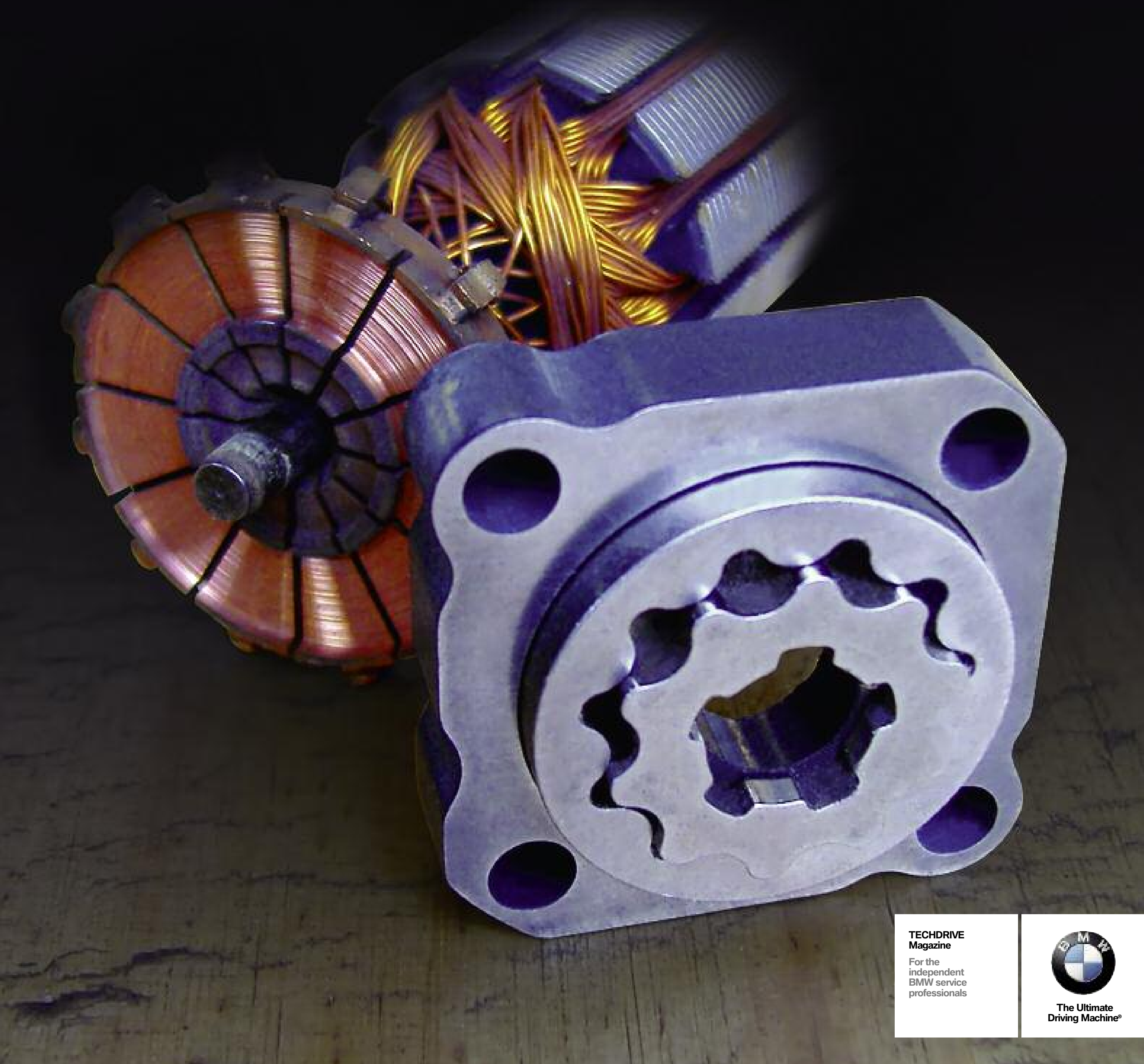
# TECHDRIVE

Original BMW Parts

VOLUME 3 NUMBER 3

A PUBLICATION FOR INDEPENDENT BMW SERVICE PROFESSIONALS SEPTEMBER 2006



TECHDRIVE Magazine
For the independent BMW service professionals

The Ultimate Driving Machine®

CAN • FUEL PUMPS • PSI

# TO OUR READERS

— What could be more useful to independent service technicians who work on BMWs than a publication dedicated specifically to them?

— That's the idea behind the magazine you're holding, TECHDRIVE. BMW of North America both sponsors the publication and provides much of the information that's included. A big part of the rationale behind TECHDRIVE is the belief that if you are able to diagnose, repair and maintain BMW vehicles properly and efficiently, your reputation and ours will be enhanced.

— TECHDRIVE's combination of feature service articles (written from both BMW tech information and interviews with successful independent BMW specialists), new technical developments, systems evolution, as well as the correct BMW replacement part, and service bulletins are intended to help you fix that BMW right the first time, on time. Our list of BMW dealers will assist you in finding Original BMW Parts.

— There's more to this effort, including highly-informative and user-friendly web sites, which we'll explain in future issues.

— We want to make TECHDRIVE the most useful and interesting technical magazine you receive, and you can help us do that. Please email us at editor@techdrivemag.com and let us know what topics you'd like to see covered, and provide any other comments you might have. With your involvement, this publication can evolve into one of your most important tools.

Thanks for your continued interest.

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## Feature Articles







## Departments



TECHDRIVE Magazine

For the independent BMW service professionals

# Riding the CAN Bus

Faster, lighter, more reliable, and cheaper

## Yes, there is a lot of wire in a car, but did you ever wonder just how much wire?

Well, based on various estimates, the typical mid-size car can have up to three miles of wiring. Now, three miles of anything weighs a lot and takes up a lot of space. And installing all the wiring in a car also takes a lot of time and money. With the apparently unending growth in the use of electronic components in modern vehicles, even more wiring will be necessary in the future.

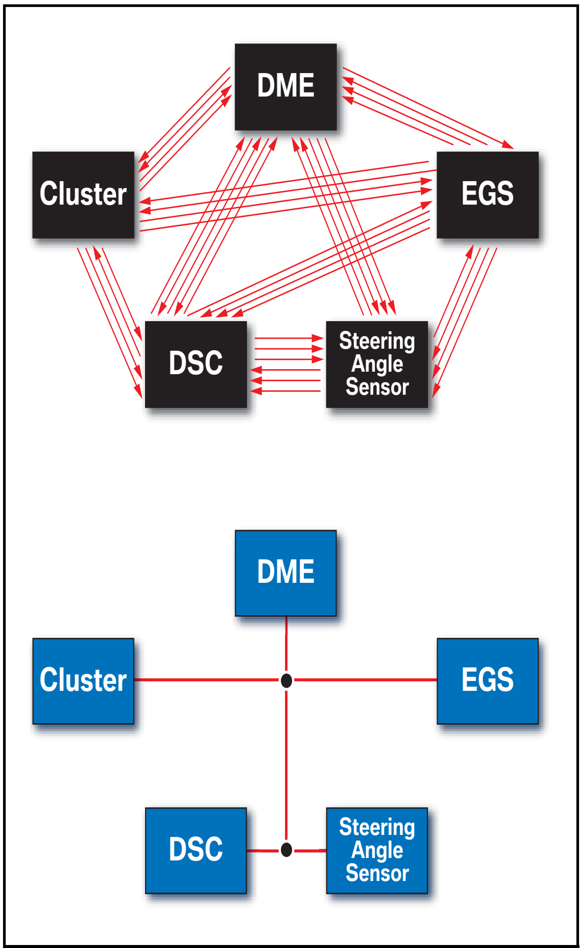
Anything that reduces the amount of wiring in a vehicle saves space, weight, and money. That's why BMW and other carmakers are jumping on the "CAN" Bus. CAN stands for “Computer Area Network” and “bus” is an electronics term for a system that links multiple points or devices together with a common connection.

CAN bus technology was developed in the late 1980s by Intel™ and Robert Bosch. The companies realized that unless there was a way to reduce the amount of wiring needed in a modern vehicle, the automotive industry was on the verge of an unmanageable wiring problem.

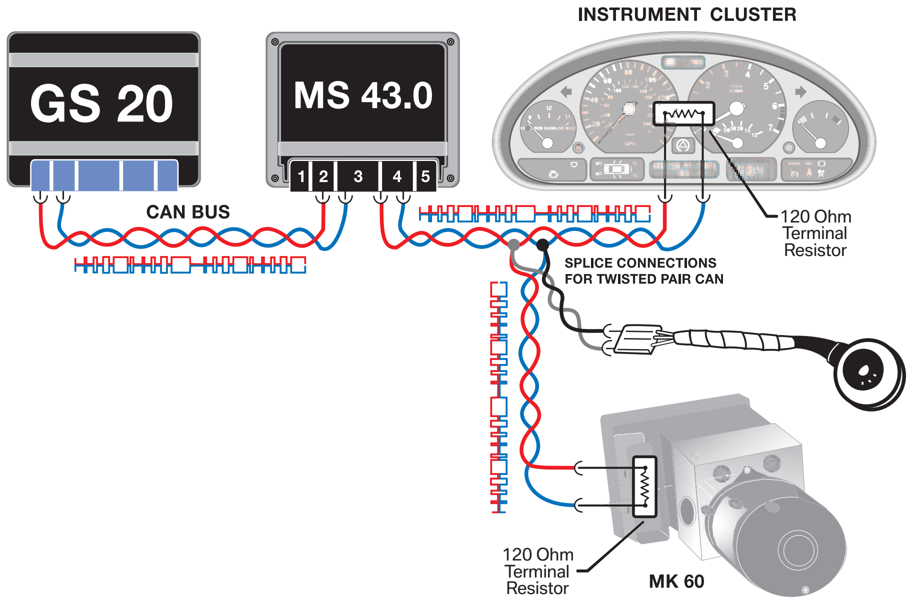
On a BMW, the ECU (Engine Control Unit) requires inputs for engine speed, air temperature, coolant temperature, throttle position, road speed, etc. to properly manage spark timing and fuel flow for optimal power and fuel economy while also minimizing emissions. In the pre-CAN bus days, each sensor had to be connected to the ECU with a separate wire, and the signals from each sensor differed by duty cycle, frequency, range, etc. So, the resulting connection to the computer was a thick wiring harness that had to fit in the limited space available inside the car.

With a CAN bus, that thick harness is gone, replaced by just two copper wires twisted together. One wire is the called the “CAN-high,” the other is “CAN-low.” Each wire transmits an opposing signal through the system at the same time. The opposing signals virtually eliminate the effects of outside electrical interference on signals sent over the CAN bus.

Both wires are attached to every component in the system. “Node” is the generic name for any device on a CAN bus. In automotive use, the nodes are usually “transmitters” and “receivers.” The transmitter nodes are the various sensors and other devices that provide input data to the computer system. The receiver nodes are the actuators that receive and respond to data.




Before CAN bus, every component was wired to every other component individually (above). With CAN bus, one set of wires connects everything.




BMW CAN bus technology connects multiple components with just two twisted wires.

BMW first used a CAN bus on the 1993 740i/iL as a data link between the DME (Digital Motor Electronics module) and the EGS (electronic transmission control), and started using it for scan tool communications on the E70 and R56. Since then, BMW has expanded its use of the technology across its entire vehicle lineup. The early BMW CAN bus installations used shielded cable, but since MY 2000, the system uses two copper wires twisted together.

On current BMWs, the CAN bus typically links the:

- Engine controller (DME)
- Electronic transmission controller (EGS)
- Dynamic stability controller (DSC)
- Instrument Cluster (KOMBI)
- Lateral acceleration sensor

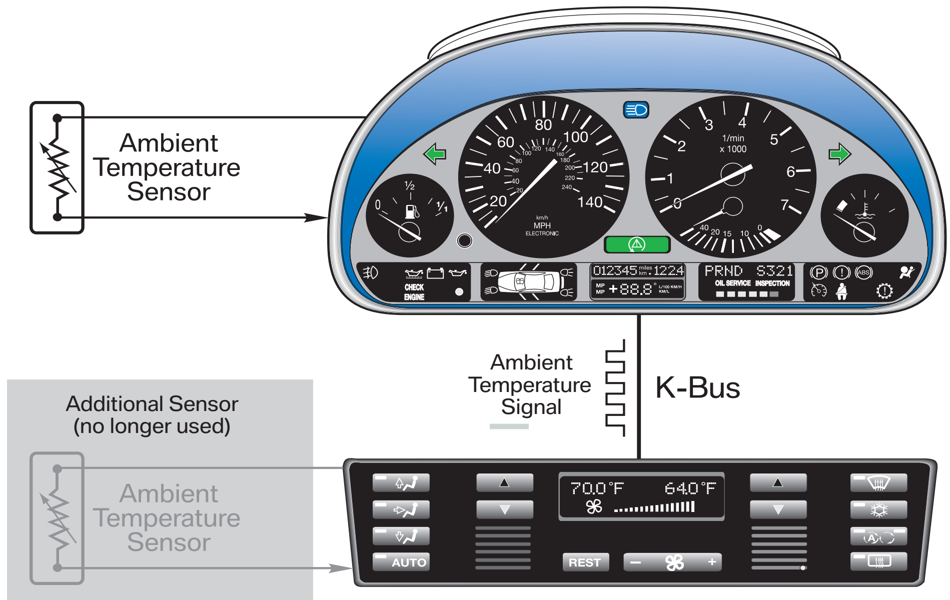
BMW also uses K-bus and MOST-bus technology on its later models. The K-bus or Body Bus is a “low speed” circuit used to connect components inside the vehicle. The MOST-bus is an extremely fast fiber optics circuit used to transmit visual or audio signals.

## Benefits

BMW is certainly not alone in riding the CAN bus. The technology has become the virtual standard for under-hood and under-car communication among electronic devices on almost every new vehicle from every manufacturer in the world. CAN bus technology is also being used in many non-automotive applications, wherever sophisticated electronic components must communicate with each other in a system. According to various electronic industry estimates, hundreds of millions of devices or systems using a CAN bus are manufactured every year.

It is easy to see why BMW has moved quickly to adopt the system, because CAN bus technology:

- Replaces multiple bundles of thick wiring harnesses with just two twisted wires, saving weight, space, and installation cost.
- Not only reduces the wiring needed, but also reduces the number of components




BMW uses a different bus, the K-bus or Body bus, for low speed data transmission inside the vehicle.

in the system because messages from any component are shared throughout the system. For example, the ambient air temperature sensor can send data to both the ECU and the climate control system, instead of requiring two temperature sensors, one for the ECU and one for the climate control.

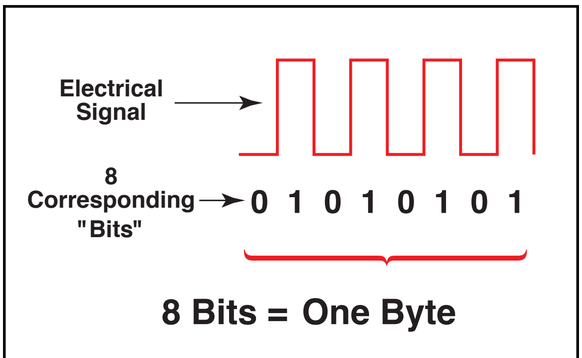
- Is energy efficient. The bus operates on 2.5 volts and goes into "sleep mode" when no messages are being transmitted. The system immediately "wakes up" when a message is sent.
- With fewer wires and components, is more reliable in the harsh under-hood and under-car environments.
- Is extremely accurate. The system has virtually no transmission failures or errors.
- Makes troubleshooting easier. The system can identify any node that is not performing properly and transmit a failure code for that component.
- Is easier to modify, adapt, or expand to meet different vehicle requirements.

## Different from multiplexing

The CAN bus concept is similar to "multiplexing" with one significant difference. In a multiplex system, each transmitter and receiver has a unique address. Each message is sent directly from one unit to another unit. The message bypasses all other components on the system.

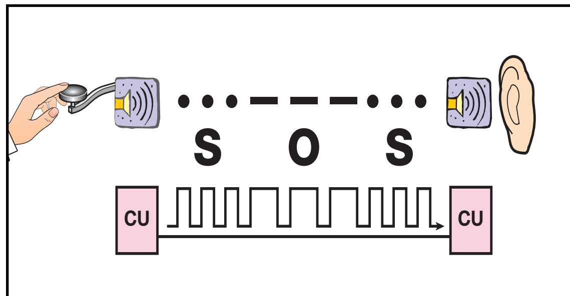
With a CAN bus, all nodes can send and receive data equally. In theory, any given node could communicate with all of the other nodes at any time. However, the programming controlling the CAN bus labels each message sent out with a unique identifier code. As the message is received, each component on the system "opens" or "reads" the message and immediately looks for the identifier code. A component will process only the messages that have the correct ID code for the component. All other messages are ignored. The use of identifier codes, instead of unique address, is one reason why CAN bus systems can be easily modified and expanded.

The identifier code also gives the message its priority. When a component receives two messages at the same time, the node will process the higher priority message first, ignoring the lower priority message. Within the CAN bus system, no messages are ever lost. The lower priority message is stored and retransmitted later, after the high priority message has been processed. In addition to priority, the identifier code also tells the CAN bus how fast to send the message. For example, the signal to activate the antilock brake system (ABS) would be sent at the fastest possible speed through the system, while an adjustment to the climate control system would be sent a at slower speed.




A digital signal is either 0 (off) or 1 (on). Each signal is a bit, and eight bits make a byte.

Of course, to a CAN bus, later and slower are measured in milliseconds. To humans, high and low priority messages are processed at the same time and there is no such thing as slower, but within the CAN bus, there is a later and slower. In a BMW CAN bus, data is transmitted at speeds up to 500K (500,000) bits per second (bps), which is an extremely fast rate for a "hard wire" system. "Bit" is the electronics term or abbreviation for "binary digit" which is either a 0 or a 1. Eight bits make up a "byte"

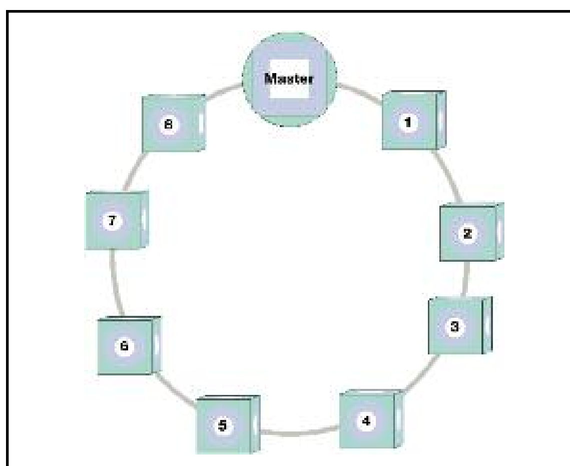



Morse code is a "human" version of the electronic bit. In between sending a dot or dash (switch on) there is no signal (switch off).

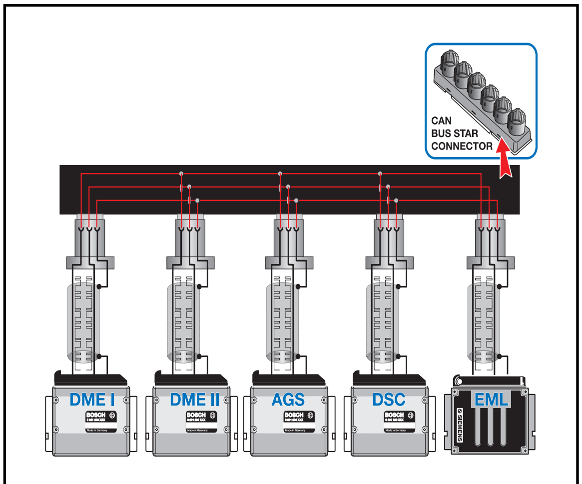
and a series of "bytes" forms the digital message or signal that is transmitted along the CAN bus.

## Troubleshooting

BMW uses a "Tree" or "Linear" arrangement for its CAN bus applications. Two other setups, the Ring and the Star, are used with the K-Bus and MOST-bus applications. In a Tree arrangement, the twisted wires are the "trunk" and each component on the circuit is a branch. The ability to easily add or delete components gives the CAN bus its flexibility for different applications.




The K-bus normally uses a "ring" structure.




The "tree" or "linear" structure is used for all of BMW's CAN bus installations.

The CAN bus is normally a very reliable system, but problems can occur. If there is a CAN bus communications fault that uses the term "Timeout," this refers to a component that cannot communicate with other units on the system. Each component will attempt to communicate several times.
If there is no success after multiple attempts, the system will store a "Timeout" or "CAN bus" failure code. The system will self-diagnose to determine if the problem is within the bus or one of the units that cannot receive its messages.

## Wiring failure

Before testing the CAN bus, check to make sure that there is normal battery voltage present and that the charging system is operating.

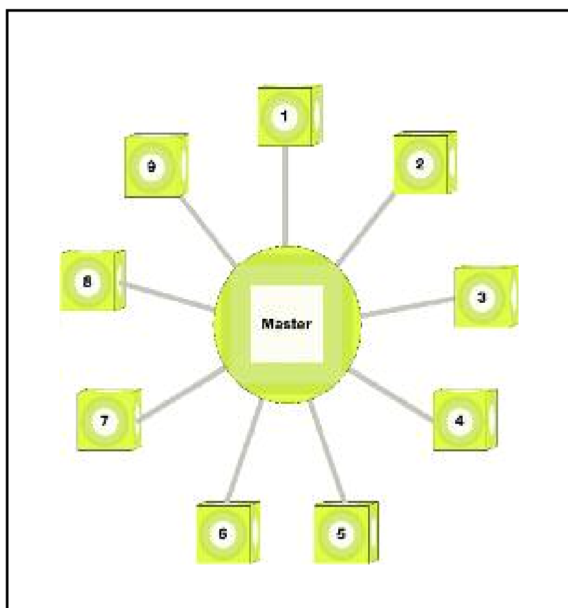
Failure of the CAN bus wiring can be caused by a break in the wire, shorts to battery voltage or ground, the two wires becoming shorted to each other, or a bad connection with one of the units on the system.

Test for voltage drop and continuity among the components. The CAN bus should show an average of 2.5V on both the CAN-high and CAN-low wires. However, the presence of 2.5 volts does not eliminate the possibility of a fault in the bus, it only indicates that there is adequate voltage for proper operation.

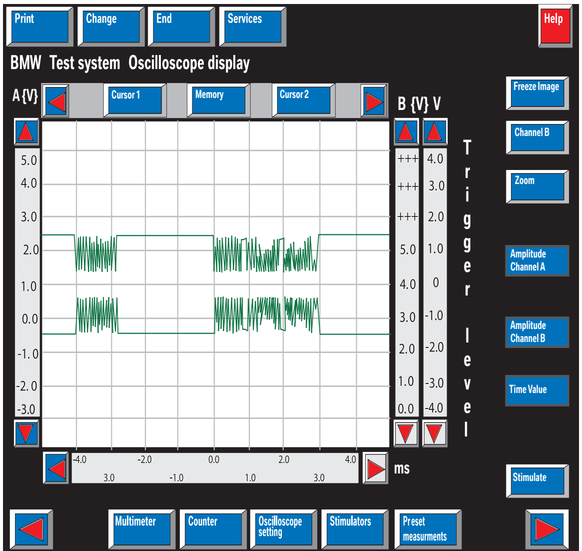
CAN bus wiring is tested like any other automotive wiring. Check the twisted wires first. Then test for continuity between the connections of the different components, with all components disconnected from a power source.

## Resistor failure

Terminal resistors are used in the CAN bus circuit to establish the correct impedance to ensure fault-free communication. A 120 Ohm resistor is installed in two control units of the CAN between CAN-H and CAN-L. Because the CAN is a parallel circuit, the effective resistance of the complete circuit is 60 Ohms. On some vehicles there is a jumper wire that connects the two parallel branches together, others have an internal connection at the instrument cluster.




The ultra-high speed MOST-bus uses a "star" structure.

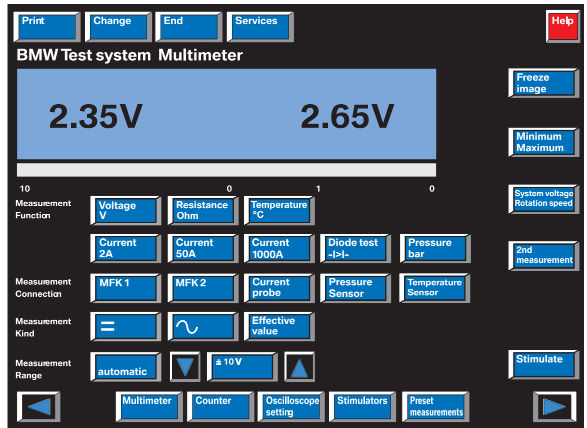



The top trace shows the 2.5V base line for the CAN-low wire. The voltage is "pulled down" during data transmission. The lower trace shows the 2.5B base for the CAN-high. Its voltage is "pulled up" during data transmission.

The resistance is measured by connecting the appropriate adapter to any of the modules on the CAN and measuring the resistance between CAN-Low and CAN-High. The resistance should be 60 Ohms. The CAN bus is very stable and can continue to communicate if the resistance on the CAN bus is not completely correct; however, sporadic communication faults will occur.

The terminal resistors are located in the ASC/DSC control unit and either the instrument cluster or in the DME. Early 750iL vehicles that used the star connector have a separate external resistor, which connects CAN-H and CAN-L together.

Modules that do not have the terminal resistor can be checked by disconnecting the module and checking the resistance directly between the pins for CAN-H and CAN-L. The value at these control units should be between 10 kOhms and 50 kOhms




Both CAN-high and CAN-low should average about 2.5V in normal operation.

## Control unit failure

Each component attached to the CAN bus has its own communications module that allows it to communicate with other nodes on the bus. Failure of a control unit's communication module normally triggers a fault code in the other units on the bus.

In rare cases, failure of one unit can take down the entire bus. When that happens, every unit will store a fault code. To isolate the defective unit, disconnect units one at a time while monitoring CAN bus readings with an oscilloscope or voltmeter. When the defective unit is disconnected, the faults will only point to communication with that unit and none of the other units.

## Interference

Interference is rare, but can happen. Unfortunately, interference problems often resemble shorts or communications failures. The primary causes of interference are a defective alternator or improperly installed aftermarket components. Check the CAN bus operation. If no problems are found with the system, verify that generator operation is normal. Then check for aftermarket devices that have been added to the car. Disconnect each device to see if the interference problem disappears.


You promised the car by 5,
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# In The Tank

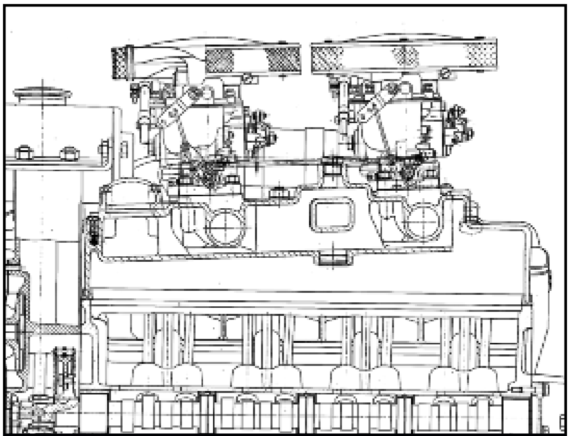
Just a fuel pump?
Give them the respect they deserve

Fuel pumps are the "Rodney Dangerfield" of the automotive world -- they get no respect. Unseen, unheard, and overlooked in terms of any scheduled maintenance, it seems the only time a customer or technician ever thinks about a fuel pump is when there's a problem.

Some technicians even consider a fuel pump to be a draft horse that just happens to share a stable with more exotic thoroughbreds like the injectors, ECU (Engine Control Unit), and the various sensors that provide input to regulate fuel flow. But let's give fuel pumps some respect. Granted, fuel pump technology is not as sophisticated as that of some other components, but without the pump, nothing else works. As an experienced technician you have no doubt witnessed the gamut of fuel system component problems, and you know when a fuel pump can't deliver, it's game over, time to call the tow truck.

Despite their somewhat lower stature in terms of sophisticated technology, fuel pump performance is impressive. Pumps are expected to immediately provide rated pressure the instant the ignition is turned on and to maintain that pressure as long as the engine is running. The design goal for most high quality pumps, like the ones used by BMW, is a service life of 10,000 hours or about 400,000 miles! That's longer than just about any other electric/electronic component on the car. If you have to replace a fuel pump, remember that only a BMW pump, from a BMW dealer, is a sure thing to match the quality of the original unit. Aftermarket pumps may not be as good as BMW Original Parts and may cause installation and noise issues.

Another advantage of using only a genuine BMW replacement pump is that the new pump will exactly match the performance required for your customer's car. To cut costs, many aftermarket pump manufacturers are following the path that the industry refers to as "parts consolidation." Companies are reducing the total number of parts they make and distribute by offering a unit for multiple applications across several vehicle brands and models. This "one size fits all" or "one size fits many" approach may help to improve the parts maker's bottom line. But this approach can result in a pump that you can't be certain is an exact match to BMW's original performance requirements. A pump that is off just a little on pressure and/or volume from BMW specs can cause all kinds of drivability and emission control problems.



It was all so simple in the days of carburetors and mechanical pumps. Just a few psi would keep the bowl full, and diagnosis was a no-brainer.

## Three Tips

It is a tribute to BMW's quality standards that its fuel pumps, unless they have seen a lot of years and a lot of miles, seldom fail because of component wear or breakage. Pump failure is almost always caused by external problems. To maximize pump life, recommend that your customers follow three rules:

- Always buy reputable brand-name gasoline, preferably at a station(s) doing

Quality electric fuel pumps, such as this genuine BMW replacement specimen, are designed to last just about forever, but all technicians know they wear out sooner or later.

a fairly good volume of business. Contamination is a major cause of fuel system problems, including pump failure. Buying quality gasoline from a busy station reduces the risk of contamination. It is no guarantee against contamination, but it is the best your customers can do short of carrying a miniature laboratory in the trunk to test for contamination before each refueling.

- Buy gasoline often. A BMW fuel pump is lubricated and cooled by the gasoline in the tank. When the fuel level is close to empty, the pump can overheat. If a driver runs the tank close to empty too often, the overheating can cause pump failure. Tell your customers they should refuel when the tank is at or close to a quarter tank.
- Only buy gasoline. BMWs are not designed to run on ethanol (E85), methanol, or any other fuel that contains over 10% alcohol by volume.

## Return/Returnless

For years, BMW has used a one-piece "saddle" fuel tank that straddles the drive shaft. The fuel pump is inside the right (passenger) section of the tank. All fuel delivery is done from the right side. The gasoline from the left half is drawn into the right side via a siphon tube that flows to the fuel pump.

Like all fuel-injected vehicles, BMW pumps are designed to provide more fuel, at higher pressure, than the injectors can handle. This assures that the injectors always have an adequate supply of fuel with plenty of pressure to deliver and properly atomize fuel to the engine. The excess capacity also permits the pump to continue providing an adequate volume at the required pressure even as pump capacity slowly deteriorates due to normal wear and tear over time.

The fuel pressure regulator valve controls the pressure delivered to the injectors. The pressure is regulated by returning excess or, to use BMW's term, "displaced," gasoline to the tank.

On early fuel injected BMWs, the pressure regulator and return line were part of the fuel rail. In recent years, BMW has converted to a "returnless" system to reduce the number of fuel lines and also to reduce potential gas vapor emissions. On a returnless system, the pressure regulator and fuel filter are incorporated in a single unit in the tank. The pressure regulator limits system pressure to the specified level. When the pressure exceeds system requirements, the regulator opens a discharge hole. "Displaced" fuel flows through the discharge hole and returns to the right hand side of the tank. Just like with a return line system, the movement of displaced fuel drives the siphon feed in the right side of the tank to deliver fuel to the pump in the left hand side.

## Operations and Testing

Normal fuel pump operation in a BMW is fairly simple. As soon as the ignition is turned on, the ECU grounds the pump feed to complete the circuit and the pump pressurizes the system. The residual pressure in the fuel line provides the gasoline to start the engine and then fuel flow from the pump takes over.

If the key is on, but the engine isn't turning over, the ECU opens the pump ground to turn off the pump. The ECU relies on the signal from the Crankshaft Position Sensor to determine if the engine is spinning.

Weak fuel delivery, which may or may not be the fault of the pump, will cause a lean condition, hard starting (both hot and cold), poor idle, hesitation or stumble under acceleration. The vehicle may even stall on the road, only to restart and run normally for a while after it has cooled down. Any lean condition can trigger diagnostic codes because of high HC levels and misfire.

Obviously, if the pump has failed, there will be no pressure at all in the system. However, in a no-pressure situation, if you can't hear the pump running when the ignition is on and the engine is turning over, your first thought should not be bad pump! Instead, think "no electricity." Check voltage to the pump. If voltage is low, look for a corrosion or loose connection problem. If there is no voltage, check the fuse and relay. If a fuse is blown, don't just replace it. A blown fuse is a symptom, not a problem. Find out what caused the excessive current draw that blew the fuse.

A low pressure output with higher than normal amperage draw can mean a badly worn pump that is about to die. It can also mean a pump that is working too hard and not getting enough fuel pushed through because of dirt or other contaminants clogging the fuel system. The contamination can be at the inlet screen to the pump, in the fuel lines, a badly clogged fuel filter, or any combination of the three.

A good fuel pressure gauge is absolutely essential to any auto service operation. Many misdiagnoses have been caused by inaccurate gauges.

Because contamination can cause higher than normal current draw, and more current accelerates wear on the pump motor, a pump that has been forced to deal with contamination for a prolonged period should be carefully tested. It may be a candidate for replacement due to excessive wear.

Some techs think that if the fuel pump relay feels hot, the pump must be bad because it is drawing too much current. Wrong. A hot relay almost always means a bad relay or corrosion somewhere in the circuit that is causing excessive resistance. It is rare for a failing pump to draw enough amperage to heat up a relay.

## Interpreting PSI

BMW has specific procedures for

*Continued on page 18*

# Original BMW Remanufac

## Why Buy Original?

**R**eplace — We replace more parts than aftermarket brands.

**E**ngineered — Designed to meet original OEM drawings.

**M**anufactured — Made with same OE components as factory parts.

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**N**ew — Fully performs as new unit.

### Quality, Reliability and Value

The quality, reliability and value of the Original BMW Remanufactured A/C Compressor wasn't meant to be taken lightly. It is not only an exact replacement for the original unit, it's also remanufactured and tested to meet the same strict specifications as the original, so it performs just as well. And like all remanufactured parts, it's covered by a two-year warranty. In fact, the only detectable difference you'll find between a Original BMW Remanufactured A/C Compressor and a new one is the price. Which we're sure you'll find quite refreshing.

### It's All In the Process

**Remanufacturing Process** (Original BMW)

1. Dismantle core and clean all components.
2. Replace key components 100% with new OE part.
3. Test all other critical components.
4. Replace components that do not meet specs.
5. Assemble, test and box.

**Rebuilt Process** (Typical Aftermarket)

1. Identify damaged part or parts.
2. Replace damaged part with non-OE part and clean.
3. Re-assemble, test and box.

# TURED A/C COMPRESSORS


Remanufactured for BMW by

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 *Continued from page 15*

interpreting fuel system pressure readings for each model, but the following steps are representative of the general technique.

- If your customer has drivability complaints, or the engine lacks power:

Run the engine at idle speed and measure fuel pressure. If the pressure reading is 0.2 bar (three psi) below normal, the pressure lines or fuel filter are clogged, or the pump voltage is low.

If the reading is 0.2 bar (three psi) above normal, turn off the engine and observe the pressure gauge. If the reading drops to normal, there is an obstruction in the fuel return or there is a kink in a fuel line. If the pressure remains high, the pressure regulator is probably faulty. A much less likely cause is a completely blocked return line.

- If your customer complains of hard starting:

Run engine briefly at idle speed and then turn it off. Record the pressure reading when the engine is shut off and then check the reading 20 to 30 minutes later. If the pressure dropped by more than 0.5 bar (7.25 psi), restart the engine and allow the pressure to stabilize. Shut off the engine while also clamping off the supply just ahead of your pressure gauge. Note that reading, then recheck 20 to 30 minutes later.

If the reading dropped by less than 0.5 bar, the problem is a fault in the fuel delivery lines, including the in tank lines; or a defective non-return valve in the fuel filter.

If the reading dropped by 0.5 bar or more again, the pressure regulator is faulty.

## Test tips

There are a number of tips for fuel system pressure testing that come in handy:

- Make sure you take accurate readings. A deviation of just 0.2 bar or three psi from spec can cause problems.
- Readings should react quickly, almost violently, between "dead head" (return line clamped) and running pressures. A slow rise means problems with the pump or clogging.
- After you've bled the air from the hose to your gauge, you should see rapid, almost violent changes when the ignition key is turned on. Again, a slow increase means problems.
- Having adequate pressure doesn't mean you also have good flow. Check system output to make sure the pump can deliver not only pressure, but also volume.
- Don't be surprised if in some cases the pressure reads normal, but as soon as you open the system for testing the test flow bleeds off enough pressure to kill the engine.
- System leak down can cause hard starting and other problems. If psi won't hold, pinch off the supply line. No change? Then the check ball in the pump isn't the culprit. In cases where leakdown disappears when the return line is pinched, the problem is a perforated diaphragm in the pressure regulator, or possibly a leaking injector.

## Parting shots

These tips will help ensure a successful fuel pump installation:

- If you find any contamination in the pump and or filter, check the tank for junk also. Installing a new pump in a dirty tank is a sure recipe for a comeback that you will pay for.
- Never reuse any seals, O-rings, screens, etc. when installing a new pump. A new pump deserves all new accessories.
- Never "test" a pump by running it dry on your bench. Without gasoline to providing cooling and lubrication, you can quickly ruin a pump. Always start a pump after installing it and filling the tank.
- Check the fuel lines whenever you replace a pump. Replace any lines that show signs of wear or physical damage.

# Packaged for Performance

## BMW High Performance Ignition Wire Sets


BMW vehicles are engineered for optimum performance. So why would you accept less than that very same engineering for anything that goes under your customer's hood? Our High Performance Ignition Wire Sets are custom designed for each BMW model to ensure optimum performance and an exact fit. Contact your authorized BMW Center for specific model information.

Original BMW Accessories

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# Monitoring Tire PSI

From Tragedy, technology for greater security

As the last century came to a close, the National Highway Traffic Safety Administration (NHTSA) became aware of a serious problem involving SUVs and rollover crashes.

A review of police records spanning several years showed that there were hundreds of rollovers that resulted in some 200 fatalities and injuring hundreds more.

The crashes were linked to tire failure caused by driving on under-inflated tires. Heat buildup and other stresses from under-inflation caused the tread to suddenly separate from the tire. Although a skilled driver who knew how to handle a blow-out probably could control the vehicle and bring it to a safe stop, many drivers lost control and rolled the vehicle.

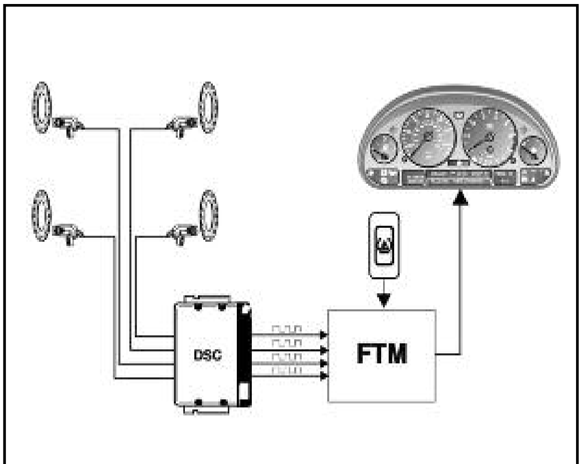
The SUV rollover problem alerted much of the nation to a fact that automotive service professionals already knew: Most drivers don't check tire pressure often enough and many cars are running on one or more improperly inflated tires. A 2001 NHTSA "Tire Pressure Special Study" showed 27 percent or more of all vehicles on the road have underinflated tires.

Out of the morass of media coverage, lawsuits, and government hearings, came major changes in federal tire safety standards. One of the biggest changes mandated by Congress and NHTSA was that all cars, SUVs, and light trucks under 10,000 lb. gross vehicle weight must be equipped with automatic monitoring systems that warn drivers when their tire pressures were too low. If drivers won't spend five minutes every two weeks to check tire pressure, then the tires would notify the driver when they needed more air.

## Two Technologies

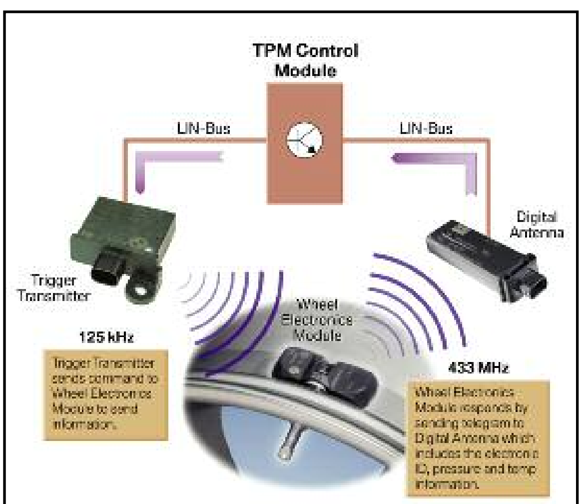
As of this writing, only the "direct" type of tire pressure monitoring system (as opposed to "indirect" -- we'll explain) is accurate enough to comply with federal regulations. That is, it must turn on a warning light whenever any tire is 25 percent or more below the recommended cold tire pressure rating. Development work continues on the indirect type with hopes that it may eventually meet the standard, but so far it's only able to tell you that one tire has gone flat.

Be very careful of the sensor/transmiters whenever you mount and demount tires.




FTM or the indirect system piggybacks on the vehicle's ABS to monitor relative tire pressure.

The indirect system piggybacks on the technology of the vehicle's anti-lock brake system (ABS). The same speed sensors monitor tire speed while the vehicle is moving. A tire that's going flat will have a smaller circumference than a fully inflated tire, so it must turn faster to keep up. When the wheel speed sensors detect a significant enough difference in the rotational speed of one tire compared to the others, a warning light is turned on. The only advantage of an indirect system is that it is fairly inexpensive. The speed sensors and related hardware are already in place for the ABS. All that is needed is additional programming to track rotation as the vehicle moves down the road and signal a warning when a flat is detected.




BMW's direct or TPM system monitors each wheel individually.

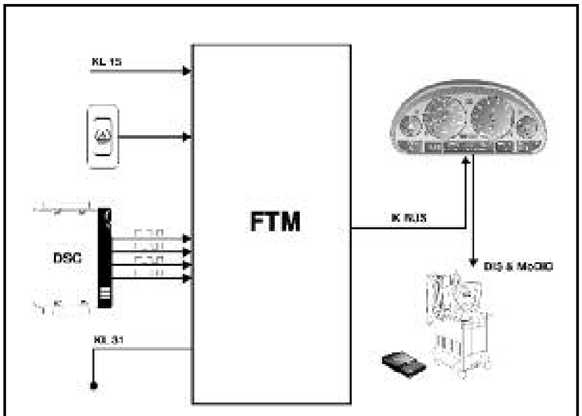
A direct system has pressure sensors and transmitters mounted inside each wheel. The sensor/transmitter is made in one piece with a special threaded metal tire valve stem, which acts as the antenna. The stem is fastened in the hole in the wheel by means of a gland nut, and the sensor resides inside the tire.

Actual tire pressure is monitored continuously. Whenever the pressure in any tire falls below a preprogrammed level, the system activates a warning. Unlike the indirect system that only notifies a driver of a flat, the direct system can tell the driver which tire is low. The direct system can warn a driver not only if there is a sudden loss of pressure, but also if there is a slow leak in any tire that causes a gradual reduction in pressure.

A direct pressure system is essentially independent of all other chassis electronics on a vehicle. The individual sensors and transmitters inside each wheel generate a signal that is picked up by dedicated receivers. The signals are coded to identify the transmitter in each wheel. So, the benefits of a direct reading system are offset by its significantly higher costs.

## BMW indirect

BMW has used both indirect and direct pressure monitoring systems in its vehicles. The indirect system is generally called FTM (for Flat Tire Warning). As we said, the indirect system uses ABS sensors to monitor the rotation speed of the wheels. It compares the rotation speed of the wheels on the diagonal (left front and right rear, to right front and left rear) and calculates an average vehicle wheel rotation speed. This value is stored in the control




FTM readings are displayed on the dash and the system can be serviced with a scan tool or a dedicated BMW diagnostic unit.

module. The earliest FTM systems on the E39 M5 and the E52 Z8 had an individual control module. Since MY 2001 FTM does not have a separate controller. Tire pressure monitoring is now another function incorporated into the DSC (Directional Stability Control) module that also regulates ABS, traction control, and stability. If the vehicle has a dedicated FTM control module, in most cases you will find it behind the glove box in the control module carrier, although it may be elsewhere (refer to the proper service information for the model at hand). In addition to receiving the four wheel speed signals, the module receives power (KL 15), ground (KL 31) and a ground signal input from the set/push button switch in the console. The control module is connected to the K-Bus for:

- Output display in the check control matrix or Warning Light
- Diagnostic communication through the instrument cluster with the DISplus tester or GT-1.

With indirect monitoring, three different messages can be displayed on the dash:

- TIRE PRESSURE FAILURE will display when the system senses a 30 percent under-inflation condition. A warning alarm will also sound. The display and alarm remain active until the ignition is turned off.
- TIRE MONITORING INACTIVE is displayed if there is a system fault, or, in the first M3 models, when the driver has manually turned the system off.
- TIRE PRESSURE SET is displayed during initialization. You must initialize the system whenever you change tire pressure during servicing, when new tires are installed, or when the control module or speed sensors are replaced..

After completing the service work, start the engine and press the dashboard button for at least four seconds. When you see "TIRE PRESSURE SET" (for E85, the Yellow Indicator light will come on), the tire pressure monitoring system has been initialized. When the vehicle is driven, the system will automatically store rotating wheel speed values based on different road speeds.

On the E85 system, a red light indicates loss of tire pressure. If the yellow light comes on after initialization, it indicates a failure of the system. After a short drive (no more than three minutes), from a vehicle speed greater than 10 mph, the system learns the new wheel speed sensor reference values and the RPA indicator light (yellow) goes out. When a flat is detected, the RPA indicator light will be red or flashing yellow, depending upon the model.

The indirect system has additional limitations in addition to not actually monitoring individual tire pressures directly. It may not work, or could trigger a false signal:

- When the system has not completed initialization for a certain speed range.
- During rapid acceleration, severe braking, or high cornering.
- At very slow speeds, generally under seven mph.
- If there is a high slip differential among individual wheels.

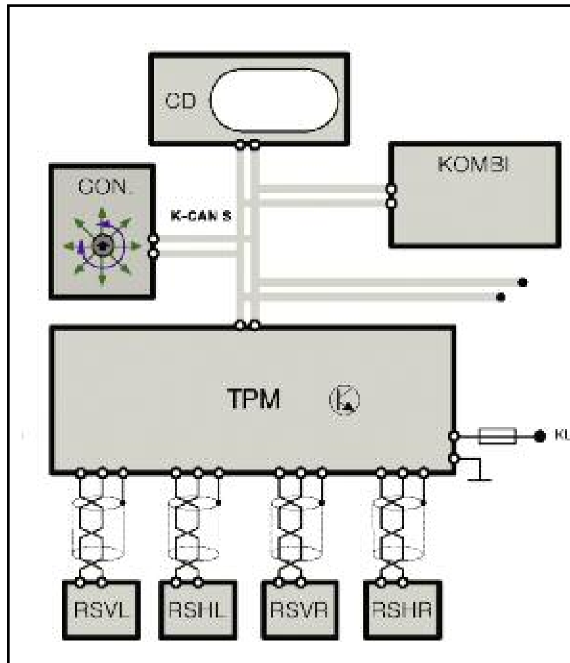
Because the indirect system has no direct connection to the wheels and tires, there are no special service considerations when mounting, dismounting, balancing, or aligning the wheels or tires.

## Direct monitoring

TPM is BMW's direct pressure monitoring system. The system monitors pressure when the vehicle is moving. If the vehicle has a full-size spare tire, it is equipped with a transmitter, but its pressure can only be monitored when it is mounted. Temporary Spares do not have a wheel sensor. If a temporary spare is mounted at any wheel position, the TPM switches to "Inactive" after several minutes. The electronic transmitter module inside each tire measures the tire pressure and temperature at regular intervals and transmits the information by radio frequency to the TPM control unit.

The transmitters are inside the tire, integral with the tire valve, forming an assembly. In most BMWs, you'll find the controller behind the glove box on the controller carrier, although it could be elsewhere depending on the model. The individual reception antennas are located behind the splash shield of each wheel house. Each transmitter includes a pressure sensor plus a 3.6V lithium battery with an expected service life of five to seven years. Each transmitter has a unique identification code. When the system is initialized, the TPM controller assigns a position (left front, right front, etc.) to each ID code. Signals from the transmitter are sent to the digital wheel house antenna each time the tire valve passes it.

Like the indirect system, TPM must be initialized whenever you add or remove air from a tire, the tires are rotated, or the tires are changed. Initialization is done in the "Settings" function of the Control Display. During initialization, the system recognizes each transmitter, assigns locations to the transmitters, and stores the "setpoint" (recommended pressure) for the tires. Recommended tire pressure must be at the psi specified on the "B" pillar label, and all tires must be within six psi (0.4 bar) of each other or the system will not complete initialization. Initialization will typically occur within two minutes of driving. "Initializing TPM!" will be displayed on the Instrument Cluster until the process is complete. When initialization is complete,




The TPM (direct monitoring) system reads the exact pressure in each wheel.

The TPM sensor is attached to the base of a specially-designed tire valve.

the tires of the car on the graphic turn green. An older TPM system will turn on the warning light whenever it detects a tire pressure that is eight psi below its initialized setting, but the latest systems react at five psi. Some versions (but not the latest) automatically adjust recommended pressure settings based on changes in ambient air temperature, and if ambient temperature is 68° F. cooler than the original initialization temperature for 14 days, the system will display an "Autumn Warning" light, to prompt the driver to recheck and inflate the tires because of cold weather. This feature was deemed unnecessary for the newest systems.

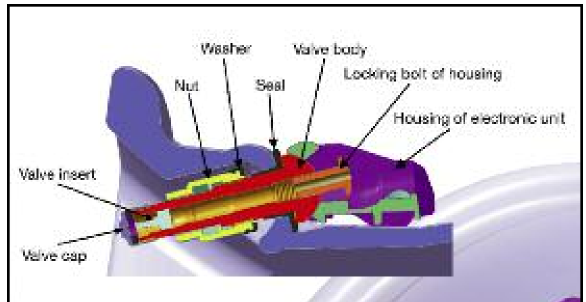
## Servicing TPM wheels

You can balance wheels and tires with pressure sensor/transmitters as you normally do because the sensor is securely mounted inside the tire. However, when mounting or dismounting tires, follow these steps:

1. Remove the Schrader valve from the stem to let all of the air out of the tire. Remove any balancing weights.
2. Press the tire off the safety shoulder inside and out. ALWAYS APPLY THE PRESSURE OPPOSITE (180° away) FROM THE VALVE. If you apply pressure near the valve, you could damage the sensor.

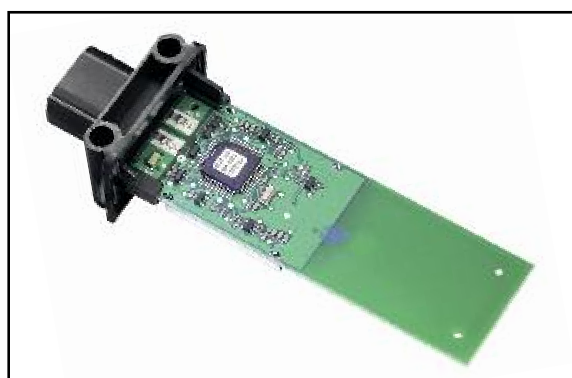
**Note:** If you're worried about damaging the sensor/transmitter during tire demounting, you could resort to a trick that's finding favor in the real world of auto service: Remove the gland nut that secures the valve stem, then push the stem through the hole so that the assembly falls into the tire.

3. Clamp the wheel onto your mounting machine according to the manufacturer's directions. Rub mounting solution on the tire bead and rim lip. Position the head about six inches away from the valve to prevent damage to the sensor.




If you had X-ray vision, this is what you would see looking at the TPM sensor and valve.

This is what the TPM antenna looks like on the outside.



And this is what the antenna looks like on the inside.

4. Place the lever on the tire bead.
5. Lift the tire bead with the mounting iron/tire shoe over the installation head and pull the tire away.

You can immediately tell if a BMW is equipped with direct TRMS by looking for a metal valve stem.

6.Pull the lower tire bead away. Position the installation head approximately six inches behind the valve, and make sure the tire bead does not press onto the sensor/transmitter assembly during the removal operation.

When mounting a tire, start opposite the valve and sensor. Be very careful that the tire bead does not contact the sensor during installation. Install the valve insert and slowly inflate the tire to its recommended pressure. Install the cap on the valve. Do not substitute any other cap. Use only the original.

## Inspection and installation

Visually inspect the rim, wheel, sensor/transmitter, and tire valve body for any damage. The valve and sensor assembly must never be cleaned with compressed air, solvents, or other cleaning solutions. Do not use any type of installation paste on the assembly. If the sensor assembly is dirty, wipe it with a clean, lint-free cloth.

If you diagnose a defective TPM sensor, get the replacement from your local BMW dealer. There are several types of aftermarket sensors with different frequencies and shapes. By getting the replacement units from a BMW dealer, you can be sure the sensors are the correct type for your customers vehicle. In North America, the BMW TPM sensors transmit at 315 MHz, except for the latest versions that transmit at 433 MHz. They do not have a beveled spacer ring.

A replacement unit includes the tire valve, sensor, a self-locking mounting screw, spacer ring, collar nut, valve cap, and mounting pin.

To install a new sensor:

1.Push the valve into the sensor and then into the valve hole of the rim.

2.Put the spacer ring on the valve and turn the screw collar nut down until it is seated.

3.Put the installation pin into the valve and then tighten the collar nut to 3.5 Nm. As soon as you have tightened the collar, remove the mounting pin.

4.Press the sensor lightly into the deep well of the rim, then tighten the mounting screw to 3.5 Nm. The valve and sensor assembly should be flat in the drop center. If not, the installation is incorrect.

5.Remount the tire and inflate to its recommended pressure.

6.The TPM must be initialized and recalibrated as explained above.

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