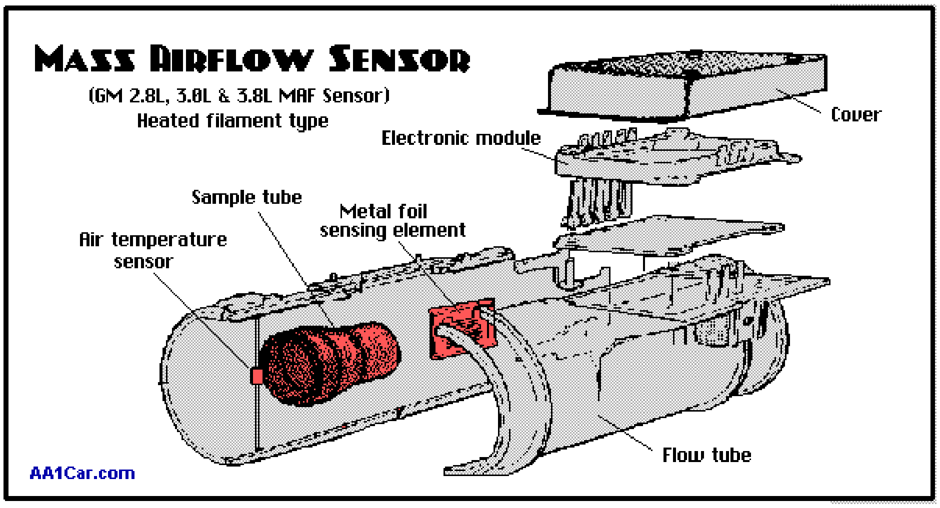


Mass Airflow MAF Sensors

by Larry Carley copyright 2019 AA1Car.com

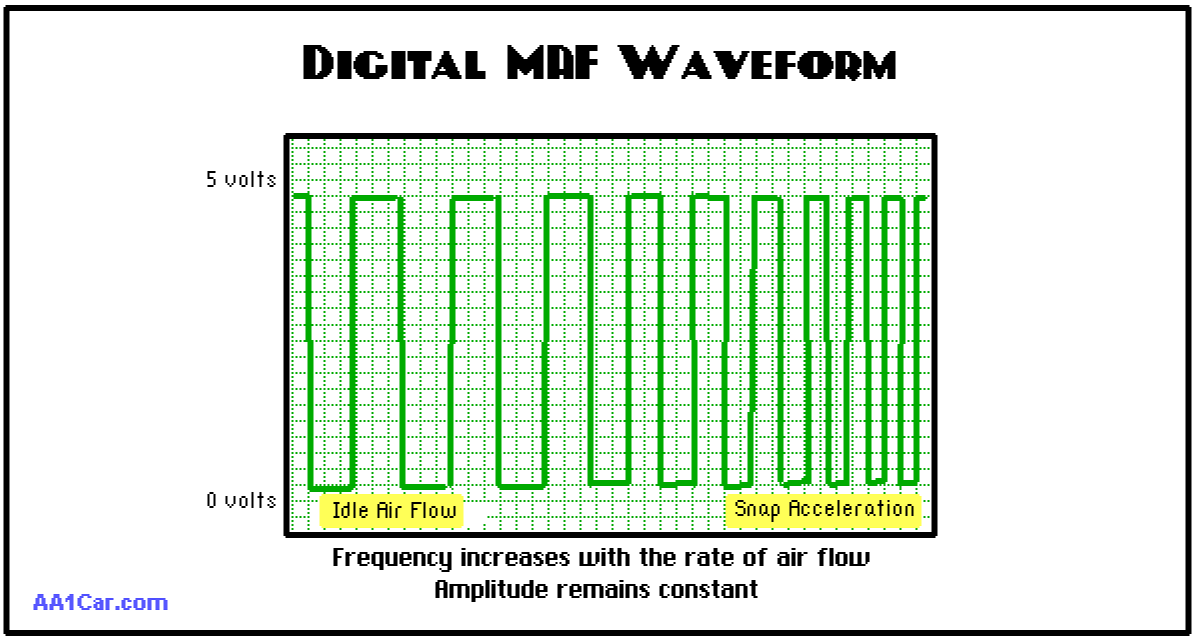
Mass airflow sensors (MAF), which are used on a variety of multiport fuel injection systems, come in two basic varieties: hot wire and hot film. Though slightly different in design, both types of sensors measure the volume and density of the air entering the engine so the computer can calculate how much fuel is needed to maintain the correct fuel mixture.

> Mass airflow sensors have no moving parts. Unlike a vane airflow meter that uses a spring-loaded flap, mass airflow sensors use electrical current to measure airflow. The sensing element, which is either a platinum wire (hot wire) or nickel foil grid (hot film), is heated electrically to keep it a certain number of degrees hotter than the incoming air. In the case of hot film MAFs, the grid is heated to 75 degrees C. above incoming ambient air temperature. With the hot wire sensors, the wire is heated to 100 degrees C. above ambient temperature. As air flows past the sensing element, it cools the element and increases the current needed to keep the element hot. Because the cooling effect varies directly with the temperature, density and humidity of the incoming air, the amount of current needed to keep the element hot is directly proportional to the air "mass" entering the engine.

MASS AIRFLOW SENSOR OUTPUT

MAF sensor output to the computer depends on the type of sensor used. The hot wire version, which Bosch introduced back in '79 on its LH-Jetronic fuel injection systems and is used on a number of multiport systems including GM's 5.0L and 5.7L Tuned Port Injection (TPI) engines, generates an analog voltage signal that varies from 0 to 5 volts. Output at idle is usually 0.4 to 0.8 volts increasing up to 4.5 to 5.0 volts at wide open throttle.

The hot film MAFs, which AC Delco introduced in '84 on the Buick turbo V6 and have since used on the 2.8, 3.0 and 3.8L V6 engines, produce a square wave variable frequency output. The frequency range varies from 30 to 150 Hz, with 30 Hz being average for idle and 150 Hz for wide open throttle.



Another difference between the hot wire and hot film sensors is that the Bosch hot wire units have a self-cleaning cycle where the platinum wire is heated to 1000 degrees C. for one second after the engine is shut down. The momentary surge in current is controlled by the onboard computer through a relay to burn off contaminants that might otherwise foul the wire and interfere with the sensor's ability to read incoming air mass accurately.

MASS AIRFLOW SENSOR DIAGNOSTIC FAULT CODES

An engine with a bad MAF sensor may start and stall or be hard to start, it may hesitate under load, idle rough or run excessively rich or lean. The engine may also hiccup when the throttle suddenly changes position.

Often, a dirty or faulty MAF sensor will cause the engine to set a LEAN code and turn on the Check Engine Light. If the MAF sensor wire becomes dirty or is contaminated with oil (from an aftermarket reusable air filter), it will be slow to react to changes in airflow. This may cause the MAF sensor to under-report airflow, causing the engine to run lean.

On OBD II vehicles, the input from the MAF sensor is combined with those form the throttle position sensor, MAP sensor and engine speed to calculate engine load. If your scan tool can display calculated engine load, look at the value to see if the load is low at idle, and higher when the engine is running under load. No change in the reading or a reading that makes no sense could indicate a problem with any of these sensors.

If you suspect a MAF sensor problem, scan for any fault codes. Trouble codes that may indicate a problem with the mass airflow sensor include:

P0100....Mass or Volume Air Flow Circuit

P0101....Mass or Volume Air Flow Circuit Range/Performance Problem

P0102....Mass or Volume Air Flow Circuit Low Input

P0103....Mass or Volume Air Flow Circuit High Input

P0104....Mass or Volume Air Flow Circuit Intermittent

P0171....System too Lean (Bank 1)

P0172....System too Rich (Bank 1)

P0173....Fuel Trim Malfunction (Bank 2)

P0174....System too Lean (Bank 2)

P0175....System too Rich (Bank 2)

On older Pre-OBD II vehicles, you can use a scan tool or manual flash code procedure to read the codes:

GM Pre-OBD II: Code 33 (too high frequency) and Code 34 (too low frequency) on engines with multiport fuel injection only, and Code 36 on 5.0L and 5.7L engines that use the Bosch hot wire MAF if the burn-off cycle after shut-down fails to occur.

Ford Pre-OBD II: Code 26 (MAF out of range), Code 56 (MAF output too high), Code 66 (MAF output too low), and Code 76 (no MAF change during "goose" test).

Of course, don't overlook the basics, too such as engine compression, vacuum, fuel pressure, ignition, etc., since problems in any of these areas can produce similar driveability symptoms.

MASS AIRFLOW SENSOR DIAGNOSIS

Unlike vane airflow meters with their movable flaps, MAFs have no moving parts so the only way to know if the unit is functioning properly is to look at the sensor's output, or its effect on injector timing.

With the Bosch hot wire sensors, sensor voltage output can be read directly with a digital voltmeter by probing the appropriate terminals. If the voltage readings are out of range, or if the sensor's voltage output fails to increase when the throttle is opened with the engine running, the sensor is defective and needs to be replaced. A dirty wire (which may be the result of a defective self-cleaning circuit or external contamination of the wire) can make the sensor slow to respond to changes in airflow. A broken or burned out wire would obviously prevent the sensor from working at all. Power to the MAF sensor is provided through a pair of relays (one for power, one for the burn-off cleaning cycle), so check the relays first if the MAF sensor appears to be dead or sluggish.

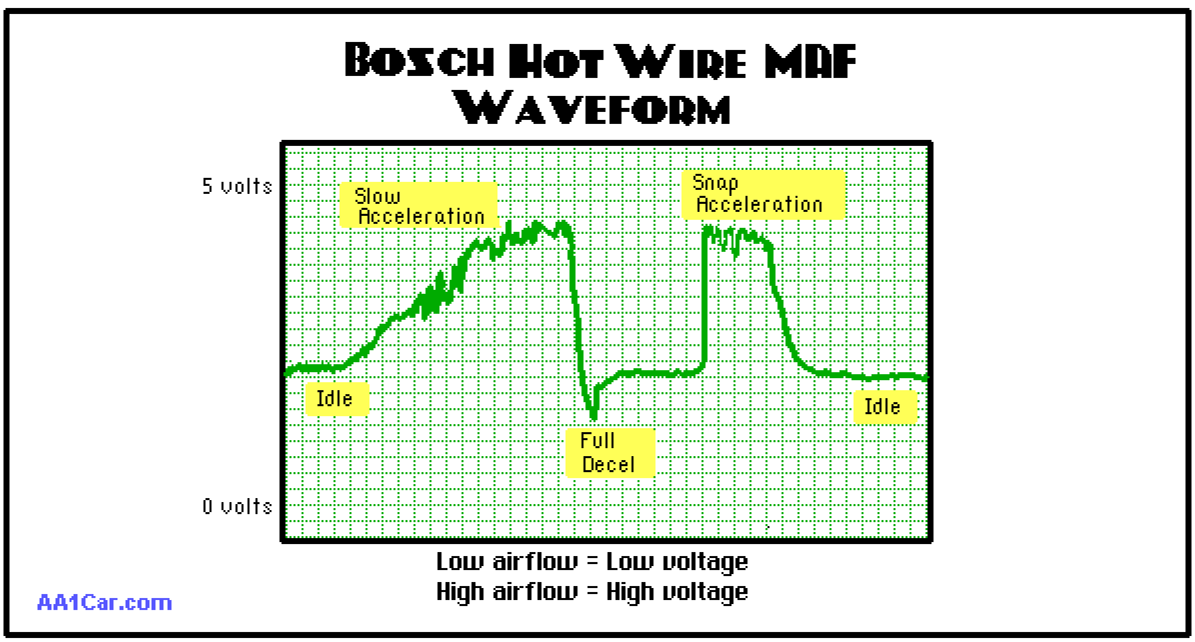
On GM MAF sensors, there are a couple of quick checks you can do for vibration-related sensor problems. Attach an analog voltmeter to the appropriate MAF sensor output terminal. With the engine idling, the sensor should be putting out a steady 2.5 volts. Tap lightly on the sensor and note the meter reading. A good sensor should show no change. If the analog needle jumps and/or the engine momentarily misfires, the sensor is bad and needs to be replaced. You can also check for heat-related problems by heating the sensor with a hair dryer and repeating the test.

This same test can also be done using a meter that reads frequency. The older AC Delco MAF sensors (like a 2.8L V6) should show a steady reading of 30 to 50 Hz at idle and 70 to 75 Hz at 3,500 rpm. The later model units (like those on a 3800 V6) should read about 2.9 kHz at idle and 5.0 kHz at 3,500 rpm. If tapping on the MAF sensor produces a sudden change in the frequency signal, it's time for a new sensor.

On the GM hot film MAFs, you can also tap into the onboard computer data stream with a scan tool to read the MAF sensor output in "grams per second" (GPS). The reading might go from 3 to 5 GPS at idle up to 100 to 240 GPS at wide open throttle and 5000 RPM.

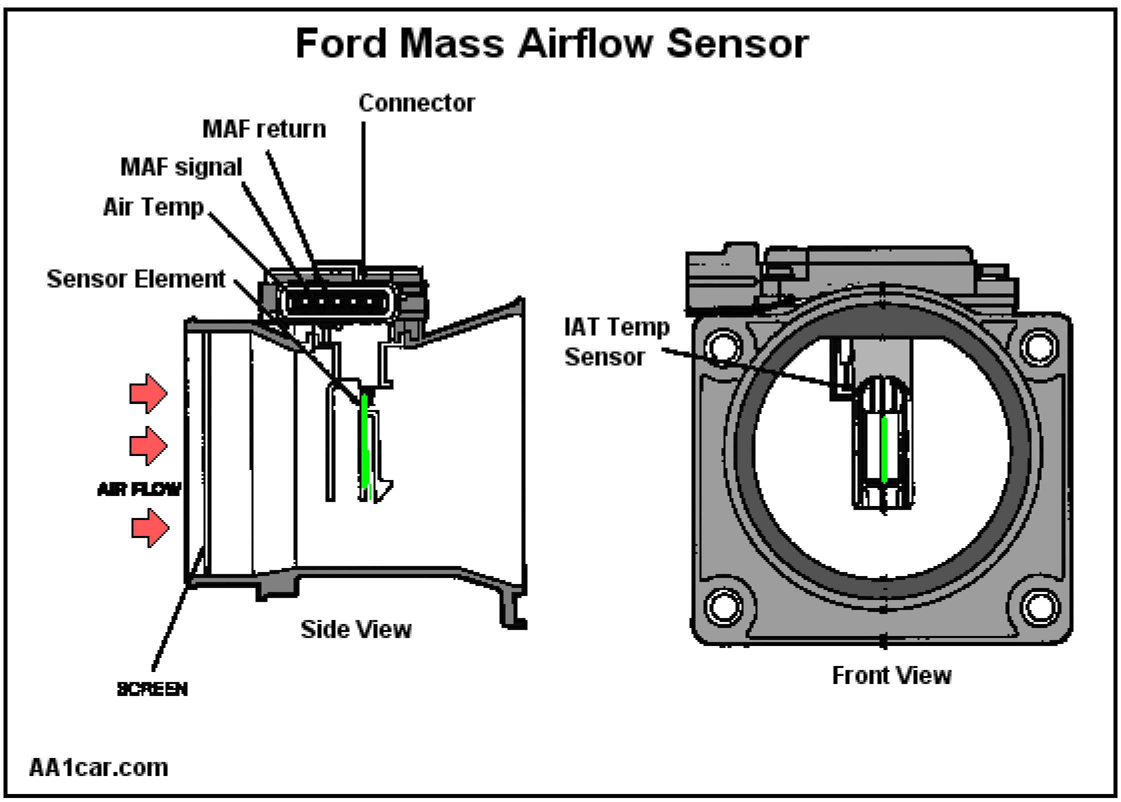
The scantool GPS reading at idle will vary by engine displacement. The larger the engine, the higher the GPS reading at idle. The GPS idle reading will roughly correspond to engine displacement in liters. A 3.0L V6 engine, for example, will generate a GPS reading of about 3.0 grams per second at idle. A larger 5.0L V8 would read around 5 grams per second, and a smaller 2.0L four cylinder would read around 2 grams per second at idle.

Some vehicle manufacturers publish MAF sensor GPS reading specifications for specific engine speeds. The engine is held steady at the specified RPM to compare the scantool GPS reading to the spec. If the reading is off by more than 10 percent, the MAF sensor is not reading airflow correctly. The cause could be a dirty sensor that needs to be cleaned.



Like throttle position sensors, there should be smooth linear transition in sensor output throughout the rpm range. If the readings jump all over the place, the computer won't be able to deliver the right air/fuel mixture and driveability and emissions will suffer. So you should also check the sensor's output at various speeds to see that it's output changes appropriately. This can be done by graphing its frequency output every 500 rpm, or by observing the sensor's waveform on a scope. The waveform should be square and show a gradual increase in frequency as engine speed and load increase. Any skips or sudden jumps or excessive noise in the pattern would tell you the sensor needs to be replaced.

Another way to check MAF sensor output is to see what effect it is has on injector timing. Using an oscilloscope or multimeter that reads milliseconds, connect the test probe to any injector ground terminal (one injector terminal is the supply voltage and the other is the ground circuit to the computer that controls timing). Then look at the duration of the injector pulses at idle (or while cranking the engine if the engine won't start). Injector timing varies depending on the application, but if the mass airflow sensor is not producing a signal, injector timing will be about four times longer than normal (possibly making the fuel mixture too rich to start). You can also use millisecond readings to confirm fuel enrichment when the throttle is opened during acceleration, fuel leaning during light load cruising and injector shut-down during deceleration. Under light load cruise, for example, you should see about 2.5 to 2.8 Ms duration.



CLEANING FORD MAF SENSORS

For some reason, Ford vehicles have had a history of MAF sensor problems caused by contamination. In some cases, dirt gets past a leaky air filter and fouls the sensor wire. In other cases, carbon varnish builds up on the sensor from fuel vapors backing up through the intake manifold. Either way, contamination makes the MAF sensor sluggish, and often sets a P0171 or P0174 lean code.

The fix is to clean the sensor element with aerosol electronics cleaner (CRC makes a good product for this). The MAF sensor is located inside the air filter housing on some applications (Windstar, for example) or between the air filter and throttle body. Spray the sensor element with electronics cleaner, let it soak for about 10 minutes, then repeat. DO NOT use any other type of cleaner as this may damage the sensor. Also, DO NOT touch, scrub or attempt to physically clean the sensor element as this too can ruin the sensor.

Repeat GM MAF Sensor Failures Blamed on Engine Backfires

GM says that repeated instances of Mass Air Flow (MAF) sensor failure on some of their vehicles may be due to engine backfires. The sudden buildup of pressure inside the intake manifold that results from a backfire can crack the heated element inside the MAF sensor causing it to fail.

Common causes of engine backfire include a lean misfire due to low fuel pressure or restricted fuel injectors, breakdown of the secondary ignition including internal ignition coil arcing, and a dead spot in the Throttle Position Sensor (TPS).

A lean fuel condition can be verified by using a scan tool to monitor the Block Learn memory value with the engine at a steady no load cruise rpm. A reading above the 135 to 140 range would indicate a lean fuel mixture, or an air leak in the exhaust manifold ahead of the oxygen sensor. Internal ignition coil arcing between the coil primary and secondary windings can be very difficult to trace. Checking for internal coil arcing requires a professional level engine analyzer/scope.

A dead spot in the TPS can be verified by monitoring the sensor voltage as the throttle is moved from the idle position to the Wide Open Throttle position (very slowly) with an analog voltmeter or a digital storage oscilloscope or scan tool with graphing capability.

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