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Information for the Independent Mercedes-Benz Service Professional

March 2020

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- MODULE UPDATES
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March 2020

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Mercedes-Benz wants to present the information you need to know to diagnose and repair Mercedes-Benz vehicles accurately, quickly and the first time; text, graphics, online and other technical sources combine to make this possible.

Feature articles, derived from approved company sources, focus on being useful and interesting.

Our digest of technical information can help you solve unanticipated problems quickly and expertly.

We want *StarTuned*® to be both helpful and informative, so please let us know just what kinds of features and other diagnostic services you'd like to see in it. We'll continue to bring you selected service bulletins from Mercedes-Benz and articles covering the different systems on these vehicles.

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*StarTuned*®

One Mercedes-Benz Drive, Sandy Springs, GA 30328

Phone: 770.705.3085

Email: [blaine.reed@mbusa.com](mailto:blaine.reed@mbusa.com)

#### MBUSA Technical Content Advisor

Donald Rotolo  
[donald.rotolo@mbusa.com](mailto:donald.rotolo@mbusa.com)

#### Collision Content Advisor

Benito Cid  
[benito.cid@mbusa.com](mailto:benito.cid@mbusa.com)

#### MBUSA Project Team

Stefanie Schweigler  
[stefanie.a.schweigler@mbusa.com](mailto:stefanie.a.schweigler@mbusa.com)

Blaine Reed  
[blaine.reed@mbusa.com](mailto:blaine.reed@mbusa.com)

#### Group Publisher

Christopher M. Ayers, Jr.  
[cayers@automotivedatamedia.com](mailto:cayers@automotivedatamedia.com)

#### Editorial Director

Joel Alson  
[jalson@automotivedatamedia.com](mailto:jalson@automotivedatamedia.com)

#### Contributing Editors

Dave Facciuto, G. Quagmire, Gary Smith,  
Wayne Riley, Frank Walker

#### Automotive Data Media Project Mgr.

Tamra Ayers Banz  
[tbanz@automotivedatamedia.com](mailto:tbanz@automotivedatamedia.com)

#### Art Director

Christopher M. Ayers III  
[ayersc3@automotivedatamedia.com](mailto:ayersc3@automotivedatamedia.com)

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## In This Issue

### 4 Regenerative Braking in Hybrids and EVs

Why not route wasted energy back into the battery pack? Brake linings will last and last!

### 10 Mercedes-Benz Assist Systems

Helping the driver down the road to autonomous

### 20 Module Updates Do Fix Shifting and Slipping Problems

Don't rush to replace that transmission, check for service bulletins and updates first! We present some cases where problems were solved with control unit updates or replacements.

### 30 Smart Power Applications in Mercedes-Benz Vehicles

Smart power control is becoming far more common. Knowing the basic principles of these control methods will make diagnosis easier.

## Also Inside:

26 Mercedes-Benz ISP Parts Information

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# Regenerative Braking in Hybrids and EVs

Consumption

Energy flow

Vehicle

Ownership



**Why not route wasted energy back into the battery pack? Brake linings will last and last!**

The upcoming EQC model incorporates all the latest technology to optimize its range.

## A quick physics lesson

When we talk about regenerative braking, the physical property we are dealing with is known as kinetic energy. Kinetic energy is the energy of mass in motion. The kinetic energy of an object is the energy it has because of its motion. Perhaps the most important property of kinetic energy is its ability to do work. Work is defined as a force acting on an object in the direction of motion. Work and energy are so closely related they are sometimes thought as interchangeable.

While energy of motion is usually expressed one-half the product of mass times the square of velocity ( $E = \frac{1}{2}mv^2$ ), work (W) is more often thought of as force times distance ( $W = Fd$ ). If we want to change the kinetic energy of a massive object, we must exert work on it. For example, in order to lift a heavy object, we must do work to overcome the force due to gravity and move the object upward. If the object is twice as heavy, it takes twice as much work to lift it the same distance. It also takes twice as much work to lift the same object twice as far.

Kinetic energy can be converted into other forms of energy and vice versa. For example, kinetic energy can be converted into electrical energy by a generator, or into thermal energy (heat) by the brakes on a car. Conversely, electrical energy can be converted back to kinetic energy by an electric motor, heat can be converted to kinetic energy by a steam turbine, and chemical energy can be converted to kinetic energy by an internal combustion engine.

In regenerative braking the kinetic energy of the vehicle is converted into electrical energy by the vehicle's electric machine (the technical term for the drive motor). This energy conversion causes the vehicle to lose kinetic energy: It slows down. The generated electrical energy is then fed to the high voltage battery for storage. In conventional braking, the kinetic energy is converted into heat, which is basically wasted.

## Not so new

The idea of a brake that could take the kinetic energy it absorbs and turn it into potential energy for later use has been around since the late 1800s. The earliest versions of this technology were a spring type regenerative braking system (RBS) on front wheel drive bicycles and horse drawn carriages. An early example of RBS technology was in the Baku-Tbilisi-Batumi railway in the early 1930s. In the 1950s, Swiss company Oerlikon developed the gyrobus, which utilized a flywheel as its energy storage method. (Unfortunately the gyroscopic motion influence it had on the bus led to its discontinued use). In 1967, the American Motor Car Company created an electrical energy regeneration brake for their concept electric car, the AMC Amitron. Toyota was the first car manufacturer to commercialize RBS technology in their Prius series hybrid cars. Since that time, RBSs have evolved to be used in almost all electric and hybrid cars, as well as some gasoline-powered vehicles.

## Does it work?

If we want to evaluate regenerative braking, we really need to look at two different parameters, efficiency and effectiveness. Efficiency refers to how well regenerative braking recovers the energy from braking. Does it waste any of that energy as heat, or does it turn all of that kinetic energy back into stored energy? Effectiveness, on the other hand, refers to how large of an impact regenerative braking really makes. Will you really notice a difference in the range or economy of your vehicle?

According to Tesla, Inc., the efficiency of the regenerative braking process varies across many vehicles, motors, batteries and controllers, but is often somewhere in the neighborhood of 60-70 percent efficient. The regenerative process itself loses around 10-20 percent of the energy being captured, and then the drivetrain loses another 10-20 percent or so when converting that energy back into acceleration.



Trying to determine effectiveness of your the regenerative braking system gets a little tricky: Will it make your vehicle travel 5 percent farther? 30 percent? Many factors have to be considered to answer this question. What type of driving? Intuitively, open freeway driving with little braking is expected to be less effective than more typical suburban driving with its frequent acceleration and deceleration cycles.

Remembering our physics, the rate of deceleration as well as the mass of the vehicle are factors, as is the terrain. A long downhill will provide a greater opportunity for energy conversion. According to Mercedes-Benz, comprehensive road tests using different test subjects have shown that it only takes a relatively short time for additional savings to be achieved as drivers learn to make increasingly deliberate and effective use of the regenerative capabilities.

Intuitive driving can significantly affect the efficiency of the system. If you anticipate stops and slowdowns in traffic, the regenerative capabilities are used to a greater extent instead of hard stops that use the brake pads.

To help the driver achieve better effectiveness, Mercedes-Benz models incorporate a Display Concept for the driver to monitor. The central display provides information on the current energy flow and the charge status of the batteries, as well as an illustration of the drivetrain and colored energy flow indicators. The driver is able to monitor fuel consumption via energy/time graphs.

### Radar sensing braking

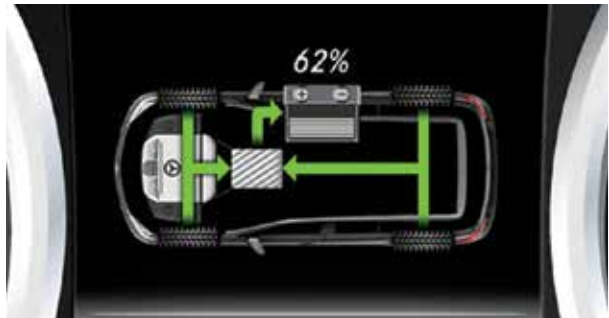
Introduced with the B-Class electric vehicle, and standard on all hybrid vehicles, Mercedes-Benz offers selectable levels of regenerative braking. Using paddles on the back of the steering wheel, the driver can customize how aggressive the regenerative braking is, in three stages: D- mode is the most aggressive, with considerable braking effect; D mode is much like a gasoline-powered model, with a moderate

braking effect; and D+ mode is ‘coasting’ mode, where no regenerative braking occurs.

A fourth setting, D-AUTO, uses the existing radar sensor to base the amount of recuperation on the traffic situation. This is the default setting when selecting a forward drive gear. When approaching a vehicle, recuperation is increased, while when either no vehicle, or a very distant vehicle is detected in front, recuperation is decreased to allow coasting. Recuperation is also increased when a steep downhill slope is detected. This is a convenient feature that also helps boost battery range.

### EQC 400 Electric SUV

Speaking of intuitive driving, the new EQC 400 employs a new feature, Eco Assist, that might be described as an interface between driver and machine in order that engineers may squeeze more efficiency from that powertrain. The system, under certain driving conditions, actually tells the driver to lift his or her foot off the accelerator to let the system manage the momentum during a coasting situation, improving the regenerative



The energy flow, here seen in a Model 166 hybrid, is displayed so the driver can better understand how the energy is flowing.



The ECO Display helps inform the driver about power consumption, generation and driving style.

braking capability without compromising speed at the same time. Like the B-Class, the system uses navigation data, traffic sign recognition, radar, and the car's stereo cameras to anticipate things like cresting hills, traffic, or upcoming reductions in speed limits, then signaling the driver with a "foot off accelerator" icon in the instrument cluster. The car then modulates motor activity to either let the car coast, or engage the regenerative function to transfer power to the battery while slowing the vehicle.

## Brake pads that last

As might be expected, vehicles with regenerative braking have much less wear on the mechanical components of the braking system e.g. the pads and rotors. It is important to note that the hybrid or EV vehicles you service will still have a conventional braking system in addition to the regenerative braking system. Due to the effectiveness of the regenerative braking system, the mechanical brake pads and rotors won't be used as often, meaning they will last longer than one might expect. It's not unusual to see a hybrid with 70,000-100,000 miles on the odometer that still has the original set of front brake pads.

This does not mean that other components, like hardware, rubber seals/boots, or that brake pads can't fail for other reasons other than general wear: Weather and time still play a major part in the overall condition of the components. This means that it's still a good practice to check the brake components during a routine inspection of the vehicle. In harsh climates, corrosion may build up between the backing plate and friction material due to water intrusion and road salt and ice-removal chemicals. A thorough inspection of the system is still warranted at the recommended intervals.

It is important to understand how the two systems function so you can be well informed, not only when servicing hybrids and EVs, but when explaining the nature of the system to your customer. This question is a common one fielded by Mercedes-Benz: "Why does the brake pedal in my Mercedes-Benz Hybrid feel different the first time I step on the brakes after I start the vehicle and sometimes during normal driving?" Engineers have offered this explanation:

"Hybrid vehicles utilize both regenerative and conventional hydraulic (friction) braking to reduce the speed of the vehicle. With regenerative braking, the kinetic energy of the decelerating vehicle is absorbed

by the electric motor to generate a brake torque. The generated electrical energy is then fed to the high voltage battery for storage. Conventional hydraulic brakes utilize hydraulic fluid to apply pressure to the brake pads which squeeze against a rotating brake rotor. Friction is created between the pads and rotor which generate a brake torque to stop the vehicle. Depending on the driving conditions, the total braking torque requested by the driver can be divided into a regenerative component and a hydraulic component. If the required total braking torque can be achieved using regenerative means alone, then none of the braking is done hydraulically: In this case deceleration is achieved solely by using the electric motors to generate electricity.

Due to the operating principles involved, the perceived brake pedal feel may be different during regenerative braking when compared to conventional braking. On the regenerative braking system, there is a length of free travel integrated into the connection of the brake pedal. This is used during the regenerative braking function. A pedal force simulator is used to create a brake pedal resistance which mimics the brake pedal feel of conventional hydraulic brakes. During the first brake actuation, the system is checked for proper operation and the regenerative braking system is activated. The pedal force simulator is switched off for the first pedal application, resulting in slightly longer pedal travel compared to subsequent brake pedal applications when the system is active."

It is important to note that if an ABS (Anti-Lock Brake System) intervention takes place, regenerative braking is terminated for this brake application and the braking torque is provided solely via the conventional hydraulic brakes. Regenerative braking is not possible below speeds of approximately 13 MPH. As soon as the vehicle drops below a speed of approximately 13 MPH during a brake application, the system switches from regenerative braking to hydraulic braking, possibly resulting in a change of brake pedal feel.

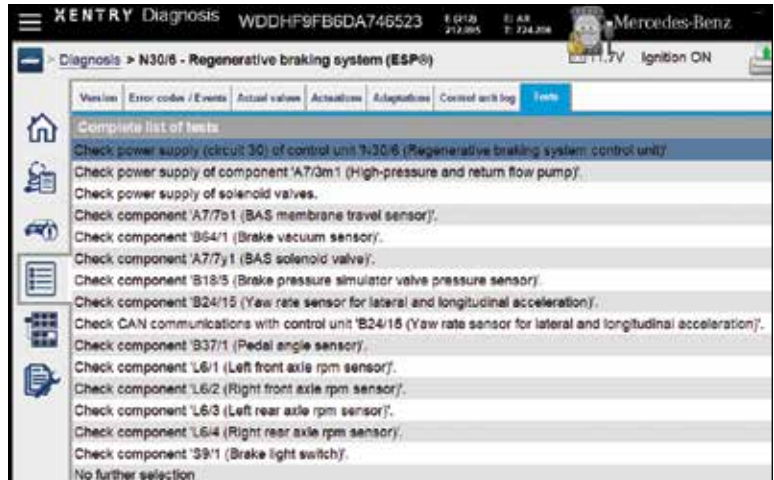
## How does it work?

In regenerative braking, the electric motor that drives the vehicle is turned into a generator, and the wheels transfer the vehicle's kinetic energy via the drivetrain to the generator. Some of us old-timers remember the days when vehicles actually had generators instead of alternators: To test them we would turn them into an

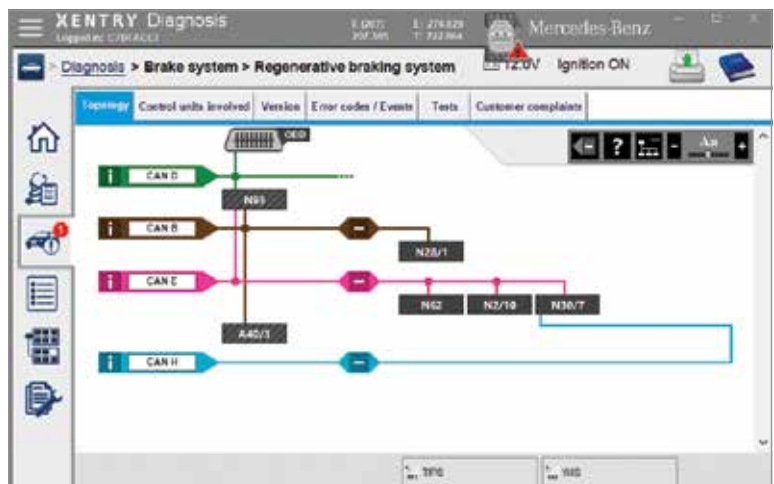


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electric motor by applying voltage. The opposite happens when regenerative braking takes place, the electric motor is turned into a generator. This is an example of Faraday's law which states that a change in the magnetic field near a wire will cause a voltage (Electro-Motive Force, or EMF) to be induced into the wire. No matter how the change in the magnetic field is produced, a voltage will be generated. The change could be produced by changing the magnetic field strength, moving a magnet toward or away from the wire, moving the wire into or out of the magnetic field, rotating the wire relative to the magnet, etc. With regenerative braking, the change that happens is the force of the drive train acting upon the electric motor of the vehicle, transforming most of the kinetic energy into electrical energy, which is then stored in a high-voltage battery. At the same time, the generator exerts a physical resistance to turning (due to the electricity created), which acts to slow the vehicle. When more braking torque is required than the generator alone can provide, additional braking is accomplished by friction brakes.



XENTRY Diagnostics has a menu of self-guided tests if you encounter RBS faults.



The communications network of the regenerative braking system in a Model 207 E-Class Coupe. N30/7, the ESP control module, operates the RBS.



## How Formula 1® racing has helped the development of EV technology and regenerative braking

Mercedes-AMG Petronas Motorsport scored its first victory of the Formula 1 hybrid-electric era at the 2009 Hungarian Grand Prix, with driver Lewis Hamilton. That early system relied on discrete battery pack and power electronics modules that sent energy to, and recovered it from, a 60-kilowatt (80 HP) electric-assist motor. It also laid the groundwork for the mighty Mercedes-Benz SLS AMG Coupe Electric Drive of 2013, according to Andy Cowell, managing director of Mercedes-AMG High-Performance Powertrains, in a video released by the F1 team.

Formula 1 termed these systems “Kinetic Energy Recovery Systems” or “KERS.” “Today we would call that a ‘regenerative braking system,’ recovering waste energy from the car,” said Cowell. “The mass and velocity of the car, recovering that energy through an electric motor, energy converted in the power electronics and stored in the cells of the energy store, using that energy to then propel the car as the car accelerates.”

While hybrid-electric production models seek to improve fuel efficiency, the technology at work is the same. “In motorsport we use it to go quicker, in the road car world we use it to go further with the same amount of fuel,” he explained.

## Maintenance

As of this writing, there really is not much in the way of maintenance in a regenerative braking system. The conventional part of the braking system will require routine service but, as noted earlier, wear items will need replacement less frequently. It should be noted that in some cases at low temperatures, the customer may report that the regeneration indicator on the dash is indicating a low regeneration rate, particularly if the EV is not at full charge. That is considered normal and is the processor’s way of protecting the battery pack until it warms up. The XENTRY Diagnostics system has menu-driven test routines to guide you though just about any possible regenerative braking system concerns your customers may have |



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# Mercedes-Benz Assist Systems

Helping the driver down the road to autonomous



While it may be rare for you to get a customer complaint about a Mercedes-Benz assist system – they are so darn reliable – in anticipation of that day, we'll offer an overview of the various systems available. After all, if you don't know what it does, how can you repair it?

Assist systems are designed to help the driver and enhance safety, either by making the drive more comfortable to relieve stress on the driver, or to support the driver in critical situations. While many assist systems offer active intervention, most are providing information and support to the driver as he or she makes decisions on the road.

One issue you will encounter is that nearly every assist system has, at one time or another, had its name changed. We're going to focus on vehicles that are a few years old, ones that you are most likely to see in your shop, and we'll be using the names and terminology of that time period. In any case, if you want to know what any assist system in any particular vehicle is called and what it does, your absolutely best resource is the owners manual. If that manual is missing from your customer's car, either visit [MBUSA.com](http://MBUSA.com) for manuals back to 2012, or log in to [StarTekInfo.com](http://StarTekInfo.com) for manuals dating back to 2001 and, for most models, even earlier. Also at [StarTekInfo.com](http://StarTekInfo.com) are two "Introduction to Service" books covering Assist Systems in great detail.

Above: Autonomous cars are in our future, thanks to years of development work on Assist Systems.



The very first driver assist system, introduced by Mercedes-Benz in the early 1980s, was ABS, the Anti-lock Braking System. This prevented the wheels from locking up under heavy braking, preventing the loss of directional control. Anyone who could literally just stomp on the brake pedal could enjoy controlled braking at least as good as the very best drivers on the planet.

This was followed by ASR, Acceleration Slip Regulation, which did for acceleration what ABS did for braking: control wheel slip and its resulting loss of directional control during acceleration. Thus, anyone who could stomp on the accelerator pedal could maintain control of the vehicle, since ASR kept the rear wheels from slipping.

These two systems were later enhanced by ESP, the Electronic Stability Program. While ABS and ASR are mainly effective when driving in a straight line, ESP operates primarily when the vehicle is turning. Using a combination of sensors, the system first determines where the driver wants the vehicle to go, and compares that to where the vehicle is actually going. If these differ, ESP brakes a single wheel in an effort to pivot the vehicle back onto course. Naturally, the system is somewhat more complex than this, and, also naturally, it can't overcome the laws of physics: Enter the curve too fast, or lose too much traction, and the system won't be as effective as the driver might want.

But these older systems are fairly well-known and understood, and so we won't go into more details about them here. Instead, we're going to look at the newer systems so that they become just as familiar as good old ABS.

## Attention Assist

Attention Assist is a standard feature in virtually all models since around 2013. The ESP module monitors several vehicle parameters using existing sensors to help identify a tired or inattentive driver, and signals the need for a break. The most important factors in evaluating driver tiredness are steering wheel angle changes, time of day, and length of journey, although active vehicle operation (pressing radio buttons, for example) are also considered as indications the driver is alert.

During the first 20 minutes of a drive, the system determines the driver's profile. When the system detects a deviation from this profile that may point to drowsiness or inattentiveness, such as quick, jerky steering movements,



Attention Assist uses several existing sensors and systems to gauge driver fatigue, and issues a warning if actions possibly indicating fatigue are detected.



Lane Keeping Assist uses a camera in the windshield to detect visible lane markings, and issues a warning by vibrating the steering wheel if the vehicle is leaving the lane.

it issues a visible and audible warning, via the instrument cluster. Note that no new systems or components are used for Attention Assist: All the signals come from existing sensors. The system can be deactivated from the instrument cluster via the assist systems menu.

As of Models 207 and 212, Attention Assist has an additional higher-sensitivity mode that the driver can select.

## Lane Keeping Assist

The Lane Keeping Assist system uses a camera in the windshield to detect lane markings and warn the driver when the vehicle starts to leave its travel lane. As a warning, the steering wheel is vibrated, to simulate road-edge rumble strips. The driver activates this function via

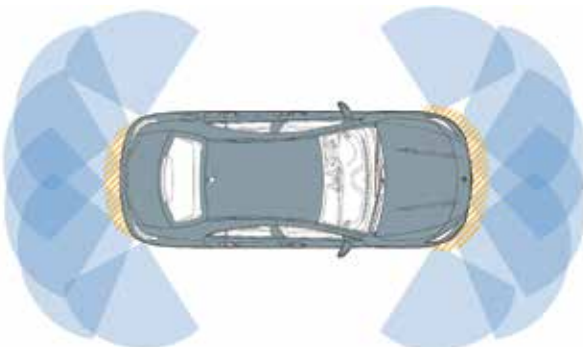
the instrument cluster, and can select either 'standard' or 'adaptive' mode.

In standard mode, warnings are suppressed if the driver uses the turn signal, or if ABS, ASR or ESP are actively operating. In Adaptive mode, warnings are additionally suppressed if the driver actively counter-steers or switches lanes, brakes or accelerates, or cuts a corner.

The system is also available as an active system in some models. Here, the vehicle uses asymmetric braking – applying the brakes on one side of the vehicle only – to pull the vehicle back into its lane. This action is very noticeable by the driver and also serves as a warning. It is relatively gentle and can easily be overcome by the driver using the steering wheel.



Blind Spot Assist warns the driver of objects detected in the blind spots by lighting a red LED in the mirror.



Several short-range ultrasonic sensors are used by PARKTRONIC to detect nearby objects, with the distance to detected objects indicated to the driver with visual and acoustic indicators.

With this system, active lane corrections are suppressed if, for example, the system detects an object (such as a vehicle) that might be in the way if a correction is made, or in a sharp curve. The system is designed to operate above moderate speeds and not during slow maneuvers. Calibration of the camera is required, which we'll discuss later in this article.

## Blind Spot Assist

Blind Spot Assist uses radar sensors in the rear sides to detect objects in the driver's blind spots at speeds above about 20 MPH. If an object is detected, the system lights up a red LED in the appropriate exterior mirror. If the driver signals an intent to change lanes while an object is detected, a warning tone sounds and the red LED flashes. If the system is not ready, for example at low speeds, the mirror LEDs light yellow.

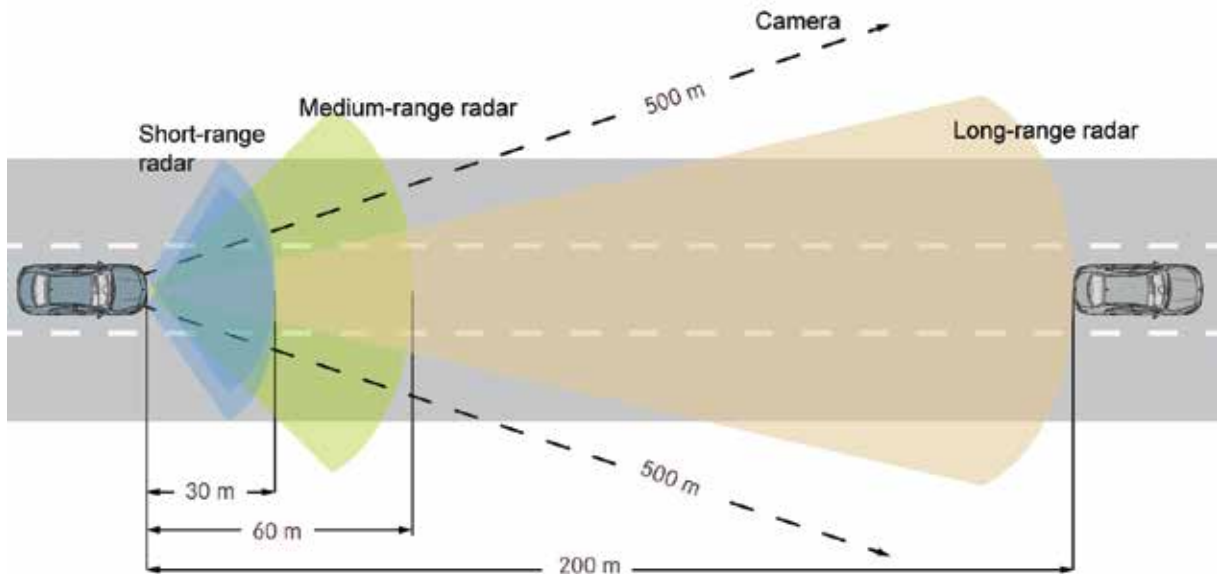
A short-range radar sensor inside each side of the rear bumper is used to detect objects. Not all objects can be detected, or detected in a timely manner: Fast-overtaking vehicles, or poor radar targets like a motorcycle may not be detected. Also note that the radar sensors are sensitive to certain (especially metallic) coatings on the bumper, as well as imperfections (such as heavy grinding marks) on the inside surface of the bumper cover. The sensors require no calibration, but must be firmly clipped into their holders.

As with Active Lane-Keeping Assist, Mercedes-Benz also offers Active Blind Spot Assist. Again, the vehicle brakes are used to nudge the vehicle away from a detected object. The lane correction is again suppressed under certain circumstances, particularly at high speeds, if the driver steers or accelerates, and in sharp curves.

## PARKTRONIC®

PARKTRONIC® uses ultrasonic sensors, which don't require calibration, positioned in the front and rear bumpers to indicate to the driver the distance to any detected objects. An LED display is used to show the driver the approximate distance to a detected object, along with an intermittent tone that sounds more frequently as the distance narrows. Poor installation of the sensor, overly thick paint coatings, or deteriorated isolation rings around the sensor can cause erratic operation.

The Park Assist function further expands PARKTRONIC by identifying potential parking spaces and, if the driver



DISTRONIC PLUS uses several sensors to detect other vehicles on the road, and is designed to maintain a constant distance to the vehicle in front.

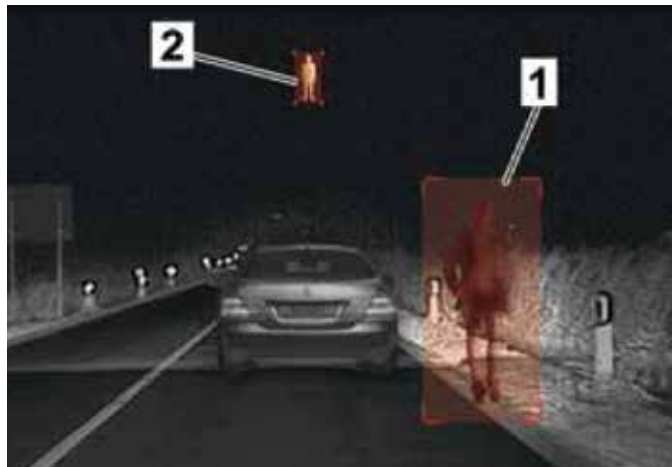
takes action, actually parking the vehicle in the identified space. Early systems could detect and park in parallel spaces only, and required the driver to control the brake and throttle. Later systems can also detect perpendicular (straight-in) spaces and back the car into one, controlling brakes and throttle along with steering, so the driver only has to initiate the parking maneuver and wait for it to be completed.

The system can also un-park the vehicle, if it was parked using the system. After all, if you are having trouble parallel parking, you might also have trouble pulling back into traffic. As expected, the system only operates at low speeds. The instrument cluster provides instruction to the driver, including a caution to verify that the identified location really is a parking space. And no, it can't prevent a ticket for violating parking restrictions.

## DISTRONIC PLUS

DISTRONIC PLUS is a convenience-oriented system that maintains a set following time from a vehicle ahead. If there is no vehicle ahead detected by the radar sensors, the system operates like normal cruise control, maintaining a set speed.

If a vehicle ahead slows down, DISTRONIC PLUS will also slow the vehicle, all the way down to a stop if necessary. Restarting requires the driver to either accelerate or tap the cruise control lever. The older DISTRONIC system



Night View Assist uses an infra-red camera and lights to extend the driver's vision distance at night without dazzling other drivers. The Night View Assist Plus system shown here is designed to detect and highlight pedestrians and larger animals and increase safety by making them more visible. 1. Visual highlighting of person detected by system. 2. 'Pedestrian Detection Active' symbol.

(without the plus) does not operate below about 20 MPH. Note that the braking rate of the system is limited, and so this is not an accident prevention system: The driver must remain alert and react to the driving situations.

The system operates with short-, medium- and long-range radar sensors mounted in front, and the camera mounted to the windshield. You can usually tell which models have DISTRONIC by looking at the star in the grille. Earlier systems used sensors that required aiming using a special tool and aiming target, while later systems are self-calibrating, requiring a test drive of several minutes.

## Night Vision Assist

This system uses a forward-facing infra-red (IR) camera, along with additional front lamps that emit only infra-red light in a pattern similar to high beams, to display an image of the road ahead to the driver. Infra-red light doesn't dazzle other drivers, meaning much more light can be projected ahead. The later system, NVA+, is



The Rear View Camera display, here shown with dynamic guidance lines, helps the driver when backing up. A camera at the rear activates when the transmission is shifted into reverse.

designed to identify and highlight pedestrians and larger animals on the display. Mercedes-Benz recommends against operating the vehicle by watching only the display, but the display clarity is remarkable.

The IR light is delivered by regular H7 headlight bulbs covered by a special IR filter. The system is switched off in daytime, and at a standstill for safety: Looking into the IR light beam can hurt your eyes, since the amount of energy is about the same as a headlamp, but your eyes don't react to IR light. The camera is mounted either in the front grille or the windshield. Any time work is performed on or near the camera, recalibration is required.

## Visible light cameras

While not a single Assist System, we wanted to close this article with an introduction to the cameras in and around the vehicle. Used for multiple systems, these wonders of technology sometimes need some special care.

The mono multipurpose camera (MPC) is used for the Lane-Keeping Assist system, for example, to detect lane



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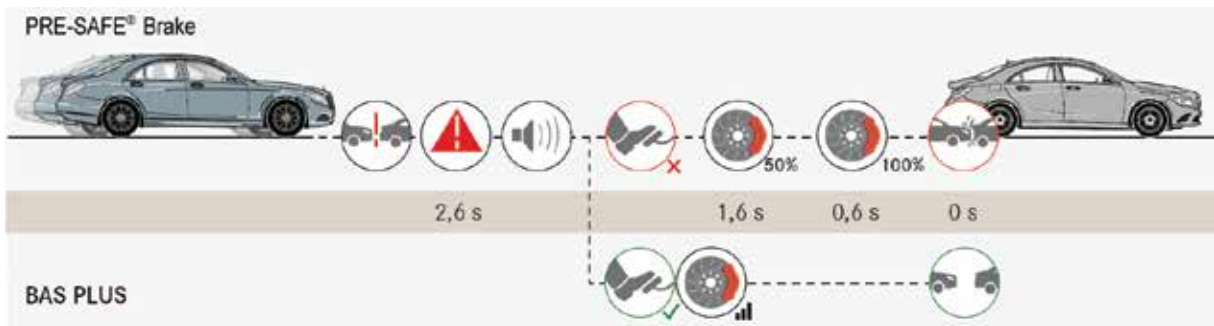
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Backed by a one-year warranty\* that includes parts and labor, StarParts can offer enhanced margins to help grow profits for your shop in the long run.

**To order StarParts, contact your Mercedes-Benz dealership today.**



\*To learn more, visit [mbwholesaleparts.com/mercedes-benz-starparts](http://mbwholesaleparts.com/mercedes-benz-starparts).



The principles of Pre-Safe® Brake and Brake Assist System (BAS) Plus are shown here. If the driver doesn't react to the warning of a detected potential collision, the brakes are applied autonomously to prevent or reduce the severity of a collision. If the driver does react, the driver's braking force is increased if necessary.

markings ahead of the vehicle. A system known as Traffic Sign Assist also uses this camera to detect road signs such as speed limit and stop signs.

More advanced is the stereo multipurpose camera (SMPC), which has two cameras mounted to the windshield several inches apart. One system that uses the SMPC is Cross-Traffic Assist with Pedestrian Protection. This system is designed to detect objects moving across the vehicle's path, such as a vehicle at an intersection or a pedestrian, and warn the driver or actively brake the vehicle if a collision is calculated. Another system, Magic Carpet, is a suspension system that uses the SMPC to detect and react to road imperfections, delivering a ride so smooth it's like riding on, well, a magic carpet. The SMPC is also used for the same functions as the MPC.

Then there are the reversing camera and the Surround View cameras. The reversing camera is mounted at the rear of the vehicle, sometimes behind a motorized cover. When the vehicle is shifted into reverse, the camera activates and shows the view behind the vehicle on the head unit screen. In some models, lines are superimposed on the display to help the driver better gauge the path and size of the vehicle. The reversing camera can be disabled in the head unit, so if it's not working, verify it is enabled.

Surround View is a system that displays a 360 degree view around the vehicle at low speeds. Extremely useful for low-speed maneuvering, the view is displayed on the audio head unit screen. The driver can select several possible viewpoints, including birds-eye (a virtual viewpoint several yards above the vehicle), surround, and left/right flank. In addition to the reversing camera, three

more cameras (one in the front grille, and one beneath each door mirror) deliver their images to the head unit, which shapes the view as selected by the driver.

The windshield-mounted cameras all require calibration after they or the windshield is replaced. Almost always this requires the use of a vision target and XENTRY Diagnostics. The camera mounting bracket is permanently adhered to the glass and cannot be removed or replaced. Make sure no dirt or smudges are on the glass when mounting the camera.

The reversing camera and Surround View cameras generally also require calibration, but different versions of the system use different methods. Check in WIS or XENTRY Diagnostics for the details. The entire system must be calibrated even if only a single camera or camera holder (e.g. side mirror) is replaced.

For all cameras, the video is delivered through special video cables. These cables cannot be repaired if damaged, but replacements are generally available.

Limitations on space prevent us from delving into many other assist systems, because Mercedes-Benz offers so many. Some of these systems are remarkable: Steering the vehicle down the road, fully-autonomous braking, compensating for cross winds, supporting emergency braking, automatically handling stop-and-go traffic, and more. As with ABS, which brings the braking ability of the average driver to a point beyond that of even the best drivers, these assist systems are laying the groundwork for the fully-automated self-driving cars of the future. While we at StarTuned can't predict when such a vehicle will be offered for sale, we are convinced that Mercedes-Benz will be among the first to do so. |



# Yet Another Great Benefit for Independent Repair Shops



It's well-known that the best way to maintain the integrity, safety, and performance of Mercedes-Benz vehicles is by always using Genuine Mercedes-Benz replacement parts. Doing so was recently made an even better business decision with the introduction of the StarParts program, which offers independent repair shops a more cost-competitive line of the most common replacement parts.

And now comes StarRewards, a brand-new program that actually pays you to buy parts from your local Mercedes-Benz dealership's parts department.

This new StarRewards program is one way Mercedes-Benz shows its appreciation for wholesale mechanical and collision customers. It's a rebate program that is based on parts purchases, and there is no cost to enroll. It's a tiered program designed to reward increases in purchases over previous 3-month (quarterly) periods. The more you buy, the more you earn. Rewards are provided in the form of a MasterCard debit card, and can be used for purchases of any kind of products or services from businesses that accept this card.

Virtually all purchases of Genuine Mercedes-Benz parts and accessories qualify for the StarRewards program, including the recently-introduced line of price-competitive StarParts.

Enrolling in the program couldn't be simpler. You simply go online to [MBStarRewards.com](http://MBStarRewards.com) and register. Enrollment is fast and free. Your purchases will automatically be tracked on a quarterly basis, and you can monitor your purchases on your own dashboard at the website.

Once you've enrolled your shop and your credentials have been verified, Mercedes-Benz will use your purchase history to establish quarterly targets for you to reach. As you surpass these targets, you will receive rebates of as much as three percent of your purchases for the quarter. Your purchases will be tracked automatically, and your reloadable gift card will be updated with your new rewards. There's no limit to the dollar value of the rebates you can earn.

It's as simple as that!

And there are not a lot of complex rules to deal with. The StarRewards program is available to single-location independent repair facilities, including both mechanical and collision shops. Only one person per shop may enroll, and purchases must exceed \$200 in a given quarter in order to qualify for StarRewards in the subsequent quarter. While there is the usual legal fine print, there's really not much more you need to know to enroll and participate, and all the details can be found at [MBStarRewards.com](http://MBStarRewards.com).

This new StarRewards program is Mercedes-Benz's way of showing its appreciation for your choosing to buy replacement parts from your local dealership's parts department. Mercedes-Benz is committed to building the finest vehicles in the world, and is also committed to supporting the independent service sector with replacement parts of OE quality, fit, and finish. Likewise, Mercedes-Benz is committed to supporting our partners in the independent service sector with products, programs, and incentives that allow ISPs to provide their customers with the highest quality service and repairs possible, while maintaining the profit margins dictated by the nature of small businesses that form the foundation of the independent service sector.

It doesn't stop here. The recent introduction of the StarParts and StarRewards programs represents the creative ways being offered to auto repair and collision repair shops to thank them for their business. Additional programs are already under development to make this partnership an even better business proposition for these important customers in the repair industry. You'll be happy to know that participants in the StarRewards program will automatically be enrolled in future programs developed to enhance the business relationship between Mercedes-Benz dealership parts departments and their valued wholesale customers.

To enroll or to learn more about this exciting new program, just visit [MBStarRewards.com](http://MBStarRewards.com). |



**\$866.00**  
MSRP\*  
A 164 490 5236 80



**\$1086.00**  
MSRP\*  
A 251 320 5613 80



**\$1206.00**  
MSRP\*  
A 164 460 0300 80

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## Mercedes-Benz

The best or nothing.

\*MSRP excludes state and local taxes, and freight if applicable. Price excludes core deposit. Price valid as of January 2020. Prices may vary by dealer. See your authorized Mercedes-Benz dealer for additional details or a copy of the Mercedes-Benz parts limited warranty.



Contact an authorized Mercedes-Benz dealer  
or learn more at [www.mbwholesaleparts.com](http://www.mbwholesaleparts.com)

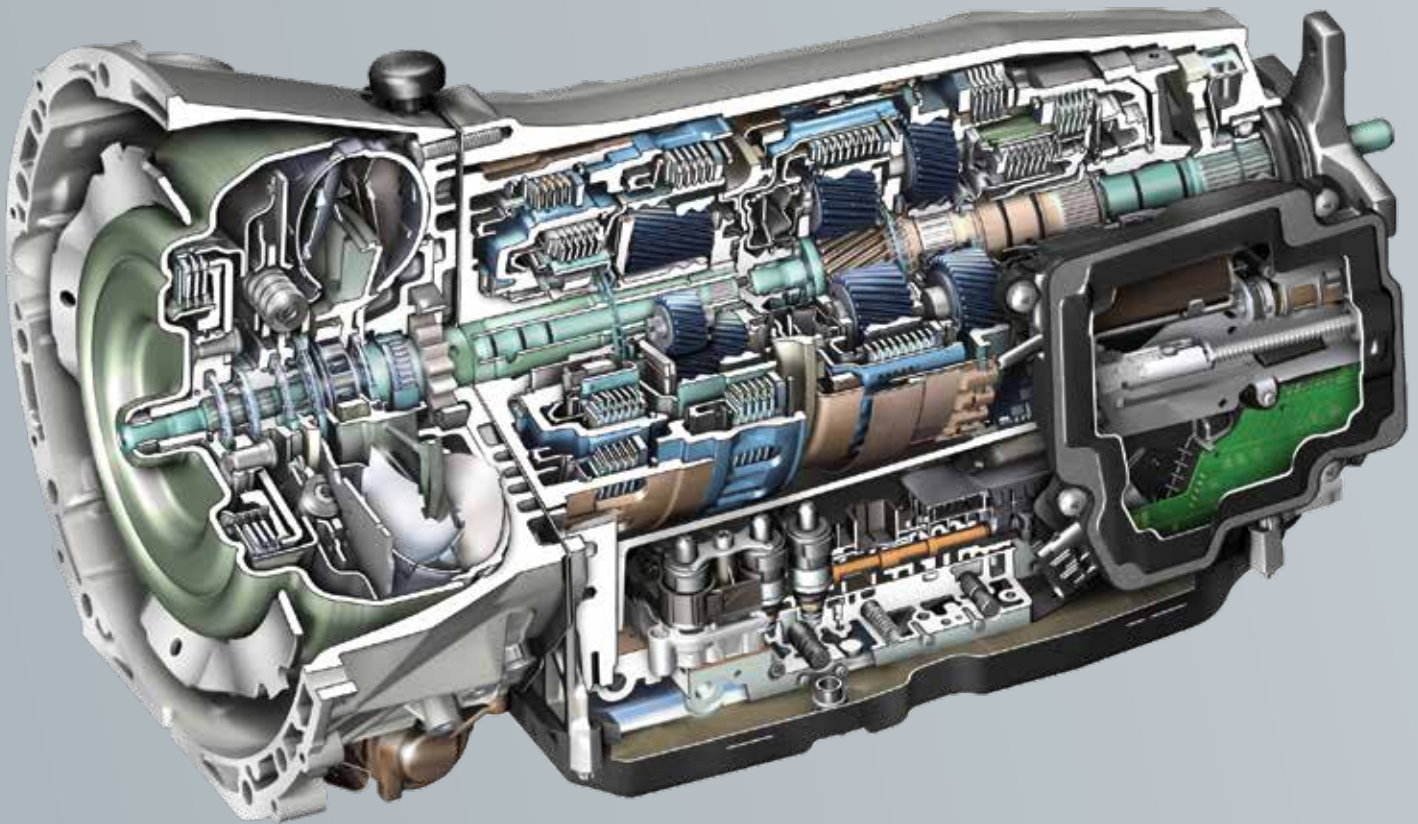


One remanufactured engine pulls the plug on climate-damaging CO<sub>2</sub> and saves 447 days of power for one laptop.



# Module Updates Do Fix Shifting and Slipping Problems

Don't rush to replace that transmission, check for service bulletins and updates first! We present some cases where problems were solved with control unit updates or replacements.



Shifting and slipping concerns can be a serious challenge, even for the most advanced drivability technicians. So many factors affect how the modern transmission shifts that it is somewhat daunting to figure out how to solve your customer's concern. You can, however, begin to narrow down the possibilities with the proper scan tool and procedures. The majority of faults lie in the mechanical or electrical areas: Here we will be only concerned with the electrical issues you may encounter with a shifting or slipping concern.

Sometimes you will be faced with problems from both areas, particularly in high mileage cars, so it is important to be diligent with diagnostic procedures. Nothing is more frustrating than to repair an electrical concern, only to find that the clutch packs are worn out. We should also point out from the onset that without XENTRY Diagnostics or at least a J2534 v05.00 API tool (preferably with a 4 CAN channel) and a subscription to Mercedes-Benz STAR TekInfo (included with the XENTRY machine) you will be very limited in the way of diagnosis, and certainly unable to perform any programming or SCN coding.

Be sure to always follow the proper initial steps when deciding to code or replace a module. Checking the fluid

levels, including the proper fluid and its quality, as well as inspection of the driveline, external leaks, and a thorough test drive are always standard procedure. You have to be able to duplicate the complaint to have a chance of knowing when it is fixed

As the title implies, many transmission complaints can be corrected in software, but of course some also need some hardware. Let's take a look at some examples where a module update has solved a customer's complaint.

## The 722.9 transmission

One of the most popular transmissions in the Mercedes-Benz line, this is also the one that many times you will find a module update (or possibly a replacement) will solve many drivability concerns.

An electronically-controlled unit with 7 forward and 2 reverse gears, all controlling elements are within the transmission case, so there are only 5 wires leading to the rest of the car. Shift quality, service life, maintenance costs and reliability are optimized by the use of electronic controls operating hydraulic elements.

The famous plug connection at the transmission housing

where it enters above the pan is a spot that can routinely cause some issues. Obviously a module update isn't going to fix a mechanical issue with the contacts, but if you have CAN communication errors with the VGS, check the plug. It is not unusual to find it moist from fluid seepage (this was more common on the older 722.6 models) and a thorough inspection of the pins may reveal the source of your communication



Replacing the fluid and filter is really an excellent idea in addition to any updates and or component repairs.





Leaking connectors may be the reason your scan tool won't communicate with the VGS. New connectors are inexpensive and easy to install if the old one is leaking. Note that the o-rings are not available separately. Note also that the 722.9 connector has only five pins, while the 722.6 transmission plug has 13 pins. When routing the wiring harness for this connector, be sure to allow free play in the harness so it is not stressed.

error. Also important, check the other ends of the harness: Fluid can wick all the way up the harness and wind up in places you'd never expect.

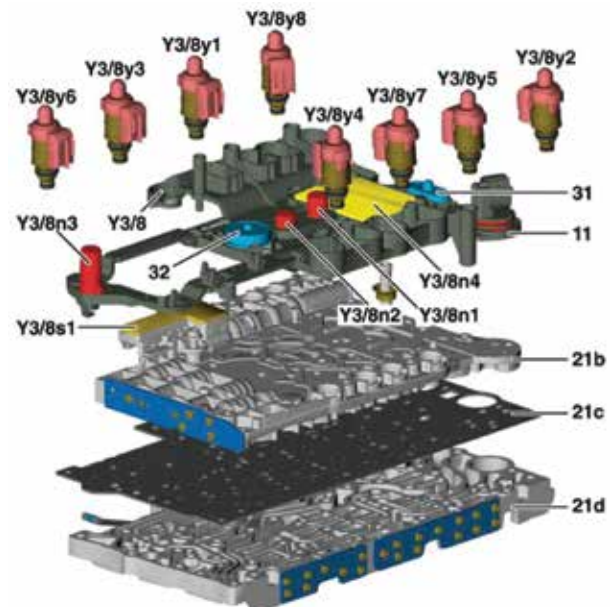
The 722.9 can be broken down into four major assemblies:

- Torque converter with torsional damper and torque converter lockup clutch.
- Oil pump for generating the necessary oil pressure and for reliable lubrication of the actuators and bearing points.
- Transmission housing with mechanical transmission components including the planetary gear sets, park pawl, multidisc clutches and multidisc brakes.
- The electrohydraulic control unit, located in the oil pan.

Data from the control unit is exchanged with the following control units via the engine CAN-C:

- Instrument cluster
- Intelligent servo module (the shifter on the side of the transmission housing)
- CDI or ME-SFI control unit (diesel/gasoline engine controller)
- ESP control unit
- EIS control unit
- Steering column module

With all these connections and systems involved, proper software coding is critical to proper function. The TCM has self-diagnostics, with several sensors and actuators monitored along with shift performance. Gear selection and shift adaptation are handled electronically, but hydraulic oil is used to move transmission elements as needed. This system allows very precise adaptation of system pressures to vehicle operating conditions,



Don't mix up the solenoid valves, they must be replaced in their original position. Otherwise a complete adaptation will be necessary.

resulting in near-perfect shift quality. This precise control offers the advantage of a flexible adaptation to various vehicle model and engine combinations.

The basic shift program sequence starts with upshift and downshift characteristics for all 7 gears based on an empty vehicle, at operating temperature on a level road, and at sea level. Then the shift program is adapted by offsetting those characteristics depending on the vehicle load, change in driving resistance and accelerator pedal movement and position. Some other influences include vehicle speed, selector lever position (including the mode switch), signals from the engine CAN and the measured

characteristics of the shift valves and clutch packs. Fine-tuning of the program can include preventing undesired downshifts in the upper vehicle speed range with a slow accelerator release or the prevention of upshifting to the next gear up with a rapid accelerator release.

Now that you're familiar with the transmission, let's look at a few case studies.

## 2005 CLK500

Vehicle won't shift and has a check engine light on. After performing a quick test the technician found DTC P2112 stored in the Engine Control Module. He tested the throttle body and APP sensor at idle and in the shop with KOEO and found both to be within specifications.

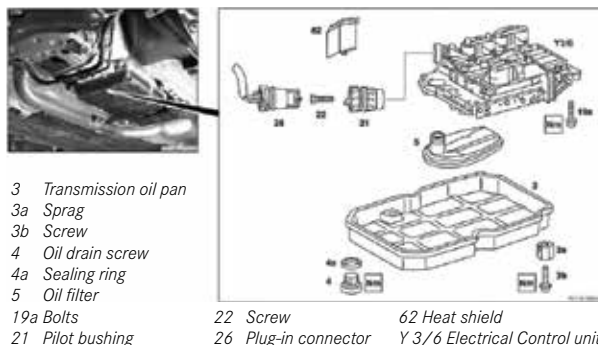
This false setting of throttle body and APP sensor codes can occur with transmission issues. What can happen is that if you are applying the throttle and the car isn't moving, the ECM may set some codes for those

components. The TCM also stored codes 0778 and 0798, which are for the brake solenoids in the valve body, indicating that an internal check has failed.

After clearing the codes and a test drive, 0778 and 0798 returned, and the scan tool indicated the transmission would not come out of second gear. At this point, an internal test of the brake solenoids is called for. The technician pulled the pan and tested the brake solenoids and found them out of spec. See the image from the workshop manual for the remedial action to take if a brake solenoid has failed.

If you suspect the circuit board is faulty, be aware that there are no tests that can check its integrity. Even though the solenoids are available separately, Mercedes-Benz recommends replacement of the entire valve body plus TCM, which includes all sensors, valves and the control unit, as an assembly. During production, the characteristics of each solenoid are measured and stored in the TCM's permanent memory, so individual solenoid replacement is less than optimal.

To properly replace the TCM, you need an online connection to the Mercedes-Benz 'flash' servers. The process also includes transferring calibration data if you decide to keep the old valve body, so be sure to use the same XENTRY Diagnostic machine that was used to extract the data from the old TCM, or you'll end up with a really unhappy transmission that needs a full adaptation sequence. When pricing the control unit separately, the price of the complete unit was more cost effective than just the control unit, so the technician wisely opted for the replacement unit. Remember that 722.9 transmission control units are Theft-Relevant Parts, so you'll need some owner and personal documentation to get one.



Here's a layout of the typical components in a 722.9 transmission oil pan.

Before starting work, the area around the valve body separation point on the transmission must be thoroughly cleaned, we call it surgically clean: Even the slightest dirt particles introduced into the hydraulic components can lead to malfunctions or even a total failure of the transmission.

After installing the replacement valve body and control unit, along with a new filter and fluid (remember: those aluminum bolts are stretch bolts and must always be replaced), the technician used his XENTRY Diagnostics machine to perform an initial startup, flash in the latest TCM software, reset the adaptations, and perform SCN

coding. In this particular case, the diagnostic menu indicated an update of the engine control unit as well. After all repairs were completed, a thorough test drive (including the adaptation routines) was performed, the fluid level verified and the shifting concern was completely eliminated.

## 2006 C280

Customer concern: check engine light is on with erratic shifting, sometimes going into limp mode. Customer can shut the vehicle off and restart after a brief wait, and shifting will be normal for a short period of time.

After performing a test drive to verify the concern, a thorough inspection was completed including a fluid check and history of maintenance. Scan tool diagnosis revealed DTCs 2767 and 2768 (Y3/8n2 (Internal speed sensor (VGS)) is faulty). XENTRY Tips article LI27.50-P-049710 was found to have specific instructions pertaining to this and several other codes. The technician followed the guided test steps in XENTRY and, in this particular case, was directed to replace the electrohydraulic controller unit. It should be noted that in some cases there is a repair kit available when directed to do so, which is detailed in document AR27.19-P0220B.

It is so important to install all solenoid valves back to their original positions if they are removed. If you don't, the calibration data stored in the TCM will be incorrect, resulting in shifting complaints. The control unit was replaced with the proper module update and programming resulting in the transmission shifting properly again.

## 2008 C300 4MATIC

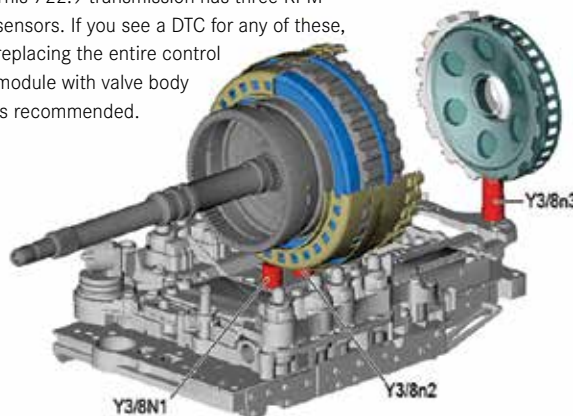
Customer complaint: After a cold start, slight slippage is felt in the 2-3 shift when the vehicle drives off for the first time. This problem can occur if a full pressurization of the K1 piston does not occur when cold.

After the technician verified both the complaint and all the basics (including fluid fill, condition and type) a quick check of STAR TekInfo showed an available service bulletin: According to bulletin LI27.00-P-048552, which was found to apply to the specific engine and controller



This is the transmission with the oil pan removed. Be sure this area is surgically clean before removing the pan or replacing components.

This 722.9 transmission has three RPM sensors. If you see a DTC for any of these, replacing the entire control module with valve body is recommended.



installed, new software was available to solve this complaint. The new software was flashed into the TCM which solved the issue. Even though the shop had to keep the car overnight (to be sure it was cold), the actual repair took just a few minutes.

## 2011 ML350 4MATIC 3.5L

The customer described the concern as a shudder, misfire or hesitation on acceleration. After a thorough inspection the technician verified the proper fluid and amount. The technician did note that the fluid was due to be changed from a maintenance standpoint. A quick test revealed no problems with the engine or associated tune-up parts. In particular it's wise to look at the misfire data if possible just to rule out other possibilities.

No related codes were found, but the technician did find a bulletin related to this issue: LI27.20-P-055758. This bulletin provides a step by step troubleshooting tree to



address this complaint. A road test was performed to verify the issue is with the torque converter. The technician was able to deactivate the torque converter solenoid and found the shudder had disappeared. The bulletin states that sometimes, on certain models, the torque converter will have increased wear on the torque converter bearing bushing, or in other models there may be slight internal leakage at the sealing ring between the transmission input shaft and the torque converter lockup clutch.

There was new software version available for this complaint, so the technician updated it and erased the fault codes in the VGS, along with a reset of the lifecycle data of the torque converter (Follow the XENTRY menu: VGS - Fully integrated transmission control (Y3/8n4) > Teach-in processes > Reset of adaptation values > Torque converter > Confirm torque converter replacement > Confirm reset of adaptation data). The transmission fluid was flushed and a new filter was installed. After a test drive the technician noted that the customer concern was no longer present.

Although in this case the original torque converter remained installed, the bulletin advises that it is possible the torque converter must be replaced, especially if the software update was not effective. According to WIS, the torque converter mount on the crankshaft must be thoroughly cleaned, polished with fine grit emery cloth and lubricated with multipurpose high heat paste before installation.

## Still have fault codes?

If after programming Engine and/or Transmission Control Units, you still have Fault Code 061B Stored

in the TCU, there is also a bulletin that deals with this. The cause may be a torque interface issue between the engine and transmission control modules. To resolve it, check for and install the latest software for the engine control module using XENTRY and perform SCN coding of the engine control module as well. Perform a quick test and erase all fault codes.

The bulletin offers two notes: If the fault code 061B reappears, it can be ignored. This is not cause for any parts replacement. And, if no newer software is available for the engine control module, simply perform the SCN coding of the engine control module.

## More bulletins

On 164, 211, and 251 models, if you receive customer reports of a brief sensation of delayed acceleration (hesitation) when accelerating back up from low speeds with only light pressure on the accelerator pedal, which does not occur when the accelerator pedal is depressed into the “kick down” range or when the vehicle is moving at higher speeds, this may be caused by the transmission shifting down with a slight delay and the engine only delivering the required power after the delayed shift is completed. To remedy, flash and SCN code the transmission with the latest software.

Although the focus of this article was on the 722.9 transmission introduced in 2004, the same basic principles apply to any electronic transmission. Without XENTRY Diagnostics, which includes access to the Mercedes-Benz flash servers, your ability to address customer complaints may be limited. But even if you have to farm out the actual flashing (which takes only

minutes) to someone else, finding the cause is the most important part. In models that are a few years old, don't think you're the first one to see this complaint: By now you are probably getting the idea: Check for bulletins! There is a library of information contained in STAR TekInfo (including bulletins, XENTRY Tips and the Workshop Information System) that deal with almost every situation you might encounter in your diagnosis of transmission concerns. |

The screenshot shows the STAR TekInfo website interface. At the top, there's a search bar with '061B' entered. Below the search bar, a table titled 'Star Bulletins: 061B | U' lists several bulletins. The table has columns for 'Issue Date', 'Categories', 'Discussion', 'Description', and 'Links'. The bulletins listed are:

Issue Date	Categories	Discussion	Description	Links
04-23-2010	Star Bulletin %OTB (U)	01B - 1-B-27-00-014 (304)	Revision: Document Superseded All Light Truck Models Equipped with 722.9 Transmission (70-Tronic) Fault Codes 2382, 2505, P0904 or P2111	Related TAC Cases
04-23-2010	Star Bulletin %OTB (U)	01B - P-B-37-00-014 (304)	Revision: Document Superseded All Passenger Models Equipped with 722.9 Transmission (70-Tronic) Fault Codes 2382, 2505, P0904 or P2111	Related TAC Cases
04-06-2010	Star Bulletin %OTB (U)	027-00-P-049201_Ver.1 (304)	Models Equipped with 722.9 Transmission Hard to Engage When Changing Gear Range Brake P No. 0	Related Warnings Jobs
04-06-2010	Star Bulletin %OTB (U)	027-00-P-049203_Ver.1 (304)	Revision: Remedy Revised/ Supersedes 026 5-D-27-00112 All Model Vehicles Equipped with 722.9 Transmission 70-Tronic 04020 Hard 1,2 Shift or Hard Torque Converter Lockup Clutch Engagement	Related Warnings Jobs
03-26-2010	Star Bulletin %OTB (U)	027-00-P-049152_Ver.1 (304)	Model 204210221 with Transmission 722.9 Poor Shift Quality	Related Warnings Jobs
03-22-2010	Star Bulletin %OTB (U)	027-00-P-049151_Ver.1 (304)	Revision: Now Possible Remedy, See Parts for Shift Rod Head and EDM/Supersedes 026 P-0-	Related Warnings Jobs

The STAR TekInfo website has thousands of service bulletins. There's a good chance your customer's complaint, and its solution, can be found here.

# Mercedes-Benz ISP Parts Information

Thousands of Independent Service Providers – workshops just like yours – subscribe to the Daimler ISP Parts Information catalog, or ISPLI. For only \$75 a year, users gain access to the full range of Mercedes-Benz parts information, including grey-market vehicles, vans, and more.

Introduced in December 2018, ISPLI will be undergoing its first major update in late April 2020. Here are some of the highlights of the update:

**Shopping Basket:** Once you find the parts needed, you have to get them. ISPLI introduces a shopping basket feature, which allows the user to build a list of parts and easily print or eMail it to your favorite dealer to place an order. Baskets can be saved for later reference.

**Expanded Data Cards:** The data card window can be expanded to show additional useful data from Daimler’s Vehicle Documentation system, including the part number(s) of the originally installed major assemblies.

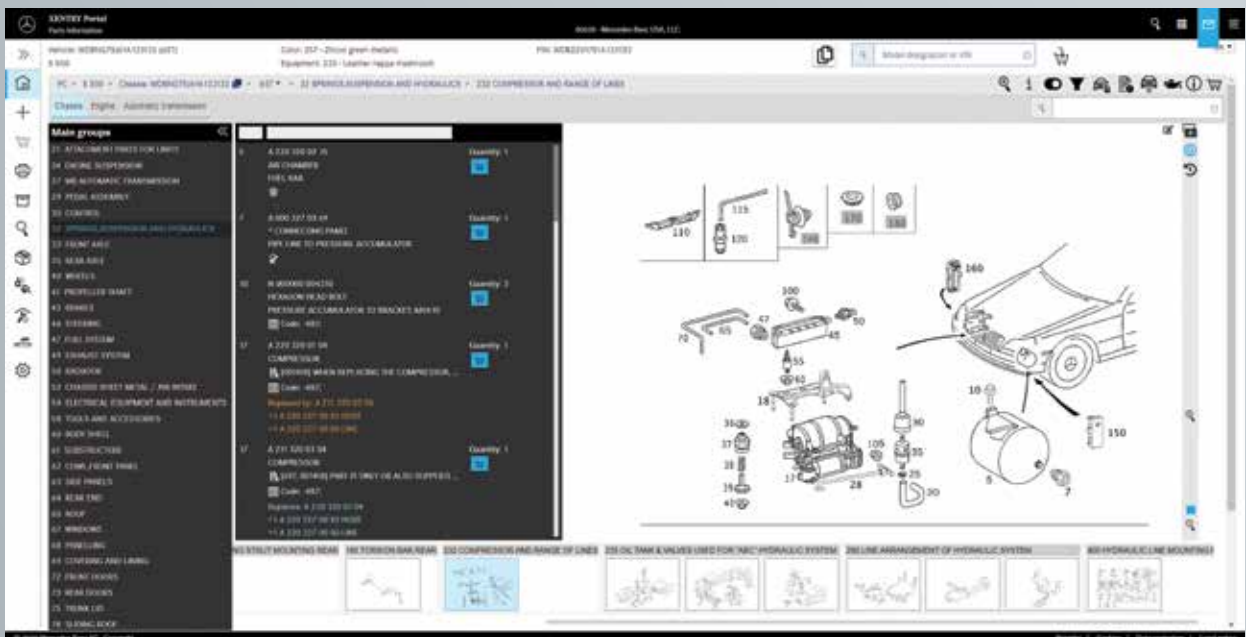
**Increased performance and reliability:** Mercedes-Benz knows that if you can’t specify parts, the workshop is out of business. Daimler will move the ISPLI system with this update to a cloud-based server system, with thousands of servers worldwide providing higher speed and tremendous redundancy: Faster and always-up. Of course, your own connection to the Internet needs to be working.

**Updated look and feel:** Some of the screen display has changed to make features easier to access. Both the VIN and FIN are displayed on the screen all the time, and either can be copied without any spaces for easy pasting. When starting a new vehicle, the VIN entry box is right on the page.

**Browser-based:** Previously, ISPLI was in a frame within a browser window, limiting how much your browser could influence the display. With this update, ISPLI is completely within the browser window, so you can open another session without touching any open already, and move it to a second monitor if desired.

**What isn’t changing is the way you find parts:** VIN selection, groups and subgroups, images and the overall workflow will be essentially the same. Testing performed at dealers worldwide showed that a parts specifier did not need any instruction or learning time to start selecting parts using the updated ISPLI. The only effort required was to set the many customizable features to their liking.

The change-over will be completely automatic, with no action necessary to use the new system. If you don’t have a subscription, visit <http://epc.startekinfo.com> (note: not www!) to get started with your own subscription. After subscribing, it can be a few days before your initial temporary password can be assigned. Once you receive it, you’ll have to create a new password, following the on-screen security rules, so don’t be surprised when the system asks you. |



The new ISPLI in action. Only small changes to the look and feel, but big changes to performance and features.

# Who's Your *Partner* in Success? Mercedes-Benz's

You've chosen your career as an ISP (Independent Service Provider) because you enjoy maintaining, diagnosing, and repairing motor vehicles. One of the most challenging pieces of your business is parts procurement.

Finding the right parts at the right price and being certain they will arrive when promised can be a challenge.

Wouldn't it be nice if there were a way to get the parts you need without the hassle and uncertainty, so you can get back to the important business of actually fixing cars and taking care of your customers?

With the Mercedes-Benz PartsPro wholesale certification program, now there is!

PartsPro is a rigorous program intended to train Mercedes-Benz dealership parts department personnel on how to better take care of you and ultimately your customers. PartsPro certified dealers have elevated their commitment to supporting the independent repair channel, and will provide you with the highest level of customer service. They focus on the things that matter most to you!

## **Convenience...Accuracy... Profitability...Delivery**

A PartsPro dealer has the tools in place to better meet the needs of their esteemed wholesale customers.

For a dealership to achieve PartsPro Certification, parts department personnel must first undergo intensive "customer-centric" training which teaches personnel how to better help YOU.

There's far more to PartsPro than just customer-service training. The dealership must make specific commitments to provide "Best in Class" service in areas such as logistics, which includes ISP-focused parts availability, regular delivery service, outside sales people to provide you personalized service, as well as a dedicated phone line and "will call" pick up area.

## **Then there's technical help**

On occasion we all need a helping hand. Your PartsPro dealer is there to assist. Whether it means providing diagnostic assistance, information on supplies or special tools, or anything else you may need, your PartsPro dealer is there to assist you in repairing your customers' Mercedes-Benz vehicles and getting them back on the road as fast as possible.

Only those dealerships that meet the stringent certification requirements earn the right to display the "PartsPro" logo. Additionally, they receive ongoing consultation and training to ensure that they are consistently providing the very best support to you, the ISP customer.

We hope you are already receiving industry leading service from your Mercedes-Benz dealer; however, once your dealer is PartsPro Certified, we believe you'll be thrilled with the new "Best in Class" parts-procurement experience!

Of course, you'll continue to have the peace of mind that installing only Genuine Mercedes-Benz parts can provide. |



# Mobil 1 and Mercedes-Benz Oil Offer

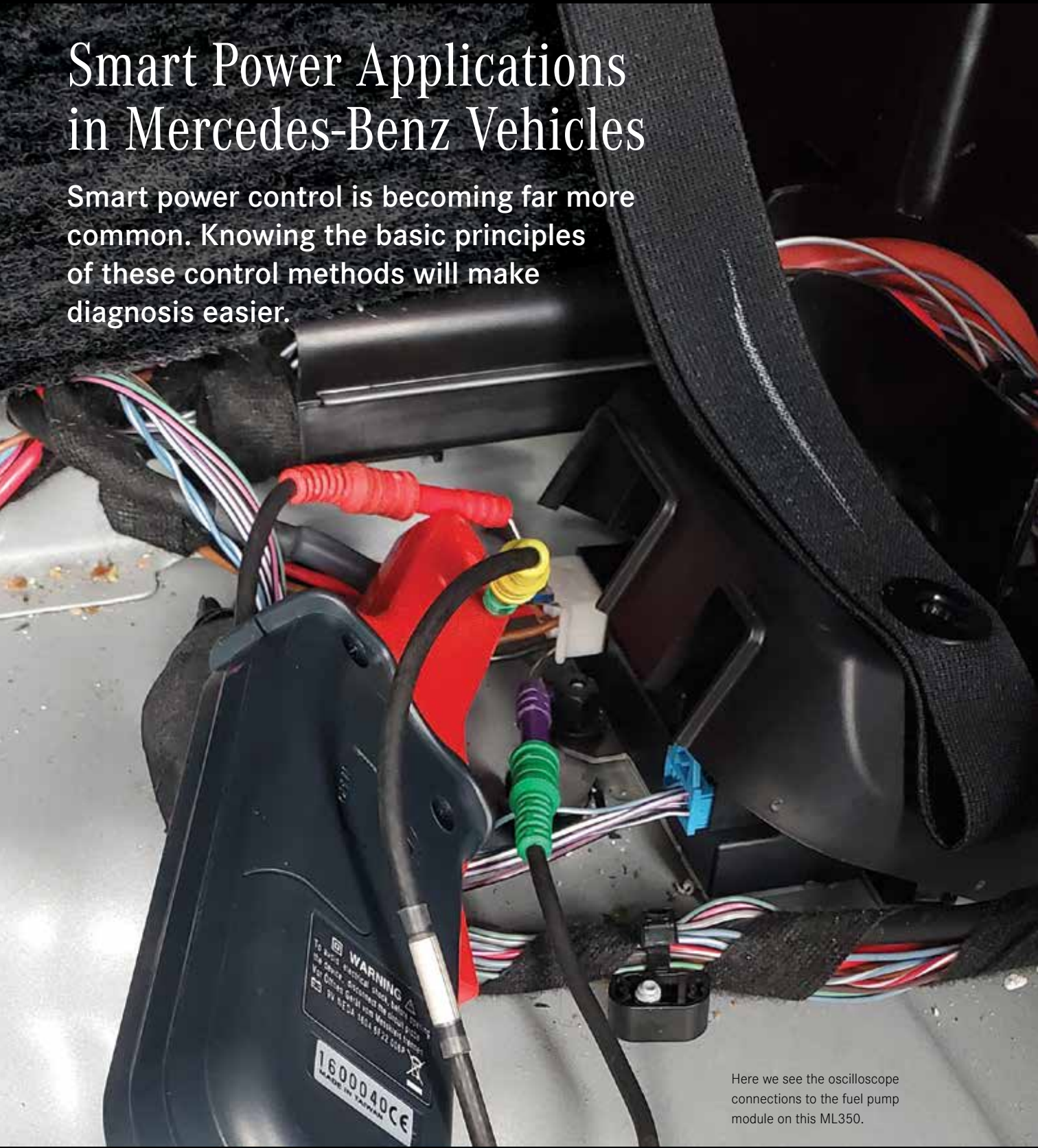
Product Name	Package Style	MBUSA Part #	Product Description	Recommended Consumer Application
MOBIL 1 0W-20	6X1 QUART	BQ.1090242	Advanced full synthetic formulation designed for enhanced fuel economy and cold weather performance	Most vehicles that specify 0W-20 (newer Toyotas and Hondas), 5W-20 and certain hybrids
	DRUM 55 GAL	BQ.1090241		
MOBIL 1 0W-30 AFE	6X1 QUART	BQ.1090174	Advanced full synthetic formulation designed for enhanced fuel economy and cold weather performance	Most vehicles that specify 5W-30 or 10W-30
MOBIL 1 5W-20	6X1 QUART	BQ.1090083	Advanced full synthetic formulation designed to meet the requirements of many newer vehicles including Hondas, Fords, Chryslers, and newer Toyotas	Vehicles that require 5W-20
	DRUM 55 GAL	BQ.1090084		
MOBIL 1 5W-30	6X1 QUART	BQ.1090250	Advanced full synthetic formula designed to meet the requirements of many domestic, including GM, and imported vehicles	Vehicles that require 5W-30. Corvette approved.
	DRUM 55 GAL	BQ.1090249		
MOBIL 1 10W-30	6X1 QUART	BQ.1090230	Advanced full synthetic formula designed for domestics and imports	Vehicles that require 5W-30 or 10W-30
MOBIL 1 15W-50	6X1 QUART	BQ.1090231	Boosted, higher viscosity, advanced full synthetic formula designed for performance vehicles	HT / HS applications. Racing and Flat tappet applications
MOBIL 1 ESP X1 0W-30	6X1 QUART	BQ.1090182	Advanced full synthetic formulas designed specifically for diesel passenger cars that have particulate filters	Low SPAsh. Available at most MB dealers.
	DRUM 55 GAL	BQ.1090183		
	BULK	BQ.1090184		
MOBIL 1 ESP 0W-30	6X1 QUART	BQ.1090278	Advanced full synthetic engine oil designed to help provide exceptional cleaning power, wear protection and overall performance	Meets MB 229.52 specification. Low Sulfur and Phosphorous content
	DRUM 55 GAL	BQ.1090279		
	BULK	BQ.1090281		
MOBIL 1 ESP 5W-30	DRUM 55 GAL	BQ.1090286	Advanced full synthetic motor oils are designed to help prolong the life and maintain the efficiency of emission systems in both diesel and gasoline-powered vehicles	Meets MB 229.52 specification. Fully compatible with passenger cars that have the latest diesel particulate filters (DPFs) and or those with gasoline catalytic converters (CATs)
	6X1 QUART	BQ.1090273		
MOBIL 1 FORMULA M 5W-40	6X1 QUART	BQ.1090213	Fully synthetic formulas designed specifically for gasoline passenger cars	Low SPAsh. Available at most MB dealers.
	DRUM 55 GAL	BQ.1090240		
	BULK	BQ.1090214		
MOBIL 1 FS 0W-40	6X1 QUART	BQ.1090015	Fully synthetic formulation designed to meet the requirements of many European vehicles	Meets MB 229.5 specification along with many other European vehicle specifications, including Porsche A40. HT / TS applications.
	DRUM 55 GAL	BQ.1090016		
	BULK	BQ.1090010		
MOBIL 1 FS X2 5W-50	6X1 QUART	BQ.1090211	Advanced full synthetic motor oils are designed with a proprietary blend of ultra-high-performance synthetic base stocks fortified with a precisely balanced component system	Suited for extreme driving conditions and motorsports applications.
MOBIL 1 SYNTHETIC ATF	6X1 QUART	BQ.1090164	Multi-vehicle, fully synthetic fluid designed to meet the demanding requirements of modern passenger vehicles	Vehicles that require Dexron III, Ford Mercon and Mercon V performance levels
	DRUM 55 GAL	BQ.1090163		
MERCEDES BENZ HIGH PERFORMANCE EO 229.5 0W-40	6X1 LITER	A000989810211BIBU	Fully synthetic formulas specifically designed for Mercedes-Benz engines that require the 229.5 specification	Mercedes-Benz engines that require 229.5 specification oil
	DRUM 208L	A000989810217BIBU		
MERCEDES BENZ GEO 229.5 5W-40	6X1 LITER	A000989790211BIFU	Fully synthetic formulas specifically designed for Mercedes-Benz engines that require the 229.5 specification	Mercedes-Benz engines that require 229.5 specification oil
	DRUM 208L	A000989790217BIFU		
	BULK	A000989790219BIFU		
MERCEDES BENZ GEO 229.52 5W-30	6X1 LITER	A000989800211BMEU	Fully synthetic formulas specifically designed for Mercedes-Benz engines that require the 229.52 specification	Mercedes-Benz engines that require 229.52 specification oil
	DRUM 208L	A000989800217BMEU		
	BULK	A000989800219BMEU		
MERCEDES BENZ GEO 229.6 5W-30	6X1 LITER	A000989820211BJEU	Fully synthetic formulas specifically designed for Mercedes-Benz engines that require the 229.6 specification	Mercedes-Benz engines that require 229.6 specification oil
	DRUM 208L	A000989800217BJEU		
MERCEDES BENZ GEO 229.71 0W-20	6X1 LITER	A000989830211BNXU	Fully synthetic formulas specifically designed for Mercedes-Benz engines that require the 229.71 specification	Mercedes-Benz engines that require 229.71 specification oil
MB GENUINE ATF FE 236.15	DRUM 208L	A000989270417BULU	Fully synthetic formulas specifically designed for Mercedes-Benz engines that require the 236.15 specification	Please check owners manual to verify ATF specification requirement of the vehicle prior to ordering.
MB GENUINE ATF FE 236.17	12X1L	BQ.1090287	Fully synthetic formulas specifically designed for Mercedes-Benz engines that require the 236.17 specification	Please check owners manual to verify ATF specification requirement of the vehicle prior to ordering.

Product Name	Package Style	MBUSA Part #	Product Description	Recommended Consumer Application
MOBIL 1 SYN GEAR LUBE LS 75W-90	12X1 QUART	BQ1090085	Exceeds the most severe service requirements in both conventional and limited slip applications	Suitable for use in modern high performance automobiles like SUV's, vans and light duty trucks requiring an API SN / SM / SL / SJ
MOBIL SUPER 5W-20	6X1 QUART	BQ1090272	A synthetic blend motor oil recommended by ExxonMobil for gasoline-filled automobiles and light-duty trucks	Recommended by ExxonMobil for gasoline-filled automobiles and light-duty trucks
MOBIL SUPER 5W-30	6X1 QUART	BQ1090269	A synthetic blend motor oil recommended by ExxonMobil for gasoline-filled automobiles and light-duty trucks	Recommended by ExxonMobil for gasoline-filled automobiles and light-duty trucks
MOBIL SUPER 10W-30	6X1 QUART	BQ1090270	A synthetic blend motor oil recommended by ExxonMobil for gasoline-filled automobiles and light-duty trucks	Recommended by ExxonMobil for gasoline-filled automobiles and light-duty trucks
MOBIL SUPER 10W-40	6X1 QUART	BQ1090271	A synthetic blend motor oil recommended by ExxonMobil for gasoline-filled automobiles and light-duty trucks	Recommended by ExxonMobil for gasoline-filled automobiles and light-duty trucks
MOBIL SPECIAL 5W-20	6X1 QUART	BQ1090226	Formulated from quality base stocks combined with modern performance additives to give the engine the expected protection and performance under a wide variety of operating conditions	Recommended for gasoline fueled automobiles and DRUM 55 GAL BQ1090254 light duty trucks requiring API SN / SM / SL / SJ
	DRUM 55 GAL	BQ1090254		
MOBIL SPECIAL 5W-30	BULK	BQ1090251	Formulated from quality base stocks combined with modern performance additives to give the engine the expected protection and performance under a wide variety of operating conditions	Recommended for gasoline fueled automobiles and DRUM 55 GAL BQ1090254 light duty trucks requiring API SN / SM / SL / SJ
	6X1 QUART	BQ1090259		
MOBIL SPECIAL 5W-30	DRUM 55 GAL	BQ1090258	Formulated from quality base stocks combined with modern performance additives to give the engine the expected protection and performance under a wide variety of operating conditions	Recommended for gasoline fueled automobiles and DRUM 55 GAL BQ1090254 light duty trucks requiring API SN / SM / SL / SJ
	BULK	BQ1090255		
MOBIL SPECIAL 10W-30	6X1 QUART	BQ1090264	Formulated from quality base stocks combined with modern performance additives to give the engine the expected protection and performance under a wide variety of operating conditions	Recommended for gasoline fueled automobiles and light duty trucks requiring API SN / SM / SL / SJ
	BULK 55 GAL	BQ1090263		
MOBIL SPECIAL 10W-30	BULK	BQ1090260	Formulated from quality base stocks combined with modern performance additives to give the engine the expected protection and performance under a wide variety of operating conditions	Recommended for gasoline fueled automobiles and light duty trucks requiring API SN / SM / SL / SJ
	6X1 QUART	BQ1090223		
MOBIL SPECIAL 10W-40	BULK 55 GAL	BQ1090268	Formulated from quality base stocks combined with modern performance additives to give the engine the expected protection and performance under a wide variety of operating conditions	Recommended for gasoline fueled automobiles and light duty trucks requiring API SN / SM / SL / SJ
	BULK	BQ1090265		
MOBIL SPECIAL 20W-50	DRUM 55 GAL	BQ109004664	Formulated from quality base stocks combined with modern performance additives to give the engine the expected protection and performance under a wide variety of operating conditions	Recommended for gasoline fueled automobiles and light duty trucks where a higher viscosity API SN / SM / SL / SJ oil is preferred or recommended
MOBIL DELVAC 1 ESP 5W-40	JUG 4X1 GAL	BQ1090229	Fully synthetic supreme performance heavy duty diesel engine oil that helps extend engine life while providing long drain capability and fuel economy for modern diesel engines operating in severe applications	Recommended for use in all super high performance diesel applications, including modern low emission engine designs with Exhaust Gas Recirculation (EGR)
	DRUM 55 GAL	BQ1090233		
MOBIL DELVAC 1300 SUP 15W-40 (CK-4)	6X1 QUART	BQ1090219	Extra high performance diesel engine oils that help extend engine life in the most severe on and off-highway applications while delivering outstanding performance in modern, high-out-put, low-emission engines including those with Exhaust Gas Recirculation (EGR) and Aftertreatment Systems with Diesel Particulate Filers (DPFs) and Diesel Oxidation Catalysts (DOCs)	Specifically recommended for the latest low-emissions, high performance diesel applications equipped with after treatment systems using Diesel Particulate Filter (DPF) and Diesel Oxidation Catalyst (DOC) technologies
	JUG 4X1 GAL	BQ1090220		
	DRUM 55 GAL	BQ1090221		
MOBIL ATF D/M	BULK	BQ1090053	Provides excellent oxidation and friction stability, anti-wear properties and low-temperature fluidity desired for most automatic transmissions	Recommended by ExxonMobil for use in applications requiring: GM DEXRON® IIIH transmission fluid Ford MERCON® transmission fluid Allison C-4 transmission fluid
	6X1 QUART	BQ1090222		
MOBIL ATF 134	DRUM 55 GAL	BQ1090274	Mobil ATF 134 is an extra high performance automatic transmission fluid formulated with selected HVI base oils	Recommended for use in Mercedes automatic gearboxes
	BULK	BQ1090275		
MOBIL ATF 134	DRUM 55 GAL	BQ1090166	Mobil ATF 134 is an extra high performance automatic transmission fluid formulated with selected HVI base oils	Recommended for use in Mercedes automatic gearboxes
MOBILGREASE XHP 222	CART 10X0.39KG/13.7OZ	BQ1090217	Formulated to provide excellent high temperature performance with superb adhesion, structural stability and resistance to water contamination	Recommended for industrial and marine applications, chassis components and farm equipment
MOBILUBE HD PLUS 80W-90	KEG 120 LB	BQ1090096	Extra high performance, automotive lubricant formulated from select base oils and an advanced additive system specifically for limited-slip differentials	Recommended for use in limited-slip differentials, exles, and final drives requiring API GL-5 level performance
DIESEL EXHAUST FLUID (AD BLUE)	JUG 4X0.5 GAL	A0005830107	Non-toxic solution that transforms harmful Nitrogen Oxide (NOx) emissions from diesel-powered vehicles into harmless water vapor and nitrogen	Recommended for use in Mercedes-Benz, Volkswagen, and VMW AdBlue (DEF) applications
	DRUM 208L	BQ1470002		
MB POWER STEERING FLUID	6X1 QUART	BQ1460002	Automatic transmissions should be checked for proper fluid levels at regular intervals, and the fluid should be changed at manufacturer-recommended intervals	Recommended for use in Mercedes-Benz vehicles



# Smart Power Applications in Mercedes-Benz Vehicles

Smart power control is becoming far more common. Knowing the basic principles of these control methods will make diagnosis easier.



Here we see the oscilloscope connections to the fuel pump module on this ML350.

The exponential advancement in vehicle systems technology in recent years has led to the emergence of “smart power” control of automotive motors, pumps, solenoids and other devices, delivering increased operating efficiency and component life. Read on to explore what it is, how it works and seriously raise your diagnostic game!

## So, what is “Smart Power”?

Back when vehicles first started showing up with electronically controlled systems, such as computer-controlled carburetors and early electronic fuel injection systems, traditional mechanical fuel pumps and other devices were replaced with electric motors, electric injectors and computers to control them.

These were relatively simple systems: A fuel pump, for example, would have the ECM (Engine Control Module) switch ground to actuate a fuel pump relay, which in turn would energize the fuel pump with system voltage, causing it to run. The pump was energized anytime the engine was running, and would stay running at 100 percent for the entire drive cycle. We considered strategies such as the “2-second key-on prime” and emergency fuel shutoff when engine speed reference was lost as “high tech.” Running full bore all the time, these motors consumed a good amount of energy while running at about 78-85 percent efficiency. Although designed for a long life, eventually they wore out because they were always running at 100 percent.

Enter the era of high-pressure injection systems: In these systems, the fueling demands are significantly different than that of a low-pressure EFI system. Not only are higher fuel pressures required, but somewhat higher volumes for heavy load conditions must be supplied. In a stratified-charge engine, used by Mercedes-Benz in Europe but not in the United States, an injector may need to fire up to five times per engine stroke (with an average of three).

A variable-speed pump which, under high load, could be ramped up to full pressure and volume, and also be

run at minimal pressure and volume in deceleration mode (e.g., injection cutoff) would be an optimal way of supplying fuel. Controlling the energy consumption of this major consumer would have a noticeable impact on the energy used by the vehicle, resulting in improved fuel economy and reduced wear and tear on the fuel supply components. But how to do this?

Using a simple on-off relay to control the fuel pump precludes varying the pump’s speed, so Mercedes-Benz engineers turned to technologies used for the control of very large industrial motors: Smart Power design. This is really a high-tech solution to a difficult problem, and knowing how it all works will serve you well.

## PWM

Pulse Width Modulation (PWM) is method of switching (cycling) voltage to an electrical load on and off at relatively high speed (frequency). If you wanted to control the brightness of a light bulb (the electrical load) for example, you might try to flick it on and off by hand, but due to the limits of the human body, you couldn’t do this fast enough to avoid seeing the bulb flicker. But get some electronics involved – say, a household dimmer switch, which operates much faster – and the light doesn’t seem to flicker any more, just its brightness is reduced. Since there is some ‘off’ time, less energy is supplied. Less energy means less brightness.

In its basic form, PWM is DC power switched on and off very rapidly, created by a control circuit, usually a microcontroller (a computer-on-a-chip). This controller generates low-power control signals. These signals trigger a ‘driver’ circuit using large solid-state devices capable of handling both the necessary electrical current and switching it on and off thousands of times each second.

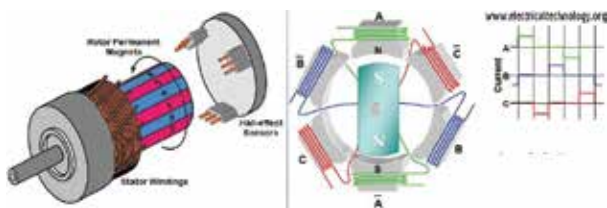
Way back in the day, a DC motor’s speed was controlled by simply reducing the voltage to the motor. Think of a ballast resistor pack for the HVAC blower motor in a W201 model: Four blower speeds created by different resistance values, which varied the voltage to the motor.



Today, instead of wasting that energy to heat in a resistor pack, we use PWM control, which has the added value of a nearly infinite speed control capability.

The basic idea is that if the power is on for just a small portion of the time, the energy delivered to the load is small; conversely, larger portions of ‘on’ time deliver more energy, just like that light dimmer in your house. If the frequency is high enough – 10 to 30 kHz are not uncommon – the load (such as an engine cooling fan) averages out the energy and runs just as if it were receiving a reduced DC voltage. The high frequencies, usually selected to be above the hearing range of humans, have two reasons: So the circuit doesn’t generate noise, and because higher frequencies can use smaller (and less costly) electronic controls. Maybe you’ve used a variable-speed drill and heard the ‘whine’ noise at very low speeds?

In the world of DC motors, there are brushed and brushless types. Brushless motors, which use powerful magnets instead of electrical coils on the rotor, are much more efficient than brushed motors – but also cost more. They are also somewhat better to use as variable-speed motors.



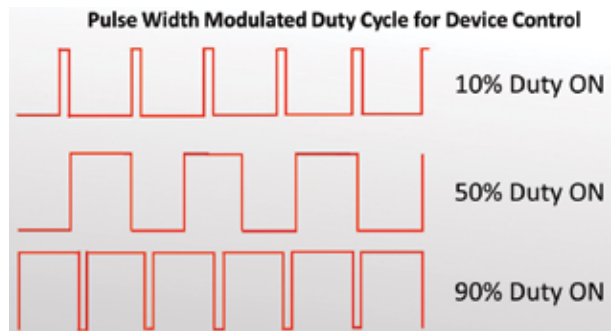
Construction, working principle and operation of Brushless DC (BLDC) motors. (Image courtesy of electricaltechnology.org.)

Varying the duty cycle of a motor’s power supply (Pulse-Width Modulation) is ideal for controlling DC brushless motors. The basic principle is to deliver pulsed (variable) voltage to the stator (outer) winding coils of the motor at a high frequency, which creates a magnetic force from each coil, driving the permanent magnet poles on the rotor, causing it to turn. The voltage can be reversed, turning the motor in the other direction.

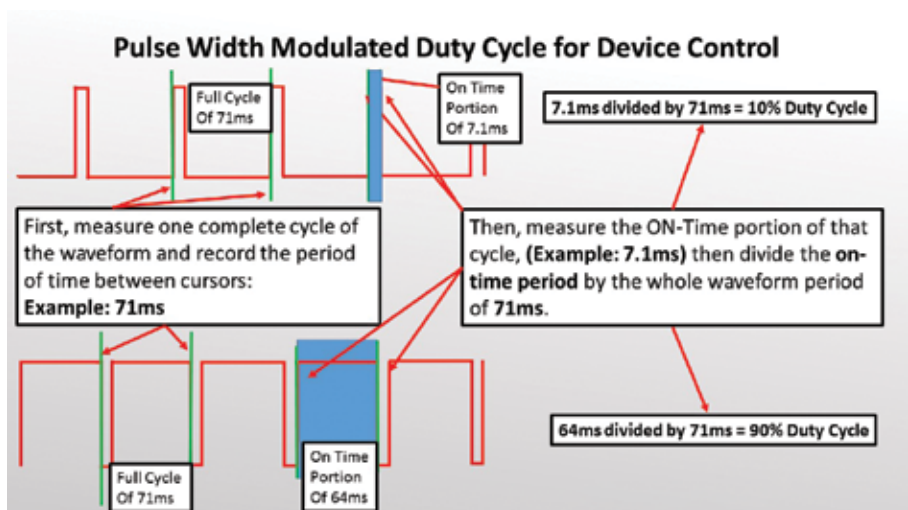
Changing the average energy (current and voltage) delivered to the motor affects the amount of power the motor can produce, changing its speed for a given load. In some cases it is also an advantage to change the drive frequency as well, but this has a minimal effect upon the speed of a brushless DC motor.

## Duty Cycle

Duty Cycle is defined as the signal’s percentage of ON time as compared the ON plus OFF time. For example, a signal that is on for 1 microsecond and off 9 microseconds would have a 10 percent duty cycle. This means that a 0 percent duty cycle would be completely off and a 100 percent duty cycle would be full on. While that describes a circuit that controls the positive voltage (‘high-side switching’), in circuits that switch the ground side on and off (‘low-side switching’) the numbers are reversed, because a ground signal turns the circuit on. In other words, for low-side switching circuits, 0 percent duty cycle is full on, and a 100 percent duty cycle is off.



Here we see the duty-cycle waveforms for 10%, 50% and 90% “on” time. (Image courtesy AutoMaster Training Series.)

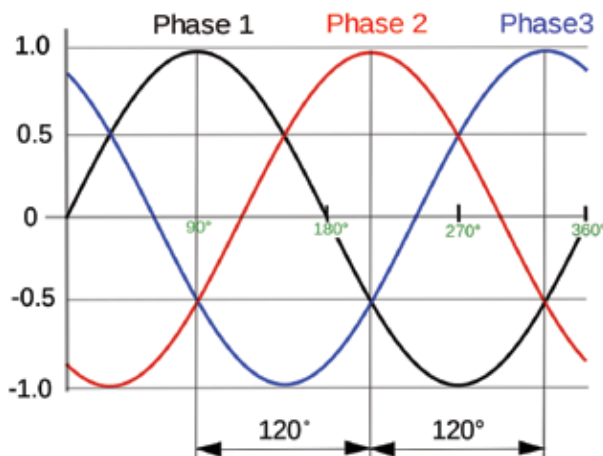


This is how we calculate the duty cycle of a PWM signal using the measured dimensions of an oscilloscope trace. (Image courtesy AutoMaster Training Series.)



Note: A good indicator of whether you are dealing with a high-side (positive voltage) device or a low-side (ground-controlled) device is that, generally, low-side devices will have a direct wire to battery voltage (possibly fed through a relay or fuse, for example an O2 sensor heater) while a high-side device will generally have a direct wire to ground. Of course, the wiring diagram should be consulted to be sure.

When PWM technology is used to power devices, there is normally some form of feedback to the control module via sensors or current monitoring. This allows the computer to sense and react to changing conditions, hence the term “Smart Power”, as we know it in driveability applications. For example, as engine coolant temperature increases, the electric cooling fan is commanded to run faster.



A typical 3-phase voltage pattern. These are always exactly 120 degrees out of phase with each other as seen here. 360 degrees represents a single AC voltage cycle.

Technicians would typically be able to see the sensor data with a scan tool such as the Actual Values screen in XENTRY Diagnostics, perhaps in the form of a motor current or speed, pressure, temperature or some other value that needs to be controlled.

## Frequency Control

While PWM speed control of an engine cooling fan has been in use for several years, new for automotive applications are 3-phase AC motors. Here, the drive current and voltage are nearly constant, while the frequency of each phase is varied. The motor winding for each phase can be made to attract or repel the windings on the rotor, or be even locked in position by supplying zero-frequency voltage (which is DC). So as the frequency increases, so does the motor speed. Also, by varying the sequence of the three phases, the motor’s direction can be reversed. This isn’t PWM, but instead a variable-frequency drive.

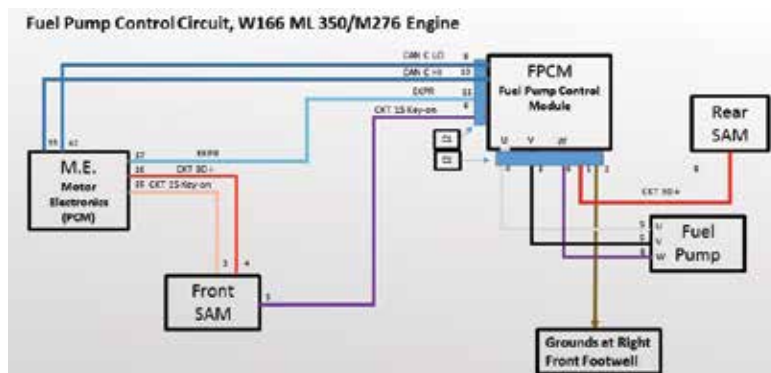
This, for example, is how an electric vehicle (EV) drive motor operates – the accelerator pedal input is used to vary the motor drive frequency output between zero and several kilohertz. Other 3-phase AC motors in newer Mercedes-Benz vehicles include the 3-phase fuel pump and the throttle control motor. Using three phases means we need each phase to be 120 degrees – both mechanically and electrically – apart for the motor to operate properly.

So, while the DC-based PWM control uses a pulsed DC voltage with a varying duty cycle to control the motor speed, 3-phase AC motor’s speed is controlled by varying the frequency of the AC drive waveform. Some PWM is also used, in this case to control the motor’s current (and therefore power output). We have already see how PWM works.

To help you better understand this 3-phase AC speed control, let’s look at a case study: The 3-phase AC fuel pump in a 2015 Mercedes-Benz ML350.

## Test Subject: 2015 Mercedes-Benz ML350

In the ML350 used in this article, we used an 8-channel lab scope to monitor several relevant signals. At the Fuel Pump Control Module, located in the spare tire well, three of the ‘scope channels (red, yellow

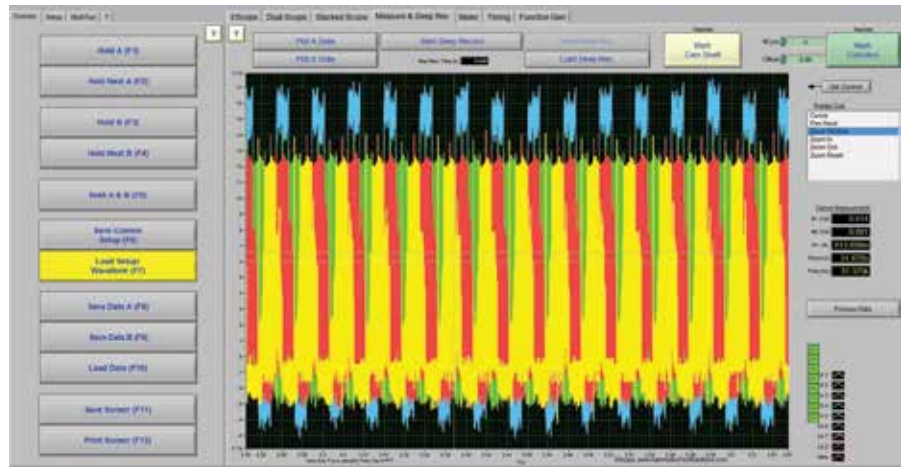


This shows the 3-phase fuel pump control circuit for a Mercedes-Benz ML350 with an M276 engine. Note the U, V and W phases powering the fuel pump. (Image courtesy AutoMaster Training Series.)

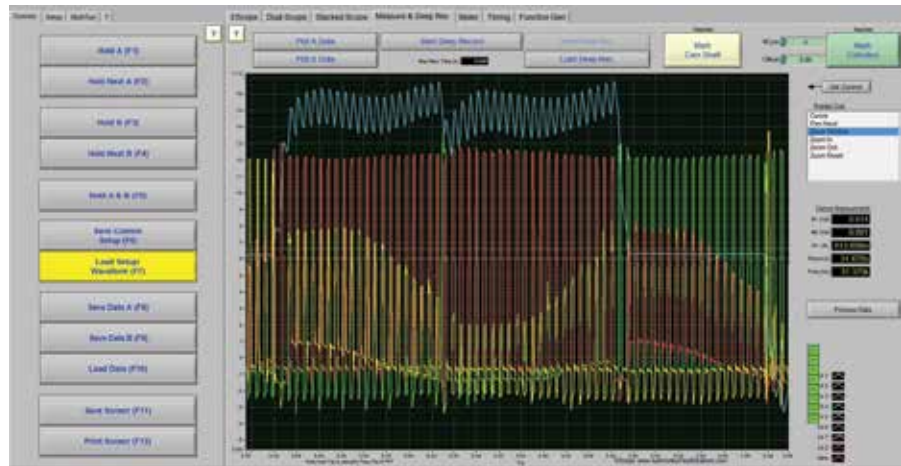
and green) were connected to the three variable-frequency motor drive signals (known in the industry, and here, as U, V and W – see the image showing the circuit). A fourth channel – blue – was connected to a Current clamp to monitor motor current on just one of the motor’s three phases. You can see just how the connections were made, which involved back-probing the electrical connector, in the photo nearby.

Let’s look at some live scope captures of the 3-phase fuel pump control system in this 2015 ML320 with an M276 Gasoline Direct Injection engine to visualize the 3-phase control. Using a lab scope in diagnosis allows the technician to see the three phases being fed to the pump, with a visual indication if any of the phases are not symmetrical with the others. In a PWM circuit, as we saw previously, the actual duty cycle can be measured. Not every diagnosis needs an oscilloscope, and indeed not every technician will learn how to use one, but those that do will have a distinct advantage.

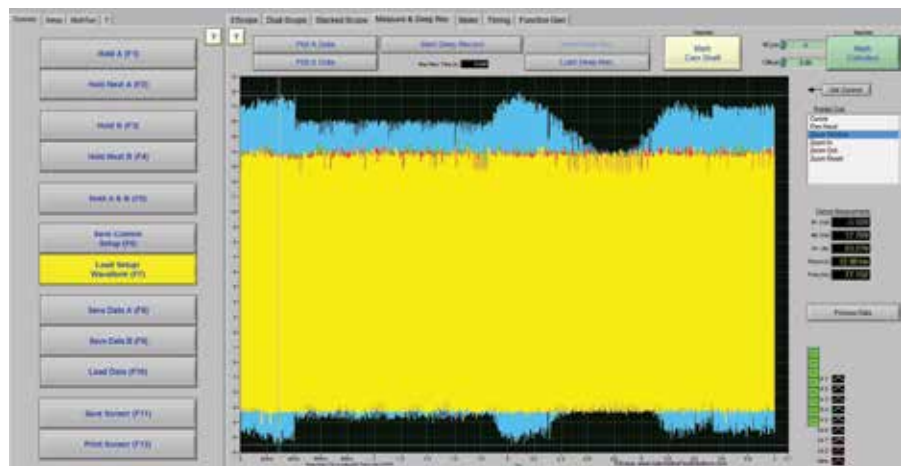
Have a close look at the oscilloscope image in the middle of this page, showing the four signals we are monitoring. We can see that the voltage is nearly constant for each of the



The 3-phase waveform of the ML320 fuel pump. You can see the 120 degree phases of voltage in the Yellow, Red and Green traces. The blue trace is the motor’s current waveform.



A closer look at the 3-phase fuel pump waveform, showing how the motor current (blue, connected to the red phase) responds to the phasing of the voltage.



The motor current (blue) changes as load is changed. See the text for the explanation.

phases (yellow, red, green). Because we have overlaid all three phases atop each other, it appears as if the voltages change – for example, the yellow signal as the

red becomes dominant – but in reality that is an illusion caused by the way the scope displays signals. We are showing this so you can see what your scope will usually show you. The image below, taken from a leading test instrument manufacturer’s site, shows 3-phase motor signals, but separated from each other for clarity, so you can see what we mean.

Also note that the voltage to each phase is pulsed: As mentioned, this is a form of PWM, but used for power control instead of speed control: When the fuel pump doesn’t need to pump so much fuel, we can cut back on the energy used using PWM. Smart control indeed.

The best part of using a scope instead of a scan tool is that you can actually see the electrical behavior of the driver, the wiring and the load all at the same time. This can help quickly isolate what the problem is in the circuit.

You can zoom in even more from here and measure the duty cycle and frequency of the motor control voltage. This can confirm or disprove that the motor is working as commanded.

Have a closer look at the image that shows mostly yellow, at the bottom of the previous page. Notice how the current (blue) changes from left to right. What you are seeing here is how the motor current changes with demand: After a period of idling, we see the current jump up as the engine speed is increased to 1500 RPM. It then drops off once the engine is at constant speed, only to jump up again as speed is increased to 3000 RPM. This confirms proper operation of the whole system.

We took some detailed measurements of all this: During idle at 650 RPM, the fuel pump operated at a 28 percent duty cycle and current was 18 to 19 amps, turning the pump at about 6,200 RPM. At an engine speed of 1,500 RPM, duty cycle was 43 percent, current draw 21 amps and the pump turned about 7,500 RPM. Finally, at an engine speed of 3,000 RPM we measured a 47 percent duty cycle, 23 amps and 8,350 pump RPM.

At the same time, the PWM frequency changed from 10.37 kHz at idle, to 12.52 kHz at 1500 RPM and 14.02 kHz at 3000 RPM, demonstrating how drive frequency changes the pump’s speed (the ratio of pump speed to frequency is about 0.6) while duty cycle affects the pump’s power. These readings were taken while revving the engine in park, in a no-load condition. Under load, the changes would be a little more dramatic, but not a whole lot: the system is very accurately controlled.

Diagnosing newer smart power and PWM circuits most definitely require a slightly deeper understanding of the operating theory behind pulse width modulation, how to measure the duty cycle, current and voltage properties of these circuits. It is our hope that this article helps you to test these systems with more confidence! |



The same 3-phase motor signals, at top shown as voltage/current pairs, and below as voltages (and currents) superimposed. Note how the voltages (yellow, pink, blue) in the lower image seem to vary in amplitude, even though the upper image shows they really do not. Image courtesy Teledyne LeCroy.

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