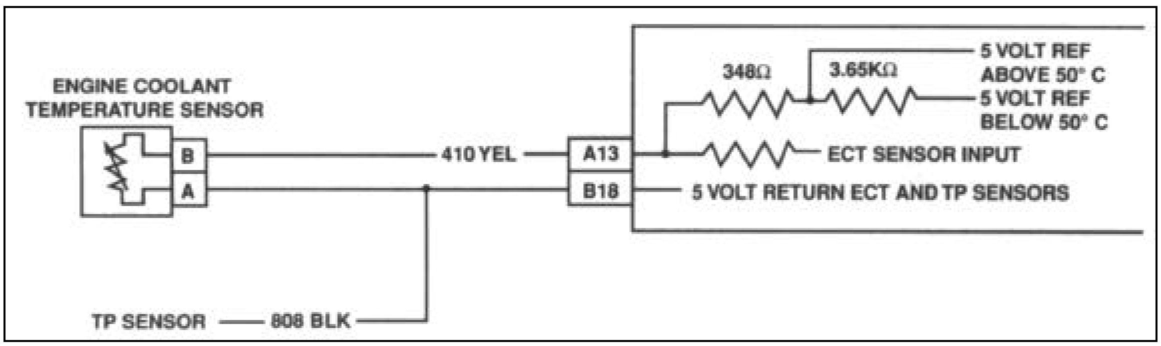
Emission Control: ***Overview of the Engine Coolant Temperature (ECT) Sensor***

When discussing engine electrical operation, there are only a few sensors that effect the operation of a wide variety of systems on the vehicle; the ECT sensor is one of them. A failed or skewed ECT sensor can effect fuel delivery, ignition control, idle speed, torque converter clutch operation, canister purge, exhaust gas recirculation, and possibly cooling fan operation. During cold engine operation, the ECT sensor plays a major role in determining how much fuel the engine needs to operate smoothly.

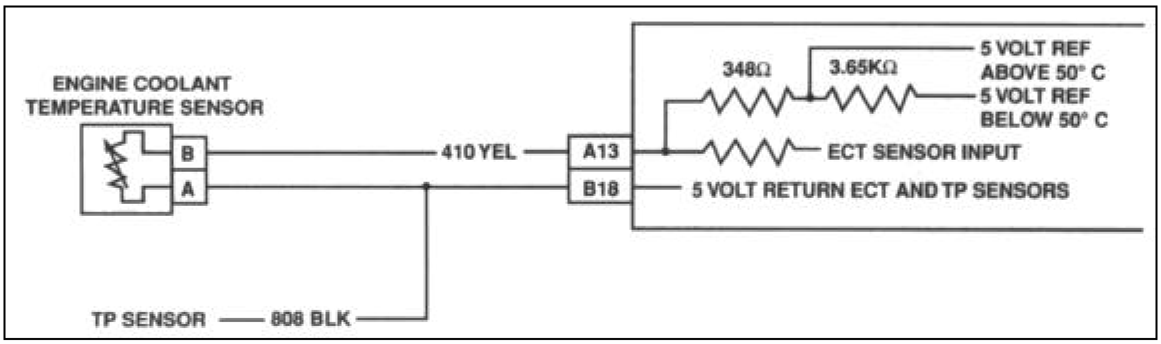
The operation of the ECT circuit is fairly simple. As the temperature of the coolant increases, the resistance of the ECT sensor decreases. The PCM monitors this change by watching the voltage drop across the ECT sensor. The PCM sends 5-volts through a fixed internal resistance in the ECT circuit and monitors the voltage after the fixed internal resistance. A change in ECT sensor resistance will cause a voltage change in the wire between the PCM and ECT sensor. The PCM looks at the voltage on this wire and determines engine coolant temperature.



If the previous paragraph did not make any sense, you should probably skip this next paragraph or risk the chance of a neural meltdown. Most PCM's use a method called "shift voltage" to increase the temperature accuracy of the ECT at higher temperatures. The way the PCM accomplishes this is through a change of the internal resistance in the PCM. Referring to the illustration, the PCM places 5 volts through the 3650-ohm resistor and the 348-ohm resistor in the PCM when temperatures are below approximately 120 degrees F. Therefore, 5-volts must travel through 3998-ohms of resistance before entering the ECT circuit. During these temperatures, the resistance of the ECT sensor is relatively high, which means the voltage on the wire between the ECT sensor and PCM will remain relatively high. NOTE: the process described relates to a General Motors PCM, other manufacturers use different resistance values in their PCM's and ECT sensors.

TEMPERATURE VS. RESISTANCE VALUES (APPROXIMATE)		
°C	°F	OHMS
100	212	177
90	194	241
80	176	332
70	158	467
60	140	667
50	122	973
45	113	1188
40	104	1459
35	95	1802
30	86	2238
25	77	2796
20	68	3520
15	59	4450
10	50	5670
5	41	7280
0	32	9420
-5	23	12300
-10	14	16180
-15	5	21450
-20	-4	28680
-30	-22	52700
-40	-40	100700

When the engine temperature increases above approximately 120 degrees, the resistance change in the ECT sensor becomes less. For example, the resistance value of the ECT at 30 degrees F is 2238 ohms and the resistance valve of the ECT sensor at 40 degrees F is 1459 ohms. The resistance difference of the ECT sensor for the 10-degree F change is 779 ohms, which is substantial when compared to the resistance change at normal engine operating temperature. The resistance of the ECT sensor at 194 degrees F is 241 ohms and at 212 degrees F, the resistance is 177 ohms. The difference is only 64 ohms for an 18-degree temperature change. If the PCM continued to provide the 5-volt reference through the 3650 ohm and 348 ohm resistors, the voltage change would not be much at higher engine coolant temperatures. Therefore, the PCM would not be able to accurately determine the engine operating temperature.



To increase the accuracy of the ECT sensor circuit, the PCM uses a shift voltage technique. Referring to the illustration, when voltage drops to approximately 1.0 volt (or about 120 degrees F), the PCM places 5 volts through the 348 ohm resister and bypasses the 3650 ohm resistor. By doing this, the voltage on the wire between the ECT sensor and PCM raises and engine coolant temperature accuracy is restored. If you ever monitored voltage on the ECT wire or viewed the voltage from a scan tool and noticed the voltage drastically change but the temperature remain the same, now you know why -- shift voltage.

ECT Circuit Failures: Most PCM's have the ability to identify just about anything that can go wrong with an ECT circuit. Most common ECT trouble codes set by the PCM may have nothing to do with the ECT circuit at all. For example, a thermostat stuck open may trigger a trouble code in the PCM for failure to achieve normal operating temperature in a given time. Excessive resistance in the ECT circuit may set a trouble code, because the PCM views the excessive resistance as colder engine operating temperature. If the vehicle is equipped with an Intake Air Temperature (IAT) sensor, the PCM can use the temperature value of the IAT and compare it to the ECT sensor. If the voltage varies more than a specified amount, one of the sensor circuits are faulty.

Skewed ECT sensor circuits are the hardest for the PCM to detect. An ECT circuit can falsely indicate engine operating temperature causing the vehicle to run rich or lean. If the ECT circuit is not skewed much, the problem will probably go unnoticed by the PCM. If skewed far enough, the vehicle may exhibit hard starts, stalling, hesitation/sag/stumble, lack of power, spark knock/detonation, erratic idle, reduced fuel mileage, and possibly failed emissions.

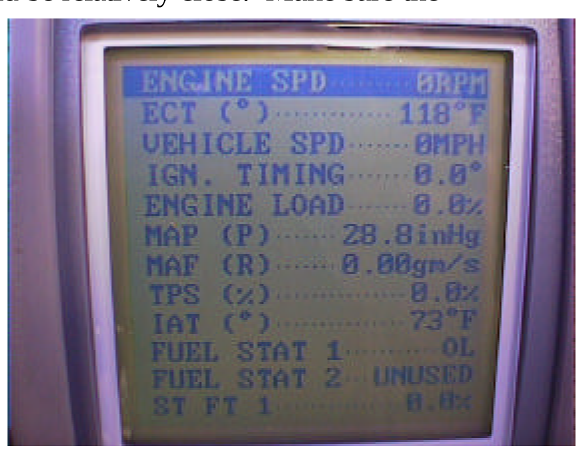
ECT Sensor Testing

DVOM: Service manuals publish resistance values for ECT sensors at different temperatures. One simple test is to compare the ECT sensor resistance value to the chart in the service manual. This method checks the ECT sensor but not the PCM or wiring.

A technician can also perform voltage drop across the ECT sensor and compare the voltage value to a published specification in a service manual. Place the positive voltmeter lead on the wire leading from the PCM to the ECT sensor. Place the negative lead of the voltmeter on the wire leading to ground. Unfortunately, some manufacturers do not provide a voltage - temperature cross-reference.

SCAN TOOL: Typically, when an ECT sensor circuit fails, a trouble code is set. In the past, the only failures most manufacturers would flag included open or shorted circuits. The PCM would recognize these failures by seeing the voltage on the ECT circuit reach to 5.00 volts (when failed open) or fall to 0.00 volts (when failed shorted to ground). During normal operation, the ECT circuit would never be at these voltages, therefore a trouble code would set. Now manufacturers have trouble codes for poor performance of ECT circuits. Erratic voltage may cause a code to set. If any diagnostic trouble codes are set, it is important to use the appropriate diagnostic charts and fix those problems first.

Scan tools are useful to diagnose the accuracy or performance of an ECT circuit even if a trouble code is not set. A scan tool can display a skewed ECT sensor (incorrectly sensing engine coolant temperature) or an ECT circuit that has excessive resistance. While monitoring engine coolant temperature with a thermometer or pyrometer, check the ECT temperature indication on the scan tool, it should be relatively close. Make sure the temperature measurement is on the radiator inlet side. If the reading is not the same, check the resistance of the ECT sensor and compare the measurement to published specifications.



If the resistance is acceptable, check the integrity of the ECT circuit. Place a 1000 ohm fixed resistor across the terminals of the ECT and monitor the voltage or temperature of the ECT on the scan tool. Use the published temperature vs. resistance chart to determine what temperature the scan tool should be displaying. If the scan tool is not displaying the proper temperature, the ECT circuit is at fault (or the PCM is bad, which is unlikely). Check voltage drop of the ground side of the ECT sensor by placing the positive lead of the voltmeter on the ground side of the ECT sensor and the negative lead on the negative post of the battery. The voltage drop should be less than .1 volt. Anything more will effect the ECT circuit enough to misinform the PCM of engine coolant temperature.

Common Problems

During cold weather operation, the ECT sensor provides important information to the PCM for fuel control. When the engine is cold, it will need more fuel to run smoothly. Problems will occur if the PCM senses a cold running engine when the engine is in fact fully warmed up. The PCM will command an overly rich mixture. The PCM "thinks" the engine is cold because the high resistance in the ECT circuit. Use a scan tool to see if the PCM is reporting correct engine coolant temperature. If not, check for excessive resistance or a skewed ECT sensor.

Coolant level and air pockets in the cooling system can lead to improper ECT readings. If the ECT sensor is not completely surrounded by coolant, the PCM will read a false engine coolant temperature. Erratic idle or surging can result from unstable ECT circuit voltages.

Corrosion around the base or sensing element of the ECT sensor will skew the coolant temperature measurements. I once diagnosed a bad ECT sensor on a car that registered -20 degrees F on the scan tool when the vehicle was at 80 degrees F. The car ran pig rich! The PCM thought the engine was extremely cold and enriched the fuel, similar to the choke function on a carburetor. When diagnosing the ECT circuit, the temperature started to work its way back to normal and the problem would never repeat itself. ECT circuit resistance or a contaminated ECT sensor element . . . who knows, who cares, the problem is fixed.