EtherCAT – The Automation Backbone Made by Beckhoff

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Bus System and Control Architecture

- Super Fast Controls (such as PC based Controls) require a super fast bus technology!

Brutus: WW1 Aircraft Engine with 47 l (!) Displacement and 740 h.p. (550 kW) Power, but inadequate tires....
Is Ethernet the right method of choice? Or, what makes the difference…
Minimum Ethernet Frame: **84 Bytes**!

- For Industrial Automation: usually only a few Bytes per device are needed
- @ 4 Bytes Process Data: Only **4,75%** Application Data Ratio

- **2 Frames per device**  
  Controller $\rightarrow$ Device: Output data  
  Device $\rightarrow$ Controller: Input data
EtherCAT Functional Principle: Processing on the Fly

- Process data is extracted and inserted on the fly
  - One frame for all Slaves
  - Minimal protocol overhead via logical addressing
    - Assigned automatically by the master during boot-up
  - Process data size individual per slave: 1 bit…60 kByte
  - Communication completely in hardware: maximum (+ predictable!) performance
EtherCAT Functional Principle: Processing on the Fly

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Up to 97% of bandwidth utilization
Switches are commonly used for Ethernet
  - Almost all Switches use „Store & Forward“
Line Topology means cascaded Switches
Example: Full frame, 20 nodes in line topology: 2,5 ms!

EtherCAT with Processing on the fly: Delay ~20µs@20 nodes
• Switches are commonly used for Ethernet
  – Almost all Switches use „Store & Forward“
• Line Topology means cascaded Switches
• Example: Full frame, 20 nodes in line topology: 2.5 ms!

- EtherCAT with Processing on the fly: Delay ~20µs

Industrial Ethernet | Switch Delays

- EtherCAT with Processing
  - Hardware delays negligible
Industrial Ethernet | Addressing

- Ethernet uses addressing by **MAC** on Layer 2
  - Device Replacement
- or **TCP/IP** on Layer 3 / 4
  - IP-Address management
  - Software Stacks involved

- **EtherCAT**

Each individual slice can be an EtherCAT slave!
Industrial Ethernet | Addressing

- Ethernet uses addressing by **MAC** on Layer 2
  (-) Device Replacement
- or **TCP/IP** on Layer 3 / 4
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**Automatic Address assignment**

**Lean software stacks**

Each individual slice can be an EtherCAT slave!
Industrial Ethernet | Stack Delays

- Industrial Ethernet Protocol Stacks are BIG

- Processing them needs TIME
- Industrial Ethernet Protocol Stacks are **BIG**
- Processing them needs **TIME**

Lean (or even no) protocol stacks
EtherCAT: Performance Breakthrough

- EtherCAT Technology Group (ETG) is the world’s largest Fieldbus organization
  - **3770 members** (June 2016)
- Outstanding adoption rate

EtherCAT is the fastest Industrial Ethernet Solution
Outstanding Adoption Rate

EtherCAT Drive Vendors: 157
- 157 Drive Vendors

EtherCAT Master (Controller) Vendors: 193
- 193 Master Vendors

EtherCAT I/O Vendors: 106
- 106 I/O Vendors

Safety over EtherCAT (FSoeE) Vendors: 27
- 27 Safety Vendors
<table>
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<th>EtherCAT Terminals</th>
<th>Embedded PC</th>
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*EtherCAT – Made by Beckhoff*
System overview – Flexible Topology

Flexible topology

- **Bus/line**
  - IPC
  - Automation suite, EtherCAT master
  - Industrial network (100BASE-TX)
  - Router (100BASE-TX)
  - EtherCAT
  - 100 m
  - Fibre optic (100BASE-FX)
  - up to 20,000 m (singlemode)

- **Tree/star**
  - Industrial Ethernet cable (100BASE-TX)
  - EtherCAT down to the IO level

Ethernet TCP/IP
Integration of legacy fieldbus systems

- High bandwidth utilization allows integration of underlying fieldbus technologies into the EtherCAT process image
  - Fieldbus master or slave
- Migration path for machine builder
- Small Embedded PC solutions with maximum flexibility
eXtreme Fast Control Technology for higher production efficiency
EtherCAT – Distributed clocks

- Time synchronization integrated in slave hardware
  - EtherCAT Slave Controller
    - Shifting accuracy to the I/O level
- Distributed absolute system synchronization
  - CPU
  - I/O
  - drive devices
- Resolution: 10 ns
- Accuracy: < 100 ns
EtherCAT – Backbone for eXtreme Fast Control XFC

eXtreme Fast I/O

eXtreme Fast Communication

eXtreme Fast Controller (IPC)

eXtreme Fast Runtime
XFC in practice

- Printer position control
- Digital cam
- Glue application
- Closed-loop control
- Linear path control
- Part tracking
EtherCAT – Backbone for Scientific Automation
Measurement technology

Scientific Automation

Resolution: 24 Bit

Measuring Error: ±0.01%

BECKHOFF EL3602

-10...+10 V
-10...+10 V
Condition Monitoring
The Beckhoff servo terminal
EtherCAT – The Automation Backbone
Made by Beckhoff