

# Self-Study Program 840293 Engine Management Systems



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## Contents

Introduction	1
Motronic ME 7	8
Motronic ME 7.1.1	18
Motronic MED 9.1	29
Motronic MED 9.1.1	41
Motronic MED 17.5	48
Reference Materials	53
Glossary	54
Knowledge Assessment	



This Self-Study Program covers information on the Volkswagen Engine Management Systems.

This Self-Study Program is not a Repair Manual. This information will not be updated. For testing, adjustment and repair procedures, always refer to the latest electronic service information. Page intentionally left blank

## What

Since the introductions of the D-Jetronic fuel injection system in Model Year (MY) 1968, the Motronic ME7 torque-based system in MY 1999, and the current Motronic MED17.5 dual gasoline/diesel system, Volkswagen engine management systems continue to evolve to meet the demands of changing emissions and fuel economy standards.

This Self Study Program (SSP) discusses changes and additions implemented since the April of 2000 publication of SSP 841003, Engine Management Systems. Components that are unchanged from previous engine management systems are listed with the new system, but are not described in detail. If a component is not described in this document, you will be referred to a previous SSP that contains the information.

## Why

Volkswagen is continually upgrading engine control systems to meet the increasing demands for increased performance and greater fuel economy, all the while decreasing tailpipe emissions.

California emission standards have been traditionally more stringent than the EPA requirements, but their evolution and structure is similar to that of the federal legislation. The California Air Resources Board (CARB) first adopted Low Emission Vehicle (LEV) standards in 1990. These first LEV standards were in effect from 1994 through 2003.

LEV II regulations, adopted in November 1998, are in effect from 2004 through 2010. LEV II affects passenger cars, light-duty trucks (such as the Touareg 2), and medium-duty vehicles.

A number of other states have adopted emission standards equivalent to the California LEV II legislation, including New York, Massachusetts, Maine, and Vermont. Adoption of California standards has been considered also by Connecticut, Rhode Island, Pennsylvania, New Jersey, Oregon, and Washington.

## Low Emission Vehicle (LEV) Standards

These California emission standards, which applied through model year 2003, were expressed using the following emission categories:

- Tier 1
- Transitional Low Emission Vehicles (TLEV)
- Low Emission Vehicles (LEV)
- Ultra Low Emission Vehicles (ULEV)
- Super Ultra Low Emission Vehicles (SULEV)
- Zero Emission Vehicles (ZEV)

Car manufacturers were required to produce a percentage of vehicles certified to increasingly more stringent emission categories, according to schedules based on vehicle fleet emission averages for each manufacturer. After 2003, Tier 1 and TLEV standards were eliminated as available emission categories.

The same standards for gaseous pollutants applied to diesel- and gasoline-fueled vehicles. Particulate Matter (PM) standards applied to diesel vehicles only. Emissions were measured over the FTP 75 test and are expressed in g/ mile. The additional Supplemental Federal Test Procedures (SFTP) were phased-in in California between 2001 and 2005.

Cotorony	50,000 miles/5 years					100,000 miles/10 years					
Category	NMOG*	CO	NOx	PM	НСНО	NMOG*	CO	NOx	PM	НСНО	
Passenger	Cars										
Tier 1	0.25	3.4	0.4	0.08	-	0.31	4.2	0.6	-	-	
TLEV	0.125	3.4	0.4	-	0.015	0.156	4.2	0.6	0.08	0.018	
LEV	0.075	3.4	0.2	_	0.015	0.090	4.2	0.3	0.08	0.018	
ULEV	0.040	1.7	0.2	-	0.008	0.055	2.1	0.3	0.04	0.011	
LDT1, LVW	<3,750 lbs										
Tier 1	0.25	3.4	0.4	0.08	-	0.31	4.2	0.6	-	-	
TLEV	0.125	3.4	0.4	-	0.015	0.156	4.2	0.6	0.08	0.018	
LEV	0.075	3.4	0.2	-	0.015	0.090	4.2	0.3	0.08	0.018	
ULEV	0.040	1.7	0.2	-	0.008	0.055	2.1	0.3	0.04	0.011	
LDT2, LVW	>3,750 lbs										
Tier 1	0.32	4.4	0.7	0.08	-	0.40	5.5	0.97	-	-	
TLEV	0.160	4.4	0.7	-	0.018	0.200	5.5	0.9	0.10	0.023	
LEV	0.100	4.4	0.4	-	0.018	0.130	5.5	0.5	0.10	0.023	
ULEV	0.050	2.2	0.4	-	0.009	0.070	2.8	0.5	0.05	0.013	
* NMH	C for all Tier	<sup>.</sup> 1 standa	rds								
				Abb	reviation	s:					
LVW Loa	ded Vehicle	Weight (c	urb weigh	nt + 300 lb	os)	co (	Carbon Mor	noxide			
LDT Ligi	nt-Duty Truc	k				NOx	Oxides of N	itrogen			
NMOG Nor	n-Methane (	Organic Ga	ases			PM I	Particulate N	Matter			
NMHC Nor	NMHC Non-Methane Hydrocarbons					FTP 75	TP 75 Federal Test Procedure 75 (grams per				
HCHO For	maldehyde					r	mile		-		

## California Emission Standards for Light-Duty Vehicles (FTP 75, g/mi)

## **LEV II Standards**

On November 5, 1998 the CARB adopted the LEV II emission standards that are in effect from 2004 until 2010. The main elements are:

- Elimination of the TLEV emission category
- Inclusion of heavier sport utility vehicles and pickup trucks in the passenger car emission standards
  - The reclassification was phased-in by the year 2007
- Extension and tightening of the fleet average emission standards during 2004-2010 (Corporate Average Fuel Economy (CAFE), that include all new vehicles from an automaker)
- Creation of the SULEV category for light-duty vehicles (SULEVs emit only a single pound of hydrocarbons during 100,000 miles of driving – about the same as spilling a pint (0.5 liter) of gasoline)

- Reduction of 75% to the oxides of nitrogen (NOX) emission standards for the LEV and ULEV categories
- Increased emission control durability standards from 100,000 miles to 120,000 miles for passenger cars and light trucks
- Creation of Partial Zero-Emission Vehicle (PZEV) credits for vehicles that achieve near zero emissions
  - The credits include full ZEV credit for a stored hydrogen fuel cell vehicle, 0.7 credit for methanol reformer fuel cell vehicles, 0.4 credit for a compressed natural gas SULEV and 0.2 for a gasoline fueled SULEV

Under the LEV II standard, NOx and PM standards for all emission categories are significantly tightened and apply to both gasoline and diesel vehicles. Under revisions adopted on November 15, 2001 gasoline vehicles are no longer exempted from the PM standard.

Cotorowy	50,000 miles/5 years					120,000 miles/11 years						
Category	NMOG*	СО	NOx	PM	нсно	NMOG	* CO	NOx	PM	нсно		
LEV	0.075	3.4	0.2	-	0.015	0.090	4.2	0.3	0.08	0.018		
ULEV	0.040	1.7	0.2	-	0.008	0.055	2.1	0.3	0.04	0.011		
SULEV	_	_	-	-	-	0.010	1.0	0.02	0.01	0.004		
	Abbreviations:											
LEV Lo	EV Low Emission Vehicle HCHO Formaldehyde											
ULEV U	tra Low Emis	-   -   -   0.010   1.0   0.02   0.01   0.004     Abbreviations:     Femission Vehicle     A LOW Emission Vehicle     CO   Carbon Monoxide     NOx   Oxides of Nitrogen										
SULEV Su	V Super Ultra Low Emission Vehicle						Oxides of Nitrogen					
NMOG N	JItra Low Emission VehicleCOCarbon MonoxideSuper Ultra Low Emission VehicleNOxOxides of NitrogenNon-Methane Organic GasesPMParticulate Matter											
NMHC N	NMOG*     CO     NOx     PM     HCHO     NMOG*     CO     NOx     PM     HCHO       0.075     3.4     0.2     -     0.015     0.090     4.2     0.3     0.08     0.018       0.040     1.7     0.2     -     0.008     0.055     2.1     0.3     0.04     0.011       -     -     -     -     0.010     1.0     0.02     0.01     0.004       -     -     -     -     -     0.010     1.0     0.02     0.01     0.004       -     -     -     -     -     0.010     1.0     0.02     0.01     0.004       -     -     -     -     -     0.010     1.0     0.02     0.01     0.004       w Emission Vehicle     K     HCHO     Formaldehyde     CO     Carbon Monoxide     NOx     Oxides of Nitrogen       on-Methane Organic Gases     PM     Particulate Matter     g/mi     Grams per Mile <thtpartial< th=""></thtpartial<>											

California LEV II Emission Standards, Passenger Cars and Light Duty Vehicles < 8500 lbs, g/mi

#### How Are We Doing?

A new car in 1965 produced about a ton of smogforming hydrocarbons during 100,000 miles of driving.

California's low-emission standards cut that to around 50 pounds for the average new car in 1998.

LEV II further reduces emissions from the average new 2010 car to approximately 10 pounds.

A SULEV emits only a single pound of hydrocarbons during 100,000 miles of driving.



## **Application Overview**

The different versions of the engine management systems contain components and/or software specific for their applications.

### ME 7.x

#### **ME 7**

• 2.8L VR6

#### ME 7.1

• 2.8L 5V V6

#### ME 7.1.1

- 2.5L 5-cylinder 4-V
- 3.2 VR6 (MY 2003 through MY 2006)
- W8
- 4.2L V8-5V
- W12

#### ME 7.5.1

• 1.8L 5V turbo



2.8L 5V V6



1.8L 5V Turbo

## Introduction

### MED 9.x

#### MED 9.1

- 2.0L FSI turbo
- 3.2L VR6 FSI (MY 2007 and up)
- 3.6L VR6 FSI

#### MED 9.1.1

• 4.2L V8 FSI



4.2L V8 FSI

## MED 17.x

#### MED 17.5

• 2.0L Chain-Driven TSI



2.0L Chain-Driven TSI

## **Motronic ME 7**

The Bosch Motronic ME 7 was implemented in the 2.8L VR-6 engine for MY 1999, and in MY 2000 for the 2.8L 5V V6 and the 1.8L 5V turbo.

Motronic ME 7 was the first torque-based system and the first to consolidate processing of all subsystems in a sub-processor responsible for all functions of engine performance. Earlier systems used separate sub-processors for functions such as ignition, fuel, or emissions.

Motronic ME 7 was the first "Drive by Wire" system offered in Volkswagen vehicles. Drive by Wire refers to the lack of a mechanical connection between the throttle pedal and the throttle valve.

## **Components of Motronic ME 7**

Motronic ME 7 has brought several changes or additions in components to both engine management and other related systems.

The changes include:

- Electronic Throttle Control
- Cruise Control
- Charge Air Pressure Sensor G31
- Integration of Barometric Pressure (BARO) Sensor F96 as a component of the Motronic Engine Control Module (ECM) J220
- Turbocharger Recirculating Valve N249

For more information on the ME 7 system, refer to SSP 842003, Motronic ME 7 Engine Management System.

These variants of Motronic ME 7 have the following application-specific features:

#### ME 7.1

• 2.8L 5V V6

#### Features:

- Electronic Throttle Control
- Dual stage intake manifold with ECM actuated Intake Manifold Tuning (IMT) Valve N156

#### ME 7.1.1

- 2.5L 5-cylinder 4-V
- 3.2 VR6 (MY 2003 through MY 2006)
- W8
- 4.2L V8-5V
- W12

#### Features:

- Electronic Throttle Control
- Dual stage intake manifold with ECM-actuated Intake Manifold Tuning (IMT) Valve N156
- Dual ECMs (W12 only)



Refer to SSP 892303, The Phaeton W12 Engine Management System, for additional information about ME7.1.1 in the W12 engine.

#### ME 7.5.1

• 1.8L 5V turbo

Several components have been added to more accurately control boost pressures and regulate engine torque. These include:

- Electronic Throttle Control
  - The throttle valve has the ability to operate independently of driver input to maximize efficiency
- Turbocharger Recirculating Valve N249
  - Using an electrically operated solenoid valve to control activation of the bypass valve allows for more accurate control of charge pressure bypass during throttle changes.
- Charge Air Pressure Sensor G31
  - The Charge Air Pressure Sensor G31 provides the ECM with exact data regarding manifold absolute pressure.

## **Cruise Control**

The addition of electronic throttle control enabled the incorporation of cruise control into the Motronic ECM J220.

The ECM controls throttle valve angle the same way as the vacuum pump used previously. This allows for a more accurate transition of throttle as well as a more stable speed.

Similar to M5.9.2 systems, the Brake Pedal Switch F47 and Brake Light Switch F are combined in a single housing. One side controls normal brake light function, and the second side provides information to the ECM regarding the application of brakes to disengage cruise control.



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## Charge Air Pressure Sensor G31 (1.8 Turbo, M7.5.1)

In ME 7, the sensor is mounted in the intake tract between the charge air cooler and the Throttle Valve Control Module J338.

#### Operation

Charge Air Pressure sensor G31 is a piezo-electro sensor. Operation is via a 5V reference from the ECM, with varying resistance to indicate manifold absolute pressure. Atmospheric pressure provides a signal of approximately 2.5V. Range of operation for the ECM to recognize a plausible signal is 0.14V - 4.88V.

#### Substitute Function

If the Charge Air Pressure Sensor G31 fails, charge pressure is controlled by a calculation map based on engine speed and load. Power output is also reduced.

#### On Board Diagnostic

The ECM recognizes short circuit to Battery +, short circuit to Ground, as well as implausible signals. The ECM cross checks the Charge Air Pressure Sensor G31 against the BARO Sensor F96. If a difference of 200 mbar is seen, a code for implausible signal is set.



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### Barometric Pressure (BARO) Sensor F96 (1.8 Turbo, M7.5.1)

TheBARO Sensor F96 is mounted internally within the Motronic ECM J220.

BARO Sensor F96 is used in conjunction with the Charge Air Pressure Sensor G31 for charge pressure control.

In higher elevations, charge pressure is reduced to prevent overspinning the turbocharger.

BARO Sensor F96 is also used for fuel mixture control, leaning out the short term fuel trim with increasing altitudes.

#### **Substitute Function**

If BARO Sensor F96 fails, boost is limited to a safe level, and power levels are reduced. Cold running fuel adaptation no longer takes place.

#### **On Board Diagnostic**

The ECM recognizes implausible signals, as well as short circuit to Battery + and Ground. The fault displays "Control unit defective."

# Turbocharger Recirculating Valve N249 (1.8 Turbo, M7.5.1)

Previous Motronic M5.9.2 systems used a charge pressure recirculating valve operated by intake manifold vacuum. The key to its functionality was a fully closed throttle valve allowing full engine vacuum to operate the valve.

Electronic throttle control may not allow for this under certain operating conditions. The throttle valve may be held partially open for emissions purposes.

Turbocharger Recirculating Valve N249 is used to provide vacuum to the recirculating valve using vacuum from a reservoir. This allows the ECM to more accurately control turbocharger performance during throttle transition.

#### Operation

N249 is a solenoid valve (see Glossary) similar in design to others used in the engine management system. Power is supplied via the fuel pump relay and the Ground is switched by the ECM.

#### Substitute Function

The system is designed so that if N249 fails, the recirculating valve will continue to function by manifold vacuum.

#### **On Board Diagnostic**

The ECM recognizes short to Battery + and short circuit to Ground.

## Heated Oxygen Sensor (HO2S) G39 and Heated Oxygen Sensor (HO2S) 2 G108

A broadband oxygen sensor is assigned to each precatalytic converter as a pre-catalytic oxygen sensor.

Using the broadband oxygen sensors, a wide range of oxygen concentration in the exhaust gas can be calculated. Both oxygen sensors are heated to reach operating temperature more quickly.

#### **Signal Utilization**

The signals from the Heated Oxygen Sensors are one of the variables used in calculating the injection timing.



#### **Effects of Signal Failure**

If the pre-catalytic converter oxygen sensor fails, there is no closed loop control. The fuel injection adaptation is not available. An emergency running mode is enabled using an engine characteristics map.

# Oxygen Sensor (O2S) Behind Three Way Catalytic Converter (TWC) G130 and Oxygen Sensor (O2S) 2 Behind Three Way Catalytic Converter (TWC) G131

The planar oxygen sensors are located downstream of the pre-catalytic converter. They measure the remaining oxygen content in the exhaust gas. Based on the amount of oxygen remaining in the exhaust gas, the ECM can draw conclusions about the catalytic converter operation.

#### **Signal Utilization**

The ECM uses the signals from the post-catalytic converter oxygen sensors to check the catalytic converter operation and the closed-loop oxygen control system.



#### **Effects of Signal Failure**

If the post-catalytic converter oxygen sensor fails, the closed loop operation continues. The operation of the catalytic converter can no longer be checked.

## **Electronic Throttle Control**

The ME 7 engine management system utilizes electronic throttle control that enables the ECM to control the intake charge volume and velocity for optimization of engine torque.

The throttle valve control module has been modified from the M5.9 system to allow the ECM to drive the throttle valve under all running conditions. This system no longer uses a mechanical link between the accelerator pedal and the throttle valve housing (Drive by Wire). The ECM positions the throttle valve according to torque demands, allowing the ECM to control throttle angle. This is a key factor in torque management.

The throttle valve control module allows the throttle valve angle to be optimized for maximum intake velocity.

Extensive safety measures have been implemented in the hardware and the software. Dual sensors are used for continual self checking of signal plausibility. A safety module is integrated in the ECM to monitor the functional processor for proper operation.



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## **Motronic ME 7**

## **Throttle Valve Control Module J338**

The throttle valve control module combines the following components:

- Throttle Drive (for Electronic Power Control [EPC]) G186
- Throttle Drive Angle Sensor 1 (for Electronic Power Control [EPC]) G187
- Throttle Drive Angle Sensor 2 (for Electronic Power Control [EPC]) G188

The throttle valve control module is controlled by the ECM, and regulates the required air charge to produce the required torque.

#### Operation

The two Throttle Drive Angle Sensors (G187 and G188) are opposite in resistance, and are used for continuous cross checking by the ECM.

The angle sensors are provided with a 5V reference voltage by the ECM. The ECM reads the voltage drop across the dual potentiometers and uses this to monitor throttle valve angle.

The Throttle Drive for EPC G186 is an electric motor that operates the throttle valve by way of a set of reduction gears. Its position is continually monitored by angle sensors G187 and G188.

#### **Substitute Function**

In the case of a component failure, the ECM initiates an "Emergency Running Mode" and allows only limited vehicle operation. There is no substitute function for the throttle drive.

#### **On Board Diagnostic**

The ECM is able to recognize range/performance faults, as well as signal range checks for the angle sensors. The G186 is monitored for range of operation and idle adaptation faults. Resistance in  $\Omega$ 

0



Throttle Valve Opening in %

8410\_176

100%

### **Accelerator Pedal Module**

The accelerator pedal module is comprised of the accelerator pedal and the accelerator position sensors as one assembly.

The components of the accelerator pedal module are:

- Throttle Position (TP) Sensor G79
- Throttle Position (TP) Sensor G185

The redundant throttle position sensors are linear to each other on different scales. Like the throttle drive sensors, the duplicate sensors are for self-diagnosis.

#### Operation

The sensors provide an analog signal to the ECM referencing accelerator position. The kickdown function is also incorporated into the module.

If the driver activates the kickdown, the full-throttle voltage of the accelerator pedal position senders is exceeded. The ECM interprets this as a kickdown and sends a signal the Transmission Control Module (TCM) by way of the CAN data bus.

#### **Substitute Function**

If one of the TP sensors fail, the ECM relies on the redundant sensor. If both TP sensors fail, an Emergency Running Mode is initiated.

#### **On Board Diagnostic**

The ECM recognizes range/performance failures, as well as signal plausibility checks.



For more information regarding electronic throttle control function and adaptation, refer to SSP #842003, Volkswagen ME 7.



## Fault Light For Power Accelerator Activation K132

A separate indicator light is used for the Electronic Power Control (EPC) system.

Malfunctions in either the electronic accelerator system or associated sensors are detected by selfdiagnosis, and indicated by the separate EPC MIL.

For example, a fault in the Mass Air Flow (MAF) Sensor G70 triggers the EPC MIL because of its usage by the ECM for an engine load signal. The ECM uses this signal to check signal plausibility of other inputs. At the same time, an entry is made in the fault memory.

#### Operation

When the ignition is switched on, K132 is illuminated for three seconds. If there are no faults in the system the light goes out.

K132 is activated by the Motronic ECM providing a Ground for the light.

#### **Substitute Function**

There is no substitute function for K132.

#### **On Board Diagnosis**

The ECM recognizes Short circuit to Battery +/ Ground, as well as Open circuit.



## Motronic ME 7.1.1

## System Overview (4.2 V8-5V Shown)

#### Sensors



## Motronic ME 7.1.1



LDP Reed Switch

## Sensors

## Engine Speed (RPM) Sensor G28

The Engine Speed Sensor is threaded either into the side of the cylinder block or transmission housing. It scans the sensor wheel on the crankshaft.

It can be an inductive sender, which senses the teeth of the dual mass flywheel or the teeth of a toothed wheel attached to the crankshaft.

It can be a Hall sensor, which senses the magnetic stripes of a tone wheel that is attached to the crankshaft.

#### **Signal Utilization**

The engine speed and the exact position of the crankshaft relative to the camshaft are determined by the engine speed sensor. The ECM uses this information to to determine the injection point, injection quantity and ignition timing and camshaft timing control.

#### **Effects of Signal Failure**

In case of signal failure, either:

- The camshaft signal is used
- The engine is switched off and cannot be restarted



360\_111

## Mass Air Flow (MAF) Sensor G70

The 6th generation hot film MAF sensor (HFM6) is used in the 3.2L and the 3.6L FSI engine. It is located in the intake manifold and operates based on a thermal measurement principle, as did its predecessor.

#### Characteristics

- Micromechanical sensor element with reverse current detection
- Signal processing with temperature compensation
- High measurement accuracy
- High sensor stability



#### Signal Utilization

The signal from G70 is used in the ECM to calculate the volumetric efficiency. Based on the volumetric efficiency, and taking into consideration the lambda value and ignition timing, the control module calculates the engine torque.

#### **Effects of Signal Failure**

If the Mass Air Flow (MAF) Sensor G70 fails, the engine management system calculates a substitute value.



2.5L engines with codes CBTA and CBUA are the new versions that now utilizes a Manifold Absolute Pressure (MAP) sensor and not a MAF sensor.

## Throttle Position (TP) Sensor G79 and Accelerator Pedal Position Sensor 2 G185

The two TP sensors are part of the accelerator pedal module and are contact-free sensors.

The ECM detects the driver request from these sensor signals.

#### **Signal Utilization**

The ECM uses the signals from the Throttle Position Sensor to calculate the fuel injection volume.

#### **Effects of Signal Failure**

If one or both sensors fails, an entry is made in the Diagnostic Trouble Code (DTC) memory and the error light for EPC is illuminated. Comfort functions such as cruise control or engine drag torque control are switched off.

### **Clutch Position Sensor G476**

The Clutch Position Sensor G476 is a mechanically actuated switch located on the clutch pedal. It is only used on vehicles with manual transmission.

#### **Signal Utilization**

The signal is used to control the cruise control and to control the ignition timing and quantity of fuel when shifting.

#### **Effects of Signal Failure**

If the Clutch Position Sensor fails, the cruise control cannot be turned on. It also results in driveability problems, such as engine jerking and increased RPM when shifting.





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## Knock Sensor (KS) 1 G61 and Knock Sensor (KS) 2 G66

The knock sensors are threaded into the crankcase. They detect combustion knocks in individual cylinders. To prevent combustion knock, a cylinder selective knock control overrides the electronic control of the ignition timing.





#### **Signal Utilization**

Based on the knock sensor signals, the ECM initiates ignition timing adjustment in the knocking cylinder until knocking stops.

![](_page_26_Picture_7.jpeg)

Knock sensors MUST be properly torqued or they will send incorrect signals to the ECM. A loose sensor can indicate knocking where there is none, and a tight sensor may not report engine knocking.

#### **Effects of Signal Failure**

If a knock sensor fails, the ignition timing for the affected cylinder group is retarded. This means that a safety timing angle is set in the "late" direction. This can lead to an increase in fuel consumption. Knock control for the cylinder group of the remaining knock sensor remains in effect.

If both knock sensors fail, the engine management system goes into emergency knock control in which the ignition angle is retarded across the board so that full engine power is no longer available.

# Camshaft Position (CMP) Sensors G40 and G163

Both Hall sensors are located in the engine timing chain cover. Their task is to communicate the position of the intake and exhaust camshafts to the ECM. To do this, they scan a quick-start sensor wheel that is located on the individual camshaft.

The ECM recognizes the position of the intake camshaft from the CMP Sensor G40, and recognizes the position of the exhaust camshaft from CMP Sensor 2 G163.

![](_page_27_Picture_4.jpeg)

#### **Signal Utilization**

Using the signal from the CMP Sensors, the precise position of the camshaft relative to the crankshaft is determined very quickly when the engine is started. Used in combination with the signal from the RPM Sensor G28, the signals from the CMP Sensors allow to detect which cylinder is at TDC.

The fuel can be injected into the corresponding cylinder and ignited.

#### **Effects of Signal Failure**

In case of signal failure, the signal from the RPM Sensor G28 is used instead. Because the camshaft position and the cylinder position cannot be recognized as quickly, it may take longer to start the engine.

### **Quick-Start Functions**

Quick-Start is accomplished through the use of the "quick-start rotor ring" introduced in the four-cylinder five-valve engines.

The quick-start rotor ring is a shutter wheel with four alternating vanes and air gaps – two wide and two narrow.

The alternating vanes and air gaps pass the Hall sensor in a sequence that produces a distinctive pulse width pattern for each 90° of camshaft rotation.

The ECM uses this distinctive signal pattern from Camshaft Position Sensor G40, together with input from Engine Speed Sensor G28, to determine the camshaft position relative to the crankshaft more quickly.

![](_page_28_Picture_6.jpeg)

217\_053

## Motronic ME 7.1.1

The ECM can thus determine the ignition TDC of the next cylinder more quickly so that the engine starts more quickly (synchronization with cylinder #1 is no longer necessary).

![](_page_29_Figure_2.jpeg)

\* The software reference mark is where the ECM begins calculating the ignition point. It is about one tooth after the hardware reference mark, which is approximately 66° to 67° of crankshaft rotation before ignition TDC of #1 cylinder. The CMP Sensor 2 G163 is used to monitor camshaft adjustment and to generate a substitute signal if the CMP Sensor G40 fails.

![](_page_30_Picture_2.jpeg)

The CMP Sensor G40 is mounted to cylinder bank 2.

The CMP Sensor 2 G163 is mounted to cylinder bank 1.

#### **Engine Run-Down**

The ECM remains active for a defined time after the ignition has been turned off and, with the aid of the RPM Sensor G28, monitors the engine as it slows to a stop.

The position of the engine mechanical components (position of the next cylinder at ignition TDC) is stored and is available the next time the engine is started. The ME 7.1.1 can immediately begin injection and has a fuel mixture ready, which results in faster starting.

![](_page_30_Figure_8.jpeg)

The advancements in fuel injection technology that led to the FSI injection system required equal advancements in electronic engine control systems. The Bosch MED 9.1 was used first with the 2.0L FSI Turbo and then with the 3.6L VR-6 FSI engine.

Differences in the Motronic MED 9.1 from Motronic ME 7 include:

- Fuel Pressure Sensor G247
- Low Fuel Pressure Sensor G410
- Engine Coolant Temperature (ECT) Sensor (on Radiator) G83

![](_page_32_Picture_7.jpeg)

## System Overview (3.2L VR6 FSI [>2007] 3.6L VR6 FSI Shown)

Sensors

Engine Speed (RPM) Sensor G28

Mass Air Flow (MAF) Sensor G70

Throttle Position (TP) Sensor G79 Accelerator Pedal Position Sensor 2 G185

Clutch Position Sensor G476

Throttle Valve Control Module J338 with Throttle Drive Angle Sensor 1 (for Electronic Power Control [EPC]) G187 Throttle Drive Angle Sensor 2 (for Electronic Power Control [EPC]) G188

Camshaft Position (CMP) Sensor G40 Camshaft Position (CMP) Sensor 2 G163

Engine Coolant Temperature (ECT) Sensor G62 Engine Coolant Temperature (ECT) Sensor (on Radiator) G83

> Knock Sensor (KS) 1 G61 Knock Sensor (KS) 2 G66

> > Brake Light Switch F

Fuel Pressure Sensor G247

Low Fuel Pressure Sensor G410

Oil Level Thermal Sensor G266

Heated Oxygen Sensor (HO2S) G39 Heated Oxygen Sensor (HO2S) 2 G108

Oxygen Sensor (O2S) Behind Three Way Catalytic Converter (TWC) G130

Oxygen Sensor (O2S) 2 Behind Three Way Catalytic Converter (TWC) G131

![](_page_33_Picture_18.jpeg)

![](_page_34_Picture_1.jpeg)

#### Actuators

Fuel Pump (FP) Control Module J538 Transfer Fuel Pump (FP) G6

Cylinder 1-6 Fuel Injector N30, N31, N32, N33, N83, N84

Ignition Coil 1-6 with Power Output Stage N70, N127, N291, N292, N323, N324

Throttle Valve Control Module J338 with Throttle Drive (for Electronic Power Control [EPC]) G186

Fuel Pressure Regulator Valve N276

Evaporative Emission (EVAP) Canister Purge Regulator Valve N80

Intake Manifold Runner Control (IMRC) Valve N316

Camshaft Adjustment Valve 1 N205 Camshaft Adjustment Valve 1 (exhaust) N318

Oxygen Sensor (O2S) Heater Z19 Oxygen Sensor (O2S) 2 Heater Z28

Oxygen Sensor (O2S) 1 (behind Three Way Catalytic Converter (TWC)) Heater Z29 Oxygen Sensor (O2S) 2 (behind Three Way Catalytic Converter

(TWC)) Heater Z30

Coolant Fan Control (FC) Control Module J293 Coolant Fan V7 Coolant Fan 2 V177

Recirculation Pump Relay J160 Recirculation Pump V55

![](_page_34_Picture_16.jpeg)

## Sensors

## Fuel Pressure Sensor G247

The Fuel Pressure Sensor is located on the lower fuel distributor pipe. It measures the fuel pressure in the high-pressure fuel system.

#### **Signal Utilization**

The ECM analyzes the signal and regulates the fuel high pressure through the Fuel Pressure Regulator Valve N276 in the high-pressure pump.

#### **Effects of Signal Failure**

If the Fuel Pressure Sensor fails, the fuel pressure regulator valve is activated at a fixed value by the ECM.

![](_page_35_Picture_8.jpeg)

### Low Fuel Pressure Sensor G410

The Low Fuel Pressure Sensor is located on the highpressure fuel pump. It measures the fuel pressure in the low-pressure fuel system.

#### **Signal Utilization**

The signal is used by the ECM to regulate the low pressure fuel system. Based on the signal from the sensor, a signal is sent by the ECM to the Fuel Pump Control Module J538, which then regulates Transfer Fuel Pump G6 as needed.

#### **Effects of Signal Failure**

If the Low Fuel Pressure Sensor fails, the fuel pressure is not regulated as needed. Fuel pressure is maintained at a constant 72 psi (5 bar).

![](_page_35_Picture_15.jpeg)

## Engine Coolant Temperature (ECT) Sensor G62

This sensor is located at the coolant distributor above the oil filter on the engine and it informs the ECM of the coolant temperature. Situated at the engine outlet, G62 measures the highest temperature of the coolant.

#### **Signal Utilization**

The coolant temperature is used by the ECM for different engine functions. For example, the computation for the injection amount, compressor pressure, start of fuel delivery and the amount of exhaust gas recirculation.

#### **Effects of Signal Failure**

If the signal fails, the ECM uses the signal from the ECT Sensor G83.

![](_page_36_Picture_7.jpeg)

### Engine Coolant Temperature (ECT) Sensor (on the Radiator) G83

The ECT Sensor (on the Radiator) G83 is located in the radiator output line and measures the coolant exit temperature. This is the lowest coolant temperature in the system.

#### **Signal Utilization**

The radiator fan is activated by comparing both signals from the ECT Sensors G62 and G83.

#### **Effects of Signal Failure**

If the signal from the ECT Sensor G83 is lost, the first speed engine coolant fan is activated permanently.

![](_page_36_Figure_14.jpeg)

## **Oil Level Thermal Sensor G266**

The oil level thermal sensor is installed at the bottom of the engine oil sump. When the ignition is turned on, filling level and temperature data are gathered continuously. The Instrument Cluster Control Module J285 uses this signal to display the engine oil temperature and as part of the calculation for the oil change interval.

![](_page_37_Picture_3.jpeg)

![](_page_37_Picture_4.jpeg)

#### **Oil Level Indicator**

The conventional warning lamp for engine oil pressure is also used as an oil level indicator.

- If the yellow LED is continuously on = oil level too low
- If the yellow LED is flashing = sender for oil level defective

An excessively high oil level is not indicated.

![](_page_37_Picture_10.jpeg)

#### **Signal Waveform and Evaluation**

The measuring element is briefly heated via the present oil temperature (output = high) and then cools down again (output = low).

This procedure is repeated continuously. The High times are dependent on the oil temperature and the Low times are proportional to the oil level.

#### **Oil Level**

The oil level is calculated from the amount of time it takes for the sensor to cool down. The calculation is accurate to approximately  $\pm$  0.08 in (2 mm).

The more oil there is in the oil sump, the quicker the sensor cools down again.

- Long cool-down time = low oil level
- Short cool-down time = normal

![](_page_38_Picture_9.jpeg)

233\_050

#### **Oil Temperature**

During the cool-down phase of the sensor, the oil temperature signal is also transmitted.

![](_page_38_Figure_13.jpeg)

## Actuators

### Camshaft Adjustment Valve 1 N205, Camshaft Adjustment Valve 1 (Exhaust) N318

These solenoid valves are integrated in the camshaft adjustment housing. They distribute the oil pressure based on the ECM signals for the adjustment direction and adjustment travel at the camshaft adjusters.

Both camshafts are continuously adjustable:

- Intake camshaft at 52° of the crankshaft angle
- Exhaust camshaft at 42° of the crankshaft angle
- Maximum valve overlap angle 47°

The exhaust camshaft is mechanically locked when no oil pressure is available (engine not running).

#### **Effects of Signal Failure**

If an electrical connection to the camshaft adjusters is defective, or if a camshaft adjuster fails because it is mechanically seized or as a result of inadequate oil pressure, there is no camshaft adjustment.

![](_page_39_Picture_11.jpeg)

# Transfer Fuel Pump (FP) G6 and the Fuel Level Sensor G

The Transfer Fuel Pump and the Fuel Filter are combined in the Fuel Transfer Unit. The Fuel Transfer Unit is located in the fuel tank.

#### Operation

The Transfer Fuel Pump transfers the fuel in the low pressure fuel system to the high-pressure fuel pump.

The ECM constantly monitors fuel pressure through the Low Fuel Pressure Sensor G410. If the fuel pressure is not adequate to meet current engine demand, the ECM activates the FP Control Module J538, which controls the Transfer FP G6 with a Pulse Width Modulation (PWM) signal.

![](_page_40_Picture_6.jpeg)

#### **Effects of Failure**

If the Transfer Fuel Pump fails, engine operation is not possible.

### **Fuel Pressure Regulator Valve N276**

The Fuel Pressure Regulator Valve is located on the underside of the High-Pressure Fuel Pump.

The ECM regulates the fuel high-pressure through the Fuel Pressure Regulator Valve at a level between 507 and 1,450 psi (35 and 100 bar).

#### **Effects of Failure**

The ECM goes into emergency running mode.

![](_page_40_Picture_14.jpeg)

# Cylinders 1-6 Fuel Injectors N30, N31, N32, N33, N83, N84

The High-Pressure Fuel Injectors are inserted into the cylinder head. They are triggered by the ECM according to firing order. When triggered, they spray fuel directly into the cylinder.

Due to the design of the engine, injection takes place from one side. For this reason, the fuel injectors for cylinder bank 1, 3, and 5 are longer than the fuel injectors for cylinder bank 2, 4, and 6.

#### Operation

Peak and Hold Injectors are used in Volkswagen FSI engines. The injector receives full current only long enough to open the pintle (Peak), then pulses the current to hold the injector open (Hold).

It has relatively low internal resistance compared to a saturation injector. Additionally, it has a faster response time that is required to inject fuel into the combustion chamber at the correct moment for the most efficient combustion.

#### **Effects of Failure**

A defective fuel injector is recognized by misfire detection and is no longer triggered.

![](_page_41_Picture_9.jpeg)

360\_137

![](_page_41_Figure_11.jpeg)

#### Peak and Hold Injector Scope Pattern

![](_page_42_Figure_2.jpeg)

- The capacitors needed to elevate battery voltage to ~60 volts are charged.
- 2. Injector opens: ~60 volts for ~200 microseconds.
  - It takes a lot of power to open the injector
- The ECM controls the injector current to a target value by modulating the voltage applied.
  Once it is opened, the injector needle can be held in position with lower solenoid current.
- 4. Induced spike as field collapses.
- 5. Total injector opening time.

## Intake Manifold Runner Control (IMRC) Valve N316

The Intake Manifold Runner Control Valve N316 is located on the variable intake manifold and is an electro-pneumatic valve.

When it is activated, it operates the intake manifold flap to change the length of the intake manifold.

#### **Effects of Failure**

If the valve fails, the intake manifold flaps are pulled by a mechanical spring to an emergency running position. This position corresponds to the power setting of the intake manifold.

![](_page_43_Figure_6.jpeg)

Bosch Motronic MED 9.1.1 is used in the 4.2 Liter 4V V8 FSI engine, which powers the Touareg II.

The major differences between Bosch Motronic MED 9.1 and 9.1.1 are related to the fundamental differences between the V6 and V8 engines in which the systems are used.

![](_page_44_Picture_4.jpeg)

388\_003

## System Overview (4.2 Liter 4V V8 FSI Shown)

Sensors

Mass Air Flow (MAF) Sensors, G70, G246 Intake Air Temperature (IAT) Sensor G42

Engine Speed (RPM) Sensor G28

Throttle Position (TP) Sensors G79, G185

Camshaft Position (CMP) Sensors G40, G163, G300, G301

Throttle Valve Control Module J338 Throttle Drive Angle Sensors (for Electronic Power Control [EPC]) G187, G188

Intake Manifold Runner Position Sensors G336, G512

Low Fuel Pressure Sensor G410

Fuel Pressure Sensor G247

Engine Coolant Temperature (ECT) Sensor G62

Engine Coolant Temperature (ECT) Sensor (on Radiator) G83

Knock Sensors G61, G66, G198, G199

Oxygen Sensors G39, G108

Oxygen Sensors G130, G131

Brake Light Switch F Brake Pedal Switch F47

Brake Booster Pressure Sensor G294

Additional Input Signals

![](_page_45_Figure_19.jpeg)

![](_page_46_Picture_1.jpeg)

Motronic Engine Control Module (ECM) Power Supply Relay J271

Fuel Pump (FP) Control Module J538 Transfer Fuel Pump (FP) G6

Fuel Metering Valves N290, N402

Cylinder Fuel Injectors 1 through 8 N30-33, N83-N86

Evaporative Emission Canister Purge Regulator Valve N80

Throttle Valve Control Module J338 Throttle Drive (for Electronic Power Control [EPC]) G186

Intake Flap Motor V157

Variable Intake Manifold Runner Motor V183

Camshaft Adjustment Valves (Intake) N205, N208

Camshaft Adjustment Valves (exhaust) N318, N319

Ignition Coils with Power Output Stages N70, N127, N291, N292, N323-N326

Map Controlled Engine Cooling Thermostat N265

Coolant Circulation Pump Relay J151 Recirculation Pump V55

Oxygen Sensor (O2S) Heaters Z19, Z28

Oxygen Sensor (O2S) Heaters [behind Three Way Catalytic Converter (TWC)] Z29, Z30

Secondary Air Injection (AIR) Pump Relay J299 Secondary Air Injection (AIR) Pump Motor V01

Coolant Fan Control (FC) Control Module J293 Coolant Fan V7

Coolant Fan Control (FC) Control Module 2 J671 Coolant Fan 2 V177

Brake Booster Relay J569 Brake System Vacuum Pump V192

Additional Output Signals

![](_page_46_Picture_22.jpeg)

## Sensors

### Intake Manifold Runner Position Sensors G336 and G512

The two intake manifold flap potentiometers are secured to the intake manifold and are connected to the shaft for the intake manifold flaps. They recognize the position of the intake manifold flaps.

#### Signal Use

The position is important because intake manifold changeover affects air flow in the combustion chamber and the inlet air mass. The position of the intake manifold flaps is therefore relevant to the exhaust gas, and must be checked via self-diagnosis.

#### **Effects of Signal Failure**

If the signal from the position sensor fails, the position of the intake manifold flaps at the time of failure and the relevant ignition timing are used as substitute values. Power and torque are reduced and fuel consumption increases. Intake Manifold Runner Position Sensor 2 G512

![](_page_47_Picture_9.jpeg)

388\_037

Intake Manifold Runner Position Sensor G336

## Actuators

### Variable Intake Manifold Runner Motor V183

The variable intake manifold motor is bolted to the intake manifold.

#### Task

The motor is actuated by Engine Control Module J623 depending on engine load and speed. The motor actuates the change-over flaps via a shaft and switches to the torque (long runners) or the output position (short runners).

#### Effects in the Event of Failure

If the Variable Intake Manifold Runner Motor V183 fails, intake manifold change-over is no longer possible. The intake manifold remains in the position in which the change-over flaps were located at the time of failure. Power and torque are reduced. Variable Intake Manifold Runner Motor V183

![](_page_48_Picture_9.jpeg)

388\_043

## Intake Flap Motor V157

The Intake Flap Motor V157 is bolted to the variable intake manifold.

#### Task

The motor is actuated by Engine Control Module J623 depending on engine load and speed. Using two operating rods, it adjusts four intake manifold flaps per cylinder bank.

If these are actuated, they close part of the intake port in the cylinder head. This leads to circular air movement in the cylinder head and improves mixture formation.

#### **Effects in the Event of Failure**

If the Intake Flap Motor V157 fails, the intake manifold flaps can no longer be actuated. This leads to a deterioration in combustion and a reduction in output and torque. The fuel consumption also increases.

Intake Flap Motor V157

![](_page_49_Picture_9.jpeg)

S388\_044

### Intake Camshaft Adjustment Valves N205 and N208

### Exhaust Camshaft Adjustment Valves N318 and N319

Except for the addition of N208 and N319, these perform the same functions with the same parameters as in Motronic MED 9.1.

Camshaft Adjustment Valve 2 N208 (Intake)

![](_page_49_Picture_15.jpeg)

Camshaft Adjustment Valve 2 N319 (Exhaust)

388\_042

Bosch Motronic MED 17.5 is used in the 2.0L chaindriven TSI engine. This 4-cylinder turbocharged engine is available in many Volkswagen vehicles.

Features of the MED 17.5 Engine Management system include:

- MED 17.5 ECM
- Hot-film air mass flow with integral temperature sensor
- Throttle valve with contactless sensor
- Map-controlled ignition with cylinder-selective, digital knock control
- Single-spark ignition coils

![](_page_50_Picture_9.jpeg)

## System Overview (2.0L Chain-Driven TSI)

Sensors Mass Air Flow (MAF) Sensor G70 Intake Air Temperature (IAT) Sensor G299

> Engine Coolant Temperature (ECT) Sensor (on Radiator) G83

Engine Coolant Temperature (ECT) Sensor G62

Change Air Pressure Sensor G31

Engine Speed (RPM) Sensor G28

Camshaft Position (CMP) Sensor G40

Throttle Valve Control Module J338 Throttle Drive Angle Sensor 1 G187 Throttle Drive Angle Sensor 2 G188

Throttle Position (TP) Sensor G79 Accelerator Pedal Position Sensor 2 G185

> Brake Pedal Switch F63 Clutch Position Sensor G476

Fuel Pressure Sensor G247

Intake Manifold Runner Position Sensor G336

Knock Sensor (KS) 1 G61

Heated Oxygen Sensor (HO2S) G39

Oxygen Sensor (O2S) 2 Behind Three Way Catalytic Converter (TWC) G131

DFM Generator, Cruise Control ON/OFF

![](_page_51_Picture_17.jpeg)

![](_page_52_Picture_1.jpeg)

Motronic Engine Control Module (ECM) Power Supply Relay J271

Engine Component Power Supply Relay J757

Intake Manifold Runner Control (IMRC) Valve N316

Wastegate Bypass Regulator Valve N75

Fuel Pressure Regulator Valve N276

Fuel Pump (FP) Control Module J538 Transfer Fuel Pump (FP) G6

Cylinder Fuel Injectors 1-4 N30-N34

Ignition Coils with Power Output Stages N70, N127, N291, N292

Throttle Valve Control Module J338 Throttle Drive for Electronic Power Control (EPC) G186

Evaporative (EVAP) Emission Canister Purge Regulator Valve N80

Oxygen Sensor (O2S) Heater Z19

Coolant Circulation Pump Relay J151 After-Run Coolant Pump V51

Camshaft Adjustment Valve 1 N205

Radiator Fan Setting 1, PWM Signal Actuators Leak Detection Pump V144

384\_054

49

## **Engine Control Module**

The 2.0LTSI engine uses the Bosch MED 17.5 ECM. The hardware and software components have been developed for future projects both for gasoline and diesel engine applications. This allows maximum use with regard to functions and vehicle interfaces independent of the engine combustion configuration. Examples of this include the Electronic Pedal Control and radiator fan activation strategies.

The new IFX Tricore processor family has enough reserve capacity to accommodate future advancements to meet market requirements.

Hardware in the engine control module:

- Infineon IFX Tricore 1766 (Leda Light)
- 80 MHz System Frequency
- 1.5 MByte Internal Flash
- Single Chip System

## **Oxygen Sensor Control**

A new feature of the MED 17.5 is the deletion of the continuous-duty oxygen sensor. Now, a nonlinear oxygen sensor is installed. The sensor is located between the close-coupled pre-catalyst and the underbody catalytic converter.

The function of the continuous-duty pre-cat sensor has been mapped by the new functions of the engine control module. These maps are generated by conducting appropriate tests during engine development.

#### Advantages:

- Fewer potential sources of fault
- More cost-effective
- Requirements of ULEV are met without continuous-duty oxygen sensor
- No adjustments needed in customer service or for exhaust emission inspections

Substitute Functions	s in Case	of Sensor/	<b>Actuator</b>	Failure
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	Symptom in Case of Failure	DTC Entry	MIL	EPC	Substitute Signal	Power Limitation	Emergency Operation
F63	No Cruise Control	Yes	No	No	No	No	No
G39	No Control	Yes	Yes	No	Yes	No	No
G61	No	Yes	No	No	Yes	Yes	No
G62	No	Yes	Yes	No	Yes	No	No
G83	Radiator Fan Runs Permanently in Setting 1	No	No	No	No	No	No
G79/G185	No Throttle Response	Yes	Yes	Yes	No	Yes	Yes
G187/G188	No Throttle Response	Yes	Yes	Yes	No	Yes	Yes
G247	No High Pressure	Yes	Yes	No	No	Yes	Yes
G336	No	Yes	Yes	No	No	No	No
G476	No Cruise Control	Yes	No	No	No	No	No
J271	No Power Supply to ECM – Engine Not Running	No	No	No	No	No	No
J538	No	Yes	Yes	No	No	No	No
J757	No High Pressure	Yes	Yes	Yes	No	Yes	Yes
Ignition Coils	Engine Not Running Smoothly	Yes	Yes	Yes	No	Yes	Yes
N30-N33	Engine Not Running Smoothly	Yes	Yes	Yes	No	Yes	Yes
N75	No	Yes	Yes	Yes	No	Yes	Yes
N205	No	Yes	Yes	No	No	No	No
N276	No High Pressure	Yes	Yes	Yes	No	Yes	Yes
N316	No	Yes	Yes	No	No	No	No

![](_page_55_Picture_3.jpeg)

This table refers to generally occurring faults. It is not a substitute for diagnosing with the "Guided Fault Finding" function. The parameters specified in the table are subject to deviation depending on fault type. Specifications are subject to change due to updating of ECM software.

## **Reference Materials**

This is a list of SSPs, recommended Instructor-Led classes, print and on-line materials for further information:

- SSP 841003 Engine Management Systems
- SSP 89S303 The Volkswagen 4.2-Liter V8-5V Engine
- SSP 823603 VW 3.2 and 3.6 liter FSI Engine
- SSP 892603 VW 4.2L V8 FSI Engine
- SSP 824803 The Volkswagen 2.0 Liter Chain-Driven TSI Engine
- SSP 892303 The Phaeton W12 Engine Management System
- SSP 842003 Motronic ME 7 Engine Management System
- SSP 843103 Passat W8 Engine Management, Motronic ME 7.1.1
- Instructor-Led Course 841002, Volkswagen Engine Management Systems Level I
- Instructor-Led Course 842002, Volkswagen Engine Management Systems Level II

#### Adaptation

The ability of an engine management system to continuously modify operating parameters to account for changing operating conditions. For example, an oxygen sensor continuously adjusts or corrects the mixture formation to account for small vacuum leaks, or a knock sensor modifies ignition timing to account for gasoline AKI variances.

#### **Adaptive Learning**

The ability of an engine management system to continuously modify operating parameters (fine control range) to account for changing operating conditions (i.e. mechanical) and the ability to adjust to long term changes by moving the control window within a larger range (coarse control range).

#### **Barometric Pressure Sensor**

A piezo-electric device used for measuring pressure. A piezocrystal structure similar to that in a knock sensor is connected to and sealed within a small diaphragm chamber. An outer chamber surrounds the diaphragm and is connected to the intake tract by a small hose or left open to the atmosphere. Changing pressure conditions act on the diaphragm and, in turn, the crystal. A small voltage signal is generated in relation to air pressure changes. Barometric pressure sensors with sensing elements left open to the atmosphere measure changes in air pressure such as those associated with changes in altitude. Sensors with elements connected to the intake tract measure manifold pressure changes.

Barometric pressure sensors can be either a separate component or built into the ECM.

#### CARB

California Air Resources Board. Created after the Clean Air Act of 1970 to implement more stringent clean air standards.

#### **Closed Loop**

A period of engine operation when the ECM is receiving and responding to information supplied by the oxygen sensor. Loop operation refers to the ECM action in response to reaction or feedback supplied by the oxygen sensor.

#### Duty Cycle

As applied to engine management systems, it is the period of time when a component is switched on or activated. It is usually expressed as a percentage, such as "a duty cycle of 60%." Since many automotive components have only two states, on or off, a duty cycle allows accurate control of a function, over a period of time, under conditions that are not always completely on or completely off. For example, the ECM pulses the Ground to the EGR vacuum regulator solenoid valve, switching it on for 10 ms and off for 10 ms continuously, yielding a 50% duty cycle. This effectively operates it at one-half of the flow capacity, even though it does not open half way.

#### FTP 75

Federal Test Procedure 75. A standardized test of vehicle emissions for certification of light duty vehicles in the U.S. The test measures exhaust gasses over specific time and distance, and through various phases of starting and operation. Results are expressed in Grams per Mile (g/mi)

## Glossary

#### **Hall Sensor**

A magnetically switched, solid state integrated circuit sensor. When the Hall effect transistor is exposed to a magnetic field, it allows current to flow through the transistor to Ground, completing a circuit. When the magnetic field is not present current flow stops. Trigger wheels are often used to pass between the magnet and the transistor. Other applications attach the magnet to a rotating component. When the magnet passes the hall sensor current flow is enabled. Unlike Inductive sensors, Hall sensors require a power source to operate.

#### I/M 240 (Inspection and Maintenance)

A 240 second test period defined in the Federal Test Procedure (FTP), in which a vehicle is tested on a dynomometer under varying engine loads. The test measures the level of emissions of HC, NOx and CO.

#### Implausible Signal

A term used in On-Board Diagnostics (OBD)-I and OBD-II to denote particular types of signal malfunctions. Generally; a signal that falls outside the range of expected values, but is not an open circuit or a short circuit. For example, an ECM sends a 5 Volt reference signal to a sensor and expects a returned signal (voltage drop) of between 0.5 Volts and 4.5 Volts in normal operation. If the ECM "sees" a signal of 4.75 Volts, it is not within the expected range (0.5 to 4.5 Volts), nor is it a short circuit (0 Volts) or an open circuit (5.0 Volts). It is in an area of undefined or implausible signals.

#### **Inductive Pickup**

Generally, a magnet wrapped with wire. A rotating trigger wheel of ferrous metal causes an alternating current signal to be generated. The signal frequency generated varies with the speed of the trigger wheel. The trigger wheel can have a gap which causes a variation in the pulses and identifies a given position. Commonly used for ABS wheel speed sensors and engine RPM and reference sensors.

#### ISO

International Standards Organization

#### Lambda Sensor

Another name for Oxygen Sensor. Lambda is the 11th letter of the Greek alphabet. Refer to " $\lambda$  – Greek Letter Lambda" later in this Glossary.

#### LSH Oxygen Sensor

(Lambda Sonde Heizung) (Lambda Sensor Heated) Designation given to Bosch<sup>™</sup> heated oxygen sensors of the "thimble" or "finger" type of construction where the center electrode is of a circular design. Commonly used in both pre-catalyst and post-catalyst positions.

#### LSF 4.7 Oxygen Sensor

(Lambda Sonde Finger) (Lambda Sensor Finger) Designation given to Bosch<sup>™</sup> heated oxygen sensors using planar (flat) technology but with operation similar to the older finger-style heated oxygen sensors. Commonly used in both pre-catalyst and post-catalyst positions.

#### LSU 4.7 Oxygen Sensor

(Lambda Sonde Universal)

(Lambda Sensor Universal)

Designation given to Bosch<sup>™</sup> universal or wideband heated oxygen sensors using planar (flat) technology and new methods of signal generation. These six-wire heated oxygen sensors operate by using an internal ion pump to supply a measuring cell. The sensor signal is derived from the strength of the signal sent to the ion pump. Used in the pre-catalyst position of some systems.

#### Manifold Absolute Pressure (MAP) Sensor

Provides manifold pressure information to the ECM. The data is used to calculate air density and determine the engine air mass flow rate, which in turn determines the required fuel metering for optimum combustion. A fuel-injected engine may alternately use a Mass Air Flow (MAF) sensor to detect the intake airflow. A typical configuration employs one or the other, but seldom both.

#### Multiplicative

The effects of the fault (e.g. faulty injector) increase with engine speed (RPM). A multiplicative learned value is a proportional change to the injector duration. This change depends on the basic injector duration.

#### Negative Temperature Coefficient (NTC) Sensor

A temperature sensing component in which the electrical resistance decreases as the temperature increases.

#### Nernst Cell

An electro-chemical (Voltaic) cell based on mathematical equations first devised by Walther Hermann Nernst (1864-1941). The equation predicts the flow of gaseous ions and the resulting voltage at very high temperatures. Used as a measuring cell in oxygen sensors.

#### **Open Loop**

A period of engine operation when the ECM is either not receiving nor responding to information supplied by the oxygen sensor. Generally, an engine management system is in open loop after start-up (hot or cold), because the oxygen sensor is not up to proper operating temperature. In this situation, the ECM is instructed to run the engine with preprogrammed values until it recognizes a valid oxygen sensor signal. An engine management system can also be in open loop during hard acceleration where the ECM is programmed to slightly enrich the mixture. In this situation, the ECM is receiving valid signal information, but is programmed to temporarily disregard it. If an engine management system receives no signal, such as in the case of a disconnected or open circuited oxygen sensor, the ECM is programmed to run on preprogrammed internal values. Open loop operation, in this context, refers to a lack of response of the ECM to feedback supplied by the oxygen sensor or the lack of a signal, thereby breaking the feedback loop.

#### **Range/Performance Malfunction**

An OBD-II term used to denote particular types of malfunctions that do not seem to be possible under normal operating circumstances. For example, a Range/Performance malfunction is a throttle position sensor that has a low voltage at a engine speed with high rpm and a high mass air flow. High engine speed and high flow through the mass air flow sensor generally equate to high throttle position voltage, so this situation should not occur and will set a DTC as appropriate.

#### **Solenoid Valve**

An electrically switched electro-magnetic valve. Usually consists of a coil of wire through which an electric current is passed. The resulting magnetic field opens a valve, allowing passage of a gas or liquid.

#### Solid State

An electronic device or circuit using transistors and similar components. Does not use vacuum tubes.

#### Stoichiometric

Theoretical optimum air/fuel ratio for operating a spark ignition gasoline engine.

#### $\vartheta$ – Greek Symbol Theta

This symbol is placed in or near a component illustration to denote the influence of temperature on the component. Commonly used in wiring diagrams to identify temperature sensors and circuit breakers.

#### $\lambda$ – Greek Letter Lambda

This symbol denotes the air factor in the air/fuel mixture of an internal combustion engine. A  $\lambda$  value of 1 ( $\lambda$  = 1) indicates Stoichiometric.

#### < – Mathematical Symbol

This symbol denotes "less than." The text " $\lambda$  < 1" is read as "lambda is less than 1."

#### > – Mathematical Symbol

This symbol denotes "greater than." The text " $\lambda >$ 1" is read as "lambda is greater than 1.

#### ~ – Mathematical Symbol

This symbol, called a tilde, is used in mathematics to indicate equivalency or similarity between two values. The text "~60 volts" is read as "approximately sixty volts".

An on-line Knowledge Assessment (exam) is available for this Self-Study Program.

You can find this Knowledge Assessment at:

#### www.vwwebsource.com

For Assistance, please call:

![](_page_62_Picture_5.jpeg)

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