November 2012

Industrial automation

CANopen in embedded machine control and factory automation

CANopen networks are used in many embedded machine control systems as well as in factory automation systems. The outstanding robustness and reliability of this communication system are important selection criteria. The flexibility and the interoperability of CANopen devices enable the design of highly optimized control and automation systems.

Key features

Robustness

The robustness of the CAN high-speed physical layer makes CANopen networks even suitable for very harsh environments. The CAN transceiver chips compliant to ISO 11898-2 are available from different suppliers for very reasonable prices. The CANopen networks have depending on selected components a very high EMC performance and they are very resistant against disturbances.

Reliability

The CAN data link layer has the capability to detect five randomly distributed bit-errors in a single data frame. The implemented mechanisms to detect faulty messages including a 15-bit CRC function results in a very low residual error probability.
In case of an error, the CAN data frame is discarded in all receiving devices and will be retransmitted automatically by the transmitting device. If this is a permanent failure, the related device will first go into passive error mode and later in bus-off mode, in order not to disturb the communication of the others.

Flexibility

The CANopen application layer provides a high flexibility regarding the optimization of the real-time communication. The time-critical control and status information is transmitted in Process Data Objects (PDO), which are configurable in respect to the priority, the transmission type, and the mapped process data. Besides the event-triggered scheduling (change-of-state), CANopen supports a synchronous transmission and actuation of process data.

Interoperability

The CANopen device profiles guarantee a very high degree of interoperability. All configuration parameters, process data, and diagnostic information are accessible by means of standardized 24-bit address (16-bit index plus 8-bit sub-index). In addition the profile predefines the PDO behavior including the process data mapping.
The standardized network-management (NMT and Heartbeat) and error handling (Heartbeat and Emergency) enable common system boot-up and shutdown procedures as well as common failure procedures.

CiA 402 – The standardized motion control profile

The internationally standardized CiA 402 device profile for drives and motion controllers (IEC 61800-7-201/301) is the most implemented solution. It is suitable for servo-controllers (closed-loop) and stepper motors (open-loop) as well as frequency inverters. The specification standardizes the PDOs containing the control-word and the command values respectively the status-word and the current values (position, velocity, or torque). The configuration parameters are also specified and accessible via the CANopen network by means of SDO (Service Data Object) read or write services.
CiA 402 profile specifies several operation modes in detail. They are selectable by means of a command and confirmed on the application level.

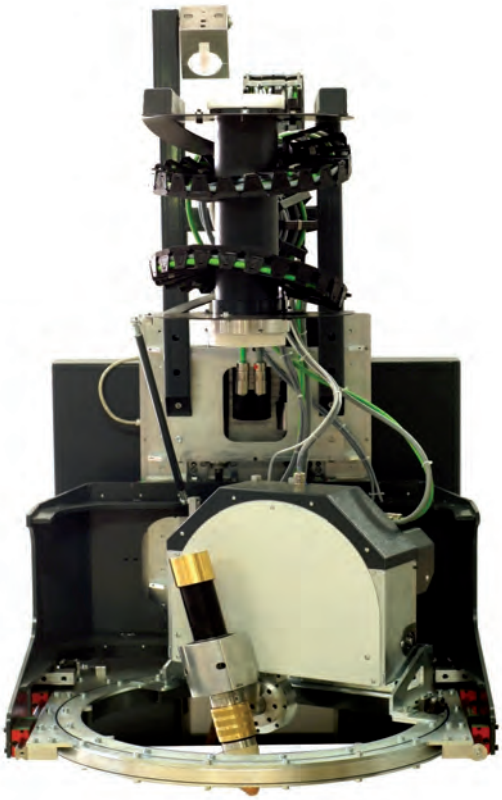
CiA 402 is implemented even in very small drives and motion controllers. This allows controlling machines with a very small footprint. On the other hand, CiA 402 compliant actuators are used in conveyor belts and other factory automation systems.

The following operation modes are defined:

- Profile position
- Interpolated position
- Profile velocity
- Profile torque
- Velocity
- Homing
- Cyclic synchronous (position, velocity, and torque)

As its archtype the six-legged robot wanders overhill and overdale

Embedded machine control



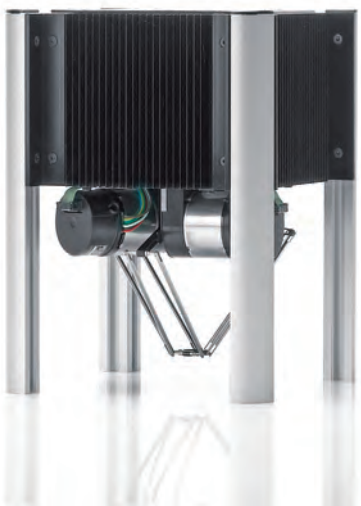
Plasma bevel-cutting aggregate

Slicing machine for kebab

CANopen is made for embedded machine control. Its flexibility combined with the interoperability enabled by the standardized device profiles support the machine builders in designing highly optimized control systems. CANopen-based embedded control systems are used in very broad range of machines. This includes printing, labeling, textile, injection molding, and wood-processing machines. Besides CiA 402 compliant drives and motion controllers, such control systems comprise CiA 401 input/output modules, CiA 406 encoders, and CiA 404 sensors. The host controllers are either PLCs running IEC 61131-3 compatible software or embedded controllers often programmable in C or C++. The human machine interfaces are normally application-specific; some of them are programmable.

In more complex machines, several CANopen networks are used; optionally they are connected via standardized PDO bridges and SDO/EMCY routers (CiA 302-7). Introducing several CANopen segments in the control system architecture enables a modular machine design, which allows reusing modules in other machines.

Due to the standardized device profiles, system integration can be simplified by using system design tools. Based on the standardized EDS files (Electronic Data Sheet) coming with the CANopen devices, the software tools get knowledge of the device's functionality. The EDS files and the corresponding DCF (Device Configuration File), you have a standardized exchange format between different CANopen tools for development, maintenance, and diagnostics.



Micro-robot with delta kinematics for micro-technology applications

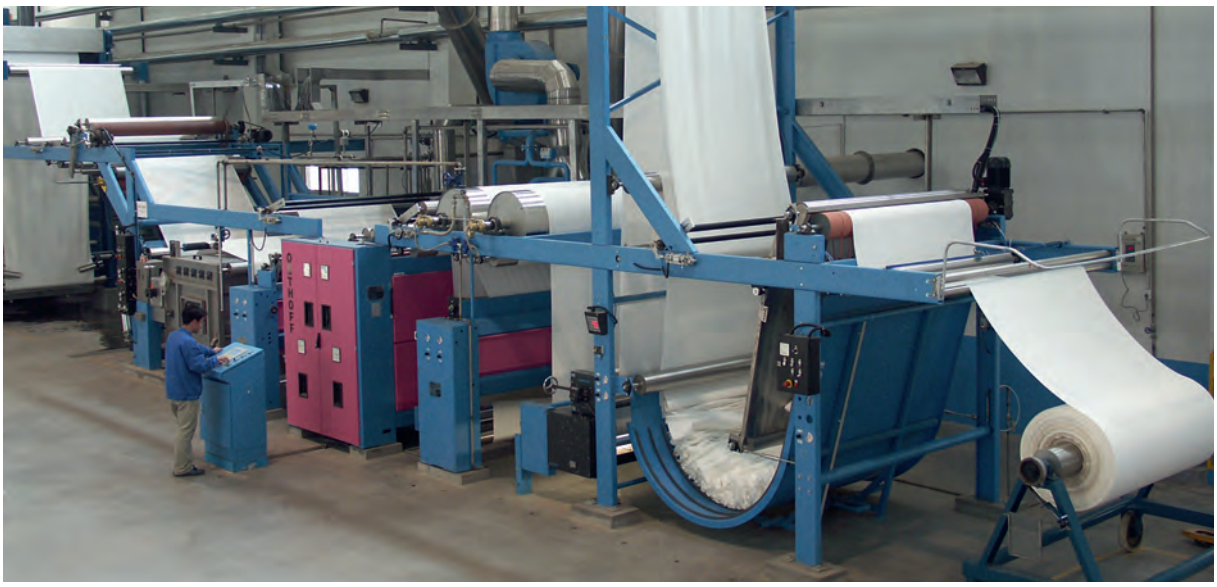
CANopen master unit controlling horizontal flow packaging machines

Linking of upstream and downstream devices in e.g.:

- Plastic processing
- Textile machines
- Printing machines
- Packaging machines
- Conveyer systems

CANopen networks are used in factory automation. In this application field, it is sometimes required to standardize the entire system. A typical example is the CiA 420 series of profiles for extruder downstream devices jointly developed with the Euromap user organization. This profile family comprises standardized CANopen interfaces for corrugators, pullers, saws, calibration tables, and co-extruders.

Most of the CANopen factory automation systems are not that extensively standardized as the extruder automation systems. They use the same profiles as in embedded machine control systems. Especially, CiA 402 drives and motion controllers are part of factory automation systems as well as CiA 401 modular devices with digital and analog inputs respectively outputs.



Textile finishing line with singeing station

CiA support and services

The CiA office in Nuremberg offers free-of-charge email and telephone support. The CiA organization also provides charged consultancy services including in-house seminars and development of proprietary profiles. However, CiA doesn't develop CANopen hardware and software for customers.

CiA publishes the product-oriented CAN Newsletter Online (www.can-newsletter.org) and the CANopen Product Guide (www.cia-productguides.org). The printed version of the CAN Newsletter features technical articles and application reports. Subscription is free-of-charge.

Most of the base CANopen specifications are downloadable free-of-charge from CiA's website (www.can-cia.org). Some specifications are available for members only. CiA is committed to submit its specification for international standardization in IEC and ISO. In this case, the related standards are available from the international and national standardization bodies and their distribution partners.

The CiA office provides the editors for the specifications and organizes also the meetings of the CANopen Special Interest Groups (SIG), which develop the profiles.

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