Fieldbus - EtherCAT

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Brief history

Beckhoff Automation, which is a major manufacturer of PLC's used in automation and real-time control systems, created their own version of a fieldbus called "Lightbus" in the late 1980's to address the bandwitdh problem of other interfaces. Additional work on this protocol resulted in the invention of EtherCAT, which was introduced in 2003.

Target group

EtherCAT stands for Ethernet for Control Automation Technology and is a fieldbus that runs on the Ethernet protocol making it very attractive for most industrial automation. This allows it to be easy and cheap to integrate regarding the hardware that is needed. It is specifically developed with real time data transfer in mind, making it perfect for motion and axis control. Therefore it is optimal for use within robotics, CNC machines and can be used in everything from semiconductor production to the sawmill industry.

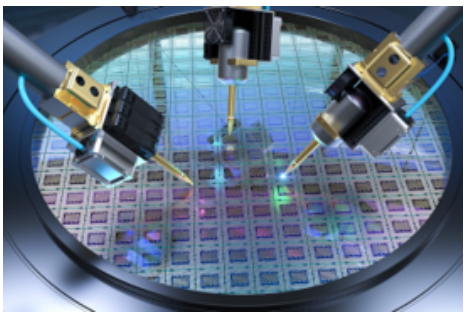

Figure 1: Chip manufacturing

Speed

EtherCAT is very fast. It sets new limits for real-time performance by processing 1000 distributed I/O signals in 30 µs or 100 µs using twisted pair or fiber optic cables. This high speed makes EtherCAT ideal for automation, IT and other applications that require real-time optimization.

Medium

EtherCAT P is an addition to the EtherCAT technology at the cabling level. P stands for power and means that you can use the standard 4-wire Ethernet cable not just for data, but also for two electrically isolated, individually switchable 24V/3A power supplies.

Functionality

EtherCAT uses data frames that are embedded in the ethernet protocol. Within these frames the master sets the header to indicate if the etherCAT datagrams is read, write or both, and to what slave it is dedicated through specific adressing. Also logical addressing can be used for multiple slaves. This figure shows how the on the fly communication happens. The best illustration is using a train, where the data requested or sendt to the specific slave, is like the passengers boarding or exiting the train. Each slave device sends on the packet to the next, just responding to the masters request. As this happens continuously during operation, the cycle time is greatly reduced and latency is minimized.

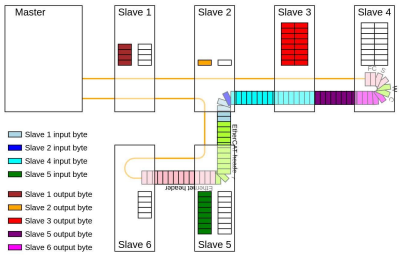

Figure 2: Functional principle

Topology

The fieldbus is very flexible and can use all different types of topology. It can work on line-, ring-, star- and tree topology. As it is a Full-duplex system, mean-

ing you can communicate both ways simultaneously. Using a ring topology you increase the redundancy incase of a broken cable. In normal etherCAT operation IP addressing is not necessary, but the slaves are automatically adressed based on there spot in the chain by the master.

Limitations

One of the limitations that EtherCAT have, the single master in the master/slave operations. In other fieldbuses, you can setup more masters that do the same task, so in case the master fail, the operation would still go on. That is not possible on EtherCAT, since it only allows for one master.
The other major drawback is that the slave units has to have a Application-Specific Internal Circuit (ASIC) component installed for the EtherCAT to work. This is such a huge drawback, that the semiconductor and robotics industries banded together and demanded that manufacturers that made components, had drives that supported EtherCAT, or they wouldn't be interested in buying the componenets.
The datamodel for these components are also quite different from other fieldbuses, and can be difficult to learn and understand.

What are the most important differences between this fielbus and some other fieldbusses.

The following parameters are used to highlight the main differences between fieldbusses.We chose to compare etherCAT with Ethernet/IP and Profinet because they are the most popular fieldbusses

Category	EtherCAT	Ethernet/IP	Profinet
Definition			
features			
application			

Definition:

- EtherCAT:Communication protocol for industrial ethernet network. A master-slave protocol that uses logical ring topology that has high-speed and deterministic behavior when processing data frames.
- Ethernet/IP:A communication protocol for industrial ethernet network that uses a producer-consumer model to exchange data. uses different topologies such as star, line or ring.
- PROFINET:an open Industrial Ethernet solution based on international standards. It is a communication protocol designed to exchange data between controllers and devices in an automation setting

Features

- EtherCAT:
  - High bandwidth which increases capacity to transmit additional TCP/IP together with control data
  - Low latency and Lower jitter due to processing on the fly. Higher scalability as it can support more nodes per second and can handle analog, digital and other types of devices without additional gateways or adapters.
  - Flexible topology, the machine structure determines the netowrk topology not the other way around.Since EtherCAT doesn't require hubs or switches, there are no limitations on the topology. This can make things cost effective
  - EtherCAT processes on the fly which means it reads the header and passes the information along, so it saves a lot of time
  - Since only the master device is allowed to send data, there are no risks of collision in etherCAT
- Ethernet/IP
  - Lower bandwidth than EtherCAT however higher latency and higher jitter
  - In conventional ethernet systems such as ethernet/IP, there are limitations on how many switches and hubs can be cascaded which limits the overall network topology.
  - Each device here needs to read the header ingest it and process it in some way before sending it which is a lot more time consuming.
- Profinet
  - A little expensive due to network infrastructure which includes switches, sensors etc
  - More precise cyclic time due to the fact that it sends data directly to the ethernet frames which eliminates transmission delays.
  - Offers real-time and isochronous real time communication
  - Provides mechanisms for integrating with older fieldbus systems like PROFIBUS

Applications:

- EtherCAT:
  - Often used in robotics, Semiconductor manufacturing, machine control. Mainly used wherever high speed is a determining factor.
- Ethernet/IP

  - Due to its features, it cannot be used for high-speed applications thus being used for data acquisition, monitoring and diagnostics.

- Profinet
  - Commonly used in automotive and machine building industries. A huge competitor to Etehrnet/IP

Hvilke lag i OSI modellen?

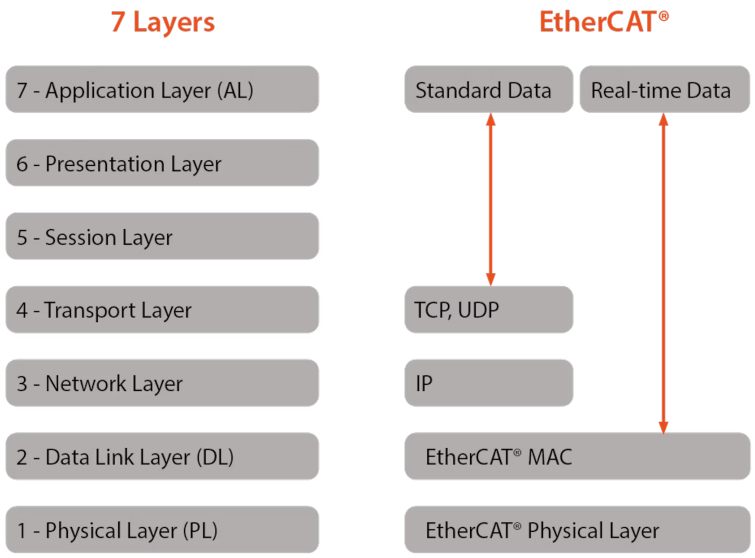

Figure 3: Ethernet and EtherCat OSI-model

Denne figuren viser oppsettet til et tradisjonelt Ethernet, og EtherCAT.

popularitet/Markedsandel

The three most popular fieldbuses in 2022 and 2023 are EtherCAT, Ethernet/IP and Profinet
A myriad of things is taken in account when calculating market share popularity. For instance, most companies such as HMS conduct market research, surveys and feedbacks along with sales data to determine the popularity of fieldbuses. Alongside, collaboration with companies and conferences are held in order to

gain insight on popularity and trendsAlthough ethernet/IP and profinet are used more than etherCAT although etherCAT is better. There are many reasons to this such as coexistence and extensive compatibility with devices. Historical adoption. Regional preferences etc