Compact Motion Solutions in Hardware and Software

Dr. Josef Papenfort
Product Manager TwinCAT

Michael Jost
Product Manager I/O Systems
1. TwinCAT Motion – from PTP to CNC
2. Compact Motion in Hardware
3. Summary
1. TwinCAT Motion – from PTP to CNC
2. Compact Motion in Hardware
3. Summary
1. TwinCAT Motion – from PTP to CNC
   – Motivation and Architecture
2. Compact Motion in Hardware
3. Summary
Scalable solutions (stepper, ..., servo drive)
Several abstraction layer
→ PLC/SCADA/HMI accesses always identical objects, independent of axis type and fieldbus
Conversion from mechanical to electronically system
(electronic cam, electronic gear, electronic clutch, electronic camshaft, „flying saw“)

Benefits:

- More flexibility in used technique (stepper, servo drive, ...)
- More flexibility in changes to the products
- Shorter time of delivery and development time
- Shorter time for commissioning,
  because of the lack of mechanical parts
- Decreasing costs

→ All to configure, program and debug in one TwinCAT System
PC-based control technology from Beckhoff sets new standards in automation. Motion Control is one important part of the system.
Functionality

<table>
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<tr>
<th>NC PTP</th>
<th>NC I</th>
<th>CNC</th>
<th>Robotics</th>
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</thead>
<tbody>
<tr>
<td>Point-to-point movement</td>
<td>Interpolated motion</td>
<td>Complete CNC functionality</td>
<td>Interpolated motion</td>
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<tr>
<td>-- gearing</td>
<td>with 3 axes and 5 additional axes</td>
<td>-- interpolated movement for up to 32 axes per channel</td>
<td>for robotic control</td>
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<td>-- camming</td>
<td>-- programming</td>
<td>-- technological features</td>
<td>-- support for a wide range of kinematic systems</td>
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<td>-- superposition</td>
<td>-- according to DIN 66025</td>
<td>-- straightforward</td>
<td>-- optional torque</td>
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<td>-- flying saw</td>
<td>-- technological features</td>
<td>utilisation through</td>
<td>pre-control</td>
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<td></td>
<td></td>
<td>function blocks from the PLC</td>
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PLCopen
motion control
TwinCAT IO Mapping:
- Separates the physical world from the logical world
- Fieldbus independent

TwinCAT Motion Control
- Separates physical axis from logical axis objects

→ Goal: flexibility in configuration!
→ Change from stepper to servo: one click
1. TwinCAT Motion – from PTP to CNC  
   – Configuration and Diagnosis
2. Compact Motion in Hardware
3. Summary
TwinCAT NC PTP

- easy setup and maintenance
- full simulation possible
- open for all axis types
  - servos, stepper, DC Motors
  - hydraulic axes
- digital+analog interfaces with different fieldbusses
- position control on the PC or in drive
- jerk limited profile
- PLCopen MC FBs
  - positioning
  - camming
  - gearing
Profile Generation and Control

\[ T_t \]

Deadtime compensation

\[ k_p, T_n, T_v \]

Position control

Limitation

\[ k_v \]

Velocity Preset (Scaling)

Output Scaling and Limitation

\[ V_{ref} \]

\[ y_{min}, y_{max} \]

Setpoint generator

\[ p_a \]

Position measurement

Process

\[ y_v \]

\[ y_{vv} \]
NC axes diagnostics

- **Current position**: 703.2000 mm
- **Override**: 100.0000%
- **Ready/References current state**: Ready, NOT Moving, In Pos. Range, Has Job
- **Set points**: 703.2000 mm
- **Manual drive commands**: F1, F2, F3, F4, F5, F6, F7, F8, F9
TwinCAT 3 Bode Plot Base

- Integrated in TwinCAT Measurement Project
- Useful when optimizing drives (AX5000)
- Frequency-Range and steps can be set
- Filter-Simulation
- Multiple curves in ONE view
- For free!
Agenda

1. TwinCAT Motion – from PTP to CNC
   - Programming
2. Compact Motion in Hardware
3. Summary
Motion Control Library for PLC

- Standardized by PlcOpen
- Function blocks for axis handling
- Motion commands
  - Single axis command
  - Multi axis commands
- Configuration commands
- Data structures
### Gearing

- One Slave-axis: position-set points will be determined through an affine transformation of the position-set points of another axis,
- linear slave-axis
- Slave position set points = coupling factor × master-position + offset

### Camming

- Software solution for electronical cams.
- To the position of the master axis (upright shaft) a corresponding position of the slave axis will be approached in a table.
1. TwinCAT Motion – from PTP to CNC
   - Example
2. Compact Motion in Hardware
3. Summary
1. TwinCAT Motion – from PTP to CNC
   – Where is the control loop closed?
2. Compact Motion in Hardware
3. Summary
- Often used in the passed and in special application
- Position control loop closed in the PC
- Possible with fast EtherCAT fieldbus
- Most used configuration
- Position Control loop closed on the drive
- Only setpoint generation on the PC in TwinCAT
- For special cases – Velocity Control loop closed on PC
- Only Current Control loop closed in drive
- Only possible with
  - Fast control cycles on the PC
  - Deterministic realtime on the PC
  - Fast fieldbus: EtherCAT
Scalable Drive Technology

Servo Drives from 0.2 to 120 KW
Servomotors from 0.2 to 180 Nm
The Beckhoff servo terminal
One Cable Technology reduces installation and cabling costs

- One Cable Technology: power and feedback system in a single standard motor cable
- reduced material costs
- reduced installation costs
- simplified commissioning
- more efficient inventory management
- reduced footprint of the machine/system
- servo drives in terminal block format
- supply voltage up to 50 V DC
- direct motor connection, for permanent magnet synchronous motors
- high servo performance in a very compact design
- integrated resolver interface
- fast control technology for highly dynamic positioning tasks

**EL7201-0010 and EL7211-0010**
- servo terminal with One Cable Technology (OCT)
- absolute feedback system
Servo terminals

- EL7201 servo terminal
  - 50 V DC
  - 2.8 $A_{\text{rms}}$
  - EL7201-0000 with resolver
  - EL7201-0010 with OCT

- EL7211 servo terminal
  - 50 V DC
  - 4.5 $A_{\text{rms}}$
  - EL7211-0000 with resolver
  - EL7211-0010 with OCT
Servo terminal with Safe Torque Off input (STO)
- One Cable Technology and absolute feedback integrated
- Fast control technology for highly dynamic positioning tasks
- Power feedback into the DC-Link when braking
- Numerous monitoring parameters offer maximum operational reliability.
- Application layer: CoE
- Plug-and-play solution for motors from the AM81xx series
- STO according to DIN EN ISO 13849-1:2008 (Cat 3, PL d)
The Beckhoff stepper terminal
Advantages of stepper motors
- step accurate positioning
- holding torque at rest
- sensorless positioning
- cost effective

Disadvantages of stepper motors
- torque reduction in speed increase
- low efficiency, especially at part load
Advantages of vector control

- less power loss
- less heat emission
- no resonances, no step losses
  - motor does not stall
- smooth movements

- Vector control works with Beckhoff motors AS10xx
  - third party motors can be controlled with standard control
Stepper Terminals

- **EL7041 w/o Vector Control**
- **EL7047 with Vector Control**
  - 50 V DC
  - 5 A
  - travel distance control
- **EL7031 w/o Vector Control**
- **EL7037 with Vector Control**
  - 24 V DC
  - 1,5 A
  - travel distance control
Brake chopper terminal & brake resistor

- **EL9576 brake chopper terminal**
  - voltage adjustable up to 72 V DC
  - capacity of 155 µF
  - connections for external ballast resistor

- **ZB8110 brake resistor**
  - 100W
  - Works with EL9576
- Forced air circulation
- Increase of power output
- Extension of the operation temperature range
- Variation of the mounting position
- Diagnosis: Fan defected

- Operation modes:
  - Temperature controlled
  - Continuous operation
  - Frequency controlled
IPC
- 7 Industrial PCs C6525

Motion
- 1216 servo terminals EL7201
- 1216 servomotors AM3121 with holding brake

Automation
- TwinCAT NC PTP
- TwinCAT NC Camming
- Motion means Software Motion and Hardware Motion
- Motion in TwinCAT means
  - Fully integrated configuration and diagnosis tools
  - Easy to use Function Blocks in PLC – PLCopen compliant
  - Integrated Motion related Safety functionality
- Hardware
  - Standard Interface to the control SW
  - Scalable: small to big drives
  - Integrated Safety
  - Various motor technologies supported
    - DC, Stepper, Servo
  - High efficiency