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History and trends: CAN on rails

CAN serves in many rail vehicles as embedded and deeply embedded network. Often CANopen is used as higher-layer protocol. CiA has developed several profiles, which need to be revised according to new feature requests.

(Source: Adobe Stock)

The complete article is published in the September issue of the CAN Newsletter magazine 2022. This is just an excerpt.

Already in the early days of CAN in Automation (CiA) in mid of the 1990s, some members used CAN in rail vehicles. One of them was Kiepe Elektrik Today, the company belongs to the Knorr-Bremse group. An early bird in applying CAN in special train utility vehicles was Windhoff. Both companies adapted CANopen, when this higher-layer protocol was handed over to CiA. Selectron (today part of the Knorr-Bremse group) and Luetze, two other CiA members, started end of the 1990s to provide CANopen devices for locomotives and coaches. At the same time, Knorr-Bremse developed CANopen solutions deeply embedded in its rail-vehicle brakes. IFE (today a part of the Knorr-Bremse group) submitted a CANopen profile for rail vehicle doors to CiA, which was released as CiA 424.

From research projects to IEC standardization

In 1994, Deutsche Bahn (German railway company) and STZP technology transfer center initiated the Ebas system development project for CAN-based data acquisition, monitoring, and control in freight trains. The system should shorten train assembly procedure including train rearrangement, identification, and configuration of the vehicles, as well as the check and determination of train's braking performance. Ebas also supported all train operating phases providing brake and traction control, and monitoring the vehicle functions. CAN fulfilled the communication requirements providing high data integrity, low implementation costs, resistance in harsh environments, and minimal power consumption especially during the long idle times.

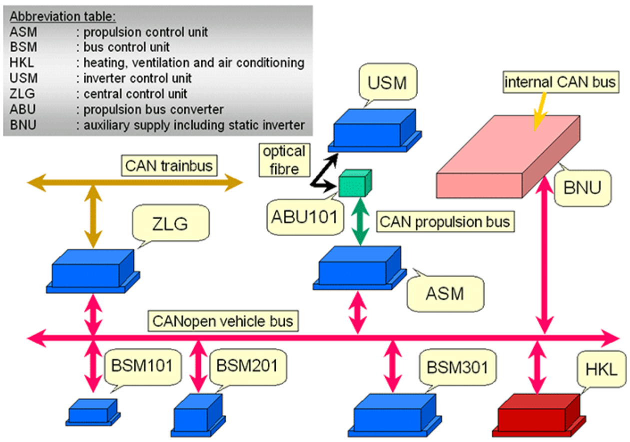

Figure 1: In-principle structure of the CAN-based networks within a vehicle (Source: Vossloh Kiepe)

The system could be deployed in trains made of up to eight 900-m segments, each consisting of up to 60 vehicles. Considering these lengths and communication delays of the CAN repeaters, the chosen bit rate of 10 kbit/s was sufficient for real-time requirements while the train operation. CAL (CAN application layer), the predecessor of CANopen, provided required objects and services for network management, vehicle configuration, transmission of high-priority braking and traction control commands, and emergency notifications. In 1996 first trains were equipped with Ebas by Mannesmann Rexroth. Later, the successfully-introduced system was also deployed in Deutsche Bahn locomotives. The well-documented specification of the CAN-based communication paved the way for further usage of CAN(open) in railway applications and for international standardization.

Public transport vehicles for from Vossloh Kiepe have comprised CAN-based networks since 1995. The use of CANopen was introduced in 1997. On the iCC (international CAN Conference) 2003, the company presented the principles of the CANopen-based control for streetcars and trolley-busses . Figure 1 shows the structure of the CAN-based networks within a vehicle. As a first step only the network management and the process data objects (PDOs) were used. The network-managing device supervised all connected CANopen devices using the node-guarding mechanism. The control and status data were transmitted via PDOs. The more recent vehicles implemented service data objects (SDOs) to exchange diagnostic and maintenance information.

On the same conference Knorr-Bremse spoke about the use of its CAN-based sub-systems (e.g. brake equipment, anti-skid system, door control, passenger information) in trams, metros, locomotives, and high-speed trains. As the base for its developments, the manufacturer used the Esra (electronic system for railway application) – a central electronic micro-processor system. At that time, the company implemented a proprietary higher-layer protocol similar to CANopen.

An expert from Deuta shown on the iCC 2005 how the company realized the CAN-based communication within the driver's desk comprising displays, dashboards, and control switches. The application implemented redundant CAN networks. A demonstration driver desk has been exhibited on the Innotrans 2004. In those days, the company considered to implement the CANopen Safety (EN 50325-5, former CiA 304) or the CANopen-based redundancy mechanism (former CiA 307) in its driver desks.

CiA profiles based on UIC leaflets

Based on UIC (international union of railways) leaflets, which specify process data for different rail-vehicle sub-systems, CiA members developed CANopen application profiles. These profiles standardize CANopen interfaces for logical units. The PDO (process data object) mapping is not specified. This enables an easy adaption by configuring the PDOs individually for each project. The following several-part profiles have been released:

Figure 2: Demonstration driver desk exhibited on the Innotrans 2004 (Source: Deuta)

- CiA 421: CANopen application profile for train vehicle control networks
- CiA 423: CANopen application profile for rail vehicle power drive systems
- CiA 424: CANopen application profile for rail vehicle door control systems
- CiA 426: CANopen application profile for rail vehicle exterior lighting control
- CiA 430: CANopen application profile for rail vehicle auxiliary operating systems
- CiA 433: CANopen application profile for rail vehicle interior lighting control

CiA is going to revise these specifications. Therefore, a free-of-charge CiA webinar (open to the entire CAN community) and a CiA workshop (limited to CiA members and invited guests) have been scheduled. Additionally, CiA exhibits on the Innotrans 2022 trade show in Berlin (Germany) in hall 27, stand 290.

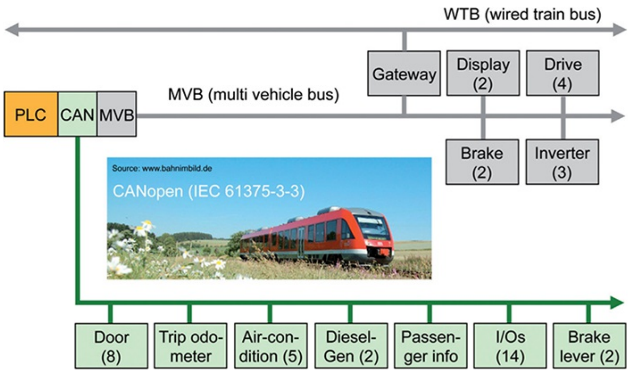

Figure 3: TCN architecture with CANopen (Source: CiA)

Internationally standardized

Since 2005, CiA experts joined the Working Group 43 of the IEC (international electrotechnical commission) Technical Committee 9. Reiner Zitzmann (now CEO of CAN in Automation GmbH) edited the IEC 61375-3-3 document named “Electronic railway equipment – Train Communication System (TCN) – Part 3-3: CANopen Consist Network”. The existing CANopen-based profiles were submitted to IEC and were considered, when the CANopen Consist Network was standardized. The standard was finally approved in April 2012 and published in June 2012. IEC 61375-3-3 specifies the data communication based on CANopen, inside a single rail vehicle or a consist, in which several vehicles share the same vehicle bus. A standardized gateway, also defined in the document, enables the full integration of CANopen-based consists in trains that follow the TCN architecture (TCN: train communication network, see IEC 61375-1/-2).

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