EtherCAT – the new standard for networking systems

White Paper

Introduction

In recent years, EtherCAT has advanced to the world-wide standard in automation and control technology. The EtherCAT Technology Group (ETG) was founded in November 2003 and by January 2009 had already 900 members from 45 countries. Since the late 90s, Ethernet has come to be seen as the supplement to if not the replacement for "proprietary" Field-bus technology – it is suited to large data volumes, but not for high-speed, deterministic processes in control and measurement engineering. EtherCAT was therefore designed with the goal of supporting the standard Ethernet and to be deployed at minimal hardware costs in real-time control tasks with rapid update cycles and low jitter. These are the features which actually make EtherCAT ideal for dispersed-location measurement applications. This article focuses on the capture of measured data and illustrates EtherCAT's possibilities as the basis for distributed measurement systems – including as a substitute for CAN or the Profibus.

How it works

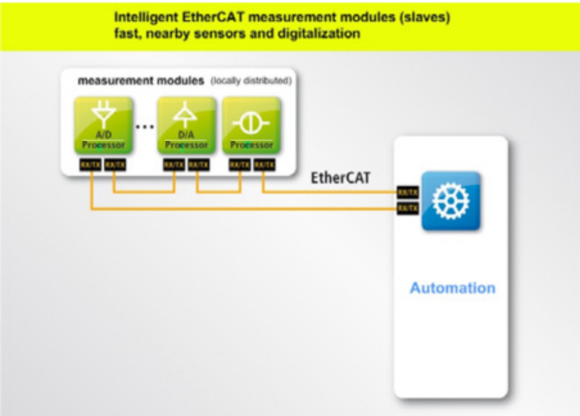
To understand the EtherCAT's advantages when used as a measurement engineering communication bus, we need to consider how data is transferred. With Ethernet-based busses – including in Master/Slave systems – a receiver is typically addressed by a sender. A data package is sent to this receiver, which must be received in its entirety before any response can be sent. This same procedure is adhered to by every subscriber in the network. EtherCAT slave devices, by contrast, only extract the data which are intended just for themselves while the telegram sent by the master streams through the device. As well, incoming data are added to the telegram during streaming. Thus, a frame need not be received in its entirety before it can be processed, rather, processing can begin as early as possible. Message sending also proceeds with a minimal offset in terms of bit cycles.

Distributed measurement systems

For some years now the trend in capturing measured data has tended towards decentralization. A main aspect of this is the attempt to digitalize analog signals as close to their origin - the sensor as possible. Interference influences in transit along the transmission lines are thus avoided. One main precondition for this type of data capture are measurement modules close to the sensor and real-time capable bus connections. In this regard, a standardized bus connection allowing additional independent subscribers would offer special advantages in universality and manufacturer-independence. In the case of low sampling rates (bandwidths of up to 20 kB/s), the CAN-bus has become the accepted standard in measurement engineering. Alongside it in the fields of automation and installation engineering, the Profibus, Interbus, and Modbus, just to name a few, have become widespread. Particularly for dynamic quantities and multi-channel applications, a higher bandwidth and optimized loading of the bus are essential. As already indicated, the Ethernet platform offers these features.

Measurement systems and EtherCAT

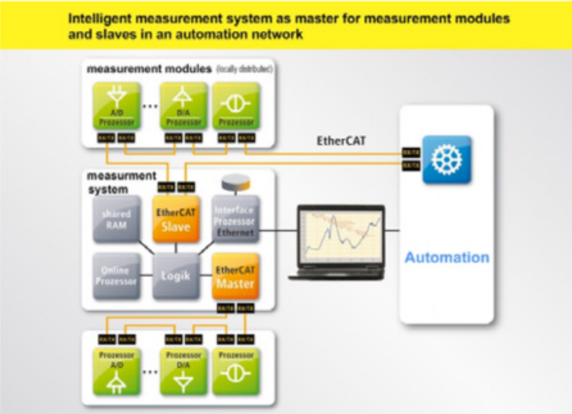
The following treatment demonstrates the use of the EtherCAT specially in measurement engineering applications by means of various examples. The first important case is the use of digitalizers connected with a higher-level system via EtherCAT.



The data recipient (Master) in this case can be either a measurement or closed- or open-loop control system.

But here, too, dynamic processes require components necessary for measurement data capturing systems.

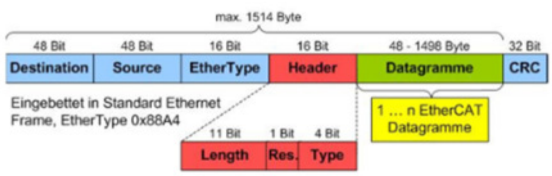
The task of a ''conventional'' measurement system is typically far beyond pure data collection. For this reason it is of course worth considering integrating a system equipped with an EtherCAT interface into a network. This leads to total integration of an intelligent subsystem. The subsystem can now perform tasks such as pre-processing, condensation, analysis and saving of (even highly-dynamic) data --- without additionally burdening the EtherCAT network or the master.



Technical background

EtherCAT is an open technology which is governed by the international standards IEC 61158 and IEC 61784 as well as in ISO 15745-4. With EtherCAT an Ethernet data package is no longer received only upon each activation, after which the process data are extracted and interpreted. The EtherCAT-slave devices extract the data intended for them while the telegram is streaming trough the device. Similarly, input data are inserted into the telegram while streaming through. The telegrams are delayed by only a few nanoseconds. Since an Ethernet frame reaches the data of many participants both in the sending and in the receiving direction, the useful data rate increases as high as 90%. Typically, EtherCAT is configured as a ring and operated either in the half- or full-duplex procedure. But tree and star topologies are also possible.

The EtherCAT protocol is transported directly in the Ethernet frame. For this purpose it uses a special EtherType. It can consist of multiple telegrams, which can each control a memory area of the 4 gigabyte logical process map.



EtherCAT UDP can package the EtherCAT protocol in UDP/IPDatagrams. This makes it possible both to address systems with Ethernet protocol stacks, as well as to transfer data packages to other subnetworks from router to router.

Using the CANopen ® protocol, devices can be integrated into an EtherCAT network without any additional drivers. CANopen ® devices and application profiles are available for a wide variety of device classes and applications --- from I/O components to actuators, encoders, proportional valves and hydraulics regulators all the way to measurement engineering application profiles. EtherCAT can provide the same communication mechanisms familiar from CANopen ®: object directory, PDO (Process Data Objects) and SDO (Service Data Objects). Even the network management is comparable. This means that EtherCAT can be integrated easily on devices which were previously equipped with CANopen ®. Beyond CANopen ®, additional protocols are defined which implement the standard services such as communication based on TCP/IP. These include:

- Ethernet over EtherCAT (EoE)
- File Access over EtherCAT (FoE) or even
- Safety over EtherCAT (FSoE)

Summary

EtherCAT meets the requirements of an ''ideal'' data bus for measurement engineering:

- Bandwidth and utilization are especially high
- Distributed topologies are also possible across long distances
- The data transfer is deterministic and very preciselysynchronized
- EtherCAT enables simultaneous configuration and data transfer
- Cost-effective integration into measurement systems possibleRobust and redundant cabling possible
- Various network topologies possible
- Existing Ethernet cabling can continue in use

Subsystems such as capture of operating data and databases can be integrated via gateways.

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