Automotive electronics

What you need to know! Part 3
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In this issue we would like to discuss the Passive Entry/Go system. These systems provide a passive means of both locking/unlocking the vehicle and starting/stopping the engine, that is to say, owners of these latest-generation systems only need to carry the RF key along with them. They no longer need to look for the RF key or have it in their hand to actuate a function by actively pressing the appropriate button on it. These access and driver authentication systems provide a plus in convenience and make it much easier to get into the car. Here we would like to explain the components and what they do. The text is illustrated with Passat B6 components. To obtain more detailed information about a vehicle-specific system, please refer to the technical data provided by the relevant manufacturer.

The Passive Entry/Go function requires a couple of system components to be added on to the conventional central locking system, including:

### Control unit

In a Passat B6, the Passive Entry/Go functions are controlled by the central control unit for convenience systems. This so-called convenience control unit is located underneath the dashboard towards the right and behind the glove compartment.

Functions controlled by the convenience control unit include:
- Central locking
- Motor-driven opening/closing of windows and sun roof
- Car alarm system
- Tyre pressure control
- Steering column lock

Another task of the control unit is to check the system for errors and store a log of any errors encountered. The RF key and the control unit communicate at different frequency ranges, i.e. 433 MHz or 315 MHz, depending on the region.
The ID transmitter is an RF key, the expanded functionality of which (identification transmitter) includes the passive functions. It therefore classifies as a combination of a “simple remote control” and an identification transmitter.

Active locking or unlocking the vehicle at distances of up to 100m requires the keys on the ID transmitter to be pressed manually. Passive unlocking is done by gripping the door handle, whereas passive locking is done by touching a sensor spot on the door handle. For safety reasons, passive operation is restricted to the immediate vicinity of the ID transmitter (approx. 2m). The ID transmitter uses radio signals to communicate with the control unit.

It also contains a mechanical emergency key that the driver can use to manually unlock the car, e.g. if the battery in the RF key is empty.

The ID transmitter consists of a splash-proof housing for the electronic circuitry, the aerials and the key panel. The keys for the manual control of functions (e.g. unlocking, locking, boot lid, panic button) are located on the top of the housing.

And there is a small LED that will light up when a button is pressed, for example. A 3D LF aerial in conjunction with a LF pre-stage IC with integral microcontroller allow an accurate measuring of field strengths received from all three directions in space and, thus, to reliably differentiate between the inside and outside of the vehicle. The UHF receiver aerial is located on the circuit board. The ID transmitter also has a battery monitoring feature.
When the battery is discharged down to a critical level an alert will appear on the dashboard display and the small LED will no longer light up when a button is pressed.
To save battery energy, intelligent wake-up algorithms ensure that the ID transmitter is not "woken up" unnecessarily (e.g. by other radio systems). An integral day counter enables a power-down mode for ID generators that are not used (e.g. a second key). This ensures that the battery retains a sufficient level of capacity for extended periods of time.

### Doorhandle- Electronic modules

The receiving aerials and the proximity and locking sensors for recognising, unlocking or locking the vehicle are located in the front door handles.
The sensors in the rear door handles are only there to recognise, unlock or lock the vehicle.

The proximity sensors are capacitive sensors, i.e. when the driver’s hand enters the capture area of the proximity sensors the capacitive sensors will detect it and output a signal to notify the convenience control unit.

### Aerials

Aerials Aerials are not only located in the door handles but also along the outer shell and on the interior of the vehicle.
An outside aerial is the rear-end aerial which is installed in the rear bumper where it is responsible for proper rear-end reception.
Passive Entry / Go

The interior, boot and rear shelf aerials make up the set of aerials installed inside the vehicle.

The interior, boot and rear-end aerials consist of a ferrite coil and capacitor and make up a series resonance circuit. The rear shelf aerial is a flexible circuit board with a conductor loop that generates the field.

Before a vehicle function is performed, the system checks whether the vehicle user is carrying an authorised ID transmitter. When the control unit receives a signal from the capacitive proximity switch in the door handle, it returns a signal to the ID transmitter which responds by sending a response telegram via a UHF channel frequency (433MHz or 315MHz). The signal sent by the vehicle on the 125kHz carrier frequency of the LF aerials is not only used for data communication with the ID transmitter but also helps to reliably find the exact position of the ID transmitter.

This provides a highly accurate means of determining whether the transmitter is inside or outside the vehicle. It is absolutely essential to determine the position as accurately as possible because the control unit must verify whether an authorised ID transmitter is actually in the passenger compartment and, thus, whether the engine can be allowed to start or whether an ID transmitter that is still in the vehicle needs to be disabled after locking the car (when the vehicle is locked with another authorised ID transmitter outside the vehicle).
Passive Entry / Go

Unlocking of vehicle:
When a vehicle user carrying an authorised ID transmitter approaches the vehicle and enters the capture area of the proximity sensors, the system will "wake up". The aerials in the door handles and the ID transmitter will establish radio communication. To check whether the ID transmitter is actually authorised to open this vehicle, the system will compare its electronic fingerprint with that of an internal electronic/logic "key". If the control unit finds that the two IDs match it will enable the central locking system and open the car. Either one or all doors can then be opened, depending on the current CLS coding. It takes the system approx. 50ms to 60ms to complete the entire process, i.e. from actuating the capacitive sensors in the door handle to unlocking the vehicle. In order to minimise power consumption during extended periods of not using the vehicle, the proximity sensors in the passenger-side and rear doors switch themselves off.

They are reactivated by one of the following events:
- The ID transmitter is recognised by the driver’s door or the boot lid
- The vehicle is actively unlocked using the RC unit
- The emergency key is used to mechanically unlock the vehicle
- Convenience unlocking is not supported by the Passive Unlock function

Starting of engine:
This vehicle provides two ways of starting the engine: using the ID transmitter or the ignition starter switch (starter button).

The ignition lock of the Passat accepts both the ID transmitter and the ignition starter switch. Its functions are equivalent to those of a normal ignition lock. If preference is given to using the ignition starter switch the switch can permanently stay in the ignition lock. All it takes for the engine to be started is that an authorised ID transmitter is detected inside the vehicle.

This type of ignition lock differs from a normal ignition lock in that the key does not need to be turned but that the ID transmitter or ignition starter switch is pushed into the ignition lock instead.
The lock can be at one of the following positions:
Position 1 = S contact on (radio turns on).
Position 2 = Terminal 15 on.
Position 3 = Default position assumed by the ignition starter switch / ID transmitter after starting the engine (terminal 15 drive).
Position 4 = Engine start (terminal 50).

To start the engine, push the ignition starter switch / ID transmitter into position 4. When the engine is running, simply let go of the ignition starter switch / ID transmitter.

Important note:
The ignition starter switch will fail to start the engine if the battery in the ID transmitter is empty. In this case you must pull out the ignition starter switch and put the ID transmitter in the ignition lock instead. Inside the ID transmitter there is a transponder pellet for disabling the steering column lock. Since this pellet is supplied with external energy it works without the battery and allows the engine to be started even if the battery in the transmitter is empty. Make sure, though, that the transponder pellet function is available only if the ID transmitter is in the ignition lock.

Vehicles with a manual gearbox can be started only if the clutch pedal is pressed. To start the engine of vehicles with automatic transmission you must press the brake pedal. Pre-heating of diesel engine vehicles works in a similar way to the pre-heating of vehicles with a conventional ignition lock. After turning on the ignition you should not start the engine until the pre-heater lamp has gone out. Only then would you push in the ignition starter switch / ID transmitter to the “Engine Start” position.

To turn off the engine:
To turn off the engine, press the ignition starter switch / ID transmitter right into the ignition lock again. When you let go it will return to the “Ignition On” position. Then pull back the key by one more step to actually turn off the ignition.

Another difference between the ID transmitter and the ignition starter switch is that you can simply remove the ID transmitter from the ignition lock, whereas the ignition starter switch is barred and can be removed only if it is unlocked first. Pull back the ignition starter switch in the ignition lock as far as possible. Then press the unlocking button on the bottom side of the switch and pull it out.

Note on the electronic steering lock:
When the ID transmitter is pulled out of the ignition lock, the steering column will be locked electronically. Since it is possible to leave the ignition starter switch in the ignition lock, the electronic steering lock will be actuated only when there is no authorised ID transmitter left in the car.
To lock the vehicle:
As with unlocking the car, there are also two ways of locking it, i.e. either actively using the RC unit or passively by touching the locking sensor in the door handle. However, the latter method requires an ID transmitter to be within close range of the vehicle. Touching the locking sensor once will lock the vehicle and enable the "Safe" function. Touching the locking sensor twice will also lock the vehicle but will not enable the "Safe" function. Passive locking also supports the "Convenience Locking" feature when the locking sensor is touched for more than two seconds. The system has a safety relock function: the vehicle will automatically relock if a door or the tailgate is not opened within 30 seconds of unlocking the car.

Door handle with locking sensor
You can unlock and lock the boot independently without having to unlock the other doors. Assuming an authorised ID transmitter is within the capture range of the rear aerial, the boot can be unlocked by pressing the Unlock Boot button (VW sign). If the boot is closed while the authorised ID transmitter is within the reception range but outside the vehicle, the boot will automatically relock.

ID transmitter inside the car
It is not possible to lock the vehicle from the outside while the ID transmitter is still inside it. This is to prevent the ID transmitter from being locked in inside the car.

ID transmitter in boot
It is not possible inadvertently to lock the authorized ID-transmitter in the boot if the doors are already locked.
If, in this situation, the ID-transmitter is detected in the boot, the boot is immediately automatically opened again.

Turning off the proximity sensors in the door handles
If you park and lock the vehicle very close to a hedge or similar object you may find that leaves, branches etc. keep actuating the proximity sensor in the door handle which will respond by searching for an authorised ID transmitter. To save battery energy the proximity sensor will be switched off for 30 minutes to avoid this unreasonably frequently repeated actuation.
If this problem affects the driver’s door only the sensor in the driver’s door will be turned off. If the rear doors or the passenger-side door are affected these doors will be turned off together. The sensor will reactivate when the vehicle is unlocked either by an active sensor or the RC unit or if the boot is opened.

The complexity of the systems installed in today’s vehicles may sometimes make it pretty complicated to locate a fault. This applies to both electronic and mechanical systems. But there are also mistakes that users make when operating Passive Entry/Go systems, suggesting that the systems don’t work properly. It is therefore quite important to take good heed of the manufacturers’ operating instructions and other sources of information.

The very design of the systems and the fact that control units are stations of CAN bus networks dictate that suitable diagnostic equipment must be used for troubleshooting and that reference must be made to specific documents provided by vehicle manufacturers, including repair instructions, circuit diagrams, descriptions of functions, etc. Just one example: in the Passat B6 we used to illustrate our text, unlocking the electronic steering wheel lock requires a release from three separate control units and the ignition lock.

This redundant way of implementation is necessary to meet strict safety requirements. Replacing defective control units is another field in which things are becoming increasingly complex. In the Passat, for example, control units (e.g. the convenience control unit or the engine control device) that belong to the steering column lock need to be online before they can be taught-in. This makes it a must to contact an authorised dealer even if diagnosis managed to successfully locate a fault.
In this section we will look at the airbag system. We will explain its components, their function within the system, the way they are actuated, and possible troubleshooting procedures. Since the introduction of airbag systems, technology has advanced by leaps and bounds in the past few years. We will therefore stick to describing the components and processes in fairly general terms. To obtain more detailed information about the systems installed in specific vehicles, you should always consult the information provided by the relevant manufacturer. Make sure that only trained and skilled experts are allowed to service and diagnose the equipment in due compliance with the applicable statutory regulations and references. Airbag systems were first thought about way back in the 1960s. A major obstacle faced in those days was the time available to inflate the airbag. Some experimented with compressed air to solve the problem. This approach failed to meet the requirements, though. In the early 1970s, pyrotechnic propellants yielded a first success in inflating the airbag within the specified time. And 25 years ago, the first luxury class cars were equipped with airbags as an optional extra. Nowadays, airbags are standard equipment even in small cars.

Airbag control unit

The electronic control unit (ECU) is the heart of the airbag system and installed at a central place inside the vehicle, normally somewhere on the centre tunnel near the dashboard.

It does the following:
- Accident detection
- Time-critical recognition of sensor signals
- Time-critical actuation of appropriate ignition circuits
- Power supply to ignition circuits by means of a capacitor, i.e. independent of the on-board battery
- Auto-diagnosis of the entire system
- Stores any faults that occur in the fault memory
  - Turns on the airbag control lamp to indicate system failures
- Connects to other control units via the CAN bus

Today’s electronic control units store a bank of data obtained from whole series of crash tests, allowing the ECU to categorise an accident by its “crash level”.

The following levels have been defined:
**Crash level 0** = minor accident, airbags will not be actuated.
**Crash level 1** = medium accident, the first level of airbag action may be actuated.
**Crash level 2** = serious accident, the first level of airbag action will be actuated.
**Crash level 3** = very serious accident, the first and second levels of airbag action will be actuated.

To be able to sustain a varied crash response, the control unit computes various pieces of information such as the crash level, the direction of impact (effect of force), e.g. 0°, 30°, and the type of accident. Moreover, it also looks at other details such as information about whether passengers have their seat belts fastened or not.

### The crash sensors

Depending on the airbag system and the number of airbags installed, the crash sensors (also referred to as acceleration sensors) are either located directly in the control unit or are networked satellites installed at the front end or the side of the car.

There are always two sensors at the front-end of the car. These sensors are usually spring-and-mass systems which work as follows: The sensor houses a weight cylinder filled with standardised weights. A bronze spring band wound around the weight cylinder is attached to the weight cylinder at one end and to the sensor housing at the other. This setup stops the weight cylinder from moving unless a force impacts the cylinder from a specific direction. Following an impact, the weight cylinder will overcome the resilience of the bronze spring and make contact with the control unit loop. To allow self-testing, the sensor also houses a high-impedance resistor.

Another possibility of building motion sensors is to use a silicon mass. An impact on the sensor will make the silicon mass move inside the sensor. The way the mass is suspended in the sensor provokes a change in electrical capacity which the control unit can pick up and use as information.
Their fast reaction makes these sensors a favoured choice because they are extremely quick with providing the control unit with information about a side impact.

Other designs use pressure sensors instead. The pressure sensors are installed in the doors to react to a change in pressure inside the doors following an accident. In vehicles equipped with pressure sensors it is absolutely crucial to replace door sealing films properly after a door has been deformed for any reason. Otherwise, i.e. if a door sealing film is not in place correctly, there may a loss in pressure inside the door which consequently may prevent the pressure sensors from responding to an accident the way they should.

Installed crash sensors must always face the right direction as indicated by an arrow on the sensor. The threshold for actuating a sensor is an acceleration of approx. 3g to 5g. To prevent airbags from being triggered unintentionally, safety reasons dictate that the airbag firing signal must always be received from two sensors working entirely separately from one another. The means of providing this safety mechanism is the safing sensor.

**The safing sensor**

The job of the safing sensor is to prevent the airbag from being triggered unintentionally. It is connected in series with the front-end sensors. It consists of a reed contact located in a tube filled with resin and a ring magnet. The open reed contact resides in a tube filled with resin, and the ring magnet is slipped over the tube. A spring holds the magnet in place at the end of the housing. Following an impact, the magnet overcomes the retaining force of the spring and slips over the resin-filled tube to close the reed contact. This will make the circuit required to trigger the airbag.

**Airbag design**

The driver airbag system in the steering wheel is made up of an airbag of a volume of about 67 l, the airbag holder, the generator, the generator carrier, and the airbag cover (steering wheel cover). Following an accident, the control unit will fire the generator by applying an ignition current to heat up a thin wire which will make the igniter go off.

Firing the propellant charge will not end in an explosion but in a combustion of the propellant charge which consists of sodium azide. Propellant combustion produces a gas that expands and reacts with the oxidator (a substance giving off oxygen, e.g. copper oxide or iron oxide) to form almost pure nitrogen that fills the airbag.

To circumvent the toxicity of sodium azide, propellant charges are sometimes made up of other, non-azide solid fuels which react to not only form nitrogen but also carbon dioxide (approx. 20%) and steam (approx. 25%). The propellant is normally located in the combustion chamber in the shape of an air-tight pack of fuel pellets.
The type of propellant used depends on the size of the airbag and on how fast the bag must inflate. The chemical reaction after firing generates temperatures of 700 °C inside the combustion chamber. The gas is passed through a filter sieve at a pressure of approx. 120 bar. In the process, the gas is cooled down to below 80 °C to avoid any risk to the passengers in the car. Firing the airbag is nearly as loud as a shotgun. It takes the airbag about 30ms to fully inflate. More recent systems use two-stage gas generators consisting of two igniters that the control unit fires one after the other, depending on how serious the accident is. The shorter the delay between the two ignitions, the faster the airbag will inflate. The system will always fire both gas generators to ensure that all passengers can be safely removed from the wrecked vehicle.

The front passenger airbags or side airbags use hybrid generators which combine the combustion gas with the gas from another gas source. A pressure vessel contains a mix of 96% argon and 4% helium at a pressure of approx. 200 bar. A diaphragm seals off the pressure vessel. When the system is fired, the propellant charge moves a piston to cut through the diaphragm and allow the gas to escape through the opening. The gas from the pressure vessel mixes with the combustion gas and cools it down to an output temperature of approx. 56°C. The front passenger airbag has a volume of about 140 l which takes the gas approx. 35ms to fill completely.

The process is very similar in the side airbags (thorax bags), the difference being that gas generators need to fire and the airbags need to inflate much faster because there is no deformation buffer (crumpling zone). Following a side impact at a speed of about 50km/h (30mph), the generators must fire after approx. 7ms, and the airbag must fully inflate within 22ms.

Side airbags are installed behind the door trim panel or in the back of the seats. Head airbags either have an "inflatable tubular structure" or are designed as an "inflatable curtain".

The "inflatable tubular structure" was the first type of head airbag. It looked like a "sausage" that unfolded out of the roof lining above the front doors. The "inflatable curtain" goes across the entire car roof. This is installed in the roof rail above the doors.

The airbag is made of very robust and non-ageing polyamide tissue which has a low coefficient of friction to allow the bag to inflate quickly and to ensure gentle contact with the skin. To protect the airbag and to prevent the material from "sticking" to itself it is powdered with talcum which can be seen as a white cloud of dust when the airbag is fired. Catch strips inside the bag make sure that the airbag inflates to and
Maintains its correct shape. Openings at the back allow the gas to escape. There are two different ways of folding the airbag, i.e. the standard fold and the star fold. Star-folded airbags expand less towards the driver and benefit passengers who are out of position on their seats.

![Driver airbag and Front passenger airbag](images)

**Contact coil**

The contact coil connects the rigid steering column with the movable steering wheel. It also ensures that the airbag control unit and the gas generator remain connected when the steering wheel is turned. The conductive strip is wound such that it follows the steering wheel for two and a half full turns in either direction. Mechanics should be particularly careful when installing or uninstalling the contact coil. They must make absolutely sure that the steering wheel is at its central position and that the wheels point perfectly straight ahead. An uninstalled contact coil must not be turned.

![Contact coil installed and Contact coil](images)

**The seat user recognition**

Seat user recognition fine-tunes airbag control and prevents airbags from firing unnecessarily.

There are different ways of recognising whether a seat is taken. A common option are sensor mats made up of pressure sensors and a logic analyser. Whereas older systems only supported sensor mats installed in the front-seat passenger seat, more recent systems also allow mats in driver’s seats and rear seats. Another option is the use of infrared or ultrasound sensors which install near the interior lamp or the rearview mirror to monitor both whether and how someone is sitting on the front passenger seat. This allows the system to recognise "out of position" passengers.
Seat user recognition provides information which influences the firing of airbags and the actuation of belt retractors and active headrests. The airbag system knows which seats are actually in use and will not actuate protective systems of seat where nobody is sitting.

The job of the belt tensioner is to remove the “belt slack” when there is an accident. Belt slack is caused by loose, baggy clothes or a “relaxed” way of sitting. Belt tensioners can be installed in the buckle or the belt reel. Buckle-mounted belt tensioners are made up of the following or similar components: tightening tube, rope, piston, gas generator and igniter. In case of an accident the gas generator is fired just like in the airbag. The gas will expand and move the piston in the tightening tube. Since the piston and the buckle are connected by the rope, the buckle will be pulled downwards to remove the slack from the belt system.

Belt tensioners in the belt reel use a tightening mechanism to remove the belt slack. Again, a generator will be fired in response to an accident. This time, the generator makes a set of balls move. The moving balls turn a winder attached to the belt reel. The rotation of the winder winds up the belt by a carefully defined amount. To prevent the balls from causing any damage, they will drop into a special container when their job is done.

Another possibility is the “Wankel engine principle”. When fired the propellant charge drives a rotary piston, the rotary movement of which removes the belt slack. In order to reduce the load on the chest, a device in the driver’s and front-seat passenger’s belt limits the belt tension.

Belt tension limiters are adaptive automatic mechanisms using a gas generator like the one in the airbag to change between a high and a low level of tensioning force.

Optimally adjusting the belt retractor to the airbag leads to the kinetic energy of the passengers being slowly absorbed and loads being rendered harmless during the entire time of the accident.
**Battery cut-off**

In order to avoid any risk of short circuits and the car catching fire because of them, the battery is cut off from the on-board mains when there is an accident.

Means used for disconnecting are either a cut-off relay or a gas generator. The airbag control unit outputs the signal required to cut off the battery. Gas generators work in more or less the same way as the belt retractor. Firing the generator cuts off the battery-to-cable connection otherwise made via the terminal.

**Airbag cabling**

Airbag system connectors are bright yellow to make airbag cables and connectors easy to find.

The connectors feature a jumper intended to prevent unintentional actuation when someone is working on the airbag system. One cause of such actuation could be static charge, for example.

The jumper is a special contact connecting the two contacts in the plug and absorbing any potential when the plug is pulled out of the socket.
One basic rule is that work on the airbag system may only be carried out by trained and skilled experts.

All statutory regulations and the manufacturer’s specifications must be heeded. The same applies to the disposal of previously fired or old airbags.

You are advised to give good training to all garage personnel because many jobs require the airbag or belt tensioner to be uninstalled even though the work does not directly concern the airbag system. One example is work on the instrument cluster.

You are recommend to start with a visual inspection just like you would do to analyse or troubleshoot any other system. Visual inspection should check all visible components of the airbag system for damage and ascertain that all plugs are connected properly. A frequent root cause is a poor contact with the belt tensioners or side airbags somewhere near the front seats. Moving the seats backwards and forwards may loosen the connection and provoke transitory resistances. Your examination should also focus on the contact coil which frequently fails because every turning of the steering wheel puts the coil under some stress. Whatever you do you will need suitable diagnostic equipment. If visual inspection reveals that there is a loose contact somewhere you will need the diagnostic tester to clear the fault memory.

If visual inspection reveals no faults you should use the diagnostic tester to read out the contents of the fault memory. System errors are usually detected by the self-diagnosis equipment and stored in the fault memory. For example, the following faults in the fault memory may have been caused by a defective cable: wrong signal, signal out of range.

In this case you could use a multimeter to check the leads connecting the sensors and the control unit for proper flow of current or body contact. You will need to obtain specific information and circuit diagrams from the manufacturer to accurately locate the sensors and plug connections and to detect the control unit’s pin wiring.

By default, you should always disconnect the battery from the on-board mains and make sure that the sensors and the control unit are disconnected from the wiring harness. You are strictly advised against using "homemade" test adapters (straightened paper clip) to attach the test lines to the connectors because you may otherwise damage the sensitive contact pins and provoke new faults which remain unnoticed at first.

It is much better to use special test tips instead, since these are made to perfectly fit over the contact pins and ensure that proper contact is made.
Battery Management

In this section we will look at the subject of battery or power management in vehicles.
Despite improved quality and performance, one of the most frequent causes of vehicle breakdowns is still the vehicle battery. For this reason, battery monitoring and diagnosis is becoming more and more important. This task is taken over by the power management system, which continually compares the power required by the consumers with the total power available, which is made up of alternator power and battery capacity. The main objective is to monitor the battery’s state of charge and to control power consumers by means of the CAN-bus, or even switch them off if necessary. This prevents excessive battery discharge and guarantees vehicle start-up at all times.

The following parameters are important in order for a statement that is exact as possible to be made about the battery state:
- Battery temperature
- Battery current
- Battery voltage

These parameters are used to determine the battery’s SoC (State of Charge) and battery’s SoH (State of Health).

In this brochure we would like to describe battery or power management using two vehicle manufacturers as examples, specifically current model types of the series Audi A6/A8 and BMW 5 Series.

Audi A6/A8

The control unit is the most important component for battery management. In the Audi A6/A8 estate model it is installed inside the spare wheel well at the rear panel. The control unit continually checks the battery’s state of charge (SoC) and start-up ability. When the engine is running, it regulates alternator voltage and can increase the idling speed in the event of increased power requirements during idling. Even when the engine is not running, the control unit can switch consumers off via the CAN-bus in order to limit the quiescent current.

The control unit’s tasks are divided into three functional modules which are active in the different vehicle states. These functional modules are:
- The battery manager (functional module 1) – This is responsible for battery diagnosis and always active.
- The quiescent current manager (functional module 2) – This is active when the engine is not running and switches consumers off if necessary.
- Dynamic management (functional module 3) – This is active when the engine is running and regulates alternator voltage and the reduction of consumption.

<table>
<thead>
<tr>
<th>Vehicle state</th>
<th>Terminal 15 off</th>
<th>Terminal 15 on engine off</th>
<th>Terminal 15 on engine running</th>
</tr>
</thead>
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<tr>
<td>Functional module 1</td>
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<td>active</td>
<td>active</td>
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<tr>
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</tr>
<tr>
<td>Functional module 3</td>
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Overview of the battery management system
(explanations are given on the following pages)

**CAN inputs**

- Engine speed
- Time at standstill
- Coolant temperature
- Outside temperature
- Ignition starter lock
- Rear window heating
- Windscreen heating
- Reference idling speed
- Switch on alternator
- Load shedding of heating systems
- Load shedding utilisation

**CAN outputs**

- Increase in idling speed
- Switch-off stages
- Load shedding
- Switch-off stage drive
- Battery manager battery voltage
- Heating systems that can be switched off
- Alternator load torque
- Alternator power consumption
- Start-up ability
- State of charge
- Switch-off stage 6
- Terminal DFM – BEM (battery power manager)
- Load response alternator
- Feedback for load shedding
- Alternator fault
- Switch-off infotainment
- Customer service fault battery manager
- Status of high-power heating systems
- Status of high-power heating systems control
- Consumer emergency switch-off active

**Inputs via bit-synchronous interface (BSS)**

- Alternator utilization (DF signal)
- Alternator fault, electrical
- Alternator fault, mechanical
- Alternator, high-temperature switch-off

**Outputs via bit-synchronous interface (BSS)**

- Alternator reference voltage
- Load response start
- Load response drive
The battery manager
The battery manager requires the following parameters for battery diagnosis:
- Battery current
- Battery voltage
- Battery temperature
- Operating times

Battery current and battery temperature are measured in the control unit. The battery temperature is converted to the battery by means of an algorithm. Battery voltage is measured at the battery’s positive terminal. The measuring ranges and output signals resulting from these are shown in the diagram below:

Battery’s state of charge display
The battery’s state of charge is displayed in the instrument cluster. The start-up ability and current state of charge are displayed here. These two parameters are also used as a basis for the quiescent current manager and dynamic management. The alternator is provided with the charge voltage required, depending on the operational state via an interface.

MMI display (Multi Media Interface)
The state of charge can be requested in the MMI under the menu item “Car”. The state of charge is displayed in the form of a bar chart. The display is represented in 10% steps. A state of charge between 60 and 80% is OK.
Battery Management

If consumers (e.g. infotainment) have been switched on for a longer period with the engine at a standstill, thus discharging the battery, the start-up ability of the engine can be endangered. In this case, a message appears in the MMI requesting the driver to start the engine to avoid the consumers being switched off within the next 3 minutes.

**Alternator control lamp (charge control lamp)**
The alternator control lamp is also controlled by the power management control unit.

**Quiescent current manager**
The quiescent current manager is always active when terminal 15 is switched off or terminal 15 is switched on but the engine is off.

When the vehicle is at a standstill, the quiescent current has to be reduced to such an extent that the engine can still be started up, even after a longer standstill. If the battery’s state of charge drops to such an extent that the consumers in operation during standstill can no longer be supplied, comfort and infotainment functions are switched off. The power management control unit sends a switch-off request to the control units responsible for the control of these specific consumers. The hierarchy according to which the consumers have to be switched off is stored in the respective control unit. The consumers of a control unit are switched off in six stages. The switch-off stage increases as the state of charge diminishes. Which switch-off stage is required is specified by the power management control unit. Information about restricted functionality is displayed in the instrument cluster.

### The six switch-off stages

**Switch-off stage 1**
During switch-off stage 1, the first consumers in the CAN-comfort control unit are switched off. These include the washer fluid heater, for example.

**Switch-off stages 2 + 3**
During switch-off stages 2 + 3, further consumers in the CAN-comfort control unit are switched off. These include the receivers for the aerials in the “tyre pressure monitoring” control unit, for example. In addition, first restrictions in the infotainment system are carried out. Switch-off stage 2 is activated after the vehicle has been at a standstill for more than 3 hours and the quiescent current measured is greater than 50 mA.

**Switch-off stage 4**
The transport mode is active in switch-off stage 4. Almost all comfort systems are switched off in order to enable as long a standstill time as possible. One special feature of switch-off stage 4 is that this cannot be activated or deactivated by the power management control unit, but only via a suitable diagnosis tester.

**Switch-off stage 5**
The parking heater is deactivated in switch-off stage 5.
Battery Management

Switch-off stage 6
It is just about possible to start the vehicle up in switch-off stage 6. For this reason, the wake-up function for the control units in the CAN-bus is limited to switching on terminal 15 and vehicle access only. All other wake-up triggers are deactivated. This also affects the infotainment system, which means it is no longer possible to use the telephone. Emergency and breakdown services can still be called, however, this is guaranteed by the emergency battery.

If switch-off stages are prescribed by the power management control unit, these are stored as fault entries in the fault memory of the control unit. A readout of which consumers have been switched off can be taken with the aid of suitable diagnosis equipment.

As soon as the driver enters the vehicle, the switch-off stages are briefly deactivated. As soon as the engine is started up, all the switch-off stages are cancelled. Cancellation also takes place if a battery charger is connected to the battery installed in the vehicle.

This does not apply to switch-off stage 4, which, as described above, cannot be activated or deactivated independently by the control unit. This is possible only with the aid of diagnosis equipment.

The sequence and dependence of the switch-off stages on the battery’s state of charge, time and start-up ability is shown in the following diagram:

The following table lists the control units that (if installed) are requested to switch off consumers by the quiescent current manager in the power manager control unit:

<table>
<thead>
<tr>
<th>Comfort-CAN</th>
<th>Most-Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control unit driver identification</td>
<td>Control unit navigation</td>
</tr>
<tr>
<td>Control unit roof electronics</td>
<td>Control unit digital sound package</td>
</tr>
<tr>
<td>Control unit Climatronic</td>
<td>Control unit telephone / telematics</td>
</tr>
<tr>
<td>Control unit driver seat adjustment</td>
<td>Aerials</td>
</tr>
</tbody>
</table>
Dynamic management

Battery Management

| Control unit front passenger seat adjustment | Chip card reader |
| Control unit rear seat adjustment | Digital radio |
| Control unit vehicle electric system | CD-ROM drive |
| Control unit vehicle electric system 2 | CD-changer |
| Control unit comfort system | Radio module |
| Control unit access + start-up authorisation | TV tuner |
| Control unit display unit in the instrument cluster | Control unit display and operating unit for information |
| Control unit for tyre pressure monitoring | Radio module |
| Door control units | |

Dynamic management is activated when the engine is running. It ensures that the power generated by the alternator is distributed to the individual systems according to their requirements and that there is always sufficient charge current available for the battery. The utilisation of the power network is carried out by the dynamic management system, measuring alternator utilisation, battery current and network voltage. This results in the following tasks:

- Regulation of battery voltage
- Regulation of high-power heating systems (e.g. heated rear window)
- Increase of idling speed
- Load shedding
- Alternator switch-on
- Alternator control dynamics

There are three control stages available to guarantee a stable power supply during requirement-oriented power distribution:

Control stage 1 = Continual power control
Control stage 2a = Partial emergency switch-off
Control stage 2b = Complete emergency switch-off

Control stage 1 kicks in when the power network is overloaded, the alternator is running at full power and the battery charge voltage drops to below the reference value.

Control stage 2a kicks in when control stage 1 is not able to stop the power network being overloaded and this state lasts for longer than 10 seconds. Further reasons for activating control stage 2a are problems with the alternator (fault memory entry 02252), slowing down of the alternator due to high temperature (fault memory entry 02253) or load shedding by the engine control unit (this is possible for a maximum of 10 seconds without fault memory entry).

Control stage 2b kicks in when an acute undervoltage occurs in the power network (less than 11.5 V for more than 1.5 seconds or less than 10.8 V for more than 0.5 seconds). One special feature here is that control stage 2b can also be required by the engine control unit during the start-up process and up to 15 seconds after, without an entry being made in the fault memory.

The effect the control stages have on the performance of the heating systems is shown in the table below:
Regulation of battery voltage
The battery manager and the dynamic management work together to regulate battery voltage. The battery manager uses the battery’s state of charge and the battery temperature to calculate the alternator reference voltage and passes this reference value onto the dynamic management. This transfers the reference value to the alternator via a data line (bit-synchronous interface), which then regulates the required reference voltage.

Load shedding
Under certain conditions, the power management control unit can reduce the load on the request of the engine control unit. This can be the case during acceleration, for example. If the engine control unit sends a load shedding request, the power management control unit reduces the power of the high-power consumers as a first measure. This takes place via the CAN-bus and the control unit responsible for the consumers: the Climatronic control unit, for example, which controls the various high-power heating systems such as windscreen and rear window heating. In the second stage, alternator voltage is reduced. These interventions have the effect of reducing the alternator’s power consumption and thus the engine load.

Regulation of high-power heating systems
The high-power heating systems are regulated by the Climatronic control unit. Power management is connected to the Climatronic control unit via the CAN-bus and can continuously control the heating power through this. This means that the definition of the maximum heating power possible is prescribed by the power management control unit.

Increase in idling speed
For the best possible battery charge and supply to the power network, the power management control unit can request a step-by-step increase in idling speed when the engine is idling. This is then carried out by the engine control unit.

<table>
<thead>
<tr>
<th>Heating system</th>
<th>Control stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Maximum power</td>
</tr>
<tr>
<td>Windscreen heating</td>
<td>1000 W</td>
</tr>
<tr>
<td>Rear window heating</td>
<td>320 W</td>
</tr>
<tr>
<td>Washer nozzle and water hose heating</td>
<td>20 – 100 W</td>
</tr>
<tr>
<td>Mirror heating</td>
<td>2 x 30 W</td>
</tr>
<tr>
<td>Seat heating</td>
<td>Front: 2 x 100 W</td>
</tr>
<tr>
<td></td>
<td>Rear: 2 x 80 W</td>
</tr>
<tr>
<td>Steering wheel heating</td>
<td>100 W</td>
</tr>
</tbody>
</table>
Battery Management

Alternator switch-on (load response start)
Alternator voltage is limited to a minimum during start-up. This means that the alternator does not provide any current during and directly after the engine start. This prevents the start-up process being extended on account of the full power (braking torque) of the alternator.

Alternator control dynamics (load response drive)
If requirements increase while the vehicle is in motion, by the windscreen heating being switched on, for example, thus increasing the alternator torque, the requirements are not forwarded directly to the engine. Alternator power output is continuously increased by the alternator control dynamics. This takes place every 3, 6 or 9 seconds, depending on the engine speed.

BMW 5 Series

Here, power management is realised with the aid of an intelligent battery sensor (IBS) and digital engine electronics. The battery sensor is the most important component element in this system. It is installed directly in the niche of the battery’s negative terminal. It continually measures the following:
- Battery temperature
- Battery terminal voltage
- Battery charging and discharging current

Structure of the battery sensor
The battery sensor is a mechatronic sensor. It can be divided into three sections: the mechanism, the electronics module and the software.

The mechanism
The battery terminal with the earth cable for connection to the battery is described as the mechanism. This completes the following tasks:
- Electrical connection between the body and the battery negative terminal
- Inclusion of the sensor element for current measurement
- Inclusion of the electronics module
- Setting up of the thermal contact between the battery negative terminal and the temperature sensor
- Earth connection of the IBS (voltage supply is via a separate supply line)
- Protection of electronic components

The electronics module
The electronics module is made up of the following components:
- Board with evaluation electronics
- Precision resistor for current measurement (shunt)
- Temperature sensor
The electronics module has the task of recording the voltage, the current flow and measuring the battery temperature.

**The software**
Since the intelligent battery sensor is regarded as a full-grade control unit, it has its own program.

### The function of the IBS
The IBS has large measuring ranges for exact data acquisition:
- Current: -200 A to +200 A
- Voltage: 6 V to 16.5 V
- Temperature: -40 °C to +105 °C
- Start-up current: 0 A to 1000 A
- Quiescent current: 0 A to 10 A

A series of functions is integrated in the IBS:
- Continual measurement of voltage, current and temperature in every operational state of the vehicle
- Calculation of the battery indicators as a basis for the battery’s SoC (State of Charge) and battery’s SoH (State of Health)
- Balancing the charging and discharging current of the battery
- Monitoring of the battery’s state of charge and activation of countermeasures when a critical state of charge has been reached
- Calculation of the start-up current curve to determine the battery’s state of health
- Monitoring of the quiescent current
- Transfer of the data to the higher-order control unit
- Self-diagnosis
- Automatic updates of the algorithm parameters and the parameters for self-diagnosis via engine electronics
- The ability of waking itself up from sleep mode

### Evaluation electronics
The evaluation electronics in the IBS continually acquire the measured data. This data is used for the calculation of the battery indicators current, voltage and temperature. The battery indicator data are sent to the engine electronics via the bit-serial interface. Parallel to the calculation of the battery indicators, a pre-calculation of the battery’s state of charge is carried out. During the “engine off” signal time and the main relay in the engine electronics being switched off, the battery sensor receives information about the current state of charge or maximum amount of battery power available from the engine electronics, guaranteeing engine start-up. After the main relay of the engine electronics has been switched off, the battery sensor continually records the battery’s state of charge.
Quiescent current measurement
When the vehicle is at a standstill, the required values for battery indicators are continually measured by the IBS. This is programmed in such a way that the sleep mode is interrupted every 14 seconds and a measurement is taken. This measurement takes approx. 50 milliseconds. The measured data are stored in the quiescent current memory in the IBS.

When the engine is started up, the engine electronics read out the quiescent current memory. Deviations can be established by comparing the quiescent current curve with the stored reference values. If there are any irregularities in the quiescent current curve, an entry is made in the fault memory of the engine control unit.

Optimum battery charge
In order to guarantee optimum battery charge in all operating states, a method of charge regulation according to battery temperature and depending on the charge state is used. For this purpose, an optimum charge voltage reference value for the current battery temperature is calculated in the control unit. The alternator regulator current is then set in such a way that the required charge current is applied directly at the battery. This also compensates loss of voltage through the alternator line. When the battery is fully charged, the alternator power can be reduced, thus reducing consumption.

Regulation of idling speed
The idling speed can be adapted to the alternator utilisation in both the Audi and the BMW.

Wake-up function for terminal 15 wake-up
This function is active only when the vehicle is at a standstill. After the engine control unit has received the message "terminal 15", it sends the information about the maximum amount of power available to the IBS. After this, the engine electronics go into sleep mode. If the maximum power available is reached and consumers are still switched on, the IBS wakes up the vehicle electric system and thus the engine electronics via the wake-up line (terminal 15 wake-up). On account of the critical battery state of charge (bordering on the start-up ability of the engine), the consumers are switched off by the engine electronics or the control units responsible. Then the vehicle returns to sleep mode. In this state, the engine electronics no longer allow the IBS to activate the vehicle electric system.

Faults and diagnosis
As in all other electronic systems, a series of faults are possible with battery management, too. These can be short circuits to the positive or negative terminals, interruptions or contact resistance in plugs and wires, faulty control units, failure of the bus system, a faulty battery or faulty alternator. As a rule, the system continues to work with alternative values in the event of a fault, and an entry is made in the fault memory.
Vehicle-specific documents such as circuit diagrams and system descriptions as well as suitable diagnosis equipment are always required for fault diagnosis. Before a complex diagnosis takes place, the battery should be tested with a suitable tester. The state of charge (SoC) and state of health (SoH) must be perfect and comply with the manufacturer’s information. Important information can be gained during the initial vehicle inspection when the vehicle is brought in, through fault messages in the instrument cluster, for example.

A readout of the fault memory can be taken with the aid of suitable diagnosis equipment. Entries are also made in the fault memory, for example, if the power management system has activated one of the switch-off stages, leading to restricted functions in certain systems. This fault entry could be:
- Alternator, mechanical fault
- Alternator, high-temperature regulation
- Alternator, electrical fault

Further information can be gained by taking a readout of the measured-value blocks (actual values). Various parameters and values are displayed in the measured-value blocks. These include the following, for example:
- Battery voltage
- Alternator reference value
- Battery temperature
- State of charge
- Communication with the alternator
- Average value of quiescent current
- Emergency switch-off
- The inner resistance of the battery, loss of state of charge
- Quiescent current switch-off

Information can be collected during diagnosis by comparing the reference and actual values. This can help to narrow down the cause of the faults recorded.
Electromechanical Parking Brake (EMP)

In this section we would like to discuss the electromechanical parking brake (EMP). The "electronic handbrake" is gradually becoming a common feature in passenger cars where it advances handling convenience. This information sheet is based around the systems installed in 7 Series BMWs (E65) and Audi A8 (4E..).

Tasks of electromechanical parking brakes

The job of the electromechanical parking brake is to stop the parked car from rolling. It also meets the statutory requirement of a second, independent brake system in vehicles, and it provides some extra safety and convenience.

Design and operation of electromechanical parking brakes

BMW and Audi use systems of a substantially different design. The EMP in the Audi A8 has an electric motor driving a spindle that directly acts upon the brake linings of the rear axle. In the BMW, an electromechanical actuator pulls the cable controls actuating the duo-servo drum brake.

Audi’s parking brake mechanism consists of a DC drive, a wobble plate transmission, and a spindle. The components are mounted directly on the rear brake callipers and turn the drive’s circular movement into small strokes of the brake piston. A belt drive transmits the DC drive’s energy to the wobble plate mechanism.

At this point the driving motor speed is reduced for the first time. The gearing of the belt drive reduces the speed by a factor of 1:3. The wobble plate mechanism further reduces the speed. At the end of the transmission, the speed is reduced by a factor of 147 compared with the original DC motor speed. A spindle that is directly driven by the wobble plate mechanism transforms the circular movement into a lifting stroke.

The brake piston houses a cylinder that can move to and fro inside the piston housing. To prevent the cylinder from turning inside the piston, its surface is ground down at two points. At the front end of the cylinder there is a press-fit nut which starts moving on the spindle thread when the spindle revolves. A Hall sensor measures the number of revolutions made by the DC drive and transfers the result to the electronic control unit which takes the value to compute the length of stroke.
When the parking brake is actuated, the circular spindle movement drives the nut forward. The cylinder is made to exert force on the brake piston which presses the brake lining against the brake disc. When the parking brake is released the nut turns back on the spindle thread and the pressure is removed from the brake piston. Like after a normal braking manoeuvre, the O-ring resumes normal shape and the brake piston is allowed to return. To make up a complete system, the above components are supplemented by a control unit with integral inclination angle sensor, the control lamps and the switch on the centre console.

To set the parking brake, the switch is pulled, and to release the brake, the switch is pushed down. The control lamps on the dashboard and in the switch tell you that the parking brake is set. One special feature is that the parking brake can be set even when the ignition is off. However, to release the brake, the ignition needs to be on.
Electromechanical Parking Brake (EMP)

Electromechanical parking brake functions
The electromechanical parking brake provides the following functions:
- Parking brake
- Dynamic emergency brake
- Adaptive starting assistant
- Brake pad wear control

■ The Parking brake
When you park the vehicle and set the parking brake the system will automatically adjust the gripping power as necessary to prevent the vehicle from accidentally rolling off.
The dashboard display will show a warning if you try to park the car on a gradient above 30%. When the brake discs cool down at standstill the control unit will automatically readjust the grip according to a simulation model that allows the control unit to determine the current brake disc temperature.

■ Dynamic emergency brake
This function is enabled by moving the switch which responds like a normal handbrake lever. While the switch is being pulled the vehicle will slow down. Braking stops when you let go of the switch. Maximum deceleration is 8 m/s.
The parking brake will emergency-brake the car only if its speed is below 8 km/h (5mph). At faster speeds, deceleration will be performed by the ESP system which evenly distributes the brake pressure among the brakes of all four wheels.
At the same time, if the accelerator is also pressed, the motor torque will be reduced and the cruise control system will be disabled (if it was on before). To avoid misuse (actuation by front-seat passenger), the emergency brake is disabled if the driver keeps accelerating.

■ Adaptive starting assistant
This function makes it possible to drive off at upward slopes without jerking or rolling backwards. The control unit needs further information in order to make optimal use of the starting assistant.
It polls the CAN bus for additional information about the current gear, the accelerator position and the motor torque, and it checks the reading of the inclination angle sensor integrated in the control unit. All of these details are put together to decide when the parking brake is to be released. The driver has no option to turn off this function.
Brake pad wear control

Pad thickness is checked every about 500km (310 miles). To check, the following conditions must be met: vehicle at standstill, parking brake released, ignition off.

The control unit moves the brake pad away from its limit stop (normal position) and towards the brake disc. The Hall sensor takes a reading and delivers it to the control unit which uses the value to compute the distance moved by the brake pad, which is indicative of the remaining pad thickness.

Brake pad wear control may be more accurate in vehicles that hardly ever use the parking brake than in vehicles where the parking brake is used regularly.

In a 7 Series BMW, the mechanism to engage the parking brake does not directly affect the rear brake pads as in the Audi but rather affects the duo-servo drum brake which is located inside of the rear brake discs. The actuator unit is installed in the floor of the boot, between the spare wheel well and the rear wall, behind the rear seat bench.

The actuator unit is made up of the following components:
The electrical drive, a spindle, the wrap spring, the balance bar, the cable pulleys, the plastic gearwheels, and the cable controls.

When the parking brake is actuated, the electrical drive moves the plastic gearwheels which drive the spindle. The thread of the spindle moves the balance bar forwards and backwards to produce equal movements on the left and right side, depending on whether the brake is engaged or released. Levers on the balance bar make the connection to the pulleys that the cable controls for the left and right side are attached to. When the parking brake is being engaged the balance bar moves on the spindle, making the pulleys turn towards the inside and pull the cable controls which set the duo-servo drum brake.
When the parking brake is being released the electrical drive turns the spindle in the opposite direction. The balance bar moves back and the pulleys turn towards the outside, retracting the cable controls and thus releasing the parking brake. The force needed to release the brake is produced by the return control springs located in the duo-servo drum brake.

The job of the wrap spring is to avoid the entire load of holding the engaged parking brake being exerted on the plastic gearwheels. The wrap spring is attached to the spindle. When the parking brake is fully engaged and the spindle has moved up to its holding stop its restoring force tries to turn the spindle in the opposite direction.

This rotation in the opposite direction presses the first couple of turns of the wrap spring outwards and against the wall of the housing around it. Consequently, the spindle is retained at its current position and the wrap spring absorbs all of the restoring force. When the parking brake is released, the electrical drive turns the spindle which takes the opposite end of the wrap spring along with it. This turns the spring inwards and makes it come away from the housing.

In order to prevent corrosion on the brake drums and brake pads and to always provide the best effect, the system runs in the brake while the car is driving. Running-in is repeated once every month or every 1000 km (620 miles). The system performs the routine automatically without the driver noticing anything. Automatic braking actuates the parking brake at approx. 20% of its maximum force. The running-in routine causes only a little wear on the material. After about 300 repeats the brake pads will have worn down by no more than 0.5 mm.

The 7 Series BMW also features some extra functions supporting the driver in some situations.

**Extra functions include:**

- **Hill-hold function** making it easier to start up a hill. The parking brake is engaged and released such that the car will not roll back down the slope.
- **Auto-stop** engaging the brake when the car stops at a traffic light, for example. This will stop the vehicle from creeping forwards and relieve the driver who no longer needs to press the brake pedal the whole time.

The difference between BMW and Audi is that in the BMW, the above functions are provided by the DSC (=Dynamic Stability Control). The electromechanical parking brake will be enabled only when the engine is off.
Emergency release

Both vehicles feature an emergency release mechanism which allows the driver or garage to release the brake following a fatal system failure. Audi’s on-board tool kit includes a special Torx wrench. If necessary the wheel has to be taken off. Use one side of the Torx wrench to loosen the screws holding the electrical drive and remove the drive, together with the wobble plate mechanism, from the brake caliper. Use the other side to turn back the spindle.

The BMW’s on-board tool kit also includes a special tool, i.e. an unlatching rod. Insert the rod into a pilot tube and push it right through to a gearwheel and further on to the actuator unit. Use the fork spanner and the screwdriver handle to turn the unlatching rod anticlockwise and release the brake.

Important: If there is a power supply failure (battery discharged) you may find it impossible to move the vehicle although the brake has been released. In this case the automatic transmission is set to ‘parking lock’. However, there is an emergency release mechanism for the parking lock, too.

First of all, locate the lid of the release mechanism on the left side of the footwell and open it. Then pull the red strip to flap out and lock a lever. This releases the parking lock.

Proceed as follows to re-enable the electromechanical parking brake following an emergency release:

Make sure that the vehicle is at a standstill and the ignition is on. Pull the switch of the electromechanical parking brake three times leaving approx. 5 seconds between each repeat. The system will start to initialise, first of all initialising the release position. Then the brake engages and the braking position is initialised. The control lamp on the display lights up red. The brake is released and ready to operate. The control lamp on the display extinguishes.
Changing brake pads

You need appropriate diagnostic equipment to replace the rear brake pads of Audi A8. Before you can start uninstalling the brake pads you must first run the diagnostic unit to move the system to its “Home” position and fully retract the cylinder.

Only then will you be able to push back the brake piston. After replacing the brake pads, run the “Home” function again to make the cylinder moves right up to the brake piston. Finally, choose “Adjustment” and enter the thickness of the new brake pads.

BMW does not require you to use any diagnostic equipment. An important thing to remember is that you must do a basic setup after you have replaced the brake shoes or the rear brake discs. Remove a wheel bolt on either side. Turn the right wheel until the thread of the wheel bolt points to “7 o’clock” and the left wheel points to “5 o’clock”. Insert a suitable screwdriver into the hole, find the adjustment screw and turn it until the wheel is set and cannot be turned. Then turn back the adjustment screw by 10 notches. Do the same on the other side. Put the wheel bolts back in and tighten at the rated torque.

Function test on dynamometer

In order to brake-test the electromechanical parking brake, you should provide means of testing the vehicle on a brakes inspection lane.

The Audi A8 automatically knows when the brake is being tested. As soon as the rear wheels on the test stand turn at a constant speed of 3 to 9 km/h (1.9 to 5.6 mph) for 3 seconds, the control unit will automatically go into test mode. It is crucial to turn on terminal 15 (ignition). The control unit will vary the way it actuates the parking brake in that it makes the piston move out a little further every time the brake is actuated, thus causing the brake to grip a little harder.

The 7 Series BMW allows the parking brake to be tested only if the engine is off and ignition is on. Pulling the brake switch will make the parking brake respond fairly quickly, i.e. you will not be able to slowly and continuously tighten the grip as you would do with a manually operated parking brake.

Attention: The vehicle may jump out of the test rollers.

If the electromechanical parking brake is found to not work properly, the first thing you should do is to test it on a brakes inspection lane. The test stand will help you find out whether the brake is only working imperfectly or not at all. If dynamometer testing finds that the brake is not working properly you should make a visual inspection next.
The focus should be on the brake pads/brake shoes, the brake cables (BMW), and any leaks that may be found (Audi). If the brake pads/brake shoes prove to be okay, the brake cables undamaged, and if no leaks are found you should go on and check the mechanical elements.

Pulling the parking brake switch while the vehicle is at a standstill and the engine is off, you will be able to hear how the brake grips. When testing the BMW, try opening the actuation unit and see if you can watch the mechanism work. In case neither visual inspection nor examining the mechanical elements reveals any faults or if the actuation unit/servo drives are not actuated, you will need appropriate diagnostic equipment to continue.

Like in many other electrical systems, the diagnostic unit allows you to read the entries in the fault memory. Depending on the unit you use, there may be options for turning the sets of measured values (readings) into an on-screen display of the function/logical state of any component or for running actuator diagnostics to actuate and function-test the components. In case the brake needs to be repaired you should always refer to the specific repair instructions, test values and tightening torques provided or specified by the manufacturer. Following repair, remember to clear the fault memory and to put the vehicle on a brakes inspection lane to verify that the brake is working properly.

**Important note:**
You need a roller-type dynamometer to test the operability of the electromechanical parking brake.
A plate-type test stand cannot be used.