2024

CAN in rolling stock

Embedded CAN-based control networks

From CAN CC via CAN FD to CAN XL

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CAN CC

Since 30 years, CAN CC is used in rolling stock

In particular, CAN CC (classic) has been used on sub-system level as well as on consist level, in so-called light rail vehicle applications, such as commuter trains, metros, or tramways. The IEC 61375-3-3 standard specifies the CANopen-based control network for locomotives, coaches, and consists. In addition to that, CAN CC has been used in multi-purpose rail vehicles, as well.

SAE J1939 is mainly used in diesel powertrains

The J1939 Digital Annex provides standardized application data, assembled to so-called parameter groups (PGs). PGs determine the unique PG Number (mapped into the 29-bit CAN-ID field) as well as the repetition rate, for communicating the grouped application data via CAN. This enables a high degree of off-the-shelf plug-and-play capability.

Suppliers of CANopen devices often implement CiA profile specifications

CiA enhances IEC 61375-3-3 by CANopen device and application profiles. This includes generic device profiles such as CiA 401 (digital/analog I/O modules), CiA 402 (drive and motion control), or CiA 406 (encoders). Additionally, there are CANopen application profiles dedicated for rail vehicles. The CiA 421 application profile specifies the CANopen interfaces of different sub-systems that can be available within one rail vehicle or consist. The CiA 423 and CiA 430 CANopen application profiles, specify the CANopen interfaces of different functional units that can be required for controlling the diesel engine respectively the accompanying auxiliary units, for example, power train cooling or pre-heating.
A standardized CANopen-based passenger information system is specified in EN 13149-4/5/6.

CANopen and J1939 comprise functional safety protocol extensions

CANopen Safety is standardized in EN 50325-5. It complies with IEC 61805 (SIL 3). IEC 61131-3 programmable host controllers, supporting CANopen Safety, are available on the market. SAE has developed the J1939-76 functional safety protocol extension for J1939-21 (CAN CC) and J1939-77 for J1939-22 (CAN FD).

CAN FD: Ready to be used

The 2nd CAN protocol generation is also known as CAN FD (flexible data rate). The CAN FD data field has a length of up to 64 byte. The bit rate can be higher than 1 Mbit/s. CAN SIC (signal improvement capability) transceivers enable transmission speeds of more than 5 Mbit/s in the data phase, even in not optimized network topologies.

The necessary building blocks for CAN FD device and system design are available from different sources. This includes hardware (protocol controllers and transceivers), as well as higher-layer protocol software (e.g. CANopen FD and J1939-17/22). Related tools are available from different suppliers.

CAN FD documents enabling interoperability

Standardization bodies have updated their higher-layer protocols for CAN FD. In addition, CiA supports CAN FD device and system design recommendations and specifications:

- ◆ CiA 601-1, CAN FD physical interface,
- ◆ CiA 601-2, CAN FD controller interface,
- ◆ CiA 601-3, CAN FD system design,
- ◆ CiA 601-6, CAN FD cable,
- ◆ CiA 1301, CANopen FD application layer,
- ◆ CiA 1305, CANopen FD layer setting services,
- ◆ J1939-17, physical layer,
- ◆ J1939-22, mapping of PGs to CAN FD,
- ◆ J1939-77, functional safety protocol extension.

CAN XL, the 3rd generation of CAN, supports data frames with a payload of up to 2048 byte

With the introduction of software defined architectures, there may be a need to map Ethernet frames to CAN-based networks. Under patronage of CiA, car makers, suppliers, and chipmakers develop CAN XL, offering a payload of up to 2048 byte. The CAN XL (extended data-field length) data frames, standardized in ISO 11898-1:2024, comprise several layer management functions, which allow running multiple higher-layer protocols on the same cable. Additionally, there are some data-link layer add-on functions under development such as cybersecurity measures (CANsec) or frame fragmentation. CAN XL networks can use any CAN transceiver technology. CAN SIC XL transceivers, as specified in ISO 11898-2:2024, can run in the data phase up to 20 Mbit/s, depending on the network design.

Start now!

CiA networks not only devices

The international users' and manufacturers' group for Controller Area Network (CAN) – CAN in Automation (CiA) – has been established in March 1992. The nonprofit association provides technical, product, and marketing information about CAN, internationally standardized in the ISO 11898 series. The association promotes CAN's image and provides a path for future developments of the CAN technology. Therefore, CiA takes part in and supports the development of CAN-related standards and specifications. Additionally, an important part of the organization's effort is spent to develop and maintain the CANopen-related specifications.

CiA organizes joint marketing activities in all parts of the world. This includes joint stands at trade shows, joint information events, workshops, and contributions to magazines and conferences. An important source of information is the CiA website.

An essential aim of the organization is the social networking of CAN-interested parties. In CiA's technical and marketing groups, engineers exchange experiences and knowledge to the benefit of all members. Additionally, CiA organizes different events, such as seminars, conferences, and information days, in which CAN newcomers can meet CAN experts. One of the most important advantages of being a member is the possibility to take part in CiA's social network, to get in touch with CAN experts, and to gain know-ledge that helps to manage challenges in your CAN-related projects.

Interoperability of devices is important for the rolling stock industry

Interoperable devices reduce system design effort. For rolling stock applications, CiA hosts already a broad range of device and application profiles. The following profiles are designed for rail vehicle applications:

- CiA 421 series: Train vehicle control system,
- CiA 423 series: Train power drive system,
- CiA 424 series: Rail vehicle door control system,
- CiA 426 series: Rail vehicle exterior lighting control system,
- CiA 430 series: Rail vehicle auxiliary operating system,
- CiA 433 series: Rail vehicle interior lighting control system,
- CiA 449 series: Rail vehicle HVAC system.

CiA members shape the future of CAN technology

Regarding applications in rail vehicles, the CiA Interest Groups "Profiles" and "J1939" are going to develop appropriate solutions. The CiA Interest Group "Safety and Security" specifies application layer independent extensions for functional safety and cybersecurity.

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