284

Service.

6-speed automatic gearbox 09E in the Audi A8 '03 - Part 2

Self Study Programme 284

For internal use only

Contents

Part 1 SSP 283

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The Self Study Programme contains information on design features and functions.

The Self Study Programme is not intended as a Workshop Manual.
Values given are only intended to help explain the subject matter and relate to the software version applicable when the SSP was compiled.

Use should always be made of the latest technical publications when performing maintenance and repair work.

New Note

Attention Note

Part 2 SSP 284

Page

Gearbox Control

Service

Mechatronik

A particularly noteworthy new feature of the 09E is the so-called "Mechatronik". This combines the hydraulic control system (hydraulics module), the electronic control unit and the sensors (electronics module) in one coordinated assembly. The Mechatronik is located in the gearbox in the vicinity of the sump.

Manufacturing tolerances of the hydraulics module (valves and pressure regulator) as well as of the output stages of the electronic control unit are established on a test bench and compensation is provided by way of the electronic control unit basic programming.

There is no provision for basic programming as part of service work and the Mechatronik can therefore only be replaced as a complete unit.

View from below

284_007

View from above

284_112

Mechatronik

The term "Mechatronik" covers all components responsible for
Detection of input signals required for gearbox control
Evaluation of input signals
Implementation of control and regulation algorithms
Actuation of control elements
Communication with periphery and establishment of electrical and mechanical link with signal generators and control elements

Advantages of Mechatronik:

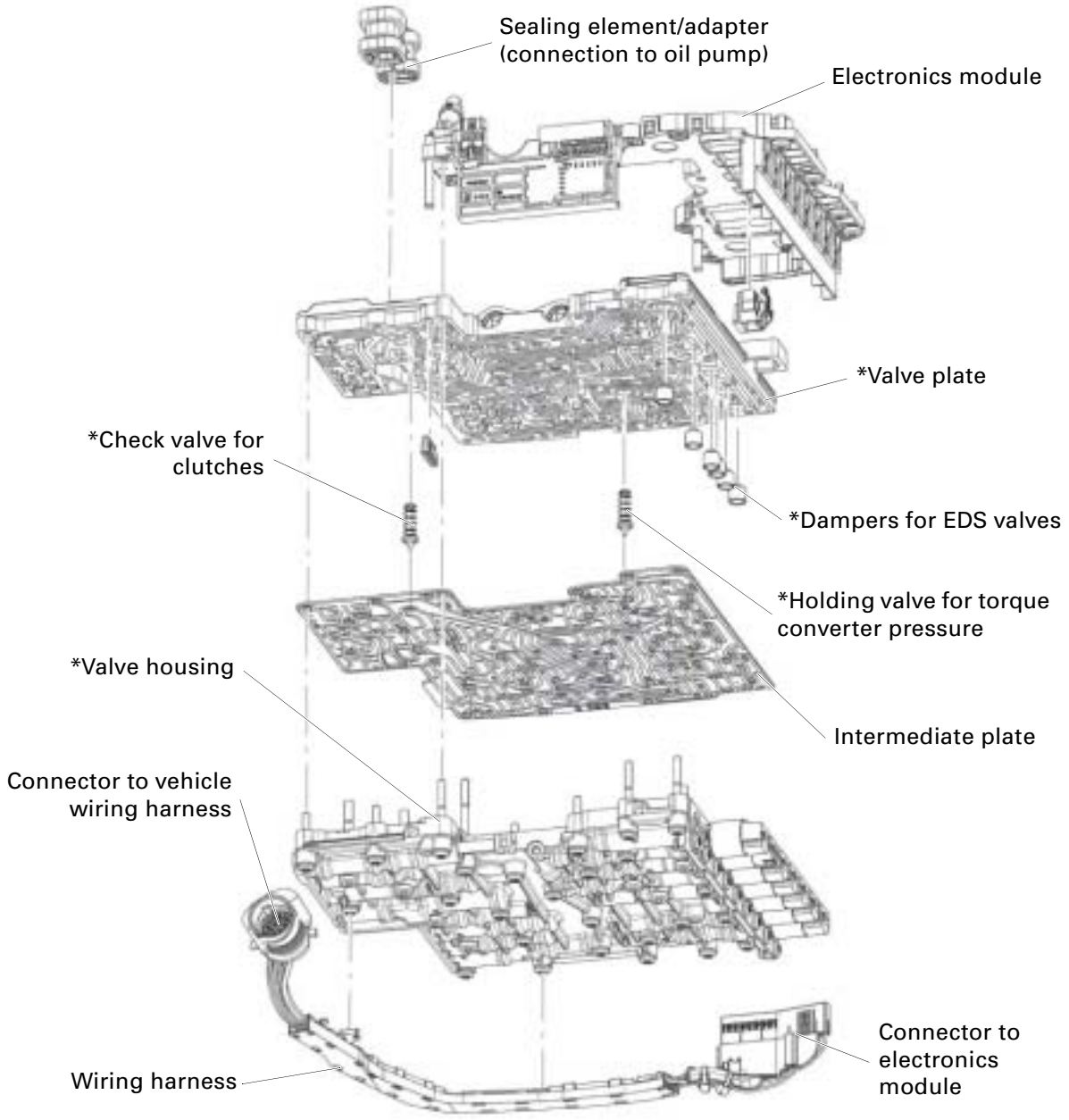
Less space required thanks to compact design.

Low-cost manufacture due to integration of components and compensation for the manufacturing tolerances of hydraulic components by appropriate programming of electronic control unit following assembly.

Lower weight due to reduction in number of pipes and housing components.

Increased reliability thanks to great reduction in number of interfaces (contacts).

Mechatronik can be calibrated and checked as one unit, thus ensuring a constant, previously unsurpassed gearshift quality.



*Hydraulics module

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Electrostatic discharge ESD

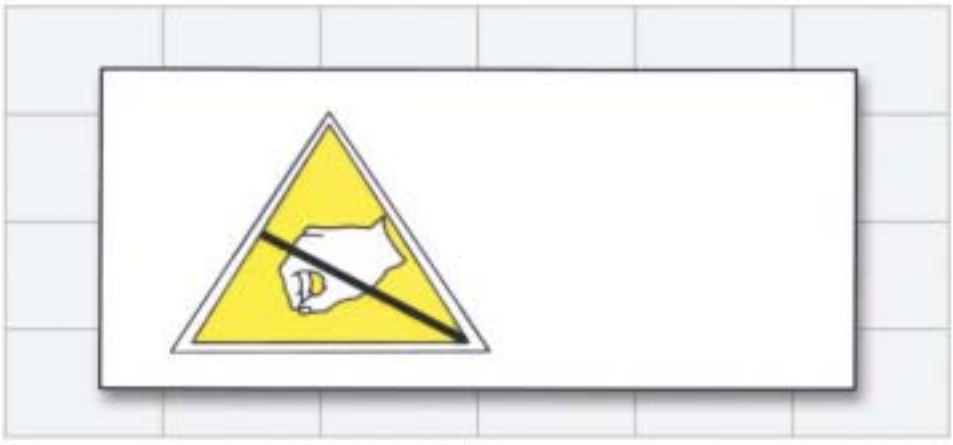
Particular attention must be paid to ESD protection on account of the use of microelectronics and the fact that some of the electronics module interfaces are open.

Before handling the Mechatronik (e.g. storage, transportation or repair), take care to discharge static by touching an earthed object or the vehicle earth when working on the vehicle.

Never touch the plug contacts of the electronics module connector.
The same applies to the contacts of the test adapter, e.g. when performing electrical checking.

The protective cap at the electronics module connector is only to be removed immediately prior to connection of the vehicle wiring harness so as to avoid unintentional touching of contacts.

The Mechatronik is always to be stored and transported in its genuine replacement part packaging. Do not remove the Mechatronik from its packaging before discharging static by touching an earthed object (e.g. water pipe, lifting platform ...).



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This symbol always indicates the presence of components or assemblies in the vicinity which are susceptible to electrostatic charging.

The applicable safety precautions are therefore always to be heeded.

Description of valves

Dr.Red.V	Pressure reduction valve	The pressure reduction valve regulates the system pressure to approx. 5 bar. This pressure (pilot pressure) is used to supply the electrically switched solenoid valves, as these require a constant pilot pressure to function accurately.
HV-A HV-B HV-D1 HV-D2 HV-E	Holding valve/Clutch A Holding valve/Clutch B Holding valve/Brake D1 Holding valve/Brake D2 Holding valve/Clutch E	The holding valves switch the clutch valves, i.e. the control function (control phase) of the clutch valve during the gearshift operation is deactivated by the holding valve at the appropriate time, thus causing the clutch pressure to increase to system pressure. Both valves (clutch and holding valves) are regulated by the corresponding pressure control valve.
KV-A KV-B KV-C KV-D1 KV-D2 KV-E	Clutch valve/ Clutch A Clutch valve/ Clutch B Clutch valve/ BrakeC Clutch valve/ Brake D1 Clutch valve/ Brake D2 Clutch valve/ Clutch E	The clutch valves are variable pressure reduction valves. They are regulated by the corresponding electronic pressure control valve and determine the clutch pressure during the gearshift operation.
Sch.V	Lubrication valve	The lubrication valve reduces and safeguards the pressure required for lubrication. It also provides an upper pressure limit.

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SV1	Selector valve 1	The function of SV1 is to maintain the current gear setting in the event of power failure whilst driving. A specific gear is accordingly selected for starting and mechanical emergency operation (solenoid valves deenergised). SV1 has a self-holding function which is cancelled on starting and re-activated by the electronic control unit.
SV2	Selector valve 2	SV2 routes the system pressure to the corresponding clutch/brake controls. It is regulated by solenoid valve N88.
SPV	Compensation valve	The SPV is located in parallel to the control circuit of N88. N88 is a so-called "ON-OFF valve" which implements the corresponding setting at high speed. The function of the SPV is to cushion the increase/decrease in control pressure and provide smooth gearshift operations.
Sys. Dr.V	System pressure valve	The system pressure valve is a variable pressure limiting valve which regulates the oil pressure generated by the oil pump. It is actuated by N233.
WDV	Torque converter pressure valve	The torque converter pressure valve reduces the system pressure and maintains the pressure required for torque converter flow and for the torque converter clutch. It also provides an upper limit for the torque converter pressure to prevent operating problems. Corresponding actuation of N371 vents the oil duct to the torque converter clutch chamber.
WKV	Torque converter clutch valve	The torque converter clutch valve is actuated together with the torque converter pressure valve by N371. This function involves reversal of the oil flow direction. The torque converter pressure valve (WDV) vents the torque converter clutch chamber, while the WKV applies torque converter pressure to the turbine chamber.
WS	Selector slide	The selector slide is actuated mechanically by the selector lever via a cable, directs the oil pressure for forward and reverse travel and provides the neutral positions.

284_080

Gearbox Control

Solenoid pressure control valves EDS 1-6
(N215, N216, N217, N218, N233 and N371)

The EDS convert an electrical control current into a proportional hydraulic control pressure.

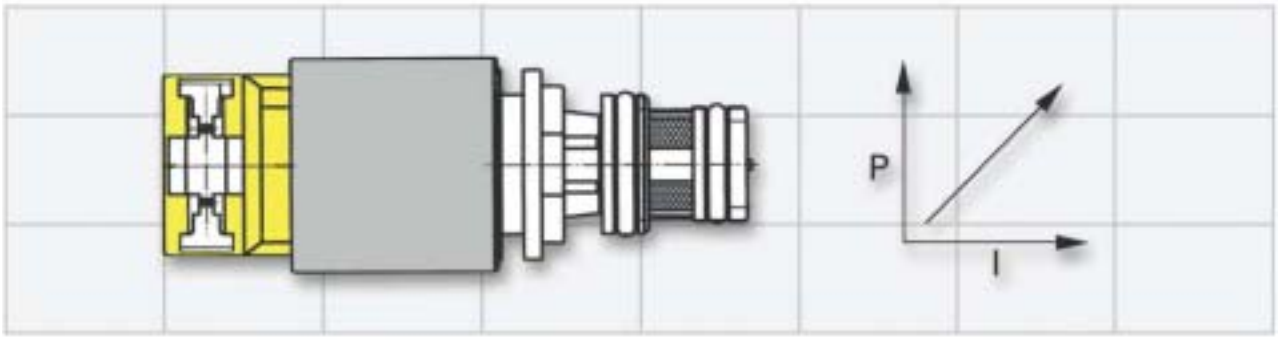
They are actuated by the automatic gearbox control unit J217 and operate the valves assigned to the selector elements.

Two different types are fitted:

EDS 1, 3 and 6 have a rising characteristic. In other words, the control pressure increases with increasing control current.
Deenergised = no control pressure
(0 mA = 0 bar)

EDS 2, 4 and 5 have a falling characteristic. In other words, the control pressure decreases with increasing control current.
Deenergised = maximum control pressure

EDS valves with rising characteristic



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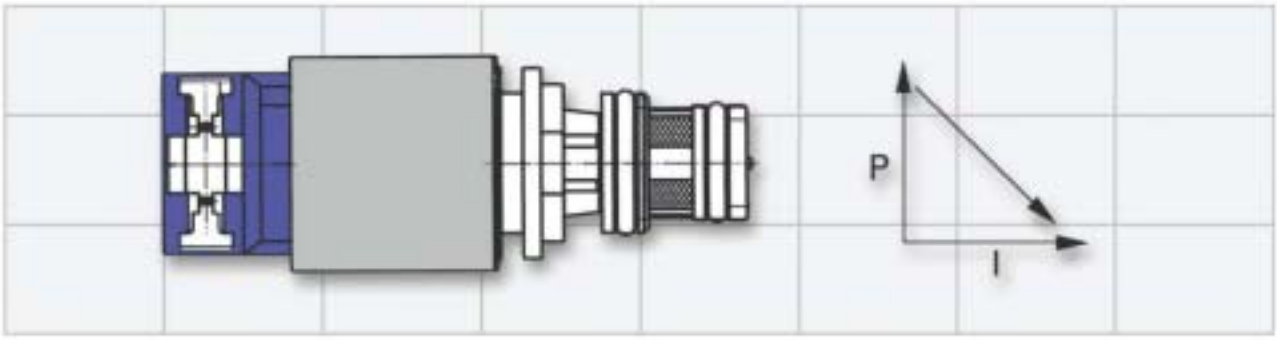
N215 (EDS1) Clutch A
N217 (EDS3) Brake C
N371 (EDS6) Torque converter clutch

P = Pressure
I = Current

EDS valves with falling characteristic



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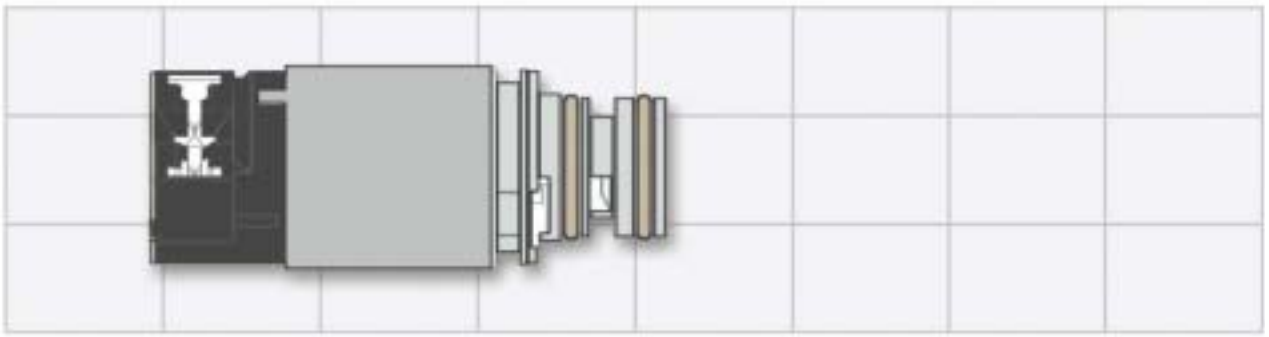
N216 (EDS2) Clutch B
N218 (EDS4) Brake D and clutch E
N233 (EDS5) System pressure

P = Pressure
I = Current

Solenoid valve MV1 (N88)

N88 is an electrically switched solenoid valve of the so-called 3/2 type, i.e. 3 connections and 2 switch positions (open/closed or on/off).

It is actuated by the automatic gearbox control unit J217 and its function is to provide corresponding hydraulic valve switching.



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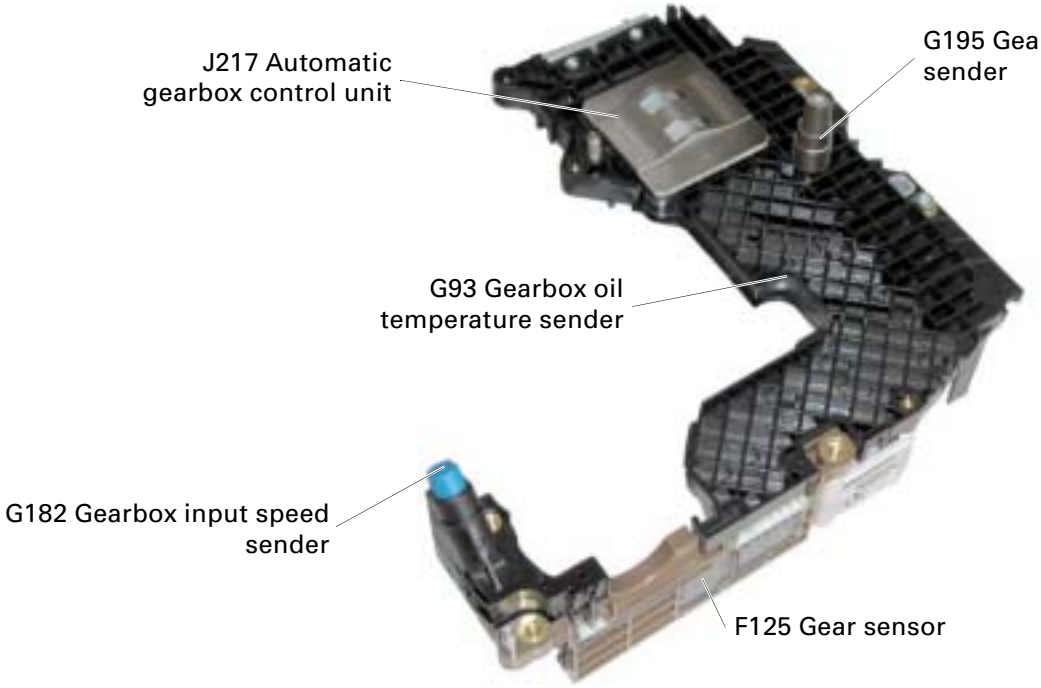
Electronics module

The electronics module combines the electronic control unit and sensors in one non-separable unit.



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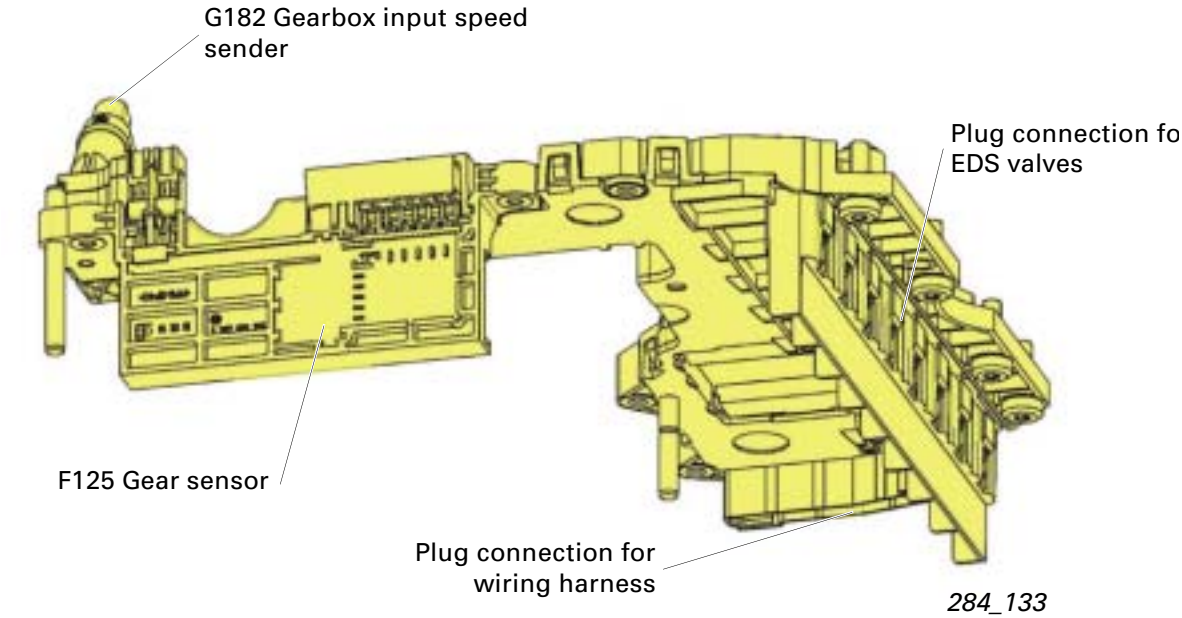
The electronics module cannot be replaced separately. The entire Mechatronik assembly has to be replaced in the event of a component fault.



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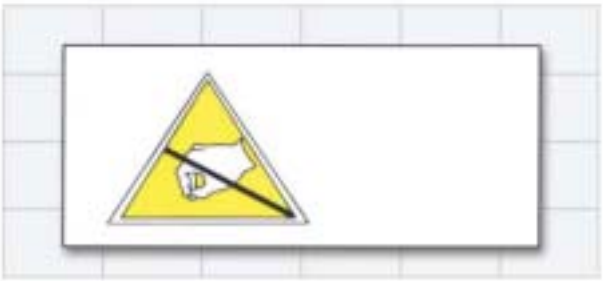
Electrostatic discharge ESD

Particular attention must be paid to ESD protection on account of the use of microelectronics and the fact that some of the electronics module interfaces are open. Refer to description and notes on Page 6.



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Automatic gearbox control unit J217

The electronic control unit is of the LTCC (low temperature cofiring ceramic) type and located in a hermetically sealed metal housing. The defined heat dissipation of the electronics is achieved via the ATF.

The extremely compact design of the control unit makes it suitable for integration into the Mechatronik and installation in the gearbox.

Temperature monitoring

The fact that the electronics are integrated into the gearbox (surrounded by ATF) means that greater significance is now attached to monitoring of the control unit temperature and thus also the gear oil temperature.

High temperatures have a crucial influence on the service life and proper functioning of electronic components.

Temperatures above 120°C have a detrimental effect on the service life of the electronic control unit components. As of 150°C, component damage and thus malfunctioning of the entire system can no longer be ruled out.

A so-called substrate temperature sensor is integrated into the substrate of the semiconductor components to record the temperature of the microprocessor (main computer of J217) as accurately as possible.

Explanatory note:
The term "substrate" refers to the ceramic base of the semiconductor components/ microprocessor. The substrate temperature sensor is situated directly in the substrate next to the microprocessor and records its temperature at the exact location.

Gearbox Control

Measures are taken to prevent overheating on exceeding defined temperature threshold values (hot mode).

There are 3 hot mode stages:

1st stage >124°C substrate temp. (126°C G93)

In conjunction with the DSP function the shift points are moved to higher engine speeds. The operating range in which the torque converter clutch is closed is extended.

For more details refer to Section on DSP, Page 36.

2nd stage >139°C substrate temp. (141°C G93)

The engine torque is significantly reduced (statically, up to 60 %) as a function of the further increase in temperature.

3rd stage >141°C substrate temp. (147°C G93)

The solenoid valve power supply is deactivated to prevent overheating of the control unit (malfunction, component damage). The gearbox switches to mechanical emergency running mode (refer to Page 34).
Fault "17018 Temperature-related control unit deactivation" is set in the fault memory.

In addition to accurate recording of component temperature, the substrate temperature sensor is used for diagnosis evaluation (plausibility checking) of the gearbox oil temperature sender G93 and provides a substitute value in the event of G93 failure.

All temperature data are referenced to the software version 0050 applicable at the time of compilation of the SSP. The temperature data may differ for other software versions.

Monitoring of oil temperature population

By way of G93, the automatic gearbox control unit J217 regularly checks the current gearbox temperature range. These values are stored. Corresponding evaluation provides a long-term record of the gearbox thermal load.

The service life (ageing) of the ATF is highly temperature-dependent. Sustained high ATF temperatures considerably accelerate the ATF ageing process.

Gearbox damage caused by prematurely aged (used) ATF can thus be prevented by changing the ATF.

If the oil temperature population reaches a defined count, the fault "18167 Multiple gear oil temperature overshoot" is set.

If this fault is detected during service work, the ATF and ATF filter are to be replaced. Precise details are given in the "assisted fault-finding" routine and the appropriate Workshop Manual.

Explanatory note:
The term "population" refers to any group of measured values or counter data permitting statistical analysis by means of weighting and corresponding evaluation.

New control unit generation

A higher performance control unit is to be introduced in the first quarter of 2003 in the course of further development.

This will extend the range of functions to include:

– Engine torque increase on change-down

– Introduction of variant encoding

This will further include extension of certain software functions such as the DSP.

Further details of the new control unit generation cannot be given at present as the exact definition of the functions had not yet been finalised at the time of compilation of the SSP.

Description of sensors

The speed sensors and gear sensor are designed to operate on the Hall principle. Such sensors are not susceptible to mechanical wear and their signals are not affected by electromagnetic influences, thus enhancing reliability.

The sensors G93, G182, G195, F125 form part of the electronics module. This cannot be replaced separately. The entire Mechatronik assembly has to be replaced in the event of a component fault.
For more details on the mode of operation of Hall-type speed sensors refer to SSP 268, Page 34 onwards.

Gearbox Control

Gearbox input speed sender G182

Due to the torque converter slip, the gearbox input speed does not correspond to engine speed (except when the torque converter clutch is completely closed).

The electronic gearbox control system requires the exact gearbox input speed (also referred to as turbine speed) for the following functions:

- Control and monitoring of gearshift operations
- Control of torque converter lock-up clutch
- Control of stationary vehicle decoupling
- Selector element diagnosis and plausibility checking of engine speed and gearbox output speed

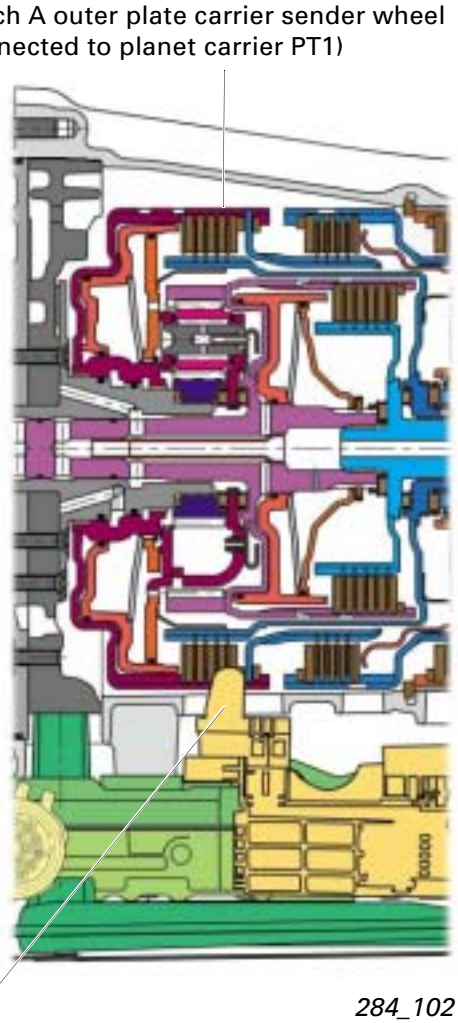
The gearbox input speed sender G182 records the speed at the outer plate carrier of clutch A, which is connected to the planet carrier P1.

The planet carrier P1 always rotates at the same ratio with respect to the turbine shaft (1 : 0.657). The speed of the planet carrier P1 can therefore be used to calculate the turbine speed (gearbox input speed).

Safety/substitute function in the event of failure:

- 4th gear electrical emergency program
- Pressure-modulated, controlled gear engagement
- Deactivation of stationary vehicle decoupling
- Opening of torque converter clutch
- Deactivation of sports program "S"
- Deactivation of tiptronic function

Fault display: Yes



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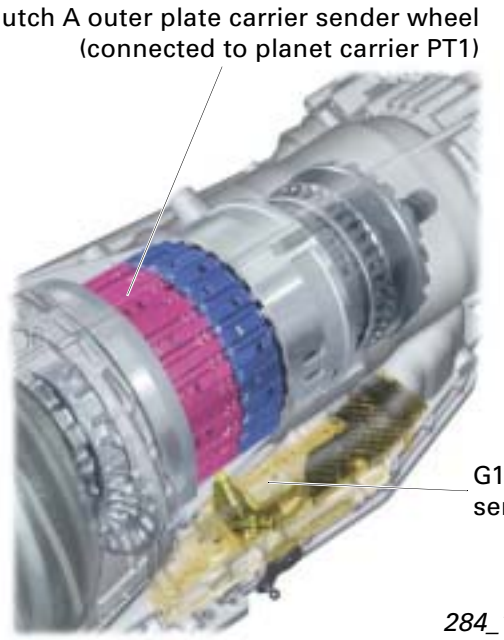

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Gearbox output speed sender G195

The gearbox output speed is one of the most important electronic gearbox control signals. The gearbox output speed, with its defined ratio in relation to vehicle speed, is required for the following functions:

- Selection of shift points
- DSP functions (e.g. driving situation assessment)
- Control of stationary vehicle decoupling (refer to Page 30)
- Selector element diagnosis and plausibility checking of engine speed and gearbox input speed

The gearbox output speed sender G195 records the speed at the ring gear H2 of the secondary planetary gear train.

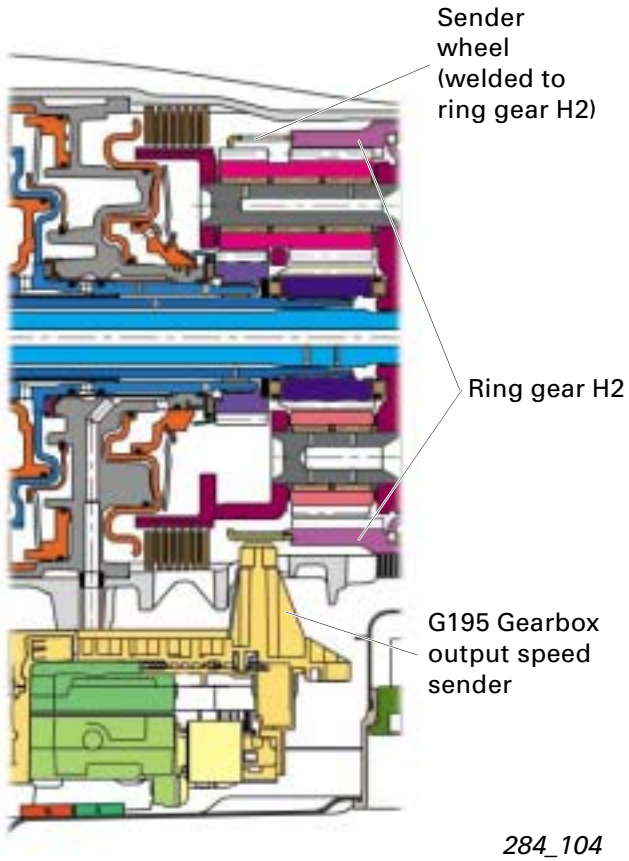
The ring gear is connected to the output shaft and there is thus a defined ratio between ring gear and vehicle speed.

Safety/substitute function in the event of failure:

The current gear/target gear is retained.
An output speed is derived from the speed of all 4 wheels.

Fault display: Yes

284_105



284_104

Gearbox Control

tiptronic switch F189

The tiptronic switch F189 is integrated into the printed circuit board of the selector lever gate. It consists of three Hall sensors actuated by the permanent magnets on the masking panel.

F189 generates a square-wave signal with a fixed frequency at pins 6, 7 and 8 of the selector mechanism. In the corresponding switch setting, the voltage level is changed/ switched to positive or negative.

Magnet 2 is used for continuous tiptronic switch F189 diagnosis in selector lever positions D and S.

The need for this additional safety function arose from the fact that the gearbox no longer features selector lever positions 4, 3 and 2. With the new selector lever gate, prevention of change-up must be selected if required using the tiptronic function (by shifting selector lever to "tip" gate).

To safeguard this function, any problems with F189 operation are now indicated to the driver even without prior tiptronic actuation.

284_009

Safety/substitute function in the event of failure:

– Deactivation of sports program "S"
– Deactivation of tiptronic function (refer to note)

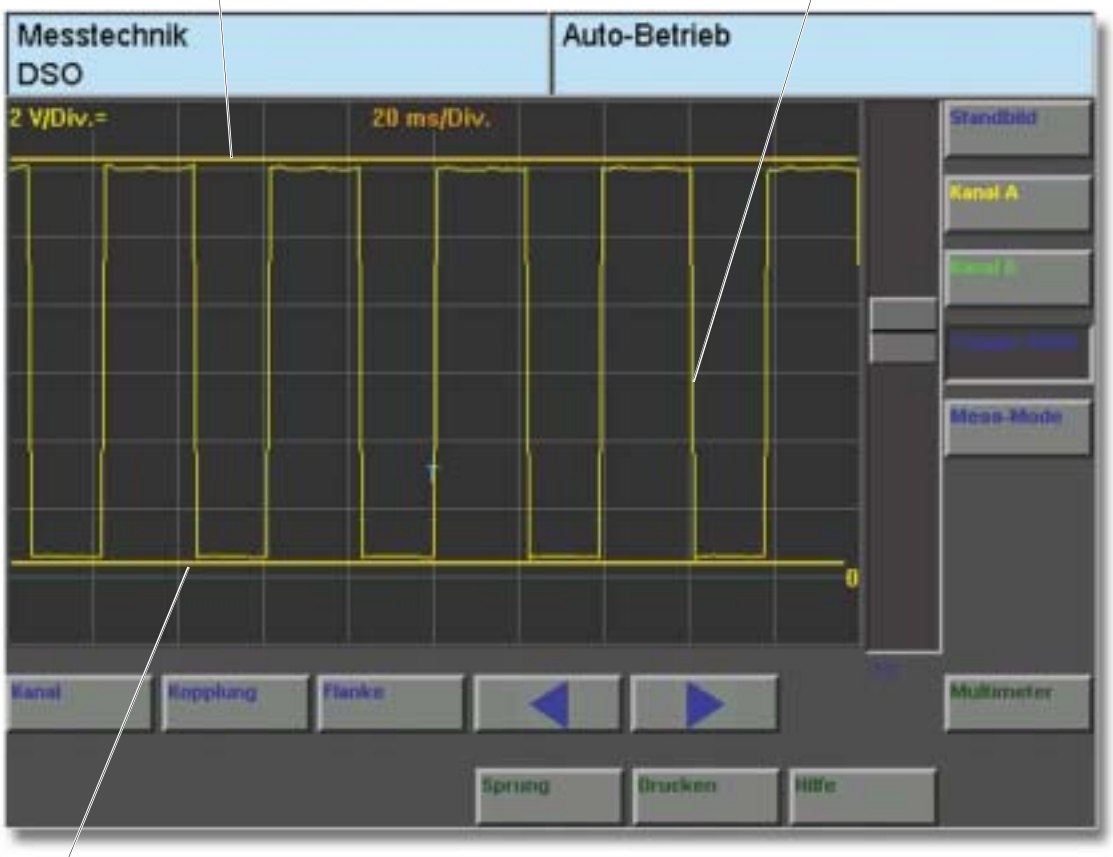
Fault display: Yes

At present, the tiptronic steering wheel function is also deactivated in position D/S. With introduction of the next control unit generation (1st quarter of 2003) it is planned to maintain the tiptronic steering wheel function in the event of F189 failure.

Tip+ or Tip- signals or "tip" gate recognition at pin 5, 4 or 1 (at gearbox)

Voltage level U_{batt} in selector lever positions P and P>R>N

Signal profile in selector lever positions D, S and D>N>R



Voltage level $U_{approx.\ 0.5\ V}$ in selector lever positions Tip+ (pin 5) or Tip- (pin 4) or gate (pin 1)

DSO connection:

Test prod DSO1	red	to pin 5/4/1	(at gearbox)
Test prod DSO	black	to pin 13	(at gearbox)

Conditions:
Ignition ON (engine not running)

284_084

Gearbox Control

Gear sensor F125

The selector lever position information is required for the following functions:

- Control of starting lock (refer to Part 1 SSP 283, Page 32 onwards)
- Control of reversing lights (Page 32 onwards)
- Control of P/N lock (selector lever lock) (refer to Part 1 SSP 283, Page 22 onwards)
- Information on driving situation (forwards/ reverse/neutral) e.g. for stationary vehicle decoupling and as information for other control units by way of bus link

The gear sensor F125 consists of 4 Hall sensors switched by a permanent magnet. The permanent magnet is actuated directly by the selector slide of the hydraulic control unit.

The gear sensor F125 indicates the position of the selector slide in the hydraulic control unit. This is used to derive the selector lever position. If the selector lever cable is not set correctly, the selector lever position does not coincide with that of the selector slide. The gear selection indicator in the dash panel insert then does not correspond to the selector lever position.

To avoid misunderstandings regarding the functions of F125, it is no longer referred to in this SSP as multi-function switch but rather as gear sensor. With the 09E gearbox, F125 has no direct multiple functions.

The Hall sensor signals are interpreted in the same way as the positions of mechanical switches. A high level signifies: Switch closed (1). A low level signifies: Switch open (0). One "switch" (Hall sensor) thus generates the two signals 0 and 1. 16 different switching combinations can be generated with 4 "switches".

5 switching combinations for recognition of selector lever positions P, R, N, D and S

4 switching combinations which are recognised as intermediate positions (P-R, R-N, N-D, D-S)

7 switching combinations which are diagnosed as not OK

Safety/substitute function in the event of failure:

Mechanical emergency running (refer to Page 34 onwards)

Fault display: Yes

284_008

Gearbox oil temperature sender G93

G93 is integrated into the electronics module of the Mechatronik.

The ATF temperature is required for the following functions:

– Adaption of shift pressures (system pressure) and pressure build-up/reduction during gearshift operations

– Activation/deactivation of temperature-dependent functions (warm-up program, torque converter clutch, stationary vehicle decoupling etc.)

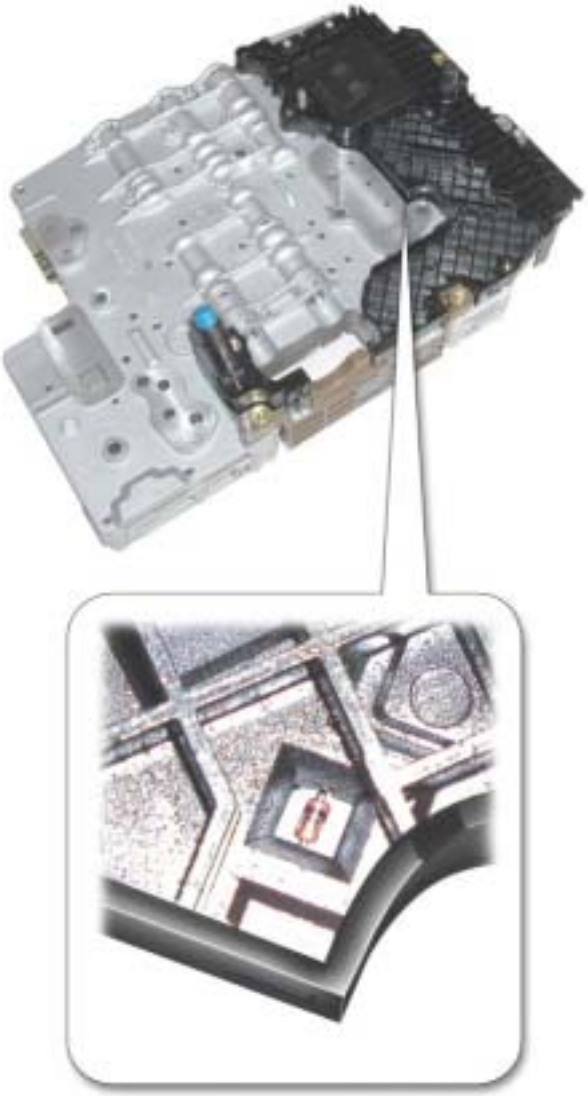
– Determination of oil temperature population

– Substitute signal for substrate temperature sender for implementation of action to reduce ATF temperature (refer to Page 13 onwards)

Safety/substitute function in the event of failure:

None

Fault display: None



284_010

Explanation of important information

"Brake pressed" information ...

... is determined from switches F and F47 (refer to block diagram, Page 26 onwards).

... is supplied to J217 by way of drive system CAN by engine control unit J623 (refer to CAN data exchange, Page 28 onwards).

... is required for P/N lock and "stationary vehicle decoupling" function.

Safety/substitute function in the event of failure:

Deactivation of P/N lock
Deactivation of stationary vehicle decoupling

Fault display: None

The brake test switch F47 is supplied with voltage from terminal 15NL.

Terminal 15NL is generated by the entry and start authorisation control unit J518. It is activated when the ignition is switched on (term. 15 normal) and remains active after switching off ignition (term. 15 OFF) until J518 receives sleep acknowledgement for the drive system CAN from the gateway J533 or until the maximum run-on time (approx. 15 minutes) has elapsed.

Sensors and actuators (e.g. brake light switch) linked to control units involved in the run-on process are connected to terminal 15NL. This maintains the function and prevents misinterpretation of self-diagnosis.

Diagnosis evaluation:

CAN information
Switch position

F	F47	Signal status	Interpretation in control unit J217
0	0	Brake not pressed	Brake not pressed
0	1	Implausible	Brake pressed
1	0	Implausible	Brake pressed
1	1	Brake pressed	Brake pressed

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"Kick-down" information ...

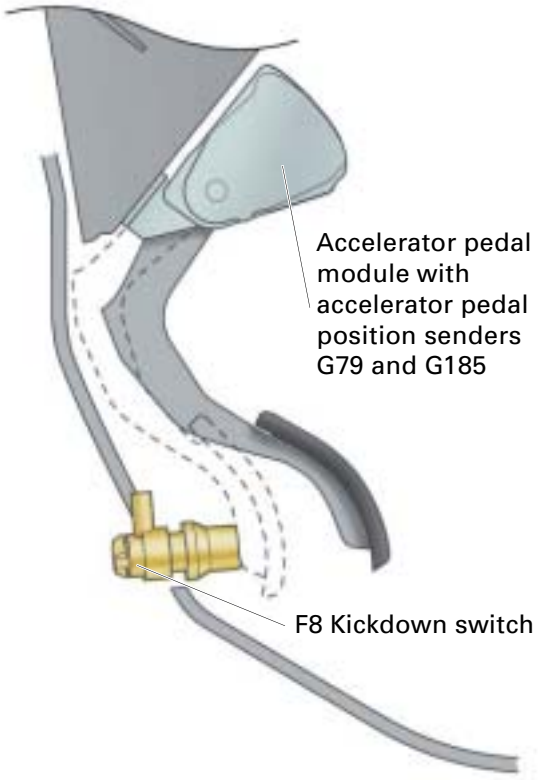
... is supplied to the engine control unit J623 by the separate kickdown switch F8. J623 evaluates the F8 switching information and transmits it to the drive system CAN (refer to CAN data exchange, Page 28 onwards).
F8 also acts as accelerator pedal stop (full throttle and kickdown positions must be set accordingly).

Safety/substitute function in the event of failure:

Self-diagnosis can only detect a short to earth.

In the event of short to earth, the kickdown signal is always applied. Kickdown takes place as a function of accelerator pedal position in line with a defined kickdown characteristic curve.

Fault display: None



284_134

"Accelerator pedal position" information...

... is supplied to the engine control unit J623 by the accelerator pedal position senders G79 and G185. J623 evaluates the signals and transmits the accelerator pedal position as information to the drive system CAN (refer to CAN data exchange, Page 28 onwards).

... forms an important item of information for shift point selection in addition to gearbox output speed.

... is used by the DSP function for evaluation of driving situations and driving style factor (sportiness rating). Refer to Page 36 onwards for more details on DSP.

Safety/substitute function in the event of failure:

Deactivation of stationary vehicle decoupling

Fault display: None

Gearbox Control

"Engine torque" information ...

... is supplied to the gearbox control unit by way of CAN data bus (drive system CAN).

... is used for regulation of system pressure, control of torque converter clutch and calculation of motion resistance in DSP.

... is used for calculation of torque request during gearshift operation.

Safety/substitute function in the event of failure:

4th gear electrical emergency program.
Pressure-modulated, controlled gear engagement.
Opening of torque converter clutch.

Fault display: Yes

"Engine speed" information ...

... is supplied to the gearbox control unit by way of CAN data bus.

... is used to control the torque converter clutch.

... is used to control stationary vehicle decoupling.

Safety/substitute function in the event of failure:

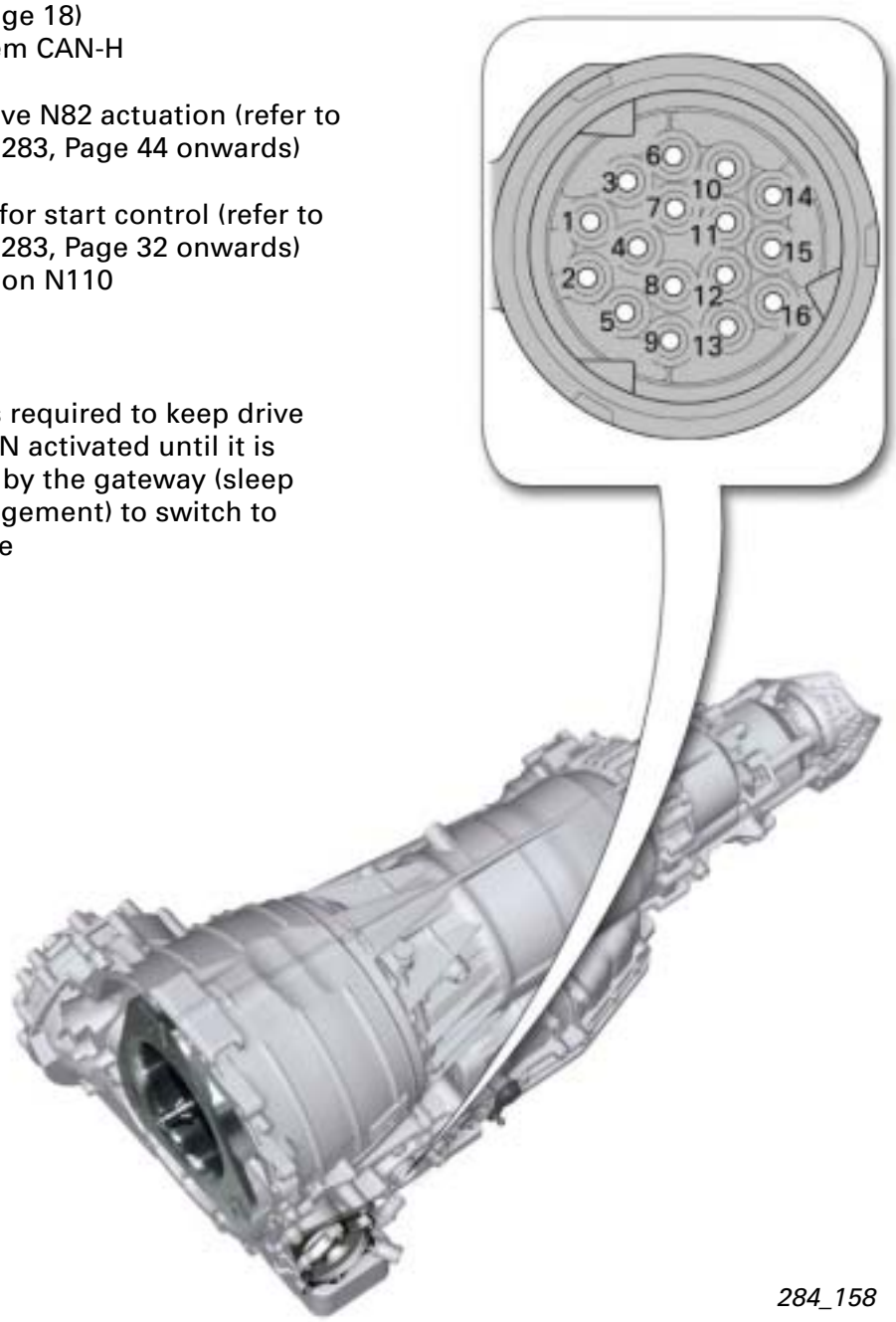
4th gear electrical emergency program.
Pressure-modulated, controlled gear engagement.
Opening of torque converter clutch.

Fault display: Yes

Interfaces/additional signals

Pin assignment at connector to gearbox

Pin 1 Signal for tiptronic gate/recognition (refer to Page 18)
Pin 2 Drive system CAN-L
Pin 3 Self-diagnosis K-wire (refer to Page 44)
Pin 4 Signal for tiptronic change-down (refer to Page 18)
Pin 5 Signal for tiptronic change-up (refer to Page 18)
Pin 6 Drive system CAN-H
Pin 7 Not used
Pin 8 Shutoff valve N82 actuation (refer to Part 1 SSP 283, Page 44 onwards)
Pin 9 Term. 15
Pin 10 P/N signal for start control (refer to Part 1 SSP 283, Page 32 onwards)
Pin 11 P/N actuation N110
Pin 12 Not used
Pin 13 Earth
Pin 14 Term. 30
Term. 30 is required to keep drive system CAN activated until it is instructed by the gateway (sleep acknowledgement) to switch to sleep mode
Pin 15 Not used
Pin 16 Earth



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Block diagram / system layout

D1 Inhibitor reading unit

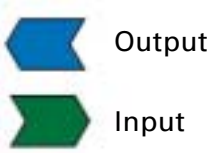
E389 tiptronic switch in steering wheel
E408 Entry and start authorisation button
E415 Entry and start authorisation switch (electronic ignition switch)

F Brake light switch
F8 Kick-down switch
F47 Brake pedal switch (test switch)
F125 Gear sensor
F189 tiptronic switch
F305 Gear selector position P switch

G85 Steering angle sender
G93 Gearbox oil temperature sender
G182 Gearbox input speed sender
G195 Gearbox output speed sender

N82 Coolant shutoff valve
N88 Solenoid valve 1
N110 Selector lever lock magnet
N215 Solenoid pressure control valve -1-
N216 Solenoid pressure control valve -2-
N217 Solenoid pressure control valve -3-
N218 Solenoid pressure control valve -4-
N233 Solenoid pressure control valve -5- (system pressure)
N371 Solenoid pressure regulating valve -6- (torque converter clutch)
N376 Ignition key withdrawal lock magnet (in E415)

J53 Starter motor relay
J104 ESP control unit
J197 Adaptive suspension control unit
J217 Automatic gearbox control unit
J285 Control unit with display in dash panel insert (selector lever position indicator FIS)
J329 Terminal 15 voltage supply relay
J428 Distance regulation control unit
J453 Multi-function steering wheel control unit
J518 Entry and start authorisation control unit
J527 Steering column electronics control unit
J533 Data bus diagnostic interface (gateway)
J540 Electric park and handbrake control unit
J623 Engine control unit
J694 Terminal 75x voltage supply relay
J695 Starter relay -2-



Output

Input

Special terminals:

Terminal 15NL = 15 run-on (refer to Page 22)

Terminal 50R = 50 feedback, used for starter actuation feedback information

Terminal 58PWM = Pulse-width modulated dimming of switch illumination