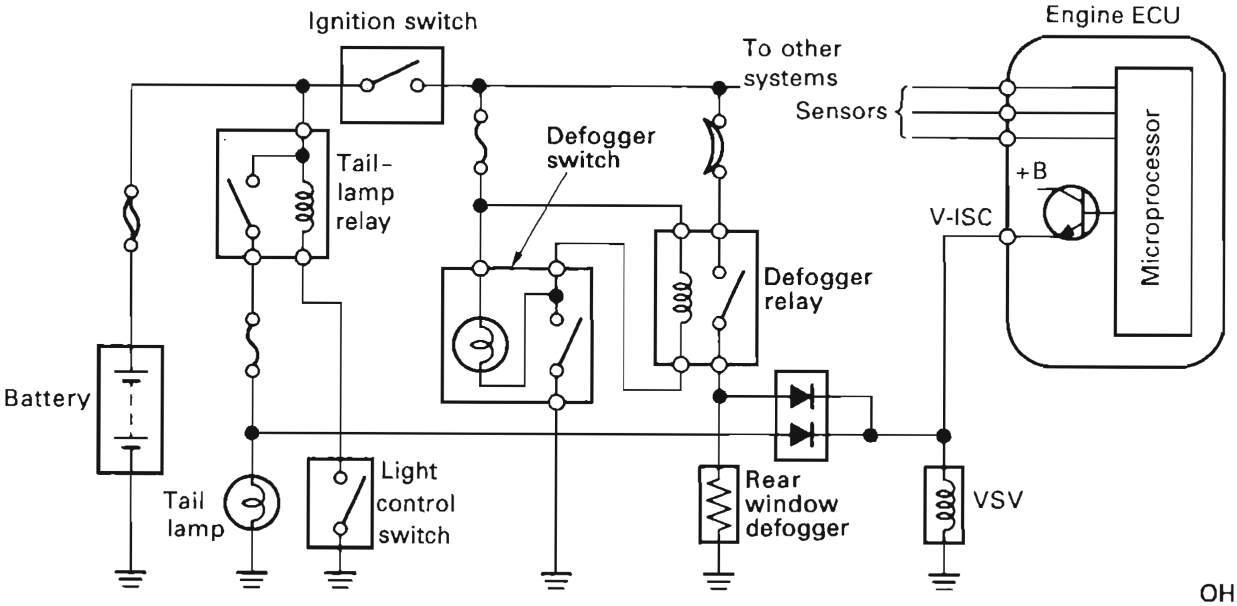
RELEVANT SIGNALS
- Throttle position (IDL)
- Air conditioner (A/C)

4. ON-OFF CONTROL VSV TYPE ISC VALVE

The Engine ECU sends signals to the VSV, in accordance with signals from various sensors, to cause the engine to idle at the appropriate speed.

During warm-up, the fast-idle speed is controlled by the air valve.

The following diagram shows one example of connections between the VSV and ECU.



OHP 78

CONDITIONS FOR VSV OPERATION

a. Off to On

- When the engine is cranking and immediately after starting.
- When engine speed falls below a predetermined rpm (depending on the neutral start switch signal) with the idle contact on*.
- Several seconds after shifting from "P" or "N" into any other range with the idle contact on (A/T vehicles).*
- The light control switch is turned on.
- The rear window defogger switch is turned on.

* The VSV stays off under this condition if check terminals T or TE1 is connected to E1. However, if the light control switch or rear window defogger switch is turned on, the VSV goes on.

b. On to Off

- When a predetermined period of time has elapsed after the engine has started.
- When engine speed rises above a predetermined rpm (depending on the neutral start switch signal) with the idle contact on and the A/C magnetic clutch disengaged.
- After a set time has elapsed after the transmission is shifted from "P" or "N" into any other range and the engine speed is above a predetermined rpm with the idle contact on and the A/C magnetic clutch disengaged (A/T vehicles).
- The light control switch is turned off.
- The rear window defogger switch is turned off.

NOTE

Learned Control

Besides the previously mentioned control, learned control is also used for control of the ISC valve.

Normally, the Engine ECU controls the idle speed by changing the ISC valve position. However, since the engine's running conditions change over time, the idle speed also changes (even though the valve positions remain the same).

So through feedback control, the Engine ECU outputs ISC signals to return the idle speed to the target level. The ISC valve position when the target speed is reached is stored in back-up memory, and is used thereafter in idling. This is known as learned control.

If all power to the Engine ECU is cut off due to the EFI fuse or STOP fuse being removed or a battery cable being disconnected, the learned value stored in back-up memory will be erased. Therefore, when the engine is restarted, the ISC valve position is set at the initial value stored in memory.

At this time, the idle speed may not be the same as the target speed, but when the engine warms up and feedback control starts, it will gradually approach the target speed.

OTHER CONTROL SYSTEMS

GENERAL

Some TCCS type engine control systems include not only the EFI, ESA, and ISC systems explained so far, but also (depending on the engine model) the systems explained in the following pages.

As with the systems described up to this point, these systems are controlled by the Engine ECU. The following table shows the specifications for the 4A-FE engine.

SYSTEMS		PAGE (THIS MANUAL)	ITEM*	REMARK
ECT OD cut-off control system		114		
Oxygen sensor heater control system		114	○	
Lean mixture sensor heater control system		114		
Air conditioner control system	Cut-off control	115	○	
	Magnetic clutch relay control	115		
EGR cut-off control system		116	○	With EGR
Fuel octane judgment		116		
SCV (swirl control valve) system		117		
ACIS (acoustic control induction system)	Type 1	120		
	Type 2	122		
T-VIS (Toyota-variable induction system)		124		
Turbocharging pressure control system		127		
Supercharger control system		128		
EHPS (electro-hydraulic power steering) control system		128		
AS (air suction) control system		129		
AI (air injection) control system		129		

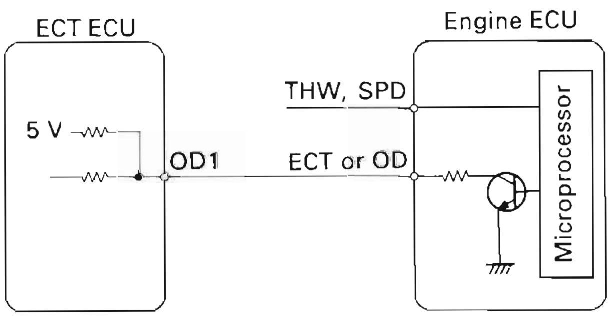
* Specifications for Corolla 4A-FE engine (Apr., 1992)

ECT OD CUT-OFF CONTROL SYSTEM

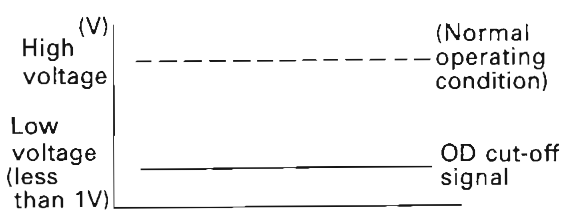
The Engine ECU sends an OD (overdrive) cut-off signal to the ECT ECU based on signals from the water temperature sensor and vehicle speed sensor to prohibit the transmission from shifting into overdrive. The purpose of this control is to maintain good drivability and acceleration performance.

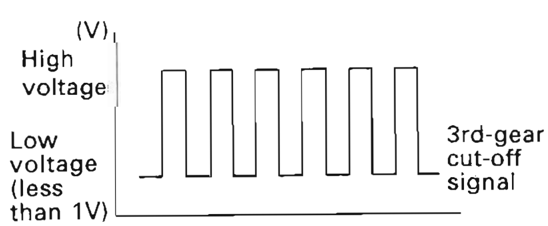
In some engines, the Engine ECU also sends a 3rd-gear cut-off signal to the ECT ECU.

For further details, see Step 3, vol. 4 (ECT).



The OD cut-off signal and 3rd-gear cut-off signal appear as follows:

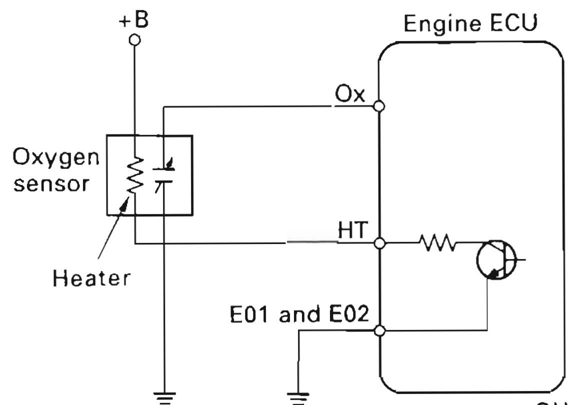




OHP 79

OXYGEN SENSOR HEATER CONTROL SYSTEM

The Engine ECU controls the operation of the oxygen sensor heater according to the intake air volume and engine speed: When the engine load is small and the exhaust gas temperature is consequently low, this heater is operated to maintain sensor efficiency. However, when the engine load and exhaust gas temperature increases greatly, heater operation is stopped to prevent deterioration of the sensor.

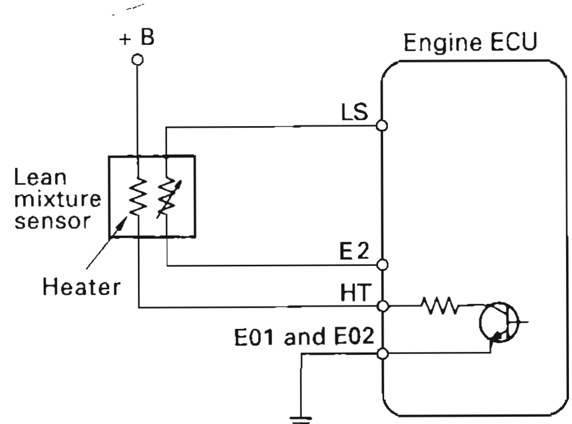


OHP 79

LEAN MIXTURE SENSOR HEATER CONTROL SYSTEM

The ECU controls the operation of the lean mixture sensor heater according to the throttle position, intake manifold pressure, engine speed, and coolant temperature signals.

The temperature range in which the lean mixture sensor can operate correctly is very narrow, so the ECU keeps it within that range by controlling the amount of current that it allows to flow to the lean mixture sensor heater.



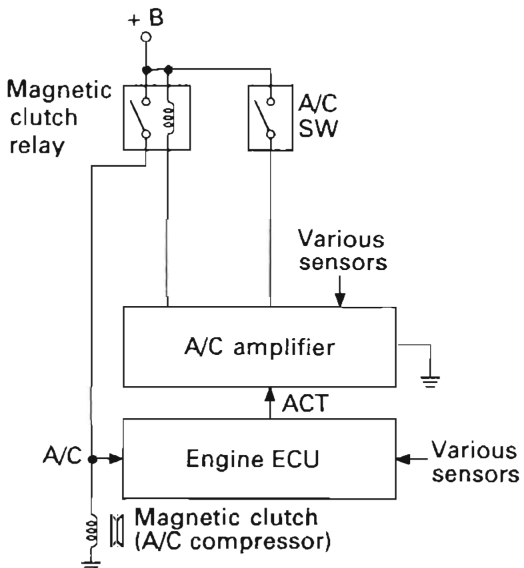
OHP 79

AIR CONDITIONER CONTROL SYSTEM

1. CUT-OFF CONTROL

The Engine ECU sends a signal (ACT) to the air conditioner amplifier to disengage the air conditioner compressor magnetic clutch in order to stop operation of the air conditioning at certain engine speeds, intake manifold pressures (or intake air volumes), vehicle speeds and throttle valve opening angles.
The air conditioner is turned off during quick acceleration from low engine speeds (depending on the vehicle speed, throttle valve position, and intake manifold pressure or intake air volume). This helps maintain good acceleration performance.
The air conditioner is also turned off when the engine is idling at speed below a predetermined rpm. This prevents the engine from stalling.

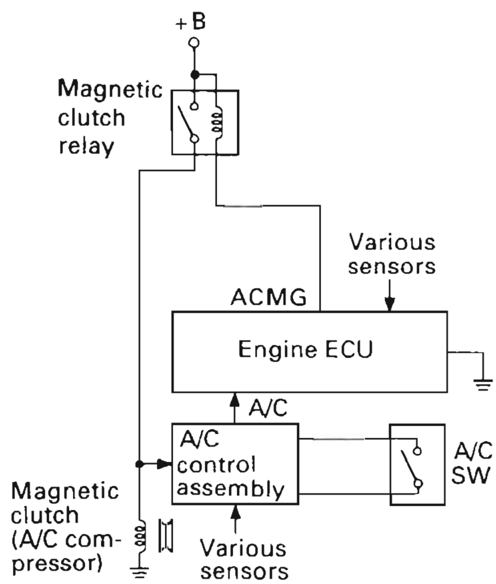
In some engine models, magnetic clutch operation is also delayed for a predetermined length of time after the air conditioner switch is turned on. During this time, the Engine ECU opens the ISC valve to offset the drop in the engine speed due to the operation of the air conditioner compressor. This prevents the idle speed from dropping.
This latter control function is called the "air conditioner compressor delay control".



OHP 80

2. MAGNETIC CLUTCH RELAY CONTROL

This air conditioner control function differs from the previously-mentioned type in that the Engine ECU controls the magnetic clutch relay directly.
When the Engine ECU detects the air conditioner (A/C) signal from the air conditioner control assembly, but does not detect the requisite air conditioner cut-off conditions from various sensors (see cut-off control to the left), this ECU outputs a magnetic clutch (ACMG) signal to the magnetic clutch relay, turning it on. As a result, the magnetic clutch goes on and the air conditioner compressor operates.
This air conditioner control function is also provided with an air compressor delay control. The operation of this is the same as that in the air conditioner cut-off control function.



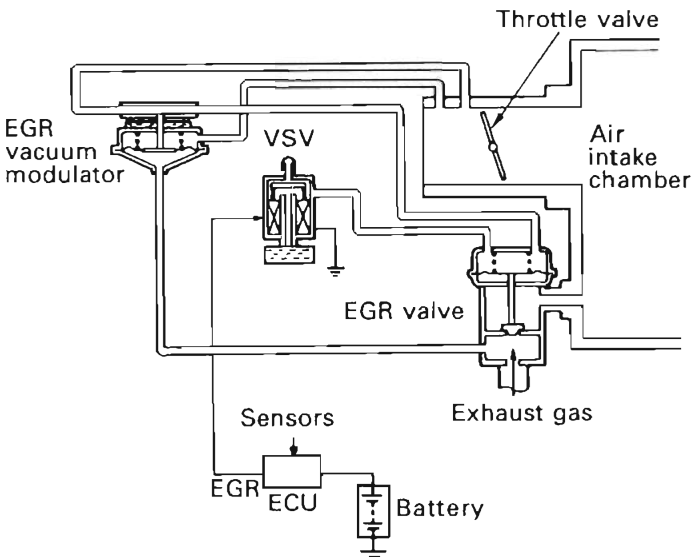
OHP 80

EGR CUT-OFF CONTROL SYSTEM

This system actuates the VSV, which therefore causes atmospheric air instead of intake manifold vacuum to act on the EGR (exhaust gas recirculation) vacuum modulator. This shuts off the EGR to maintain drivability when the engine coolant is cold or during high-speed driving etc.

OPERATION

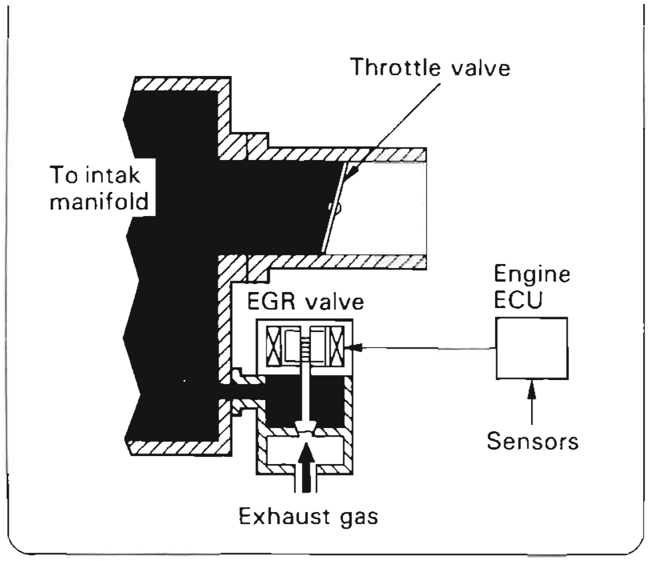
The Engine ECU actuates the VSV, shutting off the EGR when the coolant temperature is below a predetermined temperature or when the engine speed is above a set speed (roughly 4,000 to 4,500 rpm), to maintain drivability. The ECU also actuates the VSV to shut off the EGR when the intake air volume is above a predetermined level or when the fuel cut-off function is on in order to maintain EGR valve durability.



OHP 81

REFERENCE

Some recent models use stepper motor type EGR valves. An EGR vacuum modulator and VSV are not provided in this system. The Engine ECU controls EGR volume and cut-off. In addition, when current is not applied to the EGR valve, the valve is fully closed by the force of a return spring.



FUEL OCTANE JUDGMENT

The Engine ECU in some engine models determines the octane rating of the gasoline being used (whether it is "premium" or "regular") according to engine knocking signals from the knock sensor.

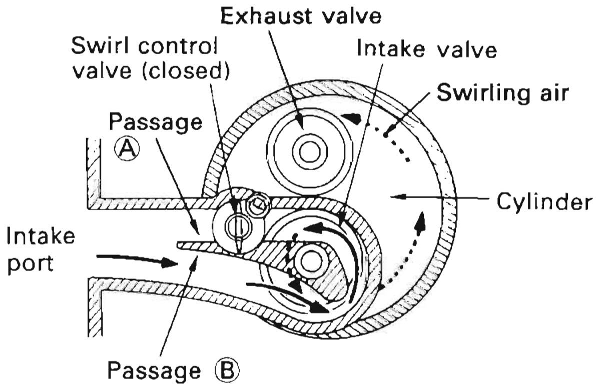
OPERATION

The ECU judges whether the gasoline is "premium" or "regular" based on the retard angle of the ignition timing, which is determined by the strength of engine knocking when the coolant temperature is above a predetermined temperature. It judges the gasoline to be "regular" when the engine knocks severely and the retard angle is larger than a predetermined value. It judges the gasoline to be "premium" when the engine knocks only mildly and the retard angle is smaller than a predetermined value. The ECU stores the result of this judgment until it judges that the octane rating of the gasoline has changed.

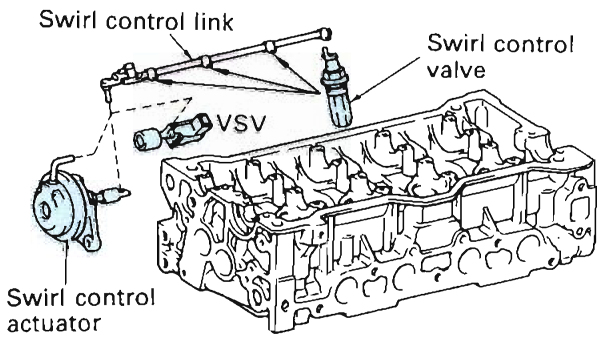
SCV (SWIRL CONTROL VALVE) SYSTEM

The intake port has been divided longitudinally into two passages as shown in the following illustration.
The swirl control valve, which is opened and closed by the intake manifold vacuum, is mounted in passage Ⓐ.

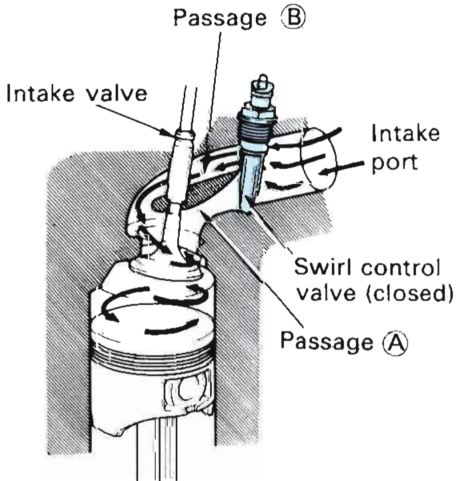
When the engine is running under a light load or below a certain rpm, this valve closes, creating a powerful swirl. This increases combustion efficiency, thereby improving fuel economy.
Under a heavy load or over a certain rpm, the valve opens, increasing intake efficiency, and thus improving engine output.
A swirl control valve is provided in the intake port of each cylinder.



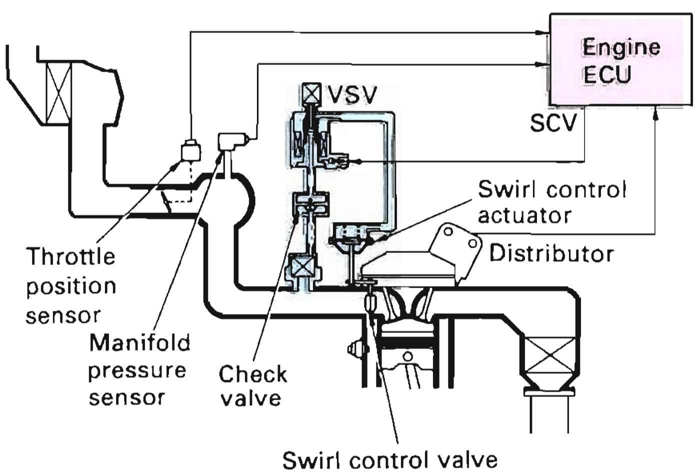
OHP 82



OHP 82



OHP 82



OHP 82

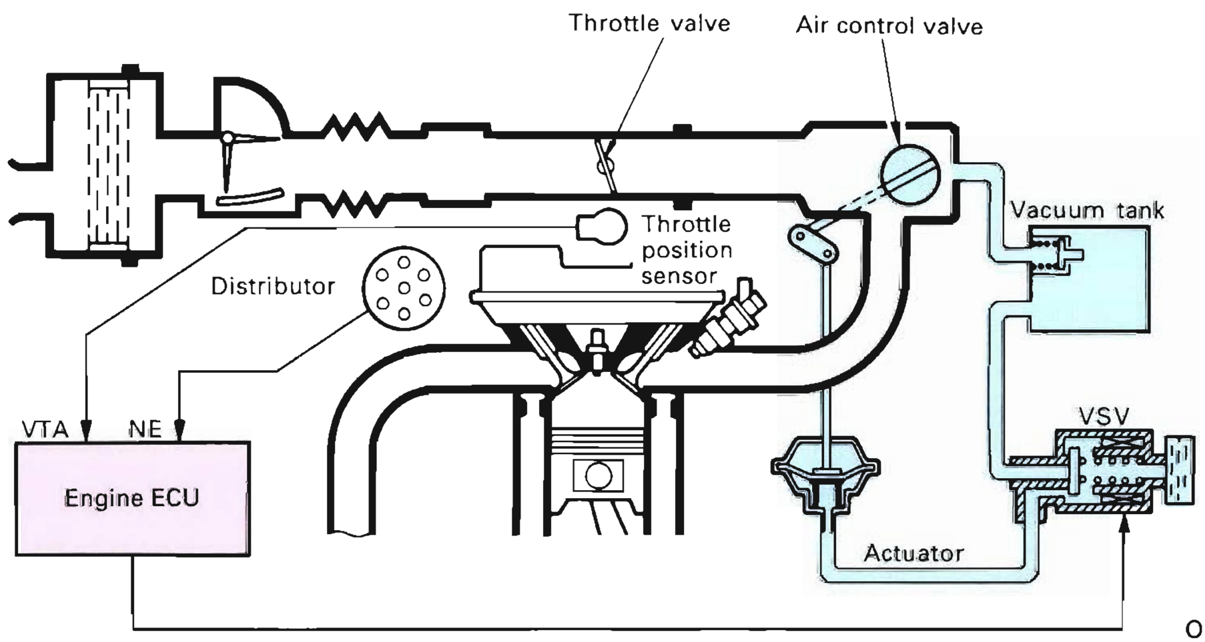
ACIS (ACOUSTIC CONTROL INDUCTION SYSTEM)

The ACIS changes the effective length of the intake manifold in order to increase air intake efficiency. There are two types of ACIS, called here for convenience "Type 1" and "Type 2". They differ both in their basic design and in the number of air control valves used.

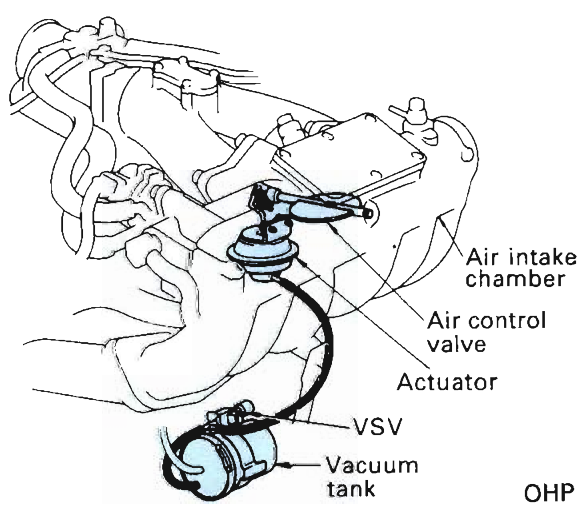
1. TYPE 1

GENERAL

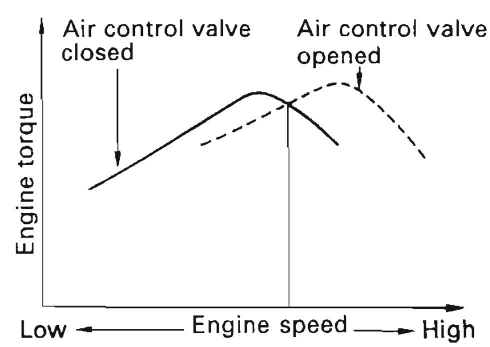
This type of ACIS has only one air control valve. This is located in the air intake chamber and is used to increase the intake efficiency of the air supplied to the cylinders. It does this in response to changes in the throttle opening (VTA) signal sent from the throttle position sensor, and the engine speed (NE) signal sent from the distributor. This air control valve is opened and closed by the Engine ECU via a VSV and an actuator.
This makes it possible to improve engine performance at both low and high engine speeds.



OHP 84



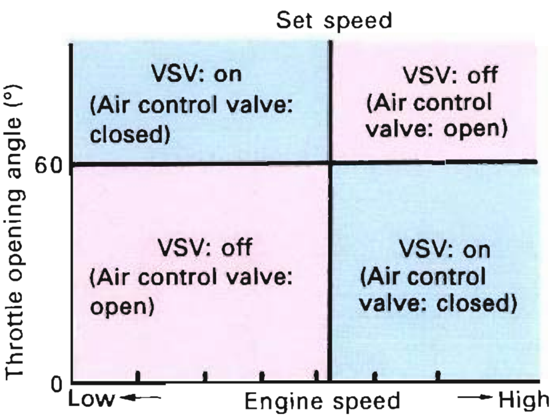
OHP 84



OHP 84

OPERATION

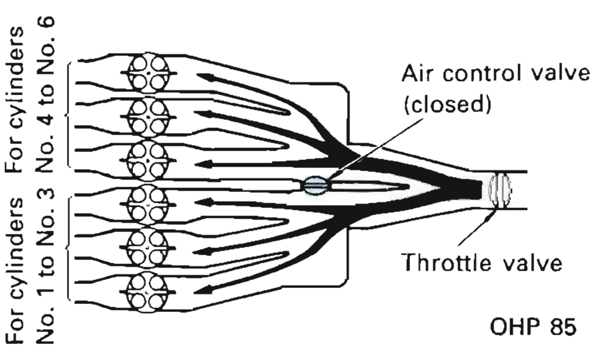
The ECU turns the VSV on or off, depending on the throttle opening angle and the engine speed, as explained below:



OHP 85

① VSV turned on

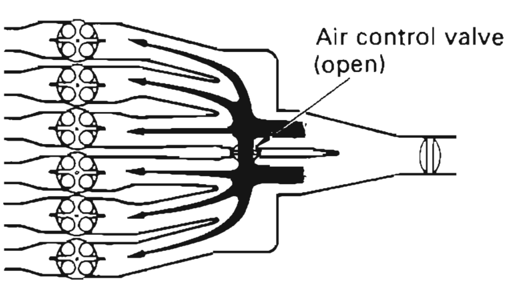
Closing air control valve has the same effect as lengthening the intake manifold.



OHP 85

② VSV turned off

Opening air control valve has the same effect as shortening the intake manifold.

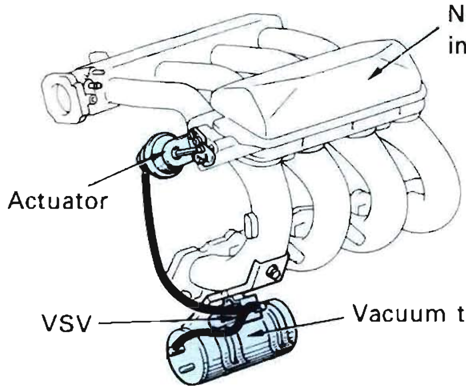


OHP 85

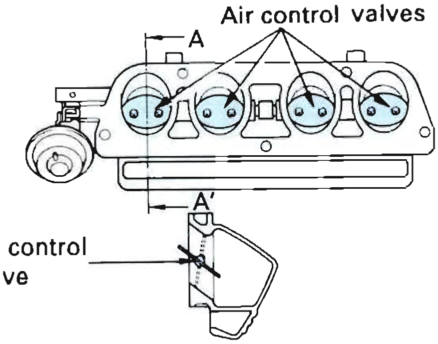
2. TYPE 2

GENERAL

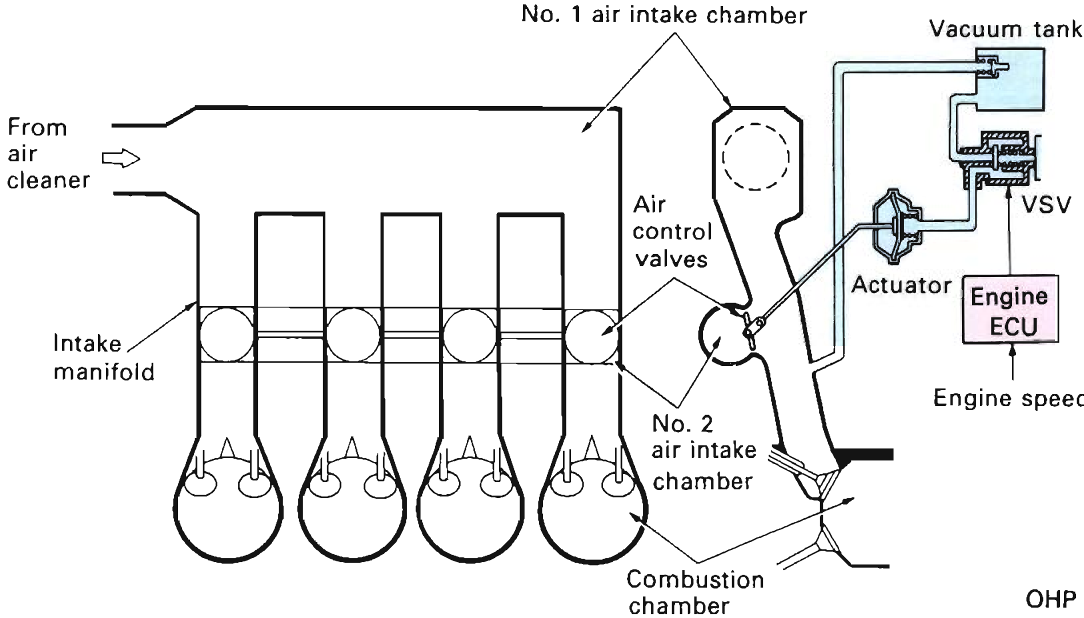
In this type of ACIS, the air control valves are located in front of the No. 2 air intake chamber. By opening and closing these valves in accordance with engine running conditions, the same effect as lengthening or shortening the intake manifold (as in Type 1) can be obtained.



OHP 86



OHP 87

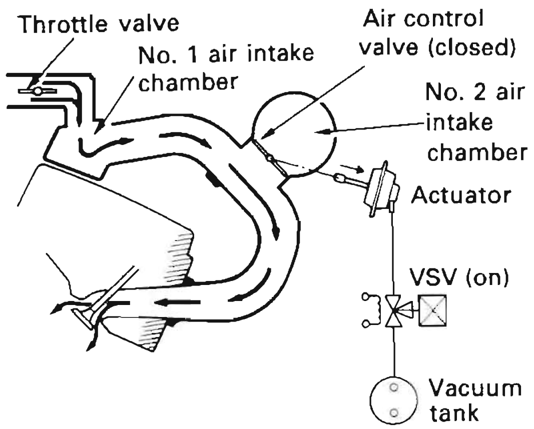


OHP 86

OPERATION

① Low and medium speeds (below set speed)

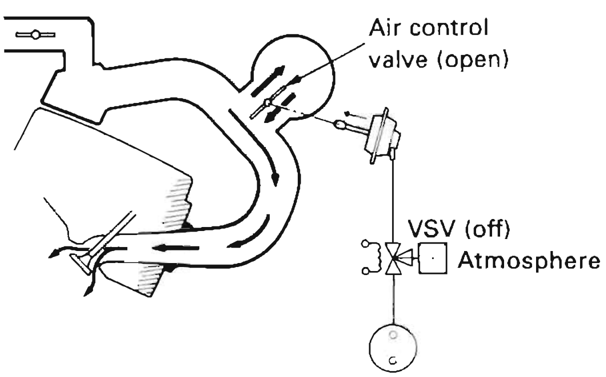
The ECU turns the VSV on when the engine is running at low to medium speeds. Therefore, the vacuum (supplied by the vacuum tank) causes the actuator to close the air control valves fully. By closing the air control valves, the same effect as lengthening the intake manifold is obtained. This improves intake efficiency in the low- and medium-speed ranges.



OHP 87

② High speed (above set speed)

When the engine speed rises above the predetermined speed, the ECU turns the VSV off and the atmospheric air acts directly upon the actuator. Therefore, the spring damper causes the actuator to open the air control valves fully. By opening the air control valves, the same effect as shortening the intake manifold is obtained. This shifts the peak intake efficiency to the high engine speed range, improving output in the high-speed range.



OHP 87

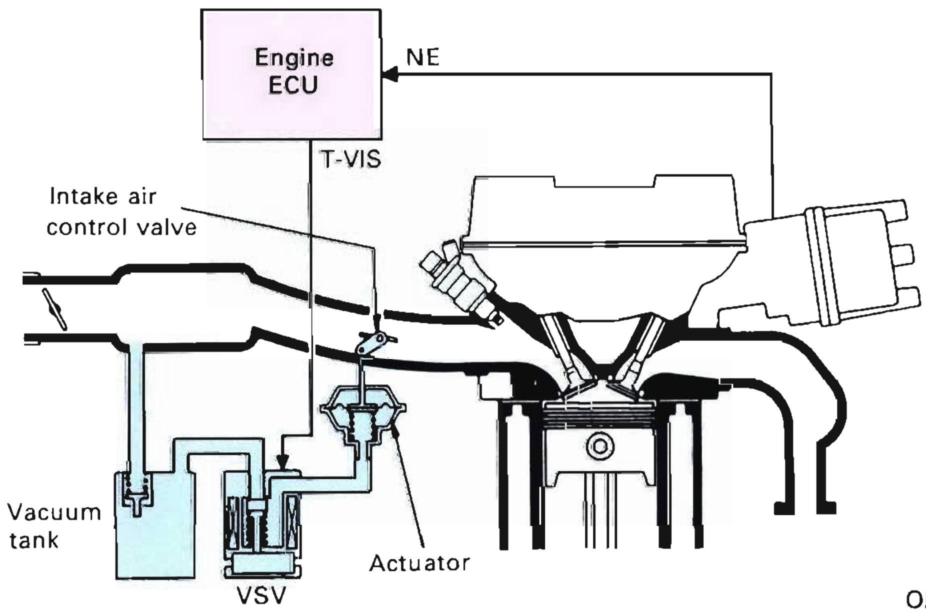
T-VIS (TOYOTA-VARIABLE INDUCTION SYSTEM)

GENERAL

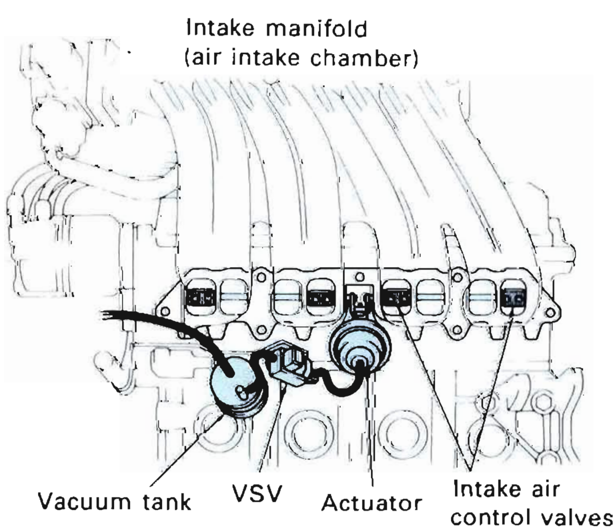
a. The intake manifold passage leading to each cylinder is divided into two parts. One of these (the variable induction passage) is provided with an intake air control valve. This valve opens and closes in accordance with the speed of the engine, thus acting as a variable induction valve. This makes it possible to improve engine performance in the low-speed range without sacrificing the high engine speed and output that are distinctive features of engines with four valves per cylinder.

b. The intake air control valves for all cylinders are constructed as one unit, and are opened and closed together by an actuator.

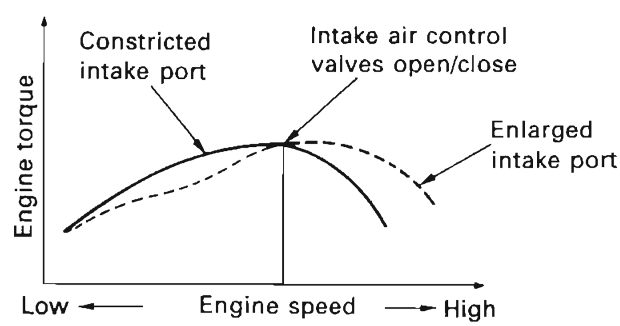
c. The improvement in the performance of the engine due to the adoption of T-VIS is shown in the graph below.



OHP 88



OHP 88



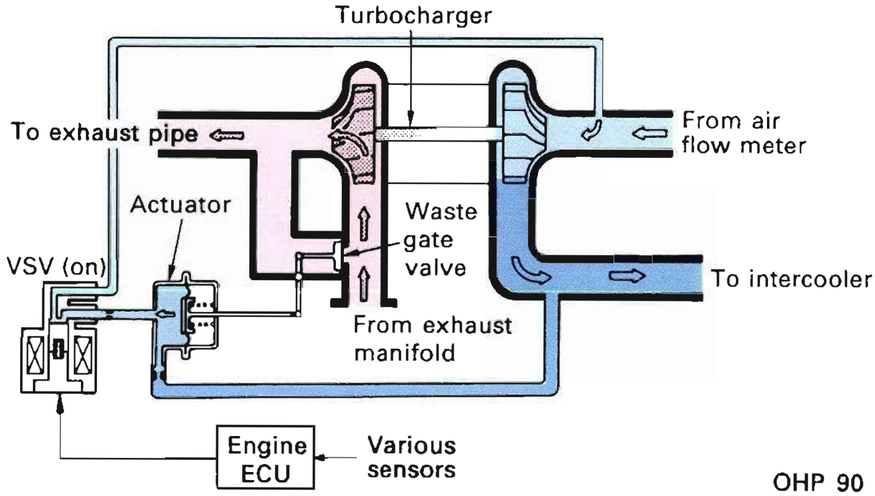
OHP 88

TURBOCHARGING PRESSURE CONTROL SYSTEM

The Engine ECU turns the VSV on and off* to control the turbocharging pressure in accordance with the type of gasoline being used (regular or premium), the coolant temperature, intake air temperature, intake air volume, and engine speed.

This maximizes engine performance and maintains engine durability, as well as suppressing knocking under all engine running conditions, including warm-up, irrespective of the gasoline octane rating.

* The VSV is controlled with the duty ratio in some models.



OHP 90

OPERATION

The VSV is turned on by the ECU to increase the turbocharging pressure when the fuel is judged to be premium by the fuel octane judgment function (See page 116), and when the coolant temperature and intake air temperature are within a predetermined temperature, and the intake air volume is above a predetermined level.

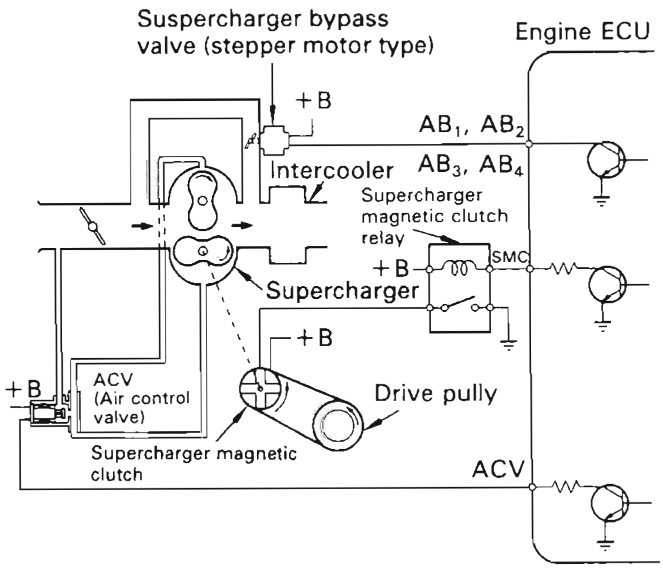
The VSV does not turn on unless all of the above conditions are met, even when premium gasoline is used.

REFERENCE

For a detailed explanation of the construction and operation of the turbocharger, see Step 3, vol. 2 (Turbocharger and Supercharger).

SUPERCHARGER CONTROL SYSTEM

The Engine ECU controls the supercharger relay, thus turning the supercharger magnetic clutch on and off. It also controls supercharger operation by controlling the supercharger bypass valve (stepper motor type).
In addition, the ECU controls the ACV to reduce supercharger oil consumption.

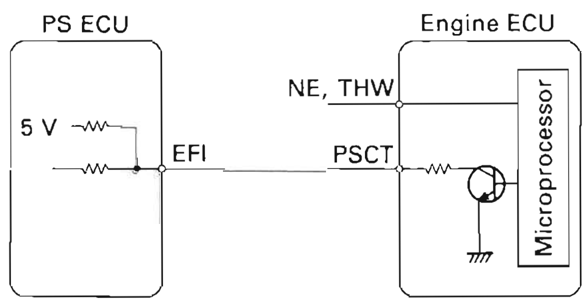


REFERRENCE

In previous models, VSV and ABV (air bypass valve) have been used instead of a supercharger bypass valve.
For a deteiled explanation of the construction and operation of the supercharger, see Step 3, vol. 2 (Turbocharger and Supercharger).

EHPS (ELECTRO-HYDRAULIC POWER STEERING) CONTROL SYSTEM

In vehicles equipped with the EHPS, when the engine coolant temperature or the engine speed is very low, the load on the alternator is increased when the vane pump motor of the EHPS is driven. This condition makes it easier for poor engine startability or engine stalling to occur. To prevent this, the vane pump motor is stopped during cold starting or when the engine speed is extremely low.



OHP 90

REFERENCE

EHPS is a type of power steering in which the vane pump is driven by an electric motor.

AS (AIR SUCTION) CONTROL SYSTEM

The AS system is operated by the ECU when exhaust emissions tend to increase; e.g., when the engine is cold and during deceleration. Under other operating conditions, this system does not operate to prevent overheating of the TWC (three-way catalyst).

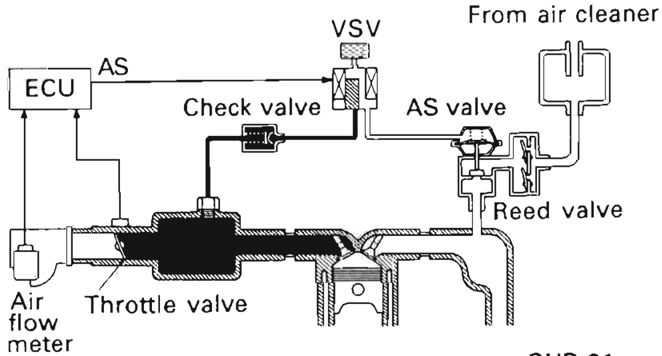
OPERATION*

The ECU switches on the VSV for the AS system and operates the AS system when all of the following conditions are met:

a. Engine cold
- Coolant temperature below 35°C (95°F)
- EFI power enrichment not operating.
- Engine speed below a predetermined level.

b. Deceleration
- Coolant temperature above 35°C (95°F)
- IDL contact closed (accelerator pedal completely released.)
- Engine speed between about 1000 and 3000 rpm.

* Depending on the engine models.



OHP 91

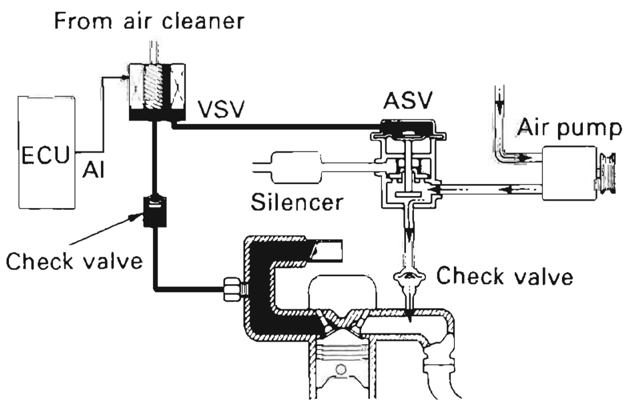
AI (AIR INJECTION) CONTROL SYSTEM

The AI system is operated by the ECU when exhaust emissions tend to increase; e.g., when the engine is cold and during deceleration. Under other conditions, this system does not operate to prevent overheating of the TWC.

OPERATION*

When it is activated by the ECU, the VSV introduces intake manifold vacuum into the ASV (air switching valve) diaphragm chamber.
This causes the air discharged by the air pump to pass through the check valve and be injected into the cylinder head's exhaust port. If the supply of current to the VSV is stopped, atmospheric air is introduced into the ASV's diaphragm chamber and the passage to the air injection exhaust port is closed off, resulting in the discharged air pushing against the spring inside the ASV and being discharged outside through the silencer.

* Depending on the engine models.



OHP 91

REFERENCE

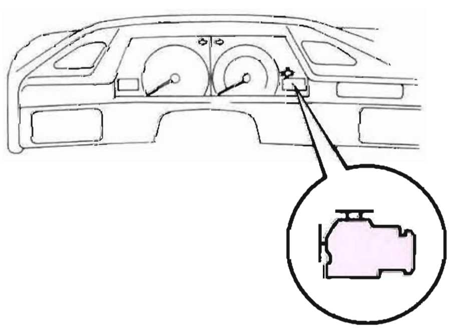
There are some recent models in which the Engine ECU sends the vehicle speed signal or engine speed signal to combination meter. The combination meter then operates the speedometer and tachometer based on these signals.

DIAGNOSIS

GENERAL

The ECU contains a built-in diagnostic system. Depending on the vehicle model, the diagnostic system has a normal mode only, or it can have a normal mode and a test mode.

In the normal mode, the ECU (which is constantly monitoring most sensors) lights the "CHECK ENGINE" lamp when it detects a malfunction in certain sensors or their circuitry. At the same time, the ECU registers the system containing the malfunction in its memory. This information is retained in memory even after the ignition switch is turned off. When the vehicle is brought into the shop because of trouble in the engine control system, the contents of the memory may be checked to identify the malfunction.



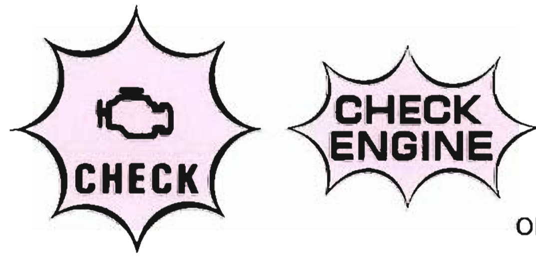
"CHECK ENGINE" lamp

OHP 92

The "CHECK ENGINE" lamp does not light when certain malfunctions are detected (See pages 138 to 140), because those malfunctions would not cause any major trouble such as engine stalling.

After a malfunction is corrected, the "CHECK ENGINE" lamp turns off. However, the ECU memory retains a record of the system in which the malfunction occurred.

In most engines, the contents of the diagnostic memory can be checked by connecting terminal T or TE1 with E1 of the check connector or TDCL (Toyota diagnostic communication link) and counting the number of times the "CHECK ENGINE" lamp blinks.



OHP 92

NOTE

In the case of OBD-II used for vehicles sold in the U.S.A. and Canada, an OBD-II scan tool or TOYOTA hand-held tester is required to read diagnostic codes (See page 137-2).

In some older model engines, the contents of the diagnostic memory can be checked by connecting a service wire to terminals T and E1 of the check connector and an analog voltmeter to terminals VF and E1 of the EFI service connector, then checking the voltage fluctuations.

In recent models, a test mode function has been added to the functions of the diagnostic system for the purpose of detecting intermittent problems (such as poor contact) which are difficult to detect in the normal mode.

The test mode is used only by the technician for troubleshooting the engine control system. Compared to the normal mode, it has been given a greater sensitivity. For example, in the normal mode, the ECU will light the "CHECK ENGINE" lamp and register the problem in memory if the same trouble is detected two times in succession; in the test mode, however, the ECU will light the "CHECK ENGINE" lamp and register it in memory if the trouble is detected even once.

The test mode is made operative by the technician by means of a predetermined procedure.

The method of reading the diagnostic codes in the test mode is the same as in the normal mode. The methods for utilizing the normal mode and test mode is explained in the TROUBLESHOOTING section (page 149).

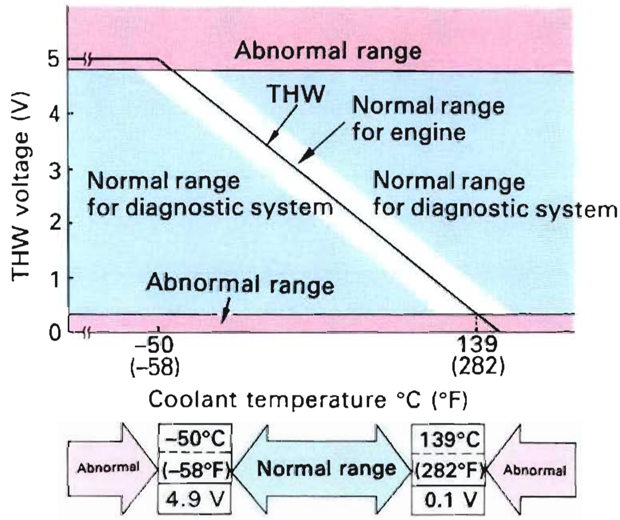
The items which cause the ECU to light the "CHECK ENGINE" lamp and the items registered in memory when the ECU detects trouble differ depending on the mode as well as on the vehicle model. Please refer to the repair manual for the affected vehicle. See CHECKING AND CLEARING DIAGNOSTIC CODES (page 159) for the normal mode and test mode setting procedure, code output methods, and code clearing methods.

In addition, various types of information are output by the VF terminal of the check connector, depending on the state of the T or TE1 terminal and the state of the IDL contacts of the throttle position sensor. For details, see VF OR VF1 TERMINAL OUTPUT in this section (page 136).

PRINCIPLE OF DIAGNOSTIC SYSTEM

The signal level that signifies to the ECU that an input or output signal is normal is fixed for that signal.

When signals for a particular circuit are abnormal with respect to this fixed level, that circuit is diagnosed as being abnormal. For example, when the coolant temperature signal circuit is normal, the voltage at the THW terminal is in a fixed range between 0.1 to 4.9 V. This signal circuit is diagnosed as being abnormal when the THW terminal voltage is less than 0.1 V (a coolant temperature of 139°C [282°F] or greater) or greater than 4.9 V (a coolant temperature of –50°C [–58°F] or lower).



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"CHECK ENGINE" LAMP AND VF OR VF1 TERMINAL OUTPUT

The "CHECK ENGINE" lamp and the output voltage of the VF or VF1 terminal have the following functions which differ depending on the state of the T, TE1 or TE2*5 terminal (of the check connector or TDCL) and the idle contact in the throttle position sensor.

T or TE1 TERMINAL	TE2*5 TERMINAL	IDL CONTACT	"CHECK ENGINE" LAMP	VF or VF1 TERMINAL OUTPUT		
Off (open)	Off (open)	Off	• Bulb check function (engine stopped) • Warning display function with normal mode (engine operating)	Results of air-fuel ratio learned control *1	5 V	Increased injection volume
					3.75 V	Increased injection volume
					2.5 V	Normal Air-fuel ratio feedback correction stopped *2
		On			1.25 V	Decreased injection volume
					0 V	Decreased injection volume Air-fuel ratio feedback correction stopped *2
	On (TE2 and E1 terminals connected)	Off	• Bulb check function (engine stopped) • Warning display function with test mode (engine operating)	Engine ECU data		
		On				
On (T or TE1 and E1 terminals connected)	Off (open)	Off	Diagnostic code display function with normal mode *3	Results of oxygen sensor signal processing	5 V	Rich signal
					0 V	Lean signal or openloop operation *4
				Results of lean mixture sensor signal processing	5 V or 2.5 V	Feedback correction not taking place
					0 V	Feedback correction taking place
		On		Results of diagnostic	5 V	Normal
					0 V	Malfunction code stored
	On (TE2 and E1 terminals connected)	Off	Diagnostic code display function with test mode *3	Engine ECU data		
		On				

*1 Some systems have five levels, as shown here, while other systems have only three levels (0 V, 2.5 V and 5 V).

*2 The VF or VF1 terminal output when air-fuel ratio feedback correction is not being carried out is either 0 V or 2.5 V, depending on the vehicle.

*3 Some models do not display diagnostic codes when the idle contact are off.

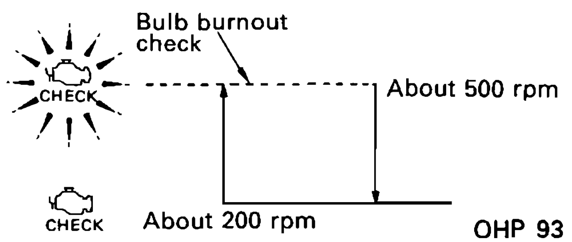
*4 "Open-loop operation" refers to the state in which the oxygen sensor signal is not being used for control (See page 75).

*5 Only models having a test mode.

1. "CHECK ENGINE" LAMP FUNCTIONS

LAMP CHECK FUNCTION (T or TE1 terminal off)

The "CHECK ENGINE" lamp goes on when the ignition switch is turned on to inform the driver that it has not burnt out. It goes out again when the engine speed reaches 500 rpm. (The engine speed may differ in some engine models.)



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WARNING DISPLAY FUNCTION (T or TE1 terminal off)

When trouble occurs and the ECU has detected its occurrence in one of the input/output signal circuits connected to the ECU (that is, one of those marked "ON" in the "CHECK ENGINE" LAMP column of the table on page 138), the "CHECK ENGINE" lamp goes on to aleart the driver. The lamp goes off when conditions are restored to normal. (This occurs only at an engine speed of 500 rpm or higher).

DIAGNOSTIC CODE DISPLAY FUNCTION (T or TE1 terminal on)

If the T or TE1 terminal is connected to the E1 terminal (after the ignition switch is turned on), diagnostic codes are displayed in order from the smallest to the largest code, with the number of times the "CHECK ENGINE" lamp blinks indicating the malfunction code number.

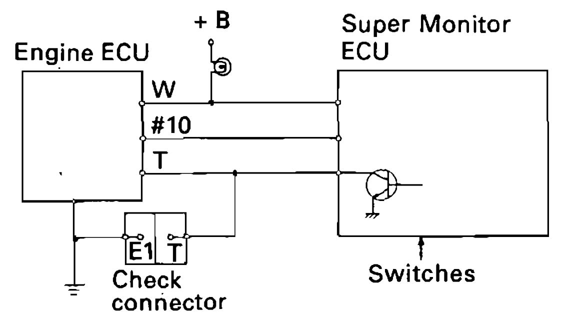
In some engines, a test mode has been provided which makes the diagnostic system more sensitive. This system is also provided with a TE2 terminal in the TDCL or check connector.

See CHECKING AND CLEARING DIAGNOSTIC CODES (page 159) for the normal mode and test mode setting procedure and the code output methods.

REFERENCE

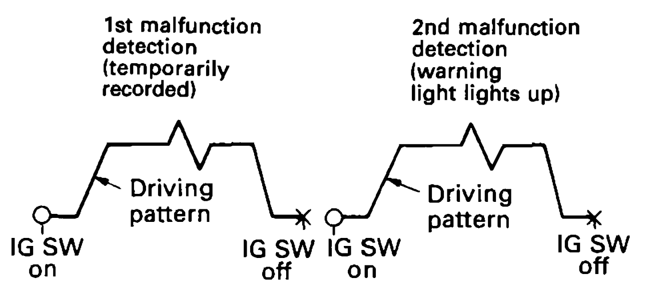
Super Monitor Display

When the results of a diagnostic output from the warning lamp terminal (terminal W) are displayed on a super monitor, the diagnostic code display will not appear on the monitor, if the injection signal is input to the Super Monitor ECU by the Engine ECU even once.



2-TRIP DETECTION LOGIC

Some diagnostic codes, such as codes 21 and 25 (See page 138), use "2-trip detection logic". With this logic, when a malfunction is first detected, it is temporarily stored in ECU memory. If the same malfuntion is detected again, this second detection causes the "CHECK ENGINE" lamp to light up. (However, the ignition switch must be turned off between the 1st time and 2nd time).



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In the test mode, the "CHECK ENGINE" lamp lights up the 1st time a malfunction is detected.

DIAGNOSTIC MODE AND "CHECK ENGINE" LAMP

The diagnostic mode (normal or test) and the output of the "CHECK ENGINE" lamp can be selected by changing the connections of the T or TE1, TE2 and E1 terminals on the check connector or TDCL, as shown in the table below.

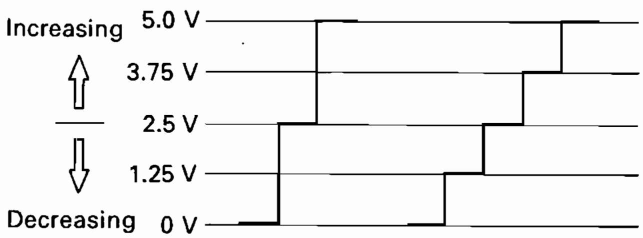
See CHECKING AND CLEARING DIAGNOSTIC CODES (page 159) for the normal mode and test mode setting procedure and the code output methods.

T OR TE1 AND E1 TERMINALS	TE2 AND E1 TERMINALS	DIAGNOSTIC MODE	"CHECK ENGINE" LAMP
Open	Open	Normal	Warns driver of malfunction
	Connected	Test	Notifies technician of malfunction
Connected	Open	Normal	Outputs diagnostic results (nature of malfunction), by number of times lamp blinks.
	Connected	Test	Outputs diagnostic results (nature of malfunction), by number of times lamp blinks.

2. VF OR VF1 TERMINAL OUTPUT

OUTPUT OF AIR-FUEL RATIO FEEDBACK CORRECTION (T, TE1 or TE2 terminal off)

The air-fuel ratio feedback correction amount is output in three or five levels from the VF or VF1 terminal of the check connector. When the value is normal, the output is constant at 2.5 V, but when the output is greater than 2.5 V, it indicates that feedback correction is on increase side, while an output lower than 2.5 V indicates that feedback correction is on decrease side.



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On engines which include a vane type air flow meter, when the VF voltage is other than 2.5 V, this voltage can be adjusted by tightening the idle mixture adjusting screw on the air flow meter.
The VF or VF1 terminal output when air-fuel ratio feedback correction is not being performed is either 0 V or 2.5 V, depending on the vehicle model.
Some vehicle models also have a VF2 terminal.
In V-type engines with a VF2 terminal, the VF1 terminal outputs information on the left bank cylinders and the VF2 terminal outputs information on the right bank cylinders.
In in-line 6-cylinder engines with a VF2 terminal, the VF1 terminal outputs information on the No. 1 to No. 3 cylinders, and the VF2 terminal outputs information on the No. 4 to No. 6 cylinders.

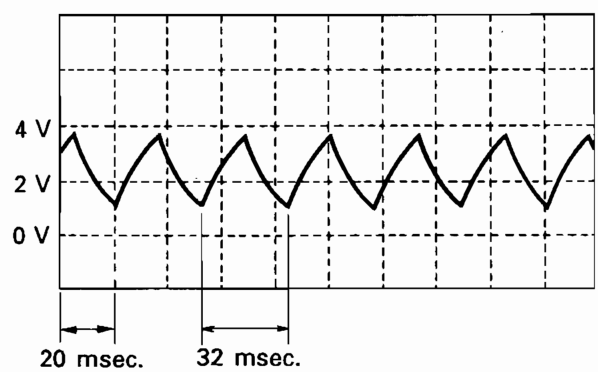
NOTE

1. **When adjusting the idle mixture adjusting screw, turn it slowly, a little at a time. If this screw is turned too quickly, air-fuel ratio feedback correction will be halted and you will not be able to adjust the VF voltage.**
2. **In vehicles in which the idle mixture adjusting screw is sealed, the ECU automatically adjusts the idle mixture. Therefore, it is not necessary to adjust the idle mixture.**

REFERENCE

VF or VF1 Terminal Voltage

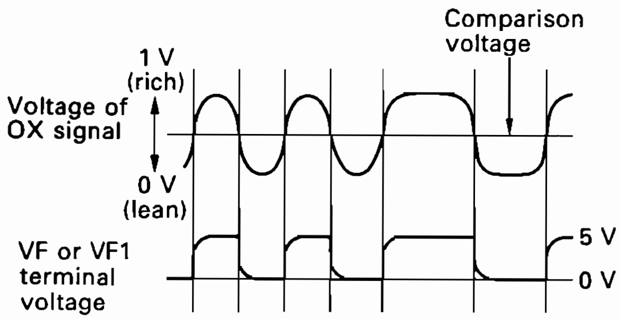
When measured on an oscilloscope, the output waveform of the VF or VF1 terminal voltage has a constant period of approximately 32 msec (depending on the engine model), as shown in the figure below.



When a voltmeter is used to measure the value, a virtually constant value is displayed.

OXYGEN SENSOR SIGNAL OUTPUT (T or TE1 terminal on, TE2 terminal off, idle contact off)

To read the output of the oxygen sensor, connect terminal T or TE1 with terminal E1, with the idle contact off. Then measure the voltage at the VF or VF1 terminal. (The output from this terminal is not the actual signal that is output by the oxygen sensor, but a signal that has been digitalized by the ECU for easier reading.)
This signal is 5 V when the input signal from the oxygen sensor is higher than the comparison voltage set by the ECU, and is 0 V when the input signal is lower than the comparison voltage or during an open-loop operation.



OHP 93

When using a voltmeter to check air-fuel ratio feedback correction, first warm up the oxygen sensor by warming up the engine, then, while maintaining engine speed at 2,500 rpm to keep the idle contact off, measure the VF voltage. (See page 182 for the method of outputting this signal.)

LEAN MIXTURE SENSOR SIGNAL OUTPUT (T or TE1 terminal on, TE2 terminal off, idle contact off)

This signal is 0 V while air-fuel ratio feedback correction is taking place, and 2.5 V or 5 V when air-fuel ratio feedback correction is not taking place. (See page 183 for the method of outputting this signal.)

DIAGNOSIS OUTPUT (T or TE1 terminal on, TE2 terminal off, idle contact on)

(1) Output of results

Connecting the T or TE1 terminal to the E1 terminal causes the ECU (VF or VF1 terminal) to signal whether there are any data in the diagnostic memory or not. If all the diagnostic results are normal, a 5 V signal will be output, but if any malfunction codes are stored in memory, a 0 V signal will be output (that is, the voltage at the VF or VF1 terminal will fall to zero).

(2) Diagnostic code number output

In older model engines, diagnostic results are read by connecting an analog voltmeter to the VF terminal and counting the number of oscillations of the needle of the voltmeter. This number corresponds to the trouble code number, which can then be looked up to identify the trouble.
See the relevant repair manual concerning the output method for the diagnostic codes and display format.

ENGINE ECU DATA OUTPUT (TE2 terminal on)

In engines having a test mode for diagnosis, the Engine ECU has the function to output data calculated according to signals from each sensor. Output data accounts for a portion of input data from sensors and output data to actuators. Since the data is output in the form of serial communications, it cannot be read without using a TOYOTA hand-held tester, DIAGNOSIS READER or DIAGNOSIS MONITOR.

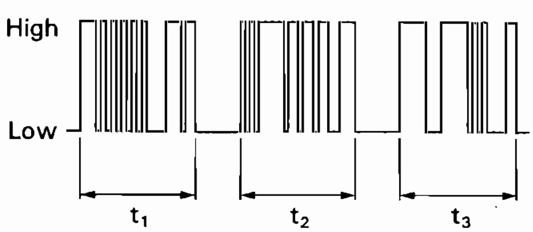
Refer to the Repair Manual or the Handling Manual of a TOYOTA hand-held tester, DIAGNOSIS READER or DIAGNOSIS MONITOR for information on the reading procedure and output parameters.

REFERENCE

Serial Communication:

Serial communication is one of digital communication. One piece of data is sent by combining high (1) and low (0) signals for each unit time (t).

Multiple pieces of data can be sent with a single communication line.



REFERENCE

OBD-Ⅱ (On-Board Diagnostic system)

OBD regulations refer to those regulations used in the U.S.A.
In order to detect if the vehicle is emitting harmful exhaust gases into the atmosphere, the OBD system enables the Engine ECU*1 to detect any malfunctions of the engine and exhaust control systems and warn the driver of such conditions via the "CHECK ENGINE" lamp *2.
There are two types of OBD regulations, namely OBD-Ⅰ and OBD-Ⅱ. OBD-Ⅰ regulations are satisfied with the diagnostic system that has been conventionally used by Toyota. OBD-Ⅱ regulations require the functions shown in the table below against OBD-Ⅰ regulations.

*1 SAE term; ECM (engine control module)
*2 SAE term; MIL (malfunction indicator lamp)

○ = Required . × = Not required

Required item	OBD-Ⅰ	OBD-Ⅱ
• Detect malfunctions and turn on "CHECK ENGINE" lamp	○ (8 items)	○ (41 items)
• Standardize malfunction codes	×	○
• Output Engine ECU data	×	○ (17 items)
• Freeze-frame data*	×	○ (13 items)
• Communicate between Engine ECU and diagnostic tool	×	○
• Standardize diagnostic tools	×	○
• Standardize diagnostic connectors	×	○

*An Engine ECU function to store important control data into internal memory during the detection of a malfunction.

The main characteristic of OBD-Ⅱ is the unification of diagnostic codes and the use of a special-purpose tester. As a result, communication protocol between the tester and the DLC (Date Link Connector) and Engine ECU are standardized. Furthermore, in the case of OBD-Ⅱ, measurement of engine rpm and inspection of each function of the Engine ECU cannot be performed without using a special-purpose tester.

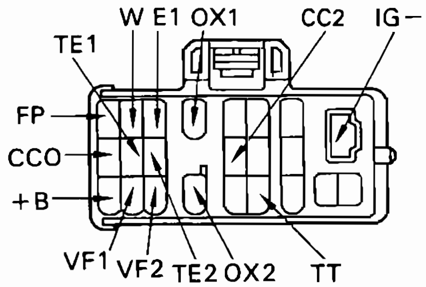
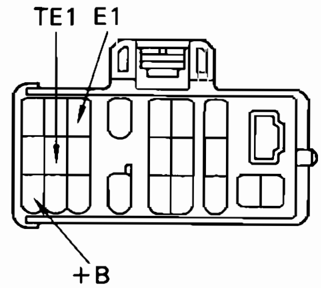
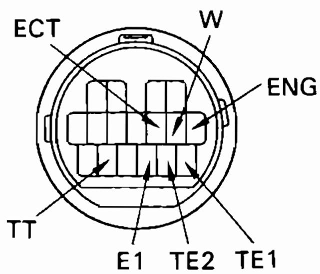
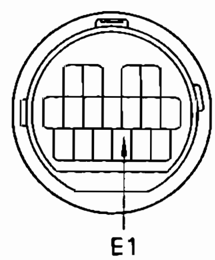
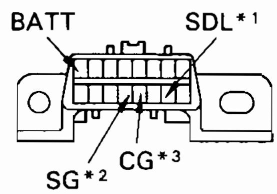
Toyota employs a system in which original functions have been added to those required by OBD-Ⅱ regulations. The following describes some of the major differences between Toyota's conventional OBD system and the new OBD system (OBD-Ⅱ) provided in vehicles sold in the U.S.A. and Canada.

		Conventional OBD	New OBD (OBD-II)
CHECK ENGINE LAMP	When a problem has been detected	Lights	Lights or blinks
	When the problem has been solved	Goes off after about 5 seconds	Goes off after 2 or 3 trips
DIAGNOSTIC CODE	Code	2 digits (e.g.: 25, 31)	5 digits (e.g.: P0120)
	Reading operation	Connection of terminal TE1 and terminal E1	OBD-II scan tool or TOYOTA hand-held tester
	Code display	"CHECK ENGINE" lamp blinks	
	Code clearing*1	Removal of memory fuse	
ENGINE ECU DATA	Reading operation	Connection of terminal TE2 and terminal E1	
	Reading instruments	DIAGNOSIS REDER, DIAGNOSIS MONITOR, or TOYOTA hand-held tester	
	Output terminal	Terminal VF	Terminal SDL*2
	Communication rate	Slow (about 1.5 seconds)	Fast (about 0.05 to 1.0 seconds)
	Data display items	Few	Many
	Data display method	Toyota standard	SAE standard
ACTIVE TEST*3		Not available	Available (performed using an OBD-II scan tool or TOYOTA hand-held tester)
FREEZE-FRAM DATA		Not available	

*1 In the case of a new OBD (OBD-II), diagnostic codes can also be cleared by removing the memory fuse in the same manner as the conventional OBD.

*2 SDL; The communication terminal between the Engine ECU and the TOYOTA hand-held tester use the VPW (Variable Pulse Width) system in accordance with the SAE J1850 requirements.

*3 Actuators (injector, ISC valve, etc.) are operated by sending a signal from the tester to the Engine ECU.

		Conventional OBD	New OBD (OBD-II)
CHECK CONNECTOR (DLC) AND TERMINAL (Only those related to the Engine ECU)	CHECK CONNECTOR (DLC 1)		
	TDCL (DLC2)		
	DLC3	—	

*1 SDL; The communication terminal between the Engine ECU and the TOYOTA hand-held tester use the VPW (Variable Pulse Width) system in accordance with the SAE J1850 requirements.
*2 SG; Signal graund
*3 CG; Chassis graund

DIAGNOSTIC CODES

The "CHECK ENGINE" lamp lights up when trouble occurs. It goes off again 5 seconds after the relevant system is restored to normal. (Remember, however, that when the engine speed is lower than 500 rpm, the lamp may light up for the bulb burnout check.)

If two or more problems have occurred and are stored in memory, the malfunction codes will be displayed in order from the smallest code.

Code numbers and their meanings for the 4A-FE engine (Corolla AE101 for Europe) are as shown in the following table.

Diagnostic items and the meanings of the malfunction codes differ depending on the engine model. For details, see the Repair Manual for the relevant engine.

(As Feb., 1992)

CODE NO.	NUMBER OF TIMES "CHECK ENGINE" LAMP BLINKS	CIRCUITRY	"CHECK ENGINE" LAMP*1 NORMAL MODE	"CHECK ENGINE" LAMP*1 TEST MODE	DIAGNOSIS (MEANING OF TROUBLE CODE)	TROUBLE AREA	*2 MEMORY
–		Normal	–	–	Output when no other code is recorded.	–	–
12		RPM signal	ON	N.A.	• No "NE" signal to ECU within 2 seconds after engine is cranked. • No "G" signal to ECU for 3 seconds when the engine speed is between 600 rpm and 4000 rpm.	• Open or short in NE, G circuit • IIA • Open or short in STA circuit • ECU	○
13		RPM signal	ON	N.A.	No "NE" signal to ECU when the engine speed is above 1500 rpm.	• Open or short in NE circuit • IIA • ECU	○
			N.A.	ON	No "G" signal to ECU while "NE" signal is input 4 times to ECU when engine speed is between 500 rpm and 4000 rpm.		
14		Ignition signal	ON	N.A.	No "IGF" signal to ECU 4 times in succession.	• Open or short in IGF or IGT circuit from igniter to ECU • Igniter • ECU	○
21		Oxygen sensor circuit	OFF	N.A.	Open or short circuit in oxygen sensor heater wire (HT).	• Open or short in heater circuit of oxygen sensor • Oxygen sensor heater • ECU	○
				ON	During air-fuel ratio feedback correction, output voltage of oxygen sensor remains between 0.35 V and 0.7 V continuously for a certain period. *3 (2 trip detection logic)	• Open or short in oxygen sensor circuit • Oxygen sensor • ECU	
22		Water temp. sensor signal	ON	ON	Open or short circuit in water temp. sensor signal (THW).	• Open or short in water temp. sensor circuit • Water temp. sensor • ECU	○
24		Intake air temp. sensor signal	OFF	ON	Open or short circuit in intake air temp. sensor signal (THA).	• Open or short in intake air temp. circuit • Intake air temp. sensor • ECU	○
25		Air-fuel ratio lean malfunction	OFF	ON	Oxygen sensor output is less than 0.45 V for at least 90 secs. or more when oxygen sensor is warmed up (racing at 2,000 rpm). *3 (2 trip detection logic)	• Engine ground bolt loose • Open in E1 circuit • Open in injector circuit • Fuel line pressure (Injector blockage, etc.) • Open or short in oxygen sensor circuit • Oxygen sensor • Ignition system	○
31		Vacuum sensor signal	ON	ON	Open or short circuit in manifold pressure sensor signal (PIM).	• Open or short in vacuum sensor circuit • Vacuum sensor • ECU	○

CODE NO.	NUMBER OF TIMES "CHECK ENGINE" LAMP BLINKS	CIRCUITRY	"CHECK ENGINE" LAMP*1		DIAGNOSIS (MEANING OF TROUBLE CODE)	TROUBLE AREA	*2 MEMORY
			NORMAL MODE	TEST MODE			
41		Throttle position sensor signal	OFF	ON	Open or short circuit in throttle position sensor signal (VTA).	• Open or short in throttle position sensor circuit • Throttle position sensor • ECU	○
42		Vehicle speed sensor signal	OFF	N.A.	No "SPD" signal to ECU for 8 seconds when vehicle is running.	• Open or short in vehicle speed sensor circuit • Vehicle speed sensor • ECU	○*4
			N.A.	OFF	No "SPD" signal input to ECU after ignition switch is turned on.		
43		Starter signal	N.A.	OFF	No "STA" signal input to ECU after ignition switch is turned on.	• Open or short in starter signal circuit • Open or short in IG SW or main relay circuit • ECU	×
52		Knock sensor signal	ON	N.A.	With engine speed between 1,200 rpm and 6,000 rpm, signal from knock sensor is not input to ECU for certain period. (KNK)	• Open or short in knock sensor circuit • Knock sensor (looseness, etc.) • ECU	○
51*5		Switch condition signals	N.A.	OFF	Displayed when A/C is ON, IDL contact OFF or shift lever is in "R", "D", "2", or "L" range and STA is OFF with the check terminals E1 and TE1 connected at test mode.	• A/C switch system • Throttle position sensor IDL circuit • Accelerator pedal, cable • ECU	×

*1 "ON" displayed in the diagnosis mode column indicates that the "CHECK ENGINE" lamp is lighted up when a malfunction is detected. "OFF" indicates that the "CHECK ENGINE" lamp does not light up during malfunction diagnosis, even if a malfunction is detected. "N.A." indicates that the item is not included in malfunction diagnosis.
Lighting of the "CHECK ENGINE" lamp varies depending on engine models and the destinations.

*2 " ○ " in the memory column indicates that a diagnostic code is recorded in the ECU memory when a malfunction is detected. " × " indicates that a diagnostic code is not recorded in the ECU memory even if a malfunction is detected. Accordingly, output of diagnostic results in normal or test mode is performed with the ignition switch ON.

*3 "2 trip detection logic" (See page 134) is only active at the normal mode.

*4 Not stored in memory at the test mode.

*5 IDL contact off is not detected until after the engine starts.

REFERENCE

Examples of diagnostic codes of OBD-II compatible engines in vehicles sold in the U.S.A. and Canada are show below. In the same manner as the conventional OBD system, the OBD-II system has a check mode function in which detection of a problem has greater sensitivity than the normal mode.

- Camry 1MZ-FE engine (1994 model year)

CODE NO.	CIRCUITRY	"CHECK ENGINE" LAMP *1	DIAGNOSIS (MEANING OF TROBLE CODE)	TROUBLE AREA	*2 MEMORY
P0100	Mass air flow circuit malfunction	ON	Open or short in mass air flow meter circuit with engine speed 4,000 rpm or less	• Open or short in mass air flow meter circuit • Mass air flow meter • ECU	○
P0101	Mass air flow circuit range/performance problem	ON	Conditions a) and b) continue with engine speed 900 rpm or less: (2 trip detection logic) *3 a) Closed throttle position switch: ON b) Mass air flow meter output > 2.2 V	• Mass air flow meter	○
P0110	Intake air temp. circuit malfunction	ON	Open or short in intake air temp. sensor circuit	• Open or short in intake air temp. sensor circuit • Intake air temp. sensor • ECU	○
P0115	Engine coolant temp. circuit malfunction	ON	Open or short in engine coolant temp. sensor circuit	• Open or short in engine coolant temp. sensor circuit • Engine coolant temp. sensor • ECU	○
P0116	Engine coolant temp. circuit range/ performance problem	ON	20 min. or more after starting engine, engine coolant temp. sensor value is 30°C (86°F) of less (2 trip detection logic) *3	• Engine coolant temp. sensor • Coolant system	○

*1 "ON" displayed in the diagnosis mode column indicates that the "CHECK ENGINE" warning light is lighted up when a malfunction is detected.

*2 "○" in the memory column indicates that a diagnostic code is recorded in the ECU memory when a malfunction is detected. Accordingly, output of diagnostic results in normal or test mode is performed with the ignition switch ON.

*3 "2 trip detection logic" (See page 134).

FAIL-SAFE FUNCTION

FAIL-SAFE FUNCTION

If the Engine ECU were to continue to control the engine based on faulty signals, other malfunctions could occur in the engine. To prevent such a problem, the fail-safe function of the ECU either relies on the data stored in memory to allow the engine control system to continue operating, or stops the engine if a hazard is anticipated.

The following table describes the problems which can occur when trouble occurs in the various circuits, and the responses of the fail-safe function.
(A circle in the "4A-FE ENGINE" column indicates the provision of the fail-safe function in vehicles equipped with the 4A-FE engine.)

CIRCUITRY WITH ABNORMAL SIGNALS	NECESSITY	OPERATION	4A-FE ENGINE
Ignition confirmation (IGF) signal circuitry	If trouble occurs in the ignition system and ignition cannot take place (the ignition confirmation [IGF] signal doesn't reach the ECU), the catalyst could overheat due to misfiring.	Fuel injection is stopped.	○
Manifold pressure sensor (vacuum sensor) (PIM) signal circuitry	If an open or short circuit occurs in the intake manifold pressure sensor signal circuitry, the basic injection duration cannot be calculated, resulting in engine stalling or inability to start the engine.	Fixed (standard) values determined at the time of starting by the condition of the idle contact are used for the fuel injection duration and the ignition timing making engine operation possible.*1	○
Air flow meter (VS, KS or VG) signal circuitry (some engine models only)	If an open or short circuit occurs in the air flow meter signal circuitry, it becomes impossible to detect the intake air volume and calculation of the basic injection duration cannot be done. This results in engine stalling or inability to start the engine.	Fixed (standard) values determined at the time of starting or by the condition of the idle contact are used for the fuel injection duration and the ignition timing making engine operation possible.	
Throttle position (VTA) signal circuitry (linear type)	If an open or short circuit occurs in the throttle position sensor signal circuitry, the ECU detects the throttle valve as being either fully open or fully closed. As a result, the engine stalls or runs rough.	Values for normal operation (standard values) are used. (These standard values differ depending on the engine model.)	○*2
Engine crankshaft angle sensor (G1 and G2) signal circuitry	Since the G1 and G2 signals are used in cylinder identification and in detecting the crankshaft angle, if an open or short circuit occurs, the engine cannot be controlled, resulting in engine stalling or inability to start the engine.	If only the G1 or only the G2 signal is still being received, the standard crankshaft angle can still be judged by the remaining G signal.	○*2

(Continued on next page)

*1 In previous models, the back-up mode is entered when terminal T is off. There were also some models in which standard values are used for the intake manifold pressure signal if terminal T is connected to the E1 terminal.

*2 Only for models which are equipped with the lean mixture sensor.

CIRCUITRY WITH ABNORMAL SIGNALS	NECESSITY	OPERATION	4A-FE ENGINE
• Water temp. sensor (THW) signal circuitry • Intake air temp. sensor (THA) signal circuitry	If an open or short circuit occurs in the water temperature or intake air temperature signal circuitry the ECU assumes that the temperature is below -50°C (-58°F) or higher than 139°C (274°F). This results in the air-fuel ratio becoming too rich or too lean, which results in engine stalling or the engine running rough.	Values for normal operation (standard values) are used. These standard values differ depending on engine characteristics, but generally, a coolant temperature of 80°C (176°F) and an intake air temperature of 20°C (68°F) are used.	○
Lean mixture sensor (LS) signal circuitry	If the cover of the lean mixture sensor becomes fouled with carbon, the ECU cannot detect the correct oxygen concentration in the exhaust gas, so it cannot keep the air-fuel ratio at the optimal level.	Air-fuel ratio feedback correction is stopped.	○*
• Knock sensor (KNK) signal circuitry • Knock control system	If an open or short circuit occurs in the knock signal circuitry, or if trouble occurs in the knock control system inside the ECU, whether knocking occurs or not, ignition timing retard control will not be carried out by the knock control system. This could result in damage to the engine.	The corrective retard angle is set to the maximum value.	
High-altitude compensatior sensor (HAC) signal circuitry	If an open or short circuit occurs in the HAC sensor signal circuitry, the high-altitude compensation correction will be either the maximum or the minimum value. This will cause the engine to run poorly or reduce drivability.	Values for normal operation (standard values) are used. The standard atmospheric pressure value is 101 kPa (60 mmHg, 29.9 in.Hg).	
Turbocharging pressure (PIM) signal circuitry	Abnormal increases in the turbocharging pressure or intake air volume, as well as other factors, may cause damage to the turbocharger or engine.	Fail-safe stops engine by stopping fuel injection.	
Transmission control signal	If trouble occurs in the microprocessor for transmission control, the transmission will not operate properly.	Torque control correction (See page 96) by the ESA is stopped.	
Intercooler ECU (WIN) signal circuitry	If the amount of coolant supplied to the intercooler is insufficient, its cooling capacity will drop. This will cause the temperature of air taken into the cylinders to rise. As a result, the temperature of the gas inside the combustion chamber will rise even higher,. making it easy for knocking to occur.	The ignition timing is retarded by 2°.	

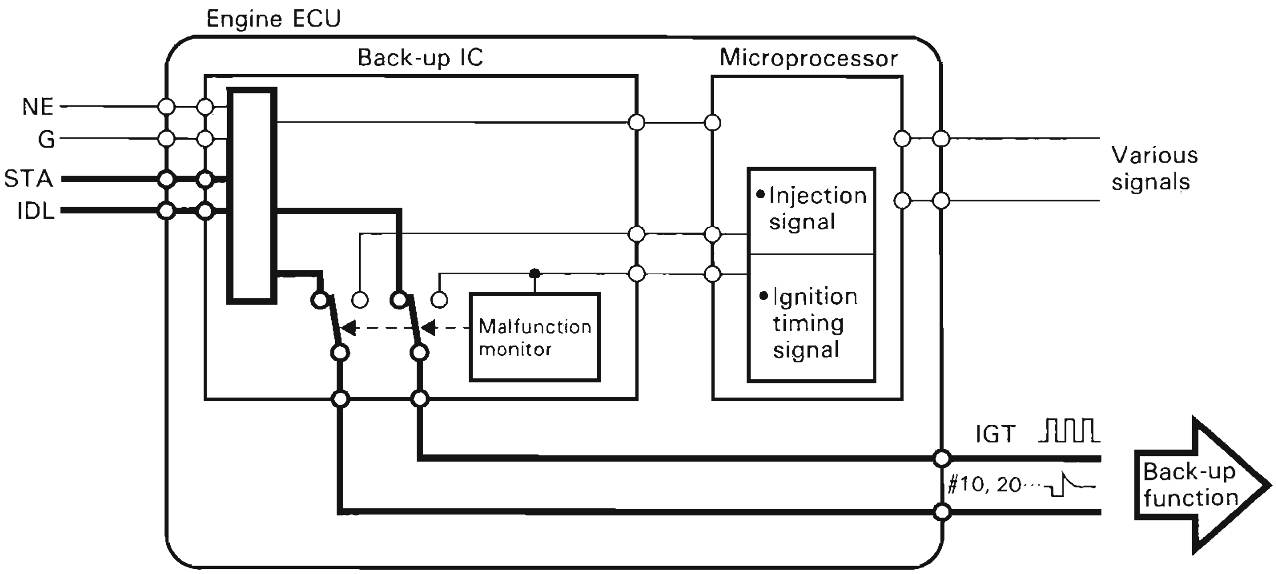
*Only for models which are equipped with the lean mixture sensor.

BACK-UP FUNCTION

BACK-UP FUNCTION

The back-up function is a system which switches to the back-up IC for fixed signal control* if trouble occurs with the microprocessor inside the ECU. This allows the vehicle to continue operating, though it assures the continuation of only basic functions; normal performance cannot be maintained.

*Control by the back-up IC in which the IC uses preprogrammed data to control the ignition timing and fuel injection duration.



OPERATION

The ECU switches to the back-up mode when the microprocessor stops outputting the ignition timing (IGT) signal.

When the ECU switches to the back-up mode, fixed values* are substituted for fuel injection duration and ignition timing and as a result, engine operation is maintained. The back-up IC sets the fixed values* according to the condition of the STA signal and the idle contact. At the same time, it lights the "CHECK ENGINE" lamp to inform the driver.

(Codes are not output in this case, however.)

*These values differ depending on the engine model.

In addition, on some recent models, when the back-up mode is entered, the engine is stopped by interrupting fuel injection.

NOTE

In the case of conventional D-type EFI, when the intake manifold pressure (PIM) signal was open or short circuited, the microprocessor forcibly switched to the back-up mode by interrupting the ignition timing (IGT) signal. More recently, however, fixed values for fuel injection duration and ignition timing are contained within the microprocessor. As a result, when a problem like that described above occurs, the microprocessor controls the engine with a fail safe function.

MEMO

TROUBLESHOOTING

GENERAL

The TCCS engine control system is a very complicated system requiring a high level of technical knowledge and expertise to troubleshoot successfully.
However, the basics of troubleshooting are the same whether an engine is equipped with a TCCS engine control system or it is a carbureted engine. In particular, you must look for:

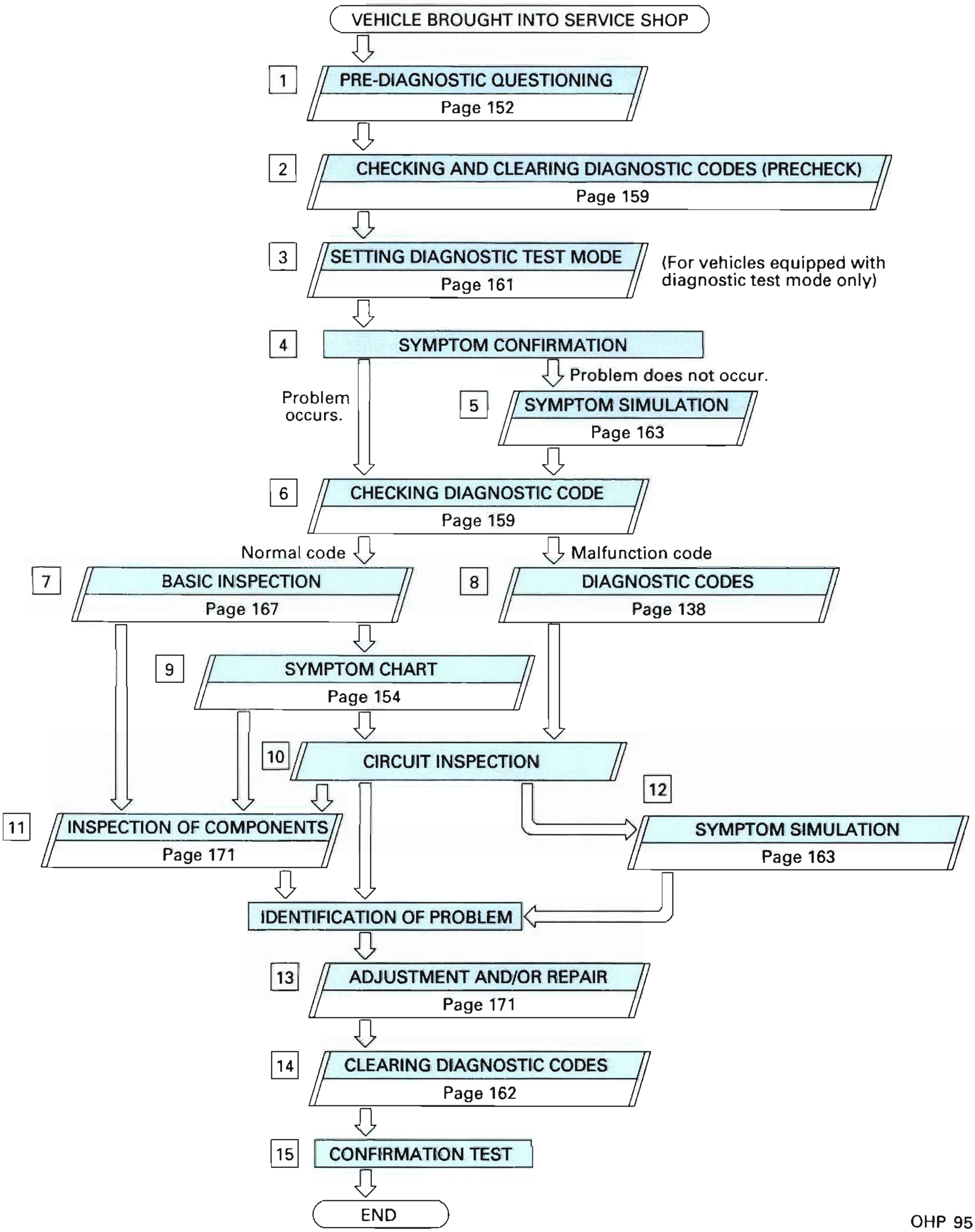
- An appropriate air-fuel mixture
- A high compression pressure
- Correct ignition timing and powerful sparks

Making effective use of the diagnostic system (See page 131) and taking into careful consideration the three items mentioned above will eliminate the complexities involved in troubleshooting vehicles with TCCS.
It is also very important to follow the correct procedures at all times. This section explains the general procedures and concepts involved in troubleshooting, from the point when the vehicle is brought into the service shop until the trouble is found and repaired and the confirmation test performed.

For correct troubleshooting procedures for a particular engine, see the Repair Manual for that engine model.

HOW TO CARRY OUT TROUBLESHOOTING

The ideal procedure for troubleshooting and how to carry out the necessary repairs are explained below.



OHP 95

1 PRE-DIAGNOSTIC QUESTIONING

Refering to the Pre-diagnostic Questioning Checksheet, ask the customer about the problem in as much detail as possible.

2 CHECKING AND CLEARING DIAGNOSTIC CODES (PRECHECK)

Before confirming the symptoms, check the diagnostic code in the normal mode and make a note of any malfunction codes displayed, then clear the codes.

3 SETTING DIAGNOSTIC TEST MODE
(for vehicles equipped with diagnostic test mode.)

In order to find the cause of the problem more quickly, set the system in the diagnostic test mode.

4 SYMPTOM CONFIRMATION

Confirm the symptoms of the problem.

5 SYMPTOM SIMULATION

If the symptoms do not reappear, use the symptom simulation method to reproduce them .

6 CHECKING DIAGNOSTIC CODE

Check the diagnostic codes. If the normal code is output, proceed to step 7. If a malfunction code is output, proceed to step 8.

7 BASIC INSPECTION

Carry out a basic inspection, such as an ignition spark check, fuel pressure check, etc.

8 DIAGNOSTIC CODES

If a malfunction code was output in step 6, check the trouble area indicated by the diagnostic code chart.

9 SYMPTOM CHART

If a trouble was not confirmed in step 7, perform troubleshooting according to the inspection items in the symptom chart.

10 CIRCUIT INSPECTION

Proceed with the diagnosis of each circuit between the ECU and the component in accordance with the inspection items confirmed in step 8 or step 9. Determine whether the cause of the trouble is in the sensors, the actuators, the wire harness or connector, or the ECU.

11 INSPECTION OF COMPONENTS

Inspect the problematic components.

12 SYMPTOM SIMULATION

If the cause of the trouble is momentary (intermittent) interruptions or shorts, pull gently on the wire harness, connectors, and terminals, and shake them gently to isolate the place where the trouble is occurring due to poor contact.

13 ADJUSTMENT AND/OR REPAIR

After the cause of the trouble is located, perform the necessary adjustment or repair.

14 CLEARING DIAGNOSTIC CODES

Clear the diagnostic codes.

15 CONFIRMATION TEST

After completing the adjustment or repairs, check to see whether the trouble has been eliminated, and perform a test drive to make sure the entire engine control system is operating normally and that the diagnostic code displayed is the normal code.

PRE-DIAGNOSTIC QUESTIONING (PDQ)

When carrying out troubleshooting, it is important that the technician remember to confirm the symptoms of the problem accurately and objectively, without preconceptions. (This means, for example, not to just guess about the cause of the problem, no matter how much experience the technician is basing his judgement on, but to carry out the troubleshooting step by step, according to the directions given here.)

No matter how experienced the technician, if troubleshooting is attempted before the symptoms have been confirmed, repairs will fail or a mistaken judgment will lead to the wrong repairs being performed.

As long as the symptoms of the problem are manifesting themselves at the time the vehicle is brought into the service shop, they can be confirmed right away. However, when the symptoms fail to manifest themselves, the technician must deliberately try to reproduce them. For example, a problem that occurs only when the vehicle is cold or the occurrence of vibration from the road surface during driving cannot be confirmed when the engine is warmed up or while the vehicle is sitting still, because the conditions under which the trouble occurred cannot be reproduced under such circumstances. Therefore, when attempting to ascertain what the symptoms are, it is extremely important to ask the customer about the problem and the conditions under which they occurred.

IMPORTANT POINTS IN PDQ

The six items shown below are especially important points to remember when carrying out Pre-diagnostic Questioning.

Information on past problems (even if they are thought to be unrelated to the present problem) and the repair history of the vehicle will also help in many cases, so as much information as possible should be gathered and its relationship with the symptoms should be correctly ascertained for reference in troubleshooting.

- **Who noticed the problem?**
  - With whom the problem most commonly occurs
- **What?**
  - Vehicle model
  - System in which problem has occurred
- **When?**
  - Date(s)
  - Time(s)
  - Frequency of occurrence
- **Where?**
  - Type of road/terrain
- **How? Under what conditions?**
  - Engine running conditions
  - Driving conditions
  - Weather
- **Why did customer bring vehicle in?**
  - Symptoms

A sample of a PDQ Checksheet is shown on the following page.

PRE-DIAGNOSTIC QUESTIONING CHECKSHEET

Inspector's Name:

Customer's name		**Model and model year**	
Driver's name		**Frame no.**	
Date vehicle brought in		**Engine model**	
License no.		**Odometer reading**	km miles

Symptoms	☐ **Engine does not start**	☐ Engine does not crank ☐ No initial combustion ☐ Incomplete combustion
	☐ **Difficult to start**	☐ Engine cranks slowly ☐ Other ______
	☐ **Poor idling**	☐ No fast idle ☐ Idling speed : ☐ High ☐ Low (rpm) ☐ Rough idling ☐ Other ______
	☐ **Poor driveability**	☐ Hesitation ☐ Backfiring ☐ Afterfiring (muffler explosions) ☐ Surging ☐ Knocking ☐ Other ______
	☐ **Engine stalls**	☐ Soon after starting ☐ After accelerator pedal is depressed ☐ After accelerator pedal is released ☐ During A/C operation ☐ Shifting from "N" to "D" ☐ Other ______
	☐ **Others**	

Date(s) of problem occurrence		
Frequency of problem occurrence		☐ Constant ☐ Sometimes (times per day/month) ☐ Once only ☐ Other ______
Conditions at time of problem occurrence	**Weather**	☐ Clear ☐ Cloudy ☐ Rainy ☐ Snowy ☐ Various/other ______
	Outdoor temperature	☐ Hot ☐ Warm ☐ Cool ☐ Cold (approx. ____°C / ____°F)
	Place /road conditions	☐ Highway ☐ Suburbs ☐ Inner city ☐ Uphill ☐ Downhill ☐ Rough road ☐ Other ______
	Engine temp.	☐ Cold ☐ Warming up ☐ Normal ☐ Other ______
	Engine operation	☐ Starting ☐ Just after starting ☐ Idling ☐ Racing ☐ Driving ☐ Constant speed ☐ Acceleration ☐ Deceleration ☐ Other ______

Condition of "CHECK ENGINE" lamp			☐ Always on ☐ Flickers ☐ Does not light up
Diagnostic code check	**1st time (precheck)**		☐ Normal code ☐ Malfunction code(s) ( )
	2nd time	☐ **Normal mode** ☐ **Test mode**	☐ Normal code ☐ Malfunction code(s) ( )

SYMPTOM CHART

If no malfunction code is output and the problem cannot be confirmed by a basic inspection, proceed to this chart and perform troubleshooting.
This is a chart of problem symptoms which was prepared based on the 4A-FE engine (Sep., 1989)*.
It is meant only to serve as a means of familiarizing you with basic troubleshooting procedures, and is by no means complete. For actual troubleshooting procedures, refer to the repair manual for the appropriate engine.

*Except for models which are equipped with the lean mixture sensor.

REFERENCE

1. The ECU is not included in the list of POSSIBLE CAUSES. However, if all other components and circuits check out okay, it can be concluded that the ECU is probably at fault.
2. Be sure to also check the wiring harness and connectors when checking the parts themselves.
3. One reason why some problems may not be detected by the diagnostic system even when the symptoms do recur is that they may have occurred outside the diagnostic system's range of abnormality detection or the problem not covered by the diagnostic system may have occurred. (See page 132.)

SYMPTOM		POSSIBLE CAUSE		
		SYSTEM	COMPONENT PART	TYPE OF TROUBLE
Engine does not start	No initial combustion	Power supply system	Ignition switch	Poor contact
			EFI main relay	Won't go on
		Fuel system	Circuit opening relay	Won't go on
			Fuel pump	Won't operate
			Injectors	Won't inject
			Pressure regulator	Fuel pressure too low
			Fuel filter, fuel line	Clogged
		Cold start system	Cold start injector	Won't inject
			Start injector time SW	Won't go on, stays on
		Ignition system	Igniter	No sparking
			Ignition coil	
			Distributor	
		Electronic control system	Distributor (G and NE signals)	G and NE signals not output

SYMPTOM		POSSIBLE CAUSE		
		SYSTEM	COMPONENT PART	TYPE OF TROUBLE
Engine does not start	There is combustion but engine does not start (incomplete combustion)	Fuel system	Circuit opening relay	Won't go on
			Injectors	Leakage, won't inject, inject continuously
			Pressure regulator	Fuel pressure too low
			Fuel filter, fuel line	Clogged
		Cold start system	Cold start injector	Won't inject
			Start injector time SW	Won't go on
		Ignition system	Spark plugs	Misfire
		Air induction system	Air hoses	Leakage
			Air valve	Won't open fully, won't open at all
		Electronic control system	Manifold pressure sensor (vacuum sensor)	Voltage or resistance are incorrect, open or short circuit
			Water temp. sensor	

Starting is difficult	Cold	Cold start system	Cold start injector	Won't inject
			Start injector time SW	Won't go on
		Air induction system	ISC valve	Won't open fully, won't open at all
			Air valve	
		Electronic control system	Water temp. sensor	Open or short circuit
			Intake air temp. sensor	
	Hot	Fuel system	Injectors	Leakage
			Pressure regulator	Fuel pressure too low
		Cold start system	Cold start injector	Leakage
		Air induction system	Air valve	Won't open fully
	Always	Fuel system	Circuit opening relay	STA circuit won't go on
			Fuel filter, fuel line	Clogging
		Cold start system	Cold start injector	Leakage
		Ignition system	Spark plugs	Fouled

SYMPTOM		POSSIBLE CAUSE		
		SYSTEM	COMPONENT PART	TYPE OF TROUBLE
Rough idling	No fast idle	Air induction system	ISC valve	Won't open fully, won't open at all
			Air valve	
		Electronic control system	Water temp. sensor	Open or short circuit
	Idle speed too high	Cold start system	Cold start injector	Leaking
		Air induction system	Throttle body	Won't close fully
			ISC valve	Stays open continuously
			Air valve	
		Electronic control system	Manifold pressure sensor (vacuum sensor)	Voltage or resistance are incorrect
			Water temp. sensor	
			Throttle position sensor	Idle contact won't go on
			Air conditioner switch	Stays on continuously
	Idle speed too low	Air induction system	ISC valve	Stays closed
		Electronic control system	Manifold pressure sensor (vacuum sensor)	Voltage or resistance are incorrect, open or short circuit
			Neutral start switch	Won't go on
			Air conditioner switch	
	Unstable idling	Fuel system	Fuel pump	Malfunctioning
			Injectors	Won't inject
			Pressure regulator	Malfunctioning
			Fuel filter, fuel line	Clogged
		Air induction system	Throttle body	Air suction
			ISC valve	Malfunctioning
			Air valve	
		Ignition system	Igniter	Malfunctioning (poor contact)
			Ignition coil	
			Spark plugs	Misfire
		Electronic control system	Manifold pressure sensor (vacuum sensor)	Malfunctioning
			Throttle position sensor	Idle contact won't go on
			Oxygen (O_2) sensor	Malfunctioning

SYMPTOM		POSSIBLE CAUSE		
		SYSTEM	COMPONENT PART	TYPE OF TROUBLE
Poor drivability	Hesitates during acceleration	Fuel system	Fuel pump	Drop in flow volume
			Injectors	Drop in injection volume
			Pressure regulator	Fuel pressure too low
			Fuel filter, fuel line	Clogged
		Ignition system	Igniter	Malfunctioning (poor contact)
			Ignition coil	
			Spark plugs	Misfire
		Electronic control system	Manifold pressure sensor (vacuum sensor)	Voltage or resistance are incorrect, open or short circuit
			Water temp. sensor	
			Intake air temp. sensor	
			Throttle position sensor	
			Oxygen (O_2) sensor	Malfunctioning
	Backfiring	Fuel system	Fuel pump	Drop in flow volume
			Injectors	Drop in injection volume
			Pressure regulator	Fuel pressure too low
			Fuel filter, fuel line	Clogged
		Ignition system	Igniter	Malfunctioning (poor contact)
			Ignition coil	
			Spark plugs	Misfire
		Electronic control system	Manifold pressure sensor (vacuum sensor)	Voltage or resistance are incorrect
			Water temp. sensor	
			Intake air temp. sensor	
			Throttle position sensor	
			Oxygen (O_2) sensor	Malfunctioning
	Afterfiring (muffler explosions)	Fuel system	Injectors	Leakage
		Cold start system	Cold start injector	Leakage, injects continuously
			Start injector time SW	Stays on continuously
		Electronic control system	Manifold pressure sensor (vacuum sensor)	Voltage or resistance are incorrect
			Water temp. sensor	
			Intake air temp. sensor	
			Throttle position sensor	Idle contact won't go on
			Oxygen (O_2) sensor	Malfunctioning

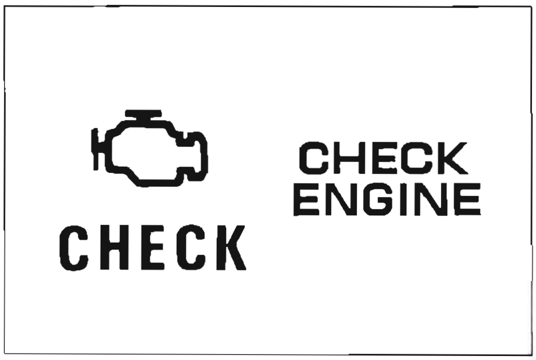
SYMPTOM		POSSIBLE CAUSE		
		SYSTEM	COMPONENT PART	TYPE OF TROUBLE
Poor drivability	Insufficient power	Fuel system	Fuel pump	Drop in flow volume
			Injectors	Drop in injection volume
			Pressure regulator	Fuel pressure too low
			Fuel filter, fuel line	Clogged
		Ignition system	Spark plugs	Misfire
		Electronic control system	Manifold pressure sensor (vacuum sensor)	Voltage or resistance are incorrect
			Water temp. sensor	
			Throttle position sensor	PSW signal not output
Engine stalling	Engine stalls shortly after starting	Fuel system	Circuit opening relay	FC circuit won't go on
			Injectors	Leaking, won't inject, injects continuously
		Cold start system	Cold start injector	Leakage, injects continuously
			Start injector time SW	Stays on continuously
	Engine stalls when accele-rator pedal is depressed	Electronic control system	Manifold pressure sensor (vacuum sensor)	Voltage or resistance are incorrect
			Water temp. sensor	
	Engine stalls when accele-rator pedal is released	Air induction system	Throttle position sensor	Malfunctioning
			Air valve	Stays closed
		Electronic control system	Manifold pressure sensor (vacuum sensor)	Voltage or resistance are incorrect
	Engine stalls when air conditioner is switched on	Air induction system	ISC valve	Malfunctioning
		Electronic control system	Air conditioner switch	Signal not output
	Engine stalls when ATM is shifted from "N" to "D" position	Air induction system	ISC valve	Malfunctioning
		Electronic control system	Neutral start switch	Signal not output

CHECKING AND CLEARING DIAGNOSTIC CODES

OBJECTIVE	:	To learn how to check and clear diagnostic codes.
PREPARATION	:	SST 09843-18020 Diagnosis check wire
APPLICABLE ENGINE	:	4A-FE (Sep., 1989)

REFERENCE

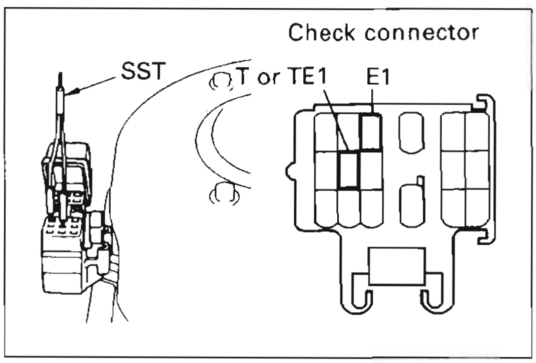
This section basically covers the 4A-FE engine. However, since the TDCL and test mode function in the diagnosis system are not provided in the 4A-FE engine, the procedures and illustrations related to these items are explained using the 1UZ-FE (Dec., 1989) engine.

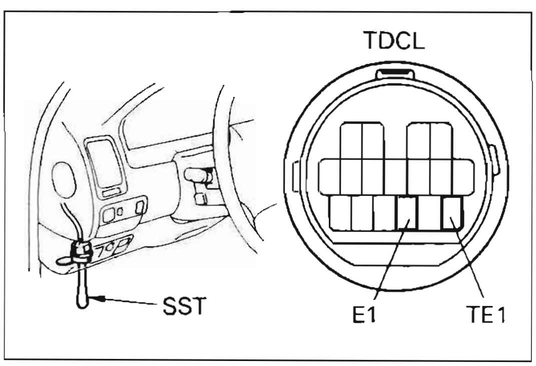


"CHECK ENGINE" LAMP CHECK

(a) The "CHECK ENGINE" lamp should come on when the ignition switch is turned on (engine not running).

(b) When the engine is started, the "CHECK ENGINE" lamp should go off. If the light remains on, it indicates that the diagnostic system has detected a malfunction or abnormality in the diagnostic system.





OUTPUT OF DIAGNOSTIC CODES

1. NORMAL MODE

To output the diagnostic codes, proceed as follows:

(a) Initial conditions:

- Battery voltage at 11 V or higher
- Transmission in "N" range
- All accessories switched off

(b) Turn the ignition switch on.

(c) Using the SST, connect terminal T or TE1 with terminal E1 of the check connector or the TDCL.

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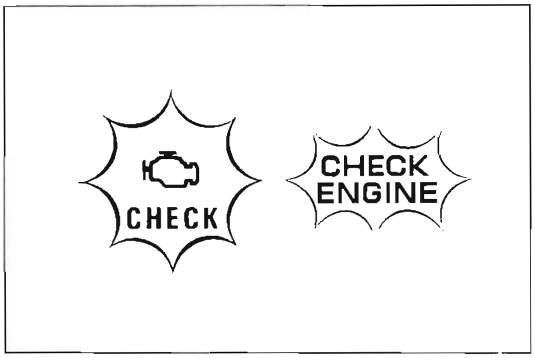
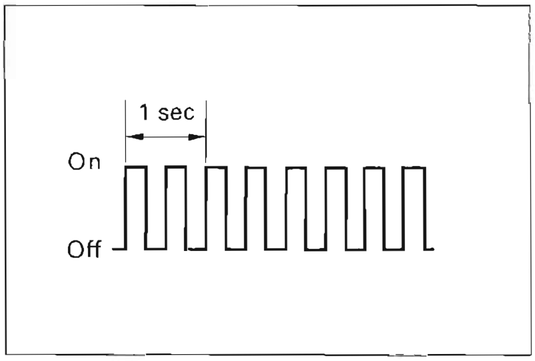


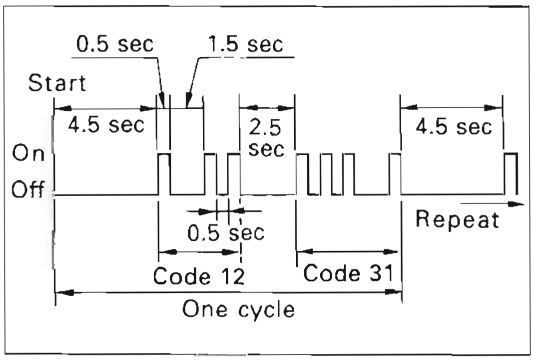
(d) Read the diagnostic code as indicated by the number of flashes of the "CHECK ENGINE" lamp.



DIAGNOSTIC CODES

(1) Normal code indication

- The lamp will alternately blink on and off 2 times per second.



(2) Malfunction code indication
As an example, the blinking patterns for codes 12 and 31 are as shown in the illustration at left.

- The lamp will blink the number of times equal to the malfunction code.

  It will go off for a longer period as follows:

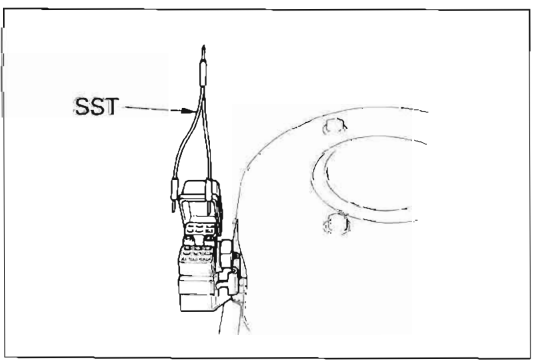
  ① Once between the first and second digit of the same code, 1.5 seconds.

  ② Once between one code and the next code, 2.5 seconds.

  ③ Once between all malfunction codes, 4.5 seconds.

NOTE:

- The diagnostic code series will be repeated as long as check connector terminals T or TE1 and E1 are connected.
- In the event of a number of malfunction codes, indication will begin from the small value and continue in order to the larger value (s).
- When the automatic transmission is in the ''D'', ''2'', ''L'' or ''R'' range, or when the air conditioner is on, or when the accelerator pedal is depressed, code ''51'' (switch condition signal) will be output, but this is normal.



(e) After the diagnostic code check, remove the SST from the check connector or the TDCL.

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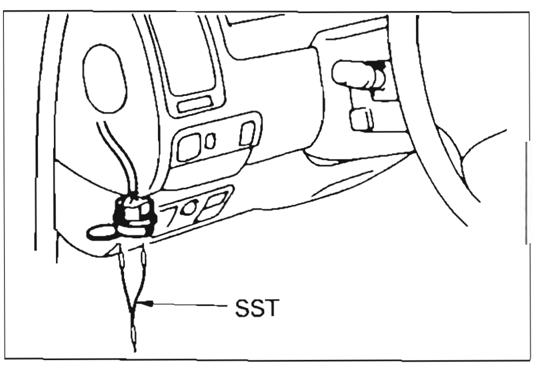

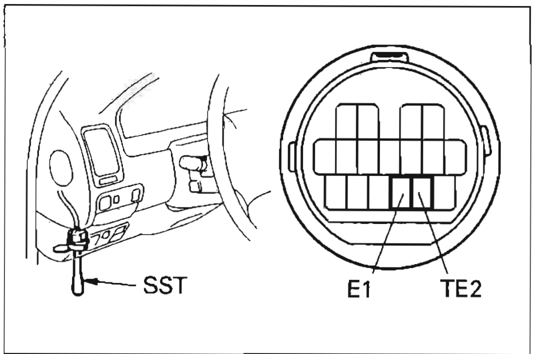

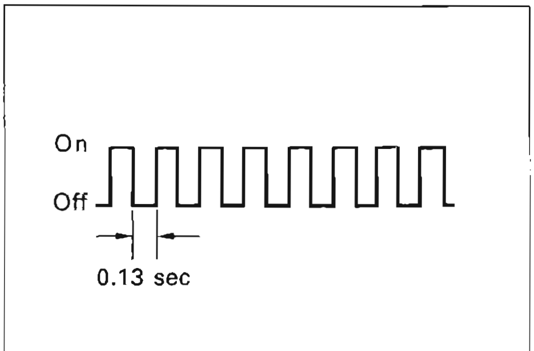

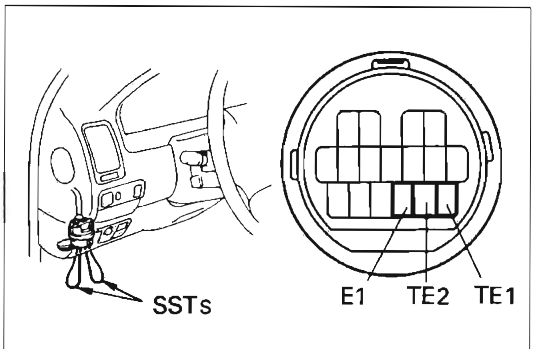

2. TEST MODE

To output the diagnostic codes, proceed as follows:

(a) Initial conditions:

- Battery voltage at 11 volts or higher
- Throttle valve fully closed (idle contact closed)
- Transmission in "N" range
- All accessories switched off

(b) Turn the ignition switch off.

(c) Using the SST, connect terminal TE2 with terminal E1 of the TDCL.

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(d) Turn the ignition switch on.

NOTE: To confirm that the test mode is operating, see whether the "CHECK ENGINE" lamp blinks when the ignition switch is turned on.
This blinking cycle is faster than blinking cycle of normal code.

(e) Start the engine.

(f) Simulate the conditions of the malfunction described by the customer.

If the diagnostic system detects a malfunction, the "CHECK ENGINE" lamp will go on.

(g) After performing a road test, connect terminal TE1 with terminal E1 of the TDCL using the SST.

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(h) Read the diagnostic code as indicated by the number of times the "CHECK ENGINE" lamp blinks.

NOTE: The method used to read the diagnostic code is the same as in the normal mode.

(i) After completing this check, remove the SSTs from the TDCL.

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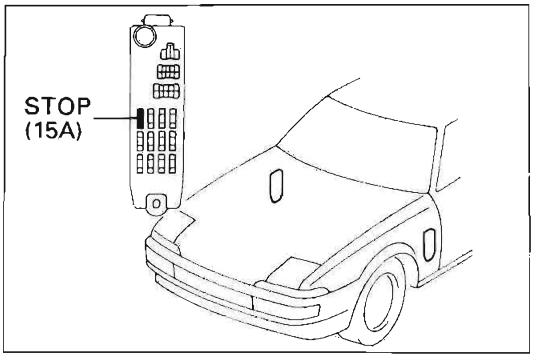
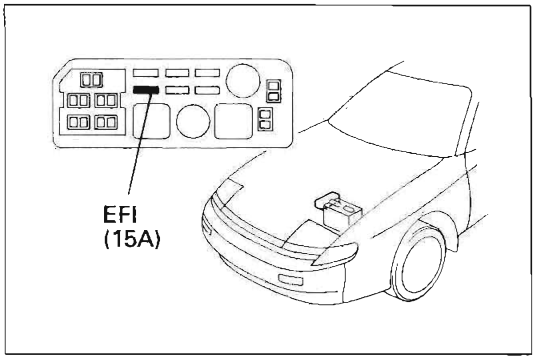
NOTE:

- The test mode will not start if terminals TE2 and E1 are connected after the ignition switch is turned on.
- If the engine is not cranked, diag. code "43" (starter signal) will be output, but this is normal.
- When the automatic transmission is in the "D", "2", "L" or "R" range, or when the air conditioner is on, or when the accelerator pedal is depressed, code "51" (switch condition signal) will be output, but this is normal.





CLEARING DIAGNOSTIC CODE

(a) After the trouble is repaired, the diagnostic code retained in memory by the Engine ECU must be cleared by removing the STOP (15 A) fuse or EFI (15 A) fuse for 10 seconds or longer, depending on the ambient temperature (the lower the temperature, the longer the fuse must be left out) with the ignition switch off.

NOTE:

- Clearing the memory can also be done by removing the battery cable from the negative terminal, but in this case other memory systems (radio, clock, etc.) will also be cleared
- If it is necessary to work on engine components requiring removal of the cable from the battery terminal, a check must first be made to see if any diagnostic codes have been recorded.

(b) After clearing the memory, perform a road test to confirm that a "normal" code can now be read.

If the same diagnostic code as before appears, it indicates that the trouble has not been completely remedied.

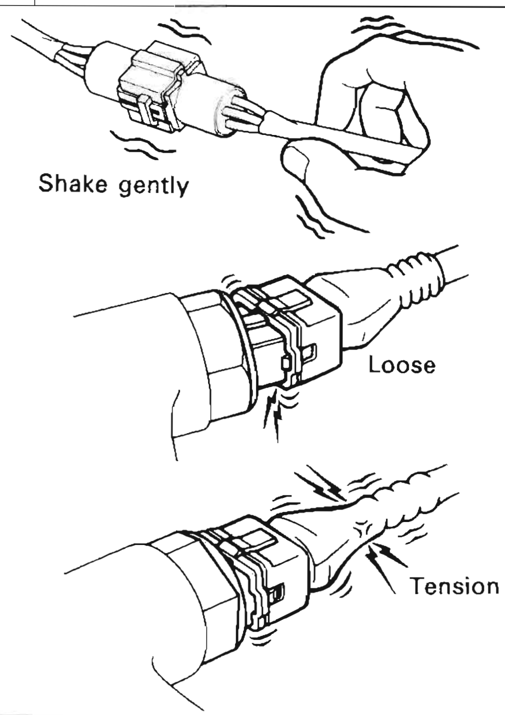
SYMPTOM SIMULATION

The most difficult problems in troubleshooting are intermittent problems: that is, problems about which the customer has a complaint, but which do not occur or cannot be comfirmed in the service shop. Intermittent problems often include complaints about the "CHECK ENGINE" lamp going on and off erratically.
To ensure accurate diagnosis of such problems, ask the customer to provide as much information as possible.

To do this, question the customer closely about the problem, using the Pre-diagnostic Questioning Checksheet, then try to reproduce the problem on the customer's vehicle.
The symptom simulation methods (applying vibration, heat, or humidity) described below are effective ways of reproducing the symptoms for problems of this nature.

OBJECTIVE	:	To learn how to reproduce intermittent problems
PREPARATION	:	————
APPLICABLE ENGINE	:	————

1 VIBRATION METHOD: When vibration seems to be the major cause.



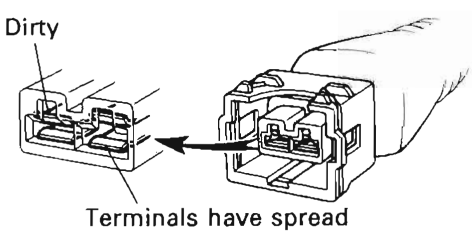
CONNECTORS

Gently shake the connectors vertically and horizontally and pull on them:

(a) Are they loose?

(b) Does the wire harness have enough slack?

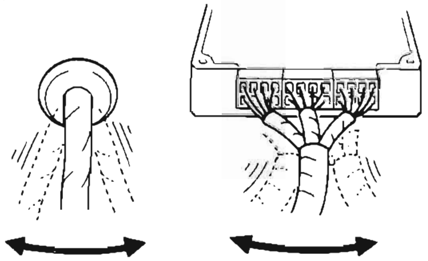
NOTICE



Watch especially for:

- Dirty terminals
- Loose contact due to spreading of terminals

1 VIBRATION METHOD (cont'd): When vibration seems to be the major cause.

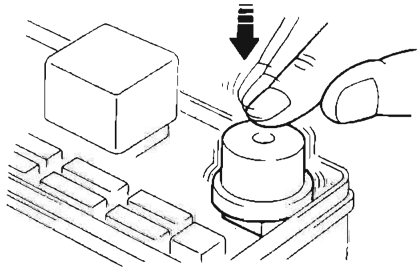


Gently wiggle

WIRE HARNESS

Gently wiggle the wire harness vertically and horizontally. Connector joints and places where wire harnesses pass through the body are the major areas to be checked.

Gently tap

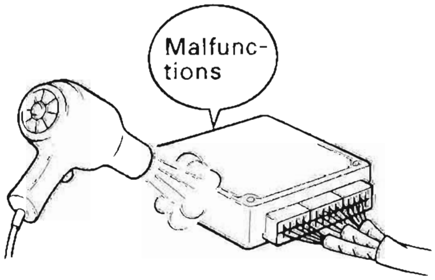


PARTS AND SENSORS

Gently tap the part or sensor in question with your finger.

NOTE: Remember that applying too much shock to a relay may cause it to open, making it appear that it is the relay that is at fault when there is really nothing wrong with it at all.

2 HEAT METHOD: When the malfunction seems to occur when the suspect area is heated.

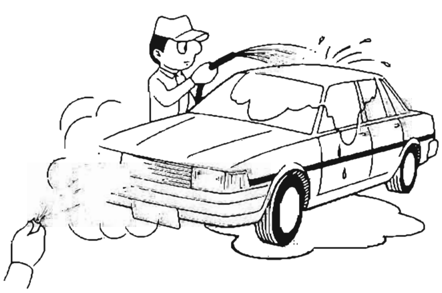


Using a hair dryer, heat the component that is the likely cause of the malfunction.

NOTICE:

- **Do not heat any component to more than 60°C (140°F) (temperature limit at which the component can be safely touched with the hand).**
- **Never open an ECU and apply heat directly to the parts inside it.**

3 WATER SPRAY METHOD: When the malfunction seems to occur on a rainy day or under conditions of high humidity.



Change the temperature and ambient humidity by spraying water onto the vehicle.

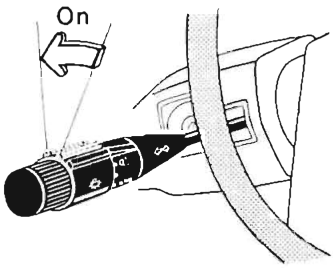
NOTICE:

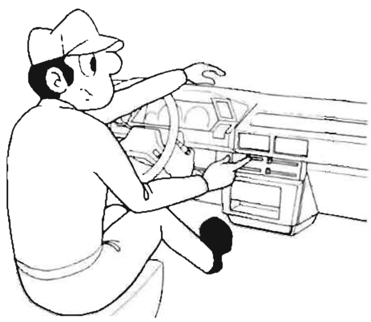
- **Never spray water directly into the engine compartment; spray it onto the front of the radiator through the grill.**
- **Never let water come in direct contact with electronic components.**

NOTE:

- If a vehicle is subject to water leakage, the leaking water may get into an ECU. When testing a vehicle with a water leakage problem, special caution must be used.

4 OTHER: When a malfunction seems to occur due to excessive electrical loads.





Switch on all electrical loads especially loads that draw a heavy current, such as the heater blower, head lamps, rear window defogger, etc.

BASIC INSPECTION

When the "normal" code is displayed during the diagnostic code check, troubleshooting should be performed in the correct order for all possible circuits considered to be the causes of the problems.

In many cases, carrying out the basic engine check shown in the following flow chart will allow you to locate the cause of the problem quickly and efficiently. For this reason, it is essential to perform this inspection *before* troubleshooting engine problems.

OBJECTIVE	:	To learn how to carry out basic inspection of the engine.
PREPARATIONS	:	● SST 09843-18020 Diagnosis check wire ● Engine tune-up tester (tachometer, timing light)
APPLICABLE ENGINE	:	4A-FE* (Sep., 1989) *Except Carina II (AT 171) with lean mixture sensor

1 **Is battery voltage 11 V or more when engine is stopped?**

YES

NO **Charge or replace battery.**

2 **Does engine crank?**

YES

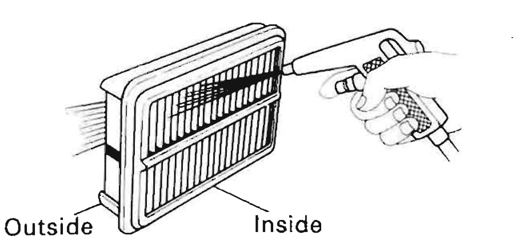
NO **Go to Symptom Chart (see page 154).**

3 **Does engine start?**

YES

NO **Go to step 8.**

4 **Check air filter.**



P Remove the air filter.

C Visually check to see whether the air cleaner element is excessively dirty, oily or damaged.

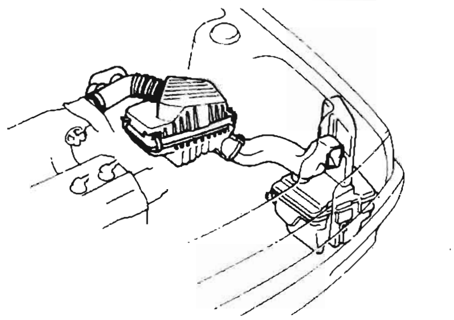
NOTE If necessary, clean the element with compressed air: first blow from the inside thoroughly, then blow off the outside of the element.

OK

NG **Replace air cleaner element.**

P Procedure **C** Check or inspection

5 Is air leaking into air intake system?



C Check for air leaking into the air intake system.

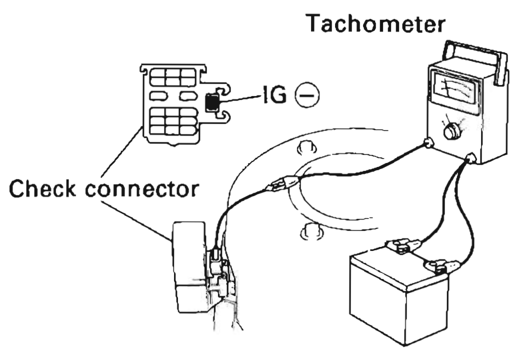
NOTE If the engine oil dipstick, oil filler cap or PCV hose, etc. is loose or missing, air can leak into the air intake system, causing the air-fuel mixture to become too lean.

OK No air leaking into the air intake system between the air flow meter and the cylinder head.

OK

NG **Repair air leakage.**

6 Check idle speed.



P
(1) Shift the transmission into the "N" range.
(2) Warm up the engine to its normal operating temperature.
(3) Switch off all accessories.
(4) Switch off the air conditioner.
(5) Connect a tachometer test probe to the IG ⊖ terminal of the check connector.

C Check the idle speed.

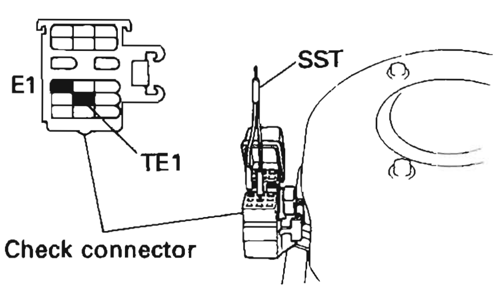
OK Idle speed: 800 rpm (cooling fan off)

NOTICE
- **NEVER allow the tachometer test probe to touch ground as it could result in damage to the igniter and/or ignition coil.**
- **As some tachometers are not compatible with this ignition system, we recommend that you confirm the compatibility of your unit before use.**

OK

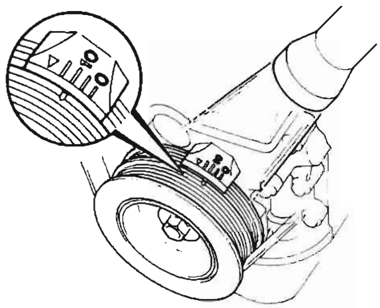
NG **Adjust idle speed.**

7 Check ignition timing.



P
(1) Connect the timing light to the engine.
(2) Run the engine at an idle.
(3) Using the SST, connect terminal TE1 with terminal E1 of the check connector.
SST 09843-18020

7 Check ignition timing (cont'd).

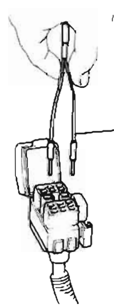


C Check the ignition timing using a timing light.

OK Ignition timing: 10° BTDC (engine idling)

NOTE Transmission in the "N" range.

FURTHER CHECK



P Disconnect the SST.

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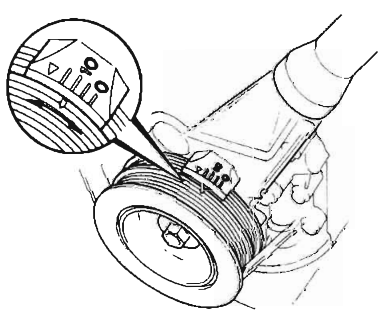


C Use a timing light to check whether the ignition timing advances properly.

OK Ignition timing: the timing mark moves no more than 5° on each side of the 10° mark.

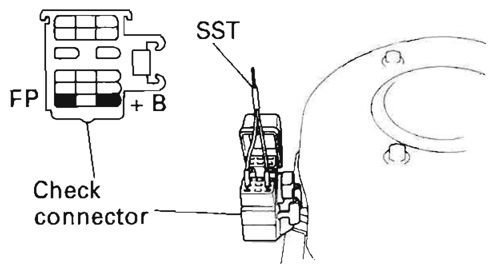
NOTE Transmission in the "N" range.

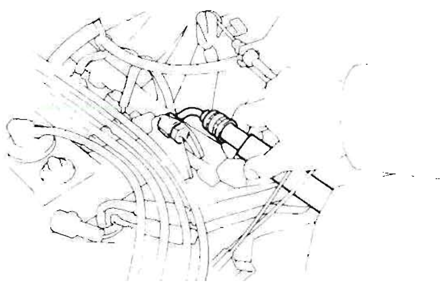
OK

NG **Adjust ignition timing.**

Go to Symptom Chart (See page 154).

8 Check fuel pressure.





P (1) Be sure that there is enough fuel in the tank.
(2) Turn the ignition switch on.
(3) Using the SST, connect terminal +B with terminal FP of the check connector.
SST 09843-18020

C Check if there is pressure in the hose from the fuel filter by pinching the hose with your fingers.

NOTE You should hear the sound of fuel passing through the fuel return hose.

OK Fuel pressure can be felt.

OK

NG **Repair EFI system. (See Step 2, vol. 5, "EFI".)**

9 Check for sparks.

OK

NG **Repair ignition system. (See Step 2, vol. 3, "Ignition System".)**

Go to Symptom Chart (See page 154).

INSPECTION AND ADJUSTMENT

GENERAL

In this section, the basic inspection and adjustment methods for the major items indicated in the following table for the 4A-FE engine are explained. (Note that inspection and adjustment methods for items with a circle in the "STEP 2, EFI" column in the table have already been explained in Step 2, vol. 5 ["EFI"], based on the 1G-FE engine, so they are not included in this Training Manual.)

Since inspection and adjustment of the idle speed and idle mixture differ depending on the vehicle model or specifications, these are included in this manual.

For inspection and adjustment methods for items not included in the following table, see the repair manuals for engines equipped with those items.

SPECIFICATION FOR 4A-FE ENGINE (As of Mar., 1991)

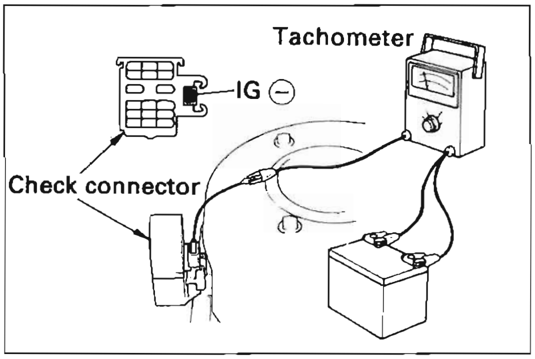
INSPECTION AND ADJUSTMENT ITEMS		PAGE (THIS MANUAL)	COROLLA (AE 9#)				CELICA (AT 180)				CARINA II (AT 171)		STEP 2 (EFI)
			EC2 *1	AUS-TRALIA	U.S. (FED.*2) CANADA	U.S. (CALIF.*3)	GEN.*4 EC*5	EC2	U.S. (FED.) CANADA	U.S. (CALIF.)	EC2	EC2 (W/LS*6)	
Idle speed and idle mixture		**172**	○	○	○	○	○	○	○	○	○	○	○
Manifold pressure sensor (vacuum sensor)		**175**	○	○	○	○	○	○	○	○	○	○	
Air flow meter	**Vane type**	–											○
Throttle position sensor and throttle body	**On-off type**	–	○	○	○	○	○	○	○	○	○		○
	Linear type	**177**										○	
Distributor	**G and NE signals**	**180**	○	○	○	○	○	○	○	○	○	○	
Water temperature sensor		–	○	○	○	○	○	○	○	○	○	○	○
Intake air temperature sensor		**181**	○	○	○	○	○	○	○	○	○	○	
Feedback correction	**Oxygen sensor (O_2 sensor)**	**182**	○	○	○	○		○	○	○	○		
	Lean mixture sensor	**183**										○	
Variable resistor		**184**					○						
Fuel pump operation		–	○	○	○	○	○	○	○	○	○	○	○
Fuel pressure		–	○	○	○	○	○	○	○	○	○	○	○
Injector operation		–	○	○	○	○	○	○	○	○	○	○	○
Injector injection volume		–	○	○	○	○	○	○	○	○	○	○	○
Cold start injector		–	○	○	○	○	○	○			○	○	○
Cold start injector injection volume		–	○	○	○	○	○	○			○	○	○
Start injector time switch		–	○	○	○	○	○	○			○	○	○
Air valve		–	○	○	○	○	○	○	○	○	○	○	○
EFI main relay		–	○	○	○	○	○	○	○	○	○	○	○
Circuit opening relay		–	○	○	○	○	○	○	○	○	○	○	○
ISC valve	**Duty control ACV type**	**186**	○	○	○	○	○	○	○	○	○	○	

*1 European specification models (models w/TWC or OC)
*2 Except California specification models
*3 California specification models
*4 General Country specification models
*5 European specification models (models w/o TWC or OC)
*6 Lean mixture sensor

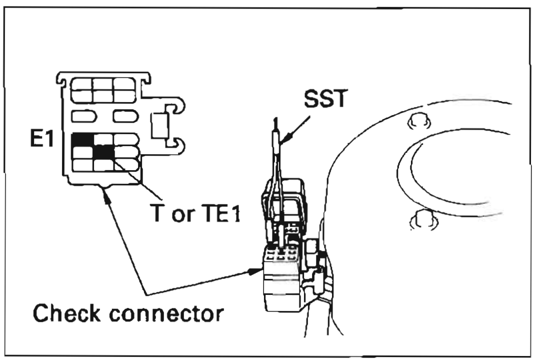
IDLE SPEED AND IDLE MIXTURE

OBJECTIVE	:	To learn the procedure for inspecting and adjusting the idle speed and idle mixture.
PREPARATIONS	:	• SST 09843-18020 Diagnosis check wire • Tachometer • CO meter
APPLICABLE ENGINE	:	4A-FE (Sep., 1989)

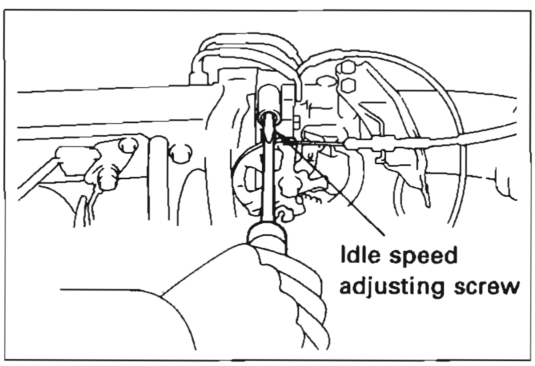
1. **INITIAL CONDITIONS**
   (a) Air cleaner installed
   (b) All pipes and hoses of the air induction system connected
   (c) All vacuum lines connected
   NOTE: All vacuum hoses for the EGR system, etc., should be properly connected.
   (d) All accessories switched off
   (e) EFI system wiring connectors securely connected
   (f) Ignition timing correctly set
   (g) Transmission in "N" range



2. **WARM UP ENGINE**
   Allow the engine to reach its normal operating temperature.
3. **CONNECT TACHOMETER**
   Connect the test probe of a tachometer to the IG $\ominus$ terminal of the check connector.
   NOTICE:
   - **NEVER allow the tachometer terminal to touch ground as it could result in damage to the igniter and/or ignition coil.**
   - **As some tachometers are not compatible with this ignition system, we recommend that you confirm the compatibility of your unit before use.**

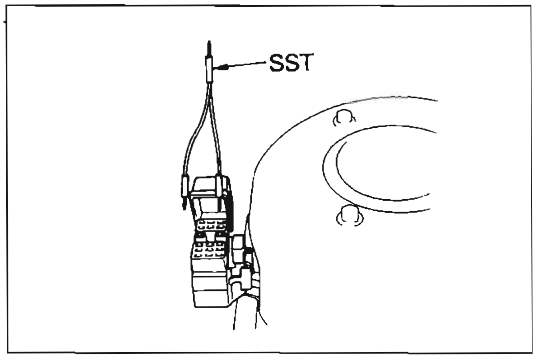


4. **CHECK AIR VALVE OPERATION**
5. **CHECK AND ADJUST IDLE SPEED**
   (a) Race the engine at 2,500 rpm for about 90 seconds.
   (b) Using the SST, connect terminal T or TE1 with terminal E1 of the check connector.
   SST 09843-18020
   (c) Check the idle speed.
   Idle speed (cooling fan off):
   2WD (Federal U.S. and Canada) 700 rpm
   Others 800 rpm



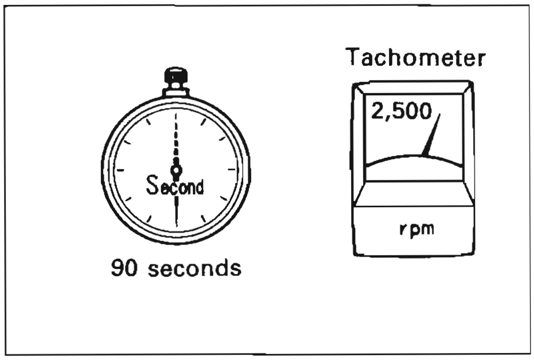
If not as specified, adjust the idle speed by turning the idle speed adjusting screw.

NOTE: For Federal U.S. and Canada 2WD manual transmission vehicles with the Daytime Running Light System, the idle speed should rise to 800 rpm.



(d) Remove the tachometer and SST.

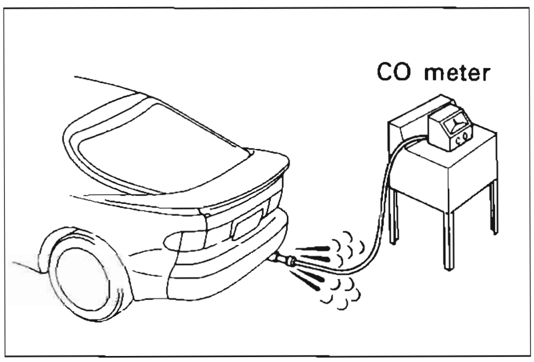
SST 09843-18020



6. ADJUST IDLE MIXTURE (MODELS WITHOUT TWC)

NOTICE: It is usually *not* necessary to adjust the idle mixture in most models, provided that the vehicle is in good condition. However, if it does become necessary to do so, always use a CO meter. If a CO meter is not available, it is best *not* to attempt to adjust the idle mixture if at all possible.

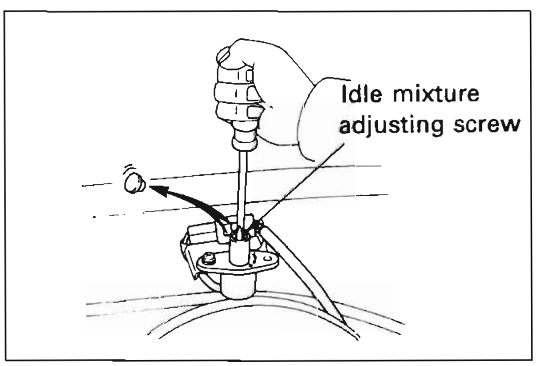
(a) Race the engine at 2,500 rpm for approx. 90 seconds.



(b) Insert a testing probe at least 40 cm (1.3 ft) into the tailpipe.

(c) Measure the CO concentration for 1 to 3 minutes.

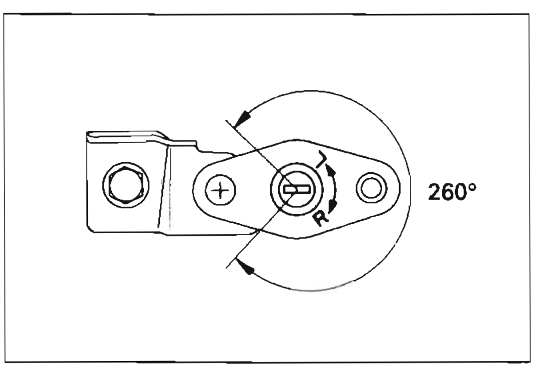
Idle CO concentration: 1.5 ± 0.5 %
(cooling fan off)



If the CO concentration is not as specified, adjust the idle mixture by turning the idle mixture adjusting screw in the variable resistor.

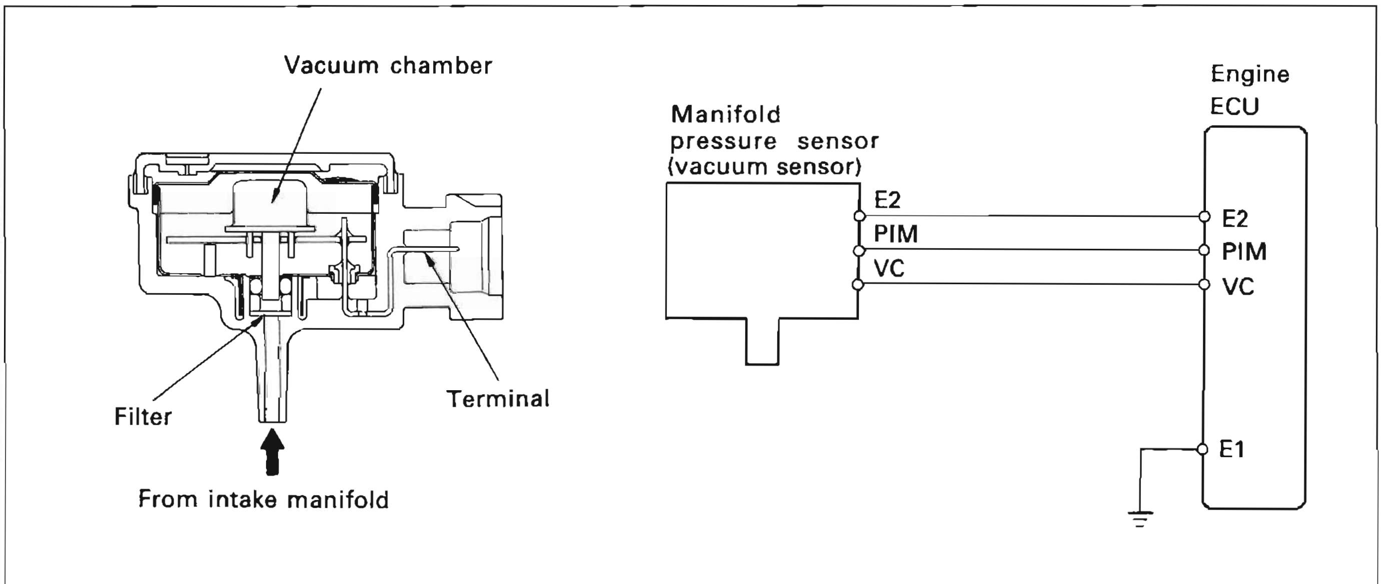
- If the concentration is within the specification, this adjustment is complete.

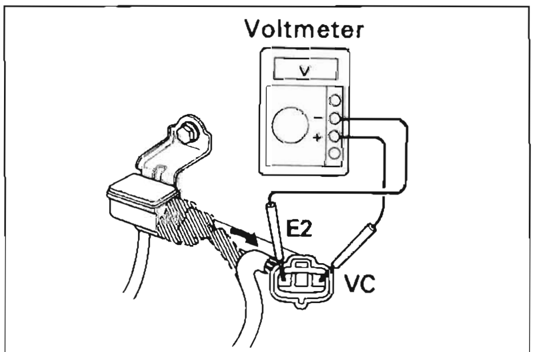
NOTE: Always check the idle speed after turning the idle mixture adjusting screw. If it is incorrect, repeat steps 5 and 6.

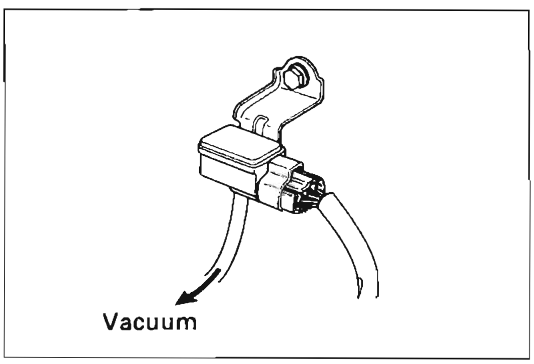


MANIFOLD PRESSURE SENSOR (VACUUM SENSOR)

OBJECTIVE	:	To learn the procedure for inspecting the manifold pressure sensor (vacuum sensor).
PREPARATIONS	:	• Voltmeter (also called "circuit tester" or "multi-tester") • Mityvac (hand-held vacuum pump)
APPLICABLE ENGINE	:	4A-FE* (Sep., 1989) *Except Carina II (AT 171) with lean mixture sensor





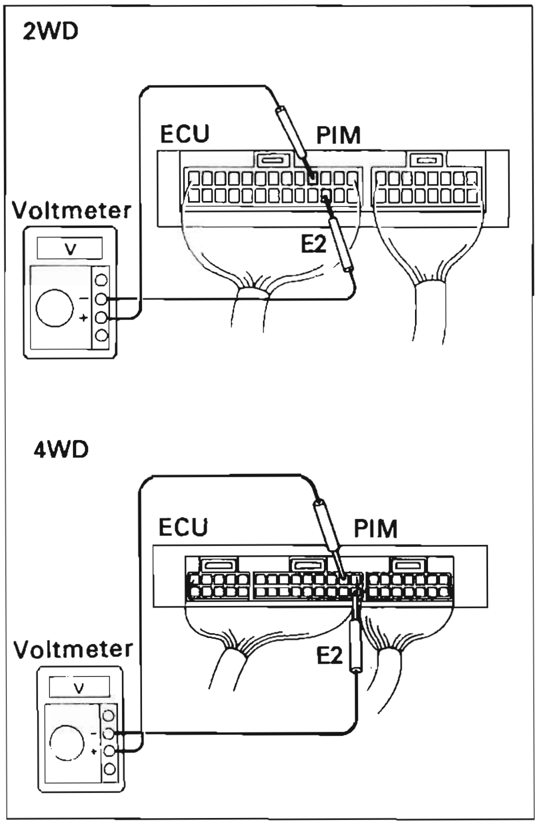


INSPECTION OF MANIFOLD PRESSURE SENSOR (VACUUM SENSOR)

1. **CHECK POWER SOURCE VOLTAGE OF MANIFOLD PRESSURE SENSOR**
   (a) Disconnect the manifold pressure sensor connector.
   (b) Turn the ignition switch on.
   (c) Using a voltmeter, measure the voltage between terminals VC and E2 of the manifold pressure sensor connector.

   Voltage: 4 – 6 V

2. **CHECK POWER OUTPUT OF MANIFOLD PRESSURE SENSOR**
   (a) Turn the ignition switch on.
   (b) Disconnect the vacuum hose at the intake chamber side.
   (c) Connect a voltmeter to terminals PIM and E2 of the ECU, and measure and record the output voltage under the ambient atmospheric pressure.
   (d) Using a Mityvac (hand-held vacuum pump), apply vacuum to the manifold pressure sensor in increments of 13.3 kPa (100 mmHg, 3.94 in.Hg) until the vacuum reaches 66.7 kPa (500 mmHg, 19.69 in.Hg).



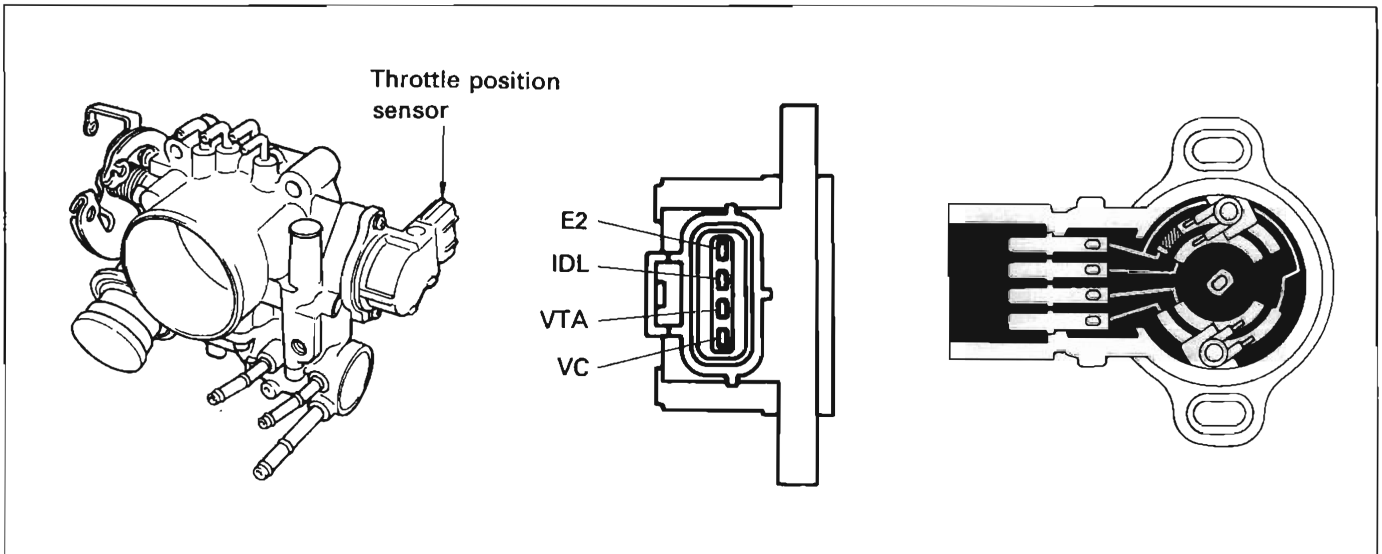
(e) Measure the voltage drop at each stage.

Voltage drop

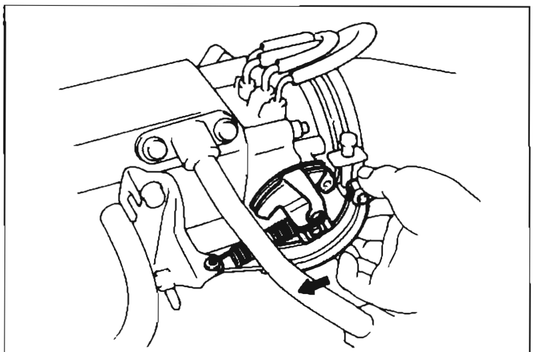
APPLIED VACUUM kPa (mmHg in.Hg)	13.3 (100 3.94)	26.7 (200 7.87)	40.0 (300 11.81)	53.3 (400 15.75)	66.7 (500 19.69)
Voltage drop (V)	0.3 — 0.5	0.7 — 0.9	1.1 — 1.3	1.5 — 1.7	1.9 — 2.1

THROTTLE POSITION SENSOR (LINEAR TYPE) AND THROTTLE BODY

OBJECTIVE	:	To learn the procedure for inspecting and adjusting the throttle position sensor and throttle body.
PREPARATIONS	:	• Ohmmeter (also called "circuit tester" or "multi-tester") • Feeler gauge
APPLICABLE ENGINE	:	4A-FE* (Sep., 1989) *Only for Carina II (AT 171) with lean mixture sensor

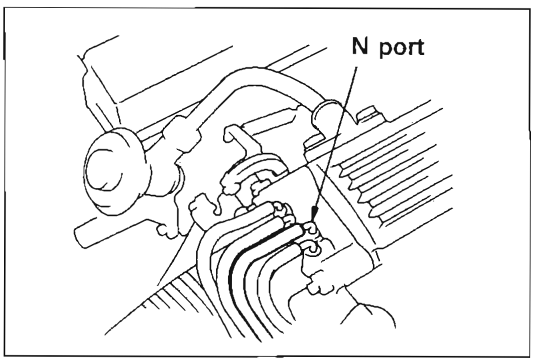


ON-VEHICLE INSPECTION

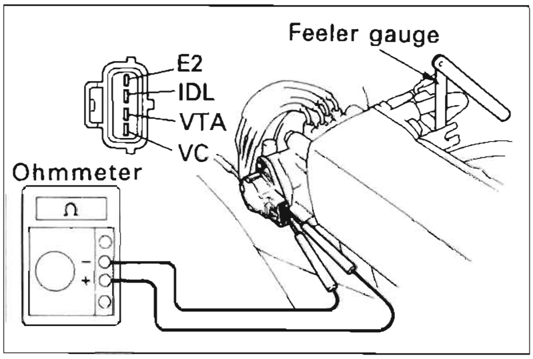


1. INSPECT THROTTLE BODY

(a) Check that the throttle linkage moves smoothly.



(b) Check for vacuum at the N port.
- Start the engine.
- Check for vacuum with your finger.



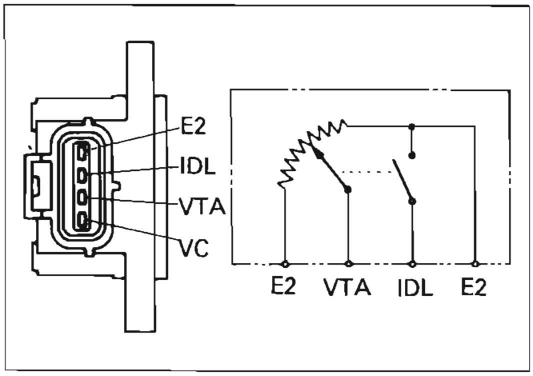
2. INSPECT THROTTLE POSITION SENSOR

(a) Disconnect the sensor connector.

(b) Insert a feeler gauge between the throttle stop screw and stop lever.

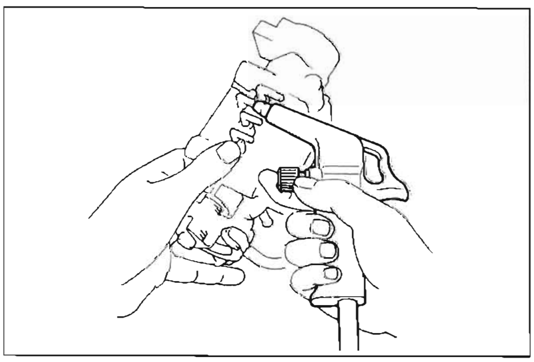
(c) Using an ohmmeter, measure the resistance between each terminal.

If the resistance is not as specified, adjust or replace the throttle position sensor.



CLEARANCE BETWEEN LEVER AND STOP SCREW mm (in.)	BETWEEN TERMINALS	RESISTANCE Ω
0 (0)	VTA – E2	200 – 800
0.35 (0.014)	IDL – E2	2,300 or less
0.59 (0.023)	IDL – E2	Infinity
Throttle valve fully opened	VTA – E2	3,300 – 10,000
–	VC – E2	3,000 – 7,000

(d) Reconnect the sensor connector.



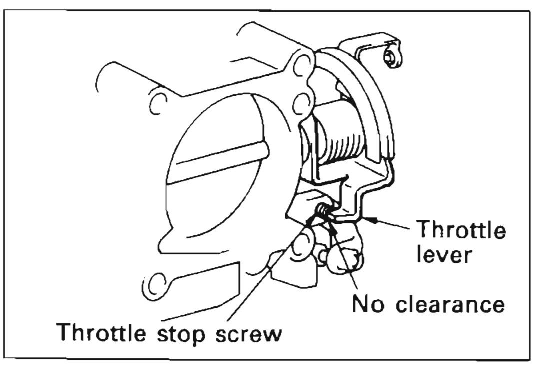
INSPECTION OF THROTTLE BODY

1. CLEAN THROTTLE BODY

(a) Using a soft brush and carburetor cleaner, clean the cast parts.

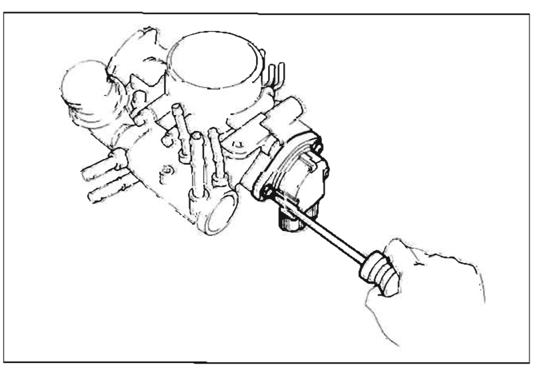
(b) Using compressed air, clean all passages apertures.

NOTICE: To prevent damage, do not clean the throttle position sensor.



2. INSPECT THROTTLE BODY VALVE

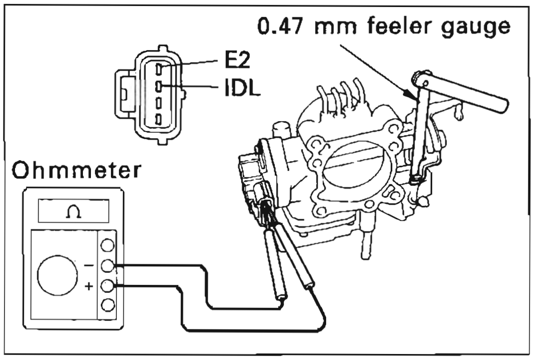
Check that there is no clearance between the throttle stop screw and throttle lever when the throttle valve is fully closed.



3. INSPECT THROTTLE POSITION SENSOR
(See step 2 on "ON-VEHICLE INSPECTION")

4. IF NECESSARY, ADJUST THROTTLE POSITION SENSOR

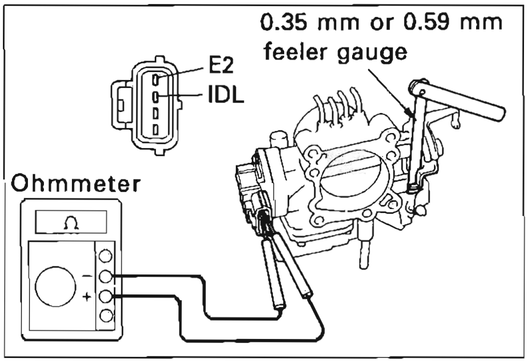
(a) Loosen the two set screws of the sensor.



(b) Insert a 0.47 mm (0.019 in.) feeler gauge between the throttle stop screw and stop lever.

(c) Connect the test probe of an ohmmeter to terminals IDL and E2 of the sensor.

(d) Gradually turn the sensor clockwise until the ohmmeter deflects, then secure it with the two screws.

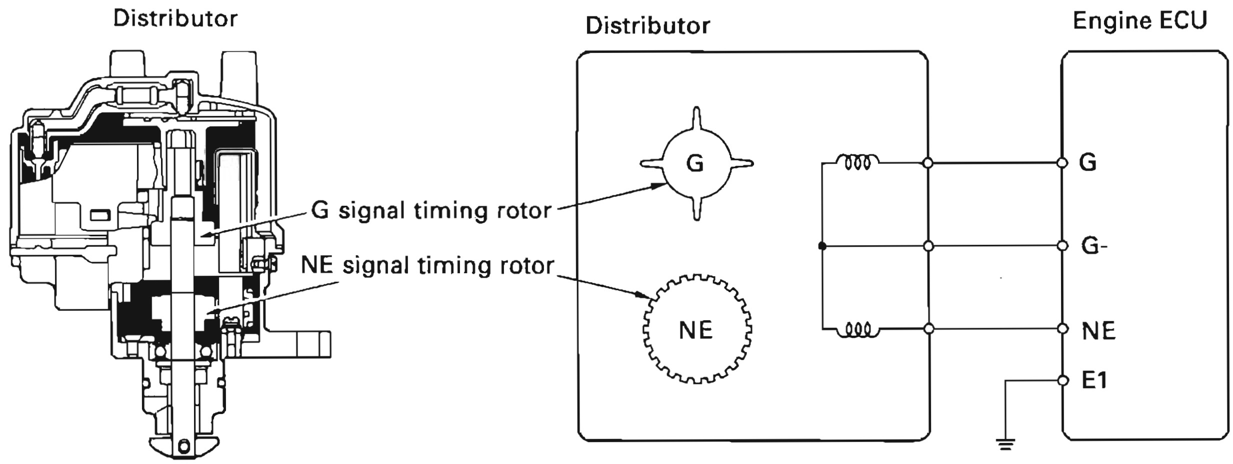


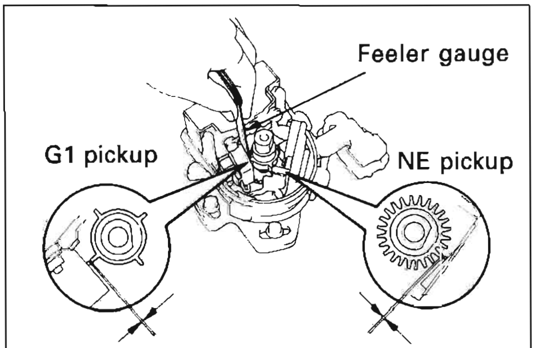
(e) Recheck the continuity between terminals IDL and E2.

CLEARANCE BETWEEN LEVER AND STOP SCREW mm (in.)	CONTINUITY (IDL – E2)
0.35 (0.014)	Continuity
0.59 (0.023)	No continuity

DISTRIBUTOR (G AND NE SIGNALS)

OBJECTIVE	:	To learn the procedure for inspecting the distributor (G and NE signals).
PREPARATIONS	:	● Ohmmeter (also called "circuit tester" or "multi-tester") ● Feeler gauge
APPLICABLE ENGINE	:	4A-FE* (Sep., 1989) *Except Carina II (AT 171) with lean mixture sensor



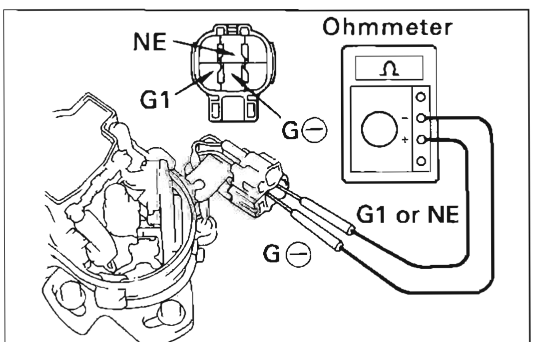


1. **INSPECT AIR GAP**

   Using a feeler gauge, measure the gap between the signal timing rotor and the pickup coil projection.

   Air gap: 0.2 mm (0.008 in.) or more

   If the air gap is not as specified, replace the distributor housing.



2. **INSPECT SIGNAL GENERATOR (PICKUP COIL) RESISTANCE**

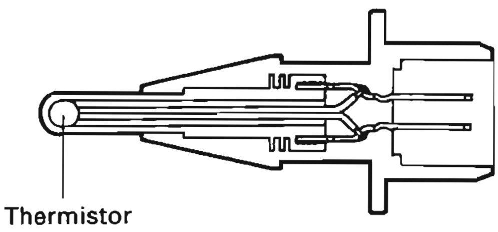
   Using an ohmmeter, measure the resistance between the terminals (G1 and G ⊖, NE and G ⊖).

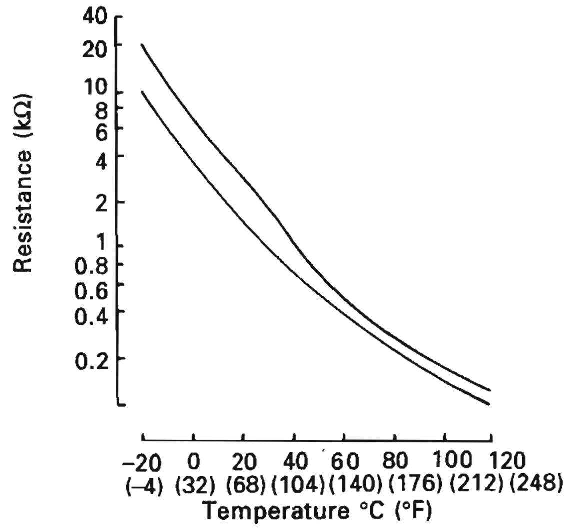
   Pickup coil resistance (cold): 185 – 265 Ω

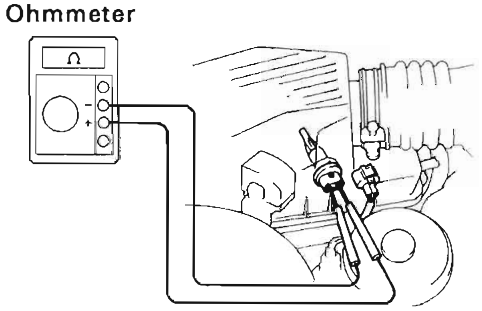
   If the resistance is not as specified, replace the distributor housing.

INTAKE AIR TEMPERATURE SENSOR

OBJECTIVE	:	To learn the procedure for inspecting the intake air temperature sensor.
PREPARATION	:	Ohmmeter (also called "circuit tester" or "multi-tester")
APPLICABLE ENGINE	:	4A-FE (Sep., 1989)







INSPECTION OF INTAKE AIR TEMPERATURE SENSOR

Using an ohmmeter, measure the resistance between the terminals.

Resistance: Refer to the chart above.

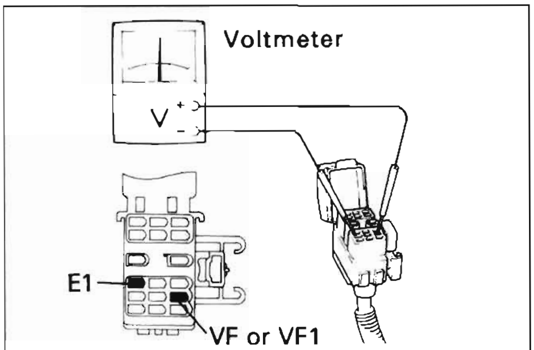
If the resistance is not as specified, replace the sensor.

FEEDBACK CORRECTION

OBJECTIVE	:	To learn how to check feedback correction.
PREPARATIONS	:	• SST 09843-18020 Diagnosis check wire • Analog type voltmeter (also called "circuit tester" or "multi-tester")
APPLICABLE ENGINE	:	4A-FE (Sep., 1989)

MODELS W/OXYGEN SENSOR (O_2 SENSOR)

CHECKING FEEDBACK CORRECTION



(a) Warm up the engine to 80°C (176°F).

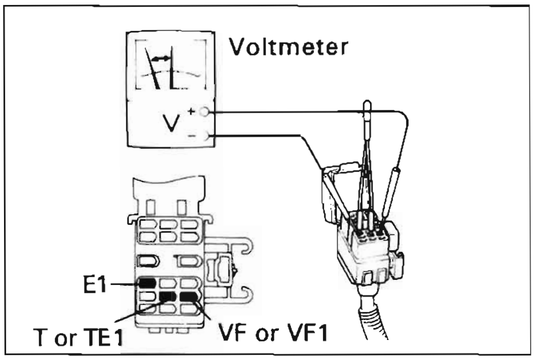
(b) Connect a voltmeter to check connector terminals VF or VF1 and E1.

NOTICE: If terminals T or TE1 and E1 are not connected, 0 V, 2.5 V, or 5 V will be output from the VF or VF1 terminal.

The meaning of this VF voltage differs depending on the engine. For further details, see page 136.

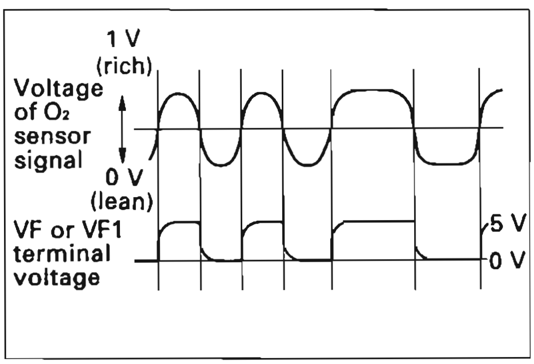
(c) Connect terminal T or TE1 with terminal E1 of the check connector.

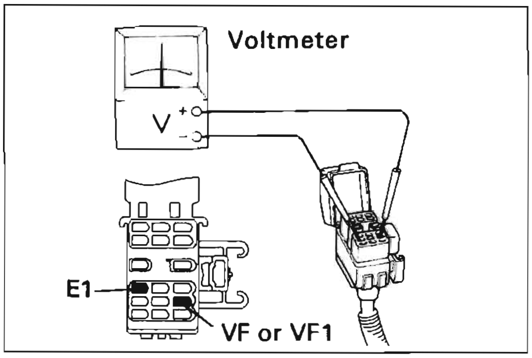
SST 09843-18020



(d) Warm up the oxygen sensor to operating temperature by running the engine at 2,500 rpm for about 2 minutes.

(e) While maintaining the engine speed at 2,500 rpm, check that the needle of the voltmeter fluctuates eight or more times in 10 seconds.



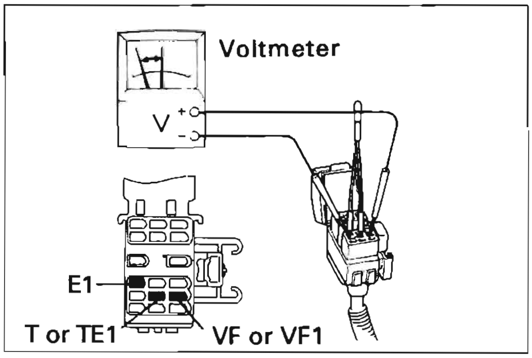


MODELS W/LEAN MIXTURE SENSOR

CHECKING FEEDBACK CORRECTION

(a) Warm up the engine to 80°C (176°F).

(b) Connect a voltmeter to check connector terminals VF or VF1 and E1.



(c) Connect terminal T or TE1 with terminal E1 of the check connector.

SST 09843-18020

(d) Warm up the lean mixture sensor to operating temperature by running the engine at idle for at least 10 minutes.

(e) To start feedback correction, race the engine at 3,500 rpm, then repeat 20 seconds later.

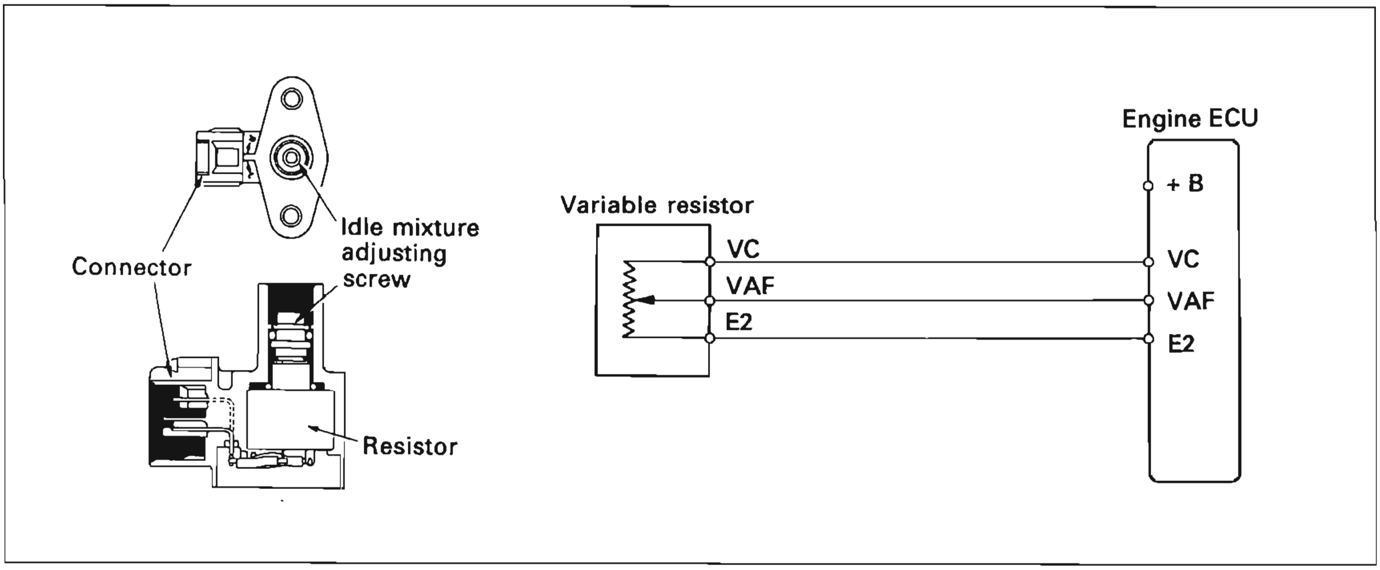
(f) While the maintaining engine speed at 1,500 rpm, check the VF terminal voltage.

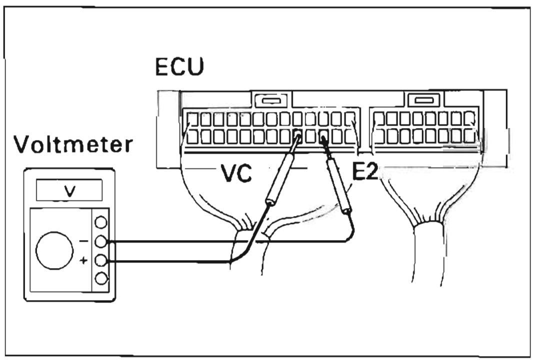
0 V: **Air-fuel ratio feedback correction is taking place**

2.5 V or 5 V: **Air-fuel ratio feedback correction is not taking place**

VARIABLE RESISTOR

OBJECTIVE	:	To learn the procedure for inspecting the variable resistor.
PREPARATION	:	Volt- and ohmmeter (also called "circuit tester" or "multi-tester")
APPLICABLE ENGINE	:	4A-FE (Sep., 1989)



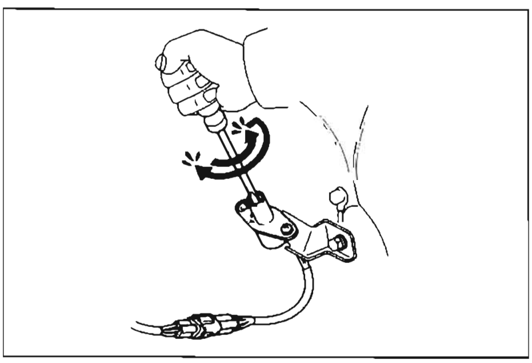


INSPECTION OF VARIABLE RESISTOR

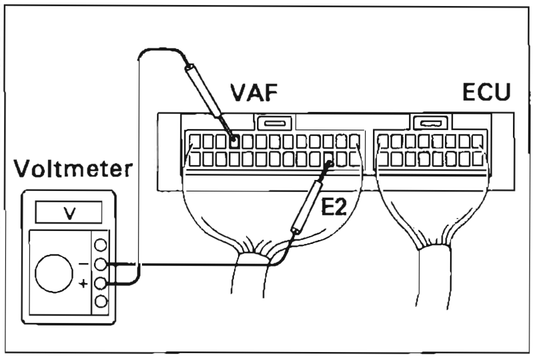
1. INSPECT VOLTAGE OF VARIABLE RESISTOR

(a) Using a voltmeter, measure the voltage between ECU terminals VC and E2.

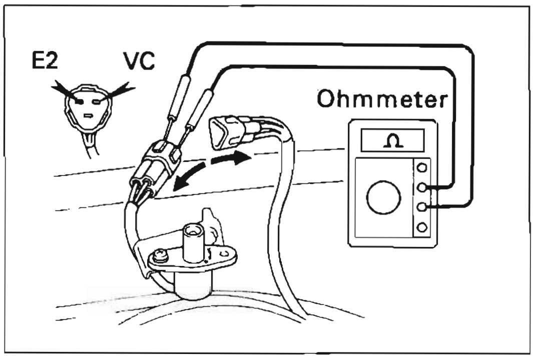
Voltage: 4 – 6 V



(b) Measure the voltage between ECU terminals VAF and E2 while slowly turning the idle mixture adjusting screw, first fully counterclockwise, then fully clockwise.



(c) Check that the voltage changes smoothly from 0 V to approx. 5 V.

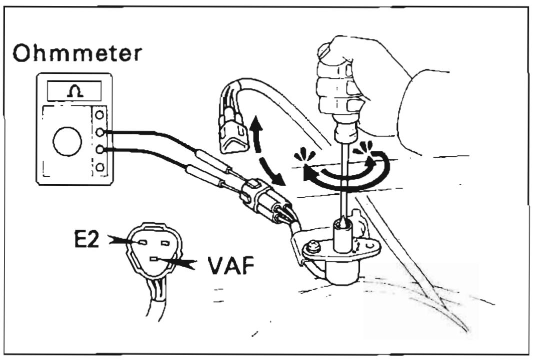


2. INSPECT RESISTANCE OF VARIABLE RESISTOR

(a) Disconnect the variable resistor connector.

(b) Using an ohmmeter, measure the resistance between terminals VC and E2.

Resistance: 4 – 6 kΩ

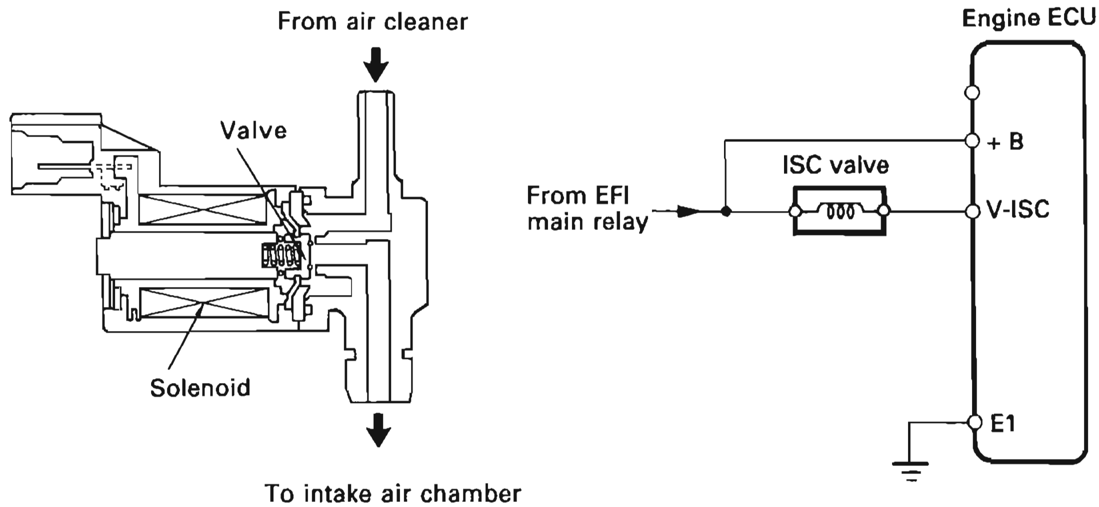


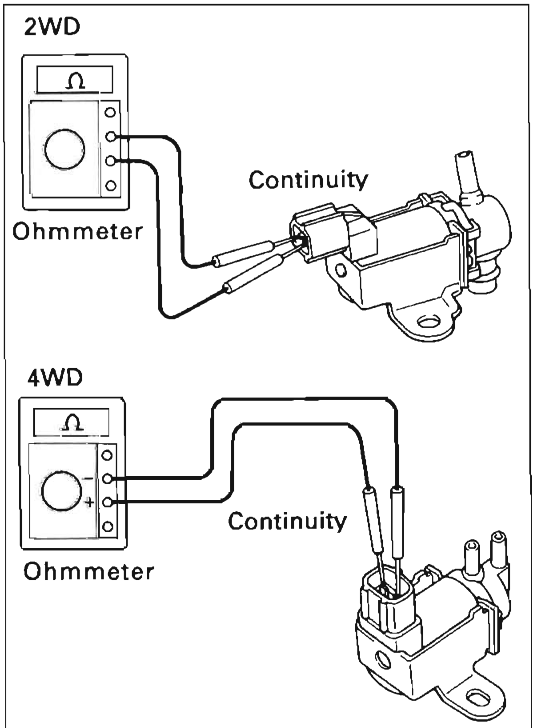
(c) Turn the idle mixture adjusting screw fully counterclockwise.

(d) Connect an ohmmeter to terminals VAF and E2. Turn the adjusting screw fully clockwise and check that the resistance changes from approx. 5 kΩ to 0 Ω.

ISC VALVE (DUTY-CONTROL ACV TYPE)

OBJECTIVE	:	To learn the procedure for inspecting the oxygen sensor.
PREPARATIONS	:	• Ohmmeter (also called "circuit tester" or "multi-tester") • 12-V battery
APPLICABLE ENGINE	:	4A-FE (Sep., 1989)





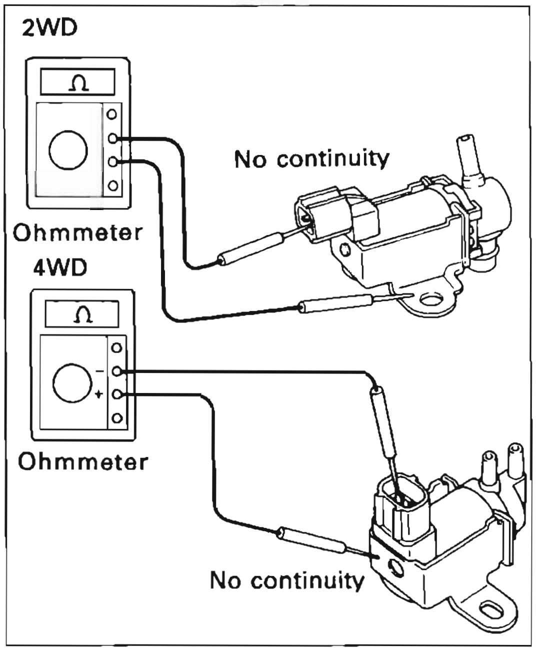
INSPECTION OF ISC VALVE

1. INSPECT ISC VALVE FOR OPEN CIRCUIT

Using an ohmmeter, check for continuity between the terminals.

Resistance: 2WD 30 – 33 Ω
4WD 30 – 34 Ω

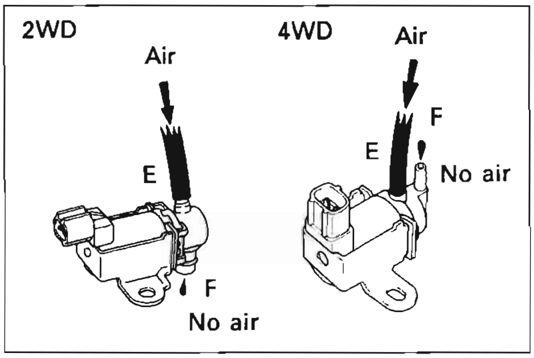
If there is no continuity, replace the ISC valve.



2. INSPECT ISC VALVE FOR GROUNDING

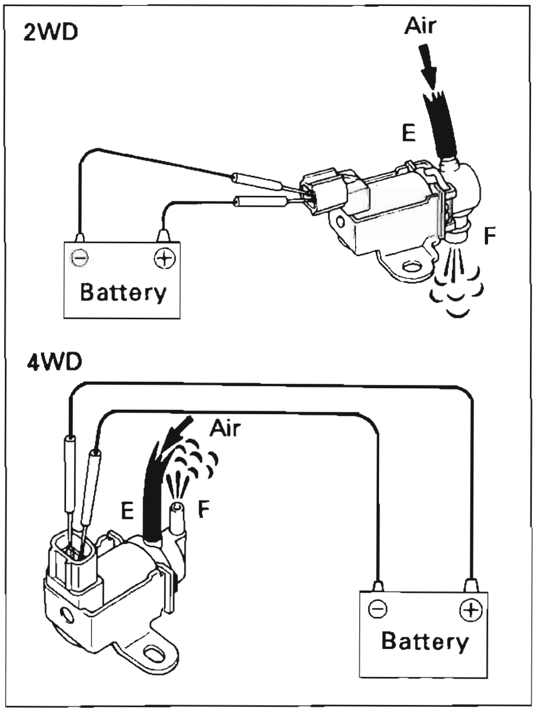
Using an ohmmeter, check that there is no continuity between each terminal and body.

If there is continuity, replace the ISC valve.



3. INSPECT ISC VALVE OPERATION

(a) Check that air does not flow from pipe E to pipe F.



(b) Apply battery voltage across the terminals.

(c) Check that air flows from pipe E to pipe F.

If operation is not as specified, replace the ISC valve.

APPENDIX

ENGINE CONTROL SYSTEM SPECIFICATION CHART

ENGINE MODEL	ENGINE CONTROL SYSTEM*1		G SIGNALS NE SIGNAL*2	THROTTLE POSITION SENSOR*3	FUEL INJECTION PATTERN	FEEDBACK CORREC-TION*4	ELECTRONIC SPARK ADVANCE CONTROL*5	KNOCK CONTROL	IDLE SPEED CONTROL VALVE AND/OR AIR VALVE
1UZ-FE	TCCS	L-EFI (KS)	G1, G2 (1) NE (12)	Linear type	4 groups	With or Without	With	With	Stepper motor
		L-EFI (VG)	↑	↑	Independent (Sequential)	↑	↑	↑	↑
3VZ-FE	TCCS	L-EFI (↘VS)	G1, G2 (1) NE (24)	Linear type	Independent (Sequential)	With or Without	With	With	Stepper motor
3VZ-E	TCCS	L-EFI (↘VS)	G1, G2 (1) NE (24)	Linear type	Simultaneous	With	With	With	Thermo wax air valve
5VZ-FE	TCCS	L-EFI (VG)	G (1) NE (36-2)	Linear type	Independent (Sequential)	With	With (DIS)	With	Rotary solenoid valve
1MZ-FE	TCCS	L-EFI (VG)	G (1) NE (36-2)	Linear type	Independent (Sequential)	With or Without	With (DIS)	With	Rotary solenoid valve
2JZ-GE	TCCS	L-EFI (KS)	G1, G2 (1) NE (24)	Linear type	Independent (Sequential)	With	With	With	Stepper motor
		D-EFI (PIM)	↑	↑	↑	With or Without	↑	↑	↑
		↑	↑	↑	3 groups	Without	↑	↑	↑
		L-EFI (VG)	G1, G2 (1) NE (24) NE2 (36-2)	↑	Independent (Sequential)	With	↑	↑	↑
2JZ-GTE	TCCS	L-EFI (VG)	G1, G2 (1) NE (12)	Linear type	Independent (Sequential)	With	With (DIS)	With	Stepper motor
1G-FE	EFI	L-EFI (↗VS)	Without	IDL, TL, PSW	Simultaneous	Without	Without	Without	Thermo wax air valve
3S-FE	TCCS	L-EFI (↘VS)	G (4) NE (24)	Linear type or IDL, E, PSW	Simultaneous	With or Without	With	Without	Rotary solenoid valve
		D-EFI (PIM)	↑	IDL, E, PSW	↑	Without	↑	↑	VSV & Thermo wax air valve
		↑	G (1) NE (4)	Linear type	2 groups	With or Without	↑	With	Rotary solenoid valve
		↑	NE (4)	↑	Simultaneous	With	↑	↑	↑
		↑	G (1) NE (36-2)	↑	Independent (Sequential)	↑	↑	↑	↑
3S-GE	TCCS	L-EFI (↘VS)	G1, G2 (1) NE (24)	Linear type	Independent (Sequential)	With or Without	With	Without	VSV & Thermo wax air valve
		↑	↑	↑	↑	↑	↑	With	Rotary solenoid valve
		D-EFI (PIM)	↑	↑	↑	↑	↑	↑	↑

* For notes, see page 190.

ENGINE MODEL	ENGINE CONTROL SYSTEM*1		G SIGNALS NE SIGNAL*2	THROTTLE POSITION SENSOR*3	FUEL INJECTION PATTERN	FEEDBACK CORRECTION*4	ELECTRONIC SPARK ADVANCE CONTROL*5	KNOCK CONTROL	IDLE SPEED CONTROL VALVE AND/OR AIR VALVE
3S-GTE	TCCS	L-EFI (VS)	G1, G2 (1) NE (24)	Linear type	Independent (Sequential)	With	With	With	Rotary solenoid valve
		D-EFI (PIM)	↑	↑	↑	↑	↑	↑	↑
5S-FE	TCCS	D-EFI (PIM)	G (4) NE (24)	Linear type or IDL, E, PSW	Simultaneous	With or Without	With	Without	Rotary solenoid valve
		↑	G (1) NE (4)	Linear type	2 groups	↑	↑	With	↑
		↑	G1, G2 (1) NE (24)	↑	Independent (Sequential)	With	↑	↑	↑
		↑	G (1) NE (36-2)	↑	↑	↑	↑	↑	↑
4A-FE	TCCS	D-EFI (PIM)	G (4) NE (24)	IDL, E, PSW	Simultaneous	With or Without	With	Without	ACV & Thermo wax air valve
		↑	G1, G2 (1) NE (24)	Linear type or IDL, PSW, E, LSW	Independent (Sequential)	With (Lean mix. sensor)	↑	↑	↑
		↑	↑	Linear type	↑	↑	↑	↑	Rotary solenoid valve
		↑	G (1) NE (4)	↑	2 groups	With or Without	↑	With or Without	↑
		↑ *6	G (1) NE (36-2)	↑	↑	With	↑	With	↑
		↑	↑	↑	Independent (Sequential)	↑	↑	↑	↑
5A-FE	TCCS	D-EFI (PIM)	NE (4)	Linear type	Simultaneous	With	With	With	Rotary solenoid valve
7A-FE	TCCS	D-EFI (PIM)	G (1) NE (4)	Linear type	2 groups	With	With	With	Rotary solenoid valve
		↑	G (1) NE (36-2)	↑	Independent (Sequential)	↑	↑	↑	↑
2E-E	TCCS	D-EFI (PIM)	NE (4)	IDL, E, PSW	Simultaneous	With	With	Without	Thermo wax air valve
4E-FE	TCCS	D-EFI (PIM)	NE (4)	IDL, E, PSW	Simultaneous	With	With	Without	ACV & Thermo wax air valve
		↑	↑	Linear type	↑	With or Without	↑	↑	Rotary solenoid valve
5E-FE	TCCS	D-EFI (PIM)	G (1) NE (4)	Linear type	2 groups	With	With	Without	ACV & Thermo wax air valve
		↑	NE (4)	↑	Simultaneous	↑	↑	↑	Rotary solenoid valve
		↑	G (1) NE (36-2)	↑	2 groups	↑	With (DIS)	With	↑

* For notes, see page 190.

ENGINE MODEL	ENGINE CONTROL SYSTEM *1		G SIGNALS NE SIGNAL *2	THROTTLE POSITION SENSOR *3	FUEL INJECTION PATTERN	FEEDBACK CORREC-TION *4	ELECTRONIC SPARK ADVANCE CONTROL *5	KNOCK CONTROL	IDLE SPEED CONTROL VALVE AND/OR AIR VALVE
1FZ-FE	TCCS	L-EFI (↳VS)	G1, G2 (1) NE (24)	Linear type	Independent (Sequential)	With	With	With	Stepper motor
		↑	G (1) NE (4)	↑	↑	With or Without	↑	↑	↑
		L-EFI (VG)	↑	↑	↑	↑	↑	↑	↑
		↑	G1, G2 (1) NE (24) NE2 (36-2)	↑	↑	With	↑	↑	↑
1RZ-E 2RZ-E	TCCS	D-EFI (PIM)	NE (4)	IDL, E, PSW	Simultaneous	With	With	With or Without	Thermo wax air valve
2RZ-FE 3RZ-FE	TCCS	L-EFI (VG)	G (1) NE (36-2)	Linear type	2 groups	With	With	With	Rotary solenoid valve
2TZ-FE	TCCS	L-EFI (↳VS)	G1, G2 (1) NE(24)	Linear type	Simultaneous	With or Without	With	With	Rotary solenoid valve
2TZ-FZE	TCCS	L-EFI (VG)	G (1) NE (36-2)	Linear type	2 groups	With	With	With	Rotary solenoid valve
22R-E	EFI	L-EFI (↗VS)	Without	IDL, TL, PSW	Simultaneous	Without	Without	Without	Bi-metal air valve
	TCCS	↑	NE (4)	Linear type	↑	With	With	With	Bi-metal or Thermo wax air valve
4Y-E	TCCS	L-EFI (↗VS)	NE (4)	IDL, E, PSW	Simultaneous	With	With	Without	VSV & Bi-metal air valve

*1 The "↳VS" means the type 1 air flow meter, while the "↗VS" means the type 2 air flow meter.
For further details, see page 20.

*2 The numbers in the parentheses indicate the number of rotor teeth.

*3 Linear type throttle position sensor generally has IDL and VTA terminals.
However, there are cases on some models that they do not use its circuit even if they have IDL terminal or they do not have IDL terminal itself.

*4 O_2 sensor is used for the engines equipped with a feedback correction.
The member of O_2 sensor differs depending on the engine models and destinations.

*5 Fuel control switch or connector and fuel octane judgement are equipped on some models.

*6 Engine ECU made by Bosch is used.

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QUALITY SERVICE

OVERSEAS SERVICE DIVISION
TOYOTA MOTOR CORPORATION

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NAME