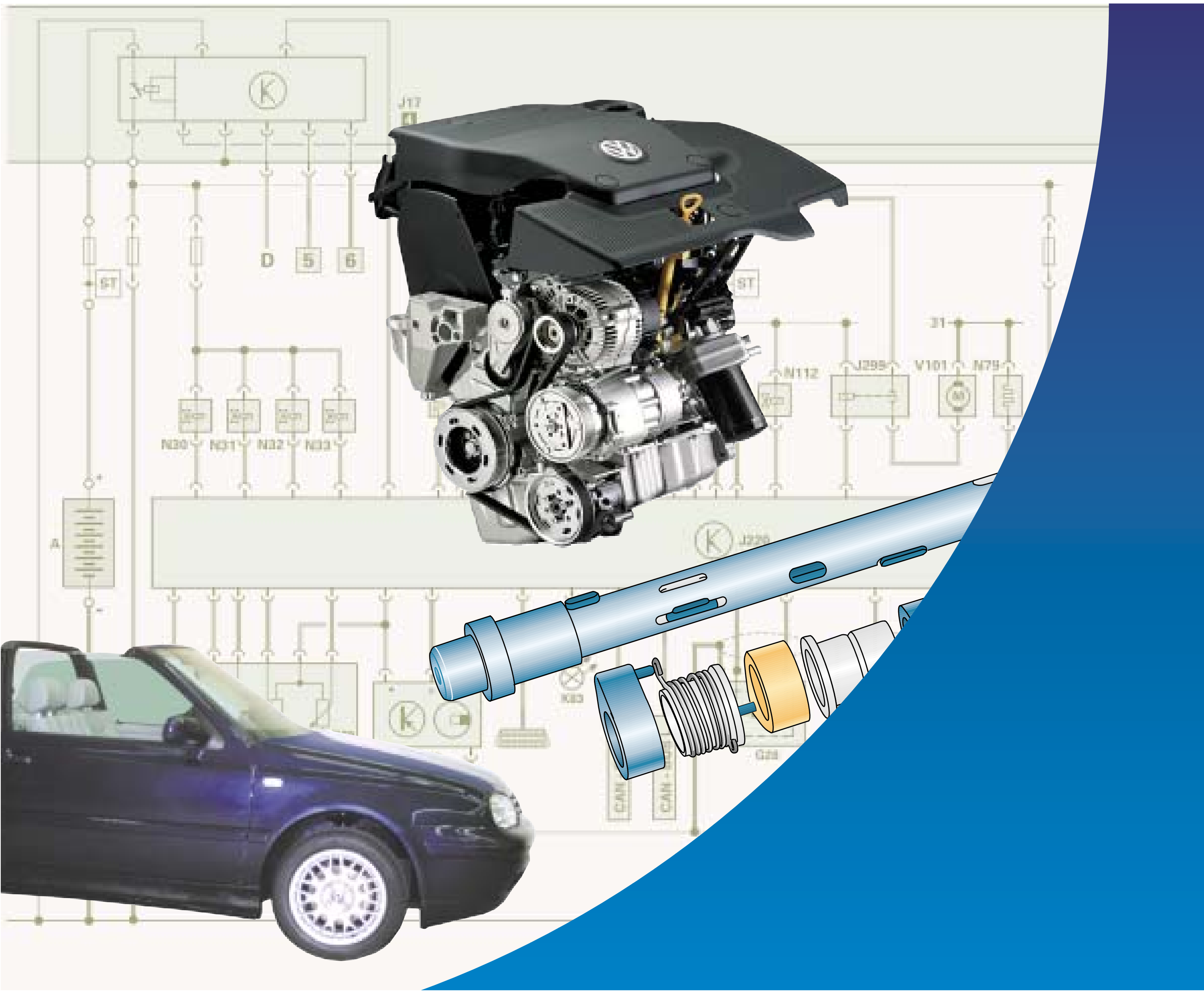
Service.

Self-Study Programme 233

2.0-litre Engine

Design and Function



The 2.0-litre engine stems from a successful engine generation and has a long history.

The engine blocks of the 1.6-litre and 1.8-litre engines have a similar design.

The functions of components such as the coolant pump, radiator, oil pump and oil pump motor are identical.

A notable feature of these engines is their closed system control loops which greatly reduce the pollutant emission in the exhaust gases.

The 2.0-litre engine has different structural design details than the 113 and 827 series.

In this Self-Study Programme, you can familiarise yourself with the design and function of the 113 series engine and 827 series engine with intermediate distributor drive shaft.

VW has been fitting the engine with intermediate shaft in the Golf convertible since May 1999.

The 2.0-litre/88 kW engine with flying camshaft (Flino) and new functional features will also be presented.

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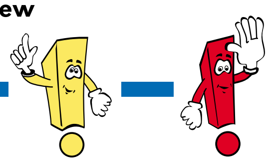

The Self-Study Programme is not a Workshop Manual!

Please always refer to the relevant Service Literature for all inspection, adjustment and repair instructions.
Service Literature.

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The 2.0l / 88kW engine will not be introduced!

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2.0-litre/85 kW engine AQY/ATU

Specifications
Differences/common features

233_012

113 series – engine AQY

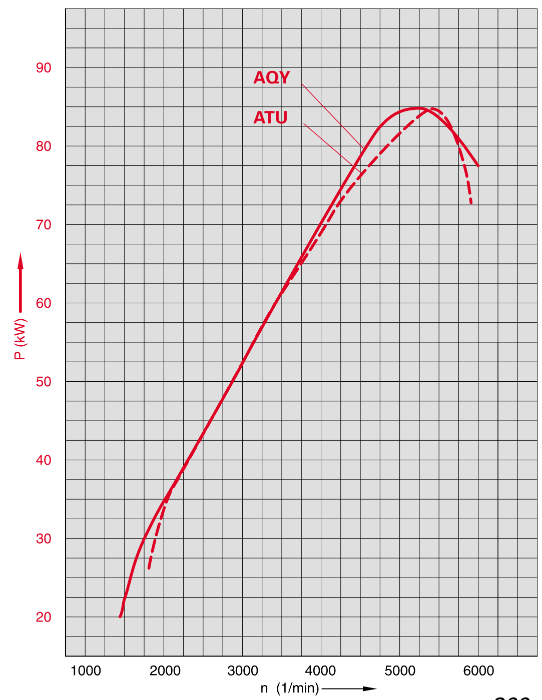
233_013

827 series – engine ATU

Series	**113**	**827**
Engine code	**AQY**	**ATU**
Type	4-cylinder in-line engine	
Displacement	1984 cm^3	
Bore	82.5 mm	
Stroke	92.8 mm	
Compression ratio	10.5 : 1	10.0 : 1
Rated power output	85 kW/5200 rpm	85 kW/5400 rpm
Torque	170 Nm/2400 rpm	165 Nm/3200 rpm

Technical features
Differences/common features

	AQY	ATU
Engine management	Motronic 5.9.2	
Lambda control	Probe upstream of catalytic converter Probe downstream of catalytic converter	
Knock control	2 knock sensors	1 knock sensor
Ignition system	Static high-voltage distribution with 2 twin spark ignition coils	Rotating distributor
Self-diagnosis fault warning lamp	in dash panel insert with manual gearbox (EU4) only	not fitted
Exhaust gas treatment	Secondary air system without secondary air injection valve	Secondary air system with secondary air injection valve
Fuel	Premium unleaded (RON 95)	Premium unleaded (RON 95)
Exhaust emission standard	EU 4 Manual gearbox D4 Automatic gearbox	D4 Manual gearbox D3 Automatic gearbox



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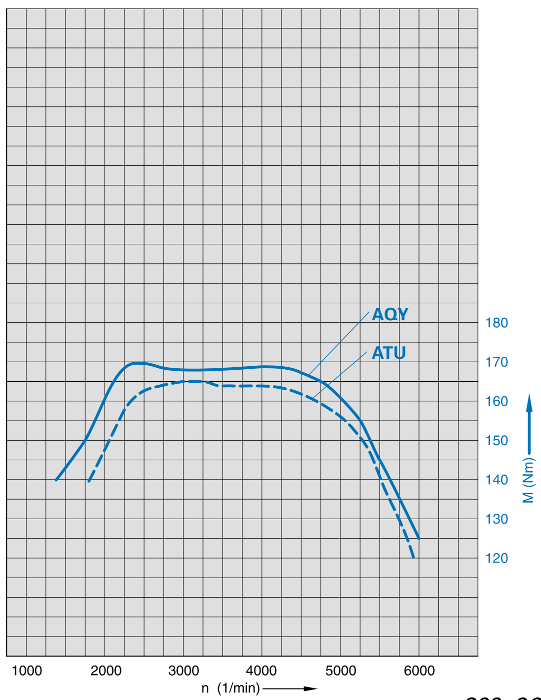
Comparison of performance curves



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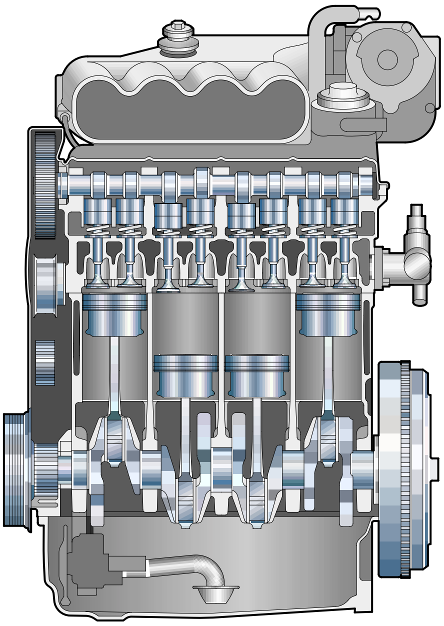
Comparison of torque curves

2.0-litre/85 kW engine AQY/ATU

Engine overview
Differences/common features



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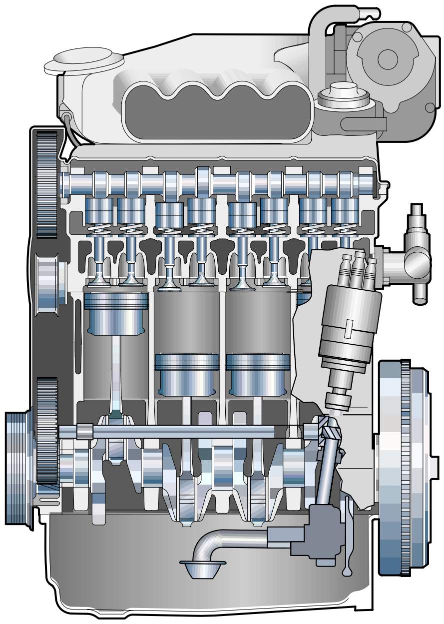
Engine AQY



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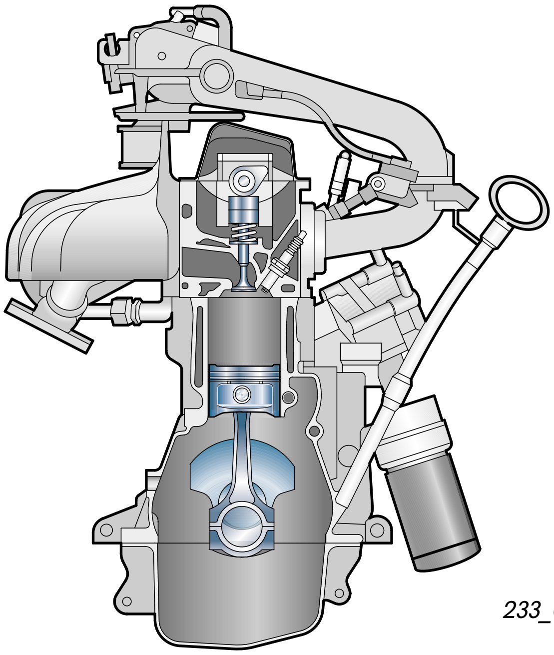
ATU engine

- AQY engine — without distributor, static high-voltage distribution; engine suspension: pendulum support.
- ATU engine — with distributor, drive by means of intermediate shaft; conventional engine suspension

Notable differences

Details of the assemblies used in both engines:

- The crankshaft is mounted on 5 bearings.
- The cylinder block is manufactured from gray cast iron.
- The crankcase is ventilated via the cylinder head cover.
- Lighter pistons reduce moving masses in the engine.
- The cylinder head is made of aluminium.
- The oil sump used in the AQY engine is made of aluminium and has 3 mounting points facing towards the gearbox.
- The oil pump used in the AQY engine is an internal gear pump. It is driven by the crankshaft by means of a chain. The oil pump used in the ATU engine is driven via the intermediate shaft.
- Spray jets for piston cooling: the ATU engine does not have a piston cooling system.
- The reference marks and engine speed are registered by senders mounted on the crankshaft.
- Phase recognition by Hall sender. Mounted on the camshaft in the AQY engine and on the distributor in the ATU engine.



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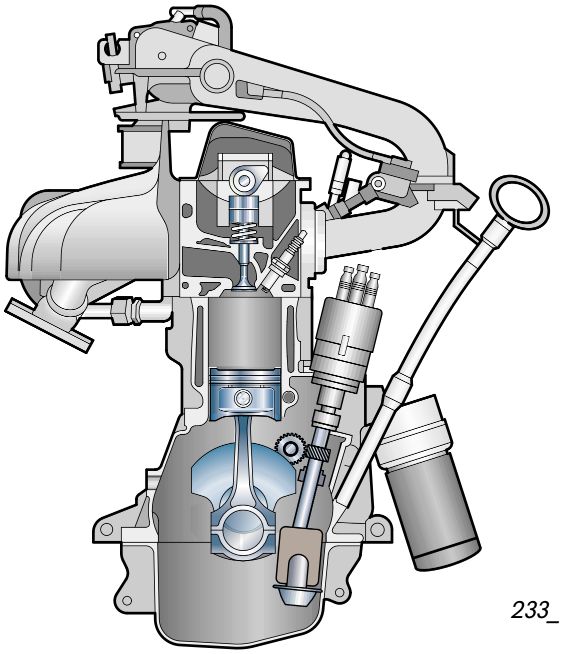
Engine AQY



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Engine ATU

The crossflow cylinder head is based on tried and tested structural design details.

It is also used in the 1.6-litre engine with twin-path intake manifold.

It offers the following advantages:

– optimised intake/exhaust ports for improved handling performance and exhaust emission through a tumble duct

– The intake manifold located at the front end of the engine reduces the crash impact, as there is more space between the intake pipe and the engine bulkhead. The manifold is a two-piece construction.

The stainless steel exhaust manifold is a double-flow manifold. Each cylinder has its own exhaust pipe; these pipes are then paired up.

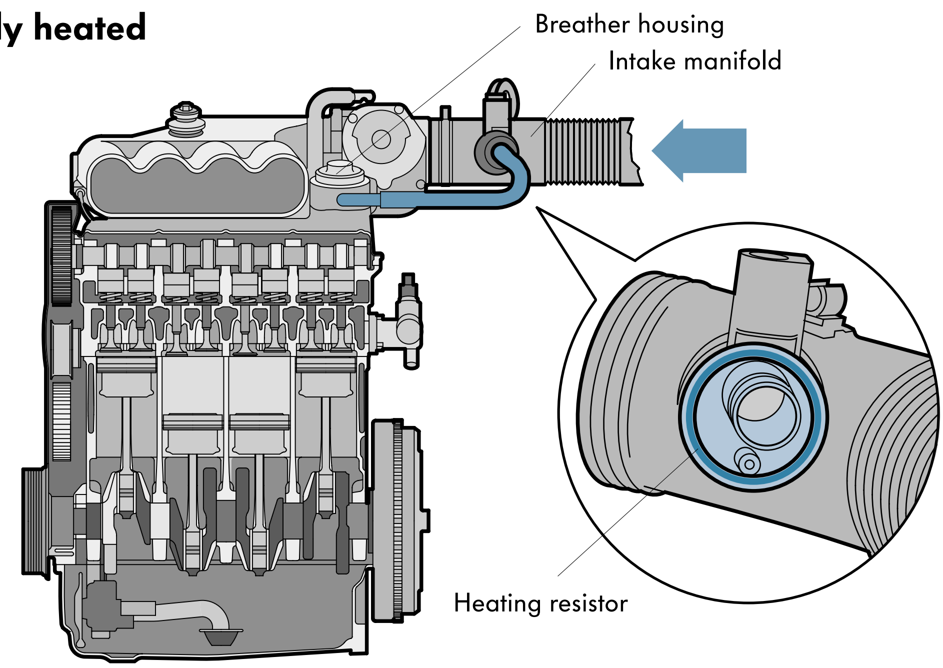
The lightweight valve gear is used:

– 35 mm dia. hydraulic bucket tappet
– 33 mm dia. exhaust valves
– 40 mm dia. intake valves
– 7 mm dia. valve stem

Intake valve lift: 10.6 mm
Exhaust valve lift: 10.6 mm

Crankcase breather

Electrically heated



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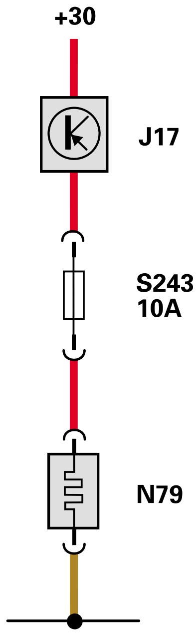
Task

The crankcase is fitted with a breather in order to equalise the pressure difference inside the crankcase.

The crankcase fills up all the way from the oil sump to the cylinder head cover. It fills up not only with oil vapour from the oil sump, but also with gases which escape from the combustion chamber by bypassing the piston rings.

The pumping movement of the pistons returns this mixture of gas and oil vapour to the intake manifold via the breather in the cylinder head cover.

To prevent the vapour from condensing and freezing when they enter the intake manifold during winter operation, there is an annular electrical heating resistor around the inlet.



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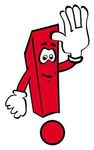
Action period

The heating resistor operates continuously when the ignition is "on".

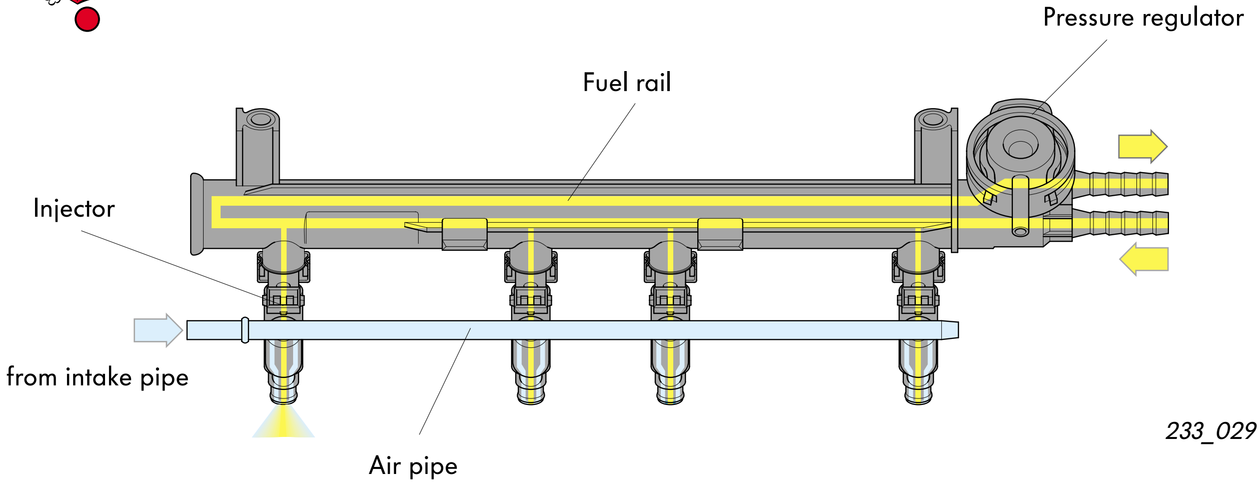
Electrical circuit

J17 Fuel pump relay
N79 Heating resistor (crankcase breather)

Injector with air shroud



The ATU engine has no air-shrouded injectors!



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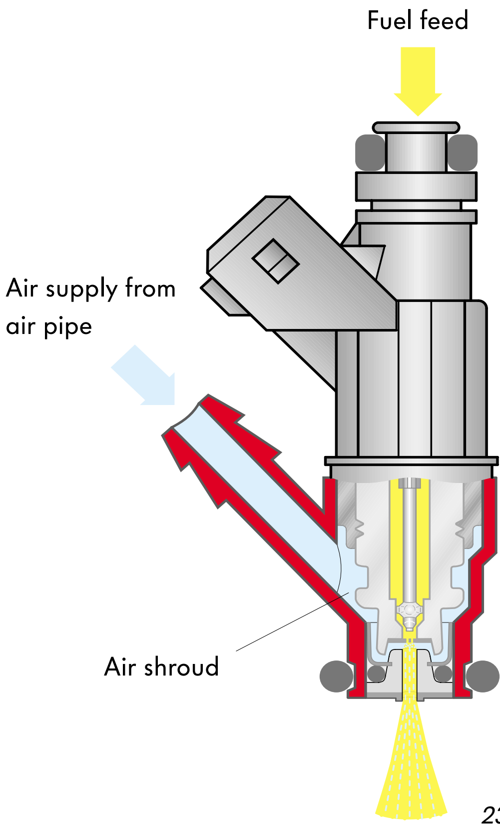
A single injector is assigned to each cylinder. The four injectors are inserted into the fuel rail at the top and into the engine intake manifold at the bottom.
Fuel flows through these injectors from top to bottom according to the so-called “top-feed” principle.

The injectors have an additional air shroud which improves mixture preparation.
An air pipe is connected to the intake pipe. Each injector is, in turn, connected to the air pipe.
The vacuum in the intake manifold draws air out of the intake pipe. This air is then fed to each individual injector along the air pipe.
The fuel and air molecules interact in such a way that the fuel is finely atomised.
The air shroud is mainly effective in the part-throttle mode of the engine.



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Advantages:

Combustion is improved.
Pollutant emissions in the exhaust gas are reduced.

Piston

Piston design

Lightweight aluminium pistons are used. They have a shortened, graphitised shaft and the bearings for the piston pins are offset inwards.

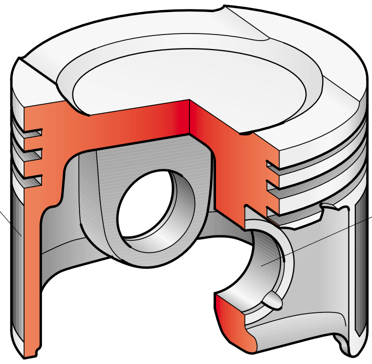
The piston is box shaped.

A shorter - and therefore lighter - piston pin can be used.

There is a recess in the base of the piston.

Over and above the advantages of lighter piston and piston pin construction, the piston has a relatively narrow slip face.

The piston shape necessitates a defined installation position. This position is marked by an arrow on the base of the piston (pointing towards belt pulley).



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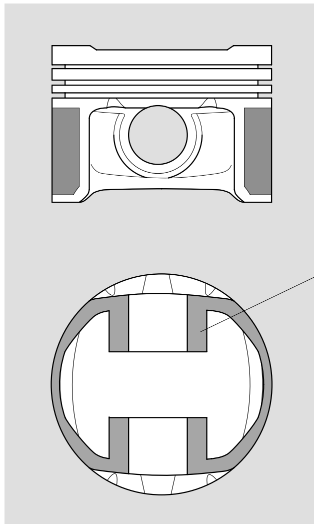

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Piston cooling

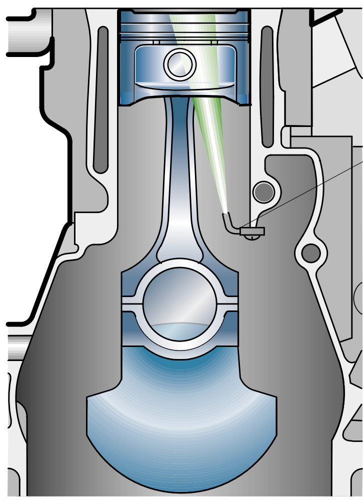
To cool the piston more rapidly, a small amount of the lubricating oil in the circuit is diverted to the piston.

For this purpose, each cylinder has an oil spray nozzle which is securely bolted to the cylinder block and supplied with oil directly from the oil pump via an oil duct.

The oil spray nozzle has a pressure relief valve which opens at a pressure of 0.25 to 0.32 MPa.

The lubricating oil is fed into the interior of the piston and cools the piston down.

The ATU engine has no oil spray nozzle for piston cooling.



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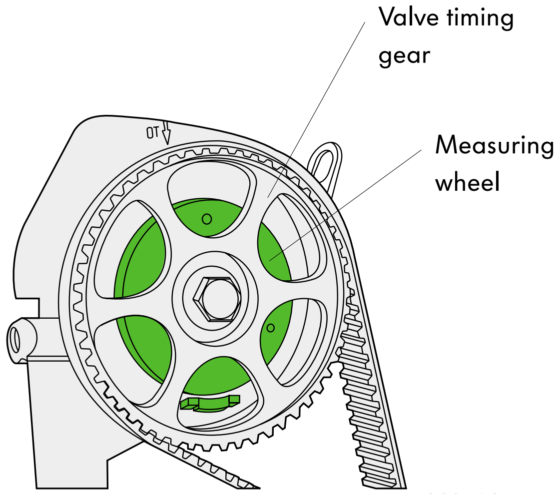
Hall sender G40

The Hall sender is located behind the valve timing gear.
The measuring wheel is secured to the back of the valve timing gear.



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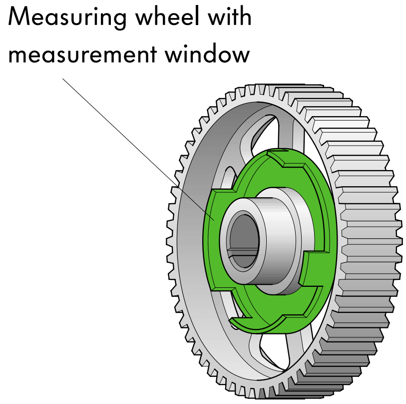
Signal utilisation

The position of the camshaft is determined via the signal from the Hall sender.
The Hall sender also acts as a quick-start sender.

Function and design

Two measuring windows on the measuring wheel are wide and two measurement windows are narrow. A characteristic signal pattern is generated for each 90° crankshaft rotation.
In this way, the engine control unit can determine the position of the camshaft and control the fuel injection and ignition sequences before the engine has completed half a revolution (quick-start sender).
Cold-starting is improved.
There is less exhaust emission during the cold start process.



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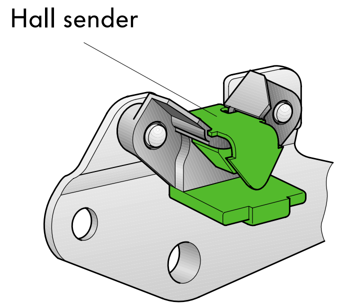
Substitute function and self-diagnosis

If the Hall sender fails, the engine continues to run and utilises a substitute signal for this purpose. The ignition advance angle is retarded as a safety precaution.
The sensor is tested during the self-diagnosis procedure.



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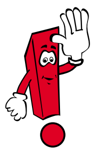
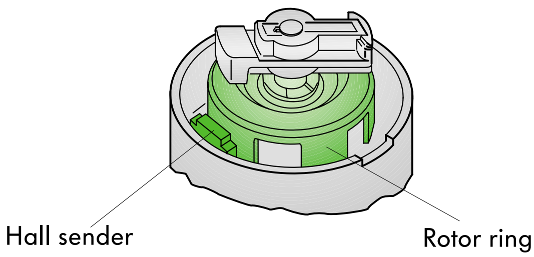


Important
The ATU engine has a rotating ignition distributor which is driven by means of the intermediate shaft.

The Hall sender and rotor ring are located in the distributor.



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PTFE oil seal

The crankshaft and camshaft oil seals are radial oil seals made of PTFE (**P**oly**t**etra**f**luoroethylene).

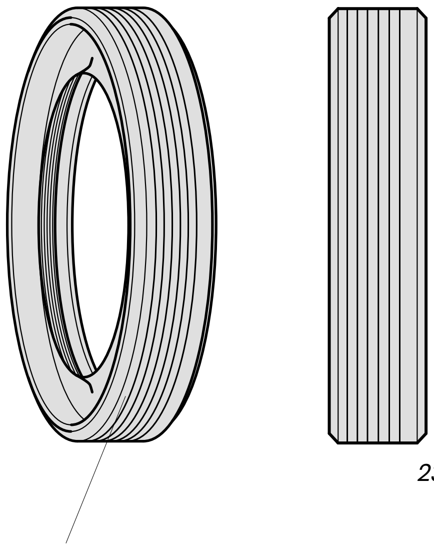
PTFE is also known under the name Teflon and is a type of heat resistant and non-wearing plastic.

These oil seals provide improved sealing from the inside and protect the engine against abrasion and dust from the exterior.

The sealing lip has a hydrodynamic recirculation feature.

Outer diameter ribs allow the oil seal to be fitted more securely in the crankcase.

The design and material require new auxiliary tools to reliably install this new seal generation, as well as different fitting characteristics.



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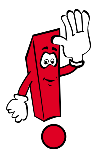
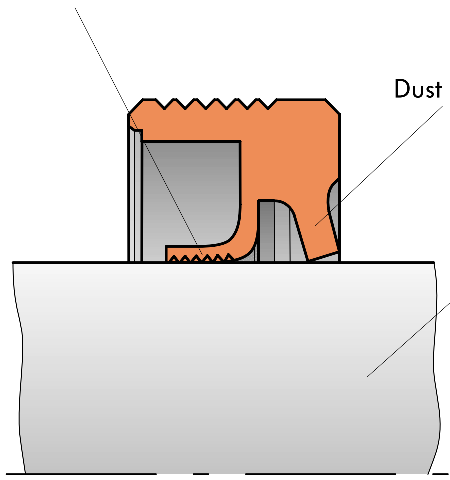


PTFE oil seals are dry fitted.
The sealing plugs of the crankshaft/camshaft must be grease free.
PTFE oil seals are always fitted in fixed directions (right and left rings).



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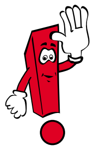
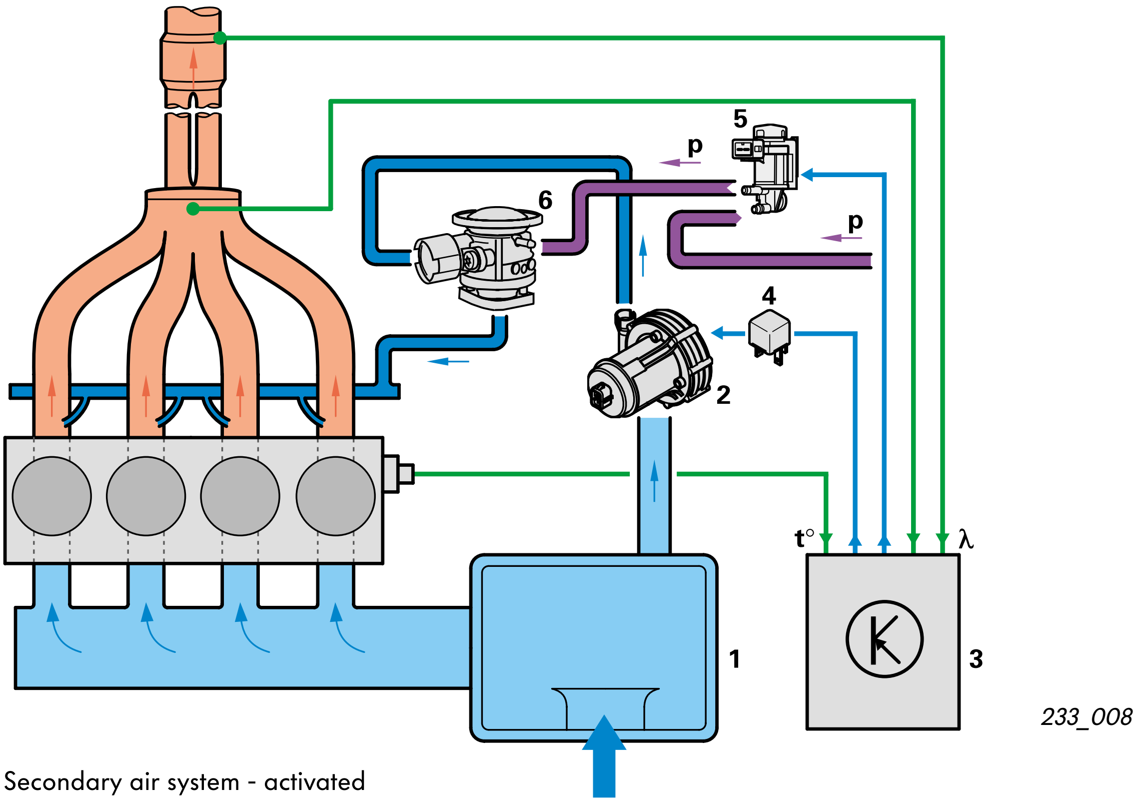
Please also refer to the detailed installation instructions given in the Workshop Manual for the 2.0-litre/85 kW Engine, Mechanicals.



The secondary air systems used in both engines are not identical. The secondary air control valve can only be found in ATU engine.

In the AQY engine, the combination valve is opened directly by the pressure exerted by the secondary air pump and closed off from the engine by a spring.



Secondary air system - activated

Starting situation

During the cold starting phase of an engine, the pollutant emissions (non-combusted hydrocarbons) are relatively high on account of the fact that the catalytic converter has not yet reached its operating temperature.

The secondary air system helps to reduce the pollutant emission during this phase.
The exhaust gas is enriched with oxygen through the injection of additional (secondary) air. The non-combusted exhaust gas constituents (carbon monoxide (CO) and hydrocarbons (HC)) are now thermally combusted.
Secondly, the catalytic converter reaches its operating temperature more quickly through the heat generated by secondary combustion.

System design

The secondary air pump -2- blows additional air from the air filter -1- directly behind the exhaust valves when the engine is started.

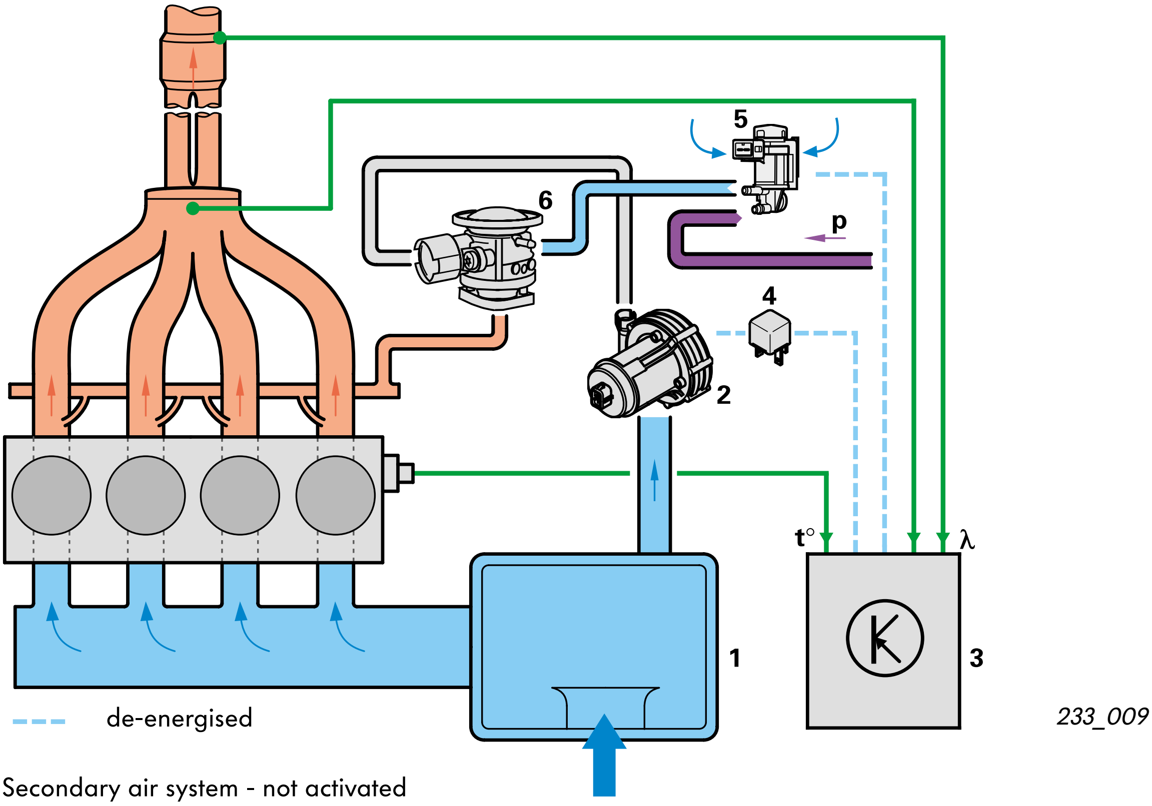
The system works on the basis of interaction between the following system components:

– Engine control unit -3-
– Secondary air pump relay -4-
– Secondary air pump -2-
– Secondary air control valve -5-
– Combination valve -6-

Input variables for the engine control unit are the coolant temperature -t°- and the lambda control -λ-.

Secondary air system

λL



Secondary air system - not activated

Functional description

The secondary air system is active in two operating states and for a limited period of time only:

– cold start
– in idling mode after warm start, for self-diagnosis

The secondary air system is activated by the engine control unit according to the prevailing operating conditions.

State	Coolant temperature	Period activated
Cold start	+5 to 33°C	100s
Warm start Idling	up to max. 96˚C	10s

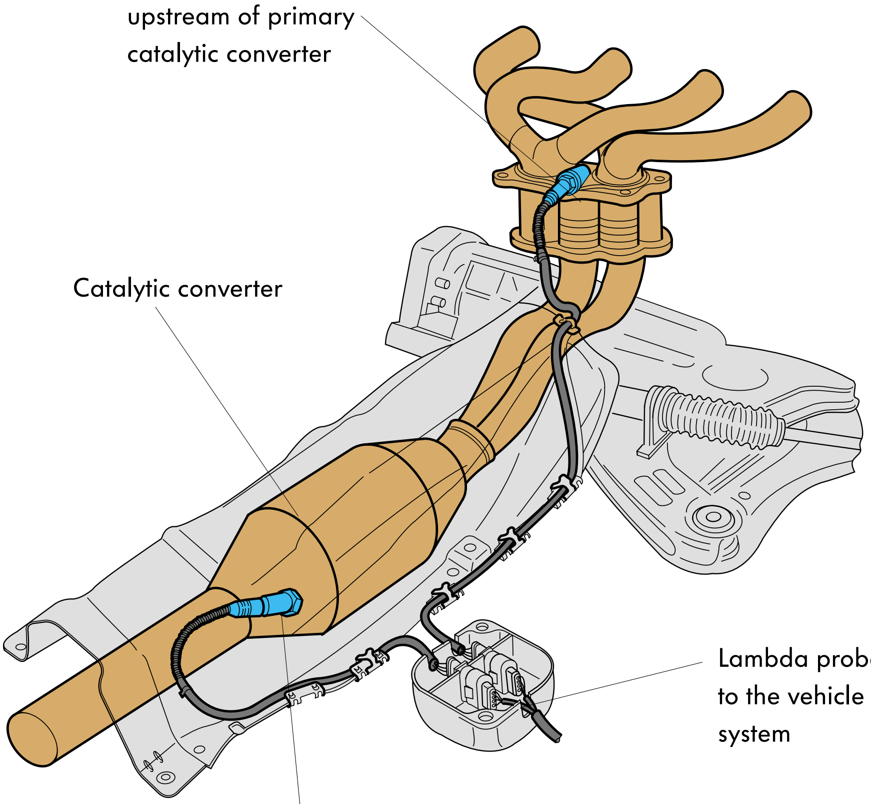
The secondary air pump receives its voltage via the secondary air pump relay. The engine control unit also activates the secondary air inlet valve via which the combination valve is actuated by means of partial pressure "p“.
The secondary air pump injects air downstream of the exhaust valves into the exhaust gas stream for a short period of time.

When the secondary air pump is inactive, the hot exhaust gases are also present at the combination valve. The combination valve seals the exhaust gases off from the secondary air pump.

During the activation procedure, the self-diagnosis checks the system.
The lambda control must be active during the self-diagnosis procedure because the increased oxygen content in the exhaust gas reduces the probe voltage.

When the secondary air system is intact, the lambda probes must register an extremely lean mixture.

Why is a second lambda probe necessary?



The position of the lambda probes in the exhaust system is very important for emission control as they are subjected to heavy soiling in the exhaust gas.

A probe located downstream of the catalytic converter is less prone to soiling.

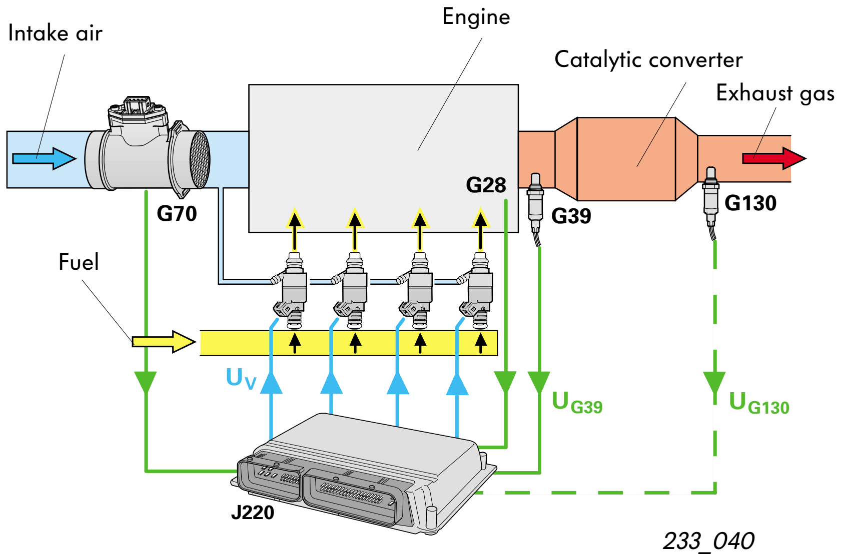
A lambda control system with only one probe downstream of the catalytic converter would be too slow because of the longer gas flow times.

However, the more stringent exhaust emission regulations require quick and precise lambda control.

A second lambda probe (with heating) therefore was installed in the exhaust system downstream of the catalytic converter (G130) in addition to the probe upstream of the catalytic converter (G39).
This probe serves to check for proper functioning of the catalytic converter. The probe upstream of catalytic converter (G39) is also adapted.

Emission control

G28 Engine speed sender
G39 Lambda probe upstream of catalytic converter
G70 Air-mass flow meter
G130 Lambda probe downstream of catalytic converter
U_{G39} Probe voltage, lambda probe upstream of catalytic converter
U_{G130} Probe voltage, lambda probe downstream of catalytic converter
U_V Control voltage, injectors



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The signals for air mass and engine speed are the basis for the injection signal (Uv).

The engine control unit calculates the additional injection time correction factor (increase/ decrease) for lambda control from the signal supplied by the lambda probe.

The lambda factor is regulated on the basis of continuous data interchange.

The lambda map is still stored in the control unit memory. This map specifies the various engine operating states.

Using a second closed control loop, the shift in the voltage curve corrected within a defined window (adaption) ensuring long-term stability of the mixture composition. The probe downstream of the catalytic converter has priority over the probe upstream of catalytic converter.

The 2nd probe simultaneously checks the degree of conversion (a measure of cleaning efficiency) of the catalytic converter.

The engine control unit compares the probe voltage U_{G39}/probe upstream of the catalytic converter and U_{G130}/probe downstream of the catalytic converter.

If the ratio deviates from the setpoint, this is registered as a catalytic converter malfunction and stored as a fault.

The voltage curves of both probes can be checked in the self-diagnosis.

Effects of malfunction

If the probe upstream of catalytic converter fails, lambda control is not performed. The adaption function is disabled.
Emergency operation via a map-based open control loop.
If the probe downstream of the catalytic converter fails, lambda control is still performed.
The function of the catalytic converter cannot be checked.

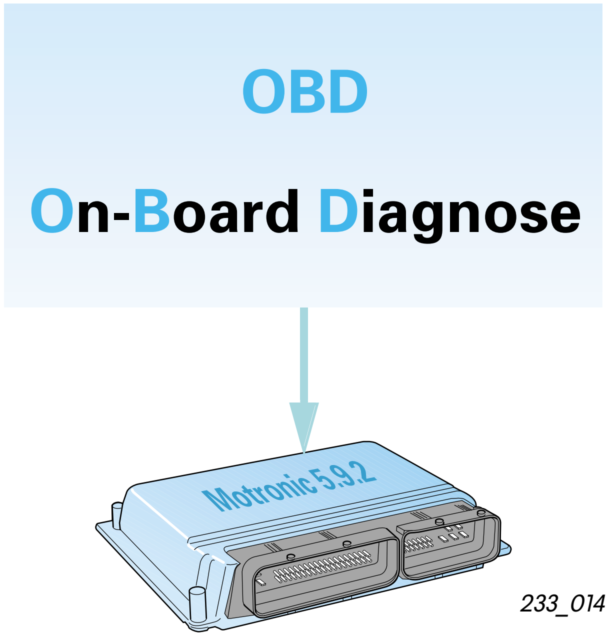
ODB II exhaust emission monitoring system

Malfunctions and defective components in the engine management system can lead to a dramatic increase in pollutant emissions.

The OBD was introduced in order to avoid this. The OBD is a diagnostic system which is integrated in the vehicle's engine management system and continuously monitors the exhaust emission levels.

The Motronic 5.9.2 of both 2.0-litre engines meets these requirements.

The driver is informed about non-conforming exhaust emission levels by a warning lamp (exhaust gas warning lamp K83) only in vehicles with the AQY engine in combination with a manual gearbox.



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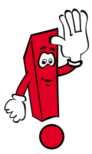
Electrical circuit

The warning lamp is integrated in the dash panel insert, directly connected to the engine control unit and registered by the fault memory.

Like all warning lamps, the exhaust gas warning lamp lights up for several seconds when the ignition is turned on.

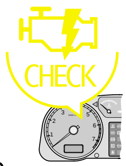
If it does not go out after starting the engine or lights up or flashes while travelling, there is a fault in the engine electronics or certain exhaust emissions are too high.

For the customer, this is a sign to take the vehicle to a service workshop.



See also SSP 175.

- Lamp flashing:
  There is a fault which can damage the catalytic converter in this vehicle operating state. The vehicle may still be operated, but only using less power.



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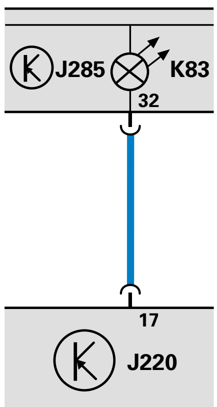
- Lamp lit continuously:
  There is a fault which adversely affects emission levels.



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System overview

Motronic 5.9.2

The new Motronic 5.9.2 implements technical improvements for starting of the engine, lower fuel consumption and exhaust emission control.

It meets the requirements of OBD II. Pollutant emissions are checked continuously. Diagnoses relevant to exhaust emissions are displayed using the readiness code.

Engine speed sender G28

Hall sender G40

Hall sender G40 in the distributor

Hot film
air mass meter G70 and
intake air temperature sender G42

Air-mass flow meter G70

Intake manifold temperature sensor G72

Throttle valve control unit J338 with
idling speed switch F60
Throttle valve potentiometer G69
Throttle valve positioner
potentiometer G88

Lambda probe G39

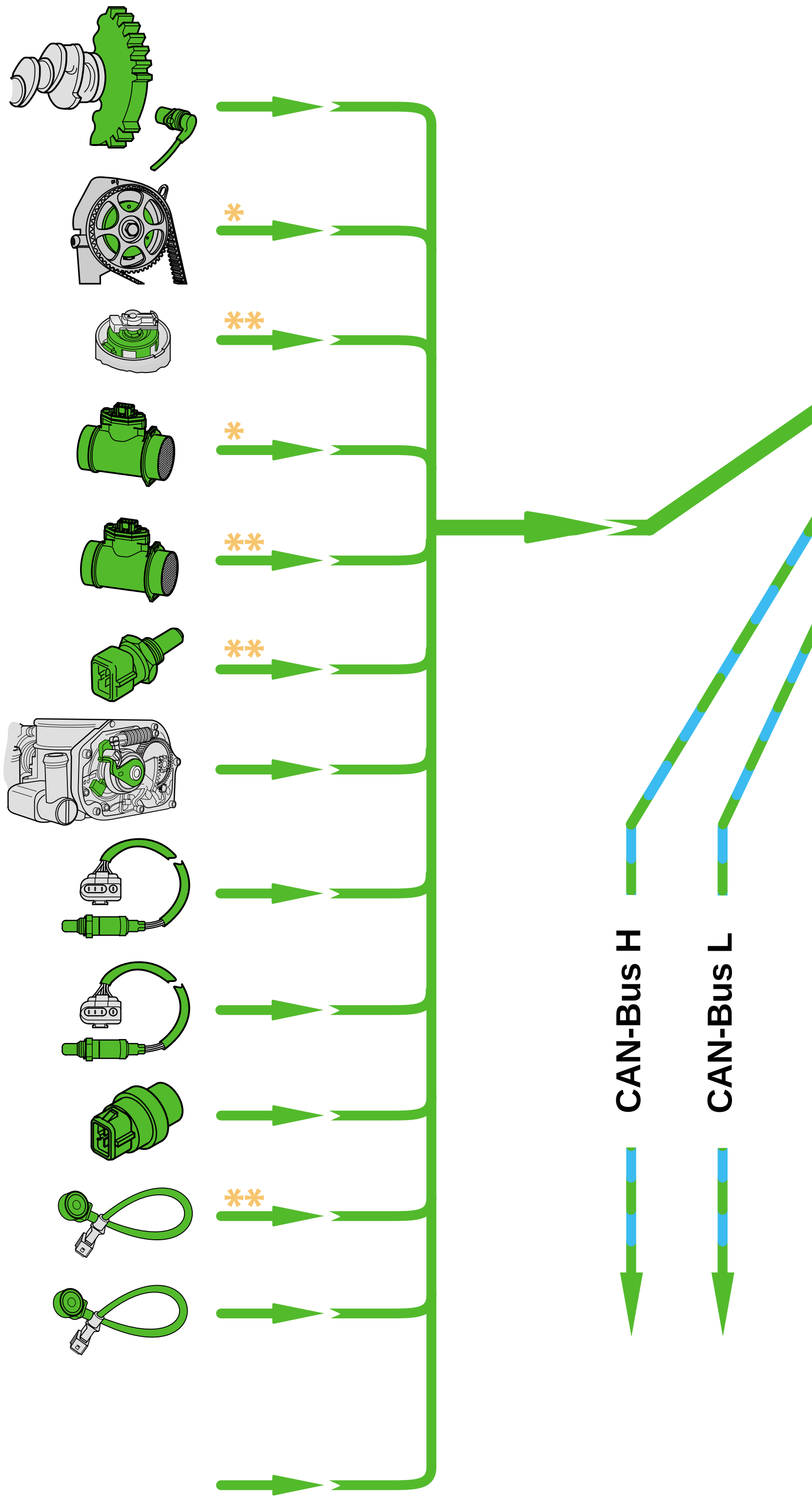
Lambda probe downstream of catalytic converter G130

Coolant temperature sender G62

Knock sensor I G61

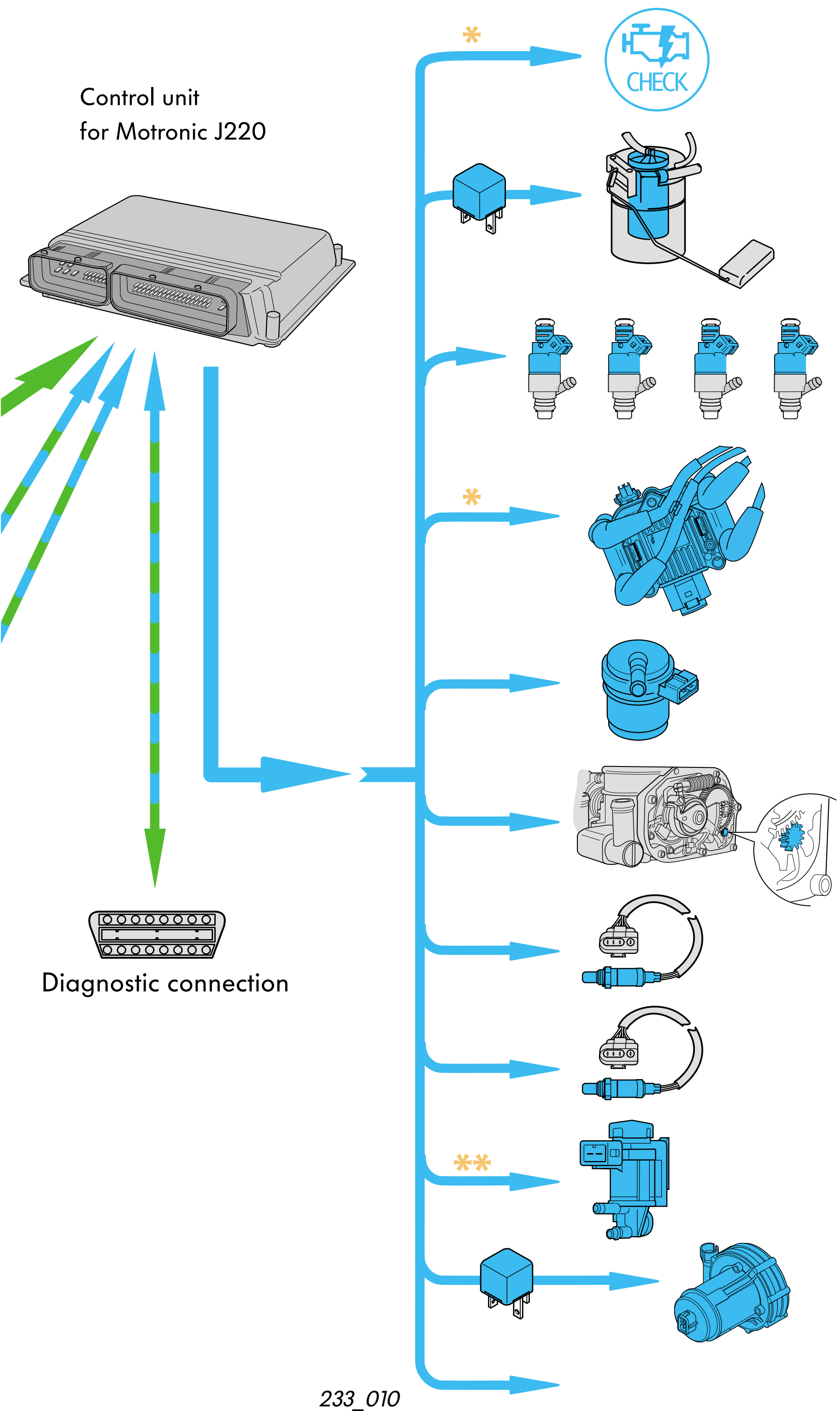
Knock sensor II G66

Auxiliary signals:
air conditioner compressor On
A/C ready
Road speed signal



In the Motronic 5.9.2 systems used the both engines, several components are different.
Differences:
* AQY only
** ATU only

See also table with heading "Differences and Common Features“



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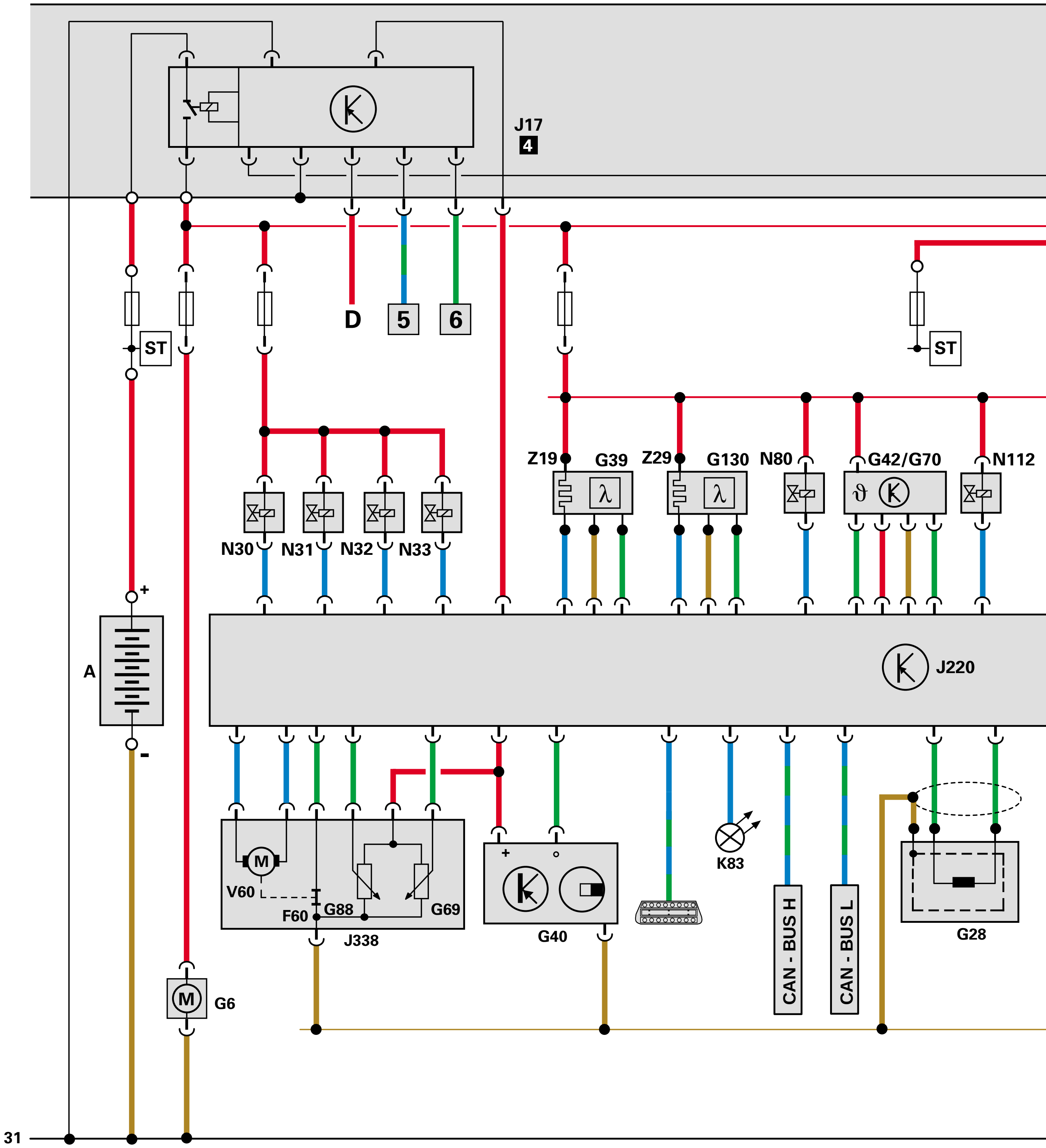
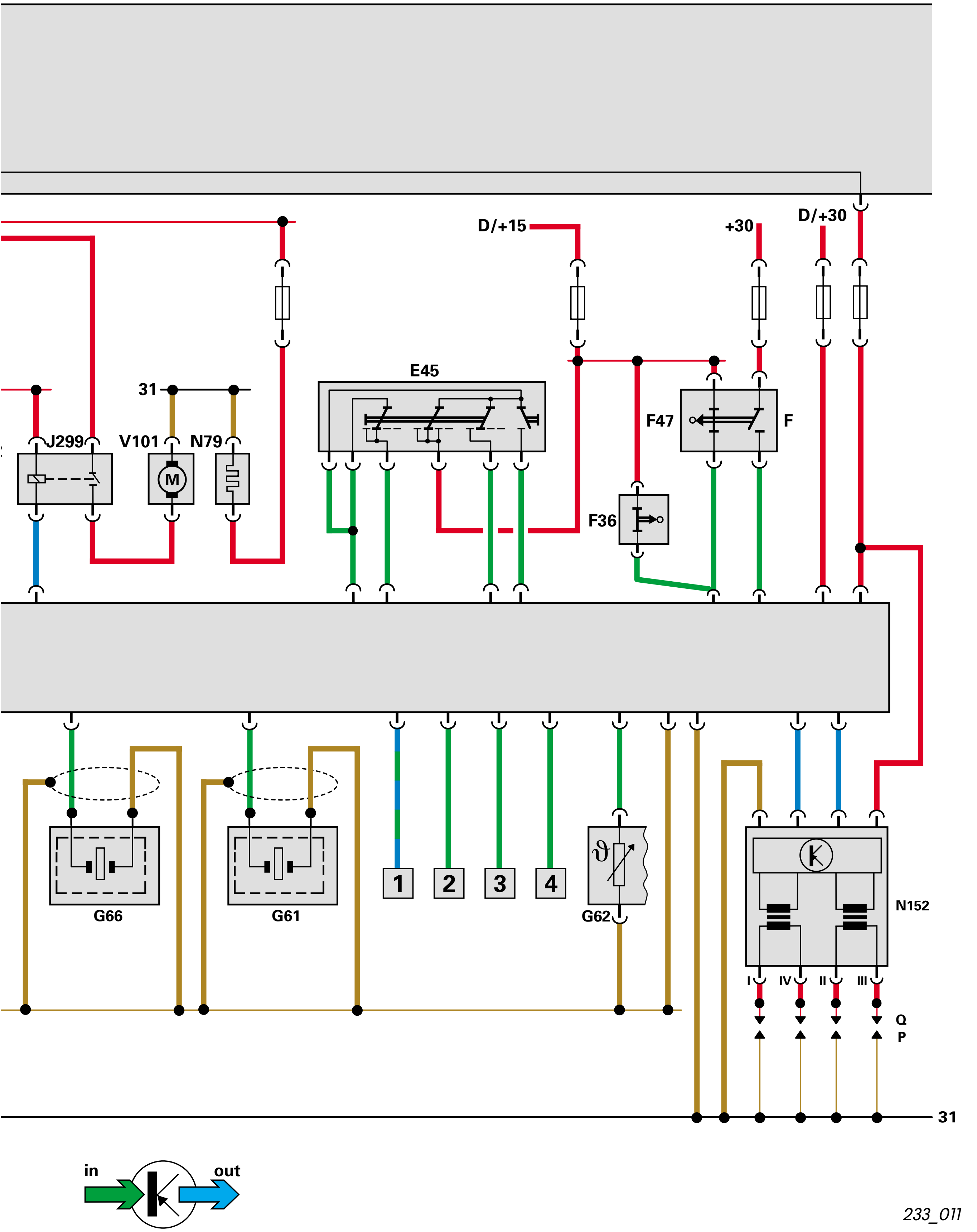
Function diagram

Engine AQY



Please refer to Page 33 for a legend of the function diagram.

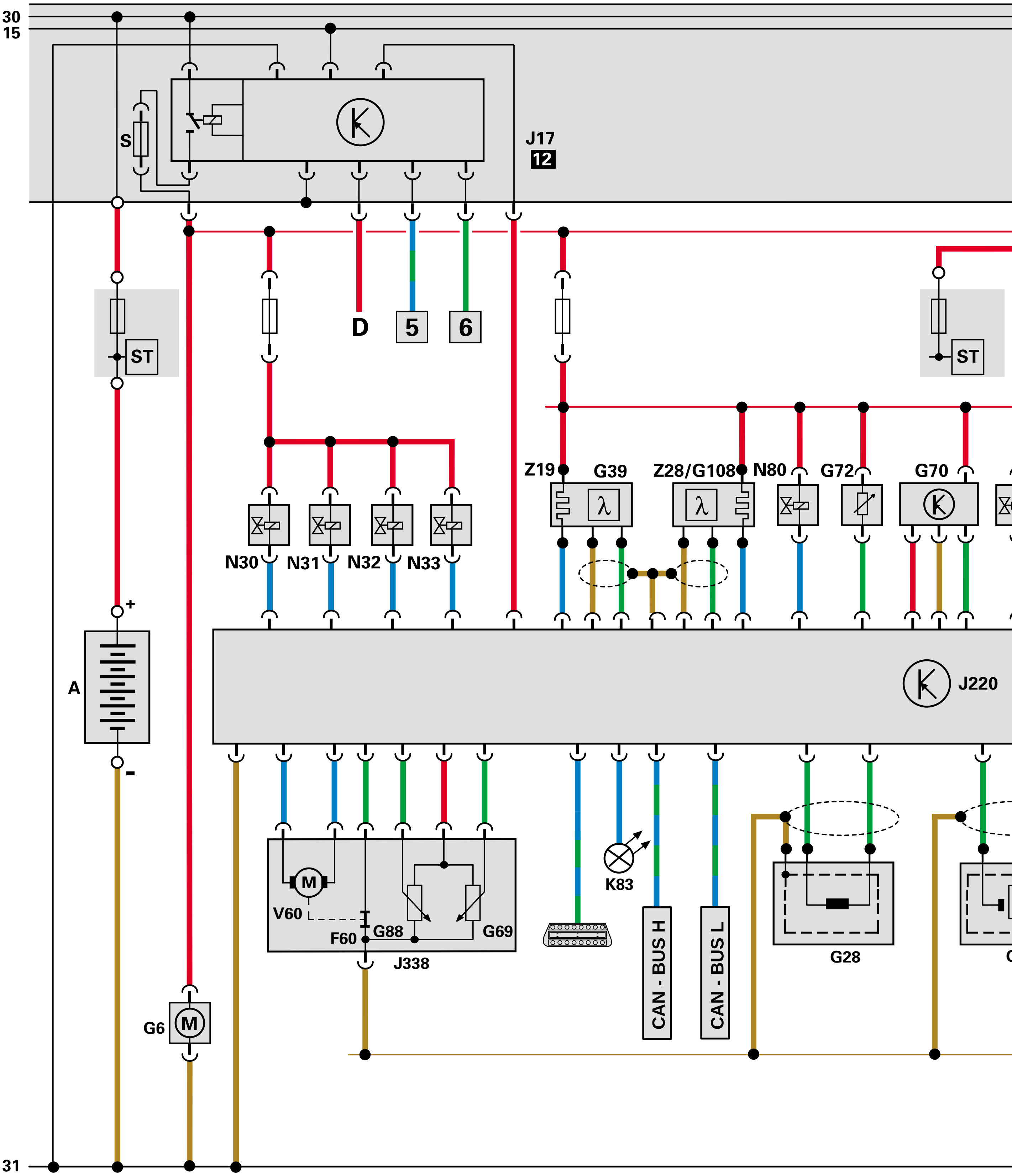


D/+15
+30
D/+30
E45
31
J299
V101
N79
F47
F
F36
1
2
3
4
G66
G61
G62
N152
I
IV
II
III
Q
P
31
in
out

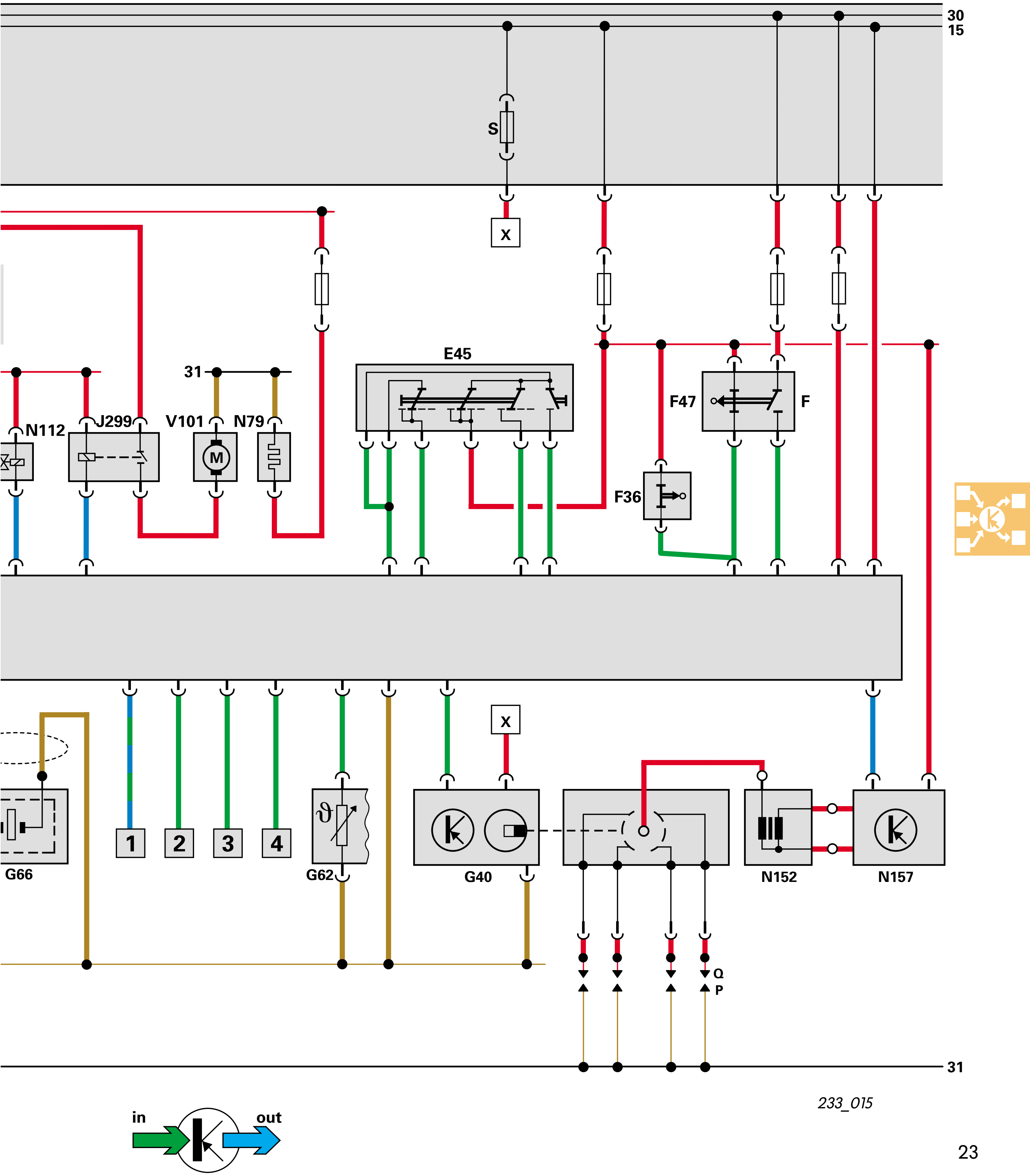
233_011

Function diagram

Engine ATU



Please refer to Page 33 for a legend of the function diagram.


30
15
S
X
E45
F47
F
F36
31
N112
J299
V101
N79
1
2
3
4
G66
G62
G40
N152
N157
Q
P
in
out
233_015