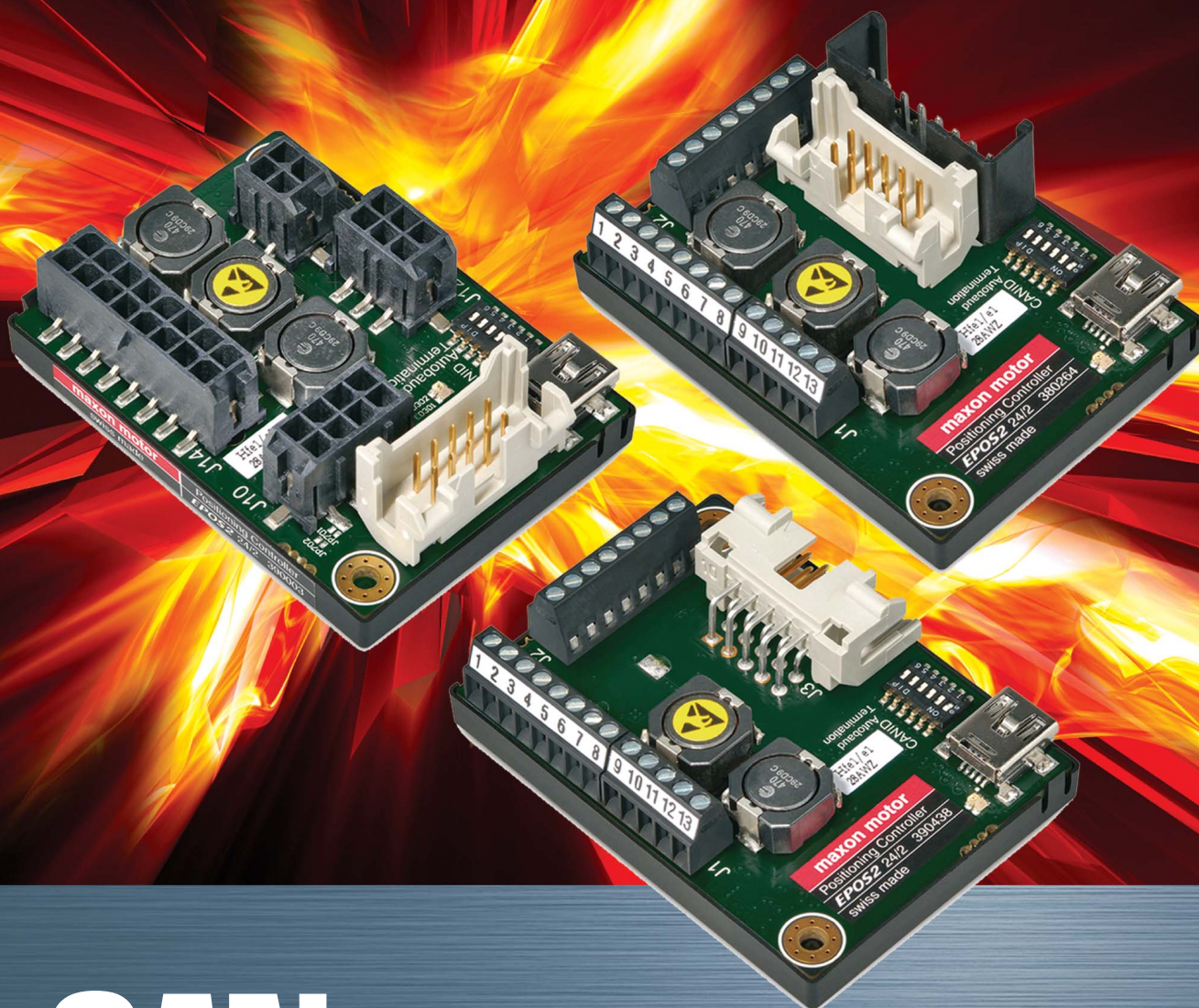




CANopen for small drives

A guide for design engineers by Dr Marcel Honegger

Presented by

maxon motor
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Originally designed as a fieldbus with line lengths of several metres, the CAN-bus today is increasingly accepted as a communication bus within compact machinery and devices.

For applications where space is limited, maxon motor offers new, extremely compact positioning controllers with CANopen interface for permanently energized brushed DC and brushless EC motors.

This brief engineers' reference guide covers popular methods using of CAN to synchronise several drives.

Why use CAN?

CAN offers a number of key benefits to engineers designing for limited spaces:

- **Compact**

Fieldbuses such as CAN-bus enable greater numbers of sensors and actuators to be used with minimal cabling.

- **Cost effective**

CAN is known as a low-cost bus, thanks to the high availability of microcontrollers and processors with integrated CAN controllers. The use of the standardized CANopen protocol according to CiA 301 and device-specific profiles such as CiA 402 also significantly reduces the development cost of control software.

- **Keeps options open**

Developers have great flexibility, as individual components can be easily exchanged without major changes. If, for example, a stepper motor with relevant controller is replaced by a DC motor with another manufacturer's controller, the control software hardly changes, as both drive systems appear almost the same on the CANbus when using CANopen-profiles.

- **Easy synchronisation**

Even for smaller devices, requirements placed on performance and functional range are increasing all the time... and it is becoming increasingly important to synchronise individual drives with each other to produce more complex motion processes.

CANopen offers a number of methods to synchronise motors – each with its own strengths.

Interpolated Position Mode (PVT: position & velocity versus time)

Here the machine controller calculates the movement of all drives, intermittently generates existing support points using position and velocity, and writes these into the positioning controller's message buffer.

This in turn calculates reference values for position control through linear or cubic interpolation. Positioning controllers' local timers can be synchronized on the CAN-bus with SYNC messages.

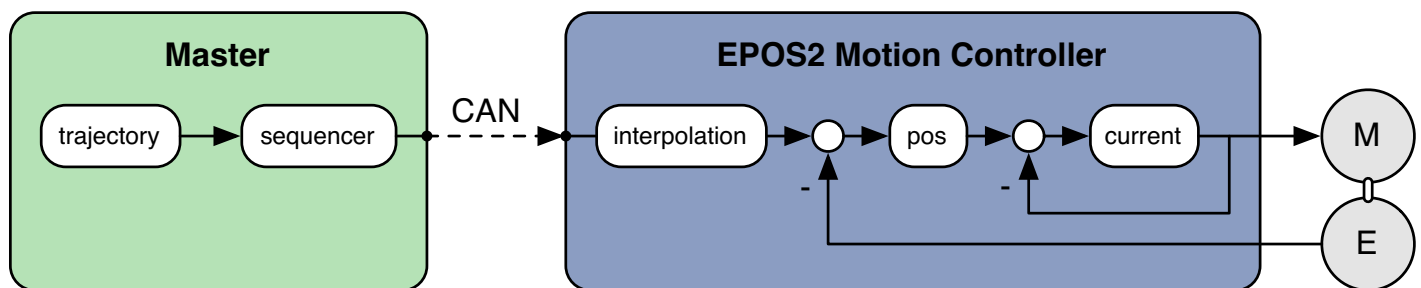


FIG1: Regular set point of interim positions for interpolated position mode

• Benefit

The periods between the support points of "interpolated position mode" are typically 10-100 ms, the bus load and real-time requirements on the bus master being low.

• Drawback

Motion cannot be changed very quickly; for example, too slow for additional synchronisation with external sensors (vision, encoder from conveyor belt etc).

Ideal applications therefore include the automatic tracking of telescope and solar mirrors, or control of machine tools where the movements of the axles are pre-determined.

Velocity Modes

Greater dynamics in motion planning can be achieved if motion planning and a degree of drive control are carried out entirely in the CANopen master, e.g. with a positioning regulator in the master and subordinate speed controller in the drive controls.

The controllers are then operated in "profile velocity mode", but care must be taken to ensure that

reference values are used immediately, otherwise the position control loop cannot be closed.

maxon EPOS2 positioning controllers also offer true "velocity mode" which is when velocity reference values are fed directly to the controller, creating high control dynamics.

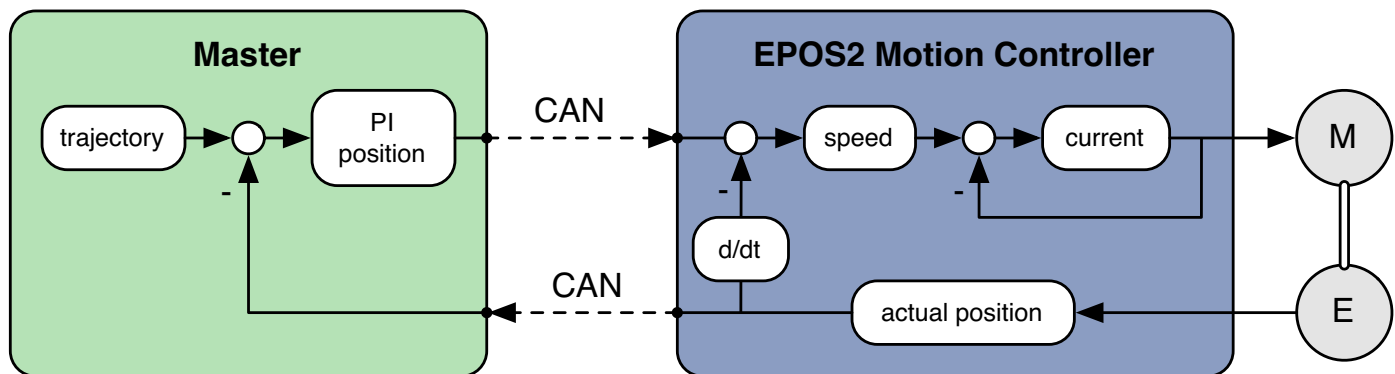


FIG2: Control loop through CAN-bus closed with velocity reference value through master

- **Benefit**

Improved dynamics in motion planning.

- **Drawback**

Bus load and requirements on the master's real-time capacity are much greater with this control architecture, with cycle times of typically 2-5 ms.

Profile Torque Mode & Current Mode

Another possibility involves realising the positioning and velocity controller in the master and specifying the torque or current set values in the drive controls via CAN-bus.

To do this, CANopen specifies "profile torque mode" for motion control products.

As an alternative, maxon EPOS2 controllers offer "current mode" which is when current references via CAN-bus are fed directly to EPOS2's current controller. This creates a high dynamic range which is essential for coreless motors.

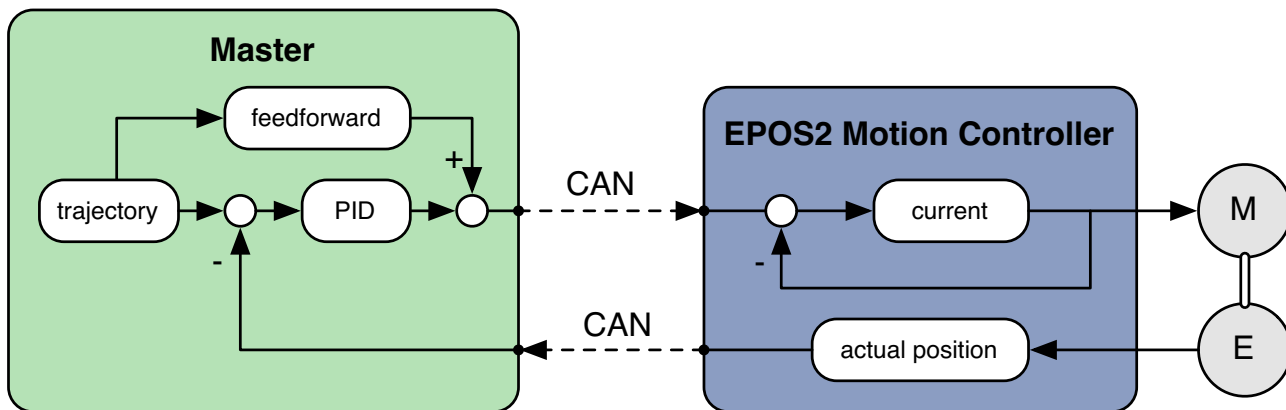


FIG3: Control loop through CAN-bus closed with current/torque reference value through the master

- **Benefit**

Maximises dynamic range; complex algorithms can be implemented in the master – ideal for robots with non-linear dynamics.

- **Drawback**

Requires hard real-time capacity; short cycle times place high demands upon CAN-bus.

Example: sending a CAN message with a current default and receiving a message with current position lasts almost 200 μ s at a transmission rate of 1 Mb/s per drive. A cycle time of 0.5 ms for only two drives on one CAN bus already utilises around 80% of its capacity.

Message	Data length	Duration at 1 Mb/s transmission rate
RPDO with current set value	2 byte approx.	82 μ s
RPDO with current set value, Controlword, mode of operation, digital outputs	7 byte approx.	122 μ s
TPDO with current position	4 byte approx.	98 μ s
TPDO with current position, Statusword, digital inputs	8 byte approx.	130 μ s
Heartbeat	4 byte approx.	98 μ s

Case Study: PocketDelta Robot

In Switzerland, asyrl S.A. has developed a microrobot with delta cinematics for microtechnology applications. It consists of a small platform, with a gripper being fed through parallelograms in 3D space.

The parallelograms are driven by three motors that are all located on a mount, making the robot's moving mass very low, and enabling maximum acceleration and velocity.

The drives used are maxon EC-i motors with 40 mm diameter and 50 Watt nominal output. An internal, multipole rotor, gives these motors low time constants, making them extremely dynamic with high torque density.

The motors are driven by our compact EPOS2 36/2 position control modules, slotted into a supporting plate developed specifically for small robots with up to four drives.

An ARM11 processor with integrated CAN controllers is used as master controller. This processor also sits on the support plate and communicates with the EPOS2 via CAN-bus. Other EPOS2 controllers, e.g. for feed systems or transfer axes, or even other CANopen devices, could be connected to the master through a connector.

Highly dynamic robots such as the PocketDelta that can reach acceleration forces of 5g and velocities of 2 m/s place high requirements on the drive controls: the dynamic equations of such systems are normally non-linear and also coupled between individual drives.

To reduce track errors to as few μm as possible at such high acceleration and velocities, a pre-control calculates the entire robot's dynamic equations, alongside a specially designed controller.

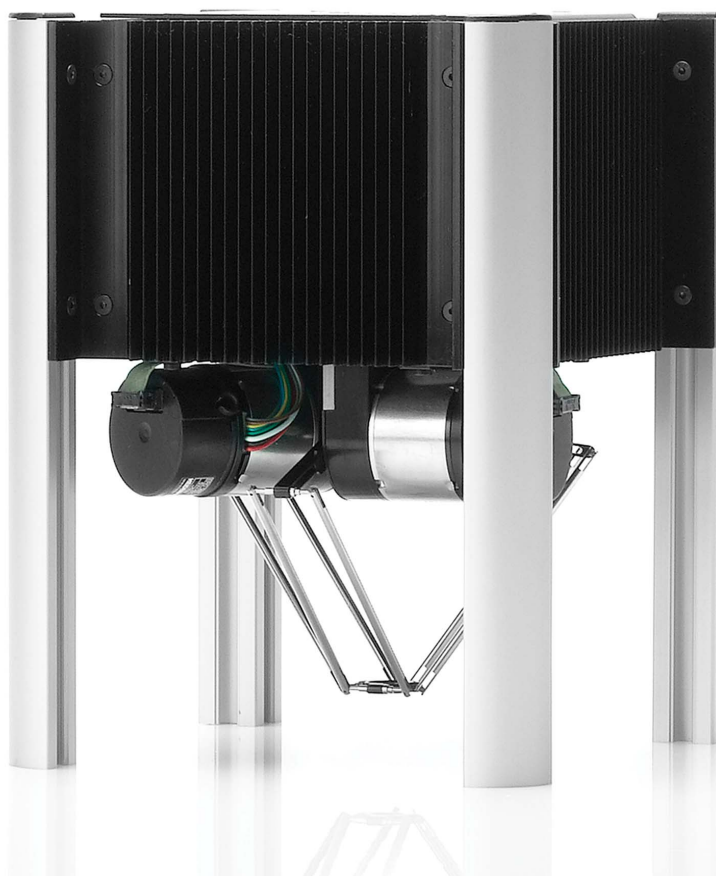
The EPOS2 36/2 module controllers are driven in "current mode".

In addition to motion planning which must be synchronous for all drives, the master also works out the robot's calculation algorithms and precontrols. The master then transmits these current set values to EPOS2 through CAN-bus.

EPOS2 also uses CAN-bus to send the master current motor positions, captured with high-resolution encoders.

This way, position and velocity control is closed through CAN-bus.

With an optimized definition of PDOs featuring as short a data length as possible and the various drive controls divided onto two CANbuses, cycle times of well under a millisecond can be achieved for control purposes.



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CAN and maxon

With EPOS2, maxon motor offers a whole family of CAN-friendly, universal positioning controllers – ideal for use with DC and EC motors from 1 to 700 W nominal output.

Our miniaturised EPOS2 24/2 controllers (up to 48 W nominal output) were specifically developed for use in compact machinery, while the EPOS2 36/2 module (72 W nominal output) was designed for OEMs.

The functional range of these small controllers is largely identical to their larger EPOS2 siblings. EC motors can be operated at up to 100,000 rpm and, thanks to the maximum 2,500,000 encoder pulses, high-resolution encoder input frequency may be up to 5 MHz.

As well as CANopen according to CiA 40, all EPOS2 controllers can interface via USB and RS232... plus the key gateway functions USB and RS232 to CAN.

These small controllers also support a wide range of operating modes, e.g. position, velocity or current mode.

Functions such as “step/direction mode” allow the incrementally controlled movement of the motor shaft, while master “encoder mode” applies the drive as electronic gearing.

Meanwhile, the graphic "EPOS Studio" user interface makes it easy to adjust instructions and parameters.

Your regional maxon sales engineer is very happy to assist in the selection and use of our controller range... as well as custom specifications, if you have challenging design, tolerance or connection requirements.

