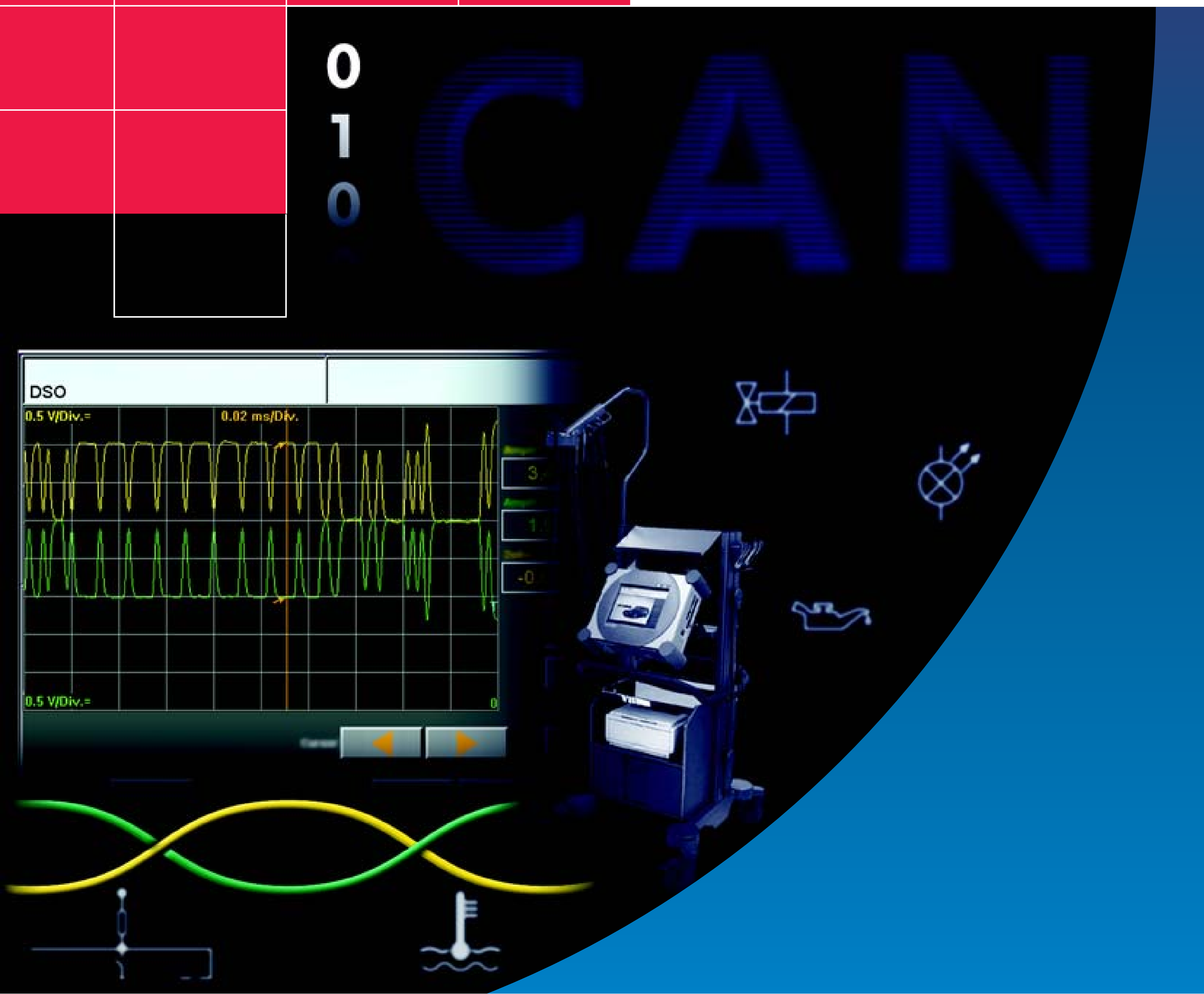
Service.

Self-study programme 269

Data transfer on CAN data bus II

Drivetrain CAN data bus

Convenience/ infotainment CAN data bus



The use of different CAN data bus systems in a motor vehicle and the utilisation of data in different networks by different systems sets new demands on diagnosis and fault finding. SSP 238 covers the basics of the CAN data bus system. This information is extended with SSP 269 to concentrate on the technical realisation of both data bus types.

The basic requirements for fault finding are explained and a flow chart shows the procedure necessary for systematic fault finding.

At the end of this SSP, practical examples of faults are described and dealt with individually. The procedure for diagnosing faults is explained and details are given as to their cause and rectification.

- **SSP 238:**
  Covers basic functions of CAN data bus systems.

- **SSP 269:**
  Covers VOLKSWAGEN and Audi CAN data bus systems, drivetrain and convenience/infotainment. Special attention is paid to fault finding with vehicle diagnosis, testing and information system VAS 5051. Next step will be introduction to and diagnosis of practical fault conditions.

238_001

NEW

Important Note

The self-study programme shows the design and function of new developments!
The contents will not be updated.

For testing, adjusting and repair instructions, please refer to the relevant service literature.

Contents

Introduction

Entire system

The CAN data bus is very reliable. CAN faults, therefore, rarely occur.
The following information is intended to help you with fault finding and to highlight a number of standard faults. It is designed to concentrate on the basics of the CAN data bus system so that the measurements from target orientated fault finding can be evaluated.

Messages that indicate a requirement for the CAN data bus to be examined more closely are provided by the vehicle diagnosis, testing and information system – VAS 5051 – such as, "Engine control unit has no signal/ communication" (sporadic) or "Drivetrain data bus defective". Further notes on fault sources are supplied by the measured value blocks of the "Gateway" (from page 20), in which the status of communication of all control units connected in the CAN data bus is stored.

CAN networking in the VW Group

In the VW Group, different types of CAN data bus systems are used.
The first type of CAN data bus was the convenience CAN data bus with a transfer rate of 62.5 kBit/s. The next one was the drivetrain CAN data bus with 500 kBit/s.
The drivetrain CAN data bus is still used in all models today. As of model year 2000, the "new" convenience CAN data bus and infotainment CAN data bus have been introduced, each with a transfer rate of 100 kBit/s.
The new convenience/ infotainment CAN data bus can now exchange data with the drivetrain CAN data bus via the dash panel insert with Gateway feature (page 20).

Practical layout

Due to different demands with regards to the required repeat rate of the signals, the volume of data that amasses and the availability (readiness), the three CAN data bus systems are configured as follows:

Drivetrain CAN data bus (high speed) with **500 kBit/s**
networks the control units of the drivetrain.

Convenience CAN data bus (low speed) with **100 kBit/s**
networks the control units in the convenience system.

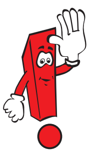
Infotainment CAN data bus (low speed) with **100 kBit/s**
networks the systems for radio, telephone and navigation, for example.

Common for all systems is the following:

- The systems are all subject to the same regulations for data exchange, i.e. the transfer protocol.
- To assure a high degree of protection from disturbances (e.g. from the engine compartment), all CAN data bus systems feature dual cable wiring which is entwined (twisted pair, page 6).
- Signals to be sent are stored in the transceiver of the sending control unit with different signal levels and then sent to both CAN lines. Not until the differential amplifier of the receiving control unit calculates the difference of both signal levels is a single, cleaned signal sent to the CAN receiver of the control unit, (chapter "Differential data transfer" from page 8).
- The infotainment CAN data bus has the same properties as the convenience CAN data bus. In the Polo (from model year 2002) and in the Golf IV, the infotainment CAN data bus and convenience CAN data bus are operated via one common pair of cables.

The main differences in the systems are as follows:

- The drivetrain CAN data bus is switched off by terminal 15 or after a brief run-on period.
- The convenience CAN data bus is supplied with power by terminal 30 and must remain on standby. To prevent the onboard supply system from being placed excessively under load, the system switches via "terminal 15 off" to "sleep mode" when it is not required by the entire system.
- The convenience/ infotainment CAN data bus remains operational, thanks to the second wire, if a short circuit in a data bus wire or open circuit in a CAN wire is evident. In this instance, the system will switch automatically to "single wire operation" (page 19).
- The electrical signals from the drivetrain CAN data bus and convenience/ infotainment CAN data bus are different.



Warning:
Contrary to the convenience/ infotainment CAN data bus, the drivetrain CAN data bus cannot be connected electrically with the convenience/ infotainment CAN data bus!
The various data bus systems for the drivetrain and convenience/ infotainment are joined in the vehicle by a Gateway (page 20). The Gateway can be included in one control unit, e.g. in the dash panel insert or onboard supply control unit. Depending on the vehicle, the Gateway could also be installed as a Gateway control unit.

CAN wiring properties

The CAN data bus is of the dual cable type with a transfer rate of 100 kBit/s (convenience/ infotainment) or 500 kBit/s (drivetrain). The convenience/ infotainment CAN data bus is also referred to as a low speed CAN and the drivetrain CAN data bus as a high speed CAN.
The CAN data bus lies parallel to all control units of the respective CAN system.
Both wires of the CAN data bus are called CAN high and CAN low wires.
Two entwined wires are referred to as a twisted pair.

Twisted pair, CAN high and CAN low wire (drivetrain CAN data bus)

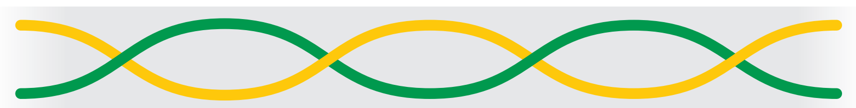
S269_002

Data is exchanged between the control units via both of these wires. The data comes in the form of engine speed, tank fill level and road speed, for example.

The CAN wires can be found in the wiring harness and these are coloured orange. The CAN high wire in the drivetrain CAN data bus has an additional black marking. On the convenience CAN data bus, the additional colour is green and on the infotainment CAN data bus, it is violet. The CAN low wire is always marked brown.

For reasons of clarity, the CAN wires are shown in this SSP as completely yellow or completely green in-line with the VAS 5051 display. The CAN high wire is always yellow, the CAN low wire is always green.

Twisted pair, CAN high and CAN low wire representation



CAN high wire

CAN low wire

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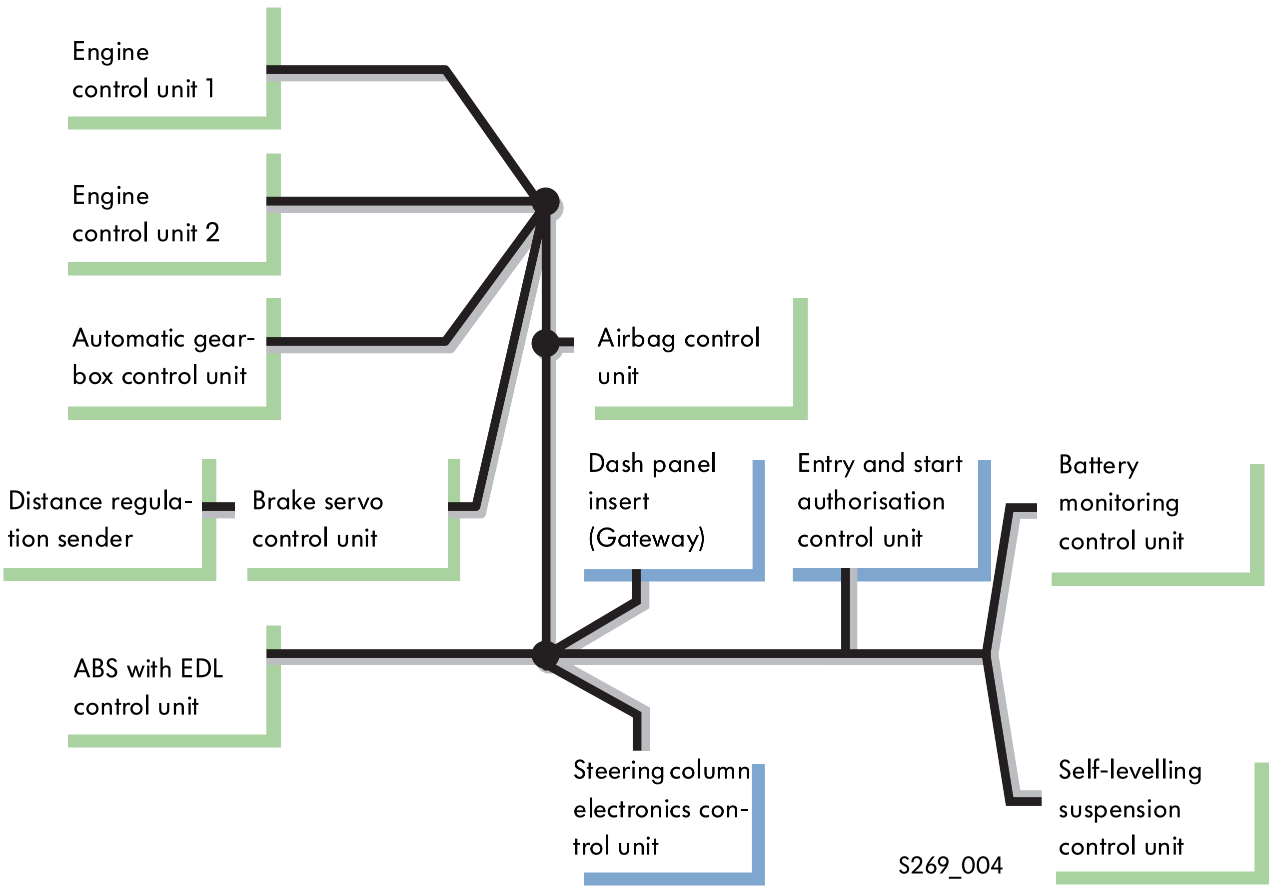
CAN wiring diagram

A special feature of the Group CAN data buses is the tree structure connection under the control units, which is not a normally found on CAN systems. It allows an optimal connection of the control unit wiring. The actual layout of the CAN wiring in a vehicle is referred to as a CAN topology diagram and is vehicle-specific.
The example shows the CAN topology diagram for the drivetrain of a Phaeton. The tree structure of the network is clear to see here.

CAN topology diagram for the drivetrain CAN data bus of the Phaeton



Differential data transfer as on the drivetrain CAN data bus, for example

Increased transfer security

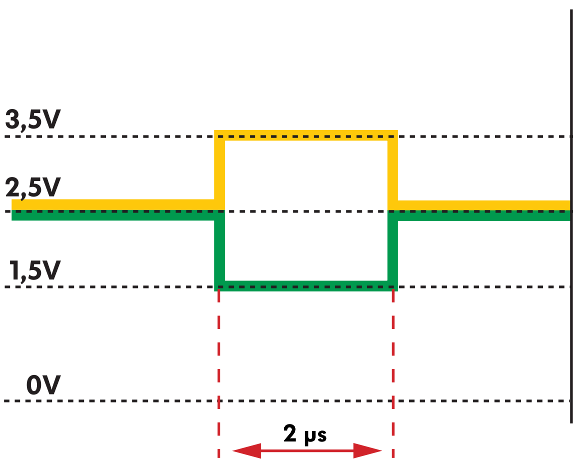
In order that a high level of security can be achieved in the transfer of data, the CAN data bus systems all feature the previously mentioned twisted pair wiring with differential data transfer.
The wires are known as CAN high and CAN low.

Voltage differences in CAN wires when changing between dominant and recessive state as on drivetrain CAN data bus, for example:

In rest state, both wires have the same default setting with regards to the signal level. On the drivetrain CAN data bus, this setting is approx. 2.5V. The rest state setting is also known as the recessive state as it can be changed by any control unit connected in the network (see also SSP 238).
In the dominant state, the voltage increases to that of the CAN high wire by a predetermined value (on the drivetrain CAN data bus this is at least 1V). The voltage of the CAN low wire drops by the same increment (on the drivetrain CAN data bus at least 1V). This results in a rise in the voltage of the CAN high wire from the drivetrain CAN data bus by at least 3.5V (2.5V + 1V = 3.5V) in active state. The voltage in the CAN low wire then drops to a maximum of 1.5V (2.5V - 1V = 1.5V).

Therefore, the voltage difference between CAN high and CAN low in a recessive state is 0V, and in a dominant state, at least 2V.

Signal pattern on the CAN data bus as on the drivetrain CAN data bus, for example



In a **dominant** state, the **CAN high wire** rises to approx. **3.5V**

In a **recessive** state, the **two wires** are at approx. **2.5V** (**rest state**)

In a **dominant** state, the **CAN low wire** drops to approx. **1.5V**

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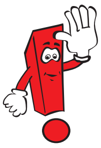
CAN transceiver

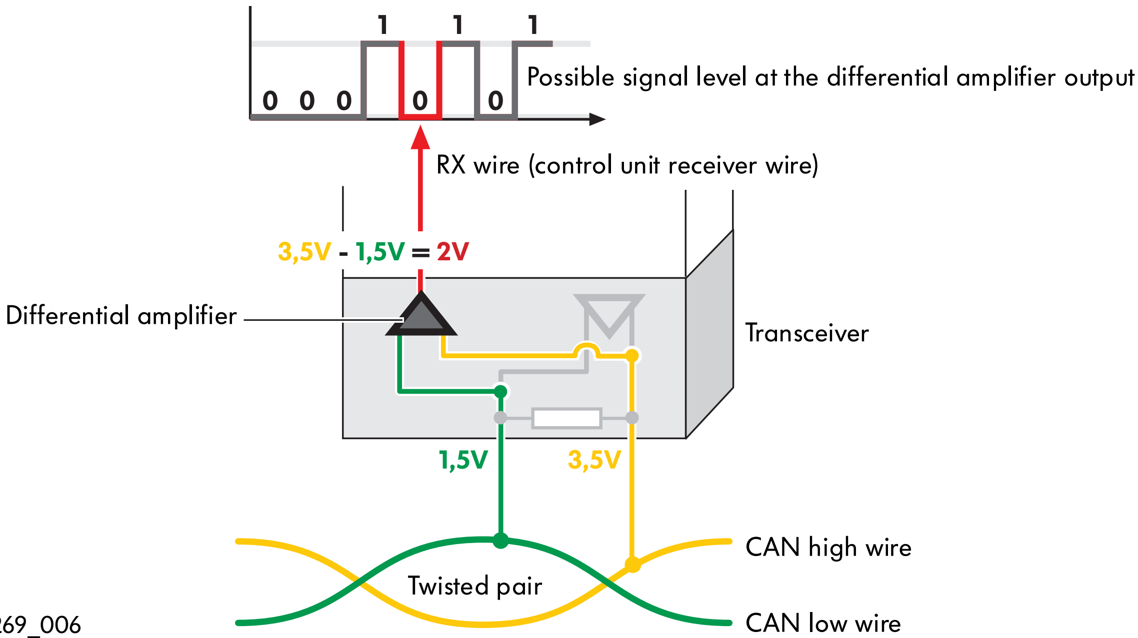


The following information describes how the transceiver works, using the drivetrain CAN data bus as an example. The way the convenience/ infotainment CAN data bus operates differently to this is described in detail in the chapter entitled "System overview/ CAN data bus convenience/ infotainment" (page 16).

Conversion of signals from CAN high and CAN low in the transceiver

The control units are connected to the drivetrain CAN data bus via the transceiver. Located in the transceiver is a receiver. This receiver is the differential amplifier installed on the receiver side.
The differential amplifier is responsible for evaluating the input signals from CAN high and CAN low. Furthermore, it transmits these converted signals to the CAN receiver area of the control unit. These converted signals are referred to as the output voltage of the differential amplifier.
The differential amplifier determines this output voltage by subtracting the voltage of the CAN low wire ($U_{CAN\ low}$) from the voltage of the CAN high wire ($U_{CAN\ high}$). In this way, the rest state (2.5V on the drivetrain CAN data bus) or any other combined voltage (e.g. disturbance, page 11) is removed.

The differential amplifier of the drivetrain CAN data bus



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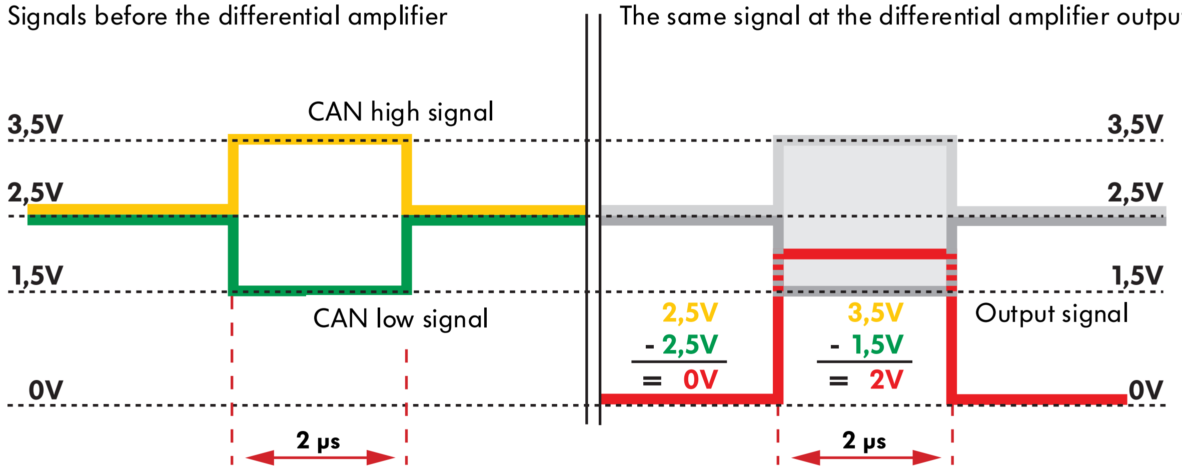
Conversion of signals in the differential amplifier of the drivetrain CAN data bus

For evaluation in the differential amplifier of the transceiver, the voltage present in the CAN low wire is deducted from that which is present at the same time in the CAN high wire.

Evaluation in the differential amplifier as on the drivetrain CAN data bus, for example



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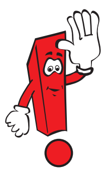
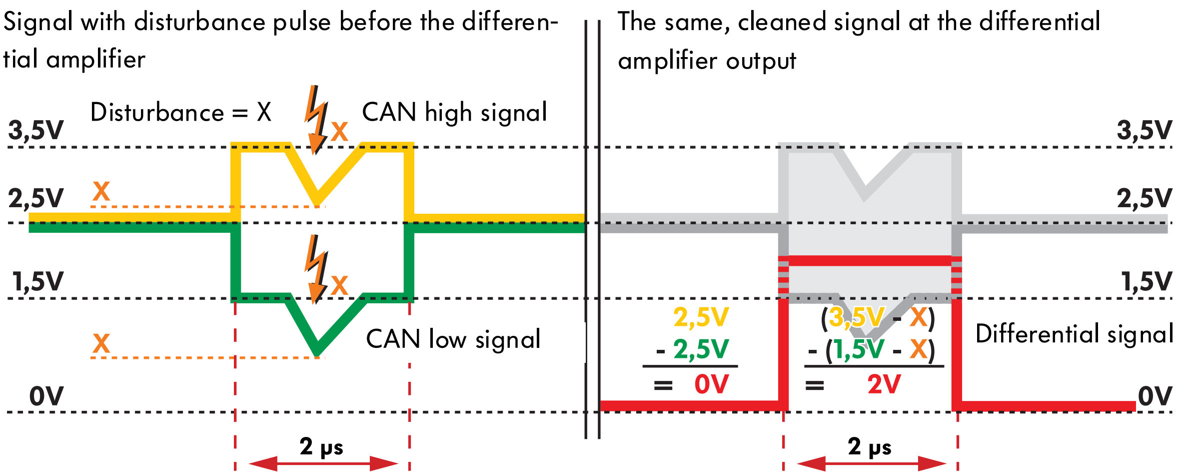


Contrary to the drivetrain CAN data bus, the convenience/ infotainment CAN data bus features an intelligent differential amplifier. In order that single wire operation can be assured, it also evaluates the signals in the CAN high and CAN low wire individually.
Further information about single wire operation and about operation of the differential amplifier in the convenience/ infotainment CAN data bus can be found in the chapter entitled "System overview/ convenience/ infotainment CAN data bus" (from page 16).

Filtering out disturbances in the differential amplifier of the drivetrain CAN data bus

As the data bus wires are also routed through the engine compartment, they are subjected to different types of disturbance. Short circuit to earth and battery voltage, overload from the ignition system and static discharge should be taken into consideration during repair.

Filtering out disturbances in the differential amplifier as on the drivetrain CAN data bus, for example



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Evaluation of the signals from CAN high and CAN low in the differential amplifier, otherwise known as differential transfer technology, means that the effects of disturbances are practically eliminated. Another advantage of differential transfer technology is the fact that fluctuations in the onboard supply (e.g. when the engine is started) do not affect the transfer of data to individual control units (transfer security).

At the top of the illustration, the effect of this type of transfer is clearly evident.
Due to the entwined CAN high and CAN low wires (twisted pair), a disturbance of factor X will always have the same equal effect on both wires.
Since the voltage in the CAN low wire (1.5V - X) is deducted from the voltage in the CAN high wire (3.5V - X) in the differential amplifier, the disturbance is eliminated during evaluation and no longer appears in the differential signal.

(3.5V - X) - (1.5V - X) = 2V

Overview

Signal level

Amplification of control unit signals in the transceiver

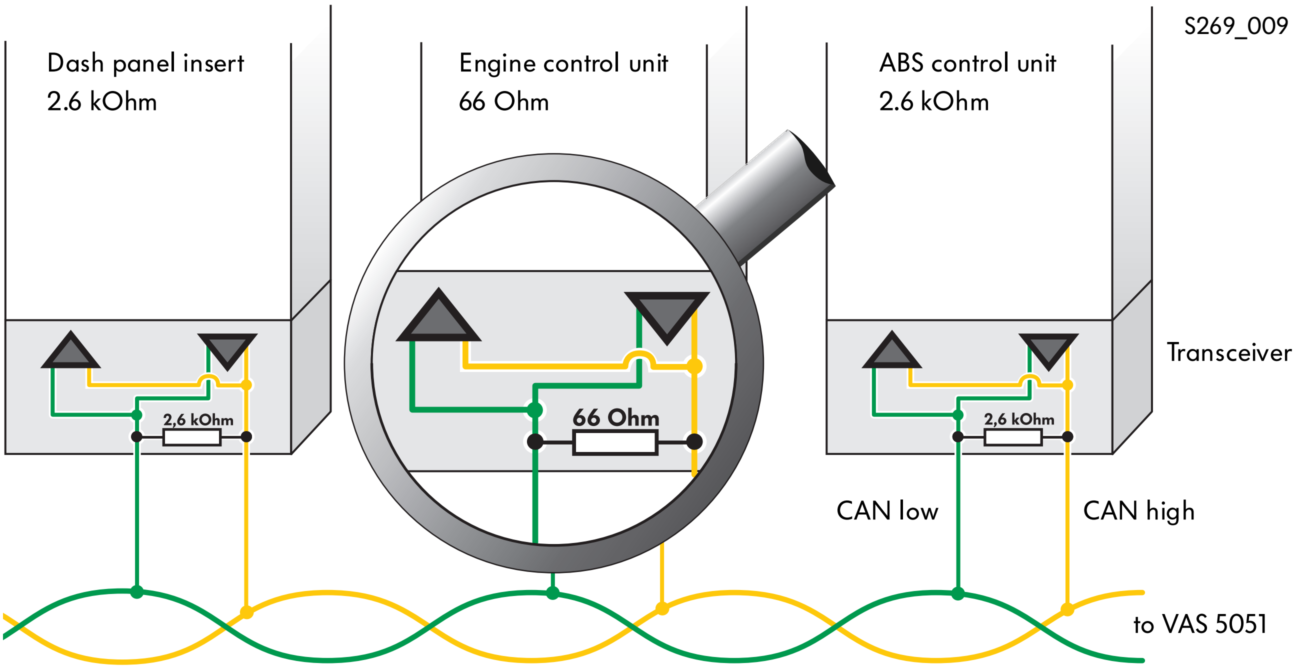
On the sender side, the transceiver is responsible for amplifying the relatively weak signals of the CAN controller in the control units so that the prescribed signal level is reached in the CAN wires and at the control unit outputs.

The control units connected to the CAN data bus respond much the same way as a load resistor on the CAN wires due the electrical components installed there. The load resistance depends on the number of connected control units and their resistances.

For example, the engine control unit places the drivetrain CAN data bus under 66 Ohm of load between CAN high and CAN low. All other control units place a load on the data bus of 2.6 kOhm each.
This means there is a total load of 53-66 Ohm, depending on the number of connected control units.
If terminal 15 (ignition) is switched off, this resistance can be measured between CAN high and CAN low using an ohmmeter.

The transceiver transmits the CAN signals to both wires of the CAN data bus. In this way, a positive voltage change in the CAN high wire equates to an equally high negative voltage change in the CAN low wire. The voltage change in one CAN wire is at least 1V in the drivetrain CAN data bus and at least 3.6V in the convenience/ infotainment CAN data bus.

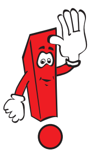
Load resistance in the CAN high and CAN low data bus wires



Special features of the Group CAN

In contrast to the data bus in its basic original form with two matching resistors at both ends of the data bus, VW uses decentral matching resistors with a "central matching resistor" in the engine control unit and high ohm resistors in the other control units. The consequence of this are stronger reflections, though these do not have negative effects due to the short data bus lengths in the vehicle. The figures for possible data bus lengths in terms of CAN standards do not apply, however, to the drivetrain CAN data bus at VW due to the reflections.

A special feature of the convenience/ infotainment CAN data bus is that the load resistors in the control units no longer lie between CAN high and CAN low but from the respective wire to earth or to 5V. If the voltage is switched off, the load resistors are also switched off, which means that these can no longer be measured with the ohmmeter.



Warning:
Even for the purposes of testing, the drivetrain CAN data bus should not be extended by more than 5 m.

System overview

Properties and special features of the drivetrain CAN data bus

The drivetrain CAN data bus, with 500 kBit/s, serves as a means of networking control units in the drivetrain CAN data bus.

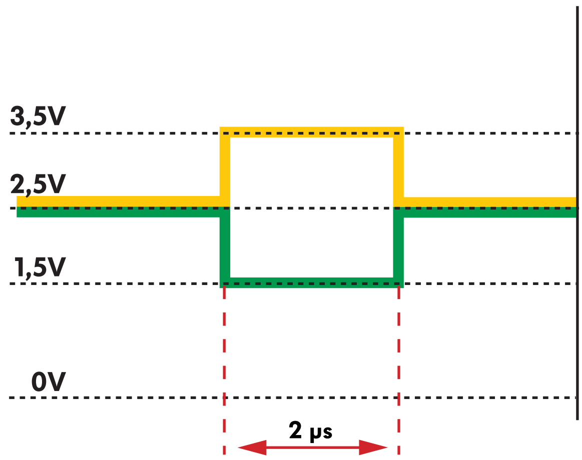
Examples of control units in the drivetrain CAN data bus are:

- Engine control unit
- ABS control unit
- ESP control unit
- Gearbox control unit
- Airbag control unit
- Dash panel insert

The drivetrain CAN data bus, as with all CAN wires, is of the twisted pair type with a transfer rate of 500 kBit/s. For this reason, it is also referred to as a high speed CAN. Data is exchanged between the control units via the CAN high and CAN low wire of the drivetrain CAN data bus.
The messages are sent in a cycle from the control units, which means that the repeat rate of the messages is generally in a range of 10 - 25 ms.

The drivetrain CAN data bus is activated via terminal 15 (ignition) and then, after a short run-on time, completely deactivated again.

Signal pattern of the drivetrain CAN data bus



In **a dominant** state, the **CAN high wire** rises to approx. **3.5V**

In **a recessive** state, **both wires** are at approx. **2.5V** (**rest state**)

In **a dominant** state, the **CAN low wire** drops to approx. **1.5V**

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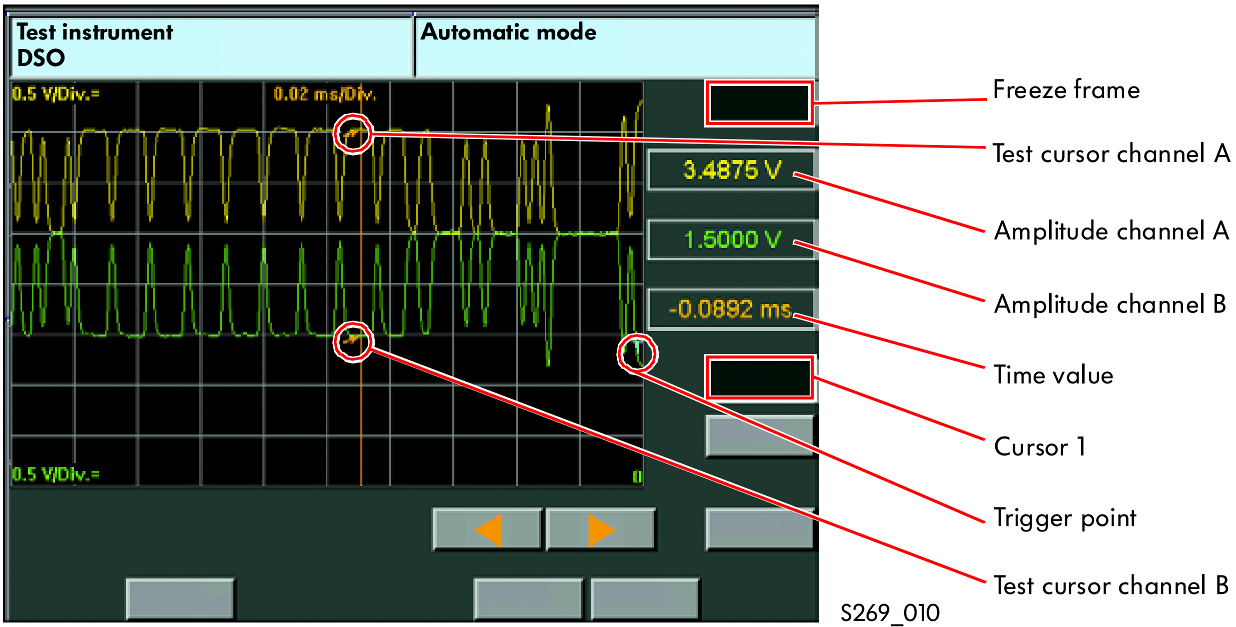
Signal pattern of the drivetrain CAN data bus

The following diagram shows the pattern of a real CAN telegram, which was created with a modern transceiver and recorded with the **d**igital **s**torage**o**scilloscope (DSO) from VAS 5051.
The combined signal pattern between levels characterises a recessive level of 2.5V. The dominant voltage at CAN high is approx. 3.5V. At CAN low it is approx. 1.5V.

Signal pattern of the drivetrain CAN data bus on the DSO of VAS 5051



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Dominant and recessive levels alternate.
$U_{CAN\ high}$ at 3.48V, $U_{CAN\ low}$ at 1.5V.
Setting: 0.5V/ Div, 0.02ms/ Div

System overview

Properties and special features of the convenience/ infotainment CAN data bus

The convenience/ infotainment CAN data bus, with a transfer rate of 100 kBit/s, serves as a means of networking the control units associated with the convenience CAN data bus and the infotainment CAN data bus.

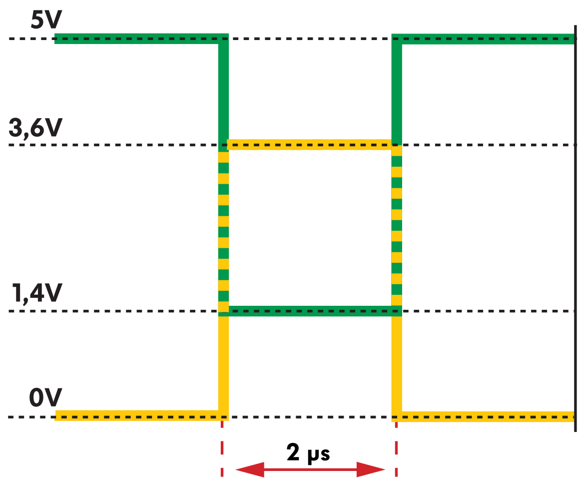
Examples of control units in the convenience/ infotainment CAN data bus are:

- Climatronic/air conditioning control unit
- Door control units
- Convenience control unit
- Control unit with display unit for radio and navigation

The convenience/ infotainment CAN data bus, as with all CAN wires, is of the twisted pair type.
The transfer rate of the data bus is just 100 kBit/s, which is why the term low speed CAN is used.

Data is exchanged between the control units via the CAN high and CAN low wire, for example doors open/ closed, interior lights on/ off, position of vehicle (GPS), and similar.
The convenience CAN data bus and infotainment CAN data bus can be operated on a common wire pair due to the fact that they have the same transfer rate (provided this is made possible on the relevant models e.g. Golf IV and Polo model year 2002).

Signal pattern of the convenience/ infotainment CAN data bus



In a **dominant** state, the **CAN low wire** drops to **approx.** 1.4V.

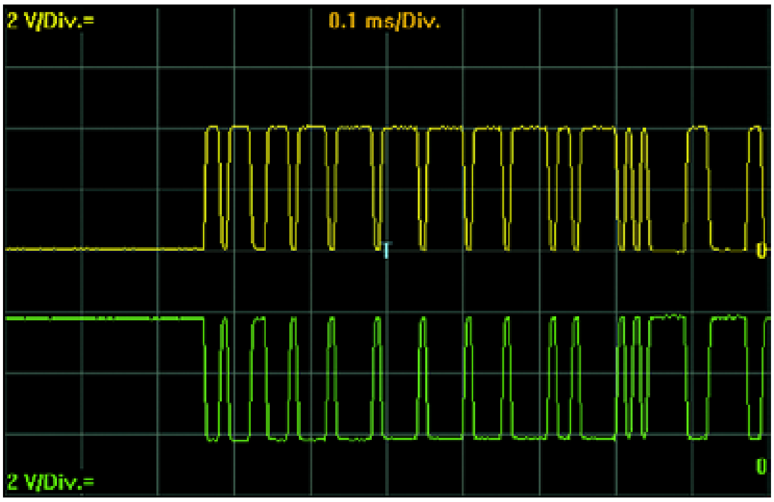
In a **recessive** state, the **CAN high wire** is at approx. **0V** and the **CAN low wire** is at approx. **5V**.

In a **dominant** state, the **CAN high wire** is at approx. **3.6V**.

Differential data transfer on the convenience/ infotainment CAN data bus

In order to combine greater resistance to disturbances and a reduction in power consumption on the low speed CAN, a number of changes were necessary compared to the drivetrain CAN data bus.
Firstly, the dependence of both CAN signals on each other was removed by introducing independent drivers (output amplifiers). Contrary to the drivetrain CAN data bus, the CAN high and CAN low wires of the convenience/ infotainment CAN data bus are not connected to each other via resistors.
This means that CAN high and CAN low no longer influence each other but rather work independently of each other as voltage sources.
There is still no common medium voltage. The CAN high signal is 0V in a recessive state (rest state), and in a dominant state, a voltage of ≥ 3.6V is reached.
With the CAN low signal, the recessive level is 5V and the dominant level is ≤ 1.4V.
In this way, the recessive level is 5V after differential build-up in the differential amplifier and the dominant level is 2.2V. The voltage change between the recessive and dominant level (voltage rise) is thereby increased ≥ to 7.2V.

Signal pattern image on DSO of VAS 5051 (freeze frame)



S269_012

Dominant and recessive levels alternate.
In dominant state $U_{CAN\ high}$ is at 3.6V, $U_{CAN\ low}$ is at 1.4V.
Setting: 2V/ Div, 0.1ms/ Div

For reasons of clarity, the CAN high and CAN low signal are pulled apart.
This is noticeable by the different zero points in the DSO image.
The different rest states for CAN high and CAN low are clearly visible. The much greater voltage rise (7.2V) is noticeable compared to the drivetrain CAN data bus.

System overview

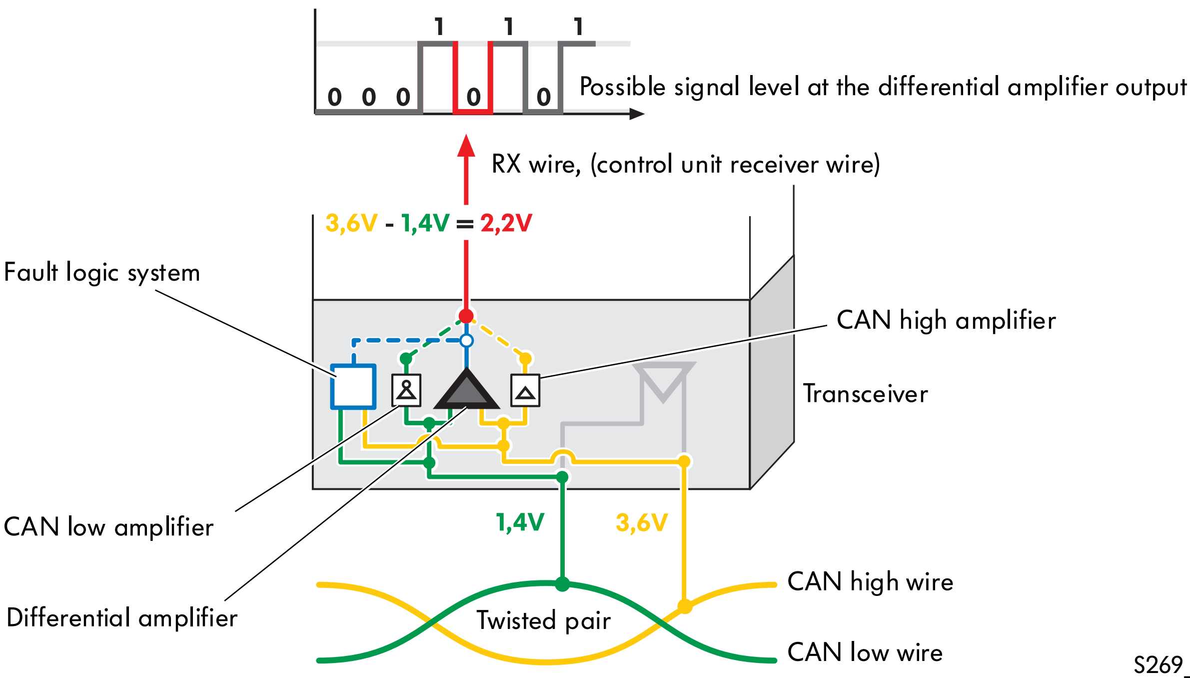
The CAN transceiver of the convenience/ infotainment CAN data bus

The transceiver in the convenience/ infotainment CAN data bus works much the same way as the transceiver in the drivetrain CAN data bus. The only difference is that different signal levels are sent and measures are taken to switch to CAN high or CAN low if there is a fault (single wire operation). Short circuits are still detectable between CAN high and CAN low and, in the case of a fault, the CAN low driver is switched off. If this happens, CAN high and CAN low have the same signal.

The transfer of data on the CAN high and CAN low wire is monitored by the fault logic system integrated in the transceiver. The fault logic system evaluates the input signals of both CAN wires.
If a fault is evident (e.g. an open circuit in one CAN wire), this will be detected by the fault logic system. For evaluation, just the intact wire is then used (single wire operation).

For normal operation, the CAN high signal "minus" CAN low is evaluated (differential data transfer, page 8). The effects of simultaneous disturbances in both wires of the convenience/ infotainment CAN data bus are thereby minimised as effectively as on the drivetrain CAN data bus (page 11).

Design of convenience/ infotainment CAN data bus transceiver



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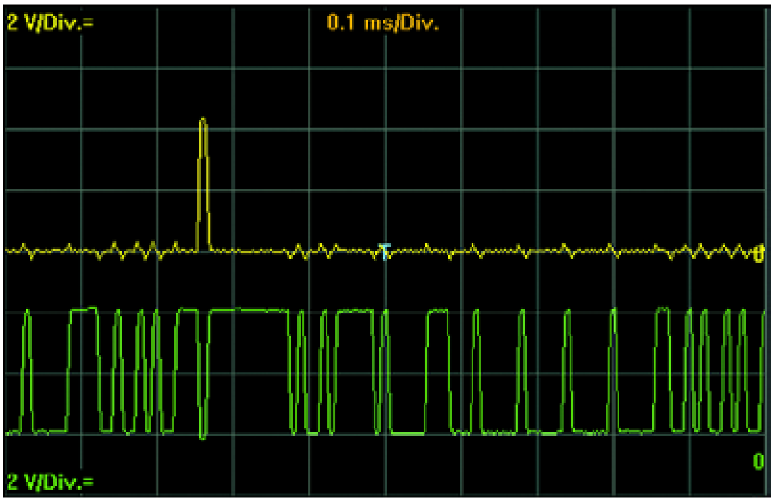
Convenience/ infotainment CAN data bus in single wire operation

If either of the CAN wires fail due to open circuit, short circuit or short to battery positive (ISO fault 1-7, from page 42), the system switches to single wire operation. During single wire operation, only the signals of the intact CAN wire are evaluated.
In this way, the convenience/ infotainment CAN data bus remains operational.
The actual CAN evaluation in the control unit is unaffected by single wire operation. Via a special fault output, the control unit provides information as to whether the transceiver is in normal or single wire operation.

Signal pattern on DSO during single wire operation (freeze frame)



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Entire system

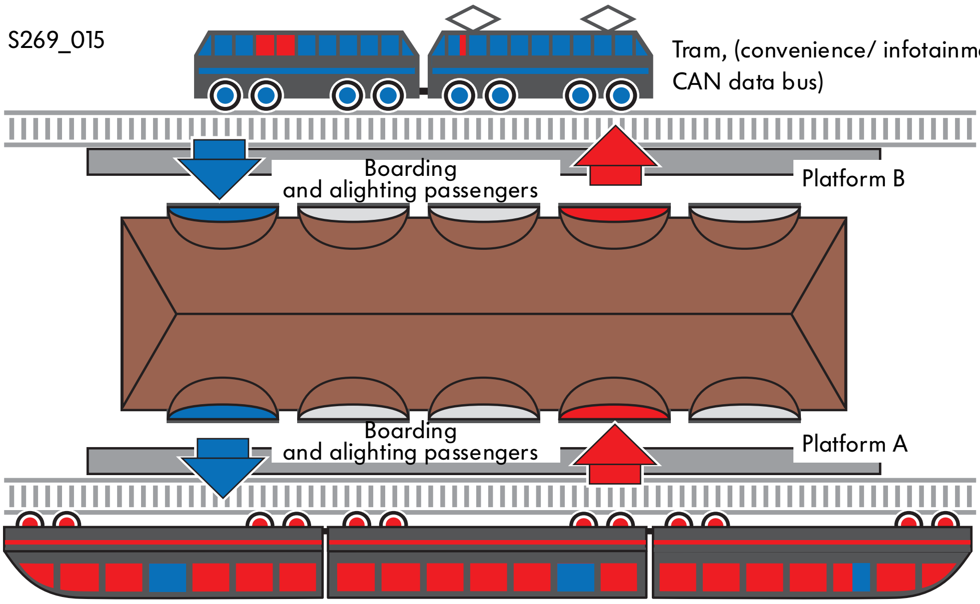
Network of three systems via Gateway

The drivetrain CAN data bus cannot be joined with the convenience/ infotainment CAN data bus due to the different signal levels and resistor layout.
Furthermore, the different transfer rate of both data bus systems makes it impossible to evaluate the different signals.

Between the two data bus systems a conversion is therefore necessary.
This conversion is carried out in the Gateway.
Depending on the vehicle, the Gateway can either be found in the dash panel insert, in the onboard supply control unit or in its own Gateway control unit.

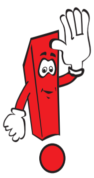
Since the Gateway has access to all of the information via the CAN data bus, this is also used as a diagnosis interface.
Interrogation of the diagnosis information is presently done via the COM wire of the Gateway, with introduction of the Touran, a CAN data bus diagnosis wire will be used.

The principle of the Gateway can be compared to a railway system



At platform A (otherwise known as the Gateway) of the railway, a fast train arrives (drivetrain CAN data bus, 500 kBit/s) with several hundred passengers onboard.
At platform B the tram is already waiting (convenience/ infotainment CAN data bus, 100 kBit/s).
A number of passengers change from the fast train to the tram and some passengers have arrived with the tram to catch the fast train.

The function of the railway/ platform is to allow passengers to change trains to take them to their chosen destination at different speeds and this describes the role of the Gateway in networking both the drivetrain CAN data bus and convenience/ infotainment CAN data bus systems.
The main role of the Gateway is to exchange information between both systems at different speeds.



Reminder:
Contrary to the convenience CAN data bus and infotainment CAN data bus, the drivetrain CAN data bus should never be connected electrically to the convenience CAN data bus or infotainment CAN data bus! The different data bus systems, drivetrain CAN and convenience/ infotainment CAN should only be connected in the vehicle via the Gateway.

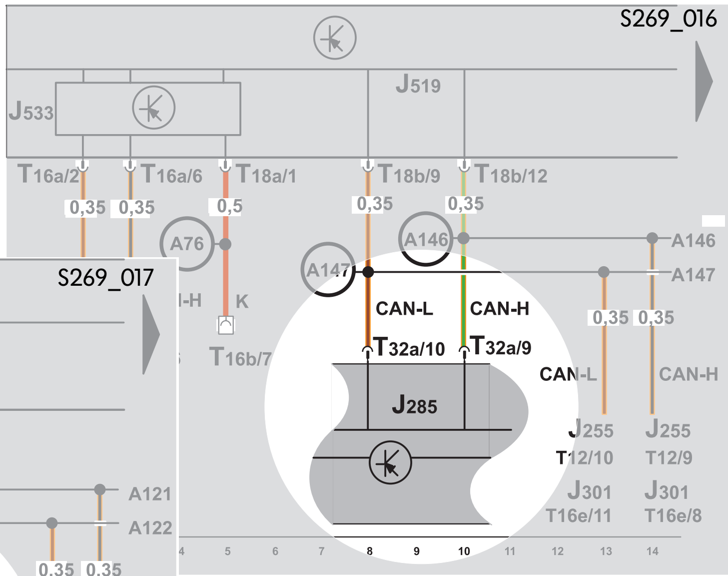
CAN service

Access to CAN data bus

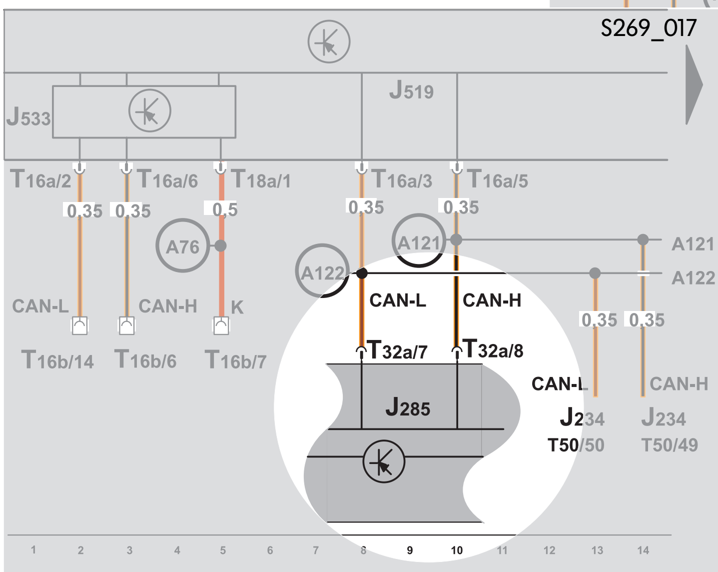
The drivetrain CAN data bus can be found as a "switched CAN data bus" on the OBD connector. However, the activation procedure is not currently supported by VAS 5051, which means that measurements cannot be conducted via the OBD connector.
An alternative is to gain access via the dash panel insert. On the Polo (model year 2002) there is a Gateway in the onboard supply control unit and on the Golf IV there is one in the dash panel insert. On both versions, the drivetrain CAN data bus and convenience/ infotainment CAN data bus can be accessed via the right (green) connector of the dash panel insert.

Assignment of right-hand, green connector in dash panel insert of Polo (MY2002)

Convenience/ infotainment CAN data bus



Drivetrain CAN data bus



Key:
J285: Control unit with display unit in dash panel insert
J519: Onboard supply control unit
J533: Diagnosis interface for data bus

Polo (MY 2002) and Golf IV use a combined convenience/ infotainment CAN data bus. On the Phaeton and Golf V, the convenience CAN data bus and infotainment CAN data bus are operated separately.

Diagnosis instructions

The starting point for fault analysis is always diagnosis using VAS 5051.
Fault messages, which can instantly be attributed to a special data bus defect, are not present. Defective control units can have similar effects as faults in the data bus. The fault messages stored in the Gateway (page 20) can now be used as a benchmark for fault finding. An inspection of the CAN data bus on the drivetrain CAN data bus system can be carried out using an ohmmeter. For the convenience/ infotainment CAN data bus, the DSO of VAS 5051 is required in all instances.
After connecting VAS 5051 to the Gateway, access can be gained to the fault messages via the main menu on VAS 5051 via function 19 (Gateway). In the Gateway menu, the user can gain access to the measured value blocks by selecting 08. The number of the measured value block to be inspected should then be entered.

The following display groups/ measured value blocks are present (as on the Phaeton, for example)

	1	2	3	4
		Drivetrain CAN data bus		
125	Engine control unit	Gearbox control unit	ABS control unit	---
126	Steering angle sensor	Airbag control unit	Electric steering *)	Diesel pump control unit *)
127	Central electrics *)	Four-wheel drive electronics *)	Distance regulation electronics	---
128	Battery management	Electronic ignition lock	Self-levelling system	Damper control
129	---	---	---	---
		Convenience CAN data bus		
130	Single wire/ dual wire	Central convenience electronics	Driver door control unit	Front passenger control unit
131	Rear left door electronics	Rear right door electronics	Driver memory seat electronics	Central electrics
132	Dash panel insert *)	Multi-function steering wheel	Climatronic	Tyre pressure monitoring
133	Roof electronics	Front pass. memory seat electr.	Rear memory seat electronics	Park distance regulation
134	Auxiliary heater *)	Electronic ignition lock	Wiper electronics	---
135	Tow hitch control unit *)	Centr. operator display unit, front	Centr. operator display unit, rear	---
		Infotainment CAN data bus		
140	Single wire/ dual wire	Radio	Navigation	Telephone
141	Voice activation *)	CD changer *)	Gateway *)	Telematics *)
142	Operator display unit, front	Operator display unit, rear	---	Dash panel insert *)
143	Digital sound system	Multi-function steering wheel *)	Auxiliary heater	---

*) Special equipment / vehicle type

S269_018

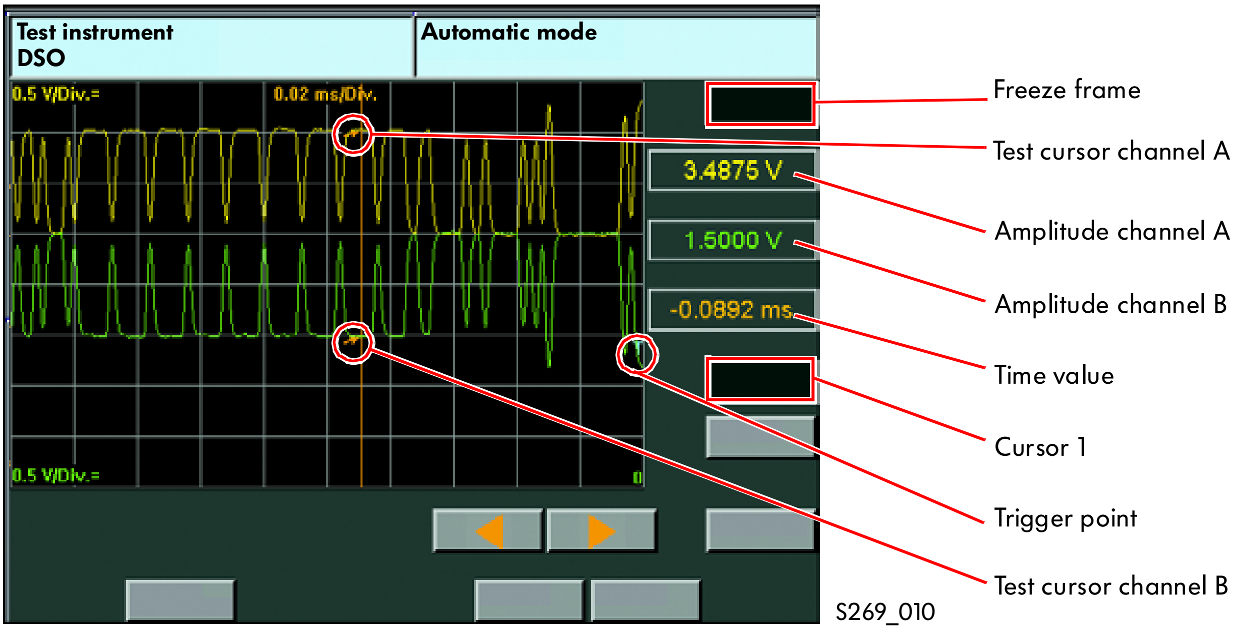
Assignment can deviate slightly from the example illustrated! Please note clear text on display groups and select other display group, if necessary.

Representation of CAN signals on DSO

Data transfer without disturbance on the drivetrain CAN data bus

On VAS 5051 the drivetrain CAN data bus is displayed with the highest resolution (0.02ms/ Div and 0.5V/ Div) and the image is then saved (freeze frame).
Due to problems with the resolution, the measurement should not be carried out in peak areas (for example at extreme left or right of image).

Representation of drivetrain CAN data bus on DSO of VAS 5051



S269_010

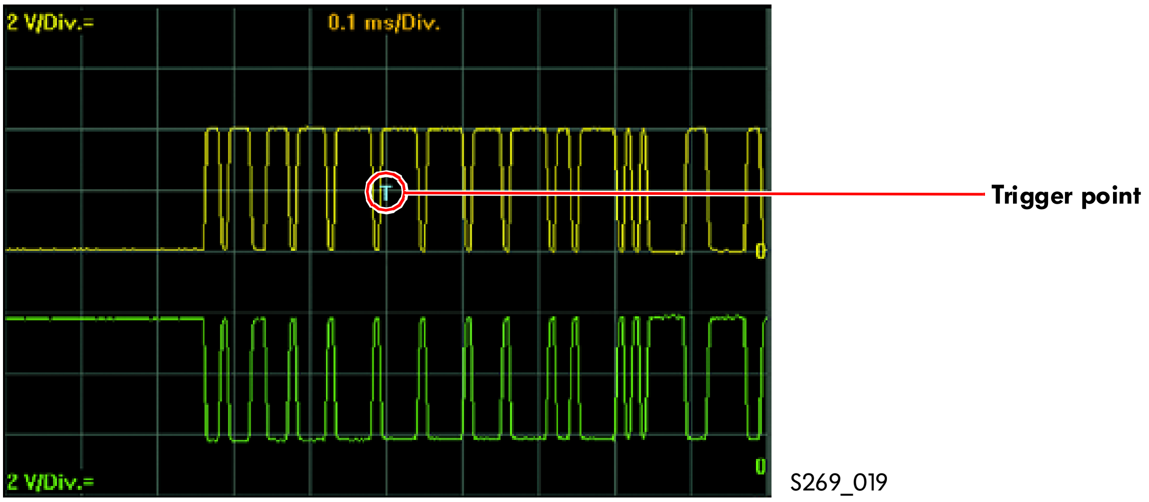
The test cursor should be positioned in the middle of one of the flat impulses to achieve reliable test figures. The displayed measurement shows a drivetrain CAN data bus that has just reached the specified value.

It should be noted that the measured values of the signal levels are determined by the individual control units and therefore completely different voltages can be measured during measurements that follow in succession.
If the signals of other control units are shown, differences of 0.5V are not uncommon.

Data transfer without disturbance on the convenience/ infotainment CAN data bus

Unlike representation of CAN data on the drivetrain CAN data bus, different zero points are selected here for illustration of the CAN data bus in order to maintain a good overview.
As was previously the case, the CAN high wire is shown yellow and the CAN low wire is shown green.
Triggering occurs here at a CAN high level of approx. 2V.

Representation of convenience/ infotainment CAN data bus on DSO of VAS 5051



S269_019

It should be noted that the measured signal values are also determined by individual control units on the convenience/ infotainment CAN data bus. Therefore, succeeding measurements could result in completely different voltages.

Warning:
Contrary to the drivetrain CAN data bus, the convenience/ infotainment CAN data bus always has voltage when the vehicle battery is connected. Checking for open circuit or short circuit can be done using an ohmmeter only when the vehicle battery has been disconnected.

ISO faults

Due to mechanical vibrations of the vehicle, the wiring insulation could be defective as well as open wiring or contact faults in the connectors. For reference purposes there is an **ISO** fault chart.
ISO stands for the "**I**nternational **S**tandards **O**rganisation".
In this ISO fault chart, all the possible CAN data bus faults are presented.
In addition, this SSP covers incorrectly connected wiring (fault 9, page 38). This fault has also been known to occur in practice, although there is no reason why it should.

ISO fault chart

ISO	CAN-High	CAN-Low
1		Open circuit
2	Open circuit	
3		Short to battery$_{voltage}$
4	Short to earth	
5		Short to earth
6	Short to battery$_{voltage}$	
7	Short to CAN low	Short to CAN high
8	Missed R_{term}	Missed R_{term}

S269_020

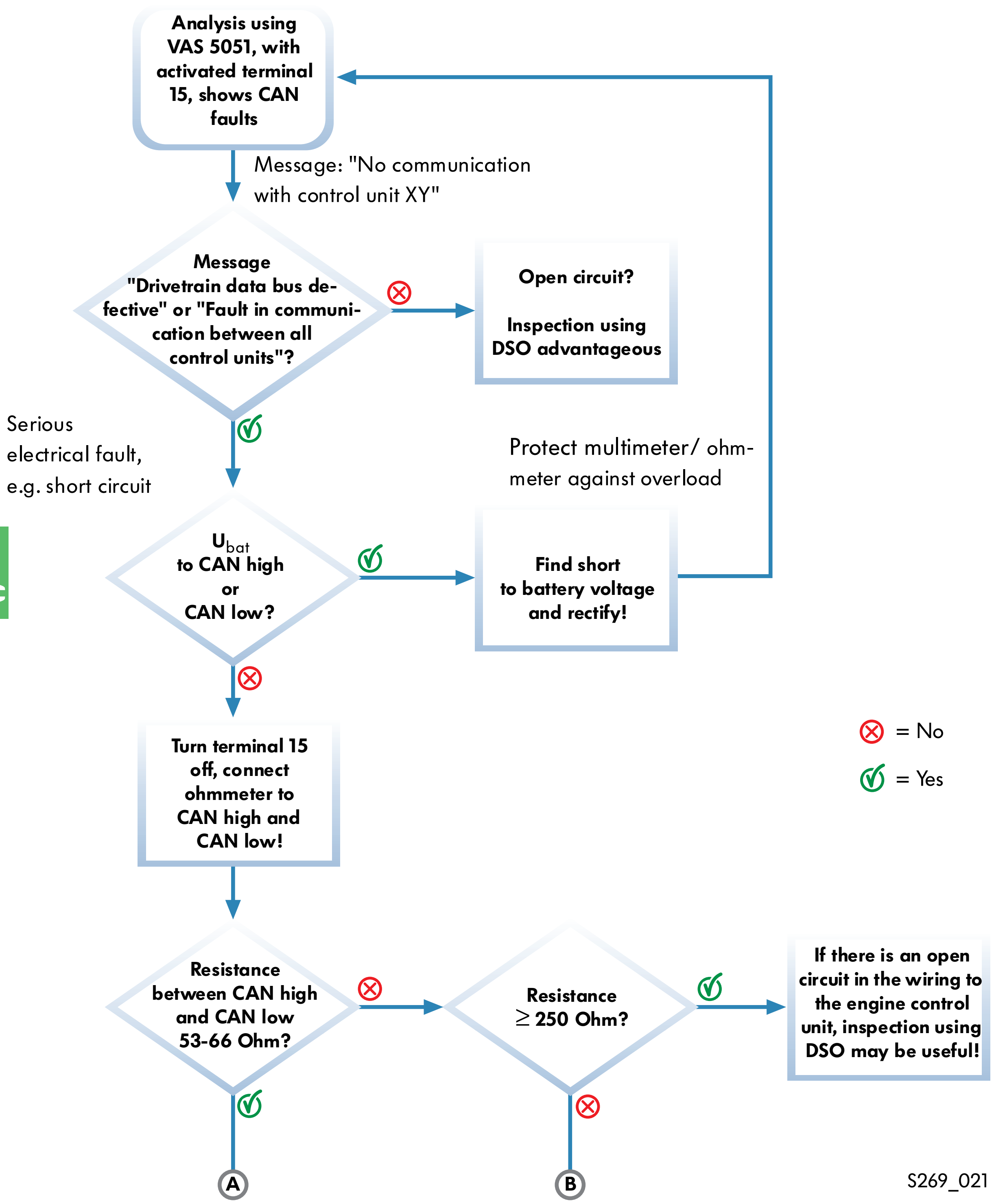
ISO fault 8 can only occur on the drivetrain CAN data bus.

Faults 3 - 8 can be found on the drivetrain CAN data bus using a multimeter/ohmmeter with great accuracy.
For faults 1, 2 and 8, a DSO has to be used.
On the convenience/ infotainment CAN data bus, fault finding is only possible using the DSO.
ISO fault 8 does not occur on the convenience/ infotainment CAN data bus.

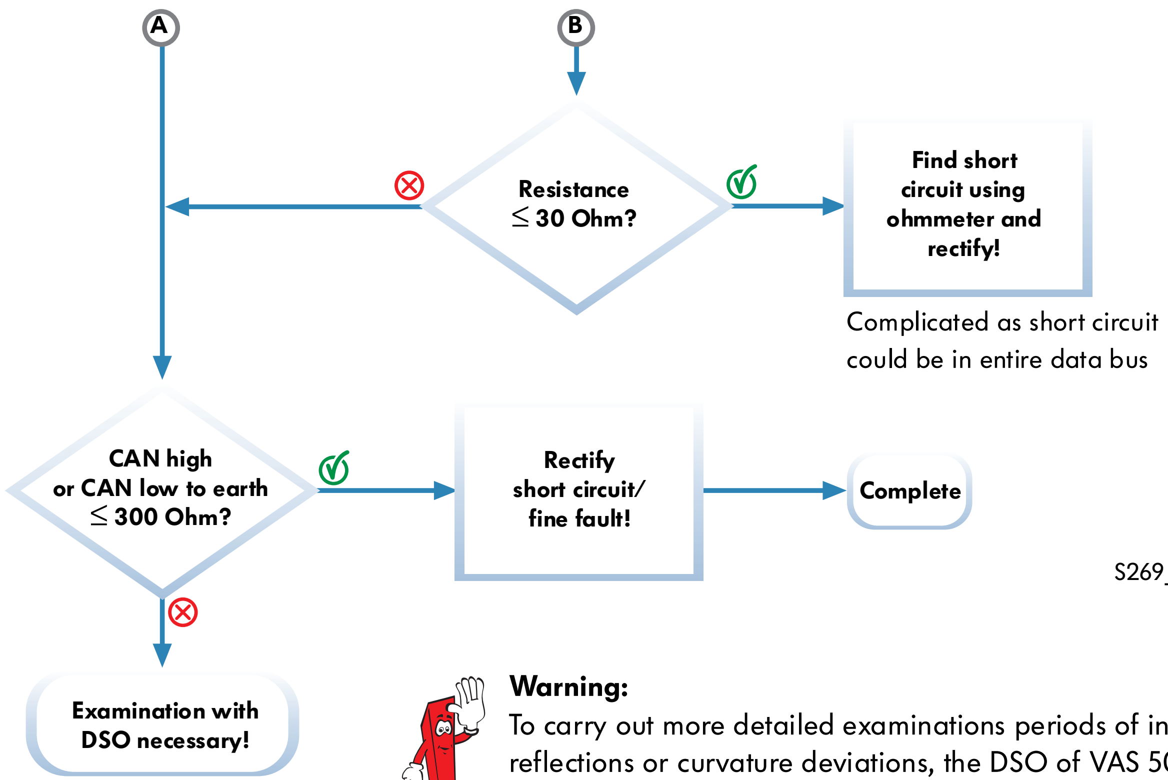
Warning:
For fault descriptions (from page 32), for which fault finding with the DSO makes more sense, the values and trigger settings to be entered in VAS 5051 are shown in addition to the DSO image. These settings must be adhered to without exception. Only then can a diagnosis, as described in the relevant examples, be carried out and steered to the correct result.

Systematic fault finding with VAS 5051 and ohmmeter on the drivetrain CAN data bus

The most common faults on the drivetrain CAN data bus can be evaluated using the integrated multimeter/ ohmmeter of VAS 5051. For some faults, however, the DSO of VAS 5051 is required.
The following tree structure of faults systemises the procedure for fault finding using VAS 5051 and a multimeter/ ohmmeter.



S269_021



S269_021

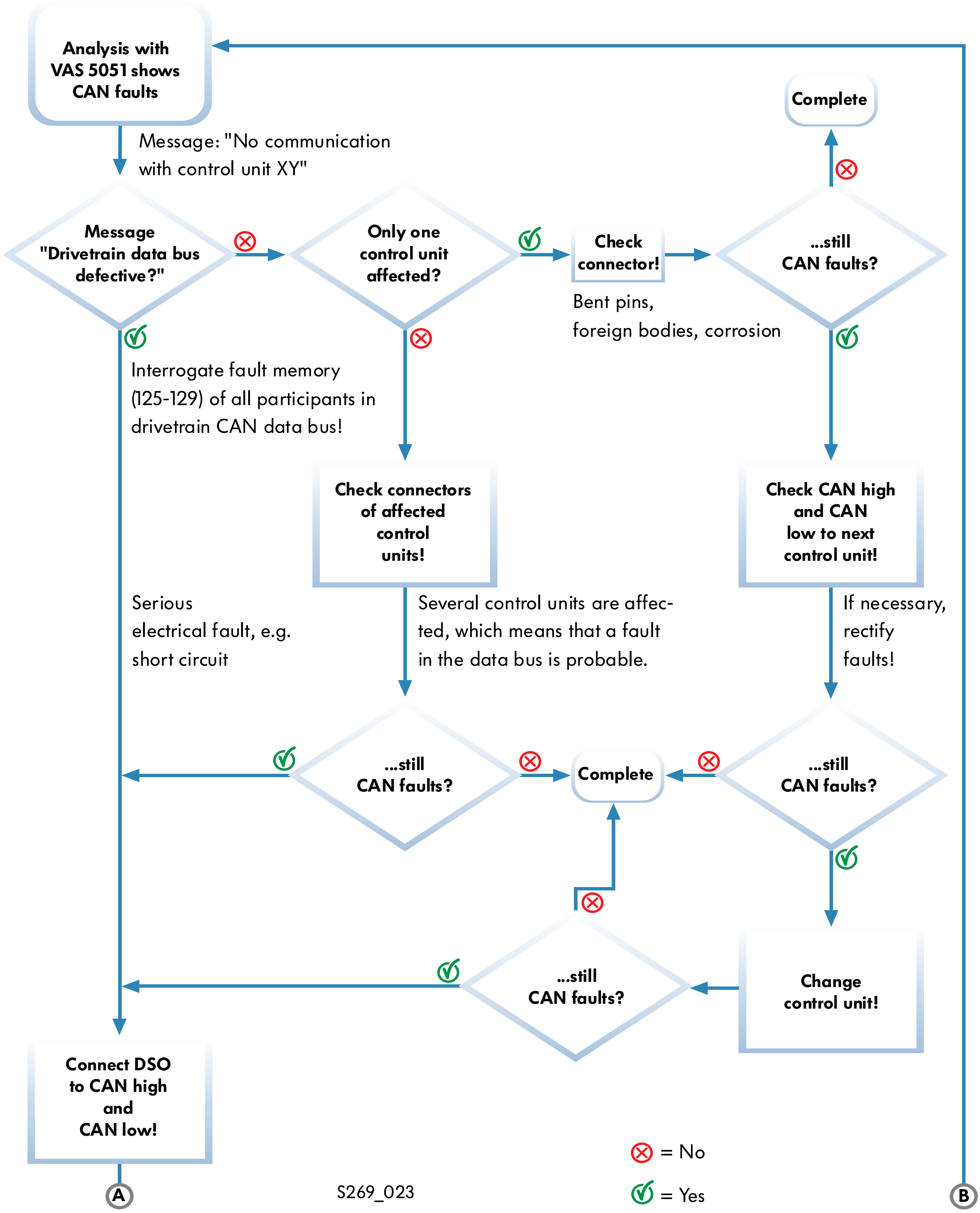
Warning:
To carry out more detailed examinations periods of incline, reflections or curvature deviations, the DSO of VAS 5051 can be used.

On measurements described as follows, for which the DSO of VAS 5051 is used, the trigger threshold must always be adjusted in addition to the period (horizontal) and voltage sensitivity (vertical).
The trigger threshold is the adjustable test voltage on VAS 5051. Recording will start if it is above or below the signal to be measured.
The trigger threshold is shown in the diagrams by the letter "T". It is otherwise not marked in the diagrams. The values for the trigger level used can therefore be found in the text.

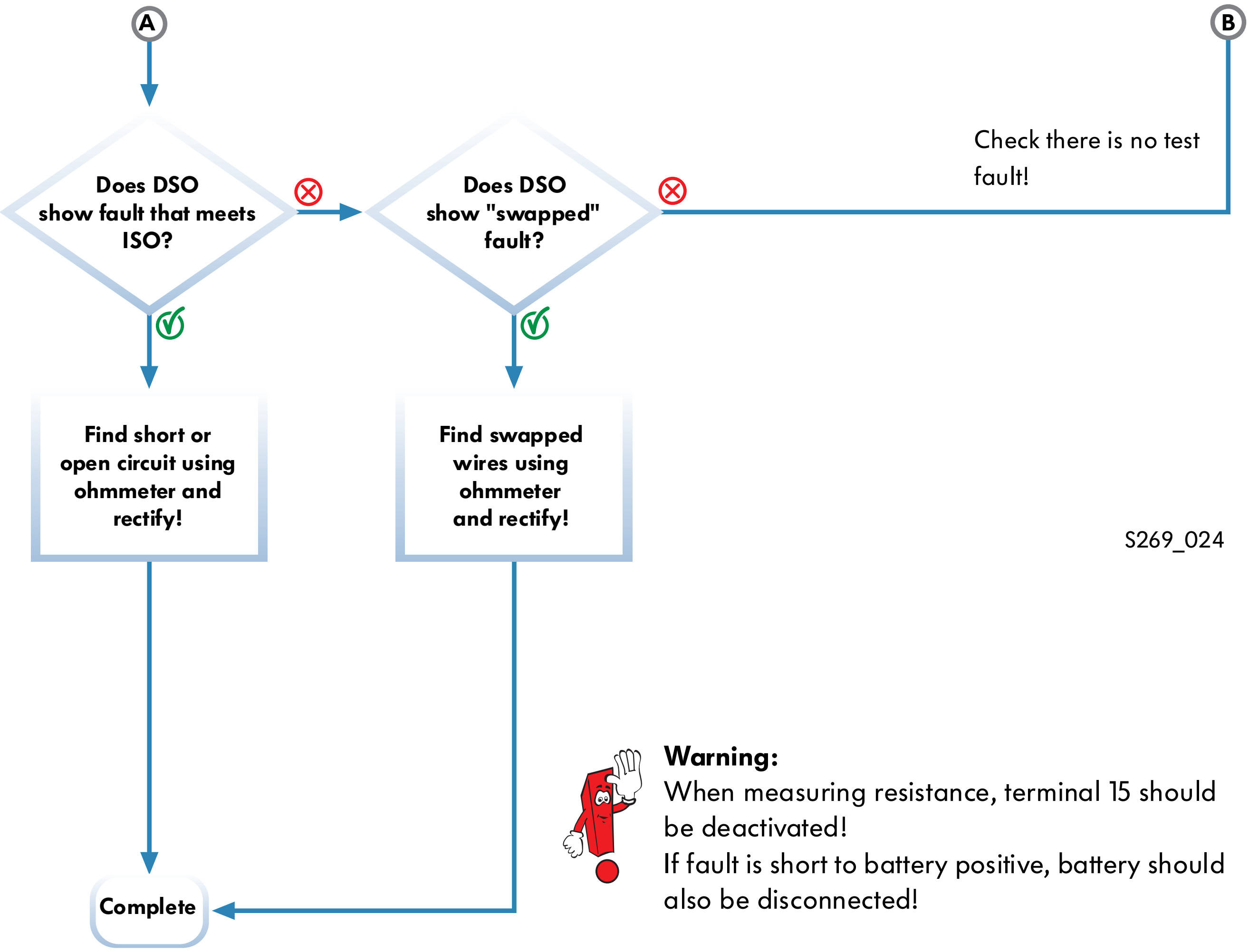
For all tests, the following applies:

- The **CAN high wire** is connected to **channel A** coloured **yellow** on the DSO.
- The **CAN low-wire** is connected to **channel B** coloured **green** on the DSO.
- VAS 5051 earth is applied to the next earth point.

Systematic fault finding with VAS 5051 on the drivetrain CAN data bus



S269_023



S269_024

Warning:
When measuring resistance, terminal 15 should be deactivated!
If fault is short to battery positive, battery should also be disconnected!

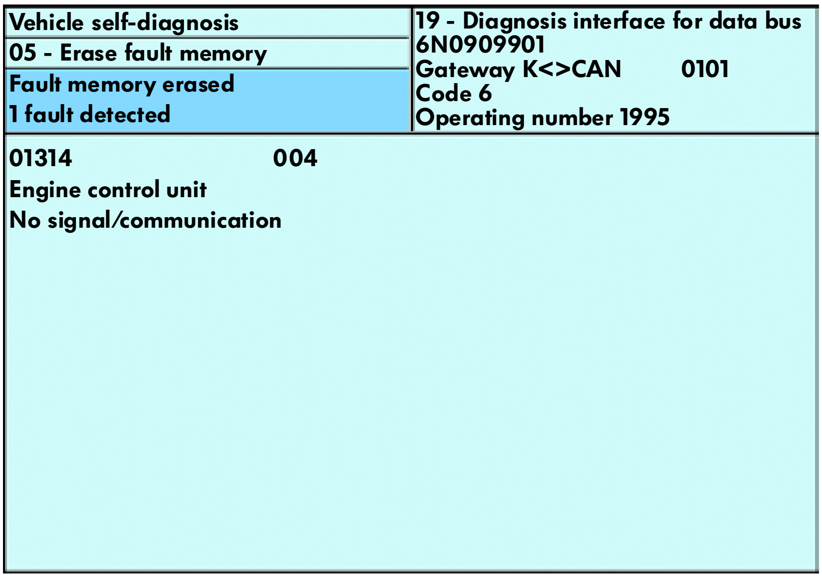
Drivetrain CAN data bus; ISO faults 1 and 2:
Open circuit in CAN data bus wire as on CAN low wire, for example

First, interrogate fault memory and measured value blocks on VAS 5051.

The relevant procedure for interrogating the fault memory via the Gateway and an overview of all measured value blocks can be found in the chapter entitled "Diagnosis instructions" on page 23.

VAS 5051 diagnosis: **"Engine control unit has no signal/ communication"**

Display on VAS 5051:



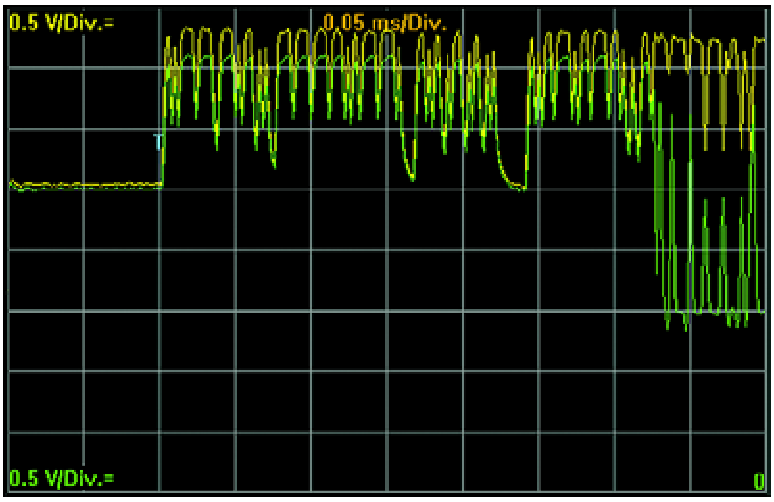
S269_025

The identifying characteristic of this fault is the presence of voltages above 2.5V in the CAN low channel. During normal operation, these voltages are not evident.

Representation of this signal is not possible using the normal trigger setting (for example 3V in channel A) as the faulty sequence does not have to occur as frequently to become visible on the display.
Therefore, use is made of the fact that no voltages above 2.5V are present in the CAN low wire during normal operation for triggering.
The trigger is thus set to channel B at a trigger level of 3V.
If there is now an open circuit in the CAN low wire, voltages above 2.5V will partly be evident in this wire.

This will result in the following fault image:

DSO representation: Open circuit in CAN low wire



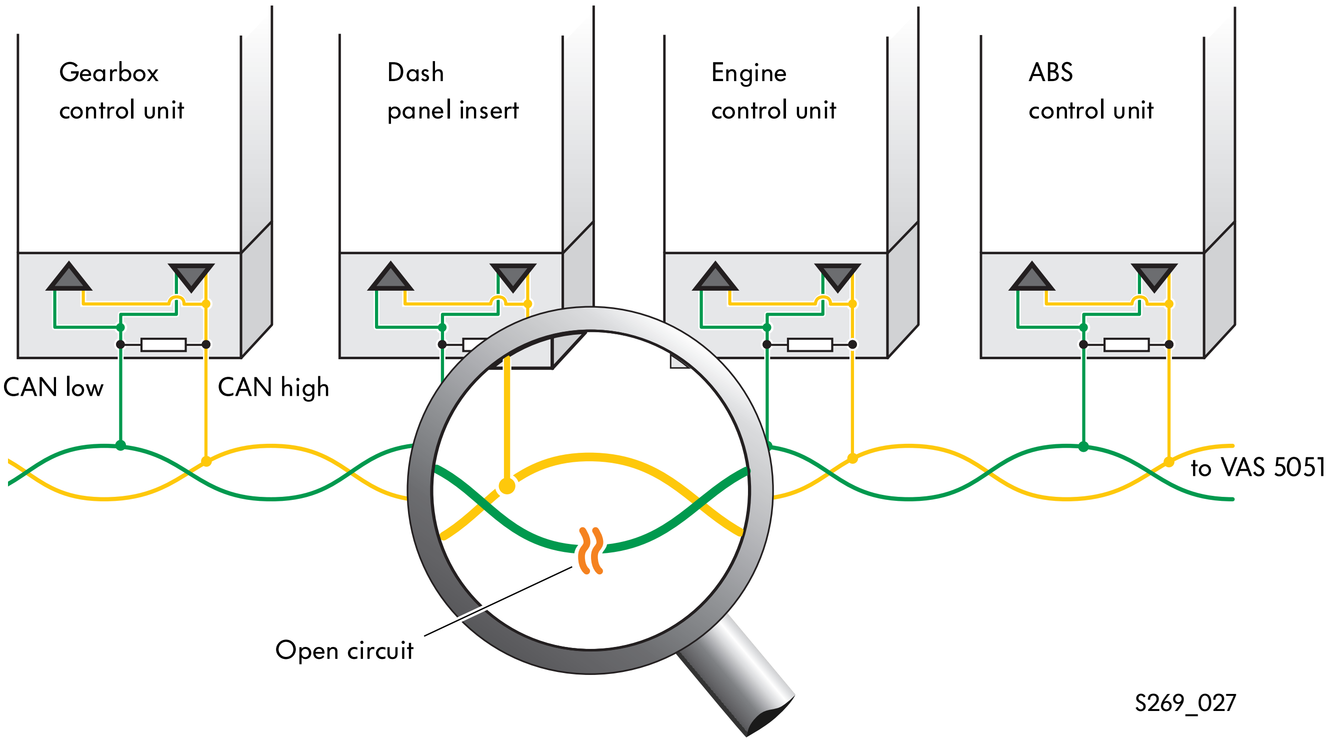
S269_026

The following settings must be made on VAS 5051:
Channel A: **0.5V/ Div**, Channel B: **0.5V/ Div**
Time: **0.05ms/ Div**, Trigger: **Channel B 3V**

To show a fault image for evaluation, the freeze frame function may have to be selected several times in succession in certain circumstances.

ISO faults 1 and 2 on the drivetrain CAN data bus as on the CAN low wire, for example

Fault representation: Open circuit in CAN low wire of engine control unit



S269_027

In this example, voltage can no longer flow to the central matching resistor.
Both wires are now practically at 5V thanks to CAN high.
If other control units are still active, the levels shown in the diagram will be reached alternately for CAN low (right margin of DSO image on page 33).

Further fault finding procedure:

1. Remove connector of relevant control unit and check for bent contacts.
2. Refit connector and check fault memory.

If fault is still shown, continue as follows:

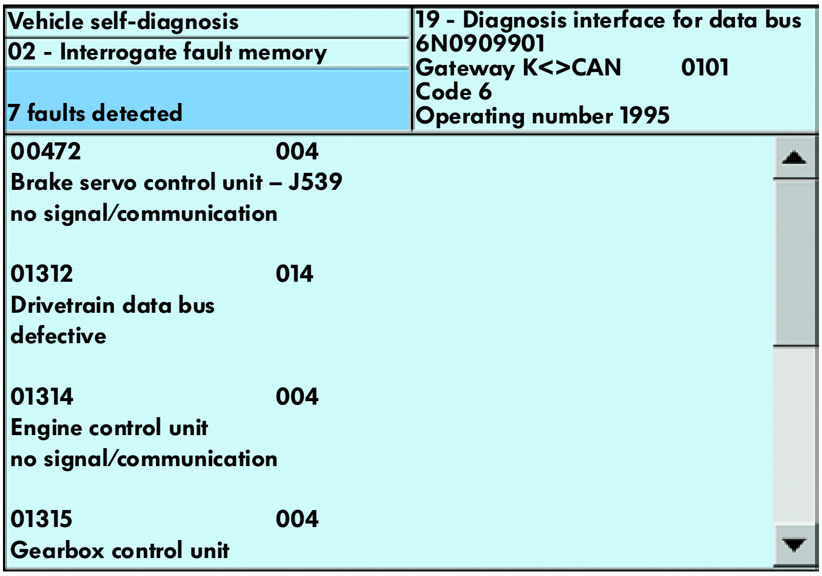
3. Remove connector of control unit with faulty communication once again.
4. Remove connector of control units that, according to wiring diagram, are directly connected to faulty control unit.
5. On CAN low wire, check connection between connector pins for open circuit.

Warning:
If CAN high wire has open circuit, follow same procedure but check CAN high wire instead. Fault image on DSO has now folded downwards and is in a range below 2.5V, the trigger should be set to 1.7V on channel A.

Drivetrain CAN data bus; ISO faults 3-8: Short circuit fault, as on CAN low wire to battery voltage, for example (terminal 30, 12V)

VAS 5051 diagnosis reads among other things: **"Drivetrain data bus defective"**

Display on VAS 5051:



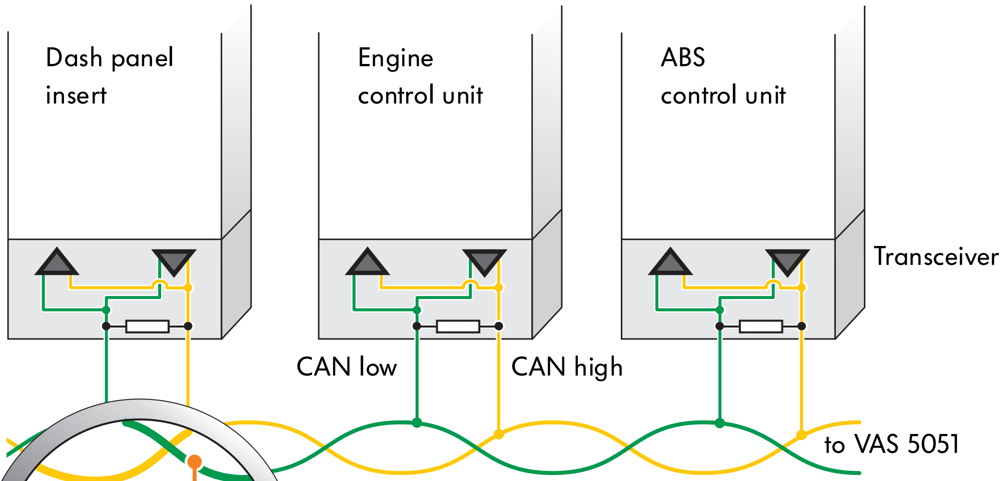
S269_028

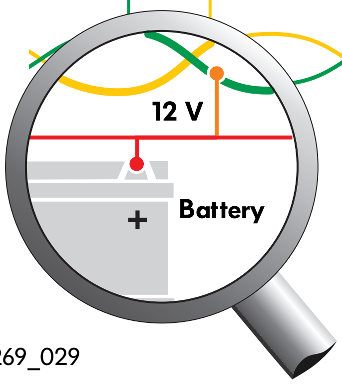
Entries for all control units are in the fault memory. Among other things, there is the message; "Drivetrain data bus defective". This message indicates a short circuit or an open circuit in the data bus directly at the Gateway.

The procedure described can be used here with respect to short circuit to battery voltage (ISO faults 3 and 6), short circuit to earth (ISO faults 4 and 5), short circuit between CAN high and CAN low (ISO fault 7) and missing matching resistors (ISO fault 8).
ISO fault 3 is used to represent all of these short circuits.
On the DSO of VAS 5051, the faults can be rectified with the respective settings, though in the example, a different path to fault diagnosis and rectification is shown.

Warning:
Short circuits (ISO faults 3-7) are relatively hard to find as they could be anywhere in the entire wiring harness. Measuring with the ohmmeter is not very effective as the contact resistance at the point of short circuit is unknown and therefore measuring the resistance is no indication of the length of the wire.

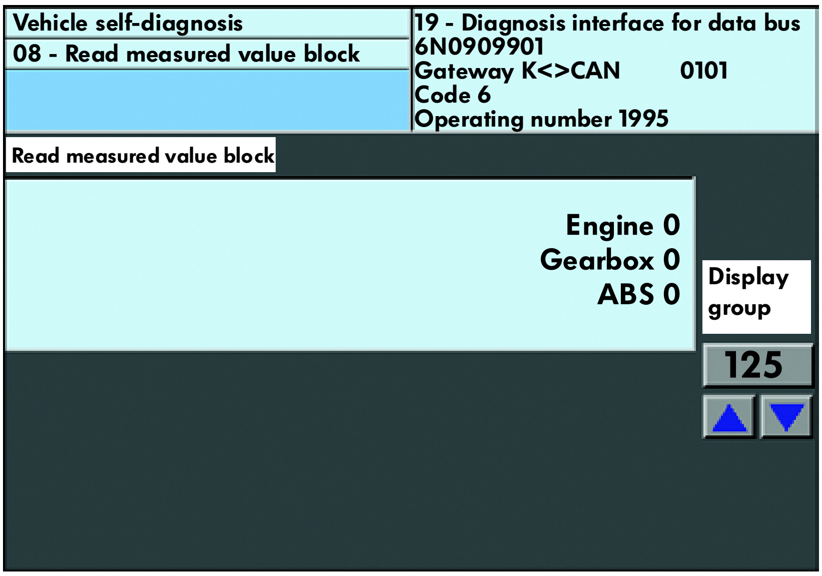
Fault representation: CAN low wire connected to battery voltage





S269_029

Evaluation of the measured value blocks from display group 125 shows communications fault with all control units of drivetrain CAN data bus (page 23).



S269_030

Further fault finding procedures:

1. Check whether short to terminal 30 or terminal 15 is evident.
2. Visually check affected wiring if short circuit is evident.
3. Disconnect control units from data bus individually and check whether short circuit is still evident.
4. Split data bus into sections as far as possible and attempt to localise short circuit.

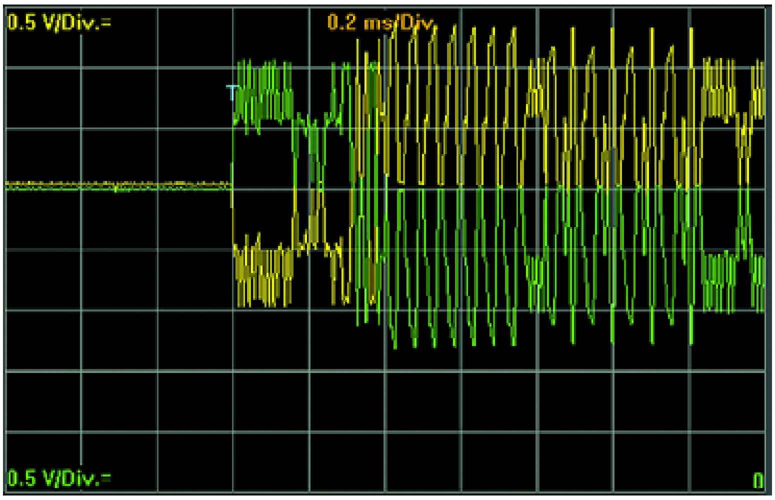
Drivetrain CAN data bus; fault 9:
CAN high wire and CAN low wire swapped over on one or more control units

VAS 5051 diagnosis: **"Engine control unit has no signal/communication"**

One representation of the relevant fault entries on VAS 5051 can be found on page 32 in chapter "ISO faults 1 and 2".

The following settings must be carried out on VAS 5051:
Channel A: **0.5V/ Div**, Channel B: **0.5V/ Div**
Time: **0.2ms/ Div**, Trigger: **Channel B 3.25V**

DSO image: CAN high and CAN low swapped over

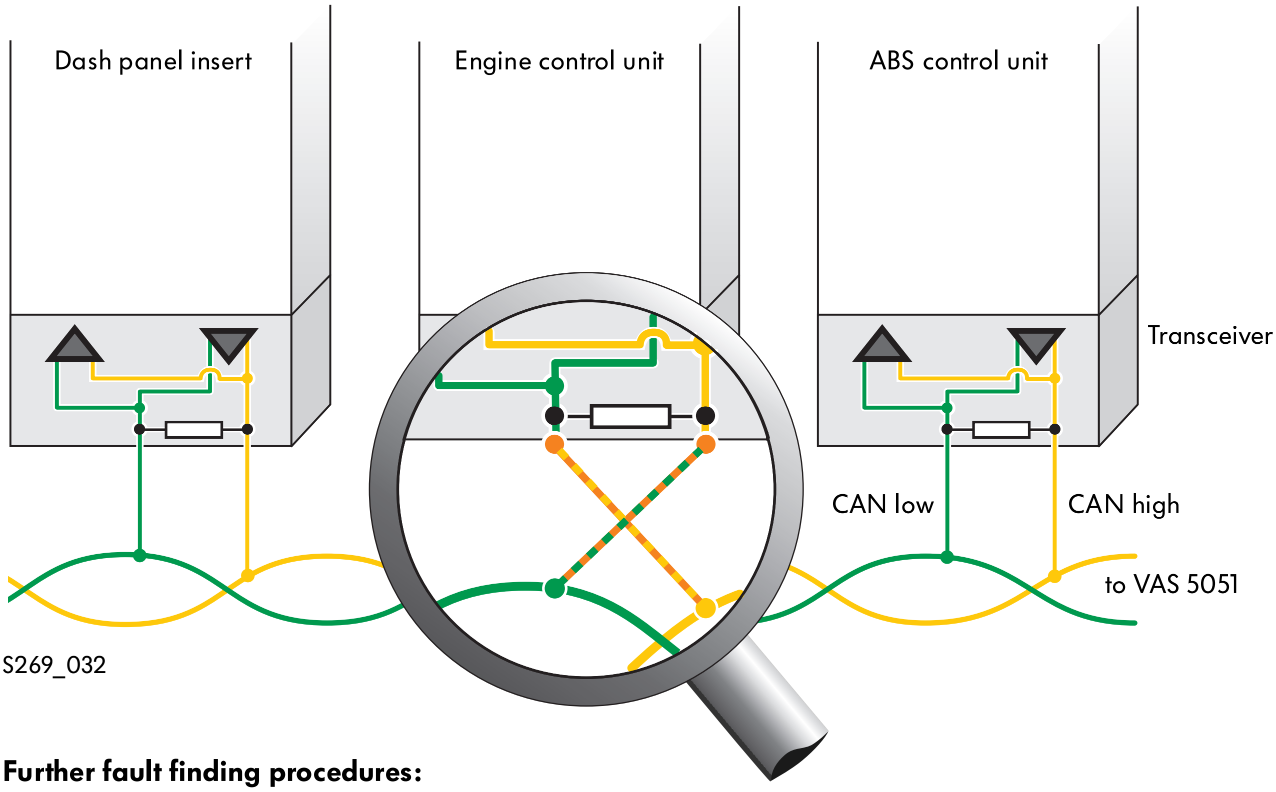


S269_031

A swapped over wire fault results in a voltage pattern in the CAN low wire at above 2.5V (rest level) and this is also used here (in DSO on left: CAN low is higher than 2.5V).

If CAN high and CAN low wires are swapped over on one or a group of control units, a deviation may not immediately be noticeable on the display.
The number of times this occurs could be so minimal that even over a long period of time no faulty sequence will be shown.
Control units with swapped wires are unable, however, of exchanging data and cause faults to occur due to the interruption in the running CAN messages, which results in a greater number of "Error frames" (fault messages on CAN data bus).

Fault: CAN high and CAN low swapped over



S269_032

Further fault finding procedures:

Check wiring of control unit without communication to next control unit (in accordance with wiring diagram) with communication; fault should be between these two control units.

Warning:
This type of fault occurs mainly when new components are installed or if wiring was repaired on or around the data bus!

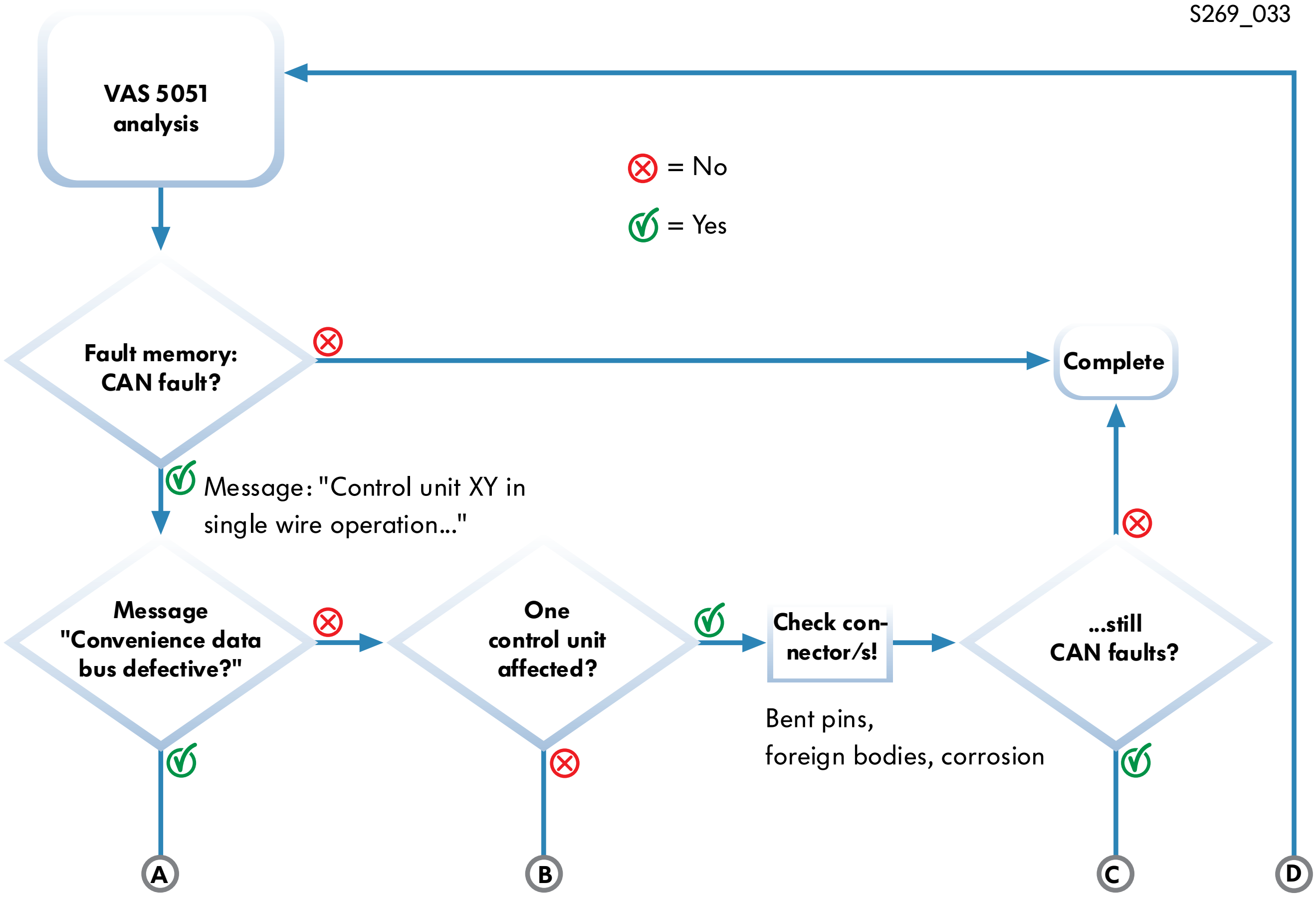
Systematic fault finding with VAS 5051 on convenience/ infotainment CAN data bus

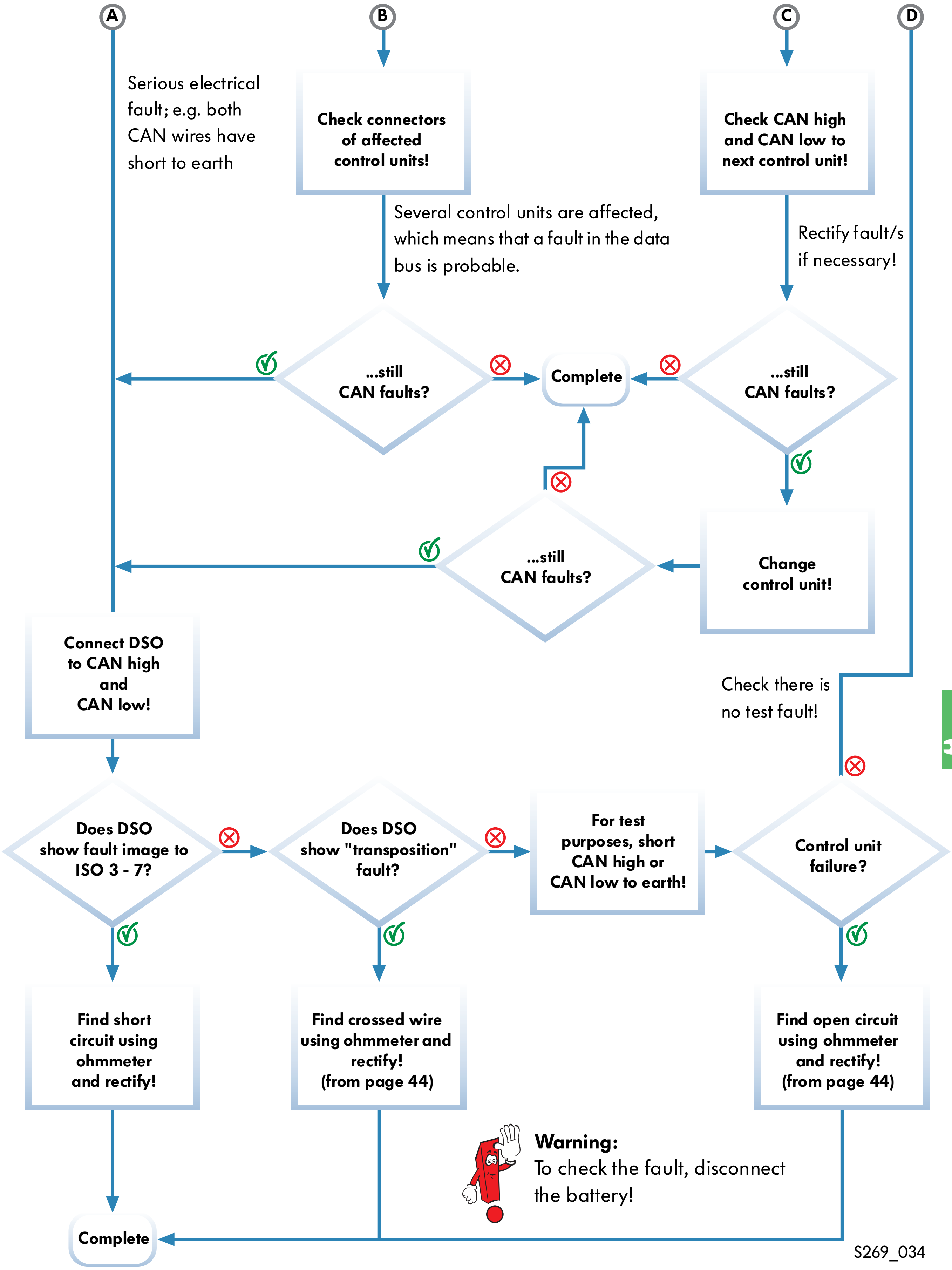
On convenience/ infotainment CAN data bus, the same faults can always occur as on the drivetrain CAN data bus (ISO fault chart on page 26).
Since the CAN wires on the convenience/ infotainment CAN data bus are not dependent on each other and due to the resulting single wire capability as well as the different voltage values for both data bus systems, fault finding on the convenience/ infotainment CAN data is still different compared with the drivetrain CAN data bus.

The starting point for fault finding is always VAS 5051 on the convenience/ infotainment CAN data bus too.
With the aid of this equipment, fault messages from the Gateway can be interrogated.
Not until evaluation of the fault messages results directly in no faults to be rectified, should fault finding be continued using the DSO.
Once the fault has been detected, the multimeter/ ohmmeter should be used carefully to pinpoint its exact location. When doing this, the battery should always be disconnected.

An overview of procedures can be found in this fault finding tree.

S269_033




A
B
C
D
Serious electrical fault; e.g. both CAN wires have short to earth
Check connectors of affected control units!
Several control units are affected, which means that a fault in the data bus is probable.
Check CAN high and CAN low to next control unit!
Rectify fault/s if necessary!
...still CAN faults?
Complete
...still CAN faults?
...still CAN faults?
Change control unit!
Connect DSO to CAN high and CAN low!
Check there is no test fault!
Does DSO show fault image to ISO 3 - 7?
Does DSO show "transposition" fault?
For test purposes, short CAN high or CAN low to earth!
Control unit failure?
Find short circuit using ohmmeter and rectify!
Find crossed wire using ohmmeter and rectify! (from page 44)
Find open circuit using ohmmeter and rectify! (from page 44)
Warning:
To check the fault, disconnect the battery!
Complete

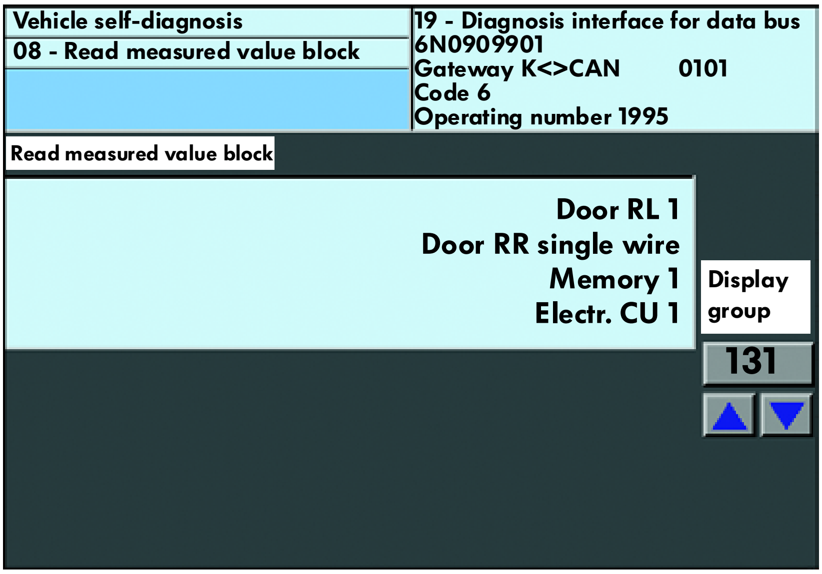
S269_034

Convenience/ infotainment CAN data bus; ISO faults 1 and 2: Wiring open circuit in CAN low or CAN high wire

Short circuits always cause single wire faults on all control units attached to the data bus. If only a few control units are affected (see measured value block below), the fault is likely to be an open circuit in one of the CAN wires. Since evaluation of open circuit faults is not easy using the DSO, the following procedure is used:

The location of the open circuit is already shown in the measured value blocks. The open circuit should always be between the now non-functional control unit and the first fully functional control unit.

Measured value block with open circuit



S269_030

In this case, the "Rear right door control unit" will switch to single wire operation (message; "door RR single wire"), while the other three control units are in dual wire mode (message: "... 1").

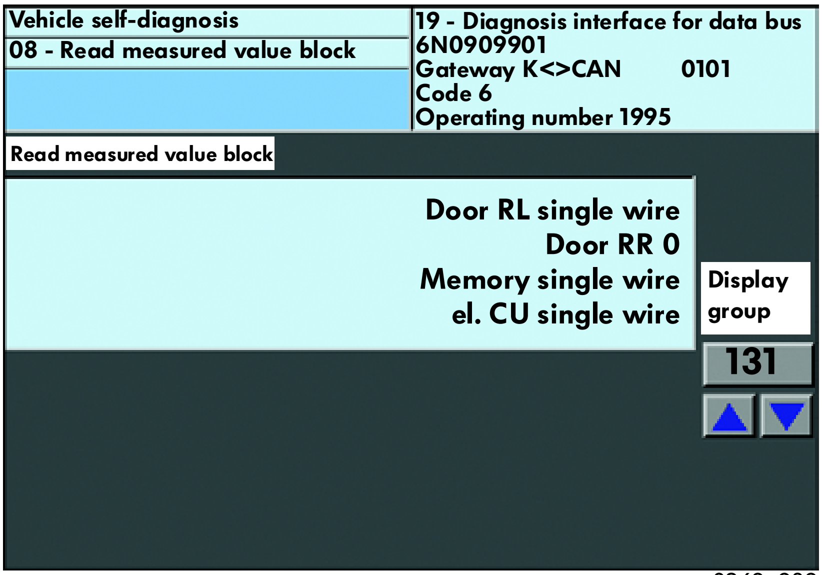
Since the message from VAS 5051 does not indicate concisely which wire has an open circuit, use is made of the fact that the convenience/ infotainment CAN data bus only fails completely if both CAN wires are faulty. Therefore, in the case of an open circuit in one CAN wire, the data bus then operates in single wire mode (page 19).
In order to now check which of the two CAN wires is affected by the open circuit, a short to earth is created in one of the wires (see also "Flow chart for fault finding" on page 45).

ISO faults 1 and 2 on the convenience/ infotainment CAN data bus as on the CAN low wire, for example

Once a short circuit in one CAN wire has been created, data transfer will now continue in single wire mode. VAS 5051 diagnosis will then read: "Convenience data bus in single wire mode". In the measured value blocks, single wire mode will be shown for all control units. If, on the other hand, the intact CAN wire without open circuit is affected by the short circuit, communication with the control units affected by the open circuit is no longer possible.

In this example, all control units continue to operate in single wire mode if there is a short circuit to earth in the CAN low wire (message: "single wire", diagram on page 46). This means that the open circuit must be in the CAN low wire since the data bus would otherwise fail completely from the point of the open circuit.
As a control measure, a short circuit is now created in the CAN high wire (diagr.: "Measured value block with open circuit and single wire mode", bottom).

Measured value block with open circuit and single wire mode



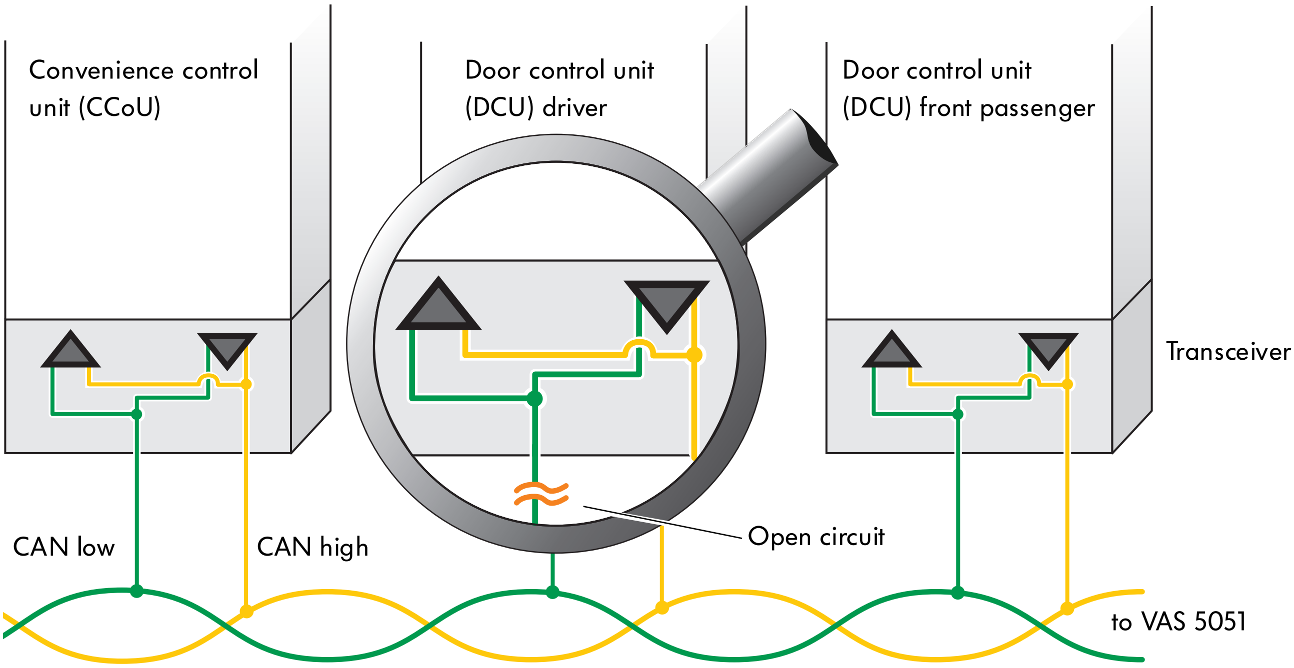
S269_030

VAS 5051 will report that all control units are in single wire mode and that the "Rear right door control unit" has no communication (message: "door RR 0"). Therefore, a connection to the "rear right control unit" in the CAN low wire is affected by the open circuit .

Using the current flow diagram of the vehicle, determine where the "rear right door control unit" is connected to the convenience wiring harness and which of the functioning control units is next in line from the wiring side to the "rear right door control unit".
The wiring open circuit should be between these two control units.
The wiring connectors are a common fault source (fault image and flow chart for fault finding can be found on the following pages).

Fault localisation

Representation of wiring open circuit in one CAN wire, using CAN low wire as an example



S269_035

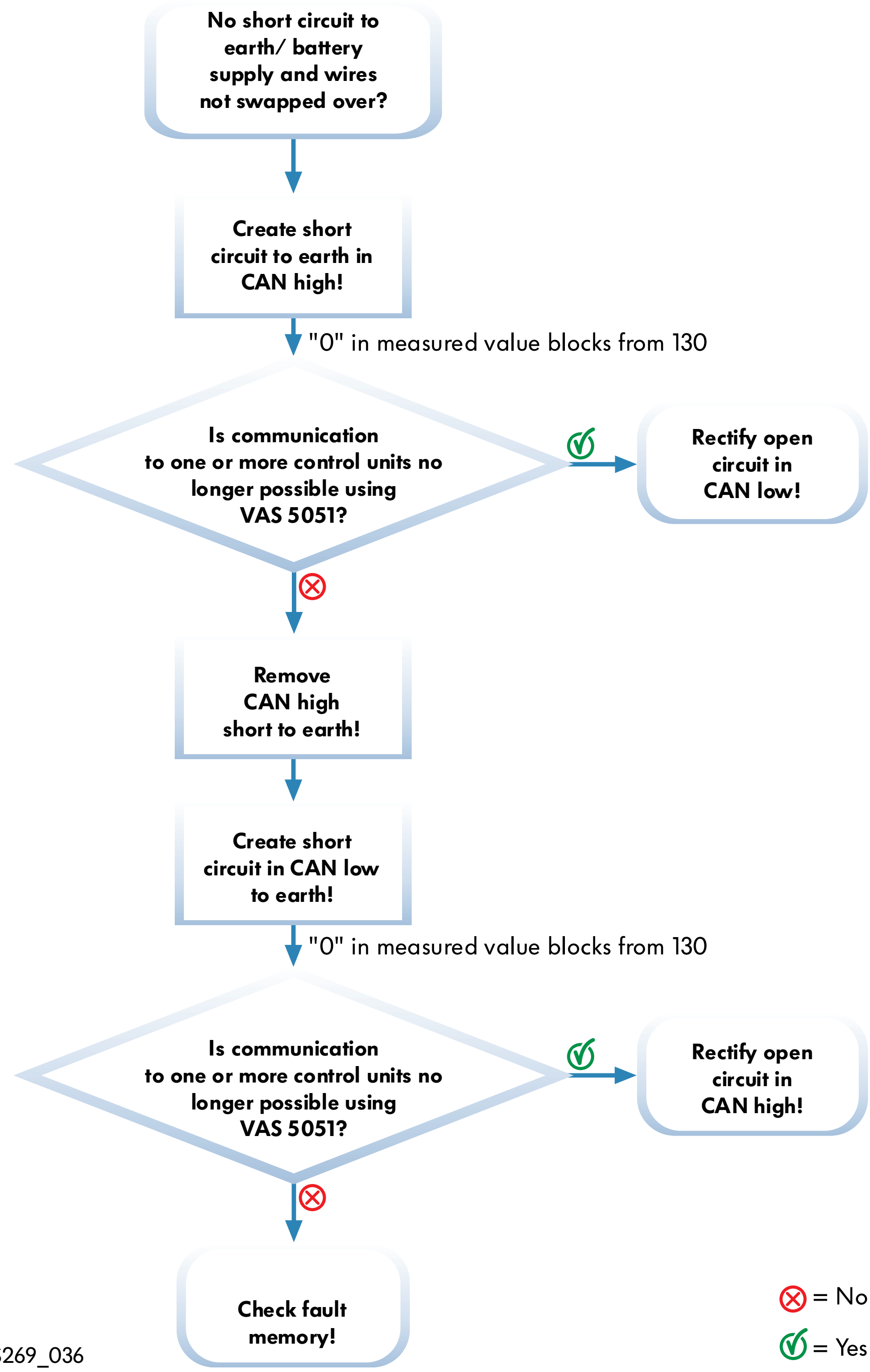
Once faulty control unit has been localised,...

1. ... remove connector,
2. ... check for missing, bent or corroded pins,
3. ... refit connector,
4. ...check whether fault has been rectified.

If fault cannot be rectified in this way, fault finding should be continued using an ohmmeter:

When fault finding using an ohmmeter, the battery should be disconnected as the convenience data bus could become active in certain circumstances and lead to unusable test results.
The CAN wire with the open circuit can then be tested using the ohmmeter. Check cable and connector and renew if necessary! In the following fault example, there is no electrical connection between the relevant pins for CAN low in the driver's door control unit and the convenience control unit. With this in mind, the fault must be traceable to a fault contact in the connector or a break in the wiring. If this is not the case, the control unit should be renewed.

Flow chart for fault finding with ISO faults 1 and 2 (single wire mode)

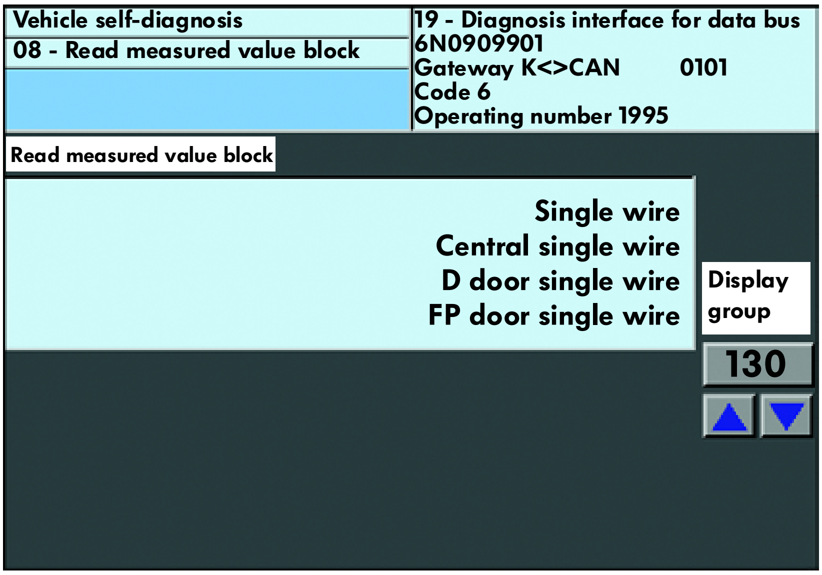


S269_036

Convenience/ infotainment CAN data bus; ISO faults 3 and 6: Short circuit in one CAN wire to battery positive (terminal 30, 12V) as on CAN low wire, for example

VAS 5051 diagnosis: "**Convenience data bus single wire**".
In the measured value blocks, single wire mode will be shown for all control units.

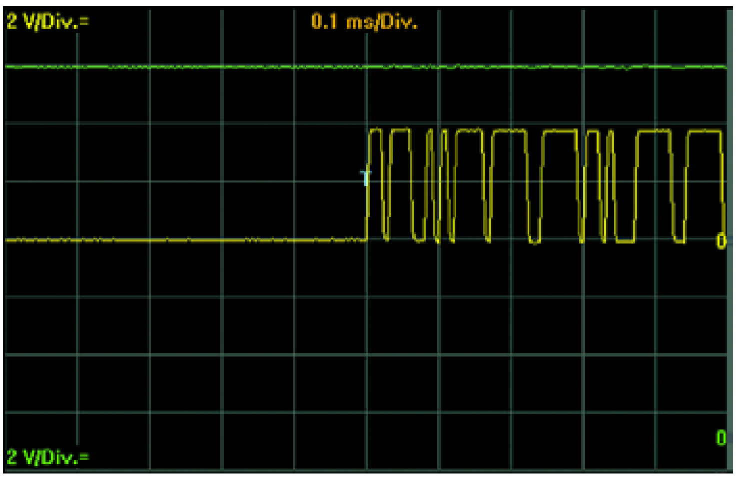
Measured value block with open circuit



S269_030

The following settings must be carried out on VAS 5051:
Channel A: **2V/ Div**, Channel B: **2V/ Div**
Time: **0.02ms/ Div**, Trigger (for **CAN low** to 12V): **Channel A 2V**
Trigger (for **CAN high** to 12V): **Channel B 2V**

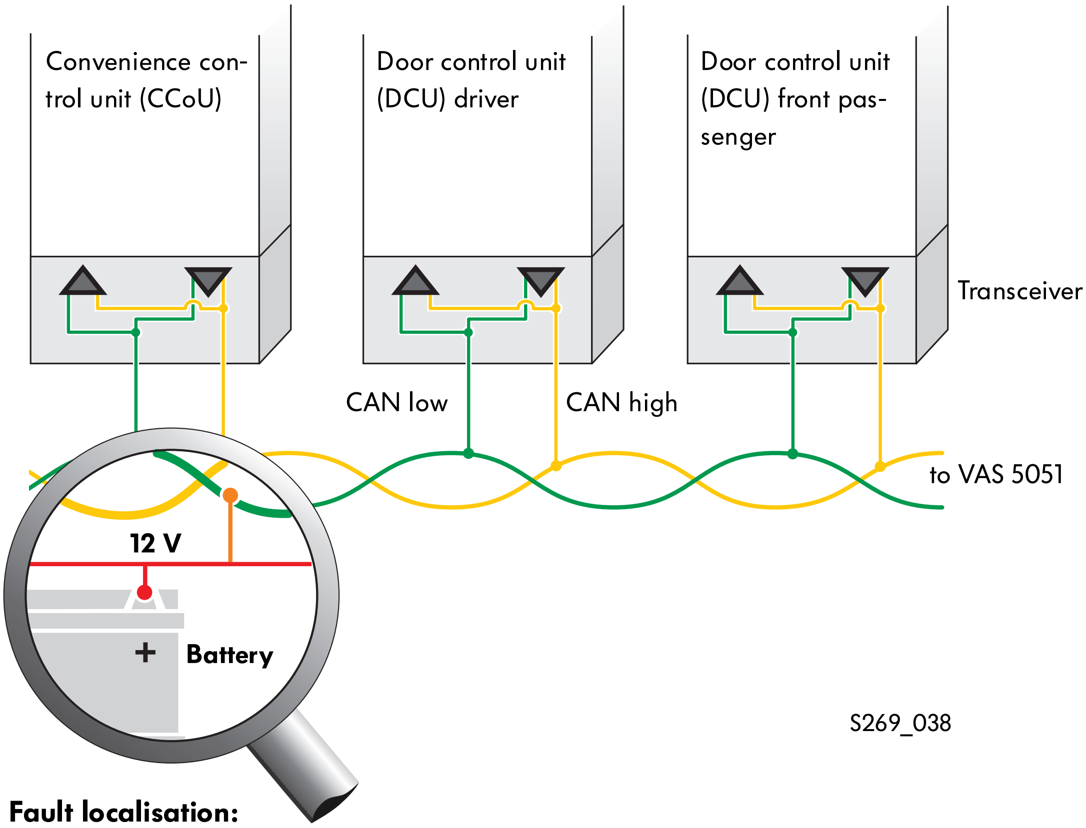
DSO image: CAN high signal on short in CAN low wire to battery positive



S269_037

It is typical in this fault instance for the CAN low wire to be shown supplied with battery power in the DSO (see bottom left illustration) and for the CAN high wire to continue to provide a signal.
The SLEEP mode differs from a short circuit of this type in the CAN low wire to battery positive due to a constant 0V level without visible effects on the CAN high wire.

Fault representation: CAN low wire connected to battery voltage



S269_038

Fault localisation:

The location of a short circuit fault in an auxiliary wiring harness is generally very difficult to find. Therefore, the first step should be to visually check the wiring for damage. If this does not lead to a result, proceed by removing the connectors of the control units individually and checking for bent pins, remains of wiring or similar. When doing this, monitor the short circuit using an ohmmeter so that it can be determined whether a control unit is causing the short circuit.
If this measure is also unsuccessful, the wiring harness should be disconnected step by step by first removing the connectors in the doors, for example. In this way, the fault can be limited to one part of the wiring harness.

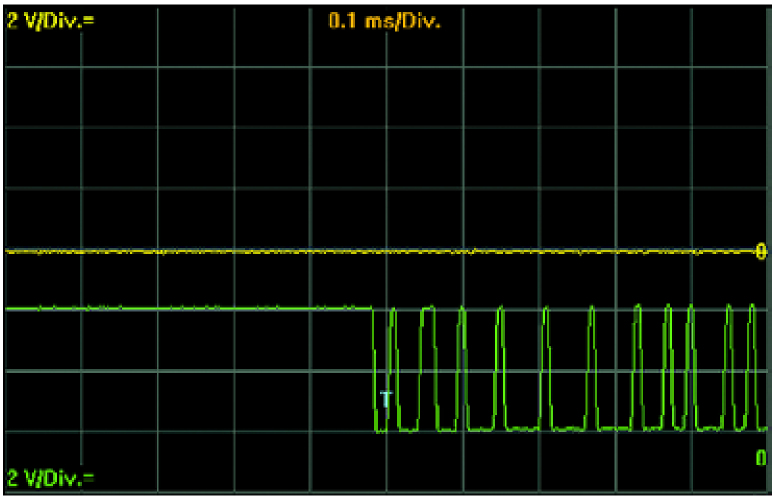
Convenience/ infotainment CAN data bus; ISO faults 4 and 5:
Short circuit in one CAN wire to earth (0V) as on CAN high wire, for example

VAS 5051 diagnosis reads: **"Data bus in single wire mode"**

Message and content of **measured value blocks** indicate ISO faults 3 and 6 (diagram on page 46).

The following settings must be carried out on VAS 5051:
Channel A: **2V/ Div**, Channel B: **2V/ Div**
Time: **0.02ms/ Div**, Trigger (for **CAN low** to 0V): **Channel A 2V**
Trigger (for **CAN high** to 0V): **Channel B 2V**

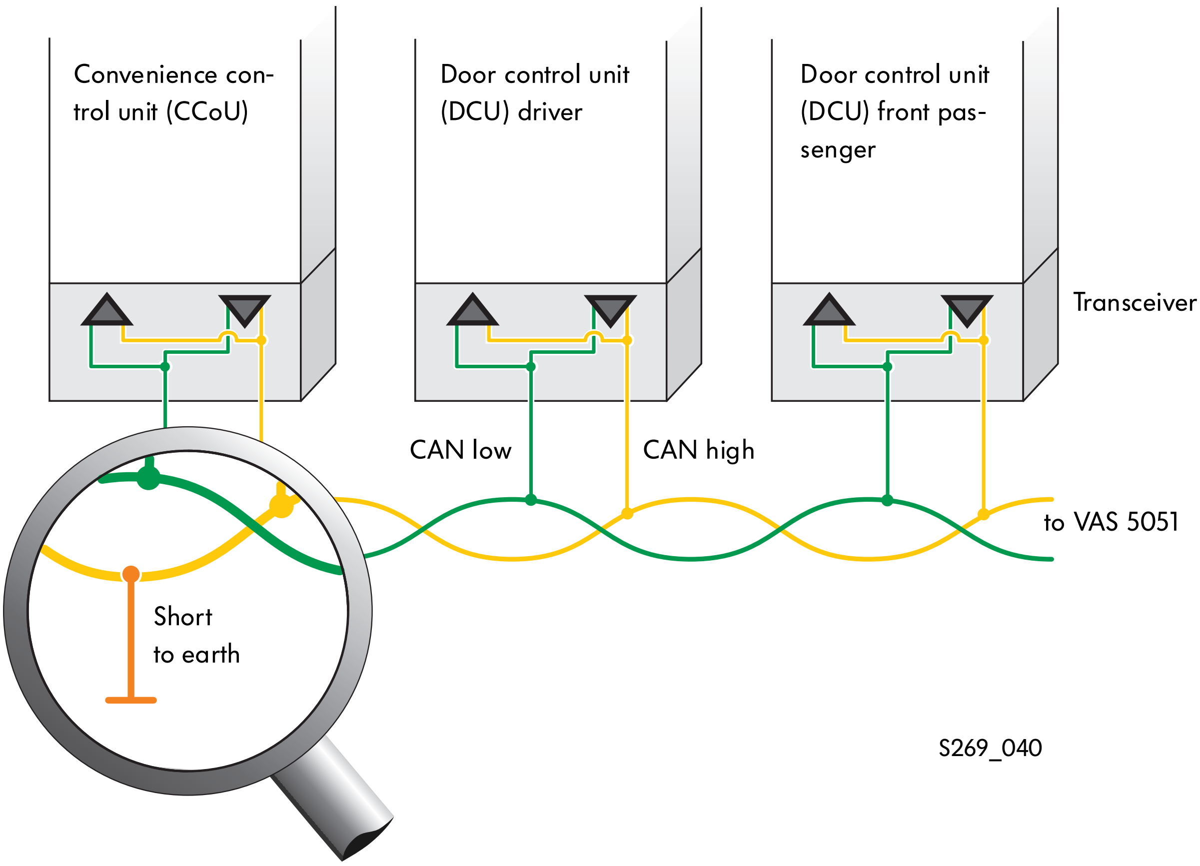
DSO display: CAN low signal when CAN high signal has short circuit to earth



S269_039

A typical instance is the CAN high signal applied to earth. Unlike an open circuit, there are no "normal" CAN signals here either! The CAN high signal remains permanently at 0V.

Fault representation: CAN high wire connected to earth



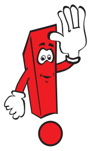
Fault localisation:

Matches description for ISO faults 3-6 (page 47).

Convenience/ infotainment CAN data bus; ISO fault 7: Short in CAN high to CAN low

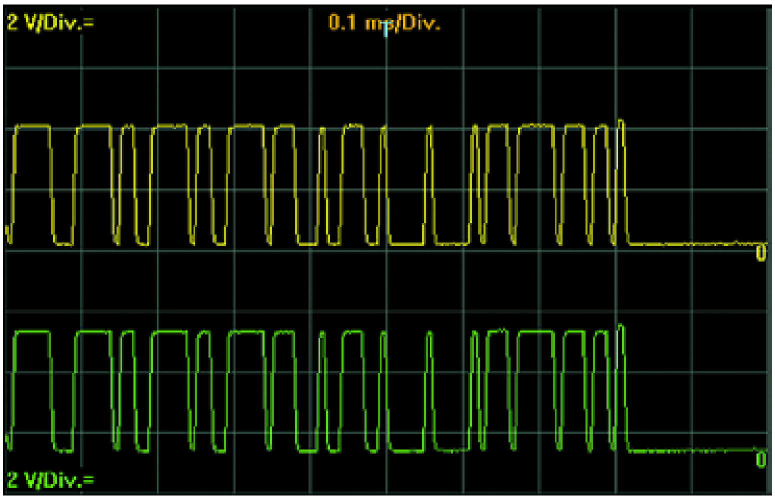
VAS 5051 diagnosis reads: **"Data bus in single wire mode"**

Message and content of **measured value blocks** indicate ISO faults 3 and 6 (diagram on page 46).



The following settings must be carried out on VAS 5051:
Channel A: **2V/ Div**, Channel B: **2V/ Div**
Time: **0.02ms/ Div**, Trigger: **Channel A 2V**

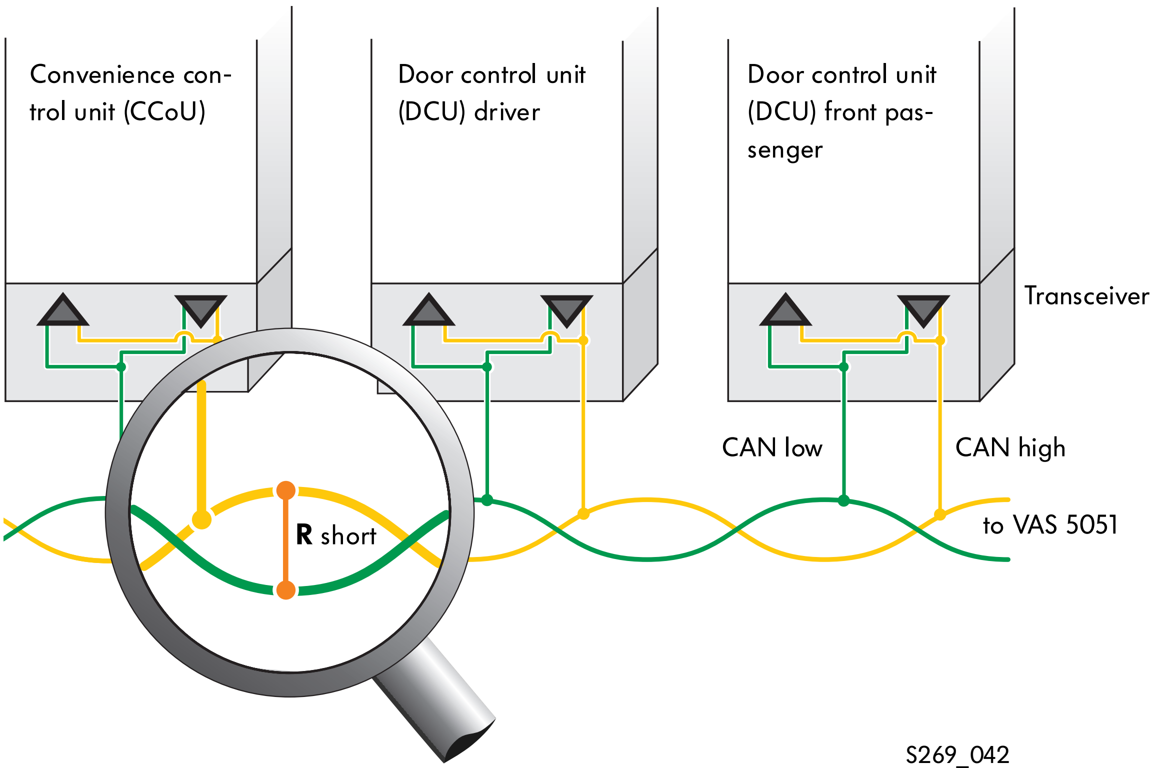
DSO representation: Short in CAN high wire to CAN low wire



S269_041

This fault is also clear. Both CAN wires maintain the same level.
Here, the CAN transceiver has deactivated the CAN low wire and now only works with the CAN high wire.

Fault representation: Short in CAN high wire to CAN low wire



S269_042

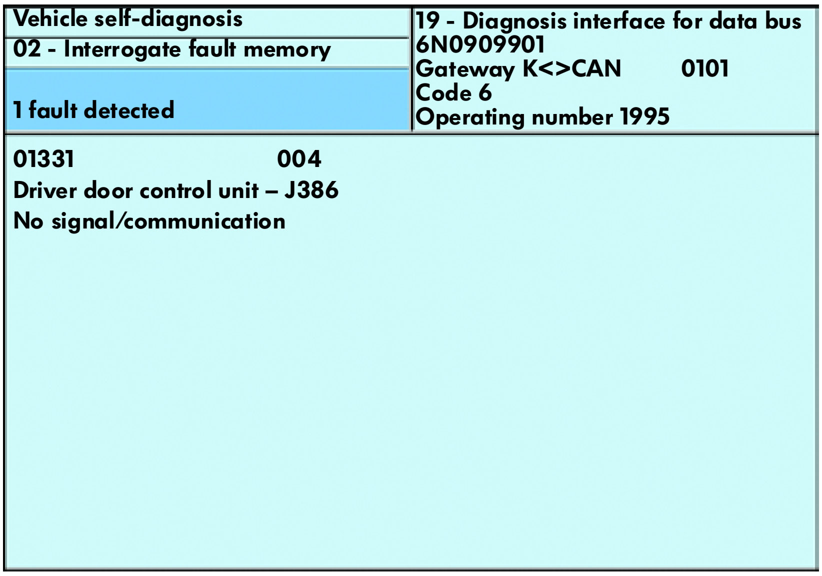
Fault localisation:

Matches description for ISO faults 3-6 (page 47).

Convenience/ infotainment CAN data bus; fault 9:
CAN high and CAN low wires swapped over on one or more control units

A break down in communication will only occur on the convenience/ infotainment CAN data bus if both wires are faulty or if one wire is swapped over (see example).

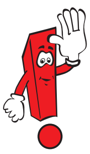
Fault memory excerpt where complete control unit has failed


Vehicle self-diagnosis
02 - Interrogate fault memory
1 fault detected

19 - Diagnosis interface for data bus
6N0909901
Gateway K<>CAN 0101
Code 6
Operating number 1995

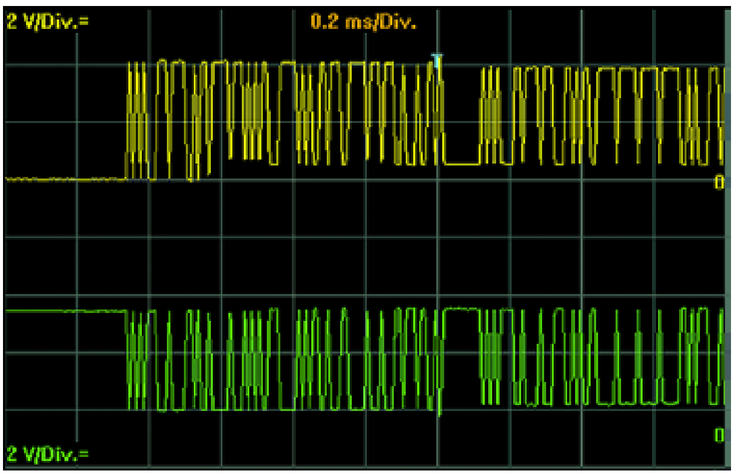
01331 004
Driver door control unit – J386
No signal/communication

S269_025



The following settings must be carried out on VAS 5051:
Channel A: **2V/ Div**, Channel B: **2V/ Div**
Time: **0.2ms/ Div**, Trigger: **Channel B 2V**

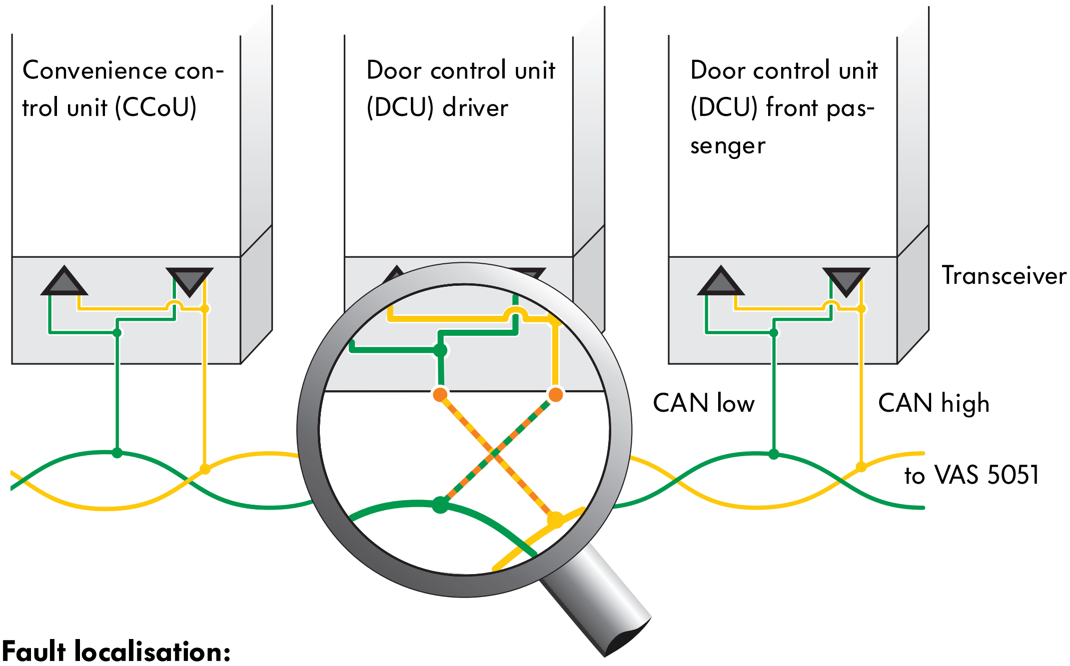
DSO image: CAN high and CAN low swapped over



S269_043

It is evident that there is movement in the recessive level (in left margin of oscillogramme).
If the wires are swapped over at one control unit, the recessive state will result in an increase in voltage in the CAN high wire and a reduction in voltage in the CAN low wire.

Fault: CAN high and CAN low swapped over



S269_044

Fault localisation:

The swapped wires can always be found in the connection from the last functioning control unit to the first non-functioning control unit.
Wires are often swapped over during repairs to the data bus and these areas should always be checked carefully. The check should be carried out visually using the colour coded wiring.
To rectify the fault, the battery should be disconnected as the convenience/ infotainment CAN data bus could become active when testing and lead to unusable test results. The CAN wires that are swapped over can now be checked using the ohmmeter.
In the fault example, there should be an electrical connection between the relevant pins of CAN low in the driver door control unit and CAN high in the convenience control unit, as well as between CAN low in the convenience control unit and CAN high in the driver door control unit. If the wiring is swapped over in the connector, this fault will also be evident at the other control units.
In each case, it is recommended that the connectors of each inaccessible control unit are checked first.

Test yourself

Drivetrain CAN data bus

1. Why must the CAN signals be checked using a storage oscilloscope?

❑ a) The data is too small for a normal oscilloscope.

❑ b) The data is not repeated, on a normal oscilloscope only a blurred image would be visible which cannot be evaluated.

❑ c) Provision must be made to print out the data.

2. Where can I find the diagnosis data for the drivetrain CAN data bus on the Polo (MY2002)?

❑ a) In the dash panel insert.

❑ b) In the measured value blocks from 125 in the Gateway.

❑ c) In the onboard supply control unit.

3. Why should I not use the ohmmeter to measure the drivetrain CAN data bus wire during operation?

❑ a) Because the measuring range is not sufficient for the resistances.

❑ b) Because the data bus is supplied with energy during operation and this leads to faulty measurements.

❑ c) Because the data bus would malfunction if I connected an ohmmeter.

4. Why does the drivetrain CAN data bus fail completely if there is an open circuit in CAN high or CAN low?

❑ a) Because current must flow through the "central matching resistor" in order to generate a CAN signal.

❑ b) Because power supply to the control units would be interrupted.

❑ c) Because the CAN signal reflections are too high.

5. **How is a short circuit between CAN wire and earth found?**

❑ a) By measuring with the ohmmeter.

❑ b) By visually checking the wiring harness and connectors.

❑ c) By disconnecting the wiring harness at suitable points.

6. **How can I detect swapped wires on the drivetrain CAN data bus?**

❑ a) By following the wiring back in the wiring harness.

❑ b) Due to fact that CAN high is partly in a range from 1.5V..2.5V.

❑ c) Data bus will then have high ohms.

7. **From what changes in the CAN signals can I detect a CAN high open circuit in the drivetrain CAN data bus?**

❑ a) CAN high is below +2.5V.

❑ b) All signals are above +5V.

❑ c) CAN low is above +2.5V.

8. **How can I detect a short circuit in CAN low to earth by the CAN signal?**

❑ a) CAN high will continue to operate normally.

❑ b) CAN low is always connected to earth.

❑ c) The recessive level for both signals is markedly below 2V.

Answers:

1. b)
2. b), c)
3. b)
4. a)
5. a), b), c)
6. b)
7. a)
8. b), c)

Test yourself

Convenience/ infotainment CAN data bus

1. What is a "fault tolerant transceiver"?

❑ a) A combined receiver and sender for CAN signals which can balance a wiring open circuit or a wiring short circuit to earth.

❑ b) Mechanically, a very non-sensitive CAN component.

❑ c) A high performance amplifier and receiver for CAN signals.

2. The convenience CAN data bus has CAN low connected to battery positive and CAN high connected to earth. What is this condition?

❑ a) Short in CAN low to battery positive.

❑ b) Open circuit in CAN high.

❑ c) "Sleep mode".

3. The convenience/ infotainment CAN data bus has CAN low connected to battery positive and CAN high is operating as normal. What is this condition?

❑ a) Short in CAN low to battery positive.

❑ b) Open circuit in CAN high.

❑ c) "Sleep mode".

4. What is meant by convenience CAN data bus in single wire operation?

❑ a) Cheap alternative using only one wire to make connection.

❑ b) Short circuit between CAN high and CAN low.

❑ c) Emergency data bus operation in case of open or short circuit.

5. CAN low level is at earth, CAN high is operating normally. What is this condition?

❏ a) Single wire operation, short circuit in CAN low to earth.

❏ b) Open circuit in CAN high.

❏ c) Open circuit in CAN low.

6. Where can I find information above the state of transfer on the convenience CAN data bus?

❏ a) From the measured value blocks from 130.

❏ a) From the measured value blocks from 140.

❏ c) From the fault memory of the Gateway.

7. What is a Gateway?

❏ a) A control unit for the airbag.

❏ b) An electronic connection between the drivetrain CAN data bus and the convenience/ infotainment CAN data bus.

❏ c) American term for VAS 5051.

8. What is the residual voltage for CAN low on the convenience/ infotainment CAN data bus?

❏ a) 1 Volt

❏ b) 2.5 Volt

❏ c) 5 Volt

Answers:

1. a), c)
2. c)
3. a)
4. b), c)
5. a)
6. a), c)
7. b)
8. c)

Glossary

CAN high:
CAN signal wire which has a higher voltage level in a dominant state. For example on the drivetrain CAN data bus: recessive state: 2.5V, dominant state 3.5V.

CAN low:
CAN signal wire which has a lower voltage level in a dominant state. For example on the drivetrain CAN data bus: recessive state: 2.5V, dominant state 1.5V.

Convenience CAN data bus:
The convenience CAN data bus is the VW designation for "low speed data bus". The current convenience CAN data bus is operated at a transfer rate of 100 kBit/s. Special features are tolerance to short circuit and open circuit in one CAN wire (single wire operation) and the ability to save power by switching to "sleep mode". The convenience CAN data bus serves as a means of controlling central locking, electric windows, etc.

Dominant state:
On the CAN data bus, a difference is made between recessive and dominant states. A dominant state overwrites a recessive state.

Differential amplifier:
Generates the differential voltage from CAN high and CAN low voltages.

Differential transfer:
For the differential transfer (page 8), two wires are used. On one wire, the signals are transferred directly and on the other, inversely. If, for example, the voltage changes in the wire with direct transfer from 2.5V to 3.5V, the voltage in the wire with inverse transfer will change respectively from 2.5V to 1.5V. In this way, the sum of all signal changes will be 0V in both wires.
The signal is then calculated as the difference of both wires (3.5V – 1.5V = 2V). If both wires are now affected by a disturbance, this will be subtracted during differential calculation.

Drivetrain:
Shortened term for drivetrain CAN data bus.

DSO:
Digitales **S**torage**O**scilloscope, this allows storage and viewing of the CAN signals on a monitor. It is required for evaluation of the CAN data bus as the CAN signals change so quickly that they cannot be seen or measured.

Dual wire system:
Transfer procedure in which a signal is always transmitted via two wires. Examples of this are the CAN signals or transfer of analogue signals via a 20mA interface. The difference in the voltages is evaluated widely to reduce disturbances (CAN data bus).

High speed CAN:
This is also known as drivetrain CAN data bus or drivetrain at VW. This is the original CAN data bus with up to 1000 kBit/s. At VW the drivetrain CAN data bus is used with 500 kBit/s.

Infotainment CAN data bus:
This is the same as the convenience CAN data bus electrically but it is used to control the radio, telephone, navigation system, etc.

Load resistor:
Resistor that can be found, for example, on the CAN data bus between CAN high and CAN low in the control unit.

Measured value blocks:
Special blocks of memory in the control units in which diagnosis information is stored. This information can be selected and evaluated using VAS 5051.

Recessive state:
On the CAN data bus, a difference is made between recessive and dominant states. The recessive state is the rest level of the CAN wire.

Signal level:
Voltage with a signal.

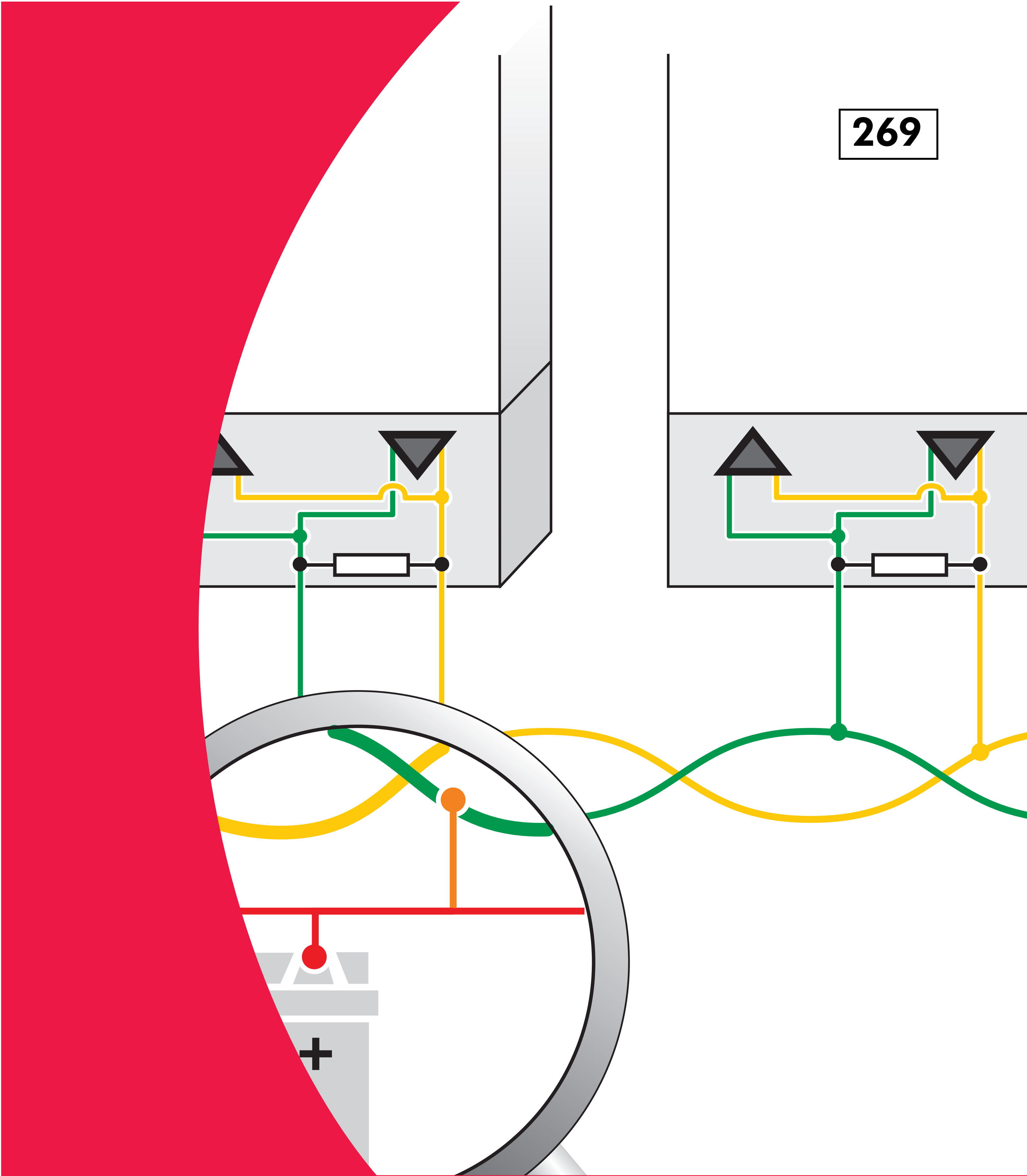
Test cursor:
On the DSO there are special lines that can be moved by the user on the screen. On VAS 5051 voltage is then measured and displayed at the points where the test cursor intersects the signal.

Topology diagram:
Layout diagram of wiring in vehicle.

Transceiver:
Made up from the words transmit and receive. A transceiver operates as a receiver for differential signals and, on the sender side, generates a differential signal from the 5V signal provided.

Trigger threshold:
Voltage level that must rise and fall before signals can be recorded on the DSO.

Twisted pair:
Two wires that are entwined together. The entwined feature is to ensure that any disturbances are placed on both wires at the same time. Together with "differential transfer", the system is kept largely free of disturbances.



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