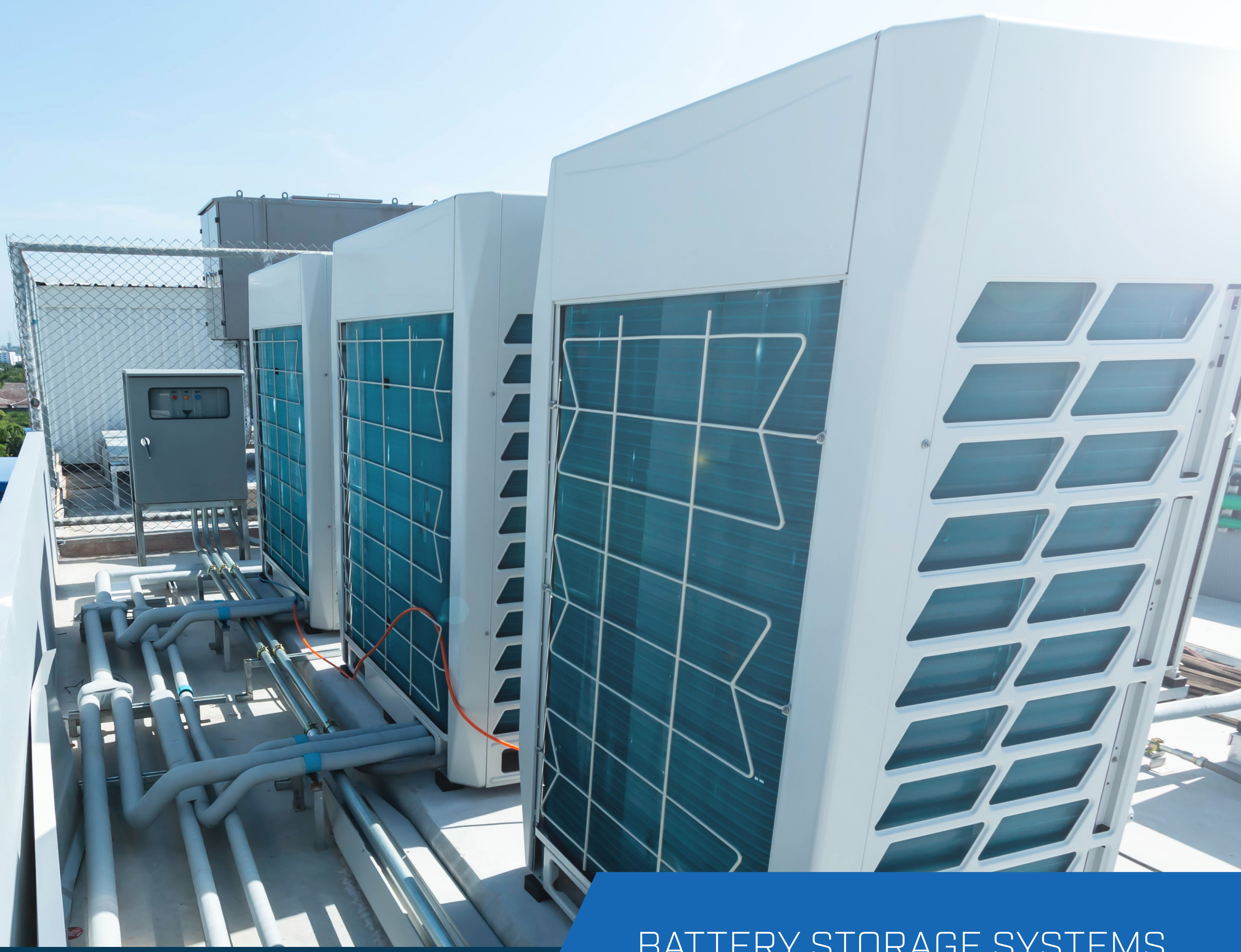


BATTERY STORAGE SYSTEMS

System and signal protection

Measures to reduce EM interference and protection against overvoltage for CAN network components

HMS

Overvoltage protection for communication interfaces and measures to reduce EM interference

DATA COMMUNICATION SOLUTIONS FOR BATTERY STORAGE SYSTEMS

Battery storage systems combine sensitive, fieldbus-networked controls and high-voltage/heavy-current components in a very small space. The systems are often exposed to external influences (lightning strikes) or are positioned close to other EM interference sources.
Environmental and internal EM influences should be taken into account from the outset when planning the often CAN-based networking of components, in order to ensure interference-free communication and to protect components from damage. This white paper shows networking strategies that enable safe and reliable CAN communication, taking into account the difficult framework conditions.

PASSIVE COMMUNICATION AND COMPONENT PROTECTION

When wiring CAN-based components in battery storage systems, EM interference can be minimized with simple measures. Important basic rules are:

Optimize cable lengths

CAN has a line/bus topology. All participants are connected to the CAN bus in parallel. The CAN bus as such is linear and must (!) be terminated at both ends with a termination resistor (120 Ohm). Branch lines are not provided and must, if necessary, be implemented using active components (e.g. repeaters). Skilful cable routing can decisively minimize the bus length and thus indirectly reduce EM influences.

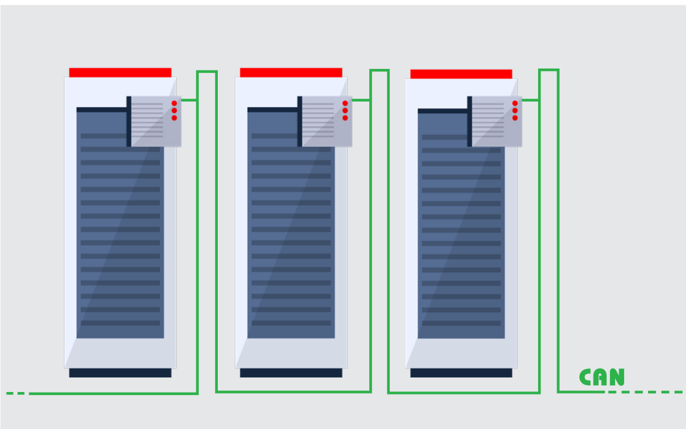


Image 1: Not optimized cable routing

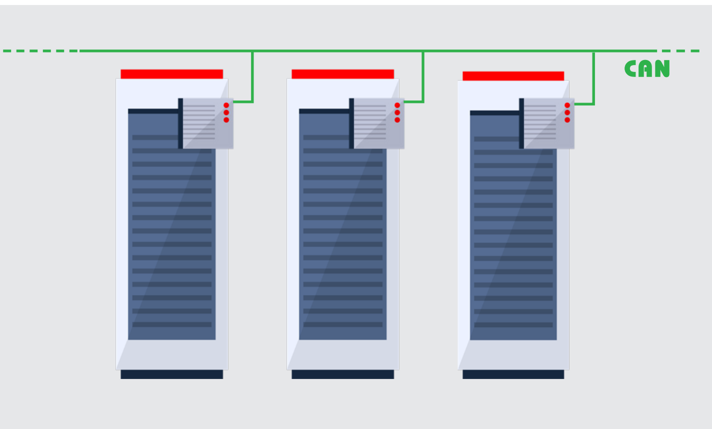


Image 2: Optimized cable routing and the resulting cable savings

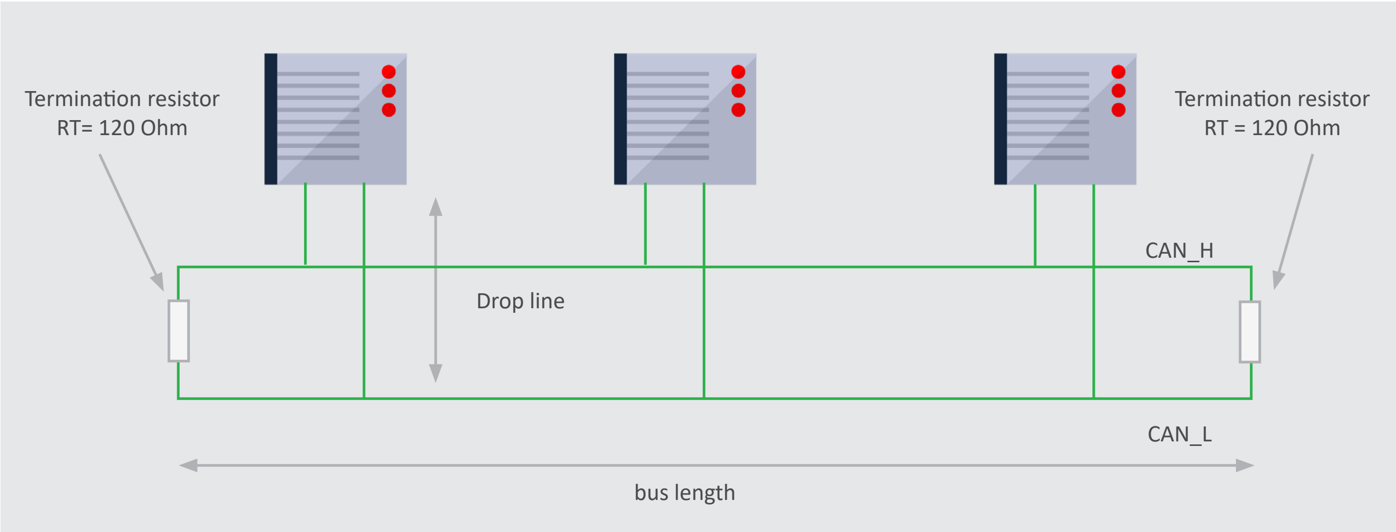


Image 3: Bus topology of a CAN network according to ISO 11898-2

Cable routing, cable type and grounding

When routing cables, if possible, pay attention to separate laying of heavily current-carrying, switched cables and the cables for data communication. CAN is considered to be very robust, however, in order to rule out problems with the signal quality in advance, care should be taken to use a suitable cable. Information on the optimal cable can be found in ISO-11898. ISO 11898-2 specifies a two-wire cable terminated at both ends with the specific wave impedance of the cable. The following electrical data are specified for the two-wire line:

- Maximum cable length at 1 Mbit/s: 40 m
- Maximum length of a cable branch at 1 Mbit/s: 30 cm
- Characteristic line impedance: 120 ohms
- Specific line resistance (nominal): 70 mOhm/m
- Specific signal delay (nominal): 5 ns/m

In order to avoid signal reflections, the topology should be designed as a line structure. In a standard CAN cable, twisting the two-wires compensates for electromagnetic interfering radiation, thus increasing the immunity to interference.

By terminating the bus line at both ends of the cable with the wave impedance of the bus line and avoiding drop lines, reflections at the line ends are avoided.

Image 4 shows a signal overlaid with the reflections at the end of the line on a non-terminated bus, Image 5 shows the signal profile when the same line is terminated at both ends with the wave impedance of the line (120 Ohms).

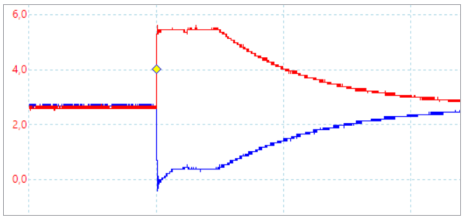


Image 4: Bus line not terminated

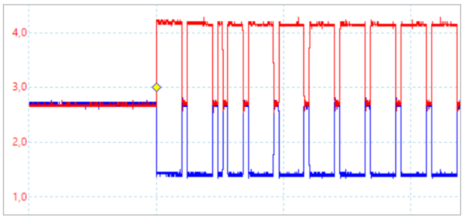


Image 5: Bus line terminated at both ends with the wave impedance of the line

In order to further reduce EM influences from outside, the use of shielded cables is recommended. Make sure that only one end of the shield is grounded – in order to avoid so-called ground loops. The use of three-wire cables is also recommended, with which, in addition to the twisted cables for CAN_H and CAN_L, CAN_GND can also be connected. Experience shows that, especially in systems with galvanically isolated CAN nodes, the reliability can be increased by using the CAN_GND line.

Baud rate and line length

Table 1 shows the relationship between the maximum possible bit rate and the maximum bus length for some bit rates, assuming common network conditions.

Baud rate (kBit/s)	Maximum bus length (m)
500	110
250	280
125	620
100	790
50	1640

For line lengths of more than 100 m, the following rule of thumb can be specified for the maximum product of bit rate and line length:

$$\text{Bitrate}_{max}\left[\frac{\text{MBit}}{\text{s}}\right] \cdot L_{max}\ [\text{m}] \leq 60$$

The influence of the bit rate on the line length ist caused by the type of arbitration and the signal transmission mechanisms, which require the presence of a defined, identical signal level for all participants at a defined bit point in time.
Inductive / capacitive influences on the signal or signal reflections due to improper termination or drop lines can change the bit edges and thus lead to a deterioration in status detection, which leads to messages being discarded through error frames and ultimately can have a massive impact on reliable data transmission.

SIGNAL IMPROVEMENT THROUGH CAN REPEATER

Despite careful wiring and the best possible line material, signal interference on the lines can often not be completely prevented. Here CAN repeaters can help by refreshing the signal level.
A repeater provides a physical link between two identical bus systems. Signals are regenerated via a repeater and transparently passed on to the respective other segment. A repeater thus divides a bus into two physically independent segments, which also enables longer stub lines to be implemented.

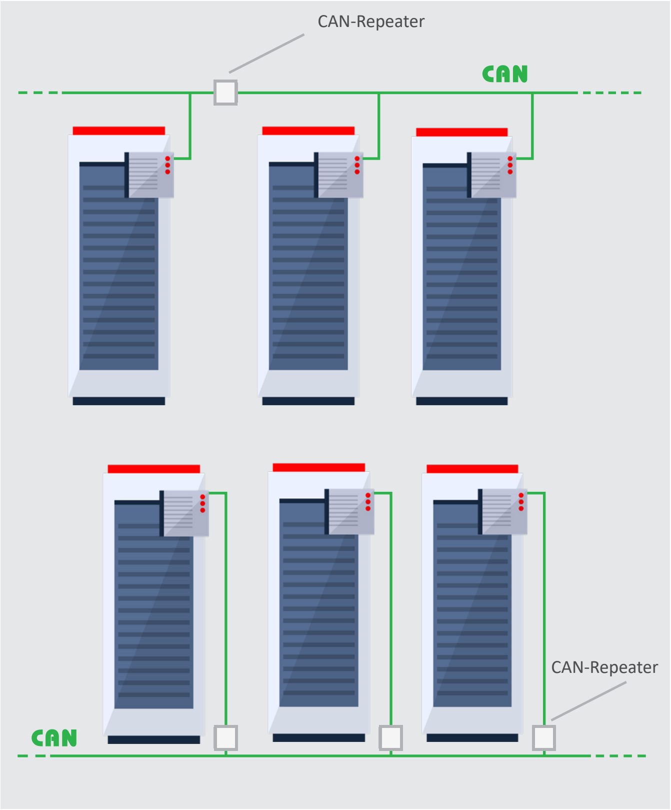


*Image 6:
System structure and place of use
of the repeater to refresh the signal and to enable longer stub lines*

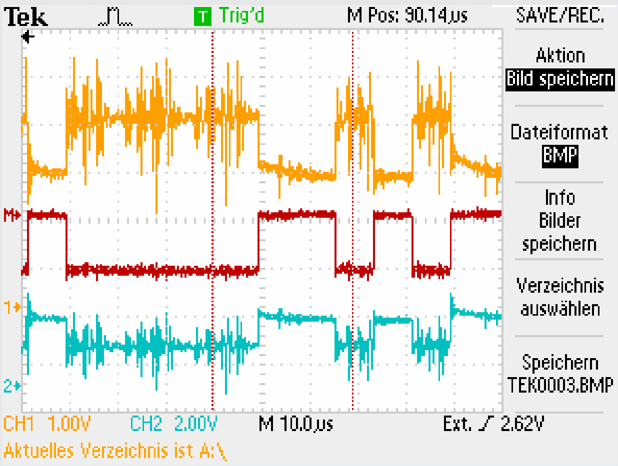


Image 7: CAN bus system with interference on the signal level

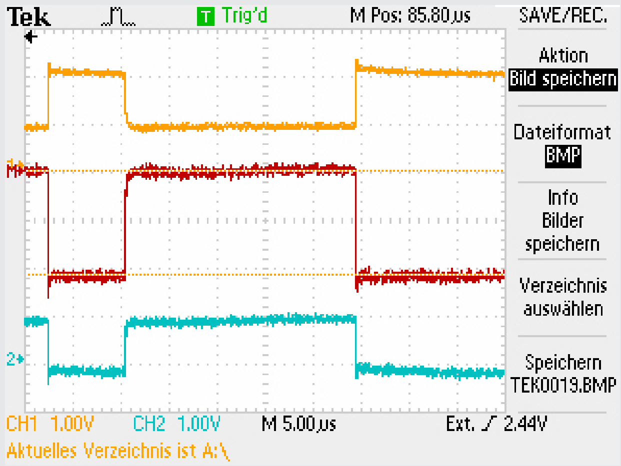


Image 8: Signal level of the same system after using a repeater. .

When using a repeater, however, it should be noted that, in terms of signal technology, this corresponds to a line with a length of approx. 35 meters (approx. 175 ns signal propagation time). Systems in which transmission problems already exist due to the large extent would not benefit from the use of a repeater.

However, the use of a repeater enables tree and star topologies* to be implemented, which, if used skilfully, leads to a significant reduction in the bus size and thus indirectly and directly solves signaling problems.

SIGNAL IMPROVEMENT THROUGH CAN BRIDGES

In contrast to the repeater, the bridge works according to the store (modify) forward principle. This means that the bridge reads in the CAN frames at one interface, processes them and outputs them at the other end. The bridge thus separates a CAN network into two independent segments.
In addition to complete signal refreshment, the bridge also enables CAN networks to be subdivided into smaller sub-segments. The reduction of the bus extension, i.e. the division into subsegments, often leads to a considerable improvement in the signal quality. The signals transmitted between the segments are optimally processed by the bridge.

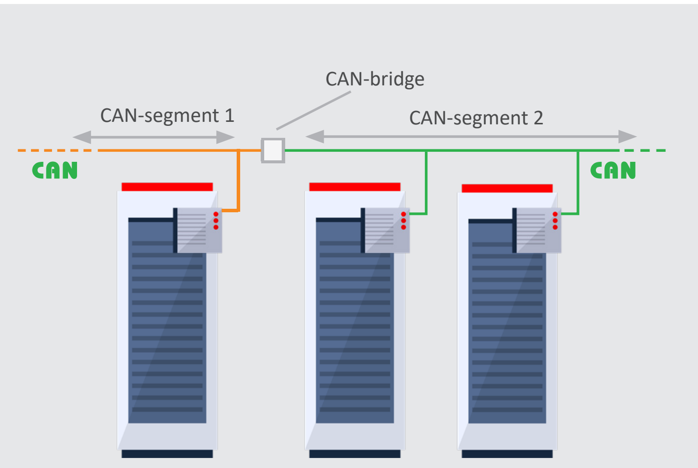


Image 9: System structure and place of use of the bridge for network segmentation and signal refreshment

* The topic of bus topologies and networking is dealt with in a further whitepaper

By using CANbridges, the CAN system expansion can be increased and tree and star topologies can be used to simplify the wiring. The possibility of message filtering and modification also offers further possibilities for network optimization.*

GALVANIC PROTECTION OF NETWORK SEGMENTS AND COMPONENTS

Voltage peaks, which can originate both inside and outside of battery storage systems, can disrupt or even destroy electronic components.
The switching of high voltages and currents, e.g. in the area of AC/DC converters, can lead to the occurrence of voltage peaks, which can act directly on the individual components via the fieldbus networks. External events, such as lightning strikes and the resulting voltage funnel, can also lead to high potential differences between the networked participants.
Galvanic isolation from the bus system is recommended to protect the networked components. Component manufacturers often offer CAN interfaces with optional electrical isolation, but if this is not available or if the existing protection in terms of voltage level is insufficient, galvanically decoupled repeaters or bridges can protect the components. Common repeaters/bridges offer galvanic protection between 1 kV and 4 kV and thus, in addition to improving the signal, make a significant contribution to protecting electronic components.
Higher protection voltages, as they may be required with larger system expansions, can be easily achieved by using glass or plastic fibers for CAN data transmission. There are special FO repeaters that can be used to convert from copper to fiber optic (and vice versa).

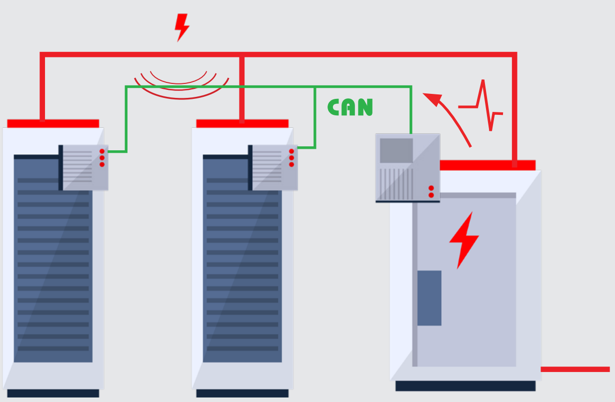


Image 10: Internal sources of interference in battery storage system segmentation

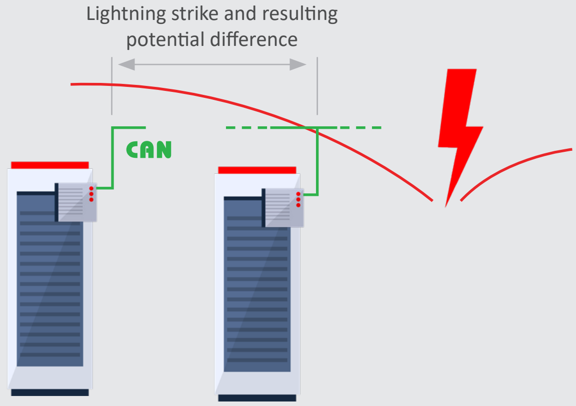


Image 11: Lightning strike with voltage funnel and effect on networked components

* The topic of bus topologies and networking is dealt with in a further whitepaper

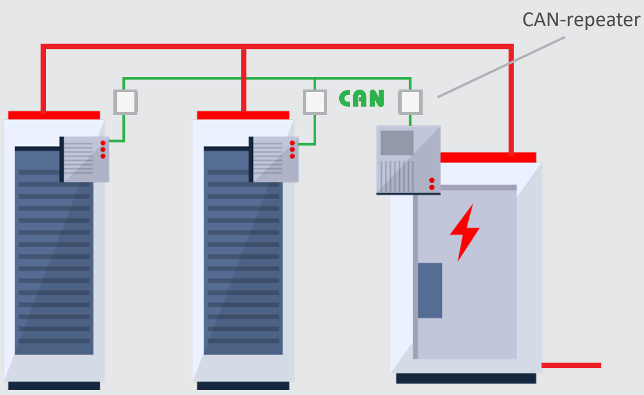


Image 12: Use of repeaters to protect components against voltage peaks

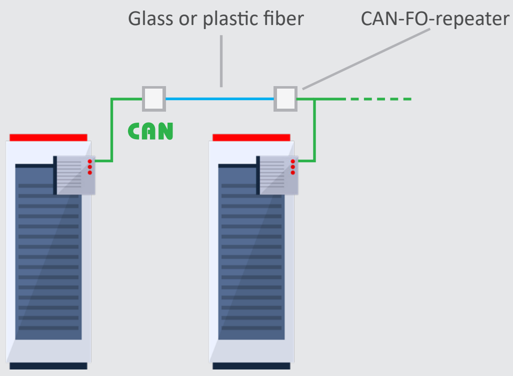
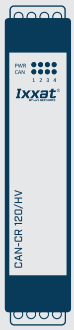


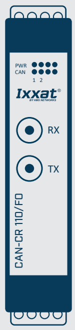
Image 13: Glass / plastic fiber for the CAN data transmission

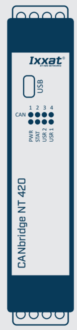
Summary

- Pay attention to optimal wiring routes and lay data lines separately from other lines if possible.
- If possible, use standard CAN cables that are shielded and twisted. .
- Make sure that the bus topology is “clean”, terminated at both ends and with the shortest possible stub lines.
- Use repeaters to protect components galvanically and to minimize EM interference through CAN bus segmentation.
- Use bridges to subdivide CAN networks; this increases the maximum system expansion and minimizes EM interference.

CAN repeaters and bridges from HMS for use in the field of battery storage systems







CAN-REPEATER
CAN-CR120/HV

- Protection of the segments up to 3 kV
- Increase in system reliability
- Very little influence on the real-time behavior of the system
- CAN and CAN FD interfaces in one device
- Cost savings through simpler wiring

FIBER OPTIC CAN REPEATER
CAN-CR110/FO

- Signal transmission in Environments with high EM exposure
- High galvanic isolation
- Increase in system reliability
- Very little influence on the real-time behavior of the system
- CAN and CAN FD interfaces in one device

CAN-BRIDGE
CANbridge NT 420

- Up to four CAN channels (two CAN FDs) in one device for easy coupling of segments
- Increasing the system expan-sion
- Higher system reliability
- Cost savings through simpl wiring
- Protection of the segments through galvanic isolation
- Powerful filter, ID translation, mapping and multiplex functionality