Self Study Programme 615
For internal use only





Audi A6 hybrid and Audi A8 hybrid

Audi
Service Training

The first series-produced Audi hybrid model of the new century, the Audi Q5 hybrid quattro, was launched in November 2011. The performance SUV is the world's first lithium-ion-battery-powered full hybrid in its segment. The Audi A6 hybrid and the Audi A8 hybrid also hit the streets in the course of 2012. They utilise the same parallel hybrid drive configuration as the performance SUV, but differ in that they only have front wheel drive.
With both large saloon models, Audi becomes the first premium manufacturer to offer full hybrid vehicles featuring lithium ion technology simultaneously in the B, C and D segments.

Drive is provided by a 2.0l TFSI engine developing 211 hp (155 kW) and an electric motor developing 54 hp (40 kW) and 210 Nm of torque; their combined power output is 245 hp (180 kW). The vehicles can cover up to three kilometres at a constant speed of 60 kph entirely under electrical power. Their top speed in electric-only mode of 100 kph also sets new standards.

Power transmission is provided by a highly modified eight-speed tiptronic gearbox which does not require a torque converter. The torque converter is replaced by an electric motor which is combined with a multi-plate clutch. This multi-plate clutch couples and decouples the electric motor and the internal combustion engine. A lithium-ion battery system weighing only approx. 38 kg serves as an energy store. A sophisticated two-way air cooling system keeps the temperature of the battery system within acceptable limits.



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Learning objectives of this self study programme:

This self study programme provides you with general information on the Audi A6 hybrid and Audi A8 hybrid models. After you have worked your way through this self study programme you will be able to answer the following questions:

- What are the distinguishing features of the Audi A6 hybrid and the Audi A8 hybrid?
- How many cells are there in a battery module in high voltage battery A38?
- Where is the cooling module for cooling the hybrid battery unit AX1 located in the Audi A8 hybrid?

Contents

Introduction
Vehicle distinguishing features 4

Safety instructions
VDE safety rules of electrical engineering 6
Warning signs 7

Basics of hybrid technology
Hybrid technology 8
Hybrid drive technology 8
Full hybrid drive 8
Other terminology 9

Engine
System data 10
8-speed automatic gearbox with hybrid module 11

Suspension System
Electro-mechanical steering 12
Vacuum pump for brake servo assist V469 13

Electrical system
Hybrid battery unit AX1 14
High voltage battery A38 16
Battery regulation control unit J840 17
Maintenance connector for high voltage system TW 18
Safety concept 20
Battery cooling 22
Electric drive power and control electronics JX1 24
Electric drive control unit J841 27
Electrical AC compressor V470 28
Three-phase AC drive VX54 29
Electro-drive drive motor V141 30
High voltage cable set for hybrid battery PX1 and PX2 34
12 volt starting 35
Hybrid manager 36
EV mode 37

Displays
Display elements for driving in hybrid mode 38

Service
Special tools 40
Workshop equipment 40

Annex
Test your knowledge 41
Self Study Programmes 43

The Self Study Programme teaches a basic knowledge of the design and functions of new models, new automotive components or new technologies.
It is not a Repair Manual! Figures are given for explanatory purposes only and, refer to the data valid at the time of preparation of the SSP.
For maintenance and repair work, always, refer to the current technical literature.

Note

Reference

Introduction

Vehicle distinguishing features

In addition to the hybrid logo on the nameplate, the Audi A6 hybrid and Audi A8 hybrid can be distinguished by the following features.

Instrument cluster with power meter and hybrid displays



Hybrid logo on the design cover in the engine bay



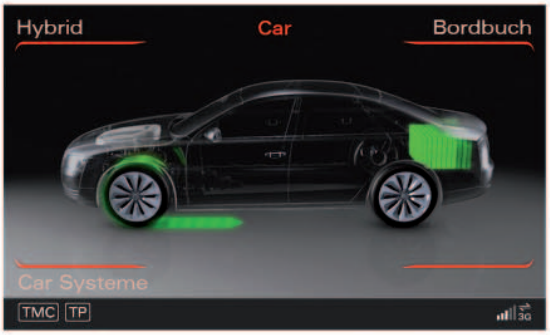


Reference
For further information on the basic models, please refer to Self Study Programme 456 "Audi A8 ’10" and Self Study Programme 486 "Audi A6 ’11".



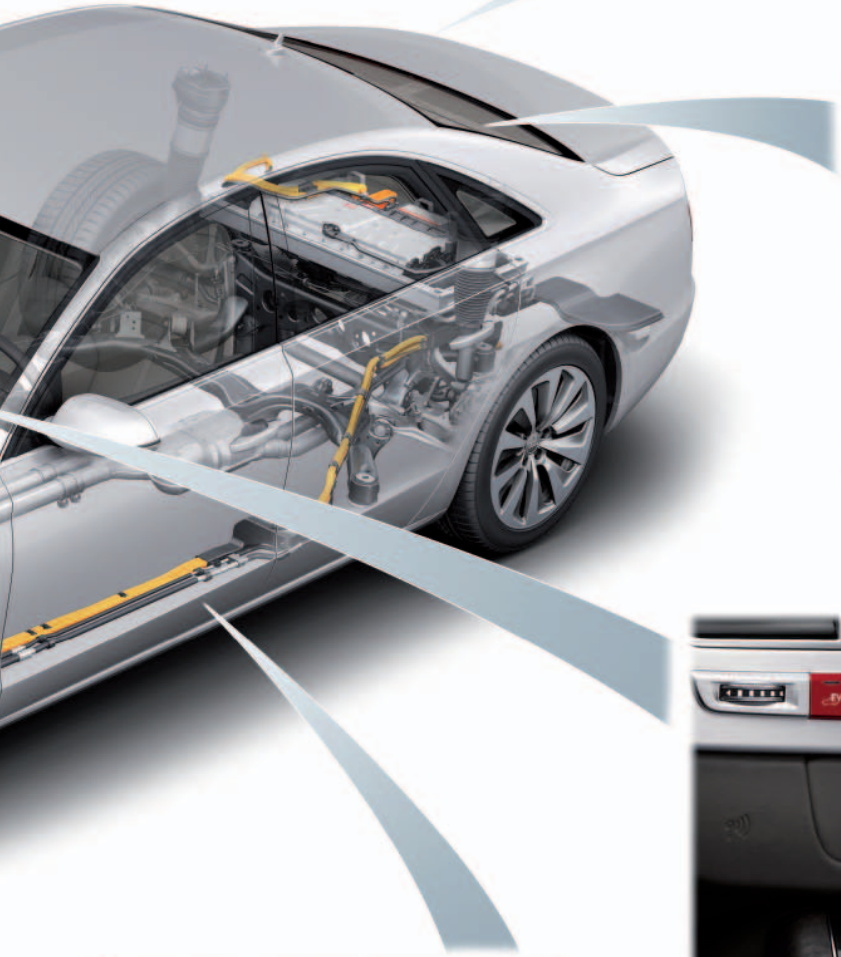
Hybrid logo on the wings

MMI system with hybrid displays





Hybrid logo on the boot lid





Hybrid logo at the front end of the luggage compartment



Switch for EV mode



Hybrid logo on the sill panels

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Safety instructions

VDE safety rules of electrical engineering

It is assumed that every household electrician is familiar with the following five safety rules based on the DIN VDE 0105 series of standards.

This also applies to the qualified person responsible for the automotive high voltage systems: the high voltage technician.
These VDE safety rules must be applied in the given order before commencing work on electrical systems.

These steps must be taken by the high voltage technician.

1. **De-energise vehicle**
2. **Provide a safeguard to prevent unintentional re-starting of the system**
3. **Check that no voltage is present**

These steps are not relevant to high voltage vehicles.

4. **Earth and short-circuit vehicle**
5. **Cover or block off adjacent live parts.**

Note
Even AC voltages of 25 volts and DC voltages of 60 volts are hazardous to humans. It is therefore important to follow the safety instructions given in the service literature and in the Guided Fault Finding, as well as the warnings displayed on the vehicle.

Note
All work on the high voltage system must be performed by a qualified high voltage technician.

Warning signs

To minimise the risk of electrical shock to users, service and workshop personnel, vehicle recovery personnel and medical emergency personnel through contact with the high voltage system, a number of warning and information labels can be found on the Audi A6 hybrid and Audi A8 hybrid.

Basically, two types of warning label are used:

- Yellow warning label with warning symbol for electrical voltage
- Warning label marked "Danger" against a red background

The following yellow warning labels are used to identify high voltage conducting components or high voltage components installed in the immediate vicinity, for example hazardous components not visible under covers.

Warning against hazardous electrical voltage acc. to DIN 4844-2 (BGV A8)



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Warning against a hazardous area according to DIN 4844-2 (BGV A8)

Warning against touching live parts

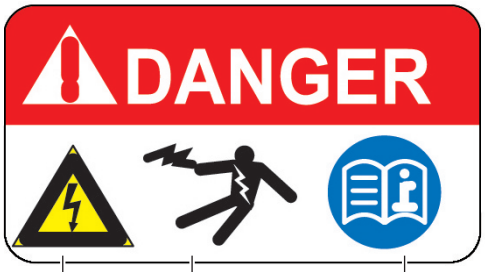


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Warning against hazardous electrical voltage according to DIN 4844-2 (BGV A8)

Mandatory signs: Observe instructions for use according to DIN 4844-2 (BGV A8)

The warning labels marked "Danger" **identify high voltage components or high voltage conducting components.**



615_038

Warning against hazardous electrical voltage according to DIN 4844-2 (BGV A8)

Warning against touching live parts

Mandatory signs: follow instructions for use according to DIN 4844-2 (BGV A8)



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Special high voltage battery identification label
This adhesive label is affixed to the top of the high voltage battery in English and in the import country's national language.

Basics of hybrid technology

Hybrid technology

The term hybrid derives from the Latin word "hibrida" and means the offspring of a mixed union.
In technology, a hybrid is a system which combines two different technologies with one another.

In the context of drive concepts, the term hybrid technology has two meanings:

- bivalent drive and
- hybrid drive technology.

Bivalent drive

Vehicles with bivalent drive have an internal combustion engine which can burn different types of fuel to provide drive power.

Systems that run on fossil and renewable fuels (diesel/biodiesel) or liquid and gaseous fuels (petrol/natural gas/liquefied petroleum gas) are well known and becoming increasingly widespread on the market.

Hybrid drive technology

Hybrid drives are a combination of two discrete drive units with different functional principles.
Hybrid technology today is the combination of an internal combustion engine and an electric motor (or e-machine).

It can be used as a means of generating electrical energy from kinetic energy (brake energy recuperation), as a motor for driving the vehicle and as a starter for the internal combustion engine.
Depending on the basic configuration, a distinction is made between three types of hybrid drive:

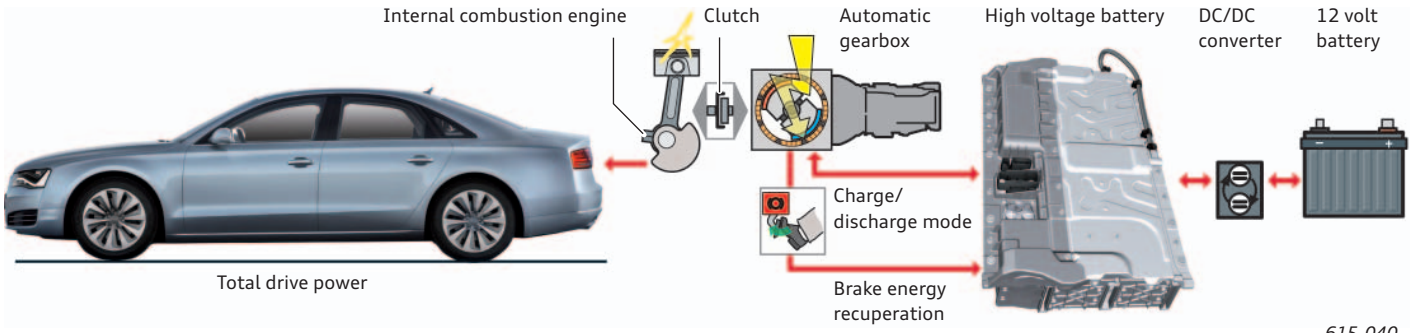
- the micro hybrid drive
- the mild hybrid drive
- the full hybrid drive

Full hybrid drive

A high-performance e-machine is used in combination with an internal combustion engine. Electric-only driving is possible.
The e-machine assists the internal combustion engine as soon as the conditions permit.
Low speed driving is all-electrical. The internal combustion engine has a start-stop function. Brake energy recuperation is used to charge the high voltage battery.

Both systems can be decoupled by a clutch between the internal combustion engine and the e-machine. The internal combustion engine is activated only when required.

Both the Audi A6 hybrid and the Audi A8 hybrid have a full hybrid drive.



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Types

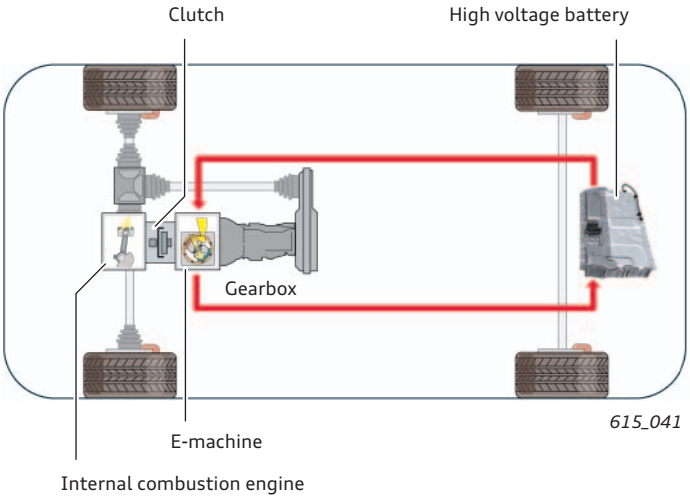
The full hybrid drives are subdivided into four subgroups:

- Parallel hybrid drive
- Power-branched hybrid drive
- Serial hybrid drive
- Power-branched serial hybrid drive

Reference
For further information on the hybrid technology, refer to Self Study Programme 489 "Audi Q5 hybrid quattro".

Parallel hybrid drive

The parallel configuration is notable for its simplicity. This solution is used for "hybridising" existing vehicles.
The internal combustion engine, e-machine and gearbox are mounted on a shaft. The total of the individual power outputs of the internal combustion engine and the e-machine corresponds to the total power output. This concept utilises a large number of carry-over parts from the original vehicle. In all-wheel-drive models with a parallel hybrid configuration, drive power is distributed to all four wheels.



Other terminology

Brake energy recuperation

The term recuperation (Latin: "recuperare" = to recover or to restore) is generally understood as the use of kinetic energy during deceleration. This means that "free" energy is recovered during the braking and acceleration phases and buffered in the car battery.

The recuperation function is a key component of the electrical energy management system.

Energy flows between the high voltage components

Electric motor operation: high voltage battery is discharged

When driving under electric power, power is drawn from the high voltage battery.
The 12 volt electrical system is powered by the high voltage battery.

Recuperation: high voltage battery is charged

Unlike during accceleration phases, the vehicle is braked electrically by the drive motor during deceleration phases in order to recharge the high voltage battery. A portion of the energy is recovered as soon as the driver takes his/her foot off the accelerator. The amount of energy recovered increases again accordingly during the braking operation.
The 12 volt electrical system is supplied by the electro-drive drive motor.

Electric machine (e-machine)

The term "electric machine" or "e-machine" is used instead of the the terms generator, electric motor and starter.
Basically, any electric motor can be used as a generator. If the e-machine motor shaft is driven externally, it delivers electrical power as a generator. If the e-machine is supplied with electrical power, it functions as a motor.

The e-machine of an electrical hybrid therefore replaces the conventional starter of the internal combustion engine and the conventional generator (alternator).

Electrical boost (e-boost)

Like the kickdown function in internal combustion engines, which delivers maximum engine power, the hybrid drive offers an e-boost function. When this function is used, the e-machine and internal combustion engine deliver their maximum power, which adds up to a higher overall value. The total of the individual power outputs of both types of drive corresponds to the total power output of the driveline.

Due to the technical power loss within the e-machine, the generator produces less power than the drive.
In the Audi A6 hybrid and in the Audi A8 hybrid, the internal combustion engine has a power output of 155 kW and the e-machine develops 31 kW as a generator. The e-machine develops 40 kW as an electric motor. The internal combustion engine and the e-machine as an electric motor have an aggregate power output of 180 kW.

Engine

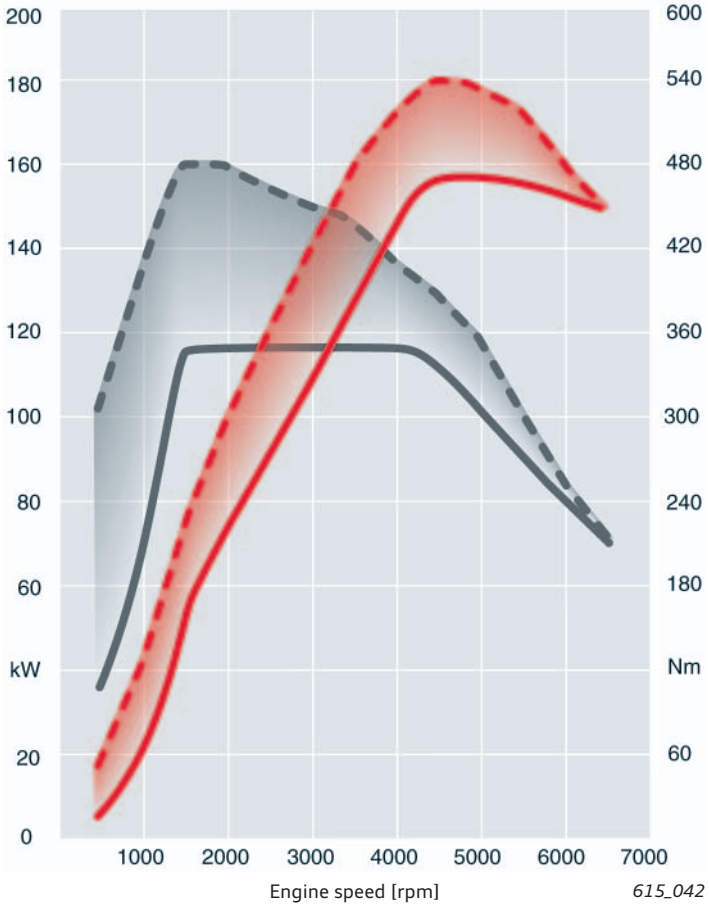
System data

Specifications

Torque-power curve

2.0l TFSI engine with engine code CHJA

- Engine power output in kW
- Engine torque in Nm
- System power output in kW (10 sec.)
- System torque in Nm (10 sec.)

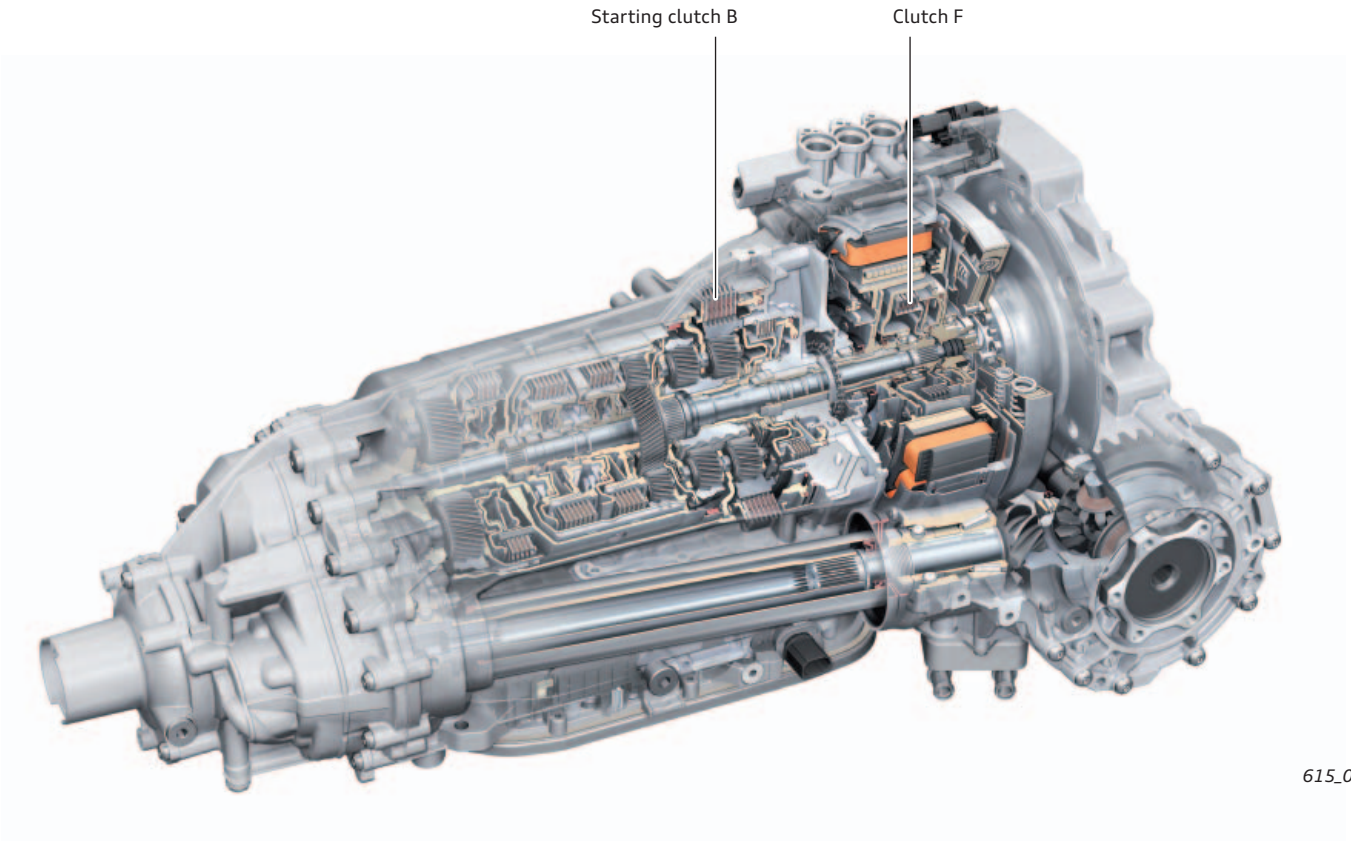


Engine code	CHJA
Type	Four-cylinder inline engine and 3-phase AC motor/generator
Displacement in cm^3	1984
Power output of int. combustion engine in kW (HP) at rpm	155 (211) at 4300 – 6000
System power output in kW (HP)	180 (245)
Torque of int. combustion engine in Nm at rpm	350 at 1500 — 4200
System torque in Nm	480
Top speed (electric drive only) in kph	100
Range (electric drive only) in km	3 (at 60 kph)
Number of valves per cylinder	4
Bore in mm	82.5
Stroke in mm	92.8
Compression ratio	9.6 : 1
Powertrain type	8-speed automatic gearbox
Engine management system	MED 17.1.1
Fuel	Premium unleaded (sulphur-free) 95 RON
Emissions standard	EU V
Additional weight due to hybrid components in kg	< 130

Reference
For more information on the internal combustion engine, refer to Self Study Programme 436 "Modifications to the chain-driven 4-cylinder TFSI engine".

8-speed automatic gearbox with hybrid module

Automatic gearbox control unit J217 is a hybrid CAN user and a powertrain CAN user.



Instead of the torque converter, the e-machine is integrated in the available installation space in the automatic gearbox as a module with multi-plate clutch (clutch K).
The multi-plate clutch runs in an oil bath and disconnects or connects the internal combustion engine to the e-machine.

Since the torque converter has been eliminated, starting clutch B is used as a starting element.

Driving state	Clutch F	Starting clutch B
Engine start	closed	open
All-electric driving	open	closed
Brake energy recuperation	open	closed
Internal combustion engine running	closed	closed
Internal combustion engine idling	closed	open
Boost	closed	closed

Additional hydraulic pump 1 for gear oil V475 is installed to lubricate the automatic gearbox and build up the oil pressure required for hydraulic actuation when the e-machine is at a standstill.

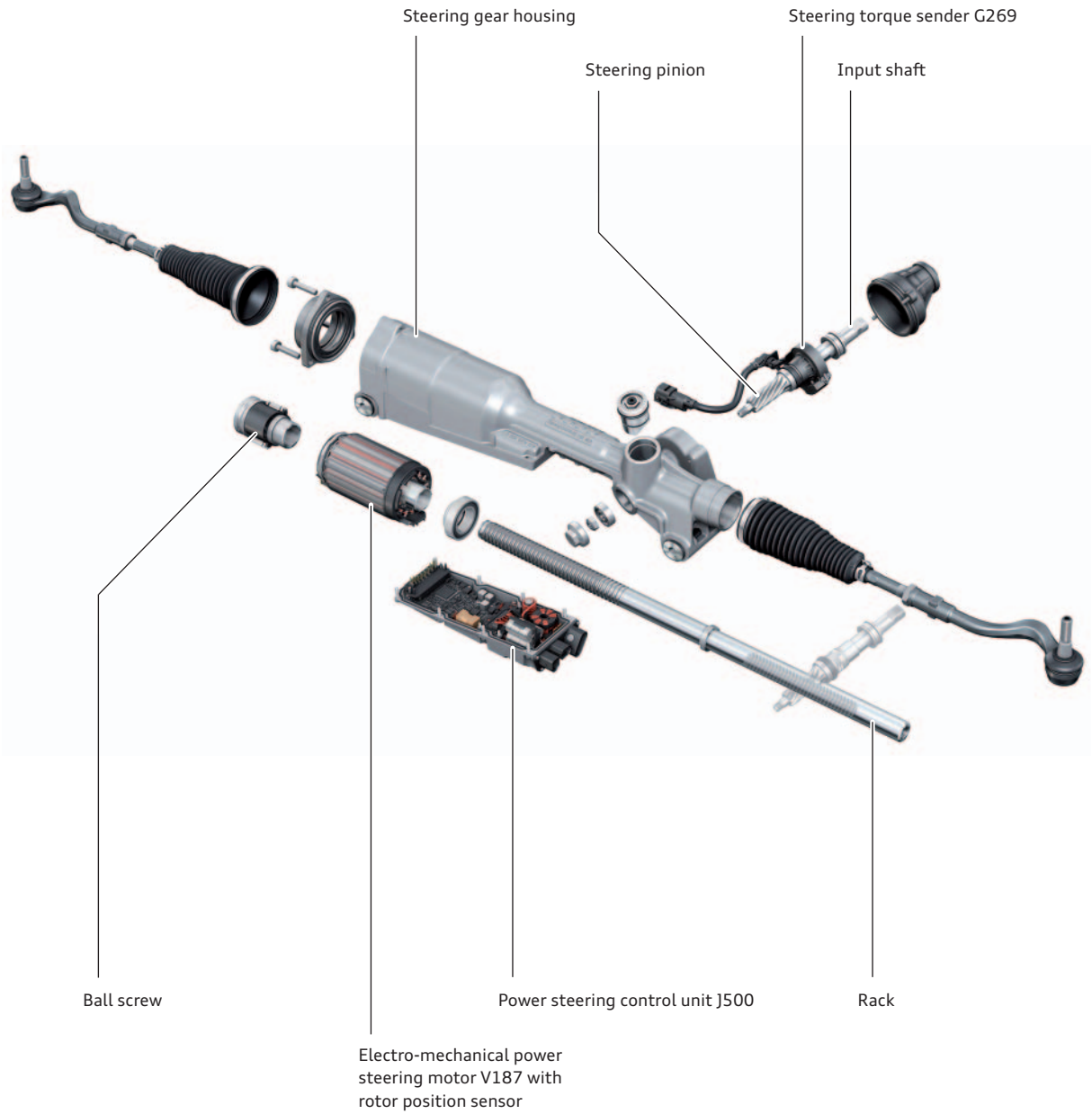
The pump cannot build up the necessary pressure at low temperatures. In this case, the required oil pressure is produced by the e-machine and by the mechanical gear oil pump in the automatic gearbox.

Note
As with the previous multi-step automatic gearboxes, the vehicle can be towed in selector lever position **N** up to a max. distance of 50 km and up to a max. speed of 50 kph because the gearbox is not lubricated during towing.

Suspension System

Electro-mechanical steering

An electro-mechanical steering system is used in the Audi A8 hybrid in place of the hydraulic power steering system. The electro-mechanical steering system from the Audi A6 ’11 was adopted for the Audi A6 hybrid.



Reference
For further information on the function and design of the electro-mechanical steering system, refer to Self Study Programme 480 "Audi A7 Sportback — Running Gear".

Vacuum pump for brake servo assist V469

Electrical vacuum pump for brake servo assist V469 is installed in the engine bay at the front left. It provides sufficient vacuum in the brake booster while the internal combustion engine is off.

The vacuum pump is controlled by engine control unit J623 via relay J318. The pump is activated as required via brake booster pressure sensor G294.



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Vacuum pump for brake servo assist V469

ESP unit

The ESP in the Audi A6 hybrid and in the Audi A8 hybrid is identical to that used in the Audi A6 ’11 and in Audi A8 ’10. The software has been expanded to include the hybrid engine drag torque control function.
Because the brake pressure cannot be reduced for stabilisation purposes under electrical braking (intensified recuperation), the engine control unit is instructed to adapt the drive torque.
If ESP is deactivated in gear selector position "**D**", the internal combustion engine runs continuously during the trip.

Brake pedal position sender G100

Brake pedal position sender G100 is connected to the engine control unit. It is used for controlling the electrical braking function (recuperation) via the engine control unit and the hydraulic braking function through the ESP unit. The brake pedal has approx. 9 mm of idle travel at the brake booster. This pedal travel allows only electric braking. A seamless transition is made to hydraulic braking when braking is applied.

After replacing the brake pedal position sender or the engine control unit, brake pedal position sender G100 on the engine control unit must be adapted.

Electrical system

Hybrid battery unit AX1

In the Audi A6 hybrid and in the Audi A8 hybrid, the hybrid battery unit AX1 is located at the front end of the luggage compartment. The hybrid battery unit AX1 is assembled from the following components:

- High voltage battery A38
- Battery regulation control unit J840
- High voltage contacts
- Connection for maintenance connector TW
- Connection for safety connector TV44
- Connections for high voltage cable set PX1
- Connections for 12 volt electrical system

The housing of the hybrid battery unit AX1 is connected to the vehicle body by an equipotential bonding.
To enable the high voltage battery A38 to cool down, the housing of the hybrid battery unit AX1 has connections for cooling air intake and discharge.
In addition, a noxious gas vent with connecting vent hose is attached to the housing of the hybrid battery unit AX1. This vent is required in order to release from under the vehicle any gas released from a faulty cell.

Installation location of hybrid battery unit AX1 in the Audi A6 hybrid



High voltage battery	
Rated voltage in V	266
Cell voltage in V	3.7
Number of cells	72 (connected in series)
Capacitance in Ah	5.0
Operating temperature in °C	+15 — +55
Energy content in kWh	1.3
Usable energy content in kWh	0.8
Power output in kW	max. 40
Weight in kg	38

Installation location of hybrid battery unit AX1 in the Audi A8 hybrid

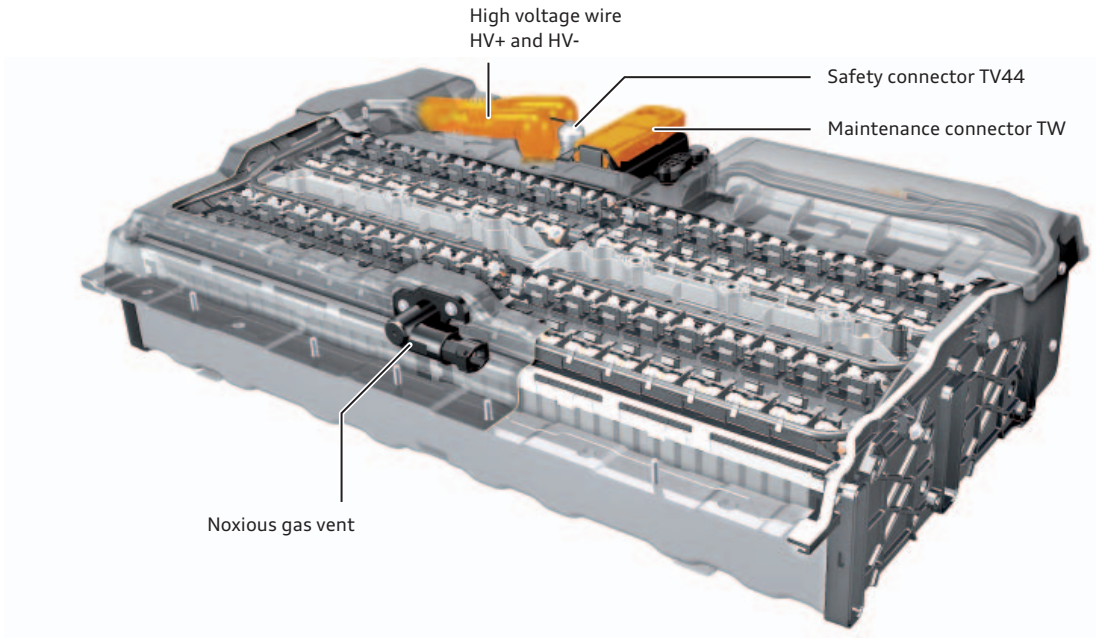


High voltage battery A38

The high voltage battery A38 comprises two battery blocks connected in series. Both battery blocks are interconnected by maintenance connector TW. Each battery block in turns consists of two battery modules. A battery module is made up of 18 lithium ion cells and has a nominal voltage of 66.5 volts. During vehicle operation, the charging and discharge currents are measured by a current sensor and monitored by battery regulation control unit J840.
The charge level of the high voltage battery A38 is maintained at between 30 % and 80 % of total capacitance. The limited charge range extends the life of the high voltage battery considerably. The battery charge indicator in the instrument cluster display reads 0 % or 100 % .

If the charge of the high voltage battery A38 drops to below 25 %, starting capacity is now at a critical level. If the internal combustion engine fails to start at this charge level, the message "Vehicle cannot be started at this time. See owner's manual" appears on the instrument cluster display. If the charge level is below 20 %, the high voltage battery is not permitted to discharge any more current. The internal combustion engine can no longer be started by electro-drive drive motor V141. The high voltage battery cannot be charged if its charge level has dropped below 5 %.

The high voltage battery is charged during vehicle operation by electro-drive drive motor V141.
During vehicle operation, the 12 volt electrical system is energised by high voltage battery A38.



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Charging the high voltage battery

If the instrument cluster display reads "Vehicle cannot be started at this time. See owner's manual", the high voltage battery must be charged by another vehicle or using a 12-volt charger.

Since the charging cycle takes place when terminal 15 is "on", the charger should ideally have a charging capacity of between 50 and 70 A.
The vehicle automatically switches terminal 15 "off" after 30 minutes. This means that the charging cycle is also aborted.

Procedure:

- Switch terminal 15 on
- Connect the jump leads or the charger to the jump start stud.
- Switch terminal 15 off
- Wait for about two minutes
- Switch terminal 15 on

The following message then appears on the instrument cluster display: "Startability restored. Vehicle can be started."

After about a minute, the instrument cluster display displays the following message: "Preparing to start vehicle. Please wait...".
When the charge level of the high voltage battery reaches 35 %, the charging cycle is automatically terminated.

If the message is "Charging cycle aborted. Cannot start engine", the donor vehicle or the charger may not have sufficient charging capacity.

Battery regulation control unit J840

The battery regulation control unit J840 is an integral part of the hybrid battery unit AX1 and is located on the left hand side inside the housing.

The battery regulation control unit J840 performs, among other things, the following tasks:

- Measurement and evaluation of the battery voltage
- Measurement and evaluation of the individual cell voltages
- Measurement of high voltage battery temperature
- Regulation of high voltage battery temperature using the battery cooling module

The control unit J840 is able to communicate with other control units and components through the interface to the hybrid CAN, CAN powertrain and the 12 volt electrical system.

- Saving history data
- Activating the high voltage contacts
- Monitoring and evaluating the safety line
- Performing and evaluating the insulation test
- Determining the charge level of the high voltage battery A38
- Measuring the charging and discharge currents

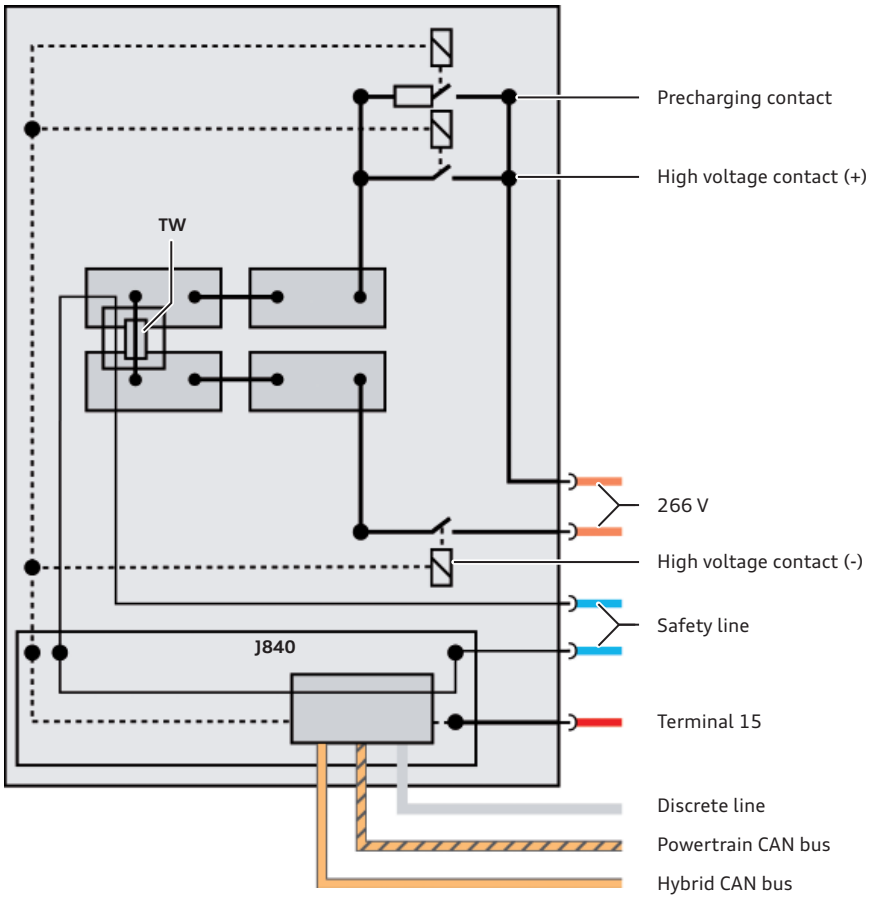
High voltage contacts

In total, there are three high voltage contacts, also known as "contactors", in the hybrid battery unit AX1. A contactor can be compared to a relay, but is designed for higher electrical outputs. If the high voltage contact are closed, the high voltage battery is connected to the other high voltage components, and electrical current is able to flow. High voltage contacts for "positive" and "negative" are fitted. A 10 ohm resistor is integrated in the second "positive" high voltage contact. This high voltage contact is referred to as a precharging contact.

At terminal 15 "on", battery regulation control unit J840 first of all closes the "negative" high voltage contact and the precharging contact. A small amount of current flows through the resistor, which charges intermediate circuit capacitor 1 C25 in the electrical drive power and control electronics JX1. The "positive" high voltage contact is not closed by control unit J840 until the intermediate circuit capacitor 1 is charged up.

The high voltage contacts are opened by battery regulation control unit J840 if:

- terminal 15 is switched "off",
- or the safety line is disconnected,
- or a crash signal from airbag control unit J234 is detected,
- or the 12-volt power supply for battery regulation control unit J840 is interrupted.

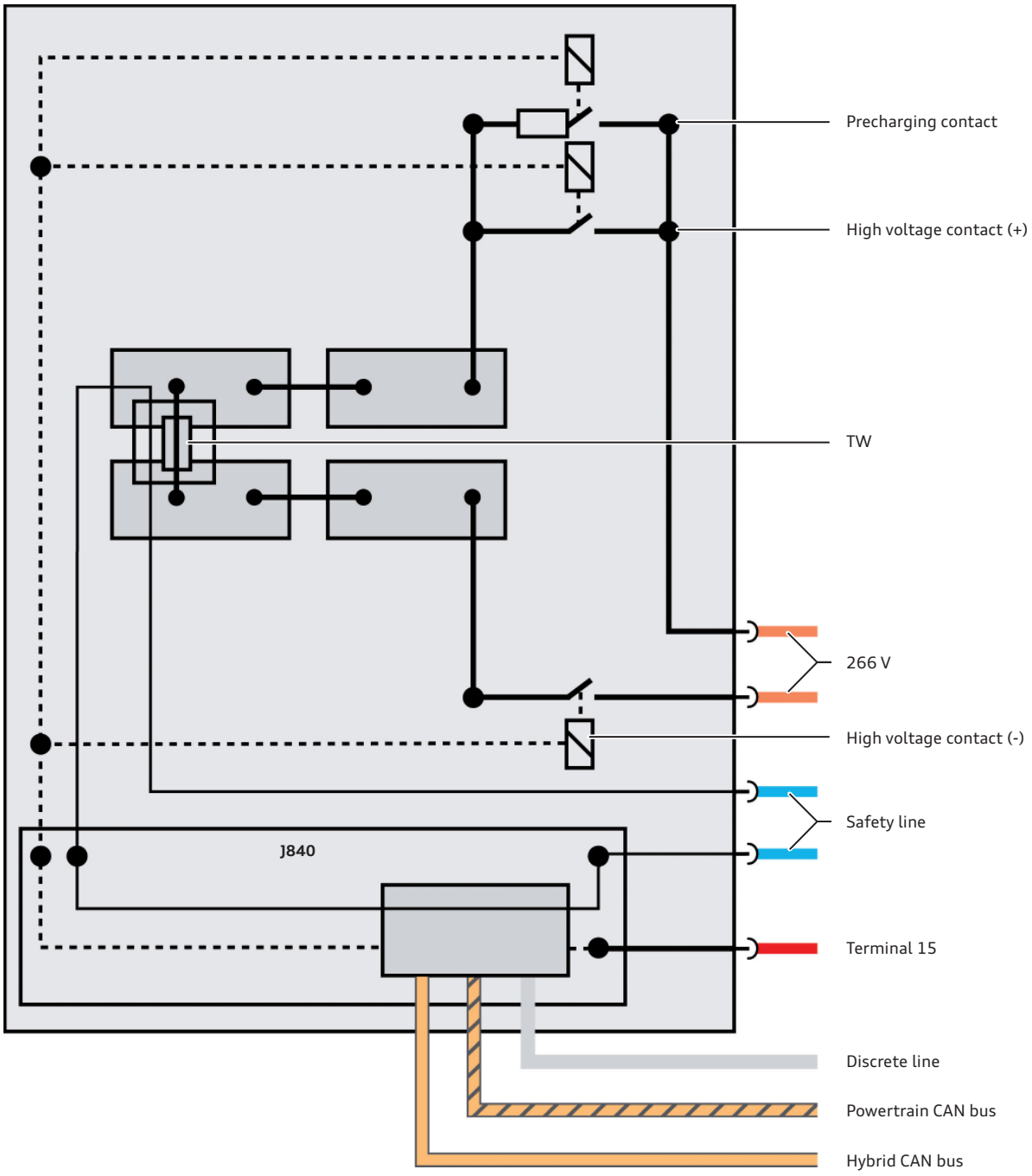


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Maintenance connector for high voltage system TW

The maintenance connector TW is the electrical connection between the two battery blocks of the high voltage battery A38. The electrical circuit is interrupted when the maintenance connector is removed.

To correctly remove the maintenance connector, please use the program for de-energising the high voltage system in the diagnostic testers. In addition, the safety line is integrated in the maintenance connector.

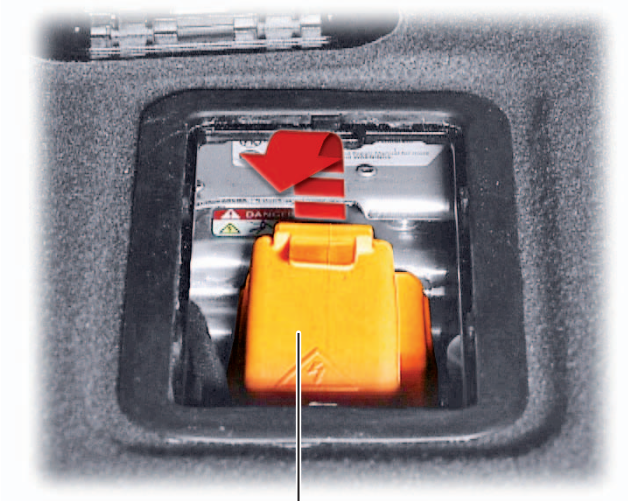


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Maintenance connector

Audi A6 hybrid

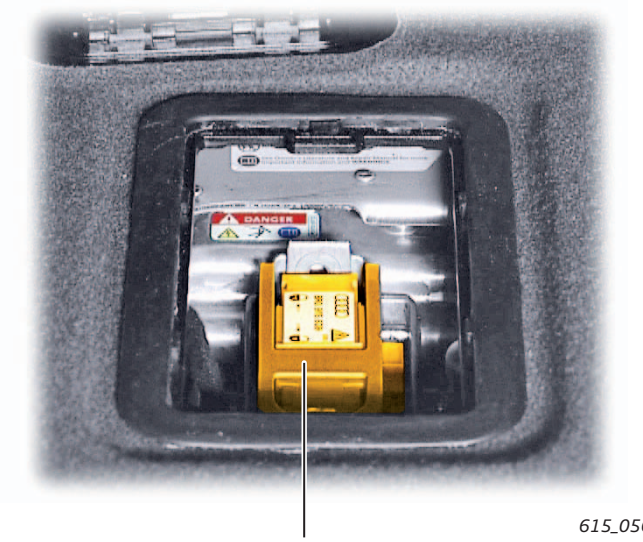
Service connector TW is plugged into the hybrid battery unit AX1 and can be accessed via the service flap in the luggage compartment.



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Rubber cover under service flap

Maintenance connector TW is located under a removable orange coloured rubber cover.

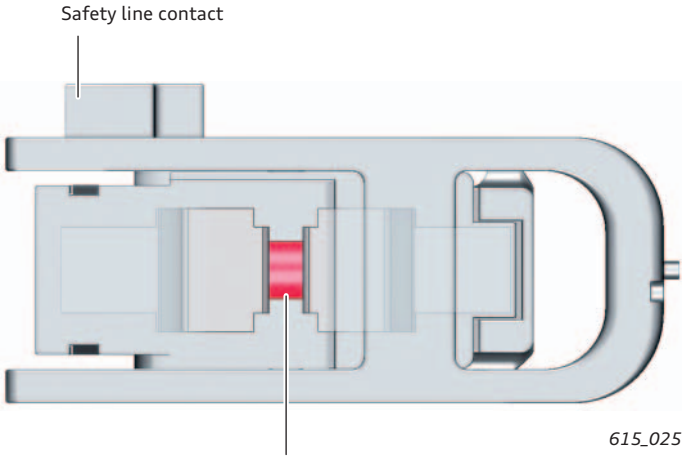


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Maintenance connector TW

Fuse in maintenance connector

A fuse for the high voltage system is integrated in the maintenance connector. The fuse is rated for 125 A.



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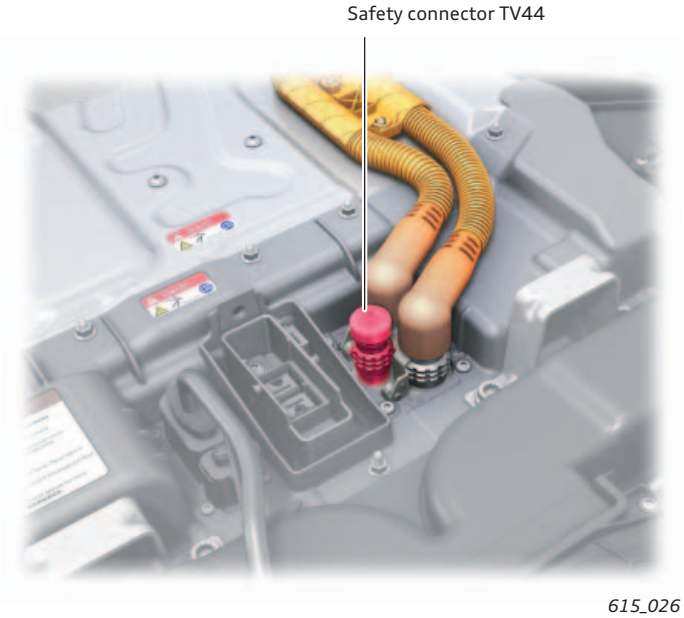
Fuse in maintenance connector

Note
Only qualified high voltage technicians are allowed to disconnect this maintenance connector in order to de-energise the vehicle.

Safety concept

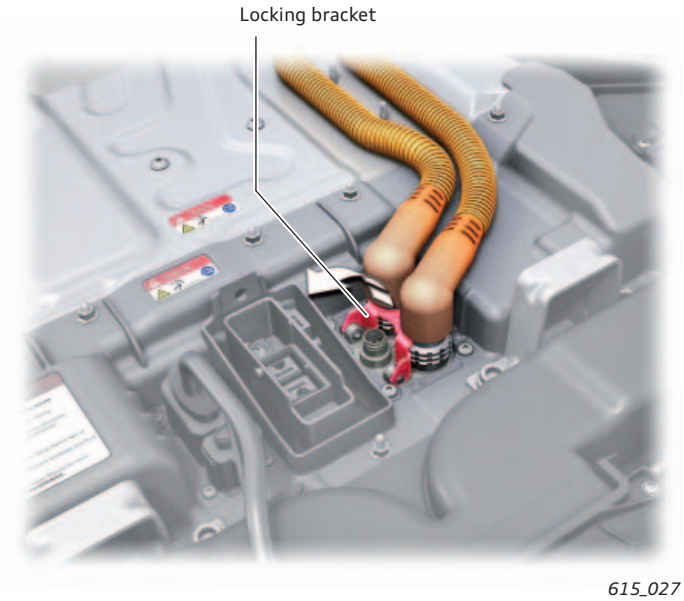
Safety connector TV44

The safety connector TV44 is an integral part of the hybrid battery unit AX1 and the safety line. In addition, the safety connector with locking bracket acts as a mechanical fuse for the high voltage cable set for hybrid battery PX1. The high voltage system must be de-energised before the safety connector TV44 may be removed. To unlock and remove the safety connector TV44, a bayonet ring must first be lifted. The safety line remains disconnected until the safety connector TV44 is fitted.



615_026

If the locking bracket is swivelled back, the bayonet rings of the high voltage cable set for hybrid battery PX1 can be released. The safety connector TV44 cannot be fitted until the locking bracket is back in its initial position.



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Insulation monitoring

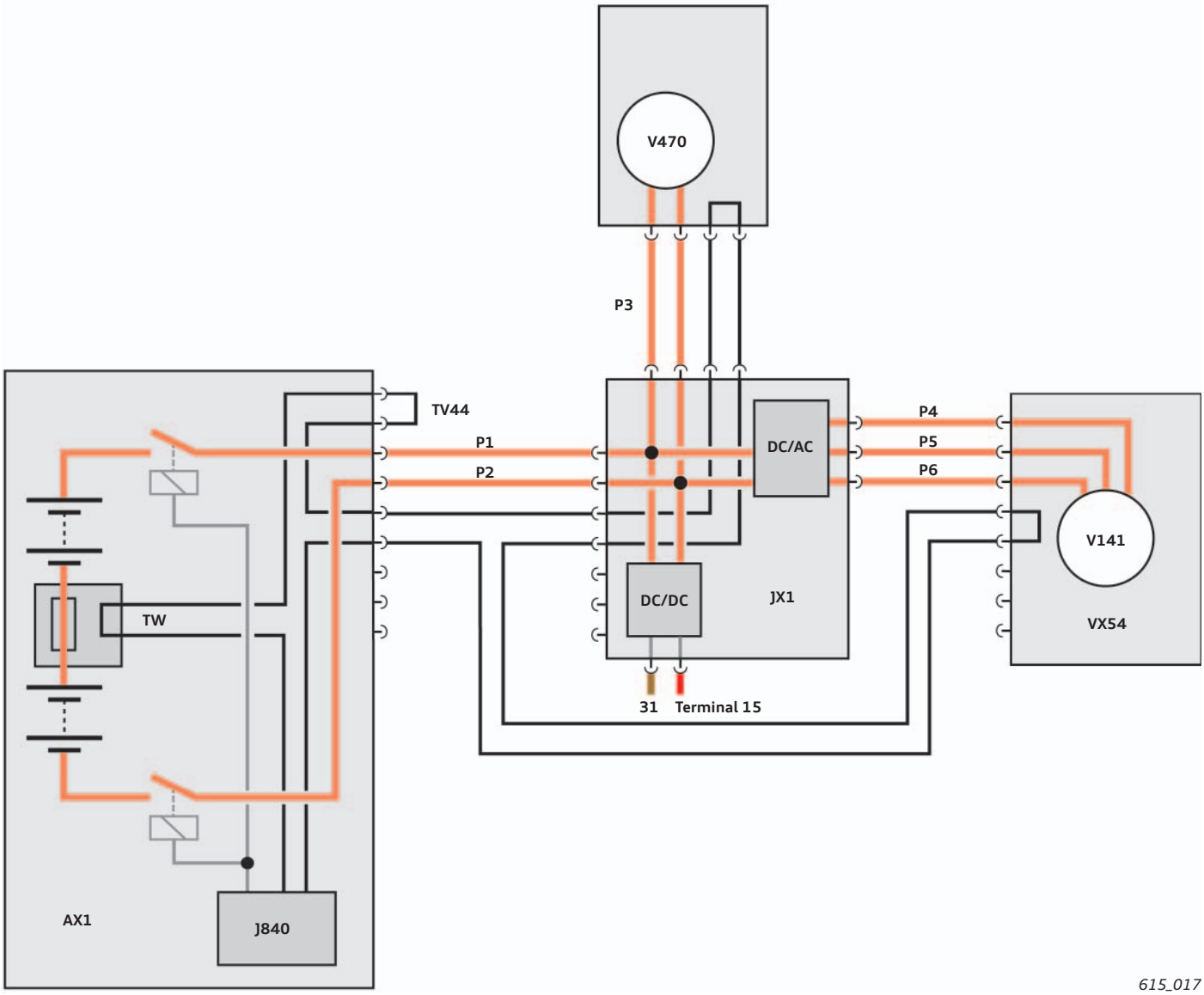
When the high voltage system is active ("*Hybrid Ready*"), battery regulation control unit J840 performs an insulation test every 30 seconds. The resistance between the current conductors and the housing of the hybrid battery unit AX1 is checked by impressing a voltage of 266 volts.

Insulation faults are detected across the entire high voltage circuit, i.e. in hybrid battery unit AX1, high voltage cable set for hybrid battery PX1, power and electric drive control electronics JX1, high voltage cable set for drive motor PX2, electro-drive drive motor V141 and electrical AC compressor V470 with lead.
If an insulation fault occurs, it is indicated on the instrument cluster display, and the customer is instructed to take the vehicle to a service workshop for repair.

Safety line

The safety line is a 12 volt ring line which interconnects all high voltage components in series.
The battery regulation control unit J840 inputs an electrical current of approximately 10 mA into the safety line and evaluates the current flow. In addition, electric drive control unit J841 monitors the safety line. If the safety line is disconnected, the high voltage system is immediately deactivated by the battery regulation control unit. The high voltage contacts are opened.
The driver is notified via the instrument cluster display.

The safety line from power and electric drive control electronics JX1 to electrical AC compressor V70 is integrated into the high voltage line to the electrical AC compressor using an additional two wires. A design safeguard has been provided to ensure that the safety line is interrupted before a high voltage line can be disconnected from a high voltage component. This ensures that no electric arcing can occur and that no high voltage contacts can be touched. In addition, all high voltage components have a mechanical safeguard which interrupts the electrical safety line when parts of the housing are opened.



Key:

High voltage wire
Safety line

AX1 Hybrid battery unit
J840 Battery regulation control unit
JX1 Electric drive power and control electronics
P1 High voltage line for hybrid battery, positive pole
P2 High voltage line for hybrid battery, negative pole
P3 High voltage line for electrical AC compressor
P4 High voltage line for 1 drive motor (U)
P5 High voltage line for 2 drive motor (V)
P6 High voltage line for 3 drive motor (W)
TV44 Safety connector 1
TW Maintenance connector for high voltage system
V141 Electro-drive drive motor
V470 Electrical AC compressor
VX54 Three-phase AC drive

Battery cooling

Chemical processes which release heat energy occur when the high voltage battery A38 is charged and discharged.
Because the high voltage batteries in the Audi A6 hybrid and in the Audi A8 hybrid are subject to continuous continuous discharge and charge cycles, there can be considerable heat build-up. This not only has the potential to prematurely age the battery, it also increases electrical resistance in the conductors, with the result being that electrical energy is not converted to work but is instead dissipated and lost as heat. The hybrid battery unit AX1 has a cooling module to ensure that it stays within an acceptable range of temperatures. The cooling module runs on the 12 volt electrical system and has a separate evaporator which is connected to the cooling circuit of the electrical AC compressor.

The components of the cooling module are:

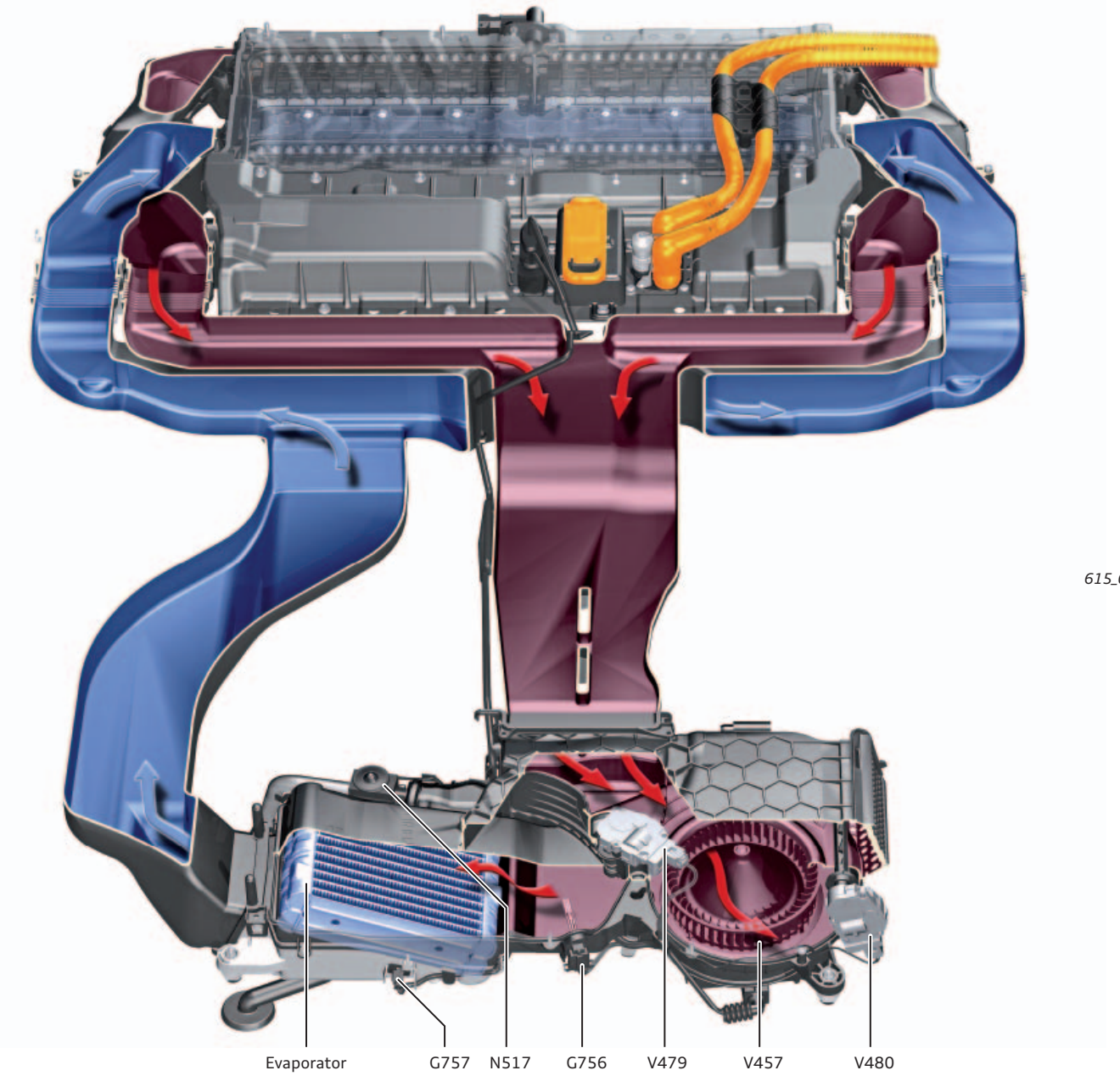
- Battery fan 1 V457
- Air recirculation flap servomotor 1 for hybrid battery V479
- Air recirculation flap servomotor 2 for hybrid battery V480
- Temperature sensor upstream of hybrid battery evaporator G756
- Temperature sensor downstream of hybrid battery evaporator G757
- Refrigerant shutoff valve 2 of hybrid battery N517
- Evaporator

Six temperature sensors are distributed across the cells of the hybrid battery unit JX1. Further temperature sensors are located in each of the cooling module air intake and outlet ducts.
If battery regulation control unit J840 detects excessively high battery temperatures, it activates battery fan V457. In fresh air mode, fan V457 draws air out of the spare wheel well, channels it through the evaporator and into the battery, and discharges the warm air into the atmosphere below the bumper at the rear left.

Battery cooling in the Audi A6 hybrid

The cooling module in the Audi A6 hybrid is installed behind the hybrid battery unit in the spare wheel well.

The cooling module has a service position which can be used to access the 12 volt battery fitted below it.



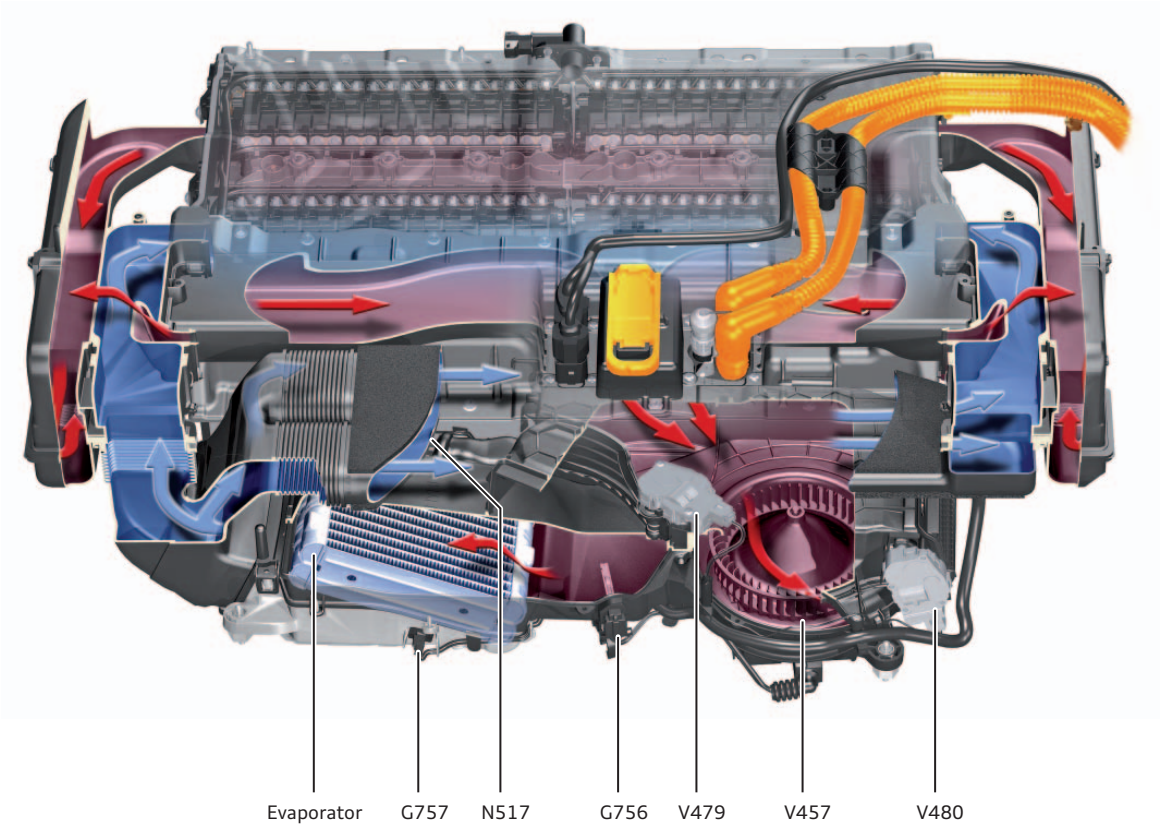
615_013

Depending on the temperature, the system switches from fresh air mode to air recirculation mode with active evaporator. Air circulation flaps 1 and 2 are closed, with the result that no more air is drawn out of the spare wheel well and no more air is discharged. In addition, hybrid battery refrigerant shut-off valve 2 N517 is energised and thus open. In addition, battery regulation control unit J840 sends, via the CAN bus, a request to the Climatronic control unit to activate electrical AC compressor V470. The cooling air temperature downstream of the evaporator is now set to 10 °C.

A cooling function model is integrated in the battery regulation control unit. Depending on the temperature, the speed of battery fan 1 V457 and the output of electrical AC compressor V470 are adapted to requirements by Climatronic control unit J255. If a high degree of cooling is required, a cooling air temperature of 3 °C can be achieved downstream of the evaporator.
Battery fan 1 V457, recirculation flap servomotor 1 for hybrid battery V479 and recirculation flap servomotor 2 for hybrid battery V480 are activated by battery regulation control unit J840 via the LIN bus.

Battery cooling in the Audi A8 hybrid

In the Audi A8 hybrid, the cooling module for cooling hybrid battery unit AX1 is located below the battery unit.



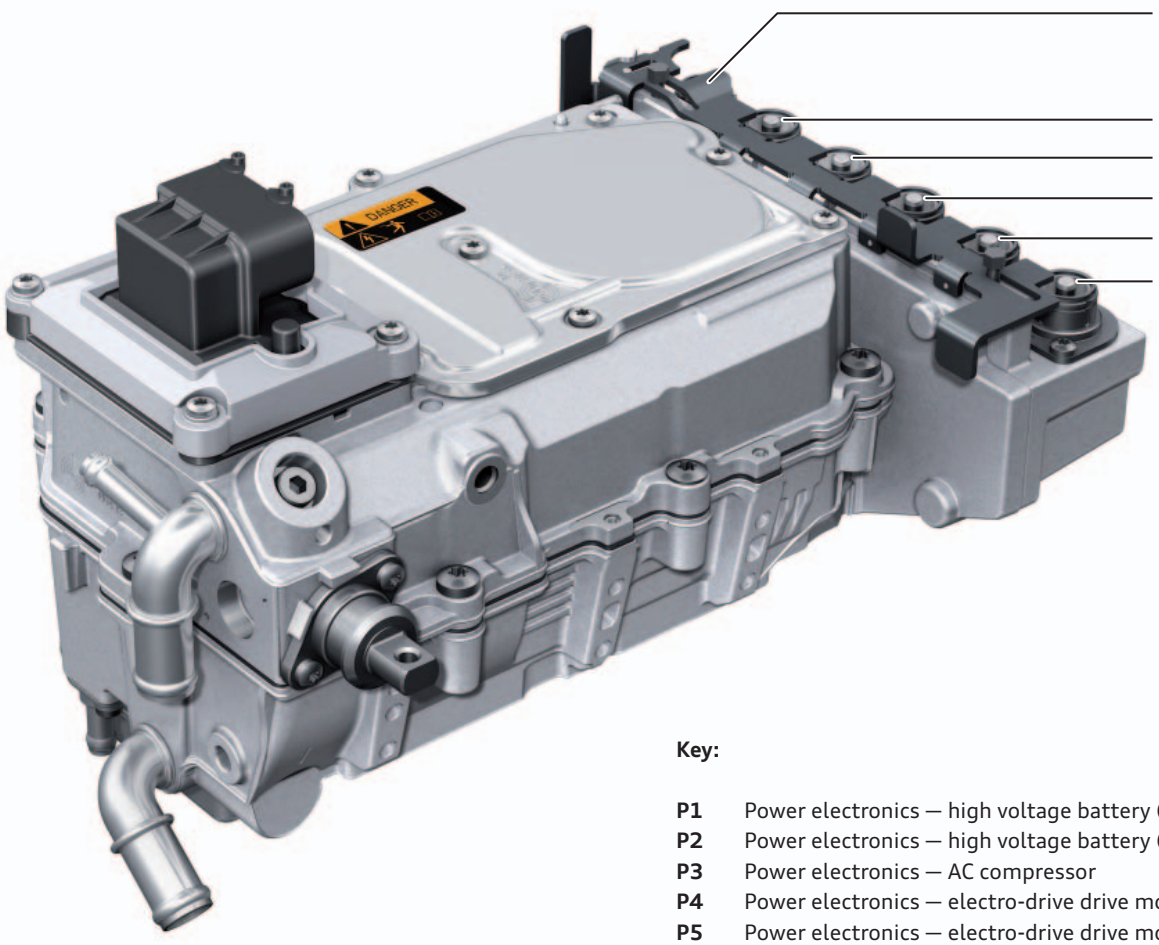
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Electric drive power and control electronics JX1

Power and electric drive control electronics JX1 comprises the following components:

- Electric drive control unit J841
- Drive motor inverter A37
- Voltage converter A19
- Intermediate circuit capacitor 1 C25

Electric drive control unit J841 is integrated in the vehicle network via the hybrid CAN bus and the powertrain CAN bus. In addition, the control unit is connected to the 12 volt electrical system. The 12 volt electrical system is supplied with voltage via a connection to power and electric drive control electronics JX1.



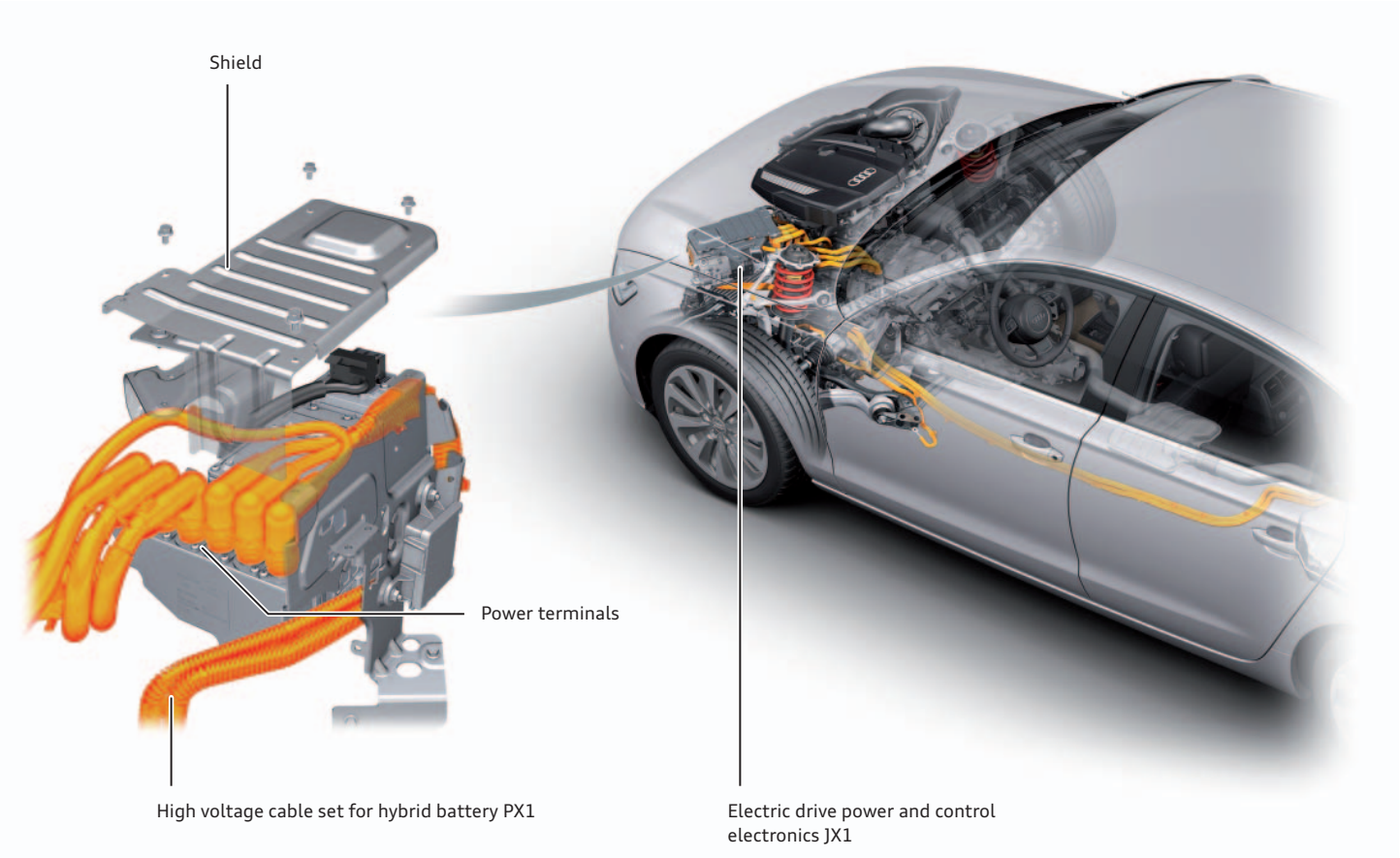
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Key:

P1 Power electronics — high voltage battery (HV positive)
P2 Power electronics — high voltage battery (HV negative)
P3 Power electronics — AC compressor
P4 Power electronics — electro-drive drive motor (U)
P5 Power electronics — electro-drive drive motor (V)
P6 Power electronics — electro-drive drive motor (W)

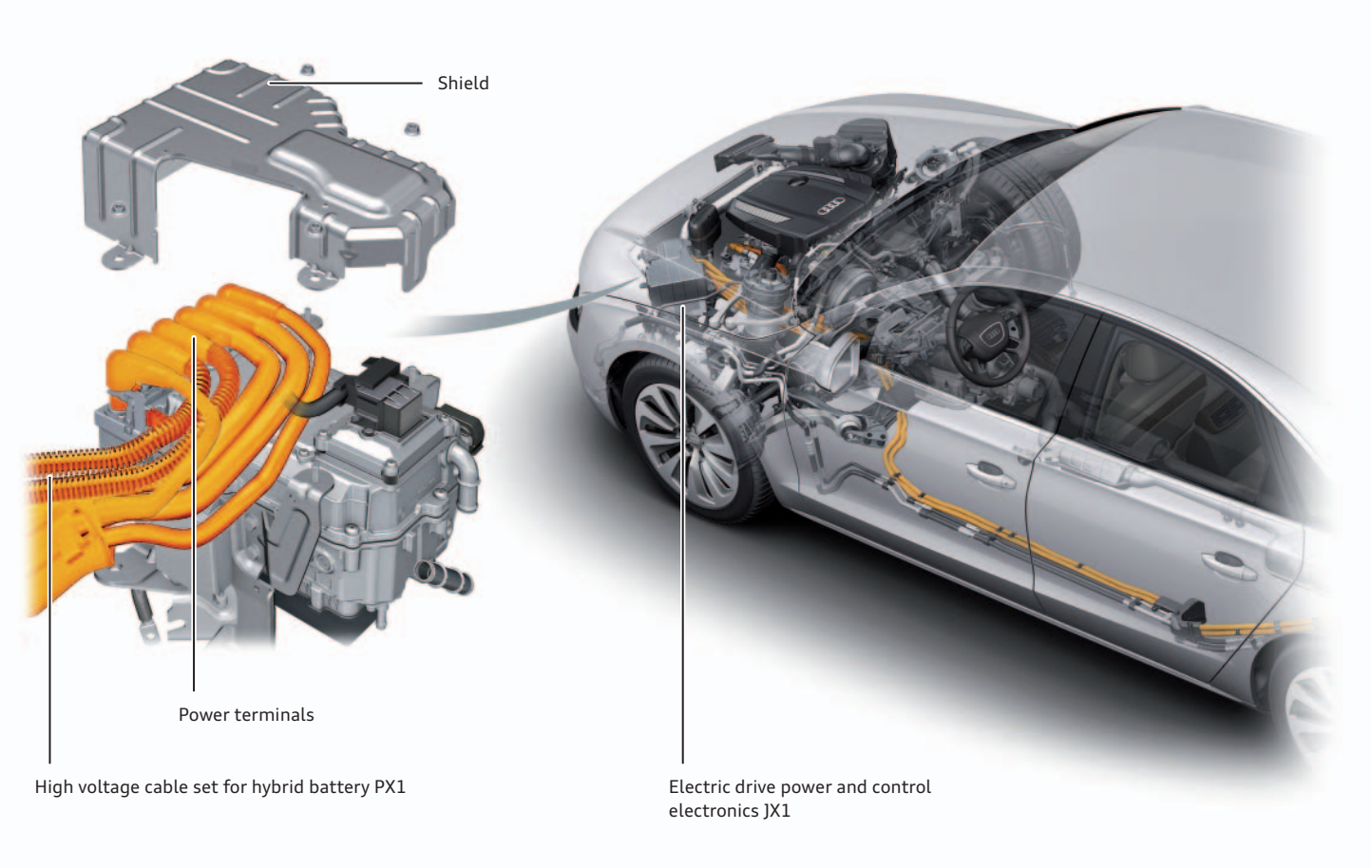
Power electronics	
DC/AC	266 $V_{nom.}$ in 189 $V_{eff.}$ AC
Continuous AC current	240 A_{eff}
Peak AC current	395 A_{eff}
AC/DC	189 V_{eff} AC to 266 $V_{nom.}$
e-machine drive	0 — 215 V
DC/DC	266 V to 12 V and 12 V to 266 V (bidirectional)
DC/DC power output in kW	2.6
Weight in kg	9.3

Installation location in Audi A6 hybrid



615_007

Installation location in Audi A8 hybrid

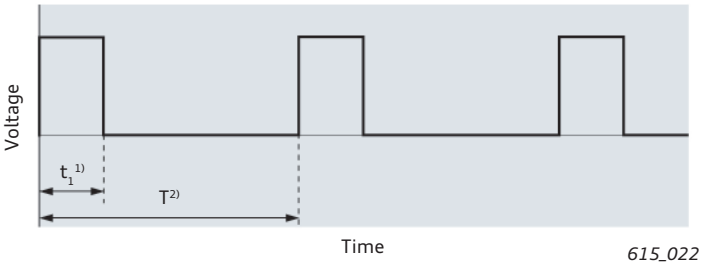


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Drive motor inverter A37

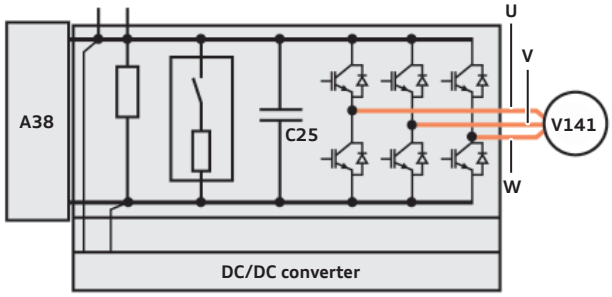
Use of electro-drive drive motor V141 as a motor

If electro-drive drive motor V141 is used as a motor, drive motor inverter A37 converts the direct current from high voltage battery A38 to a three-phase AC voltage. The direct voltage is converted to an AC voltage by pulse width modulation.



615_022

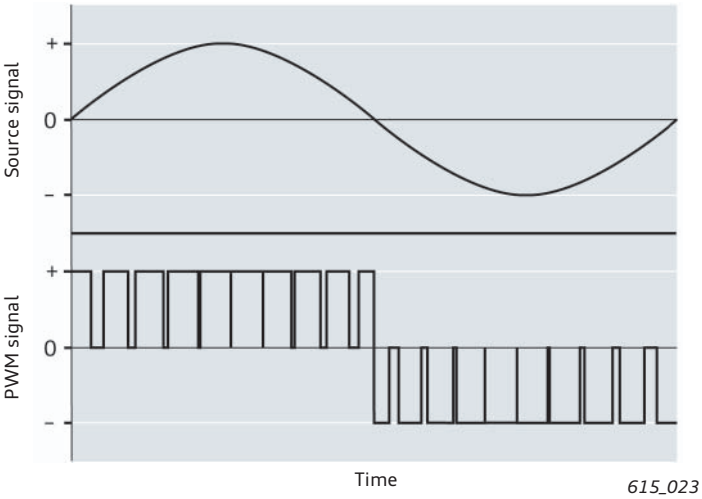
There are six transistors in drive motor inverter A37 - two for each of the three phases U, V and W. Each phase has a separate transistor for positive and negative. When A37 is activated, the corresponding potential is switched. The transistors are activated by electric drive control unit J841 using pulse-width-modulated signals.



615_031

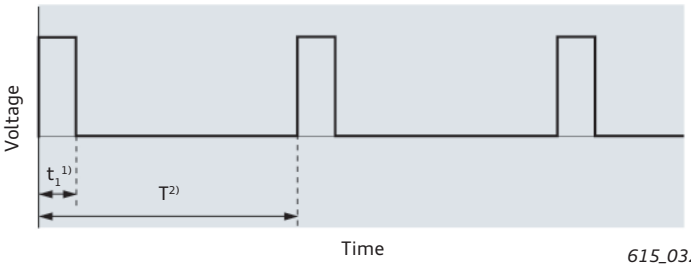
Example:

A sine-wave curve is subdivided into 20 pulse widths.
A sine-wave voltage can be generated by the on-times of the individual pulse widths. In this example, all 20 pulse widths are generated once within a second. If all 20 pulse widths are now activated once within 0.5 seconds, the frequency has increased and, with it, the speed of electro-drive drive motor V141.
The speed of electro-drive drive motor V141 is controlled by modulating the frequency of the AC voltage. At a speed of, say, 1000 rpm, the electrical frequency is approx. 267 Hz.



615_023

The torque produced by electro-drive drive motor V141 is controlled by modifying the on-times of the individual pulse widths.



615_032

t_1 1) "On" time
T2) Pulse width

Electro-drive drive motor V141 in generator mode

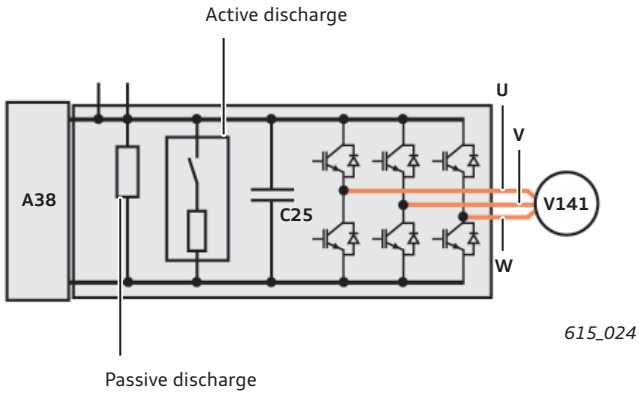
If electro-drive drive motor V141 is in generator mode, drive motor inverter A37 converts the generated three-phase AC voltage to a 266 volt DC voltage. Drive motor inverter A37 is, therefore, both an AC/DC converter and a DC/AC converter. The high voltage system is supplied with the generated DC voltage and the 12 volt electrical system via voltage converter A19.

Voltage converter A19

Voltage converter A19 is a DC/DC converter and converts the 266 volt DC voltage to the low DC voltage (12 volts) of the vehicle's electrical system. It is also capable of converting a voltage of 12 volts to a voltage of 266 volts. This function is also used for jump starting (charging high voltage battery A38).

Intermediate circuit capacitor 1 C25

A further component is intermediate circuit capacitor 1 C25 in the power and electric drive control electronics JX1. Its task is to stabilise the voltage. Voltage fluctuations can occur for example at start-up or at kick-down (boost).
The intermediate circuit capacitor is actively and passively discharged at terminal 15 OFF or if the high voltage system is deactivated due to a crash signal. Passive discharge means that the intermediate circuit capacitor 1 C25 is discharged through a 22 kOhm resistor. During active discharge, a 1 kOhm resistor is connected in parallel to a 22 kOhm resistor. This ensures that intermediate circuit capacitor 1 C25 is discharged in the shortest possible time.



Electric drive control unit J841

Electro-drive drive control unit J841 checks the rotor speed and position of electro-drive drive motor V141 using drive motor rotor position sensor 1 G713.
In addition, control unit J841 checks the temperature of electro-drive drive motor V141 using drive motor temperature sensor G712.

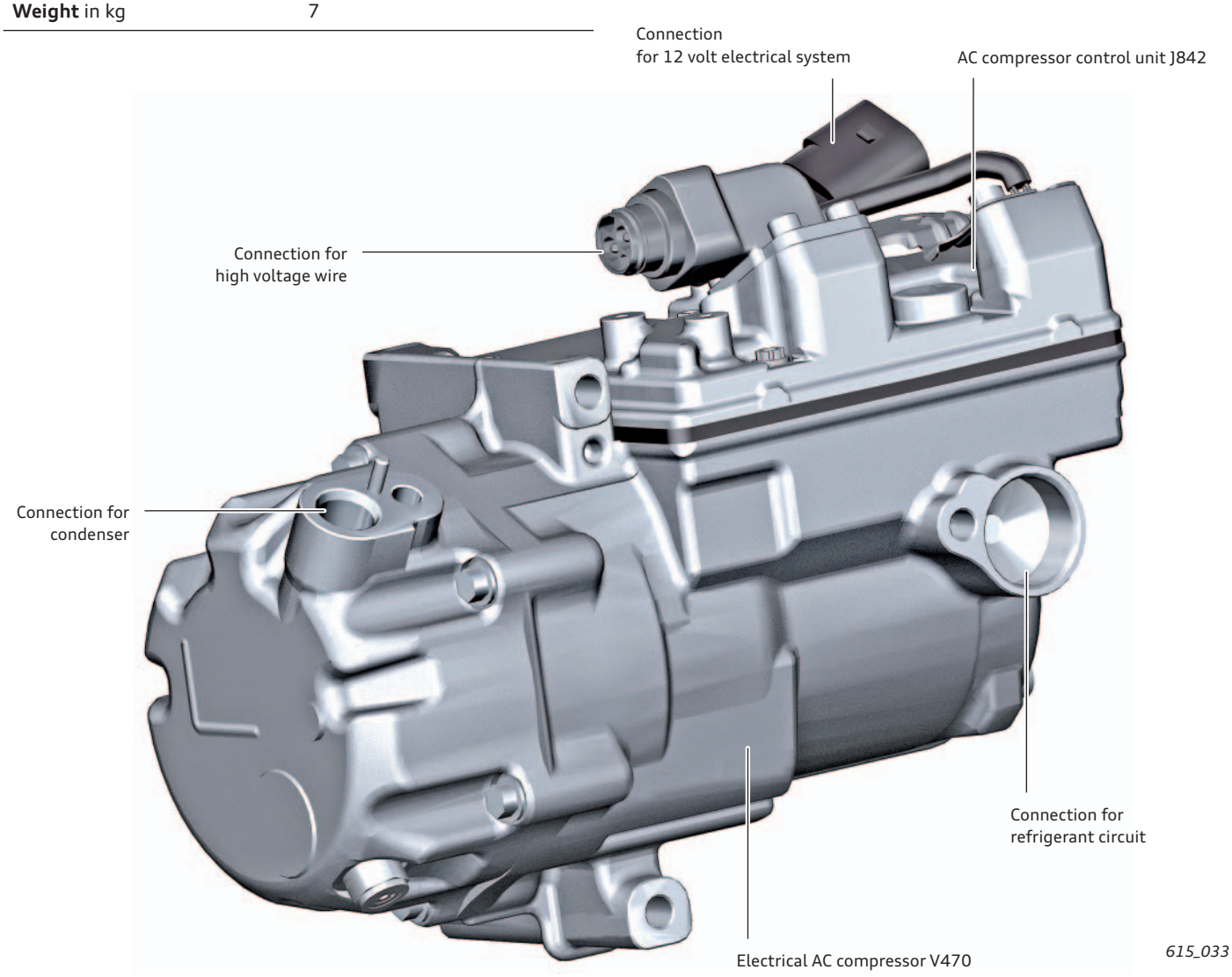
The electric drive power and control electronics JX1 has its own low temperature cooling circuit, which is connected to the coolant reservoir of the engine cooling circuit. Temperature sensors in the electric drive power and control electronics JX1 signal the temperatures to electric drive control unit J841.
Because the low temperature circuit is an integral part of the internal combustion engine's thermal management system, electric drive control unit J841 sends the relevant information on engine control unit J623. This allows engine control unit J623 to activate low temperature circuit coolant pump V468 according to requirements via electric drive control unit J841.

Electrical AC compressor V470

Electrical AC compressor V470 replaces the belt-driven AC compressor. Electrical AC compressor V470 is integrated in the high voltage system via power and electric drive control electronics JX1 and is supplied with a voltage of 266 volts.
In power and electric drive control electronics JX1 there is a 30 A fuse which protects the high voltage current circuit for the electrical AC compressor.
AC compressor control unit J842 is integrated in electrical AC compressor V470. AC compressor control unit J842 is able to exchange data with other control units via the Extended CAN bus.
The electrical AC compressor is controlled by Climatronic control unit J255.
The hybrid battery unit AX1 is cooled independently of the cabin air conditioning.

Hybrid battery refrigerant shut-off valve 1 N516 is integrated in the left suspension strut area and controls refrigerant flow to the cabin air conditioner. Hybrid battery refrigerant shut-off valve 1 N516 is open when de-energised. If necessary (e.g. AC-OFF), the Climatronic control unit J255 can activate hybrid battery refrigerant shut-off valve 1 N516 via battery regulation control unit J840.

Electrical AC compressor V470	
Electric motor	Brushless asynchronous motor
Power consumption in kW	up till 6
Voltage supply in V	266 DC
Current consumption in A	up till 22
Speed in rpm	800 – 8600
Weight in kg	7

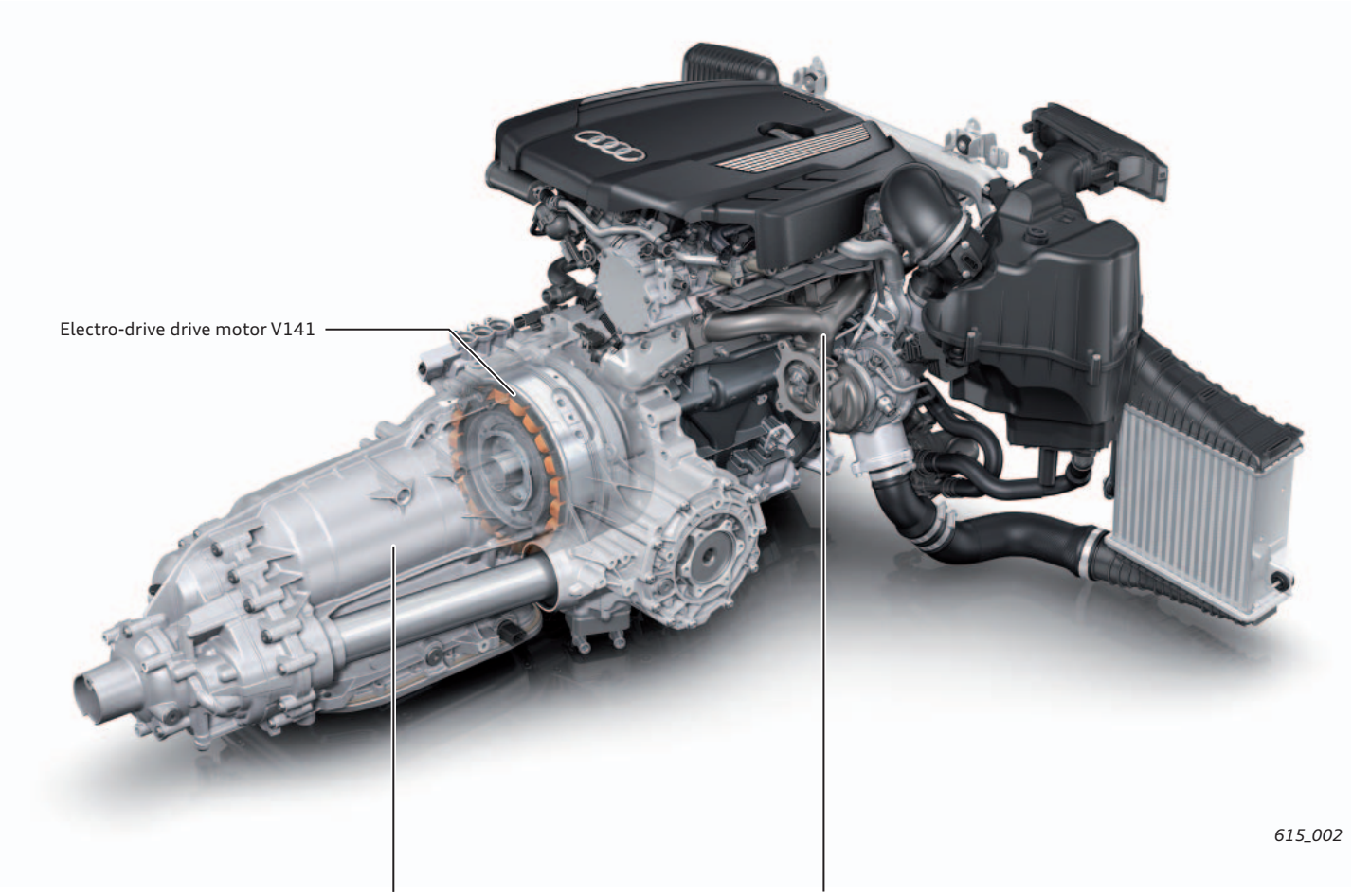


Three-phase AC drive VX54

In the Audi A6 hybrid and in the Audi A8 hybrid, the three-phase AC drive VX54 is fitted in place of the torque converter in the available installation space between the internal combustion engine and the 8-speed automatic gearbox.

Three-phase AC drive VX54 comprises the following components:

- Electro-drive drive motor V141
- Dual mass flywheel
- Terminal box for high voltage terminals
- Connector for safety line



Electro-drive drive motor V141

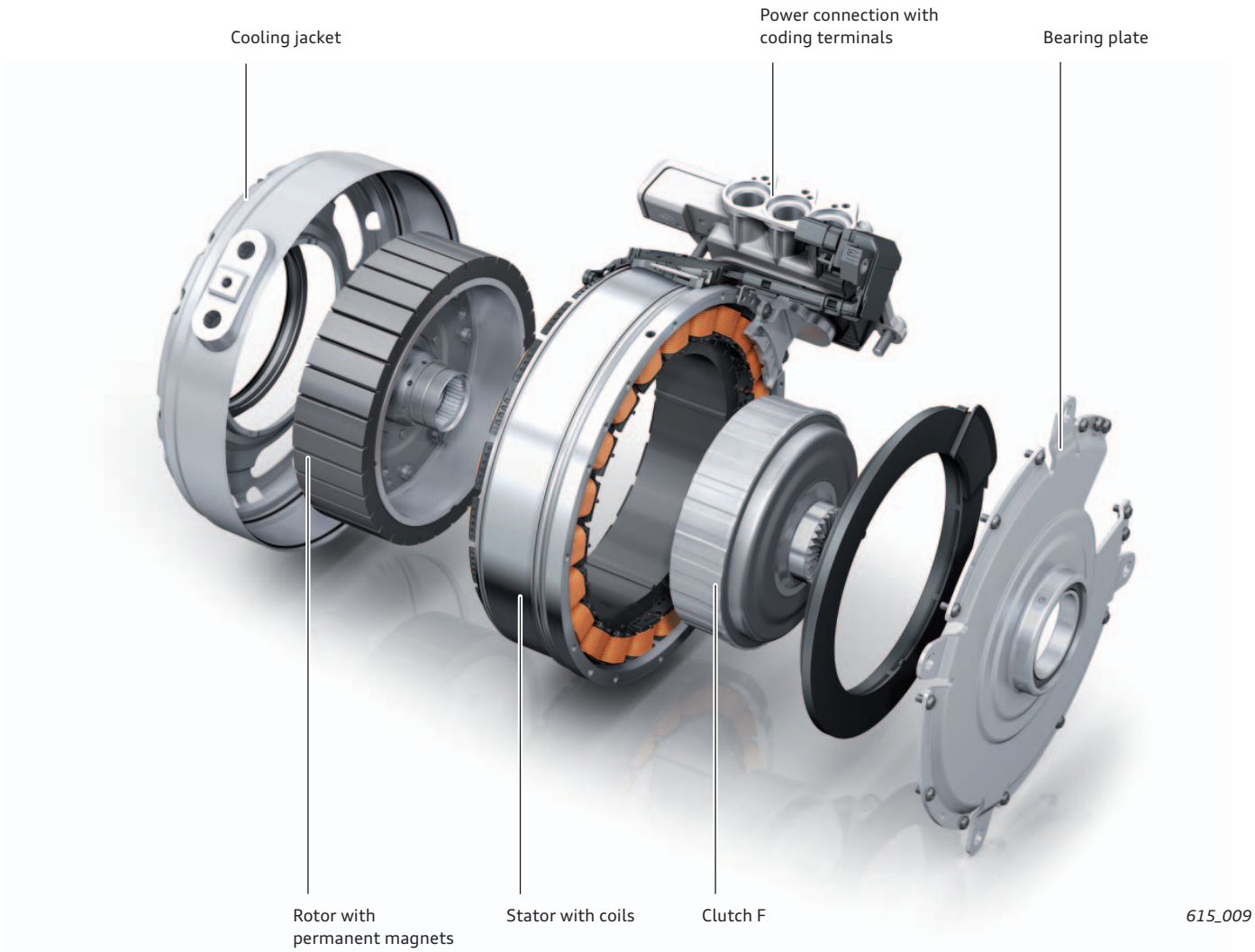
Electro-drive drive motor	
Power output in kW at rpm	40 at 2300
Torque in Nm	210
Weight of e-machine in kg	26
Voltage in V	AC 3 ~ 145

Electro-drive drive motor V141 is a permanently excited synchronous motor and is driven by a three-phase field source. Permanently excited means that the rotor has 32 permanent magnets and is not excited by an external source. The magnets are made of neodymium iron boron (NdFeB). As with a synchronous motor, the rotor rotates in sync with the generated magnetic fields, i.e. there is no time offset. The magnetic fields are generated by 24 magnetic coils which are supplied with AC voltage by electric drive power and control electronics JX1.

The fact that there are more permanent magnets than magnetic coils ensures that electro-drive drive motor V141 starts automatically when electrical magnetic fields are generated. Electro-drive drive motor V141 is used for starting the internal combustion engine, while also allowing the vehicle to operate solely under electric power and assisting the internal combustion engine during acceleration. When it not being used as an electric motor, electro-drive drive motor V141 acts as a generator and supplies the entire vehicle with power.

Electro-drive drive motor V141 is made up of the following components:

- Rotor with permanent magnets
- Stator with coils
- Cut-out clutch F
- Cooling jacket
- Bearing plate
- Power connection with coding terminals
- Drive motor temperature sensor G712
- Drive motor rotor position sensor 1 G713



Drive motor temperature sensor G712

Drive motor temperature sensor G712 is an NTC resistor that measures the temperature of electro-drive drive motor V141. It is positioned between two magnetic coils. The temperature of the complete electro-drive drive motor V141 is controlled by engine control unit J623 based on a temperature model. If the temperature exceeds a range of 180–200 °C, the power output of electro-drive drive motor V141 is gradually reduced to zero.

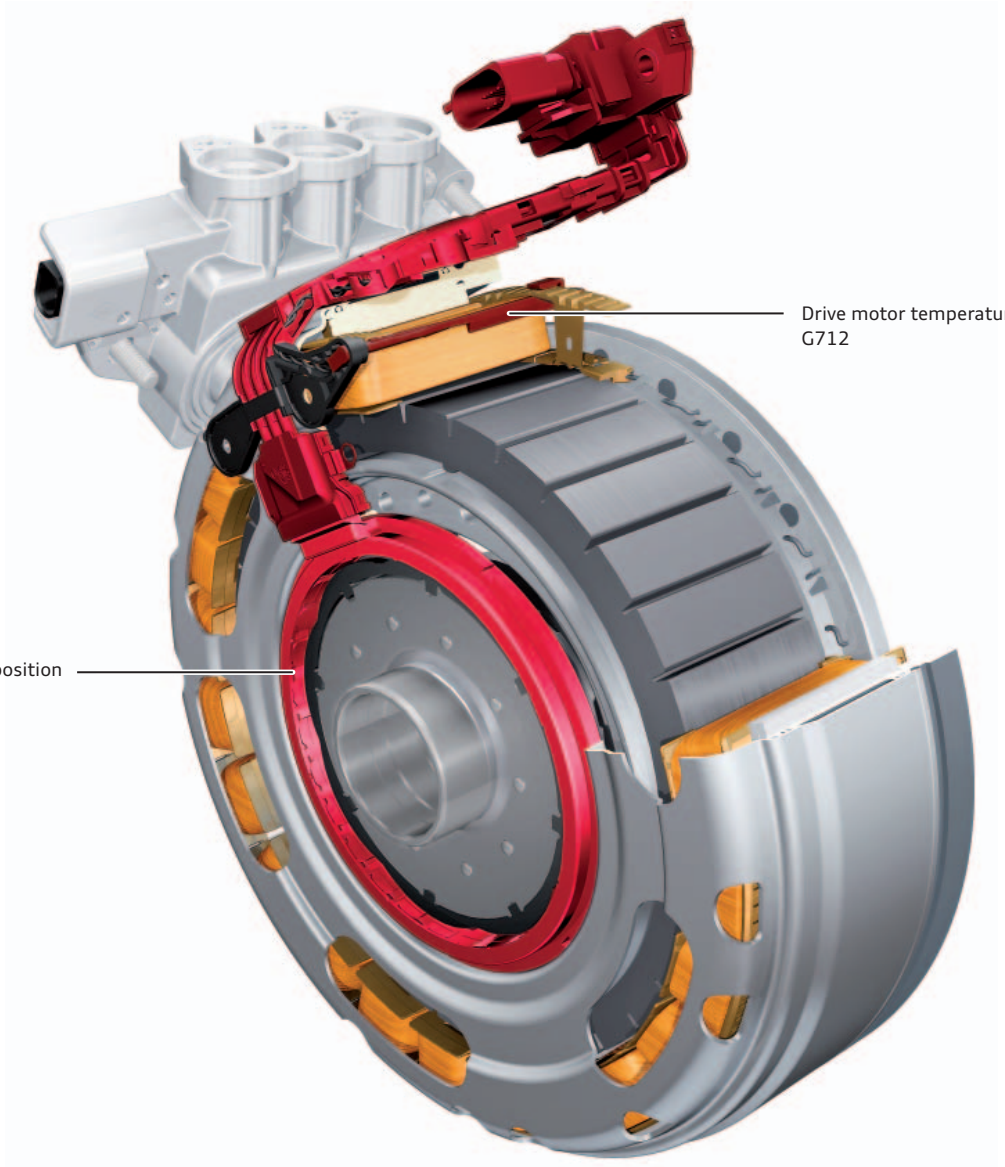
The electro-drive drive motor is water-cooled and integrated in the high-temperature circuit of the internal combustion engine. Coolant is circulated by the high-temperature circuit coolant pump V467 (in three stages) as required. The pump is activated by engine control unit J623.

If drive motor temperature sensor G712 is found to be faulty, this is indicated via the instrument cluster display and the customer is requested to take the vehicle to an authorised service centre for repair.

Drive motor rotor position sensor 1 G713

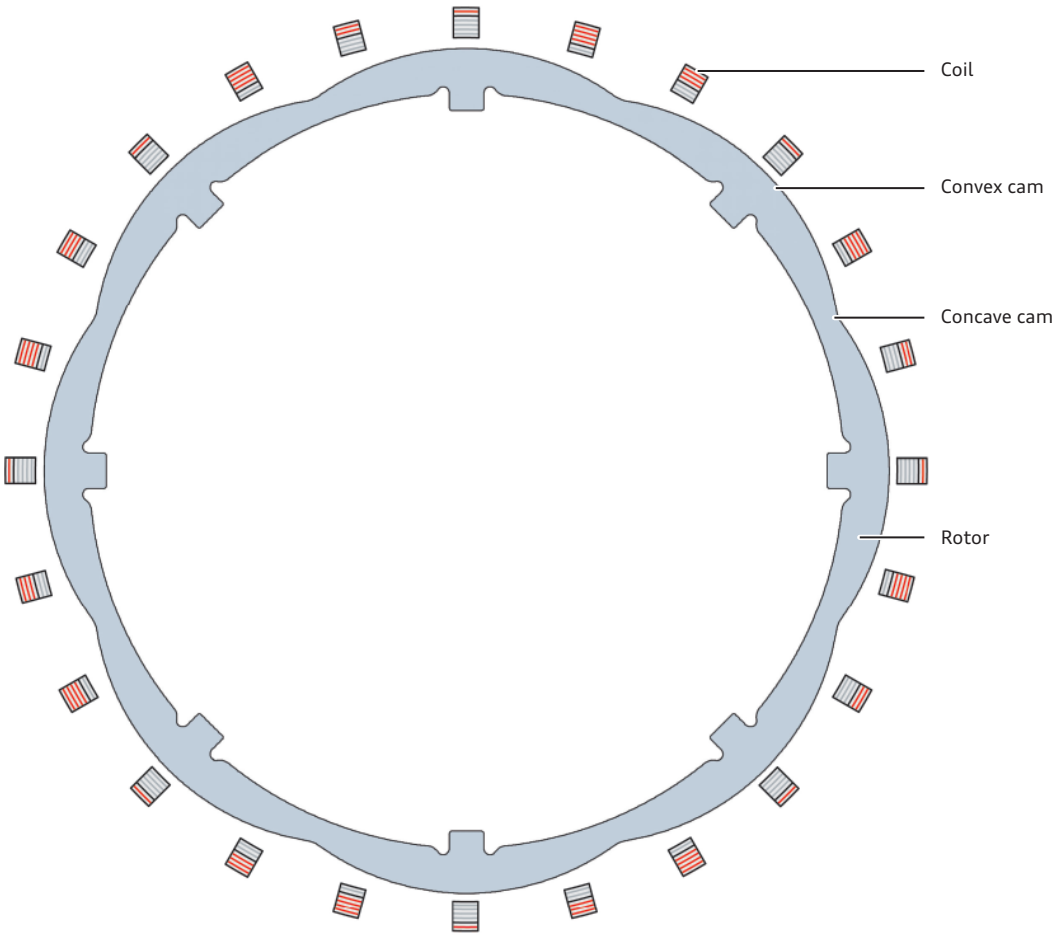
For precision control of the magnetic field in the stator of electro-drive drive motor V141, it is important that electric drive control unit J841 know the exact position of the rotor and its permanent magnets. Drive motor rotor position sensor 1 G713 is used for this purpose. It consists of 24 coils and a metal cam plate with eight cams. The cam plate is connected rigidly to the rotor.

In each coil there is an exciter winding and two secondary windings. All windings are separately connected in series through all coils. Secondary windings 1 and 2 are distinguished by the different number of windings in each coil. Drive motor rotor position sensor 1 G713 operates on the resolver principle and is, in simple terms, a transformer.



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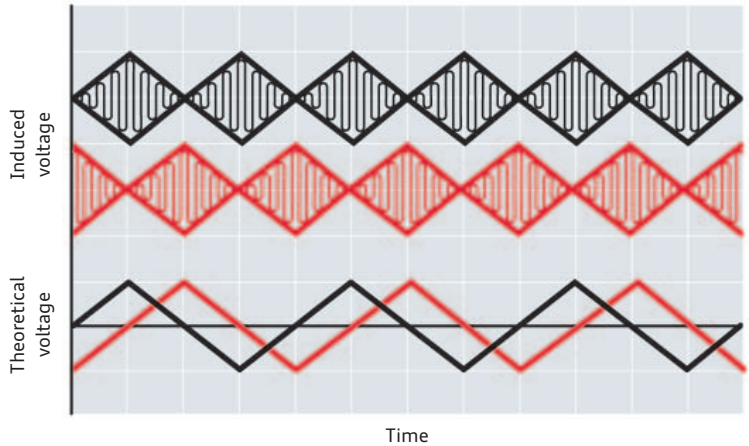
Function diagram



615_018

When the rotor begins to turn, the cam plate also begins to turn. The convex cams now travel from coil to coil and amplify the voltage induced in the secondary windings.
The different number of windings of secondary windings 1 and 2 in each individual coil results in an offset of 90° between amplitudes. Using the amplitudes, electric drive control unit J841 calculates the position of the rotor in electro-drive drive motor V141.

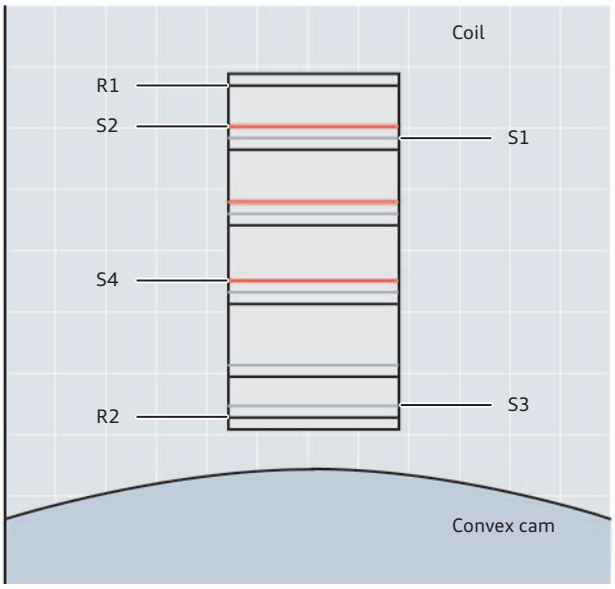
The change in rotor position is, in turn, the basis for calculating the speed of electro-drive drive motor V141.
When "terminal 15" is activated, electric drive control unit J841 begins to calculate the position of the rotor in all operating states.



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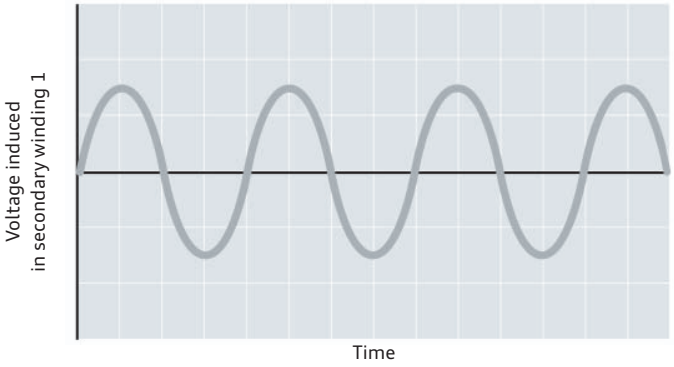
Resolver principle

A high frequency AC voltage is applied to the exciter winding by electric drive control unit J841, thus inducing an AC voltage in secondary windings 1 and 2. If a convex cam is in proximity to a coil on the cam plate, the induced voltage is amplified in the secondary windings. Different voltages are induced in the secondary windings due to the different number of windings of secondary windings 1 and 2 in each individual coil. From the voltages of secondary windings 1 and 2, electric drive control unit J841 can now calculate the position of the rotor.

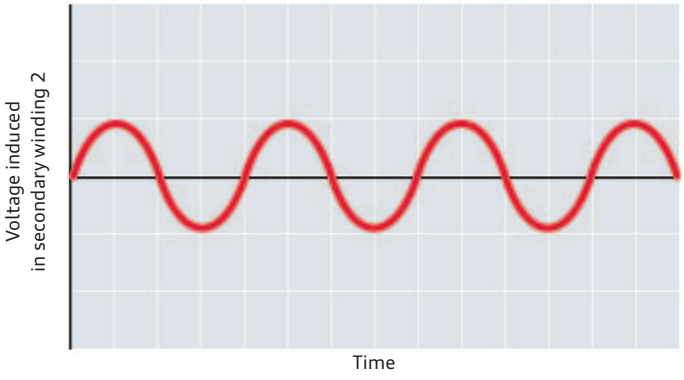


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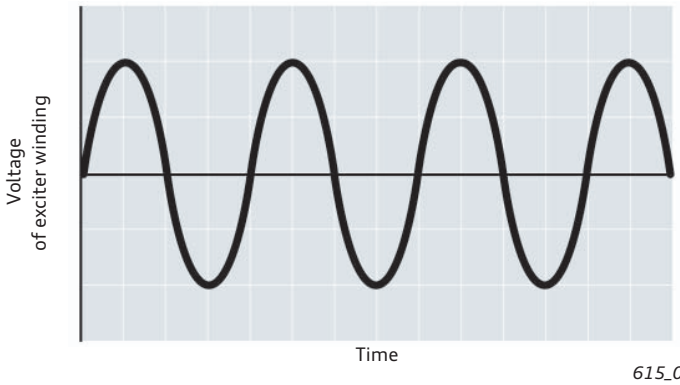
S1 and S3



S2 and S4



R1 and R2



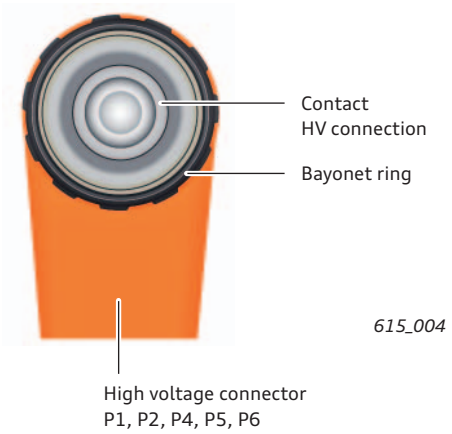
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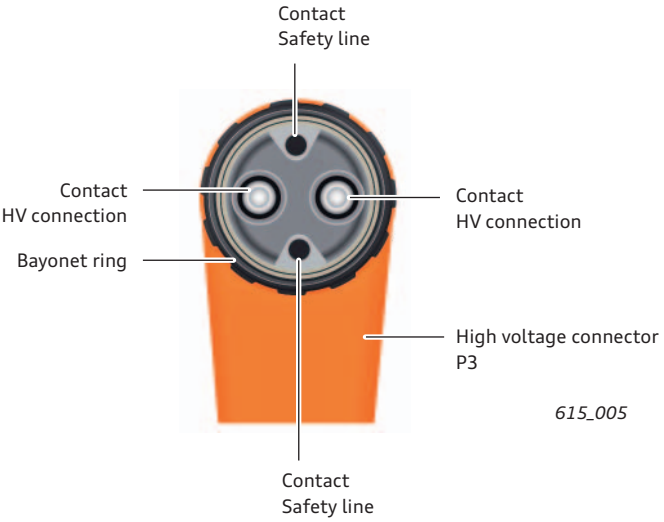
High voltage cable set for hybrid battery PX1 and PX2

High voltage wires

All high voltage wires in the high voltage system are are colour coded orange. Due to the high voltage and current levels, the electrical lines have a significantly larger cross section and are connected by special plug-in contacts. The electrical lines of the high voltage system differ from the other lines in the 12 volt electrical system in terms of their core design.

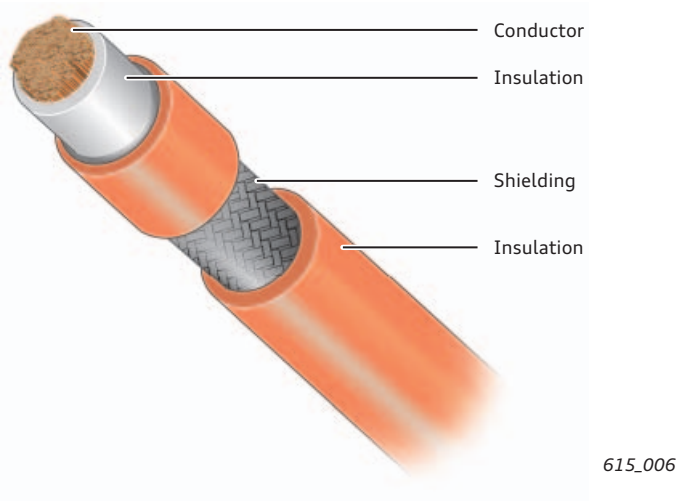
The high voltage lines can also be provided with a corrugated plastic tube as protection against chafing.
Two different types of high voltage lines are used in the high voltage system: single pole and four pole.





Design of single-pole high voltage line

The shielding in all high voltage wires is connected to the connector housings. When the connector is inserted into a high voltage component, the shielding is electrically conductive.



Protection against incorrect assembly

To avoid incorrect assembly, the high voltage connectors are mechanically coded and identified by a coloured ring under the bayonet ring. The terminals for the high voltage wires are also mechanically coded on the high voltage components and indicated by a coloured dot.

In addition, all plug-in connections in the high voltage system are shock-proofed for safe use.

Connection	Number	Ring and point colour	Phase 2
Power electronics — high voltage battery High voltage cable set for hybrid battery PX1	**P1**	red	T+ (HV positive)
	P2	brown	T- (HV negative)
Power electronics — AC compressor	**P3**	red	—
Power electronics — electro-drive drive motor High voltage cable set for drive motor PX2	**P4**	blue	U
	P5	green	V
	P6	violet	W

12 volt starting

The 12-volt starter is used only for starting the internal combustion engine in certain operating states. Battery A is disconnected from the vehicle's electrical system by the engine control unit via starter battery switch-over relay J580.
As a result, the full capacitance of battery A available to the 12 volt starter motor for starting the internal combustion engine.
The vehicle's electrical system is then powered by auxiliary battery A1 and the DC/DC converter.

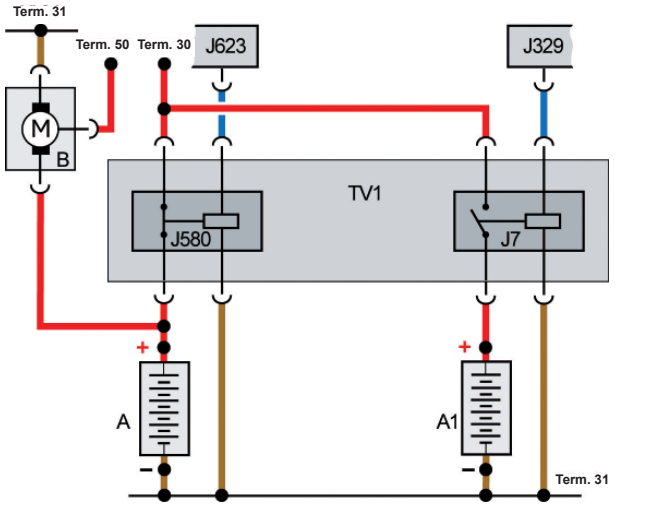
The auxiliary battery must have a temperature of at least approx. -10 °C and a charge level of higher than approx. 12.5 volts before the 12 volt auxiliary starter can be enabled.
If the high voltage system is not ready for operation, 12 volt starting is not possible.

Key:

A	Battery
A1	Second battery
B	Starter
J7	Battery cut-off relay
J329	Terminal 15 power supply relay
J580	Starter battery switch-over relay
J623	Engine control unit
TV1	High voltage distribution junction

Terminal 15 "off"

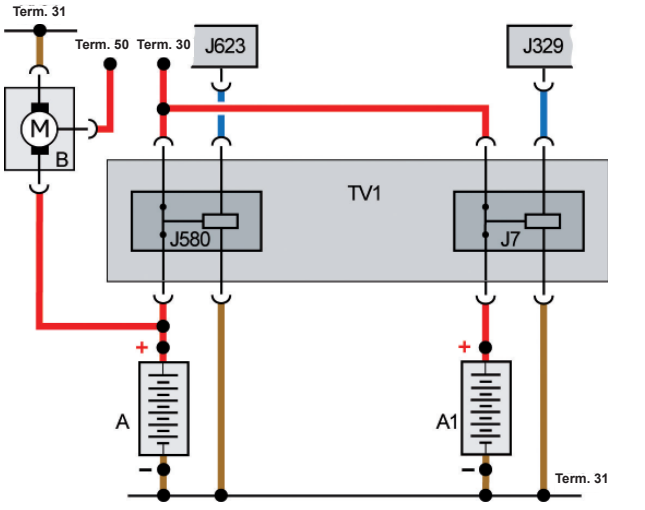
- Battery cut-off relay J7 is open.
- Starter battery switch-over relay J580 is closed.
- The 12 volt vehicle electrical system is powered by battery A.



615_053

Terminal 15 "on"

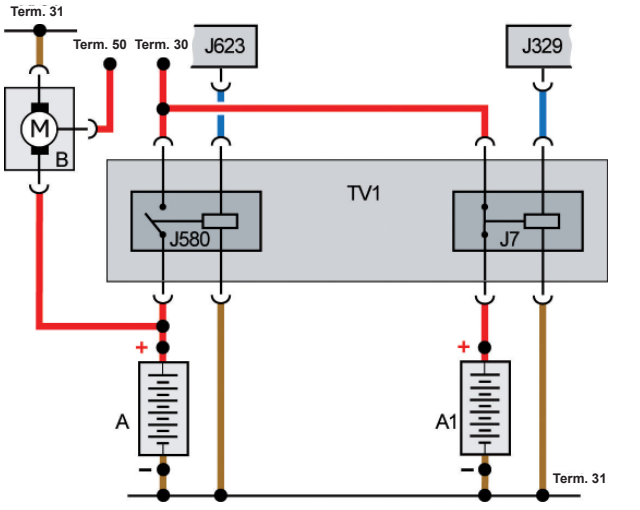
- Battery cut-off relay J7 is closed.
- Starter battery switch-over relay J580 is closed.
- The 12 volt vehicle electrical system is powered by battery A and auxiliary battery A1.
- During vehicle operation or when the vehicle is ready for operation (*Hybrid Ready*), the 12 volt electrical system is supplied by the high voltage system via the DC/DC converter.



615_054

Terminal 15 "on" – 12-volt starting

- Battery cut-off relay J7 is closed.
- Starter battery switch-over relay J580 is open.
- The 12 volt starter is supplied with voltage by battery A.
- The 12 volt electrical system is powered by the high voltage system and assisted by auxiliary battery A1.



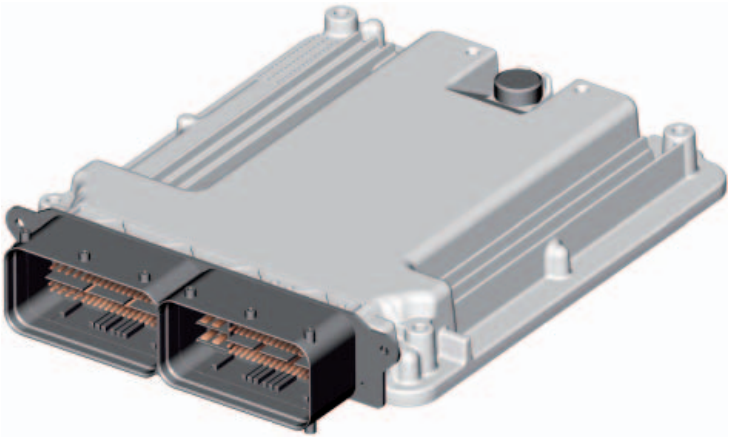
615_055

Note
Both 12 volt batteries must be disconnected before carrying out work on the 12 volt electrical system.

Hybrid manager

Engine control unit J623 has been expanded to include the hybrid manager function. The hybrid manager incorporates all hybrid-specific functions of the vehicle:

- Operating strategy
- Recuperation under braking and during acceleration
- High voltage co-ordinator
- Control and cooling of electro-drive drive motor V141 and electric drive power and control electronics JX1
- Torque distribution to electro-drive drive motor V141 and the internal combustion engine
- Control of hybrid displays
  - Powermeter
  - High voltage battery charge indicator
  - Display — display in instrument cluster
  - MMI energy flow diagrams



615_034

Operating strategy

The task of the operating strategy is to operate the vehicle as efficiently and comfortably as possible taking into account all necessary ambient conditions, in-car component requirements and customer specifications (in-car controls).
The decision as to whether the vehicle is driven by the internal combustion engine, the electric motor or both depends on the driving situation and the charge level of high voltage battery A38. In addition, further internal combustion engine users (component requirements) also have to be enabled to implement all-electric driving. Such users include the Climatronic control unit J255 (in the form of a cabin heating request), diagnoses of the internal combustion engine (event memory entries), the activated charcoal system, etc.

The extended electric driving mode (EV mode) also requires that the 12 volt batteries be enabled. A low charge level or low temperature of the 12 volt batteries prevents the use of the 12 volt starter during vehicle operation, with the result that EV mode cannot be selected.
Taking into account the torque load of electro-drive drive motor V141 and the current driving situation, the hybrid manager decides whether the internal combustion engine is to be started by electro-drive drive motor V141 or by the 12 volt starter.

	Internal combustion engine is	Electro-drive drive motor operates as
Internal combustion engine starting	off	electric motor
Electric driving	off	electric motor
Drive by internal combustion engine	on	generator
Hybrid driving	on	electric motor
Boost	on	electric motor
Recuperation with and without electrical braking	on or off	generator

Recuperation under braking and during acceleration

The hybrid manager also controls brake energy recuperation during acceleration and under braking (electrical braking) depending on the accelerator pedal position, the brake pedal position, the charge level of the high voltage battery, the criteria for vehicle stability (ESP) and vehicle speed.

High voltage coordinator

Another task of the hybrid manager is to monitor and co-ordinate all high voltage components.
Electric drive power and control electronics JX1, electro-drive drive motor V141, hybrid battery unit AX1 and electrical AC compressor V470 are all controlled by the hybrid manager, which acts as a central "co-ordinator".

If engine control unit J623 receives a crash signal via the power-train CAN bus, this signal is also evaluated by the hybrid manager and relayed to the connected high voltage components on the hybrid CAN bus. As a result, the voltage is disconnected as quickly as possible.
When the charge level of high voltage battery A38 decreases, current draw by high voltage components is prioritised and reduced as of a defined threshold in order to prevent damage to the high voltage battery.

Cooling control

Tasks of the hybrid manager also include cooling three-phase AC drive VX54 and electric drive power and control electronics JX1.

EV mode

By pressing the extended electric driving mode button E709 (EV mode), the driver can extend the limits of electric driving and utilise the overall power of the e-machine for all-electric driving. All-electric driving in EV mode is possible up to a speed of 100 kph and down to a high voltage battery charge of 33 %.

Requirements for driving in EV mode:

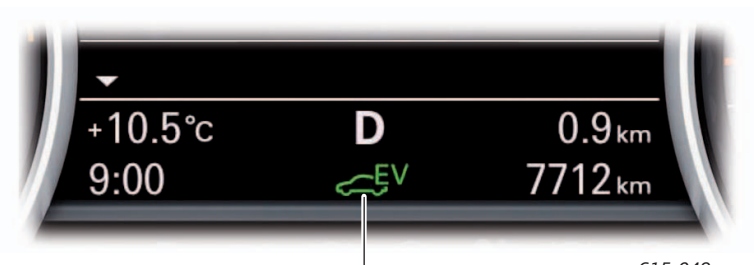
- Speed < 100 kph
- Charge level of high voltage battery > 40 % (for activation)
- Charge level of high voltage battery < 33 % (for automatic deactivation)
- Temperature of high voltage battery > +10 % (for activation)
- Temperature of high voltage battery < +5 % (for automatic deactivation)
- 12 volt starter enabled
- no Tiptronic mode
- no Sport mode
- Stop enable signals are present.

When EV mode is activated, it is indicated by a green symbol in the instrument cluster and by a green bar below the EV mode button.

Audi A8 hybrid



615_048



615_049

The instrument cluster display when EV mode is activated

Displays

Display elements for driving in hybrid mode

For display of the electric drive, the Audi A6 hybrid and the Audi A8 hybrid have the following features:

- Power meter instead of rev counter
- Special display in the instrument cluster
- Animated display on MMI screen
- High voltage battery charge indicator instead of coolant temperature display

Displays in power meter

The power meter displays various vehicle operating states and the power output or charging capacity of the hybrid system during the trip.



615_050

Key:

1	Vehicle ready "*Hybrid Ready*", "*Terminal 15 ON*" and "*Enable terminal 50 ON*" depending on enabling conditions
2	Electric driving (engine starting is possible) or hybrid driving
3	Limit for engine starrting in EV mode
4	Economical driving (partial throttle range)
5	Full throttle range
6	Internal combustion engine 100 %
7	Electric drive motor provides assistance in addition to maximum engine torque (boost).
8	"Terminal 15 OFF" or "terminal 15 ON" and "terminal 50 OFF"
9	Hydraulic braking in addition to electrical braking
10	Energy recovery by recuperation (under braking and during acceleration)
11	Charge level of high voltage battery

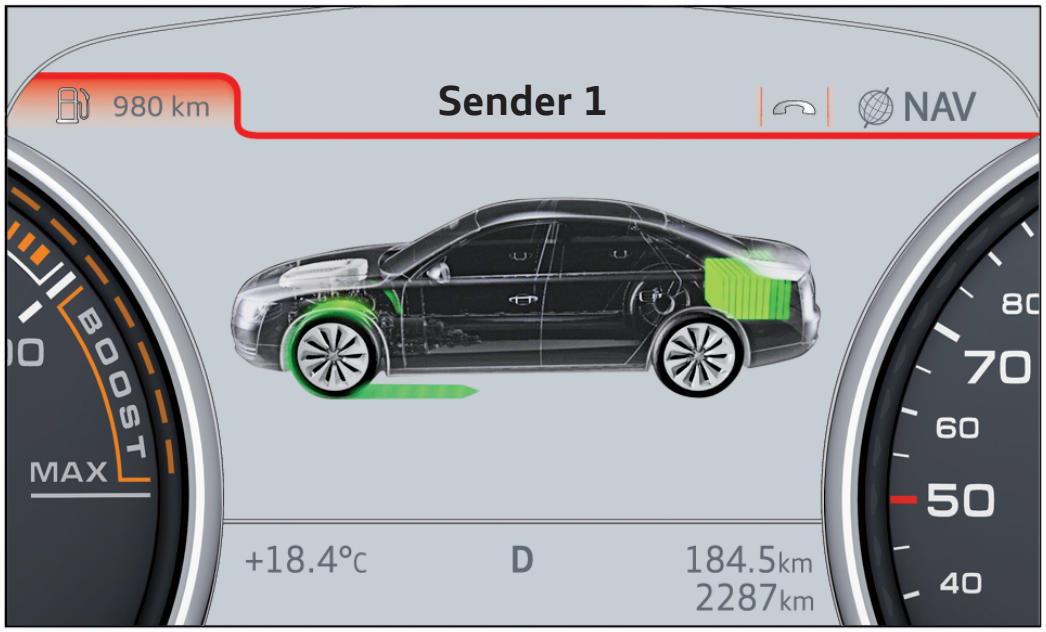
Messages on instrument cluster display and MMI display

The occupants can see the energy flow within the high voltage system.

The messages on the instrument cluster display and/or the MMI display can be used for this purpose.

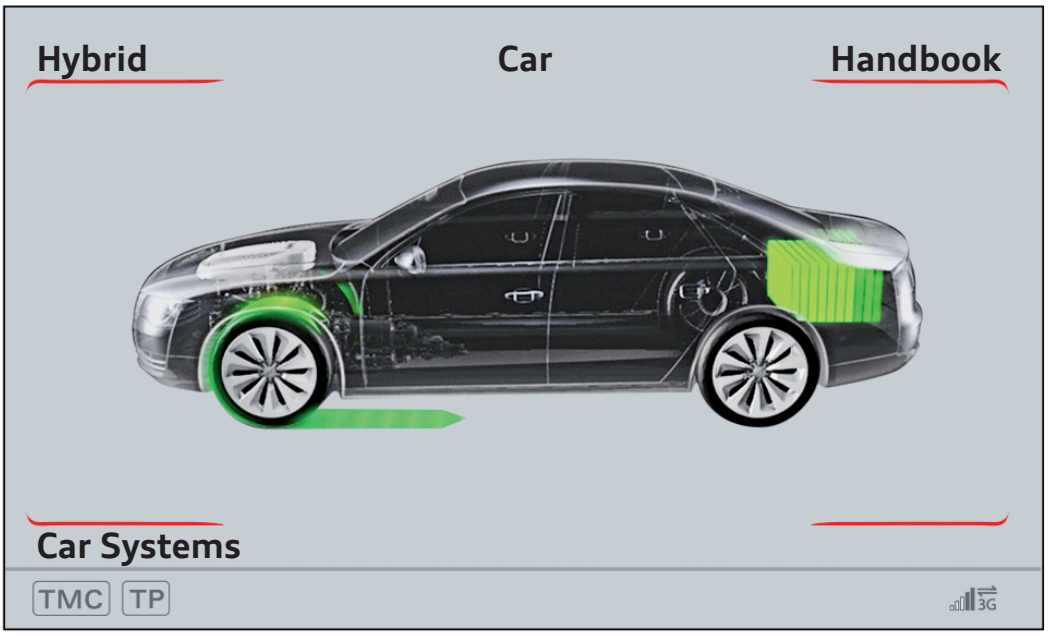
Message on the instrument cluster display of the Audi A8 hybrid – Drive by electric motor only

The high voltage battery symbol and the green arrows pointing away from the wheels indicate that drive is currently being provided by the high voltage battery and the electric drive motor.



615_052

Message on the instrument cluster display of the Audi A8 hybrid – Drive by electric motor only



615_051

Reference
For further information about messages on the instrument cluster display and MMI display, refer to Self Study Programme 489 "Audi Q5 hybrid quattro" or the vehicle Owner's Manual.

Service

Special tools

Locking cap T40262



615_057

Other special tools are as follows:

- Adapter T40259
- Release tool T40258
- Tracks T40275

Workshop equipment

Hybrid warning sign (lightning bolt) VAS 6649



615_058

Hybrid warning sign (switch) VAS 6650A



615_059

Other workshop equipment is as follows:

- Isolating box VAS 6606
- Test adapter VAS 6606/10
- High voltage testing module VAS 6558A
- Hybrid test adaptor VAS 6558/1A with:
  - Test adaptor for determining voltage-free status VAS 6558/1-1
  - Adaptor for measuring insulation resistance in high voltage system VAS 6558/1-2
  - Adaptor for measuring insulation resistance in AC compressor and safety line VAS 6558/1-3A

Note
Adapters VAS 6558/1-2 and VAS 6558/1-3A may only be used if the vehicle is voltage-free.

Note
All work on the high voltage system must be performed by a qualified high voltage technician. Only qualified high voltage technicians are allowed to disconnect this maintenance connector to de-energise the vehicle.

Note
To ensure the proper and safe use of high voltage special tools, the guidelines in the workshop manuals must be strictly observed. Refer to ELSA for instructions.

Test your knowledge

1. What it is the electrical safety line and what is its task?

☐ a) It is an electrical line which passes through all components of the high voltage system.

☐ b) It acts as a voltage stabiliser for the 12 V onboard power supply.

☐ c) It serves as a reference voltage for the high voltage system.

2. What is the maintenance connector used for?

☐ a) The maintenance connector connects the two halves of the high voltage battery.

☐ b) It is the mechanical lock for the high voltage wire terminals.

☐ c) It acts as a charging current limiter for the high voltage battery.

3. What is the auxiliary battery needed for?

☐ a) It supplies the 12 volt starter with supply voltage.

☐ b) It acts as a voltage stabiliser when starting the internal combustion engine with the 12 volt starter.

☐ c) It acts as an energy storage device for the high voltage battery.

4. What steering system does the Audi A8 hybrid have?

☐ a) An electro-hydraulic steering system.

☐ b) An electro-mechanical steering system.

☐ c) A hydraulic steering system with pressure reservoir.

5. What is the supply voltage of the AC compressor?

☐ a) 266 V DC from the high voltage battery.

☐ b) 266 V DC from the power electronics.

☐ c) 12 V DC from the power electronics.

6. What is the rated voltage of the high voltage battery?

☐ a) 288 V AC

☐ b) 266 V AC

☐ c) 266 V DC

7. How many cells does a battery block in high voltage battery A38 comprise?

☐ a) 18

☐ b) 36

☐ c) 72

8. What is the resistance used for charging intermediate circuit capacitor 1 C25?

☐ a) 1000 ohms

☐ b) 100 ohms

☐ c) 10 ohms

9. What is special tool T40262 for?

☐ a) It is a safeguard against removal of the maintenance connector.

☐ b) It is a safeguard against unintentional re-starting of the high voltage system.

☐ c) The vehicle's ignition key can be locked inside the vehicle.

10. What is the passive discharge resistance of intermediate circuit capacitor 1 C25?

☐ a) 1 kOhm

☐ b) 11 kOhms

☐ c) 22 kOhms

Test solutions:
1 a; 2 a; 3 b; 4 b; 5 b; 6 c; 7 b; 8 c; 9 b; 10 c

Self Study Programmes

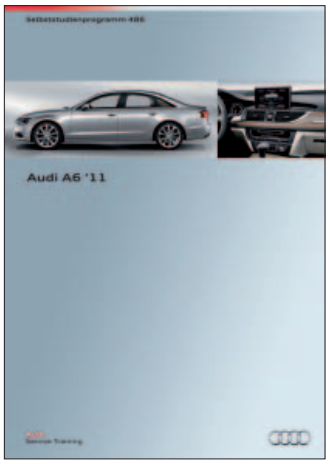
For further information, please refer to the following self study programmes.



615_062



615_063



615_064

SSP 436 SSP 436 Modifications to the chain-driven 4-cylinder TFSI engine, order number: A08.5S00.52.20

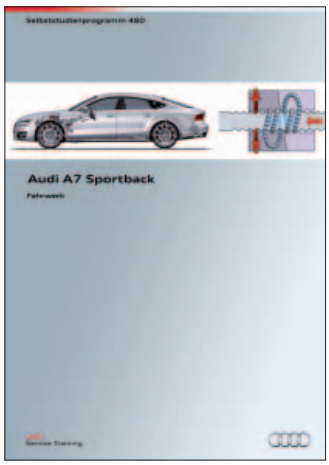
- Information on the internal combustion engine

SSP 456 Audi A8 '10, order number: A10.5S00.60.20

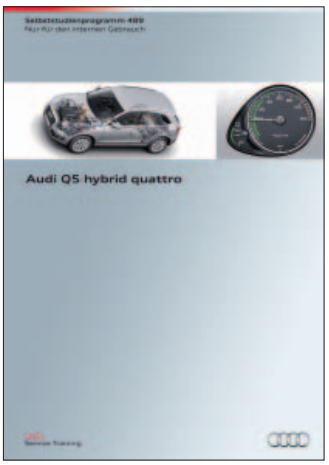
- Information on basic vehicle

SSP 486 Audi A6 '11, order number: A11.5S00.80.20

- Information on basic vehicle



615_060



615_061

SSP 480 Audi A7 Sportback — Running Gear, order number: A10.5S00.73.20

- Electro-Mechanical Steering

SSP 489 Audi Q5 hybrid quattro, order number: A11.5S00.83.20

- Hybrid Technology

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AUDI AG
I/VK-35
service.training@audi.de

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