BMW Motronic

PART ONE

Bosch chose the name Motronic to identify a new engine management system introduced in 1982. The system combined fuel delivery, ignition, and emissions under the control of a central ECU. We take these features for granted today, but they were pretty advanced back in 1982.

As you'll see, BMW Motronic has many similarities to earlier electronically actuated injector systems. Think of BMW Motronic as a digital L-Jetronic system with ignition control and other extra cost options added. BMW, Porsche, Peugeot, and Volvo have all used versions of the Motronic system.

Things got confusing recently when Volkswagen and Audi started calling their CIS-based systems Motronic too. Up until then, if a system was called Motronic, it was safe to say that it was an electronic injector system. The Motronic Name Game is enough to give an engine management system an identity crisis.

Maps

The Motronic ECU would be lost if it didn't have a set of operating instructions to help control the Motronic system. To avoid this confusion, the ECU contains a set of "maps" or instructions which tell the ECU exactly how to respond to information from its input sensors. These maps are charted through dynamometer and road testing during the development of each new Motronic system.

The data from this testing is converted into map form, then stored in the ECU's Read Only Memory (ROM). The ECU uses its maps to control the following Motronic functions:

- **Fuel Injection**
- **Ignition Timing**
- **Dwell Angle**
- **Idle Speed Control**
- **Lambda Closed Loop Fuel Control**
- **Warm-up Enrichment**
- **Acceleration Enrichment**

Ignition Timing Control

A brief description of how the ECU controls the ignition timing will help you understand how the ECU uses its maps to make decisions.

- The ECU keeps track of engine speed (using the speed sensor) and engine load (using the air flow meter).
- Information from these two sensors is converted into digital voltage signals that can be understood by the ECU.
- The ECU uses its ignition timing map to find the point where these input voltage signals intersect.
- Previous testing has determined the exact amount of ignition advance that's necessary for this combination of engine speed and load.
- The ECU sends its timing decision to the ignition coil based on the map data.
- If the load and RPM readings fall between two points on the ECU's timing map, the ECU splits the difference to figure the proper amount of advance.
- The ECU analyzes input data and reads its map fast enough to adjust the timing to individual spark plugs as the engine goes through its firing order.

Custom Tailoring

You could probably find a suit to wear right off the rack, but how well it would fit is another story. A few alterations by a skilled tailor are usually necessary to make the suit fit you, instead of fitting everybody who is approximately your height and weight.

Later Motronic control units include a built-in tailor called adaptive circuitry. Adaptive circuitry makes custom alterations to the ECU's factory programmed data maps so they fit the car, its operating conditions, and its driver.

And instead of just one custom tailored suit, adaptive circuitry gives the ECU a suit that changes a little each time the car is driven. This electronic suit never goes out of style.

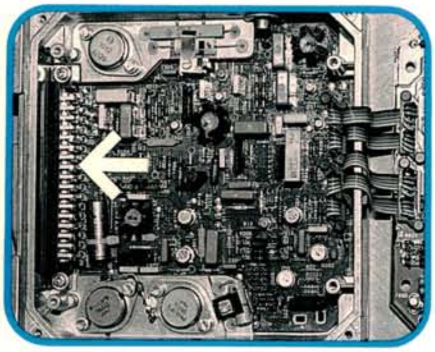
Dual Sensor Motronic

It would be impossible to cover every variation of every Motronic system used on every BMW model since 1982 in two magazine articles. Instead, we're going to concentrate on what BMW calls their Dual Sensor Motronic system. "Dual Sensor" refers to the two sensors that provide the ECU with engine speed and crankshaft position information.

The basic BMW Dual Sensor Motronic system has a 35 pin plug at the ECU. More advanced Motronic systems have 55, or even 88 pins at the ECU. A clear understanding of the Dual Sensor system will give you a firm foundation to handle the Motronic systems on other BMW models. All Motronic systems; whether early or late model, Single or Dual Sensor, use similar operating principles.

We'll begin this two part article with operating theory and a description of Dual Sensor Motronic system components. We'll finish up with diagnostic and troubleshooting information in Part Two.

—By John Bradley,
Photos by Karl Seyfert



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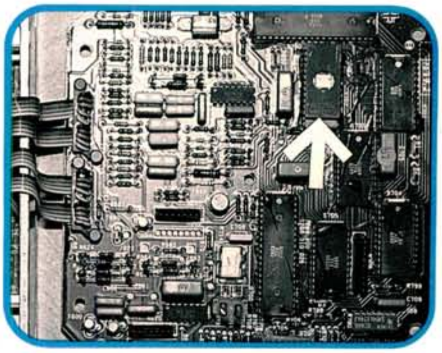
This dissected ECU shows you some of the more than 200 electrical components inside a Motronic ECU. A single 35 pin plug (arrow) connects the ECU to the battery, input sensors, and output devices. This circuit board holds the power output stages for the fuel injectors, ignition, and fuel pump.



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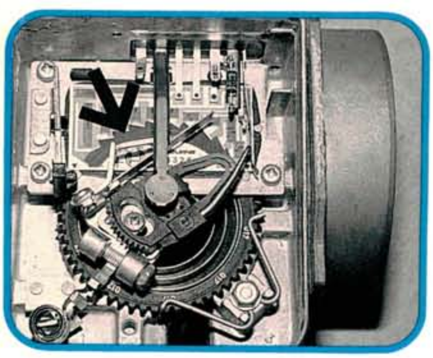
The ECU's computing circuits are mounted on a second circuit board. All of the ECU's maps are stored on one ROM chip (arrow). All input and output signals are digitally processed by the ECU at a clock speed of 6 Mhz. That's slow by computer standards, but plenty fast for automotive use.



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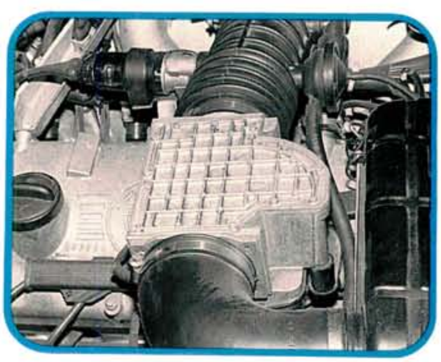
The ECU sends a constant reference voltage signal to the air flow meter. The air flow meter's potentiometer (arrow) returns part of the reference voltage to the ECU, converting engine load into a voltage signal that can be understood by the ECU. The voltage signal increases as engine load increases.



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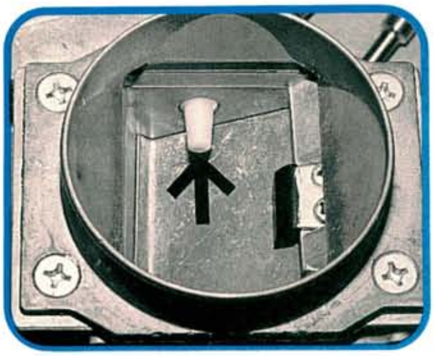
All intake air should pass through the air flow meter before reaching the engine. Any vacuum leaks (false air) will affect the accuracy of the air flow meter's signal to the ECU. The air flow meter adjusts for engine wear, valve clearance changes, compression changes, and intake valve or combustion chamber deposits.



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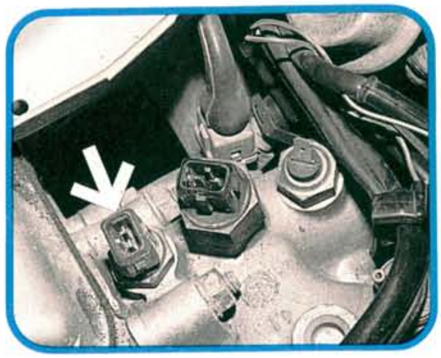
The air temperature sensor on the inlet side of the air flow meter helps the ECU decide the best air/fuel ratio and ignition timing over a wide range of temperatures. The air flow meter shouldn't be disassembled. If the sensor fails, the air flow meter must be replaced.



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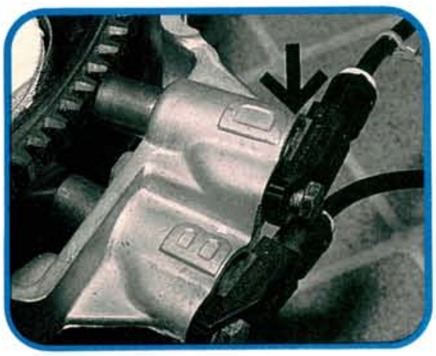
The negative temperature coefficient coolant temperature sensor (arrow) helps the ECU determine the proper injector pulse duration, idle speed, and ignition timing during engine warm-up. After the engine reaches operating temperature, the temperature sensor signal has almost no affect on Motronic operation.



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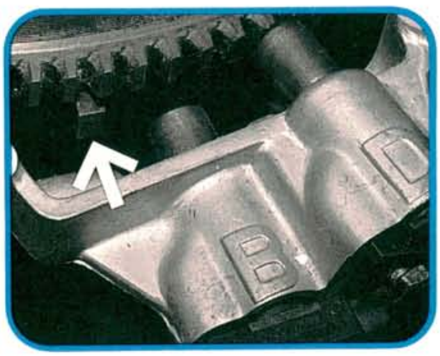
This demonstration rig shows two important Motronic input sensors in action. The engine speed sensor (arrow) generates an alternating current as it scans the spinning flywheel teeth. For proper operation, the sensor tip must be clean and sit 0.7-1.0 mm from the ring gear.



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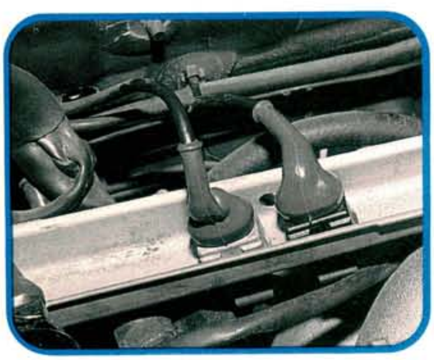
The mark sensor (letter "B") is electrically identical to the engine speed sensor. A flywheel-mounted plate (arrow) induces one mark sensor signal per engine revolution, 100 degrees before TDC. The ECU must receive at least three mark sensor signals during cranking before the engine will start.



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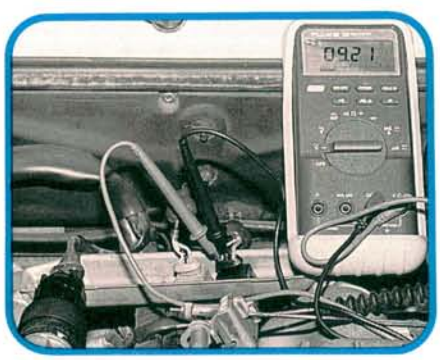
Reversing the mark sensor and engine speed sensor connections will confuse the ECU. The mark sensor socket is gray and the harness plug has a gray band (left). The speed sensor socket is black and the harness plug has no band (right).



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Ignition timing isn't manually adjustable. Changing the distance between the sensors and the flywheel will change signal strength and affect system operation, but it won't change the ECU's timing decisions. Clutch debris, oil, and flywheel damage or runout will also affect sensor operation.

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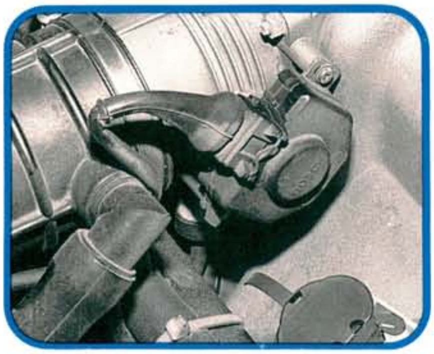

One set of throttle valve switch contacts is closed only at idle. A second set of contacts closes as the engine approaches full throttle. Both sets of contacts are open between these points. Switch position affects idle speed, timing, deceleration fuel cutoff, and full throttle enrichment.

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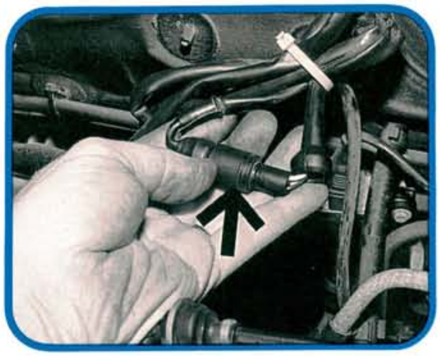

The oxygen sensor is mounted in the catalytic converter on the 535. The sensor's harness connector is at the left side of the firewall (arrow). Changes in oxygen sensor voltage help the ECU determine closed loop injector pulse duration. The 535's heated sensor starts sending signals to the ECU quickly.

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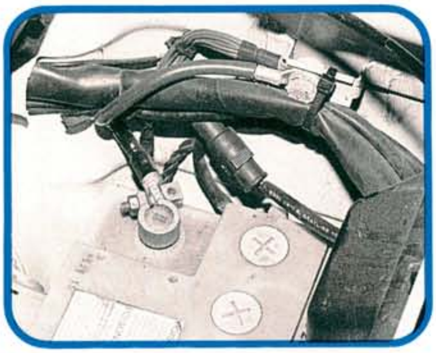

Steady battery voltage and good system grounds are essential for proper Motronic operation. Low battery voltage affects injector operation and also affects the coil operating efficiency. ROM maps help the ECU adjust injector pulse width and ignition dwell to compensate for battery voltage changes.

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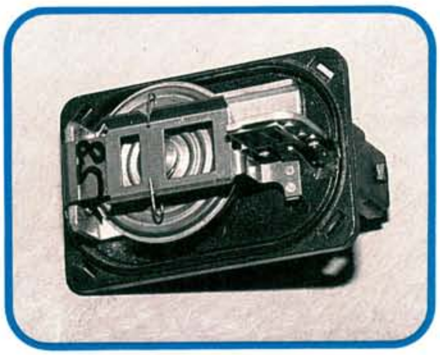

The atmospheric pressure sensor helps the ECU decide the correct injector pulse width as altitude changes. This type of pressure sensor sends an "on" or "off" signal to the ECU that changes when a preset altitude is reached. Other sensor types send a variable voltage signal that's linked to actual altitude.

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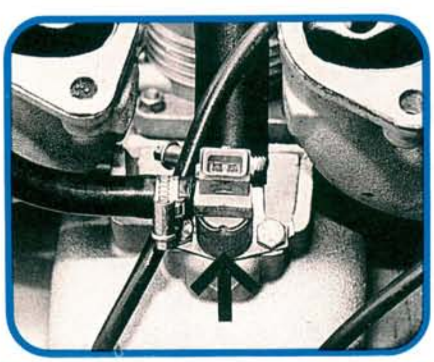

The cold start injector is mounted at the bottom of the intake manifold on the 535, so we'll give you an intake valve's eye view. The injector sprays a fine mist to help during cold starts. The injector is only opened while the engine is cranking, and is controlled by the thermo-time switch (not the ECU).

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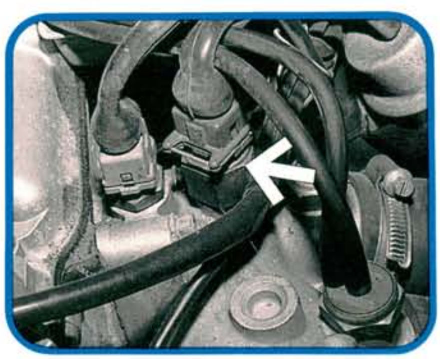

The thermo-time switch on this engine opens the cold start injector for a maximum of eight seconds during cranking, as long as the engine coolant temperature is below 35 degrees C (95 degrees F). The switching off temperature and maximum open time are stamped on the side of the switch.

17

An output stage inside the ECU controls the ground side of the coil's primary windings. The ECU controls ignition timing and dwell functions at the coil with no intermediate step. The ECU also advances or retards the ignition timing to fine tune small changes in engine idle speed.

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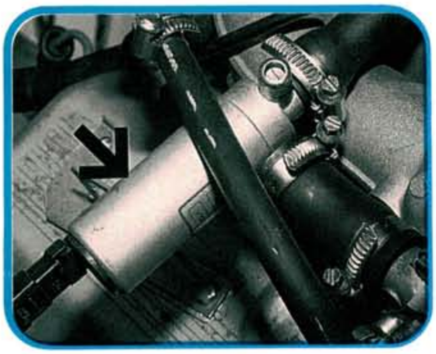
There are no vacuum or centrifugal advance parts inside the distributor. The rotor bolts straight to the end of the camshaft. The ECU responds to its sensors quick enough to advance or retard the timing to individual cylinders as the engine goes through its firing order.



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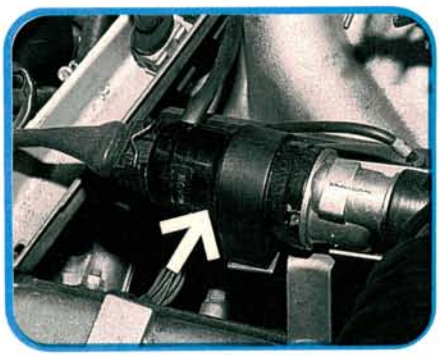
Larger changes in idle speed are handled by the idle control valve. Early Motronic systems use a plunger-style idle control valve that's controlled by a separate idle control unit above the Motronic ECU. Some early systems also used a temperature controlled idle air bypass valve to provide a cold fast idle.



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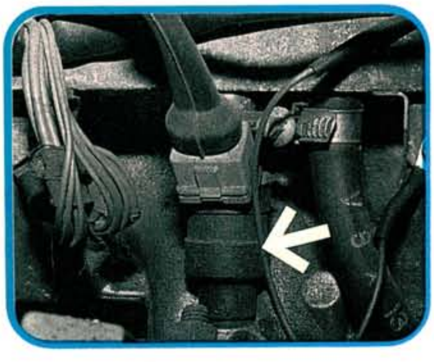
Later Motronic systems use a rotary-style idle control valve that is controlled directly by the ECU. The ECU sends constantly changing voltage signals (duty cycle) to a pair of windings inside the idle control valve. The valve responds by opening or closing an air passage to maintain a steady idle speed.



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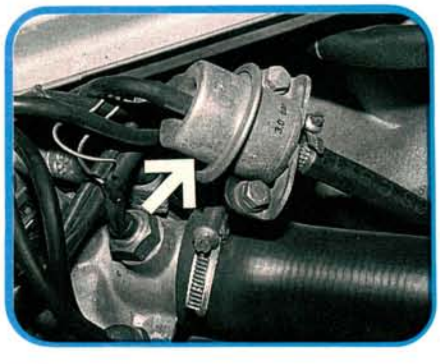
Dual Sensor Motronic injectors are wired in parallel to fire as a group, once per crankshaft revolution. That means all cylinders get two injections for each combustion cycle. When an injector opens on a cylinder that's not at TDC on the power stroke, the fuel has to wait its turn behind the closed intake valve.



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The fuel pressure regulator uses a manifold vacuum signal to control fuel pressure. The regulator vents excess fuel back to the fuel tank to maintain a constant pressure difference between fuel and intake manifold pressures. The ECU has no control over this very important adjustment.

23

Fuel pressure normally runs in the 2.5 bar (36 PSI) range at idle. Since the ECU can't adjust the system to compensate for incorrect fuel pressure, begin any diagnostic work with a quick fuel pressure check. The system should also hold 2.0 bar (29 PSI) residual pressure for at least 15 minutes after shutdown.

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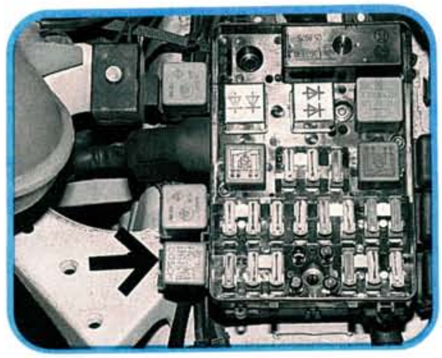

For safety's sake, the ECU powers the fuel pump through the fuel pump relay only when the engine is running at more than 300 RPM or during cranking. The ECU receives a voltage signal from the ignition switch during cranking and uses the engine speed sensor to detect minimum engine RPM.

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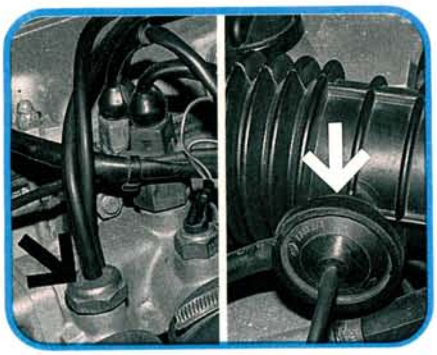

Vapor canister purge is a non-ECU controlled function on most 35 pin Motronic systems. A thermo-vacuum valve (left photo) prevents canister purge until coolant temperature is above 46 degrees C (115 degrees F). The manifold vacuum switch (right photo) also stops vapor flow until the engine is above idle.

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The maintenance reminder lights are reset using the diagnostic connector. Engine temperature, ignition signals, alternator charging rates, and other information can also be picked up here. To avoid damage, refer to a service manual for exact terminal identification before attaching any test equipment.