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Troubleshooting Temperature Sensor Circuits

How Temperature Sensors Work

Electronic engine control modules, air conditioning control modules, transmission control modules and other controllers that measure temperature values typically employ two-wire sensors to measure temperature. These sensors are called thermistors. They are variable resistance devices that change their resistance value based on temperature values. As their temperature increases their resistance decreases. Figure 1 illustrates how these temperature sensors are typically wired to the Electronic Control Module (ECM). The signal wire to the sensor is supplied either 3 volts or 5 volts through a fixed value resistor. Pre-EPA 07 engines typically use 5V temperature sensors, and EPA 07 and newer engines typically use 3V temperature sensors. This fixed resistor and the variable resistance sensor are connected in series. The return wire takes the sensor to ground inside the ECM. Because they are wired in series these two resistance devices share the voltage. A voltage measuring device inside the ECM measures the voltage on the signal wire. As the resistance value of the temperature sensor changes, the voltage on the signal wire will change. The more voltage the sensor consumes the less voltage the fixed resistor will consume.

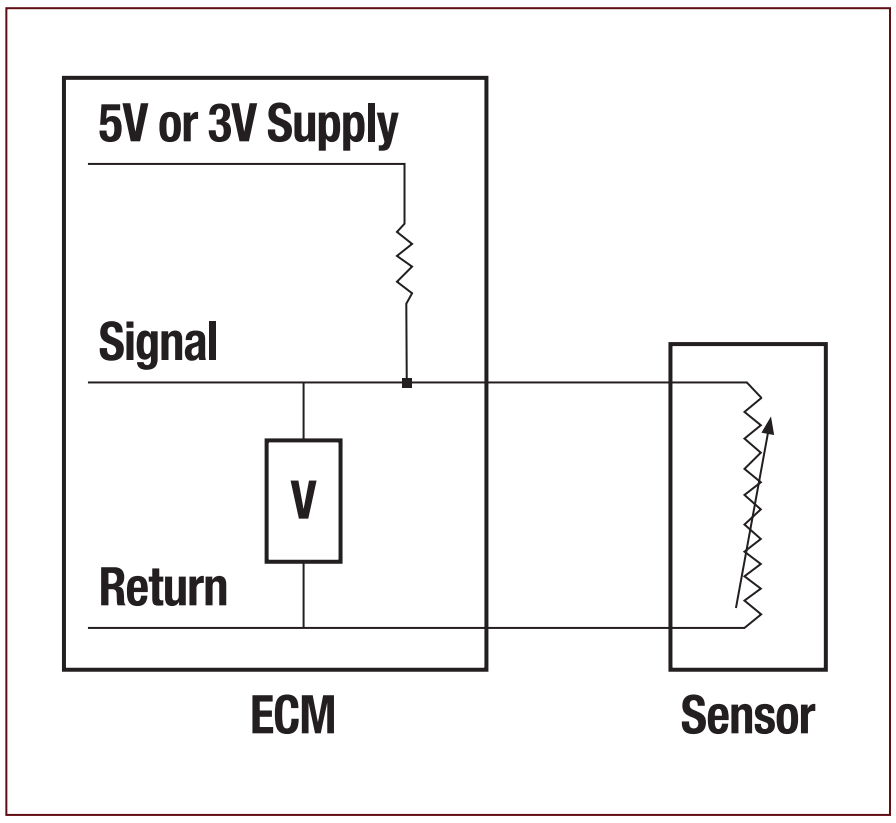

Figure 1

Sensor Voltage Ranges

As long as the sensor is operated at temperatures within its measuring range the voltage on the signal wire will be within a normal operating range. Figure 2 illustrates the operating ranges of a 5V temperature sensor circuit. Typically, the normal range of the sensor is .25V to 4.75V. If the ECM sees a voltage value below .25V on the signal wire the ECM will store a "low voltage" code for the sensor. If the voltage value is above 4.75V the ECM will store a "high voltage" code. The normal high and low voltage limits of a 3V temperature sensor are similar. A "low voltage" code is stored when the voltage sensed is below .25V approximately. A "high voltage" code is stored above 2.75V approximately.

Open Circuit Failures

Whenever there is an open circuit in the signal wire, sensor, or the return wire, the voltage on the signal wire inside the ECM will go to 5V because there will be no voltage drop across the fixed resistor since there is no current flow through it. The ECM will store a "high voltage" code since the voltage is above the normal operating range of the sensor.

Shorted Circuit Failures

Whenever the signal wire is shorted to the return wire, shorted to chassis ground, or the sensor is shorted internally, the voltage value on the signal wire inside the ECM will go to a value that is below the normal operating range of the sensor. This happens because the fixed resistor will consume most or all of the voltage since it is not sharing voltage with the sensor any longer as a result of the short. The ECM will store a "low voltage" code.

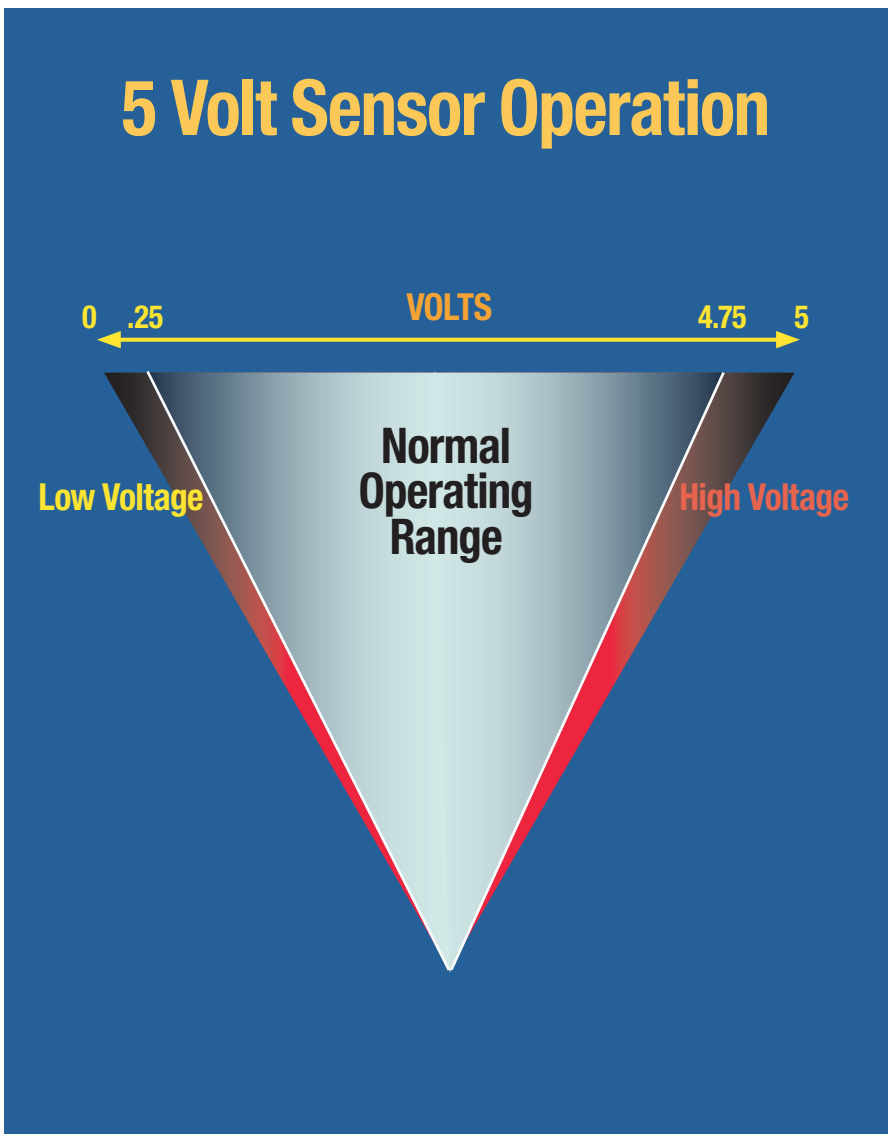

Figure 2

Troubleshooting "High Voltage" and "Low Voltage" Fault Codes

When an ECM stores one of these high voltage or low voltage fault codes the technician should determine whether the fault is caused by the wiring between the sensor and the ECM, or caused by a faulty sensor. A good way to test this circuit is to connect the service tool to the truck datalink and monitor the active fault codes.

1. If the code is a high voltage code, disconnect the sensor and, using proper test pins that won't damage the connectors, install a jumper wire that is fused with a 2 amp fuse or smaller across the two pins in the connector that is disconnected from the sensor. This creates a short circuit between the signal wire and the return wire. If the fault code changes to a low voltage code, the ECM, the signal wire, and the return wire are not at fault. The sensor is open.

2. If the original code is a low voltage code, disconnect the sensor. If the fault code changes to a high voltage code, the ECM, signal wire, and return wire are not at fault. The sensor is shorted.

3. With the sensor disconnected, and a fused jumper wire installed across the sensor connector, the ECM should store a low voltage code. If it doesn't store a low voltage code, the signal wire is open, or the return wire is open, or the ECM is defective.

Conclusion

Using a fused jumper wire to simulate a shorted sensor circuit is typically the quickest way to determine whether a low voltage code or a high voltage code is being caused by the sensor, the wiring, or the ECM. **Warning: Technicians performing this troubleshooting procedure should make sure the test pins they plug into the sensor connector terminals will not spread or otherwise damage the terminals. The jumper wire should be made out of the same size terminals that normally plug into the connectors.**

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