June 2025

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CAN in "mobile machines"

CAN is, was, and will be the dominating serial communication technology used in vehicles. More than two billion CAN nodes are applied annually. Besides road vehicles, CAN is used increasingly in "mobile machines", this could be truck-mounted body applications such as cranes or water pumps, excavators, pavers, agriculture harvesters, etc. It does not matter, if they use wheels, caterpillars, legs, or anything else. One of the challenges is autonomous operation without human interaction. CAN XL running up to 20 Mbit/s is an appropriate candidate for such applications. For low-speed applications, CAN FD with CAN SIC transceiver allowing bit rates up to 8 Mbit/s is an option.

Because most of the "mobile machine" markets are of low volume, standardization is an issue. Standardized interfaces simplify system integration and reduce development efforts. Recently, CiA has established the Special Interest Group (SIG) for radar sensors developing a device profile mappable to CANopen and SAE J1939 higher-layer protocols.

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Imprint

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Ethernetification of CAN

CiA has established an IG (interest group) to specify the mapping of Ethernet frames to CAN data frames. This means, CAN is used as an alternative PHY for Ethernet-based networks. The Ethernet data link layer remains as the base for higher-layer protocols. This approach enables using MACsec as a security measure also for CAN-based networks.

There is a demand within the automotive industry for an "Ethernet everywhere" approach, where Ethernet frames are the fundamental protocol unit for carrying information around a car between all nodes, from the smallest sensor device to a central zonal controller.

The existing CAN networks within cars are now regarded as 'legacy' and automakers are looking for a way to move the functionality to an Ethernet network. In particular, there is a demand to avoid placing proprietary CAN FD-based software stacks around the rest of the vehicle with layer-7 (application layer) conversion to new Ethernet protocols. This transition needs to be managed and to be made easier.

A brief introduction to Ethernet physical layers: There are many of them, some dating back even decades. The relevant physical layers for automotive are based on a single twisted-pair cable, and are known as Single Pair Ethernet (SPE). Examples include 100Base-T1 (100 Mbit/s, one twisted pair) developed by Broadcom (originally called BroadR-Reach). Recently, a 0,6-Gbit/s OFDM physical layer has been developed by JLR and NXP.

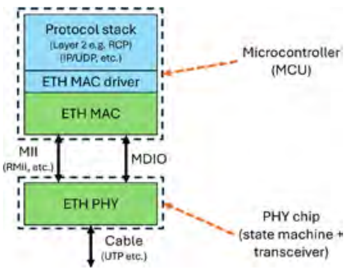

Figure 1: Generic implementation of an Ethernet node (Source: JK Energy)

A microcontroller (MCU) with an on-chip Ethernet MAC (medium access controller) sublayer implementation is connected to an external physical layer chip (PHY) via a standardized data interface (typically MII or a reduced pin count MII) and a generic control interface (MDIO). The PHY converts digital signals between an Ethernet MAC and the cable. Inside the PHY typically is a digital state machine and transceiver chip. The PHY chip implements the PMA (physical medium attachment) sublayer and PCS (physical coding sublayer) aspects and presents them to the MAC as an Ethernet frame. The Ethernet frame includes as payload higher-layer protocol (HLP) data. Typical examples are:

- Remote Control Protocol (RCP) for communicating between I/O endpoints and a central compute resource (intended for control loops over the bus)
- Internet Protocol (IP) packets, the protocol unit of all IP protocols (TCP, UDP, etc.)

MACsec, the generic data link layer security solution for Ethernet, is not regarded as a higher-layer protocol.

A software driver interfaces the specific MAC hardware (sometimes called the 'Ethernet controller') on the MCU to the protocol stack. In cost-constrained applications this arrangement is costly. In the 10Base-T1S physical layer, an integrated approach is under development.

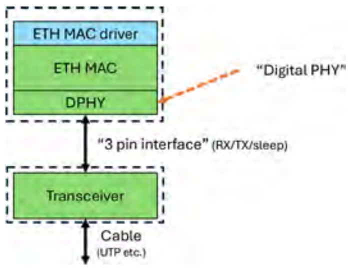

Figure 2: Highly-integrated 10Base-T1S chip comprising a MAC controller and a digital PHY (Source: JK Energy)

The digital part of the PHY is integrated with the MCU and the analog part of the PHY becomes an external transceiver, interfaced with three digital pins. Development of this approach is underway (it is being specified by Open Alliance).

One way to implement an Ethernet physical layer is to use an existing protocol and then use an "adaption" layer to transport Ethernet frames by means of the related protocol. An example of this is the JLR OFDM Ethernet, where an underlying time-division multiple access (TDMA) protocol is used to give each node a small time slot access to the network. The Ethernet frame is 'sliced up' and each fragment is transmitted in these slots. This is done so that short control frames achieve deterministic low latencies, essential for real-time control applications that will send and receive RCP frames in a 2-ms control loop (and hence the worst-case latency for a given frame must be much lower than 2 ms).

The established CiA interest group is going to specify an "adaption" layer for CAN FD mapping Ethernet frames. In other words, the Ethernet PHY is substituted by CAN lower layers (OSI layer 1 and layer 2) by means of mapping Ethernet frames to CAN data frames. There are some goals to be achieved:

- Use existing CAN FD hardware (controller, transceiver) and cabling. This is because these are proven technologies at low cost.
- Permit other non-Ethernet traffic to share the same CAN FD network. This is to allow existing CAN-based applications to migrate to Ethernet incrementally without requiring complete re-development.
- Support short deterministic latencies for small and urgent real-time control frames (as described above).

Before specifying the CAN "adaption" layer (CANAL) for CAN FD, it is important to understand the fundamentals of Ethernet frames and CAN frames. ▷

Figure 3: Ethernet frame structure (Source: JK Energy)

The destination address (DA) and source address (SA) have a length of 6 byte each. The FCS is a 32-bit CRC (with polynomial $4C11DB7_h$). The EtherType is a 2-byte field that indicates the type of the application data that follows (and this type implicitly encodes for the length of the application data). Normally the MAC performs the CRC generation and checking. The FCS field is not usually presented to the Ethernet driver.

The destination address may be a physical node address, or it may be a multicast address: a multicast address sets the least significant bit of the first byte of the address. There are ranges of multicast addresses reserved for various layer-2 protocols (for network management, time synchronization, etc.). The address FF:FF:FF:FF:FF:FF is used as a broadcast address.

There can be multiple EtherTypes in a single Ethernet frame, depending on the configuration. For example, an 802.1Q VLAN tag can precede the application data: this tag has an EtherType of 8100_h and contains a two-byte field defining properties of the frame, including its priority (one of eight levels) and a VLAN Identifier (VID) field that indicates which virtual LAN the frame belongs to. The EtherType and application data will typically follow this VLAN tag.

Another example is Ethernet MACsec frame. This has a header (called the SecTAG) and an integrity check value (ICV) that 'wraps' around application data (itself with an EtherType plus data):

Figure 4: Structure of an Ethernet MACsec frame (Source: JK Energy)

The SecTAG in MACsec can have a length of 8 byte or 16 byte, and starts with an EtherType of $88E5_h$. The ICV can be of different sizes (depending on the MACsec configuration) but is generally 16 byte.

CAN is a standard that emerged in the late 1980s and today has several variants:

- CAN CC (classic) with data field lengths from 0 byte up to 8 byte,
- CAN FD (flexible data rate) with data field lengths from 0 byte up to 64 byte,
- CAN XL (extended data field length) with data lengths from 1 byte to 2048 byte (CAN XL is not discussed in this article).

There are a huge number of networks using CAN CC not just in passenger cars: the SAE J1939 specifications are used in trucks, buses, ships, construction equipment, agricultural machinery, for example.

Figure 5: Generic structure of CAN CC and CAN FD data frames; the User Data (application data) is normally mapped into the CAN data field (Source: JK Energy)

The ID field of CAN CC and CAN FD data frames is used for two purposes: It defines the bus access priority and it defines the content of the data field. The ID shall be assigned uniquely, in order to avoid bus arbitration problems causing CAN error frames. There are two formats of the CAN ID: 11-bit IDs, and 29-bit IDs.

The SAE J1939 specifications define an industry-wide message catalogue, based on 29-bit IDs. There is a basic layout of the J1939 ID as follows:

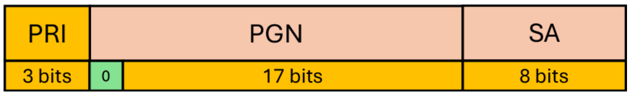

Figure 6: In J1939-21/22, the 29-bit ID is split into three sub-fields, a 3-bit priority (PRI), an 18-bit parameter group number (PGN), and a unique 8-bit source address (SA) (Source: JK Energy)

The SA is mapped in the ID field to ensure that two nodes using the same PG at the same priority result not in the very same ID value. The SA can be "hardwired" into a node, or it can be set dynamically using Address Claim protocol (not recommended by CiA, because of arbitration conflicts). The top bit of the PGN is always set to 0. The PGN is specified by the SAE J1939DA to define various vehicle-related parameters. For example, a PGN of $FE6C_h$ is defined as tachograph information.

Most CAN controllers contain ID filtering hardware, that specify whether data frames are rejected or accepted, and if accepted how they are handled (e.g., in which buffer to place data frames, and whether to generate an interrupt). In general, each filter can be programmed with 'don't care' and 'must match' bits. The adaption layer for CAN FD must meet the following requirements:

- It must carry all legal Ethernet frames and present them unchanged to all receivers.
- It must support the broadcast of Ethernet frames to multiple receivers on a single network.
- It must handle short real-time control Ethernet frames with short latency requirements in the most-timely manner possible.
- It must support deterministic worst-case latencies (i.e., meet the requirements for CAN response time analysis or network calculus).
- It must be able to run as a software layer on existing hardware with CAN FD controllers.
- It must use CAN FD IDs such that it can co-exist with all other 11-bit ID CAN traffic and also all J1939-22 CAN traffic.

CANAL specification

An arbitrary Ethernet frame is converted by the CANAL encoder into one or more CAN FD frames, each with a specific ID layout. These are sent in order on the CAN network. At each receiver, the CAN FD frames are collected and decoded into a single Ethernet frame. The original and received Ethernet frames are identical. The encode/decode operations are able to operate on any Ethernet frame.

The encoding process performs deterministic compression on the Ethernet frame so that small Ethernet frames commonly used for real-time control are compressed ▷

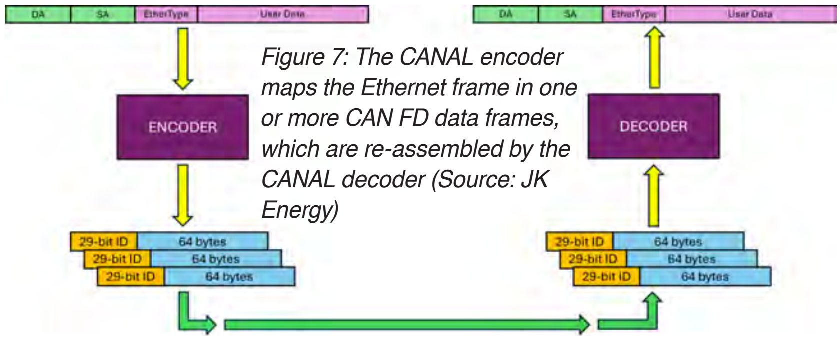

Figure 7: The CANAL encoder maps the Ethernet frame in one or more CAN FD data frames, which are re-assembled by the CANAL decoder (Source: JK Energy)

and fit into a single CAN FD data frame. The compression method is the subject of a patent application. Larger Ethernet frames are put into multiple CAN FD frames.

The compressed fields of an Ethernet frame are:

- Source address
- Destination address
- EtherType
- VLAN tag
- MACsec SecTAG

Other fields may be compressed in future revisions of this specification.

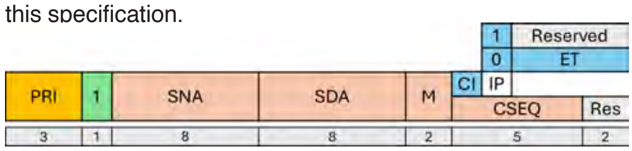

Figure 8: The CAN ID layout of the mapped compressed fields of the Ethernet frame (Source: JK Energy)

The CAN ID is always an extended 29-bit ID.

Table 1: Definition of CAN ID subfields

Subfield	Size [bit]	Description
ID.PRI	3	The priority of the Ethernet frame. This priority can come via the application program through a driver API, or it can be determined by the PCP field of a VLAN tag.
ID.J	1	Fixed to 1. This is to ensure that there is no conflict with J1939 frames (all J1939 frames have that bit set to 0).
ID.SNA	8	Source node address (SNA). A unique physical address of the sending node. This field is included for two reasons: to ensure no two nodes can generate the same ID on the CAN bus (required by the CAN protocol) and to act as a short code for a source Ethernet address.
ID.SDA	8	Short destination address (SDA). A lookup code for the Ethernet destination address. If the SDA field has a value of FF_h then all receivers shall look in the CAN frame payload for a full 6-byte Ethernet destination address.
ID.M	2	Defines which of multiple frames are sent. 00_b indicates that the original Ethernet frame is encoded into a single CAN FD frame. 01_b indicates that the original Ethernet frame is encoded into more than one CAN FD frame, and that this is the first. 10_b indicates this is one of several frames (but not the first or last). 11_b indicates that this is the last of several frames.
ID.CSEQ	5	When ID.M is 10_b or 11_b, ID.CSEQ is used to indicate the CAN FD frame number used to contain the original Ethernet frame, starting with an initial value of 1.
ID.CI	1	Indicates that there is a 2-byte control information (CI) field in the payload of the CAN FD frame.
ID.IP	1	0=EtherType field follows; 1=Reserved for future.
ID.ET	5	A lookup code for the EtherType of the frame (Table 2 gives the values). Only valid if ID.IP=0 and ID.M[1]=0. A value of $1F_h$ indicates that a 2-byte EtherType field is included in the payload of the CAN FD frame.

The layout of the CAN ID field ensures that each sequential CAN FD data frame for a given Ethernet frame has a monotonically increasing value. This ensures that no two CAN frames containing data from the same Ethernet frame have the same ID and ensures that CAN controllers cannot then arbitrarily re-order frames within an internal priority queue (a feature of many CAN controller implementations). It also means that the sequence of frames is in priority order. Together this ensures that the generated CAN FD data frames are transmitted in order (and consequently are received in order).

Table 2: Definition of codes for the ID.ET field (when valid)

Code	EtherType	Description
0	-	Always reserved
1	0800_h	IP packet
2	0806_h	ARP
3	5243_h	RCP
4	$888E_h$	MKA
5 to 30	-	Reserved for future use
31	-	Payload contains 2-byte EtherType field

The control information (CI) field encodes information for an optional VLAN tag and an optional MACsec SecTAG and is laid out a 16-bit field (as two bytes in the payload) as shown.

Figure 9: Control information field structure (Source: JK Energy)

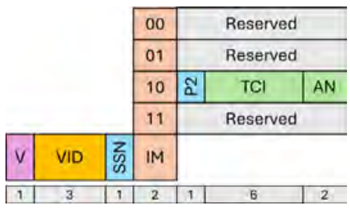

Table 3: Control Information (CI) flag values

Subfield	Size [bit]	Description
CI.V	1	The Ethernet frame started with an 802.1Q VLAN tag.
CI.VID	3	A VLAN ID short code. If CI.VID = 7 then the remaining two bytes of the VLAN tag follow in the CAN frame payload. If CI.VID < 7 then the VLAN tag VID = CI.VID, DEI=0 and PCP is derived from ID.PRI.
CI.SSN	1	Indicates if a full Ethernet source is included in the CAN payload.
CI.IM	2	Indicates the security of the Ethernet frame. A value of 00_b indicates that there is no security. A value of 10_b indicates that the Ethernet frame is protected by MACsec. Other values of CI.IM are reserved.
CI.P2	1	Bit 2 of a 3-bit Port (P) field. Only valid if CI.IM=10_b.
CI.TCI	8	The TCI field of the SecTAG. Only valid if CI.IM=10_b.
CI.AN	2	The AN field of the SecTAG. Only valid if CI.IM=10_b.

Table 4: Mapping of PCP to PRI

PRI	PCP
0	7
1	6
2	5
3	4
4	3
5	2
6	0
7	1

The CI.SSN flag is typically used by a sending node that is a switch or a bridge and where the Ethernet source address is not included in a SNA configuration map and cannot be assigned a physical address. Instead, the SNA is set to the physical address of the bridge, CI.SSN is set, and the Ethernet source address included in the CAN FD payload. ▷

PCAN-GPS Pro FD

The PCAN-GPS Pro FD is a sensor module for precise and high-frequency acquisition of position, acceleration, and orientation data. It has a magnetic field sensor, an acceleration sensor, a gyroscope, and a satellite receiver, transmitting their data via CAN CC or CAN FD. The connection to the CAN bus is designed with two interconnected LEMO circular connectors for integration into measuring chains. Thanks to its sealed aluminum profile casing, the device is usable under tough conditions. Configuration is carried out via USB using the supplied Windows® software. Afterwards, the module runs as an independent CAN node.

Specifications

- High-speed CAN connection (ISO 11898-2)
  - Complies with CAN specifications CAN CC and CAN FD
  - CAN bit rates from 40 kbit/s up to 1 Mbit/s
  - CAN FD data bit rates up to 10 Mbit/s
  - CAN transceiver NXP TJA1043
  - CAN termination can be activated with a DIP switch
  - CAN connection and supply via 9-pin LEMO circular connectors with Alpha coding (30°)
  - 2 interconnected connectors with pin assignment according to M-CAN for integration in measuring chains
- High-speed USB 2.0 via USB-C connector
- Receiver for navigation satellites u-blox NEO-M9N
  - Supported navigation and supplementary systems: GPS, Galileo, BeiDou, GLONASS, SBAS, and QZSS
  - Simultaneous reception of 4 navigation systems
  - Maximum update rate 25 Hz
  - Configurable supply of active GPS antennas to 3.3 V or 5 V
  - Optional direct access to the u-blox via USB
- Gyroscope and three-axis accelerometer ST ISM330DLC
- Electronic three-axis magnetic field sensor ST IIS2MDC
- Supercap for preserving the RTC and the GPS data to shorten the TTFF (Time To First Fix)

- STM32H745 microcontroller with Arm® Cortex® M7 and M4 dual core and 2 MByte flash
- Memory: 8 MByte QSPI flash and 4 GByte eMMC
- 2 RGB LEDs for status signaling
- Aluminum casing with Ingress Protection IP50
- Configuration with a Windows® software via USB
- Extended operating temperature range from -40 to +85 °C
- Voltage supply from 8 to 32 V via LEMO circular connectors for operation
- 5 V supply via USB for configuration

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When CI.IM=10_b, an encoding of SecTAG is included in the payload:

- PSL is the SecTAG SL field where the top two bits are combined with P2 to form a 3-bit Port (P) field.
- PN is the 4-byte SecTAG PN field.

If the original Ethernet frame SecTAG included an SCI (i.e., CI.TCI.SC=1) then the P subfield defines how that SecTAG SCI is encoded in the CAN FD payload.

Table 5: Encoding of the P subfield

P	Encoding
0	Port = 0000_h, SCI = {SA, Port}
1	Port = 0001_h, SCI = {SA, Port}
2	Port = PCP, SCI = {SA, Port}
3	Port encoded by 2-byte PORT subfield in payload, SCI = {SA, PORT}
4	Reserved
5	Reserved
6	Reserved
7	SCI encoded directly by 8-byte SCI subfield in payload

Table 6: The 33-byte CANAL compression data is placed in the CAN FD data field ahead of the application data

Subfield	Size [byte]	Condition for appearing
DA	6	ID.SDA = FF_h
ET	2	ID.ET = $1F_h$
CI	2	ID.CI = 1
SA	6	CI.SSN = 1
VLAN	2	CI.VID = 7
PSL	1	CI.IM = 10_b
PN	4	CI.IM = 10_b
PORT	2	CI.IM = 10_b and P = 3, where P = {CI.P2, PSL[7:6]}
SCI	8	P = 7

The application data occupies the remainder of the CAN FD frame data, and potentially subsequent CAN FD data frames where ID.IM is not 00_b until all application data is filled.

For a MACsec-protected Ethernet frame, the ICV follows the protected application data.

The final CAN FD data frame (also the first CAN FD data frame if ID.M = 00_b) contains a padding byte in the last (i.e., 64^{th}) byte of the CAN FD data field. This byte indicates the total number of unused bytes after the application data and ICV. This total includes the padding byte itself. For Ethernet frames where the application data and ICV fit exactly into a CAN FD frame then a subsequent CAN FD frame is generated where the padding byte has a value of 64.

A CANAL node is configured as:

- an 8-bit physical source node address (SNA),
- a 6-byte Ethernet address.

Each node also contains a configuration map that defines:

- a list of Ethernet destination addresses and an 8-bit short destination address (SDA) for that Ethernet address,
- a list of Ethernet source addresses and an 8-bit physical source node address (SNA) for that Ethernet address.

The map does not need to be the same at each node: Entries in the map are only needed for specific Ethernet source and destination address combinations that a given node wishes to receive from. In Ethernet terminology, the system is an 'engineered network' (i.e., it is known at design or deployment time).

In addition to the Ethernet configuration maps, there may be IPv4 address maps. The system designer needs to ensure that the configuration maps at each node are consistent with respect to each other. In effect, there must be a single configuration map for the network, subsets of which are programmed into each node.

For an Ethernet frame containing a small real-time control RCP frame that is MACsec-protected and in a VLAN, the Ethernet frame is reduced by:

-6 (SA)
-6 (DA)
-2 (EtherType)
-4 (VLAN)
-16 (SecTAG)
= -34 byte

The CAN FD compression data to specify is:

+2 (CI)
+1 (PSL)
+4 (PN)
+1 (Padding)
= +8 byte

In effect, 26 bytes of fixed Ethernet and MACsec overhead have been removed. If the application data in an RCP frame is less than or equal to 40 byte, then the Ethernet frame fits into a single CAN FD frame. ◀

hz

This article is based on a white paper by Dr. Ken Tindell (JK Energy) submitted to the IG08 Ethernetification of CAN.

(Source: Adobe Stock)

Awarded rear lights

The rear lights of the Audi Q6 e-tron car have received the 2025 PACE award, the annual award recognized by the "Automotive News" publication. The rear light is based on a CAN FD light prototype protocol and has been developed jointly by Marelli and OLEDWorks in close co-operation with the automaker. The digital OLED taillamp relies on 60-segment OLED light panels.

Due to the strong contrast, the taillamps are gradually turning into exterior displays, making them an enabler of communication with the car's surroundings. This, in turn, improves road safety, as demonstrated by the communication light in the digital OLED rear lights. With a total of eight optional digital light signatures of the digital OLED rear lights 2.0, Audi customers can design the look of their vehicle.

Historically, OLED panels had a maximum of 10 segments per panel and each light component within the vehicle's architecture was controlled by an individual electronic control unit (ECU) physically residing within the component. The new configuration reduces mechanical parts and space requirements and improves energy efficiency through fewer connections. Moreover, it offers flexible styling, as the direct light source control allows the creation of more animations and signatures in an easy, centralized way.

The individual control of each OLED segment is performed via a CAN FD light network that connects the domain controller to the rear-lamp gateway. The used responder nodes by STMicroelectronics comply with an early version of the CAN FD light specification. The applied commander node is a regular CAN FD node. The bit rate is 1 Mbit/s. It is the first time that this kind of communication protocol has been used in a rear-lamp application. The

(Source: Marelli/Audi)

electronic architecture of the system enables refreshing of each image on the OLED panel every 10 ms respectively 100 Hz. This refresh rate is even higher than compared with a usual monitor screen, which refreshes at 60 Hz.

The implemented refresh algorithm lets the active digital light signature demonstrate the car's vibrancy and ability to interact personally by making the Q6 e-tron's "brain activity" visible through constant movement. Drivers can select the digital light signature directly on the vehicle's HMI (human machine interface) or by means of the myAudi app.

Moreover, the digital OLED 2.0 taillight introduces the capability to communicate with the surrounding environment (V2X – Vehicle to Everything). Proximity indication, a feature familiar to other Audi models, is expanded in the Q6 e-tron to include a communication light. Integrated with the digital OLED rear lights, it warns other road users foresighted of accidents and breakdowns by displaying a specific static rear light signature with integrated warning symbols and the regular rear light graphic in critical road situations. The assistance system thus provides proactive support to Audi drivers and all other road users. *hz*

LED driver IC with CAN FD

Elmos has launched the E522.95 multi-channel PWM (pulse-width modulation) driver chip connectable to 2-Mbit/s CAN FD networks. This interface enables light animation sequences remotely controlled by a body controller or a light control unit. The IC (integrated circuit) provides 16 digitally configurable current sinks up to 100 mA with an independent 10-bit PWM generator for each channel. For fail-safe operation, the chip features an internal nonvolatile memory to store channel-individual parameters. The embedded power management allows an LED channel bundling with automatic current balancing to external resistors, resulting in a reduced power dissipation. *hz*

Standards and specifications

(Source: Adobe Stock)

This regular column provides news from standardization bodies and nonprofit associations regarding CAN-related documents. Covered are also recommended practices, application notes, implementation guidelines, technical reports, and open-source projects.

DIN 14700: Truck-mounted fire-fighting equipment

Recently, the DIN 14700 German standard written in English language has been published. It specifies CANopen-based interfaces for a body application unit (BAU) host controller and several dedicated fire-fighting units (FFUs). Such FFUs include warning signal units, water cannon units, powder extinguishing units, and light mast units. The standard provides parameter specifications and the related CANopen dictionary addresses as well as the mapping to PDOs (process data objects). Warnings and FFU diagnostic information are standardized, too.

The DIN 14700 standard has a long history. It started under the FireCAN nickname initiated by OEMs (original equipment manufacturers) including Rosenbauer, an Austrian company manufacturing fire-fighting vehicles. CiA was involved by means of a dedicated SIG (special interest group), but the participating companies agreed to submit the CANopen-based specifications to DIN, the German standardization body. DIN published after some time the DIN 14700 series, comprising twelve parts. It was a challenge to keep the documents consistent, because some of them were updated and revised. Another issue was that international suppliers need to interpret correctly standards written in German language. Additionally, the DIN documents did not always reference precisely the CANopen application layer specification. This is why DIN decided to merge the DIN 14700 documents into one single DIN standard and to publish it in English language. It is already decided to submit the new standard for international standardization to ISO or some other standardization body.

The ecosystem: DIN 14704 specifies the in-vehicle gateway unit (IGU)

The fire-fighting equipment network specified in DIN 14700:2025 is part of a larger standardization approach as shown in Figure 1. Normally, the OEM-specific in-vehicle networks provide a gateway for body builders. In the past, this was often vehicle-specific. In the meantime, it is standardized in DIN 4630, which has been submitted to ISO and is currently in review under the name ISO 25200. DIN has specified an IGU (in-vehicle gateway unit) for fire-fighting vehicles based on DIN 4630 in the DIN 14704 standard (also written in English language). This document specifies parameters and mappings to J1939 parameter groups. The related interface to the fire-fighting host controller is not specified, but can be implemented by means of corresponding IGU parameter groups. But FMU (fleet management unit) and TGU (telematic gateway unit) parameters are not yet specified.

The fire-fighting host controller (HC) acts as a gateway between the J1939-based body application network and the CANopen-based network connecting the FFUs. It ensures that the FFUs have access to relevant vehicle-related information like engine speed and that data from the attached FFUs can be forwarded to other ECUs or human machine interface devices connected to the IVNs.

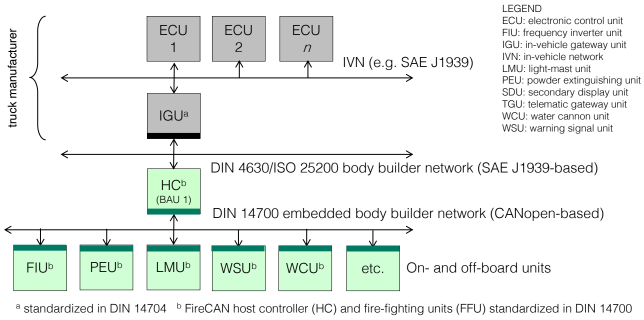


Figure 1: The DIN 14700 network is connected by means of the host controller to the ISO 25200 body builder network, which provides the in-vehicle network gateway unit to the truck networks (Source: CiA)

The DIN 14700 standard specifies the host controller (HC) and the FFU interfaces. In general, they comply with CiA 301 respectively EN 50325-4, the CANopen application layer and communication profile. The following FFUs are standardized:

- Battery charger unit (BCU) 1 to 5
- Frequency inverter unit (FIU) 1 to 4
- Light-mast unit (LMU) 1 to 2
- Powder extinguishing unit (PEU)
- Portable power generating unit (PGU)
- Vehicle-mounted PGU
- Portable water-pump unit (PWU) 1 to 3
- Traffic warning unit (TWU)
- Warning signal unit (WSU) 1 to 5
- Water cannon unit (WCU) 1 to 3
- Winding unit (WU)

The recommendations given in CiA 106, CiA 303-1, and CiA 301 specifications are suitable for DIN 14700 networks. A wiring harness featuring 120-Ohm impedance is feasible. The red wire connects to Vcc and the black wire connects to GND (ground). The white wire connects to the CAN_H wire and the blue wire connects to the CAN_L wire. The CANopen interface of fixed mounted FFU devices shall use 5-pin M12 plug circular connectors compliant with DIN EN 61076-2-101 (VDE 0687-76-2). The connector shall be A-coded and shall be in minimum IP67-rated as specified in DIN EN 60529 (VDE 0470-1).

The pin-assignments of the socket connectors attached to the wiring harness correspond to those given in DIN 14700 for the plug connectors. Wires for fixed-mounted devices having a cross-section of 0,34 mm^2 respectively for portable devices having a cross-section of 1,5 mm^2 are suitable.

The CANopen interface shall comply with the mandatory requirements of the CAN high-speed physical layer given in ISO 11898-2. Low-power and selective wake-up functionality should not be used. The transmission rate shall be 250 kbit/s. The bit-timing recommendations given in CiA 301 shall be applied, especially the sample-point range. Trunk and stub cables providing four wires for fixed-mounted devices and six wires for portable devices are recommended. The cables can be shielded. In case of using shielded cables, ground loops shall be avoided. The CAN interface shall not apply galvanic isolation between CAN protocol controller and CAN transceiver. The DIN 14700 devices shall not integrate termination resistors.

CANopen communication services: PDOs, SDOs, etc.

The CANopen FFU interfaces may support all communication services as specified in CiA 301 respectively EN 50325-4. This includes also the SDO (service data object) access to all process data parameters mapped into PDOs as well as PDO communication and mapping parameters. In the legacy DIN 14700 documents this was not possible. Legacy DIN 14700 devices can still be integrated in FireCAN networks, but the use of generic CANopen tools is limited. One of the benefits of the new DIN 14700 edition is that generic CANopen

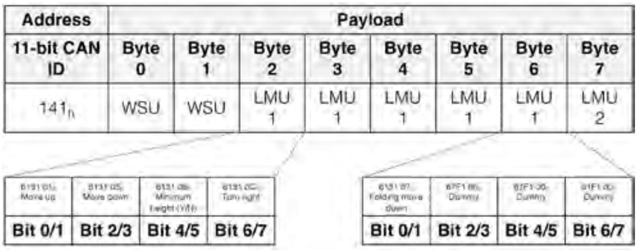


Figure 2: A PDO produced by the host controller and consumed by the WSU and LMU 1 as well as LMU 2 (Source: CiA)

protocol stacks can be applied. CANopen protocol stacks are available from commercial software suppliers and as open-source projects.

The NMT (network management) manager functionality is implemented in the host controller. It consumes the heartbeat messages of all connected CANopen devices. The heartbeat message is sent periodically with 1 ms. The heartbeat consumer time is specified as 2 ms, in order to avoid "missing" a heartbeat message just because it is delayed due to high-prior frame transmissions.

Additional to the generic CANopen communication services, DIN 14700 standardizes an ERR (error) message. This is a dedicated PDO-like protocol and service. It is mandatory. The periodically transmitted ERR message contains a 32-bit parameter with a dedicated object dictionary address (6000 01_h). This parameter contains the latest warning or failure code. The complete list of legacy warning and failure codes can be accessed by means of SDO services. The ERR message is firstly transmitted, when the CANopen device transits into the NMT operational state.

Process data parameters: Mapped into pre-defined PDOs

The in DIN 14700 specified PDO messages have a pre-defined length of 8 byte (data field). The standard specifies all transmit PDOs (TPDOs) regarding communication parameters and mapping parameters as well as the corresponding receive PDOs (RPDOs). In order to achieve a high degree of interoperability, PDO parameters are not configurable.

TPDOs are sent by the CANopen device, when it transits from the NMT pre-operational state to the NMT operational state. They are transmitted periodically (3000 ms). The inhibit time is specified as 100 ms. RPDOs are processed after reception within the TPDO event time (3000 ms).

The pre-specified PDO connection set as given in CiA 301 does not apply to this document. This means, the used CAN-IDs (identifiers) of the PDO messages are specified by DIN 14700. Therefore, generic devices need to be configured regarding the used CAN-IDs for PDOs, in order to avoid double use of CAN-IDs in the same network segment.

In some cases, a TPDO of the host controller can be relevant for different FFUs (see Figure 2). The corresponding FFUs listen to such PDO messages simultaneously. On the CAN data link layer the related data frames are distributed in broadcast. Every CAN node is able to read every CAN data frame. The CANopen protocol stack decides on the implemented PDO communication parameter, if a PDO is processed or not.

The parameters mapped into PDOs are also specified in DIN 14700. They have unique addresses in the CANopen object dictionary. This 24-bit address is made of a 16-bit index and an 8-bit sub-index. This allows SDO read and write accesses for diagnostic and troubleshoot purposes. Having SDO access to the parameters enables the use of generic and dedicated tools available from different suppliers.

Future of DIN 14700

DIN is going to submit the DIN 14700 standard to ISO for international standardization. It is intended to add some new features. One of them is the connection to the cloud by means of a telematic gateway unit (TGU). If there is a TGU already implemented on the ISO 25200 body application network, the DIN 14700 host controller can forward the relevant parameters to this unit. In addition, some FFUs (e.g., a light-mast unit) need a local TGU entity, in case it is disconnected from the DIN 14700 network, because the fire-fighting truck leaves the burn site. There are more new feature requests in the pipeline. They will be discussed and introduced, when DIN 14700 becomes an ISO standard. *hz*

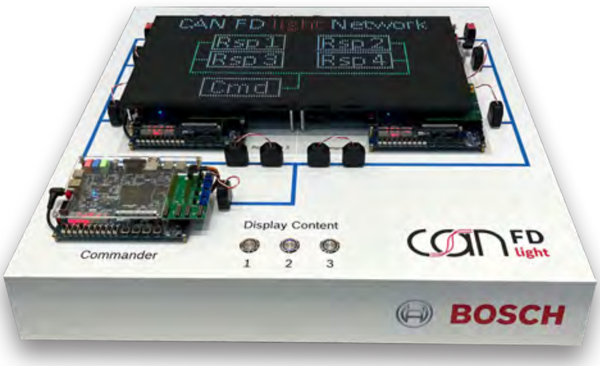
Brief news

- ***CiA 710:*** CiA has released the version 1.0.0 of the document as a DSP (draft specification proposal). The generic CANopen bootloader specification provides additional application layer functions, which complement CiA 301 or CiA 1301 CANopen application layer and communication profile for CANopen CC respectively CANopen FD. It specifies the bootloader mode and the switching to the application mode.
- ***ISO 11992-2:*** The application layer for the CAN-based network between towing and towed commercial road vehicles is going to be revised. The ISO 11992-2:2023 standard is missing PGNs (parameter group numbers), which need to be added. Additionally, new PGs (parameter groups) are demanded for e-trailers. ISO 11992-2 is referenced by EU regulations.
- ***ISO 16844 series:*** The tachograph standard is currently under revision. This includes the CAN-based parts specifying J1939 PGs (parameter groups) for service purposes, etc.
- ***SAE J1939DA:*** This digital annex (DA) is updated quarterly. The last edition has been released end of March. It includes (suspect) parameter (SP) and parameter group (PG) specifications.
- ***SAE J3271:*** Recently, the Megawatt Charging System (MCS) specification has been released. It covers the charging equipment and control elements from the point of utility interconnection to the vehicle battery terminals. SAE J3271 specifies an optional CAN FD/XL communication compliant with ISO 15118-20, as well as SAE J1939-equivalent message sets. *hz*

(Source: Adobe Stock)

CAN FD light improvements

CiA presented on its Embedded World booth in Nuremberg three CAN FD light demonstrators. The demonstrator by Bosch showed a network connecting responder nodes based on the company's CAN FD light IP cores running at 8 Mbit/s. The nodes used CAN SIC transceivers. STMicroelectronics demonstrated a rear light application based on the company's L99LDLH32 and L99LDLL16 LED driver chips (see insert "LED driver chips with CAN FD light responder functionality"). The third demonstrator by Vector showcased the configuration of CAN FD light networks by means of tools.



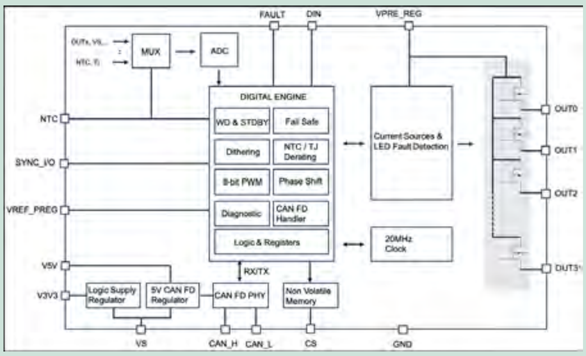
Bosch's CAN FD light demonstrator at the Embedded World booth of CiA (Source: CiA)

Originally, the CAN FD light specification has been developed within CiA. In the meantime, the related CiA 604-1 document has been submitted to ISO and is now the base of an ISO 11898-1:2024 annex. The corresponding CiA document has been withdrawn.

CiA has started to develop a CAN FD light system design recommendation (CiA 604-3). A work draft is already available for CiA members. Recently, CiA has started a CAN FD light high bit-rate specification. Additionally, CiA is working on ISO 11898-1:2024 clarifications regarding CAN FD light. They will be introduced into the next edition of ISO 11898-1. The ISO 16845-1 conformance test plan will reference some of these clarifications. The conformance test plan of the CAN FD light high bit rate approach will be specified in CiA 604-11, which will be submitted later to ISO.

The improved CAN FD light approach allows bit rates up to 8 Mbit/s, when using CAN SIC transceivers as standardized in ISO 11898-2:2024. The high bit rate approach has also some impacts on the CAN FD light commander nodes, which are also covered by the CiA documents. *hz*

LED driver chips with CAN FD light responder functionality



Block diagram of the L99LDLH32 OLED driver chip (Source: STMicroelectronics)

The L99LDLH32 from STMicroelectronics is a monolithic 32-channel linear current regulator specifically designed for automotive exterior OLED rear lighting applications. It is suitable to drive OLED panels with a common cathode. The chip guarantees up to 35-V output driving capability – to cover the OLED forward voltage wide spread – and features 32 regulated current sources able to provide from 1 mA up to 15 mA individually programmable current to drive each pixel of the OLED panel independently. As the L99LDLL16, the L99LDLH32 integrates a CAN FD light compatible communication interface, which allows a bit rate of up to 1 Mbit/s. Besides the CAN FD light compatible physical layer, the chips also integrate the protocol handler, so no additional external components are needed to facilitate communication with a CAN FD light commander node, which can be a normal CAN FD controller. *hz*

Semiconductors

(Source: : Adobe Stock)

Rocking the mine

Sany has developed driverless heavy-duty vehicles. For the simulation of a drive control system for an autonomous dump truck, the private Chinese company used tools by Dspace (Germany). The radar sensors were connected by means of a CAN FD network. “The dump truck is equipped with an autonomous driving (AD) control unit, high-precision satellite navigation (global navigation satellite system, GNSS), and various sensor technologies such as radar, lidar, and camera," explained Huijun Zhen from Sany. With the help of these systems, the vehicle can detect its surroundings and follow the routes planned on a cloud platform. It finds the best route through the constantly changing mining area and avoids obstacles.

The vehicle manufacturer opted for a simulation-based approach with two combined test methods to validate the AD control unit of its autonomous dump truck: hardware-in-the-loop (HIL) simulation and vehicle-in-the-loop (VIL) simulation. To validate the autonomous dump truck, the synchronous simulation of the sensor system is of fundamental importance. At the same time, all vehicle functions and the vehicle environment must be simulated realistically in order to be able to take a comprehensive view of the vehicle's behavior by simulating a realistic, digital twin. Last but not least, the simulator must provide interfaces for all necessary input and output signals of the control unit to be tested. This includes CAN FD interfaces for the radar sensors.

The VIL simulator was realized with the AutoBox by Dspace, in which a Scalexio system with CAN FD connectivity functions as a real-time computing platform. The virtual world and the vehicle are calculated on this with the Simulation Tool Suite ASM. The AD control unit "sees" a virtual environment that is simulated with the ASM sensor models for camera, radar, and lidar and made available by the simulator as object lists via CAN FD. "The synchronous simulation of different sensor types with physical accuracy is crucial for success, as this is the only way to create a plausible virtual world for the perception and decision-making algorithms," emphasized Huijun Zhen. *hz*


(Source: : Adobe Stock)

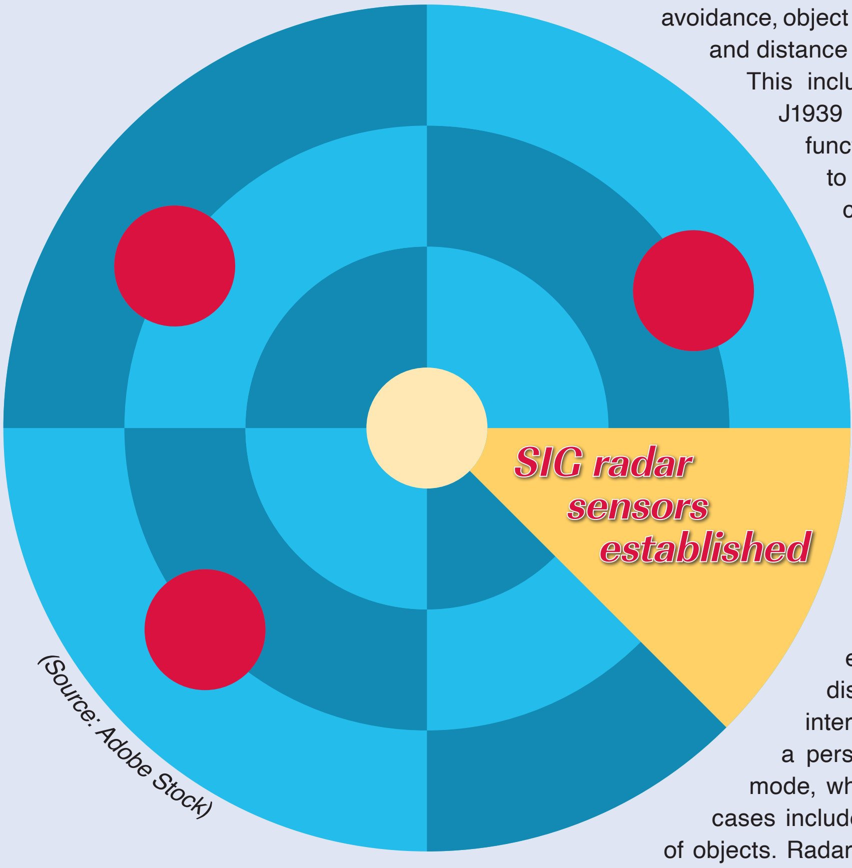
Magnetic guide sensor

(Source: Naviq)

Naviq, a warehouse navigation system provider, has introduced the MTS160 magnetic guide sensor for autonomous mobile robots (AMRs). The product features a patented angle measurement with 1° precision and 1-mm position accuracy. Magnetic guidance involves placing adhesive magnetic tape on the floor, which the robot senses and follows. The company stated that magnetic guidance is among the most precise guidance techniques and is often combined with laser systems for high-accuracy positioning. The simplicity of magnetic guidance systems is one of the strengths, requiring minimal maintenance and being less susceptible to environmental changes such as lighting variations or obstacles that can disrupt other navigation systems. Modifying the path is as simple as moving the tape.

Unlike traditional magnetic line-following sensors that only detect position along a single dimension, the MTS160's angle detection allows robots to assess the curvature of the track. This enables the AMR to distinguish between minor trajectory adjustments needed on straight paths and more proactive steering for navigating curves.

The product features an M8 4-pin watertight connector for power and signal transmission. The CAN interface enables communication with a programmable host controller from different manufacturers. It can run at 125 kbit/s, 250 kbit/s, 500 kbit/s, and 1 Mbit/s. The sensor supports CANopen. The IP54-rated enclosure measures 165 mm x 35 mm x 25 mm. *hz*



(Source: Adobe Stock)

CiA members have inaugurated the Special Interest Group (SIG) radar sensors. There are several companies offering radar sensors, supporting CANopen or J1939 higher-layer protocols (HLP). In the March issue of the CAN Newsletter, you can find two articles about such products by Pepperl+Fuchs (Germany) respectively Turck (Germany).

The participants of the inaugural SIG meeting agreed on the following scope: "This group specifies the profile for radar sensors that are applied in collision avoidance, object detection (2D and 3D), level, velocity, and distance measurement, and other use cases. This includes a mapping to CANopen and J1939 higher-layer protocols and related functional safety protocols." It is intended to develop a CiA specification series, comprising a Part B (Functional behavior and parameters) as well as a Part C (Mapping to CANopen CC), a Part F (Mapping to CANopen FD), and a Part J (Mapping to J1939).

These specifications should reference the CiA 406 series (Encoder device profile) and CiA 462 (CANopen device profile for item detection), where appropriate. Radar sensors are used for different purposes in different application domains. One example is the use in mobile machine displays: HMI (human machine interface) devices are switched on, when a person comes closer and enters sleep mode, when no person is nearby. Other use cases include measuring distances and velocity of objects. Radar sensors can also be used to avoid collisions of vehicles or collisions with obstacles. Many of these use cases are already covered by the CiA 462 specification, which is not yet applicable for J1939 communication.

CiA invites all radar sensor suppliers to join the SIG radar sensors. The next meeting is scheduled on July 9, 2025. Guests are welcome. Besides engineers from Pepperl+Fuchs and Turck, representatives from ifm, Pride Mobility Products, and Pulsotronic participated in the first SIG meeting.

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The future of powertrain solutions for construction machinery

Over one million construction vehicles are produced worldwide in 2025. Most of the them are powered by diesel engines. Many of them use embedded J1939 networks. In the future, there will be other powertrain solutions, too.

(Source: Bosch)

At the Bauma 2025 trade fair, Bosch showed how carbon emissions can be reduced in this vehicle segment. "Renewable synthetic fuels make operating both new and existing vehicles much more climate-friendly," said Jan-Oliver Roehrl from Bosch. "And, in the future, hydrogen engines and electrification also stand to make construction machinery much more sustainable."

Construction vehicles are already subject to comprehensive exhaust-emission regulations, such as Stage V in Europe, Tier 4 in the U.S.A., and Phase IV in China. Nowadays, however, their climate-relevant emissions have been regulated only to a limited extent, at least by law. One simple option for reducing their carbon emissions that is already available today is to use renewable synthetic fuels such as HVO100. Because these fuels are based on residual and waste materials, they are much more climate-friendly than fossil fuels in terms of overall carbon emissions. They are also "drop-in" fuels, meaning they can be mixed with normal diesel fuel as required.

According to Bosch forecasts, four out of five new construction vehicles worldwide with over 56 kW will still have a diesel engine in 2035. That is why Bosch will continue to develop injection technology and urea-dosing technology for exhaust-gas treatment in the future to suit the various segments of the construction machinery market.

When it comes to hydrogen engines, German manufacturers and suppliers can draw on decades of expertise, particularly in the field of engine technology: some 80 percent to 90 percent of the technology involved can be transferred from conventional combustion engines. Some construction machinery is stationary and operates under heavy loads. "This is precisely where hydrogen engines, with their high efficiency and robustness, can really excel," stated Roehrl. "The first applications of hydrogen engines featuring Bosch injection technology will be launched this year."

Another option is electrification of powertrains. With the E-Lion electrification portfolio, Bosch Rexroth offers a range of motors, inverters, gearboxes, software, and accessories,

The E-Lion inverters feature CAN interfaces (Source: Bosch Rexroth)

including appropriate hydraulics. The Bosch subsidiary is currently expanding its range to include devices for 96-V vehicle electrical systems; at the end of 2025. It will introduce a software platform for all voltage classes. Bosch Engineering presented at Bauma a solution for 800-V batteries. This solution is also suitable for construction machinery with high-power requirements and limited installation space, such as wheel loaders.

Since years, Bosch Rexroth offers the Bodas family of CAN-connectable electronic control units (ECU) designed for construction vehicles and other off-highway vehicles as well as off-road vehicles. At the Bauma, the Bodas RC/41 controller was launched. It comes with body control functionality and the Bodas off-road robotics control unit as a feature. Manufacturers of off-highway vehicles face the challenge of differentiating themselves with a strong machine identity and reducing development costs. The My-Bodas digital experience platform helps to solve ▷

development issues. In addition to the digital workspace, users benefit from a knowledge database with an AI-supported search engine, exchange with Bodas experts via tickets and forums and get free access to validated solutions and development tools.

According to Bosch Rexroth, the Bodas-Studio development environment shortens code creation based on the open Masar software architecture with many integration options. This means that the Bodas software packages released via the try-it-first process can be modified for the individual solution, e.g., with Mathlab and Simulink from Mathworks or in C language. A free C-compiler is available for development with RC/4x control units.

The Bodas controllers provide multiple CAN ports (some of them are CAN FD capable), which are supported by higher-layer protocol stacks. This includes XCP (extended calibration protocol), J1939-21/71, CANopen (EN 50325-4), CANopen Safety (EN 50325-5), and parameter-based communication configured via DBC (data base CAN) files. Communication with a service tool is also realized via one of the CAN interfaces. The Bodas service tool is based on the UDS (unified diagnostic service) standard (ISO 14299-3 and ISO 15765-2). It is suitable for software development, commissioning, and service. In particular, it can be used to download programs to the controller. Implementing a telematic gateway unit such as the Bodas RCU lite enables OTA (over-the-air) software downloads.

The ORC2 off-road robotics controller based on the QNX real-time operating system supports the ROS2 (robot operating system) software. ROS2 features CANopen support including CiA 402, the device profile for electrical drives and motion controllers. According to Bosch Rexroth, the company attaches importance to compliance with legal safety and security requirements for Bodas and other solutions. This includes new EU directives such as the Machinery Regulation 2023 and the Cyber Resilience Act (CRA). ◀

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CAN FD is coming

The construction machine industry is somehow slow in adapting new communication technologies similar to other mobile machine industries (e.g., agriculture and forestry). CAN CC (classic) networks are well-established including higher-layer protocols such as CANopen (EN 50325-4, CiA 301) and SAE J1939-21/-71. The migration to CAN FD with data fields up to 64 byte and bit rates up to 8 Mbit/s (when using SIC transceivers) is just starting.

At Bauma, TTControl (Austria) presented several control units, featuring CAN FD interfaces (from one port up to eight ports). They are capable to support data phase bit rates up to 2 Mbit/s. The Tricore-based controllers are equipped with additional Ethernet interfaces as well as local I/O ports. The company offers several CAN-based software stacks for CANopen, Isobus, and J1939. Currently, CANopen FD and J1939-22 higher-layer protocols are not supported. The manufacturer also enables equipment of CANopen capable devices (e.g., I/O modules) to CANopen Safety devices using their appropriate software add-ons.

Another early bird adapting CAN FD is Elfatek (Turkey). The company has launched the patent-protected CANvoice speech transmitter with a CAN FD interface as well as other CAN-connectable devices (e.g., the BlueCAN Bluetooth gateway and two- as well as three-axes inclinometers). The company also manufactures joysticks, CAN-to-USB interfaces, light warning systems, electronic control units, remote control solutions as well as I/O modules with CAN interfaces.

Veethree (United Kingdom) has announced the C4.3 display with one CAN FD and one CAN CC interface. The 4,3-inch TFT display provides five backlit tactile feedback buttons and a resolution of 480 pixel x 272 pixel. It additionally implements a 100-Mbit/s Ethernet interface as well as different I/O connectivity. Based on the ARM Cortex-M microcontroller, the IP66/67-rated device supports a secure boot function.

On the trade show, Kvaser (Sweden) announced the Kvaser Edge with CAN FD support. It is a Linux computing platform and can be used as a CAN-FD-to-Ethernet interface, a data logger, an edge computer for CAN/LIN networked applications, or as part of a HIL (hardware-in-the-loop) system. The collected data can be processed and analyzed on the device or sent to the cloud. The IP67-protected device implementing the ARM four-core Cortex-A53 CPU (central processing unit) can manage up to eight CAN interfaces. Another Scandinavian company Exertus (Finland) introduced four controller solutions for mobile machinery. For example, the HCM2030 features three CAN FD interfaces, 62 configurable I/O lines, a 6-axis IMU (inertial measurement unit), and a SIL 2/PL d compliant functional safety architecture.

Septentrio (Belgium) manufactures multi-frequency GPS/GNSS positioning technology for demanding applications. For instance, the AsteRx RBi3 Pro+ GNSS/INS positioning and heading receiver features a CAN-FD interface. Due to integrated IMU, it enables accurate machine positioning in the areas where satellite-guided localization is not possible.

Microcontrol (Germany) has also exhibited CAN-FD-capable products including I/O modules, control systems, and sensors. The company offers protocol stacks for such higher-layer protocols as CANopen and J1939 and is ready to provide its expertise for CANopen FD. According to the firm, the stacks are proved in ten thousands of applications. Recent I/O modules are based on the ARM Cortex M microcontroller and support the CANopen bootloader function as specified in CiA 710.

There are more CANopen devices manufacturers (e.g., ifm electronics), which have prepared their products to support the CAN FD data link layer. However, the demands from the customers on CANopen FD or J1939-17/22/71 is still low. This may change, when a cybersecure communication is required. The maximum 8-byte data-field length of CAN CC is than not more sufficient. Currently, a functional safety protocol for CANopen FD is missing. A functional safety protocol for J1939-22 is under development (J1939-77) and will be published within this year.

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Mining machinery connection to IoT

Figure 1: Hydraulic excavators from Liebherr are used to mine gold, diamonds, platinum, coal, iron ore, or copper (Source: Microsys, Liebherr)

Liebherr Mining is a manufacturer of dump trucks and hydraulic excavators for surface mining. Utilizing the Miriac system-on-modules (SoM) from Microsys Electronics, the company has made its mobile machines part of the Internet of Things (IoT) to facilitate economic fleet operations and maintenance.

In many areas of day-to-day life and the economy, we depend on mineral raw materials retrieved from the earth's crust in mines. As these are not renewable, continuous consumption reduces their availability. This makes ensuring high efficiency in mining a necessity.

The German construction machinery manufacturer Liebherr is aware of the challenges the mining industry is facing. In Colmar (France), and Newport News, Virginia (U. S. A.), the Liebherr Mining product segment produces excavators and dump trucks with up to 800 t service weight and up to 47,5 m³ bucket capacity for raw material extraction in surface mining. Designed to meet the specific requirements of the mining environment, these are powered by diesel engines or electric motors.

Liebherr draws from more than 50 years of experience. To ensure high-quality products, the company manufactures mining excavators with a high degree of in-house production. In-house designed and manufactured components, such as control systems, electronics, and turning and traction drives, enhance the reliability and performance of the machines used across all continents.

Data acquisition and communication

One of the goals of modern mining technology is to minimize environmental impact while optimizing yields and ensuring fast, concise documentation of all material movements. Another is to ensure a high availability of the mining equipment using predictive maintenance.

In pursuit of these goals, Liebherr turned to Microsys Electronics for the design and production of a connectivity box for use in the heavy mining machines. The company based at Sauerlach near Munich (Germany), mainly designs and manufactures Miriac system-on-modules (SoM). As an NXP Gold Partner, the company uses NXP's Arm Cortex-based platforms to create application-ready embedded solutions. Using these SoMs, Microsys also designs customized system solutions. These range from embedded computing platforms to real-time control hardware for mobile as well as stationary machines or high-bandwidth network and edge computing applications. The company can also provide high-precision system solutions or assists in obtaining certifications for international standards such as IEC 61508 (functional safety of electronic equipment).

The connectivity box was meant to accommodate a processor module and provide a wide variety of interfaces. Its task is to acquire, concentrate, and pre-process a variety of vehicle data and transmit the resulting information via existing Wifi or cellphone networks.

Embedded computing

"According to the original specification, the connectivity box should be the size of a pack of cigarettes", Jörg Stollfuß, Field Application Engineer at Microsys Electronics, recalls. "We actually achieved 260 x 140 x 70 millimeters." In view of the fact that the central vehicle network SoM Miriac MPX-S32G274A alone has a size of 82 mm x 50 mm and ▷

the box has about 100 external contacts in several connectors, this is a respectable achievement. Even more so, if the impermeability and shock resistance requirements are taken into account as well."

Figure 2: Miriac MPX-S32G274A vehicle network SoM is based on NXP's S32G2 processor (Source: Microsys, Liebherr)

The Miriac MPX-S32G274A SOM is equipped with the NXP S32G2 processor featuring four Arm Cortex-A53 cores and three Arm Cortex-M7 cores with lockstep support. It communicates via 18 CAN FD interfaces and a dedicated protocol generator as well as numerous other interfaces such as Flexray, LIN, SPI, Ethernet with TSN, PCI Express, USB, and I²C. Additionally, the SoM also provides a hardware security engine for secure booting and fast security services.

Robust vehicle data acquisition

To clarify the requirements, Microsys made a concept study determining the system architecture, mechanics, and preliminary component placement. This formed the foundation for the full custom design of both the electronics and the housing of the Conbox (connectivity box) and for prototyping.

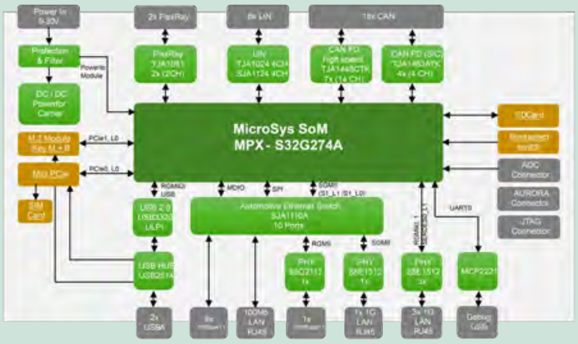
During the custom design of the carrier board and housing of the connectivity box, Microsys needed to take the extreme environmental conditions during mining operations into account. The devices are screwed onto the vehicle frames. They need to operate at altitudes up to 5500 m, withstanding temperatures from -40 °C to +70 °C and vibrations up to 6 G. They are IP68-rated, ensuring protection against dust and permanent flooding. "Only fanless equipment can meet this bundle of specifications," says Jörg Stollfuß. "These were complemented by strict electromagnetic compatibility (EMC) requirements."

Secure data concentration

The Conbox features a 4-GB memory in the shape of a soldered-on eMMC (embedded multimedia card). Serving as a battery-less backup, it facilitates up to 250 ms uninterrupted operation to bridge short interruptions of the on-board power supply and to allow an orderly shutdown of the system in case of continued power failure. Settings are stored in a non-volatile 512-KB EEPROM.

The connectivity box acts as a central gateway between the in-vehicle networks (CAN, Ethernet) and a separate uplink box that transfers the data to the Liebherr Cloud via a safeguarded link. This mainly serves the purposes of predictive maintenance, but is also used to transmit transport data used for optimizing material movements and for efficiency monitoring.

Single board computer



SBC-S32G274A block diagram (Source: Microsys)

The miriac SBC-S32G274A single board computer (SBC) is based on NXP's S32G274A vehicle network processor. It integrates a Miriac MPX-S32G274 system on module designed by Microsys. The system combines numerous high speed Ethernet interfaces for automotive networking - provided by the SJA1110 automotive switch - with such automotive interfaces as 18 CAN FD (flexible data rate), two Flexray, and eight LIN ports. Different Ethernet and USB connectivity is offered. It is a communication and compute board for automotive and industrial sensor fusion applications.

The NXP S32G274A CPU (central processing unit) comprises four Arm Cortex-A53 64-bit cores and three Arm Cortex-M7 dual-cores. The SBC features a 4-GiB 32-bit soldered LPDDR4 RAM, a 64-MiB Flash, and a 16-GiB eMMC. Required power supply can vary from 9 V_{DC} to 36 V_{DC}. The SBC with dimensions 200 mm x 140 mm is dedicated for operating temperatures from 0 °C to +70 °C. Supported operating systems are Linux and, on request, VxWorks or others. Additionally, the company provides a development kit for immediate start up. It includes the power supply and the pre-installed Linux operating system.

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The design of the connectivity box allows its use not only in new equipment but also for retrofitting or upgrading existing machines. This is why it can handle power supply voltages from 19 V_{DC} to 32 V_{DC}. Equipped with a Miriac MPX-S32G274A processor module, it has a power consumption of about 50 W.

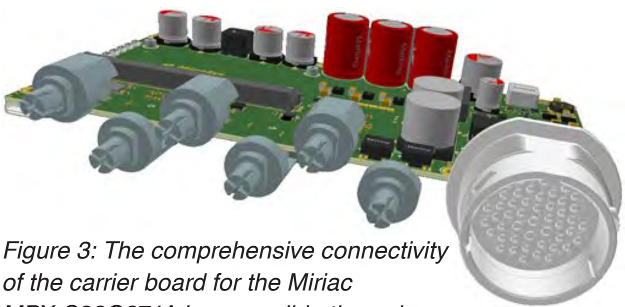

Figure 3: The comprehensive connectivity of the carrier board for the Miriac MPX-S32G274A is accessible through a 47-pin circular connector, eight X-coded M12 Ethernet connectors, and a USB Type C connector (Source: Microsys, Liebherr)

Tiny connectivity giant

In spite of its minuscule dimensions, the connectivity box offers a broad variety of connectivity options. On the vehicle side, it features eight separate CAN interfaces serving various parts of the vehicle itself such as engine control, excavator shovel control, etc. Via up to five 1-Gbit/s Ethernet interfaces, this data is concentrated, mostly combined and filtered as well as preliminarily stored using software designed by the vehicle manufacturer and finally passed on to the Liebherr Cloud using a vehicle-based modem.

The connectivity box is EMC-certified according to ISO 13766. It also features a 1-Gbit/s Ethernet switch. Two of its six ports can be used without separate power supply lines using the 15-W power over Ethernet. There are also a PCI Express interface and two serial UART interfaces. The box's connectivity portfolio is supplemented by a GPS (global positioning system) module for independent positioning, a USB interface for programming or updating and a Wifi module for local maintenance access using a tablet computer. This comprehensive connectivity is accessible through a 47-pin circular connector, eight X-coded M12 Ethernet connectors, and a USB Type C connector.

Figure 4: The IP68-rated devices are screwed on to the vehicle frames. They can operate at altitudes up to 5500 m, withstanding temperatures from -40 °C to +70 °C and vibrations up to 6 G (Source: Microsys, Liebherr)

The design of the connectivity box took place in several iterations. This was due in part to the Covid pandemic and in part to new requirements formulated after prototyping. "The first preproduction prototypes have been in operation without any failures since late 2021", says Frédérique Muller, Manager R&D Electrics, Electronics, and Cloud Services at Liebherr Mining Equipment. "Final acceptance can be expected by the end of 2024." This will be followed by serial production with about 150 connectivity boxes per year, plus some for retrofit. ◀

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The article is based on the information from Microsys Electronics (www.microsys.de)

CANopen Safety gains acceptance in mobile machine networks

At the Bauma 2025 trade show, several companies have introduced products featuring CANopen Safety connectivity. This includes programmable controllers as well as sensor devices.

The CANopen Safety protocol developed 25 years ago is standardized in EN 50325-5 and has been approved by TÜV Rhineland for SIL-3 applications according to IEC 61508. It has been implemented in several CANopen programmable control devices as well as in CANopen sensor devices. Controllers supporting CANopen Safety are provided by Epec (Finland), ifm (Germany), Intercontrol (Germany), STW (Germany), and TTControl (Austria) – just to name a few. Since many years, several sensor suppliers offer their products with an optional EN 50325-5 compliant interface. Among them are rotary and linear encoders, inclinometers, pressure sensors, load cells, etc.

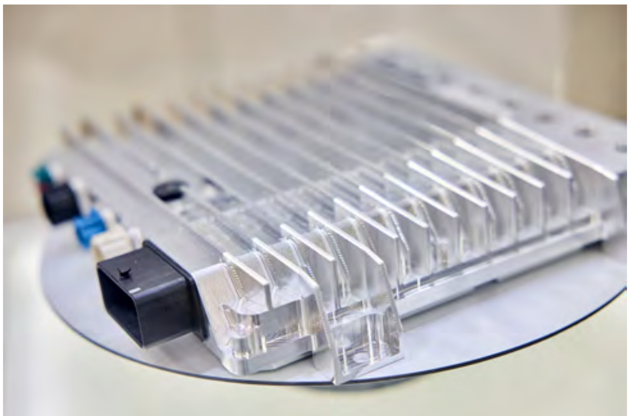
(Source: Bauma, Messe Munich)

One of the major applications of CANopen Safety are mobile machines. At the Bauma 2025 exhibition, additional CANopen Safety products have been launched. A typical CANopen Safety application is a crane overload protection system avoiding that the crane falls down. Companies such as KST Systems, Tecsis, and Wika offer since several years CANopen Safety controllers and related inclination and weighing sensors. Brosa exhibited in Munich its 0656 Flexlim Safe Overload Electronics CANopen Safety system, comprising weighing, force, angle, and pressure sensors as well as host control units. This CANopen Safety solution can also be applied for Solas container weight verification purposes. The control unit and the sensors come in IP67- or IP69K-rated housings. Miunske (Germany) is another supplier of crane controllers featuring CANopen Safety interfaces.

CANopen Safety sensors

CANopen Safety sensors, especially rotary encoders and inclinometers, are available since some years. TWK-Elektronik (Germany) is one of the early birds. Siko (Germany) introduced in Munich the NEO draw-wire encoder series. Measurement lengths range from 3 m to 15 m. The certified product complies with SIL 2/PL d and is equipped with a CANopen Safety interface. It provides not only a dynamically compensated and reliable static inclination value, but also other important data, such as acceleration, rotation rates, and Euler angles, which are also available as safety values. These are essential functions for autonomous machines. With the WV3600MR and WH3600MR, the company presented absolute multi-turn encoders with a diameter of 36 mm. They measure safely position and speed.

At Bauma, Temposonics (Germany) demonstrated its MH-Series Flex safety linear position sensors, measuring distances of up to 10,5 m. These magnetostrictive sensors are available with CANopen Safety and J1939-76 ▷



Host controllers with CANopen Safety interfaces are increasingly available from different manufacturers (Source: Bauma, Messe Munich)

Mobile machinery

Bauma 2025: 600 000 visitors and 3 600 exhibitors

(Source: Bauma, Messe Munich)

Visitors from 200 countries came to Munich to see the products from exhibitors coming from 57 nations. CiA and some of its members were present with a joint stand at Bauma 2025. The next Bauma will be held from April 3 to 9, 2028, again in Munich. Wolfgang Sochor, CEO (chief executive officer) of CiA member Hawe Hydraulik stated: “Bauma 2025 has impressively demonstrated that trends such as CO_2 reduction and alternative drives have established themselves in the industry.” Most of the electronic-supplying CiA members rated the exhibition as a success.

Electric motors are going to replace combustion engines even in earth-moving and construction machinery. Of course, CAN-based networks are used to control electric drives. Besides J1939, CANopen is a candidate for higher-layer protocols. Besides others, DMC (Germany) has presented several e-motor controllers with CANopen/J1939 connectivity. Selcom, a daughter company of Bonfiglioli (Italy), exhibited the 48-V single-motor inverter with a CANopen interface to power mobile machines. Additionally, Bonfiglioli has announced a partnership with Turntide Turnkey Solutions (U.S.A.) to develop electrification projects. This covers excavator track, swing, and pump drives as well as pump drives for compact construction, agriculture, and forestry equipment. As a system partner, Turntide provides host controllers and application software to OEMs (original equipment manufacturers).

Andreas Klauser, CEO of CiA member Palfinger summarized: “Bauma 2025 was the perfect setting to show what Palfinger is doing for its customers today – and what we are working on for tomorrow. The exhibition created unique opportunities for personal exchange. The fact that our two trade fair stands have become a popular and sought-after meeting point for customers, partners and the international trade audience is therefore a special highlight for me.”

For CiA, the Bauma exhibition in Munich is an important trade show. Next year, CiA plans to participate in the ConExpo trade show in Las Vegas (U.S.A.), which also addresses the construction industry. CiA has applied for a joint both with CiA members.

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interfaces. The sensors have been reviewed against IEC 61508:2010 and ISO 13849-1:2015 and found to be capable of achieving SIL (safety integrity level) 2 and PL (performance level) d, when used correctly within a safety system for measurement of position and velocity. Applications include safety functions with hydraulic cylinder feedback on aerial work platforms, man-lifts, cranes, and other safety-related measurements. The product can be used without breaking the hydraulic seal on the cylinder. Competing embedded sensors are protected from the external environment, but they require dismantling the cylinder in order to be serviced. This introduces logistical problems for vehicles with long extensions and little clearance. The sensor by Temposonics solves this problem, because it can bend around obstructions from other machine parts requiring only 200 mm of clearance regardless of stroke length. Getting spare parts to the field is also more efficient as even 10,5-m sensors can be coiled and shipped economically.

The KMC pressure transducers by Gefran (Italy) are based on a film-sensible element placed on a steel membrane. The latest generation of SMD electronic, combined with a stainless-steel body, makes these sensors a robust solution for applications in earth moving, agriculture, and material handling machinery. The product features a CANopen Safety interface. The company also introduced the GSH-A 12.5 wire position transducer with embedded single-axis inclinometer. It is intended to support CANopen Safety in the future. Hydac (Germany) presented in Munich its HPT 1400 pressure transducer with an optional CANopen Safety interface, too.

The SMX.igs-a inclination sensor series by STW (Germany) features IMU (inertial measurement unit) functionality with functional safety and are available in PL b and SIL 2/PL d versions. Acceleration, rotation rate, and inclination values are measured and output in all three spatial axes. Various configurable filter algorithms are available to improve measurement stability, depending on the sensor type, including low-pass filters such as Butterworth and critically damped, which are particularly suitable for dynamic applications such as mobile machinery. In addition, the Kalman filter can be activated for dynamic applications (PL-b variant). The measured values are output via a CANopen Safety port (SIL 2/PL d). In addition, the company’s Opensyde open-source software platform is supported, allowing the sensor to be integrated into network applications. Preconfigured projects and dashboards help to get the sensor up and running. The product comes in a zinc die-cast housing with an M12 socket connector.

CANopen Safety joysticks and keypads

Functional safe remote control of mobile machines is done since many years. The wirelessly connected receiver communicates safely with the hand-held device. The receiver providing access to the in-vehicle networks is often the host controller. Some remote-control receivers feature CANopen Safety communication, in order to be linked safely to other CANopen Safety devices. HBC-Radiomatic is doing so, for example. Another exhibitor, ▷

Scanreco is also a provider of radio remote control solutions with CANopen Safety.

FSG (Germany) exhibited CANopen Safety joysticks, meeting PL d/SIL 2 requirements. The range of IP65/IP67-rated products can be equipped with multi-functional ball and control handles. Of course, joysticks are highly application-specific and can be customized. The company also offers other CANopen Safety sensors such as rotary and draw-wire encoders as well as inclinometers. Elobus (Germany) offer also joysticks with CANopen and CANopen Safety connectivity. They can be integrated in modular armrests manufactured by the company. Another supplier supporting CANopen Safety is GT Joysticks (Switzerland). The products have up to three axes. They come in different sizes from thumb joysticks to big handles. Tyro by Cattron /Netherlands) showed on the CiA booth its remote controllers with receivers, featuring CANopen Safety interfaces.

At Bauma, Gessmann (Germany) presented its keypads with CANopen Safety interfaces. They are available in 2-by-3, 2-by-4, 2-by-5, and 4-by-5 push-button variants. The push-buttons can be illuminated individually in red, green, and blue.

Unfortunately, the CiA 401 profile for joysticks does not include a mapping to SRDOs (safety-related data objects) as it is specified for CiA 406 encoders and CiA 410 inclinometers. Standardized safety parameters and mappings to SRDOs would simplify system integration. The same applies to remote control receivers, keypads, and other I/O modules compliant to the CiA 401 profile for modular I/O devices.

Recently, EAO (Swizerland) launched the 09 keypad series, which is suitable for safety-related applications in accordance with ISO 26262 and ISO 13849. The optional CANopen Safety interface enables the safe communication with a host controller. The keypads are IP6K9K-rated and available in different versions including customized configurations. Robert Davies from EAO in UK said that the keypads significantly reduced maintenance downtime.

EN 50325-5 review and CiA 319 specification

The EN 50325-5 released in 2016, references outdated documents. Thus, the European Cenelec standardization body has requested a review of the CANopen Safety standard. Therefore, the CiA SIG (special interest group) functional safety is currently updating the EN 50325-5 standard. The technical content will not be changed. Besides updating the normatively referenced documents, necessary additional editorial improvements will be introduced.

Additionally, the CiA SIG is revising the CiA 319 technical report, which provides CANopen Safety implementation and configuration guidelines. CiA will start the development on functional safe communication on CANopen FD communication, when there is a demand from members. ◀

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MiC 4.0 Bus: Next generation network for construction machine attachments

As part of a German research project, the 213-pages MiC 4.0 Bus specification has been developed. It is based on J1939. The specified messages are mapped to CAN CC (classic). The nonprofit VDMA association has released the version 1.1.0 and calls for comments until beginning of July. The specification in English language can be downloaded free of charge.

MiC 4.0 is a cooperation of VDMA Construction-Equipment and Plant Engineering (VDMA) and the Federation of the German Construction Industry (HDB). As part of this project, the MiC 4.0 Bus has been specified. The main objective is to standardize an open network comprising a construction machine (carrier) and up to three attachments. The MiC 4.0 Bus document specifies the CAN-based physical layer, the J1939-based addressing, and the J1939/21-compliant mapping of parameter groups (PGs). A functional-safety concept is given, as well. Based on the MIC 4.0 Bus database, the different messages that make up the communication on the network and the corresponding machine as well as attachment functions are explained in detail. This is amended by necessary definitions, including an attachment classification and the specification of attachment geometry parameters.

(Source: Bauma, Messe Munich)

The physical layer

The MiC 4.0 Bus connector is an 8-pin socket connector designed according to MILDTL 26482, for example Amphenol Ecomate RM 12-8 or an equivalent product from other suppliers. The pins used for the CAN interface are E (CAN_H), F (CAN_L), and G (CAN termination). For diagnostic purposes, the MIC 4.0 Bus interface can be added to an OBD (on-board diagnostics) connector. The CAN bit timing complies with SAE J1939-15 (2018). The bit rate is 250 kbit/s. This also means, that unshielded twisted-pair cables are used, featuring a 120-Ω impedance. The minimum distance between nodes is 0,1 m and the maximum distance is 40 m. The single stub length is 3 m. The accumulated stub length is not specified.

To guarantee a proper termination, in the cabin and at the end of the dipper stick there have to be 120-Ω resistors. The resistor at the dipper stick is a switchable resistor. It is active as long as there is no signal on a connected line called CAN-Term (pin G). If there is power on this cable, the resistor is disabled. If there is no attachment connected, this resistor terminates the CAN cable. In case of a connected attachment the resistor is turned off by using the CAN-Term line.

The higher layers

In general, the MiC 4.0 Bus complies with SAE J1939/21 and SAE J1939/71. For the construction machine (carrier) control unit and an additional display, the source addresses (SA) as given in SAE J1939DA (digital annex) apply. The SAs (80_h to $F7_h$) for the attachments are specified in the MiC 4.0 Bus document. For examples, a rotator uses 93_h and a hammer $C2_h$. Other attachment classes are extension beams, mulcher, forks, compactors, etc.

The specified parameter groups (PGs) containing the specified suspect parameters (SPs) are transmitted periodically with not faster than 20 ms. The system designer, meaning the construction machine operator, has to take care that the busload is not exceeding 50 percent. An attachment does not send more than five PGs with a 20-ms period. The attachments transmit their J1939 messages in broadcast, while the carrier unit sends the J1939 messages with a dedicated destination address (DA) to control a single attachment.

The CMDT (connection mode data transfer) protocol is supported, enabling transmission of messages longer than 8 byte. This transport protocol can be used to transmit manufacturer data, serial numbers, attachment types, or a ▷

production date. This transmission is not safety related. It is sent on request to a specific DA.

Operational PGs use a priority of three. The priority of the transport protocol segments is seven (lowest priority). Because the busload is a safety-related issue, the PGs are sent with ±10-percent accuracy of the specified period. There are also given some restrictions regarding the busload depending on how many attachments are used. This includes the usage of additional proprietary messages. The attachment provider is responsible for guaranteeing the busload limits are met.

The specified PGs for controlling the attachments and reporting the attachment status use PGNs (parameter group numbers) defined as proprietary in the SAE J1939DA. This applies also to the hydraulic and geometric PGs. Additionally, the MiC 4.0 Bus document specifies suspect parameters (SPs) in detail. This guarantees interoperability between construction machines and attachments. This includes also SPs for geometry data, working points, center of gravity, etc. In the QCCON parameter group, there are interface descriptions for mechanical, hydraulic, and electrical mapped. These descriptions can be used to check the interoperability between construction machine and attachment. The details are given in the MiC data base.

The attachment implements an autocalibration function. This function can also be initialized by the carrier module of the construction machine. For diagnostic purposes, DMs (diagnostic messages) as specified in SAE J1939/73 can be used.

The functional-safety concept

Using the MIC 4.0 Bus, connected attachments can be controlled directly via the HMI (human machine interface) of the construction machine. For the control of the attachment, a function is parameterized on a joystick button, or wheel, or other control element. The command is then routed via the embedded network of the construction machine to the MIC 4.0 Bus carrier device with gateway functionality. The safety of the transmission from the joystick to the gateway is the responsibility of the construction machine manufacturer. The safe execution of the command is in the responsibility of the attachment supplier. Any vendor providing a MIC 4.0 Bus interface on their products must agree to follow the specified rules and to implement the functions accordingly.

The safety-related communication is a black-channel approach. This means, the CAN communication link is not part of the safety concept. It is an end-to-end safety – from one application to another application, protected by means of a 4-bit message counter and a 4-bit CRC (cyclic redundancy check) sequence. The checksum is calculated using the first seven data bytes, the message counter, and the bytes of the message identifier. The safety-related PG is sent periodically and after a specified time-out, the device transits into the defined safe state. According to the MiC 4.0 Bus authors, this concept achieves the PL (performance level) d as specified in ISO 13849-1.

Call for comments

The free-of-charge downloadable MiC 4.0 Bus specification (version 1.1.0) is not yet perfect. Besides editorial issues, there might be some technical improvements necessary, in order to avoid incompatibilities and misinterpretations of transmitted PGs. One issue is the usage of PGNs defined for proprietary purposes by SAE in an open network approach.

Comments can be submitted directly to VDMA. Additionally, CiA collects comments, observes them, and submits a collated list to VDMA. The VDMA deadline is beginning of July. ◀

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MiC 4.0 Bus based on J1939

VDMA presented the MiC 4.0 Bus at Bauma 2025 (Source: Bauma, Messe Munich)

The MiC 4.0 Bus document specifies the J1939-based communication network connecting the host controller of construction machines such as excavators and one or more attachments (e.g., gripper, driller, cutter, hammer). VDMA calls for comments. CiA will collect comments, discuss them, and submit them as joint and harmonized CiA comments to VDMA.

At Bauma trade show, VDMA presented the MiC 4.0 Bus on a special booth. The J1939-based network connects a host controller with optional gateway functionality to in-machine networks and attachments. It is intended to control and monitor attachments. This includes the identification of the attached tool type as well as the serial number, the transmission of status data (e.g., angular position), and the control of the tool. The J1939 communication is functional safe.

Several companies showed already prototype implementations and advertised the support of the MiC 4.0 Bus. About 140 companies are involved in this development, most of them observe it. Vemcon (Germany) presented a 15-m boom cable, a socket connector, and a coupler module for MiC 4.0 networks. Additionally, the company introduced a proportional tilt-rotator and attachment control unit as well as I/O units. The Copilot software enables the communication via the MiC 4.0 network. *hz*

FACTS & FIGURES

CAN FD channels

Kvaser (Schweden) has developed a PCIe board with eight CAN FD interfaces. The CAN FD ports use SIC (signal improvement capability) transceivers and support bit rates up to 8 Mbit/s in the dataphase. They can be set to silent mode, just listening and not interfering the communication of other CAN FD nodes. SocketCAN driver support is available; higher-layer protocols such as CANopen, DeviceNet, J1939, or NMEA 2000 need to run on the host controller.

The TC1017 USB dongle by Tosun (China) features eight CAN FD interfaces. It supports the loading of DBC and ARXML data base files. It can be used for UDS (unified diagnostic services) diagnostics, ECU (electronic control unit) flashing, CCP/XCP calibration, etc. Linux and Windows driver software is available. According to the supplier, data-phase bit rates of up to 8 Mbit/s are possible.

Racegrade (U.S.A.) has launched the CAN FD Gateway (Pro) providing eight CAN FD ports. Each port can be configured individually regarding frame format, bit rate, and bus termination. The CAN switch is equipped with LEDs indicating the bus status and configuration. The product has also an Ethernet interface.

The TTC 2740 host controller by TTControl (Austria) designed for mobile machines provides eight CAN FD channels. They use FD transceivers with wake-up capability supporting data-phase bit rates up to 2 Mbit/s. The product based on a Tricore microcontroller by Infineon comes in an IP65- or IP67-rated enclosure. *hz*

SBC with on-chip CAN FD transceiver

In the March issue 2025, there was an article about system-base chips (SBCs) with integrated CAN FD transceivers. Unfortunately, the products by Onsemi (U.S.A.) were not listed. The NCV7450 chip comprises one 5-Mbit/s CAN FD transceiver, an LDO regulator and one high-side driver with diagnostic capability. The NCV7450 provides in addition a local wake-up comparator, directly controlled by dedicated pins. Both products feature a dominant timeout timer, preventing a faulty CAN FD node from blocking the CAN traffic. After exceeding the timeout, the transceiver transits automatically to recessive state. They also provide an on-chip watchdog triggered by the CAN FD node's host controller, typically a microcontroller. The watchdog timer restarts immediately after a successful trigger is received. *hz*

DIN 14700 tool

(Source: Sodoq)

Insidefirecan is a software tool for diagnosis and simulation of DIN 14700 networks. An upgrade of the tool is under development to support the updated version of DIN 14700, which specifies the CANopen-based interfaces of fire-fighting equipment. The standard has been published in March 2025. The tool by Sodoq (Germany) is currently available only with German language support; the updated tool will support English, too. *hz*

12,1 inch, 7 inch, 4,3 inch

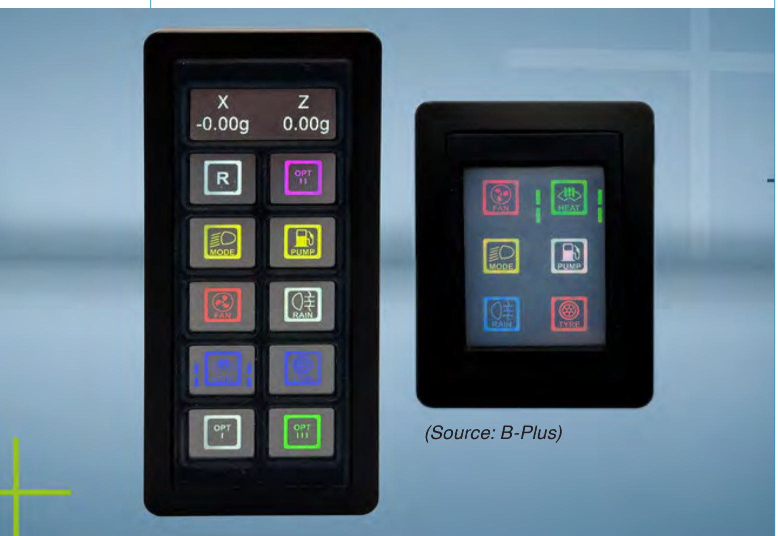
The 6512 12-inch human-machine interface has three CAN ports and two 100-Mbit/s Ethernet channels (Source: Epec)

Epec (Finland) has released CAN-connectable displays programmable in C/Qt and Codesys. The 6512 terminal is based on the iMX8 quad-core processor featuring three CAN interfaces. It provides a 1280-pixel by 800-pixel resolution. The capacitive touch screen comes with a Linux driver software. The two other smaller display units have two CAN ports and no Ethernet interface. They can be used as Isobus terminals, for example.

MRS Electronic (Germany) has also launched 7-inch (480 pixel by 272 pixel) and 4,3-inch (800 pixel by 400 pixel) displays with two CAN FD tolerant interfaces. C/Qt software support is provided. With the Opus projector tool, the user can design human machine interaction with drag-and-drop functionality. The company also offers several other CANopen-connectable products designed for use in mobile applications. *hz*

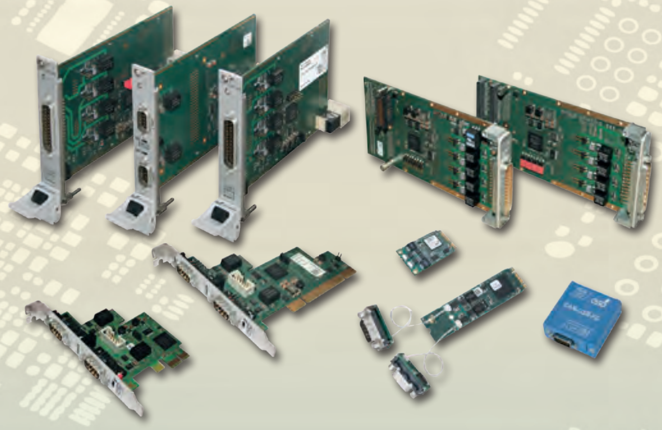
256 RGB LEDs

Lumissil (U.S.A.) has developed the IS32FL3202 RGB (red-green-blue) LED (light-emitting diode) driver IC (integrated circuit), intended to control LEDs in car-interior lighting applications. The chip enables dynamic color and intensity-changing arrays of hundreds of LEDs. It is a three-channel LED controller. Each channel supports 6-bit current adjustment for color setting and 12-bit PWM (pulse-width modulation) symbol for dimming control. To minimize EMI (electromagnetic interferences), the product supports a spread spectrum on the PWM clock generator. It features a location address assignment for addressing hundreds of RGB LEDs without the need for address pins. The maximum output current of each LED channel is 63 mA. The chip embeds a CAN interface. In addition, it implements an electronic circuitry measuring the RGB LED temperature and employing a built-in temperature compensation algorithm to ensure consistent luminance. The temperature compensated PWM data is stored in 16-bit registers. All registers can be accessed and updated via the CAN interface. Ven Shan from Lumissil said: "Up to 256 RGB LEDs connected in a single daisy chain string and multiple other LED strings, can be controlled by a single microcontroller. Additionally, the die can be co-packaged with LEDs to offer integrated smart LEDs." The supplier also offers the IC in die form, with a layout optimized for LED integration. This design eliminates the need for LED binning and manufacturing line calibration." The chip is available in production quantities in a WFDFN-10 (3 mm × 3 mm) package or in die form. It operates within a voltage range of 3,5 V to 6,5 V over a temperature range of -40 °C to +125 °C. *hz*



(Source: B-Plus)

The shown touch keypads are displays with six or twelve soft-keys, coming with a CAN interface and support for CANopen, Isobus, and J1939 higher-layer protocols. hz



Part II – CAN XL physical layer network design

With CAN XL protocol in combination with the CAN SIC XL transceiver bit rates up to 20 Mbit/s are possible. In two articles, the author presents testing results of this transmitter concept in different network topologies. This is the second article on this topic. The first article has been published in the CAN Newsletter 1-2025.

The transmitter concept for the data phase of CAN XL has been tested in different network topologies in a special physical layer plug fest beginning of January 2023. This second article continues to present the results of this plug fest.

Topology investigations

During the plugfest in January 2023 in Nuremberg, the following topologies were verified, in order to evaluate the maximum possible bit rate:

- Point-to-point network with different distances between the nodes
- Daisy-chain topology as used in 10BaseT1S networks with different distances between the nodes
- Linear topology with different stub lengths
- Single-star topology
- Multi-star topology

In this second article the results of the topologies as shown in Figure 21 to Figure 23 will be presented.

The verified pattern

The most critical scenarios in the CAN XL frame transmission are:

- The transition from SIC mode to FAST mode;
- A burst of short bits;
- A short bit after a long level_0 phase or a long level_1 phase (maximum 11 bit due to the stuff bit rule) with the opposite level.

During the ADH (arbitration to data high) bit, the transmitter switches from dominant state to level_0 and afterwards to level_1 (see Figure 24). In parallel, all receiving nodes change the receiver thresholds. This is caused by PWM-coded (pule-width modulation) symbols sent from the CAN XL protocol controller to the TXD pin of the transceivers. Before the PWM-coded symbol on the TXD pin is detected the receiving nodes transmit a short dominant pulse followed by a shortened SIC phase. The requirement is, that level_1 is stable before the SDT (service data unit type) field starts. Also, the length of the ▷

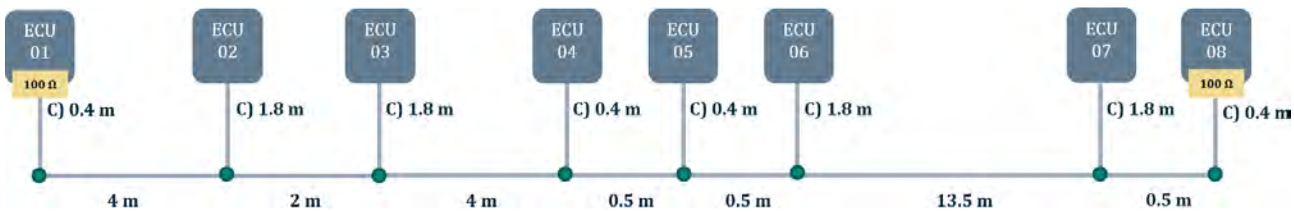


Figure 21: Linear topology with different stub lengths (Source: Infineon)

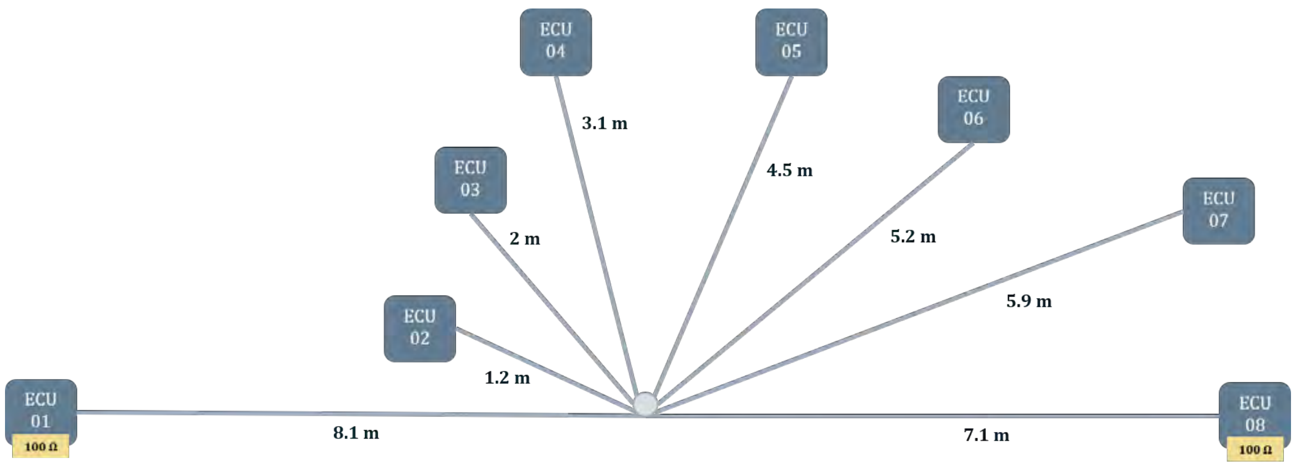
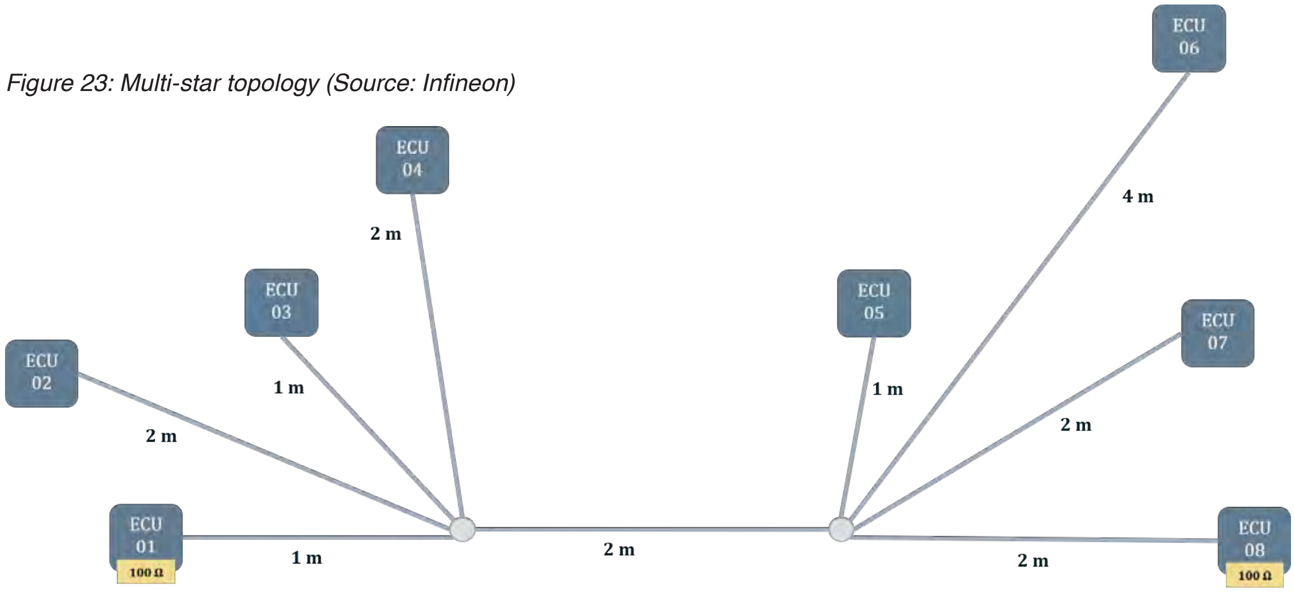


Figure 22: Single-star topology with stub lengths of 1 m, 2 m, and 4 m (Source: Infineon)

Figure 23: Multi-star topology (Source: Infineon)



DL1 (data low) bit is of interest. The transition from DH2 (data high) to DL1 is used for resynchronization of the CAN XL protocol controller after the transition into the data phase. Also, level_0 should be achieved. In the SDT field a "0101" pattern was chosen to analyze the impact of short bits in case of high bit rates.

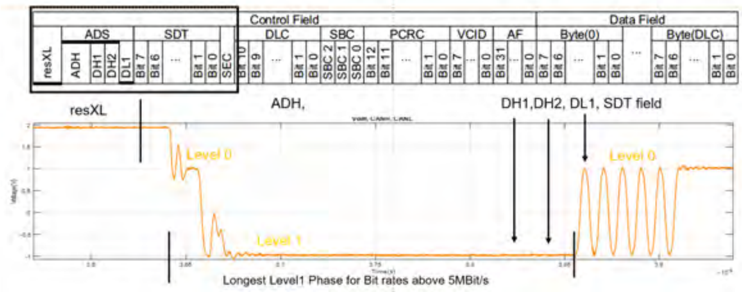


Figure 24: SIC-mode to FAST-mode transition during ADS field (Source: Infineon)

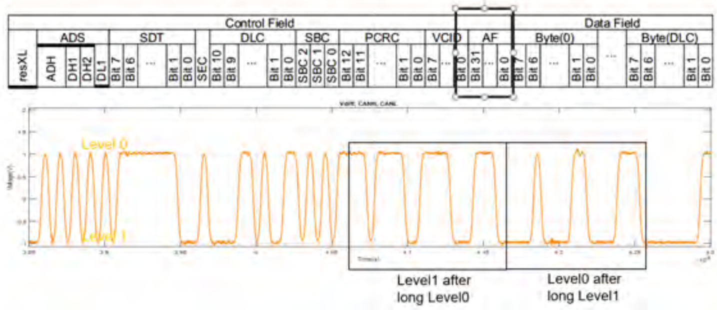


Figure 25: One, two, or three bits with opposite level after a long level_0 or a long level_1 sequence (Source: Infineon)

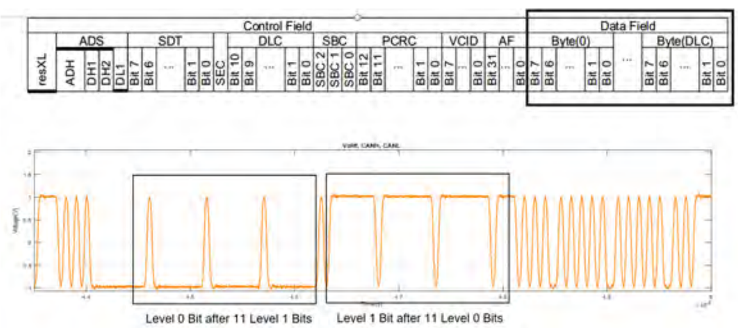


Figure 26: Level_1 or level_0 bit after a long phase (Source: Infineon)

Figure 25 shows a long phase (four consecutive bits) followed by short bits (one, two, or three) with the opposite level: The objective was to find out, how long it takes, until the bus signals are stable, especially at high bit rates. The bit lengths are measured after a longer level_0 or level_1 phase and the impact of the length of the following bits.

One bit after 11 consecutive level_1 or level_0 bits (highest possible number of consecutive bits) (see Figure 26): The objective was to find out, how the bit length and the level behave after the longest possible phase in the frame.

The test criteria

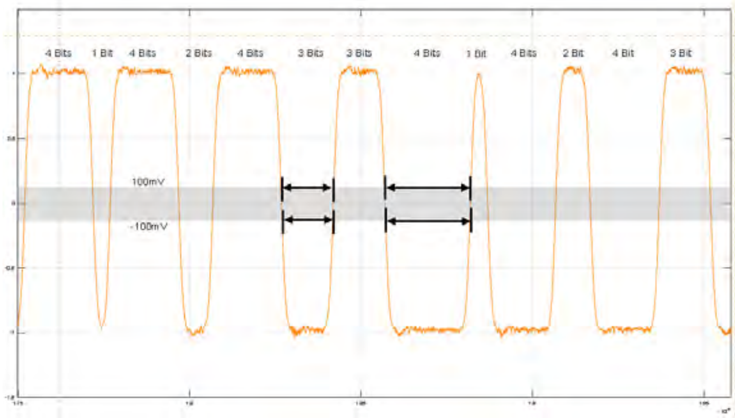


Figure 27: Test criteria timing (Source: Infineon)

The bit-time lengths (see Figure 27) were measured at +100-mV and -100-mV thresholds. The bit time should be close to the nominal bit time or multiples of them. For high bit rates the 0-V threshold was used. Glitches with a length of 20 ns were ignored.

The test topology 5a (see Figure 28) is a linear network with 40-cm stubs running at 20 Mbit/s. The difference to the daisy-chain network are the 6 stars, which cause reflection due to impedance mismatch and the high number of un-twisted parts (in total 26, one per ECU and three per start point). There is an impact of the signal integrity due to the high number of mismatches compared with the daisy-chain network with the same cumulated wire length. In this test scenario 1, both terminated nodes are analyzed. ▷

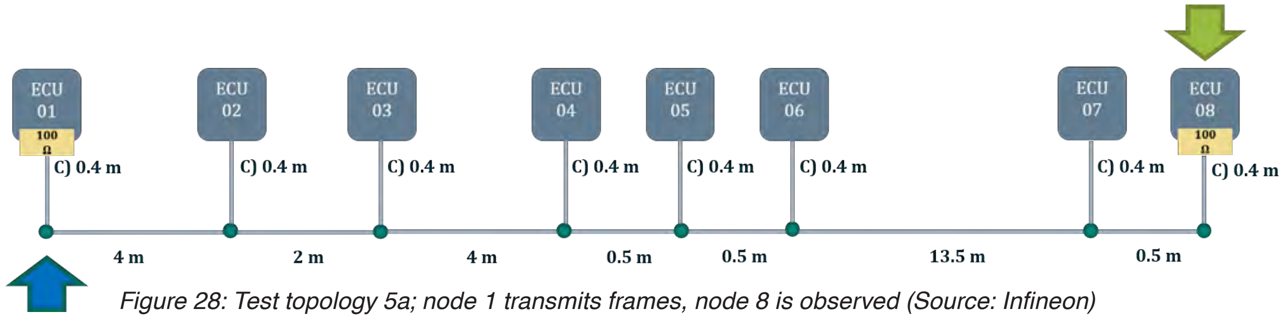


Figure 28: Test topology 5a; node 1 transmits frames, node 8 is observed (Source: Infineon)

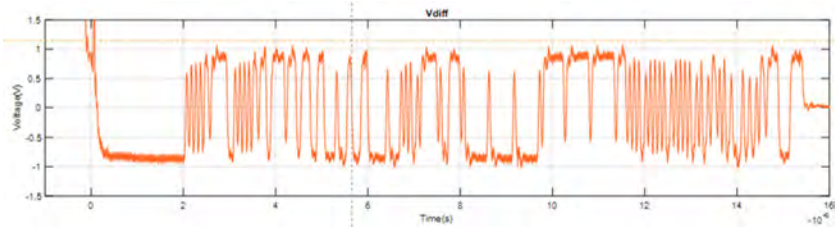


Figure 29: Full FAST phase of the transmitting node 1 (Source: Infineon)

As seen in Figure 29, the voltage levels of short bits in the SDT field or after long level_0 or level_1 phase do not achieve the maximum values for level_0 and level_1. The levels are lower than in the daisy-chain network. The maximum voltage values become closer to receiver thresholds. The bit lengths were shortened but close to the nominal bit time. All CAN XL protocol handler were able to detect all frames. In this test, the results for 20-Mbit/s frame transmissions were acceptable including the low bit-time degradation. In high-volume applications, temperature dependencies and wire-impedance variations due to fabrication variations or mechanical stress need to be analyzed.

In a second scenario using test topology 5b (see Figure 30), node 3 is transmitting and node 4 is observed. The maximum bit rate is 20 Mbit/s. In this scenario two unterminated nodes with a 4-m difference were analyzed.

Compared with the terminated nodes the voltage levels especially in single-bit bursts are higher and the bit timings are closer to the nominal bit time (see Figure 31). Pump effects could not be observed. But the voltage levels of short bits do not achieve the maximum values for level_0 and level_1. The distance to the receiver thresholds is higher compared with the results on the terminated nodes. The low bit-time degradation is acceptable.

In scenario 3 (see Figure 32), the transmitting node 6 is unterminated and the observed node 8 is terminated. The results can be compared with scenario 1 and 2. In Figure 33, the waveforms on node 8 are shown. The voltage levels of short bits do not achieve the maximum values of level_0 and level_1, but are higher than in scenario 1 and lower than in scenario 2. Up to a bit rate of 20 Mbit/s, the bit-time degradation is low and acceptable.

The topology 5c (see Figure 34) uses different stub lengths (40 cm or 1,8 m); node 8 transmits data frames with 20 Mbit/s and node 3 is observed. Longer stubs cause more ringing compared with topology 5a. ▷

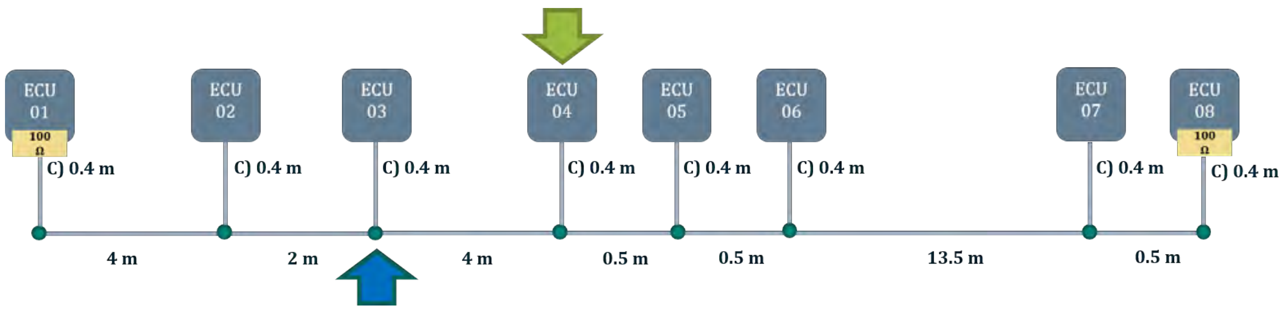


Figure 30: Test topology 5b (Source: Infineon)

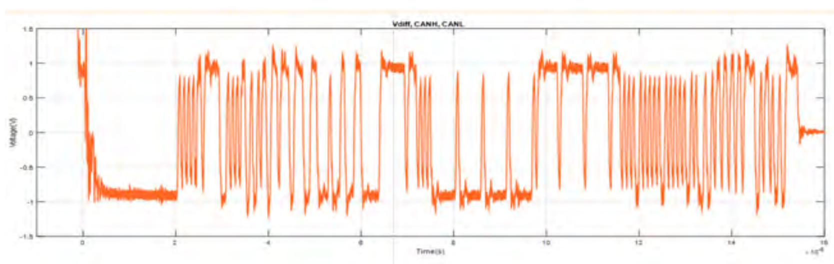


Figure 31: Full FAST phase of the transmitting node 3 (Source: Infineon)

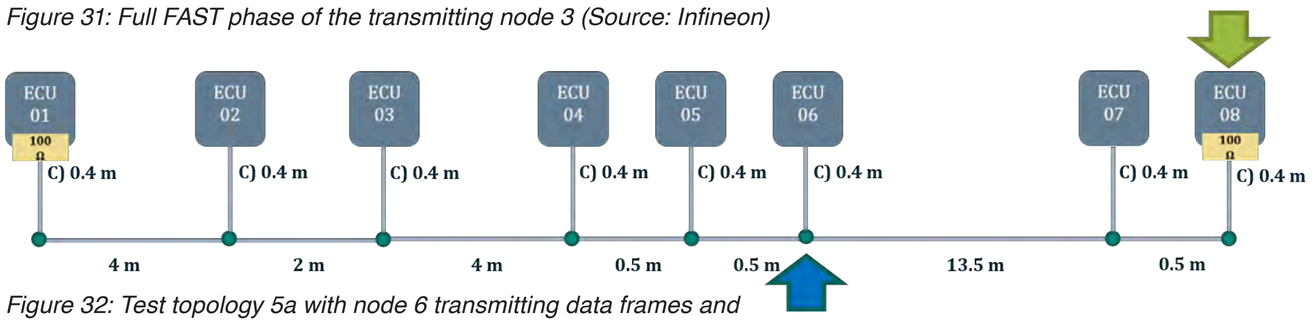


Figure 32: Test topology 5a with node 6 transmitting data frames and observing node 8 (Source: Infineon)

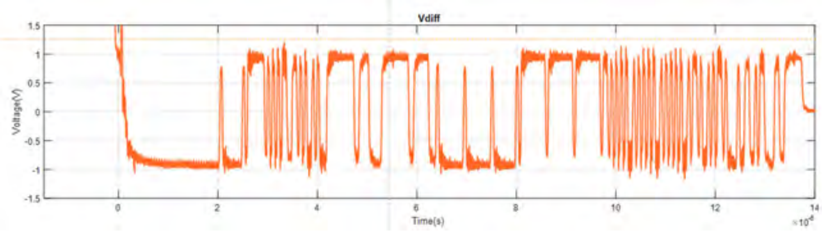


Figure 33: Full FAST phase at node 8, when node 6 is transmitting (Source: Infineon)

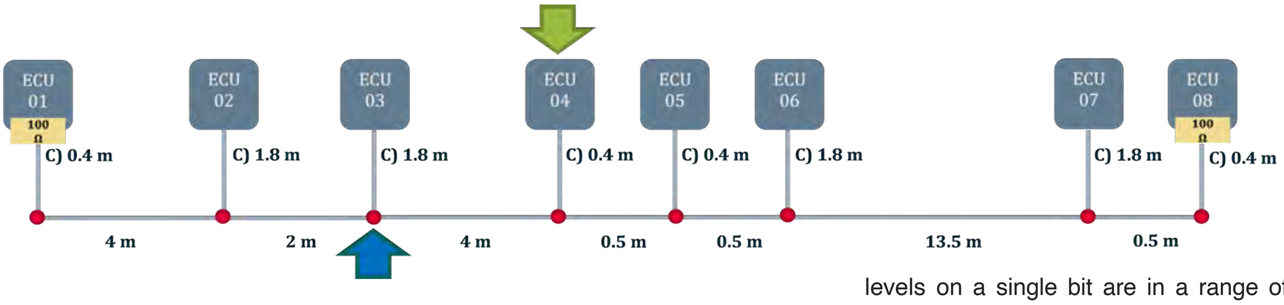


Figure 34: Test topology 5c (Source: Infineon)

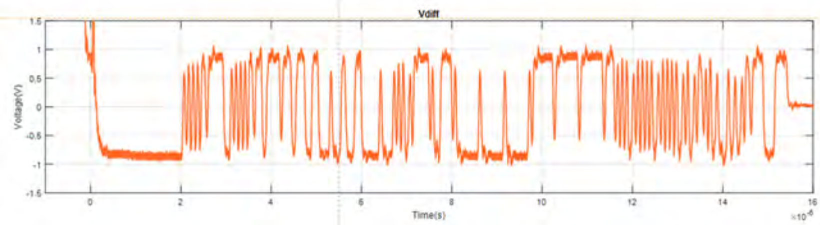


Figure 35: Full FAST phase on node 4 at 20 Mbit/s in scenario 1 (Source: Infineon)

The FAST mode measurements on node 4 are shown in Figure 35. Voltage values of short bits do not achieve the maximum values of level_0 and level_1. They were close to ±500 mV. Due to the difference of the voltage values of single bits or longer bit phases, the bit times are also more asymmetric. In Figure 36, the ADS phase plus the following SDT phase shows the difference of single-bit values and longer-bit values in detail. In case of two consecutive bits, the maximum voltage level could be achieved, while a single bit achieves sometimes only 500 mV. During the transition from level_0 to level_1 or vice versa, also reflections can be seen as small plateaus.

In the SDT field, the voltage values of level_0 and level_1 are in a range of ±500 mV instead of ±1 V. Reflections in longer level_0 or level_1 phases were also observed.

In Figure 37, the worst-case scenario (one bit level after a long stable phase of level_0 or level_1 before) is shown. The maximum voltage levels on a single bit are in a range of ±500 mV instead of ±1 V. The bit times are shortened and the situation might be critical in case of temperature, wire impedance, and transceiver parameter variation. Result: The deviation from the nominal bit time is not acceptable.

In scenario 2, the topology 5c was tested at a bit rate of 16 Mbit/s (see Figure 38). In the FAST phase, the voltage levels of the single bits are higher than at 20 Mbit/s, but the voltage level doesn't achieve the maximum values of level_0 and level_1. Also, at 16 Mbit/s the bit length deviation from the nominal bit time was not acceptable.

When transmitting with 14 Mbit/s in topology 5c (see Figure 39), the voltage levels of single bits were in the expected range. They still do not achieve the maximum voltage values of level 0 and level 1. The bit-length deviation from the nominal bit time was acceptable.

Topology 7 (see Figure 40), is a typical automotive topology with a star point and long stubs between 1,2 m and up to 8,1 m. High bit rates are not possible. Acceptable results are possible at 8 Mbit/s. In Figure 41, the complete CAN XL data frame is shown including CAN-H (in blue), CAN-L (in red), the bus differential signal (in yellow), and the RxD signal (in green).

Voltage levels of single bit burst in SDT field are symmetric, but strong reflections after level_0 to level_1 transition and vice versa can be seen (see Figure 42). The reflections are crossing the 0-V line and shorten the bit. But the receiver filters out this noise and the timing symmetry of the RXD signal depends on the receiver-filter performance.

In Figure 43, the one-, two-, and three-bit scenarios after four consecutive bits are shown. It can be seen that the time until a reflection is finished, is longer than two bit times. ▷

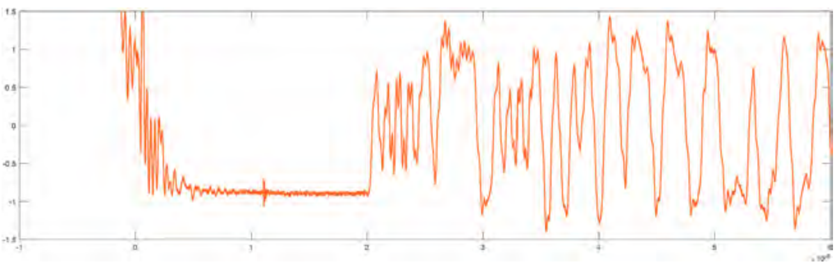


Figure 36: Zoom into ADS and SDT fields at 20 Mbit/s (Source: Infineon)

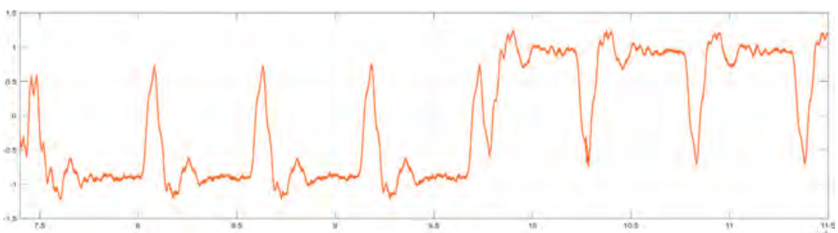


Figure 37: Zoom into the pattern field at 20 Mbit/s (Source: Infineon)

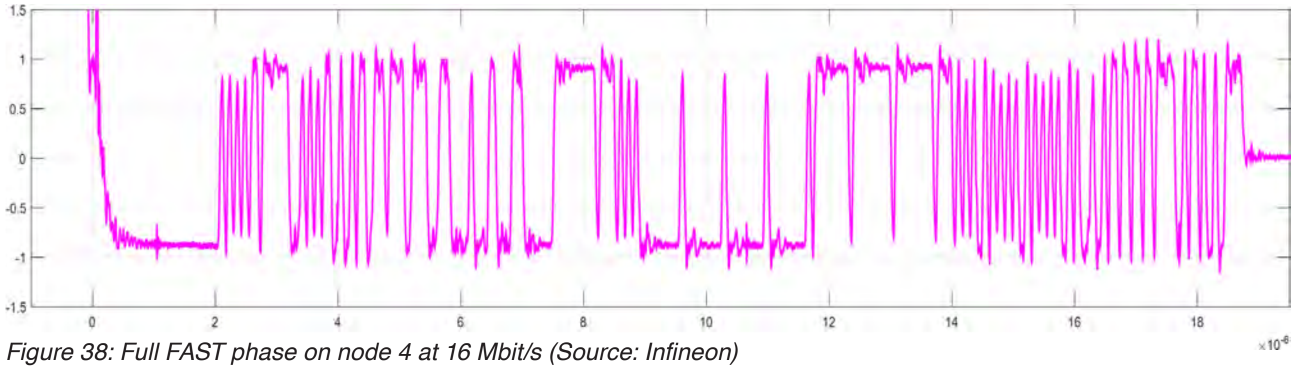


Figure 38: Full FAST phase on node 4 at 16 Mbit/s (Source: Infineon)

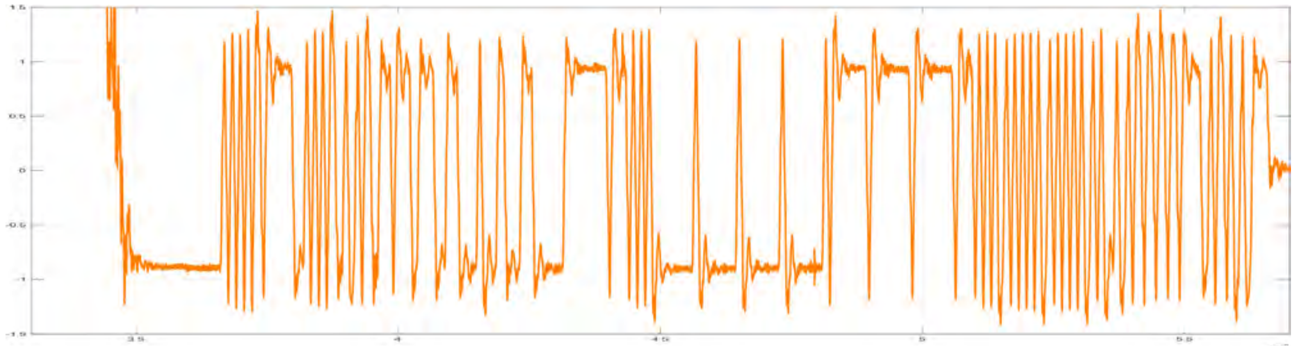


Figure 39: Full FAST phase on node 4 at 14 Mbit/s (Source: Infineon)

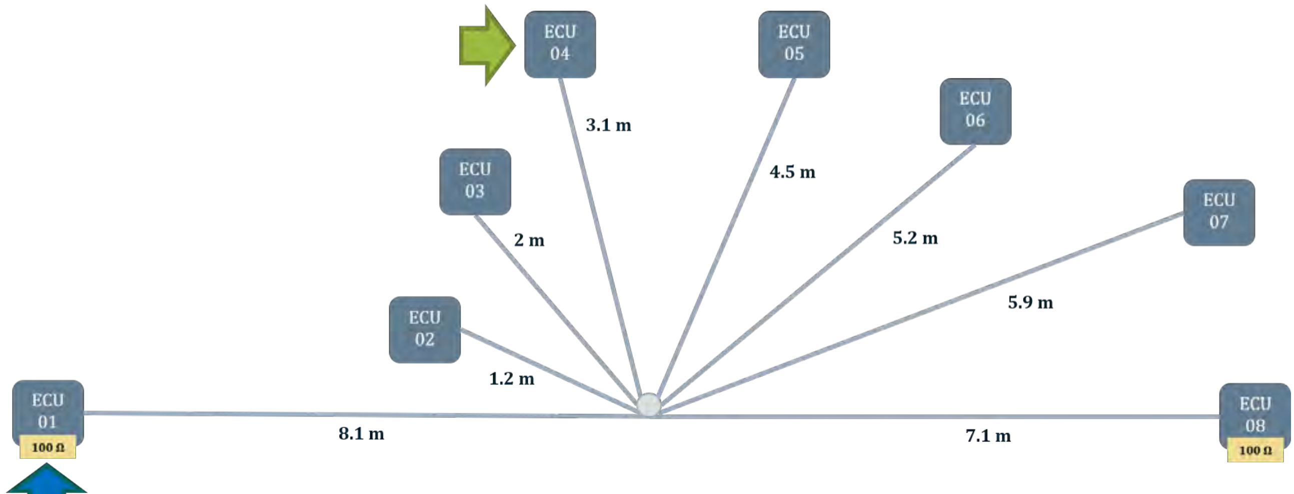


Figure 40: Test topology 7 (Source: Infineon)

Figure 41: Full CAN XL frame on node 4 using topology 7 (Source: Infineon)

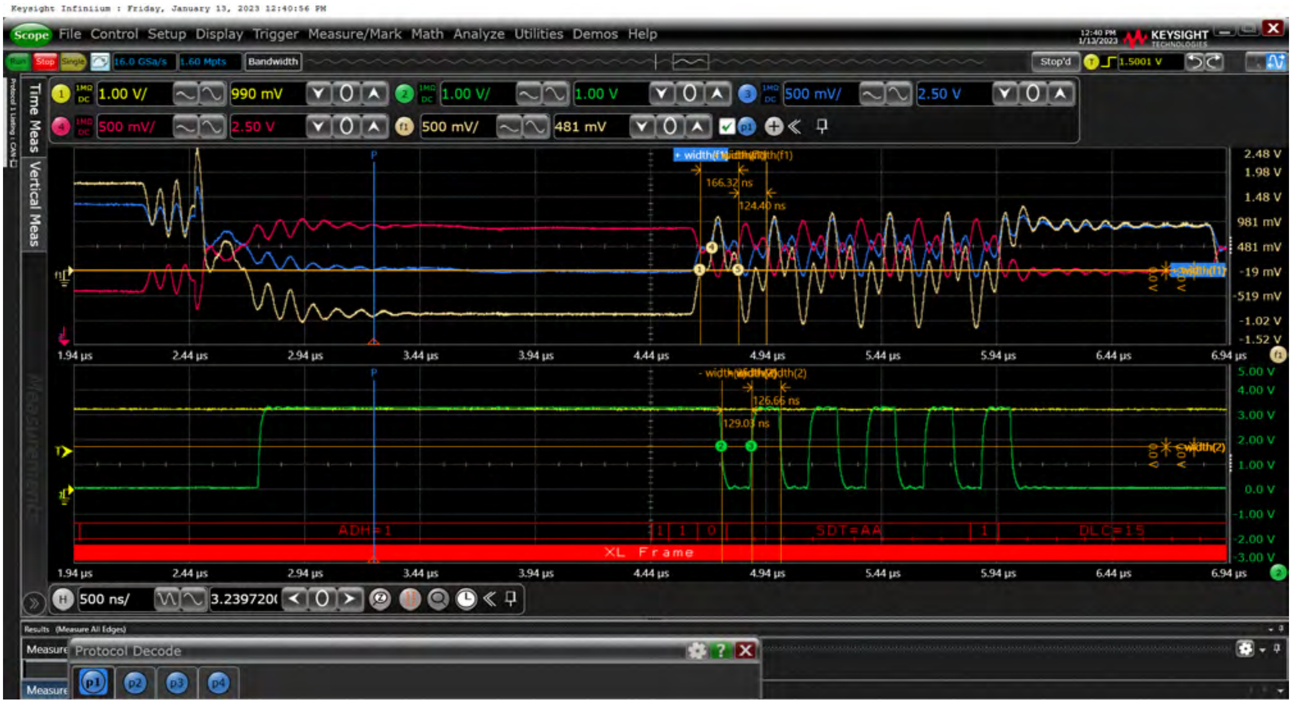


Figure 42: SIC-to-FAST mode transition in the ADS SDT phase (Source: Infineon)

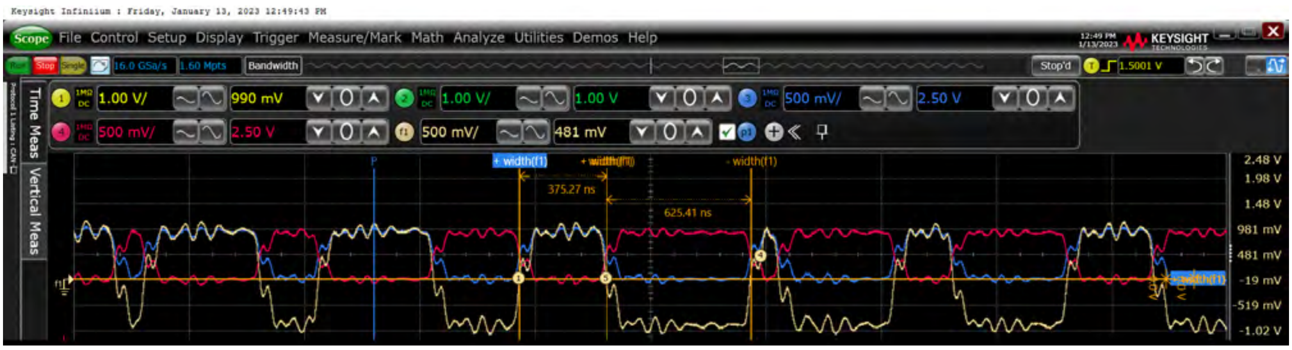


Figure 43: Pattern field in the FAST phase (Source: Infineon)

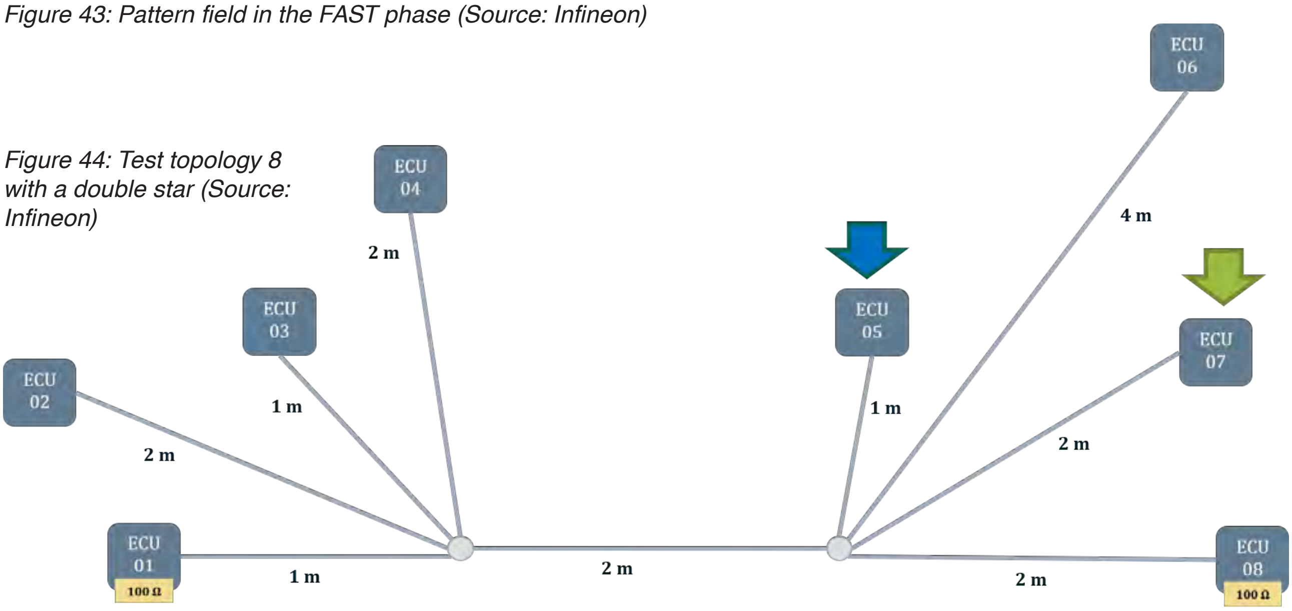


Figure 44: Test topology 8 with a double star (Source: Infineon)

At the end, it could be observed, that

- The asymmetry of the bit time depends on number of bits;
- The plateau during the transitions from level_0 to level_1 or vice versa (at V_{diff} = 0 V) might cause asymmetries;
- The asymmetry on the RXD pin depends on the receiver threshold;
- The timing symmetry on the RXD pin depends on the receiver-filter performance.

The reflections due to the star point and the long stubs limit the maximum achievable bit rate to 8 Mbit/s. ▷

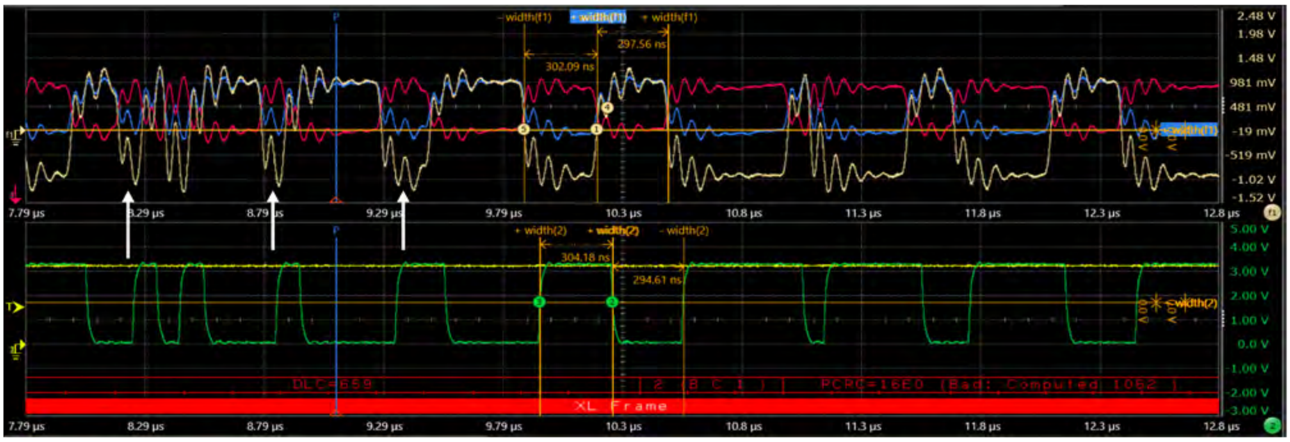
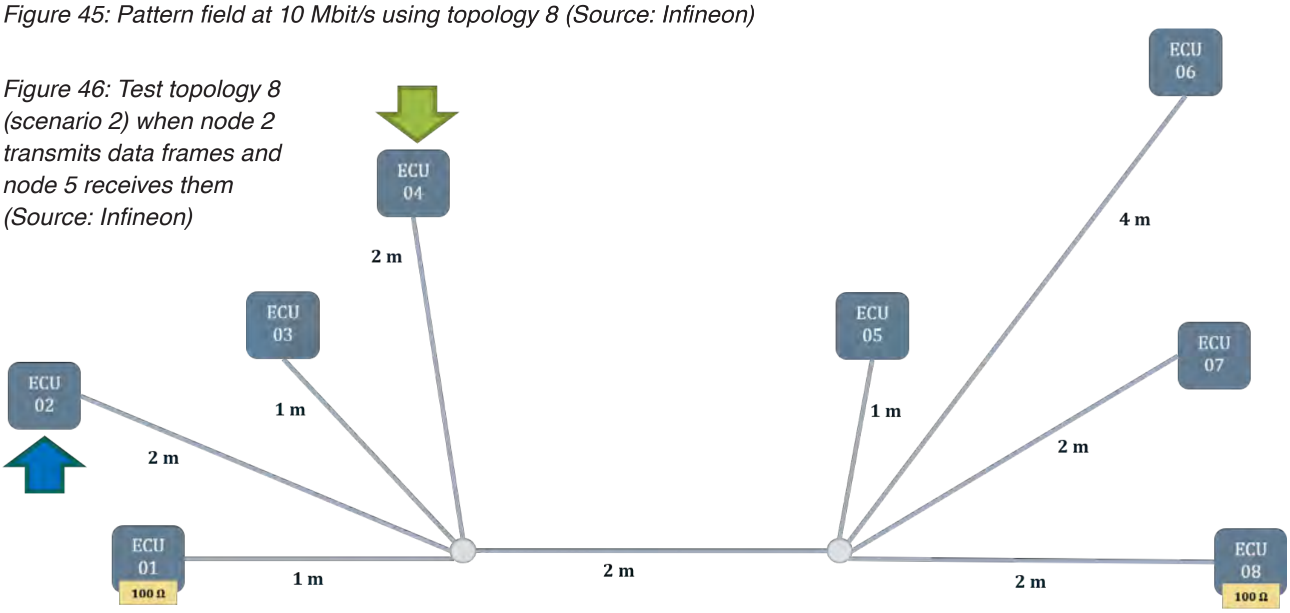


Figure 45: Pattern field at 10 Mbit/s using topology 8 (Source: Infineon)

Figure 46: Test topology 8 (scenario 2) when node 2 transmits data frames and node 5 receives them (Source: Infineon)



In topology 8 (see Figure 44), the distance between the two stars is 2 m; the stub lengths are 1 m or multiples of them (2 m or 4 m). This is a critical topology in terms of reflections. The reflected wave can accumulate to high levels on the connected nodes.

The following observations were made: ringing not finished during one bit time (it is longer than two bit times); there was an impact on the timing symmetry. Within this test, less ringing and more robust communication were observed. Transmitting with 13 Mbit/s was tested, ▷

Figure 47: Pattern field at 10 Mbit/s for scenario 2 in topology 8 (Source: Infineon)

but not documented. In all combinations with a bit rate of 13 Mbit/s, the communication was reliable and robust. Ringing was observed on the network, but the receiver was able to filter out the noise and on RXD the bit length symmetry was in an acceptable range. Figure 45 shows the pattern field at 10 Mbit/s using topology 8. Figure 47 shows the pattern field at 10 Mbit/s for scenario 2 in topology 8.

Summary and conclusion

With the CAN SIC XL transmitter concept in combination with the CAN XL protocol a big step in terms of bit rates in the data phase is possible. The maximum bit rate depends dramatically on the network design and the wire impedance. As more harmonic the impedance in the network is, as higher the possible bit rate can be. Long stub lengths and a high number of unterminated stubs as well as a high number of star points limit the maximum possible bit rate.

Recommendations to achieve high bit rates:

- The topology should be as linear as possible.
- As shorter the stubs should be.
- The number of stubs should be less.
- The wire length of CAN-L and CAN-H should be close together.
- The wire impedance should be 100 Ω with a low temperature dependency, production variation, and pressure dependency.
- The untwisted part at the end of a wire should be short.

It is recommended to verify the topology by means of simulation.

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(Source: Adobe Stock)

CAN XL IP-core

T2M (India) offers a CAN XL IP (intellectual property) core compliant with ISO 11898-1:2024. The CAN XL data link layer protocol features data field lengths between 1 byte and 2028 byte. The integrated PCS (physical coding sublayer) supports data-phase bit rates up to 20 Mbit/s in the FAST mode depending on the physical layer design (topology and applied transceiver).

The CAN XL implementation includes a single- or dual-ported RAM for data frames. The IP core also provides interface wrappers such as for AMBA, APB/AHB/AXI Lite (ARM), Avalon (Altera), and OPB (Xilinx). Available in basic and Safety-Enhanced versions, the latter is developed as an ISO 26262-10 safety-related element out of context with necessary safety mechanisms and documentation. Third-party audits ensure compliance with ASIL-B requirements. Comprehensive FMEDA analysis is provided for integration and system-level safety analysis, making it suitable for automotive safety systems and higher ASIL level readiness. Integration to Autosar environments is supported.

The synthesizable IP core features up to 128 base ID filters, up to 64 extended ID filters, and two configurable receive FIFOs (first-in, first-out). A FIFO overflow generates an overload frame. There are 32 configurable transmit buffers (FIFO or queue) possible. According to the supplier, a listen-only mode is supported. Other features include a 6-bit transmitter delay compensation, two configurable interrupt lines, two clock domains (CAN clock and CPU clock), and frame transmission request aborts. *hz*

System-on-module with CAN XL

Microsys Electronics (Germany) has announced the Miriac MPX-S32Z system-on-module (SoM) with two CAN XL and 16 CAN FD interfaces. It was designed within the framework of the BayChamp project to develop a future-proof integrated modular avionics platform publicly funded by the German state of Bavaria. The SoM is a versatile platform for systems used in aerospace, automotive, and mobile machinery applications.

The module features the NXP S32Z2 real-time processor with eight 600-MHz to 1000-MHz Arm Cortex-R52 cores, a Lockstep Arm Cortex-M33 system manager core, and a 25-Giga-Flop DSP/ML processor. Together with an up to 2-GiB LPDDR4-RAM, the module combines multi-core, real-time processing with core-to-pin hardware virtualization and DSP/ML processing. Thus, it provides ample processing power for multi-tenant software integration, says the manufacturer. The SoM also includes a microcontroller for module management.

Besides the CAN connectivity, the module's 310 pin MXM3 edge connector accommodates eight analog inputs, two Flexray, four LIN, SPI, JTAG, and Trace interfaces. A 512-Mbit/s QSPI and two 1-Gbit/s Ethernet LAN interfaces supporting TSN (time sensitive networking) for real-time data transmission allow for fast and secure communication. The SoM is an AEC-Q100 Grade 1 module supporting temperatures from -40 °C to +150 °C. It comes with a 15-year availability guarantee.

Miriac system-on-modules are application-ready platforms for NXP processor technology. The modules are "made in Germany" and support all processor-integrated features with a functionally validated package, informs the company. *of*

CAN XL starter bundle

With the PCAN-XL starter bundle, Peak-System (Germany) has released an all-in-one bundle for getting started development of applications using the CAN XL protocol. Peak-System is a part of HMS Networks.

The starter bundle has been presented on the Embedded World 2025 trade show. Depending on the version, the bundle contains the PCAN-USB XL, which is a USB-to-CAN-XL interface for connecting Windows computers to CAN XL networks. Since at least two participants are required for a functioning CAN XL communication, the company offers the bundle with one or two PCAN-USB XL interfaces. This enables customers without a suitable CAN XL counterpart to gain their first experiences with CAN XL. The PCAN-USB XL interface enables connection to CAN XL, CAN FD, and CAN CC networks via the USB port of a computer. Galvanic isolation of up to 500 V decouples the PC from the CAN network. Providing a compact plastic casing, the interface is suitable for mobile applications.

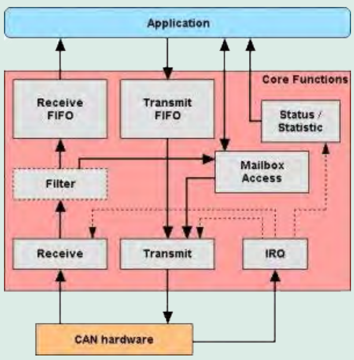
(Source: Peak-System)

In addition, the starter bundle includes the Early Access edition of the professional CAN analysis software PCAN-Explorer 7.

With the Early Access edition, users can analyze, generate, and record CAN XL data traffic. Further, the new version of the PCAN-Basic programming interface for Windows enables developers to add a CAN XL connection to their software and to receive and send CAN XL frames.

of

CANpie FD driver for STM32C0



CANpie FD driver block diagram (Source: Microcontrol)

The CANpie FD (CAN programming interface environment) driver is an open interface for development of CAN-FD-based applications. The Microcontol engineers developed the concept of a standardized driver interface to facilitate integration of different controllers in varying projects. As company's software products are equipped with both CANopen CC (classic) and CANopen FD, migration to CAN FD is possible at any time. The CANpie driver for STM32C0 MCUs was launched at the Embedded World 2025 in a robotic application on the booth of STMicroelectronics.

In combination with the new CANopen (FD) protocol stack, additional PDO (process data object) and SDO (service data object) functions as well as improved support of J1939 are available. *of*

CANopen FD protocol stack for STM32C0

CANopen FD protocol stack "in action" (Source: Microcontrol)

Microcontrol has developed a CANopen FD protocol stack for the recent STM32C0 MCU series. The CANopen FD protocol stack has been shown in action on the stand from STMicroelectronics at the Embedded World exhibition in Nuremberg (Germany). Microcontrol is a partner from STMicroelectronics.

Visitors of STMicroelectronics have also received a free sample of the new Nucleo-C092RC development board. The board features the STM32C092RC MCU, supports CAN FD, Arduino, and ST morpho connectivity. It allows users to try out new concepts and build prototypes by choosing from the various combinations of performance and power consumption. *of*

Data acquisition in automotive testing

(Source: Adobe Stock)

DAQ software for complete tests

Kistler Group expanded its vehicle testing portfolio with Kistudio VT data acquisition software. Thanks to new modules and acquisition of CAN FD data, the Kidaq data acquisition system can now also be used in vehicle development. Thus, complex vehicle tests with various sensors and a high number of channels can be performed from a single source.

Modern vehicle tests require a growing number of sensors that generate ever larger amounts of valuable data. The complexity of test setups is increasing, and so are the demands on data acquisition and analysis. To create more consistency and increase efficiency during development, Kistler is offering the Kistudio VT (2915A) data acquisition software and the extended Kidaq data acquisition system. Thus, customers have access to a complete measurement chain for vehicle testing from a single source. Developers benefit from higher efficiency, fewer sources of error, and shorter development times through the seamless integration of all test components, says the provider. Kistler has shown its solutions at the Sensor+Test 2025 trade fair.

Using Kistudio VT control and visualization of complex test setups with over 500 channels are possible (Source: Kistler)

With Kistudio VT, multiple Kidaq systems can be connected for over 500 measurement channels in a single test. All connected sensors can be intuitively integrated and configured via software. Data recording can be visualized in real time. Additionally, users can also perform calculations, use filters, and set triggers. Over 1000 signals per system are possible when recording via CAN CC (classic) and CAN FD. Data acquisition is synchronized across all devices via precision time protocol (PTP).

On the hardware side, Kistler's Kidaq data acquisition system has been expanded with additional modules for vehicle applications: The Kidaq controllers of the 5552A series feature four CAN CC or CAN FD interfaces, making them suitable for data acquisition in vehicle testing. Due to Kidaq's modular architecture, customers can flexibly adapt test setups for vehicle dynamics testing, long-term load studies, or other applications.

A typical setup for vehicle durability testing could include different sensors for recording force, acceleration, positions, and temperatures. For example, these are wheel force transducers, piezo force sensors, accelerometers, potentiometers, and thermocouples from Kistler. All these sensors, supplemented by customer-specific solutions or third-party products, are seamlessly connected to the universal data acquisition system Kidaq.

With Kistudio VT, all connected systems can be intuitively configured, monitored and synchronized. The DAQ software also supports the acquisition of CAN CC and CAN FD signals via the recent Kidaq module 5552A, meaning that even extensive data streams can be processed. Other Kistler systems such as Kiroad Wireless, Kitorq DS, and Correvit can also be connected. Analog and digital channels can be visualized, recorded, and analyzed in parallel. Post-processing is carried out with the connected analysis software Jbeam from the company.

With the help of modular architecture and complete integration, Kistler offers a measuring chain that can be adapted to the specific requirements of vehicle test projects – from data acquisition to analysis. *of*

News ticker: Sensor+Test 2025

+++ Agostec (Germany) is working on solutions for mobile measurement, data logging, and CAN software/simulation using (and distributing) devices from e.g., Klaric, Kvaser, and Race Technology. +++ Handheld recorder and analyzer series Coco (e.g., Coco-80X) with CAN CC connectivity enables time-signal data acquisition from up to 16 channels. The devices from Crystal Instruments are distributed by ADM Messtechnik. +++ Dewesoft (Slovenia) presented its vehicle analysis solutions such as Krypton modular data acquisition devices. Vehicle connection can be done via CAN CC, CAN FD, J1939, OBDI-II, XCP, CCP, etc. +++ Oros (France) offers the MODS (mobile DAQ system) for noise and vibration measurement. OR10-CAN is a 16-channel module for connection to CAN. Measurement data access via a smartphone app or a web-based platform is possible. +++ Tedra IV (thermo couple enhanced disc brake radio access) system by Sentec Elektronik (Germany) enables wireless transmission of the disc-brake temperatures via the worldwide-available 2,4-GHz frequency band. +++ Teac (Japan) provides the LX-1000 data recorder with the LX-CAN1000 module for connection to CAN FD networks. Bit-rates up to 5 Mbit/s are supported. +++ *of*

DAQ device with CAN FD

(Source: Brüel & Kjaer)

HBM, part of Brüel & Kjaer, has introduced CAN FD (flexible data-rate) support for its Quantum-X data acquisition product family. The Somat MX471C module is intended for automotive testing. It enables the synchronous integration of up to four CAN FD networks. The module, combined with a data recorder and analog measurement modules, is suitable for mobile vehicle tests and as a measurement gateway in test benches.

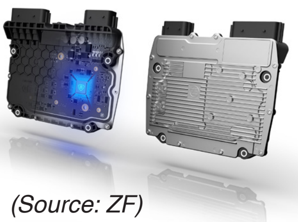
With the channel in recorder mode, parameters (such as vehicle speed, steering wheel position, or brake command) can be acquired simultaneously, with the analog inputs of other QuantumX amplifiers and used, for example, to trigger data storage. This reduces the need for manually applied sensors in the prototype phase and simplifies testing due to a minimized setup duration, said the supplier. The DAQ device can transmit up to 200 analog inputs signals to an automation system. The signals can be encoded in real-time which allows latencies of less than 1 ms.

For applications in harsh environments such as in mobile data acquisition for trucks or excavating machines, the SomatXR MX471C-R rugged version has been developed. This module is shock resistant, coming an IP65/IP67-rated enclosure. The CAN FD frames can be recorded as a raw data stream and then decoded in the PC or on the recorder. Alternatively, real-time decoding in the device itself enables the integration of parameters into a test bench.

Higher-layer protocol support for CCP (CAN calibration protocol), XCP-on-CAN/FD, J1939-21-22, Isobus (ISO 11783 series), and CANopen is available. Combination with analog measurement input modules is possible. The acquired signals can also be decoded in real-time and transferred to analog voltage output (MX878B) or, for instance, to an Ethernet-based network (CX27C). The DAQ device features CAN FD gateway functionality, enabling the splitting or re-assembling of messages. *hz*

(Source: Bauma, Messe Munich)

Drive control unit ready for cybersecurity and functional safety


(Source: ZF)

ZF (Germany) has introduced the EC5 drive controller. The product is designed to meet the upcoming cybersecurity standards. According to the supplier, the drive controller complies with both the European Cyber Resilience Act (CRA) as well as the EU Machine Regulation, which will become active in 2027.

The product is plug-and-play hardware-compatible with previous drive control units, stated the supplier. The implemented CAN software provided to OEMs (original equipment manufacturers) is also unchanged. *hz*

Comfortable seat for construction industry

At the trade show, Grammer (Germany) presented the all-electric MSG 297/2900 seat featuring a CAN interface. It brings the seating comfort familiar from premium passenger car models to construction machinery, informs the manufacturer. The basis for the so-called ‘Ultimate Comfort’ is the company’s double-roll suspension offering a balance of friction minimization and reduced play. Thanks to the suspension and automatic weight adjustment, the seat should offer a safe and comfortable ride for all types of drivers. The seat construction is also designed for heavy multifunctional armrests and attachments. Settings and seat status can be operated/called up via customer-specific vehicle displays. Simple seat diagnostics is possible via vehicle electronics using the CAN interface.

Depending on the variant, the basic version can be upgraded with comfort-enhancing features. These include the electric ten-way seat adjustment (height, backrest, forward/backward, depth/tilt seat cushion), memory function for selected seat alignment, and adjustable side contour of the backrest by filling it with air. Further features include seat climate control, dual-motion backrest for short backs as well as a massage system. *of*

(Source: Grammer)

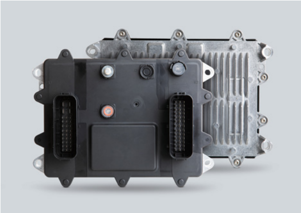
Host controller with four CAN ports

At the Bauma, STW (Germany) launched the ESX.4cl-ag control unit designed for mobile machines with limited installation space. The programmable device implements an Auris processor with six cores by Infineon. It provides four CAN interfaces and a managed Ethernet switch with one 100Base-Tx Ethernet and three Single-Pair Ethernet (SPE) ports (100Base-T1 and 1000Base-T1). The Ethernet switch enables the exchange of large amounts of data without affecting the controller's available processing performance. The specially designed SPE interfaces are capable of implementing the 1-Gbit/s Ethernet (ISO 23870 series), which is jointly under development by experts from earthmoving, agriculture, and other mobile machine industries. The controller comes in an IP6k5k- or IP67k-rated aluminum die-cast enclosure.

The host controller features 58 configurable (analog and digital) multifunctional inputs. Most of them feature also Sent (single-ended nibble transmission) functionality compliant with SAE J2716. The user has the choice of supplying the connected sensors from either programmable or fixed supply voltages, ranging from 5 V to 12 V. A total of 56 low-side and high-side outputs each deliver up to 4 A, depending on the configuration. This allows connected actuators to be supplied with power. Two 10-A half-bridges make it possible to control brushed electric motors. A second switch-off path disconnects the outputs of the host controller safely. This emergency shutdown path is mandatory for safety-related applications. The optional i.MX6 coprocessor can be used to provide connections to the IoT world, including cloud services.

The open-source Opensyde development and lifecycle management tool by STW enables application programming and mapping as well as testing of functionalities in "C" and in Structured Text (ST) according to IEC 61131. Functional-safety certifications according to SIL 2, PL d, and Ag PL d are in progress. With pre-installed widgets in the tool, data pools available via CAN or Ethernet can be displayed and used in HMIs (human machine interface) or cloud applications. Functions, such as current controller and ramp functions for outputs or frequency averaging for inputs, are integrated and available for application programming. Additionally, libraries for CANopen, J1939, or Isobus are available. Matlab support is also planned. *hz*

For power management in vehicles



(Source: Würth Elektronik ICS)

Würth Elektronik ICS presented the ePDM 70-150 power distribution controller for vehicle electrical systems. The solution with two CAN ports is dedicated for mobile machines and commercial vehicles. It combines logic processing, communication, diagnostic possibilities, and high-current outputs in a compact device. Equipped with nine analog and digital inputs and a variety of outputs up to 35 A, it operates over a temperature range of -30 °C to +85 °C, with a current carrying capacity of 150 A at +70 °C. IP67/IP69K protection ensures reliable operation in harsh environments. The device enables various wake-up scenarios, such as activating the in-cab HMI (human machine interface) when the door opens. It also features "always on" outputs that remain active even in sleep mode, ensuring a protected power supply to critical components such as telematics modules. The controller supports software updates for continuous function development and optimization without hardware changes. The use of identical hardware for different vehicle models reduces overall system costs. The programmable ePDM 70-150 is supported by the Wecontrol Designer programming environment. The wide range of features includes a J1939 library and online debugging functionality. *of*

Brief news: Bauma 2025

- ***Mobile Control Systems (Belgium):*** The company is a member of the Addtech Group (Sweden), offering angular position sensors in compliance with the ISO 26262 safety standard. The sensors can be integrated into hand, underfloor, suspended, and floor-mounted throttle pedals. J1939 interfaces are optionally available.
- ***Makersan (Turkey):*** The manufacturer offers electronic pedals and levers supporting CANopen CC and J1939-21/71. The company also manufactures rotary position sensors and inclinometers with CAN interfaces. Additionally, there are CAN-connectable keypads (MO 405) and joysticks (MO 406, MO 407) in the company's portfolio.
- ***Deep Sea Electronics (UK):*** The programmable host controllers (DSEM640 and DSEM643) provide four CAN interfaces supporting CANopen CC and J1939-21/71. Additionally, the company offers 3,5-, 4,3-, 7-, 10-, and 12-inch displays with two or three independent CANopen/ J1939 interfaces.
- ***MRS Electronic (Germany):*** The Microplex 3CAN LIN is a gateway for transmission, filtering, and manipulation of frames within and between CAN networks. With dimensions of 30,4 mm x 23,6 mm x 25,75 mm, it implements the 32-bit S32K148 processor and an optional LIN interface. The IP6K8-rated programmable device can route data between CAN and LIN networks and CAN networks with different bit rates.
- ***North Valley Research (U.S.A.):*** The company provides electronic control units (ECUs), displays, chargers, motor drivers, and telematics solutions with multiple CAN channels used in material handling, construction and commercial vehicles as well as agricultural machinery. *hz and of*

Bauma 2025 ticker

+++ Comes (Italy) presented CAN-connectable displays, sensors, actuators, and control modules. +++ CSM (Germany) shown a CAN-enabled solution for temperature measurements of high-voltage batteries in vehicles. +++ EBI Motion Control (Italy) offers the ESJ02E joystick with CANopen and J1939 support. +++ Elca (Italy) demonstrated its IP65-rated PIC AR remote control receivers, providing a CANopen interface. +++ Girmatic (Switzerland) shown CANopen- and J1939-enabled GJx series of joysticks used in hydraulic, pneumatic, and electromechanical applications. +++ Graf-Syteco presented the GS Multiline HMI (human-machine interface) incorporating a two-part display with programmable touch-buttons. +++ IMET (Italy) introduced the CAN-capable Titan series of remote-control devices. +++ Miunske (Germany) displayed its CAN-connectable Multi-Sound-Module with up to 50 voice messages. It is supported by a library comprising 80 sounds. +++ Mobil Elektronik (Germany) exhibited its functional-safe CAN angle sensor compliant with ASIL d (ISO 26262) and SIL 3/PL e (IEC 61508/ISO 13849). +++ Moog Rekofa presented high-power slip-ring assemblies with CAN and Ethernet connectivity. +++ MTA (Italy) supplies ruggedized on-board chargers with CAN (FD) interfaces supporting J1939. It also provides HMIs and controllers e.g., for agriculture vehicles. +++ REMdevice (Italy) presented remote control devices with CANopen support. +++ Schaeffler (Germany) showcased its Torquesense device, coming optionally with a CAN interface. +++ Stoneridge's Mirroreye camera monitor system with a CAN interface enables monitoring of rear- and side-mirror views on the car's display. +++ Texa (Italy) offers automotive hard and soft diagnostic solutions, which can be connected to in-vehicle CAN (FD) networks via company's adapters. +++ TSM Sensors (Italy) showed its CANopen-inclinometers enclosed in an IP67 housing. +++ Tyro (Netherlands), a Cattron company, offered remote control solutions with CANopen and J1939 support. +++ Wandfluh (Switzerland) presented the MD2 IP67-rated mobile control unit as well as the DSV and PD2 amplifier, controlling proportional hydraulic valves and featuring CANopen as well as J1939 connectivity. +++ Zhimin (China) introduced CAN-connectable tension load cells as well as load pins suitable for crawler and tower cranes as well as rotary drilling rigs. +++ *hz and of*

(Source: Adobe Stock)

News in this regular column came in, close to the editorial deadline. Nevertheless, they have been doublechecked on accuracy and correctness.

CAN FD repeater

(Source: HMS Networks, Ixxat)

HMS Networks (Sweden) has introduced a CAN FD repeater under its product brand Ixxat. The necessary termination resistors are adjustable from the outside via piano switches. This means that users don't need to open the housing. The network infrastructure component features push-in connectors. With it, connecting the product to the CAN lines can be done quickly. Another feature is the built-in cable tie hole, which offers a solution for tidy installations, further simplifying cabinet organization. The repeater connecting two CAN FD sub-segments comes with an IP20-rated housing for DIN-rail mounting (108 mm x 149 mm x 27 mm). There are LED indicators implemented showing the status of the product.

The repeater provides a 5-kV galvanic isolation between the CAN FD physical interfaces. "By using repeaters in CAN networks, connected equipment can be protected very easily", said Frank Iwanitz from HMS Networks. "It's not only about the optimization of your network topology or optimizing your signal quality but about increasing and protecting the health of your whole CAN network."

The product is based on two TCAN1044 CAN FD transceivers by Texas Instruments with no SIC (signal improvement capability) functionality. In multi-drop applications, data-phase bit rates up to 2 Mbit/s are supported. In point-to-point networks, higher bit rates are possible. The maximum nominal (arbitration) bit rate is 1 Mbit/s according to the data sheet. The operating temperature is -25 °C to +70 °.

hz

MCU family with CANopen support

(Source: Infineon)

RT-Labs (Sweden), a partner of Infineon, provides for the XMC7000 microcontroller (MCU) family six industrial communication protocol stacks. This includes CANopen. The firmware is available through Infineon's Modus-Toolbox development platform. This enables users to implement the required protocols on the microcontroller, utilizing its performance capabilities in applications, including servo drives, I/O modules, robotic arms, industrial gateways, PLCs, and more.

"Infineon's XMC microcontrollers have a long history of enabling the factory floor. As Industry 4.0 continues to build momentum, existing fieldbus and Ethernet-based protocols are critical for industrial automation," said Panagiotis Venardos from Infineon. "We continue to invest in higher performance microcontrollers and connected MCUs to help drive further enhancements to how the factory floor seamlessly communicates. Our partner RT-Labs helps bring scale to this effort with their field-proven and highly optimized Ethernet and fieldbus protocol stacks."

"As a Premium Partner with Infineon, we're bringing plug-and-play connectivity to Modus-Toolbox," said Marcus Ekerhult from RT-Labs. As a result of the collaboration, customers now have access to a CANopen protocol stack. A GitHub repository hosts the middleware, ensuring up-to-date, easily accessible libraries. In addition, Infineon supports implementation by providing code examples and comprehensive documentation, eliminating the need for in-depth expertise or extensive resources on the customer's side, stated Infineon in a press release.

RT-Labs' C-Open CANopen protocol stack can be used to implement a CANopen device with NMT (network management) server or NMT manager functionality. It supports multiple instances and can be run on bare-metal hardware, an RTOS such as RT-Kernel, or on Linux or Windows. A device application software interfaces with the protocol stack primarily using the object dictionary. The NMT manager entity uses the full API (application programming interface) to control the CANopen network. According to the software provider, the CANopen stack is designed for minimal footprint and efficiency (memory usage on Cortex-M4: 14968 byte of ROM / 368 byte of RAM, plus user defined parameters stored in RAM). The protocol stack was tested using the CANopen Conformance Test Tool by CiA.

hz

CiA 447 and FireCAN products

The Rettmobil international trade show took place in Fulda (Germany) mid of May. Several companies presented warning signal units including roof-bars with CiA 447 interfaces. Among them were products by Hänsch, Eurosignal, and Standby. Additionally, Kienzle Argo exhibited an accident recording unit with CiA 447 connectivity. Unfortunately, just a few of German vehicle manufacturers provide in-vehicle network gateways supporting CiA 447 (e.g., Audi, BMW, and Volkswagen). There were also warning signal units with proprietary CAN interfaces (e.g., by Amber Coast Signal and Whelen) exhibited.

On some stands, FireCAN products were displayed. Implementations of the recently updated DIN 14700 standard (successor of FireCAN), were not yet available. Several warning signal unit (WSU) suppliers (e.g., Hänsch and Standby) offered FireCAN interfaces. EDSC presented its powder extinguishing unit (PEU), supporting FireCAN. Rosenbauer and Ziegler exhibited fire-fighting vehicles implementing FireCAN host controllers communicating with FireCAN-compatible devices.

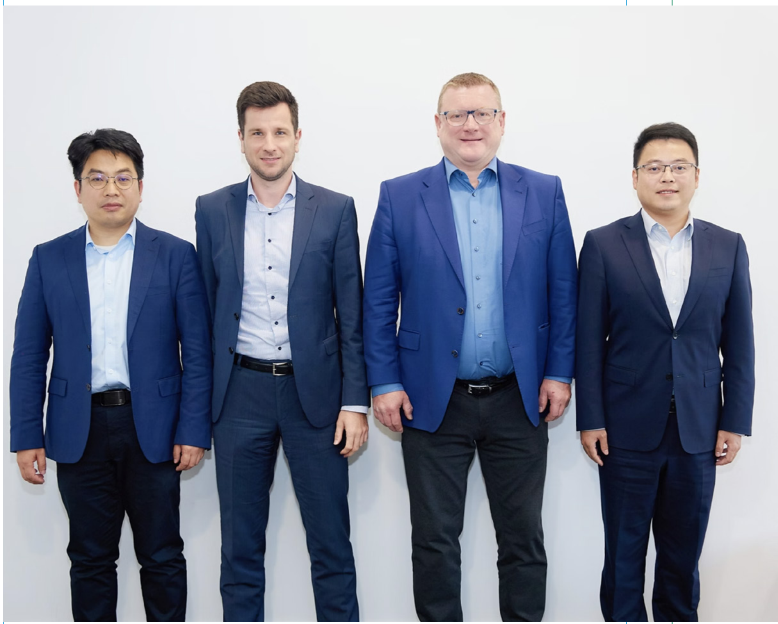
On the fair, some companies showcased generic controllers, I/O modules, etc. featuring CAN connectivity. The products by EDSC using a proprietary CAN network can be connected by means of a gateway to CiA 447 and FireCAN devices. Inomatic offers also controllers and I/O modules, but they comply with CANopen and can be connected to CiA 447 devices. *hz*

Research paper on intrusion detection for CAN

Several researchers (Ritu Rai, Jyoti Grover, Prinkle Sharm, and Ayush Pareek) have jointly published the 22-pages whitepaper “Securing the CAN bus using deep learning for intrusion detection in vehicles”, downloadable from the world wide web. It describes the researched attack scenarios and deep-learning methods (in very detail) used to mitigate them. The authors summarized: “In this research, we evaluate various deep-learning techniques for mitigating security threats within in-vehicle systems. The method combines deep-learning techniques with temporal and spatial representations of CAN data. Spatial features are utilized to represent network traffic as traffic images, while temporal characteristics capture the dependencies among features over time.” These datasets are consolidated into a single file and employed to anticipate the category of each CAN data/remote frame. The objective is to identify all potential attacks that can impact the intra-vehicle network, explained the authors. Although the proposed approach demonstrates promising results, it falls short of attaining perfect detection of all automotive cyber-attacks. Further investigation is needed. The authors intend to explore additional RNN (recurrent neural network) variants and other deep learning architectures to further enhance detection performance. *hz*

Jointly developed system base chips

Recently, Continental (Germany) and Novosense (China) have expanded their cooperation to system base chips (SBC) featuring CAN transceivers and other circuitries. Following the collaboration in the development of sensor ICs (integrated circuit) with functional safety, the two companies plan to work together on the joint development and integration of SBCs into Continental's global platforms. SBCs combine a variety of functions into a single chip, including voltage regulators, (CAN) transceivers, and monitoring functions. SBCs are primarily used in control modules, such as seat control and gateway modules.



From left to right: Gavin He, Markus Almeroth, Theo Brunner, and William Yao (Source: Continental, Novosense)

Shengyang Wang, co-founder and CEO (chief executive officer) of Novosense, stated: "The expansion of our collaboration with Continental on SBCs is a significant step in our globalization strategy. We are committed to delivering exceptional reliability and performance in automotive systems and look forward to working together on these important technologies." Theo Brunner, Head of Electronics Purchasing at Continental Automotive, added: "The expansion of our partnership with Novosense on SBCs supports our goals of establishing a more diverse supply chain and enhancing the competitiveness of our safety applications. This collaboration helps us better manage geopolitical risks while providing innovative solutions for the automotive industry."

In 2024, Novosense delivered more than 363 million automotive ICs. Continental is a Tier-1 supplier for the automotive industry providing ECUs (electronic control units). Continental is a CiA member. *hz*