8-cylinder spark-ignition engine N62TU

E60, E61, E63, E64, E65, E66, E70

Introduction

The N62TU is an advanced development of the N62.

> N62TU

The 8-cylinder spark-ignition engine N62TU has been modified. Compared to the N62, the engine develops more output and torque.

The N62TU is available in 2 displacement versions: 4.0 litre and 4.8 litre. The current version of the digital engine electronics is the DME 9.2.2.

The N62TU is currently installed in the E65, E66 (BMW 7-Series).

Further installation schedule:

> E60, E61 (BMW 5-Series) and E63, E64 (BMW 6-Series): **from** 09/2005

> E63, E64 (BMW 6-Series): **from** 09/2005

New features on the N62TU:

- 2-stage differentiated intake manifold with 2 DISA servomotors (each DISA servomotor has one output stage)
- EURO 4 emissions standard without secondary air system
- Hot-film air-mass sensor with digital signal
- Electronic oil level control

> N62TU upgraded

Introduction schedule:

> E60, E61: **from** 03/2007

>E63, E64: **from** 09/2007

>E65, E66: **from** 09/2007

> E70 (BMW X5): **from 09/2006**

New features on the N62TU:

- New digital engine electronics (DME 9.2.3)
- New D-CAN diagnosis interface

  D-CAN is a new diagnosis interface with a new communication protocol (supersedes the previous OBD interface). D-CAN transfers data between the vehicle and the BMW diagnosis system (D-CAN = "Diagnosis-on CAN"). D-CAN is first being introduced on the E70.

  > E65, E66 (US version only)
- CO_2 measures (Europe version only):
  - Increased idling speed (for limited time) after a cold start to heat up the catalysts more quickly. In addition, modifications to the engine settings produce improved residual gas combustion.
  - Active air flap control

    Active air flap control will be introduced on the E60, E61 in 03/2007 (introduction on E70 in 09/2007).
  - Intelligent alternator regulation (sales designation: "Brake Energy Regeneration"). Intelligent alternator regulation is first being introduced on the E60, E61 (introduction on the E70 in 09/2007).

Engine-specific data: [more ...]

The 8-cylinder spark-ignition engine is characterised by the following technical features:

- 90° V8 engine
- Valvetronic with separate Valvetronic control unit
- 2-stage differentiated air intake system (DISA)
- Variable camshaft control (double VANOS)
- Integrated supply module for power supply to DME and other components (not E70)

[System overview ...]

History

Model series / Model	Engine	kW/HP at rpm	Nm at rpm	Emissions standard	DME
E65/735i	N62B36	200/272 6200	360 3700	EURO 4 LEV II	DME 9.2*
E65/745i	N62B44	245/333 6100	450 3600	EURO 4 LEV II	DME 9.2*
E60/545i E61/545i E63/645Ci E64/645Ci	N62B44	245/333 6100	450 3600	EURO 4 LEV II	DME 9.2.1*
E53/X5 4.4i	N62B44	235/320 6100	440 3700	EURO 4 LEV II	DME 9.2.1*
E60/540i E65MU/740i	N62B40TU	225/306 6300	390 3500	EURO 4 ULEV II	DME 9.2.2*
E53/X5 4.8i	N62B48TU	265/360 6200	490 3900	EURO 3 LEV	DME 9.2.1*

E60/550i
E61/550i
E63/650Ci

E64/650Ci E65/750i	N62B48TU	270/367 6100	490 3400	EURO 4 LEV II	DME 9.2.2*
E70/X5 4.8i from 09/2006	N62B48TU	261/355 6200	475 3400	EURO 4 LEV II	DME 9.2.3*
E60/540i E61/540i from 03/2007	N62B40TU	225/306 6300	390 3500	EURO 4 LEV II	DME 9.2.3*
E60/550i E61/550i from 03/2007	N62B48TU	270/367 6200	490 3400	EURO 4 LEV II	DME 9.2.3

* with separate Valvetronic control unit
Info for model series with introduction 09/2007 in next update.

Brief description of components

The engine control system of the V8 engine is described for the E65.

With the digital engine electronics (DME) on the N62TU, the following sensors supply signals to the DME control unit:

- **2 eccentric shafts**

  The eccentric shaft sensor records the position of the eccentric shaft for the Valvetronic. The eccentric shaft adjusts the camshaft so that the optimum valve lift for the inlet valve is achieved regardless of operating condition (infinitely adjustable valve lift at intake).

  The eccentric shaft is adjusted by the Valvetronic actuator. The eccentric shaft sensor is equipped with 2 angle sensors which operate independently of one another. For safety reasons, 2 angle sensors are used with opposed maps. Both signals are digitally transmitted to the Valvetronic control unit.

- **2 inlet camshaft sensors and 2 exhaust camshaft sensors**

  The valve gear is equipped with variable camshaft control (double VANOS) for the inlet and exhaust camshaft. The 4 camshaft sensors record camshaft adjustment. To this end, a camshaft sensor gear is fixed to the camshaft. The camshaft sensor works according to the Hall effect. The integrated supply module supplies voltage to the camshaft sensors.

  > E70

  Power supply from front power distributor in junction box

- **Accelerator pedal module**

  The accelerator pedal module identifies the position of the accelerator pedal.

  Using this information, the DME control unit calculates the required position of the Valvetronic or the throttle valve while taking other criteria into account. The accelerator pedal module is equipped with 2 independent Hall sensors.

  These Hall sensors each emit a voltage signal corresponding to the current accelerator pedal position. For safety reasons, two Hall sensors are used. The two Hall sensors supply a signal proportional to the position of the accelerator pedal.

  The 2nd Hall sensor always generates exactly half the voltage signal of the 1st Hall sensor. The two signal voltages are permanently monitored by the DME.

  The accelerator pedal module receives a constant voltage of 5 volts from the DME. For safety reasons, each Hall sensor has its own power supply from the DME.

- **Hot-film air-mass sensor with intake air temperature sensor**

  The hot-film air-mass sensor records the air-mass which is drawn in. The DME control unit calculates the charge state using this information (base value for fuel injection period).

  A heated area on the hot-film air-mass sensor in the intake air flow is regulated to a constant excess temperature to the intake air. The intake air flow cools the heated area. This causes the resistance to mass. The new hot-film air-mass sensor (HFM 6) now works digitally. The electronic evaluation unit in the hot-film air-mass sensor digitalises the sensor signal.

The hot-film air-mass sensor supplies a pulse-width-modulated signal to the DME.

The integrated supply module provides the power supply to the hot-film air-mass sensor.

> E70

Power supply from front power distributor in junction box

There is also an intake air temperature sensor in the hot-film air-mass sensor housing. The intake air temperature sensor is a resistance with negative temperature coefficient (NTC).

The intake-air temperature is input into a great many DME functions, e.g.:

- Ignition timing calculation
- Knock control adaptation
- Idle speed control
- VANOS actuation
- Valvetronic actuation
- Electric fan actuation

A fault in the intake air temperature sensor will cause an entry to be stored in the DME fault memory. A substitute value is then used for engine operation.

- **Crankshaft sensor**

  The crankshaft sensor records the position of the crankshaft with the aid of an increment gear screwed to the crankshaft. The crankshaft sensor is required in order to achieve fully sequential fuel injection (individual fuel injection for each cylinder at optimum firing point). The crankshaft sensor works according to the Hall effect.

  The circumference of the increment gear is divided into 60 equal teeth. The crankshaft sensor generates signal pulses. These signal pulses become shorter as the engine speed increases. The precise position of the pistons must be known for the fuel injection and the ignition to be synchronised. The increment gear has a gap of 2 teeth for this purpose.

  The number of teeth between the two gaps is permanently monitored. The signals from the camshaft sensors are compared to that from the crankshaft sensor. The signals must be within specified limits.

  If the crankshaft sensor fails, a substitute value is generated from the camshaft sensor signal (for engine starting and running).

  The integrated supply module supplies voltage to the crankshaft sensor.

  > E70

  Power supply from front power distributor in junction box

- **Coolant temperature sensor**

  The coolant temperature sensor records the coolant temperature in the engine cooling circuit.

  The coolant temperature is the measured variable used in these calculations, for example:

  - Injection quantity
  - Nominal idle speed

- **Temperature sensor on radiator outlet**

  The temperature sensor on the radiator outlet records the coolant temperature downstream of the radiator.

  The DME control unit requires information on the coolant temperature at the radiator outlet, e.g. to actuate the electric fan.

- **Inlet pipe pressure sensor**

  On engines with Valvetronic, no vacuum is generated in the intake manifold in unthrottled operation. However, a vacuum is needed for certain functions, e.g. fuel tank ventilation or brake booster. For this reason, the electric throttle-valve actuator is closed as far as necessary to generate the required vacuum.

  The inlet pipe pressure sensor measures low pressure in the intake manifold.

  In engines with Valvetronic, for example, a partial vacuum of approximately 50 millibars is set in idle speed. Together with other signals, the inlet pipe vacuum serves as a substitute value for the load signal.

- **4 knock sensors**

  The 4 knock sensors detect combustion knock.

  The piezoelectric knock sensors record structure-borne sound in the individual cylinders. The DME control unit evaluates the converted voltage signals for each cylinder separately. The DME does this using a special evaluation circuit. Each knock sensor monitors 2 cylinders. Two knock sensors are packages as a single component.

- **4 oxygen sensors**

  For each cylinder bank, there is one oxygen sensor upstream of the catalytic converter and one oxygen sensor downstream of the catalytic converter.

  The oxygen sensors upstream of the catalytic converter are permanent sensors (LSU 4.9 control sensors).

  The oxygen sensors downstream of the catalytic converter are the familiar jump sensors (jump-like voltage changes at Lambda = 1).

  These oxygen sensors are the control sensors.

  The oxygen sensors are heated by the DME control unit so that they reach their operating temperature more quickly.

- **Brake light switch**

  Two switches are fitted in the brake light switch: The brake-light switch and the brake light test switch (duplicated as a safety measure). The signals enable the DME control unit to determine whether or not the brake pedal is depressed.

  The Car Access System (CAS) provides the terminal R supply for the brake light switch via the light module (LM).

  > E70

  Power supply direct from CAS.

- **Clutch module**

  The DME control unit uses the clutch switch signal in coupling mode to recognise whether the clutch pedal is depressed (manual transmission).

  This signal is important for the internal torque monitoring. Coasting mode, for example, is not possible when the clutch is depressed.

- **Oil condition sensor**

  The oil condition sensor increases the function range of the thermal oil level sensor.

  The oil condition sensor measures the following ratings:

  - Engine oil temperature
  - Oil level
  - Engine oil quality

  The oil condition sensor sends the recorded measurement values to the DME.

  A bit-serial interface is used to transmit the signal to the DME.

  The integrated supply module supplies voltage to the oil condition sensor.

- **Oil pressure switch**

  The oil pressure switch provides the DME control unit with an indication of whether or not there is sufficient oil pressure in the engine.

  The oil pressure switch is connected to the integrated supply module. The signal is fed through the integrated supply module to the DME.

  > E70

  The oil pressure switch is directly connected to the DME control unit.

  The signal from the oil pressure switch is checked for plausibility in the DME.

  To do this, the signal from the oil pressure switch is observed after the engine has been switched off.

  After a certain time, the oil pressure switch should not detect any more oil pressure. Is oil pressure is detected, the DME responds by recording a fault memory entry.

The following control units and other interfaces are involved in the digital engine electronics (DME):

- **DME control unit**

  3 additional sensors are located on the board in the DME control unit:

  - Temperature sensor
  - Ambient-pressure sensor
  - New: Voltage sensor

  The thermal monitoring of components in the DME control unit is carried out by the temperature sensor.

  The ambient pressure is required to calculate the mixture composition. The ambient pressure reduces as the height above sea level increases.

  The voltage sensor on the DME control unit board monitors the power supply using terminal 87.

  The DME control unit is connected to the vehicle electrical system by 5 connectors.

  [more ...]

  The DME control unit is linked to the safety and gateway module (SGM) and to the rest of the bus system by means of the powertrain CAN.

  > E60, E61, E63, E64 from 09/2005

  The body gateway module (KGM) is the gateway between the PT-CAN and the rest of the bus system.

  > E70

  The junction box electronics (JBE) is the gateway between the PT-CAN and the rest of the bus system.

- **Valvetronic control unit**

  The 8-cylinder spark-ignition engine has its own Valvetronic control unit.

  Communication between the DME control unit and the Valvetronic control unit takes place via a separate local CAN (local, two-wire CAN bus).

  The DME activates the Valvetronic control unit via a separate wire.

  The DME control unit calculates all values needed to actuate the Valvetronic. The Valvetronic control unit evaluates the signals from the two eccentric shaft sensors. The Valvetronic control unit actuates the Valvetronic actuator motor to adjust the eccentric shaft.

  The Valvetronic control unit receives its power supply via the Valvetronic relay in the integrated supply module.

  > E70

  The Valvetronic control unit receives its power supply from the front power distributor in junction box.

  The Valvetronic control unit continuously checks whether the actual position of the eccentric shaft corresponds with its nominal position. This makes it possible to detect any stiff movements in the mechanics. In the event of a fault, the valves are opened as wide as possible. The air supply is then controlled by the throttle valve.

  [more ...]

- **Integrated supply module**

  > N62TU in the E70

  The E70 does not have an integrated supply module.

  > N62TU

  The 8-cylinder spark-ignition engine has an integrated supply module. The integrated supply module includes various fuses and relays (not a control unit, just a distributor). The integrated supply module acts as the central interface between the vehicle wiring harness and the engine wiring harness.

  The PT-CAN is also routed through the integrated supply module.

  [more ...]

- **CAS control unit**

  The electronic immobiliser is integrated into the CAS control unit as an anti-theft system.

  The engine can only be started if the electronic immobiliser enables this.

Moreover, the CAS control unit provides the powertrain CAN wake-up signal (terminal 15 wake-up) to the DME.

The CAS control unit switches the starter motor on (convenient-start system).

> E65, E66

The DME switches the starter motor on.

- **Alternator**

  The alternator exchanges data with the DME control unit using a bit-serial data interface. The alternator sends the DME control unit information on type and manufacturer, for example. This enables the DME control unit to modify the alternator control to suit the alternator model which has been installed.

- **DSC control unit**

  The DSC control unit sends the signal containing information on the vehicle's road speed via a separate line (redundant to PT-CAN) to the DME control unit. The signal is needed for various functions, e.g. for the cruise-control system and speed limiter.

- **Instrument cluster**

  The outside temperature sensor sends its signal to the instrument cluster.

  The instrument cluster forwards the signal through the bus to the DME.

  The outside temperature is needed for a number of functions in the control unit that include temperature-dependent values.

  In the event of a fault in the outside temperature sensor, the DME control unit reacts with an entry in the fault memory. The DME calculates a substitute value from the intake-air temperature.
  The instrument cluster switches the DME indicator and warning lights on, e.g. the emissions warning light.
  The instrument cluster displays any Check-Control messages present.

  The fuel level sensor is also connected to the instrument cluster. The instrument cluster emits the signal from the level sensor as a message on the CAN. The DME needs this CAN message about the fuel level so that it can deactivate misfiring detection when the fuel level is low and to enable the DMTL (DMTL = "diagnosis module for tank leak").

- **A/C compressor**

  The DME control unit is connected to the integrated automatic heating/air conditioning system (IHKA) through the bus system. The IHKA switches the A/C compressor on or off.

  The DME control unit supplies the signal to the IHKA through the bus.

- **Active Steering, Active Cruise Control, electronic transmission control**

  The DME control unit is connected by the bus system to the following control units (depending on the equipment fitted in the vehicle):

  - AL: Active Steering
  - ACC: Active Cruise Control
  - EGS: Electronic transmission control
  - LDM: Longitudinal dynamics management

  These interfaces are needed for the torque monitoring function.

The digital engine electronics (DME) activates the following actuators:

- **2 Valvetronic actuator motors via the Valvetronic control unit**

  The air flow to the engine during throttle-free operation is adjusted by the variable valve lift and not the throttle valve.

  Valvetronic is driven by an electric motor. The Valvetronic actuator is mounted on the cylinder head. The Valvetronic actuator uses a worm gear to drive the eccentric shaft in the cylinder head oil chamber.

  The eccentric shaft sensor indicates the position of the eccentric shaft to the DME control unit via the Valvetronic control unit.

- **2 DISA servomotors for variable intake manifold**

  The N62TU has a 2-stage differentiated air intake system (DISA).

  The DISA servomotor drives 4 sliding sleeves for each cylinder bank.

The sliding sleeves lengthen or shorten the intake port.

This means that a more ample torque curve is reached at low engine speeds without a loss of engine output at higher engine speeds.

[more ...]

- **Electric throttle-valve actuator**

  The DME control unit calculates the position of the throttle valve: from the position of the accelerator pedal and the torque required by other control units. In the electric throttle-valve actuator, the position of the throttle valve is monitored by 2 potentiometers.

  The electric throttle-valve actuator is electrically opened or closed by the DME control unit.

  With Valvetronic, the throttle-valve actuator is activated for the following functions:

  - Engine start (warm-up)
  - Idle speed control
  - Full load operation
  - Emergency operation

- **4 VANOS solenoid valves**

  The purpose of the variable camshaft control is to increase torque in the low and medium engine speed ranges.

  A VANOS solenoid valve controls a VANOS adjustment unit on the intake end and the exhaust end.

  The VANOS solenoid valves are controlled by the DME control unit.

- **Electric fuel pump**

  > E65, E66

  The right-hand B-pillar satellite actuates the electric fuel pump as required.

  The following control units are involved in controlling the fuel pump:

  - DME: Detection of the current fuel consumption in the engine on the basis of the required injection quantity
  - SGM (safety and gateway module): Signal transfer
  - SBSR (B-pillar satellite, right): Fuel pump regulation and emergency fuel cutoff

  > E60, E61, E63, E64 and E70

  The DME control unit monitors the activation of the fuel pump relay. The fuel pump relay is controlled via a safety circuit only when the engine is running and shortly after terminal 15 ON for pressure build-up (delivery line for fuel pump).

- **8 injectors**

  During fully sequential fuel injection, each injector is controlled by the DME control unit via its own final stage.

  Here, the injection timing for the cylinder concerned is adjusted to the operating conditions (engine speed, load and engine temperature).
  The integrated supply module provides the power supply for the injectors.

- **Fuel evaporation control valve**

  The fuel evaporation control valve regenerates the activated carbon filter using scavenging air. The scavenging air which is drawn through the activated carbon filter is then enriched with hydrocarbons and fed to the combustion engine.

  In a current-free state, the fuel evaporation control valve is closed. This prevents the ingress of fuel vapour from the activated carbon filter into the inlet pipe when the engine is switched off.

  The integrated supply module supplies voltage to the fuel evaporation control valve.

  > E70

  The rear power distributor supplies power to the fuel evaporation control valve.

- **8 ignition coils with overload-protection relay**

  The ignition coils are activated by the DME control unit. The ignition coils receive their power supply from the overload-protection relay in the integrated supply module.

> E70

No integrated supply module; the relief relay is fitted separately.

- **Mapped thermostat**

  The opening and closing of the mapped thermostat is controlled by a characteristic map.

  The mapped thermostat ensures that within its control range a constant coolant temperature is maintained at the engine inlet.

  For driving conditions with low loads, the mapped thermostat sets a high coolant temperature (efficient consumption).

  For full loads or higher engine speeds, the coolant temperature is reduced to protect the components.

  The integrated supply module supplies voltage to the mapped thermostat.

  > E70

  The mapped thermostat receives its power supply from the front power distributor in junction box.

- **Electric fan**

  The electric fan is controlled by the DME control unit via a pulse-width-modulated signal (evaluation by electronic circuitry in the fan).

  The DME control unit controls the various electric fan speeds by means of a pulse-width-modulated signal (between 10 and 90 %).

  Cycle ratios which are less than 5 % and greater than 95 % will not trigger the control device and are used for the purposes of fault recognition.

  The speed of the electric fan is dependent on the coolant temperature at the coolant outlet (radiator) and the pressure in the air-conditioning system. When the car's road speed increases, the speed of the electric fan decreases.

- **Electronics box fan**

  Extremely high temperatures are encountered in the electronics box.

  These are caused by the heating from the engine compartment and the power loss from the control units in the electronics box. The electronics box fan is installed because control units can only be operated in a certain temperature range.

  The maximum permissible operating temperatures must not be exceeded. The expected service life of electronic components increases with decreasing temperature.

- **Exhaust flap**

  > E70

  The E70 has no exhaust flap.

  A diaphragm canister is fixed onto the right-hand rear silencer exhaust pipe. The diaphragm canister is linked to the exhaust flap via an adjustment mechanism.

  The vacuum hose goes from the solenoid valve to the diaphragm can.

  The exhaust flap reduces the noise level when the engine is idle and when the engine speed is close to idle.

  The exhaust flap is closed at low engine speeds and when the engine is not running. At higher engine speeds, the exhaust flap opens.

  The DME controls the solenoid valve for the exhaust flaps. The adjacent partial vacuum opens the exhaust flap. The degree of opening depends on engine load and engine speed.

  > E65, E66

  When the engine is switched off, the diaphragm can is ventilated via a restrictor. This allows the exhaust flap to execute a damped closing. The cutoff valve is actuated by the power module (PM).

System functions

The following system functions are described:

- Power management

- Electronic immobiliser
- Comfort start
- Air supply: 2-stage differentiated air intake system "DISA"
- Charge monitoring
- "Valvetronic" variable valve gear
- "VANOS" variable camshaft control
- Fuel supply system
- Fuel injection
- Ignition-circuit monitoring
- Alternator actuation
- Oil supply
- Engine cooling
- Knock control
- Tank ventilation
- Lambda control system
- Torque monitoring
- Evaluation of road speed signal
- A/C compressor actuation
- Intelligent alternator regulation
- Active air flap control

Power management

The integrated supply module provides the power supply to the DME control unit.

3 relays in the integrated supply module distribute terminal 87 (power supply) to the various components.

For memory functions, the DME control unit also requires an uninterrupted power supply via terminal 30. Terminal 30 also supplies power to the integrated supply module.

The earth connection for the DME control unit is provided by several pins which are connected inside the control unit.

Power management includes the following functions:

- Closed-circuit current monitoring
- Consumer shutdown
- Control of the alternator
- Battery voltage monitoring

The battery voltage is regularly monitored by the DME control unit. If the battery voltage falls below approx. 6 volts or exceeds 24 volts, a fault is registered.

Diagnosis become active 3 minutes after the engine has started. This ensures that the effects of the starting operation or starting assistance on the battery voltage will not be registered as a fault.

> E60, E61, E63, E64
The intelligent battery sensor (IBS) monitors the battery. The intelligent battery sensor is connected to the bitserial data interface (BSD).

> E70
The fuse box supplies power to the DME control unit via the front power distributor in the junction box (for terminal 30 and terminal 87).

The intelligent battery sensor (IBS) monitors the battery.

Electronic immobiliser

The electronic immobiliser is an anti-theft and start-enabling device.

The CAS control unit controls the electronic immobiliser.

Each remote control unit has a transponder chip. The ignition lock is surrounded by a ring antenna.

Power is supplied from the CAS control unit to the transponder chip via this coil (remote control key does not require a battery).

The power supply and data transfer function is performed according to the transformer principle. For this, the remote control sends identification data to the CAS control unit.

If the identification data are correct, the CAS control unit activates the starter via a relay which is located in the control unit.

At the same time, the CAS control unit sends the DME control unit an encoded release signal (alternating code) to start the engine. The DME control unit only enables the start if a correct release signal has been received from the CAS control unit.

These operations may result in a slight delay in starting (up to half a second).

The following faults are stored in the DME control unit:

- Missing or disturbed release signal from the EWS control unit
- Alternating code from the CAS control unit does not tally with the alternating code computed by the DME control unit.

If a fault is detected, the engine start is blocked.

Convenient-start system

The convenient-start system allows the engine to be started in a user-friendly manner as the starter motor automatically remains engaged until the engine is running.

When the START-STOP button is pressed, the CAS control unit first activates terminal 15. The relief relay for the ignition coils is activated.

When the START-STOP button is pressed, the CAS control unit checks that the brake pedal is depressed and the selector lever is in P or N.

The engine start process runs as follows:

- First, the EWS is checked via the EWS data wire.
- If the data is correct, the DME enables the ignition and the fuel injection.
- The CAS control unit switches battery voltage to the DME control unit via terminal 50E. This gives the signal for the required engine start.
- The CAS control unit switches battery voltage to the starter motor via terminal 50L. The starter motor is switched on by the DME via the starter inhibitor relay.

  > E65, E66 and E70

  The DME switches the starter motor on.
- The starter motor continues to turn until the CAS control unit receives the "engine running" signal from the DME through the data bus. The terminals 50 are then switched off by the CAS control unit.

  If the engine does not start, the terminals 50L and 50E will be switched off after a maximum of 20 seconds. The engine start is thus aborted.

Air supply: 2-stage differentiated air intake system "DISA"

The intake strokes of the pistons generate cyclic pressure waves in the inlet pipe.

These pressure waves travel along the inlet pipe and are reflected by the closed inlet valves.

A precise matching of the inlet pipe length with the valve response time produces the following effect:

Shortly before the inlet valve is closed, a pressure maximum of the reflected air wave reaches the inlet valve. This has a supercharging effect which pumps a higher proportion of fresh air into the cylinder.

The differentiated air intake system also makes use of the inherent benefits of both short and long inlet pipes.

- The effect of short inlet pipes or inlet pipes with a large diameter is a high efficiency in the upper engine speed range (and also low torque in the medium engine speed range).
- Long inlet pipes or inlet pipes with a small diameter make high torque in the medium engine speed range possible.

A front intake pipe is installed upstream of each resonating pipe. When the sliding sleeves are closed, the combined effect of the front intake pipe and resonating pipe is similar to that of a long inlet pipe.

The pulsating air column inside it increases torque in the medium engine speed range considerably.

To increase performance in the higher engine speed range, the sliding sleeves are opened. This largely reduces the dynamics in the front intake pipes. The short resonating pipes which are now effective can make high performance figures in the upper engine speed range possible.

The DME control unit adjusts the sliding sleeves via the two DISA servomotors (12 volts) with integrated transmission. Each DISA servomotor has one output stage. The information as to whether a downwards or upwards gearshift was made is saved by the DME control unit.

When the value falls below 4700 rpm, the DME control unit closes the sliding sleeve with the assistance of the DISA servomotors. When the value of 4800 rpm is exceeded, the sliding sleeves are opened again (N62B40TU: 4800 and 4900 rpm). At changeover, these engine speeds are displaced reciprocally (hysteresis) to prevent the sleeves opening and closing in rapid succession.

In the event of system failure, the sliding sleeves remain in their respective positions. The driver will be aware of system failure through a loss of power and reduction in the final speed.

Once the engine has been switched off (terminal 15 OFF), the sliding sleeves are run once to their limit position.

This prevents deposits accumulating and blockage of the sliding sleeve during longer journeys at low engine speeds.

[more ...]

Charge monitoring

The following input variables are used to monitor the charge state of the DME:

- Throttle-valve angle
- Valvetronic lift
- Air intake pressure
- Intake air-mass

From these 4 input variables on the inlet side, the DME calculates the charge state for all operating conditions.

"Valvetronic" variable valve gear

Valvetronic was developed to reduce fuel consumption.

The quantity of air supplied to the engine when Valvetronic is active is adjusted by the variable valve lift on the inlet valve and not the throttle-valve actuator.

An electrically-adjustable eccentric shaft changes the action of the camshaft on the roller cam follower via an intermediate lever. The result of this is variable valve lift.

With Valvetronic, the throttle-valve actuator is activated for the following functions:

- Engine start (warm-up)
- Idle speed control
- Full load operation
- Emergency operation

In all other operating conditions, the throttle valve only remains open far enough to induce a slight low pressure.

This low pressure is required to ventilate the tank, for example.

The DME control unit calculates the associated setting of Valvetronic using the position of the accelerator pedal and other variables.

The DME control unit activates the Valvetronic actuator motor on the cylinder head via the Valvetronic control unit. The Valvetronic actuator uses a worm gear to drive the eccentric shaft in the cylinder head oil chamber.

The eccentric shaft sensor records the current position of the eccentric shaft. The eccentric shaft sensor is equipped with 2 angle sensors.

The Valvetronic control unit adjusts the current position of the eccentric shaft via the Valvetronic actuator until the nominal position is reached.

For safety reasons, 2 angle sensors are used with characteristic curves which have opposing directions. Both signals are digitally transmitted to the DME control unit. The DME control unit supplies 5 volts to both angle sensors.

Both signals from the eccentric shaft sensors are continuously monitored by the DME control unit.

Checks are made as to whether the signals are plausible in their own right and also in relation to one another. The signals may not differ. Where a short circuit or fault develops, the signals lie outside the measuring range.

The DME control unit continuously checks whether the actual position of the eccentric shaft corresponds with its nominal position. This makes it possible to detect any stiff movements in the mechanics.

In the event of a fault, the valves are opened as wide as possible. The air supply is controlled by the throttle valve.

If the actual position of the eccentric shaft cannot be detected, the valves are opened to the maximum extent without regulation (controlled emergency operation).

In order to achieve the correct valve opening, an adaptation must be made to balance all tolerances in the valve gear. During this adaptation process, the mechanical stops on the eccentric shaft are adjusted.

The positions registered are subsequently saved. These positions are used as the basis for calculating the actual valve lift at any point during operation.

The adaptation process is automatic: Each time the engine is restarted, the position of the eccentric shaft is compared with the values registered. If following a repair, for example, a different position of the eccentric shaft is detected, the adaptation process is carried out. In addition, the adaptation can be initiated via the BMW diagnosis system.

"VANOS" variable camshaft control

The variable camshaft control improves torque in the low and medium engine speed range.

Due to a larger valve overlap, the volume of residual fumes at idle speed is reduced. A recirculation of internal exhaust gas in the part-load range reduces the volume of nitrogen oxide.

The following is also achieved:

- Faster heating of catalytic converters
- Reduced exhaust emissions following a cold start
- Reduced fuel consumption

A controlled VANOS adjustment unit is mounted at both intake and exhaust camshafts (controlled using oil pressure).

A VANOS solenoid valve is used to control the VANOS adjustment unit. The required position of the intake and exhaust camshaft is calculated using the engine speed and load signal (dependent on intake temperature and engine temperature). The DME control unit activates the VANOS adjustment unit accordingly.

The control of the intake and exhaust camshaft is variable within their maximum adjustment range.

Once the correct camshaft position has been reached, the VANOS solenoid valves ensure that the oil volume in the servo control cylinders in both chambers remains constant. This keeps the camshafts in this position.

To perform the adjustment, the variable camshaft control requires information on the current position of the camshaft. Camshaft sensors on the intake and exhaust end record the position of the camshafts.

When the engine is started, the inlet camshaft is in the end position ("retarded" position). When the engine is started, the exhaust camshaft is pretensioned by a spring and held in the "advanced" position.

Fuel supply system

> E65, E66

The fuel supply system on the BMW 7-Series is requirement-orientated and thus depends on consumption.

The DME calculates the amount of fuel required on the basis of various operating variables.

In turn, the engine's current fuel requirement is calculated from this value. The DME requests this value as a volumetric flow with the unit "litres per hour".

The DME sends this request on the following path: DME (digital engine electronics -> PT-CAN -> SGM (safety and gateway module) -> **byteflight** -> SBSR (B-pillar satellite, right) -> EKP (regulated fuel pump).

The B-pillar satellite, right converts the amount of fuel requested into a nominal speed for the fuel pump.

The pump speed is regulated via the cycle ratio of a pulse-width-modulated signal. This rectangular signal gives the effective supply voltage for the fuel pump: The longer the pause between the edges of the rectangular signal, the lower the supply voltage for the fuel pump. The fuel pump delivery volume is correspondingly lower. The fuel pump speed is sent back to the B-pillar satellite, right as an input variable.

This method has the following benefits compared to the conventional way of actuating the fuel pump (fuel-pump relay):

- Lower current draw from fuel pump
- Reduced heating up of fuel
- Longer service life for fuel pump
- No fuel-pump relay needed

The flow of fuel is interrupted in the event of a crash of sufficient impact. This prevents the fuel from escaping or igniting (emergency fuel cutoff).

The fuel pump can be reactivated by switching the ignition off and on again.

If the request signal from the DME or the pulse-width-modulated signal from the SBSR is not received: The fuel pump will operate a maximum delivery capacity. This guarantees sufficient fuel supply for all operating conditions (emergency operation).
> E60, E61, E63, E64 and E70

The DME switches the fuel pump on using the fuel-pump relay.

Fuel injection

During fully sequential fuel injection, each injector is controlled by means of its own final stage.

Fully sequential fuel injection has the following advantages:

- Improved fuel preparation for each individual cylinder
- Adaptation of the fuel injection timing to suit the engine's operating condition (engine speed, load, engine temperature)
- Cylinder-selective correction of injected fuel quantity for varying load (during a cycle, the fuel injection timing can be corrected by extending or shortening it)
- Cylinder-selective cutoff (e.g. when an ignition coil is defective)
- Diagnosis for each individual injector possible

The control of each injector by means of its own individual final stage achieves a fuel build-up which is the same in all cylinders. This ensures a uniformly-effective fuel preparation throughout.

The fuel build-up time is variable and depends on the load, engine speed and engine temperature.

As it is only injected once per camshaft rotation, the spread of fuel due to tolerances in the components is reduced.

In addition, the idle-running performance is improved as the response and dropout times at the injectors are reduced.

Moreover, a marginal reduction in fuel consumption is also achieved.

When the vehicle is in motion and there is a sudden acceleration or the throttle is closed, the fuel injection period can be adjusted. If the injectors are still open, the mixture at every valve can be adjusted by extending or shortening the fuel injection period. This achieves an improved engine response.

Ignition-circuit monitoring

The current in the primary coil for the ignition coil is used to monitor the ignition circuit. When the engine is switched on, the current must stay within specific values during certain time thresholds.

The ignition diagnosis monitors the:

- Primary power circuit for the ignition coil
- Ignition wiring harness
- Secondary power circuit for the ignition coil with the spark plug

The ignition-circuit monitoring can detect the following faults:

- Short circuit at the primary end of the ignition coil
- Short circuit at the secondary end of the ignition coil
- Defective spark plug
- Break in wire to actuator
- Defective ignition output stage

The following are not detected:

- Intermittent faults such as loose contacts in the wire to the actuator
- Spark-over in high-tension circuit parallel to spark gab where a short-circuit in the coil does not develop

Alternator actuation (bit-serial data interface)

The following functions have been implemented in the DME control unit for the alternator with bit-serial data interface (BSD):

- Switching the alternator on and off using defined parameters
- Specification of the alternator's maximum permissible power consumption
- Calculation of the input torque for the alternator based on the power consumption
- Control of the alternator's response when higher electrical loads are connected (load-response function)
- Diagnosis for the data line between the alternator and DME control unit
- Storage of faults which develop in the alternator in the fault memory of the DME control unit
- Actuation of the charge-current indicator light in the instrument cluster via bus connection
- Introduction of intelligent alternator regulation:

  > from 03/2007 in the E60, E61

  > from 09/2007 in the E63, E64, E70

The principal function of the alternator is also guaranteed when communication between the alternator and DME control unit is interrupted.

The following fault causes can be distinguished in fault memory entries:

- Overheating protection:

  The alternator is overloaded. For safety reasons, the alternator voltage is reduced until the alternator has cooled down (charge telltale light does not light up).

- Mechanical fault:

  There is a mechanical block in the alternator. or: The belt drive is defective.

- Electrical fault:

  Excitation diode defective, excitation coil has been interrupted, overvoltage due to defective governor.

- Communication failure:

  Line between DME control unit and alternator defective.

An interruption or short circuit in the alternator coils will not be detected.

Oil supply

The oil condition sensor reports the engine oil level and engine oil quality back to the DME control unit. A temperature sensor in the oil condition sensor indicates the engine oil temperature. The engine oil temperature is used together with the coolant temperature to calculate the engine temperature.

The oil pressure is indicated by the oil-pressure switch.

The oil level is also measured for the electronic oil level check. The 2nd capacitor in the upper part of the oil condition sensor registers the oil level. The capacitor is at the same level as the oil level in the oil sump.

As the oil level falls, the capacitance of the capacitor falls. The electronic evaluation unit creates a digital signal from this. The DME then calculates the engine oil level.

The DME control unit activates the warning and indicator lamp in the instrument cluster via the PT-CAN (red: oil pressure low; yellow: oil level low).

Electronic oil level check:

The dipstick now has a black handle. The engine oil level is measured by the oil condition sensor.

The measured value is displayed in the Central Information Display (CID).

The signal from the oil condition sensor is evaluated in the DME. Besides the oil level, the thermal oil level sensor also indicates the engine oil temperature.

Condition Based Service:

In addition, the engine oil quality is measured for the Condition Based Service (CBS).

The electrical material properties of the engine oil change as the engine oil wears and ages. The changed electrical properties of the engine oil (dielectrics) cause the capacity of the capacitor in the oil condition sensor to change.

The electronic evaluation unit converts the measured capacity into a digital signal.

The digital sensor signal is transmitted to the DME as a statement about the condition of the engine oil.

The DME uses this to calculate the next engine oil change as part of Condition Based Service (CBS).

Engine cooling

The opening and closing of the mapped thermostat is controlled by a characteristic map. This regulating operation can be split into 3 operating ranges:

- Mapped thermostat closed:

  The coolant only flows through the engine and the coolant circuit is closed.

- Mapped thermostat open:

  The entire coolant volume flows through the radiator. This results in maximum use of the available cooling output.

- Control range of the mapped thermostat:

  A proportion of the coolant flows through the radiator. The mapped thermostat maintains a constant coolant temperature within the control range at the engine inlet.

  In this operating range, the coolant temperature can now be selectively controlled with the assistance of the mapped thermostat. This means that a high coolant temperature can be set in the part-load range of the engine. High operating temperatures in the part-load range result in improved combustion. This in turn leads to reduced consumption and exhaust emissions.

  During full load operation, certain disadvantages are associated with higher operating temperatures (retarding of ignition due to knock).

  A lower coolant temperature is therefore specifically set during full load operation with the assistance of the mapped thermostat.

Knock control

The engine is equipped with a cylinder-selective adaptive knock control.

4 knock sensors detect combustion knock (cylinders 1 and 2, cylinders 3 and 4, cylinders 5 and 6, cylinders 7 and 8). The sensor signals are evaluated in the DME control unit.

If the engine is operated with combustion knock for longer periods of time, this can cause serious damage.

Knock is encouraged by:

- Increased compression ratio
- High cylinder fill levels
- Inferior fuel grade (RM/MM)

- High intake-air and engine temperature

The value of the compression ratio can also become too high due to spread due to deposits or the manufacturing process. On engines without knock control, these unfavourable influences must be taken into account. The design of the ignition system must include a safety gap to the anti-knock limit. This makes reduced efficiency in the upper load range unavoidable.

The knock control prevents knock. The firing point of the relevant cylinder (cylinder-selective) is set as far as possible in the retarded direction only when a knocking risk is present.

This means that the ignition control grid can be designed around ideal consumption values (without having to take the anti-knock limit into account). A safety margin is no longer necessary.

The knock control performs all the necessary corrections to the firing point due to knock and also makes trouble-free driving with regular grade petrol (minimum RM 91) possible. The knock control provides:

- Protection from damage caused by knock (also in unfavourable conditions)
- Reduced consumption and increased torque throughout the entire upper load range (according to the quality of fuel used)
- High economic efficiency through optimum use of the available fuel quality and by taking the specific engine condition into account

The knock control self-diagnosis performs the following checks:

- Check for signal interference, e.g. breaks in wiring or defective connector
- Self-test for evaluating circuit
- Check of engine noise level recorded by the knock sensor

If a fault is identified during one of these checks, knock control is deactivated. An emergency program assumes control of the ignition angle. A fault is simultaneously registered in the fault memory. The emergency program guarantees damage-free operation from a minimum of RON 91. The emergency program depends on the load, engine speed and engine temperature.

Tank ventilation

The fuel evaporation control valve controls the regeneration of the activated carbon filter with scavenging air.

Scavenging air drawn through the activated carbon filter is enriched with hydrocarbons (HC) depending on the loading of the activated carbon. The scavenging air is subsequently fed to the engine for combustion.

The formation of hydrocarbons in the fuel tank is dependent on:

- Fuel temperature and ambient temperature
- Air pressure
- Fill level in the fuel tank

In a current-free state, the fuel evaporation control valve is closed. This prevents the ingress of fuel vapour from the activated carbon filter into the inlet pipe when the engine is switched off.

Closed-loop Lambda control system

Optimum efficiency of the catalytic converter can only be achieved if an ideal fuel/air ratio is used for combustion ($\lambda = 1$). To this end, oxygen sensors are used upstream and downstream of the catalytic converter.

The oxygen sensors upstream of the catalytic converter have a steady characteristic output curve (measure oxygen content in rich and lean ranges.)

The measurement method employed by this oxygen sensor is different to an oxygen sensor with an erratic characteristic output curve. The oxygen sensor is therefore connected using 6 pins instead of 4.

- **Oxygen sensors upstream of catalytic converter**

  The oxygen sensors upstream of the catalytic converter (control sensors) are used to assess the composition of the exhaust gas.

  The control sensors are screwed into the exhaust manifold.

  The oxygen sensors measure the residual oxygen content in the exhaust fumes. The voltage values determined are relayed to the DME control unit. The DME control unit corrects the mixture composition by adjusting the injection period.

Values which are greater or less than $\lambda = 1$ are aimed at depending on the operating condition.

- **Oxygen sensors downstream of catalytic converter**

  The oxygen sensors downstream of the catalytic converter (monitoring sensors) are used to monitor the control sensors. In addition to this, the function of the catalytic converter is monitored.

To ensure full operational reliability of the oxygen sensors upstream of the catalytic converter, a temperature of approximately 750 °C is required (350 °C for oxygen sensors downstream of the catalytic converter). For this reason, all oxygen sensors are heated.

The oxygen sensor heating is controlled by the DME control unit. When the engine is cold, the oxygen sensor heating remains switched off, as condensation which is present would otherwise destroy a hot oxygen sensor due to thermal strain.

This means that the closed-loop Lambda control only becomes active a short time after the engine has started, once the catalytic converters have warmed up. The oxygen sensor is initially warmed up using a reduced heating power, to avoid imposing unnecessary loads on it due to thermal strain.

Torque monitoring

The DME monitors the torque required.

The following systems may request torque data from the DME control unit:

- Active Steering
- Servotronic
- Alternator
- Cruise control
- Dynamic Stability Control
- Transmission management
- Internal monitoring against "self-acceleration"

Evaluation of road speed signal

The road speed signal is required by the DME control unit in order to perform several functions:

- Speed limiting function:

  Once the maximum road speed has been reached, the fuel injection and ignition are adjusted. If required, individual ignition and injection signals are suppressed. A "soft" speed limiting function is thus carried out.
- Control of A/C compressor:

  When the air-conditioning system is switched on, the A/C compressor is switched off during full-load acceleration,
  provided that: the car's road speed is less than 13 km/h.
- Idle speed control:

  If the car's road speed is 0 km/h, the idle speed is adjusted (depends on A/C compressor ON, selected drive position for automatic transmission, light ON).
- Poor-road-surface detection:

  At low road speeds, the check for smooth engine operation is switched off.

A/C compressor activation

The DME control unit supplies the signal to actuate the A/C compressor.

The A/C compressor is switched off under the following conditions:

- Full engine load
- car's road speed under 13 km/h

- Engine overheating

The IHKA actuates the A/C compressor. The DME sends the signal on the bus system.

Intelligent alternator regulation

Intelligent alternator regulation systematically controls the battery charge state.

The battery is predominantly charged in overrun mode.
Depending on the battery charge state, the battery will not be charged during an acceleration phase.

Active air flap control

Active air flap control regulates the air supply for the engine and assemblies cooling system by only opening the air flaps as they are needed.

Notes for service staff

The following information is available for service staff:

- General note: [more ...]
- Diagnosis: [more ...]
- Encoding/programming: ---

US national version

Fuel tank leakage diagnosis module

The fuel system leak test is regularly conducted when the engine is switched off. Here, the following processes are executed during the DME run-down period:

- Initial situation

  During normal engine operation, the switchover valve in the diagnosis module is in the "Regeneration" position. Fuel vapours are stored in the activated charcoal filter and fed into the engine depending on the actuation of the fuel evaporation control valve (please refer to "Fuel tank ventilation").

- Starting conditions check

  After the engine is switched off, the conditions necessary to restart are checked:

  - Engine off
  - Battery voltage between 11.5 and 14.5 volts
  - No fault memory entry in the DME regarding diagnosis module for tank leak or tank-ventilation system
  - Fuel level greater than 10 % and less than 90 %

  If the result is positive, tank leakage diagnosis is started with a comparison measurement.

- Comparison measurement

  The fuel evaporation control valve is always closed when the engine is switched off. The switchover valve in the diagnosis module remains in the "Regeneration" position. The electric leakage diagnosis pump impels fresh air from the surrounding area through a defined leak of 0.5 mm diameter. The current draw needed for this is stored as a value. The actual tank leakage diagnosis then follows.

- Tank leakage diagnosis:

  The fuel evaporation control valve remains closed. The switchover valve in the diagnosis module is switched to the "Diagnosis" position. The leakage diagnosis pump impels fresh air from the surrounding area into the tank, causing the interior pressure to slowly increase. At the start of tank leakage diagnosis, the interior pressure is equal to the ambient pressure. The current draw is therefore low. As the pressure inside the tank increases, the current draw also increases. The DME evaluates the current draw of the leakage diagnosis pump.

- Pump current evaluation

  The DME evaluates the increase in the current draw over a certain time.

  If the current draw exceeds the value stored within this time, the fuel system is considered to be OK. Tank leakage diagnosis is ended.

If the current draw does not reach the value stored, the fuel system is considered to be defective.

Tank leakage diagnosis allows a difference to be made between:

- Major leak, e.g. fuel cap missing
- Minor leak
- Micro-leak

The relevant fault is entered in the DME fault memory. Tank leakage diagnosis is then ended.

- End of tank leakage diagnosis:

  The switchover valve is switched back to the "Regeneration" position. The DME run-down period remains available for other functions.

Tank leakage diagnosis can also be started with the BMW diagnosis system. In this case, the processes run as described above.

Subject to change.