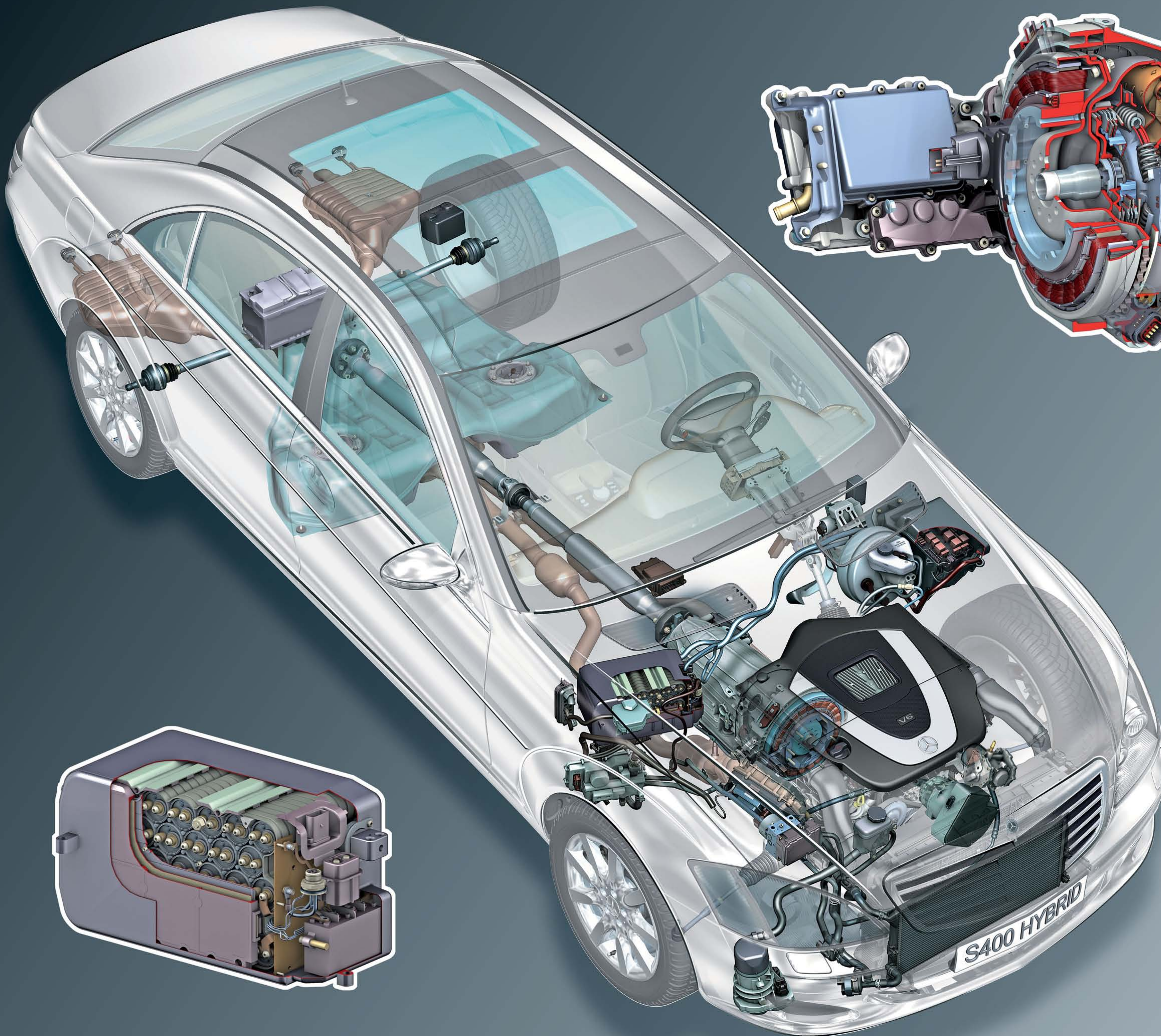
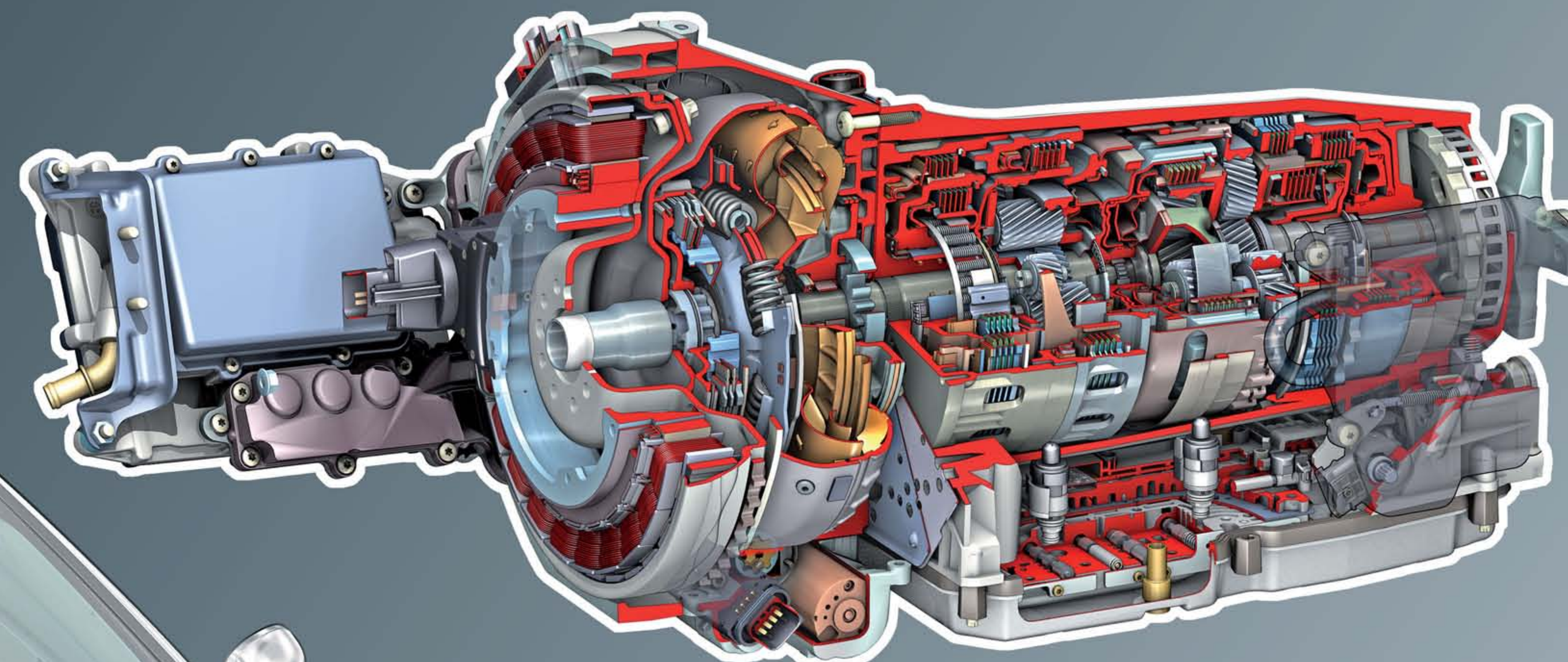




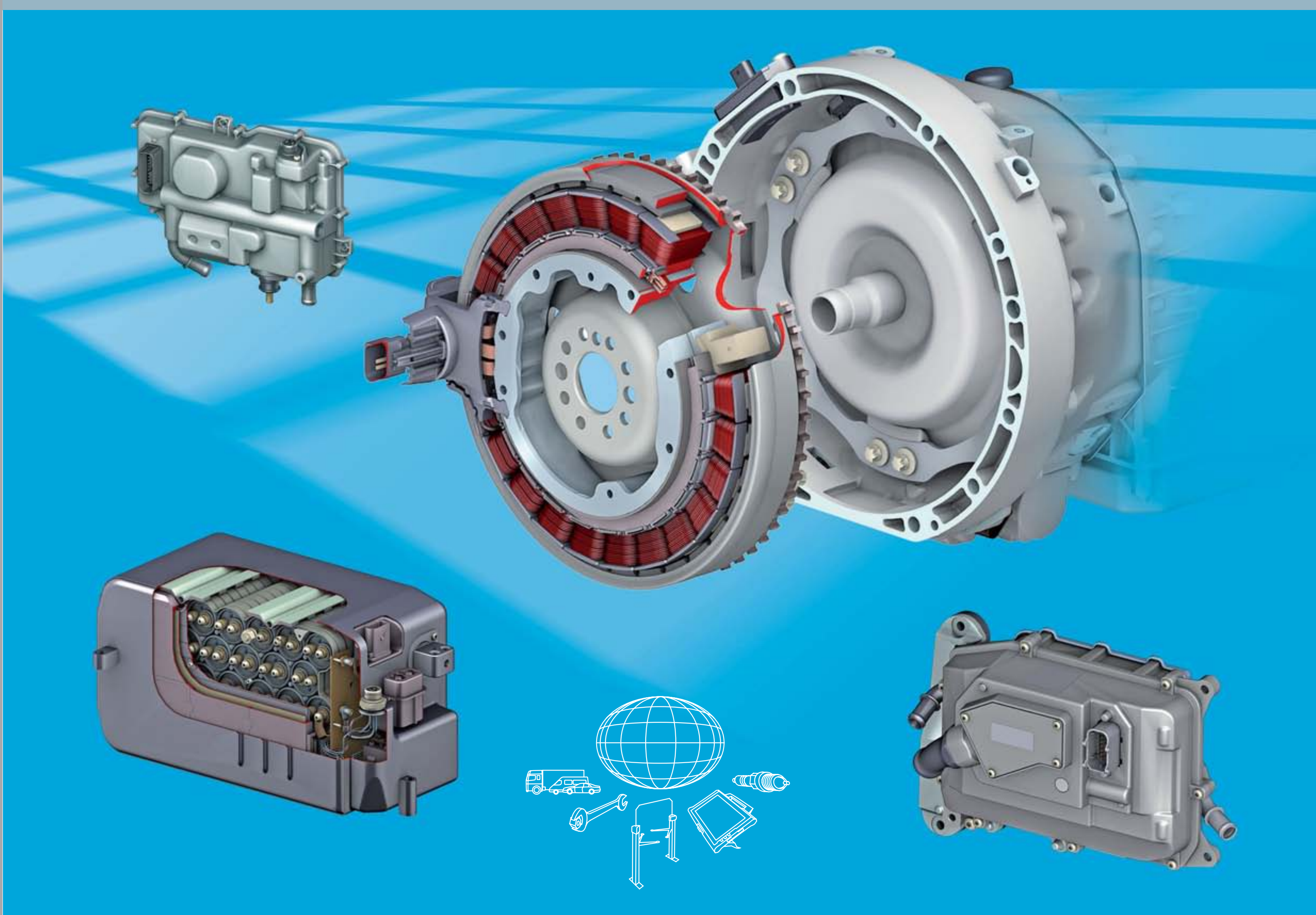
S 400 HYBRID (221)

Daimler AG, GSP/OI, HPC R 822, D-70546 Stuttgart

Hybrid Concept in S 400 HYBRID

System Description

Mercedes-Benz



System Description
Hybrid Concept in S 400 HYBRID

Daimler AG · Technical Information and Workshop Equipment (GSP/OI) · D-70546 Stuttgart

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03 / 2009

Contents

Contents

Dear Reader,

This system description presents the hybrid concept of the S 400 HYBRID from Mercedes-Benz.

It allows you to familiarize yourself with the technical highlights of this new concept in advance of its market launch. This brochure primarily intended to provide information for people employed in service, maintenance and repair as well as for aftersales staff. It is assumed that the reader is already familiar with the Mercedes-Benz model series and major assemblies currently on the market.

In terms of the contents, the emphasis in this system description is on presenting new and modified components, systems, system components and their functions.

This system description aims to provide an overview of the technical innovations and an insight into the systems.

However, this system description is not intended as a basis for repair work or technical diagnosis. For such needs, more extensive information is available in the Workshop Information System (WIS) and in the Diagnosis Assistance System (DAS).

These systems are updated on a monthly basis. Therefore, the information available there reflects the latest technical status of our vehicles.

The contents of this brochure are not updated and no provision is made for supplements. We will publicize modifications and new features in the relevant WIS documents. The information presented in this system description may therefore differ from the more up-to-date information found in the WIS.

All the information relating to specifications, equipment and options is valid as of the copy deadline in March 2009 and may therefore differ from the current production configuration.

Daimler AG

Technical Information and Workshop Equipment (GSP / OI)

Introduction

The new Mercedes-Benz S 400 HYBRID is based on the S 350 but its drivetrain has undergone significant modification. The modifications include the further developed 3.5-liter V6 gasoline engine, the additional permanently energized synchronous motor, the 7-speed automatic transmission (7G-TRONIC) which has been specially designed to accommodate the hybrid module, the required power and control electronics, the voltage converter and the lithium-ion battery.

The compact hybrid module consists of a disk-shaped electric motor, which also serves as a starter and high-voltage alternator. The system has two advantages: on the one hand, it helps to save fuel and, on the other, it increases driving pleasure. One reason for this is the "boost effect", whereby the electric motor powerfully supports the combustion engine in the high-consumption acceleration phase. The driver benefits from the interaction of the two major assemblies in the form of an even more impressive torque curve and superior power development every time the vehicle starts off or accelerates.

The hybrid module is also equipped with a convenient start-stop function which shuts off the engine when the vehicle is stopped e.g. at traffic lights. When it is time to drive on, the electric motor starts the combustion engine almost unnoticeably and very comfortably. This also makes a contribution to fuel economy and protecting the environment because the engine starts almost immediately with the first ignition. This means that the emissions are also minimized during the start-up phase.

When the vehicle decelerates, the electric motor operates as a high-voltage alternator and is able to recover braking energy through the "regenerative braking" process. In doing so, the electric motor works harmoniously to support the engine braking effect of the combustion engine and the conventional wheel brakes in a seamless series of steps. The recovered energy is stored in a high-performance compact lithium-ion battery for later usage as required. The "major assembly coordinator" integrated in the engine control unit is responsible for managing the hybrid drive system with its energy management and torque coordination modules.

i Note

Only trained workshop staff (electrical technician for high-voltage on-board electrical systems in motor vehicles) may carry out work on a high-voltage on-board electrical system.

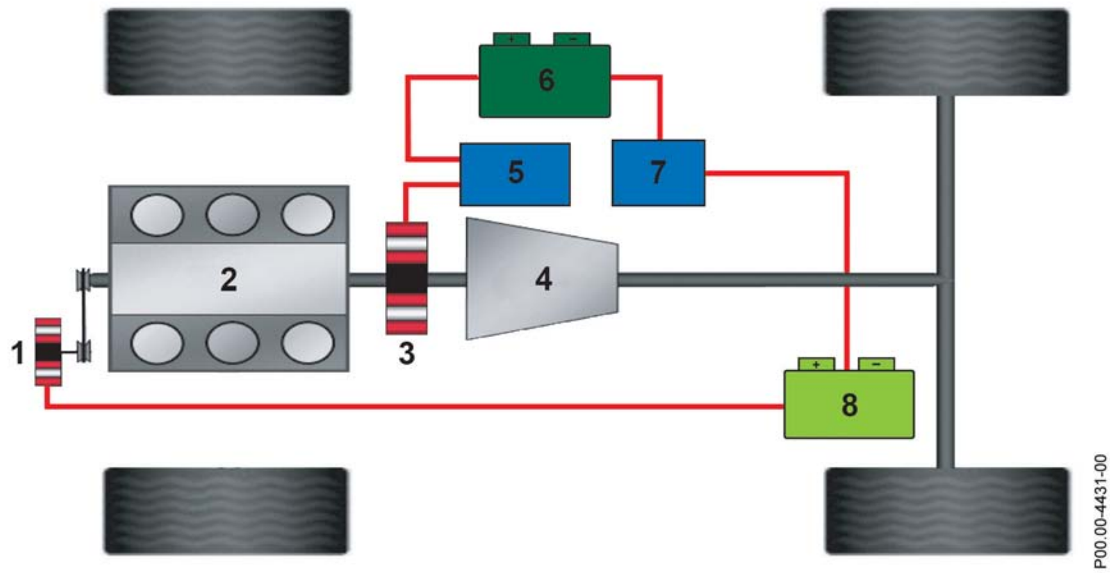
i Why a hybrid?

The automobiles of the future will be increasingly influenced by the following factors:

- Limited natural resources
- Long-term rises in energy prices
- Legal stipulations on environmental compatibility and CO_2 emissions
- Changes in purchasing behavior in favor of more environmentally friendly and economical vehicles

The S 400 HYBRID is equipped with a parallel hybrid drive. With this drive system, both the combustion engine and the electric motor are mechanically connected to the drive wheels (parallel connection of engine and motor).

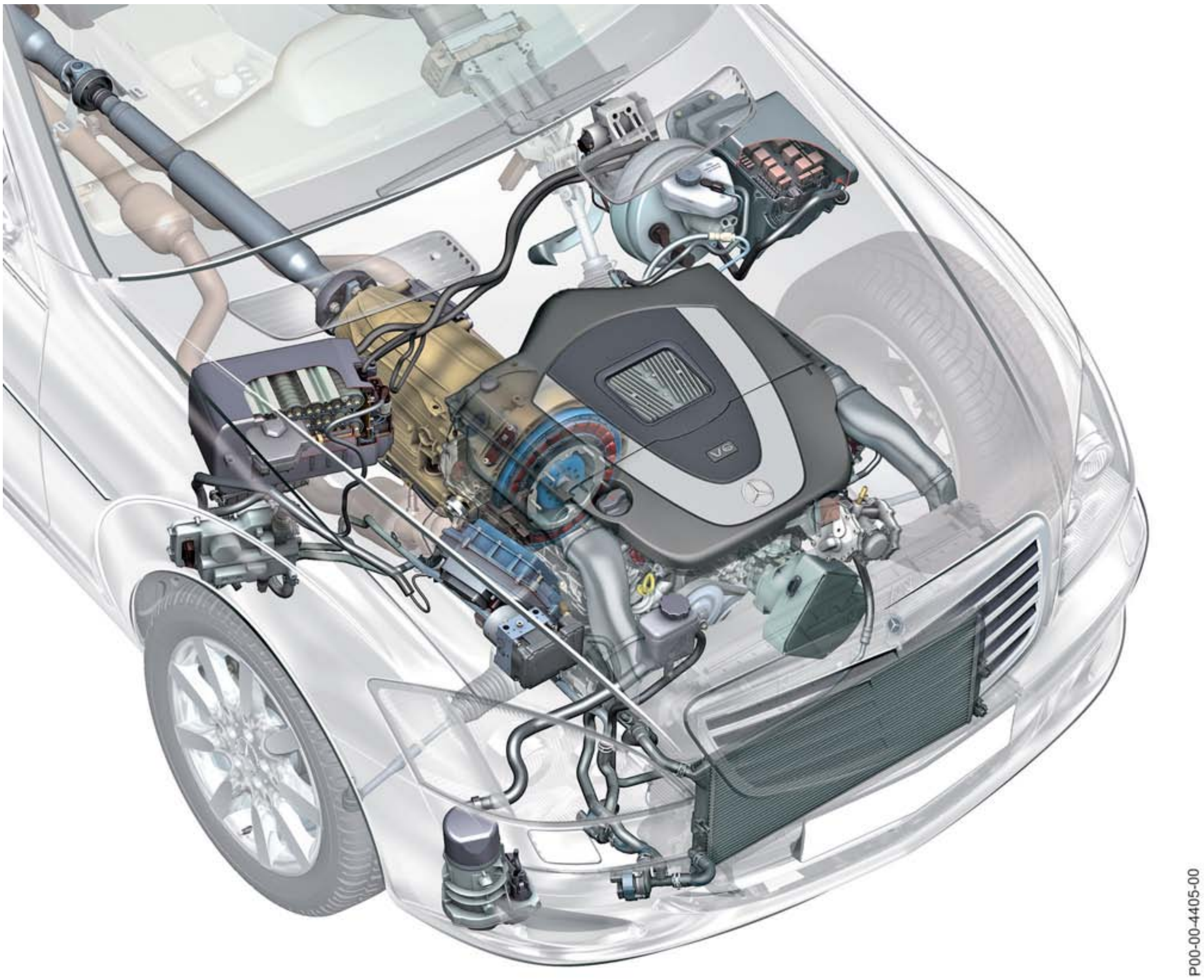
The power supplied by the electric motor and the engine can be added together, which means that the individual power ratings of both can be kept lower. It is not possible to drive the vehicle solely using the electric drive system.



Overview of drive concept

1 12 V alternator
2 Internal combustion engine
3 Electric motor
4 7-speed automatic transmission (7G-TRONIC)
5 Power electronics module
6 High-voltage battery module
7 DC / DC converter module
8 12 V battery

Introduction



View of vehicle from right front

Designation	Market launch	Model designation W 221 / V 221	Engine	Transmission
S 400 HYBRID	ECE 06 / 2009 Japan 08 / 2009 USA 08 / 2009 China 09 / 2009	221.095 / 221.195 (USA)	272.974	722.950

Overview of hybrid components

1 High-voltage battery module
2 DC / DC converter module
3 Power electronics module
4 Electric motor
5 Pedal assembly
6 RBS brake booster
7 Electric vacuum pump
8 Electric refrigerant compressor
9 Low temperature cooler
10 Low-temperature circuit circulation pump
11 Electrohydraulic power steering
12 Hydraulic unit with regenerative braking system control unit

Technical data

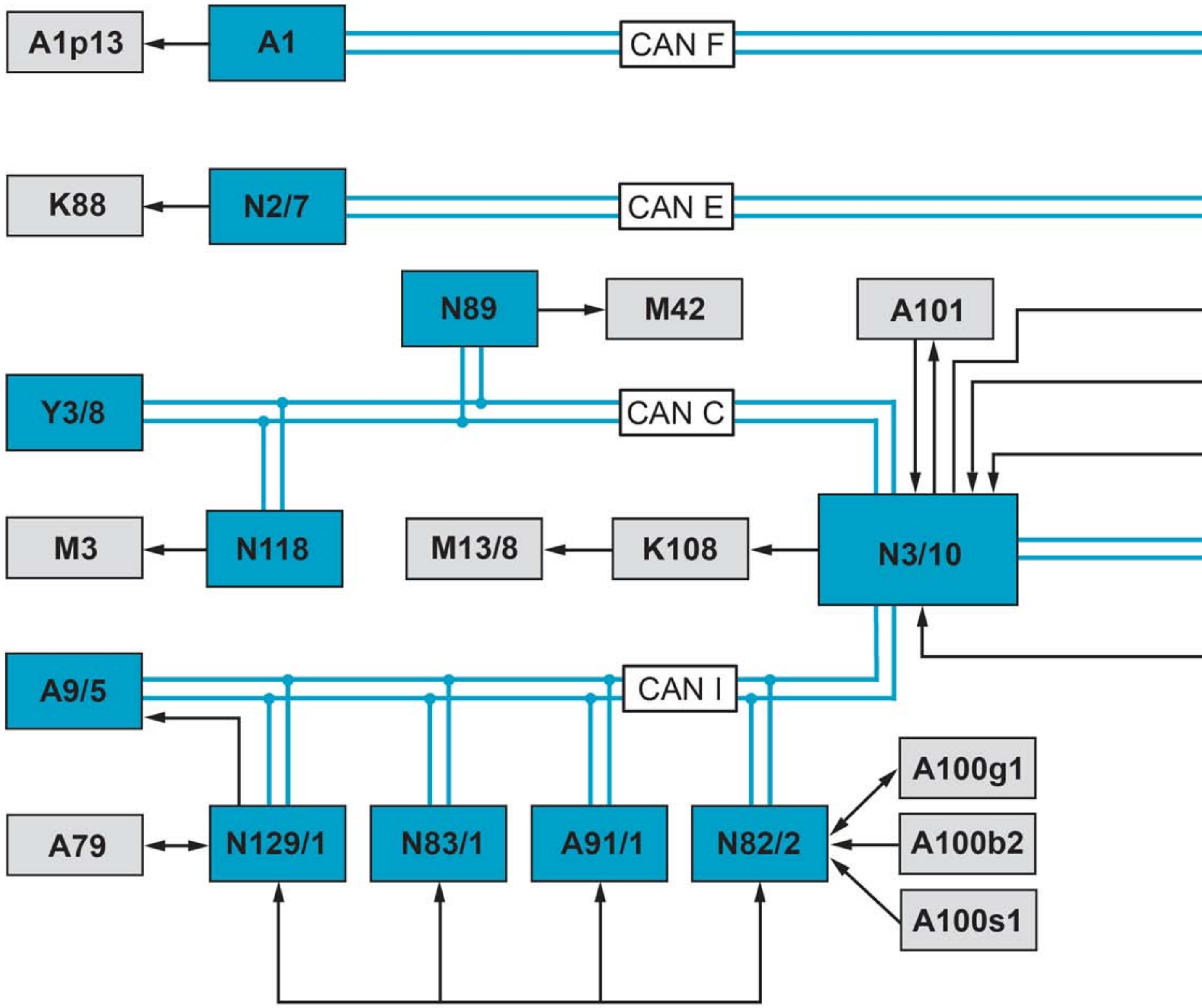
	Unit	S 400 HYBRID
Combustion engine		
Rated output at engine speed	kW (hp) rpm	205 (279) 6,000
Rated torque at engine speed	Nm rpm	350 2,400 – 5,000
No. of cylinders	–	6
Displacement	cm^3	3,498
Max. rpm	rpm	6,500
Compression ratio	–	10.7:1
Valves per cylinder	–	4
Mixture formation	–	Microprocessor-controlled gasoline injection with hot film mass air flow sensor
Power transmission		
Drive	–	Rear wheel drive
Automatic transmission	–	7G-Tronic
Electric motor		
Type		Permanently energized synchronous motor
Rated output	kW (hp)	15 (20)
Rated torque at engine speed	Nm rpm	160 1,000
Max. starting torque	Nm	215
Rated voltage	Volts	126

	Unit	S 400 HYBRID
High-voltage battery		
Type		Lithium-ion battery
Rated voltage	V	126 (35 cells x 3.6 V)
Capacity	Ah	7
Weight	kg	approx. 28
Combustion engine and hybrid module combined		
Rated output at engine speed	kW (hp) rpm	220 (299) 6,000
Rated torque at engine speed	Nm rpm	385 2,400 – 4,000
Performance		
Maximum speed	km / h	250
Acceleration from 0 to 100 km / h	s	7.2
Fuel consumption[1]	l / 100 km	7.9
CO_2 emissions[1]	g / km	186
Weight penalty of hybrid components		
Electric motor	kg	20
High-voltage battery	kg	28
Power electronics[2]	kg	8
DC / DC converter[2]	kg	3.2

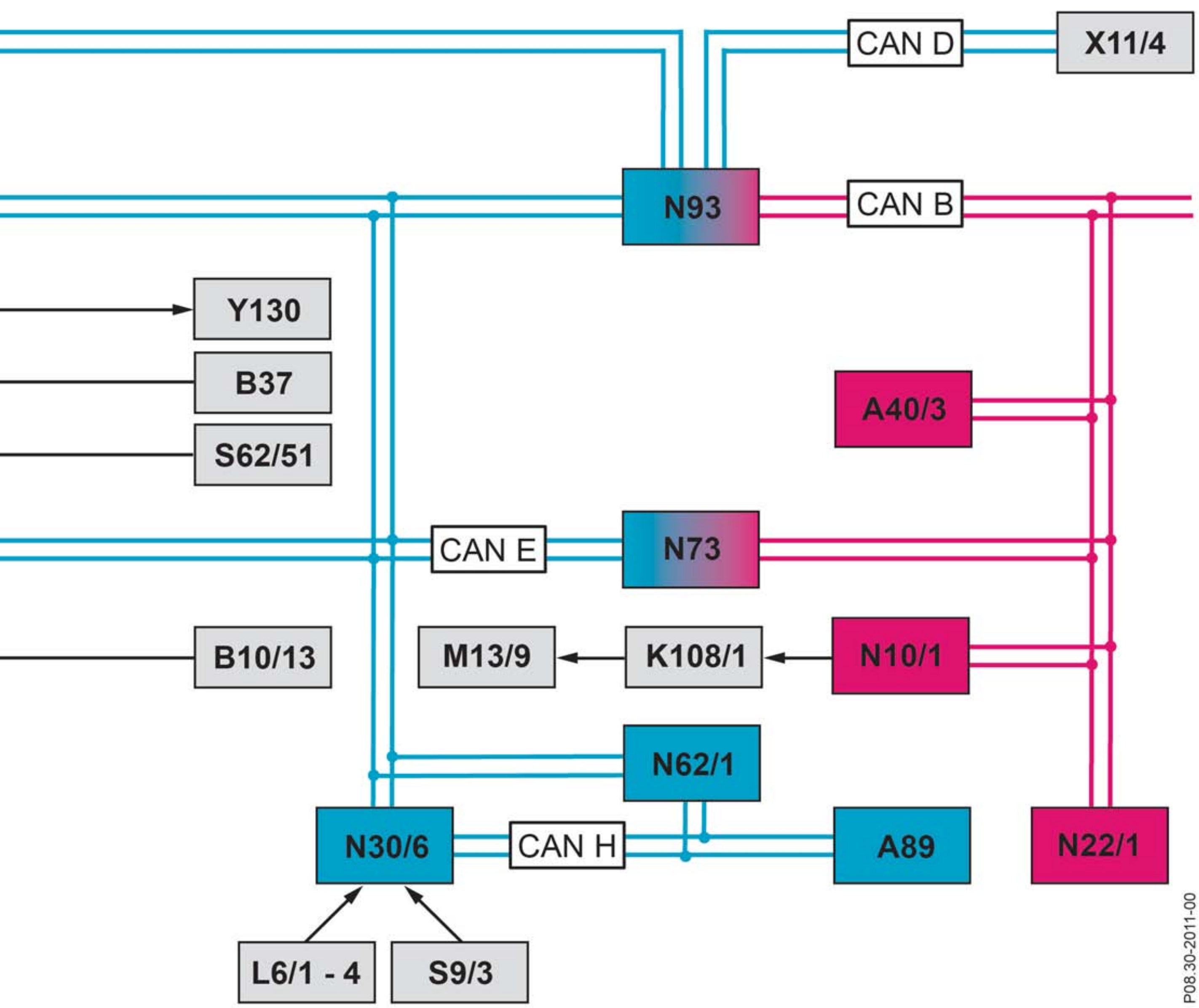
[1] As per NEDC cycle

[2] Without wiring harness

Technical data



A1	*Instrument cluster*	*CAN B*	*Interior CAN*
A1p13	*Multifunction display*	*CAN C*	*Drivetrain CAN*
A9/5	*Electric refrigerant compressor*	*CAN D*	*Diagnostic CAN*
A40/3	*COMAND controller unit*	*CAN E*	*Chassis CAN*
A79	*Electric motor*	*CAN F*	*Central CAN*
A89	*DTR controller unit (with DISTRONIC PLUS or adaptive cruise control)*	*CAN H*	*Vehicle dynamics CAN*
		CAN I	*Drivetrain sensor CAN*
A91/1	*Electrohydraulic power steering*	*K88*	*Pyrotechnical separator*
A100b2	*High-voltage battery cell temperature sensors*	*K108*	*Circulation pump relay 1 (power electronics)*
A100g1	*High-voltage battery*	*K108/1*	*Circulation pump relay 2 (power electronics)*
A100s1	*Protection switch*	*L6/1*	*Left front rpm sensor*
A101	*Tank leak diagnostic module*	*L6/2*	*Right front rpm sensor*
B10/13	*Low-temperature circuit temperature sensor*	*L6/3*	*Left rear rpm sensor*
B37	*Accelerator pedal sensor*	*L6/4*	*Right rear rpm sensor*

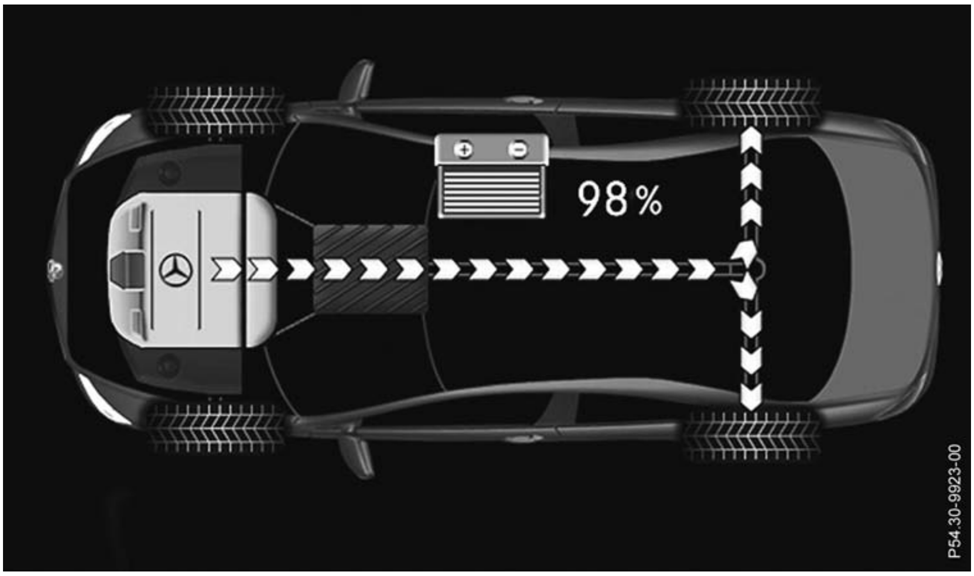


M13 / 8	*Circulation pump 1 (power electronics)*
M3	*Fuel pump*
M13 / 9	*Circulation pump 2 (power electronics)*
M42	*Additional electric transmission oil pump*
N2 / 7	*Restraint systems control unit*
N3 / 10	*ME-SFI [ME] control unit*
N10 / 1	*Front SAM control unit with fuse and relay module*
N22 / 1	*AAC [KLA] control unit*
N30 / 6	*Regenerative braking system (RBS) control unit*
N62 / 1	*Radar sensors control unit (SGR) (with DISTRONIC PLUS or adaptive cruise control)*
N73	*EZS control unit*
N82 / 2	*Battery management system control unit (BMS)*
N83 / 1	*DC / DC converter control unit*
N89	*Additional transmission oil pump control unit*
N93	*Central gateway control unit*
N118	*Fuel pump control unit*
N129 / 1	*Power electronics control unit*
S9 / 3	*Hybrid brake light switch*
S62 / 51	*Hybrid engine hood contact switch*
X11 / 4	*Data link connector*
Y3 / 8	*Electric controller unit (VGS)*
Y130	*Engine oil pump valve*

Display concept

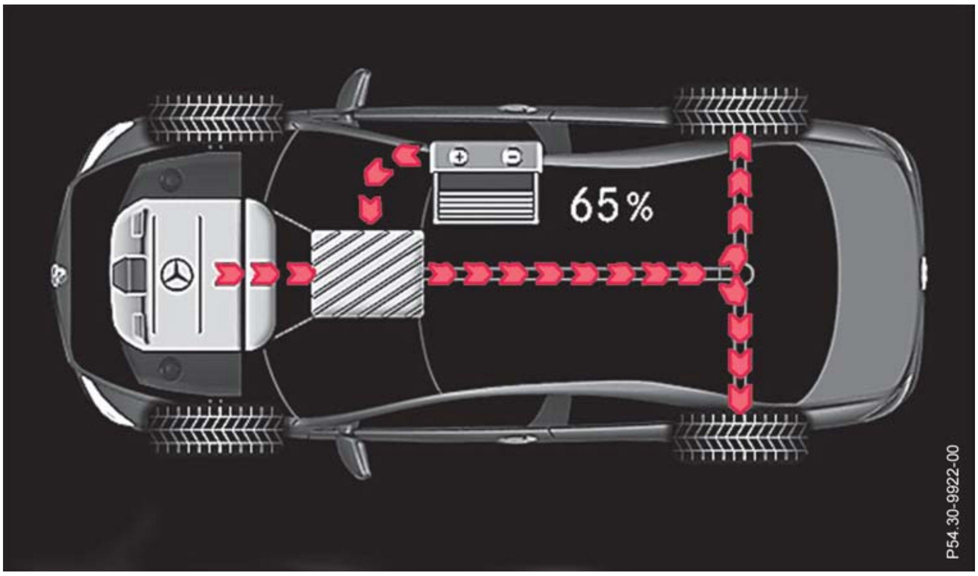
The current power flows of the various driving modes of the hybrid drive can be displayed on the display unit of the COMAND system.

In **driving mode**, power flows only from the combustion engine to the rear axle.



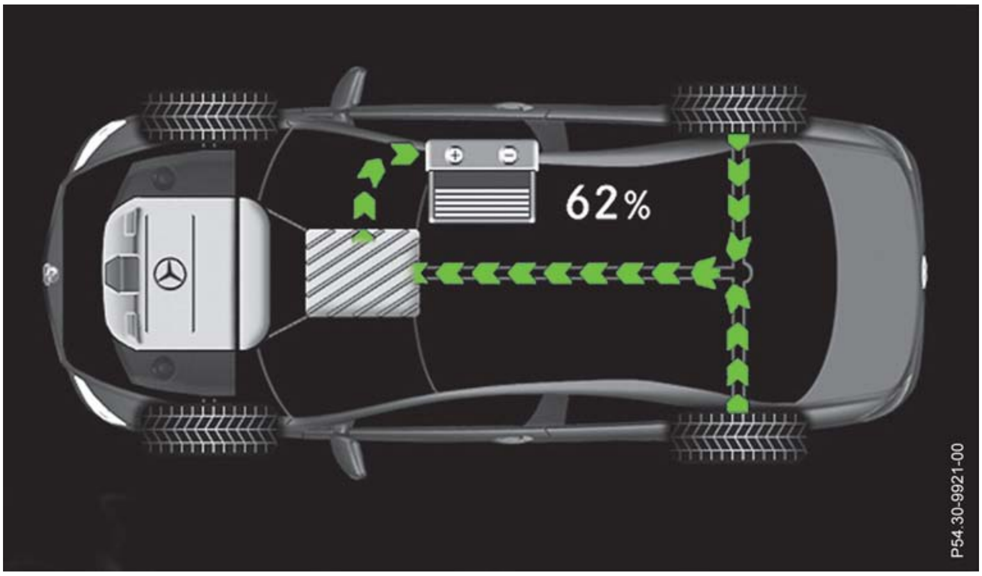
Driving mode

In **acceleration mode**, power flows from the combustion engine and from the electric motor to the rear axle. The high-voltage battery supplies power to the electric motor, which then generates drive torque to support the torque produced by the combustion engine.



Acceleration mode

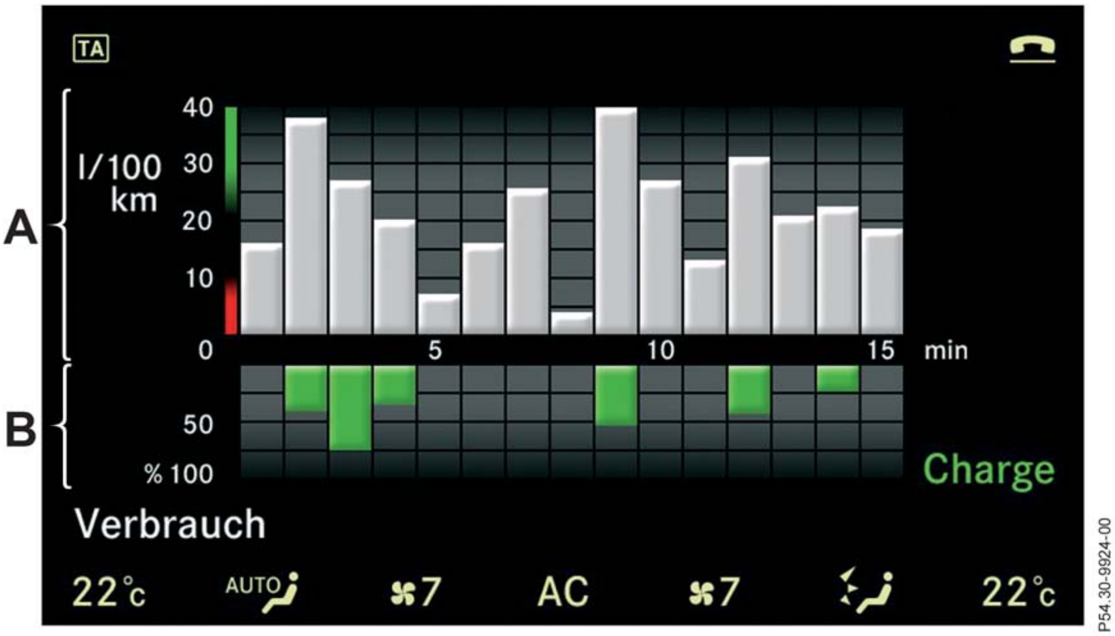
In **alternator mode**, power flows from the rear axle to the electric motor. The kinetic energy of the vehicle is converted into electrical energy by the electric motor. The electric motor acts as a high-voltage alternator and charges the high-voltage battery.



Alternator mode

Display concept

A consumption bar chart shows the fuel consumption and the electrical energy generated.



Display of fuel consumption and energy balance

A Fuel consumption over last 15 min
B Display of energy recovered by high-voltage battery in last 15 min

Instrument cluster displays

The energy flows during the various operating modes and the current charge level of the high-voltage battery can also be displayed on the instrument cluster.

The message "READY" is output as soon as the hybrid drive system is operational.

When the ECO start-stop function is available, the green READY indicator lights up

When the ECO start-stop function is temporarily unavailable, the yellow READY indicator lights up

Charge indicator

The charge level of the high-voltage battery shown on the instrument cluster and COMAND system is an adjusted figure which only represents the battery capacity which is actually available.

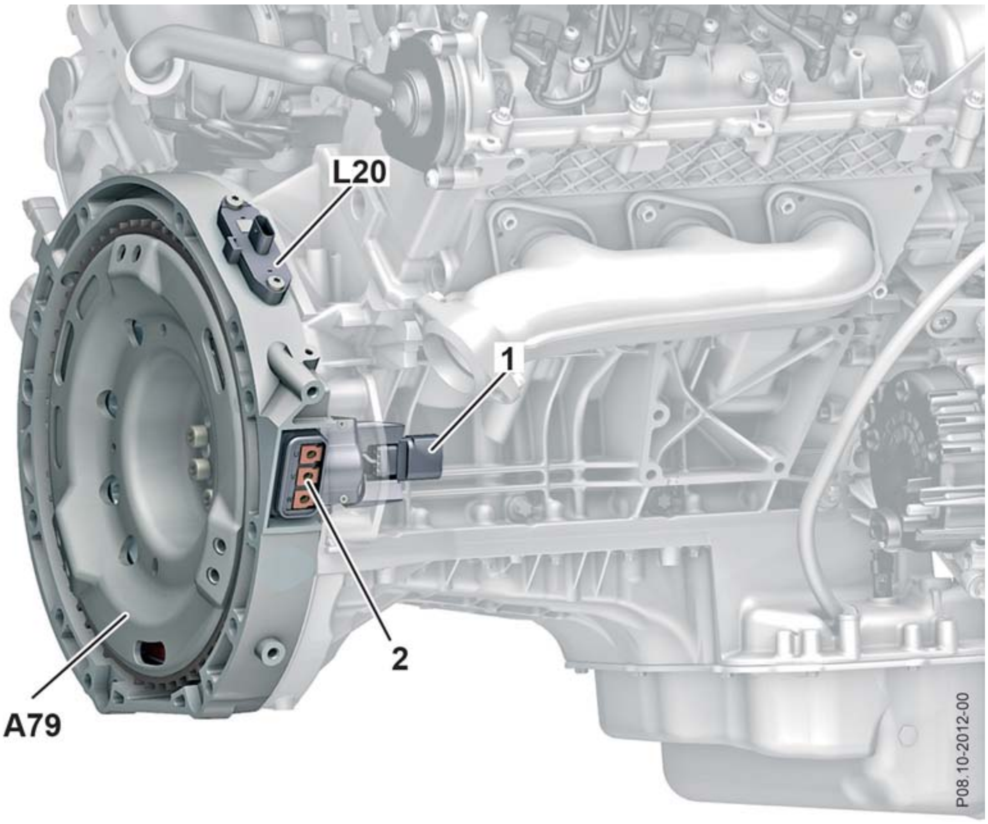
The actual charge level of the high-voltage battery in terms of the SOC (State of Charge) can be read out via the Diagnosis Assistance System (DAS).

Engine

Engine 272.974 has been modified and optimized for the hybrid drive. The output has been increased by 5 kW through the use of new cylinder heads, modified camshafts with a different camshaft control system and different pistons.

The use of the Atkinson principle increases the thermal efficiency and lowers specific fuel consumption. This improves consumption under partial-load conditions.

The rotor of the electric motor is connected directly to the crankshaft and positioned between the engine and automatic transmission.



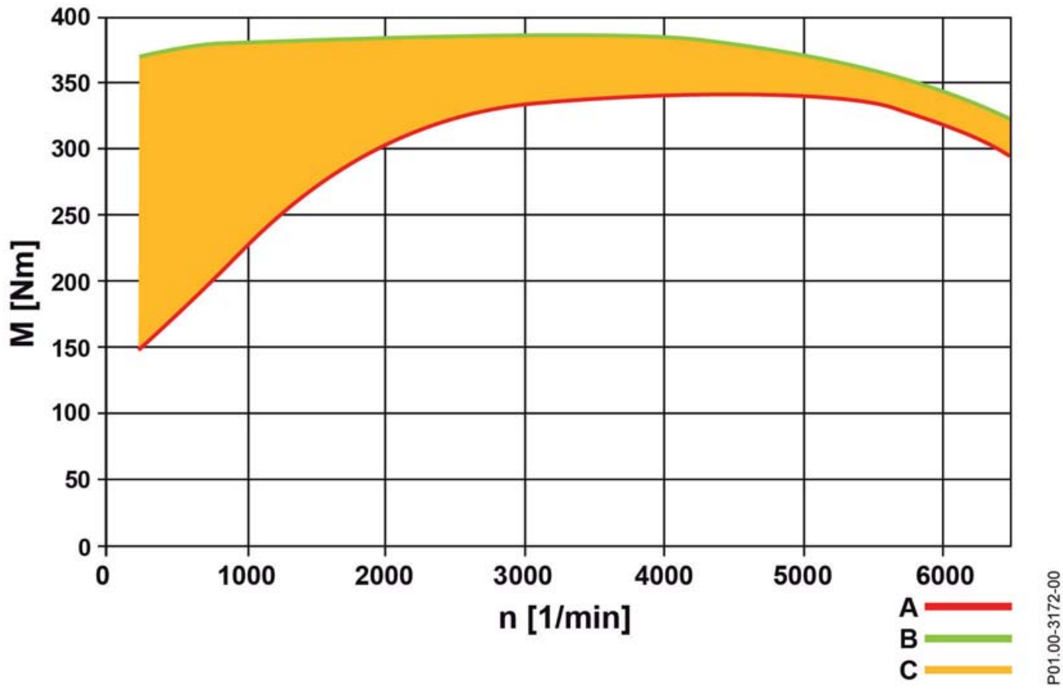
View of engine from right rear

1 Electrical plug connection
2 UVW screw connection

A79 Electric motor
L20 Rotor position sensor

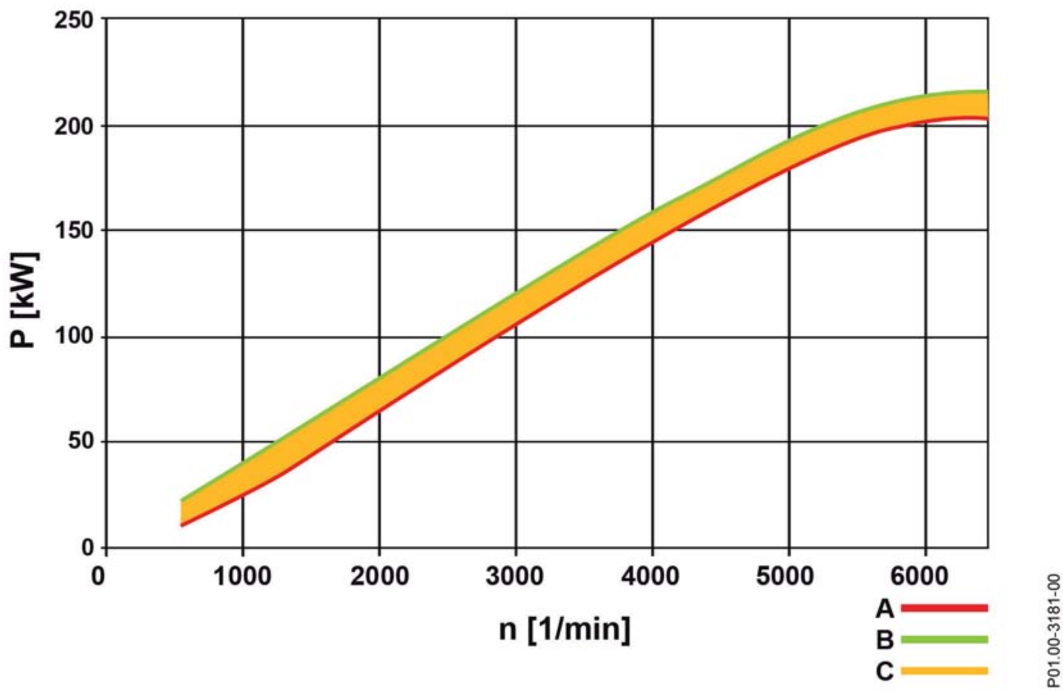
Note

The Atkinson principle optimizes the valve timing by briefly opening the intake valves between the intake and compression phase. This makes the expansion phase longer than the compression phase.



Torque diagram

A Combustion engine torque
B Maximum combined torque
(electric motor and combustion engine)
C Maximum boost torque



Performance graph

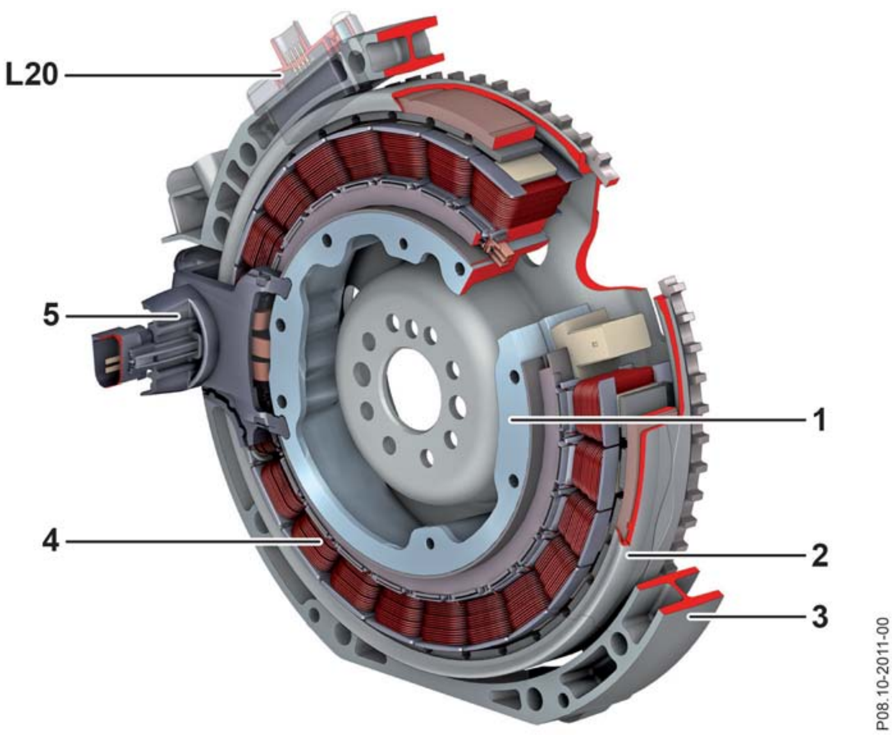
A Combustion engine output
B Maximum combined output
(electric motor and combustion engine)
C Maximum boost output

Electric motor

The disk-shaped electric motor is a permanently energized synchronous motor which is installed between the combustion engine and automatic transmission. It performs the function of a starter and high-voltage alternator. This design is also referred to as an integrated starter-alternator.

The electric motor acts as a damping element to reduce drive / torsional vibrations. Depending on the operating mode, the electric motor can apply torque in the direction of rotation of the crankshaft in order to start the combustion engine (**drive mode**) or apply torque in the opposite direction to the rotation of the crankshaft in order to charge the high-voltage battery (**alternator mode**). During start-off, the electric motor supports the combustion engine (boost mode) and, during brake application, part of the braking energy is converted into electrical energy (regenerative braking).

Switching between the individual operating modes (motor mode / alternator mode) is controlled by the power electronics control unit. The power electronics are connected to the three power connections of the electric motor by three busbars. The three-phase currents are regulated depending on the operating mode and rotor position. These phase currents generate a magnetic field which, together with the field of the rotor, generates torque to produce rotational movement.



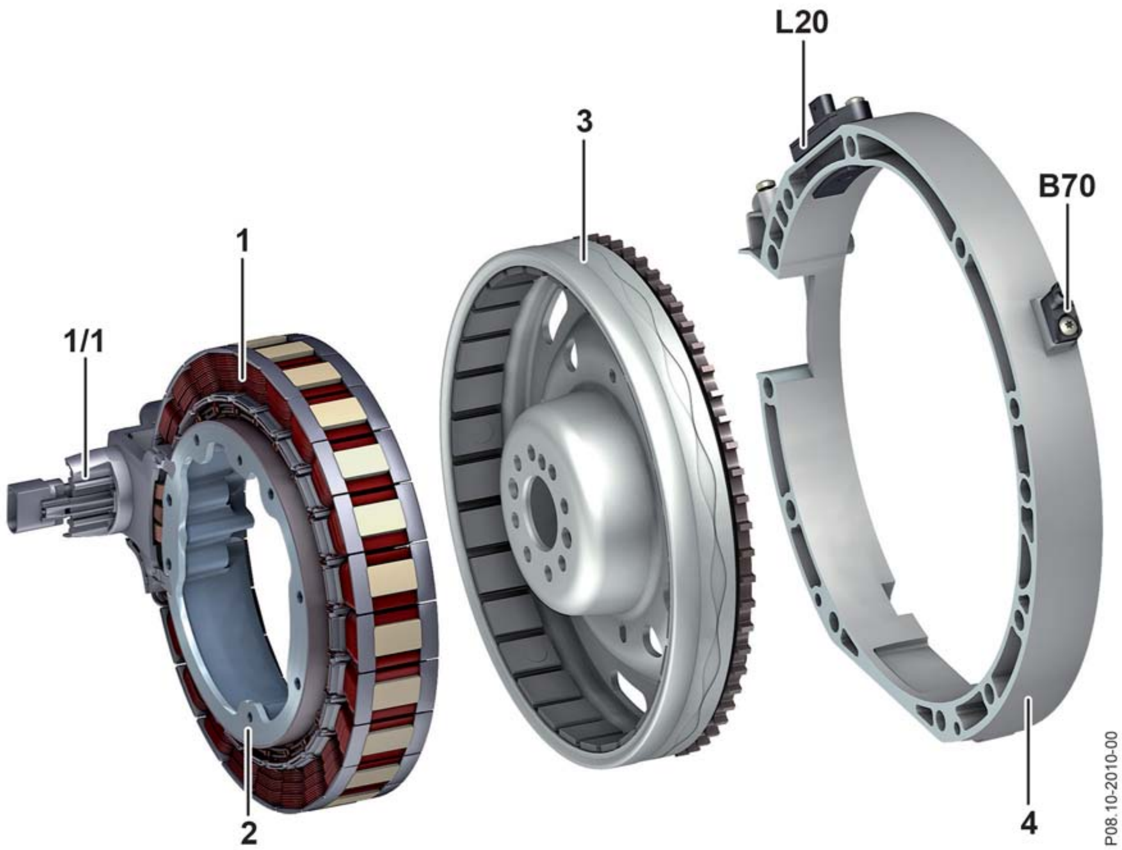
Sectional view

1 Stator carrier
2 Rotor with increment ring and position sensor track
3 Intermediate housing
4 Stator with coils
5 Electric screw connection and temperature sensor coupling

L20 Rotor position sensor

Information about the current rotor position is required in order to regulate the electric motor. For this purpose, the rotor position sensor supplies an amplitude signal even when the electric motor is stationary and forwards this to the power electronics control unit so that angle can be calculated and the rotational speed derived from this.

A temperature sensor integrated in the stator winding records the temperature of the winding and transmits this to the power electronics control unit as a voltage signal. If a certain temperature threshold is exceeded, appropriate power limitation functions are activated in the power electronics in order to protect the electric motor from overheating.



Exploded view

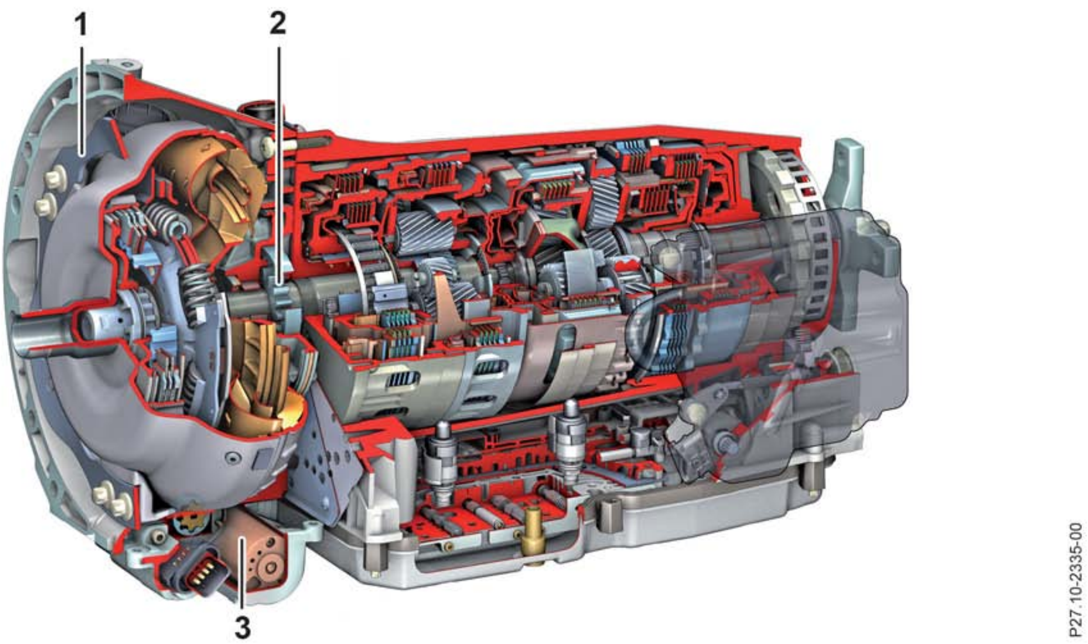
1	*Stator with coils*	*3*	*Rotor with increment ring and position sensor track*
1 / 1	*Electric screw connection and temperature sensor coupling*	*4*	*Intermediate housing*
2	*Stator carrier*		
		B70	*Crankshaft Hall sensor*
		L20	*Rotor position sensor*

Automatic transmission

The S 400 HYBRID is equipped with a 7-speed automatic transmission (7G-TRONIC). The transmission has been modified for the hybrid drive system. Along with new software for transmission control, an additional electric transmission oil pump is also installed.

It is necessary to ensure that oil continues to be supplied to the transmission hydraulics when the engine is off or being restarted as part of the start-stop function in order to prevent any delay between the driver's request to start off and the point when the vehicle actually starts to move.

For this reason, the additional electric transmission oil pump supplies oil for the transmission control system when the internal transmission oil pump is shut off because the combustion engine has also been switched off.



Sectional view of automatic transmission

1 Carrier ring
2 Internal transmission oil pump
3 Additional electric transmission oil pump (M42)

Electric refrigerant compressor

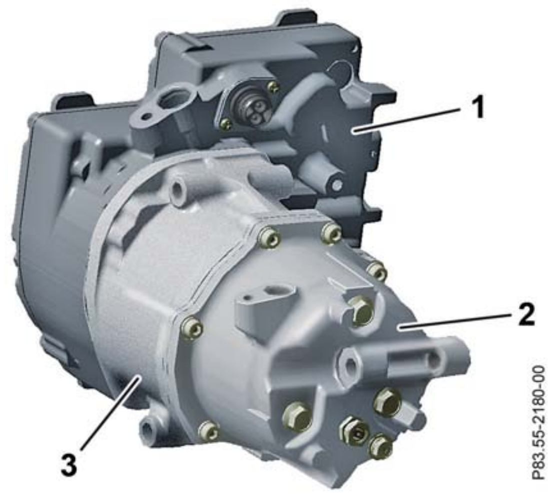
In order to provide adequate cooling output even when the engine has been automatically stopped, the drive system for the refrigerant compressor has to be separated from the combustion engine to provide independent climate control for the vehicle interior and independent cooling for the high-voltage battery. This is achieved by means of an electrically driven refrigerant compressor. This cooling system only operates as required and thus also helps to optimize fuel consumption.

The electric refrigerant compressor draws in and compresses the refrigerant (R134a) and pumps the refrigerant through the system. Depending on the evaporator temperature, the electric refrigerant compressor is steplessly regulated by the AAC [KLA] control unit from 800 to 9,000 rpm.

The electric refrigerant compressor consists of the following three main groups:

- Control unit with integrated power electronics (1)
- Electric motor (2)
- Spiral compressor (3)

The control unit of the electric refrigerant compressor regulates the speed of the electric motor and the quantity of refrigerant. The electric motor drives the spiral compressor. This consists of two spiral coils nested inside each other, whereby the first coil is permanently attached to the housing and the second moves in a circular pattern inside the first. The spiral coils thus touch each other at several points and form a number of chambers of ever decreasing size within the coils. The refrigerant is thus compressed and moves towards the center of these chambers, where it then exits the spiral in compressed form.



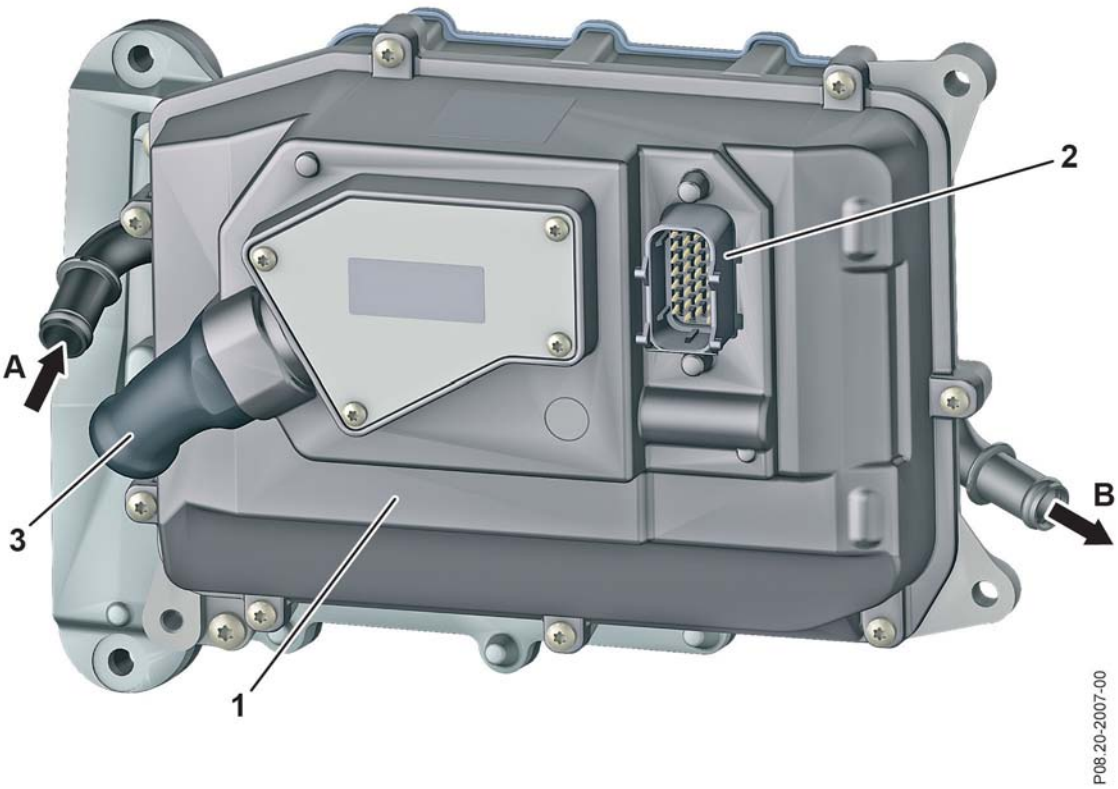
View of refrigerant compressor

1 Control unit
2 Electric motor
3 Spiral compressor

Power electronics module

The power electronics control unit is integrated in the power electronics module. This is positioned on the right underneath the exhaust manifold. It is fitted with a heat shield to protect it against thermal radiation.

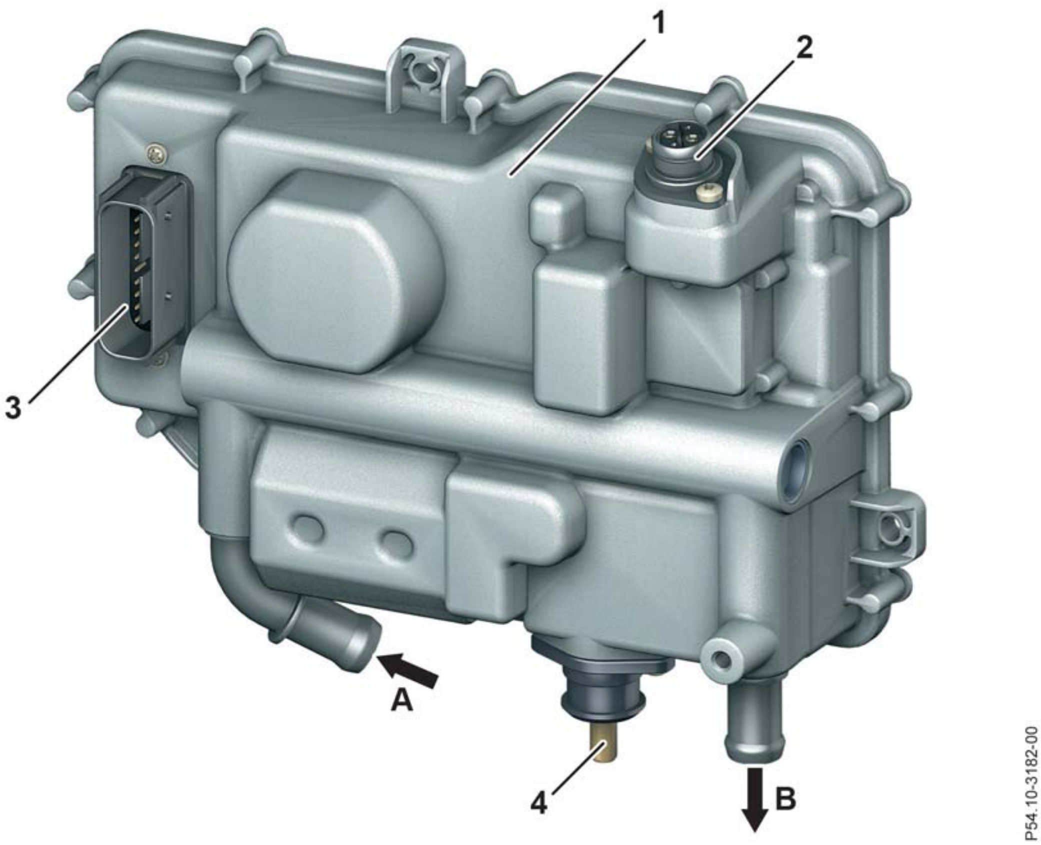
The power electronics control unit supplies the electric motor with three-phase AC voltage upon request. It monitors the temperature of the electric motor as well as performing diagnosis and providing forecasts of the available torque to the ME-SFI [ME] control unit.



Design of power electronics module

1 Power electronics module
2 12 V plug connection for power electronics control unit
3 High-voltage line to high-voltage battery
A Coolant inlet
B Coolant outlet

The DC voltage converter (DC / DC converter) is located in the right front wheel well. It generates a high DC voltage and a 12 V DC voltage and also allows the exchange of energy between the high-voltage on-board electrical system and the 12 V on-board electrical system. High-voltage is converted into 12 V or vice versa.



Design of DC / DC converter module

1 DC / DC converter module
2 High-voltage plug connection (high-voltage battery)
3 12 V plug connection for DC / DC converter control unit
4 Circuit 30 screw connection

A Coolant inlet
B Coolant outlet

Note

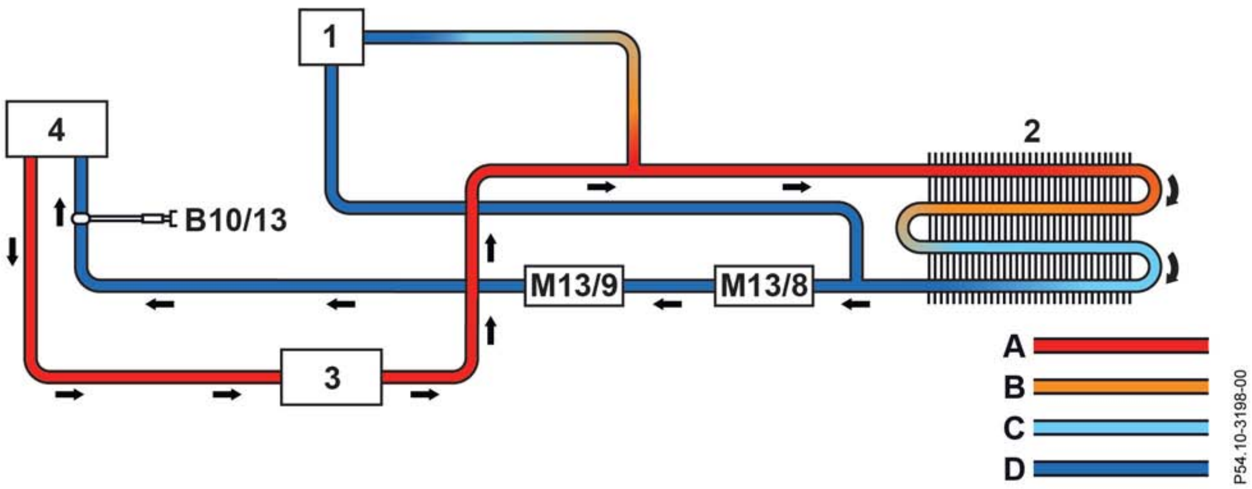
Since battery energy is exchanged between the 12 V on-board electrical system and the high-voltage on-board electrical system, it is possible to jump start the vehicle with a 12 V jumper cable with the ignition switched on. In other words, a separate high-voltage charger is not required to start the vehicle if the battery has been discharged.

Power electronics and DC/DC converter cooling

The power electronics module and the DC / DC converter module have a common low-temperature cooling system which is separate from the cooling system of the combustion engine. This low-temperature cooling system protects the power electronics module and the DC / DC converter module from damage due to overheating. The ME-SFI [ME] control unit records the coolant temperature in the power electronics cooling system by means of the voltage signal from the low-temperature circuit temperature sensor.

Depending on the coolant temperature, the ME-SFI [ME] control unit actuates circulation pump relay 1 and circulation pump 1 is switched on. Circulation pump 2 is switched on via circulation pump relay 2. Circulation pump relay 2 is actuated by circuit 15 when the ignition is switched on.

The coolant flows through the DC / DC converter module and the power electronics module and absorbs thermal energy from these components. The coolant then flows through the low-temperature cooler, where it is cooled by the airstream and flows back to circulation pump 1.



Schematic illustration of power electronics cooling circuit

1 Expansion tank
2 Low-temperature cooler
3 Power electronics module
4 DC / DC converter module

B10 / 13 Low-temperature circuit temperature sensor
M13 / 8 Circulation pump 1
M13 / 9 Circulation pump 2

A Feed to low-temperature cooler, coolant temperature very high
B High coolant temperature
C Medium coolant temperature
D Return from low-temperature cooler, coolant temperature low

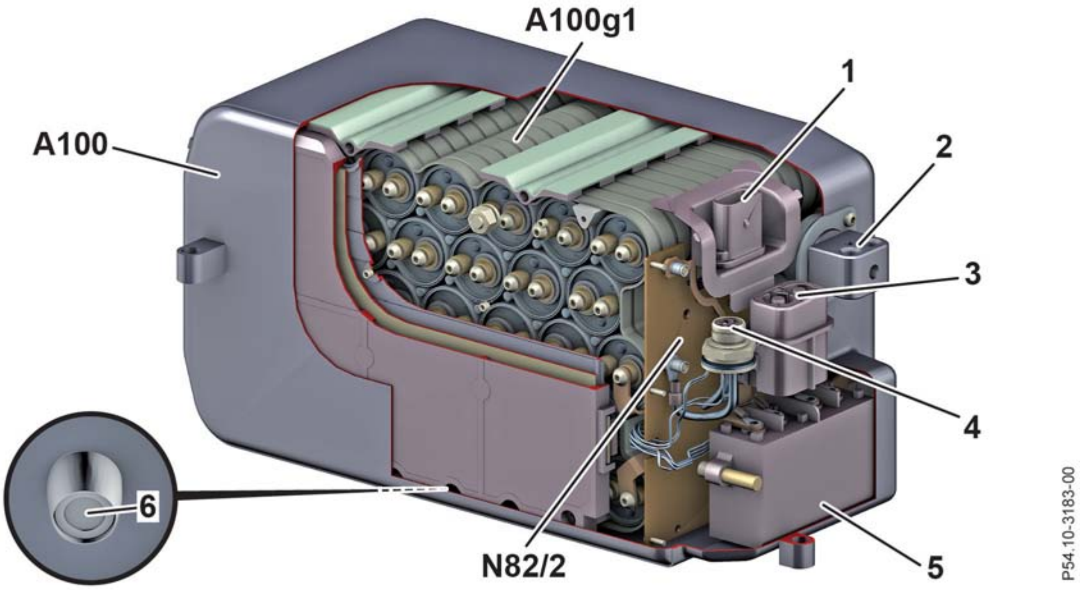
High-voltage battery module

The high-voltage battery module is located at the rear of the engine compartment on the right. It protects the high-voltage battery from external heat and provides physical stability. The high-voltage battery module incorporates the high-voltage battery, the battery management system (BMS) control unit and the protection switch. Refrigerant lines and electrical lines (high-voltage / 12 V) can be connected to the high-voltage battery module. The high-voltage battery is a lithium-ion battery, which stores energy for the electric motor.

The advantages compared to nickel metal hydride batteries are:

- Greater electrical efficiency
- Higher energy density and thus lower weight and more compact dimensions

The high-voltage battery is connected to the 12 V on-board electrical system via the DC / DC converter so that it can provide support to the 12 V on-board electrical system if necessary. The protection switch is actuated by the battery management system (BMS) control unit and internally isolates the high-voltage battery positive and negative terminals from the high-voltage on-board electrical system.



Sectional view of high-voltage battery module

1 12 V plug connection for battery management system control unit
2 Refrigerant line connections
3 High-voltage plug connection (power electronics, electric refrigerant compressor)
4 High-voltage plug connection (DC / DC converter)
5 Protection switch
6 Blow-off fitting with membrane and bursting disk

A100 High-voltage battery module
A100g1 High-voltage battery
N82 / 2 Battery management system (BMS) control unit

High-voltage battery cooling

The operating temperature of the high-voltage battery must be within a certain range in order to ensure that the charging capacity, number of charging cycles and life expectancy of the high-voltage battery are optimized.

The battery management system (BMS) control unit evaluates the data from the high-voltage battery cell temperature sensors in order to determine the current high-voltage battery temperature and, if necessary, requests cooling output via the ME-SFI [ME] control unit. The battery management system (BMS) control unit sends the request for cooling to the ME-SFI [ME] control unit via the drive train sensor CAN. This compares the request against the targets of the energy management system and allows actuation of the electric refrigerant compressor.

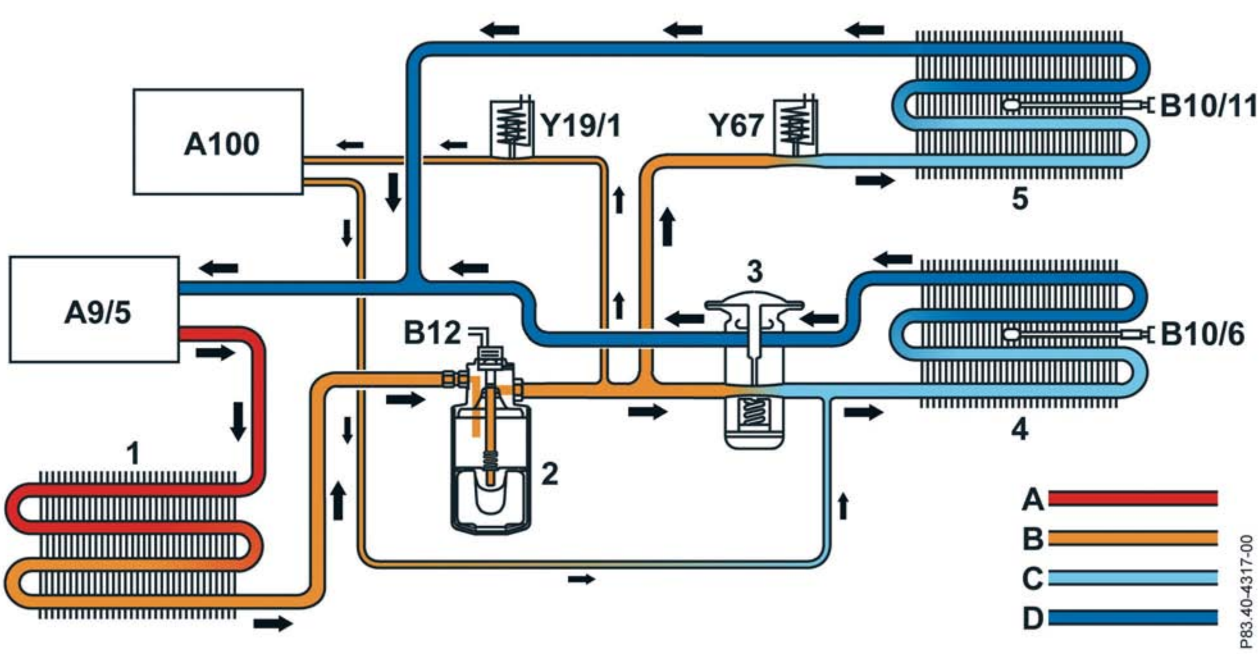
Electric refrigerant compressor actuation is allowed depending on the charge level of the high-voltage battery and the maximum tolerable discharge voltages / currents. Actuation is first allowed after the vehicle is started with the key and this permission is withdrawn when circuit 15 is switched off.

If the energy management system allows actuation, this information is transmitted by the ME-SFI [ME] control unit to the central gateway control unit via the chassis CAN together with the request for cooling output. This approval is forwarded to the AAC [KLA] control unit on the interior CAN, which actuates the electric refrigerant compressor via the CAN network.

The air conditioning shutoff valve is opened and the refrigerant flows through the evaporator integrated in the high-voltage battery module. Thermal energy is extracted from the high-voltage battery and battery management system (BMS) control unit.

The cooling output is largely dependent on the actuation level of the electric refrigerant compressor. When the engine is idling or has been stopped automatically, the output of the electric refrigerant compressor is limited to a maximum of 2 kW.

The output of the electric refrigerant compressor can also be temporarily (< 10 s) reduced right down to 0 kW if rapid acceleration is required.



Schematic illustration of high-voltage battery cooling

1	*Condenser*
2	*Fluid reservoir*
3	*Expansion valve*
4	*Evaporator*
5	*Rear air conditioning evaporator (with rear air conditioning)*
A9/5	*Electric refrigerant compressor*
A100	*High-voltage battery module*
B10/6	*Evaporator temperature sensor*
B10/11	*Evaporator temperature sensor, rear air conditioning (with rear air conditioning)*
B12	*Refrigerant pressure sensor*
Y19/1	*High-voltage battery cooling shutoff valve*
Y67	*Rear air conditioning refrigerant shutoff valve (with rear air conditioning)*
A	*High pressure, gaseous*
B	*High pressure, liquid*
C	*Low pressure, liquid*
D	*Low pressure, gaseous*

Brake pedal assembly

The tasks of the brake pedal assembly are:

- Register driver braking requests
- Simulate pedal feel (pedal force simulator)
- Perform conventional hydraulic wheel braking at the fallback level

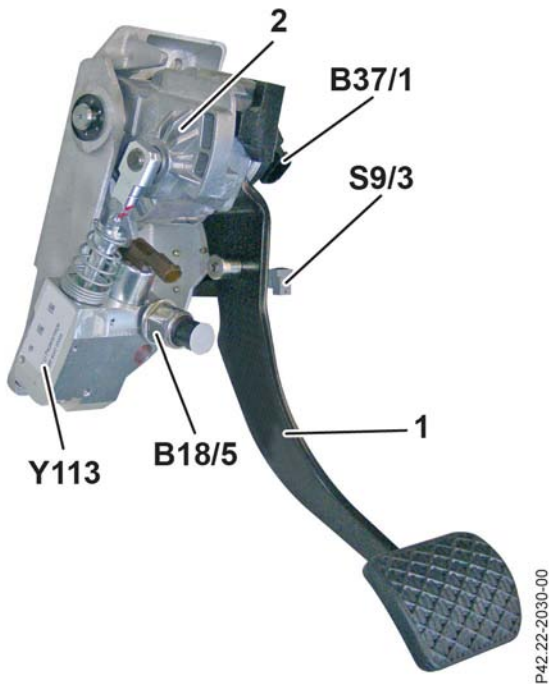
The pedal angle sensor registers driver braking requests and forwards the signal to the regenerative braking system (RBS) control unit. Using Hall sensors, the pedal angle sensor measures the angular position of the brake pedal and transmits the signal to the regenerative braking system (RBS) control unit.

During normal operation, pedal resistance is generated by the pedal force simulator.

Due to the operating principles involved, brake pedal feel may be perceived differently on a regenerative braking system compared to a conventional braking system.

In the event of a fault, the pedal force simulator is deactivated (fallback level) and the simulated pedal resistance is no longer present. The driver then generates the required brake pressure by the force of his / her foot as on a conventional braking system. This means that the pedal travel is slightly longer than during normal operation.

During the first brake actuation, the system is checked for proper operation and the regenerative braking system is activated. The simulator force is initially switched off, resulting in a slightly longer pedal travel than for the subsequent actuations when the system is active.



Design of brake pedal assembly

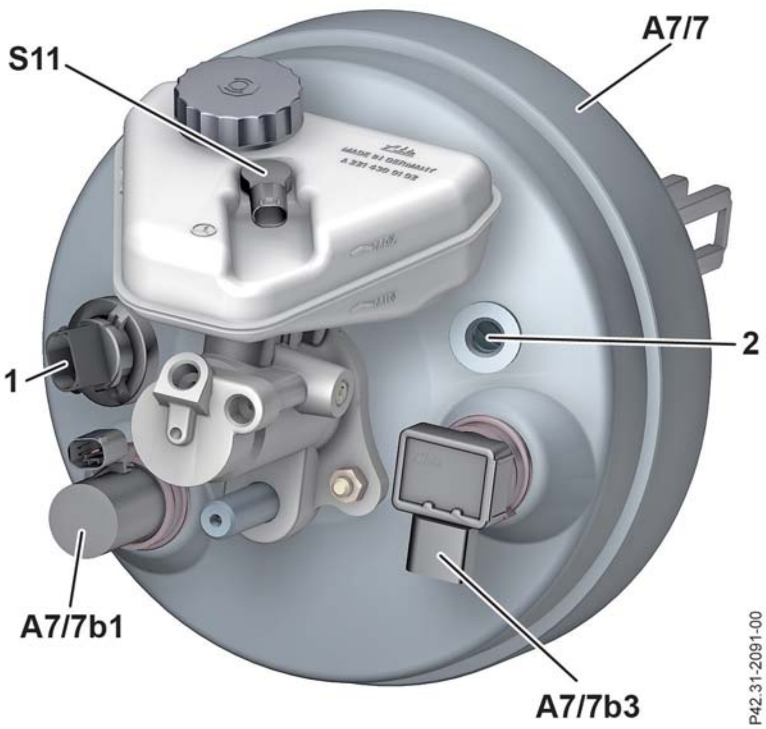
1	*Brake pedal*
2	*Pedal force simulator*
B18 / 5	*Pedal force simulator valve pressure sensor*
B37 / 1	*Pedal angle sensor*
S9 / 3	*Hybrid brake light switch*
Y113	*Pedal force simulator valve*

RBS brake booster

Vacuum is supplied to the RBS brake booster both by the combustion engine and by an electrically driven vacuum pump.

The RBS solenoid valve in the RBS brake booster serves as an actuator to implement the driver braking request. It is actuated electronically by the regenerative braking system (RBS) control unit.

The RBS brake booster contains an RBS vacuum sensor which measures the vacuum in the vacuum chamber of the RBS brake booster. The RBS brake booster still also features an RBS diaphragm travel sensor. The RBS diaphragm travel sensor records the position of the diaphragm plate of the RBS brake booster.



Design of RBS brake booster

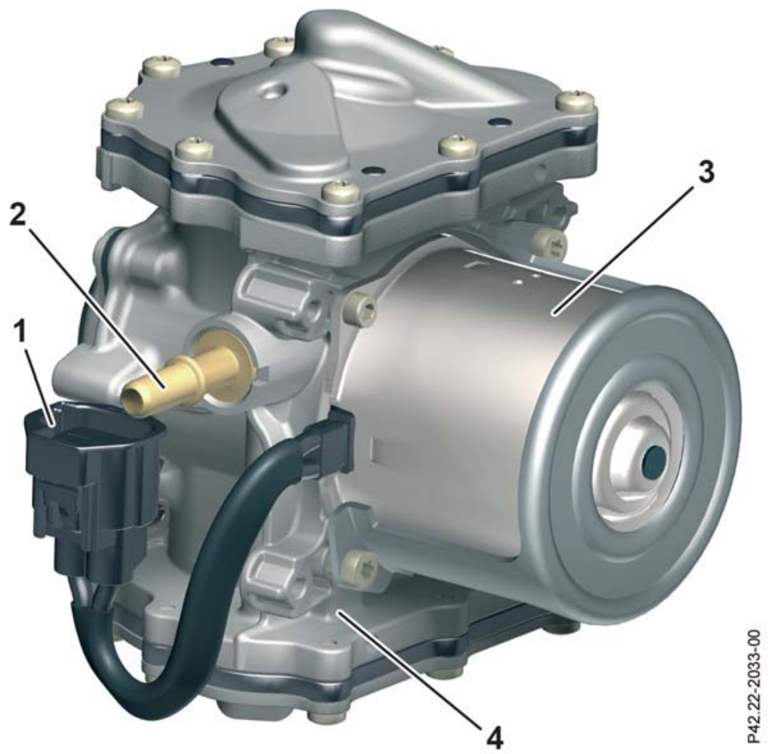
1 RBS solenoid valve electrical connection
2 Vacuum line connection

A7/7 RBS brake booster
A7/7b1 RBS diaphragm travel sensor
A7/7b3 RBS vacuum sensor
S11 Brake fluid indicator switch

Electric vacuum pump

The electric vacuum pump is actuated by the regenerative braking system (RBS) control unit. The tasks of the vacuum pump are:

- Ensure adequate vacuum in the RBS brake booster
- Maintain vacuum supply during start-stop operation



View of electric vacuum pump

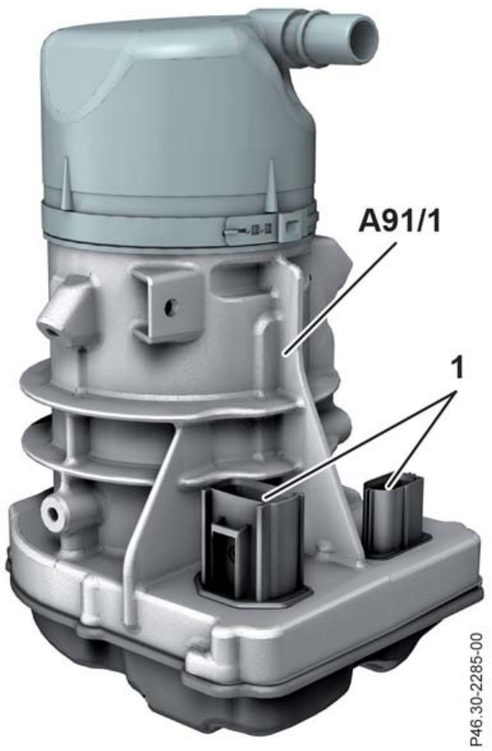
1 Electrical plug connection
2 Vacuum outlet connection
3 Electric motor
4 Pump unit

Electrohydraulic power steering

In order to ensure adequate servo assistance for the steering after an automatic engine stop, the steering assistance system has to be separated from the combustion engine so that independent steering assistance is available. This is achieved hydraulically by means of the electrically driven power steering pump of the electrohydraulic power steering system. This steering assistance system only operates as required and thus also helps to optimize fuel consumption. The output is regulated according to need via the CAN using the signals for vehicle speed, steering angle rate of change and steering angle. This steering assistance regulation takes place inside the rack and pinion steering gear itself.

The steering wheel's rotary motion is converted into horizontal movement through the rack-and-pinion steering gear. The steering gear has a variable gear ratio. The gear ratio increases continuously from the center and reaches its maximum value at a steering wheel angle of 90°.

The manual effort required to turn the steering wheel is increased from vehicle standstill up to a speed of 100 km / h in accordance with a given characteristic. The hydraulic reaction assembly is adapted to the respective requirements via a solenoid valve. Electronic control is performed by the regenerative braking system (RBS) control unit.



View of electrohydraulic power steering

1	*Electrical plug connection*
A91 / 1	*Electrohydraulic power steering*

Overview

The combustion engine must be started in order to drive the vehicle, because this represents the main drive system. During acceleration, the electric motor provides torque to support the combustion engine. This increases the driving power and lowers fuel consumption. In deceleration mode and during braking, the electric motor is used to convert kinetic energy into electrical energy (regeneration). The combustion engine is generally in the deceleration fuel shut off phase at this time.

If no energy is required to drive the vehicle and the vehicle is stationary, the combustion engine can be shut off (start-stop function). The vehicle cannot be driven solely by the electric motor.

The diagram provides an example of the interaction between combustion engine and electric motor:

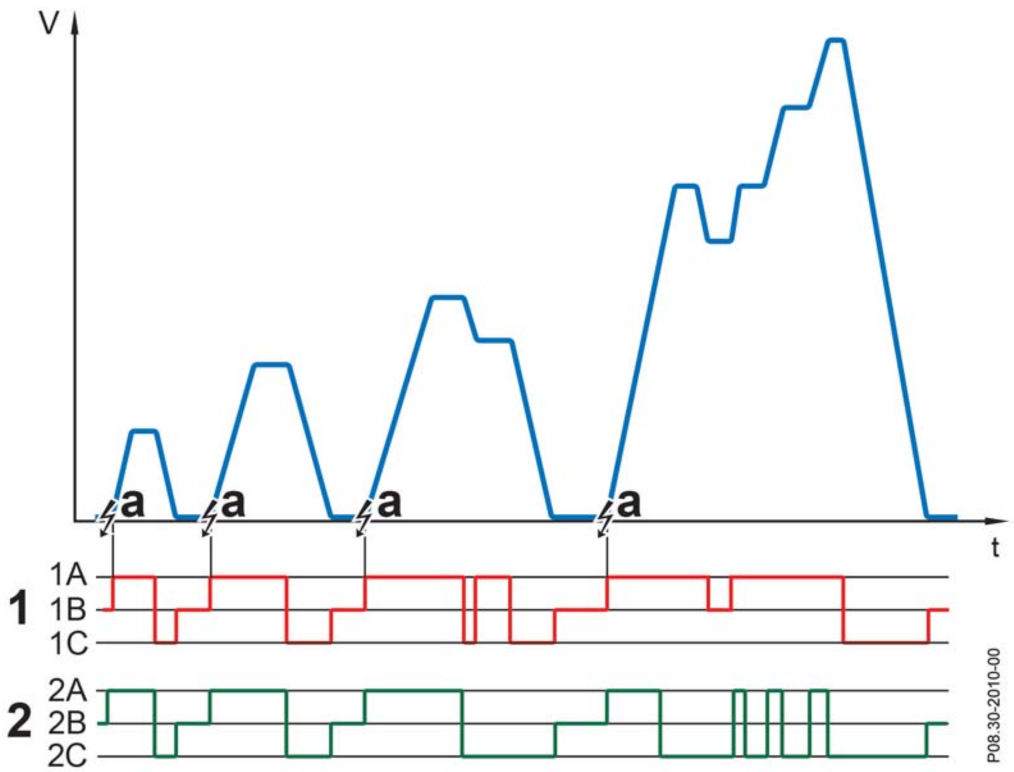


Diagram of operating strategy

1 Operating mode of combustion engine
1A Combustion engine running
1B Combustion engine OFF
1C Deceleration fuel shutoff
2 Operating mode of electric motor
2A Hybrid drive operation (alternator operation or boost mode or load point offset)
2B Standby
2C Regeneration mode
a Start of combustion engine
t Time
v Vehicle speed

Overview

The control system for the hybrid drive system is integrated in the ME-SFI [ME] control unit. The hybrid drive system consists of the 272 Hybrid engine, an electric motor with power electronics control unit and a high-voltage system with battery management system (BMS) control unit and DC / DC converter control unit.

Note

The hybrid / engine control system in the ME-SFI [ME] control unit consists of version "ME 17.7". The code "ME 17.7" means:

M = Motronic

E = Electronic accelerator

17.7 = Version 17.7 (Hybrid)

Driving mode

The vehicle can be driven either by the combustion engine (in the event of failure of hybrid system) or in hybrid mode. In hybrid mode, the torque of the electric motor is combined with (provides support to) the torque of the combustion engine depending on the requirements on and charge level of the high-voltage battery. Support is provided during acceleration (boosting). In addition, the combustion engine can operate the electric motor as a high-voltage alternator.

Drive by combustion engine

Standard driving mode is when the vehicle is driven by the combustion engine. The vehicle operates in standard driving mode if the specified torque can be provided by the combustion engine and hybrid mode is not possible due to faults detected in the hybrid drive system.

Starting off

When starting off, the torque request of the driver is read in by the ME-SFI [ME] control unit. If a boost is requested based on the accelerator pedal position, the ME-SFI [ME] control unit calculates the required starting torque and distributes it between the combustion engine and electric motor. The additional torque from the electric motor is requested by the ME-SFI [ME] control unit via the power electronics control unit. The electric motor is supplied with power from the high-voltage battery via the power electronics control unit. If the vehicle starts off following an automatic engine stop, the combustion engine is started (automatic engine start).

Boosting

In boost mode, the electric motor supports the combustion engine so that the specified torque is reached as quickly as possible. The duration and intensity of the boost support provided depend on the charge level of the high-voltage battery and the position of the accelerator pedal.

A distinction is made between coordinated and uncoordinated boosting. Uncoordinated boosting means that the specified torque requested from the combustion engine and electric motor is too high and cannot be supplied. In order to meet the driver's request for torque, the ME-SFI [ME] control unit requests the maximum available torque from the electric motor via the power electronics control unit. The power electronics control unit then actuates the electric motor accordingly based on the signals for "tolerable discharge voltage" and "tolerable discharge current" (supplied by the battery management system (BMS) control unit). If the specified torque is not reached by the combustion engine in combination with the electric motor, the uncoordinated boosting changes over to coordinated boosting. The electric motor thus operates together with the combustion engine as a drive unit.

Load point offset

With a SOC (**S**tate **o**f **C**harge = charge level) greater than 55%, the charge level of the high-voltage battery is reduced by means of "load point offset". Initially, an electric motor torque of 0 Nm is requested so that the electrical energy is consumed directly via the DC / DC converter or electric refrigerant compressor.

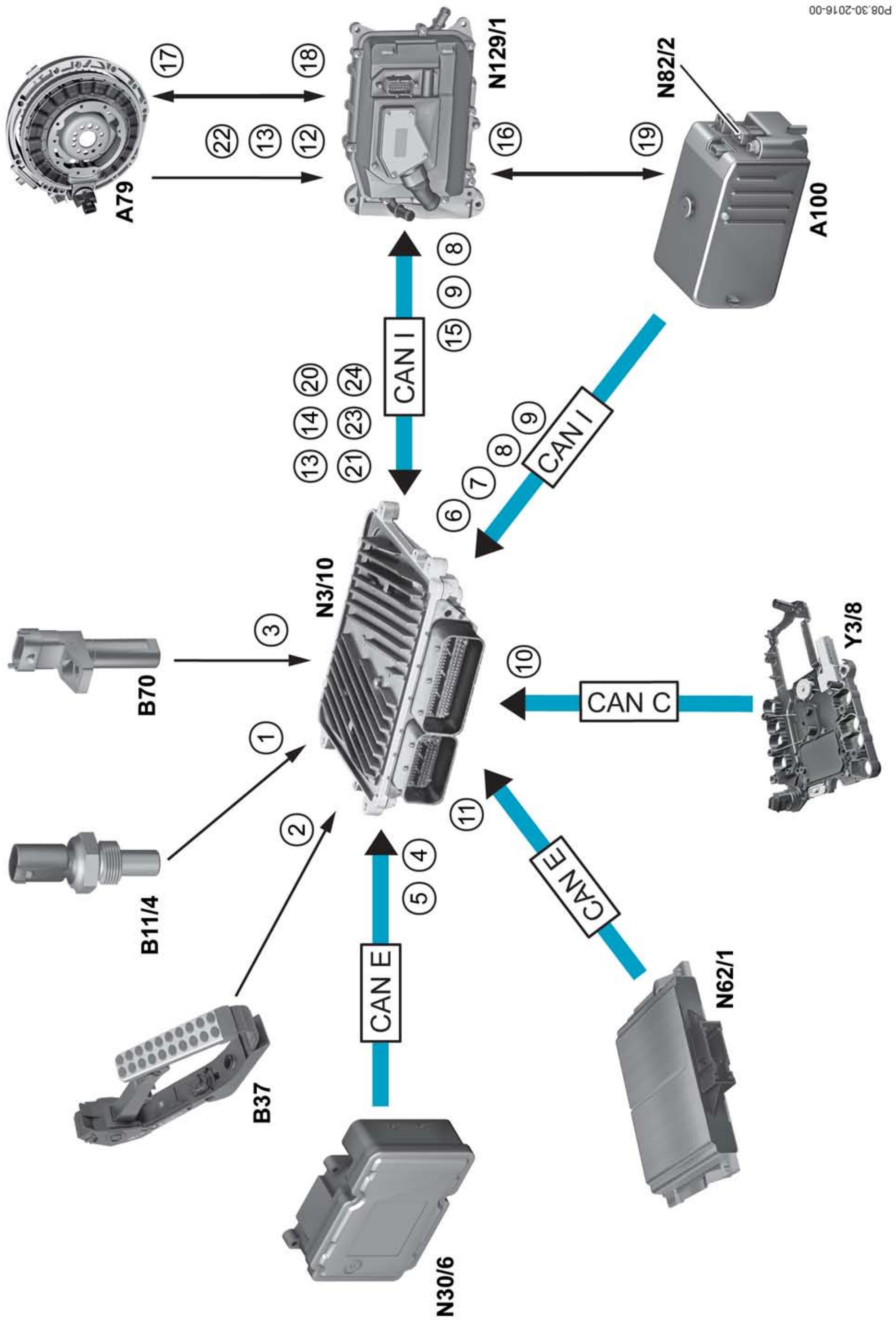
If the SOC continues to increase, positive torque from the electric motor is supplied to support the drive system. This support is provided in such a manner as to keep the efficiency of the combustion engine as high as possible. Accordingly, the load point of the combustion engine is offset. This means that the torque supplied by the combustion engine is reduced via the ME-SFI [ME] control unit in order to keep the engine speed constant. The aim is to offset the load point within the load point range where the efficiency level is still high wherever possible.

Alternator mode

In alternator mode, the electric motor is used as a high-voltage alternator to generate electrical energy, powered by the combustion engine or drivetrain. The three-phase AC voltage which is thus generated is converted into DC voltage by the power electronics in order to charge the high-voltage battery and supply the 12 V on-board electrical system via the DC / DC converter.

The kinetic energy of the crankshaft is applied to the rotor of the electric motor. The rotational movement of the rotor then induces AC voltage in the three-phase winding of the stator. This generates electrical energy in the form of three-phase current, which is limited, monitored and converted into high DC voltage by the power electronics.

Driving mode



Function schematic for driving mode

1	*Coolant temperature, signal*
2	*Accelerator pedal position, signal*
3	*Engine speed, signal*
4	*Wheel speed, signal*
5	*Service brake, status*
6	*High-voltage battery voltage, signal*
7	*High-voltage battery temperature, signal*
8	*Tolerable discharge voltage / current, signal*
9	*Tolerable charging voltage / current, signal*
10	*Gear range, status*
11	*DISTRONIC, request*
12	*Electric motor temperature, signal*
13	*Electric motor rpm, signal*
14	*Electric motor, status*
15	*Electric motor specified torque, request*
16	*Discharge current, energy flow*
17	*Discharge current for motor operation, energy flow*
18	*Charging current from alternator operation, energy flow*
19	*Charging current, energy flow*
20	*Charging voltage and charging current, signal*
21	*Available torque, signal*
22	*Electric motor rotor position, signal*
23	*Electric motor generating torque, signal*
24	*Electric motor drive torque, signal*

A79	*Electric motor*
A100	*High-voltage battery module*
B11 / 4	*Coolant temperature sensor*
B37	*Accelerator pedal sensor*
B70	*Crankshaft Hall sensor*
CAN C	*Drivetrain CAN*
CAN E	*Chassis CAN*
CAN I	*Drivetrain sensor CAN*
N3 / 10	*ME-SFI [ME] control unit*
N30 / 6	*Regenerative braking system (RBS) control unit*
N62 / 1	*Radar sensors control unit (SGR) (with DISTRONIC PLUS or adaptive cruise control)*
N82 / 2	*Battery management system control unit (BMS)*
N129 / 1	*Power electronics control unit*
Y3 / 8	*Electric controller unit (VGS)*

Torque coordination

The ME-SFI [ME] control unit collects and prioritizes torque requests and coordinates how the required torque will be generated. To do this, it monitors the state of the combustion engine and electric motor along with the charge level of the high-voltage battery and the status of the automatic transmission.

Coordination of torque requests

The regenerative braking system (RBS), Electronic Stability Program (ESP), electronic traction system (ETS), cruise control, adaptive cruise control, DISTRONIC PLUS systems and the driver all issue torque requests and transfer these requests to the ME-SFI [ME] control unit via the chassis CAN, the drivetrain CAN and the drivetrain sensor CAN. The ME-SFI [ME] control unit prioritizes these torque requests and uses them to calculate the required drive torque.

The system requests are prioritized in the following order:

- Electric transmission control
- Electronic Stability Program (ESP)
- Regenerative braking system (RBS)
- DISTRONIC PLUS, cruise control, adaptive cruise control
- Driver engine load request

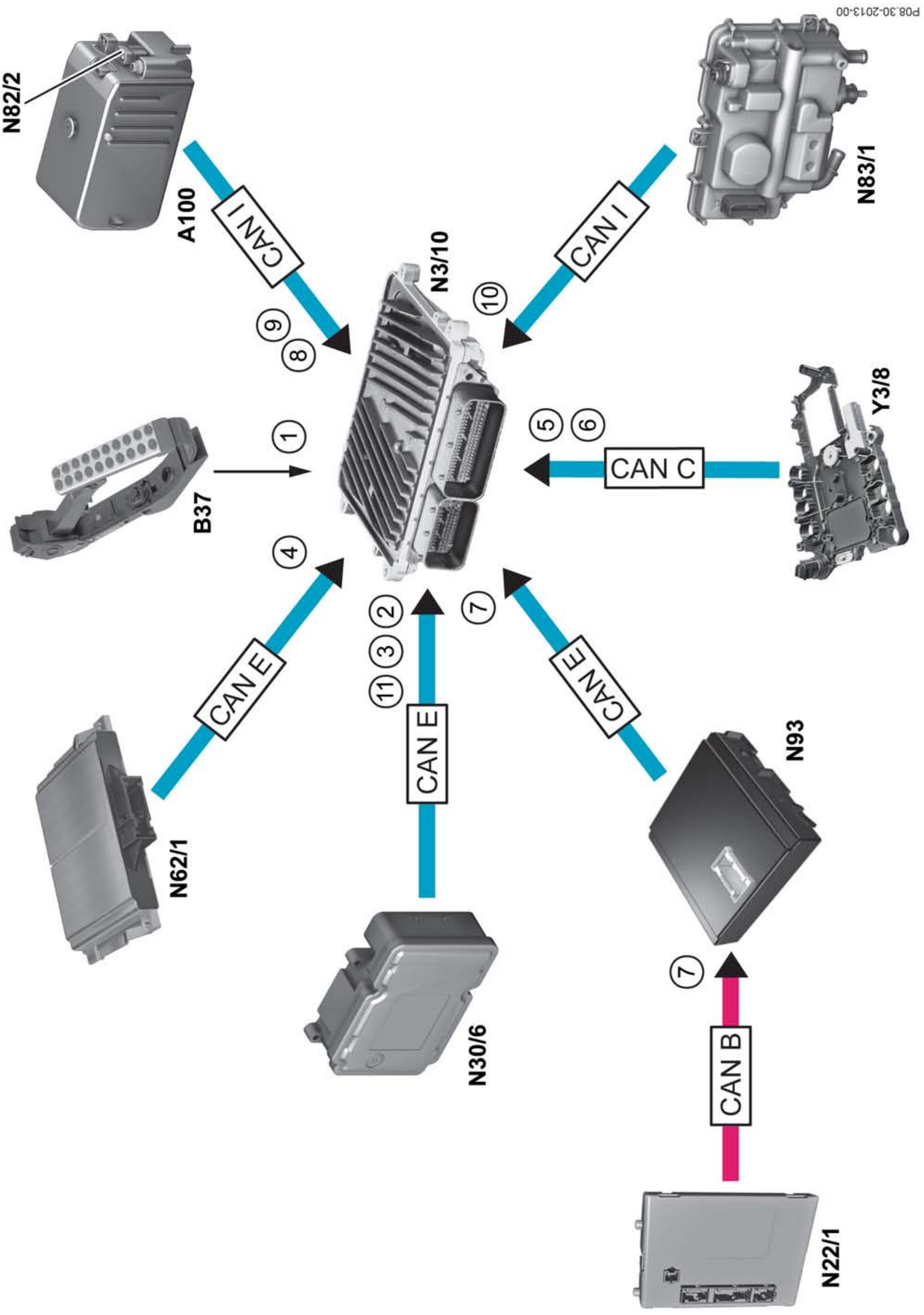
Coordination of torque generation

Depending on the instructions from the energy management system, the ME-SFI [ME] control unit coordinates torque generation and torque interventions.

Dynamic torque interventions are not only achieved by changing the ignition angle to reserve torque from the combustion engine. Initially, the ME-SFI [ME] control unit increases and reduces the torque from the electric motor to provide the current drive torque. It requests electric motor drive torque from the power electronics control unit via the drivetrain sensor CAN in order to increase the torque applied.

Reductions in torque are achieved by requesting generating torque. The power electronics control unit implements these requests and then reports the generated torque back to the ME-SFI [ME] control unit via the drivetrain sensor CAN If the torque interventions of the electric motor are not adequate, the torque from the combustion engine is additionally reduced or raised by changing the ignition angle (torque reserve).

Torque coordination



Function schematic for torque coordination

1	*Accelerator pedal position, signal*
2	*Wheel speed, signal*
3	*Regenerative braking torque, request*
4	*Torque change / DISTRONIC dynamics, request*
5	*Transmission protection torque lowering, request*
6	*Gear range, status*
7	*Air conditioning, status*
8	*High-voltage battery voltage, signal*
9	*High-voltage battery temperature, signal*
10	*12 V battery voltage, signal*
11	*Torque lowering / ESP dynamics, request*

A100	*High-voltage battery module*
B37	*Accelerator pedal sensor*
CAN B	*Interior CAN*
CAN C	*Drivetrain CAN*
CAN E	*Chassis CAN*
CAN I	*Drivetrain sensor CAN*
N3 / 10	*ME-SFI [ME] control unit*
N22 / 1	*AAC [KLA] control unit*
N30 / 6	*Regenerative braking system (RBS) control unit*
N62 / 1	*Radar sensors control unit (SGR) (with DISTRONIC PLUS or adaptive cruise control)*
N82 / 2	*Battery management system (BMS) control unit*
N83 / 1	*DC / DC converter control unit*
N93	*Central gateway control unit*
Y3 / 8	*Electric controller unit (VGS)*

Automatic engine stop

An automatic engine stop is initiated if the vehicle does not require any drive energy and systems which depend on the drive system have not made any requests.

For an automatic engine stop, the engine is switched off by the ME-SFI [ME] control unit using the electric motor without the ignition being switched off.

An automatic engine stop can only be performed if the following conditions are met:

- Combustion engine running
- Electric motor operational
- Charge level of high-voltage battery adequate for restarting engine
- Additional electric transmission oil pump operational
- Temperature sensors of combustion engine (for engine oil, coolant, catalytic converter temperature) indicate operating temperature has been reached
- Engine hood closed
- Gear range "D" or "N" engaged

Automatic engine stop

The following factors trigger an automatic engine stop:

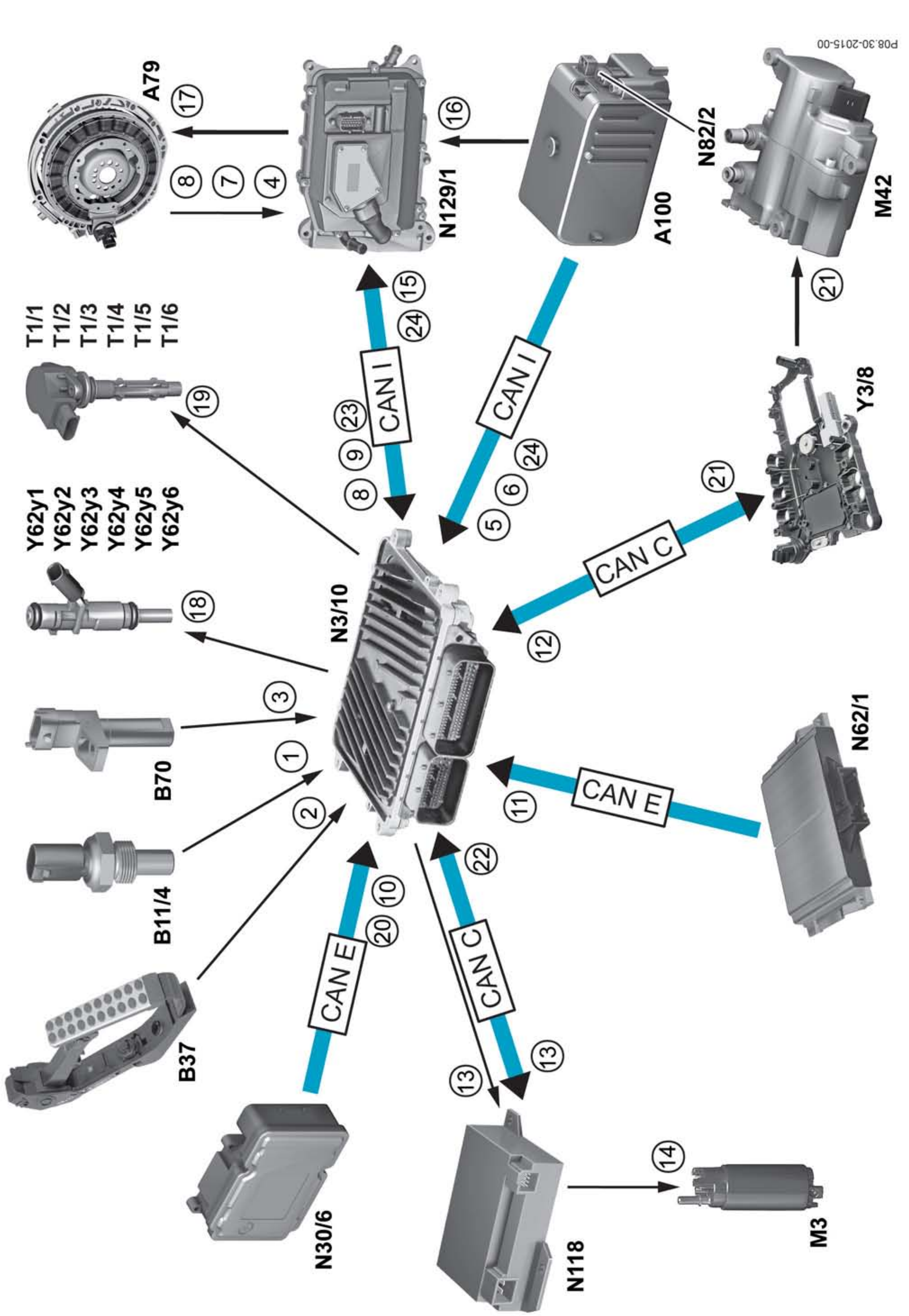
- Evaluation of vehicle speed
  An automatic engine stop is triggered if the vehicle speed drops below a programmable threshold value. In order to determine the vehicle speed, the ME-SFI [ME] control unit evaluates the rotation direction and rpm values of the wheels, which are placed on the chassis CAN by the regenerative braking system (RBS) control unit.
- Increase of braking torque depending on vehicle speed
  If the braking torque during driving increases by a programmable value when the ratio of vehicle speed to braking torque is at a certain level, an automatic engine stop is triggered.

When the conditions for an automatic engine stop are met and a corresponding trigger condition is present, the ME-SFI [ME] control unit switches off the engine by shutting off the fuel injection valves and ignition coils.

The ME-SFI [ME] control unit requests actuation of the electric motor in order to shut down the combustion engine from the power electronics control unit over the drivetrain sensor CAN. This prevents any jolts during shutdown and any effects on the behavior of the vehicle in deceleration mode (speed > 0 km / h).

The engine is also shut down if a crash signal is present and the high-voltage on-board electrical system is immediately deactivated.

Automatic engine stop



Function schematic for automatic engine stop

1	*Coolant temperature, signal*
2	*Accelerator pedal position, signal*
3	*Engine speed, signal*
4	*Electric motor rotor position, signal*
5	*High-voltage battery voltage, signal*
6	*High-voltage battery temperature, signal*
7	*Electric motor temperature, signal*
8	*Electric motor rpm, signal*
9	*Electric motor, status*
10	*Wheel speed, signal*
11	*DISTRONIC, request*
12	*Additional electric transmission oil pump, status*
13	*Fuel pump, request OFF*
14	*Fuel pump, actuation OFF*
15	*Electric motor specified torque, request*
16	*Discharge current, energy flow*
17	*Discharge current for motor operation, energy flow*
18	*Fuel injection valves, actuation OFF*
19	*Ignition coils, actuation OFF*
20	*Service brake, status*
21	*Additional electric transmission oil pump, actuation ON*
22	*Fuel pump actuation ratio, signal*
23	*Electric motor drive torque, signal*
24	*Tolerable discharge voltage / current, signal*

A79	*Electric motor*
A100	*High-voltage battery module*
B11 / 4	*Coolant temperature sensor*
B37	*Accelerator pedal sensor*
B70	*Crankshaft Hall sensor*
CAN C	*Drivetrain CAN*
CAN E	*Chassis CAN*
CAN I	*Drivetrain sensor CAN*
M3	*Fuel pump*
M42	*Additional electric transmission oil pump*
N3 / 10	*ME-SFI [ME] control unit*
N30 / 6	*Regenerative braking system (RBS) control unit*
N62 / 1	*Radar sensors control unit (SGR) (with DISTRONIC PLUS or adaptive cruise control)*
N82 / 2	*Battery management system control unit (BMS)*
N118	*Fuel pump control unit*
N129 / 1	*Power electronics control unit*
T1 / 1	*Cylinder 1 ignition coil*
T1 / 2	*Cylinder 2 ignition coil*
T1 / 3	*Cylinder 3 ignition coil*
T1 / 4	*Cylinder 4 ignition coil*
T1 / 5	*Cylinder 5 ignition coil*
T1 / 6	*Cylinder 6 ignition coil*
Y3 / 8	*Electric controller unit (VGS)*
Y62y1	*Cylinder 1 fuel injection valve*
Y62y2	*Cylinder 2 fuel injection valve*
Y62y3	*Cylinder 3 fuel injection valve*
Y62y4	*Cylinder 4 fuel injection valve*
Y62y5	*Cylinder 5 fuel injection valve*
Y62y6	*Cylinder 6 fuel injection valve*

Automatic engine start

An automatic engine start is initiated if the vehicle requires drive energy or if systems which depend on the drive system make a request. In the case of an automatic engine start, the combustion engine is started by the ME-SFI [ME] control unit using the electric motor.

An automatic engine start can only be performed if the following conditions are met:

- An automatic engine stop was triggered
- Protection switch of high-voltage battery is closed
- No crash has been detected
- There are no faults in the high-voltage on-board electrical system (high-voltage interlock open)

The following factors trigger an automatic engine start:

- Brake pedal released:
  If the brake pedal is released by the driver, either the current braking torque or the braking torque requested by the driver is evaluated. An automatic engine start takes place when the braking torque drops below a threshold value.
- Actuation of accelerator pedal:
  If the driver actuates the accelerator pedal, the pedal value of the accelerator pedal is compared to a threshold value. If the current value exceeds the threshold value, this triggers an automatic engine start.
- Selector lever moved out of position "P":
  If the selector lever is moved out of position "P", this triggers an automatic engine start.
- Vehicle speed exceeded:
  If a vehicle speed which is above a programmable threshold is registered, this triggers an automatic engine start.
- Withdrawal of approval of external systems:
  If the radar sensors control unit (SGR) (with DISTRONIC PLUS or adaptive cruise control) withdraws approval for the automatic engine stop, this triggers an automatic engine start and DISTRONIC PLUS can accelerate the vehicle. If approval is withdrawn by the AAC [KLA] control unit, the fully integrated transmission control (VGS) control unit or the energy management system, the braking torque must be high enough (over a specified deceleration torque) to trigger an automatic engine start.
- Opening of driver door or seat belt buckle (detection of driver presence).
- Engagement of gear range "R" (maneuvering detection).

Automatic engine start

For an automatic engine start, the drive torque required from the electric motor is calculated by the ME-SFI [ME] control unit and checked for plausibility.

The ME-SFI [ME] control unit requests actuation of the electric motor in order to start the combustion engine from the power electronics control unit over the drivetrain sensor CAN.

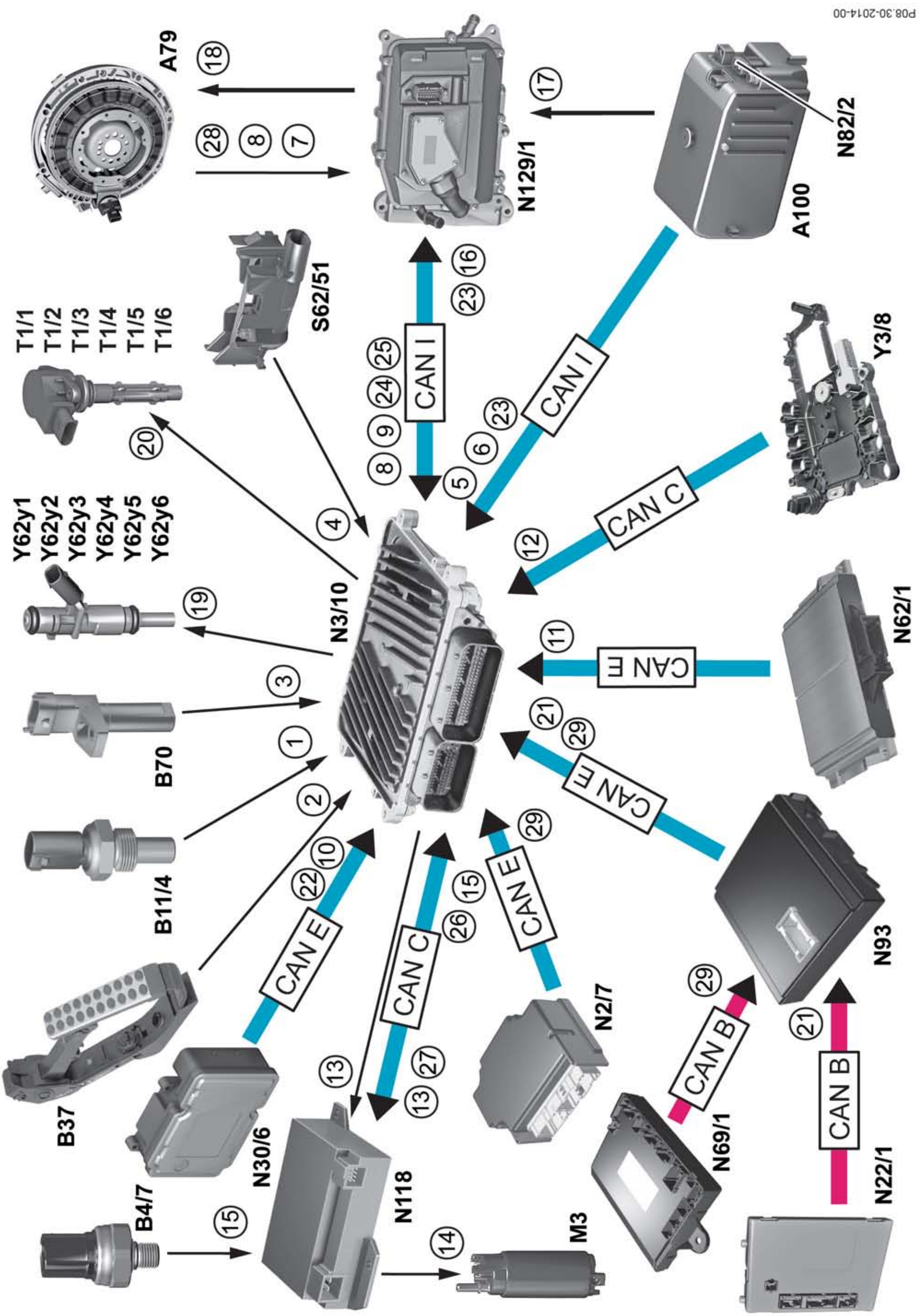
As soon as the starting rpm is reached, the ME-SFI [ME] control unit actuates the fuel injection valves and ignition coils. Depending on the accelerator pedal position or coolant temperature of the combustion engine, the system performs a torque-led start or a speed-led start.

The end of the starting procedure is detected by means of the engine speed or, in the case of a torque-led start, by means of the difference between the drive torque generated by the electric motor and the overall drive torque.

i Note

While maneuvering or parking, maneuvering mode is activated by gear range "R" of the automatic transmission and the start-stop function is suppressed (even in the case of an automatic engine stop).

Automatic engine start



Function schematic for automatic engine start

1	*Coolant temperature, signal*
2	*Accelerator pedal position, signal*
3	*Engine speed, signal*
4	*Hybrid vehicle engine hood contact switch, status*
5	*High-voltage battery voltage, signal*
6	*High-voltage battery temperature, signal*
7	*Electric motor temperature, signal*
8	*Electric motor rpm, signal*
9	*Electric motor, status*
10	*Wheel speed, signal*
11	*DISTRONIC, request*
12	*Gear range, status*
13	*Fuel pump, request ON*
14	*Fuel pump, actuation*
15	*Fuel pressure, signal*
16	*Electric motor specified torque, request*
17	*Discharge current, energy flow*
18	*Discharge current for motor operation, energy flow*
19	*Fuel injection valves, actuation*
20	*Ignition coils, actuation*
21	*Air conditioning, status*
22	*Service brake, status*
23	*Tolerable discharge voltage / current, signal*
24	*Electric motor generating torque, signal*
25	*Electric motor drive torque, signal*
26	*Fuel pump actuation ratio, signal*
27	*Fuel pressure specified value, request*
28	*Electric motor rotor position, signal*
29	*Driver presence detection, status*

A79	*Electric motor*
A100	*High-voltage battery module*
B4 / 7	*Fuel pressure sensor*
B11 / 4	*Coolant temperature sensor*
B37	*Accelerator pedal sensor*
B70	*Crankshaft Hall sensor*
CAN B	*Interior CAN*
CAN C	*Drivetrain CAN*
CAN E	*Chassis CAN*
CAN I	*Drivetrain sensor CAN*
M3	*Fuel pump*
N2 / 7	*Restraint systems control unit*
N3 / 10	*ME-SFI [ME] control unit*
N22 / 1	*AAC [KLA] control unit*
N30 / 6	*Regenerative braking system (RBS) control unit*
N62 / 1	*Radar sensors control unit (SGR)*
N69 / 1	*Left front door control unit*
N82 / 2	*Battery management system (BMS) control unit*
N93	*Central gateway control unit*
N118	*Fuel pump control unit*
N129 / 1	*Power electronics control unit*
S62 / 51	*Hybrid engine hood contact switch*
T1 / 1	*Cylinder 1 ignition coil*
T1 / 2	*Cylinder 2 ignition coil*
T1 / 3	*Cylinder 3 ignition coil*
T1 / 4	*Cylinder 4 ignition coil*
T1 / 5	*Cylinder 5 ignition coil*
T1 / 6	*Cylinder 6 ignition coil*
Y3 / 8	*Electric controller unit (VGS)*
Y62y1	*Cylinder 1 fuel injection valve*
Y62y2	*Cylinder 2 fuel injection valve*
Y62y3	*Cylinder 3 fuel injection valve*
Y62y4	*Cylinder 4 fuel injection valve*
Y62y5	*Cylinder 5 fuel injection valve*
Y62y6	*Cylinder 6 fuel injection valve*

Energy management

The energy management module in the ME-SFI [ME] control unit coordinates the energy flows of the hybrid drive system and provides, in terms of the electrical variables, the interface to the battery management system (BMS), DC / DC converter and power electronics control units. For this purpose, it exchanges information with all relevant control units via the CAN network and, if necessary, actuates the 12 V alternator via the drive LIN.

The ME-SFI [ME] control unit communicates with the internal torque interface to coordinate energy recovery and energy usage.

In addition, the energy management system performs the following tasks:

- Calculation and calibration of SOC value (State of Charge) for the charge level of the high-voltage battery
- Implementation of the charging / discharge strategy taking into account the boundary conditions of the high-voltage battery, combustion engine and electric motor
- Forecast energy reserves and maximum available output of high-voltage battery
- Control energy exchange between the high-voltage and 12 V on-board electrical systems

Alternator interface

The 12 V alternator is actuated by the ME-SFI [ME] control unit to support the 12 V on-board electrical system if the DC / DC converter control unit reaches its utilization limit. Messages are exchanged between the 12 V alternator and the ME-SFI [ME] control unit over the drive LIN via the alternator interface to control the behavior of the 12 V alternator.

The ME-SFI [ME] control unit controls the behavior of the 12 V alternator in order, for example, to reduce the regulation voltage (charging voltage) with the engine idling if the battery is adequately charged. This reduces the engine load, meaning that less fuel is consumed and the exhaust gas emission levels are improved.

The ME-SFI [ME] control unit controls the following functions:

- Switching on 12 V alternator after engine start.
- Regulation of 12 V alternator according to performance maps stored in the ME-SFI [ME] control unit. To achieve this, the regulation voltage is specified by the ME-SFI [ME] control unit.
- Adaptation of regulation voltage with a delay in the event of frequent load changes at the 12 V alternator to stabilize the idle speed.
- Protection of 12 V alternator against overheating.
- Reporting of detected faults to the instrument cluster for actuation of the respective warning lamps and display messages.

Deceleration mode

If the brake pedal and accelerator pedal are not actuated when the vehicle is rolling, the kinetic energy is absorbed by the electric motor and converted into electrical energy (regeneration). In addition, deceleration fuel shutoff of the combustion engine can be performed. If the brake pedal is actuated, regenerative braking takes place.

If the accelerator pedal is not actuated during driving operation with the vehicle rolling, the ME-SFI [ME] calculates a specified deceleration torque, which it implements with regenerative deceleration and deceleration fuel shut off, depending on the road surface inclination, the charge level of the high-voltage battery and the transmission mode selected.

In deceleration mode and with deceleration fuel shutoff active, the combustion engine generates a deceleration torque which, together with the regenerative deceleration torque can be greater than the specified deceleration torque. In this case, deceleration fuel shutoff is not activated and the combustion engine generates a minimal controllable torque.

The effect of this concept is that drive system behaves in the same way for the driver with or without deceleration fuel shutoff.

Regenerative deceleration

The specified deceleration torque calculated by the ME-SFI [ME] control unit is transmitted via the drivetrain sensor CAN to the power electronics control unit through a request for generating torque.

The power electronics control unit actuates the electric motor in generation mode, thus generating the requested regenerative deceleration torque. Actuation of the electric motor in generation mode generates AC voltage. This is converted into DC voltage by the power electronics control unit and fed to the high-voltage battery.

Deceleration fuel shutoff

Deceleration fuel shutoff of the combustion engine is activated depending on the specified deceleration torque calculated by the control unit in order to save fuel.

In deceleration mode, the ME-SFI [ME] control unit switches off the fuel injection valves and the ignition coils depending on the coolant temperature, the engaged gear and the engine speed if the accelerator pedal is not actuated.

The fuel injection valves are switched on again when the accelerator pedal is operated.

In addition, the ME-SFI [ME] control unit sets the valve overlap to its minimum value through the left and right intake camshafts solenoids and the left and right exhaust camshaft solenoids. This ensures that an optimal conversion rate of the catalytic converters is more rapidly achieved.

After deceleration fuel shutoff, the ME-SFI [ME] control unit briefly enriches the fuel-air mixture by extending the injection time in order to relieve the catalytic converters of the enriched oxygen. In order to prevent a sudden torque rise when combustion is reestablished after deceleration fuel shutoff, the ignition timing of the ignition coils is briefly adjusted towards "retarded" by the ME-SFI [ME] control unit.

The deceleration fuel shutoff is suppressed at excessive exhaust gas temperatures, because the high oxygen content in the exhaust during deceleration fuel shutoff can lead to an increased oxidation (afterburning) of carbon monoxide and hydrocarbon.

Stall protection

The extended deceleration fuel shutoff and the regeneration process do lower fuel consumption, but they also increase the risk of the combustion engine stalling.

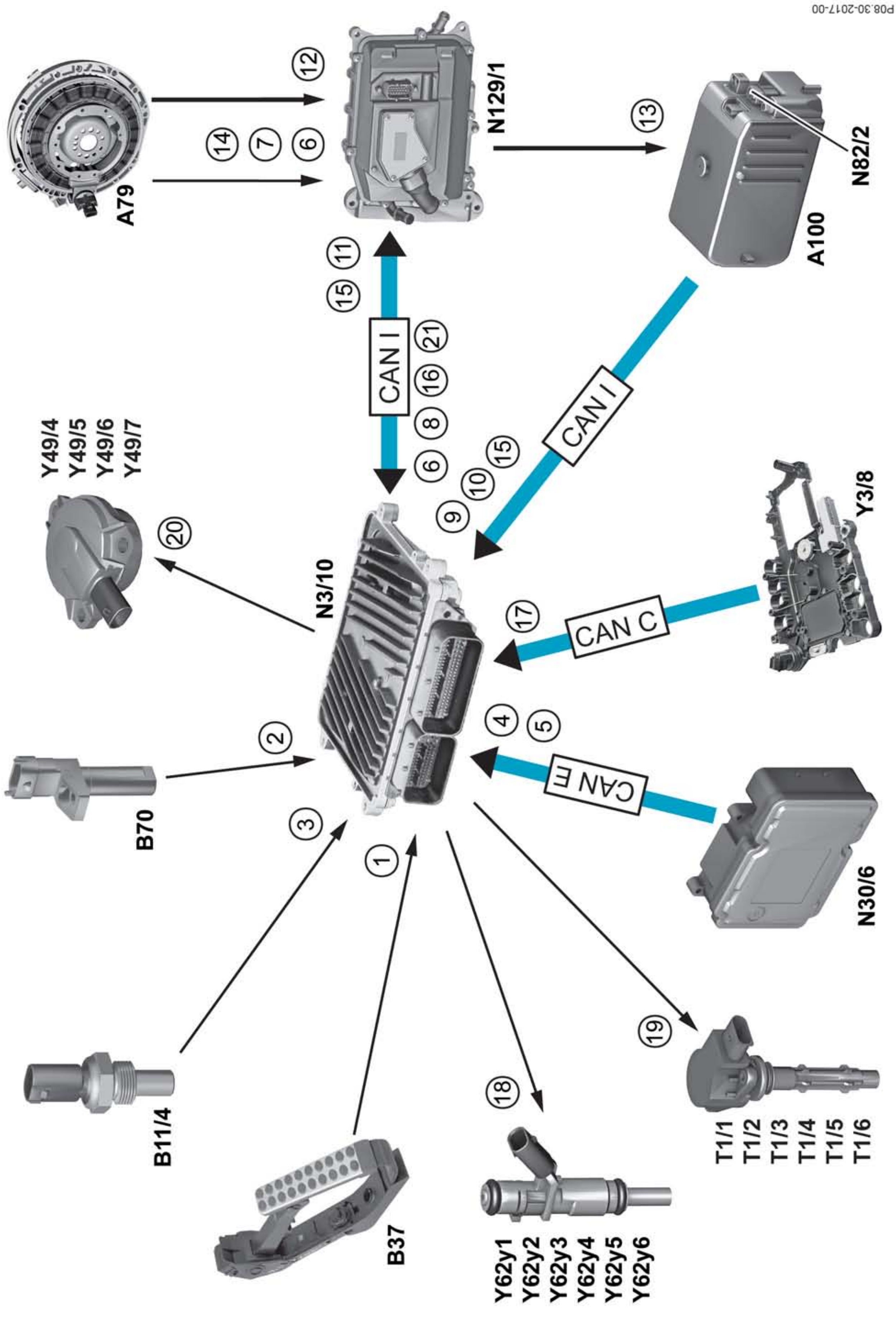
If there is a possibility that the engine may stall unexpectedly due to a low engine speed, a torque-led engine start is requested and the combustion engine is brought back to idle speed.

i Note

Deceleration mode is more energy-efficient with deceleration fuel shutoff. However, if the charge level of the high-voltage battery is low and the specified deceleration torque is low, the greater regenerative deceleration without deceleration fuel shutoff is more advantageous.

During driving operation, the engine speed is continuously monitored by the stall protection function.

Deceleration mode



Function schematic for deceleration mode

1	*Accelerator pedal position, signal*
2	*Engine speed, signal*
3	*Coolant temperature, signal*
4	*Service brake, status*
5	*Wheel speed, signal*
6	*Electric motor rpm, signal*
7	*Electric motor temperature, signal*
8	*Electric motor, status*
9	*High-voltage battery voltage, signal*
10	*High-voltage battery temperature, signal*
11	*Electric motor specified torque, request*
12	*Charging current from alternator operation, energy flow*
13	*Charging current, energy flow*
14	*Electric motor rotor position, signal*
15	*Tolerable charging voltage / current, signal*
16	*Charging voltage and charging current, signal*
17	*Gear range, status*
18	*Fuel injection valves, actuation OFF*
19	*Ignition coils, actuation OFF*
20	*Intake camshaft solenoids, actuation*
21	*Electric motor generating torque, signal*

A79	*Electric motor*
A100	*High-voltage battery module*
B11 / 4	*Coolant temperature sensor*
B37	*Accelerator pedal sensor*
B70	*Crankshaft Hall sensor*
CAN C	*Drivetrain CAN*
CAN E	*Chassis CAN*
CAN I	*Drivetrain sensor CAN*
N3 / 10	*ME-SFI [ME] control unit*
N30 / 6	*Regenerative braking system (RBS) control unit*
N82 / 2	*Battery management system control unit (BMS)*
N129 / 1	*Power electronics control unit*
T1 / 1	*Cylinder 1 ignition coil*
T1 / 2	*Cylinder 2 ignition coil*
T1 / 3	*Cylinder 3 ignition coil*
T1 / 4	*Cylinder 4 ignition coil*
T1 / 5	*Cylinder 5 ignition coil*
T1 / 6	*Cylinder 6 ignition coil*
Y3 / 8	*Electric controller unit (VGS)*
Y49 / 4	*Intake camshaft solenoid, left*
Y49 / 5	*Intake camshaft solenoid, right*
Y49 / 6	*Exhaust camshaft solenoid, left*
Y49 / 7	*Exhaust camshaft solenoid, right*
Y62y1	*Cylinder 1 fuel injection valve*
Y62y2	*Cylinder 2 fuel injection valve*
Y62y3	*Cylinder 3 fuel injection valve*
Y62y4	*Cylinder 4 fuel injection valve*
Y62y5	*Cylinder 5 fuel injection valve*
Y62y6	*Cylinder 6 fuel injection valve*

Regenerative braking

During regenerative braking, part of the braking torque or, in the case of gentle braking, the entire braking torque is used by the electric motor to generate energy. The electrical energy generated is used to charge the high-voltage battery.

Depending on the driving condition, the regenerative braking system (RBS) control unit divides the total braking torque requested by the driver into a regenerative part (implemented by drivetrain) and a hydraulic part (implemented by wheel brake).

If the required total braking torque can be generated using regenerative means alone, then none of the braking torque is generated hydraulically. In this case, deceleration is achieved solely through the generating torque.

The three-phase current generated by the electric motor during regeneration is converted into high DC voltage by the power electronics control unit and fed to the high-voltage battery.

Regenerative braking is shut off for the ignition sequence if:

- The required regenerative braking torque cannot be provided correctly or
- There is a fault in the hybrid drive system.

If the high-voltage battery is fully charged, regenerative braking is not possible. In this case, the vehicle is braked solely via the hydraulic brake until the high-voltage battery is again partially discharged and can accept electrical energy.

If an ABS control intervention takes place, regenerative braking is terminated for this brake application and the braking torque is provided solely via the hydraulic wheel brakes.

On the regenerative braking system, there is a length of free travel integrated in the connection of the brake pedal to the push rod of the brake booster. This is used to implement the regenerative braking function.

During normal operation, the braking request from the driver (pedal travel 1) is recorded by the pedal angle sensor and read in and processed by the regenerative braking system (RBS) control unit. At the same time, artificial pedal resistance is generated by the pedal force simulator for each brake actuation.

If regenerative braking is performed, the free travel between the brake pedal and push rod becomes increasingly shorter as the regenerative braking torque increases. To build up hydraulic pressure in the wheel brakes, the regenerative braking system (RBS) control unit actuates the RBS solenoid valve, which causes the RBS brake booster to build up the hydraulic brake pressure. In this case, the free travel does not become shorter.

i Regeneration:

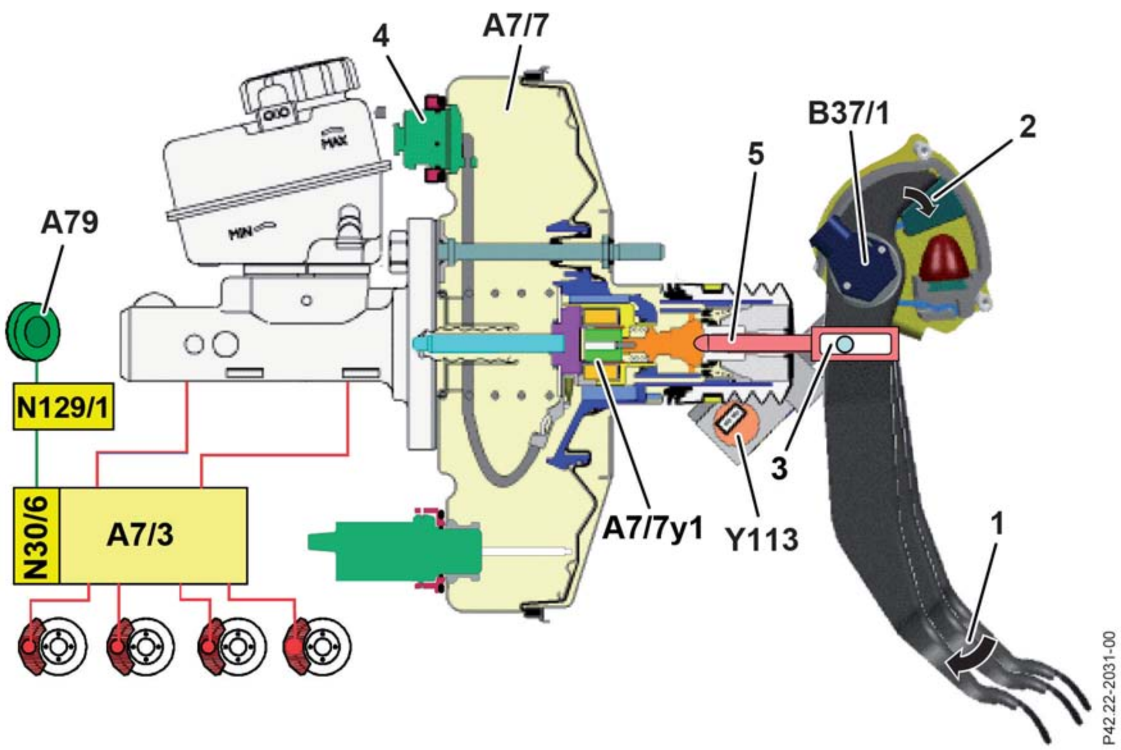
Energy is recovered during deceleration by converting the kinetic energy which needs to be dissipated into electrical energy. The electrical energy which is generated is fed to the high-voltage battery for storage.

The regenerative braking system has to be activated during the first brake actuation. For this purpose, the pedal force simulator is deactivated and the pedal travel during the first brake actuation is slightly longer than during normal operation. The regenerative braking system is activated the next time the brake pedal is fully released.

In the event of a fault, the pedal force simulator is deactivated (fallback level) and the simulated pedal resistance is no longer present. The driver then depresses the pedal through the length of free travel and generates the required brake pressure by the force of his / her foot as on a conventional braking system. This means that the pedal travel is slightly longer than during normal operation.

Regenerative braking is not possible below speeds of 20 km / h.

As soon as the vehicle drops below a speed of 20 km / h during a brake application, the system switches from regenerative braking to hydraulic braking.

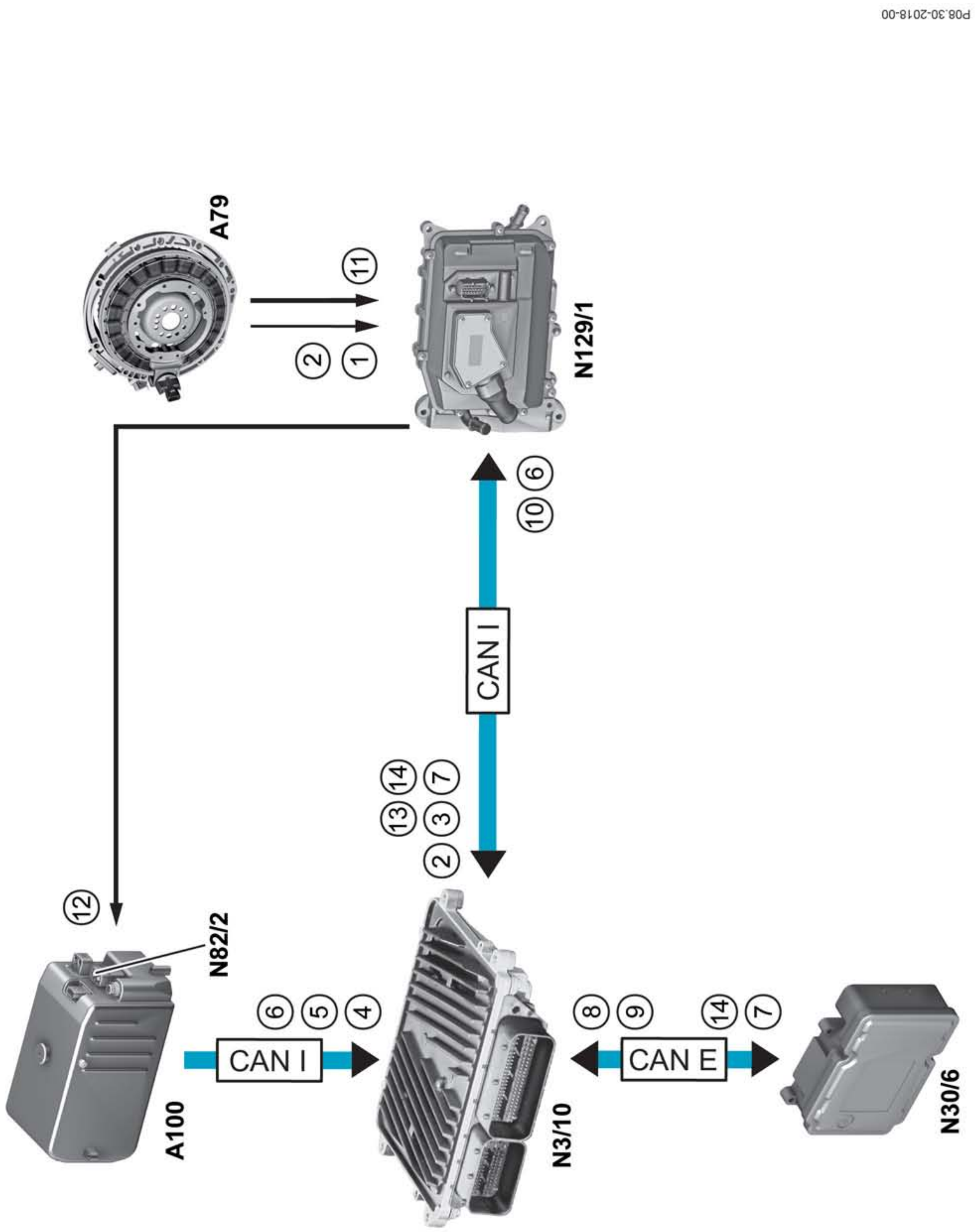


Functional principle

1	*Travel at brake pedal*
2	*Travel at pedal force simulator*
3	*Free travel*
4	*RBS solenoid valve electrical connection*
5	*Push rod*

A7 / 3	*Traction system hydraulic unit*
A7 / 7	*RBS brake booster*
A7 / 7y1	*RBS solenoid valve*
A79	*Electric motor*
B37 / 1	*Pedal angle sensor*
N30 / 6	*Regenerative braking system (RBS) control unit*
N129 / 1	*Power electronics control unit*
Y113	*Pedal force simulator valve*

Regenerative braking



Function schematic for regenerative braking

1	*Electric motor temperature, signal*
2	*Electric motor rpm, signal*
3	*Electric motor, status*
4	*High-voltage battery voltage, signal*
5	*High-voltage battery temperature, signal*
6	*Tolerable charging voltage / current, signal*
7	*Available regenerative braking torque, signal*
8	*Regenerative braking torque, request*
9	*Wheel speed, signal*
10	*Electric motor specified torque, request*
11	*Charging current from alternator operation, energy flow*
12	*Charging current, energy flow*
13	*Charging voltage and charging current, signal*
14	*Generated regenerative braking torque, signal*

A79	*Electric motor*
A100	*High-voltage battery module*
CAN E	*Chassis CAN*
CAN I	*Drivetrain sensor CAN*
N3 / 10	*ME-SFI [ME] control unit*
N30 / 6	*Regenerative braking system (RBS) control unit*
N82 / 2	*Battery management system (BMS) control unit*
N129 / 1	*Power electronics control unit*

Ignition ON/OFF

Ignition on

When the ignition is switched on, the EZS control unit forwards the signal for the change in on-board electrical system voltage from "Circuit 30" to "Circuit 15" via the circuit 15 relay.

When the engine control system is switched on, the ME-SFI [ME] control unit performs the following functions to start the hybrid system:

- Transmission of the signal "Circuit 15 ON" from the EZS control unit to the power electronics control unit, battery management system (BMS) control unit and DC / DC converter control unit takes place via the chassis CAN and drive train sensor CAN.
- Protection switches are closed.

Ignition OFF

When the ignition is switched off, first the engine is switched off followed by the engine control system in the ME-SFI [ME] control unit and the protection switches are opened.

Transmission of the signal "Circuit 15 OFF" to the ME-SFI [ME] control unit, power electronics control unit, battery management system (BMS) control unit and DC / DC converter control unit takes place via the EZS control unit over the CAN network.

The ME-SFI [ME] control unit requests opening of the protection switches from the battery management system (BMS) control unit, which causes the high-voltage components to be disconnected from the high-voltage battery. The power electronics control unit then initiates discharge of the intermediate circuit.

Note

When the ignition is switched on, the safety tests are also performed in the high-voltage components.

Starting

Starting of the engine takes place via the electric motor.

The ME-SFI [ME] control unit communicates with the power electronics control unit and the battery management system (BMS) control unit over the drive train sensor CAN to determine how the engine should be started.

The engine is started when the "Circuit 50 signal" is received from the EZS control unit (key start).

The following distinction is made for engine starting:

- Speed-led start
- Torque-led start

Speed-led start

This type of start is the preferred type and offers the greatest comfort.

A speed-led engine start is only performed if the coolant temperature is less than –10 °C or greater than +48 °C and the calculated output in order to reach idle speed can be supplied by the high-voltage battery. The starting process is terminated when the minimum idle speed is exceeded for greater than 0.7 s.

Torque-led start

This type of start is used for cold starting and emergency starting depending on the position of the accelerator pedal or the coolant temperature of the combustion engine (between –10 °C and +48 °C).

If the conditions for a speed-led start are not fulfilled, a torque-led engine start is performed. The starting process is terminated when the engine speed reaches 600 to 750 rpm. The engine speed required to terminate the starting process is dependent on the coolant temperature.

Note

Automatic engine start can only take place after an automatic engine stop with start-stop function activated.

Monitoring/deactivation

In order to ensure road safety during acceleration, the system monitoring function monitors and limits the drive torque of the vehicle based on the request made by the driver using the accelerator pedal.

The entire monitoring concept is integrated in the ME-SFI [ME] control unit and the power electronics control unit.

The monitoring concept of the ME-SFI [ME] control unit is divided into the following three levels:

- Function level (level 1)
- First monitoring level (level 2)
- Second monitoring level (level 3)

Function level

Whereas the function level incorporates all of the functions of the hybrid drive system implemented in the ME-SFI [ME] control unit such as torque coordination, energy management and sensor / actuator actuation, the other levels are used to monitor the system and ensure the functional reliability and plausible behavior of the vehicle.

First monitoring level

This level incorporates a comparison of the specified / actual values for driver torque request (accelerator pedal position) and total drive torque (sum of torque from combustion engine and electric motor). In the ME-SFI [ME] control unit, Level 2 checks whether the total drive torque generated is greater than that requested by the driver via the accelerator pedal sensor. If this is the case, it is assumed that there is a fault in the ME-SFI [ME] control unit and the system switches to the limp-home function of the combustion engine (speed limited to 1,500 rpm).

In Level 2, a check is also made in the power electronics control unit to determine whether the drive torque requested by the ME-SFI [ME] control unit via the drive train sensor CAN is continuously greater than the drive torque generated by the electric motor based on the calculation of currents and angular position of the rotor. If this is the case, the integrated starter-alternator is switched to passive mode by the power electronics control unit.

Second monitoring level

This level is based on independent hardware monitoring. It consists of a monitoring processor, which checks the basic functions of the first monitoring level in the ME-SFI [ME] control unit.

Deactivation of hybrid drive system

To deactivate the hybrid drive system, the ME-SFI [ME] control unit requests the battery management system (BMS) control unit to switch off the protection switches, evaluates their status, controls the discharge of the intermediate circuit via the power electronics control unit and withdraws approval for system operation.

The protection switches are only opened when the DC / DC converter and power electronics stop requesting output so that the protection switches can be opened in a deenergized state.

Depending on the operating conditions present, deactivation can take place in the following ways:

- Normal deactivation
- Delayed deactivation (only in case of fault)
- Immediate deactivation (only in case of fault)

Normal deactivation

If no switch-on request has been received, the ME-SFI [ME] control unit requests the battery management system (BMS) control unit to switch off the protection switches via the drive train sensor CAN after the expiry of a programmable time period (approx. 1.5 s). To prevent the protection switches from being opened under load, before the expiry of this period the ME-SFI [ME] control unit requests deenergization of the consumers connected to the high-voltage system from the power electronics control unit, DC / DC converter control unit and AAC [KLA] control unit.

Delayed deactivation (in case of fault)

Delayed deactivation is triggered by the following faults:

- Interlock fault
- Cooling requirement of electric motor
- Critical cooling requirement of electric motor
- Insufficient charging capacity with low charge level of high-voltage battery

Automatic delayed deactivation is only reset when the signal edge of the ignition signal rises. If the charge level of the high-voltage battery is low and the outgoing battery current is greater than the expected minimum charging current resulting in unexpected consumption of capacity (discharge) then delayed deactivation due to a fault is requested and a fault is stored in the fault memory at the same time. The current integral is initialized by the rising signal edge of circuit 15.

Immediate deactivation (in case of fault)

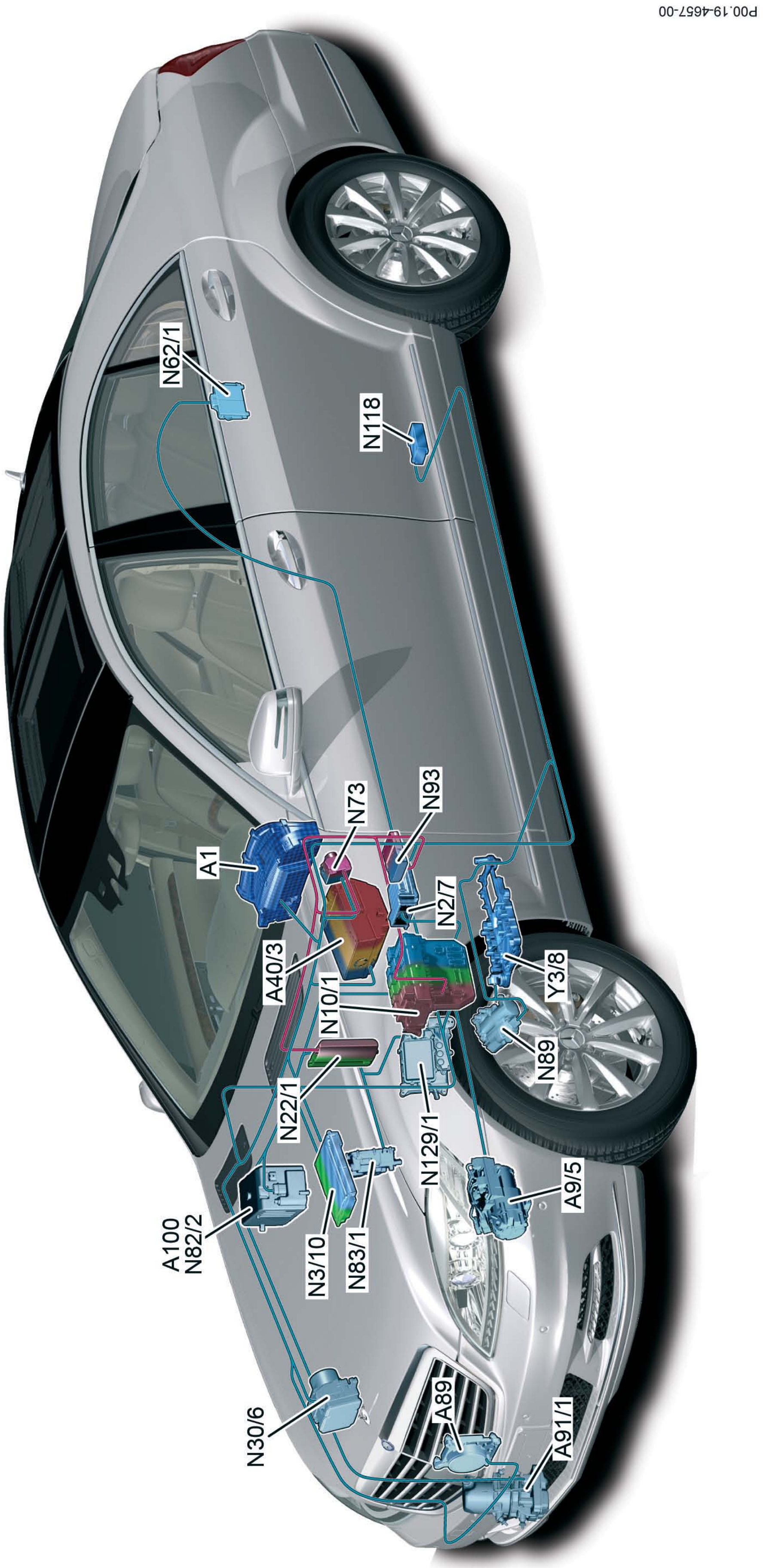
Immediate deactivation due to a fault takes place when the battery management system (BMS) control unit requests immediate switch off (opening) of the protection switches or a crash signal is present. In this case, limp-home mode (e.g. due to CAN failure) is deactivated.

A crash-dependent shutoff takes place if one of the following conditions is met:

- Crash signal via CAN
- Loss of crash signal redundancy line (circuit 30c)

The crash-dependent shutoff condition is only reset when the engine is restarted or the signal edge of circuit 15 rises.

Location of control units



Overview of arrangement of hybrid system control units

A1	*Instrument cluster*
A9 / 5	*Electric refrigerant compressor*
A40 / 3	*COMAND controller unit*
A89	*DTR controller unit (with DISTRONIC PLUS or adaptive cruise control)*
A91 / 1	*Electrohydraulic power steering*
A100	*High-voltage battery module*
N2 / 7	*Restraint systems control unit*
N3 / 10	*ME-SFI [ME] control unit*
N10 / 1	*Front SAM control unit with fuse and relay module*
N22 / 1	*AAC [KLA] control unit*
N30 / 6	*Regenerative braking system (RBS) control unit*
N62 / 1	*Radar sensors control unit (SGR) (with DISTRONIC PLUS or adaptive cruise control)*
N73	*EZS control unit*
N82 / 2	*Battery management system control unit (BMS)*
N83 / 1	*DC / DC converter control unit*
N89	*Additional transmission oil pump control unit*
N93	*Central gateway control unit*
N118	*Fuel pump control unit*
N129 / 1	*Power electronics control unit*
Y3 / 8	*Electric control unit (VGS)*

Networking of high-voltage/12 V on-board electrical systems

In addition to the energy flows in the high-voltage on-board electrical system, the energy management module in the ME-SFI [ME] control unit also controls voltage conversion and energy exchange from and to the 12 V on-board electrical system. To achieve this, the ME-SFI [ME] control unit communicates with the DC / DC converter control unit via the drive train sensor CAN and with the 12 V alternator via the drive train LIN. In order to ensure a continuous supply of electrical energy, the DC / DC converter is designed as a bidirectional DC voltage converter which converts high DC voltages into 12 V DC voltage and vice versa, as well as transferring DC voltages between the high-voltage and 12 V on-board electrical systems.

The system operates in the following modes depending on the operating condition:

- Charging / supporting the 12 V on-board electrical system
- Supporting the high-voltage on-board electrical system

Charging / supporting the 12 V on-board electrical system (buck mode)

The charging / supporting function for the 12 V on-board electrical system can only be performed if the following conditions are met:

- The engine must have run for at least one cycle first
- SOC value > 26%

The generation of electrical energy by the electric motor and DC / DC converter control unit is more efficient than via the belt-driven 12 V alternator. For this reason, the power supply for the 12 V on-board electrical system is provided solely via the DC / DC converter control unit. In the event of faults and in operating conditions which exceed the utilization capacity (1.5 kW power output) of the DC / DC converter control unit, the 12 V alternator is switched on to provide support (max. 3 kW) with the combustion engine running.

The supporting function for the high-voltage on-board electrical system (boost mode) can only be performed if the following conditions are met:

- The engine has not yet been started since the last time the ignition was switched on
- The charge level of the on-board electrical system battery is above the minimum value or an external power supply for the on-board electrical system is connected

If the battery output of the high-voltage battery is very low (< 8 kW) when the hybrid drive system is started but the charge level of the on-board electrical system battery is very high or an external power supply (12 V charger) is connected, energy can be transferred from the 12 V on-board electrical system to the high-voltage on board electrical system to allow the vehicle to be started.

Supporting the high-voltage on-board electrical system (boost mode) without external 12 V charger

If there is a risk that the vehicle cannot be started due to the low charge level of the high-voltage battery or due to low temperatures, the high-voltage battery receives support from the 12 V battery. This takes the form of a boost of max. 1 kW for the DC / DC converter. The support is provided from when the ignition is switched on until the combustion engine has started or the ignition is switched off.

Supporting the high-voltage on-board electrical system (boost mode) with external 12 V charger

If an external 12 V charger is connected and the DC / DC converter control unit measures a voltage greater than 12.8 V in the 12 V on-board electrical system with the engine hood open, energy is transferred at a maximum output of 500 W into the high-voltage on-board electrical system via the 12 V on-board electrical system battery and the DC / DC converter control unit and the high-voltage battery is charged (only with ignition ON).

Interlock

The interlock circuit serves to protect people who deal with the high-voltage on-board electrical system. The interlock circuit detects an open connector circuit in the high-voltage on-board electrical system.

Since capacitors are present in the high-voltage components, the high-voltage on-board electrical system is not immediately rendered voltage-free once the protection switch is opened. For this reason, an active rapid discharge function is incorporated in the high-voltage components. This discharges the high-voltage on-board electrical system to voltages below 60 V within 2 to 5 s.

If the interlock circuit is interrupted, this causes the protection switch in the high-voltage battery module to open and the high-voltage on-board electrical system to shut down.

In addition, accidents trigger a 2-stage crash shut-down procedure. This shuts down the high-voltage battery and discharges the high-voltage on-board electrical system:

- Stage 1: Reversible (without airbag triggering)
- Stage 2: Irreversible (circuit 30c shutoff via the pyrotechnical separator with airbag triggering)

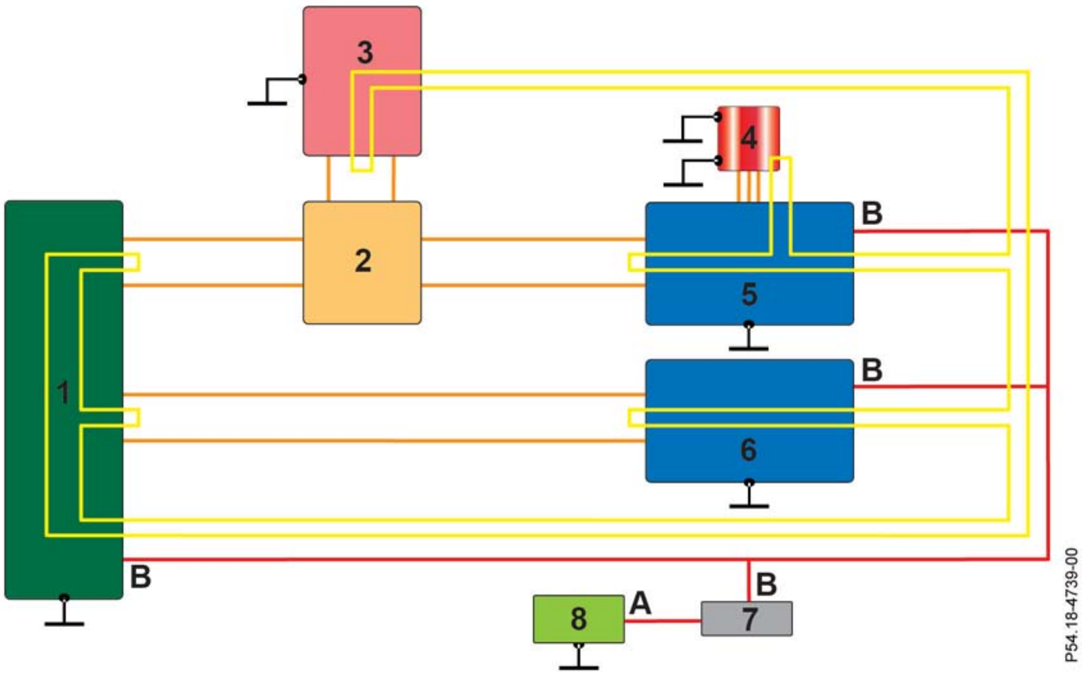
Furthermore, an additional signal line from the airbag control unit (restraint systems control unit) to the ME-SFI [ME] control unit and the battery management system (BMS) control unit ensures that the combustion engine is shut off and the protection switch is opened.

Interlock

The interlock signal (12 V / 88 Hz) is generated in the battery management system (BMS) control unit and transmitted to the following components over a series connection:

- DC / DC converter control unit
- Power electronics control unit
- Electric motor
- Electric refrigerant compressor

The battery management system (BMS), the drive system and the DC / DC converter control unit are equipped with a circuit to evaluate the interlock signal.



Interlock layout

1 Battery management system (BMS) control unit
2 High-voltage distribution
3 Electric refrigerant Kompressor
4 Electric motor
5 Power electronics control unit
6 DC / DC converter control unit
7 Pyrotechnical separator
8 12 V battery

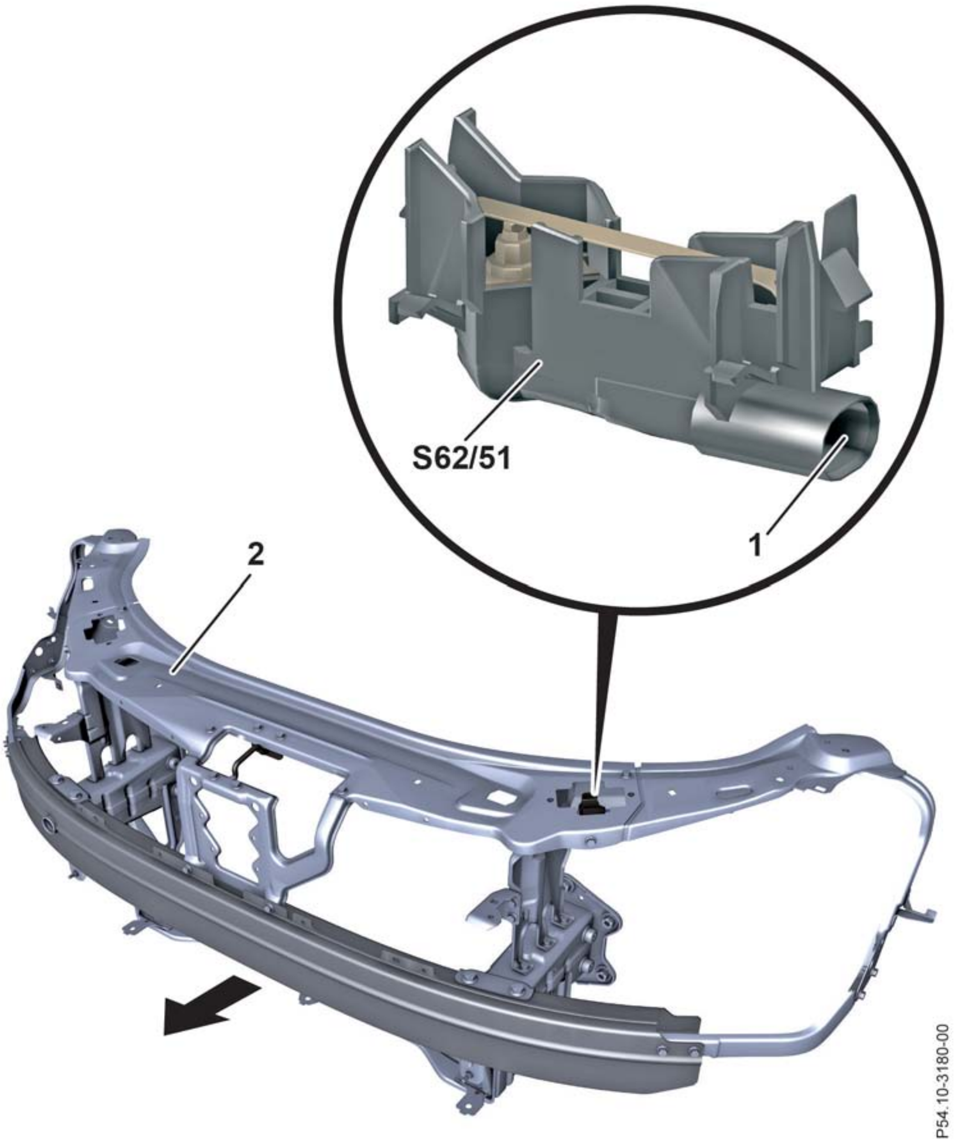
A Circuit 30
B Circuit 30c

Red 12 V line
Yellow Interlock signal line
Orange High-voltage line

Hybrid engine hood contact switch

A signal contact, which is evaluated in the engine control unit, is fitted to the engine hood. Safety precautions (e.g. shut off engine and prevent automatic engine start) are implemented depending on the boundary conditions (driving condition, driver seat belt buckle signal, driver door lock signal).

When the engine hood is closed, the contact switch opens its switching contact and the ground connection to the ME-SFI [ME] control unit is interrupted.



View of front module

1 Electrical plug connection
2 Front module

S62 / 51 Hybrid engine hood contact switch

Arrow Direction of travel

Diagnosis

As usual, diagnosis of the S 400 HYBRID is performed using the Diagnosis Assistance System (DAS). In addition to this, the following measures must be implemented for the diagnosis of the hybrid components:

- Legal requirements for carrying out diagnosis activities on hybrid vehicles:
  Personnel who perform diagnosis activities on vehicles with high-voltage on-board electrical systems must have completed a special course of qualification.

- General safety information on handling high-voltage on-board electrical systems:
  Components of high-voltage on-board electrical systems carry voltages of > 48 V.
  Touching these components can results in burns, spasms and damaged blood cells.
  Exposed lines or exposed, current-conducting contact points on high-voltage systems must not be touched under any circumstances. In particular, this applies to accident vehicles whereby it is not known whether the operating voltage is active or not.
  Persons who wear electronic implants (e.g. heart pacemakers) must not carry out work on high-voltage on-board electrical systems.

- Precautionary measures when working on high-voltage on-board electrical systems:
  Every component of the high-voltage on-board electrical system installed in the vehicle is identified by a yellow warning sticker.
  All electrical lines carrying high voltage are identified by a warning color (orange).

Warning sticker on components of the high-voltage on-board electrical system

Deenergization

To allow service operations to be performed without any risk of electric shock, the high-voltage on-board electrical system must be deenergized and protected against reactivation.

Only trained workshop staff (electrical technician for high-voltage on-board electrical systems in motor vehicles) may carry out work on a high-voltage on-board electrical system.

The system is deenergized by disconnecting the positive and negative terminals of the high-voltage battery from the rest of the high-voltage on-board electrical system. To do this, the plug connection on the high-voltage battery module is disconnected and replaced with the high-voltage activation lock. This prevents the high-voltage on-board electrical system from being reactivated.

The plug connections of the activation lock will be voltage-free a maximum of two minutes after the lock is installed. Service operations can then be performed.

High-voltage activation lock

High-voltage battery with high-voltage activation lock installed

Working on the vehicle

High-voltage safety precautions when working on a vehicle

In the event of an accident, shutoff of the high-voltage battery and discharge of the entire high-voltage on-board electrical system takes place in two stages:

- Triggering of emergency tensioning retractors, stage 1:
  This shutoff function can be reversed by switching the ignition on or off.
  Triggering of emergency tensioning retractors, stage 2:
  This shutoff function can only be reversed by trained personnel.

Deenergizing the high-voltage on-board electrical system before repair measures or after an accident. The latest procedure in DAS must be followed in order to deenergize high-voltage on-board electrical system:

1. Read out fault memory.
2. Shut off combustion engine by switching ignition off.
3. Disconnect the 12 V battery.
4. Disconnect the electrical connector for the high-voltage interlock (HVIL) on the battery management system (BMS) control unit. This causes the protection switches in the high-voltage battery module to open immediately.
5. Disconnect the connector between the high-voltage battery and the DC / DC converter.
6. Install and lock the high-voltage activation lock (keep the key in a safe place!)
7. Check that no voltage is present at the high-voltage activation lock.
8. Display the deactivation log in the vehicle so that it can be seen easily.

High-voltage safety devices in the vehicle

High-voltage interlock:

- The conducting loop runs through the entire high-voltage on-board electrical system.
- If the signal transmitted on the conducting loop is interrupted, the high-voltage on-board electrical system is deenergized and discharged.

High-voltage activation lock:

- When the electrical connector for the high-voltage interlock (HVIL) on the battery management system (BMS) control unit is disconnected by workshop personnel, the entire high-voltage on-board electrical system is shut off (HVIL open) and protected against reactivation through switching the ignition on.
- Installing the high-voltage activation lock provides additional protection against reactivation of the high-voltage on-board electrical system.

Galvanic separation:

- The high-voltage on-board electrical system is insulated from both the vehicle body and the 12 V on-board electrical system. The high-voltage on-board electrical system is thus safe in the event of isolated faults without the need for further safety precautions.

Monitoring of insulation resistance:

- Insulation faults are detected in the entire high-voltage on-board electrical system.
- Faults can be displayed on the display systems.

Protection against the dangers of electrical current:

- High-voltage components are protected against direct touching
- Components which carry high voltages during operation are identified by their color (orange cables)
- Warning messages on high-voltage components

Shutoff of the high-voltage on-board electrical system in the event of an accident through triggering of the pyrotechnical separator, which is actuated by the restraint systems control unit (crash detection):

- Disconnection of power sources and storage devices at all terminals.
- Deactivation of generator operation (both electric motor and DC / DC converter).
- Discharge of intermediate circuit capacitors to below the dangerous voltage range.

Shutoff of high-voltage on-board electrical system in the event of short circuit:

- Shutoff in stages in event of short circuit (software and fuse).

Active discharge:

- Protection from residual voltage through discharge of intermediate circuit capacitors to below the dangerous voltage range.

Requirements of service personnel

Workshop personnel must complete a high-voltage training course in order to be able to perform maintenance and repair work on hybrid vehicles. In addition, workshop personnel may only perform work on high-voltage components or remove high-voltage components if they meet the following requirements:

- Qualified as "electrical technician for high-voltage on-board electrical systems in motor vehicles"
- Completion of a high-voltage basic training course
- Completion of a high-voltage product training course

Before work is performed on high-voltage components or high-voltage components are removed, the required high-voltage safety precautions must be implemented and the deenergization status (DAS, instrument cluster) must be OK. If the deenergization status is not OK, the work may not be performed.

i Maintenance strategy

The S 400 HYBRID has the same service scope and same service items as the S 350 i.e. an optional PLUS package containing certain service items and a basic package.

The service scope, methods and labor times remain unchanged. The hybrid components installed in the vehicle such as the electric motor, high-voltage battery and the major assembly coordinator installed in the engine control unit are maintenance free.

Training

The workshop and qualification requirements for hybrid drive systems must be checked within the respective markets to ensure that they meet legal requirements (training, work safety etc.).

The trade association regulations which apply in Germany require that:

- Every workshop specialist who performs diagnosis or repair work on high-voltage on-board electrical systems must be qualified to do so
- Every workshop specialist must be instructed by his / her supervisor on all aspects of work safety for dealing with high-voltage components in motor vehicles

A two-stage training system for qualifying workshop personnel to work with electrical voltages > 48 V and the new technology in the vehicle is available for the S 400 HYBRID.

An overview of the training courses available can be found at the following address:

http: / / gt.intra.daimler.com / global_training

http: / / www.daimler.com / dc_gtraining

Note

Only trained workshop staff (electrical technician for high-voltage on-board electrical systems in motor vehicles) may carry out work on a high-voltage on-board electrical system.

Questions about the hybrid drive

What does "Hybrid" mean?

- The term "hybrid" comes from the Greek word "hybrida", which means "crossbreed" in English and refers to the fusion of two elements into a new whole. If the word "hybrid" is added to the front of a word, this refers to the fact that two objects of differing nature have been combined into one.

What is the difference between a hybrid drive and a conventional engine?

- A conventional vehicle is powered by an engine which uses fuel as a source of energy e.g. a gasoline engine, which runs on gasoline. On the other hand, a hybrid drive does not just have one power plant, it has at least two: a combustion engine and one or more electric motors. However, the S 400 HYBRID still only has to be fueled with gasoline because it generates the required electrical power itself. The S 400 HYBRID does not have to be connected to the power grid.

What are the advantages of a hybrid drive during day-to-day driving?

- Greater power with low consumption and lower emissions.

At what speed does the engine switch off?

- The stop procedure is initiated at speeds below 20 km / h.

Why does the vehicle still have a 12 V alternator but no starter?

- The DC / DC converter is not able to supply the 12 V on-board electrical system with power in every driving condition. Since a large number of comfort-related consumers are installed in the S-Class, the power requirement of the 12 V on-board electrical system can be up to 100 A, which corresponds to an output of 1.2 kW (12 V x 100 A = 1,200 W). There was not enough installation space available for a DC / DC converter of this capacity. This solution was therefore not implemented.
  The DC / DC converter installed in the vehicle can only supply an output of approx. 0.7 kW to the 12 V on-board electrical system. The efficiency of the DC / DC converter is greater than that of the 12 V alternator. This means that the power requirements are reduced despite the small size of the DC / DC converter.

What special safety precautions are in place for the hybrid technology?

- All cables of the high-voltage components are colored and feature safety notices.
- The entire high-voltage on-board electrical system features a generous amount of insulation and newly developed special connectors.
- The lithium-ion battery (high-voltage battery) is protected against impact in the engine compartment and housed in a newly designed, high-strength steel housing. The individual cells are also stored in a special gel which effectively dampens physical shock. The system also features a blow-off fitting with membrane and bursting disk (only activated in the event of multiple faults) and a separate cooling circuit which ensures that the high-voltage battery is cooled even if the combustion engine is damaged. An internal electronic controller permanently monitors the safety requirements and immediately indicates any malfunctions that occur.
- The battery terminals are separated from each other and all high-voltage components have separate wiring. All high-voltage components are connected to each other by an electric loop. The high-voltage on-board electrical system is automatically shut off in the event of a malfunction.
- The high-voltage on-board electrical system is instantaneously discharged when the ignition is switched off or in the event of a malfunction.
- In the event of an accident, the high-voltage on-board electrical system is completely shut off within fractions of a second.
- An electronic system continuously monitors the high-voltage on-board electrical system for short circuits and shuts off the high-voltage on-board electrical system in the event of malfunction.

Is a lithium-ion battery maintenance free?

- Yes

Can the high-voltage battery be charged by an external 12 V charger?

- Yes, if the required charging conditions are met (information about the charging process can be found in WIS).

Mechanical damage (collision between two vehicles) can cause internal short circuits in lithium-ion batteries. How are fires prevented?

- Safety valves in the cell and the safety devices of the electronics, such as fuses and switches ensure maximum protection against fire. The electronics provide redundant protection against fires resulting from battery overcharging.

What happens if the power electronics malfunction?

- If the electronic system malfunctions, the high-voltage on-board electrical system is shut off.

Abbreviations

ABS

Antilock Brake System

BMS

Battery Management System

CAN

Controller Area Network

DAS

Diagnosis Assistance System

DC

Direct Current (direct voltage)

ETS

Electronic Traction System

ESP

Electronic Stability Program

EZS

Electronic ignition switch

HVIL

High-Voltage Interlock

RBS

Regenerative Braking System

SOC

State of Charge

UVW

Terminal designation (3-phase AC voltage)

VGS

Fully electronic transmission control

WIS

Workshop Information System

Notes

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