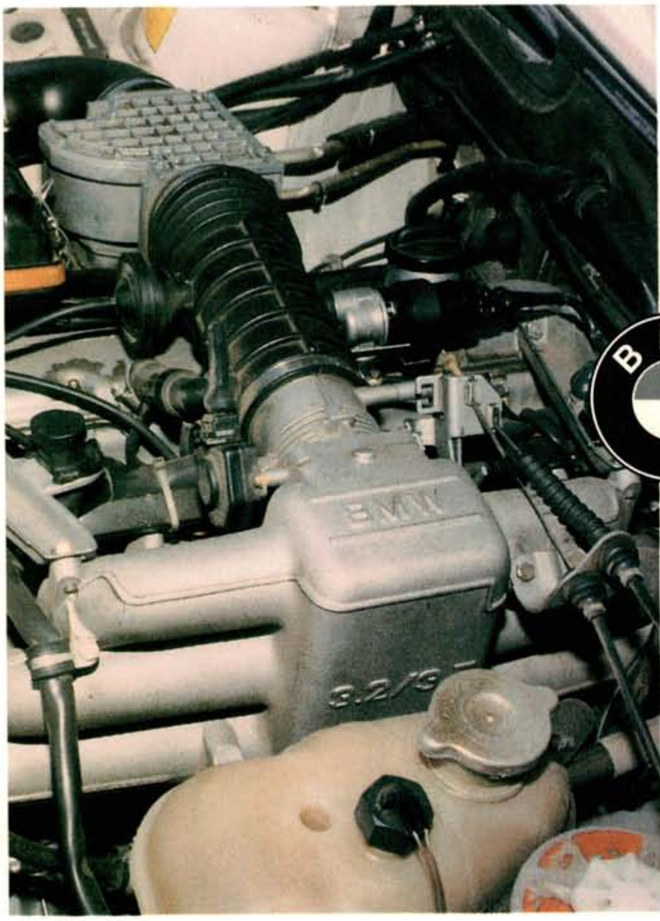
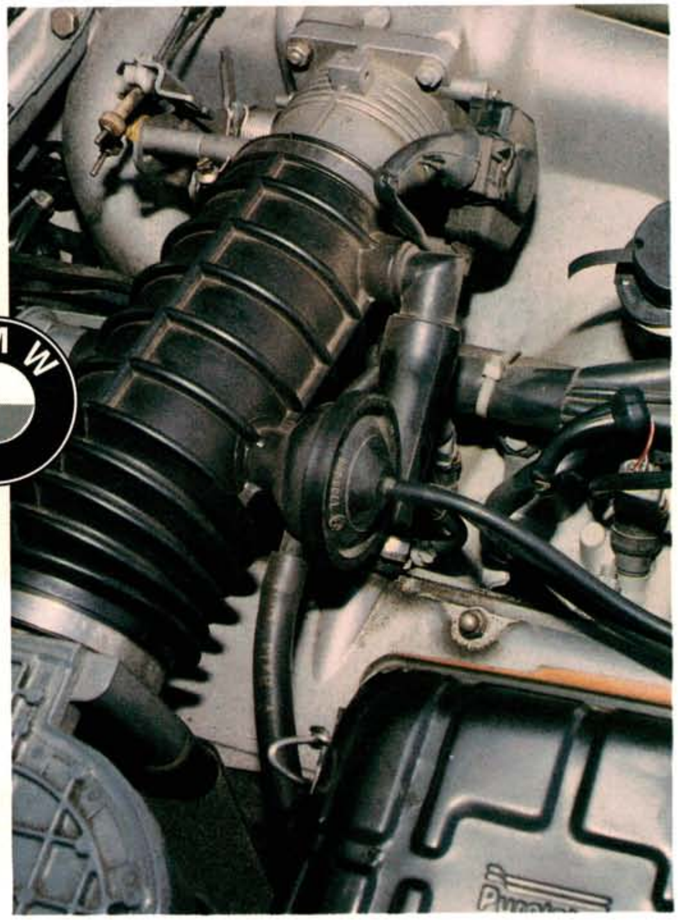




BMW Motronic

PART TWO

In last month's introduction to BMW Motronic, we described Motronic's adaptive circuitry. Adaptive circuitry allows the Motronic system to learn and change as its operating conditions change, giving a Motronic-equipped engine better driveability than anyone could have reasonably expected only a few years ago. But there's a hitch.

The engineers who designed Motronic's adaptive circuitry had to anticipate a variety of changes that the ECU would need to compensate for. Changes in engine operating temperature, outside air temperature, and engine load are just a few examples. If any of these variables changed, the ECU was programmed to know just what to do.

The hitch comes in when special problems and operating conditions start asking the ECU questions it can't answer. The following list of problems weren't included in the engineer's list of possible variables. As a result, any one of these variables can spoil the system's performance:

- Supply voltage problems caused by a low battery or weak charging system operation
- Corroded or damaged wiring harness connections
- Poor system grounds
- Clogged fuel injectors or poor injector spray pattern
- Intake valve and combustion chamber deposits
- Unmetered intake air leaks
- Improper evaporative emission system operation
- Excessive oil dilution
- Substandard fuels or unapproved fuel additives
- Neglected maintenance items like fuel and air filters, distributor caps, and rotors

BMW spent millions in the '80s removing carbon deposits from the intake valves and cleaning fuel injectors on Motronic-equipped engines. These weren't Motronic problems, but they sure drove the Motronic system nuts. The system just wasn't designed to compensate for these problems and couldn't tolerate them.

We point out these problem areas to stress the fact that most Motronic problems aren't really Motronic problems at all. Very often they are problems that are outside the system's control. You'll waste a lot less time looking for problems in the Motronic system if you make sure that the basics are right first.

Air Flow Meter Reference Voltage

There's a very big difference between early and late Dual Sensor Motronic systems. It even changes the way the ECU thinks. The most obvious difference is that early systems send a 10 volt reference signal to the air flow meter. Later systems use the more common 5 volt signal.

But the difference in the two systems goes beyond the difference between 5 volts and 10 volts. It has more to do with the way the signals are used by the ECU.

On 10 volt reference systems, the ECU sends out a 10 volt reference signal. Then:

• At idle, the resistance in the air flow meter is very high, so very little of the reference voltage gets back to the ECU. But this system ALWAYS compares reference voltage to GROUND (zero volts). So at idle, the returning reference voltage signal (a very low voltage) is close to zero volts.

• As load increases, the resistance in the air flow meter decreases. More voltage gets back to the ECU. The gap between returning reference voltage and ground INCREASES as the load INCREASES.

The 5 volt system doesn't compare the returning voltage to ground, however. Instead it compares the strength of the returning signal to the 5 volt reference signal, not directly to ground.

• The ECU sends out 5 volts to the air flow meter at idle. Again, resistance is high in the air flow meter when the engine is idling and load is light. At this point, the gap between voltage out and voltage in is greatest. The voltage gap DECREASES as the load INCREASES, until the ECU is comparing almost equal voltages (reference voltage and return voltage) to indicate full engine load.

Understanding how 5 and 10 volt systems think should make diagnosing problems that much easier.

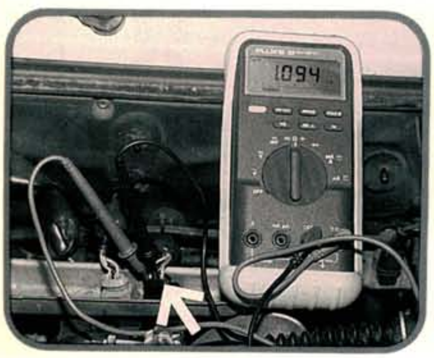
What's Ahead?

Up to this point we've been concentrating on the Dual Sensor Motronic system. All late model BMWs now use a version of the system called Single Sensor Motronic. The RPM and Mark Sensors have been replaced by a single sensor called an Engine Speed/Reference Mark Sensor (that's why they call it Single Sensor Motronic). The basic operating principles of the rest of the system are very similar to Dual Sensor Motronic.

BMW has tied several other sub-systems (electronic throttle control, electronic transmission, cruise control, traction control, ABS) into the Motronic systems on these later model cars. As we said last time, you'll need to understand the basic system before getting into these newer systems. You've got to walk before you can run.

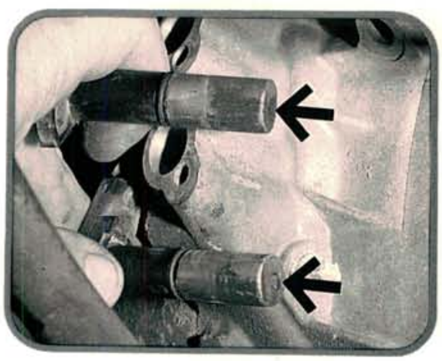
For troubleshooting information on late model BMW Single Sensor Motronic systems, refer to this month's **Dealer Direct**, beginning on page **50**. We've listed this information separately to avoid confusing it with the Dual Sensor information contained in our photo captions.

—By John Bradley
Photos by Karl Seyfert



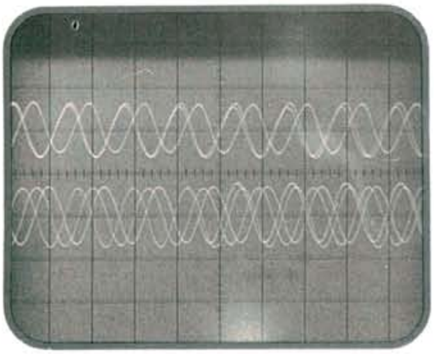
1

The RPM and Mark Sensor signals are probably the two most important Motronic input sensors. Internal resistance for both sensors should be between 800 and 1250 ohms. ECU bias voltage to the sensors should be between 1.0 and 2.5 volts. Also check for shorts between the sensor wiring and the harness shielding.



2

Remove both sensors and check them for dirt, oil, or damage to their tips. A chipped flywheel tooth (or teeth) can throw off the RPM Sensor's signal to the ECU and make the engine run poorly or miss over a limited RPM range. The engine will often run normally above or below this speed.

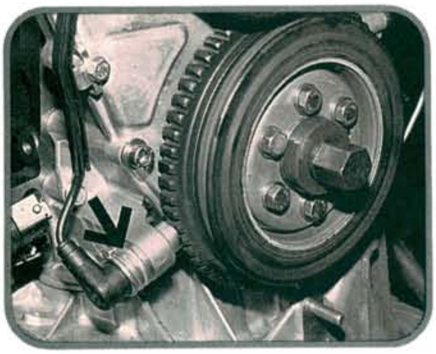


3

It's hard to see the flywheel teeth without removing the transmission. An oscilloscope can be used to quickly check the teeth for damage. Backprobe the RPM sensor's yellow lead wire, then attach the oscilloscope's probe. A good flywheel will have a smooth, even wave pattern. Damaged teeth will show up as a skip in the pattern.

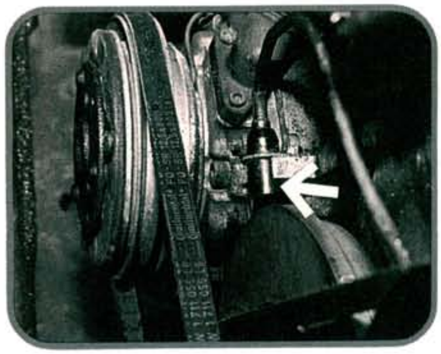
4

Check for a minimum of 2.5 volts of alternating current from both sensors at idle. The Mark Sensor will send incorrect crankshaft position information to the ECU if the flywheel reference tab has been damaged, or if the flywheel has been incorrectly installed. This will cause injection and ignition timing errors.



5

Single Sensor Motronic systems combine the Mark and RPM Sensors into a single Engine Speed/Reference Sensor. The sensor's signal is induced by a pulse wheel at the front of the crankshaft. Undercoating on the sensor tip can weaken the sensor's signal to the ECU and cause hard starting problems.



6

Just to confuse matters, many BMW engines also have a timing sensor that's mounted at the front of the engine (arrow). This sensor uses the front crankshaft pulley as a reference to generate its signal. The sensor sends its signal to the diagnostic connector and isn't tied into the Motronic ECU.

7

At first glance, it looks like you'll have to do all of your ECU harness connector testing with the ECU disconnected unless you've got a dedicated breakout harness. The plastic cover at the back of the connector can be removed if you're especially persistent. This reveals the back of the ECU connector's terminals.

8

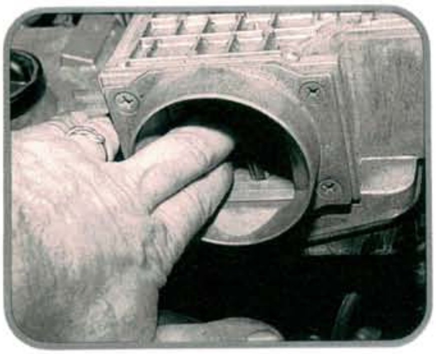
Disconnect the oxygen sensor harness connector, then check for a bias voltage signal (0.4 to 0.5 volts) from the ECU with the ignition on. Reconnect the sensor, backprobe the sensor connector, then run the engine to measure oxygen sensor activity and response to fuel mixture changes.

9

To check a later "adaptive" idle speed control actuator, measure the ECU's duty cycle signal as engine loads (A/C, headlights, defogger) are applied and removed. If the ECU's duty cycle signal changes, but idle speed stays the same, the actuator is either clogged or damaged internally.

10

Remove the actuator, then flush out any deposits. If the actuator still hangs up, measure its resistances with a DVOM. Resistance between terminals 1 and 3 should be approximately 40 ohms. Resistance between terminals 1 and 2 or between terminals 2 and 3 should be approximately 20 ohms.

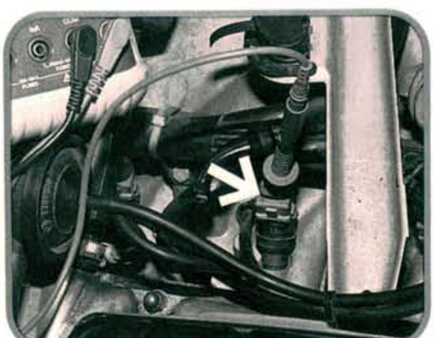


11

An engine backfire can distort the air flow meter flap. This can cause the flap to stick in one position during operation. The flap will usually stick in a partially open position, causing the engine to run rich and stall when it returns to idle. Check for binding by slowly opening and closing the flap.

12

Check which reference voltage the ECU is sending to the air flow meter. Early Motronic systems send a 10 volt reference voltage signal to the air flow meter. Later systems use a 5 volt reference voltage. Backprobe terminal 3 at the air flow meter to determine which system you're working on.



13

Published information on normal injector pulse duration is scarce. Collect your own reference library of "known good" injector pulse width readings. As a rule of thumb, small injectors used on smaller engines will have larger pulse width readings than larger injectors at the same RPM (measured in milliseconds).

14

If an exhaust gas analyzer tells you the car is running lean, but your pulse duration reading tells you the ECU is sending the injectors a rich pulse duration signal, the ECU may be trying to compensate for clogged injectors like this one. Compare the problem car's pulse duration readings to "known good" readings.

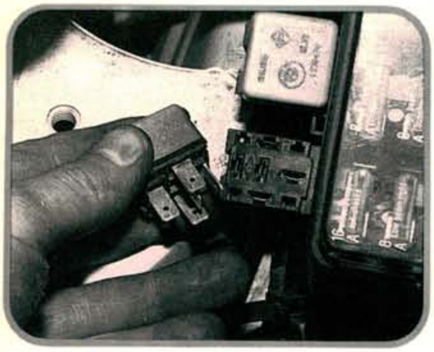
15

Another possible cause of driveability problems or a rich fuel mixture, is an inaccurate temperature sensor, or corroded harness connections. Air and coolant temperature sensor resistances *decrease* as the surrounding temperature *increases*. Both sensors should have 2400 ohms resistance, ±50 ohms at 20 degrees C (68 degrees F).

16

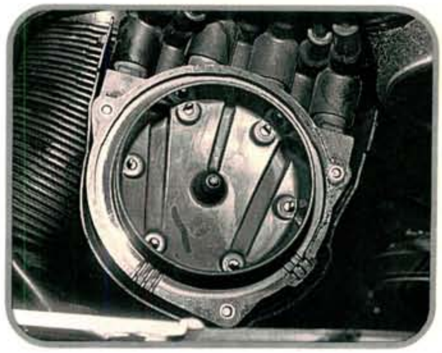
An off-idle hesitation and other driveability problems can be caused by water in the throttle switch. The water can bridge the idle contacts, which makes the ECU think the engine is idling, even after the throttle is opened. The switch isn't waterproof, and can be damaged if the engine is steam cleaned.

17



Moisture and corrosion inside the Motronic main relay can cause intermittent stalling problems. The extra resistance causes the relay contacts to open when the relay gets hot, and the engine will stall. This can be hard to trace because the engine may start and run normally after the relay cools.

18



As you see, there aren't too many adjustments to make on a Motronic system. When the system develops a problem, we often overlook the basics. You can't expect the engine to run right with worn out spark plugs, dirty filters, or a distributor cap that's got more tracks than a railroad switching yard.