

Reference Manual



ENGINE ELECTRONICS



Technical Training

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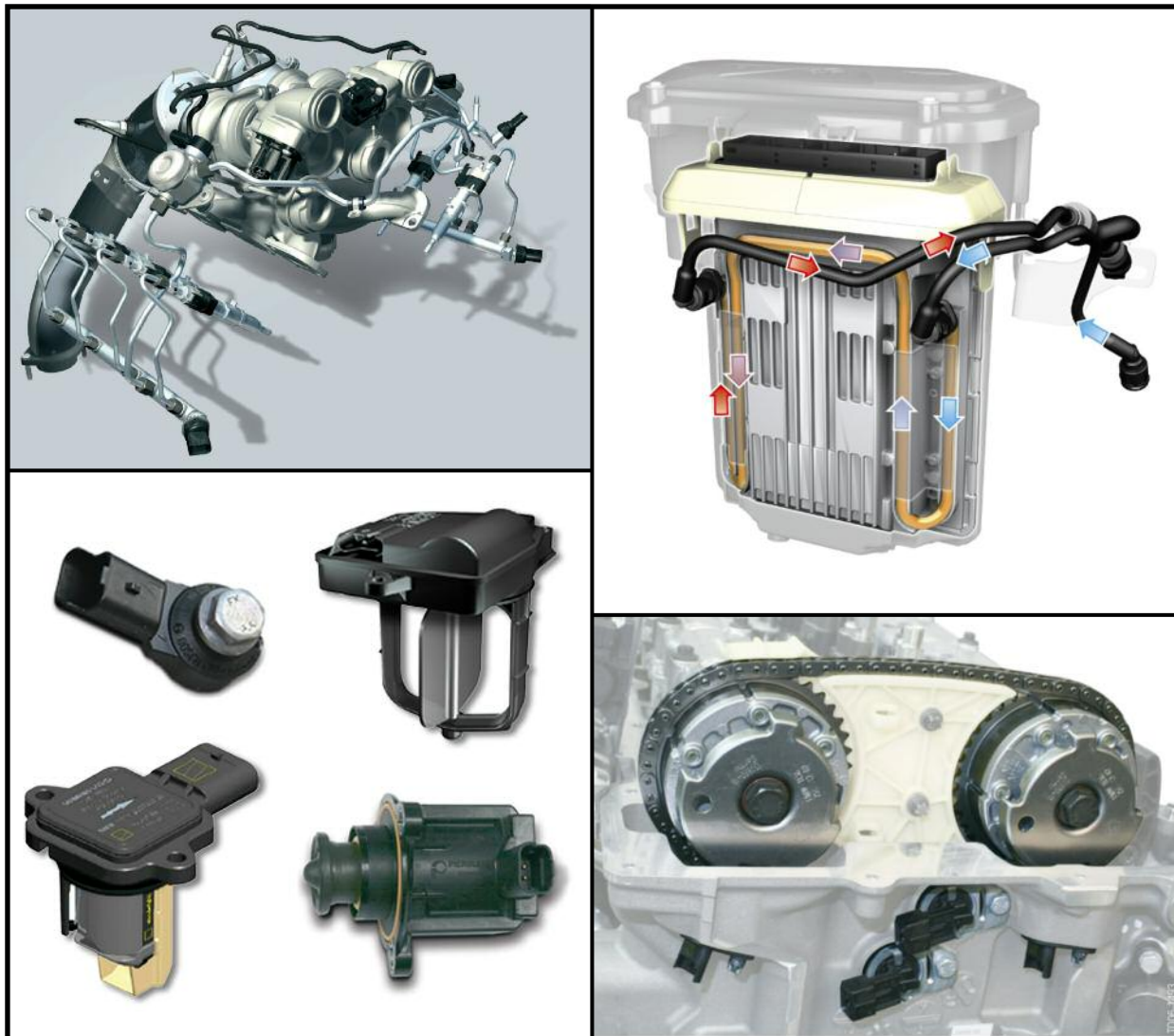


The Ultimate
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BMW

Technical Training

Engine Electronics



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Course Code: **ST055 Engine Electronics**

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This training manual or any attached publication is not intended to be a complete and all inclusive source for repair and maintenance data. It is only part of a training information system designed to assure that uniform procedures and information are presented to all participants.

For changes/additions to the technical data, repair procedures, please refer to the current information issued by BMW of North America, LLC, Technical Service Department.

This information is available by accessing TIS at www.bmwcenternet.com.

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Engine Electronics Overview

Model: All

Production: All

OBJECTIVES

After completion of this module you will be able to:

- Understand the basics of Engine Electronics
- Describe the Power Supply for the Fuel Injectors and Ignition Coils
- Understand the EDK and Idle Air Actuator Operation
- Explain Why Two Sensors are Used to Monitor Accelerator Pedal Movement
- List the Inputs Required for Fuel Injector Operation
- Name the Two Types of Emissions the ECM Controls
- Understand DM-TL Evaporative Leak Testing

Introduction

Welcome to ST055 Engine Electronics!

ST055 Engine Electronics is 5 days in length.

This handout is representative of selected 6, 8, and 12 cylinder Engine Management Systems. The handout serves two purposes, “stand alone” system reference material for the BMW Technician and a platform for Instructor selected topics.

Understanding that all of the material pertaining Engine Management can't be covered in five days, this class will be system based. This approach will ensure that the student comprehends how BMW Engine Management Systems work and thus is able to diagnose them. Nevertheless, BMW Technicians can find detailed information from particular Engine Management Systems in former BMW Training Manuals.

Objectives

Familiarize BMW Technicians with an understanding of the current Engine Electronics Systems and transferable diagnostic skills. Perform hands on practicals in the shop to ensure “all” Technicians have participated in diagnosis and component testing.

Objectives are provided on page 2 of each system to guide you to the key learning points of each module. A final test will be given at the end of the course.

It is very important to study the content which will assist you with important “on the job” information and successful completion of this course.

As a Mention the following information can be found online...

- Service Information
Bulletins
- Technical Training Information
Courses
- Repair Information
Manuals
- Technician Feedback Systems
Quality Control Information
Reports



The chart shown below is a quick reference of BMW Engine Management Systems by application to BMW models, engines and model years. This will help you to get familiar with the systems by identifying the correct version that you are diagnosing.

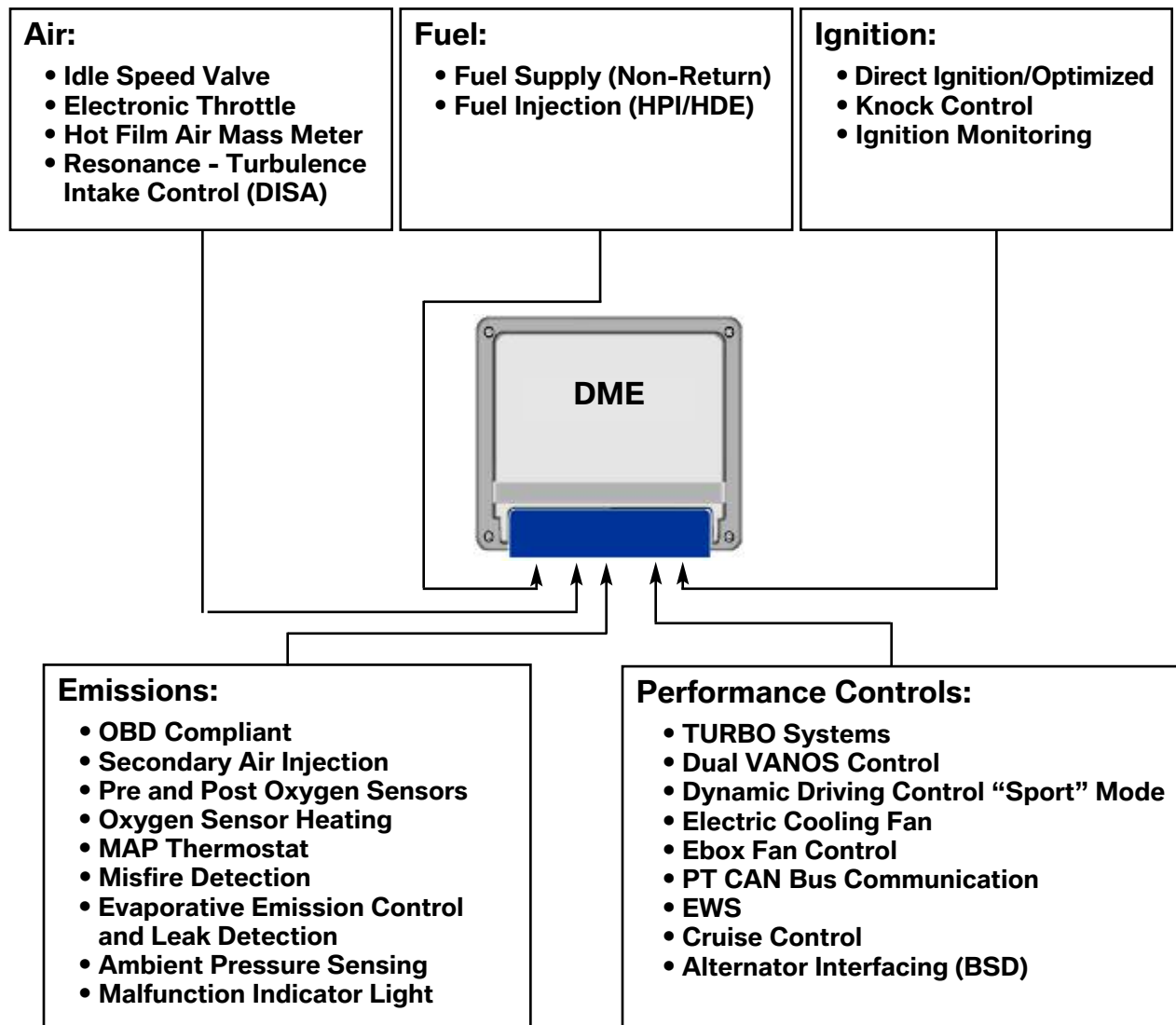
ENGINE MANAGEMENT CONTROL VERSIONS			
VERSION	VEHICLE MODEL	ENGINE	MODEL YEAR
M1.2	E32 / M5	M70 / S38	M70 = 1988 - 1999 S38 = 1991 - 1993
M1.7	E31 / E32	M70	1991 - 1994
M1.7	E30	M42	1990 - 1993
M1.7	E36	M42	1992 - 1995
M1.7	E36	M42 / DISA	1995
M1.7.1	E31	S70	1991 - 1992
M1.7.2	E36	M42 /DISA	1992
M3.1	E34	M50	1991 - 1992
M3.1	E36	M50	1992
M3.3	E32	M60	1993 - 1994
M3.3	E31 / E34	M60	1994 - 1995
M3.3.1	E34 / E36	M50TU	1993 - 1995
M5.2	E36 / Z3	M44	1996 - 1998
M5.2	E31 / E38 / E39	M62 / M73	1995 - 1997
MS41.1	E36 / E39 /Z3	M52	1996 - 1998
MS41.2	E36 M3	S52	1996 - 1998
M5.2.1	E38 / E39	M62 / M73	1998 - 1999
MS42	E46 / E39 /Z3	M52TU	1998 - 2000
MS43	E46 / E39 / E53 / Z3	M54	E46 2001 - 2002 Z3 2001 - 2002 E39 2001 - 2003 E53 2001 - 2006
ME7.2	E39 / E38 / E53	M62TU	1999 - 2001
MS S52	E39 M5 / E52 Z8	S62	M5 1999 - 2003 Z8 2000 - 2003
MS S54	E46 M3	S54	2001 -2007
BOSH = M; SIEMENS = MS			

ENGINE MANAGEMENT CONTROL VERSIONS			
VERSION	VEHICLE MODEL	ENGINE	MODEL YEAR
MS45	E85	M54	2003 - 2006
MS45	E83 all except M54B30 AUTO	M54	2003 - 2006
MS54.1	E83 with M54B30 auto	M54	2003 - 2006
MS45.1	E46	M54	2003 - 2006
MS45.1	E46	M56 SULEV	2003 - 2006
ME 9.2	E65/66	N62	2002 - 2003
ME9.2.1	E53 / E60 / E63 / E64 / E65 / E66	N62	2004 - 2004
ME 9.2.2	E53 / E60 / E63 / E64 / E65 / E66	N62	2005 - 2007
MED 9.2.1	E66	N73	2003 - 2006
ME 9.2.3	E70	N62	2006 - 2010
MSS65	M5, M6 (E6x)	S85	2006 - 2009
MSV70	E90, E91, E92, E93, E60, E70.	N52	2004 - 2006
MSV80	E82, E88, E90, E91, E92, E93, E60, E70.	N52KP	2006 -
MSD80	E82, E90, E92, E93, E60, E61.	N54	2006 - 2008
MSD81	E70, E71, E82, E84, E88, E89, E90, E92, E93, F07, F10	N54	2008 -
MEVD 17.2	E82, E88, E90, E91, E92, E93, E60, E70.	N55	2010 -
MSD85	E70, E71, E72, F01, F02, F04, F07, F10	N63	2009 -
MSD85.1	E70 M / E71 M	S63	2009 -
MSD87-12	F01, F02	N74	2009 -
BOSH = M; SIEMENS = MS			

ENGINE MANAGEMENT CONTROL VERSIONS			
VERSION	VEHICLE MODEL	ENGINE	MODEL YEAR
MSD 90	F10	N52TU	2010-2011
MEVD 17.2	E82, E88, E90, E91, E92, E93, E60, E70, F34	N55	2010 -
MEVD 17.2.2	F25, F12, F13	N55	2010 -
MEVD 17.2.4	E84, E89, F25, F10, F22, F23, F30, F31, F32, F33	N20, N26	2011 -
MEVD 17.2.6	F06, F15, F16, F22, F23, F25, F30, F30 M, F32, F32M, F33, F33M	N55	2011 -
MEVD 17.2.8	F01, F02, F06, F10, F12, F13 F15, F16, M5, M6	N63TU, S63TU	2012 -
MEVD 17.2.2.x	E70, F10H, F01H	N55	2010 -

BOSH = M; SIEMENS = MS

Engine Electronics Overview

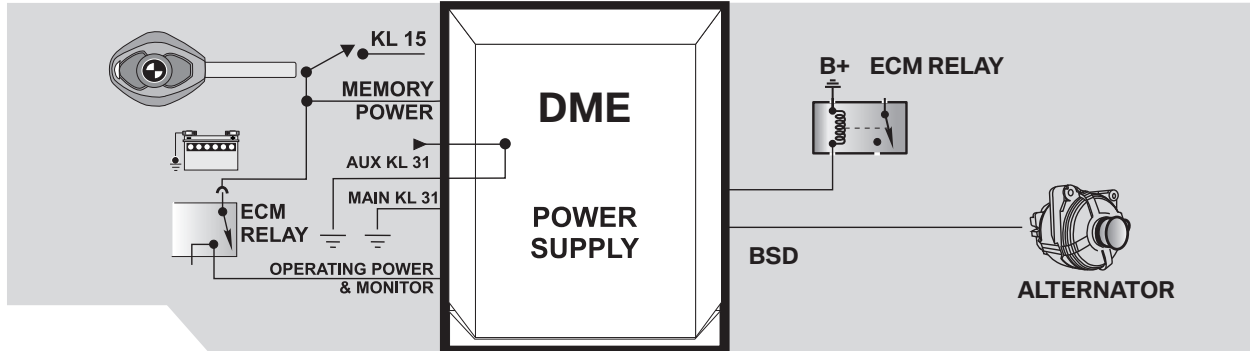


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Power Supply Overview

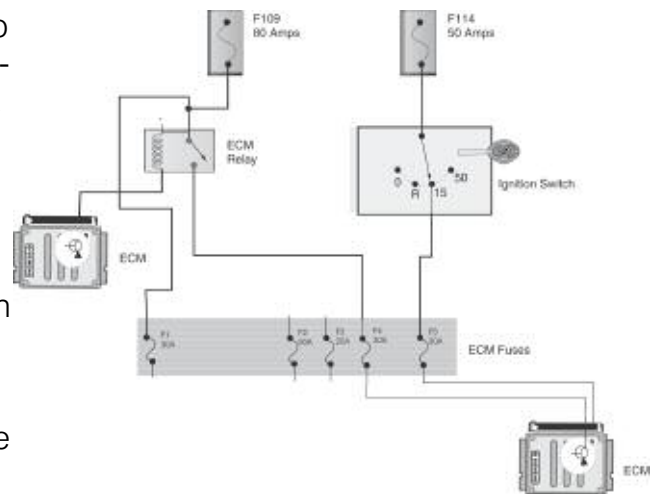
Example of IPO for a Power Supply System



One of the main purposes of the ECM is to control the Power Supply of several components. In the following pages you will find a generic explanation on how this system works. For more detailed information please access BMW Training Reference Manuals found online.

KL_30 - Battery Voltage: B+ is the main supply of operating voltage to the ECM.

The power supplies (KL_15 and ECM Relay) are fused to the ECM. The fuses are housed in the Engine Fuse Block located in the Electronics Box.



KL_15 - Ignition Switch. When the ignition is switched “ON” the ECM is informed that the engine is about to be started. KL_15 (fused) supplies voltage to the Engine Control Module Relay and the Fuel Injector Relay. Switching KL_15 “OFF” removes the ECM operating voltage.

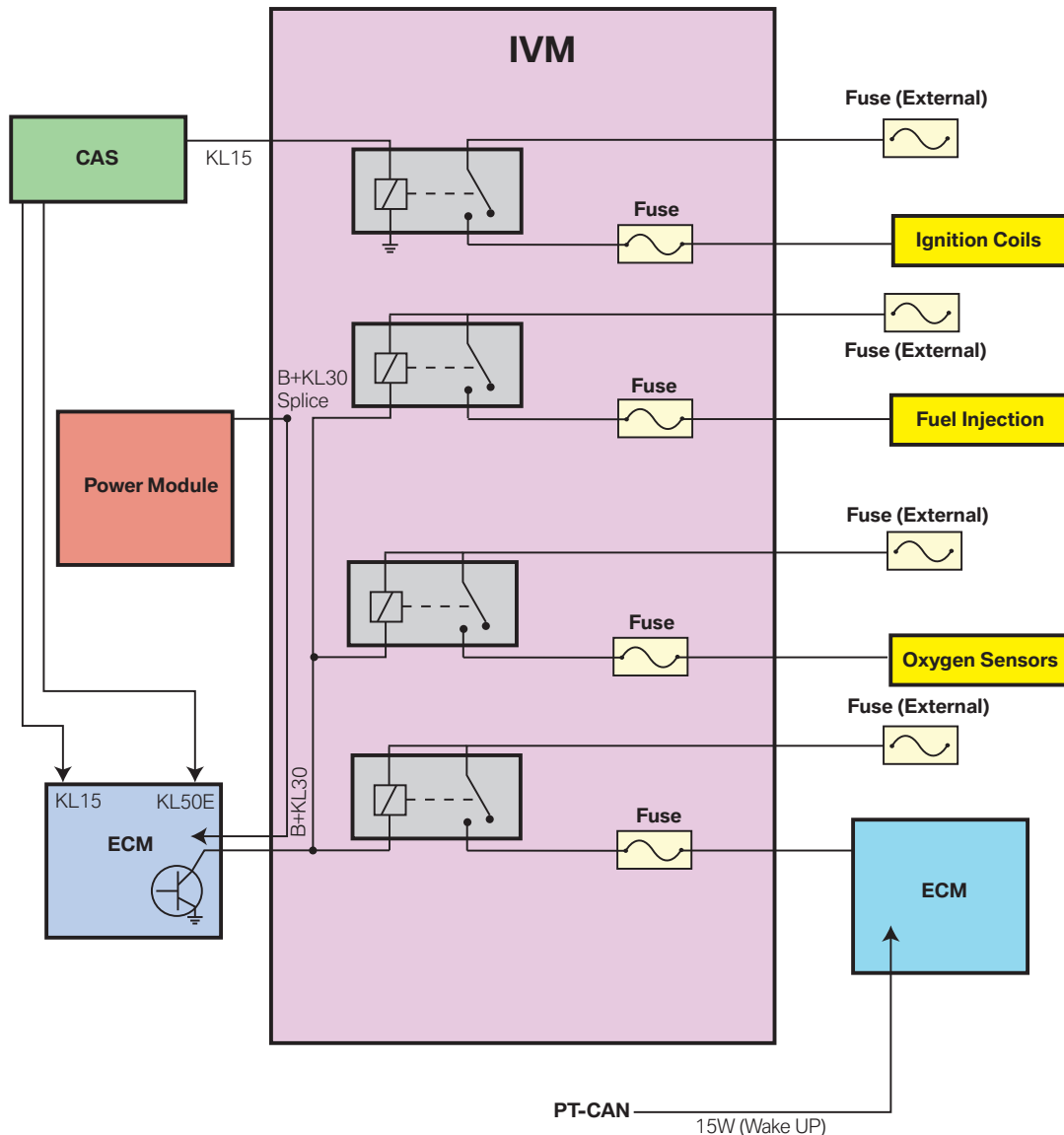
Engine Control Module Relay

ECM Relay Provides the operating Voltage to:	
ECM	Ignition Coil
Fuel Injection	Evaporative Leak Detection Pump
Idle Air Actuator	Camshaft Sensor
Evaporative Emission Valve	Hot Film Air Mass
Fuel Pump Relay	Oxygen Sensor Heaters

Ground: Multiple ground paths are necessary to complete current flow through the ECM.

Integrated Voltage Supply Module (IVM)

The IVM contains integral relays, replaceable fuses and offers a convenient splice point for harness connections. The IVM serves as a central power supply for Engine Management (including VALVETRONIC), Electronic Transmission (EGS) and Dynamic Stability Control (DSC). This diagram is a partial representation of the IVM for Engine Electronics. (FIX COLORS, AND "COLOR" THE IVM)



Principle of Operation

When **KL_15** is switched “ON” the ECM is ready for engine management. The ECM will activate a ground path to energize the Engine Control Module Relays in the IVM (see diagram on the previous page).

- The 1st ECM Relay supplies operating voltage through a fuse (in the IVM) to the ECM.
- The 2nd ECM Relay supplies operating voltage through a fuse (in the IVM) to the Fuel Injectors.
- The 3rd ECM Relay supplies operating voltage through a fuse (in the IVM) to the Oxygen Sensors.

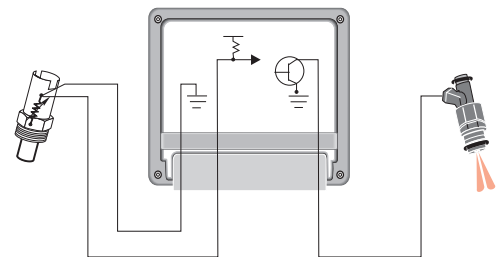
The Ignition Coil Relay (4th relay) is energized by the CAS Module which supplies operating voltage through a fuse (in the IVM) to the Ignition Coils.

The IVM receives high amperage voltage supply from fuses. This supply is for the consumers that are controlled by the IVM internal relays.

When **KL_15** is switched “OFF” the ECM operating voltage is removed. The CAS Module will maintain voltage to the Ignition Coil Relay for a few seconds to maintain ignition coil activation (Emission Optimized - introduced in 2000 MY).

Ground is required to complete the current path through the ECM. The ECM also:

- Internally links a constant ground (1) to the engine sensors.
- Switches ground (2) to activate components.



Battery Voltage

Battery Voltage is monitored by the ECM for fluctuations. It will adjust the output functions to compensate for a lower (6V) and higher (14V) voltage value. For example, the ECM will:

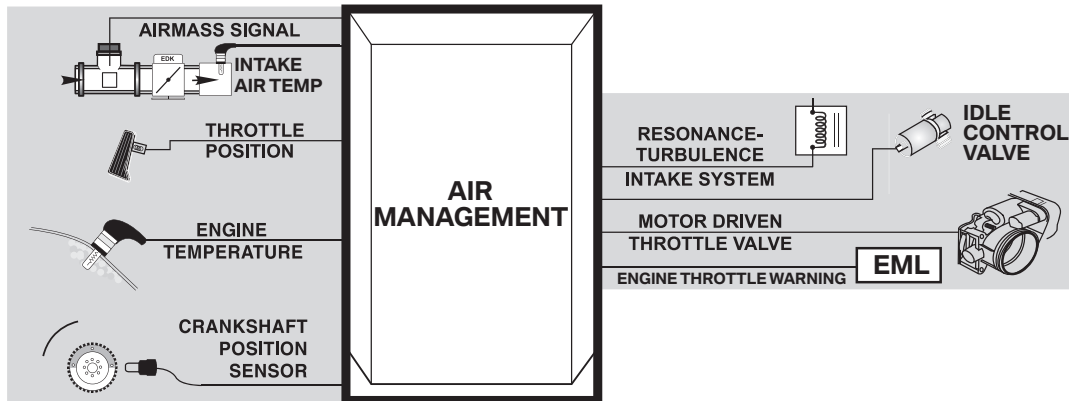
- **Modify pulse width duration of fuel injection**
- **Modify dwell time of ignition**

When **KL_15** is switched “ON” the ECM is ready for Engine Management. The ECM will activate ground to energize the Engine Control Module Relay. The Engine Control Module Relay supplies operating voltage to the ECM and the previously mentioned operating components. Five seconds after the ignition is switched on and the voltage at the KL_15 input is >9 volts, the ECM compares the voltage to the ECM Relay supplied voltage. If the voltage difference between the two terminals is greater than 3 volts, a fault code will be set.

When **KL_15** is switched “OFF” the ECM operating voltage is removed. The ECM will maintain a ground to the Engine Control Module Relay for a few seconds to maintain ignition coil activation (Emission Optimized) and as long as **three minutes to complete the DM-TL test.**

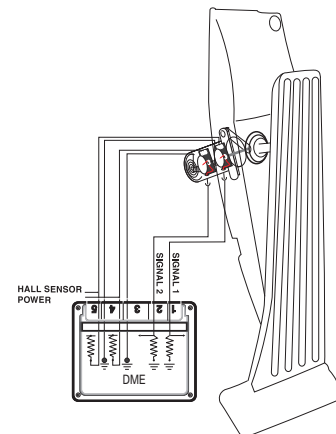
Air Management Overview

Example of IPO for an Air Management System



One of the main purposes of the ECM is Air Management which includes the actuation of several components. In the following pages you will find a generic explanation on how this system works. For more detailed information please access BMW Training Reference Manuals found online.

Air flow into the engine is regulated by the Throttle Valve and/or the Idle Air Actuator. Both of these air “passages” are necessary for smooth engine operation from idle to full load. The Throttle Valve and the Idle Air Actuator are **electrically controlled**. All of the ECM monitoring, processing and output functions are a result of regulated air flow.



Accelerator Pedal Position (Pedalwertgeber - PWG)

The Accelerator Pedal Position is monitored by the ECM for pedal angle position and rate of movement. As the accelerator is moved, it provides two variable voltage signals to the ECM that represents accelerator pedal position and rate of movement.

Dual Hall Sensors are integral in the accelerator pedal module. The ECM compares the two values for **plausibility**. The module contains internal springs to return the accelerator pedal to the rest position.

The ECM will increase the volume of fuel injected into the engine, advance the ignition timing and open the Throttle Valve and/or Idle Air Actuator.

The “full throttle” position indicates maximum acceleration to the ECM, and in addition to the functions just mentioned, this will have an effect on the air conditioning compressor.

As the accelerator pedal is released (integral springs), a decrease in voltage signals the ECM to activate fuel shut off if the RPM is above idle speed (coasting). When the Throttle Valve is completely closed, the Idle Air Actuator is opened to maintain engine idle speed.

The ECM monitors the engine idle speed in addition to the accelerator pedal position and throttle position voltage. If the voltage values have changed (mechanical wear of throttle plate or linkage), the ECM will adjust the Idle Air Actuator to maintain the correct idle speed.

The Potentiometers/Hall sensors are non-adjustable because the ECM “learns” the throttle angle voltage at idle speed. If the throttle housing/accelerator pedal module is replaced, the adaptations must be cleared and adaptation procedure must be performed using ISTA. If this is not performed, the vehicle will not start, or run in “fail-safe” mode.

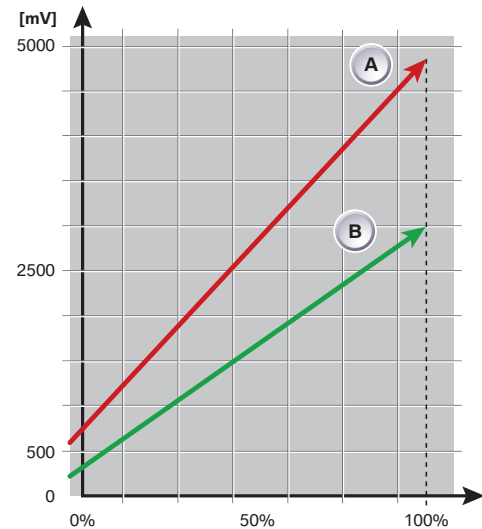
If this input is defective, a fault code will be stored and the “Malfunction Indicator and/or EML” Light will be illuminated. Limited engine operation will be possible.

The ECM provides voltage (5V) and ground for the Hall sensors. As the accelerator pedal is moved from rest to full throttle, the sensors produce a variable voltage signal.

- Hall sensor 1(request)
- Hall sensor 2 (plausibility)



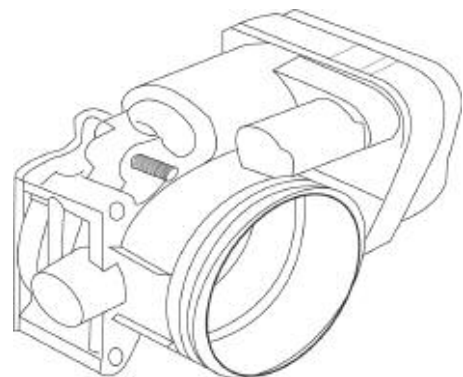
If the signals are not plausible, the ECM will use the lower of the two signals as the requested input. The throttle response will be slower and the maximum throttle response will be reduced.



Throttle Valve (EDK)

The throttle valve plate is electronically operated to regulate intake air flow by the ECM. The main characteristics are:

- Precision throttle operation,
- OBD compliant for fault monitoring,
- DSC and Cruise Control.



This integrated electronic throttle reduces extra control modules, wiring, and sensors. Adjusting electronic throttles is not permitted, the throttle assembly must be replaced as a unit. The adaptation values must be cleared and adaptation procedure must be performed using ISTA.

The throttle assembly for the system is referred to as the EDK:

- EDK does not contain a PWG, It is remotely mounted (integrated in the accelerator pedal assembly).
- The accelerator pedal is not mechanically “linked” to the EDK.

Throttle Motor and Feedback Position

The ECM powers the EDK motor using pulse width modulation (PWM) for opening and closing the throttle plate. The throttle plate is also closed by an integrated return spring.

Two integrated potentiometers provide voltage feedback signals to the ECM as the throttle plate is opened and closed.

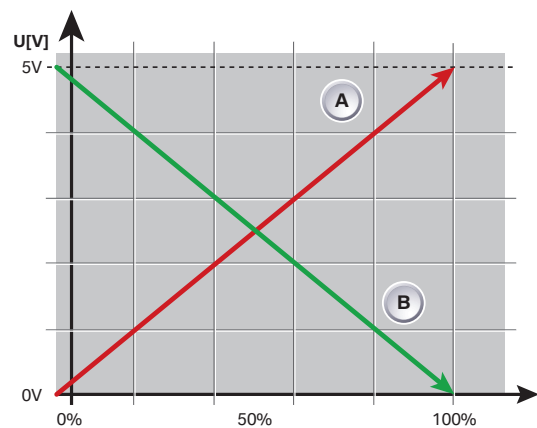
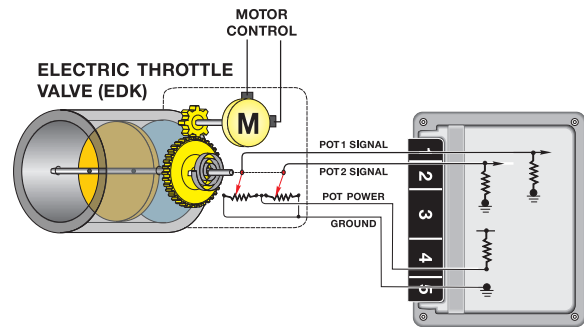
- **Feedback signal 1** provides a signal from 0.5V (closed) to 4.5 V (Full Throttle)
- **Feedback signal 2** provides a signal from 4.5V (closed) to 0.5V (Full Throttle)

Potentiometer 1 is the **primary feedback** signal of throttle plate position and signal 2 is the **plausibility cross check** through the complete throttle plate movement.

Total Intake Air Flow Control is performed by the ECM simultaneously operating the EDK throttle control and the Idle Air Actuator.

The ECM detects the driver’s request from the potentiometers/Hall Sensors monitoring the accelerator pedal position. This value is added to the Idle Air control value and the total is what the ECM uses for EDK activation. The ECM then controls the Idle Air Actuator to satisfy the idle air “fill”. In addition, the EDK will also be activated = pre-control idle air charge. Both of these functions are utilized to maintain idle RPM.

The EDK is electrically held at the idle speed position, and all of the intake air is drawn through the Idle Air Actuator. Without a load on the engine (<15%), the EDK will not open until the extreme upper RPM range. If the engine is under load (>15%), the Idle Air Actuator is open and the EDK will also open.





Failsafe Operation - EDK

When a fault is detected in the system:

- The EDK provides two separate signals from two integrated potentiometers (Pot 1 and Pot 2) representing the exact position of the throttle plate.
- EDK Pot 1 provides the primary throttle plate position feedback. As a redundant safety feature, Pot 2 is continuously cross checked with Pot 1 for signal plausibility.
- If plausibility errors are detected between Pot 1 and Pot 2, the ECM will calculate the inducted engine air mass (from HFM signal) and only utilize the potentiometer signal that closely matches the detected intake air mass.
 - The ECM uses the air mass signaling as a “virtual potentiometer” (Pot 3) for a comparative source to provide failsafe operation.
 - If the ECM cannot calculate a plausible conclusion from the monitored Pots (1 or 2 and virtual 3) the EDK motor is switched off and fuel injection cut out is activated (Failsafe operation is not possible).
- The EDK is continuously monitored during all phases of engine operation. It is also briefly activated/adapted when KL_15 is initially switched on as a “preflight check” to verify it’s mechanical integrity (no binding, appropriate return spring tension, etc). This is accomplished by monitoring both the motor control amperage and the reaction speed of the EDK feedback potentiometers. If faults are detected the EDK motor is switched off and the fuel injection cut off is activated (failsafe operation is not possible). The engine does however continue to run extremely rough at idle speed.
- When in emergency operation, the engine speed is always limited to 1300 RPM by fuel injector cutout, and activation of the “EML” light to alert the driver of a fault.
- When a replacement EDK is installed, the ECM adapts to the new component (required amperage draw for motor control, feedback pot tolerance difference, etc). This occurs immediately after the next cycle of KL_15 for approximately 30 seconds. During this period of adaptation, the maximum opening of the throttle plate is 25%.

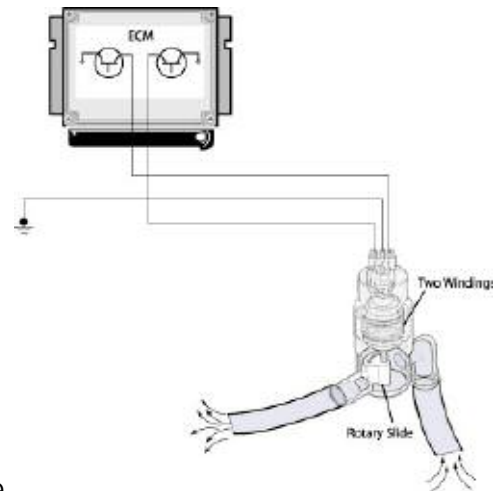
Idle Air Actuator

This valve regulates air by-passing the throttle valve to control the engine idle/low speed.

The valve is supplied with battery voltage from the ECM Relay. The Idle Air Actuator is a two-coil rotary actuator. The ECM is equipped with two final stage transistors which will alternate positioning of the actuator.

The final stages are "pulsed" simultaneously by the ECM which provides ground paths for the actuator. The duty cycle of each circuit is varied to achieve the required idle RPM.

If this component/circuits are defective, a fault code will be set and the "Malfunction Indicator Light" will be illuminated when the OBD II criteria is achieved.



Failsafe Operation - Idle Air Actuator

If a fault is detected with the Idle Air Actuator, the ECM will initiate failsafe measures depending on the effect of the fault (increased air flow or decreased air flow). If there is a fault in the Idle Air Actuator/circuit, the EDK will compensate to maintain idle speed. The "Malfunction Indicator and/or EML" Light will be illuminated to inform the driver of a fault.

If the fault causes increased air flow (actuator failed open), VANOS and Knock Control are deactivated which noticeably reduces engine performance.

Hot-Film Air Mass Meter (HFM)

The air volume input signal is produced electronically by the HFM which uses a heated metal film (180°C above intake air temperature) in the air flow stream.

The ECM Relay provides the operating voltage. As air flows through the HFM, the film is cooled changing the resistance which affects current flow through the circuit. The sensor produces a 1-5 volt varying signal. Based on this change the ECM monitors and regulates the amount of injected fuel.

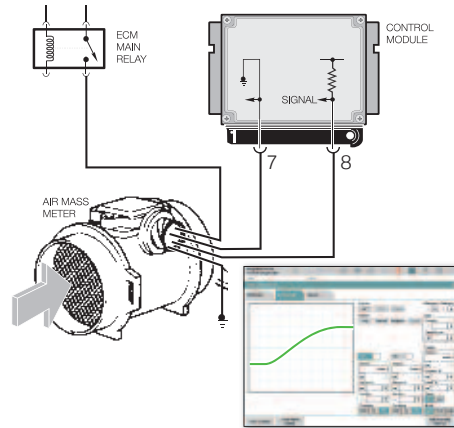
The Hot-Film Air Mass Meter (HFM) varies voltage monitored by the ECM representing the measured amount of intake air volume. This input is used by the ECM to determine the amount of fuel to be injected.

The heated surface of the hot-film in the intake air stream is regulated by the ECM to a constant temperature of 180°C above intake air temperature. The incoming air cools the film and the ECM monitors the changing resistance which affects current flow through the circuit. The hot-film does not require a “clean burn”, it is self cleaning due to the high operating temperature for normal operation.



If this input is defective, a fault code will be set and the “Malfunction Indicator Light” will illuminate when the OBD II criteria is achieved. The ECM will maintain engine operation based on the Throttle Position Sensors and Crankshaft Position/Engine Speed Sensor.

The HFM is non-adjustable.



Air Temperature Signal

The HFM contains an integral air temperature sensor. This is a Negative Temperature Coefficient (NTC) type sensor. This signal is required by the ECM to correct the air volume input for changes in the intake air temperature (air density) affecting the amount of fuel injected, ignition timing and Secondary Air Injection activation.

The ECM provides the power supply to the sensor which decreases in resistance as the temperature rises and vice versa. The ECM monitors an applied voltage to the sensor that will vary as air temperature changes the resistance value.



If this input is defective, a fault code will be set and the “Malfunction Indicator Light” will be illuminated when the OBD II criteria is achieved. The ECM will operate the engine using the Engine Coolant Sensor input as a back up.

The Air Temperature signal allows the ECM to make a calculation of intake air temperature. The varying voltage input from the NTC sensor indicates the larger proportion of oxygen found in cold air, as compared to less oxygen found in warmer air. The ECM will adjust the amount of injected fuel because the quality of combustion depends on oxygen sensing ratio.

The ignition timing is also affected by air temperature. If the intake air is hot the ECM retards the base ignition timing to reduce the risk of detonation. If the intake air is cooler, the base ignition timing will be advanced. The ECM uses this input as a determining factor for Secondary Air Injection activation.



If this input is defective, a fault code will be set and the “Malfunction Indicator Light” will illuminate when the OBD II criteria is achieved. The ECM will maintain engine operation based on the HFM and Engine Coolant Temperature sensor.

Variable Intake Manifold (DISA)

The intake manifold on the N52 uses a three stage differential intake air system (**DISA**). The air flow through the intake manifold is controlled and re-directed by two DISA actuator motors.

Each actuator motor is operated by an electric motor controlled by the Engine Control Module (ECM) via a PWM signal. The PWM signal is at a frequency of 200 Hz. The ECM varies the duty cycle to control the position of the DISA flap. The actuator consists of a flap and motor drive. **There are only two positions possible - closed or opened.** When activated, the motor moves the flap to each end position. Both actuators are switched to the closed position at idle.



The DISA motors are similar in design and operation, but they are not interchangeable. Each actuator assembly has its own individual part number.

DISA Operation

■ 1st stage - idling/lower engine speed range

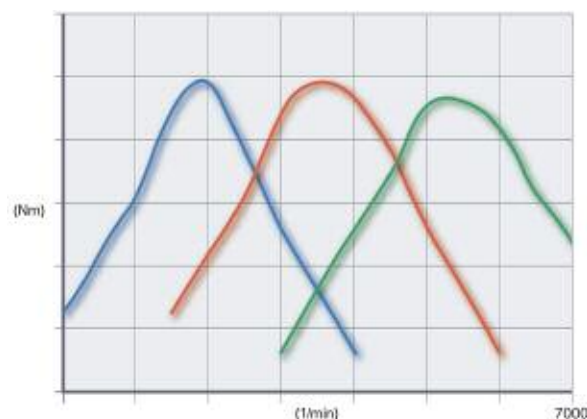
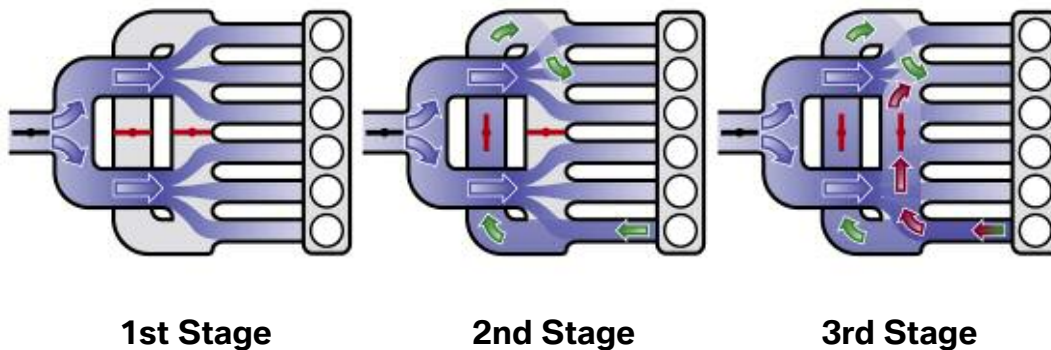
At idle speed and in the lower engine speed range, actuators 1 and 2 are closed. The intake air flows past the throttle valve into the resonance pipe. In the resonance pipe, the intake air mass splits. The air is fed via the collector pipe and resonating pipes into the individual cylinders. In this way, three cylinders are provided with a comparably high air mass.

■ 2nd stage - medium engine speed range

In the medium engine speed range, DISA actuator motor 2 is opened. In this case, it is assumed that the inlet valves of the first cylinder are just closing. The gas motion creates a pressure peak at the closing inlet valves. This pressure peak is passed on via the resonating and collector pipes to the next cylinder in the firing order. This improves the fresh gas filling of the next cylinder to be filled.

■ 3rd stage - upper engine speed range

In the upper engine speed range, both DISA actuator motors are opened. In this case, it is assumed that the inlet valves of the first cylinder are just closing. The gas motion creates a pressure peak in front of the closing inlet valves. The intake air mass is now fed via the resonating, overshoot and collector pipes.

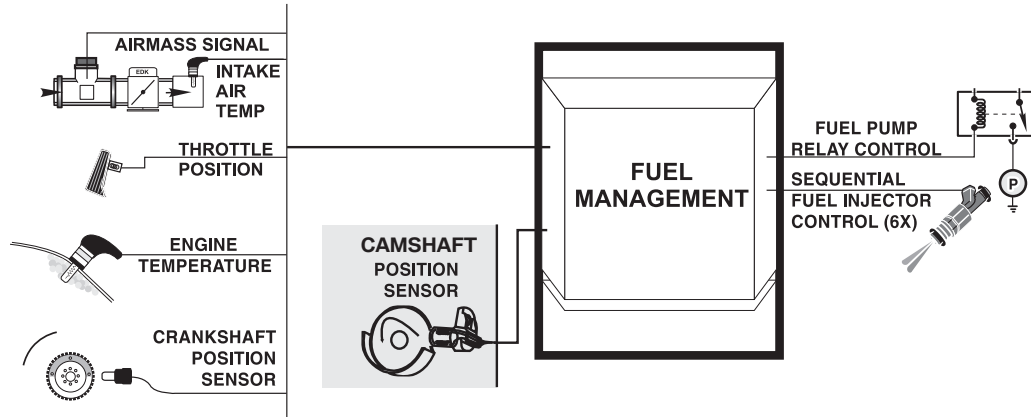


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Fuel Management Overview

Example of IPO for a Fuel Management System



One of the main purposes of the ECM is Fuel Management which includes the actuation of several components. In the following pages you will find a generic explanation on how this system works. For more detailed information please access BMW Training Reference Manuals found online.

Fuel Delivery Unit

The fuel delivery unit is located inside the fuel tank. It consists of the following:

In the right half of the fuel tank

Fuel baffle with electric fuel pump (EKP), right fuel level sensor and right suction jet pump.

In the left half of the fuel tank

Fuel filter with pressure regulator, left fuel level sensor and left suction jet pump.

The components are firmly connected to the respective service cover. When replacing the electric fuel pump, it can be removed from the fuel tank complete with the service cover, fuel baffle, suction jet pump and fuel level sensor.

Fuel Supply

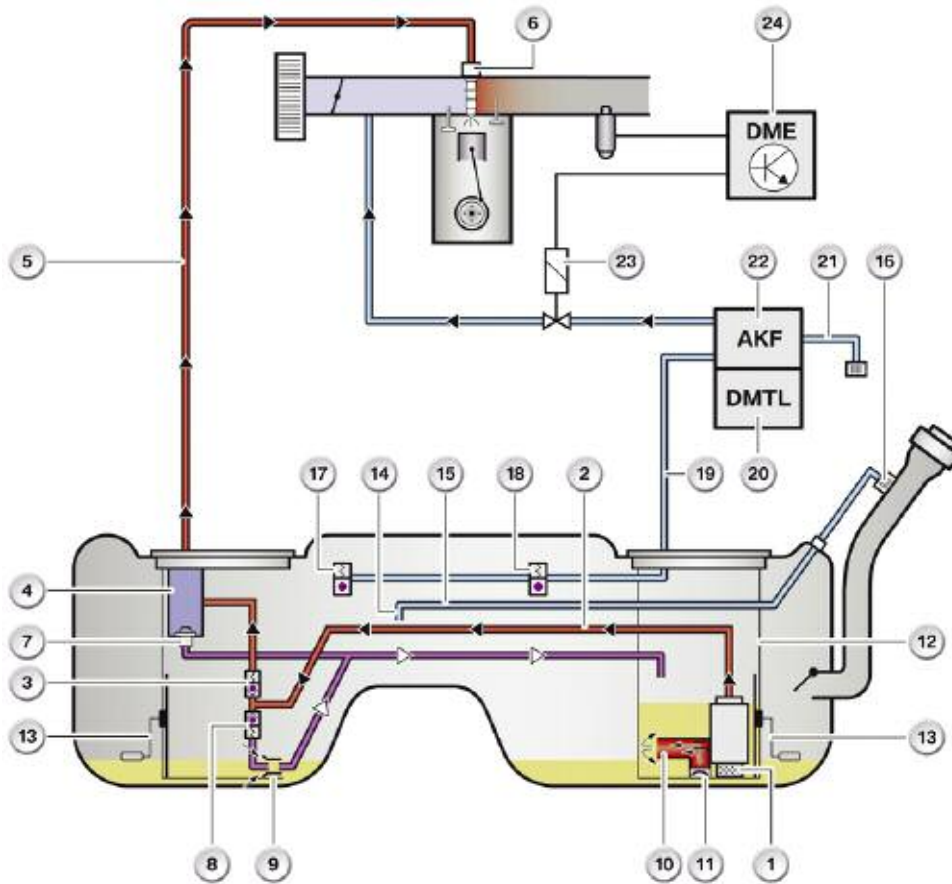
The fuel is delivered from the fuel tank to the engine in the following sequence:

- From the right half of the fuel tank;
- through the initial filler valve (11);
- into the fuel baffle (12);
- from the electric fuel pump (1);
- via a T-piece, on the one side, through the check valve (3) into the fuel filter (4);
- through the feed line (5) in the left-hand service opening to the engine;
- and, on the other side, via the check valve (8) to the left-hand suction jet pump (9) back into the fuel baffle;
- parallel from the electric fuel pump to the right-hand suction jet pump (10);
- and from the right half of the fuel tank into the fuel baffle.

The fuel filter (4) and pressure regulator (7) are located at the left-hand service opening. The check valve (8) opens at a fuel pressure above 2.5 bar. It ensures the engine receives sufficient fuel before the left suction jet pump cuts into the circuit.

As an example, on the N52 engine the pressure regulator (7) routes the fuel back into the fuel baffle (12). A 5 bar pressure regulator is used for vehicles with the N52 engine.

N52 Fuel Supply



Index	Explanation	Index	Explanation
1	Electric Fuel Pump	13	Fuel Level Sensor
2	Feed Line	14	Refuelling Line Connection Piece
3	Check Valve	15	Refuelling Ventilation Line
4	Fuel Filter	16	Refuelling Ventilation
5	Feed Line to Engine	17	Left Operation Ventilation Valve
6	Fuel Injector	18	Right Operation Ventilation Valve
7	Pressure Regulator	19	Operation Ventilation Line
8	Check Valve	20	Diagnosis Module for Tank Leakage (DM-TL)
9	Left Suction Jet Pump	21	Atmosphere Line
10	Right Suction Jet Pump	22	Carbon Canister
11	Initial Filling Valve	23	Fuel Tank Vent Valve
12	Fuel Baffle	24	Digital Motor Electronics

Electric Fuel Pump

The electric fuel pump delivers fuel simultaneously through two separate circuits into a main channel and a secondary channel.

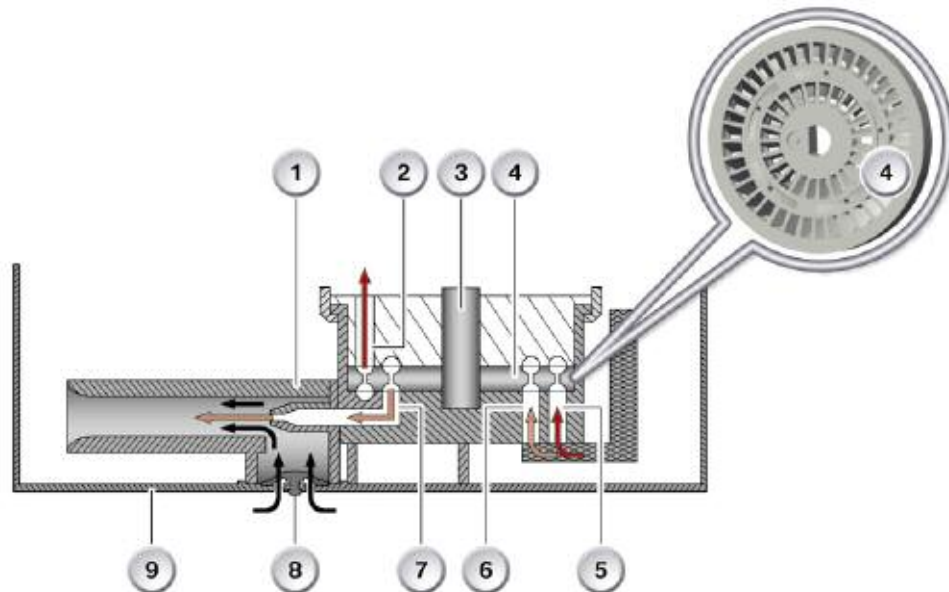
The main channel is used for conveying fuel to the fuel supply system. The secondary channel supplies the right hand suction jet pump with fuel.

Channels are located above the pump wheel, in which a helical flow circulation is produced by the position of the delivery blades.

The fuel is thus conveyed from the intake side to the outlet side. An electric fuel pump with increased output is used and has a maximum pressure of 5bar (N52, N54, N55, N63, N74).



On Engines with Direct Injection (N54, N55, N63, N73 and N74), this low fuel pressure pump feeds the high fuel pressure pump(s) with maximum pressures typically between 50 and 200bar.

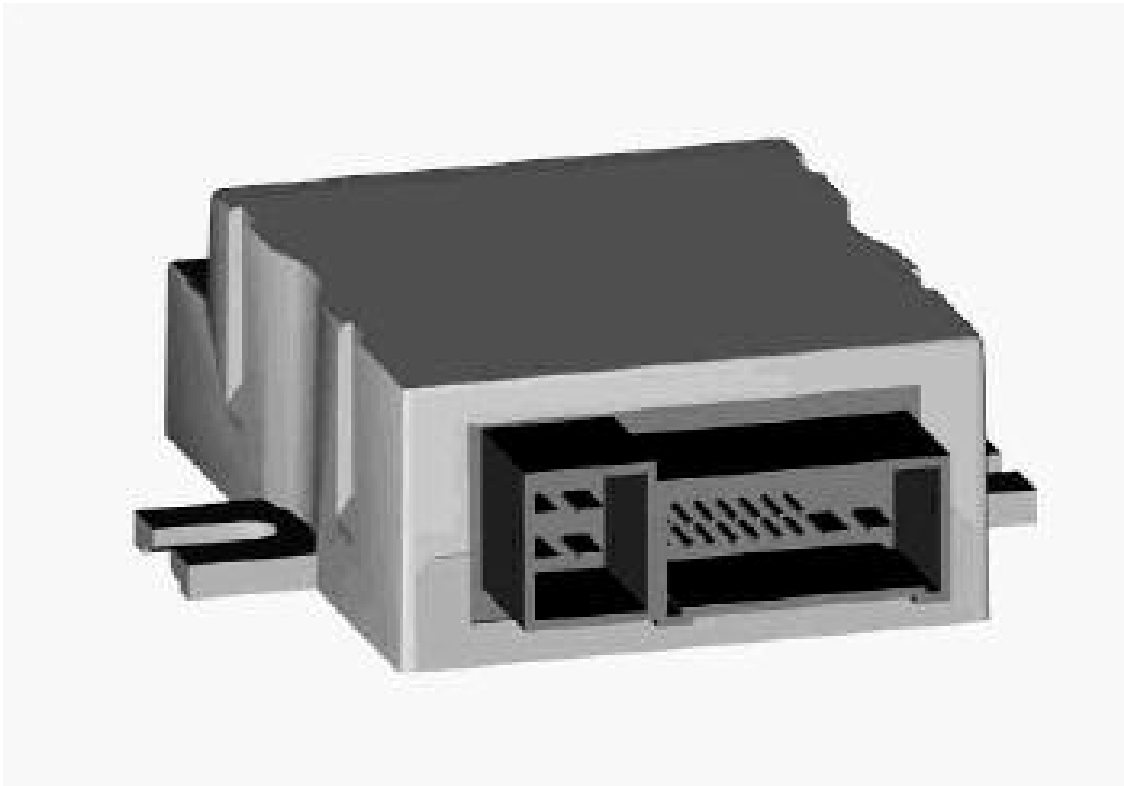


Index	Explanation	Index	Explanation
1	Suction jet pump	6	Intake opening, secondary channel
2	Main channel in supply	7	Secondary channel to suction jet pump
3	Driveshaft from electric motor	8	Initial filling valve
4	Impeller	9	Fuel baffle
5	Intake opening, main channel		

Fuel Pump Control

In conventional systems, the electric fuel pump is operated continuously at maximum speed using the highest on-board supply voltage available. The maximum amount of fuel that may be required is made available regardless of the operating conditions.

The fuel pump control is managed by the EKP module. The fuel pump is a variable speed controlled unit which means the EKP module only supplies the required fuel for engine operation thus eliminating excess fuel delivery. This arrangement also reduces pump wear and running losses are kept to a minimum.



In this case, EKP stands for the "Electronic fuel pump control" system. The EKP abbreviation is often used to refer to the electric fuel pump itself. The electronically controlled fuel pump system described here is controlled by a control unit called the EKP control unit. The abbreviation EKP is used here to refer to the system as a whole.

Principle of Operation

Fuel Management delivers fuel from the tank to the intake ports of the engine. To accomplish this, fuel supply must be available to the fuel injectors. Then the fuel must be injected in the precise amount and at the correct time. The ECM does not directly monitor fuel supply, although it does control it. The ECM controls and monitors fuel injection.

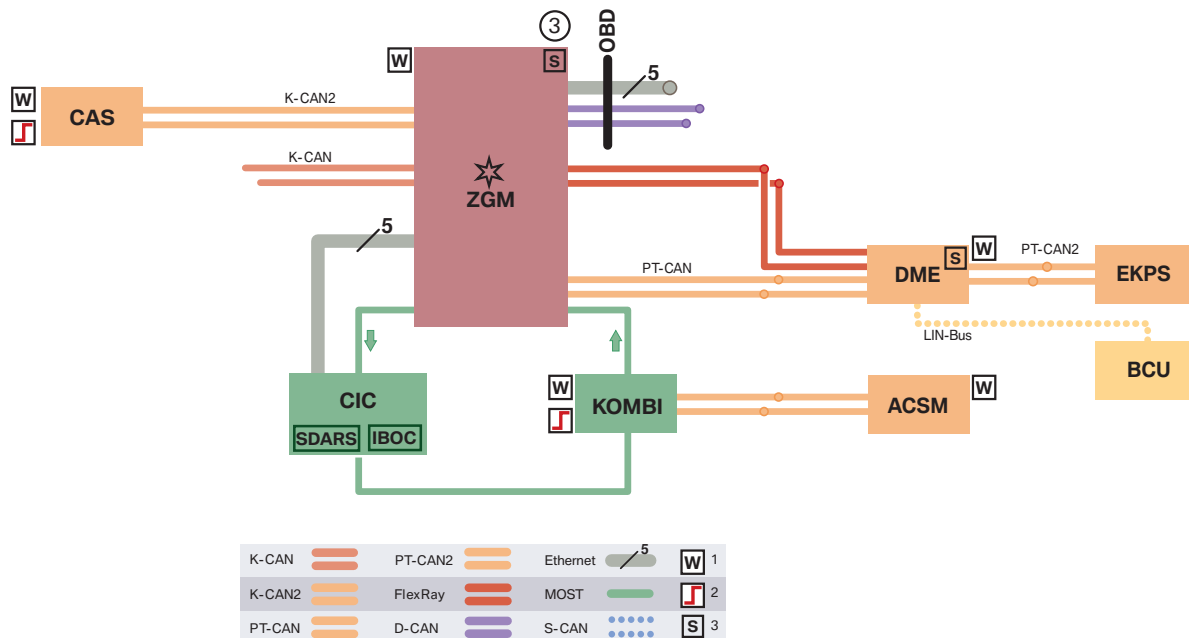
The ECM (DME) is connected to the EKP module via the PT-CAN network via a pulse width modulated (PWM) signal according to the fuel quantity required by the ECM. The electric fuel pump in the EKP system is activated as required. The DME calculates the amount of fuel required at the given point in time. The total volume required is transmitted as a message to the EKP control unit via PT-CAN.

The EKP control unit controls the electric fuel pump on the basis of mappings so that the electric fuel pump delivers the exact amount of fuel required.

The EKP control unit converts this message into an output voltage. This output voltage is then used to control the speed of the electric fuel pump. This achieves a delivery which corresponds with the requirements.

The illustrations shown below are from an E90 and an F10. The EKP module on the E90 contains one of the terminating resistors for the PT-CAN.

F10 Fuel Requirement Signal Path



Fuel requirement mappings are stored in the EKP control unit. The fuel requirement mappings are encoded for each specific engine and model. The EKP control unit uses the mappings as the basis on which to calculate the total amount of fuel to be delivered from the following variable:

- Amount of fuel required by the engine (request from the ECM). This results in a pulse-width modulated output voltage from the EKP control unit. The output voltage of the EKP control unit is the supply voltage for the electric fuel pump. The EKP control unit controls the speed of the electric fuel pump via the supply voltage. The EKP control unit controls the speed by comparing the actual speed with the specification.

The current speed of the electric fuel pump is calculated as follows:

The EKP control unit sends the current supply to the fuel pump (pulse-width modulated). This voltage is absorbed as a specific ripple due to the individual armature windings of the rotating electric motor. The ripple corresponds with the number of segments in the commutator which corresponds with the number of armature windings in the electric motor.

The number of waves produced per revolution is equal to the number of existing commutator segments.

This means that the EKP control unit can employ a patented procedure - "Ripple Counter" as the basis for calculating the actual speed of the fuel pump using power consumption ripple.

Coding and Programming

The data for the electronically controlled fuel pump system is encoded as follows:

- In the ECM (DME), the engine and model-related characteristic curves for fuel delivery according to requirements.
- In the EKP control unit: specific characteristic curves for the relevant fuel system



Failsafe Operation

If the fuel quantity requirement from the ECM and/or the EKP rotation speed signal fails, the fuel pump will continue to operate with the greatest delivery rate (100%) when terminal KL_15 is activated. This guarantees fuel supply even if the control signals fail.

Fuel Injectors/Fuel Rail

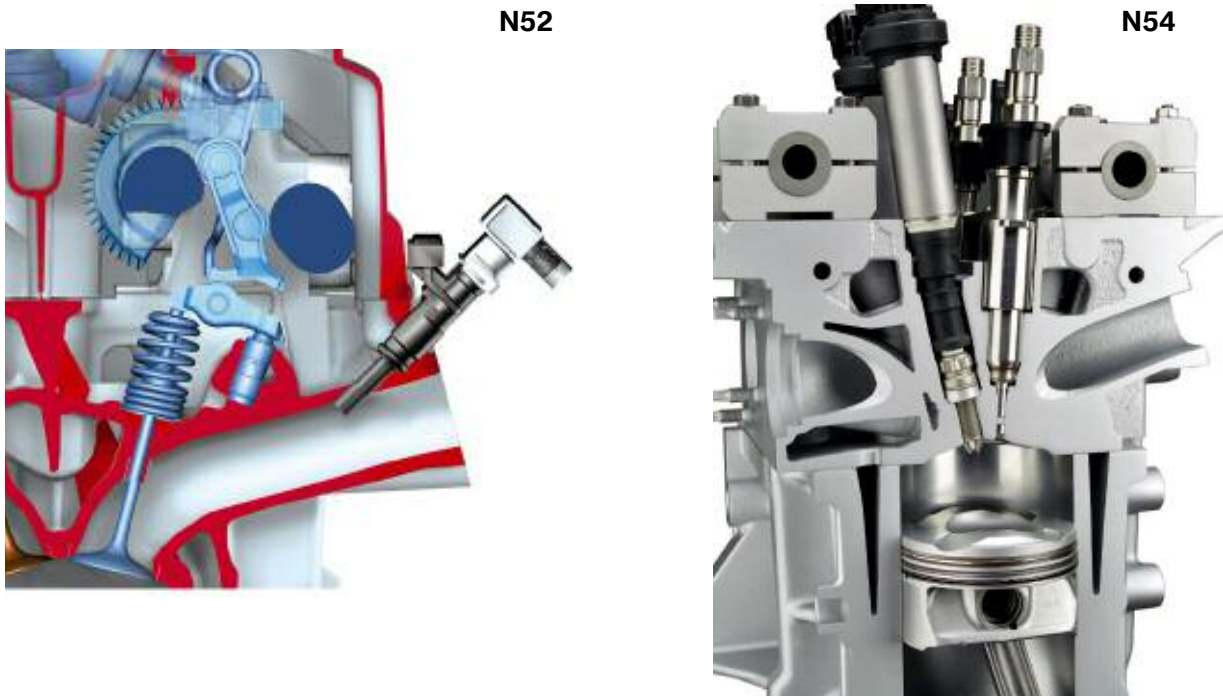
The type of fuel injector depends on the engine design. BMW for the most part utilizes two different configurations:

- Injectors mounted into the cylinder head spraying fuel into the intake port and;
- Injectors mounted into the cylinder head spraying fuel directly into the combustion chamber, also known as **Direct Injection**.

Furthermore, BMW uses two different types of injectors:

- Solenoid Injector (in low and high pressure systems)
- Piezo Injector (only used in high pressure systems)

In Normally Aspirated (NA) engines like the N52, due to the wider design of the cylinder head, the fuel injectors are not located in the intake manifold as on previous 6-cylinder engines. This is why, as mentioned earlier, the injectors are now mounted into machined bore in the cylinder head. This design allows the injectors to be closely mounted to the intake valves.



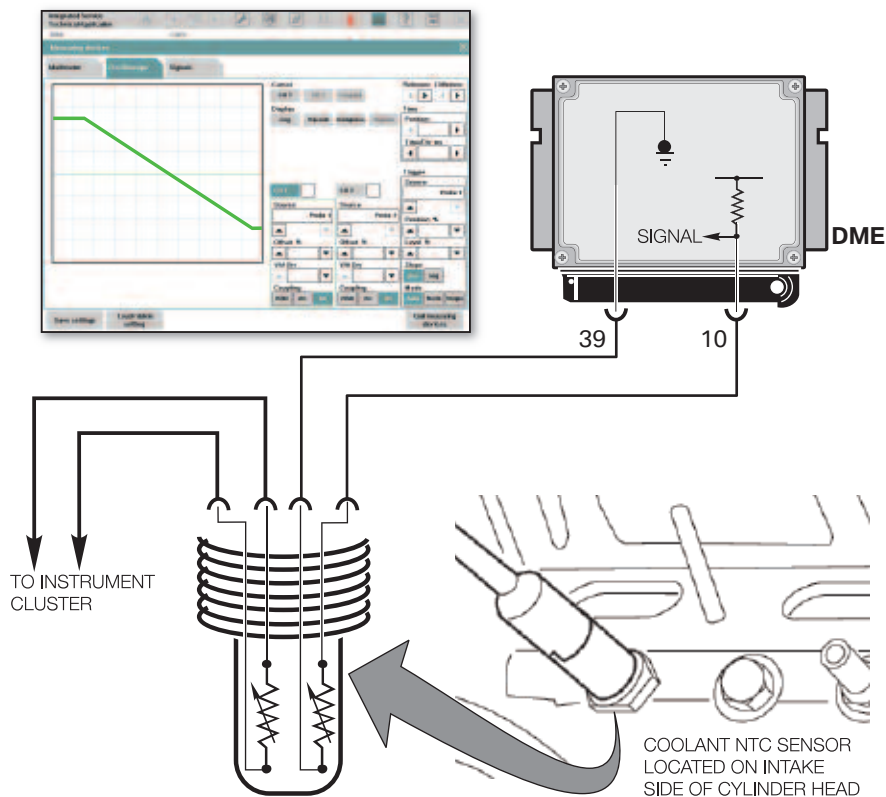
Power supply for the fuel injectors is from Terminal KL_87 of the fuel injector relay.

The fuel rail is a non-return design which includes a service port for diagnosis.

Engine Coolant Temperature

The Engine Coolant Temperature is provided to the ECM from an NTC type sensor located in the coolant jacket of the cylinder head. The sensor contains two NTC elements, the other sensor is used for the instrument cluster temperature gauge.

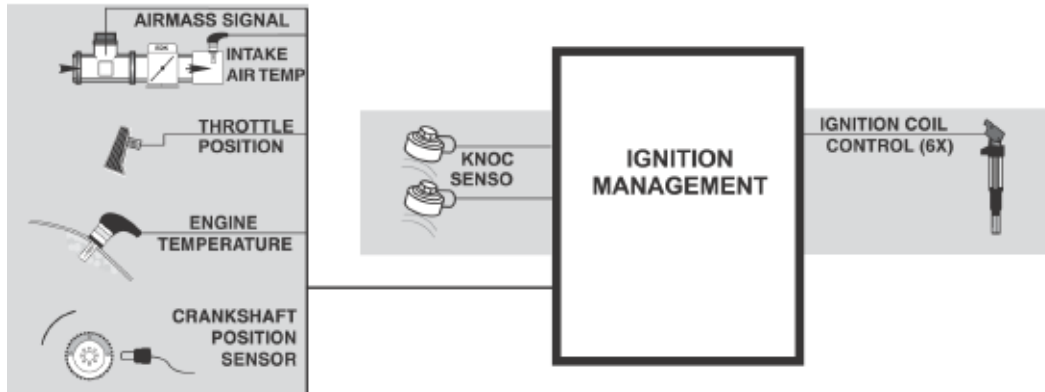
The ECM determines the correct air/fuel mixture required for the engine temperature by monitoring an applied voltage to the sensor (5V). This voltage will vary (0-5V) as coolant temperature changes the resistance value.



If the Coolant Temperature sensor input is faulty, a fault code will be set and the ECM will assume a substitute value (80°C) to maintain engine operation.

Ignition Management Overview

Example of IPO for an Ignition Management System



One of the main purposes of the ECM is Ignition Management which includes the actuation of several components. In the following pages you will find a generic explanation on how this system works. For more detailed information please access BMW Training Reference Manuals found on-line.

Ignition System Inputs

The ignition system on the engine management system uses several inputs to control ignition functions. Proper ignition timing control is dependent upon inputs such as RPM, throttle position, crankshaft position, air mass and temperature (coolant and intake air) and in our turbocharged engines, intake boost pressure.

Ignition Coils

The ignition coils are the familiar “pencil” type. The secondary ignition “boot” and resistor are integrated into the coil housing.



Spark Plugs

The spark plugs used on BMW Engines are designed by NGK. The plugs use an Iridium center electrode. The center electrode is only 0.6 mm thick. The insulator is also redesigned. The new spark plug technology allows for longer service life and improved cold starting.



Iridium is a precious metal that is 6 times harder and 8 times stronger than platinum, it has a 1,200° F higher melting point than platinum and conducts electricity better.



Crankshaft Position/RPM Sensor (Hall Effect)

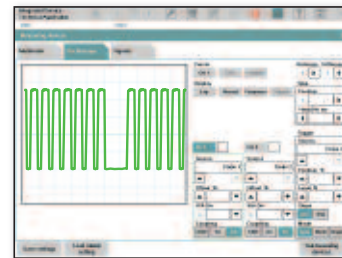
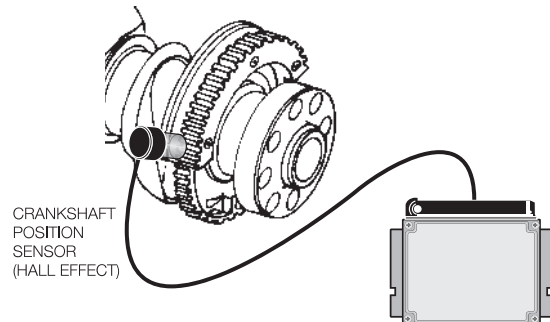
A Hall Sensor provides the crankshaft position and engine speed (RPM) signal to the ECM for fuel pump and Injector operation.

The Hall sensor is supplied with voltage from the ECM. A digital square wave signal is produced by the sensor as the teeth of the impulse wheel pass by. The “gap” allows the ECM to establish crankshaft position.



The crankshaft position sensor is monitored as part of OBD II requirements for Misfire Detection. If this input is faulty, the ECM will operate the engine (limited driveability) from the Camshaft Sensor input. A fault with this input will produce the following complaints:

- Hard Starting/Long Crank Time
- “Malfunction Indicator Light”
- Driveability/Misfire/Engine Stalling



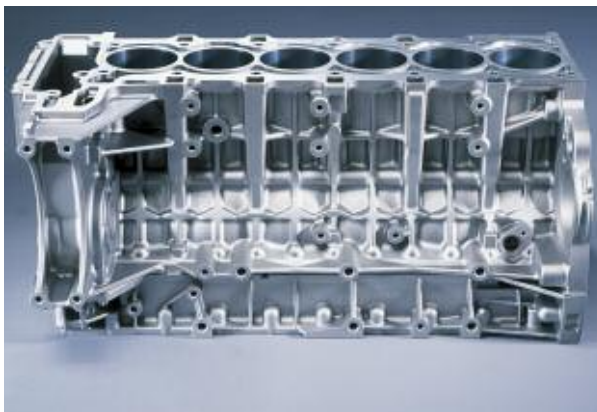
SMOOTH RUNNING ENGINE
(NOTE SQUARE WAVE SIGNAL)

Description of Operation

The crankshaft position sensor provides the ECM with a 5 volt square wave signal. The ECM calculates engine speed (RPM) and crankshaft position for ignition and injection system operation.

The sensor is supplied with 12 volts from the engine electronics fuses and ground from the ECM.

The crankshaft position sensor is also monitored for variations in crankshaft speed to determine misfires.



Intake and Exhaust Camshaft Sensors

"Static" Hall sensors are used so that the camshaft positions are recognized once ignition is on (KL_15) before the engine is started. The main functions of the intake cam sensor are:

- Cylinder "work cycle" for injection timing;
- Synchronization;
- Engine speed sensor (if crankshaft speed sensor fails);
- VANOS position control of the intake cam.



If these sensors fail there are no substitute values, the system will operate in the failsafe mode with no VANOS adjustment. The engine will still operate, but torque reduction will be noticeable. Use caution on repairs as not to bend the impulse wheels.

The two camshaft sensors are mounted into the cylinder head and monitor the impulse wheels which are bolted to the front of the VANOS units.



Camshaft Sensor



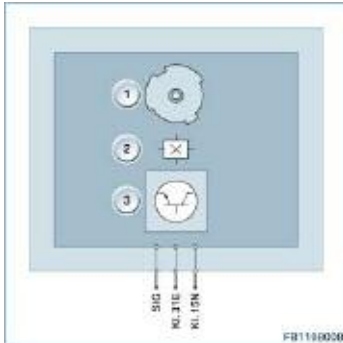
Camshaft Sensor Trigger Wheel



Power is supplied to the sensors via the engine electronics fuses. Ground is supplied via the ECM. The sensors are hall effect and provide the ECM with a 5V square wave signal.

The two camshaft sensors, one for the intake camshaft and one for the exhaust. They are mounted at the front of the cylinder head and monitor the impulse wheels which are bolted to the front of the VANOS units. These sensors are required for the camshaft-feedback signal to adjust the intake and exhaust camshaft (VANOS).

The sensors are supplied power via the engine electronics fuses. Ground is supplied via the ECM. The sensors are **hall effect** and provide the ECM with a **5 volt** square wave signal.



Index	Explanation
1	Camshaft sensor wheel
2	Hall effect sensor
3	Evaluation electronics

The camshaft sensor operates in accordance with the Hall principle and it is used for detecting the camshaft position. A camshaft sensor wheel is mounted on the camshaft for this purpose.

Intake Camshaft Sensor

The sensor for the intake camshaft has the following tasks:

- Detection of the camshaft allocation with respect to the crankshaft (cylinder compression cycle or cylinder charge cycle).
- Positioning the camshaft with respect to the crankshaft for VANOS adjustment.

With the aid of the sensor, the ECM can determine the position of the intake camshaft with respect to the crankshaft and adjust the camshaft with the aid of VANOS corresponding to ECM requirements.

Exhaust Camshaft Sensor

An exhaust camshaft sensor is also used. With the aid of the sensor, the ECM can determine the position of the exhaust camshaft with respect to the crankshaft and adjust the camshaft with the aid of VANOS corresponding to ECM requirements.

■ Description of operation

To perform the adjustment, the variable camshaft timing control requires a feedback signal on the current position of the camshaft. Camshaft sensors on the intake and exhaust side record the position of the camshafts.

The exhaust camshaft sensor is designed as an inductive hall effect sensor. The camshaft sensor wheel has 6 different flank spacings. The flank spacings are detected by the hall effect sensor.

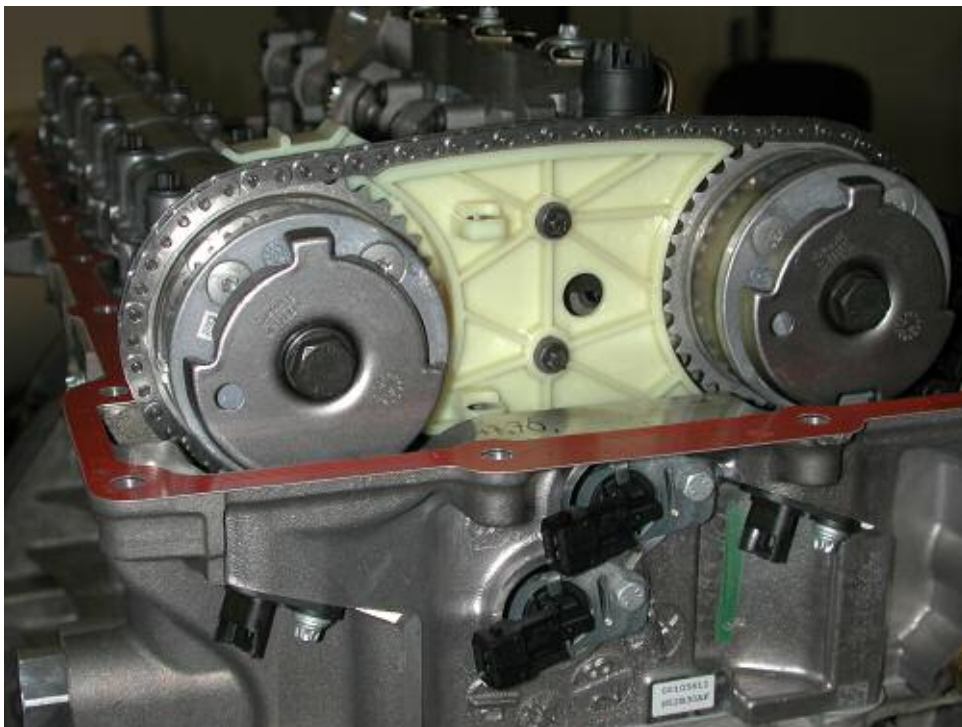
The engine control system uses these to calculate the following:

- Camshaft speed
- Camshaft speed
- Exact position of the camshaft

VANOS Overview

Performance, torque, idle characteristics and exhaust emissions reduction are improved by Variable Camshaft Timing. The VANOS system on the N52 is weight optimized and is similar in design to the VANOS on the N62.

The Vanos units are mounted directly on the front of the camshafts and adjusts the timing of the Intake and Exhaust camshafts throughout the entire spread range from retarded to advanced. The ECM controls the operation of the VANOS solenoids which regulates the oil pressure required to move the VANOS units. Engine Rpm, load and temperature are used to determine VANOS activation.

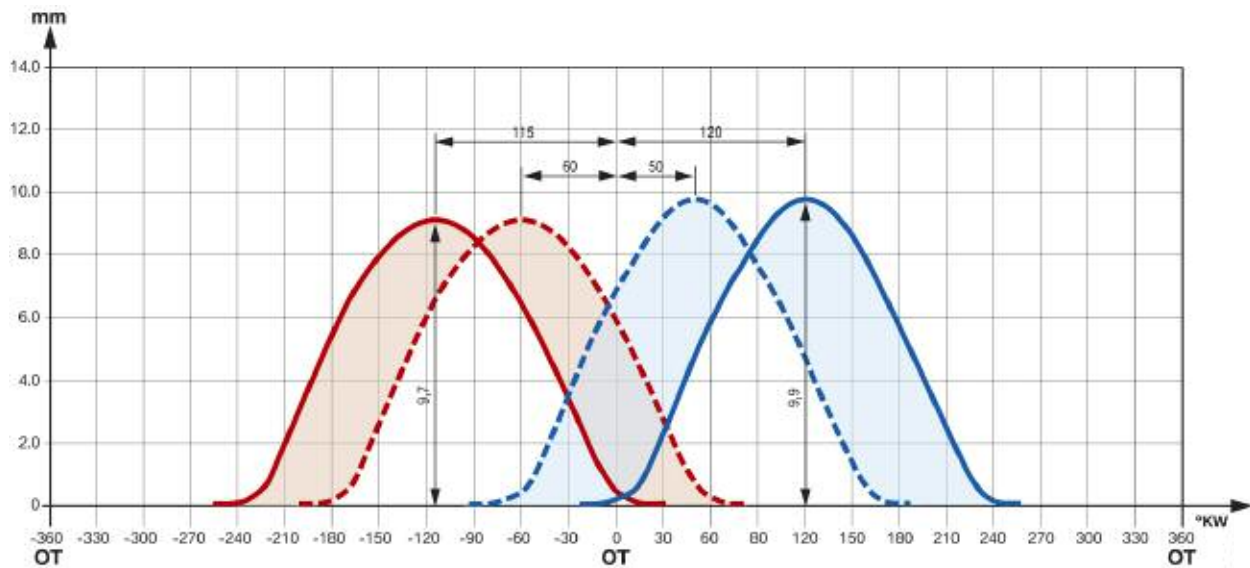


The VANOS mechanical operation is dependent on engine oil pressure applied to position the VANOS units. When oil pressure is applied to the units (via ports in the camshafts regulated by the solenoids), the camshaft hubs are rotated in the drive sprockets changing the position which advances/retards the intake/exhaust camshafts timing. The VANOS system is “fully variable”. When the ECM detects that the camshafts are in the optimum positions, the solenoids maintain oil pressure on the units to hold the camshaft timing.

The operation of the VANOS solenoids are monitored in accordance with the OBD II requirements for emission control. The ECM monitors the final stage output control and the signals from the Camshaft Position Sensors for VANOS operation.

Note: Currently all BMW engines feature Double VANOS.

N55 valve timing diagram



		N54B3000	N55B30M0
Intake valve Ø	[mm]	31.4	32
Exhaust valve Ø	[mm]	28	28
Maximum valve lift, intake valve/exhaust valve	[mm]	9.7/9.7	9.9/9.7
Intake camshaft spread (VANOS adjustment range)	[°crankshaft]	55	70
Exhaust camshaft spread (VANOS adjustment range)	[°crankshaft]	45	55
Intake camshaft opening angle (max.-min. spread)	[°crankshaft]	125 - 70	120 - 50
Exhaust camshaft opening angle (max.-min. spread)	[°crankshaft]	130 - 85	115 - 60
Opening period intake camshaft	[°crankshaft]	245	255
Opening period exhaust camshaft	[°crankshaft]	261	261

Note: The N55 has a larger intake and exhaust VANOS adjustment range as well as larger intake valve lift, and cam duration than the N54 engine.

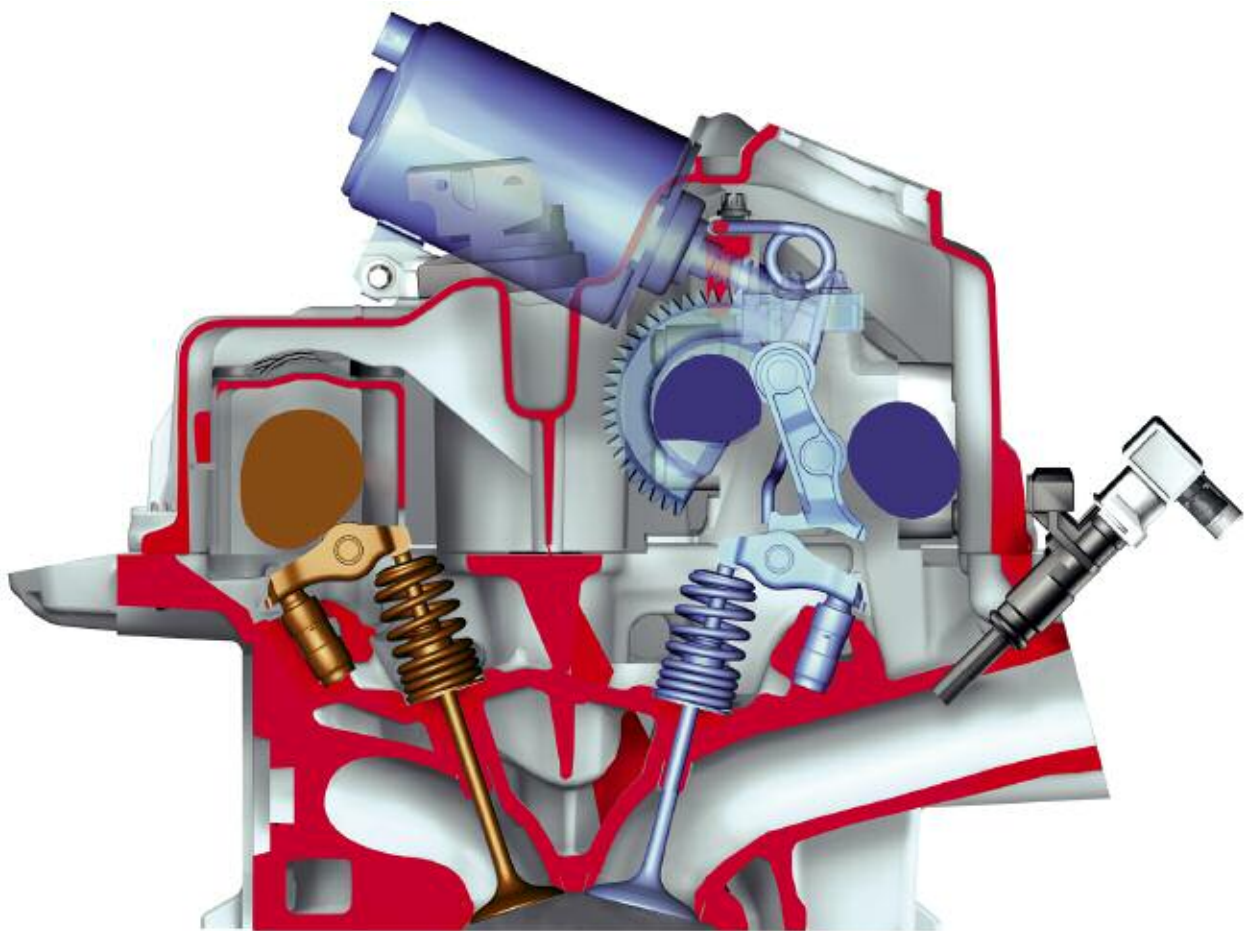
VALVETRONIC Overview

Since the introduction of the N52, the 6-cylinder engine is now also equipped with the load control system based on the valve timing gear. The VALVETRONIC I system that was used on the 8 and 12-cylinder engines already achieved a substantial increase in efficiency.

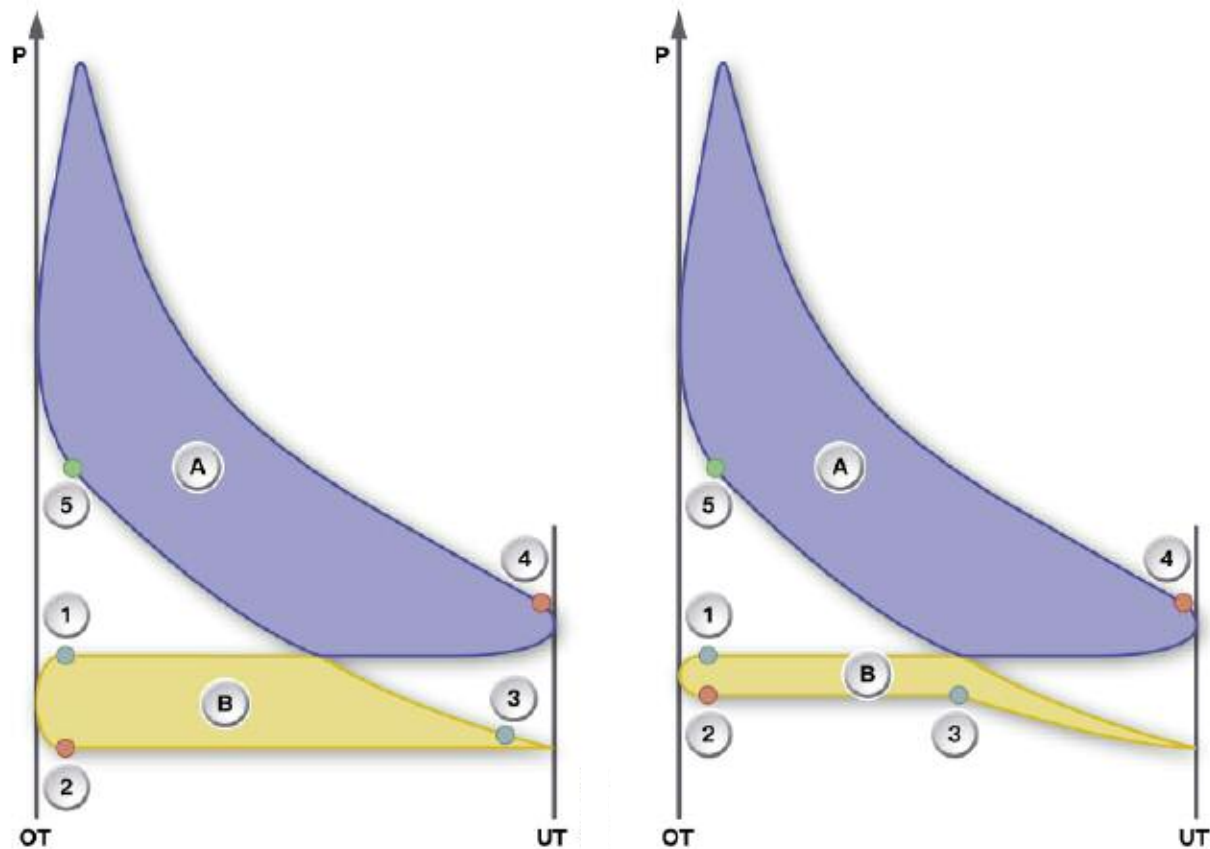
BMW has further developed this concept with the VALVETRONIC II.

The results of this further development are:

- Increased engine dynamics
- Increased efficiency
- Improved emission values



Load Control



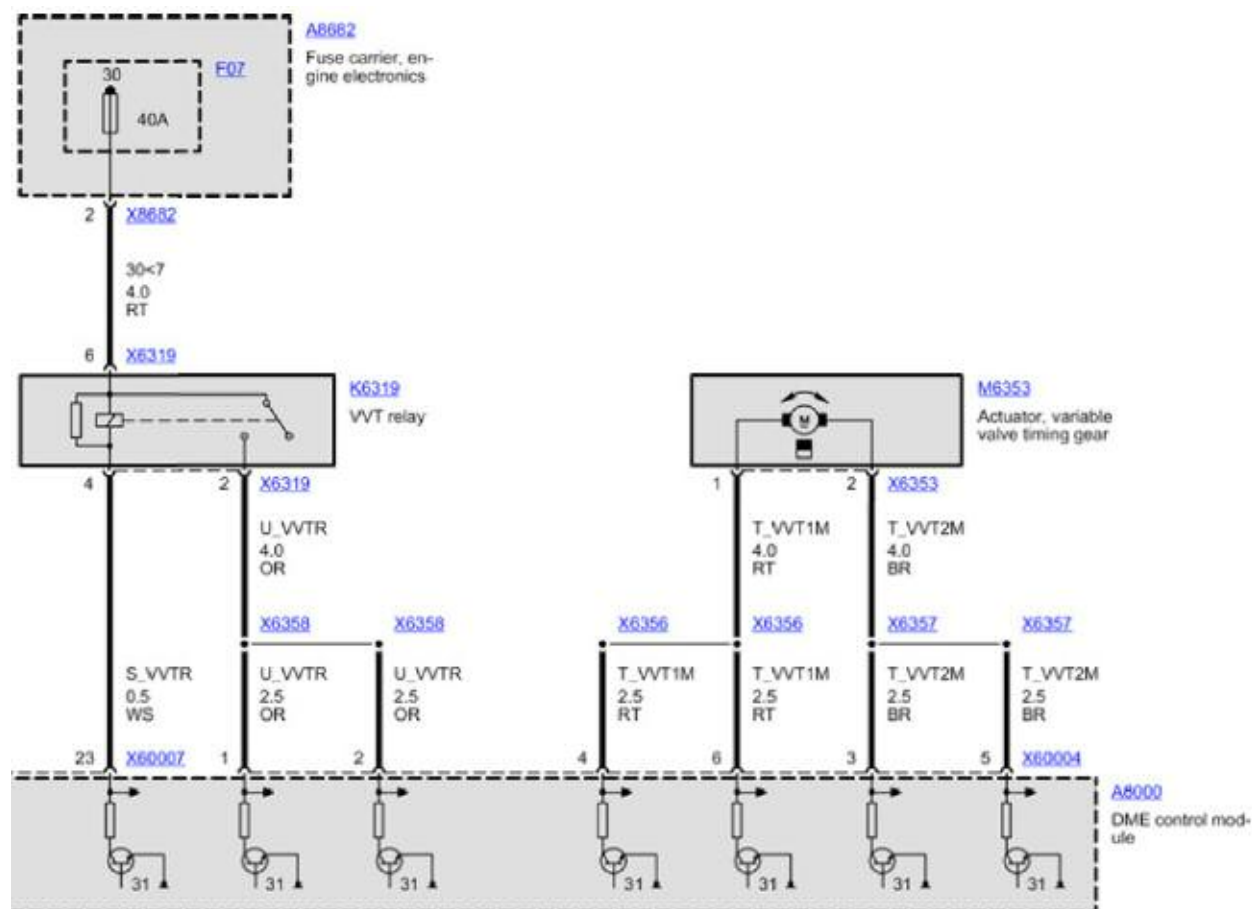
Index	Explanation	Index	Explanation
OT	Top dead center	4	Exhaust valve opens
UT	Bottom dead center	5	Firing point
1	Intake valve opens	A	Gain
2	Exhaust valve closes	B	Loss
3	Intake valve closes	P	Pressure

The illustration on the left shows the conventional method with the higher loss. The reduced loss can be clearly seen in the illustration on the right. The upper area represents the power gained from the combustion process in the petrol engine. The lower area illustrates the loss in this process.

The loss area can be equated to the charge cycle, relating to the amount of energy that must be applied in order to expel the combusted exhaust gasses from the cylinder and then to draw the fresh gasses again into the cylinder.

VVT Motor

As an example, on the N52 engine the VVT motor is controlled directly by the ECM. The motor receives power from a relay located in the E-box.



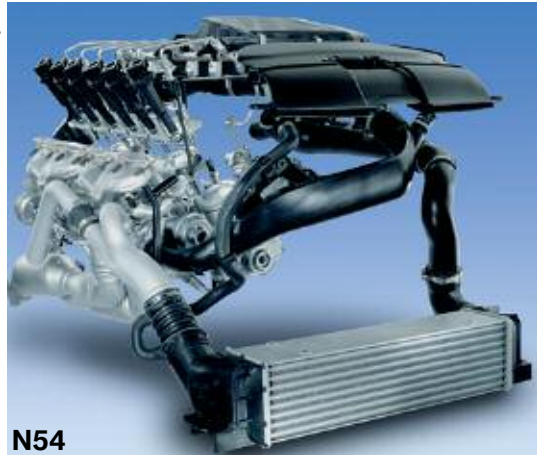
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Turbocharging Technology Overview

Until now, BMW has built a reputation for building high performance engines which are naturally aspirated. Much research has gone into the development of an efficient engine design which meets not only the expectations of the customer, but complies with all of the current emissions legislation.

Currently, the global focus has been centered around the use of alternative fuels and various hybrid designs. While BMW recognizes these concerns, there is still much development to be done on the internal combustion engine. Therefore, BMW will continue to build some of the best internal combustion engines in the world.



That is why in 2006 BMW introduced the N54 engine as the first turbocharged powerplant in the US market. In addition to turbocharging, the N54 features second generation direct injection and Double-VANOS.

As far as gasoline engines are concerned, turbocharging has not been in widespread use at BMW, that is until now. As a matter of fact, the last turbocharged BMW production vehicle was the E23 (745i) which was not officially imported into the US. The previous “turbo” model before that was the legendary 2002 tii turbo in the early 1970’s. This 2002 tii turbo was also not officially imported into the US.

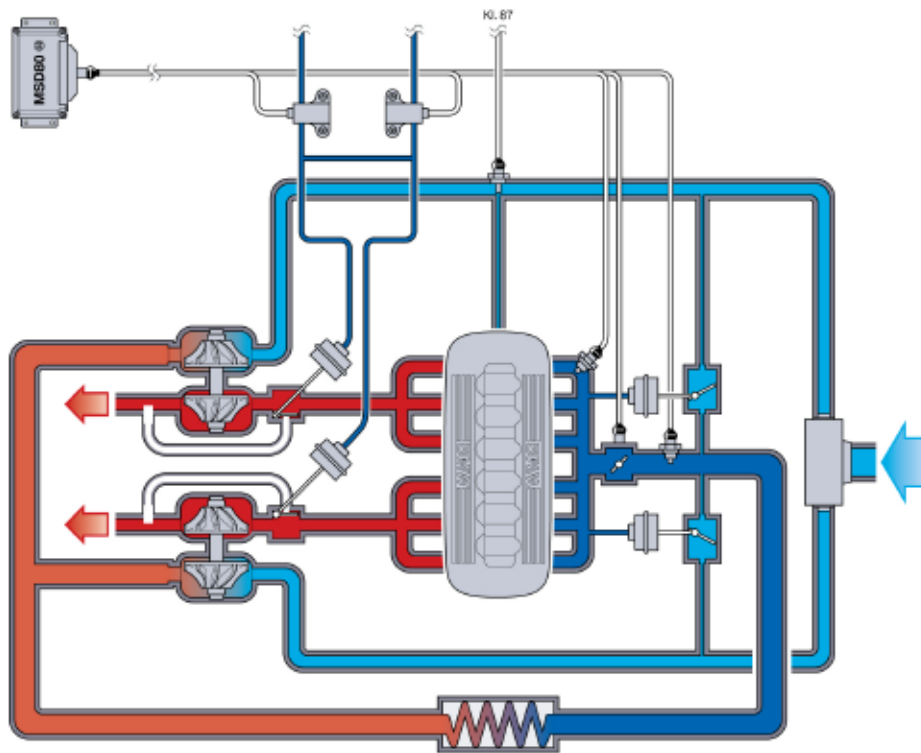
Principles of Operation

The turbocharger consists of a turbine and compressor assembly on a common shaft inside of the turbocharger housing. A turbocharger is driven by waste (exhaust) gases and in turn drives a compressor which forces air into the engine above atmospheric pressure. This increase pressure allows for an air charge with a greater density. The result is increased torque and horsepower. The turbine and the compressor can rotate at speeds of up to 200,000 rpm and the exhaust inlet temperature can reach max temperatures of up to 1050°C.

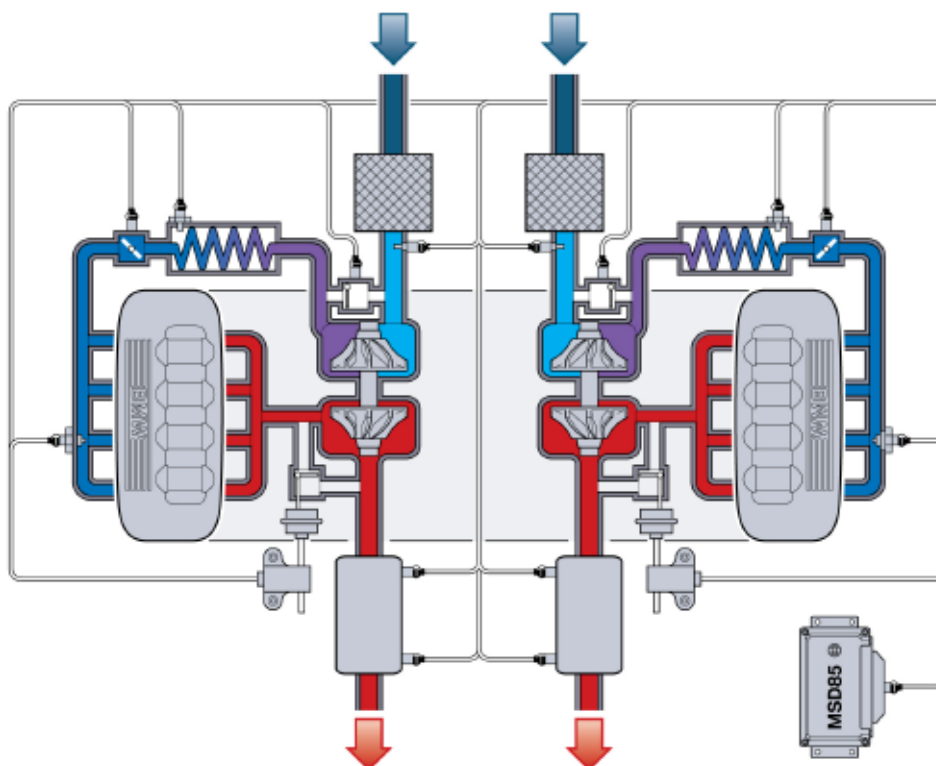
This increased density during the intake stroke ultimately adds up to the creation of more engine output torque. Of course, this increased density must be accompanied by additional fuel to create the desired power. This is accomplished by engine management system programming to increase injector “on-time” and enhance associated maps.

The use of an exhaust driven turbocharger is used to create more engine power through increased efficiency. In the case of BMW turbocharged engines, the turbocharger is used in conjunction with direct fuel injection. This provides the best combination of efficiency and power with no compromise.

N54 Turbo schematics



N63 Turbo schematics



Bi-turbocharging

A major advantage of the smaller-sized turbochargers is their low moment of inertia. Even the slightest impetus given by the driver with the accelerator pedal receives a response with an immediate build-up of pressure. The lag typically experienced until now in turbocharged engines - i.e. the time it takes for the turbocharger to attain its power-delivering effect - is thus no longer perceptible.



This requirement is met in the N54 engine with two small turbochargers, which are connected in parallel. Cylinders 1, 2 and 3 (bank 1) drive the first turbocharger (5) while cylinders 4, 5 and 6 (bank 2) drive the second (2). The advantage of a small turbocharger lies in the fact that, as the turbocharger runs up to speed, the lower moment of inertia of the turbine causes fewer masses to be accelerated, and thus the compressor attains a higher boost pressure in a shorter amount of time.

Twin-scroll Turbo System

The response characteristics of the use of twin-scroll exhaust turbochargers are enhanced when compared to the single-scroll turbos. For example, the S63's turbocharger turbines are fed through two separate channels within the turbine housing (highlighted red in the graphic). Each of these channels or "scrolls" is always fed by the exhaust pulses from the same two cylinders.



The layout and cross sections of the turbine impeller and compressor wheels have been correspondingly adapted and are designed for the maximum exhaust inlet operating temperature of 1020° C (1868° F).

The specially designed exhaust manifold connects each of the 8 cylinders in sequence according to the exhaust pulses in the firing order. This delivers a uniform flow of exhaust gas to the turbochargers which improves volumetric efficiency by promoting cylinder scavenging.

Every 180° of crankshaft rotation, one exhaust gas pulse is fed to each turbocharger over the entire ignition sequence (1-5-4-8-6-3-7-2).

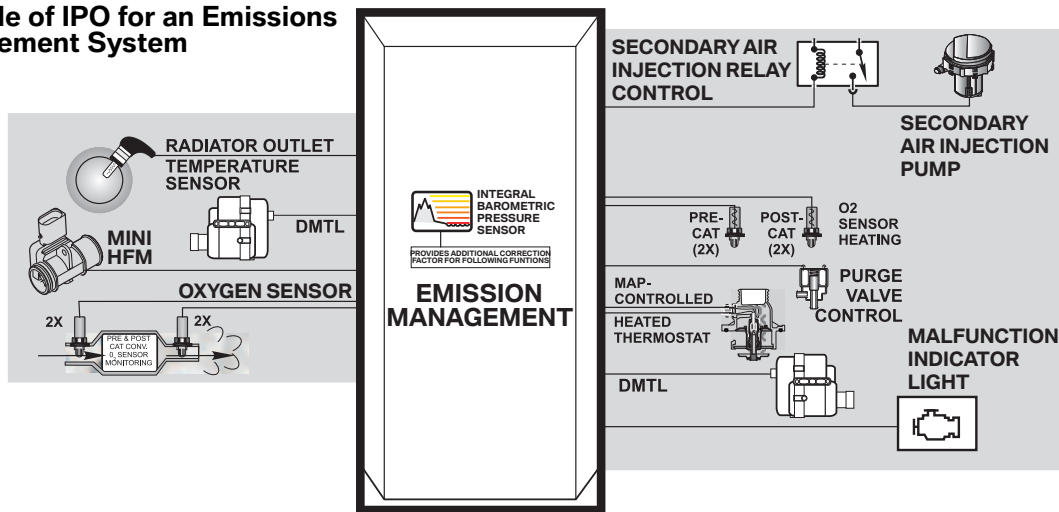
This highly efficient charging concept achieves optimum energy transmission of the exhaust flow to the turbine blades of the turbochargers. The result is the fastest and most direct response characteristics of any turbo engine worldwide. The innovative technology is patented by BMW and therefore represents a unique selling point over the competition.

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Emissions Management Overview

Example of IPO for an Emissions Management System



One of the main purposes of the ECM is Emissions Management which includes the actuation of several components. In the following pages you will find a generic explanation on how this system works. For more detailed information please access BMW Training Reference Manuals found on-line.

The Emissions Management controls **evaporative** and **exhaust** emissions. The ECM monitors the fuel storage system for evaporative leakage and controls the purging of evaporative vapors. The ECM also monitors and controls the exhaust emissions by regulating the combustible mixture and after treating by injecting fresh air into the exhaust system. The catalytic converter further breaks down the remaining combustible exhaust gases and is monitored by the ECM for catalyst efficiency.

Oxygen Sensors

Oxygen sensor before catalytic converter

The pre-cat oxygen sensors measure the residual oxygen content of the exhaust gas. The sensors produce a low voltage proportional to the oxygen content that allows the ECM to monitor the air/fuel ratio.

The sensors are mounted in the hot exhaust stream directly in front of the catalytic converters.

Full operational readiness is achieved after 10 seconds (LSU 4.2 20 seconds).

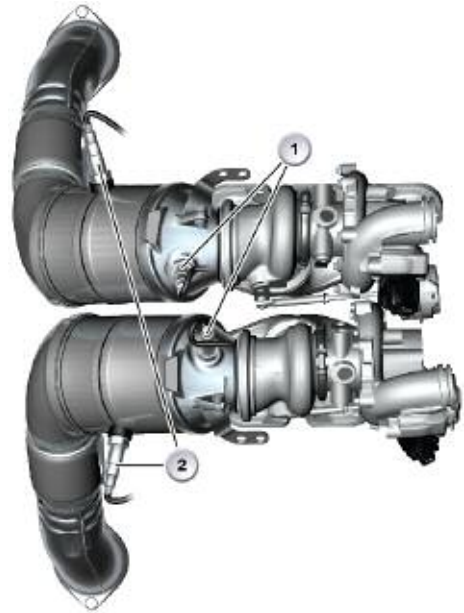


Oxygen sensor after catalytic converter

The oxygen sensor after catalytic converter is also known as the monitoring sensor. Their purpose is to monitor the pre-cat sensor for proper operation.

The familiar Bosch monitoring and pre-cat sensors are used in most of our NG engines.

Index	Explanation
1	Pre-catalyst sensors
2	Post-catalyst sensors



Carbon Canister (AKF)

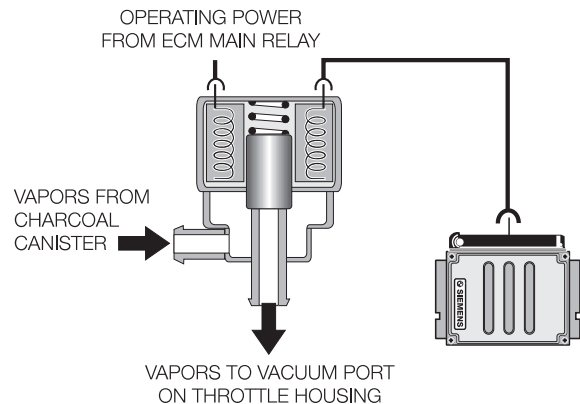
The AKF is used to prevent HC vapors from going to the atmosphere. As the hydrocarbon vapors enter the canister, they will be absorbed by the active carbon. The remaining air will be vented to the atmosphere through the end of the canister, DM TL and filter, allowing the fuel tank to “breathe”.

When the engine is running, the canister is "purged" using intake manifold vacuum to draw air through the canister which extracts the HC vapors into the combustion chamber.



Evaporative Emission Valve

This ECM controlled solenoid valve regulates the purge flow from the Carbon Canister into the intake manifold. The ECM Relay provides operating voltage, and the ECM controls the valve by regulating the ground circuit. The valve is powered open and closed by an internal spring.



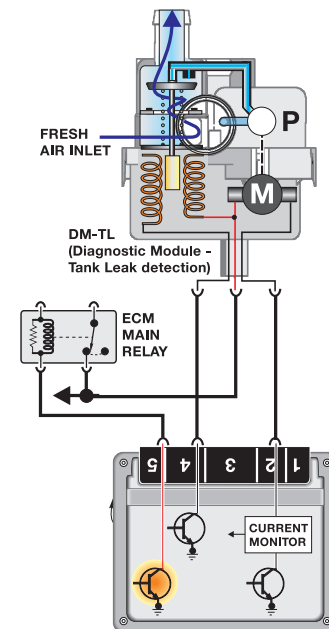
If the Evaporative Emission Valve Circuit is defective, a fault code will be set and the “Malfunction Indicator Light” will illuminate when the OBD II criteria is achieved.

Evaporative Leakage Detection (DM-TL)

This component ensures accurate fuel system leak detection for leaks as small as 0.5 mm by slightly pressurizing the fuel tank and evaporative components. The DM-TL pump contains an integral DC motor which is activated directly by the ECM. The ECM monitors the pump motor operating current as the measurement for detecting leaks.

The pump also contains an ECM controlled change over valve that is energized closed during a Leak Diagnosis test. The change over valve is open during all other periods of operation allowing the fuel system to “breathe” through the inlet filter.

A heating element is integrated in the DM-TL pump to eliminate condensation. The heater is provided battery voltage with “KL15” and the ECM provides the ground path.



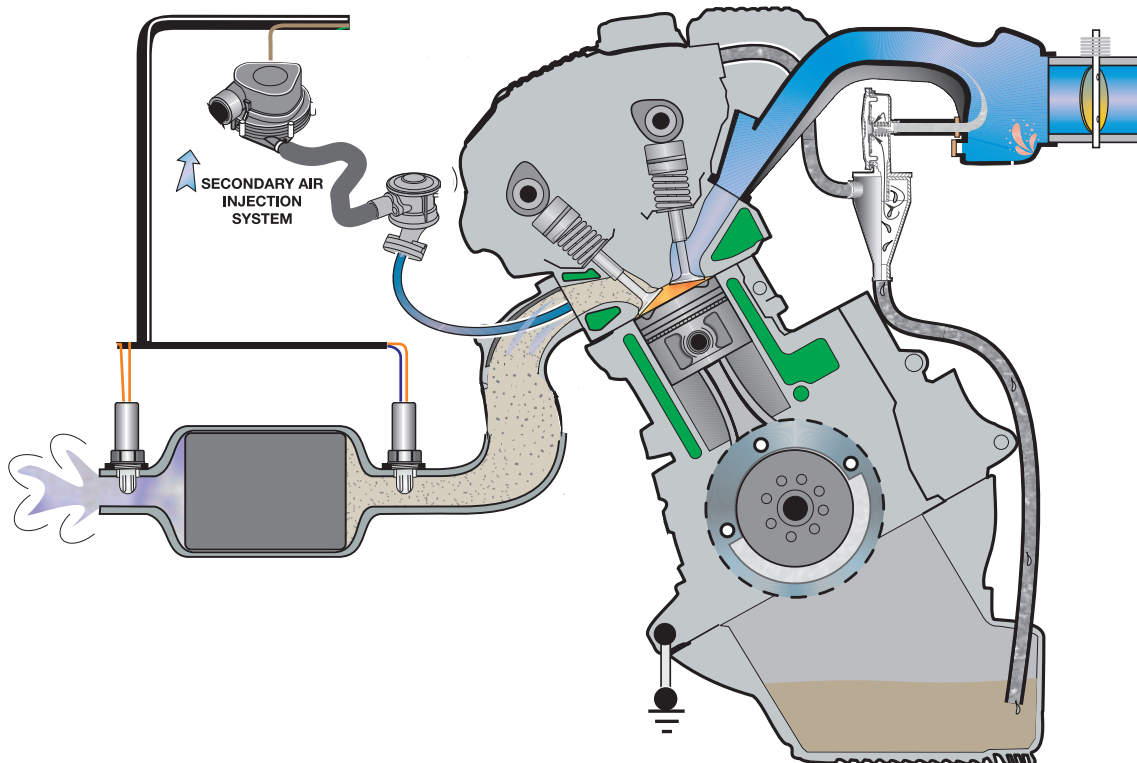
Exhaust Emissions

The combustion process of a gasoline powered engine produces Carbon Monoxide (CO), Carbon Dioxide (CO₂), Hydrocarbons (HC) and Oxides of Nitrogen (NO_x).

- Carbon Monoxide is a product of incomplete combustion under conditions of air deficiency. CO emissions are dependent on the air/fuel ratio.
- Carbon Dioxide is a greenhouse gas that traps the earth's heat and contributes to Global Warming.
- Hydrocarbon are also a product of incomplete combustion which results in unburned fuel. HC emissions are dependent on air/fuel ratio and the ignition of the mixture.
- Oxides of Nitrogen are a product of peak combustion temperature (and temperature duration). NO_x emissions are dependent on internal cylinder temperature affected by the air/fuel ratio and ignition of the mixture.

Control of exhaust emissions is accomplished by the engine and engine management design as well as after-treatment.

- The ECM manages exhaust emissions by controlling the air/fuel ratio and ignition.
- The ECM controlled Secondary Air Injection further dilutes exhaust emissions leaving the engine and reduce the catalyst warm up time.
- The Catalytic Converter further reduces exhaust emissions leaving the engine.



Electrically Heated Thermostat

Model specific variants of the electrically heated thermostat are equipped on all LEV/ULEV compliant engines. This thermostat allows the engine to run more efficiently than conventional thermostats improving fuel economy.

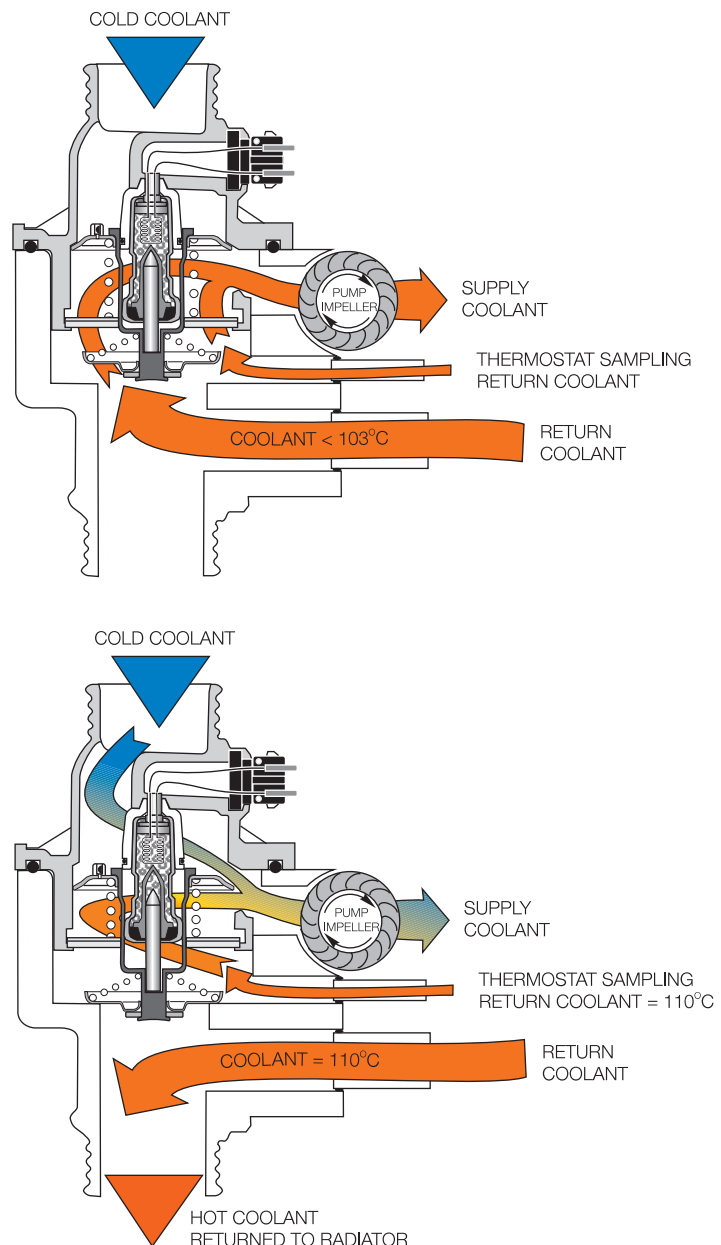
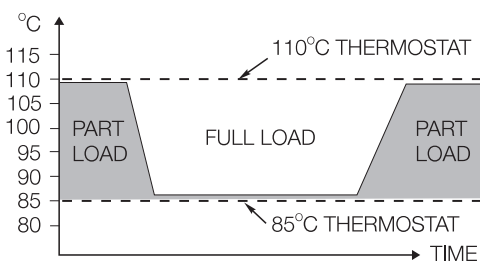
The ECM also electrically activates the thermostat to lower the engine coolant temperature based on monitored conditions. It is both a conventionally functioning and ECM controlled thermostat (two stage operation). The ECM control adds heat to the wax core causing the thermostat to open earlier than it's mechanical temperature rating providing increased coolant flow.

■ Conventional Function

The thermostat begins to open at 103°C. This is at the inlet side of the water pump and represents the temperature of the coolant entering the engine. Before the 103°C temperature is realized, the coolant is circulated through the engine block by the water pump.

After the temperature reaches 103°C it is maintained as the inlet temperature by the thermostat. The coolant temperature at the water pump engine outlet is approximately 110°C. The additional 7°C are achieved after the coolant has circulated through the block.

The operating temperature of the engine will remain within this range as long as the engine is running at part load conditions and the engine coolant temperature does not exceed 113°C.

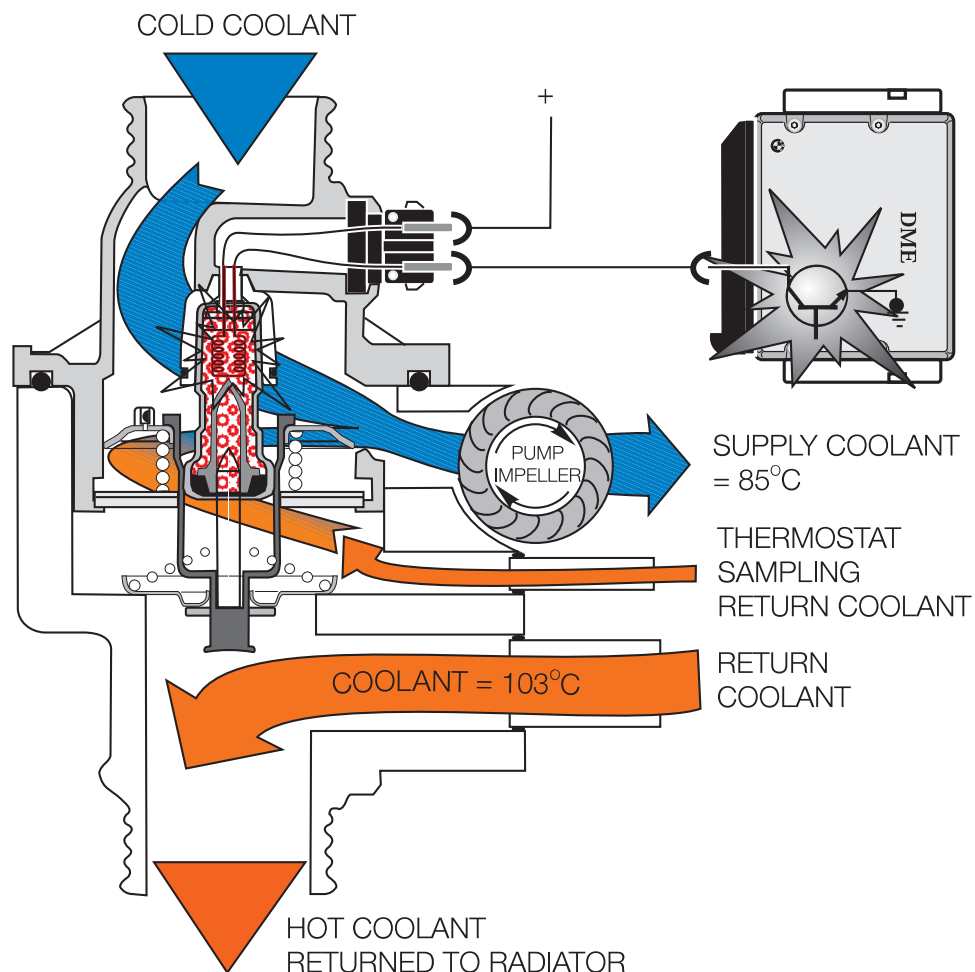


Electric thermostat activation is based on the following parameters:

- Engine temperature > 113°C
- Radiator Coolant Outlet Temperature
- Load signal “ti” > 5.8 ms
- Intake air temp > 52°C
- Vehicle speed > 110 MPH

When one or more of these monitored conditions is determined, the ECM activates (switched ground) the thermostat circuit. The activated heating element causes the wax core in the thermostat to heat up and open the thermostat increasing coolant circulation through the radiator which brings the engine temperature down.

The temperature of the coolant at the inlet side of the water pump will drop to approximately 85°C and the temperature at the outlet side will drop to approximately 103°C when activated.



Crankcase Ventilation

The crankcase ventilation system varies according to the engine. The pressure control valve and cyclonic oil separator are commonly used and combined into one unit.



Although the crankcase ventilation system and principle of operation remain the same, component location may change.

The pressure control valve varies the vacuum applied to the crankcase ventilation depending on engine load. The valve is balanced between spring pressure and the amount of manifold vacuum.

The oil vapors exit the separator labyrinth in the cylinder head cover. The oil vapors are drawn into the cyclone type liquid/vapor separator and regulated by the pressure control valve.

The oil vapors exit the pressure control valve into the intake manifold. The collected oil will drain back into the oil pan.

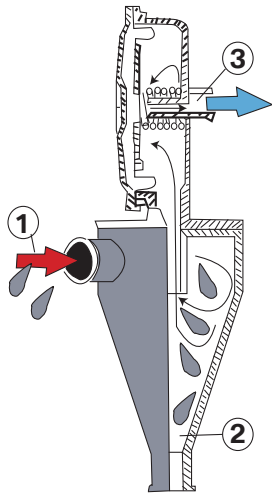
The vapors exit the pressure control valve and are drawn into the intake manifold through a centrally located port.

For turbocharged engines such as the N54, N55, N63 and N74, two non-return valves are used to prevent the risk of boost pressure being introduced into the crankcase.

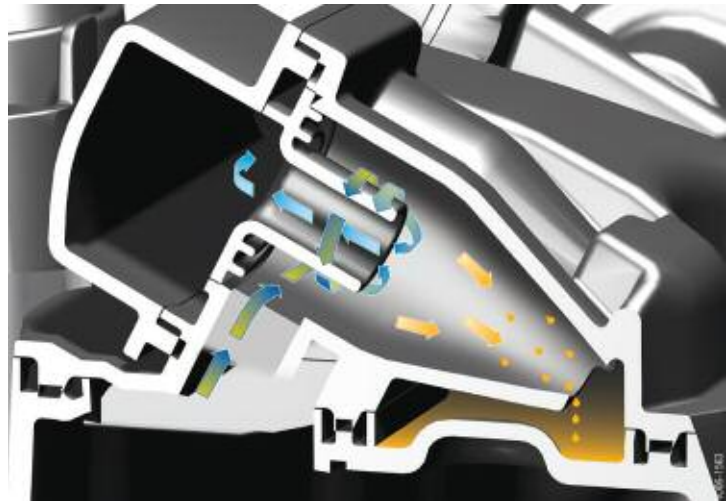
As the vapors exit the pressure control valve, they are drawn into the intake manifold.

At idle when the intake manifold vacuum is high, the vacuum reduces the valve opening allowing a small amount of crankcase vapors to be drawn into the intake manifold.

At part to full load conditions when intake manifold vacuum is lower, the spring opens the valve and additional crankcase vapors are drawn into the intake manifold.

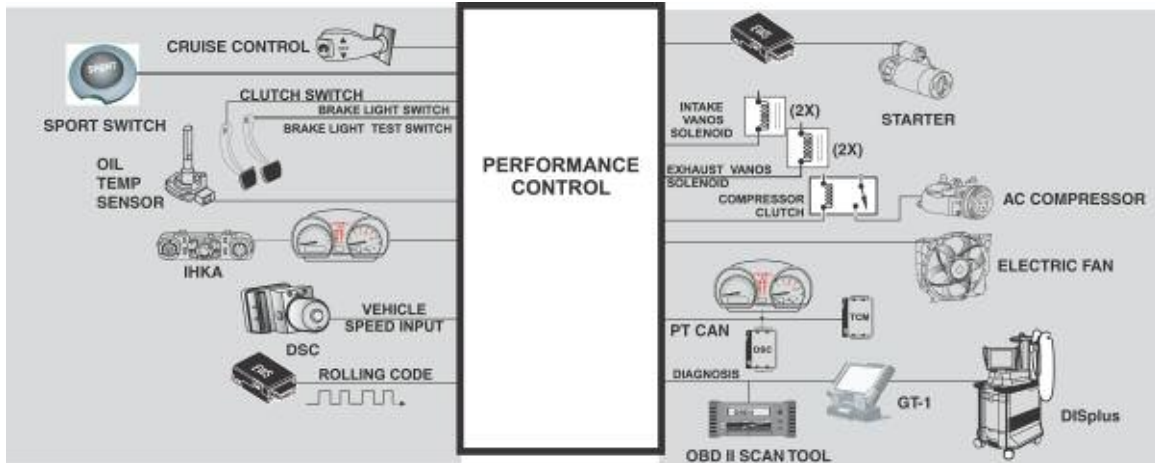


Index	Explanation
1	Engine Oil Vapors
2	Collective Drain Back Oil
3	Oil Vapors to the Intake Manifold



Performance Control Overview

Example of IPO for a Performance Control System



Dynamic Cruise Control

The cruise control with braking function was introduced with the BMW 3 Series (E9x). It is also referred to as "Dynamic Cruise Control" (DCC).

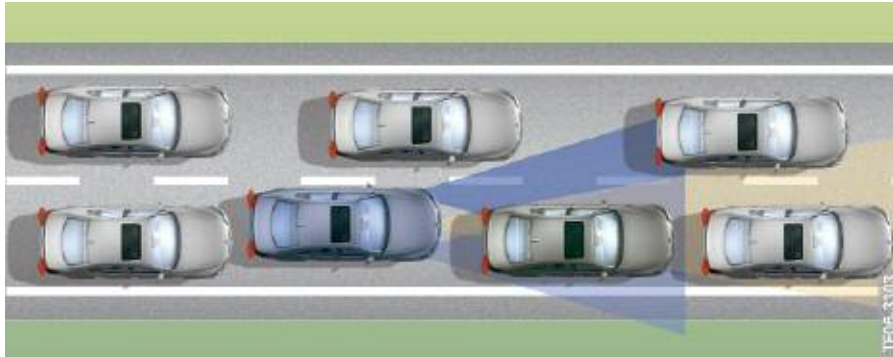
Mostly, DCC is a conventional cruise control system with some additional functions. The DCC offers the driver the opportunity to adjust the set speed in small or large increments, which is then set and maintained by the system by controlling power output and braking.

The brakes are also controlled during steep downhill driving if sufficient deceleration is not achieved by engine drag-torque alone.

Dynamic Cruise Control in vehicles with BN2020 is not computed in the DSC control unit as it is in other vehicles. Instead, it has been integrated into the ICM control unit.

Active Cruise Control with Stop & Go Function

ACC Stop & Go is largely identical to that in the E6x LCI. ACC Stop & Go extends the operating range of the former ACC system to include low speeds down to a standstill.



In other words, speed and distance from the vehicle in front are automatically controlled at those speeds as well.

ACC Stop & Go will automatically stop the car if necessary and then indicate to the driver as soon as it detects that it is possible to start moving again.

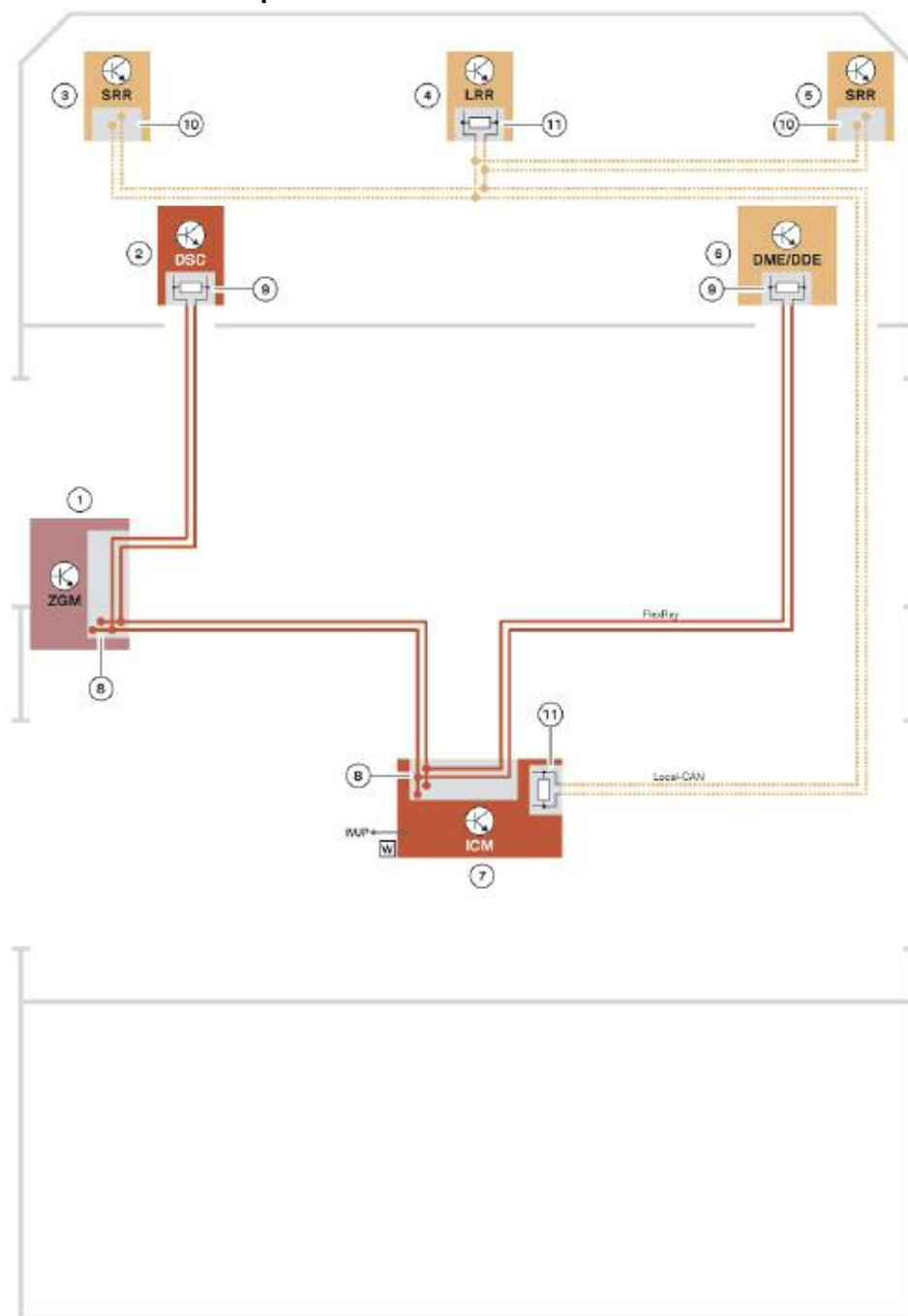
To pull away again, the driver has to acknowledge this message. The pulling-away process is controlled fully automatically by ACC Stop & Go only if the duration of the standstill is very short.

Thus, ACC Stop & Go provides optimum assistance for the driver not only in moving traffic but also in traffic jams such as are more and more frequently encountered on highways. However, this system (in common with ACC) is not intended for use in urban areas for negotiating junctions or traffic lights.

The functions of ACC Stop & Go differ from those in the E6x LCI in the following areas:

- Operation and display
- Behavior in response to driver's intention to get out.

F01 Bus Interface for ACC Stop & Go

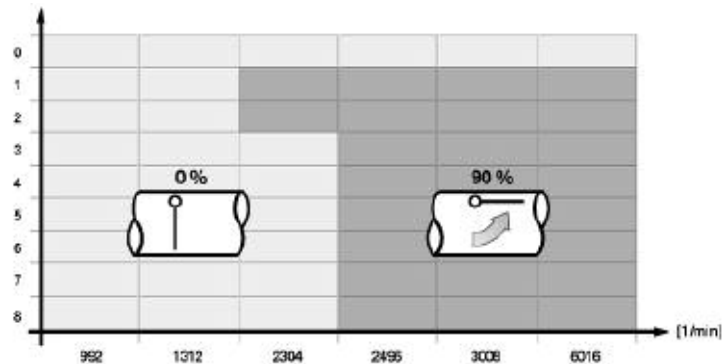


Index	Explanation	Index	Explanation
1	ZGM	7	ICM
2	DSC	8	FlexRay bus
3	Short range radar sensor, left	9	FlexRay terminating resistor, DSC and DME
4	Long range radar sensor	10	Lo-CAN bus termination
5	Short range radar sensor, right	11	Lo-CAN terminating resistor
6	DME		

Exhaust Flap Control

The exhaust flap is designed to reduce noise at idle, low RPM acceleration and while coasting. The exhaust flap is controlled via vacuum actuator. The vacuum actuator is supplied vacuum via the engine driven vacuum pump.

The ECM controls the flap using a vacuum vent valve.



As compared to previous vehicles, the system no longer needs a vacuum reservoir. This is due to the fact that the vacuum is not supplied by the engine and not subject to variations in intake manifold vacuum.

The exhaust flap is sprung open and closed by vacuum. The ECM will de-activate the vacuum vent valve in order to open the flap.

The flap is opened above approximately 2500 RPM. Flap operation is also dependent upon engine load.

Dynamic Driving Control - “Sport Switch”

A central, higher-level of Driving Dynamics Control system was first introduced in BMW vehicles several years ago. Control elements are already installed in a number of BMW models that the driver can use to switch individual systems to a sporting mode. This includes the sports setting of the automatic selector lever where only the shift characteristics of the automatic gearbox are influenced.

The system behaves in a similar manner when the SPORT button for the Electronic Damping Control or Vertical Dynamics Control (shown right) is used. This only changes the characteristic (hardness) of the shock absorber.

The first time a SPORT button influenced several systems was in the E85/E86. The corresponding “Driving Dynamics Control” function effects a changeover between a standard mode and a sporting mode in the steering, automatic gearbox and accelerator pedal. This meant it was now possible to coordinate these three systems far more effectively in both modes with the result that the customer now experiences a car that is uncompromisingly tailored to “Sport” in every sense.

SPORT Button in E70/E71



Index	Explanation	Index	Explanation
1	SPORT button	2	Vertical Dynamics Control with electronically adjustable shock absorbers

The Driving Dynamics Control has been further improved in vehicles with BN2020 (e.g. F01/F02) as it now contains two groundbreaking features when compared to the E85/E86:

1. All drive and dynamic driving systems installed in the vehicle are comprehensively switched over.
2. Four settings are available. The status of the Dynamic Stability Control is also taken into account thus ensuring that two additional settings are possible.

The changeover operations for many drive and driving dynamics functions are therefore bundled in the driving dynamics control. The vehicle as a whole then behaves as the driver would expect in accordance with his/her chosen setting. This bundling can make the handling characteristics of the vehicle considerably more distinctive and less compromising.

When sport mode is activated, the driving dynamics of the vehicle take on sportier qualities. The Sport mode ("Sport +") is available in certain models) can be operated via a driving dynamics switch located in the center console. The electronic control units switch to more dynamic settings, making the engine more responsive (EDK) with a firmer steering strategy (EPS), less body roll (ARS) and a sportier suspension setting (VDM - EDC).

Additionally in vehicles equipped with automatic transmission (EGS), BMW's Double Clutch Transmission (DCT) or Sequential Manual Gearbox (SMG), activating the sport mode shortens gearshift times and makes the gearshift characteristic even more dynamic.

In certain vehicles the Dynamic Driving Control allows the driver to customize the system it wants to influence: **Drive Train, Chassis, and/or Transmission** (in addition the driver can use the controller to make further settings).

The Dynamic Driving Control function request is carried over by the DME/ICM (depending on the vehicle) through the bus network to the following control modules:

- ICM - Integral Chassis Management.
- DME - The engine control system for the accelerator pedal characteristic.
- EGS/DCT/SMG - The electronic gearbox control for driving programs and shift speed.
- EPS - Power Steering assistance (Servotronic).
- KOMBI/CID - Display relevant DDC information to the driver.
- ARS - Active Roll Stabilization varies the stiffness/response characteristic of the sway bars.
- VDM - The Vertical Dynamics Management varies the stiffness/response characteristic of the dampers.
- DSC - DTC is activated in "Sport +".

DTC button and Driving Dynamics switch

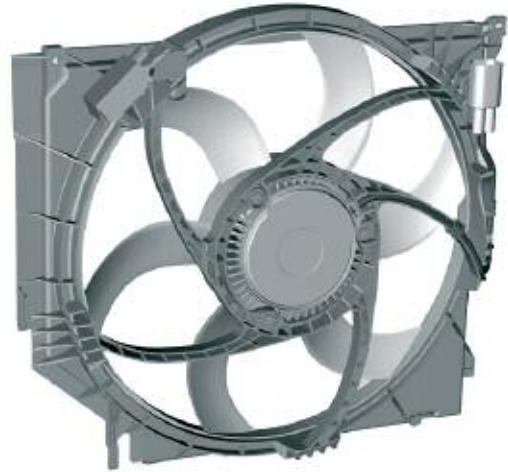


Index	Explanation
1	DTC button-
2	Driving Dynamics Switch

Electric Fan

As usual, the electric fan has its own electronics module and is controlled dependent on engine speed and temperature by a pulse-width modulated signal. The pulse duty factor during normal operation (100 Hz) is converted into a speed signal.

- 7% pulse duty factor wakes the fan electronics
- 11% pulse duty factor equates to 33% of the maximum fan speed
- 93% pulse duty factor equates to the maximum fan speed
- 97% pulse duty factor is a command for self-diagnosis of the fan electronics



To output the fan after-running command, the output frequency of the DME is reduced to 10 Hz during the latching phase (terminal KL_15 OFF). The fan time and speed are selected based on the pulse duty factor.

A further new feature is that the DME switches the power supply through terminal 30 via a relay.

The electric cooling fan is controlled by the ECM for engine cooling system and air conditioning system requirements. The ECM uses a remote power output final stage (mounted on the fan housing). The electric fan is controlled by a pulse width modulated signal from the ECM.

The fan (and speed) is activated by the ECM based on:

- Coolant outlet temperature
- Catalyst temperature
(calculated by the ECM)
- Vehicle speed
- Battery voltage
- Air Conditioning refrigerant pressure
(calculated by IHKA and sent via the PT CAN bus to the ECM)

ECM Integrated Temperature Sensor

The E Box fan is controlled by the ECM. The control module contains an integral NTC temperature sensor for the purpose of monitoring the E box temperature and activating the fan.

When the internal temperature exceeds 65° C, the ECM provides a switched ground for the E Box fan to cool the E box control modules.



Alternator Interface

The alternator communicates data with the ECM via the BSD line (bit-serial data interface - single wire). This is necessary to allow the ECM to adapt its calculations and specific control data to the alternator output. In addition, the ECM controls the following functions:

- Activation/deactivation of the alternator.
- Informing the voltage regulator of the nominal voltage value to be set.
- Controlling the alternator's load response.
- Diagnosing the BSD line.
- Storing alternator fault codes.
- Activating the charging indicator light in the instrument cluster.

The charging indicator light operation has not changed from present vehicles.

PT-CAN Bus Communication

The ECM provides signals to other “driveline” related modules for torque control, shift quality, diagnosis, safety enhancements, etc.

NOTES

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MSD87-12 (N74): DME Interface	54
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Engine Electronics IPO's

Model: All

Production: All

OBJECTIVES

After completion of this module you will be able to:

- Understand the concept of IPO
- Name the main IPO's for Engine Electronics
- Describe the main components of the DME Interface

IPO's

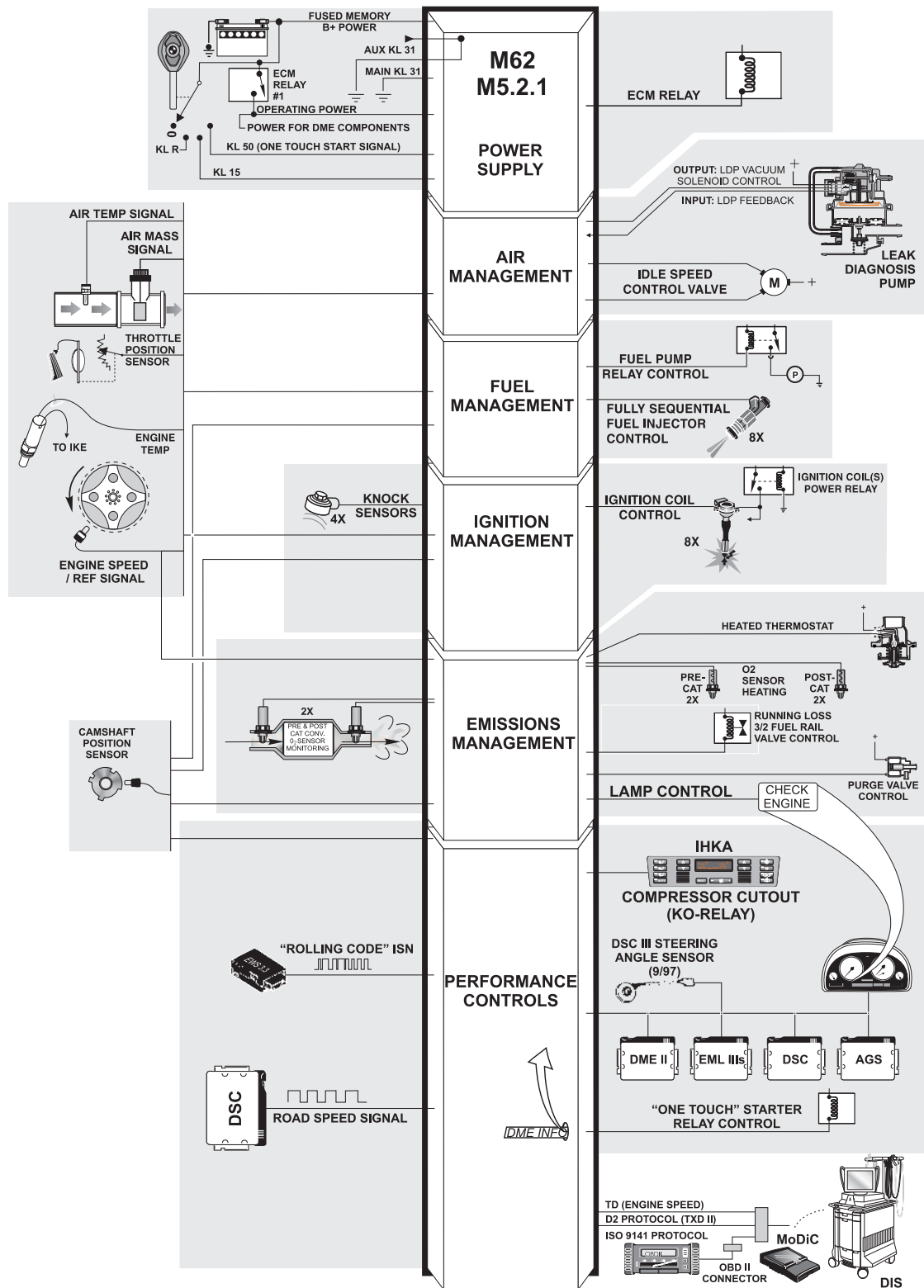
The cart shown below is a quick reference of BMW Engine Management Systems by application to BMW models, engines and model years. This will help you get familiar with the systems by identifying the correct version that you are diagnosing.

ENGINE MANAGEMENT CONTROL VERSIONS			
VERSION	VEHICLE MODEL	ENGINE	MODEL YEAR
M1.2	E32 / M5	M70 / S38	M70 = 1988 - 1999 S38 = 1991 - 1993
M1.7	E31 / E32	M70	1991 - 1994
M1.7	E30	M42	1990 - 1993
M1.7	E36	M42	1992 - 1995
M1.7	E36	M42 / DISA	1995
M1.7.1	E31	S70	1991 - 1992
M1.7.2	E36	M42 /DISA	1992
M3.1	E34	M50	1991 - 1992
M3.1	E36	M50	1992
M3.3	E32	M60	1993 - 1994
M3.3	E31 / E34	M60	1994 - 1995
M3.3.1	E34 / E36	M50TU	1993 - 1995
M5.2	E36 / Z3	M44	1996 - 1998
M5.2	E31 / E38 / E39	M62 / M73	1995 - 1997
MS41.1	E36 / E39 /Z3	M52	1996 - 1998
MS41.2	E36 M3	S52	1996 - 1998
M5.2.1	E38 / E39	M62 / M73	1998 - 1999
MS42	E46 / E39 /Z3	M52TU	1998 - 2000
MS43	E46 / E39 / E53 / Z3	M54	E46 2001 - 2002 Z3 2001 - 2002 E39 2001 - 2003 E53 2001 - 2006
ME7.2	E39 / E38 / E53	M62TU	1999 - 2001
MS S52	E39 M5 / E52 Z8	S62	M5 1999 - 2003 Z8 2000 - 2003
MS S54	E46 M3	S54	2001 -2007
BOSH = M; SIEMENS = MS			

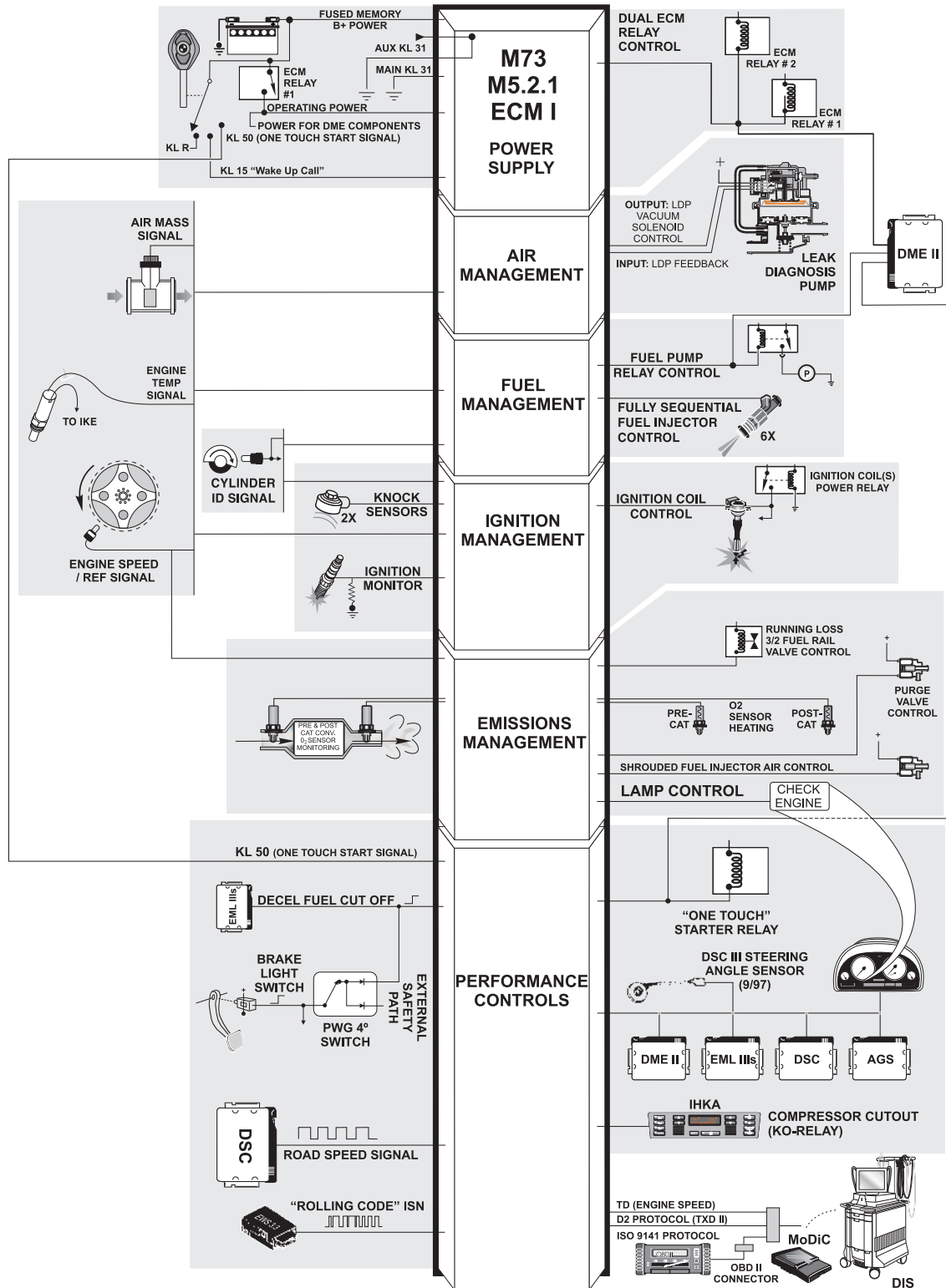
ENGINE MANAGEMENT CONTROL VERSIONS			
VERSION	VEHICLE MODEL	ENGINE	MODEL YEAR
MS45	E85	M54	2003 - 2006
MS45	E83 all except M54B30 AUTO	M54	2003 - 2006
MS54.1	E83 with M54B30 auto	M54	2003 - 2006
MS45.1	E46	M54	2003 - 2006
MS45.1	E46	M56 SULEV	2003 - 2006
ME 9.2	E65/66	N62	2002 - 2003
ME9.2.1	E53 / E60 / E63 / E64 / E65 / E66	N62	2004 - 2004
ME 9.2.2	E53 / E60 / E63 / E64 / E65 / E66	N62	2005 - 2007
MED 9.2.1	E66	N73	2003 - 2006
ME 9.2.3	E70	N62	2006 - 2010
MSS65	M5, M6 (E6x)	S85	2006 - 2009
MSV70	E90, E91, E92, E93, E60, E70.	N52	2004 - 2006
MSV80	E82, E88, E90, E91, E92, E93, E60, E70.	N52KP	2006 -
MSD80	E82, E90, E92, E93, E60, E61.	N54	2006 - 2008
MSD81	E70, E71, E82, E84, E88, E89, E90, E92, E93, F07, F10	N54	2008 -
MEVD 17.2	E82, E88, E90, E91, E92, E93, E60, E70.	N55	2010 -
MSD85	E70, E71, E72, F01, F02, F04, F07, F10	N63	2009 -
MSD85.1	E70 M / E71 M	S63	2009 -
MSD87-12	F01, F02	N74	2009 -
BOSH = M; SIEMENS = MS			

ENGINE MANAGEMENT CONTROL VERSIONS			
VERSION	VEHICLE MODEL	ENGINE	MODEL YEAR
MSD 90	F10	N52TU	2010-2011
MEVD 17.2	E82, E88, E90, E91, E92, E93, E60, E70, F34	N55	2010 -
MEVD 17.2.2	F25, F12, F13	N55	2010 -
MEVD 17.2.4	E84, E89, F25, F10, F22, F23, F30, F31, F32, F33	N20, N26	2011 -
MEVD 17.2.6	F06, F15, F16, F22, F23, F25, F30,F30 M, F32, F32M, F33, F33M	N55	2011 -
MEVD 17.2.8	F01, F02, F06, F10, F12, F13 F15, F16, M5, M6	N63TU, S63TU	2012 -
MEVD 17.2.2.x	E70, F10H, F01H	N55	2010 -
BOSH = M; SIEMENS = MS			

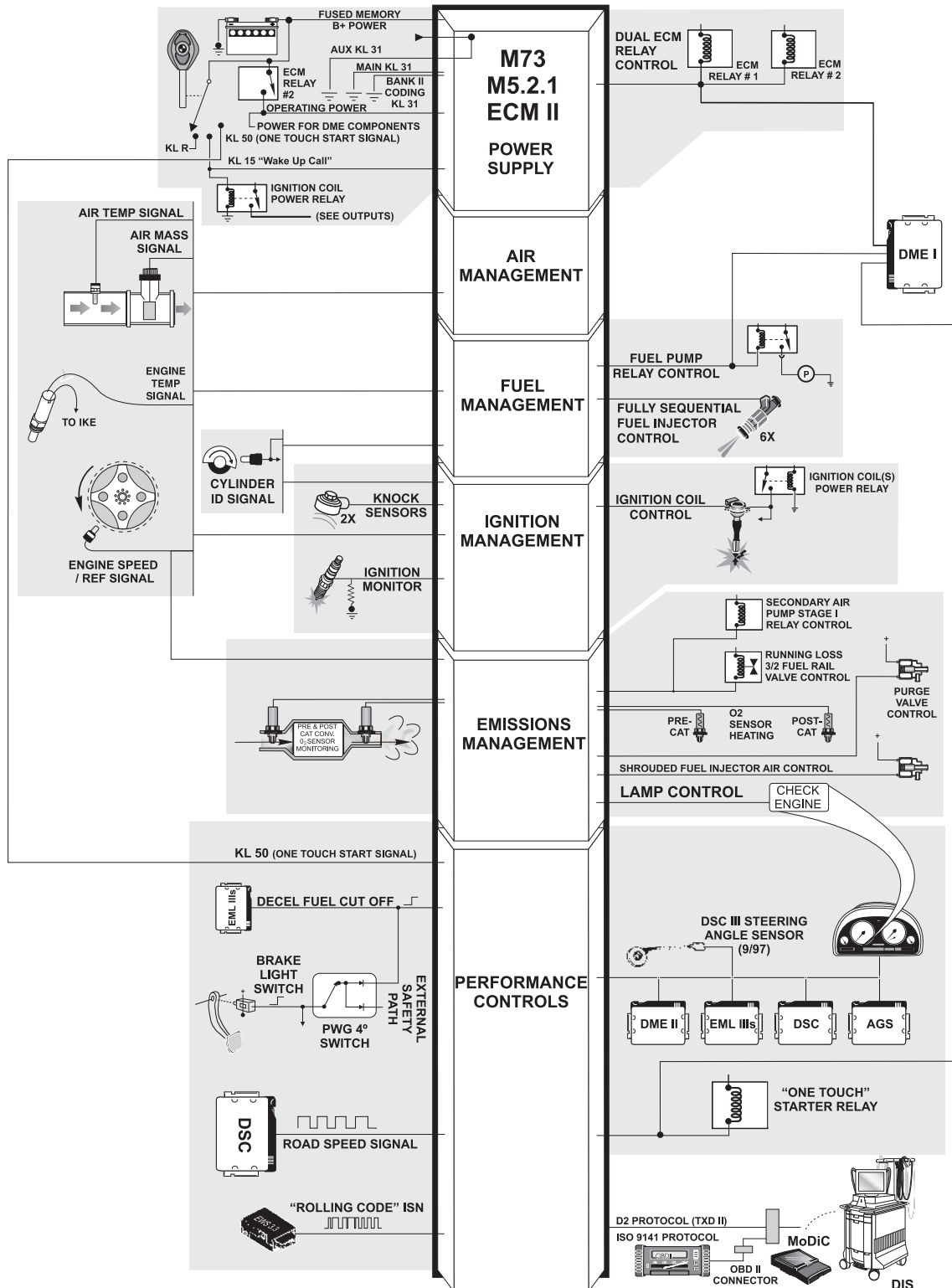
M5.2.1: Inputs - Processing - Outputs



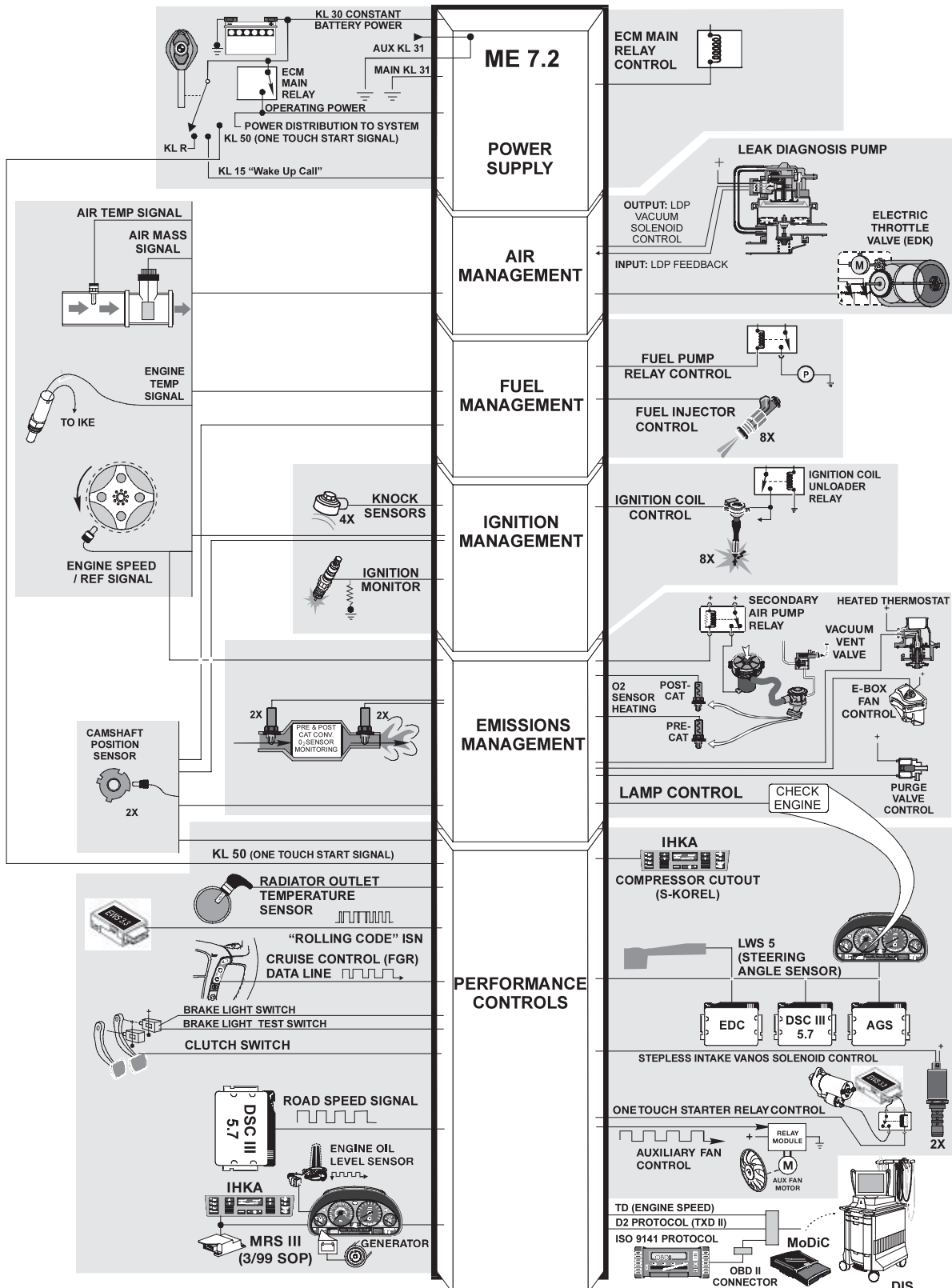
M5.2.1 ECM I: Inputs - Processing - Outputs



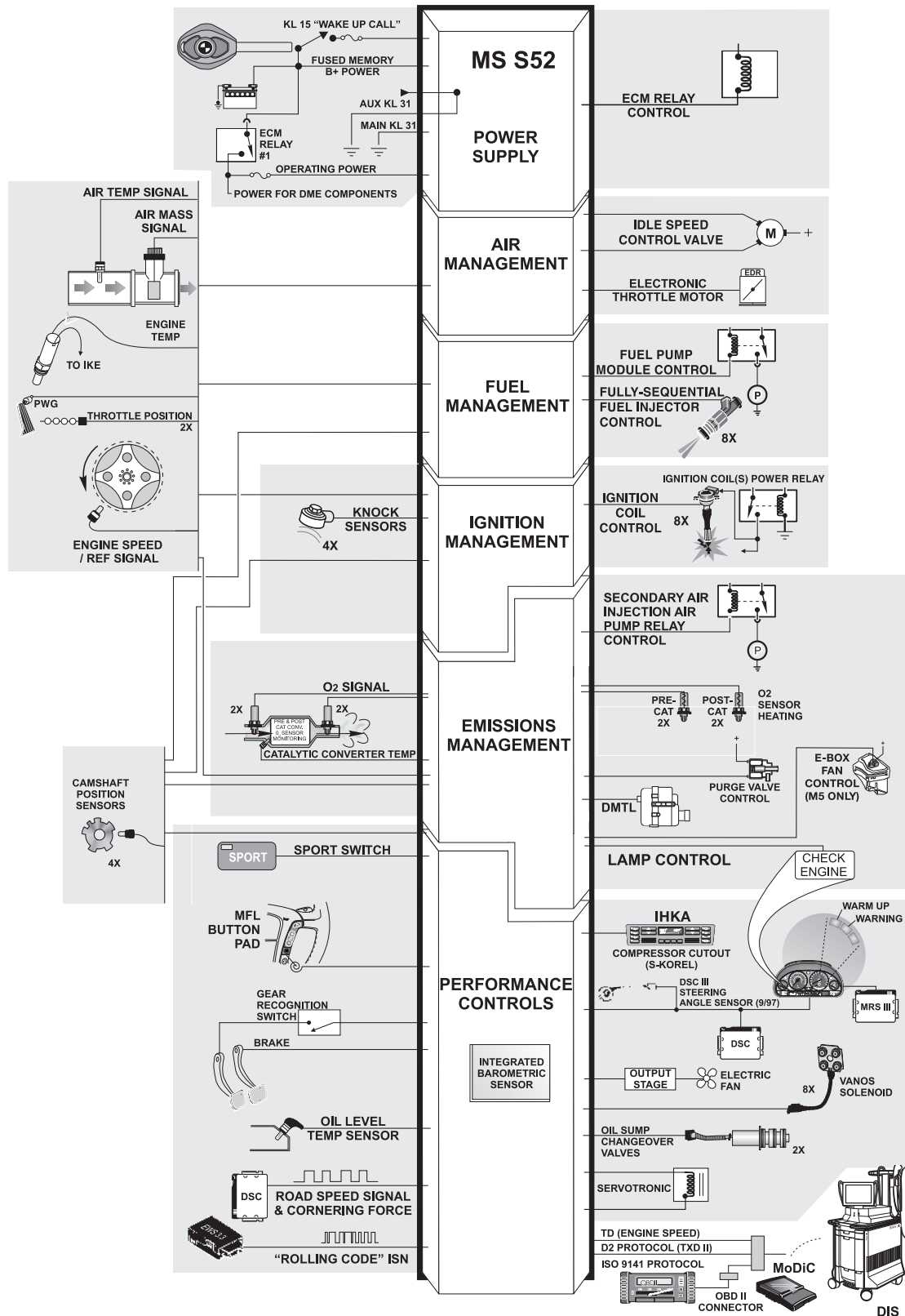
M5.2.1 ECM II: Inputs - Processing - Outputs



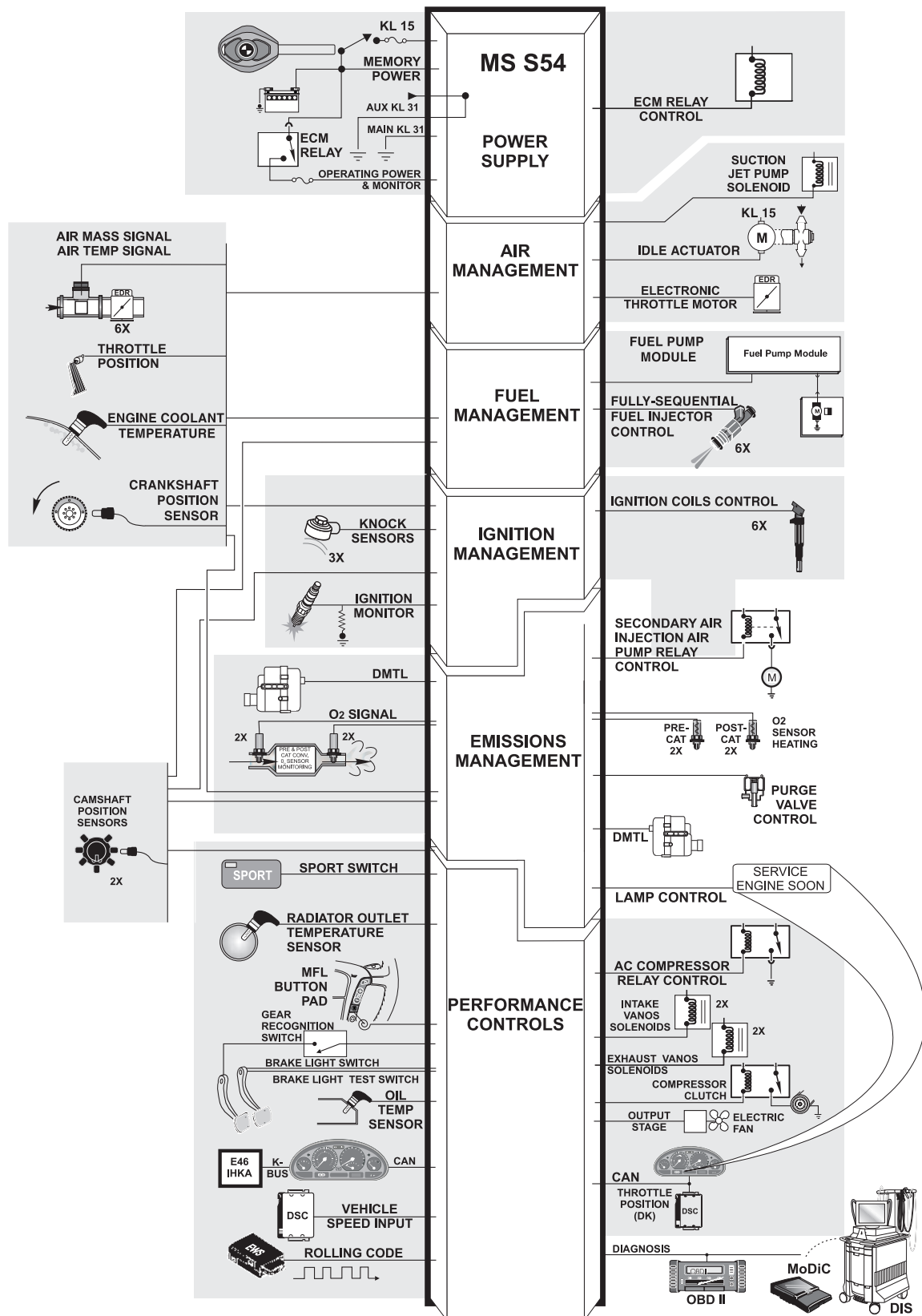
ME7.2: Inputs - Processing - Outputs



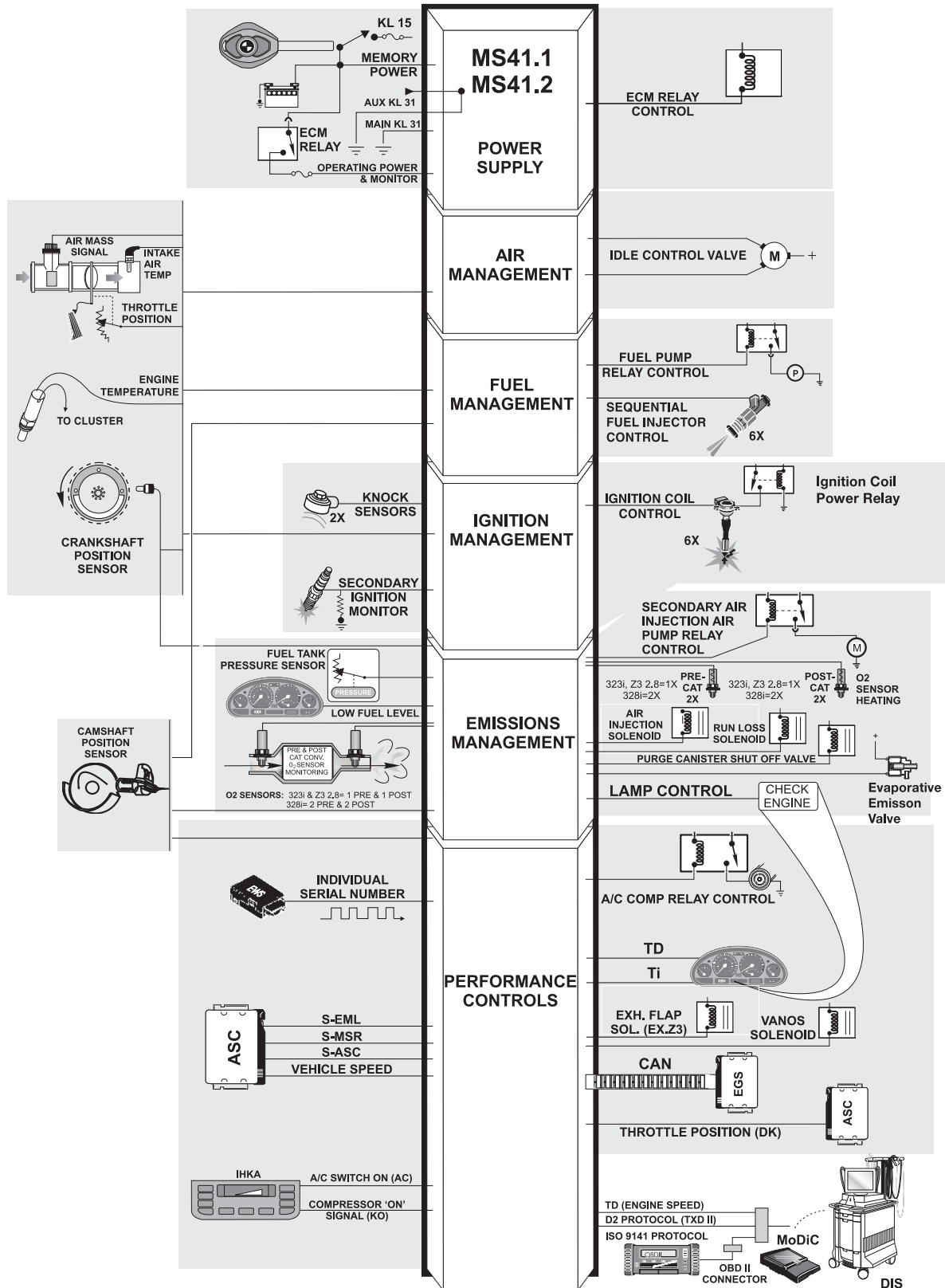
MS S52: Inputs - Processing - Outputs



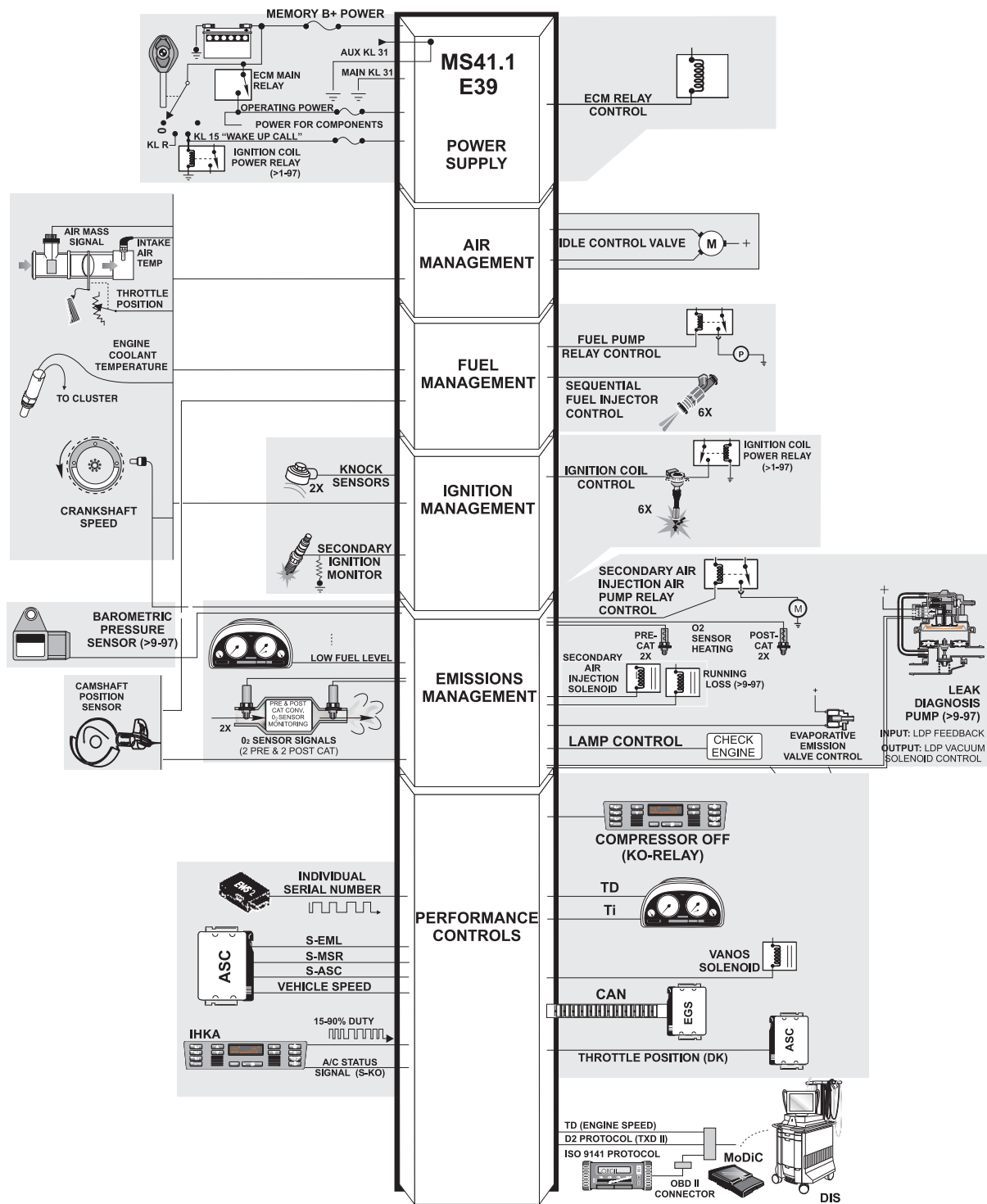
MS S54: Inputs - Processing - Outputs



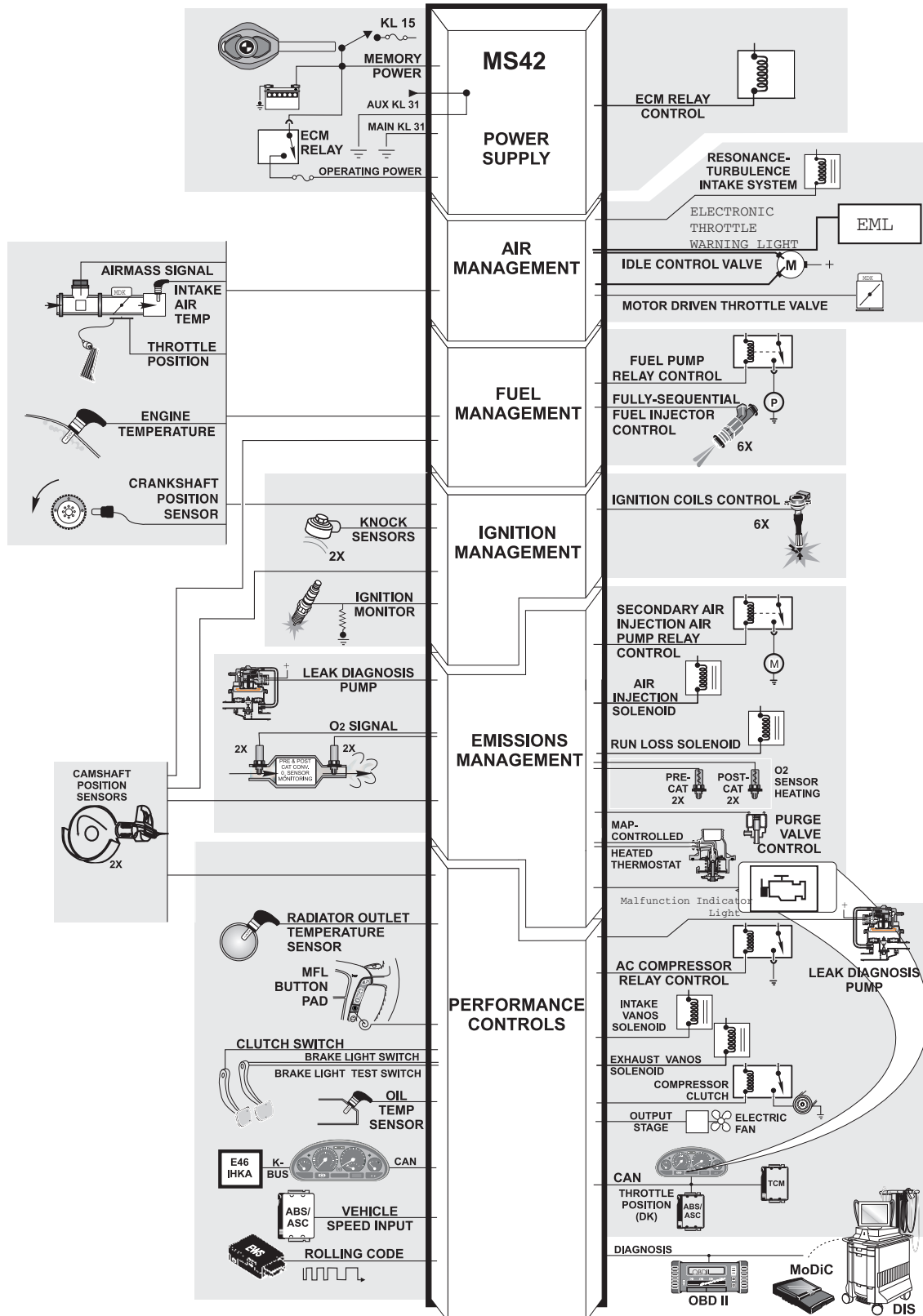
MS41.1 & MS41.2: Inputs - Processing - Outputs



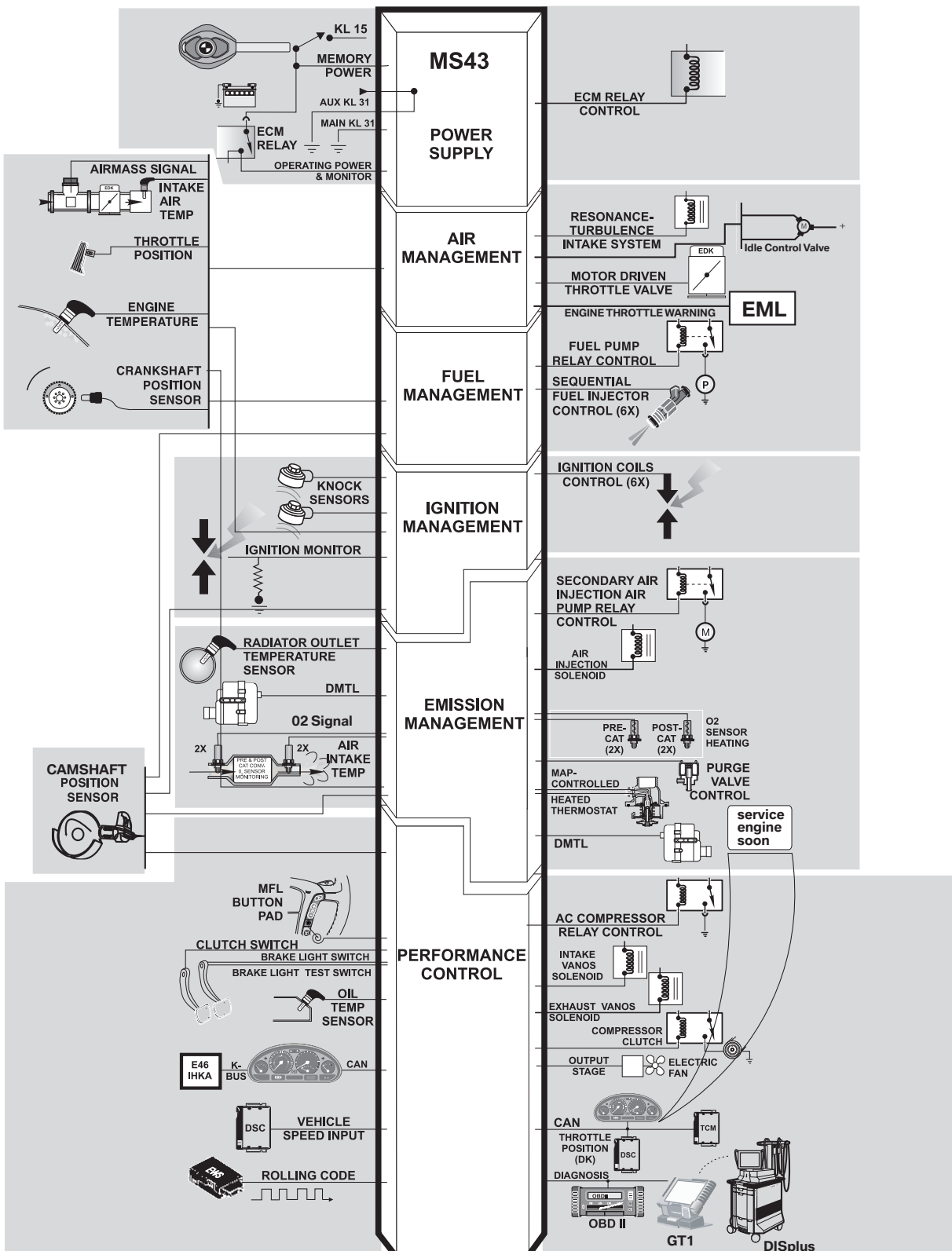
MS41.1: Inputs - Processing - Outputs



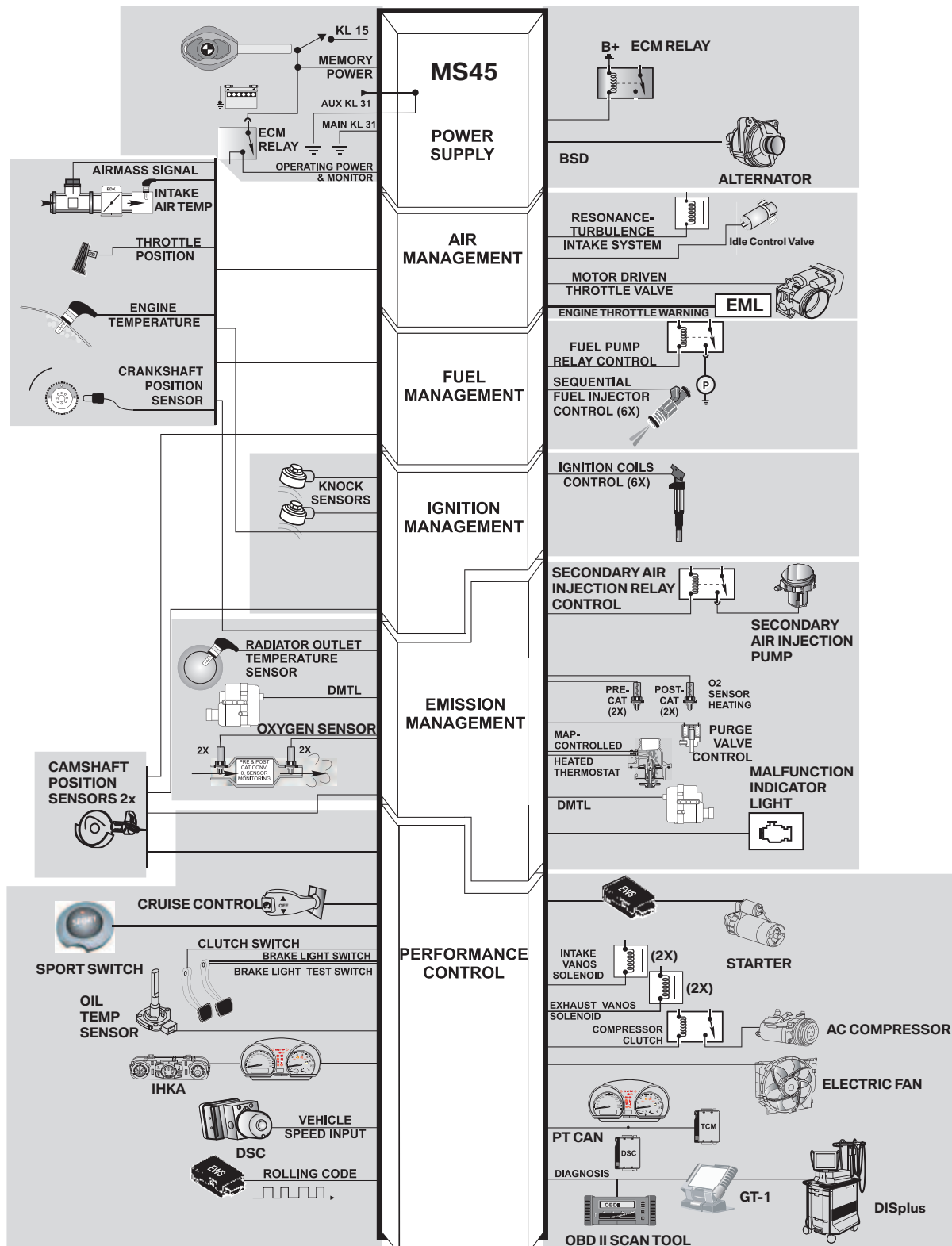
MS42: Inputs - Processing - Outputs



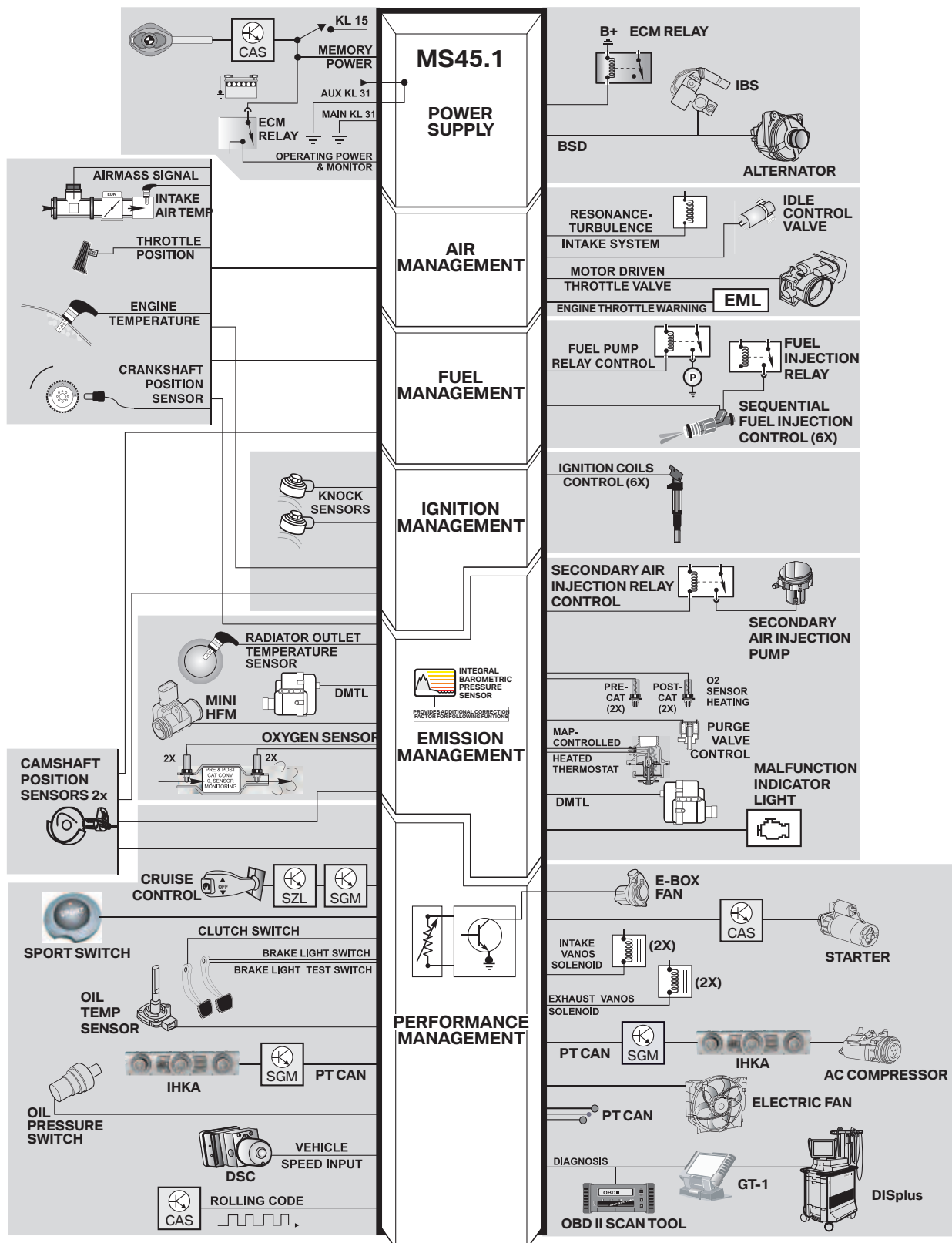
MS43: Inputs - Processing - Outputs



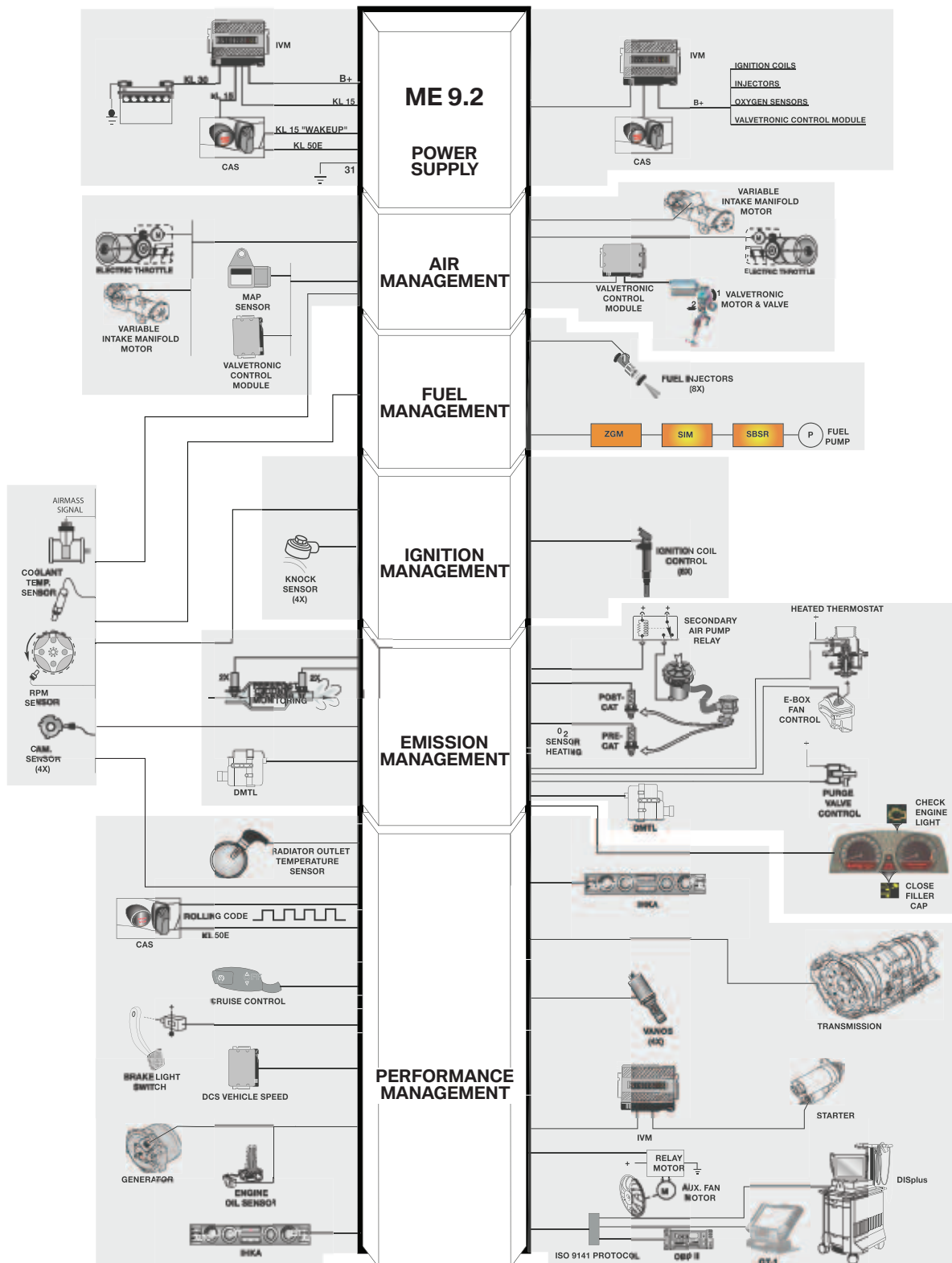
MS45: Inputs - Processing - Outputs



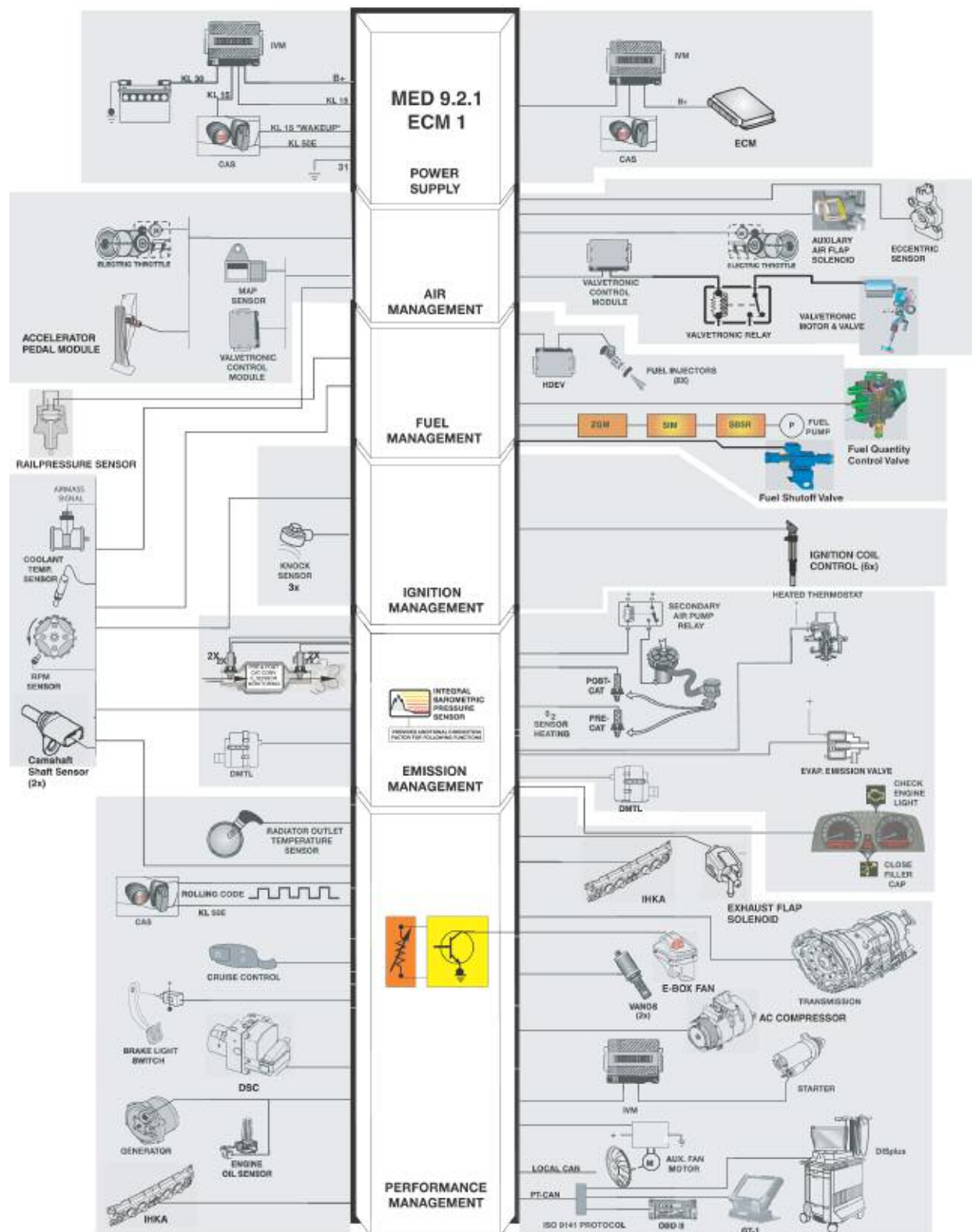
MS45.1: Inputs - Processing - Outputs



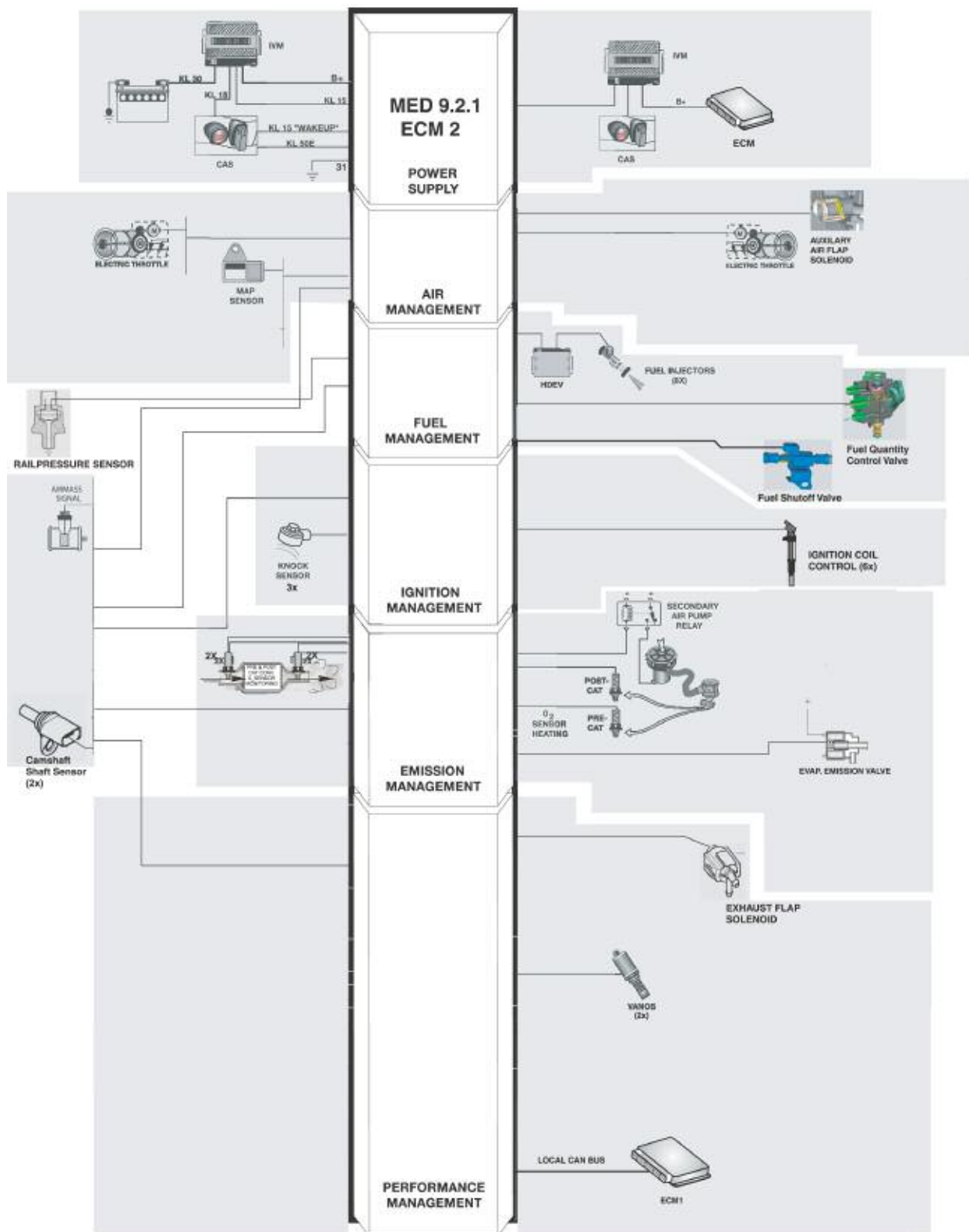
ME 9.2: Inputs - Processing - Outputs



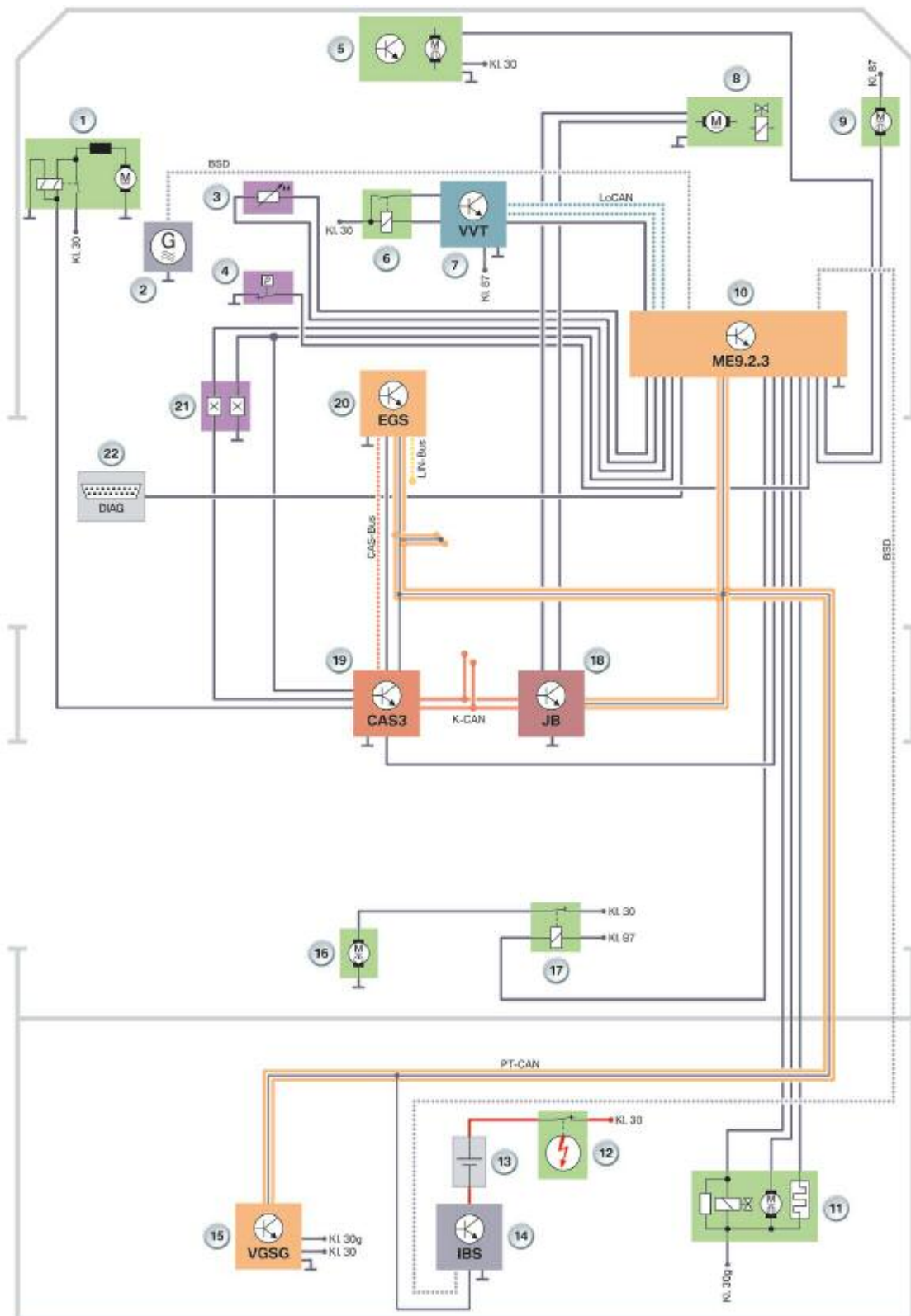
MED 9.2.1: Inputs - Processing - Outputs



MED 9.2.1: Inputs - Processing - Outputs

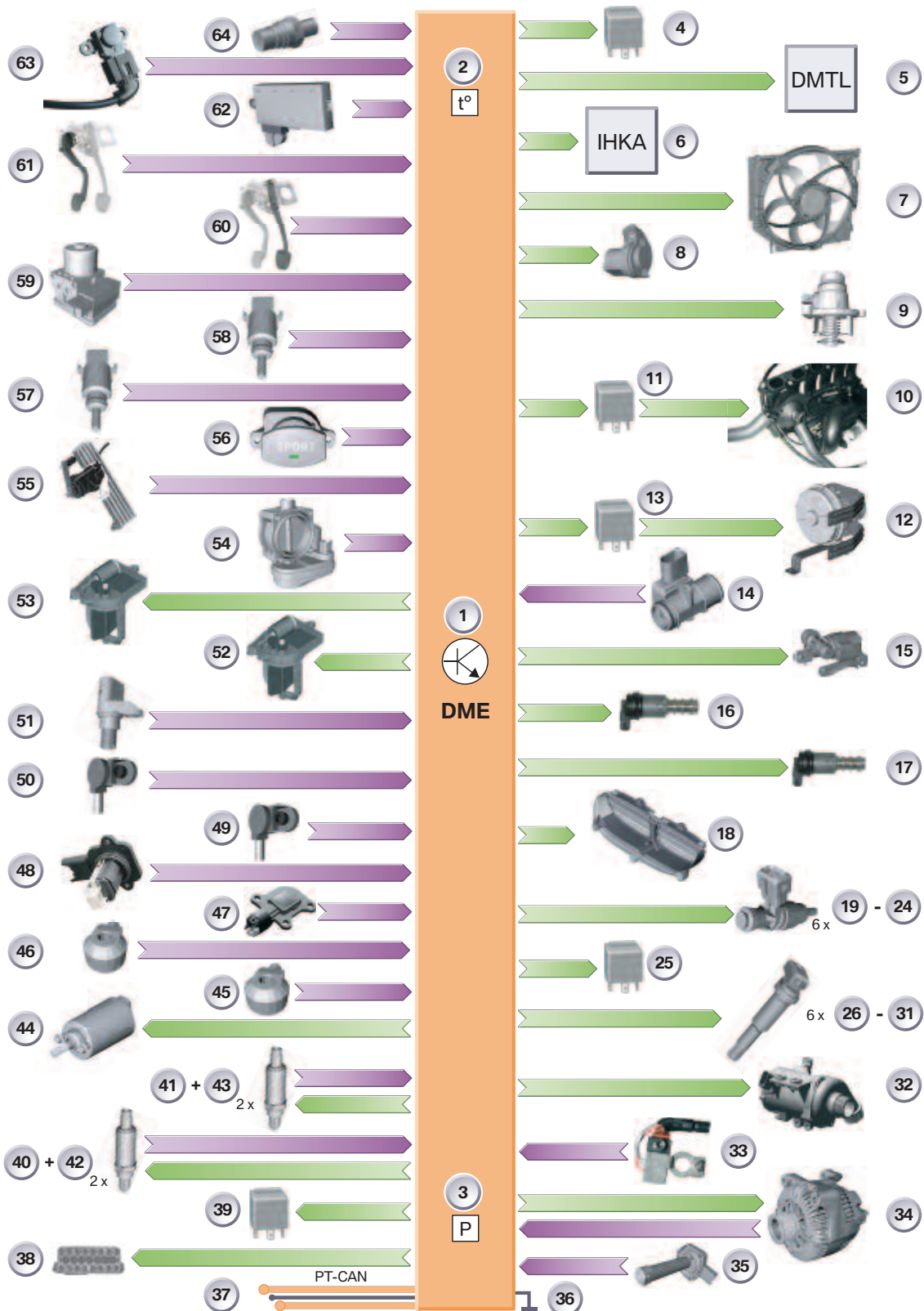


MED 9.2.3: DME Interface (N62)



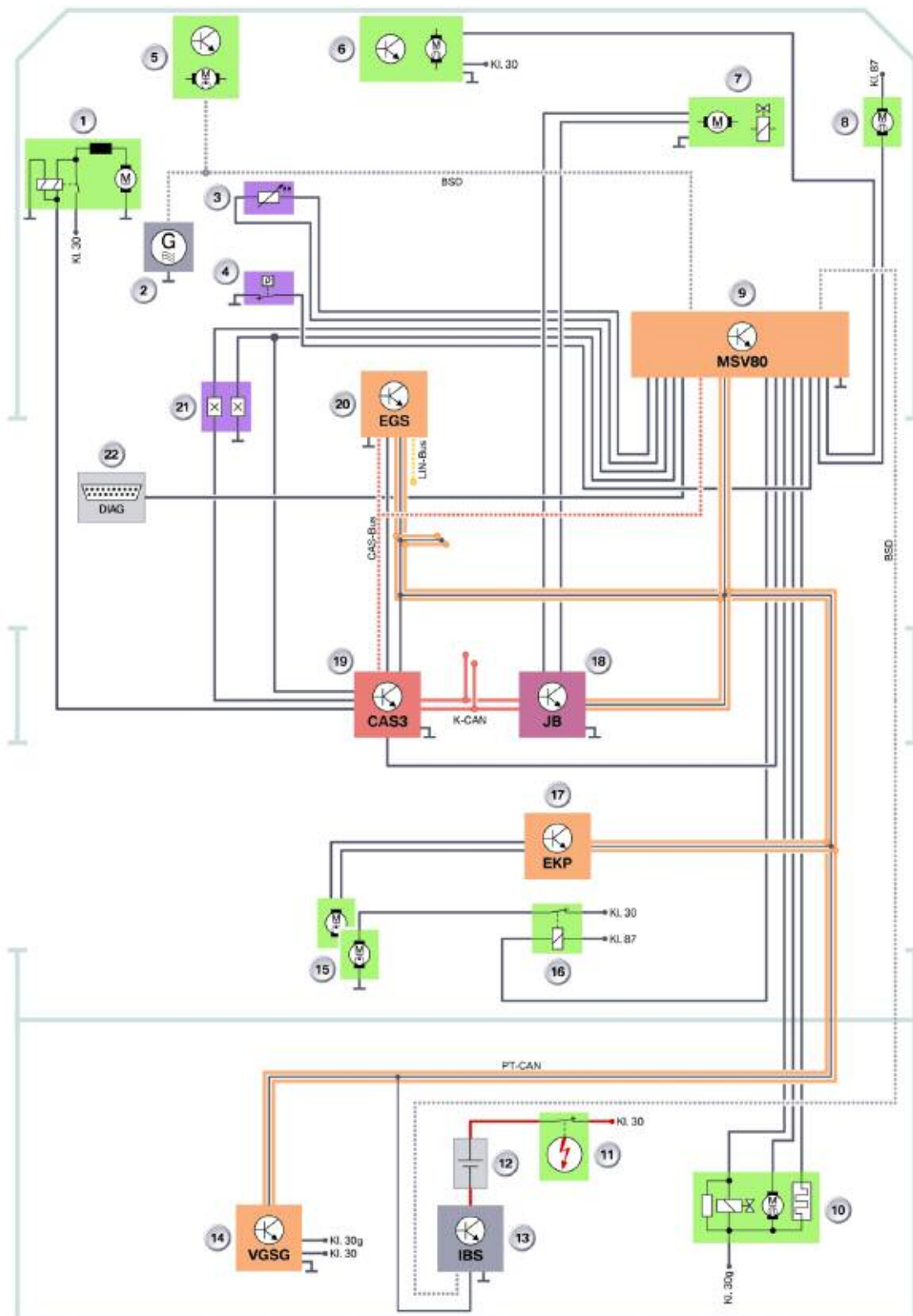
Index	Explanation
1	Starter
2	Alternator
3	Coolant temperature sensor at radiator outlet
4	Oil pressure switch
5	Electric fan (engine cooling)
6	VALVETRONIC relay
7	VALVETRONIC control unit
8	Magnetic clutch, A/C compressor
9	E-box fan
10	DME control unit (Digital Motor Electronics)
11	Diagnosis module for fuel tank leakage (DMTL)
12	Safety battery terminal
13	Battery
14	Intelligent battery sensor
15	Transfer box control unit
16	Electric fuel pump (EKP)
17	EKP relay
18	Junction box control unit
19	CAS control unit (Car Access System)
20	EGS control unit (Electronic Transmission Control)
21	Brake light switch
22	Diagnosis connection

MSV70: Inputs - Processing - Outputs



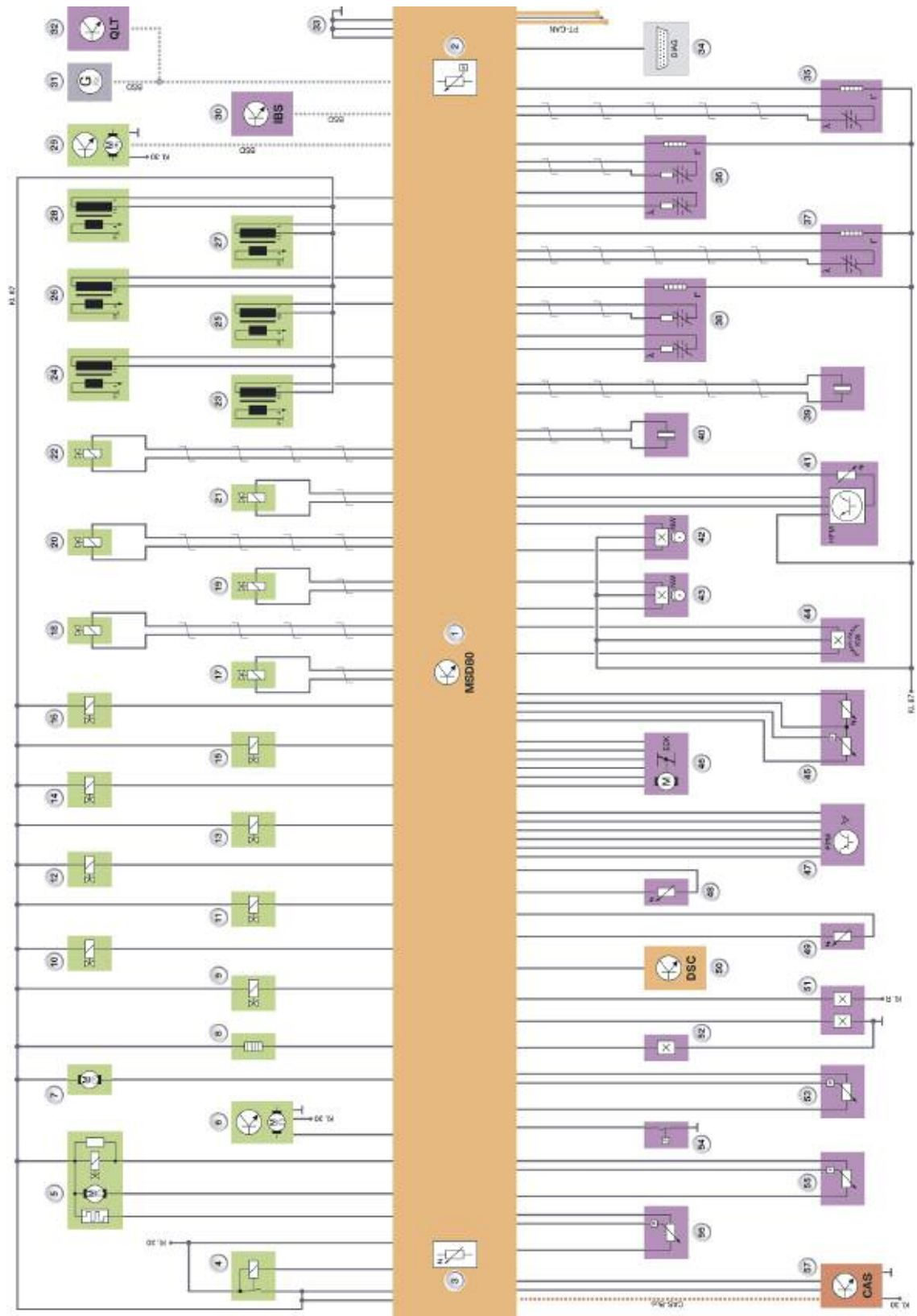
Index	Explanation	Index	Explanation
1	DME (ECM)	38	Diagnosis connection
2	Integral ambient temperature sensor	39	Valvetronic relay
3	Integral ambient pressure sensor	40	Oxygen Sensor
4	DME (ECM) main relay	41	Oxygen Sensor
5	DM-TL	42	Oxygen Sensor
6	IHKA	43	Oxygen Sensor
7	Electric engine cooling fan	44	Valvetronic motor
8	E-Box fan	45	Knock sensor (cyl 1-3)
9	Characteristic map thermostat	46	Knock sensor (cyl 4-6)
10	Crankcase ventilation heater	47	Eccentric shaft sensor
11	Crankcase ventilation heater relay	48	Hot-film air mass meter (HFM)
12	Secondary air pump	49	Exhaust camshaft sensor
13	Secondary air pump relay	50	Intake camshaft sensor
14	HFM for Secondary air	51	Crankshaft sensor
15	Fuel tank vent valve (TEV)	52	DISA actuator
16	VANOS solenoid valve (Intake cam)	53	DISA Actuator
17	VANOS solenoid valve (Exhaust cam)	54	Electric Throttle Valve (EDK)
18	Electro-magnet for airflap control (not for US)	55	Accelerator Pedal Module (FPM)
19-24	Fuel injectors	56	SPORT button
25	Fuel injector relay	57	Coolant temperature sensor (engine temp)
26-31	Ignition coils	58	Coolant temperature sensor (radiator outlet)
32	Electric coolant pump	59	DSC module
33	Intelligent Battery Sensor (IBS)	60	Brake Light Switch (BLS)
34	Alternator	61	Clutch switch
35	Oil Condition Sensor (OZS)	62	Car Access System (CAS)
36	Ground connection	63	Differential pressure sensor
37	PT-CAN	64	Oil pressure switch

MSV80 (N52KP): DME Interface



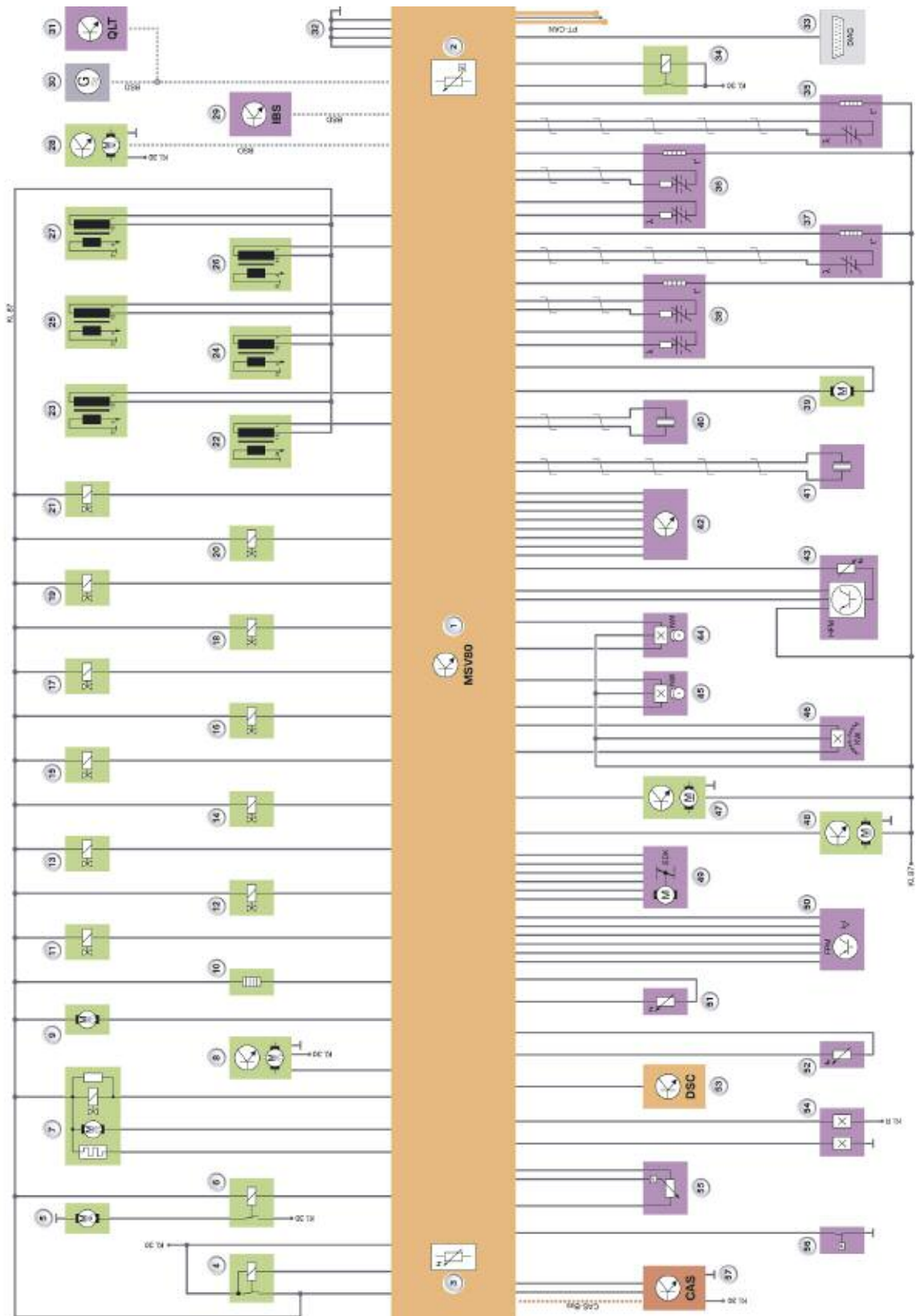
Index	Explanation
1	Starter
2	Alternator
3	Coolant temperature sensor at radiator outlet
4	Oil pressure switch
5	Electric coolant pump (EWP)
6	Electric fan (engine cooling)
7	Magnetic clutch, A/C compressor
8	E-box fan
9	DME control unit (Digital Motor Electronics)
10	Diagnosis module for fuel tank leakage (DMTL)
11	Safety battery terminal
12	Battery
13	Intelligent battery sensor
14	Transfer box control unit
15	Electric fuel pump (EKP)
16	EKP relay
17	EKP module (only ECE)
18	Junction box control unit
19	CAS control unit (Car Access System)
20	EGS control unit (Electronic Transmission Control)
21	Brake light switch
22	Diagnosis connection

MSD80 (E9x): Inputs - Processing - Outputs



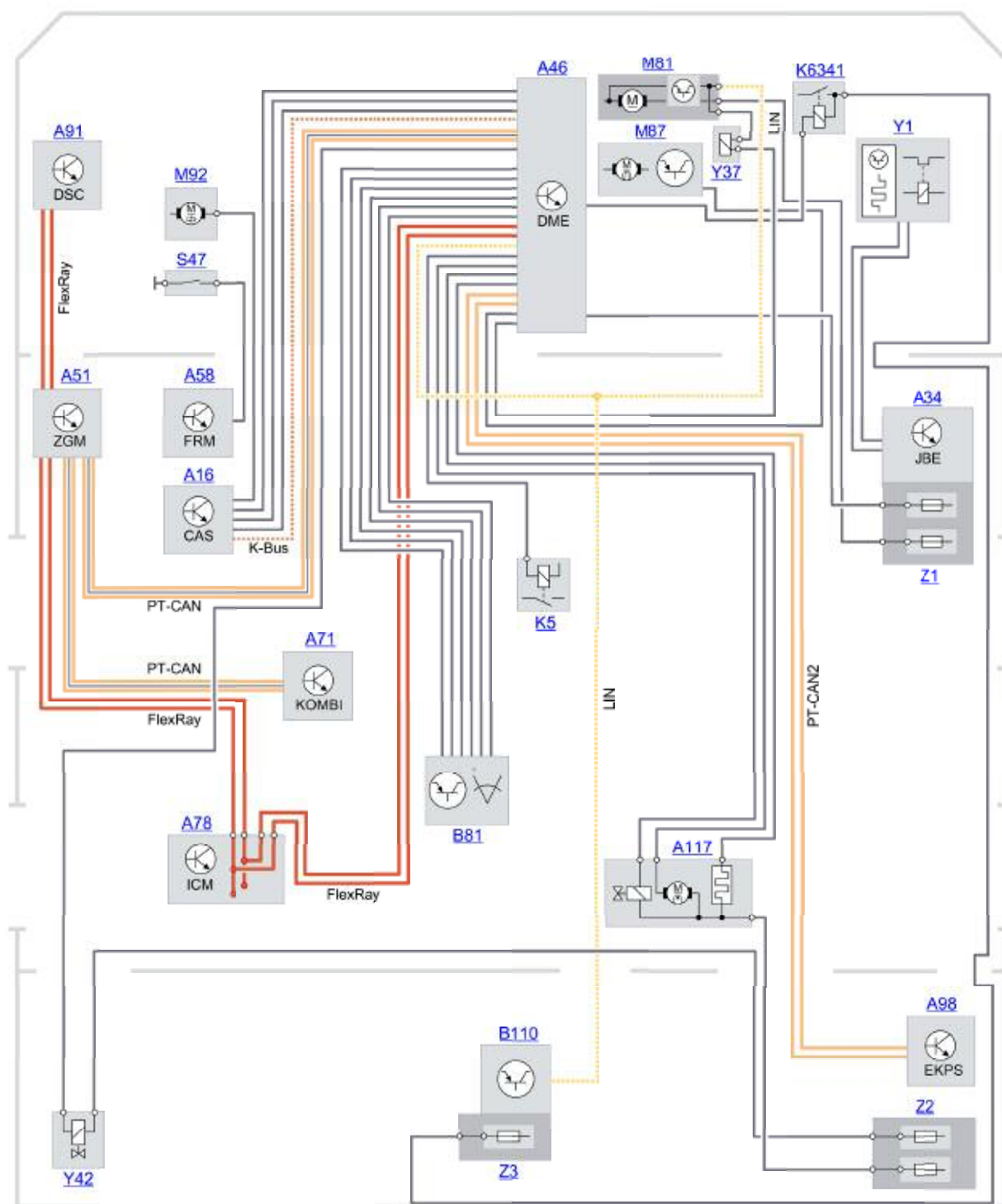
Index	Explanation	Index	Explanation
1	ECM (DME - MSD80)	34	Diagnostics connection
2	Temperature sensor in DME control unit	35	Oxygen sensor (secondary O2 sensor with discontinuous characteristic)
3	Ambient-pressure sensor in DME control unit	36	Oxygen sensor (primary O2 sensor with continuous characteristic)
4	DME main relay	37	Oxygen sensor (secondary O2 sensor with discontinuous characteristic)
5	Diagnosis module for fuel tank leakage (DMTL)	38	Oxygen sensor (primary oxygen sensor with continuous characteristic)
6	Electric fan (engine cooling)	39-40	Knock sensors
7	E-box fan	41	Hot-film air-mass sensor (HFM)
8	Characteristic map thermostat	42	Camshaft sensor, inlet
9	Fuel tank vent valve (TEV)	43	Camshaft sensor, exhaust
10	VANOS solenoid valve, inlet	44	Crankshaft sensor
11	VANOS solenoid valve, exhaust	45	Pressure/temperature sensor before throttle valve (boost pressure)
12	Sound flap	46	Throttle valve
13	Exhaust flap	47	Accelerator pedal module
14	Fuel-supply control valve	48	Coolant-temperature sensor at engine outlet
15	Wastegate valve, bank 1	49	Coolant-temperature sensor at radiator outlet
16	Wastegate valve, bank 2	50	DSC control unit (Dynamic Stability Control)
17-22	Piezo-injectors	51	Brake-light switch
23-28	Ignition coils	52	Clutch switch
29	Electric coolant pump	53	Pressure sensor after throttle valve (intake-manifold pressure)
30	Intelligent battery sensor	54	Oil pressure switch
31	Alternator	55	Low-pressure fuel sensor
32	Oil condition sensor	56	High-pressure fuel sensor (rail pressure sensor)
33	Ground connection	57	CAS control unit (Car Access System)

MSD80 (E7x): Inputs - Processing - Outputs



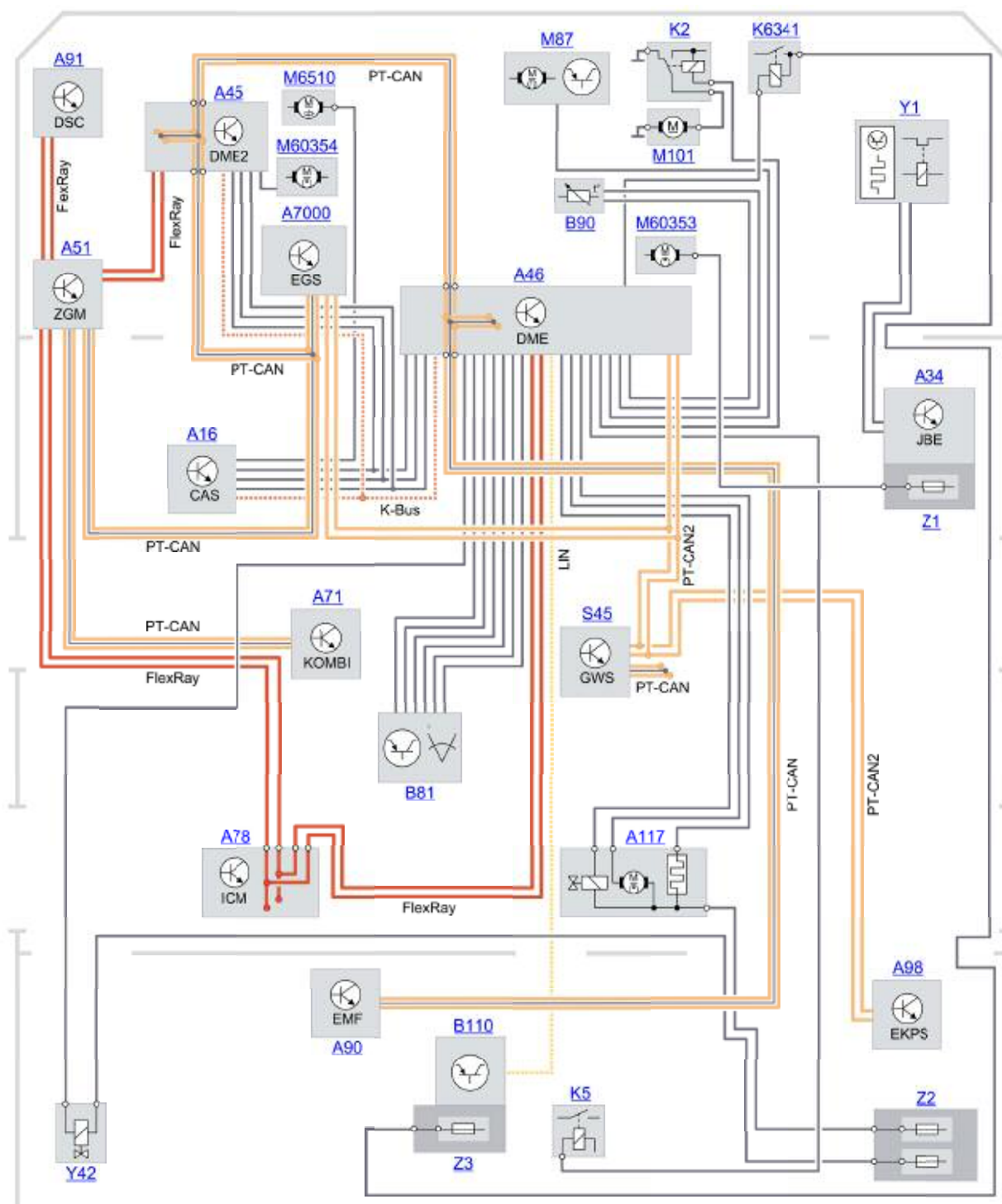
Index	Explanation	Index	Explanation
1	ECM (DME - MSD80)	34	Valvetronic Relay
2	Temperature sensor in DME control unit	35	Oxygen sensor (secondary O2 sensor with discontinuous characteristic)
3	Ambient-pressure sensor in DME control unit	36	Oxygen sensor (primary O2 sensor with continuous characteristic)
4	DME main relay	37	Oxygen sensor (secondary O2 sensor with discontinuous characteristic)
5	Electric Fuel Pump (EKP)	38	Oxygen sensor (primary oxygen sensor with continuous characteristic)
6	EKP Relay	39	Valvetronic actuator motor (VVT)
7	DM-TL	40-41	Knock sensors
8	Electric fan (engine cooling)	42	Eccentric shaft sensor
9	E-box fan	43	Hot-film Air Mass Meter (HFM)
10	Characteristic map thermostat	44	Camshaft sensor, inlet
11	Fuel tank vent valve (TEV)	45	Camshaft sensor, exhaust
12	VANOS solenoid valve, inlet	46	Crankshaft sensor
13	VANOS solenoid valve, exhaust	47	DISA Actuator motor
14	Sound flap	48	DISA Actuator motor
15	Exhaust flap	49	Throttle valve
16-21	Fuel injectors	50	Accelerator pedal module
22-27	Ignition coils	51	Coolant-temperature sensor at engine outlet
28	Electric coolant pump	52	Coolant-temperature sensor at radiator outlet
29	Intelligent battery sensor	53	DSC control unit
30	Alternator	54	Brake light switch
31	Oil condition sensor	55	Differential pressure sensor
32	Ground connection	56	Oil pressure switch
33	Diagnostics connection	57	CAS control unit (Car Access System)

MSD80 (N52): DME Interface



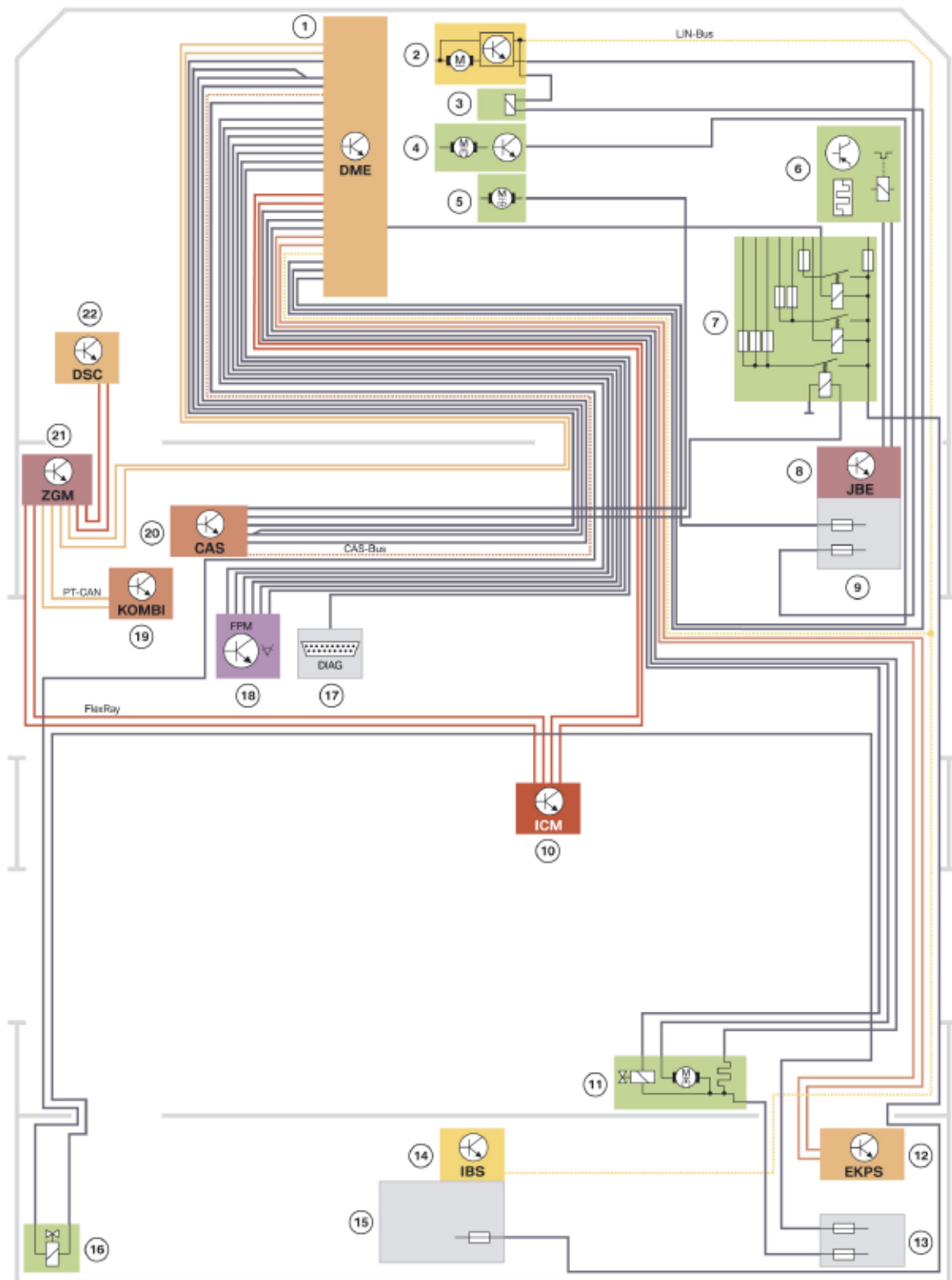
ISTA wiring schematic: SSP-BSB-T6109024 Motor interface N52

MSD81 (N54): DME Interface



ISTA wiring schematic: SSP-BSB-T6109019 Motor interface N54

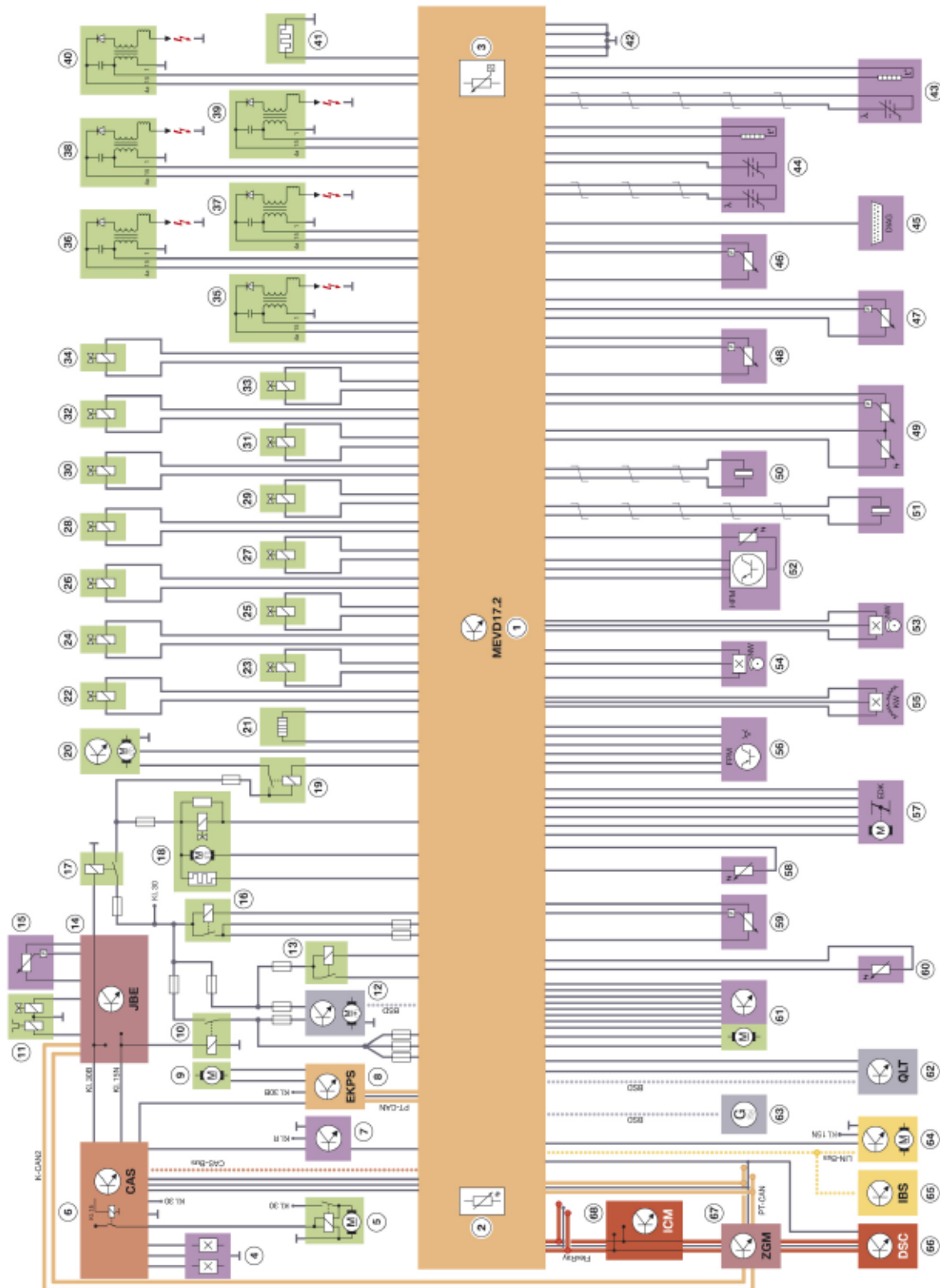
MEVD17.2 (N55): DME Interface



ISTA wiring schematic: SSP-BSB-T6109023 Motor interface N55

Index	Explanation
1	Digital Motor Electronics
2	Electric air flap control
3	Mechanical air flap control
4	Electric fan
5	Starter
6	A/C compressor
7	Front power distribution box
8	Junction box electronics
9	Junction box
10	Integrated Chassis Management
11	Fuel tank leak diagnostic module
12	Electronic fuel pump controller
13	Rear power distribution box
14	Intelligent battery sensor
15	Battery power distribution box
16	Exhaust flap changeover valve
17	Diagnosis socket (engine speed signal)
18	Accelerator pedal module
19	Instrument cluster
20	Car Access System
21	Central Gateway Module

MEVD17.2 (N55): Inputs - Processing - Outputs



Index	Explanation	Index	Explanation
1	Engine electronics Valvetronic, direct injection 17.2 MEVD17.2	35-40	Ignition coils
2	Ambient pressure sensor	41	Engine breather heater
3	Temperature sensor	42	Ground connections
4	Brake light switch	43	Oxygen sensor after catalytic converter
5	Starter	44	Oxygen sensor before catalytic converter
6	Car Access System (CAS)	45	Diagnostic socket
7	Clutch module	46	Low-pressure fuel sensor
8	Electronic fuel pump control (EKPS)	47	Intake manifold pressure sensor after throttle valve
9	Electric fuel pump	48	Fuel rail pressure sensor
10	Terminal 15N relay	49	Charge air temperature and pressure sensor
11	A/C compressor	50	Knock sensor, cylinders 1 - 3
12	Coolant pump	51	Knock sensor, cylinders 4 - 6
13	Valvetronic relay	52	Hot-film air mass meter (HFM)
14	Junction Box Electronics (JBE)	53	Intake camshaft sensor
15	Refrigerant pressure sensor	54	Exhaust camshaft sensor
16	Relay, ignition and injection	55	Crankshaft sensor
17	Terminal 30B relay	56	Accelerator Pedal Module (FPM)
18	Fuel tank leak diagnosis module (DMTL)	57	Throttle valve (MDK)
19	Electric fan relay	58	Coolant temperature sensor at engine outlet
20	Electric fan	59	Oil pressure sensor
21	Characteristic map thermostat	60	Oil temperature sensor
22	Diverter valve	61	Valvetronic servomotor
23	Fuel tank vent valve	62	Oil condition sensor
24	VANOS solenoid valve, intake camshaft	63	Alternator
25	VANOS solenoid valve, exhaust camshaft	64	Active cooling air flap control
26	Oil pressure control valve	65	Intelligent battery sensor (IBS)
27	Electropneumatic pressure converter (EPDW) for wastegate valve	66	Dynamic stability control (DSC)
28	Quantity control valve	67	Central Gateway Module (ZGM)
29-34	Fuel injectors	68	Integrated Chassis Management (ICM)

MEVD17.2 Control Unit

The N55 engine is equipped with the Bosch engine management MEVD17.2 :

- The MEVD17.2 is integrated in the intake system and is cooled by the intake air.
- The MEVD17.2 is FlexRay-compatible and directly supplies voltage to the sensors and actuators.

The top side of the DME housing also serves as the bottom section of the intake manifold. The housing is contoured in the area of the intake manifold to ensure optimum air flow. An O ring type seal is installed between the DME housing and the intake. The plug connections between the wiring harness and DME are water-tight.

N55, engine management MEVD17.2



Index	Explanation
1	Engine wiring harness, sensor 1 (Module 100)
2	Engine wiring harness, sensor 2 (Module 200)
3	Connection, vehicle wiring harness (Module 300)
4	Engine wiring harness, Valvetronic (Module 400)
5	Connection, voltage supply (Module 500)
6	Engine wiring harness, injection and ignition (Module 600)

For the first time, an engine-mounted Digital Motor Electronics (DME) module is used. The DME is bolted to the intake manifold and is cooled by the intake air.

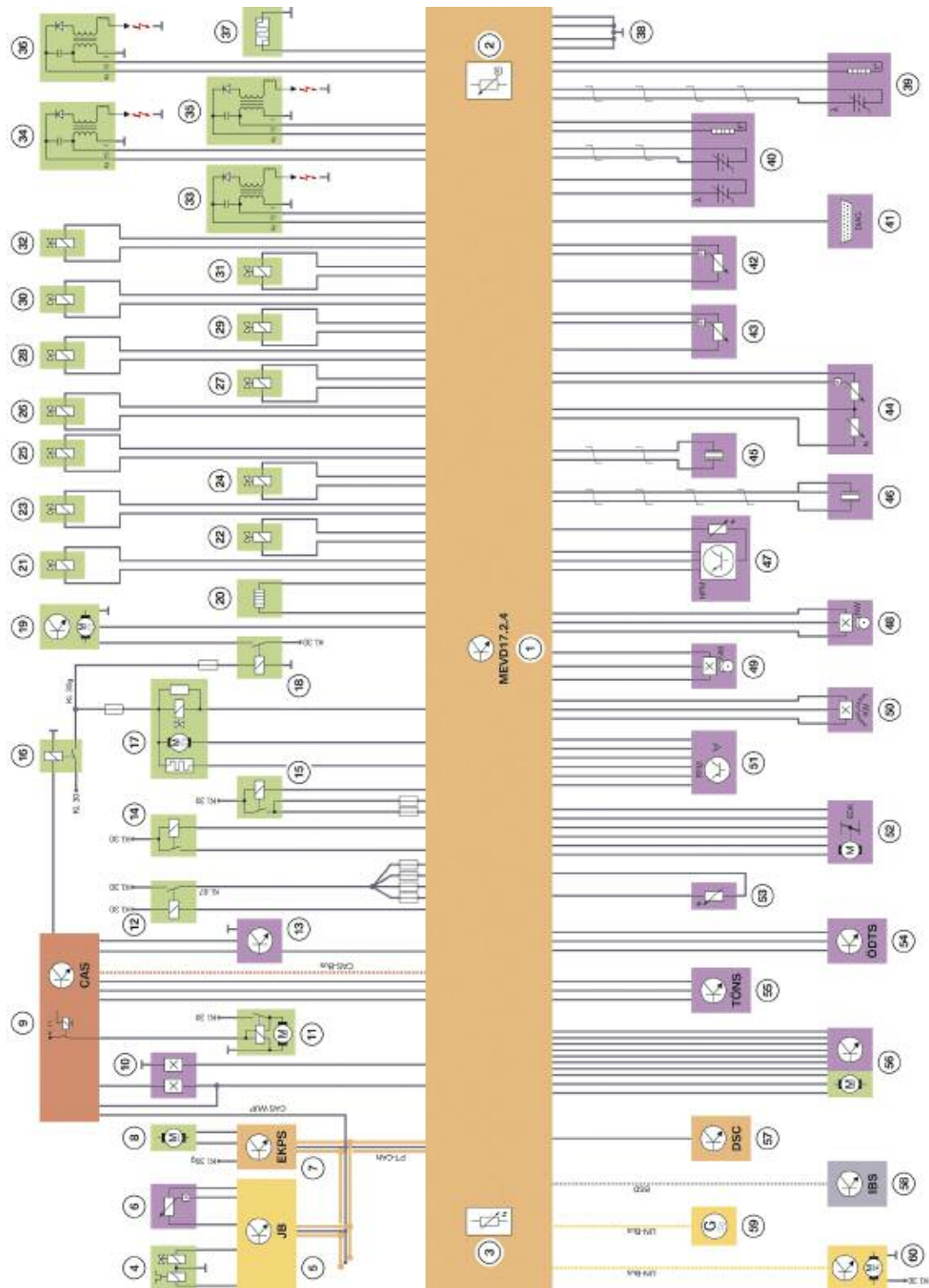
The engine mounted DME has the following advantages:

- Engine wiring harness is divided into six individual modules
- All electrical components on the engine are supplied directly via the DME
- The E-box is no longer needed
- 211 pins are available
- The plug-in connectors are water-tight

N55, wiring harness routing

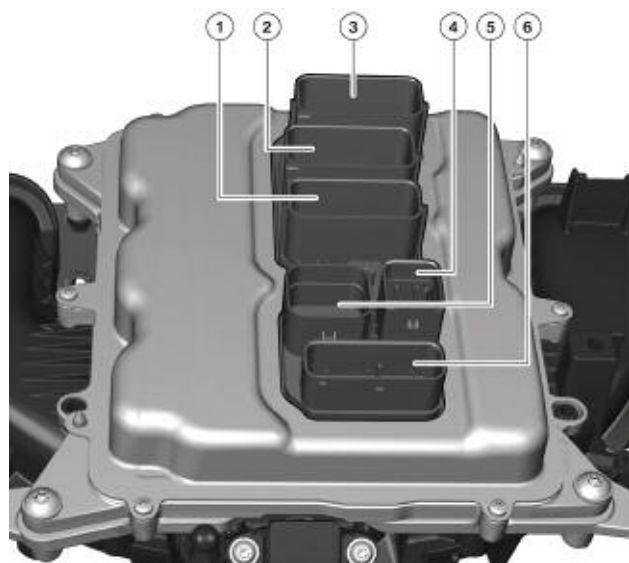


MEVD17.2.4 (N20/N26): Inputs - Processing - Outputs



Index	Explanation	Index	Explanation
1	Engine electronics Valvetronic direct fuel injection MEVD17.2.4	28	Quantity control valve
2	Ambient pressure sensor	29-32	Fuel injectors
3	Temperature sensor	33-36	Ignition coils
4	A/C compressor	37	Engine breather heater
5	Junction box electronics	38	Ground connections
6	Refrigerant pressure sensor	39	Oxygen sensor after catalytic converter
7	Electronic fuel pump control	40	Oxygen sensor before catalytic converter
8	Electric fuel pump	41	Diagnostic socket
9	Car Access System CAS	42	Intake manifold pressure sensor
10	Brake light switch	43	Rail pressure sensor
11	Starter motor	44	Charge air temperature and pressure sensor
12	DME main relay	45	Knock sensor 1 – 2
13	Clutch module	46	Knock sensor 3 – 4
14	Relay, Valvetronic	47	Hot-film air mass meter
15	Relay, ignition and injectors	48	Camshaft sensor, intake camshaft
16	Relay, terminal 30 switched	49	Camshaft sensor, exhaust camshaft
17	Diagnosis module, tank ventilation	50	Crankshaft sensor
18	Relay for electric fan	51	Accelerator pedal module
19	Electric fan	52	Throttle valve
20	Map thermostat	53	Coolant temperature sensor
21	Blowoff valve	54	Oil pressure and temperature sensor
22	Tank vent valve	55	Thermal oil level sensor
23	VANOS solenoid actuator, intake camshaft	56	Valvetronic servomotor
24	VANOS solenoid valve, exhaust camshaft	57	Dynamic Stability Control DSC
25	Switchable engine sound system	58	Intelligent battery sensor IBS
26	Map control valve	59	Alternator
27	Electro-pneumatic pressure converter for wastegate valve	60	Coolant pump

The N20 engine DME (MEVD17.2.4) is designed to be mounted on the engine's intake manifold on an aluminum heat sink plate. The DME is cooled through the heat sink plate by the air flowing through the intake manifold. It is important for the DME to be correctly mounted on the heat sink plate (tightening torque, good level contact) so as to ensure heat transfer to the plate and thereby cool the DME. The connect concept is identical to the MEVD 17.2 used in the N55 engine. There is a logical division into six modules.



Index	Explanation
1	Module 100, vehicle connection, 48 pins
2	Module 200, sensors and actuators 1, 58 pins
3	Module 300, sensors and actuators 2, 58 pins
4	Module 400, Valvetronic servomotor, 11 pins
5	Module 500, DME supply, 12 pins
6	Module 600, fuel injection and ignition, 24 pins

The Digital Engine Electronics (DME) is the computing and switching center of the engine management system. Sensors on the engine and the vehicle deliver the input signals. The signals for activating the actuators are calculated from the input signals, the nominal values calculated using a computing model in the DME control unit and the stored program maps. The DME control unit activates the actuators directly or via relays.

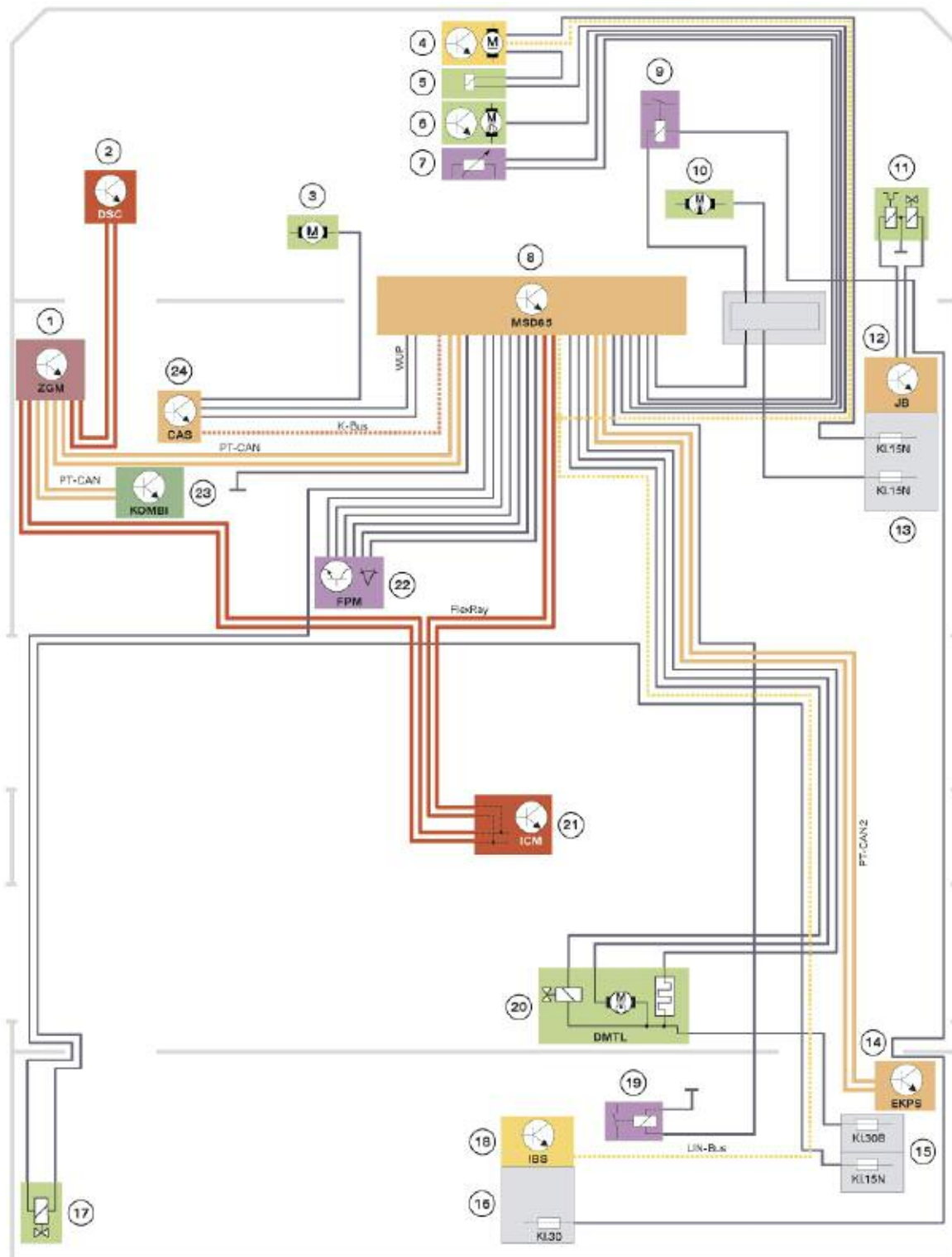
The DME control unit is woken up via the wake-up line (terminal 15 Wake-up) by the Car Access System (CAS).

The after-run starts after terminal 15 OFF. The adaptation values are stored during the after-run.

The DME control unit uses a bus signal to signal its readiness to “go to sleep”. When all the participating control units have signalled their readiness to “go to sleep”, the bus master outputs a bus signal and the control units terminate communication five seconds later.

The printed circuit board in the DME control unit accommodates two sensors: a temperature sensor and an ambient pressure sensor. The temperature sensor is used to monitor the temperature of the components in the DME control unit. The ambient pressure is required for calculating the air/fuel mixture.

MSD85 (N63): DME Interface



ISTA wiring schematic: SSP-BSB-T6109021 Motor interface N63

Index	Explanation	Index	Explanation
1	Central gateway module	13	Junction box power distributor
2	Dynamic Stability Control	14	Electronic fuel pump controller
3	Starter	15	Power distributor, rear right
4	Active cooling air flaps	16	Power distributor, battery
5	Passive cooling air flaps	17	Exhaust flaps
6	Electric fan	18	Intelligent battery sensor
7	Coolant temperature sensor at radiator outlet	19	Electric fan relay
8	MSD85	20	Fuel tank leak diagnostic module
9	Electric auxiliary coolant pump for charge air cooling	21	Integrated Chassis Management
10	DME main relay	22	Accelerator pedal module
11	A/C compressor	23	Instrument cluster
12	Junction box electronics	24	Car Access System

MSD85 Control Unit

Due to the changes brought about with the new N63 engine, the engine management system has been adapted accordingly.

The new system, designated MSD85, works in conjunction with the High Precision Injection (HPI) system which is familiar from the N54 engine.

The high level of technology on the N63 engine place high demands on the DME system. The ECM used features a very powerful 150 MHz processor and features a new connector concept.

The connector concept consists of five chambers and functional configuration. This means each chamber is assigned to a specific function group.



The following list outlines the configuration of the chambers in corresponding order:

- Chamber 1 (8 pins): Ignition
- Chamber 2 (59 pins): Engine plug, cylinder bank 1 and several central engine functions
- Chamber 3 (40 pins): Vehicle plug
- Chamber 4 (54 pins): Engine plug, cylinder bank 2 and several central engine functions
- Chamber 5 (16 pins): Fuel injection

An engine plug relates to sensor/actuator connections on the engine while the vehicle plug represents the interface to the vehicle specific components.

The functions of the engine management system are described in the respective systems.



The N63 engine is controlled by the MSD85. This control unit has been modified to make it compatible with the FlexRay bus.

The control unit is located to the front of the right-side spring strut dome. This control unit is liquid-cooled rather than air-cooled.

For this purpose, the housing of the control unit features two windings in the one coolant line, which is connected to the low temperature cooling circuit for charge air cooling.

The lower section of the electronics box is open to the outside. The upper section, which contains the connections, has a watertight seal.

Cooling of the engine control unit of the N63 engine

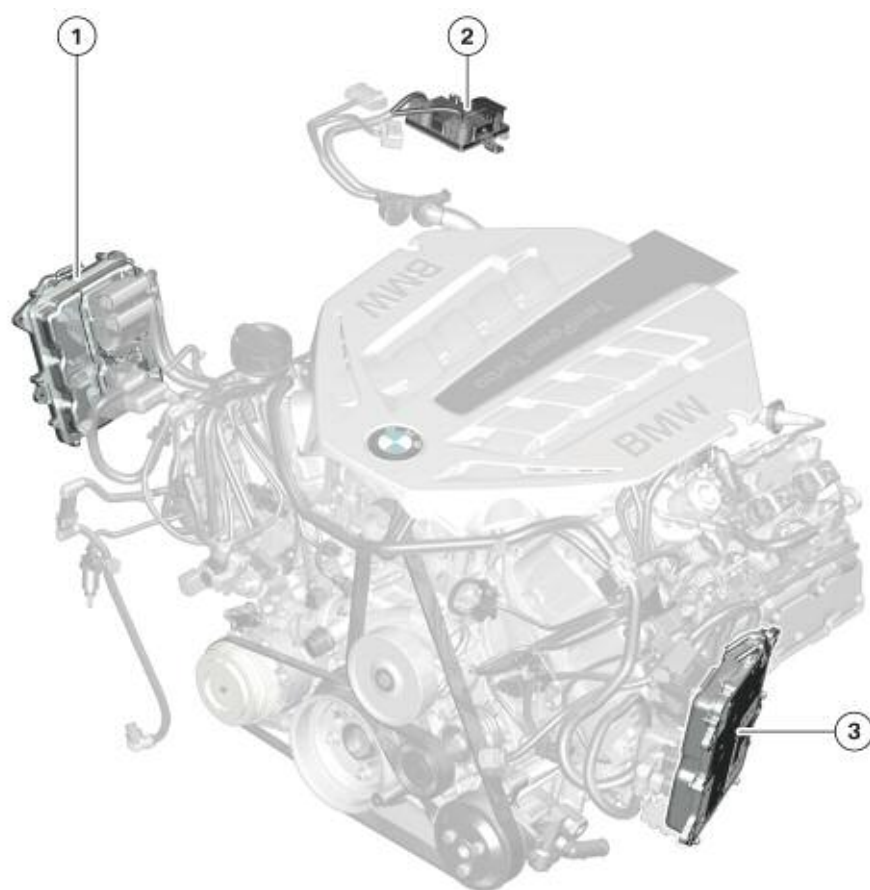


Index	Explanation	Index	Explanation
1	Sealing frame	5	Coolant line
2	Electronics box cover	6	Engine control unit
3	Coolant return	7	Electronics box
4	Coolant supply		

MEVD17.2.8 Control Unit (N63TU)

The N63TU engine uses a Bosch DME with the designation MEVD17.2.8. It is strongly related to the Digital Engine Electronics of the N55 engine. There is a separate water-cooled engine control unit fixed to the engine for every bank. The actuators and sensors of bank one are assigned to the DME 1 control unit, the DME 2 control unit is responsible for the functions of bank two. DME 1 is the master control unit and also assumes all information concerning the entire engine, such as turning on the crankshaft sensor and making it available to the DME 2 control unit directly or via the bus system. Due to the variety of sensors and actuators a distribution to two control units was necessary.

N63TU, Digital Engine Electronics



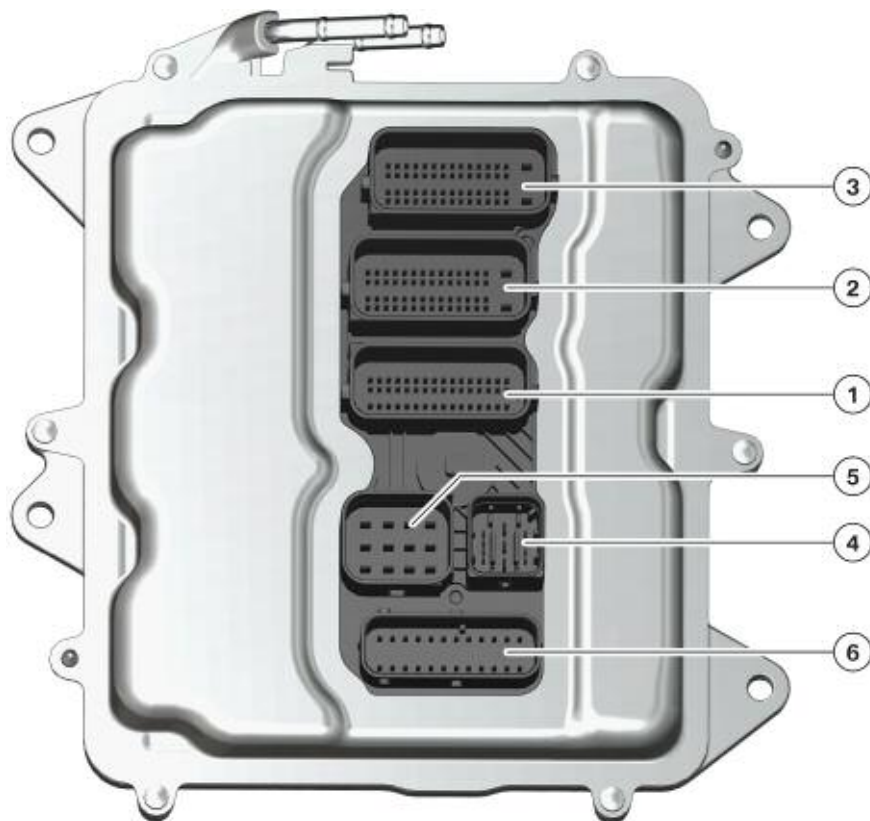
Index	Explanation
1	DME control unit, bank 1
2	Power distribution boxes
3	DME control unit, bank 2

Note: Do not attempt any trial replacement of control units.

Because of the electronic immobilizer, a trial replacement of control units from other vehicles must not be attempted under any circumstances. An immobilizer adjustment cannot be reversed.

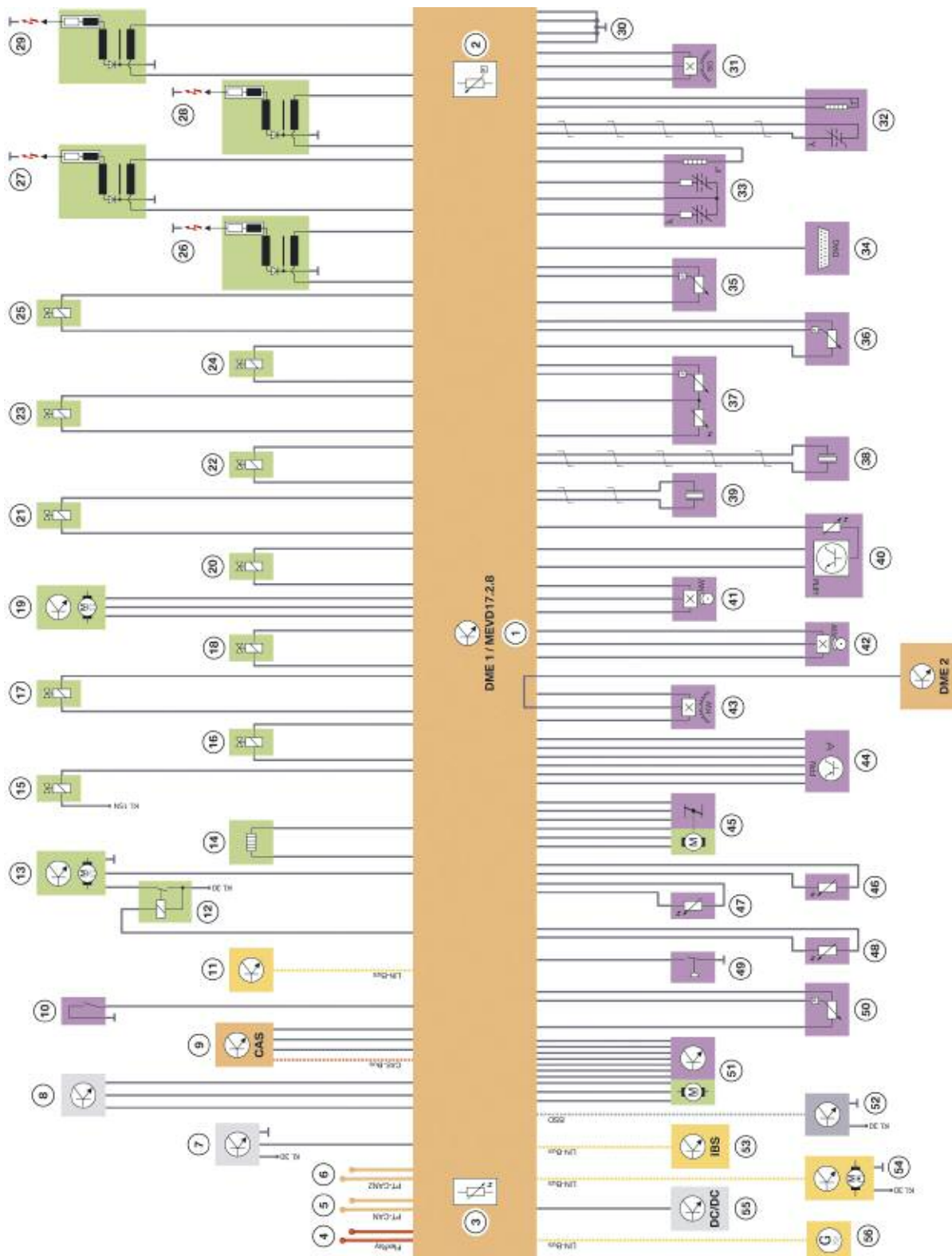
The cooling of the two control units of the Digital Engine Electronics is done by connection to the cooling circuit of the charge air cooling. An aluminum cooling loop is integrated in the housing base of the control units for this system.

The plug connector concept is identical to the MEVD17.2 in the N55 engine. There is a logical division into six modules.



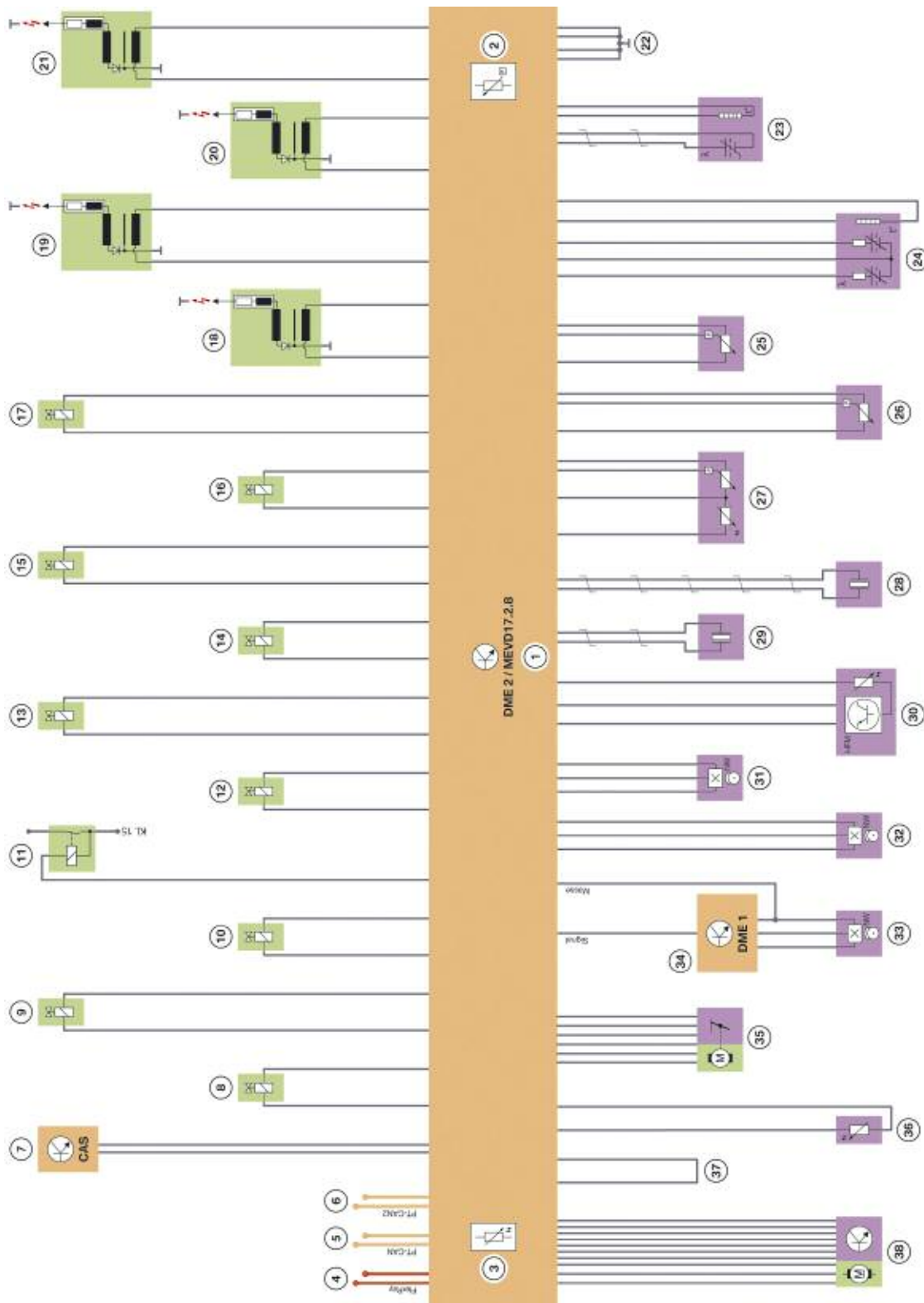
Index	Explanation	Index	Explanation
1	Module 100, vehicle connection, 48 pins	4	Module 400, Valvetronic servomotor, 11 pins
2	Module 200, sensors and actuators 1, 58 pins	5	Module 500, DME supply, 12 pins
3	Module 300, sensors and actuators 2, 58 pins	6	Module 600, fuel injection and ignition, 24 pins

N63TU, DME 1/system wiring diagram MEVD17.2.8



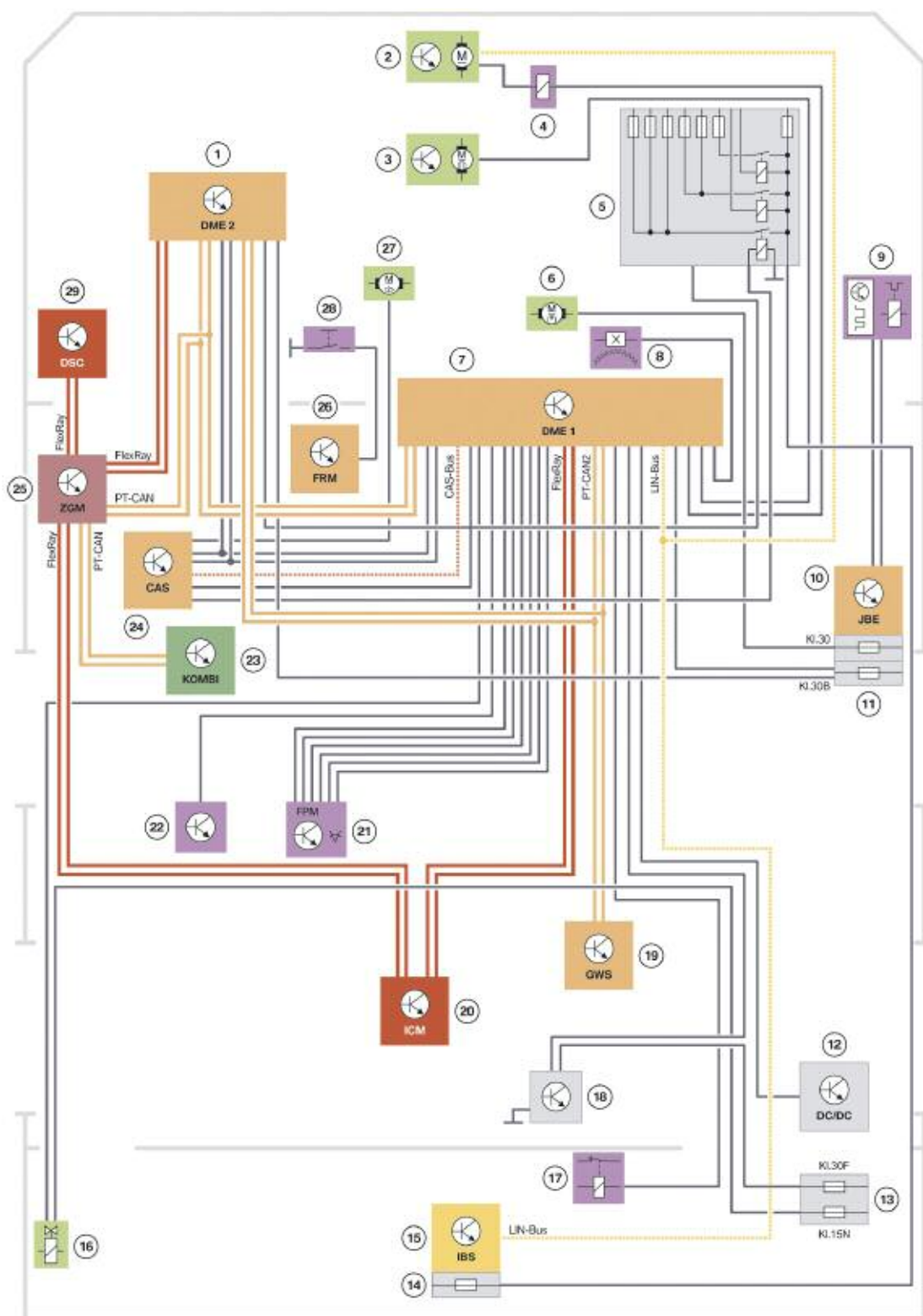
Index	Explanation	Index	Explanation
1	Engine electronics Valvetronic direct fuel injection MEVD17.2.8 DME 1	33	Oxygen sensor LSU ADV
2	Ambient pressure sensor	34	Engine speed signal diagnostic connector
3	Temperature sensor	35	Charging pressure sensor before throttle valve
4	FlexRay	36	Rail pressure sensor
5	PT-CAN	37	Charge air temperature sensor and intake-manifold pressure sensor after throttle valve
6	PT-CAN2	38	Knock sensors 1 – 2
7	Tank leak diagnosis, Natural Vacuum Leak Detection	39	Knock sensors 3 - 4
8	Zero-gear sensor(only with MSA function, manual gearbox)	40	Hot film air mass meter (HFM) 7
9	Car Access System (CAS)	41	Camshaft sensor, intake camshaft
10	Clutch switch (with manual gearbox only)	42	Camshaft sensor, exhaust camshaft
11	Active cowl flap control	43	Crankshaft sensor, signal is looped through to DME slave
12	Relay for electric fan	44	Accelerator pedal module
13	Electric fan	45	Throttle valve
14	Map thermostat	46	Engine temperature (sensor at housing of coolant pump)
15	Exhaust flaps (1 valve, 2 flaps)	47	Coolant temperature at radiator outlet
16	Tank vent valve	48	Oil temperature sensor
17	VANOS solenoid valve, intake camshaft	49	Oil pressure switch
18	VANOS solenoid valve, exhaust camshaft	50	Brake vacuum sensor (only with MSA function, manual gearbox)
19	Electric coolant pump, exhaust turbocharger	51	Valvetronic servomotor
20	Electropneumatic pressure converter (EPDW) wastegate	52	Oil level sensor
21	Quantity control valve	53	Intelligent battery sensor (IBS)
22-25	Injectors	54	Electric coolant pump, charge air cooler and Digital Engine Electronics (DME)
26-29	Ignition coils	55	DC/DC converter (for MSA function)
30	Ground	56	Alternator
31	Speed sensor (manual gearbox only)		
32	Oxygen sensor LSF4.2		

N63TU, DME 2/system wiring diagram MEVD17.2.8



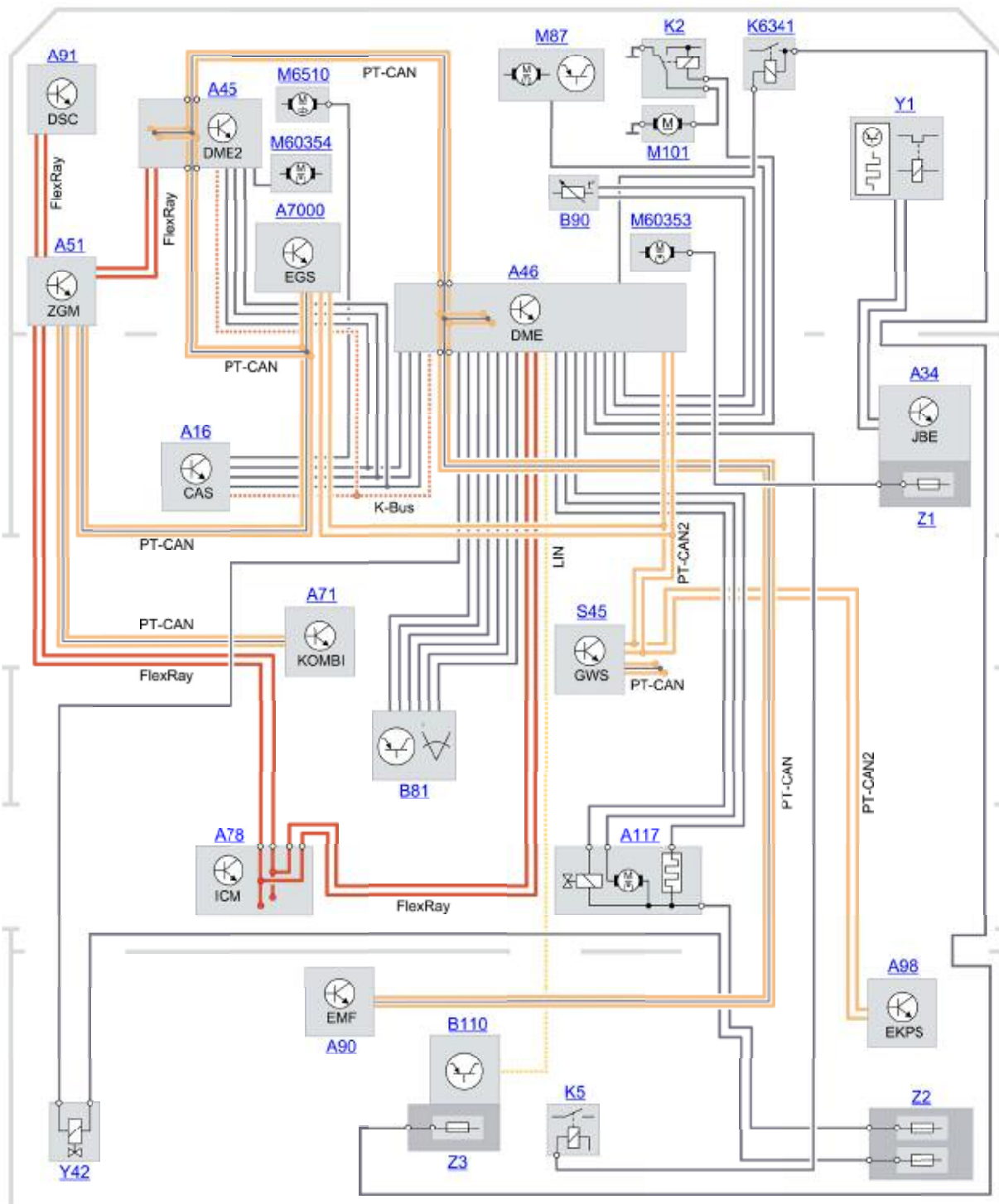
Index	Explanation	Index	Explanation
1	Engine electronics Valvetronic direct fuel injection MEVD17.2.8 DME 2	23	Oxygen sensor LSF4.2
2	Ambient pressure sensor	24	Oxygen sensor LSU ADV
3	Temperature sensor	25	Charging pressure sensor before throttle valve
4	FlexRay	26	Rail pressure sensor
5	PT-CAN	27	Charge air temperature and intake-manifold pressure sensor after throttle valve
6	PT-CAN2	28	Knock sensors 5 - 6
7	Car Access System (CAS)	29	Knock sensors 7 - 8
8	Tank vent valve	30	Hot film air mass meter (HFM) 7
9	VANOS solenoid valve, intake camshaft	31	Camshaft sensor, intake camshaft
10	VANOS solenoid valve, exhaust camshaft	32	Camshaft sensor, exhaust camshaft
11	Relay, transmission oil pump (manual gearbox only)	33	Crankshaft sensor
12	Pressure converter (EPDW)	34	Digital Engine Electronics (DME) master
13	Quantity control valve	35	Throttle valve
14-17	Injector	36	NTC transmission oil temperature (only with manual gearbox)
18-21	Ignition coil	37	DME 1/ DME 2 encoding
22	Ground	38	Valvetronic servomotor

N63TU, vehicle connection module 100 of DME 1 and DME 2



Index	Explanation
1	Digital Engine Electronics (DME 2)
2	Automatic air flap control
3	Electric fan
4	Solenoid for the automatic air flap control
5	Power distribution boxes
6	Electric auxiliary water pump for charge air and DME
7	Digital Engine Electronics (DME 1)
8	Transmission speed sensor (manual gearbox only)
9	A/C compressor
10	Junction box (JB)
11	Fuse, terminal 30B
12	DC/DC converter (for automatic engine start-stop function)
13	Rear right power distribution box
14	Fuse, terminal 30
15	Intelligent battery sensor (IBS)
16	Valve, exhaust flap
17	Relay for electric fan
18	Tank leak diagnosis (only for US)
19	Gear selector lever (only automatic)
20	Integrated Chassis Management (ICM)
21	Accelerator pedal module
22	Coupling switch module (manual gearbox only)
23	Instrument cluster
24	Car Access System (CAS)
25	Central gateway module (CGM)
26	Footwell module (FRM)
27	Starter motor
28	Switch reversing light (manual gearbox only)
29	Dynamic Stability Control DSC

MSD87-12 (N74): DME Interface



ISTA wiring schematic: SSP-BSB-T6109020 Motor interface N74

MSD87-12: Control Unit

Two water-cooled MSD87-12 control units are used. The same water tight components as those on the MSD85 (N63 engine in the F01) have been used. As on the predecessor engine N73, a primary (master) and secondary concept strategy has been implemented with the two control units. They have the same hardware, software and data records. The connected sensor system runs an automatic primary (master) and secondary identification. In this arrangement, the master is responsible for communication with the complete vehicle and the specified nominal values for the engine functions. The control unit is designed with the current software for the vehicle network with FlexRay.

NOTES

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Air Management

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Air Management

Model: All

Production: All

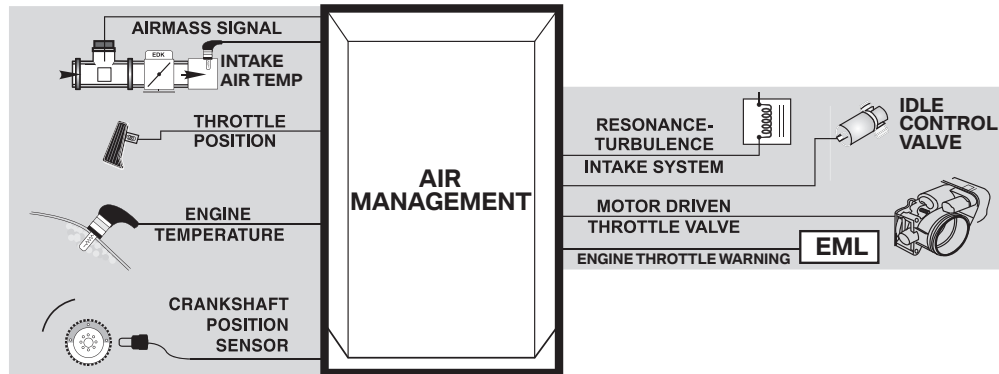
OBJECTIVES

After completion of this module you will be able to:

- Understand how different intake manifolds and air intake systems function
- Understand how the Air System influences Engine Management
- Be able to test the Mass Air Flow system
- Be able to test the throttle assembly and the inputs that affect the throttle
- Understand EDK and Idle Air Actuator operation

Air Management

Example of IPO for an Air Management System

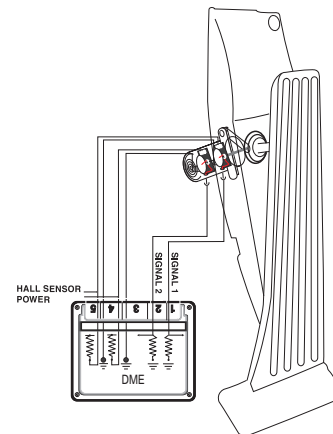


One of the main purposes of the ECM is Air Management which includes the actuation of several components. In the following pages you will find a generic explanation on how this system works. For more detailed information please access BMW Training Reference Manuals found online.

Air flow into the engine is regulated by the Throttle Valve and/or the Idle Air Actuator. Both of these air “passages” are necessary for smooth engine operation from idle to full load. The Throttle Valve and the Idle Air Actuator are **electrically controlled**. All of the ECM monitoring, processing and output functions are a result of regulated air flow.

Accelerator Pedal Position (Pedalwertgeber - PWG)

The Accelerator Pedal Position is monitored by the ECM for pedal angle position and rate of movement. As the accelerator is moved, it provides two variable voltage signals to the ECM that represents accelerator pedal position and rate of movement.



Dual Hall Sensors are integral in the accelerator pedal module. The ECM compares the two values for **plausibility**. The module contains internal springs to return the accelerator pedal to the rest position.

The ECM will increase the volume of fuel injected into the engine, advance the ignition timing and open the Throttle Valve and/or Idle Air Actuator.

The “full throttle” position indicates maximum acceleration to the ECM, and in addition to the functions just mentioned, this will have an effect on the air conditioning compressor.

As the accelerator pedal is released (integral springs), a decrease in voltage signals the ECM to activate fuel shut off if the RPM is above idle speed (coasting). When the Throttle Valve is completely closed, the Idle Air Actuator is opened to maintain engine idle speed.

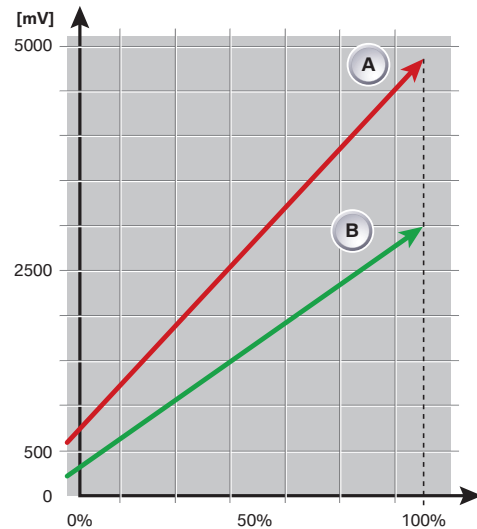
The ECM monitors the engine idle speed in addition to the accelerator pedal position and throttle position voltage. If the voltage values have changed (mechanical wear of throttle plate or linkage), the ECM will adjust the Idle Air Actuator to maintain the correct idle speed.

The Potentiometers/Hall sensors are non-adjustable because the ECM “learns” the throttle angle voltage at idle speed. If the throttle housing/accelerator pedal module is replaced, the adaptations must be cleared and adaptation procedure must be performed using ISTA. If this is not performed, the vehicle will not start, or run in “fail-safe” mode.

If this input is defective, a fault code will be stored and the “Malfunction Indicator and/or EML” Light will be illuminated. Limited engine operation will be possible.

The ECM provides voltage (5V) and ground for the Hall sensors. As the accelerator pedal is moved from rest to full throttle, the sensors produce a variable voltage signal.

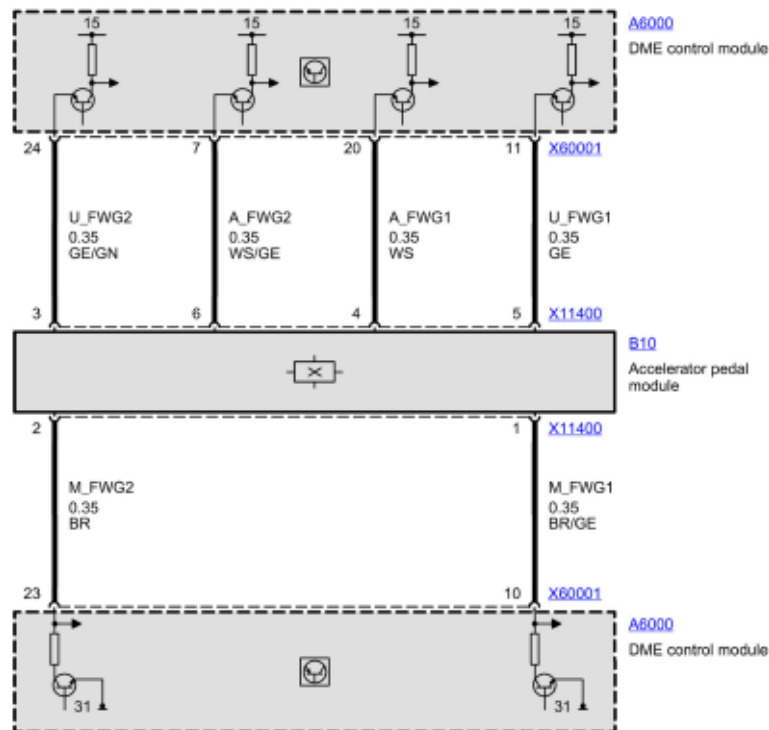
- Hall sensor 1(request)
- Hall sensor 2 (plausibility)



If the signals are not plausible, the ECM will use the lower of the two signals as the requested input. The throttle response will be slower and the maximum throttle response will be reduced.

The pedal position sensor is **monitored** by checking **each individual sensor circuit** and comparing the two pedal values. Monitoring is active as soon as the sensors receive voltage (KL15). The ECM decides what operating mode the pedal position sensor is to assume.

- Pedal position sensor fully operable.
- Failure of one pedal position sensor (maximum engine speed is limited).
- Failure of both pedal position sensors (engine speed limited to 1500 rpm).



Throttle Valve (EDK)

The throttle valve plate is electronically operated to regulate intake air flow by the ECM.

The main characteristics are:

- Precision throttle operation,
- OBD compliant for fault monitoring,
- DSC and Cruise Control.



This integrated electronic throttle reduces extra control modules, wiring, and sensors. Adjusting electronic throttles is not permitted, the throttle assembly must be replaced as a unit. The adaptation values must be cleared and adaptation procedure must be performed using ISTA.

The throttle assembly for the system is referred to as the EDK:

- EDK does not contain a PWG, It is remotely mounted (integrated in the accelerator pedal assembly).
- The accelerator pedal is not mechanically “linked” to the EDK.

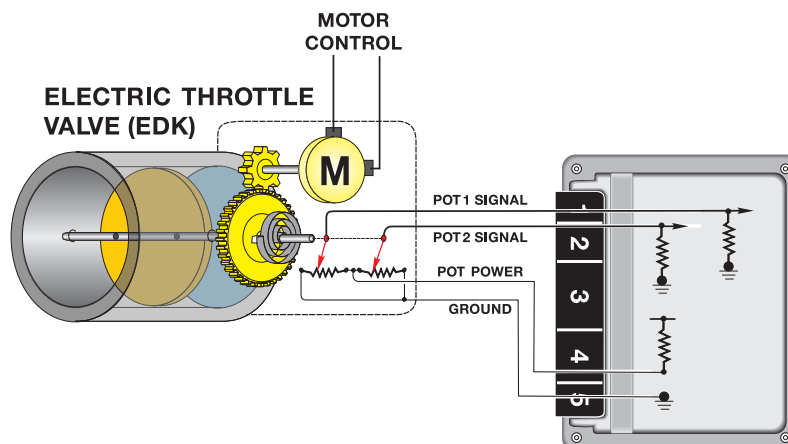
Throttle Motor and Feedback Position

The ECM powers the EDK motor using pulse width modulation (PWM) for opening and closing the throttle plate. The throttle plate is also closed by an integrated return spring.

Two integrated potentiometers provide voltage feedback signals to the ECM as the throttle plate is opened and closed.

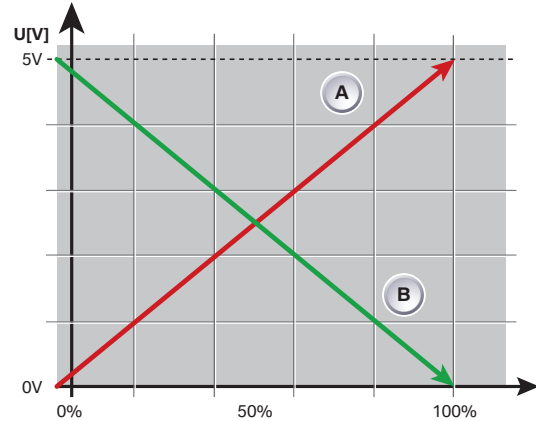
- **Feedback signal 1** provides a signal from approx. 0.5V (closed) to approx. 4.5 V (Full Throttle)
- **Feedback signal 2** provides a signal from approx. 4.5V (closed) to approx. 0.5V (Full Throttle)

Potentiometer 1 is the **primary feedback** signal of throttle plate position and signal is the **plausibility cross check** through the complete throttle plate movement.



Total Intake Air Flow Control is performed by the ECM simultaneously operating the EDK throttle control and the Idle Air Actuator.

The ECM detects the driver's request from the potentiometers/Hall Sensors monitoring the accelerator pedal position. This value is added to the Idle Air control value and the total is what the ECM uses for EDK activation. The ECM then controls the Idle Air Actuator to satisfy the idle air "fill". In addition, the EDK will also be activated = pre-control idle air charge. Both of these functions are utilized to maintain idle RPM.



The EDK is electrically held at the idle speed position, and all of the intake air is drawn through the Idle Air Actuator. Without a load on the engine (<15%), the EDK will not open until the extreme upper RPM range. If the engine is under load (>15%), the Idle Air Actuator is open and the EDK will also open.



Vehicles equipped with VALVETRONIC, e.g. N52, N55, will only use the EDK in certain operating conditions.

All variants of the **NG6 engines** receive the new EGAS 08 throttle by Siemens/VDO. The new throttle uses a plastic throttle valve and magneto-resistive feedback to the ECM.

The previous system used a potentiometer, whereas the new throttle uses a “contactless” system featuring magneto-resistive technology which is familiar from the eccentric shaft sensor on Valvetronic systems.

The magneto-resistive sensors are integrated into the housing cover. The sensors are also non-wearing.

For plausibility, the one sensor outputs the analog signal in the range from **0.3 to 4.6 V** and the other sensor inverts it again from **4.6 to 0.3 V**.

Consequently, the contact force is 10 times greater than that of a conventional plug connector



**It is possible to twist the connector before plugging it in.
This can cause damage to the harness and connector.**



Failsafe Operation - EDK

When a fault is detected in the system:

- The EDK provides two separate signals from two integrated potentiometers (Pot 1 and Pot 2) representing the exact position of the throttle plate.
- EDK Pot 1 provides the primary throttle plate position feedback. As a redundant safety feature, Pot 2 is continuously cross checked with Pot 1 for signal plausibility.
- If plausibility errors are detected between Pot 1 and Pot 2, the ECM will calculate the inducted engine air mass (from HFM signal) and only utilize the potentiometer signal that closely matches the detected intake air mass.
 - The ECM uses the air mass signaling as a “virtual potentiometer” (Pot 3) for a comparative source to provide failsafe operation.
 - If the ECM cannot calculate a plausible conclusion from the monitored Pots (1 or 2 and virtual 3) the EDK motor is switched off and fuel injection cut out is activated (Failsafe operation is not possible).
- The EDK is continuously monitored during all phases of engine operation. It is also briefly activated/adapted when KL_15 is initially switched on as a “preflight check” to verify it’s mechanical integrity (no binding, appropriate return spring tension, etc). This is accomplished by monitoring both the motor control amperage and the reaction speed of the EDK feedback potentiometers. If faults are detected the EDK motor is switched off and the fuel injection cut off is activated (failsafe operation is not possible). The engine does however continue to run extremely rough at idle speed.
- When in emergency operation, the engine speed is always limited to 1300 RPM by fuel injector cutout, and activation of the “EML” light to alert the driver of a fault.
- When a replacement EDK is installed, the ECM adapts to the new component (required amperage draw for motor control, feedback pot tolerance difference, etc). This occurs immediately after the next cycle of KL_15 for approximately 30 seconds. During this period of adaptation, the maximum opening of the throttle plate is 25%.

Idle Air Actuator

This valve regulates air by-passing the throttle valve to control the engine idle/low speed.

The valve is supplied with battery voltage from the ECM Relay. The Idle Air Actuator is a two-coil rotary actuator. The ECM is equipped with two final stage transistors which will alternate positioning of the actuator.

The final stages are "pulsed" simultaneously by the ECM which provides ground paths for the actuator. The duty cycle of each circuit is varied to achieve the required idle RPM.

If this component/circuits are defective, a fault code will be set and the "Malfunction Indicator Light" will be illuminated when the OBD II criteria is achieved.

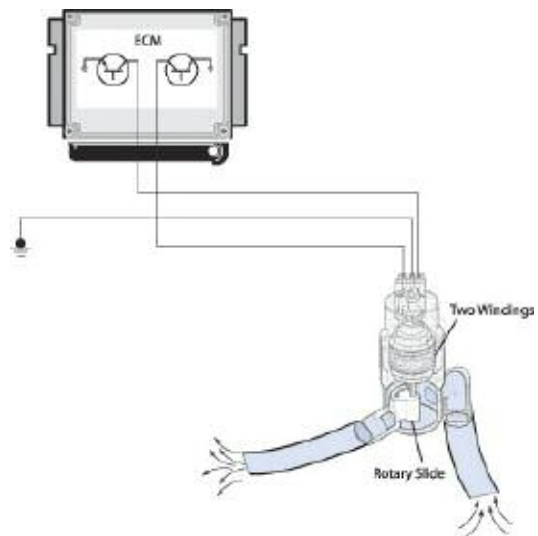
The Idle Air Actuator is controlled by the ECM modulating the ground signals (PWM at 100 Hz) to the valve. By varying the duty cycle applied to the windings, the valve can be progressively opened, or held steady to maintain the idle speed.

The ECM controls the Idle Air Actuator to supply the necessary air to maintain idle speed. When acceleration is requested and the engine load is low (<15%), the actuator will also supply the required air.

The basic functions of the idle speed control are:

- Control the initial air quantity (air temp <0° C, EDK is simultaneously opened).
- Variable preset idle based on load and inputs.
- Monitor RPM range intake for each preset position.
- Vacuum Limitation
- Smooth out the transition from acceleration to deceleration.

Under certain engine operating parameters, the EDK throttle control and the Idle Air Actuator are operated simultaneously. This includes all idling conditions and the transition from off idle. As the request for load increases, the idle valve will remain open and the EDK will supply any additional air volume required to meet the demand.





Failsafe Operation - Idle Air Actuator

If a fault is detected with the Idle Air Actuator, the ECM will initiate failsafe measures depending on the effect of the fault (increased air flow or decreased air flow). If there is a fault in the Idle Air Actuator/circuit, the EDK will compensate to maintain idle speed. The “Malfunction Indicator and/or EML” Light will be illuminated to inform the driver of a fault.

If the fault causes increased air flow (actuator failed open), VANOS and Knock Control are deactivated which noticeably reduces engine performance.

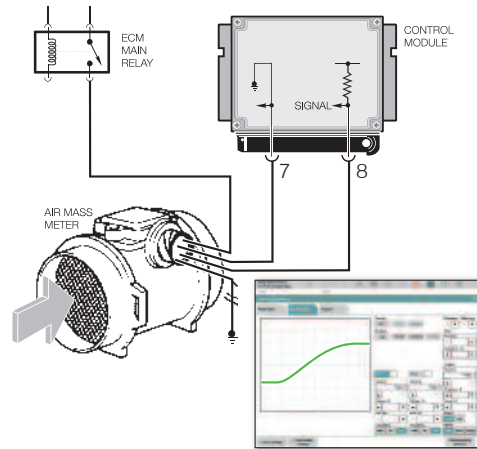
Hot-Film Air Mass Meter (HFM)

The air volume input signal is produced electronically by the HFM which uses a heated metal film (180°C above intake air temperature) in the air flow stream.

The ECM Relay provides the operating voltage. As air flows through the HFM, the film is cooled changing the resistance which affects current flow through the circuit. The sensor produces a 1-5 volt varying signal. Based on this change the ECM monitors and regulates the amount of injected fuel.

The Hot-Film Air Mass Meter (HFM) varies voltage monitored by the ECM representing the measured amount of intake air volume. This input is used by the ECM to determine the amount of fuel to be injected.

The heated surface of the hot-film in the intake air stream is regulated by the ECM to a constant temperature of 180°C above intake air temperature. The incoming air cools the film and the ECM monitors the changing resistance which affects current flow through the circuit. The hot-film does not require a “clean burn”, it is self cleaning due to the high operating temperature for normal operation.



If this input is defective, a fault code will be set and the “Malfunction Indicator Light” will illuminate when the OBD II criteria is achieved. The ECM will maintain engine operation based on the Throttle Position Sensors and Crankshaft Position/Engine Speed Sensor.

The HFM is non-adjustable.



HFM on NG6 Engines

The HFM on all new NG6 engines has been upgraded to a digital HFM. The output of the sensor is a digital signal in which the duty cycle responds to changes in air mass.

The Siemens SIMAF GT2 Hot-Film air Mass meter is used in several BMW engines. This sensor is equipped with planar metal resistors on glass. Based on the tried and tested sensor technology used in the SIMAF GT1 for more than 15 years, the SIMAF GT2 represents a further-development and optimization with higher vibration resistance, improved accuracy (at all operating temperatures), and lower sensitivity to air pulsations and water.

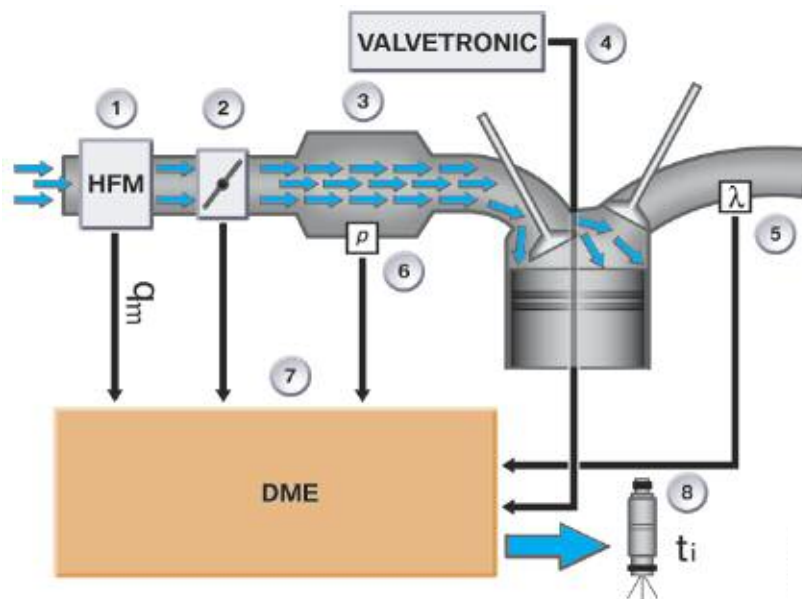
The output of the sensor is converted to a digital signal. This eliminates the need for signal conversion in the ECM. The signal corresponds proportionally to changes in air mass.

Hot-film air mass meter



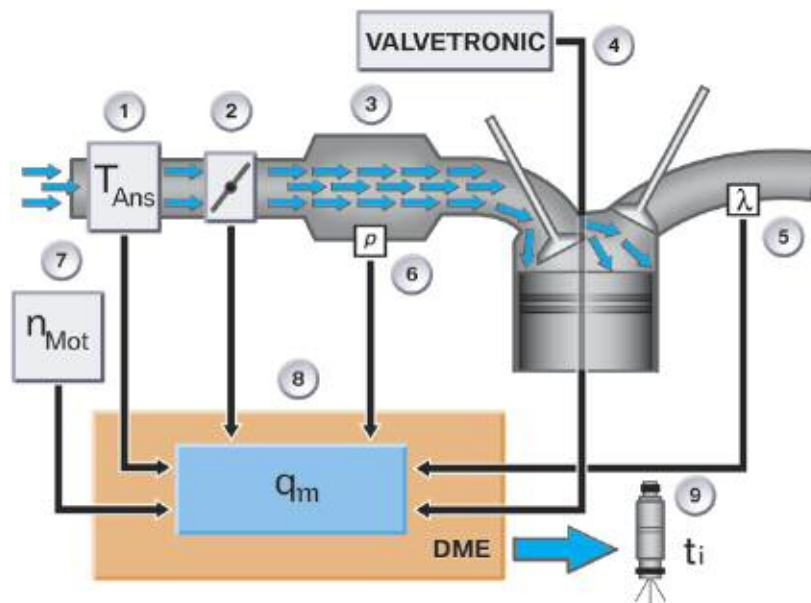
The N54 engine uses a virtual HFM. The signal is “calculated” in the ECM from various parameters such as engine speed, intake air temperature, throttle position etc.

Air Measurement with HFM



Index	Explanation	Index	Explanation
1	Measurement of intake air temperature and air mass	5	Residual O2 content in exhaust gas
2	Throttle valve position	6	Intake manifold vacuum
3	Intake manifold	7	Engine speed
4	Intake valve lift (from VVT)	8	Injection Timing

“Virtual” Air Measurement without HFM



Index	Explanation	Index	Explanation
1	Intake air temperature	6	Intake manifold vacuum
2	Throttle valve position	7	Engine speed
3	Intake manifold	8	ECM (DME) with characteristic map for air mass calculation
4	Intake valve lift (VVT if equipped)	9	Injection Timing
5	Residual O2 content in exhaust (O2 sensor)		



The HFM is non-adjustable and tampering is not permitted. A faulty Hot-Film Air Mass Sensor can produce the following complaints:

- **Difficult To Restart When Engine Is Hot.**
- **Engine Starts Then Stalls.**
- **“Malfunction Indicator Light” Illuminated.**
- **Engine Starts and Runs Only With Accelerator Pedal Depressed.**

Air Temperature Signal

The HFM contains an integral air temperature sensor. This is a Negative Temperature Coefficient (NTC) type sensor. This signal is required by the ECM to correct the air volume input for changes in the intake air temperature (air density) affecting the amount of fuel injected, ignition timing and Secondary Air Injection activation.

The ECM provides the power supply to the sensor which decreases in resistance as the temperature rises and vice versa. The ECM monitors an applied voltage to the sensor that will vary as air temperature changes the resistance value.



If this input is defective, a fault code will be set and the “Malfunction Indicator Light” will be illuminated when the OBD II criteria is achieved. The ECM will operate the engine using the Engine Coolant Sensor input as a back up.

The Air Temperature signal allows the ECM to make a calculation of intake air temperature. The varying voltage input from the NTC sensor indicates the larger proportion of oxygen found in cold air, as compared to less oxygen found in warmer air. The ECM will adjust the amount of injected fuel because the quality of combustion depends on oxygen sensing ratio.

The ignition timing is also affected by air temperature. If the intake air is hot the ECM retards the base ignition timing to reduce the risk of detonation. If the intake air is cooler, the base ignition timing will be advanced. The ECM uses this input as a determining factor for Secondary Air Injection activation.



If this input is defective, a fault code will be set and the “Malfunction Indicator Light” will illuminate when the OBD II criteria is achieved. The ECM will maintain engine operation based on the HFM and Engine Coolant Temperature sensor.

Variable Intake Manifold (DISA)

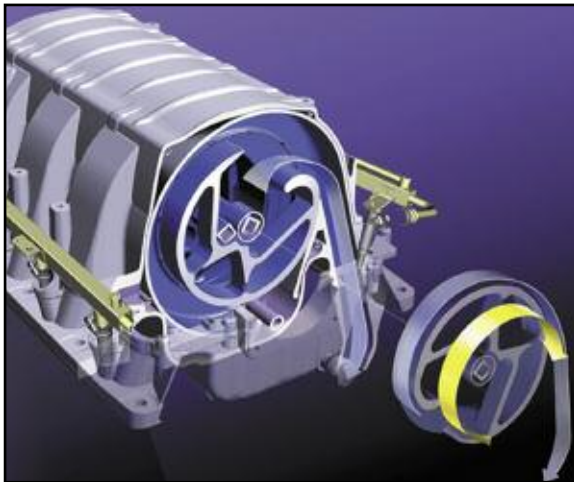
Fully Variable DISA

In the **N62** engine, the infinitely variable differential intake air system (**DISA**) intake manifold is operated by turning the rotor in the intake manifold.

Adjustments to the intake manifold are carried out by the ECM controlling a drive unit. The drive unit is mounted on the rear of the intake manifold.

The drive unit consists of a **12V DC** electric motor with worm gears and an integral potentiometer for the intake manifold position feedback.

The drive unit is equipped with a 5-pin connector.



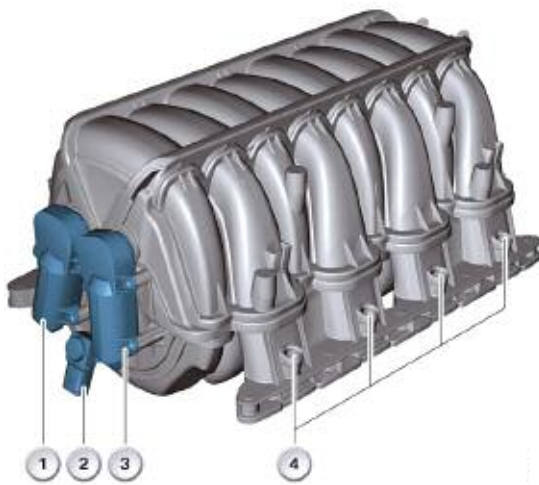
**If the drive unit fails, the system remains in its current position.
The driver may notice a loss in power.**

Two Stage DISA

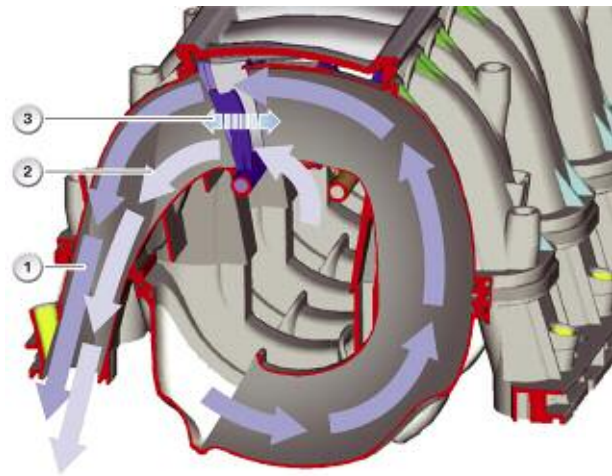
The previous fully variable intake system is no longer used in the **N62TU** engine. A new two-stage intake system (DISA) is used instead. The previous intake manifold was made from magnesium; the new intake is manufactured from glass fiber reinforced plastic.

There are two servomotors which provide a 2-stage (long/short) function of the intake manifold runners. Due to the increased displacement and engine power, the fully variable intake system is no longer required.

The **12V** servomotors are actuated by the ECM via a PWM signal. While the sliding sleeves are open (power setting), the servomotors are actuated with a **5 % PWM** signal in order to hold the sleeves in their open position.



Index	Explanation
1	Servomotor, cylinder bank 1
2	Differential Pressure Sensor
3	Servomotor, cylinder bank 2
4	Bores for fuel injectors



Index	Explanation
1	Long Intake Passage
2	Short Intake Passage
3	Directional movement of sliding sleeves



Variable Intake Manifold (DISA)

The intake manifold on the **N52** uses a three stage differential intake air system (**DISA**). The air flow through the intake manifold is controlled and re-directed by two DISA actuator motors.

Each actuator motor is operated by an electric motor controlled by the Engine Control Module (ECM) via a PWM signal. The **PWM** signal is at a frequency of 200 Hz. The ECM varies the duty cycle to control the position of the DISA flap. The actuator consists of a flap and motor drive. **There are only two positions possible - closed or opened.** When activated, the motor moves the flap to each end position. Both actuators are switched to the closed position at idle.



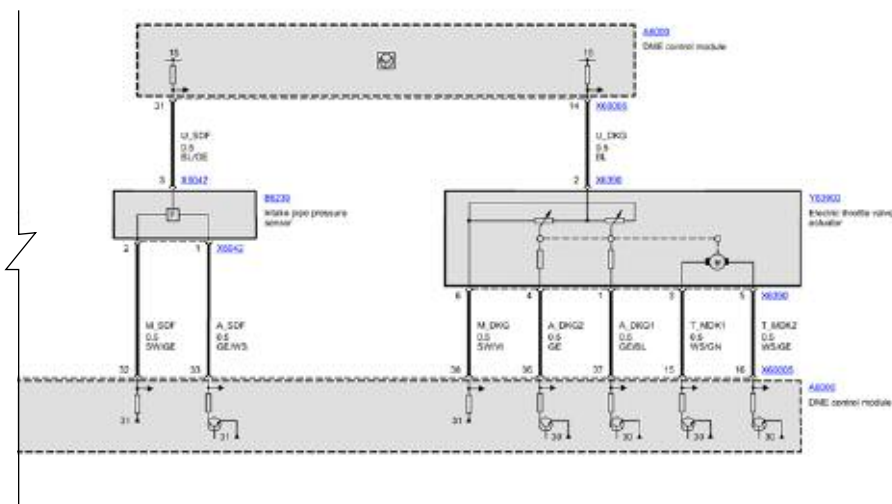
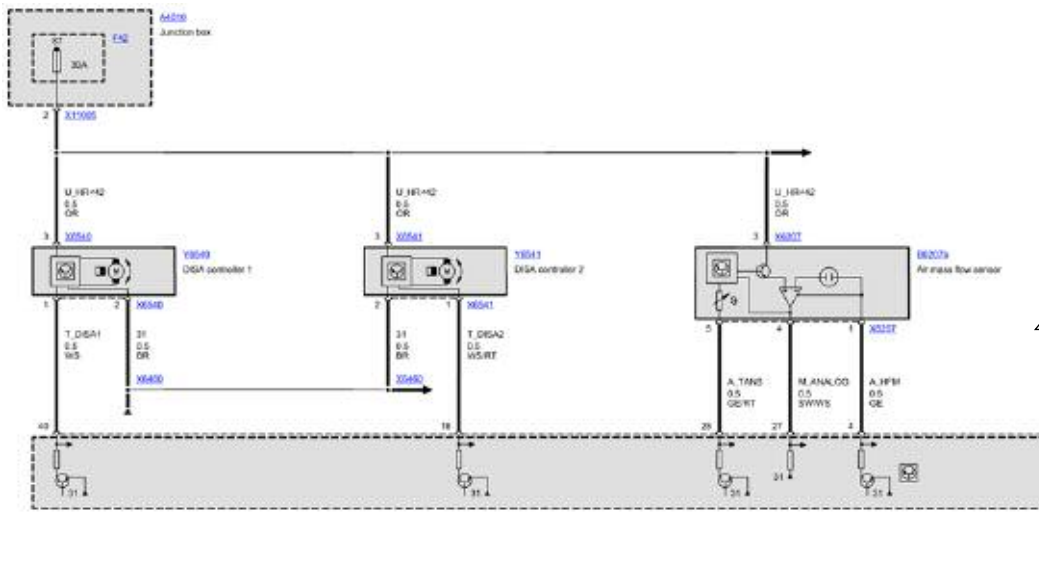
The DISA motors are similar in design and operation, but they are not interchangeable. Each actuator assembly has its own individual part number.

DISA Actuators

Together with the drive, the DISA valve (flap) forms one unit. The DISA valve is driven by an electric motor and a gear mechanism.

The electronic control is integrated in the DISA actuator. The DISA actuator is driven by a pulse width-modulated signal from the DME.

There are only two possible positions: The valves (flaps) can either be closed or opened, i.e. when activated, the motor moves the valve to the respective end position.



DISA Operation

■ 1st stage - idling/lower engine speed range

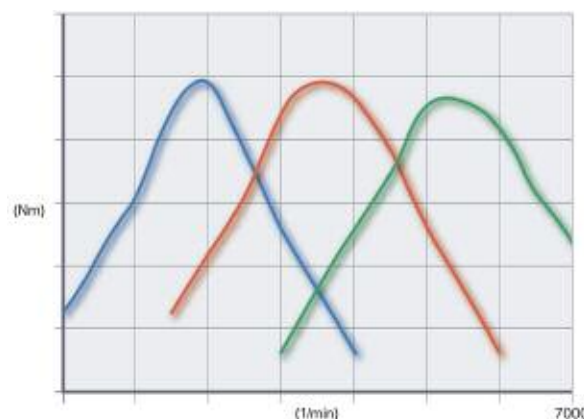
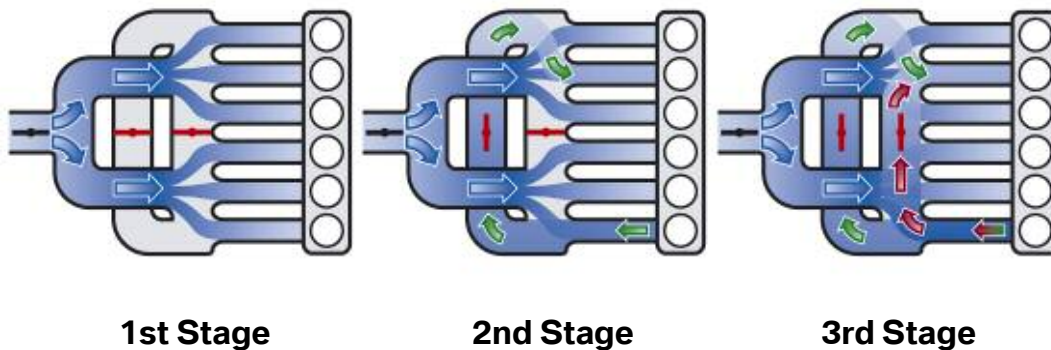
At idle speed and in the lower engine speed range, actuators 1 and 2 are closed. The intake air flows past the throttle valve into the resonance pipe. In the resonance pipe, the intake air mass splits. The air is fed via the collector pipe and resonating pipes into the individual cylinders. In this way, three cylinders are provided with a comparably high air mass.

■ 2nd stage - medium engine speed range

In the medium engine speed range, DISA actuator motor 2 is opened. In this case, it is assumed that the inlet valves of the first cylinder are just closing. The gas motion creates a pressure peak at the closing inlet valves. This pressure peak is passed on via the resonating and collector pipes to the next cylinder in the firing order. This improves the fresh gas filling of the next cylinder to be filled.

■ 3rd stage - upper engine speed range

In the upper engine speed range, both DISA actuator motors are opened. In this case, it is assumed that the inlet valves of the first cylinder are just closing. The gas motion creates a pressure peak in front of the closing inlet valves. The intake air mass is now fed via the resonating, overshoot and collector pipes.





DISA N52KP and N51

As far as the air management system on the N52KP and N51 engines is concerned, the previous intake manifold system on the N52 is carried over. Depending upon application, the engines will use the 3-stage DISA or the single stage (no DISA) intake manifold.

For more information on the DISA system refer to the previous training material in the training course “ST501 - New Engine Technology”.

Workshop Hints

Air Management

Unmetered air leaks can be misleading when diagnosing faults causing “Malfunction Indicator Light”/driveability complaints. Use the Smoke Machine to help you find leaks.

Crankcase Ventilation System

A fault in this system can often “mislead” diagnosis. This type of fault can produce:

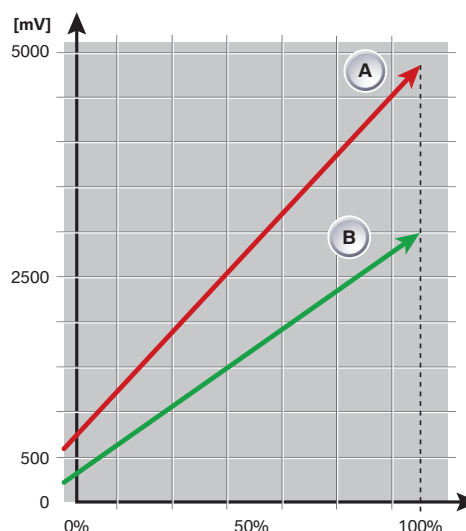
Please refer to the following Service Information Bulletins for details on the Crankcase Ventilation System:

- Mixture/misfire detected codes
- Whistling noise
- Performance/driveability complaints

Accelerator Pedal Position (PWG)

The Throttle Position Sensors can be tested with the following methods:

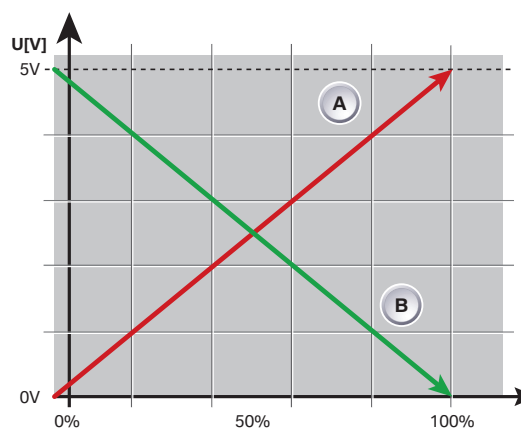
- ISTA Status Page (approx.. 0.5V. to 4.5V)
- IMIB Oscilloscope - Select from the Present measurement which requires taking the measurement with the ECM and the Universal Adapter connected to the circuit as shown on the right).



Throttle Valve (EDK)

Two integrated potentiometers provide voltage feedback signals to the ECM as the throttle plate is opened and closed.

- **Feedback signal 1** provides a signal from approx. 0.5V (closed) to approx. 4.5 V (Full Throttle)
- **Feedback signal 2** provides a signal from approx. 4.5V (closed) to approx. 0.5V (Full Throttle)



Hot-Film Air Mass Meter (HFM)

This component is non-adjustable and tampering is not permitted.
A faulty Hot-Film Air Mass Sensor can produce the following complaints:

- Difficult To Restart When Engine Is Hot.
- Engine Starts then Stalls.
- “Malfunction Indicator Light” Illuminated.
- Engine Starts and Runs Only With Accelerator Pedal Depressed.

The Hot-Film Air Mass Sensor can be tested with the following methods:

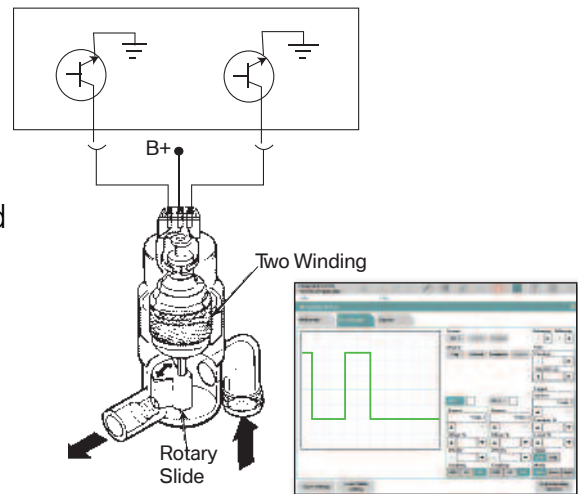
- ISTA Fault Code and Component Testing.
- ISTA Status Page
- IMIB Oscilloscope-which requires taking the measurement with the ECM and the Universal Adapter connected to the circuit (engine running).



Visually inspect the sensor for damaged, missing or blocked screens. The screens affect air flow calibration. Also inspect the sealing rings where the sensor inserts in the air filter housing and intake boot. Ensure the pin connections are tight.

Idle Air Actuator

- The Idle Air Actuator Valve and air circuit (passage ways) should be checked for physical obstructions. Visually inspect the sealing gasket, mounting bracket and air hose clamps.
- The resistance of the valve winding should be checked.
- The ECM output and Idle Speed Control Valve operation can be tested by “Component Activation” on ISTA.
- The Pulse Width Modulation ground outputs from the ECM can be tested using the IMIB Oscilloscope.
- Consult Technical Data for specified idle speed.



If the valve is blocked or contaminated, an HFM fault code can also be present.

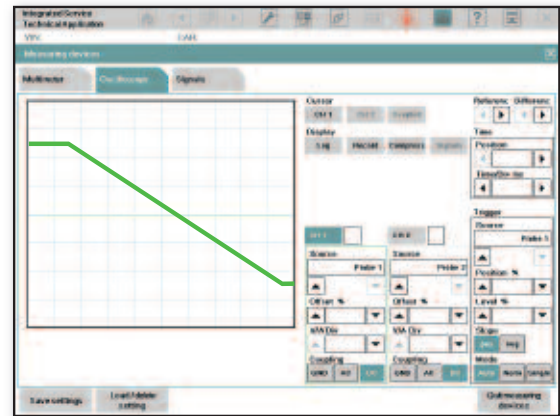
Air Temperature Signal

The HFM contains an integral air temperature sensor. NTC sensors decrease in resistance as the temperature rises and vice versa. The ECM monitors the sensor voltage which varies as temperature changes the resistance value. For example, as temperature rises:

- Resistance through the sensor decreases.
- Voltage drop across the sensor decreases.
- Input signal voltage also decreases (5-0V).

This sensor should be tested using:

- ISTA Diagnostic Query
- IMIB Multimeter (ohms)



NOTES

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Fuel Management

Model: All

Production: All

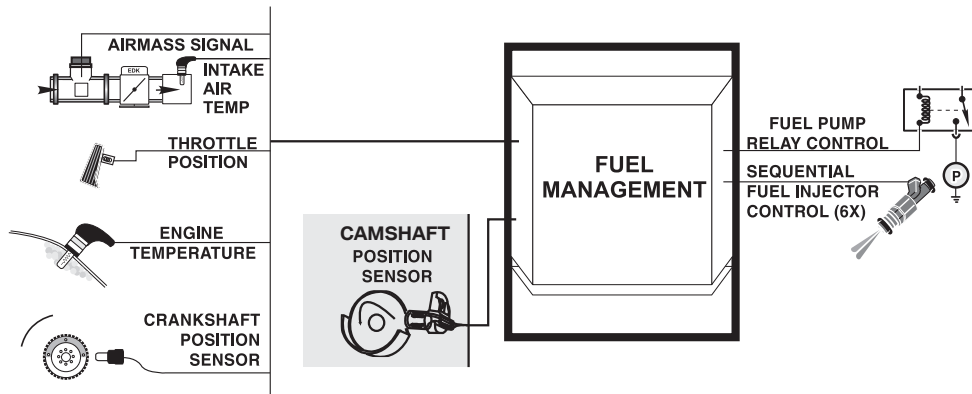
OBJECTIVES

After completion of this module you will be able to:

- Understand and perform a low pressure fuel system test
- Understand all inputs used in determining the proper fuel injector operation
- Perform a scope test of fuel injectors
- Understand how a BMW high pressure fuel system operates

Fuel Management

Example of IPO for a Fuel Management System



Principle of Operation

One of the main purposes of the ECM is Fuel Management which includes the actuation of several components. In the following pages you will find a generic explanation on how this system works. For more detailed information please access BMW Training Reference Manuals found online.

Fuel Management delivers fuel from the tank to the intake ports of the engine. To accomplish this, **fuel supply** must be available to the fuel injectors. Once this is accomplished, the fuel must be injected in the precise amount and at the correct time. The ECM does not directly monitor fuel supply, although it does control fuel supply. The **Fuel Pump** supplies fuel when it receives operating voltage from the Engine Control Module Relay supplying the **Fuel Pump Relay**. **The ECM controls and monitors fuel injection.**

The **Fuel Pump** will be activated when the ignition (KL_15) is switched “on” and the ECM supplies a ground circuit to activate the Fuel Pump Relay. The Fuel Pump Relay supplies operating power to the in-tank mounted fuel pump. This is a momentary activation to “pressurize” (prime) the fuel system.

The ECM then requires an engine speed signal from the **Crankshaft Position/RPM** Sensor to maintain continuous Fuel Pump Relay activation.

If the engine RPM signal is not present, the ECM will deactivate the Fuel Pump Relay.

The Fuel Injectors will be opened by the ECM to inject pressurized fuel into the engine. The Fuel Injectors receive voltage from the Engine Control Module Relay. The ECM controls the opening by activating the ground circuits. The ECM will vary the duration (in milli-seconds) of “opening” time to regulate the air/fuel ratio.

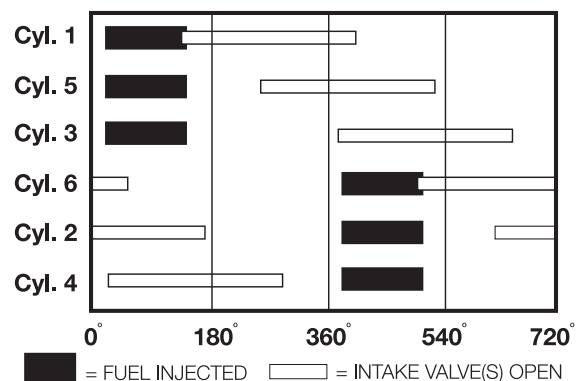
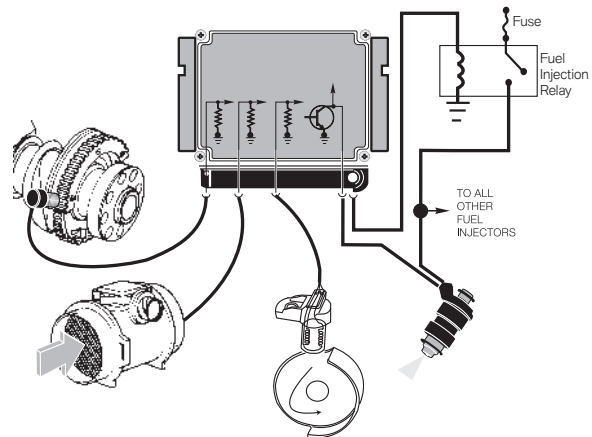
The ECM has the Final Stage output transistors that switch ground to the injectors. The Injector “triggering” is first established from the Crankshaft Position/RPM Sensor.

The ECM is programmed to activate the Final Stage output transistors once for every two revolutions of the crankshaft. in two groups (Semi-Sequential Injection).

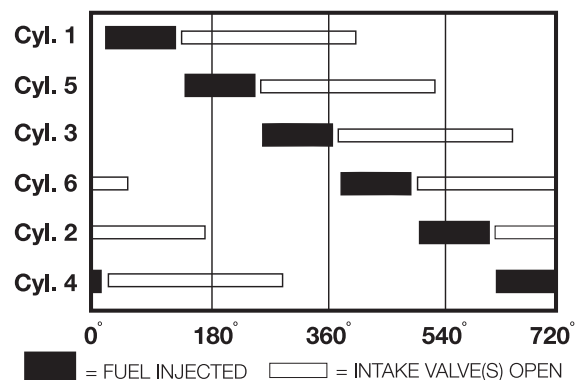
The injectors are opened in two groups for every complete “working cycle” of the engine. This delivers the fuel charge for cylinders 1,5,3 during one revolution of the crankshaft and cylinders 6,2,4 during the second revolution of the crankshaft. This process enhances fuel atomization during start up.

During start up, the ECM recognizes the Camshaft Position (Cylinder ID) input. The camshaft position is referenced to the crankshaft position. It then switches the injection to Full Sequential. This process “times” the injection closer to the intake valve opening for increased efficiency.

When activated, each injector delivers the full fuel charge at separate times during each engine working cycle.



If this input is faulty, the ECM will activate the injectors in Parallel to maintain engine operation and set a fault code.

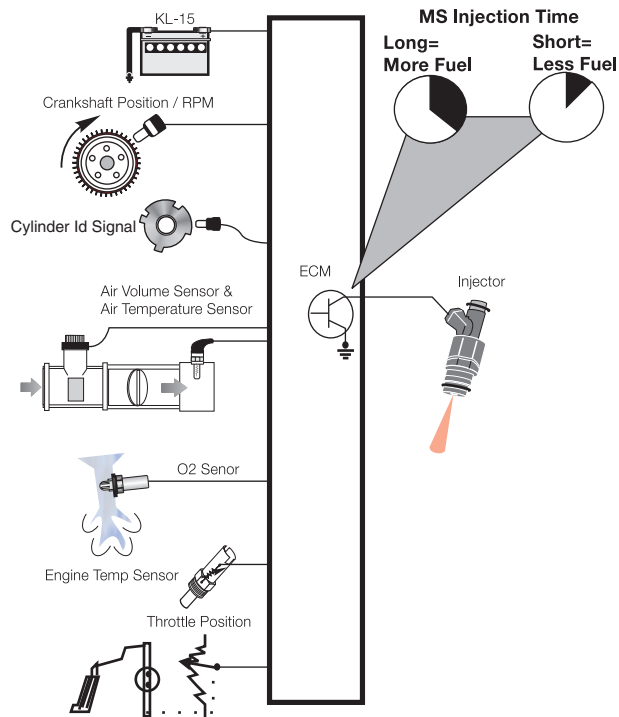


After the engine has been started, the ECM determines the **Injector “open” time** to maintain engine operation. The ECM will calculate the injection “timing” based on a combination of the following inputs.

- Battery Voltage
- Throttle Position
- Air Flow Volume/Mass
- Air Temperature
- Crankshaft Position/RPM
- Camshaft Position (Cylinder ID)
- Engine Coolant
- Oxygen Sensor

Additionally in turbocharged engines the ECM also employs:

- Boost Pressure Sensor.
- Charge Air Pressure and Temperature Sensor (Before EDK).
- Intake Manifold Pressure Sensor (After EDK).



The injection millisecond (ms) value will be regulated based on battery voltage. When cranking, the voltage is low and the ECM will increase the ms value to compensate for injector “lag time”. When the engine is running and the battery voltage is higher, the ECM will decrease the injection ms value due to faster injector reaction time.

Cold starting requires additional fuel to compensate for poor mixture and the loss of fuel as it condenses onto cold intake ports, valves and cylinder walls . The cold start fuel quantity is determined by the ECM based on the Engine Coolant Temperature Sensor input during start up.

During cranking, additional fuel is injected (in Semi-Sequential) for the first few crankshaft revolutions. After the first few crankshaft revolutions, the injected quantity is metered down as the engine comes up to speed. When the engine speed approaches idle rpm, the ECM recognizes the Camshaft Position and switches to Full Sequential injection.

When the engine is cold, optimum fuel metering is not possible due to poor air/fuel mixing and an enriched mixture is required. The Coolant Temperature input allows the ECM to adjust the injection “ms” value to compensate during warm up and minimize the injected fuel at engine operating temperature.

When the engine is at idle, minimum injection is required. Additional fuel will be added if the ECM observes low engine rpm and increasing throttle/air volume inputs (acceleration enrichment). As the throttle is opened, the ECM monitors acceleration and rate of movement. The ECM will increase the volume of injected fuel into the engine by increasing the injection “ms” value. The “full throttle” position indicates maximum acceleration and the ECM will add more fuel (full load enrichment).

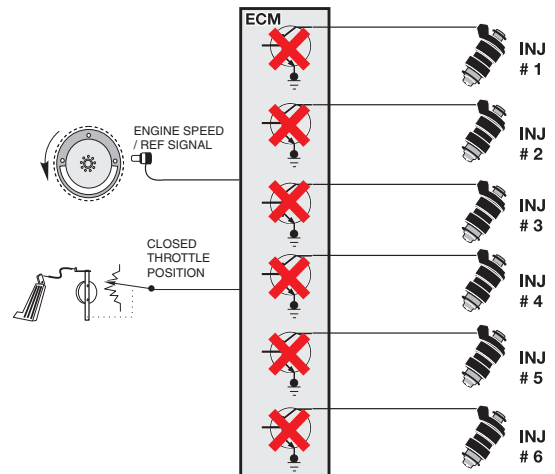
As the throttle is closed, the ECM decreases the injection “ms” value (fuel shut off) if the rpm is above idle speed (coasting). This feature decreases fuel consumption and lowers emissions. When the engine rpm approaches idle speed, the injection “ms” value is increased (cut-in) to prevent the engine from stalling. The cut-in rpm is dependent upon the engine temperature and the rate of deceleration.

The Hot-Film Air Mass (HFM) signal provides the measured amount of intake air volume/mass. This input is used by the ECM to determine the amount of fuel to be injected to “balance” the air/fuel ratio.

The Air Temperature Signal allows the ECM to make an additional calculation of air density. The varying voltage input from the NTC sensor indicates the larger proportion of oxygen found in cold air, as compared to less oxygen found in warmer air. The ECM will adjust the amount of injected fuel because the quality of combustion depends on oxygen sensing ratio.

The Crankshaft Position/RPM signals the ECM to start injection as well as providing information about the engine operation. This input is used in combination with other inputs to determine engine load which increases/decreases the injection “ms” value. Without this input the ECM will not activate the injectors.

The Camshaft Position (Cylinder ID) affects the injection timing (Semi-Sequential/Full Sequential). To accomplish this, the ECM contains six Final Stage output transistors that activate the injectors individually. The engine operates sufficiently on Semi-Sequential Injection (two groups of three), but more efficiently on Full Sequential Injection (six individual). If one of the fuel injector circuits faulted, the engine can still operate on limited power from the other remaining fuel injector circuits.



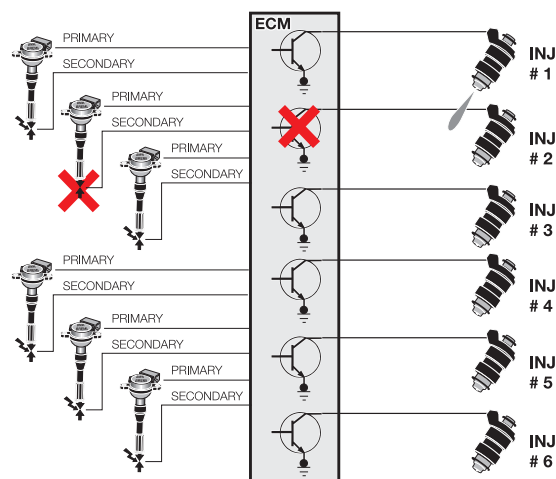
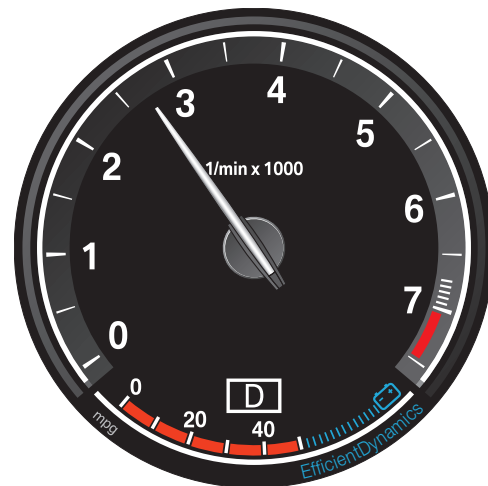
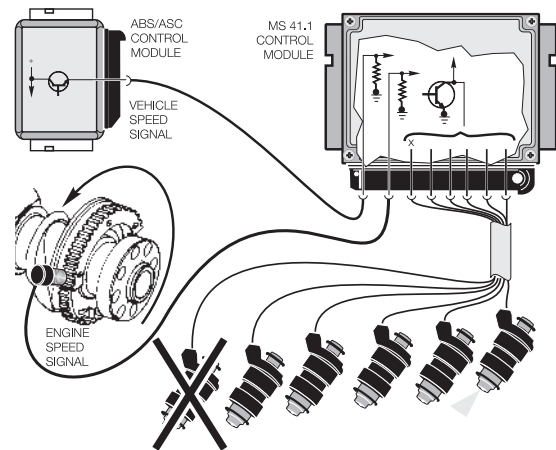
The ECM will selectively deactivate injectors to control maximum engine rpm (regardless of vehicle speed). When the engine speed reaches its “redline”, the injectors will be individually deactivated as required to protect the engine from over-rev. As the engine speed drops below “redline”, injector activation will be resumed. This feature does not protect the engine from a forced over-rev situation such as improperly downshifting a manual transmission equipped vehicle (driver error).

The ECM will also protect the Catalytic Converter by deactivating the injectors.

If the ECM detects a “misfire” (ignition, injection or combustion) it can selectively deactivate the Final Stage output transistor for that cylinder(s).

The injector(s) will not open, preventing unburned fuel from entering the exhaust system.

The ECM controls the individual injector circuits resulting in deactivation of one or multiples. This will limit engine power, but protect the Catalytic Converter.



Maximum vehicle speed is also limited by the ECM selectively deactivating the injectors (regardless of engine rpm).

This limitation is based on the vehicle dimensions, specifications and installed tires (speed rating).

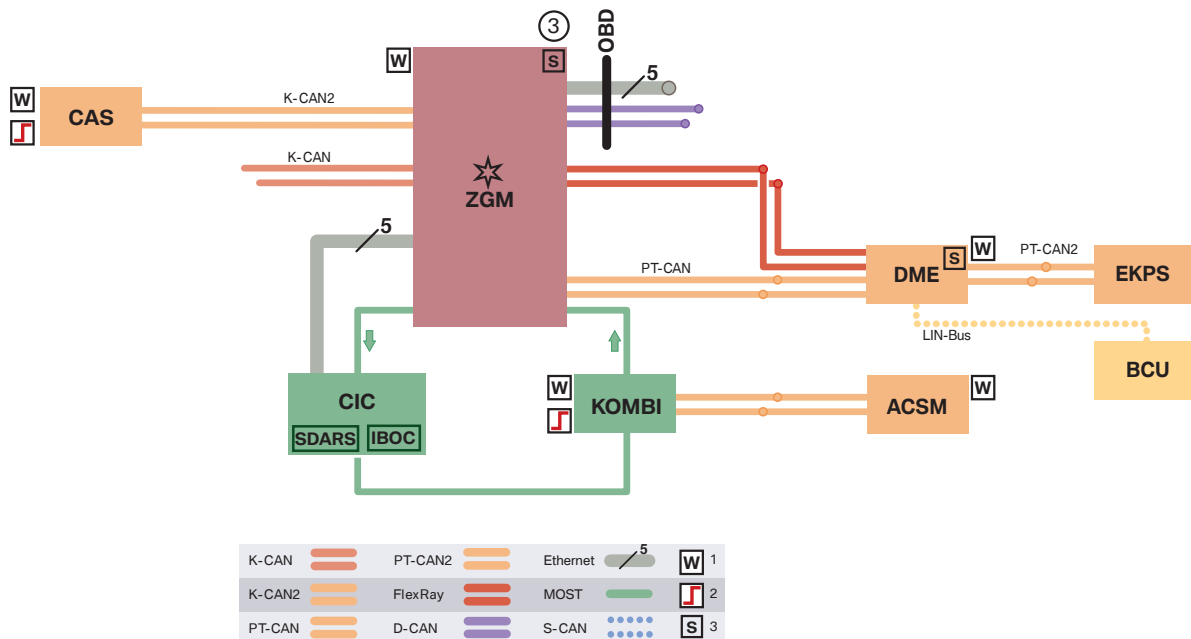
The ECM (DME) is connected to the EKP module via the PT-CAN network via a pulse width modulated (PWM) signal according to the fuel quantity required by the ECM. The electric fuel pump in the EKP system is activated as required. The DME calculates the amount of fuel required at the given point in time. The total volume required is transmitted as a message to the EKP control unit via PT-CAN.

The EKP control unit controls the electric fuel pump on the basis of mappings so that the electric fuel pump delivers the exact amount of fuel required.

The EKP control unit converts this message into an output voltage. This output voltage is then used to control the speed of the electric fuel pump. This achieves a delivery which corresponds with the requirements.

The illustrations shown below are from an E90 and an F10. The EKP module on the E90 contains one of the terminating resistors for the PT-CAN.

F10 Fuel Requirement Signal Path



Fuel Requirement Mappings

Fuel requirement mappings are stored in the EKP control unit. The fuel requirement mappings are encoded for each specific engine and model. The EKP control unit uses the mappings as the basis on which to calculate the total amount of fuel to be delivered from the following variable:

- Amount of fuel required by the engine (request from the ECM). This results in a pulse-width modulated output voltage from the EKP control unit. The output voltage of the EKP control unit is the supply voltage for the electric fuel pump. The EKP control unit controls the speed of the electric fuel pump via the supply voltage. The EKP control unit controls the speed by comparing the actual speed with the specification.

Speed of the Electric Fuel Pump

The EKP control unit sends the current supply to the fuel pump (pulse-width modulated). This voltage is absorbed as a specific ripple due to the individual armature windings of the rotating electric motor. The ripple corresponds with the number of segments in the commutator which corresponds with the number of armature windings in the electric motor.

The number of waves produced per revolution is equal to the number of existing commutator segments.

This means that the EKP control unit can employ a patented procedure - "Ripple Counter" as the basis for calculating the actual speed of the fuel pump using power consumption ripple.

Coding and Programming

The data for the electronically controlled fuel pump system is encoded as follows:

- In the ECM (DME), the engine and model-related characteristic curves for fuel delivery according to requirements.
- In the EKP control unit: specific characteristic curves for the relevant fuel system



Failsafe Operation

If the fuel quantity requirement from the ECM and/or the EKP rotation speed signal fails, the fuel pump will continue to operate with the greatest delivery rate (100%) when terminal KL_15 is activated. This guarantees fuel supply even if the control signals fail.

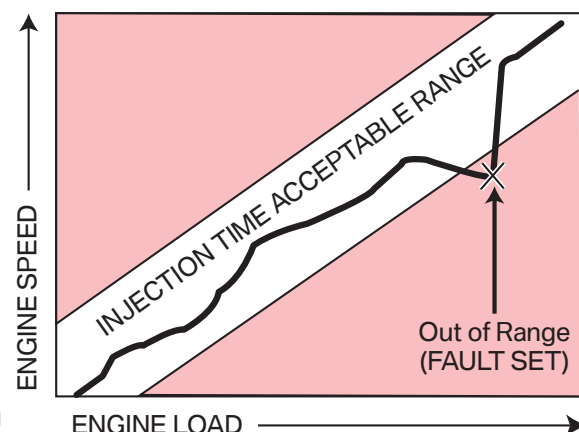
Fuel Injection Control Monitoring

Fuel Injection Control Monitoring is performed by the ECM for OBD II requirements. Faults with the fuel injectors and/or control circuits will be stored in memory. This monitoring includes:

- Closed Loop Operation
- Oxygen Sensor Feedback

These additional corrections are factored into the calculated injection time. If the correction factor exceeds set limits a fault will be stored in memory.

When the criteria for OBD II monitoring is achieved, the "Malfunction Indicator Light" will be illuminated.



Fuel Supply

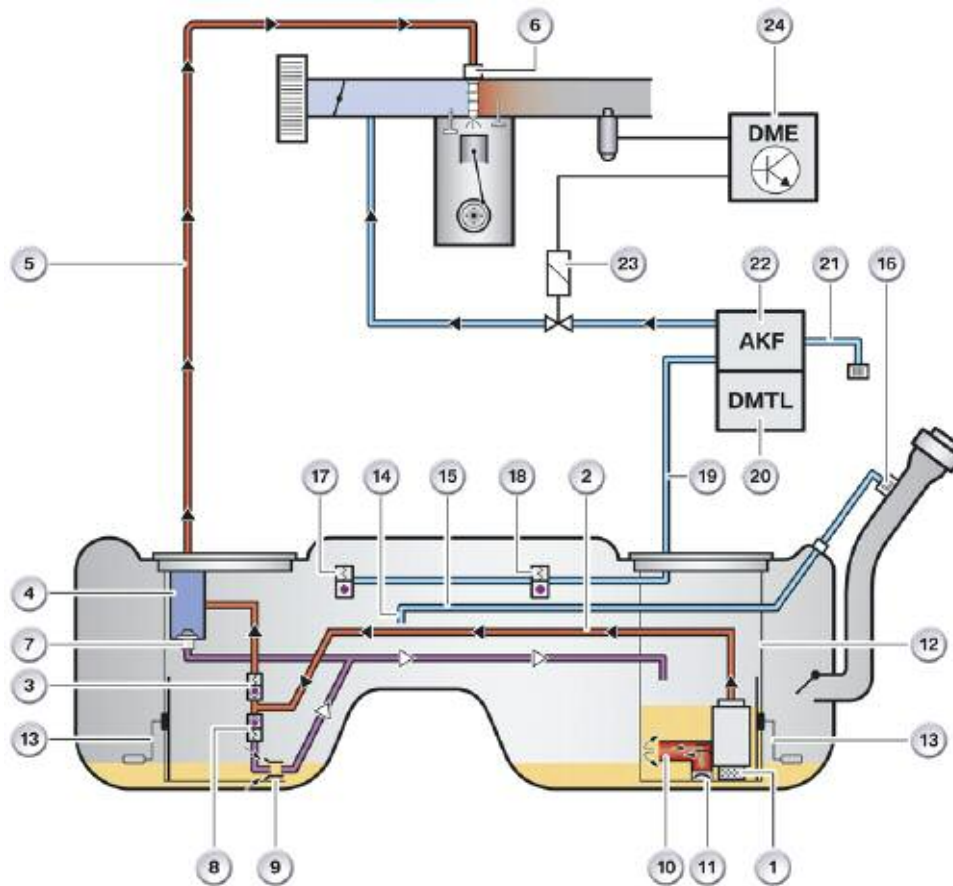
The fuel is delivered from the fuel tank to the engine in the following sequence:

- From the right half of the fuel tank;
- through the initial filler valve (11);
- into the fuel baffle (12);
- from the electric fuel pump (1);
- via a T-piece, on the one side, through the check valve (3) into the fuel filter (4);
- through the feed line (5) in the left-hand service opening to the engine;
- and, on the other side, via the check valve (8) to the left-hand suction jet pump (9) back into the fuel baffle;
- parallel from the electric fuel pump to the right-hand suction jet pump (10);
- and from the right half of the fuel tank into the fuel baffle.

The fuel filter (4) and pressure regulator (7) are located at the left-hand service opening. The check valve (8) opens at a fuel pressure above 2.5 bar. It ensures the engine receives sufficient fuel before the left suction jet pump cuts into the circuit.

As an example, on the N52 engine the pressure regulator (7) routes the fuel back into the fuel baffle (12). A 5 bar pressure regulator is used for vehicles with the N52 engine.

Fuel supply system on E9x



Index	Explanation	Index	Explanation
1	Electric Fuel Pump	13	Fuel Level Sensor
2	Feed Line	14	Refuelling Line Connection Piece
3	Check Valve	15	Refuelling Ventilation Line
4	Fuel Filter	16	Refuelling Ventilation
5	Feed Line to Engine	17	Left Operation Ventilation Valve
6	Fuel Injector	18	Right Operation Ventilation Valve
7	Pressure Regulator	19	Operation Ventilation Line
8	Check Valve	20	Diagnosis Module for Tank Leakage (DM-TL)
9	Left Suction Jet Pump	21	Atmosphere Line
10	Right Suction Jet Pump	22	Carbon Canister
11	Initial Filling Valve	23	Fuel Tank Vent Valve
12	Fuel Baffle	24	Digital Motor Electronics

N55 Engine

■ Fuel supply system

The fuel pressure sensor sends a voltage signal, corresponding to the system pressure applied between the fuel pump and the high pressure pump, to the engine control unit (DME/ECM). The system pressure (fuel pressure) is determined with the fuel pressure sensor upstream of the high pressure pump. The target pressure is constantly compared to the actual pressure in the DME.

If the target pressure deviates from the actual pressure, the engine control unit increases or decreases the voltage for the electric fuel pump. This voltage is sent in the form of a message via the PT-CAN to the EKP control unit.

The electric fuel pump (EKP) control unit converts the message into an output voltage for the electric fuel pump, thus regulating the required delivery pressure for the engine (or high pressure pump). The electric fuel pump is pilot-controlled in the event of signal failure (fuel pressure sensor). Should the CAN bus fail the EKP control unit operates the electric fuel pump with the applied system voltage. The fuel flows via the high pressure line to the fuel rail. The fuel is buffered in the fuel rail and distributed to the fuel injectors.

■ Fuel quantity control

The rail pressure sensor measures the current fuel pressure in the rail. The excess fuel is returned to the inlet of the high pressure pump when the quantity control valve in the high pressure pump opens. Vehicle operation is restricted in the event of the high pressure pump failing.

The quantity control valve controls the fuel pressure in the rail. The engine management actuates the quantity control valve with a pulse width-modulated signal. Depending on the pulse width, a variable throttle cross section is released, thus providing the quantity of fuel required for the current load status of the engine. It is also possible to reduce the pressure in the rail.

N63 Engine

The fuel system on the F01/02 has gone under some design changes as compared to previous models. The familiar fuel tank with divided chambers is still in use. The familiar configuration which features the fuel pump on the right (passenger) side is also retained.

■ Fuel Supply System

In order to comply with the regulations regarding evaporative emissions, there have been several changes to internal fuel tank components as well as the fuel tank itself.

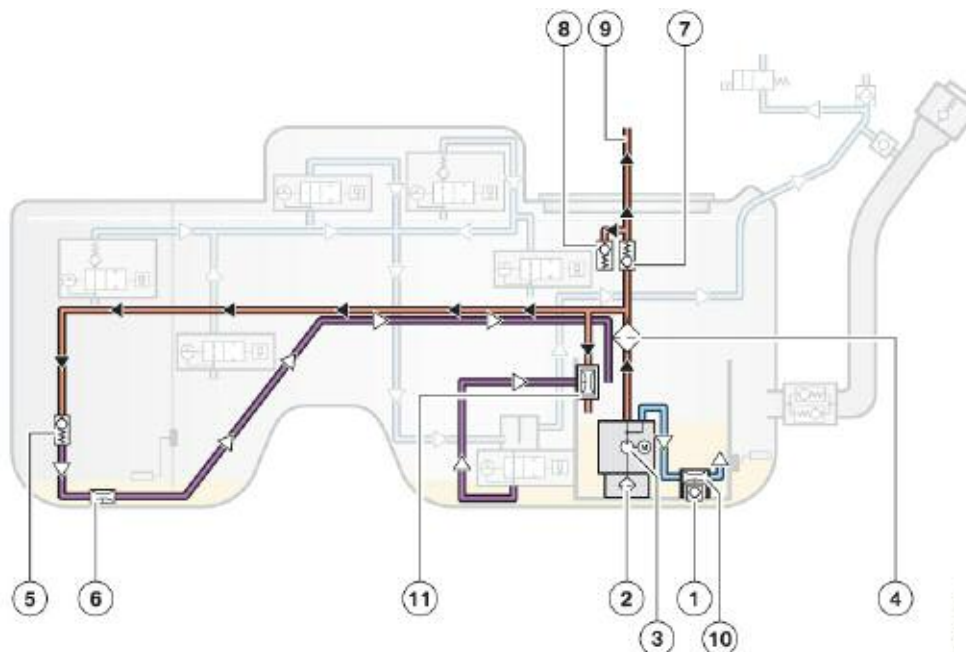
The fuel supply system has also been modified to eliminate the fuel pressure regulator. The following text summarizes the changes to the fuel supply system:

- the fuel supply system is now “pressure controlled”.
- the fuel pressure regulator has been replaced by the “pressure limiting valve” (8).
- the pressure in the fuel supply system is limited to a maximum of 5.8 bar by the pressure limiting valve (8).
- the EKPS will control the fuel pump in order to deliver only the amount of fuel required based on information from the fuel pressure sensor (low pressure).

Due to the nature of the installation space in the vehicle, the fuel tank is divided into two chambers. The fuel supply system has two delivery units that are accommodated in the right and left fuel tank halves.

In the event of the surge chamber being completely empty, initial fill valve (1) enables fuel to enter the surge chamber during the refueling process.

Fuel supply system on F01/F02 with N63 engine

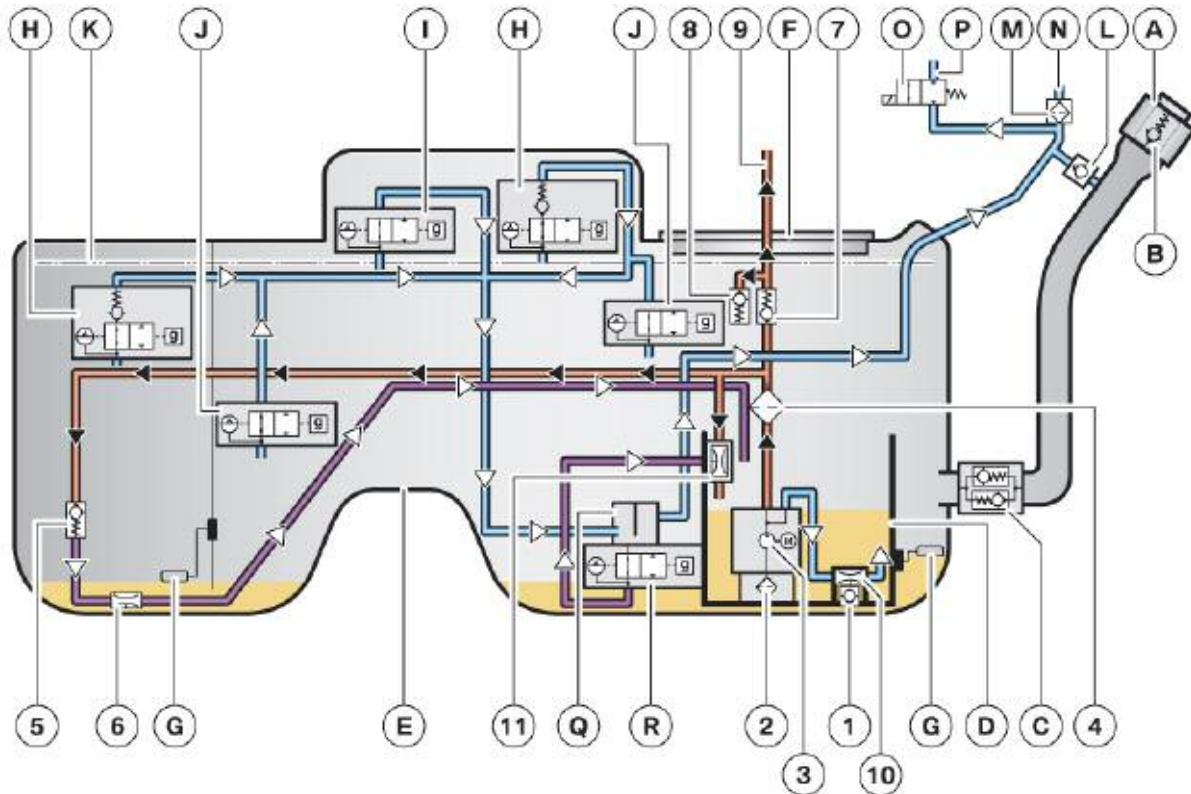


Index	Explanation	Index	Explanation
1	Initial fill valve	7	Anti-leak valve
2	Intake mesh filter	8	Pressure limiting valve
3	Fuel pump	9	Feed line
4	Fuel filter	10	Suction jet pump
5	Non-return valve	11	Suction jet pump
6	Suction jet pump		

N63 System Overview

Fuel passes through suction strainer (2) and enters fuel pump (3) and is then pumped to feed line (9) through fuel filter (4). The fuel pump resides in the surge chamber. A pressure limiting valve (8) is integrated into the feed line in the fuel tank.

Fuel tank on F01 with N63 engine



For the first time for a gasoline engine, we are no longer using a pressure regulator. Instead, operation of the electric fuel pump is pressure-regulated. In response to the signal from the low-pressure fuel sensor, the speed of the electric fuel pump is adjusted to achieve the desired delivery pressure upstream of the high-pressure pump.

A further line branches off downstream of the fuel pump into the left half of the fuel tank and carries fuel from the left half into the surge chamber by way of a non-return valve (5) and suction jet pump (6).

Index	Explanation	Index	Explanation
A	Fuel cap	P	Purge air line
B	Pressure relief valve	Q	Fuel trap
C	Non-return flap with pressure relief valve	R	Roll-over valve
D	Surge chamber	1	Initial fill valve
E	Fuel tank	2	Intake mesh filter
F	Service cover	3	Electric fuel pump
G	Lever-type sensor	4	Fuel filter
H	Service breather valve with over fueling protection	5	Non-return valve
I	Filler breather valve	6	Suction jet pump
J	Service breather valve without over fueling protection	7	Anti-leak valve
K	Maximum fill level	8	Pressure limiting valve
L	Non-return valve	9	Feed line
M	Carbon canister (AKF)	10	Suction jet pump
N	Opening	11	Suction jet pump
O	Fuel tank vent valve (TEV)		

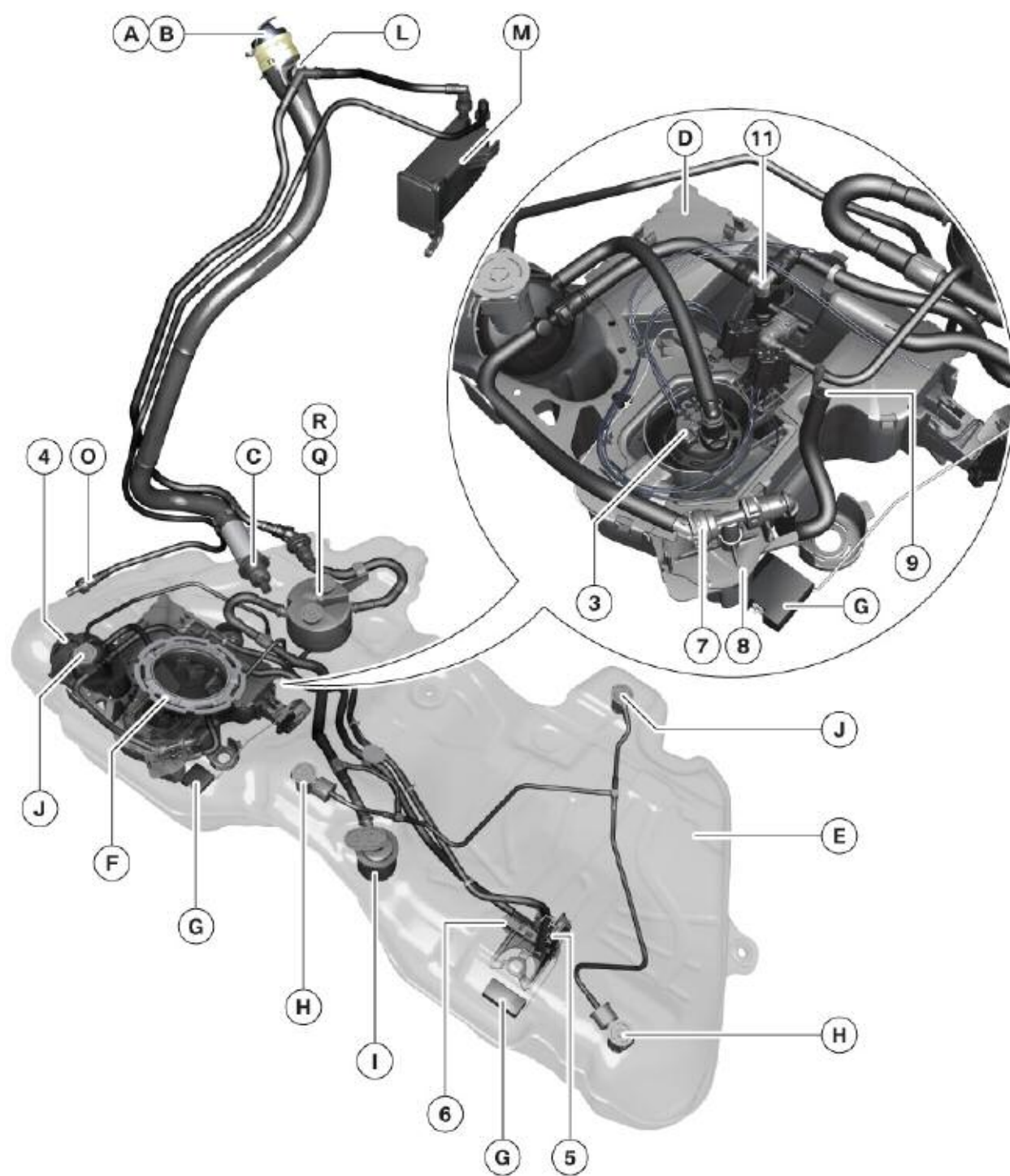
The non-return valve (5) prevents fuel from flowing back from the right half to the left half of the fuel tank while the engine is switched off.

When you switch off the engine, the feed line is depressurized but cannot run dry because, with the system being airtight, no air is able to enter the line. Anti-leak valve (7) prevents the fuel tank from leaking in the event of damage to the lines on the engine or underbody.

A further line en route to the left half of the fuel tank branches off to another suction jet pump (11), which sucks fuel out of the fuel trap and delivers it to the surge chamber.

Another line exits the pump carrying fuel pumped from the fuel tank to the surge chamber by suction jet pump (10).

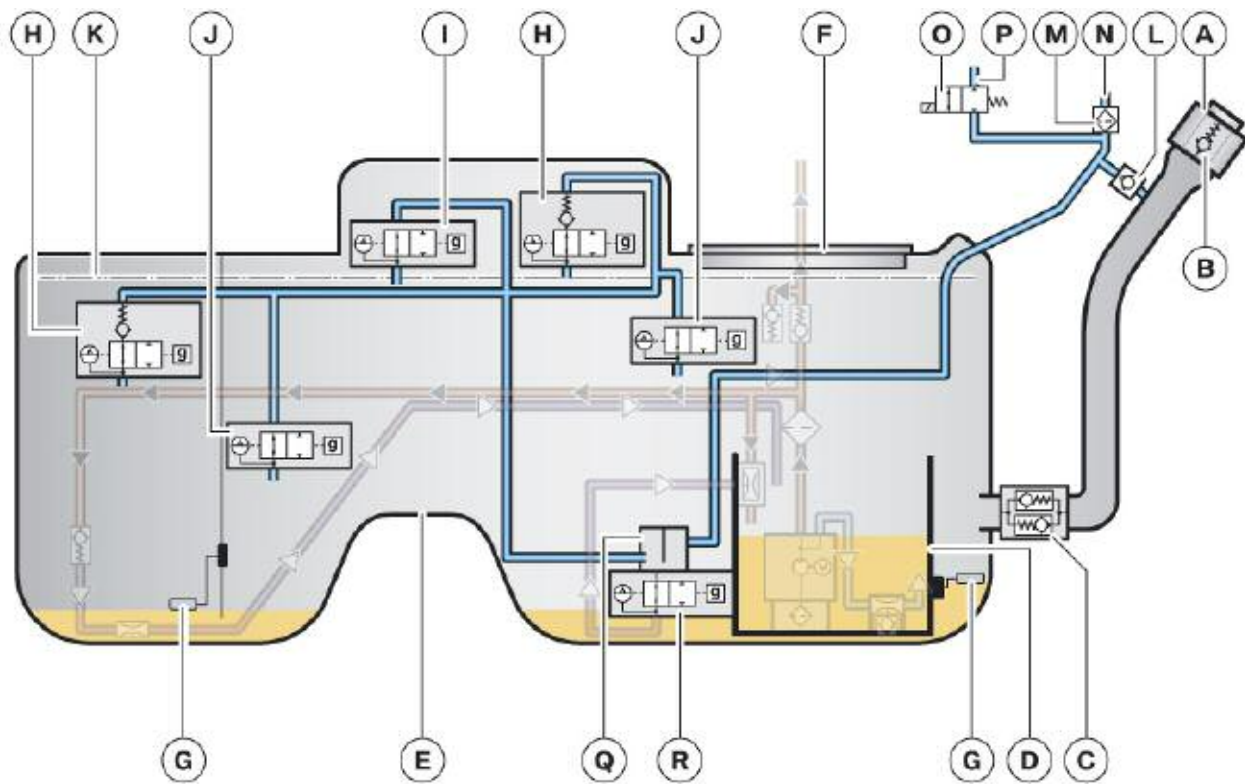
Fuel tank overview on F01 with N63 engine



Index	Explanation	Index	Explanation
A	Fuel cap	P	Purge air line
B	Pressure relief valve	Q	Fuel trap
C	Non-return flap with pressure relief valve	R	Roll-over valve
D	Surge chamber	1	Initial fill valve
E	Fuel tank	2	Intake mesh filter
F	Service cover	3	Electric fuel pump
G	Lever-type sensor	4	Fuel filter
H	Service breather valve with over fueling protection	5	Non-return valve
I	Filler breather valve	6	Suction jet pump
J	Service breather valve without over fueling protection	7	Anti-leak valve
K	Maximum fill level	8	Pressure limiting valve
L	Non-return valve	9	Feed line
M	Carbon canister (AKF)	10	Suction jet pump
N	Opening	11	Suction jet pump
O	Fuel tank vent valve (TEV)		

Fuel Tank Breather System And Functions

Fuel tank breather system on F01/F02 with petrol engine



Index	Explanation	Index	Explanation
A	Fuel cap	J	Service breather valve without over fueling protection
B	Pressure relief valve	K	Maximum fill level
C	Non-return flap with pressure relief valve	L	Non-return valve
D	Surge chamber	M	Carbon canister (AKF)
E	Fuel tank	N	Opening
F	Service cover	O	Fuel tank vent valve (TEV)
G	Lever-type sensor	P	Purge air line
H	Service breather valve with over fueling protection	Q	Fuel trap
I	Filler breather valve	R	Roll-over valve

Fuel filler cap (A) has an integral pressure relief valve (B) to protect fuel tank (E) from excess pressure. At the end of the fuel filler neck, there is a non-return flap with a pressure relief valve (C). The non-return flap prevents fuel from sloshing back into the fuel filler neck. The non-return flap is sealed closed by a spring. In the event of a build-up of pressure in the fuel tank, the pressure relief valve in the non-return flap ensures that the excess pressure can escape through the fuel filler pipe and out of the fuel filler cap through the pressure relief valve.

The components in the fuel tank are accessible through the service cover (F). The fuel level is detected by the two lever-type sensors (G).

The surge chamber (D) ensures that the fuel pump never pumps dry. The surge chamber is permanently connected to the fuel tank and cannot be replaced separately.

The F01/F02 has a whole range of breather valves in the fuel tank. In principle, all of these valves fulfil the breather function, both during vehicle operation and during refueling.

Despite this, they are named to reflect their main purpose. They are therefore divided into filler valves and service breather valves. The service breather valves have a smaller opening, which means that, during refueling, they alone would not be able to let air escape from the fuel tank fast enough. There are service breather valves with and without over fueling protection.

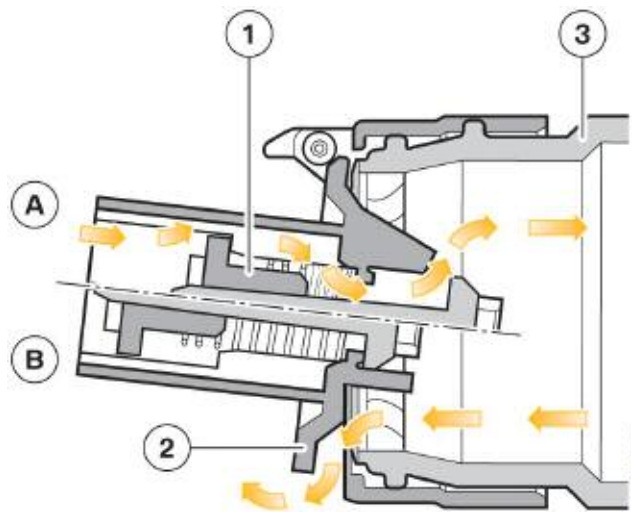
The service breather valves are arranged in such a way that air can still be released even if the vehicle is parked up on one side.

The filler breather valve is located at a high position. If the fuel level rises to this height during refueling, the valve closes. Air can no longer escape from the fuel tank fast enough, which causes fuel to rise up the filler pipe and switch off the fuel nozzle.

To enable the release of air to continue, there is a service breather valve located at the highest point. However, the presence of the valve in this location means that the fuel tank could be overfilled in the event of persistent refueling. Consequently, fuel would enter the activated charcoal filter and ultimately flow back out of the opening. To prevent this, the highest service breather valve is equipped with over fueling protection like the one on the left-hand side of the vehicle (as a safeguard if the vehicle were parked up on one side).

Fuel that is carried along with the release of air is collected in a fuel trap and pumped back into the surge chamber.

Non-return Flap



Index	Explanation
A	Pressure relief valve open
B	Pressure relief valve closed
1	Pressure relief valve
2	Non-return flap
3	Fuel filler pipe

The non-return flap forms a tight seal. A force of approximately 0.15 N is required to open the non-return flap. This force is slightly exceeded during any type of refueling.

The non-return flap on the F01 is equipped with a pressure relief valve. The purpose of this pressure relief valve is to prevent excessive pressures from building up in the fuel tank. If the pressure in the fuel tank rises to over 150 mbar, the pressure relief valve opens and the pressure is able to escape through the fuel filler pipe and the breather line/pressure relief valve in the fuel cap.

The pressure relief valve in the non-return flap on the F01 is a new concept because the breather line is not protected by the body along its entire length. In the event of an accident, therefore, the breather line could be squeezed closed.

Filler Breather Valve

The filler breather valve has several functions. As the name suggests, the valve fulfils the filler-neck breather function. In addition, however, it also performs the service breather function. It also has a rollover function.

The filler breather valve is notable for its large opening, which allows air to escape rapidly from the tank during refueling. If, during refueling, the float of the filler breather valve ascends with the rising fuel level and thereby closes the breather hole, fuel will rise up the fuel filler pipe and switch off the fuel nozzle.

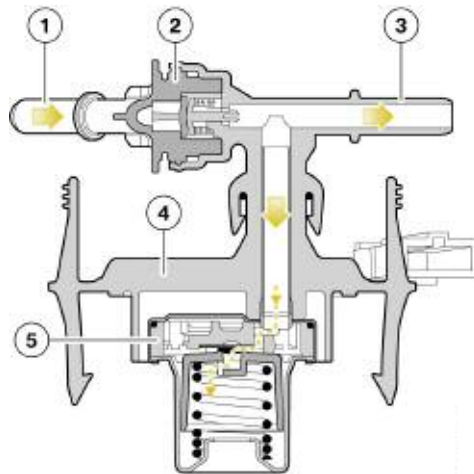
During vehicle operation, the pressure in the fuel system can rise as a result of the increase in temperature. This pressure is allowed to escape through the filler and service breather valve and the fuel trap. Fuel that is carried along in the process is collected in the fuel trap and sucked back while the fuel pump is in operation.

■ Pressure Limiting Valve

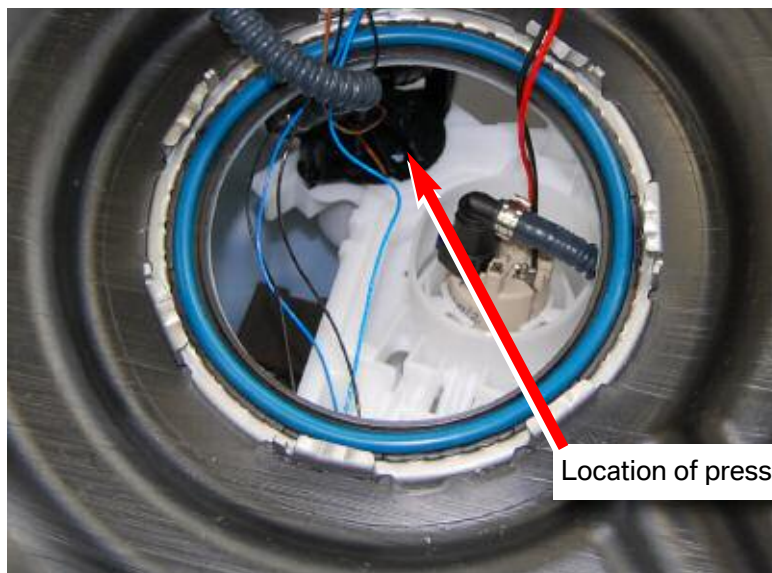
The pressure limiting valve is connected to ground by the plug-in contacts on the service cover. This prevents electrostatic charge on the valve.

The pressure limiting valve keeps fuel pressures in the feed section lower than approximately 5.8 bar in the N63 engines

This prevents excess pressures from building up in the feed line. Excess pressures would otherwise occur if the fuel filter were to become blocked, which would place the feed section of the fuel system under unnecessarily heavy loads.



Index	Explanation	Index	Explanation
1	Connection from electric fuel pump	4	Housing
2	Anti-leak valve	5	Pressure limiting valve
3	Connection to fuel filter		



Location of pressure limiting valve

Fuel Tank Breather System

The increased demands on the evaporative emission systems require continuous development and improvements. The F01/F02 is no different. One of the first things to notice on the fuel tank is that there is only one service port. Also, the tank is made from two pieces and joined by a plastic “welding” process.

The only items which are serviceable at this time are the fuel pump, fuel filter and pressure limiting valve. There are several breather valves installed to help the fuel tank “breathe” during refueling and during operation.

These valves are therefore divided into filler valves and service breather valves. The service breather valves have a smaller opening, which means that, during refueling, they alone would not be able to let air escape from the fuel tank fast enough.

There are service breather valves with and without over fueling protection. The service breather valves are arranged in such a way that air can still be released even if the vehicle is parked up on one side.

The filler breather valve is located at a high position. If the fuel level rises to this height during refueling, the valve closes. Air can no longer escape from the fuel tank fast enough, which causes fuel to rise up the filler pipe and switch off the fuel nozzle.

To enable the release of air to continue, there is a service breather valve located at the highest point. However, the presence of the valve in this location means that the fuel tank could be overfilled in the event of persistent refueling.

Consequently, fuel would enter the activated charcoal filter and ultimately flow back out of the opening. To prevent this, the highest service breather valve is equipped with over fueling protection like the one on the left-hand side of the vehicle (as a safeguard if the vehicle were parked up on one side). Fuel that is carried along with the release of air is collected in a fuel trap and pumped back into the surge chamber.

Direct Injection

The term “Direct Injection” refers to a fuel injection system which injects fuel directly into the combustion chamber rather than into the intake manifold. This technology has been around since the 1930's, but has not been in widespread use until the late 20th century.

The early development of this type of injection system took place in Germany in 1937 on an aircraft engine. The first passenger car to run on direct engine was a car called the “Gutbrod” in the early 1950's.



Due to the complexity and cost of the direct injection system, the technology did not take hold. Later, the development of more cost efficient components and the need for a more efficient internal combustion engine, the DI engine made a comeback in the late 1990's.

The first application of this technology on a BMW was in 2003 on the 760Li (N73 Engine). The N73 V-12 engine utilized direct injection with the combination of VAL-VETRONIC and the latest direct injection technology.

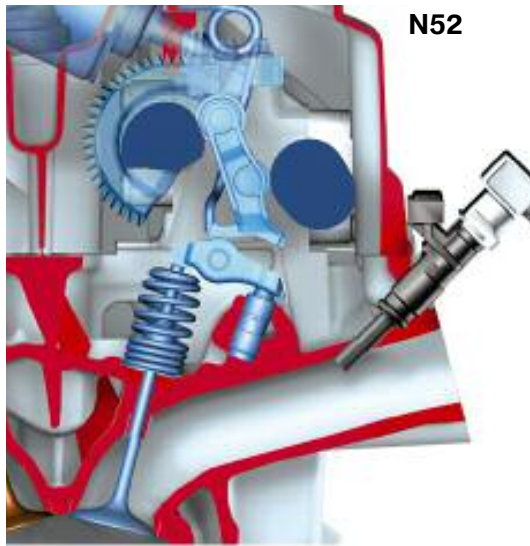
For the 2007 model year, BMW introduced a new 6-cylinder engine with direct fuel injection. The N54, which is turbocharged, uses the second generation of direct injection (DI 2), which is referred to as High Precision Injection (HPI).

Since then BMW introduced the N55, N63, S63 and N74, all of which incorporate Direct Injection Systems with either Piezo Injectors (HPI; N54, N63, S63, N74) or Solenoid type Injectors (HDEV; N55).

Direct Injection Principles

As the name suggest, the direct injection (DI) system use a fuel injector which sprays fuel directly into the combustion chamber. The fuel injection pressure (N73). The A/F mixture in a DI engine is formed inside of the combustion chamber.

In comparison, a manifold injection system sprays fuel into the intake manifold or into the intake port near the intake valve. In this case, the A/F mixture is formed outside of the combustion chamber. The injection pressure on most manifold injection systems is between 3 and 5 bar.



The DI system allows for increased engine efficiency and has several distinct advantages over manifold injection systems:

- The fuel is evaporated and atomized in the combustion chamber, which provides a “cooling effect” on combustion. A cooler combustion chamber allows an increase in air density, which allows for more available oxygen. In addition, cooler combustion allows for an increase in compression ratio which equates to improved efficiency and engine power.
- By injecting the fuel directly into the combustion chamber, there is less possibility for fuel to condense or accumulate on the manifold walls or the back of the intake valve. This results in less fuel needed to achieve the desired A/F ratio.
- The increased injection pressure causes the fuel droplet size to be reduced. This allows for improved atomization and therefore improved mixture formation.

Mixture Formation

In a conventional (manifold injection) engine, the air fuel mixture is formed outside of the combustion chamber. In contrast, the mixture must be formed inside the combustion chamber in a DI engine.

A DI fuel system has two basic operating concepts:

■ Homogeneous Mixture Formation

A homogeneous mixture means that the A/F ratio is stoichiometrically controlled much in the same way as a manifold injection system. This means that the A/F mixture is evenly spread throughout the combustion chamber. One of the primary advantages of this arrangement is that a conventional three-way catalytic converter can be used. Also, the sulfur content of the fuel is not a factor which allows the engine to be used in all global markets.

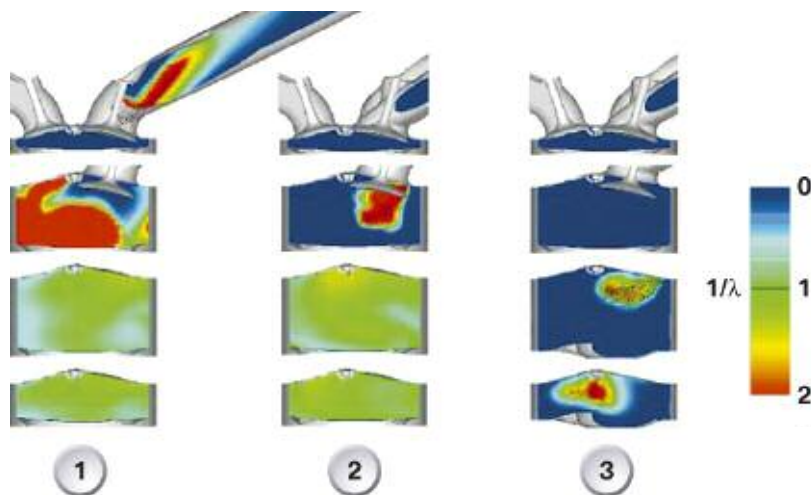


Currently, BMW only uses engines which operate in this mode. The N52, N54, N55, N63 and N74, all operate mostly at $\Lambda = 1$.

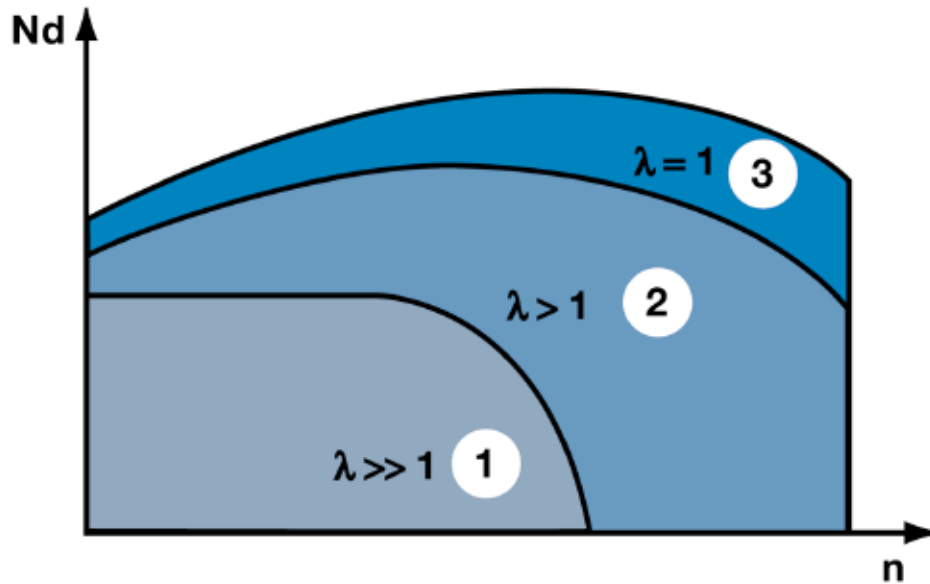
■ Stratified Mixture Formation

In the stratified injection method, a homogeneous mixture is only created around the area of the spark plug. A lean (inhomogeneous) mixture exists in the rest of the combustion chamber. Therefore the overall A/F mixture in the combustion chamber is lean ($\Lambda > 1$). This results in increased combustion chamber temperature, and subsequently increased NO_x emissions. The increased NO_x requires the use of a DeNO_x catalyst which is not effective when sulfur is present in the fuel. Therefore, sulfur free fuel must be used which is not readily available in all markets.

For the time being, BMW does not have any engines which operate as “stratified charge” engines.



Index	Explanation
1	Manifold injection
2	Homogeneous direct injection
3	Stratified direct injection



Index	Explanation
1	Lean, charge stratification
2	Lean, homogeneous
3	Homogeneous
Nd	Engine torque
n	Engine speed

As the above chart shows, the use of load stratification (1) is only possible in a limited load and speed range. Over and above this load and speed range, the engines can only be operated in homogeneous mode (2-3).

Through the deployment of VALVETRONIC, the N73 engine in the middle torque/speed range (1) demonstrates the same consumption advantages as engines of other manufacturers with charge stratification.

Because large-capacity engines are mainly operated in the lower to middle load and speed range, it is only advisable to use load stratification in these engines.

Smaller-sized engines are mainly operated in the high load and speed range and thus in homogeneous mode.



In the US market, BMW only uses engines that operate in “Homogeneous Mixture Formation”.

High Precision Injection (HPI)

BMW High Precision Injection (HPI) is the latest development of BMW direct fuel injection. This is the second generation of direct injection (DI 2) for BMW. The first generation was on the N73 engine in 2003.

The term “High Precision” refers to the precise metering and directional control of the atomized fuel. Also, the injection process now allows for multiple injection events due to the use of piezo injectors. The HPI system represents a key function in the concept for the most economical use of fuel without compromising performance.



Engine	Compression Ratio [ϵ]
N52 ¹	10.7
N54 ²	10.2
N55 ²	10.2
N62 ¹	10.5
N63 ²	10.0
N73 ¹	11.5
N74 ²	10.0
1 = NA Engine 2 = Turbocharged Engine	

High Precision Injection allows for a more precise metering of the fuel injection process and therefore permits higher compression ratios e.g. 10.2 to 1 in the N54 and N55 (see table). One of the key reasons that makes this possible is the use of the so called “spray guided” injection which cools the air charge and decreases the possibility of unwanted engine knock.

The operating pressure of the HPI system varies from 50-200 bar.



The N52KP and N51 engines continue to use the conventional “manifold injection” system from the N52.

High-precision injection represents the key function in the concept for as economic a use of fuel as possible. The new generation of petrol direct injection satisfies the expectations placed on it with regard to economic efficiency without compromising on the engine's dynamic qualities.

High-precision injection provides for a more precise metering of mixture and higher compression - ideal preconditions for increasing efficiency and significantly reducing consumption.

This is made possible by locating the piezo injector (or solenoid type in the N55) centrally between the valves. In this position, the new injector, which opens in an outward direction (inward in the N55), distributes a particularly uniform amount of tapered shaped fuel into the combustion chamber.

BMW HPI spark ignition engines operate according to the spray-directed process.

N54 - High Precision Injection

Using the N54 engine as an example, the fuel is delivered from the fuel tank by the electric fuel pump via the feed line (5) at a “feed” pressure of 5 bar to the high pressure pump. The feed pressure is monitored by the low-pressure sensor (6). The fuel is delivered by the electric fuel pump in line with demand.

The high pressure pump is driven “in-tandem” with the vacuum pump which is driven by the oil pump chain drive assembly.

The fuel is compressed in the permanently driven three-plunger high-pressure pump (8) and delivery through the high-pressure line (9) to the rail (3). The fuel accumulated under pressure in the rail in this way is distributed via the high-pressure lines (1) to the piezo injectors (2).

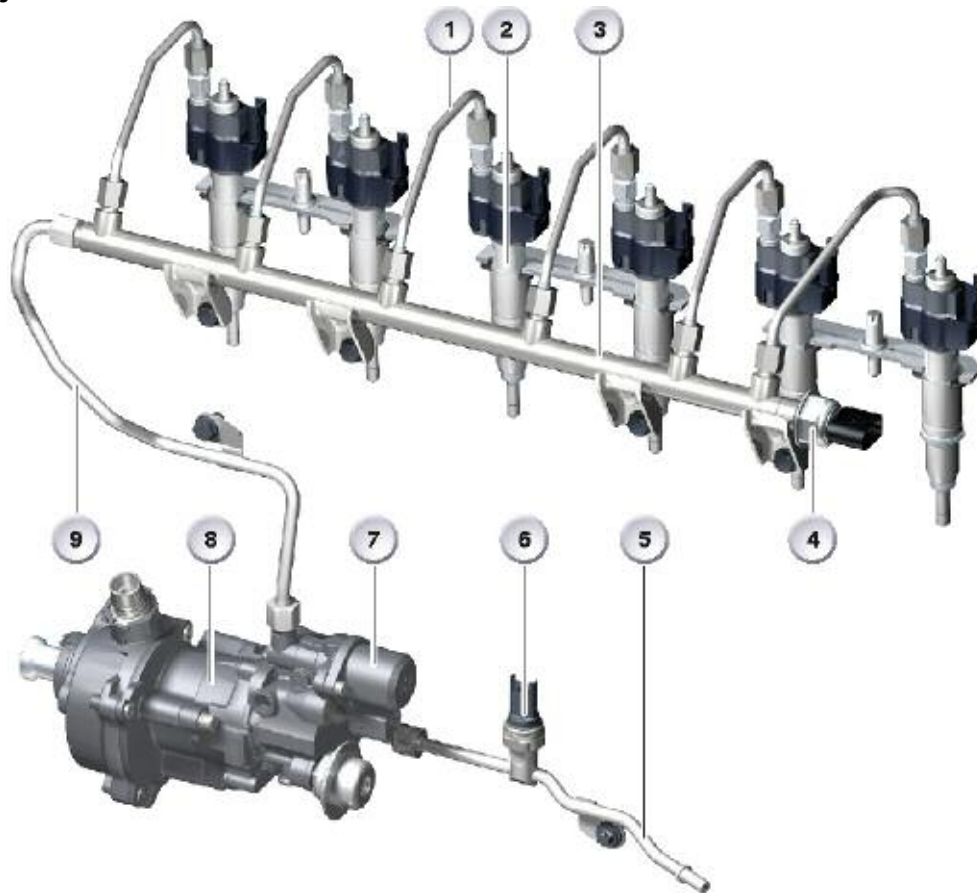


If the low fuel pressure sensor fails, the electric fuel pump continues to run at 100% delivery with terminal KL_15 ON.

The required fuel delivery pressure is determined by the engine-management system as a function of engine load and engine speed among other variables. The reached pressure level is recorded by the high-pressure sensor (4) and communicated to the Engine Control Unit.

Control is effected by the fuel-supply control valve (7) by way of a setpoint/actual-value adjustment of the rail pressure. Configuration of the pressure is geared towards best possible consumption and smooth running of the engine.

N54 HPI System



Index	Explanation	Index	Explanation
1	High-pressure line to injector (6)	6	Low-pressure sensor
2	Piezo injector	7	Fuel supply control valve
3	Fuel rail	8	Three plunger high pressure pump
4	High pressure sensor	9	High pressure line (pump to rail)
5	Feed line from in-tank pump		

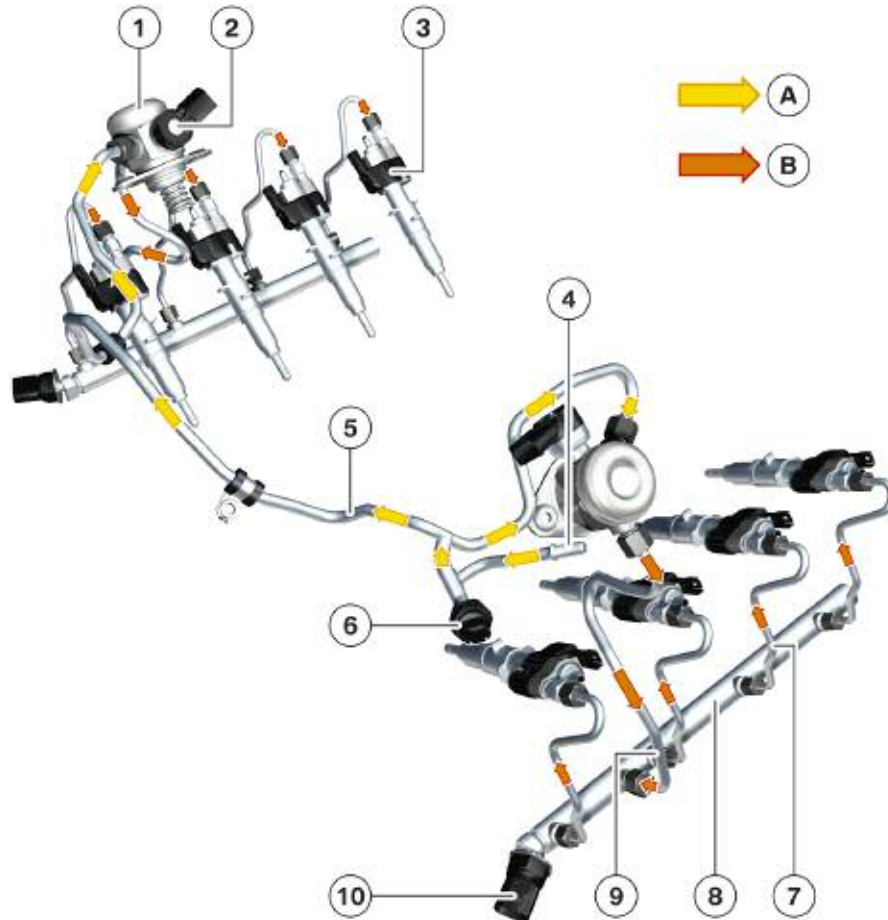


200 bar is required only at high load and low engine speed.

N63 - High Precision Injection

The operation on the N63 engine is similar to that of the N54.

N63 HPI System



Index	Explanation	Index	Explanation
1	High pressure pump (2 x)	6	Low pressure sensor
2	Volume control valve	7	High pressure fuel line
3	Piezo-injector	8	Fuel rail
4	Low-pressure feed from fuel pump	9	High pressure fuel line (pump to rail)
5	Low pressure feed line	10	Rail pressure sensor (2 x)



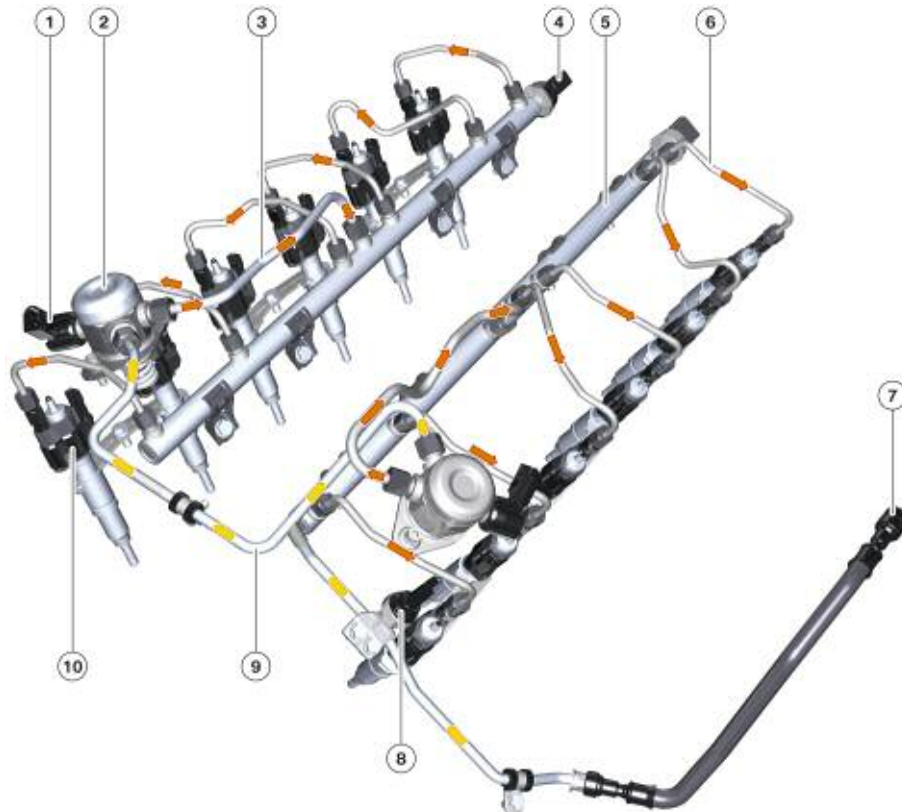
If the low fuel pressure sensor fails, the electric fuel pump continues to run at 100% delivery with terminal KL_15 ON.

200 bar is required only at high load and low engine speed.

N74 - High Precision Injection

The N74 engine is also equipped with HPI. This second generation direct fuel injection operates in homogeneous operation at all times and has the same structure as on the N63 engine.

N74 HPI System



Index	Explanation	Index	Explanation
1	Quantity control valve	6	High pressure line (rail - injector)
2	High pressure pump	7	Fuel feed from the electric fuel pump
3	High pressure line (pump - rail)	8	Fuel pressure sensor
4	Rail pressure sensor	9	Feed line
5	Rail	10	Piezo injector



If the low fuel pressure sensor fails, the electric fuel pump continues to run at 100% delivery with terminal KL_15 ON.

200 bar is required only at high load and low engine speed.

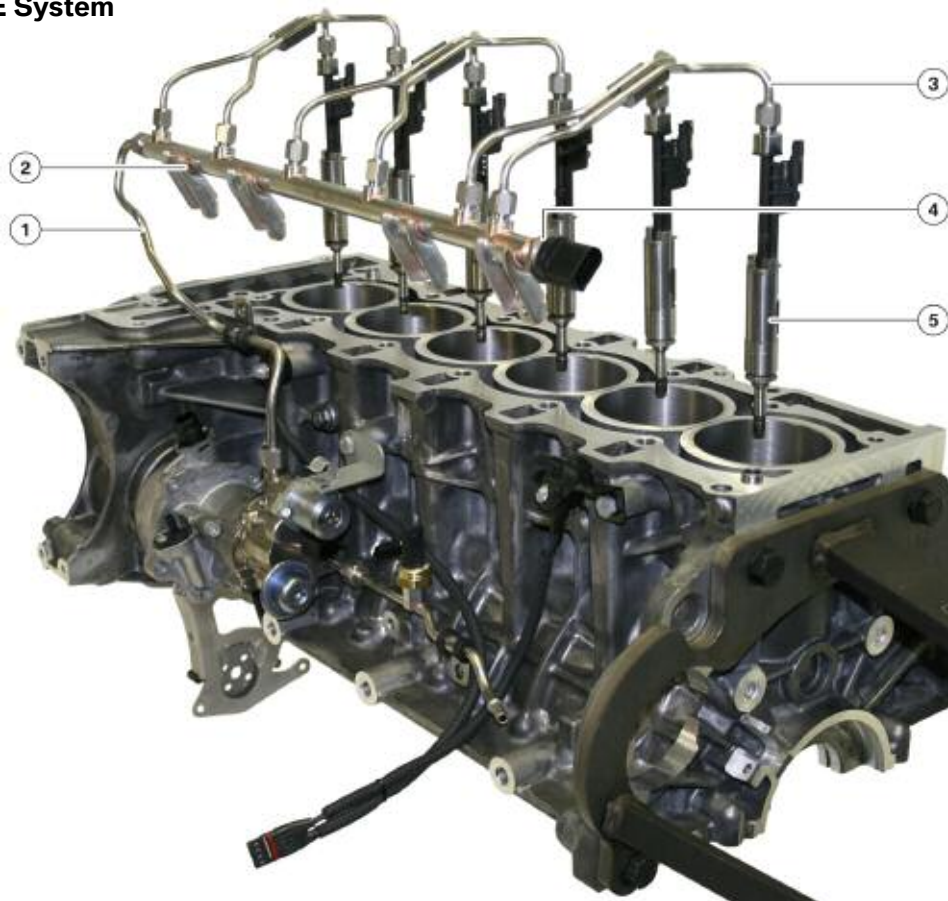
High Pressure Fuel Injection (HDE)

N55 - HDE

The high pressure fuel injection system (HDE) is used on the N55 engine. **In contrast to high precision injection (HPI), HDE uses solenoid fuel injectors with multi-hole nozzles.**

The following overview shows the complete fuel injection system. The system is similar to the N54 fuel injection. Although the same high pressure pump, pressure sensor, and fuel rail are used, the high pressure fuel injection valves are new. The HDE system uses Bosch high pressure solenoid type fuel injection valves with the designation HDEV5.2.

N55 HDE System

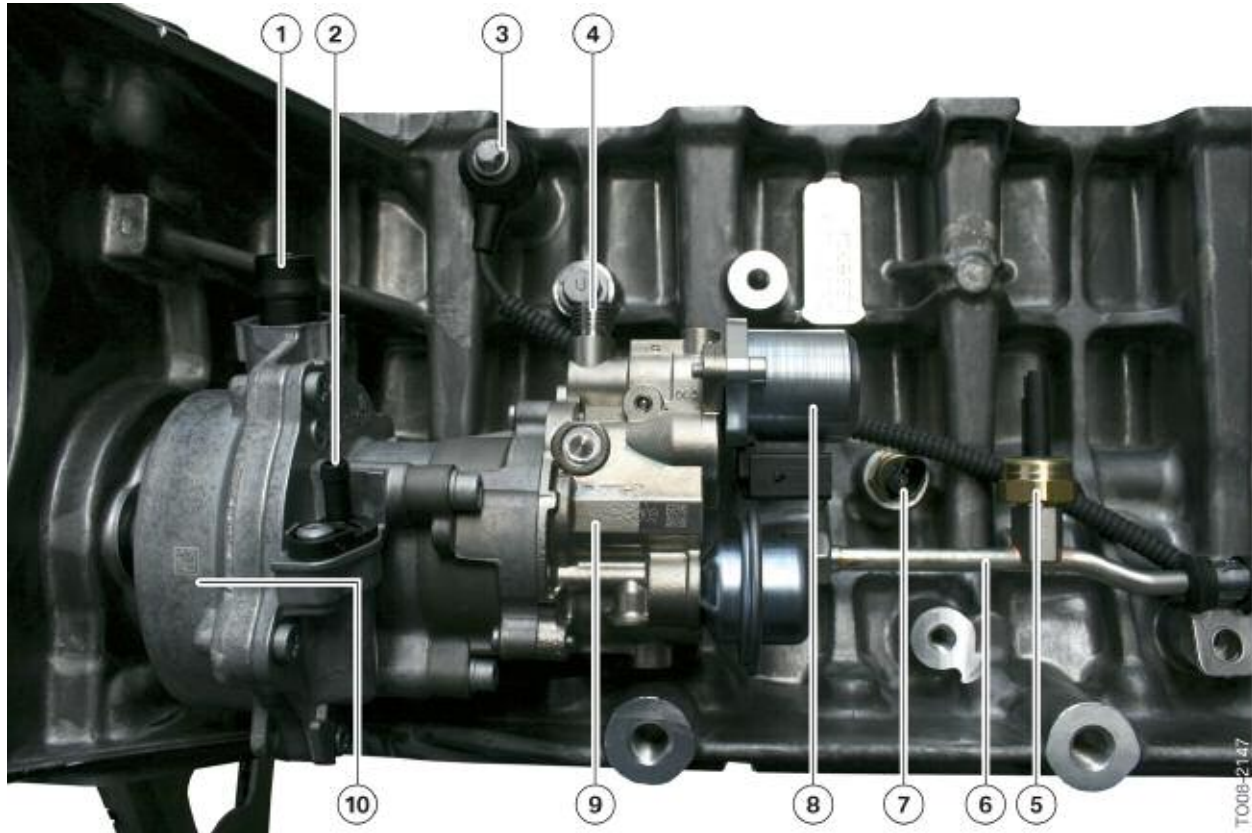


Index	Explanation
1	High pressure line
2	Rail
3	High pressure line
4	Fuel rail pressure sensor
5	Solenoid valve fuel injector

High Fuel Pressure Pump

The fuel is supplied at a primary pressure of **5 bar** by the electric fuel pump from the fuel tank via the supply line to the high pressure pump. The primary pressure is monitored by the fuel pressure sensor (5). The fuel is delivered by the electric fuel pump corresponding to engine requirements. The same **fuel pressure sensor** is used in the N54, N55, N63 and N74.

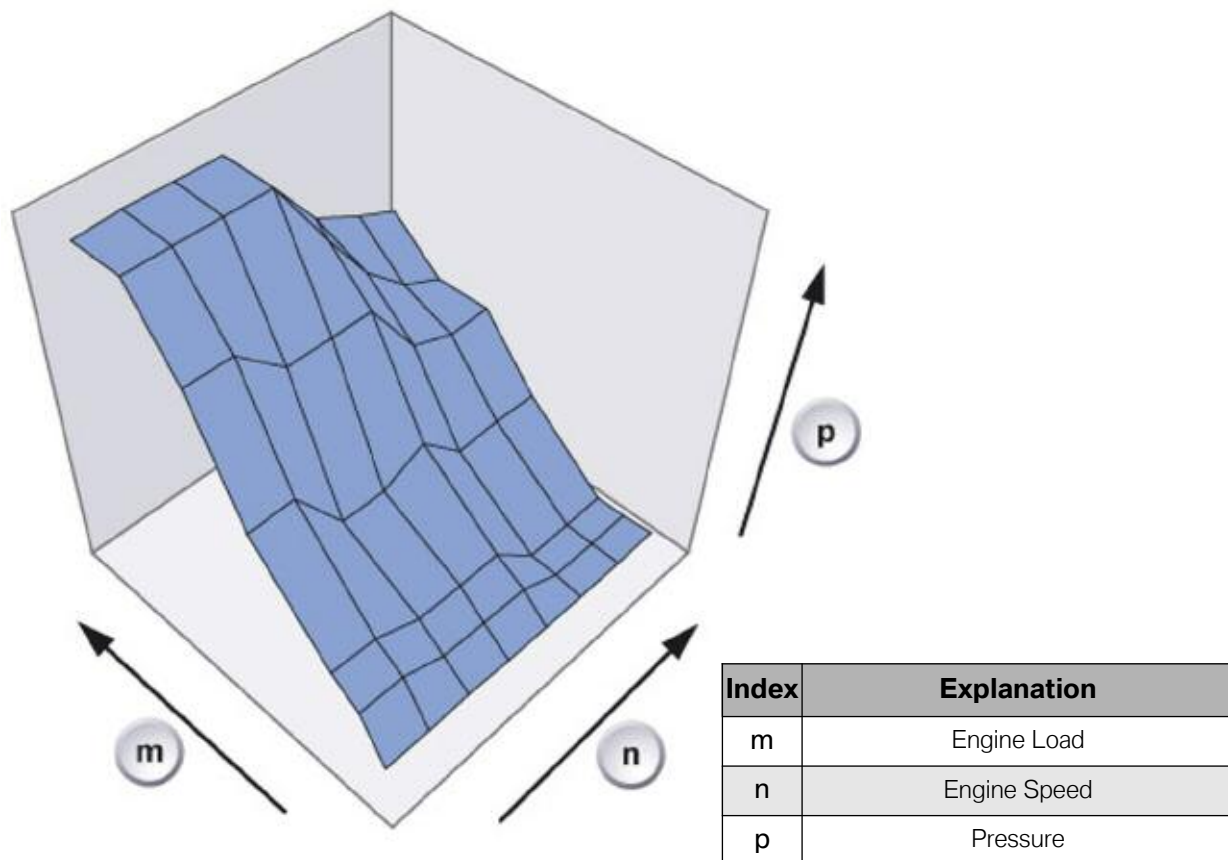
N55 High Fuel Pressure Pump



Index	Explanation	Index	Explanation
1	Non-return valve for brake booster	6	Fuel supply line
2	Non-return valve for auxiliary consumers	7	Oil pressure sensor
3	Knock sensor	8	Quantity control valve
4	Connection, high pressure line to fuel rail	9	High pressure pump
5	Fuel pressure sensor	10	Vacuum pump

The fuel is pressurized in the permanently driven three-piston high pressure pump and delivered to the fuel rail via the high pressure line. The fuel stored under pressure in the fuel rail is distributed via the high pressure lines to the high pressure fuel injection valves. The required fuel pressure is determined by the engine management as a function of the engine load and engine speed. The pressure level is registered by the rail pressure sensor and sent to the engine control unit. The fuel is regulated by the quantity control valve based on a target/actual value comparison of the rail pressure. The pressure level is configured such to achieve the smoothest running properties with the best possible fuel consumption.

High Fuel Pressure diagram



As you can see on the diagram, a pressure of 200 bar is only required at high load and low engine speed.

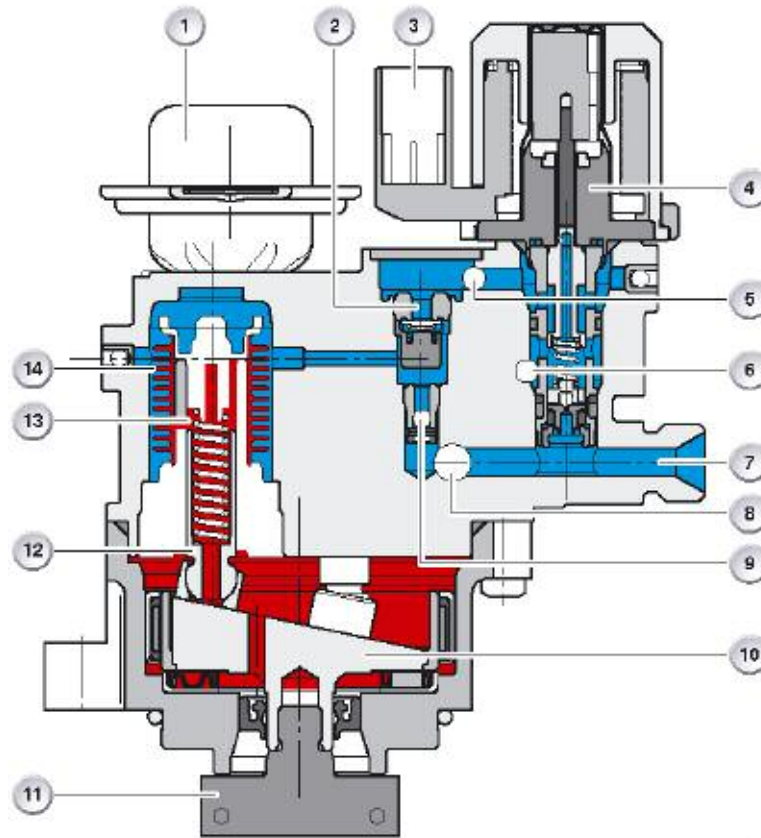
The high pressure pump is of the same design in the N54 and N55 engines.

High Pressure Pump Function and Design

■ N54/N55

In the N54/N55 the fuel is delivered via the supply passage (6) at the admission pressure generated by the electric fuel pump to the high-pressure pump. From there, the fuel is directed via the fuel supply control valve (4) and the low-pressure non-return valve (2) into the fuel chamber (14) of the plunger-and-barrel assembly. The fuel is placed under pressure in this plunger-and-barrel assembly and delivered via the high pressure non-return valve (9) to the high pressure port (7).

N54/N55 High Pressure Fuel Pump



Index	Explanation	Index	Explanation
1	Thermal compensator	8	Supply passage, pressure limiting valve
2	Low pressure non-return valve (check valve)	9	High pressure non-return valve (x 3)
3	Connection to engine management	10	Pendulum disc
4	Fuel supply control valve	11	Drive flange, high pressure pump
5	Return, pressure limiting valve	12	Plunger (x 3)
6	Supply from electric fuel pump (in-tank)	13	Oil filling, high pressure pump
7	High pressure port to fuel rail	14	Fuel chamber (x 3)

The high-pressure pump is connected with the vacuum pump via the drive flange (11) and is thus also driven by the chain drive, i.e. as soon as the engine is running, the three plungers (12) are permanently set into up-and-down motion via the pendulum disc (10).

Fuel therefore continues to be pressurized for as long as new fuel is supplied to the high-pressure pump via the fuel-supply control valve (4). The fuel-supply control valve is activated by means of the engine management connection (3) and thereby admits the quantity of fuel required.

Pressure control is effected via the fuel-supply control valve by opening and closing of the fuel supply channel. **The maximum pressure in the high-pressure area is limited to 245 bar.** If excessive pressure is encountered, the high-pressure circuit is relieved by a pressure-limiting valve via the ports (8 and 5) leading to the low-pressure area.

This is possible without any problems because of the incompressibility of the fuel, i.e. the fuel does not change in volume in response to a change in pressure. The pressure peak created is compensated for by the liquid volume in the low-pressure area.

Volume changes caused by temperature changes are compensated for by the thermal compensator (1), which is connected with the pump oil filling.

■ N63/N74

The fuel is delivered via the supply passage at the admission pressure generated by the electric fuel pump to the high pressure pump.

From there, the fuel is directed via the volume control valve and the low pressure non-return valve into the fuel chamber of the plunger and-barrel assembly.

The high pressure pump on the N74 is in principle, the same as the one used on the N63 engine. The only difference is that the fuel lines are positioned at a different angle.

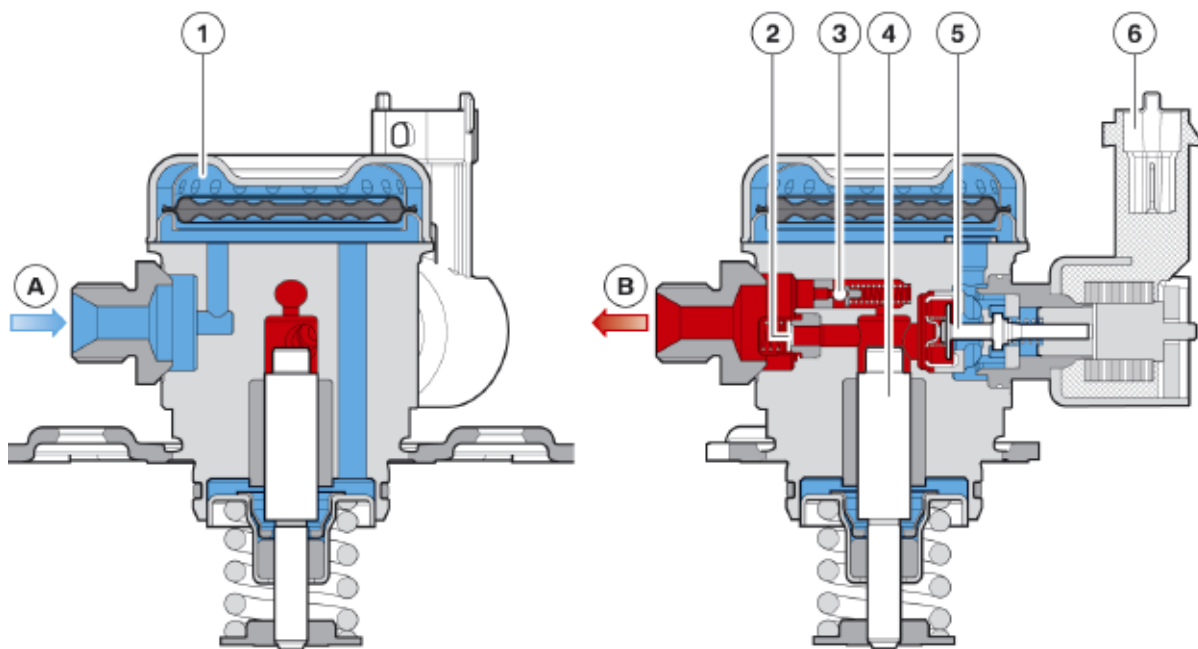
N63



The fuel is delivered to the high-pressure pump via the inlet with delivery pressure generated by the electric fuel pump. The fuel is then fed via the volume control valve and into the compression chamber of the pump element. In this pump element, the fuel is placed pressurized by a plunger and supplied via the high-pressure non-return valve to the high-pressure connection.

The high-pressure pump is bolted onto the cylinder head and is driven by the camshaft by a triple cam. This means that, as soon as the engine is running, the triple cam continuously moves the plunger. Fuel is pressurized until new fuel is delivered via the volume control valve into the high-pressure pump. The volume control valve is activated by the engine management system; it specifies the delivered volume of fuel. Pressure regulation takes place via the volume control valve in that it is opened or closed by the pump element towards the fuel feed. When the quantity control valve is opened, most of the fuel drawn in by the piston is pressed back into the fuel feed.

N63/N74 High Pressure Fuel Pump



Index	Explanation	Index	Explanation
A	Low pressure connection	3	Pressure relief valve
B	High pressure connection	4	Piston
1	Equalization chamber	5	Volume control valve
2	High pressure non-return valve	6	Electrical connection for the volume control valve

The **maximum pressure** in the high-pressure area is restricted to **245 bar**. If the maximum high pressure is reached, the high-pressure circuit is relaxed to the low-pressure area by a pressure limiting valve. In this case the pressure peak in the low pressure area is compensated for by the fluid volume in the area and pressure damper in the compensating chamber. The compensating chamber is integrated into the inlet towards the high pressure pump.

This set-up ensures that pressure peaks are lowered by connecting and disconnecting the high and low-pressure areas. When the piston generates pressure, fuel flows between the piston and its guide. This is deliberate, as it lubricates the pair of sliding elements. On downward movement of the pressure piston, a high pressure would arise at its rear side. This would lead to danger if the fuel is pressed through the sealing of the piston from the pump into the oil circuit of the engine.

The connection to the compensating chamber means that there is never a higher pressure behind the piston than in the fuel feed. This prevents pressure fluctuations from being transferred into the low pressure fuel system, as the volume changes in front of and behind the piston are balanced.

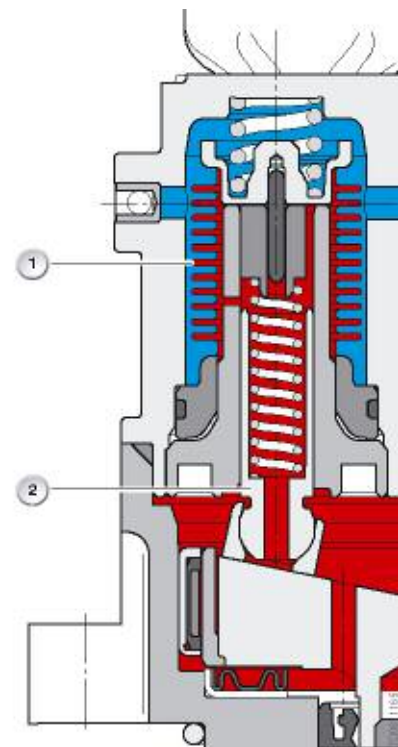
■ Pressure Generation in High-pressure Pump

The plunger (2) driven by the pendulum disc presses oil (red) into the metal diaphragm (1) on its upward travel. The change in volume of the metal diaphragm thereby reduces the available space in the fuel chamber. The fuel thereby placed under pressure (blue) is forced into the rail.

Depending on the activation signal, a restrictor cross-section of varying size is opened and the fuel-mass flow required for the respective load point is set. There is also the possibility of reducing the pressure in the rail.



The fuel supply control valve controls the fuel pressure in the rail. It is activated by the engine management system via a pulsewidth modulated (PWM) signal.



Index	Explanation
Red	Oil filling
Blue	Fuel
1	Metal diaphragm
2	Plunger

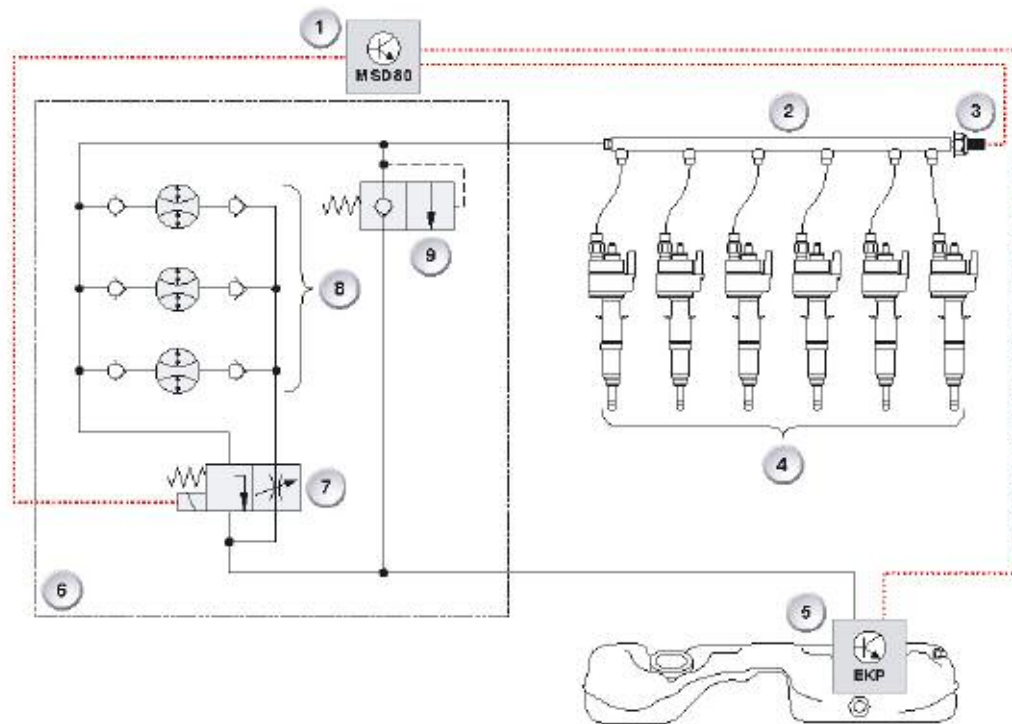
Hydraulic Circuit Diagram of Fuel System

The volume control valve controls the fuel pressure in the rail. It is activated by the engine management system via a **pulse-width modulated** (PWM) signal.

Depending on the activation signal, a restrictor cross-section of varying size is opened and the fuel-mass flow required for the respective load point is set.

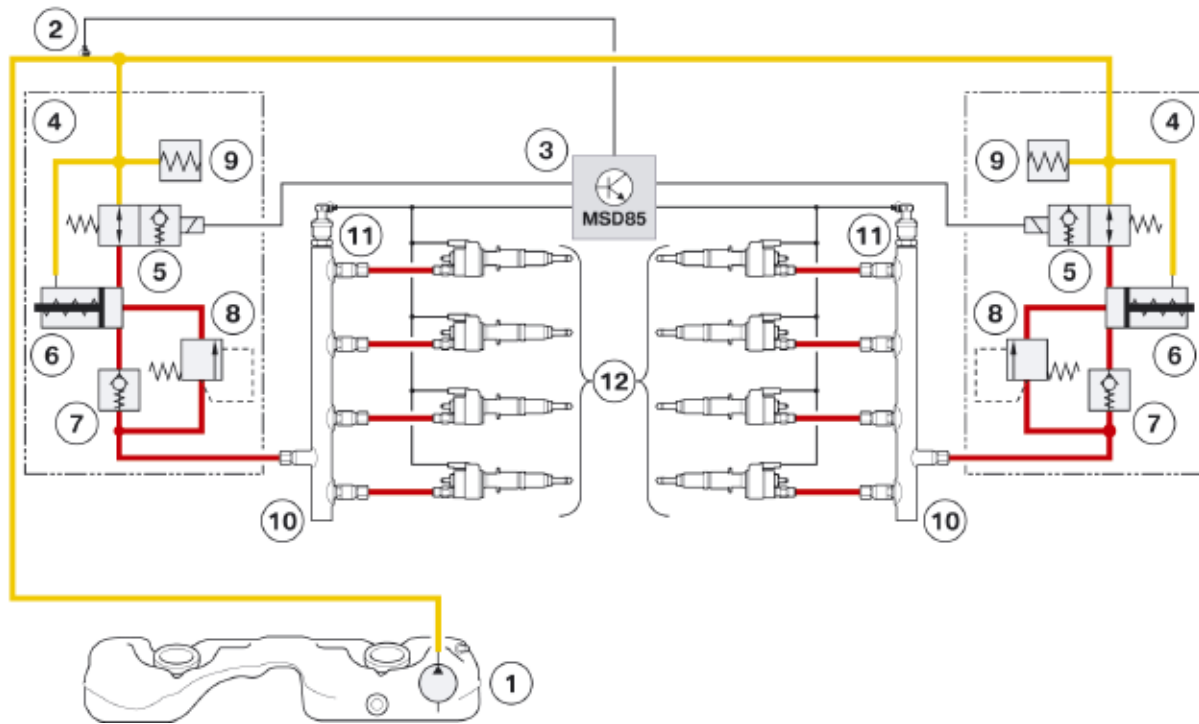
The pressure relief valve additionally provides the option of reducing the pressure in the fuel rail by directing the fuel out of the high pressure system back into the pump element.

N54/N55 Fuel System, Hydraulic Circuit Diagram



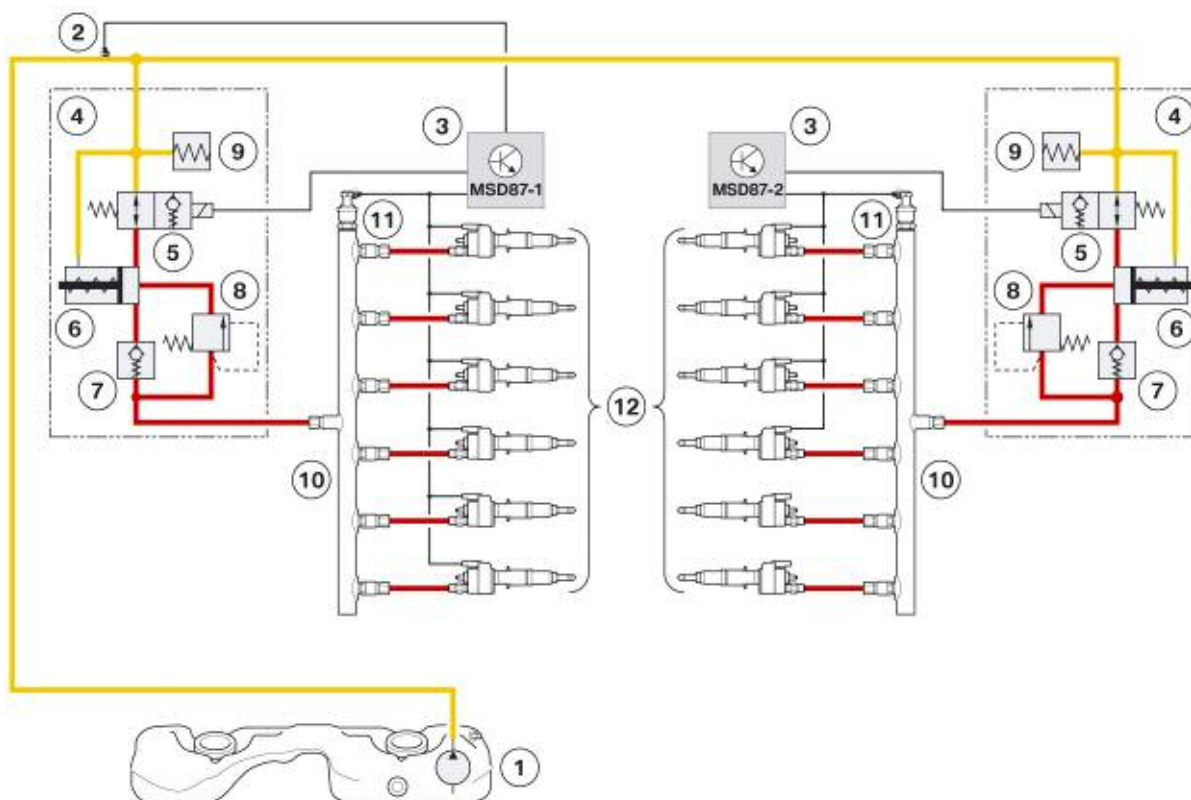
Index	Explanation	Index	Explanation
1	Engine control module (MSD80)	6	High-pressure pump
2	Fuel rail	7	Fuel supply control valve
3	High pressure sensor	8	High pressure pump with non-return valves
4	Piezo injectors	9	Pressure limiting valve with bypass
5	Electric fuel pump		

N63 Fuel System, Hydraulic Circuit Diagram



Index	Explanation	Index	Explanation
1	Electric fuel pump	7	High pressure non-return valve
2	Low pressure sensor	8	Pressure relief valve
3	Engine control module	9	Rail
4	High pressure pump	10	Rail pressure sensor
5	Volume control valve	11	Piezo-injectors
6	High pressure pump element		

N74 Fuel System, Hydraulic Circuit Diagram



Index	Explanation	Index	Explanation
1	Electric fuel pump	7	High pressure non-return valve
2	Fuel pressure sensor	8	Pressure limiting valve
3	Engine control unit	9	Compensating chamber
4	High pressure pump	10	Rail
5	Quantity control valve	11	Rail pressure sensor
6	High pressure pump element (piston)	12	Piezo injectors

Fuel Injectors/Fuel Rail

The type of fuel injector depends on the engine design. BMW for the most part utilizes two different configurations:

- Injectors mounted into the cylinder head spraying fuel into the intake port and;
- Injectors mounted into the cylinder head spraying fuel directly into the combustion chamber, also known as **Direct Injection**.

Furthermore, BMW uses two different types of injectors:

- Solenoid Injector (in low and high pressure systems)
- Piezo Injector (only used in high pressure systems)

Piezo Fuel Injectors (HPI)

It is the outward-opening piezo-injector that renders possible spray-directed direct injection and thus the overall innovations of BMW engines i.e. N54, N63 & N74. Due to the fact that only this component ensures that the injected fuel spray cone remains stable, even under the prevailing influences of pressure and temperature in the combustion chamber.

This piezo-injector permits injection pressures of up to 200 bar and extremely quick opening of the nozzle needle. In this way, it is possible to inject fuel into the combustion chamber under conditions released from the power cycles limited by the valve opening times.

Piezo Fuel Injector (HPI)



The piezo-injector is integrated together with the spark plug centrally between the inlet and exhaust valves in the cylinder head. This installation position prevents the cylinder walls or the piston crown from being wetted with injected fuel. A uniform formation of the homogeneous air/fuel mixture is obtained with the aid of the gas movement in the combustion chamber and a stable fuel spray cone.

The gas movement is influenced on the one hand by the geometry of the intake passages and on the other by the shape of the piston crown. The injected fuel is swirled in the combustion chamber with the boost air until a homogeneous mixture is available throughout the compression space at the point of ignition.

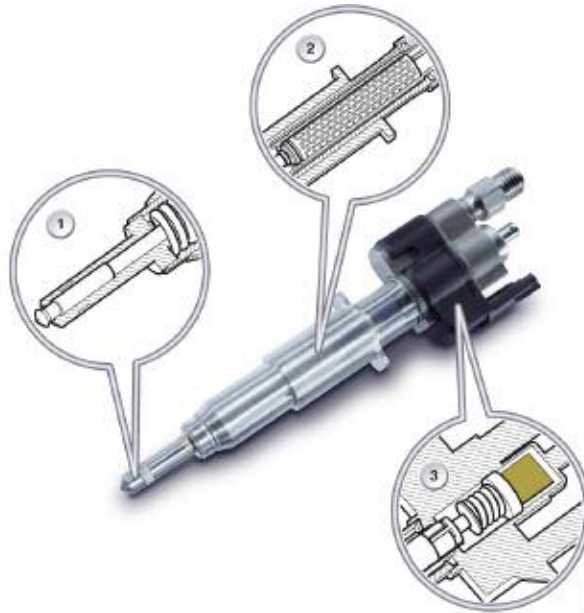


When working on HPI/HDE Fuel Systems it is important to ensure that the ignition coils are not fouled by fuel. The resistance of the silicone material is significantly reduced by heavy fuel contact. This can cause sparkover at the spark-plug head and with it misfires.

- **Before making modifications to the fuel system, remove the ignition coils without fail and protect the spark-plug slot against the ingress of fuel with a cloth.**
- **Before refitting the piezo-injector, remove the ignition coils and ensure conditions of absolute cleanliness.**
- **Ignition coils heavily fouled by fuel must be replaced.**

■ Injector Design and Function

The piezo-injector essentially consists of three sub-assemblies. The expansion of the energized piezo-element lifts the nozzle needle outwards from its valve seat. To be able to counter the different operating temperatures with comparable valve lifts, the injector has a thermal compensating element.



Index	Explanation	Index	Explanation
1	Outward opening nozzle needle	3	Thermal compensator
2	Piezo-element		

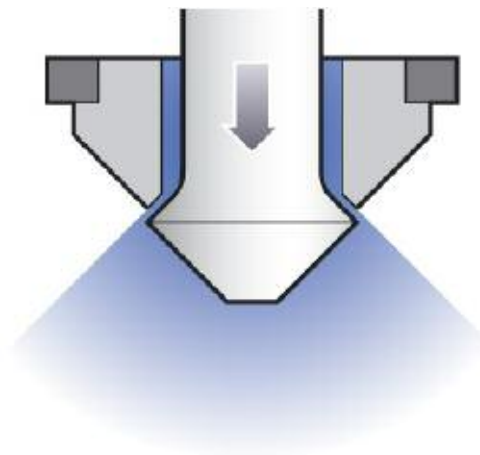
The nozzle needle is pressed outwards from its tapered valve seat. This opens up an annular orifice. The pressurized fuel flows through this annular orifice and forms a hollow cone, the spray angle of which is not dependent on the backpressure in the combustion chamber.



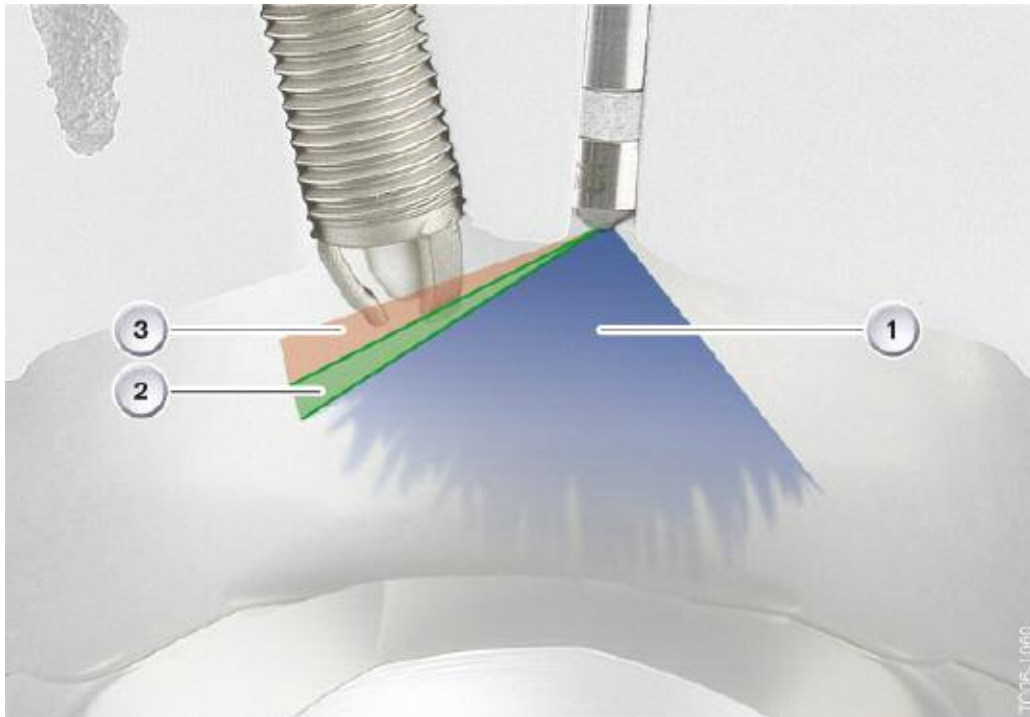
Do not attempt to clean the injectors in any way. This may result in damage which can effect the spray pattern.

Any divergence in the spray pattern can cause damage to the spark plug or the engine itself.

Outward opening injector nozzle needle



The spray cone (1) of a piezo-injector can diverge during operation (2). Due to the formation of soot inside the engine, such divergence is perfectly normal and acceptable to a certain extent. If, however, spray divergence reaches the stage where it begins to spray the spark plug wet, the spark plug may incur damage.



Index	Explanation	Index	Explanation
1	Ideal "spray" cone	3	Non-permitted divergence of spray cone
2	Permitted divergence of spray cone		



Replace the Teflon sealing ring when fitting and removing the piezo-injector. This also applies when an injector that has just been fitted has to be removed again after an engine start.

A piezo-injector provided with a new Teflon sealing ring should be fitted as quickly as possible because the Teflon sealing ring could swell up. Please observe the repair instructions and follow without fail.

When fitting, make sure that the piezo injector is correctly seated. The hold-down element for securing the piezo-injectors must rest on both injector tabs, otherwise the necessary force is not applied to the piezo-injector. Do not clean the nozzle-needle tip of the piezo-injector.

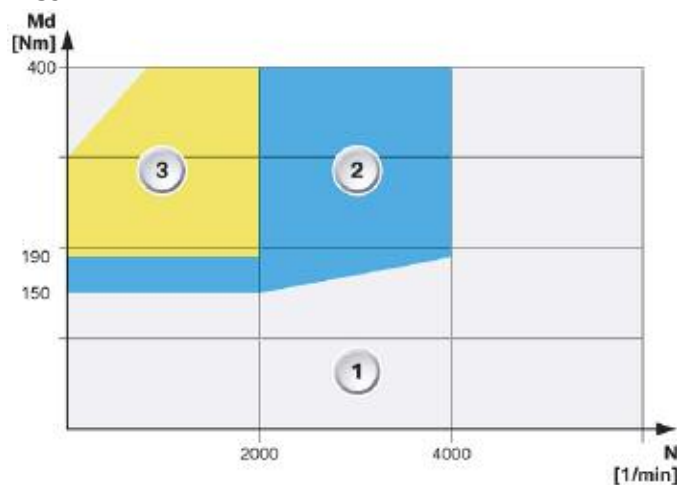
■ Injection Strategy

Injection of the fuel mass required for the operating situation can take place in up to three individual injections. Which option is used in the relevant operating situation is dependent on engine load and speed. Here, the actual time resulting from the engine speed available for metering the fuel is an important framework quantity.

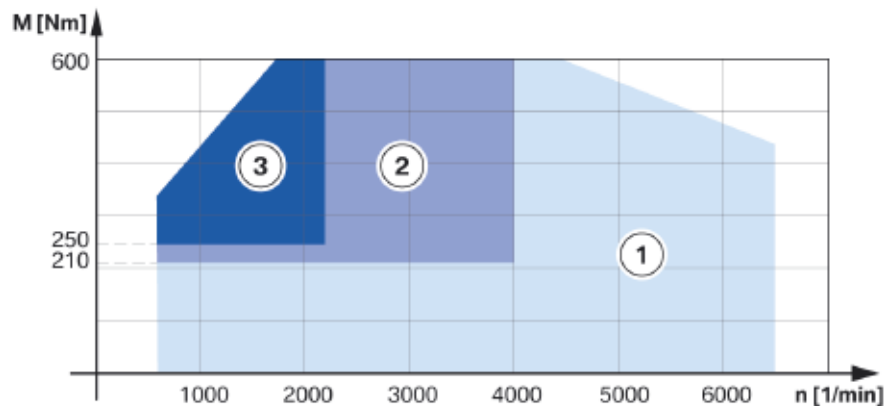
A special situation during the operation of any engine is the range in which a high load occurs at low engine speed, so-called "Low End Torque" operation. In this operating situation, the required fuel mass is metered to the engine in three individual injections.

This results in a highly effective mixture formation which in the final analysis has the effect of both increasing power output and saving fuel.

N54 Injection Strategy



N63 Injection Strategy



Index	Explanation	Index	Explanation
n	Engine speed	2	Two-time injection
m	Torque	3	Three-time injection
1	One-time injection		

■ Catalytic Converter Heating Mode

In order to bring the catalytic converters up to operating temperature as quickly as possible, BMW engines enter a catalyst-heating mode when the engine performs a cold start. In this mode, combustion heat is intentionally introduced into the exhaust train and not used first and foremost to develop power output.

The point of ignition is moved to 30° (crankshaft degrees) after TDC. The main quantity of the required fuel is injected before TDC and mixed with boost air. The piston is situated after TDC in its downward travel such that the air/fuel mixture is already expanding again, which reduces the ignitability of the mixture.

In order to ignite the mixture reliably, a small residual quantity of fuel is injected 25° after TDC and this guarantees an ignitable mixture at the spark plug. This small fuel quantity therefore provides for ignition of the residual charge in the combustion chamber.



This operating mode is set by the engine-management system after a maximum period of 60 seconds from engine starting but is terminated if the catalytic-converter response temperature is reached earlier.

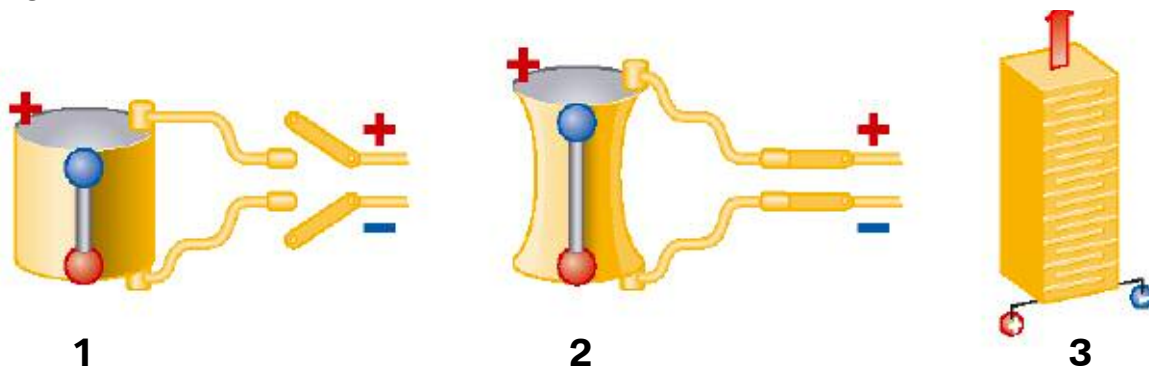
■ Piezo Element

The movement of the nozzle needle in the injector is generated no longer by a solenoid coil but rather by a piezo-element.

A piezo-element is an electromechanical converter, i.e. it consists of a ceramic material which converts electrical energy directly into mechanical energy (force/travel). A familiar application is the piezo cigarette lighter - when a piezo-crystal is pressed, voltage is generated until a spark flashes over and the gas ignites.

In the case of the piezo-actuator, voltage is generated so that the crystal expands. In order to achieve greater travel, it is possible to design a piezo-element in several layers.

The actuator module consists of layers of the piezo-ceramic material connected mechanically in series and electrically in parallel. The deflection of a piezo-crystal is dependent on the applied voltage up to a maximum deflection; the higher the voltage, the greater the travel.



Index	Explanation	Index	Explanation
1	Piezo crystal - not energized	3	Piezo element in layers (stacked)
2	Piezo crystal - energized		

■ Injector Adjustment

When the injectors are manufactured, a multitude of measurement data is recorded at specific points in the factory. In this way, the tolerance ranges for injector-quantity adjustment are determined and specified in a six-digit number combination.

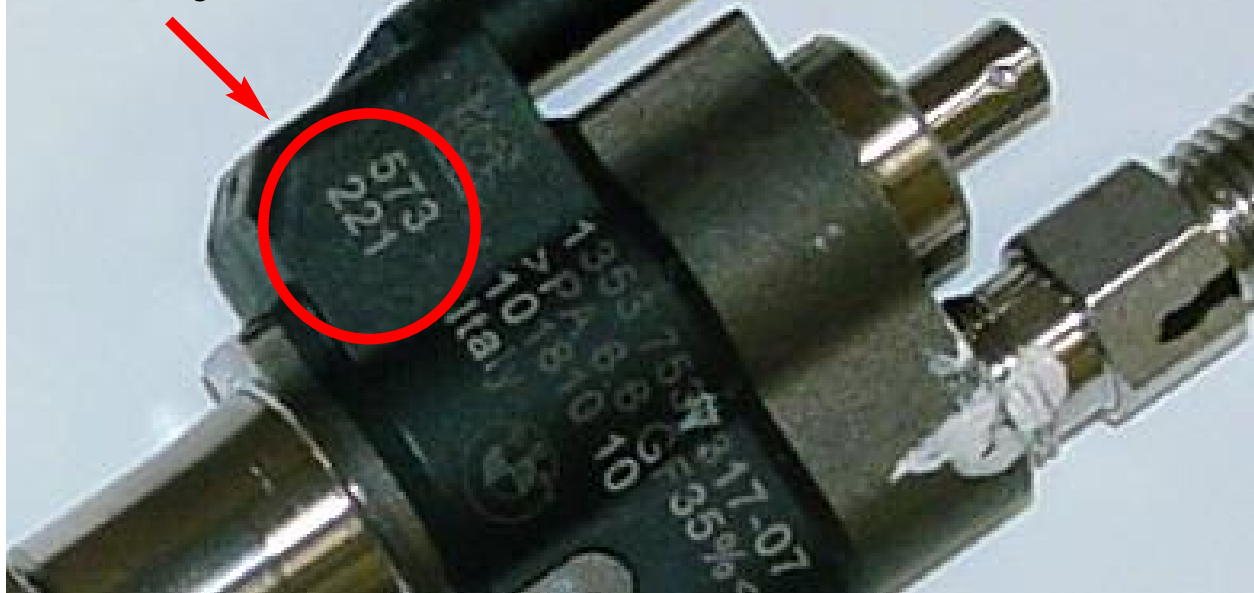
Information on the lift performance of the injector is also added for injector voltage adjustment. Injector adjustment is required because of the individual voltage demand of each piezo actuator. An allocation is made to a voltage demand category, which is included in the number combination on the injector.

These data items are transmitted to the ECM. During engine operation, these values are used to compensate for deviations in the metering and switching performance.



When replacing an injector, it is absolutely essentially to carry out an injector adjustment.

Tolerance range numbers



■ **Injector Control and Adaptation**

The fuel mass required for the operating situation is injected by the piezo-injector into the combustion chamber. This mass can be influenced by three correcting variables:

- Rail pressure
- Injector opening time
- Injector opening lift

The injector opening time and the injector opening lift are activated directly at the piezo injector. The opening time is controlled via the “ti” signal and the opening lift via the energy quantity in the activation of the piezo-injector.

■ **Injector Adaptation**

The fuel masses and injection cycles determined from the load/speed map are included in a pilot-control program map. Here, while further framework parameters are taken into consideration, the energy quantities and injector opening times required to activate the injectors are determined. BMW engines can be safely and reliably operated with these program-map values.

■ Optimization

For optimization of:

- Emission values;
- Smooth running;
- Fuel consumption;
- Power output;

the controlled variables of energy quantities and injector opening times are continuously monitored. This occurs on a bank-selective basis by way of lambda closed-loop control.

The residual oxygen in the exhaust gas is measured in each case for cylinder bank 1 and cylinder bank 2. This measurement result is compared with the values expected from the set correcting variables. The result of a deviation is that the injector opening signal is adapted. This adaptation is stored in the control unit and is therefore available for subsequent engine operation.

However, these stored values are lost when the system is flashed and must be relearned. A further adaptation of the injector activation takes place depending on time and use. This cylinder-selective adaptation involves a check of the residual-oxygen content with a conclusion as to the cylinder causing the situation. To this end, it is necessary for part of the exhaust-gas flow not to be swirled in the turbocharger. For this reason, the flap of the wastegate valve must be fully opened, i.e. swung out of the exhaust-gas flow. This wastegate-flap position extends beyond its normal opening position in engine operation. Based on the result of this cylinder-selective monitoring, the energy quantity is adapted if necessary to activate the injectors.

Furthermore, the cylinder-selective adaptation includes, if necessary, an adaptation of the injector opening signal based on smooth running monitoring of BMW engines.



Overall adaptation of the injectors is limited to a 15% additional quantity.

Solenoid Type Fuel Injectors N55 (HDE)

The high pressure fuel injection valve Bosch HDEV5.2 is a solenoid type injector. In contrast to the piezo-electric injectors used on the current BMW engines, the solenoid valve fuel injectors are designed as inward-opening multi-hole valves with highly variable jet angle and form. They operate at a system pressure of up to 200 bar.

CAUTION!!!

Do not open the fuel system if the coolant temperature is above 40°C/104°F. The residual pressure in the high pressure fuel system could cause bodily injury.

It is essential to observe the utmost cleanliness when working on the high pressure fuel system and to follow the proper working procedures described in the repair instructions. Even minute soiling or damage at the thread connections of the high pressure lines could cause leaks.

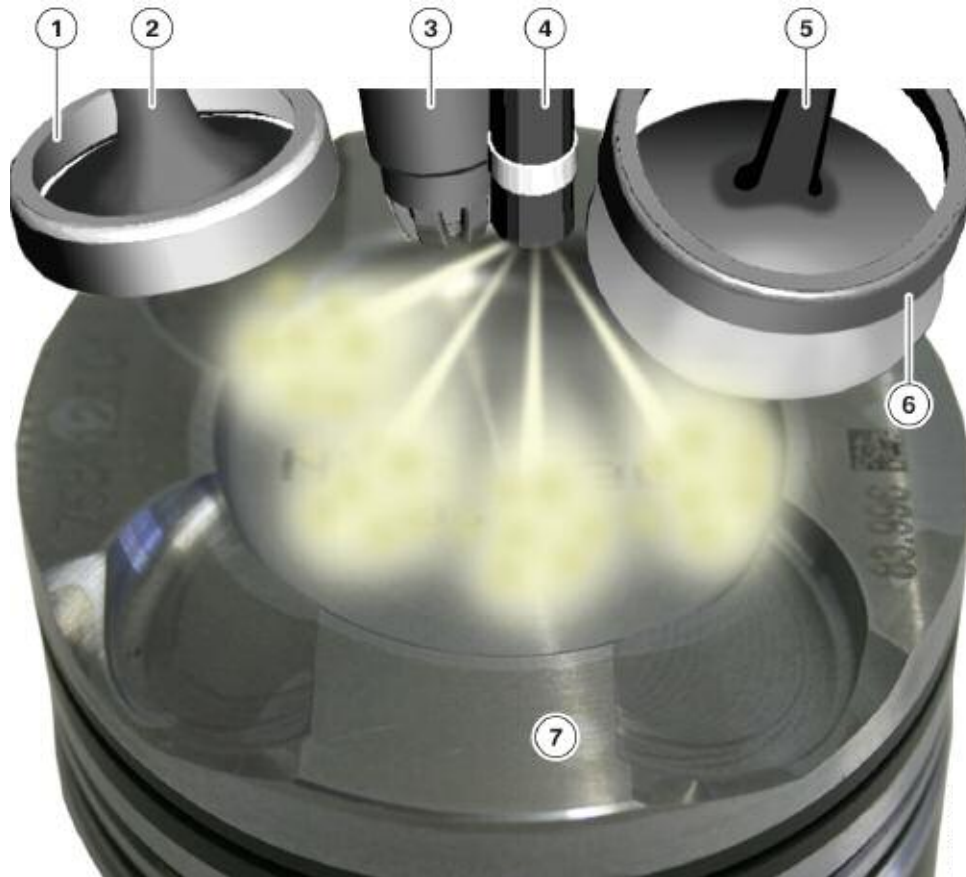


Special tool # 13 0 270 must be used to remove the HDEV5.2 high pressure injector valves from the engine. Damage to the injector or the related components may occur otherwise. See the Service Information section in this training material for more information.

Particular care must be taken when working on the fuel system of the N55 engine to ensure that the ignition coils are not wet with fuel. The resistance of the silicone insulating material of the coils is greatly reduced by the contact with fuel. This could result in arcking at the top of the spark plug and misfiring. See the Service Information section and repair instructions for more information.

The following graphic shows the arrangement of the individual components in the combustion chamber of the N55. It can be seen that the BMW (spray-guided) high precision injection (HPI) system is not used but rather a Bosch solenoid valve fuel injector with multi-hole nozzle. The fuel injection is specially adapted to the combination of Valvetronic III and turbocharging. For better illustration, a set of valves has been removed in the graphic.

N55, combustion chamber with components



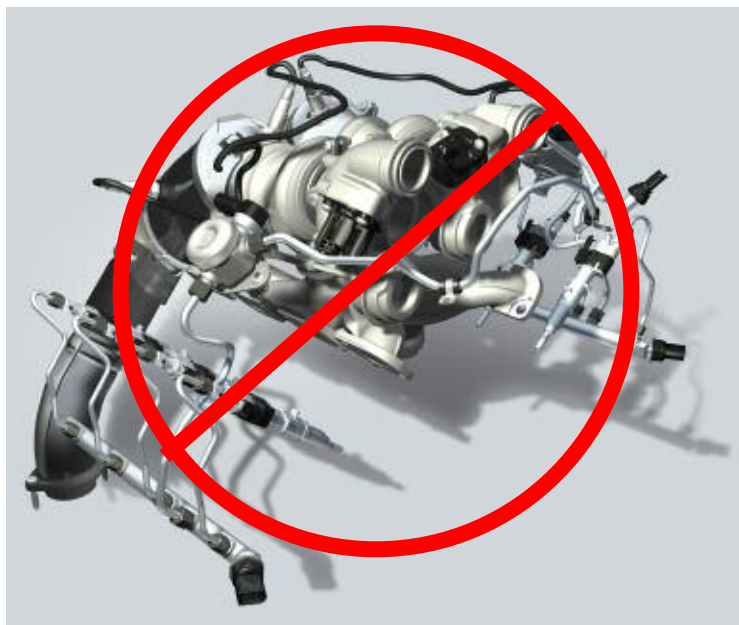
Index	Explanation
1	Valve seat, exhaust valve
2	Exhaust valve
3	Spark plug
4	Fuel injector
5	Intake valve
6	Valve seat, intake valve
7	Piston

Service Information

HPI/HDE System Service

Fuel System Safety

- Working on the fuel system is only permitted after the engine has cooled down. The coolant temperature must not exceed **40°C/104°F**. This must be observed without fail, otherwise there is a danger of fuel sprayback on account of the residual pressure in the high pressure fuel system.
- When working on the high pressure fuel system, take particular care to ensure conditions of absolute cleanliness and follow the work sequences described in the repair instructions. Even the tiniest contaminants and damage to the screw connections on the high pressure lines can cause leaks.
- When working on the fuel system of BMW engines, it is important to ensure that the ignition coils are not fouled by fuel. The resistance of the silicone material is significantly reduced by heavy fuel contact. This can cause sparkover at the spark-plug head and cause misfires.
- Before making modifications to the fuel system, remove the ignition coils without fail and protect the spark-plug slot against the ingress of fuel with a cloth.
- Before refitting piezo-injectors, remove the ignition coils and ensure conditions of absolute cleanliness.
- Ignition coils heavily fouled by fuel must be replaced.

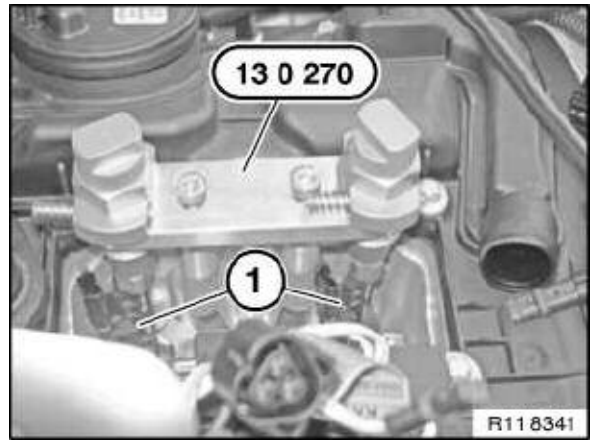
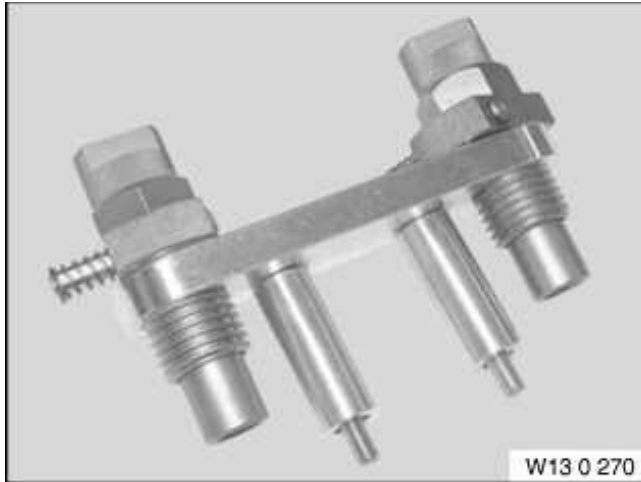


ACHTUNG! Öffnen des Kraftstoffsystems bei Kühlmitteltemperatur über 40 °C nicht zulässig. Gefahr von Körperverletzung. Reparaturanleitung beachten.
CAUTION! Do not open the fuel system if the coolant temperature is above 40 °C/104 °F – risk of injury! Consult the repair manual.
ATTENTION ! Il est interdit d'ouvrir le système d'alimentation en carburant lorsque la température du liquide de refroidissement est supérieure à 40 °C. Risque de blessure. Respecter les instructions du Manuel de réparation.
¡ATENCIÓN! Prohibido abrir el sistema de combustible cuando la temperatura del líquido refrigerante supere los 40 °C. Peligro de lesiones. Consultar el manual de reparaciones.
注意! 冷却液温度高于40摄氏度时禁止打开燃油系统。存在身体伤害的危险。请查阅维修手册。

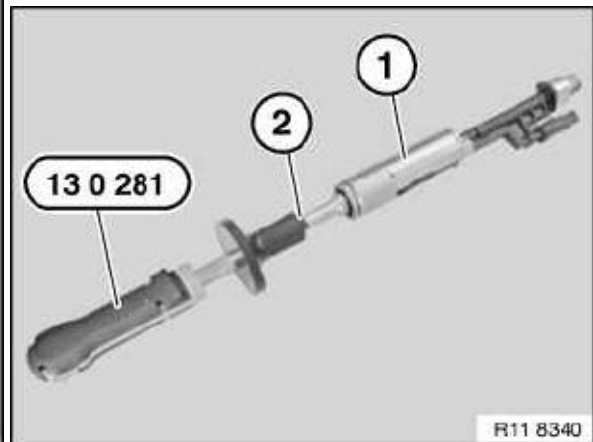
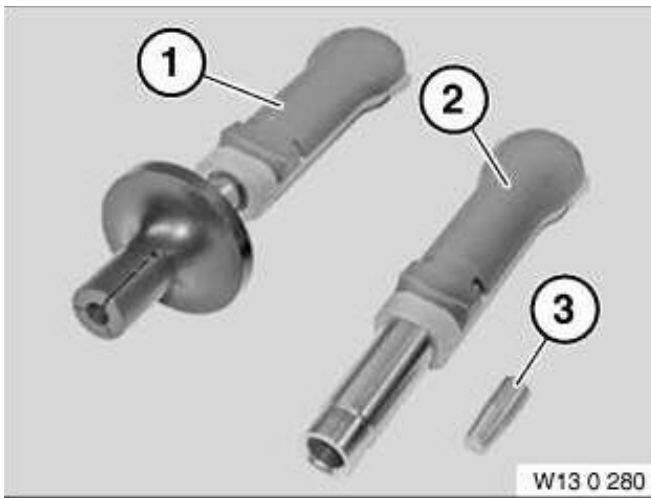
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Fuel Injectors - N55

In order to remove the N55 fuel injectors from the cylinder head, special tool **#13 0 270** must be utilized. Failure to use the special tool will result in damage to the injectors.



There is a new tool **# 13 0 280** that must be used when replacing the PTFE seals on the tips of the solenoid valve injectors. As with piezoelectric injectors these seals must be replaced if and when the injectors are being re-installed.



Do not open the high pressure fuel injection system if the coolant temperature is above 40°C . The residual pressure in the high pressure fuel system could cause bodily injury.

It is essential to follow the repair instructions and observe the utmost cleanliness when working on the high pressure fuel system. Even minute soiling or damage at the connections of the high pressure lines and cause leaks.

High Pressure Fuel Injector Valve (HDE)

The HDEV5.2 solenoid type injector valves used on the N55 engine are a new development.

1 Booster phase:

Opening of the HDEV5.2 is initiated in the booster phase by a high booster voltage from the DME. The booster phase ends on reaching approximately 10 amps. The high current is achieved by a voltage of up to approximately 65 Volt.

2 Energizing phase:

In the energizing phase, the HDEV5.2 is completely opened by controlling the current to approximately 6.2 amps. At the end of the energizing phase, the current is reduced to the holding current level of approximately 2.5 amps.

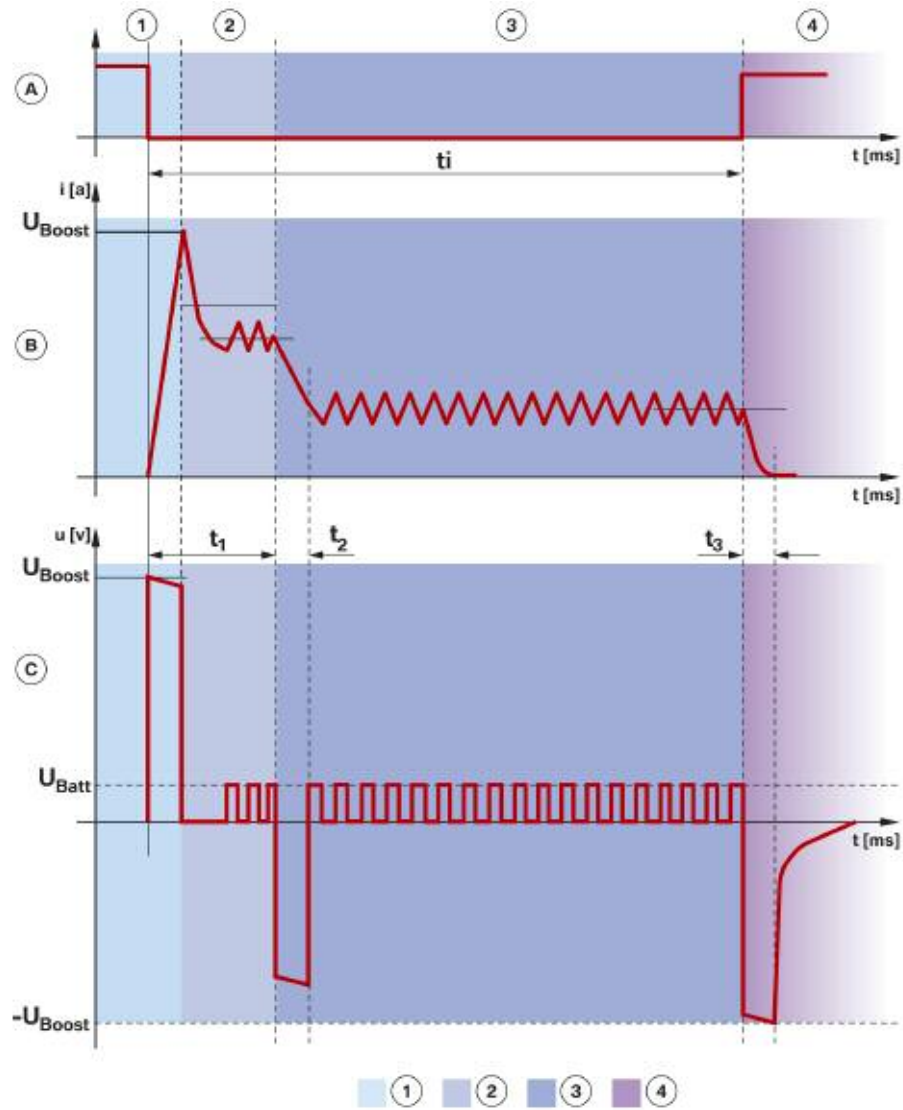
3 Hold phase:

The energized HDEV5.2 is kept open by controlling the current at approximately 2.5 amps in the hold phase.

4 Switch off phase:

The current is switched off at the end of the injection time (in the switch off phase). At least 2 milliseconds elapse between two injection cycles.

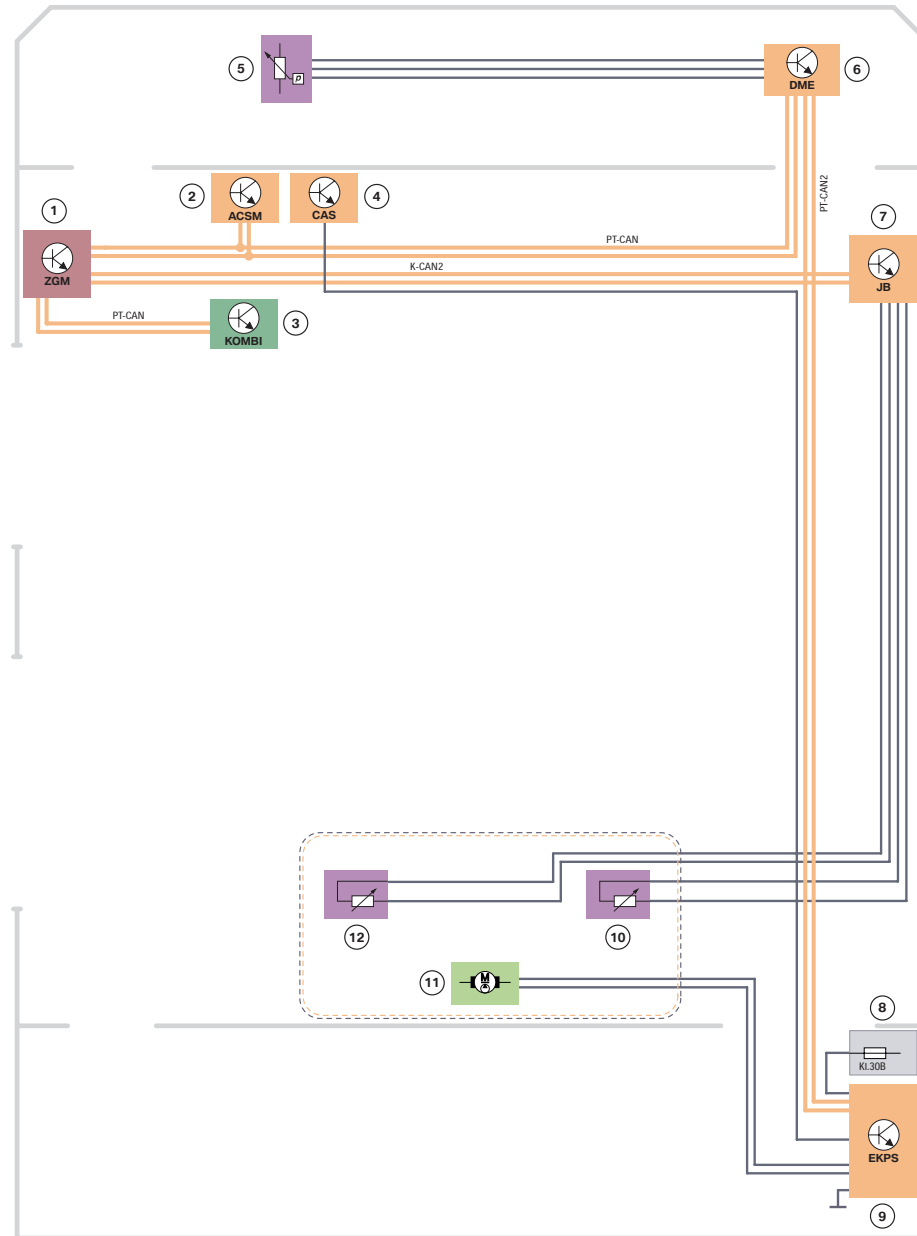
N55, Actuation Phases of the HDEV5.2



Index	Explanation	Index	Explanation
A	DME actuation signal	1	Booster phase
B	Current flow HDEV5.2	2	Energizing phase
C	Voltage at HDEV5.2	3	Hold phase
		4	Switch off phase

Fuel Supply and Control Schematic Overview on BN2020

ISTA wiring schematic: SSP-BSB-T6109018 Fuel Supply



Index	Explanation	Index	Explanation
1	Central Gateway Module	7	Junction Box Electronics
2	Advanced Crash Safety Module	8	Power distribution box, right rear
3	Instrument Cluster	9	Electric Fuel Pump Module
4	Car Access System	10	Fuel level sensor, right
5	Fuel pressure sensor	11	Electric fuel pump
6	Engine Control Module (DME)	12	Fuel level sensor, left

Workshop Hints

Before any service work is performed on any fuel system related component, always adhere to the following:

- Observe relevant safety legislation pertaining to your area.
- Ensure adequate ventilation.
- Use exhaust extraction system where applicable (alleviate fumes).
- DO NOT OPERATE THE FUEL PUMP unless it is properly installed in the fuel tank and is submersed in the fuel (fuel lubricates the pump).
- Always wear adequate protection clothing including eye protection.
- Use caution when working around a hot engine compartment
- During fuel system repair that involves “sealing rings”, always replace them with new COPPER rings only.
- BMW does not recommend any UNAUTHORIZED MODIFICATIONS to the fuel system. The fuel system is designed to comply with strict federal safety and emissions regulations. In the concern of product liability, it is **unauthorized** to sell or perform modifications to customer vehicles, particularly in safety related areas.
- Always consult the Repair Instructions on the specific model you are working on before attempting a repair.

Fuel

Fuel quality should always be considered when diagnosing a driveability complaint. The type of fuel, proper AKI/PON rating, impurities and moisture are not factored by the ECM.

Please refer to the Owner's Manual and following Service Information Bulletins regarding fuel:

- SI B 13 07 06 Gasoline Quality & Detergent Additives
- SI B 13 02 10 Fuel Systems
- SI B 13 02 06 Top TIER Detergent Gasoline in BMW Vehicles
- SBS 1996-13 06 96 (139) Group 13 (on ISTA>Workshop/Operating fluids)

Draining the Fuel Tank

In order to remove the fuel tank it must be drained first to avoid fuel spills and handling excessive weight. In some cases depending on the fuel tank dimensions (vehicle specific), it is also necessary to drain the fuel tank to replace the sending units and/or fuel pump.

CAUTION!!!

In some vehicles, the sending units/fuel pump is mounted lower than the top of the fuel tank. A fuel spill will be encountered if the fuel is not drained.



Consult the BMW Service Workshop Equipment for the proper evacuation equipment. The saddle type tank requires an additional step to drain the fuel from the driver side. The evacuation equipment should be attached to the tank compensating hose (arrow) to drain out the remaining fuel.

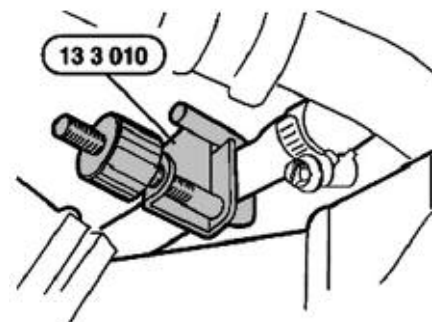
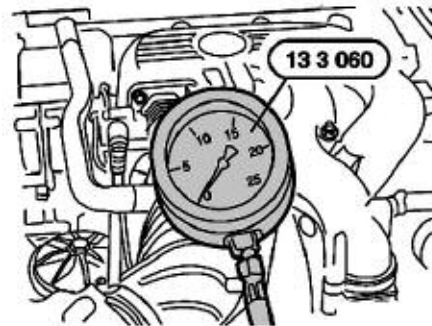
Fuel Pump/Pressure Regulator - Testing

The fuel pump should be tested for delivery pressure and volume. Caution when disconnecting fuel hoses because there is the possibility of residual fuel pressure! Install the fuel pressure adapter and IMIB pressure sensing lead to the fuel pressure fitting *IMIB starts with atmospheric pressure as the base.

If the 3.5 (*+ atmosphere IMIB base starting point) bar fuel pressure is not achieved or bleed off is more than 0.5 bar, refer to

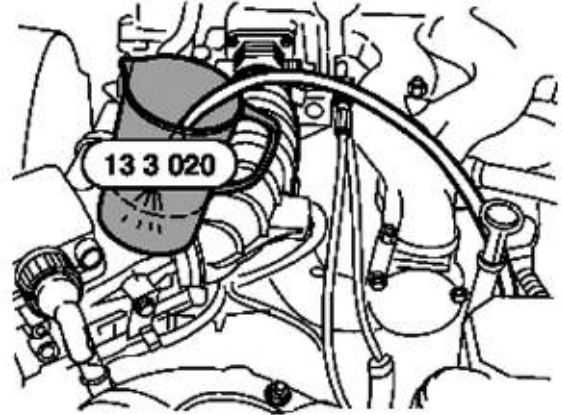
- REP 13 31 032 Check fuel pressure
- REP 13 31 029 Checking fuel pump delivery pressure (N52)
- REP 13 31 029 Checking fuel pump delivery pressure (M54)

for further diagnosis. The Fuel Hose Clamp Tool can be used to isolate bleed off from the pump (non-return check valve) or the pressure regulator (restriction valve). Also verify power supply to the fuel pump.



Fuel volume must be tested to verify:

- Fuel Pump Output
- Restrictions are not present in the pump pickup lines/hoses and fuel filter.



Fuel Injectors

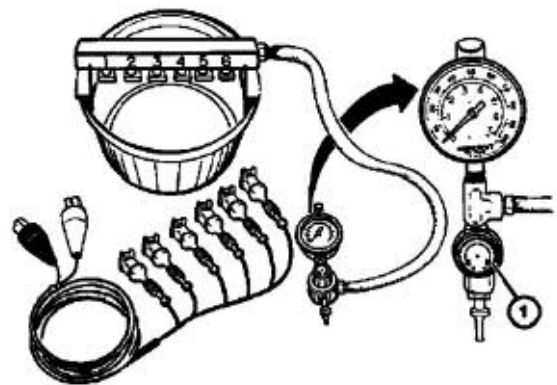
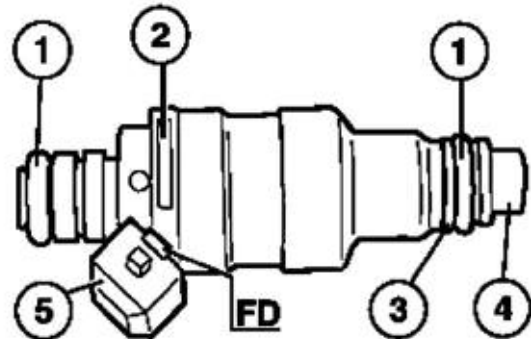
When inspecting the fuel injectors, consider the following:

- O-rings should be replaced, lubrication with Vaseline or SAE 90 gear oil for installation.
- Verify the code number (different engine applications)
- Plastic spacer washer is not damaged
- Color code of housing (different engine applications)

Fuel injectors can leak which bleeds off fuel pressure and increases emissions. The injectors can be tested using the Fuel Injector Leakage Tester.

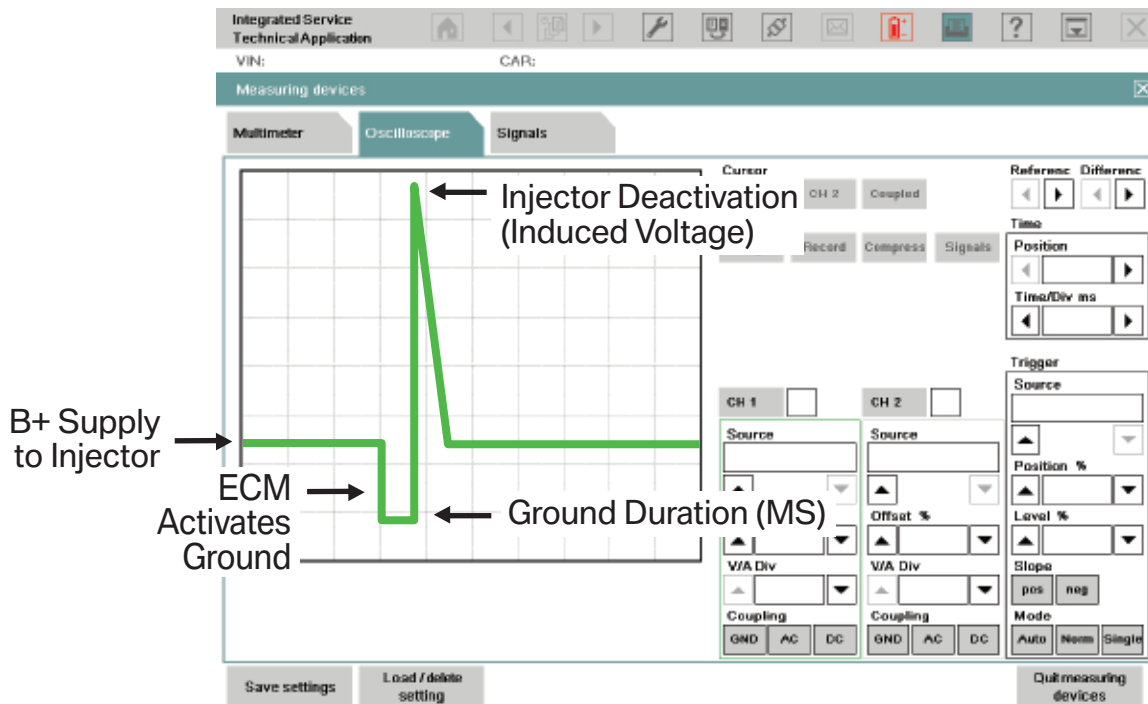
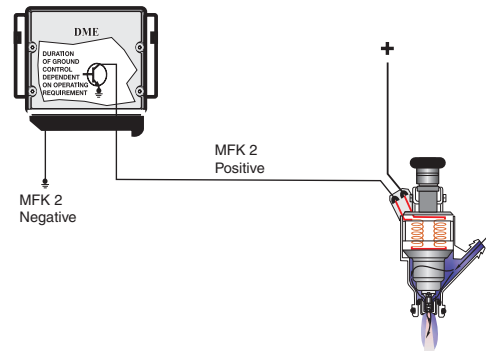
The fuel injectors can be cleaned, refer to:

- SI B 04 07 07 Fuel Injection and Induction System Cleaning



The Fuel Injectors should also be tested using the ISTA for:

- Resistance
- Power Supply
- Status Display - Fuel Injection Signal
- ECM Final Stage transistor activation. This test functions is found under the oscilloscope Preset list - "Ti Injection Signal". Install the Universal Adapter, Diagnostic cable, MFK 2 negative lead to ECM ground and MFK 2 positive lead to the ground activation circuit for the injector. This test is performed with the engine cranking or running.

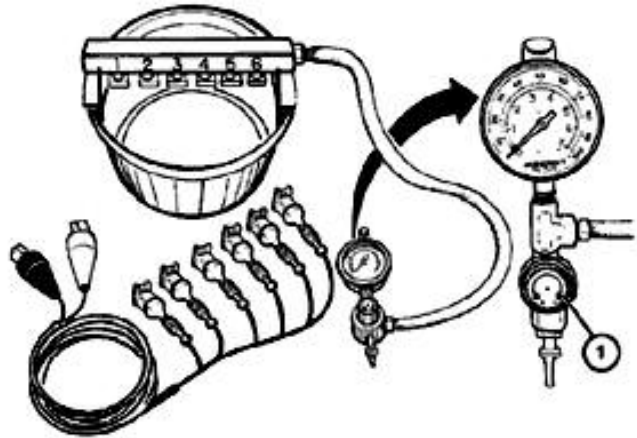


When testing fuel pressure, the hand held fuel pressure gage (SWZ 13 3 060) can be used.

Caution: Residual fuel pressure may be present!

The IMIB is equipped with a pressure measuring function, found in Measurement testing. The following adapters (Special Tool numbers) will be necessary:

- SWZ 13 6 051
- SWZ 13 6 055
- SWZ 13 6 057



These adapters install “inline” in the fuel pressure hose.

For vehicles equipped with “quick-release” couplings, install special tool (SWZ 13 5 270) between the fuel filter (1) and pressure supply hose (2). This tool will couple to the IMIB Pressure Adapter (3).

Later production fuel rails are equipped with a threaded adapter fitting (1).

This threaded adapter fitting allows Adapter (SWZ 13 5 220) to be threaded on to the fuel rail and coupled to the IMIB Pressure Adapter.

When testing the fuel injectors for leakage, use Special Tool #88 88 5 000 362. Leak testing the fuel injectors is one of the diagnostic steps listed in:

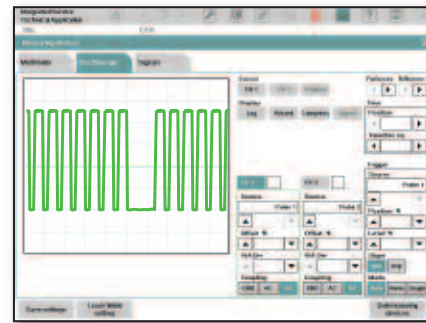
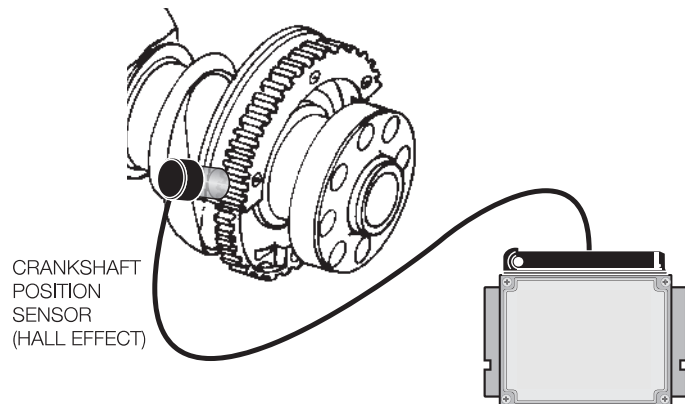
- SI B 13 08 90 (3096) Long Cranking Times.

This tool pressurizes the injectors with air and the injector tips are submersed in water. If air bubbles are present, this indicates the leaking injector(s).

Crankshaft Position/RPM Sensor

This sensor should be tested using the IMIB for:

- Power Supply
- DC Voltage
- Status Display
- Oscilloscope Display found under Preset Measurements - "Engine Speed Sensor Signal"



**SMOOTH RUNNING ENGINE
(NOTE SQUARE WAVE SIGNAL)**

Crankshaft Sensor (N55)

The function of the new crankshaft sensor is identical to that of the crankshaft sensors used for the automatic engine start-stop function (MSA). The engine reversal detection is required for the MSA function. (MSA is not currently offered in the US.)



Index	Explanation
1	Connector
2	Dust seal
3	Sensor

NOTES

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Ignition Management

Model: All

Production: All

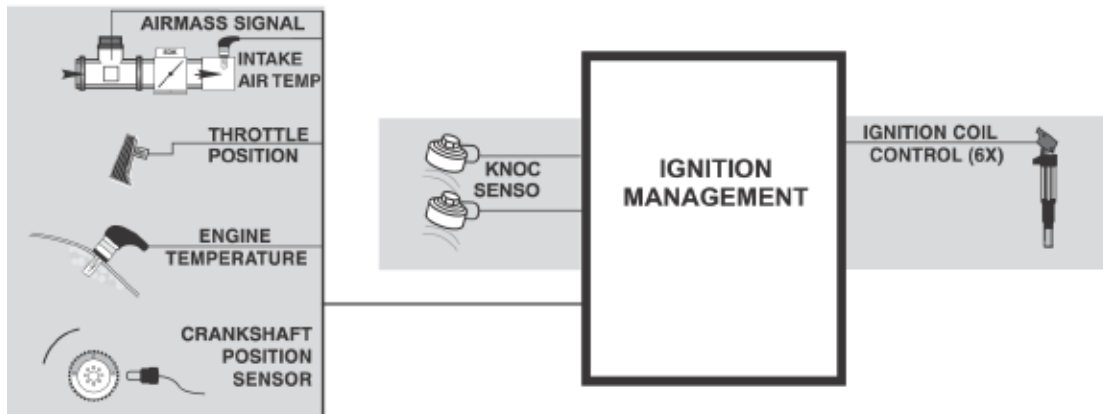
OBJECTIVES

After completion of this module you will be able to:

- Understand how spark is formed and used in BMW engines
- Perform an ignition primary scope measurement
- Perform an ignition secondary scope measurement
- Interpret the spark measurements and relate them to diagnosis
- Understand optimized emission
- Describe how the ignition system is monitored

Ignition Management

Example of IPO for an Ignition Management System



One of the main purposes of the ECM is Ignition Management which includes the actuation of several components. In the following pages you will find a generic explanation on how this system works. For more detailed information please access BMW Training Reference Manuals found on-line.

Principle of Operation

Ignition Management provides ignition to the combustion chambers with the required voltage at the correct time. Based on the combination of inputs, the ECM calculates and controls the ignition timing and secondary output voltage by regulating the activation and dwell of the primary ignition circuits. The ECM controls and monitors the secondary ignition output including Misfire Detection.

The ECM has a very “broad” range of ignition timing. This is possible by using a Direct Ignition System, or sometimes referred to as “Static Ignition System” (RZV). Reliability is also increased by having separate individual ignition circuits.

The Ignition Control is determined by the ECM (load dependent). The ECM will calculate the engine “load” based on a combination of the following inputs:

- Battery Voltage;
- Accelerator Pedal Position;
- Air Flow Volume;
- Air Temperature;
- Engine Coolant Temperature;
- Crankshaft Position / RPM;
- Camshaft Positions (Cylinder ID);
- Knock Sensors;
- *In a Turbocharged engine, Boost Pressure is also used.

The dwell time will be regulated based on battery voltage. When cranking, the voltage is low and the ECM will increase the dwell to compensate for saturation “lag time”. When the engine is running and the battery voltage is higher, the ECM will decrease the dwell due to faster saturation time.

The **Crankshaft Position/RPM** signals the ECM to start ignition in firing order as well as providing information about the engine operation. This input is used in combination with other inputs to determine engine load which **advances/retards the ignition timing**. Without this input, the ECM will not activate the ignition.

Cold start is determined by the ECM based on the engine coolant temperature and rpm during start up. A cold engine will crank over slower than a warm engine, the ignition timing will range between top dead center to slightly retarded providing optimum starting.

When starting a warm engine, the rpm is higher which results in slightly advanced timing.

If the engine coolant and intake air temperature is hot, the ignition timing will not be advanced reducing starter motor “load”.

Ignition System Inputs

The ignition system on the engine management system uses several inputs to control ignition functions. Proper ignition timing control is dependent upon inputs such as RPM, throttle position, crankshaft position, air mass and temperature (coolant and intake air) and in our turbocharged engines, intake boost pressure.

Most of the ignition system components have remained the same for all NG6 engines. There are some minor changes to the ignition coils that apply to all versions. The coils have been optimized for more durability.

Ignition Coils

The high voltage supply required to ignite the mixture in the combustion chambers is determined by the stored energy in the ignition coils. The stored energy contributes to the ignition duration, ignition current and rate of high voltage increase. The Coil circuit including primary and secondary components consists of:

The Coil Assembly contains two copper windings insulated from each other. One winding is the primary winding, formed by a few turns of thick wire. The secondary winding is formed by a great many turns of thin wire.



The primary winding receives battery voltage from the Ignition Coil Relay (in the IVM) which is activated by the CAS Module. The ECM provides a ground path for the primary coil (Coil Terminal 1) by activating a Final Stage transistor. The length of time that current flows through the primary winding is the “dwell” which allows the coil to “saturate” or build up a magnetic field. After this storage process, the ECM will interrupt the primary circuit at the point of ignition by deactivating the Final Stage transistor. The magnetic field built up within the primary winding collapses and induces the ignition voltage in the secondary winding.

The high voltage generated in the secondary winding is discharged through Coil Terminal 4 to the spark plug (insulated by the boot connector).

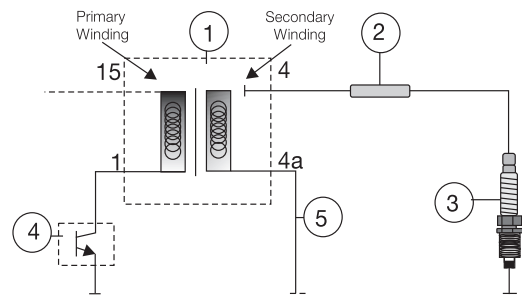
The primary and secondary windings are un-coupled, therefore, the secondary winding requires a ground supply (Coil Terminal 4a).

The high voltage generated in the secondary winding is discharged through Coil Terminal 4 to the spark plug (insulated by the boot connector).

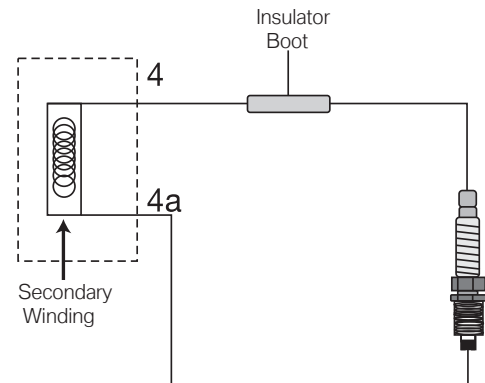
The primary and secondary windings are un-coupled, therefore, the secondary winding requires a ground supply (Coil Terminal 4a).

The ECM uses “pencil type” ignition coils. The individual ignition coils are integrated with the insulated connector (boot).

The coils are removed by lifting the swivel latch connector retainer to release the wiring harness, apply a slight twist and lift the assembly upwards. The primary ignition cables are routed on the top of the cylinder head covers.



Index	Explanation
1	Coil Assembly
2	Insulator Boot
3	Spark Plug
4	ECM Final Stage Transistor
5	Secondary Coil Ground



Spark Plugs

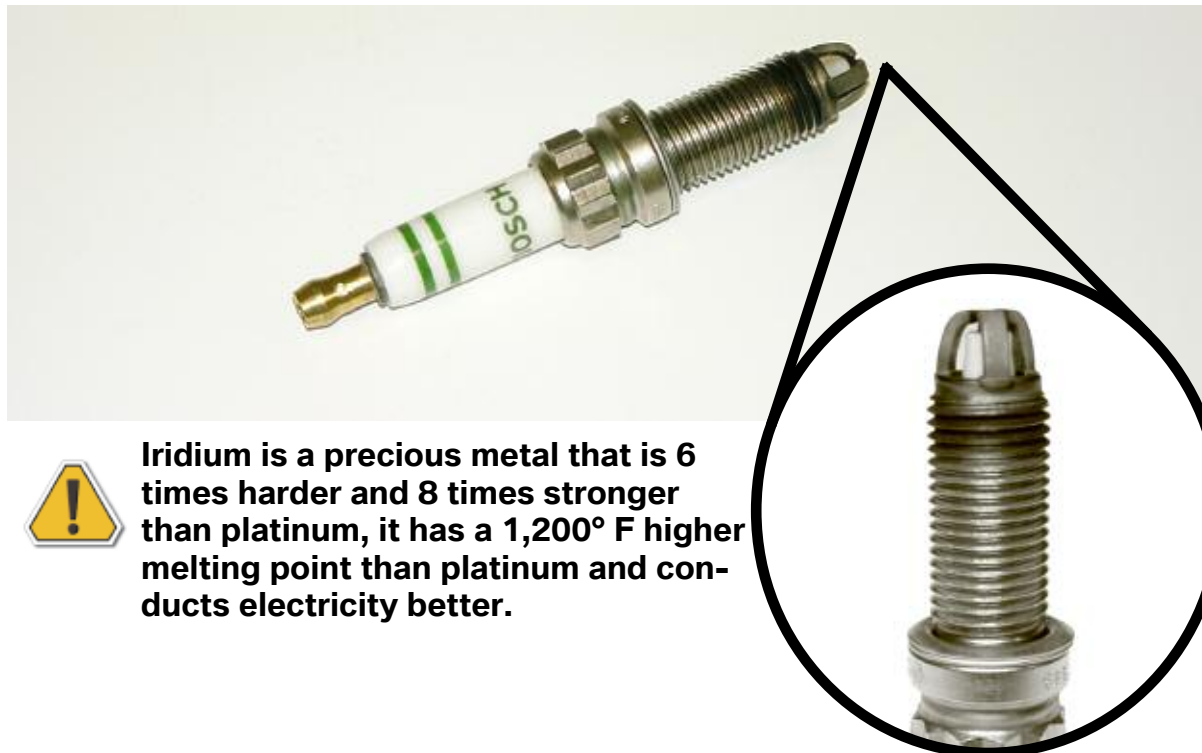
The spark plugs introduce the ignition energy into the combustion chamber. The high voltage “arcs” across the air gap in the spark plug from the positive electrode to the negative electrodes. This creates a spark which ignites the combustible air/fuel mixture.

The spark plugs are located in the center of the combustion area (on the top of the cylinder heads) which is the most suitable point for igniting the compressed air/fuel mixture.

The spark plugs used on BMW Engines are designed by NGK. The plugs use an Iridium center electrode. The center electrode is only 0.6 mm thick. The insulator is also redesigned. The new spark plug technology allows for longer service life and improved cold starting. The correct spark plug for each engine should be used.

The Ignition System is monitored by the ECM via the **Crankshaft Position/RPM Sensor**. If a Misfire fault is present, the ECM will deactivate the corresponding fuel injector for that cylinder. Engine operation will still be possible.

The spark plugs for the N51 and N52KP remain the same as N52. However, the N54 uses a completely new spark plug from Bosch. The spark plug design consists of a 12mm thread which contrasts from the 14mm design on the N52 which prevents any possibility of improper installation. The hex on the spark plug is also a 12 point design which requires a special tool. The tool (socket) has a “thinwall” design to facilitate access in the confined area of the N54 cylinder head.



Iridium is a precious metal that is 6 times harder and 8 times stronger than platinum, it has a 1,200° F higher melting point than platinum and conducts electricity better.

Knock Sensors

The knock sensor registers structure-borne vibrations (knocking). Knocking combustion can damage the engine. The data from the knock sensor make it possible for the DME to implement countermeasures. Abnormal, reverberating combustion processes can occur under certain conditions in petrol engines. These abnormal combustion processes curtail the earliest possible ignition timing point and therefore limit the power output and efficiency of the engine.



Such combustion processes are referred to as knocking and occur as the result of self ignition of the fuel-air mixture not yet reached by the flame front. Normal combustion and compression produced by the piston cause pressure and temperature to rise, resulting in self-ignition of the fuel-air mixture not yet ignited. This produces flame velocities in excess of 2000 m/s while the flame speed during normal combustion is approx. 30 m/s.

Conditions favoring knocking operation include:

- Increased compression ratio (e.g. deposits)
- High cylinder charge
- Poor fuel quality (RON/MON)
- High intake air and engine temperature

The knock sensors operate on the piezo electric principle. Vibrations from combustion events are converted into electrical signals which are monitored by the ECM. Excessive vibration indicates engine knock which will cause the ECM to retard the ignition timing to retard as necessary.

The number of Knock sensors will vary depending on the engine; typically 6 cylinder engines use two (2), V8's four (4) and V12's six (6).

Note: Excessive knocking will cause the MIL to illuminate.



When installing knock sensors, be sure to torque to specification. Under or over-tightening the knock sensors can result in erroneous knock sensor faults or poor engine performance.

If a fault is detected with the sensor(s), the ECM deactivates Knock Control and it will set the ignition timing to a conservative basic setting based on intake air temperature/pressure and a fault will be stored.

Superknocking

The term superknocking refers to irregular combustion that occurs in turbocharged/supercharged engines. During this process, the maximum combustion pressure increases from approx. 100 bar up to about 200 bar. This situation could be caused by foreign bodies in the combustion chamber such as oil, residual gas or carbon particles that trigger ignition of the fuel-air mixture before the actual firing point.

Superknocking cannot be eliminated by corresponding interventions in the ignition system so to prevent engine damage, the ECM reduces the power output when it detects superknocking. Temporary superknocking is caused by individual dirt particles. Fuel injection into the affected cylinder is shut down in the short term (3 to 6 cycles) in response to superknocking. A corresponding fault code is stored in the fault code memory.



Multiple Ignition Pulses

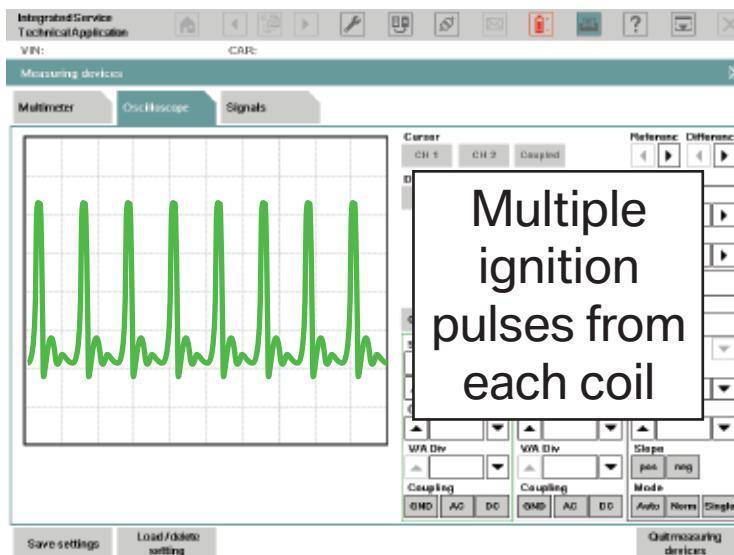
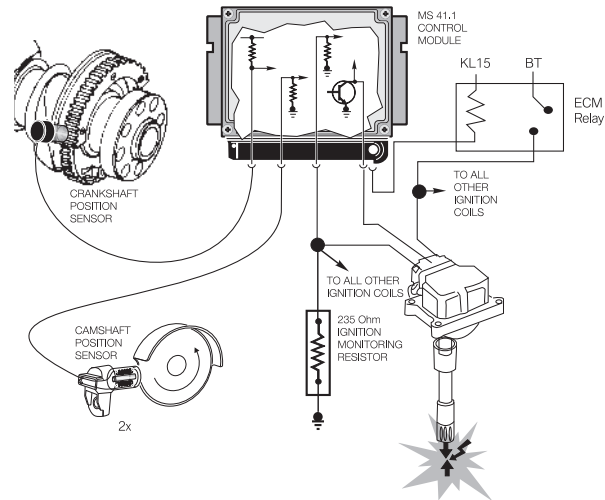
Multiple Ignition Pulses ensure good spark quality during engine start up. The ECM will activate the ignition coils 9 times (voltage dependent) per 720° of crankshaft revolution.

The ignition timing will be progressively advanced assisting the engine in coming up to speed. As the engine speed approaches idle rpm, the timing remains slightly advanced to boost torque. When the engine is at idle speed, minimum timing advance is required. This will allow faster engine and catalyst warm up.

The multiple pulsing switches to single pulse when:

- Engine Speed >1350 RPM (varied with engine temperature)

The timing will be advanced when the ECM observes low engine rpm and increasing throttle/air volume inputs (acceleration torque). As the throttle is opened, the ECM advances the timing based on engine acceleration and at what rate. The ECM will fully advance timing for the “full throttle” position indicating maximum acceleration (torque).



Crankshaft Position/RPM Sensor (Hall Effect)

The crankshaft position sensor provides the ECM with a 5 volt square wave signal. The ECM calculates engine speed (RPM) and crankshaft position for ignition and injection system operation.

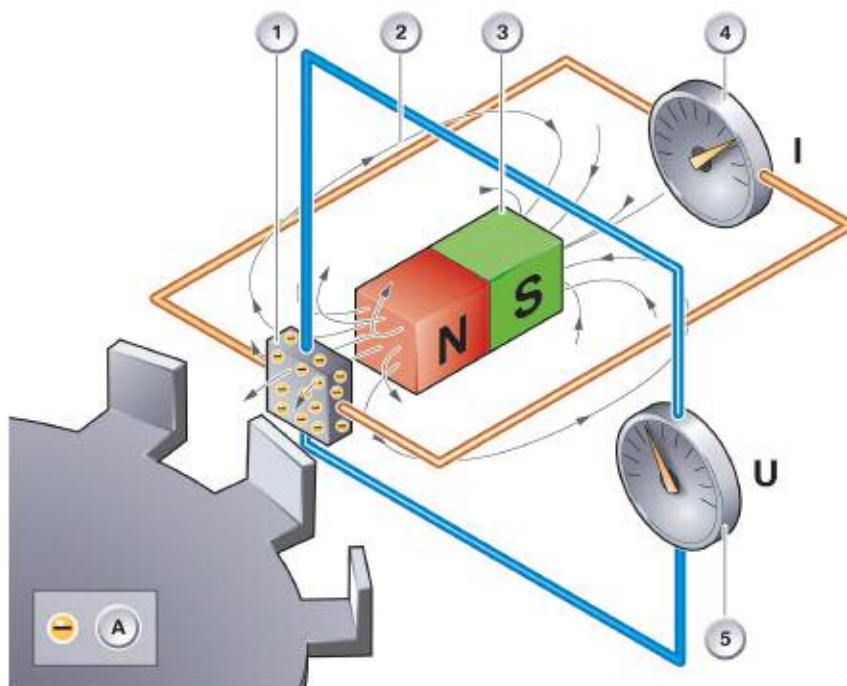
The sensor is supplied with 12 volts from the engine electronics fuses and ground from the ECM.

An effective signal that can be evaluated is output as from a speed of approx. 20 rpm.



The control unit detects the tooth gap in that the measured spacing of the gaps is more than double as great as the previous or subsequent gaps. The tooth gap itself is assigned to a defined crankshaft position of cylinder number 1. The DME synchronizes the crankshaft position with respect to this timing point. With each subsequent low signal it increments the crankshaft position by 6°.

Exact assignment is necessary for the DME to be able to adapt the ignition and fuel injection to specific requirements. The time interval measured between two level changes (e.g. High to Low) is therefore divided into smaller units of time.



Index	Explanation
A	Electrons
1	Hall Module
2	Lines of magnetic force
3	Permanent magnet
4	Power supply
5	Hall voltage



The crankshaft position sensor is also monitored for variations in crankshaft speed to determine misfires.

Crankshaft Sensor (N55)

The function of the new crankshaft sensor is identical to that of the crankshaft sensors used for the automatic engine start-stop function (MSA). The engine reversal detection is required for the MSA function. (MSA is not currently offered in the US.)



Index	Explanation
1	Connector
2	Dust seal
3	Sensor

NOTES

PAGE

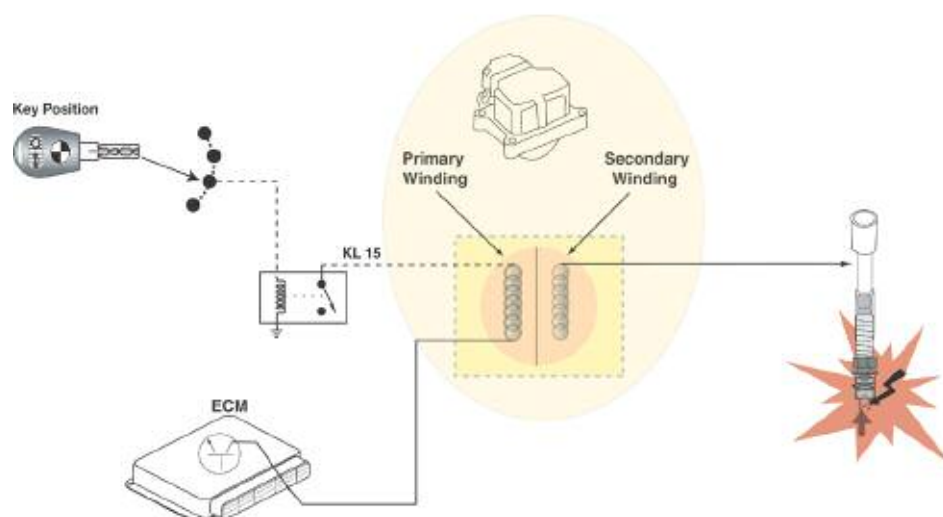
Service Information

A fault survey should first be performed using the IMIB to determine if there is a fault in the primary ignition or secondary ignition. If there is a fault in the primary ignition, testing should include:

- Power Supply at the coil (KL 15).
- Resistance of the harness and ignition coil primary winding using the Universal Adapter with the ECM disconnected.

If there is a fault in the secondary ignition, testing should include:

- Primary Ignition.
- Evaluation of Secondary Oscilloscope Patterns.

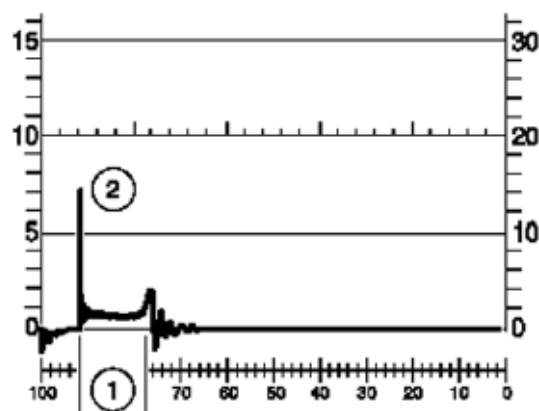


The Following are Examples of Secondary Oscilloscope Patterns

(consult Repair Instructions for ignition pattern variations per coil manufacturer):

This is a normal pattern for one ignition circuit with the engine at idle speed.

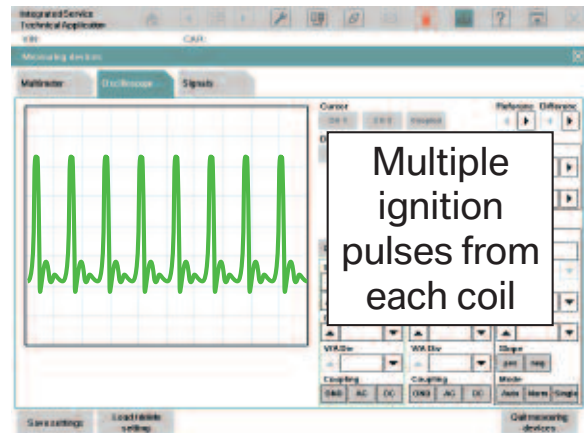
- Normal Combustion Period.
- Normal Ignition Voltage Peak.



Multiple Ignition Pulses ensure good spark quality during engine start up. The ECM will activate the ignition coils 9 times per 720° of crankshaft revolution.

This is a normal pattern for one ignition circuit when:

1. Normal Combustion Period
2. Normal Ignition Voltage Peak

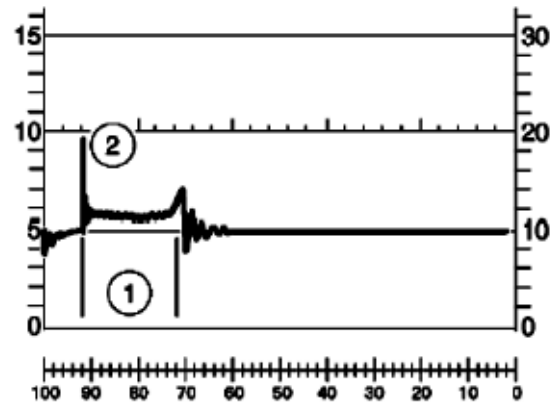


Long Spark Period (1) with Low Ignition Voltage Peak (2). If Spark Period is Fluctuating:

- Indicates Low Compression
- Contamination on Spark Plug or Defective Spark Plug

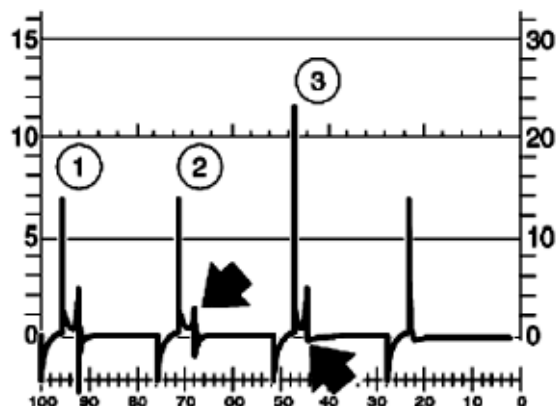
If instead you measured a Short Spark Period (1) with High Ignition Voltage Peak (2):

- Defective Ignition Connector or Resistive Adaptive Boot



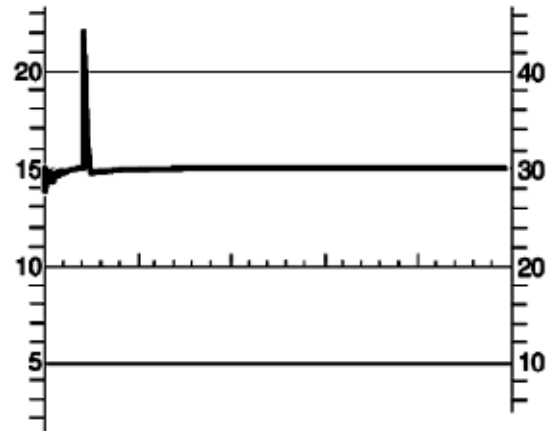
Evaluation of Ignition Voltage Peaks at Idle Speed (Multiple Cylinders Displayed).

1. Normal Attenuation (Voltage Reduction) Process
2. Shorten Attenuation Process (arrow)- Defective Ignition Coil
3. Absence of Attenuation (arrow)-Defective Ignition Coil



No Sparking Voltage Line (Single Cylinder Displayed)

- Defective Ignition Coil.

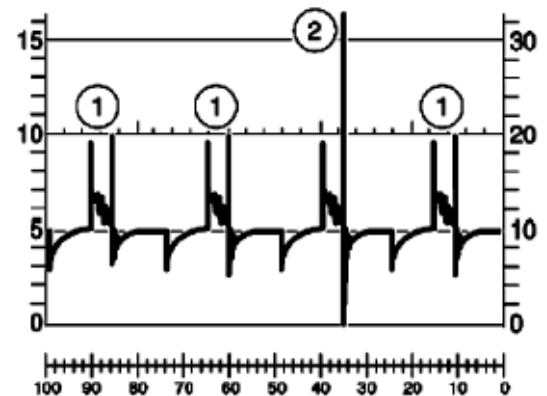


Evaluation of Ignition Voltage Peaks under Sudden Loads (Multiple Cylinders Displayed).

- Defective Ignition Coil.

Decaying Process is considerably Higher than Ignition Voltage Peak (2):

- Lean Mixture.
- Defective Fuel Injector.
- Low Compression.



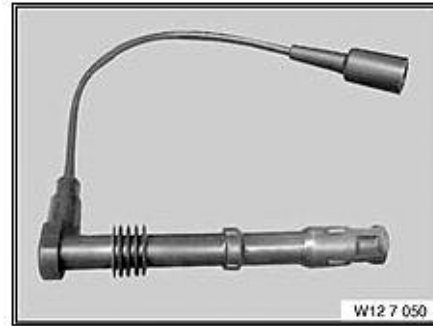
Allow at least 3 minutes to elapse after the key was set to the “OFF” position before disconnecting the ECM. This will allow sufficient time to complete the DM-TL test. Voltage may be present (up to 3 minutes) causing damage to the ECM if it is disconnected during this time period (arcing).

The Repair Instructions should be consulted for additional Oscilloscope Patterns under various engine speeds.

When Testing the Secondary Ignition System, use Special Tool (Secondary Voltage Test Cable) **#90 88 6 127 050 / SWZ 12 7 050** This provides a clamping surface for the IMIB primary and secondary ignition adapter clamps.

CAUTION!!!

Observe safety precautions, high voltage is present with the engine running!



The ignition current circuit is monitored based on the current in the primary coil. When switching on, the current must be within certain values during defined time thresholds.

The following items are monitored:

- Primary current circuit of ignition coil.
- Ignition wiring harness.
- Secondary current circuit of ignition coil with spark plug.
- Spark duration.

The following defects are detected by the ignition circuit monitoring:

- Short-circuit on primary side of ignition coil.
- Spark plug.
- Line break in ignition wiring harness.
- Defective ignition output stages.

The following **are not detected**:

- Sporadic faults such as loose contacts in the ignition wiring harness.
- Sparkover in the high voltage circuit parallel to the spark gap without producing an interturn fault.

In Summary,

If the Secondary Ignition Voltage is Too High (Excessive Resistance for Ignition):

- Spark Plug Gap is too Large (Worn or Burned).
- Incorrect Heat Range Spark Plug.
- Compression is too High (Carbon, etc.).
- Interruption in the Secondary Ignition Connector or Resistive Adapter Boot.

If the Secondary Ignition Voltage is Too Low (Low Resistance for Ignition):

- Spark Plug Gap is Too Small (Mishandled on Installation).
- Incorrect Heat Range Spark Plug.
- Compression is Too Low.
- Voltage Leak in the Secondary Ignition Connector or Resistive Boot to Ground.

Ignition Coils

The ignition coils of BMW engines have been redesigned for better rigidity and durability. Particular care must be taken when working on the fuel system to ensure that the ignition coils are not wet with fuel. The resistance of the silicone material is greatly reduced by contact with fuel. This could compromise the coils insulation and result in arcking at the top of the spark plug causing a misfire.

- The ignition coils must be removed before working on the fuel system.
- When installing new solenoid valve fuel injectors utmost cleanliness must be observed.
- After removing the ignition coils use a rag to prevent fuel from entering the spark plug well.
- Ignition coils that have been saturated with fuel must be replaced.

Knock Control

Knock Control allows the ECM to further advance the ignition timing under load for increased torque. Knock Control is only in effect when the engine temperature is greater than 35°C and there is a load on the engine. This will disregard false signals while idling or from a cold engine.

Based on the firing order, the ECM monitors the Knock Sensors after each ignition for a normal (low) signal.

If the signal value exceeds the threshold, the ECM identifies the “knock” and retards the ignition timing (3°) for that cylinder the next time it is fired. This process is repeated in 3° increments until the knock ceases.

The ignition timing will be advanced again in increments to just below the knock limit and maintain the timing at that point.

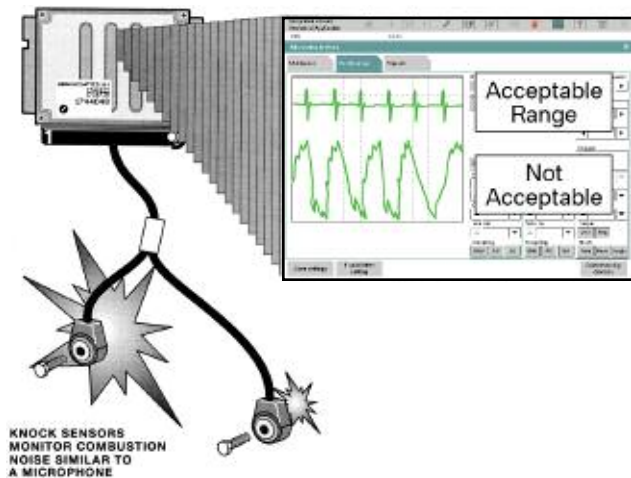
If a fault is detected with the Knock Sensor(s) or circuits, the ECM deactivates Knock Control. The ignition timing will be set to a conservative basic setting (to reduce the risk of detonation) and a fault will be stored. The “Malfunction Indicator Light” will be illuminated when the OBDII criteria is achieved.

The Knock Sensors should be tested using the IMIB for:

- Fault Codes
- Status Display - Knock Control (active / not active)
- Oscilloscope Display (Low AC Voltage -mV setting)

When installing Knock Sensors:

- **Do not mix the locations! or Engine Damage will result!** The Knock Sensors use a combined connection to the engine harness. The Knock Sensor with the shorter cable is for cylinders 4 - 6.
- **Do not over tighten attaching bolt! -** Piezo ceramic will be cracked. Torque to 20 nm.
- **Do not under tighten attaching bolt!** A loose sensor can vibrate producing a similar signal to a knock.



Conditions favoring knocking operation include:

- Elevated compression ratio.
- High cylinder charge.
- Poor fuel quality (RON/MON).
- High intake air and engine temperature.

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

- Check for signal error, e.g. line break or plug connection defective.
- Self-test of evaluator circuit.
- Check of noise level registered by the knock sensor for the engine.

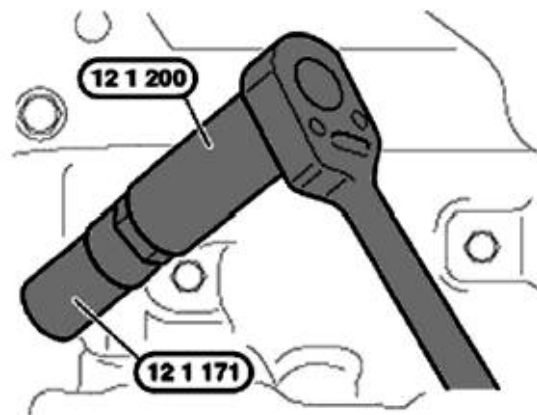
Knock control is switched off if an error is determined in one of these checks. In this case, an emergency program controls the ignition timing. At the same time, a corresponding fault code is entered in the fault code memory. The emergency program ensures safe, damage-free operation. The emergency program depends on the load, engine speed and engine temperature.

Spark Plugs

The Spark Plugs should be inspected for the proper type, gap and replaced at the specified intervals.

Refer to the Service Information Bulletins:

- SI B 12 01 05 High Performance Iridium Spark Plug/Spark Plug Application Chart
- SI B 12 01 99 High Performance Platinum Spark Plug/Spark Plug Application Chart for the proper type and a visual of the spark plug (showing effects of combustion, fouling, etc.)



The Spark Plugs should be properly installed and torqued using the following Special Tools:

- SWZ 12 1 200 Torque Limiter
- SWZ 12 1 171 Spark Plug Socket



Never use Air Tools for removal or installation.

Spark Plug Diagnosis (HPI engines)

Due to the proximity of the spark plug to the fuel injector nozzle, any divergence in the fuel spray may cause possible spark plug damage. This makes spark plug diagnosis an important part of HPI engine service concerns. Information gained by the spark plug diagnosis may indicate possible fuel injector faults. Spark plug replacement interval has been reduced to 45,000 miles on this engines. The illustrations below can be used to assist in spark plug diagnosis:



The spark plug above shows a normal wear pattern with no excessive electrode wear or insulator damage.



The spark plug above shows a normal wear pattern for a spark plug with high mileage. Spark plug is due for replacement.



The spark plug above shows erosion of the electrode on one side which could be an indication of fuel spray "diversion".



The spark plug above shows erosion of the electrode on one side and damage on the insulator nose. This could also be an indication of fuel spray "diversion".

Engine Misfire Diagnosis

Engine Misfire is the result of inefficient combustion in one or more cylinders. The causes of Engine Misfire are extensive but can be grouped into the following sub-systems. Consider the charts below as an additional diagnostic aid once ISTA is connected, the correct fault symptom has been chosen and the fault memory has been interrogated. Follow the Test Module as displayed by ISTA.

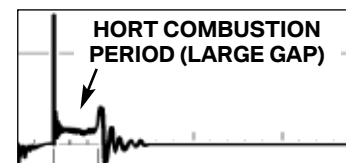
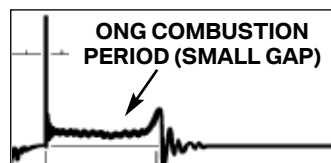
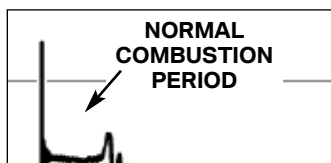
IGNITION SYSTEM			
COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Spark Plug:	• Incorrect spark plug installed • Electrode gap closed or too small • Electrode(s) missing • Oil or fuel fouled spark plug • Ceramic insulation cracked	Secondary Ignition	• Verify correct spark plug • Replace if necessary • Swap with another cylinder
Secondary circuit: (wiring, M73-cap, rotor)	• Wet or moist due to water infiltration. • High resistance due to corrosion.		• Check water ingress, repair, replace • Check resistance value, replace
Ignition Coil(s):	• Secondary/Primary Circuits open or shorted. • Housing cracked, damaged.	Secondary and Primary	• Inspect and replace if necessary • Swap with another cylinder
Ignition Coil & Engine Harness Connectors	• Power supply, Primary control and ground (shunt signal) circuits impaired.	Primary Ignition & Term 4A feed-back Preset Measurements	• Look for open, loose connector, corrosion, crossed or backed out pins (also consider ignition unloader or ECM relay on MY97 and newer cars). • Determine defective condition, repair or replace.

- A secondary ignition oscilloscope display provides vital information about the ignition system's condition.
- Follow the precautions in REP 12 00 Instructions for working on the ignition system.
- Use the following scope patterns as a guideline for ignition system diagnosis.



Evaluation of secondary signal amplitude at idle speed.

1. Normal Ignition Voltage Peak: **Spark Plug is OK**
2. Low Ignition Voltage Peak: **Gap too small (defective)**
3. High Ignition voltage peak: **Gap too large (defective)**



ENGINE MECHANICAL SYSTEMS

COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Pistons, Rings, Valves, Camshaft:	Hole in piston crown, ring(s) broken, valve(s) not seating, valve(s) bent, valve spring(s) broken, camshaft lobe cracked, etc.	- Idle Quality - Rough Running Preset. - Cylinder compression & leakdown tests.	Correct condition as required.
Hydraulic Valve Actuator (HVA):	- HVA oil bore restricted or blocked. - Engine oil pressure builds up too slow. Intermittent Misfire Fault - Not Currently Present. - HVA binding/sticking in bore.	- Idle Quality - Rough Running Preset. - Listen to HVA - Check Oil Pressure - Cylinder leakdown	- Always consider mechanical components when diagnosing misfire. - Inspect for scoring.
Vacuum Leaks:	Unmetered vacuum leaks causing a "lean" operating condition. Possible "Excessive Mixture Deviation" fault codes.	- Idle Quality - Rough Running Preset. Test for vacuum leaks per Repair Instr. and SI B on "Crankcase Ventilation". - Interpret Add. & Multiple adaptation values	Correct condition as required.

FUEL QUALITY, DELIVERY, INJECTION & EVAPORATIVE SYSTEMS

COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Fuel (quality):	Contaminated fuel. (water, other non combustible).		Clean fuel system, replace fuel.
Fuel Delivery:	- Fuel pump delivery pressure low, restriction in fuel line to fuel rail or running loss valve. - Fuel filter restricted (clogged). - Low fuel in tank.	- Check fuel pressure & volume. - Check fuel pump power and ground	- Determine restriction/flow reduction, replace component as necessary. - Interpret Additive and Multiplicative adaptation values.
Running Loss Valve:	Valve stuck in "small circuit" position.	Check valve	Display "diagnosis requests" in DISplus and test valve for proper function, replace valve as necessary.
Fuel Injectors:	- Leaking fuel injector pintle seats cause rich engine starts with hot ambient temperatures. - Blocked (dirty) injector(s).	- Ti Preset & status page. - Sec Ign scope pattern.	- Check injectors for leakage. - Swap suspect injector with another cylinder. - Inspect injector, replace if necessary.
Fuel Pressure Regulator:	Regulator defective, causes fluctuation in the injected quantity of fuel causing mixture adaptation faults.	Fuel pressure	Check nominal fuel pressure value with engine operating under varied speeds.
Evaporative System:	Defective evaporative system vent causing fuel tank collapse and fuel starvation.	DISplus status, Evap test with pressure tool, purge valve func. test.	- Check the fuel tank condition and vent line. - Check Fresh Air Valve on TLEV E36 vehicles or LDP/DM TL and filter on ORVR vehicles for proper system "breathing".

IMPLAUSIBLE ECM CONTROL FUNCTION OR SENSOR INPUT SIGNALS

COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Crankshaft Position Sensor or Increment Wheel:	• Implausible signal for misfire detection. • Increment wheel loose or damaged (internal on M44, M52 and M54, external on M62 & M73). • Air gap between sensor and wheel. • Noticeable at higher rpm.	• ISTA preset measurement.	• Determine defective sensor or increment wheel and replace.
Catalyst Damaged:	• Excessive exhaust back pressure (bank specific fault present, more noticeable under heavy load and high rpm).	• ISTA preset measurement of oxygen sensor. • Back pressure test per SI B with Special Tool.	• Determine catalyst condition, replace or repair as necessary.
Oxygen Sensor:	• Excessive mixture deviation, possible vacuum leaks.	• Monitor oxygen sensor signal via DIS preset.	• Swap sensor from other bank (if applicable) and see if fault transfers to other bank.
Engine Control Module	• Internal control module fault. • Misfire Reprogramming.	• Check fault memory. • Refer to SI B	• Highly unlikely but must be considered. • Check Model/Prod range - reprogram

When diagnosing a Misfire fault code, Remember:

“Misfire” is caused by a defect in the internal combustion engine or a defect in the control of the engine operation.

“Misfire” is the result of improper combustion (variation between cylinders) as measured at the crankshaft due to:

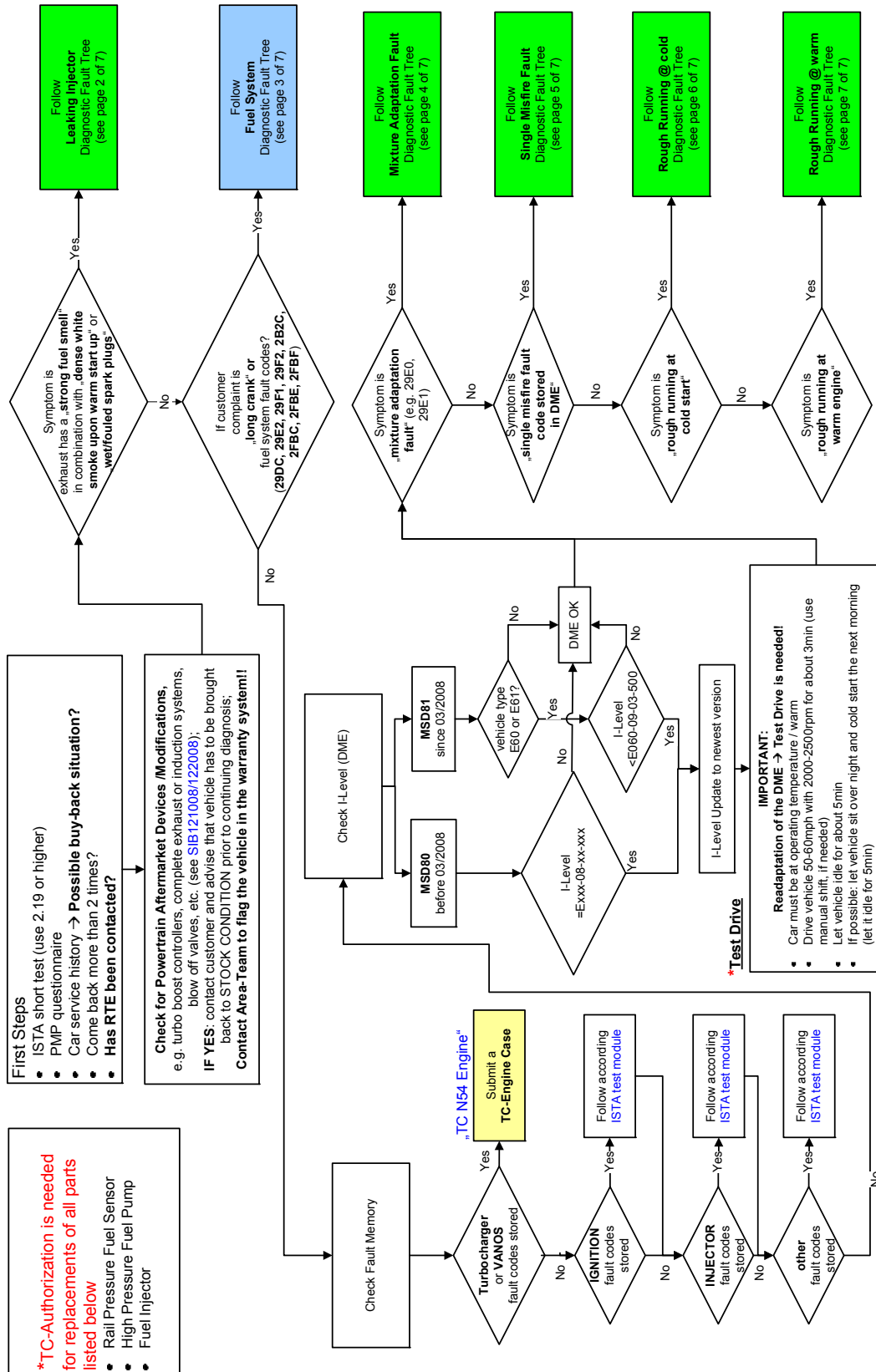
- Engine mechanical defects; breakage, wear, leakage or improper tolerances.
- Excessive mixture deviation; air (vacuum leaks), fuel and all the components that deliver air/fuel into the combustion chambers.
- Faulty ignition; primary, secondary including spark plugs.
- Faulty exhaust flow; affecting back pressure.
- Tolerance parameters; ECM programming.

A Misfire fault code(s) is the “symptom” of a faulty input for proper combustion. When diagnosing a misfire, review the charts to assist you in finding the faulty input.

SI B 12 06 10 N54 - Misfire Faults, Diagnosis with ISTA

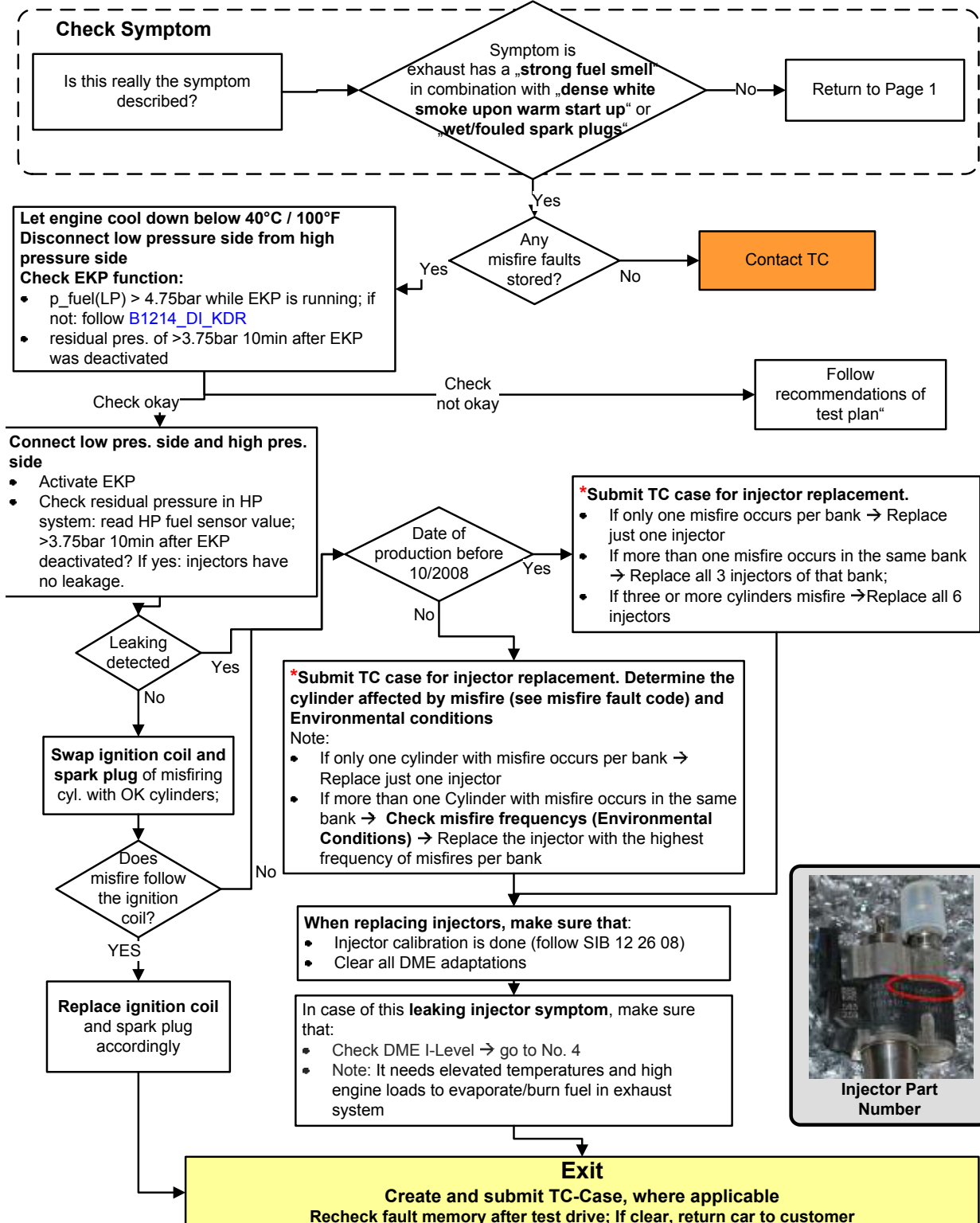
Page 1

N54 Engine Diagnostic Fault Tree version 06_04_10



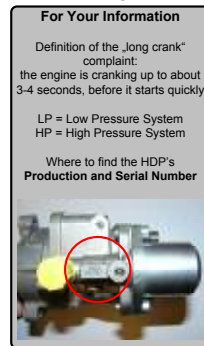
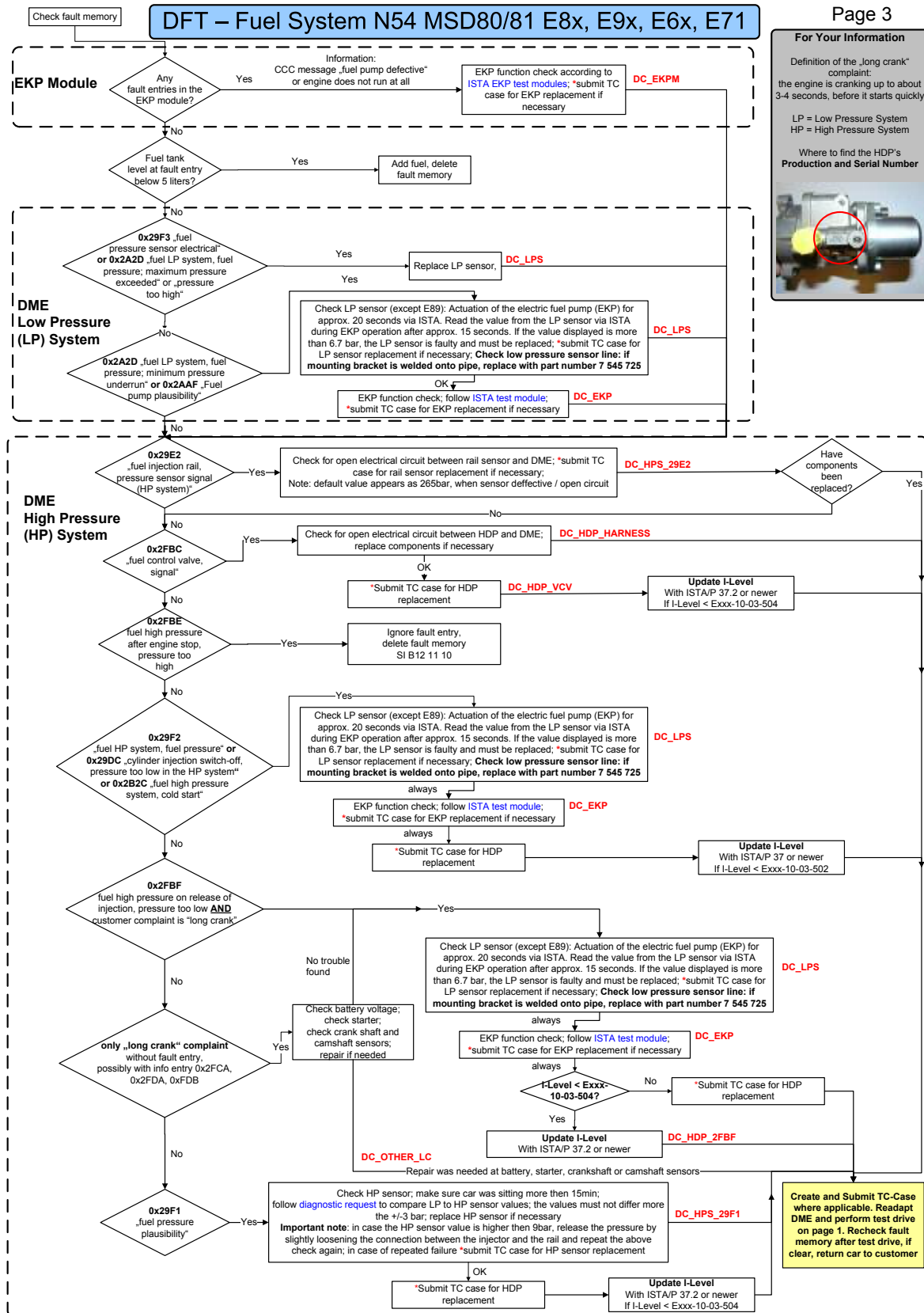
DFT – Leaking Injector

Page 2



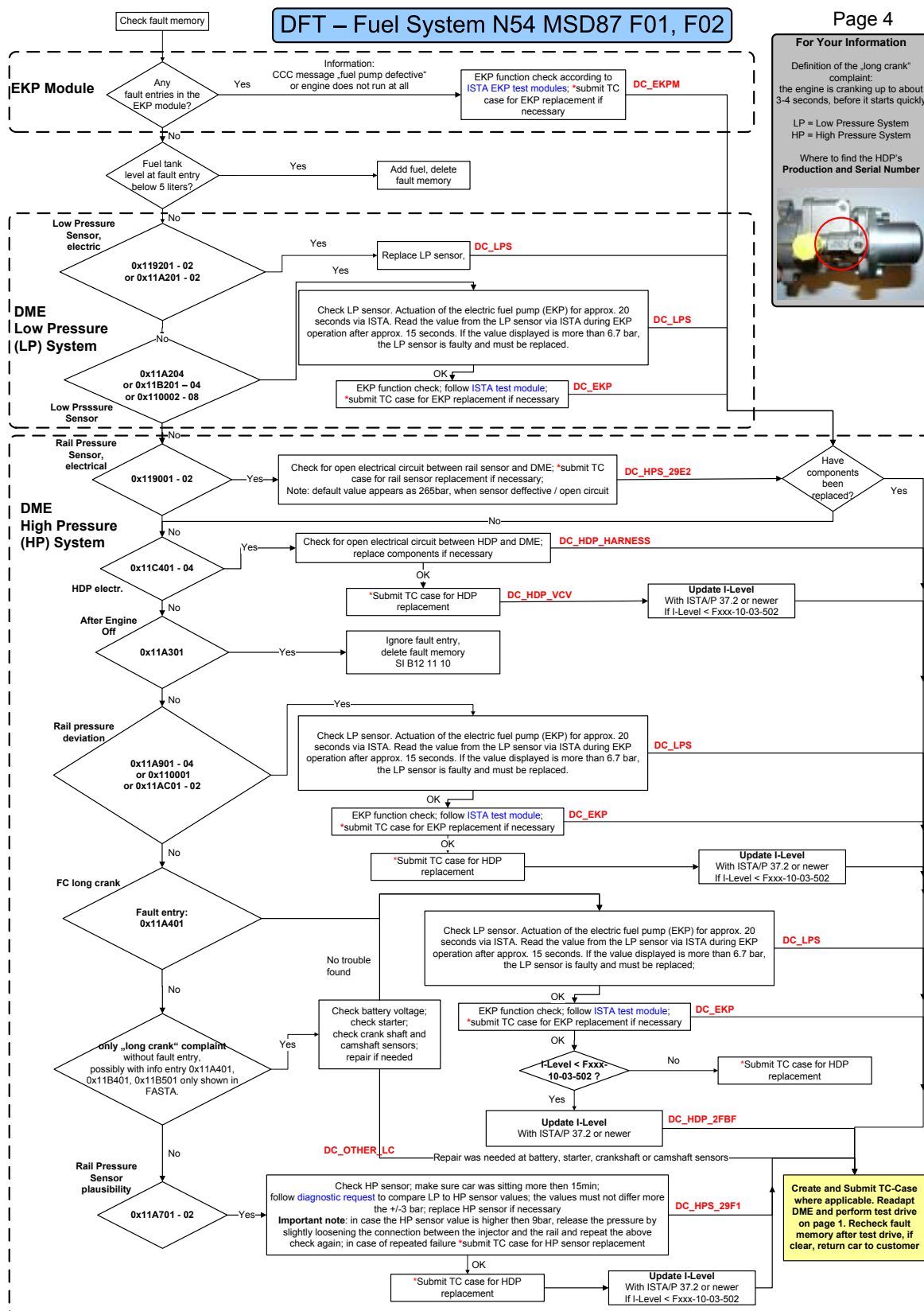
SI B 12 06 10 N54 - Misfire Faults - Diagnosis with ISTA

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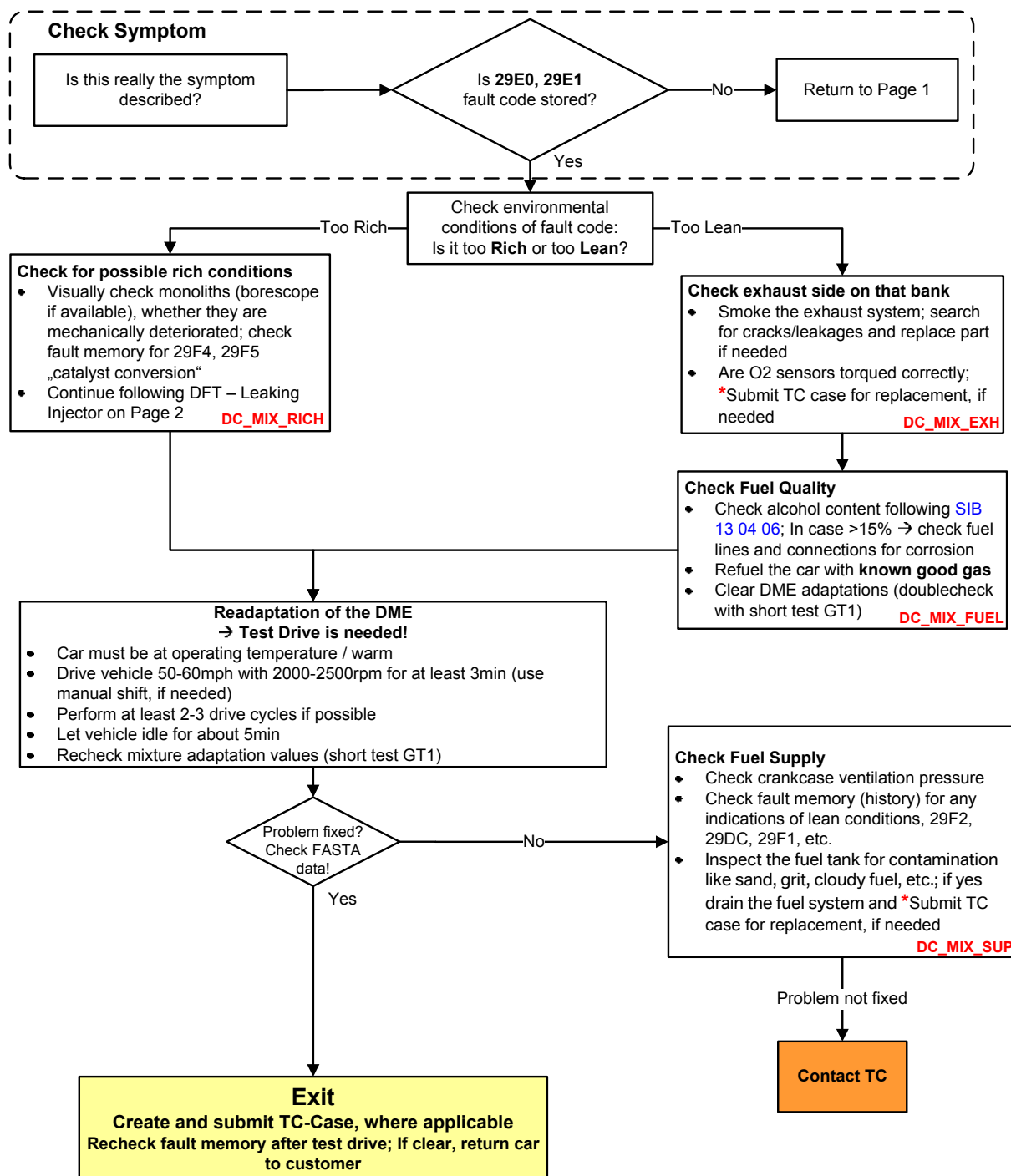
SI B 12 06 10 N54 - Misfire Faults, Diagnosis with ISTA

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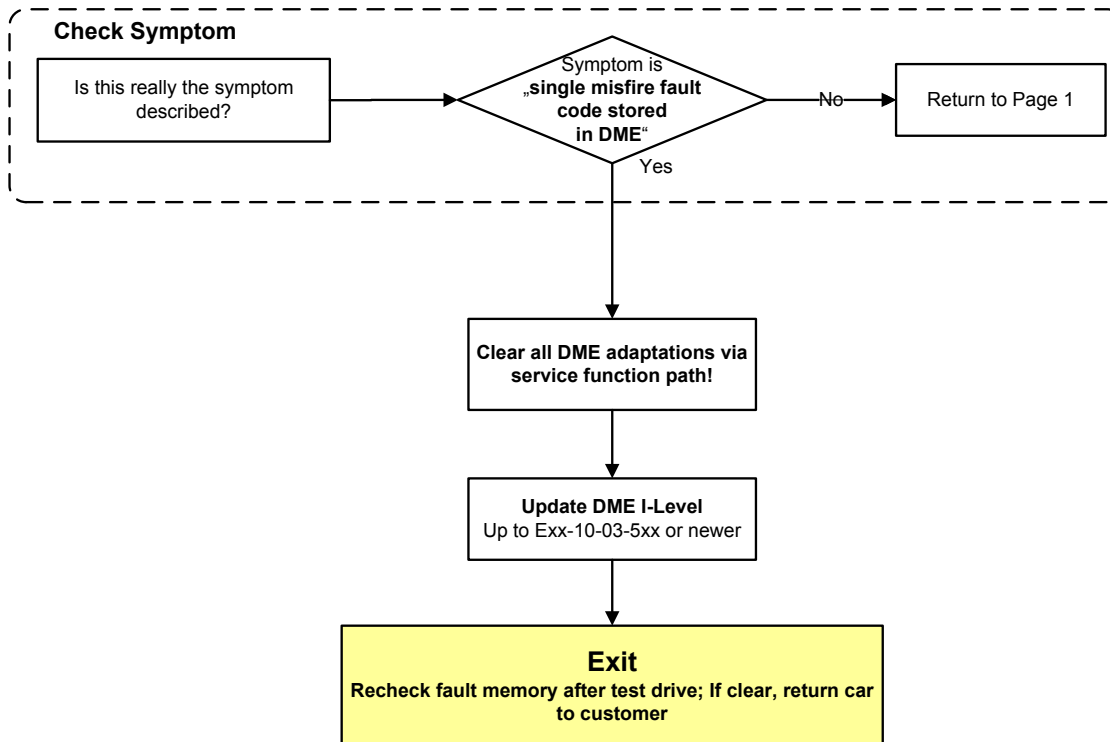
DFT – Mixture Adaptation Fault

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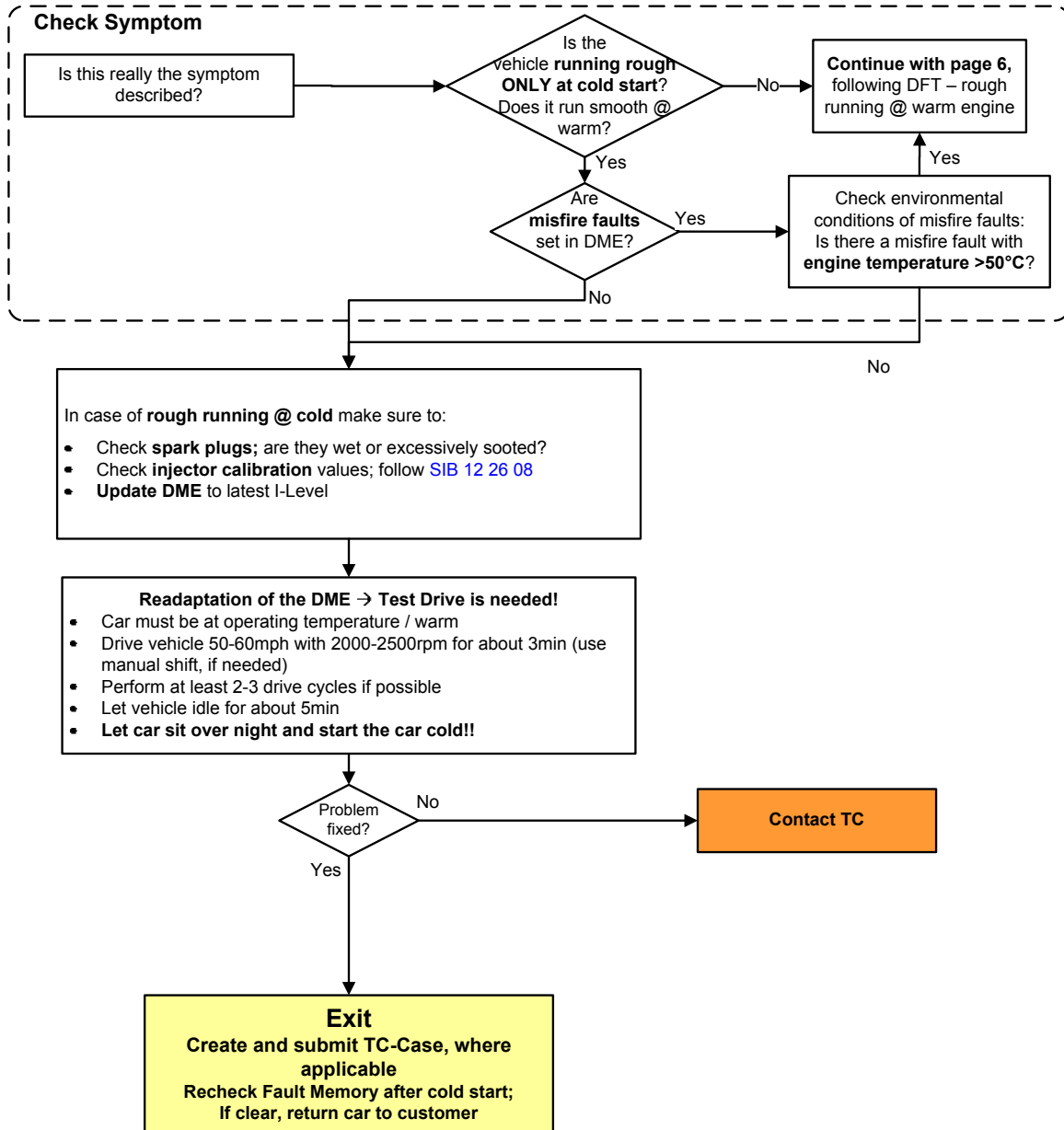
DFT – Single Misfire Fault

Page 6



DFT – Rough Running @ Cold Start

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SI B 12 06 10 N54 - Misfire Faults, Diagnosis with ISTA

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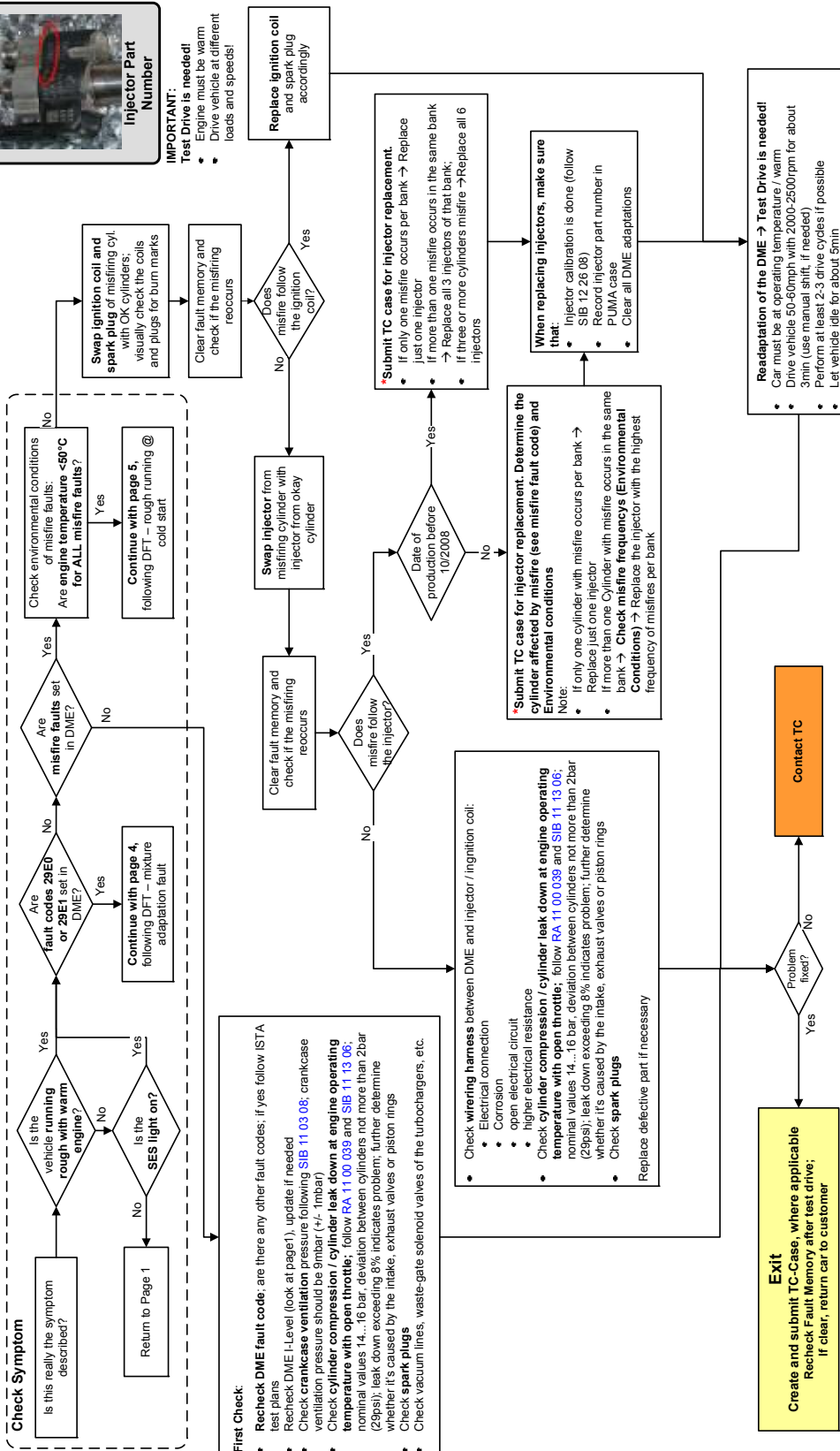
DFT – Rough Running @ Warm Engine



Injector Part Number

IMPORTANT:

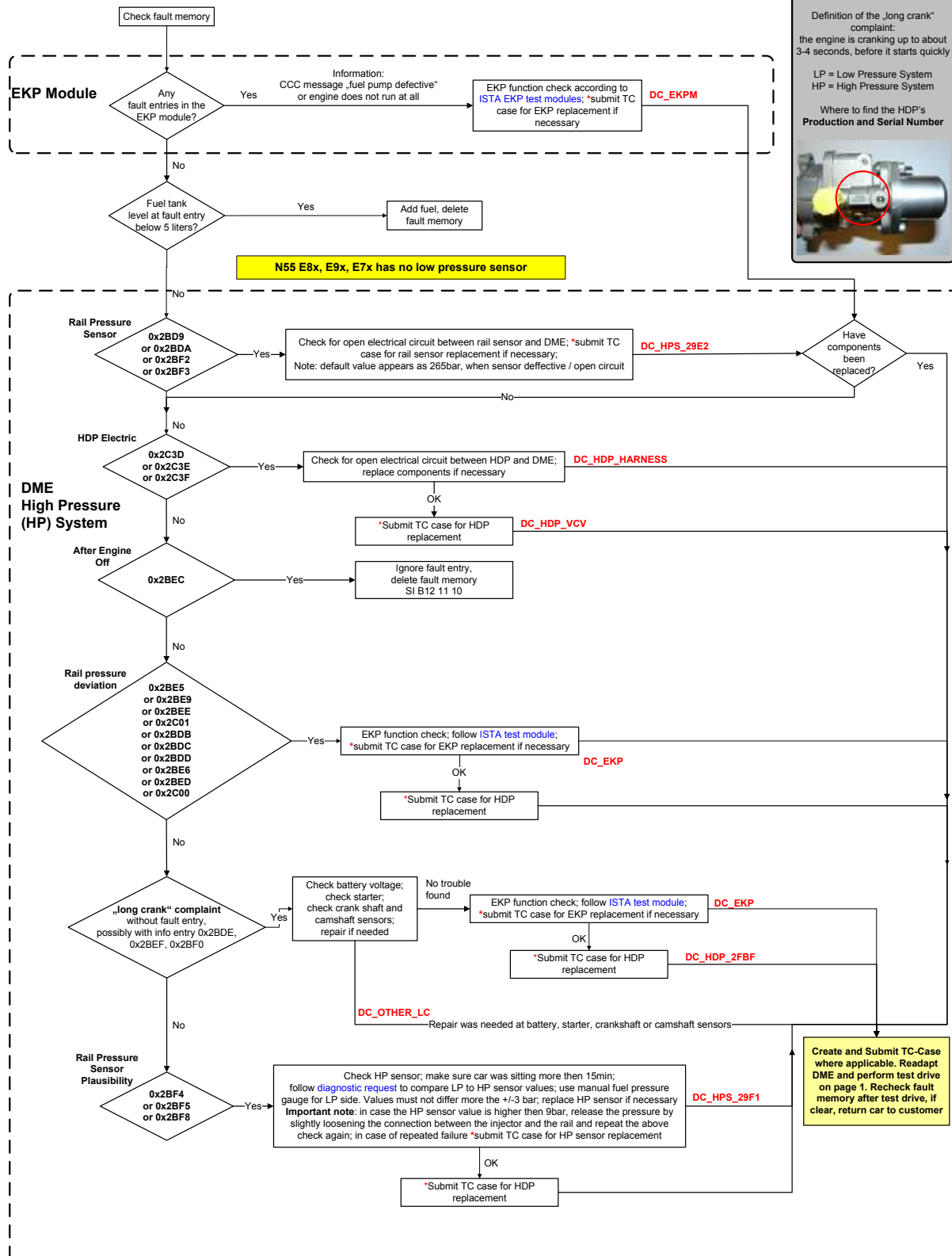
- Test Drive is needed!
- Engine must be warm
- Drive vehicle at different loads and speeds!



SI B 12 11 10 N54, N54T, N55 - Diagnosis for HDP High-pressure Faults

DFT – Fuel System N55 E8x, E9x, E7x

Page 1



SI B 12 11 10 N54, N54T, N55 - Diagnosis for HDP High-pressure Faults

Page 2

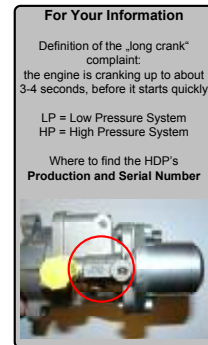
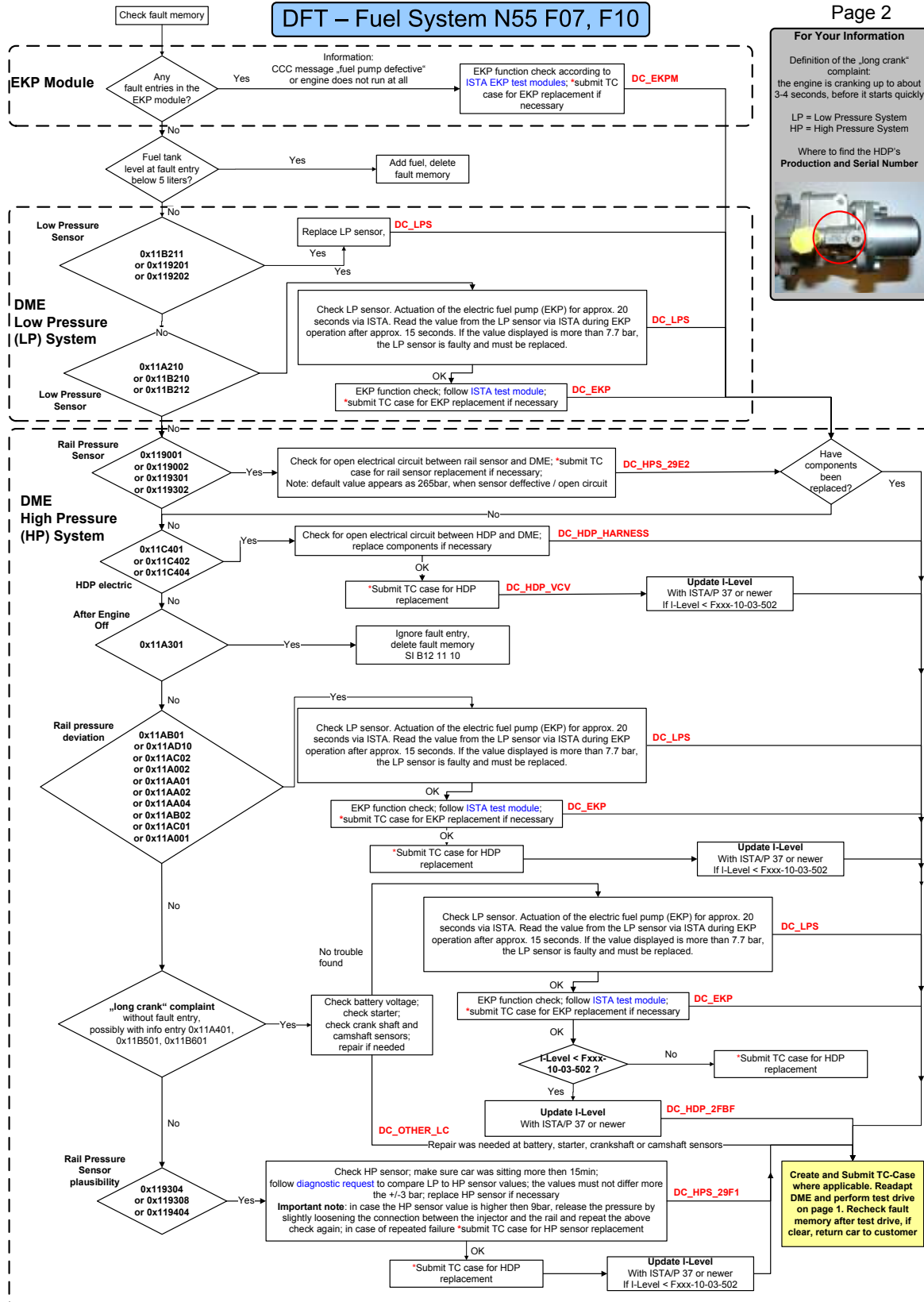


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VANOS

Model: All

Production: All

OBJECTIVES

After completion of this module you will be able to:

- Using the Status requests (cam sensors) identify whether or not the VANOS Solenoids are adjusting the Cam Timing.
- Explain why it is necessary to check engine timing when the VANOS system is faulted.
- Explain how oil condition, level and pressure affect VANOS operation.
- Using an ISID, IMIB and ETM properly check the VANOS circuit electrically.
- Locate and identify the components used for VANOS operation.

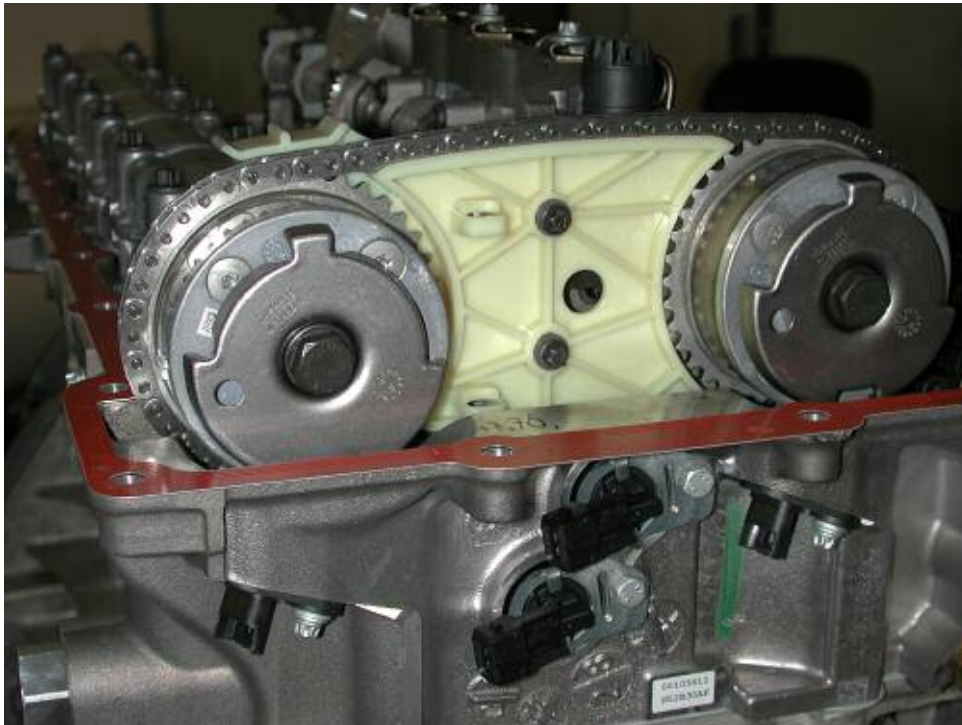
VANOS

Introduction

Performance, torque, idle characteristics and exhaust emissions reduction are improved by Variable Camshaft Timing. The VANOS system is currently used in all BMW engines.

The Vanos units are mounted directly on the front of the camshafts and adjusts the timing of the Intake and Exhaust camshafts throughout the entire spread range from retarded to advanced. The ECM controls the operation of the VANOS solenoids which regulates the oil pressure required to move the VANOS units. Engine rpm, load and temperature are used to determine VANOS activation.

N52 VANOS units



The VANOS mechanical operation is dependent on engine oil pressure applied to position the VANOS units. When oil pressure is applied to the units (via ports in the camshafts regulated by the solenoids), the camshaft hubs are rotated in the drive sprockets changing the position which advances/retards the intake/exhaust camshafts timing. The VANOS system is “fully variable”. When the ECM detects that the camshafts are in the optimum positions, the solenoids maintain oil pressure on the units to hold the camshaft timing.

The operation of the VANOS solenoids are monitored in accordance with the OBD II requirements for emission control. The ECM monitors the final stage output control and the signals from the Camshaft Position Sensors for VANOS operation.

Solenoid Valves

The VANOS solenoid valves are mounted through the front of the cylinder head. There are two solenoids, one for the intake VANOS and one for the exhaust. The solenoids control the oil flow to the camshaft ports for the intake and exhaust VANOS units.

The 4/3 way proportional solenoid valve is activated by the ECM to direct oil flow. The solenoid valve is sealed to the head by a radial seal and secured by a retaining plate.



The variable camshaft control serves the purpose of increasing torque in the lower and medium engine speed ranges. The VANOS solenoid valve activates the VANOS adjustment unit on the intake side. The VANOS solenoid valves are driven by the ECM control unit.

The VANOS solenoid valve is connected by means of two lines to the ECM. The ECM control unit activates the VANOS solenoid valve as required.

Activation takes place **pulse-width modulated** with system voltage. PWM activation means that the actuator piston can be controlled in any position, making exact positioning of the VANOS unit possible.

Intake Solenoid Valve

The intake VANOS solenoid valve is responsible for controlling the timing of the intake camshaft.

Exhaust Solenoid Valve

The exhaust VANOS solenoid valve is responsible for controlling the timing of the exhaust camshaft.

Camshaft Sensors

There are two camshaft sensors, one for the intake camshaft and one for the exhaust. They are mounted at the front of the cylinder head and monitor the impulse wheels which are bolted to the front of the VANOS units.

The sensors are supplied power via the engine electronics fuses. Ground is supplied via the ECM. The sensors are **hall effect** and provide the ECM with a **5 volt** square wave signal.

The camshaft sensor operates in accordance with the Hall principle and it is used for detecting the camshaft position. A camshaft sensor wheel is mounted on the camshaft for this purpose.

With the aid of the camshaft sensor, the ECM can determine whether the cylinder is in the compression cycle or in the charge cycle.

This deduction cannot be made from the crankshaft position. The corresponding assignment is necessary for the purpose of controlling the fuel injection and ignition accordingly.

Camshaft Sensor



Camshaft Sensor Wheel



A further task of the sensor is to provide feedback relating to the camshaft position for VANOS control. In this way, the ECM can regulate the camshaft position based on a characteristic map with the aid of a VANOS solenoid valve.

The ECM supplies the sensor with a 5V voltage and ground. The sensor sends a digital signal via the signal line to the ECM.

The camshaft sensor operates corresponding to the same principle as the crankshaft sensor. The camshaft sensor wheel however, is fundamentally different. A special aperture pattern facilitates emergency operation in the event of the crankshaft sensor failing. The resolution of the camshaft sensor signal, however, is too inaccurate to replace the crankshaft sensor during normal operation.

Intake Camshaft Sensor

The sensor for the intake camshaft has the following tasks:

- Detection of the camshaft allocation with respect to the crankshaft (cylinder compression cycle or cylinder charge cycle).
- Positioning the camshaft with respect to the crankshaft for VANOS adjustment.

With the aid of the sensor, the ECM can determine the position of the intake camshaft with respect to the crankshaft and adjust the camshaft with the aid of VANOS corresponding to ECM requirements.

Exhaust Camshaft Sensor

An exhaust camshaft sensor is also used. With the aid of the sensor, the ECM can determine the position of the exhaust camshaft with respect to the crankshaft and adjust the camshaft with the aid of VANOS corresponding to ECM requirements.

■ Description of operation

To perform the adjustment, the variable camshaft timing control requires a feedback signal on the current position of the camshaft. Camshaft sensors on the intake and exhaust side record the position of the camshafts.

The exhaust camshaft sensor is designed as an inductive hall effect sensor. The camshaft sensor wheel has 6 different flank spacings. The flank spacings are detected by the hall effect sensor.

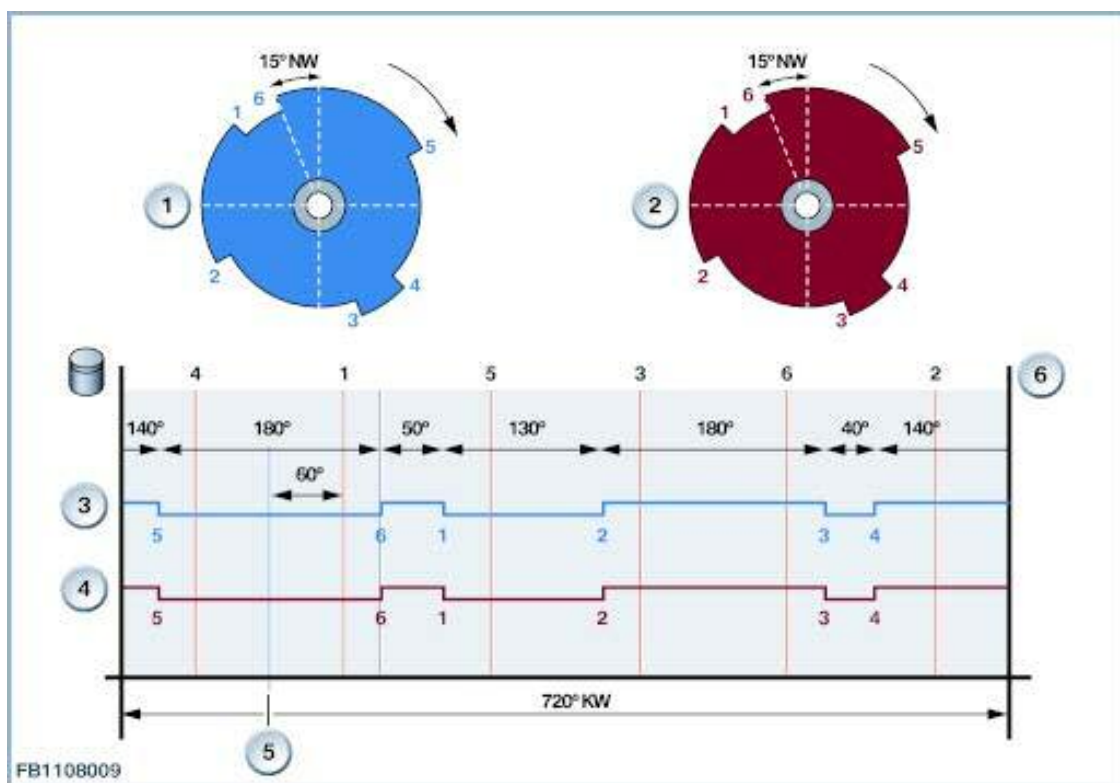
The engine control system uses these to calculate the following:

- Camshaft speed
- Camshaft speed
- Exact position of the camshaft

A controlled VANOS unit is fitted at both intake and exhaust camshafts. A VANOS solenoid valve activates the VANOS unit. The required positions of the intake and exhaust camshafts are calculated from the engine speed and the load signal (depending on the intake air temperature and engine temperature).

The DME control unit activates the VANOS unit accordingly. The control of the intake and exhaust camshaft is variable within their maximum adjustment range. When voltage is applied, it is detected whether the sensor is above a tooth or above a gap.

The engine control unit reads in the sensor signal and then compares that signal against a template in its memory unit. By comparing the sensor signal against this saved template, the precise position of the camshaft or the deviation is identified.



Index	Explanation
1	Intake camshaft
2	Intake camshaft signal
3	Reference mark for top dead center, cylinder 1 (ignition)
4	Exhaust camshaft
5	Exhaust camshaft signal
6	Cylinder

VANOS Units

The infinitely variable double VANOS system uses a hydraulic oscillating motor type VANOS units for the intake and the exhaust cams. Although they have identical function, the oscillating motor VANOS units are a further development of the variable vane type motor VANOS units used on previous systems. They are designed as an integrated component in the chain drive and are mounted with a central bolt on the respective camshaft. When de-pressurized, a coil spring holds the VANOS unit in the base position.

N52 Hydraulic oscillating motor/VANOS unit



Index	Explanation
1	Front plate
2	Locking pin
3	Oil channel
4	Casing with ring gear
5	Pressure chamber for advancing
6	Oscillating rotor
7	Pressure chamber for retarding
8	Oil channel

The VANOS units are controlled by oil pressure from the 4/3 proportional solenoid valves. The valves are located in the front of the cylinder head and are controlled by the ECM. The ECM regulates the VANOS based on factors such as engine RPM, load and coolant temperature.

N52 VANOS system



Index	Explanation
1	VANOS unit, Exhaust
2	VANOS unit, intake
3	Intake camshaft sensor
4	Exhaust camshaft sensor
5	VANOS solenoid valve
6	VANOS solenoid valve

The **infinitely variable double VANOS** system was first introduced on the M52B20TU engine. The design is similar to that of two-setting intake VANOS; the main difference is that in addition to the timing of the intake camshaft, the timing of the exhaust camshaft can also be varied. The system allows for infinite variation of timing of both camshafts according to the control commands from the engine management ECM.

The advantages of infinitely variable double VANOS are:

- Higher torque at low and medium engine speeds
- Smaller quantity of residual exhaust when idling due to smaller valve overlap resulting in improved idling
- Internal exhaust recirculation in the medium power band in order to reduce nitrogen oxide emissions
- Faster warm-up of catalytic converters and lower raw emission levels after a cold start
- Reduction of fuel consumption

The possible adjustment range of the double VANOS system is clearly identifiable by the blue/red shaded areas.



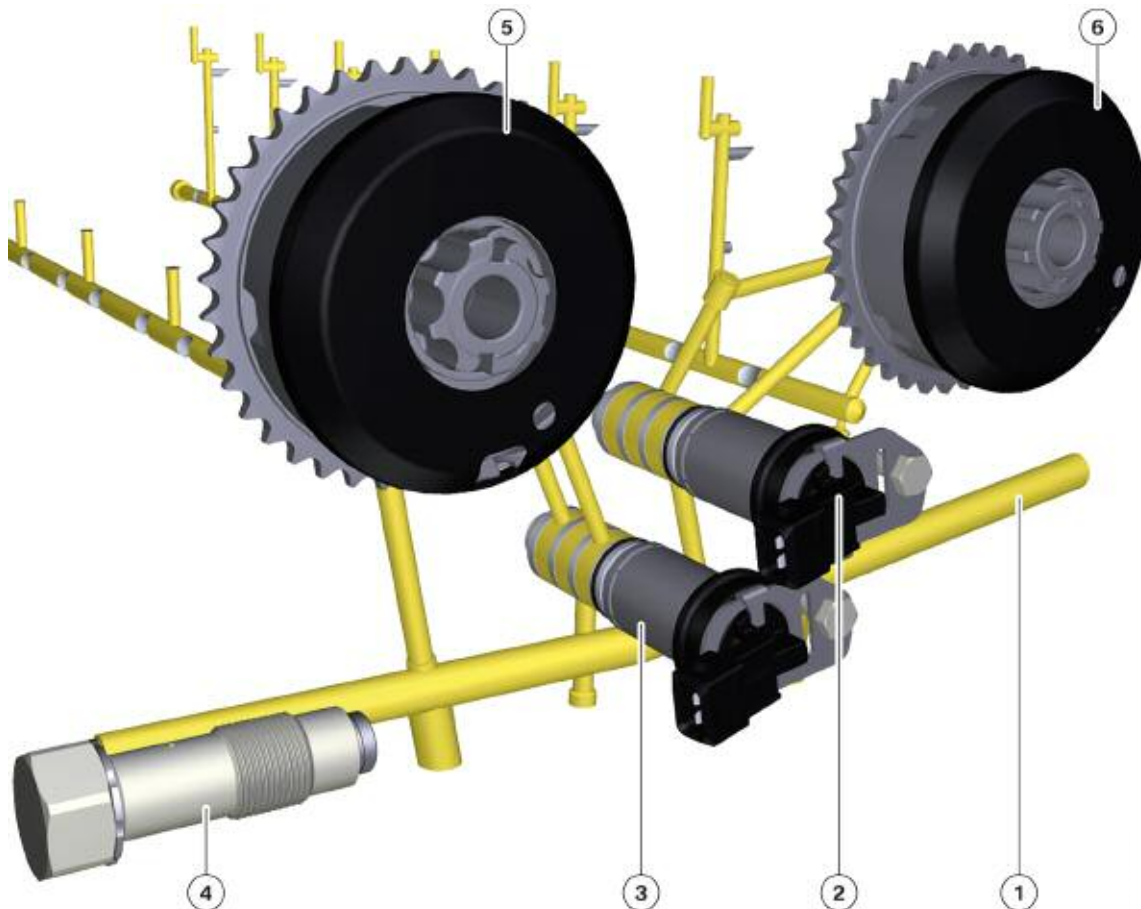
The infinitely variable double VANOS system is used on all current engines. The only change to the system is that each engine uses different spread ranges (check engine specifications for the individual cam spread).

As with previous systems, the VANOS units should not be mixed up as the spread ranges for the intake and exhaust are different and engine damage could result.

VANOS N55

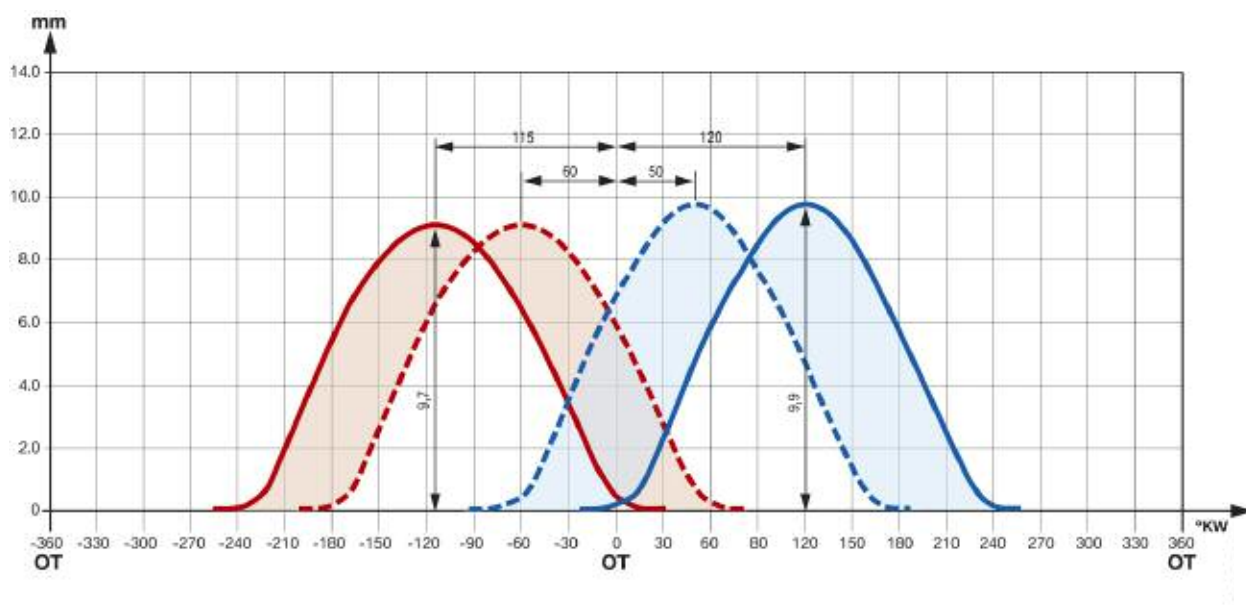
The VANOS system has been optimized to provide even faster adjustment speeds of the VANOS units. The aluminum VANOS units are much lighter and are also less susceptible to soiling. It can be seen by comparing the N54 VANOS system with the N55 VANOS that fewer oil passages are required and that the non-return valves are no longer on the cylinder head but rather incorporated into the solenoid valves on N55.

N55, VANOS with oil supply



Index	Explanation
1	Main oil duct
2	VANOS solenoid valve, intake side
3	VANOS solenoid valve, exhaust side
4	Chain tensioner
5	VANOS adjustment unit, exhaust side
6	VANOS adjustment unit, intake side

N55 valve timing diagram



		N54B3000	N55B30M0
Intake valve Ø	[mm]	31.4	32
Exhaust valve Ø	[mm]	28	28
Maximum valve lift, intake valve/exhaust valve	[mm]	9.7/9.7	9.9/9.7
Intake camshaft spread (VANOS adjustment range)	[°crankshaft]	55	70
Exhaust camshaft spread (VANOS adjustment range)	[°crankshaft]	45	55
Intake camshaft opening angle (max.-min. spread)	[°crankshaft]	125 - 70	120 - 50
Exhaust camshaft opening angle (max.-min. spread)	[°crankshaft]	130 - 85	115 - 60
Opening period intake camshaft	[°crankshaft]	245	255
Opening period exhaust camshaft	[°crankshaft]	261	261



The N55 has a larger intake and exhaust VANOS adjustment range as well as larger intake valve lift, and cam duration than the N54 engine.

VANOS Solenoid Valves (N55)

The non-return valve with screen filter used on the N54 engine have now been integrated in the VANOS solenoid valves on the N55 engine. This measure has made it possible to reduce the number of oil ducts in the cylinder head. The screen filters on the VANOS solenoid valve ensure trouble-free operation and reliably prevent the VANOS solenoid valve from sticking due to dirt particles.

Cam Sensor Wheels (N55)

The sensor wheels are now “deep-drawn” sheet metal components and no longer made from two parts. This design increases production accuracy while reducing manufacturing costs.

N55, camshaft sensor wheel



Index	Explanation
A	Rear View
B	Front view

VANOS N63

The charge cycle in the N63 engine is realized with four valves per cylinder, which are driven by two overhead camshafts.

The engine timing can be variably influenced by means of the two infinitely variable VANOS units.

The VANOS units used here have the following timing angles:

- Intake VANOS unit: 50° crankshaft angle
- Exhaust VANOS unit: 50° crankshaft angle



The VANOS units on the N63 engine differ from the VANOS units on the N62 engine. The function is identical but some components have been omitted and the VANOS unit has been optimized.

On the N63 engine, the individual vanes of the VANOS unit are no longer individual parts but rather they have been further developed to form an oscillating rotor (as on the N52 engine).

The torsion spring integrated in the N62 VANOS unit is now designed as a coil spring accommodated on the front of the N63 VANOS unit protected by a plastic cover.

VANOS N74

Like all current BMW gasoline engines, the N74 engine is also equipped with variable double VANOS. The VANOS units are common parts shared with the N63 engine, with the exception of the intake unit on cylinder bank though this is also designed to the same principle, it features a drive flange with a slot for the vacuum pump. The N74 uses two VANOS non-return valves, they are now integrated into the VANOS solenoid valves.

The VANOS units have the following adjustment angles:

- VANOS unit intake: 50° crank angle
- VANOS unit exhaust: 50° crank angle

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VALVETRONIC

Model: ALL

Production: ALL

OBJECTIVES

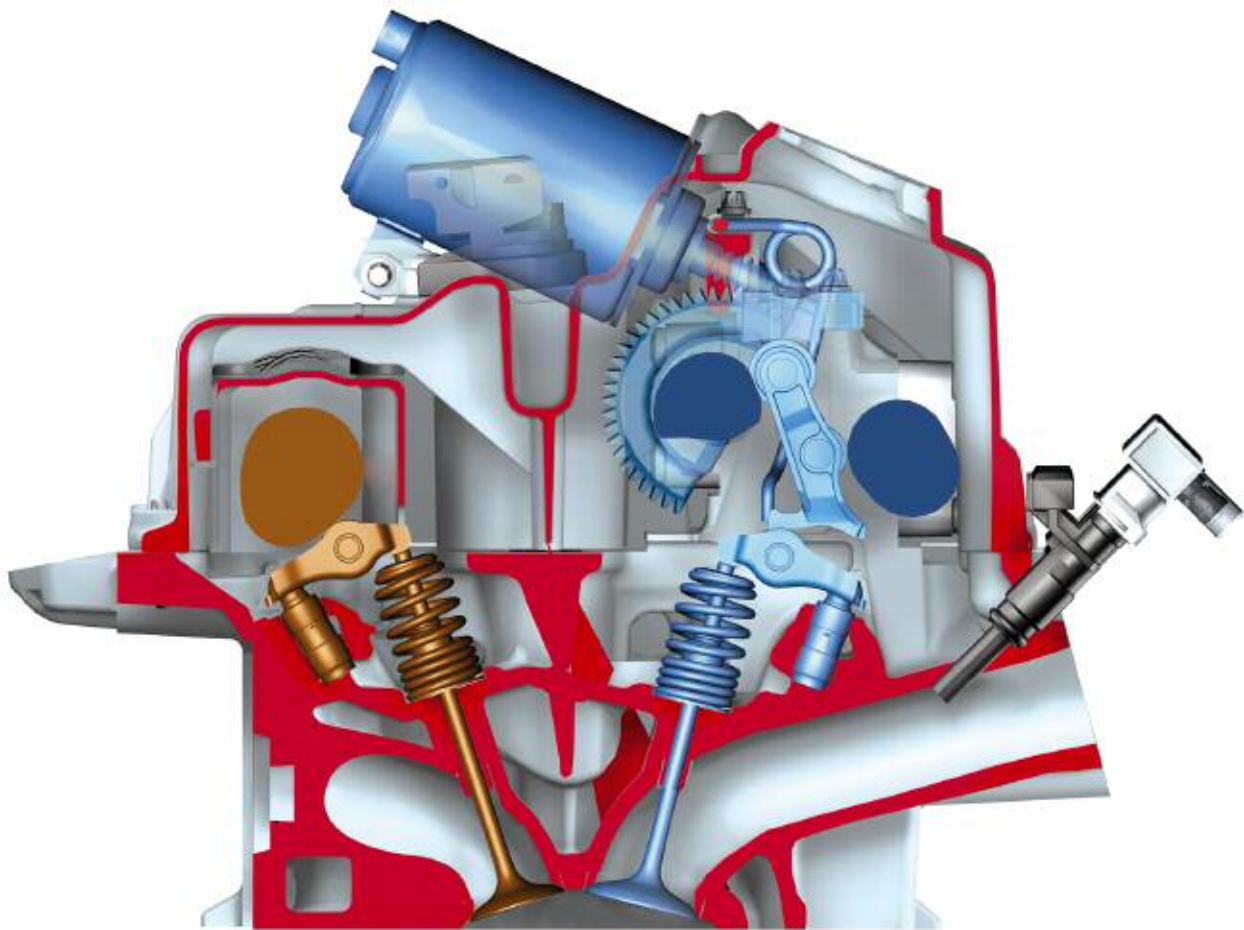
After completion of this module you will be able to:

- Name the service functions for VALVETRONIC .
- Explain how the VALVETRONIC system will function if faulted. Fail safe operation.
- Explain the relationship between the EDK and the VALVETRONIC system.
- Identify how the VALVETRONIC motor is powered using the appropriate SSP's.
- Locate and identify the components used for VALVETRONIC operation.

VALVETRONIC

Introduction

With the introduction of the N52, the 6-cylinder engine incorporated the load control system based on the valve timing gear (VALVETRONIC II). The VALVETRONIC I system that was used on the 8 (N62) and 12 (N73) cylinder engines already achieved a substantial increase in efficiency.



BMW has further developed this concept with the VALVETRONIC II.

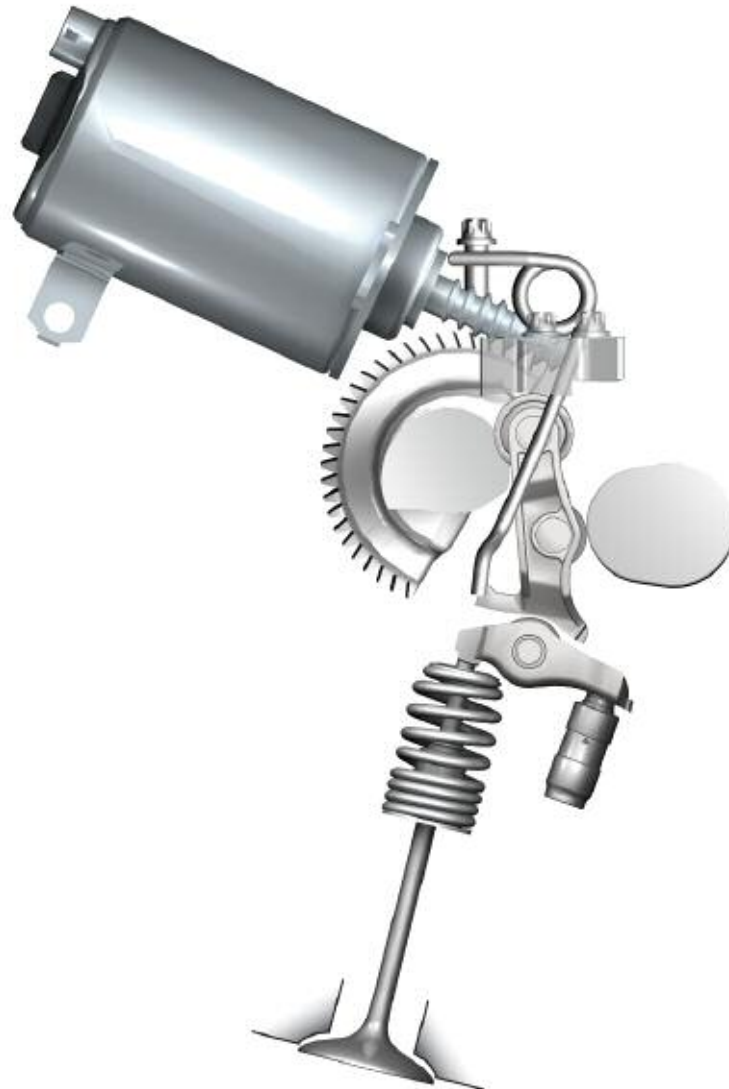
The results of this further development are:

- Increased engine dynamics
- Increased efficiency
- Improved emission values

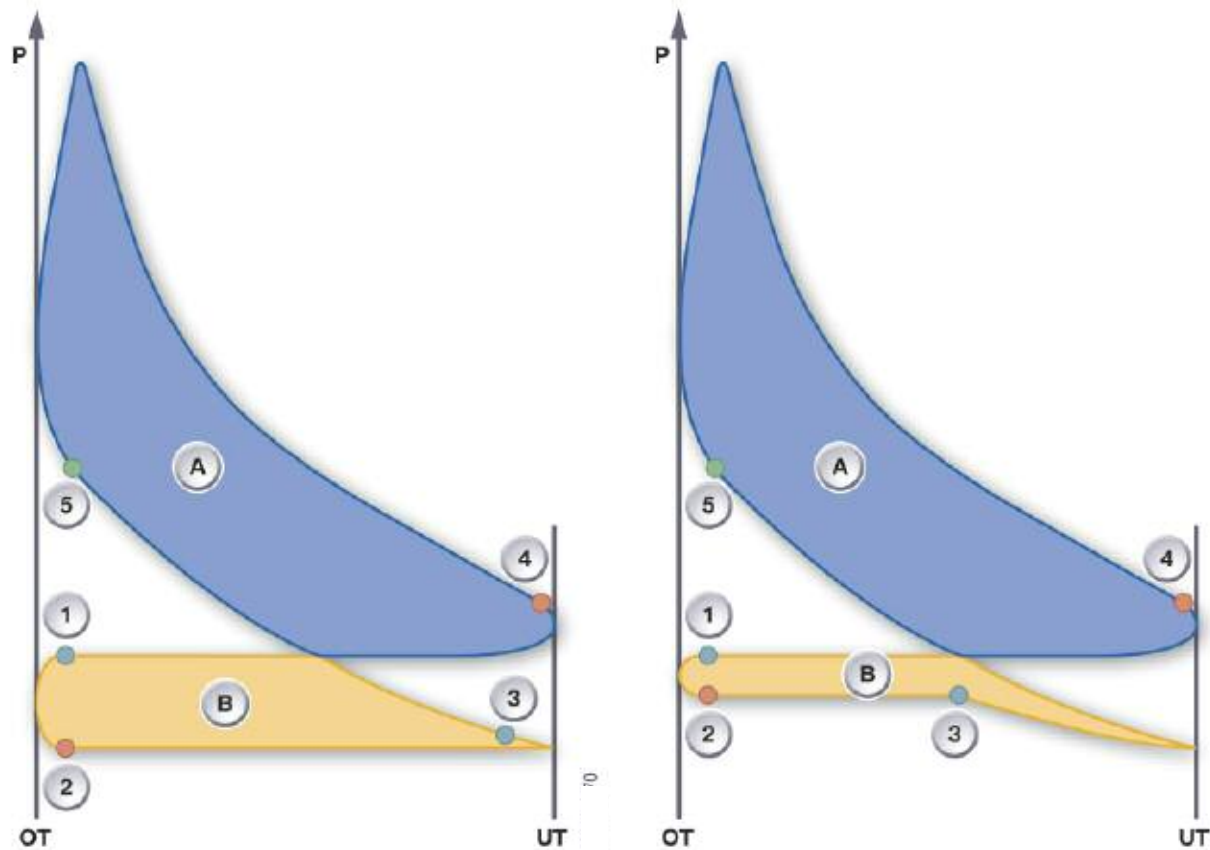
These results underscore BMW specific standards. As an example of VALVETRONIC II, the N52 engine features the following optimizations which further enhances the Ultimate Driving Machine:

- The top engine speed has been increased to 7,000 rpm.
- The specific power output has been increased to 63.4 kW/l.
- The specific engine torque is 100 Nm/l over a broad engine speed range.
- Distinctly increased valve acceleration values and friction-optimized transmission elements result in an even more responsive engine.
- CO emissions reduced.
- The world's most stringent exhaust emission regulations are complied with.

Valvetronic II - used on N52, N52KP and N51



Load Control



Index	Explanation	Index	Explanation
OT	Top dead center	4	Exhaust valve opens
UT	Bottom dead center	5	Firing point
1	Intake valve opens	A	Gain
2	Exhaust valve closes	B	Loss
3	Intake valve closes	P	Pressure

The illustration on the left shows the conventional method with the slightly higher loss. The reduced loss can be clearly seen in the illustration on the right. The upper area represents the power gained from the combustion process in the petrol engine. The lower area illustrates the loss in this process.

The loss area can be equated to the charge cycle, relating to the amount of energy that must be applied in order to expel the combusted exhaust gasses from the cylinder and then to draw the fresh gasses again into the cylinder.

Apart from the full load setting, the intake of fresh gasses in a throttle valve controlled engine always takes place against the resistance offered by the throttle valve to the inflowing gasses. The throttle valve is virtually always fully opened during intake on the VALVETRONIC controlled engine. The load is controlled by the closing timing of the valve.

Compared to the conventional engine where the load is controlled by the throttle valve, no vacuum occurs in the intake manifold. This means no energy is expended for the purpose of producing the vacuum. The improved efficiency is achieved by the lower power loss during the intake process.

A minimum vacuum in the intake system is required for the crankcase ventilation and evaporative purge systems. The throttle valve is slightly adjusted for this purpose.

Function

The VALVETRONIC II consists of the fully variable valve lift control combined with the variable camshaft control (double VANOS). The valve lift is controlled only on the intake side while the camshaft (VANOS) is adjusted also on the exhaust side.

The throttle-free load control is implemented by:

- variable valve lift of the intake valve,
- variable valve opening timing of the intake valve and
- variable camshaft spread of the intake and exhaust camshaft.

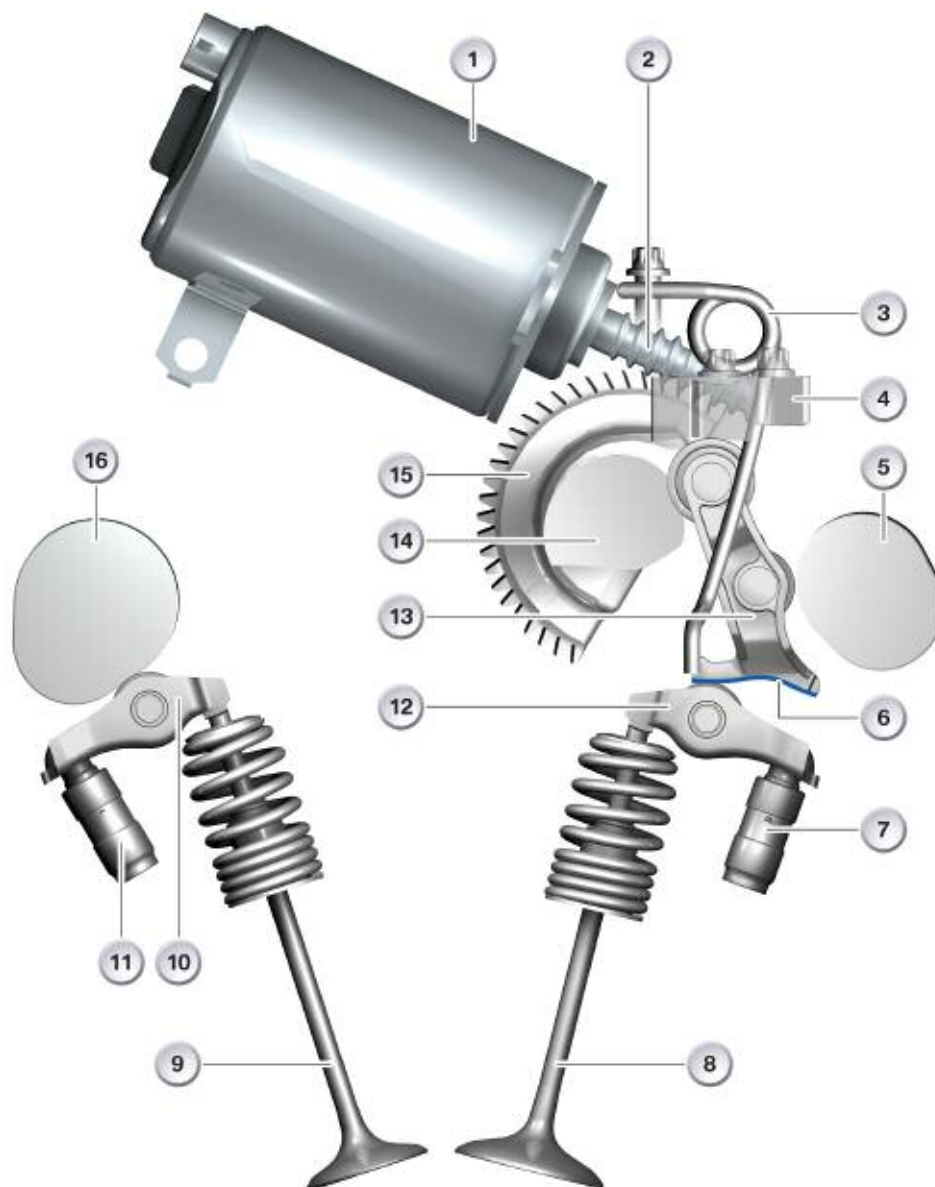
System optimization includes modification of the valve gear kinematics, a modified actuator motor and the adapted spread range of the VANOS units.

The main differences are:

- The plain bearing on the intermediate lever to the eccentric shaft has been replaced by a roller bearing, thus reducing the friction in the valve timing gear.
- Guidance of the intermediate lever is more precise. Only one spring is now required to guide and hold the intermediate lever.
- The moved mass of the valve timing gear has been reduced by 13%.
- The lift range of the intake valves has been improved. The maximum lift has been increased to 9.9 mm but more importantly the minimum lift has been further reduced to 0.18 mm.

The overall result is supported by further improvements in the intake manifold and exhaust dynamics.

Valvetronic II - used on N52, N52KP and N51



Index	Explanation	Index	Explanation
1	Actuator	9	Exhaust Valve
2	Worm Shaft	10	Roller Cam Follower
3	Return Spring	11	HVA, exhaust
4	Gate Block	12	Roller Cam Follower, Intake
5	Intake Camshaft	13	Intermediate Lever
6	Ramp	14	Eccentric Shaft
7	HVA, Intake	15	Worm Gear
8	Intake Valve	16	Exhaust Camshaft

The fully variable valve lift control is activated with the aid of an actuator motor (1), an eccentric shaft (14), an intermediate lever (13), the return spring (3), the intake camshaft (5) and the roller cam follower (12). The actuator motor is installed in the cylinder head above the camshafts. It serves the purpose of adjusting the eccentric shaft. The worm shaft of the electric motor meshes with the worm gear mounted on the eccentric shaft. Following adjustment, the eccentric shaft does not have to be locked in position as the worm gear is sufficiently self-locking. The eccentric shaft adjusts the valve lift on the intake side.

The intermediate lever varies the transmission ratio between the camshaft and the roller cam follower. The valve lift (9.9 mm) and opening time are at a maximum in the full load position.

The valve lift (0.18 mm) and opening time are set to minimum in the idling position. The roller cam followers and the associated intermediate levers are divided into four classes. A corresponding code number is punched on the components. They always have the same class per pair. Assignment of the roller cam followers and the intermediate levers at the production plant ensures that the cylinders are uniformly charged even at the minimum valve lift of 0.18 mm.

Valvetronic II at minimum valve lift



Valvetronic II at maximum valve lift



The eccentric shaft sensor (3) signals the position of the shaft back to the ECM.

This sensor operates based on the magnetoresistive principle: A ferromagnetic conductor changes its resistance when the applied magnetic field changes its position.

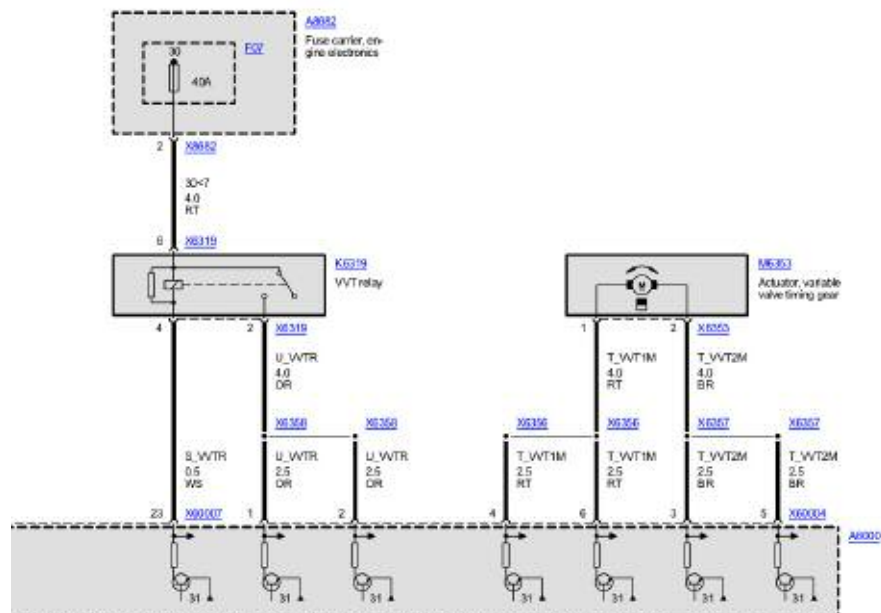


For this purpose, a magnetic wheel (1) that contains a permanent magnet is mounted on the eccentric shaft. As the shaft rotates, the magnetic field lines of the magnet intersect the magnetically conductive material in the sensor. The resulting change in resistance is used as a correcting variable for the signal for the engine control unit.

The magnetic wheel must be secured on the eccentric shaft by means of a non-magnetic screw (2) otherwise the sensor will not function.

VVT Motor and Relay

The VWT motor is controlled directly by the ECM. The motor receives power from a relay located in the E-Box.



Phasing

The new VALVETRONIC II, is a very fast and exact engine control system. So-called phasing is implemented to assist adjustment in the lower valve lift range. The intake valves of a cylinder are opened synchronously up to a lift of 0.2 mm. Valve 1 then begins to lead (advance). Therefore, valve 2 opens with a slight delay behind valve 1 and catches up to valve 1 again at a lift of approximately 6 mm. From here on they open synchronously again.

This opening characteristic has a favorable effect on the inflow of gasses into the cylinder. By keeping the opening cross section of the intake valves small this results in a distinctly higher flow rate at a constant intake volume. In connection with the geometry in the upper area of the combustion chamber, this higher flow rate is used to mix the air/fuel mixture more effectively.

This phasing eliminates the need for the turbulence ports used on the previous generation six-cylinder engines. The phasing feature of the Valvetronic creates the necessary turbulence (swirl) in the combustion chamber.

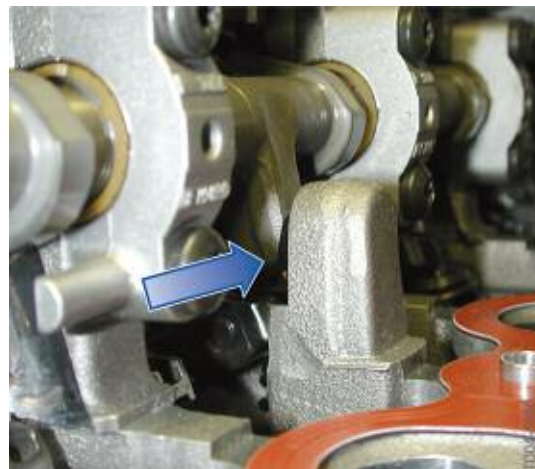
MIN/MAX Stops

A stop routine can be implemented between the mechanical stops in order to detect the positions of the mechanical stops. For this purpose, the eccentric shaft is adjusted from zero lift to full lift. The stop routine is executed only when the motor electronics determines implausible values during the engine start procedure. This routine can also be initiated by the diagnosis systems.

Eccentric Shaft - MIN Stop



Eccentric Shaft - MAX Stop

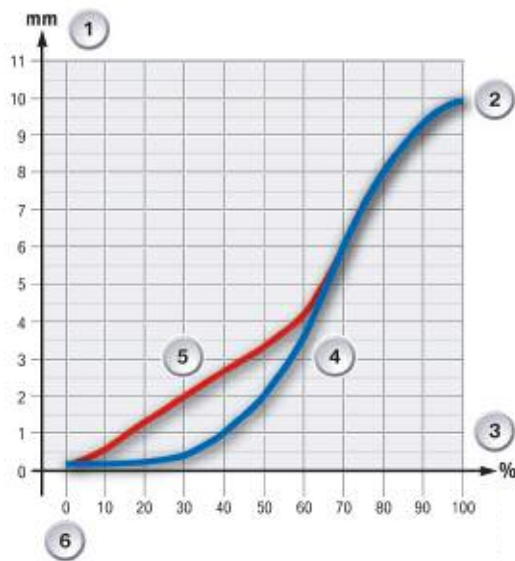


VALVETRONIC III

The main differences between VALVETRONIC III and VALVETRONIC II are in the arrangement of the VALVETRONIC servomotor and the VALVETRONIC sensor. As in VALVETRONIC II, the turbulence level is increased at the end of the compression cycle for the purpose of optimizing the mixture formation with the use of phasing and masking measures. This movement of the cylinder charge improves the combustion during partial load operation and in catalytic converter heating mode. The quench areas also contribute to mixture formation.

Phasing

Phasing results in a lift difference between both intake valves of up to **1.8 mm** in the lower partial load range. Consequently, the flow of fresh air is distributed asymmetrically.



Index	Explanation
1	Valve Opening (mm)
2	Maximum Valve Opening (mm)
3	Load (%)
4	Intake Valve 2
5	Intake Valve 1
6	Minimum Valve Opening (mm)

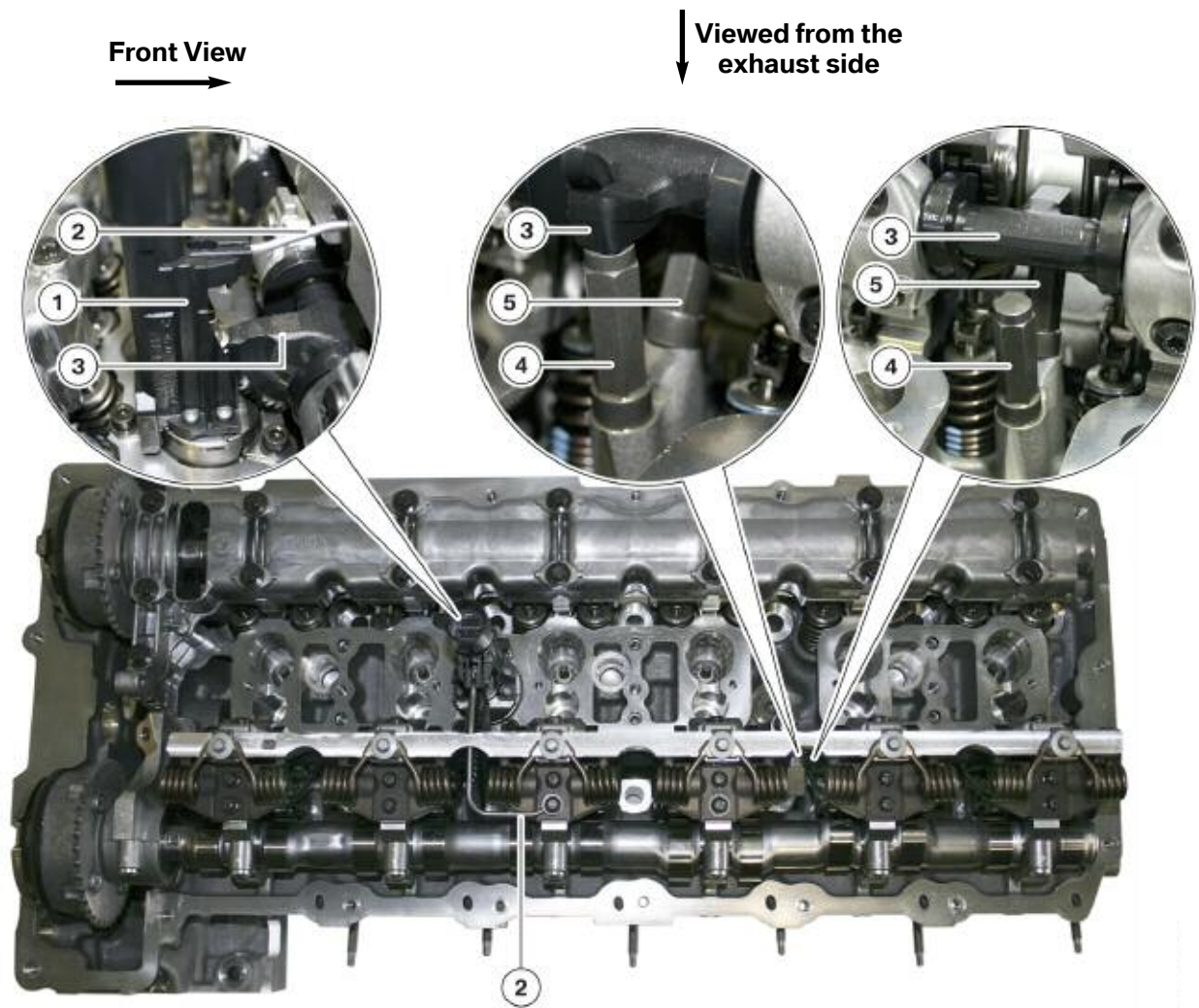
Masking

Masking refers to the design of the valve seats. This machining ensures that the incoming fresh air is aligned in such a way as to give rise to the required cylinder charge movement. The advantage of this measure is that the combustion retardation is reduced by approximately 10° of crankshaft rotation. The combustion process takes place faster and a larger valve overlap can be achieved, thus considerably reducing NOx emissions.

Valve Lift Adjustment Overview

As can be seen from the following graphic, the installation location of the servomotor has changed with VALVETRONIC III. Another new feature is that the eccentric shaft sensor is no longer mounted on the eccentric shaft but has been integrated into the servomotor.

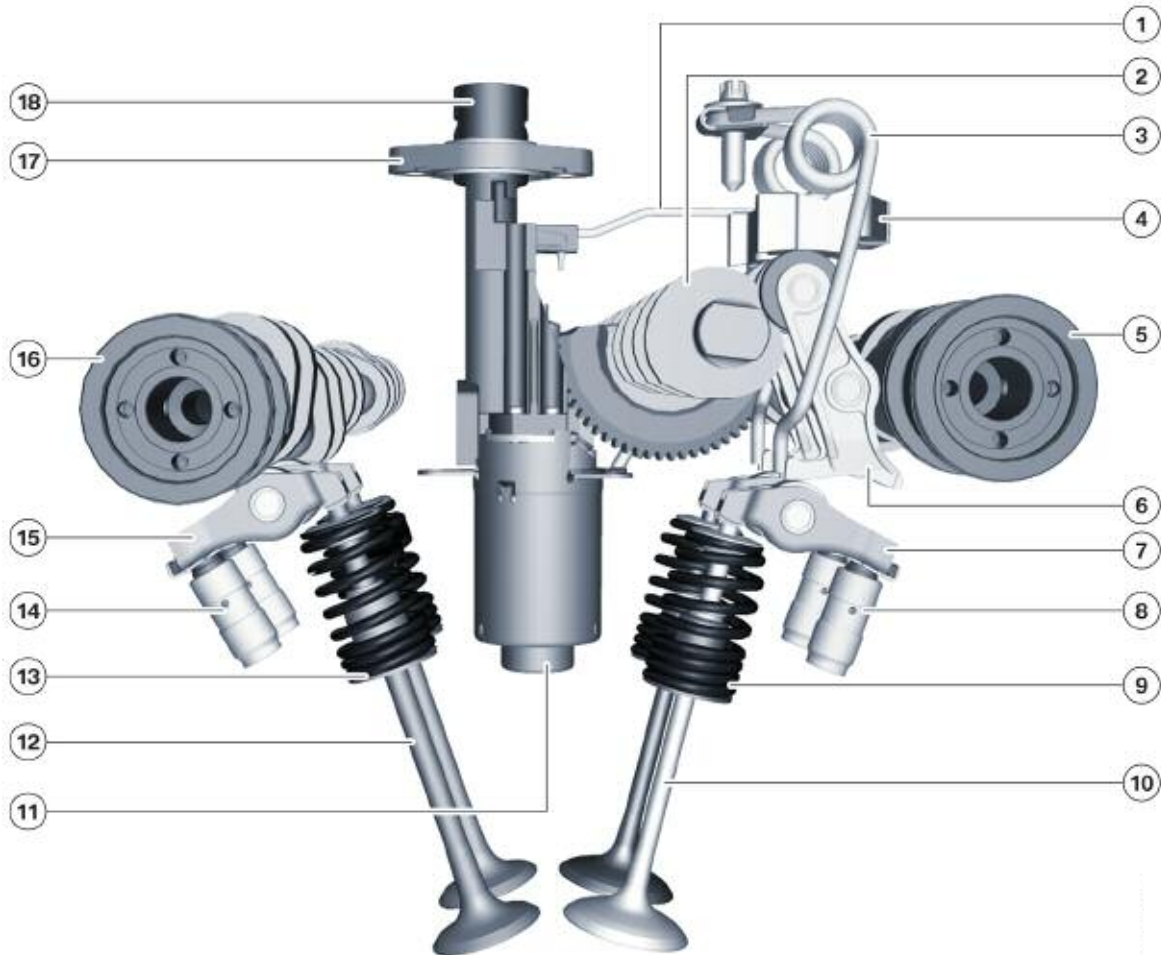
N55, valve lift adjustment



Index	Explanation
1	Valvetronic servomotor
2	Oil spray nozzle
3	Eccentric shaft
4	Eccentric shaft minimum stop
5	Eccentric shaft maximum stop

The VALVETRONIC III servomotor contains a sensor for determining the position of the motor and the eccentric shaft. The servomotor is lubricated with engine oil by means of an oil spray nozzle (1) aimed directly at the worm drive and the eccentric shaft mechanism.

N55, design of valve lift adjustment



Index	Explanation	Index	Explanation
1	Oil spray nozzle	10	Intake valve
2	Eccentric shaft	11	Valvetronic servomotor
3	Return spring	12	Exhaust valve
4	Gate block	13	Valve spring
5	Inlet camshaft	14	Hydraulic valve lash adjustment
6	Intermediate lever	15	Roller cam follower, exhaust
7	Roller cam follower, intake	16	Exhaust camshaft
8	Hydraulic valve lash adjustment	17	Sealing sleeve
9	Valve spring	18	Socket

VALVETRONIC Servomotor

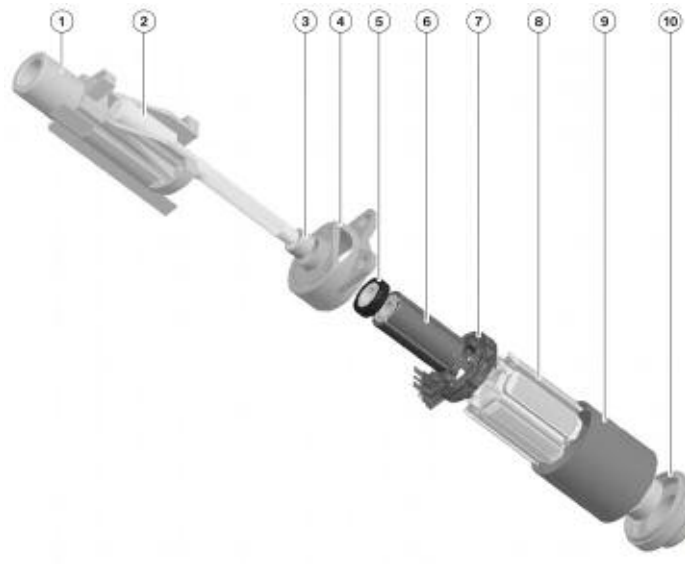
A brushless direct current motor (BLDC motor) is used. The BLCD motor is maintenance-free and very powerful, due to the contactless energy transfer system. The use of integrated electronic modules ensures precision control.

The Valvetronic servomotor has the following special features:

- Open concept (engine oil is directly supplied to the motor).
- The eccentric shaft angle is determined by angle increments from the integrated sensor system.
- Power consumption is reduced by about 50%.
- Higher actuating dynamics (e.g. cylinder-selective adjustment, idle speed control, etc.).
- Lightweight design is approximately 600 grams.

Function

Actuation of the Valvetronic servomotor is limited to a maximum of 40 amps. A maximum of 20 amps are available over a period of > 200 milliseconds. The Valvetronic servomotor is actuated by a pulse width modulated signal. The duty cycle is between 5% and 98%.



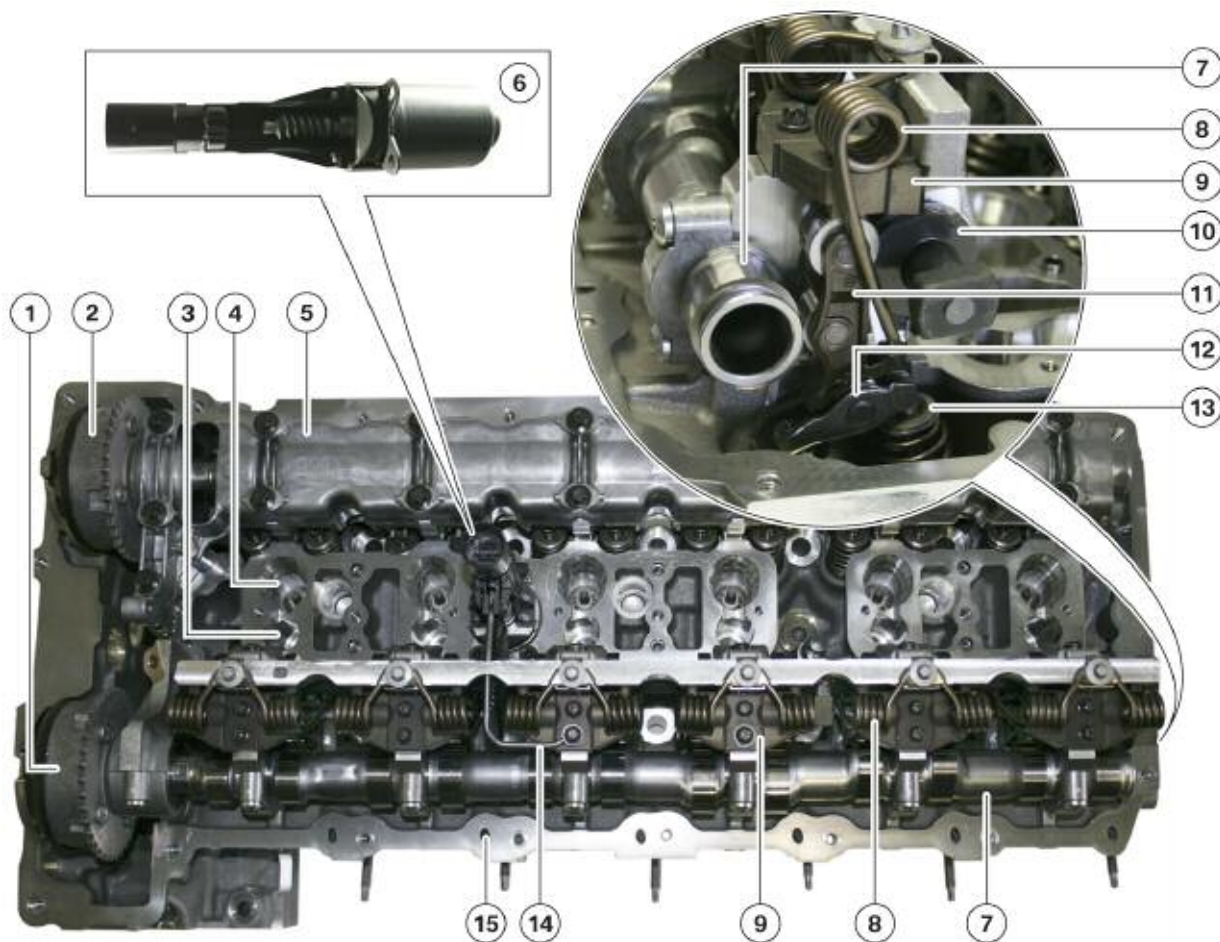
Index	Explanation	Index	Explanation
1	Socket	6	Rotor with four magnets
2	Worm shaft	7	Sensor
3	Needle bearing	8	Stator
4	Bearing cover	9	Housing
5	Magnetic sensor wheel	10	Bearing

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The following graphic shows the design of the cylinder head on the N55 engine with Valvetronic III and direct fuel injection.

N55, overview of valvetrain



Notice the hollow, lightweight design of the camshafts (7) and the blow-by passages leading into the intake ports (15).

Index	Explanation
1	VANOS unit, intake camshaft
2	VANOS unit, exhaust camshaft
3	Injector well
4	Spark plug well
5	Camshaft housing
6	Valvetronic servomotor
7	Inlet camshaft
8	Torsion spring
9	Gate
10	Eccentric shaft
11	Intermediate lever
12	Roller lever tappet
13	Valve head
14	Oil spray nozzle
15	Passages for introducing blow-by gas into the intake ports

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Turbocharging Technology

Model: All

Production: All

OBJECTIVES

After completion of this module you will be able to:

- Explain which inputs does the DME use to calculate charge air.
- Locate the charge air pressure and/or Temperature sensors.
- Locate the electropneumatic pressure converters (EPDW) for the waste gate operation.
- Demonstrate the ability to check the power to the EPDW and verify the DME signal to the EPDW.
- Explain how the pulse width modulated signal changes with the operation of the waste gate.
- Demonstrate the ability to use a vacuum gauge, IMIB or vacuum pump to diagnose the vacuum lines from the EPDW to the wastegate(s) on the turbo(s).

Introduction

New Generation Engine Technology

In 2005, the first of the new generation 6-cylinder engines was introduced as the N52. The engine featured such innovations as a composite magnesium/aluminum engine block, electric coolant pump and Valvetronic for the first time on a 6-cylinder.

To further increase the power and efficiency of this design, three new engines were introduced for the 2007 model year. These engines are the N52 K, the N51 SULEV II and the N54.

The N52K (N52KP) engine is the naturally aspirated version of the new 6-cylinder engines. The "K" designation indicates that there are various efficiency and cost optimization measures. This engine can also be referred to as the "KP" engine.

The measures include new optimized components such as the consolidation of various items such as the crankcase ventilation system into the cylinder head cover.

The N51 engine is introduced to comply with SULEV II requirements. The N51 features much of the same measures and technology as the previous SULEV engine, the M56.



The N54 engine is the first turbocharged powerplant in the US market. In addition to turbocharging, the N54 features second generation direct injection and double VANOS.

Based on the N54, the N63 twin turbo V8 was launched with the introduction of the E71 xDrive50i in 2008. It features double VANOS, DI and two turbochargers.

In 9/2009 the successor of N73, the N74 V12 was introduced with the launch of the F01/F02 760i/760Li. This engine largely based on N73 and N63 technology.

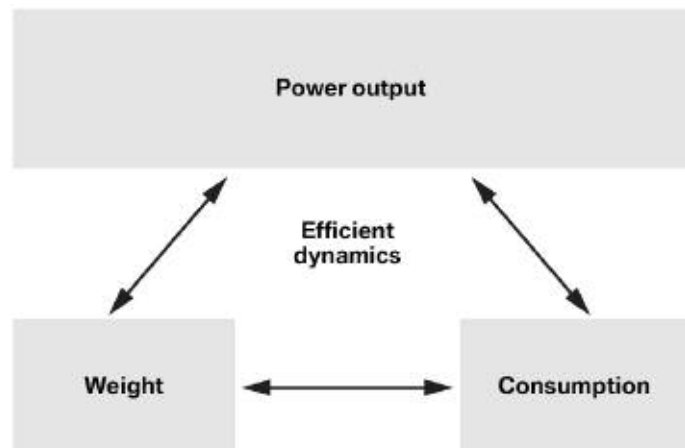
The N55 engine is the direct successor to the N54 engine and was introduced to the US market with the in the launched of the F07 535i Gran Turismo in the Spring of 2010. Technical updates and modifications make it possible to use only one exhaust turbocharger. The technical data have remained virtually the same - with reduced costs and improved quality.

The N55 combines for the first time Valvetronic III with double VANOS, direct injection and turbocharging and is referred to as TVDI.

EfficientDynamics

The central impetus in always striving for new innovations arises from the way in which the BMW marque sees itself, from the company's technological expertise and from the derived demands placed on the products. The Ultimate Driving Machine is the motif that underlies not only the expectations of the customers but also the challenges facing the engineers.

Thus, BMW is opening up further potential for engine technology with its turbocharged engines.



The spray-directed direct-injection process of high-precision injection (HPI) represents a lasting solution to reducing fuel consumption. In combination with this injection system, fundamental drawbacks of gasoline-engine turbocharging such as a reduced compression ratio and a high tendency to knock are avoided. This system ensures that the potential of turbocharging for increasing power and torque are fully exploited.

Today, however, driving pleasure is derived not just from the highest possible levels of dynamics but also increasingly from increased efficiency. Conscious enjoyment of the Ultimate Driving Machine also includes the certainty of not having to take pleasure in dynamics at the cost of excessively high fuel consumption. BMW has therefore defined the overall development of efficient dynamics with very clear specifications. Each new engine generation offers the preconditions for still better performance. At the same time, however, each new drive unit also always provides increased economy.

The incorporation of the latest turbocharger technology in conjunction with direct fuel injection, opens up the power potential of an engine with a larger cubic capacity, but avoids the associated consumption drawbacks.

Technical innovations at BMW are based on previous innovations and complement each other. Examples of this are the N54, N55, N63 and N74 engines, all of which use consumption-reducing technologies that maximize what EfficientDynamics is all about.

History of Turbocharging

As far as gasoline engines are concerned, turbocharging has not been in widespread use at BMW. As a matter of fact, the last turbocharged BMW production vehicle was the E23 (745) which was not officially imported into the US. The previous “turbo” model before that was the legendary 2002 tii turbo in the early 1970’s. This 2002 tii turbo was also not officially imported into the US.



Until now, BMW has built a reputation for building high performance engines which are naturally aspirated. Much research has gone into the development of an efficient engine design which meets not only the expectations of the customer, but complies with all of the current emissions legislation.

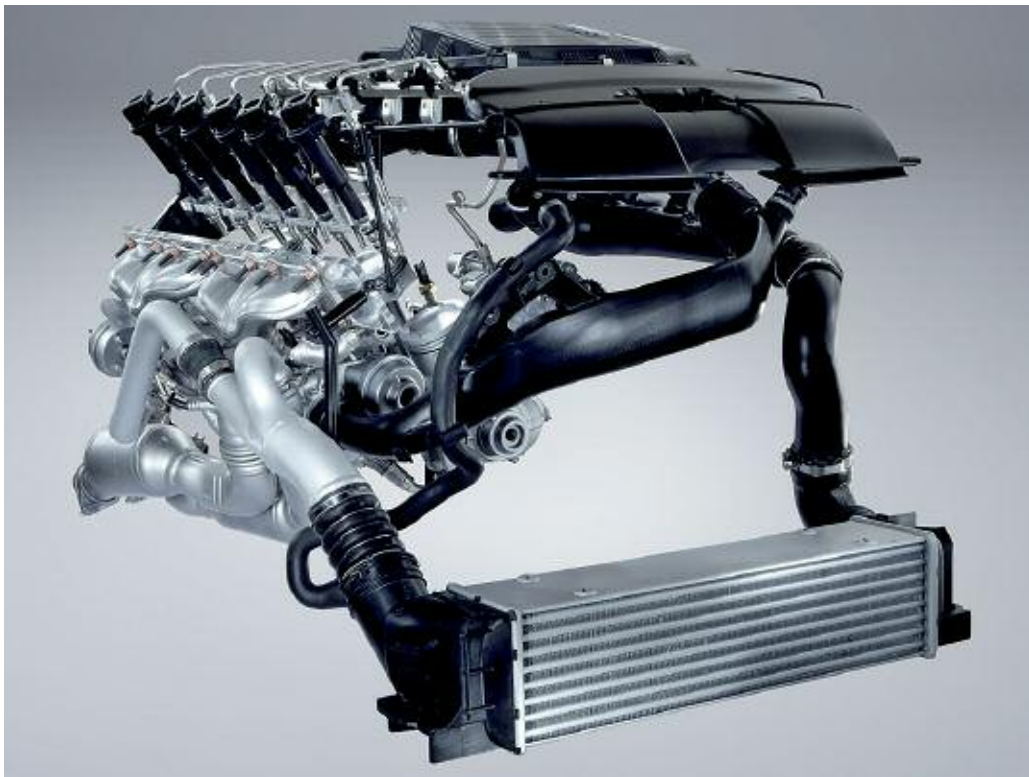
Currently, the global focus has been centered around the use of alternative fuels and various hybrid designs. While BMW recognizes these concerns, there is still much development to be done on the internal combustion engine. Therefore, at least for the time being, BMW will continue to build some of the best internal combustion engines in the world.

Principles of Operation

The turbocharger consists of a turbine and compressor assembly on a common shaft inside of the turbocharger housing. A turbocharger is driven by waste (exhaust) gases and in turn drives a compressor which forces air into the engine above atmospheric pressure. This increase in pressure allows for an air charge with a greater density. The result is increased torque and horsepower. The turbine and the compressor can rotate at speeds of up to **200,000 rpm** and the exhaust inlet temperature can reach maximum temperatures of up to **1050°C!**

This increased density during the intake stroke ultimately adds up to the creation of more engine output torque. Of course, this increased density must be accompanied by additional fuel to create the desired power. This is accomplished by engine management system programming to increase injector “on-time” and enhance associated maps.

The use of an exhaust driven turbocharger is used to create more engine power through increased efficiency. In the case of BMW turbocharged engines, the turbocharger is used in conjunction with direct fuel injection. This provides the best combination of efficiency and power with no compromise.



BMW Twinpower Turbo: One Term – Three Different Turbo Technologies

The aim of further reducing fuel consumption and CO2 emissions in motor vehicles has led to a new trend referred to as “engine downsizing” by industry insiders: away from large-capacity naturally-aspirated engines towards smaller-sized turbo units. BMW is among the pioneers of this development, with the **BMW EfficientDynamics** strategy ensuring not just considerably improved fuel economy but also increased dynamic performance.

As expected, BMW went the usual step further in its turbocharger development, using twin chargers for its most powerful turbo units in each category. As a result, customers not only enjoy higher outputs, increased torque at lower engine speeds, and better fuel economy – they also notice these engines’ more immediate response compared to conventional turbo units. While they are all referred to as **BMW TwinPower Turbo** engines, these powerplants in fact employ three different types of turbocharging technologies.



The three different turbocharging technologies for BMW TwinPower Turbo engines: to the left, a turbocharger powered by two exhaust gas streams (twin-scroll design), in the centre, the engine variant with two same-size chargers (parallel design), and to the right, the model with one small and one large charger (sequential design).

Advanced Turbo Engines Use Less Fuel

Until recently, gasoline turbo engines had a reputation of being exceedingly powerful while also using excessive amounts of fuel. Today’s turbo engines are considerably less thirsty: advanced technologies such as electronically controlled injection or more heat-tolerant materials (which no longer require additional fuel to cool the combustion chamber at full load) ensure that the differences in fuel usage between naturally aspirated and turbocharged engines under high-load conditions have disappeared. The benefit of today’s turbocharged engines is that they allow for outputs which in the past were only possible by increasing an engine’s capacity and/or the number of cylinders, which inevitably entailed higher fuel consumption.

Today’s solution is referred to as “engine downsizing”. At the same time, current BMW turbo engines offer considerably higher torque at low revs than comparable engines without turbochargers. This pulling power “from below” enables a more refined ride at low revs, which in turn reduces fuel consumption during everyday driving.

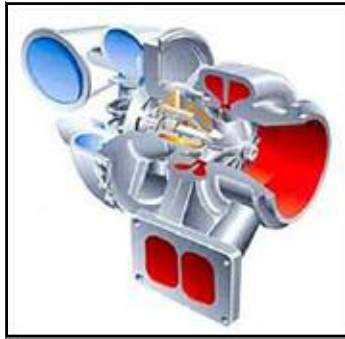
Three Technologies – One Effect: Twin-Turbocharging

To combine great power with reduced fuel consumption, BMW now uses BMW TwinPower Turbo engines for its most powerful turbocharged models in each vehicle category. The BMW term refers to turbo engines (both gasoline and diesel units) that operate with twin-turbocharging.

Twin-turbocharging:

- Can refer to the use of **two turbochargers**. In this version, each turbocharger is powered by a separate exhaust stream.
- Can also refer to just one turbocharger powered by two separate exhaust streams. BMW refers to this technology as a **twin-scroll** design. Just like the system using two smaller chargers, this enables faster pressure build-up and therefore faster engine response.

Twin Scroll Turbocharger



This means: the “twin” in the BMW TwinPower Turbo term represents either the **number of turbochargers** or, in the case of a single-charger system, the **number of exhaust gas inlets**. This technology provides an ideal way of combining fast, sporty response, high power output and excellent fuel efficiency.

BMW TwinPower Turbo thus refers to three different twin-turbocharging technologies:

- a **single turbocharger**, powered by two exhaust streams (e.g. BMW 535i, N55 with twin-scroll technology);
- **two same-size, smaller turbochargers** (e.g. BMW 750i, N63);
- **one large and one small turbocharger** operating in **sequence** (e.g. BMW X5 X35d M57TU Top).

BMW TwinPower Turbo: one charger, two exhaust gas inlets.

The six-cylinder in-line gasoline engine in the BMW 135i, BMW 335i, BMW 535i, BMW X3 xDrive35i, BMW X5 xDrive35i and BMW X6 xDrive35i is the latest-generation BMW engine. Its turbocharger is powered by two exhaust streams.

The **twin-scroll** technology makes the charger react especially fast. This single twin-scroll charger requires less space than two separate chargers, and provides additional weight-saving benefits. In conjunction with **High Precision Injection** (HPI) and **VALVETRONIC III** (variable valve lift control), this design ensures high power output and increased torque, coupled with excellent fuel efficiency. This combination is so far unique in engine manufacturing.

BMW TwinPower Turbo: two same-size chargers.

The six-cylinder gasoline models BMW Z4 sDrive35i, BMW Z4 sDrive35is, and BMW 740i; the eight-cylinder gasoline models BMW 550i, BMW 750i, BMW X5 xDrive50i, BMW X6 xDrive50i, and the twelve-cylinder BMW 760i, use the technology with **two same-size turbochargers**. They are set up in **parallel**, with each charger providing compressed air to half of the cylinders. And just like the variant with one turbocharger used for the new straight-six gasoline engines (see above), this design, in conjunction with **High Precision Injection** (HPI), enables superior power development and excellent fuel efficiency in each vehicle class.

BMW TwinPower Turbo: two different-sized turbochargers.

The most powerful four-cylinder diesel engine, used in the BMW 123d and BMW X1 xDrive23d (currently only available in Europe), and the most powerful six-cylinder in-line diesel engine, featured in the BMW 335d, BMW and X5 xDrive40d, use **one small and one large turbocharger operating in sequence**.

This system ideally complements the power and fuel consumption characteristics of our diesel engines and also enables superior performance and an almost unbelievably favorable output-to-fuel-consumption ratio.

NOTES

PAGE

Turbocharging

Turbocharging Terminology

An engine which does not use any form of “forced induction” is referred to as a “naturally aspirated” engine. This means that the air which is entering the engine is at atmospheric pressure. Atmospheric air enters the engine due to the low pressure created during the intake stroke.

An engine which uses “forced induction” is referred to as supercharged. This means that the air entering the engine is under pressure (above atmospheric). As far as terminology is concerned, supercharging is the broad term for this type of technology.

Supercharging can be broken down into two categories, those engines which use a mechanical supercharger and those which use an exhaust driven turbocharger. Today, BMW is only using turbochargers.

Basic Principles of Turbocharging

In order to make an engine more efficient it is necessary to ensure an adequate supply of air and fuel on the intake stroke. This mixture can then be compressed and ignited to create the desired engine power output. A normally aspirated engine relies on the basic principle of gas exchange without the use of forced induction.

The volumetric efficiency refers to the ratio between the theoretical cylinder volume and the actual amount of air (and fuel) filling the cylinder during the intake stroke. A naturally aspirated engine has a volumetric efficiency of between 0.6 and 0.9 (60-90%). With the turbocharged engine, volumetric efficiency can peak at over 100%.

A turbocharger is driven by waste (exhaust) gasses and in turn drives a compressor which forces air into the engine above atmospheric pressure. This increase pressure allows for an air charge with a greater density. The result is increased torque and horsepower.

The turbocharger consists of a turbine and compressor assembly (1) on a common shaft inside of the turbocharger housing. The turbine wheel is driven by waste exhaust gases and in turn drives the compressor wheel.

The compressor forces air into the intake manifold of the engine. The air entering the engine from the compressor is above atmospheric pressure. The increased atmospheric pressure allows for an air-charge that is more dense and therefore contains more oxygen.

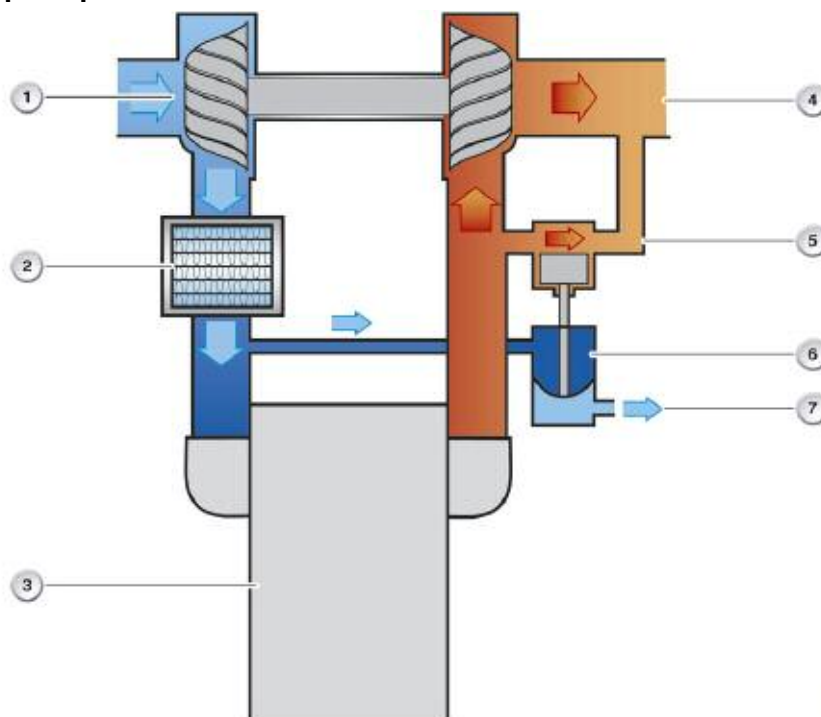
This increased density during the intake stroke ultimately adds up to the creation of more engine output torque. Of course, this increased density must be accompanied by additional fuel to create the desired power. This is accomplished by engine management system programming to increase injector “on-time” and enhanced associated maps.

To prevent the turbocharger from providing too much boost, a “wastegate” (6) is added to allow exhaust to bypass the turbine. This provides a means of control for the turbocharger system. The wastegate is usually actuated by a vacuum diaphragm (6) which is controlled via vacuum fed from solenoids. These solenoids are typically controlled by the engine management system.

Once the intake air is compressed, it is also heated which is not desirable for maximum efficiency. To counter this situation a heat exchanger (2) is added between the compressor and the engine intake. This heat exchanger is commonly referred to as an intercooler. The intercooler is usually an air-to-air heat exchanger which is installed in the air stream ahead of the radiator (direct charge air cooling) or air to coolant heat exchanger (indirect charge air cooling). Regardless of the type, the intercooler lowers the intake air charge to achieve the maximum density possible.

The use of an exhaust driven turbocharger is used to create more engine power through increased efficiency. In the case of the most current BMW engines, the turbocharger is used in conjunction with direct fuel injection. This provides the best combination of efficiency and power with no compromise.

Turbocharging principles



Index	Explanation	Index	Explanation
1	Compressor and turbine wheel (on common shaft)	5	Exhaust bypass from wastegate
2	Charge air cooler (intercooler)	6	Wastegate (and diaphragm)
3	Engine	7	Vacuum control for wastegate diaphragm
4	Exhaust outlet from turbine housing		

Bi-Turbocharging

The induction air is pre-compressed in such a way that a higher air mass is admitted into the engine's combustion chamber. In this way, it is possible to inject and combust a greater quantity of fuel, which increases the engine's power output and torque.

The turbine and the compressor can rotate at speeds of up to 200,000 rpm. The exhaust inlet temperature can reach a maximum of 1050°C. Because of these high temperatures, turbochargers are not only connected with the engine-oil system but also integrated in the engine-coolant circuit.

By operating an electric coolant pump even after the engine has been switched off it is possible to dissipate the residual heat from the turbochargers and thus prevent the oil in the bearing housing from overheating.

N54 turbocharger



Index	Explanation
A	Compressor
B	Cooling/lubrication
C	Turbine

Utmost importance is attached to turbochargers response characteristics. A delayed response to the driver's command, i.e. the accelerator-pedal position, is not acceptable. The driver therefore must not experience any so-called "turbo lag".

This requirement is met in the **N54** engine with two small turbochargers, which are connected in parallel. Cylinders 1, 2 and 3 (bank 1) drive the first turbocharger (5) while cylinders 4, 5 and 6 (bank 2) drive the second (2).

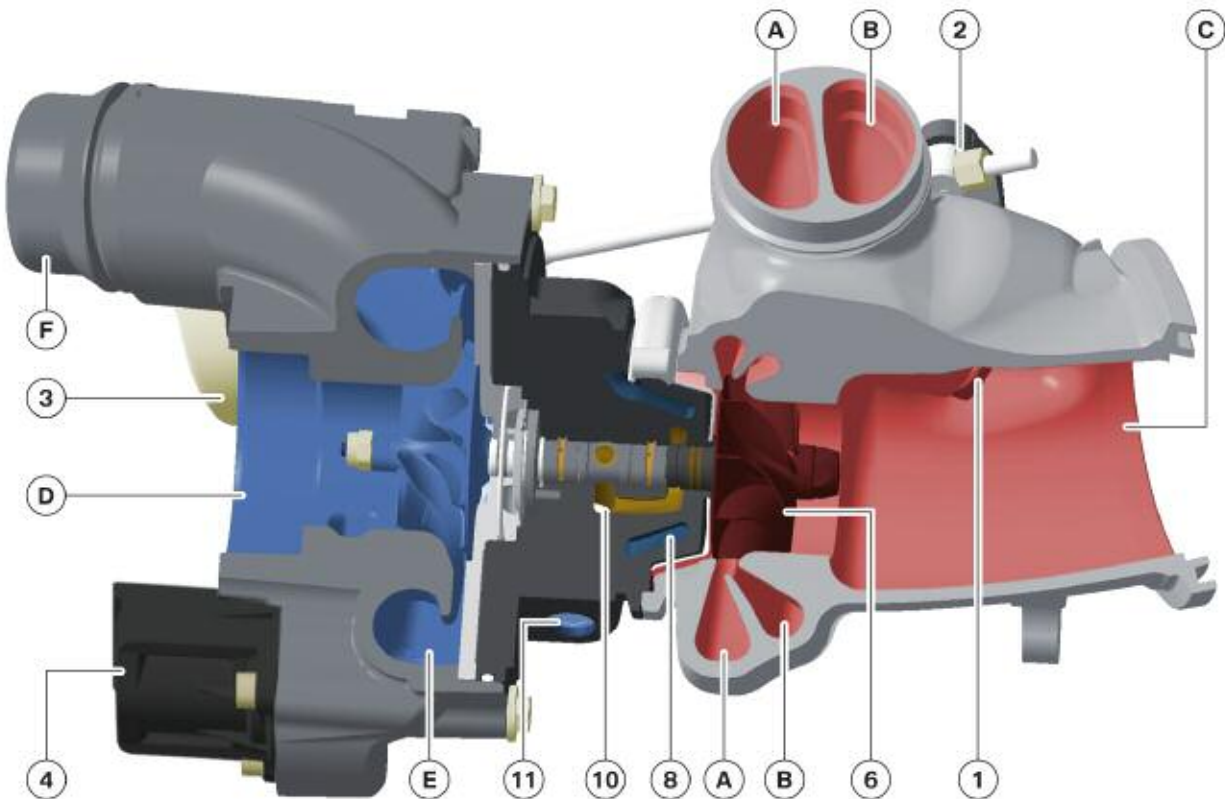
The advantage of a small turbocharger lies in the fact that, as the turbocharger runs up to speed, the lower mass of the turbine allows it to accelerate quicker, and thus the compressor attains a higher boost pressure in a shorter amount of time.

NOTES

Twin Scroll Turbocharger

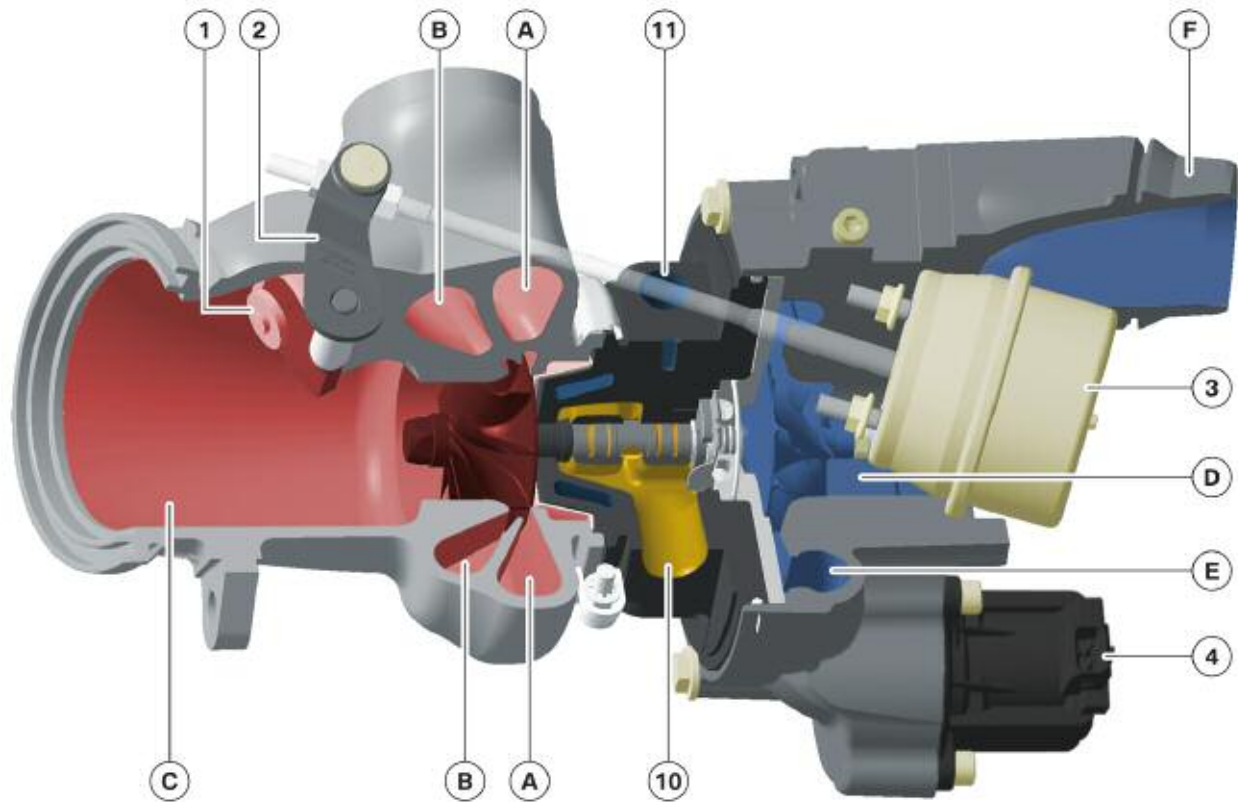
The **N55** is equipped with a single twin scroll turbocharger instead of two separate small turbochargers as on the N54 engine. The following graphics show the operating principle of the twin scroll turbocharger.

N55 Twin scroll turbocharger rear view



Index	Explanation	Index	Explanation
A	Exhaust duct 1 (cylinders 1 - 3)	2	Lever arm, wastegate valve
B	Exhaust duct 2 (cylinders 4 - 6)	3	Vacuum unit for wastegate valve
C	Connection to catalytic converter	4	Diverter valve
D	Inlet from intake silencer	6	Turbine wheel
E	Ring channel	8	Cooling duct
F	Outlet to intercooler	10	Oil return
1	Wastegate valve	11	Coolant return

Twin scroll turbocharger front view



Index	Explanation	Index	Explanation
A	Exhaust duct 1 (cylinders 1 - 3)	1	Wastegate valve
B	Exhaust duct 2 (cylinders 4 - 6)	2	Lever arm, wastegate valve
C	Connection to catalytic converter	3	Vacuum unit for wastegate valve
D	Inlet from intake silencer	4	Diverter valve
E	Ring channel	10	Oil return
F	Outlet to intercooler	11	Coolant return

■ Function of the twin scroll turbocharger

The system is designed so that constant exhaust gas pressure is nearly applied to the turbocharger. At low engine speeds, the exhaust reaches the turbine in tuned pulsed form. Due to this pulsation, a higher pressure ratio is temporarily reached in the turbine. Since the efficiency increases as the pressure rises, the pulsation improves the boost pressure progression and thus the torque progression of the engine. This is the case particularly at low engine speeds.

The response characteristics of the twin scroll turbocharger are enhanced when compared to a single scroll setup. The turbocharger turbines are fed through two separate channels within the turbine housing (highlighted red in the graphic to the left). Each of these channels or “scrolls” is always fed by the exhaust pulses from the same two cylinders.

To limit the back pressure and ensure that the individual cylinders do not mutually influence each other during the cylinder charging process, cylinders 1 - 3 (bank 1) and cylinders 4 - 6 (bank 2) are combined to form two exhaust channels. The exhaust gas pulses in the exhaust channels (1 and 2) are directed into two scrolls (spirals) within the turbocharger to drive the turbine wheel. This design layout makes it possible to optimally use the exhaust pulsations for generating boost pressure based on the firing order of the engine. This improves engine efficiency by enhancing throttle response and limiting unwanted turbo lag.

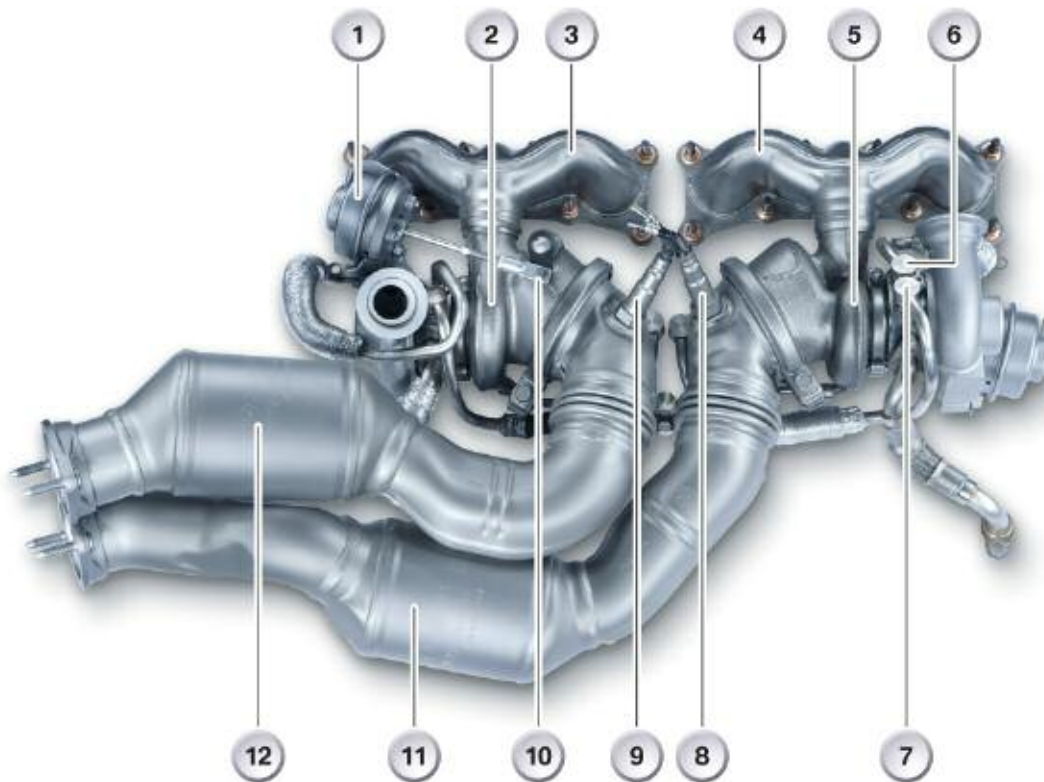
The **wastegate** valve is used for the purpose of limiting the boost pressure and is already known from previous BMW turbo engines. It is vacuum operated and electronically controlled through a vacuum control solenoid by the ECM.

Exhaust Manifold

N54

The **N54** engine uses two small turbochargers connected in parallel. Cylinders 1, 2 and 3 (bank 1) drive the first turbocharger (5) while cylinders 4, 5 and 6 (bank 2) drive the second (2).

N54, exhaust manifolds, turbos and related components

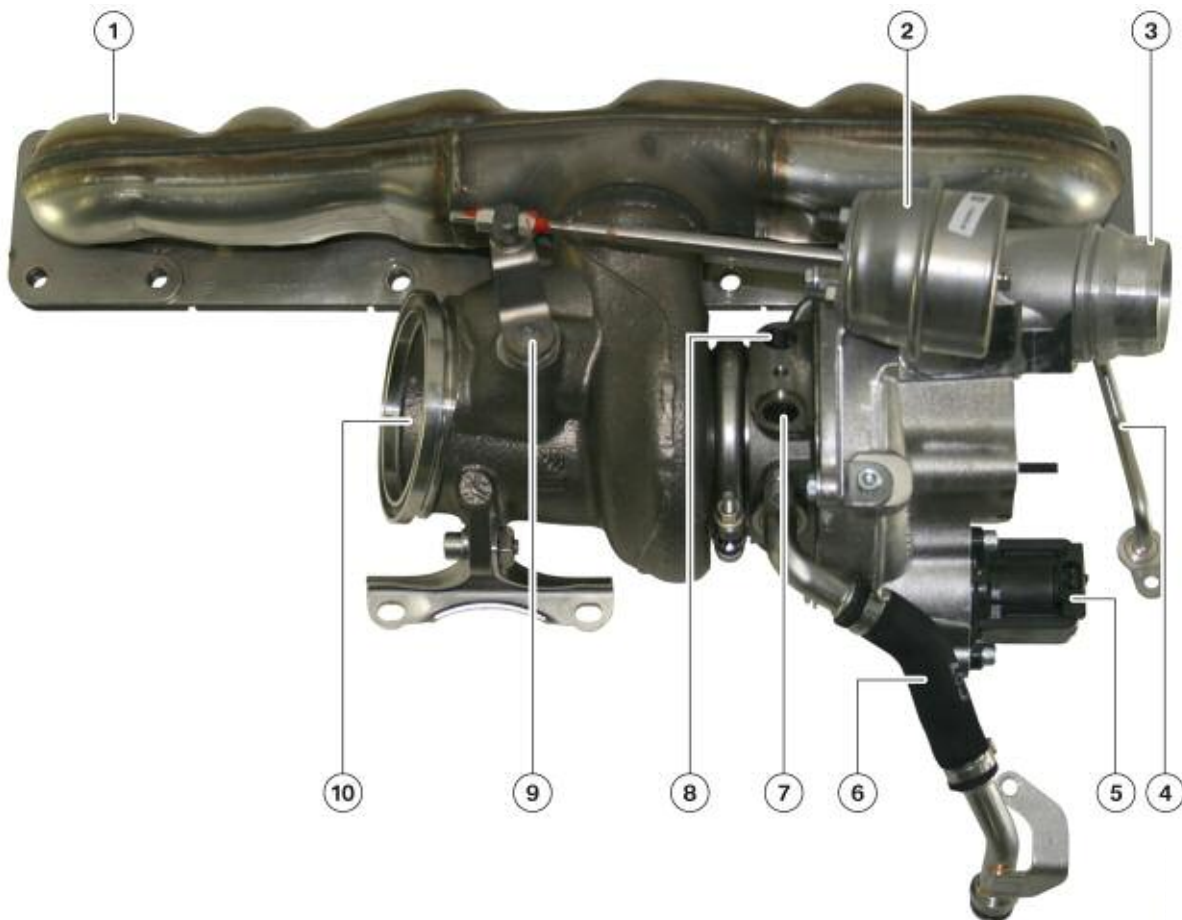


Index	Explanation	Index	Explanation
1	Wastegate actuator, bank 2	7	Coolant supply
2	Turbocharger, bank 2	8	Planar broad-band oxygen sensor, bank 1
3	Exhaust manifold, bank 2	9	Planar broad-band oxygen sensor, bank 2
4	Exhaust manifold, bank 1	10	Wastegate actuating lever
5	Turbocharger, bank 1	11	Catalytic converter, bank 1
6	Coolant return	12	Catalytic converter, bank 2

N55

On the **N55** the exhaust manifold is air-gap insulated and designed as a six ports into two chamber manifold. Dividing six exhaust ports into two exhaust chambers is necessary in order to ensure optimum flow to the twin scroll turbocharger. The exhaust pulses from the first three cylinders (1-3) feed one scroll (duct 1) of the turbo, while the last three (4-6) feed the second scroll (duct 2). The exhaust manifold and turbocharger are welded together to form one component.

N55, tuned pulsed exhaust manifold and turbocharger to engine block



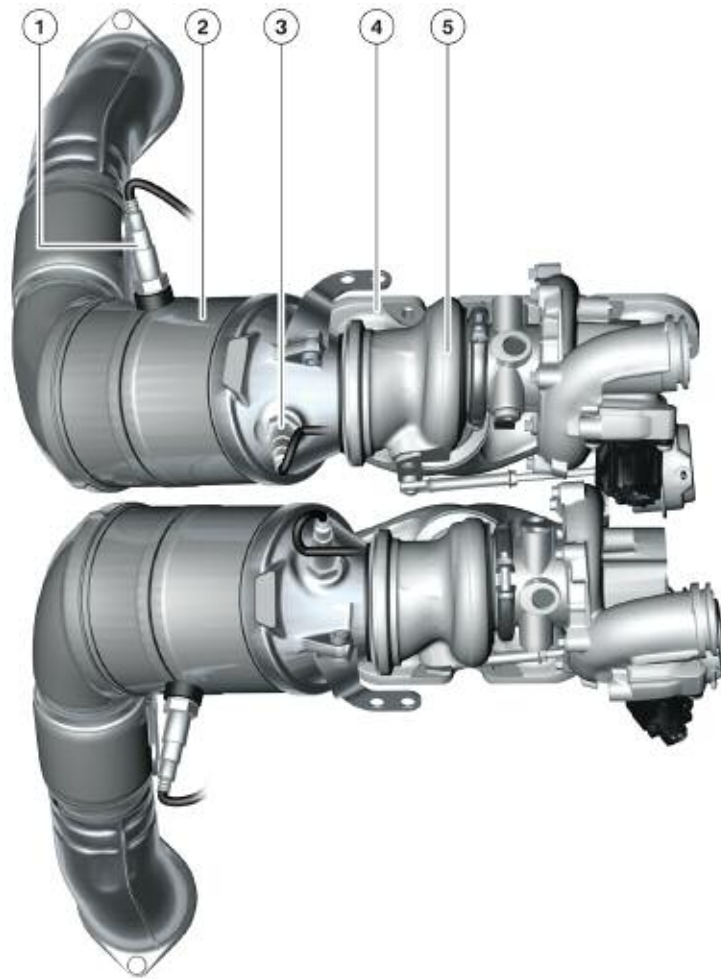
Index	Explanation	Index	Explanation
1	Exhaust manifold	6	Oil return line
2	Vacuum unit	7	Coolant infeed
3	Connection to intercooler	8	Coolant return
4	Oil feed line	9	Shaft, wastegate valve
5	Diverter valve	10	Connection to exhaust system

N63

The turbocharging principle of the **N63** engine is very similar to that of the N54 engine. Two relatively small, parallel-connected exhaust turbochargers ensure rapid response already at low engine speeds.

The main change to the air intake and exhaust system of the N63 engine is the interchanged positions of the intake and exhaust sides. Consequently, the exhaust manifolds and turbochargers as well as the catalytic converters are located in the V-space of the engine. This arrangement makes the N63 engine very compact despite the turbocharging. Blowoff valves are also used.

N63 Exhaust



Index	Explanation	Index	Explanation
1	Oxygen sensor (monitor sensor LSF4.2 after catalytic converter)	4	Exhaust manifold
2	Catalytic converter	5	Exhaust turbocharger
3	Oxygen sensor (monitor sensor LSF ADV before catalytic converter)		

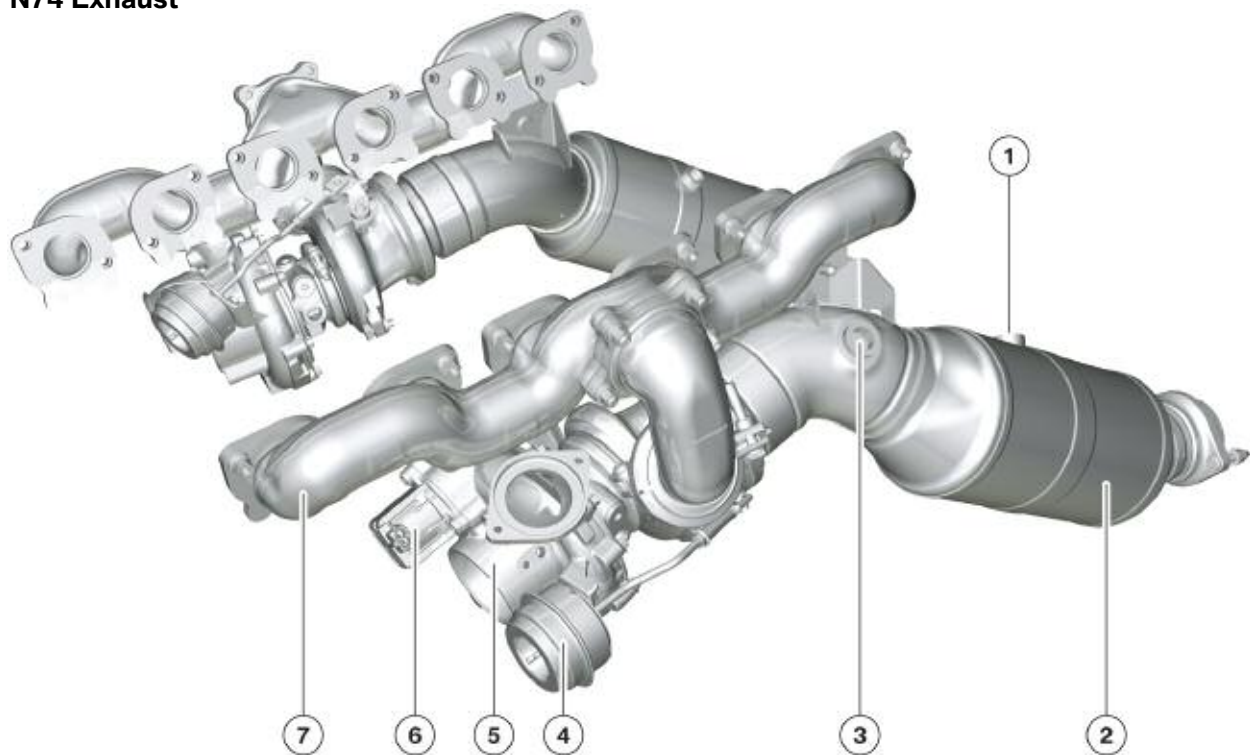
N74

The turbochargers on the **N74** engine are located on the outside. In the case of a V12-cylinder engine with 60° cylinder angle, this is the optimal arrangement of the turbocharger system.

These are conventional single scroll turbochargers (no variable turbine geometry, VNT, or twin scroll are used) in which vacuum-controlled wastegate valves are used for charging pressure control.

The turbocharging process on the N74 engine is identical, in terms of its principle to that utilised on the N63 engine. Each bank of cylinders has its own (relatively small) turbocharger, which ensures fast response even at low engine speeds. The charging pressure control is via wastegate valves. Blowoff valves are also used.

N74 Exhaust



Index	Explanation	Index	Explanation
1	Position of exhaust gas oxygen sensor (monitoring sensor) after catalytic converter	5	Exhaust turbocharger
2	Catalytic converter	6	Diverter (blow-off) valve
3	Position of exhaust gas oxygen sensor (control sensor) before catalytic converter	7	Exhaust manifold
4	Vacuum unit for wastegate valve activation		

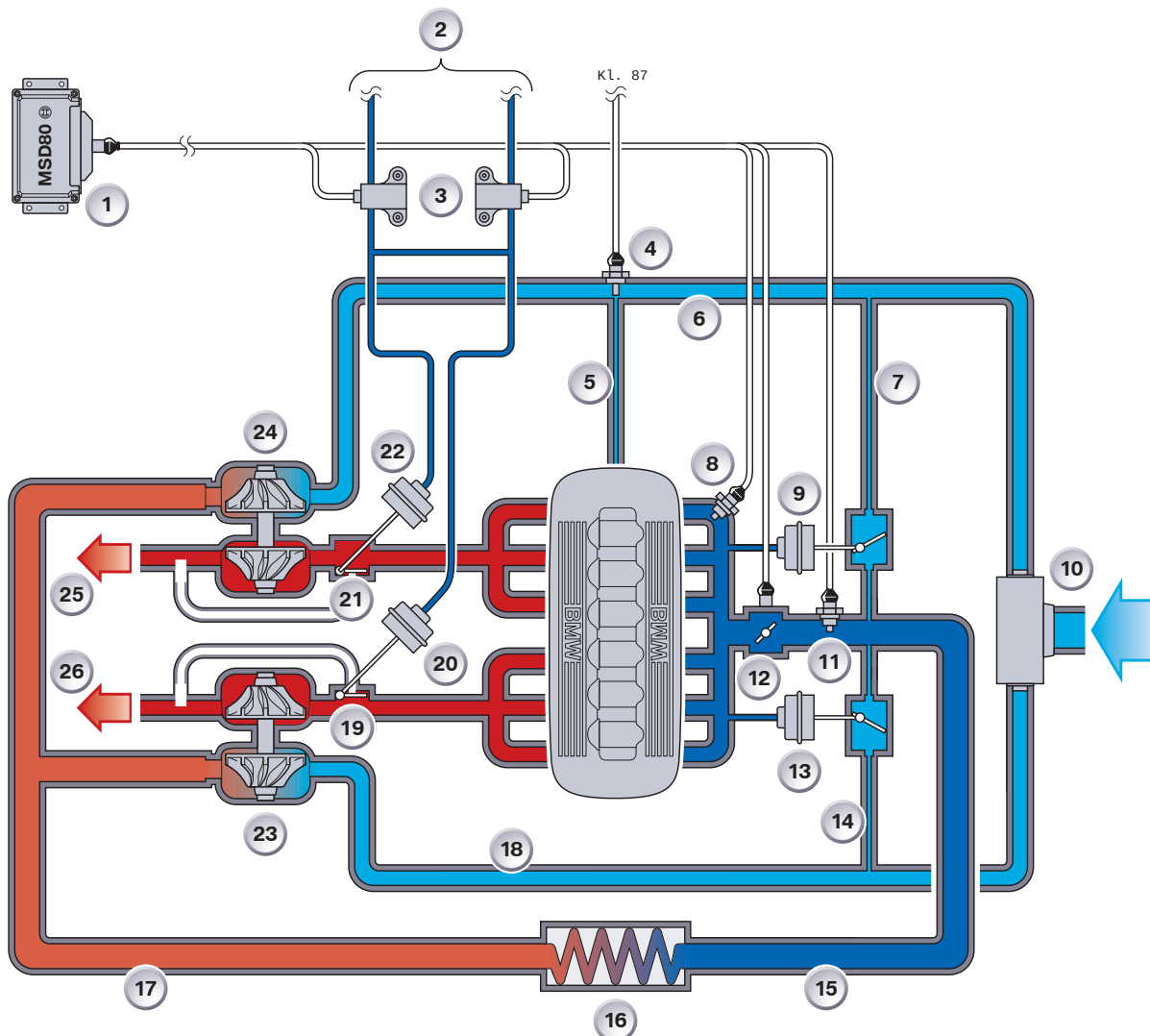
Air Ducting Overview

The fresh air is drawn in via the air cleaner (10) and the charge-air suction lines (6 + 18) by the compressors of turbochargers (23 + 24) and compressed.

Because the turbochargers can get very hot during operation, they are connected with the engine's coolant and engine-oil circuits. The charge air is greatly heated when compressed in the turbocharger, making it necessary for the air to be cooled again in an intercooler (16).

The compressed and cooled charge air is routed from the intercooler via the throttle valve (12) into the intake manifold. The system is equipped with several sensors and actuators in order to ensure that the load of fresh air is optimally adapted to the engine's respective operating conditions. How these complex interrelationships are controlled is discussed in the following.

N54 forced induction overview

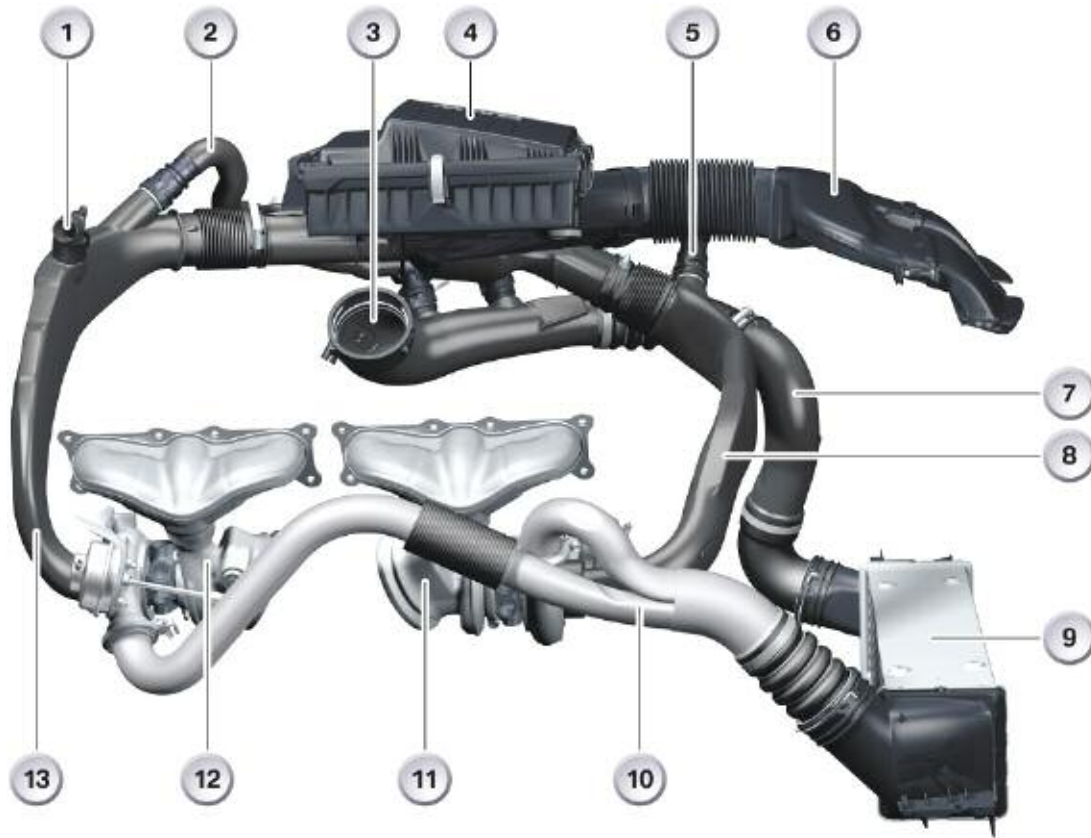


N54 forced induction overview legend

Index	Explanation	Index	Explanation
1	MSD80 Engine control module	14	Recirculated-air line, bank 1
2	Lines to vacuum pump	15	Charge air pressure line
3	Electro-pneumatic pressure transducer	16	Intercooler
4	Heater, blow-by gases	17	Charge air manifold
5	Blow-by line turbocharged operation mode	18	Charge air suction line, bank 1
6	Charge air suction line, bank 2	19	Wastegate flap, bank 1
7	Recirculated-air line, bank 2	20	Wastegate actuator, bank 1
8	Intake manifold pressure sensor	21	Wastegate flap, bank 2
9	Blow-off valve, bank 2	22	Wastegate actuator, bank 2
10	Air cleaner	23	Turbocharger, bank 1
11	Charge air pressure and temperature sensor	24	Turbocharger, bank 2
12	Throttle valve	25	To catalytic converter, bank 2
13	Blow-off valve, bank 1	26	To catalytic converter, bank 1

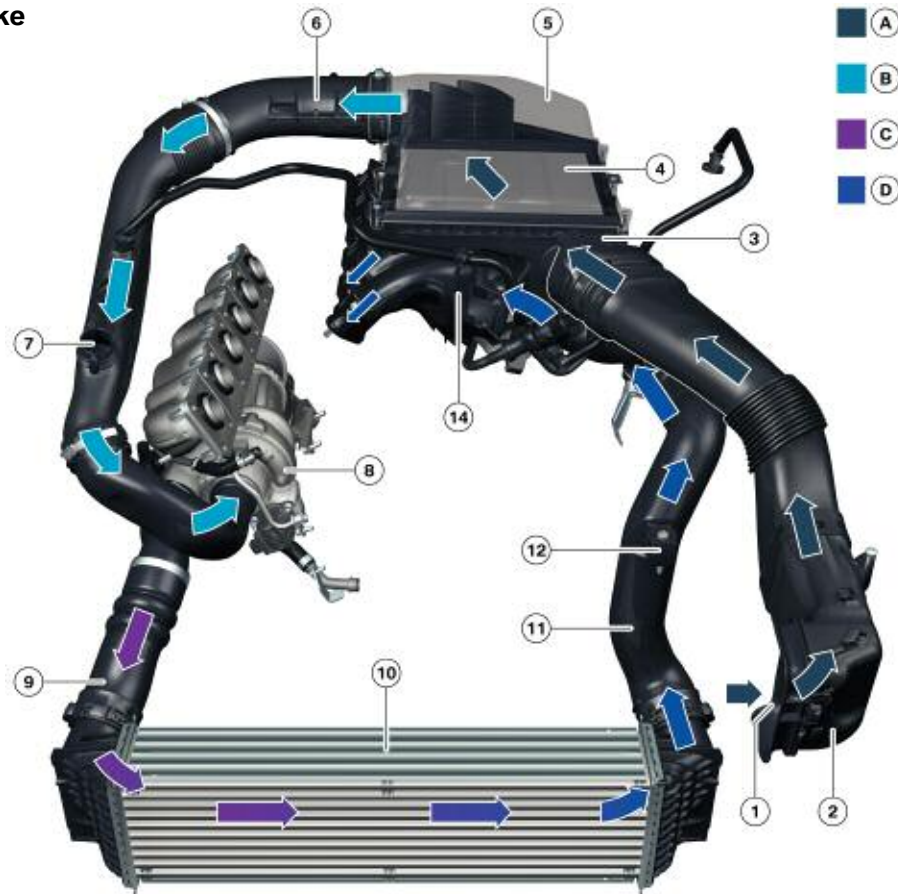
In principle, the energy of the escaping exhaust gases is utilized to “pre-compress” the inducted fresh air and thus introduce a greater air mass into the engine. This is only possible if the air intake ducting is “leak-free” and installed properly.

N54 Air Intake



Index	Explanation	Index	Explanation
1	PTC heater, blow-by gases (in turbo mode)	8	Charge air suction line, bank 1
2	Recirculated air line, bank 2	9	Intercooler
3	Connecting flange, throttle valve	10	Charge air manifold
4	Air cleaner	11	Turbocharger, bank 1
5	Recirculated air line, bank 1	12	Turbocharger, bank 2
6	Air-intake snorkel	13	Charge air suction line, bank 2
7	Charge air pressure line		

N55 Air Intake



Index	Explanation	Index	Explanation	Index	Explanation
A	Unfiltered air	3	Intake silencer	9	Charge-air pipe
B	Purified air	4	Filter element	10	Intercooler
C	Heated charge air	5	Air intake silencer cover	11	Charge air pipe
D	Cooled charge air	6	Hot-film air mass meter	12	Boost pressure-temperature sensor
1	Intake snorkel	7	Crankcase ventilation connection	14	Intake air manifold
2	Unfiltered air pipe	8	Exhaust turbocharger		



A leaking system may result in erroneous boost pressure. This would be detected by the engine management system and will ultimately result in “limp-home” operation. There would also be a noticeable reduction in engine power.

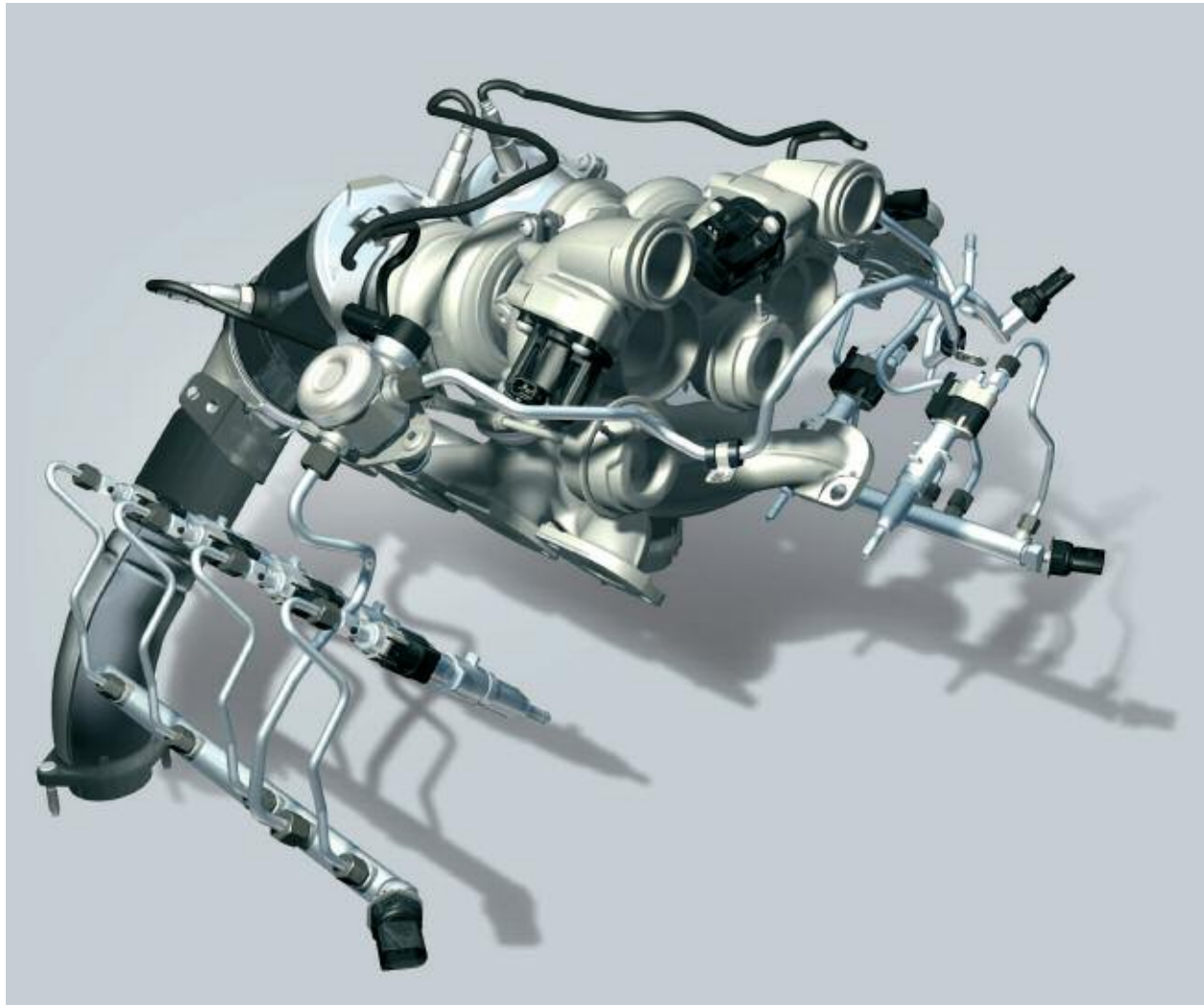
For some of the duct work, there are special tools to ensure proper connections.

As mentioned earlier, the main change to the air intake and exhaust system of the **N63** engine is the interchanged positions of the intake and exhaust sides.

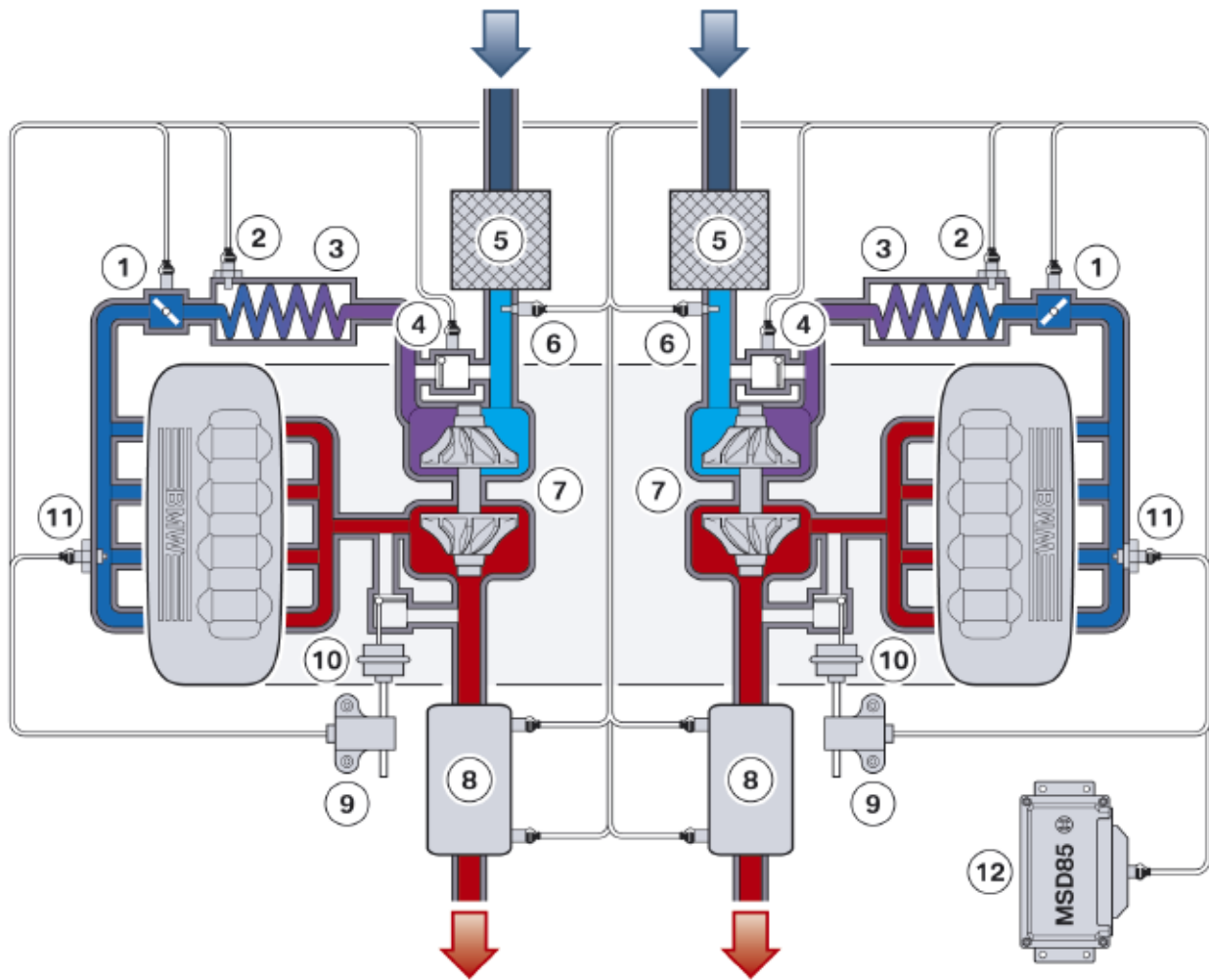
Consequently, the exhaust manifolds and turbochargers as well as the catalytic converters are located in the V-space of the engine.

This arrangement makes the N63 engine very compact despite the turbocharging. Another new feature is indirect charge air cooling with intercoolers mounted on the engine.

N63 exhaust manifold, turbos, HPI and related components

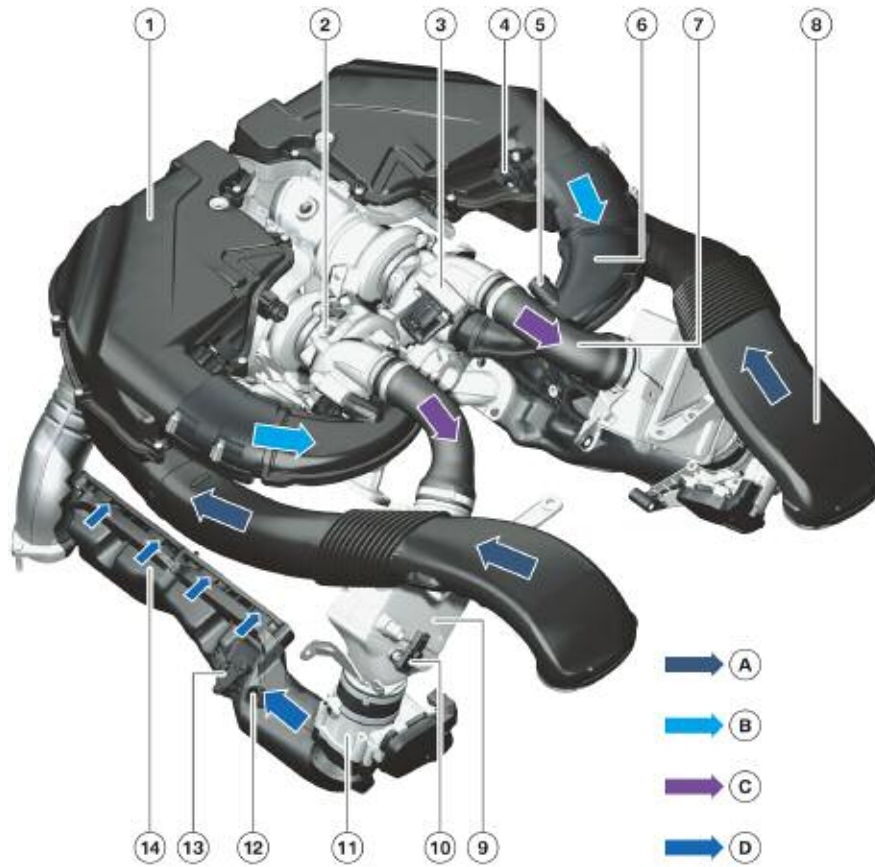


N63 forced induction overview



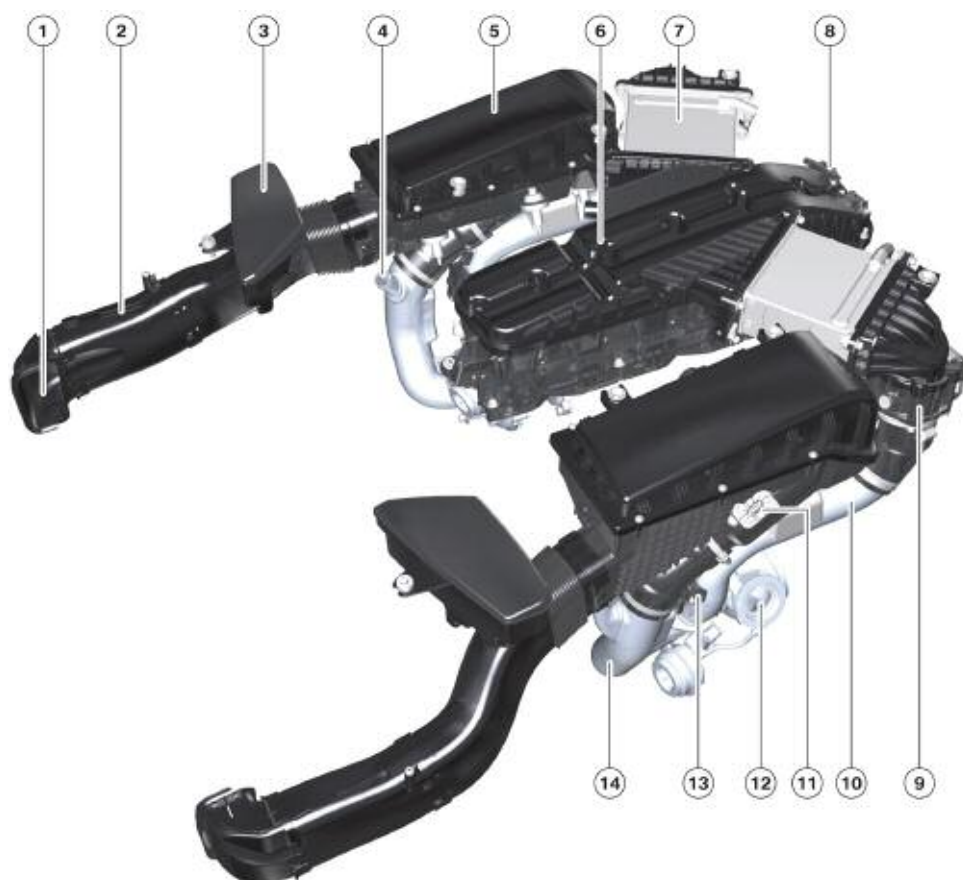
Index	Explanation	Index	Explanation
1	Throttle valve	7	Exhaust turbocharger
2	Charge air temperature and pressure sensor	8	Catalytic converter
3	Intercooler	9	Electro-pneumatic pressure converter (EPDW)
4	Diverter valve	10	Watergate valve
5	Intake silencer	11	Intake manifold pressure sensor
6	Hot-film air mass meter	12	Digital Motor Electronics (DME)

N63 Air Intake



Index	Explanation	Index	Explanation
1	Intake silencer	8	Unfiltered air pipe
2	Exhaust turbocharger	9	Intercooler
3	Diverter valve	10	Charge air temperature and pressure sensor
4	Hot-film air mass meter	11	Throttle valve
5	Crankcase breather connection for turbocharged engine operation	12	Crankcase breather connection for naturally aspirated engine operation
6	Clean air pipe	13	Intake manifold pressure sensor
7	Charge air pipe	14	Intake manifold

N74 Air Intake



Index	Explanation	Index	Explanation
1	Unfiltered air intake	8	Charging pressure sensor
2	Unfiltered air pipe	9	Throttle valve
3	Unfiltered air resonator	10	Charge air pipe
4	Connection for crankcase ventilation, charged operation	11	Hot film air mass meter
5	Intake silencer	12	Exhaust-gas turbocharger
6	Intake manifold	13	Charge-air temperature sensor
7	Charge-air cooler	14	Purified air pipe

Boost-Pressure Control (Wastegates)

The boost pressure of the turbochargers is directly dependent on the flow of exhaust gas which reaches the turbocharger turbines. Both the velocity and the mass of the exhaust-gas flow are directly dependent on engine speed and engine load.

The engine-management system uses **wastegate valves** to control the boost pressure. These valves are operated by vacuum-pressure actuators, which are controlled via **electropneumatic pressure transducers (EPDW)** by the engine-management system.

The vacuum pressure is generated by the permanently driven vacuum pump and stored in a pressure accumulator. The system is designed to ensure that these loads and consumers do not have a negative influence on the brake-booster function.

The exhaust-gas flow can be completely or partially directed to the turbine wheel with the wastegate valves. When the boost pressure has reached its desired level, the wastegate valve begins to open and direct part of the exhaust-gas flow past the turbine wheel. This prevents the turbine from further increasing the speed of the compressor. This control option allows the system to respond to various operating situations.

N54 boost pressure control



Index	Explanation	Index	Explanation
1	Oil return, bank 1	5	Coolant return, bank 2
2	Oil supply	6	Wastegate valve
3	Coolant supply	7	Coolant return, bank 1
4	Oil return, bank 2	8	

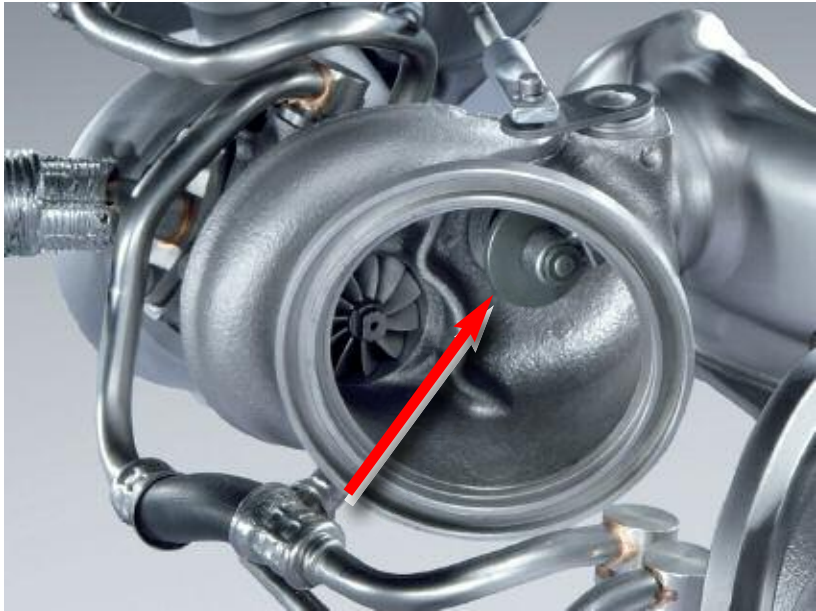
In the idle phase, the wastegate valves of both turbochargers are closed. This enables the full exhaust-gas flow available to be utilized to speed up the compressor already at these low engine speeds.

When power is then demanded from the engine, the compressor can deliver the required boost pressure without any noticeable time lag. In the full-load situation, the boost pressure is maintained at a consistently high level when the maximum permissible torque is reached by a partial opening of the wastegate valves. In this way, the compressors are only ever induced to rotate at a speed which is called for by the operating situation.

The process of the wastegate valves opening removes drive energy from the turbine such that no further increase in boost pressure occurs, which in turn improves overall fuel consumption.

The maximum overpressure (boost) of BMW engines at full-load vary depending on the engine itself as well as other contributing factors e.g. air temperature, ambient pressure, oil and coolant temperature etc.

N54 Wastegate Valve.



Electropneumatic Pressure Transducers (EPDW)

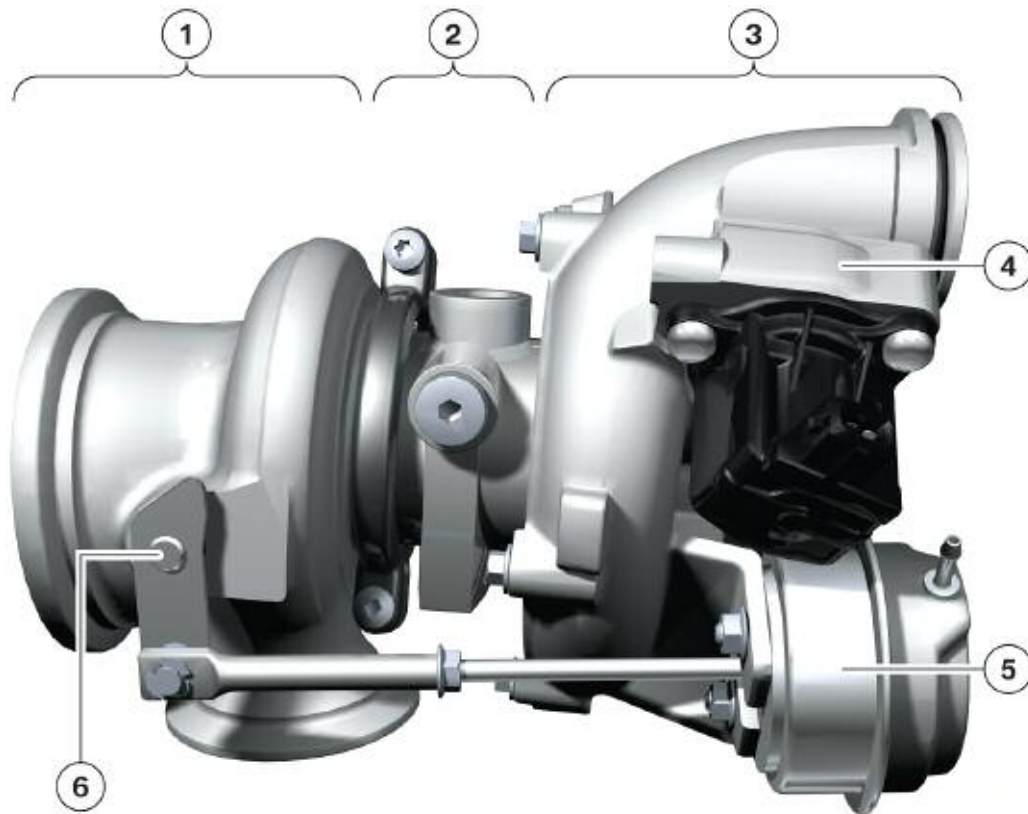
The boost pressure is controlled infinitely variable by the ECM via a wastegate valve. The wastegate valve is adjusted pneumatically by a diaphragm unit. An electropneumatic pressure transducer subjects the diaphragm cam to negative pressure (vacuum).

The electropneumatic pressure transducer is connected by means of two lines to the ECM. It receives system voltage via the ECM main relay. The ECM drives the electropneumatic pressure transducer with a **pulse-width modulated** (PWM) signal.

The pulse duty factor can be between 0 – 100 %. The negative pressure (vacuum) can be controlled infinitely variable depending on the pulse duty factor.

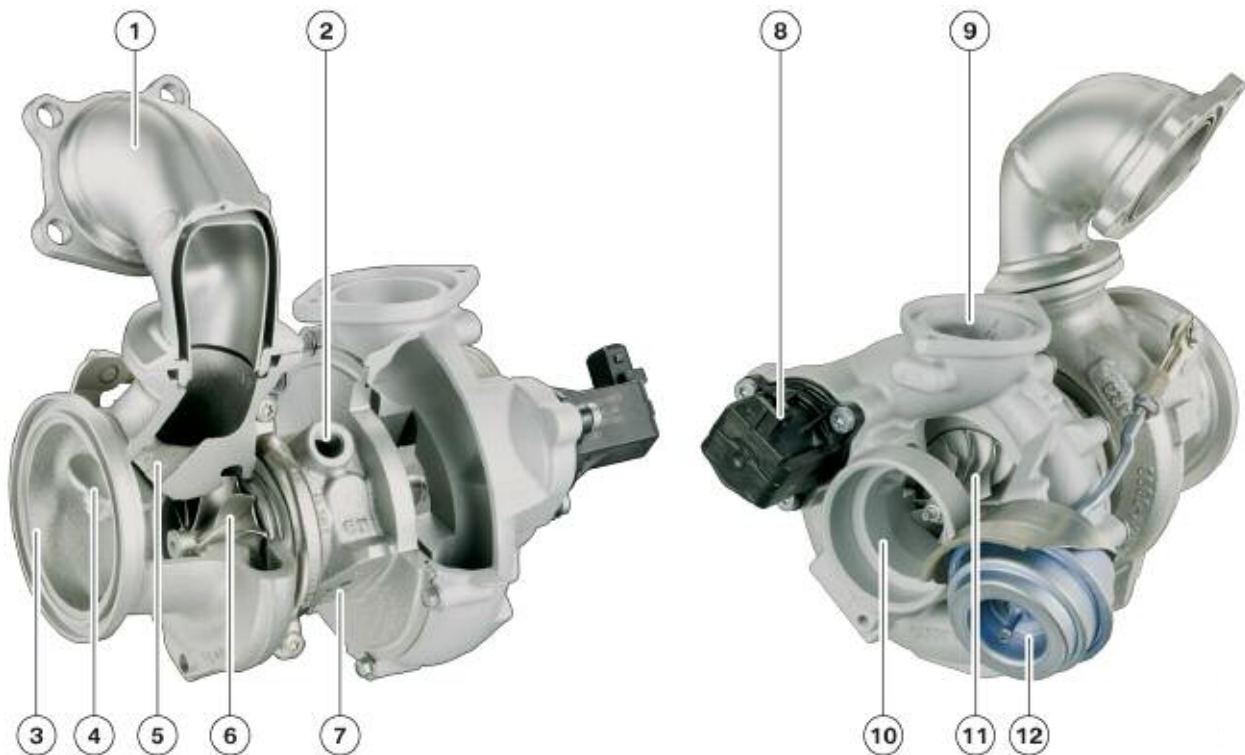


N63 boost pressure control



Index	Explanation	Index	Explanation
1	Turbine	4	Diverter valve
2	Bearing Pedestal	5	Vacuum unit
3	Compressor	6	Wastegate valve

N74 boost pressure control



Index	Explanation
1	Connection from exhaust manifold (turbine inlet)
2	Connection for coolant line
3	Connection to catalytic converter (turbine outlet)
4	Wastegate valve
5	Wastegate duct
6	Turbine wheel
7	Connection for overflow duct
8	Diverter (blow-off) valve
9	Connection to charge air cooler (compressor outlet)
10	Connection from intake silencer (compressor inlet)
11	Impeller
12	Vacuum unit for wastegate valve activation

Blow-off Control (Diverter Valves)

The blow-off valves in BMW Turbocharged engines reduce unwanted peaks in boost pressure which can occur when the throttle valve closes quickly. They therefore have an important function with regard to engine acoustics and help to protect the turbocharger components.

A vacuum pressure is generated in the intake manifold when the throttle valve is closed at high engine speeds. This leads to a build-up of high dynamic pressure after the compressor which cannot escape because the route to the intake manifold is blocked.

This leads to a "pumping up" of the turbocharger which means that:

- a clearly noticeable, disruptive pumping noise can be heard,
- and this pumping noise is accompanied by a component-damaging load being exerted on the turbocharger, since high-frequency pressure waves exert axial load on the turbocharger bearings

In the **N54** the blow-off valves are mechanically actuated spring-loaded diaphragm valves which are activated by the intake-manifold pressure as follows:

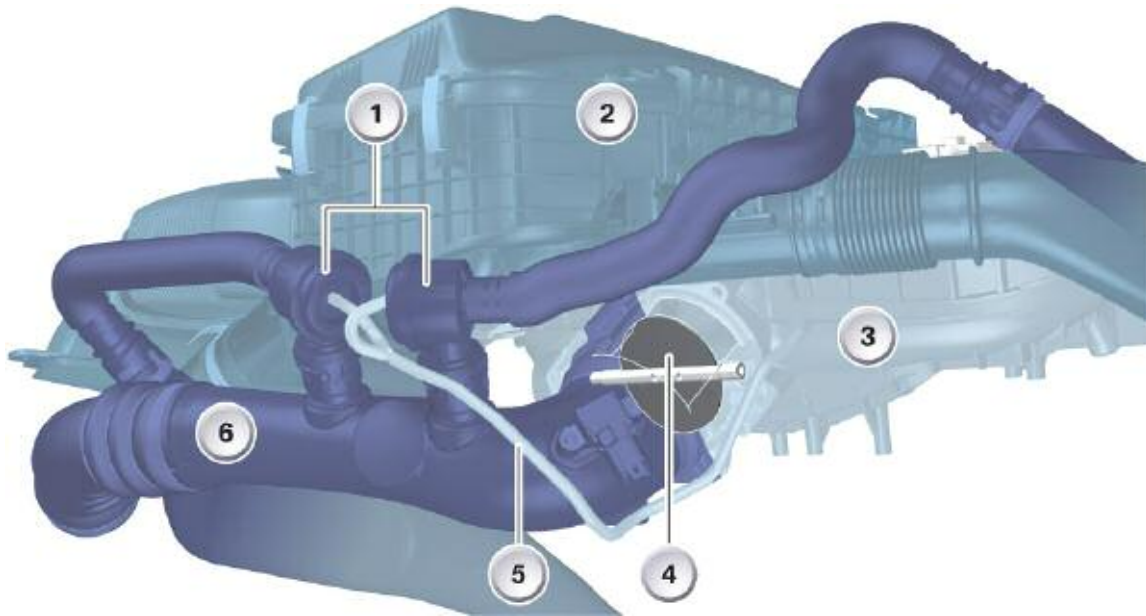
In the event of a pressure differential before and after the throttle valve, the blow-off valves are opened by the intake-manifold pressure and the boost pressure is diverted to the intake side of the compressor. The blow-off valves open starting from a differential pressure of 0.3 bar. This process prevents the disruptive and component-damaging pumping effect from occurring.

The system design dictates that the blow-off valves are also opened during operating close to idle (pressure differential $P_{\text{charger}}/P_{\text{suction}} = 0.3 \text{ bar}$). However, this has no further effects on the turbocharging system.

The turbocharger is pressurized with the full exhaust-gas flow at these low speeds and already builds up a certain level of induction-air precharging in the range close to idle. If the throttle valve is opened at this point, the full boost pressure required is very quickly made available to the engine.

One of the major advantages of the vacuum pressure-actuated wastegate valves is that they can be partially opened in the mid-range in order not to allow excessive induction-air precharging to the detriment of fuel consumption. In the upper load range, they assume the required control position corresponding to the necessary boost pressure.

N54 Diverter (Blow-off) valves



Index	Explanation	Index	Explanation
1	Blow-off valves	4	Throttle valve
2	Air cleaner (ambient pressure)	5	Control line, blow-off valves
3	Intake manifold	6	Charge air pressure line

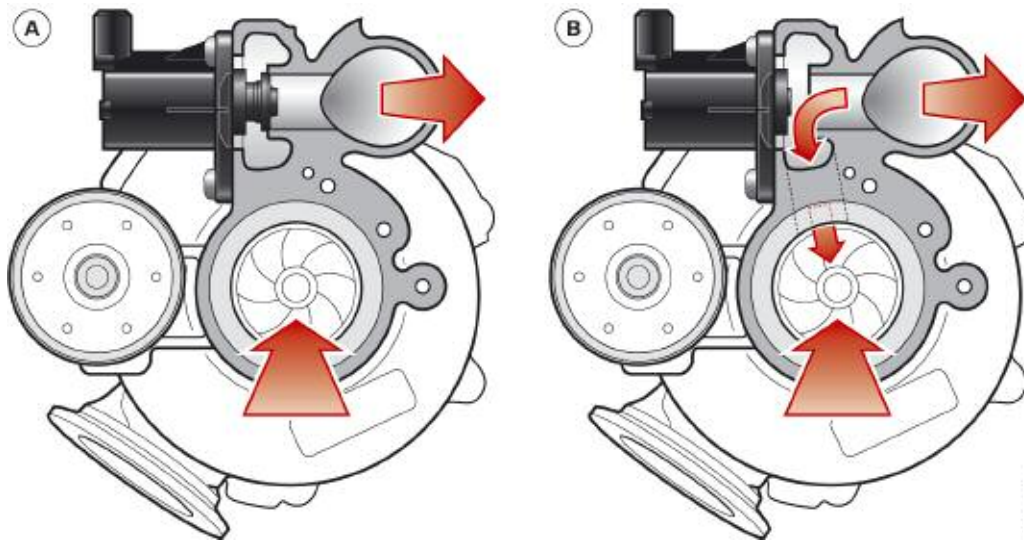
On the **N55** the basic function of the diverter valve remains the same. The difference compared to the N54 engine is that the diverter valve is not operated pneumatically. **The diverter valve(s) on the N55, N63 and N74 engines is an electric actuator that is controlled directly by the DME.** The number of components has been greatly reduced by positioning the diverter valve on the turbocharger compressor housing.

The diverter valve is designed to release unwanted pressure in the intake by connecting the pressure side of the induction system to the inlet side under deceleration. The undesirable peaks in the boost pressure that can occur when the throttle valve is quickly closed are reduced. This means the diverter valve plays an important role in terms of the engine acoustics while protecting the components of the turbocharger.

Electric Diverter valve



N63 Diverter valve operation



Index	Explanation	Index	Explanation
1	Diverter valve, closed	2	Diverter valve, open

As mentioned earlier, the diverter valves in the **N63** engine also reduces unwanted peaks in boost pressure which can occur when the throttle valve closes quickly. As with the N54, a vacuum is generated in the intake manifold when the throttle valve is closed at high engine speeds. This leads to a build-up of high dynamic pressure after the compressor which cannot escape because the route to the intake manifold is blocked.

On the **N74**, the basic function of the diverter valve remains the same. Once more the difference compared to the N54 engine is that the diverter valve is not operated pneumatically. The diverter valve on the N74 engine is an electric actuator that is controlled directly by the ECM.



On N55 and N74 the diverter valve is located on the compressor housing.

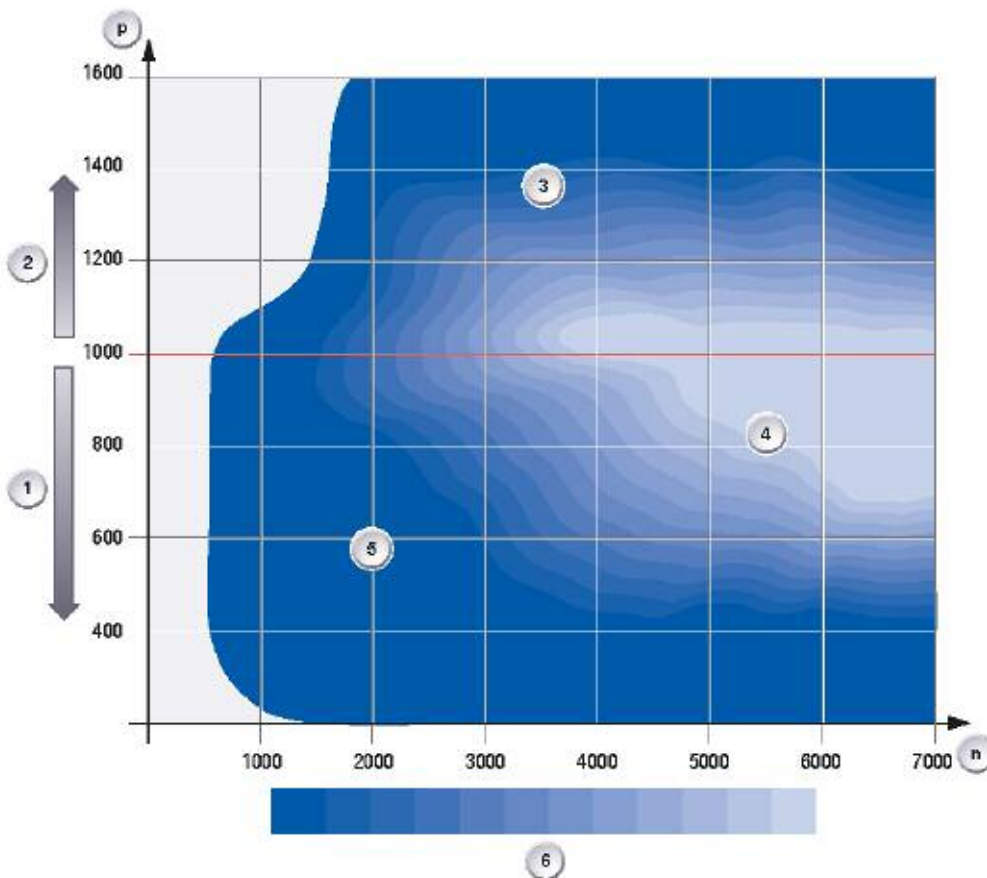
Load Control

Load control on turbocharged engines is effected by means of the **throttle valve** and the **wastegate valves**.

The throttle valve is the primary component in this process. The wastegate valves are actuated to bring about a fine tuning of the boost pressure. At full load the throttle valve is completely open and load control is undertaken by the wastegate valves.

The load-control graphic shows that the wastegate valves are integrated in load control in all operating situations of the N54 engine on the basis of map control.

Load Control Overview N54

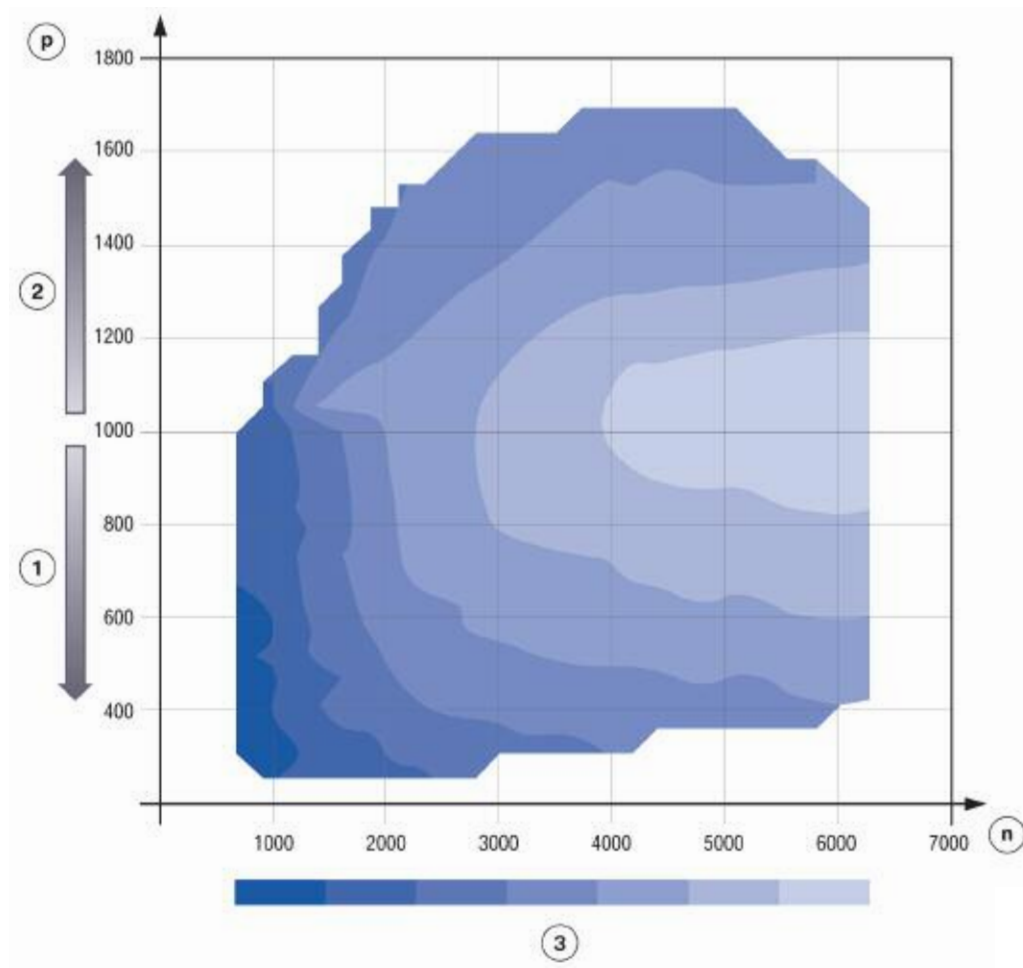


The Load Control Graphic on the N55 is similar to that of the N54.

Index	Explanation	Index	Explanation
n	Engine speed in RPM	3	Wastegate controlled as a function of boost pressure
p	Absolute pressure in the intake in millibar	4	Wastegate partially opened
1	Naturally aspirated engine operation	5	Wastegate closed
2	Turbocharged operation	6	Dark = Wastegate fully closed Light = Wastegate fully open

The following load control graphic shows that the wastegate valves are integrated in load control in all operating situations of the **N63** engine on the basis of characteristic map control.

Load Control Overview N63



The Load Control Graphic on the N74 is similar to that of the N63.

Index	Explanation	Index	Explanation
n	Engine speed in RPM	2	Turbocharged operation
p	Absolute pressure in intake manifold (mbar)	3	Dark = wastegate closed Light = wastegate open
1	Naturally aspirated operation		

Controlled Variables

The following variables, among others, influence control of the engine's boost pressure:

- Intake-air temperature
- Engine speed
- Throttle-valve position
- Ambient pressure
- Intake-manifold pressure
- Pressure before the throttle valve (reference variable)

The electropneumatic pressure transducers are activated by the engine control unit on the basis of these variables. The result of this activation can be checked from the boost pressure achieved, which is measured before the throttle valve.

There follows a comparison of the boost pressure achieved with the setpoint data from the program map, which can if necessary give rise to an activation correction. The system therefore controls and monitors itself during operation.

Intake Boost Pressure and Temperature Sensor

The combined intake temperature and boost pressure sensor is used on BMW Turbocharged engines. It is located in the air channel downstream of the intercooler and supplies the ECM control unit with information on the temperature and pressure of the charge air (boost pressure) **before the throttle valve** (absolute).



The sensor serves the purpose of controlling the boost pressure. The ECM control unit uses the signal from the intake manifold pressure sensor to adjust the position of the throttle valve.

■ Boost-pressure sensor

The sensor receives a 5V voltage and ground supply from the ECM. The information relating to the boost pressure is sent via a signal line to the ECM.

The useful signal for the boost pressure fluctuates depending on the pressure. The measuring range from approx. 0.5 to 4.5 V corresponds to a boost pressure from 20 kPa (0.2 bar) to 250 kPa (2.5 bar).

■ Intake temperature sensor

The ECM supplies ground to the intake temperature sensor. A further connection is routed to a voltage divider circuit in the ECM.

The intake temperature sensor contains a temperature-dependent resistor that protrudes into the flow of intake air and assumes the temperature of the intake air.

The resistor has a negative temperature coefficient (NTC). This means that the resistance decreases as temperature increases. The resistor is part of a voltage divider circuit that receives a 5V voltage from the ECM. The electrical voltage at the resistor is dependent on the air temperature. There is a table stored in the ECM that specifies the corresponding temperature to each voltage value and therefore compensates the non-linear correlation between voltage and temperature.

Intake-manifold Pressure Sensor

The intake manifold pressure sensor is used only on BMW Turbocharged engines. It is located on the intake manifold. It measures the pressure (absolute) in the intake manifold **after the throttle valve**.

The ECM uses the signal from the intake manifold pressure sensor to calculate the mass of intake air. The pressure also serves as a substitute variable for the load signal.

The ECM supplies the sensor with a 5V voltage and with ground. The information is sent to the ECM via a signal line. The evaluation signal fluctuates depending on the pressure. The measuring range from approx. 0.5 to 4.5 V corresponds to an air pressure from 20 kPa (0.2 bar) to 250 kPa (2.5 bar).



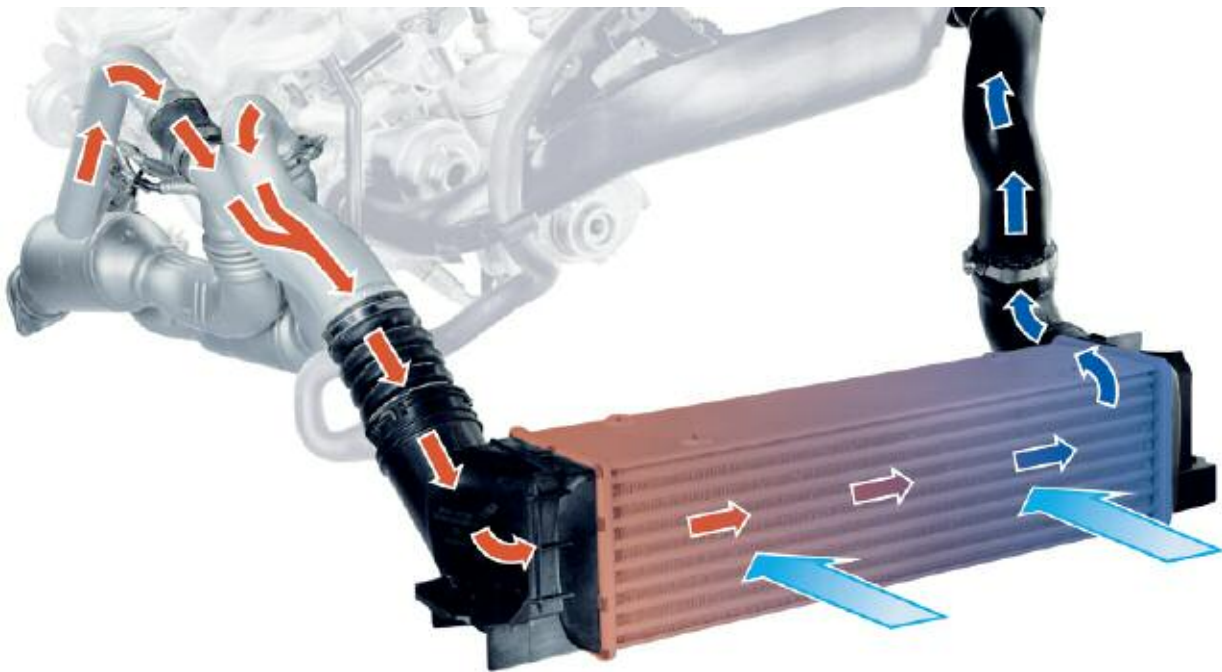
Charge Air Cooling (Intercoolers)

N54/N55

Cooling the charge air in BMW Turbocharged engines serve to increase power output as well as reduce fuel consumption. The charge air heated in the turbocharger by its component temperature and by compression is cooled in the intercooler by up to 80°C.

This increases the density of the charge air, which in turn improves the charge in the combustion chamber. This results in a lower level of required boost pressure. The risk of knock is also reduced and the engine operates with improved efficiency.

N54 Intercooler flow



The N55 Intercooler flow is similar to that of the N54.

N63/N74

Indirect charge air cooling is used for the first time on the **N63** engine. The charge air is not routed directly to an air-to-air heat exchanger.

The charge air is cooled by means of an air-to-coolant heat exchanger. The N63 engine therefore features a separate self contained low-temperature coolant circuit.

Indirect charge air cooling has the advantage of requiring little space as the system can be mounted directly on the engine. Due to the near-engine installation position, the distinctly shorter pipe length required for charge air routing also have a positive effect.

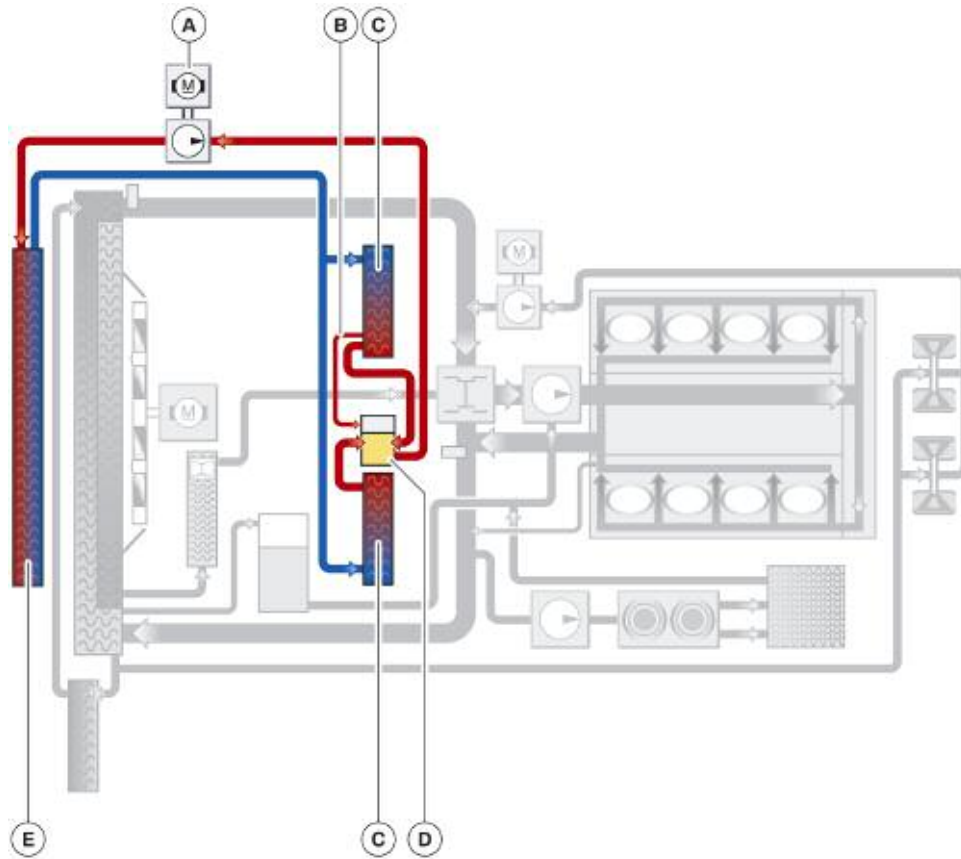
In this way, pressure loss has been substantially reduced, thus improving power yield and engine response.

N63 Indirect Charge Air Cooling Flow



Index	Explanation	Index	Explanation
A	Hot charge air	D	Hot coolant
B	Cooled charge air	1	Intercooler
C	Cooled coolant	2	Charge air pressure/temperature sensor

N63 Cooling Circuit for Charge Air Cooling

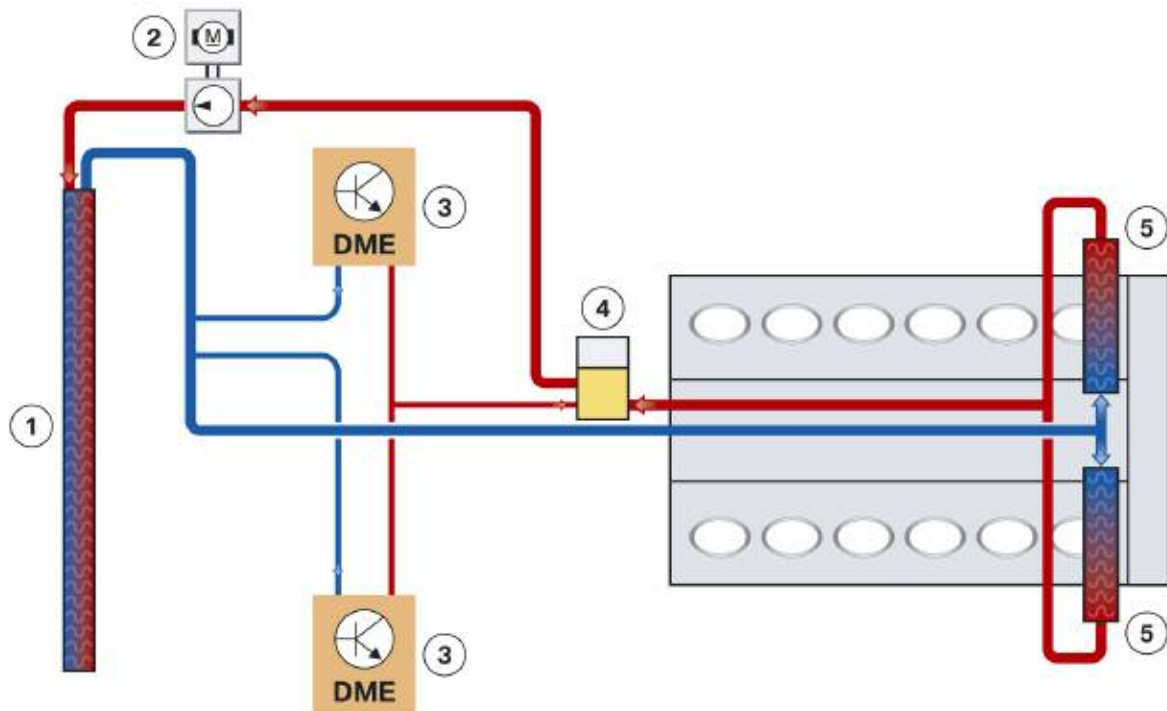


Index	Explanation	Index	Explanation
A	Electric coolant pump for charge air cooling	D	Expansion tank for charge air cooling
B	Vent line	E	Radiator for charge air cooling
C	Intercooler		

In the **N63** engine heat is taken from the charge air by means of an **air-to-coolant heat exchanger**. This heat is then given off via a coolant-to-air heat exchanger into the ambient air. For this purpose, the charge air cooling system has its own low temperature cooling circuit with a **dedicated electric water pump**, which is independent of the engine cooling circuit.

The intercoolers in the N63 are installed on the end faces of the cylinder heads. They operate in accordance with the counterflow principle and cool the charge air by up to 80°C.

N74 Cooling Circuit for Charge Air Cooling



Index	Explanation
1	Radiator for charge air cooling
2	Electric coolant pump for charge air cooling
3	Engine control unit
4	Expansion tank
5	Charge-air cooler

The use of **indirect charge air cooling** has also been adopted for the **N74** engine. The heat is extracted from the charge air by means of an air to coolant heat exchanger. This heat is then released to the ambient air across a coolant to air heat exchanger. To achieve this, the charge air cooling has its own low-temperature cooling circuit with a **dedicated electric water pump**, just as in the N63.

A **50W pump** is used to operate the coolant circuit for charge air coolant on the N63 and N74 engines. This pump does not run automatically when the engine is turned on.



Pump actuation on the N63 and N74 depend on the following values:

- **Outside temperature.**
- **Difference between charge air temperature and outside temperature.**

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Turbocharger Diagnosis

Golden Rules

It is important to focus on the causes rather than the effects.

With regard to the diagnosis and subsequent repair of turbocharging components, it is important to ensure that they are also actually identified as defective components with the diagnostic technology available.

It is always vital to ensure that the cause of the fault is determined and rectified and that if necessary work is not carried out on symptoms of fault consequences.

Thus, for instance, a leaking flange on the intercooler can have far-reaching consequences.

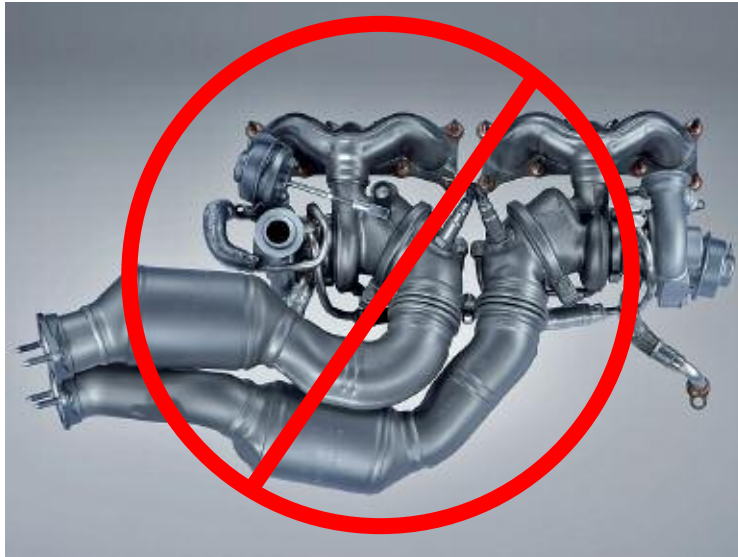
When diagnosing a turbo complaint always follow the three golden rules of procedure:

1. Do not rashly trace loss of power and engine malfunctions back to the turbocharger. To avoid the replacement of turbochargers which are in perfect working order, the following should be observed:

When blue smoke emerges from the exhaust system, check whether the air cleaner is contaminated or the engine is consuming too much oil because of wear. Or, if the crankcase ventilation system is faulty. Only then resort to checking the turbocharger. If the turbocharger is running too loud, inspect all the connections on the turbocharger pressure side. If black smoke or a loss of power is detected, in this case too check the engine and the connecting pipes first.

2. Main causes of turbocharger damage:
 - Insufficient lubrication and consequently bearing failure. Compressor and turbine wheels will grind in the housings, the seals will be damaged and the shaft may also shear off.
 - Foreign bodies damage the turbine and impeller. The resulting imbalance will reduce efficiency and may cause rotor damage.
 - Contaminated oil causes scoring on shaft journals and bearings. Oilways and seals will become clogged and cause oil leakage. Elements entering the turbocharger system from the outside such as sand, dirt, screws and the like will be trapped by a filter before the compressor.
 - Service the filters at regular intervals (service intervals). Make sure to keep the clean-air area of the air cleaner and the air ducting to the compressors clean and free from all types of debris.

-
3. Do not make any alterations to the turbocharger: Never attempt to alter the boost-pressure control linkage. The turbocharger has been optimally configured at the factory. If the turbocharger operates at higher boost pressures than permitted by the engine manufacturer, the engine may run hot and pistons, cylinder heads or engine bearings may fail, or the safety function of the engine electronics may respond and activate the engine's limp-home program.



No modifications to the turbochargers are permitted.

Controlled Variables

The following variables, among others, influence control of the engine's boost pressure:

- Intake-air temperature
- Engine speed
- Throttle-valve position
- Ambient pressure
- Intake-manifold pressure
- Pressure before the throttle valve (reference variable)

The electropneumatic pressure transducers are activated by the engine control unit on the basis of these variables. The result of this activation can be checked from the boost pressure achieved, which is measured before the throttle valve.

There follows a comparison of the boost pressure achieved with the setpoint data from the program map, which can if necessary give rise to an activation correction. The system therefore controls and monitors itself during operation.

Limp-home Mode

In the event during operation of malfunctions, implausible values or failure of any of the sensors involved in turbocharger control, activation of the wastegate valves is shut down and the valve flaps are thus fully opened. Turbocharging ceases at this point.



The list below sets out those components or functional groups in which a failure, a malfunction or implausible values result in boost-pressure control being deactivated. The driver is alerted to a fault of this type via an EML indication.

- **High-pressure fuel system**
- **Inlet VANOS**
- **Exhaust VANOS**
- **Crankshaft sensor**
- **Camshaft sensor**
- **Boost-pressure sensor**
- **Knock sensors**
- **Intake-air temperature sensor**

Turbocharger System Check

1. Visual inspections

Visual inspections of all lines, hoses, connections and cables are intended to help locate obvious defects quickly.

Connection plan for **partial-vacuum** activation see: Repair Instructions (REP)

- 11 Engine
- 00 Engine in general

2. Active diagnosis of the turbochargers

The active diagnosis is a DME function. The function runs within of a temperature window of 80 - 95 °C. To decouple the two turbochargers, the connecting line (low pressure hose) between the two electropneumatic pressure converters (EPDWs) must be disconnected (air-tight) by means of a special tool (see illustration). The function generates an artificial load. Only then is diagnosis in the charged mode possible. However, the engine generates a great amount of heat here, which is why the coolant pump and electric fan are activated. These components react sluggishly, which is why the function possibly aborts in the vicinity of the two limits. The function increases the speed to generate a load. Subsequently, the DME alternately activates the wastegates of the turbochargers. In the process, the courses of pressure are monitored by the pressure sensors. In accordance with the courses of pressure of the two decoupled turbochargers, the DME evaluates the behavior of the turbocharger system.

At the end of the function, a message regarding the status of the charge is displayed. If the turbocharger system is judged to be “OK” and there is only a customer complaint, further troubleshooting is unnecessary!



3. Check the exhaust flap

The back pressure generated in the exhaust system means that the function of the exhaust flap affects the charge in various operating points. A permanently closed exhaust flap can lead to charge faults!

The exhaust flap is vacuum-controlled. A disconnected vacuum hose can draw in particles (dust, salt water, etc.) and deliver them up to the vacuum pump. This can damage the vacuum pump.

4. Check the electropneumatic pressure converters (EPDW)

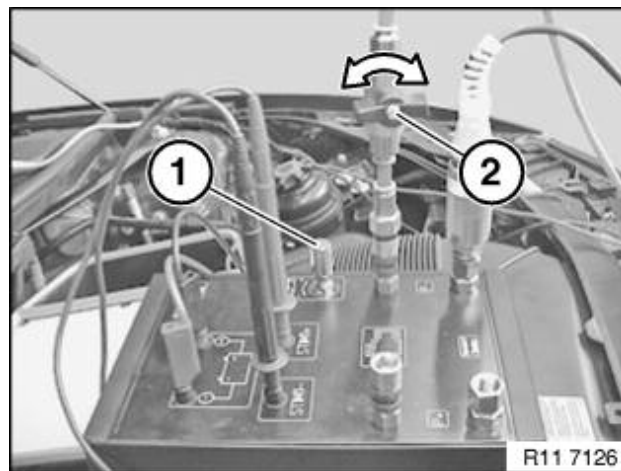
The electropneumatic pressure converters are activated individually in such a way that - 450 hPa is fed to the wastegates. Some of the adjustment of the wastegates can be observed from above, but with some engines like the N54 it is better to observe from below (underbody panels removed).

During activation, if necessary, the partial vacuum can be checked using a pressure gauge. If the vacuum hose is disconnected, there will be a delay in the vacuum build-up!

5. Check the intake system for leak-tightness with the diagnosis device

To find leaks, be sure to use diagnosis device **81 29 0 426 464**. In this context, consult repair instruction **REP 11 61 730 BMW leak test for intake system!** The seal plugs must close off the intake system and make it air-tight.

- Small leakages can be found because of hissing noises.
- As a rule, larger leakages are visible or the pressure cannot be built up with the diagnosis device.



6. Check the wastegate and blow off valve (BOV/Diverter Valve)

If a wastegate or blow off valve does not close, i.e. jams open, it is usually not possible to build up adequate charge-air pressure. Wastegates that jam closed might generate over-load fault; blow off valves might produce noises (vibrating).

The wastegates are closed by partial vacuum, -300 hPa must be sufficient for this operation. If the wastegates are only closed at lower pressures, they are difficult to move. With further wear, the flaps no longer close completely or jam in their seats.

The blow off valves are force-opened by partial vacuum from the intake pipe after the throttle valve.

7. Check the catalytic converter and turbo module

Catalytic converters can influence the charge due to changed exhaust-gas back-pressure. As a rule, this can be seen by traces of melting or burns in the honeycomb structure. Smeared colors on the outside of the catalytic converter can also indicate damage of this nature.

As a rule, damage to the turbocharger is visible, e.g. broken turbine wheel, jamming turbine wheel shaft or oil spillage. In the case of oil spillage, the catalytic converter must be checked for consequential damage without fail.

Intake-air Temperature of Charge-air Pressure Sensor

The charge-air pressure sensor registers the absolute pressure (charge-air pressure and atmospheric pressure together) in the intake system and serves as a measured value generator or charge-air pressure control.

The intake air temperature pressure sensor is attached to the charge air pipe. This combined sensor delivers the following information to the engine management system:

- Temperature of the charge air
- Charge-air pressure

The purpose of the charging pressure sensor is charging pressure control. The engine control unit also uses the signal of the intake-manifold pressure sensor to calibrate the position of the throttle valve.

Functional Description

Boost pressure sensor

Expansion measurement strips are used to detect the pressure. The pressure applied deforms a steel membrane in the sensor that is fitted with expansion measurement strips. The changes in resistance in the expansion measurement strips are detected electronically by a measurement bridge and evaluated. The measured voltage is then included as an actual value in the charge-air-pressure control.

■ Intake-air temperature sensor

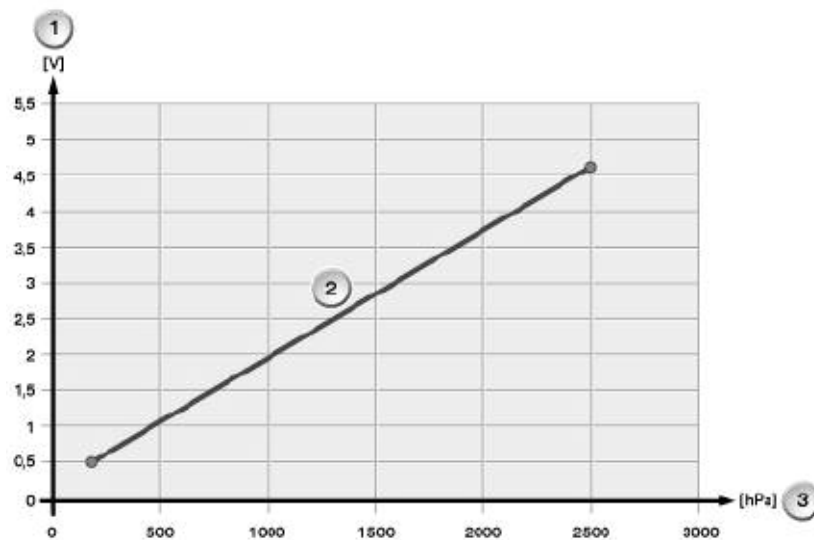
A temperature-dependent electrical resistor is used for temperature detection. The circuit contains a power

diplexer where the resistance can be measured depending on the temperature. A temperature is converted using a characteristic curve specific to the sensor. An NTC resistor is installed in the intake air temperature sensor; its resistance value falls as the temperature rises. The resistance changes depending on the temperature.

Characteristic Curve and Nominal Values

The charge-air pressure information is sent to the engine management system across a signal line. The signal for the charge-air pressure, which can be evaluated, fluctuates depending on the pressure. The measuring range of approx. 0.5 to 4.5 Volts corresponds to a charge-air pressure of 20 kPa (0.2 bar) to 250 kPa (2.5 bar).

The resistance of the intake air temperature sensor changes depending on the temperature.



Index	Explanation	Index	Explanation
1	Voltage	3	Pressure
2	Charge-air pressure characteristic curve		

Observe the following nominal values for the intake air temperature pressure sensor:

Variable	Value
Voltage range for charge-air pressure sensor	0.5 to 4.5 Volts
Measuring range for charge-air pressure	0.2 to 2.5 bar
Intake air temperature sensor accuracy	+/- 1°C
Maximum output current	10mA
Temperature range	-40 °C to 130 °C

Failure of the Component

If the charge-air pressure sensor fails, the following behavior is to be expected:

- Fault code memory entry in the engine control unit
- Emergency operation with substitute value

Intake Air Temperature Sensor (NOT Pressure)

Intake Air-Intake temperature sensor [C] ADD [F]		RESISTANCE [Ω]
[°C]	[°F]	
-30	-22	23500-27500
-20	-4	14000-16000
-10	14	8500-10000
0	32	5000-6100
10	50	3500-3900
20	68	2300-2600
25	77	1900-2100
30	86	1600-1750
40	104	1100-1200
50	122	750-850
60	140	550-600
70	158	410-440
80	176	305-325
90	194	230-245
100	212	180-190

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Cooling Systems

Model: All

Production: All

OBJECTIVES

After completion of this module you will be able to:

- Understand the operation of the main components in the cooling system
- Understand the different charge air cooling systems
- Understand the principles of Heat Management
- Understand the difference between static and dynamic oil measurement
- List the advantages of EWP

Introduction

Cooling System N54

The cooling system of the **N54** engine consists of a radiator circuit and an isolated oil cooling circuit. The fact that there is an isolated oil-cooling circuit ensures that heat is not introduced via the engine oil into the engine's coolant system.

There is a significantly greater quantity of heat on account of this engine's increased power of 75.5 kW/l in comparison with the N52.

This boundary condition is satisfied by the engine cooling system with its increased performance. This increase in power was to be realized in spite of some factors less advantageous to cooling.

Factors to be mentioned here are:

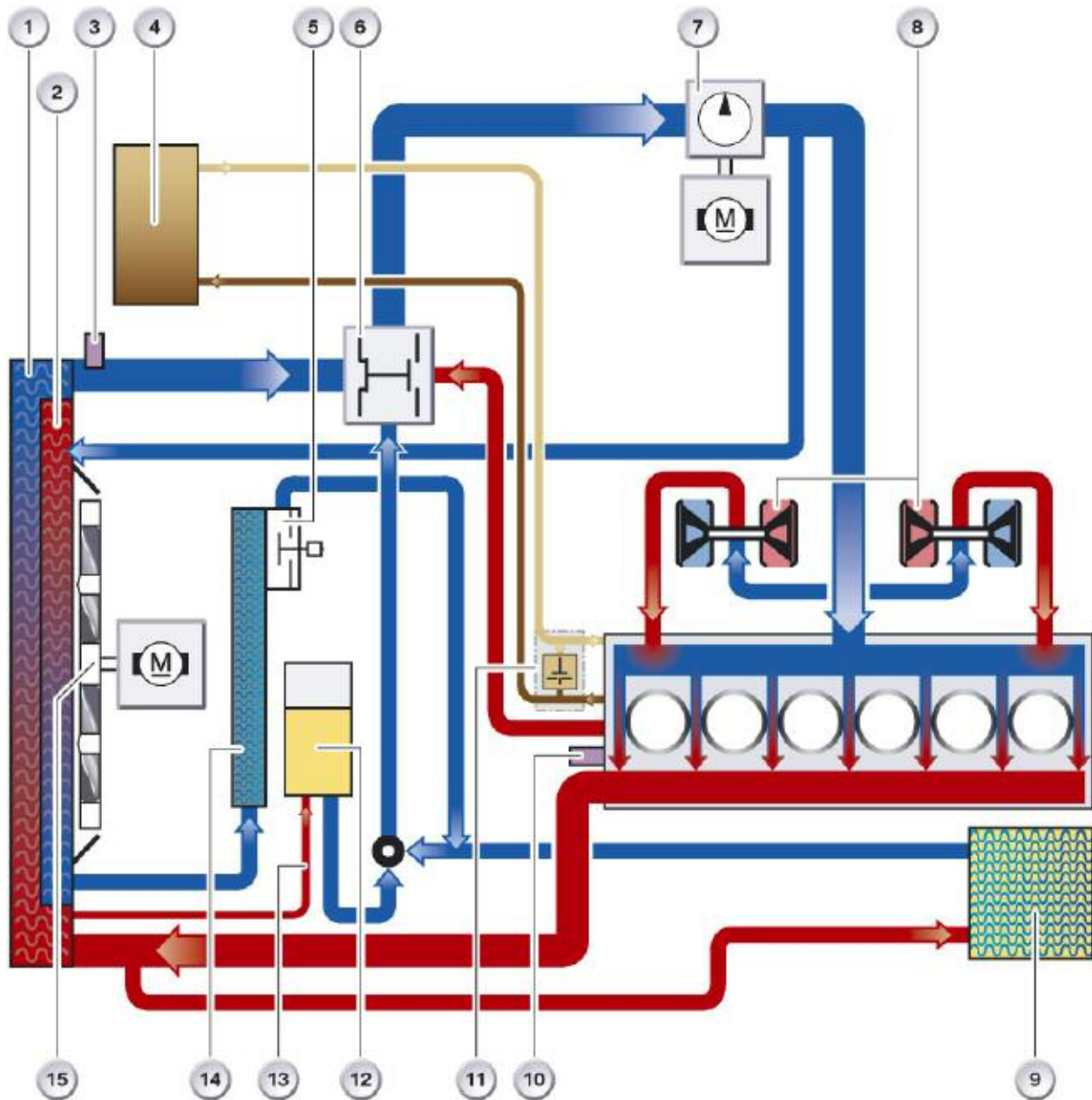
- Approximately 15% less flow area is available on account of the intercooler located below the radiator.
- The already small amount of space provided by the engine compartment is further limited by the accommodation of further components.
- Because the exhaust turbochargers are cooled by the coolant, an additional quantity of heat is introduced into the system via these turbochargers.

Measures for increasing cooling-system performance:

- Coolant pump with increased power 400 W/9000 l/h
- Separation of water and engine-oil cooling
- Radiator with increased power
- Electric fan with increased power 600W for all gearbox variants

Charge-air cooling is described in the section dealing with air-intake ducting.

N54 Cooling System



Index	Explanation	Index	Explanation
1	Radiator	9	Heat exchanger
2	Gear-box oil cooler	10	Outlet temperature sensor, cylinder head
3	Outlet temperature sensor	11	Thermostat, engine oil cooler
4	Engine oil cooler	12	Coolant expansion tank
5	Thermostat for gearbox oil cooler	13	Vent line
6	Map thermostat	14	Gearbox oil cooler
7	Electric coolant pump	15	Fan
8	Exhaust turbocharger		

Layout

The structure of the coolant circuit on the **N54** is the same as that of the N52 engine. The engine is flushed through with coolant in accordance with the cross-flow concept. Cooling output can be influenced as a function of load by activating the following components:

- Electric fan
- Electric coolant pump
- Map thermostat

It is also possible in an N54 engine in conjunction with an automatic gearbox to utilize the lower area of the radiator to cool the gearbox by means of the gearbox-oil cooler. This is achieved as in the N52 engine with control sleeves, which are introduced into the radiator tank.

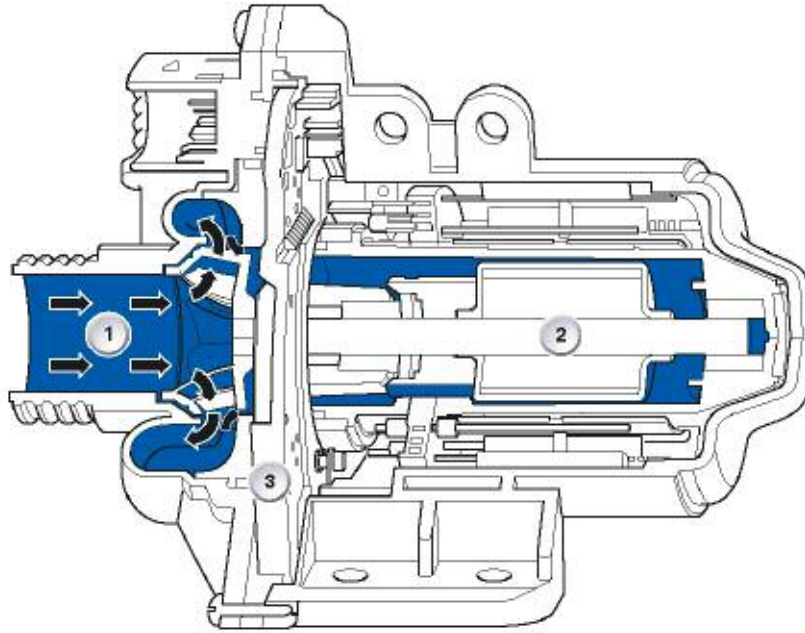
Radiator

Design measures have been used to increase the performance of the radiator itself. The performance of a radiator is dependent on its radiation surface. However, the intercooler still had to be installed underneath the radiator, and this meant that it was necessary to compensate for the smaller flow area available.

Compared with the N52 engine, the radiator used in the N54 engine has a block depth which has been increased to 32 mm. In addition, the water pipes are situated closer together than in previously used radiators. The upshot of this is an increase in the utilizable radiation surface.

Electric Coolant Pump (EWP)

The coolant pump of the **N54** engine is an electrically driven centrifugal pump with a power output of 400W and a maximum flow rate of 9000 l/h. This represents a significant increase in power of the electric coolant pump used in the N52 engine, which has a power output of 200 W and a maximum flow rate of 7000 l/h.



Index	Explanation	Index	Explanation
1	Pump	3	Electronics for coolant pump
2	Motor		

The power of the electric wet-rotor motor is electronically controlled by the electronic module (3) in the pump. The electronic module is connected via the **bit-serial data interface** (BSD) to the ECM engine control unit.

The engine control unit uses the engine load, the operating mode and the data from the temperature sensors to calculate the required cooling output. Based on this data, the engine control unit issues the corresponding command to the electric coolant pump.

The electric coolant pump regulates its speed in accordance with this command.

The system coolant flows through the motor of the coolant pump, thus cooling both the motor as well as the electronic module. The coolant lubricates the bearings of the electric coolant pump.



The same rules apply to all Electric Coolant Pumps (EWP). The pump must be filled with coolant when removed for service to prevent any corrosion. Also, the pump impeller must be turned by hand before installation to ensure the pump is not seized.



Particular care must be taken when performing servicing work to ensure that the pump does not run dry. When the pump is removed, it should be stored filled with coolant. The bearing points of the pump could stick fast if the pump were not filled with coolant. This could jeopardize subsequent start-up of the pump thus rendering the entire heat management system inoperative **(the pump not starting up could cause serious engine damage)**. If the pump should ever run dry, the pump wheel should be turned by hand before finally connecting the coolant hoses. The system should then be immediately filled with coolant.



Particular care must be taken during assembly to ensure that the connector is clean and dry and the connections are undamaged.

Diagnosis should be performed only with the approved adapter cables. The information provided in the repair instructions must be observed.



Due to this coolant pump, a special filling and **bleeding procedure** must be implemented for servicing:

1. Fill system with coolant via the expansion tank (AGB).
Top up coolant level to lower edge of expansion tank.
2. Close expansion tank.
3. Switch on ignition.
4. Set heating to maximum (temperature), switch on blower (lowest stage).
5. Press accelerator pedal module right down for at least 10 seconds. The engine must NOT be started.
6. Bleeding via EWP takes approx. 12 minutes. Then check coolant level in expansion tank, top up to MAX marking if necessary.
7. Check cooling circuit and drain plugs for leaks.
8. If the procedure needs to be repeated several times, allow DME to completely de-energize (remove ignition key for approx. 3 minutes) and then repeat procedure as from Point 3.

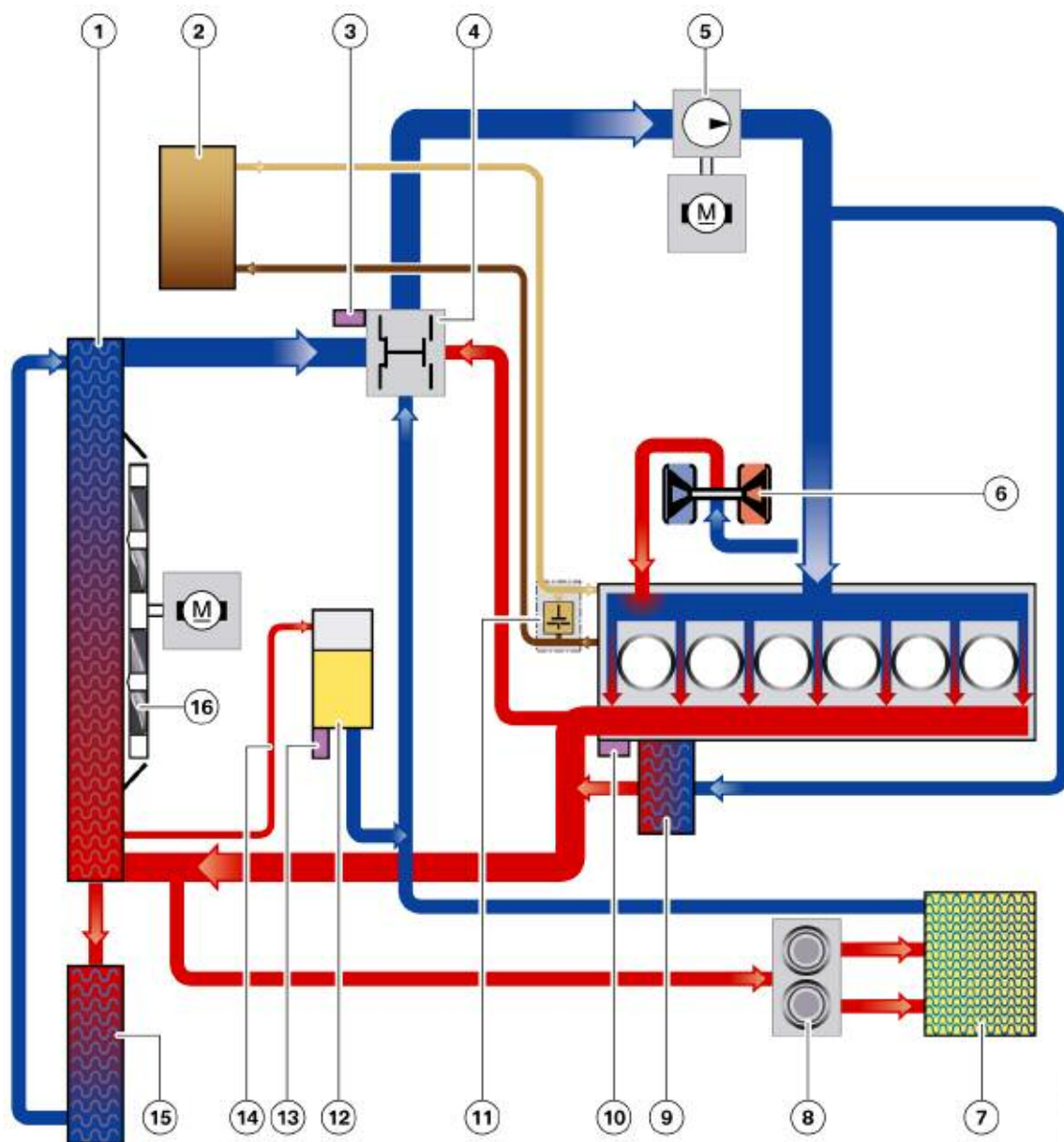
Connect battery charger if battery charge level is low.

Cooling System N55

The cooling system of the **N55** is enhanced with additional oil cooling.

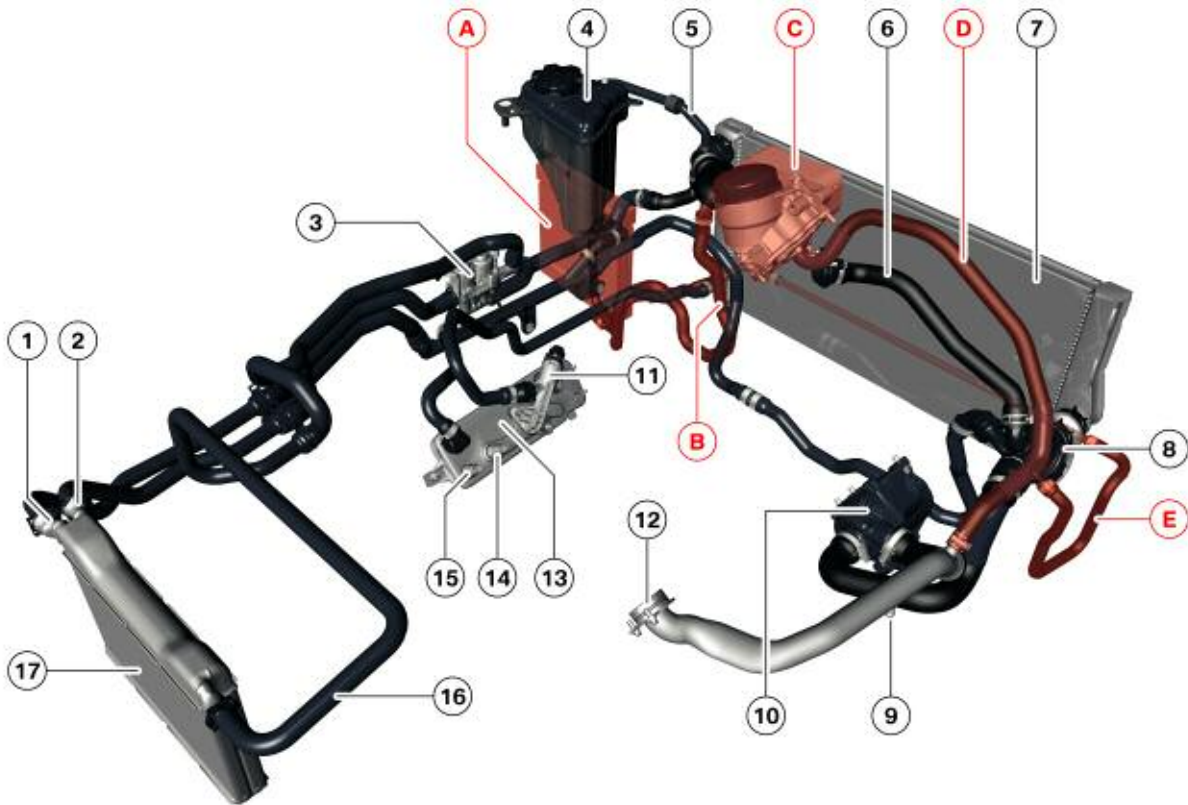
Two different types of oil cooling systems are used depending on the model and application. In the “hot climate” version, heat transfer from the engine oil to the engine coolant is avoided by separating the oil cooler from the engine coolant circuit. The other version uses an auxiliary radiator in combination with an oil to coolant heat exchanger bolted to the oil filter housing. The auxiliary radiator enhances cooling efficiency by adding surface area to the cooling system.

N55 Cooling System



Index	Explanation
1	Radiator
2	Engine oil to air cooler (hot climate version)
3	Heater coil
4	Characteristic map thermostat
5	Electric coolant pump
6	Exhaust turbocharger
7	Heating heat exchanger
8	Coolant valve
9	Oil-to-coolant heat exchanger
10	Coolant temperature sensor
11	Engine oil thermostat (hot climate version)
12	Expansion tank
13	Coolant level switch
14	Equalization line
15	Auxiliary radiator
16	Electric fan

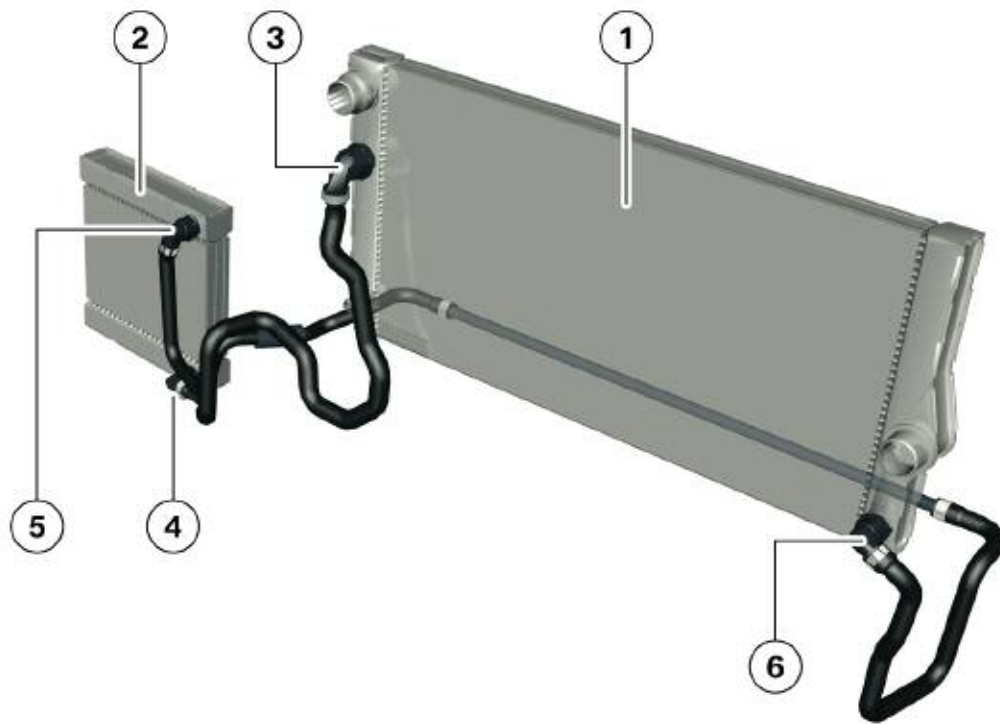
N55 Cooling System



Index	Explanation	Index	Explanation
A	Auxiliary radiator	7	Bypass line for small cooling circuit
B	Coolant feed line to auxiliary radiator	8	Thermostat
C	Oil-to-coolant heat exchanger	9	Electric coolant pump
D	Coolant feed line to oil-to-coolant heat exchanger	10	Exhaust turbocharger supply line
E	Coolant return line from auxiliary radiator	11	Thermostat for transmission oil cooling
1	Zone 1 feed line, heating heat exchanger	12	Coolant feed line to engine block
2	Zone 2 feed line, heating heat exchanger	14	Transmission oil-to-coolant heat exchanger
3	Coolant valve	15	Connection, transmission oil line
4	Expansion tank	16	Connection, transmission oil line
5	Equalization line	17	Return, heating heat exchanger
6	Radiator		

The following graphic shows the connection of the auxiliary radiator to the cooling system. The auxiliary radiator is connected to the radiator by means of parallel coolant lines, thus increasing the cooling surface area. This system is combined with an **oil-to-coolant heat exchanger** mounted on the oil filter housing. (See component “C” in page 12.)

N55 Auxiliary Radiator

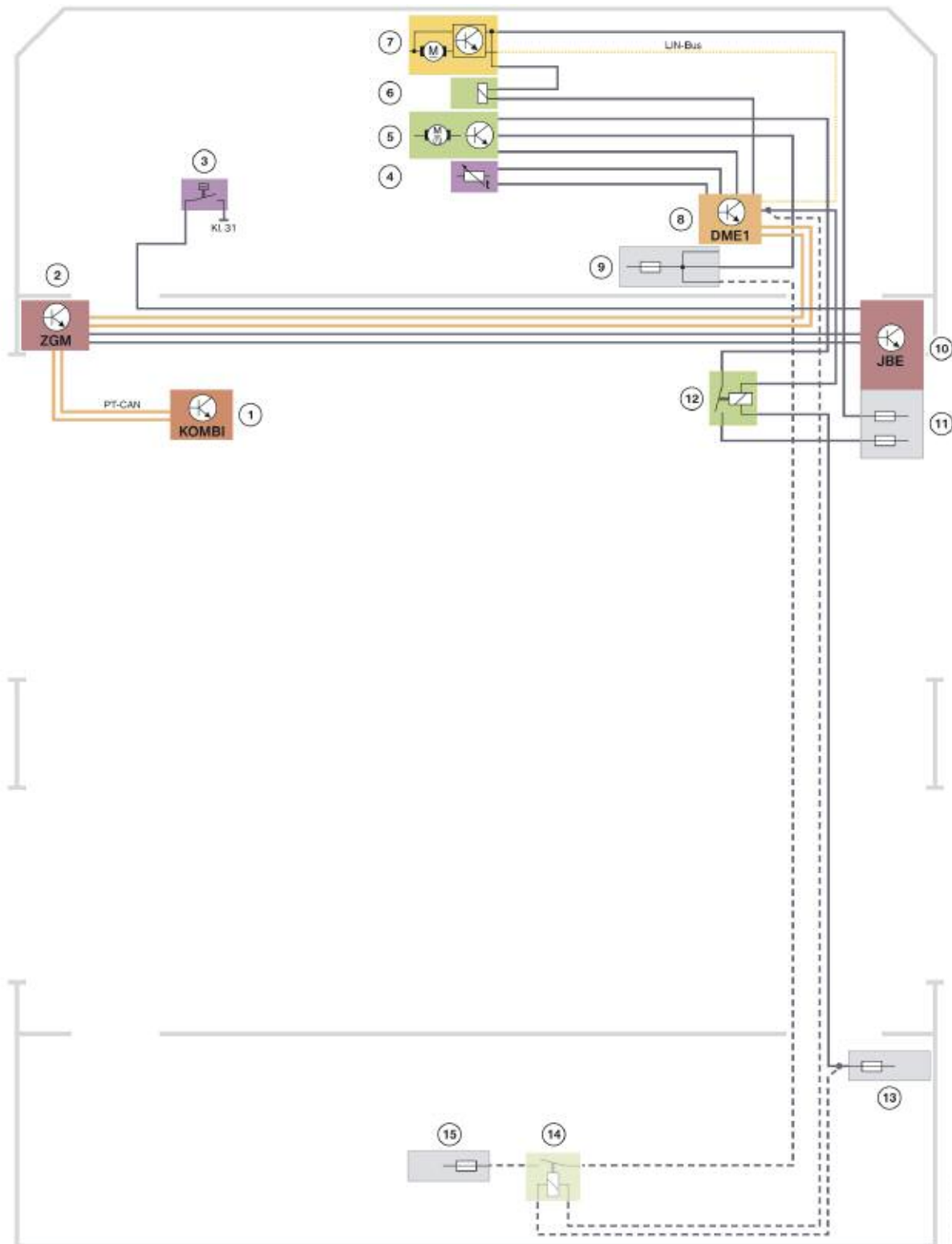


Index	Explanation
1	Radiator
2	Auxiliary Radiator
3	Feed connection to the auxiliary radiator
4	Feed connection at the auxiliary radiator
5	Return connection to the auxiliary radiator
6	Return connection from the auxiliary radiator



If a separate oil to air cooler is not installed, an auxiliary radiator in conjunction with an oil to coolant heat exchanger is used to cool the engine oil.

Engine Cooling Circuit Diagram (N55)

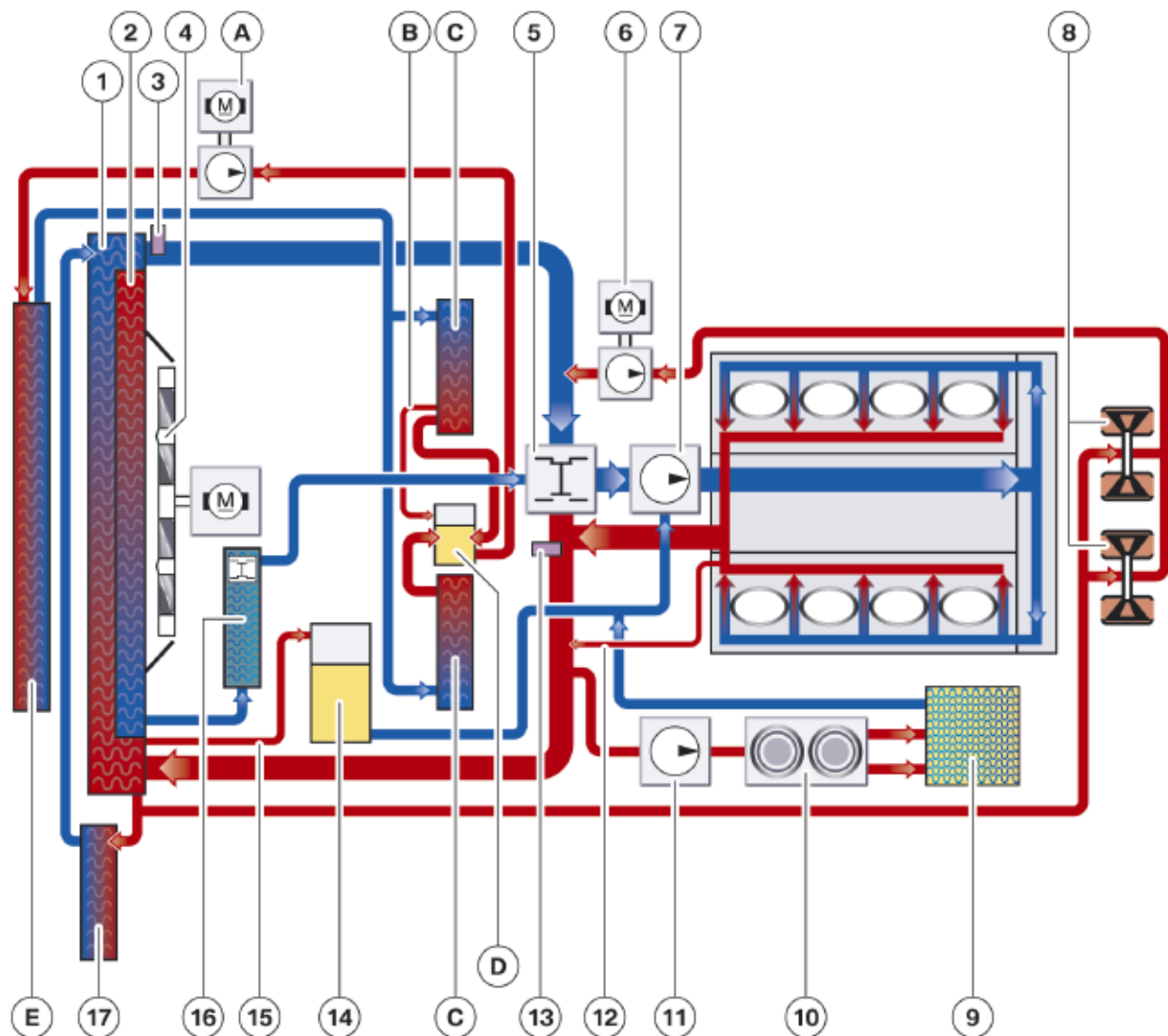


Index	Explanation
1	Instrument cluster
2	Central Gateway Module
3	Coolant level switch
4	Coolant temperature sensor
5	Electric fan
6	Mechanical air flap control
7	Electric air flap control
8	Digital Motor Electronics
9	Front power distribution box
10	Junction box electronics
11	Junction box
12	Electric fan relay
14	Rear power distribution box
15	Electric fan relay (only for 850 Watt and 1000 Watt electric fan)

Cooling System N63

Due to the exhaust turbocharging system and the compact arrangement of the turbochargers in the V-space, the heat output of the **N63** engine is very high. Correspondingly, great significance is attached to the cooling system. In addition, an indirect charge air cooling system has been developed for the first time where the charge air is cooled by an air-to-coolant heat exchanger. There are two separate cooling circuits for engine and charge air cooling.

N63 Cooling System



Index	Explanation	Index	Explanation
1	Radiator	12	Vent line
2	Radiator for transmission cooling	13	Coolant temperature sensor at engine outlet
3	Coolant temperature sensor at radiator outlet	14	Expansion tank
4	Electric fan	15	Vent line
5	Characteristic map thermostat	16	Transmission fluid-to-coolant heat exchanger
6	Electric auxiliary coolant pump for turbocharger cooling	17	Auxiliary coolant radiator
7	Coolant pump	A	Electric coolant pump for charge air cooling
8	Exhaust turbocharger	B	Vent line
9	Heating heat exchanger	C	Intercooler
10	Duo-valve	D	Expansion tank for charge air cooling
11	Electric auxiliary coolant pump for vehicle heating	E	Radiator for charge air cooling

The engine cooling system undertakes the classic task of carrying heat away from the engine and maintaining a defined operating temperature as constant as possible. As on the N54 engine, the two turbochargers are also cooled.

Coolant Pumps N63

■ Main coolant pump

The **N63** engine features a conventional coolant pump that is driven by the belt drive. This pump cannot be used to continue cooling the turbochargers after the engine has been shut down. For this reason the N63 is also equipped with an auxiliary coolant pump.

■ Auxiliary coolant pump for turbocharger cooling

The electric coolant pump on the N54 engine features an after-running function to carry away the heat build-up from the turbochargers after the engine has been shut down.

For this function, the **N63** engine is equipped with an additional electrically operated coolant pump with an output of 20 W. This pump is also used during engine operation to assist turbocharger cooling.

The auxiliary electric coolant pump cuts in, taking the following factors into consideration:

- Coolant temperature at engine outlet
- Engine oil temperature
- Injected fuel quantity

The heat input into the engine is calculated based on the injected fuel quantity. This function is similar to the heat management function on 6-cylinder engines.

The after-running period of the auxiliary electric coolant pump can extend up to 30 minutes. The electric fan also cuts in to improve the cooling effect.



As in previous systems, the electric fan runs for a maximum of 11 minutes, however, it now operates more frequently.

System Protection

As on the N54 engine, the **N63** in the event of the coolant or engine oil being subject to excessive temperatures, certain functions in the vehicle are influenced in such a way that more energy is made available to the engine cooling system, i.e. temperature increasing loads are avoided.

Cooling System N74

Because of the turbocharging and indirect charge air cooling, the **N74** engine has the same cooling requirements as the N63 engine. Consequently it too has two separate cooling circuits. One is for cooling the engine and exhaust turbochargers, the other is for charge air cooling and for cooling the two engine control units.

The engine cooling system performs the task of drawing heat off the engine and maintaining the operating temperature as constant as possible. As on the N54 and N63 engines, the two exhaust turbochargers are also cooled.

On the N74 engine, the coolant passages have been integrated mainly in the engine block. Optimizations to the engine cooling circuit have enabled a significant reduction in the coolant quantity for the bypass mode, thus shortening the warm-up phase.

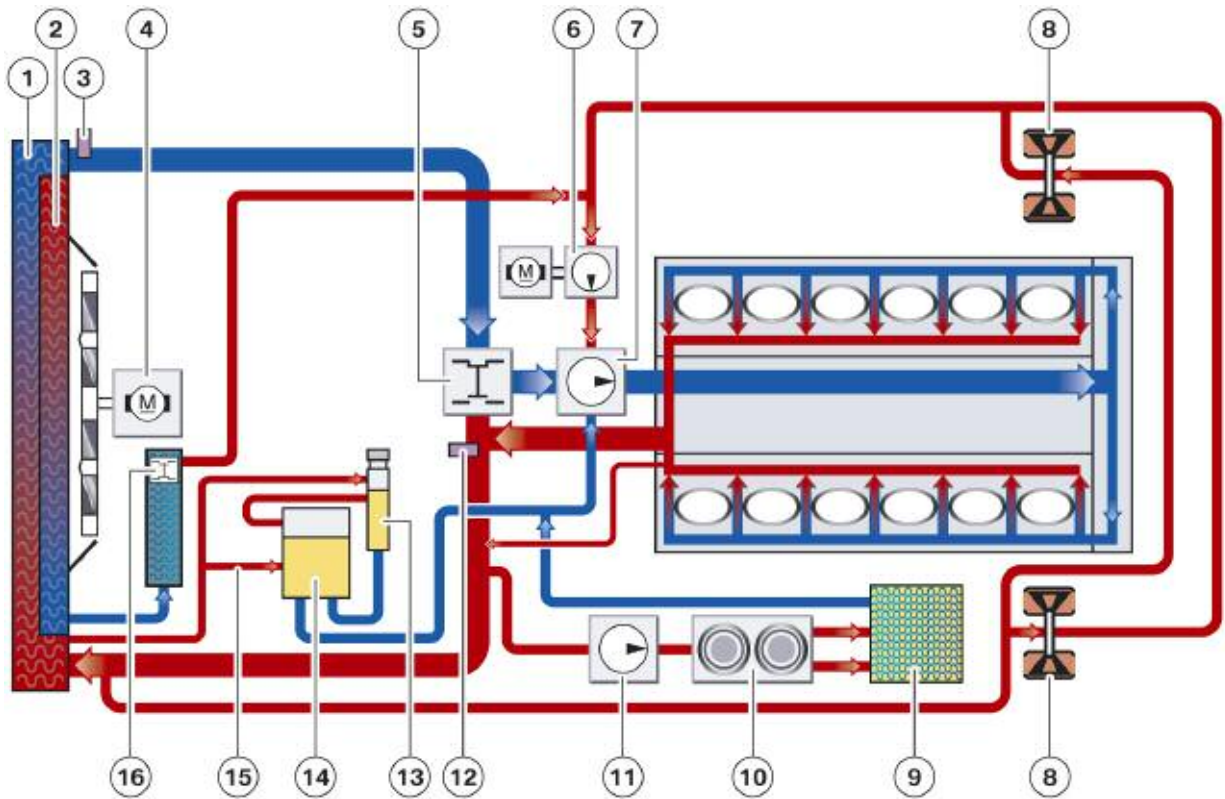
The coolant feed line downstream of the coolant pump is routed directly beside the engine's main oil duct. The oil in the main oil duct flows in the opposite direction to the coolant. This enhances the heat exchange between the two media, and has a positive effect on the engine oil temperature. The overall cooling effect is comparable with that of an engine oil-coolant heat exchanger.

The coolant passages in the cylinder heads are similar to the N63 engine. The coolant flows through the cylinder heads diagonally from the outside to the inside, whereby it flows in at the rear (outside) and flows out at the front (inside). This is also known as diagonal cooling.



As on the N63 engine, an additional electric coolant pump is used which supplies the bearings of the exhaust turbochargers with coolant.

N74 Cooling System



Coolant Pumps N74

■ Main coolant pump

The main coolant pump is a conventional coolant pump driven mechanically by the belt drive.

■ Auxiliary water pump for exhaust turbochargers

Like the N63 engine, the N74 engine has an electric auxiliary water pump which allows heat to be dissipated from the exhaust turbochargers even after the engine has been switched off. This coolant pump has an electrical power output of 20 W. It is also used during engine operation to support exhaust turbocharger cooling. The electric auxiliary coolant pump is activated based on the following factors:

- Coolant temperature at the engine outlet
- Engine oil temperature
- Injected volume of fuel

Index	Explanation
1	Radiator
2	Radiator for transmission cooling
3	Coolant temperature sensor at radiator outlet
4	Electric cooling fan
5	Characteristic map thermostat
6	Electric auxiliary coolant pump for turbocharger cooling
7	Coolant pump (mechanical)
8	Exhaust turbocharger
9	Heater core
10	Duo Heater valve
11	Electric auxiliary coolant pump for vehicle heating
12	Coolant temperature sensor at engine outlet
13	Filling canister
14	Expansion tank
15	Vent line
16	Transmission fluid thermostat and the fluid-to-coolant heat exchanger

The injected volume of fuel is used to calculate the heat contribution to the engine. Operation is similar to that of the heat management system on the 6-cylinder engines. The after-running period of the electrical auxiliary coolant pump can last up to 30 minutes.



To improve the cooling effect, the electric fan is also switched on. As in previous systems, the electric fan runs for a maximum of 11 minutes, however, it now operates more frequently.

Expansion Tank

For space reasons, the expansion tank is located in the front fender behind the wheel arch. A separate filling canister bolted to the front of the engine enables filling. The expansion tank and filling canister are interconnected by an expansion and tank ventilation line.

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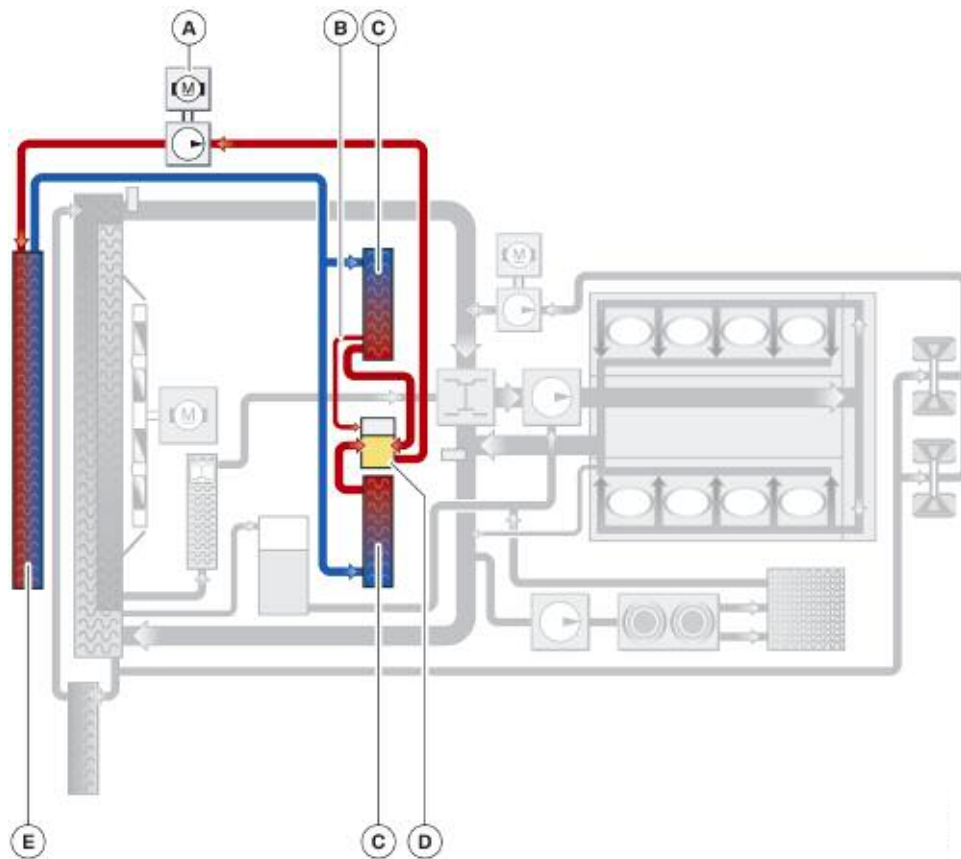
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Charge Air Cooling

Charge Air Cooling N63

With the introduction of the **N63** engine, indirect charge air cooling is used for the first time at BMW. Heat is taken from the charge air by means of an air-to-coolant heat exchanger. This heat is then given off via a coolant-to-air heat exchanger into the ambient air. For this purpose, the charge air cooling system has its own low temperature cooling circuit, which is independent of the engine cooling circuit.

N63 Charge Air Cooling System



Index	Explanation	Index	Explanation
A	Electric coolant pump for charge air cooling	D	Expansion tank for charge air cooling
B	Vent line	E	Radiator for charge air cooling
C	Intercooler		

Intercoolers

The intercoolers are installed on the end faces of the cylinder heads. They operate in accordance with the counterflow principle and cool the charge air by up to 80°C.

Electric Coolant Pump

The coolant circuit for charge air coolant is operated with a 50 W pump. This pump does not run automatically when the engine is turned on.

Pump actuation depends on the following values:

- Outside temperature
- Difference between charge air temperature and outside temperature

Venting

A separate venting routine is provided for the purpose of venting the low-temperature circuit of the charge air cooling system. This venting is initiated in the same way as for the cooling circuit on 6-cylinder engines.

The venting test module can be found in the “Service Functions” section of the diagnostic program.

Charge Air Cooling N74

The N63 engine was the first BMW engine to use indirect charge air cooling; this has now also been adopted for the **N74** engine. The heat is extracted from the charge air by means of an air to coolant heat exchanger. This heat is then released to the ambient air across a coolant to air heat exchanger. To achieve this, the charge air cooling has its own low-temperature cooling circuit. This is independent of the engine cooling circuit.

Auxiliary Coolant Pump for Charge Air Cooling

The cooling circuit for charge air cooling is operated with a 50 W pump. It does not run automatically when the engine is switched on.

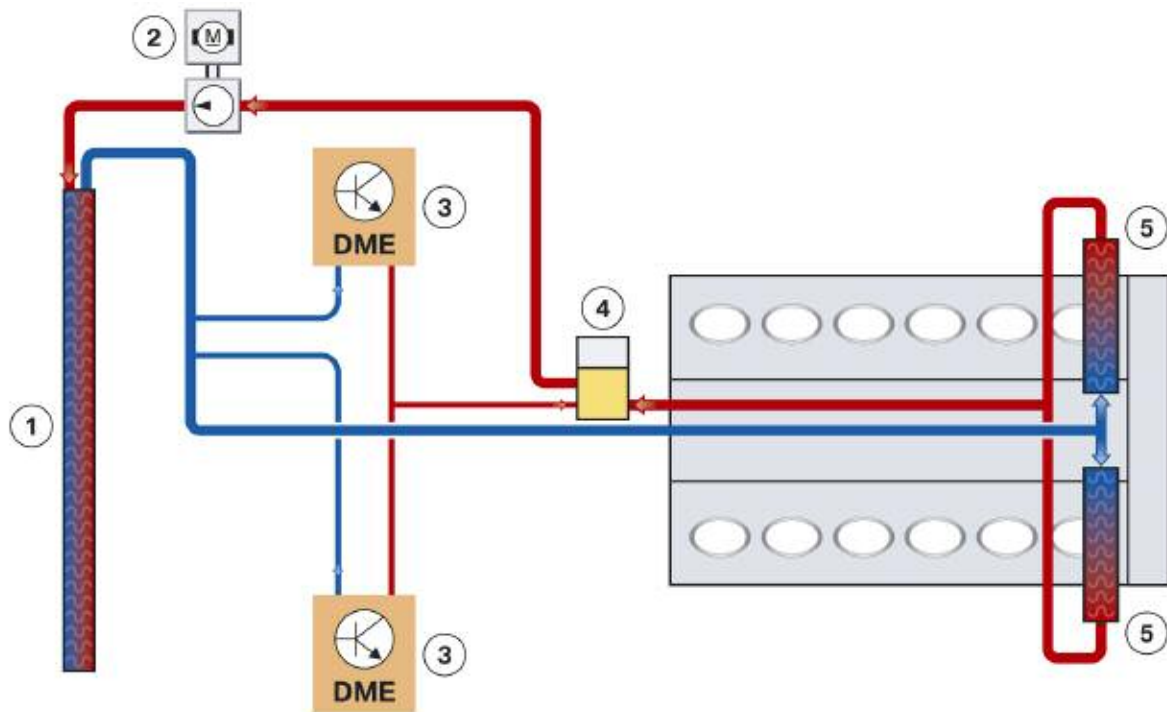
The following parameters are used for the auxiliary pump activation:

- Outside temperature
- Difference between charge-air temperature and outside temperature.

Charge-air Cooler

The charge air coolers (intercoolers) are attached to the intake system near the rear of the cylinder heads. They enable efficient cooling of the charge air by extracting heat energy from the air charge and carrying it away to the coolant to air heat exchanger located in the front of the vehicle.

N74 Charge Air Cooling System



Index	Explanation
1	Radiator for charge air cooling
2	Electric coolant pump for charge air cooling
3	Engine control unit
4	Expansion tank
5	Charge-air cooler

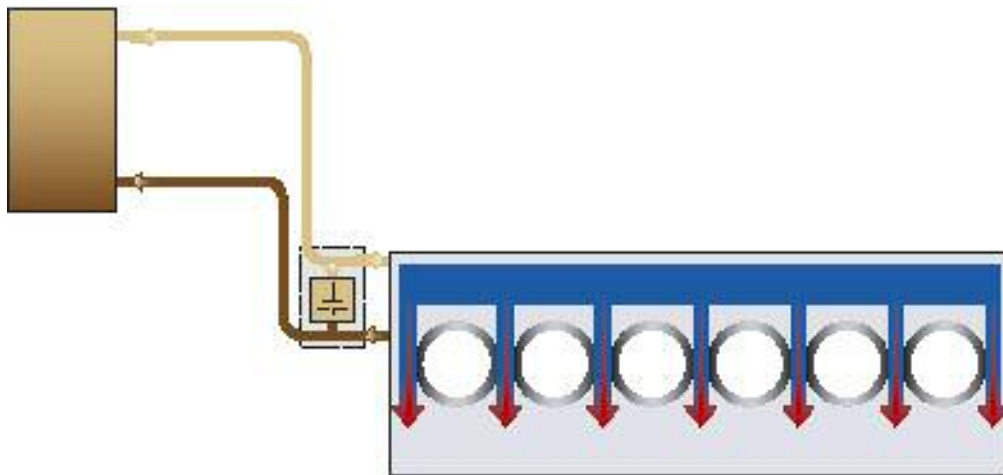
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PAGE

Engine Oil Cooling

One of the main purposes of the ECM is to monitor and control the Engine-Oil Cooling which includes the actuation of several components. In the following pages you will find a generic explanation on how this system works. For more detailed information please access BMW Training Reference Manuals found on-line.

Engine Oil Cooling (N54)



The **N54** engine is equipped with a high performance engine-oil cooler. The pendulum-slide pump delivers the oil from the oil sump to the oil filter. A thermostat flanged to the oil-filter housing admits the oil to the engine-oil cooler. The engine-oil cooler is located in the right wheel arch. The thermostat can reduce the resistance opposing the oil by opening the bypass line between the feed and return lines of the engine-oil cooler. This ensures that the engine warms up safely and quickly.

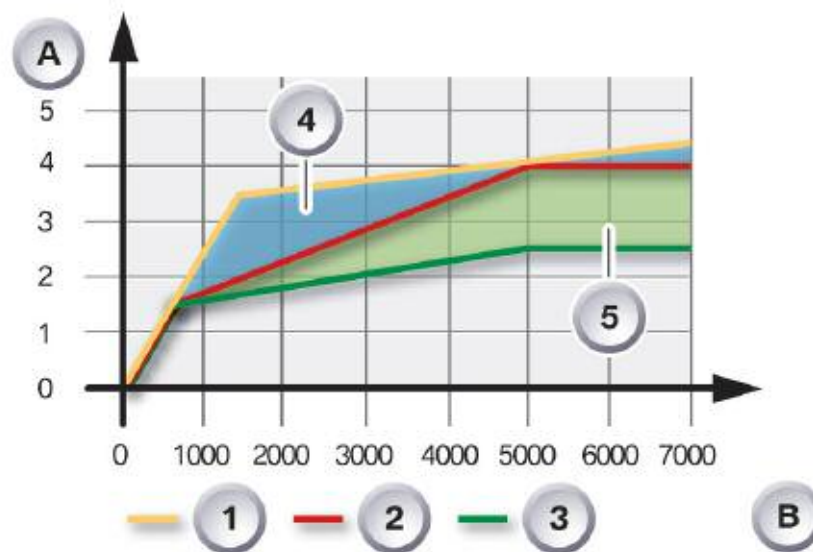
Oil Pump and Pressure Control (N55)

The oil pump has been redesigned with regard to the functionality and durability of the Duroplast reciprocating slide valve. The oil pump used in the **N55** engine is a further development of the shuttle slide valve volume control oil pump. The activation of the oil pump is adapted by the engine management and controlled through an oil pressure control valve.

The delivered oil volume is controlled by means of the oil pressure, based on specific requirements. The modifications, compared to previous pumps, are primarily in the pump activation system. The oil pressure no longer acts directly on the control piston but rather directly on the slide valve. The engine management activates the electrohydraulic pressure control valve, which affects the oil pressure at the slide valve control mechanism within the oil pump, altering the pump output. This has the advantage of avoiding power losses by running the oil pump only when needed.

The electrohydraulic pressure control valve controls the pump output and is bolted to the front of the engine block. It is operated based on a characteristic map within the DME (ECM) which in turn is based on feedback from the oil pressure sensor. The N55 uses a special oil pressure sensor for this purpose which functions in the similar way as the HPI fuel pressure sensor.

Characteristic map-controlled oil pressure (N55)



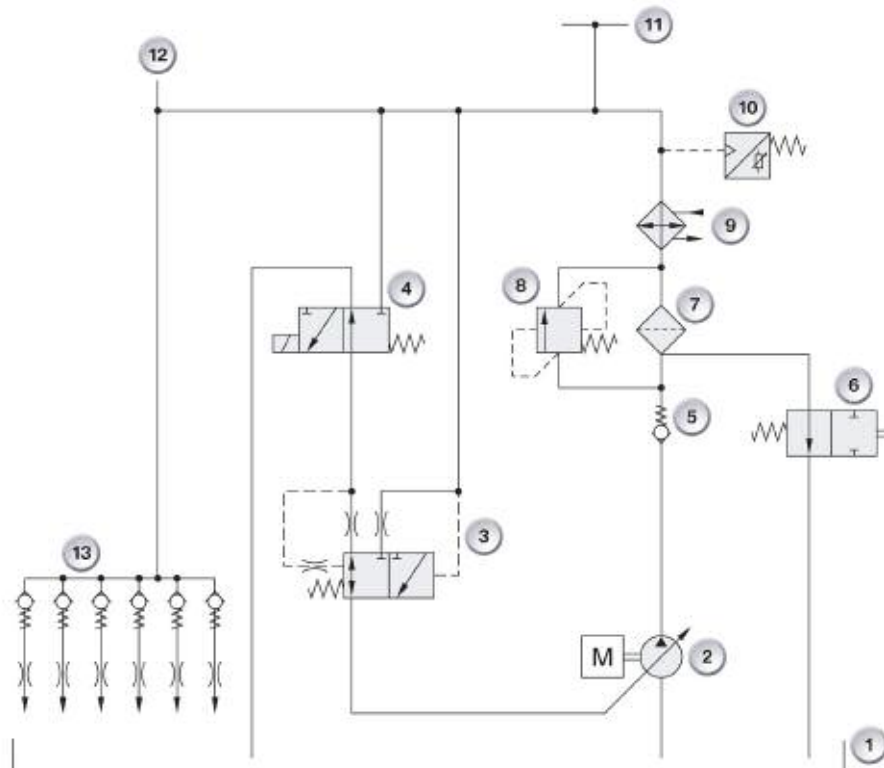
Index	Explanation	Index	Explanation
A	Oil pressure (bar)	3	Characteristic map-controlled oil pressure, no load
B	Engine speed (rpm)	4	Saving potential, full load
1	Oil pressure control, hydraulic/ mechanical	5	Saving potential, no load
2	Characteristic map-controlled oil pressure, full load		

The oil pressure generated by the oil pump (2) is delivered to the engine's lubricating points and hydraulic actuators. This system uses oil pressure feed back to control the desired operating oil pressure. For this purpose, the oil pressure downstream of the oil filter (7) and engine oil-to-coolant heat exchanger (9) is adjusted by the DME (map-controlled) via the pressure control valve (4) to the pressure control valve (3).

The actual generated oil pressure is registered by the oil pressure sensor (10) and recognized by the engine management.

In the event of an electrical malfunction, the oil pressure is set to the default control setting. The pump compression springs are allowed to expand, moving the slide valve to its maximum oil pressure position.

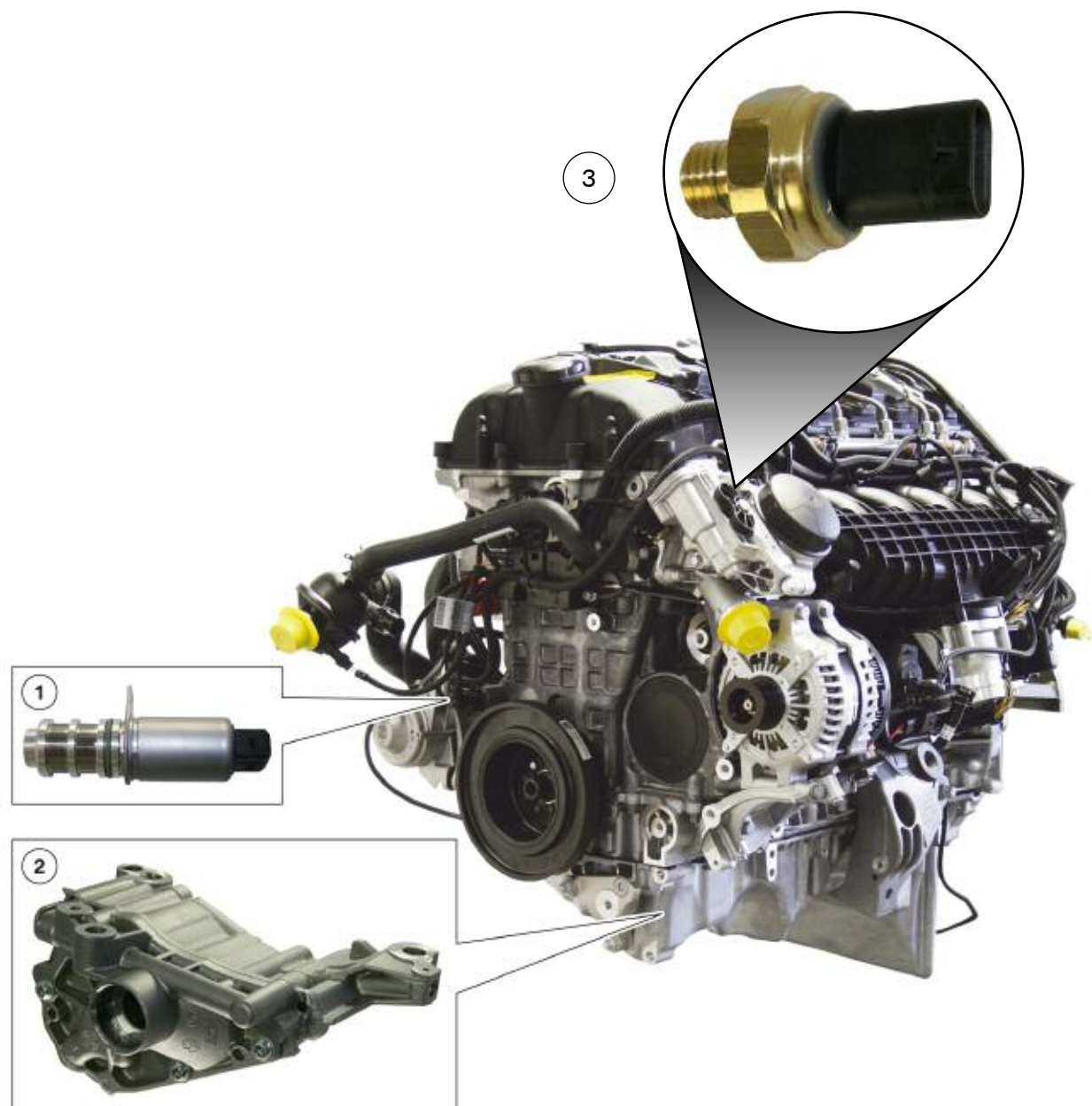
Hydraulic diagram of the N53 engine oil circuit with electronic pressure control



Index	Explanation	Index	Explanation
1	Oil Pan	8	Filter By-pass valve
2	Volume controlled oil pump	9	Engine oil to coolant heat exchanger
3	Pressure regulating valve	10	Oil Pressure sensor
4	Electro-hydraulic pressure regulating valve	11	Lubricating points, cylinder head
5	Non-return valve	12	Lubricating points, engine block
6	Outlet valve at the filter	13	Oil spray nozzles, piston crowns
7	Oil filter		

Note: The N53 hydraulic circuit diagram shown is for explanation of the oil pressure control only, and does not apply directly to the N55 engine.

N55, oil pump and pressure control valve



Index	Explanation
1	Oil pressure control valve
2	Oil pump
3	Oil pressure sensor

Oil Pressure

Since the **N55** engine has an oil pump with electronic volumetric flow control, it is necessary to measure the oil pressure precisely. For this reason, a new oil pressure sensor is installed.

Advantages of the new oil pressure sensor:

- It now measures absolute pressure (previous measured relative pressure).
- It is characteristic map control in all speed ranges.

Oil Pressure Sensor

The new oil pressure sensor can now determine the absolute pressure.

The sensor delivers a more accurate pressure reading which is required for the electronic volume control oil pump function.

The sensor design is identical to that of the (high) fuel pressure sensor. The DME supplies a voltage of 5 Volt to the oil pressure sensor.



N55, oil pressure sensor

Electronic Oil Condition Monitoring

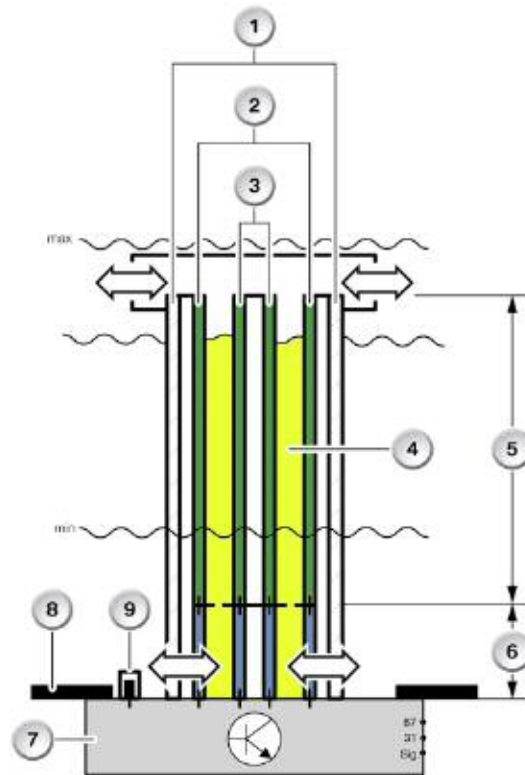
The oil quality sensor is used for measuring the oil level as on previous BMW engines. No oil dipstick is used in most BMW NG Engines.

There is no dipstick including the guide tube on most BMW NG engines. This represents a convenience function for the customer while enabling more accurate recording of the engine oil level.

The engine oil level is measured by an oil condition/quality sensor and indicated in the central information display (CID) or KOMBI. The engine oil temperature and the oil condition are also registered or calculated by the oil condition sensor. The signal from the oil condition sensor is evaluated in the ECM. The evaluated signal is then routed via the proper Bus to the instrument cluster and to the CID.

Registering the engine oil level in this way ensures the engine oil level in the engine does not reach critically low levels thus protecting the engine from the associated damage. By registering the oil condition, it is also possible to determine when the next engine oil change is due. Overfilling the engine with oil can cause leaks - a corresponding warning is therefore given.

Oil condition sensor



Index	Explanation	Index	Explanation
1	Housing	6	Oil Condition Sensor
2	Outer Metal Tube	7	Sensor Electronics
3	Inner Metal Tube	8	Oil Pan
4	Engine Oil	9	Temperature Sensor
5	Oil Level Sensor		

Function of the Oil Condition Sensor

The sensor consists of two cylindrical capacitors arranged one above the other. The oil condition is determined by the lower, smaller capacitor (6). Two metal tubes (2 + 3), arranged one in the other, serve as the capacitor electrodes. The dielectric is the engine oil (4) between the electrodes. The electrical property of the engine oil changes as the wear or ageing increases and the fuel additives break down.

The capacitance of the capacitor (oil condition sensor) changes in line with the change in the electrical material properties of the engine oil (dielectric). This means that this capacitance value is processed in the evaluation electronics (7) integrated in the sensor to form a digital signal.

The digital sensor signal is transferred to the ECM as an indication of the status of the engine oil. This actual value is used in the ECM to calculate the next oil change service due.

The engine oil level is determined in the upper part of the sensor (5). This part of the sensor is located at the same level as the oil in the oil pan. As the oil level drops (dielectric), the capacitance of the capacitor changes accordingly. The electronic circuitry in the sensor processes this capacitance value to form a digital signal and transfers the signal to the ECM.

A platinum temperature sensor (9) is installed at the base of the oil condition sensor for the purpose of measuring the engine oil temperature.

The engine oil level, engine oil temperature and engine oil condition are registered continuously as long as voltage is applied at terminal KL_15. The oil condition sensor is powered via terminal KL_87.



Faults/Evaluation

The electronic circuitry in the oil condition sensor features a self-diagnosis function. A corresponding error message is sent to the ECM in the event of a fault in the oil condition sensor.

Electronic Oil Level Indicator

The oil level is measured in two stages:

- **Static** oil level measurement while the vehicle is stationary
- **Dynamic** oil level measurement during vehicle operation

Static Oil Level Measurement at Engine OFF



This is only a reference measurement as the oil condition sensor (OZS) is flooded when the engine is turned off and can only detect the minimum oil level. The oil level is measured correctly only when the engine is running (see Dynamic oil level measurement).

After switching on the ignition, the static oil level measurement provides the driver with the opportunity of checking whether there is sufficient engine oil for safely and reliably starting the engine.

1. It is important that the vehicle is parked horizontally otherwise the oil level measurement may be incorrect.
2. Select on-board computer function "Service" -> "Oil level".

If there is sufficient engine oil for safe and reliable engine start, a graphic appears in the CID in the form of an engine with a **green oil sump**.



If the oil level is close to minimum, the graphic appears with a **yellow oil sump** and an oil dipstick that represents the low oil level in yellow.

A top-up request +1 liter additionally appears as a text message. The display will not change if less than 1 liter of oil is topped up. MAX is indicated only after topping up a quantity of 1 liter.

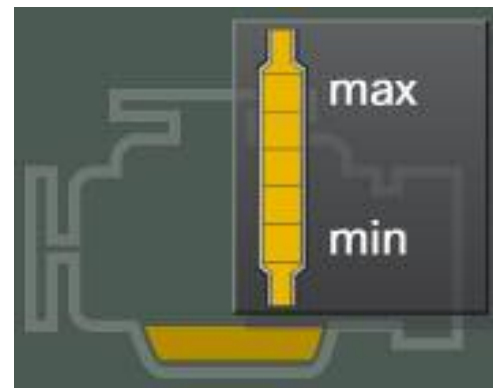
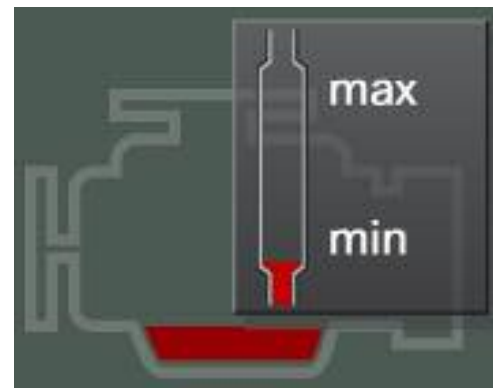
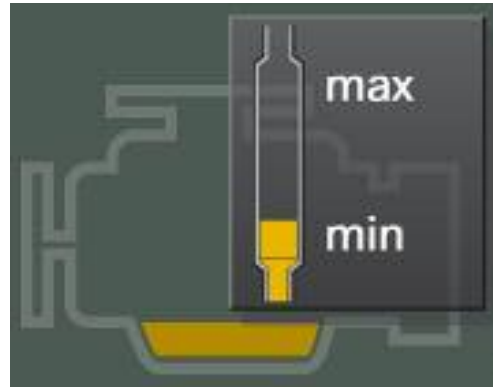
If the oil level drops below minimum, the graphic appears with a **red oil sump** and an oil dipstick that represents the low oil level in red.

A top-up request +1 liter will additionally appear as a text message.

The display will not change if less than 1 liter of oil is topped up. MAX is indicated only after topping up a quantity of 1 liter.

If the oil level is above maximum, the graphic appears with a yellow oil sump and an oil dipstick that represents the high oil level in yellow.

A text message is also displayed for the driver.

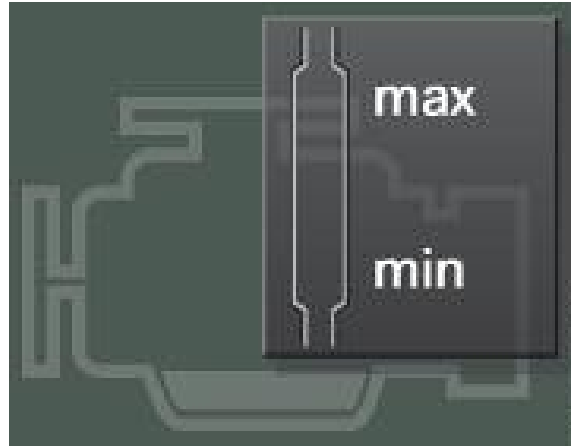


Dynamic Oil Level Measurement During Vehicle Operation



Always perform the dynamic oil level measurement (approx. 5 minutes driving time) after an oil change. The oil level could be misinterpreted as the oil level last stored is initially displayed after an oil change. No oil level is initially stored after replacing or reprogramming the engine control unit. "Oil level below min" is therefore displayed. The correct oil level is indicated after running the engine for approx. 5 minutes.

1. Start engine.
2. Select on-board computer function - "Check oil level".
3. The oil level is measured. A clock symbol may appear while the level measurement is running. The clock symbol appears for up to **50 seconds** after starting the engine when there is no measured value or the long-term value last stored is not within the tolerance range of the currently measured oil level.

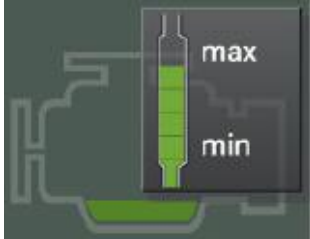
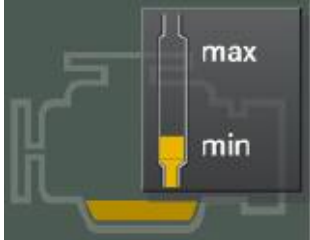
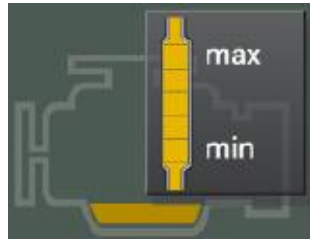


Dynamic oil level measurement begins when following values are reached:

- Engine temperature **> 60°C**
- Engine speed **> 1000 rpm**
- Transverse and longitudinal acceleration **< 4-5 m/s²**.
The transverse acceleration signal is supplied by the DSC. The longitudinal acceleration is calculated from the speed and time factors.
- Increase **< 5%** after covering a distance of approx. 200 m. The increase value is detected by the ambient pressure sensor in the ECM.

On reaching this value, the oil level indicator is updated approx. 5 minutes after starting vehicle operation. The oil level is then continuously measured. The indicator is updated at **20 minute** intervals. The "Check oil level" menu in connection with the dynamic oil level measurement is exited while driving (vehicle speed > 0) approx. 15 seconds after the oil level is displayed.

Display Options

Significance	Remark	Display
Oil OK with engine stationary	The oil level appears in the CID in the form of a graphic together with the "OK" message, indicating that the oil level is in the safe operating range.	Text für Zustand: Keine genaue Messung möglich Ölstand in Ordnung 
Oil level OK at idle speed	The oil level appears in the CID in the form of a graphic together with the "OK" message, indicating that the oil level is in the safe operating range. A further graphic showing a dipstick appears above the displayed graphic. It shows the oil level in green.	
Oil level too low	The oil level appears in the CID in the form of a graphic together with the request to top up with 1 liter of oil. If the oil is not topped up, this request is repeatedly indicated until the minimum oil level is exceeded.	
Oil level too high	The oil level appears in the CID in the form of a graphic together with the indication that the maximum oil level has been exceeded. The excess engine oil must be extracted in the workshop down to the maximum limit. If no oil is extracted, this request will be repeated until the oil level drops below the maximum limit. This represents an advantage that extends beyond the user friendliness of the monitoring system. Over filling of the engine that can cause leaks is indicated as a warning in the instrument cluster.	
Service	There is a problem with the measurement system if SERVICE appears in the display. In this case, the oil level is forecast from the oil consumption last measured and shown in the display. It is not necessary to immediately visit a workshop. The remaining kilometers are shown in the service menu. In the event of the instrument cluster failing, the oil level can also be read out with the diagnosis tester.	

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Heat Management

The engine control unit of the N54 engine controls the coolant pump according to requirements:

- Low output in connection with low cooling requirements and low outside temperatures
- High output in connection with high cooling requirements and high outside temperatures

The coolant pump may also be completely switched off under certain circumstances, e.g. to allow the coolant to heat up rapidly during the warm-up phase. However, this only occurs when no heating is required and the outside temperature is within the permitted range.

The coolant pump also operates differently than conventional pumps when controlling the engine temperature. To date, only the currently applied temperature could be controlled by the thermostat.

The software in the engine control unit now features a calculation model that can take into account the development of the cylinder head temperature based on load. In addition to the characteristic map control of the thermostat, the heat management system makes it possible to use various maps for the purpose of controlling the coolant pump. For instance, the engine control unit can adapt the engine temperature to match the current operating situation.

This means that four different temperature ranges can be implemented:

- 108°C ECO mode
- 104°C Normal mode
- 95°C High mode
- 90°C High + map-thermostat mode

The control system aims to set a higher cylinder-head temperature (108°C) if the engine control unit determines ECO (economy) mode based on the engine performance.

The engine is operated with relatively low fuel consumption in this temperature range as the internal friction is reduced.

An increase in temperature therefore favors slower fuel consumption in the low load range. In HIGH and map-thermostat mode, the driver wishes to utilize the optimum power development of the engine. The cylinder-head temperature is reduced to 90°C for this purpose. This results in improved volumetric efficiency, thus increasing the engine torque. The engine control unit can now set a certain temperature mode adapted to the respective operating situation. Consequently, it is possible to influence fuel consumption and power output by means of the cooling system.

The temperatures specified only ever represent a target value, the attainment of which is dependent on many factors. These temperatures are first and foremost not attained precisely.

The consumption-reducing and power increasing effects arise in each case in a temperature spectrum. The function of the cooling system is to provide the optimal cooling output according to the boundary conditions under which the engine is being operated.

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Intelligent Heat Management Options

The previous section dealt with the various temperature ranges in which heat management is effected. However, an electrically driven coolant pump makes available even further options. For instance, it is now possible to warm up the engine without recirculating the coolant or to allow the pump to continue to operate after turning off the engine to facilitate heat dissipation. The advantages offered by this type of pump are listed in the following table:

Consumption	• Faster warm-up as coolant is not recirculated until needed • Increased compression ratio due to greater cooling output all full load as compared to similar engines without this option
Emissions	• Faster engine warm-up by drastically reduced pump speed and the lower volumetric flow of coolant • Reduced friction • Reduced fuel consumption • Reduced exhaust emissions
Power Output	• Component cooling independent of engine speed • Requirement controlled coolant pump output • Avoidance of power loss
Comfort	• Optimum volumetric flow - Heating capacity reduced as required - Residual heat with engine stationary
Component Protection	• After-running of electric coolant pump = improved heat dissipation from engine switch off point. Allows protection of turbochargers by reduced oil “coking” during heat soak.

System Protection

In the event of the coolant or engine oil being subject to excessive temperatures while the engine is running, certain functions in the vehicle are influenced so that more energy is made available to the engine-cooling system, i.e. temperature-increasing loads are avoided. These measures are divided into two operating modes:

- Component protection
- Emergency

Measures and Displays for Engine Oil Temperature

Engine oil temp (T-oil °C)	Operating mode	Display in Cluster	Power output reduction, Air conditioning	Power output reduction, Engine	Torque converter clutch lockup
148			Start 0 %	Start 0 %	
149			–		
150	Component Protection		–		
151	Component Protection		–	From here = clear reduction	
152	Component Protection		End - 100 %		
153	Component Protection				
154	Component Protection				
155	Component Protection				
156	Component Protection				
157	Component Protection			End @ 90 %	
158	Emergency				Active
159	Emergency				Active
160	Emergency				Active
161	Emergency				Active
162	Emergency				Active
163	Emergency				Active

Measures and Displays for Coolant Temperature

Coolant (T-Coolant)	Operating mode	Display in Cluster	Power output reduction, Air conditioning	Power output reduction, Engine	Torque converter clutch lockup
115					
116					
117	Component Protection		Start 0 %	Start 0 %	
118	Component Protection		–	From here = clear reduction	
119	Component Protection		–	–	
120	Component Protection		End - 100 %	–	
121	Component Protection			–	
122	Component Protection			–	Active
123	Component Protection			–	Active
124	Component Protection			End @ 90 %	Active
125	Emergency				Active
126	Emergency				Active
127	Emergency				Active
128	Emergency				Active
129	Emergency				Active

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Emissions Management

Model: All Equipped with OBD II

Production: 1995 to Present

**Manufacturer: Bosch and Siemens Engine
Control Modules**

OBJECTIVES

After completion of this module you will be able to:

- Describe what is required to illuminate the Malfunction Indicator Lamp
- Access readiness codes using the ISID
- Understand how a oxygen sensor operates
- Understand how the DM-TL system operates
- Test a DM-TL system using a smoke tester
- Understand the how the NVLD system operates
- Understand how misfire monitoring takes place

Introduction

OBD History

As a result of low fuel costs, together with a high standard of living and a dense population, the state of California was affected particularly heavily by air pollution. This spurred the state to pass the most comprehensive and stringent emissions and consumption laws in the world. The automobile manufacturers were reminded of their obligations and this drove them on to comply with the new regulations at enormous expense.

- In continuing efforts to improve air quality, the Environmental Protection Agency (EPA) amended the Clean Air Act in 1990. The Clean Air Act was originally mandated in 1970. The Clean Air Act has a direct impact on automobile manufactures whereby they are responsible to comply with the regulations set forth by the EPA. The 1990 amendment of the Clean Air Act set forth all of the changes currently being introduced on vehicles sold in the United States today.
- In 1967, the State of California formed the California Air Resources Board (CARB) to develop and carryout air quality improvement programs for California's unique air pollution conditions. Through the years, CARB programs have evolved into what we now know as ON Board Diagnostics and the National Low Emission Vehicle Program.
- The EPA has adopted many of the CARB programs as National programs and laws. One of these earlier programs was OBD I and the introduction of the "Check Engine" Light.
- BMW first introduced OBD I and the check engine light in the 1987 model year. This enhanced diagnosis through the display of "flash codes" using the check engine light as well as the BMW 2013 and GT-1. OBD I was only the first step in an ongoing effort to monitor and reduce tailpipe emissions.
- By the 1989 model year all automotive manufactures had to assure that all individual components influencing the composition of exhaust emissions would be electrically monitored and that the driver be informed whenever such a component failed.
- Since the 1996 model year all vehicles must comply with OBD II requirements. OBD II requires the monitoring of virtually every component that can affect the emission performance of a vehicle plus store the associated fault code and condition in memory.

If a problem is detected and then re-detected during a later drive cycle more than one time, the OBD II system must also illuminate the "Check Engine" Light in the instrument cluster to alert the driver that a malfunction has occurred. **However, the flash code function of the Check Engine Light in OBD I vehicles is not a function in OBD II vehicles.**

- This requirement is carried out by the Engine Control Module (ECM/DME) as well as the Automatic Transmission Control Module (EGS/AGS) and the Electronic Throttle Control Module (EML) to monitor and store faults associated with all components/systems that can influence exhaust and evaporative emissions.

OBD I

The essential elements here are that electrical components which affect exhaust emissions are monitored by the motor-electronics system and an optical warning signal (CHECK ENGINE Light) is issued in the event of an OBD I-relevant malfunction. The corresponding fault can be read out via a flashing code without the aid of a testing device.

OBD II

Since January 1996, OBD II has been compulsory on all vehicles in the US market. The main difference from OBD I is that not only are the purely electrical components monitored but also all the systems and processes that affect exhaust emissions and fuel system evaporative emissions.

The operational reliability of the exhaust-treatment system must be guaranteed for 5 years and/or 100,000 miles; this is maintained by emission certification. In this case, the data relevant to exhaust/evaporative emissions are read out via a standardized interface with a universal "diagnosis device". If a violation is identified, the vehicle manufacturer in question is legally bound to eliminate the fault throughout the entire vehicle series.

Objectives of OBD II

- Permanent monitoring of components relevant to exhaust emissions in all vehicles.
- Immediate detection and indication of significant emission increases over the entire service life of each vehicle.
- Permanently low exhaust emissions in the field.



Emissions Overview

Purpose of the System

What is OBD?

Today many of the engine's control systems such as throttle opening, fuel injection, ignition, emissions and performance are controlled by an electronic control module and the related sensors and actuators. The first on-board diagnostic (OBD) systems were developed by the manufacturer as a way to detect problems with the electronic systems.

Beginning with 1994 model year, requirements for OBD systems have been established by the EPA and CARB. The purpose of the OBD system is to assure proper emission control system operation for the vehicle's lifetime by monitoring emission-related components and systems for deterioration and malfunction. This includes also a check of the tank ventilation system for vapor leaks.

The OBD system consists of the engine and transmission control modules, their sensors and actuators along with the diagnostic software. The control modules can detect system problems even before the driver notices a driveability problem because many problems that affect emissions can be electrical or even chemical in nature.

What happens if a problem is detected?

When the OBD system determines that a problem exists, a corresponding "Diagnostic Trouble Code" is stored in the control module's memory.

The control module also illuminates a yellow dashboard Malfunction Indicator Light indicating "Check Engine" or "Service Engine Soon" or displays an engine symbol.

This light informs the driver of the need for service, NOT of the need to stop the vehicle. A blinking or flashing dashboard light indicates a rather severe level of engine misfire.

After fixing the problem the Fault code is deleted to turn off the light. If the conditions that caused a problem are no longer present the vehicle's OBD system can turn off the dashboard light automatically. If the OBD system evaluates the component or system three consecutive times and no longer detects the initial problem, the dashboard light will turn off automatically.



What is the most common problem detected by OBD?

■ Fuel Filler Cap

If the fuel filler cap is not properly closed after refueling, the OBD system will detect the vapor leak that exists from the cap not being completely tightened.

If you tighten the cap subsequently, the dashboard light should be extinguished within a few days or after deleting the Fault code. This is not an indication of a faulty OBD system. The OBD system has properly diagnosed the problem and accordingly alerted the driver by illuminating the dashboard light.

Please check the fuel filler cap first when the dashboard light comes on to avoid unnecessary diagnostic time. To check the fuel filler cap turn the cap to the right until you hear a click or the cap reaches the full stop. Make sure that the retaining strap is not caught between the filler pipe and the fuel filler cap. If the light should stay on further in depth evaporative leak diagnosis is required.

■ Misfire Detection

As part of the CARB/OBD II regulations the Engine Control Module must determine if misfire is occurring and also identify the specific cylinder(s). The ECM will determine severity of the misfire event, and whether it is **emissions relevant** or **catalyst damaging** (more information is available in the Emission Management section). In order to accomplish these tasks the ECM monitors the crankshaft for acceleration losses during firing segments of cylinder specific firing order. If the signal is implausible an erroneous reference mark can be obtained by the ECM which will result in a misfire fault being set.

Possible causes of cylinder misfire faults (actual field findings):

- Vehicle ran low or out of fuel
- Poor fuel quality (ex. water in fuel, customer uses an additive, etc.)
- Low/high fuel pressure
- Ignition coil
- Fouled spark plug(s)
- Restricted / contaminated fuel injector(s)
- Crankshaft position sensor
- Poor combustion due to low compression or high leakage
- Blocked/restricted Catalyst

Engine Misfire Diagnosis

Engine Misfire is the result of inefficient combustion in one or more cylinders. The causes of Engine Misfire are extensive but can be grouped into the following sub-systems. Consider the charts below as an additional diagnostic aid once ISTA is connected, the correct fault symptom has been chosen and the fault memory has been interrogated. Follow the Test Module as displayed by ISTA.

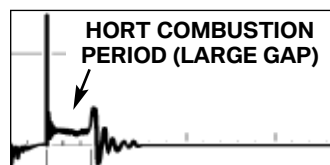
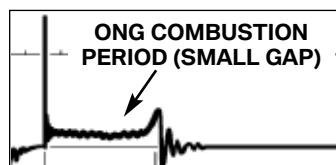
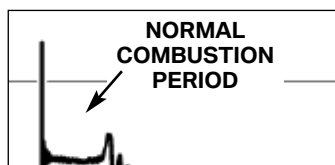
IGNITION SYSTEM			
COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Spark Plug:	- Incorrect spark plug installed - Electrode gap closed or too small - Electrode(s) missing - Oil or fuel fouled spark plug - Ceramic insulation cracked	Secondary Ignition	- Verify correct spark plug - Replace if necessary - Swap with another cylinder
Secondary circuit: (wiring, M73-cap, rotor)	- Wet or moist due to water infiltration. - High resistance due to corrosion.		- Check water ingress, repair, replace - Check resistance value, replace
Ignition Coil(s):	- Secondary/Primary Circuits open or shorted. - Housing cracked, damaged.	Secondary and Primary	- Inspect and replace if necessary - Swap with another cylinder
Ignition Coil & Engine Harness Connectors	Power supply, Primary control and ground (shunt signal) circuits impaired.	Primary Ignition & Term 4A feed-back Preset Measurements	- Look for open, loose connector, corrosion, crossed or backed out pins (also consider ignition unloader or ECM relay on MY97 and newer cars). - Determine defective condition, repair or replace.

- A secondary ignition oscilloscope display provides vital information about the ignition system's condition.
- Follow the precautions in group 12 of the Repair Instructions.
- Use the following scope patterns as a guideline for ignition system diagnosis.



Evaluation of secondary signal amplitude at idle speed.

1. Normal Ignition Voltage Peak: **Spark Plug is OK**
2. Low Ignition Voltage Peak: **Gap too small (defective)**
3. High Ignition voltage peak: **Gap too large (defective)**



ENGINE MECHANICAL SYSTEMS

COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Pistons, Rings, Valves, Camshaft:	Hole in piston crown, ring(s) broken, valve(s) not seating, valve(s) bent, valve spring(s) broken, camshaft lobe cracked, etc.	- Idle Quality - Rough Running Preset. - Cylinder compression & leakdown tests.	Correct condition as required.
Hydraulic Valve Actuator (HVA):	- HVA oil bore restricted or blocked. - Engine oil pressure builds up too slow. Intermittent Misfire Fault - Not Currently Present. - HVA binding/sticking in bore.	- Idle Quality - Rough Running Preset. - Listen to HVA - Check Oil Pressure - Cylinder leakdown	- Always consider mechanical components when diagnosing misfire. - Inspect for scoring.
Vacuum Leaks:	Unmetered vacuum leaks causing a "lean" operating condition. Possible "Excessive Mixture Deviation" fault codes.	- Idle Quality - Rough Running Preset. Test for vacuum leaks per Repair Instr. and SIB on "Crankcase Ventilation". - Interpret Add. & Multiple adaptation values	Correct condition as required.

FUEL QUALITY, DELIVERY, INJECTION & EVAPORATIVE SYSTEMS

COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Fuel (quality):	Contaminated fuel. (water, other non combustible).		Clean fuel system, replace fuel.
Fuel Delivery:	- Fuel pump delivery pressure low, restriction in fuel line to fuel rail or running loss valve. - Fuel filter restricted (clogged). - Low fuel in tank.	- Check fuel pressure & volume. - Check fuel pump power and ground	- Determine restriction/flow reduction, replace component as necessary. - Interpret Additive and Multiplicative adaptation values.
Running Loss Valve:	Valve stuck in "small circuit" position.	Check valve	Display "diagnosis requests" in ISTA and test valve for proper function, replace valve as necessary.
Fuel Injectors:	- Leaking fuel injector pintle seats cause rich engine starts with hot ambient temperatures. - Blocked (dirty) injector(s).	- Ti Preset & status page. - Sec Ign scope pattern.	- Check injectors for leakage. - Swap suspect injector with another cylinder. - Inspect injector, replace if necessary.
Fuel Pressure Regulator:	Regulator defective, causes fluctuation in the injected quantity of fuel causing mixture adaptation faults.	Fuel pressure	Check nominal fuel pressure value with engine operating under varied speeds.
Evaporative System:	Defective evaporative system vent causing fuel tank collapse and fuel starvation.	ISTA status, Evap test with pressure tool, purge valve func. test.	- Check the fuel tank condition and vent line. - Check Fresh Air Valve on TLEV E36 vehicles or LDP/ DM-TL and filter on ORVR vehicles for proper system "breathing".

IMPLAUSIBLE ECM CONTROL FUNCTION OR SENSOR INPUT SIGNALS

COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Crankshaft Position Sensor or Increment Wheel:	• Implausible signal for misfire detection. • Increment wheel loose or damaged (internal on M44, M52 and M54, external on M62 & M73). • Air gap between sensor and wheel. • Noticeable at higher rpm.	• ISTA preset measurement.	• Determine defective sensor or increment wheel and replace.
Catalyst Damaged:	• Excessive exhaust back pressure (bank specific fault present, more noticeable under heavy load and high rpm).	• ISTA preset measurement of oxygen sensor. • Back pressure test per SIB with Special Tool.	• Determine catalyst condition, replace or repair as necessary.
Oxygen Sensor:	• Excessive mixture deviation, possible vacuum leaks.	• Monitor oxygen sensor signal via ISTA/IMIB.	• Swap sensor from other bank (if applicable) and see if fault transfers to other bank.
Engine Control Module	• Internal control module fault. • Misfire Reprogramming.	• Check fault memory. • Refer to SIB	• Highly unlikely but must be considered. • Check Model/Prod range - reprogram

When diagnosing a Misfire fault code, Remember:

“Misfire” is caused by a defect in the internal combustion engine or a defect in the control of the engine operation.

“Misfire” is the result of improper combustion (variation between cylinders) as measured at the crankshaft due to:

- Engine mechanical defects; breakage, wear, leakage or improper tolerances.
- Excessive mixture deviation; air (vacuum leaks), fuel and all the components that deliver air/fuel into the combustion chambers.
- Faulty ignition; primary, secondary including spark plugs.
- Faulty exhaust flow; affecting back pressure.
- Tolerance parameters; ECM programming.

A Misfire fault code(s) is the “symptom” of a faulty input for proper combustion. When diagnosing a misfire, review the charts to assist you in finding the faulty input.

Misfire Detection

As part of the OBD II regulations the ECM must determine misfire and also identify the specific cylinder(s), the severity of the misfire and whether it is emissions relevant or catalyst damaging based on monitoring crankshaft acceleration.

In order to accomplish these tasks the ECM monitors the crankshaft for acceleration by the impulse wheel segments of cylinder specific firing order. The misfire/engine roughness calculation is derived from the differences in the period duration of individual increment gear segments.

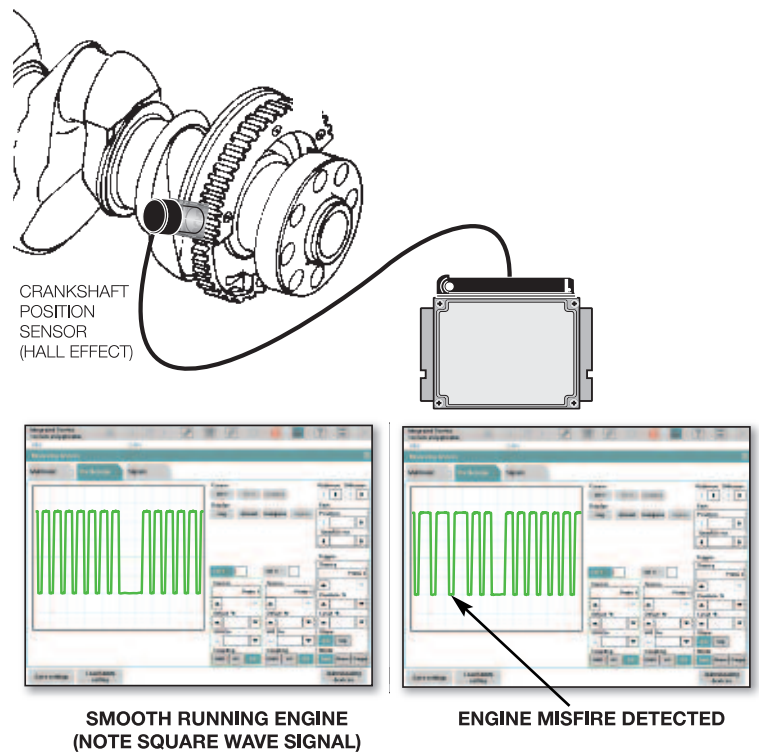
Each segment period consist of an angular range of 90° crank angle that starts 54° before Top Dead Center.

If the expected period duration is greater than the permissible value a misfire fault for the particular cylinder is stored in the fault memory of the ECM.

Depending on the level of misfire rate measured the ECM will illuminate the "Malfunction Indicator Light", deactivate the specific fuel injector to the particular cylinder and switch oxygen sensor control to open-loop.

In order to eliminate misfire faults that can occur as a result of varying flywheel tolerances (manufacturing process) an internal adaptation of the flywheel is made. The adaptation is made during periods of decel fuel cut-off in order to avoid any rotational irregularities which the engine can cause during combustion. This adaptation is used to correct segment duration periods prior to evaluation for a misfire event.

If the sensor wheel adaptation has not been completed the misfire thresholds are limited to engine speed dependent values only and misfire detection is less sensitive. The crankshaft sensor adaptation is stored internally and is not displayed via ISTA. If the adaptation limit is exceeded a fault will be set.



Overview of the National Low Emission Vehicle Program

Emission Reduction Stages

While OBD II has the function of monitoring for emission related faults and alerting the operator of the vehicle, the National Low Emission Vehicle Program requires a certain number of vehicles produced (specific to manufacturing totals) currently comply with the following emission stages;

TLEV: Transitional Low Emission Vehicle

LEV: Low Emission Vehicle

ULEV: Ultra Low Emission Vehicle.

SULEV Super Ultra Low Emission Vehicle

Prior to the National Low Emission Vehicle Program, the most stringent exhaust reduction compliancy is what is known internally within BMW as HC II. The benefit of exhaust emission reductions that the National Low Emission Vehicle Program provides compared with the HC II standard is as follows;

Grams/Mile @ 50° F - Cold Engine Startup				
Compliance Level	NMHC Non-Methane Hydrocarbon	CO Carbon Monoxide	NOx Oxide(s) of Nitrogen	
TLEV	0.250	3.4	0.4	
LEV	0.131	3.4	0.2	
ULEV	0.040	1.7	0.2	

Grams/Mile @ 50,000 miles				
Compliance Level	NMHC Non-Methane Hydrocarbon	CO Carbon Monoxide	NOx Oxide(s) of Nitrogen	
TLEV	0.125	3.4	0.4	
LEV	0.075	3.4	0.2	
ULEV	0.040	1.7	0.2	

Grams/Mile @ 100,000 miles				
Compliance Level	NMHC Non-Methane Hydrocarbon	CO Carbon Monoxide	NOx Oxide(s) of Nitrogen	
TLEV	0.156	4.2	0.6	
LEV	0.090	4.2	0.3	
ULEV	0.055	2.1	0.3	

PZEV regulations include:

- Vehicles must meet SULEV tailpipe emissions standard (approx. 1/5 of ULEV standards)
- Vehicles conform to Zero Evaporative Emissions
- Vehicles subject to extended OBD regulations
- Emission relevant components warrantied for 15 years or 150,000 miles

BMW SULEV & PZEV Engines**BMW M56 Engine**

The following components are used to achieve SULEV (Super Ultra Low Emission Vehicle) and ZEV Zero Evaporative Emission requirements:

- Pistons - Revised to change spark travel path
- Catalytic Converters - Ceramic carriers with high cell density for better "Warm Up" Control
- Oxygen Sensors - Planar wide band O₂ sensors in front of the cats
- Vanos - Positioning changed during start up for improved start up and emissions
- Fuel Pump Control - Revised with raised pressure and more accurate flow control
- Fuel Injectors - New design for improved fuel flow and higher working pressure
- Fuel System - All metal fuel system components made of stainless steel
- Air Intake System - Revised to block HC escape
- Crankcase Ventilation - Revised
- Secondary Air System - Mass air flow sensor to monitor secondary air flow
- Cooling System - Revised to reduce Ozone levels



BMW N51 Engine

In order to comply with SULEV requirements, the **N51** is another variant of the N52 engine. There are various measures to meet the EPA/CARB standards, some of which are familiar from the previous SULEV (M56) engine.

Some of the SULEV measures for the N51 include:

- Near engine catalyst with additional underbody catalyst
- Secondary air system
- Optimized combustion chamber geometry in cylinder head
- Modified piston crown for lower compression
- Plastic valve cover with integrated crankcase vent valve and separator (from N52KP)
- Stainless steel fuel lines with threaded connections
- Radiator with “Prem-air” coating
- Throttle system - EGAS08 carried over from N52KP
- Airbox with Activated carbon filter for EVAP control
- Purge system pipes are made from “optimized” plastic



Catalytic Converters

The catalysts attached in direct proximity to the engine and are equipped with ceramic(s) carriers in high cell density technology. These converters reach operating temperature faster and offer quicker control of exhaust emissions. Vehicles are also equipped with dual downstream converters.

Oxygen Sensors

The M56 engine use for Oxygen sensors, two planar broadband sensors upstream of the converter and two sensors downstream.

The planar broadband sensor reach operating temperature very fast and are able to effect fuel mixtures in approximately 5 seconds.

Fuel Pump System

Fuel system operating pressure is increased to 5 Bar.

The fuel pump is controlled by the Fuel pump control unit, based on engine demand as received from the DME over the Lo-CAN. The fuel pump control unit additionally receives information over the K-Bus, specifically crash information from the MRS.

Fuel Injectors

Nozzle diameter of the fuel injectors has been reduced and the installation angle has been changed. The injectors were also adapted to perform at the higher system operating pressure.

Injectors screw into the rail and a tap to test pressure readings is NOT provided.



Secondary Air System

The secondary air pump has been revised to improve its response time in cold weather starting situations.

A HFM (Hot Film Air Mass Meter) has been added to the secondary air system to monitor air volume pumped into the exhaust for more accurate control of the NOx emissions.



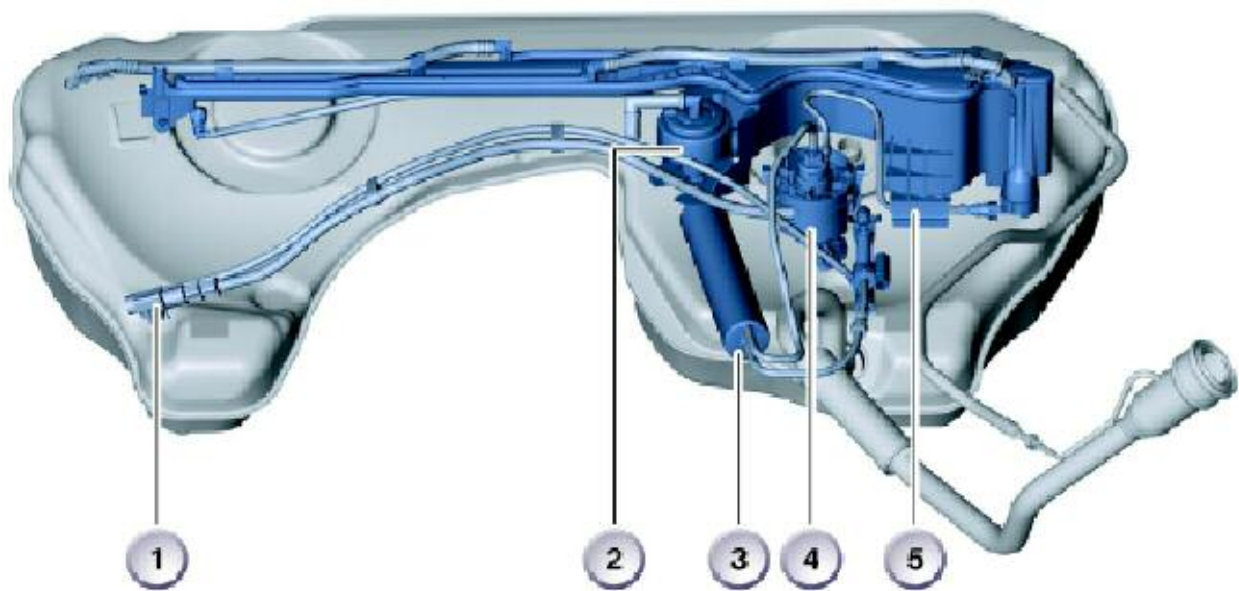
Fuel System

In order to meet the **Zero Evaporative Emission** requirement, the fuel system was completely revised. The fuel tank, tank filler neck, charcoal canister, fuel rail and tank ventilation valve are all made of stainless steel.

When perform repairs on the fuel system, it is imperative that all fitting remain clean and that the proper tightening torques are observed.

The fuel tank is manufactured of high grade steel and completely coated to meet the requirements of a minimum durability of 15 years.

The fuel tank can be exchanged only as a complete unit.



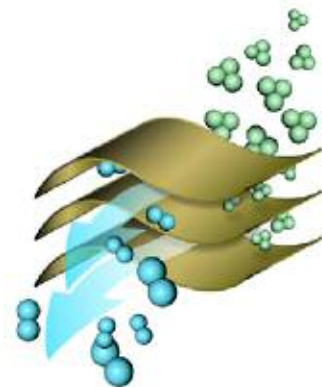
Index	Explanation
1	Syphon Jet
2	Roll over valve
3	Fuel Filter
4	Electric fuel pump
5	Liquid Vapor Separator

Cooling System

The radiator of SULEV looks similar to the standard radiator.

The surface of the cooling fins are coated with a special "PremAir" coating.

The coating consists of multiple porous layers of a catalytic surface. The task of the catalyst coating is to convert Ozone into Oxygen.



N26 Engine

The N26 engine is the third generation of the BMW SULEV engines used in the US market. The N26 shares many technical features with the current N20 engine. This engine is currently available in the F30 328i as of 3/2012. The new N26 engine is the first turbocharged SULEV gasoline engine worldwide that requires no secondary air system.

This not only means that the BMW Group is complying with the requirements of the world's most stringent exhaust emission legislation, but also underlines the fact that the term "premium" is being defined by the many facets of substantiality to an ever increasing extent. Twin Power Turbo technology enables dynamic performance and achievement of low fuel consumption while adhering to the most stringent exhaust emission limits.

N26B2000 engine

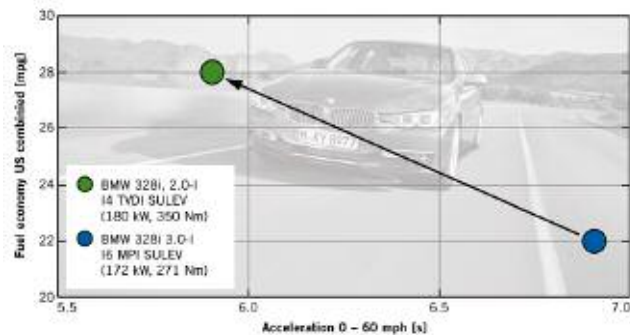


Some of the SULEV measures for the N26 engine include:

- Crankcase ventilation pressure regulating valve is now welded to the cylinder head cover. This is now considered hydrocarbon emissions tight.
- The air intake and exhaust systems differ slightly on the N26 engine.
- There is an additional HC filter located in the air filter box to capture hydrocarbon emissions.
- The exhaust turbocharger now incorporates an electric wastegate valve actuator.
- Vacuum reservoir no longer integrated into engine cover.
- The fuel injectors are referred to as “sorted”, which means that they are less prone to leakage. The leakage is $<0.5\text{mm}^3/\text{min}$ @20MPa (200bar).
- Engine management MEVD17.2.9 with new internal programming.
- Adaption algorithm for continuous injector individual measurement of the opening and closing time. (flight phase of the injector needle) by characteristics of the current signal. Higher precision of the injected fuel quantity, especially required for ‘double’ injection for heating-up of catalytic converter.
- The fuel lines and the HP fuel pump have been modified to insure that no leakage occurs.
- Catalytic Converter is fitted in close proximity to the engine, the close-coupled catalytic converter has been designed as a two-stage construction (first monolith: 900 cpsi, second monolith: 600 cpsi) “Cells Per Square Inch”. The catalytic converter used on the N20 uses 600 cpsi on the first monolith and 400 cpsi on the second.
- There is an additional catalytic converter located under the vehicle downstream of the exhaust. This converter is not monitored and contains 400 cpsi.

■ Driving Performance and Fuel Consumption

The SULEV version of BMW’s new 2.0-l four-cylinder gasoline engine also offers the dynamic driving performance that is typical of BMW in conjunction with low fuel consumption. The engine delivers a maximum torque of 350 Nm and a maximum power of 180 kW/240 hp. These figures represent a 30% and 4% improvement over the respective values of the predecessor engine. At the same time, the useable engine torque range is greatly enhanced. Compared with its predecessor the N51, the new 328i SULEV boasts significant improvements in driving performance, as well as a substantial reduction in fuel consumption.



System Monitoring

Within the framework of OBD II, certain components/systems must be monitored once per driving cycle while other control systems (e.g. misfire detection) must be monitored permanently. A "driving cycle" consists of engine startup, vehicle operation (exceeding of starting speed), coasting and engine stopping.

Permanent Monitoring

Permanently monitored systems are monitored according to temperature immediately after startup. In the event of malfunctions (e.g. oxygen sensor), the Malfunction Indicator Light will illuminate immediately.

The following are monitored permanently:

- Misfire Detection
- Fuel System (duration of injection)
- All emission related electrical circuits, components and systems of the ECM, TCM and EML (if equipped).

Cyclic Monitoring

Systems monitored once per driving cycle will only result in a fault being registered after the corresponding operating conditions have been completed. Therefore, there is no possibility for checking when the engine is started up briefly and then shut down.

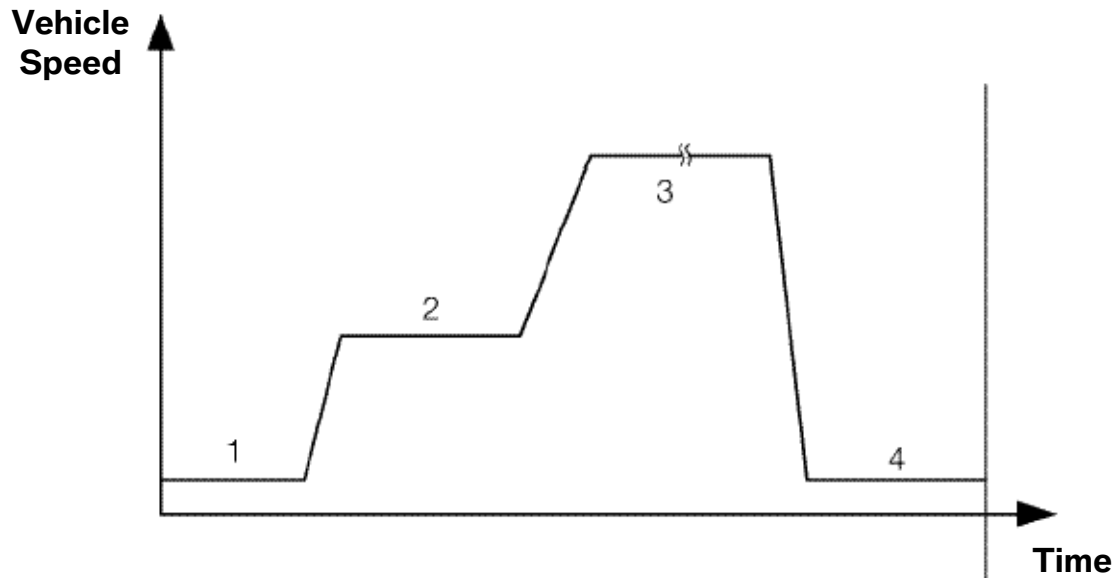
The following are monitored once per driving cycle:

- Oxygen Sensor Function
- Secondary Air Injection System
- Catalytic Converter Function (efficiency)
- Evaporative Vapor Recovery System

Due to the complexity involved in meeting the test criteria within the defined driving cycle, all tests may not be completed within one "customer driving cycle". The test can be successfully completed within the defined criteria, however customer driving styles may differ and therefore may not always monitor all involved components/systems in one "trip".

Drive Cycle

The following diagram shows how a drive cycle is set (test drive) in order for all the systems to be monitored once. The test conditions can be created in any desired order after startup.



Example of a Drive Cycle for Completing all OBD II Relevant Checks:

1. Engine cold start, idling, approximately 3 minutes. Evaluated:
 - Secondary Air System
 - Evaporative Leak Detection (LDP Equipped Vehicles)
2. Constant driving at 20 to 30 MPH, approximately 4 minutes. Evaluated:
 - Oxygen Sensors - Achieved "Closed Loop" Operation
 - Oxygen Sensors - Response Time and Switching Time (Control Frequency)
3. Constant driving at 40 to 60 MPH, approximately 15 minutes (sufficient vehicle coasting phases included). Evaluated:
 - Catalytic Converter Efficiency
 - Oxygen Sensors - Response Time and Switching Time (Control Frequency)
4. Engine idling, approximately 5 minutes. Evaluated:
 - Tank-Leak Diagnosis (DM-TL Equipped Vehicles after KL 15 is switched OFF)

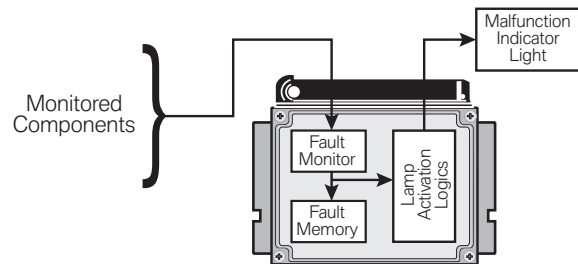


The diagnostic sequence illustrated above will be interrupted if:

- **The engine speed exceeds 3000 RPM**
- **Large fluctuations in the accelerator pedal position.**
- **The driving speed exceeds 60 MPH**

The “Malfunction Indicator Light” (MIL) will be illuminated under the following conditions:

- Upon the completion of the next consecutive driving cycle where the previously faulted system is monitored again and the emissions relevant fault is again present.
- Immediately if a “Catalyst Damaging” fault occurs (Misfire Detection).



The illumination of the light is performed in accordance with the Federal Test Procedure (FTP) which requires the lamp to be illuminated when:

- A malfunction of a component that can affect the emission performance of the vehicle occurs and causes emissions to exceed 1.5 times the standards required by the (FTP).
- Manufacturer-defined specifications are exceeded.
- An implausible input signal is generated.
- Catalyst deterioration causes HC-emissions to exceed a limit equivalent to 1.5 times the standard (FTP).
- Misfire faults occur.
- A leak is detected in the evaporative system, or “purging” is defective.
- ECM fails to enter closed-loop oxygen sensor control operation within a specified time interval.
- Engine control or automatic transmission control enters a "limp home" operating mode.
- Ignition is on (KL15) position before cranking = Bulb Check Function.

Within the BMW system the illumination of the Malfunction Indicator Light is performed in accordance with the regulations set forth in CARB mail-out 1968.1 and as demonstrated via the Federal Test Procedure (FTP). The following page provides several examples of when and how the Malfunction Indicator Light is illuminated based on the "customer drive cycle".

	DRIVE CYCLE # 1			DRIVE CYCLE # 2			DRIVE CYCLE # 3			DRIVE CYCLE # 4			DRIVE CYCLE # 5			* DRIVE CYCLE # 43		
TEXT NO.	FUNCTION CHECKED	FAULT CODE SET	MIL STATUS CHECK ENGINE	FUNCTION CHECKED	FAULT CODE SET	MIL STATUS CHECK ENGINE	FUNCTION CHECKED	FAULT CODE SET	MIL STATUS CHECK ENGINE	FUNCTION CHECKED	FAULT CODE SET	MIL STATUS CHECK ENGINE	FUNCTION CHECKED	FAULT CODE SET	MIL STATUS CHECK ENGINE	FUNCTION CHECKED	FAULT CODE SET ERASED	MIL STATUS CHECK ENGINE
1.	YES	YES	OFF															
2.	YES	YES	OFF	YES	YES	ON												
3.	YES	YES	OFF	NO	NO	OFF	YES	YES	ON									
4.	YES	YES	OFF	YES	NO	OFF	YES	NO	OFF	YES	YES	OFF	YES	YES	ON			
5.	YES	YES	OFF	YES	YES	ON	YES	NO	ON	YES	NO	ON	YES	NO	OFF			
6.	YES	YES	OFF	YES	YES	ON	YES	NO	ON	YES	NO	ON	YES	NO	OFF	YES	FAULT CODE ERASED	OFF

1. A fault code is stored within the ECM upon the first occurrence of a fault in the system being checked.
2. The "Malfunction Indicator Light" will not be illuminated until the completion of the second consecutive "customer driving cycle" where the previously faulted system is again monitored and a fault is still present or a catalyst damaging fault has occurred.
3. If the second drive cycle was not complete and the specific function was not checked as shown in the example, the ECM counts the third drive cycle as the "next consecutive" drive cycle. The "Malfunction Indicator Light" is illuminated if the function is checked and the fault is still present.
4. If there is an intermittent fault present and does not cause a fault to be set through multiple drive cycles, two complete consecutive drive cycles with the fault present are required for the "Malfunction Indicator Light" to be illuminated.
5. Once the "Malfunction Indicator Light" is illuminated it will remain illuminated unless the specific function has been checked without fault through three complete consecutive drive cycles.
6. The fault code will also be cleared from memory automatically if the specific function is checked through 40 consecutive drive cycles without the fault being detected or with the use of either the ISTA and IMIB.

Note: In order to clear a catalyst damaging fault (see Misfire Detection) from memory, the condition must be evaluated for 80 consecutive cycles without the fault reoccurring.

With the use of a universal scan tool, connected to the "OBD" DLC an SAE standardized DTC can be obtained, along with the condition associated with the illumination of the "Malfunction Indicator Light". Using the ISTA, a fault code and the conditions associated with its setting can be obtained prior to the illumination of the "Malfunction Indicator Light".

Readiness Code

The readiness code provides status (Yes/No) of the system having completed all the required monitoring functions or not. The readiness code is displayed with an aftermarket Scan Tool or ISTA. The code is a binary (1/0) indicating;

- 0 = Test Not Completed or Not Applicable - six cylinder vehicles (not ready - V8 and V12)
- 1 = Test Completed - six cylinder vehicles (ready - V8 and V12)

A "readiness code" must be stored after any clearing of fault memory or disconnection of the ECM. A readiness code of "0" will be stored (see below) after a complete diagnostic check of all components/systems, that can turn on the "Malfunction Indicator Light" is performed.

The readiness code was established to prevent anyone with an emissions related fault and a "Malfunction Indicator Light" on from disconnecting the battery or clearing the fault memory to manipulate the results of the emissions test procedure (IM 240).

Interpretation of the Readiness Code by the ECM(s) (SAE J1979)

The complete readiness code is equal to "one" byte (eight bits). Every bit represents one complete test and is displayed by the scan tool, as required by CARB/EPA. For example:

0 = EGR Monitoring (=0, N/A with BMW)

1 = Oxygen Sensor Heater Monitoring

1 = Oxygen Sensor Monitoring

0 = Air Condition (=0, N/A with BMW)

1 = Secondary Air Delivery Monitoring

1 = Evaporative System Monitoring

0 = Catalyst Heating

1 = Catalyst Efficiency Monitoring



Drive the car in such a manner that all tests listed above can be completed (refer to the drive cycle). When the complete "readiness code" equals "1" (ready) then all tests have been completed and the system has established its "readiness".

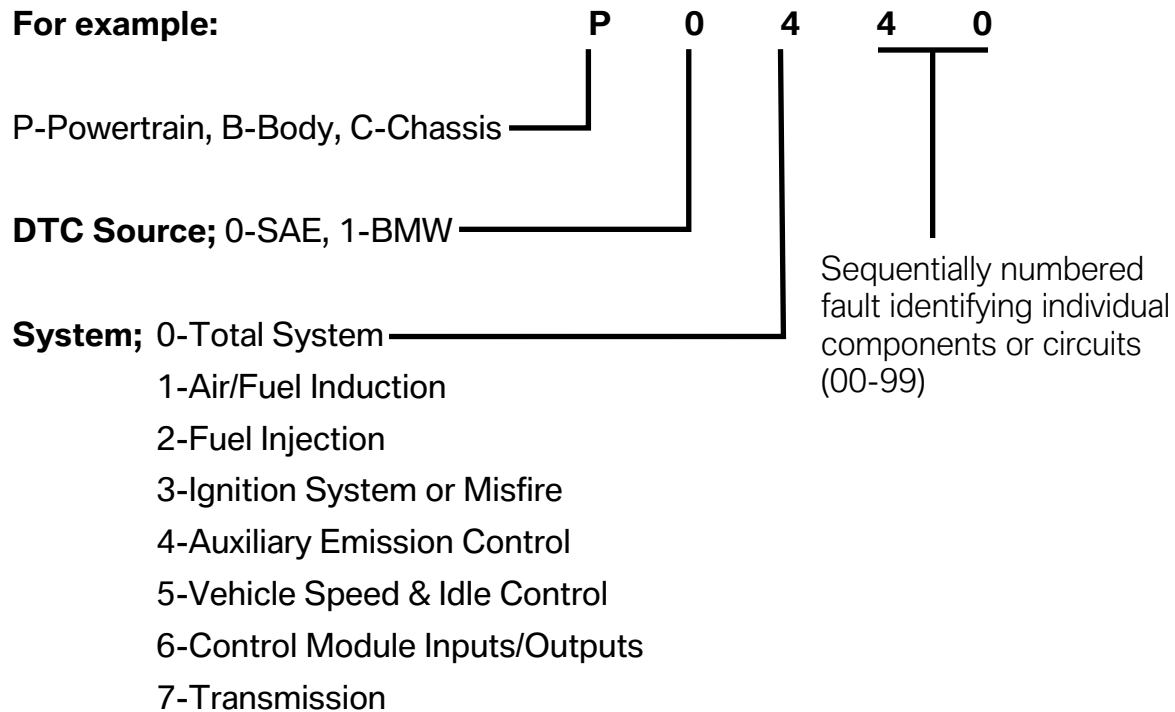
Readiness Code using the ISTA

The readiness code can be checked with the ISTA. This is particularly helpful in verifying that "drive cycle" criteria was achieved. A repair can be confirmed before returning the vehicle to the customer by a successfully completed drive cycle.

OBD II Diagnostic Trouble Codes (DTC)

The Society of Automotive Engineers (SAE) established the Diagnostic Trouble Codes used for OBD II systems (SAE J2012). The DTC's are designed to be identified by their alpha/numeric structure. The SAE has designated the emission related DTC's to start with the letter "P" for Powertrain related systems, hence their nickname "P-code".

For example:



- DTC's are stored whenever the "Malfunction Indicator Light" is illuminated.
- A requirement of CARB/EPA is providing universal diagnostic access to DTC's via a standardized Diagnostic Link Connector (DLC) using a standardized tester (scan tool).
- DTC's only provide one set of environmental operating conditions when a fault is stored. This single "Freeze Frame" or snapshot refers to a block of the vehicles environmental conditions for a specific time when the fault first occurred. The information which is stored is defined by SAE and is limited in scope. This information may not even be specific to the type of fault.

BMW Fault Code

- BMW Codes are stored as soon they occur even before the "Malfunction Indicator Light" comes on.
- BMW Codes are defined by BMW, Bosch and Siemens Engineers to provide greater detail to fault specific information.
- **Siemens systems** - one set from four fault specific environmental conditions is stored with the first fault occurrence. This information can change and is specific to each fault code to aid in diagnosing. A maximum of ten different faults containing four environmental conditions can be stored.
- Bosch systems - a maximum of four sets from three fault specific environmental conditions is stored within each fault code. This information can change and is specific to each fault code to aid in diagnosing. A maximum of ten different faults containing three environmental conditions can be stored.
- BMW Codes also store and displays a "time stamp" when the fault last occurred.
- A fault qualifier gives more specific detailed information about the type of fault (upper limit, lower limit, disconnection, plausibility, etc.).
- BMW Fault Codes will alert the Technician of the current fault status. He/she will be advised if the fault is actually still present, not currently present or intermittent.
- The fault specific information is stored and accessible through ISTA.
- BMW Fault Codes determine the diagnostic output for ISTA.

OBD II Fault Memory and Fault Codes

Within the framework of OBD II, a diagnosis of all emission-related components/functions must take place during driving. Faults will be stored and displayed if necessary. For this purpose, the ECM includes OBD II memory. The standardized P codes for malfunctions are stored in this memory. The memory can be read out with the ISTA or a Scantool.

Emission Control Function Monitoring & Comprehensive Component Monitoring

OBD II regulations are based on section 1968.1 of Title 13, California Code of Regulations (CCR). The law set forth in section 1968.1 requires an increased scope of monitoring emission related control functions including:

- Catalyst Monitoring
- Heated Catalyst Monitoring
(currently used on BMW 750iL vehicles)
- Misfire Monitoring
- Evaporative System Monitoring
- Secondary Air System Monitoring
- Air Conditioning System Refrigerant Monitoring
(Not applicable for BMW vehicles)
- Fuel System Monitoring
- Oxygen Sensor Monitoring
- Exhaust Gas Recirculation (EGR) System Monitoring
(Not applicable for BMW vehicles)
- Positive Crankcase Ventilation (PCV) System Monitoring
(Not required at this time)
- Thermostat Monitoring (if equipped)

Monitoring these emission requirements is a function of the ECM which uses “data sets” while monitoring the conditions of the environment and the operation of the engine using existing input sensors and output actuators.

The data sets are programmed reference values the ECM refers to when a specific monitoring procedure is occurring. If the ECM cannot determine the environmental and/or engine operating conditions due to an impaired or missing signal, it will set a fault and illuminate the “Malfunction Indicator Light”.

This input or control signal monitoring falls under another category called “Comprehensive Component Monitoring”. The ECM must recognize the loss or impairment of the signal or component. The ECM determines a faulted signal or sensor via three conditions:

1. Signal or component shorted to ground.
2. Signal or component shorted to B+.
3. Signal or component lost (open circuit). Specific fault codes are used to alert the diagnostician of these conditions.

OBD II System Information on TIS

BMW TIS includes a section with OBD II related information and it is divided into three main categories:

- **Mode \$06 Interface Data;** features a list of current and previous DME's for specific on board monitoring test results.
- **OBD II Overview and Drive Cycle;** features a brief summary of the Emissions Overview contained in this Reference Manual.
- **OBD II Systems;** features a list of current and previous DME's with information on Fault Codes Conditions with possible fault causes and suggested repair procedures as well as specific OBD II Description information as per DME version. This section is an important tool that can help you in your diagnosis process!

To access the information contained in the OBD section, access CenterNet, then go to TIS and select the category you wish to browse.

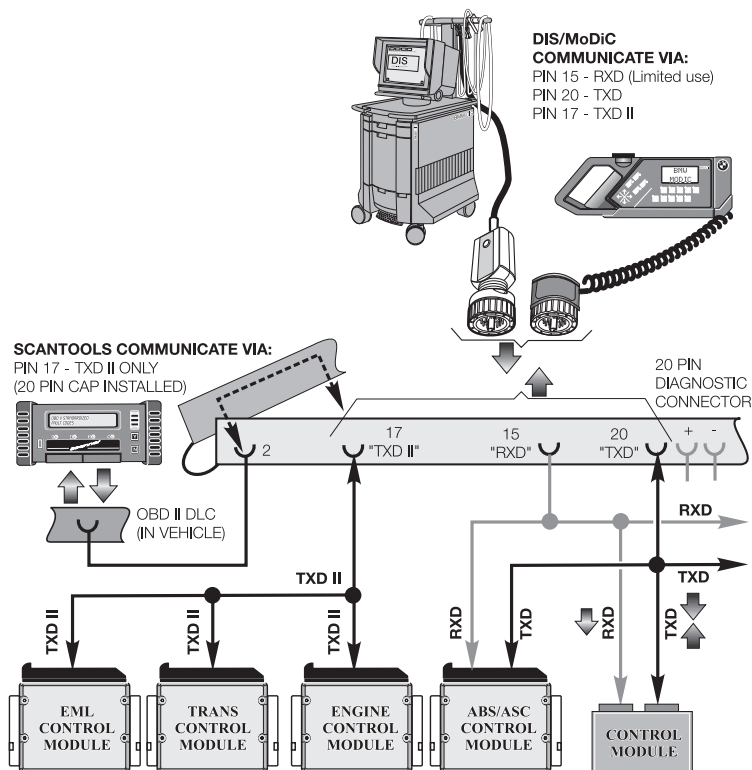
Scan Tool Connection

Starting with the 1995 750iL, soon after on all 1996 model year and later BMW vehicles, a separate OBD II Diagnostic Link Connector (DLC) was added.

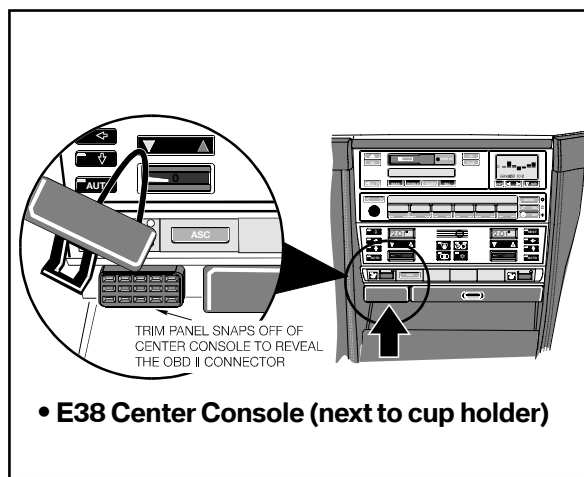
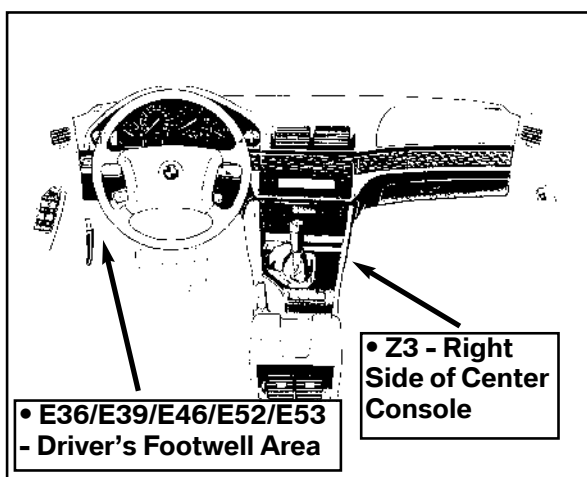
The DLC provides access for an aftermarket scan tool to all emission related control systems:

- ECM - Engine Management Monitored Emissions Functions / Components
- TCM (AGS/EGS) - Transmission Control
- EML - Electronic Throttle Control

This diagnostic communication link uses the existing TXD II circuit in the vehicle through a separate circuit on the DLC when the 20 pin cap is installed.



The DLC Connector bridging cap is marked "OBD II" and is found:



E38 and older models have a cosmetic cover and a secured DLC cover.

16 Pin Diagnostic Socket

Model and Production Date: E46 from 6/00

E39, E52, E53 from 9/00

For model year 2001 the E39, E46 and E53 **will eliminate the 20 pin diagnostic connector** from the engine compartment. The 16 pin OBD II connector located inside the vehicle will be the only diagnosis port.

The E38 and Z3 will continue to use the 20 pin connector until the end of production.

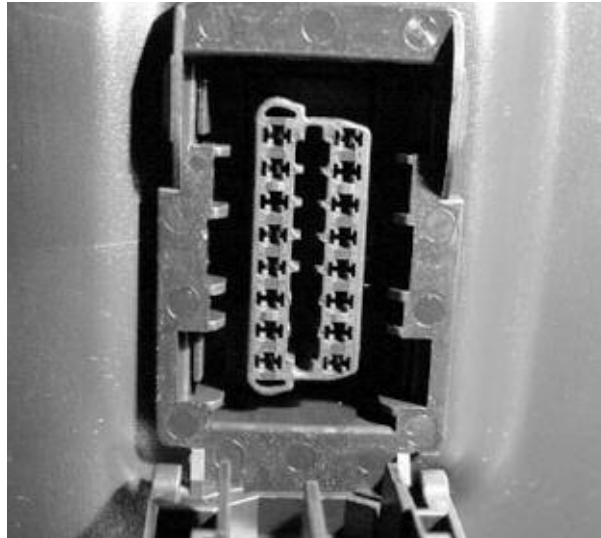
The 16 pin OBD II connector has been in all BMW's since 1996 to comply with OBD regulations requiring a standardized diagnostic port.

Previously before 2001, only emissions relevant data could be extracted from the OBD II connector because it did not provide access to TXD (D-bus).

The TXD line is connected to pin 8 of the OBD II connector on vehicles without the 20 pin diagnostic connector.

The cap to the OBD II connector contains a bridge that links KL 30 to TXD and TXD II. This is to protect the diagnostic circuit integrity and prevent erroneous faults from being logged.

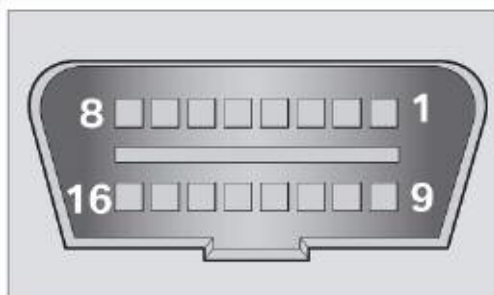
The OBD II connector is located in the driver's footwell to the left of the steering column for E39, E46 and E53 vehicles.



BoardNet 2020

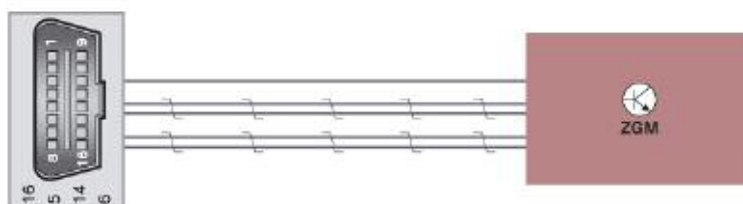
Vehicles equipped with BN2020 have the following configuration in the OBD II Diagnostic Socket:

Diagnostic socket



Index	Explanation	Index	Explanation
1	Not assigned	9	Engine speed
2	Not assigned	10	Not assigned
3	Ethernet Rx+	11	Ethernet Rx-
4	Terminal 31	12	Ethernet Tx+
5	Terminal 31	13	Ethernet Tx-
6	D-CAN High	14	D-CAN Low
7	Not assigned	15	Not assigned
8	Ethernet activation	16	Terminal 30F

Ethernet connection between the diagnostic socket and ZGM



These five lines are routed from the diagnostic socket to the central gateway module (ZGM).

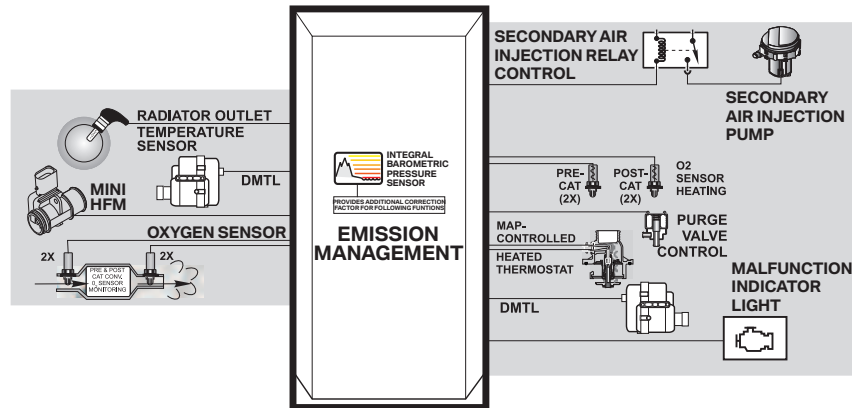
One of the five lines transmits the activation signal. The remaining four lines are twisted pair and are used for data transmission.



For further information please refer to the F01 Reference Manual.

Emission Management

Example of IPO for an Emissions Management System



One of the main purposes of the ECM is Emissions Management which includes the actuation of several components. In the following pages you will find a generic explanation on how this system works. For more detailed information please access BMW Training Reference Manuals found on-line.

The Emissions Management controls **evaporative** and **exhaust** emissions. The ECM monitors the fuel storage system for evaporative leakage and controls the purging of evaporative vapors. The ECM also monitors and controls the exhaust emissions by regulating the combustible mixture and after treating by injecting fresh air into the exhaust system. The catalytic converter further breaks down the remaining combustible exhaust gases and is monitored by the ECM for catalyst efficiency.

Malfunction Indicator Light (MIL)

The MIL will be illuminated under the following conditions:

- Upon the completion of the next consecutive driving cycle where the previously faulted system is monitored again and the emissions relevant fault is again present.
- Immediately if a "Catalyst Damaging" fault occurs (see Misfire Detection).



The illumination of the light is performed in accordance with the Federal Test Procedure (FTP) which requires the lamp to be illuminated when:

- A malfunction of a component that can affect the emission performance of the vehicle occurs and causes emissions to exceed 1.5 times the standards required by the (FTP).
- Manufacturer-defined specifications are exceeded.
- An implausible input signal is generated.
- Catalyst deterioration causes HC-emissions to exceed a limit equivalent to 1.5 times the standard (FTP).
- Misfire faults occur.
- A leak is detected in the evaporative system, or "purging" is defective.
- ECM fails to enter closed-loop oxygen sensor control operation within a specified time interval.
- Engine control or automatic transmission control enters a "limp home" operating mode.
- Ignition is on (KL15) position before cranking = Bulb Check Function.

Within the BMW system the illumination of the Malfunction Indicator Light is performed in accordance with the regulations set forth in CARB mail-out 1968.1 and as demonstrated via the Federal Test Procedure (FTP). The following page provides several examples of when and how the Malfunction Indicator Light is illuminated based on the "customer drive cycle".

Evaporative Emissions

The control of the evaporative fuel vapors (Hydrocarbons) from the fuel tank is important for the overall reduction in vehicle emissions. The evaporative system has been combined with the ventilation of the fuel tank, which allows the tank to breath (equalization). The overall operation provides:

- An inlet vent, to an otherwise “sealed” fuel tank, for the entry of air to replace the fuel consumed during engine operation.
- An outlet vent with a storage canister to “trap and hold” fuel vapors that are produced by the expansion/evaporation of the fuel in the tank, when the vehicle is stationary.

The canister is then “purged” using the engine vacuum to draw the fuel vapors into the combustion chamber. This “cleans” the canister allowing for additional storage. Like any other form of combustible fuel, the introduction of these vapors on a running engine must be controlled.

The ECM controls the Evaporative Emission Valve which regulates purging of evaporative vapors. The evaporative system must be monitored for correct purge operation and Leak Detection.

Exhaust Emissions

The combustion process of a gasoline powered engine produces Carbon Monoxide (CO), Hydrocarbons (HC) and Oxides of Nitrogen (NOx).

- Carbon Monoxide is a product of incomplete combustion under conditions of air deficiency. CO emissions are dependent on the air/fuel ratio.
- Hydrocarbon are also a product of incomplete combustion which results in unburned fuel. HC emissions are dependent on air/fuel ratio and the ignition of the mixture.
- Oxides of Nitrogen are a product of peak combustion temperature (and temperature duration). NOx emissions are dependent on internal cylinder temperature affected by the air/fuel ratio and ignition of the mixture.

Control of exhaust emissions is accomplished by the engine and engine management design as well as after-treatment.

- The ECM manages exhaust emissions by controlling the air/fuel ratio and ignition.
- The ECM controlled Secondary Air Injection further dilutes exhaust emissions leaving the engine and reduce the catalyst warm up time.
- The Catalytic Converter further reduces exhaust emissions leaving the engine.

Adaptation Values

In order to maintain an “ideal” air/fuel ratio, the engine control module is capable of adapting to various environmental conditions encountered while the vehicle is in operation (i.e. changes in altitude, humidity, ambient temperature, ambient pressure, fuel quality, etc.).

The adaptation system can only make slight corrections and can not compensate for large changes which may be encountered as a result of incorrect airflow or incorrect fuel supply to the engine.

Within the areas of adjustable adaptation, the engine control module modifies the injection rate under two areas of engine operation:

1. During idle and low load mid range engine speeds (Additive Adaptation)
2. During operation under a normal to higher load when at higher engine speeds (Multiplicative Adaptation)

These values are displayed in the “Diagnosis Query” section of ISTA and are a helpful diagnostic tool that shows how the system is trying to compensate for a less than ideal initial air/fuel ratio.

Note: If the adaptation value is greater than “0.0 ms” the Engine Control Module is trying to en-richen the mixture. If the adaptation value is less than “0.0 ms” the Engine Control Module is trying to lean-out the mixture.

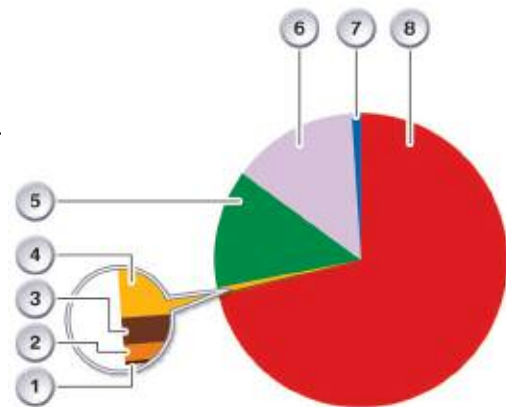
Diagnosis Request Status	Explanation
Additive mixture adaptation (Idle)	If the value is greater than 0.2ms there is an unmetered air leak or not enough fuel being supplied to the system. • The O₂ sensor indicates a LEAN condition • The engine control module tries to RICHEN the mixture. If the value is less than -0.2 ms there is an air restriction or too much fuel is being supplied to the system. • The O₂ sensor indicates a RICH condition. • The Engine Control Module tries to LEAN out the mixture.
Multiplicative mixture adaptation (Part load)	If the value is greater than 8% there is an unmetered air leak or not enough fuel being supplied to the system. • The O₂ sensor indicates a LEAN condition • The Engine Control Module tries to RICHEN the mixture If the value is less than -8% there is an air restriction or too much fuel being supplied to the system • The O₂ sensor indicates a RICH condition • The Engine Control Module tries to LEAN out the mixture

Oxygen Sensors

The oxygen sensor is an indispensable component for controlling and measuring the composition of exhaust gas with the aim of conforming to legally stipulated emission values. This is achieved by measuring the residual oxygen content in the exhaust gas.

A fuel-air ratio of 1 kg of fuel to 14.7 kg of air is required for optimum combustion.

Exhaust gas composition before catalytic converter



Oxygen sensor before catalytic converter

■ Bosch LSH25 Oxygen Sensor

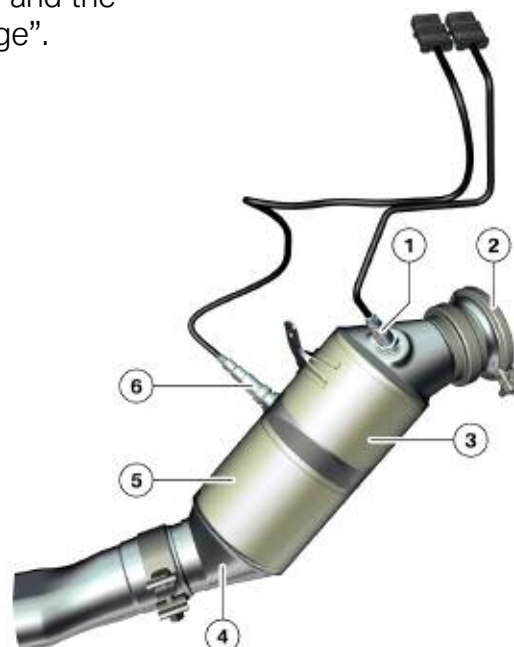
The pre-cat Bosch LSH 25 oxygen sensors measure the residual oxygen content of the exhaust gas. The sensors produce a low voltage (0-1000 mV) proportional to the oxygen content that allows the ECM to monitor the air/fuel ratio.

The sensors are mounted in the hot exhaust stream directly in front of the catalytic converters.

The “tip” of the sensor contains a microporous platinum coating (electrodes) which conduct current. The platinum electrodes are separated by solid electrolyte which conducts oxygen ions. The platinum conductors are covered with a highly porous ceramic coating and the entire tip is encased in a ventilated metal “cage”.

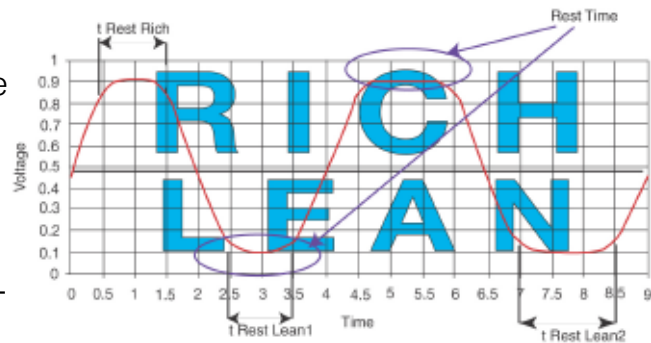
Index	Explanation
1	Solids 0.005%
2	NO _x 0.1%
3	HC 0.2%
4	CO 0.7%
5	CO ₂ 14%
6	H ₂ O 13%
7	Oxygen + others 1%
8	N ₂ 71%

Index	Explanation
1	Oxygen sensor upstream of catalytic converter
2	Connection to the turbocharger
3	Ceramic structure 1
4	Catalytic converter outlet funnel
5	Ceramic structure 2
6	Oxygen sensor after ceramic structure 1



This assembly is submersed in the exhaust stream. The sensor body (external) has a small vent opening in the housing that allows ambient air to enter the inside of the tip.

The ambient air contains a constant level of oxygen content (21%) and the exhaust stream has a much lower oxygen content. The oxygen ions (which contain small electrical charges) are “purged” through the solid electrolyte by the hot exhaust gas flow. The electrical charges (low voltage) are conducted by the platinum electrodes to the sensor signal wire that is monitored by the ECM.



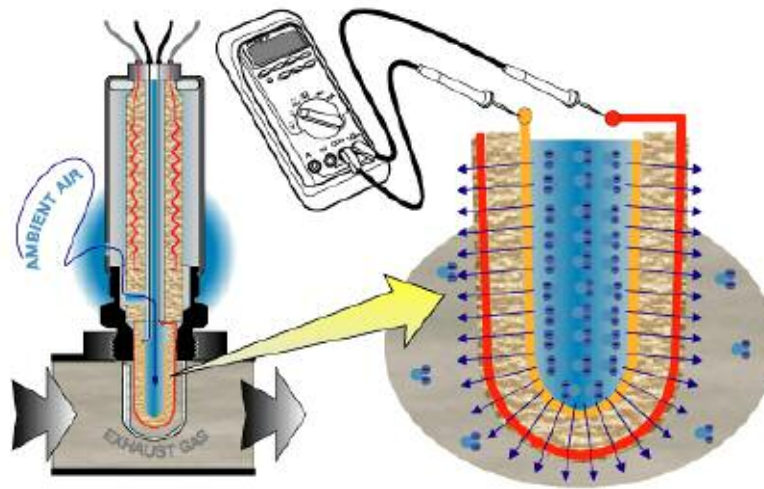
If the exhaust has a lower oxygen content (rich mixture), there will be a large ion “migration” through the sensor generating a higher voltage (950 mV).

If the exhaust has a higher oxygen content (lean mixture), there will be a small ion “migration” through the sensor generating a lower voltage (080 mV).

This voltage signal is constantly changing due to combustion variations and normal exhaust pulsations.

The ECM monitors the length of time the sensors are operating in the lean, rich (including the time of rise and fall) and rest conditions. The evaluation period of the sensors is over a predefined number of oscillation cycles.

This conductivity is efficient when the oxygen sensor is hot (250° - 300° C). For this reason, the sensor contains a heating element. This “heated” sensor reduces warm up time, and retains the heat during low engine speed when the exhaust temperature is cooler.



■ Bosch LSU Planar Wideband Oxygen Sensor

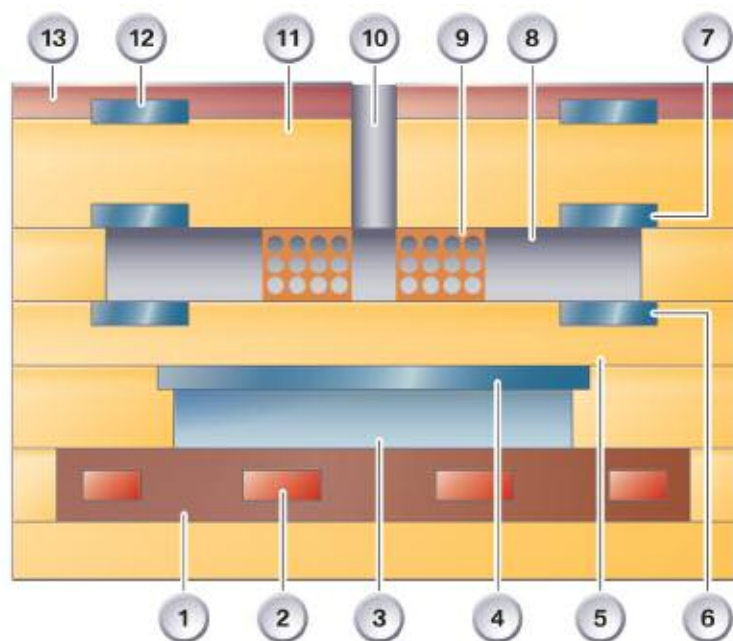
Engines equipped with planar wideband oxygen sensors (pre-catalyst) are identified by its planar shape (type of construction) which is more compact and is made up of thin layers of zirconium dioxide (ZrO_2) ceramic films. This modular lamination structure enables the integration of several functions including the heating element which ensures the minimum operating temperature (750 °C) is reached rapidly.

In contrast to conventional oxygen sensors, the wideband features can measure not only at $\text{Lambda}=1$, but also in the rich and extremely lean range ($\text{Lambda}=0.7$ to complete atmospheric oxygen) very rapidly.

To operate effectively, the oxygen sensor requires ambient air as the “reference gas” inside the sensor. **The ambient air reaches the inside of the sensor through the plug connection and through the harness.** The plug connection socket must therefore be protected from contamination (wax, preservatives, engine degreasers, engine washing, etc.). In the event of the oxygen sensor malfunctioning, the connector should always be checked first with regard to contamination and cleaned if necessary. The plug connection must be disconnected and then reconnected to remove any oxidation from the connector pins.

The pump cell and reference cell are made of zirconium dioxide and each coated with two porous platinum electrodes. They are arranged so that there is a measuring gap of approx. 10 to 50 microns between them. This measuring gap is connected by an inlet opening to the exhaust gas. The pump cell is controlled by the ECM applying voltage to the electrodes to initiate oxygen ion pumping across the porous membrane of the reference cell, providing a quicker response time.

Design of broadband oxygen sensor



Index	Explanation
1	Insulation layer
2	Heating element
3	Reference air channel
4	Inner electrode, reference cell
5	Ceramic layer made of ZrO_2
6	Outer electrode reference cell
7	Inner electrode, O_2 pump cell
8	Diffusion gap
9	Porous diffusion barrier
10	Exhaust inlet hole
11	Ceramic layer made of ZrO_2
12	Outer electrode, O_2 pump cell
13	Protective layer

If the exhaust gas content is lean, the pump cell pumps oxygen away from the measuring gap to the outside. The direction of flow is reversed for rich exhaust gas content, then oxygen is pumped from the exhaust gas into the measuring gap. The pump current flow is proportional to the oxygen concentration (lean) or the oxygen requirement (rich). The pump is constantly working to maintain that the gas composition in the measuring gap is constantly at $\lambda=1$. The required current of the pump cell is evaluated by the ECM as a signal that represents oxygen content in the exhaust gas.

■ **Bosch LSU ADV (Planar Wideband)**

The Bosch oxygen sensor LSU ADV is used as the control sensor before the catalytic converter. The abbreviation LSU stands for “Lambdasonde Universal” and ADV for “Advanced”. The function is similar to that of the LSU 4.9 oxygen sensor and is therefore described in detail in the E71 X6 training material under “N63 engine” available in TIS and ICP.

The oxygen sensor before catalytic converter (LSU ADV) offers the following advantages:

- High signal stability specially during turbocharged operation due to low dynamic pressure dependence.
- Increased durability due to reduced pump voltage.
- Increased accuracy (by a factor of 1.7 compared to LSU 4.9).
- Ready for operation in < 5 seconds.
- Greater temperature compatibility.
- Improved connector with more effective contacting properties.

The LSU ADV has an extended measuring range, making it possible to measure precisely from λ 0.65. The new oxygen sensor is ready for operation faster so that exact measured values are available within 5 seconds of start up.

The higher measuring dynamics of the sensor makes it possible to more effectively determine and control the fuel-air ratio separately for each cylinder. This results in a homogeneous exhaust flow that reduces emissions while also having a favorable effect on long-term emission characteristics.

Oxygen Sensor after Catalytic Converter

The oxygen sensor after catalytic converter is also known as the monitoring sensor. The familiar Bosch LSF 4.2 monitoring sensor are used in most of our NG engines.

The voltage range is 0.10 to 1.0 volts.

Oxygen Sensor Signals

The sensor conductivity is efficient when the oxygen sensor is hot (750° C). For this reason, the sensor contains a heating element. This reduces warm up time, and retains the heat during low engine speed when the exhaust temperature is cooler. The oxygen sensor heating elements receive power from the IVM (12 V) and the ground supply is pulse width modulated by the ECM.

The monitored voltage signal is constantly changing due to combustion variations and normal exhaust pulsations.

- At a value of $\Lambda = 1$, the pump cell requires approx. 3 mA

The oxygen sensor signal voltage is approx. 1.5V

The reference cell voltage is approx. 450mV

- At a Λ value <1 (rich), the oxygen sensor signal voltage is approx. 0.3V
- At a Λ value >1 (lean), the oxygen sensor signal voltage is approx. 4.3V

If necessary, the ECM will “correct” the air/fuel ratio by regulating the ms injection time. The ECM monitors the length of time the sensors are operating in the lean, rich and rest conditions. The evaluation period of the sensors is over a predefined number of oscillation cycles and pump cell amperage.

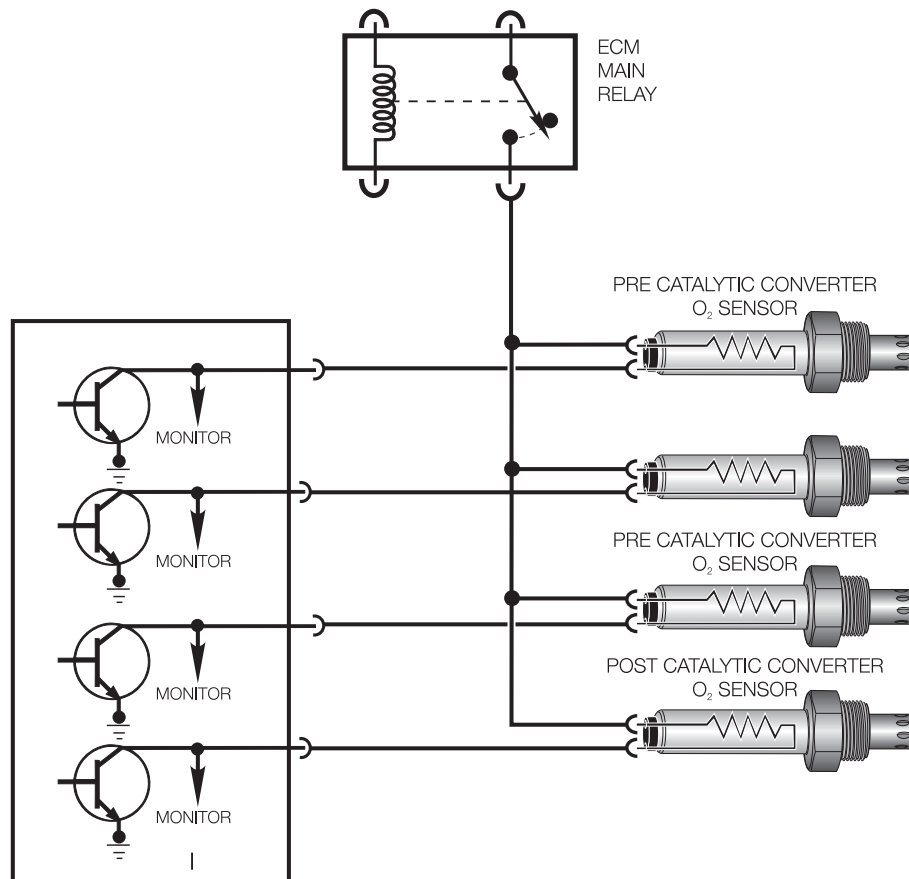
Direct Oxygen Sensor Heating

The oxygen sensor conductivity is efficient when it is hot (600° - 700° C). For this reason, the sensors contain heating elements. These “heated” sensors reduce warm up time, and retain the heat during low engine speed when the exhaust temperature is cooler. OBD II requires monitoring of the oxygen sensor heating function and heating elements for operation.

The four oxygen sensor heating circuits receive operating voltage from the ECM Relay when KL15 is switched “ON”. Each of the sensors heaters are controlled through separate final stage transistors.

The sensor heaters are controlled with a pulse width modulated voltage during a cold start. This allows the sensors to be brought up to operating temperature without the possibility of thermal shock. The duty cycle is then varied to maintain the heating of the sensors.

When the engine is decelerating (closed throttle), the ECM increases the duty cycle of the heating elements to compensate for the decreased exhaust temperature.



Testing the Oxygen Sensor

Testing should be performed using ISTA/IMIB Oscilloscope. List.
The scope pattern should appear for a normal operating sensor.

If the signal remains high (rich condition) the following should be checked:

- Fuel Injectors
- Fuel Pressure
- Ignition System
- Input Sensors that influence air/fuel mixture
- Engine Mechanical

If the signal remains low (lean condition) the following should be checked:

- Air/Vacuum leak
- Fuel Pressure
- Input Sensor that influence air/fuel mixture
- Engine Mechanical



A MIXTURE RELATED FAULT CODE SHOULD BE INVESTIGATED FIRST AND DOES NOT ALWAYS INDICATE A DEFECTIVE OXYGEN SENSOR!

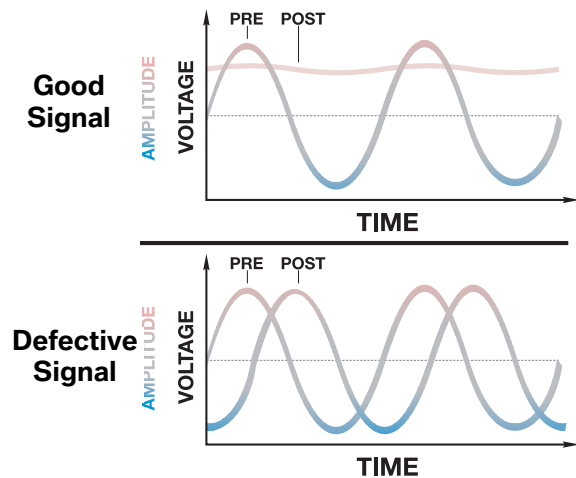
Catalytic Converter Monitoring

The efficiency of catalyst operation is determined by evaluating the oxygen consumption of the catalytic converters using the pre and post oxygen sensor signals. A properly operating catalyst consumes most of the O₂ (oxygen) that is present in the exhaust gas (input to catalyst). The gases that flow into the catalyst are converted from CO, HC and NO_x to CO₂, H₂O and N₂ respectively.

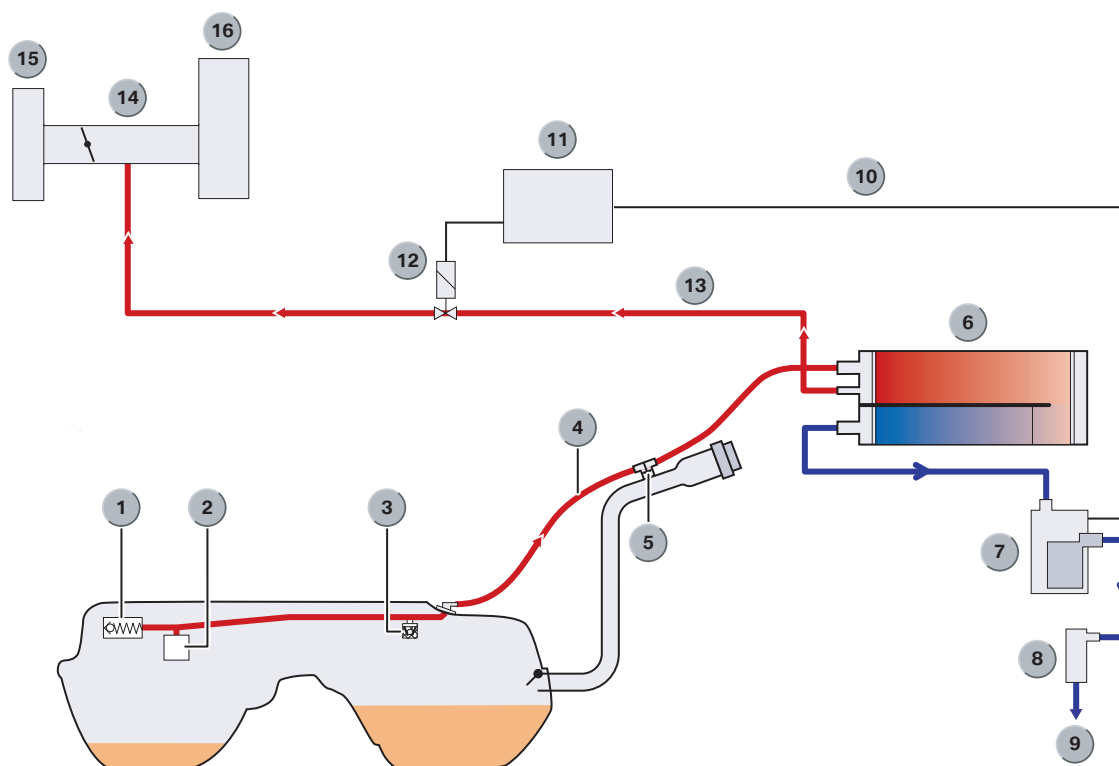
In order to determine if the catalysts are working correctly, post catalyst oxygen sensors are installed to monitor exhaust gas content exiting the catalysts. The signal of the post cat. O₂ sensor is evaluated over the course of several pre cat. O₂ sensor oscillations.

During the evaluation period, the signal of the post cat. sensor must remain within a relatively constant voltage range (700 - 800 mV). The post cat. O₂ voltage remains high with a very slight fluctuation. This indicates a further lack of oxygen when compared to the pre cat. sensor.

If this signal decreased in voltage and/or increased in fluctuation, a fault code will be set for Catalyst Efficiency and the "Malfunction Indicator Light" will illuminate when the OBD II criteria is achieved.



On-Board Refueling Vapor Recovery (ORVR)



Index	Explanation	Index	Explanation
1	Overpressure protection valve	9	Atmospheric vent line
2	Filling vent valve (rollover valve)	10	DM-TL (electrical control circuit)
3	Operating vent valve	11	ECM (DME)
4	Ventilation line	12	Evaporative emission (purge) control valve
5	Mushroom valve ("T" fitting)	13	Evaporative emission (purge) line
6	Carbon canister	14	Intake manifold
7	DM-TL (leakage diagnosis pump)	15	Engine air filter
8	Filter	16	M54 engine

The ORVR system recovers and stores hydrocarbon fuel vapor that was previously released during refueling. Non ORVR vehicles vent fuel vapors from the tank venting line back to the filler neck and in many states reclaimed by a vacuum receiver on the filling station's fuel pump nozzle.

When refueling an ORVR equipped vehicle, the pressure of the fuel entering the tank forces the hydrocarbon vapors through the Filling Vent Valve (2) and the large tank ventilation line (4) into the Carbon Canister (6). The HC is stored in the Carbon Canister and the system can then "breathe" through the DM-TL (7) and the filter (8).

The ventilation continues until the rising fuel level lifts the float in the Filling Vent Valve (2) and closes the outlet. When the ventilation outlet is closed, a pressure cushion (vapor area) is created in the fuel tank. This creates a backup of fuel into the filler neck and the tank is full.

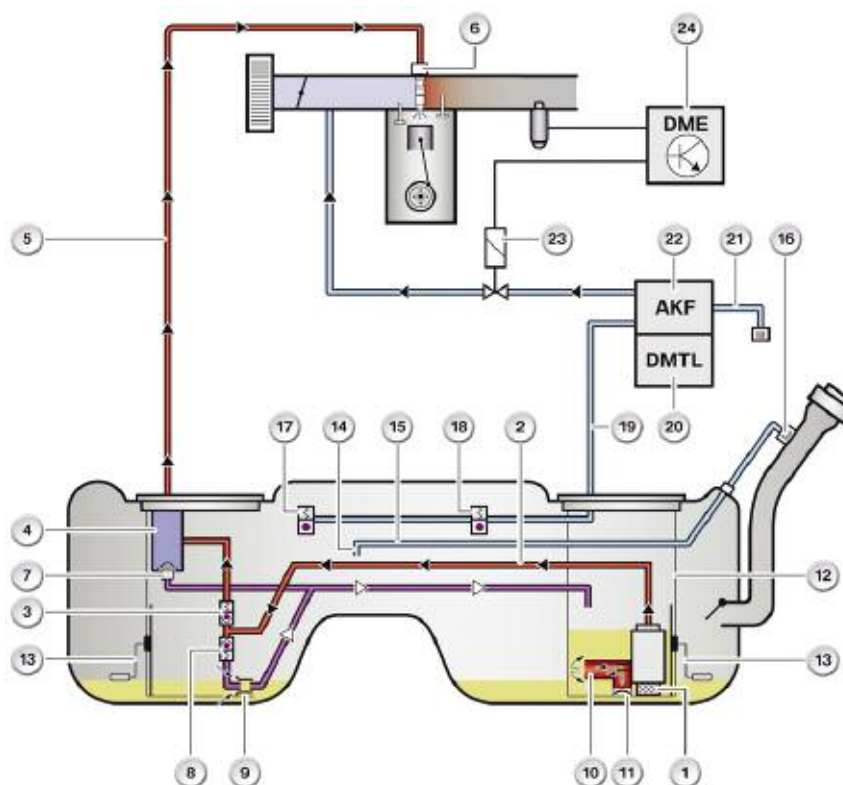
This leaves a vapor area of approximately 6 liters above the fuel level. This area provides integral liquid/vapor separation. The vapor condensates separate and drain back into the fuel. The remaining vapors exit the fuel tank (when sufficient pressure is present) through the Operating Vent Valve (3) to the Carbon Canister.



A small diameter connection to the filler neck is provided by the Mushroom Valve “T fitting” (5). This is necessary for checking the filler cap/neck during Evaporative Leak Testing.

The Operating Vent Valve is also equipped with a protection float in the event of an “overfill” situation.

On-Board Refueling Vapor Recovery (ORVR) E9x Vehicles



Index	Explanation	Index	Explanation
1	Electric Fuel Pump	13	Fuel Level Sensor
2	Feed Line	14	Refuelling Line Connection Piece
3	Check Valve	15	Refuelling Ventilation Line
4	Fuel Filter	16	Refuelling Ventilation
5	Feed Line to Engine	17	Left Operation Ventilation Valve
6	Fuel Injector	18	Right Operation Ventilation Valve
7	Pressure Regulator	19	Operation Ventilation Line
8	Check Valve	20	Diagnosis Module for Tank Leakage (DM-TL)
9	Left Suction Jet Pump	21	Atmosphere Line
10	Right Suction Jet Pump	22	Carbon Canister
11	Initial Filling Valve	23	Fuel Tank Vent Valve
12	Fuel Baffle	24	Digital Motor Electronics

The ORVR system recovers and stores hydrocarbon fuel vapors during refueling. When refueling the E90, a downward open adapter (14) is located on the refueling ventilation line (15) in the fuel tank. During the refueling procedure, the air can escape out of the tank via the refueling ventilation line (15) and the fuel filler neck.

When the fuel level rises up to the opening of the refueling ventilation line, it is closed off and the fuel level increases in the fuel filler neck up to the fuel station pump. The fuel station pump then switches off automatically.

After the fuel station pump has switched off, an expansion volume (approx. 10 liters) remains above the refueling ventilation line.

Ventilation During Engine Operation

The fuel vapors produced in the fuel tank pass:

- through the operation ventilation valves (17 + 18),
- through the ventilation line (19),
- into the carbon canister AKF (20),
- through the purge air line and
- through the fuel tank vent valve TEV (22),
- to the engine intake manifold.

The two operation ventilation valves are located above the refueling ventilation adapter (14). They are connected by a line. The left operation ventilation valve (17) only has a ventilation function while the right operation ventilation valve (18) additionally has a pressure holding function (50 mbar).

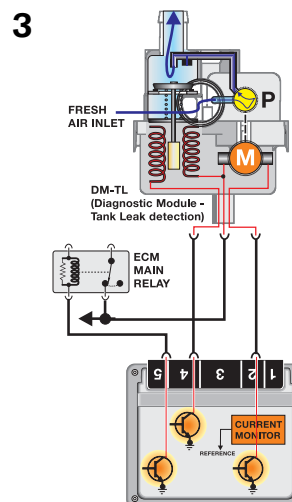
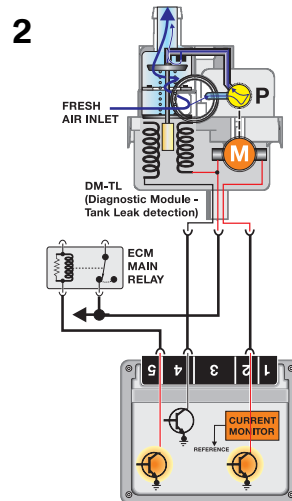
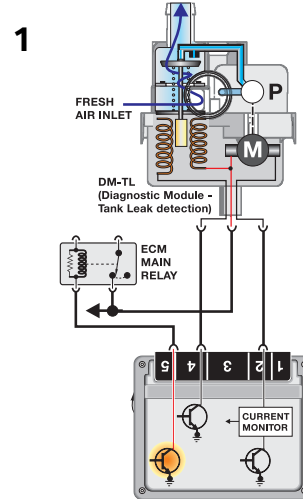
The aim of the pressure holding function is to avoid the remaining air of the expansion volume escaping via the carbon canister while refueling (with refueling ventilation line closed).

Evaporative Leakage Detection (DM-TL)

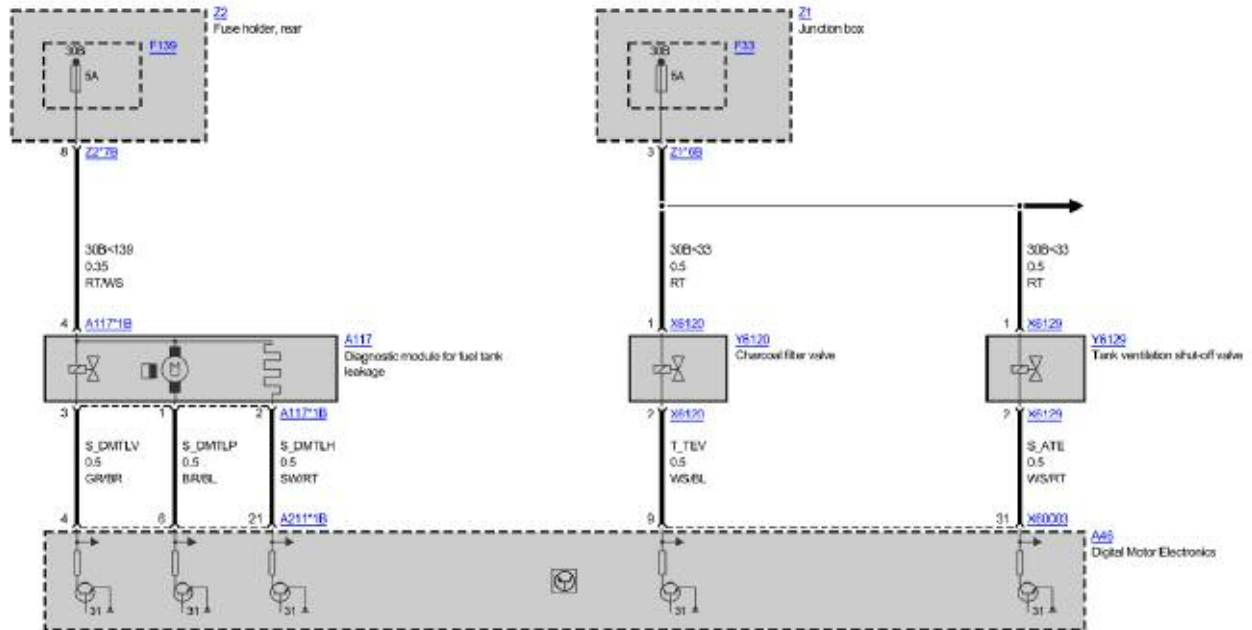
This component ensures accurate fuel system leak detection for leaks as small as 0.5 mm by slightly pressurizing the fuel tank and evaporative components. The DM-TL pump contains an integral DC motor which is activated directly by the ECM. The ECM monitors the pump motor operating current as the measurement for detecting leaks.

The pump also contains an ECM controlled change over valve that is energized closed during a Leak Diagnosis test. The change over valve is open during all other periods of operation allowing the fuel system to “breathe” through the inlet filter. The DM-TL is located under the luggage compartment floor with the Carbon Canister.

1. In its inactive state, filtered fresh air enters the evaporative system through the sprung open valve of the DM-TL.
2. When the DME activates the DM-TL for leak testing, it first activates only the pump motor. This pumps air through a restrictor orifice (0.5 mm) which causes the electric motor to draw a specific amperage value. This value is equivalent to the size of the restrictor.
3. The solenoid valve is then energized which seals the evaporative system and directs the pump output to pressurize the evaporative system.
 - A large leak is detected in the evaporative system if the amperage value is not achieved.
 - A small leak is detected if the same reference amperage is achieved.
 - The system is sealed if the amperage value is higher than the reference amperage.



SSP-SP0000052267 Diagnostic module for fuel tank leakage

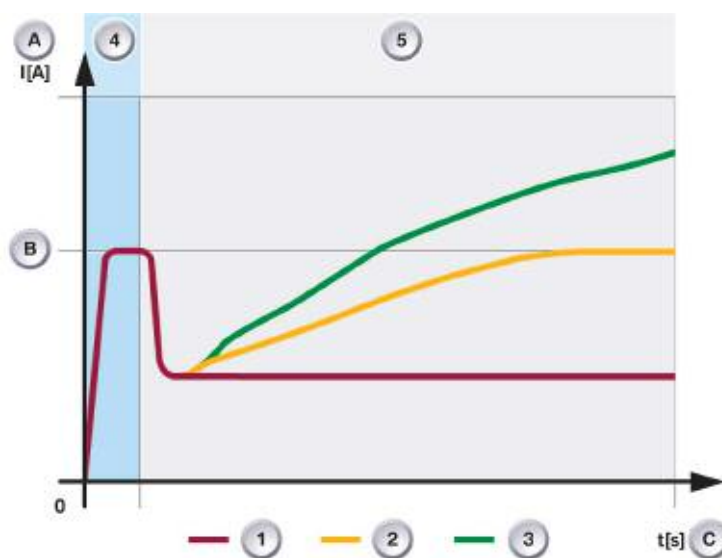


To prevent condensation buildup in the DM-TL pump, a heating element is integrated into the housing of the pump. The heating element is ground controlled by the ECM.

Test Results

The time duration varies between 30 & 360 seconds depending on the resulting leak diagnosis test results (developed tank pressure “amperage” within a specific time period).

When the ECM detects a leak, a fault will be stored and the “Malfunction Indicator Light” will be illuminated. Depending on the amperage measurement detected by the ECM, the fault code displayed will be “small leak” or “large leak”.



Index	Explanation	Index	Explanation
A	Current	2	Leak = 0.5mm
B	Overpressure 25hPa (25mbar)	3	No leak in system (leak <0.5mm)
C	Time	4	Reference measurement (leak 0.5mm)
1	Leak >1mm	5	Leakage measurement

Refuelling While a Leak Diagnosis is Taking Place:

The ECM detects refueling during a leak diagnosis as a result of the pressure drop when the fuel filler cap is opened and the increase pressure while filling the tank is being filled.

In this case, the leakage diagnosis is interrupted. The solenoid valve in the DM-TL is switched off and the tank pressure escapes through the activated carbon canister.

If refueling does not take place immediately after the fuel filler cap has been opened, the system will detect a large leak and the a fault will be stored in the ECM. If refueling is detected in the next driving cycle (increase in fuel level), the fault is cleared.

The ECM detects refueling from a change in the fuel tank sending unit level. If the filler cap was not properly installed, when the leakage test is performed and leakage is detected; the variable indicator lamp (shown to the right) and the “Please Close Filler Cap” Check Control message will be displayed.

If the filler cap is correctly installed and leakage is not present the next time the test is performed, the “Malfunction Indicator Light” will not be illuminated.

Starting with 2002 MY, a heating element was added to the DM TL pump to eliminate condensation.

The heater is provided battery voltage when KL_15 is switched “on” and the ECM provides the ground path (see page 47).



Principle of Operation

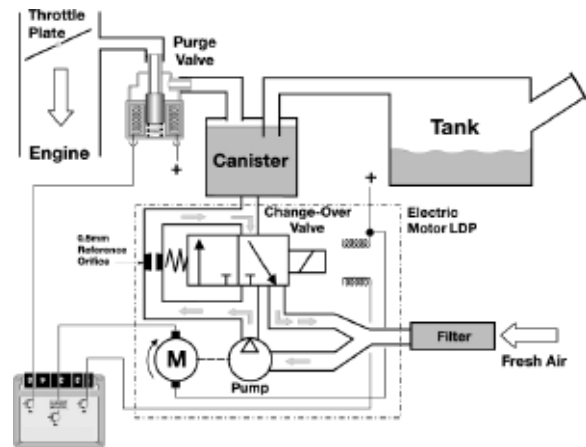
The Evaporative Leakage Detection is performed on the fuel storage system by the DM-TL pump which contains an integral DC motor that is activated by the ECM. The ECM monitors the pump motor operating current as the measurement for detecting leaks.

The pump also contains an ECM controlled change over valve that is energized closed during a Leak Diagnosis test. The ECM initiates a leak diagnosis test every time the criteria are met. The criteria is as follows:

- Engine **OFF** with ignition switched **OFF**.
- ECM still in active state or what is known as “follow up mode” (ECM Relay energized, ECM and components online for extended period after key off).
- Prior to Engine/Ignition switch OFF condition, vehicle must have been driven for a minimum of 20 minutes.
- Prior to minimum 20 minute drive, the vehicle must have been OFF for a minimum of 5 hours.
- Fuel Tank Capacity must be between **15 and 85%** (safe approximation between 1/4 - 3/4 of a tank).
- Ambient Air Temperature between **4°C & 35°C** (40°F & 95°F)
- Altitude **< 2500m** (8,202 feet).
- Battery Voltage - **between 10.95 and 14.5 Volts**

■ PHASE 1 - Reference Measurement

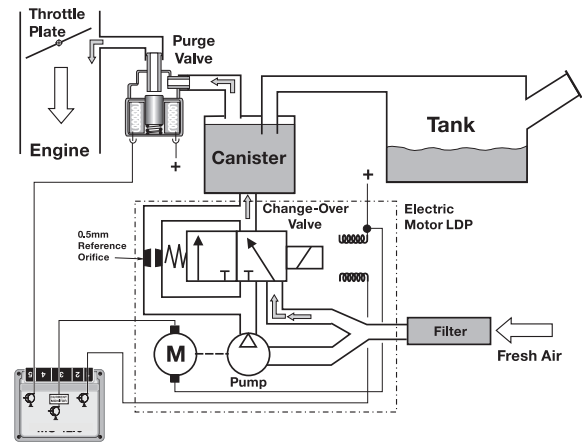
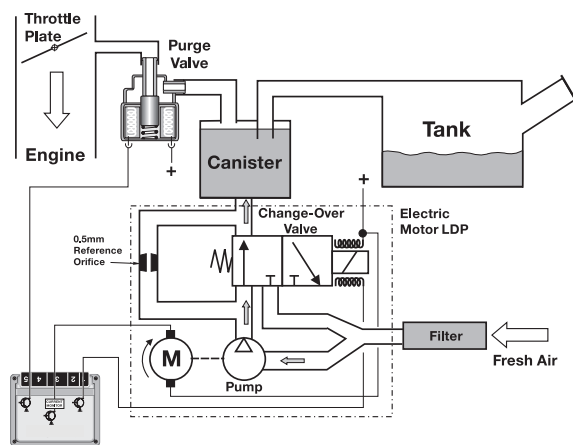
The ECM activates the pump motor. The pump pulls air from the filtered air inlet and passes it through a precise 0.5 mm reference orifice in the pump assembly. The ECM simultaneously monitors the pump motor current flow. The motor current raises quickly and levels off (stabilizes) due to the orifice restriction. The ECM stores the stabilized amperage value in memory. The stored amperage value is the electrical equivalent of a 0.5 mm (0.020”) leak.



■ PHASE 2 - Leak Detection

The ECM energizes the Change Over Valve allowing the pressurized air to enter the fuel system through the Charcoal Canister. The ECM monitors the current flow and compares it with the stored reference measurement over a duration of time.

Once the test is concluded, the ECM stops the pump motor and immediately de-energizes the change over valve. This allows the stored pressure to vent thorough the charcoal canister trapping hydrocarbon vapor and venting air to atmosphere through the filter.



Evaporative Emission Purging

Evaporative Emission Purging is regulated by the ECM controlling the Evaporative Emission Valve. The Evaporative Emission Valve is a solenoid that regulates purge flow from the Active Carbon Canister into the intake manifold. The ECM Relay provides operating voltage, and the ECM controls the valve by regulating the ground circuit. The valve is powered open and closed by an internal spring.

The “purging” process takes place when:

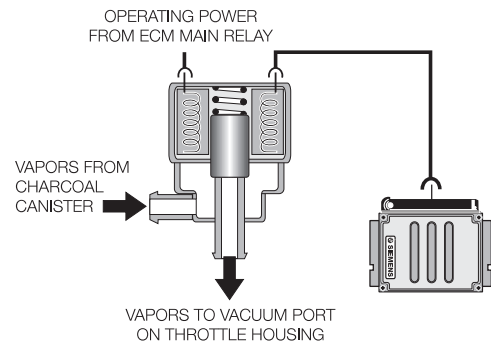
- Oxygen Sensor Control is active
- Engine Coolant Temperature is $> 67^{\circ}\text{C}$
- Engine Load is present

The Evaporative Emission Valve is opened in stages to moderate the purging.

- Stage 1 opens the valve for 10 ms (milli-seconds) and then closes for 150 ms.
- The stages continue with increasing opening times (up to 16 stages) until the valve is completely open.
- The valve now starts to close in 16 stages in reverse order.
- This staged process takes 6 minutes to complete. The function is inactive for 1 minute then starts the process all over again.
- During the purging process the valve is completely opened during full throttle operation and is completely closed during deceleration fuel cutoff.

Evaporative Purge System Flow Check is performed by the ECM when the oxygen sensor control and purging is active. When the Evaporative Emission Valve is open the ECM detects a rich/lean shift as monitored by the oxygen sensors indicating the valve is functioning properly.

If the ECM does not detect a rich/lean shift, a second step is performed when the vehicle is stationary and the engine is at idle speed. The ECM opens and close the valve (abruptly) several times and monitors the engine rpm for changes. If there are no changes, a fault code will be set.



Carbon Canister

As the hydrocarbon vapors enter the canister, they will be absorbed by the active carbon. The remaining air will be vented to the atmosphere through the end of the canister, DM TL and filter, allowing the fuel tank to “breathe”.

When the engine is running, the canister is "purged" using intake manifold vacuum to draw air through the canister which extracts the HC vapors into the combustion chamber.

The Carbon Canister with DM TL and air filter are located at the right rear underside of the vehicle, below the luggage compartment floor.

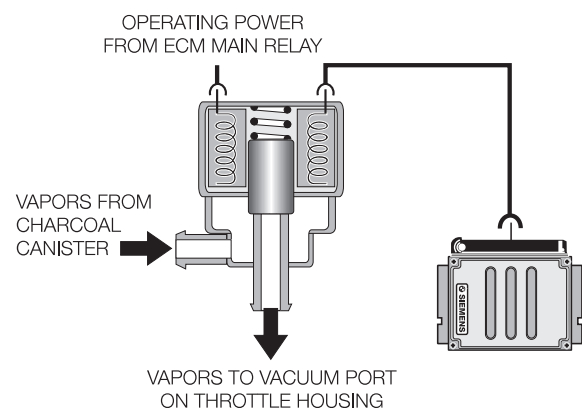


Evaporative Emission Valve

This ECM controlled solenoid valve regulates the purge flow from the Carbon Canister into the intake manifold. The ECM Relay provides operating voltage, and the ECM controls the valve by regulating the ground circuit. The valve is powered open and closed by an internal spring.

If the Evaporative Emission Valve circuit is defective, a fault code will be set and the “Malfunction Indicator Light” will illuminate when the OBD II criteria is achieved.

If the valve is “mechanically” defective, a drive-ability complaint could be encountered and a mixture related fault code will be set.



Natural Vacuum Leak Detection system (NVLD)

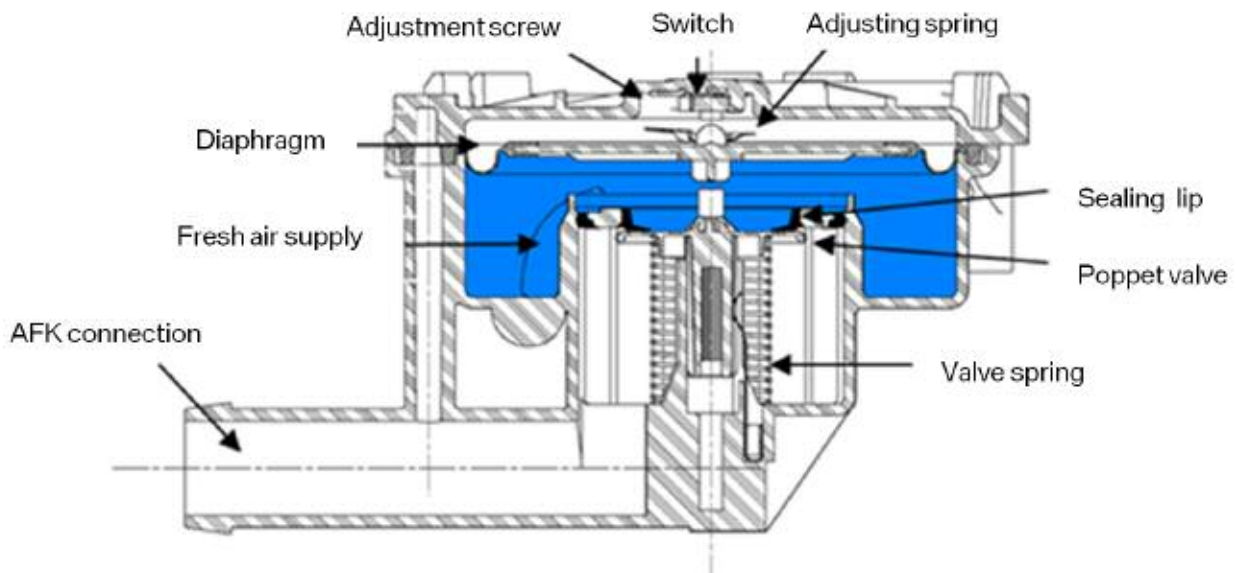
BMW's NVLD, or Natural Vacuum Leak Detection system will be first introduced in September 2011 as an alternative to its Leak Detection Pump (DMTL) method for the onboard testing of the evaporative emissions system. This method of leak detection is based on the "Ideal Gas" law that states, in part, that the pressure in a sealed vessel will change linearly as a function of the temperature of the gas in that vessel. Any loss of seal will allow the internal pressure to equalize with the atmospheric pressure outside the container.

In an automotive application, the fuel system is sealed when the vehicle is in a key off condition (KL_0). The Engine Control Module (ECM) monitors the state of a switch contained within the NVLD assembly via a DMTLH line. As the temperature in the fuel system drops, whether due to the cooling of the fuel or internal temperature change, pressure in the sealed system will drop.

If the ECM does not see this change of state within a calculated time limit, it registers a failure and then tests to determine the size of the leak. Natural Vacuum Leak Detection (NVLD) is a passive diagnosis system for the fuel evaporation system. The NVLD requires a longer engine cutout time in order to identify a leakage. Therefore a short leakage test is not possible. Depending on the ambient conditions, the diagnosis normally requires that the engine is off for between 6 and 12 hours.

The NVLD system is basically a pressure system for the EVAP system. By monitoring vacuum, it can detect leaks throughout the system. In addition, during cool down it prevents an excess build-up of vacuum. When the engine is off, it maintains a seal on the EVAP system to prevent the release of fuel vapors. Finally, when the vehicle is refueling and pressure builds up in the evaporative system, it pressure then vents to the fresh air filter.

NVLD Unit



The diagram illustrates a hydraulic system for a vehicle, showing the flow of hydraulic fluid from a reservoir (6) through various components including a pump (4), filter (5), and actuators (1, 2, 3, 7). The diagram includes a legend for hydraulic symbols and a numbered list of components.

Legend:

- 1. Hydraulic pump
- 2. Hydraulic filter
- 3. Hydraulic valve
- 4. Hydraulic cylinder
- 5. Hydraulic hose
- 6. Hydraulic reservoir
- 7. Hydraulic line

System Components and Flow:

- Hydraulic Reservoir (6):** The source of hydraulic fluid, containing a float valve and a pump.
- Hydraulic Pump (1):** Draws fluid from the reservoir and sends it to the filter.
- Hydraulic Filter (2):** Filters the fluid before it reaches the valve.
- Hydraulic Valve (3):** Controls the flow of fluid to the cylinder.
- Hydraulic Cylinder (4):** Converts hydraulic energy into mechanical work.
- Hydraulic Hose (5):** Connects the cylinder to the reservoir.
- Hydraulic Line (7):** Connects the reservoir to the pump.

The diagram shows the flow of fluid from the reservoir (6) through the pump (1), filter (2), valve (3), and cylinder (4), and back to the reservoir via the hose (5) and line (7). The reservoir (6) is shown with a float valve and a pump. The pump (1) is connected to the filter (2), which is connected to the valve (3). The valve (3) is connected to the cylinder (4). The cylinder (4) is connected to the hose (5), which is connected to the reservoir (6) via the line (7).

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Emissions Management

EVAP System Monitoring

Principles of CARB Act (USA)

The CARB regulation serves as a basis for leak diagnosis:

>> Title 13, California Code Regulations, Section 1968.2, Malfunction and Diagnostic System Requirements for 2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II) <<

This regulation states that an overall leakage in the fuel evaporation system exceeding 0.51 mm (0.02 inches) must be identified.

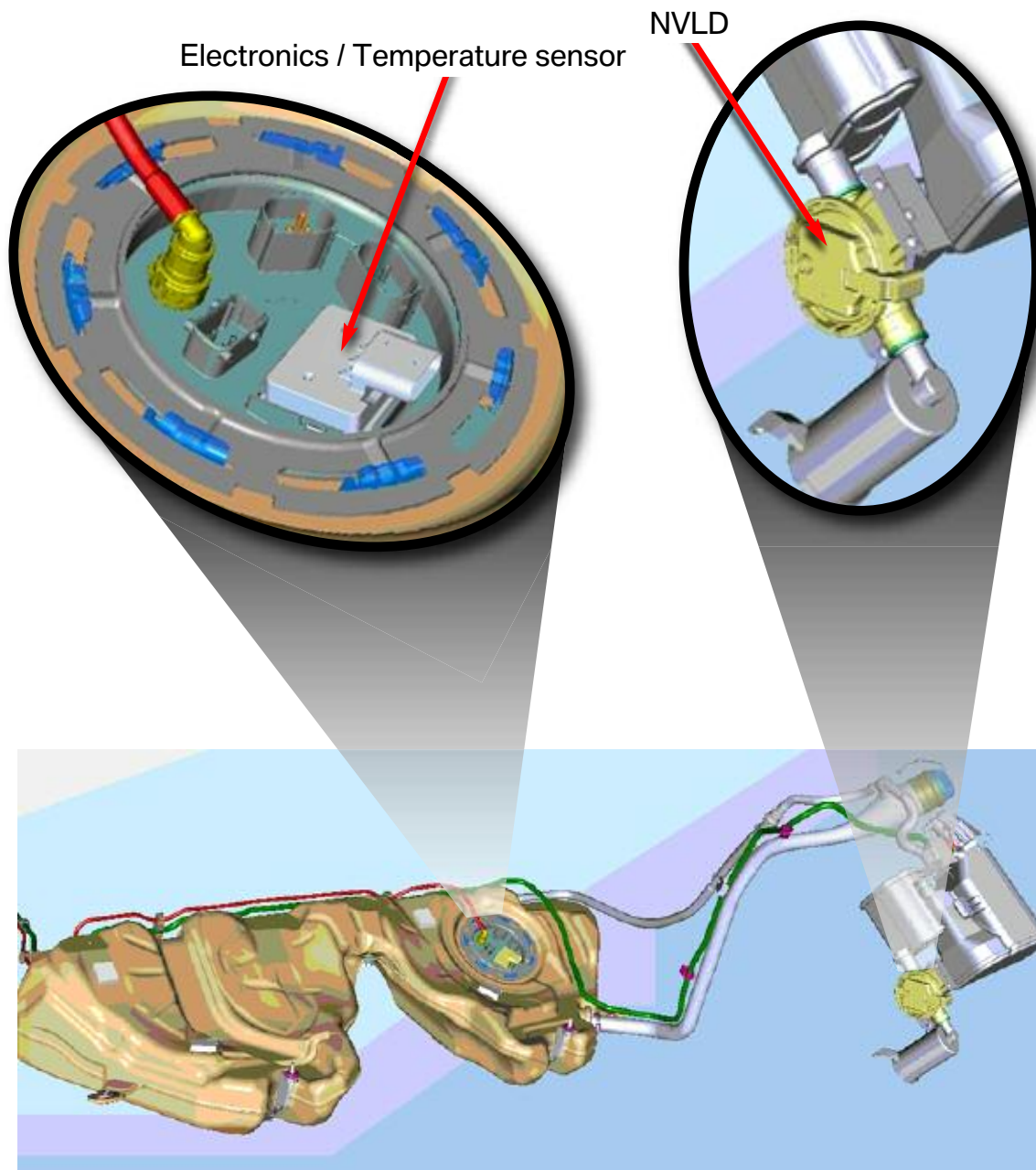
The fuel evaporation system must therefore meet the following requirements:

- Sealed against the environment
- Identify and display a leak

EVAP System Components

- Tank
- Tank flange
- Filler tube
- Fuel filler cap
- AKF (Active Carbon Canister)
- Air filter
- Diagnosis module (NVLD)
- Vent pipes
- TEV (Tank Vent Valve)
- TAV (Fuel Tank Non-Return Valve)
- DME (software)

NVLD Basic Version Component Location



■ System Restrictions

The EVAP system is connected to the engine and the environment through diverse interfaces. All components mentioned on the previous page and their subsystems are part of the EVAP system. The EVAP system restrictions are defined at the following locations:

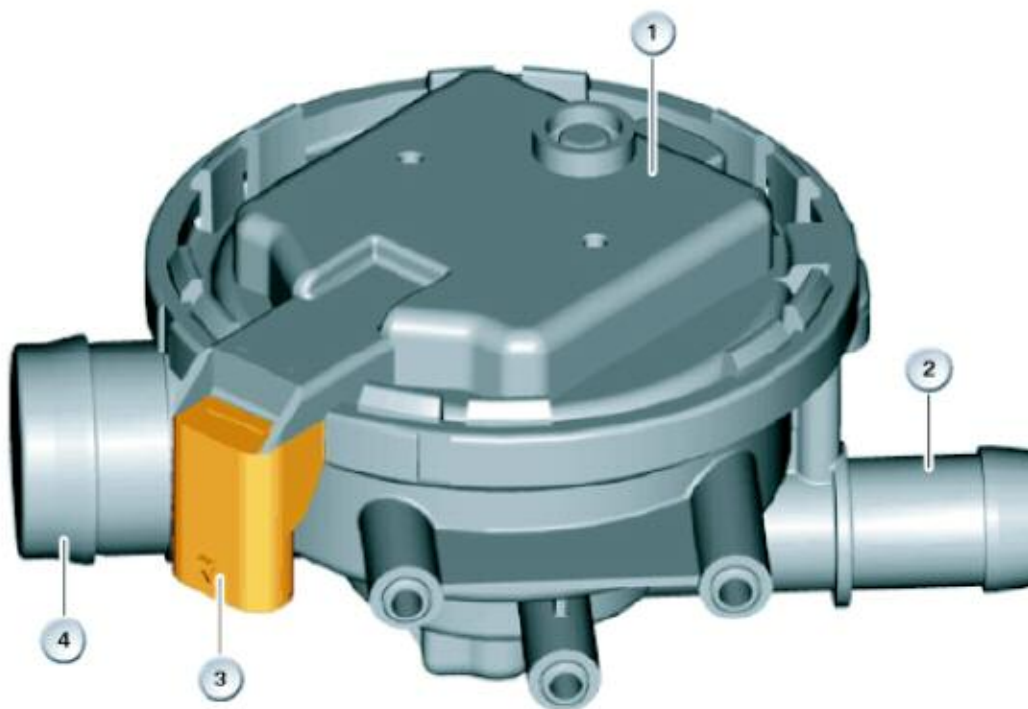
- Fuel filler cap (inclusive)
- Tank Vent Valve (TEV) (inclusive)
- Air filter (inclusive)

NVLD Variants

Integrated Version

Natural Vacuum Leak Detection temperature sensor and pressure switch in one unit.

NVLD Intergraded (F30) 2012MY



Index	Explanation	Index	Explanation
1	Temperature sensor and pressure switch	3	Three pin plug connection
2	To carbon canister	4	To fresh air filter

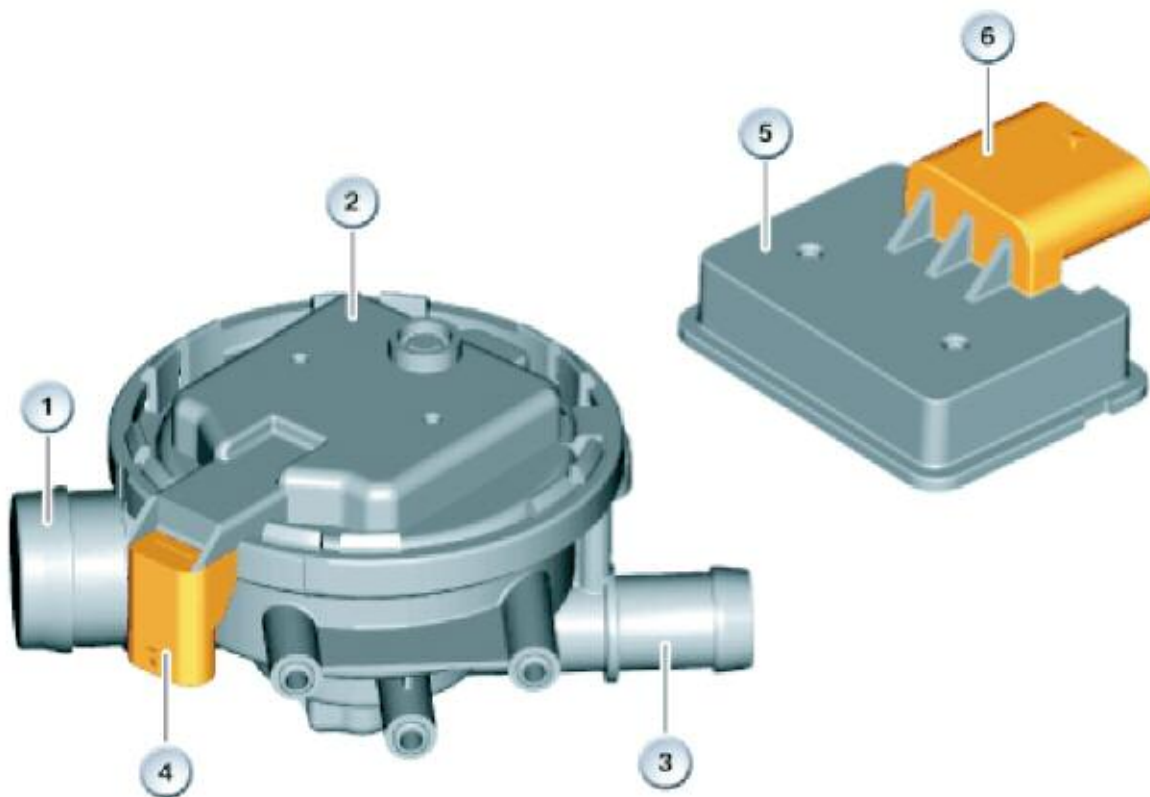


This system will gradually be replacing the DMTL Pump in all future models.

Basic Version

Natural Vacuum Leak Detection pressure switch and temperature sensor.

NVLD Basic for F10 with (N20 engine) as of September 2011



Index	Explanation	Index	Explanation
1	To fresh air filter	4	Three pin plug connection
2	Pressure switch	5	Electronics and temperature sensor
3	To carbon canister	6	Five pin plug connection



This system will gradually be replacing the DMTL Pump in all future models.

Physical Principle and Pressure Patterns

The physical principle is based on the Ideal Gas Law

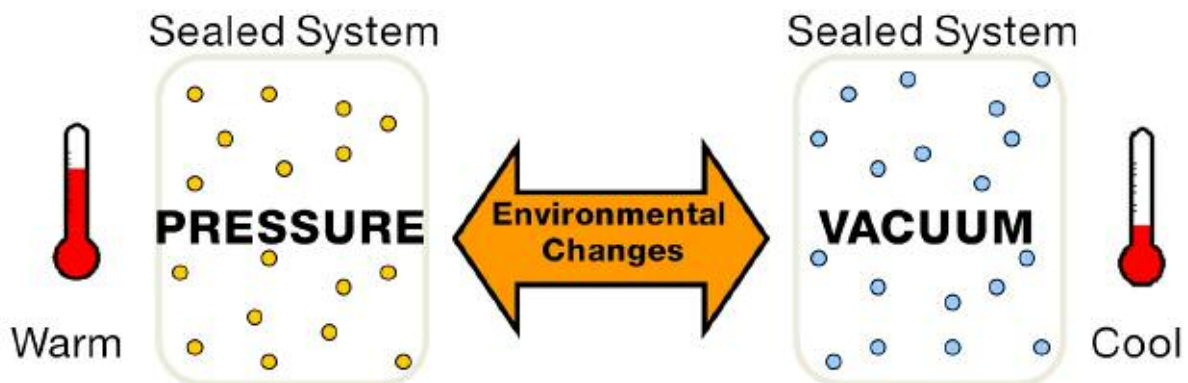
Pressure and temperature have a direct proportional relationship when quantity and volume remain constant. The NVLD uses this physical principle to identify leaks in the fuel evaporation system. This means that a vacuum forms when the temperature in the fuel tank drops. The NVLD uses a temperature sensor to measure the temperature. The NVLD uses the diaphragm-operated pressure switch to determine the vacuum. This diaphragm switches the pressure switch at a certain vacuum / ambient pressure combination.

The following graphic demonstrates the temperature profile and pressure pattern both when there is a leak in the fuel tank and when there is no leak.

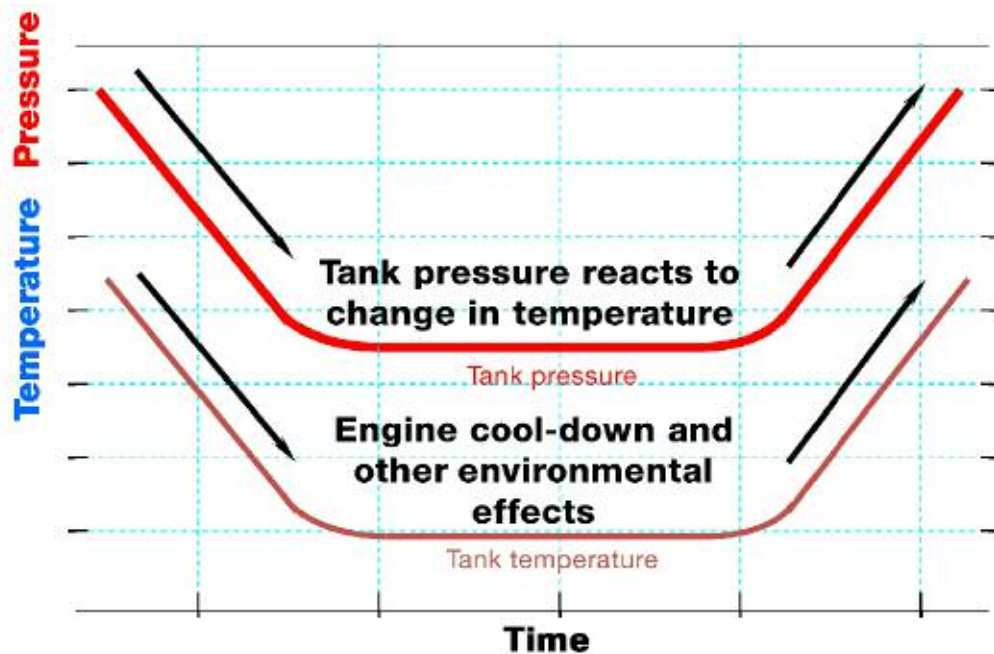
This property is described by "Charles' Law" (also known as the "Law of Volumes").

This phenomenon is used to detect leaks in the EVAP system via the NVLD.

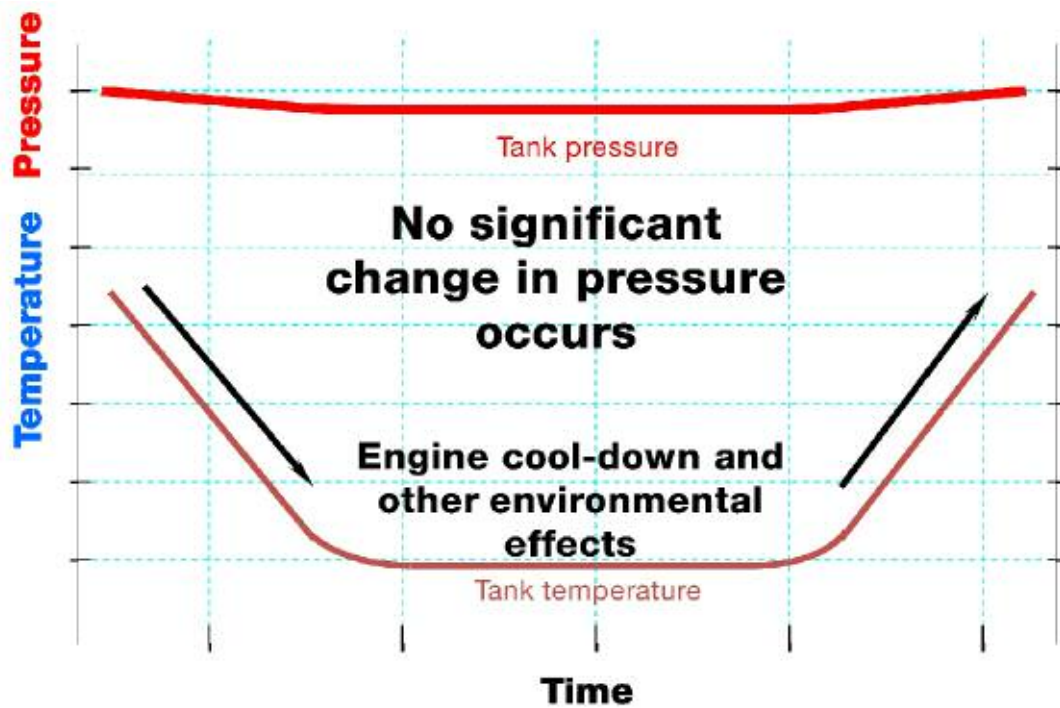
Ideal Gas Law



Pressure Patterns



Pressure pattern in the tank with temperature change and without leakage.



Pressure pattern in the tank with temperature change and leakage larger than 0.51 mm/0.02in.

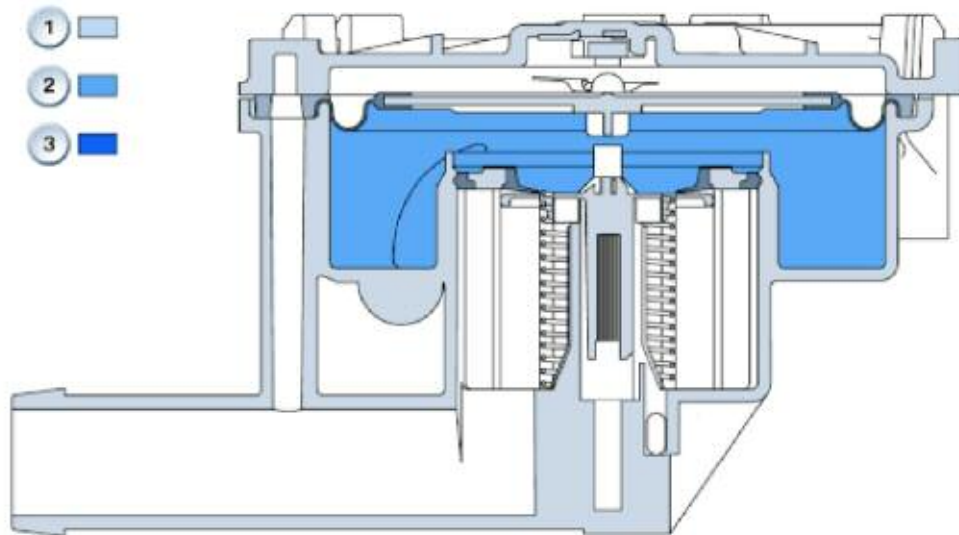
NVLD States of Operation

There are 5 possible mechanical functional states of the NVLD diagnosis module based on design and application.

The NVLD system is installed between the AFK (Active Carbon Canister) and the fresh air filter on the surrounding area side. The connection to the AFK is established via the small connecting branches. The module has a diaphragm and a poppet valve between the connection to the surrounding area.

Rest State

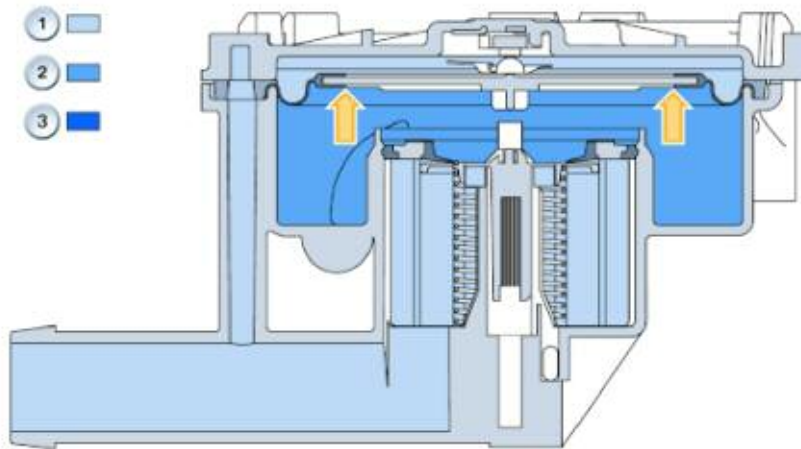
In rest state there is atmospheric pressure on the surrounding area side of the diaphragm and poppet valve. The pressure in the inside is not defined here. The switch is open. The poppet valve is tight. There is no gas exchange between the tank and surrounding area.



Index	Explanation	Index	Explanation
1	Partial Vacuum	3	Excess pressure
2	Atmospheric pressure		

Switch Closed

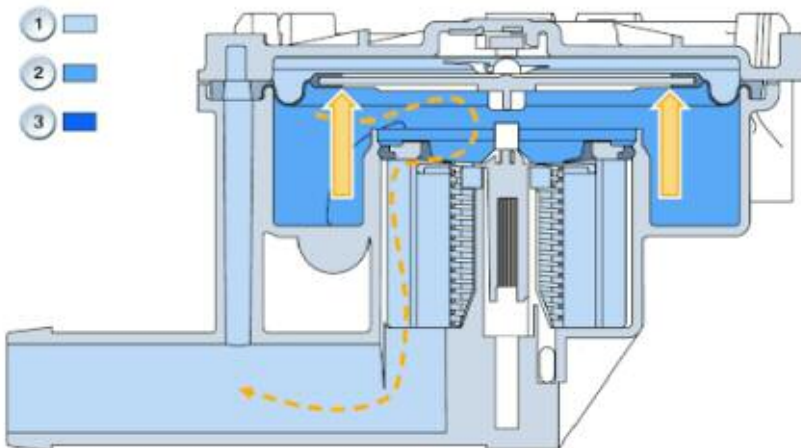
A vacuum in the tank system lifts the upper rubber diaphragm against the switch and closes it. There is no air exchange between the tank and surrounding area. The lower poppet valve is pressed onto the gasket by the springs. **The EVAP system is tight.**



Index	Explanation	Index	Explanation
1	Partial Vacuum	3	Excess pressure
2	Atmospheric pressure		

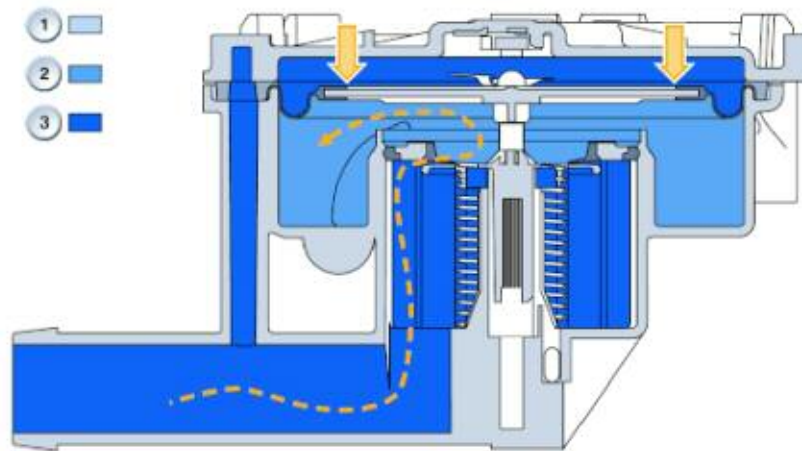
Scavenging Air Mode

In the case of an increased vacuum (scavenging air) in the tank system the poppet valve opens a fraction. Scavenging air flows from the air filter to the AKF. The prevailing vacuum still lifts the diaphragm against the switch. **The switch remains closed.**



Excess Pressure

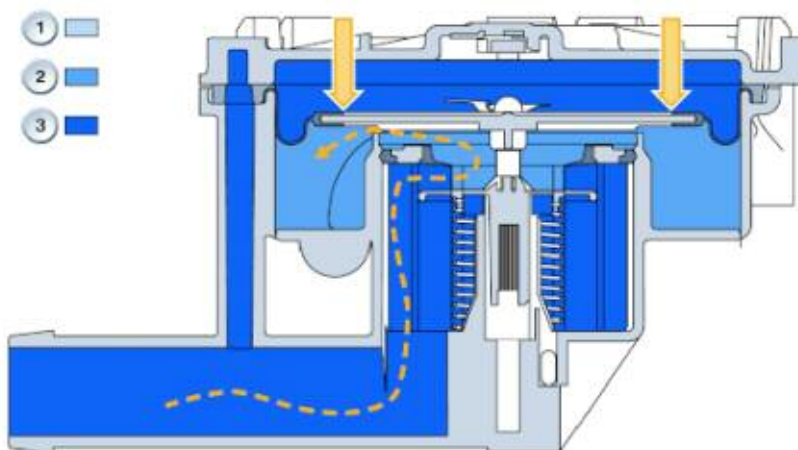
If the system pressure is slightly higher than the atmospheric pressure, the diaphragm presses down onto the poppet valve. This opens and gas flows outwards from the tank system via the fresh air filter. **The switch is open.**



Index	Explanation	Index	Explanation
1	Partial Vacuum	3	Excess pressure
2	Atmospheric pressure		

Refueling

The system pressure rises sharply during refueling. This causes the upper diaphragm to lower. At the same time, this presses down on the poppet valve underneath. Gases in the inner part of the system escape via the fresh air connection. **The switch is open.**



Functional Description

NVLD Diagnosis Module

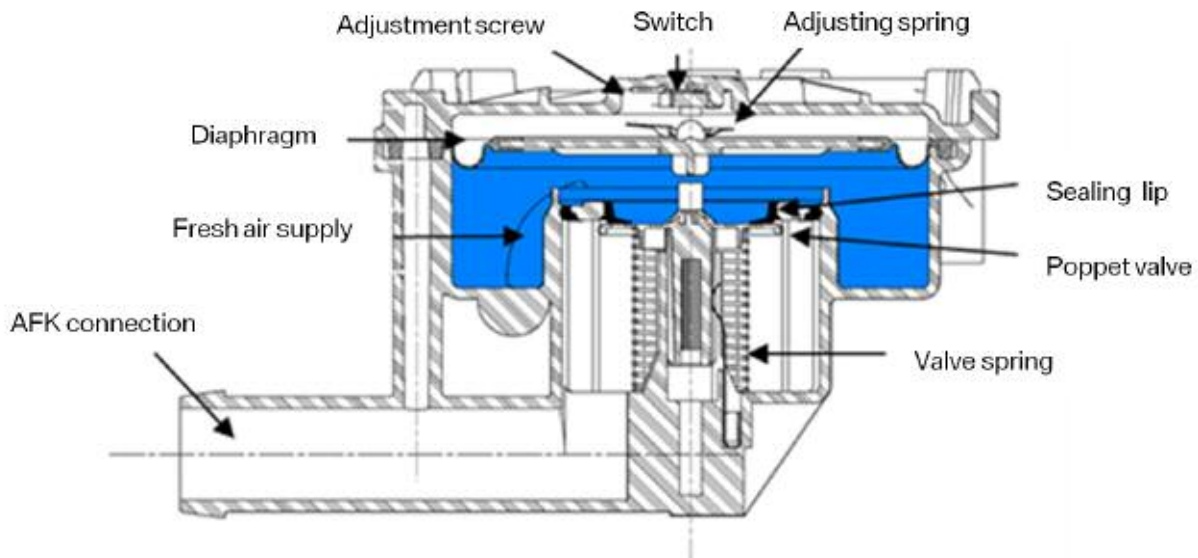
As required by CARB, the NVLD diagnosis module is used to detect leaks in the EVAP system. The physics principle applied here is used to detect excess pressure or a vacuum in the tank, based on the atmospheric ambient pressure. This diaphragm actuates a switch from a defined vacuum on the tank side (compared to the surrounding area side). In the case of reverse pressure ratios the diaphragm opens the poppet valve in order to dissipate the excess pressure from the tank. The same valve is opened when there is a large vacuum in the fuel tank. This arrangement is designed so that when fuel is being extracted from the tank a large vacuum does not arise in the tank and the flow resistance is not too high.

The actual diagnosis takes place in rest state after stopping the vehicle. The fuel in the tank cools down at night day/night temperature difference. A natural vacuum develops in the tank. If there are no leaks, the vacuum in the system remains. The diaphragm lifts and closes the switch.

The system is leak proof. In the case of a leak, air flows into the tank system as the vacuum is no longer sufficient to keep the switch closed.

The EVAP system has a leak.

NVLD Unit



NVLD Components

The following subsystems within the NVLD diagnosis module must fulfill certain tasks:

■ Diaphragm

Responds to pressure differentials by lifting and lowering the diaphragm area. A flexible rubber ring establishes a connection to the outer wall of the NVLD and guarantees freedom of movement of the diaphragm area with parallel tightness.

■ Valve spring

Presses the poppet valve against the sealing ring. A defined spring force ensures corresponding functionality in relation to the desired state (open/closed).

■ Poppet valve

The poppet valve positively seals the EVAP system with the sealing lip on the tank side against the environment.

■ Sealing lip

See poppet valve.

■ Switch

Opens/Closes electronic contact. It makes possible electronic state inquiry.

■ Adjusting spring

Between the diaphragm and the switch it defines the lifting force of the diaphragm and thus determines the switching point of the switch.

■ Adjustment screw

Controls the switching point of the switch via the adjusting spring.

■ Smart module

Communication with DME via a DMTLH line.

Leak Diagnosis Starting Conditions

Overview of Leak Diagnosis Process

Start criterion	Start precondition
Driving cycle	No (motor cold start required)
Fuel tank	Level No
Ambient Temperature	> 4.5°C/40°F
Min. temperature difference	8°C (14°F) drop in temp (for > 1 Hour)
Height above sea level	< 2500 m/8,200ft
TEV setting	Closed (basic setting)
Cold start precondition	Yes
Terminal status	KL_0/Asleep
Battery voltage	> 11 V and < 16 V
Pressure difference for ambient pressure between engine OFF and engine start	Less than 6 hPa (6 mbar)

Taking into consideration the diagnosis starting conditions, the electronic unit solely detects the switch position. Two states are possible:

- Closed switch
- Open switch

The electronic unit checks the state of the switch by applying current. The determined state is requested by the DME at the next engine start.

■ Frequency of Leak Diagnosis

The leak diagnosis begins after each driving cycle (after stopping the engine) and positive check of the starting conditions.

A test is always completed for all leaks from 0.51 mm/0.02in. There is no differentiation between a fine/micro leak. The evaluation generally takes place overnight due to the diagnosis starting conditions.

■ Requirements

At the same time, the tasks of the EVAP system determine the requirements of the overall NVLD system:

- Tightness of the EVAP system vis-a-vis its environment
- Identification and display of a leak

Self-Diagnosis of NVLD

1. Switch (short circuit to ground, battery, line disconnection, plausibility)
2. Temperature sensor (value range, gradient, plausibility)
3. Internal timer (plausibility)
4. Communication line DMTLH to the DME (short circuit to ground, battery, line disconnection, plausibility)
5. Power interruption

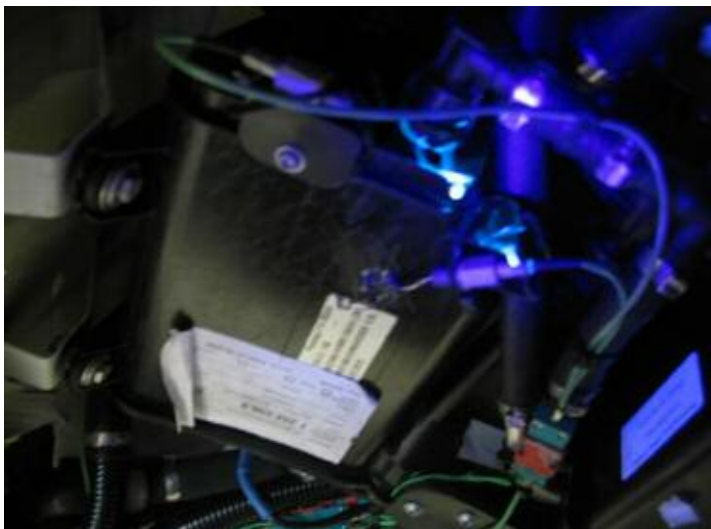
Abbreviations

- AKF: Active Carbon Canister
- CARB: California Air Resources Board
- DME: Digital Motor electronics
- KVS: Fuel Supply System
- NVLD: Natural Vacuum Leak Detection
- OBD: On-board Diagnosis
- TAV: Fuel Tank Non-Return Valve
- TEV: Tank Vent Valve

Workshop Hints

Detecting leaks in the evaporative system require the use of a smoke machine.

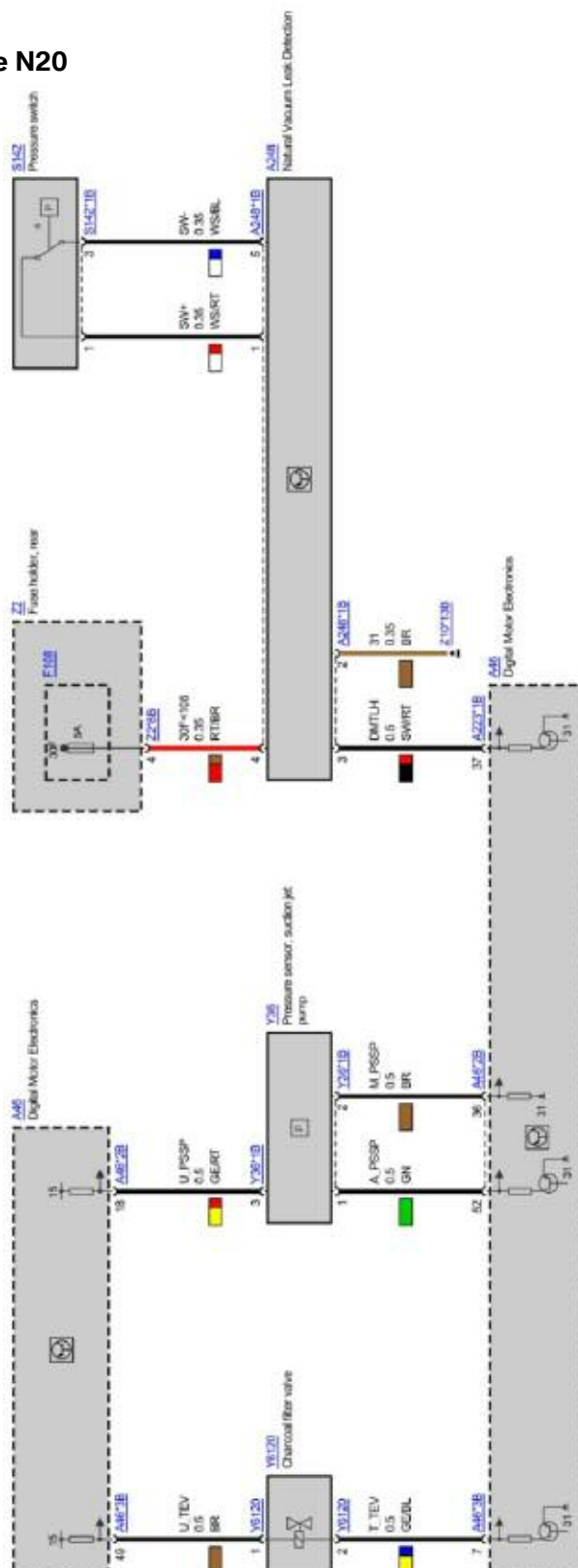
Leak at carbon canister found with smoke machine.



Wiring Diagram

Basic Version

2012MY F10 528i xDrive N20



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Secondary Air Injection

This system is required to reduce HC and CO emissions while the engine is warming up. Immediately following a cold engine start (-10 to 60°C) fresh air/oxygen is injected directly into the exhaust stream.

The temperature signal is provided to the ECM by the Air Temperature Sensor in the HFM.

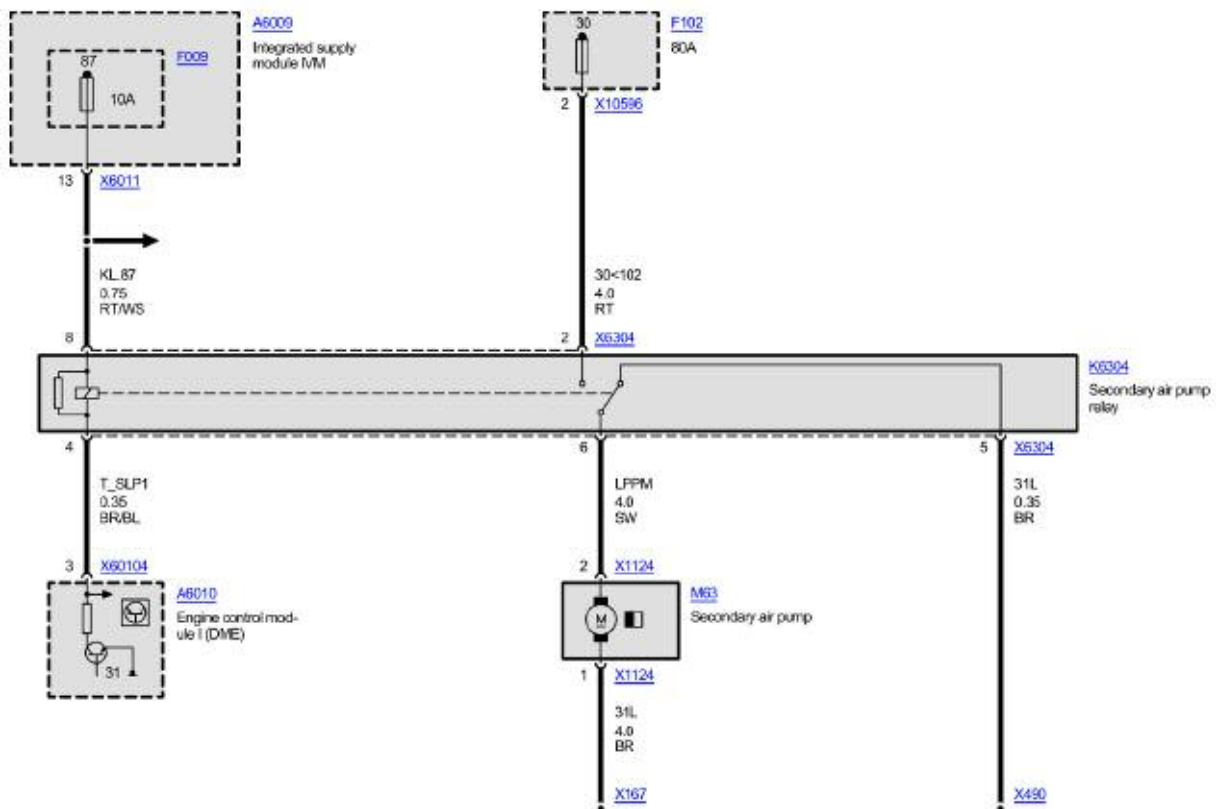
The ECM provides a ground circuit to activate the Secondary Air Injection Pump Relay. The relay supplies voltage to the Secondary Air Injection Pump.

The single speed pump runs for approximately 90 seconds after engine start up.



Below -10° C/ the pump is activated briefly to “blow out” any accumulated moisture.

SSP-SP0000017943 Secondary air pump

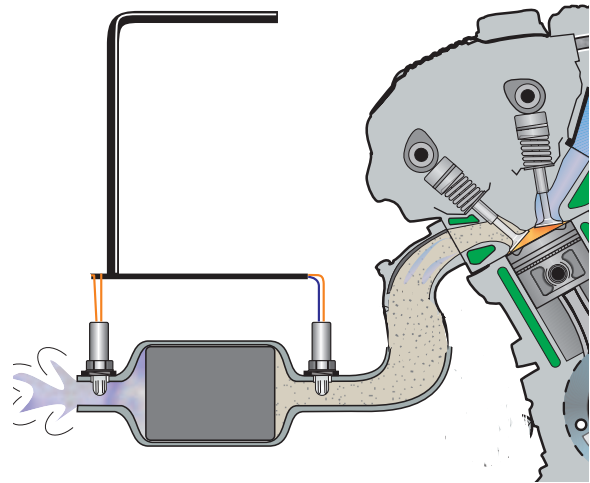


Secondary Air Injection Monitoring

The monitoring of Secondary Air is performed by the ECM via the use of the pre-catalyst oxygen sensors. Once the air pump is active and air is injected into the exhaust system the oxygen sensor signals will indicate a lean condition (up to 16 seconds).

If the oxygen sensor signals do not change within a predefined time a fault will be set and identify the faulty bank.

If the additional oxygen is not detected for two consecutive cold starts, the ECM determines a general fault with the function of the secondary air injection system. After completing the next cold start and a fault is again present the "Malfunction Indicator Light" will be illuminated when the OBD II criteria is achieved.



Secondary Air System

As on **N73** engine, the **N74** is equipped with a secondary air system. Blowing additional air (secondary air) into the exhaust gas duct in the cylinder head during the warm-up phase initiates thermal post-combustion that leads to a reduction in the unburned hydrocarbons (HC) and carbon monoxide (CO) contained in the exhaust gas. The energy generated here heats up the catalytic converter faster in the warm-up phase and increases its conversion rate. The catalytic converter response temperature (light-off temperature) of 300°C is reached only a few seconds after the engine is started.

What is new is that there is one pressure sensor before each secondary air valve. The function of the secondary air system is monitored by registering the pressure conditions.

■ Secondary air pump

The electrically operated secondary air pump is attached to the cylinder head of cylinder bank 1.

During the warm-up phase, the pump draws in fresh air from the engine compartment. This is cleaned by the filter integrated in the pump and delivered across the pressure line to the two secondary air valves.



After the engine start, the secondary air pump is supplied with vehicle voltage by the DME via the secondary air pump relay. The switched-on period is about 20 seconds and it depends essentially on the coolant temperature at engine start. It is activated from a coolant temperature of +5°C to +50°C (40°F to 120°F).

■ Secondary air valve

A secondary air valve is bolted onto the rear of each cylinder head. The secondary air valve opens as soon as the system pressure generated by the secondary air pump exceeds the opening pressure of the valve. Secondary air is fed via the secondary air line into the elongated passage of the cylinder head. From the elongated passage, 24 tap holes lead to the 12 exhaust ducts where the thermal post-combustion takes place.

The secondary air valve closes as soon as the secondary air pump switches off, thus preventing exhaust gas from flowing back to the secondary air pump.



**Secondary Air Valve
and Pressure Sensor**

■ On-board diagnosis of secondary air system

Monitoring takes place with the help of the pressure sensors that are fitted before each of the secondary air valves. The exhaust gas oxygen sensors are also used.

The overall diagnosis is divided into a rough diagnosis that begins immediately after the secondary air pump starts up and the fine diagnosis that begins around 12 to 14 seconds after the secondary air injection starts.

The rough diagnosis uses only the pressure signals. Every fault in the secondary air system is detected if there is a drop below a minimum pressure in the event of a leakage or if a maximum pressure is exceeded when a valve is clogged or jammed closed. However, under certain circumstances, it might not be possible to assign the fault correctly, because the pressure sensors indicate the same pressure due to the connecting line.

The fine diagnosis uses the exhaust gas oxygen sensor signals in addition to the pressure signals. The combination of exceeding or falling short of fault thresholds for the pressure and exhaust gas oxygen sensor values means the fault can be precisely assigned to the relevant cylinder bank. The fine diagnosis relies on the oxygen sensor readiness, this is available much later than in naturally aspirated engines due to the heat loss through the turbocharger.

There is also an electrical diagnosis for the secondary air pump relay and for the pressure sensors. These indicate the usual electrical faults (line disconnection, short circuit to ground, short circuit to supply voltage). There is an additional mutual plausibility check of the pressure sensors on initialization with ambient pressure.

Misfire Detection

Misfire detection is part of the OBD II regulations the ECM must determine misfire and also identify the specific cylinder(s). The ECM must also determine the severity of the misfire and whether it is **emissions relevant** or **catalyst damaging** based on monitoring crankshaft acceleration.

Emission Increase

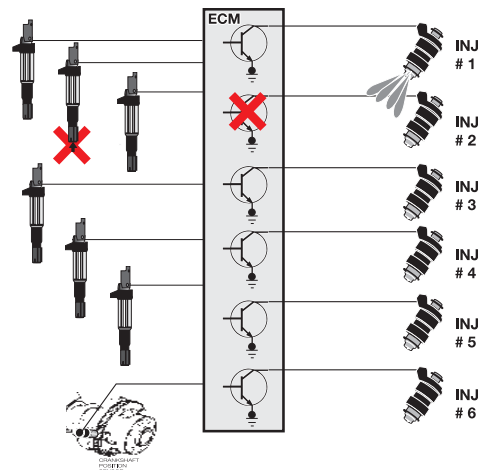
- Within an interval of 1000 crankshaft revolutions, the ECM adds the detected misfire events for each cylinder. If the sum of all cylinder misfire incidents exceeds the pre-determined value, a fault code will be stored and the “Malfunction Indicator Light” will be illuminated.
- If more than one cylinder is misfiring, all misfiring cylinders will be specified and the individual fault codes for each misfiring cylinder, or multiple cylinders will be stored. The “Malfunction Indicator Light” will be illuminated.

Catalyst Damage

- Within an interval of 200 crankshaft revolutions the detected number of misfiring events is calculated for each cylinder. The ECM monitors this based on load/rpm. If the sum of cylinder misfire incidents exceeds a predetermined value, a “Catalyst Damaging” fault code is stored and the “Malfunction Indicator Light” will be illuminated.

If the cylinder misfire count exceeds the predetermined threshold the ECM will take the following measures:

- The oxygen sensor control will be switched to open loop.
- The cylinder selective fault code is stored.
- If more than one cylinder is misfiring the fault code for all individual cylinders and for multiple cylinders will be stored.
- The fuel injector to the respective cylinder(s) is deactivated.

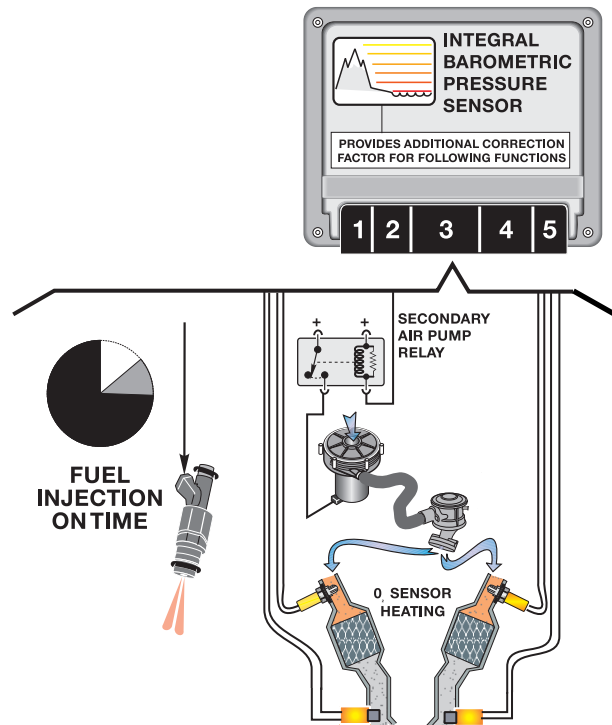


Ambient Barometric Pressure

The Integrated Ambient Barometric Pressure Sensor is part of the ECM and is not serviceable. The internal sensor is supplied with 5 volts. In return it provides a linear voltage of approx. 2.4 to 4.5 volts representative of barometric pressure (altitude).

The ECM monitors barometric pressure for the following reasons:

- The barometric pressure signal along with calculated air mass provides an additional correction factor to further refine injection “on” time.
- Provides a base value to calculate the air mass being injected into the exhaust system by the Secondary Air Injection System. This correction factor alters the secondary air injection “on” time, optimizing the necessary air flow into the exhaust system.



Crankcase Ventilation

One of the major changes on the new NG6 engines is that the crankcase ventilation system has been upgraded and improved. This applies to all of the new NG6 versions (N52KP, N51 and N54).

There are two distinct versions of crankcase ventilation. One type is unique to the N54 and the other applies to N51 and N52KP.

The N52, which is still in production continues to use the “external” crankcase ventilation system with the electrically heated crankcase ventilation valve/cyclone separator.

Crankcase Ventilation System on N52



Crankcase Ventilation (N51 and N52KP)

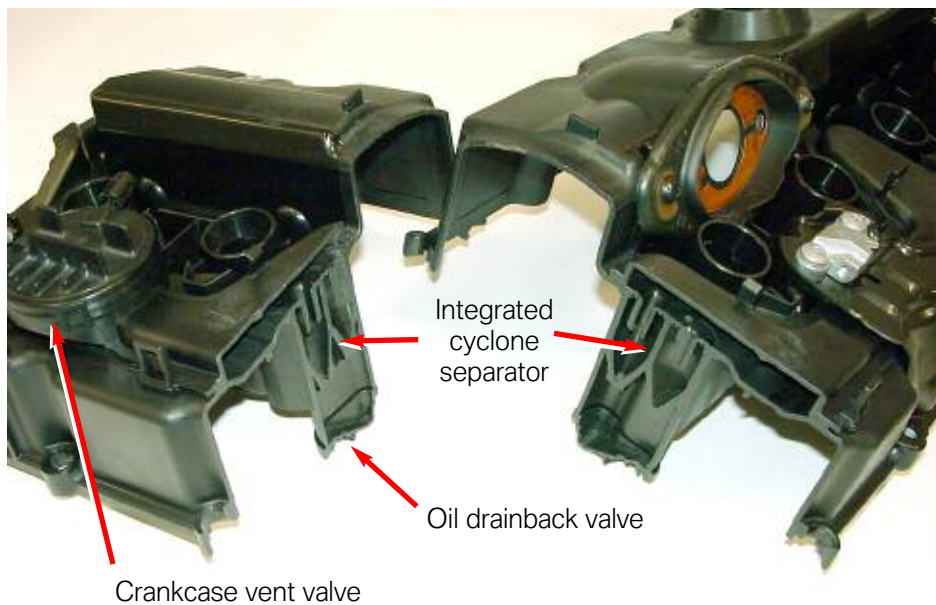
The crankcase ventilation system on the N51 and N52KP has been modified as compared to the N52. The system is integrated into the plastic cylinder head cover.

The crankcase gases are regulated by a crankcase ventilation valve similar to the design used on the N62. The crankcase vent valve is currently part of the cylinder head cover and is not replaceable as a separate component.

Oil separation is carried out via a “labyrinth” system and two cyclone separators which are incorporated into the cylinder head cover. By having the system components integrated into the cylinder head cover, the crankcase gases are heated by the engine rather than an electric heater as on the N52. However, there is still one electric heating element at the manifold inlet.

Once the liquid oil is separated from the crankcase vapors, the oil is allowed to drain back through check valves back into the engine.

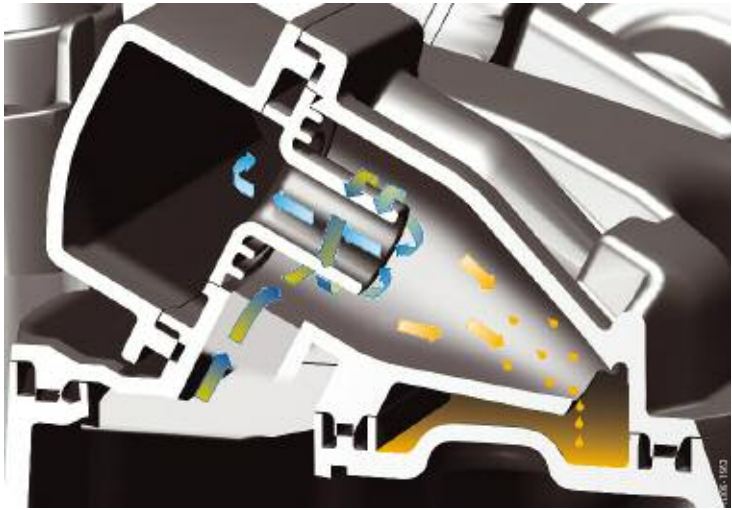
N52KP Cylinder Head Cover (cutaway view)



Crankcase Ventilation (N54)

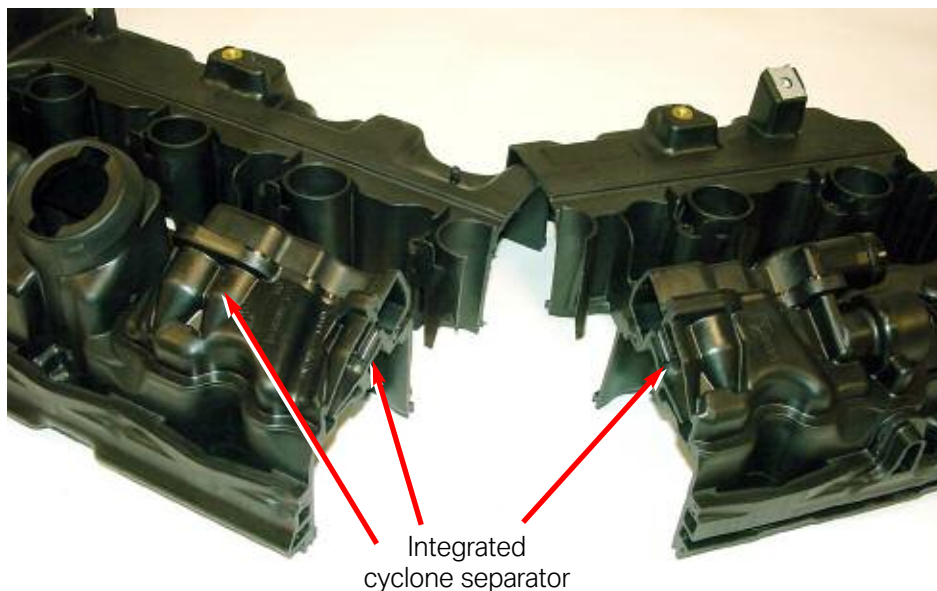
Since the N54 is a turbocharged engine, the crankcase ventilation system has to meet certain design requirements. For example, when the engine is in turbocharged mode, the increased manifold pressure should not have an adverse effect on the crankcase venting. This is why, there is no crankcase ventilation valve in the system.

The system consists of four small cyclone separators which are integrated into the plastic cylinder head cover. The flow of crankcase gases is metered through a series of restrictions which control the ultimate crankcase pressure.



One of the main operating principles behind the crankcase venting system on the N54 is that there are two strategies - one for the turbocharged mode and one for “non-turbocharged” operation such as decel. These strategies are dependent upon the intake manifold pressure.

N54 Cylinder Head Cover (cutaway view)



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Crankcase Ventilation System Overview (N55)

The blow-by gasses flow into the settling chamber of the cylinder head cover through an opening located in the rear of the cover. Here, the blow-by gasses are directed through holes on to an impact plate, against which the oil impacts at high speed, and drains off. The blow-by gasses, cleaned of oil, flow via the pressure control valve (depending on the operating mode) through the non-return valves into the inlet pipe upstream of the turbocharger, or via passages in the cylinder head ahead of the intake valves. The separated oil is drained via a return flow duct into the oil pan.

■ Naturally Aspirated Mode (N55)

The standard function can only be used as long as a vacuum prevails in the intake air manifold, i.e. in naturally-aspirated engine mode.

With the engine operating in naturally-aspirated mode, the vacuum in the intake air manifold opens the non-return valve (15) in the blow-by duct within the cylinder head cover. This draws off blow-by gasses via the pressure control valve. At the same time, the vacuum also closes the second non-return valve (12) in the duct to the charge air intake pipe.

The blow-by gasses flow via a distribution rail integrated in the cylinder head cover, through the intake passages (16) in the cylinder head, which lead directly into the intake ports, ahead of the valves.

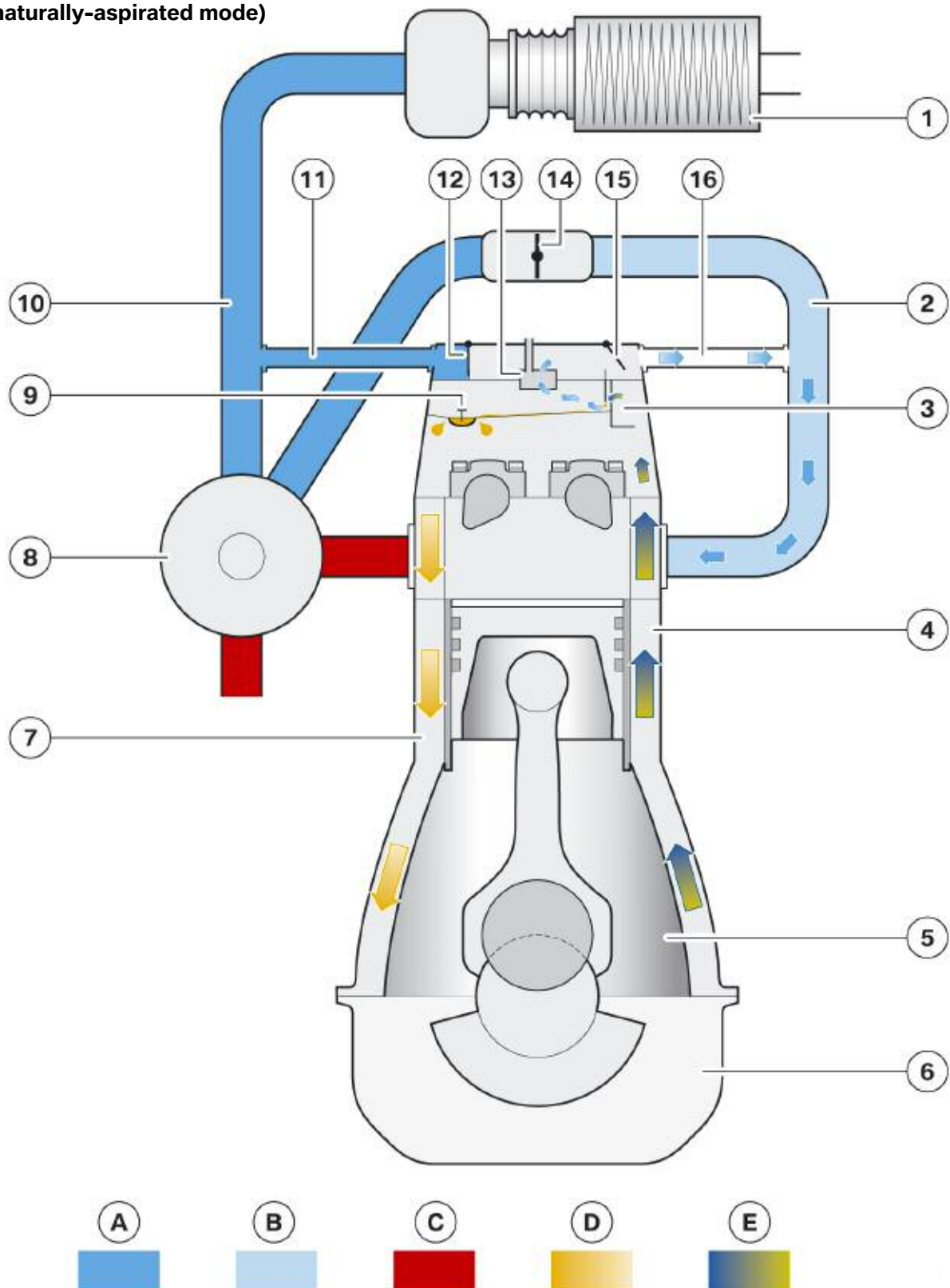
■ Boost Mode (N55)

As the pressure in the intake air manifold increases in boost mode, blow-by gasses can no longer be introduced via the passages in the cylinder head, otherwise, the boost pressure could enter the crankcase. A non-return valve (15) in the blow-by channel within the cylinder head cover closes the connection (16) to the intake air manifold. This protects the crankcase from excess pressure.

The increased demand for fresh air creates a vacuum in the clean air pipe between the turbocharger and intake silencer. This vacuum is sufficient to open the non-return valve (12) and draw the blow-by gasses via the pressure control valve.

Crankcase Ventilation Overview (N55)

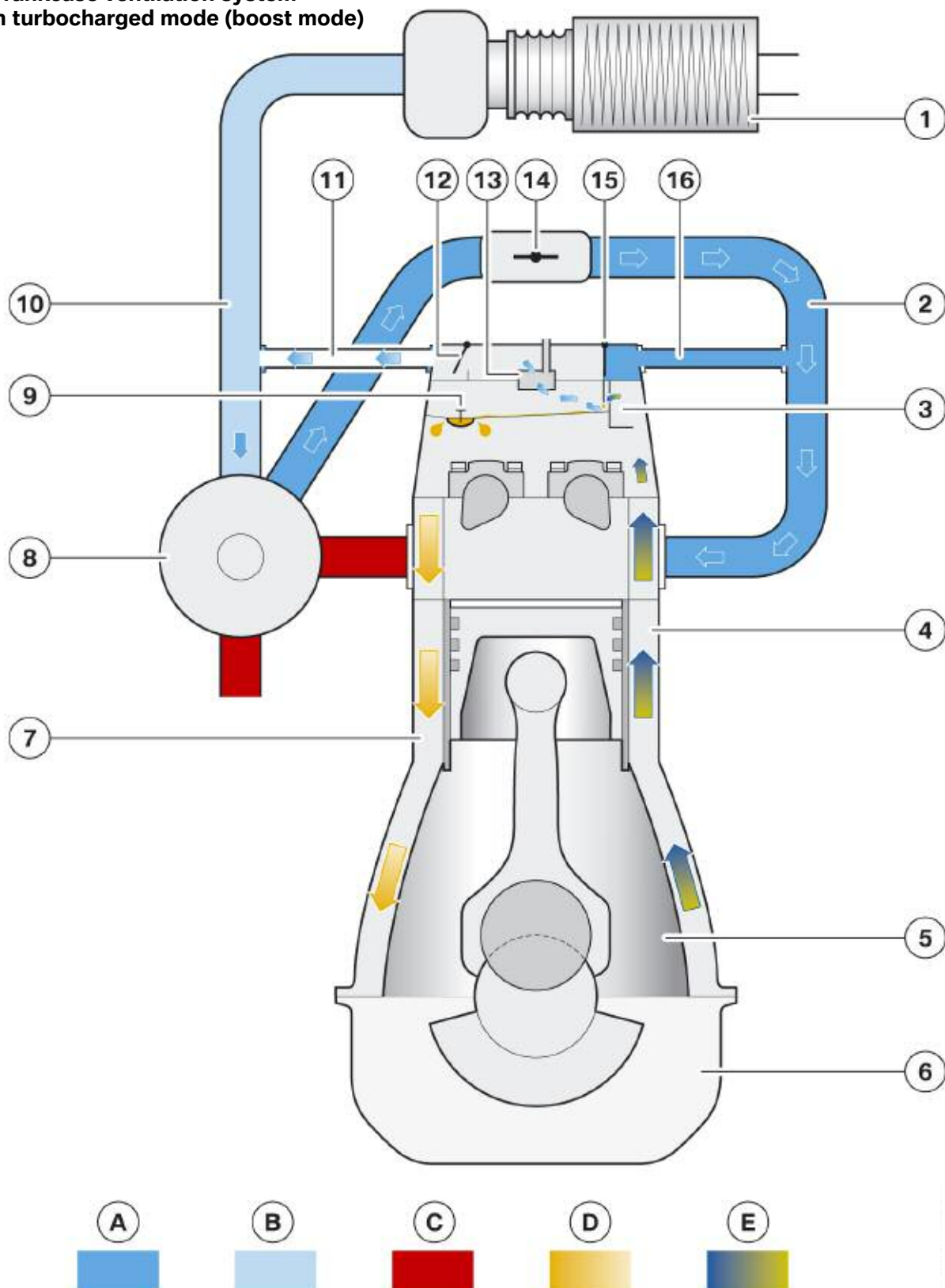
Crankcase ventilation system in “decel mode”
(naturally-aspirated mode)



Index	Explanation
A	Ambient pressure
B	Vacuum
C	Exhaust gas
D	Oil
E	Blow-by gas
1	Air cleaner
2	Intake manifold
3	Impact plates
4	Oil return channel
5	Crankcase
6	Oil sump
7	Oil return channel
8	Exhaust turbocharger
9	Oil drain valve
10	Charge air intake line
11	Hose to charge air intake line
12	Non-return valve
13	Pressure regulating valve
14	Throttle valve
15	Non-return valve
16	Passages in cylinder head and cylinder head cover

Crankcase Ventilation System Overview (N55)

Crankcase ventilation system
in turbocharged mode (boost mode)





If a customer complains about high oil consumption and oil is discovered in the turbocharger, it should not be immediately assumed that the turbocharger is defective. If the oil is present in the fresh air pipe (before the turbocharger) then the entire engine should be checked.

Index	Explanation
A	Excess pressure
B	Vacuum
C	Exhaust gas
D	Oil
E	Blow-by gas
1	Air cleaner
2	Intake manifold
3	Impact plates
4	Oil return channel
5	Crankcase
6	Oil sump
7	Oil return channel
8	Exhaust turbocharger
9	Oil drain valve
10	Charge air intake line
11	Hose to charge air intake line
12	Non-return valve
13	Pressure regulating valve
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15	Non-return valve
16	Passages in cylinder head and cylinder head cover

NOTES

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Crankcase Ventilation System Overview (N54)

■ Naturally Aspirated Mode (N54)

When the engine has low manifold pressure such as in decel, the crankcase vapors are routed through a channel (15) between the cylinder head cover and intake manifold. The liquid oil is separated before the channel in the cyclonic separators (3) in the cylinder head cover. The liquid oil returns to the engine via the oil discharge valve (4).

The channel contains a pressure restrictor (16) which regulates the flow of crankcase vapors. During deceleration, the crankcase vapors (E) are directed via a check valve (14) which is located in the cylinder head cover. The check valve is opened when low pressure is present in the intake manifold (throttle closed).

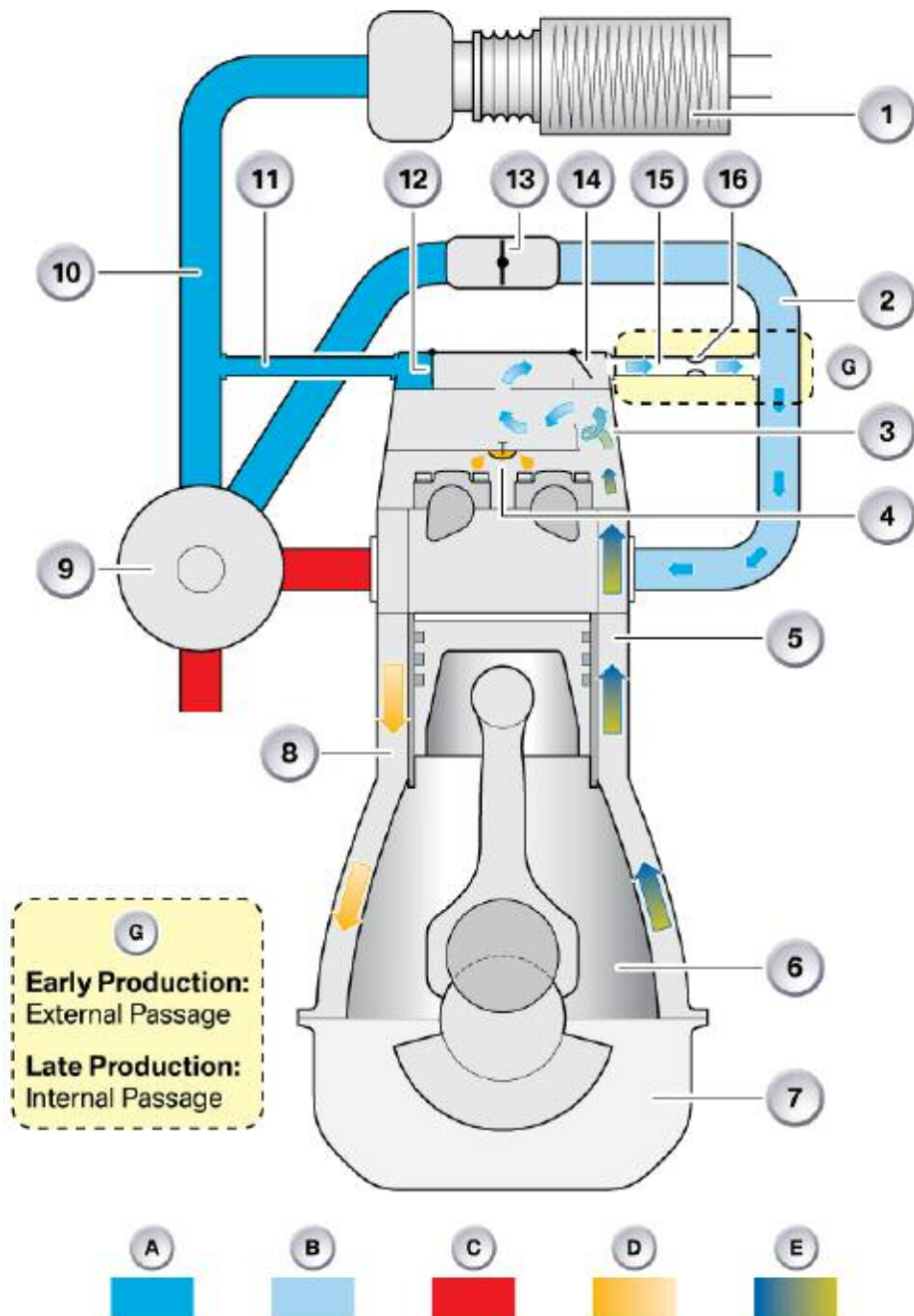
Also, a PTC heater has been integrated into the intake manifold inlet. The inlet pipe is connected to the channel (15) and prevent any moisture from freezing at the inlet.

■ Boost Mode (N54)

When in turbocharged mode, the pressure in the intake manifold increases and then closes the check valve (14). Now, a low pressure is present in the charge air suction line (10). This causes a low pressure in the hose (11) leading to the manifold check valve (12). The crankcase vapors (after separation) are directed through the check valve (12) into the charge air suction line (10) and ultimately back into the engine. The check valve (12) also prevent boost pressure from entering the crankcase when the intake manifold pressure is high.

Crankcase Ventilation System Overview (N54)

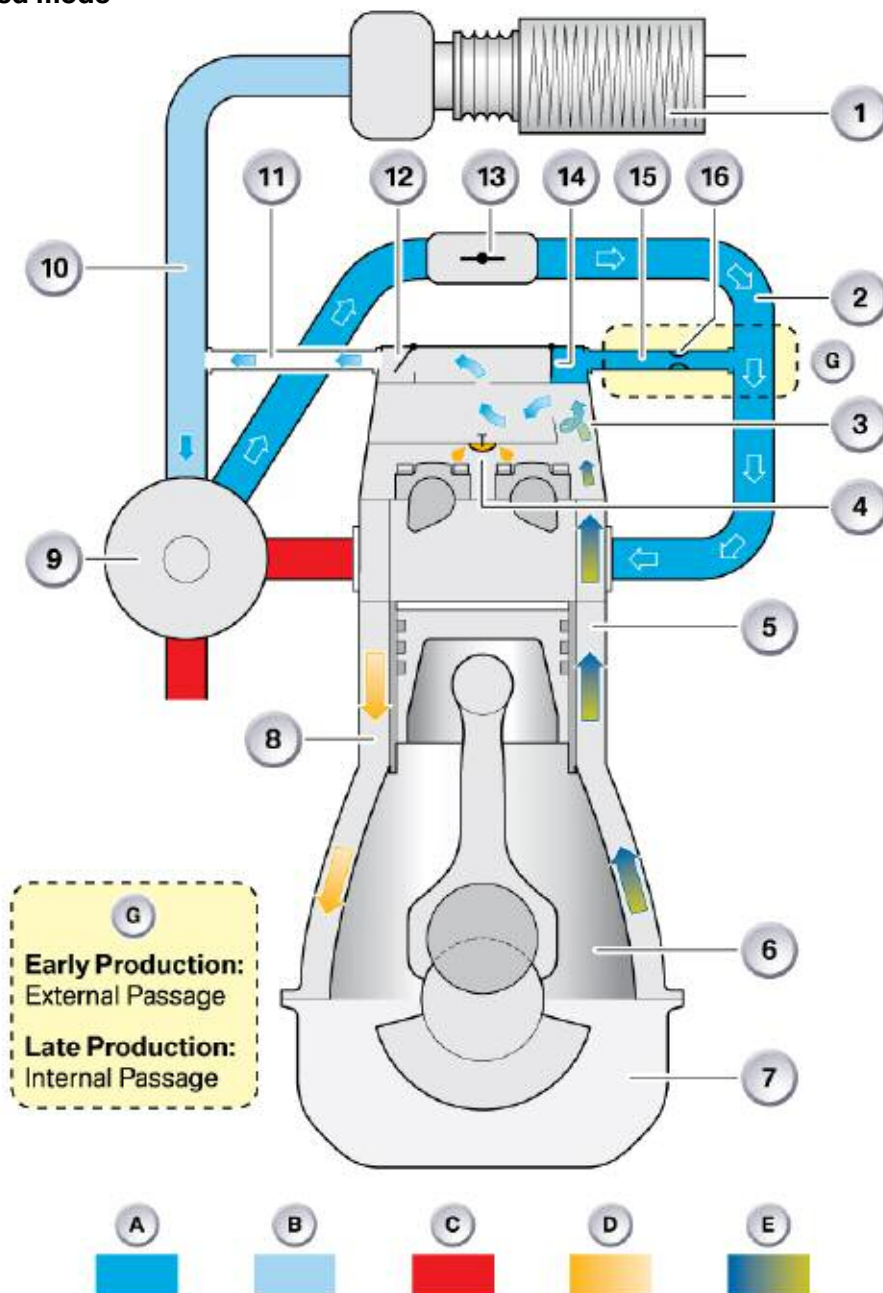
Crankcase ventilation system
in “decel mode”



Index	Explanation	Index	Explanation
A	Overpressure	7	Oil sump
B	Low Pressure (Vacuum)	8	Oil return channel
C	Exhaust gas	9	Turbocharger
D	Liquid oil	10	Charge air suction line, bank 2
E	Blow-by gases (Crankcase vapors)	11	Hose to charge air suction line, bank 2
1	Air cleaner	12	Check valve, manifold
2	Intake manifold	13	Throttle valve
3	Cyclone separators	14	Check valve, charge air suction line
4	Oil discharge valve	15	Channel to intake manifold
5	Venting channel	16	Pressure restrictor
6	Crankshaft cavity		

Crankcase Ventilation System Overview (N54)

Crankcase ventilation system in
“turbocharged mode”



If a customer complains about high oil consumption and oil is discovered in the turbocharger, it should not be immediately assumed that the turbocharger is defective. If the oil is present in the fresh air pipe (before the turbocharger) then the entire engine should be checked.

Index	Explanation	Index	Explanation
A	Overpressure	7	Oil sump
B	Low Pressure (Vacuum)	8	Oil return channel
C	Exhaust gas	9	Turbocharger
D	Liquid oil	10	Charge air suction line, bank 2
E	Blow-by gases (Crankcase vapors)	11	Hose to charge air suction line, bank 2
1	Air cleaner	12	Check valve, manifold
2	Intake manifold	13	Throttle valve
3	Cyclone separators	14	Check valve, charge air suction line
4	Oil discharge valve	15	Channel to intake manifold
5	Venting channel	16	Pressure restrictor
6	Crankshaft cavity		



Be aware that any check valve failure could cause excessive oil consumption possibly accompanied by blue smoke from the exhaust. This should not be mistaken for a failed turbocharger. Always perform a complete diagnosis of the crankcase ventilation system, before replacing any turbocharger or associated components.

Crankcase Ventilation Heating

Also integrated into the design of the crankcase ventilation is an electric heating system designed to prevent moisture buildup. Moisture buildup can eventually lead to ice at low ambient temperatures leading to malfunctions of the crankcase ventilation.

The crankcase vent valve and cyclonic separator are also insulated by a protective foam covering to provide additional shelter from low ambient temperatures.

The PTC heating elements are integrated into the crankcase ventilation valve and hose assemblies. There is a junction point on the intake manifold which provides a connection point for the individual heating elements.

There is also a heating element located on the centrally located port on the intake manifold. This port is also provided with a separate heating circuit controlled by a PTC thermistor.

The ECM receives the ambient temperature information from the outside temperature sensor.

SSP-SP0000052251 Oil Supply (Engine Breather Heater)

