Diagnosis on CAN-bus

The CAN (Controller Area Network) bus system is a linear bus system that is characterised by the following features:

- signals are broadcast in both directions
- a message is received by all bus nodes. Each node decides for itself whether to process the message or not.
- new nodes can be added by simple parallel connection
- the bus system forms a multi-master structure
- each node can be master or slave depending on whether it is connected as transmitter or receiver
- the transmission medium is a two-core lead; the cores are designated CAN Low and CAN High.
- Switching off defective control units

In general, every node can communicate with all other nodes via the bus. An access mechanism controls data exchange on the bus. The main differences between the K-CAN (body CAN) bus and the PT-CAN (powertrain CAN) bus are detailed below:

- K-CAN: Data transfer rate around 100 kBits/s. Single-wire operation possible.
- PT-CAN: Data transfer rate around 500 kBits/s. No single-wire operation possible.

Master: the master is the active communicating node, i.e. the one that initiates communication. The master is in control of the bus and controls communication. It can send messages to the passive communicating nodes (slaves) on the bus network and on request receive messages from them.

Slave: the slave is the passive communicating node. It is instructed to receive and send data.

Multimaster system: a multimaster system is one in which all communication nodes can take on the role of master or slave at a particular time.

Causes

The failure of communication on the CAN-bus may be caused by the following:

- Circuit breaks or short circuits on the CAN Low or CAN High communication leads

- Defective plug connections (contact damage, soiling, corrosion)

- Interference voltages in the vehicle electrical system (caused for instance by defective ignition coils or ground connections)

- Failure of the communication modules in the individual control units

- Failure of the voltage supply of individual control units (a battery voltage decreasing gradually when the battery is almost discharged can also lead to fault code entries as not all control units switch off simultaneously due to the voltages supply being too low).

Inspection procedure for impedance measurement PT-CAN, F-CAN, Local-CAN

When measuring impedance, it is generally necessary to *disconnect* the circuit being tested from the power supply beforehand. The *vehicle's battery should therefore be disconnected*. Wait about three minutes to allow all capacitors in the system to discharge.

Inspection procedure for resistance test:

- the CAN bus must be disconnected from the power supply
- No other testing equipment must be in use (connected in parallel)
- The measurement is taken between the CAN Low and CAN High leads
- the measurements recorded may differ from the specified levels by a few Ohms

Impedance measurement with matching resistor PT-CAN, F-CAN, Local-CAN

On the Tester, switch to *Measurement system -> Multimeter*

- Measurement function: Resistance
- Measuring range: automatic

In order to prevent signal reflection, a 120 Ω resistor is fitted to two CAN bus nodes (at the extremities of the PT-CAN network). The two terminal resistors are connected in parallel and form a shunt impedance of 60 Ω. When the power supply is switched off, that shunt impedance can be measured across the communication leads. In addition, the individual resistors can be tested independently of one another. (Tip for 60 Ω measurement: disconnect an easily accessible control unit from the bus and then measure the impedance between the CAN Low and CAN High leads on the connector.)

DC voltage measurement PT-CAN, F-CAN, Local-CAN

Precondition for the measurement: *battery connected and ignition on!*

On the Tester, switch to *Measurement system -> Multimeter*

- Measurement function: Voltage
- Measurement type: =
- Measuring range: automatic

In order to establish whether the CAN Low or CAN High lead is defective, you can measure the CAN Low (CAN High) voltage to earth.

CAN Low to earth: voltage approx. 2.4 V

CAN High to earth: voltage approx. 2.6 V

These values are approximate values and can vary by a few hundred mV depending on the bus load.

Oscilloscope measurement PT-CAN, F-CAN, Local-CAN

Precondition for the measurement: *battery connected and ignition on!*

On the Tester, switch to *Measurement system -> Oscilloscope setting*

- Measurement type: =
- Measuring range: +/- 5 V
- Frequency range: 1 kHz

In order to obtain a clear idea of whether the CAN bus is functioning properly, it is very useful to be able to observe activity on the bus. What is important here is not to analyse the actual data being transmitted but simply to be able to see that the CAN bus is operating. The oscilloscope test can state that, ”the CAN bus is probably operating without faults”.

If the oscilloscope is used to measure the voltage differential between the CAN Low and CAN High ground leads, a square wave signal with the voltage limits U(min) = 1.5 V and U(max) = 2.5V is obtained.

If the oscilloscope is used to measure the voltage differential between the CAN High and CAN Low ground leads, a square wave signal with the voltage limits U(min) = 2.5 V and U(max) = 3.5V is obtained.

These values are approximate values and can vary by a few hundred mV depending on the bus load.

Resistance test K-CAN

No defined resistance test can be carried out at the K-CAN data bus, as the resistance varies depending on the internal switching logic of the control units!

Measuring K-CAN DC Voltage

Precondition for the measurement: *battery connected and ignition on!*

On the Tester, switch to *Measurement system -> Multimeter*

- Measurement function: Voltage
- Measurement type: =
- Measuring range: +/- 10 V

In order to establish whether the CAN Low or CAN High lead is defective, you can measure the CAN Low (CAN High) voltage to earth.

CAN Low to earth: voltage approx. 4.8 V

CAN High to earth: voltage approx. 0.2 V

These values are approximate values and can vary by a few hundred mV depending on the bus load.

Oscilloscope measurement K-CAN

Precondition for the measurement: *battery connected and ignition on!*

On the Tester, switch to *Measurement system -> Oscilloscope setting*

- Measurement type: =
- Measuring range: automatic
- Frequency range: 1 kHz

In order to obtain a clear idea of whether the CAN bus is functioning properly, it is very useful to be able to observe activity on the bus. What is important here is not to analyse the actual data being transmitted but simply to be able to see that the CAN bus is operating. The oscilloscope test can state that, ”the CAN bus is probably operating without faults”.

If the oscilloscope is used to measure the voltage differential between the CAN Low and CAN High ground leads, a square wave signal with the voltage limits U(min) = 1 V and U(max) = 5V is obtained.

If the oscilloscope is used to measure the voltage differential between the CAN High and CAN Low ground leads, a square wave signal with the voltage limits U(min) = 0 V and U(max) = 4V is obtained.

These values are approximate values and can vary by a few hundred mV depending on the bus load.

CAN bus without function

If the K-CAN or PT-CAN data bus indicate no function, it is likely that a short circuit has occurred on the CAN Low and/or CAN High lead, or that a control unit is defective. In order to localise the cause of the fault, it makes sense to use the following procedure:

- Disconnect one CAN-bus node after the other until the unit causing the fault (= control unit x) is found
- Check the lines to control unit x for short circuits
- If possible, check control unit x

However, this procedure only leads to success if a tap line from a control unit to the CAN bus has a short circuit. If a CAN bus lead itself has a short circuit, the wiring harness must be checked.

Diagnosis

Two different bus faults can be entered in the CAN bus control units:

- CAN communication fault
- CAN wire fault

The communication fault provides an overview of the control units that have failed on the CAN bus, i.e. were no longer able to communicate. The ”CAN communication fault” can only be read out if the fault is currently not present. If the fault is currently present, it is no longer possible to communicate with the control unit. This means that the fault code memory cannot be read, either!

Physical wire fault can be detected by the use of fault-tolerant CAN transceivers. However, at the moment there are only fault-tolerant transceivers for the K-CAN data bus. This means that only control units that are connected to the *K-CAN* data bus can have made the fault code memory entry *”CAN wire fault”* The CAN transceiver is also unable to distinguish between the individual fault categories listed below. If the bus fault ”CAN wire fault” is entered in a control unit, this can mean:

- Break in wiring CAN High
- Break in wiring CAN Low
- Short circuit CAN High to earth or positive
- Short circuit CAN Low to earth or positive
- Short circuit CAN High to CAN Low

Break in wiring (single-wire operation): each control unit contains a separate bus termination. This means that, even in the case of a break in wiring, the voltage level can be maintained across the entire K-CAN network. The consequence of this is that a transmitting control unit does not detect this fault and continues to work in two-wire operation. However, if a control unit transmits a message across the break, the receiving control unit only detects activity on the undamaged bus line. The receiving control unit thus detects single-wire operation and sets the fault ”CAN wire fault”. If different control units receive messages across the break, a number of control units can have made this fault code memory entry in single-wire operation!

Short circuit: if there is a short circuit in the system, *all* K-CAN control units must have entered the fault ”CAN wire fault”. In order to localise the short circuit, follow the procedure for ”CAN bus without function”.