WELLS Counter Point

Volume 3 Issue 3, July 1999

THE ELECTRONIC, DIAGNOSTIC AND DRIVEABILITY RESOURCE.

Making Sense Of Engine Air Flow

To create a balanced fuel mixture in a fuel-injected engine, the engine's powertrain control module needs to know how much air is entering the engine. There are two ways of doing this.

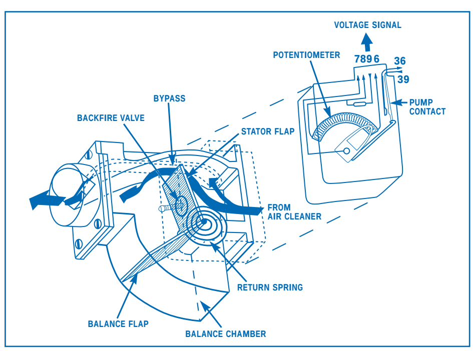
One is to estimate air-flow according to engine load and throttle position using inputs from the MAP and TPS sensors (speed-density systems), and the other is to directly measure it (air-flow systems).

In the last issue of *Counter Point*, we covered hot-wire and hot-film type mass air-flow sensors. This month, we'll look at vane air-flow (VAF) and Karman-Vortex type mass air-flow sensors.

Vane air-flow sensors (also called air-flow meters) are used on some fuel-injected engines to measure the volume of air entering the engine. This type of air-flow sensor is used mostly on European imports equipped with Bosch L-Jetronic fuel injection, Japanese imports equipped with Nippondenso multiport electronic fuel injection, and Ford vehicles equipped with the Bosch multiport EFI (Escort/Lynx, Turbo T-Bird and Mustang with the 2.3L turbo engine, and Ford Probe with the 2.2L engine).

HOW A VAF TYPE MASS AIR-FLOW SENSOR WORKS

A vane air-flow sensor is located ahead of the throttle and monitors the volume of air entering the engine by means of a spring-loaded mechanical flap. The flap is pushed open by an amount that's proportional to the volume of air entering the engine. The



flap has a wiper arm that rotates against a sealed potentiometer (variable resistor), allowing the sensor's resistance and output voltage to change according to air flow. The greater the air flow, the further the flap is forced open. This changes the potentiometer's resistance and the resulting voltage return signal to the computer. Thus a vane air-flow sensor measures air flow directly, enabling the computer to calculate how much air is entering the engine independent of throttle opening or intake vacuum. The computer then uses this information to adjust injector duration for a balanced fuel mixture.

The vane air-flow sensor also contains a safety switch for the electric fuel pump relay. Air-flow into the engine activates the pump. So if the engine will not start because the fuel pump won't kick in, check the air-flow sensor. The easiest way to do so is to turn the key on and push the flap open. If you don't hear the fuel pump come on, the contact inside the sensor may be defective. A sealed idle-mixture screw is also located on the air-flow sensor. This controls the amount of air that bypasses the flap, and consequently the air/fuel mixture ratio.

VAF PROBLEMS

Air-flow sensors can't tolerate air leaks. A vacuum leak downstream of the VAF sensor allows "unmetered" air to enter the engine. The extra air can lean-out the fuel mixture causing a variety of driveability problems. The oxygen sensor can compensate for small air leaks once the engine warms up and goes into closed loop, but not for large air leaks. The oxygen sensor is also an "after the fact" sensor, which means air leaks can cause hesitation or stumbling when the throttle is suddenly opened.

Vane air-flow sensors are also vulnerable to dirt. Unfiltered air passing through a torn or poor fitting air filter can allow dirt to build up on the flap shaft causing the flap to bind or stick. You can test the operation of the flap by gently pushing it open with your finger. It should open and close smoothly with even resistance. If it sticks, a shot of carburetor cleaner might loosen it, otherwise the sensor will have to be replaced.

Backfiring in the intake manifold can force the flap backwards violently, often bending or breaking the flap. Some sensors have a "back-fire" valve built into the flap that's supposed to protect the flap in case of a back-fire by venting the explosion. But the anti-backfire valve itself can become a source of trouble if it leaks as it can affect the air/fuel mixture. A leaky backfire valve will cause the sensor to read low and the engine to run rich.

VAF SENSOR CHECKS

Though there are special testers for troubleshooting VAF sensors, you don't always need one to check the sensor's operation. By watching the VAF sensor's output with an analog voltmeter or ohmmeter, or better yet an oscilloscope, you can look for a change in the sensor's output as air-flow changes.

One simple check is to look for a voltage change as you slowly push the air-flow flap all the way open. A good sensor should produce a smooth

continued on page 3

WHAT'S INSIDE:

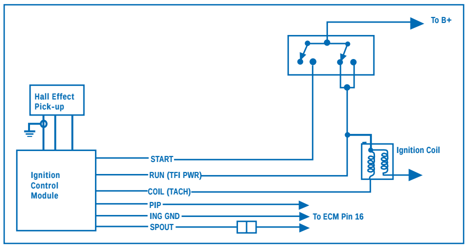
Fine Tuning

Fine **Tuning** *questions are answered by Jim Bates, WELLS' Technical Services Director.*

Q: "I have been working on a 1990 Ford Bronco II 2.9L that was towed in and has a no-spark condition because of a broken rotor. We pulled the distributor and cleaned and inspected it for damage. But after it was reinstalled with a new cap and rotor, there is still no spark. The ignition module and Hall effect pick-up have also been replaced. Still no spark. The module has power and a good ground back to the negative battery terminal. Have we overlooked something?"

Jim's Roadside Service, East Aurora, NY

There is a TFI ground wire (black/orange) connected between the ignition control module and pin 16 on the ECM that could be causing the problem. With a DVOM attached between the TFI ground wire and battery negative, there should be less than .04 volts. If not, the TFI ground wire or the ECM should be checked.



Q: "I have always bench-tested EGR valves to be sure they hold vacuum before I install them. Lately, I haven't found many that will hold vacuum at all. I have tried several valves from different sources, but they are all the same. Why is this?"

Timmond's Auto Service, Bayone, IN

Many EGR valves today are of the back-pressure type. They have an internal valve that must be closed by about one to three pounds of exhaust back-pressure. Tiny holes in the pintle or stem channel the back pressure up the hollow stem to close the internal valve. Once this internal valve is closed, vacuum applied to the top of the EGR valve diaphragm will open the pintle to allow exhaust gas recirculation. You can test this type of EGR valve by running the engine at a high idle, about 1800-2000 RPM or so, then applying vacuum to watch the valve pintle move, listen for a slight drop in RPM or observe intake manifold pressure changes.

◆

Q: "We are working on a 1994 Chevrolet Cavalier with the 2.2L engine that turned out to have a head gasket problem. After replacing the head gasket set, the car has a very poor idle, but runs OK at higher RPM's. Compression checks out OK but the intake manifold vacuum is low. Valve timing, intake manifold gaskets, hoses and EGR valve and spacer all check out OK. Have we missed something?"

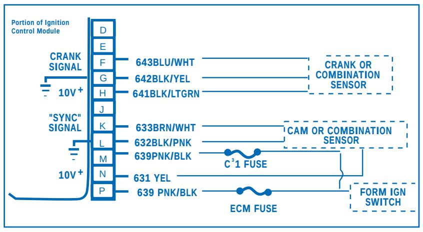
George Kieth, Patterson Tire, Pontoon Beach, IL

If you haven't looked at the EGR valve gasket itself, you should do so because the EGR valve-spacer configuration changes from model to model. Because of this, some gasket sets contain more than one EGR valve gasket. While the gaskets are the same size and shape, the EGR passage-hole patterns vary. If the wrong gasket is used or supplied, intake manifold vacuum would be exposed to the EGR passage continually.

Q: "I am working on a 1987 Buick Century 3.8L and I receive very low voltage on terminal "N" (circuit 631, 10V+ yellow power lead to cam sensor). DVOM reads 1.52 to 1.60 volts. There are no shorts in any of the cam or crankshaft sensor leads. The module acts as if it is internally grounded in this circuit because when I break module ground with the engine, I have proper voltage on yellow 10V+ power lead (circuit 631). I have proper voltage to "M" terminal (power) and proper voltage to crankshaft sensor. ECM is responding properly. When module ground is broken, I read 9.83 volts from the bottom of the module to engine ground. I have even replaced the module and get the same results. Help! Is this normal?"

Mark Evans, Pell City, AL

Based on what you have already checked and replaced, the problem may be a shorted crankshaft position sensor, which would pull the voltage down on circuit 631 when the module is grounded. Disconnect the crankshaft position sensor and check the voltage at terminal "N". If it is OK, the problem may be in circuit 642 or a shorted crankshaft position sensor.



Please send your questions to: *Jim Bates c/o WELLS Manufacturing Corp., P.O. Box 70, Fond du Lac, WI 54936-0070 or e-mail him at technical@wellsmfgcorp.com. We'll send you a WELLS shirt if your question is published. So please include your shirt size with your question.*

Corrections

In the April issue of Counter Point, there were two inaccuracies in the Fine Tuning questions. The question from Gene's Super Service should have referenced a 5.0L engine, not a 5.7L. The question from Big John's Service should have referenced a 4.3L engine, not a 4.5L. We apologize for any resulting confusion.

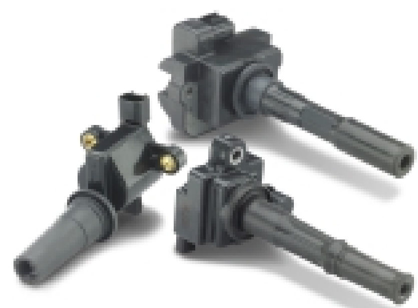
Quality Points

Coil-On-Plug Systems: They Are The Future

Ignition distributors have mostly disappeared from under the hoods of newer model cars and trucks, and now spark plug wires are vanishing, too. A growing number of engines today have direct ignition systems where the coils are mounted over the spark plugs and no spark plug wires are used. Some of these are "waste spark" systems where each coil fires a pair of cylinders that are opposite each other in the firing order, while others are "individual" or "independent" systems that have a separate coil for each spark plug. In both cases, coil longevity is expected to be significantly longer than that of a coil used with a distributor because individual coils don't have to fire as often. Consequently, they run cooler and last longer.

Most coil-on-plug ignition systems have no plug wires, which means there are no wires to come loose, burn, leak current, break down or replace. Eliminating the plug wires also reduces radio frequency interference (RFI) and electromagnetic pulsation (EMP) that can interfere with onboard electronics. But the absence of plug wires also means the coils have to be removed and reconnected with adapters or plug wires to test for spark, connect an ignition scope pick-up or to perform a manual cylinder power balance test.

One of the most common coil-on-plug applications is General Motor's "Integrated Direct Ignition" (IDI) found on the 1988 through 1995 2.3L Quad Four engine, and the 1996 and newer



continued from page 1

Making Sense Of Engine Air Flow

and gradual transition in resistance (ignition off) and/or voltage readings (ignition on) all the way from full closed to full open. If you see any sudden jerks in the movement of the needle (analog ohmmeter or voltmeter) or dips or blips in the scope trace (similar to sweeping a TPS), the VAF sensor needs to be replaced.

Changes in the sensor's voltage output should also produce a corresponding change in fuel injector duration when the engine is running. Injector duration should increase as the VAF flap is pushed open.

On the Ford EFI systems, you can use a breakout box and voltmeter to check VAF sensor voltage readings. Pushing the flap open should cause a steady and even increase in the sensor's output from 0.25V when the flap is closed to about 4.5V with the flap fully open. The reference voltage to the air-flow sensor from the computer should be 5 volts.

Ford's trouble codes that apply to the VAF include: code 26 indicates a VAF reading out of range, code 56 indicates sensor input too high, code 66 is sensor input too low, and code 76 indicates no sensor change during the goose test.

Most manufacturers also give specific resistance specs for the various VAF terminals in a shop manual. Bosch, for example, lists the following for some of its applications:

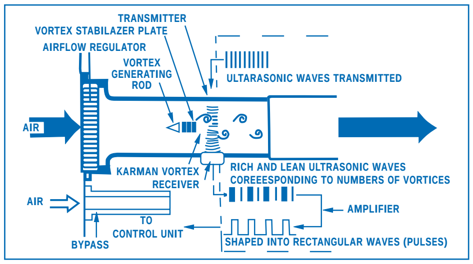
Terminals 6 & 9	200 - 400 ohms
Terminals 6 & 8	130 - 260 ohms
Terminals 8 & 9	70 - 140 ohms
Terminals 6 & 7	40 - 300 ohms
Terminals 7 & 8	100 - 500 ohms
Terminals 6 & 27	max 2800 ohms @ 68° F

On a Mazda 323, the resistance reading between VAF sensor terminals E2 and VS should be 20 ohms with the flap closed, and 1000 ohms when the flap is open. Readings that are out of range would indicate a bad sensor.

VAF REPLACEMENT

Vane air-flow sensors are a sealed unit, preset at the factory with nothing that can be replaced or adjusted except the idle-mixture screw. Opening up a VAF that's still under warranty voids the warranty. So if the unit is defective in any way, it should be replaced.

The potentiometer is set and sealed at the factory, so the only adjustment that's required when a sensor is replaced is to set the idle-mixture screw. This should be done using an exhaust gas analyzer to obtain the proper carbon monoxide readings.



KARMAN-VORTEX TYPE MASS AIR-FLOW SENSORS

Another type of mass air-flow sensor that is used on some Japanese vehicles is a Karman-Vortex type air-flow sensor. What makes this sensor different from vane air-flow and hot wire mass air-flow sensors is its unique approach to measuring air flow.

The advantage of using a Karman-Vortex air-flow sensor instead of a vane air-flow sensor is that it causes less restriction. And compared to other types of mass air-flow sensors, it is simpler and more reliable, as contamination of the heated wire or filament in MAF sensors is always a concern. What's more, a Karman-Vortex air-flow sensor can respond more quickly to changes in air flow than other types of mass air-flow sensors, which allows the PCM to maintain better control over the fuel mixture.

HOW IT WORKS

The sensor uses something called the Karman-Vortex principle to measure air flow. When air flows past a stationary object, it creates turbulence or "vortice" (swirling eddies of air) behind the object. It's similar to the wake created by a passing boat. The greater the air flow, the greater the turbulence. So the sensor measures the amount of turbulence behind a small object that is placed in the path of the incoming air to generate an air-flow signal.

The turbulence is measured electronically one of two ways: by passing light or sound waves through the air to detect the changes in pressure, or by counting the frequency of the pressure changes (air turbulence). This allows the sensor to generate a signal that is proportional to air flow.

TOYOTA & LEXUS APPLICATIONS

Karman-Vortex air-flow sensors are used on 1987 and later turbocharged Toyota Supra's, and all Lexus engines except the ES 250 and ES 300. The sensor on these applications has a five-pin connector and an integral air-temperature sensor.

A light-emitting diode (LED), mirror and photo receptor are used to count the pressure changes in these applications. The mirror is mounted on the end of a very weak leaf spring, which is placed over a hole leading directly to the area in the sensor where the vortices form (the "vortex generator"). Every time a vortex forms, the drop in pressure wiggles the spring, which causes the reflected light from the LED to flicker as it is picked up by the photo receptor. The vibrations of the mirror produced by the vortices thus causes the light to flicker on and off in proportion to air flow.

The photo receptor inside the sensor generates an on-and-off digital signal that varies in frequency in direct proportion to air flow. At idle when air flow is low, the signal frequency is also low (about 30 Hz). But as air flow increases, the frequency of the signal increases. At high speed the signal may go to 160 Hz or higher.

MITSUBISHI APPLICATIONS

Karman-Vortex air-flow sensors are also used on 1983 and later Mitsubishi's with turbocharged engines, and 1987 and later fuel-injected applications.

In the earlier applications, ultrasonics are used to detect the pressure changes. A small speaker sends a fixed ultrasonic tone through the vortex area of the sensor to a microphone. The greater the number of vortices, the greater the turbulence and the more the tone is disrupted before it reaches the microphone. The sensor's electronics then translate the amount of tone distortion into a frequency signal that indicates air flow.

The 1983-86 Mitsubishi sensor has a four-pin connector while the 1987 to 1990 versions have a six-pin connector. The early units also contain an integral air-temperature sensor while the later ones also contain an integral barometric-pressure sensor. In 1991, Mitsubishi changed to a redesigned Karman-Vortex sensor with an eight-pin connector that replaces the ultrasonic generator with a pressure sensor that measures fluctuations in air pressure directly

KARMAN-VORTEX SENSOR DIAGNOSIS

Both Toyota/Lexus and Mitsubishi Karman-Vortex air-flow sensors put out two signals: an air-flow frequency signal and an air-temperature or barometric-pressure voltage signal. The Karman-Vortex signal should be a square-wave signal that flips back and forth from 0 to 5 volts. The frequency of the signal will increase (narrower pulse width) as air flow increases. Frequency should increase smoothly and steadily with rpm.

Driveability problems such as surging, hesitation, stalling and elevated emissions may indicate a sensor failure. Most sensor problems are caused by a loose or corroded wiring connector.

On the early Mitsubishi applications, the sensor is mounted inside the air cleaner. A poorly fitting air filter may prevent the air cleaner lid from fully seating against the sensor and cause problems. Similar problems can be caused by air leaks in the intake plumbing or manifold.

Codes 31 & 32 indicate no signal from the air-flow sensor on the Toyota & Lexus applications. Code 12 refers to a fault in the air-flow sensor circuit on Mitsubishi applications.

2.4L engine single overhead cam engine that replaced the Quad Four. But coil-on-plug ignition systems are also found on 1998-99 Lincoln Town Car 4.6L, 1996-99 Ford Taurus 3.4L, 1998-99 Chrysler Intrepid and Dodge Concorde 3.2L, 1997 and 1999 Plymouth Prowler, 1997-99 Cadillac Catera 3.0L, and many import nameplates including late model Acura, Honda, Infiniti, Isuzu, Lexus, Nissan, Saab and Toyota.

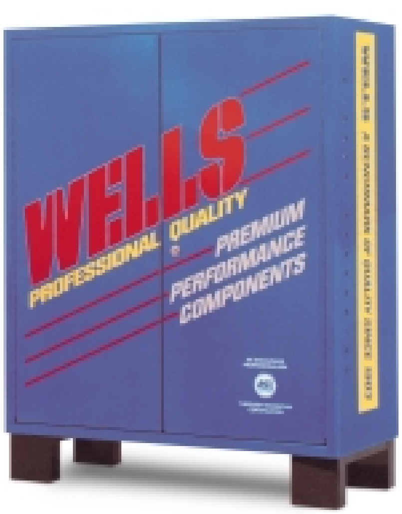
"Coil-on-plug systems are the future of the industry," said Gavin Spence, WELLS Vice President of Sales. "At WELLS, we are committed to making sure that technicians can obtain from us the coil-on-plug components that they need, including some that previously were available only through new car dealers."

WELLS MANUFACTURING CORP.
P.O. Box 70
Fond du Lac, WI 54936-0070

Hot off the Wire

WELLS Cabinet Program: Parts At Your Fingertips

Tired of waiting for parts to be delivered? Or worse yet, getting the wrong parts? If you lose just one hour a day phoning for parts, waiting for parts to arrive, or returning parts that weren't the ones you needed, you're losing $1,400 in billable income every month if your labor rate is $55 per hour.



WELLS Cabinet Program can place the fastest-moving ignition parts at your fingertips, including ignition modules, rotors, caps, regulators and wire sets. What's more, WELLS offers Bonus Pack pricing to provide technicians with a better profit margin on every one of these parts they install.

The cabinet comes fully stocked, features heavy-duty 20/22 gauge steel construction with full-length door hinges, three adjustable shelves, scratch-resistant paint and dynamic graphics including the ASE logo. There's also a handy 30-inch/760-mm ruler printed on the side for quick measuring of things like single-wire leads.

The WELLS Cabinet Program gives you additional advantages, too, such as access to state-of-the-art training programs on today's high-tech engine-management systems, and WELLS toll-free Tech Hotline. WELLS Technical Services Department is staffed with ASE-certified professionals who specialize in ignition and engine performance systems and are happy to share their expertise.

Publisher's Information

WELLS President ....William Allen
Vice President Sales........Gavin Spence
Technical Services Director .....Jim Bates
Newsletter Editor ....Ron Raposa

Counter Point is a quarterly publication of WELLS Manufacturing Corp., P.O. Box 70, Fond du Lac, WI 54936-0070. Letters and comments should be directed to: Counter Point Editor, c/o WELLS Manufacturing Corp, P.O. Box 70, Fond du Lac, WI 54936-0070.