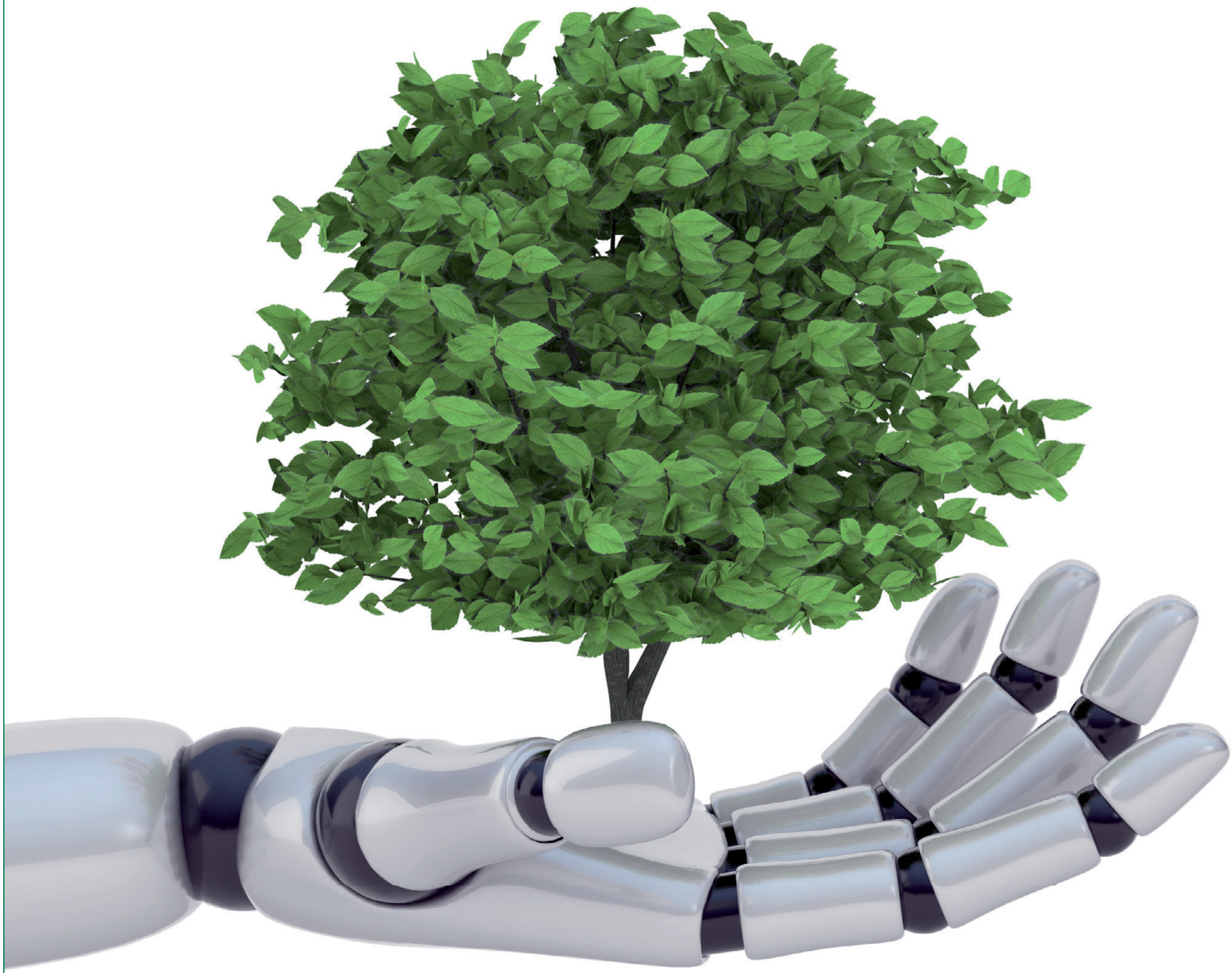
December 2017

CAN Newsletter

Hardware + Software + Tools + Engineering

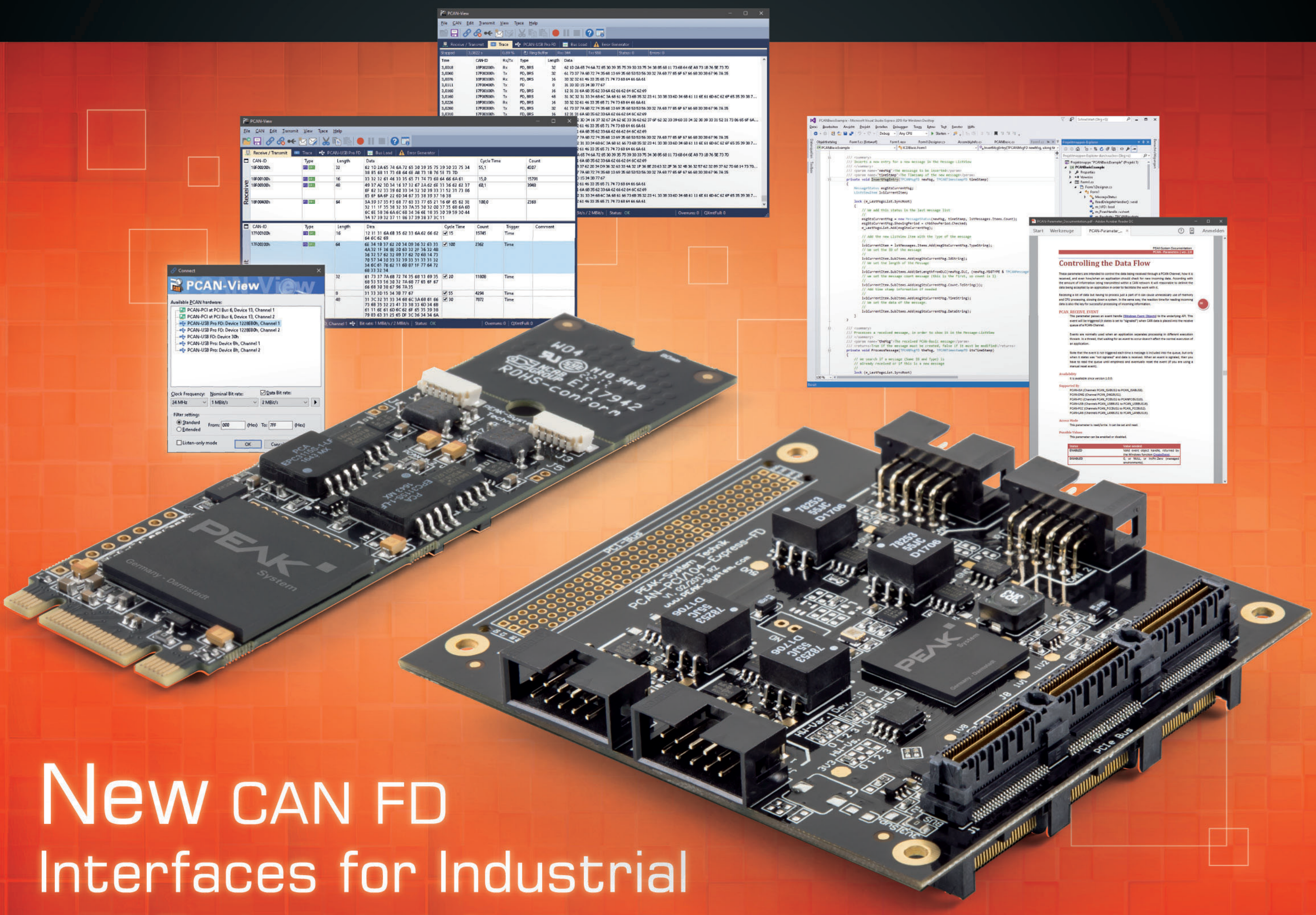


CANopen

CANopen FD – more than just higher bandwidth

Sensing the load and adapting the phase current

Two axes as a single CANopen node



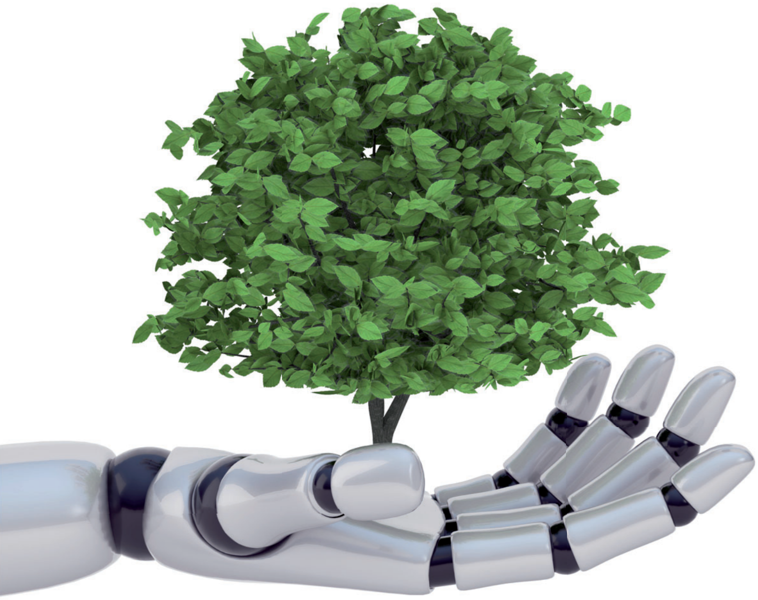


Table of contents

CANopen

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Applications

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Standardization of CANopen profiles

CiA has published many CANopen device, application, and interface profiles. In total, they sum up to more than 20 000 pages. Just a few of them have been internationally standardized yet. One of them is the CiA 402 profile for drives and motion controllers. It is published in IEC 61800-7-201 and IEC 61800-7-301. These standards are currently under systematic review. Beginning of 2018, the CANopen Special Interest Group (SIG) Motion is going to evaluate the requested functional extension and the submitted comments.

Other CANopen profiles internationally standardized include CiA 422 (application profile for refuse collecting vehicles), CiA 443 (profile for subsea devices), and CiA 454 (application profile for energy management systems). The related standards are EN 16815 (CiA 422), ISO 13628-6 (CiA 443), and IEC 61851 series (CiA 454). The CiA 442 profile for low-voltage gear devices specifies the mapping of the IEC 61915-2 generic profile to CANopen.

CANopen FD: The countdown runs

The CiA 1301 application layer and communication profile was released end of September. In 2018, the first products are expected.

(Photo: Fotolia)

10 *reasons to migrate to CANopen FD:*

- Higher throughput due to more bandwidth offered by the CAN FD hardware
- Higher protocol efficiency due to larger payload per message (up to 64 byte)
- Larger PDOs with up to 64 byte process data
- Low-cost CAN FD controller and transceiver qualified for up to 5 Mbit/s
- Improved specification of NMT finite state automata
- Broadcast and multicast option for configuration purposes
- Remote access to CANopen FD devices in other network segments
- Still low memory and computing power resource requirements
- Improved error history functionality
- Better support for multiple logical devices (e.g. multi-axes controller)

9 *USDO protocols for local access are specified in CiA 1301:*

- USDO upload expedited unicast
- USDO download expedited unicast
- USDO upload expedited broadcast
- USDO download expedited broadcast
- USDO upload segmented unicast
- USDO download segmented unicast
- USDO download bulk transfer unicast
- USDO download bulk transfer broadcast
- USDO abort

8 device type sub-parameters are provided in CiA 1301, in order to describe up to eight logical devices. The device type parameter (object 1000h) is now an array. This makes it simpler to check the functionality of a CANopen device supporting multiple logical devices, e.g. several CiA 402 drives (multi-axes device) or a drive (CiA 402) with an embedded I/O module (CiA 401).

7 OSI layers, but not all are used: CiA 1301 specifies the physical and data link layer, the network and transport layer as well as the layer-7; the layer-6 and layer-5 are empty, meaning they have no specified functionality.

6 *standardized fields in the new 20-byte EMCY message:*

- Logical device number
- CiA specification number
- Error register (1001_h)
- Emergency error code (ECC)
- Status (Error priority, class, and state)
- Time given as Time-of-day value

(Photo: Fotolia)

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(Photo: Fotolia)

5 *companies participating in the CANopen FD demonstrator shown on the CiA booth at the SPS IPC Drives 2017 tradeshow:*

- Esacademy
- Emtas
- ESD
- HMS
- Microcontrol

3 *new communication parameters:*

- Version information (boiler plate), an array indicating all implemented CiA specifications
- Active error history, an array showing all occurred errors after the last reset
- Active error list, an array providing all currently active errors

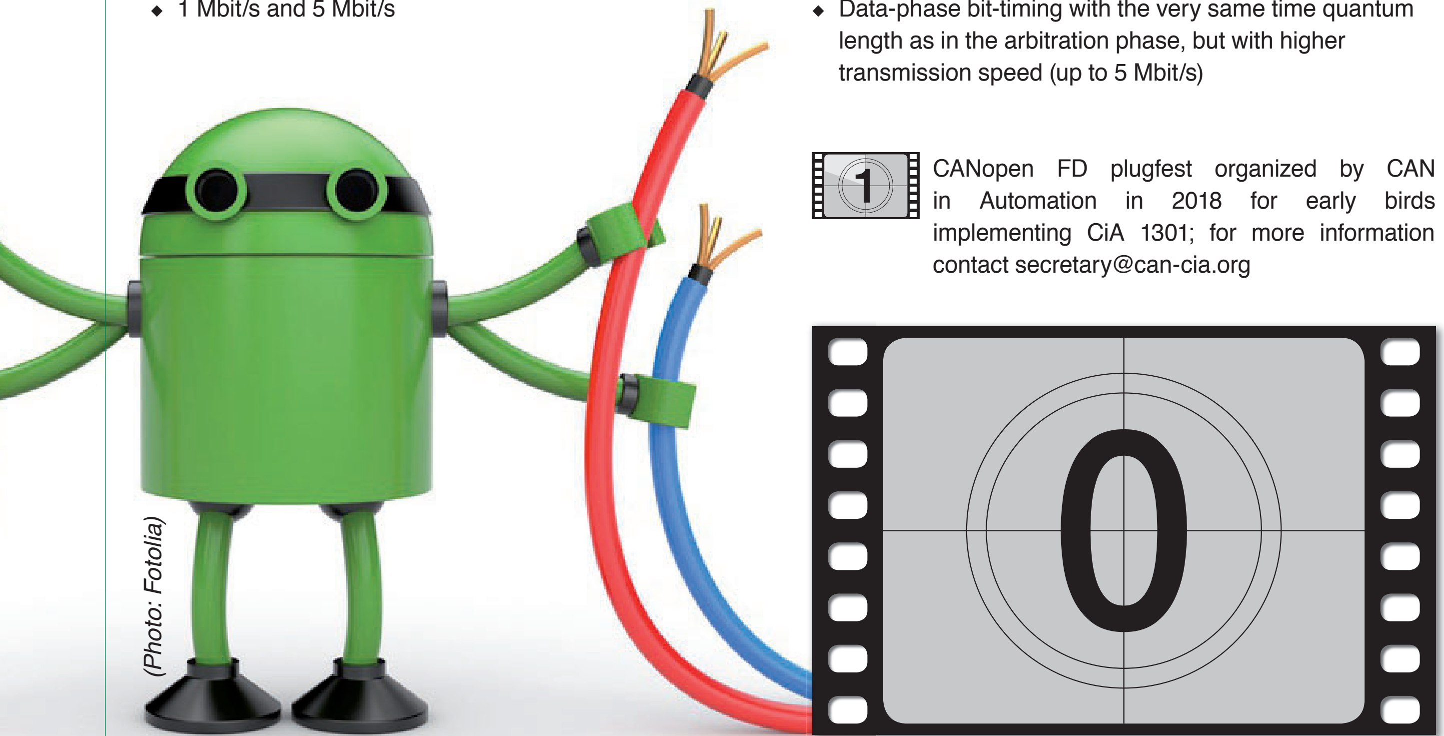
4 *pairs of bit-rates (arbitration phase and data-phase) are mandatory:*

- 250 kbit/s and 1 Mbit/s
- 250 kbit/s and 2 Mbit/s
- 500 kbit/s and 2 Mbit/s
- 1 Mbit/s and 5 Mbit/s

2 *bit-timing settings in CANopen FD:*

- Arbitration bit-timing as known from Classical CAN but with more time quanta, in order to minimize the quantization error
- Data-phase bit-timing with the very same time quantum length as in the arbitration phase, but with higher transmission speed (up to 5 Mbit/s)

1 CANopen FD plugfest organized by CAN in Automation in 2018 for early birds implementing CiA 1301; for more information contact secretary@can-cia.org



(Photo: Fotolia)

CANopen FD – more than just higher bandwidth

CANopen FD provides new CANopen features to meet future requirements in embedded networking, makes use of the higher data throughput provided of CAN FD, and keeps well-known features of the classic CANopen.

(Photo: Fotolia)

The purely event-driven CAN network had been developed with special regard to automotive applications. But it was not limited to this application field. Today CAN interconnects sensors and actuators to the host controller in many application fields. Due to the increasing requirement of data exchange, e.g. derived by connecting applications to the Internet, CAN-based networks have in some applications already reached their limits with regard to data throughput. To overcome these bandwidth limitations of CAN, Bosch has introduced in 2013, the new CAN FD protocol on occasion of the 13th international CAN Conference. Since these days CAN FD has been internationally standardized and considered by many carmakers. Therefore there is a high probability that CAN FD controllers will be available for reasonable prices from most of the semiconductor manufacturers, such as today for Classical CAN. For this reason several CAN-based higher layer protocols have already been adapted to CAN FD to make use of the advantages of CAN FD in the related application fields. Also the widespread used CANopen application layer and communication profile has been adapted. End of September 2017, CAN in Automation has released CANopen FD, in the document CiA 1301 Version 1.0. CANopen FD provides new CANopen features to meet future requirements in embedded networking, makes use of the higher data throughput provided of CAN FD, and keeps well-known features of the classic CANopen.

CAN with Flexible Data rate

In March 2012, employees of Robert Bosch presented the improved CAN FD protocol, which had been developed based on the request of the automotive industry. As illustrated in Figure 1, CAN FD data frames are able to carry up to 64 Byte of payload. This is an eight times enlarged data field, compared to the Classical CAN that is used today. Furthermore, such enlarged data fields are transmitted with an accelerated bit rate.

One requirement of the automotive industry had been, to keep CAN FD as reliable as today's Classical CAN. Therefore in CAN FD, the mechanisms used for the data integrity check were improved. A 17-bit CRC for data fields up to 16 byte as well as a 21 Bit CRC for data fields up to 64 byte ensure a very small residual error probability. In order to offer the benefits of CAN FD to their users, CAN-based higher layer protocols need to be adapted. Among others, the standardized and in many projects installed CANopen protocol was updated, as well. As a result, by end of September 2017, CAN in Automation has published the CAN FD-based successor of CANopen, CANopen FD in the document CiA 1301 Version 1.0.

When updating CANopen with regard to CAN FD, the responsible working group SIG application layer did not just lengthen the payload of the existing CANopen services but introduced new CAN FD-based, powerful means, for embedded networking. In addition, the working group did always try to keep the modifications of CANopen as small as possible. As a consequence, apart from minor clarifications, the differences between CANopen and CANopen FD are limited to modifications of CiA services that are limited in their efficiency by the Classical CAN data field. In particular these are the data transport-oriented services SDO and PDO as well as the Emcy write service. ▷

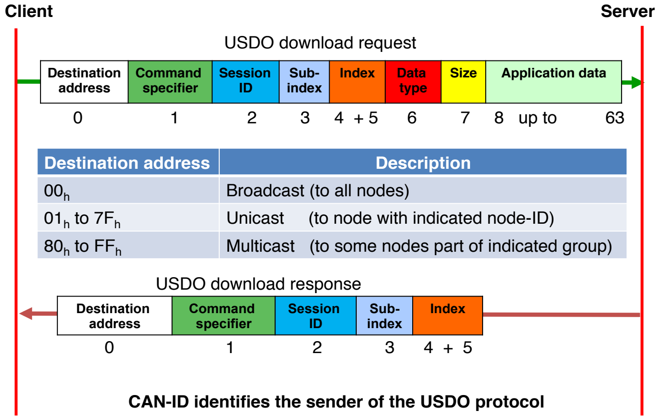


Figure 1: CAN FD data frame control field (Photo: CiA)

Therefore todays CANopen users have just to learn the possibilities, provided by the updated services and can save already existing CANopen know-how. This should ease the migration from CANopen to CANopen FD.

The process data object (PDO) was the service that could be adapted to CAN FD in the simplest way. Classic CANopen determines one PDO by means of two parameter sets, the communication, and the mapping parameters. The communication parameters, specifying the CAN-ID, triggering event, and busload management for this service, do not need any adaptation, as CANopen FD determines in general that all services are transferred in the CAN FD frame format. The PDO mapping parameters determine the data content that is transferred within the PDO, as reference to the local object dictionary. Already in classic CANopen, up to 64 data elements are mappable to a single PDO. Considering a minimum granularity of mapped data elements of 1 byte, no modifications are required. Implementations have only to shift the limit of data bytes mappable to a single PDO, from 8 byte to 64 byte.

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[4] CiA 301, CANopen application layer and communication profile

[5] CiA 1301, CANopen FD application layer and communication profile

[6] CiA 309, CANopen access from other networks

[7] ISO 11898-1, Road vehicles – Controller area network – Part 1: Data link layer and physical signalling

CAN Newsletter Online: CANopen FD

The CAN Newsletter Online reports briefly about products and services.

CiA 1301 specification

CANopen FD released

CAN in Automation has released the version 1.0 of the CANopen FD application layer and communication profile. CANopen FD is based on the CAN FD data link layer.

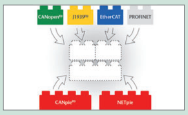
Read on

Interview

The future of CANopen FD

Uwe Koppe (CiA Technical Director), Christian Schlegel (CiA Business Director), and Reiner Zitzmann (CEO of CiA) answered questions about the next steps in CAN technology.

Read on



Embedded World 2017

CANopen FD protocol stacks

Microcontrol offers a new generation of its CAN protocol stacks. Migration from CANopen Classic to CANopen FD is possible at any time by exchanging one single component.

Read on

General assembly 2017

Electing CiA's board of directors

At CAN in Automation's (CiA) annual general assembly, the associations' members elected the board of directors.

Read on

16th international CAN Conference

The future is bright, but some things are still to do

The two-day conference took place in Nuremberg, the hometown of the nonprofit CiA (CAN in Automation) association. About 100 engineers attended this event.

Read on

A modification of the SDO service, which is intended for configuration and diagnoses, was much more complex. A simple enhancement of the SDO was just not possible. A solution, difficult to implement, but keeping all the limitations of todays SDOs, was rejected by the group. As a result, the SIG application layer decided to introduce a new service, the Universal Service Data Object (USDO). The new USDO allows establishing dynamical communication channels between one USDO client and one (unicast), several (multicast), or all (broadcast) available USDO server(s). The USDO enables accessing all data elements and reading or writing any amount of data, in a segmented way. This feature could be very advantages and time saving, in case of configuring several devices of the same type in the very same way, e.g. in case of firmware update in end-of-line production.

The USDO is simple to implement and the service is simply extendable. One of the next extensions of the USDO will be the adaptation of the logical addressing, as specified for classic CANopen in CiA 309. Due to its inherent routing capability, the USDO can become the most relevant CANopen FD communication object. E.g. gateway implementations adding an embedded CANopen network to the "Internet of Things", are enabled to provide any data element in the embedded network architecture to the cloud.

In order to allow more sophisticated diagnostics, the Emcy write service was adapted, as well. In addition to the error information of the classic CANopen, the CANopen FD Emcy write service provides further information on the occurred error event as well as a time stamp. Furthermore these error events can now be recorded in a more comprehensive, standardized error history.

CANopen FD will not just provide a higher data throughput to CAN-based embedded control systems. Especially the highly flexible USDO will serve as multi-function knife for embedded networking. It is able to meet the requirements, derived from more and more embedded networks that are either modifiable by the end user and/or connected to the Internet. In both use cases, the capability of establishing dynamically communication channels during system runtime is required and can be met by the USDO. The lengthened PDOs serve the demand for more data e.g. for generating the database for condition monitoring or predictive maintenance applications, or allow the support of sophisticated security features. CANopen FD provides these new features together with the option of reusing existing CANopen knowledge and CAN topologies. ◀

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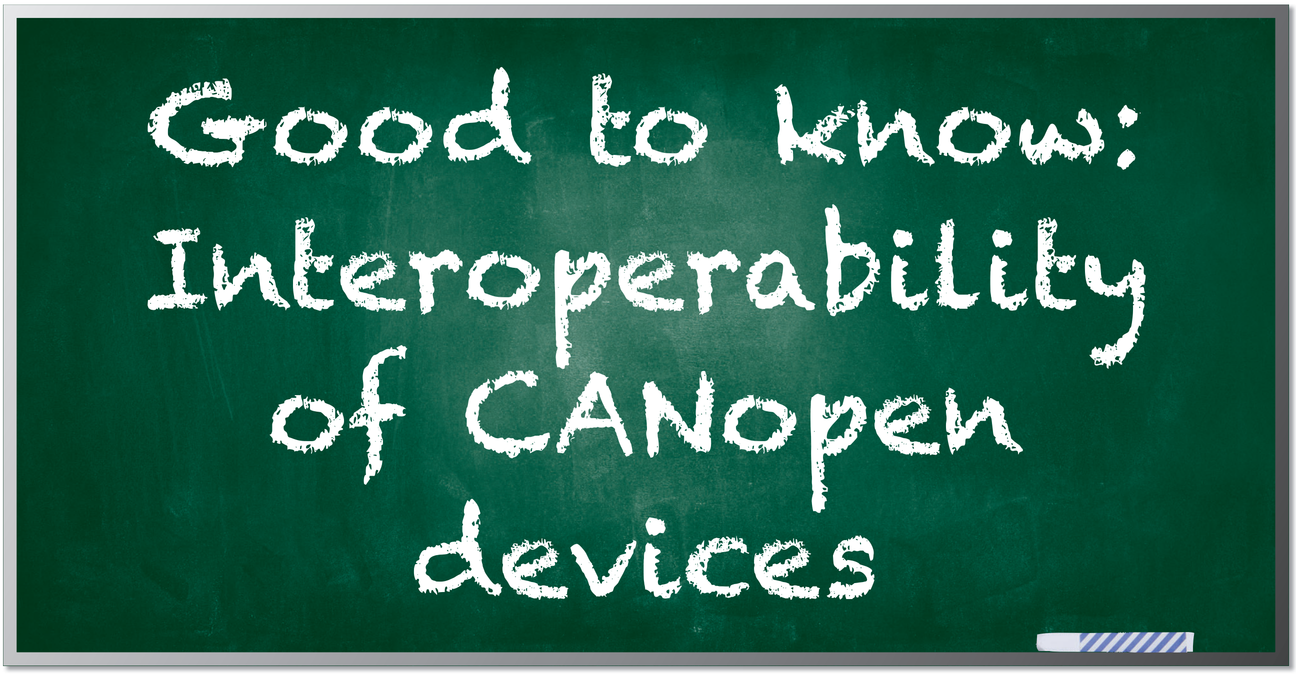

Conformity to CiA 301 does not guarantee interoperability of CANopen devices. In particular, SDO time-out and boot-up behavior needs to be evaluated by the system designer.

The system designer is responsible to select the appropriate CANopen devices. Of course, the provided functionality should match to the application requirements. This is obvious. But there is more to be considered. For example, that the SDO client time-out is configurable to the SDO server response time capability. Some CANopen devices are "slow" regarding the response to an SDO request. In particular, when the SDO write request is permanently stored in EEPROM or flash memory.

Another interoperability issue is the boot-up behavior. There are CANopen devices on the market, which send as required a boot-up messages with the Heartbeat CAN-ID and the 1-byte payload containing a value of "0". If the host controller with NMT master functionality uses the reception of the boot-up message as a trigger for the configuration of this device, it could happen that the device is still not in the NMT pre-operational state. In this case, the SDO configuration requests are aborted due to the SDO time-out configured in the host controller. Theoretically, there should be no delay, but some implementations are not immediately in NMT pre-operational state.

To overcome those interoperability problems, the system designer can program the configuration application software to wait for the Heartbeat message with the status pre-operational (value of 127) in the 1-byte payload. Unfortunately, the Heartbeat is by default disabled. This means, the host controller would wait until the cows come home. Of course, you can use pre-configured CANopen devices with a heartbeat producer set to unequal "0".

To summarize: Conformity to CiA 301 does not guarantee interoperability of CANopen devices. Nevertheless, conformity to the CANopen specifications increases the probability of interoperability with other CANopen conformant devices; in particular, when they have been tested by CAN in Automation (CiA). Interoperability can be tested by means of so-called plugfests. The CANopen Special Interest Group (SIG) "Lift" schedules bi-annually such plugfests to test new CANopen Lift products on interoperability. Additionally, CiA Headquarters organizes on members' demand general CANopen plugfests. ◀

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Keypads in a 28-m concrete mixer

Figure 1: The CAN-connectable keypads by Blink Marine are used in Coime's concrete machines (Photo: Blink Marine)

The CAN-connectable keypads by Blink Marine are used in Coime's concrete machines. The products support CANopen and J1939.

Coime Concrete Equipment based in Pregnana Milanese, Italy, is a longstanding Italian concrete machine company that designs and builds innovative equipment for interesting niche markets, and recently inaugurated its new 28-meter concrete mixer. This is a truly important machine, divided into three sections mounted on three axes, and even weighs 1 000 kilograms less than the preceding, 27-meter model. Boasting a 9-m^2 drum, the machine is embellished with keypads created by Blink Marine.

Relying on extensive experience in the marine sector, Blink Marine has developed versatile products that are easy to integrate with onboard commands, and intelligent from every point of view. We were given a chance to see them in action on the 28-meter Coime concrete mixer, a machine for which the company didn't hesitate to employ high-resistance steel, was used to realize all the arm sections, as well as the core structure of the machine, while the designers opted for high-quality Fe52 for the drum, utilized in order to achieve extended endurance. The pump group is a closed, high-pressure structure that includes 200 mm tubes that provide considerable drive, perfect for the particularly hard materials that often characterize concrete currently employed in various environments.

Figure 2: Keypads by Blink Marine (Photo: Blink Marine)

The machine does not have any electric panel, and is totally set in CAN networks, allowing it to save considerable added weight and guaranteeing an increase in reliability. "It's a perfect machine for the Italian market," explained Stefano Baiardo, Coime's Technical Director. "It's ideal for clients who have to deal with complex work areas, generally in mountainous regions, or in coastal zones like Liguria, where the passage to a four-axes equipment can prove particularly complicated. The machine is designed for those who want a differentiated machine fleet, in which the three-axes equipment resolves all the most difficult situations from the point of view of spaces within the work site."

Onboard, the machine boasts two Blink Marine keypads, one for each side. The smaller keypad presents essential functions, governing elements like the horn, the vibrator, and lights. The second, more complex keypad is used to command the concrete mixer (substituting radio commands) and the pump, regulating engine RPMs, and the mixer. "Our need to build command keypads for the driver was problematic, and furthermore it struck me as pointless to put inefficient key commands on machines of this quality," continues Baiardo. ▷

CANopen and j1939 keypads

The Powerkey Pro keypad features interchangeable icons for each key. The substitution system for the inserts makes working on the user interface as simple and economic as possible. It can be implemented in a separate manner for each key, reprogramming the bus at a later date without any need for challenging hardware interventions. The use of open protocols like CANopen and J1939 enables keypads an easy integration with the onboard systems present on worksite machinery, including earth-moving and earth-lifting machinery. Designed to guarantee extended life even under the most extreme conditions, the products boast IP67 classification for resistance to water and dust. All the models are resistant to sunlight exposure and operate at temperatures between -40 °C and +85 °C.

The keypads are easy to read and can be used in any given circumstance, due in part to smart management of the light signals produced by their incorporated LED lighting. They are available in four different versions. Powerkey Pro 2200 and 2400 (respectively four and eight keys) provide spacious (24 mm) keys for quick and easy recognition, as well as clear, distinct finger pressure even when using heavy gloves and operating the keypad outside the cockpit. Powerkey PRO 2300 and 2600 (respectively six and twelve keys) are high-density keypads with 15 mm keys.

“Instrumentation like these are often exposed to water infiltration and the keys often break. Traditional keypads require wiring, are clumsy and difficult to integrate within the machine structure. Blink Marine’s solution provides CAN connectivity, which was originally developed for the marine sector. From an IP point of view it doesn’t create any difficulty, and makes it possible to operate in any conditions. In fact we use Blink Marine products for our tunnel machinery too, as well as those working in saline environments. Best of all, these keypads are easy to connect and relatively inexpensive.”

“For our kind of production,” explained Baiardo, “we need continuous support from our suppliers. We always need to augment keypads with additional keys in order to enable new functions. As a consequence, we have to make sure we’re dealing with a flexible company, one that can respond quickly to our requests. That’s a perfect description of Blink Marine. Furthermore, their keypads have the advantage of making it possible to manage keypads at the level of software. Blink provides us a basic software as the remote element, a CANopen that interfaces with the main circuit, then lets us decide how we want to integrate it in complete autonomy and freedom.” ◀

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Analysis of atmospheric plasma processes

By measuring its dynamic electrical curve, an atmospheric plasma process can be monitored and controlled. The described solution uses a CANopen power supply connected to several sensors.

Figure 1: The PS2000 high-voltage supply in a 19-inch housing and the Plasmabrush plasma generator (Photo: Relyon)

The smartest way for predictive maintenance and avoiding machine downtime is having an exact knowledge of the process flow as well as all relevant parameters.

Maintenance planning in particular faces the daily challenge of ensuring maximum machine availability while at the same time minimizing material consumption for maintenance and repairs. This is a requirement, which most existing maintenance concepts cannot meet. The exit nozzles used in atmospheric plasma processes have a limited lifespan. Either, the nozzles are changed prophylactically at fixed intervals, accepting the fact that only about 70 percent of their potential life cycle is exploited, or the process is continued up to the point when it becomes apparent that the desired effect begins to lack in quality. In many cases, the latter is not acceptable as it involves the risk of producing substandard products or rejects.

Of course, there are other conditions, which influence process stability. For instance, fluctuations or faults in the system can be caused by the facility's gas/compressed air supply system.

An integrated process network is one of the keys to success. Network capability as such is not effective without the specific ability of recognizing relevant patterns in the primary process data and consequently triggering events (e. g. maintenance or readjustments). Our solution for predictive maintenance opens new ways of recording the current state of your plasma process in real time, without the use of additional sensors potentially susceptible to faults. The data is screened for patterns, which point to possible interferences. Any looming failures or malfunctions can be detected in advance and corrective measures can be planned and initiated in the best way possible in order to avoid unforeseen downtime and optimize the dedication of personnel and resources. If the information is integrated into an MES (Manufacturing Execution System), there is a multitude of possibilities when it comes to maintenance planning, quality assurance and constant process documentation.

Atmospheric plasmas have conquered many fields of industrial application. Relyon Plasma develops especially compact and durable plasma generators equipped with nozzles. The use of a unipolar-pulsed high voltage power supply and a vortex flow inside the nozzle keeps the electric arc from stabilizing at a "hot spot".

The electric arc rotates inside the combustion chamber at a high frequency. In spite of the high power density, the nozzle warms only slightly and the electrodes hardly erode at all. The plasma temperature can be freely adjusted over a wide range.

Our approach in process control is to monitor the electric impedance of the plasma discharge precisely and with high time resolution. The required measuring technology is already integrated into the PS2000 high-voltage supply by default. The data collected is processed internally and provided digitally on the CANopen network, without any additional sensors being necessary. The high-voltage supply unit has consciously been designed to be compatible with the internationally standardized CANopen application layer (EN 50325-4), which facilitates extremely robust and reliable communication in even the roughest industrial environment. A huge number of sensors also use this CANopen standard. All industrial controls commonly used worldwide provide the according interfaces, which come pre-integrated in modern versions.

For direct connection with any common PC, there is a compact USB/CAN interface and our Plasma-Control software for control and visualization purposes. Data points from the dynamic electrical map can be recorded with high temporal resolution and be transferred to the PC. Naturally, this communication can also be established with any other commonly used industry solution, PLC or IPC.

Figure 2: The basic communications package for USB bus including converter, CAN cable, terminating resistor and software on USB stick (Photo: Relyon)

The following typical process parameters greatly influence the effect, which atmospheric plasma jets have on the object treated:

- working distance
- composition of the process gases
- volume flow or pre-pressure of the process gas
- age condition of the nozzle
- conductivity of the substrate
- setting of the plasma output

The superordinate system determines a few other parameters such as the speed or the trajectory of the plasma nozzle relative to the substrate.

Variations in all of these influential parameters can be accounted for by the precise, time-resolved measuring of power and voltage in the control circuits of the power supply. The atmospheric plasma jet can thus be viewed as a probe or sensor, which is highly sensitive to any changes in the process conditions. In the simplest case, warning signals can be triggered if the predefined map range is exceeded.

Any variation in the plasma generator's airflow changes the flow conditions and the burning behavior. In practice, it is always possible to find a work area, which allows the process to run smoothly and where small fluctuations do not matter. However, unexpected short-term malfunctions or a steady drift (change in pre-pressure) may cause the predefined work area to be left, or signs of a systematic fault in the compressed air supply can become apparent. Even if the burning map of the plasma jet remains constant to the bare eye, a fluctuation in the air throughput of as little as one percent can already be identified clearly in the electrical parameters.

The example of a momentary dropout of the compressed air supply (e. g. caused by a brief squashing of the supply line) makes it apparent that the electrical response function shows a microstructure characteristic of a collapsed vortex flow. A fluctuation in the flow ratios causes the medium voltage level to slump down and the electric arc burns in an unstable way with stochastically variable length and intensity. This interruption of the electric arc can be delineated with a time resolution of one millisecond. In practice, it is not desirable for a system to immediately shut down when there is a very brief fluctuation. However, it is possible that in this short time interval of technical malfunction the products have been treated incompletely and an error message should be relayed to the superordinate system.

An oxidative erosion of the cathode drives primarily the nozzle's aging process. On the outside, the nozzles discolor and show signs of erosion at the nozzle exit. Even when there is visible outward wear, such a nozzle can still keep running steadily for a long time and fulfill its original function, e.g. activation performance. The practical question therefore is when the nozzle will have to be replaced and how the system will request this maintenance.

Interestingly, all aging processes show a similar pattern in which the original working voltage decreases and consequently, in order to maintain the "constant output" mode, the operating current increases accordingly. While neither an absolute voltage level nor the operating current are dependable indicators of a nozzle's wear, it is the fluctuations in electric current and voltage that reliably reveal irregular burning behavior. Changes in burning geometry and an unstable ▷

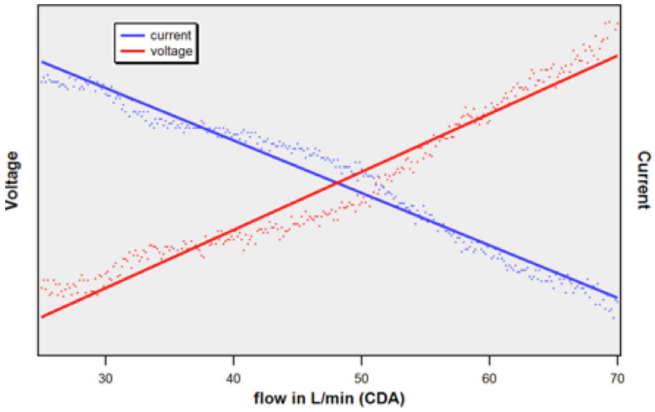

Figure 3: Over a time span of several hours, stochastic modifications were made in the air supply and the U/I parameters were read out of the PS2000; with rising airflow, the working voltage increases while the operating current decreases; under typical operating conditions, this relation is linear in good approximation (Photo: Relyon)

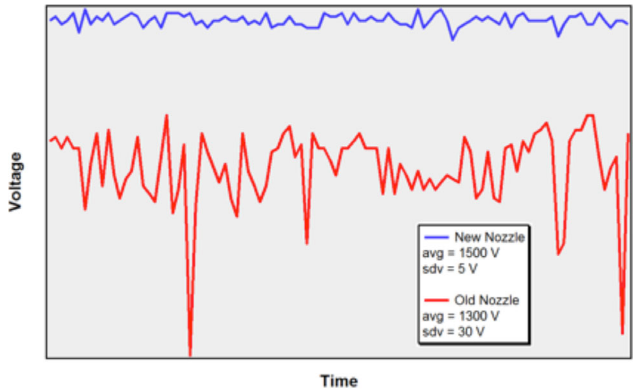

Figure 5: Comparison of a nozzle after 200 hours of operating time with a nozzle, which has reached its wear limit; both nozzles still provide good activation performance and run on identical electrical power; the worn nozzle shows first signs of flickering and a change in its burning geometry by displaying a six-fold electrical fluctuation margin in its working voltage (Photo: Relyon)

operating behavior are reflected in an increased standard deviation in the time-resolved measurements of current and voltage values. This information can trigger a proactive nozzle exchange without dismantling and visual inspection.

Not all applications use compressed air, but process gases such as nitrogen, CO2, oxygen or hydrogenous forming gas are also employed. Surfaces sensitive to oxidation, for instance, should principally be treated with inert nitrogen. Even the smallest amounts of oxygen might interfere with the process and substantially alter the plasma chemistry.

The U/I parameter reacts very sensitively to the gas composition. In the experiment presented, in which slight amounts of oxygen were added to a nitrogen carrier gas, even 0,1 % of oxygen were reliably detected. This proves the sensitivity of the method to be entirely satisfactory for practical applications using mixed gases.

A change in the process gas mixture can occur intentionally or be the result of a fault, such as a leak or a mixing component running empty.

In a production process, the nozzle is typically guided over the product to be treated along a predefined course. If a product, e. g. an electronic assembly, is composed of various areas with differing ohmic and dielectric characteristics, these changes will be reflected in the electrical parameters of the high frequency plasma process. If the plasma flame is to be used as a dielectric "probe", the pulse frequency may be varied in order to perform a contactless (that is, purely electrical) scan of the material.

A stable production process can thus be reliably facilitated, e.g. by detecting a missing product or wrong product on the conveyor.

The working distance is one of the parameters, which are of particular importance for a consistent interaction between the plasma beam and the surface treated. The local intensity of the plasma's effect increases sharply in a nonlinear way with diminished working distance. The jet is maximally focused near the nozzle exit and has its peak temperature there. Accordingly, there are higher concentrations of non-equilibrium species (ions, radicals and dissociated molecules) inside this hot zone of the gas flow. In order to achieve reproducible surface treatment, the working distance should be kept constant, with variation no higher than about ±1 mm. Consistent results within this tolerance band are best achieved by keeping a steady traversing speed and choosing a medium working distance of e.g. 15 mm. ▷

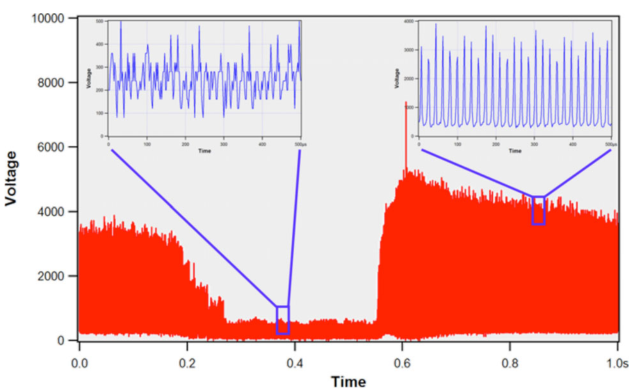

Figure 4: A brief drop in air supply of less than half a second causes an instable transient in the plasma's burning behavior; the disruption is short enough for the system to not shut down and keep running steadily after the dropout (Photo: Relyon)

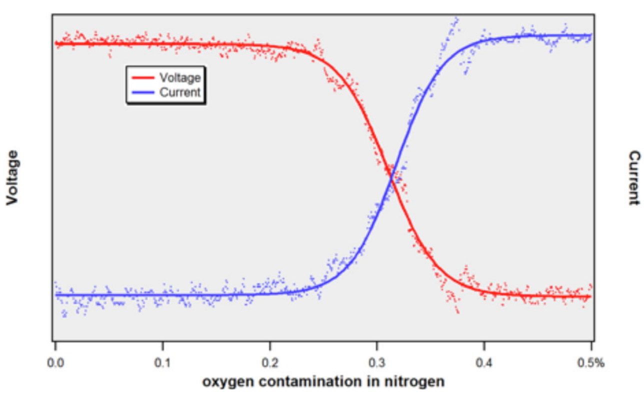

Figure 6: Oxygen is gradually added to nitrogen carrier gas until an oxygen level of 0,5 % is reached; even a modification of 0,1 % significantly alters the characteristic U/I curve (Photo: Relyon)

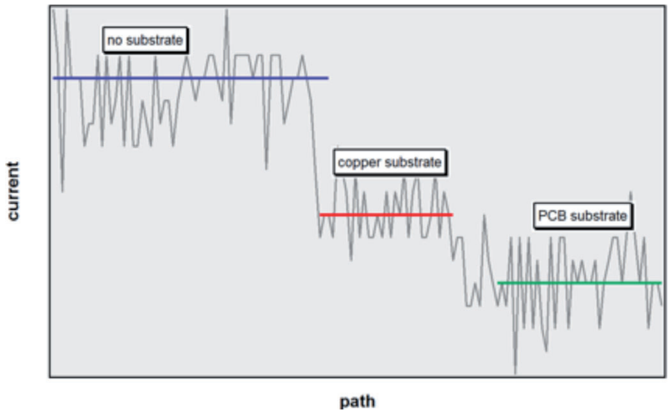

Figure 7: In this measurement, the plasma generator was run over a circuit board at constant speed; as soon as the plasma jet begins to cross the board, the impedance of the electrical environment alters, as it does again when the board's metalized area changes into not metalized area (Photo: Relyon)

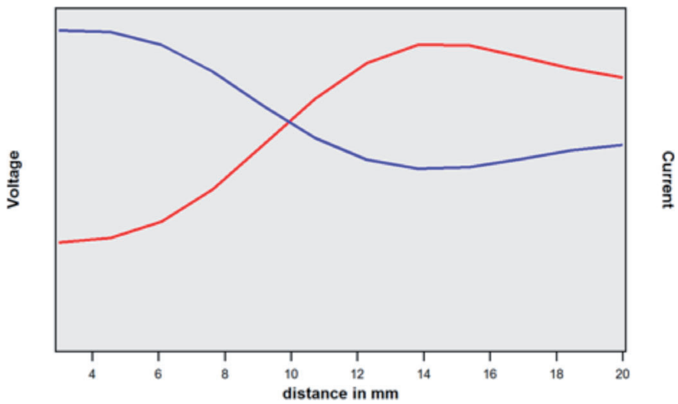

Figure 8: There is a distinct change in the current and voltage curve when the distance of the nozzle is reduced from 20 mm to 4 mm; above 20 mm, the curve flattens and approximates totally open jet behavior (Photo: Relyon)

In one application in vehicle manufacture, for example, the contour where a PUR seal is later applied onto the car body is pre-activated with plasma. The plasma nozzle and sealant nozzle are accordingly mounted onto a multi-axes robot. The relative positioning of the car to the robot can cause faults, which may lie outside the tolerance band. To counter this, the process can however be stabilized by adapting the performance parameters of the plasma generator without any mechanical readjustments of the initial positions; alternatively, the robot path can be dynamically reprogrammed. Naturally, the distance information gained from the plasma process can be read to serve as a collision sensor or be logged as a set of QS data. ◀

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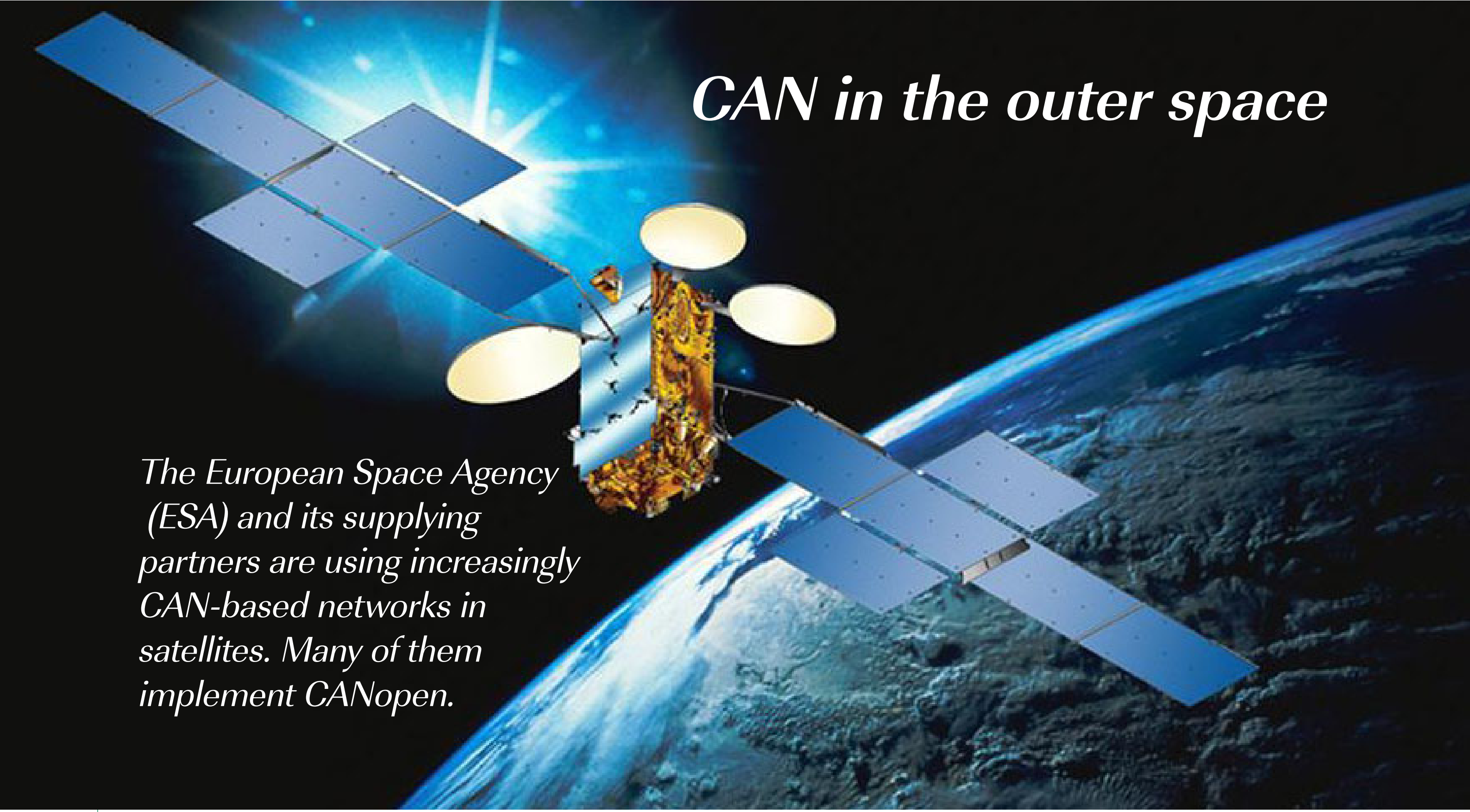
CAN in the outer space



The European Space Agency (ESA) and its supplying partners are using increasingly CAN-based networks in satellites. Many of them implement CANopen.

In summer 2017, ESA organized its "CAN in Space" workshop in the south of Italy. It took place in the facilities of CiA member Sitael implementing CAN and CANopen completely in Asics. About 60 engineers from ESA, satellite suppliers, device makers, and semiconductor vendors participated in the three-day event. "CAN for space is a true ESA success story," said ESA's Gianluca Furano. "Achieving standardization is an immensely complex challenge, requiring detailed engineering coordination among many different players, something that could only be achieved under the aegis of an organization like ESA, with the long-term support of the Artes (Advanced Research in Telecommunication Systems) program. As the aerospace industry adopts the CAN, the multiplier effect of the Artes investment should be enormous."

The market for satellite is still growing – especially for mini- and micro-satellites in the range of 30 kg to 100 kg. Several vertical markets are demanding more those small-sized satellites. This includes web providers, and oil-and-gas companies, and many others, who like to provide communication services in remote areas. Rumors tell that Google has ordered more than 1000 satellites. Market & Market, a research company, predicts for the next couple of years a growth of the satellite modem market from US-$ 282,4 million in 2016 to US-$ 420,4 million by 2023. This is an annual increase of about six percent.

In the past, satellites used frequently the MIL-STD-1553 bus system as embedded network. This approach was first published as a U.S. Air Force standard in 1973, and was used initially on the F-16 Falcon fighter aircraft. In 1978, the MIL-STD-1553B specification was introduced, which is still valid today. Since several years, CAN in Automation (CiA) member ESA develops jointly with the supplying industry CAN-based solutions for new satellite designs. Using radiation-resistant CAN hardware is not just cheaper, but also less power consuming. This is important, because there is an increasing demand to minimize the size of satellites. Nevertheless, CAN will not substitute existing MIL-STD-1553B networks, because of the golden rule in the space business: "If it works, don't touch it!" But for new designs, CAN will be preferred.

From EIA 485 to ISO 11898-2

The first CAN networks in satellites used an EIA 485-based physical layer. In the early days of CAN in space, no radiation-resistant ISO 11898-2 compliant transceivers were available. In the above-mentioned workshop several suppliers presented their CAN transceivers compliant to ISO 11898-2 (first edition) that fits for outer space applications. Key features are the SEL (single event latch-up), the SET (single event transient), and the TID (total ionizing dose) performance, measurements for the tolerance of radiation. All the announced transceiver chips fulfill the requirements of ESA.

At the ESA workshop, Cobham (UK) presented its UT64CAN333x family of ISO 11898-2 compliant transceiver family. It includes CAN transceivers with low-power capability, bus-isolated diagnostic feedback, or bus-monitor functionality. The supplier claims that the components are also suitable for CAN FD networks. As the products of the competitors, the 3,3-V chips are 5-V supply tolerant. They can drive up to 120 nodes. The worst-case loop-delay is 125 ns. The company reported several design-wins even one with a volume of more than 500 pieces.

Intersil a brand of Renesas has launched the ISL7202xASEH transceiver. The "rad-hard" 3,3-V chip is optimized for 500 kbit/s (medium-speed version) and 250 kbit/s (low-speed version), said the company. The total loop-delay allows cable lengths of 50 m respectively 150 m. The legacy product, the ISL7202xSHE is still produced. It has been developed in cooperation with ▷

ESA and Airbus. There are three versions available: listen-only mode and loopback, listen-only mode and split termination, as well as low-power mode and split termination.

Intersil has released also “rad-hard” CAN transceivers in plastic housings that meet the requirements of ESA and Nasa. This includes a one-time characterization to 30 krad (Si) at a dose rate of ≤ 10 mrad/s. The temperature range will cover -55 °C to +125 °C. The ISL71026MVZ comes in TSSOP package.

Microchip is developing a “rad-hard” CAN transceiver. This is done by the recently acquired Atmel department in France.

Texas Instruments introduced the 8-pin SN55HVD233-SP transceiver, which is available by end of 2017. The 3,3-V chip is short-circuit protected to ±36 V. The ESD protection exceeds 16 kV. The 1-Mbit/s compliant transceiver has propagation delay of 85 ns (low-to-high) respectively 120 ns (high-to-low). The common-mode range is -7 V to +12 V.

Radiation-resistant CAN controllers

On the previous ESA workshop on CAN in Space, CAN FD was regarded as oversized for satellite applications. This has changed. It is not the increased speed what is appreciated; it is the larger payload of up to 64 byte what matters.

The CAN protocol controllers for satellites need to be radiation-resistant. Besides FPGA implementations, Cobham offers a micro-controller with on-chip CAN modules. Microchip offers the ATmegaS64M1 8-bit micro-controller,

Figure 1: The workshop was sponsored by Cobham, Intersil, Microchip, Sitael, and Skylabs (Photo: ESA)

which is radiation-tolerant and features one CAN port. The on-chip CAN module provides six message buffers and has been conformance tested (ISO 16845-1). The sister products, the SAM3XE (Cortex-M3) and the SAMV71 (Cortex-M7) 32-bit micro-controller features two CAN modules providing eight message buffers respectively 64 receive plus 32 transmit buffers. The CAN modules on the Cortex-M7 micro-controller support the CAN FD protocols, too.

Currently, most in use is the Hurricane IP by Sitael. Unfortunately, this CAN core has some overload frame anomaly. This is reported in a technical note released by ESA. In brief: The CAN interface produces an indefinite sequence of error frames if an overload frame is detected in the second bit of the intermission field after transmitting a frame. This means no frames can be received and the current transmissions cannot be completed. Additionally, the CAN error counters remain incorrectly at zero during the sequence of error frames. The only known way to recover from this state is to reset the CAN controller.

Figure 2: The CANopen-based specification by ESA released in May 2015 (Photo: European Space Agency)

Higher-layer protocols

ESA has specified CANopen as the preferred higher-layer protocol for satellite applications. The ECSS-E-ST-50-15C specification released in 2015 requires a subset of CANopen application layer functions. One of the limitations is that this specification does not support SDOs, because up to now, no configuration is allowed. All the CANopen functions are implemented in hardware, e.g. in Sitael's CCIPC CANopen chip. This chip has been approved in several projects and missions. Leonardo has used it for example in the Exomars multi-rod drill unit system.

Sitael has implemented the ESA specification (subset of CANopen) completely in its above-mentioned FPGA. This includes the CAN data link layer as well as the required CANopen protocols, e.g. NMT and PDO. The FPGAs also implement the object dictionary and the application functionality. They provide 43 TPDOs, 24 RPDOs, and 19 SDO clients, Heartbeat producer and consumer functionality as well as NMT master capability. The NMT master can manage two CAN ports. Sync is supported as well. The chips comprise a 16-KiB SRAM and an 110-KiB flash memory.

Another implementation of the ESA's CANopen specification is the Picosky-FT system-on-chip (SoC) by Skylabs (Slovenia). This SoC is based on FPGAs by Microsemi. The Slovenian company provides also several development boards featuring two CAN interfaces. Additionally, the Nanortu cards are offered, which can be mounted in the Nanorack remote terminal unit. The unit can communicate via CAN with other equipment. It uses a redundant CAN-based backbone network. This approach is already CAN FD suitable and supports bit-rates up to 5 Mbit/s. Besides CANopen, it implements the proprietary CAN-TS application layer. In 2018, the company will launch its Nanoimager with 20 spectral channels. This product features also a redundant CAN connectivity.

The redundancy concept is not based on CiA 302. It uses the CAN data frames with 29-bit identifiers (extended frame format). The redundancy concept is based on the Heartbeat: The NMT master node broadcasts periodically Heartbeat messages on the active CAN port. If the NMT slave unit misses a number of them, it switches to the redundant port and start producing Heartbeats on it. The NMT master device switches to the redundant bus, and start broadcasting Heartbeats on it. All other nodes swap then also to the second CAN port. Infinite toggling is possible (process above repeated). This redundancy concept is already implemented in Sitael's CANopen chip (see above).

Sitael offers the S9216 CANopen development board, which is based on the CCIPC core implemented on the Proasic-3E FpGA by Microsemi. The Compact-PCI formatted board can be equipped with ISO 11898-2 transceivers. The Italian company provides also the OBDH (on-board data handling) card featuring four CANopen channels. It is equipped with a 32-bit ARM Cortex-M4 micro-controller. Another board-level product is dedicated for telemetry/telecommand (TMTC) applications. The board provides a redundant CAN interface. These products are used in the company's micro- and mini-satellite platforms. OHB System (Germany), one of the leading European satellite manufacturers, is also committed to use CAN and CANopen in future developments.

ESA prefers CANopen

Before CANopen-based products are going into the outer space, they need to be tested. Adelsy (Switzerland) provides such testing services covering the physical layer (based on EIA-485 or ISO 11898-2) up to the application layer (based on CANopen CiA 301). The test engineers are using commercial off-the-shelf tools from Esacademy, HMS (Ixxat), and Vector. Thales Alenia Space (France) has also tested CAN for space applications. The test system comprised up to 80 CANopen nodes. The French company will use CAN in its Spacebus Neo platform geostationary telecommunications satellites. ▷

Figure 3: The markets for micro- and mini-satellites is increasing (Photo: OHB)

Figure 4: The ESA workshop was accompanied by a tabletop exhibition; Skylabs presented its development boards featuring CANopen connectivity (Photo: Skylabs)

Airbus Defense and Space intends to use CAN-based networks in the Eurostar E3000 and Eurostar Neo satellites as a serial bus for telecom payload applications. It will replace the company's LSSB proprietary serial bus system. It is planned to run CAN at 250 kbit/s with up to 64 nodes in a 40-m segment. As higher-layer protocol CANopen has been selected. The CAN units include up/down converters, channels amplifiers, stable oscillators, telemetry transmitters, and telecommand receivers. So far, products from Airbus, Kongsberg, NEC Soace Technologies, Tesat, and Thales Alenia Space have been tested. First launch of CAN-based satellites are planned for 2019. Other applications with CANopen supported by Airbus Defense and Space includes the Exomars Rover running at 1 Mbit/s. There is a 7-m network with ten nodes and 3,8-m network with eight nodes. There are still some issues to be fixed regarding internal node delays and the currently used electronic data sheets (EDS) not compliant to the CANopen EDS specification.

Airbus Defense and Space has used CAN-based networks in the Larad (light advanced robotic arm demonstrator) project. It controls the six joints of the robot's arm. The joint's electronic is based on the AT90CAN128 micro-controller by Microchip (formerly Atmel).

The Exomars mission use also several embedded CANopen networks compliant to the ESA specification. They are installed in the Trace Gas Orbiter (TGO) and the EDL Demonstrator Module (EDM). Also in the Exomars RSP mission (planned for 2020) CANopen will fly to the Mars, in the carrier and descent modules as well as in the rover. By the way, CANopen was working without issues until the fateful moment, when the TGO was not more responding. CAN was even not mentioned in the failure investigation report.

Summary and outlook

"CAN for telecom payloads is assumed to be the enabling factor for equipment standardization and implementation of new functionalities while moving towards a minimum ▷

Figure 5: The Italian company offering the Hurricane IP core provides also hardware platforms for micro- and mini-satellites (Photo: Sitael)

harness. Going towards this standard will finally help to focus development effort on equipment key features rather than on interface adaptations," said Jens Freese from Tesat Spacecom. "Beyond the improved data bus performance and harness reduction, we expect that CAN for space will reduce time-to-market and insure interoperability," stated Jean Dalenq from Airbus Defence and Space. "During this development, all players (agencies, primes, equipment suppliers and components manufacturers) have pushed in the same direction. This was clearly a significant part of the success."

"CAN for space has been adopted by all the major European satellite manufacturers," said King Lam, ESA Spacecraft Engineer in the Telecom directorate's Platform section. "It is base-lined to be used for all their future commercial telecoms platforms and payloads. Eventually it should become a global standard, as satellite manufacturers in the United States move to adopt it as well."

CAN is reliable and robust. It is well suitable for applications, in which failures are not an option. ESA's CANopen specification will be updated considering the made experiences and the future functional requirements. The bit-timing settings should, for example, consider some extra cable length for connecting tools. A configurable bit-timing would overcome this problem. ◀

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CAN Newsletter Online: Aerospace

The CAN Newsletter Online reports briefly about products and services.

Aerospace

CAN on Mars

After seven month, the Trace Gas Orbiter (TGO) of ESA's Exomars 2016 has reached the Red Planet. Contact with the mission's test lander from the surface has not yet been confirmed.

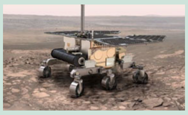
Read on

Aerospace

CAN we find life on Mars?

The successful launch of Exomars 2016 is the first step towards bringing CAN to the Red Planet. CAN networks are also used in other aerospace projects. Chipmakers provide radiation-resistant CAN transceivers and FPGAs.

Read on



Aerospace

CAN in space avionics

The European Space Agency (ESA), member of CiA, uses and will use in several space projects CAN networks. During the 7th workshop on Avionics Data Control Software Systems (ADCSS), one session was dedicated to CAN technology.

Read on

Large Hadron Collider

Restart with an improved superconducting magnet

The world's largest and most powerful particle smasher Large Hadron Collider (LHC) has restarted circulating beams of protons. It uses a lot of CANopen networks to control the high-energy physical experiments.

Read on

Aerospace

Looking to the outer space

In March 2013, the Alma (Atacama Large Millimeter/submillimeter Array) ground-based telescope starts operation. A special-purpose correlator comprising more than 134 million processors controls it.

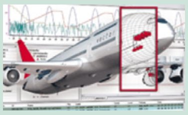
Read on

Oscilloscope

For applications in communication and aerospace

Rigol (Germany) has introduced the DS2000A-(S) series digital oscilloscope. It was designed to reduce test time in research, development, and failure analysis applications.

Read on



Aerospace

Increasing use of CAN

The demands on the availability of data in the cabin and cockpit have been increasing in recent years. Since many years, CAN has been used in airborne systems. With the acceptance of CAN technology by Airbus and Boeing, the standardization in the Arinc organization has taken off. Arinc 825 is the standardized higher-layer protocol for this industry.

Read on

Trigger the airbag of your neighbor's car

(Photo: Fotolia)

Recently, some German researchers detected vulnerability in the CAN-based communication, when intentionally deploying the car's airbag at the end-of-life on the scrapyard.

Security of automotive electronics is in the headlines. In the last years, the well-networked computer emergency response teams (Cert) reported several times about security vulnerabilities in CAN networks. Often the CAN protocol is accused and is therefore regarded as unsecure. Of course, CAN was originally not designed for security applications. This has to be done on the higher-layer protocols. Some CAN-based networks provide already in the application some security mechanism. Examples include the ISO 16844 tachograph systems and the ISO 26021 end-of-life activation of on-board pyrotechnic device standards.

Researchers from the university in Karlsruhe (Germany) detected that the secure CAN communication specified in ISO 26021-2 has some weaknesses. They found out that under some circumstances the airbag control units (also known as pyrotechnical control units) are affected. This issue was reported in the Common Vulnerabilities and Exposures (CVE) list under CVE-2017-14937. "The airbag detonation algorithm allows injury to passenger-car occupants via predictable Security Access (SA) data to the internal CAN network (or the OBD connector). This affects the airbag control units (aka pyrotechnical control units or PCUs) of unspecified passenger vehicles manufactured in 2014 or later, when the ignition is on and the speed is less than 6 km/h. Specifically, there are only 256 possible key pairs, and authentication attempts have no rate limit. In addition, at least one manufacturer's interpretation of the ISO 26021 standard is that it must be possible to calculate the key directly (i.e., the other 255 key pairs must not be used). Exploitation would typically involve an attacker who has already gained access to the CAN network, and sends a crafted Unified Diagnostic Service (UDS) message to detonate the pyrotechnical charges, resulting in the same passenger-injury risks as in any airbag deployment." ▷

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It is not that bad as described: The ISO 26021 series mentioned the password protection as an example and specifies additional optional security mechanisms –a dedicated hardwired line, for example. If OEMs just implement the mentioned 16-bit password with an 8-bit version number, it is easy to "hack" the airbags. Of course, the car has to be nearly in standstill.

Nevertheless, the seed and key pair required for the security access (SA) is calculated by means of a weak algorithm (key by complementation) complying with the example given in ISO 26021-4. "This ISO standard gives the impression that the description of the SA is not only an example for an algorithm but a binding requirement," criticized the researchers. "Thus, we suppose that several manufacturers copied the respective SA algorithm from the standard and implemented it without any alteration. This enables an attacker to calculate the proper key for the SA if he or she has the ISO 26021 available."

The researchers also attacked successfully the CAN interface by means of brute-force without knowing the key algorithm: "The ISO 26021 proposes to use a 2-byte key, which results in 65536 different key pairs to be checked by an attacker in case he or she does not know the algorithm. Furthermore, the ISO standard states the following: 'There is no time period, which needs to be inserted between access attempts'. Already these two weaknesses facilitate a brute-force attack on the SA seed and key pair. Additionally, the ISO 26021 requires that byte 1 of the only two-byte long seed includes the definite version number (00h) of the implemented load detonation method. This means that the first byte of the seed is known and the resultant seed and key pairs are reduced from 65536 to only 256 possible pairs."

The ISO 26021 application protocol, a crafted Unified Diagnostic Service (UDS) message, is running physically on the diagnostic interface. This means, for an attack you need access to the OBDII connector. Except, a wireless remote access OBDII dongle is installed and powered. In this case, you may have remote access to the diagnostic CAN network and can perhaps trigger the airbags. The airbag detonation attack is in reality very unlikely. Of course, OEMs have been already informed and the corresponding ISO working group calls for experts, in order to improve the ISO 26021 standard.

Denial-of-service attacks

Earlier this year, the ICS-Cert (Industrial control systems cyber emergency response team) listed a denial-of-service (DoS) attack related to CAN networks. Under ICS-Alert-17-209-01, Italian researchers described that they have successfully attacked CAN networks by means of insertion of a permanent CAN error frame producing electronics. Of course, this causes a malfunction of the network. Since many years, there are tools on the market for testing purposes doing the very same. To achieve the mentioned DoS attack you need access to the bus-lines. If you have physical access to the network, you can also just cut the network cable to corrupt the communication. Another DoS attack could be remove the wheels – possible when you have access to the vehicle.

The ICS-Cert recommends to limit access to input ports (specifically OBDII) on automobiles. But this does not help on the described DoS attack, which requires physical access to the bus-lines, in order to install the error frame producing component.

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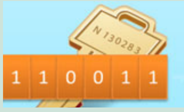
CAN Newsletter Online: Security

The CAN Newsletter Online reports briefly about products and services.



Security system

Securing CAN communication

The CANcrypt system by Esacademy (Germany) adds multiple levels of security to CAN. It supports the grouping of multiple devices and the encrypted and authenticated communication between them.

Read on

Security framework

Example software now available

After publishing the CANcrypt book, Embedded Systems Academy (Germany) now provides software examples on its security solution.

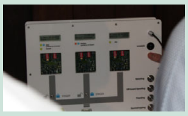
Read on

Processors with security

Protecting cars against cyber threats

STMicroelectronics protects connected cars against cyber threats with its latest automotive processors that feature built-in security and CAN moduls.

Read on



Secure transceiver

Engineering samples are available

NXP has developed a CAN FD transceiver with cyber security features. This includes an ID whitelist and a bus-load measuring capability.

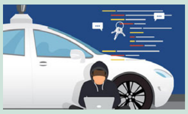
Read on

End-to-end solutions

Securing connected cars

Continental has introduced its security strategy, which includes to check continuously the communication on the CAN-based in-vehicle networks.

Read on



Remote attack

Security vulnerabilities

Recently, Keen Security Lab discovered another security vulnerabilities on Tesla cars and realized an attack to CAN-connected ECUs with latest firmware.

Read on

Capture-the-flag

Hack the car using an Arduino board with two CAN ports

Riscure and Argus Cyber Security have scheduled the RHme3 event, the third episode of a Hack Me CTF (capture-the-flag).

Read on

CAN fault confinement

It is a feature not a flaw!

The CiA Managing Director, Holger Zeltwanger, responses to the accusations that the CAN error detection and fault confinement has some cyber security weaknesses.

Read on

CANopen goes into the cloud

Gradient One brings instrument data collection, visualization, and analysis to the cloud, and is now compatible with CANopen devices.

The software's popularity is often influenced more by its platform than its intrinsic properties. Wordperfect failed to keep its eighties market dominance because it kept development resources in OS/2 instead of switching to Microsoft Windows as soon as possible. The resulting slow, buggy word processor drove people to switch to the newer Microsoft Office.

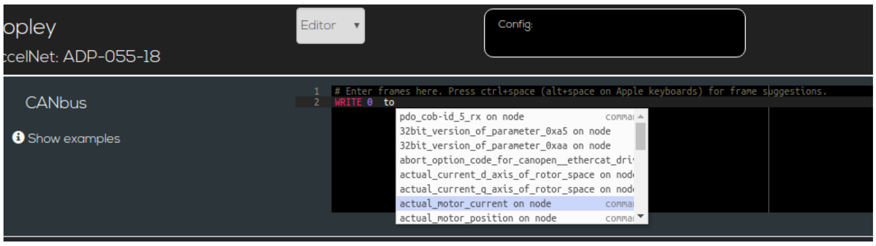


Figure 1: CANopen device control and data acquisition (Photo: Gradient One)

In 2006, Google bought a web-based collaborative document editing startup, which became Google Docs. Microsoft, assuming that Google Docs' popularity was driven by the desire to share documents but not the ability to edit them, released One Drive less than a year later, but only got around to releasing a web-based word-processor in 2009. But the computing landscape of the 2000s was already different from the nineties. The unpopularity of Vista meant that users were no longer willing to quickly adopt new Microsoft operating systems. Users could no longer guarantee that any two personal computing devices would be able to run the same software, while at the same time it was more and more likely that they had a web browser with an internet connection - the native platform of Google Docs. Because of this, Google Docs has surpassed MS Office in many industries.

While the word processor – the main piece of software for many businesses – has moved to the "cloud", the software for industrial research and development and control has not - and this is the problem Gradient One aims to solve. Gradient One is a web-based software application for automating instrument control, data acquisition, visualization, and data analytics. Gradient One recently introduced support for CANopen devices, including writing and parsing CANopen frames. Gradient One offers a free 30-day trial.

Gradient One's web-based editor facilitates the composition of CAN frames. CAN frames can be written out as a series of integers or hex bytes, or a human-readable format hinted by the editor using the SDO names from an uploaded EDS file. For example, both:

601_h, 40_h, 08_h, 25_h, 00_h

and

```
QUERY x on node 1
```

will generate the corresponding CANopen frame to query the SDO named x in the EDS file with the address of 25h, 08h. The editor also has a few python-like expressions for repeating frames, for example:

```
SYNC for i in range(10)
```

will add the CANopen synchronization frame to the queue 10 times. In addition to translating human-readable instructions into CAN frames, incoming response frames from the client receive human-readable explanations - for example, receiving:

601_h, $2F_h$, 60_h, 60_h, 00_h, 01_h

is interpreted as:

```
Writing 0x1 to 96,96,0 (mode_of_operation) on node: 1
```

Repeated PDO and SDO numerical data, including from arrays spanning multiple frames, are automatically detected and plotted in a chart based on timestamps. Status flag changes are plotted with vertical lines.

All SDO values, whether written to the device or read in, are saved in the search index for session's ID. Previous sessions can be found by looking up when a specific SDO had a specific value. Finally, the CANopen message queues can be named, edited, and saved so that the same configuration can be run multiple times, and errors uncovered by the previous runs fixed.

CAN engineers may also find Gradient One's analysis functionality of use. Gradient One has trained a Neural

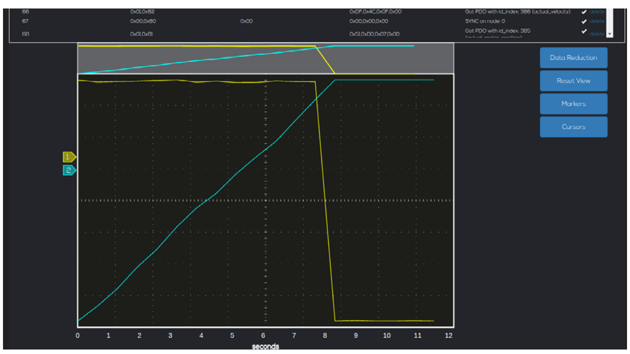


Figure 2: CANopen data visualization (Photo: Gradient One)

Figure 3: Cloud-powered analytics (Photo: Gradient One)

Network to decode the bytes in the arbitration field and data based on the voltage trace. Many higher-end oscilloscopes have the ability to decode digital protocols, however, few have Gradient One's ability to then interpret the decoded bytes as CANopen human-readable messages based on the EDS file. In addition, unlike the signal decoding capabilities of oscilloscopes, Gradient One can automatically identify the protocol and frequency, simplifying the decoding.

Other analysis tools can find matching patterns in x/y plottable series from either the detected plottable data from the CANopen messages or from the oscilloscope voltages, measuring fall/rise times in square pulses, and defining pass/fail criteria from threshold or in-range values of stored SDOs. These measurements can be chained together and then run against all or a subset of sessions based on the saved name. For example, a pattern could be defined around a known bad behavior, like a sudden jerk in a motor's velocity, and then the pass/fail criteria could be defined based on whether that jerk appeared in the trace data for all collected samples.

However, the most useful tool to most users is the ability to access and view previous test results from any device, be it a desktop computer in the lab running Windows, a tablet during a meeting, or a smartphone away from the office. It eliminates the hassle of having to worry about the cross-compatibility of drivers and testing software against different versions of Windows, or of keeping a local record of documents, just as Google Docs did for the word processor. ◀

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Communication from CAN to IoT

Insys Icom has created a system with its Smart IoT Ecosystem that is able to collect and process data via various protocols like CAN or CANopen – also using CAN Universal Gateways of MBS.

The Internet of Things (IoT) is driver for new business models and their implementation. Many companies want to realize innovative applications using data communication, but a variety of devices and protocols give distinction to the modern IT infrastructure: These so-called multi-protocol environments form new challenges for data communication. Insys Icom has created a flexible, adaptable system with its Insys Smart IoT Ecosystem that is able to collect and process data via various protocols like CAN or CANopen – also using CAN Universal Gateways of MBS.

The characteristic feature of the "new industrial world", also called Industry 4.0, is the integration and connectivity of different devices, sensors or actors, controls, web cams, measuring or monitoring relays. The range of serial or IP field devices that provide data to the operators, manufacturers, and service providers is wide. The devices often communicate via various protocols. If these coincide, so-called multi-protocol environments arise, which make data exchange and processing difficult. This is, because not each device "talks" in the same protocol as its counterpart – "language barriers" arise. The challenge for IoT solution developers is therefore to handle the variety of protocols that exist in the professional field, and avoid communication problems.

Insys Icom, supplier of professional data communication solutions, has found a possible solution with the Insys Smart IoT Ecosystem. It is a highly pre-integrated end-to-end ecosystem and contains all necessary elements to gather, process, and provide data from distributed applications quick and easy. The professional routers of Insys Icom, the so-called Smart Devices, themselves speak some common protocols like for Logo!, S7, MQTT, or Modbus TCP/RTU connections. So-called Destination Connectors are available with HTTP, e-mail, and SMS amongst others for transmitting data to customer-specific infrastructures like clouds, ERP, or Scada systems. Many protocols have already been implemented in projects: A Smart Device of the modular router series MRX is in theory able to realize each protocol technology using an extension card for example. Various serial or IP-capable devices and I/O peripheries can be connected easy, quick and, in particular, flexible with many different protocols accordingly.

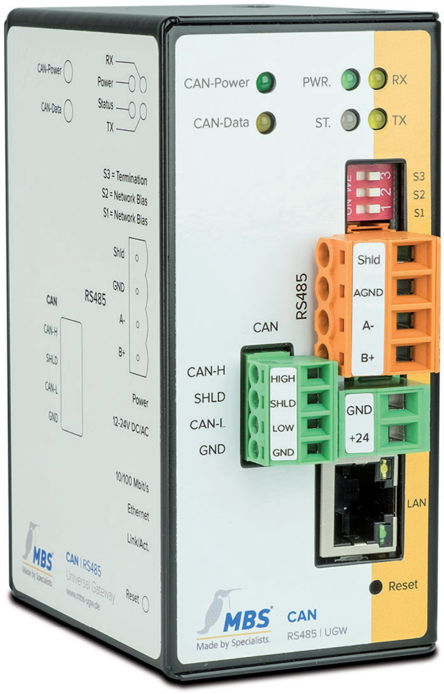

Figure 1: CAN protocol converter (Photo: MBS)

Nevertheless, field devices of Insys Icom customers that are connected to the Smart Devices sometimes use a protocol that is not known by the router. Then, an "interpreter" between customer device and industrial router will be used: The Application Connector as it is called by Insys Icom converts ("translates") the protocol into a protocol that is understandable by the router. Depending on the customer application, a suitable "Connector" will be prepared that can also be a combination of software and hardware. The company often resorts to the know-how of partners for such projects, like for the CAN and CANopen protocols: These are often used in applications for buildings, machine controls, or in the automotive industry. They can be integrated in the Insys Smart IoT Ecosystem using the CAN Universal Gateways of MBS.

CAN and CANopen for buildings and industry

CAN is used for wired, digital data exchange. Developed in the 1980s for the automotive industry and standardized as ISO 11898, CAN is also used in industrial applications for machine controls. The standard is also basis for CANopen, a protocol for modern automation technology (EN 50325-4). It is often used for the communication between field devices and process control in Europe. In the field of building automation, these are virtually the building's lifelines – air conditions, lifts, or energy supply systems that are interconnected for control and monitoring purposes.

Basically, the benefit of using communication protocols is that different devices of different manufacturers can act in concert in a network. This interoperability is ensured by the CAN Universal Gateways of MBS. They can be used for CANopen data exchange as quick and ▷

Figure 2: One of the Insys Icom Smart Devices (Photo: Insys Icom)

easy as for manufacturer-specific communication protocols with their integrated protocol-hardware-adapter – without the otherwise usual bus couplers and complex wiring. Moreover, the quick connection to serial or network-based communication protocols becomes possible. Data of the individual building systems will be collected locally and transmitted via CAN. The CAN Universal Gateways convert this information for data exchange in the building automation so that it can be evaluated by the staff in the control centers – transmitted and, if required, pre-processed by routers like the Insys Icom Smart Devices.

A fundamental security aspect is important here: The information to be collected and its use can be defined exactly to prevent manipulation of important building infrastructures. Security and control data can be excluded; values to be read and changed can be defined explicitly. Moreover, the amount of data to be collected will be reduced to the minimum. Benefits can be generated by using the IoT: The CAN Universal Gateways of MBS collect the previously defined data of the field level, convert, and forward them. Professional routers of Insys Insys Icom can pre-process these data locally and transmit them flexible to cloud services or Scada systems for example thanks to their integrated Linux environment and the software package Icom Data Suite. Moreover, the values can be visualized on a dashboard directly on the router or in the cloud.

Theoretically, a connection to each third party solution is possible and expressly desired with this system. The customer himself shall decide how to set up his infrastructure and which elements are ideal for it. The technical implementation of Industry 4.0 is very important since ideas have to be turned to sales in permanently decreasing periods. It is obvious that multi-protocol environments that can be found in M2M or IoT applications require complete solutions that adapt to the individual requirements of the users. A highly pre-integrated end-to-end ecosystem like the Smart IoT Ecosystem and the gateways of MBS allow to realize applications across various protocols. Such solutions become more and more important for the overlap of humans, data, and intelligent machines in the age of industrial Internet of Things and as long as there is no uniform standard. ◀

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Mobile machinery communication concepts

There is a growing demand for high bandwidth for function control. This article presents an overview of the current situation, a future forecast of the communication requirements, and a specific approach for meeting them.

There is a growing demand for high bandwidth – not only for diagnostics, debugging, and operation/start-up, but also particularly for function control. This is not only about sensitive and safety-relevant data. It also includes visualization or camera data, which, due to the simplistic wiring of the system, is not sent through separate cables, but is rather transmitted through a central backbone of the vehicle communications system. In this article we present an overview of the current situation, a forecast of the communication requirements for the near future, and a specific approach for meeting these requirements.

Current situation

Typical system architectures in complex machinery are based on connecting several ECUs (electronic control unit) via a sufficiently robust and safe (or at least it is made safe with additional protocol stacks) communication channel. CAN is the best known such standard, including the CANopen and CANopen Safety protocol extensions.

This communications standard is perfectly adapted to frequent, fast, time-critical transmission of small data packets (data lengths up to 8 bytes, data rates up to 1 Mbit/s – possibly even higher with CAN FD). However, it was rapidly acknowledged that there is a need to transmit – possibly less frequently – larger data packets. This need is met by e.g. the CANopen standard, which allows for the transmission of data packets larger than 8 bytes. However, this affects efficiency: it operates by the de facto separation of a larger block into the aforementioned 8-byte low-level packets, creating payloads of only 4 bytes maximum per packet, i.e. a maximum efficiency of 50 %.

The problem of diagnostics and system parameterization can – at least ostensibly – be tackled at system level, envisaging a system with a central ECU with a suitably powerful interface (often Ethernet or USB; for the sake of completeness we should also mention EIA-232). There are obvious disadvantages to this: the central ECU must gather diagnostic data from the system in order to be able to provide information to the associated diagnostic tool. Meanwhile, configuration files go in the opposite direction: rapid transmission from the launch tool to the central ECUs, then painstaking distribution within the system to the relevant ECUs.

These disadvantages, as well as the limitations for diagnostics and parameterization, can be avoided by connecting one or more of the ECUs in the system to a suitable high-speed backbone. Standard Ethernet should not be the first choice here: it is clear that solely on the grounds of cabling and connector standards (as well as EMC robustness requirements), Ethernet is not a sufficiently robust standard for use in mobile machinery. By contrast, a standard like BroadR-Reach (already established in the automotive industry, it can be implemented with simple twisted-pair cabling and offers data rates of 100 Mbit/s) is ideally suited. This standard is also seeing increasing use in the field of off-highway machines, since as well as its technical characteristics, affordable components are available; the agricultural sector is leading this field.

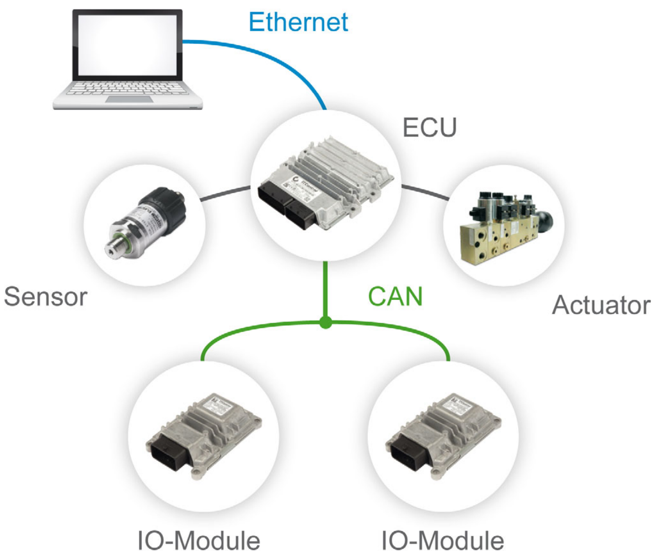


Figure 1: Simple system: one central ECU, several smart sensors, and I/O modules, diagnostic connection to a laptop over Ethernet (Photo: TTControl)

Tomorrow's requirements

As outlined above, a significant need will – we are inclined to think – continue to challenge generations of developers: the demand for sufficient bandwidth. It should be added that in this context, “sufficient” is a rather flexible concept (when does the memory of "640 KiB ought to be enough for anybody" fail to raise a smile?).

The request for bandwidth can be outlined straightforwardly by dividing demand into the following categories:

Program downloads: Size of available program memory in ECUs is continually increasing, in line with ever-growing application complexity and thus application size. For interfaces that do not change, the time required to program an ECU thus increases correspondingly. This is a non-negligible ▷

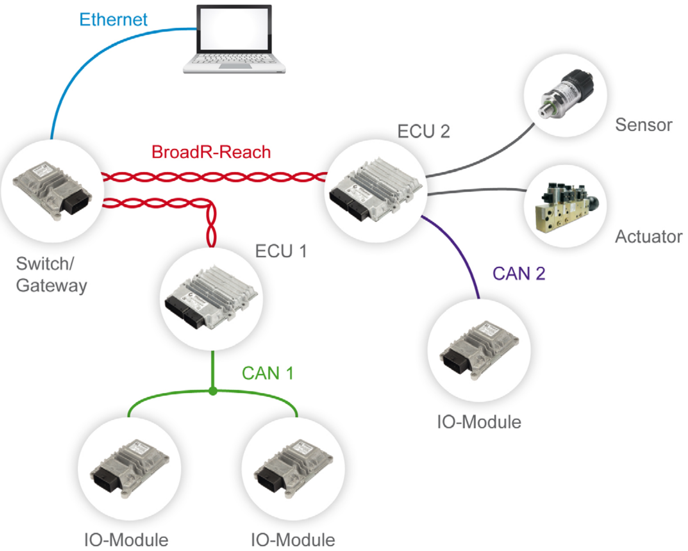


Figure 2: Complex system: two large ECUs, each connected to sensors and CAN nodes, gateway with diagnostic connection (Photo: TTControl)

contributor to rising costs, not only for development and maintenance (downloading new program versions), but also for production (end-of-line programming, production cycle time).

Furthermore, SW updates may in future be integrated remotely; however, for security reasons only powerful ECUs – capable of decrypting securely encrypted data in real time – will be connected to the internet. An Ethernet or BroadR-Reach backbone can help here with rapid distribution to the connected units.

Debugging and testing: In the “good old days” developers were happy if they could view the value of an individual variable while the system was running, without having to pause operations. Now, as complexity increases, testing, launch, and debugging are shifting more towards high-level abstractions in the control system, meaning that rather than outputting individual variables, they aim to display the progression of numerical process variables over time. This is not only a challenge for the runtime system of an ECU; it is also a challenge to make available the necessary bandwidth for the transmission of all this information along with the process data itself. Furthermore, if a possibility of intervention in ECU behavior should arise (e.g. modifying parameters or variables at runtime), then functional safety during communications also becomes a relevant consideration – depending on the planned application area.

Visualization and display: As well as the increase in the quantity of information required for debugging and testing, there is an ever-widening array of displays for operating personnel, showing process, and system states throughout operation. Due to the requisite wide range of possible system configurations, the display device mounted on the operator's platform does not always know all the details of some connected subsystem (e.g. a tractor-trailer with Isobus). The ECU for the attached unit (e.g. trailer) is responsible for providing the complete content of the operators display. It then becomes hardly surprising that the communication protocols currently used for this purpose – particularly subject to expectations shaped by mobile phone developments (“but ▷

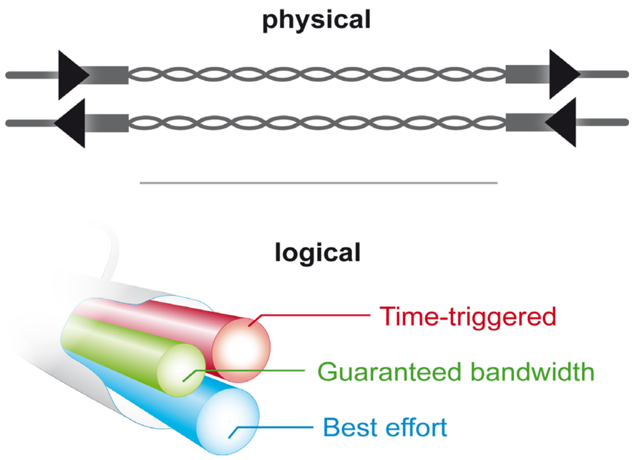


Figure 3: Time-triggered: Three channels in one (physical) cable (Photo: TTControl)

that's much clearer on my smartphone") – reach their limits relatively quickly.

Current communication approaches reach their limits even faster when the transmission of camera images (video streaming) also comes into play: greater bandwidth is needed to display areas not directly visible to the driver/operator (e.g. rear view camera, etc.) without making use of an additional network for transmitting analog video signals.

Given the current trend towards the Internet of Things (IoT), it can be assumed that Ethernet cameras will prevail over analog cameras. Particularly in the field of driver-assistance systems and self-driving machines, a significant share of the market will be given over to cameras with a direct connection to high-speed backbones.

Process communication: The requirements so far have been primarily concerned with use cases distinct from the actual control system operation, or with system status visualization tasks that are parallel to operation. However, the process communication itself also entails continually higher demands on communication bandwidth: increasingly powerful ECUs enable increasingly demanding processes to be dynamically controlled, thus making it possible to control systems which are not inherently stable in themselves and thereby improving their usability. As soon as the sensors, controllers, and actuators within a control loop of this kind cease to be connected to the same ECU, every communication between several ECUs gives rise to an unavoidable delay (or, in technical terms, time lag), which has significant consequences for the stability of the control loop.

For completeness, let us repeat here that the option mentioned initially, fitting out one of the ECUs with a suitably high-performance diagnostic interface, only meets one of the requirements mentioned in the above discussion, and that only partially.

Cabling: In addition to the performance specifications for communication channels, it should be borne in mind that the cost of an individual system cannot be arbitrarily increased to meet these. In fact, new technologies would ideally result in cost reductions. It can therefore be concluded that there should be as few connections as possible in the system (vehicle, vehicle - attachment or trailer, etc) – i.e., the cable lengths and the number of connectors should be minimized – and the requirements should be met using the most affordable media possible. To this end, a clear trend can be observed towards BroadR-Reach: an Ethernet-based standard which uses a simple twisted-pair cabling inside the vehicle.

Implementation of requirements

How would a future-oriented system architecture designed towards implementation of the above requirements look? For a simple system, the majority of the communications will be handled by currently commonplace standards (e.g. CAN or CANopen). A system is considered simple if it has the following characteristics:

- One central ECU in the system contains the complete control logic
- All other devices are smart sensors and/or I/O modules
- All process-relevant and diagnostic-relevant data is collected in the central ECU
- Only the central ECU has application-specific programming
- The central ECU is able to configure all other units (e.g. over CANopen)

With these restrictions, the need for a high-performance data connection within the system is reduced or eliminated. If the central ECU provides a dedicated diagnostic interface with correspondingly high bandwidth (e.g. Ethernet), then the currently foreseeable future requirements can also be handled well by a suitable system architecture.

However, the situation looks very different if this central role is not to be taken on by an individual ECU, but instead two or more ECUs form the intelligence of the whole system. The system architecture which then presents itself as suitable to meet the above requirements is a central communication backbone (e.g. based on the BroadR-Reach standard mentioned earlier). Technically, this backbone could be connected through a system diagnostic connector and also used for diagnostic purposes; however, it is recommended for security reasons that a gateway isolates the process communications from all externally accessible interfaces. This yields the additional advantage of being able to use an Ethernet connection as a diagnostic interface, thus

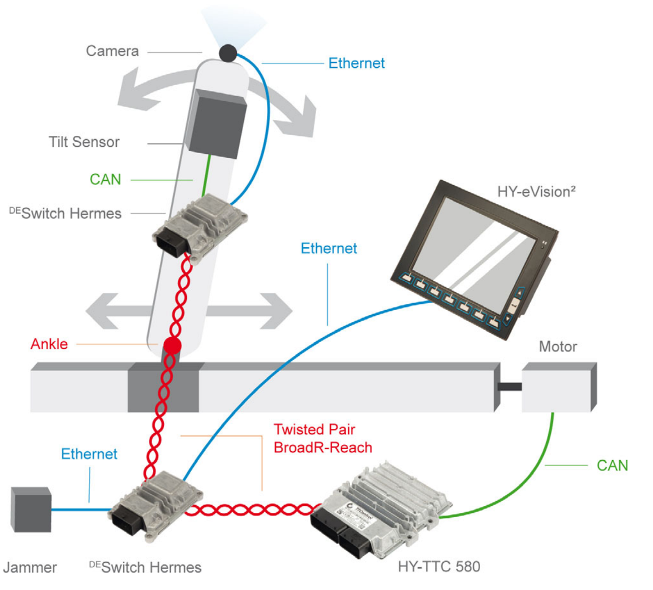


Figure 4: Pendulum demo setup including visualization (Photo: TTControl)

eliminating the need for additional interface modules when connecting a laptop.

It also might make sense - depending on the system complexity - to provide for further gateways in the architecture at each location where simple systems (according to the above definition) could or should be amalgamated into subsystems.

A division into further subsystems can also significantly contribute to reducing the load on CAN networks, since CAN/Ethernet gateways (among others), are able to map CAN IDs to IP addresses. They can then transmit messages to targeted addresses in the required subsystems, minimizing the bus load in unrelated bus subsystems or segments.

Process data – integrity: At this juncture, it is worth noting that during system architecture development it must be constantly kept in mind that bandwidth is not the only concern: if a system – particularly a safety-relevant system – makes bandwidth available during operation for the above tasks, it must be guaranteed in all cases that there is never any risk of compromising data relevant to the core functioning of the system. The concept of Time-Sensitive Networking (TSN) emerges as particularly promising here: in a nutshell, TSN can be described as providing a way to define, at the lowest communication layer, channels that have different priorities:

- Time-triggered: These data channels can be statically configured to specify absolute times when the communication media should be reserved for them.
- Guaranteed bandwidth: The available bandwidth is guaranteed for these channels (comparable with a CANopen PDO which can be sent at a specified time, but does not have to be sent).
- Best effort: These are data channels where as much bandwidth can be used as is currently available (the currently possible best effort can vary over time, e.g. because a guaranteed bandwidth channel is not being fully used at a particular time).

Following the above theoretical treatment, we will now prove our solution, describing our demo system in detail. Effectively, the system is yet another inverted pendulum, but we have raised the bar somewhat beyond a simple implementation:

- The tilt sensor sends its values over CAN
- A gateway connects the tilt sensor with the backbone (BroadR-Reach)
- The ECU with control algorithm is also connected to the backbone
- The same backbone is used to transmit the video stream between the camera and display

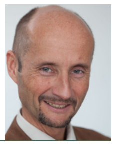
Two of the data channels described above are used in this demo: guaranteed bandwidth to transfer control-relevant data values to the ECU and best effort for transmitting the streamed video image from the camera to the display.

The choice of an inverse pendulum for the demo system was based on the observation that relatively small delays in transmission result in the pendulum no longer being stable and calmly regulated, and it can be clearly seen starting to swing. The loss of values over even a brief time period leads to its complete collapse.

This is particularly clear when an adjustable noise generator (a source on the backbone which sends an adjustable number of data packets per second) is activated. The separate data channels achieve the desired result: no effect on the control values is evident, although it can be clearly seen that image transmission from the camera is visibly affected as the rate of noise packets increases, ultimately coming to a complete halt.

Summary

The pendulum demo described above clearly demonstrates how a combination of hard real-time requirements and maximum bandwidth usage can be achieved combining devices currently available on the market, such as the TTConnect 616, with technologies such as BroadR-Reach, to effectively and efficiently meet boundary conditions in off-highway system contexts. It goes without saying that the devices not only fulfill the relevant safety requirements, but also meet all other requirements for the off-highway sector – robustness, EMC, impermeability, vibrations, etc. TTControl has thus succeeded in taking an important step in the off-highway machinery sector, towards establishing high-performance networking technology for the industrial vehicle sector. These components make it possible for the manufacturer to implement up-to-date applications in their machinery; ideally, incorporated into existing system architectures.



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Engineering

A bouquet of CAN FD compliant transceivers

Infineon has launched different versions of stand-alone transceivers and system base chips (SBC) supporting bit-rates of up to 5 Mbit/s. They are qualified for automotive applications according to AEC-Q100.

(Photo: Fotolia)

The CAN high-speed media access unit is standardized in ISO 11898-2:2016. It specifies the transceiver parameters for 2 Mbit/s as well as for 5 Mbit/s. CiA recommends to use even for 2-Mbit/s CAN FD networks implementations that comply with the 5-Mbit/s parameters. Nearly all automakers have started the migration from Classical CAN to CAN FD networks. Other industries are slower, except commercial vehicles. The market-leading truck OEMs and some manufacturers of construction machines have also launched internally CAN FD projects.

Infineon has developed a broad range of products compliant with ISO 11898-2:2016 supporting bit-rates of up to 2 Mbit/s respectively 5 Mbit/s. One of these products is the TLE9250X stand-alone transceiver. The product coming in a PG-DSO-8 or in a leadless PG-TSON-8 package is qualified for transmission rates up to 5 Mbit/s. While the transceiver is not supplied, the network is switched off and illustrates an ideal passive behavior with the lowest possible load to all other nodes of the CAN FD network. Fail-safe features like over-temperature protection, output-current limitation or the TxD time-out feature protect the product and the external circuitry from irreparable damage.

Based on symmetric CAN-H and CAN-L output signals, the component provides a low level of electromagnetic emission (EME) within a wide frequency range. The transceiver fulfills even stringent EMC test limits without additional external circuit, like a common mode choke, for example. The transmitter symmetry combined with the optimized delay symmetry of the receiver enables the transceiver to support 5 Mbit/s. Of course, this depends on the size of the network and the along coming parasitic effects.

Modes of operations

The TLE9250X supports three modes of operation: normal-operating, receive-only, and forced-receive-only mode. Mode changes are either triggered by the RM mode selection input pin or by an under-voltage event on the transmitter supply. An under-voltage event on the VIO digital supply powers-down the transceiver.

In normal-operating mode, the transmitter is active and drives the serial data stream on the TxD input pin to the CAN-H and CAN-L pins. The receiver is also enabled and converts the signals from the network to a serial data stream on the RxD output. The forced-receive-only mode is a fail-safe mode, which is entered when the transmitter supply is not available. The transmitter is disabled and the data available on the TxD input is blocked, but the normal-mode receiver is enabled. In receive-only mode, the transmitter is disabled and the receiver is active. The user triggers this mode.

There is also a power-down state, in which the differential input resistors of the receiver are switched off. The CAN-H and CAN-L lines are floating. The transceiver acts as a high-impedance input with a very small leakage current. The high-ohmic input does not influence the “recessive” level of the CAN FD network and allows an optimized EME performance. In power-down state, the transceiver is an invisible node to the network.

Fail-safe functions

The transceiver provides fail-safe functions like short-circuit protection, TxD time-out, and over-temperature protection. Additionally, the RM input pin has an internal pull-down current source to GND. All other logic input pins have an internal pull-up current source to VIO. In case the VIO and VCC supply is activated and the logical pins are open, the transceiver enters into the normal-operating mode by default.

The TxD time-out feature protects the CAN network against permanent blocking in case the logical signal on the TxD pin is continuously “low”. A continuous “low” signal on the TxD pin might have its root cause in a locked-up micro-controller or in a short circuit on the printed circuit board, for example. All these fail-safe functions are not required by the ISO 11898-2:2016 standard. They are implementation-specific, but usually requested by the automakers.

Further transceivers and SBCs

Infineon has also introduced the TLE9251X transceiver family providing the same features, but with additional wake-up ▷

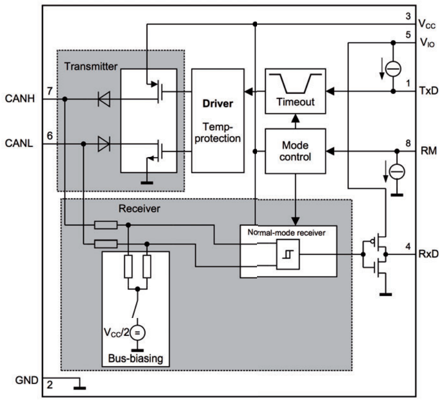

Figure 1: Block diagram of the TLE9250X transceiver supporting several modes and providing fail-safe functions (Photo: Infineon)

behavior. It supports 3,3-V and 5-V operations. Such as the TLE9251, the TLE9252X chips feature regular wake-up functionality and are coming in 14-pin packages. They also support Battery Supply Access. The TLE9255WXX provide selective wake up functionality according to ISO 11898-2:2016. Of course, all these products are qualified for bit-rates up to 5 Mbit/s. There are also 14-pin dual-port transceivers available. All these products comply with ISO 11898-2:2016. This standard substitutes the three predecessors: ISO 11898-2, ISO 11898-5, and ISO 11898-6. The related conformance test plan will be standardized in ISO 16845-2:2018.

The CAN transceivers are also available in SBCs. This are chips providing additional functionality. Infineon's Lite SBC family comprises LDO (low-dropout) regulators and DC/DC modules as well as one CAN transceiver. The mid-range SBCs feature one CAN and up to four LIN transceivers. There are also CAN products with DC/DC unit and up to four LIN transceivers. Besides those products in development, Infineon offers already the Multi-CAN SBC with four CAN transceivers.

Just the first step

The availability of ISO 11898-2:2016 compliant chips is just the first step. For device and network system more standardization is needed. It is necessary to standardize other physical layer components. CiA, Jaspar (Japan), and SAE (U.S.A) develop such specifications. Recently, CiA started a recommendation for common-mode chokes and for cables. SAE has released already the SAE J2284-4/5 recommendations for dedicated CAN FD networks and Jaspar has launched also some device and system design recommendations.

Some applications would benefit from ringing suppression circuitry integrated into the CAN transceiver chips. In particular, if non-linear topologies are used, for example hybrid topologies with one or multiple stars. The usage of ringing suppression circuitry is also suitable, when higher bit-rates than 5 Mbit/s are demanded. There is a CiA task force specifying the requirements for ringing suppression. Infineon is actively participating as well as Denso and NXP. Of course, OEMs participate, too. ◀

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Sensing the load and adapting the phase current

The Loadsense drives by Sonceboz comprises power electronics and an integrated controller. The products featuring brushless motors provide CANopen connectivity and are suitable also for "outdoor" applications.

Figure 1: The Loadsense drives come in Nema 34 format (Photo: Sonceboz)

At the device level the Loadsense drive technology represents a first step towards decentralized control, whereby existing modules – in the field of actuation these are a motor, a transmitter, and the drive electronics – are equipped with a CANopen interface. In order for decentralized actuators and sensors to satisfy requirements regarding reliability, working life, and often unfavorable environmental conditions, it is advisable that such systems are designed as integrated mechatronic units. The family of Loadsense drives from Sonceboz, is an example of such an approach. The motor adapts permanently the phase current to meet the torque load. This reduces the energy consumtion.

A brushless multi-pole motor is the drive technology used in conjunction with Loadsense. Such motors have already proved themselves in tough environments for many years, for example, in actuators for hydraulic systems on John Deere and Agco Fendt tractors. A robust magnetic sensor has been specially developed to detect the actual value for the position control loop. It offers high resolution, which permits evaluation of the load angle of the motor and thus creates an actual value equivalent to the motor load. This gives its name to the Loadsense drive family. The information on the load controls the motor current and thus ensures energy-efficient operation combined with low heat generation and smooth running. In addition, the motor can be controlled without restrictions right down to speeds of zero rotations per minute.

Suitable for outdoor applications

When installed in a housing of protection class IP67 and an extended temperature range of -40 °C to +85 °C, new fields of application open up, for example in outdoor areas or in applications that are greatly exposed to dust or moisture. Many industrial solutions are unsuitable due to a lack of impermeability or temperature stability. The high level of integration of motor, transmitter, driver, and control electronics enable Sonceboz to reduce the number of components and internal interfaces, and permit a very compact physical design. With a power supply of just 24 V_{DC} to 48 V_{DC}, the drive can also be powered directly from batteries without requiring inverters. Furthermore, the drives can be integrated into complete systems by means of the CiA 402 CANopen device profile for drives and motion control, which is a standard for many client applications, such as tooling machines or solar plants.

It is precisely such decentralized systems that demand mechatronic drive units, which can be easily combined and pre-tested, which encapsulate the complexity and thus contribute to the clarity of the concept. The integrated electronics of the drive family provide analog and digital inputs and outputs that can be used for specific control tasks directly in the motor environment. Integration into an overall system is achieved by means of standardized communications interfaces such as CANopen. Due to the CANopen integration, the driver offers complete versatility to the user: SDO configuration to tackle most application's needs; and PDO mapping for tailored, fast and dedicated data exchanges.

Multiple modes of control such as position, speed, etc., enable one solution for multiple purposes. Moreover, it was an easy integration for Sonceboz, as an efficient stack of the CiA 301 application-layer was bought and quickly set up in the micro-controller. Not only can manufacturers take advantage of the CANopen integration, it is also the client that goes from a complex centralized clock and direction control system, to a simple CANopen communication and Loadsense motor. In the end, a smarter and simpler solution with better performances is achieved.

For specific functions, there exists the option of creating application-specific software and transferring them to the drive for local execution. Many applications not only demand the shortest possible downtime for maintenance purposes but also flexible adaptation to suit new applications. Downloading software functions via the network provides an appealing basis for such adaptations. The inbuilt diagnostic functions also contribute to minimizing downtimes. They facilitate access for remote maintenance and thus contribute to the high availability of the plant.

Many applications for industrial positioning drives and intermittent drives (S5 mode) demand torques in the Nm range at low to medium speeds of 1 000 rotations per minute. Geared motors are often used for such applications. However depending on the loadings, the gearboxes may ▷

quickly come up against the limits of their working life. The only wearing parts are the two sets of ball bearings on the motor. This means that the actuator can even withstand continual switching between high acceleration and braking torques without any problems, so that well over 40 000 operating hours are reliably achievable at torques up to 8 Nm directly at the motor shaft. A direct drive eliminates the mechanical play on the gearbox. In conjunction with high-resolution sensors with a resolution of 0,06° per increment this enables them to be used even for high-precision applications.

The smooth running, low generation of heat, and long working life, mean that the drives are used in medical devices for blood pumps, for example. The compact physical design, the programmable control functions, and the direct drive eliminating the gearbox for high availability allow it to satisfy the requirements of manufacturers of intra-logistics systems such as roller conveyors. Their overall efficiency and their power supply of 24 V_{DC} to 48 V_{DC} make them a suitable drive module for mobile machines, since they do not require a complex power system with inverters. Applications for direct drives outdoors, where dust-tight and watertight characteristics coupled with freedom from maintenance for decades of operation are required, for instance, heliostat drives in CSP solar panel installations.

Sonceboz specializes in developing innovative solutions for demanding drive problems in industrial, medical, and automotive applications, and undertakes large series production of industrialized drives, always with the aspiration of achieving 0 parts per million. The challenges of a hostile environment such as high levels of vibration, extreme temperatures, high IP protection ratings, long working life, flexible integration within tight spaces and miniaturization of the control electronics with network communications and sensors do not present a problem for Sonceboz mechatronic drive systems. This is, because, for the Loadsense drive family, as with all other Sonceboz products, the customer benefits from the expertise of the Swiss company, built up through decades of experience and fundamental research in the various fields, and serving as the basis for new solutions. With its product range designed on the modular principle, the company offers the customer maximum flexibility with solutions to satisfy the customer's individual requirements. ◀

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Two axes as a single CANopen node

Ferrocontrol, a daughter company of Eckelmann has extended its portfolio of 2-axes CANopen servo controllers. The units comply with CiA 402.

Figure 1: New E°Darc C08D double axis module and compact dynamic servo motors by Ferrocontrol (Photo: Ferrocontrol)

Ferrocontrol develops, manufactures, and distributes automation components and complete automation solutions in the field of drives technology (hardware and software) for the manufacturers of processing machines. "Our goal was to develop a controller that is easy to configure and maintain, even for complex systems, so that highly automated production processes can be designed efficiently and economically", Peter Schicker, technical sales department at Ferrocontrol, said. "To meet these requirements, we developed the FPGA-based drive controller E°Darc." The E°Darc family was introduced first at the SPS IPC Drives 2009.

The medium-sized company located in Herford, Germany, is one of the pioneers in the field of FPGA-based control algorithms for real-time processing in servo drives. The main advantages of this technology are a precise and fast current and position control by massively parallel processing and a more flexible architecture for application specific drive solutions. Ferrocontrol is a subsidiary of Eckelmann, Wiesbaden (Germany). Together, the companies act as a full-service supplier for machine automation worldwide. The product range includes drive and control technology as well as IPC technology and software.

The recent development is a powerful double-axis module. The E°Darc C08D integrates two power amplifiers

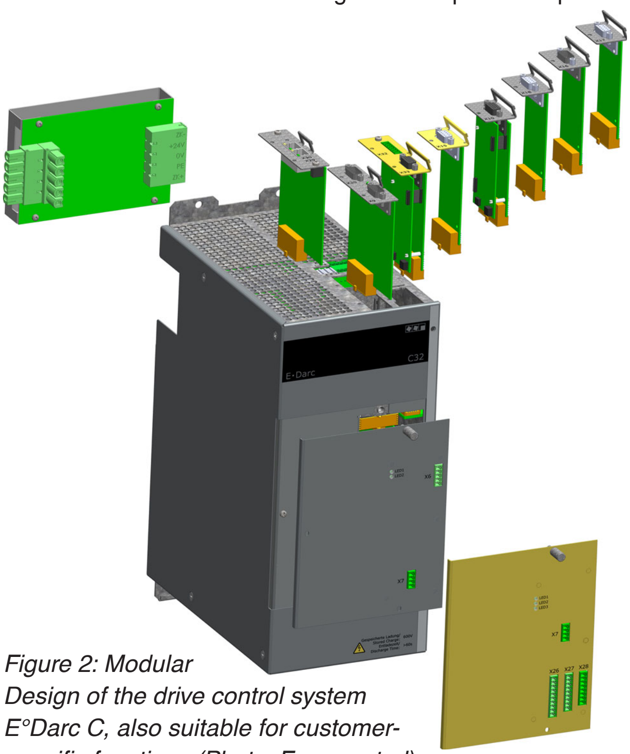

Figure 2: Modular Design of the drive control system E°Darc C, also suitable for customer-specific functions (Photo: Ferrocontrol)

and has a 2 x 8 A rated current. The design saves fieldbus interfaces as opposed to single-axis controllers and offers a cabling concept, which saves costs during purchase and assembly. FPGA-based control algorithms enable a dynamic control performance and positioning, depending on the configured control clock frequency (up to 12 kHz) for current control. The current measurement takes place virtually in real-time. In addition oversampling methods for position and current measurement acquisition improve the control quality without generating any latency within the control loops. This ensures that low-noise signals are available for current and position control. The main benefits of FPGA technology are therefore increased contour sharpness and higher production capacity. A pulse inhibitor STO (certified according to SIL 3), which is implemented as standard, ensures a reliable interruption of the power supply to the drive.

The E°Darc C08D is suitable for the controlled operation of synchronous and linear motors and can be operated with Ferrocontrol motors, which are optimally matched to the controllers. At the encoder interfaces, the controller is convincing by its diversity: resolver, Hiperface, Endat, Sincos, and incremental. The drives can be connected via a CANopen or Ethercat interface.

The CAN interface of the product has been realized as a multi-device according to CiA 402 series: one CAN interface hardware, one CAN address, and a doubled object directory for two drive axes. The module has a freely configurable PDO-mapping for cyclic process data communication. The following CiA 402-compliant standard operating modes are implemented:

- IPM (Interpolated Position Mode),
- PPM (Profile Position Mode),
- PVM (Profile Velocity Mode),
- HM (Homing Mode)

The service operation of the controllers is implemented via CiA's (CAN in Automation) remote-bit-mechanism. The service tool can use the connected PLC ▷


Lufthansa LEOS

Dr.-Ing. Marco Münchhof (Photo: Eckelmann)

Eckelmann celebrates 40th company anniversary.

In 1977, the success story of Eckelmann in Wiesbaden took its start. Since then the engineering firm of the founder Dr.-Ing. Gerd Eckelmann has grown into a prospering medium-sized company group, whose automation solutions are used in many sectors all over the world. Whereas earlier Eckelmann focused on microprocessors for industrial application, today the company is an experienced partner in digitalizing and connecting industries. Eckelmann and its subsidiary companies in Germany, Czech Republic, and China count about 450 employees. In 2016 the revenue amounted to 60 million euros. Ferrocontrol; Herford is a subsidiary of Eckelmann since 2006.

Q: Good morning, Dr. Marco Muenchhof, you are a member of the Management Board of Eckelmann. One of the main focus has always been the machine automation, which you now provide as a complete equipment supplier together with your subsidiaries Ferrocontrol and Rex Automationstechnik. What is so special about the machine solutions from Eckelmann of yesterday and today?

A: Eckelmann's experience with CNC controllers in fact dates back to its founding years. Following an initially strong customer and technology-specific phase, the company changed its focus during the course of the years to universal controllers to cover a broad application range. What has not changed over the years is our strong focus on high quality and reliability of our products as well as our passion for engineering. We strive to make complex things simple to use. Therefore, we also offer complete solutions for different industrial branches as e.g. cutting, window processing and SMT processing. Also, close customer relationships have been and will always be important for us. Therefore, customer-specific extensions and functions continue to be strength of our controllers.

E°EXC 88 embedded controller for PLC, motion control and CNC solutions (Photo: Eckelmann AG)

Q: How important are standards such as CANopen for your solutions?

A: Since the mid 1990's, our E°EXC controller supports CANopen as a powerful, flexible, and robust fieldbus protocol. Several thousand machines have been automated successfully using CANopen. In our endeavor to make complex things simple, we have equipped our controllers with plug&play functionality. For example, if an E°Darc C drive controller is connected, the controller already takes care of the correct network communication initialization. By offering up to four independent CAN segments, we have never encountered problems due to limits in busload or communication speed on the CAN segments. In fact, even in highly dynamic multi-axes applications using several drive controllers, we have always been able to provide a high level of synchronicity. Our standard controllers provide up to 32 CNC axes and 64 motion axes, which can also act as combined axes. However, we have also provided an application with 12 CAN segments that controlled over 700 drive controllers.

Q: What are the main advantages of CANopen from your point of view?

A: It's extreme reliable and robust and is designed for real-time communication from the very beginning. Despite the advent of Ethernet-based protocols, I still see a long future ahead for CANopen. It is a well-established protocol and we will also continue our support for CANopen in parallel to Ethernet-based field busses. There are a lot of machines out there based on CANopen communication and these also have to be supported in the future, not only with spare parts, but also with new functionalities e.g. in retrofit. In addition, CANopen is still an attractive choice in terms of easy wiring and low wiring cost. Especially in small embedded solutions it will be a good choice, also for the future.

hardware as a "gateway" to the drive. Thus, no rewiring is necessary and the machine HMI can also be used as a typical commissioning notebook.

Despite the increasing use of Ethernet-based fieldbus systems, CANopen still plays an important role in the area of drive control and has a firm place in machine automation. This is thanks to CANopen's sophisticated and powerful application profiles, such as the CiA 402, which allows drives to be connected easily and flexibly. Nowadays, the CiA 402 series is one of the most commonly used drive profiles. Many standard tasks are covered, from tasks such as positioning or speed control to controlling processes. However, it allows you, in addition, to implement your own special functions. Peter Schicker emphasized: „As a provider of customer application- and customer-specific drive solutions, e.g. for profile machining centers, this flexibility is important to us."

Another advantage is the rapid and on-demand exchange of process data, i.e. of real-time data such as target and actual values. For example, multi-axis systems can be controlled precisely and with minimal response times via a synchronization pulse and without unnecessary overhead. And also for the efficient transfer of device parameters, such as when the machine is started up, CANopen ▷

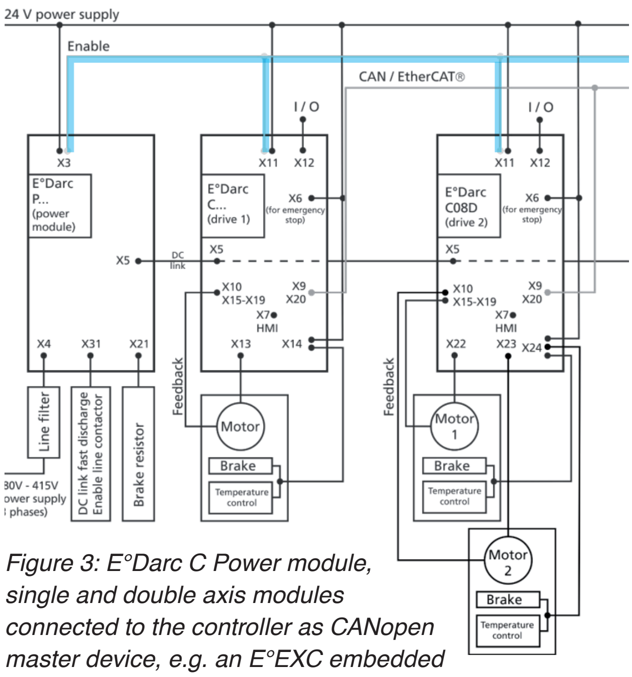

Figure 3: E°Darc C Power module, single and double axis modules connected to the controller as CANopen master device, e.g. an E°EXC embedded controller by Eckelmann (Photo: Ferrocontrol)

offers a proven communication channel with Service Data Objects (SDO) to transfer such data cyclically. In the interest of a consistent communication, the drive system can be connected directly to the control via CAN network, such as, for example, the E°EXC controller from Eckelmann for CNC, Motion, and PLC applications. The controller can control up to four independent CAN networks.

Ferrocontrol designed the E°Darc system so that the entire drive control is on one FPGA in parallel, "cast in VHDL" so to speak. This quasi-analog control provides the greatest possible dynamics, even for position and rotational speed control.

As already stated, oversampling procedures are used for capturing position and current measurements to improve the quality of control without producing additional latencies within the control loop. Actual value filters are therefore not necessary.

Overlaid functionalities such as the profile generator and the controller's state machine are executed on a soft-core processor. Because this processor is also on the FPGA, there is one central component that executes the entire firmware of the axle controller. The control algorithm has been developed with Matlab / Simulink and later translated with a VHDL autocoder.

The E-Darc's modular axle controller design contains not only pluggable incremental encoder cards, but also field bus cards. Even customer-specific modules are available, e.g. a Torque-Level-Trigger, which can recognize a faulty equipment or tool breakage.

How is CANopen implemented?

Two slots are available for a wide variety of application cases. The plug-on field bus module ensures that the system is upgradable and independent of any specific field bus system; the modules currently available are for CANopen and Ethercat.

To ensure the axle controller has high interference immunity, the individual modules are connected to one another via purely digital interfaces (SPI, Serial Peripheral Interface). This enables the test and development of individual modules independently of the axle controller.

The modular servo drive system by Ferrocontrol is especially suitable for multi-axle applications in drives and automation technology, such as in timber processing or window-frame machining centers, and for CNC processing centers in general. E°Darc C axle modules with output currents from 4 A to 75 A and supply modules in a range of 5 kW to 25 kW cover a wide range of user requirements. In machining centers, the new double-axis module has already proven its value repeatedly. It is used here to control the A and C axes. The controller is also attractive for the control of tool spindle modules with integrated axis mechanics. ◀

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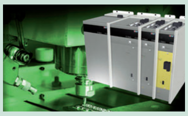
CAN Newsletter Online: Highlights

The CAN Newsletter Online reports briefly about products and services. This are the most visited articles in 2017 so far:



CANopen servo controller

In FPGA architecture

With the E°Darc C08D, Ferrocontrol which is part of the Eckelmann group (Germany) is extending its portfolio of 2-axis servo controllers by a more powerful model.

Read on

Motion controller for lower and middle power range

Ferrocontrol (Germany), which is part of the Eckelmann group (Germany), has expanded its selection of motion controllers with two controllers for the lower and middle power range, from1,5 kW to 5 kW.

Read on

Control center

For supermarket refrigeration systems

The setup and commissioning of refrigeration systems in supermarkets or cold stores is made easier with Eckelmann's E*LDS system control center. With the CI 4x00 panel, it offers touch screen operation.

Read on

Control and I/O functions in one controller

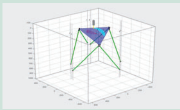
Eckelmann (Germany) combines its CNC motion controller with customer-optimized I/O functions in a platform for CNC applications. The E°EXC 880 will be presented for the first time at the SPS IPC Drives 2013.

Read on

Gateway combines CAN and LAN

Eckelmann (Germany) has extended its E*LDS product range with a Combi Gateway. It combines the CAN network with LAN and facilitates a rapid CAN connection (ca. 250 kbit/s) with the CI 3000 store computer.

Read on



Controller combines CNC and motion control functions

Eckelmann (Germany) will present the E°EXC 88 controller series with CANopen connectivity at the SPS/IPC/Drives exhibition in Nuremberg. The top-hat rail mountable controller combines CNC and motion control functions

Read on