BMW
TechDrive
Magazine

For independent
BMW service
professionals

The Ultimate
Driving Machine®

# TechDrive

Volume 4 Number 2 June 2007


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:
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Cover Photo:
BMW 7 Series - Spring 2005
Control Display with Climate menu

Modern clutches are vastly superior to their predecessors in terms of performance and pedal feel, but accurate diagnosis remains a challenge.

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A Publication For The Independent BMW Service Professional

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Original BMW Parts

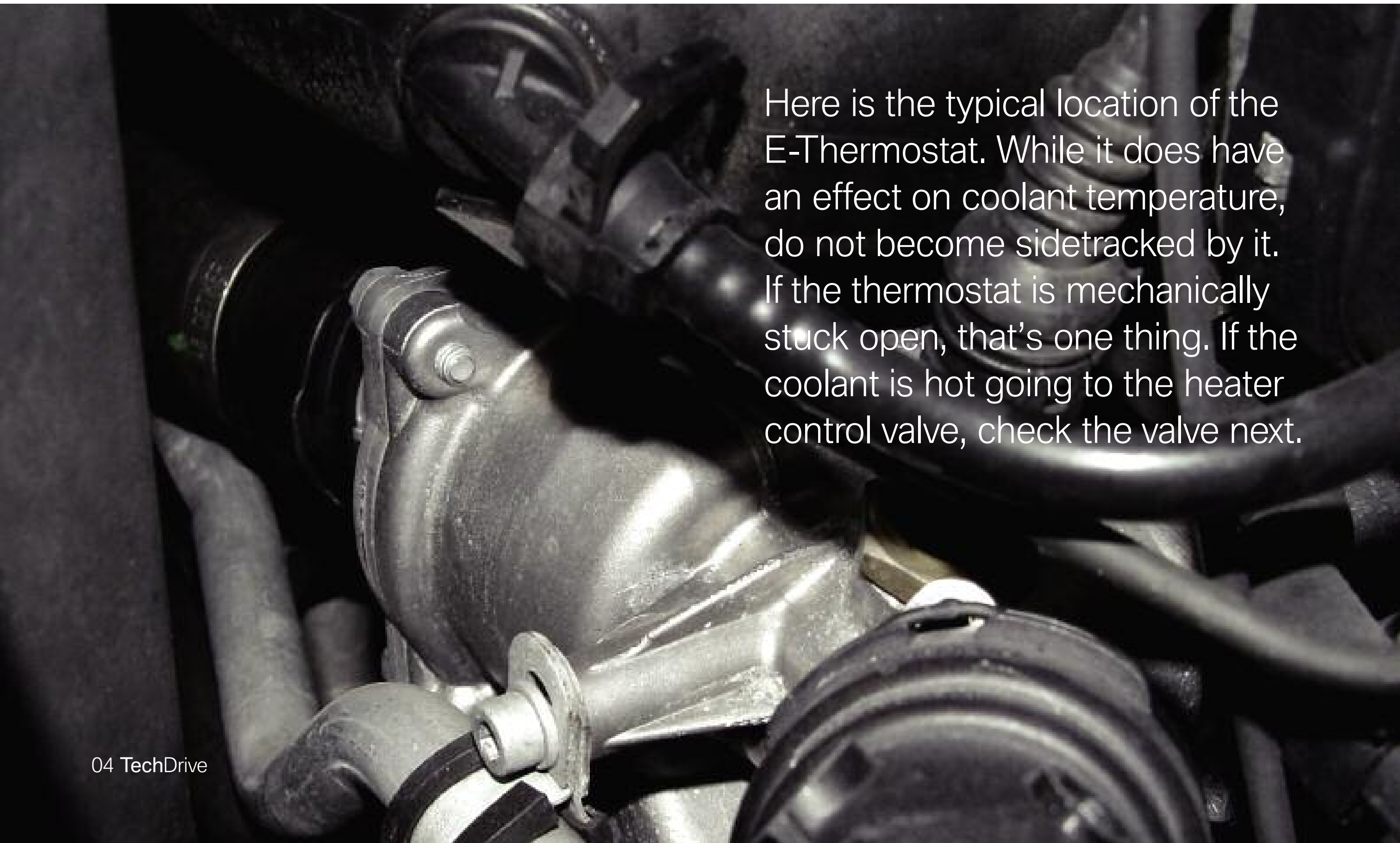
## Operation and troubleshooting of the BMW IHKS, IHKR and IHKA climate control systems

# Saving the Environment

□ It's that time of year again. The record cold temperatures are over – we hope – but considering the wild fluctuations in our weather patterns, your customers may want heat one day and A/C the next. Here is some insight on how sophisticated BMW Climate Control systems function and how to diagnose them when something goes wrong.

## Evolution

BMW's climate control systems have evolved from the three-dial IHKS to the temperature feedback IHKR and IHKA systems. All systems control both heating and air conditioning, but there are subtle differences in how they go about it. Also, the IHKS/R/A systems control rear window defrosting, but since it is through electrical means, straightforward electrical diagnostics apply. The old and new IHKS are non-feedback systems -- while the temperature is computer controlled, it is not regulated. The IHKR/A systems are computer controlled and the temperature is regulated. On manual systems you merely set a temperature and that's it. On computer regulated systems, a control unit monitors interior and exterior temperatures and modulates heating and cooling controls to adapt to any changes in the environment.



Here is the typical location of the E-Thermostat. While it does have an effect on coolant temperature, do not become sidetracked by it. If the thermostat is mechanically stuck open, that's one thing. If the coolant is hot going to the heater control valve, check the valve next.

# Inside the Car!

BMW added to customer comfort by installing dual climate control systems, so drivers and passengers can enjoy separate temperature control zones. Further advancements now include rear air conditioning and rear climate control systems. These technologically-advanced systems require computer control to adequately monitor cabin temperature, manipulate temperature controls and monitor the effects of these changes. Over the next few pages we will review BMW's approach to heating, air conditioning, and computer control with the IHKS/R/A systems. We will discuss the heating system first, focusing on heating control inside the cabin. We'll follow up with air conditioning, from compressor type to temperature control, then go over electronic and computerized mode door and blower motor control. Finally, we'll look at the computer control and diagnostics involved in these advanced systems.

## Keeping the temperature up

In order to provide heat inside the cabin, we first need a reliable heat source -- the heated engine coolant. Of course, to assist in bringing coolant up to temperature faster, a thermostat blocks flow through the radiator until a calibrated temperature is reached. BMW has added an electronic control to what's typically a single stage thermostat by incorporating a solenoid and a heating element. This heats up the wax element inside the thermostat itself, causing it to open sooner. This is referred to as "Characteristic Map" cooling.

If this E-Thermostat is malfunctioning, very often the DME will flag a code for it, so it's always a good idea to check for DTCs (Diagnostic Trouble Codes) when dealing with heater problems. The exception is the Z8, which does not have an E-Thermostat. While this provides additional cooling capacity for the engine, it does not have a significant effect on the temperature of the heating system.

The heated coolant is piped into a heater control valve (the E90 from 6/05 production with IHKA no longer uses a water valve, substituting flap control instead). When this is open, it allows hot coolant into the heater core. BMW uses two variations on its heater control valves. The IHKS system uses an electric heater control valve that is normally open to pass coolant through the heater core. This way if there is some electrical failure the passenger compartment will always at least have heat. The electric heater control valve is energized when the air conditioning system is turned on. This closes the valve and blocks hot coolant from reaching the heater core. In the IHKS system, the heater control valve is either on or off -- there is no modulating of its position. In the IHKR/A systems, the valve responds to a pulse-width modulated signal commanded by the control unit. This varies the amount of coolant entering the heater core giving greater control of the temperature. Also different about the IHKR/A systems is the addition of an auxiliary coolant pump. This provides sufficient hot coolant flow to both heater control valves in dual climate systems and at low engine speeds.

Early IHKS systems are not connected to the CAN lines for scan tool diagnostics. Diagnosis of a low/no-heat symptom must be carried out manually. Only on the Z8 is the IHKS system connected via the K-Bus.

Testing the heater control valve is fairly simple. Since the valve is normally open, all you have to do is unplug it electrically and itt should default to full heat. If the hose leading to the valve is hot and the heater core pipe is still cool we can conclude the valve is probably stuck closed, or the heater core is clogged. Corrosion in an improperly maintained cooling system can cause this, but on IHKA systems don't forget about a malfunctioning auxiliary coolant motor. If this motor is seized, the result will be a restriction. Another symptom is insufficient cool air when A/C is requested.

This can occur if the heater control valve is stuck fully open, or if it is not being commanded closed. On the 318ti, this is done by grounding the valve. On the Z3, power is switched to the valve. Check the wiring diagram before you start testing.

## Cooling the motorist

In its air conditioning systems, BMW has used either rotary vane or swash plate compressors. Starting in the '95 for the 7-Series, '97 for the 5-Series, and '99 for the 3-Series, BMW introduced the variable displacement compressor. This uses a swash plate, but the plate is designed to move. This changes the piston stroke, thereby varying displacement based on changes in refrigerant pressures in the compressor. This system, coupled with the use of an expansion valve, reduces the cycling of the compressor and the parasitic load on the engine. Keep this in mind when diagnosing high-side and low-side pressures.

Here are some simple rules for adding compressor oil when servicing air conditioning systems on these cars, unless otherwise indicated:

- Use PAG oil for R-134 systems, mineral oil for R-12.
- Refill compressors with the quantity of oil drained.
- New compressors are often shipped full of oil, so you need to drain first.
- If replacing lines only, there's no need to add oil as there's very little in the lines.
- If replacing a condenser or evaporator, add 2.0oz oil.
- If replacing the receiver/dryer add 1.0oz oil.
- BMW does not approve the use of any blend refrigerant.

In the IHKS system, A/C compressor control is provided by the DME unit (the DME also boosts idle speed to account for the additional load of the compressor). The command for A/C starts when the A/C switch provides that input to the IHKS control unit (mounted on either side of the HVAC housing, depending on the model). If the evaporator temperature is above freezing, it

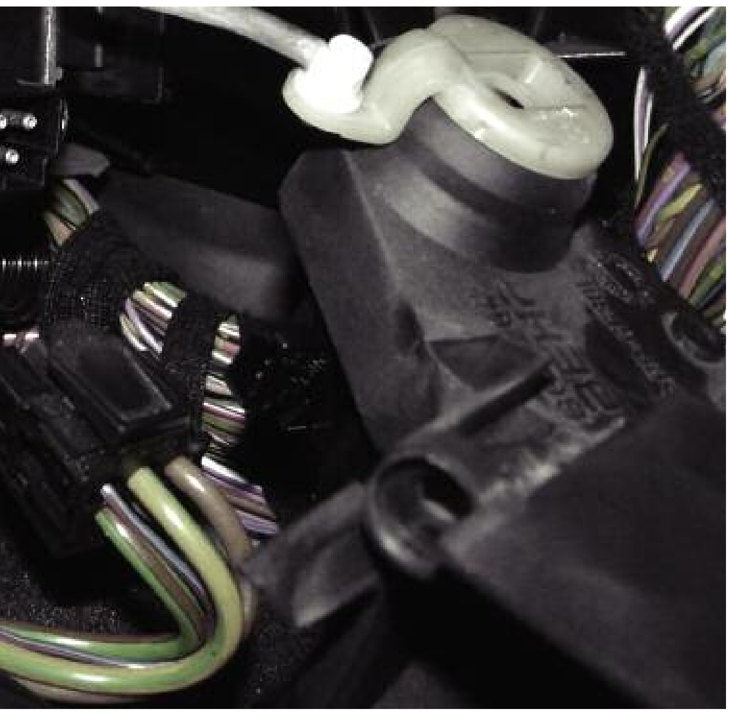

On systems where the DME is in control of compressor operation, there is almost always a PID to indicate if the A/C request is making it to the DME and if the DME is commanding the compressor on. It may not turn the compressor on if the engine temperature is too high.

allows the A/C request signal to be passed on to the DME through high and low pressures switches. If either switch is open due to excessively high pressure or insufficient refrigerant charge, the command will never make it to the DME unit. We should mention that on the E90, compressor output activation is controlled by the JB (Junction Box).

If the switches are closed, the DME increases idle speed and grounds the A/C relay, which energizes the compressor. While the expansion valve compensates for subtle fluctuations in refrigerant temperatures and pressures, the evaporator temperature sensor can also send a signal to the IHKS control unit to shut off the compressor. Also, as refrigerant pressures increase the high pressure switch can shut off the compressor.

When diagnosing a no-A/C complaint, monitor the A/C request in the engine data. If the request is there, then everything is okay electrically. If the A/C request is not there, check voltages at the high and low [2] pressure switches. Usually battery voltage is supplied from the DME to the IHKS unit through the switches. The IHKS unit grounds this voltage signal to command the DME to turn on the compressor. The low pressure switch will open below 22psi and close at 38psi. The high pressure side of the switch will open above 435psi and close below 305psi. If the pressures are between these limits, they are okay. If the scan tool does not indicate that the compressor is turned on, make sure the signal at the switches is going to ground. If the IHKS control unit is not grounding the signal, check the wiring, then start

If you're looking for the blower motor final stage, you'll find it located in the HVAC control box. In this case, it's under a door motor. This is an E46 chassis, so once you remove the glove box everything is pretty much there.



testing the evaporator temperature sensor input.

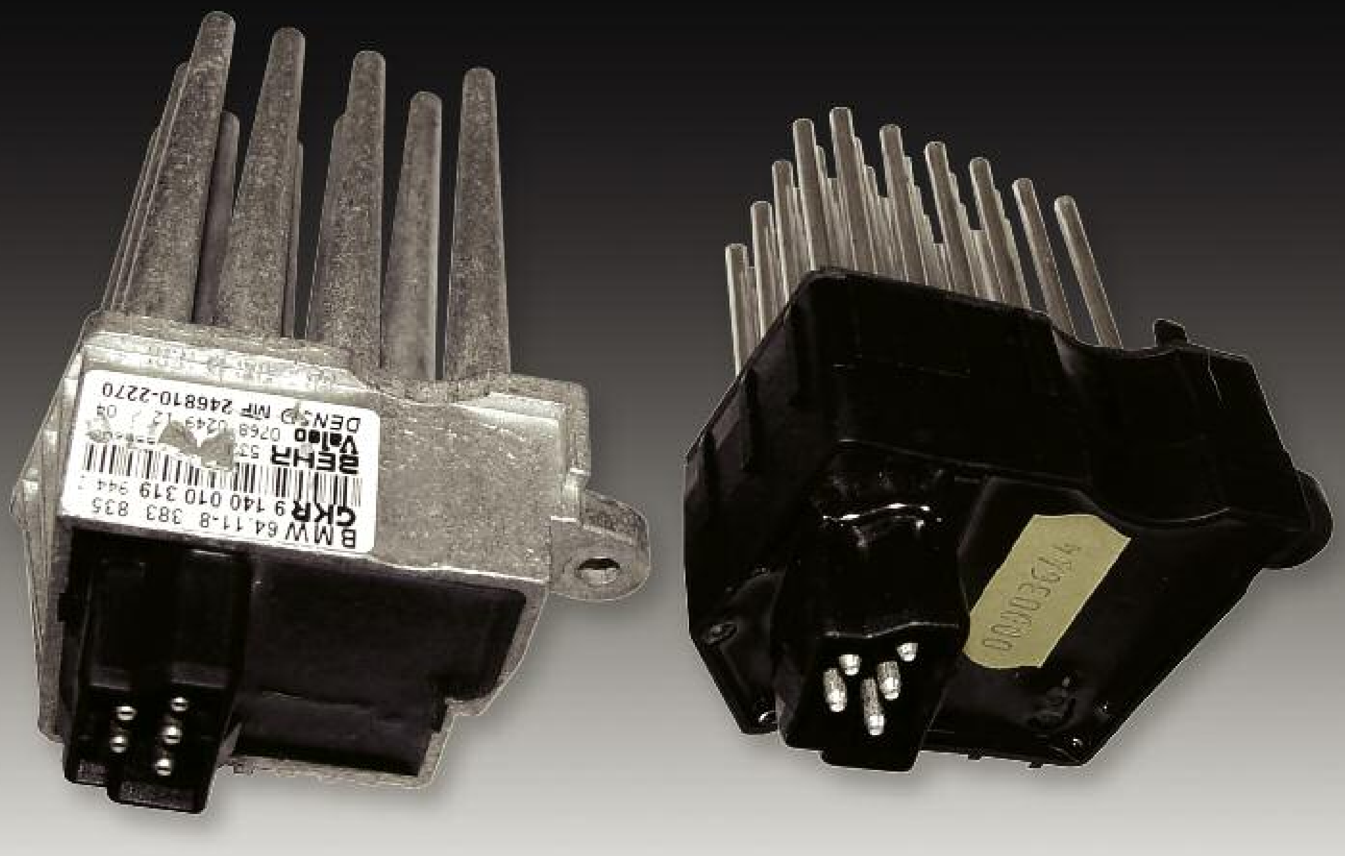
There is a bit more involved in IHKR/A systems. These have been around since ’88 on the 7-Series, but here we will focus on the updated IHKA after ’95. Since ’96, BMW has added IHKA to its 3- and 5-Series as well. IHKR/A are feedback systems that monitor inside and outside temperatures and automatically make changes to all of the computer-controlled outputs. One of the characteristics of the updated IHKA is that the control panel is also the control unit. All of the inputs and outputs go through the control unit, so it, not the DME, directly controls the compressor. Previous to ‘94, the control unit sends the A/C compressor request to a Lock Control unit whose job it is to detect if the compressor is seized, and, if it is, shut off power to it. The lock control unit function is now part of the compressor.

Despite all computer-controlled inputs going directly to the IHKA unit, the command signal still must pass through a combination high/low pressure switch on its way to the compressor. The pressure switches open and close at slightly higher pressures than those mentioned above. The low pressure switch opens below 30psi and closes above 40psi. The high pressure switch opens above 475psi and closes below 330psi. Typically, high and low pressures do not cycle the compressor on and off on these systems. The IHKA unit monitors evaporator temperature and cycles the compressor.

The DME still plays a role in compressor activation. A signal is sent from the IHKA to the DME that A/C has been requested. The DME raises rpm, then sends a confirmation signal of this. The IHKA receives the signal and activates the compressor. Without this confirmation signal the compressor will not come on. An engine running at over 240 deg. F. will not allow the compressor to come on. In ’99, BMW did away with the pressure switches and added a pressure sensor to the IHKA list of inputs, but its function remained the same. Due to all the computer controlled inputs and outputs, a scan tool is indispensable in diagnosing any problem, from malfunction codes to monitoring data.

## Mode Door and Blower Motor Control

Starting with the IHKS system, both the mode and the blower motor are manually controlled except for the fresh air/recirculation flap, which is electronically controlled -- voltage is sent from the recirculation switch to pin #3 of the recirculation flap actuator to energize the motor. Otherwise, mechanical linkages open and close the other mode door flaps, and blower




Here are the old and new blower motor final stages. Notice how the replacement unit has more heat sink surface area to dissipate heat. This unit has also been known to stay on with the key off and run down the battery.

motor control is through a resistor block (except at full speed where all the resistors are bypassed).

With the IHKR system, mechanical linkages are used for mode door control, but blower motor operation has changed. Instead of a resistor block, the blower motor uses a "Final Stage" transistor. This provides a variable ground path for the blower motor depending on the pulse-width modulated signal sent from the IHKR control unit. By varying the duty cycle to the Final Stage, it can vary the amount of current that passes through it, thus making the blower motor speed increase and decrease. The IHKA system also uses this Final Stage blower motor control, but the mode doors are not mechanically controlled. There can be up to 10 stepper motors in each system depending on the model. One is the fresh air/recirculation motor.

This is operated much faster than the other stepper motors. It's made to respond more quickly to adjust its opening to compensate for increased road speed, and, if the system has AUC, close the flap when poor air quality is detected.

Previous to '94, BMW used conventional gear reduction stepper motors. Each motor had four wires to gradually step it into position. On a dual system with rear climate control, there could be up to nine stepper motors and 36 wires to test.


Here is the ’96 E36 control panel. A Sensor test mode can be pulled up by hitting the Auto and Rear Defroster buttons at the same time (two buttons, one on the lower left, the other on the lower right). You can select the next sensor by pushing the blower speed button. To exit the sensor test mode, push the Auto and Recirculation buttons at the same time.

Post ’95, BMW introduced the “Smart Stepper Motor.” Each one has its own control unit mounted in it. Power and ground are provided to each motor, and a bus signal is sent to all motors on one wire. Each motor gets its own specific signal, so one motor can move without the others moving. The stepper motors on later-model BMW vehicles are connected via an M-Bus or LIN-Bus. Once again, a scan tool is indispensable in diagnosing these systems.

You can use a digital multi-meter to check for power and ground at the motor, and a scope to see the command signal, but all you will be able to tell is that the signal is there. Bi-directional control from a scan tool is necessary to conclusively determine which actuator is failing and why.

## IHKS/R/A: Keeping things under control

IHKS systems are for the most part manual with some electronic controls. They have three dials to control temperature, blower speed, and mode, and the control unit is separate from the panel. IHKR provides feedback for temperature control and uses a final stage resistor for blower motor control, but everything else is manual. IHKR also has three dials, but there are additional sensors to account for changes in environment and the control unit is incorporated into the panel. IHKA is fully feedback-controlled where the control unit makes decisions programmed into it to provide selected airflow and temperature. The controls are push button for everything and the control unit is part of the panel. For the most part, if the control panel is also the control unit scan tool diagnosis is

| System | Temperature Control | Mode Door Control | Compressor and Cooling Fan Control | Blower Motor Control |
|---|---|---|---|---|
| IHKS | Manual | Mechanical | DME | Resistor Unit |
| IHKR | Feedback | Mechanical | DME | Final Stage |
| IHKA | Feedback | Computer | IHKA* | Final Stage |

* Except E46 and E36, in which the DME still controls the compressor

This is a ’95 IHKA control unit, which is no longer available. If it fails, it will have to be replaced with an updated unit. While it does not have malfunction codes, it will give you data. The updated control unit can store up to six codes.


possible and coding is required when replacing these units. The chart below will help you determine which system you are working on:

On ’96 to early ’97 3-Series a sensor display mode is accessible by pushing the Auto and Rear Defrost buttons at the same time. You can scroll through the various sensors by hitting the blower motor speed buttons. By the way, this will give you sensor data, not voltages. Other than this, there are no self-diagnostic features. A scan tool is a tremendous time saver, as opposed to checking all the signal voltage inputs. If you are going to use your scan tool, here is a short list of temperature input sensors to be checked:

- Ambient Temperature sensor (thru K-Bus IKE)
- Interior Temperature sensor
- Vent Air Temperature sensor (two on Dual Zone)
- Heater Core Temperature sensor (two on Dual Zone)
- Evaporator Temperature Sensor

They all use 5V references, NTC type resistors and have replacement values in the IHKR/A when one of them fails. On the scan tool, look for this replacement value by manipulating the heater control and watch for the scan data not changing. If the evaporator temperature sensor fails, A/C is shut off. A code should also set with this value. These aren’t the only inputs to the IHKR/A systems. Here is a list of the input controls and how they're applied:

- Mode door control (push button)
- Mode door position sensor (up to 10 stepper motors)
- Temperature request (three wire, two on Dual Zone)
- Center vent air flow (three wire, two on Dual Zone)
- Temperature mixing (three wire, on center vent)
- Mixing door (three wire, in housing)
- Blower motor (three wire, two on Dual Zone)
- Air recirculation sensor (four wire)
- Refrigerant Pressure sensor (three wire)

That is plenty of data to evaluate when diagnosing a climate control issue, not to mention the Y factor. The Y factor is a computer calculated value by which the control unit tells us how much it is trying to change the temperature. There are two on Dual Zone systems. This may give you some indication of what’s wrong if the climate control is not properly adjusting temperature. A feature that may confuse a new owner is that previous to ’96 the driver’s side functions would over-ride the passenger side functions. Since ’96, the Dual Zones operate independently. Another feature that may trick some customers, particularly if the car was purchased used, is the key personality. If you have a wife saying the temperature is always set wrong, and a husband who says the temperature is just fine, the answer is in the keys. When the doors are unlocked the car can determine which key has been used, and engages presets for the climate control system. This is done through coding.

Now that we have an understanding of how IHKS/R/A systems function, let's go out there and get the job done! ☐

As testament to how integrated today's BMW models are, you can actually get data on clutch operation from a GT1.

# BMW Clutch

Since BMW vehicles are made for people who enjoy sporty driving, a higher percentage of them are built with manual transmissions than is the case with most other makes. So, clutch service isn't uncommon in your shop. Don't jump to any unfortunate diagnostic conclusions

# Diagnostic Policies

☐ The worst thing that can happen with a clutch job is that it fails to resolve the customer's complaint. Before dropping a transmission, what can the service writer and tech do to ensure that clutch removal and replacement will actually resolve the complaint? First, adequate time must be invested in fully understanding the customer's concerns. Second, diagnosis should rule out all possible external causes of clutch complaints before the transmission comes down. These practices will not only save the shop time, but may also save the customer unnecessary expenses, and prevent some very unpleasant comebacks.

Clutch diagnosis begins by confirming the customer's complaint. These generally come in four manifestations: noises, pedal Feel, clutch actuation, and engaged operation. No two clutches feel exactly the same. Pedal height, pressure and speed of release that are acceptable to one customer may be unacceptable to another. Riding along with the customer to fully understand his or her perception of the problem is especially worthwhile on these high-ticket repairs.

## Defining Clutch Feel

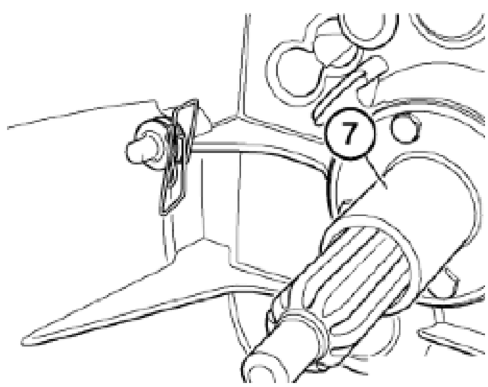
The feel of a clutch is determined by a number of factors, including the spring rate on the pressure plate, pedal leverage, the pedal over-center or return spring, free play and so forth. Several items particularly affect the engagement feel on a BMW. One is the Clutch Delay Valve (CDV), or "lock" valve, which limits the rate of clutch engagement by restricting the flow of hydraulic fluid. Self-adjusting clutch features attempt to maintain a constant pedal height. These noticeably affect feel, in a manner not all drivers are accustomed to. Lastly, a dual mass flywheel, because of its greater mass, and increased torsional dampening, will affect engagement feel. Ideally, the hydraulic system itself is neutral in terms of feel. However, a sticking master or clutch cylinder can further slow down clutch travel, thereby affecting engagement. Binding of the release bearing on the splines, fork, or input shaft sleeve can similarly affect feel.

The most frequent complaint regarding engaged clutch operation is slippage. When you have a clutch that slips under high-torque situations, the usual suspects are, "Friction surfaces on the disc worn down to the rivets" or "Oil contamination." But that's not necessarily the case. What if the clutch simply isn't disengaging fully? Something as simple as a lack of free play on the clutch pedal can cause slippage. Adjusting a pedal, or clutch linkage is a lot faster and less expensive than replacing a clutch disc, only to find the problem is still there. Or, does this model have automatic adjustment? Could it have failed?

## Release mechanism

Pedal and hydraulic system issues often masquerade as clutch issues. The first diagnostic step should be measuring the "throw" of the slave cylinder, and comparing it to specifications. When a clutch won't fully disengage, it makes it difficult to put the transmission into first gear at a stop. Try pressing the pedal repeatedly to see if it "pumps up" and gets firmer, easing engagement. If so, air in the hydraulic system is indicated. Either air or a fluid leak can cause a loss of

No matter how well designed and manufactured, the release bearing is sometimes the cause of noise when the clutch pedal is depressed.



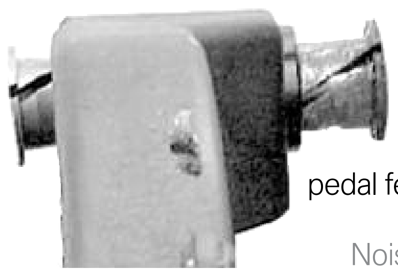

Contrary to popular belief, you should never grease the release bearing guide sleeve as it may cause sticking.

"throw," causing the gears to grind. Another often-missed cause of lost throw can be loose bolts between the bell housing and the engine.

Fluid contamination can "melt" seals inside the master and slave cylinder. A non-release situation as well as lack of throw can be caused by damaged master cylinder seals. Inspect the reservoir cap, sometimes shared with the brake system. Is it abnormally clean, indicating that it has been removed recently? How's the level? Does it appear that fluid has been lost? Look at the fluid, and smell it. If something's not right, get suspicious, and find out if the owner has perhaps added the wrong fluid. Motor oil, of course, will destroy seals, but we've also heard of people using ATF, antifreeze, and even windshield washer fluid.

Loose hardware securing either the slave or master cylinder can likewise cause a loss of throw. Similarly, check for pedal problems caused by loose or bent brackets, a bent pedal, worn-out pivots, missing or deformed springs.

## Noises



The condition of the clutch pedal lever bushings is crucial to pedal feel.

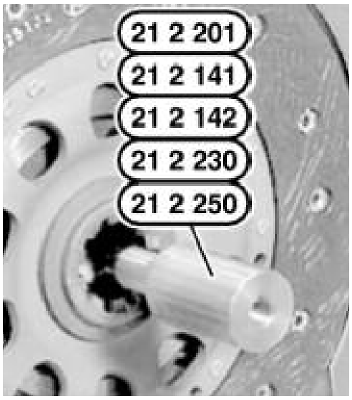
Noisy pedal operation is typically caused by worn-out bushings on the lever pin, which are replaceable. Installation of aftermarket pedal bushings and other pedal components can sometimes lead to binding, or other problems. Make sure everything is O.E., and well lubricated. Before diagnosing a stiff pedal as broken tabs on a release bearing, check the pedal assembly itself for binding or wear, including the over-center spring.

Some pilot bearing noise may be audible when the clutch is depressed and the transmission input shaft stops turning. With the engine running and the transmission in neutral, any noise is most likely coming from the transmission's front bearing, and a small amount is usually acceptable. Release bearings can make different noises at different stages of their demise. A slave cylinder with inadequate free play can cause a release bearing to continuously rub against the fingers of the pressure plate, causing a high pitched squeal. Later on, a release bearing approaching the final stage of seizing up can make quite a howl whenever the pedal is pressed. In this case the cure will still require a clutch job, but preventing the problem from recurring is what's gained by diagnosing a lack of free play that may have CAUSED the release bearing to fail. Again, this is something that can be done before pulling the bell housing.

Examine the bottom of the bell housing. If oil is present the rear main seal of the engine or the front seal of the transmission may need to be replaced. Smell the fluid and see if you can determine whether it's engine oil, ATF or gear lube. Some dual mass flywheels are hydraulically damped, and can also leak fluid when they fail. If the customer complaint included slippage and/or a bad smell, oil contamination of the clutch could easily be the cause. Some bell housings provide an inspection port. This eases checking disc and pressure plate condition, looking for leaks, and hunting down clutch noises.

## Hot judder

Many 3-Series exhibit slight takeoff judder when they are hot, such as in summertime stop-and-go traffic. Typically, they're fine once they cool down. Replacement of the friction disk with new genuine BMW parts will cure the problem. Before diving into any more serious clutch judder (on takeoff) problems, carefully examine the engine, transmission, and differential mounts. This may require removing them for a thorough inspection since cracks often can't be seen in place, especially when the mount is dirty.




The best way to be sure of perfect disk and pilot hole alignment, thus easing transmission installation, is to use the special BMW tool for the model at hand.

Care must be taken to avoid damage when re-installing the transmission. Using the bolts to pull in an out-of-line transmission can destroy a disk or pilot bearing. Instead, readjust your transmission hoist to the proper angle that allows it to slide in easily. When plastic alignment tools don't fit, or don't fit snugly enough, consider purchasing the appropriate BMW special tool.

## DMF Concerns

The issue of dual mass flywheels, their diagnosis, pattern failures, and replacement will be the subject of a future article. Needless to say, when diagnosing any clutch complaint today, you must consider the possible role of the DMF in causing certain problems. Excessive gear chatter at idle is a warning sign. Unusual engine vibration at low-to mid rpm is another, and will occur whether the vehicle is moving or not. Normally, DMFs should last the life of the car. Racetrack or other "hard" driving may shorten their life to 50K miles or less.

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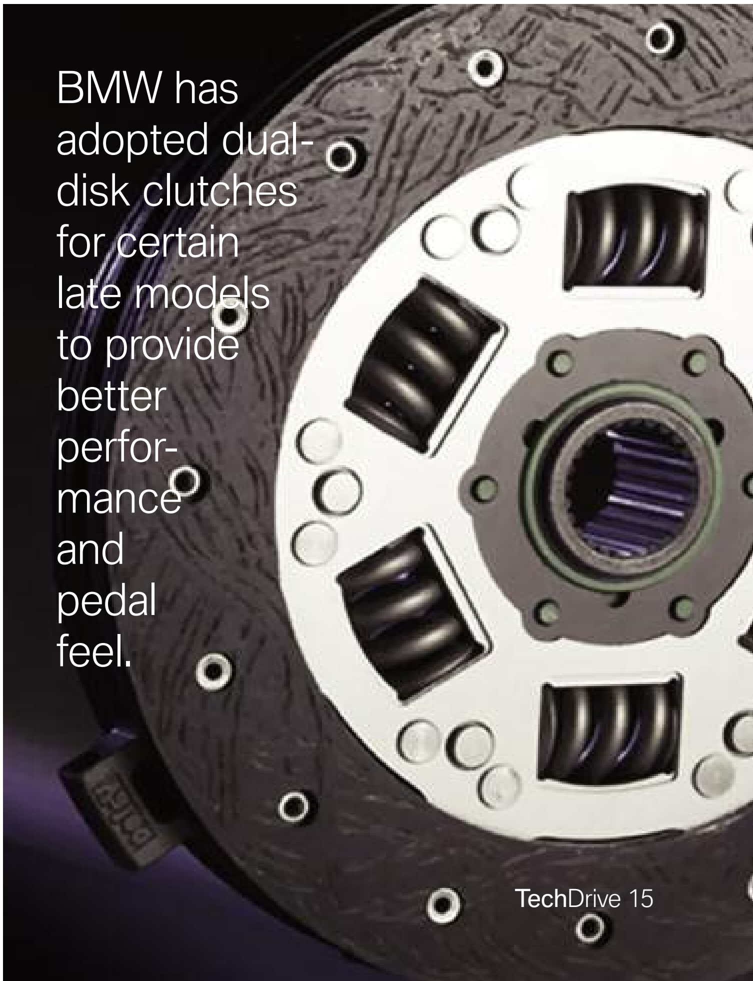

BMW has adopted dual-disk clutches for certain late models to provide better performance and pedal feel.

# ORIGINAL BMW REMANUFAC

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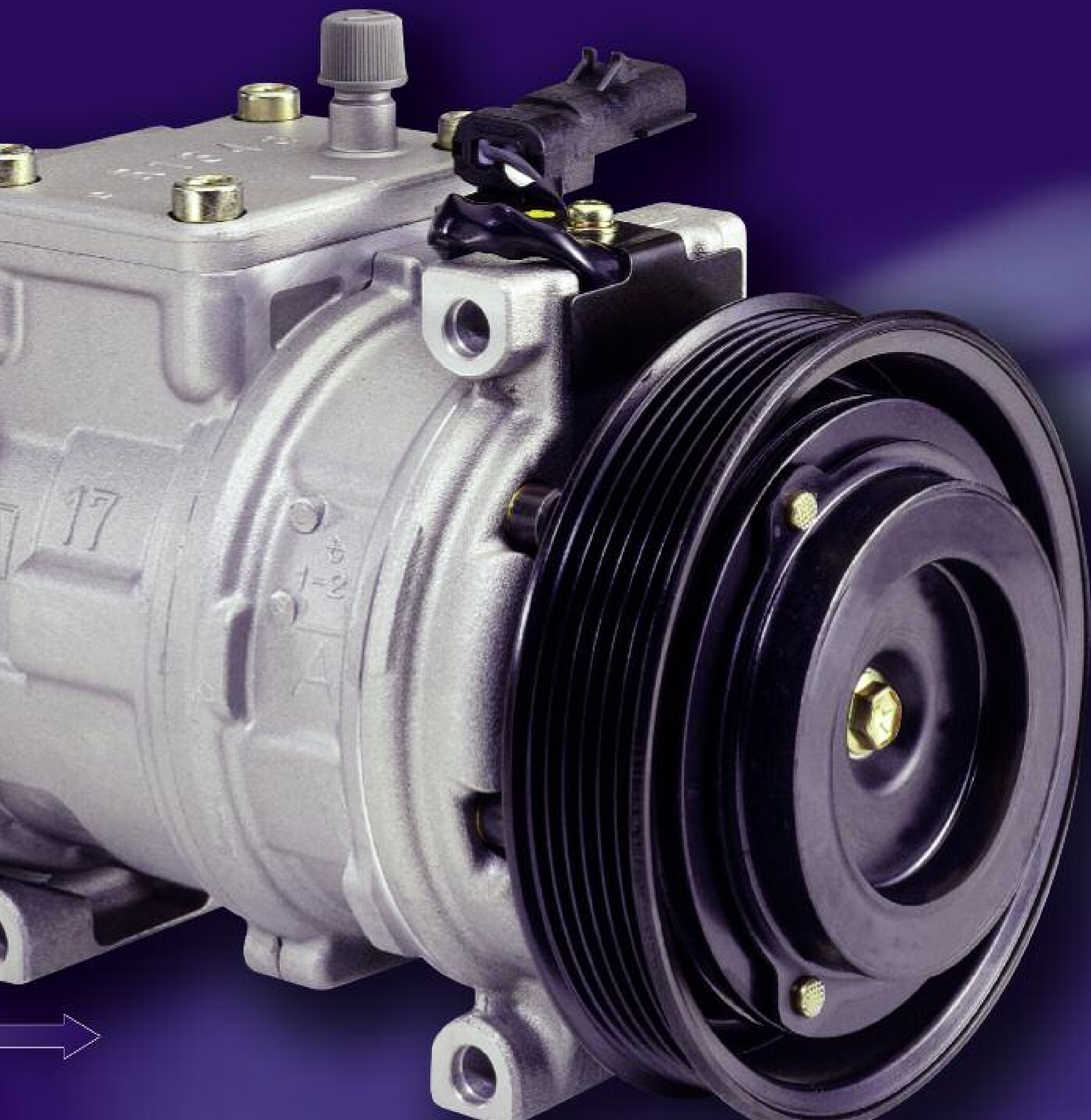
2. Replace key components 100% with new OE part.
3. Test all other critical components.
4. Replace components that do not meet specs.
5. Assemble, test and box.

**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

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 – Continued from page 15

Dual-disk clutches are being fitted to the latest M5 sedans, and are forthcoming on future models. Information on servicing these may be found on TIS.

The bottom line on clutch work is that it's an expensive nightmare when you replace a clutch, but the problem doesn't go away. Instead of asking yourself then, "Well, what else could be causing this problem," always ask that question before you start the clutch job. Now and then you will save yourself a big headache and the customer a pile of money. □

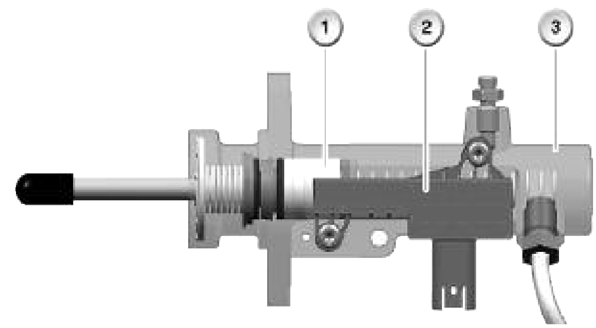
# Writing Clutch Service

Ride-alongs give the tech or service writer the opportunity to see how skillfully customers use the clutch. Ask them to accelerate quickly from a stop, and see how high they rev the engine before engaging the clutch. Ask non-threateningly how often they use an SMG's "launch" feature, and record their answers – which you can later compare to GT1.

Sneak a peek and see if the driver continually "rides" the clutch. Does the driver shift into neutral at stoplights, or hold the clutch down interminably? Get the driver to perform an uphill start if you can. Does he or she cheat and use the clutch as a hill-holder? Ask the person to shift down a gear to slow the vehicle and see if he or she does so smoothly, or violently crunches the transmission into a lower gear and backdrives the engine to high rpm. Ask young drivers, "Are you hard on the clutch?" in a non-threatening manner. "Do you chirp the tires? How often?"

When components of the clutch system must be replaced, even a little knowledge of the customer's clutch skills can provide you with the confidence to make an accurate diagnosis and address the issue.

Without sufficient detail of the customer complaint recorded on the RO, during a test drive a tech will compare the clutch's operation to what the tech him or herself believes the clutch should feel like, instead of how the customer believes it should behave – or how it "used" to feel. The result is all too often an expensive repair that doesn't alleviate the customer complaint.A simple note of "bad clutch" or "needs new clutch" is insufficient. What is needed by the tech is a FULL description of when and where the clutch misbehaves, along with what it sounds or feels like. Write down the customer's own words whenever possible. The customer should be asked, "Has the clutch always felt like this, has it changed recently, or just gotten steadily worse over time?"




Here's the SMG clutch actuator slave cylinder (3), showing the permanent magnet (1) and the clutch travel sensor (2).

Jumping to the conclusion that a driver (especially a young one) is responsible for clutch problems, even a prematurely worn clutch, is a mistake that immediately erodes customer satisfaction and distracts the tech from searching for the real cause of a problem. Never excuse a clutch complaint with "All of those models feel like that."

## Links: Clutch Diagnostic Tables

http://www.lukclutch.com/support/diagnostics_pre_teardown.phtml

http://www.valeoclutches.com/Troubleshooting.asp

http://www.exedy.co.uk/discs.asp

http://www.finoauto.com/clutch_study1.html

http://www.drivetrain.com/clutdiag.html

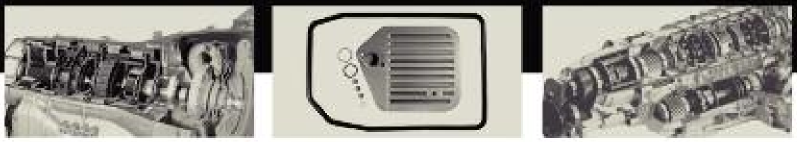
http://www.enjoythedrive.com/content/?id=26045

http://www.zeckhausen.com/CDV.htm

Dual Mass Flywheel Diagnostics

http://www.standardtransmission.com/dmf.html

http://www.cesuk.com/LUK%20DMF-Back001.pdf

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

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# Servicing BMW's Advanced

# Charging Systems

## Advanced Glass Mat batteries and future Intelligent Alternator Control make everything different

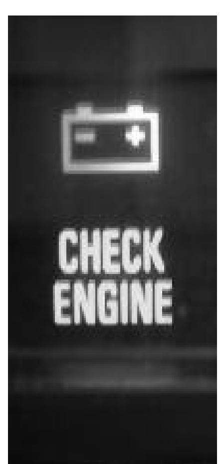
☐Soon, diagnosing a charging system will no longer be *just* about testing alternator output. Energy savings and management protocols such as BMW's Intelligent Alternator Control (IAC), which will appear on some models in the near future, have placed the Digital Motor Electronics (DME) in full control of charging. Monitoring of operating conditions, current flowing in and out of the battery, and battery temperature help determine the optimum charging strategy. Also, the superior Advanced Glass Mat batteries found in many new BMW models have different charging requirements than ordinary batteries.

### Good reasons

What's behind the addition of advanced energy, battery and alternator control? First and foremost is a desire to prevent dead batteries. Frequent short trips with a large number of comfort and convenience features turned on by drivers can quickly develop into no-start situations. An adequate charge level can't always be maintained by a vehicle's electrical system under these heavy use conditions. Secondary and tertiary goals of intelligent alternator control include improving gas mileage and vehicle performance. Also, avoiding overcharging extends battery life.

Instead of boosting idle speed to continually maintain a desired voltage, the ideal energy-saving strategy is to make it acceptable for a battery to partially discharge during extended idling on the assumption that it can be quickly recharged once the vehicle begins moving. This saves fuel, but not allowing discharge to go past the point where the engine can't be restarted is an equally important part of this strategy. Only under DME control, with continuous battery monitoring, do such advanced charge/discharge strategies become possible.

Another IAC feature is sequentially turning off or reducing the power level of comfort features like heated seats and window defrosters when the alternator can't keep up, even at a boosted idle speed. The speed of a heater blower fan may be temporarily reduced. Knowing that a comfort feature can be disabled by IAC is imperative when diagnosing an accessory that has become inoperative. Is it actually broken, or just disabled?




Today, the charging and electronic engine management systems are closely related in more than the relative positions of their warning lamps on the dash.

Engaging the "intelligence" of the ECM for the job of controlling alternator output makes for a much more efficient and effective charging system.


Intelligent controls can only maximize the potential of the charging system. Higher capacity alternators are also needed to fulfill the requirements of modern BMW vehicles.

## More output

BMW combines advanced charging strategies like IAC with traditional improvements such as larger, more powerful alternators -- some are even water-cooled -- to supply the increasing electrical loads of its vehicles.

A BMW equipped with IAC will only charge at idle, cruise, or during acceleration when the battery charge level falls below 80%. This requires the addition of a system that can constantly estimate the battery's "State of Charge" (SOC).

Place the leads of a DMM across the battery terminals while the alternator is charging and what will you measure? Between 13.8 and 14.5 volts or so. If you can't obtain an accurate battery voltage reading with the engine running, how can the vehicle's ECM possibly use battery voltage to determine whether the battery is above or below 80% of charge, which would be approximately 12.5 volts? One can accurately measure battery voltage only when all loads are removed. The solution is placing a current sensor between the battery terminal and the ground cable. Current sensors add up the total amount of current that has gone into, or left the battery since startup. Combine all the current that has flowed into a battery and out of it with the battery voltage before start-up, and the ECM can come up with a reasonably accurate estimate of the battery's current state of charge.

Total charge added or reduced allows the ECM to do a better job of calculating battery state of charge (SOC) as well as state of health (SOH). Such sensors measure battery temperature as well since a cold battery can be charged "harder" than a warm one, say, 15.5 volts for an AGM (Advanced Glass Mat) battery instead of 15.0V. BMW has set a target of 80% charge above which charging will only occur regeneratively, during braking, and below which additional charging is deemed necessary.

BMW's battery current monitor "talks" to the ECM/DME by way of a single wire LIN bus connection. Techs may easily confuse a single wire for a ground or battery connection instead of a network connection, but an oscilloscope will quickly show the network traffic. The chemically harsh environment surrounding most batteries suggests techs prepare for diagnosing LIN bus opens/shorts resulting from corrosion of the

Late-model BMW vehicles have a battery current monitor that supplies the ECM with vital information.

battery terminal. BMW's AGM battery, however, should tremendously reduce any such leakage and corrosion. As well, the GT1 should display any network faults on the LIN bus. A primer on the LIN Bus concept is available at http://www.lin-subbus.org.

## Idle state

"Idle state management" is another feature of the IAC systems of the future. It might be better named "Long-Term Parking" management, since it has nothing to do with engine idling. When a vehicle has been parked for a long time and the battery slowly discharges, both from parasitic draws and self-discharge, the idle state management feature kicks in. It can progressively turn off components that normally remain powered up even while the vehicle is at rest to try and maximize the time remaining before a no-start situation occurs. Hence, the loss of memory features could be a diagnostic tip that ISM has engaged -- or is malfunctioning.

In addition to its primary purposes, the current monitor opens up the possibility of enhanced diagnostics in the form of automated measurement of parasitic currents, perhaps even including trapping intermittents, all accessible via scan tool. When a customer repeatedly has a dead battery, the sensor, combined with the DME and a GT1 scan tool, may allow the technician to view the charge/discharge conditions that preceded a flat battery. It may even be possible for the DME to signal the technician when the battery's state-of-health has undeniably deteriorated, indicating that it's time for battery replacement.

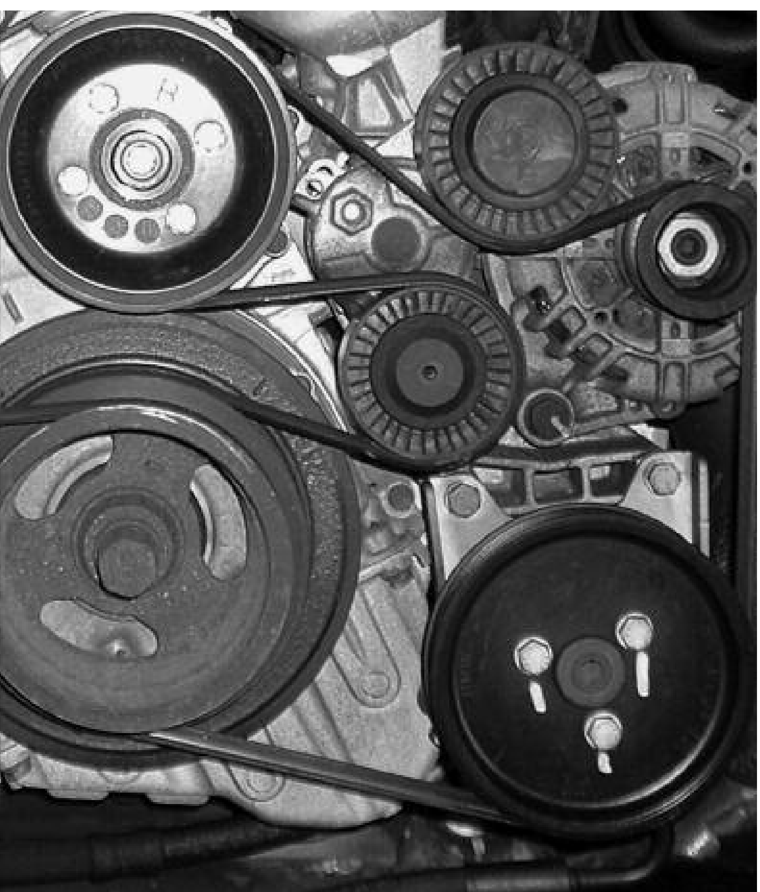
## Glass mat

Advanced Glass Mat (AGM) batteries are less apt to gas and leak electrolyte than the traditional flooded-plate type, which reduces the potential for corrosion of components located nearby.

Another issue in testing BMW charging systems you will soon be seeing in your shop is the adoption of Advanced Glass Mat (AGM) batteries. Simply stated, an AGM is a higher-tech, "better" battery than the flooded lead/acid type, and should last considerably longer. But the one thing an AGM cell can't withstand is overcharging. Shops that upgraded their battery chargers years ago to be able to handle lead-chloride "Maintenance Free" batteries now must go the other direction. While a completely discharged "Maintenance Free" battery might need a solid 16 volts to begin charging, 15.5-15.6 is about the top voltage you ever want to apply to an AGM, and that only briefly. During normal charging, 15.0 volts is recommended by AGM battery manufacturers. Since testing a charging system normally requires first fully charging the battery, be sure you're using the right charger, such as the Deutronics units available through the BMW equipment program. Likewise, in-vehicle charging voltages over 15.5 volts in such systems may be indicative of a problem. Consult your factory manual.

Multi-function controllers, which replaced a standard regulator in the back of many traditional alternators, will turn off any charging until two seconds after the engine starts. This minimizes the work the starter must perform. These controllers, fitted to numerous BMW alternators, also control the charging system indicator light on the dash. As a result, the lamp can indicate an overvoltage condition as well as a lack of charging and other conditions. Because BMWs typically have a resistor in parallel with the dash CIL, a simple bulb failure generally won't cause the vehicle to stop charging. However, it makes performing a bulb test with the GT1 an important part of any charging system evaluation.


Even though charging system control is now handled by the ECM, the traditional VAT tester can still be used to force the alternator to produce at its maximum potential.



BMW serpentine accessory drives make for extremely long belt life, but there's still the chance that slippage under magnetic drag will keep the alternator from spinning fast enough to keep up with electrical demands.

## Diagnosis

Charging system problems were traditionally indicated when a battery tested good, and parasitic draws were nominal. Today, consumer behavior, such as powering a current-hungry accessory from the cigarette lighter, must frequently be considered as a cause of dead batteries, although schemes like IAC will reduce this need. A check on TIS for model-specific TSBs before performing any diagnosis consistently proves to be a huge timesaver.


A sophisticated test bench will find problems in the alternator itself, but can't be expected to address issues of field circuit control.

Charging system problems can be caused by mechanical or electrical failure of the alternator itself, failure of the alternator cooling system, faulty ECM control of the alternator, dirty connections/bad grounds, and failed current sensing devices (which could also lead to overcharging or undercharging). Mechanical causes such as misaligned, damaged or slipping belts can also cause charging problems. Visual inspection, especially of connectors, can rule out many causes. Simple voltage tests can determine the battery state, and whether the charging system is operating at all.

Since alternators today operate under control of the DME, "full fielding" as a method of alternator testing has gone the way of the dinosaurs. Connection of a scan tool is necessary to command the alternator to generate maximum out put in order to perform load testing. In general, an alternator should be able to put out at least 80% of its rated amperage when fully loaded.

Testing of an alternator itself consists of measuring the output voltage at different amperage loads, and measuring ripple, which can indicate a failed diode (it can also be caused by a battery with poor capacitance, but that belongs in another article). Traditionally, such testing has been done with a carbon pile load tester, which "fools" the electrical system into believing a large electrical load has been switched on. Alternator testing can also be performed by removing the alternator and testing it on a special test bench. Again, since alternators are now under computer control, such testing becomes limited by the test bench's ability to "command" full fielding, simulating the commands given by the ECM when maximum output is needed. □

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