Note

Sensor wheel adaptation must be carried out after replacing a DME control unit or increment wheel. If only the increment wheel is replaced, the sensor-wheel adaptation must first be deleted (disconnect control unit from power supply for 5 minutes). Sensor wheel adaptation is implemented automatically as soon as the engine is operated in overrun condition for at least 10 seconds. See sensor-wheel adaptation.

Note

After conducting repairs on the pedal position sensor or EML control unit it is possible that the vehicle does not respond to the throttle control system. In this case, pedal position sensor adaptation must be carried out (see EML).

Changes Compared to the Previous Digital Motor Electronics DME M1.7, 12-Cylinder M70

M1.7 M70	M5.2 M73
No knock control	2 knock sensors per row of cylinders
1 inductive pulse generator (cylinder reference sensor) at ignition lead, cylinder 6	1 Hall sensor (camshaft sensor) on camshaft of cylinder row cyl. 1...6
2 air mass meters	2 hot-film air mass meters
1 intake air temperature sensor per row of cylinders	1 intake air temperature sensor (for cylinder row, cyl. 7...12)
2 engine temperature sensors in one joint housing	1 engine temperature sensor on cylinder row, cyl. 1...6
1 tank ventilation valve per row of cylinders "open with no power applied" as soon as vacuum builds up in intake system and the mechanical non-return valve opens	1 tank ventilation valve per row of cylinders "closed with no power applied".
1 oxygen sensor per row of cylinders ahead of catalytic converter	4 oxygen sensors: 1 oxygen sensor per row of cylinders before and after the catalytic converter
-	New spark plugs and smaller, lighter ignition coils
Speed signal from instrument cluster	Speed signal from ABS/DSC control unit
No secondary air pump	1 secondary air pump to improve exhaust gas at cold start
1 fuel pump and one EKP relay per row of cylinders	1 fuel pump and 1 EKP relay activated by both DME control units

No CAN-bus	Data exchange between DME control units via CAN-bus
No automatic start	Automatic start. If the DME detects a signal from terminal 50, the starter relay is activated directly by the DME control unit. The relay is triggered once the engine has started (detection via speed signal).

DME Control Units

2 DME control units operate in this system. The DME control unit I supplies the row of cylinders 1 (cylinders 1...6), the identical control unit supplies the row of cylinders II (cylinders 7...12). For the purpose of differentiation in diagnosis mode, Pin 48 on control unit II is connected to ground. Relevant components are mostly installed in duplicate. Exceptions are:

- Start relay

- Start lock-out relay

- Camshaft sensor

- Intake temperature sensor

- Engine temperature sensor

- Secondary air pump

- Electrical fuel pump

- EKP relay (electrical fuel pump)

The DME control units are connected with following systems:

- Adaptive transmission control AGS

- Electronic throttle control EML

- Dynamic stability control DSC

- Instrument cluster electronics IKE

- Central body electronics ZKE

- Antitheft system DWA via ZKE

- Multi-information display MID via IKE

The digital motor electronics DME undertakes following functions:

- Cylinder-individual injection with correction feature

- Ignition

- Ignition circuit monitoring

- Cylinder-selective, adaptive knock control with 2 sensors per row of cylinders

- Idle control via throttle valves of electronic throttle control EML

- Lambda control

- Load setting via hot-film air mass meter HFM

- Incremental system for engine speed and reference mark signal

- Cylinder reference by inductive pulse generator on camshaft gear

- Electrical fuel pump activation (EKP) with safety lockout function at speed zero

- Characteristic map-controlled tank ventilation

- DSC engine intervention (dynamic stability control)

- Drive-away protection via antitheft system (DWA), multi-information display MID or electronic drive away inhibit EWS

- Characteristic map programming

- Idle CO adjustment (vehicles without lambda control)

- Secondary air pump control

- Interface to AGS via CAN (Controller Area Network) data bus

- Ignition timing (angle) intervention by adaptive transmission control (AGS)

- Self-diagnosis and emergency operation characteristics

The EML undertakes following functions:

- Engine speed limitation

- Speed limitation by V-signal

- The idle system is controlled by the DME and carried out by the EML by correspondingly positioning the throttle valve.

- Maximum speed limitation takes place directly by reducing the throttle angle.

Injection

The DME control unit calculates the correct injection timing on the basis of the engine speed, air mass, throttle position, oxygen sensor voltage, engine and intake air temperature. A change in the fuel-air mixture is achieved on the basis of the opening duration of the fuel injectors. The battery or system voltage is also included in the calculation for the injection timing since the pickup and dropout times of the fuel injectors are extended as the voltage drops.

Each fuel injector is activated by its own output stage. This facilitates precise metering of the injection quantity and rapid response to load change.

Once the start procedure has been initiated, fuel is injected cylinder-selective 1 x per working cycle (2 crankshaft revolutions).

The injection timing (ti) is derived from the programmed basic start injection quantity and the correction variables from the input signals of the coolant and intake air temperature. Cylinder activation is based on the reference mark generator signal (crankshaft signal generator).

The DME M5.2 features cylinder-individual fuel injection CIFI. The term CIFI refers to individual activation of each cylinder. The system ensures that fuel injection of each cylinder is completed before the the inlet valve opens. An optimum fuel-air mixture and thus improved combustion with low fuel consumption is achieved in this way.

Injection of each cylinder can be deactivated individually if a fault occurs in the ignition or injection system. These faults are then also stored in the defect code memory.

Ignition

The ignition timing (ignition angle) is determined by the DME control unit on the basis of the engine speed and load signals and output via the ignition output stages. This procedure also takes into account other input signals such as the engine temperature, intake air temperature, throttle valve position and signals from the electronic throttle control EML, dynamic stability control DSC and adaptive transmission control AGS.

The engine speed and battery or system voltage are decisive with regard to the time available to build up the primary voltage in the ignition coil. From these variables, the digital motor electronics then determines the necessary dwell angle thus ensuring adequate ignition voltage under all operating conditions.

Misfiring detection

Misfiring causes irregularities in the rotational speed of the crankshaft. These irregularities can be detected by way if changes in the segment time.

Segment times (time, in which a certain number of teeth on the increment wheel move past the sensor) are constantly determined via the reference mark sensor (= crankshaft sensor). These segment times are constantly checked during engine operation. In the event of a fault, a defect code is stored and injection of the corresponding cylinder is deactivated.

Note

Sensor wheel adaptation must be carried out after replacing a DME control unit or incremental wheel. If only the incremental wheel is replaced, first the sensor-wheel adaptation must be deleted (disconnect control unit from power supply for 5 minutes). Sensor-wheel adaptation is implemented automatically as soon as the engine is operated in overrun condition for at least 10 seconds. See sensor-wheel adaptation.

Ignition circuit monitoring

Misfiring below an engine speed of 3000 rpm is detected by the misfiring detection system. Above 3000 rpm misfiring is detected by the ignition circuit monitoring (self-diagnosis) and prevents damage to catalytic converters.

The secondary circuit monitoring operates with a "shunt" (resistor in secondary ground line).

If, after successful ignition, the threshold voltage for misfiring detection is not reached, a defect code is stored, the fault lamp activated (US models only) and the corresponding row of cylinders deactivated.

Deceleration fuel cutout

If the throttle is closed and the engine speed is above approx. 800 rpm, the deceleration fuel cutout is activated in order to reduce consumption. The DME blanks out the fuel injection and shifts the ignition timing (angle) in retard direction until the engine speed has dropped to below the cut-in speed. Below this speed, the injection is reactivated and the ignition timing drifts back in advance direction.The cut-in speed is dependent on the engine temperature and the drop in engine speed.

Acceleration enrichment

A sudden change in the throttle position in full load direction causes the digital motor electronics to increase the injection quantity for the duration of the acceleration procedure. This process takes into consideration the criteria of maximum torque, clean exhaust gas and no acceleration knocking.

Knock control

Tasks of the knock control system

Operation of an engine with knocking combustion over a prolonged period can lead to serious damage. Knocking tendency is increased by:

- Increased compression ratio

- High cylinder charge

- Poor fuel quality (RON/MON)

- High intake air and engine temperatures

The compression ratio can also reach excessively high values due to deposits or production-related scatter.

On engines without knock control, these unfavourable influences must be taken into consideration in the ignition design by providing a safety distance to the knock limit. However, this results in unavoidable losses in efficiency in the upper load range.

The knock control can prevent knocking engine operation. For this purpose, it retards the ignition timing of the cylinder(s) concerned (cylinder-selective) as far as necessary only when there is an actual danger of engine knocking. In this way the ignition characteristic map can be laid out to combustion-optimum values without having to take the knock limit into consideration. A safety distance is no longer necessary.

The knock control system carries out all knock-related corrections to the ignition timing and enables perfect operation also with regular grade fuel (minimum RON 91).

The knock control provides:

- Protection against knocking damage also under unfavourable conditions

- High efficiency due to optimum utilisation of the fuel quality and consideration of the relevant engine status

- Logistics advantages with regard to fuel availability

- Lower consumption and higher torque over the entire upper load range (corresponding to the fuel quality used).

Design of knock control system

The M73 is equipped with a cylinder-selective, adaptive knock control system. Two knock sensors per row of cylinders detect knocking combustion. The sensor signals are evaluated in the DME control units.

- Increased compression ratio

- High cylinder charge

- Poor fuel quality (RON/MON)

- High intake air and engine temperatures

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- High efficiency due to optimum utilisation of the fuel quality and consideration of the relevant engine status

- Logistics advantages with regard to fuel availability

- Lower consumption and higher torque over the entire upper load range (corresponding to the fuel quality used).

The knock sensor is a piezo-electric structure-borne noise microphone. It picks up the structure-borne noise and converts it into voltage signals.

Function of the knock control system

If knocking occurs, the ignition is retarded for a certain number of working cycles and then gradually approaches the original value.

A defect is stored in the defect code memory of the DME control unit in the event of a knock sensor failing. In this case, both rows of cylinders are always protected by constant retard setting of the ignition timing (knock protection function in DME control unit I and II) .

Installation Locations/Conditions

The 4 knock sensors are secured with 8 mm screws on the cylinder heads of the engine block between the two rows of cylinders. They are arranged in such a way that one sensor monitors three adjacent cylinders.

Only screw locking compound may be used to lock the screws. Washers, spring washers or serrated lock washers must under no circumstances be used.

Self-diagnosis and emergency operation of the knock control system

Self-diagnosis of the knock control system includes following checks:

- Check for sensor signal interference/line break, plug connector defective etc.

- Self-test of entire evaluation circuit

- Check of the basic engine noise level recorded by the knock sensors

The knock control system is switched off if a fault is found during the course of one of these checks. The emergency program adopts the task of controlling the ignition timing. At the same time, a defect code is stored in the defect code memory. The emergency program ensures damage-free operation as of minimum RON 91. It is dependent on the load, speed and temperature of the engine.

The diagnosis procedure cannot detect whether the plug connectors of the sensors have been interchanged. The engine can be damaged if the sensors are interchanged. Particular care must therefore be taken during service work to ensure that the sensors are connected correctly (see repair instructions).

Lambda control on models with catalytic converter

In order to maintain optimum efficiency of the catalytic converters, the system endeavours to provide the ideal air-fuel mixture ratio (Lambda = 1) for combustion. 2 heated oxygen sensors (in front and behind the catalytic converter) serve as the sensors which measure the residual oxygen in the exhaust gas and transfer corresponding voltage values to the control unit. Here, if necessary, the mixture composition is corrected accordingly in that the injection timing is varied. The operability of the catalytic converter (conversion efficiency) is monitored via the oxygen sensor behind the catalytic converter.

The heating resistors in the oxygen sensors are supplied with a voltage since a temperature of approx. 300 °C is necessary for effective operation of the oxygen sensors.

Hot-film air mass meter

A heated surface of the hot-film sensor in the flow of intake air is controlled to a constant overtemperature with respect to the intake air. The intake air flowing past cools the heated surface and thus changes its resistance. The heating current which is necessary in order to maintain the constant temperature is the measurement variable for the air mass drawn in. The DME control unit uses this variable to calculate the injection timing.

Important advantages:

- Changes in air pressure (air density) are recorded

- Temperature influences are compensated

- No moving parts

- Large measuring range

The hot-film air mass meter renders unnecessary clear-burning of the sensor after the engine has been shut down. Any dirt deposits on the surface do not influence the sensor signals directly since the protective film cleans itself due to the constant overtemperature.

Tank ventilation on models with catalytic converter

The ventilation line of the fuel tank is connected to an activated carbon filter (carbon canister), in which the fuel vapours produced in the tank are collected. The activated carbon filter is connected by a further line to the air manifold. A tank ventilation valve is integrated in this line.

When the tank ventilation valve is open, fresh air is drawn in via the activated carbon filter due to the vacuum in the air manifold. The fresh air flushes out the fuel collected in the filter and feeds it to the engine for combustion.

Since this additionally supplied fuel-air mixture has a considerable effect on combustion, the tank ventilation valve is designed as an electrically controlled valve. The tank ventilation valve is closed when no power is applied.

After starting, the first flushing phase is initiated in that the tank ventilation valve is activated for approx. 6 minutes (348 seconds). The valve is then closed for 100 seconds in order to implement basic adaptation. Once basic adaptation has been completed successfully, the subsequent flushing phase has a duration of 90 minutes (5400 seconds). Otherwise a further short flushing phase (approx. 6 minutes) takes place. In order to conclude basic adaptation successfully, the engine must idle and run in the part-load range.

CO-correction on models without catalytic converter

Correction can be carried out by a compensating value in the DME control unit. This Co-correction can be carried out solely via the corresponding diagnosis program with DIS or MoDiC.

Adaptations

The fuel-air mixture formed in the intake tract requires a certain period of time until is reaches the oxygen sensor in the form of exhaust gas. This time decreases as load and engine speed increase. For this reason, the response time of the emission (lambda) control system is also dependent on load and engine speed. Fuel-air mixture deviations detected by the oxygen sensor result in adaptation values (learned correction values) being stored. By way of the adaptations, the injection can be brought close to the nominal value in advance.A reduction in the response time is achieved in this way.

For instance, if the basic injection values of the DME characteristic map are too low during idling or in order to maintain the ideal fuel-air mixture, the emission (lambda) control system would have to constantly increase the injection timing. In this case, an adaptation value is learnt which corrects the basic injection value. The emission (lambda) control then only needs to undertake the fine adjustment.

Following adaptations are performed during engine operation:

Tank ventilation adaptation

When the tank ventilation valve is open, an additional combustible mixture is supplied from the activated carbon filter to the engine. The shift in mixture detected by the oxygen sensor is completely corrected out by means of the tank ventilation adaptation value.

Idle air adaptation

The task of idle air adaptation is carried out by the idle actuator. On the basis of the air volume it ensures a constant idle speed.

Idle mixture adaptation

If idling is detected on the basis of the throttle position during the rest phase of the tank ventilation system, idle mixture adaptation takes place at certain intervals.

Partial load mixture adaptation

Also in the partial load range, mixture adaptation takes place at certain intervals. The determined adaptation value is taken into consideration in all partial load ranges.

Sensor-Wheel Adaptation

Misfiring causes irregularities in the rotational speed of the crankshaft. These irregularities can be detected on the basis of changes in the segment time.

Segment times (time which a certain number of teeth on the increment wheel move past the sensor) are constantly determined via the reference mark sensor (= crankshaft sensor). These segment times are constantly checked during engine operation. In the event of a fault, a defect code is stored and the injection of the corresponding cylinder deactivated. Refer to misfiring detection.

In order to avoid incorrect evaluation, sensor-wheel adaptation must be carried out after replacing a DME control unit or increment wheel. If only the increment wheel is replaced, first the sensor-wheel adaptation must be deleted (disconnect control unit from power supply for 5 minutes).

The sensor-wheel adaptation determines the irregularity of the increment wheel and takes it into consideration when evaluating the segment times. Sensor-wheel adaptation is implemented automatically as soon as the engine is operated in overrun condition for at least 10 seconds.

Intake air temperature sensor (NTC-I)

The intake air temperature sensor is mounted in the clean air bowl of the air cleaner. A precision NTC resistor is used to convert the "temperature" into a measurement value "resistance" which can be evaluated electrically by the DME control unit.

The intake air temperature sensor is not required for correction of the injection timing since the intake air temperature is taken into consideration automatically during air mass measurement. The intake air temperature sensor (NTC-I) is required during the start procedure in conjunction with the coolant temperature sensor (NTC-II). The resistance values of both sensors supply exact information for calculating the injection timing. In this way hot start problems in particular are avoided.

Speed signal

The input of the driving speed signal (V-signal) is required in the DME control unit for several functions.

- On vehicles with the air conditioning switched on compressor activation is interrupted up to a driving speed of 13 km/h when accelerating under full load.

- Idle control

- Increasing deceleration fuel cutout. At a very low driving speed, the threshold for the deceleration fuel cutout is increased in order to avoid the engine stalling (e. g. driving over curbstone).

- Poor road detection. Poor road conditions also influence smooth running of the engine and can be interpreted as misfiring by the misfiring detection function. In order to avoid this situation, the misfiring detection function is blanked out for as long as poor road conditions are detected.

Dynamic stability control DSC

The dynamic stability control is integrated in the ABS/DSC control unit. The rotational speeds of the wheels are monitored by sensors. Too high a speed difference between driven and non-driven wheels is detected as wheel slip. In addition, the system detects whether the vehicle is oversteered or understeered with the aid of the steering angle sensor.

Depending on the severity of the necessary intervention, the DSC initiates following measures:

For drive slip control:

- The EML control unit reduces the throttle opening

- The DME control unit adjusts the ignition timing in retard direction

- The DME control unit blanks out injection and ignition

- Spinning drive wheel is braked

For engine drag torque control:

- The EML control unit increases the throttle opening

Secondary air system

An electrical secondary air pump which ensures rapid heating of the catalytic converter is used to subsequently treat the exhaust gas during the start phase. During the start phase, the secondary air pump pumps air via the shut-off valve into the manifolds of both rows of cylinders. The two shut-off valves are activated by a pneumatically operated electrical switchover valve. Depending on the engine temperature the valve is operated for a duration of approx. 20 seconds (warm start) up to approx. 100 seconds (cold start). The secondary air pump is also switched off as soon as an engine speed greater than 3000 rpm or full load is reached.

CAN-bus

The CAN-bus (Controller Area Network) is a serial bus system, in which all connected stations are equally entitled, i.e. each control unit can both send as well as receive. In other words, the connected control units can "communicate" and exchange information via the lines.

Due to the linear structure of the network, the bus system is fully available for all other stations in the event of one station failing. The connection consists of two data links (CAN_L and CAN_H) which are interface-protected by means of shielding (CAN_S).

At present, the control units adaptive transmission control AGS, digital motor electronics DME, electronic throttle control EML and dynamic stability control DSC are interconnected with this system.

The connected control units must all have the same CAN status. The CAN status can be checked via the diagnosis interface. The CAN status (bus index) is specified on the identification of the relevant control unit connected to the CAN-bus.

A large number of information items such as CAN statuses or operating variables such as engine speed and temperature, are exchanged between the control units via the CAN-bus.

Subfunction

In the event of sensors failing, substitute values are made available which enable continued, restricted engine operation. In the event of the speed sensor failing, engine operation is no longer possible on the corresponding row of cylinders.

Component	Substitute measures
Intake temperature sensor	Substitute values active
Engine temperature sensor	Substitute values active
Hot-film mass meter	Substitute value from position of throttle valve (EML information via CAN)

Interface, adaptive transmission control AGS

During the shift procedure, the EGS control unit sends a signal to the DME control unit resulting in the ignition timing been set in retard direction and thus a reduction in torque. This measure ensures a smooth transition to the next drive stage.

As soon as the torque converter clutch is closed, the DME control units switch over to a different ignition characteristic map.

Drive-away lockout

With the aid of the electronic drive-away lockout EWS of the multi-information display MID or of the antitheft system DWA, DME ignition and injection can be blanked out and the fuel pump prevented from being switched on.

Automatic start

The automatic start is an improvement in comfort for the start procedure. It keeps start operation and the resulting noise emission as short as possible. The starter is triggered by briefly turning the ignition key into the start position (momentary touch function).

Note

The vehicle is not ready for operation if basic adaptation of the pedal position sensor has not been carried out correctly. Although the engine can be started it does not respond to the throttle system.

Functions

The use of dynamic stability control (DSC) on the 12-cylinder engines M73B54 in the series E31 and E38 renders an electronic accelerator pedal necessary.

For this purpose, the principle of the electronic throttle control (EML M30 and EML M70) known from the 6-cylinder engines M30 and the 12-cylinder engines M70 was taken as a basis and further developed to a considerable extent.

As before, the electronic throttle control EMLIIIS enables any setting of the throttle position independent of driver requirements. In contrast to conventional throttle operating systems, there is no mechanical connection (linkage or operating cable) between the throttle valve and accelerator pedal. In this way it is possible by means of interventions in cylinder charging to prevent the drive wheels spinning or locking thus maintaining vehicle stability.

In addition to interventions in cylinder charging on the basis of the requirements of driving dynamics, other operating conditions are possible which make it necessary to influence the throttle angles; these requirements have been extended and adapted to the M73B54 engine:

- Position of throttle valves for optimum engine start
- Control of throttle angle for stabilisation of idler speed (cylinder synchronisation, ZSY)
- Adjustment of throttles while coasting to reduce high vacuum in the intake pipe
- Reduction of throttle angle to limit engine speed and limit driving speed
- Cruise control (FGR) by corresponding activation of throttle valves

Components

The EMLIIIS system consists of following components:

- EMLIIIS control unit
- Pedal position sensor including external safety path

- Kick-down switch

- Electronic brake switch

- 2 throttle valves for both rows of cylinders

- Steering column switch for operating cruise control on E31 vehicles

- Cruise control (FGR) main switch and operating unit in multifunction steering wheel for operating cruise control on E38 vehicles

- Connection via CAN-bus to the control units of digital motor electronics (DMER and DMEL), adaptive transmission control (AGS) and of dynamic stability control (DSC)

- Connection to EML warning lamp in instrument cluster on E31 vehicles

- Connection to check-control module of instrument cluster on E38 vehicles

- Connection to fault lamp (check-engine lamp) in instrument cluster on US vehicles

Safety Concept

Since the EMLIIIS system controls access to the engine output particular importance must be attached to ensuring a high degree of safety. Furthermore, facilities must be provided to ensure the vehicle remains operable in the event of a defect.

This is achieved by way of a redundancy concept for components critical to safety, i.e. these components are installed in duplicate or triplicate in order to prevent unwanted intervention in the engine output or to ensure safe emergency operation in the event of an individual fault occurring:

- Dual computer concept in the EMLIIIS control unit, i.e. 2 microprocessors (computer MC1 and computer MC2) carry out all working steps simultaneously and are controlled accordingly; in addition, each computer features its own memory module (EEPROM)

- The pedal position sensor (PWG) records the accelerator pedal angle simultaneously with 3 PWG sensors (PWG1-SIG, PWG2-SIG, PWG3-SIG) and compares all 3 signals with respect to each other to ensure they are correct

- The 3 measured signals of the PWG sensors are routed via separate, shielded supply lines to the 3 angle pulse generator ICs in the EMLIIIS control unit where they are evaluated separately.

- Each throttle valve is controlled by 2 stepper motors with the one operated by computer MC1 and the other by computer MC2.

- The activation signals for the 4 stepper motors of the 2 throttle valves are sent from a total of 8 stepper motor ICs on separate supply lines.

- Each throttle valve features 2 potentiometers for correct feedback of the current throttle position.

- 2 supply voltages are provided for the 4 potentiometers so that in each throttle valve one potentiometer is supplied by the one voltage and the other by the other voltage.

- The electronic brake switch detects operation of the brake in a dual system and sends these signals on 2 separate supply lines to the EMLIIIS control unit.

In addition, all functions and components of the EMLIIIS are constantly tested and monitored by the EMLIIIS control unit and, depending on how serious the fault is, either a function or even a component (e.g. one of the 2 throttle valves) is deactivated. Added to this, the safety fuel cutout in the two DME control units can be activated via an external safety path independent of the EMLIIIS control unit.

A serious fault in a component detected by the self-diagnosis function of the EMLIIIS control unit is signalled to the driver by means of a warning lamp with the inscription "EML" (in E31 vehicles) or the message "engine emergency program" in the check-control module (in E38 vehicles).

Pedal position sensor (PWG)

The pedal position sensor in the EMLIIIS system is used to record the driver’s requirements. For this purpose, a measured signal (signal name PWGx-SIG; x = 1, 2 or 3) proportional to the accelerator pedal angle is generated in a pair of coils in the pedal position sensor (PWG).

3 pedal position sensors are installed in order to ensure in the event of a sensor failing that the driver’s requirements are recorded without losses in safety.

The 3 measured signals are transferred via 3 shielded supply lines to the EMLIIIS control unit where they are processed in 3 evaluation circuits (so-called angle pulse generator ICs, WIG-ICs).

The valid value range of the accelerator pedal angle is between 0 and 99.6 %.

The WIG-ICs also feature

- a calibration function to adjust tolerances

- and an oscillator to generate the input signal (signal name PWGx-OSZ, x = 1, 2 or 3) for the PWG sensor.

By way of the self-diagnosis function of the EMLIIIS control unit, every step from acquisition up to evaluation of the driver's requests, including the calibration function and PWG basic adaptation is monitored and in the event of a malfunction, the cause is indicated and described.

Basic adaptation of pedal position sensor

In order to compensate for production-related tolerances in the pedal position sensor (PWG) system, the PWG limit stop (idle point and kick-down limit stop) are determined in a basic adaptation-learn mode. For this reason, it is necessary when replacing the EMLIIIS control unit or the pedal position sensor to carry out PWG basic adaptation in order to adapt the new tolerances. To ensure this step is carried out, the engine will not accept the throttle system before PWG basic adaptation has been carried out.

The EMLIIIS control unit assumes the start status for learn mode when the PWG basic adaptation values are deleted by one of the following conditions:

- A new variant is coded in the EMLIIIS control unit; this is only possible with the encoding program "encoding ZCS" via the DIS or MoDiC testers.

- The pedal position sensor (PWG) is unplugged at ignition ON so that all 3 signals are detected as faulty

- The PWG adaptation values are reset by means of the corresponding instruction on the DIS or MoDiC testers

The PWG basic adaptation procedure is described both in the diagnosis program of the EMLIIIS system as well as in the encoding program "encoding ZCS".

Only after PWG basic adaptation has been carried out correctly are the learn words stored in 2 EEPROM's in the EMLIIIS control unit and sensing of the driver's request is enabled.

Note

The defect code memory in the EMLIIIS control unit is cleared automatically after successful PWG basic adaptation when the variant was newly coded or the PWG unplugged beforehand. Therefore read out the defect code memory or print out the test code beforehand to ensure no defect information is lost.

Safety fuel cutout (SKA)

The safety fuel cutout signal for the two DME control units can come on the one hand from the EMLIIIS control unit and on the other hand from the external safety path specially used for this purpose.

The safety path consists of the brake light switch, a 4-degree switch in the pedal position sensor (PWG) and 2 diodes in the pedal position sensor (PWG). This path independent of the EMLIIIS control unit ensures that a defective EMLIIIS control unit cannot activate the accelerator system uncontrolled since, when the accelerator pedal is not depressed (4-degree switch closed) the signal of the operated brake is routed via this path to both DME control units thus activating the safety fuel cutout.

2 driving situations which result in activation of the safety fuel cutout function are described in the following:

- When idle is detected, the EMLIIIS control unit automatically outputs the signal for safety fuel cutout to both DME control units.

- If the brake is pressed and the accelerator pedal is not depressed, the two DME control units additionally receive via the external safety path the brake signal as a request to activate the safety fuel cutout.

The correct status of the safety fuel cutout is constantly checked by the self-diagnosis function in the EMLIIIS control unit.

Note

The EML test adapter used in the previous EML to test the external safety path is no longer required in the EMLIIIS (EML test adapter 12 7 010/011 with adapter lead 12 7 012/013)

Throttle valves (DK)

The throttle valve is a component part of the air intake system of the engine and controls the quantity of air required to combust the fuel.

In the EMLIIIS system, the 2 throttle valves for the 2 rows of cylinders are not opened and closed as in conventional systems by means of an operating cable but rather by actuator motors.

Stepper motors are used to drive the throttle valves which, in contrast to the DC motors used in the previous EML system, require no gear mechanism and therefore feature better dynamics.

Potentiometers which constantly signal the current position of the throttle valves to the EMLIIIS control unit are connected directly to the throttle valves.

In view of the fact that the throttle position has a direct influence on the engine output, for safety reasons, 2 stepper motors are installed per throttle valve and 2 potentiometers to signal their position.

Each throttle valve is driven simultaneously by 2 stepper motors mounted on the same drive shaft with one controlled by the computer MC1 and the other by computer MC2 so that the function of both throttle valves can be maintained by the other computer in the event of a computer failing.

Each stepper motor consists of a sine winding and a cosine winding, each of which are controlled via shielded, separate supply lines by its own stepper IC. If one stepper IC fails the function is adopted by the other stepper IC.

If, despite the integrated redundancy, perfect operation of the throttle valve can no longer be ensured due to a fault in a throttle valve, this throttle valve and thus the relevant row of cylinders is shut down. Restricted operation with the remaining row of cylinders is possible.

Each throttle valve features 2 independent potentiometers to signal the current position of the valve to the EMLIIIS control unit. The 2 potentiometers are operated with 2 voltage supplies which are decoupled from each other so that in the event of one voltage supply or one potentiometer failing the other potentiometer can still ensure correct position feedback.

As part of the self-diagnosis function, the throttle valves are checked exactly in a large number of tests:

- Checking the validity of the position feedback of 2 throttle valves

- Checking 2 supply voltages of 4 potentiometers

- Checking the difference of 2 potentiometer voltages of one throttle valve

- Comparing the setpoints (activation of stepper motor) with actual values (feedback of potentiometer) of each of the 2 throttle valves

- Comparing the setpoints calculated separately by each computer for one throttle valve

- Monitoring the 2 throttle valves before the engine start-phase (predrive check during initialisation phase); for this purpose, the EML warning lamp in the E31 is activated for the first 2 seconds and switched off again on completion of the predrive-check

- Testing the 8 stepper motor ICs before the engine start phase

Cruise control (FGR)

The cruise control uses the speed signal V1 of the CAN message from the DSC control unit as the control variable and calculates the required cylinder charging. The cruise control (FGR) is activated in different ways in the E31 and E38 (provided there are no switch-off conditions or switch-on inhibits):

- On E31 vehicles via operating lever (steering column switch LSS)

- On E38 vehicles via a main switch on the instrument panel and via the right-hand button pad in the multifunction steering wheel (MFL)

Data Transfer and FGR Operation in E31 Vehicles

In E31 vehicles data is transferred from the operating lever to the EMLIIIS control unit as in the previous EML system by means of resistor coding and the resulting analog voltage.

The following functions are possible, however, the steering column switch (LSS) is designed in such a way that several functions cannot be active simultaneously:

- Lever in rest position: Rest (voltage value 3.33 to 3.55 V)

- Lever forward: Set/accelerate (voltage value 0.76 to 0.91 V)

- Lever back: Decelerate (voltage value 2.49 to 2.75 V)

- Lever up: OFF (voltage value 4.13 to 4.27 V)

- Lever down: OFF (voltage value 4.13 to 4.27 V)

- Press lever: Resume (voltage value 1.57 to 1.80 V)

Data Transfer and FGR Operation in E38 Vehicles

In E38 vehicles, data is transferred from the multifunction steering wheel (MFL) to the EMLIIIS control unit via digital signals. There is no mechanical interlock between the buttons on the multifunction steering wheel (MFL) to prevent simultaneous operation of several functions so that the functions are recognized in accordance with a priority table with "OFF" having the highest priority.

In order to avoid malfunctions on the multifunction steering wheel, the driver must first switch on the cruise control (FGR) via the FGR main switch on the instrument panel (FGR ready indicator in instrument cluster lights up). The following functions are then possible:

- Buttons not operated: Rest

- Button "+" pressed: Set/accelerate

- Button "-" pressed: Decelerate

- Button "0" pressed: OFF

- Button "pointer" pressed: Resume

Switch-On Inhibits and Switch-Off Conditions

There are various switch-on inhibits and switch-off conditions in both vehicles.

Switch-on inhibits include CAN-bus faults in the DSC message or faults in the brake switch.

Cruise control (FGR) operation can be switched off soft or hard by the EMLIIIS control unit:

- Soft shut-down takes place when the "OFF" function is operated or when the travelling speed is too low

- Hard shut-down takes place when the brake is operated, at excessively high acceleration or excessively high travelling speed, if a gear is no longer engaged in the automatic transmission or in the case of certain defects detected by the self-diagnosis function in the EMLIIIS system.

Interfaces

The EMLIIIS control unit transmits and receives signals from other control units or components both in digital as well as in analog form.

Digital data transfer takes place via the CAN-bus between the control units, analog data transfer takes place to the brake switch, kick-down switch and fault indication in the instrument cluster.

CAN-bus

Communication between the EMLIIIS control unit and the control units AGS, both DMEs and DSC takes place via the CAN-bus, facilitating extensive data exchange on digital level. The only exception to this is the safety fuel cutout signal from the EMLIIIS control unit to both DME control units which is transferred via the external safety path.

For this purpose, a CAN-module is installed in the EMLIIIS control unit and in the other control units which are interconnected via a star coupler, to which shielded supply lines lead from each control unit with a total line resistance of 60 Ohm. This is achieved in that the terminal resistor in the DSC control unit (fixed to 120 Ohm) and in the AGS control unit (120 Ohm, activated by a jumper) are connected in parallel.

By way of self-diagnosis, the EMLIIIS control unit constantly checks both for correct transmission and reception of messages on the CAN-bus as well as identical CAN status of all control units.

Note

Particular care must be taken when replacing one of the CAN-bus control units to ensure the identical CAN status otherwise communication via the CAN-bus will not be possible. Check by means of diagnosis program on identification page under "Bus index".

Electronic brake switch

An electronic brake switch is installed in both series E31 and E38, in that 2 brake switches are accommodated in one housing. The function of the electronic brake switch is checked by the self-diagnosis function every time the brake is operated.

In E31 vehicles the electronics simulates the switching characteristics of the 2 mechanical brake switches of the previous EML system, which switch slightly offset. The first switch (BLS signal) is a make contact, i.e. during operation it closes to U-batt and transfers this signal to the external safety path. The slightly delayed second switch (BTS signal) is also a make contact which, however, when operated closes to ground and transfers this signal to the EMLIIIS control unit.

In E38 vehicles, the two brake switches switch at the same time exactly. The one switch (B-EML signal) is a make contact, i.e. when operated it closes to U-batt and transfers this signal to the external safety path. The second switch (BL-ON signal) is a break contact, i.e. when operated it opens from ground and transfers this signal to the EMLIIIS control unit.

Kick-down Switch (KDS)

The kick-down switch is used to activate the downshift procedure in automatic transmissions. This switch is used in all series E31 and E38 vehicles with 12-cylinder engine M73B54 since these vehicles are equipped solely with automatic transmission.

The kick-down switch in both series E31 and E38 is a make contact, i.e. when operated it closes to ground.

Fault Indication

The task of fault indication is to inform the driver of a fault in the EMLIIIS system which can lead to limitations in output or to deactivation of various functions, and is intended to draw the driver's attention to a necessary workshop visit.

In E31 vehicles, a fault is indicated in the form of a warning lamp with the inscription "EML" in the instrument cluster.

In E38 vehicles, a fault is indicated by way of a "engine emergency program" message in the check-control module of the instrument cluster.

Note

The ignition must be switched off for approx. 10 seconds after clearing the defect code memory of the EMLIIIS control unit. The fault indication is then deactivated when the ignition is switched on again.

Control unit	Transmission	Engine
AGS-8.34	A4S 270R (GMPT R1)	M43, M44
AGS-7.32	A5S 310Z (5HP-18)	M60B30
AGS-8.32	A5S 310Z (5HP-18)	M52
AGS-8.32	A5S 310Z (5HP-18)	M51
AGS-8.51	A5S 440Z (5HP-24)	M62
AGS-8.55	A5S 440Z (5HP-24)	M62
AGS-9.22	A5S 560Z (5HP-30)	M60B40
AGS-9.22	A5S 560Z (5HP-30)	M62B44
AGS 9.22	A5S 560Z (5HP-30)	M73

The task of the adaptive transmission control is to adapt gear selection to the driving characteristics of the driver as well as to the current driving situation. The main arguments for the use of adaptive transmission control are:

- Reduction in fuel consumption in conjunction with steady driving characteristics

- Avoidance of frequent gearshifts

- Optimisation of driving safety on slippery roads

- Reduction in amount of necessary driver interventions

The control unit transfers the shift pulses for upshifts and downshifts to the transmission selector unit (solenoid valves, pressure regulator) and decides when the torque converter lockup clutch is to be engaged, taking factors such as comfort and safety into consideration. For this purpose, it processes, in a computer program, input variables such as engine speed, output speed, turbine speed, injection signal, throttle (accelerator pedal) position, kick-down switch, drive program, selector lever position and oil sump temperature.

Note

The control unit is installed in the E-box in the engine compartment.

Driver type evaluation

The influencing factors which are used to classify the type of driver are described in the following. The result of driver type evaluation has an effect on the selection of the gearshift program.

Approach evaluation

The behaviour when approach driving (forced or more moderate) influences the selection of the gearshift program.

Kick-fast evaluation

A sporty, performance-oriented gearshift program is selected automatically from a low gearshift, consumption-oriented driving program by quickly depressing the accelerator pedal (kick-fast). This normally results in a downshift.

Driving evaluation

When driving with a constant accelerator pedal position, a consumption-oriented gearshift program is selected within a short space of time and the transmission shifts into a higher gear.

Kick-down evaluation

The sporty gearshift program is selected immediately by "kick-down". On completion of kick-down, the gear selection is still influenced for a certain period of time in the sporty direction.

Braking evaluation

Above average braking manoeuvres cause the system to change to the sports gearshift program with earlier downshifts.

Gearshift program selection

In addition to driver type evaluation, there are still further factors for selecting one of the four gearshift programs. These programs are classified from very comfort and consumption-oriented through to very sporty.

Program selection button

This button makes it possible for the driver to intervene in the driving program manually. Selection of the S-program (sports) leads directly and exclusively to the sports gearshift program. This program is not exited before the A-program (adaptive) is selected and the adaptive functions are activated once again. The A-program is always selected when the vehicle is started.

Up-hill driving/trailer detection

A performance-oriented gearshift program is selected when negotiating extreme gradients or when driving with above-average load. This avoids frequent upshifts and downshifts.

Winter detection

The winter gearshift program is selected if the drive wheels slip through even at low acceleration. The program starts off in 2nd gear and ensures earlier upshifts. This driving situation is evaluated by way of the sensors of the antilock brake system (ABS). Different wheel speeds at the front and rear axle result in winter detection. The winter program is exited automatically as soon as a road surface with good grip in conjunction with high drive torque is detected for several seconds.

In addition to automatic gear selection in accordance with the above-specified criteria for gearshift program selection, four special functions are provided to ensure special driving situations are detected.

Down-hill detection

Upshifts are suppressed when driving downhill without pressing the accelerator. If the driver presses the brake pedal, the transmission shifts down by one gear to provide extra assistance. This ensures the braking effect of the engine is utilised more effectively.

Fast-off detection

An upshift is prevented when the accelerator pedal is taken back rapidly. As a result the braking effect of the engine is utilised more effectively in these driving situations (fast changeover from accelerator pedal to brake pedal). This function considerably reduces the gearshift frequency when driving with a more sporty style.

Stop-and-go detection

In this driving situation there is no downshift into 1st gear. The car starts off automatically in 2nd gear. This increases driving comfort, reduces fuel consumption and reduces the crawling tendency when the car is stationary. By depressing the accelerator pedal more intensively, a downshift can be triggered in order to utilise the full power potential.

AGS interfaces

AGS inputs

The AGS control unit receives information from the following components via various interfaces:

Component	Information
Automatic transmission	Output speed, turbine speed, transmission oil temperature
Program button	Manual program selection

Selector lever	Gear selection, gear limit
Kick-down switch	Kick-down operation
Brakes	Brake pedal operation
Digital motor electronics DME	Engine speed, engine temperature, throttle angle
Speed control (cruise control)	Information concerning constant driving or acceleration, braking procedures
ABS/ASC	Current wheel speeds

AGS outputs

Information is supplied to the following components by the outputs of the AGS control unit:

Component	Information
Automatic transmission	Activation of solenoid valves and electronic pressure controller
Instrument cluster electronics IKE	Current driving program, selector lever position, if necessary "transmission emergency program" are shown in the text display of the IKE.

Cruise control (tempomat) interface

When the cruise control (GR) is selected, the AGS control unit switches over to a special transmission program for controlled driving. This gearshift program ensures that the available engine output can be utilised to the full extent in this driving situation. Frequent up and downshifts, i.e. frequent, fast successive gearshifts between two adjacent gears, are reduced to a minimum. A time delay is programmed to avoid abrupt gearshifts.

The information from the cruise control (GR) control unit to the transmission control unit flows via a serial interface. Data are transferred on the one-wire line at a rate of approx. 25 Baud.

The gearshift program takes into consideration the following driving situations:

Driving situation	Characteristics
Constant driving	Comfort-oriented, i.e. low engine speed level
Resume	Maximum tractive force
Acceleration procedures	Maximum tractive force
Deceleration procedure	Upshifts are avoided for optimum deceleration capacity

Instrument cluster interface

A serial data link is routed from the AGS control unit to the instrument cluster electronics (IKE). The transmission selector unit uses this data link to send the position of the selector lever, the active drive program (**A**daptive or **S**ports) and, if necessary, the "transmission emergency program" message to the instrument cluster electronics (IKE).

Kick-down switch

The AGS control unit receives the transmit signal for kick-down gearshifts via a signal line and a switch to ground. The switch must be adjusted such that driving is possible under full load, i.e. accelerator pedal position 100%, and the kick-down shifts when the accelerator pedal is further depressed.

Selector lever switch

The AGS control unit detects the selector lever position by way of a switch on the transmission. This switch converts the current selector lever position into a code. This selector lever code is transferred to the AGS control unit via four lines (L1-L4).

Selector lever position	L1 to L4 (0 = open, 1= U-batt)
P	L1 =1, L2 = 1, L3 = 0, L4 =1
R	L1 =1, L2 = 0, L3 = 0, L4 =0
N	L1 =1, L2 = 1, L3 = 1, L4 =0
D	L1 =0, L2 = 0, L3 = 1, L4 =0
4	L1 =0, L2 = 0, L3 = 0, L4 =1
3	L1 =0, L2 = 0, L3 = 1, L4 =1
2	L1 =1, L2 = 0, L3 = 1, L4 =1

CAN-bus

The CAN-bus (Controller Area Network) is a serial bus system, in which all connected stations are equally entitled, i.e. each control unit can both send as well as receive. In other words, the connected control units can "communicate" and exchange information via the lines.

Due to the linear structure of the network, the bus system is fully available for all other control units in the event of one control unit failing. The connection consists of two data links (CAN-L and CAN-H) which are interface-protected by means of shielding (CAN-S).

The control units AGS, ASC/DSC (M62 only) and digital motor electronics (DME) are currently interconnected with this system. Linking-in of further control units will follow. The following signals are exchanged between AGS, ASC/DSC and DME control units via the CAN-bus:

- Accelerator pedal position

- Load signal

- Engine speed

- Driver program

- Gear

- Engine intervention

- Wheel speeds (M62 only)

The connected control units must all have the same CAN status. The CAN status can be checked via the diagnosis interface. The CAN status (bus index) is specified in the identification of the relevant control unit connected to the CAN-bus.

Transmission oil temperature sensor

The transmission oil sump temperature is sensed by a temperature-dependent resistor which is soldered in the transmission wiring harness. Among other things, engagement of the torque converter lockup clutch is controlled dependent on the transmission oil temperature.

Wheel speeds

The ASC/ABS control unit supplies four processed signals relating to the wheel speeds from the ABS sensors. The speed information received by the AGS control unit is determined by frequency. Evaluation enables detection of cornering and winter operation.

Driving programs

Two driving programs can be selected on the E38 with the program switch.

Driver program	Function
A = Adaptive	From the four available gearshift programs, the adaptive control selects the most favourable program automatically. At the time the vehicle is started, the AGS control unit assumes the adaptive program.
S = Sports	After manual selection of this program, the transmission switches over directly and permanently to the sports gearshift program.

Adaptive gearshift characteristic curve control

When pulling a trailer or negotiating gradients, the changed acceleration capacity of the vehicle is evaluated by the control unit. For this purpose, the control unit selects (adapts) suitable gearshift programs in order to avoid frequent upshifts and downshifts.

Torque converter lockup clutch control

The torque converter lockup clutch is controlled dependent on the accelerator pedal position, transmission output speed, drive program, transmission oil temperature as well as the engaged gear (in 4th and 5th gear only).

Adaptive pressure control

Adaptive pressure control improves the gearshift quality over the life of the vehicle. During an upshift, the slip times are measured and compared to a nominal value range. The mean deviations are then stored. As soon as a programmed limit value is exceeded, the pressure is increased or reduced in steps of 0.1 bar. In this way, the control system corrects engine scatter, compensates for differences in the friction lining and adapts to altitude.

Steptronic

The Steptronic function makes it possible to shift all gears of the automatic transmission manually. The gear required by the driver is transmitted via three switches (to ground) in the manual gate to the AGS control unit: The "manual gate" switch is closed if the selector lever is moved out of the automatic gate into the manual gate. By pressing the selector lever forward or back, the "strike-up" or "strike-down" contact is additionally closed.

Note

After installing a new AGS control unit, the selector lever must be moved once into the "downshift" or "upshift" position with terminal 15 switched on in order for the control unit to detect that the Steptronic facility is installed.

P/N lock (shift-lock in Japan and US version up to 09/96, in all country-specific variants as from 09/96)

It is only possible to shift out of the positions "P" or "N" after evaluation of the signals:

- Brake (brake light switch or brake light test switch)

- Road speed

- Engine speed

- Time

The selector lever is locked when no brake signal is detected with the engine running and the vehicle stationary. A time delay function of approx. 0.5 s is used for operation under winter conditions. The brake light switch is designed as a normally-opened contact referred to 12 V and the brake light test switch as a normally-open contact referred to ground. The shift lever is locked by way of a solenoid on the selector lever switch.

Safety functions

By way of plausibility checks and checking the line connections for shorts or breaks, the control unit can detect and store defects. Manually engaged downshifts are not carried out at excessively high speeds. At a vehicle speed above approx. 8 km/h, the reverse lockout function prevents reverse being shifted hydraulically.

In the event of failure of the transmission control or when defects are detected which lead to critical driving situations (e.g. impermissible downshifts), the mechanical emergency program is activated, i.e. the transmission control unit is switched off and the failure display activated. A self-test of the entire safety hardware is carried out during each new start.

Restricted driving of the vehicle is possible in the emergency program (4th gear). Various substitute programs are also made available depending on the type of defect which has occurred.

General

The instrument cluster is made up of the instrument cluster electronics (**IKE**) and a display unit (**AE**). The instrument cluster electronics unit (**IKE**) is plugged on to the display unit.

Since 5/97 an instrument cluster has been phased-in which features the plugged-on instrument cluster electronics (**IKE**) integrated in the display unit (**AE**). This instrument cluster can replace older instrument cluster versions.

Bus interfaces, via which the information link (serial data link) to the connected control units is established, are integrated in the **IKE** .

These busses are:

- I-bus (instrumentation bus)

- K-bus (body bus)

- Diagnosis bus (link to diagnostic socket).

- CAN bus (instrument cluster-integrated version phased-in as from 5/97)

Coded data which determine the scope of functions of the instrument cluster electronics (**IKE**) are stored in a non-volatile data memory (data are retained when supply voltage is disconnected).

The various scope of functions includes, for example, the vehicle model and the country language variant.

At present, eight country variants can be chosen:

- Australia/ Gulf States/ South Africa

- Germany

- United Kingdom

- France

- Italy

- Japan

- Canada

- Spain

- USA

Display and indicator instruments

All display and indicator instruments are housed in the display unit. This unit contains display instruments, indicator lamps and the LCD module. The display unit of the instrument cluster is equipped with different display and indicator instruments depending on the vehicle model.

Replacing Instrument Cluster Electronics (IKE)

The four cases described in the following show the steps which must be taken under certain circumstances in order to ensure trouble-free replacement of the instrument cluster electronics (**IKE**).

These four cases also apply to the integrated version of the instrument cluster phased-in as from 5/97. In this case, the instrument cluster can only be replaced.

Case 1: The control unit for the instrument cluster electronics (IKE) is defective and the light check module control unit (LCM) is OK.

Measures	Result	Remarks
Replace IKE (new part)	The manipulation point is set with the ignition switched on.	The manipulation point is set since the vehicle identification number in the light check module differs from the vehicle identification number in the instrument cluster.
Recode IKE		Encode IKE with the central encoding code
Code vehicle identification number into IKE		As long as the vehicle identification number is not coded in the instrument cluster electronics (IKE), total odometer recording (only trip odometer recording) does not take place either in the IKE or in the LCM. It should be noted that in the case of an instrument cluster with CAN bus (instrument cluster-integrated version phased-in as from 5/97) AND dynamic stability control (DSC as from 9/97) the DSC is inactive due to the non-

		matching vehicle identification number. The fault code memory in the DSC control unit should be cleared on completion of this work.
Switch off ignition and switch on again	The manipulation point goes out, the IKE adopts the total odometer reading (mileage) from the LCM as well as the SIA data.	The data exchange between the IKE control unit and LCM control unit for mutual data storage (SIA data, total odometer reading, vehicle identification number etc.) is now OK. again.

Case 2: The control unit for the instrument cluster electronics (IKE) is OK. and the light check module control unit (LCM) is defective.

Measures	Result	Remarks
Replace LCM (new part)	The manipulation point is set with the ignition switched on.	The manipulation point is set since the vehicle identification number in the light check module differs from the vehicle identification number in the instrument cluster.
Recode LCM		Encode LCM with the central encoding code
Encode vehicle identification number in the LCM		As long as the vehicle identification number is not coded in the LCM, the total odometer reading will not be recorded in the LCM.
Switch off ignition and switch on again	The manipulation point goes out, the LCM adopts the total odometer reading (mileage) from the IKE as well as the SIA data.	The data exchange between the IKE control unit and LCM control unit for mutual data storage (SIA data, total odometer reading, vehicle identification number etc.) is now OK. again.

Case 3: The control unit for the instrument cluster electronics (IKE) and the light check module control unit (LCM) must be replaced.

Only replace both control units at the same time when this is unavoidable (stored total odometer reading is irretrievably lost).

Note

Disconnect battery !

Measures	Result	Remarks
Replace IKE and LCM with battery disconnected (new parts)	The manipulation point is set with the ignition switched on and the total odometer reading (mileage) is set to zero.	The previous total odometer reading (mileage) is irretrievably lost.
Code IKE and LCM		Encode IKE and LCM in accordance with the central encoding code
Code vehicle identification number in IKE and in LCM		As long as the vehicle identification number is not coded, the total odometer reading (mileage) is recorded in the IKE and in the LCM. It should be noted that in the case of an instrument cluster with CAN bus (instrument cluster-integrated version phased-in as from 5/97) AND dynamic stability control (DSC as from 9/97) the DSC is inactive due to the non-matching vehicle identification number. The fault code memory in the DSC control unit should be cleared on completion of this work.
Switch off ignition and switch on again	The manipulation point goes out, the LCM adopts the total odometer reading (mileage) from the IKE as well as the SIA data.	The data exchange between the IKE control unit and LCM control unit for mutual data storage (SIA data, total odometer reading, vehicle identification number etc.) is now OK. again.

Case 4: As a check, replace the control unit for the instrument cluster electronics (IKE) or the light check module control unit (LCM).

Note

Although exchanging one of the two control units is possible in principle, it should, however, be avoided wherever possible.

Measures	Result	Remarks
An IKE or LCM control unit from another vehicle is installed as a check.	The manipulation point is set with the ignition switched on and the IKE continues to record the total odometer reading (mileage).	For as long as the vehicle identification number differs, the total odometer reading is only recorded in the instrument cluster electronics (IKE). There is no total odometer reading calibration with the light check module (LCM). It should be noted that in the case of an instrument cluster with CAN bus (instrument cluster-integrated version phased-in as from 5/97) AND dynamic stability control (DSC as from 9/97) the DSC is inactive due to the non-matching vehicle identification number. The fault code memory in the DSC control unit should be cleared on completion of this work.

Scope of function

Following functions are displayed or used for a function:

Display/function	Required signal
Speed display	Position signal tw from /ABS/ASC/DSC control unit
Engine speed display	Speed signal TD from engine control unit
Fuel consumption (economy) display	Injection signal ti from engine control unit/ engine speed signal TD from engine control unit/position signal tw from /ABS/ASC/DSC control unit
Fuel gauge	Resistance value of both lever sensors (analog input)

Coolant temperature gauge	Resistance value from coolant temperature sensor (temperature-dependent resistor)/ speed signal TD from engine control unit
Service interval display	Position signal tw from /ABS/ASC/DSC control unit/ resistance value from coolant temperature sensor/ engine speed signal TD from engine control unit
Reset service interval display	Line connection to diagnostic socket
Total odometer reading	Position signal tw from /ABS/ASC/DSC control unit
Trip odometer reading	Position signal tw from /ABS/ASC/DSC control unit
Outside temperature display	Resistance value from outside temperature sensor/ position signal tw from /ABS/ASC/DSC control unit
Text display	Steering column switch (BC function button)/ check-control button (CC button)
Dimming instruments	Dimmer signal from light check module (LCM)/ internal signal from photo transistor
Gong activation	Tone 1 (T1) short "peep tones" at 1 kHz/ tone 2 (T2) single gong at 1 kHz/ tone 3 (T3) priority gong at 1 kHz
Speed-A signal/output	Speed signal
Brake pad wear indication	Resistance value of brake pad wear sensor and sensor lines arranged in a ring (analog positive output to analog ground input). Information link (I-bus telegram) to check-control module (CCM).
Reverse detection (manual transmission)	ground from reverse gear switch
Transmission program display (automatic transmission)	Information link (data link/serial) from transmission control unit
I-bus (instrumentation bus)	Information link (data link/serial) to connected control units
K-bus (body bus)	Information link (data link/serial) to connected control units
Diagnosis bus (RxD/TxD)	Information links (data link/serial) to BMW service tester

	systems

Note

All warning lamps not listed have no functional connection with the instrument cluster electronics (**IKE**). They are only supplied with positive or negative from the display unit of the instrument cluster.

Warning lamps	Required signal
General brake warning lamp	Brake fluid level signal via the I-bus from light check module
Parking brake warning lamp	Ground from parking brake switch (parking brake)
Seat belt indicator lamp	I-bus signal from light check module
Fuel reserve lamp	Resistance value of both lever sensors (analog input)
Turn signal indicator lamps	I-bus signal from light check module
Fog light indicator lamp	I-bus signal from light check module
Rear fog light indicator lamp	I-bus signal from light check module
High beam indicator lamp	I-bus signal from light check module
Oil pressure indicator lamp	Ground from oil pressure switch

Test functions

The test functions which could be called up in the on-board computer in previous series can now be called up in the instrument cluster.

System test (Test No. 2): The system test serves the purpose of testing the display unit together with its elements controlled by the instrument cluster electronics (**IKE**).

These elements are:

- All pointer instruments

- All LC displays with a segment test and their background lighting

The indicator and warning lamp for

- Belt warning

- Fuel reserve

- General brake warning lamp

- Parking brake

- Left turn signal indicator

- Right turn signal indicator

- Front fog light

- Rear fog light

- High beam

Pointer instruments: During the system test, operation of the pointer instruments is diagnosed and a corresponding fault code is set in the fault code memory if an electrical fault occurs. In addition, particular care must be taken to observe whether the pointers move smoothly and continuously over their entire indication range during the first test run. During the second run within a system test sequence, the pointer instruments are no longer moved continuously and smoothly over their entire indication range. In this case, the electrical drive data are measured at various indication angles of the pointers.

Selecting test functions:

All test functions, apart from test numbers one and two, are interlocked and must be released by means of test function number nineteen.

Procedure: Press and hold the check control button (right-hand button in the instrument cluster) at terminal 15 "ON" until "Test No.: 01" appears in the text display (text field for check control messages). The corresponding test can be selected by repeatedly pressing the button. Then activate the set test by pressing the trip odometer reset button (left-hand button in the instrument cluster). If the test is a locked test (test 3 to 21), "Lock ON" will appear after the trip odometer reset button has been pressed. In this case, the checksum of the digits for the vehicle identification number must be set by repeatedly pressing the trip odometer reset button. The test must now be reselected with the CC button and confirmed with the trip odometer reset button. The tests one and two can be confirmed directly and thus selected with the trip odometer reset button.

To form checksum: Read out vehicle identification number with test 1.

Display example: "VIN: XY12345"

Cross sum example: 1+2+3+4+5 = 15

Test No.	Function
1	Identification instrument cluster electronics (**IKE**)
2	System test
3	SIA data
4	Momentary consumption values in l/100 km and l/h
5	Range consumption and momentary range
6	Fuel tank content values
7	Coolant temperature and engine speed
8	Momentary speed in km/h
9	System voltage terminal 30 in Volt
10	Read out country-specific code
11	Read out units (AM/PM or mm.dd/dd.mm) etc.
12	Average speed for arrival and momentary arrival
13	Triggering acoustic signals
14	Read out of error bytes (self-diagnosis)
15	Display of I/O port statuses
16	free
17	free
18	free
19	Locking and Unlocking Test Functions
20	Entry of a correction factor for average consumption
21	Reset IKE (software reset)

Speed display

The speed indication function is equipped with various types of speedometer depending on the vehicle model.

The instrument cluster receives the position signal tw from the antilock brake system (ABS)/automatic stability control (ASC)/dynamic stability control (DSC) control unit.
In this way, the instrument cluster electronics (**IKE**) controls the speedometer, total odometer reading and trip odometer reading displays.

The instrument cluster derives the speed from the position signal **tw** and from the position pulse number (**K-number**) stored as coding data in the instrument cluster electronics (**IKE**). In addition, the instrument cluster makes available a speed signal (**speed-A**) for the connected control units. The speed information is made available in the form of a telegram on the instrument bus **(I-bus**) and body bus (**K-bus**).

Engine speed display

Since 5/97 an instrument cluster has been phased-in which features the plugged-on instrument cluster electronics (**IKE**) integrated in the display unit (**AE**). This instrument cluster can replace older instrument cluster versions.

The instrument cluster uses the engine speed signal from the engine control unit (**td** for petrol engines) to determine the engine speed. Adaptation to match the various types of engines takes place by means of the stored coding data.

In the case of the integrated version of the instrument cluster, phased-in as from 5/97, the coding data defines whether the engine speed signal is routed via the CAN bus or via a separate line to the instrument cluster.

As of terminal 15 "ON", the engine speed instrument (rev counter) is controlled by the instrument cluster electronics (**IKE**) with the corresponding engine speed signal. The engine speed information is also made available on the instrument bus **(I-bus**) and body bus (**K-bus**) for other control units.

Fuel consumption display

Since 5/97 an instrument cluster has been phased-in which features the plugged-on instrument cluster electronics (**IKE**) integrated in the display unit (**AE**). This instrument cluster can replace older instrument cluster versions.

The fuel consumption signal t_{KVA} is derived from the injection signal supplied by the engine control unit. By linking it with the position signal, it corresponds to the consumption per unit of distance (e.g. l/100 km).

In the case of the twelve-cylinder engine, the consumption is determined from the fuel injection signals of both engine control units and the position signal.

In the case of the integrated version of the instrument cluster, phased-in as from 5/97, the coding data defines whether the injection signal is routed via the CAN bus or via a separate line to the instrument cluster.

Fuel gauge

General

The tank content is measured with two lever sensors which are separately linked to the instrument cluster electronics (**IKE**). Each lever sensor is connected with a separate ground (analog ground) and a sensor line (analog positive) to the instrument cluster electronics (**IKE**). There is no reserve contact in the level sending unit to activate the fuel reserve warning lamp. The fuel reserve warning lamp is switched on dependent on the tank contents in comparison with a reserve threshold value.

Tank

At present tank sizes with 85l and 95l capacity are installed in the 7 Series (E38). A 95l tank can be recognised by the fact that it extends lower than the floor assembly and a stone guard is installed. At present, only a 70l tank is installed in the 5 Series (E39). The different methods of determining the fuel level for the fuel gauge with the 85l / 95l (E38) and 70l (E39) tank are adapted by means of the coding data.

If defined training of the left-hand or right-hand tank half is necessary for test purposes, particular care must be taken to ensure that the correct connection is used (on 7 Series E38 only). For both tank halves it is located on the left-hand half of the tank. On both drain connections, a reclined rectangle is stamped on the connection for the right-hand half of the tank and an upright rectangle is stamped on the connection for the left-hand half of the tank.

On the 5 Series (E39) it is not possible to drain off fuel via separate connections. In this case, the fuel must be drained off via the filler tube (tank neck).

Coolant temperature display

Since 5/97 an instrument cluster has been phased-in which features the plugged-on instrument cluster electronics (**IKE**) integrated in the display unit (**AE**). This instrument cluster can replace older instrument cluster versions.

The instrument cluster determines the current coolant temperature by way of the coolant temperature sensor (NTC resistor). The coolant temperature sensor is connected with a separate ground (analog ground) and a sensor line (analog positive) to the instrument cluster electronics (**IKE**).

In the case of the integrated version of the instrument cluster, phased-in as from 5/97, the coding data defines whether the coolant temperature signal is routed via the CAN bus from the engine control unit or via a separate line from the coolant temperature sensor to the instrument cluster.

The instrument cluster electronics (**IKE**) transfers the "coolant temperature" information via the instrument bus (**I-bus**) and body bus (**K-bus**).

Service interval display

The service interval display (**SIA**) serves the driver and the workshop as an indication showing that an engine oil service, distance inspection or time inspection is due. The inspection intervals of the vehicle are not rigidly referred to the kilometres covered but rather they depend on the consumption. The current service interval status is displayed as of "Terminal 15 ON" for 10 seconds after reaching a minimum engine speed of 400 rpm.

The data of the service interval display (**SIA**) are also stored in the light check module (**LCM**).

Reset service interval display

The service interval display (**SIA**) is reset by pulses of a defined length at the service interval reset input. Each reset operation can be carried out individually and independently (service interval display [**SIA**] reset). The oil service, time inspection or/and distance inspection can be reset.

Total odometer reading

Display of the total distance covered is a component part of the LC display. The current mileage is indicated on the display as of terminal R "ON". At "Terminal R OFF" the mileage can be displayed by pressing the instrument cluster button for approx. 25 seconds after the button has been released. The unit of distance (km/miles) dependent on the coded country-specific version is displayed next to the trip odometer. The total distance is made available in the form of a telegram on the instrument bus **(I-bus**) and body bus (**K-bus**).

The total distance is stored in the instrument cluster electronics (**IKE**) and in the light check module (**LCM**). "999999" is displayed as the total distance if the instrument cluster electronics (**IKE**) cannot read the total distance and it cannot be determined by way of the light check module (**LCM**).

Trip odometer reading

Display of the distance covered on a trip is a component part of the LC display. The current trip odometer reading is shown on the display as of "Terminal R ON". At "Terminal R OFF", the mileage can be displayed for 25 seconds by pressing the instrument cluster button. The unit of distance (km/miles) dependent on the coded country-specific version is displayed next to the trip odometer.

Outside temperature display

The instrument cluster determines the current outside temperature by way of the outside temperature sensor (NTC resistor). The outside temperature sensor is connected with a separate ground (analog ground) and a sensor line (analog positive) to the instrument cluster electronics (**IKE**). The outside temperature is not displayed in the multi-information display (**MID**), but rather permanently in the instrument cluster. If, while driving, the outside temperature drops below +3 °C, dependent on the coding, the gong warning 2 (T2) is triggered and the displayed value flashes. The display unit (°C/ °F) is determined in the coding data.

The display change is delayed since heat from the engine and other ambient conditions influence the outside temperature display.

The instrument cluster electronics (**IKE**) transfers the "outside temperature" information via the instrument bus (**I-bus**) and body bus (**K-bus**). In ignition lock position "0", the outside temperature sensor is read by the IKE at time intervals which are within the minute range. For this purpose, the IKE is temporarily activated, provides the information and then switches itself off again.

Text display

The text display is an LC display which is highlighted by lamps. The 5 lamps provide the background lighting for the service interval display (**SIA**), the total odometer, trip odometer, outside temperature display and the text field for messages.

Instrument dimming

The dimming function for dimming the highlighting is carried out independent of instrument dimming. The brightness sensor (photo transistor in warning lamp field under oil pressure warning lamp) only influences the background light of the LC display. In contrast to this, the brightness of the instruments and of the LC display is influenced by the dimming signal from the light check module (LCM) when the light is switched on.

Gong

The electronic gong serves as an acoustic signal generator for the hour signal tone 1 (T1), the temperature warning tone 2 (T2), a warning signal tone 3 (T3) and the code signal tone 1 with tone 2. The signal lines for gong activation of tone 1 - tone 3 are used by the instrument cluster, however, they can be interrupted by the park distance signal tone 4 (T4). The tones T4 and T5 can be activated via further inputs at the gong, dependent on the vehicle equipment level. These acoustic functions **cannot** be triggered by the instrument cluster electronics (**IKE**) but rather they are a functional part of vehicle components.

The hour signal T1 with three short "peep tones" (1 kHz) reminds the user of radio news broadcasts or traffic announcements.

In the case of the temperature warning T2, one single gong (1 kHz) is triggered which warns the driver of low outside temperatures (ice hazard).

The warning signal T3 warns the user by means of a long tone (1 kHz), followed by the gong sounding. It serves the light check module (LCM) as a form of acoustic output. The light check module (LCM) informs the instrument cluster that the acoustic signal has been triggered in the form of an I-bus telegram (instrument bus).

The short code signal is triggered by the tone T1 and T2 (750 Hz). It indicates to the user that the programmed speed limit has been exceeded or it draws attention to a code function still active when starting.

Speed signal speed-A

The instrument cluster receives the position signal tw from the antilock brake system (ABS)/automatic stability control (ASC)/dynamic stability control (DSC) control unit.

The instrument cluster derives the speed signal from the position signal **tw** and from the position pulse number (**K-number**) stored as coding data in the instrument cluster electronics (**IKE**). The speed signal (**Speed-A**) is made available as a signal output for connected control units. The speed information from the speed-A signal is received by the connected control units by measuring the frequency or period duration. This speed information is also made available in the form of a diagram via the instrument bus **(I-bus**) and body bus (**K-bus**).

Reverse detection (manual transmission)

The "Reverse detection" function is only active when this function is correspondingly coded in the instrument cluster. If the instrument cluster is coded for manual transmission, the program and selector lever display for automatic transmission is masked out.

The information "reverse engaged" is made available in the form of a telegram via the body bus (**K-bus**).

Transmission program display (automatic transmission)

Since 5/97 an instrument cluster has been phased-in which features the plugged-on instrument cluster electronics (**IKE**) integrated in the display unit (**AE**). This instrument cluster can replace older instrument cluster versions.

The instrument cluster is connected to the transmission control unit by means of a separate data link. By way of this data link, the transmission control unit informs the instrument cluster electronics (**IKE**) which drive stage is engaged, which drive program is switched on and whether the transmission is in the emergency program. If the transmission signals "emergency program", the signal is transferred to the light check module (LCM) as a bus signal. If the instrument cluster is coded for automatic transmission, the program and selector lever display for automatic transmission is activated.

In the case of the integrated version of the instrument cluster, phased-in as from 5/97, the coding data defines whether the transmission data is routed via the CAN bus from the transmission control unit or via separate data links from the transmission control unit to the instrument cluster.

Instrumentation bus (I-bus)

The instrumentation bus (I-bus) is one of three information links (data link/serial) via a data link to other control units. The instrument bus is monitored by the instrument cluster electronics (**IKE**). The IKE also sets up the interconnection of the bus systems:

- I-bus (instrumentation bus)

- K-bus (body bus)

- Diagnosis bus (link to diagnostic socket),

- CAN bus (instrument cluster-integrated version phased-in as from 5/97)

(gateway function).

Body bus (K-bus)

The body bus (K-bus) is one of the three information links (data link/serial) via a data link to other control units. The body bus is only monitored electrically by the instrument cluster electronics (**IKE**). The body bus is monitored by the general module (GM).

Diagnosis bus (D-bus)

The diagnosis bus (D-bus) is one of three information links (data link/serial) via two data links to the control units with diagnostic capabilities. The diagnosis bus is only active when a BMW service test system is connected to the diagnostic socket.

Warning lamps

General: The background lighting of all warning lamp symbols as well as the engaged drive stage for automatic transmission together with the selected drive program is provided by LEDs.

General brake warning lamp: The warning lamp can be switched on by the light check module (LCM) when, for example, the LCM detects the brake fluid level as being too low. The warning lamp is also switched on after ignition "ON" as a function check (pre-drive check) and goes out when a minimum engine speed of 400 rpm is exceeded.

In the event of a break in the line connection from the IKE sensor output to the IKE sensor input, the brake lining wear detection function sends an I-bus telegram to the LCM. On receiving this signal, a corresponding message is sent from the LCM to the IKE where it is indicated in the text display. The general brake warning lamp is not switched on for this purpose.

Parking brake warning lamp: The warning lamp is activated by a switch on the parking brake. The switch is open when the parking brake is released.

The "parking brake" information is made available in the form of a telegram via the instrument bus **(I-bus**) and body bus (**K-bus**).

Seat belt indicator lamp: The seat belt indicator lamp is activated dependent on the coding data. For vehicles without a seat belt buckle contact, it is switched on for approx. 6 seconds after terminal 15 "ON".

On vehicles equipped with a seat belt buckle contact, the warning lamp is switched on as of terminal 15 "ON" by a corresponding I-bus telegram from the light check module (LCM) until the seat belt contact is opened (seat belt buckle locked in position).

Fuel reserve lamp: The fuel reserve warning lamp is not switched by a reserve contact in the level sensor. It is switched dependent on the tank content compared to a reserve threshold value.

Turn signal indicator lamps: The turn signal indicator lamps are switched by means of a corresponding I-bus telegram from the light check module (LCM) to the instrument cluster electronics (IKE).

Fog light indicator lamp: The fog light indicator lamp is switched by means of a corresponding I-bus telegram from the light check module (LCM) to the instrument cluster electronics (IKE).

Rear fog light indicator lamp: The rear fog light indicator lamp is switched by means of a corresponding I-bus telegram from the light check module (LCM) to the instrument cluster electronics (IKE).

High beam indicator lamp: The high beam indicator lamp is switched by means of a corresponding I-bus telegram from the light check module (LCM) to the instrument cluster electronics (IKE).

Oil pressure indicator lamp: The warning lamp is switched by the oil pressure switch. The information from the oil pressure switch is read by the instrument cluster electronics (IKE) as status data and a corresponding I-bus telegram is sent to the light check module (LCM). On receiving this signal, a corresponding message is sent from the LCM to the IKE where it is indicated in the text display.

Note

All warning lamps not listed have no functional connection with the instrument cluster electronics (**IKE**). They are only supplied with positive or negative from the display unit of the instrument cluster.

The functional description contains the following sections:

- Engine components / basic engine

- Engine components / cylinder head

- Engine mounting parts

- Cooling circuit

- Digital Motor Electronics DME M5.2

INTRODUCTION

The M62 engine series replaces the M60 engine. The M62 engine is a consistent further development of the BMW V-8 cylinder engine series introduced in 1992. As of 1/96 it will be installed in the series E31, E38 and E39 over a staggered period of time.

The new M62 engine is based on the M60 engine with regard to its essential features:

- 8-cylinder V-engine

- Cylinder arrangement 90 ^{o}

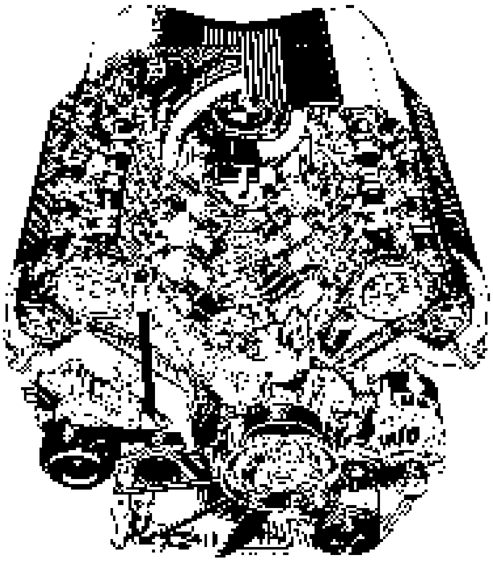
- 2 four-valve cylinder heads

- Light alloy design

The M62 engine is offered in two capacity variants, i.e. a 3.5 l and a 4.4 l variant.

It is installed in the following model series:

Model series / engine	M62B35	M62B44
E31	-	840i
E38	735i	740i
E39	535i	540i



Engine M62

The most important objectives of the further development were compliance with new legal stipulations and improvement of comfort and quality.

Particular attention was paid to the following features:

- Reduction of fuel consumption
- Rounder/fuller torque curves (for improved vehicle elasticity)
- Optimization of engine acoustic and comfort characteristics
- Compliance with new exhaust emission regulations (EU-2) as well as the expected on-board diagnosis (OPD II) requirements in the USA.

Essentially, these objectives were realised by increasing the engine capacity, modifications to the crank drive, modifications to the camshaft drive, further development of various engine components as well as by implementing the new digital motor electronics DME M5.2.

Engine components / basic engine

Crankcase

For production reasons (production capacity at crankcase manufacturer), two different aluminium alloys are used in the production of the crankcase.

The crankcases of engines for markets with critical fuel quality (high sulphur content in fuel) are made of Alusil (same as M73). These are engines for

- USA/CND

- GB (incl. Ireland)

- South America

- Mexico

- Saudi Arabia

- South Africa

In the same way as the M73 engine, the crankcase of these engines is made from an aluminium alloy (Alusil) in a chilled casting process. The cylinder barrels are not coated. The required surface quality of the cylinder barrels is achieved by means of an etching process as part of the production process.

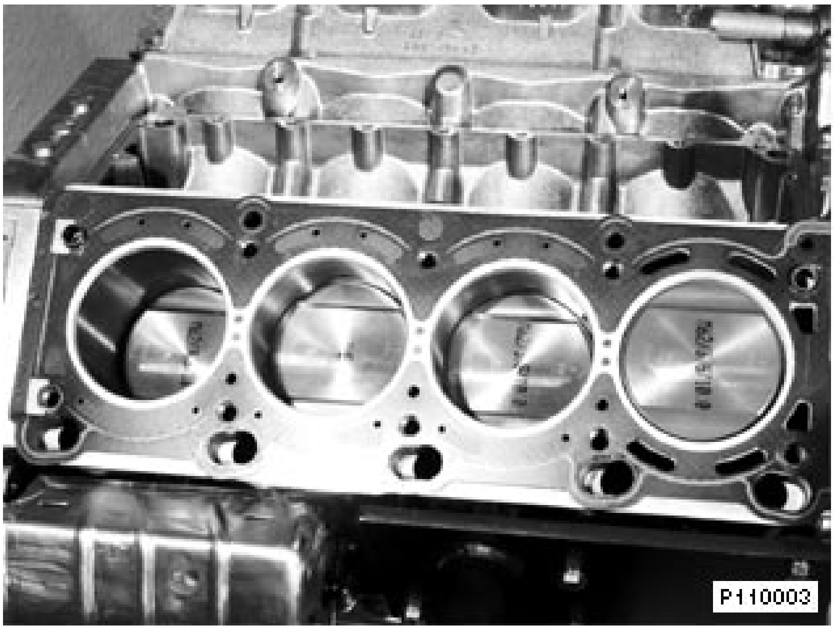
The crankcases of the M62 engines for all other markets are made of the aluminium alloy (AlSi9Cu3) as known from the M60 engine. The cylinder barrels of these crankcases are coated in a nickel-dispersion process (Nikasil)

The part number serves as the external identification feature for both crankcase variants (aluminium alloys). The two material variants of the crankcases also feature correspondingly different surface coatings for the pistons (refer to ’Pistons’).

Irrespective of the different production methods, the design of the crankcases is identical for both variants.

As already fitted on the M52 and M73, piston cooling by means of hook-type nozzles is implemented on the M62. These hook-type nozzles are screwed directly into the bearing blocks. With the aid of these hook-type nozzles, the oil jet is directed at the piston crown over the entire path of piston travel.

The hook-type nozzles are assembled and disassembled in a different way than known from the M52 / M73. Please follow repair instructions!



M62 engine block with pistons

Crankshaft

Due to the extended stroke, the crankshaft is new for both engine capacity variants. As on the M60, it is mounted in 5 bearings. The crank pins are offset by 90 $^{\circ}$. Six counterweights ensure smooth engine operation.

The crankshaft is forged in steel for both M62 engine capacity variants. Weight is reduced by the central hollow cavity.

Pistons

Corresponding to the two different aluminium alloys used for the crankcase (dependent on country variant), the pistons and piston rings feature different surface coatings. The pistons for the crankcases made of Alusil are ferrous-coated. The pistons are differentiated by their part numbers.

If pistons need be replaced during repairs, care must be taken particularly on vehicles from foreign markets to ensure that the pistons and piston rings, allocated to the crankcase on the basis of their corresponding part numbers, are installed.

Irrespective of the surface coating, the design of the pistons is identical (full slipper skirt pistons).

The pistons are designed to enable operation with fuel RON 95. The compression ratio for both engine capacity variants is 10.0 : 1.

Connecting rods

The connecting rods are of the same design as on the M60 engine.

For the first time on the M60 engine and now also on the M62 engine, sintered metal connecting rods are fitted. In addition to the lower weight (moved masses), these connecting rods offer high strength over the entire output range of an engine.

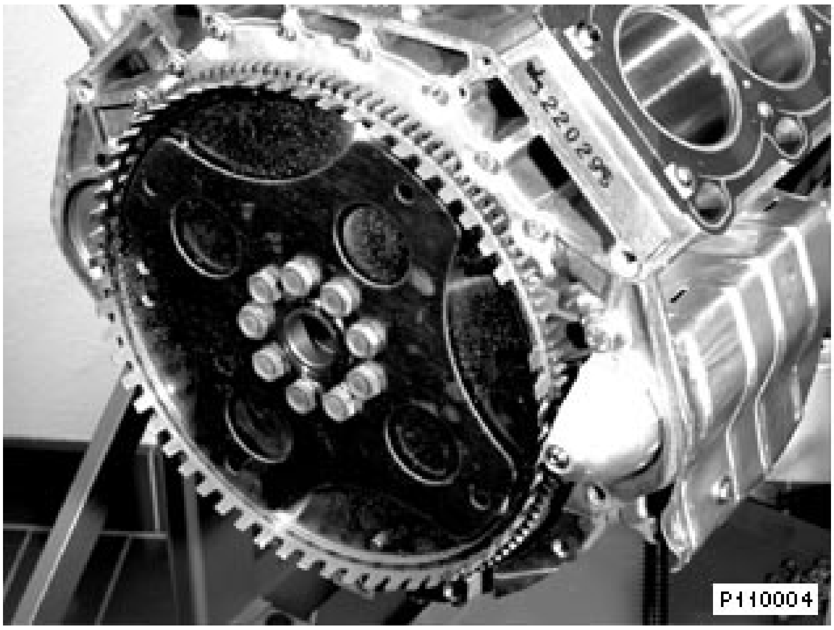
The connecting rod and the big-end bearing cap are separated during manufacture of the forged sintered connecting rods. This renders conventional centring by means of fitted dowels during assembly unnecessary. Centring is achieved by means of the break structure and the guide for the connecting rod bolts. Taring (coloured dots or identification numbers for the weight class) is not necessary thanks to the high production accuracy achieved in the sintered forging process.

On the M62 engine, new antifatigue bolts are used to secure the connecting rod to the crankshaft.

Flywheel

In connection with the automatic transmission, the flywheel is of a one-piece design and made of steel. A hydraulically dampened dual mass flywheel (ZMS) is used on manual transmission vehicles.

As on the M73 engine, the increment gearing for the crankshaft sensor is located on the flywheel for both variants. The inductive pulse generator is mounted in the transmission/clutch bell housing. The new installation location for the increment wheel on the flywheel now makes it possible for the DME control unit to detect misfiring.



Flywheel with increment gearing

On the previous engines, the increment wheel was mounted radially dampened by means of a vulcanised rubber element on the torsional vibration absorber. With this arrangement, it would not be possible to detect irregularities in engine speed.

On the flywheel, the increment wheel is connected rigidly to the crankshaft without a damping element.

In this way, irregularities in engine speed, caused by misfiring for example, are transmitted directly to the increment wheel. In addition to the engine speed and reference mark, misfiring caused by faults in the ignition or fuel injection systems can now be detected with the inductive pulse generator. Misfiring detection is a requirement laid down in OBD II (US).

You will find a detailed description of the operating principle of misfiring detection in Section DME.

Oil pan

As on the E38 M60, the oil pan is of a two-piece design. The upper part is an aluminium die casting. The bottom part of the oil pan is based on a double sheet metal plate design.

The oil filling capacities are identical to those of the M60 engine.

The oil filling capacities for both M62 engine displacement variants are:

- The oil filling capacities for both M62 engine displacement variants are:

- 9.25 l for initial filling

- 7.5 l oil change with oil filter

- 8.5 l oil change with oil filter including oil cooler (tropics)

The difference between ’MIN’ and ’MAX’ on the dipstick is 1.5 l.

Oil pump

The oil pump housing and the oil pump cover of the M62 are made of aluminium die casting (M60 magnesium). The design and drive of the oil pump are identical to those of the M60.

Oil level sensor

As in the E38 M60 and in the M73 engines, a thermal oil level sensor is fitted in the M62.

This oil level sensor sends a pulse width modulated signal to the check-control module (E31: CCM; E38/E39: LCM).

The pulse duty factor of this signal is a measure for the oil level in the engine. If the level drops below a threshold value stored in the CCM/LCM control unit, the check control message "Check engine oil level" is displayed for the driver.

You will find a technical description in the Trainer’s Guide Instrument Cluster Electronics IKE / I-Bus Network E38.

Oil filter

The oil filter is of identical design as that on the M62, however, the filter housing is secured on the body.

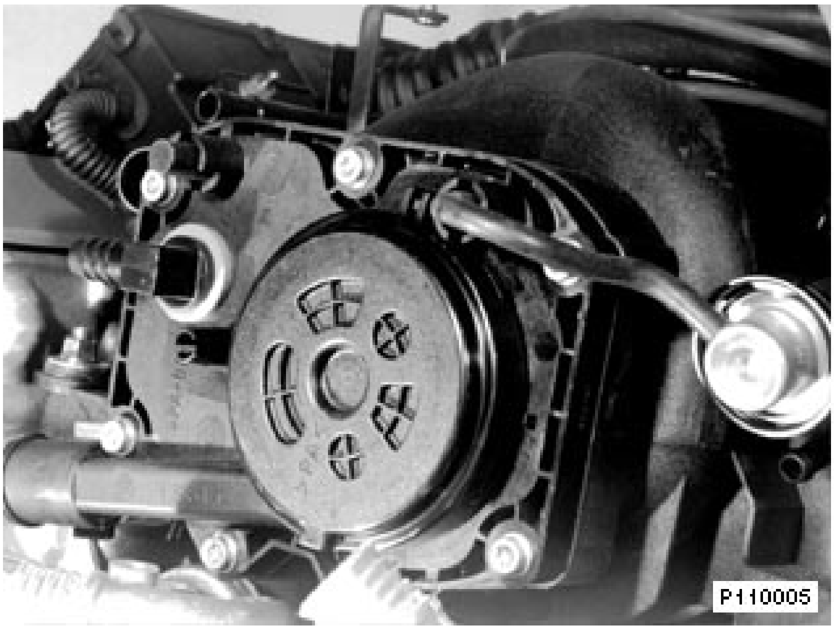
Crankcase ventilation

As on the M60, the crankcase is ventilated by means of a pressure-controlled system. The design of the crankcase ventilation is the same as the system already known from the M60.

The blow-by gasses which are produced during engine operation collect in the crankcase.

The intake system is connected to the crankcase by means of a pressure control valve integrated in the end cover of the intake system. The resulting vacuum draws off the blow-by gasses in the crankcase via a cyclone separator.

The oil vapours contained in the blow-by gasses condense on the cool walls of the cyclone separator and are returned to the oil sump via a return line. The remaining gaseous components are fed via a distributor pipe in the intake system to the mixing chamber in the throttle housing.

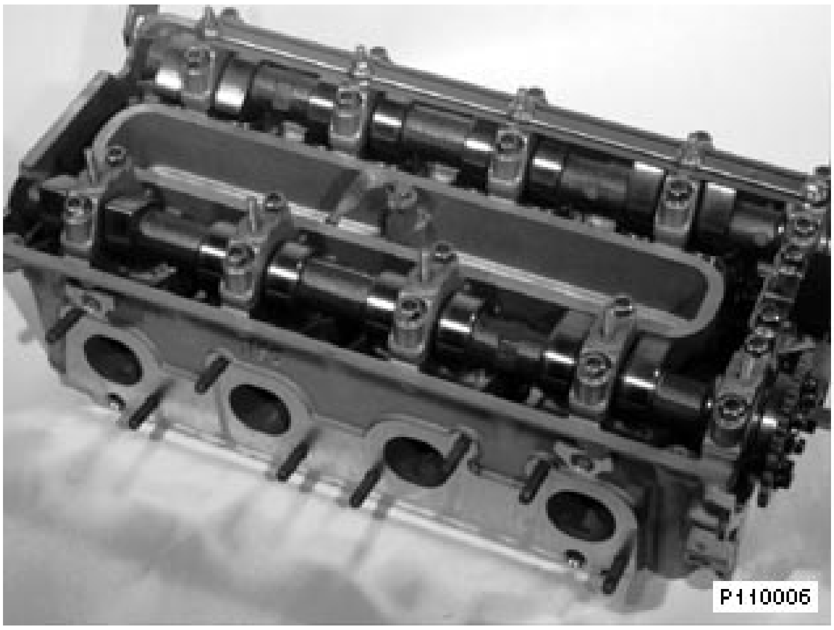


Pressure control valve in intake system

Engine components / cylinder head

Cylinder head

The 4-valve cylinder heads of the M62 basically correspond in design to those of the M60, however, they are not a common part. To facilitate external differentiation, the lettering M60 or M62 as well as the relevant capacity variant (e.g. B35) are cast in the unmachined blank.



M62 cylinder head

Cylinder head gasket

The cylinder head gasket is asbestos-free. In contrast to the cylinder head gasket of the M60, it no longer covers the area of the timing case cover. A new rubber formed gasket is now used in this area (refer to timing case cover). For this reason, the identification designation of the cylinder head gasket (3.5 l / 4.4 l) has been relocated towards the rear.

Cylinder head cover

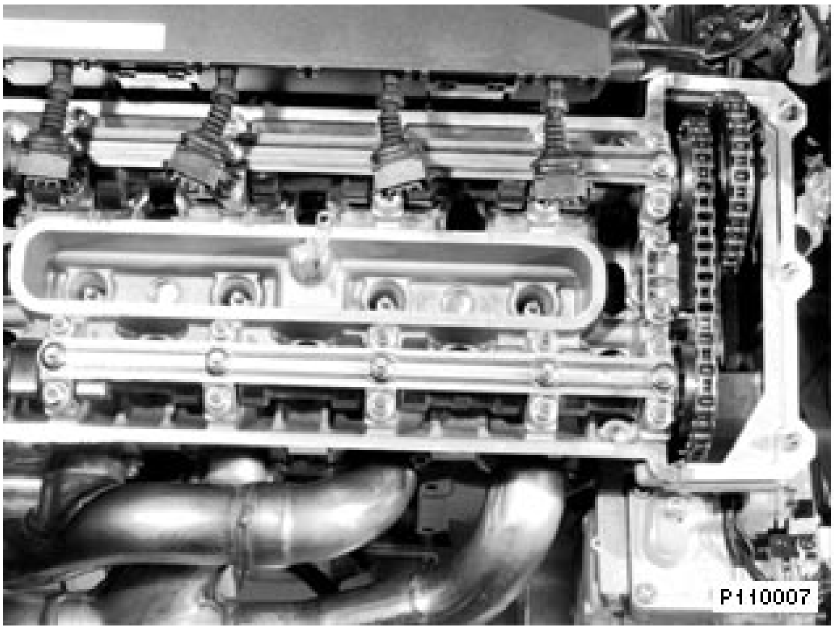
The cylinder head cover is made of magnesium.

Care must be taken to avoid damaging the surface of the magnesium cylinder head covers as surface damage increases the risk of corrosion.

Camshafts

Two overhead camshafts are allocated to each cylinder head. In the same way as the camshafts of the M60 engine, they are designed as solid shafts made of high-carbon steel casting.

The angle position of the engagement dihedron of the camshafts has been adapted to the existing M60 engagement tools. In this way, the M60 engagement tools can also be used for setting the M62 camshafts.



Cylinder head with camshafts and oil lines

Camshaft identification

As on the M60, the camshafts are identified by punched alphanumeric combinations (E1-4, A1-4, E5-8, A5-5).

Valve train

The main aim in the design of the valve train was to reduce the moved masses. The masses of the hydraulic tappets, the valve springs and of the upper valve spring retainer have been considerably reduced in conjunction with lower frictional torque and noise reduction. This has made it possible to achieve lower frictional torque and reduction in noise.

Valves

With regard to their dimensions and weight, the valves are identical to those on the M60 (common part M60).

HVA bucket tappets

The diameter of the HVA bucket tappets has been reduced (M60: (35 mm / M62: (33 mm). In this way it has been possible to reduce the weight by 32g to 48g (M60: 80g)(common part M52). These are INA bucket tappets, self-venting with carbon nitrited cam surface.

Valve springs

The use of conical single valve springs has made it possible to reduce the moved masses even further.

Spring retainer

The weight of the top spring retainer has also been optimised (common part M44 and M52). The bottom spring retainer is a common part with M52.

As a whole, a distinct reduction in weight of the valve train has been achieved by these measures as illustrated in the table below.

	M60B40	M62B44
Inlet valve (g)	49	49
Exhaust valve (g)	48	48
HVA bucket tappets (g)	80	48
Valve spring(s) (g)	36	12
Upper valve retainer (g)	15	8
Valve collets (g)	1	1
Inlet per valve (g)	181	118
Outlet per valve (g)	180	117

Timing drive

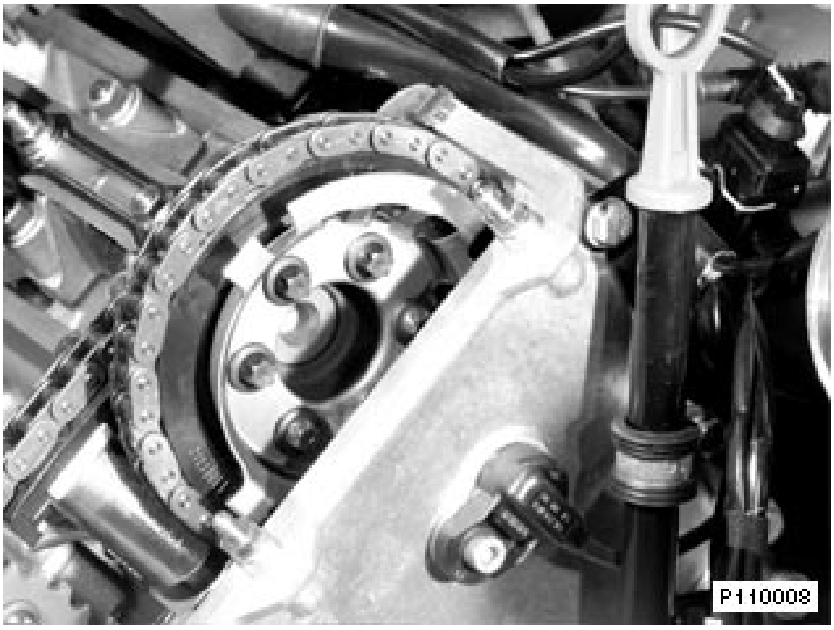
Primary drive

To facilitate precision optimisation with regard to noise, weight and friction, the primary drive is transmitted via a single roller chain (M60: double roller chain) from the crankshaft to the inlet camshaft. The primary drive sprockets are rubberized to enable low-noise engagement of the chain.

Camshaft sensor wheel

A sensor wheel with 4 sensor markings for identifying cylinder number 1 (DME) is mounted on the inlet camshaft sprocket for cylinders 1-4. In contrast to the M60 (inductive position sensor), a hall sensor is used as the camshaft position sensor on the M62 engine.

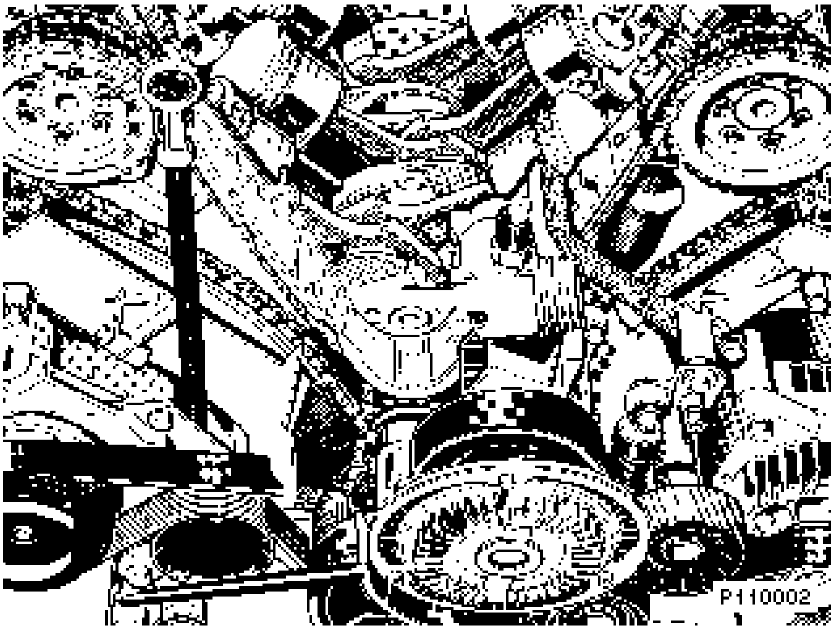
Due to the new design of the camshaft position sensor wheel, positioning of the sensor wheel for the camshaft drive has also been newly defined. The camshaft sensor wheel now features a mark (notch). Particular care must be taken during assembly to ensure that this mark faces downward with respect to the cylinder axis. For more details, refer to the repair instructions.



M62 camshaft sensor wheel

Deflection rail for primary chain

The deflection wheel in the V-chamber has been replaced on the M62 by an aluminium deflection rail with clip-on plastic track. The chain is tensioned by means of a hydraulic chain tensioner with a pressure limiting facility.



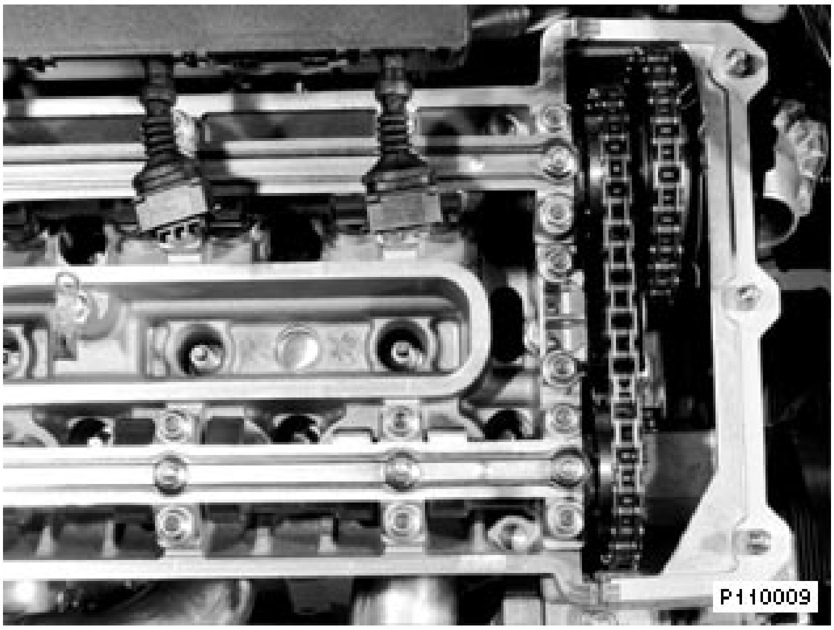
M62 engine with deflection rail for primary drive

Due to the use of a deflection rail (instead of the deflection wheel), during assembly of the primary drive, modified torque values for pretensioning the rail must be observed (refer to repair instructions).

Secondary drive

The secondary drive is also based on a single roller chain. It extends from the inlet camshafts to the exhaust camshafts.

A hydraulic chain tensioner is integrated on each cylinder head



M62 cylinder head with single roller chains

Timing case cover

As on the M60, the timing case covers are attached at the cylinder heads and at the central crankcase.

The sealing system is new:

The two upper timing case covers are sealed with respect to the cylinder head and the lower timing case cover by means of a rubber formed gasket. This rubber formed gasket achieves better tolerance compensation and acoustic decoupling between the lower and upper timing case covers.

Due to the use of the modified gasket, a new procedure for assembling the upper timing case cover must be observed in order to achieve the optimum sealing effect. Refer to assembly not in repair instructions!

The lower timing case cover is sealed with respect to the crankcase by means of a flat gasket.

Engine mounting parts

Throttle valve

The throttle body of the M62 has been newly designed. A mixing chamber has been realised in the area of the orifice for idle air control (ZWD 2).

This mixing chamber is formed by a plate with precisely designed orifices installed between the intake system and throttle valve.

The air for the idle actuator, the purge air of the carbon canister and the blow-by gasses via the uniform distribution pipe, leading from the pressure control valve for crankcase ventilation to the throttle housing, flow into this mixing chamber. Here, the blow-by gasses and the purge air of the carbon canister are mixed with fresh air. This ensures all cylinders receive the blow-by gasses uniformly thus providing a smooth and uniform idle quality.

Intake manifold

The intake manifold of the M62 is a one-piece plastic part. It corresponds to that fitted on the M60B40.

The pressure control valve for crankcase ventilation is mounted directly on the intake manifold. A distribution pipe leads from the pressure control valve through the intake manifold to the mixing chamber in the throttle valve in order to evenly distribute blow-by gasses over all cylinders.

A connection for the Master-Vac of the brake booster is provided in the cover of the intake manifold.

Ignition system

In the same way as the majority of BMW engines, the M62 features a static high-voltage distribution system.

Ignition coils

New ignition coils are used for the M62 engine. The ignition coils are of the same design as those fitted on the M52 engine. Due to their modified mechanical design, they are smaller and lighter compared to the ignition coils used to date.

Comparison of ignition coils M60 - M62

Alternator

A compact alternator (140 A) with fresh air intake is used on all vehicles equipped with the M62 engine.

A water-cooled 220 A alternator is still used on E31 vehicles (two batteries in luggage compartment!) with increased power requirements and thus a higher closed-circuit current (due to special options such as in-car telephone or independent heating).

Auxiliary fan

In connection with the special option air conditioning, a 3-stage electrically powered auxiliary fan is used in the E39.

This auxiliary fan is a standard feature in the models E31 and E38 since the air conditioning system is standard equipment in these vehicles.

To facilitate noise optimisation, the previous two-stage circuit has been extended by a third stage. The cut-in criteria for the individual stages have been redefined.

Cut-in criteria

Cut-in	Stage I	Compressor clutch active and outside temperature> 10 °C. - Water temperature> 91 °C.
Cut-in	Stage II	- Pressostat medium pressure switch closed > 21 bar
Cut-in	Stage III	- Water temperature> 104 °C. (Cut-in via dual temperature switch)
Cut-out	Stage IV	-Compressor clutch inactive - outside temperature < 8 °C. - Water temperature < 91 °C

Starter

As on the M60, the starter used for all variants is a 12 V Bosch countershaft starter with an output power of 1.7 kW.

The lines and line arrangement to the battery charge terminal point are new in the series E38 and E39. The B+ lead is routed under the engine to the alternator and to the battery charge terminal point.

The battery charge terminal point is located on the timing case cover of cylinder bank 5 - 8.

On the E31, the battery charge terminal point is still located on the right-hand MacPherson strut tower.

Exhaust system

The complete exhaust system from the manifold to the tail pipe is made of stainless steel and is one piece from the manifold flange downward.

Exhaust manifold

As on the M60, air-gap insulated sheet metal exhaust manifolds are used on the M62.

Catalytic converter

The headpipes are also air gap-insulated double pipes (tube-in-tube).

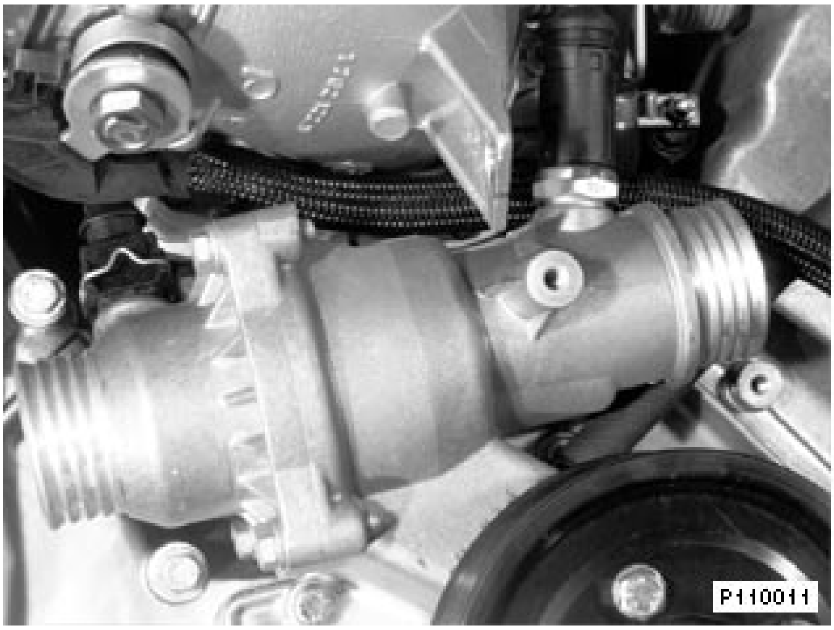
Catalytic converter is of a twin flute design each with 2 trimetall layers (platinum, palladium, rhodium) ceramic monolith per exhaust line. In order to achieve the lowest possible exhaust gas backpressure, the monoliths have the same cross section as those on the M73.

Cooling circuit

The principle design of the water circuit corresponds to that of the M60 engine.

Water pump

The design of the water pump is identical to that of the M60 engine. The housing is an aluminium die casting and is secured on the timing case cover. Differing from the M60, a dual temperature sensor for the coolant is installed in the water pump housing. This dual temperature sensor is located at the point where the coolant flows out of the engine.



Detail view water pump with dual temperature sensor

Radiator

The design of the M62 radiator is identical to that fitted on the M60 engine.

An engine oil cooler is additionally fitted for specific country variants.

Characteristic map thermostat

The thermostat is integrated in the housing of the water pump.

As on the M60, a conventional thermostat with integrated vent valve is installed on the E31 with M62 engine. This thermostat opens at 85 ^{o}C.

A new characteristic map-controlled thermostat is used on the vehicle series E38 and E39 with M62 engine.

Function of a conventional thermostat

The control of the engine cooling system with a conventional thermostat is determined by the coolant temperature only. This control system can be subdivided into three operating ranges:

- Thermostat closed: The coolant only flows in the engine. The radiator circuit is closed.

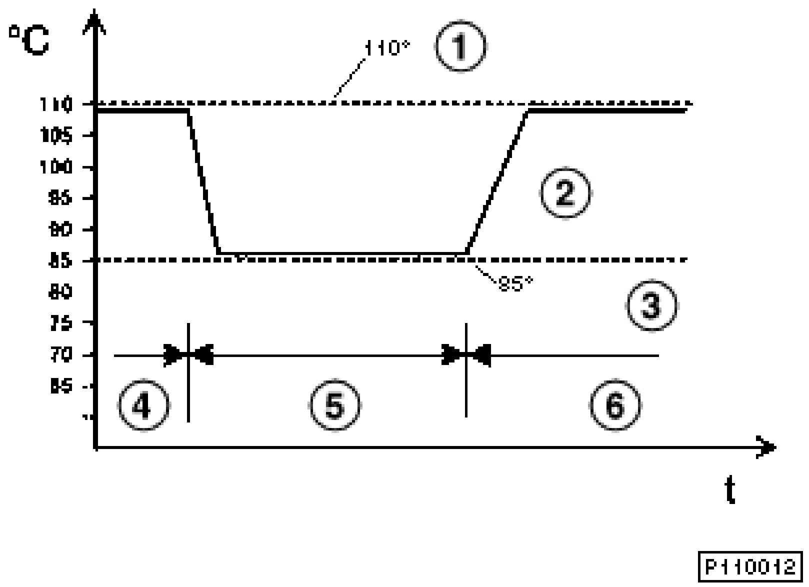
- Thermostat open: The entire volume of coolant flows via the radiator. This ensures the maximum cooling capacity available is utilized.

- Thermostat control range: A part of the coolant volume flows via the radiator. The thermostat sets a constant engine inlet temperature within the control range.

With the aid of the characteristic map thermostat, the coolant temperature can now be influenced specifically within this operating range (thermostat control range).

In this way it is possible to set a higher coolant temperature in the partial load range of the engine. Higher operating temperatures in the partial load range achieve improved combustion, reflected in lower fuel consumption and pollutant emission.

However, higher operating temperatures in the full load range would involve specific disadvantages (ignition timing (angle) reduction due to knocking). For this reason, lower coolant temperatures are set specifically in the full load range with the aid of the characteristic map thermostat.



	Control characteristics of characteristic map cooling
1	Characteristic curve of a 110 °C thermostat
2	Characteristic curve of a characteristic map thermostat
3	Characteristic curve of an 85 °C thermostat
4	Partial load range
5	Full load range
6	Partial load range

BMW is thus the first automobile manufacturer worldwide to use a characteristic map-controlled thermostat for specific control of the coolant temperature in a large volume production engine. With the aid of this thermostat it is possible to specifically increase the coolant temperature in the partial load range. By increasing the coolant temperature under these engine operating conditions, it is possible to reduce fuel consumption. The characteristic map thermostat is controlled by the DME M5.2 in conjunction with a characteristic map.

This characteristic map is determined by the following factors:

- Engine load

- Engine speed

- Vehicle speed

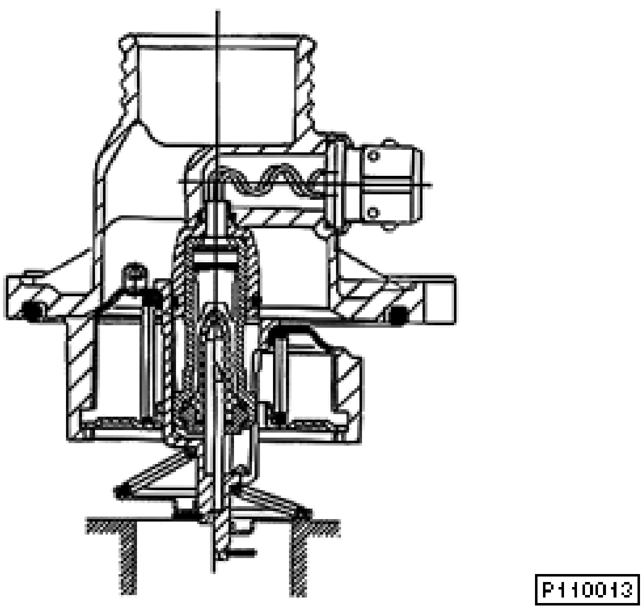
- Intake temperature

- Coolant temperature

Design of a characteristic map thermostat

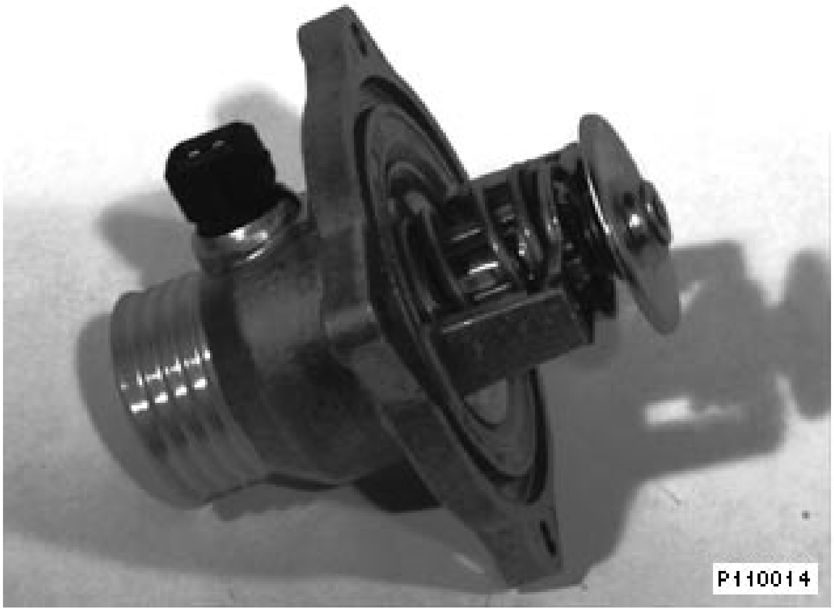
The characteristic map thermostat is an integral thermostat, i.e. the thermostat and thermostat cover make up one unit.

The principle mechanical design of the characteristic map thermostat corresponds to that of a conventional thermostat. However, a heating element is additionally integrated in the expansion element (wax element).



Cross sectional view of the characteristic map thermostat

The cover of the characteristic map thermostat is made of an aluminium die casting. The electrical connection for the heating element linked to the expansion element of the characteristic map thermostat is integrated in the thermostat cover.

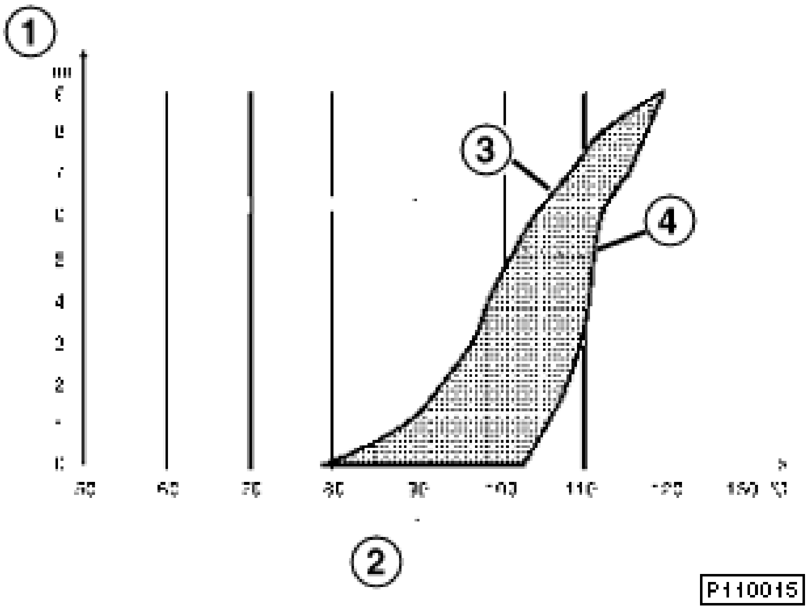


Characteristic map thermostat with electrical connection for heating element

Function of the characteristic map thermostat

The characteristic map thermostat is designed such that it opens (engine inlet) at a coolant temperature at the thermostat of 103 °C without intervention of the integrated heating system. Due to the coolant heating up in the engine, a temperature of approx. 110 °C is measured at the point the coolant flows out of the engine (installation location of coolant temperature sensor for DME and instrument cluster gauge). This is the operating temperature of the engine, at which the characteristic map thermostat begins to open without control intervention.

In the event of control intervention by the DME control unit, power (12 V) is applied to the heating element integrated in the thermostat. Heating the expansion element means that the thermostat now opens at lower coolant temperatures than would be the case without the additional heating function (thermostat control range: approx. 80 °C - 103 °C).



1 Opening path of the thermostat
2 Coolant temperature
3 Activation of heating element with 12 V
4 Activation of heating element with 0 V

If the coolant temperature exceeds 113 °C at the engine outlet, the heating of the characteristic map thermostat is activated by the DME irrespective of the other parameters.

Diagnosis

The line connection and the function of the characteristic map thermostat are monitored by the diagnosis function in the DME control unit. Any faults are stored in the fault code memory of the DME control unit.

Coolant temperature gauge

The indicator characteristics of the coolant temperature gauge in the instrument cluster have been adapted to the higher temperature level of the engine due to the use of the characteristic map thermostat.

The pointer of the coolant temperature gauge in the instrument cluster is located in the mid-position at coolant temperatures of

75 °C - 113 °C

Digital motor electronics DME M5.2

Introduction

The digital motor electronics DME M5.2 from Bosch as already used in the M73 is now used on the M62 engine. It replaces the DME M3.3 of the M60 engine.

This new version of the DME has been developed to meet the objectives specified in the introduction and to comply with new American legislation (e.g. OBD II). The Californian standards in particular stipulate very stringent requirements with regard to exhaust emission values.

These CARB functions (Californian Air Resource Board) are realised in the DME M5.2.

The vehicles designated for the American market are equipped with an on-board diagnosis (OBD) interface which is standardized for all vehicle manufacturers. This interface makes it possible for the state traffic supervisory authority to read out OBD-relevant information from the DME fault code memory at any time. Access to this limited scope of fault code memory information is enabled by internal coding in the DME control unit.

The most important features of the DME M5.2 are:

- Operation of all 8 cylinders with one control unit

- Static high-voltage distribution

- Fully sequential cylinder-individual fuel injection

- Integrated adaptive knock control

- Stereo emission (lambda) control

- Self-diagnosis and emergency operation characteristics

- CAN-bus link

- OBD II functions

- Vehicle immobilization via EWS II (electronic vehicle immobilization)

- Automatic start function

- Control of characteristic map thermostat

OBD II (US only)

In order to monitor compliance with exhaust emission limit values, the Californian and US legislation require monitoring of all emission-related components during vehicle operation. This made more effective self-diagnosis necessary which, among other things, includes a misfiring detection function. If an emission-related fault occurs, the DME activates the ’check engine’ lamp in the instrument cluster on US vehicles. This signals to the driver that a fault has occurred in the engine management system which influences exhaust emission and must therefore be eliminated immediately in a specialist workshop.

The most important OBD II diagnosis functions are:

- Misfiring detection

- Catalytic converter monitoring (oxygen sensor monitor)

- Fuel supply

- Fuel tank ventilation system

A further component part of the OBD II system is an interface which is standardized for all vehicle manufacturers and which can be used by US traffic supervisory authorities to read out emission-related faults stored in the control unit with the aid of a scan tool. Access to the data in the fault code memory is restricted for these authorities to emission-related faults.

With the exception of the functions

- Activation of ’check engine’ lamp

- Oxygen sensor monitor downstream of catalytic converters

All OBD II-relevant monitoring functions which are not designated for the US market are also realised in the DME 5.2 control units. The standardized OBD II interface which permits supervisory authorities access to the fault code memory is also installed only in US vehicles.

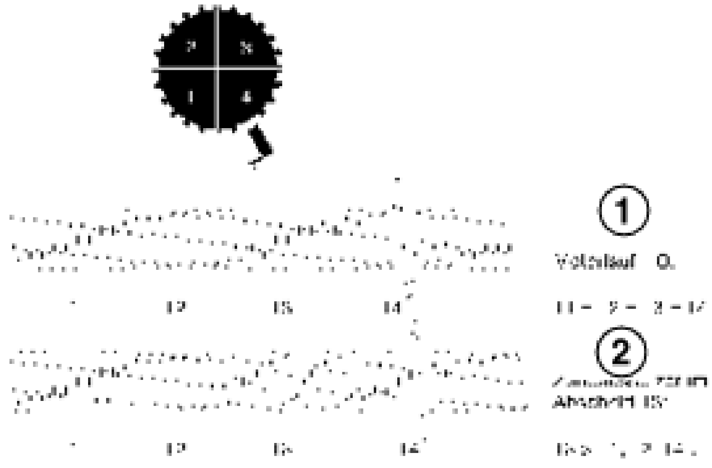
Misfiring detection

The rotary speed of the engine is measured at the increment wheel with the aid of the inductive pulse generator. In addition to measuring the engine speed, misfiring is also detected on the M62 (same as M73).

To facilitate misfiring detection, the increment wheel is now subdivided internally in the control unit into four segments corresponding to the ignition interval (on 8-cylinder engine, 4 ignition cycles per crankshaft revolution).

The period duration (T) of the individual increment wheel segments is measured in the control unit. If the combustion sequence is OK in all cylinders, the period duration of all increment segments will be of the same length (T1 = T2 = T3 = T4).

If a fault (misfiring) now occurs at one cylinder, the period duration allocated to this cylinder is extended by fractions of milliseconds (see Fig.: T3> T1, T2, T4). These segment times are evaluated statically in the control unit.



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Principle of misfiring detection

1 Engine operation OK.

2 Misfiring in section T3

The maximum permissible irregularity values, i.e. the deviation of the period duration of one segment are stored for each characteristic map point as a function of engine speed, load and engine temperature.

On exceeding these permissible values, the cylinders detected as faulty are stored in the fault code memory. In this case, the 'check engine' lamp is activated on US vehicles.

As a further measure, fuel injection to the faulty cylinders is switched off in order to protect the catalytic converter from overheating.

Adaptation

Manufacture-related tolerances of the increment wheel can lead to malfunctions of the misfiring detection system. For this reason, the DME automatically carries out adaptation.

The manufacture-related tolerances of the increment wheel are adapted in coasting phases of the engine without ignition and injection as the engine produces no irregularities due to the combustion procedure in these phases.

Service note:

After replacing a flywheel, increment sensor or DME control unit, particular care must be taken as part of the subsequent test run to ensure that a longer engine cruising phase (approx. 10 sec) is maintained to make it possible for the DME control unit to adapt the flywheel.

CAN-bus link

Digital data transfer between the following control units takes place via the CAN-bus link:

- DME

- AGS

- ABS/ASC

Fuel injector valves

Conical jet valves (as on M60) from Bosch and Lucas are used for both engine capacity variants.

Air mass meter

As on the M60, a hot-film air mass meter is used on the M62.

Idle speed control

As on the M60, the idle speed is controlled on the M62 engine by means of a two-winding rotary actuator (ZWD 5). The air drawn in by the ZWD 5 at idling speed is routed to the mixing chamber of the throttle valve.

Oxygen sensors

An oxygen sensor is arranged upstream of each of the two catalytic converters. The M62 models designated for the US market are additionally equipped with a second oxygen sensor (monitor) downstream of the catalytic converter in order to comply with OBD II regulations. The oxygen sensors are of identical design to those on the M73 engine. (Type designation: Bosch LSH 25).

Knock control / knock sensors

The M62 also features a knock control system. The knock control prevents knocking engine operation. For this purpose, if there is a risk of knocking, the control retards the ignition timing of the corresponding cylinder(s) as far as necessary.

The 4 knock sensors are mounted on the water jacket of the engine block between the two rows of cylinders. They are arranged such that one sensor monitors the two adjacent cylinders. The design and function of the knock sensors are identical to those of the M60.

Coolant temperature sensor

A dual temperature sensor is used on the M62 (as on M52). It serves the purpose of registering the coolant temperature both for the engine management system as well as for the remote thermometer in the instrument cluster. For this purpose, two galvanically isolated NTC pellets with different resistance characteristic curves are integrated in the sensor.

The dual temperature sensor is mounted on the end face of the engine in the water pump housing.

Automatic start function

The automatic start function serves to improve driver comfort during the starting procedure. In order to start the engine, it is only necessary to turn the ignition key into the ’start’ position for a short time (terminal 50). After the DME control unit has received the input signal from terminal 50, the starter motor is activated until the engine starts up. All E38 vehicles with M73 engine are already equipped with this function.

Now all E38 and E39 vehicles with M62 engine are equipped with the automatic start function in conjunction with the special option automatic transmission.

Function

The starter relay is no longer activated directly via terminal 50 with the automatic start function. Terminal 50 now only serves as an input signal for the DME 5.2.

When the DME 5.2 control unit receives the incoming start signal (terminal 50) and the EWS control unit detects the correct change code at the same time, the DME activates the starter relay via the ’automatic start’ output. The prerequisite for this is that the gear selector lever is in ’P’ or ’N’ position.

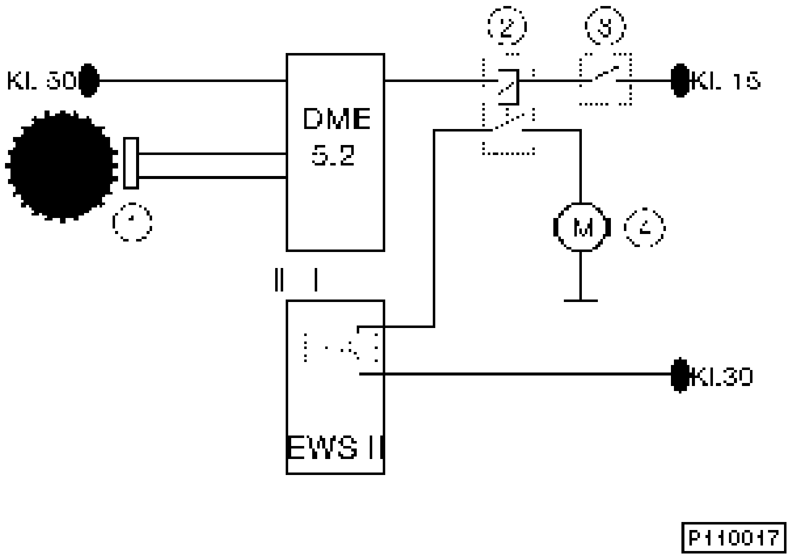
The starter motor is activated by the starter relay until ’engine running’ is detected by the crankshaft sensor.

’Engine running’ is detected when the engine speed

- nMot> 920 rpm when the engine is cold or

- nMot> 680 rpm when the engine is at operating temperature is temporarily exceeded during the starting procedure.

On detecting the ’engine running’ signal, the DME control unit switches off the starter relay. If starting the engine is unsuccessful, the automatic start procedure is terminated after 20 sec by a ground signal output by the DME.



Function diagram ’Automatic start’

1 Crankshaft sensor

2 Starter relay

3 With automatic transmission (L2)

ASC functions

All vehicles with M62 engine are equipped with ASC+T as standard. In order to implement the ASC functions, the M62 engine is equipped with a choke (as on the M60) which is controlled by the ADS II actuator as required in conjunction with a bowden operating cable assembly.

The ABS II actuator is controlled by the ABS/ASC control unit. Other ASC interventions such as ignition timing adjustment as well as ignition and injection cutout are controlled by the DME control unit.

The idle speed actuator (ZWD 5) is also used on the M62 engine to realize the engine drag torque control function (MRS). The idle speed actuator opens specifically when the engine drag torque control (MSR) is activated. It receives a pulse width modulated signal from the DME for this purpose.

The information necessary to control the ASC functions in the DME control unit is transferred via the CAN-bus.

General

The instrument cluster is made up of the instrument cluster electronics (**IKE**) and a display unit (**AE**). The instrument cluster electronics unit (**IKE**) is plugged on to the display unit.

Since 5/97 an instrument cluster has been phased-in which features the plugged-on instrument cluster electronics (**IKE**) integrated in the display unit (**AE**). This instrument cluster can replace older instrument cluster versions.

Bus interfaces, via which the information link (serial data link) to the connected control units is established, are integrated in the **IKE** .

These busses are:

- I-bus (instrumentation bus)

- K-bus (body bus)

- Diagnosis bus (link to diagnostic socket).

- CAN bus (instrument cluster-integrated version phased-in as from 5/97)

Coded data which determine the scope of functions of the instrument cluster electronics (**IKE**) are stored in a non-volatile data memory (data are retained when supply voltage is disconnected).

The various scope of functions includes, for example, the vehicle model and the country language variant.

At present, eight country variants can be chosen:

- Australia/ Gulf States/ South Africa

- Germany

- United Kingdom

- France

- Italy

- Japan

- Canada

- Spain

- USA

Display and indicator instruments

All display and indicator instruments are housed in the display unit. This unit contains display instruments, indicator lamps and the LCD module. The display unit of the instrument cluster is equipped with different display and indicator instruments depending on the vehicle model.

Replacing Instrument Cluster Electronics (IKE)

The four cases described in the following show the steps which must be taken under certain circumstances in order to ensure trouble-free replacement of the instrument cluster electronics (**IKE**).

These four cases also apply to the integrated version of the instrument cluster phased-in as from 5/97. In this case, the instrument cluster can only be replaced.

Case 1: The control unit for the instrument cluster electronics (IKE) is defective and the light check module control unit (LCM) is OK.

Measures	Result	Remarks
Replace IKE (new part)	The manipulation point is set with the ignition switched on.	The manipulation point is set since the vehicle identification number in the light check module differs from the vehicle identification number in the instrument cluster.
Recode IKE		Encode IKE with the central encoding code
Code vehicle identification number into IKE		As long as the vehicle identification number is not coded in the instrument cluster electronics (IKE), total odometer recording (only trip odometer recording) does not take place either in the IKE or in the LCM. It should be noted that in the case of an instrument cluster with CAN bus (instrument cluster-integrated version phased-in as from 5/97) AND dynamic stability control (DSC as from 9/97) the DSC is inactive due to the non-

		matching vehicle identification number. The fault code memory in the DSC control unit should be cleared on completion of this work.
Switch off ignition and switch on again	The manipulation point goes out, the IKE adopts the total odometer reading (mileage) from the LCM as well as the SIA data.	The data exchange between the IKE control unit and LCM control unit for mutual data storage (SIA data, total odometer reading, vehicle identification number etc.) is now OK. again.

Case 2: The control unit for the instrument cluster electronics (IKE) is OK. and the light check module control unit (LCM) is defective.

Measures	Result	Remarks
Replace LCM (new part)	The manipulation point is set with the ignition switched on.	The manipulation point is set since the vehicle identification number in the light check module differs from the vehicle identification number in the instrument cluster.
Recode LCM		Encode LCM with the central encoding code
Encode vehicle identification number in the LCM		As long as the vehicle identification number is not coded in the LCM, the total odometer reading will not be recorded in the LCM.
Switch off ignition and switch on again	The manipulation point goes out, the LCM adopts the total odometer reading (mileage) from the IKE as well as the SIA data.	The data exchange between the IKE control unit and LCM control unit for mutual data storage (SIA data, total odometer reading, vehicle identification number etc.) is now OK. again.

Case 3: The control unit for the instrument cluster electronics (IKE) and the light check module control unit (LCM) must be replaced.

Only replace both control units at the same time when this is unavoidable (stored total odometer reading is irretrievably lost).

Note

Disconnect battery !

Measures	Result	Remarks
Replace IKE and LCM with battery disconnected (new parts)	The manipulation point is set with the ignition switched on and the total odometer reading (mileage) is set to zero.	The previous total odometer reading (mileage) is irretrievably lost.
Code IKE and LCM		Encode IKE and LCM in accordance with the central encoding code
Code vehicle identification number in IKE and in LCM		As long as the vehicle identification number is not coded, the total odometer reading (mileage) is recorded in the IKE and in the LCM. It should be noted that in the case of an instrument cluster with CAN bus (instrument cluster-integrated version phased-in as from 5/97) AND dynamic stability control (DSC as from 9/97) the DSC is inactive due to the non-matching vehicle identification number. The fault code memory in the DSC control unit should be cleared on completion of this work.
Switch off ignition and switch on again	The manipulation point goes out, the LCM adopts the total odometer reading (mileage) from the IKE as well as the SIA data.	The data exchange between the IKE control unit and LCM control unit for mutual data storage (SIA data, total odometer reading, vehicle identification number etc.) is now OK. again.

Case 4: As a check, replace the control unit for the instrument cluster electronics (IKE) or the light check module control unit (LCM).

Note

Although exchanging one of the two control units is possible in principle, it should, however, be avoided wherever possible.

Measures	Result	Remarks
An IKE or LCM control unit from another vehicle is installed as a check.	The manipulation point is set with the ignition switched on and the IKE continues to record the total odometer reading (mileage).	For as long as the vehicle identification number differs, the total odometer reading is only recorded in the instrument cluster electronics (IKE). There is no total odometer reading calibration with the light check module (LCM). It should be noted that in the case of an instrument cluster with CAN bus (instrument cluster-integrated version phased-in as from 5/97) AND dynamic stability control (DSC as from 9/97) the DSC is inactive due to the non-matching vehicle identification number. The fault code memory in the DSC control unit should be cleared on completion of this work.

Scope of function

Following functions are displayed or used for a function:

Display/function	Required signal
Speed display	Position signal tw from /ABS/ASC/DSC control unit
Engine speed display	Speed signal TD from engine control unit
Fuel consumption (economy) display	Injection signal ti from engine control unit/ engine speed signal TD from engine control unit/position signal tw from /ABS/ASC/DSC control unit
Fuel gauge	Resistance value of both lever sensors (analog input)

Coolant temperature gauge	Resistance value from coolant temperature sensor (temperature-dependent resistor)/ speed signal TD from engine control unit
Service interval display	Position signal tw from /ABS/ASC/DSC control unit/ resistance value from coolant temperature sensor/ engine speed signal TD from engine control unit
Reset service interval display	Line connection to diagnostic socket
Total odometer reading	Position signal tw from /ABS/ASC/DSC control unit
Trip odometer reading	Position signal tw from /ABS/ASC/DSC control unit
Outside temperature display	Resistance value from outside temperature sensor/ position signal tw from /ABS/ASC/DSC control unit
Text display	Steering column switch (BC function button)/ check-control button (CC button)
Dimming instruments	Dimmer signal from light check module (LCM)/ internal signal from photo transistor
Gong activation	Tone 1 (T1) short "peep tones" at 1 kHz/ tone 2 (T2) single gong at 1 kHz/ tone 3 (T3) priority gong at 1 kHz
Speed-A signal/output	Speed signal
Brake pad wear indication	Resistance value of brake pad wear sensor and sensor lines arranged in a ring (analog positive output to analog ground input). Information link (I-bus telegram) to check-control module (CCM).
Reverse detection (manual transmission)	ground from reverse gear switch
Transmission program display (automatic transmission)	Information link (data link/serial) from transmission control unit
I-bus (instrumentation bus)	Information link (data link/serial) to connected control units
K-bus (body bus)	Information link (data link/serial) to connected control units
Diagnosis bus (RxD/TxD)	Information links (data link/serial) to BMW service tester

	systems

Note

All warning lamps not listed have no functional connection with the instrument cluster electronics (**IKE**). They are only supplied with positive or negative from the display unit of the instrument cluster.

Warning lamps	Required signal
General brake warning lamp	Brake fluid level signal via the I-bus from light check module
Parking brake warning lamp	Ground from parking brake switch (parking brake)
Seat belt indicator lamp	I-bus signal from light check module
Fuel reserve lamp	Resistance value of both lever sensors (analog input)
Turn signal indicator lamps	I-bus signal from light check module
Fog light indicator lamp	I-bus signal from light check module
Rear fog light indicator lamp	I-bus signal from light check module
High beam indicator lamp	I-bus signal from light check module
Oil pressure indicator lamp	Ground from oil pressure switch

Test functions

The test functions which could be called up in the on-board computer in previous series can now be called up in the instrument cluster.

System test (Test No. 2): The system test serves the purpose of testing the display unit together with its elements controlled by the instrument cluster electronics (**IKE**).

These elements are:

- All pointer instruments

- All LC displays with a segment test and their background lighting

The indicator and warning lamp for

- Belt warning

- Fuel reserve

- General brake warning lamp

- Parking brake

- Left turn signal indicator

- Right turn signal indicator

- Front fog light

- Rear fog light

- High beam

Pointer instruments: During the system test, operation of the pointer instruments is diagnosed and a corresponding fault code is set in the fault code memory if an electrical fault occurs. In addition, particular care must be taken to observe whether the pointers move smoothly and continuously over their entire indication range during the first test run. During the second run within a system test sequence, the pointer instruments are no longer moved continuously and smoothly over their entire indication range. In this case, the electrical drive data are measured at various indication angles of the pointers.

Selecting test functions:

All test functions, apart from test numbers one and two, are interlocked and must be released by means of test function number nineteen.

Procedure: Press and hold the check control button (right-hand button in the instrument cluster) at terminal 15 "ON" until "Test No.: 01" appears in the text display (text field for check control messages). The corresponding test can be selected by repeatedly pressing the button. Then activate the set test by pressing the trip odometer reset button (left-hand button in the instrument cluster). If the test is a locked test (test 3 to 21), "Lock ON" will appear after the trip odometer reset button has been pressed. In this case, the checksum of the digits for the vehicle identification number must be set by repeatedly pressing the trip odometer reset button. The test must now be reselected with the CC button and confirmed with the trip odometer reset button. The tests one and two can be confirmed directly and thus selected with the trip odometer reset button.

To form checksum: Read out vehicle identification number with test 1.

Display example: "VIN: XY12345"

Cross sum example: 1+2+3+4+5 = 15

Test No.	Function
1	Identification instrument cluster electronics (**IKE**)
2	System test
3	SIA data
4	Momentary consumption values in l/100 km and l/h
5	Range consumption and momentary range
6	Fuel tank content values
7	Coolant temperature and engine speed
8	Momentary speed in km/h
9	System voltage terminal 30 in Volt
10	Read out country-specific code
11	Read out units (AM/PM or mm.dd/dd.mm) etc.
12	Average speed for arrival and momentary arrival
13	Triggering acoustic signals
14	Read out of error bytes (self-diagnosis)
15	Display of I/O port statuses
16	free
17	free
18	free
19	Locking and Unlocking Test Functions
20	Entry of a correction factor for average consumption
21	Reset IKE (software reset)

Speed display

The speed indication function is equipped with various types of speedometer depending on the vehicle model.

The instrument cluster receives the position signal tw from the antilock brake system (ABS)/automatic stability control (ASC)/dynamic stability control (DSC) control unit.
In this way, the instrument cluster electronics (**IKE**) controls the speedometer, total odometer reading and trip odometer reading displays.

The instrument cluster derives the speed from the position signal **tw** and from the position pulse number (**K-number**) stored as coding data in the instrument cluster electronics (**IKE**). In addition, the instrument cluster makes available a speed signal (**speed-A**) for the connected control units. The speed information is made available in the form of a telegram on the instrument bus **(I-bus**) and body bus (**K-bus**).

Engine speed display

Since 5/97 an instrument cluster has been phased-in which features the plugged-on instrument cluster electronics (**IKE**) integrated in the display unit (**AE**). This instrument cluster can replace older instrument cluster versions.

The instrument cluster uses the engine speed signal from the engine control unit (**td** for petrol engines) to determine the engine speed. Adaptation to match the various types of engines takes place by means of the stored coding data.

In the case of the integrated version of the instrument cluster, phased-in as from 5/97, the coding data defines whether the engine speed signal is routed via the CAN bus or via a separate line to the instrument cluster.

As of terminal 15 "ON", the engine speed instrument (rev counter) is controlled by the instrument cluster electronics (**IKE**) with the corresponding engine speed signal. The engine speed information is also made available on the instrument bus **(I-bus**) and body bus (**K-bus**) for other control units.

Fuel consumption display

Since 5/97 an instrument cluster has been phased-in which features the plugged-on instrument cluster electronics (**IKE**) integrated in the display unit (**AE**). This instrument cluster can replace older instrument cluster versions.

The fuel consumption signal t_{KVA} is derived from the injection signal supplied by the engine control unit. By linking it with the position signal, it corresponds to the consumption per unit of distance (e.g. l/100 km).

In the case of the twelve-cylinder engine, the consumption is determined from the fuel injection signals of both engine control units and the position signal.

In the case of the integrated version of the instrument cluster, phased-in as from 5/97, the coding data defines whether the injection signal is routed via the CAN bus or via a separate line to the instrument cluster.

Fuel gauge

General

The tank content is measured with two lever sensors which are separately linked to the instrument cluster electronics (**IKE**). Each lever sensor is connected with a separate ground (analog ground) and a sensor line (analog positive) to the instrument cluster electronics (**IKE**). There is no reserve contact in the level sending unit to activate the fuel reserve warning lamp. The fuel reserve warning lamp is switched on dependent on the tank contents in comparison with a reserve threshold value.

Tank

At present tank sizes with 85l and 95l capacity are installed in the 7 Series (E38). A 95l tank can be recognised by the fact that it extends lower than the floor assembly and a stone guard is installed. At present, only a 70l tank is installed in the 5 Series (E39). The different methods of determining the fuel level for the fuel gauge with the 85l / 95l (E38) and 70l (E39) tank are adapted by means of the coding data.

If defined training of the left-hand or right-hand tank half is necessary for test purposes, particular care must be taken to ensure that the correct connection is used (on 7 Series E38 only). For both tank halves it is located on the left-hand half of the tank. On both drain connections, a reclined rectangle is stamped on the connection for the right-hand half of the tank and an upright rectangle is stamped on the connection for the left-hand half of the tank.

On the 5 Series (E39) it is not possible to drain off fuel via separate connections. In this case, the fuel must be drained off via the filler tube (tank neck).

Coolant temperature display

Since 5/97 an instrument cluster has been phased-in which features the plugged-on instrument cluster electronics (**IKE**) integrated in the display unit (**AE**). This instrument cluster can replace older instrument cluster versions.

The instrument cluster determines the current coolant temperature by way of the coolant temperature sensor (NTC resistor). The coolant temperature sensor is connected with a separate ground (analog ground) and a sensor line (analog positive) to the instrument cluster electronics (**IKE**).

In the case of the integrated version of the instrument cluster, phased-in as from 5/97, the coding data defines whether the coolant temperature signal is routed via the CAN bus from the engine control unit or via a separate line from the coolant temperature sensor to the instrument cluster.

The instrument cluster electronics (**IKE**) transfers the "coolant temperature" information via the instrument bus (**I-bus**) and body bus (**K-bus**).

Service interval display

The service interval display (**SIA**) serves the driver and the workshop as an indication showing that an engine oil service, distance inspection or time inspection is due. The inspection intervals of the vehicle are not rigidly referred to the kilometres covered but rather they depend on the consumption. The current service interval status is displayed as of "Terminal 15 ON" for 10 seconds after reaching a minimum engine speed of 400 rpm.

The data of the service interval display (**SIA**) are also stored in the light check module (**LCM**).

Reset service interval display

The service interval display (**SIA**) is reset by pulses of a defined length at the service interval reset input. Each reset operation can be carried out individually and independently (service interval display [**SIA**] reset). The oil service, time inspection or/and distance inspection can be reset.

Total odometer reading

Display of the total distance covered is a component part of the LC display. The current mileage is indicated on the display as of terminal R "ON". At "Terminal R OFF" the mileage can be displayed by pressing the instrument cluster button for approx. 25 seconds after the button has been released. The unit of distance (km/miles) dependent on the coded country-specific version is displayed next to the trip odometer. The total distance is made available in the form of a telegram on the instrument bus **(I-bus**) and body bus (**K-bus**).

The total distance is stored in the instrument cluster electronics (**IKE**) and in the light check module (**LCM**). "999999" is displayed as the total distance if the instrument cluster electronics (**IKE**) cannot read the total distance and it cannot be determined by way of the light check module (**LCM**).

Trip odometer reading

Display of the distance covered on a trip is a component part of the LC display. The current trip odometer reading is shown on the display as of "Terminal R ON". At "Terminal R OFF", the mileage can be displayed for 25 seconds by pressing the instrument cluster button. The unit of distance (km/miles) dependent on the coded country-specific version is displayed next to the trip odometer.

Outside temperature display

The instrument cluster determines the current outside temperature by way of the outside temperature sensor (NTC resistor). The outside temperature sensor is connected with a separate ground (analog ground) and a sensor line (analog positive) to the instrument cluster electronics (**IKE**). The outside temperature is not displayed in the multi-information display (**MID**), but rather permanently in the instrument cluster. If, while driving, the outside temperature drops below +3 ^{o}C, dependent on the coding, the gong warning 2 (T2) is triggered and the displayed value flashes. The display unit (^{o}C/ ^{o}F) is determined in the coding data.

The display change is delayed since heat from the engine and other ambient conditions influence the outside temperature display.

The instrument cluster electronics (**IKE**) transfers the "outside temperature" information via the instrument bus (**I-bus**) and body bus (**K-bus**). In ignition lock position "0", the outside temperature sensor is read by the IKE at time intervals which are within the minute range. For this purpose, the IKE is temporarily activated, provides the information and then switches itself off again.

Text display

The text display is an LC display which is highlighted by lamps. The 5 lamps provide the background lighting for the service interval display (**SIA**), the total odometer, trip odometer, outside temperature display and the text field for messages.

Instrument dimming

The dimming function for dimming the highlighting is carried out independent of instrument dimming. The brightness sensor (photo transistor in warning lamp field under oil pressure warning lamp) only influences the background light of the LC display. In contrast to this, the brightness of the instruments and of the LC display is influenced by the dimming signal from the light check module (LCM) when the light is switched on.

Gong

The electronic gong serves as an acoustic signal generator for the hour signal tone 1 (T1), the temperature warning tone 2 (T2), a warning signal tone 3 (T3) and the code signal tone 1 with tone 2. The signal lines for gong activation of tone 1 - tone 3 are used by the instrument cluster, however, they can be interrupted by the park distance signal tone 4 (T4). The tones T4 and T5 can be activated via further inputs at the gong, dependent on the vehicle equipment level. These acoustic functions **cannot** be triggered by the instrument cluster electronics (**IKE**) but rather they are a functional part of vehicle components.

The hour signal T1 with three short "peep tones" (1 kHz) reminds the user of radio news broadcasts or traffic announcements.

In the case of the temperature warning T2, one single gong (1 kHz) is triggered which warns the driver of low outside temperatures (ice hazard).

The warning signal T3 warns the user by means of a long tone (1 kHz), followed by the gong sounding. It serves the light check module (LCM) as a form of acoustic output. The light check module (LCM) informs the instrument cluster that the acoustic signal has been triggered in the form of an I-bus telegram (instrument bus).

The short code signal is triggered by the tone T1 and T2 (750 Hz). It indicates to the user that the programmed speed limit has been exceeded or it draws attention to a code function still active when starting.

Speed signal speed-A

The instrument cluster receives the position signal tw from the antilock brake system (ABS)/automatic stability control (ASC)/dynamic stability control (DSC) control unit.

The instrument cluster derives the speed signal from the position signal **tw** and from the position pulse number (**K-number**) stored as coding data in the instrument cluster electronics (**IKE**). The speed signal (**Speed-A**) is made available as a signal output for connected control units. The speed information from the speed-A signal is received by the connected control units by measuring the frequency or period duration. This speed information is also made available in the form of a diagram via the instrument bus **(I-bus**) and body bus (**K-bus**).

Reverse detection (manual transmission)

The "Reverse detection" function is only active when this function is correspondingly coded in the instrument cluster. If the instrument cluster is coded for manual transmission, the program and selector lever display for automatic transmission is masked out.

The information "reverse engaged" is made available in the form of a telegram via the body bus (**K-bus**).

Transmission program display (automatic transmission)

Since 5/97 an instrument cluster has been phased-in which features the plugged-on instrument cluster electronics (**IKE**) integrated in the display unit (**AE**). This instrument cluster can replace older instrument cluster versions.

The instrument cluster is connected to the transmission control unit by means of a separate data link. By way of this data link, the transmission control unit informs the instrument cluster electronics (**IKE**) which drive stage is engaged, which drive program is switched on and whether the transmission is in the emergency program. If the transmission signals "emergency program", the signal is transferred to the light check module (LCM) as a bus signal. If the instrument cluster is coded for automatic transmission, the program and selector lever display for automatic transmission is activated.

In the case of the integrated version of the instrument cluster, phased-in as from 5/97, the coding data defines whether the transmission data is routed via the CAN bus from the transmission control unit or via separate data links from the transmission control unit to the instrument cluster.

Instrumentation bus (I-bus)

The instrumentation bus (I-bus) is one of three information links (data link/serial) via a data link to other control units. The instrument bus is monitored by the instrument cluster electronics (**IKE**). The IKE also sets up the interconnection of the bus systems:

- I-bus (instrumentation bus)

- K-bus (body bus)

- Diagnosis bus (link to diagnostic socket),

- CAN bus (instrument cluster-integrated version phased-in as from 5/97)

(gateway function).

Body bus (K-bus)

The body bus (K-bus) is one of the three information links (data link/serial) via a data link to other control units. The body bus is only monitored electrically by the instrument cluster electronics (**IKE**). The body bus is monitored by the general module (GM).

Diagnosis bus (D-bus)

The diagnosis bus (D-bus) is one of three information links (data link/serial) via two data links to the control units with diagnostic capabilities. The diagnosis bus is only active when a BMW service test system is connected to the diagnostic socket.

Warning lamps

General: The background lighting of all warning lamp symbols as well as the engaged drive stage for automatic transmission together with the selected drive program is provided by LEDs.

General brake warning lamp: The warning lamp can be switched on by the light check module (LCM) when, for example, the LCM detects the brake fluid level as being too low. The warning lamp is also switched on after ignition "ON" as a function check (pre-drive check) and goes out when a minimum engine speed of 400 rpm is exceeded.

In the event of a break in the line connection from the IKE sensor output to the IKE sensor input, the brake lining wear detection function sends an I-bus telegram to the LCM. On receiving this signal, a corresponding message is sent from the LCM to the IKE where it is indicated in the text display. The general brake warning lamp is not switched on for this purpose.

Parking brake warning lamp: The warning lamp is activated by a switch on the parking brake. The switch is open when the parking brake is released.

The "parking brake" information is made available in the form of a telegram via the instrument bus **(I-bus**) and body bus (**K-bus**).

Seat belt indicator lamp: The seat belt indicator lamp is activated dependent on the coding data. For vehicles without a seat belt buckle contact, it is switched on for approx. 6 seconds after terminal 15 "ON".

On vehicles equipped with a seat belt buckle contact, the warning lamp is switched on as of terminal 15 "ON" by a corresponding I-bus telegram from the light check module (LCM) until the seat belt contact is opened (seat belt buckle locked in position).

Fuel reserve lamp: The fuel reserve warning lamp is not switched by a reserve contact in the level sensor. It is switched dependent on the tank content compared to a reserve threshold value.

Turn signal indicator lamps: The turn signal indicator lamps are switched by means of a corresponding I-bus telegram from the light check module (LCM) to the instrument cluster electronics (IKE).

Fog light indicator lamp: The fog light indicator lamp is switched by means of a corresponding I-bus telegram from the light check module (LCM) to the instrument cluster electronics (IKE).

Rear fog light indicator lamp: The rear fog light indicator lamp is switched by means of a corresponding I-bus telegram from the light check module (LCM) to the instrument cluster electronics (IKE).

High beam indicator lamp: The high beam indicator lamp is switched by means of a corresponding I-bus telegram from the light check module (LCM) to the instrument cluster electronics (IKE).

Oil pressure indicator lamp: The warning lamp is switched by the oil pressure switch. The information from the oil pressure switch is read by the instrument cluster electronics (IKE) as status data and a corresponding I-bus telegram is sent to the light check module (LCM). On receiving this signal, a corresponding message is sent from the LCM to the IKE where it is indicated in the text display.

Note

All warning lamps not listed have no functional connection with the instrument cluster electronics (**IKE**). They are only supplied with positive or negative from the display unit of the instrument cluster.

General

At series launch, the instrument cluster (basic) features two bus interfaces which enable the information link (data link/serial) to the connected control units.

These busses are:

- K-bus (body bus)

- Diagnosis bus (link to diagnostic socket).

A further bus interface provides the link to the automatic transmission for as long as the instrument cluster does not feature a CAN interface. On manual transmission vehicles, the reverse switch status is read in via this connection.

Coded data which determine the scope of functions of the instrument cluster are stored in a non-volatile data memory (data are retained when supply voltage is disconnected).

The various scope of functions includes, for example, the vehicle model and the country language variant.

At present, nine country variants can be chosen:

- Australia/ Gulf States/ South Africa

- Germany

- United Kingdom

- France

- Italy

- Japan

- Canada

- Spain

- USA

Replacing Instrument Cluster

The four cases described in the following show the steps which must be taken under certain circumstances in order to ensure trouble-free replacement of the instrument cluster.

Case 1: The instrument cluster control unit is defective and the light check module control module (LCM) is OK.

Measures	Result	Remarks
Replace instrument cluster (new part)	The manipulation point is set with the ignition switched on.	The manipulation point is set since the vehicle identification number in the light check module differs from the vehicle identification number in the instrument cluster.
Re-encode the instrument cluster		Encode the instrument cluster in accordance with the central encoding code
Encode vehicle identification number into instrument cluster		As long as the vehicle identification number is not coded in the instrument cluster, total odometer recording (only trip odometer recording) does not take place either in the instrument cluster or in the light check module (LCM).
Switch off ignition and switch on again	The manipulation point goes out, the instrument cluster adopts the total odometer reading (mileage) from the LCM as well as the SIA data.	The data exchange between the instrument cluster control unit and LCM control unit for mutual data storage (SIA data, total odometer reading, vehicle identification number etc.) is now OK. again.

Case 2: The instrument cluster control unit is OK. and the light check module control module (LCM) is defective.

Measures	Result	Remarks
Replace LCM (new part)	The manipulation point is set with the ignition switched on.	The manipulation point is set since the vehicle identification number in the light check module differs from the vehicle identification number in the instrument cluster.
Recode LCM		Encode LCM with the central encoding code
Encode vehicle identification number in the LCM		As long as the vehicle identification number is not coded in the LCM, the total odometer reading will not be recorded in the LCM.
Switch off ignition and switch on again	The manipulation point goes out, the LCM adopts the total odometer reading (mileage) from the instrument cluster as well as the SIA data.	The data exchange between the instrument cluster control unit and LCM control unit for mutual data storage (SIA data, total odometer reading, vehicle identification number etc.) is now OK. again.

Case 3: The control unit for the instrument cluster and the control unit for the light check module (LCM) must be replaced.

Only replace both control units at the same time when this is unavoidable (stored total odometer reading is irretrievably lost).

Note

Disconnect battery !

Measures	Result	Remarks
Replace instrument cluster and LCM with battery disconnected (new parts)	The manipulation point is set with the ignition switched on and the total odometer reading (mileage) is set to zero.	The previous total odometer reading (mileage) is irretrievably lost.
Encode instrument cluster and LCM		Encode instrument cluster and LCM in accordance with the central encoding code
Encode vehicle identification number in the instrument cluster and in the LCM		As long as the vehicle identification number is not coded, the total odometer reading (mileage) is recorded in the instrument cluster and in the LCM.
Switch off ignition and switch on again	The manipulation point goes out, the LM adopts the total odometer reading (mileage) from the instrument cluster as well as the SIA data.	The data exchange between the instrument cluster and the LCM for mutual data storage (SIA data, total odometer reading, vehicle identification number etc.) is now OK. again.

Case 4: As a check, replace the control unit for the instrument cluster or the light check module control unit (LCM).

Note

Although exchanging one of the two control units is possible in principle, it should, however, be avoided wherever possible.

Measures	Result	Remarks
An instrument cluster or LCM control unit from another vehicle is installed as a check.	The manipulation point is set with the ignition switched on and the instrument cluster continues to record the total odometer reading (mileage).	For as long as the vehicle identification number differs, the total odometer reading is only recorded in the instrument cluster. There is no total odometer reading calibration with the light check module (LCM).

Scope of function

Following functions are displayed or used for a function:

Display/function	Required signal
Speed display	Position signal tw from /ABS/ASC/DSC control unit
Engine speed display	Speed signal TD from engine control unit
Fuel consumption	Injection signal ti from engine control unit/ engine speed

(economy) display	signal TD from engine control unit/position signal tw from /ABS/ASC/DSC control unit
Fuel gauge	Resistance value of both lever sensors (analog input)
Coolant temperature gauge	Resistance value from coolant temperature sensor (temperature-dependent resistor)/ speed signal TD from engine control unit
Service interval display	Injection signal ti from engine control unit
Reset service interval display	Line connection to diagnostic socket
Total odometer reading	Position signal tw from /ABS/ASC/DSC control unit
Trip odometer reading	Position signal tw from /ABS/ASC/DSC control unit
Outside temperature display with ice warning (+3 °C)	Resistance value from outside temperature sensor/ position signal tw from /ABS/ASC/DSC control unit
Text display	Simple text display of basic BC for outside temperature, consumption, range, average speed, operable via steering column switch.
Dimming instruments	Dimmer signal from light check module (LCM)/ internal signal from photo transistor
Gong activation	Tone 3 (T3) priority gong at 1 kHz
Speed-A signal/output	Speed signal
Brake pad wear indication	Resistance value of brake pad wear sensor and sensor lines arranged in a ring (analog positive output to analog ground input).
Reverse detection (manual transmission)	ground from reverse gear switch
Transmission program display (automatic transmission)	Information link (data link/serial) from transmission control unit
K-bus (body bus)	Information link (data link/serial) to connected control units
Diagnosis bus (RxD/TxD)	Information links (data link/serial) to BMW service tester systems

Test functions

The test functions which could be called up in the on-board computer in previous series can now be called up in the instrument cluster.

System test (test No. 2): The system test serves the purpose of testing the display unit together with its elements which can be controlled from the instrument cluster.

Controlled elements are:

- All pointer instruments

- All LC displays with a segment test and their background lighting

Indicator and warning lamps for:

- Belt warning

- Fuel reserve

- General brake warning lamp

- Parking brake

- Left and right turn signal indicators

- Front and rear fog light

- High beam

- Gear indicator (automatic transmission)

- Service interval display SIA

- Check control displays (if coded)

- Air suspension

- Fault automatic transmission

- Engine oil level

Pointer instruments. During the system test sequence, activation of the pointer instruments is diagnosed and the defect code memory is set in the event of an electrical fault occurring. In addition, particular care must be taken to observe whether the pointers move smoothly and continuously over their entire indication range during the first test run. During the second run within a system test sequence, the pointer instruments are no longer moved continuously and smoothly over their entire indication range. In this case, the electrical drive data are measured at various indication angles of the pointers.

Selection of test functions:

All test functions, apart from test numbers one and two, are interlocked and must be released by means of test function number nineteen.

Procedure: With terminal R "ON", press the trip odometer reset button (left-hand button in the instrument cluster) until "__tESt__1._" appears in the display of the instrument cluster. The corresponding test (system test corresponds to test 2 "__tESt__2._") can be selected by repeatedly pressing/releasing the button within 1 second. The first subfunction of the set test then appears after approx. 1 second. The subfunction (the system test has no further subfunction) of the corresponding test can be selected by further pressing the button. Since test 2 (system test) has no further subfunction, the system test is triggered after the display "__tESt__2.0" appears and the trip odometer reset button is pressed. If the test is a locked test (test 3 to 21) this is confirmed by pressing the trip odometer button when "_L_oFF" appears in the display. The display then jumps to test 0 so that the corresponding test can be selected by briefly pressing the button.

Test No.	Function
1	Identification Instrument Cluster
2	System test
3	SIA data
4	Momentary consumption values in l/100 km and l/h
5	Range consumption and momentary range
6	Fuel tank content values
7	Coolant temperature, outside temperature, current engine speed, current road speed
8	ADC values (system voltage, voltage at left and right lever sensor, voltage at photo transistor and BVA, voltage at coolant and outside temperature sensor)
9	System voltage terminal 30 in Volt
10	Read out country-specific code
11	Read out units (AM/PM or mm.dd/dd.mm) etc.
12	not used
13	Triggering acoustic signals
14	Read out of error bytes (self-diagnosis)
15	Display of I/O port statuses
16	free
17	free
18	free
19	Locking and Unlocking Test Functions
20	Entry of a correction factor for average consumption
21	Reset instrument cluster (software reset)
0	End of test, the test mode can be exited with this function.

Speed display

The speed indication function is equipped with various types of speedometer depending on the vehicle model.

The instrument cluster receives the position signal tw from the antilock brake system (ABS)/automatic stability control (ASC)/dynamic stability control (DSC) control unit. In this way, the instrument cluster controls the speedometer, total odometer reading and trip odometer reading displays.

The instrument cluster derives the speed from the position signal **tw** and from the position pulse number (**K-number**) stored as coding data in the instrument cluster).

In addition, the instrument cluster makes available a speed signal (**speed-A**) for the connected control units. The speed information is made available in the form of a telegram on the body bus (**K-bus**).

Engine speed display

The instrument cluster uses the engine speed signal from the engine control unit (**td** for petrol engines) to determine the engine speed. Adaptation to match the various types of engines takes place by means of the stored coding data.

As of terminal 15 "ON", the engine speed instrument (rev counter) is controlled by the instrument cluster with the corresponding engine speed signal. The engine speed information is also made available on the body bus (**K-bus**) for other control units.

Fuel consumption display

The fuel consumption signal t_{KVA} is derived from the injection signal supplied by the engine control unit. By linking it with the position signal, it corresponds to the consumption per unit of distance (e.g. l/100 km).

The fuel consumption signal t_{KVA} is not only used for calculating the fuel consumption but also for controlling and therefore indicating the service interval display.

Fuel gauge

The tank content is measured with two lever sensors which are separately linked to the instrument cluster. Each lever sensor is connected with a separate ground (analog ground) and a sensor line (analog positive) to the instrument cluster. There is no reserve contact in the level sending unit to activate the fuel reserve warning lamp. The fuel reserve warning lamp is switched on dependent on the tank contents in comparison with a reserve threshold value.

The "fuel reserve" signal is output as information for engine management. It is coupled to the fuel reserve warning lamp and is switched on for 2 seconds as a function check when switching on terminal 15 (pre-drive check).

The different methods of determining the fuel level for each tank half is adapted by means of the coding data.

Coolant temperature display

The instrument cluster determines the current coolant temperature by way of the coolant temperature sensor (NTC resistor). The coolant temperature sensor is connected with a separate ground (analog ground) and a sensor line (analog positive) to the instrument cluster.

The instrument cluster makes available the "coolant temperature" information via the body bus (**K-bus**) for other systems.

Service interval display

The service interval display (**SIA**) serves the driver and the workshop as an indication showing that an engine oil service, distance inspection or time inspection is due. The inspection intervals of the vehicle are referred to the consumption. The current service interval status is displayed as of terminal 15 "ON" for 10 seconds after reaching a minimum engine speed of 400 rpm.

The data of the service interval display (**SIA**) are also stored in the light check module (**LCM**).

Reset service interval display

The service interval display (**SIA**) is reset by pulses of a defined length at the service interval reset input. Each reset operation can be carried out individually and independently (service interval display [**SIA**] reset). The oil service, time inspection or/and distance inspection can be reset.

Total odometer reading

Display of the total distance covered is a component part of the LC display. The current mileage is indicated on the display as of terminal R "ON". At terminal R "OFF" the mileage can be displayed by pressing the trip odometer reset button for approx. 25 seconds after the button has been released. The unit of distance (km/miles) dependent on the coded country-specific version is displayed between the total odometer and the trip odometer. The total distance is made available in the form of a telegram on the body bus (**K-bus** .

The total distance is stored in the instrument cluster and in the light check module (**LCM**). "999999" is displayed as the total distance if the instrument cluster cannot read the total distance and it cannot be determined by way of the light check module (**LCM**).

Trip odometer reading

Display of the distance covered on a trip is a component part of the LC display. The current trip odometer reading is shown on the display as of terminal R "ON". At terminal R "OFF" the mileage can be displayed by pressing the instrument cluster button for approx. 25 seconds after the button has been released. The unit of distance (km/miles) dependent on the coded country-specific version is displayed between the total odometer and the trip odometer.

Outside temperature display

The instrument cluster determines the current outside temperature by way of the outside temperature sensor (NTC resistor). The outside temperature sensor is connected with a separate ground (analog ground) and a sensor line (analog positive) to the instrument cluster. The outside temperature is displayed permanently in the instrument cluster. If, while driving, the outside temperature drops below +3 °C, dependent on the coding, a warning tone (gong or peep tone for ice warning dependent on coding) is triggered and the displayed value flashes.

The display unit (°C/°F) is determined in the coding data. However, it is possible (as of diagnosis index 31, refer to "diagnosis program", "instrument cluster", "identification") to change the display unit from °C to °F and from °F to °C. For this purpose the ignition lock must be switched from position "1" (terminal "R") to position "0" (terminal "15" and terminal "R" OFF) with the trip odometer reset button pressed. The displayed temperature unit is changed after releasing the trip odometer reset button and as of ignition lock position "1" (terminal "R"). The set unit display is retained for as long as supply voltage is applied to the instrument cluster and no reset is triggered.

The display range extends from -40 °C to +50 °C. An increasing outside temperature display is delayed since heat from the engine and other ambient conditions influence the outside temperature display. A drop in the outside temperature is not delayed.

The instrument cluster transfers the "outside temperature" information via the body bus (**K-Bus**). In ignition lock position "0", the outside temperature sensor is read by the instrument cluster at time intervals which are within the minute range. For this purpose, the instrument cluster is temporarily activated, provides the information and then switches itself off again.

Visual LC displays

General

The background lighting of all LC display fields is provided by(**LEDs**). The **LEDs** provide the background lighting for the field service interval display (**SIA**) together with gear display, total odometer with trip odometer and outside temperature or functions of the on-board computer display and the field for check control messages.

On-board computer functions

If no on-board computer functions are envisaged and coded, instead of them, the instrument cluster (basic) only features the outside temperature display.

Check-control messages

As optional equipment (standard in certain models), the instrument cluster (basic) features an LC display field for check-control messages. The background lighting of the vehicle symbol is only switched on by the light check module when a check-control message is applicable. Light faults for left and right low beam, left and right reversing light, left and right brake light are displayed in the LC display field for check-control messages. In the case of a defective brake light switch, both brake lights are indicated as a light fault. If the centre brake light is defective, the light check module sets the symbol for the right-hand brake light. Light fault statuses occurring simultaneously are displayed in parallel.

The "top up wash water" message is also displayed in the form of a pictogram in the display field for the check-control messages. The light fault messages and the "top up wash water" message are sent by the light check module via the body bus (**K-bus**) to the instrument cluster. The "top up wash water" message has a priority status in the display system. When the message is received, it is retained until the next terminal 15 "OFF" goes out after 60 seconds. The message is re-evaluated during the next terminal 15 "ON".

The four doors and the boot/trunk lid can be displayed separately for the "door open" message. These messages are sent on the body bus (**K-bus**) from the general module to the instrument cluster.

Instrument dimming

The brightness of the LC display fields is controlled by a phototransistor. When the vehicle lights are switched on, the brightness is controlled by way of the phototransistor and the dimmer setting.

The light-check module (**LCM**) transfers the dimmer setting for the instrument lights and the indicator lamps in the form of a telegram on the body bus (**K-bus**) and via the 58g line as a power signal to the instrument cluster.

Acoustic indicator

Monitoring turn signal indicator lamps

The turn signal indicator lamps are monitored by means of the switching noise of an encapsulated relay operating synchronously with respect to the turn signal indicator lamps.

Light warning

The light warning is provided only acoustically. The relay installed in the instrument cluster for monitoring the turn signal indicator lamps is also used for the light warning. The light warning sounds when the driver’s door is opened for the first time and when the parking lights are switched on for 8 cycles each at approx. 0.5 seconds continuous tone at approx. 64 Hz and with a subsequent 0.5 second pause. During the light warning, the turn signal indicator lamps are only monitored by means of the indicator lamps.

Seat belt warning

The acoustic seat belt warning is dependent on the coded data and is controlled by the light check module in the form of a telegram on the body bus (**K-bus**) to the instrument cluster. When the seat belt warning is triggered, the gong tone 3 (T3) is activated for may. 6 seconds with pauses of approx. 1.3 seconds.

Ignition key warning

The acoustic ignition key warning is dependent on the coded data and is controlled by the light check module in the form of a telegram on the body bus (**K-bus**) to the instrument cluster. When the ignition key warning is triggered, the gong tone 3 (T3) is activated for max. 60 seconds with pauses of approx. 1.3 seconds.

Temperature warning

The acoustic outside temperature warning is controlled dependent on the temperature detected by the outside temperature sensor. If the temperature drops below a threshold of +3 ^{o}C, a warning tone in the basic instrument cluster sounds at approx. 2 kHz generated by a beeper built into the instrument cluster.

In the case of an instrument cluster with on-board computer functions, the temperature warning is provided by a short gong tone 3 (T3).

Speed warning

The speed warning is dependent on the coded data where the speed value, at which the warning is to be activated is defined by the coding program. The speed warning is legally stipulated for the country-specific version "Gulf State".

Speed signal speed-A

The instrument cluster receives the position signal tw from the antilock brake system (ABS)/automatic stability control (ASC)/dynamic stability control (DSC) control unit.

The instrument cluster derives the speed signal (**speed -A**) from the position signal **tw** and from the position pulse number (**K-number**) stored as coding data in the instrument cluster.

The speed signal (**Speed-A**) is made available as a signal output for connected control units. The speed information from the speed-A signal is received by the connected control units by measuring the frequency or period duration. This speed information is made available in the form of a telegram via the body bus (**K-bus**).

Reverse detection (manual transmission)

The "Reverse detection" function is only active when this function is correspondingly coded in the instrument cluster. If the instrument cluster is coded for manual transmission, the program and selector lever display for automatic transmission is masked out.

The information "reverse engaged" is made available in the form of a telegram via the body bus (**K-bus**).

Transmission program display (automatic transmission)

If the instrument cluster is coded for automatic transmission, the program and selector lever display for automatic transmission is activated.

The instrument cluster is connected to the transmission control unit by means of a separate data link. By way of this data link, the transmission control unit informs the instrument cluster which drive stage is engaged, which drive program is switched on and whether the transmission is in the emergency program. If reverse is engaged, the message is made available on the K-bus.

Body bus (K-bus)

The body bus (K-bus) is one of the two information links (data link/serial) via a data link to other control units. The body bus is only monitored electrically by the instrument cluster. The body bus is monitored by the general module (GM). The instrument cluster is also responsible for linking the two bus systems:

- K-bus (body bus)

- Diagnosis bus (link to diagnostic socket),

(gateway function).

Diagnosis bus (D bus)

The diagnosis bus (D-bus) is one of two information links (data link/serial) via two data links to the control units with diagnostic capabilities. The diagnosis bus is only active when a BMW service test system is connected to the diagnostic socket.

Warning lamps

Warning lamps	Required signal
General brake warning lamp	Resistance value of brake pad wear sensors or brake fluid level message from light-check module via the K-bus
Parking brake warning lamp	Ground from parking brake switch (parking brake)
Seat belt indicator lamp	K-bus message from light check module
Fuel reserve lamp	Resistance value of both lever sensors (analog input)
Turn signal indicator lamps	K-bus message from light check module
Fog light indicator lamp	K-bus message from light check module
Rear fog light indicator lamp	K-bus message from light check module
High beam indicator lamp	K-bus message from light check module
Oil pressure indicator lamp	Ground from oil pressure switch
Oil level warning lamp	K-bus message from light check module
Coolant over-temperature (red)	Resistance value from coolant temperature sensor (temperature-dependent resistor)/ speed signal TD from engine control unit
Air suspension	K-bus message from air suspension control unit
Battery charge indicator lamp	D+ terminal 61 from alternator
ABS indicator lamp	Signal from antilock brake system control unit
Airbag indicator lamp	Signal (ground) from airbag control unit
Catalytic converter indicator lamp	Signal (ground) thermal switch country-specific version Japan

Check engine (exhaust gas warning lamp)	Signal (ground) from engine control unit
Preheater indicator lamp (diesel)	Signal (ground) from engine control unit
Cruise control indicator lamp	Signal (ground) from cruise control unit
ASC control	Signal (ground) from ASC control unit
Fault - automatic transmission	Information link from automatic transmission control unit

General: The background lighting of all warning lamp symbols as well as the engaged drive stage for automatic transmission together with the selected drive program is provided by LEDs.

General brake warning lamp: The warning lamp can be switched on by the light check module (LCM) when, for example, the LCM detects the brake fluid level as being too low or the instrument cluster detects that the brake pad sensor loop has a break to ground. The warning lamp is also switched on after ignition "ON" as a function check (pre-drive check) and goes out when a minimum engine speed of 400 rpm is exceeded.

Seat belt indicator lamp: The seat belt indicator lamp is activated dependent on the coding data. For vehicles without a seat belt buckle contact, it is switched on for approx. 6 seconds after terminal 15 "ON".

On vehicles equipped with a seat belt buckle contact, the warning lamp is switched on as of terminal 15 "ON" by a corresponding K-bus telegram from the light check module (LCM) until the seat belt contact is opened (seat belt buckle locked in position).

Fuel reserve lamp: The fuel reserve warning lamp is not switched by a reserve contact in the level sensor. It is switched dependent on the tank content compared to a reserve threshold value.

The "fuel reserve" signal is output as information for engine management. It is coupled to the fuel reserve warning lamp and is switched on for 2 seconds as a function check when switching on terminal 15 (pre-drive check).

Turn signal indicator lamps: The turn signal indicator lamps are switched by means of a corresponding K-bus telegram from the light check module (LCM) to the instrument cluster.

Fog light indicator lamp: The fog light indicator lamp is switched by means of a corresponding K-bus telegram from the light check module (LCM) to the instrument cluster.

Rear fog light indicator lamp: The rear fog light indicator lamp is switched by

15 is switched on (pre-drive check).

means of a corresponding K-bus telegram from the light check module (LCM) to the instrument cluster.

High beam indicator lamp: The high beam indicator lamp is switched by means of a corresponding K-bus telegram from the light check module (LCM) to the instrument cluster.

Oil level warning lamp: The warning lamp is switched by means of a corresponding K-bus telegram from the light check module (LCM) to the instrument cluster.

As a function check, the warning lamp is switched on for 2 seconds when terminal 15 is switched on (pre-drive check).

Air suspension: If coded, the warning lamp is switched by means of a corresponding K-bus telegram from the air suspension control unit (EHC) to the instrument cluster.

If coded, the warning lamp is switched on for 2 seconds as a function check when switching on the terminal 15 (pre-drive check).

Air suspension: If coded, the warning lamp is switched by means of a corresponding K-bus telegram from the air suspension control unit (EHC) to the instrument cluster.

Transmission fault: If automatic transmission is coded, the warning lamp is switched by means of a corresponding telegram (150 Baud) from the automatic transmission control unit. By way of this data link, the instrument cluster is also informed of the engaged drive stage in order to display the corresponding drive stage.

Note

The indicator lamps listed in the following are controlled directly via corresponding connector pins by the relevant system.

Oil pressure indicator lamp: The warning lamp is switched by the oil pressure switch.

Battery charge indicator lamp: The warning lamp is switched by the D+ terminal 61 signal (charge mode approximately system voltage) to the instrument cluster.

Parking brake warning lamp: The warning lamp is activated by a switch on the parking brake. The switch is open when the parking brake is released.

As a function check, the warning lamp is switched on for 2 seconds when terminal

Airbag indicator lamp: The warning lamp is switched by a signal (ground) from the airbag control unit.

Antilock brake system indicator lamp: The warning lamp is switched by the ABS control unit. Since the warning lamp must light in the case of a signal line failure a second signal input is provided in the instrument cluster for this warning lamp. In the case of this new ABS control unit, this second line must be connected to ground for the ABS warning lamp to light. The new function, signal line high (system voltage) warning lamp active, signal line low (ground) warning lamp off and signal line high (high-ohmic, interrupted) warning lamp active, also takes into account a break in the signal line. The previous function, signal line high (high-ohmic) warning lamp off and signal line low (ground) warning lamp active is still possible.

Catalytic converter indicator lamp (country version Japan): The warning lamp "catalytic converter excess temperature" is switched by a signal (ground) from a thermo switch on the exhaust gas cleaning system.

Check engine (exhaust gas warning lamp): The warning lamp "check engine" is switched by a signal (ground) from the engine control unit.

Preheater indicator lamp (diesel): The warning lamp "preheater" is switched by a signal (ground) from the engine control unit.

Cruise control active indicator: The "cruise control active indicator" is switched by a signal (ground) from the cruise control unit or by the engine control unit for diesel engines.

Check engine (exhaust gas warning lamp): The "ASC" warning lamp is switched by a signal (ground) from the engine control unit. The warning lamp is switched on statically if the ASC is switched off. When the ASC is switched on, the warning lamp goes out after a function check (pre-drive check) and flashes during a control phase.

As a function check, the warning lamp is switched on for 2 seconds when terminal 15 is switched on (pre-drive check).