December 2023

CAN Newsletter

Hardware + Software + Tools + Engineering

Trade shows

Interlift 2023: CANopen Lift is set!

CANopen for manual welding

Wind power and CANopen

SPS 2023: Smart product solutions

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Position & Orientation Data via CAN FD

PCAN-GPS FD: Programmable Sensor Module with CAN FD

The new PCAN-GPS FD from PEAK-System is a programmable sensor module for position and orientation determination with CAN FD connection. It has a satellite receiver, a magnetic field sensor, an accelerometer, and a gyroscope. Incoming sensor data is processed by the NXP microcontroller LPC54618 and then transmitted via CAN or CAN FD.

The behavior of the PCAN-GPS FD can be programmed freely for specific applications. The firmware is created using the included development package with GNU compiler for C and C++ and is then transferred to the module via CAN. Various programming examples facilitate the implementation of own solutions.

On delivery, the PCAN-GPS FD is provided with a standard firmware that transmits the raw data of the sensors periodically on the CAN bus.

Specifications

- High-speed CAN connection (ISO 11898-2)
  - Complies with CAN specifications 2.0 A/B and FD
  - CAN FD bit rates for the data field (64 bytes max.) from 40 kbit/s up to 10 Mbit/s
  - CAN bit rates from 40 kbit/s up to 1 Mbit/s
- NXP TJA1043 CAN transceiver
- CAN termination can be activated through solder jumpers
- Wake-up by CAN bus or by separate input
- Receiver for navigation satellites u-blox MAX-M10S
  - Supported navigation and supplementary systems: GPS, Galileo, BeiDou, GLONASS, SBAS, and QZSS
  - Simultaneous reception of 3 navigation systems
  - 3.3 V supply of active GPS antennas
- NXP LPC54618 microcontroller with Arm® Cortex® M4 core
- Electronic three-axis magnetic field sensor ST IIS2MDC
- Gyroscope and three-axis accelerometer ST ISM330DLC
- 8 MByte QSPI flash
- 3 digital I/Os, each usable as input (High-active) or output with Low-side switch
- LEDs for status signaling
- Connection via a 10-pole terminal strip (Phoenix)
- Voltage supply from 8 to 32 V
- Button cell for preserving the RTC and the GPS data to shorten the TTFF (Time To First Fix)
- Extended operating temperature range from -40 to +85 °C (with exception of the button cell)
- New firmware can be uploaded via a CAN interface

The PCAN-GPS FD is expected to be available at the beginning of Q1 2024.

www.peak-system.com

Take a look at our website for the international sales partners. Scan the QR code on the left to open that page.

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Applications

Engineering

Tools

Vertical and horizontal markets

This CAN Newsletter issue focuses on some dedicated CAN embedded network vertical markets. It is increasingly heavy to get detailed information about these CAN applications. They are sometimes highly hidden: Users of CAN embedded and CANopen embedded networks do not like to talk about their solutions. But on vertical market exhibitions such as the Interlift, the leading elevator suppliers fair or the Husum Wind trade show, you find, having trained eyes, products with CAN-based embedded networks.

In this issue, we report about those products dedicated for vertical markets. Besides CAN-based elevator devices and CAN-based pitch control systems, we provide information about CAN-based solutions for welding and cutting equipment.

The SPS trade show in Nuremberg is the topic of another article. This fair addresses a horizontal market: industrial automation in general. One of the main topics was and is motion control. Products based on CANopen and the CiA 402 profile were on many stands shown, but not explicitly mentioned, because it is state of the art. CANopen-connectable drives are the milk cows, especially for small servos.

Interlift 2023: CANopen Lift is set!

At the Interlift trade show, elevator suppliers showed their CANopen Lift devices. These products are interoperable enabling an easy integration into a lift control system. Besides new lift applications using an open network approach, there are retrofit projects implementing CANopen Lift networks.

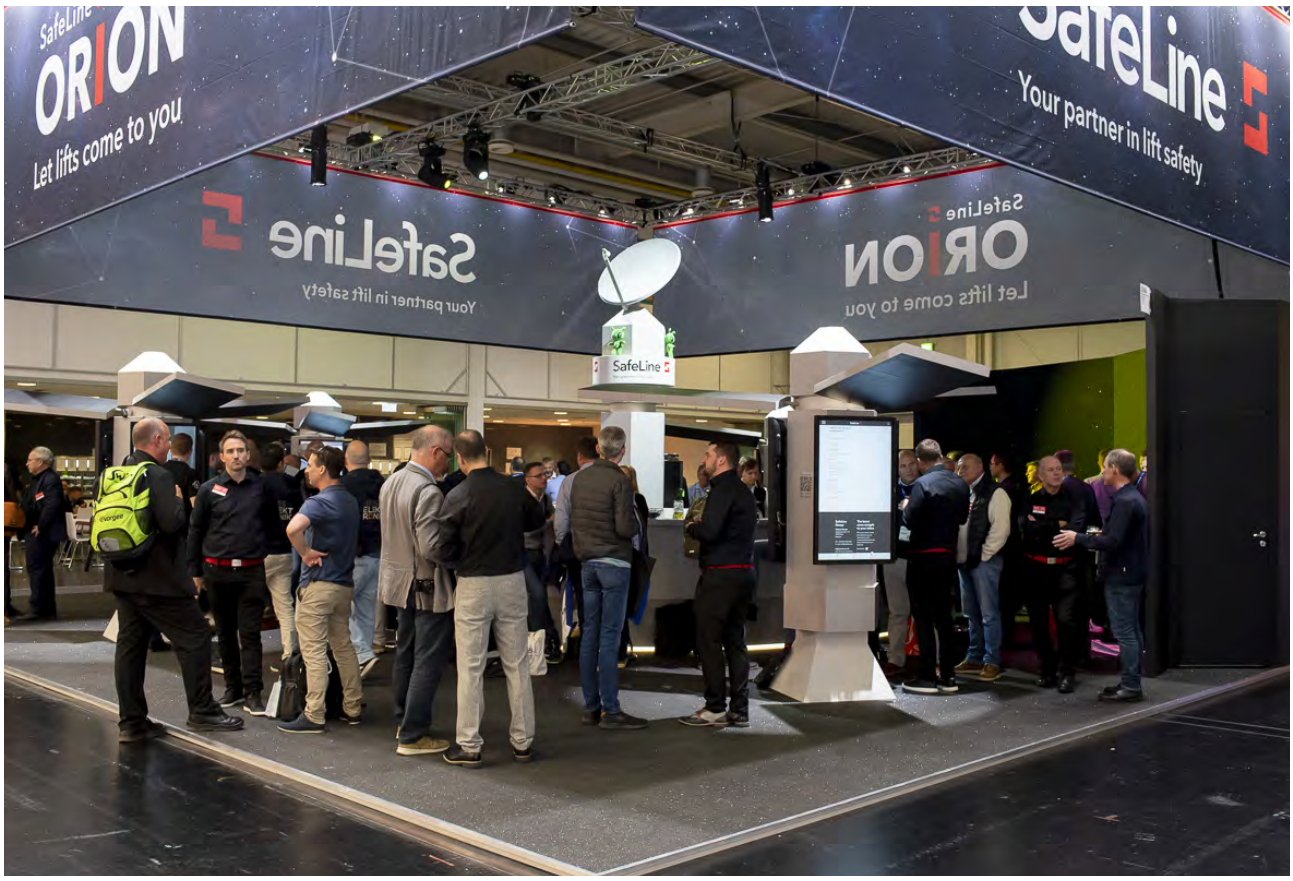

Figure 1: At the Interlift 2023 in Augsburg (Germany), more than 500 companies presented their products to about 19000 visitors coming from 110 countries (Source: Interlift)

Retrofitting is an increasing business in the elevator markets. In Europe, there are installed about 6,6 million elevators (2022). In 2022, circa 140000 new lifts have been positioned according to the European Lift Association. A growing number of CANopen Lift compliant controllers is used in retrofit projects. CANopen Lift is specified in the CiA 417 application profile documents (see insert “CANopen Lift is 20 years old”).

Boehncke & Partner, a member of the Schmersal group, is one of the early birds in the CANopen Lift business. The company has installed more than 35000 elevator controllers compliant with CiA 417. The host controllers can communicate via the CANopen Lift network with frequency inverters from different suppliers such as Danfoss, Fuji, and Ziehl-Abegg. The company announces to provide software support for the car drive units from Delta, too. Boehnke & Partner offers also other lift control devices including indication and operator panels, absolute encoders, etc. Some of these products are brand-labelled or jointly developed with partners.

Other suppliers provide also CiA 417 compliant host controllers. Thor Engineering has developed an open CANopen Lift controller hardware platform, which is used by several companies: Hisselektronik, Hydroware, Masora, Mitsubishi, Safeline, Weber, etc. “We believe in the open-source idea, where using software comes with certain rights, but also certain obligations. Because of that we decided to open the CANopen stack used in the Thor system, as well as the Toolbox to all the members of the Next group, giving them the opportunity to use and contribute.” The open-source CiA 417 protocol stack is also used by suppliers of CANopen Lift units such as car door units.

The Toolbox is a Windows-compatible configuration software. It can check, if all intended CANopen Lift devices are in the network. The software tool provides a graphical way of editing inputs and outputs in the panel units. It can ▷

scan the network by using EDS (electronic data sheet) files and save the result as a snapshot into an XML file, which can later be loaded again. This makes it possible to handover a lift configuration to the office and back.

Thor Engineering offers the Thor E2 host controller with eight programmable I/O lines, a lift car panel, and C3 floor displays. Weber Lifttechnik, another CANopen Lift pioneer, uses the Thor E2 platform and has added additional software functions for dedicated applications. The company also offers the WE408 lift controller based on the hardware by Schmersal. Weber Lifttechnik is known for application-specific elevators, especially in power plants. Their lift controllers are also used in the Queen Elizabeth 2 passenger ship.

The Safeline's Nova touch controller series is also based on the open-source hardware platform by Thor Engineering. It comes with a 5,5-inch TFT (thin-film transistor) touch display and with soft menu buttons. The product is suitable for both traction and hydraulic lifts. Using a touch-based graphical interface, the lift controller is intuitive even for inexperienced technicians. It displays connected CANopen devices and CANopen messages. Inputs and outputs can be configured with just a few swipes, explained the company.

Hydroware, another Thor Engineering partner, applied CANopen Lift to several elevator controllers. These controllers can operate with CiA 417 compatible drives, for example with the Unidrive products by Control Techniques, a brand of the Nidec enterprise. Hydroware has modernized many lifts with CiA 417-based devices. Intec, a long-time CiA member, exhibited in Augsburg its MLC-8000 lift host controller featuring CANopen Lift connectivity. The company launched the Digital Safety System (DSS), which is based on a proprietary CAN-based higher-layer protocol. It comprises one safety commander and safety responders. The German company has supplied CAN Lift systems to the Deutsche Bahn, the state-owned German railway company and to the carmakers Audi and Porsche.

The Austrian company Rocket manufactures a CiA 417 compliant elevator controller, as well. One of the sales partners is Variotech. The elevator host controller is suitable for up to 16 floors and supports a double and a triple lift group functionality. It is intended for new elevator installations as well as for modernization projects. Liftern, an Italian company, showed at the Interlift the EON C200 lift controller compliant with CiA 417. It supports up to 64 stops.

Drives moving the car

Elevator cars are moved by electrical motors or by hydraulic actuators. The CiA 417 specifications standardize the CANopen Lift car drive units. Several frequency inverter suppliers offer CiA 417 compliant interfaces. One of them is the Brazilian company Weg, which has acquired Gefran's drive department. At the Interlift, Weg presented its ADL500 CANopen Lift inverter product series. There are three models. The ADL510 is suited to asynchronous motors typical for low-rise buildings or modernization in open and close loop. The ADL530 is designed for both asynchronous and synchronous motors and features an on-board encoder interface. The ADL550 is the high-end model with safety functions. It features a safe brake test and safe brake control in conjunction with the CAN-connectable EBC500 accessory to replace electro-mechanical brakes control.

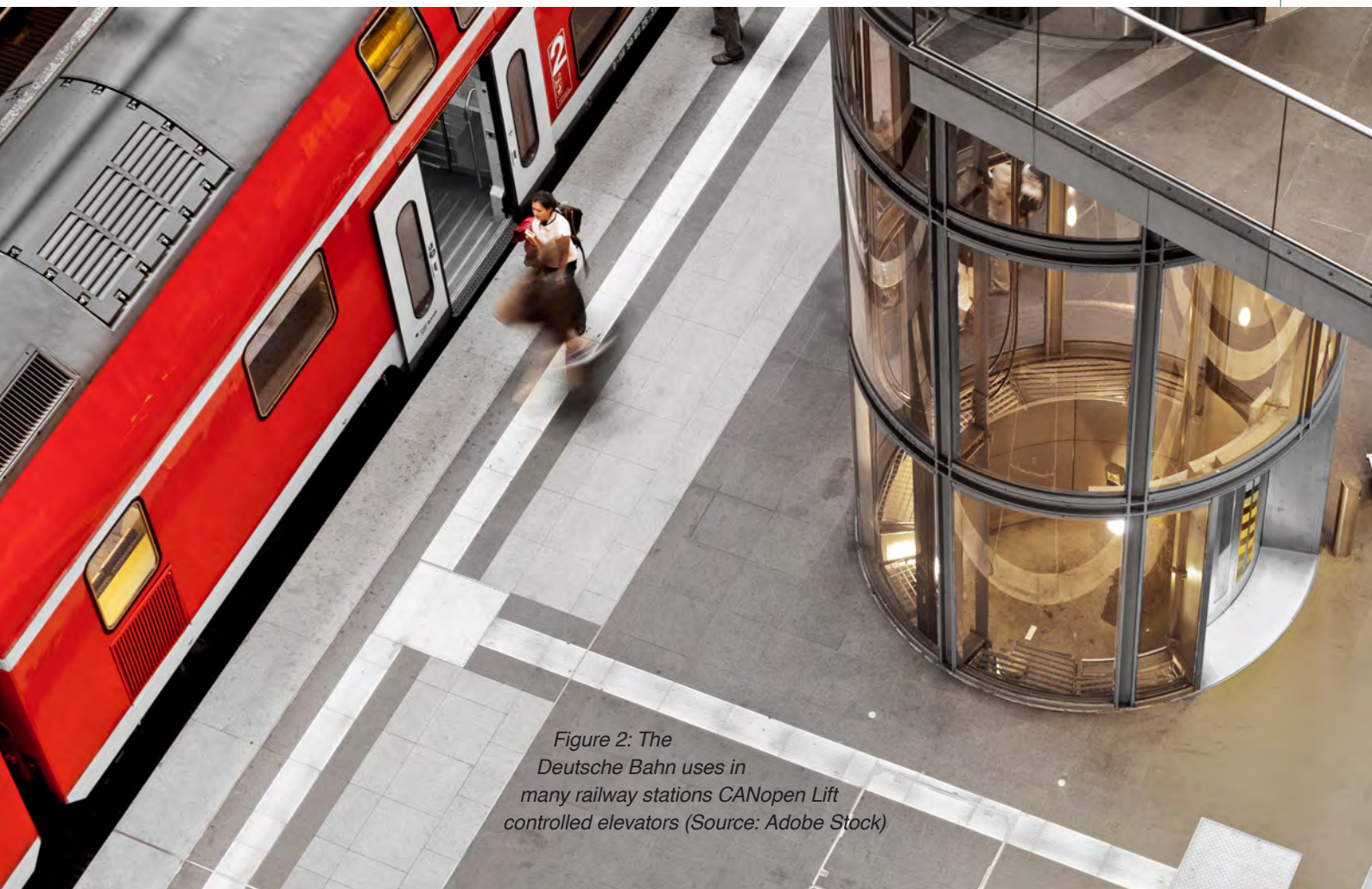

Figure 2: The Deutsche Bahn uses in many railway stations CANopen Lift controlled elevators (Source: Adobe Stock)

Anniversary: CANopen Lift is 20 years old

At the Interlift 2003 trade show, CiA has had introduced the CiA 417 series of CANopen Lift specifications. Currently, four specifications are available plus an application note.

In 2001, several CiA members started to develop that was is nowadays the state-of-the-art open network approach for elevators: CANopen Lift. Joerg Hellmich chaired the responsible CiA special interest group (SIG) developing the CiA 417 specifications (CANopen application profile for lift control systems). After two years, the documents were launched at the Interlift exhibition as version 1.0.1.

The CANopen Lift demonstration has been shown on several events including the Interlift trade show, it was a real joint activity of competitors (Source: CiA)

In the meantime, the specifications have been several times reviewed and updated (version 2.0.0, 2.1.0, 2.2.0, and 2.3.0). The version 2.0.0 is publicly available and can be downloaded free of charge from the CiA website. The access to the version 2.3.0 is limited to CiA members. The CiA 814-1 CANopen lift bootloader implementation guideline can also be downloaded by everyone from the CiA website.

In the beginning of the CANopen Lift story, CiA organized in cooperation with members the development of a demonstrator to proof the interoperability of CANopen Lift products. Still to today, the CANopen Lift community tests the interoperability of devices compliant with CiA 417. The next CANopen Lift plugfest is scheduled for spring 2024.

The SIG CANopen Lift members discuss currently some functional enhancements. There are also requirements regarding functional safety and cybersecurity on the table. Oskar Kaplun from CiA provided on the Interlift Forum 2023 a presentation about cybersecurity possibilities for CANopen Lift using the not yet used 18-bit extended ID-field in CAN CC (classic) data frames. Another option is to prevent mechanically an access to the CAN network lines and to protect a remote access by means of firewalls.

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Figure 3: The ADL500 frequency inverter family features CANopen Lift connectivity (Source: Weg)

At the Interlift 2023, other inverter suppliers including KEB, Yaskawa, and Ziehl-Abegg presented their CANopen Lift drive units, as well. Ziehl-Abegg exhibited the ZAdyn4Bplus frequency inverter for control cabinet mounting. It features an up to 110-kW nominal power capability, programmable I/O ports, and is compliant with CiA 417. The product provides an STO (safe torque off) function according to IEC 61800-5-2 (SIL 3). Yaskawa launched its LA700 frequency inverter, the successor of the LA500 series. It implements a CANopen Lift interface. The product is quieter in operation than the predecessor and offers an app function for remote programming and monitoring, explained the Japanese company.

Emotron showed its CiA 417 compliant DSV15 (0,25 kW to 2,5 kW) and DSV35 (0,37 kW to 110 kW) frequency inverters. Most of these products have been tested on interoperability in the CiA 417 plugfests organized by CiA. KW-Aufzugstechnik launched the Goliath 921 frequency inverter, which provides a CANopen Lift interface. In view of the coming ISO 8100-1 standard, the product provides already brake ventilation, wear monitoring, and control of a third brake element. The company offers a CANopen Lift host controller, too.

Interlift 2025 in Nuremberg

The next Interlift will take place at the Nuremberg Exhibition Center from October 14 to 17, 2025. Since 1991, Augsburg has been the home of the bi-annual trade show. “With the move to Nuremberg we are setting the course for the further development of the Interlift, which is not given at the current location,” said Achim Hütter, chairman of the VFA-Interlift association, one of the exhibition organizers. The Interlift 2025 will be located in five halls and two congress centers with numerous rooms offering possibilities for lectures and meetings. ◀

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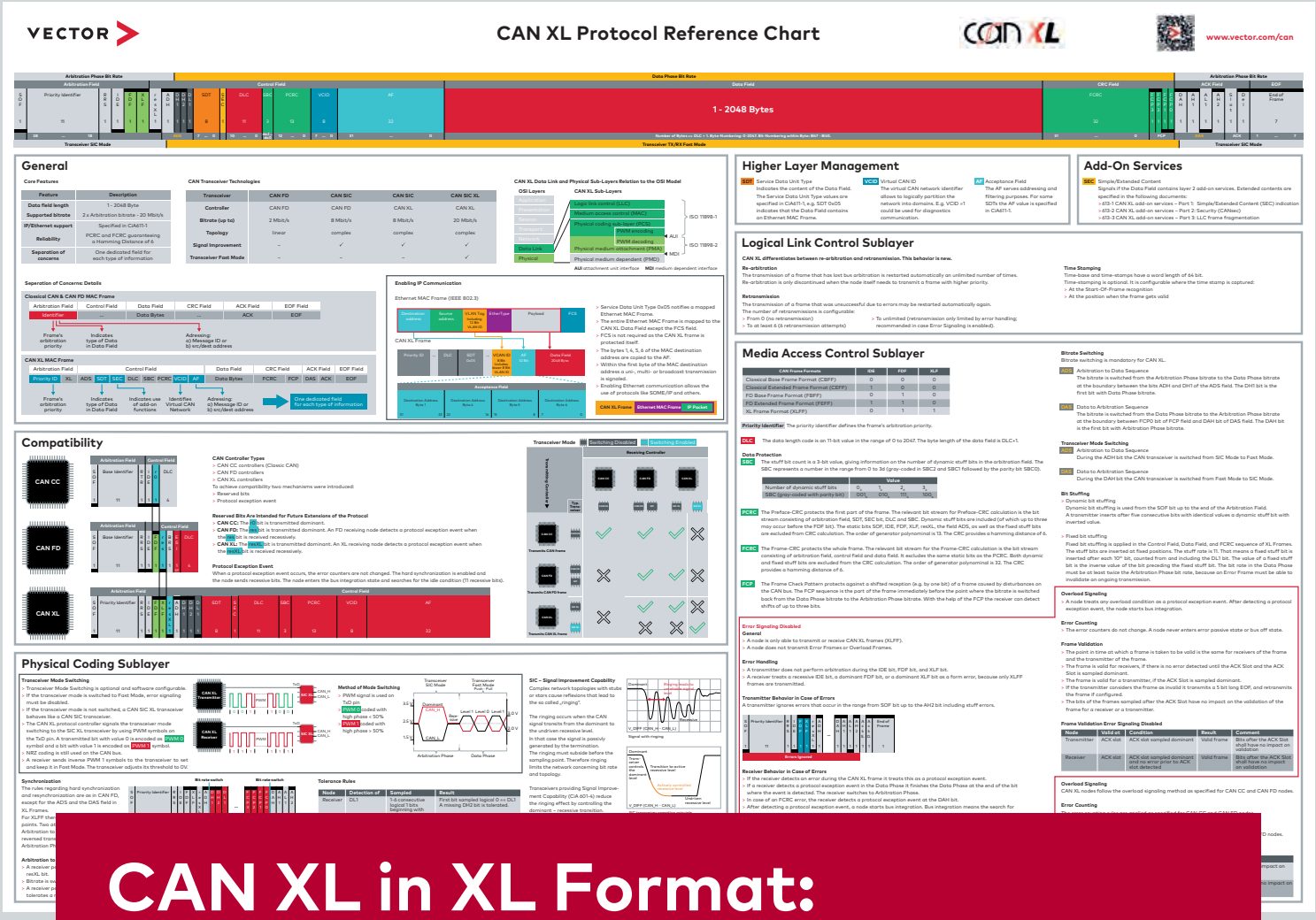

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CANopen for manual welding

A torch from Lorch: The German company is one of the CiA members participating in the SIG specifying the CiA 464 profile for manual arc welding and laser cutting (Source: Lorch Schweißtechnik)

CiA has established the Special Interest Group (SIG) welding and cutting. CiA promoted this specification development on the "Schweissen & Schneiden 2023" trade show in Germany.

Embedded CAN networks are used since many years in the welding and cutting industry. ESAB and other welding equipment manufacturers provide also CANopen interfaces to connect their products to CANopen host controllers. The ESAB Aristo CANopen gateway features NMT (network management) server functionality, for example. The Swedish company uses in some automated equipment embedded CAN networks running proprietary higher-layer protocols. Welding robots also provide CAN-based interfaces and communicate internally via embedded CAN networks.

Abicor Binzel has initiated the development of a CANopen profile for manual welding and cutting devices. Usually, these manual arc welding and laser cutting systems comprise several devices supplied by different companies. This means, there is a need to specify device interfaces, in order to provide interoperability between them. Some of these interfaces can use CANopen as communication technology, while in other use cases communication systems with more bandwidth are necessary. All these joint developments have been started under the "Weldbus" term. The related CANopen profile is the CiA 464 series. It is intended to develop a multi-part application profile specifying the parameters for different units and the mapping to CANopen.

CiA presented this joint development on the Abicor Binzel booth on the "Schweissen & Schneiden" exhibition in Essen, Germany. This trade show focuses on joining, cutting, and surfacing technologies. It is market-leading with over 800 exhibitors from 40 countries and about 40000 visitors from 124 nations. According to Reiner Zitzmann from CiA, the interest in the CiA 464 profile was high, especially, because Abicor Binzel has provided a very first demonstrator on the fairground.

The CiA 464 profile will specify CANopen interfaces for torch units, fume extraction units, power units, wire-feeder units, cooling units, and calibration units. Additionally, human machine interface units are in the scope of the CiA 464 profile. In a first step, the generic profile will be mapped to CANopen CC (classic). Proposals for some ▷

CNC plasma cutting

Figure: The K 200 plasma power source (Source: Kjellberg)

Kjellberg (Germany) produces CNC cutting and welding systems. Some products use host controllers and actuators from Eckelmann, a long-time CiA member. The E°EXC 66, E°ECX 89, and E°EXC 880/882 controllers feature Codesys programming software compliant with IEC 61131 (also known as PLCopen). Eckelmann also provides CNC cutting software developed in close cooperation with its customers. Kjellberg is one of them. On the "Schweissen & Schneiden 2023" trade show, the German machine builder demonstrated for the first time the K 200 power source for plasma cutting. The product can be integrated into CNC guidance systems. Eckelmann supplies CNC plasma cutting solutions also to ERL Automation and Sato Schneidsysteme, for example.

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parameters to be specified are already reviewed by the SIG members. They also discuss the need of unit status information to be exchanged between the devices via CANopen CC.

CiA cooperates with other nonprofit associations to develop and to promote the profile for welding and cutting. The EWA (European Welding Association) and the ZVEI (German Electro and Digital Industry Association) are the first partners. Representatives participate in the SIG meetings. Interoperable interfaces for manual arc welding and laser cutting improve worker's safety and regulatory compliance functions to minimize the worker exposure to harmful conditions, such as automatically maintaining the required fume extraction flow rate of the welding torch in use both during arc ignition and subsequent operation. Engmar, situated in France, hast presented on the "Schweissen & Schneiden" fair the Atmoflow fume extraction system. The company is going to support CiA 464, when the profile is ready to be released.

The welding market is in general expanding. Manual welding is growing, too: Especially for portable and lightweight equipment. Furthermore, the market is experiencing a surge in the development of eco-friendly manual welders with reduced emissions and energy consumption. This is where CiA 464 comes into the game: Interoperable manual welding devices with smart functions are needed.

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Wind power and CANopen

Since many years, embedded CANopen networks are used in wind turbines. The market is still growing and some elder turbines need to be retrofitted. Especially in pitch control, CANopen has a significant market share.

At this year's Husum Wind trade show, retrofitting was an important topic. In September, around 600 exhibitors showcased product innovations and cutting-edge technology in the fields of onshore and offshore wind, green hydrogen, energy storage, sector coupling, digitalization, recycling, and repowering. For over thirty years, the industry fair in northern Germany has supported the wind energy markets. More than 12000 visitors from 51 countries came to Husum.

According to the recently published semi-annual figures and wind power expansion report of the German Wind Energy Association (BWE) and the German Engineering Federation (VDMA), the wind energy market is showing significant growth, particularly in onshore wind, with a gross addition of 1565 MW of installed capacity. The upward trend is even more evident in the 3175 MW of newly approved projects. At the biennial trade fair for the wind industry, exhibitors from Germany and abroad presented what the industry can achieve the target of 10 GW of onshore wind capacity per year from 2025.

In addition to new projects, the industry in Germany relies on repowering to accelerate the energy transition and meet expansion targets. By 2025, around 8000 turbines will no longer be subsidized. Companies presented the entire range of second-life solutions for wind turbines, from repowering and recycling to marketing models such as PPAs (power purchase agreement) and trading on the international used-turbine market.

Baerbel Heidebroek, President of the nonprofit BWE, said: "Wind energy will play a central role in Germany's energy supply. The ambitious expansion targets underline this. If more land is available, approval processes are speeded up, and transport issues are solved pragmatically, the targets are achievable."

Hydraulic and electrical pitch control

Since many years, the CiA members Deif, Emerson (formerly Mita-Teknik), and Moog provide hydraulic and electrical pitch control solutions. Moog was one of the fathers of the CANopen protocol development in the 90ties. Deif situated in Denmark, offers customized hydraulic pitch systems as well as electrical pitch motors, pitch servo drives, and sensors.

The primary functions of the pitch system are to optimize the power production as well as to stop the wind turbine in maintenance and emergency situations. Deif designs the pitch system to individually match the specific

Figure 1: Exhibition patron and German Federal Minister of Economics, Robert Habeck, opened the Husum Wind 2023 exhibition: "The trade fair is the beating heart of the energy transition in Germany." (Source: Husum Wind/Marcus Dewanger)

wind turbine design in order to optimize the operation under certain conditions. These are high, medium, low wind as well as extraordinary situations like LVRT (low-voltage ride through) conditions and emergency stop. The offered pitch system design is based on the load data and aerodynamic characteristics of the turbine.

Deif pitch boxes are customized to match the physical size of the hub. Metal, coating, and color are specified by the customer. Two preferred metals are available; construction steel and stainless steel. The cabinets have an important function not only for enclosure but also for damping electrical noise (EMI), an increased demand stipulated by IEC 61400. The cabinets and interconnections are designed with reference to the specific lightning zones inside the hub.

The system can be delivered in different variants, from three to seven box solutions, depending on the space inside the hub. The choice of energy storage affects the required number of boxes and the possibilities customers have. Batteries are to be placed in separate battery boxes for each blade due to the explosive gases they generate during charging. The inverter, pitch controller, and the remaining system units are placed in other boxes. In the seven-box solution, for instance, a center box contains the pitch motion controller, the over-voltage protection and the grid connection point. For each blade there are identical battery boxes, and pitch drive boxes – three of each. Another example is a four-box ultra-cap solution, in which a center box contains the pitch motion controller and three other identical boxes contain ultra-caps and power inverters for each blade.

Figure 2: Retrofitting the pitch control system can optimize the power production of the wind turbine system (Source: Husum Wind/Marcus Dewanger)

An important topic is the design of the pitch cabinet. It should fit to the environment conditions (see "INSERT"). Deif tests its pitch control solutions on EMC (electromagnetic compatibility) requirements and surge protection.

Pitch motion control

The offered pitch motion controller is based on the Deif's advanced wind turbine controller platform. Being the center of the pitch control system, it collects inputs from other units such as sensors, chargers, and drives. The pitch motion controller works by command from the wind turbine controller, or independently, if CANopen communication to the controller is lost.

The application comprises sensors for monitoring of the pitch system itself and for monitoring the service need of the wind turbine. The control system further comprises monitoring of the battery lifetime and the grid connection. The pitch system is self-protected – undetected system faults cannot occur. It monitors also the battery voltage and estimates the lifetime.

The Integrated Motor Drive (IMD) by Deif is developed with offset in decades of accumulated knowhow about the entire wind turbine and its pitch systems. With its integrated motor solutions, the IMD reduces cabling in the system and provides a high reliability at minimum cost, states the supplier: "Engineered to customers' application, the IMD is bound to become a preferred choice for pitch and yaw control." The IMD is an all-in-one solution and comes with units such as I/O (input/output) devices, ballast resistor, EMC filters, charger, power supply, motor brake control, choke, and safety chain designed in accordance with the European Machinery Directive.

Functional safety is a vital function in electric pitch systems, and the IMD is the main part controlling the blade angle during turbine operation and in safe stop situations. In modern wind turbines ranging from kW to MW, the pitch system is the only brake capable of stopping the wind turbine during operation. This makes the pitch drive a safety-related system. The IMD complies with the ISO 13849 functional safety standards due to the failsafe hardware compliant with MTTF-d (mean time to failure) and PL-d (performance level).

Since many years on the market

Emerson has acquired the Danish Mita-Technik. Since many years, the Mita pitch control system is on the market. According to Emerson about 3000 pitch controllers are in the field and more than 60000 wind power controllers have been installed. The modular pitch control system suits wind turbine systems up to 10 MW. For turbines up to 20 MW and for two-bladed turbines, the pitch control system can be customized with load-sharing between the pitch servo motors and the blade units. The pitch control system uses a CANopen-based embedded network connecting the used modules (motors, sensors, energy storage, etc.).

Emerson regards the retrofit business as important, too: "Our retrofit solution upgrades both the control and electrical systems of wind turbines so that they meet the latest local and industry standards. Our experience across more than 40 different wind turbine generator designs provides a safe and simple upgrade path for regaining the maximum performance within your wind turbines." Wind turbines, ranging from kW to MW sizes, can benefit from an upgrade. This includes stall, active stall, pitch, and 2- or 3-bladed wind turbines. An Emerson retrofit includes advanced control algorithms to improve energy production, to heighten turbine availability, and to provide remote access.

The hub unit, the blade unit, and the energy storage unit come in IP65-rated housings. They can be used in onshore and offshore wind turbines. Emerson's pitch control system is developed, tested and manufactured according to the APQP4Wind specifications. APQP4Wind is a non-profit organization endorsed by world-leading utilities, wind turbine manufacturers, and suppliers. The background for APQP4Wind is the continuous quality improvement needed to keep pace with the ongoing trend toward decreases in the levelized cost of energy.

Fiber sensor interrogators

Insensys located in United Kingdom showed on the Husum Wind exhibition its OEM-4030 fiber sensor interrogator (FSI). This is a measurement device, which sends pulses of light through the blade sensor arrays. Each sensor returns a reflection to determine the strain at that location. The ▷

Figure 3: Fiber sensor interrogators with CANopen connectivity can be integrated into pitch control networks (Source: Insensys)

Retrofitting pitch control

Christian Reichmann, a Deif application software designer, explained in a blog: “Poor cabinet build quality is a frequent cause of Suzlon S88 downtime because of moisture and vibration issues. Opting for a retrofit pitch control solution not only solves the immediate problem through better cabinet quality, it also offers a number of additional benefits such as optimized pitch control and full data access while making you independent of expensive OEM support.”

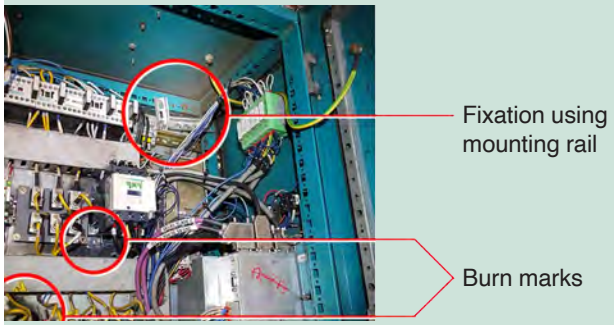

Figure: Short circuits can result in burns inside the cabinet (Source: Deif/Christian Reichmann)

A pitch system on a wind turbine is used to optimize power production. In addition, it is a safety sub-system on the turbine, allowing it to stop in high winds or other unfavorable operating conditions. Reichmann wrote in his blog: “On the Suzlon S88, however, the pitch system has sometimes been a source of turbine failure; not so much because of the pitch system itself as the cabinet housing the pitch control system. The poor build quality of the S88 pitch control cabinet means that moisture can enter the cabinet, causing short circuits and component failures. On some S88s, short circuits have resulted in burns inside the cabinet. Also, on at least one occasion the cabinet mounting plate was fixed with a mounting rail, increasing vibrational stress on the cabinet components and further aggravating the risk of component failure.”

Issues such as these can result in wind turbine downtimes. The situation is further worsened as the pitch controller has limited reporting and monitoring options. Reichmann explained: “You know that the turbine is down, but you do not know why. To find the cause of the problem, you are dependent on OEM support which often comes at a significant hourly fee. Until the problem is identified and solved, the turbine is wasting valuable production time – sometimes for months.”

In cases such as this, opting for a retrofit pitch control system from another manufacturer is a solution. A third-party pitch control system with a better cabinet build quality solves the problem by preventing moisture and vibrational stress from adversely affecting the pitch control system. In addition, the new control system often provides several additional benefits such as more accurate pitch control, better suitability for MW-scale production, and a wider operating temperature range.

Reichmann stated: “Equally importantly, it can also empower you to carry out service and maintenance on the pitch control system yourself, or outsource it to a third-party ISP as required. With detailed error messages and full logging access, you are no longer dependent on OEM support and can take full control of all service activities. You may also have more options for interfacing with SCADA systems or similar, letting you take full control of your wind farm.”

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sensor then outputs all measurements in a data packet to the turbine controller, which uses the data for real-time blade load calculations. The data can be sent by the CANopen interface. Customized CAN communication can be also used. The FSI comes in an IP40-rated housing and measures 240 mm x 120 mm x 97 mm. It is designed to fit into pitch cabinets.

Additionally, the British company offers the TL20 fiber sensor interrogator. It has evolved from the current FSI product line with 17 years of interrogator design and build experience in harsh environments. The TL20 uses lower cost core optical components to achieve a mid-range price/benefit position. The product enhances the existing cyclic pitch control routine by feeding in actual load data, which can compensate for pitch encoder errors, and therefore reduces the fatigue damage to the gearbox. The system offers additional load monitoring alarm capability, e.g. extreme load events and other blade condition monitoring functionality such as damage and de-bonding. It also can provide ice build-up alerts to trigger heaters and prevention systems.

For individual pitch control (IPC), the Insensys sensing system consists of one FSI unit and three sensor arrays (one per blade). Each sensor array comprising four sensor patches each containing an FBG (fiber Bragg grating) strain and temperature sensors. An FBG sensor is a type of distributed Bragg reflector constructed in a short segment of optical fiber that reflects particular wavelengths of light and transmits all others.

The FSI unit is typically located within a turbine hub electrical cabinet. It measures optical signals, converts optical measurements to electrical signals, and this data can be delivered to the turbine PLC (programmable logic controller), for example, via already existing communication systems such as CANopen or proprietary CAN-based networks. Sensor arrays are installed around the root section of the turbine blade positioned at 90° to each other enabling edge-wise and flap-wise bending moment and load calculations. ◀

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SPS 2023: Smart product solutions

For the three days from 14 to 16 November 2023, the 16 halls of the Exhibition Center Nuremberg (Germany) opened the doors for the 32nd edition of the SPS. 1229 exhibitors showcased their automation innovations to more than 50000 visitors.

(Source: Mesago/Arturo Rivas Gonzalez)

Networked automation technology is the key to success. "We are proud to have achieved results such as these with this year's SPS, and the figures speak for themselves. Due to the high demand from exhibiting companies, we preempted this positive growth by expanding exhibition halls to 3C and 8. This proved to be the right decision," explains Sylke Schulz-Metzner, Vice President SPS at Mesago Messe Frankfurt. The SPS conference program included topics ranging from digital transformation, Industry 4.0, industrial communication, safety & security, data-driven and intelligent concepts for control and visualization, and sensor innovations, to drives and sustainability through automation. In addition to the classic automation topics of control technology, drive technology, and sensor technology, software & IT is becoming an increasingly important issue in manufacturing. As a result, attention is increasingly turning to the use of artificial intelligence and IT security in the automation world.

CAN in Automation has been participating in the trade show with its own stand in hall 5. About 40 products on six panel walls have shown CAN and CANopen devices from CiA member companies. Additionally to the visitor speeches at the stand, the CiA editorial team was "on the way" across the halls to collect information about CAN-related trends and new products.

Motion control

As in the previous exhibition years, the most important topic for the CAN-based automation have been motion control solutions. The most of them support the CiA 402

Figure 1: Stepper motor drive platform from Elra (Source: Elra Antriebstechnik)

CANopen device profile for drives and motion control also internationally standardized in the IEC 61800-7 series. The exhibited CiA 402 products ranged from high-power inverters to tiny stepper motors and servo controllers.

For example, Elra Antriebstechnik, a recent CiA member, provides a stepper motor drive platform for Nema 23, Nema 24, and Nema 34 motors. The device can be supplied with 24 V_{DC} to 60 V_{DC} and provides a holding torque of 12 Nm. TIM is an integrated servo motor solution by STXi Motion for applications with limited control cabinet space and a decentral machine architecture. The manufacturer also provides the ZED servo drive with output currents of 23 A. The devices support the STO (safety torque off) function and are suited for implementation in automated guided vehicles (AGVs), for example. STXi also offers customized end-to-end motion solutions. The Danish manufacturer JVL has introduced a 33-mm-long integrated servo motor for 3 kW to 4,5 kW. The MAC083 integrated servo motor (for 83 W) and the MAC231 (for 320 W) integrated brushless DC motor are the further recently-developed products by JVL. The Italian company Mini Motor has presented the FCL brush-less linear servo motor with integrated drive and multi-turn absolute encoder. The WFCL device variant enables a wireless CoA (CAN over air) link using the CANopen higher-layer protocol. Wireless communication up to 60 m between according devices is possible.

Sensors

Also important for the automation solutions are encoders, sensors reading the position of a movement.

Figure 2: EAM580RS encoder by Baumer (Source: Baumer)

For instance, Baumer recently introduced the EAM580RS encoder for mobile machinery, especially such as loader and tower cranes as well as mobile working platforms. It supports the safety integrity level SIL 2/PLd according to IEC 61508, ISO 13849:2023, and IEC 61800-5-3. The single- or multi-turn encoder variants are available with CANopen and J1939 connectivity.

Another exhibiting company, EBE Elektro Bau Elemente provides customized sensors and motion solutions. For example, a customized double rotary encoder implements two CAN interfaces, redundant signal processing, preparation, and output, thus enabling deployment in safety-relevant applications. A further encoder with two CAN interfaces for safe position detection has been shown by Fritz Kuebler. The Ants LES02D is a compact (126 mm x 55 mm x 37 mm), contactless measuring system with a resolution of 0,5 mm and a travel speed of up to 10,5 m/s. For instance, it can be used to determine absolute position values of an elevator car via a non-contact measuring principle.

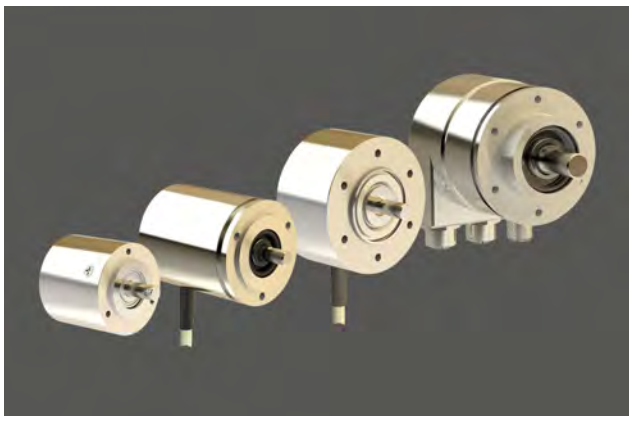


Figure 3: Safety sensor range from TWK (Source: TWK)

TWK has exhibited its new safety sensor range at the show. The compact encoders and inclinometers are offered with SIL 2 or SIL 3 certification. Such sensors are in demand, especially in the field of autonomous vehicles such as AGVs and AMRs (autonomous mobile robots). Safety sensors ensure that the steering angle, wheel speed, and position of any mounted tool are always reliably available. A further safety aspect is the vehicle tilt. TWK offers safety tilt sensors, the so-called inclinometers. In addition to the 360° dynamically-corrected angle signal, these provide a speed signal and raw values. The encoders and inclinometers are available with CANopen Safety and J1939 Safety interfaces.

The Italian company Lika offers a wide range of encoders such as rotary encoders, magnetic encoders, draw-wire encoders, and linear encoders. Beside others, CANopen and DeviceNet connectivity is provided. The manufacturer also supplies one- or two-axis inclinometers used in CANopen networks, for example the recent IXB and IXC devices. The company's Drivecod rotary actuators (e.g. RD4 and RD5 with CANopen) can be used for decentralized automation of positioning axes.

Krohne Messtechnik is specializing in process measurement technology. Offered portfolio includes sensors, systems, and accessories for flow, level, temperature, and pressure measurements. Process analyzing solutions are provided as well. For the equipment, different customized communication interfaces can be realized. For example, in the Batchflux 5500 flow meter a CANopen interface has been implemented.

HMIs: Human-machine interfaces

On the SPS, ifm electronic has shown its products such as sensors, controllers, I/O modules, HMIs, gateways, and software for automation and digitalization of customer's facilities. The devices are available with CANopen and J1939 connectivity as standard. For example, the new ▷

Figure 4: 4,3-inch Ecomat touch-screen displays (Source: ifm electronic)

rugged 4,3-inch Ecomat touch-screen displays are dedicated for use in mobile working machines, agriculture and forestry machines, as well as in municipal machines. The HMIs support CAN CC (classic) with CANopen and J1939 higher-layer protocols.

The Mvisio HMI from Zander Aachen is available in different variants. For instance, the Mvisio 7 with a 7-inch touch-display is dedicated for applications in packaging machines, cutting equipment, filling plants, gluing stations, plastic injection molding machines, etc. The IP66-rated device bases on a 1-GHz ARM Cortex A8 processor. Beside others, it supports CANopen NMT (network management) manager functionality to control CANopen-connectable devices.

Figure 5: CAN-CBX-Bridge-FD (Source: ESD Electronics)

Gateways

ESD Electronics has exhibited the CAN-CBX-Bridge-FD. The DIN-rail mountable bridge enables for connecting CAN CC and CAN FD networks with data buffering. Exchanged data can be filtered by variable masking. The networks can operate with different bit rates. Configuration of bit rates and frame filter settings can be selected via a rotary switch. Galvanic isolation of CAN networks is built in to reduce ground loops. The two CAN FD interfaces support a maximum data-phase bit rate of 8 Mbit/s. 1 Mbit/s is the possible bit rate on the CAN CC side. Deutschmann Automation has presented the Unigate Falcon Profinet gateway with an optional CAN interface. The compact DIN rail module is based on the ARM Cortex-M processor technology. The company's exhibited starter kits are arranged in such a way that a connection of a product to the selected communication network (e.g. CANopen or DeviceNet) at the laboratory bench is possible in a fast and reasonable manner. B-Plus has shown its Isobus-capable gateways such as B-Isobus IO Gateway, the B-Isobus CAN Gateway, and B-Isobus AUX-N Gateway. These devices should enable standardized connectivity between ECUs (electronic control units) within agricultural machines (e.g. tractors) and Isobus-connectable implements.

Embedded boards

Seco has presented its Smarc release 2.1.1 (smart mobility architecture) module SOM-Smarc-Genio700 with a CAN CC port. The system on module can be used for development of fanless industrial applications with high demands on graphics and AI performance, informs Seco. The SOM-Smarc-MX93 computer-on-module (COM) provides two CAN CC interfaces.

Figure 6: MIO-5377R SBC with two CAN CC ports (Source: Advantech)

Advantech has introduced embedded single board computers (SBCs) with the latest 13th generation Intel Core processors bringing performance enhancements and making the products suitable for smart factories, machine automation, machine vision, transportation, medical, retail, and edge AI applications. The product range includes MIO-5377R SBC with two CAN CC ports and the MIO-4370 with one CAN CC interface.

Stationary and remote control

The Irish exhibitor Horner Automation is a designer and manufacturer of complete factory automation control solutions consisting of programmable logic controllers, I/O modules, and human-machine interfaces able to communicate (among others) via CANopen and the proprietary CsCAN network. The embedded PCs UC-8220 and UC-4400A from Moxa support CANopen and DeviceNet higher-layer protocols. The manufacturer also produces PCI cards to connect CAN-based networks to a PC. Bamboo Dynamics, a brand from Blackbear Techhive in Taiwan, produces TCC (True control CAN) controller series. These devices are used to control roller systems deployed e.g. for movement of transportation boxes in logistic and factory automation applications. Errevi Automation, another member of the Blackbear group, acts as system integrator developing and manufacturing such complete solutions.

Figure 7: Imet radio remote control solutions (Source: Imet)

Several companies have presented their remote-control solutions on the fair. Such solutions consist of a controlling device with a (wireless) transmitter and a receiver device to be integrated in a controlled application. Tele Radio offers the customizable Exter system for the ▷

external control of trucks from Volvo. Additionally, the company offers the Panther, Tiger G2, and Puma remote controls, which can fulfill safety requirements up to SIL 3 (safety integrity level). The systems support CANopen and J1939 higher-layer protocols. A further manufacturer of remote-controls supporting CANopen on the receiver device, is Imet Radio Remote Controls from Italy. Simple and more sophisticated devices are offered for different applications. Arcon produces and customizes safety radio remote controls used e.g. in hazard zones on the construction sites. The supported higher-layer protocols include CANopen, CANopen Safety, DeviceNet, and J1939.

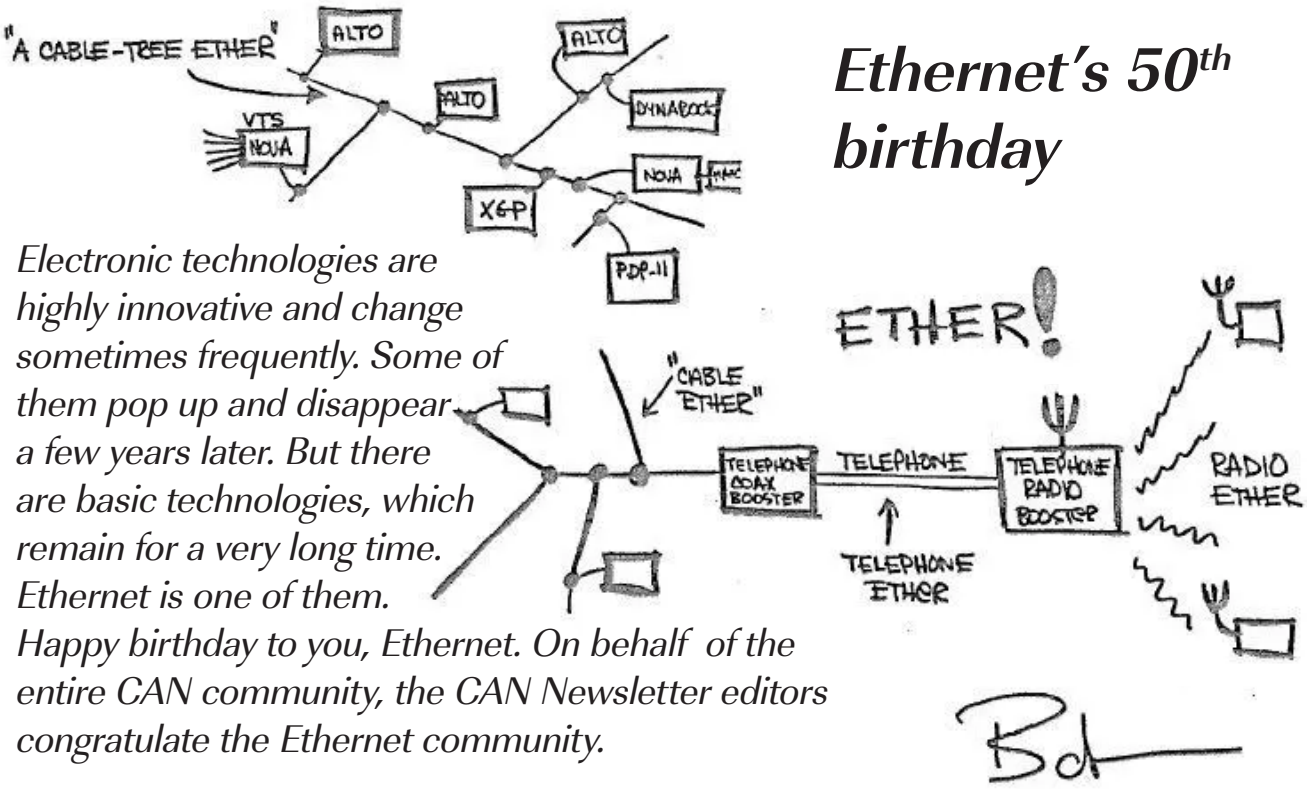
Miscellaneous

Gantner Instruments has exhibited its test and measurement technology solutions. The recent Q.station X and Q.monixx edge devices for monitoring, control, and remote configuration provide CAN CC connectivity. The hand-held measuring unit HMG 4000 with a 5,7-inch touch screen by Hydac Electronic fulfills measuring tasks in stationary and mobile machines. The unit provides ten channels for acquisition of analog and digital signals. An additional CAN interface enables connection of 28 transmitters. The CAN interface supporting J1939 and further higher-layer protocols can also be used to connect the HMG 4000 to an existing CAN system and to monitor the networked sensors.

The German company Safety System Products (SSP) has developed the Safety Simplifier. The device flexibly collects safety-related signals from light curtains, emergency-stop HMIs, or safety switches and forwards the signals to a higher-level controller via a CAN network or wirelessly. In case of emergency, it can interact with connected devices according to a programmed scenario. For example, several Safety Simplifier units can be located in a fabric hall to provide the required safety precautions up to PLd or PLe performance level. ◀

of

Ethernet's 50th birthday



Bob Metcalfe's Ethernet sketch in the 1973 memo (Source: Xerox)

Electronic technologies are highly innovative and change sometimes frequently. Some of them pop up and disappear a few years later. But there are basic technologies, which remain for a very long time. Ethernet is one of them.
Happy birthday to you, Ethernet. On behalf of the entire CAN community, the CAN Newsletter editors congratulate the Ethernet community.

Once upon the time, in 1973, Robert Metcalfe wrote at the Xerox Palo Alto Research Center (PARC) a first document mentioning Ethernet. Of course, there was a team involved in the Ethernet development. In the 1976 granted patent, David Boggs, Butler Lampson, and Chuck Thacker were co-credited as inventors. At this time, Xerox handed over its Ethernet trademark to the IEEE (Institute of Electrical and Electronics Engineers) association, which standardized Ethernet.

Metcalfe said that Ethernet was born on May 22, 1973, the day he circulated a memo titled "Alto Ethernet". This sheet of paper contained a rough schematic of how Ethernet would work. "That is the first time Ethernet appears as a word, as does the idea of using coax as ether, where the participating stations, like in Alohanet or Arpanet, would inject their packets of data, they'd travel around at megabits per second, there would be collisions, and retransmissions, and back-off," explained Metcalfe. For Boggs, November 11, 1973, is the Ethernet birthday: It is the first day the system actually functioned. It does not matter, what is historically "correct", the year of birth for Ethernet is the same: 1973. Happy birthday!

The first version, 10BASE5, featured a stiff cable nearly a half-inch in diameter, and was later joined by 10BASE2, using a cable about half as thick and much more flexible. In 1979, Metcalfe founded 3Com Corporation to make money of Ethernet. The company offered Ethernet circuit boards for mini-computers before releasing an Ethernet card (plug-in circuit board) for the IBM personal computer (PC) in 1982.

Nowadays, Ethernet is scalable by means of bit rates. But some variants are incompatible regarding the physical layer, the so-called PHY. Ethernet has been improved several times regarding the speed grade. Starting with a 10-Mbit/s copper coaxial-type approach (10Base5), the next step, in 1995 was the introduction of the well-known 100-Mbit/s Ethernet (better known as 100Base-TX) followed in 1999 by 1000Base-T providing a 1-Gbit/s bit rate. There are electrical, optical, and wireless physical transmission variants available. In 2002, the 10-Gbit/s Ethernet (10GBase-T) was born. Currently, the 40-Gbit/s solution is the highest speed grade, but research is already going to 100-Gbit/s bit rates.

IEEE has accompanied the Ethernet community and maintains the related documents. A number of IEEE 802.3 standards specify the physical and data-link layer for Ethernet:

- 10Base-T (IEEE 802.3): 10-Mbit/s with category 3 unshielded twisted pair (UTP) wiring for up to 100-m networks.
- 100Base-TX (IEEE 802.3u): Known as Fast Ethernet using category 5, 5E, or 6 UTP wiring for up to 10-m networks.
- 100Base-FX (IEEE 802.3u): Fast Ethernet that uses multi-mode optical fiber for up to 412-m networks.
- 1000Base-CX (IEEE 802.3z): So-called Gigabit Ethernet using copper twisted-pair cabling for up to 25-m networks.
- 1000Base-T (IEEE 802.3ab): Gigabit Ethernet that uses Category 5 UTP wiring for up to 100-m networks.
- 1000Base-SX (IEEE 802.3z): Gigabit Ethernet running over multi-mode fiber-optic cable.
- 1000Base-LX (IEEE 802.3z): Gigabit Ethernet running over single-mode fiber.
- 10GBase-T (802.3.an): 10-Gbit/s connections over category 5e, 6, and 7 UTP cables.

The first number in the name represents the speed of the network in Megabits per second. The word "Base" refers to baseband, meaning that the signals are transmitted without modulation. The last part of the name indicates the used cabling to carry symbols. For example, 1000Base-T means that the speed of the network is up to 1000 Mbit/s, baseband signaling is used, and the twisted-pair cabling is used (T stands for twisted-pair).

The success of Ethernet in office applications is not questionable. There is no real competing communication technology, except USB, which is used for completely other purposes. ▷

Figure 1: Robert Metcalfe in 1973, one of the Ethernet fathers (Source: Metcalfe)

Figure 2: David Boggs, one of the other Ethernet fathers, with an Alto Ethernet card (Source: Boggs)

From the office into the factory and into road vehicles

Beginning of this millennium, Martin Jetter introduced Ethernet into the industrial automation markets. His Jetweb was commercially not that successful; his company became not the market-leading supplier for industrial Ethernet. The automation industry made the same mistake during the so-called “fieldbus war” beginning of the 90ties. All big players in this business invented their own flavor of industrial Ethernet, which were not compatible to each other. Nevertheless, the different industrial Ethernet variants were successful in high-speed-requiring network applications as well as in their captive markets. But the industrial Ethernet market nowadays is still highly fragmented.

Automotive Ethernet is another success story – not yet by number of nodes in the car, but by publicity. It is the base of the upcoming so-called software-based vehicles and is intended to be used for autonomous driving, too. In the future, it also will backbone CAN-based networks. This means, CAN classic (CC) as well as CAN FD are not competing with 100-Mbit/s and faster Ethernet variants. Fast Ethernet and CAN FD will complete each other. Both network technologies, CAN and Ethernet, will be the two dominating automotive network technologies in the next decade. But they will compete in the 10-Mbit/s domain, because CAN XL and 10Base-T1S address the same applications. The CAN community is prepared for this contest. CAN fellows congratulate Ethernet to the 50th anniversary. Fifty years in electronics is a Methuselah age. CAN is a little bit younger – just 37 years counted from the first presentation in 1986 on the SAE congress in Detroit. Ethernet and CAN are somehow mature and successful communication technologies. ◀

hz

Standards and specifications

This section provides news from standardization bodies and nonprofit associations regarding CAN-related documents. Included are also recommended practices, application notes, implementation guidelines, and technical reports.

Common terminology for CAN protocols and CAN transceivers

The next editions of the ISO base standards for Controller Area Network (CAN) are close to be finalized. ISO 11898-1 is titled “Data link layer and physical coding sublayer”. ISO 11898-2 is called “Physical medium attachment (PMA) sublayer” often implemented as stand-alone transceivers. The CiA Business Committee (BC) and the CiA Technical Committee (TC) jointly agreed to recommend a common terminology for CAN protocol generations and CAN transceivers.

With the introduction of CAN FD and CAN XL, there are now three CAN protocol generations. In order to avoid misunderstandings, the term “CAN” should not more be used for the legacy CAN Classic protocol (1st generation). In the future, the term “CAN” covers all three CAN protocol generations and could be therefore misleading, if an interface does not support all these CAN data link layer protocols.

If you want to address precisely the 1st CAN protocol generation, write “CAN CC (ClassiC)”. The 2nd CAN protocol generation should be named “CAN FD (flexible data rate)” and the 3rd one “CAN XL (extended data-field length)”. In order to avoid confusion, write “CAN CC/FD” resp. “CAN CC/FD/XL”. If you want to indicate the supported frame formats of a CAN interface, it is recommended to list them: “The CAN interface supports CBFF, CEFF, FBFF, FEFF resp. XLFF” (select what is appropriate).

For the term “CANopen” this is similar. The term “CANopen” covers both protocol generations: CANopen CC (ClassiC) and CANopen FD (flexible data rate). If a CANopen implementation supports both generations and you like to express this explicitly, it is recommended to write “CANopen CC/FD”.

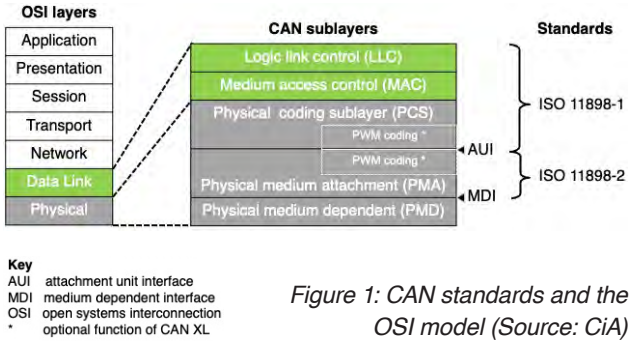


Figure 1: CAN standards and the OSI model (Source: CiA)

It is not necessary to change legacy documents. But consider the recommended terminology for new and updated documents. CiA is going to update all of its documents step-by-step. In CiA publications, the new terminology will be used, immediately. The review regarding the CiA website has been started.

With the introduction of CAN PMA (physical medium attachment) sublayers providing SIC (signal improvement capability) functionality and an optional PWM (pulse-width modulation) coding, we have additional CAN transceiver types on the market. In order to avoid misunderstandings, it is recommended to use the following terms. For legacy implementations limited to bit rates of 1 Mbit/s, the term “CAN HS (high-speed) transceiver” should be used. For implementations supporting bit rates higher than 1 Mbit/s, it is suggested to name them “CAN FD transceivers”. Implementations featuring SIC functionality should be called “CAN SIC transceivers” (they enable to use higher bit rates compared with CAN FD transceivers). “CAN XL SIC transceivers” feature SIC functionality and support additionally a PWM coding; they are made to run up to 20 Mbit/s depending on the network design. *hz*

Call for experts: CAN-based greenhouse automation networks

(Source: Adobe Stock)

South Korea is going to submit a new work item (NWI) to the ISO Technical Committee 23 (tractors and machinery for agriculture and forestry) Sub-Committee 19 (agriculture electronics). The purpose is to standardize CAN-based networks for the automation of greenhouses. This includes networks for heating, ventilation, and air-conditioning (HVAC), for controlling doors and windows, for monitoring the irrigation, for managing lighting, etc.

In several greenhouse automation systems, CAN-based networks are already in use. To standardize the CAN interfaces for dedicated sensors, actuators, and host controllers would reduce the number of variants. This could increase the volume, for example, for temperature sensors using the same CAN interface. Higher volumes normally lead to lower prices. This would be benefitable especially for farmers in countries with limited natural resources.

CANopen is one of the candidates for the higher-layer protocol. Existing CiA profile specifications could be adapted and new ones could be developed. The intended NWI is sponsored by the Korean government. CiA is supporting this standardization project. Interested parties can contact the CiA office for more information. *hz*

Brief news

The CiA 603 (CAN network time management) specification has been updated editorially (version 1.1.0). The technical content has not been changed.

The CiA 1310-1 CANopen conformance test plan specifying CiA 1301-related (CANopen FD) test cases has been released as version 1.0.0. It is the base for the CANopen FD conformance test procedure by CiA.

The ISO 11783-3 (Isobus application and transport layer) standard is in review. Pending comments will be considered as well as new once.

The ISO 11898-1 next edition has passed successfully the DIS (draft international standard) ballot. The submitted comments need to be resolved. An FDIS (final draft international standard) ballot will be started beginning of 2024.

The ISO 11898-2 next edition will be in FDIS (final draft international standard) ballot, soon. Technical comments are not more possible – only editorial and general comments are allowed.

The ISO 11992-2:2023 (Interchange of digital information on electrical connections between towing and towed vehicles, Part 2: Application layer for brakes and running gear) standard is unfortunately not complete and contains some errors.

The ISO 15765-5 (Diagnostic communication over CAN (DoCAN), Part 5: Specification for an in-vehicle network connected to the diagnostic link connector) standard has been revised and the 2nd edition is under publication. It has been improved technically and editorially.

The SAE J1939DA (digital annex) spreadsheet is updated quarterly. The last released version is from October 2023. It includes new Parameter Groups (PG) and Suspect Parameters (SP) discussed in the August meeting. *hz*

Motion systems for intralogistics and robotics

For AGVs, AMRs, and robotics there is a lot of different technical options when it comes to a motion solution. The most drives and motors with motion controllers from Delta Line (Switzerland) used in such applications are available with CANopen connectivity.

(Source: Adobe Stock)

Modern storage and distribution warehouses are home to a variety of machines and systems, from conveyors to autonomous mobile robots. All of these have one thing in common: they all involve motion. And that motion is produced by electric motors.

Given the diversity of the equipment, the motion systems solutions must be optimally matched to its application. Delta Line, a recent CiA member, provides experience in development, design, and manufacturing of motion systems solutions for intralogistics and robotics applications.

Motion system solutions for intralogistics

With the growing popularity of online shopping in the consumer sector and just-in-time ordering in industry, distribution warehouses are springing up almost everywhere. Increasingly, they embody a very high degree of automation. Traditional conveyor, diverter, and lift systems are still frequently encountered, but now these are often partnered by automatic guided vehicles (AGVs), automatic storage and retrieval shuttles (ASRSs), and autonomous mobile robots (AMRs). Each of these presents challenges in specifying and sourcing of the needed motion system solutions.

Conveyors, for example, need robust drive systems with long operating lives suitable for continuous operation. Wheel drive systems for AGVs and AMRs must be capable of withstanding high radial loads and offer excellent dynamic performance in the smallest possible package. Robot applications require high torque density in a small package at a competitive price.

By no means do all of the requirements relate to mechanical performance. The electronic control systems for the motors must meet requirements for energy savings, easy integration with plant control systems, and safe operation, such as safe torque off (STO) under fault conditions. And, of course, the motion system must be suitable for operation from the available supply, which, in the case of AGVs, AMRs and other mobile applications, maybe 48 V_{DC} derived from a battery. Another important challenge is ensuring that the motion system solutions are available in the required quantities when needed.

Delta Line is working in close cooperation with its customers to provide the suitable solution for their application, whether it is a standard off-the-shelf product, a standard product with customization, or a completely custom product designed for the application. The manufacturer's product range includes brushless motors, gearboxes, hub wheels, servomotors, linear actuators stepper motors, electronic controllers, and more. Since they are manufactured in-house, they can be readily fine-tuned to suit specific applications. Motors, gearboxes, and other devices can be supplied separately or as complete packages including motors, gearboxes, electronic controllers, encoders, and brakes. These integrated solutions, which are supplied tested and ready for use, simplify ordering and stocking, and reduce build and test time for the customer, leading to lower costs.

As one of Europe's largest manufacturers of motion system solutions, Delta Line claims to respond rapidly to peaks in customer demand and is also amenable to holding buffer stocks to help smooth out problems due to component shortages further up the supply chain.

Intralogistics application examples

Parcel sorting machine: The machine customer wanted a second source for an existing motion system solution. Delta Line responded by supplying a standard product with ▷

Figure 1: Parcel sorting machine (Source: Delta Line)

minor customization for the mechanical elements, complemented by a new electronic control system developed from scratch. The Delta Line solution offered enhanced performance compared with its predecessor, allowing the sorter to work with packages up to 50 kg, whereas the previous limit had been between 35 and 40 kg. The customer appreciated the high level of technical expertise that the Delta Line engineers could bring to the project and also the company's competitive pricing.

Conveyor system: This project was for a new application for which Delta Line developed a fully customized solution based on two sizes of stepper motor, complete with brakes and an electronic control system. As an initial step, Delta Line supplied the customer with separate components so that the design approach could be checked

Figure 2: Conveyor system (Source: Delta Line)

and validated. After the customer has had completed this evaluation, Delta Line combined the components to produce a fully integrated solution. Once again, the customer commented favorably on Delta Line's expertise and the keen pricing for the finished assembly and the involved development work.

Shuttle and lift drives: For this project Delta Line has provided a customized solution based on brushless DC (BLDC) motors. This application relies on a lift mechanism and a retrieval shuttle. For the lift, a BLDC slotted motor fitted with a brake was used in combination with the recent standalone Leo controller to drive the whole system. For the shuttle, six BLDC slotted motors were used, four to move the wheels, one to activate the picking arms and the last one to activate the retrieving conveyor belt. Using the Delta ▷

Line Phoenix multi-axis electronic controller allowed to use only two drives for the six motors of the shuttle, resulting in less complexity and smaller space. This innovative design has satisfied the customer's requirements at a very attractive price point.

Motion system solutions for robotics

Robotics is a fast-growing field integrating modern technology. Nowadays, robotic solutions in industry can be readily and inexpensively programmed and reprogrammed to meet changing product and process requirements. All robots depend on precisely-controlled mechanical movement mostly provided by motion system solutions based on small motors.

The main challenge faced by robotic system designers is the need to fit more and more into a limited space e.g. in prosthetics and industrial robot applications. The company offers (frameless) motors, with high power density suited for compact yet powerful motion solutions. Typical robotics applications also require smooth motion, with minimal cogging or torque ripple and feedback from devices such as absolute shaft encoders, to enable precise positioning. Such solutions involve complete systems including the drive electronics, feedback devices and, in some cases, a gear train. Delta Line helps to select and realize the right motion system solution for a particular robotic application. The standard or customized solutions are optimized in terms of performance, reliability, longevity, size, and cost.

Figure 3: Delta Line provides standardized and customized motion control systems for robotics applications (Source: Adobe Stock)

Robotics application examples

Dual-arm cobot: This application requires motion system solutions for five to seven axes, depending on the specification and model of the cobot. The motors had to interface easily with the customer's control system. Delta Line provided frameless motors with ratings from 60 W to 180 W to meet the needs of all cobot models. Problem-free interfacing was guaranteed by supplying the motors with customized windings. The solution enabled the cobot manufacturer to use fewer components in its products, and thanks to the compact motor construction, it could accommodate them within the body of the cobot.

Servo motor controller

Delta Line has extended its Leo drive family with the Leo B2000 drive, a closed-loop servo drive controller suitable for servo and BLDC motors. It features CANopen connectivity, compact housing (105 mm x 75 mm x 24 mm or 28 mm), and is suited for motors up to 2000 W. The operating voltage can range from 12 V_{DC} to 48 V_{DC}. The small footprint and the presence of a heatsink allow the controller to be used in size-limited applications. The device is provided with several general-purpose inputs and outputs to implement alarm signals, connect digital sensors, and activate external devices (LEDs, brakes, actuators, solenoids, etc.).

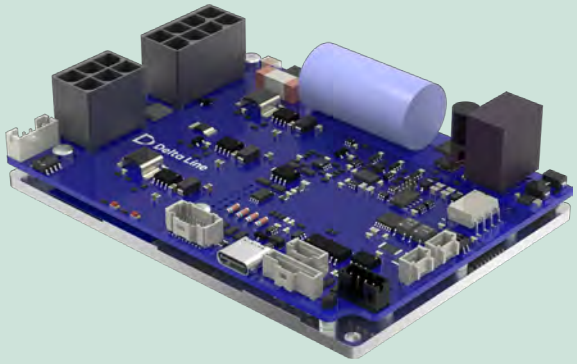


Figure: Leo B2000 drive is available with CANopen connectivity (Source: Delta Line)

The servo drive also offers the opportunity to manage a double incremental and absolute multi-turn encoder. It also implements the STO (safe torque off) function, thus fulfilling the requirements of SIL 3 (safety integrity level) according to IEC 61508. The controller is suited for applications such as automatic guided vehicles (AGVs), electric vehicles, and industrial production machines. *of*

Drive system for automated guided vehicle: To meet the requirements for a motion system solution for the main drive wheel of an automated guided vehicle intended for use in healthcare environments, Delta Line worked closely with the end user to develop a custom-designed gearbox and housing. Delta Line supplies this as a complete and tested assembly, meaning the customer benefits from reduced logistics costs and faster, easier vehicle assembly.

Cobotic arm: The arms in this application have either five or seven axis joint motors and require very high positional accuracy. Delta Line provided motion system solutions using flat brushless DC motors ranging in size from 45 mm to 61 mm. To achieve the high positional accuracy, the motors were equipped with encoders, and, were supplied with hollow shafts to accommodate the connecting leads. This arrangement saves space and ensures that the leads are well protected against mechanical damage. ◀

of, based on information from Delta Line (www.delta-line.com)

The program of the 18th iCC

The next international CAN Conference (iCC) will take place in Baden-Baden, Germany. The two-days event is scheduled on May 14 and 15, 2024. Recently, the iCC program committee has finalized the conference program.

The iCC program committee chaired by the CiA Managing Director, Holger Zeltwanger, evaluated the submitted abstracts, selected the speakers, and grouped the papers to seven sessions. The conference starts with the keynote by Markos Moch from Cariad, a Volkswagen daughter company. His paper is titled “From Flexray to CAN-XL: Migrating real-time high-performance networks into the future”. The VW group has started to consolidate its EE (electic/electronic) architectures towards E32.0 for all types of cars, e.g. volume, premium, sports, etc. and a solution is required to have one technology for all, together with some other handy features and thus, supported the CAN XL development. Moch will discuss challenges and gained possibilities of migrating Flexray networks to CAN XL using the example of the powertrain, also considering CAN FD and why this is only an intermediate solution.

The 21 selected papers are mapped to seven sessions comprising three presentations each. The sessions are named (in alphabetic order) application, CAN XL network design, functional safety, network design, security, software, and system design. It is obvious that many papers are somehow related to network and system design. Interesting are also the security-related papers. Of course, the conference covers many topics.

The CAN XL network design session starts with the paper titled “About clock tolerances and margins for physical-layer effects” by Dr. Athur Mutter from Bosch. The other two presentations are about CAN XL in-vehicle network validation (Patrick Isensee, C&S group) and CAN-XL EMC performance at car level (Frank Schade, VW). There is also another CAN-XL-related paper in the software session: Linux CAN XL support and programming by Dr. Oliver Hartkopp (Cariad/VW). In the security session, Peter Decker (Vector) will give a presentation about security concepts with CAN XL.

The conference program also includes several generic CAN- and CANopen-related papers. Functional safety in commercial vehicles is the topic of the presentation by Travis Breitkeutz (Caterpillar) and Dr. Chris Quigley (Warwick Control Technologies) will talk about cybersecurity in maritime CAN networks (NMEA 2000). Security is also the topic of Ben Gardiner (NMFTA) and Dr. Kenneth Tindell (Canis Labs), they discuss security requirements for vehicle security gateways.

Besides functional safety and cybersecurity, there are presentations about generic CAN bootloaders (Thorsten Gedenk, Emotas), dual-mode redundancy (Uwe Koppe, Microcontrol), and cabling in conjunction with appropriate CAN transceivers (Kent Lennartsson, Kvaser). The complete conference program is online as well as the registration possibility. The conference is accompanied by a tabletop exhibition. In the first evening a diner is planned. This gives the attendees an opportunity for social networking. ◀

hz

(Source: Kongresshaus Baden-Baden Betriebsgesellschaft mbH)

AGVs – Safety through smart sensors

In AGVs (automated guided vehicles), the implemented sensing, controlling, and actuating technology has to replace the driver. Wachendorff Automation provides encoders and according measurement systems used to ensure safety in AGV applications.

The logistics industry is currently experiencing a major upturn as a result of increasing automation and constant technical progress. Automated guided vehicles have long been standard in modern warehouses. Using AGVs is becoming more and more commonplace. Driverless transport vehicles are used when a driver can be removed. Applications include, for example, automated industrial trucks or transporting of different goods within a warehouse. This development will change the infrastructure and quality of life worldwide.

Automated guided vehicles (AGV) are self-propelled transport systems. They are guided without contact and are controlled automatically. The machine operation and control are performed by the machine itself and no person has a direct access to the inner life. Thus, accurate data acquisition by the vehicle and a quick response to a given situation is necessary. The vehicle must be able to stop immediately or reduce speed in a controlled way.

Using different sensor technologies ensures the safety of AGVs. One type of sensor used in such vehicles is the rotary encoder. Wachendorff Automation is a specialist in the development of encoders and measurement systems based on these. The medium-sized, owner-managed company is based in Rheingau near Frankfurt/Main (Germany). Rotary encoders are used in a variety of applications in AGVs. With different encoders optimally adapted to the requirements, many problems can be solved in a smart way.

Height position

Precise positioning of the system is required, for example, to determine the exact height of a forklift truck when filling the shelves in a warehouse. With a high-precision SZG165 draw-wire system and a WDGA 36A absolute encoder with a lateral cable outlet, the measurement can be integrated into the rail. Position and speed data are transmitted via a CANopen or a proprietary CAN-based network.

The exact position is determined by the implemented Quattromag single-turn technology. Using a patented calculation algorithm and four Hall sensors, the single-turn position of a magnetic absolute encoder can be calculated. The measured value is cross-correlated with the reference value to produce a more accurate value. A suitable calculation of the magnetic field generated by a diametrical magnet cancels out any interference from the Hall sensors. This allows the use of magnetic single-turn technology in dynamic and high-precision applications.

Absolute encoders are available in single-turn and multi-turn versions. Single-turn encoders can output an exact position within one rotation. Multi-turn encoders can also output an exact number of rotations. The patented Endra technology makes it possible to build encoders without a battery or gearbox that can detect and record rotations even in a de-energized state. This is achieved using the proven Wiegand effect.

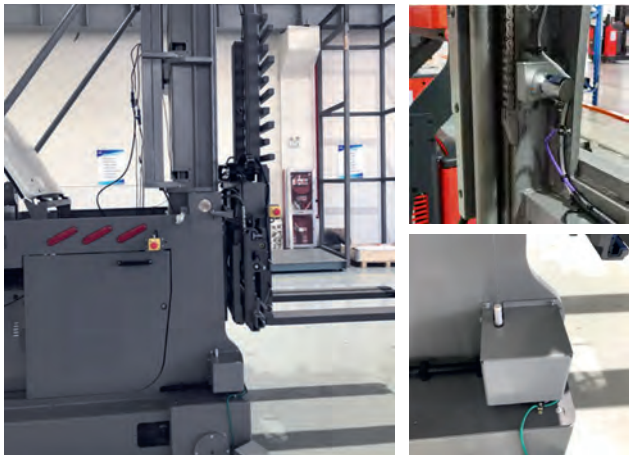


Figure 1: SZG165 draw-wire system and WDGA 36A absolute encoder used for precise positioning of a forklift truck (Source: Wachendorff Automation)

Speed control

Reliable speed control is essential for an AGV. Depending on the speed, the protective fields of the AGV are also extended. As soon as the protective field is disturbed, the AGV must safely reduce its speed. A WDGI 58A incremental encoder can be used to determine a safe speed value. The encoder is mounted directly on the wheel and the values are verified with the controller. Wachendorff also offers redundant incremental encoders with integrated optical and magnetic independent sensor systems.

Figure 2: Redundant encoder WDGR 58B for speed detection (Source: Wachendorff Automation)

Figure 3: WDGA 58E for detecting the rotation angle of the steering motor (Source: Wachendorff Automation)

The WDGR 58B encoder provides two independent signals that are matched in the control system. The combination of the measuring principles of a magnetic and an optical encoder increases reliability. The encoder has a high immunity to the electromagnetic interference and can withstand high bearing loads. With the redundant encoder, signal generation, and power supply are completely independent. The redundancy gives the encoder a multi-channel capability, which provides two values. This provides a hardware fault tolerance of one. The system is therefore safer than a standard encoder and less expensive than two standard encoders. The multiple redundancy protects against a common cause of failure (CCF). The advantage of redundant encoders is that the required level of safety for the entire application can be achieved with the appropriate vehicle concept and safety control.

Angle of rotation

The correct rotation angle of the steering system is important for precise steering of the autonomous vehicle. The space-saving WDGA 58E absolute hollow shaft encoder is mounted on the head of the steering motor to continuously measure the angular position of the steering wheel. Depending on the concept, one signal (for example sent via CAN) is sufficient, which is synchronized with the distance sensors for the safety of the environment. The use of a redundant encoder is also possible.

The high bearing loads of Wachendorff encoders are particularly in demand when the user envisages connection to a gear wheel. The available encoder variants are very compact and easy to implement for precise adaptation even in small installation dimensions. By using a field programmable gate array (FPGA), company's Universal-IE encoder can activate an Industrial Ethernet protocol (e.g. Profinet, Ethercat, and Ethernet/IP) via a web server. By using a single hardware for all protocols, the user has a maximum of flexibility. Future updates can also be imported via the integrated web server.

The increasing level of automation is a challenge for many operators. Wachendorff's value promise is to provide high-precision, flexibly-mountable, reliable, and compact encoders. These features as well as their robustness and high-vibration resistance make them ideal sensors for use in driverless transport systems such as AGVs.

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CANopen servo amplifier used for screwdriving control

For six decades, Weber has been setting trends in development and production of automatic handheld screwdrivers and stationary tightening systems. For more than 20 years, the company has been cooperating with Sieb & Meyer, a German motion control supplier.

(Source: Adobe Stock)

Weber Schraubautomaten located in Wolfratshausen, Germany, develops and manufactures handheld and stationary screw tightening equipment including feeding systems. The product range comprises electric handheld screwdrivers, spindles for tightening technology, stationary screwdriving systems, tightening units, and tightening systems – each adapted to customer-specific requirements. All these products are designed to make the tightening process as fast and as reliable as possible. "Automation processes for assembly work are very complex," said Christian Schoenig, head of development at Weber. "It is about finding solutions that meet various requirements and parameters." The servo amplifiers by Sieb & Meyer, a CiA member, help with this aim – for several decades now.

The used SD4S ("S" stands for stand-alone) servo amplifier is suited to stationary applications in switch cabinets, and succeeds the SD2S device series, which is also in use at Weber. The close collaboration with Weber proved a stroke of luck for the product development: "We were in close contact with Weber already in the early development stages of the SD4S series," related Ralph Sawallisch, key account manager drive technology at Sieb & Meyer. Beforehand, the specialist for tightening systems has already signaled his interest in testing and using the new servo amplifiers. "We received a lot of important input from Weber, which we have implemented. When the first prototypes were available, Weber was the first customer to put the device through its paces."

Figure 1: The SD4S servo amplifier family comes in different sizes and features CANopen connectivity (Source: Sieb & Meyer)

When the motion control supplier started the development of the SD4x series, the collaboration of the two companies reached a new phase. "Our main requirements for SD4S were a smaller size and a reduced price compared to SD2S," remembered Christian Schoenig. "These were prerequisites for the use of the device in our C5S process control." This screwdriving control can perform various screw tightening tasks using different screwdriving methods, which take the torque, angle, and depth into account. The C5S control comes with a wear-free servo drive that ensures an extended service life of the control and the drive unit.

The C5S is suitable to control for tightening tasks that do not require highly precise torque measurement or documentation of the tightening results. The control is used, for example, in furniture production to fasten fittings and hinges. When tightening screws in wood, the torque fluctuates due to the varying texture of the natural material. Therefore, direct measurement of the torque is not necessary, which makes an indirect torque determination by the servo amplifier possible.

In the C5S control, Weber uses the smallest SD4S model so far with an AC-mains supply of 230 V – even smaller devices require a DC voltage between 48 V and 72 V. The SD4S drives the motor of the tightening spindle that tightens the screw via the bit. During this process, the servo amplifier uses the measured motor current to determine the torque at the screw. The torque should be as precise as possible over the rotation angle of the motor. Hereby, SD4S effectively reduces motor cogging. The cogging torque of synchronous servo motors is created by the permanent magnets in the rotor. Depending on the motor design, the effect varies in intensity. The high-dynamic control of SD4x reduces this effect to a minimum so that the resulting torque at the screw is uniform.

"Other fieldbus systems cause further costs on both sides of the bus. Equally important is the fact that SD4S allows controlling servo motors of various manufacturers."

Christian Schoenig

Another important feature for Weber is the simple and low-cost connection of the host controller via CANopen. With the multi-parameter set function, users can connect different motors to the servo amplifier without further parameterization effort. The integrated EMC filter reduces the costs for an external filter circuit.

Figure 2: Ralph Sawallisch, key account manager drive technology (Source: Sieb & Meyer)

"For this project, a special motor is used because it comes with a manufacturer-specific rotor position encoder," said Ralph Sawallisch. "We adapted our SD4S device for Weber so that it can reliably evaluate this encoder." Christian Schoenig adds some background information: "There are small-build motors on the world market but they have manufacturer-specific feedback systems. SD4S can evaluate these, which means more flexibility in the motor selection for us. In light of the current supply problems, this opens up alternatives regarding the motors we use. Christian Schoenig appreciated that the servo supplier is flexible and makes no compromises in terms of price and support: "Sieb & Meyer knows the customer and the special use case. The communication is at eye level and we get honest answers."

As of June 1st, Sven Kapitza has taken over as group leader of the Sieb & Meyer service team and coordinates the customer support. Until now, the three-person service team was officially part of the development division "power electronics". Kapitza previously worked for 12 years in the CNC hardware development. There, he was responsible for the PCD36 application solution, which is based on the MC2 motion controller and the servo amplifiers of series SD2X. PCD36 is used for scoring of printed circuit boards.

Figure 3: Sven Kapitza, head of the service team (Source: Sieb & Meyer)

The SD4x product family has been exhibited in Nuremberg on the SPS trade show. The product family includes the SD4S, SD4B, and SD4M series. The SD4S series comprises in numerous sizes servo amplifiers in 50-V, 230-V, and 400-V classes. The products feature an output frequency of synchronous motors up to 4000 Hz and of asynchronous motors up to 6000 Hz as well as additional control functions. As a result, the devices operate synchronous motors with magnets embedded in the rotor, so-called interior permanent magnet motors (IPM). The reluctance torque generated by hese motors is optimized in real-time depending on the operaing point. CANopen and other serial network technologies are supported. The CANopen interface complies with the CiA 301 application layer and communication profile as well as the CiA 402 profile for drives and motion control (internationally standardized in IEC 61800-7-201/-301).

hz (based on information from Sieb & Meyer and Weber Schraubautomaten)

Tester for physical network diagnostics

(Source: Adobe Stock)

Gemac, a specialist in the field of physical fieldbus diagnostics, has been dealing with its technological fundamentals for almost 30 years. The company presented the first diagnostic solutions for CAN-based networks on the market about 20 years ago.

Fieldbus Diagnostics is a concept applied in industrial networks and automation systems to monitor the performance and integrity of CAN-based networks (e.g. such supporting CANopen and SAE J1939 higher-layer protocols) and to identify any faults or errors. A fieldbus is a digital communication system that enables communication of different devices and sub-systems in an industrial environment. The central system of communication in mobile machines are typically CAN-based networks. Main objectives of fieldbus diagnostics are improved availability, reliability, and efficiency of the machines and systems, as well as reduced downtimes.

The current diagnostics solutions from Gemac are applied primarily in the environment of mobile machines, but also in stationary automation of railway and logistics systems, for example, and in the field of development of CAN-based systems. Continuing this technology, the company is going to present a new generation of Intensive Fieldbus Diagnostics (IFD), which alongside physical diagnostics also includes digital and functional diagnostics.

CAN-Bus Tester GT3

The new CAN-Bus Tester GT3 is a handheld diagnostic unit. It provides a robust outdoor housing with a standardized Vesa mount. With its 10-inch rugged touch display, it constitutes an optimum basis for use in mobile and industrial work environments. The remote measuring head for direct connection of the measuring circuit to CAN CC and CAN FD networks (without stubs distorting the signals) allows measurements even at inaccessible spots or in environments placing special demands.

The software of the mobile tester can be adapted to the used network (e.g. CAN CC, CAN FD) and higher-layer protocol (e.g. CANopen, DeviceNet, or SAE J1939) used in the appropriate application. It can be released by way of a license key as necessary. The tester integrates an M12 plug connector and is shipped with an adapter for the 9-pin D-Sub connection. This ensures interoperability and increases the convenience for the user.

In addition, comprehensive project management, including segment, node, and measurement management, will be integrated. Furthermore, an expansion by a database solution for a large variety of machine documents (e.g., circuit diagrams, manuals, machine log books) is planned.

Even more comprehensive measurements at the CAN networks are possible at the physical level. The combination of a two-channel oscilloscope, which is equipped with a 12-bit ADC (analog-digital converter) with decoding and automatic determination of the signal quality, makes the GT3 tester a powerful tool for troubleshooting, signal analysis, protocol monitoring, and development of CAN-based circuits and systems. This is useful in the fields where signals and communication logs are used to monitor and analyze the communication between micro-controllers, sensors, actuators, or other devices.

The protocol monitor function is provided at the digital level. Furthermore, it can also receive and analyze CAN frames to monitor the communication between different nodes. Sending and receiving of CAN CC and ▷

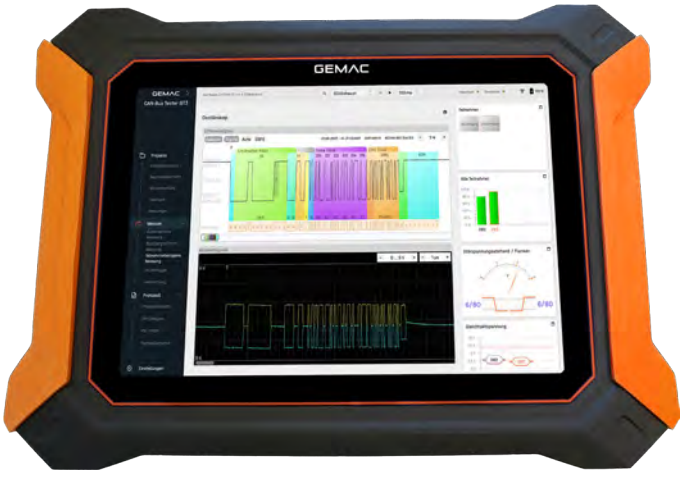

Figure 1: CAN-Bus Tester GT3 in combination with a high-resolution oscilloscope enables users to decode CAN CC or CAN FD messages (Source: Gemac)

Figure 2: CAN-Bus Tester GT3 (Source: Gemac)

CAN FD frames and frame sequences, as well as symbolic decoding of CAN CC, CAN FD, CANopen, and SAE J1939 are possible.

Integration of OBD-II analysis for the functional level is also planned as a service extension. OBD-II (on-board diagnostics) is a system for standardized vehicle diagnostics and intends to facilitate the vehicle repair. Although OBD-II uses a common set of error codes, vehicle manufacturers can also implement manufacturer-specific codes to provide further diagnostic information going beyond the general codes. In this field, Gemac intends to closely cooperate with mobile machines manufacturers to be able to provide users with relevant information in a compact and customized form.

A complete solution for fieldbus diagnostics for mobile machines is planned to be offered in the future. This will combine the digital and functional levels in one diagnostics solution.

All in all, with Intensive Fieldbus Diagnostics (IFD) for mobile machines, the company offers a solution for monitoring and control of machines to increase their safety, efficiency, and reliability. Technology plays an important part in state-of-the-art construction and agricultural machines as well as other mobile applications. Proactive diagnostics help avoid expensive breakdowns and increase the total efficiency of the enterprise. Gemac Academy offers training courses on this topic for beginners and professionals.

Presented at Agritechnica 2023

The CAN-Bus Tester GT3 was presented for the first time at Agritechnica in November 2023 in Hanover (Germany), one of the world's largest trade fairs for agricultural technology, agricultural machinery, and equipment.

Figure 3: The Motus sensor family enables inclination measurements in mobile work environments and is available in three performance classes (Source: Gemac)

Furthermore, the manufacturer has presented its recent Gemac Motus sensor family. The IMU (inertial measurement unit) for mobile machines is a configurable sensor measuring unit, which enables 6-axis motion tracking at mobile machines. There are product lines with three performance classes:

- Gemac Motus as the premium product provides a dynamic precision of ± 0,25° and a robust zinc pressure die casting housing;
- Gemac Motus Blackline possesses similar technical properties, but due to its availability in plastic housings and as an inclination sensor for purely statistic purposes, it also offers affordable variants;
- Gemac Motus Greenline with its slim design sets the focus on flexibility and price. The two standard housing variants are offered for 2- or 4-point assembly on the mobile machines.

The device is available as a static or as a dynamic inclination sensor and as an inertial measurement unit (IMU) with automatic configuration of the mounting position and flexible zeroing. All product lines support analog (current and voltage), CAN CC, CANopen, and SAE J1939 interfaces. ◀

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Using ChatGPT to analyze large CAN data sets

In a recent tutorial by CSS Electronics, it has been shown how one may leverage ChatGPT (GPT4) with 'Code Interpreter' to analyze large amounts of CAN data.

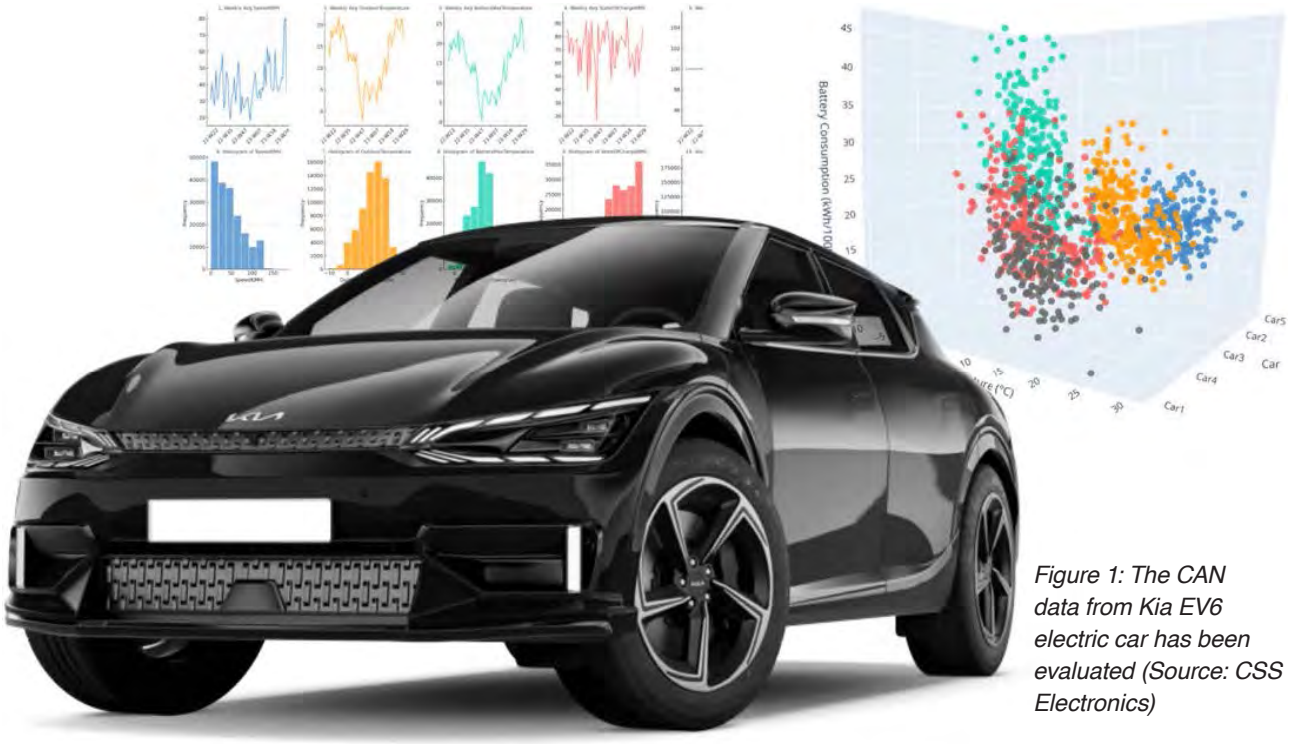


Figure 1: The CAN data from Kia EV6 electric car has been evaluated (Source: CSS Electronics)

CSS Electronics uses a dataset from a Kia EV6 electric car, which was recorded using a CANedge3 CAN data logger with an SD card and 3G/4G connectivity. The data consists of Unified Diagnostic Services (UDS) data and GPS/IMU data from the internal sensor of the CANedge3. More than one year of raw CAN data was decoded using the Python API (application programming interface) and DBC (data base CAN) files, resulting in a 100-MiB CSV-file with more than 80 signals, ready for analysis.

By using a ChatGPT Plus account (20$/month), the team enables the 'Code Interpreter'. This allows for uploading the data files (e.g. CSV) and asking the chat bot to analyze the data by creating and executing the Python code. ChatGPT directly outputs the code as well as the results e.g. as images, HTML files, etc.

The full article available from CSS Electronics explains how to prepare the CAN data and provides 12 example show cases. For each example, the company shows what prompt they use and the resulting output from the ChatGPT. Below, the company recaps four of the 12 examples.

Example #1: Creating 10 insightful data visualizations

The first example shows how ChatGPT can be asked to visualize the data in different ways. The team initially asks the chat bot to come up with 10 insightful data visualizations on its own - but this type of high-level task results in rather random visuals. However, by instead asking it to produce a specific plot with specified signals and charts, ChatGPT very effectively does this with a minimal follow-up.

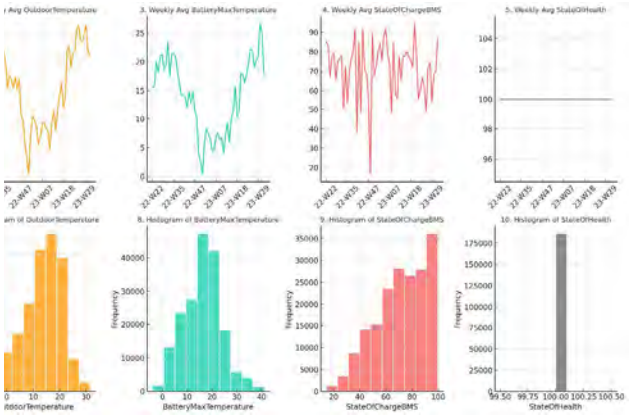
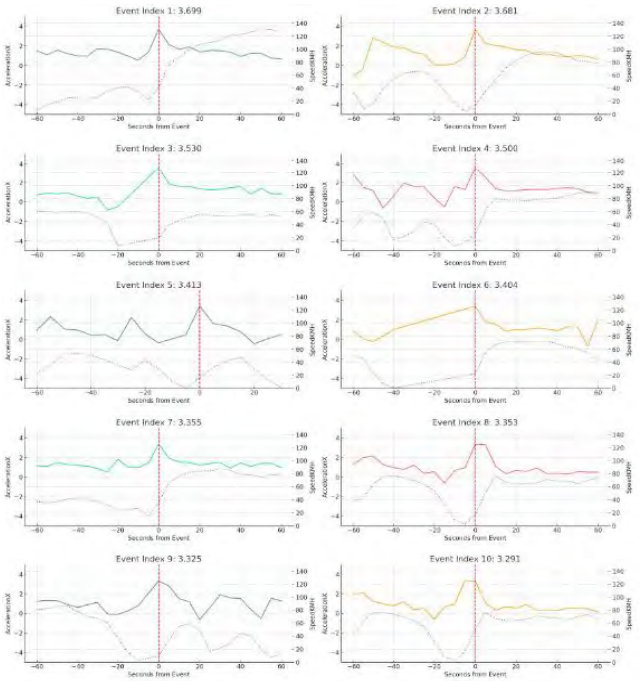
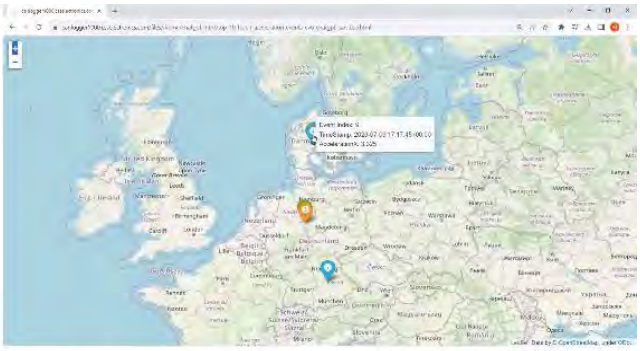


Figure 2: Plots produced by ChatGPT for specified signals and charts (Source: CSS Electronics)

Example #7: Visualizing top 10 acceleration events

When analyzing large amounts of data, it is often relevant to look for specific events. To illustrate this, the article shows how to identify the top 10 acceleration events of the electric ▷





Event Index	TimeStamp	AccelerationX
1	2023-07-18 14:35:20+00:00	3.699
2	2023-07-17 15:02:10+00:00	3.681
3	2023-07-06 15:12:40+00:00	3.5302
4	2023-07-09 17:18:50+00:00	3.5
5	2023-07-06 06:52:20+00:00	3.4125
6	2023-07-09 17:22:50+00:00	3.4036
7	2023-07-17 14:45:20+00:00	3.3546
8	2023-06-30 11:14:00+00:00	3.3534
9	2023-07-09 17:17:45+00:00	3.325
10	2023-06-30 11:14:05+00:00	3.2908

Figure 3: Plots produced by ChatGPT for top 10 acceleration events (Source: CSS Electronics)

vehicle, under the restriction that there must be a certain number of observations before/after the event - and that the vehicle speed must be non-zero.

ChatGPT successfully produces a plot of each acceleration event (see Figure 3). In addition, it manages to visualize each event in a geographical plot as requested by the user's prompt. Notably, all of these outputs were produced in about 15 minutes - with zero knowledge required from the user.

Example #11: Who's the better driver - Martin or Josefine?

In perhaps the most complex request, ChatGPT was asked to perform a multi-step analysis to benchmark the driving behavior of two drivers of the EV6, Martin and Josefine.

To segment the data by the driver, ChatGPT was initially asked to group the data by trips and subsequently to map each trip to a driver based on whether the car starts/ends in ▷

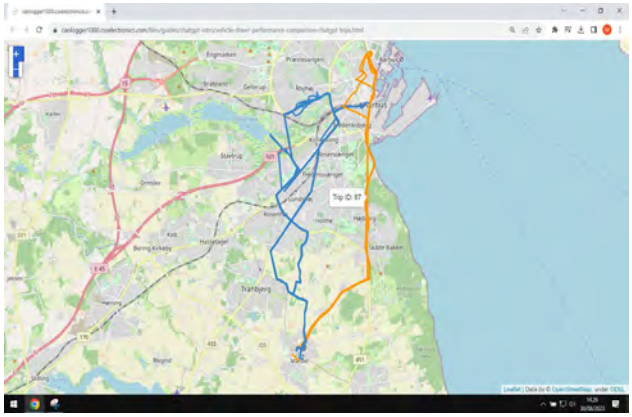


Figure 4: Visualized vehicle trips mapped to either driver (Source: CSS Electronics)

a specific geofence (thus determining if the trip was a work commute by either driver). To review the result, ChatGPT was asked to visualize the trips.

With the vehicle trips grouped, ChatGPT was asked to calculate the vehicle's power consumption and plot this in a histogram for each driver. The resulting plot shows how one driver, Josefine, manages to perform a lot better in terms of regenerative braking.

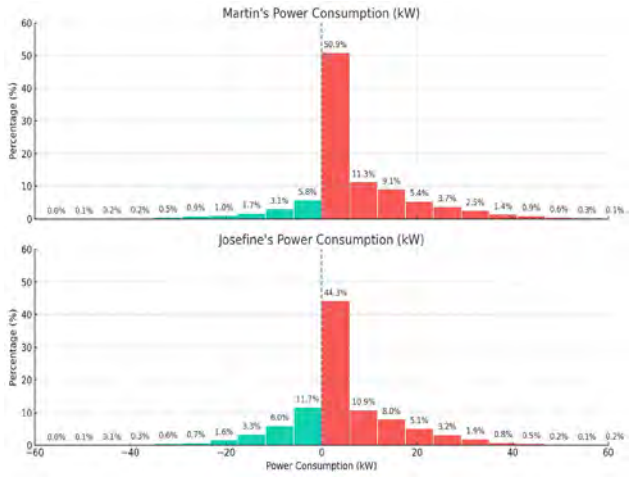


Figure 5: Visualized power consumption from Martin and Josefine (Source: CSS Electronics)

To further solidify this conclusion, ChatGPT was asked to break down power consumption into the accumulated regenerated/consumed/net amounts and to also compare the battery consumption in kWh/100km. The result clearly displays that due to regenerative braking, Josfine is driving 20-% more efficiently to work than Martin.

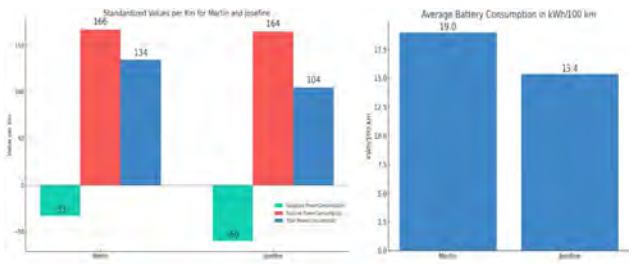
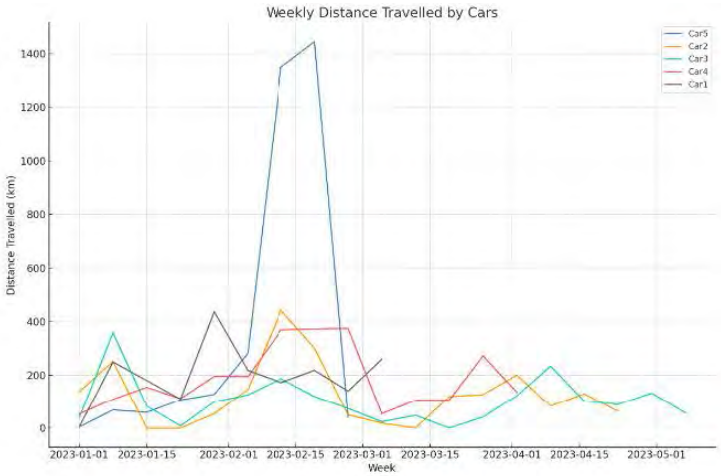
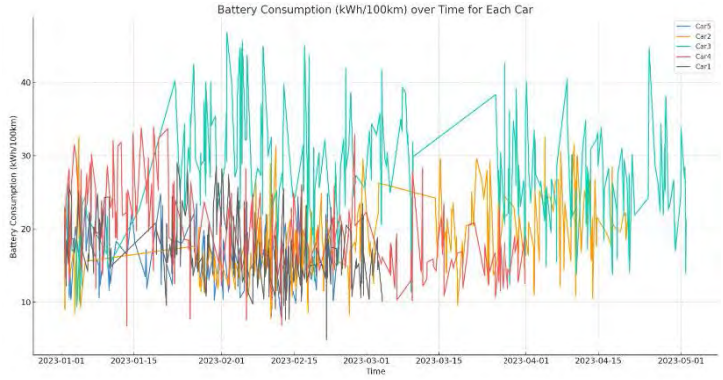
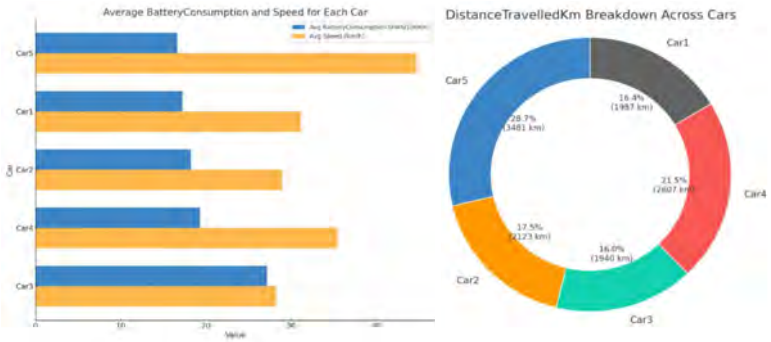


Figure 6: Compared power consumption from Martin and Josefine (Source: CSS Electronics)







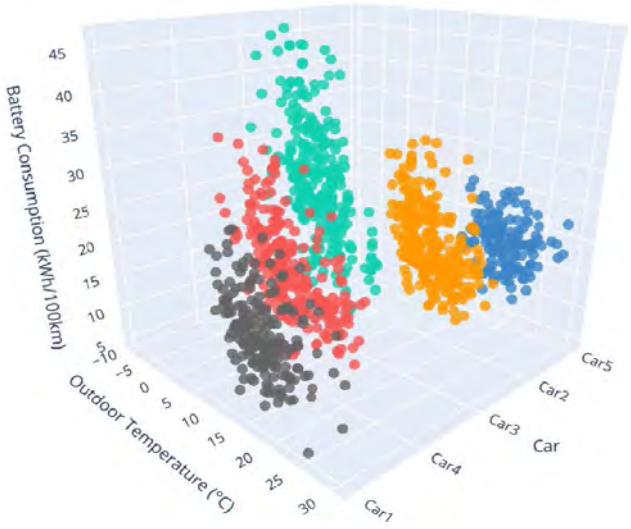


Figure 7: Data analyzed by ChatGPT across multiple vehicles (Source: CSS Electronics)

Example #12: Analyzing data from multiple vehicles

ChatGPT can also be used to analyze data across multiple vehicles and CSV files (see Figure 7). CSS Electronics illustrates this by simulating data from 5 cars and showcasing how this can be visualized in both regular charts and more advanced 3D scatter plots.

Conclusions and verdict

CSS Electronics shows that practically any analysis can be performed using ChatGPT. Using the tool does not require any coding knowledge - and it enables time savings of more than 90 %.

There are, however, also limitations. Many companies will not be allowed to upload their CAN data to ChatGPT due to data sensitivity concerns, though this may be resolved in the near future.

In addition, caution must be taken when asking ChatGPT to make conclusions based on the data. While ChatGPT generally gets the code, numbers and visuals right in almost all cases, it is still prone to hallucination when it comes to interpreting its own results. Nevertheless, CSS Electronics is convinced that ChatGPT will be a game changer for engineers and analysts working with CAN data.

Learn more in the full article or by contacting CSS Electronics. ◀

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Making NO_X measurements easier

ECM has developed the EZ-PEMS mobile demonstrator of its miniPEMS compliance tool that integrates two Kvaser products, the Air Bridge gateway and the Memorator data logger. This solution can be used by governmental and national law enforcement agencies to measure NO_X on a driving car.

The EZ-PEMS system measures NO_X emissions on a driving vehicle. The compact housing can be mounted to a flat surface, such as a car's rear window, using a suction mount. Within the housing is the ECM NO_X module, a Memorator data logger to receive CAN frames, connected to one of the pair of Air Bridge gateways connecting CAN in-vehicle networks wirelessly to the measurement unit. A T-script running on the data logger performs signal filtering and conversions before sending the data to the Air Bridge. This transmits data to a cockpit display for immediate viewing and to a cloud server.

Oskar Hellsten from ECM Europe explained: "The EZ-PEMS is particularly quick and simple to set up, differentiating it from the non-mobile systems on the market today. This system adapts particularly well to different vehicles. For example, truck exhausts can be hard to access, so the Air Bridge is a much more reliable and ergonomic way of routing live data to the display in the cabin than a wired solution."

At present, legislation is lacking regarding harmful NO_x emissions in vehicles that are already in service and when there is legislation, a simple, routine test tool is needed. In certain parts of the world, it is common practice to remove emission reduction equipment from cars and trucks to cut costs, notably the purchase of expensive urea used to reduce NO_X emissions to nitrogen and water. EZ-PEMS proves that a reliable, mobile test solution is ready to catch the perpetrators.

Figure 1: The mobile demonstrator of the miniPEMS compliance tool uses an exhaust adapter to which the sensor fits, without requiring modification of the exhaust (Source: Kvaser)

(Source: Kvaser)

Measurement module kits

The shown measurement kit comes in an IP67-rated housing featuring CANopen connectivity (Source: ECM)

ECM (Engine Control and Monitoring) provides test instrumentation and control systems for vehicle powertrains, engines, and combustion systems. Founded in 1988, the U.S.-headquartered company produces ceramic sensor-based engine- and combustion-system test instrumentation. This includes the sensor-based NOxCANf, NOxCANg, and NOxCANt kits. They are recommended for spark ignition and diesel engine applications. The NOxCANg kit has a more stable zero point and is therefore recommended for diesel and lean-burn combustion processes where the NO_X level is less than 10 ppm (parts per million). The provided CAN interface complies with CANopen.

The products have a cross-sensitivity to NH_3. For the NOxCANt kit, the cross-sensitivity is 1:1 (1 ppm NH_3 looks like 1 ppm NO_X to the sensor). For the NOxCANg, the cross-sensitivity is approximately 1:0,67 (1 ppm NH_3 looks like 0,67 ppm NO_X). The NOxCANf has a built-in and replaceable NH_3 absorption filter. It has zero cross-sensitivity to NH_3, however the exhaust gas temperature cannot exceed 210 °C and the filter requires replacement at intervals as short as 20 min. *hz*

Suitable for PTI

Martin Sventen, CEO of Kvaser, explained: “Something that is fantastic with the system is that it is not only a measurement system. It also provides a method that would enable NO_X measurement for periodical technical inspection (PTI) services of road vehicles in a very easy and efficient way. A 2-km drive with this system mounted is all that is needed in order to check if the vehicle is within regulations or not. Total testing time with setup, driving, generating a report and so on is around 15 min. The same system could also be used for more extended PEMS measurements or other applications such as marine engines or heavy-duty diesel used in construction machines and so on. To simplify, we use NO_X measurement and then CO_2 that tells how the engine is working. The result is an emission index that will give the threshold for the emission level. These techniques have been known within the industry since at least the mid 90s, but it is only now that components have become available to make small, light measurement systems that can be mass produced. The EZ-PEMS system is co-developed by ECM and EXIS. EXIS is a Swe-dish company that has done many measurement projects for TÜV as well as for Swedish and Danish environmental organizations. There are some reports from the work conducted that prove the method, concept, and product.”

Martin Sventen, CEO of Kvaser

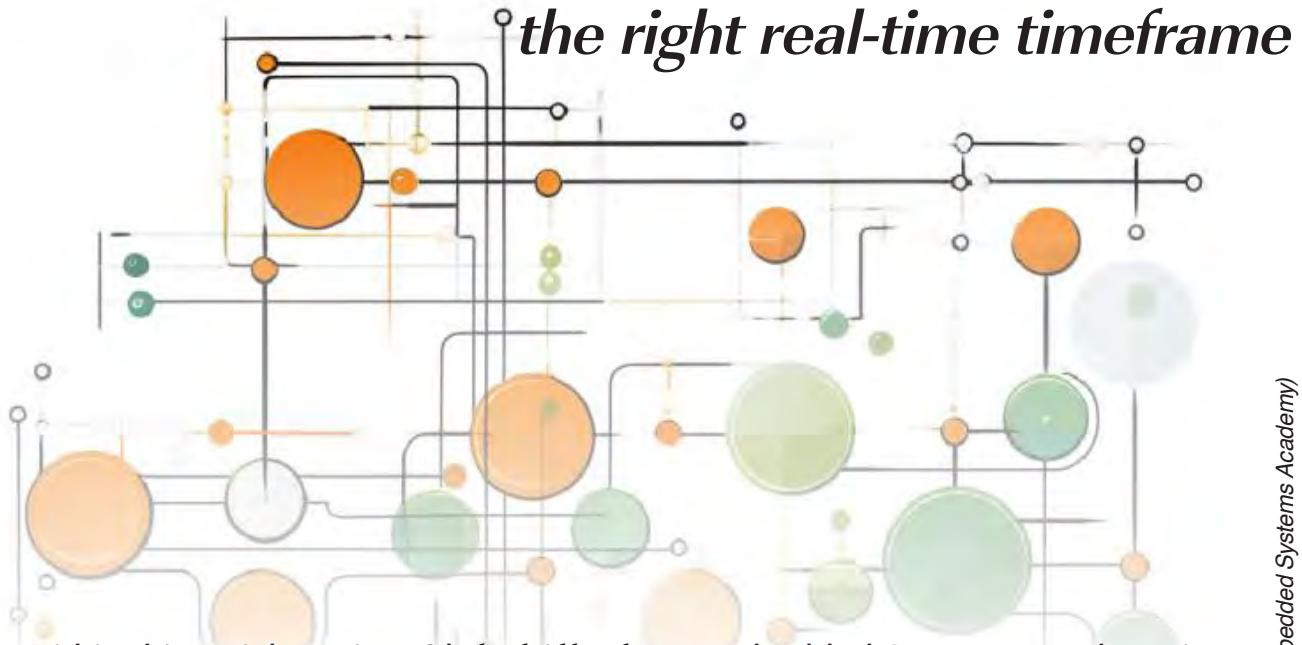
hz

Combined with the Air Bridge and Memorator devices, EZ-PEMS has the potential to answer the needs of the U.S. Environmental Protection Agency (EPA), the California Air Resources Board (CARB), and Environment and Climate Change Canada (ECCC), who have worked together for some time to find solutions for real-world emissions data gathering on smaller vehicles, such as quads, snowmobiles, and motorcycles. Testing how driving and usage patterns impact emissions on all vehicles is a key step in finding ways to reduce them.

ECM bills the measurement product as suitable for Periodic Technical Inspections (PTI), investigation of malfunctioning or manipulated emissions control systems, screening tests according to Commission Regulation (EU) 2018/1832 and engine test cells or real-world NO_X PM (particulate matter) and PN (particle number) measurement. The wireless CAN communication from the sensor to the cabin display enables testing without laptops or complicated PC programs, stated Kvaser. ◀

hz, based on information by Kvaser (www.kvaser.com)

Real-time communication: Part I – Selecting the right real-time timeframe



(Source: Embedded Systems Academy)

Within this article series, Olaf Pfeiffer from Embedded Systems Academy is setting in perspective the timing requirements for different real-time capable communication systems, such as CAN, CANopen, and real-time Ethernet.

In this first article, the author takes a "step back" to first find the right perspective. Here, he reviews an application's requirement – to get an idea of the "ballpark" to be operating within. The “Part II – The demands of real-time communication systems" shows the different timeframes required by different applications and reviews what this means for the communication system used. In "Part III – The temporal dynamics of CAN-based systems," the author applies the findings from Embedded Systems Academy (EmSA) to CAN and CANopen, giving recommendations on "how to use" (configure) the communications to meet the demands found earlier. The last article "Part IV – From theory to practice: CANopen source code configuration" shows which optimization options are typically available when working with CANopen source code, here, on example of Micro CANopen Plus from EmSA.

If the required responsiveness of your system is in the area of 100 ms, then you do not need to review in detail every cause adding a delay of a single millisecond or less. To give an example, in CAN communication, collisions are resolved by prioritization. However, without collision, even the lowest-priority frame gets immediate network access. Therefore, if your system only has a busload of 50 % or less and some mechanisms are in place that no device can produce back-to-back high-priority traffic, then discussions about optimizing priorities or managing software handlers by priority may become purely theoretical, without significant practical application.

In the context of timing behavior, it is also essential to recognize that if exchanged signals require safety or security measures or both, additional metadata will be necessary to safeguard the original signal data. This may include redundant information, counters, timestamps, and various cryptographic checksums.

Selecting the right real-time timeframe

In the world of embedded systems, real-time applications occupy a crucial niche. These applications are characterized by their requirement to process inputs and produce outputs within a specific timeframe. The accuracy of the results they provide depends not only on their logical correctness but also on the precise timing of their responses. As these systems interact with the physical world, the stakes can be high, often involving human safety, product quality, or efficient system operation. Therefore, the responsiveness of these applications becomes a basic aspect of their design. However, “within a specific timeframe” can be very different depending on the application. For the rudder and thrust control of a large ship, this might be a second or more. For a high-speed sorting and packaging unit in a cookie factory, it might be single milliseconds. And these two cases already show nicely the different demands regarding safety: The “slow” commands in the ship need to be much more reliable (or safer) than those commands sorting cookies.

As you can imagine, the specific challenges of implementing real-time applications often depend on the communication channels involved. As applications tend to grow more complex and geographically distributed, it is impractical to have direct connections from the main processing unit to every input and output. Instead, many real-time systems rely on remote connections. Sensors, actuators, and other devices might be located ▷

far from the central processing unit, making some form of communication between them necessary. Often, this also means that data has to be transmitted twice within the required timeframe: Inputs from sensors to the processing unit and secondly the processing units' outputs to the actuators.

All of this brings additional challenges and considerations: Communication channels introduce delays, or potential data corruption or loss. Designers of real-time systems must now account for these factors, ensuring that the communication methods used can still meet the system's real-time requirements. In addition, these systems must now be able to handle multiple, often simultaneous, data streams and manage the prioritization of these streams based on their urgency and importance.

The increasing sophistication and requirements of real-time applications, coupled with the growing distance between the processing unit and input/output devices, have made the design of real-time systems a multi-faceted and challenging endeavor. Such a development demands a deeper understanding of communication protocols, network topologies, and error handling mechanisms. Only by addressing all these factors can we ensure that real-time systems continue to meet the stringent demands placed upon them.

Figure 1: Before diving into the design process, the first and most crucial question is determining the required timeframe for a specific application (Source: Embedded Systems Academy)

Before diving into the design process, the first and most crucial question is determining the required timeframe for a specific application. Are we talking about seconds? Hundreds of a second? Or even milliseconds? Once a system has been fully designed and developed, shortening the timeframe might not be possible, as many design decisions would have been based on the initial timeframe estimate. After you've established a desired timeframe for the real-time responsiveness of the system, the author recommends taking some extra time to review it thoroughly. Consider having your boss, customer, or partners sign off on it, as making changes to the established timeframe later on can be costly.

If your application requires that the “the entire input to output” has to be included into the calculation, then you have multiple times to add up: Processing time in the input sensor to collect the input and preparing it for transmission, transmission delay, processing time in the main processor (receiving the inputs and eventually waiting for others, processing them, and preparing for transmission to the outputs) and on the outputs the processing delay of receiving the data and actually applying it. In the following, some application examples sorted by the required response times are given.

Applications with response times beyond seconds

For applications operating in timeframes of single or multiple seconds, the systems often don't require special precautions. This is because the delay tolerance of these applications is significantly larger than the typical delays introduced by communication protocols. Interestingly, even when the control code is executed on slower non-real-time operating systems, timely operation is achievable.

Figure 2: While managing seabed operations commands may take multiple seconds to reach their destination and cause the desired action (Source: Embedded Systems Academy)

Challenges may arise if the operating system is tasked with excessive concurrent operations, but these situations are generally exceptions rather than the norm. Nevertheless, do not underestimate the consequences: Even if in your application the real-time timeframe is 1 s – what exactly will happen if that 1 s is not met? Is that just annoying – or will something get damaged – or does the data even need to be ‘safe’ as otherwise some serious damage or even deaths could occur?

Solar tracking of solar panels: Solar panels with tracking capabilities adjust according to the sun's position. Delays of seconds to minutes are typical in this application, ensuring optimal energy capture even with occasional control delays.

HVAC systems: Heating, ventilation, and air conditioning systems often incorporate sensors to modulate temperature and air quality. While immediate adjustments are beneficial, a delay of several seconds is generally well within the acceptable range.

Mining equipment: In mining operations, large machinery such as conveyors and large-scale excavators require multiple seconds to start or stop. Given the scale, a delay of a second in system response can be acceptable, especially for non-critical adjustments. However, safety-critical functions like an emergency shut-off will have more stringent requirements.

Maritime applications: Given the relatively slow movement dynamics of large maritime vessels, a second of delay for data processing and navigation can be acceptable.

Sub-sea operations: In deep-sea systems, reliability stands as the foremost priority. While managing seabed operations – from pipeline control to equipment adjustments – commands may take multiple seconds to reach their destination and cause the desired action.

Applications with response times of 100 ms

In many scenarios, especially those centered around human-machine interaction, response times in the ballpark of 100 milliseconds are crucial. This range is rooted in the fundamental limits of human perception and reaction. When a system responds within this timeframe, the interaction feels nearly instantaneous to the user, promoting a sense of seamless control and real-time feedback. Given that the average human reaction time to visual stimuli is greater than 100 ms, systems that operate within a 100-ms timeframe are within the range to feel immediate and intuitive. To achieve these response times, one generally doesn't need to take any special measures regarding the communication channel. Even at relatively slow communication speeds like 100 kbit/s this can be reached.

Vehicle instrumentation and controls: In a variety of human-controlled vehicles, such as cars, forklifts, cranes, and agricultural vehicles, a myriad of displays and controls – from touchscreens to dials – rely on swift feedback. This ensures that the operator remains informed and in control. Sending controls via switches or joy-sticks, or receiving real-time feedback from sensors, all need to occur within this timeframe.

Industrial machine interfaces: Operators at manufacturing plants interact with complex machinery through control panels. Quick feedback is essential, ensuring the user's commands translate to machine actions almost instantly, which in turn enhances operational safety and efficiency. Where it takes longer to activate a command, some immediate visual feedback should be provided to signal the operator that the selected function is now about to be executed.

Medical equipment: Devices such as patient monitors and specific diagnostic tools require timely feedback when healthcare professionals adjust settings or input commands. This prompt response ensures both patient safety and the confidence of healthcare professionals.

Figure 3: The prompt response time of medical equipment ensures both patient safety and the confidence of healthcare professionals (Source: Embedded Systems Academy)

Applications with response times of 10 ms

For applications demanding a response time around 10 milliseconds, precision is imperative. These timings significantly surpass the boundaries of human perception, resulting in systems often responding or adjusting even before a human can register the event. Consequently, the foundational systems must operate with unparalleled efficiency and consistency. Realizing these rigorous timings demands detailed planning, balance between speed and priority, but potentially also going deep into the software layers, including drivers and firmware, that process the data. With precise optimization, these systems exhibit the ability to react promptly, reinforcing safety, preserving functionality, and assuring peak performance.

Driver assistance systems: Advanced driver assistance systems like traction control, lane-keep assist, and anti-lock brakes are paramount in delivering quick responses. These systems sense and react to instantaneous shifts in vehicle dynamics, often in situations where any delay could lead to potential accidents.

Industrial robotics: In state-of-the-art manufacturing setups, robotic arms and their allied machinery are tasked with instantaneous adjustments. Such promptness ensures meticulous precision, safeguards the sanctity of the production process, and curtails errors.

Emergency shut-off systems: In various control settings, the quick actuation of emergency shut-off systems is crucial. Whether responding to machinery malfunctions, hazardous leaks, or any unpredictable scenario, ▷

Figure 4: The slightest data exchange delay within high-precision robotics systems can lead to significant errors (Source: Embedded Systems Academy)

the swift activation of these systems can prevent significant damage, financial losses, and more importantly, protect human lives.

Applications with response times of single milliseconds

For applications that demand response times in the order of single milliseconds, the capabilities of several communication networks are stretched to their limits. Keep in mind that this is not about total throughput (typically only a few bytes are exchanged here) but get these bytes to the destination quickly. Achieving such rapid reactions requires a review of every facet of the system – from the configuration of the network to the underlying code – to be optimized. When getting into such demanding requirements, a comprehensive evaluation should be conducted to determine if the chosen communication protocol is indeed the most suitable solution or if other solutions are available to complete the tasks at hand.

High-speed motion control: In specialized industrial setups, machinery requires instantaneous adjustments based on rapid feedback loops. Such applications could involve fine-tuning motor speeds, swiftly actuating valves, or modulating high-speed actuators in real-time.

Advanced robotics: Especially prevalent in high-precision tasks, these robots might be involved in operations like placing delicate electronic components onto a PCB (printed circuit board) at accelerated speeds, where the slightest delay can lead to significant errors.

Airbag deployment: In vehicular safety systems, the time between detecting a potential crash and deploying an airbag can be mere milliseconds. Such a rapid response is crucial to ensure the safety of the vehicle's occupants, where every millisecond counts towards mitigating injury.

Real-time focus: Safety and security considerations

This article series concentrates on the timing requirements for real-time communication systems with a focus specifically on real-time performance. It is crucial to understand that considerations of safety and security are outside the review of this discussion and should be added, where required.

In safety-critical applications, redundant mechanisms are often necessary, which might require transmitting multiple CAN frames for a single command or piece of data. And, also security mechanisms require adding more data, which either makes frames longer or even adds additional frames. This means that both additional data and actions must be integrated into the established time window to ensure the system's reliability and/or security without affecting its real-time capabilities.

Conclusion Part I and outlook Part II

As we have seen in this first part of the article series, applications across various sectors have different response time requirements, ranging from seconds to mere milliseconds. The ability of a communication system to meet these needs is critical to achieving optimal performance and efficiency. However, understanding these response time requirements is only one part of the puzzle.

In the upcoming second part of this series, the author will go deeper into the specific demands placed on a communication system to meet requirements for real-time capable communication. We will explore the technical aspects that impact communication speed, latency, and arbitration, including considerations such as network architecture, bandwidth, and data processing capabilities. Furthermore, we will examine the trade-offs and compromises that must be made when selecting a communication system that strikes a balance between speed, complexity, and cost. ◀

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System-level testing of CAN FD transceivers

For multi-node CAN FD networks, the author recommends to apply a system-level testing of CAN transceivers and CAN protocol controllers.

(Source: Adobe Stock)

A CAN FD interface is mainly comprising a CAN FD protocol controller (often integrated in the micro-controller) and a CAN transceiver. CAN FD is scalable regarding the bit time. CAN FD transceivers use arbitration bit rates of up to 1 Mbit/s as CAN CC (classic) is doing. In the data phase, the bit rate can be higher depending on the physical network design. In multi-node networks, you can achieve 2 Mbit/s. Using in some nodes CAN SIC (signal improvement capability) transceivers can enable bit rates above 2 Mbit/s, but this is not the topic of this article.

CAN FD transceivers are connected to the CAN-H and CAN-L network lines. The bit values are represented by differential voltages. A nominal 2-V differential voltage represents a dominant bit and a nominal 0-V differential voltage is regarded as a recessive bit. Differential voltages greater than 1,5 V are interpreted as dominant bits. Whereas, differential voltages less than 200 mV are regarded as recessive bits.

Evaluating a multi-node CAN FD network and the achievable bit rates in the arbitration as well as the data phase requires a proper selection of transceiver chips and other electromechanical components, especially the cable. Also used network topology has an important impact. A daisy-chain bus-line topology or a bus-line topology with very short (not terminated) stubs fit best. The CiA 601-6 specification contains requirements for cables to be used for CAN FD networks.

Why to perform system-level testing?

Most of the time, while choosing CAN transceivers, customers evaluate the CAN transceiver by sending a bit stream on the TXD pin of the CAN transceiver through the function generator. Although this method is perfectly suitable for the evaluation of a single-node CAN, it seems to be flawed while developing a multi-node, far-spaced CAN FD network. Hence, a system-level testing of CAN controllers and CAN transceivers is necessary to select the right CAN transceiver.

Figure 1: CAN arbitration in a two-node network (Source: Analog Devices)

The primary reason for this system-level testing approach is the arbitration feature of the CAN protocol. If two nodes try to occupy the bus simultaneously, access is implemented with a non-destructive, bit-wise arbitration. The node that sends a first CAN-Identifier bit as a “zero” (dominant), while the other nodes send this bit as a “one” (recessive), retains control of the CAN network and goes on to complete its data frame.

As shown in the Figure 1, node 1 and node 2 are connected to each other over the CAN network. So, CAN-H and CAN-L lines are common to both nodes. TXD1 and RXD1 pins provide the physical layer symbols (NRZ-coded bits; NRZ: non-return-to-zero) to the node-1 protocol controller, whereas TXD2 and RXD2 pins do this for node 2. As it can be seen, the first three bits of node 1 and node 2 are the same: 1, 0, and 1, respectively. The fourth bit of node 2 is 1, whereas this bit of node 1 is 0. As node 1 has a dominant bit, it wins the arbitration and continues sending the complete data frame. The date frame is acknowledged by node 2. Once node 1 finishes the transmission, node 2 can start the sending of its data frame. Node 1 acknowledges this data frame by means of the ACK slot bit.

Each node should use a unique CAN-Identifier (CAN-ID), in order to avoid arbitration deadlocks. They can lead to situations, in which one node goes bus-off. In CAN FD communication, the arbitration (nominal) bit rate can be ▷

kept the same or different from the data phase bit rate. In CAN CC (classic), both the arbitration and data phase bit rate are the same.

CAN nodes synchronize on observed edges within the NRZ-coded bits, but the signal propagation time on the bus line introduces phase shifts between the nodes. CAN's non-destructive arbitration mechanism for media access control requires that the phase shift between any two nodes is less than half of one bit time. This lower boundary for the nominal (arbitration phase) bit time defines an upper boundary for the nominal bit rate as well as for the network length. Thus, the rise time and fall time of the RXD, the loop delay of the CAN transceiver as well as the cable come into the picture. At a higher bit rate, for example, 10 Mbit/s, the propagation delay, and rise time/fall time need to be less than 50 ns.

Example transceiver testing

Let's take an example of the MAX33012E CAN transceiver, which has been tested up to 13,3 Mbit/s with a 20-m cable. As shown in Figure 2, the TXD2 bit width is 75 ns (corresponding to 13,3 Mbit/s) and the RXD2 bit width is 72 ns. As the controller samples at 80 percent of the TXD bit width, the minimum RXD bit width including rise time/fall time and loop delay of the RXD required is 60 ns. It can be seen that the received bit width is 72 ns. Thus, the MAX33012E satisfies the condition and is robust enough to work at higher bit rates. In this situation, the CAN controller doesn't detect any error and continues to perform data communication.

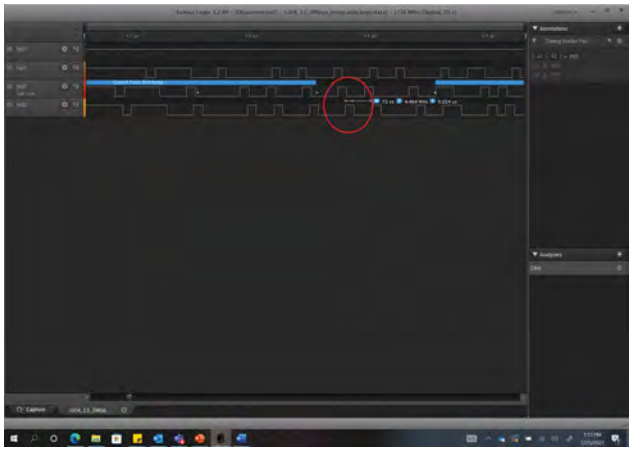

Figure 2: CAN transmission using a MAX33012E (Source: Analog Devices)

The shown oscilloscope shot of a competitor transceiver (see Figure 3), which was also tested at 13,3 Mbit/s, demonstrates the transmitted bit width of 75 ns (corresponding to 13,3 Mbit/s) and the received bit width of less than 80 % of the transmitted bit width (48 ns). Thus, the arbitration phase bit transmission failed, leading to an error in communication, and finally the system stopped working.

These kinds of data transmission errors can only be uncovered by performing complete system-level testing, which includes multiple CAN controllers, CAN transceivers, and a long cable.

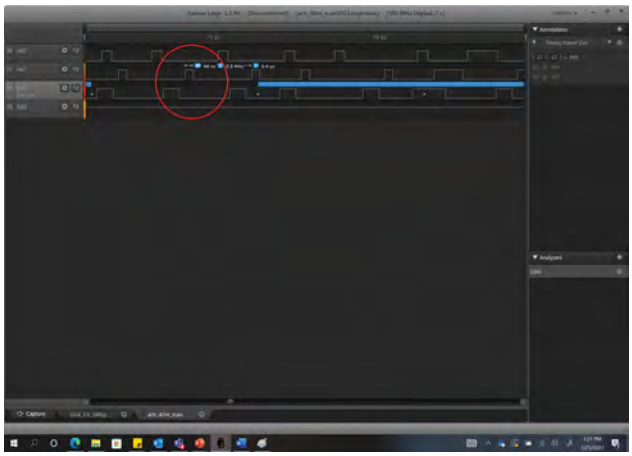

Figure 3: CAN transmission using a CAN transceiver from a competitor (Source: Analog Devices)

Conclusion

System-level testing of the CAN transceiver helps to unveil the possible future data transmission problems in your system. These problems can be avoided by evaluating a CAN transceiver with a CAN protocol controller and a cable that satisfy the required timing and voltage specifications. Robustness of the CAN system is a cumulative performance of each component in the CAN network. Evaluating only one component, or CAN transceiver, does not provide an accurate measure of system functionality. Performing a prior validation of the system is much more cost-effective than replacing a faulty one. Thus, we highly recommend system-level testing before choosing your CAN transceiver. ◀

According to documentation from Analog Devices.
For further questions, please contact
adi-germany@analog.com

CAN in Automation

The nonprofit CiA organization promotes CAN. CiA and its members shape the future of CAN-based networking, by developing and maintaining specifications and recommendations for classical CAN, CAN FD, and CAN XL.

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