

Service Training



Self Study Program 890323

# The Jetta Hybrid

Design and Function



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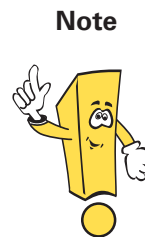
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This Self-Study Program provides information regarding the design and function of new models. This Self-Study Program is not a Repair Manual.

**This information will not be updated.** For maintenance and repair procedures, always refer to the latest electronic service information.





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# Introduction

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The Jetta Hybrid from Volkswagen combines innovative full-hybrid technology and low fuel consumption in a compact sedan. German engineering, European design, and Volkswagen's high-quality is setting new quality standards for hybrid vehicles in the US.

The highly modern hybrid drivetrain includes ground breaking technical elements: an economical 150 hp (110 kW) TSI engine with a 20hp (15 kW) electric engine, a lithium ion battery with the latest technology, and the efficient 7-speed dual clutch transmission (DSG®).

The exterior and interior unmistakably display the design and quality of Volkswagen. At the same time, the use of eco-friendly materials emphasizes VW's strong environmental commitment.

As a sporty high-tech hybrid, the Jetta Hybrid offers uncompromising power and plenty of driving fun with low fuel consumption and the highest environmental compatibility.



S525\_031

# Introduction

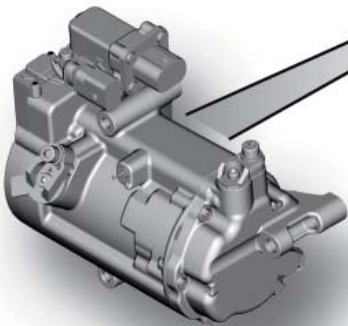
Hybrid lettering on the dashboard



Hybrid powerflow representations in the radio navigation system



Hybrid lettering in the engine compartment



High voltage A/C compressor



Hybrid lettering on the grille

# Introduction

Hybrid information in the instrument cluster



Hybrid lettering on the rear of the vehicle



High-voltage battery in the luggage compartment



Electric mode button



E-machine

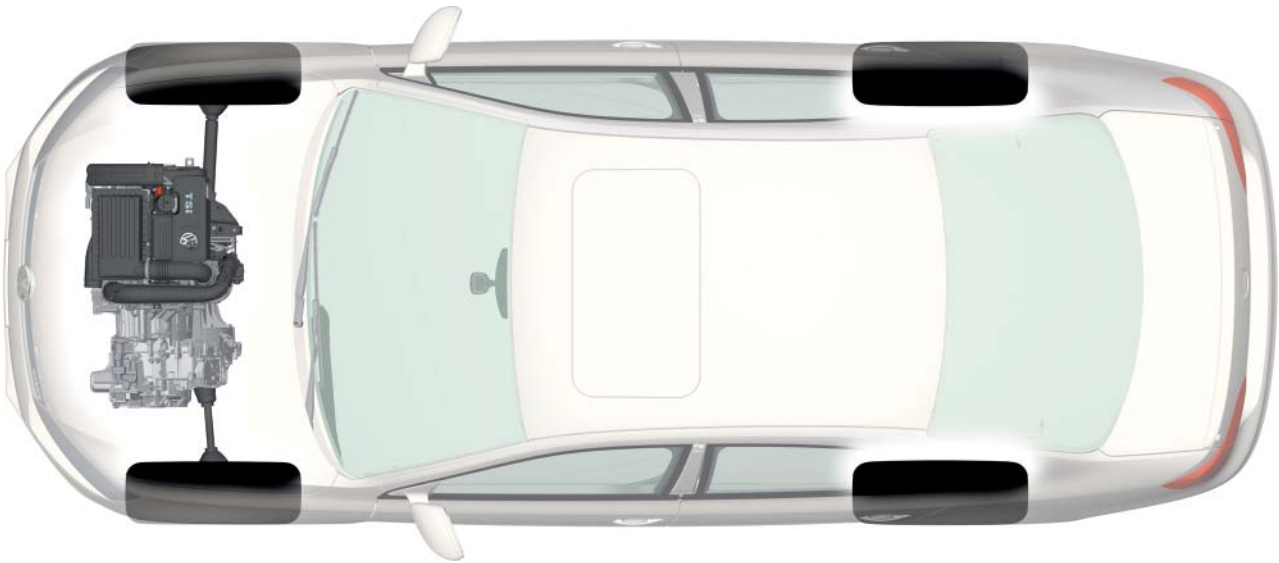


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# Introduction

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## The Jetta Hybrid Concept



S525\_002

The Jetta Hybrid concept is based on a parallel hybrid drive. The electric motor and the internal combustion engine are both used for mechanically driving the drivetrain. Both components are mounted on a single symbolic shaft.

Using electrical systems, the following components are electrically-driven instead of mechanically-driven using a belt:

- Coolant pumps (12 volt)
- Power steering (12 volt)
- Vacuum pump for brake boost (12 volt)
- Air compressor (high voltage)



## Drive

Volkswagen is extending its range of hybrid vehicles using the Jetta Hybrid. The following reliable concepts from the Touareg Hybrid are used in the Jetta Hybrid:

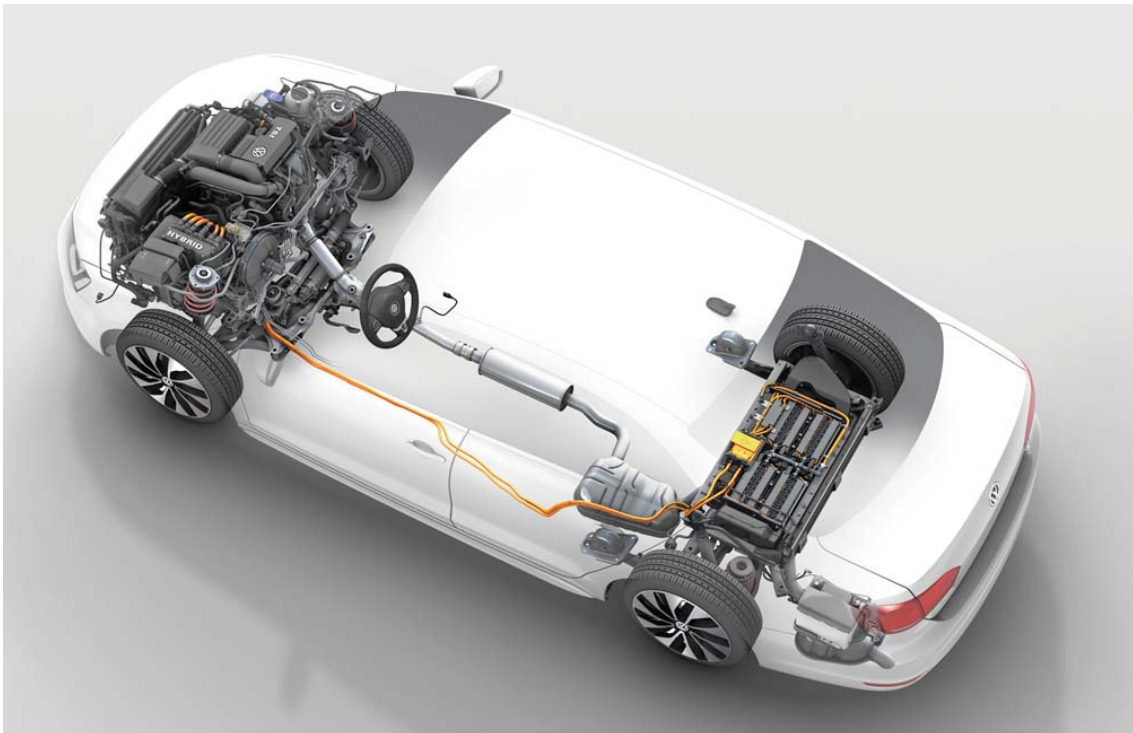
- Electric driving (using the electric motor only)
- Boost (combined power of the internal combustion engine and the electric motor)
- Recuperation (using deceleration to recharge the high voltage battery)

Even with these capabilities, the following needed to be retained:

- Comfort
- Quick acceleration
- Ease of use
- Durability

The Jetta Hybrid was designed with the following additional requirements:

- Reduced fuel consumption
- Smaller internal combustion engine
- Improved boost mode performance
- 7-speed dual-clutch transmission
- Use of existing components and systems
- Extensive use of space and weight saving components



S525\_031

# Introduction

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## Performance and Consumption

The overall goal of the Jetta Hybrid was to combine impressive driving performance with low fuel consumption.

Thanks to the following technologies and features, a Jetta Hybrid of the same size and power (as compared to conventional vehicles) will have a fuel consumption advantage of more than 30% in city driving and up to 20% in combined operation. The following help to achieve this fuel reduction:

- The latest engine and transmission technology with the 1.4 L TSI, twin clutch transmission and the latest integrated hybrid module
- Aerodynamic optimization of the vehicle in the modified bumpers, side skirts and flat rear spoiler
- Coasting mode
- Hybrid functions: Electric driving, start/stop system, and brake recuperation

The TSI engine is not only turned off during pure electric driving (up to 37 mph or 60 km/h on level surfaces) but is decoupled using a separating clutch to prevent engine drag. This separation also occurs when the driver releases the gas pedal (coasting). The Jetta rolls significantly longer due to the elimination of engine drag. This occurs at speeds of up to 77 mph (125 km/h).

Significant fuel savings are achieved in city driving from regenerated brake energy as well as the start/stop system.

When the internal combustion engine and the E-machine are working simultaneously (boosting), the output is briefly 170 hp (125 kW) and the torque is 184 lb/ft (250 Nm).



S525\_038

## Technical Data

|  |   |
|--|---|
| Internal Combustion Engine                   | 1.4 L 4VTSI Engine with Turbocharger    |
| Internal Combustion Engine Output            | 150 hp (110 kW)                         |
| Transmission                                 | 7-speed Dual Clutch Transmission (DSG®) |
| E-machine                                    | Permanently Excited Synchronous Motor   |
| E-machine Output                             | 20 hp (15 kW)                           |
| Maximum Output in Boost                      | 170 hp (125 kW)                         |
| Maximum Torque in Boost                      | 184 lb/ft (250 Nm)                      |
| Battery Technology                           | Lithium Ion Battery with 60 Cells       |
| Voltage of High-voltage Battery              | 220 V (3.7 V per cell)                  |
| Capacity of the High-voltage Battery         | 1.1 kWh                                 |
| Acceleration from 0 to 62 mph (100 km/h)     | 8.9 s                                   |
| Additional Weight from the Hybrid Components | Approximately. 227 lb (103 kg)          |

### Torque/Performance

Because the E-machine has 100% of its power from 0 RPM, it can be used to assist with low-RPM acceleration. This allows the Jetta Hybrid to have extraordinarily fast acceleration from a standstill for its weight class. In the power curve, the drive output from the internal combustion engine and the E-machine add up to a maximum total output of 170 hp (125 kW).

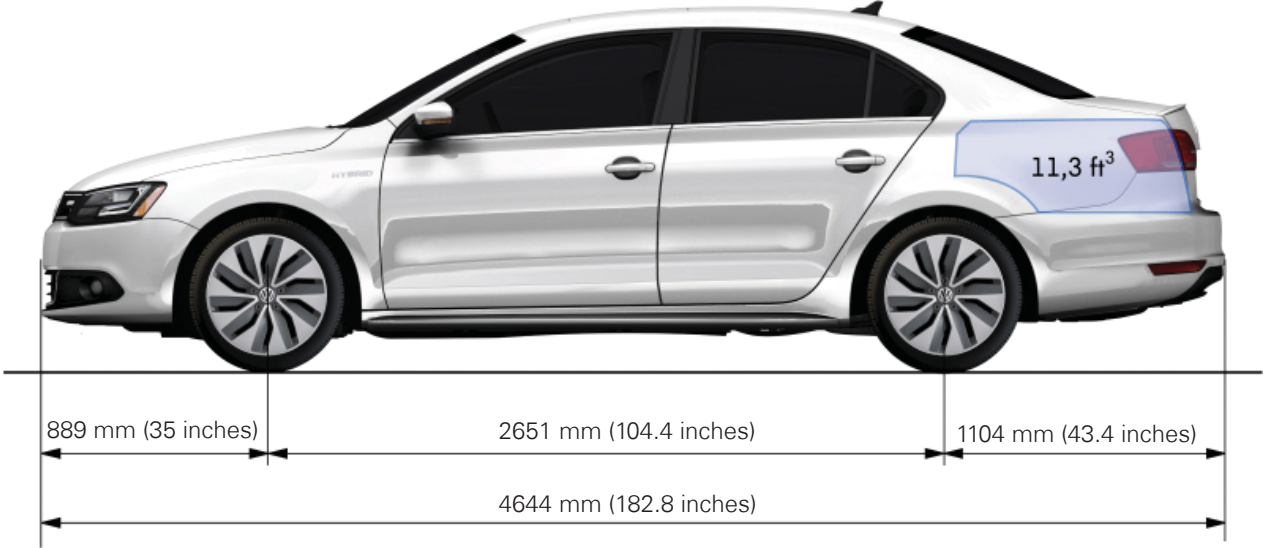
The increase in drive performance occurs over almost the entire speed range. Operation is mixed while the internal combustion engine is running.

This integration enables the internal combustion engine to work within its optimum effective range. This load point shift increases efficiency.

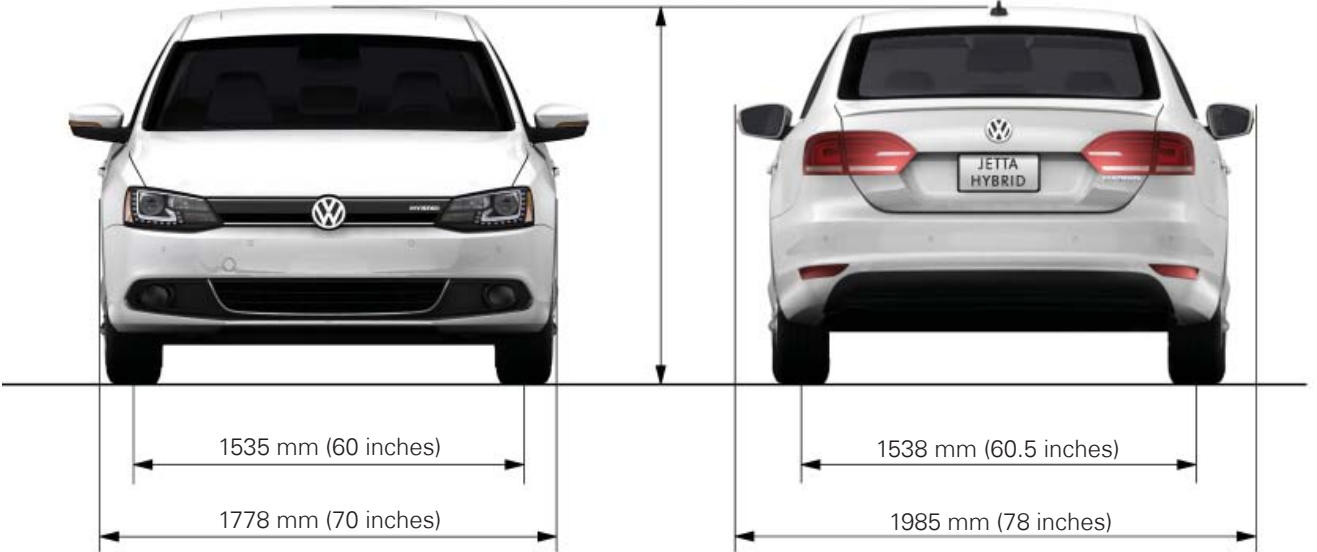
# Introduction

## Dimensions

The vehicle dimensions are identical to those of the Jetta without the hybrid drive, except for the trunk volume. Because of the high-voltage battery, the trunk volume has been reduced from 18 ft<sup>3</sup> to 11.3 ft<sup>3</sup> (510 L to 320 L).



S525\_039



S525\_040

## Wheels and Tires

195/65 R15 and 205/50 R17 tires with low rolling resistance are used with the Jetta Hybrid. The tires offered also include the 16 inch 205/55 R16 tire.



15" Cast aluminum  
6Jx15 H2 ET 47 195/65  
R15 91H RoWi, all-season



16" Cast aluminum  
6½Jx16 H2 ET 50 205/55  
R16 91H, all-season



17" Cast aluminum  
6Jx17 H2 ET 48.5 205/50 R17  
93H RoWi, all-season

S525\_037

# Introduction

## Distinguishing Features

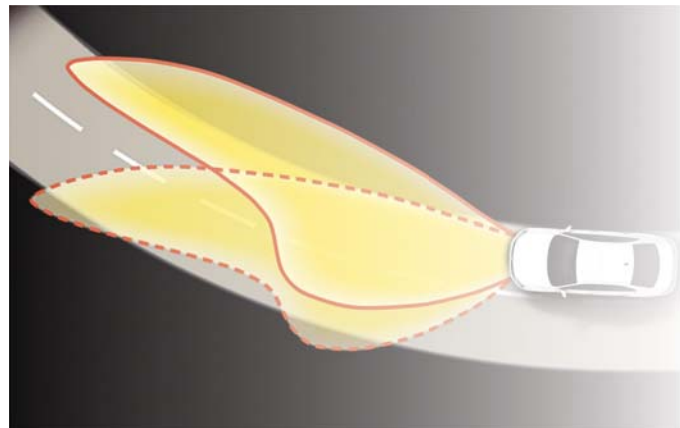
### Xenon Headlamps

The bi-xenon headlamps with LED daytime running lights have typical Volkswagen design features.



S525\_032

A mercury-free "D3S" lamp is used for the xenon bulb. In addition to the xenon projection module, Light Emitting Diode (LED) lamps are used. These 15 individual LEDs are positioned around the module in a unique light pattern. The pattern can be seen during the day (daytime running lights) and at night when the LEDs dim.

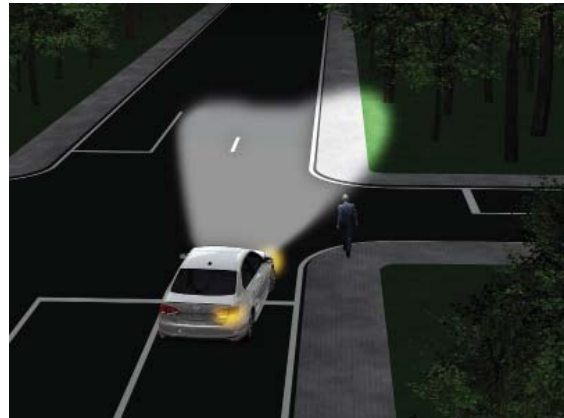


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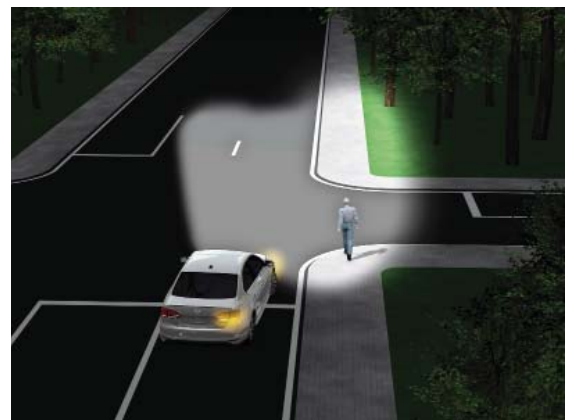
## Static Cornering Light

In addition to its basic functions and the turn signal, the Adaptive Front-Lighting System (AFS) headlamps also contain a static cornering light. This light illuminates the road to the side of the vehicle at speeds of less than 25 mph (40 km/h). This light is controlled by activating the turn signal or the position of the steering wheel angle.

The cornering light installation position, which is higher than the combined cornering light/fog lamp offered with halogen headlamps, improves illumination because it works in addition to the wide illumination range of the xenon lamp. This increases driving safety for both day and night driving.



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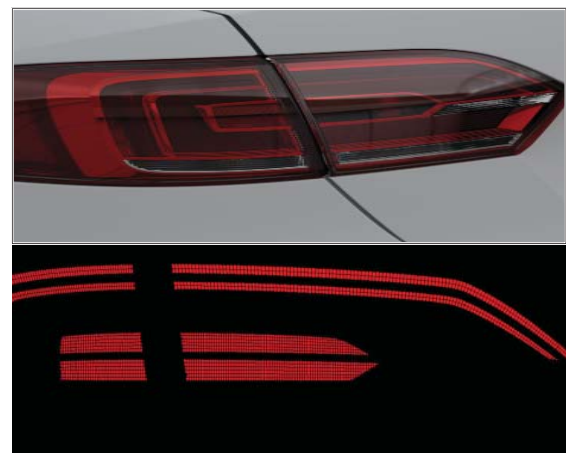


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## LED Lights

LEDs are used for the taillights and brake lights. The taillights and brake lights are integrated into the two-part lamps in the body (turn signal lights and taillights in one unit).

On average, approximately 45 W is saved compared to the regular bulb version, reducing power consumption by about half. In addition, weight has been reduced by 0.55 lbs (250 g).



s525\_036

# High Voltage Safety

## High Voltage Warnings

There are several warnings and stickers in the Jetta Hybrid to prevent high-voltage system hazard to users, service and workshop personnel, as well as those working in technical and medical rescue services. These stickers comply with all applicable Deutsche Industrie for Standardization (DIN) standards.

There are basically two types of warning labels:

- Yellow warning stickers with the symbol for “electric voltage” on the covers of high-voltage components.
- Warning stickers with the word “Danger” against a red background indicate components that conduct high-voltage.



Warning of dangerous electric voltage

S525\_074



Warning of dangerous electric voltage

Note usage instructions

Warning against touching voltage-conducting parts (Mortal Danger Warning)

Warning of dangerous electric voltage

Warning of hazardous site



Note usage instructions

Warning against touching voltage-conducting parts

S525\_041

S525\_042



# Mechanical Construction

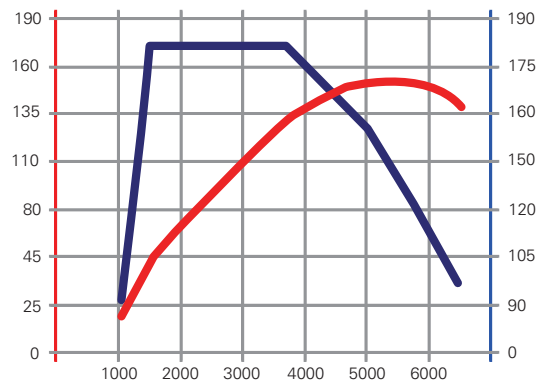
## 1.4 L Turbocharged Engine

The Jetta Hybrid is equipped with a 1.4 L 4V TSI engine with a single turbocharger. It has the following characteristics:

- Engine block with integrated secondary air channel, hybrid oil passages and hybrid coolant passages
- Crankshaft with splines for connection to the E-machine
- Cylinder head with 4 valves per cylinder and integrated exhaust manifold
- Intake and exhaust camshaft adjustment
- Belt-driven camshafts
- Electrical and mechanical coolant pumps
- Positive Crankcase Ventilation (PCV) unit on the front of the engine block
- Water-cooled intercooler
- Electric vacuum pump
- No accessory drive belt
- Integrated turbocharger module with electric charge pressure controller, cast steel turbine housings with integrated lambda sensor



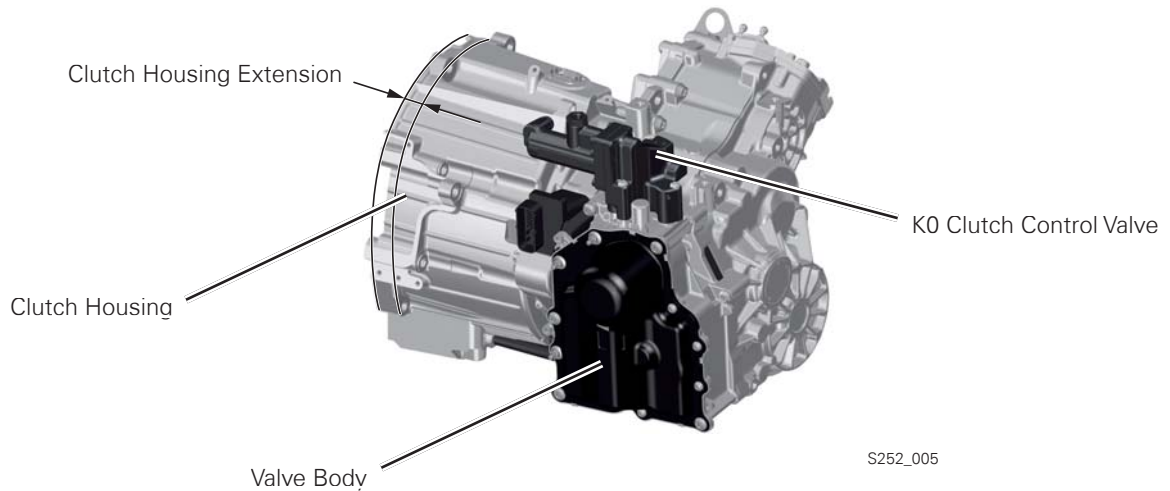
S525\_003



|                                   |   |
|-----------------------------------|---|
| Engine Code                       | CNLA  |
| Engine Configuration              | 1.4 L TSI with Turbocharger                 |
| Displacement                      | 1,395 cm <sup>3</sup> (85 in <sup>3</sup> ) |
| Bore                              | 74.5mm (2.9 inches)                         |
| Stroke                            | 80mm (3.1 inches)                           |
| Valves per Cylinder               | 4   |
| Internal Combustion Engine Output | 150 hp (110 kW)                             |
| Maximum Torque (limited)          | 162 lb/ft (220 Nm)                          |
| Engine Management                 | Bosch MED 17.1.6                            |
| Emissions Rating                  | PZEV  |

# Mechanical Construction

## The 7-Speed Dual Clutch Transmission 0CG

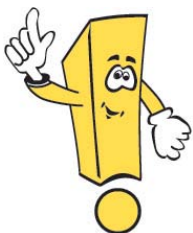


The Jetta Hybrid has a 7-speed DSG transmission. This transmission has been used extensively in other markets, and this is its first application in the North American market.

Due to the E-machine, the clutch housing was extended by 83 mm (3.3 inches). There is also a separate valve in the valve body, external control valve and master cylinder to control the K0 clutch.

The K0 separating clutch is controlled by the ECM and not by the Mechatronics. The ECM controls the operation of the valve in the valve body. The same fluid used by the Mechatronics is used in the clutch activation circuit. The actuators of the K0 clutch and the Mechatronics

The transmission has a maximum torque rating of 184 lb/ft (250 Nm).



### Note

Even though the 1.4L engine can produce up to 184 lb/ft (250 Nm) of torque, it is limited to 162 lb/ft (220 Nm). This assures that when the E-Machine is providing torque (22 lb/ft), the maximum transmission torque rating is not exceeded (184 lb/ft). This torque rating is constantly adjusted by the ECM, even when the E-machine is working, to make sure that the input torque does not exceed the transmission capabilities.

## The K0 Clutch

The single-disc dry clutch is located inside of the E-machine between the engine and the E-machine. The clutch actuator (N511 Decoupler Pressure Actuator) is located on the top of the transmission and is controlled by the hybrid system. The driver does not have any direct influence on this clutch. The hydraulic fluid is provided from the transmission itself.

The clutch is engaged when:

- Starting the internal combustion engine
- The internal combustion engine is running
- The charge of the hybrid battery is low

The clutch is disengaged when:

- The vehicle is at a standstill
- The internal combustion engine is deactivated
- The vehicle is being driven electrically
- The vehicle is in recuperation mode

## The E-machine

The foundation of the hybrid drive is the E-machine. It takes on three essential tasks within the hybrid system:

1. Starter for the internal combustion engine
2. Generator for charging the high-voltage battery
3. Electric engine for moving the vehicle.

The rotor runs inside of the stator without contact.



S252\_004a

Purely electric driving on flat land is possible at varying speeds. The maximum speed depends on driving resistance and the charge of the high-voltage battery.

# Mechanical Construction



S252\_036

During electric driving, the regeneration of the carbon canister is irregular. As a result the Jetta Hybrid uses a pressurized fuel tank system. It holds the fuel vapors in the tank to prevent overloading of the carbon canister.

Unlike in the conventional Jetta fuel tank, this one can handle pressures from -15 kPa (-2 psi) to +25 kPa (3.7 psi) using outer and inner reinforcements. It is also flameproof. The tank has a slightly lower filling volume 11.3 gallons (43 liters), versus the 11.8 gallons (45 liters) of the regular Jetta tank.

A pressure regulator is located between the fuel tank vent valve and the carbon canister.

The tank pressure is controlled by a pressure sensor that determines the pressure difference between the tank and ambient air. The pressure sensor is mounted on the fuel filler neck assembly and measures the pressure inside the gas tank.

## Pressure Control Valve

The pressure control valve controlled by the engine control module. It is a normally-closed valve. The valve has a positive and negative pressure protection feature and mechanically opens below -10 kPa (-1.5 psi) and above + 30 kPa (4.4 psi).

The engine control module regulates the tank pressure during driving between 4 and 20 kPa (0.5 and 3 psi). The pressure is dependent on the ability of the combustion engine to burn fuel vapor.

When the vehicle is turned off, the pressure control valve is closed. It will open when the button for the fuel door release is activated, or during diagnosis.

## Tank Ventilation

The release button for the tank flap is located in the driver's door. After pressing the button, the fuel filler flap will open and the pressure regulator will release the fuel tank pressure to allow for filling. The pressure reduction may take up to 7 seconds. In a few exceptional cases it may take longer.

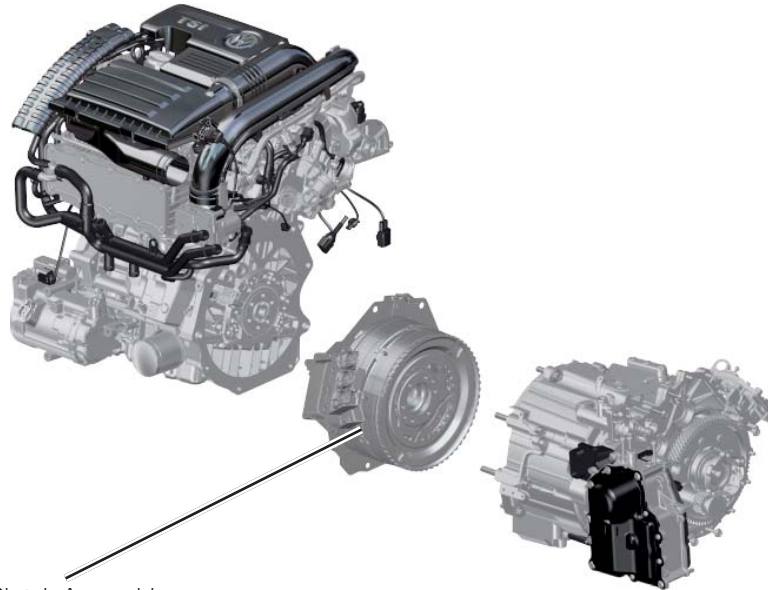
When filling the fuel tank, the pressure control valve must be open so the displaced fuel gases can escape. When the fuel reaches the pressure control valve, the fuel nozzle will turn off.

The pressure control valve will close in one of the following conditions:

- The tank cap is inserted
- The vehicle speed is greater than 15 km/h (9 mph)
- 17 minutes have passed since the tank was opened using the fuel filler switch

# Electrical Components

## E-Machine



E-Machine with Clutch Assembly

S525\_006

The E-machine, clutch and the dual mass flywheel are a single hybrid component. The water-cooled E-machine provides high torque in a minimum amount of space. The E-Machine is located between the internal combustion engine and transmission.

The connection between the dual mass flywheel and the transmission dual clutches is unchanged for the hybrid application.

The parallel hybrid powertrain of Jetta with TSI technology and dual-clutch transmission enables full hybrid functionality:

- Electric Driving
- Stopping the internal combustion engine when the vehicle is stationary
- Brake Recuperation
- Boost Mode

# Electrical Components

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S252\_004

The integration of the hybrid components provides a fuel savings of average of 20% compared to a conventional vehicle. In urban areas a fuel savings of around 30% is possible.

This is made possible by an innovative operational strategy that is integrated in the engine control module. This strategy chooses the optimal operation of the drivetrain. The combustion engine is turned off at low torque or power requirements. All accessories are electrically powered, so features such as air conditioning are always available.

The E-machine is a permanently excited synchronous machine that is driven by a 3-phase field. The 220 V DC voltage is converted to alternating voltage with three phases by the power electronics. These three phases create an electromagnetic 3-phase field in the E-machine.

# Electrical Components

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## Operation

Depending on the driving situation and operating mode, the E-machine can take on various tasks. During the switchover from the electric drive to the combustion mode, the E-machine functions as a starter for the internal combustion engine. As combustion mode continues, the E-machine switches from the hybrid system to serve as the generator. The electric power obtained is used to charge the high-voltage battery (220 V) and the 12 V electric system battery using a voltage converter.

When the vehicle is braked, the E-machine provides electrical energy to the high-voltage battery via the recuperation function and recovers some of the excess kinetic energy as electric power.

The pedal travel sensor is located on the brake pedal. If light braking is detected, the hybrid system activates the E-machine so it can charge the high-voltage battery as a generator. Energy that is converted into heat using conventional hydraulic brakes is stored in the high-voltage battery. This energy is used later to power the vehicle.

During this recuperation process, enough energy is provided to at least run the 12 V on-board electrical system battery. The internal combustion engine is deactivated during this process. The E-machine assumes the function of a start/stop system for the hybrid drive.

During electronic driving mode, the E-machine switches from the generator function to the electric engine function. When the internal combustion engine is disengaged, the E-machine propels the vehicle. Depending on the various driving resistances (air, rolling, inclination, and friction resistance), the E-machine can propel the vehicle as an electric engine. However, if the driver wants faster acceleration, the output of the E-machine no longer satisfies the driver's demand. The hybrid system automatically starts the internal combustion engine.



# Electrical Components

## Construction

The E-machine consists of the following components:

- Cast aluminum housing
- Interior magnetic rotor
- Stator with magnetic coils
- Intermediate plate to connect to the 7-speed dual clutch transmission
- Main bearing
- High-voltage connection with three phases
- G712 Drive Motor Temperature Sensor
- G713 Drive Motor Rotor Position Sensor 1
- V141 Electro-Drive Drive Motor

On the engine side, the clutch engages with the internal combustion engine and a flywheel. The three-phase connections to the magnetic coils are designed so that three adjacent coils are connected to different phases.

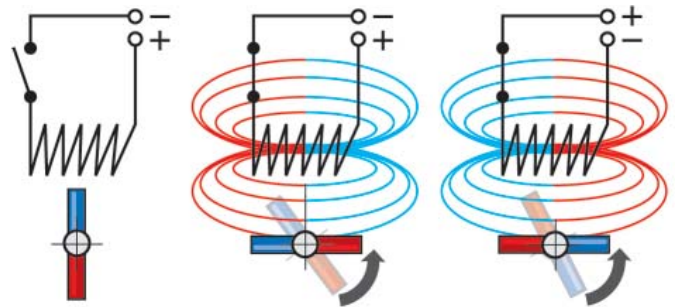
## Function

The E-machine has a stator winding which, as an engine, generates a magnetic rotational field.

If the E-machine is running as an engine, the stator winding generates a rotating magnetic field. The rotor works with the permanent magnets to generate the field. The rotational speed of the synchronous motor is precisely controlled by the frequency of the supplied three-phase current.

A frequency converter is used to smoothly control the rotational speed of the synchronous motor. The rotor position sensors constantly measure the rotor location. The control electronics use the location of the rotor to determine the actual rotational speed.

If the E-machine is functioning as a generator, the rotor is set into motion by outside forces. When the magnetic field of the rotor passes by the coils of the stator, voltage is induced in the coils for each phase. The magnetic field of the rotor proceeds sequentially through each of the coils. The control electronics convert the electrical energy obtained into a charging DC voltage of 220 V for the high-voltage battery.



S525\_043

# Electrical Components

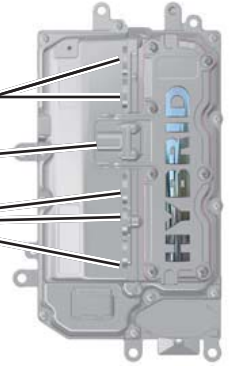
## The Power and Control Electronics for the Electric Drive



2 high-voltage battery connections

1 A/C compressor connection

3 E-machine connections



S525\_044

For clarity, JX1 Electric Drive Power and Control Electronics are identified below as “power electronics.”

The power electronics is the energy conversion system for the electric drive. They are located to the left side of the engine compartment and consist of the following components:

- J841 Electrical Drive Control Module
- C25 Intermediate Circuit Capacitor 1
- A19 Voltage Converter
- A37 Drive Motor Inverter
- Two high-voltage connections for the cables coming from the high-voltage battery
- Three high-voltage connections for the cables going to the E-machine
- One high-voltage connection for the line going to the A/C compressor
- Low-voltage connection to the 12 V on-board electric system
- Cooling system integrated into the low-temperature cooling circuit
- Safety line
- Fuse for the air conditioning compressor



The power electronics should only be opened if directed by repair procedures. Some components must be replaced when opening the power electronics.

The power electronics must be replaced if damaged. It cannot be repaired.

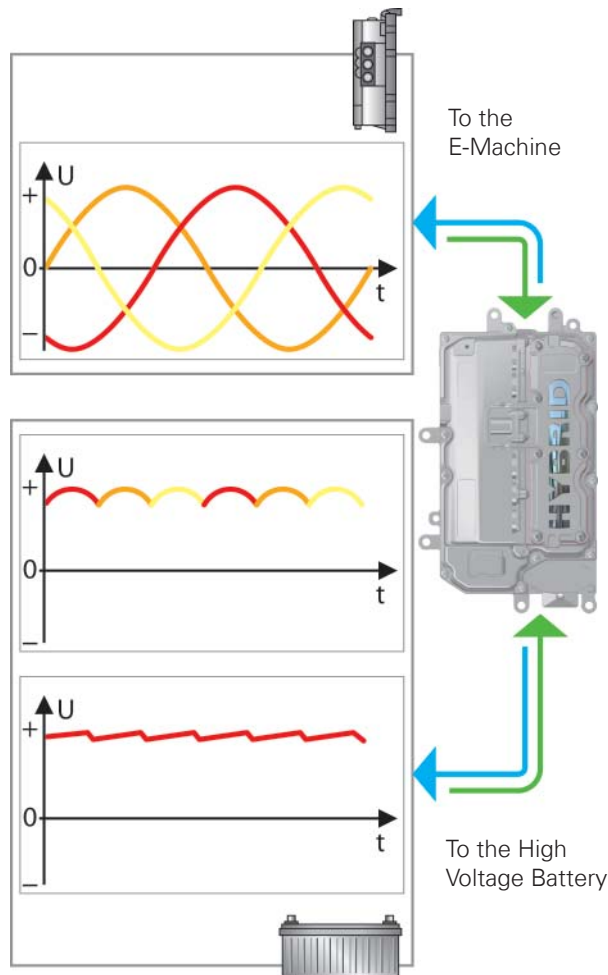
## Power Electronics Functions

Two voltage converters/inverters are integrated into the power electronics. One is a DC/DC converter for supplying the onboard electronics with 12V. The other is a AC/DC and controls the E-machine.

### A19 Voltage Converter

This voltage converter is the interface between the high-voltage system and the vehicle's 12 V system.

Because the alternator has been eliminated, the battery for the 12 V on-board electric supply can only be charged using the E-machine. In order to do this, the 220 V DC from the high-voltage system must be transformed into a charging voltage for the battery for the 12 V electric supply.



### A37 Drive Motor Inverter

Because the E-machine is a three-phase synchronous generator, but batteries can only store DC voltage, an AC/DC voltage converter is also integrated into the power electronics.

This voltage converter/inverter transforms the 220 V DC voltage from the high-voltage battery for supplying the E-machine into alternating voltage with three phases. If the E-machine is running as a generator, it converts the alternating voltage into 220 V DC voltage for charging the high-voltage battery. The rectified voltage is filtered via the high-voltage battery for the high-voltage network and via the 12 V battery. This supplies power to the 12 V on-board electric system in the left rear of the luggage compartment, and the capacitors in the power electronics.

S525\_009

# Electrical Components

## High-Voltage Battery A38

A lithium ion battery is used for electrochemical energy storage in the Jetta Hybrid; this battery is housed in the luggage compartment.

Compared to a nickel/metal hybrid battery, this modern technology increases capacity and enables a more compact design. This battery provides high electrical output for brief periods during acceleration to support the internal combustion engine, and it is capable of recovering electricity during braking. In addition, completely electric driving is also possible for short distances.

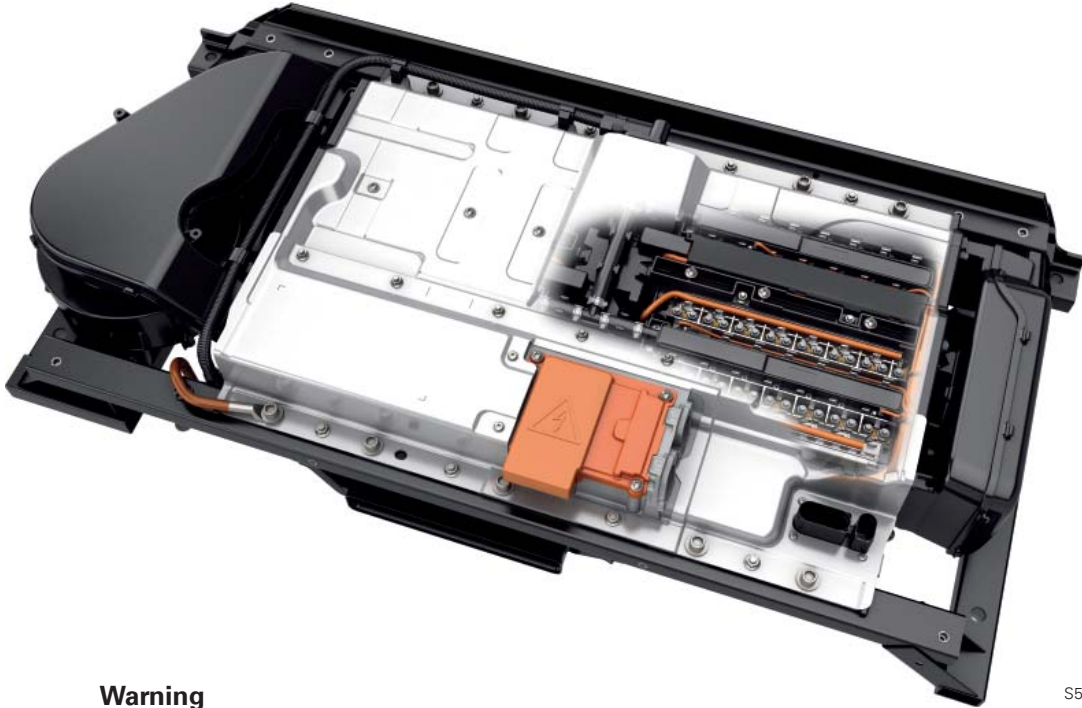


S525\_011

The battery is equipped with a management system that handles the safety, diagnostic, and monitoring functions and, among other things, also regulates the temperature balance. The fan is activated as necessary based on ambient temperature, power loss, and other factors. This allows the battery to remain stable within an optimum temperature range in all situations.

The electric relays integrated into the system switch the battery to idle mode or completely shut off the voltage in critical situations such as a crash. The energy storage system is mounted in a stabilizing frame and housed behind the rear seat in the luggage compartment.

# Electrical Components



S525\_010

## Warning



Alternating voltages as low as 25 V and DC voltages as low as 60 V can be hazardous to humans. Follow all safety instructions in the repair information, Guided Fault Finding, and the warnings posted on the vehicle. Only qualified High Voltage Technicians may disable high voltage systems for repair procedures.

The high-voltage battery is not comparable with a conventional 12 V battery. In regular operation, the high-voltage battery operates between 20% and 85% of the charge. A 12 V battery could not continuously withstand this type of load

The high-voltage battery must be considered a short-term storage unit of the electric drive. Just like a capacitor, it can absorb energy and then discharge it. This means that recuperation, or energy recovery, can be considered a way to refuel the car during a trip.

# Electrical Components

## High Voltage Battery Module

The high-voltage battery module consists of:

- A38 Hybrid Battery
- J840 Battery Regulation Control Module
- J937 Fan Activation Relay
- V457 Battery Fan 1
- Fan housing
- Inlets and outlets for the ventilation system

The battery consists of 60 individual five Ah cells. There are 15 cells to each module, and there are four modules in the battery assembly. These four modules combine to yield a nominal voltage of 220 V and nominal power of 1.1 kWh. The battery system is 26 in x 6 in x 17 in (661 mm x 154 mm x 436 mm) and weighing 79 lb (35.8 kg).

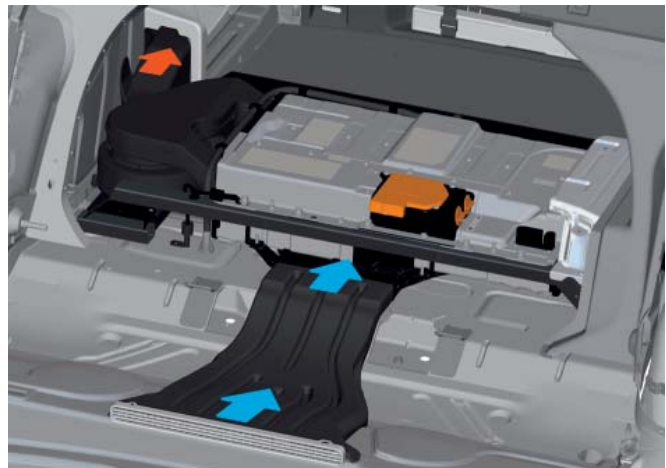
The housing is connected to the vehicle with a potential equalization cable. A toxic gas ventilation line is attached to the housing to remove escaping gas from a defective cell via a ventilation hose underneath the vehicle.

### Battery Cooling System

#### Task

While the battery is charging or discharging, the chemical processes that spontaneously occur cause heat. If the heat cannot be quickly released to the environment, the battery can be damaged.

To keep the battery in its optimal temperature range, the high-voltage battery has its own electric cooling system.



S525\_012

## The Battery

The core of this cooling system is an electric cooling fan. The fan is part of the high-voltage battery module and draws part of the air from the interior through the battery. It runs off of the 12 V on-board electrical system. This fan is V457 Battery Fan 1.

### Function

If the control unit for battery management finds that the battery temperature is too high through the sensor cluster at the battery terminal, it actuates the cooler fan. The air is then drawn through the intake located under the rear seats and routed to the high-voltage battery. The fan then directs the heated air to the right side luggage compartment vent panel.



S525\_045

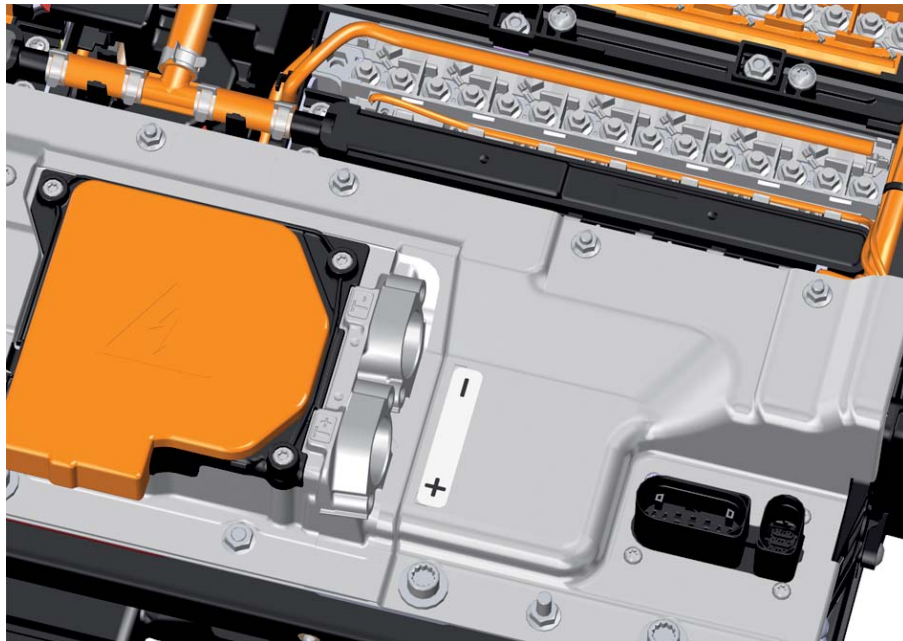
# Electrical Components

## Connections

The high-voltage battery has the following connections:

- Connection for high-voltage cables
- Connection for the on-board electrical system

The high-voltage battery is connected to the 220 V cables using bolted terminals. There are also connections to provide power to the 12V system of the vehicle.



S525\_013



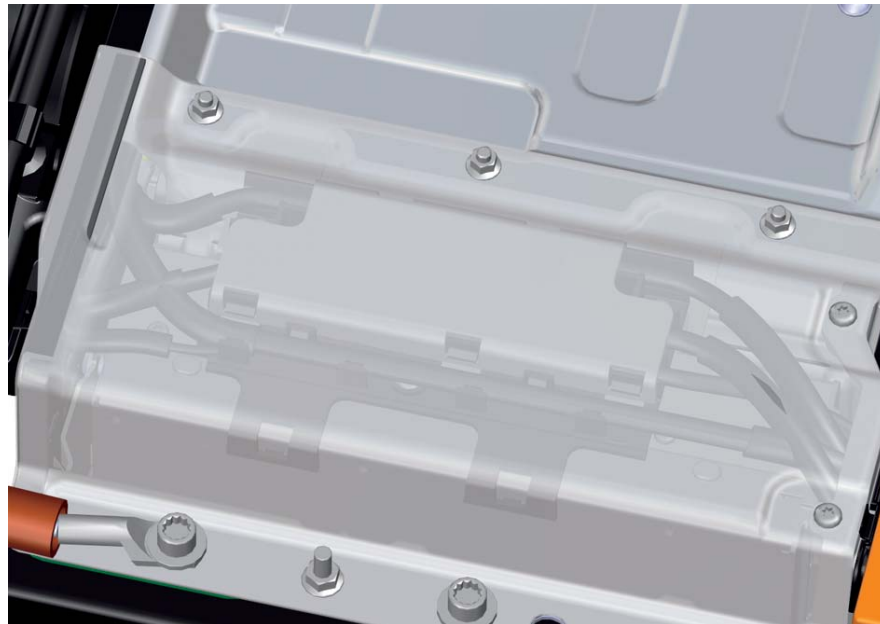
## J840 Battery Regulation Control Module

The J840 Battery Regulation Control Module is integrated on the left side in the AX1 Hybrid Battery Unit and is connected to the hybrid CAN and drive CAN.

### Tasks:

- Monitors the battery cell temperature, voltage and health
- Controls the battery fan
- Monitors insulation resistance
- Monitors the protective relay
- Monitors the pilot line

This information is forwarded through the Hybrid CAN-Bus to the Engine Control Module. For vehicle diagnostic purposes, it stores event memory for any problems in the battery or the electronics box.

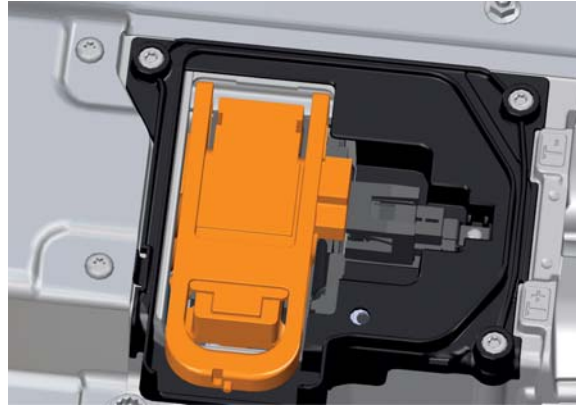


S525\_014

# Electrical Components

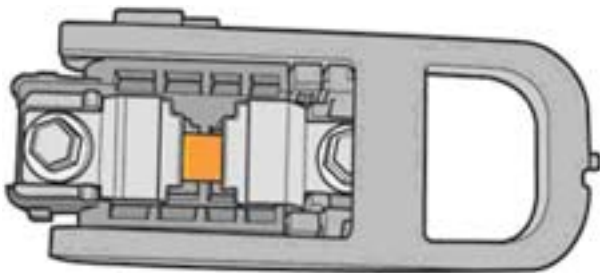
## Maintenance Connector TW

The maintenance connector is located under the orange-colored cover in the electronics box.



S525\_015

The maintenance connector is an electrical bridge for the high-voltage battery. If this connector is disconnected, the high voltage circuit will be disabled and the high voltage energy will dissipate. This connector should be unplugged whenever working on or near high voltage components. ElsaWeb has a list of when to disable the high voltage system under safety precautions. Always follow the GFF test plan for de-energization.



S525\_046

### Fuse

A thermal 125A fuse is integrated in the maintenance connector. This fuse is replaceable, but further diagnostics should be performed if this fuse needs replacement.



### Warning

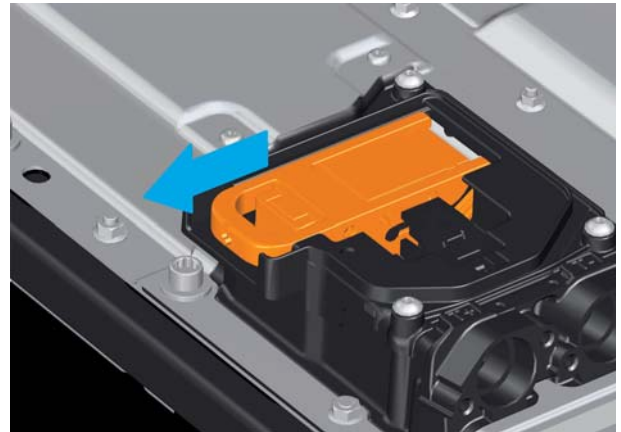
Any deactivation procedures should only be performed in case of an emergency, or when directed through a GFF test plan by an HVT.

# Electrical Components

## Diagnostic Connector Positions

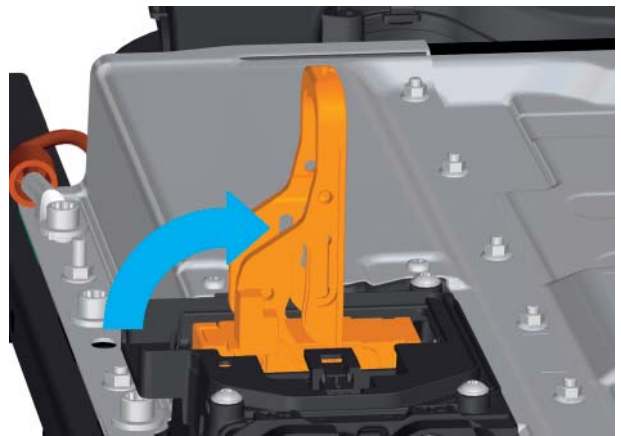
To deactivate the high-voltage system, the maintenance connector must be removed.

In the first position, the top section of the maintenance connector is slid to the side. At this point, the safety line is disconnected. The safety relays (contactors) are then opened as an emergency shutoff. The safety line acts primarily for arc protection.



S525\_016

In the second position, the tab is raised. At this point, the batteries are separated.



S525\_017

The maintenance connector can now be pulled from its seat. The high-voltage system is deactivated and must be checked with GFF to be sure the system is completely de-energized.



S525\_018



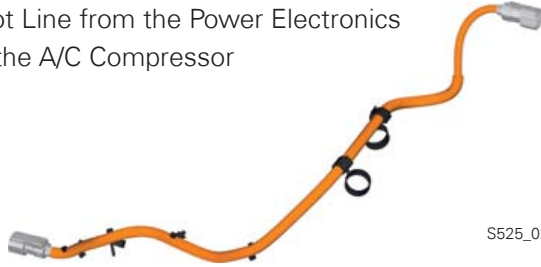
### Warning

This deactivation procedure should only be performed in case of an emergency, or when directed through a GFF test plan by an HVT.

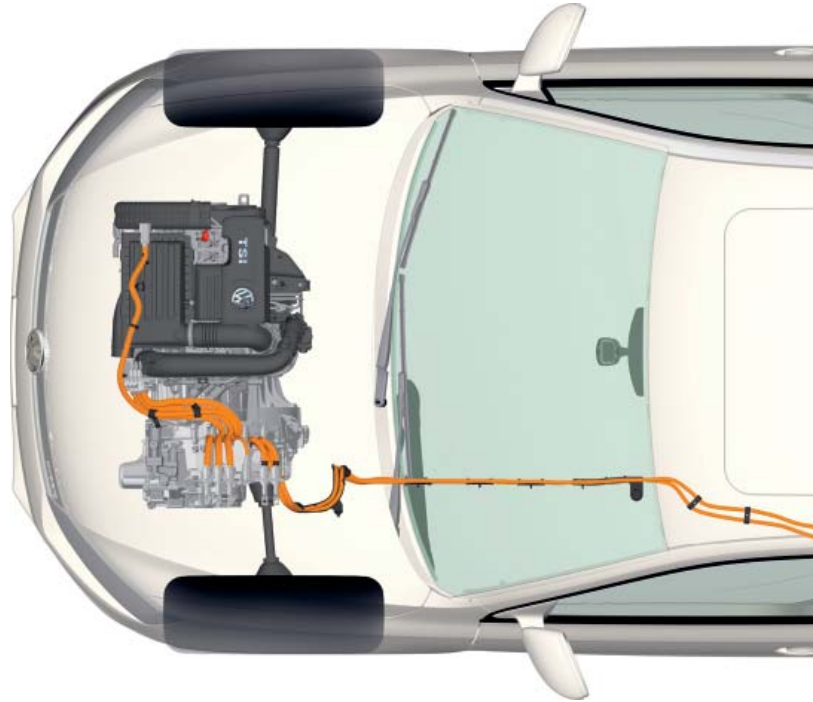
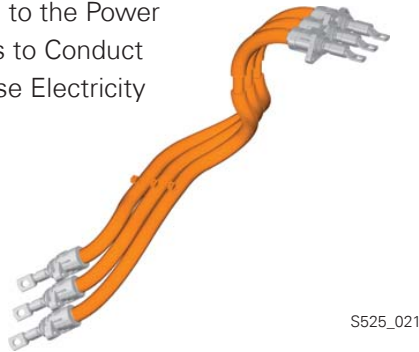
# Electrical Components

## High-Voltage Cables

Two-wire HV Cable with Integrated Pilot Line from the Power Electronics to the A/C Compressor



Three Cables from the E-Machine to the Power Electronics to Conduct Three-Phase Electricity



The electrical cables for the high-voltage system are very different than wires in the rest of the on-board electrical system and the 12 V vehicle electrical system. Due to the high-voltage and the current levels, the high voltage cables have a significantly larger diameter and are connected using special connections.

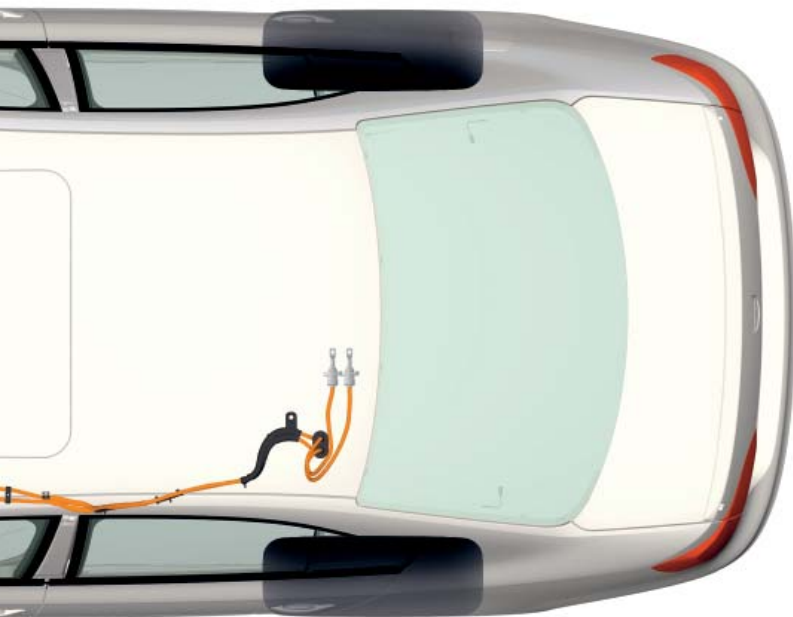
To identify the hazards of the high-voltage, all of the cables from the high-voltage system are completely orange. All manufacturers of electric vehicles use the color orange.

In the high-voltage system, all plug-in connections have contact protection. All high-voltage cables have thick insulation and corrugated tubing as additional sheathing to protect from chafing and abrasion.

The high voltage cables cannot be swapped or repaired. If damaged they can only be replaced.

# Electrical Components

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S525\_019



S525\_020

Two High Voltage Cables from the Battery to the Power Electronics

# Electrical Components

## High-Voltage Battery and Power Electronics

Electric charges between the high-voltage battery and the power electronics are exchanged through two orange high-voltage cables. Both cables have potential. The applied voltage is 220 V DC. The cables are designed as single-pole with shielding.

### Power Electronics to E-machine

Inside of the control electronics, the 220 V DC voltage from the high-voltage battery is converted into three-phase alternating voltage for operating the E-machine by a DC/AC voltage converter. The E-machine is connected to the power electronics via three short high-voltage cables.

### Power Electronics to A/C Compressor

The high voltage A/C compressor makes the climate-control system a part of the high-voltage system. This allows the vehicle interior to retain climate-control even when the internal combustion engine is stopped. The climate-control system remains active depending on the battery charge. If the charge of the high-voltage battery continues to drop, the system automatically starts the internal combustion engine.

The A/C compressor is connected to the power electronics via a four-strand cable with an integrated pilot line.



S525\_047

## E-Machine Sensor

### G713 Drive Motor Position Sensor 1

Because the internal combustion engine with its engine speed sensors is mechanically decoupled from the E-machine when the vehicle is in electric mode, the E-machine requires its own set of sensors for determining the rotor position and the rotor speed. G713 is integrated into the E-machine for this purpose.



S525\_035

### Signal Usage

The engine and transmission management system receive information on the status and the RPM of the E-machine from G713. The following components of the high-voltage system are controlled with this information:

- E-machine as the generator
- E-machine as the engine
- E-machine as a starter for the internal combustion engine

### Failure Effects

If the sensor fails, a warning light illuminates in the instrument cluster and the engine will no longer start. If the engine is already running, a message appears in the instrument cluster telling the driver not to shut down the internal combustion engine until a repair shop can be reached.

# Electrical Components

## G712 Drive Motor Temperature Sensor

### Signal Usage

G712 is responsible for detecting the temperature of the E-machine. This signal is used to control the cooling of the high-temperature circuit in the thermal management system. Depending on the signal, coolant flow can be stopped or commanded to full flow using the electric auxiliary coolant pump.



S525\_026

### Effects of Failure

The warning light for the hybrid system illuminates in the instrument cluster. The vehicle can be driven, but the hybrid drive has very limited functionality.



# Electrical Components

## Hybrid System Electrical Components

Because the internal combustion engine is not always on, all components that have comfort and security-related tasks are electrically-driven. This includes the power steering system, the brake system, transmission and any components that require vacuum. Depending on the needs of the component, it is provided with either high voltage or 12V of electricity.

## 12 V Components

### The 12 V Battery

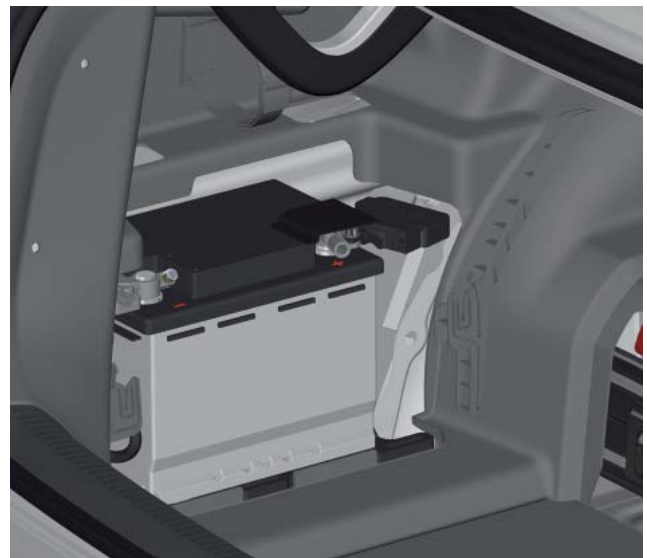
The 12 V battery has been moved to the luggage compartment and supplies the 12 V electrical system with power.

The hybrid vehicle does not have a conventional 12 V alternator. The vehicle's electric supply of 12 V is provided by a DC/DC converter in the power electronics from the high-voltage battery.

The 12V battery is monitored by J367 Battery Monitoring Control Module. It is located at the negative terminal of the 12 V battery cable.

J367 uses the 12V system to open and close the high voltage relays that supply high voltage to the hybrid system.

If the 12 V battery is dead, it can be charged using the (+) and (-) points in the engine compartment.



S525\_023

# Electrical Components

## Electronic Ignition Lock

Upon receiving the information “Ignition key is inserted,” the ignition lock commands the high-voltage system to enter the travel readiness mode. J840 Battery Regulation Control Module requires the ignition key to be inserted before it will activate the high-voltage contacts to link the high-voltage battery to the high-voltage power system. If the ignition key is removed, the control module will automatically disconnect high-voltage battery from the high-voltage system.

The terminals have the following states:

| Ignition ON with brake not applied | Ignition ON with brake applied   |
|------------------------------------|----------------------------------|
| Terminal 15 ON                     | Terminal 15 ON                   |
|                                    | Terminal 50 ON                   |
|                                    | Travel readiness, “Hybrid ready” |

The vehicle can now be driven electrically, or the internal combustion engine starts if the charge of the high-voltage battery is low.

## J234 Airbag Control Module

To prevent endangering occupants or rescue personnel from the high-voltage system in a crash, a crash detection signal from J234, the Airbag Control Module is sent to J840 Battery Regulation Control Module. If a crash is detected, the battery control unit disconnects the high-voltage battery from the high-voltage current system using the high-voltage contacts/relays.

This disconnection between the high-voltage battery and the high-voltage system can only be reset by the scan tool.

The triggered airbags are an indicator to emergency personnel that the HV relays were opened during the crash and that the high-voltage system has been disconnected from the high-voltage battery.

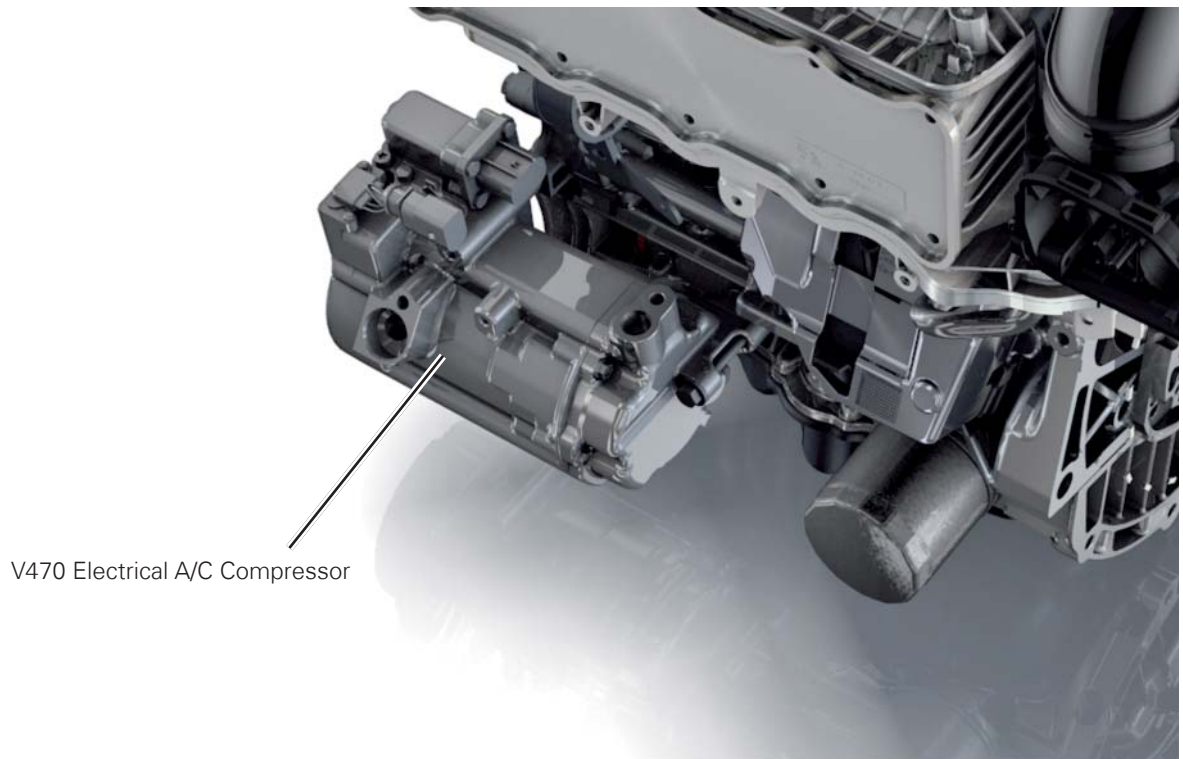


S525\_027

# Electrical Components

## 220 V Components

### V470 Electrical A/C Compressor



V470 Electrical A/C Compressor

S525\_048

Instead of a belt-driven A/C compressor, the Jetta Hybrid has an electric compressor that is bolted to the engine block and is connected to the power electronics via a high-voltage cable. The 220V supplied power is converted from DC to AC internally.

Since it is connected to the high-voltage system, the A/C compressor can also be operated when the vehicle is being driven in only electric mode. The interior climate is controlled even when the internal combustion engine is deactivated, regardless of the charge of the high-voltage battery. The J842 A/C Compressor Control Module is integrated into the A/C compressor.

# System Management

## System Management

### Display and Control Elements

To control and display electric driving mode, the Jetta Hybrid has the following elements:

- Display in the radio navigation unit
- Display in dashboard insert
- Button for switching to extended electric driving mode

### E709 Extended Electric Driving Mode Button

When the E-Mode button is pressed, the system will allow the vehicle to run in electric mode (no combustion engine) for a longer period of time. This allows for a slightly deeper drain on the battery.

This enables the Jetta Hybrid to be driven emissions-free, almost noise-free, and with low fuel consumption.



S524\_049

Extended electric mode is limited depending on driver demands. It can be activated when the high-voltage battery is within an acceptable temperature range and has sufficient charge. The travel speed must be less than approximately 43 mph (70 km/h). If acceleration is too strong or if the battery charging status lower limit is not maintained, electric mode is interrupted. Once acceleration is reduced and the battery has recharged, extended electric mode is automatically reactivated without the driver having to press the button again.

If the battery becomes too hot (ex. too much extended electric mode usage), the extended electric mode is deactivated.

# System Management

## Instrument Cluster Displays

In the "Hybrid" menu, the current status of the vehicle is displayed in an energy flow display. The energy flows are schematically displayed as arrows between the following components: the internal combustion engine, high-voltage battery, and wheels. The display of the energy flows varies in terms of arrow direction and component status (active/passive) so the driver can see which components are activated.

In addition, the displayed energy flow of the battery charge is symbolized by a "fill level" of up to 10 charge bars. This ePower meter is directly under the energy flow indicator and indicates the relative performance of the E-machine.

The values of the bars change to display the fill level of the battery. The maximum value symbolizes the operating point at which the vehicle switches from purely electric operation to operation with the internal combustion engine. The display has the following active states: "Electric driving," "E-mode," and "Boost." Otherwise, the display is grayed out.



# System Management

## Instrument Cluster Indicators

Indicator lights in the instrument cluster warn of faults in the hybrid system. A text message will be displayed with the lights.

With the illumination of a yellow light, the driver should immediately bring the vehicle to the dealer.

With a red light, the driver should stop the vehicle as quickly as possible and call the dealer.



S525\_033



S525\_034

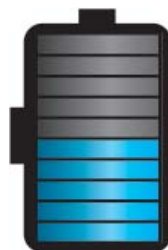
## Battery Charge Control



S525\_069

### High-Voltage Battery Fully Charged

After a long braking phase, the high-voltage battery could be fully-charged by the regenerative braking system.



S525\_070

### High-Voltage Battery Half-Charged

Electric driving or A/C compressor operation will drain the high-voltage battery.



S525\_071

### High-Voltage Battery Almost Fully Discharged

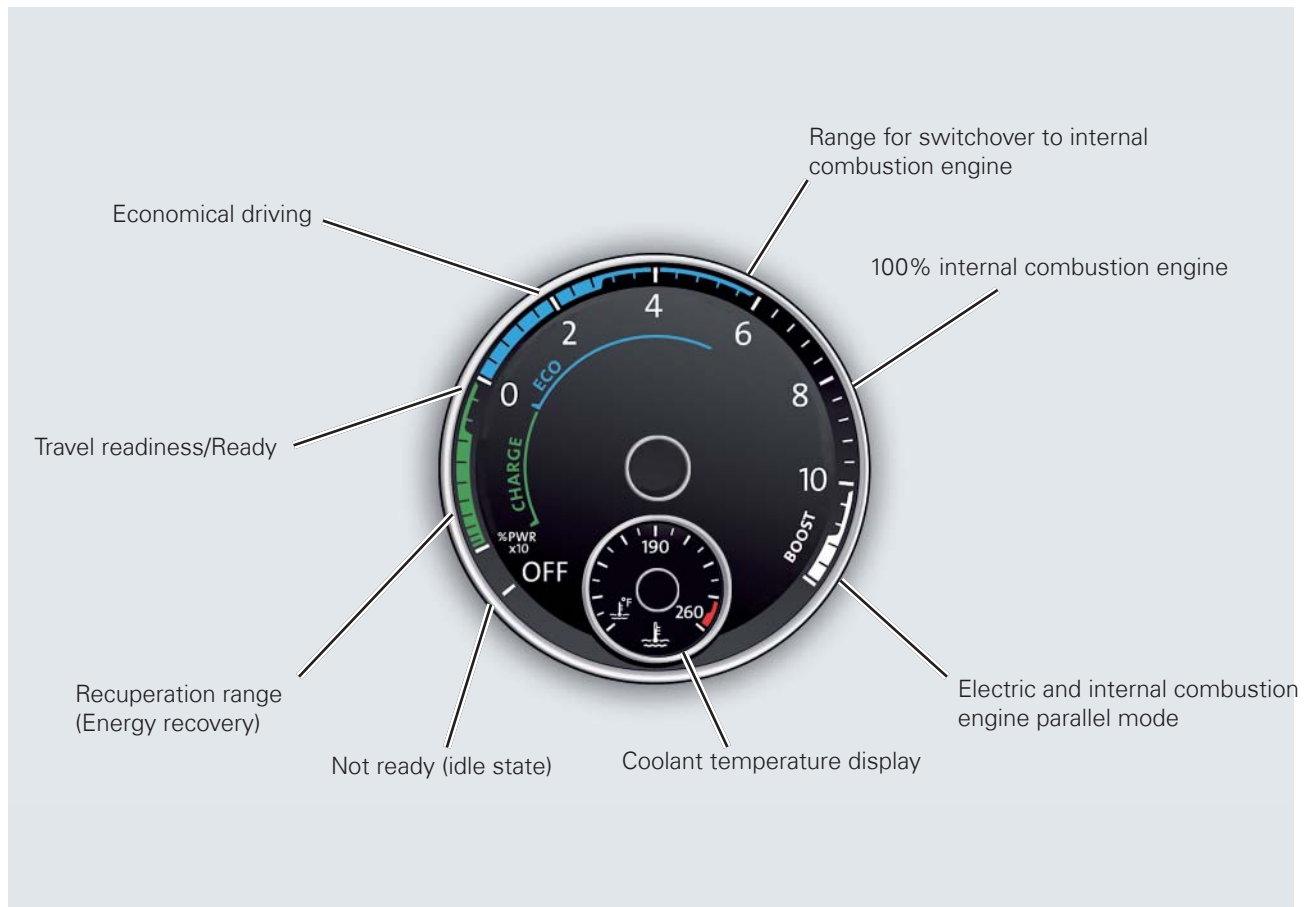
If the high-voltage battery is fully discharged, the internal combustion engine automatically starts to charge the high-voltage battery. This can happen if the car is driven in electric mode for long periods or sits still for a long time with the climate-control system running.

# System Management

## Powermeter

The Powermeter informs the driver of the current driving status of the Jetta Hybrid and has the following sections:

- Travel readiness (READY)
- Recuperation (CHARGE)
- Eco-friendly driving (ECO)
- Boosting (BOOST)
- Driving purely with the internal combustion engine
- Ignition off (OFF)



S525\_051

# System Management

## Operational Displays

### Display – Travel Readiness

When the vehicle is ready for travel, the word “READY” is displayed, and the Powermeter pointer position is at 0.



S525\_052

### Display – Electric Driving

Purely electric driving.



S525\_053

### Display – E-mode

When electric mode has been switched “ON” with the button, the word “E-mode” is shown.



S525\_054



# System Management

## Display – Engine

Driving using internal combustion engine with simultaneous charging of the high-voltage battery.



S525\_055

## Display – Engine

Driving using internal combustion engine without simultaneous charging of the high-voltage battery.



S525\_056

## Display – Boost

Parallel operation of the internal combustion engine and the electric drive.



S525\_057

# System Management

## Display – Charge

Recovery of energy during recuperation.



S525\_058

## Display – Fuel Tank Pressure

Information about the status of the pressurized fuel tank.



S525\_059

## Radio and Navigation System Hybrid Displays

### Zero Emission

The submenu “Zero emission” in the radio and navigation system provides a symbolic representation of emission-free driving time. The zero emission values are shown as percentages in the form of a bar graph. In this graph, the measuring interval of a bar corresponds to a minute of driving. For example, a value of 100% means that the corresponding minute of driving was also free of emissions (driven with the internal combustion engine turned off). This can be achieved through electric driving, coasting, or start/stop mode.

A zero emission value of 0% means that the internal combustion engine was fully in operation for an entire minute of driving.

New bars appear at the left of the graph (in the “current” area/1 minute), which causes the bar graph to shift from left to right. The system can display a maximum time of 30 min. The value range applied to the Y axis is scaled according to the percentages shown in the graph. If all of the bar values shown are less than or equal to 50%, the Y axis will have a maximum value of 50%. If at least one value is more than 50%, the scale will be expanded to a maximum of 100%.



S525\_060

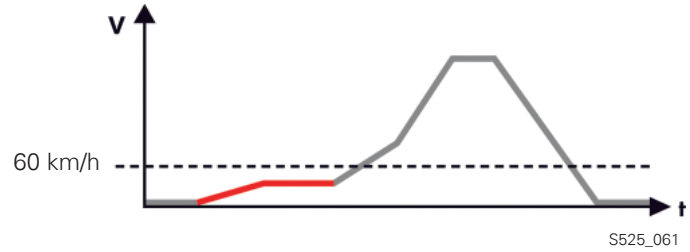
# System Management

## System display: E-mode

The Jetta Hybrid starts driving in purely electric mode and retains this status during moderate acceleration up to speeds of about 35 mph (60 km/h). The maximum range of electric driving is approximately 1.2 miles (2 km).

To prevent drag loss, the E-machine activates providing power while the engine remains decoupled.

If necessary, the internal combustion engine will be turned on using a low fuel consumption operating mode. The internal combustion engine is only engaged depending on the driver's power and torque demands and on the charge of the high-voltage battery.



The charge of the high-voltage battery is displayed by the amount of blue in the battery. Because the vehicle is being driven in electric mode, blue lines go from the battery to the drive wheels and just behind the wheels. The text "Electric motor" indicates that the vehicle is in electric mode



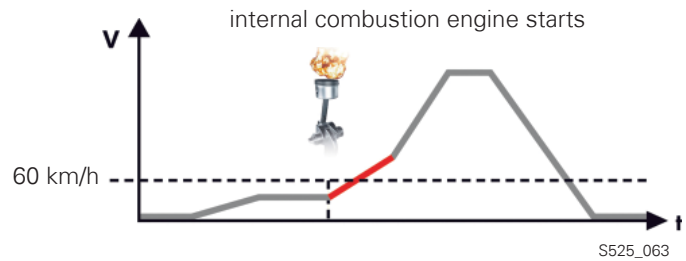
# System Management

## System Display: Driving with the Internal Combustion Engine

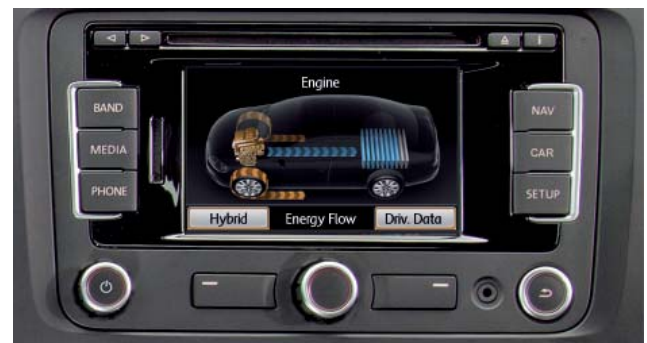
If the load is higher, the engine is started by engaging the separating clutch. Depending on the charge of the high-voltage battery, the engine drives the vehicle and simultaneously charges the high-voltage battery.

The high-voltage battery is charged with recovered braking energy or, if that is not possible, by the E-machine operating in generator mode (driven by the internal combustion engine). When this happens, the load point of the internal combustion engine is raised above the level necessary to overcome driving resistance, and the resulting excess torque is routed to the battery in the form of electrical energy.

The operating point takes into account the partial efficiency and the energy requirements of the electrical system. The operating point of the internal combustion engine can be adjusted with far greater efficiency than with conventional vehicles. These so-called active charging phases are designed to interact with the electric driving phases to minimize consumption for the driver of the Jetta Hybrid.



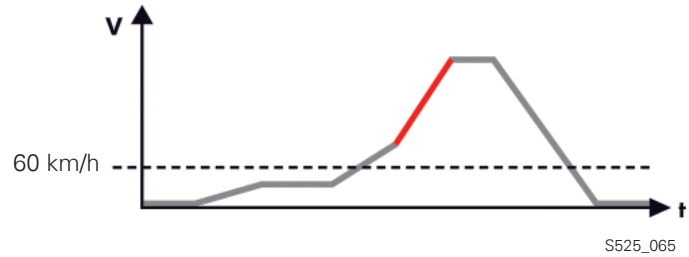
The charge of the high-voltage battery is displayed by the amount of blue in the battery. Orange lines on the drive wheels and the text "Engine" indicate that the vehicle is running with the internal combustion engine. Blue lines going from the powertrain area to the battery indicate that the battery is being charged.



# System Management

## System Display: Boost

Under very high loads, the torque and output of the internal combustion engine and the E-machine can be combined for short periods (max. 184 lb-ft (250 Nm), 170 hp (125 kW)) to significantly increase vehicle acceleration.



Because the engine performance is outstanding even without this support and boosting only contributes to fuel consumption, the use of the boost is limited to:

- The kick-down position of the accelerator pedal at selector lever position "D"
- When there is strong acceleration at selector lever position "S"
- When the "Tiptronic" shift gate is engaged.

There are two different boost states:

1. Active boost: The E-machine provides some torque in the drivetrain; the wheel torque results from the total torque from both the E-machine and the internal combustion engine.
2. Passive boost: The E-machine is torque-neutral; the electrically powered units are provided with energy only from the battery. In conventional vehicles, this corresponds to turning off the alternator.

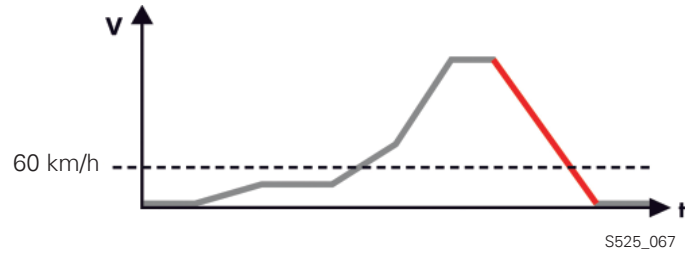
The charge of the high-voltage battery is displayed by the amount of blue in the battery. Orange and blue lines on the drive wheels and the text "Boost" indicate that the vehicle is being driven by both the internal combustion engine and the E-machine.



# System Management

## System Display: Driving with Brake Force Recuperation

When the driver lifts off the accelerator pedal, the clutch is disengaged and the engine is turned off. Depending on the path of the brake pedal, electric deceleration torque is generated, and the kinetic energy is stored in the battery as electric power.



The braking recuperation is the only method with which more-or-less “free” energy can be stored in the high-voltage battery; a significant amount of the vehicle’s kinetic energy can be stored in the battery instead of being converted into heat at the brake disks.

When the driver takes his or her foot off of the accelerator pedal before braking, the separating clutch is disengaged to decouple the engine and eliminate its drag loss. The vehicle then rolls extremely well which can be utilized for further fuel savings, particularly with cautious driving behavior.

If the driver presses the brake pedal, the regenerated torque of the E-machine increases as a function of the pedal path, and the electrical energy is stored in the battery. To facilitate the controlled delivery of the “electrical” braking torque and braking without the hydraulic system, the braking pedal is provided with slightly more free travel during which the E-machine's torque builds up. The recovered energy is available later for supplying the electrical units, for electric driving, or also for boosting.

Shifting maps, specifically for this mode, are stored in the Transmission Control Module control the efficiency of the E-machine during the downshifting that is required while braking.

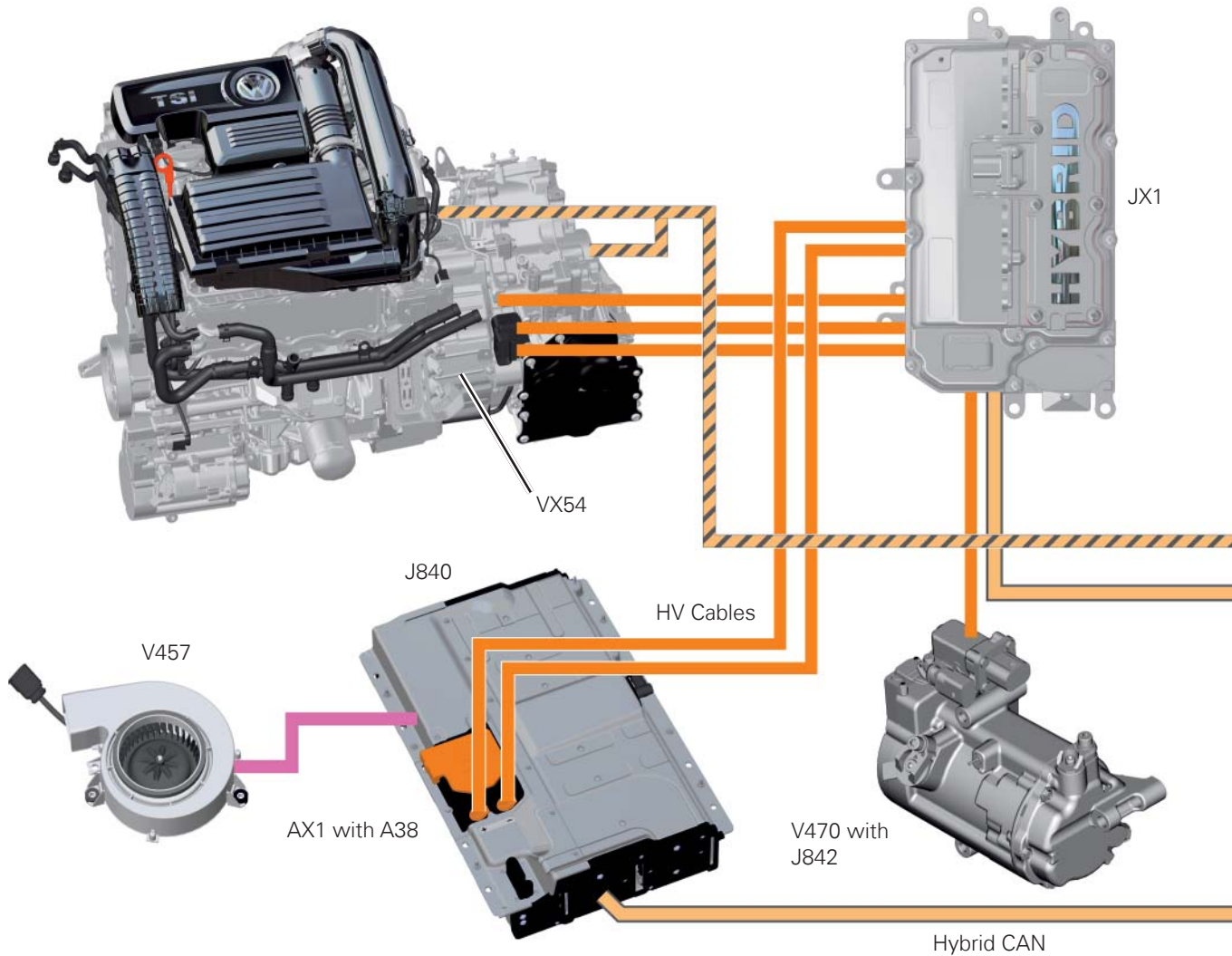
The charge of the high-voltage battery is displayed by the amount of blue in the battery. The green lines surround wheels, representing recuperation. In this mode, the E-machine is generating electricity from the turning wheels and sending it to the battery (represented by the blue line to the battery).



S525\_681

# System Management

## System Overview

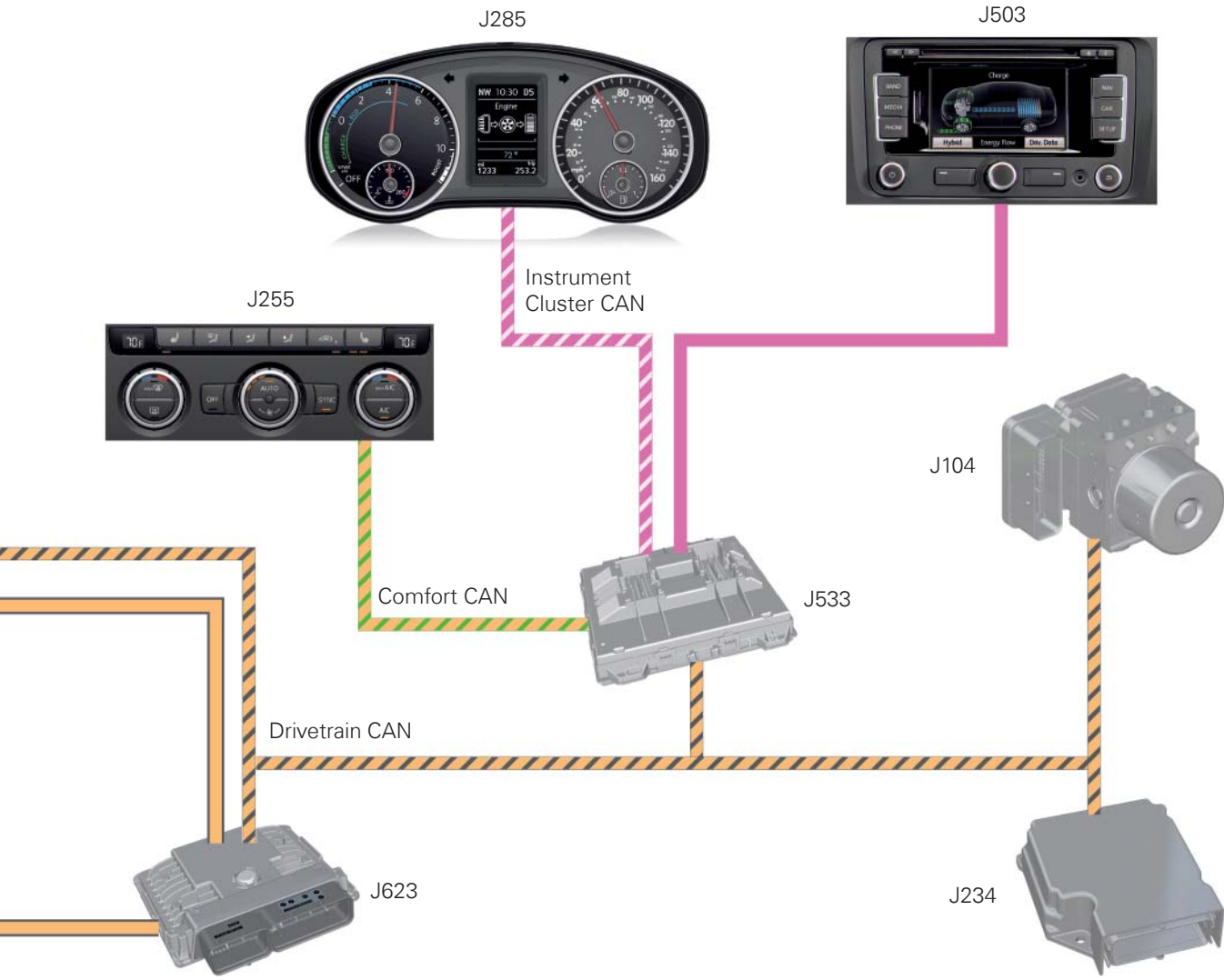


A38 Hybrid Battery  
AX1 Hybrid Battery Unit  
J104 ABS Control Module  
J234 Airbag Control Module  
J255 Climatronic Control Module  
J285 Instrument Cluster Control Module  
J503 Radio/Navigation Display Unit Control Module  
J533 Data Bus Onboard Diagnostic Interface

J623 Engine Control Module  
J840 Battery Regulation Control Module  
J842 A/C Compressor Control Module  
JX1 Electric Drive Power and Control Electronics  
V457 Fan 1 for Hybrid Battery  
V470 Electrical A/C Compressor  
VX54 Three-Phase Current Drive



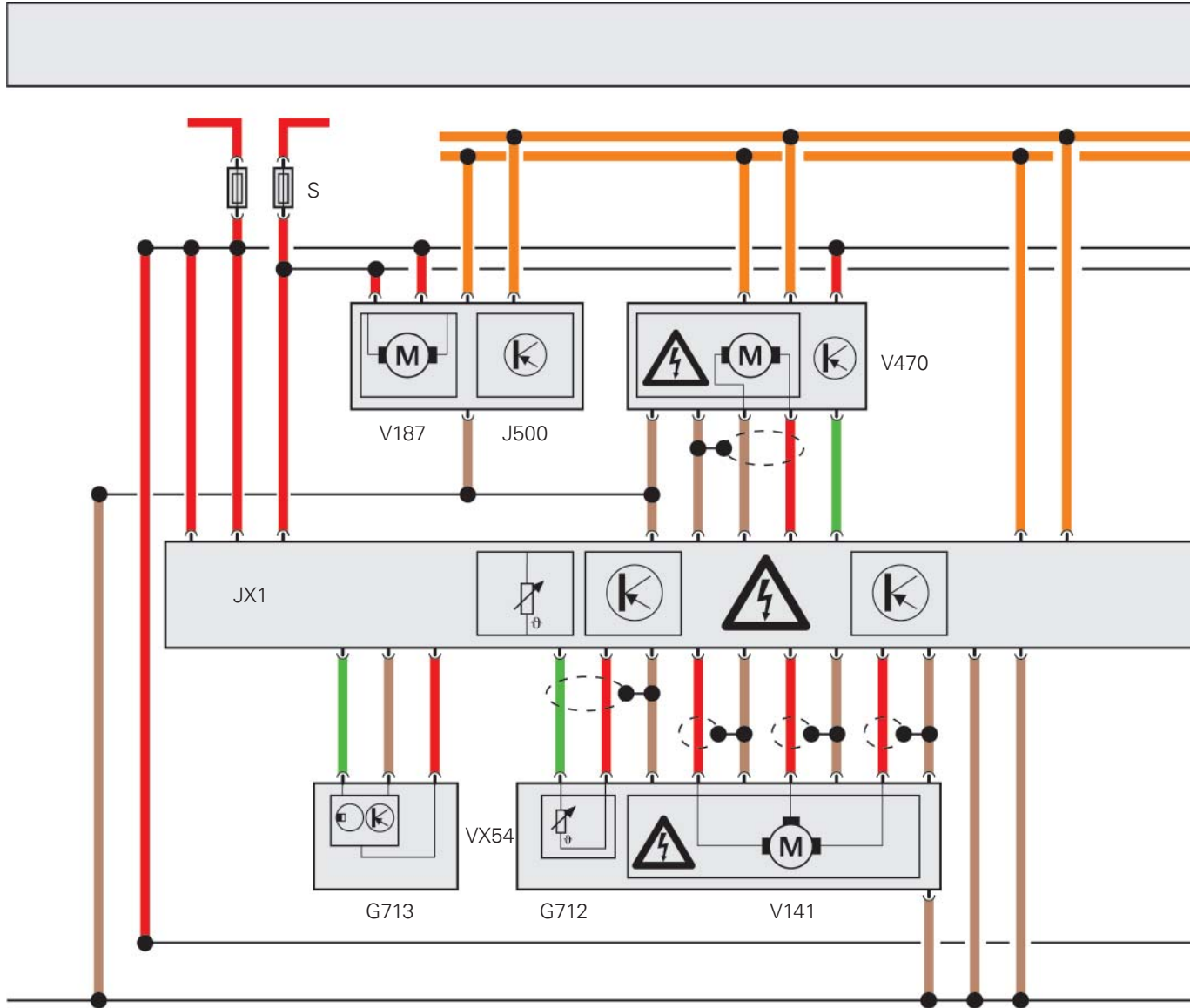
# System Management



S525\_025

# System Management

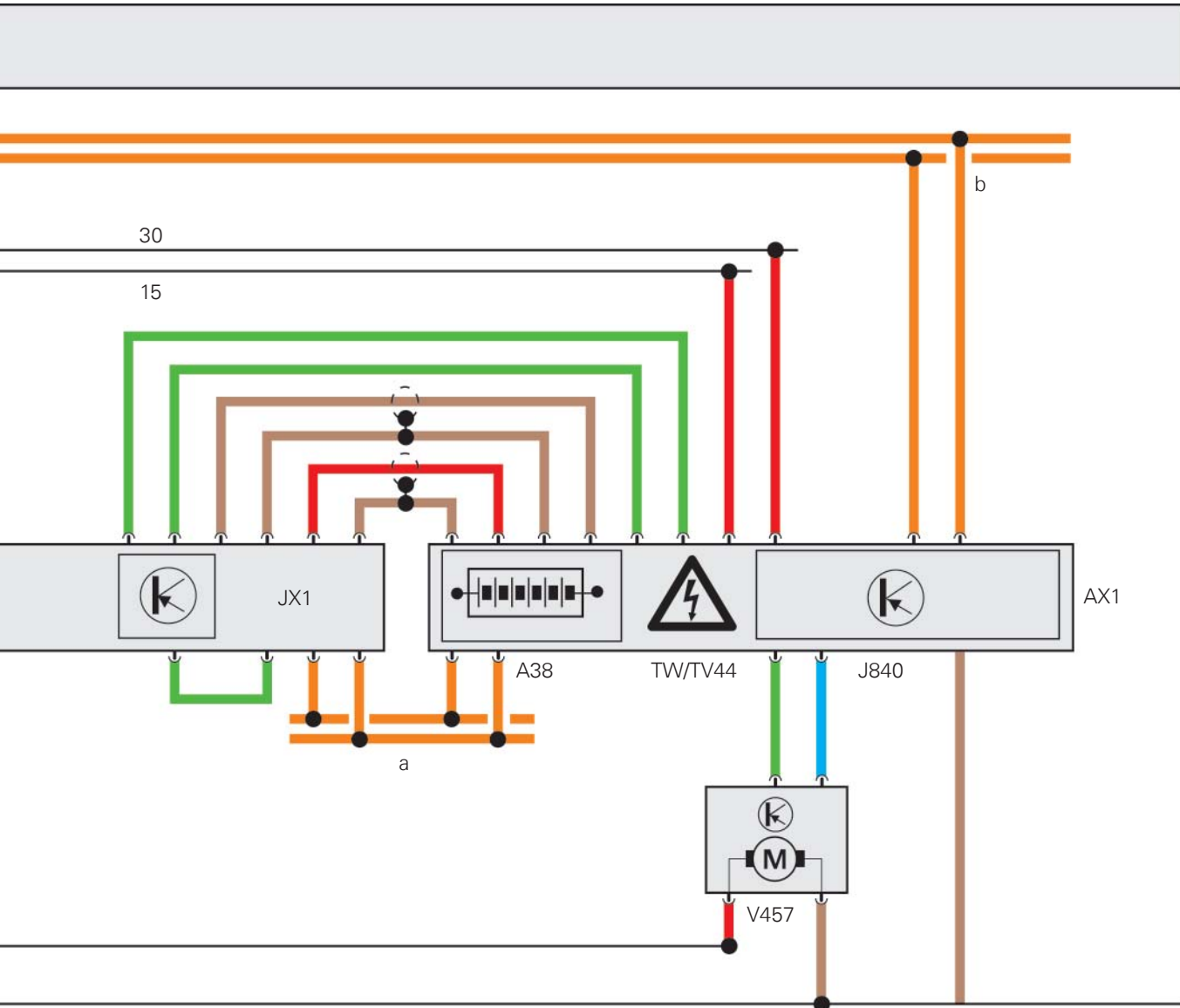
## Functional Diagram



A38 Hybrid Battery  
 AX1 Hybrid Battery Unit  
 G712 Drive Motor Temperature Sensor  
 G713 Drive Motor Rotor Position Sensor 1  
 J500 Power Steering Control Module  
 J840 Battery Regulation Control Module  
 JX1 Electric Drive Power and Control Electronics  
 S Fuse

TV44 Pilot Line Connector 1  
 TW High Voltage System Maintenance Connector  
 V141 Electro-Drive Motor  
 V187 Electromechanical Power Steering Motor  
 V457 Fan 1 for Hybrid Battery  
 V470 Electrical A/C Compressor  
 VX54 Three-Phase Current Drive  
 a Hybrid CAN-Bus  
 b Drivetrain CAN-Bus

# System Management



S525\_024

# Service

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## Special Tools

### VAS 6649

Warning sign for dangerous high voltage.

It must be displayed clearly prior to any work on the vehicle.



S525\_074

### VAS 6650A

Disabled high voltage system warning sign.

It must be displayed clearly on the vehicle when directed by Guided Fault Finding.

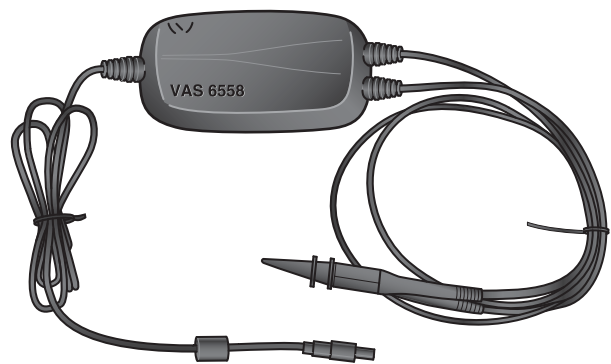


S525\_075

### VAS 6558A

This is a high voltage measurement module. It is used for:

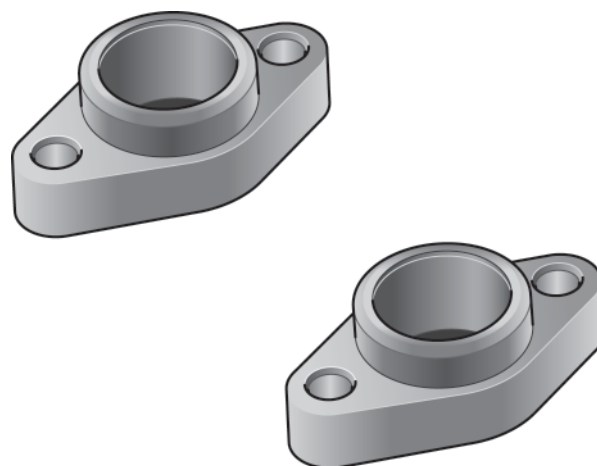
- Measuring for lack of voltage
- Insulation resistance tests
- Potential measurement
- Resistive continuity tests



S525\_073

## T 10506

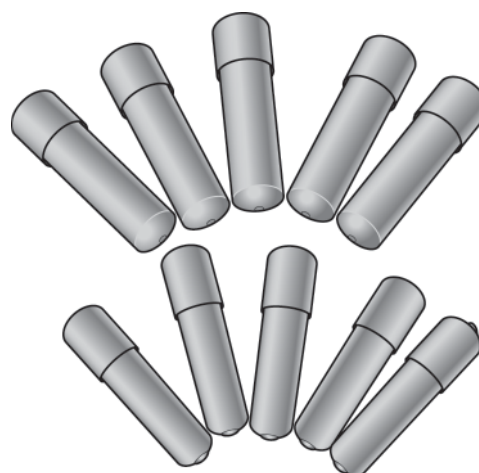
Caps to cover the high voltage connections of the battery.



S525\_076

## VAS 6762/10

Caps to cover the ends of the high voltage cables.



S525\_077



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# Knowledge Assessment

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An on-line Knowledge Assessment (exam) is available for this Self-Study Program.

The Knowledge Assessment may or may not be required for Certification.

You can find this Knowledge Assessment at:

**[www.vwwebservice.com](http://www.vwwebservice.com)**

For Assistance, please call:

**Volkswagen Academy**

**Certification Program Headquarters**

**1-877-791-4838**

**(8:00 a.m. to 8:00 p.m. EST)**

Or, E-mail:

**[concierge@volkswagenacademy.com](mailto:concierge@volkswagenacademy.com)**



Volkswagen Group of America  
2200 Ferdinand Porsche Drive  
Herndon, VA 20171  
August 2012

