

System Diagnosis and Troubleshooting

An Overview of the Self Diagnostic System

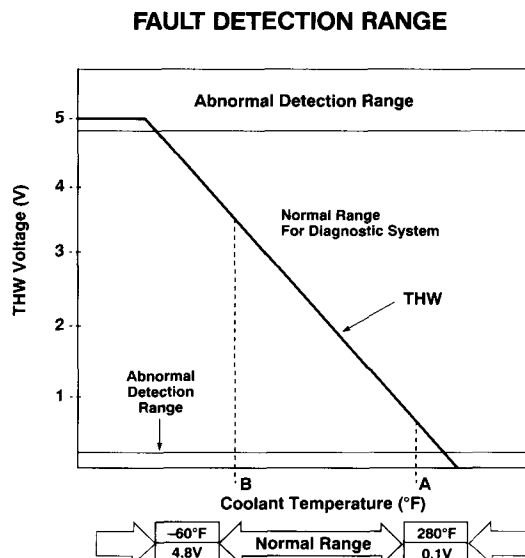
The ECU on all P7 and TCCS engines has a self diagnostic system which constantly monitors most of the electronic control system's input circuits. When the ECU detects a problem, it can turn on the check engine light to alert the driver that a fault exists in the system. At the same time, the ECU registers a diagnostic code in its **keep alive memory** so that the faulty circuit can be identified by a service technician at a later time.

if the circuit fault goes away, the check engine light will go off. However, the diagnostic code will remain in the ECU memory even after the ignition switch is turned off. For most engines, the contents of the diagnostic memory can be checked by shorting check connector terminals T (or TE1) and E1 together and counting the number of flashes on the check engine light.

After the problem has been repaired, the technician can clear the diagnostic system by removing the power from the ECU BATT feed.

Fault Detection Principles

The ECU fault detection system is programmed to accept sensor signal values within a certain range to be normal, and signals outside of that range to be abnormal. The normal signal range used to diagnose most sensor circuits covers the entire operating range of the sensor signal. As long as the signal value falls within this range, the ECU judges it to be normal. As a result, it is possible for the sensor to generate a signal which does not accurately represent the actual operating condition and not be detected as a problem by the ECU.



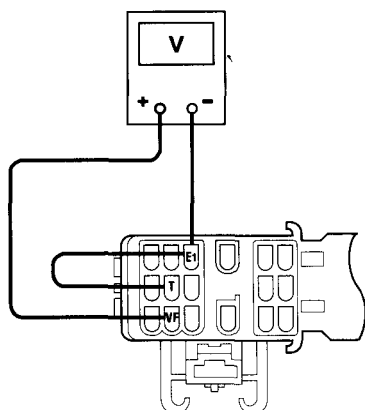
The fault detection range graph shows typical THW signal parameters. Point A is normal operating temperature and falls within the fault detection normal range. Point B represents the freezing point of water and also falls in the normal range. If the engine is at normal operating temperature but the THW sensor signals the ECU that the coolant temperature is freezing (point B), the engine will operate excessively rich and may not start when hot. Because point B falls within the normal range, the ECU will not recognize this as a problem. No diagnostic code will be set for this problem.

Limitations of the Self Diagnostic System

The self diagnostic system provides an excellent routine to direct the technician to the heart of an electronic control system problem. There are however, several limitations which must be kept in mind when troubleshooting.

- The ECU must see a signal in an abnormal range for more than a given amount of time before it will judge that signal to be faulty. Therefore, many intermittent problems cannot be detected by the ECU.

- When the ECU stores a diagnostic code, the code indicates a problem somewhere in the sensor circuit, not necessarily in the sensor itself. Further testing is always required to properly diagnose the circuit.
- Not all circuits are monitored by the ECU. Just because the ECU generates a normal code does not mean that there are no problems within the electronic control system.
- Occasionally, diagnostic codes can be set during routine service procedures or by problems outside the electronic control system. Always clear codes and confirm that they reset prior to circuit troubleshooting.



Check Engine Lamp Functions

The check engine lamp serves two functions in the self diagnostic system, depending on the status of the T terminal. When the T terminal is off (not shorted to E1) the check engine light goes on to warn the driver when a major problem is detected in the electronic control system. When the **T terminal** is on (shorted to E1) the check engine light displays stored diagnostic codes for use by the technician.

VF (Voltage Feedback) Terminal Function

The **VF terminal** also serves two diagnostic functions depending on the status of the T terminal. When the T terminal is off, the VF terminal voltage represents **learned value** correction factor. When the T terminal is on, the VF terminal will either display an emulated oxygen sensor signal (throttle open, IDL contact off) or indicate whether a diagnostic code is stored in the ECU memory (throttle closed, IDL contact on).

CHECK ENGINE LAMP AND VF TERMINAL OUTPUT

T Terminal	IDL Contacts	Check Engine Lamp	VF Terminal Output	
OFF (Open)	N/A	Lamp check function (when engine is stopped)	Air/fuel ratio feedback correction amount or air/fuel ratio learned control value	5V : Increased amount (3.75V)
		Warning display function (during engine operation)		2.5V : Normal (1.25V) 0V : Decreased amount Some systems have five levels, and other systems have three levels.
ON (Shorted)	OFF	Diagnostic code display function	Results of O2 sensor signal processing	5V : Rich signal 0V : Lean signal
	ON		Results of diagnosis	5V : Normal 0V : Trouble code stored

Four Systematic Steps In Diagnosis

Simply stated, there are four steps to follow when performing a methodical diagnosis from start to finish. Using this systematic approach will generally lead to reduced diagnostic time and a higher degree of success. The four steps are listed as follows.

- Routine Quick Checks
- Use of the Self Diagnostic System
- Troubleshooting by Symptom
- Quality Control Check

Routine Quick Checks

This step in diagnosis includes confirmation of the problem and routine mechanical and electrical engine checks.

Confirmation of the customer concern is an excellent place to begin any diagnosis. It is important to gather and analyze as much information as the customer can supply and, if the check engine warning lamp is on, to retrieve and record the diagnostic codes.

The conditions of the battery and charging system are critical to the proper operation of the electronic control system. Both should be routinely checked by measuring cranking and engine running battery voltage prior to proceeding with diagnosis.

Depending on the problem or driveability symptom indicated, the following checks should be conducted under the hood:

- Inspection of the engine's mechanical condition (i.e., audible cranking rhythm and visual ignition secondary condition).
- Brief inspection of accessible electrical, vacuum and air induction system duct connections.
- Locate and inspect the condition of the ECU main grounds.
- Inspect for leakage in the EGR and PCV valves.
- Inspect for unwanted fuel entering the intake manifold from the EVAP system.

The entire routine quick check procedure can be performed in less than ten minutes and will often save an hour or more of unnecessary diagnostic time.

Use of the Self Diagnostic System Once you are satisfied that there are no routine problems causing the customer concern, use of the self diagnostic system is in order. This system is available on all P7 and TCCS equipped engines and is capable of indicating if certain faults exist in ECU monitored circuits.

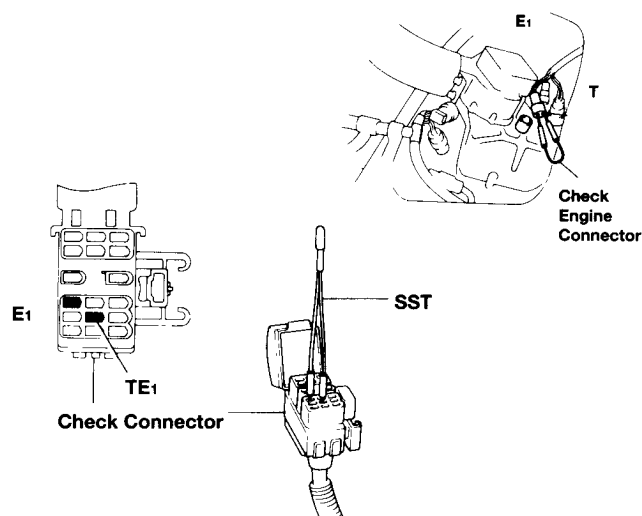
The P7 systems have limited diagnostic capabilities and can only display seven diagnostic codes, including a system normal code. This system will only indicate a fault if the circuit is open or shorted to ground.

Late model TCCS systems have more sophisticated diagnostics which monitor more ECU related circuits with as many as 21 or more diagnostic codes. The latest TCCS ECUs have some special capabilities which make them more useful in diagnosis and prevent the check engine warning light from becoming a source of customer dissatisfaction.

- To allow the diagnostic system to find more system faults, the electrical parameters which the ECU uses to set a diagnostic code are altered to find sensor performance faults like oxygen sensor degradation.
- Some minor TCCS system fault codes will set a diagnostic code in the ECU keep alive memory but will not turn on the check engine light and unnecessarily alarm the customer.
- To prevent false indication of certain system faults, some ECUs are programmed to use a two-trip detection logic which prevents the check engine light from illuminating, or certain codes from setting, until the problem has duplicated itself twice, with a key off cycle in between.
- Some ECUs have a special diagnostic TEST mode which causes the ECU to narrow its diagnostic parameters for the technician, thereby, making troubleshooting intermittent problems easier.

Procedures to Retrieve Trouble Codes

There are several different types and locations of diagnostic connectors which are used to trigger and, in some cases, read diagnostic code output from Toyota EFI engines. All late model TCCS applications, from 1988, use a multiple terminal diagnostic **check connector**. Earlier models use this same multiple terminal or a two-terminal check connector, all located under the hood.



The procedure to examine the ECU memory for diagnostic codes is typically very simple regardless of which vintage engine being diagnosed. All engines equipped with self diagnostic systems have one terminal of the check connector identified as T or TE1. When grounded, this terminal triggers the self diagnostic feature of the ECU. The E1 ground circuit is also located in the check connector.

To enter engine diagnostics:

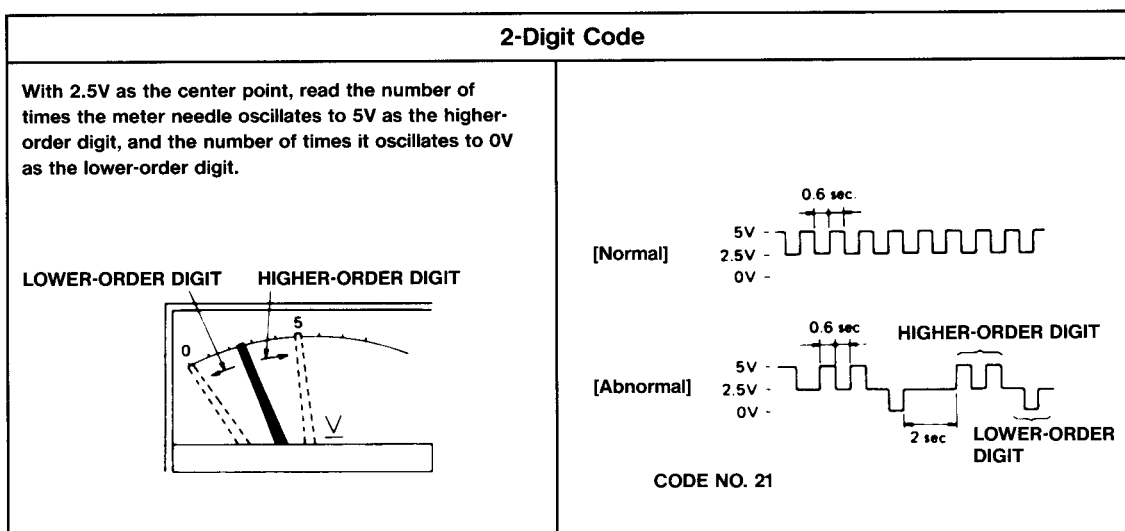
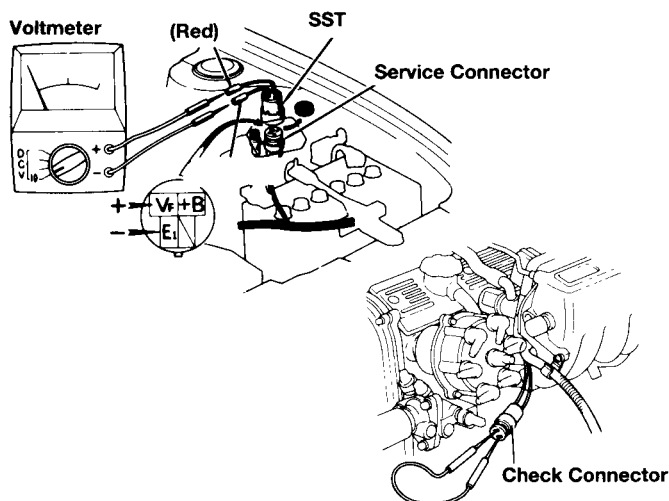
- Locate the check connector under the hood and identify the T (TE1 on late model TCCS) and E1 terminals.
- Turn the ignition switch to the "on" position and make sure that the check engine light is on.
- Confirm that the throttle is closed (IDL contact on).
- Jumper check connector terminals T (TE1) to E1.

	2-Digit Code	1-Digit Code
Example of Display Format	[Normal] 0.26 sec. 0.26 sec. 0.26 sec. T or TE1 Terminal On [Abnormal] (Trouble codes 12 and 23 are displayed.) 0.52 sec. 1.5 sec. 0.52 sec. 2.5 sec. 1.5 sec. 4.0 or 4.5 sec. T or TE1 Terminal On	[Normal] 4.5 sec. 0.52 sec. 4.5 sec. T or TE1 Terminal On [Abnormal] (Trouble codes 2 and 3 are displayed.) 0.52 sec. 2.5 sec. 1.04 sec. 4.0 or 4.5 sec. T or TE1 Terminal On

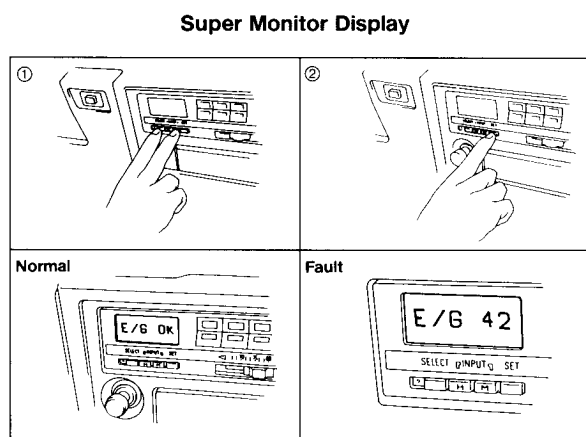
When the T terminal is grounded with the ignition switch in the "on" position, the ECU sees the voltage at terminal T go low. Low voltage on T causes the ECU to enter diagnostic mode, producing diagnostic codes on the check engine light. On '83 through '85 Cressida and Supra models, the check engine light does not flash diagnostic codes. An analog voltmeter must be used to read the codes from the VF terminal of the EFI Service Connector.

Depending on the vintage of the system being tested, the codes will be displayed in either one or two digit format. It is important to refer to the proper repair manual for specific information about diagnostic connector location, code format, and proper procedures for the vehicle you are troubleshooting.

'83 THROUGH '85 CRESSIDA AND SUPRA



Super Monitor Display: On some 1983 through 1987 Cressida and Supra models, a Super Monitor trip computer was offered as optional equipment. This display can be used to read diagnostic codes by simply pressing and holding the monitor "Select" and "Input M" keys together, for three seconds, with the ignition switch in the "on" position. When the "DIAG" message appears on the display, pressing and holding the "Set" key for three seconds will put the TCCS system into diagnostic mode. The display will indicate any diagnostic codes stored in the ECU's keep alive memory.

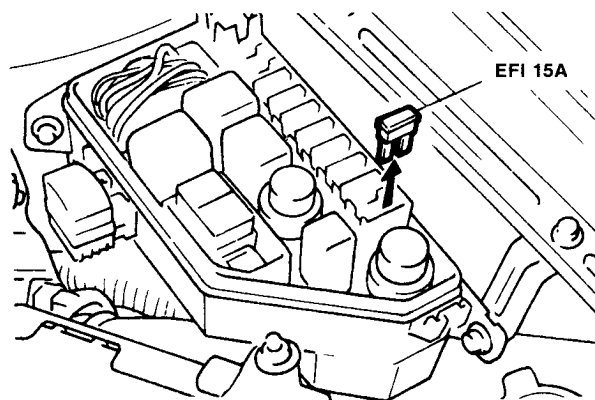


Once Diagnostic Codes Are Retrieved

Once diagnostic codes have been retrieved from the ECU keep alive memory, it is advisable to erase the codes and road test the vehicle. The purpose of this procedure is to confirm that the problem(s) will be present during your diagnosis.

If the diagnostic code re-occurs, the problem can be considered a **hard fault** and troubleshooting will be routine. If the diagnosis code does not re-occur, the problem is either intermittent or was inadvertently stored during a previous service procedure.

If an **intermittent fault** is suspected, a physical check of the indicated circuit must be performed by flexing connectors and harnesses at likely failure points while monitoring the circuit with a multimeter or oscilloscope. If the problem is temperature, vibration, or moisture related, the circuit can be heated, lightly tapped, or sprayed with water to simulate the failure conditions. Attempting to troubleshoot intermittent problems using the normal diagnostic routines will likely result in a misdiagnosis and wasted time.

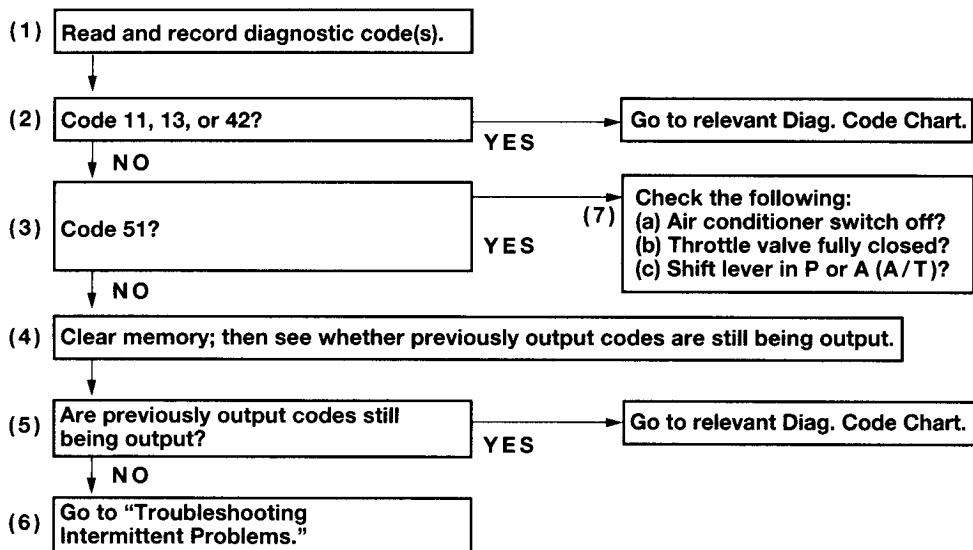


Erasing Long Term Memory

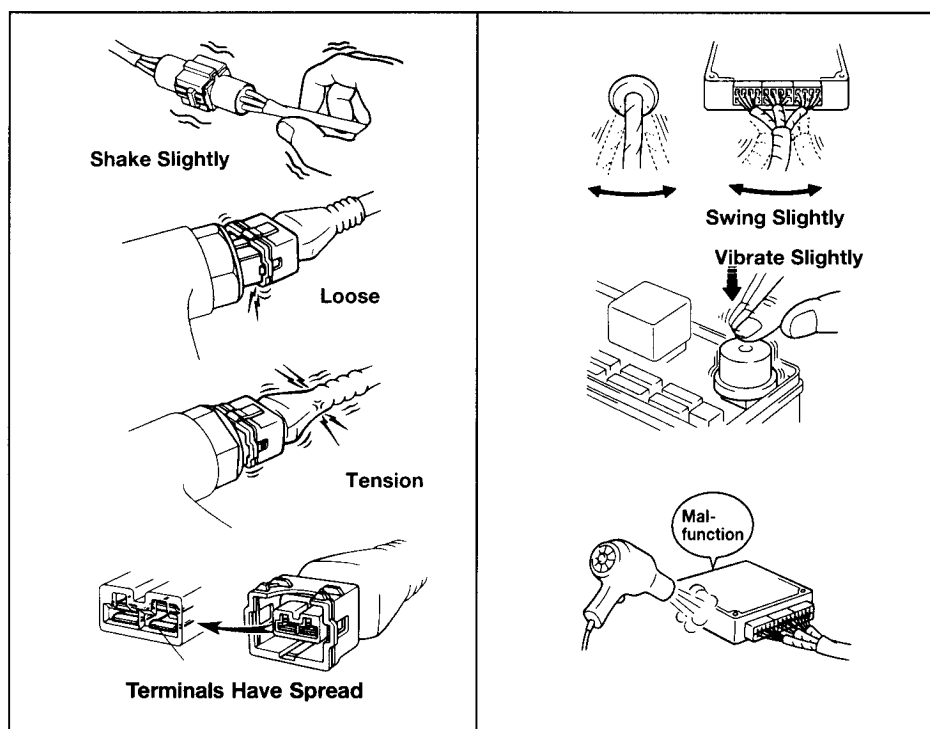
The procedure to erase stored diagnostic codes is as simple as removing a fuse or disconnecting the battery negative terminal for at least thirty seconds. Fuse removal is the method of choice because it will not disturb any other computer memories in the vehicle (ETR radio stations, trip computer data, etc.)

The proper fuse to remove depends on application but will always be the one which feeds the ECU BATT terminal. The following fuses supply BATT power distribution to the ECU keep alive memory: EFI, STOP, or on some P7 applications, ECU +B.

READING AND CONFIRMING DIAGNOSTIC CODES



RECREATING INTERMITTENTS



Monitored and Non-monitored Circuits

Although the newer TCCS self diagnostic system is getting more sophisticated every model year, there are still many electronic control system circuits which the ECU does not monitor. Generally speaking, most input sensors are monitored for faults, but most output actuators are not. Exceptions to this are the Neutral Start Switch (NSW) and Power Switch (PSW)* input signals which are not monitored. Codes 25 and 26 monitor the air/fuel ratio rather than the status of a particular circuit.

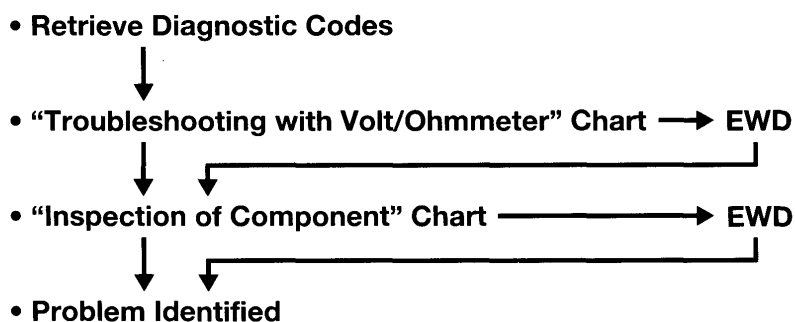
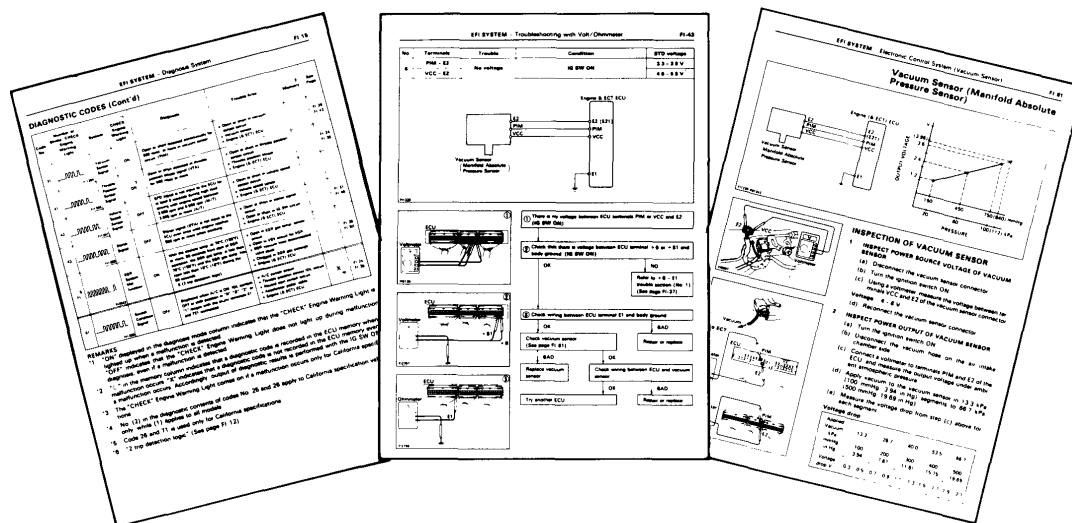
Troubleshooting After Code Retrieval

The diagnostic code leads only to a **circuit level diagnosis**. A pinpoint test of the circuit indicated will be required to isolate the problem down to the component or wiring level.

To find the appropriate diagnostic procedure to follow:

- Refer to the last column of the repair manual "Diagnostic Codes" list.
- This will lead to one or more "Troubleshooting with a Voltmeter/Ohmmeter" diagnostic charts which will facilitate circuit diagnosis.
- This may also lead to an "Inspection of Component" procedure which will facilitate diagnosis of the sensor or actuator in the circuit.

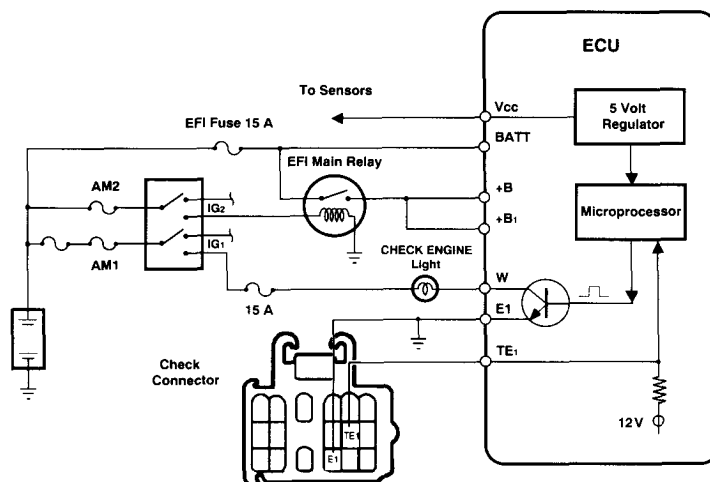
But what if you do not have a diagnostic code to help lead you to the cause of the customer complaint? What do you do next? Before we address the third step in the systematic diagnostic approach, the subject of an inoperative self diagnostic system must be addressed.



No Self Diagnostic System Output (Use of Diagnostic Circuit Inspection Schematic)

There are several conditions which could cause the self diagnostic system to malfunction. In the event the check engine light does not work or if the system will not flash diagnostic codes, it will be impossible to make an accurate diagnosis of the electronic control system. Following are some suggestions to help troubleshoot this condition if it is encountered.

DIAGNOSTIC CIRCUIT INSPECTION



Normal Operation

The following sequence of events should occur when diagnostics are functioning normally:

- With the ignition switch in the "on" position, the check engine light should be on steady.
- When the T circuit is grounded, the check engine light should flash a normal code if all monitored circuits are in proper working order.
- If a fault exists in any monitored circuit, the appropriate diagnostic code should be displayed. If there is more than one code stored in the ECU keep alive memory, codes will be displayed in numerical sequence from lowest to highest.
- Diagnostic codes will continue to repeat until the key is turned off or the T circuit ground is removed.

Abnormal Operation

In the event the self diagnostic system is not functioning normally, it will likely exhibit one of the following symptoms.

- 1) Check engine light fails to come on at power up (key on, engine off, T circuit open).
- 2) Check engine light will not flash code when T circuit grounded (T jumpered to E1), check engine lamp stays on or stays off.

These conditions must be corrected before further diagnosis can be performed! The following charts will help to direct you to perform a "Diagnostic Circuit Inspection."

ENGINE CONTROLS PART #4 - DIAGNOSIS

Check Engine Light Fails to Come On At Bulb Check

Possible Cause	Action to Take/Items To Inspect
Faulty fuse or wiring in BATT or +B circuit(s) to ECU	• Repair cause and replace fuse. • Repair open in BATT circuit. • Repair EFI Main Relay to ECU +B terminal.
Faulty fuse or wiring in IG1 feed to check engine lamp	• Repair cause of burned fuse and replace fuse. • Repair open in wiring to check engine lamp.
Burned out check engine bulb	• Replace bulb.
Faulty wiring in W circuit between fuse and ECU (including ECU connection at terminal W)	• Isolate circuit fault using multimeter starting at ECU terminal W. - With ignition off, disconnect ECU connector, turn ignition on; there should be battery voltage at ECU harness terminal W. - Grounding harness terminal W should turn on check engine light if circuit is good.
Faulty E1 ground circuit	• Isolate fault using multimeter and repair as necessary.
Grounded Vcc circuit in wiring or sensor	• With ECU connected and ignition on, measure voltage at Vcc terminal. - A grounded Vcc will pull this voltage low. - Start disconnecting sensors fed by Vcc one at a time until the voltage goes up to 5 volts; this identifies the offending sensor. • If all sensors are disconnected and voltage is still low at Vcc, turn off the ignition and disconnect the ECU. - Use ohmmeter to measure harness for continuity to ground on the Vcc circuit. - If no fault is found in sensors or harness, the ECU is at fault.
Faulty ECU	• Make sure that connections at the ECU are good (use terminal contact gauge on harness to confirm). • Check +B, W, and E1 circuit connections. If these connections are good, replace ECU.

Check Engine Light Does Not Flash Codes (Stays On or Off)

Possible Cause	Action to Take/Items To Inspect
Faulty wiring in T circuit (including ECU connection at terminal T)	• With T circuit open and ignition switch in "on" position, there should be 12 volts at the T terminal of the check connector. - If voltage is zero, re-check voltage at ECU under same condition. - If voltage is still zero, turn ignition switch off and disconnect ECU. • Check connection at terminal T in harness connector using a terminal contact gauge. - If connection checks O.K., replace ECU.
Grounded W circuit between check engine bulb and ECU	• Turn off ignition switch, disconnect ECU connector. - Turn ignition on, if check engine light comes on, W circuit is grounded. - Disconnect connector at combination meter and isolate unwanted ground.
Faulty E1 ground circuit	• Isolate fault using multimeter and repair as necessary.
Faulty ECU	• Make sure that connections at the ECU are good (use terminal contact gauge on harness to confirm). - Re-confirm T connection. - If this connection is good, replace ECU.

At this stage in your diagnosis, you may have already diagnosed the problem and are ready for repair and a quality control check. If the problem has not yet been identified, you are ready for the next diagnostic step.

Troubleshooting By Symptom

When the self diagnostic system fails to indicate a problem with the electronic control system (normal code displayed), there are two possibilities left. Either there is a problem in the electronic control system which the ECU is not capable of detecting or the problem lies outside of the electronic control system entirely. In either case, the "Troubleshooting" section of the repair manual will help you locate the appropriate diagnostic routine to quickly isolate the problem cause.

The third step in a systematic diagnosis requires use of the "Troubleshooting" and cc Voltage at ECU Wiring Connectors" sections of the repair manual. Based on the symptom the vehicle exhibits, these manual sections will lead you to the diagnostic routine which will assist in solving the problem.

Voltage at ECU Connector Checks

The self diagnostic system is not capable of detecting sensor circuits which are feeding out of range information to the ECU. By using the Voltage at ECU Wiring Connectors chart, measured voltage signals at the ECU can be compared to **standard voltage values** listed

in the repair manual. Signals which are out of the normal range can be identified and the cause diagnosed by referring to the far right column of the chart; this will lead to the appropriate pinpoint test to perform.

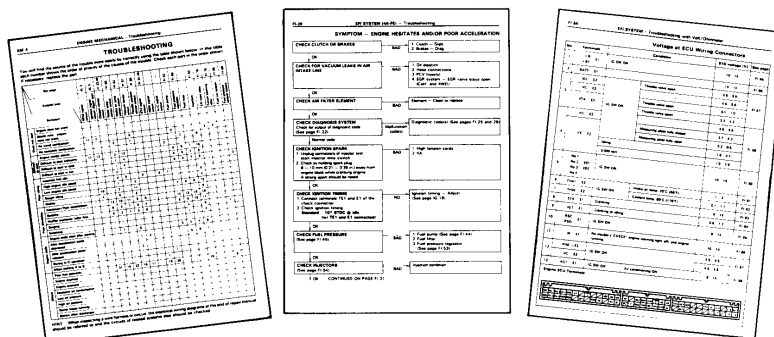
In the event that all listed values fall within a normal range, the symptom charts in the repair manual should be consulted. Starting with new models introduced after '90, repair manuals include a comprehensive troubleshooting matrix that replaces the symptoms charts. Beginning with '92 repair manuals, this matrix is located at the beginning of the Emissions (EM) section of the repair manual.

Using the Symptom Charts and Troubleshooting Matrix

The most important part of troubleshooting by symptom is to identify the symptom accurately. An accurate description of the problem will ensure that the appropriate diagnostic routines will be selected. Based on the symptom chosen, a series of testing routines are available to assist in pinpointing the problem area.

These test routines address items within the electronic control system as well as areas outside the system which could cause the symptom chosen. The technician's knowledge and experience will be his guide to which tests to perform first and which tests to disregard in any particular situation.

TROUBLESHOOTING BY SYMPTOM



Quality Control Check and Confirmation of Closed Loop

The final step in any diagnosis and repair is a quality control check to confirm that the original customer complaint has been corrected and that the system is functioning normally. In the case of the engine electronic control system, the Quality Control Check should consist of the following items:

- Clear any stored diagnostic codes.
- Confirm closed loop operation.
- Confirm normal air/fuel ratio calibration.
- Confirm codes do not reset.

Three of these confirmations can be performed using the VF terminal of the check connector.

Using the VF Terminal As A Closed Loop Monitor

The VF terminal serves as a closed loop monitor, allowing the technician to track the oxygen sensor activity and confirm closed loop operation.

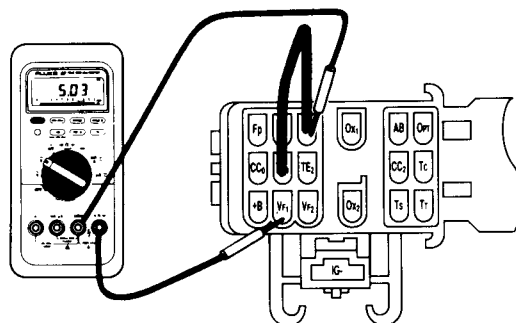
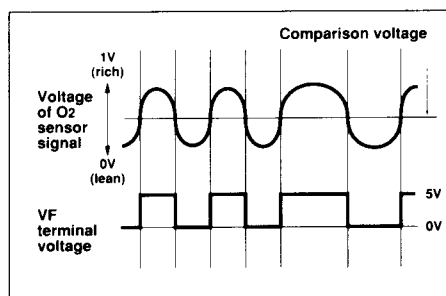
To Use the VF Terminal as a Closed Loop Monitor

- T terminal must be on (shorted to E1).
- IDL contacts must be off (throttle open).

When these conditions have been satisfied, the voltage signal on the VF terminal will imitate the oxygen sensor signal. Whenever the oxygen sensor signal is high, indicating a rich exhaust condition, the VF terminal voltage will be 5 volts. When the oxygen sensor signal is low, indicating a lean exhaust condition, the VF terminal voltage will be 0 volts.

At 2500 rpm, oxygen sensor switching should occur a minimum of eight times in ten seconds if the closed loop system is operating normally. To test, the engine must be fully warmed up and run at 2500 rpm for one minute to ensure the oxygen sensor has reached operating temperature.

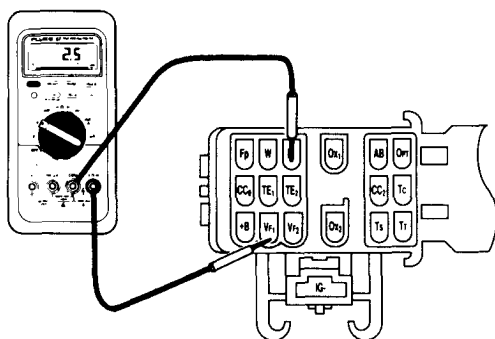
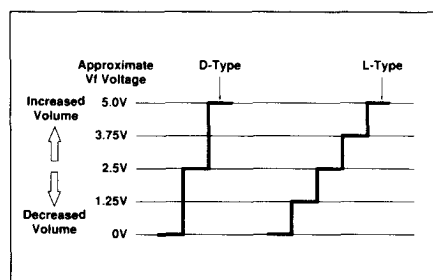
VF VOLTAGE (TE1 GROUNDED)
Closed Loop Monitor



To Use the VF Terminal to Confirm Air/Fuel Ratio

- T terminal must be off (not grounded).

**VF VOLTAGE (TE₁ OPEN)
LEARNED VALUE**



Under this condition, the VF voltage represents the learned value correction factor to fuel injection duration. As you learned in Chapter 5, final injection duration is the sum of basic injection plus injection corrections. Learned value is simply another correction factor which is used to bring the corrected air/fuel ratio as close to the stoichiometric air/fuel ratio as possible.

The ECU fuel injection duration program is the same for every engine; however, each engine is a little bit different from the next. The purpose of the learned value correction is to tailor the standard fuel injection duration program to each individual engine. The injection duration calculation, before oxygen sensor correction, is the ECU's best guess at a stoichiometric air/fuel ratio. The oxygen sensor correction fine-tunes injection duration precisely to 14.7 to 1. The learned value correction factor ensures that oxygen sensor corrections do not become too large to manage.

In this mode, the VF voltage signal will be at one of five different steps (three steps on D type EFI) depending on how close the calculated air/fuel ratio (before oxygen sensor correction) is to stoichiometry. With the engine operating in closed loop, learned value VF should be somewhere in the 1.25 to 3.75 volt range with a nominal value of 2.5 volts.

Generally speaking, a lower voltage indicates the ECU is decreasing fuel to correct for some long term rich condition. Examples of conditions which could cause low learned value VF:

- Crankcase diluted with fuel
- Loaded evaporative canister
- High fuel pressure

A higher voltage indicates that the ECU is increasing fuel to correct for some long term lean condition. Examples of conditions which could cause high learned value VF:

- Atmospheric leaks into intake system
- Worn throttle shaft
- Low fuel pressure

Toyota Diagnostic Communications Link (TDCL)

The TDCL is an enhanced diagnostic check connector which adds a special diagnostic TEST mode to the self diagnostic system. It is only used on '89 and later Cressida, '92 and later Camry, and all Lexus models. It is located under the left side of the instrument panel.

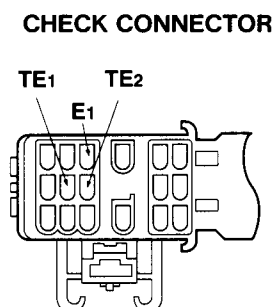
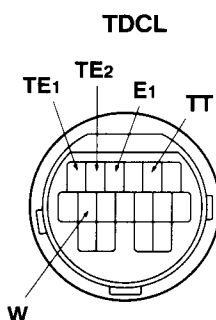
The TDCL uses a TE2 test terminal, which when grounded, triggers the special TEST mode. In TEST mode, the ECU is capable of detecting intermittent electrical faults which are difficult to detect in a normal diagnostic mode. The ECU eliminates most code setting conditions when TEST mode is entered, allowing it to immediately detect a malfunction in many of the monitored circuits.

Using the Diagnostic TEST Mode Procedure

With the ignition switch off, connect terminals TE2 and E1 using SST #09842-18020 (TEST mode will not start if TE2 is grounded after the ignition switch is already on).

- Turn the ignition switch on; then start the engine and drive the vehicle at least 6 mph or higher (code 42, vehicle speed sensor will set if vehicle speed does not exceed 6 mph).
- Simulate driving conditions that problem occurs under.
- When the check engine lamp comes on, jumper TE1 to E1 without disconnecting TE2.
- Note and record diagnostic codes (codes display in same manner as in normal diagnostic mode).
- Exit diagnostic TEST mode by disconnecting TE2 and turning the ignition switch off.

Diagnostic TEST mode is also available on the > '92 Celica 5S-FE and 3S-GTE applications through the check connector TE2 terminal. For more information on using the VF terminal and the TE2 TEST mode diagnostics, refer to Course #872, TCCS Diagnosis.



TE1 and E1 Terminals	TE2 and E1 Terminals	Diagnostic Mode	Output of Check Engine Lamp
Open	Open	Normal	Lamp lights if malfunction occurs and warns the driver.
	Connected	Test	Lamp lights if malfunction occurs and informs the technician.
Connected	Open	Normal	Output of diagnostic results (content of malfunction), in normal mode indicated by the number of times the lamp blinks.
	Connected	Test	Output of diagnostic results (content of malfunction), in test mode indicated by the number of times the lamp blinks.