Motronic ME 7 Engine Management System

Design and Function

Self Study Program
Course Number 842003

Volkswagen of America, Inc.
Service Training
Printed in U.S.A.
Printed 7/2000
Course Number 842003

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Always check Technical Bulletins and the Volkswagen Worldwide Repair Information System for information that may supersede any information included in this booklet.

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Motronic ME 7, introduction

Volkswagen has used a variety of fuel injection systems in production vehicles for over 30 years. From the first D-Jetronic systems of the 1968, to the most current Motronic system for 2000 and beyond, each system has always been on the forefront of technology. As a result, Volkswagen vehicles run cleanly and efficiently, resulting in lower exhaust emissions. The combination of ME 7 technology and Volkswagen engineering ensures Volkswagen will continue to surpass the current technology.

This course is an operational overview of the ME 7 system, introducing the technician to the operating principles of the Motronic ME 7 engine management system.

Course Goals

- Introduce and define torque-based system architecture
- Explain electronic throttle control functions
- Detail component changes associated with the ME 7 system

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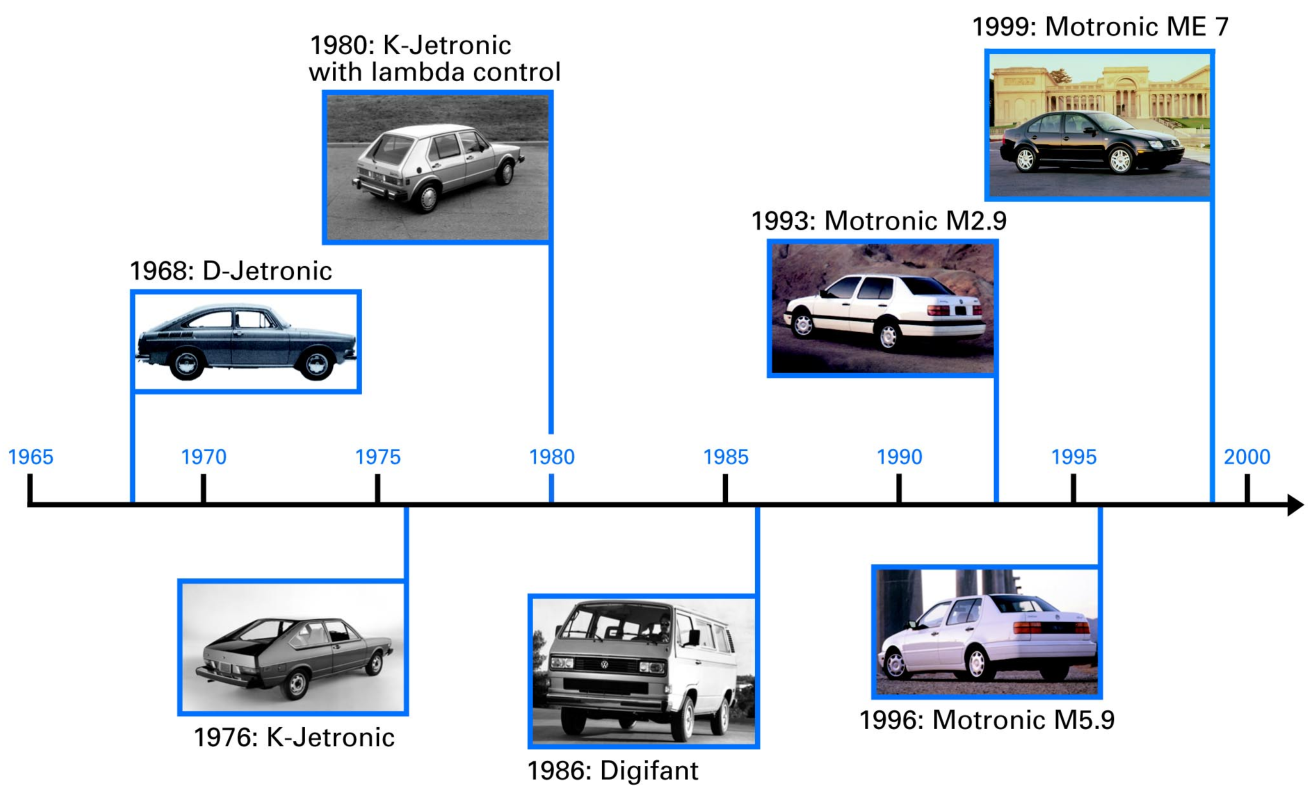
Introduction

Progression of Volkswagen engine management

In the mid 1960s, new emissions laws necessitated a change in technology. Volkswagen responded to this by introducing fuel injection to its product line.

The first vehicle to receive fuel injection was the 1968 Type III. This early Bosch™ D-Jetronic fuel injection system was substantially more efficient than previously used carbureted systems, allowing Volkswagen to meet continually changing emissions standards.

Volkswagen has continued to evolve from this early fuel management system to the current ME 7 engine management system. The ME 7 system is capable of not only cleaner exhaust emissions, but intergrated torque management as well.



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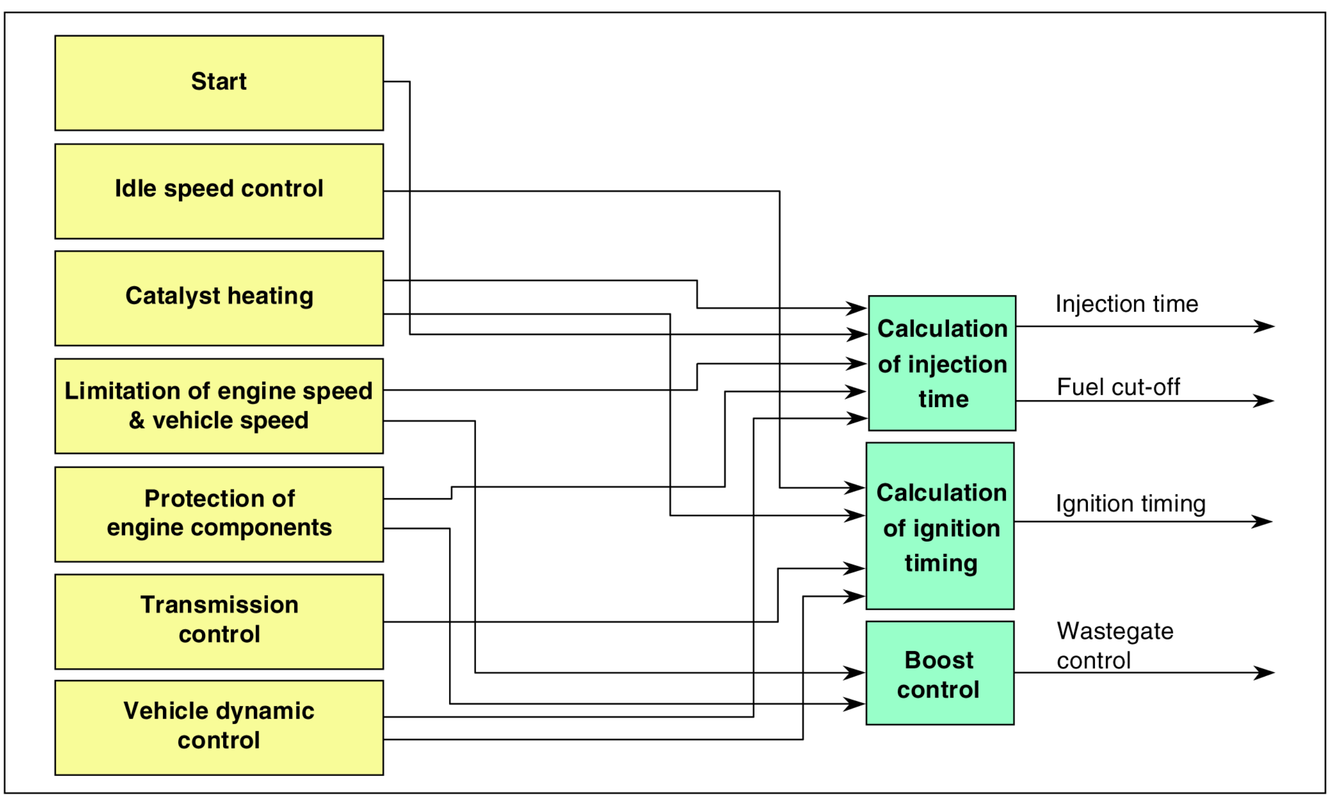
In early analog fuel/ignition systems, inputs and actuators were controlled by separate control units, or subsystems, including ignition timing, injection time and duration, boost control, etc. In the late 1960s, Bosch introduced D-Jetronic fuel injection. This early system used few inputs to control injector time and duration, and ignition was controlled separately by a breaker points type distributor.

The addition of an oxygen sensor to the K-Jetronic system in 1980 allowed the fuel systems to begin adapting to running conditions. This was the first step toward the fuel systems of today.

Volkswagen introduced a new digital engine management system in the 1986 Vanagon, called Digifant. This was the first Volkswagen engine management system with intergrated timing control.

Digifant I was able to control ignition timing according to inputs from a variety of sensors. The integration of fuel and timing management into one control unit was another milestone in the development of Volkswagen engine management systems.

From 1968 to the present, the sophistication of Volkswagen engine management systems continued to increase. The interaction between these subsystems has become increasingly complicated, as new demands such as traction control and vehicle dynamic controls are added to the system.



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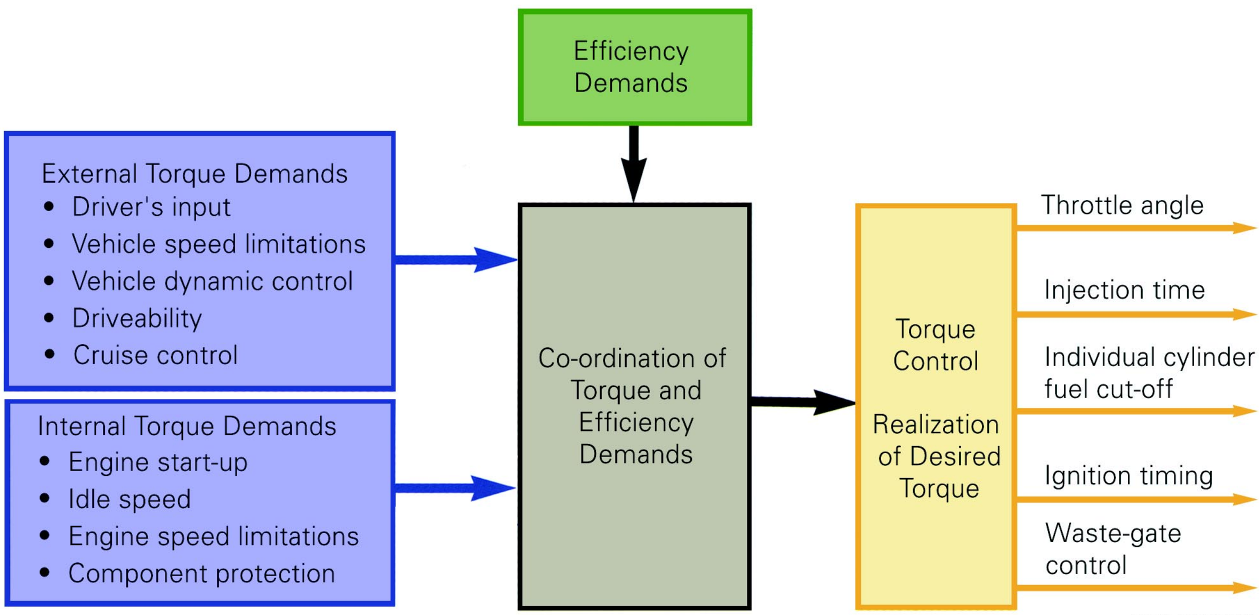
Torque management

The Motronic ME 7 system processes changes in inputs to control engine torque. Any change in engine torque is interpreted as a torque demand. The ME 7 system is therefore referred to as a "torque-based engine management system".

Definition: Torque demands are any signals that require a change in the torque output of the engine.

Torque demands are converted within the Motronic ECM J220 into signals which are sent to system actuators, altering injection timing, ignition timing, throttle valve angle, boost control and individual injector cutoff.

These changes affect the regulation of engine torque, affecting performance, efficiency, traction and vehicle dynamic control.



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ME 7 Architecture

Torque demands/requests

The Motronic ME 7 system designates functions via torque demands.

Torque demands can originate from external sources, or internally within the Motronic ECM. These may include:

- Driver input
- Cruise control
- A/C demands
- ABS/ASR/ESP
- Transmission Dynamic Shift Program (DSP)

The Motronic ME 7 system takes into account additional torque demands from other external sources, such as:

- Automatic transmission/transaxle
- Air conditioning
- Power steering

Effects of torque demands on engine torque

The Motronic ECM constantly regulates engine torque. The ECM uses signals from multiple components to continually modify system actuators for the desired engine torque.

Example:

The Motronic ECM receives a varying signal from the A/C High Pressure sensor G65. As A/C pressures vary, the pressure switch sends a signal to the Motronic ECM that is interpreted as a torque demand.

The Motronic ECM is able to increase engine torque by making a torque request that is fulfilled along the charge air path.

This allows for stable running characteristics under continually varying load conditions.

Torque Reduction

- Traction control
- Engine speed limitation
- Speed limitation
- Power output limitation
- Cruise control system
- Driving dynamics control systems

Torque Increase

- Speed control
- Engine breaking control
- Dash pot function
- Idling control
- Driving dynamics control systems

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Pathways

In order to meet the torque demands as efficiently as possible, demands for torque are separated via two paths:

- The **charge air path** controls all charge influencing components, such as throttle valve angle and wastegate actuation.
- The **crankshaft synchronous path** controls all interactions that occur simultaneously with the operating cycle of the engine, such as ignition and injection timing.

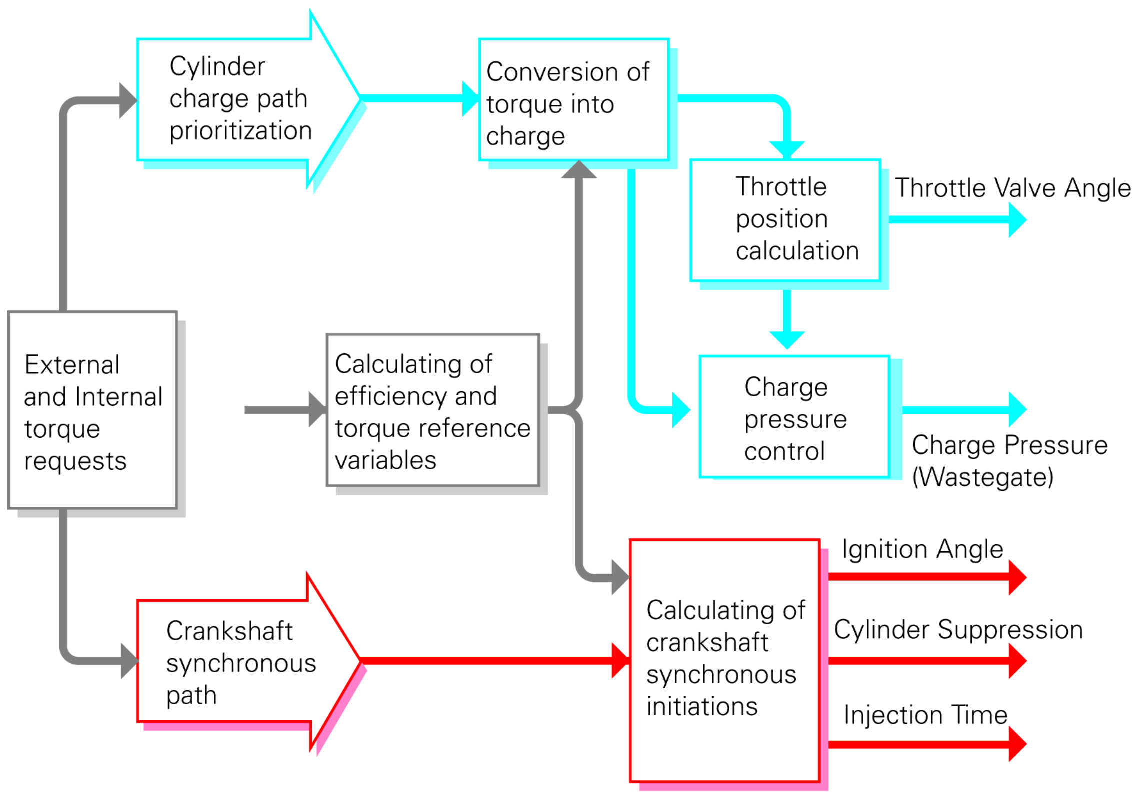
Charge air path

The air mass necessary to develop a specific torque is made available via the charge air path. This may include throttle angle or boost pressure on a turbocharged application.

Along this path, long-term torque demands are fulfilled.

Crank synchronous path

The crank synchronous path coordinates injector timing and pulse width, as well as cylinder-selective ignition timing. This path is particularly well suited to meeting short term torque demands, usually having a torque reduction effect.



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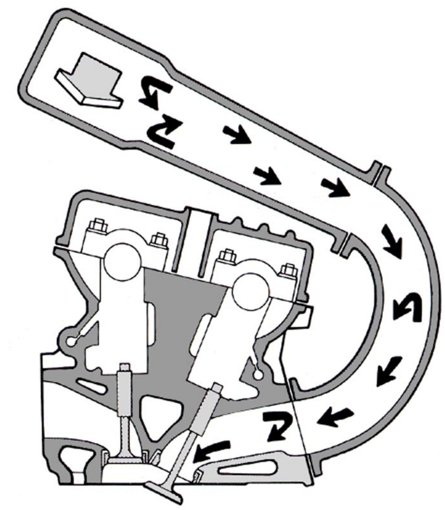
Primary functions of charge air path

The charge air path is primarily used for increases in engine torque. The goal of the charge air path is to provide a smooth increase in torque, as well as high efficiency at all operating ranges.

Components of the charge air path include:

- Electronic throttle control
- Mass Air Flow (MAF) sensor G70
- Charge air pressure sensor G31
- Barometric Pressure (BARO) sensor F96
- Intake Air Temperature (IAT) sensor G42
- Wastegate bypass regulator valve N75
- Intake manifold change-over valve N156
- Recirculating valve for turbocharger N249
- EVAP canister purge regulator valve N80

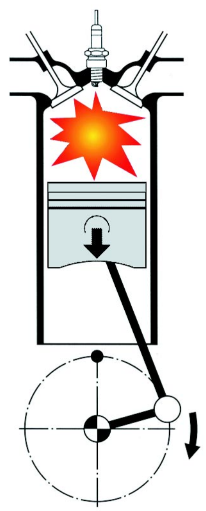


Charge air path features

The most significant component difference compared to previous engine management systems is the electronic throttle control system. This will be discussed in detail in the section titled "Electronic Throttle Control."

An additional difference in the charge air path on turbocharged vehicles applies to charge pressure regulation. The addition of the charge air pressure sensor G31 allows for more accurate control of boost levels.

The previous Motronic M5.9.2 engine management system did not directly measure manifold absolute pressure. Boost pressures were controlled by a calculation map. The Motronic ECM took readings from multiple inputs and controlled boost levels according to operating conditions.



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Primary functions of the crank synchronous path

The Motronic ME 7 engine management system uses several inputs and actuators for control of the crank synchronous path.

These signals are used for fine tuning of short term torque demands and associated fuel trim.

Components of the crank synchronous path include:

- Engine Speed (RPM) sensor G28
- Camshaft Position (CMP) sensor(s) G40/ G163
- Fuel injectors
- Ignition coils/Final power stages
- Knock Sensors (KS) G61/G66

Torque reduction is primarily handled via the crank synchronous path. The ability to alter injector timing and pulse width, as well as individual cylinder ignition timing, allows for a smooth transition of torque demands.

Primary functions of this path allow for:

- Injector cut off on deceleration
- Cylinder-selective fuel mixture
- Cylinder-selective ignition timing
- Speed limiter function
- Torque reduction during shifts (automatic and manual transmissions)

System components

The Motronic ME 7 system uses many of the same components as the M5.9 system. The major change is the addition of electronic throttle control.

Inputs

The Motronic ECM requires many of the same inputs and signals to effectively control running under all conditions. Any changes to components specific to the Bosch™ ME 7 engine management system are documented in detail in the *Volkswagen Engine Management Systems SSP # 841003*.

The engine management system no longer processes inputs by separate sub-systems. As previously discussed, these inputs are interpreted as changes to torque demands, and can have a strong influence on the charge air path, as well as the crank synchronous path. These components include:

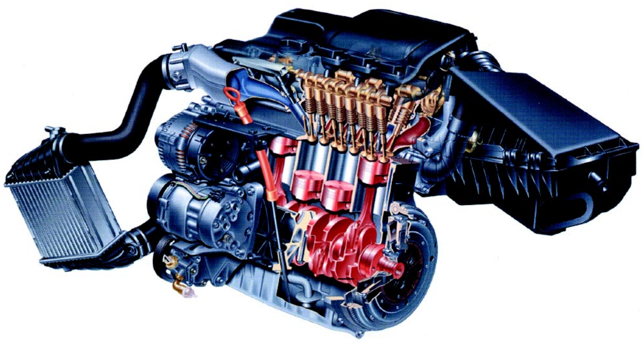
- Throttle Position (TP) sensor G79
- Sender -2- for accelerator pedal position G185
- Angle Sensors -1- and -2- for throttle drive G187/G188
- Engine Coolant Temperature (ECT) sensor G2/G62
- Intake Air Temperature (IAT) sensor G42
- Heated oxygen sensors (HO2S)
- Knock Sensors (KS) G61/G66
- Vehicle Speed Sensor (VSS) G54
- Charge Air Pressure sensor G31

Actuators

Changes to actuators outside of electronic throttle control are minimal. These components include:

- Fuel injectors
- Wastegate bypass regulator valve N75
- Intake Manifold Tuning (IMT) valve N156
- Recirculating valve for turbocharger N249
- Camshaft adjustment valve(s) N205/N208
- Throttle Drive G186

Several components have been changed or added to enhance driveability, or increase efficiency. On turbocharged engines, these changes are aimed at improving the efficiency of the turbocharger.



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Application Summary

1.8 liter 5V turbo, ME 7.5.1

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.

- Recirculating valve for turbocharger 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.

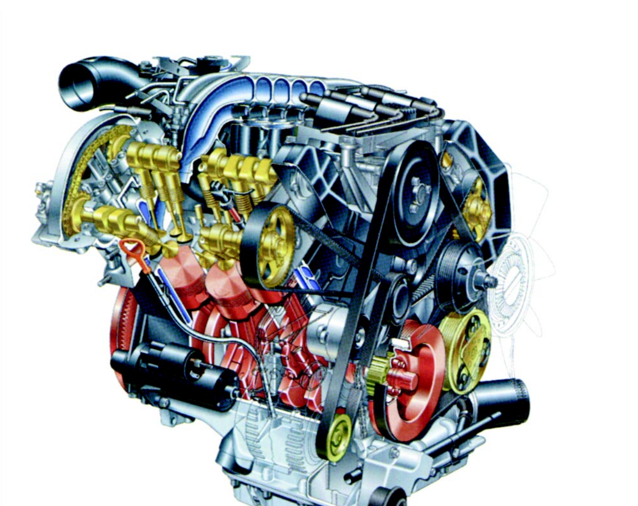
- Charge air pressure sensor G31

The charge air pressure sensor G31 provides the Motronic ECM with exact data regarding manifold absolute pressure.

2.8 liter 5V V6 ME 7.1

Features:

- Electronic throttle control
- Dual stage intake manifold with ECM actuated Intake Manifold Tuning (IMT) valve N156



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2.8 liter VR6 ME 7

Features:

- Electronic throttle control
- Dual stage composite intake manifold with rotary changeover valve, controlled by Intake Manifold Tuning (IMT) valve N156

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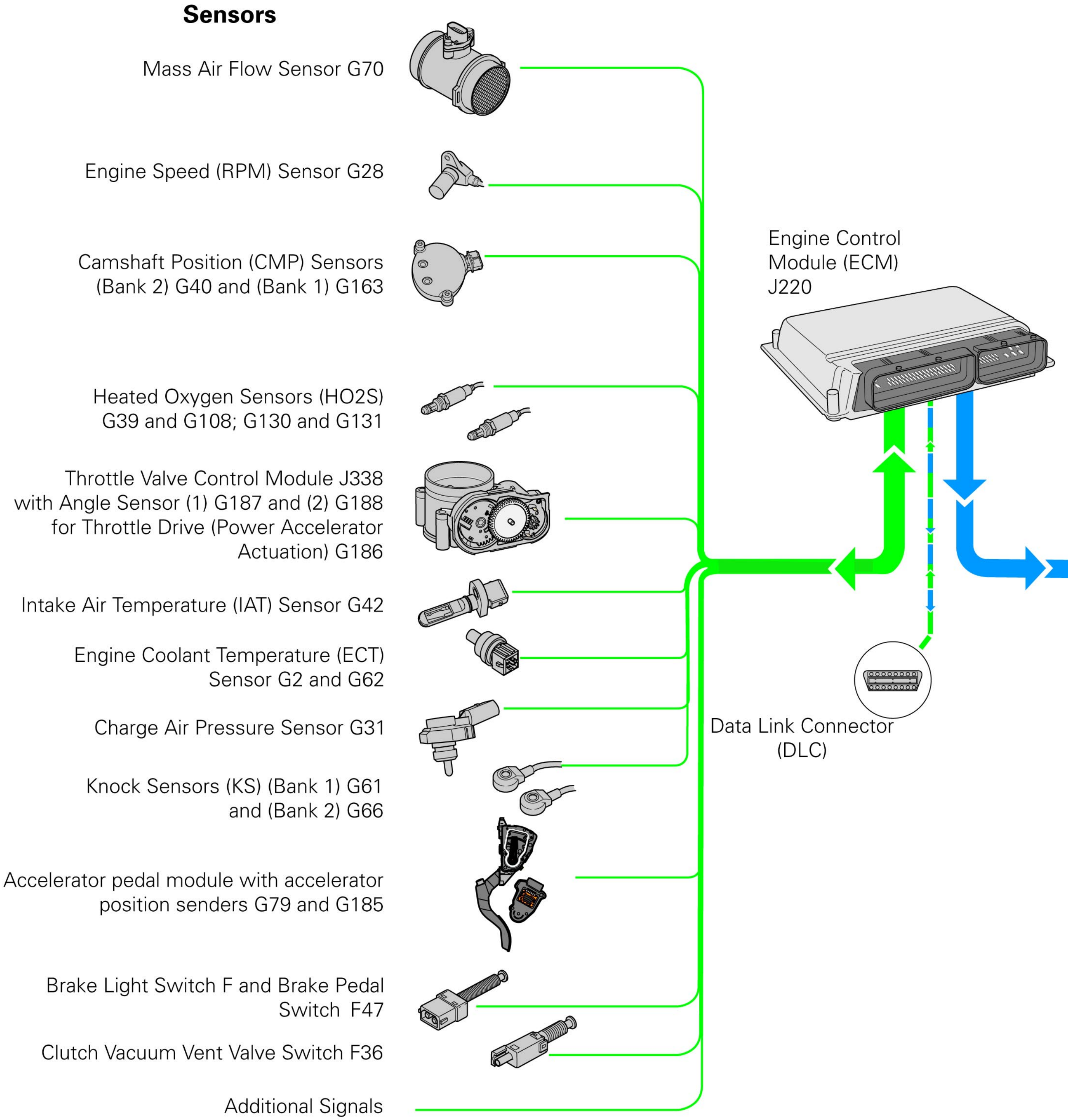
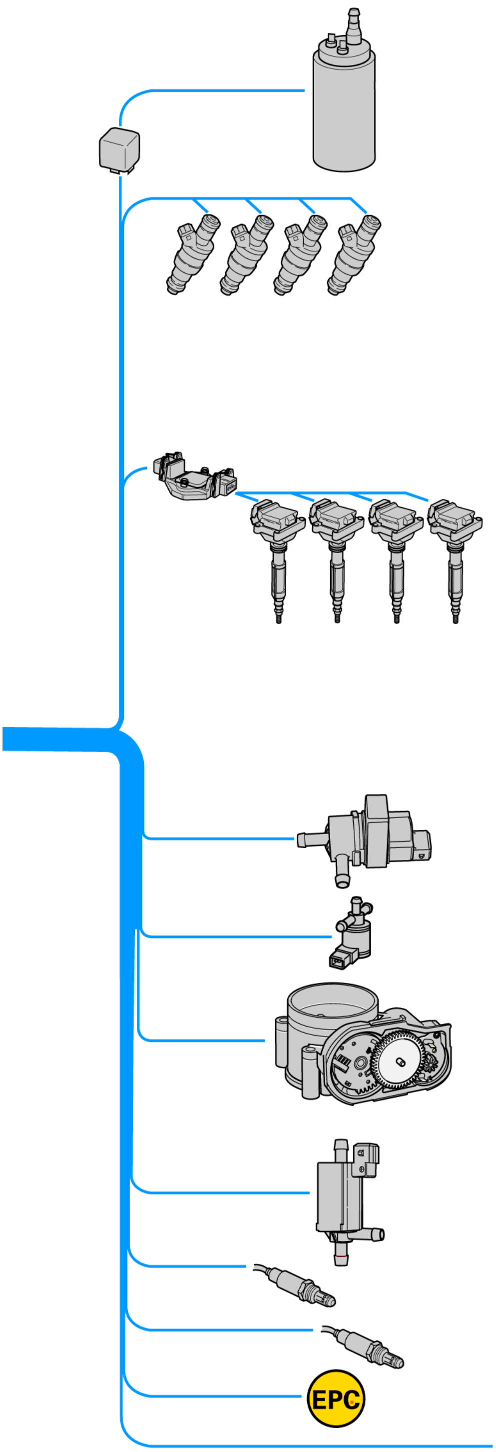
The following four pages show examples of ME 7 components as they apply to the 1.8 T (ME 7.5.1) and the 2.8 liter 5V V6 (ME 7.1) engines.

1.8 liter 5V Turbo (ME 7.5.1), overview



Actuators



Fuel Pump (FP) Relay J17 and
Fuel Pump (FP) G6

Fuel Injectors N30, N31, N32, N33

Power Output Stage N122 and Ignition Coils
N (Cyl.1)
N128 (Cyl.2)
N158 (Cyl.3)
N163 (Cyl.4)

EVAP Canister Purge Regulator Valve N80

Wastegate Bypass Regulator Valve N75

Throttle Valve Control Module J338
with Throttle Drive (Power Accelerator
Actuation) G186

Recirculating Valve for Turbochargers N249

Oxygen Sensor (O2S) Heaters
Z19 and Z28; Z29 and Z30

Fault Light for Electronic Throttle
Control K132

Additional Signals

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2.8 liter V6 5V (ME 7.1), overview

Sensors

Oxygen Sensors (02S) behind TWC's G130, G131

Heated Oxygen Sensors (H02S) I & II G39, G108

Mass Air Flow Sensor G70

Intake Air Temperature (IAT) Sensor G72

Knock Sensors G61 & G66

Engine Speed (RPM) Sensor G28

Camshaft Position (CMP) Sensor G40

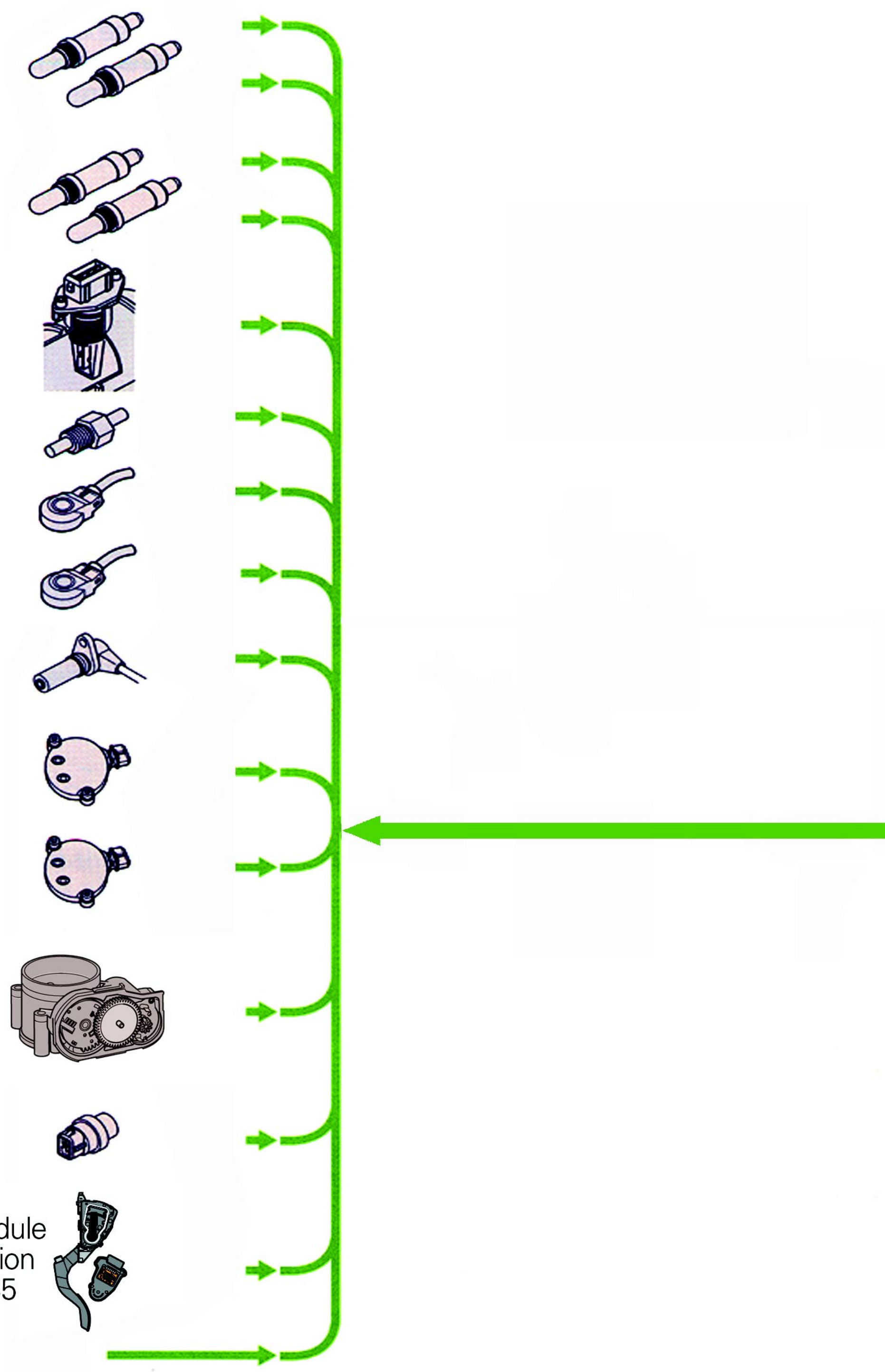
Camshaft Position (CMP) Sensor II G163

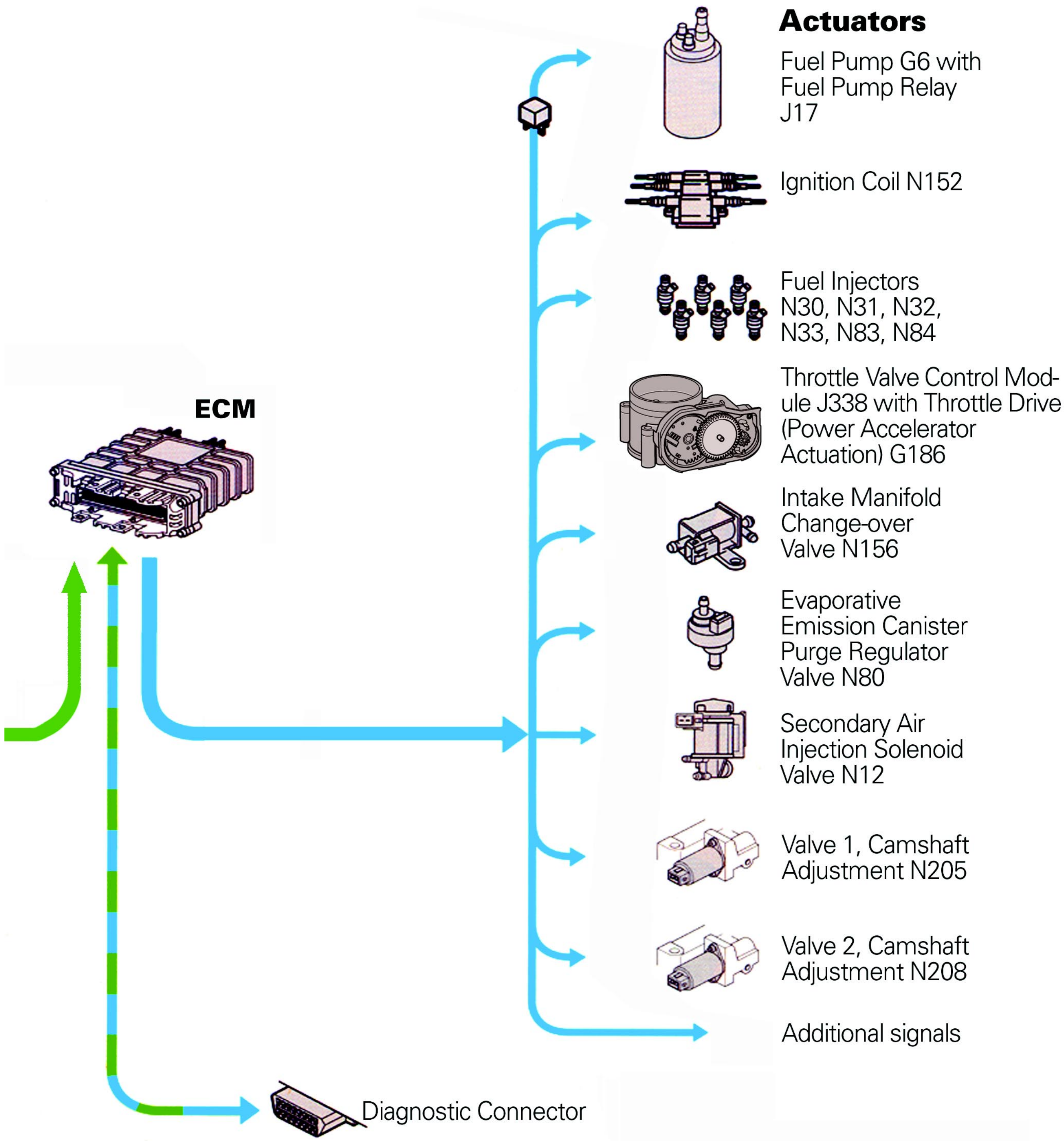
Throttle Valve Control Module J338 with Throttle Drive (Power Accelerator Actuation) G186

Engine Coolant Temperature (ECT) Sensor G62

Accelerator Pedal Module with Accelerator Position Sensors G79 and G185

Additional signals




Actuators
Fuel Pump G6 with
Fuel Pump Relay
J17
Ignition Coil N152
Fuel Injectors
N30, N31, N32,
N33, N83, N84
Throttle Valve Control Mod-
ule J338 with Throttle Drive
(Power Accelerator
Actuation) G186
Intake Manifold
Change-over
Valve N156
Evaporative
Emission Canister
Purge Regulator
Valve N80
Secondary Air
Injection Solenoid
Valve N12
Valve 1, Camshaft
Adjustment N205
Valve 2, Camshaft
Adjustment N208
Additional signals
ECM
Diagnostic Connector

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Electronic Throttle Control, function

To more accurately regulate the charge air path, the ME 7 system uses electronic throttle control in place of a cable between the accelerator pedal and the throttle valve.

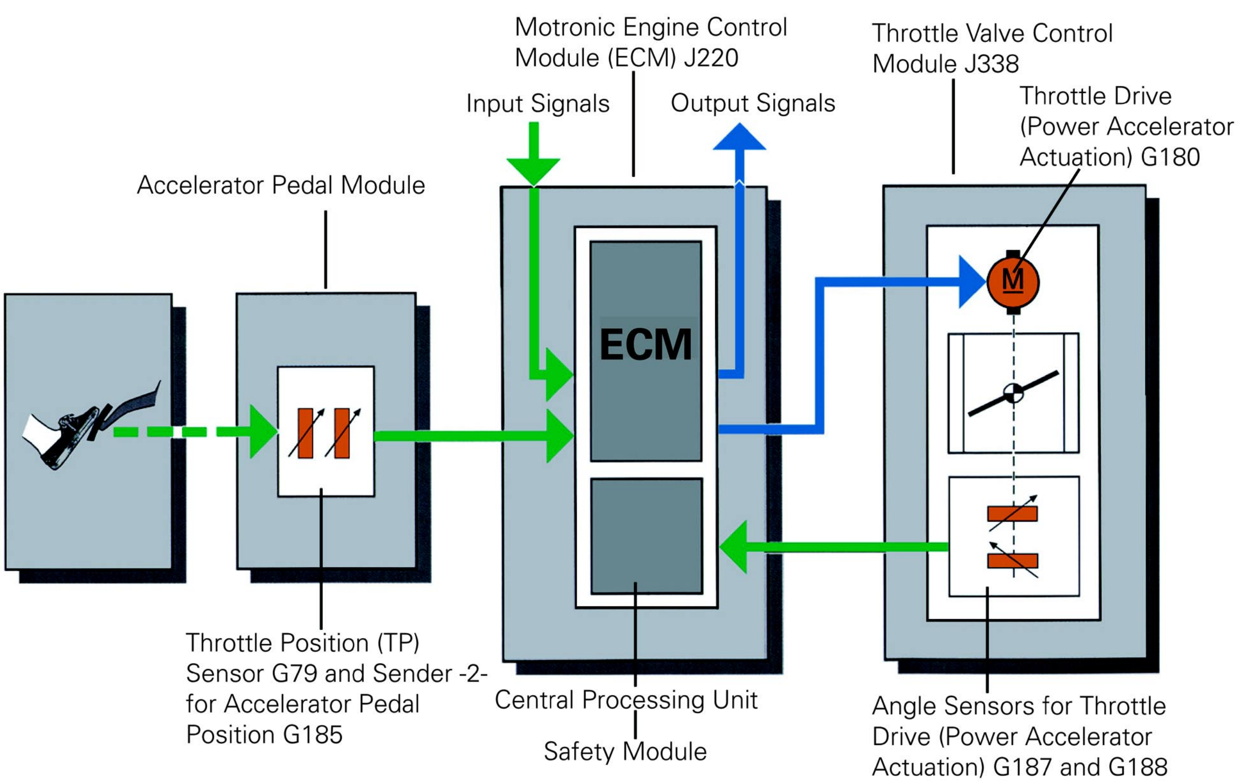
The Electronic Throttle Control system includes the following components:

- Accelerator pedal module (includes throttle position sensors G79/G185)
- Throttle valve control module J338 (includes position sensors G187/G188 and throttle valve drive G186)
- Motronic Engine Control Module (ECM) J220
- Malfunction Indicator Lamp (MIL) for Electronic Power Control (EPC) K132

The driver input at the accelerator pedal is registered by the senders for accelerator pedal position, and transmitted to the Motronic ECM J220.

Motronic ECM J220 positions the throttle valve via an electric motor. J220 is provided with continuous feedback on the throttle valve position.

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



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Accelerator pedal module function

The accelerator pedal module is comprised of the accelerator pedal and the accelerator position sensor together as one unit.

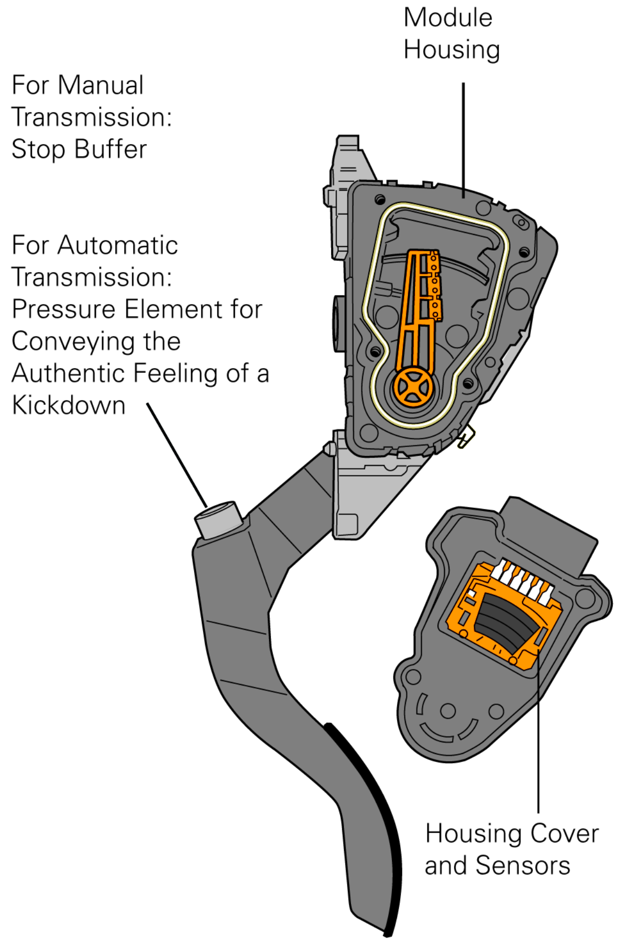
The throttle position sensors transfer an analog signal corresponding to the accelerator position to the Motronic ECM. To ensure that the electronic accelerator functions reliably, the accelerator pedal module has two independent potentiometers, G79 and G185. Each has a different characteristic curve. If one sender fails, the other sender acts as a substitute.

There is no longer a separate switch for the kickdown function. When the normal voltage limit of the accelerator position sensor is exceeded, the Motronic ECM recognizes the signal and interprets it as a kickdown. The resulting signal is transmitted to the Transmission Control Module (TCM) via the CAN data bus.

Automatic transmission Kick down Adaptation

If the Accelerator Pedal Module or the Motronic ECM is replaced on a vehicle equipped with an automatic transmission, the ECM must learn the kick down position. This is accomplished through the activation of Basic Settings in function 04, measuring value block 063. The accelerator pedal is depressed completely, past the kick down point, and the values of the accelerator position sensors are stored in the ECM.

Note:
Always check VESIS for the most current information.



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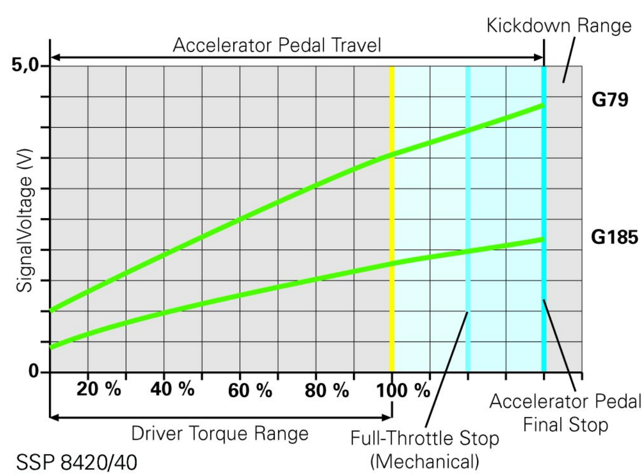

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Emergency running modes, introduction

If a malfunction occurs in the accelerator pedal module or the wiring, two emergency programs can be run (depending on type of malfunction).

Emergency running mode 1

If one accelerator position sensor fails:
- Acceleration position is limited to a predefined value.
- If a full load is predefined, the power output is increased slowly.
- In the case of implausible signals between G79 and G185, the lower value is used.
- The signal from the Brake Pedal Switch F47 indicates idling speed.
- Comfort functions are disabled.
- MIL K132 for EPC is illuminated.

Emergency running mode 2

If both accelerator position sensors fail, driver input recognition is not possible. In this case:
- MIL K132 for EPC is illuminated.
- Engine runs only at idle speed.

Note:
At idling speed the Throttle Position (TP) sensor G79 and the sender -2- for Accelerator pedal position are not monitored. If the accelerator pedal module becomes disconnected, a fault is not stored in the Engine Control Module. The Fault Light for power accelerator activation is not illuminated, the engine runs at idling speed and does not respond to drivers input.

CAUTION!
For safety reasons, the throttle valve is closed to a predetermined position when both the brake pedal and the accelerator pedal are depressed. If the brake is depressed before the accelerator, then the accelerator input is carried out.

Throttle valve control module J338 function

The throttle valve control module J338 contains the following components:

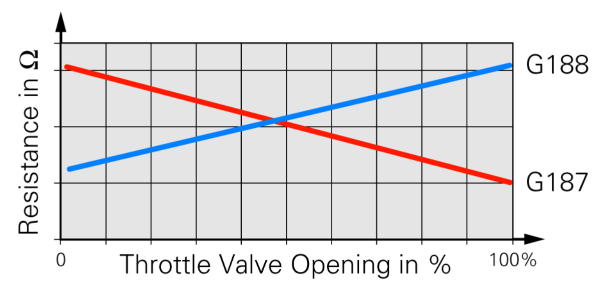
- Throttle drive (power accelerator actuation) G186
- Angle sensor for throttle drive G187
- Angle sensor for throttle drive G188

For safety reasons, the two position sensors have opposite resistance curves and are used for continual self-diagnosis. The Motronic ECM always cross checks the signals from both senders for plausibility.

The throttle valve control module is controlled by the Motronic ECM J220, and regulates the required air charge to produce the required torque.

Note:
The throttle valve control module J338 has no user serviceable components. If an internal component fails, the complete module must be replaced.

If an angle sensor fails, the second sensor maintains the electronic throttle control function via an emergency running mode.



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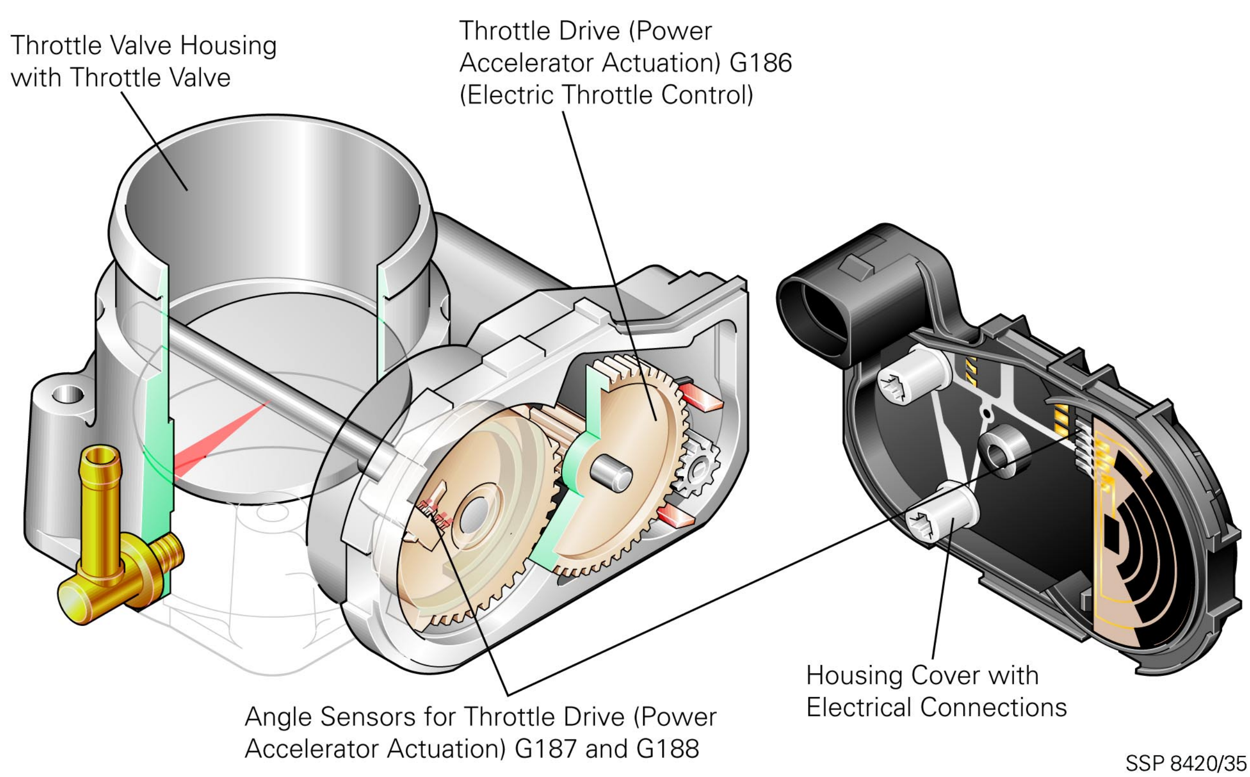

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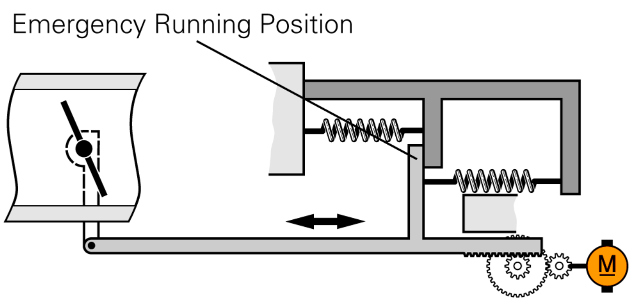
Adaptation and Functional positions

The adaptation process enables the ECM to learn the various positions of the throttle valve. These positions are stored in the ECM.

- **Emergency running position**

  This position is the de-energized position of the throttle valve drive motor. The ECM records the values from the two throttle position sensors.

  This position ensures that during emergency running mode, the throttle valve will allow sufficient airflow for approximately 1000 RPM. This allows limited vehicle operation.



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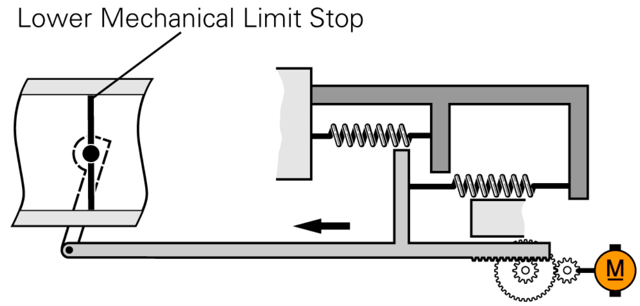
- **Spring test**

Once the ECM has stored the values for the emergency running position, the throttle valve is then opened a predetermined amount, and the values from the two throttle position sensors are stored in the ECM. The throttle drive is then de-activated. The spring should return the throttle valve to the emergency running position within a specified period of time. The ECM stores this time value. This enables the ECM to adapt to manufactured tolerances, as well as individual component wear.

- **Lower mechanical limit stop**

  The throttle valve is then completely closed and the values from the throttle position sensors are stored in the ECM. This setting is only used for adaptation.



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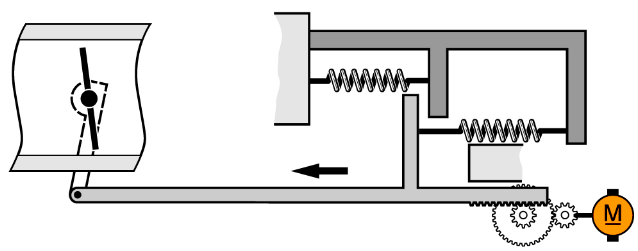
Additional Functional positions

- **Lower electrical limit stop**

  This position is defined by the Motronic ECM J220 and is just past the lower mechanical stop. During normal running conditions the throttle valve never closes further than this setting.

Position of Lower Electrical Limit Stop



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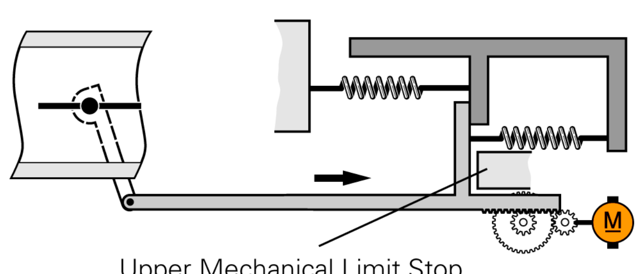
- **Upper electrical limit stop**

  This position is defined by the Motronic ECM J220 and does not require adaptation.

Position at Upper Electrical Limit Stop



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Adaptation procedure

Any time work is performed on the electronic throttle control system, or the power supply to the ECM is interrupted, adaptation must be carried out using the VAS 5051 or VAG 1551. This is both a complete check of the throttle valve control module, as well as the accelerator pedal module. Specific readings must be received by the Motronic ECM J220 to allow normal running.

The adaptation is performed in two ways:

1. **Specifically:**

   When adaptation has been initiated by an outside source, i.e. the VAS 5051. This is accomplished through activation of Basic Settings in function 04, measuring value block 060.

Note:
Always check VESIS for the most current information.

2. **Automatically:**

   If the ignition is switched on for six to ten seconds, and if the ECM registers a "learning requirement." The ECM will register a "learning requirement" if the previously registered voltage values from the throttle position sensors are out of tolerance to the new voltage readings. In this case there is no way of knowing if the adaptation was successful or not.

Throttle valve control module failures

If a fault occurs in the throttle valve control module or wiring, one of three emergency running modes may be selected by the Motronic ECM (depending on the type of fault). The MIL for the Electronic Power Control (EPC) K132 will illuminate.

Emergency running mode 1

If one throttle position sensor fails, or an implausible signal is received, power output of the engine is reduced. The customer may complain of a lack of power.

This mode requires one functional throttle position sensor with an intact signal, and appropriate engine load readings from the Mass Air Flow (MAF) sensor G70.

Emergency running mode 2

If the throttle valve actuator fails or malfunctions, the voltage to it is shut off and the throttle valve defaults to its emergency running position (mechanical stop). Driver inputs are executed as far as possible via ignition angle and charge pressure regulation. As a result, the engine will show very little response to the throttle. This running mode requires plausible signals from both throttle position sensors.

Emergency running mode 3

If the throttle valve position is not clearly recognized, or if the throttle valve is not definitely known to be in the emergency running position (implausible signals), the voltage to it is shut off and the throttle valve goes to its emergency running position (mechanical stop). The engine speed is limited to 1200 RPM by restricting the fuel injector pulse width and ignition timing.

Fault light for power accelerator activation K132

Malfunctions in the either the electronic accelerator system or associated sensors are detected by self-diagnosis and indicated by the separate EPC fault light.

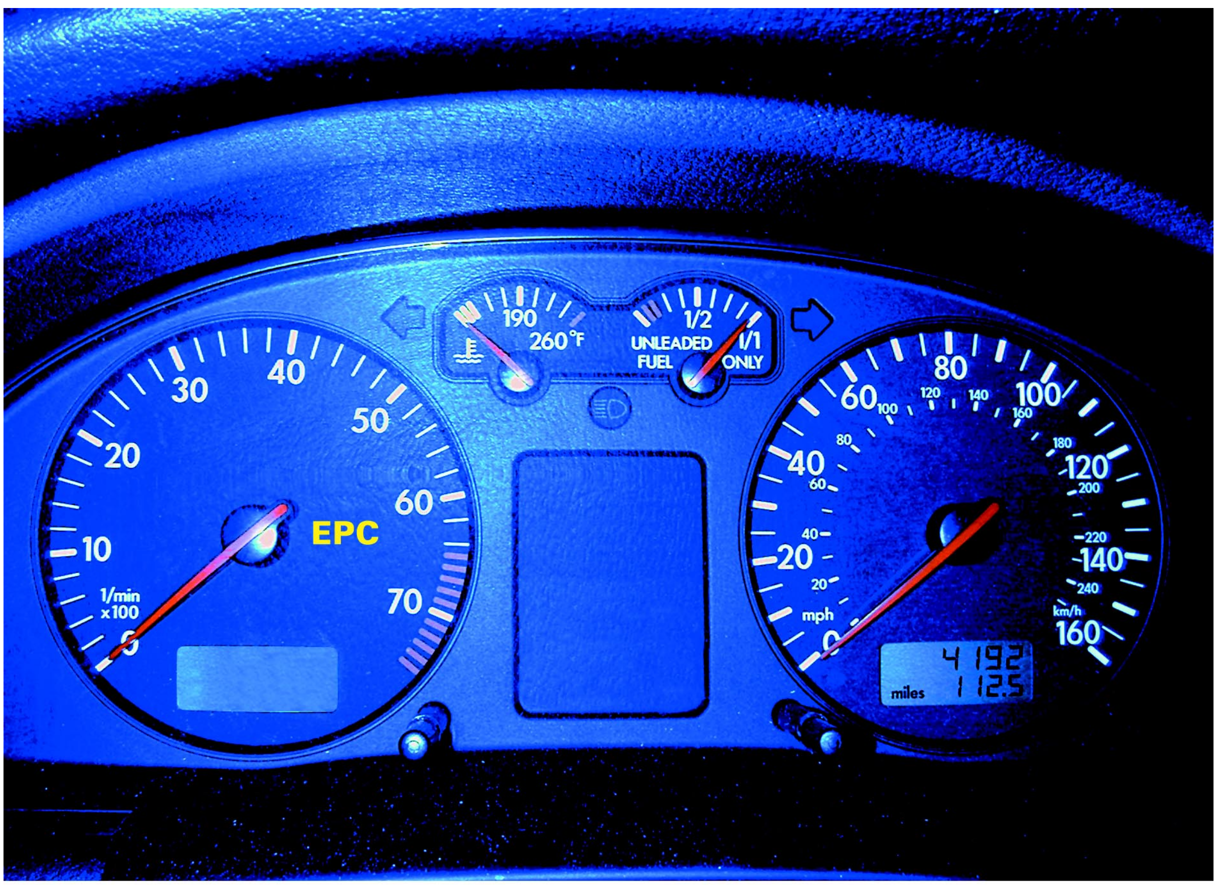
For example, a fault in the Mass Air Flow (MAF) sensor G70 will trigger the EPC light, due to its usage by the Motronic ECM for an engine load signal. The Motronic ECM uses this signal for checking signal plausibility of other inputs. At the same time, an entry is made in the fault memory.

Note:
Faults in the electronic throttle control that will adversely effect emissions will also illuminate the MIL.

When the ignition is switched on, the fault light is illuminated and must go out again after 3 seconds if no Diagnostic Trouble Codes (DTCs) are stored.

The Fault Light for Power Accelerator Activation K132 is illuminated by being electronically switched to ground through the engine control module.

If a fault occurs in the electronic throttle control system, the appropriate emergency running mode will be activated.



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On Board Diagnostic (OBD), introduction

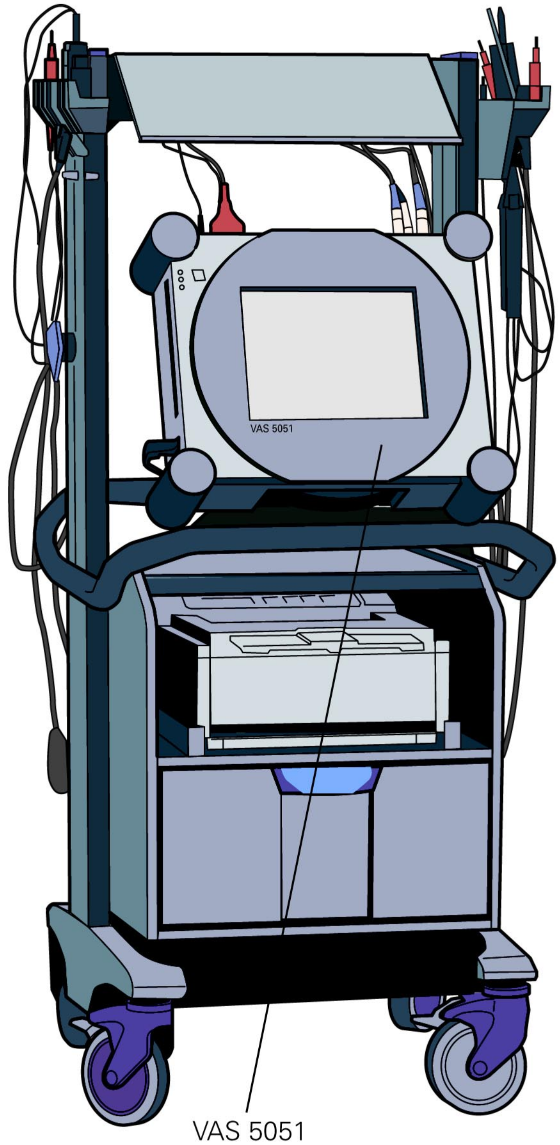
The Motronic ME 7 system is a full OBD II compliant system. The system is capable of self-diagnosis, and well as external diagnosis from sources like the VAS 5051 and the VAG 1551/1552.

The ME 7 system is continually monitoring itself. From the throttle valve control module running adaptation programs, to the Leak Detection Pump (LDP) testing the integrity of the fuel system, the ME 7 system is constantly monitoring exhaust emissions.

VAS 5051

The VAS 5051 Vehicle Diagnostic Testing and Information System integrates service information, diagnostic test equipment and real time data transfer into a single tool. This greatly simplifies the diagnostic procedure, as well as ensures accurate diagnosis the first time.

Features:
- Digital Storage Oscilloscope (DSO)
- Digital Multimeter (DMM)
- Guided fault finding
- Vehicle On Board Diagnostic (OBD)



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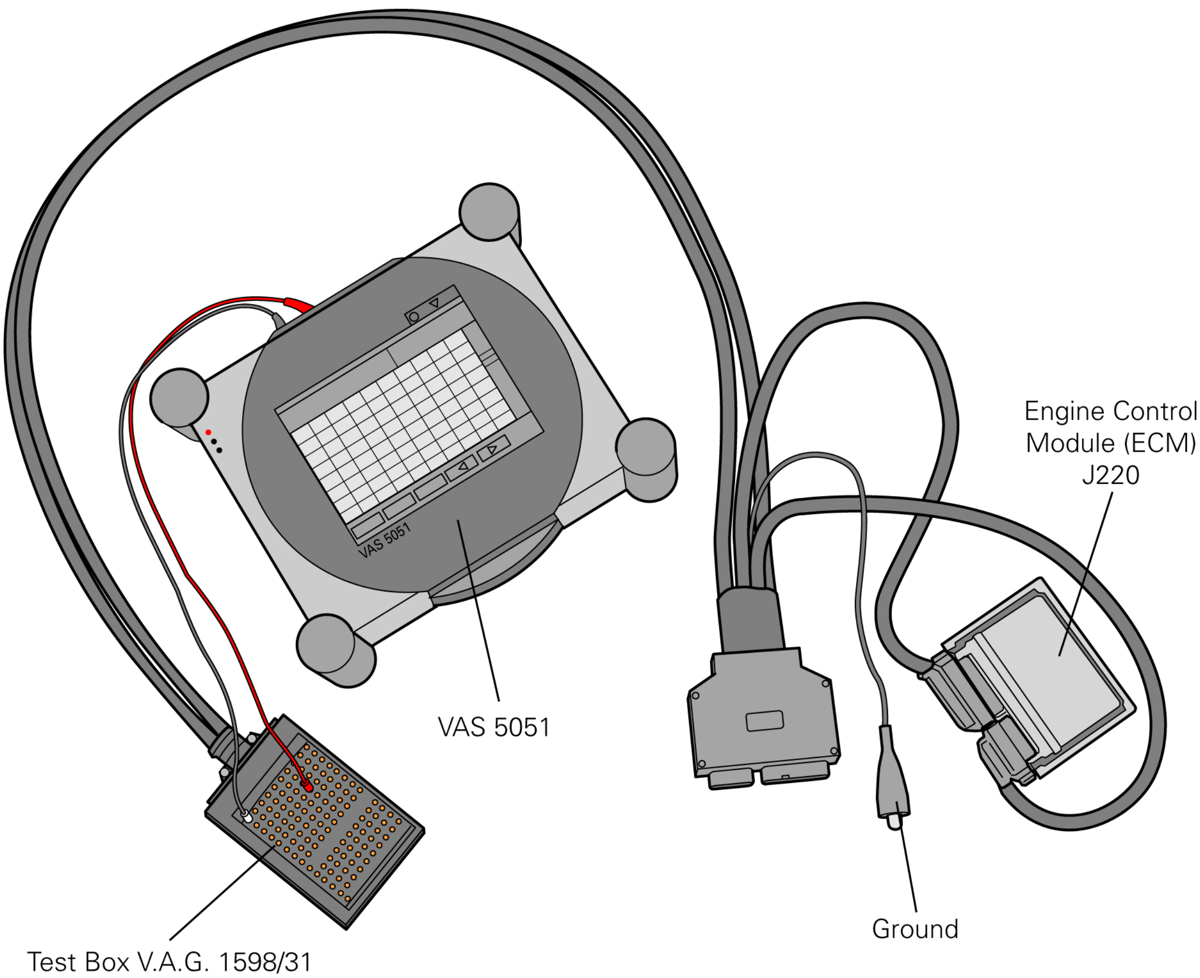
VAG 1598/31

The ability to test individual components with the engine running is an important diagnostic capability. the VAG 1598/31 pinout box is designed to be installed in series between the engine wiring harness and the motronic ECM. using this tool, technicians are able to test any circuit associated with the running of the ME 7 system under all operating condiions.



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Volkswagen ME 7 Engine Management System Teletest

The test accompanying this course, #842003, has been prepared and shipped as a separate document. Please refer to your copy of that document and follow the testing instructions to complete the Teletest.

Additional copies are available by contacting:

Certification 2001 Program Headquarters
Toll-free Hotline & Testing: 1-877-CU4-CERT (1-877-284-2378)
Fax:1-877-FX4-CERT (1-877-394-2378)

Hotline assistance is available Monday-Friday
between 9:00 a.m. and 5:00 p.m., EST.

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