



Drive

Fuel system

The M57TU engine is equipped with the common rail system (2nd generation Bosch, 1600 bar nominal pressure) familiar from the M47TU.

- Changes

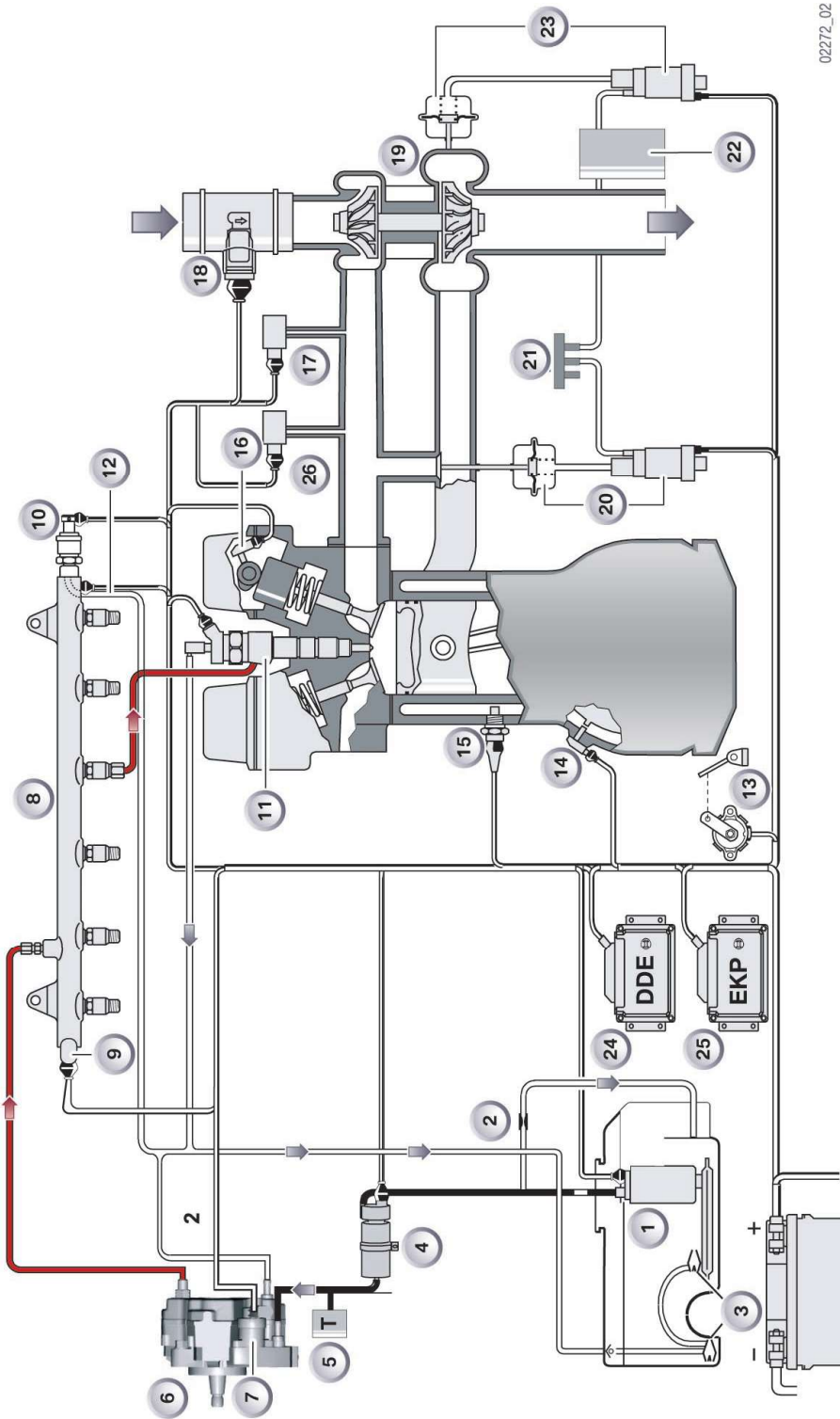
The common rail system of the M47TU was adapted to the 6-cylinder M57TU engine in the following areas:

- High pressure pump with increased delivery capacity.
- The electric fuel pump is equipped with volume control and a separate control unit.
- No auxiliary electric pump.
- The fuel filter is equipped with an electric heater.
- A temperature sensor is used for monitoring the fuel temperature in the feed line.



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System overview



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Fig. 16: Fuel system M57TU

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Index	Explanation	Index	Explanation
1	Electric fuel pump	14	Crankshaft incremental sensor
2	Return restrictor	15	Coolant temperature sensor
3	Suction jet pump	16	Camshaft sensor
4	Heated fuel filter	17	Boost pressure sensor
5	Fuel temperature sensor	18	Hot-film air mass meter (HFM)
6	High pressure pump CP3.2+	19	Turbocharger (VNT)
7	Volume control valve	20	Vacuum unit and solenoid valve for EGR
8	High pressure accumulator (rail)	21	Vacuum distributor
9	Rail pressure sensor	22	Vacuum reservoir
10	Pressure control valve	23	Vacuum unit and solenoid valve for VNT
11	Fuel injector	24	Control unit: Digital diesel electronics (DDE)
12	Return from pressure control valve	25	Control unit: Electric fuel pump
13	Pedal position sensor	26	Charge air temperature sensor



Drive

System function

In the first generation common rail system, the rail pressure is controlled by a pressure control valve on the high pressure pump. The high pressure pump delivers the maximum fuel volume irrespective of the various operating statuses. The fuel is heated by the high pressure produced by the pump running continuously at its maximum delivery rate. In connection with a heat exchanger (fuel cooler) located in the fuel return, the fuel gives off energy in the form of heat.

Two-actuator concept

The two-actuator concept comprises fuel volume control before the high pressure pump followed by pressure control at the rail.

Pressure in the rail is controlled by the pressure control valve only during starting and when the coolant temperature is below 19 °C. Fuel volume control does not take place thus ensuring the fuel heats up at a rapid rate. The pressure control valve is still briefly actuated while coasting by way of rapid pressure reduction.

The volume control valve on the high pressure pump controls the fuel volume in all other operating modes. Pressure control by the pressure control valve is not active.

The volume control valve on the intake side of the high pressure pump is actuated by the DDE control unit. The volume control valve controls the pump delivery volume such that the high pressure pump only delivers the amount of fuel that is actually required. This results in a lower surplus quantity of fuel and therefore in distinctly lower heating of the fuel.



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Advantages

Volume control reduces the power demand of the high pressure pump in the engine part-load range. This results in reduced fuel consumption of up to 6% depending on the engine operating point.

The associated lower heating of the fuel in connection with pressure generation renders the fuel cooler in the engine compartment unnecessary.

Multiple injection

The introduction of the second generation common rail facilitates finer distribution of the fuel injection per power stroke.

Instead of injecting the fuel in two stages per power stroke (pre-injection for minimizing noise and main injection for developing power) as was previously the case, the fuel is now injected in up to 3 stages. As a result, the engines run even more quietly and produce less nitrogen oxides and soot particles.

Operating range	M47TU	M57TU	M67 (E65)
Near idle speed	1 pre-injection 1 main injection	2 pre-injections 1 main injection	1 pre-injection 1 main injection
Partial load	1 pre-injection 1 main injection	1 pre-injection 1 main injection 1 post-injection	1 pre-injection 1 main injection
Full load	1 pre-injection 1 main injection	1 pre-injection 1 main injection	1 pre-injection 1 main injection
Maximum output	1 main injection	1 main injection	1 main injection

The following factors enable triple injection:

- Increased processor capacity of the DDE
- Higher efficiency of the coils in the fuel injectors



Drive

- High pressure pump

The volume-controlled high pressure pump CP3.2+ (Bosch) is used on the M57TU. At 866 mm³, it now has a greater delivery volume per revolution than the CP3.2 (677 mm³) used on the M47TU.

High pressure pumps CP3.2/CP3.2+ are no longer fitted with an integrated pre-supply pump (gear pump). Volume control has rendered such a pre-supply pump unnecessary.

The design and functional principle correspond to the high pressure pump CP3.2 known from the M47TU.

Functional principle

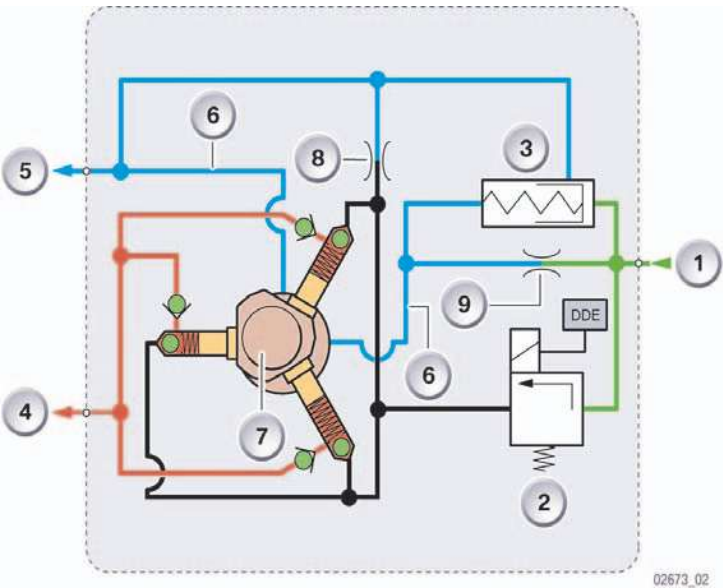


Fig. 17: Functional principle of the high pressure pump

Index	Explanation	Index	Explanation
1	Feed	6	Line for lubricating the drive cam and leakage oil return
2	Volume control valve	7	Drive cam
3	Overflow valve	8	Zero delivery restrictor
4	High pressure connection to rail	9	Throttle for drive cam lubrication
5	Return		

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The electric fuel pump supplies fuel to the high pressure pump via the feed line (1).

The high pressure pump accommodates three pistons that are raised by a common triple cam (7). Springs press the pistons against the drive cam.

Each cylinder of the high pressure pump features ball valves for fuel inlet and outlet.

The volume of fuel calculated by the DDE flows via the volume control valve (2) into the cylinders of the high pressure pump.

During the downward stroke of the pistons, the fuel flows from the volume control valve into the cylinders of the high pressure pump.

Due to the downward movement of the pistons, the fuel is delivered at high pressure into the rail (4).

The drive cam is lubricated by the diesel fuel. For lubrication purposes, a quantity of the fuel flows from the feed (1) via throttle (9) and line (6) to the drive cam and from here into the return (5) of the high pressure pump.

An overflow valve (3) is integrated in the high pressure pump. The fuel now released for delivery by the volume control valve flows via the overflow valve into the return of the high pressure pump.

A small quantity of fuel can leak out of the closed volume control valve. To ensure this leakage fuel does not reach the main fuel delivery, it is routed via the zero delivery restrictor (8) into the return flow (5).



Drive

- High pressure fuel rail

The high pressure fuel rail is mounted on the cylinder head. The rail sensor and the pressure control valve are secured on the rail. The rail is adapted to the increased pressure requirements (1600 bar).

- Rail pressure sensor

The rail pressure sensor is located on the front of the rail.

It measures the current pressure in the rail and sends a voltage signal, corresponding to the applied pressure, to the DDE.



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Fig. 18: Rail pressure sensor

The rail pressure sensor and the pressure control valve are adapted to the pressure ranges of the 2nd generation common rail system.



Drive

- Pressure control valve

The pressure control valve is located at the rear of the rail.



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Fig. 19: Pressure control valve

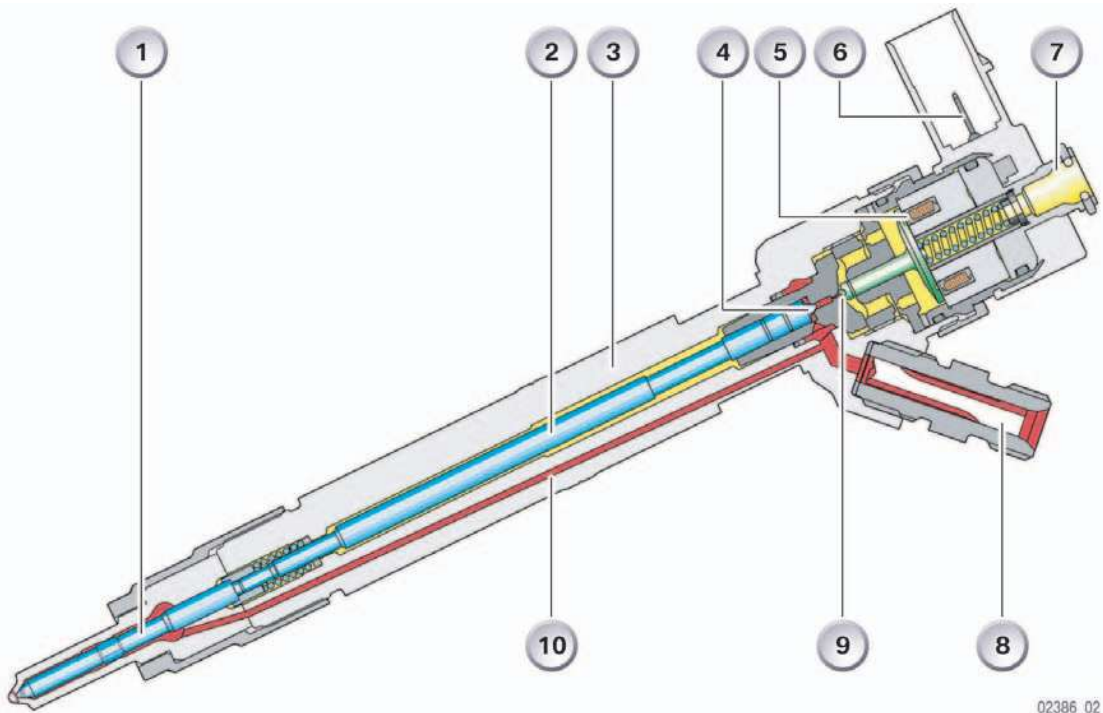
The purpose of the pressure control valve is to control the pressure in the rail while starting the engine and when the coolant temperature is below 19 °C. It is actuated by the DDE control unit.



Drive

- Fuel injectors

The fuel injectors have been designed to comply with the more demanding requirements of the 2nd generation common rail system. Their operating principle remains unchanged.



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Fig. 20: Fuel injector

Index	Explanation	Index	Explanation
1	Nozzle needle	6	Electrical connection
2	Valve control spool	7	Fuel return
3	Housing	8	Fuel supply
4	Valve control chamber	9	Valve ball
5	Actuator unit (2/2-way solenoid valve)	10	Supply channel to nozzle

M57TU Engine

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Drive

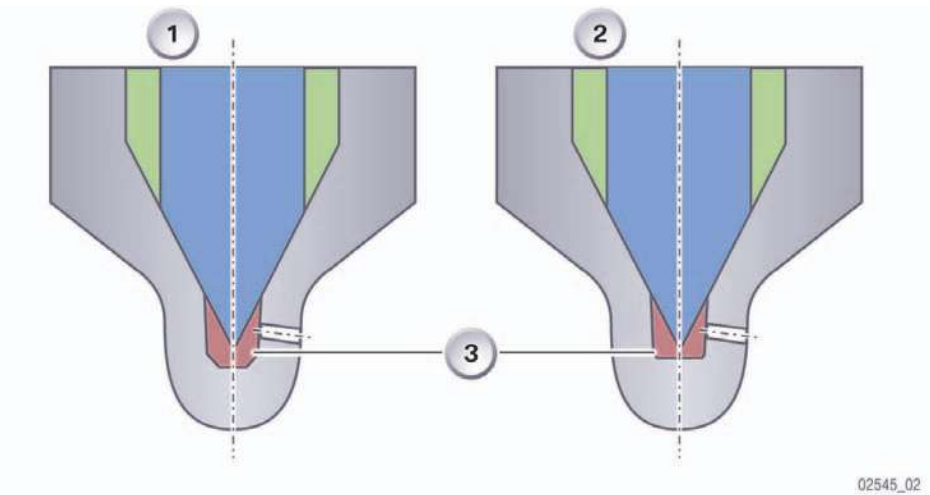
Technical data

Armature opening and closing time:	200-250 μ s
Pickup current:	20 A max. 450 μ s
Holding current:	12 A max. 4000 μ s
Shortest actuation interval:	0.8 ms (previously: 1.8 ms)
Pressure range:	250 to 1600 bar (start from 120 bar)
Holes:	6
Maximum flow:	450 cm ³



Drive

Micro-blind hole nozzle



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Fig. 21: Comparison of mini and micro-blind hole nozzle

Index	Explanation	Index	Explanation
1	Mini-blind hole nozzle	3	Blind hole
2	Micro-blind hole nozzle		

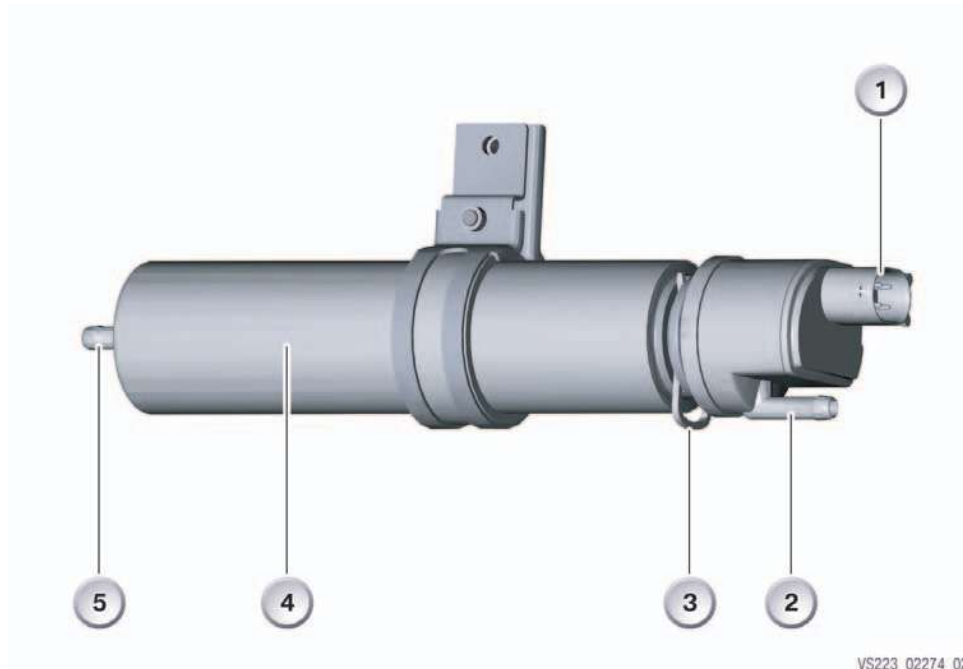
Using micro-blind hole nozzles instead of mini-blind hole nozzles reduces the hydrocarbon content of the exhaust gas by approximately 30%. The volume (3) of the blind hole in the micro-blind hole nozzle has been reduced thus decreasing the volume of fuel in the blind hole.

With the nozzle needle closed, correspondingly less residual fuel can flow from the blind hole into the combustion chamber.



Drive

- Fuel filter with electric filter heater



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Fig. 22: Fuel filter

Index	Explanation
1	Electrical connection
2	Line connection from electric fuel pump
3	Retaining clip
4	Fuel filter
5	Line connection to high pressure pump

The electric filter heater prevents paraffin separation in the diesel fuel in winter.

The fuel filter with electric heater is secured crash-safe on the left of the underbody.

The filter heater is inserted in the fuel filter housing and secured with a clip to prevent it falling out. Simple replacement of the fuel filter is therefore possible.



Drive

Functional principle

The fuel flows through the electric filter heater (380 W) into the filter element.

The electric filter heater features an electronic control circuit with a pressure switch and a temperature sensor. The pressure switch and temperature sensor are positioned at the inlet to the fuel filter.

The electric fuel heater switches on under the following conditions depending on the fuel pressure **and** fuel temperature:

- On exceeding a certain fuel pressure (in filter inlet) by cold, viscous fuel.
- On exceeding a certain temperature value (below 2 °C) of the diesel fuel.

The electric heating element is powered via terminals 30. The heating element is activated (terminal 31) on the ground side directly by the integrated electronic control circuit. Voltage is supplied to the electronic control via terminal 15.

The filter heater is normally not switched on during operation with winter diesel.

- Fuel temperature sensor

Installation location

The fuel temperature sensor is located in the feed line between the fuel filter and high pressure pump (see Chapter DDE5.0 for functional description).



Drive

- Electric fuel pump with volume control

The in-tank pump delivers fuel from the fuel tank to the high pressure pump.

The fuel is delivered load-dependent by a control system based on the engine requirements. This system provides the following advantages:

- The charge status of the alternator and battery is improved by the low power requirements of the fuel pump.
- The low power intake also reduces the amount of heat given off by the fuel pump, resulting in reduced fuel heating in the fuel tank.
- Extended service life of the fuel pump.
- No fuel pump relay.

Installation location

The electric fuel pump is located in the fuel tank. The control unit for the electric fuel pump in the E60 is located in the luggage compartment on the rear right wheel arch. In the E65 electric fuel pump control is integrated in the right B-pillar satellite (SBSR).

Design

The fuel pump is designed as a two-stage internal gear pump.

The first stage is the presupply stage. It supplies bubble-free fuel to the pair of internal gears designed as the second delivery stage. Both stages are driven by a common electric motor.



Drive

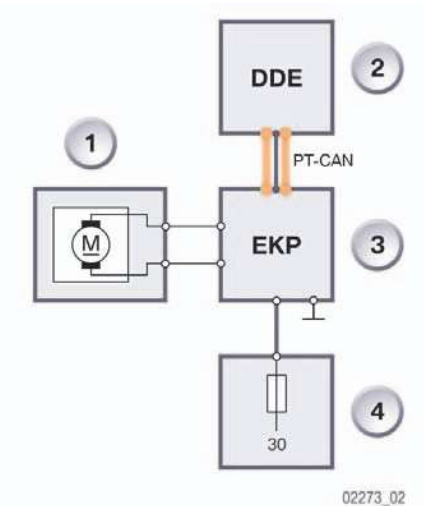
Control matching engine requirements (E60)

The DDE sends the fuel requirement via the PT-CAN to the control unit of the electric fuel pump.

The control unit for the electric fuel pump uses a pulse width-modulated signal corresponding to the amount of fuel required by the engine to drive the electric fuel pump.

In the electric fuel pump control unit, the current pump speed is determined from the power intake of the fuel pump and the delivered fuel volume derived from this value.

Following correction based on the relevant pump speed (PWM control voltage), the required delivery volume is then set via the delivery characteristic curve coded in the fuel pump control unit.



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Fig. 23: Activation of electric fuel pump in E60

Index	Explanation
1	Electric fuel pump
2	Digital diesel electronics (DDE)
3	Electric fuel pump control unit
4	Rear power distribution box



Drive

Control matching engine requirements (E65)

Electric fuel pump control and fuel cut-out in the event of a crash are an integral part of the ISIS (Intelligent Safety Integration System).

The DME transmits the fuel requirement via PT-CAN and *byteflight* to the right-hand B-pillar satellite (SBSR).

Electric fuel pump control is integrated in the SBSR. (The SBSR controls the front right seat belt force limiter and the fuel pump.)

The SBSR uses a pulse width-modulated signal corresponding to the amount of fuel required by the engine to drive the electric fuel pump.

In the SBSR, the current pump speed is determined from the power intake of the fuel pump and the delivered fuel volume derived from this value.

Following correction based on the relevant pump speed (PWM control voltage), the required delivery volume is then set via the delivery characteristic curve coded in the SBSR.



Drive

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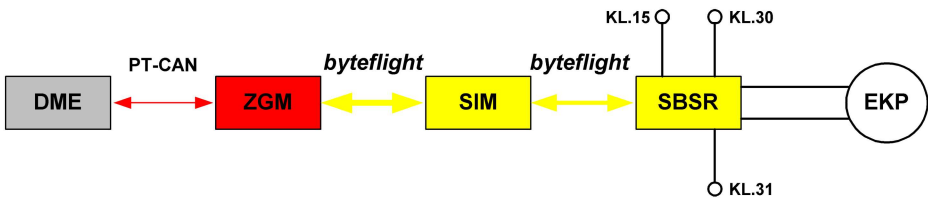


Fig. 24: Fuel request signal progression

Index	Explanation
DME	Digital Motor Electronics
PT-CAN	Powertrain CAN
ZGM	Central Gateway Module
byteflight	byteflight
SIM	Safety and Information Module
SBSR	B-pillar satellite, right
EKP	Electric fuel pump
KL.15	Terminal 15
KL.30	Terminal 30
KL.31	Terminal 31

Possible faults/effects

In the event of the fuel volume requirements signals from the DDE and the pump speed signal in the electric fuel pump control unit failing, the fuel pump continues to operate at maximum delivery rate with terminal 15 activated.

This ensures fuel supply is maintained even if the control signals fail.