The CAN Data Bus

History of the CAN data bus

1983 Start of CAN development.

1985 Start of co-operation with Intel for chip development.

1988 The first CAN series type is available from Intel. Mercedes Benz begins CAN development in the automotive field.

1991 First use of CAN in a standard vehicle model (S-Class).

1994 An international CAN standard is introduced (ISO11898).

1997 First use of CAN in vehicle interior (C-Class).

2001 Entry of CAN in compact vehicles (Opel Corsa) in the power train and bodywork fields.

What CAN actually means:

CAN stands for Controller Area Network

Advantages of the CAN bus:

- Data exchange in all directions between several control units.
- Multiple use of sensor signals is possible.
- Extremely quick data transmission.
- Low fault rate thanks to numerous controls in the data protocol.
- Usually, software modifications alone are sufficient for extensions.
- CAN is standardised the world over, i.e. data exchange is possible between control units from different manufacturers.

What is a CAN data bus?

A CAN bus can be compared with a normal bus. Just as a bus transports lots of people, the data bus transports large amounts of information (Fig. 1).

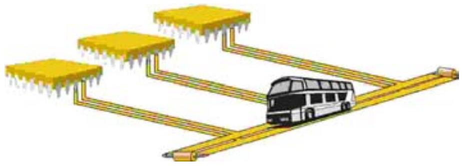


Fig. 1

Without a data bus, all the information has to be guided to the control units via a number of cables. This means a cable exists for each individual piece of information.

With the data bus, the number of cables is significantly reduced. All the information is exchanged via a maximum of two cables between the control units.

Structure of the data bus system:

(Fig. 2)

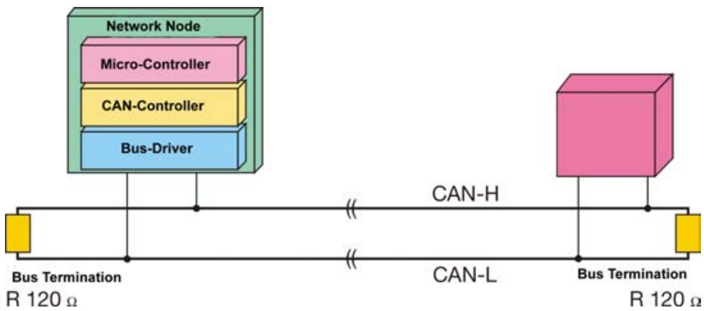


Fig. 2

Network node:
This houses the micro-controller, the CAN controller and the (control unit) bus driver.

Micro-controller:
Is responsible for controlling the CAN controller and processes transmission and received data.

CAN controller:
Is responsible for transmission and receive mode.

Bus driver:
Transmits or receives the bus level.

Bus cable:
Is a two-wire cable (for both signals, CAN-High and CAN-Low). The cables are twisted to reduce electromagnetic interference.

Bus termination:
Termination resistors with 120 Ω each prevent an "echo" in the cable ends and thus avoid signal break-up.

How a data bus works:

The principle of data transmission can be visualised as follows. Data transmission using the CAN data bus works in a similar way to a telephone conference. A participant (control unit) "speaks" its information (data) into the cable network, while the other participants "listen in" on this information. Some participants find the information interesting and use it. Others simply ignore it.

Example:

A car starts to move without the driver door being closed properly. For the driver to be warned, the check-control module, for example, requires two pieces of information.

- Vehicle is moving.
- Driver door is open.

The information is recorded or produced respectively by the door contact sensor / wheel speed sensor and converted into electrical signals. In turn, these are converted into digital information by the respective control units and then transmitted as a binary code through the data line until they are picked up by the receiver. In the case of the wheel speed signal, this information is also required by other control units, e.g. the ABS control unit, or by some vehicles which are fitted with an active chassis. Depending on the speed, the distance to the road can be changed to optimise road holding. Therefore, all the information is passed via the data bus and can be analysed by every participant.

The CAN data bus system has been designed as a multi-master system, i.e.

- All network nodes (control units) have equal priority.
- They are equally responsible for bus access, troubleshooting and failure control.
- Each network node has the property of accessing the joint data line independently and without the help of another network node.
- If one network node fails, this does not lead to the failure of the complete system.

With a multi-master system, bus access is not controlled, i.e. as soon as the data line is free, several network nodes can access it. If all the information were now sent down the line simultaneously, however, there would be chaos. It could lead to a "data collision". So there has to be order in data transmission. For this reason, CAN bus has a clear hierarchy, regulating who can transmit first and who has to wait. When the network nodes are programmed, the order of importance of individual data is defined. Which means a high priority message will assert itself against a low priority message. If a network node transmits with high priority, all the other network nodes automatically switch to receive.

Example:

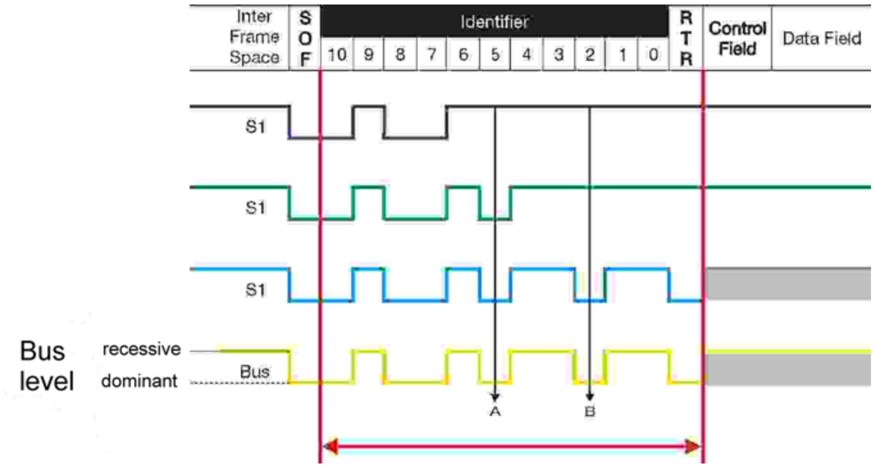
A message which comes from a safety-related control unit such as the ABS control unit will always have a higher priority than a message from a gear control unit, for example.

Function (bus logic)

With CAN, a distinction is made between dominant and recessive bus levels. The recessive level has the value 1 and the dominant level the value 0. If several control units transmit dominant and recessive bus levels simultaneously, the control unit with the dominant level is allowed to transmit its message first.

The example detailed below (Fig. 3) illustrates bus access even more clearly. In this case, three network nodes want to transmit their message via the bus. During the arbitration process, control unit S1 will prematurely abort attempted transmission at Point A, since its recessive bus level is overwritten by the dominant bus levels of the control units S2 and S3. For the same reason, control unit prematurely aborts its attempted transmission at Point B. In this way, control unit S3 asserts itself over the others and is able to transmit its message.

Fig. 3



Structure and function of the data protocols:

Data transmission is via a data protocol (Fig. 4) at very short intervals. The protocol is made up of a large number of consecutive bits. The number of bits depends on the size of the data field. One bit is the smallest unit of information, eight bits correspond to one byte = a message. This message is only digital and can only have the value 0 or 1.

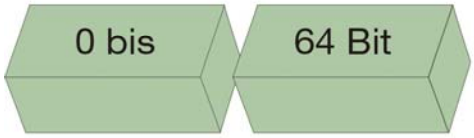
Fig. 4

Start Field (Start of Frame)
Marks the start of a message and synchronises all the stations.

Status Field (Arbitration Field)
Is made up of a message identifier (11 bits) and a control bit. During the transmission of this field, the transmitter checks for each bit whether or not it is still authorised to transmit or whether another station with a higher priority is transmitting. This is where the so-called arbitration takes place, i.e. definition of which of the control unit signals is to have priority during transmission. The control bit is decisive in terms of whether the message is a *Data Frame* (transmitted message) or a *Remote Frame* (answer from the receiving control unit).

Control Field
Contains the code for the number of data bytes to follow in the data field.

Data Field
Information for the other stations is transmitted in the data field, in other words information about switch positions, sensor signals etc.. The information can make up between 0 and 8 bytes (8 bits = 1 byte). (In figure opposite: bis = to)



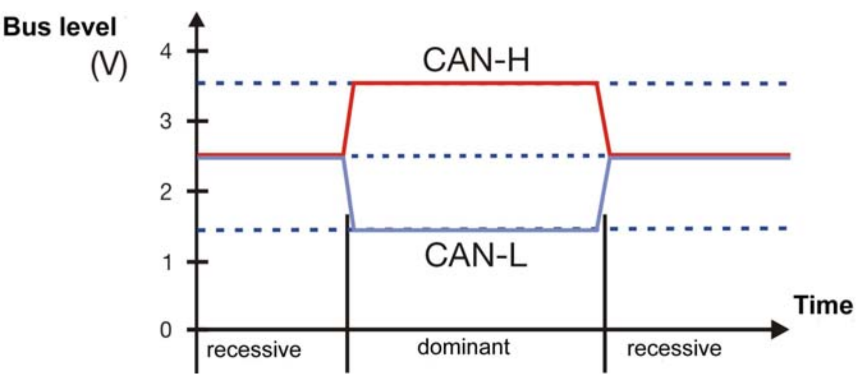
Safety Field (CRC Field)
Is used to recognise transmission faults.

Actuation Field
In the actuation field, the receivers signal to the transmitter that they have received the message transmitted without any problems. If a problem is recognised, it is communicated to the transmitter without delay. This then repeats transmission.

End Field (End of Frame)
This field completes the message. Faults can be noticed here, too, leading to the message being sent again.

Signal characteristics:

- The signals CAN-H (high) and CAN-L (low) are on the bus.
- The two signals are mirror images of each other (Fig. 5):



CAN data bus diagnosis:

Possible faults with the CAN data bus:

- Line interruption.
- End to ground.
- End to battery.
- End CAN-High / CAN-Low.
- Battery / supply voltage too low.
- Lack of terminating resistors.
- Interference voltages e.g. through a defective ignition coil which can lead to implausible signals.

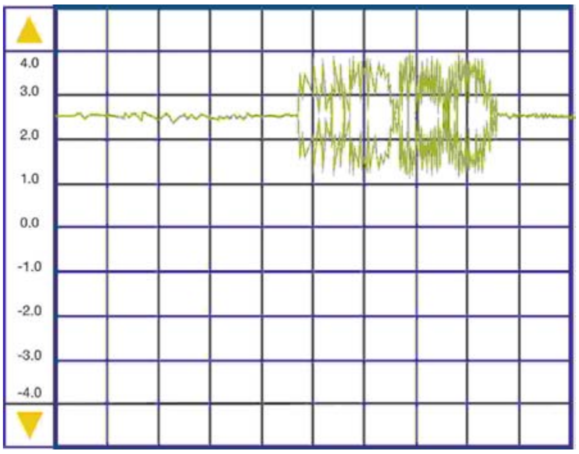
Troubleshooting

- Check the function of the system.
- Read out fault memory.
- Read measured value block.
- Record signal using an oscilloscope.
- Check level voltage.
- Measure line resistance.
- Measure resistance of the terminating resistors.

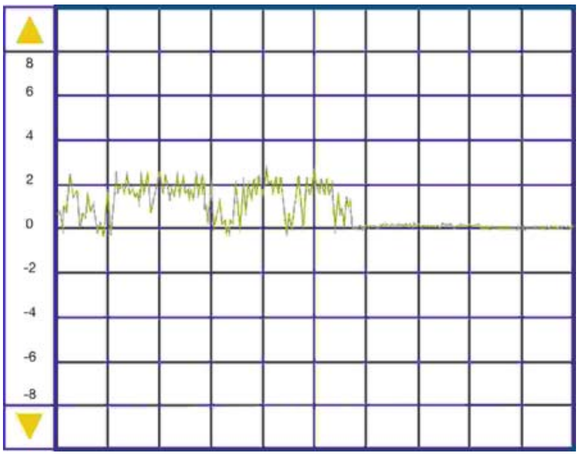
In the case of a fault, remove the individual control units from the data bus one after the other. In this way it can be established which of the control units is causing the short-circuit or interruption.

If there is still a fault following disconnection of all the bus participants, the line is damaged.

Comparison between conform and non-conform images on the oscilloscope



Conform image: Both signals CAN-H and CAN-L can be seen.



Non-conform image: only one signal is visible.

CAN data buses in passenger cars:

Today, two CAN buses are used in modern vehicles.

The High-Speed Bus (ISO 11898)

SAE CAN Class C
Transmission rate 125 kBit/s - 1Mbit/s
The transmission of a data protocol takes approx. 0.3 milliseconds
Bus length up to 40 metres at 1 Mbit/s
Transmitter output current > 25 mA
Short-circuit proof
Low current consumption
Up to 30 nodes

Thanks to its high transmission speed (real-time critical information transfer in milliseconds), this bus is used in the power train where control units from the engine, gears, chassis and brakes are networked together.

The Low-Speed Bus (ISO 11519-2)

SAE CAN Class B
Transmission rate 10 kBit/s - 125 kBit/s
The transmission of a data protocol takes approx. 1 millisecond
Max. bus length depends on the transmission rate
Transmitter output current < 1 mA
Short-circuit proof
Low current consumption
Up to 32 nodes

This bus is used in the vehicle interior where components of bodywork and comfort electronics are networked together.