TechDrive

Volume 4 Number 3 October 2007

BMW
TechDrive
Magazine

For independent
BMW service
professionals

The Ultimate
Driving Machine®

Original BMW Parts

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.

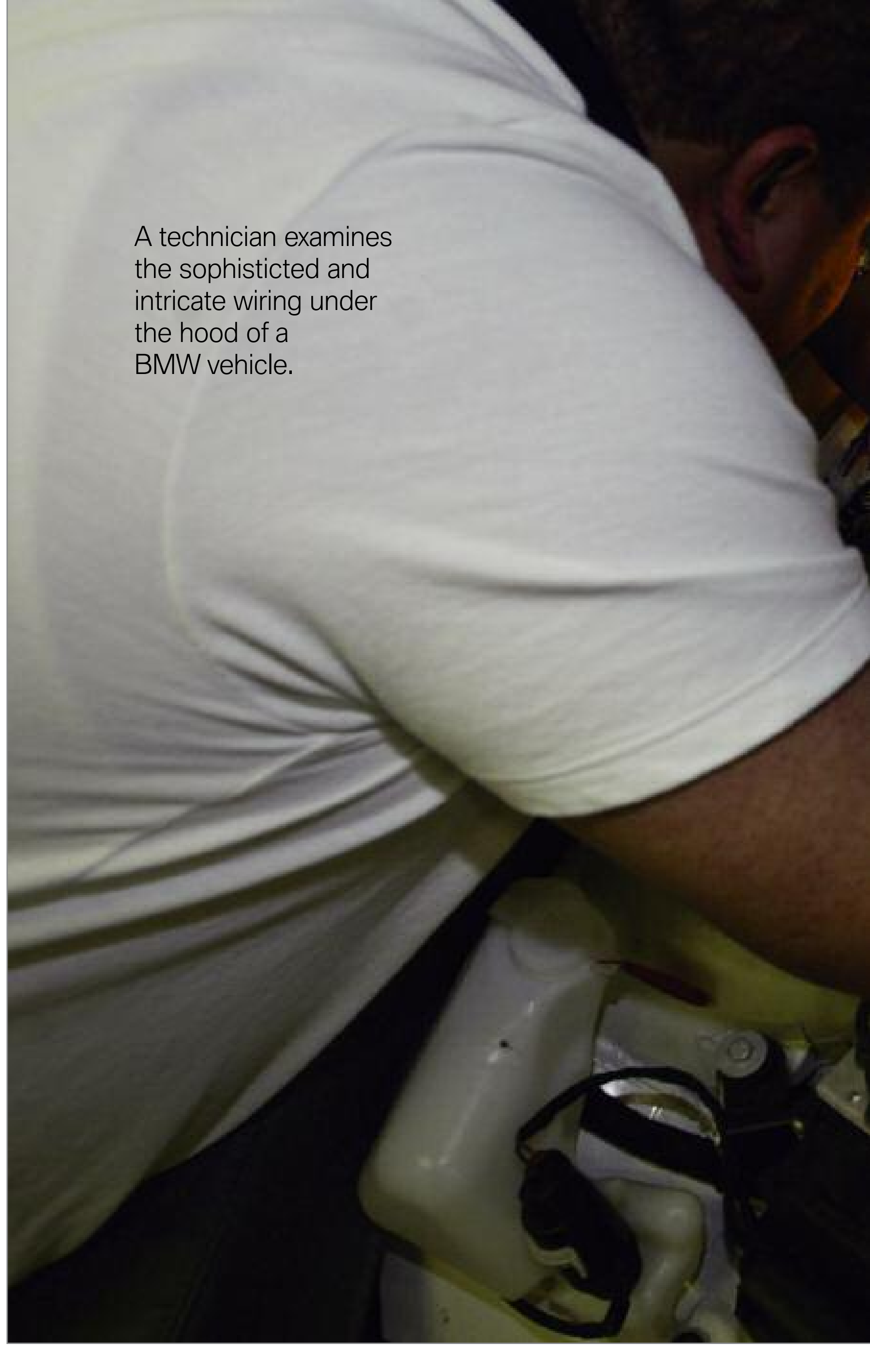
There's more to this effort, including highly-informative and user-friendly web sites, which we'll explain in future issues.

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.

For more information please email us at: editor@techdrivemag.com

Cover Photo:
Ignition coil with ionic current measurement system and sparkplug



A technician examines the sophisticted and intricate wiring under the hood of a BMW vehicle.

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A Publication For The Independent BMW Service Professional

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Original BMW Parts

"Ladies and Gentlemen... We Have Ignition!"

The coordination of ignition, fuel delivery and basic engine function is required before internal combustion can take place. Here, we'll look at the ignition system from its basic function and proper operation to advancements made by BMW to reduce maintenance, decrease emissions and increase performance.

Whether the space shuttle or an almost equally high-tech BMW, vehicles won't go anywhere without ignition.

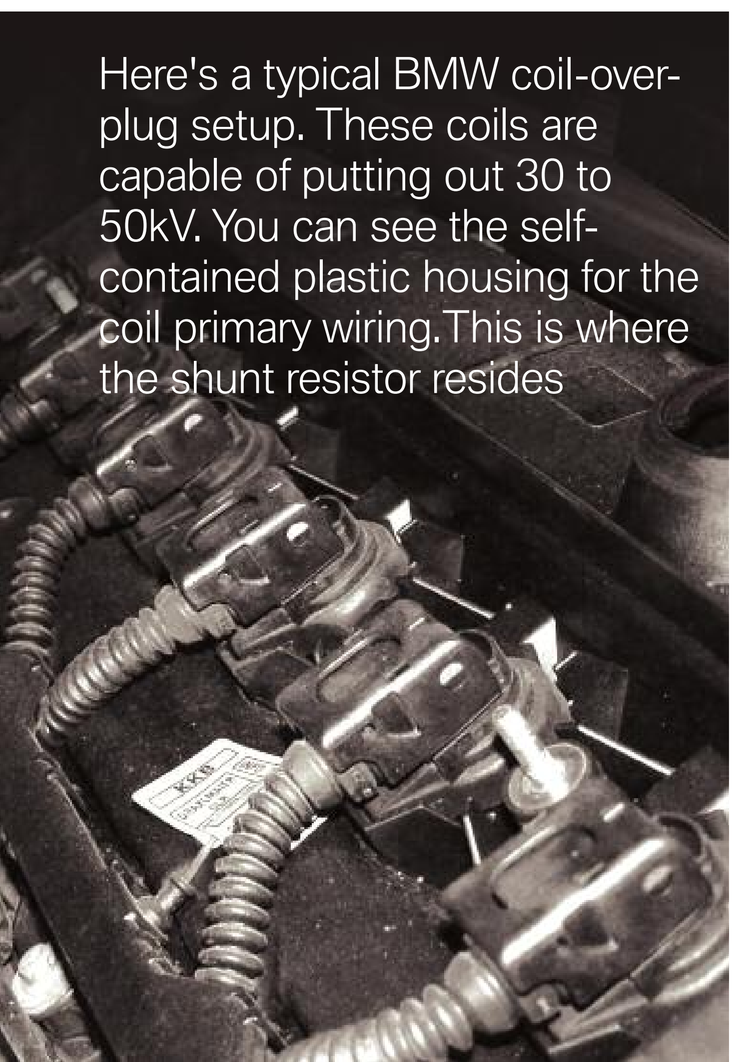
After pulling off the engine cover, but before removing the coil, a quick scope pattern of the coil primary circuit will indicate if the coil is being commanded to fire, and also give an indication of the quality of the spark.

☐ For whatever reason, when a “no-start” condition was encountered the first test traditionally performed was usually that for ignition output. Maybe it was the ease of the test, or that the carburetor, working on natural principles, would be expected to supply fuel. As long as the engine sounded like it was turning over normally, the “spark test” was as simple as pulling a plug or coil wire, holding it ? inch away from ground and cranking. If you were smart, you used a test plug to avoid any shocking personal involvement in the process. Today, however, this test can be time consuming because of engine covers, bolted-down coils and involved spark plug access. In order to remain efficient and profitable we must develop faster methods of determining if we have sufficient spark to ignite a compressed air/fuel mixture. When it comes to misfires, we also have to judge the quality of the spark. Of course, anything from fuel quality and proper mixture to basic engine compression can cause a misfire, but we need to be able to determine if spark is the cause of the problem.

A brief history of spark distribution

Before electronics took over, we had “breaker point” ignition. A mechanically-driven distributor would spin a cam that opened a set of points against spring pressure. When the points were closed they completed the circuit through the primary winding of the ignition coil, which created a magnetic field, the duration of which was called "dwell." When a cam lobe pushed the points open, the field would collapse generating high voltage (15kV or so) in the secondary winding of the coil. Spark became available at the coil tower and would then pass through the rotor and distributor cap and continue on to the spark plugs.

With the advent of electronic ignition, a module was used to control coil dwell and was commanded either directly by a “pick-up,” or by a control unit using crank and cam position sensors. In the case of older BMW vehicles, the Bosch Motronic control unit would receive the sensor signals (both reference and TDC) and directly control the dwell and firing time of the coil. The use of electronic control increased the output of the coil to about 28kV. In 1992 on certain models, BMW started using individual coils to fire each spark plug separately. Each coil is directly controlled by the Digital Motor Electronics unit (DME). These coils are capable of producing 30 to 50kV. Another benefit of individual coil control is the DME’s ability to manage coil dwell and timing in response to engine load signal, knock sensor inputs and ignition monitoring feedback.



Here's a typical BMW coil-over-plug setup. These coils are capable of putting out 30 to 50kV. You can see the self-contained plastic housing for the coil primary wiring.This is where the shunt resistor resides

What, Where, When, Why and How?

How does the DME unit know when to fire the coil? Obviously, it must know the position of the crankshaft in order to determine the proper ignition advance for each cylinder. Before the mid-1990s, two crankshaft sensors were used. One was called a TDC (Top Dead Center) sensor and the other was known as the reference (Speed) sensor. Both were mounted in the bell-housing of the transmission. The TDC sensor would inform the Motronic control unit as to when the Number One cylinder was coming up to top dead center. The Reference sensor would read the teeth on the flywheel or flex-plate to indicate how fast the engine was spinning. The Motronic unit would fire the single coil and the coil wire would pass on the induced spark to the distributor cap and it would then continue on to the cylinder.

With this system, the distributor cap, rotor and spark plug wires, along with the plugs themselves, would periodically be replaced in a tune-up. Since BMW has moved on to a coil-over-plug design, the parts that used to channel high voltage have been eliminated.

With individual coils for each cylinder, the DME control unit must also know the position of the camshaft in order to determine if the cylinder is under compression or exhaust. This is not a waste-spark system where a single coil provides spark to a cylinder under compression and another under exhaust! The DME fires each coil according to a preprogrammed map using various inputs from sensors on such things as coolant and intake air temperature and mass airflow. The crankshaft position sensor is critical to spark control, and the DME will not attempt to fire the coils without it. The camshaft position sensor is also important, but on coil-over-plug applications the engine will start without this signal, but will run poorly. The symptom even applys to later vehicles -- more on this later.

So, ignition control is determined from the internal map from a properly powered-up DME control unit and inputs from the crankshaft and camshaft position sensors. The DME in turn grounds the appropriate coil to saturate its field until it opens the circuit, which causes the field to collapse and provide a spark. So far we have answered What, Where, When, Why but we have not answered How.

And How!

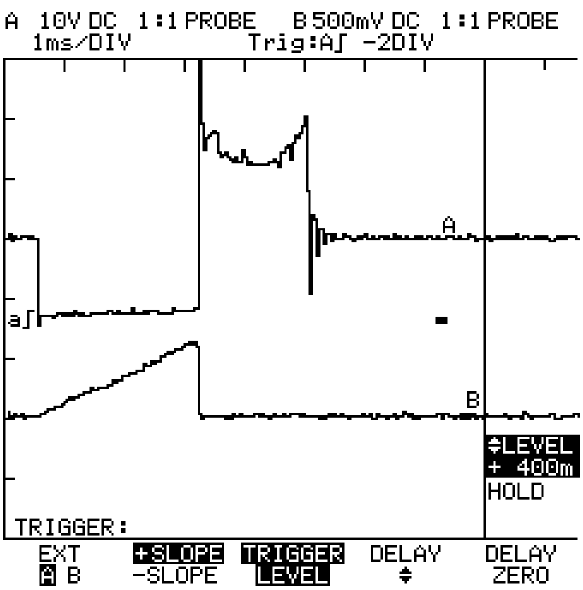
As mentioned earlier, since the inception of the Motronic control unit, the coil(s) has been controlled directly. On the ‘92 318 (E36), BMW used a coil pack and plug wires, but this was abandoned by ‘94. Coil-over-plug became the preferred method of ignition. Not only was timing controlled on an individual cylinder basis, but so was the amount of coil current. The way BMW powers up its coils has changed also. Since ’97, the power supply for the multiple coils is from an ignition coil relay otherwise known as an “unloader relay.” Since the relay provides power, the current does not have to pass through the ignition switch, thus reducing its electrical load.

BMW uses two manufacturers for its coils, Bosch and Bremi. The coil specifications are essentially the same, however. Coil resistance on the primary winding is about .5 ohm previous to 1996. For ’96 (’95 for the 4.0L engine), the coil primary resistance increased to about .8 to 1.0 ohms (measured between the two outer pins of the coil). The center terminal of the coil is wired from ground through a “shunt resistor”

This is often the first test performed on a coil -- the static test of primary winding resistance, measured across the two outside pins of the three-pin connector. Remember, just because a coil passes this test does not mean it is actually functioning.

and is connected to the secondary winding. This resistance is too high for most ohmmeters to measure. The only measurable difference between the Bosch and Bremi coils is the resistance of the extension boot out of the secondary tower. The Bosch coil is about 1K ohms and the Bremi boot is about 1.8K ohms.

How are we going to test it?



Watch the top pattern and you'll see the pull to ground, the inductive kick and the burn time. This shows that adequate spark took place. The lower waveform is the current pattern of the same coil. The low current probe was set to 100mV per amp. Just over one 500mV per division means over 5 amps are being produced. Compare to other cylinders, or previous test results.

If you have a no-start and you want to check for spark, you do not have to remove the coil and install a HEI (High Energy Ignition) spark tester. Instead, you can remove the coil cover and scope the coil primary trigger. You will see a typical coil primary pattern -- the initial pull to ground followed by the inductive kick or "spike" of the coil's ground being released, the "burn time," and finally the coil oscillations. If you see a pattern without the pull to ground, inductive kick or burn time you do not have sufficient spark. If the vehicle is starting, but you feel you may have an ignition-related misfire, monitoring coil primary will probably not be enough information to lead to a diagnosis.

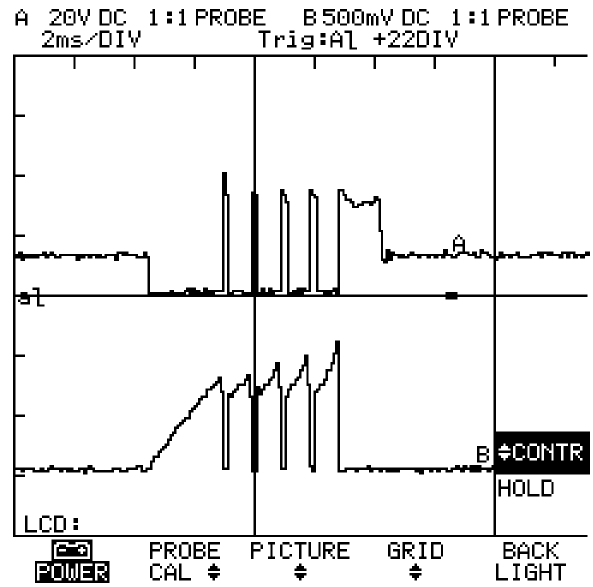
You do not have to remove the coil to determine its resistance. Back-probing the terminals will suffice. Remember, before '95 resistance of the primary winding is .45 ohms, and after '96 it's about .8 ohms.

The first step is typically the primary and secondary resistance test. This is a “static” test, which means you are testing the component outside of the operating system. A resistance test will tell you if you have a bad coil, but it will not tell you if you have a good one. That is, if the resistance values are within specification that does not guarantee that we have a good coil.

Another method of evaluating a coil's performance is monitoring its current draw. This is known as a “dynamic” test. The test is performed while the coil is operating in the system. This can be achieved by using a low-current inductive probe around the coil power feed or ground trigger wire and watching the “current ramp” on a scope. The rate at which the coil builds current and its peak current are critical to determining if the coil is functioning properly. You can look at a known-good pattern for comparison by reading another cylinder or another similar vehicle that is running properly. When comparing current ramp patterns, be sure you are comparing "apples to apples." Most low current probes have multiple output settings, so you have to make sure the setting is the same when comparing one pattern to another. If the rate is higher or lower than normal, or the peak current is too low or high, it indicates a failed coil or coil driver. Since the coil driver is inside the DME control unit, a coil is easier to replace and retest. Peak coil current draw is just under seven amps on single-fired coils. These are coils that are only fired once.

Multiple sparks

BMW has advanced to the Siemens MS43 system, which includes an ignition feature called MSD (Multiple Spark Discharge). This form of ignition control grounds and un-grounds the coil multiple times during each cylinder firing. This provides multiple flame fronts to help promote complete combustion, particularly at idle. While evaluating a scope waveform you will notice the multiple inductive kicks. If you monitor the current waveform you will see the multiple current



This is the MSD coil control. The top pattern is the voltage waveform. The lower waveform is the amperage draw. Each time you see the pattern rise and fall a spark is generated. This plug was fired five times at idle.

ramps for each coil firing. The current gradually increases with each firing to a 10 amp peak. The primary resistance of a coil is about the same whether it is a MSD system or not.

The DME control unit has its own way of monitoring spark. The secondary winding (center terminal) of the coil is mounted to a 235-ohm resistor that is wired to ground. This wire is also spliced off to the DME unit. The DME monitors the voltage drop across the resistor to determine if proper spark took place. The DME is looking for two-volt spikes for each ignition spark. This spark confirmation signal plus monitoring crankshaft fluctuations helps the DME determine if misfires are occurring. The DME compares camshaft/crankshaft “sync” to identify which cylinder(s) are misfiring and set misfire codes for those cylinders. Aside from code numbers P0301 to P0312 to identify the specific cylinder, you can use a scan tool to observe the DME’s

Here we are measuring the resistance of the shunt resistor. You must read 235 ohms. The red test lead is on the ground side, and the black lead on the coil side. You would need to reverse the leads to properly monitor the voltage drop as the coil fires.

This is the ground mounting point of the shunt resistor. If this isn't mounted properly, there'll be no spark and the engine won't start, so be careful when reinstalling the ignition coil.

view of cylinder combustion in data. So, by monitoring the coil primary voltage and amperage waveforms, cylinder misfire codes, and scan data misfire monitor we should be able to determine which cylinder is misfiring and if the coil is at fault.

Servicing the secondary ignition system

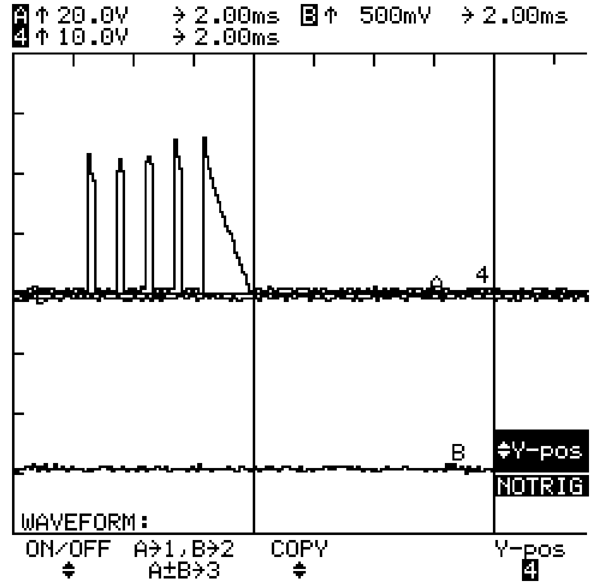
Previous to the early 1990s, servicing the secondary ignition system included replacing the coil wire, spark plug wires and spark plugs. With age and heat stress they crack and leak voltage. If this is bad enough, the spark will arc to another ground path instead of that through the gap of the spark plug. Spraying a salt-water solution on the plug wires and watching them under low light may show if they need to be replaced. Otherwise, new ones should be installed every 60,000 miles. The spark plugs should also be replaced at this interval.

Proper spark plug torque is often overlooked in the process. The specification is 30 NM or 23 ft. lbs. When spark plug torque is not correct, the plug's ability to shed heat is reduced. This and the compromised ground path reduce plug life. The effect is minimal at first, but over time will affect the plug's performance. Throughout the '90s to the present BMW uses either NGK or Bosch spark plugs as Original Equipment. These evolved from a single ground electrode design to dual and four-prong electrodes in an effort to increase mileage between service intervals. It is strongly recommended that you stick with these plugs when it's time for replacement.

With the coil-over-plug design, the secondary system tune-up was reduced to changing the spark plugs. Also, with multiple electrodes, current-controlled coils and efficient combustion

chambers, spark plug replacement intervals increased. Previous to '98, the recommended spark plug replacement was at the Service Inspection II, so when the red indicator came on you installed new plugs. For post '98 models, BMW recommends that the plugs be replaced every 100,000 miles. However, we would suggest that you allow engine performance and misfire status to supersede these intervals. Do not wait for the full 100K if there's any problem. Poor fuel quality and neglected maintenance may influence when the plugs need to be replaced. While coils and boots carry no regular replacement interval, outside factors may cause them to deteriorate. For instance, leaking valve cover gaskets can fill spark plug holes with oil, softening the coil boots and allowing the spark to arc directly to the cylinder head.

In closing, we should mention that ignition systems perform a stressful task. This repeated stress requires regular maintenance intervals. If these maintenance procedures are adhered to, your BMW-owner customers should enjoy trouble-free performance for years to come. If there is ever an ignition-related problem, however, you should now have the basic knowledge required to deal with it. □

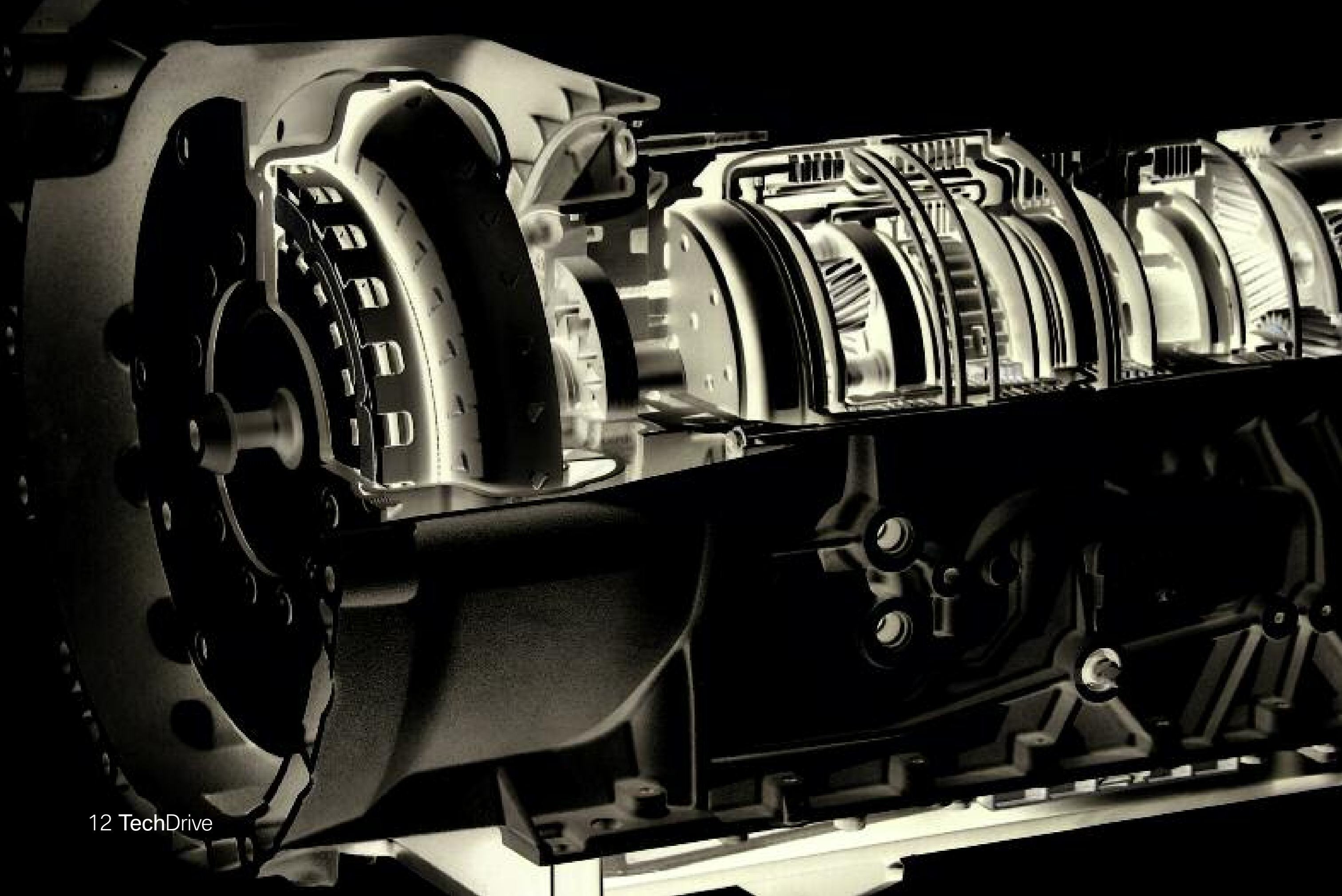


Here we are looking at the voltage kicks produced on the coil side of the shunt resistor for an MSD coil event. If these kicks are below two volts, the DME determines that there was a problem with combustion.

If you look down at the spark plug hole, you may see that it's filled with oil leaking from the valve covers. This can soften the boots and possibly allow the spark to arc to the cylinder head.

Shifting Gears, Even When It's Done For You

Knowing how to diagnose and service sophisticated transmissions will keep your customer's BMW performing like a BMW should



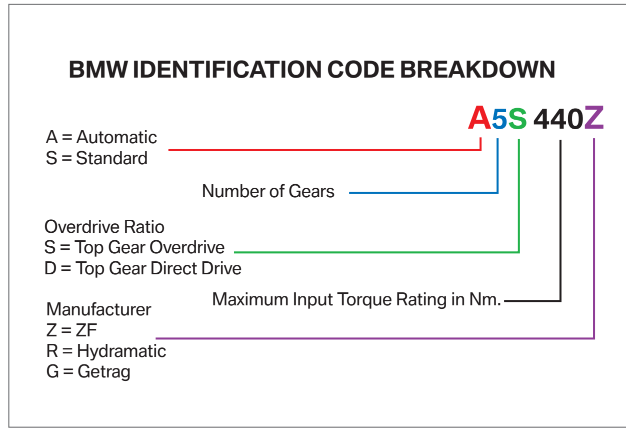
BMWs are performance vehicles driven by performance-oriented owners. The way the vehicle accelerates and handles are two of the main reasons they purchased a BMW. So, they're more inclined to notice peculiar handling characteristics, as well as shifting concerns.

BMW has two automatic transmission suppliers, and knowing what goes wrong, how to handle diagnosis, and how to perform service will give you the ability to keep your customers' BMW vehicles performing as BMWs are engineered to perform.

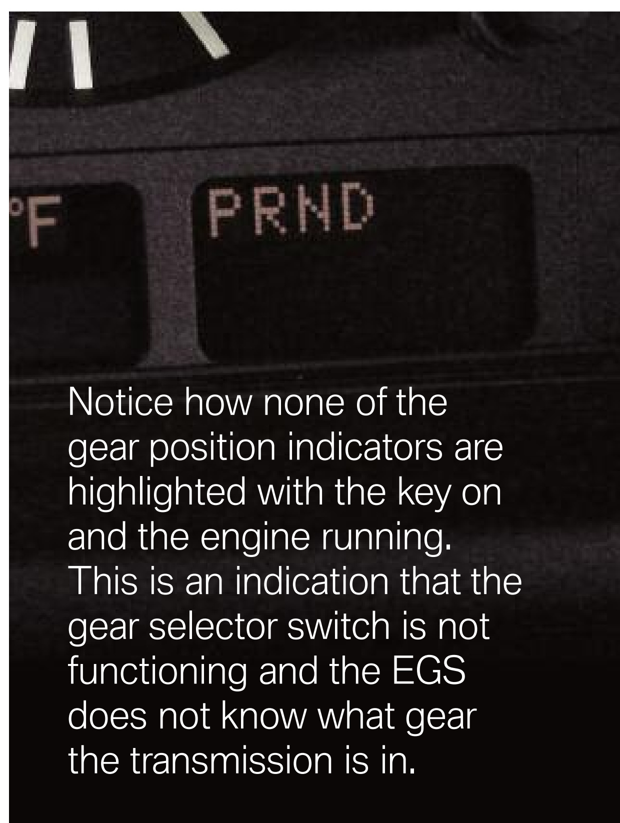
First, what are we working on?

As already mentioned, BMW uses automatic transmissions from two manufacturers. One is ZF (Zahnradfabrik Friedrichshafen), which also produces manual transmissions for BMW, and the other is GM (GM Powertrain). So, there are two possible identification numbers on each transmission. One number is provided by the original equipment manufacturer and the other is supplied by BMW. Obviously, this is important for ordering parts, but most dealer parts personnel will ask for the last seven digits of the VIN to identify the vehicle and its transmission application. When searching for service information, it's important to know both the BMW designation and the control unit version and/or production date. This is critical when evaluating a wiring diagram or diagnostic service information. Without the proper identification, the system layout, pin location and wire colors may be incorrect. This could lead either to an incorrect diagnosis, or wasted time, or both.

Because of the two different manufacturers, BMW had to provide its own identification method. This alpha/numeric system gives pertinent information about the transmission. Look at the illustration and you'll see how BMW identifies the type of transmission, number of forward gears, overdrive or direct drive, torque capacity and, finally, the manufacturer. If you use the identification tag mounted on the transmission, you'll have to match the manufacturer tag with the service information. Software versions also have an effect on information. Much like on your home computer, a higher number software version means there has been an update engineered into the system. For instance, the EGS 8.34 system uses only one output speed sensor to the transmission control unit. The later system EGS 8.60 uses two speed sensors, one each for the input and output shafts. You can find the version number on the ECM identification screen of your GT1 (or other compatible scan tool).



Because BMW has two transmission suppliers, it produced its own alpha/numeric identification system for the different units.



Notice how none of the gear position indicators are highlighted with the key on and the engine running. This is an indication that the gear selector switch is not functioning and the EGS does not know what gear the transmission is in.

What are you looking for?

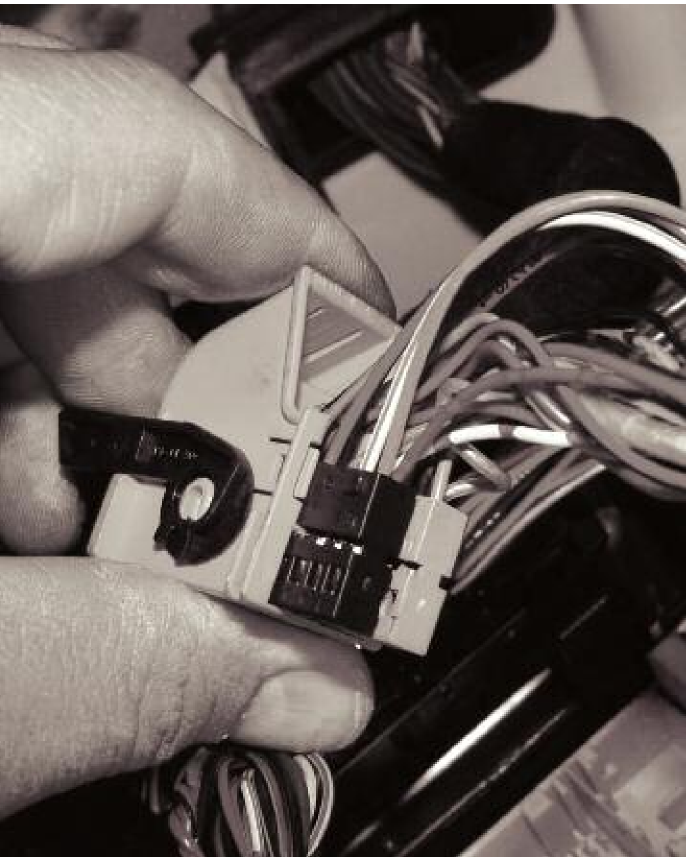
When dealing with any customer complaint, it is always a good idea to road test the vehicle, preferably with the customer at the wheel. Watching the way he or she drives may give some indication as to what is causing the problem. If the issue is as simple as a “Service Engine Soon” light (Malfunction Indicator Lamp -- BMW doesn't use a separate “Check Transmission” lamp), then a quick scan for codes and data may give you a diagnostic path to follow. In the case of multiple codes in the transmission and/or engine systems, record the codes and clear them first. After clearing, check for codes with the ignition turned on. This will let you know if there are any “hard” failures happening right now. Also check for codes after starting the engine and after putting the transmission in gear. If you find a code at this stage, either by starting the engine or shifting into gear, it reduces the number of possibilities. Finally, test drive the vehicle yourself and see if any code(s) return.

The gear selector switch is mounted on the side of the transmission on this ZF unit. There are a few technical service bulletins to look out for on this switch, so don’t forget to check this first.

One quick item to point out is that you should watch the gear position display in the instrument cluster. As you move the shift handle you should see the indicator on the display change from P to R, then to N and finally to D. If you see the indicator disappear, it's a good indication that the instrument cluster computer is not receiving the signal on the CAN line from the transmission control unit.

The control unit receives the signal from the gear selector switch, which, in the case of a ZF, is mounted on the driver’s side of the transmission. A bad switch contact will send an implausible signal, and the EGS unit will not be able to pass it on to the instrument cluster. Scan the gear selector switch in the transmission control unit and you will see the switch input as you shift through each gear. If you do not see the gear indicated in the data, this indicates that you should test the switch contacts with a voltmeter at the sensor. Keep in mind that these switch contacts should include the “Steptronic” switch, which indicates to the transmission control unit that the shifts will be controlled manually by the driver.

The EGS 8.60 system uses speed sensors to determine if there is any slippage between the input and output shafts. This could indicate worn or sticking clutch plates. It could also indicate sticking pistons or solenoids in the valve body. If the problem is worn clutch plates, the transmission is going to need to be overhauled or replaced. However, it would be a very embarrassing mistake to do that job only to find out that shift quality problems were caused by sticking shift solenoids. Using a scope you can monitor solenoid control while driving, or you can activate the solenoids through your scan tool and monitor the voltage/current draw of each solenoid. You can perform these voltage drop and current draw tests at either the EGS control unit, or the connector at the transmission. Either way will allow you access to the wiring you are concerned with. By accessing the wiring at the control unit, you will also test the entire wiring harness. If you chose to perform your testing at the transmission connector, you may be able to isolate the cause more quickly.



Here is the EGS control unit connector cover. Look for the locking tab. By pushing this tab out you can slide out the wiring connector, plug it back into the EGS and start testing.

You can check the current draw with an inductive amp probe. In this case, one of the pressure regulator solenoids is being checked while it is activated.

Six of one, half a dozen of the other

If you remove the cover to the E-Box you will see the powertrain system computers. Removing the transmission control unit's connector covers (blue) will give you access to the pins on the control unit for voltage and current testing. To remove the connector covers, simply unplug all the connectors involved to get at the one you need. On one side of the connector cover you'll see the tabs that lock the wiring connector into the cover. After you slide off the covers, you can carefully plug the wiring connectors into the EGS control unit and begin testing.

Using your scan tool, you can activate each of the shift and pressure solenoids and monitor their voltage/current. An inductive current probe will give you an overall view of the amperage drawn by each solenoid. Each pressure regulator solenoid draws about half an amp, whereas ach shift solenoid draws just under half an amp. If you need to take solenoid operation a little further, you can scope the solenoids and monitor the waveform patterns.

While monitoring the pressure regulator solenoid, you'll see that the EGS intermittently grounds the solenoid very quickly and it's not even activating the solenoid (why it does this is not important for this discussion). The solenoid is not grounded for very long and therefore not enough electro-motive force is generated for activation. When you activate the solenoid through the scan tool, you'll see that the voltage signal is pulled to ground much longer. The solenoid is activated and as a result you can now measure the amperage draw.

If you would rather perform your electrical tests at the connector on the transmission, this

– Continued on page 18

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WHY BUY ORIGINAL?

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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.

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5. Assemble, test and box.

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

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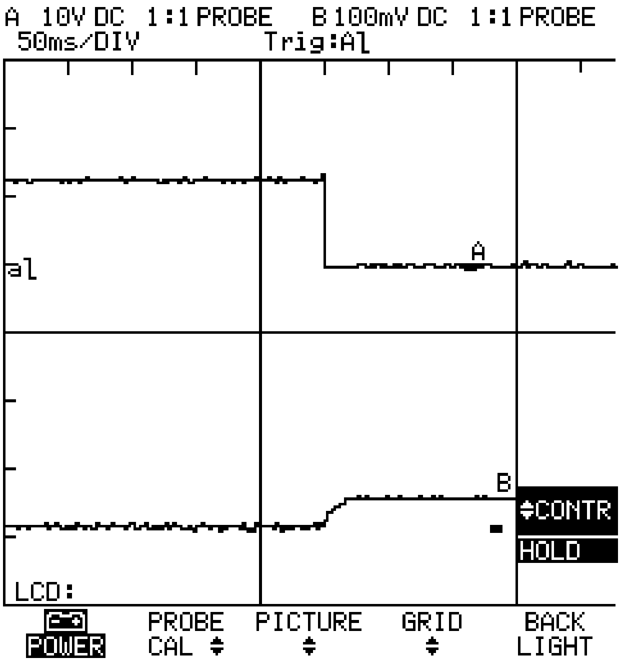
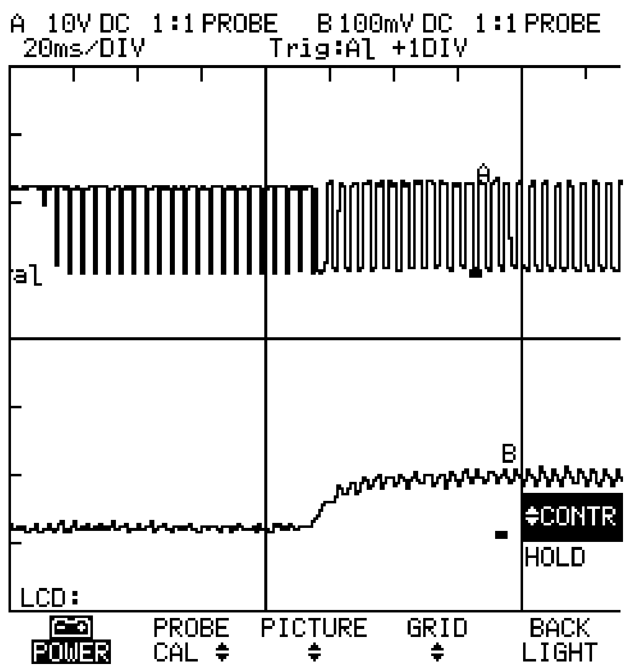


Here, the voltage control (upper trace) and amperage draw (lower trace) of a shift solenoid are being monitored. The resistance of these solenoids is about 30 ohms. In this case, the low current probe was set to put out 100mA per amp, so with the scope set to 100mA divisions we see just below .5 amp.

is possible also. This is a good idea if you suspect a problem with the harness in the transmission. To unlock the connector at the transmission case, you have to pull on the cam lock of the connector and then pull the connector backwards. Now would be a good time to check for corrosion in the connector.

Once again, it's important to know the production date of the vehicle you are working on. On this E39 chassis, you will find that the wires that provide voltage to the solenoid are different from one year to the next. For instance, from 9/1998 to 9/1999 pin #12 provided power to the four pressure regulator solenoids, and pin #16 provided power to the three shift solenoids. After 9/1999, pin #12 provides voltage to pressure regulator solenoids 2 and 3 only. Pin #16 provides voltage to the rest of the solenoids.

It is not difficult to drop the transmission pan and expose the solenoids. You can also remove the securing clip of the connector and remove it from the housing of the transmission to check the wiring harness more easily. When checking the resistance of the solenoids you will see just under 30 ohms for the shift solenoids and just over six ohms for the pressure regulator solenoids. According to Ohm's Law, the shift solenoids reading makes sense, but the pressure regulator solenoids should draw about two amps.



The voltage control (upper trace) and amperage draw (lower trace) of a pressure regulator solenoid are shown here. This solenoid is current-limited by the EGS unit. The solenoid is pulsed to ground, but there's no current draw. When the EGS activates the solenoid, it increases the duty cycle to ground, which in turn operates the solenoid.

With the pan dropped and the connector removed, you can easily check the wiring harness inside the transmission. You can also check the solenoid resistance directly. The green solenoids are the shift solenoids and the black solenoids are the pressure regulator solenoids.

The answer is that the EGS unit controls the current flow, so that's why when you activate the solenoid you only monitor about .5 amp.

The right ATF is crucial

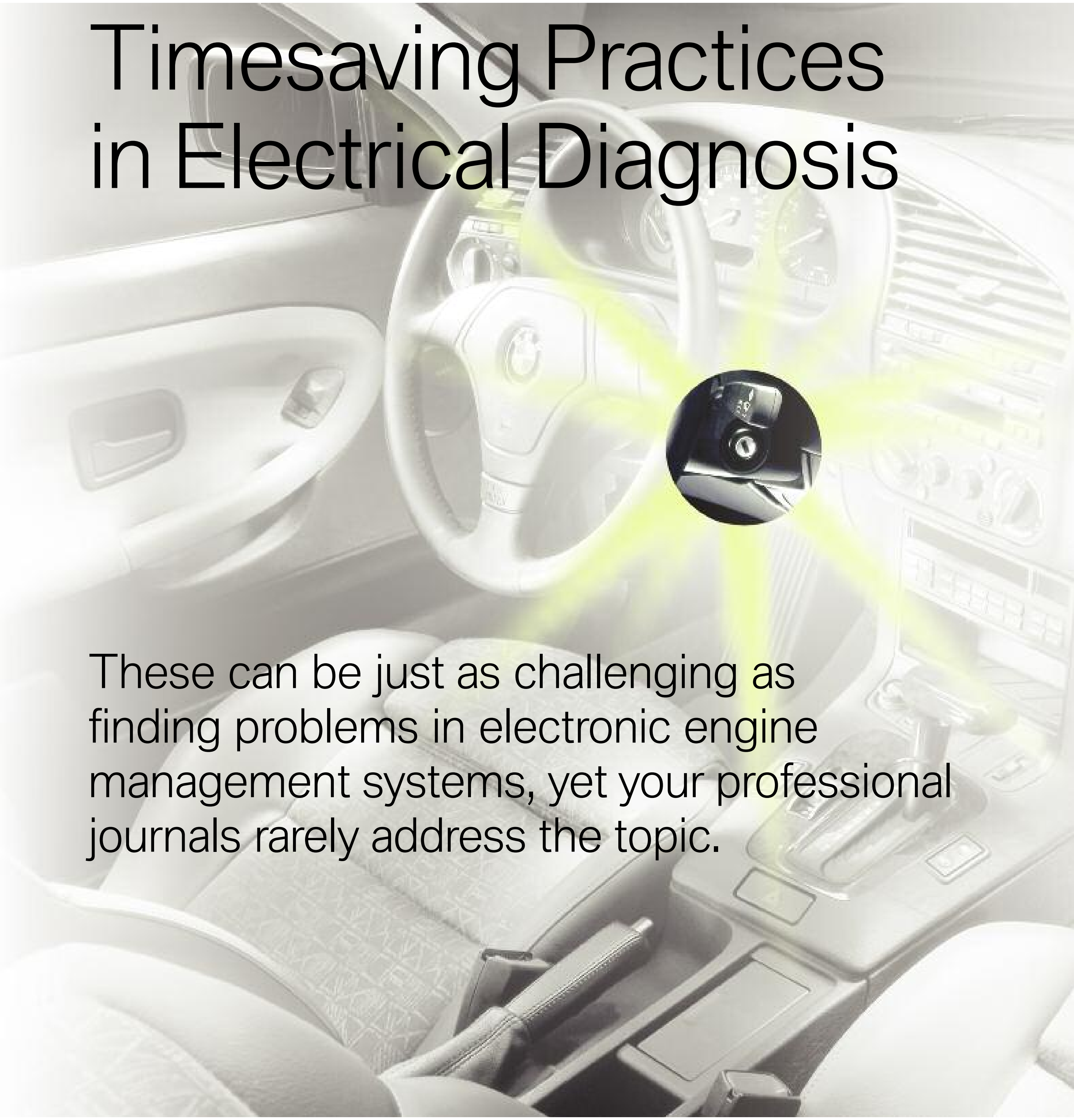
On the GM four-speed units such as the A4S 270/310R previous to '98, you can use Dexron III. After '98, BMW introduced five-speed transmissions manufactured by GM. On these, check the sticker affixed to the transmission pan, which indicates the type of automaticv transmission fluid that was used at the factory. The GM units use Texaco ETL-7045E, or ETL-8072B, which are available at your BMW dealer's parts department in 25 liter containers.

In '92, BMW started to phase in the five-speed ZF transmission. These use Esso LT 71141, or Shell LA 2634. Only the E34 530i/iT had the A5S 310Z that uses Dexron III fluid. The Esso ATF is available in a 20-liter container and the Shell comes in a five-liter bottle. BMW has saved you the trouble of looking it up by printing the part number for the oil right on the sticker.

A proper finish

As with any automatic transmission, fluid level can have an effect on shift performance, so it must be correct. One of the conditions for accurately checking the level is making sure the fluid temperature is between 30 and 50 deg. C, which you can read on your scan tool. Have the engine running, turn on the A/C and set the blower motor to maximum speed. It's not that BMW wants you to be comfortably cool while checking the fluid level, but that the resulting increase in idle speed will help the transmission pump produce more pressure and volume. This will be needed because the next step is to move the shifter into each gear. This ensures all the valve body channels are filled with transmission fluid. At this point, you can check the level. If you have a dipstick, use it. On vehicles without a dipstick, remove the fill plug on the pan of the transmission and watch. You should see a stream of transmission fluid run out of this hole. If not, add fluid at the fill plug until it starts to run out and install the plug. □

Electrical Gremlins: Timesaving Practices in Electrical Diagnosis



These can be just as challenging as finding problems in electronic engine management systems, yet your professional journals rarely address the topic.

Electrical problems that appear downright baffling are invariably solved by getting back to basics. A review of over 200 BMW electrical issues reported on international Automotive Technicians Network (iATN) suggests that half a dozen "best practices" could significantly speed the repair of even the most mysterious electrical troubles.

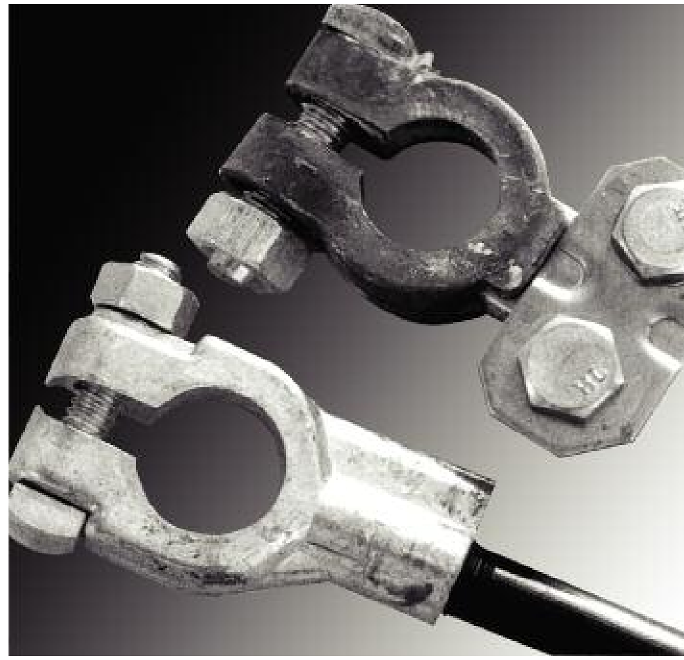
Bulletin search

The first "lesson learned" was that techs will save themselves considerable time by initiating all gremlin hunts with a search for Technical Service Bulletins (TSBs). If the symptom was a radio that cut in and out, or a steering wheel that telescoped as if it were possessed, would you instinctively know to replace the ignition switch? Otherwise, a lot of time could be wasted looking for the cause of an intermittent 800mA parasitic draw that kept flattening batteries. A review of TSBs would have eliminated these and dozens of similar requests for assistance.

After a TSB check, obtaining a schematic of the affected circuit(s) should follow. As one successful BMW independent puts it, "Since you can't see electricity, electrical problems have to be solved in your head. All you do on the vehicle, meter in hand, is confirm or disprove what you already suspected from looking at the schematic, and thinking about the symptoms."

Sufficient straight DC

Next is checking for the availability of clean power from the battery and charging system. Never start looking for a gremlin with a battery that isn't fully charged (12.6-12.72V or better), or with an alternator that fails a load test, or puts out excessive ripple. The figure most techs agree upon as the maximum permissible ripple is .5V AC, measured at 2,000 rpm using a Digital Mult-Meter (DMM) set on AC voltage, and lights, heater, or some other load on. Scoping the alternator output is an even better practice. Spikes shouldn't exceed +/- 1.0 V. Measure or scope directly across the alternator battery terminal and the case, not at the battery.



Emergency clamps are just that, but are often considered a permanent repair. Install a new cable and clamp assembly and you'll head off problems.

Battery basics

As one BMW technician tells TechDrive, "A bad cell in the battery can raise havoc with engine management systems. I load test the battery to spec and then use a Midtronics battery tester for the final test."

Numerous BMW techs in the survey reported vehicles that would start and run, yet experienced all manner of gremlins due to a single bad cell in a failing battery. Naturally, this should have been the first thing they caught. Even with a surface charge, a battery with only five cells working could never achieve 12.0 volts. Battery service (that is, cleaning or replacing corroded battery terminals and clamps) should be performed before chasing electrical problems.

Next, of course, is checking fuses. Don't just look for blown fuses, but for fuses missing altogether. You may not be the first tech who's tried to solve this particular problem, and the last tech (or the vehicle owner) may have given up in mid-repair, leaving one or more uninstalled.

Compare the guide printed on the lid of the fusebox to what's actually in a problem circuit to make sure someone hasn't installed a larger amperage fuse.

Fuses can be checked without removal by using either a DMM or a clip-on fuse tester.

Minifuses don't always have to be removed and visually inspected. With power applied, you can touch DMM leads to the two tiny contacts on the face of most fuses to determine which show a 12V voltage drop, indicating they're blown, or use an inexpensive clip-on tester.

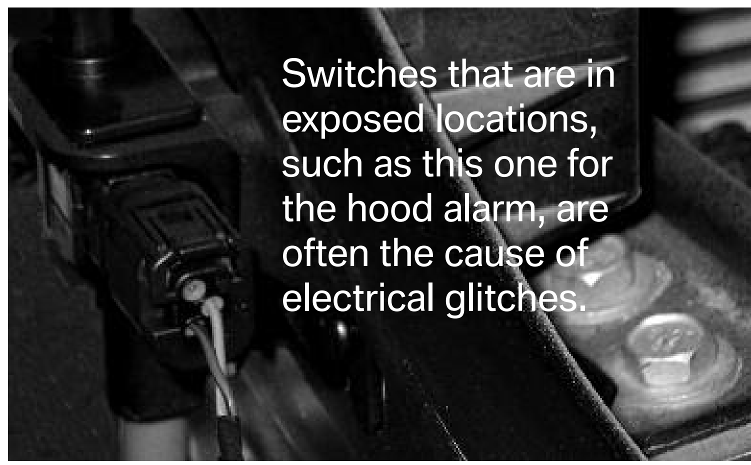
Asking your customer about seemingly unrelated symptoms is the third "best practice" TechDrive's review of 200+ requests for assistance suggested. The customer may have come in to get a single problem fixed. Perhaps this problem is all he or she can afford to repair at this time, or is simply the most annoying of several problems. Something that didn't get mentioned will often give you critical clues toward solving the primary problem.

Ask, "Has your car been doing anything else strange, even if you don't want it fixed today?" Invariably, weird symptoms are somehow related. "Other customer comments" duly noted on the repair order may not always prove helpful, but the times when they do may make you look like a super diagnostician!

After the customer interview, it's time to head on over to the Internet. Pattern failure information is a tremendous time saver on ghostly electrical problems. With a service like Identifix/DirectHit, you can type in symptoms and see if there are any known causes. You can do the same thing searching iATN's archives, or even just using Google.

Our review of 200+ electrical issues saw techs repeatedly seeking help on symptoms that turned out to be caused by failed:

- Ignition Switches
- Blower Resistors/Final Stage
- Fuel Door Actuators
- Alarm hood switches
- Wiper Relays
- Power Seat Switches
- Oil Level Sensors
- Door Lock Actuators
- Water seals on modules & connectors



Switches that are in exposed locations, such as this one for the hood alarm, are often the cause of electrical glitches.

More than half of the complaints related to ignition switches discussed symptoms dealing with radios and telescoping steering columns. Five minutes searching pattern failure information could save a tech hours of panel-removing and trying to figure out why a steering column, radio or dome lamp was misbehaving.

Time for the DMM? Not yet. Instead, get out the GT-1 or other scan tool. On a couple of the "downright nasty" problems that led BMW techs around the block and over the curb a few times, superior engineering was the cause. Specifically, failsafes designed in by engineers. One vehicle refused to turn on its interior lights. Another refused to turn off its headlights. Both vehicles had codes, which, until read and cleared, caused a module to enter a failsafe mode. Headlight failsafes may be great for getting the vehicle home after dark, but not knowing that the interior lights had been disabled by the module just about sent one independent BMW tech to search for a new career.

Okay, you can get out your DMM now. Gremlins seem to breed in body shops. Overcome by paint fumes, they often pass out and end up in your shop as grounds placed on top of freshly painted metal, or connectors that didn't get physically re-connected, and/or damaged pins in connectors unskillfully jammed together. Anytime you have SRS, lighting, window, door, or hatch problems in the physical area where body work was performed, start by checking grounds and connectors. While physical inspection is viable, voltage drop testing is the preferred method for checking any and all grounds, and will sometimes allow you to avoid pulling off body panels.

Keep this in mind: Aside from module and sensor failures, the majority of electrical problems result from mechanical failures of electrical conductors, including chafed wires, corroded connectors, bent pins, and the like. Besides body work, major component jobs such as engine or transmission replacement often result in these kinds of failures.

Intermittents

Now for the fun part: chasing intermittents. The key to diagnosing intermittents once again lies with your customer interface. Before an intermittent is run down, you may need to go for a ride-along with the customer. It's hard enough to catch intermittents "in the act" in order to solve them, and next to impossible if you haven't personally experienced them. It becomes too easy to doubt the customer's word.

Furthermore, his or her description of the symptoms usually won't be in clear tech-speak. As well, you may notice other symptoms, warning lights, or clues to diagnosis the customer didn't mention.

You should begin with questions about when the intermittent misbehavior occurs. In the rain, after sitting a while, after a hot or cold soak? After short drives, or long ones? After being in the garage? Where is just as critical. Driving down rough roads or over train tracks? You may have to drive the exact same route the customer drives to work to get it to misbehave, or ride along with him or her. It's frequently some everyday behavior that didn't get mentioned – plugging in a cell phone charger and setting it on the unoccupied passenger seat with the resultant Radio Frequency Interference (RFI) setting off an error, for instance – that gets you. Riding along is often the ONLY way to see exactly what customers are doing, even what radio station they listen to, or how they consistently park on a downhill slope.


Any time major work is done, such as engine R&R, there's the potential for damaged wires, poor connections, bad grounds, etc.

Since the majority of electrical problems have underlying mechanical causes, heat, moisture, motion, or vibration, can all make an intermittent fault come and go.

If a problem arises only after a vehicle has been driven a certain distance, it usually indicates that it's heat-related. This could be a cold solder joint, a loose connector, corrosion inside a connector, and so on. There are several techniques for diagnosing heat-related intermittents. You can use a can of freeze spray to try and cool a suspect sensor, or module while it's misbehaving. The other approach is to let the vehicle idle, or use a heat gun to try to induce a suspected overheating component into misbehaving.

Intermittent problems that show up when crossing train tracks or driving along rough roads often indicate loose connectors, loose ground connections, or damaged insulation that allows a wire to chafe when it is moved.

Automotive flight data recorder technology can help capture an image of intermittent problems.

Tugging and pushing on wiring to try and duplicate the problem is about all that can be done, aside from performing a close visual inspection. A DMM with a min/max recording function can be invaluable if you're diagnosing this sort of problem solo. Don't be afraid to get aggressive with wiring looms. You won't solve intermittents by being too gentle and you can always repair any damage you do by tugging too hard. The only crime is NOT solving the problem.

Water intrusion into modules and connectors occurs all too often. On cold mornings moisture can condense into connectors, and then evaporate in the afternoon and the problem will totally disappear. The appearance of "flood cars" from Hurricane Katrina has made inspecting for water intrusion a regular task when mystery problems show up. Visual inspection is the first step. Spray bottles can help. Dielectric grease, which doesn't contain elemental carbon, and therefore doesn't conduct electricity, can be packed inside connectors to prevent future water intrusion.

The weapons of war

There are several excellent "weapons of war" available to the tech attacking intermittent electrical problems. A min/max recording DMM is a good start. A digital storage oscilloscope can, during a ride-around, allow you to spot an intermittent waveform, or dropout from a sensor. The scope's advantage over other tools is that you can set a trigger not to record anything until a suspect signal changes state – a signal suddenly being grounded or driven to battery voltage. But what if the problem only happens once in a LONG while. Longer than you want to hang onto the car.

The ultimate in gremlin capture is a flight data recorder, or FDR. This is a "black box" that allows the vehicle owner to press a "Panic Button" when an event occurs. The box is continuously recording selected signals, in a loop fashion, and will STOP recording 30 seconds or so after the button is pressed, giving the operator a view of the recorded signals both before and after the event. With one of these, you can capture even the most elusive of electrical gremlins.

Once you've identified a wire that is open or shorting, a tracing tool such as a FaultFinder will allow you to inject a signal into that wire and trace it, even behind panels or underneath carpets, to where it is open or shorted. A FaultFinder is quite a step up from the old compass and circuit-breaker approach to hunting down broken or chafed wires. Yet even it requires some practice to use effectively. There are several manufacturers of such tracers, including Waekon.

Electrical gremlins are elusive little creatures. They breed in paint and body shops. Only the most methodical techs are able to capture them. Taking shortcuts like not cleaning the battery terminals, or not testing the charging system before starting an electrical diagnosis can make an otherwise simple diagnosis turn mysterious. Once all your "homework" such as checking TSBs and pattern failure information is complete, then diagnostic work can begin. As with all auto problems, intermittents require the most effort to successfully diagnose and repair. Fortunately flight data recorders and other technologies can make previously "impossible" problems not so difficult to solve. □

...but that knock off part won't fit and it's 4:30.

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