2026

Construction machines

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 construction machinery

CAN CC (classic) is the dominating network technology in construction and heavy-duty vehicles. Since 1993, it has been standardized in ISO 11898. Today, part 1 covers the data link layer and physical signaling, while part 2 addresses the physical media attachment sub-layer. Initially, several original equipment manufacturers (OEMs) used proprietary higher-layer protocols. Over the time, many machine builders have migrated to standardized higher-layer protocols, particularly CANopen (EN 50325-4) and SAE J1939.

Suppliers of CANopen devices apply often CiA profile specifications

This includes generic device profiles such as CiA 401 (input/output modules including joysticks), CiA 404 (e.g. pressure, temperature, or force sensors), CiA 406 (rotary and linear encoders), CiA 408 (hydraulic actuators), and CiA 410 (inclinometers). These profiles enable a standardized access to process data, configuration parameters, and diagnostic information.

CiA supports the integration of construction machine data into clouds

There are several approaches under development to process machine-internal data by means of big-data processing. This includes the CiA 309-5 specification (Internet of Things) as well as ISO 25200 (formally known as DIN 4630, CAN-based network for body applications).

Connecting attachments

The MiC 4.0 Bus document by the nonprofit VDMA association specifies a J1939-based profile. The main objective is to standardize an interoperable communication link between construction machine (carrier) and attachments. Additionally, this approach features a functional-safe communication. This “open” CAN-based network is using a bit rate of 250 kbit/s, complying with SAE J1939-15.

Robust and reliable CAN hardware is available for reasonable prices

Microcontrollers with on-chip CAN protocol controllers as well as CAN transceivers feature extended temperature ranges (-40 °C to +125 °C). Several suppliers provide higher-layer protocol stacks for CANopen and J1939. Engineering and diagnostic tools are available from several companies.

SAE J1939 is mainly used in powertrain control systems

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.

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 601-3, 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 data fields 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 data fields 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.

CANopen FD and J1939-22 will support functional safety and cybersecurity

The extended payload of up to 64 byte per CAN FD data frame provides sufficient space for protocol extensions. However, such extensions for functional safety and cybersecurity have not been standardized, yet. But they are under development.

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 nonprofit 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 knowledge that helps to manage challenges in your CAN-related projects.

Interoperability of devices is important for the construction machine industry

Interoperable devices reduce system design effort. This can be achieved by standardized device and application profiles. CiA adapts its broad range of construction machine relevant profile specifications to CANopen FD and other application layer approaches. On demand of the construction machine industry additional profiles are specified.

CAN FD and CAN XL for construction machines

Emerging requirements in cybersecurity and functional safety increasingly exceed the payload capacity of CAN CC. CAN FD provides the necessary data throughput to address these demands. CAN XL goes a step further by offering embedded add-on functions that support, for example, cybersecurity measures.

CiA members are evaluating the boundary conditions for operating CAN FD and CAN XL in large network topologies. As part of this effort, they are preparing CiA 601-5, which includes, among other aspects, bit-timing recommendations to support the robust deployment of CAN FD in large networks..

CiA members shape the future of CAN technology

Regarding applications in construction machinery, the CiA Interest Groups (IGs) "Profiles" and "J1939" are going to develop appropriate solutions. The CiA IG "Safety and Security" specifies application layer independent extensions for functional safety and cybersecurity.

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