September 2025

CAN Newsletter

Hardware + Software + Tools + Engineering

Agri-food system standards

CAN/CANopen in milking and feeding robots

TIM: tractor/implement management

CANopen in vertical farms

Agriculture

www.can-cia.org

Configurable Sensor Module

PCAN-GPS Pro FD

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

Specifications

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

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

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CAN in agriculture machinery, live-stock automation, and vertical farming

Historically, the first ideas to use CAN in agriculture machines goes back to the end of 80ties. Nowadays, CAN is not only used as embedded network in tractors and implements, but also as a standardized integration backbone network in agriculture machines, known as Isobus specified in the ISO 11783 standard series. One of the emerging functions is the tractor-implement management (TIM), which enables implements to control partly the tractor. CAN is also used in animal feeding and milking robots as well as live-stock automation, for example, to control the heating, air-conditioning, and ventilation (HVAC). Another emerging application is vertical farming. This is an agri-food system with a bright future, expect and hope scientists all over the world. In this issue you will find related articles. The editors of this magazine invite you to write articles and to provide information on these topics to be reported in future CAN Newsletter issues.

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(Source: Adobe Stock)

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

(Source: Adobe Stock)

Agri-food systems and embedded CAN networks

The FAO (Food and Agriculture Organization of the United Nations) defines agri-food systems as all the interconnected activities and actors involved in getting food from field to fork. This broad definition encompasses everything from agricultural production and processing to distribution, consumption, and waste management. It also highlights the critical role of economic, social, and environmental factors in shaping how food reaches our plates.

ISO has established the TC (technical committee) 347 (Data-driven Agri-food Systems), developing standards for agri-food systems. It covers all aspects of food industries:

- Production includes "classic" agriculture, livestock farming, fisheries, aquaculture, and forestry activities that provide the raw materials for food.
- Post-harvest handling and storage involves activities like cleaning, sorting, drying, and storing agricultural products after harvest.
- Processing includes transforming raw agricultural products into food and non-food products, such as milling, canning, freezing, and baking.
- Waste management covers food loss and waste generated at all stages of the system, posing environmental and economic challenges.

CiA has established a liaison with ISO/TC 347 and CiA staff is observing and contributing to the planned standards, in which CAN technology is considered. A strategic objective of the proposed data-driven agri-food systems TC is to concentrate expertise on data management to serve as a resource for other relevant committees and, where appropriate, work in liaison and on joint projects with existing committees. The ISO/TC 347 scope covers the standardization in the field of big-picture, data-driven, principled-decision-making, multi-objective optimization of agricultural and food systems. This includes interoperability challenges such as:

- Agri-semantics;
- Sustainability models, metrics and data in agri-food systems;
- Livestock activities data management;
- Greenhouse, controlled environment, and urban farming.

Excluded are standardization activities covered by ISO/TC 34 (Food Products) and ISO/TC 23/SC 19 (Agricultural Electronics). Of course, CiA staff is actively participating in ISO/TC 23 SC 19 standardization, especially, the CAN-based ISO 11783 series (also known as Isobus). This is an "open" network connecting tractors to implements such as sprayer, harvester, etc.

In general, agri-food systems need to standardize data semantics and data syntax. This relates to sensor data, actuation commands, and actuator status data. Data semantics refers to the meaning and interpretation of data. It goes beyond just the data itself, encompassing the relationships and constraints. Data syntax refers to the structure, rules, and conventions used to express commands, measured and status information. At the end, we need sensors, actuators, human-machine interfaces, and controllers, which are interoperable and partly exchangeable. In order to keep the cost for such devices as low as possible, fragmentation of device markets should be as low as possible. High volumes lead normally to reasonable prices. For example, CO_2 sensors are needed for very different applications. A standardized communication interface would enable to use such sensors for multiple purposes, as CiA 404 compliant temperature sensors are already doing, for example.

In agriculture and forestry machines, the CAN-based Isobus enables interoperability between tractors and implements with some degree of exchangeability. In other agri-food markets, this needs to be developed.

Greenhouse automation

Greenhouse automation comprises several tasks. This includes climate, irrigation, and fertilization control, harvesting as well as, in some applications, even the packing of plants ready to be transported. Besides traditional greenhouses, vertical farming is increasingly of high importance. It reduces the need of water to a minimum and can be located even in megacities. This helps to save water and energy (no long distances to the end-user). Growy, a new CiA member, uses CANopen networks, to automate its vertical farming systems.

Livestock automation

Livestock automation includes feeding of animals. Another task is the heating, ventilation, and air-conditioning (HVAC) of livestock facilities. There are also mobile robots in use to automate livestock. In case of cowsheds, also the milking is automated. For all such equipment, CAN-based networks can be applied. Most of them use proprietary higher-layer protocols. A standardization of data to be provided to the agri-food systems would be helpful to simplify the design of gateways, routers, and switches.

Brief news

- ***SAE J1939 DA:*** The May version of the digital annex provided in an Excel file has been published. It specifies parameter groups, (suspect) parameters, and provides slot definitions. The document is, so to speak, an application profile for J1939 networks. Dedicated Isobus (agriculture machine) parameters are available in another data dictionary provided by ISO and hosted by VDMA.
- ***MiC 4.0:*** CiA has submitted comments on this specification released by the nonprofit VDMA association. This document specifies the J1939-based interface between construction machines and attachments.
- ***IEEE 1722:*** CiA has reviewed and submitted comments on this IEEE document in respect to tunneling/mapping of CAN CC (classic) data/remote frames, CAN FD data frames, and CAN XL data frames via Ethernet frames containing an ACF message.
- ***ISO 11992-2:*** ISO/TC 22/SC 31/WG 4 is improving this standard specifying a J1939-based profile for linking towing to towed commercial (heavy-duty) road vehicles. This document relates to braking and running gear functions. The new edition, to be released as soon as possible, will cover e-trailers, too.
- ***DIN 14700:*** The CANopen-based standard for fire-fighting units (FFUs) has been submitted to ISO/TC 22/SC 31 for international tandardization. It has been accepted as a NWIP (new work item proposal) and will be voted by national standardization bodies, soon.
- ***ISO 16844 series:*** These documents include a J1939-based tachograph interface and they are under revision. Especially, Part 7 needs some improvements.
- ***CiA 601-2:*** This specification (CAN FD node and system design – Part 2: Protocol controller interface) has been withdrawn.
- ***ISO 11992-3:2021:*** This international standard specifying parameters transmitted between towing and towed commercial road vehicles (not related to braking and running gear) will be systematically reviewed in 2026; therefore, CiA calls for comments.
- ***CiA 443:*** The CANopen profile for SIIS level-2 devices (CiA 443) has been revised (version 4.1.0). It specifies so-called subsea (Christmas) trees comprising a host controller as well as sensors, meters, batteries, and actuators (valves/drives). The main technical change is the introduction of electric actuators (object 6520_h). Additionally, editorial improvements have been made.
- ***CiA glossary:*** CiA has revised and updated its glossary of term definitions used in CiA technical documents. Especially, new terms related to CAN XL have been introduced. Terms related to CAN CC (classic), CAN FD, and CAN FD light were updated.

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Embedded and deeply embedded CAN networks

There are already many embedded and deeply embedded CAN networks installed. In order to enable interoperability between these networks, specification of dedicated profiles would be necessary. CiA is committed to support such profile specifications for greenhouse and livestock automation. They can be communication technology independent. CiA would also support the mapping to CANopen CC (classic) and CANopen FD. Mapping to other non-CAN network technologies should be specified by other standardization bodies.

In the CiA technology day “CAN-based networking in agriculture”, the speakers discussed this in some detail. The presentations have been recorded and can be watched on CiA’s Youtube channel. CiA plans to organize a workshop for its members and interested partners, to discuss missing specifications for agri-food systems, in general, and for dedicated greenhouse as well as livestock automation systems, in particular.

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PDU-embedded layer management for CAN FD

The CAN XL protocol features PDU-embedded (protocol data unit) layer management data: For example, the 8-bit SDT (service data unit type) field, the 8-bit VCID (virtual CAN network identifier), and the SEC (simple/extended content) bit. In order to provide as similar standardized functionality for the CAN FD protocols, CiA members have established the SIG CAN FD under the umbrella of the IG lower layers.

It is intended to specify a CAN FD based PDU (protocol data unit) embedding layer management data, including optional security measurements. Of course, this PDU exceeds the 64-bit data field length limitation of CAN FD data frames. In order to map the CAN FD extended PDU, a fragmentation is needed. Such a fragmentation protocol is also in the scope of the established SIG.

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Figure: Mixing and feeding robot (MFR) of the Vector feeding system (Source: Lely)

Since more than 20 years: Lely uses CAN/CANopen in its milking and feeding robots

CiA member Lely Industries, located in the Netherlands, uses CANopen in its milking and feeding systems. This includes also robots applying CANopen networks. Jos Seldenthuis, software architect in the Embedded Software Competence Center of Lely, answered the questions by CAN Newsletter editors.

Q: For which purposes you are using CAN/CANopen in Lely's robots?

A: We use the CAN to communicate with almost all sensors and actuators in our robots. We have done so for decades. We prefer CAN for several reasons:

- It's simple and robust, even in environments with a lot of electrical interference, like robots on a farm.
- CAN controllers are cheap and ubiquitous. Even simple microcontrollers typically have at least two CAN ports on chip these days.
- Software support is excellent, especially on Linux, which has native drivers for most CAN controllers.

The majority of our sensors and actuators use CANopen. Although we still have a few that use a legacy Lely-specific protocol. The first version of our flagship product, the Astronaut milking robot, predates the first version of the CANopen standard. And it took a while for CANopen to become widespread enough to be adopted by Lely. Fortunately, the transition was easy. CANopen defaults to 11-bit identifiers, whereas our legacy protocol uses 29-bit identifiers. That makes it possible to have both kinds of devices on the same CAN network (provided they use the same bit rate of course).

Nowadays, CANopen is the preferred, if not mandatory, protocol for new sensors and actuators. We prefer it because it is a standard, and quite a good one. Not just the device profiles, but also the network management functionalities, like CiA 305 layer setting services (LSS) and firmware upgrades (CiA 302-3). We maintain our products for a long time, over 20 years in some cases. During that time, we have to replace or update components regularly. And having standards that facilitate updating and configuring new devices really improves the reliability of the maintenance process.

Another important consideration is the off-the-shelf availability of CANopen peripherals. We sell about 10 000 robots a year with, on average, maybe about a dozen CANopen peripherals in each. Those volumes rarely make it cost effective to do custom development.

Finally, CANopen makes it easy to develop generic diagnostic and monitoring tools. We have over 200 Lely centers in over 50 countries servicing over 45 000 farms, ▷

often in remote areas. So, anything that helps our (over 2000) technicians diagnose or even fix a problem remotely is of great benefit.

Q: Which devices are connected by means of CAN/ CANopen in feeding and milking equipment?

A: Apart from milking and feeding, we also have robots for barn cleaning and manure handling. Like mentioned above, we use CAN for almost all sensors and actuators, and the majority of those use CANopen.

The two most common device profiles are CiA 401 (modular I/O devices) and CiA 402 (drives and motion control). In case of the I/O device profile, we mostly use digital inputs and outputs. The inputs are used for simple sensors. For example, a photocell to detect the presence of a cow in a robot. Similarly, we use the digital outputs to control simple actuators, like valves or relays (for example, to open and close gates). Most of our products have at least one CANopen I/O board. Some, like the Astronaut milking robot, can have up to four.

We also use a lot of CiA 401-profile pumps and motors in our products. In the case of our milking robot and supporting systems, we have several pumps for transporting milk and cleaning liquids, as well as vacuum pumps, which are used for milking the cows, amongst other things. The robot arm in the milking robot also has an X, Y, and Z motor drive, so it can attach to the udder and follow the movements of the cow. And the self-driving mixing and feeding robot uses CiA 401-profile motors for driving.

Next to this, we use a few other device profiles. Like, for example, the battery and charger profiles (CiA 418 and CiA 419) in our feeding robot. However, we can't always find an appropriate device profile for every device. We have multiple sensors for measuring the quality of the milk and the health of the cow. Those use cases are probably too specific to have an official CiA device profile, at least for now.

Q: What are your future plans for CAN/CANopen? Is Lely going to migrate to CAN FD or CAN XL?

A: We plan to keep using CAN and CANopen for the foreseeable future. It's still the best solution for many, if not most, of the sensors and actuators in our robots. That being said, it does have its limitations, particularly when it comes to bandwidth. For simple I/O or motion control, the maximum CAN bit rate of 1 Mbit/s is plenty. But some sensors produce a lot of data.

In our newest milking robot, we have a camera that we use to determine the position of the cow and, by extension, the udder relative to the robot. Those images are sent via CAN networks, which can really stress them to its limit. Other sensors would take it over the limit. Particularly when it comes to vision (cameras) or object detection (radar, lidar, etc.).

Whether CAN FD or CAN XL would be the solution mostly depends on the off-the-shelf availability of a sensor that meets the (quite constraining) requirements of an autonomous robot in a farm environment. Like I said before, due to our production volumes, we'll probably follow what the market decides to standardize. This could be CAN and CANopen, but it doesn't have to be.

One challenge for deploying CAN FD or CAN XL is that all devices on the CAN network need to support it. ▷

Milking robot

Figure 1: Astronaut A5 Next automatic milking robot (Source: Lely)

The Lely Astronaut A5 Next is the latest generation of the Lely's flagship product. First introduced in 1995, the Astronaut is the main component of the company's automatic milking system. It provides optimal comfort for cows by letting them the choice when to eat, drink, relax, or be milked. It has a user-friendly interface that makes automatic milking easy to understand for everybody. And it integrates seamlessly with Horizon, Lely's farm management system. Three decades of experience, with over 50 000 robots on thousands of farms, have made the Astronaut a robust and reliable solution, capable of realizing a significantly lower cost per kilogram of milk produced, adds Mr. Seldenthuis.

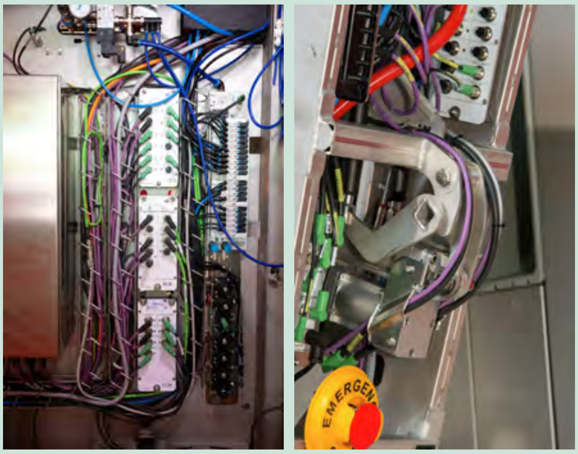

Figure 2: Inside the Astronaut A5 Next: in the cabinet (left) and in the robot arm (right). The purple CAN cables in the cabinet are used to control pump and valves, as well as other peripherals. In the robot arm, they control arm motors, milk quality sensors, etc. (Source: Lely)

The hybrid arm, the distinguishing feature of the Astronaut, combines fast, silent and accurate electrical-driven movements with the softness and the power of air for stress-free milking. The air protects the electrical system by balancing the heavy load of the arm and buffering cow kicks. The hybrid arm is silent, allowing cows to experience more rest during milking.

Feeding robot

The Vector automatic feeding system (see lead photo) is designed to provide every animal group access to fresh and precisely mixed ration based on their needs. It consists of two parts: the mixing and feeding robot and the feed kitchen, where the feed is stored, selected, and loaded. It's the unique combination of mixing the feed, feeding the cows based on their needs, and always pushing the feed along the feed fence that provides effective feeding and saves the farmer valuable time. Thanks to the pushing technology at two sides of the robot, cows always have feed within reach. The robot enables the farmer to adjust and enhance their feeding strategy, which can lead to improved milk yields and healthier cows.

And since we usually have multiple devices per network, we need to wait for all of them to provide support before we can make the switch.

Q: Why Lely has launched an open-source CANopen protocol stack?

A: Back in 2016, when I started development of our stack, I was mostly driven by dissatisfaction with the existing commercial stacks that we were using. Some of that was caused by performance and stability issues. But it was mostly because the architecture and APIs (application programming interfaces) of those stacks didn't fit well with how we wanted to write and maintain the CANopen NMT (network management) managers in our robots.

That made me think, perhaps a bit naively, "how hard can it be to write our own stack?" And while not particularly difficult, it was a lot more work than initially expected. However, the investment paid off and we're very happy with the result.

The stacks that we were using at the time were quite "opinionated" and would determine the structure of the CANopen NMT manager application. For example, they would require a dedicated I/O thread, which would for the application to be multithreaded. And that didn't mix well with software application frameworks like Qt or ROS/ROS2, which have their own dedicated event loops. Instead, we wanted a stack that didn't make any assumptions and would be flexible enough to be integrated into any type of application.

So, we decided to make our stack "passive". It would wait for the application to feed it incoming CAN data frames or trigger timers. And it would notify the application, via callbacks, when a CAN data frame needs to be sent, or when the next timer expires. At least, that's what the C API looks like. We did add a C++ API on top of that, that does make some "opinionated" choices. That's convenient for many use cases, but it's optional when it doesn't fit.

Additionally, the stacks we were using before relied on code generated from EDS/DCF (electronic data sheet/device configuration) files. That would result in function stubs that could then be filled in. And while that might be a good approach for a CANopen NMT server device that implements a particular device profile, it's not a good fit for a CANopen NMT manager device that controls many peripherals. We needed a modular architecture, that would allow us to write reusable device drivers for individual peripherals. We wanted the NMT manager application to be generic and be able to load drivers on demand, even allowing hot plugging if necessary.

We did look at existing open-source stacks. But they were either just as opinionated as the commercial stacks, or they lacked important features, such as LSS or firmware upgrades.

Once we were happy with the implementation and were introducing it into our robots, we quickly decided to make it available to others. Lely is happy to support the open-source robotics community and this was a nice contribution we could make. We uploaded the first version to GitLab in June of 2018 and quite quickly saw and heard of adoption outside Lely, both for commercial and open-source products. That really sped up after we set up a site with documentation and tutorials (at https://opensource.lely.com/canopen) in October 2019.

But the most important moment was when we were contacted by the company N7 Space in 2019. They were bidding on a contract from the European Space Agency (ESA) to develop a CANopen protocol stack suitable for use in spacecraft. ESA itself suggested our stack as a possible basis, and N7 Space won the bid on that proposal. Over the next two years, we supported them with making the necessary changes. And they developed a test suite with 100-percent code coverage of the parts of the stack that are in scope for ESA.

The end result is that the stack is now very robust and stable. It's been a long time since we had an issue in the field caused by a bug in the stack. And while we've invested quite a lot of time in both the development and support of our stack (both for users inside and outside Lely), we're really happy with the result. And we're proud that we've been able to contribute to so many other projects. Apart from dairy robots, our stack is used in boats, submarines, solar cars, and spacecraft, as well as the CANopen module of the Robot Operating System (ROS). And those are just the products I know about.

> We're quite happy in general with the CANopen specifications.
>
> *Jos Seldenthuis (Lely)*

Q: Additionally, I am interested what Lely is missing regarding CAN/CANopen communication.

A: As mentioned above, CiA doesn't always have a device profile ready for some of our more specific sensors and actuators. But even when we have to resort to custom development, the protocols specified in the CiA 3xx document series really simplify the requirements specification process. And we can often learn from the best practices on other device profiles. ▷

Lely Industries

Figure: Lely headquarters in Maassluis, the Netherlands (Source: Lely)

Lely, founded in 1948, is dedicated to ensuring a sustainable, profitable, and enjoyable future for the agricultural sector. With the well-being of cows at its center, Lely develops robots and data systems that enhance animal welfare, farm efficiency, and sustainable production on dairy farms. The company offers a range of innovative solutions for milking, feeding, manure, and farm management.

For decades, Lely has been a global leader in the automation of dairy farming, serving multiple generations of dairy farmers, says Jos Seldenthuis. The company also delivers tailored support and expert advice through its global network of dedicated Lely Center branches. With its headquarters in Maassluis, Lely operates in more than 50 countries, employing around 2500 people globally. More information is available on the company's website.

Apart from that, we have only a few minor occasional issues with CANopen. Sometimes the specified functions are a little underspecified: Like which timeouts or retries to use during the boot-up and configuration processes. And sometimes a feature that sounds really promising is hard to use in practice. For example, we would like to be able to have different peripherals send their PDOs at different rates on the same CAN network. And while that would be possible with SYNC counters, it requires all devices to be configured to use the counter. And many off-the-shelf peripherals don't support that, so we can't use this feature in practice.

But these are minor gripes. And we're quite happy in general with the CANopen specifications. ◄

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TIM: tractor/implement management

The CAN-based Isobus specifications include the TIM (tractor/implement management) system, enabling an implement to control the tractor.

Figure 1: In June 2025, AEF organized a TIM plugest (Source: AEF)

The nonprofit AEF (Agricultural Industry Electronics Foundation) association predeveloped the TIM specification. Originally, it was released in 2019. Recently, it was updated and published as AEF 023 Isobus Automation Principles guideline. The following new contents were introduced:

- Incrementing the TIM generation number to TIM generation 2.
- Re-designing the message structure to introduce the ability to control one TIM function in different ways, such as front hitch position (available) or front hitch pressure (future scope).
- Providing the ability to obtain additional information about the TIM server's specifications.
- Supporting the TIM function for front and for rear top linkage (TIM Generation 2 only).

Currently, the AEF guideline is only available for members. It is intended to submit the guideline to ISO/TC 23/SC 19.

The implement controls the tractor

Traditionally, the tractor controls the implement. Applying the TIM functionality, the implement can command the connected tractor. The TIM system is an Isobus-based solution for a barrier-free and cross-vendor agricultural system. A typical example is a baler implement that adjusts the tractor's speed according to the work load and the need to stop and to eject the round bale. Another application is a seed driller implement that controls the tractor movement. The TIM system is based on a bidirectional communication, enabling control of certain tractor functions – for example the forward speed or the remote valves. By requesting certain tractor functions the implement can optimize its operation themselves. The tractor control requests are confirmed on the TIM application level by status data of the tractor.

The TIM project is intended to be an "open" solution, enabling multi-vendor solutions. In order to achieve legal ▷

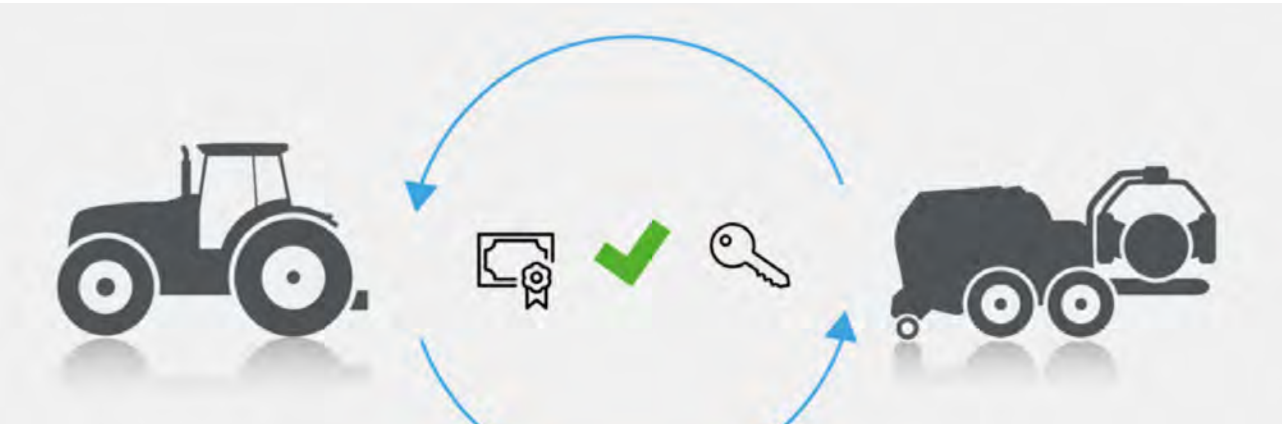

Figure 2: Standardized certified communication (Source: AEF)

security and safety requirements, the integrated tractor and the implement must be both AEF-certified on compatibility and interoperability. AEF develops related test plans. The tests are performed by dedicated test houses. In order to obtain an AEF certification, Isobus devices have to pass a conformance test and provide evidence of the compatibility according to the Isobus standard and the AEF guidelines. Moreover, the product must meet the safety standards. As soon as the conformance test has been successfully completed, the AEF also supplies a „digital certificate“, which will be integrated in the tested TIM machine.

With the first connection between the tractor and implement combination, the machines check the validity of their digital certificates. If in agreement, the tractor and implement exchange a shared key. This key will be checked when starting the combination of tractor and implement. Only, if the result is positive, the farmer will be able to use the TIM functionality, meaning the implement controls the tractor without intervention from the driver.

TIM plugfest

The June 2025 AEF plugfest brought together around 100 participants from member companies to test the performance of multi-branded machine combinations. Deula (Germany) hosted the event. According to AEF, feedback from participants was overwhelmingly positive. Many appreciated the opportunity for practical testing and highlighted the benefits of such collaborative events supporting multi-brand compatibility. There is a strong desire for similar events in the future to continue advancing the AEF Isobus TIM functionality.

Participants brought a variety of equipment, including tractors, balers, spreaders, mowers, harvesters, and guidance systems, implementing TIM functionality. This hands-on approach provided valuable insights into the interoperability and efficiency of TIM in actual field operations. ◀

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(Source: Adobe Stock)

CANopen in modular and scalable vertical farms

Growy (the Netherlands) designs, builds, and operates automated vertical farms with the aim to make tasty, healthy, and affordable food accessible to all. The farms are built to be highly efficient, data-driven, and scalable. Central to this is a reliable, modular communication infrastructure, based on CAN and CANopen.

CAN/CANopen plays a key role in the architecture of the company's farm automation systems. Growy relies on CAN/CANopen networks to connect, control, and monitor machines across different farm modules. This has significantly shortened the development time thanks to the use of standardized, well-documented protocols. It also ensures that new modules can be seamlessly integrated into available systems, even when individual farm processes are expanded or scaled.

Use case: Automated seeding line

One of the best examples of CAN/CANopen in action is Growy's automated seeding line, means the author. This system automatically fills gutters with substrate, sprays them with water, deposits seeds, and tags each gutter with an RFID chip. These gutters are then linked to the central control software, enabling full traceability of every plant from seed to harvest.

All sub-components of the seeding line are connected to a single CAN network. The system is orchestrated by a main controller, an Industrial Revolution Pi running on Linux, which interfaces with both in-house developed and third-party devices. The conveyor controller, the gutter prep unit, and the seeding heads are designed and built in-house using hardware based on STM32 microcontrollers from STMicroelectronics. These devices implement the CiA 402 motion control profile, supporting homing, profile velocity, and profile position modes. The company continues to expand this implementation by adding new profiles whenever specific use cases arise. In addition to motion control, CANopen is used for sensor interfacing as well. This is done through CiA 401 (CANopen profile for I/O devices), allowing sensor data to be transmitted transparently over the CAN network to the main controller. The RFID (radio frequency identification) reader in the system is supplied by IFM (Germany) and uses a proprietary CANopen implementation, based on the manufacturer-specific area of CiA 301. ▷

Figure 1: One of the best examples of CAN/CANopen in action is Growy's automated seeding line (Source: Growy)

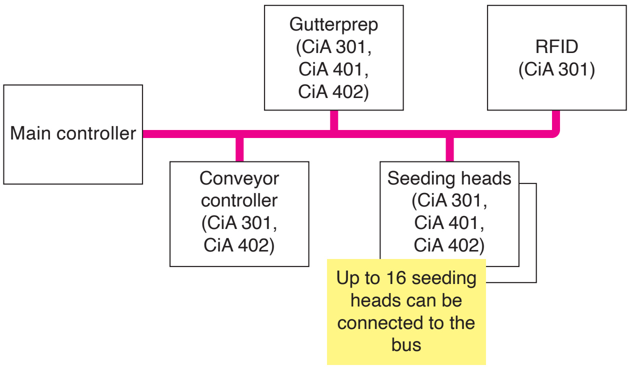

Figure 2: Seeding line architecture (Source: Growy)

The network itself is approximately 10 m long. While CANopen supports up to 127 nodes in theory, the seeding line currently uses 20 connectors. Four of these are assigned to the main controller, conveyor, gutter prep unit, and RFID reader. The remaining connectors are used to support different interchangeable seeding heads, giving the developer enough flexibility to configure various combinations as needed. The interconnected CANopen devices exchange a mix of motion control commands, sensor data, and identification information from the RFID system. This real-time communication allows for precise coordination and monitoring of each process step in the seeding line.

While CAN networks handle the real-time machine control, the farm management system communicates with the seeding lines over a local Ethernet network. Each seeding line is connected to the farm's internal network, allowing the central controller to send task instructions and monitor performance. This setup supports modular scaling: currently, Growy is operating two seeding lines and plans to scale up to four as demand for fresh microgreens and salads increases.

CiA specifications in use

The CiA specifications currently in use at Growy include CiA 301 for the application layer, CiA 401 for general-purpose I/Os, and CiA 402 for motion control. These standards form the foundation of the company's CANopen software stack and enable the developers to build and maintain highly modular systems.

In the new development project for an automated gantry system, which will handle watering and tray transport, Growy extends the use of CiA specifications. This system, still in early development, will make use of CiA 301, CiA 401, CiA 402, CiA 445, and CiA 459 specifications. While CiA 445, the device profile for RFID readers and writers, is not used in the seeding line, it will play a role in the gantry system. The CiA 459 specifies the CANopen interface for on-board weighing devices and is also intended to be implemented in the new project.

Outlook: standardization and shared code

Migrating all of the Growy's machines to CANopen is part of the company's long-term strategy. CAN has proven to be a stable, reliable communication platform, even in the harsh and dynamic environment of a vertical farm. Additionally, having already developed a CANopen software stack with most of the necessary features, Growy is now able to design and deploy new machines more efficiently by reusing tested components, adds the author.

Looking ahead, Growy believes that there's a strong need for greater access to shared development resources. Publicly available reference implementations of key CiA device profiles, such as CiA 402 and CiA 445, would significantly reduce development time and support wider adoption across the agricultural technology sector. For example, a CiA-hosted code repository, where CiA-members could contribute and share reusable implementations, would be a valuable step forward, proposes Growy.

Conclusion

In a world where farming must become more efficient, transparent, and sustainable, CAN/CANopen provides the technical foundation for scalable, smart agricultural systems. For Growy, it enables seamless integration, rapid development, and reliable performance – from the seed to the shelf. ◀

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MCU with AI accelerator and CAN FD on chip

(Source: Renesas)

The microcontroller suppliers go AI (artificial intelligence). Renesas has introduced single- and dual-core MCUs, combining Arm Cortex-M85 and M33 cores with an Arm Ethos-U55 NPU (neural processing unit). These ICs (integrated circuits) deliver an AI performance up to 256 GOPs (giga operations per second). The MCUs are already available as well as an RA8P1 evaluation kit.

Beginning of July, the Japanese semiconductor supplier has launched the RA8P1 microcontroller (MCU), targeting AI and ML (machine learning) applications. These MCUs are designed for real-time control applications. They combine a 1-GHz Cortex-M85 core and a 250-MHz Cortex-M33 CPU core with the Arm Ethos-U55 NPU. Paul Williamson, senior vice president and general manager, IoT Line of Business at Arm, said: “By building on the advanced AI capabilities of the Arm compute platform, Renesas’ RA8P1 MCUs meet the demands of next generation voice and vision applications, helping to scale intelligent, context-aware AI experiences.”

The Taiwanese TSMC chip manufactures the MCUs, using the 22-nm ultra-low leakage (ULL) process. The microcontrollers are optimized for edge and endpoint AI applications, using the Ethos NPU to offload the CPU for compute intensive operations in convolutional and recurrent neural networks (CNNs and RNNs).

The MCUs feature several peripherals, including CAN FD protocol engines. Renesas was an active participant in CiA and ISO technical groups during the CAN FD protocol development. Additionally, there are A/D (analog/digital) and D/A (digital/analog) converters, a temperature sensor as well as two camera interfaces on chip. The implemented graphical LCD controller supports resolutions up to 1280 pixels by 800 pixels. The MCU comes with a RSIP-E50D cryptographic engine, Arm’s Trustzone, immutable storage, and a secure bootloader. ▷

Arm Ethos-U55

Figure: The E1C microcontroller features two CAN FD channels (Source: Alif Semiconductors)

Already in 2020, Arm had launched the Ethos-U55 neural processing unit (NPU). It has been designed to be paired with Cortex-M55 cores. The NPU is configurable and is able to accelerate ML (machine learning) inference in area-constrained embedded and IoT (Internet of Things) devices. Its compression techniques save power and reduce ML model sizes to enable execution of neural networks that previously only ran on larger computing systems. In 2021, Alif Semiconductor has demonstrated an MCU featuring Ethos-U55 and Cortex-M55 cores. Three years later, the Californian chip supplier, has released the E1C microcontroller implementing these Arm cores and two CAN FD on-chip protocol controllers. This product provides also A/D as well as D/A converters and a low-energy Bluetooth connectivity. *hz*

Brief news: Microcontroller

- ***NXP:*** The Dutch chipmaker offers the i.MX 93 application processor featuring an Arm Cortex-A55 core and an Arm Ethos-U65 neural processing unit (NPU), dedicated for Linux-based machine learning (ML) applications. The MCU provides two CAN FD ports. Part of the Edgeverse portfolio, the product family is offered in commercial, industrial, extended industrial, and automotive level variants.
- ***Nuvoton:*** The M55M1 series of MCUs combines an Arm Cortex-A55 core and an Arm Ethos-U55 neural processing unit (NPU). The product comes with two CAN FD ports and features a 1,5-MiB SRAM as well as a 2-MiB flash memory. The company also offers development boards with these MCUs.
- ***Renesas Electronics:*** The 64-bit RZ/G3E microprocessor (MPU) with CAN FD connectivity is dedicated for high-performance human machine interface (HMI) applications. It combines a quad-core Arm Cortex-A55, a Cortex-M33 core, and the Ethos-U55 NPU for AI tasks. This architecture runs AI applications such as image classification, object recognition, voice recognition, and anomaly detection while minimizing CPU load. RZ/G3E delivers smooth Full HD (1920 pixels x 1080 pixels) video on two independent displays, with output interfaces including LVDS (dual-link), MIPI-DSI, and parallel RGB. A MIPI-CSI camera interface is also available for video input and sensing applications. *hz and of*

Along with the RA8P1 MCUs, Renesas has introduced the RUHMI (Renesas Unified Heterogenous Model Integration) framework. It offers AI deployment, applying neural network models in a framework-agnostic manner. The framework enables model optimization, quantization, graph compilation and conversion, and generates source code. RUHMI provides native support for machine-learning AI frameworks such as Tensorflow Lite, Pytorch & ONNX. It also provides tools, APIs, a code-generator, and a runtime entity needed to deploy a pre-trained neural network, including ready-to-use application examples and models optimized for RA8P1. The framework is integrated with Renesas's own E2 Studio IDE (integrated development environment). *hz*

(Source: Rohm)

AI processor with on-chip CAN FD

Rohm (Japan) has launched an MCU family, featuring the Solist-AI core, which can learn without cloud or network connections. The product is based on a 48-MHz Cortex M0+ processor and comes with an on-chip CAN FD protocol controller. It is intended for front-end industrial and non-automotive applications. Therefore, the chip provides a 3-phase motor PWM (pulse-width modulation) control circuitry and dual A/D (analog/digital) converters. The power consumption is approximately 40 mW.

The MCU family consists of 16 products in different memory sizes, package types, and pin counts. Mass production of eight models in TQFP packages began sequentially in February 2025. Among these, two models with 256 KiB of code-flash memory and taping packaging are available for purchase, along with an evaluation board.

The Japanese chipmaker has released the Solist-AI simulation tool that allows users to evaluate the effectiveness of learning and inference. The data generated by this tool can also serve as training data for the actual AI MCU. To facilitate adoption, the company has built an ecosystem in collaboration with partner companies, offering support for model development and integration.

AI (artificial intelligence) processing models are generally classified into three types: cloud-based, edge, and endpoint AI. Cloud-based AI performs both training and inference in the cloud, while edge AI utilizes a combination of cloud and on-site systems. Typical endpoint AI conducts training in the cloud and performs inference on local devices, so network connection is still required. Furthermore, these models typically perform inference via software, necessitating the use of GPUs or high-performance CPUs. In contrast, the AI MCUs by Rohm, although categorized as endpoint AI, can independently carry out both learning and inference through on-device learning. Equipped with a proprietary AI accelerator, these chips are about 1000 times faster than conventional software-based MCUs. *hz*

With 20 CAN FD and four CAN XL ports

Aurix TC4Dx MCU from Infineon is the first member of the Aurix TC4x family. It features 20 CAN FD and four CAN XL interfaces, four 10/100-Mbit Ethernet and two 5-Gbit Ethernet modules. The 32-bit MCUs supply 6/6 lockstep cores at 500 MHz, up to 20 MiB of non-volatile memory, and 10 MiB of SRAM. Based on the 28-nm technology, the microcontroller offers suitable connectivity for zone controllers, integration platforms, and safety applications. For applications like sensor fusion and integration platforms (e.g., vehicle motion controllers) TC4Dx offers AI capability, smart accelerators like the PPU (parallel processing unit) with private scalar core, and a 256-bit wide vector unit. The implemented security module CSRM (cybersecurity real-time module) provides a tenfold performance versus TC3x HSM. For connectivity applications like zone controllers and gateways TC4Dx offers features for improved data routing and integration of functions from end-point ECUs. The optimized architecture with accelerators enables high throughput without main cores intervention through the data routing engine (DRE) and Ethernet bridges for efficient data routing. TC4Dx also features a decentralized security concept with crypto satellites (CSS) for offloading the main security module. Used software is backward compatible with the Aurix TC3x MCUs. *of*

Microcontroller for about ten cents

For price-sensitive applications, WCH (China) has introduced the CH32V203 microcontroller. It comes with an on-chip CAN CC (classic) protocol controller. The MCU is based on a proprietary 32-bit Risc-V core (QingKe). It integrates a dual USB interface, four groups of USART, a dual I²C port, and, a 12-bit A/D (analog/digital) converter as well as a 10-channel touch-key port. The 144-MHz microcontroller features 64 KiB of SRAM and 224 KiB of program memory. The bootloader has a capacity of 28 KiB.

The CAN protocol controller has three frame transmit mailboxes and two 3-level deep receiving FIFOs for data/remote frames. There are 14 configurable CAN frame filters. The 512-byte SRAM needs to be shared with them USB module for frame transmission and reception. When used at the same time, USB can only use the lower 384 bytes. *hz*

System on module with three CAN ports

Netburner (U.S.A.) has developed the SOMRT1061 module featuring the 528-MHz NXP i.MX RT1061 microcontroller based on a Cortex M7 core. The module measuring 25,4 mm x 25,4 mm comes with two CAN CC (classic) and one CAN FD (flexible data rate) interfaces. It provides two Ethernet ports, which makes the module suitable for gateway applications. The features also include other interfaces such as seven UARTs (universal asynchronous receiver/transmitter), three SPIs (serial peripheral interfaces), three I²C (inter-integrated circuits), and 67 general-purpose I/O (input/output) lines. Additionally, the module is equipped with two USB (universal serial bus) ports. *hz*

Entry-level MCUs with CAN FD

The recent members of the STM32C0 MCU family from STMicroelectronics provide extended storage capabilities than the predecessor STM32C031 group. Additional features include extra interfaces and more I/O channels. The STM32C092 MCUs extend the Flash density up to 256 KiB in packages up to 64 pins, adding a CAN FD interface. The family contains such interfaces as crystal-less USB Full Speed Device and USARTs, as well as timers and an analog/digital converter (ADC). Complemented with on-chip clocks and just one power-supply input saves additional external components. These savings enable a smaller, simpler PCB (printed circuit board) design. As members of the STM32 family, designing with STM32C0 MCUs also eases compliance with product-level approvals such as IEC 61508 for functional safety. The chips contain the Arm Cortex-M0+ core that also powers STM32G0 MCUs designed for higher performance and advanced features. The two MCU series share many aspects including package styles, pinout, and peripheral IP, enabling designs to migrate easily between the both. *of*

Low-power MCUs supporting segment LCD

Figure: RA4L1 MCUs with segment LCD and security support (Source: Renesas)

Renesas (Japan) offers the 14-members RA4L1 MCU group providing CAN FD connectivity. The group features ultra-low power consumption, advanced security features, and segment LCD support. Based on an 80-MHz Arm Cortex M33 processor with Trustzone support, the units enable designers to address various applications, including water meters, smart locks, IoT sensors, and more. The MCUs are available in very small packages including a 3,64 mm x 4,28 mm wafer-level chip-scale package (WLCSP) for use in e.g., portable printers, digital cameras, and smart labels. The chips are supported by Renesas' Flexible Software Package (FSP) including multiple RTOS (real-time operating system), BSP (board support package), peripheral drivers, middleware, connectivity, networking, and Trustzone support. Additionally, FSP includes the reference software to build complex AI (artificial intelligence), motor control, and cloud solutions. The microcontroller units provide a 256-KiB to 512-KiB dual-bank flash, a 64-KiB SRAM, and an 8-KiB data flash. They also offer support of segment LCD, capacitive touch, USB-FS, CAN FD, low-power UART, SCI, SPI, QSPI, I²C, I³C, and SSI.

Additionally, Renesas informs that it has successfully obtained the PSA Certified Level 1 certification with the European Cyber Resilience Act (CRA) compliance extension for the RA4L1, RA8E1, and RA8E2 MCU groups. RA8E1 and RA8E2 groups, designed for industrial automation, smart homes, and medical devices, provide two CAN FD interfaces, respectively. *of*

Diagnostic solution for lithium-ion batteries in rail applications


(Source: Adobe Stock)

AMP Rail, a developer of lithium-ion power systems for locomotives and heavy industrial equipment partnered with Odosolutions (ODOS) to provide deep operational visibility into battery performance, particularly under extreme and variable conditions.

The rail industry is undergoing a significant transition from traditional lead-acid batteries to advanced lithium-ion alternatives. This shift is driven by the urgent need for cleaner, more efficient, and reliable energy sources in locomotive power systems. For decades, lead-acid batteries have been the standard across the sector, used to start diesel engines and power auxiliary systems, but they are increasingly being outpaced by lithium-ion technologies, which offer higher energy density, longer cycle life, and reduced maintenance.

AMP Rail, a leader in lithium-ion power systems for locomotives and heavy industrial equipment with a specific focus on starter battery solutions, is at the forefront of this transition. Rather than simply replacing one technology with another, AMP Rail is helping guide its partners through the complexities of adopting lithium-ion batteries in real-world rail environments.

To succeed in this role, AMP Rail required a solution that could provide deep operational visibility into battery performance, particularly under the kinds of extreme and variable conditions that rail fleets routinely face. Real-time, accurate data would be essential for validating safety, managing performance, and overcoming the industry's long-standing hesitation around lithium-ion adoption. Recognising the central role of data in this transition, AMP Rail turned to ODOS for their expertise in embedded vehicle data systems and cloud-based analytics.

Key challenges

The shift to lithium-ion battery systems brought with it a range of technical and operational challenges. Safety remained a top concern, with persistent fears around overheating, thermal runaway, and potential fire risks continuing to affect industry confidence. In parallel, batteries needed to deliver reliable performance across a wide range of environments – from freezing Arctic conditions to desert heat exceeding +50 °C.

In addition to safety and environmental performance, AMP Rail faced the challenge of integrating these new technologies within a landscape built around lead-acid systems. Maintenance teams were trained and equipped for legacy platforms and lacked the tools and data required for predictive diagnostics and proactive decision-making. This contributed to inefficient maintenance cycles, unnecessary battery replacements, and increased operational costs driven by reactive fault management and avoidable downtime.

AMP Rail's role wasn't just to engineer high-performance battery systems; it was also to help its partners adapt. That required not only technology but also transparency. To build trust in lithium-ion as a safe and scalable solution, AMP Rail needed the ability to monitor performance, detect early signs of failure, and validate resilience across operating environments. That's why capturing and interpreting data became so critical – and why they partnered with ODOS.

Solution approach

ODOS deployed its advanced monitoring and analytics platform to give AMP Rail real-time visibility into the performance of their lithium-ion battery systems. Smart sensors and robust data loggers (e.g., the Megalog with two or four CAN-FD interfaces) were embedded directly into each battery unit, capturing critical metrics such as voltage, charge cycles, temperature, current draw, and long-term degradation patterns. ▷

These insights allowed operators and engineers to:

- Detect early warning signs of battery failure, well before safety thresholds were crossed;
- Validate safe, stable performance under extreme temperature and environmental stress;
- Automate diagnostics and reduce the need for manual inspections;
- Build a rich data record to support safety certification and regulatory compliance.

The ability to monitor in real time was especially vital for mitigating risks like thermal runaway where internal battery conditions can quickly escalate into dangerous overheating. Drawing parallels with the automotive sector, where high-end British sports car manufacturers monitor vehicle parameters in real time before approving testing, ODOS brought similar standards of scrutiny and safety assurance to the rail industry.

Implementation

The initiative began with a structured pilot, co-developed by ODOS and AMP Rail's technical teams. A test fleet was fitted with sensors and data loggers, with data collected via CAN FD and streamed to ODOS's secure, cloud-based platform for analysis and monitoring.

Engineers accessed a centralised dashboard that offered live views, performance alerts, and historical trend analysis aligned to AMP Rail's specific operational protocols. Custom configuration was a major success factor – the platform's notifications and reporting tools were tailored to existing maintenance workflows, minimising disruption and requiring minimal training for engineers, drivers, and depot teams.

Following the successful pilot, including stress-testing in demanding environmental conditions, the solution was scaled up across additional fleets and is now fully integrated into AMP Rail's predictive maintenance and safety processes.

Results and impact

The following quantitative outcomes have been achieved:

- Very high reduction in diagnostic time for battery-related faults,
- Significant fuel savings due to reduced engine idling and smarter charge management,
- Battery life extended through predictive maintenance,
- Zero critical failures in extreme temperatures from -40 °C to +50 °C during the trial period,
- Accelerated lithium-ion adoption across multiple industry partners by an estimated period of five to ten years.

The qualitative benefits comprised:

- A data-rich environment for decision-making, reducing reliance on assumption-based diagnostics;
- A shift in industry perception from viewing lithium-ion as risky to seeing it as proven and future-ready;
- A competitive edge positioning of AMP Rail as a leader in green rail innovation;
- Increased confidence and satisfaction amongst engineers thanks to faster fault resolution and fewer system breakdowns.

David Eldridge from AMP Rail concluded: "The more data we have, the more confident the industry becomes in making the transition to lithium-ion. ODOS has been instrumental in giving us and our customers confidence. The system has removed the guesswork and we're already seeing the impact in reduced downtime and higher operational reliability." ◀

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Cloud data logging solution

Figure 1: MG4 data logger of Megalog series (Source: Odosolutions)

The Megalog data logger series from Odosolutions is dedicated for applications in industrial and heavy duty sectors. Variants with two or four CAN-FD interfaces are available. The devices implement the 1,6-GHz ARM Cortex A53 processor. With IP67-rated durability, they ensure uninterrupted data capture in challenging conditions from scorching deserts to deep underground mines, informs the manufacturer. Megalog is equipped with edge processing, 5G, and Wifi 6 connectivity, enabling over-the-air monitoring, real-time diagnostics, FOTA (firmware over-the-air updates), and cloud integration. High-voltage isolation, a built-in UPS (uninterruptable power supply) for continuous power management, and flexible storage options are offered. Logging to a local SSD (solid state drive) or to the secure ODOS cloud enables longterm data logging and analysis. Integrated with ODOS' GDPR-compliant cloud platform, Megalog delivers real-time data streaming, AI/ML-driven analytics (artificial intelligence/machine learning), and actionable insights.

Figure 2: ODOS CloudSoft tool dashboard (Source: Odosolutions)

The ODOS CloudSoft tool together with Megalog data loggers form an integrated system for monitoring and analyzing CAN (FD) data. The solution is secure, stable and scalable to meet the needs of any fleet, says the company. *up*

CANopen in autonomous robotic applications

Figure 1: CURTmini is a research platform for mobile navigation in agriculture and intralogistics (Source: Fraunhofer IPA)

CANopen and CANopen-based CiA 402 profile for drives and motion control are used in many robot developments at Fraunhofer IPA (Fraunhofer Institute for Manufacturing Engineering and Automation). Examples include mobile, autonomously navigating robots for outdoor applications in agriculture, horse farm management, and at airports.

The "Navigation of mobile robots" research group at Fraunhofer IPA, headed by Kevin Bregler, has spent the last few years building up the CURT ecosystem, a system consisting of mobile robots and a universal autonomous navigation software. Physical robot models include CURTmini (see Figure 1), CURTtrac (see Figure 2), and CURTdiff. CURTmini and CURTdiff are research platforms for mobile navigation in agriculture and intralogistics and are intended for the use in research, such as quickly acquiring data in test runs for developing new navigation modules, for onsite testing, and finally as a development platform for the transfer to industrial solutions on bigger machines and systems.

Figure 2: CURTtrac at a riding stable (Source: Fraunhofer IPA)

CURTtrac, on the other hand, was developed as a new robot product category in the field of agriculture with the intend to reach commercialization. Autonomous navigation can be used on all three robots but can also be retrofitted to other machines available on the market, such as agricultural systems for asparagus cultivation or permanent crops, as well as machines in highly specialized applications at airports, for refueling or luggage transport. Collaborations between the research group working on CURT technologies are mainly characterized by small and medium-sized enterprises (SMEs) to meet their sometimes very specific requirements in the field of mobile autonomous robotics. ▷

Navigation system

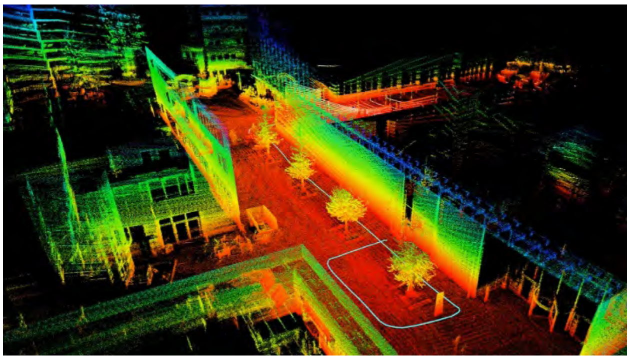

Figure 3: CURT robots use and postprocess Lidar-data to detect their environment and generate a map for navigation (Source: Fraunhofer IPA)

Autonomous robot for riding centers

A team at Fraunhofer IPA (Germany), led by Kevin Bregler, has developed an autonomous track-based robot using CAN and CANopen for internal communication. The robot can level the riding arena floor and should master additional tasks in the future. In March 2025, it has been shown at Equitana trade show in Essen (Germany).

Thanks to its long-year experience and the developed software navigation stack, the team was able to begin prototype endurance tests of the autonomous robot after less than a year of development. ARA (autonomous riding center assistant) is currently leveling the floor of an indoor riding arena at the large riding center "Leuchtfeuerhof" in the Palatinate region in Germany. Riding center owners, the Orth family, asked Kevin Bregler end of 2023 about a solution for this application, as no suitable solution was to find in industry or research. ARA was able to enter permanent test operation in January 2025.

Figure: ARA is leveling an indoor riding arena at the riding center "Leuchtfeuerhof" (Source: Fraunhofer IPA)

High interest from horse industry

The need for more automation at riding centers is high and so is the interest in the new robot. Leveling the floors in riding arenas is essential to protect horses from injury. Until now, this work has been carried out by riding center staff, using traditional tractors with track levelers. The disadvantages: The weight of the tractors compacts the ground, causing it to shift when cornering, operating and labor costs are high, the mostly diesel-powered vehicles leave emissions in the arenas, and operating large vehicles pose risks for humans and animals.

ARA can perform the work autonomously at night when there is no riding activity. It is significantly lighter and therefore doesn't compact the soil. Since it's electrically powered, there are no more emissions. Orth family is highly satisfied with the current status: "With this robot, we are better positioned in terms of quality and cost than before. The soil surface is ideally loosened, the robot drives well to the fence and can also remove the piles in the hoof track there, and it distributes the soil material into the dimples." In addition, it is much quieter on the farm, because many tractor trips are eliminated. This makes humans and animals happy.

Further developments

More than a dozen riding stables, where ARA is also being tested, provide feedback to the next development steps. Simple (one-button) usability is crucial to ARA's success. Riding center staff has to unpack the robot, switch it on, and send it on a short mapping run through the indoor riding arena. Thus, the staff can setup ARA themselves, which should take a maximum of 15 minutes. After the mapping run, the robot can navigate indoor and outdoor riding arenas independently due to its sensors and autonomous navigation.

To develop further autonomous application scenarios, the research team intends to work with riding stables, research groups, and machine attachment manufacturers for riding industry across Europe. Intended application scenarios include tasks such as sweeping, mucking out, and transporting. Each of the task will place specific demands on robot's hardware and software. Intensive collaboration between the horse industry, users, and researchers is intended to bring robotics to horse farms and contribute to their profitability. The robot is expected to cost not more than 40000 € upon a potential market launch.

The navigation system is particularly robust and can function without a global navigation satellite system (GNSS) indoors and outdoors in any terrain up to a speed of 15 km/h. To achieve this, the navigation system uses sensors that can be carried by the robot, such as Lidar, cameras, inertial sensors, and absolute encoders in the motors. Figure 3 shows how CURT robots use and postprocess Lidar-data to detect their environment and generate a map that they can use to navigate to various applications.

ROS integration

Depending on the application, semantic information is obtained via RGB (red-green-blue) or NIR (near-infrared) cameras. These developments are based on the widely used framework Robot Operating System (ROS). ROS offers excellent opportunities for rapid prototyping, as it is backed by a large open-source community, which includes Fraunhofer IPA. The resulting further developments can also be used commercially. Another interesting feature is the integration of the CAN communication system with the CANopen higher-layer protocol, which is used in various versions in CURT navigation for both motor control and feedback.

Usage of CAN and CANopen

The connection to the CAN network is established via SocketCAN. The manufacturer of the CAN interface (Peak-System Technik) supplies the appropriate drivers. The CANopen library used is Kacanopen from the ▷

Karlsruhe Institute of Technology (KIT). CURTmini and CURTdiff use motor controllers that implement the CiA 402 device profile for drives and motion control. For the second generation of CURTtrac, one of the motor controllers from Zapi was selected from a limited range available on the market. Although these communicate via CANopen, none of the profiles standardized by CiA are supported. Instead, these controllers essentially use proprietary CANopen objects. However, with the help of the documentation and the electronic data sheet (EDS file), it was still possible to implement all the required functions. In both robots, CANopen enables precise control and monitoring of the motors and offers comprehensive functions such as network management (NMT), service data objects (SDO), process data objects (PDO), synchronization objects (SYNC), emergency objects (EMCY), and heartbeats. These services ensure reliable and secure communication between the various components of the robot.

Advantages of the CURT ecosystem

The implementation of the software architecture in C++ is divided into several layers to maximize flexibility and expandability. The CANopen NMT manager is automatically configured based on the EDS files of the connected NMT server devices. The battery management system (BMS) used in CURT also communicates via the CAN network. Although the BMS itself does not implement any CANopen profiles, it can still be operated on the same CAN network. The messages containing information on the present discharge current, remaining capacity, and diagnostics are specified by the manufacturer using CAN DBC (data base CAN) and can therefore be used with little effort in the navigation software, for example to interrupt the work process in good time and drive to a charging station.

Another advantage of the CURT ecosystem is its seamless integration with the ros_control framework, which allows the controller interface to be abstracted from the hardware implementation. This facilitates the development and adaptation of control algorithms to the specific requirements of different application scenarios.

CAN also plays a crucial role in the integration of software into other systems. In research projects where autonomous navigation software is to be implemented on different vehicles, CAN provides a standardized interface that enables the exchange of information between the navigation system and the PLC (programmable logic controller) as well as other existing basic vehicle technology. The standardized CiA profiles are often used for this purpose.

Autonomous navigation

Fraunhofer IPA is continuously developing the CURT ecosystem and the software stack for autonomous navigation. This enables the research group to offer broad support in the planning, design, software architecture, and development of robots or autonomous systems with its in-depth know-how and expertise. In addition, Fraunhofer IPA heads the European branch of the ROS Industrial consortium, which promotes the introduction and use of the ROS framework in industrial applications. ◀

Radar-based altimeter with CAN FD connectivity

(Source: Ainstein)

Ainstein (U.S.A.) has developed the US-D1 Pro altimeter, engineered for up to 120-m altitude measurements to be used in drone and unmanned aerial system (UAS) applications. "The US-D1 Pro was purpose-built to fill a gap in the market for high-performance, mid-range radar altimeters that offer both airworthiness compatibility and affordability," said Maggie Williams from Ainstein. The radar sensor operates from 0,5 m to 120 m and maintains a ±0,1-m accuracy at low altitudes for vertical take-off and landing (VTOL). It comes in an IP69K-rated housing and is specified for a temperature range from -45 °C to +85 °C. The radar sensor complies with DO-160, DO-178, and DO-254 requirements.

The product features a dual CAN FD interface, which enables an integration into in-drone networks. The sensor provides built-in test equipment and self-diagnostics. Whether used for jobsite inspections, powerline monitoring, or other industrial applications with BVLOS operations, the altimeter enables drones to fly with precision. Its reliability and consistency are critical for applications, in which safe flight and accurate data collection are non-negotiable. Production deliveries begun in August 2025. *hz*

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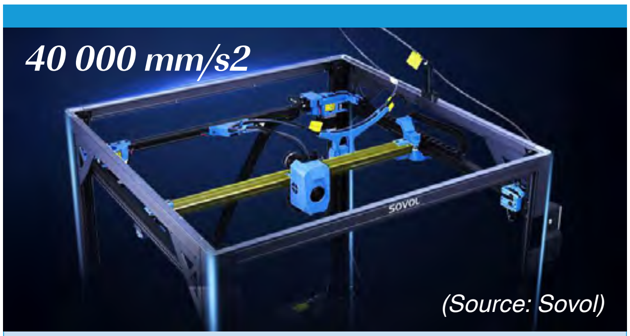
FACTS & FIGURES

Non-contacting CAN access

(Source: Hioki)

Hioki (Japan) has launched the SP7001 and SP7002 dongle, which can capture CAN CC and CAF FD frames without contacting bus lines. The wire remains undamaged. The received frames can be displayed via the USB interface on a PC-based analyzing tool. The company also offers the LR8450-01 data-logger, which can store the received data and correlate them with analog measured temperature inside the vehicle, for example. This can be done in real-time. *hz*

40 000 mm/s2



(Source: Sovol)

The SV08 3D-printer by Sovol features a maximal acceleration of 40 000 mm/s² and a maximum nozzle flow of 50 mm³/s. The open-source product measures 500 mm x 500 mm x 500 mm. Print speed is 700 mm/s. The stepper motors based on the TMC2209 and TMC5160 motor driver chips from Analog Devices communicate via a CAN network. They are part of the Corexy kinematic system. *hz*

IP50/54-rated

(Source: HMS Networks)

The PCAN-GPS Pro FD configurable sensor by HMS Networks/Peak Systems features a CAN FD interface, enabling data phase bit rates up to 10 Mbit/s. It captures position, orientation, and acceleration of objects. The product comes in an aluminum housing with sealed circular connectors by Lemo. It is equipped with a dual-core microcontroller, a magnetometer, a 3-axes gyroscope, a 3-axes accelerometer, and a satellite receiver supporting GPS, Galileo, SBAS, and QZSS. *hz*

Electric vertical take-off and landing aircraft

(Source: Volz)

The VX4 eVTOL (electric vertical take-off and landing) aircraft prototype by Vertical applies CAN-connectable servo controllers from Volz Servos (Germany). The DA 30-HT, DA 30-HT-D, and DA 58-D actuators are in use for the steerage of all control surfaces of the electrical aircrafts. Vertical's VX4 is a piloted four-passenger aircraft, with zero operating emissions. Vertical is partnering with aerospace companies, including GKN, Honeywell, and Leonardo. There are already 1500 pre-orders for the VX4 e-aircraft by several airlines, including American Airlines, Japan Airlines, GOL, and Bristow. "Volz has been working with Vertical since 2019 and we are proud to support the latest phases of VX4 flight testing alongside other industry leaders. Our actuators have proven their precision and reliability in a demanding flight test environment.", said Volz-CEO Phillipp Volz. *hz*

1 µm

The absolute linear encoder by Willtec provides a CANopen interface compliant with CiA 301 (version 4.2.0), CiA 406 (encoder profile, version 3.1), and CiA 305 (layer setting services, version 2.0). The magnetic product features a minimum resolution of 1 µm.

(Source: Willtec)

The maximum measuring length is 30 000 mm. The company offers several T-connectors with and without integrated CAN termination resistor. *hz*

CANopen-based AGVs in furniture production

A German furniture manufacturer has implemented a pilot project to automate its intralogistics. The aim was to make internal transport processes more efficient, make production logistics more flexible, and reduce the workload for employees. The solution was implemented together with EK Robotics, a manufacturer and integrator of automated guided vehicles (AGVs).

Figure 1: With the AGV, the German furniture manufacturer has opted for a future-proof solution to optimize intralogistics (Source: EK Robotics)

Logistical challenges of multi-variant furniture production place special demands on the internal material flow: different product dimensions, changing load carriers, and limited space make manual transportation inefficient and error-prone in the long term. In collaboration with EK Robotics, two individually configured automated guided vehicles were therefore implemented to automate transport processes and increase logistical flexibility. The vehicles connect warehouse and production areas and are dynamically integrated into the existing processes via a smart control system.

A central element of the AGV is the internal vehicle communication network based on CANopen. This technology, based on CAN, enables reliable and standardized control of all key assemblies - from the drive unit to the safety controller as well as the battery and encoder systems. The mobile hand-held control unit is also integrated into the CANopen communication. Depending on the vehicle configuration, between seven and up to 17 CANopen nodes are active. Other networks such as Ethernet are also used to connect specific subsystems. Not all devices are controlled via CANopen, such sensors as light scanners are controlled separately; safety-relevant signals (e.g., from emergency stop systems or laser scanners) run via their own safety-oriented architecture. The modular structure of the vehicles supports scalable implementation and future expansions. By using the established CANopen specifications from CAN in Automation (CiA), the used devices can be made compatible across different manufacturers. This is a significant advantage when it comes to integration and maintenance.

Customized vehicle configuration

The two used vehicles are from the modular Vario Move series from EK Robotics and were specifically adapted to the requirements of the furniture manufacturer. These adaptations include extended forks for large-format loads, additional sensors for detecting width and length, and a ▷

Figure 2: The vehicles serve over 900 storage locations in the shelving warehouse and move loads of up to 1000 kg (Source: EK Robotics)

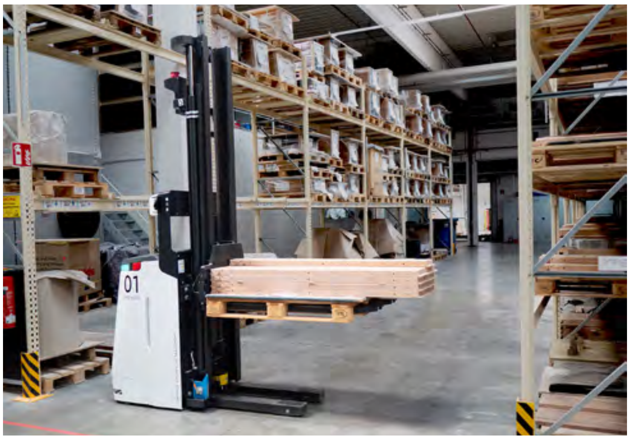


Figure 3: Thanks to extended forks and additional sensors in the fork tips, the AGVs can also store and retrieve long goods (Source: EK Robotics)

duplex lift mast for storage operations up to four meters high. Thereby, the weights up to 1000 kg can be lifted. The extensive safety equipment includes laser scanners for personal protection as well as visual and acoustic warning systems. This ensures safe operation in the ongoing production environment. Already in the project planning

Figure 4: Transfer heights of up to 4 m are no problem with the duplex lift mast (Source: EK Robotics)

phase, the feasibility was tested using envelope curve analyses and simulations in order to optimally integrate the vehicles into the existing infrastructure.

Results and outlook

The AGV has quickly established itself as a reliable component of internal logistics. Manual transportation processes were reduced, throughput times were shortened, and employees were relieved. The furniture manufacturer's maintenance team received training from the EK Academy to enable them to make small adjustments and maintain the system independently. Following the successful pilot operation, the furniture manufacturer is already planning expansions. The automation of the material flow is seen as the key to sustainably meeting the increasing complexity of production and the requirements of the Industry 4.0. The project-specific solution from EK Robotics has laid a solid foundation for this development. ◀

About EK Robotics

EK Robotics is one of the world's leading manufacturers and system integrators of innovative transport robotics for production and warehouse logistics. At five locations worldwide (Hamburg, DE, headquarters), Reutlingen (DE), Milan (IT), Prague (CZ), and Buckingham (UK), the company with over 300 employees creates smart, networked, and flexible transport solutions for the fully automated, internal material flow of its globally active customers. Established for more than 60 years, the manufacturer provides experience in the development, production, integration, and turnkey delivery of automated guided vehicles (AGVs) offering support over the entire AGV life cycle.

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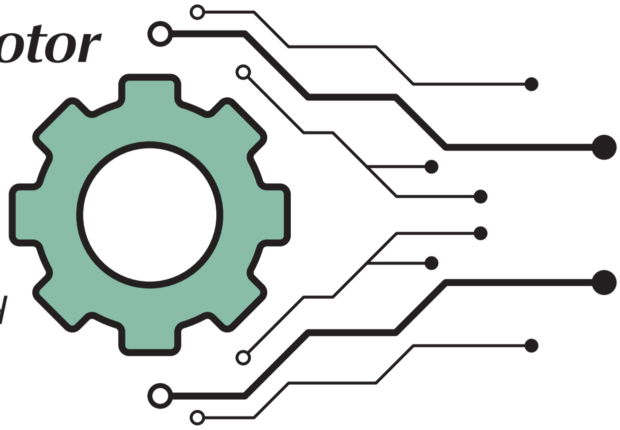
CANopen drives for precise motor control without encoder



The recent Escon2 series of Maxon servo controllers with CANopen connectivity and different I/O functionality introduced an innovative method for Hall sensor-based speed control and FOC (field-oriented control) commutation.

The Escon2 platform offers speed, current, and torque control combined with highly integrated power stages, making it suitable for BLDC and DC motors used in industrial, robotics, medical and analytical applications. The available variants Escon2 Nano, Escon2 Micro, and Escon2 Module can be directly integrated into the electronic design of small and hand-held devices. The Escon2 housed and compact controllers are ready-to-connect solutions that can be placed in a control cabinet or close to the motor.

Figure 1: Escon2 designs for drop-in integration in customer electronics from Escon2 Nano 24/2 (23 mm × 16 mm, 2,5 g) up to Escon2 Module 60/30 (67 mm × 43 mm, 19 g) (Source: Maxon)

Figure 2: Escon2 variants for mounting close to the motor or inside a cabinet (from left to right): Escon2 60/12, Escon2 Compact 60/12, Escon2 Compact 60/30 (Source: Maxon)

The command and monitoring features of the Escon2 allow both the use of pre-configured I/O functions and integration into CANopen systems based on the CiA 402 device profile for drives and motion control.

Commutation and operation without encoder

The 10-kHz speed control rate, 50-kHz current control rate, field-oriented control (FOC), combined with the latest control algorithms and overload-resistant power stages, enable motors to follow high accelerations and precise motion profiles. The FOC generates sinusoidal motor currents over the entire speed range of up to 120000 rpm (rotations per minute).

For BLDC motors with Hall sensors only (without encoders), a new Maxon method (patent pending) allows a more precise speed measurement than it was previously possible. Due to their operating principle, Hall sensors only provide a low resolution per rotor revolution and the switching edges are not perfectly distributed over one revolution of the motor shaft due to manufacturing tolerances. The method introduced in the Escon2 analyzes the switching edge distribution of the Hall sensors during the first few motor revolutions and generates virtual, precise sensor information from this. From a speed of just a few hundred rpm, the speed stability and smooth operation of the motor is comparable to systems based on encoder feedback.

Figure 3 compares the speed stability of a common speed controller (blue curve) with that of an Escon2 (orange curve) operated with Hall sensor feedback only. The speed measurement for the evaluation was performed independently using a high-resolution encoder 16384 CPT, which is not used for Escon2's control or commutation. The measured speed of the Escon2 (orange curve) shows a lower fluctuation/better smoothness along the set value than the other controller (blue curve). Figure 4 shows a comparison of the motor currents. The actual motor current of a typical controller (blue curve) shows larger current fluctuations than the motor current of the Escon2 (orange curve), which is very smooth and free of cyclic oscillations.

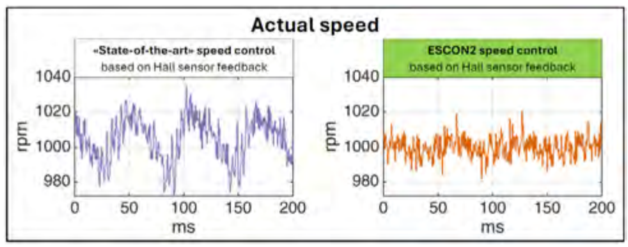


Figure 3: Comparison of the speed stability between a typical motor controller and the Escon2 with Hall sensor feedback only in the speed-controlled operation of a BLDC motor (Source: Maxon)

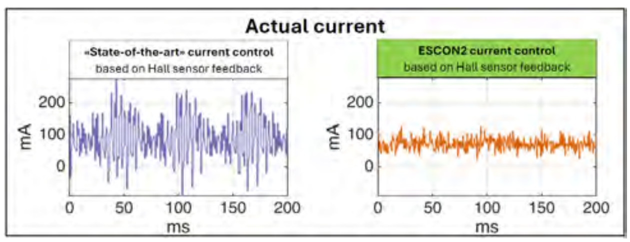


Figure 4: Comparison of the motor current between a typical controller and the Escon2 with Hall sensor feedback only in the speed-control operation of a BLDC motor (Source: Maxon)

In practice, this means that the speed control of the Escon2 with a Hall sensor feedback only is significantly smoother than that of other servo controllers, even at speeds as low as a few 100 rpm. This difference also results in higher energy efficiency. The potential elimination of the encoder means cost savings and a reduction in the amount of wiring required. Nevertheless, for very low speed applications a wide range of digital incremental, SSI and BiSS-C encoders can be used.

Communication interfaces

Escon2 offers a wide range of analog and digital inputs/outputs and interfaces such as USB, EIA-232 (also known as RS-232), and CANopen (supporting CiA 402) for configuration, control, and access to data for process monitoring, IoT (Internet of Things), and predictive maintenance. The motion controller supports the profile velocity mode (pvm), cyclic synchronous velocity (csv), and cyclic synchronous torque (cst) modes as specified in the CiA 402 device profile. In addition, two Maxon-specific operating modes are available: the I/O velocity mode (IOVM) and I/O current mode (IOCM), which combine control via analog and digital inputs/outputs with data exchange and process feedback via the network. This enables flexibility, compatibility, and scalability for use in simple devices with analog control up to fully digital systems based on CANopen. A system integrator from Maxon summarized: “The standardized CiA 402 CANopen device profile used by the Escon2 reduces integration and development efforts and the risk of incompatibility when using mixed system components.”

Software for configuration and data recording

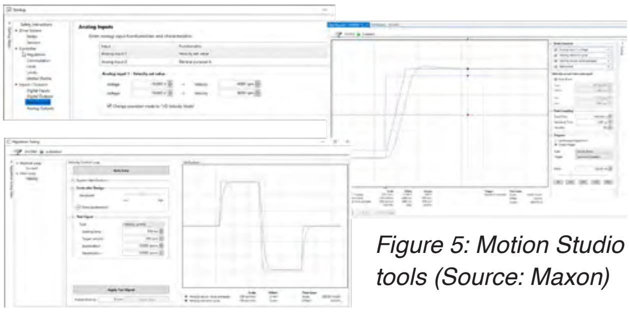


Figure 5: Motion Studio tools (Source: Maxon)

Maxon's Motion Studio software uses a Startup wizard to guide the user through the basic configuration of the drive unit and the desired I/O functions. The Regulation Tuning wizard automatically determines all control parameters. The Data Recorder tool integrated in Motion Studio, which can record four channels, is helpful for system developers or service staff. ◀

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CANopen vendor-IDs assigned by CiA

The CANopen vendor-ID must be implemented in any commercial CANopen device. CAN in Automation (CiA) assigns uniquely a 32-bit identifier to the requesting company. This service is free of charge for CiA members.

The CANopen vendor-ID is mandatory since CiA 301 version 4.0.0 equivalent to the EN 50325-4 standard. CiA has assigned in 26 years more than 1700 CANopen vendor-IDs. They are necessary for some dedicated functions such as the CiA 305 layer-setting services (LSS) and protocols and the CANopen node-claiming procedure. Additionally, the CANopen vendor-ID is useful to identify the device. By means of SDO (service data object) services other CANopen devices can read the CANopen vendor-ID, the product code, the revision number, and the serial number. All these parameters are part of the Identity object accessible in the CANopen object dictionary by means of SDO read services to the index 1018_h and the related sub-index (01_h to 04_h).

Since the end of February 2024, CiA has assigned more than 70 CANopen vendor-IDs. The business of the companies is widely spread ranging from device manufacturers for the open market and for in-house use. Here are some examples from the requesting companies.

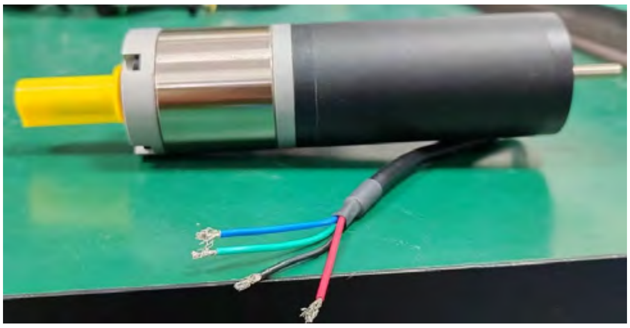

Figure 1: Newly-developed BLDC motor supporting CiA 301 and CiA 402 (Source: Jiangsu Fulling Motor Technology)

Jiangsu Fulling Motor Technology (China), a CiA member, mainly produces motors with integrated drivers. For instance, the newly-developed BLDC motor with a gearbox and a built-in driver (see Figure 1) supports the CiA 301 and CiA 402 CANopen profile for drives and motion control. The four wires represent the positive and negative poles of the 24-V_{DC} power supply (red and black) as well as the CAN_H and CAN_L wires (blue and green). All movements are operated via CANopen. Former, such devices were based on EIA-485 (RS-485) and CAN. Another new vendor-ID owner and CiA member is Q-Drives (Austria). It designs and manufactures innovative drive solutions for automated guided vehicles (AGVs) and autonomous mobile robots (AMRs). For example, the Q-Prime drive is an omnidirectional wheel-hub drive including two driven wheels. The load is distributed over two wheels on each drive unit, resulting in better traction and driving force.

Figure 2: ICMS sensor is now available with CANopen (Source: Micro Resonant Technologies)

Micro Resonant Tech-nologies, a former spin-off of Johannes Kepler University, is an SME (small-sized enterprise) based in Linz (Austria). The CiA-member company specializes in the development and production of robust viscosity and density sensors for condition monitoring of technical fluids in industrial environments. The ICMS sensor (see Figure 2), available since 2022, has now been upgraded to also support CANopen.

A further CiA member Specs corporation (South Korea) is currently working on CANopen implementation in its Specsvision COMD series (diesel engine crank case oil mist detection system, see Figure 3). COMD measures the oil mist inside engine crank chambers. When the oil-mist concentration exceeds the set value, an alarm is triggered to prevent the risk of engine explosion. The series includes a remote monitoring unit, an oil mist monitor, a junction box as well as Vision IIIC, Vision 5X, and Vision 5C detection systems.

CANopen products currently developed by Marel (Island) are intended for internal use. They are integrated as part of the company's food production lines and are ▷

Figure 3: Specsvision COMD series (Source: Specs corporation)

only delivered as spare-parts for the lines in exceptional cases. The new CANopen modules will be used in such food production lines as Smart Line Grader, Poultry Streamline, Process Check Weighers, and the Flow Scale. The Marel group also provides scales, which can be sold as separate products. These are intended to support CANopen in the future.

Metron Automation (Greece) is a CiA member since the beginning of 2025. Currently, the company is adding CANopen connectivity to its lift door controller, which is going to support the CiA 417 CANopen application profile for lift control systems (CANopen Lift).

Mean Well Europe (The Netherlands) offers the FMB series of flat, modular lithium battery packs with nominal voltages of 24 V and 48 V. These products from the CiA member company support CANopen NMT (network management) manager and NMT server functionality. The battery pack is scalable up to 16 pieces in parallel and is engineered for hot swapping. It features a BMS (battery management system) and a battery parameter logger. An app is available for data visibility on a portable device e.g., a smart phone.

Figure 4: FMB series of flat, modular lithium battery packs (Source: Mean Well Europe)

Scorpion Technologies (Canada) manufactures customized industrial joysticks, control grips, and control boxes for heavy equipment and machinery in agriculture, construction, forestry, infrastructure, marine, material handling, and oil and gas industries. Having integrated its product with the J1939 connectivity for many years, the manufacturer now added CANopen to its product line. Addressing, control configurations, and settings can be adjusted through a CANopen interface using SDO services.

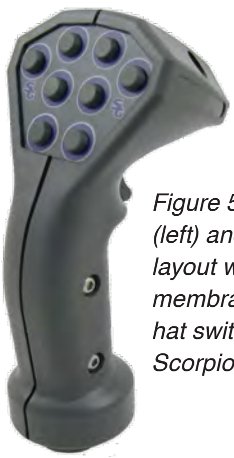

Figure 5: L Series standard (left) and custom (right) layout with backlit membrane buttons and hat switch option (Source: Scorpion Technologies)

Due to a customizable faceplate with integrated CAN electronics in the L Series joysticks, the standard layout with up to eight buttons can be customized regarding layout, graphics, branding, and LED indication or backlighting (see Figure 5). The L Series is available with J1939 or CANopen and up to 17 inputs, three of which can be analog (0 V to 5 V), and four that can be used with an optional ten-button side keypad module. For larger controls, or to implement CAN-connectivity into existing controls, an in-line CAN module (up to 12 inputs) can be installed along the length of the control's cable. A larger, full-featured EM-CAN-07 board (2,5 inch x 3,5 inch) can be installed in an external enclosure. It has 28 discreet inputs, eight of which can be configured as outputs, or six of which can be analog inputs (0 V to 5 V).

Feedback is welcome

The examples included in this article show only a few ongoing developments of companies with recently assigned CANopen vendor-IDs. Further manufacturers and developers are welcome to share information about their available or planned CANopen solutions with the CAN community via email to pr@can-cia.org. ◀

of

Open-source CANopen tools for Windows

CANopenMonitor is the first open-source CANopen analysis tool for Windows, claims the author. The software is used to inspect CANopen messages, enables reading and writing from/to the object dictionary, transfers firmware updates, configures CANopen devices, sends NMT (network management) commands, and simulates emergency messages (EMCY).

CANopen messages are recorded and decoded in the CANopen Log window. The filter function can be used to limit data traffic to the essentials. The recorded data can be saved as an XML (extensible markup language) file and loaded back into the program. NMT and emergency messages are also displayed in separate windows.

CANopenMonitor tool is plugin-capable. The plugins provide an option of decoding received messages and changing the text in the "Info" column. Here is the list of existing plugins:

- SDO Editor plugin: Enables reading and writing of parameters in the object dictionary of individual CANopen devices. The object database can be loaded as an EDS (electronic data sheet) or XDD (XML device description) file. It is possible to read individual entries, several selected entries, or all entries in the object dictionary cyclically. Loading and writing of a DCF (device configuration file) as well as saving the parameters in the EEPROM, is possible.

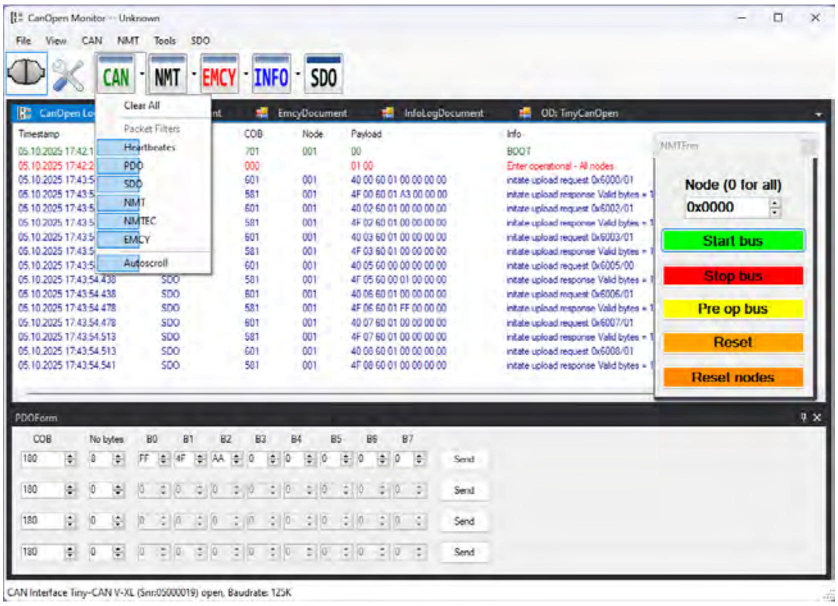

Figure 1: CANopenMonitor main window (Source: MHS Elektronik)

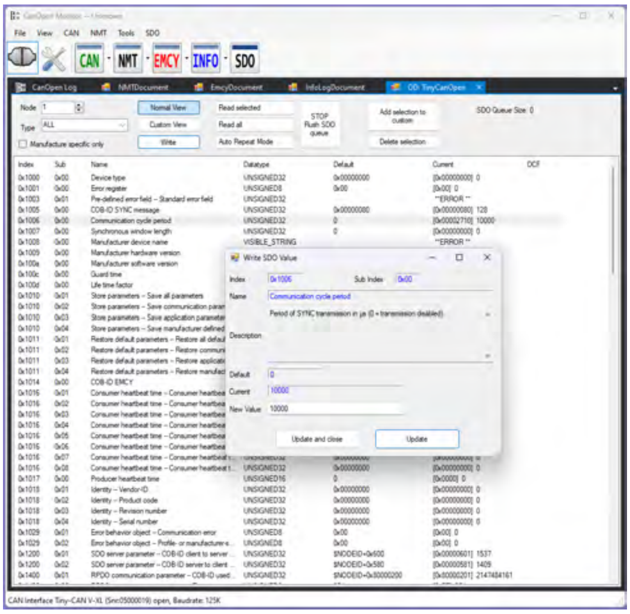

Figure 2: CANopenMonitor window of the SDO editor (Source: MHS Elektronik)

- NMT plugin: Sends NMT commands (e.g., setting the device into NMT operational state or NMT stopped state) to individual CANopen devices or to all network participants.
- EEPROM plugin: Initializes EEPROM with default values, saves data in EEPROM.
- Emergency Simulator plugin: Simulates emergency messages.
- Flash Loader plugin: Is used for firmware updates of individual CANopen devices.
- PDO Injector: Sends PDO (process data object) messages.

As mentioned before, CANopenMonitor is an open-source project. The source code and an executable version are available for download on Github: https://github.com/MHS-Elektronik/CanOpenMonitor.

The application and plugins were originally developed by Robin Cornelius. Klaus Demlehner from MHS Elektronik has made the user interface more appealing, fixed numerous bugs, implemented Tiny-CAN hardware and "opened the way" for CAN FD. The program and plugins are developed in C# based on Microsoft Forms. The CAN drivers were developed in C. Everything can be compiled using the Visual Studio 2022 Community Edition: https://visualstudio.microsoft.com/vs/community. ▷

Virtual CANopen digital I/O module

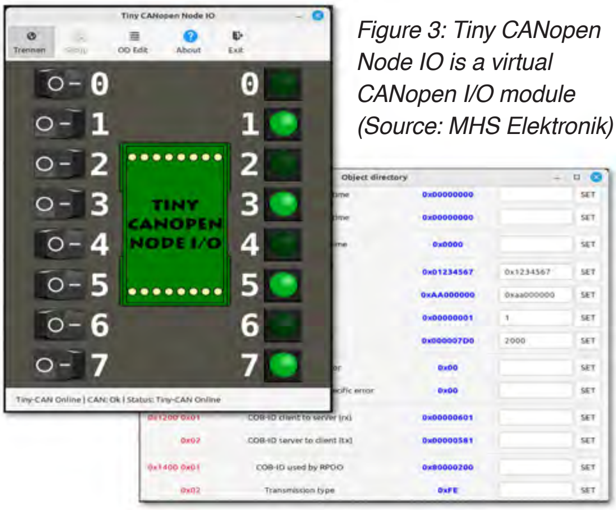

Figure 3: Tiny CANopen Node IO is a virtual CANopen I/O module (Source: MHS Elektronik)

The author uses a second open-source tool "Tiny CANopen Node IO", which is a fun project for teaching purposes, to test the CANopenMonitor analysis tool. A Tiny-CAN adapter acts as the physical CAN interface, enabling communication between the Tiny CANopen Node IO and the CANopenMonitor on a physical CAN network. Only, the switches and LEDs are not real. Tiny CANopen Node IO is based on specifications CiA 301 (base CANopen specification) and CiA 401-1 (CANopen profile for generic I/O modules). The "CANopenNode" protocol stack runs as the CANopen backend. The object dictionary is accessed via API (application programming interface) calls from the CANopenNode; additional information such as data type, access type, and parameter name is read from the EDS file. The software is programmed in C, based on GTK3 (https://gtk.org), and GooCanvas, allowing it to run on Linux, Windows, and the small Raspberry Pi. The sources and compiled versions for these systems are available here: https://github.com/MHS-Elektronik/TinyCanOpen. "Code::Blocks" was used as the development environment for the program: https://www.codeblocks.org.

Free ANSI-C CANopen protocol stack

With over 1600 stars on Github, it is probably the biggest highlight in this list of open-source programs: https://github.com/CANopenNode/CANopenNode.

There is an article on CANopenNode published in the June issue 2022 of the CAN Newsletter Magazine.

I would like to comment some technical details regarding the program. The CANopenNode protocol stack has been developed to operate without a real-time operating system. Basically, three functions need to be called for the protocol stack to work, and none of them are blocking. The "CO_CANinterrupt" function is the interrupt routine called when CAN frames are received and sent. The "tmrTask_thread" function is called cyclically by a Timer Interrupt, normally every 1 ms. There is also the "CO_process function", which must be called cyclically from the main loop. The time difference since the last call must be passed to the function as a parameter.

All files in the stack should be integrated into a project. The individual modules are then integrated and configured using the "define" macros in the "301/CO_config.h".

EDS file editor

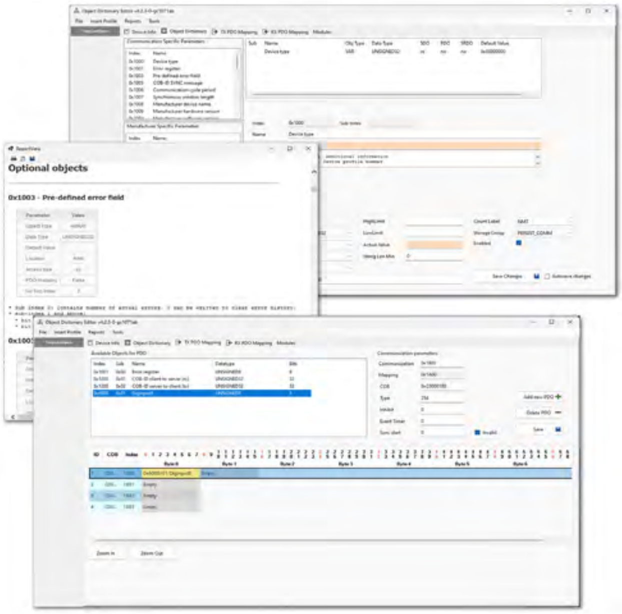

Figure 4: CANopenEditor offers not only editing functions (Source: MHS Elektronik)

Besides loading and saving of EDS files, CANopenEditor supports also other file formats such as XDD. The program can be used to convert the files. The import profile function is helpful when creating a new project; parts of an existing EDS/XDD file can be imported. CANopen profiles CiA 301, CiA 401, and CiA 302 can be imported from template files. It is also possible to create documentation in HTML or Markdown format. The CANopenEditor generates two files required for operating the CANopenNode, the "OD.c" and "OD.h". The two files contain the object dictionary. Access to the object dictionary can be done directly or via API functions of the CANopenNode.

Conclusion

The open-source world provides all the tools needed to develop CANopen devices. CANopenNode and CANopenEditor no longer have to hide behind commercial tools. CANopenNode is cleanly structured and programmed in C. Documentation and numerous examples for various microcontrollers, Linux, and Windows are available. The CANopenNode stack is being continuously maintained and developed. The same applies to CANopenEditor, which is also being maintained and developed. CANopenMonitor is a bit behind its two counterparts, but there are some exciting developments taking place, too. I believe that it is only a matter of time before these tools are ported to CAN FD. ◀

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Enhancing EMC performance for CAN (FD) using common mode choke coils

(Source: Adobe Stock)

Murata Manufacturing (Japan) provides the DLW32SH_XF2 series of CMCCs (common mode choke coils) engineered for high-speed differential communication lines, such as those found in CAN FD networks. These CMCCs meet the most stringent Class III criteria set in IEC 62228-3:2019.

Designers of automotive and industrial systems employing CAN networks for mission-critical communications must consistently address the challenge of ensuring electromagnetic compatibility (EMC). At the physical layer, a key requirement is to limit the emission of common mode noise and ensure immunity to external interference.

The increasing requirements for EMC necessitate passive filtering solutions at the physical layer to limit the emission of common mode noise and ensure compliance with regulatory standards. Common mode choke coils (CMCCs) are widely used to meet this objective, as they attenuate unwanted common mode currents without degrading differential signal quality. When correctly specified, CMCCs can suppress conducted emissions at the source while also improving immunity to external disturbances. Therefore, understanding the operational principles, performance metrics, and selection criteria of CMCCs is essential – particularly when designing systems to comply with standards such as IEC 62228-3:2019.

Noise challenge in CAN (FD) networks

Differential transmission is fundamental to CAN (FD), offering inherently low electromagnetic emissions by leveraging voltage differences across twisted pair cables (see Figure 1).

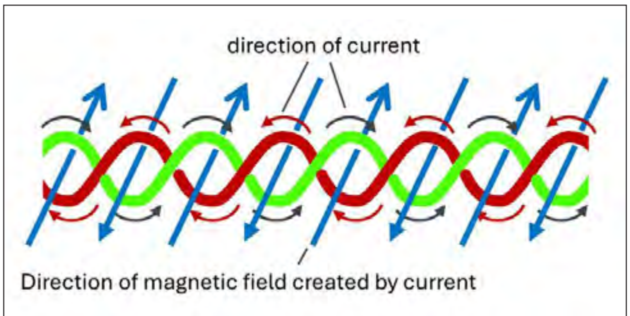

Figure 1: Twisted pair signaling can help to enhance noise rejection and reduce emissions (Source: Murata)

From the perspective of immunity, the arrangement of these pairs cancels out the current generated by external electromagnetic fields, and minimizes common-mode noise due to the differential receiver's signal subtraction (see Figure 2).

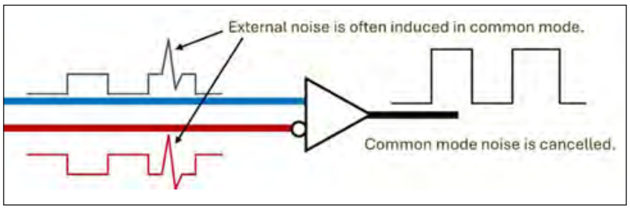

Figure 2: Twisted-pair signaling can effectively eliminate common-mode noise, due to the differential receiver's signal subtraction (Source: Murata)

However, these benefits do not eliminate the challenge of electromagnetic compatibility. On the one hand, CAN (FD) networks can emit common mode noise, particularly when driven by asymmetric signaling paths or layout imbalances such as unbalanced trace routing, long cable runs, or inconsistent terminations. On the other hand, external interference can couple onto communication lines and induce common mode currents, which can cause bit errors if not properly filtered.

Both aspects, emissions and immunity, must be managed to meet the requirements of standards such as IEC 62228-3:2019. These considerations are especially important in complex systems with extended cabling and multiple nodes, where layout variations and termination mismatches can introduce asymmetries. This is where CMCCs provide essential functionality. They offer a first line of defense in filtering common mode currents, making them especially important for networks operating under the stringent EMC demands of automotive and industrial safety standards.

CMCC operation and mode conversion

CMCCs are extensively utilized for the selective attenuation of common-mode currents, while ensuring minimal signal ▷

degradation for differential signals. Fundamentally, a CMCC is a magnetically coupled inductor that is applied across a differential pair. When a differential signal passes through the CMCC, the opposing currents generate canceling magnetic flux in the core, allowing the signal to pass through with minimal impedance (see Figure 3).

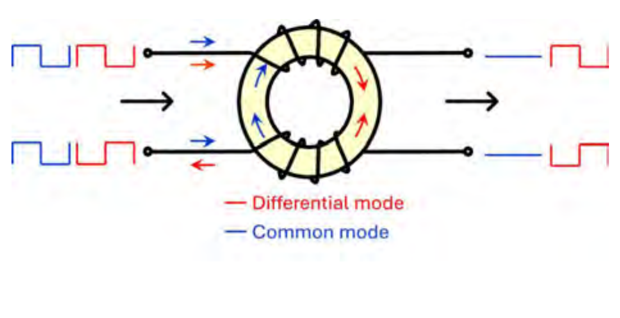

Figure 3: The CMCC's core experiences canceling magnetic flux from opposing currents within a differential signal (Source: Murata)

Additionally, if common-mode signals are present, their currents flow in the same direction through both windings of the CMCC. This causes the magnetic fields to reinforce each other in the core, increasing inductive impedance and thereby attenuating the noise.

For engineers selecting CMCCs, a key design consideration is the mode conversion – the unintended transformation of a part of the differential signal into common mode noise. This phenomenon can contribute to increased emissions, and is characterized using scattering parameters, specifically Ssd12 and Ssd21, which quantify how much differential input appears as a common mode output. Lower values indicate minimal conversion and better signal fidelity, making these parameters critical when specifying CMCCs for EMC-sensitive CAN (FD) applications.

Design considerations for CMCC selection

Selecting an appropriate CMCC for CAN (FD) applications requires balancing several interrelated factors. While practical aspects such as packaging and footprint remain important, electrical performance parameters — particularly leakage inductance and S parameters — must align with the requirements defined in IEC 62228-3:2019. This standard sets limits on key characteristics such as mode conversion, which are categorized into three classes, with Class III stipulating the most stringent requirements for mode conversion characteristics and common mode attenuation, targeting systems operating in particularly noise-sensitive environments or those with tighter EMC margins.

CMCCs must offer strong attenuation of common mode currents while maintaining minimal impact on the differential signal. Performance is typically assessed using S parameters, which capture the combined influence of impedance characteristics, winding structure, and layout. Selecting a CMCC with well-balanced characteristics ensures compliance without compromising communication performance.

Murata's DLW32SH_XF2 series (see Figure 4) is engineered with all of the mentioned requirements in mind and features optimized core materials and winding geometries. The series has been engineered to provide strong suppression across a wide frequency range while maintaining minimal differential signal distortion.

Figure 4: Murata's DLW32SH_XF2 series (Source: Murata)

Notably, Murata's engineering team has designed the DLW32SH_XF2 variant with mode conversion characteristics (Ssd12, Ssd21) that meet the strict Class III thresholds specified in Annex D of IEC 62228-3:2019 (see Figure 5).

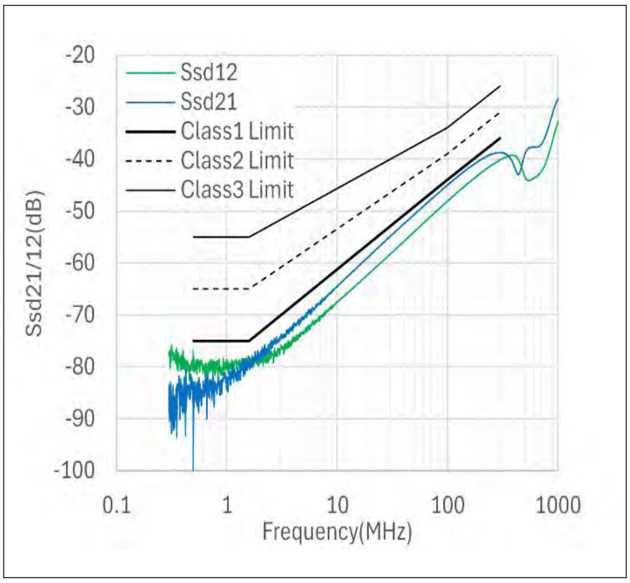

Figure 5: Ssd12/Ssd21 mode conversion values for DLW32SH101XF2 against IEC 62228-3 Class III limits (Source: Murata)

CMCC validation using EMC evaluation boards

Murata's DLW32SH_XF2 series are surface-mount, wire-wound CMCCs specifically engineered for high-speed differential communication lines, such as those found in CAN FD networks. Due to its innovative wire-wound structure, Murata's components are among the most compact CMCCs that meet the Class III criteria set in IEC 62228-3:2019. Each device is AEC-Q200 qualified and can operate effectively across a temperature range of -40 °C to +125 °C, ensuring their reliability in demanding automotive environments.

To confirm compliance and demonstrate practical efficacy, Murata has employed a dedicated CAN FD EMC evaluation board for the validation of the DLW32SH101XF2. Its tests followed the procedures outlined in IEC 62228-3:2019 Chapter 6, covering both radiated emission and conducted immunity scenarios.

For radiated emissions, the board was tested using the 150-Ω method, as specified in IEC 62228-2:2019. In this setup, common mode noise was extracted from the ▷

signal lines and measured via a spectrum analyzer (see Figure 6).

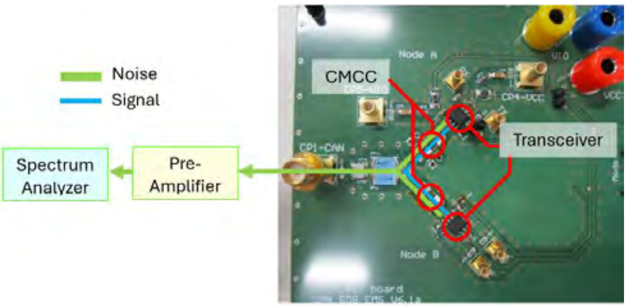

Figure 6: 150-Ω method test setup for measuring radiated emissions using a spectrum analyzer (Source: Murata)

Findings verified that emissions stayed significantly under Class III thresholds with the Murata CMCC in place, thus confirming its ability to mitigate high-frequency noise while preserving communication efficacy (see Figure 7).

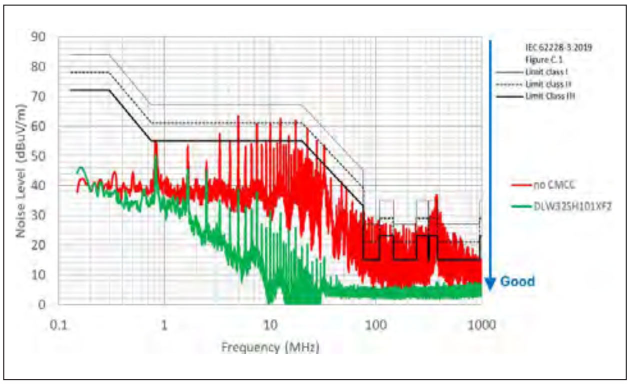

Figure 7: RF disturbances with DLW32SH101XF2 vs. without CMCC (Source: Murata)

An immunity test was also conducted in which a power amplifier and signal generator introduced RF noise directly into the signal lines via direct power injection (DPI), with the system monitored for communication errors. This test demonstrates the device's stable communication under high-noise conditions, in compliance with IEC 62228-3:2019 for RF disturbance immunity, making it suitable for the latest CAN (FD) applications (see Figure 8).

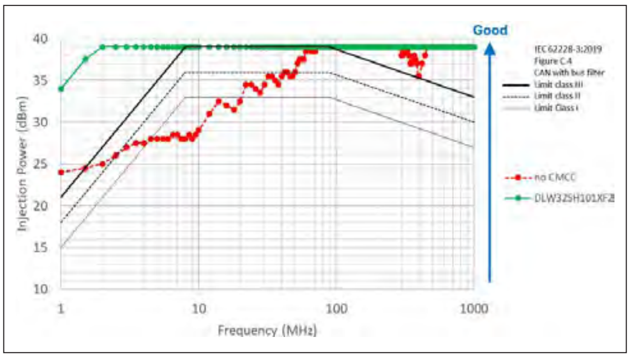

Figure 8: Results from DPI immunity test configuration using signal generator and power amplifier to inject RF noise (Source: Murata)

Summary

Across both automotive and industrial applications, CMCCs are critical performance enablers, ensuring the reliable communication that underpins today's increasingly electrified and digitized systems. In automotive networks, they contribute directly to functional safety, particularly in domains such as advanced driver assistance systems (ADAS) and electrified powertrains, where reliable vehicle operation depends on robust communication. The same is true for industrial applications like high-speed control systems for robotic manipulators, where CAN communication underpins countless safety-critical systems.

For engineers, CMCCs are not just a compliance tool, but a risk mitigation component that ensures long-term system reliability. However, selecting the right component requires careful attention not only to filtering performance but also to mode conversion behavior as well as adherence to established specifications. Selecting a proven CMCC, such as Murata's DLW32SH_XF2 series, which has undergone rigorous engineering and validation using standardized test methods, can ensure system performance and shortening development times. ◀

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(Source: Adobe Stock)

This regular column provides some hints and kinks about CAN-related protocol (including higher-layer protocol) functionality and physical layer topics.

Do not configure bit timing by SDO

From time to time, there should be a reminder, not to configure the bit timing in the CANopen object dictionary by means of an SDO (service data object) write service. Background: Even, if the configuration (the new bit-timing setting) becomes valid after an NMT (network management) reset command (or power cycle), it could happen that not all CANopen nodes start with the very same bit-timing setting. In this case, one or more nodes use another bit rate than the other nodes. This causes CAN error frames and one or more nodes transit into bus-off state. You need to disconnect all nodes and to re-connect them one-by-one to find those with another bit-timing setting.

Using layer setting services (LSS) is a safe possibility to change the bit rate. LSS protocols are specified in CiA 305 and can be used not only in CANopen networks, but also in J1939-based networks and networks applying proprietary higher-layer protocols (if the CAN identifiers used by LSS protocols are "free"). Alternatively, automatic bit-rate detection can be used, to overcome the bus-off issue. The CiA 801 technical report provides implementation hints for automatic bit-rate detection; the document can be downloaded free of charge from the CiA website. *hz*

Intermission: The "unknown field"

The 3-bit intermission (field) represents a transition phase. It does not belong to the previous CAN data/remote frame, which has ended with the last bit of the 7-bit EOF (end of frame) field. In intermission, the CAN node remains for two bits in transmitter or receiver state. Nodes in transmitter state shall not sent dominant bits. At the third bit of intermission, the CAN node transits into idle state. If there is a pending transmission request, a CAN node is allowed to send a dominant bit in the third bit of intermission (this represents the SOF (start of frame) bit). Other nodes with pending transmission requests send in the next bit their first (highest prior) identifier bit, trying to get bus access. When a CAN node detects in the first two bits of intermission a dominant bus value, it sends an overload frame. When in this overload frame a bit error is detected, the TEC (transmit error counter) respectively the REC (receive error counter) are increased by 1. This applies to all three CAN protocol variants: CAN CC (classic), CAN FD (flexible data rate), CAN XL (extended data-field length). *hz*

The PGN is not the PG

The J1939 parameter group number (PGN) is a unique 18-bit information identifying the content of a J1939 parameter group (PG). The PGN is just a "number", mapped into the 29-bit CAN identifier. The PG is a protocol data unit (PDU) of the J1939 application layer. It comprises the 3-bit priority field, the 8-bit source address (both are mapped into the CAN identifier), and the (suspect) parameters mapped into the 8-byte CAN data field. In some J1939-related documents PGs are named PGNs. But this is misleading (the terms "PG" and "PGN" are not synonyms) and can lead to confusion (in particular, for newcomers). All PGNs are uniquely assigned to PGs by the SAE J1939 committee. A couple of years ago, the SAE J1939 committee has started to improve its J1939-related documents, using the terms "PG" and "PGN" correctly. ISO has done the same in the ISO 11783, ISO 11992, and ISO 16844 series.

There are some PGs with dedicated PGNs defined for proprietary purposes in SAE J1939 specifications. They are just "empty" containers for (suspect) parameters (SP). They should not be renamed, in order to avoid misinterpretations by generic J1939 diagnostic tools. Additionally, it is recommended to use just a few percent of the busload for proprietary PGs, especially, in open network approaches such as Isobus (standardized in the ISO 11783 series), used in agriculture vehicles as integration network connecting the tractor to so-called implements (e.g., harvesters and sprayers). *hz*

If you have questions regarding CAN-related protocols or CAN physical layer issues, you may contact CAN Newsletter editors to get them answered. The answers might be also interesting for other CAN fellows and will be published in the "Good to know!" column.

Control systems for caravans and special vehicles

Modern vehicle construction, especially in the caravan and special vehicle sectors, places high demands on flexibility, interface diversity, and customizability. Inomatic offers an open, scalable, and freely programmable control system for caravans and special vehicles.

Inomatic, based in Nordhorn (Germany), has been active in the field of special vehicles for over 20 years. These vehicles also include ambulances, firefighting vehicles, and police vehicles. The company offers smart CAN-connectable control systems and operating concepts keeping them up to date due to continuous development. The compact control systems with diverse inputs and outputs as well as multiple CAN and LIN interfaces can be centrally integrated into the vehicle in a space-saving manner.

The control units, featuring haptic buttons and RGBW backlighting, communicate with the central control device via the CAN CC (classic) network. CAN FD (flexible data rate) support is in preparation. Touch displays or control units can be used to control and evaluate air conditioning systems, auxiliary heaters, lighting, or other devices. Such automated functions as shutting off certain devices when leaving the vehicle or after a defined period of time, are also feasible. This allows for energy savings and implementation of safety-related functions.

The system has a modular design and can be expanded with additional input and output modules or control units in a plug-and-play manner. Software updates or configuration changes can be installed via the USB interface. To enhance user-friendliness, App-based control via smartphones or tablets is planned for the future.

With the BT2000 control panel series, the ZSG and Pico-FP control units, and other modules, Inomatic offers an open, scalable, and freely programmable control system. The system has been successfully used in government emergency vehicles for years, informs the company. The included devices are tested according to the ECE R10 vehicle directive and approved by the German Motor Transport Authority (German: Kraftfahrt-Bundesamt, KBA) with E1 approval for electromagnetic compatibility (EMC) and vehicle performance in professional environments.

Customizable control and display unit

Figure 1: BT2012 customizable HMI for caravans and special vehicles (Source: Inomatic)

The BT2000 control and display unit series includes variants offering three to 17 buttons. The BT2012 model also integrates a 2,4-inch TFT display for plain text and graphic representation of vehicle statuses. Communication with networked devices takes place via CAN CC (classic) according to ISO 11898-2 with support of 11-bit and 29-bit CAN-Identifiers. Support of CAN-FD connectivity is in the pipeline. The series offers a flexible operating concept with a uniform button design, regardless of the model type. Customers can create and print own graphics and icons for button assignments via a web-based interface, e.g., for special functions, individual designs, or for changing vehicle configurations. ▷

Interactive touch display

Figure 2: Mangora X-7 touch display (Source: Inomatic)

The Mangora X-7 touch display was developed for flexible use in vehicles. With a 7-inch IPS (in-plane switching) touchscreen, robust technology (up to IP65-rated), and modular configurability, the device offers a central unit for displaying, control, and on-board entertainment. Also here, customers can configure the button layout and create their own operating interface, e.g., for indication of fuel levels, battery status, etc.

The device with the size of 202 mm x 142 mm x 23 mm works with a power supply from 9,8 V_{DC} to 32 V_{DC} and is tested according to the ECE R10 directive. Variants with 1 GiB to 4 GiB of RAM memory and 8-GiB to 32-GiB flash memory are provided. Due to support of CAN CC (11-bit and 29-bit CAN-IDs), Bluetooth, Wi-Fi, and an input for analog cameras, it is suitable for integration into existing systems. An optional navigation unit is offered to transform the panel into a navigation system. Depending on variant, Android or Linux are available as operating systems.

PLC-programmable control units

The ZSG and the more compact Pico-FP control units are programmable in an identical way. The units differ only in the number of digital/analog inputs and outputs and the available interfaces. Programming is done via a graphical user interface or structured text according to IEC 61131-3. This allows the user or OEM (original equipment manufacturer) to define the vehicle logic themselves – from the lighting concept to heating and air conditioning control as well as energy management.

Figure 3: Pico-FP control unit (Source: Inomatic)

The units provide three CAN CC interfaces (CAN FD in preparation) and several LIN interfaces supporting the company's proprietary CI protocol. Additionally, specific protocols for controlling heating and air conditioning units from Webasto, Eberspächer, and Dometic are supported. Devices from these manufacturers can also be controlled via CAN, if implemented. Optional add-on module for connection of devices (e.g., for inverters or external control units) via EIA-232 and EIA-485 is offered. Integration of Lithium batteries (e.g., SuperB) via CAN or LIN to monitor the battery-related status, is possible. Lead and lead-gel batteries can be integrated via a dedicated LIN battery sensor. An optional IoT module adds Bluetooth and Wi-Fi connectivity to the system, enabling wireless programming and mobile visualization of system statuses via an app-based or a web-based interface. The units with a power supply of 10,8 V_{DC} to 32 V_{DC} are dedicated for operating temperatures from -25 °C to +70 °C.

Flexible CAN I/O module

Figure 4: CanTronic I/O module (Source: Inomatic)

The CanTronic I/O module is designed to read relevant data from in-vehicle CAN networks (in future also CAN FD), to processes it internally, and to provide it to up to 14 discrete outputs. The module measures 95 mm × 60 mm × 35 mm and works with a power supply from 9,8 V_{DC} to 32 V_{DC} at operating temperatures from -25 °C to +70 °C. CanTronic is freely configurable depending on the application using graphical, web-based configuration. Via the company's online platform InoIDE, the user can select the appropriate vehicle model, assign the desired signals with a mouse click, and transfer the configuration to the device via a mini-USB interface. This enables implementation of a control solution without any programming knowledge. Furthermore, the control system can be programmed using structured text in the inoIDE.

The I/O module is suited for applications in special vehicles, rebuilt vehicles, retrofit solutions, or test setups in vehicle development. It allows the targeted control of components such as relays, lights, displays, or control elements. ◀

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Mobile machine news

Battery-powered crane

(Source: Danfoss, Sany)

Sany (China) offers a 200-t lattice-boom crawler crane using the Editron synchronous reluctance assisted, permanent-magnet motor by Danfoss (Denmark). The electrically-controlled system is based on a CAN network. It comprises an Editron PMI375-T1100 motor and a D1P 260-cc pump as well as Series 90 pumps and PVG 128 valves. Danfoss supports for its hydraulic products CANopen (CiA 301 and CiA 408) and for safety-related communication a Plus+1 proprietary protocol. "Conventional hydraulics still plays a role in the electrification of heavy machinery, particularly machines of this size," said Henrik Jørgensen from Danfoss Power Solutions. By integrating the electrical motors into cranes by Sany, a migration path to battery-powered heavy-duty construction machines was demonstrated. *hz*

Controlling motors via CANopen

Ifm (Germany) provides the Ecomat-Relay device suitable for 10-A PWM-controlled (pulse-width modulation) H-bridges. The IP67-rated CANopen device complies with the CiA 401 specification for I/O modules. It is intended for use in mobile machinery including road vehicles. Suited for use in demanding environments, it is vibration-resistant, E1-certified, and supports both 12-V and 24-V on-board systems. The temperature range is -40 °C to +85 °C. According to the supplier, the product can be used to control electrical motors. The current consumption in sleep mode is 6 mA. The device features three additional 12-bit analog input channels. *hz*

Dongle for electric vehicle diagnostics


(Source: HMS Networks, Ixxat)

HMS Networks (Ixxat brand) has launched the Mobilizer gateway series for automotive communication and testing. Applications include data logging, gateway functionality, residual bus simulation, firmware flashing, and end-of-line testing. All Mobilizer models come with the Advanced Configuration Tool (ACT) drag-and-drop software solution to configure the gateway without any programming knowledge. The series supports up to eight CAN (FD), Automotive Ethernet, LIN, Flexray, and further interfaces. The CAN interface implements the TCAN1462 SIC (signal improvement capability) transceiver supporting data-phase bit rates up to 8 Mbit/s. The Mobilizer enables connection of CAN (FD) and Automotive-Ethernet (100/1000Base-T1) in-vehicle networks (IVN). A plug-in-based encryption system and support for Matlab models is available. The IP40-protected gateway is designed for harsh conditions providing an aluminum housing with cooling, allowing operation at temperatures from -40 °C to +70 °C. All models feature an embedded processor platform with a quad-core i.MX 8M Plus processor, 1 GiB of RAM, and 4 GiB of flash memory. *of*

Inclinometer measures acceleration and rotation rate

(Source: Kübler)

The IN78 CANopen-connectable inclinometer from Kübler unites one- or two-axis angle measurement and processes the measured values from the acceleration and rotation rate measuring cell (gyroscope). This sensor fusion enables fast measurement results and reduces the effects of vibrations and interfering accelerations. The device provides adjustment options for adaptation to specific requirements. The IN78 is designed with protection class IP68/IP69K, which ensures reliable operation under harsh conditions such as temperatures from -40 °C to +85 °C, salt spray, and rapid temperature changes. LED displays facilitate commissioning and diagnostics by visualizing the operating status, CANopen communication, and setting of the mid-point position. *hz*

From buttons to CAN-based human machine interfaces

Historically, single push-buttons and simple joysticks were sufficient to control a mobile machine. Nowadays, human machine interfaces (HMI) are sometimes more complex and feature CAN connectivity. Nevertheless, they need to operate reliably in harsh environments.

In mobile machinery, control elements must withstand extreme conditions while remaining intuitive and reliable in use. Dust, vibration, temperature fluctuations, and moisture put the HMI devices to the test every day, particularly in applications such as construction equipment, agricultural vehicles, or municipal service fleets. At the same time, system complexity continues to grow – driven by tighter integration via CAN-based networks supporting higher-layer protocols such as CANopen, J1939, Isobus, and emerging technologies like TIM. This makes intuitive, fail-safe interfaces more critical than ever, ensuring operators can manage advanced functions safely and efficiently.

Rugged basics

As in the past, there are implemented robust keypads, single switches, and push-buttons in mobile machines. Increasingly, they are connected to J1939-based and CANopen networks. Their modular design allows for flexible configuration of button count, symbol layout, and functionality. Integrated status LEDs and backlighting support intuitive operator feedback. Especially in vehicles with limited installation space or standardized dashboards, these modules offer seamless integration and ergonomic access to both basic and application-specific functions.

NOx sensors support CAN

(Source: Forvia Hella)

Forvia Hella (Germany) has expanded its NOx sensor portfolio. The company has launched sensors for trucks (24-V variants) and for passenger cars (12-V versions). They come with a CAN interface adapter. NOx sensors play a crucial role in monitoring and reducing nitrogen oxide emissions from diesel-powered vehicles in order to comply with Euro 5 and Euro 6 requirements. Of course, when using these products as spare parts, they need to be configured remotely to calibrate them. For passenger cars, Hella Gutmann offers the Macsremote service to integrate the NOx sensor into the CAN-based in-vehicle networks. This includes a special coding of the sensor with the software provided by the automaker. This enables independent garages and workshops to exchange NOx sensors quickly and efficiently, stated the supplier. *hz*

(Source: b-plus)

With high protection ratings (up to IP68) and an extended operating temperature range (-40 °C to +85 °C), they are built for demanding environments in mobile machinery.

Multi-functional control

For more dynamic input scenarios, compact joystick units with integrated push buttons and rotary encoders are commonly used. These combine multiple control functions within a single, space-saving device – ideal for confined operator cabins or for machines with frequently changing operational demands. Typical applications include municipal service vehicles for controlling auxiliary equipment or construction machinery for precise hydraulic actuation. Combining buttons, rotary encoders, and joystick axes in one device allows operators to control multiple machine functions simultaneously and intuitively – improving workflow efficiency and ergonomics. Adjustable LED feedback and customer-specific, laser-engraved symbols enhance usability, ensuring clear function indication and intuitive control – even under poor lighting conditions or heavy vibration.

Centralized and configurable

Where broader information and configuration capabilities are required, CAN-compatible display solutions come into play. Modern HMIs not only visualize machine and ▷

B-plus supplies touch screen displays from different companies and supports their integration into CAN-based embedded control networks (Source: b-plus)

sensor data, but also serve as central interaction points for diagnostics, control parameters, and user feedback. With support for protocols such as CANopen, J1939, and Isobus (ISO 11783 series), such displays integrate seamlessly into the machine's embedded control network.

In addition, flexible software frameworks like Qt or Codesys (IEC 61131-3 compliant) allow for tailored design and application development – whether for operational monitoring, parameter adjustment, or touchscreen-based control workflows.

Selection criteria for CAN-based HMI devices in mobile machinery

When specifying input and display components for mobile machines, a number of technical and application-related factors should be considered to ensure long-term performance, operator usability, and seamless system integration:

- *Environmental protection*
  Ensure adequate IP rating (e.g., IP67 or IP69K) and temperature range (-40 °C to +85 °C) to withstand dust, water, vibration, and thermal cycling.
- *CAN interface and higher-layer protocol support*
  Check compatibility with higher-layer protocols such as SAE J1939, CANopen, or Isobus. Configurable CAN-IDs and diagnostic capabilities are essential for flexible integration.
- *Form factor and mounting options*
  Consider space constraints in operator cabins and dashboards. Compact housings and standardized cutout dimensions simplify installation.
- *Input type and feedback*
  Choose between tactile buttons, rotary encoders, joysticks, or touchscreen input dependent of task complexity. Features like LED backlighting, status indication, or haptic feedback enhance usability.
- *Symbol customization*
  Fixed, laser-engraved icons provide clarity for static functions, while dynamically changeable symbols (e.g., via CAN in hybrid modules) allow context-based control surfaces.
- *Software architecture and configurability*
  Interfaces supporting Qt, Codesys, or custom configuration tools enable adaptation to customer-specific logic, layouts, and workflows.
- *Mechanical and electrical durability*
  A long lifecycle (> 1 million cycles), robust housing, and a voltage input range (e.g., 7 V_{DC} to 32 V_{DC}) contribute to system reliability. *si*

Hybrid approach

Combining tactile feedback, the KeypadModules Touch offer a compelling solution for modern control panels in mobile machinery. Available in variants with six or twelve touch-sensitive keys, these modules feature customizable, backlit icons that can be dynamically changed via CAN – allowing the control surface to adapt to the active machine state or task. This supports intuitive operation even in multifunctional or role-based workflows. With IP67-rated enclosure, an operating range from -25 °C to +70 °C, and a lifetime of over one million cycles per key, the modules are built for rugged environments. Due to their configurable CAN interface, they integrate into networks based on J1939, CANopen, or Isobus. A PC-based configuration tool supports setup and icon management, enabling deployment without deep software integration.

Robust control for evolving machine architectures

From switch modules to advanced touch interfaces, all HMI devices described are available from b-plus – tailored for the demands of mobile machinery. Designed for harsh environments, they meet protection ratings up to IP69K and can be customized to meet specific application needs. Whether for simple switching tasks or programmable HMIs, these CAN-based solutions provide a robust and future-ready foundation for the next generation of intelligent machine control. ◀

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(Source: Adobe Stock)

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

CAN-based control in a forestry machine

(Source: MRS Electronic)

The Moritz forestry machine by PM Pfanzelt Maschinenbau (Germany) uses a CAN-based network linking two M2600 ECO CAN host controllers and one MicroPlex 7H control unit by MRS Electronic. The used higher-layer protocol is J1939. The machine is a radio-controlled implement carrier that has evolved from a classic forestry tractor concept into a versatile carrier platform. The CAN-connected controllers take over central vehicle functions:

- Hydraulic control: adjustment of the chassis width, control of the PTO (power take-off) shaft, the cable winch, and the spiral fan as well as control of the solenoid valves for the hydrostatic drive.
- Protection function: If the oil pressure drops, the engine is automatically switched off for effective protection against costly consequential damage.
- Cable-winch control: The cable position, i.e., the number of windings, is detected via a sensor system. Depending on the cable position, the hydraulic pressure is adjusted to achieve a constant pulling force of the winch.
- Radio-receiver protection: The MicroPlex 7H control unit protects the sensitive receiver from overvoltage and ensures that the cable is always tensioned when the cable is ejected by means of a time delay.

The application programming has been supported by the MRS Developers Studio, providing a graphical programming using function blocks. "We regularly use controllers from MRS Electronic in our projects – even in series applications. We are also impressed by the reliability of the M2600 ECO CAN PLC (programming logic controller): it has been running absolutely fault-free since the start of the project," stated Thomas Fischer, responsible for electronics development at Pfanzelt. *hz*

CAN-connectable signal light

(Source: FSG)

The SG-OA-Z-CAN-GS80 optical warning device from FSG is intended for autonomous agricultural machinery in accordance with the ISO 18497 standard. It has been developed with OEMs (original equipment manufacturers). The signal lights coming in an aluminum housing feature CAN connectivity, supporting CANopen with a pre-defined node-ID (19_h). The default bit-rate is 250 kbit/s. They generate visual and audible warning signals that can be adapted to individual requirements. Typical situations in which the products come into action are the indication of autonomous driving movements and the safeguarding of changing, dynamic danger zones, when operating such vehicles.

The IP66-rated device can use light and sound to indicate different driving modes, changes in the direction of movement or general status changes as well as malfunctions and faults. In contrast to conventional signaling devices, the integrated loudspeaker emits stored audio files with a volume of up to 105 dB instead of tones. *hz*

Gateway for a remote trouble-shooting platform

(Source: Helios Technologies)

“The launch of the Atlas Connect Gateway marks a major step forward in Helios Technologies’ vision for intelligent machine connectivity”, commented CEO (chief executive officer) Sean Bagan. The gateway gives OEMs (original equipment manufacturers) and fleet managers the possibility to monitor critical data, to send remote commands, and to update software on equipment in the field without needing to be on site. “By pairing the Atlas Connect Gateway with Cygnus Reach, Helios’ patented remote troubleshooting platform — we’re delivering a powerful new advantage to OEMs by enabling remote support capabilities”, said Billy Aldridge, Helios’ Electronics Segment managing director.

The IP67-rated gateway can be wired into any CAN-based network in a matter of minutes, he added. It operates at temperatures ranging from -20 °C to +70 °C. Using Cygnus Reach it is possible to monitor the CAN traffic, take CAN data frame recordings, and share this data with cellular mobile devices. *hz*