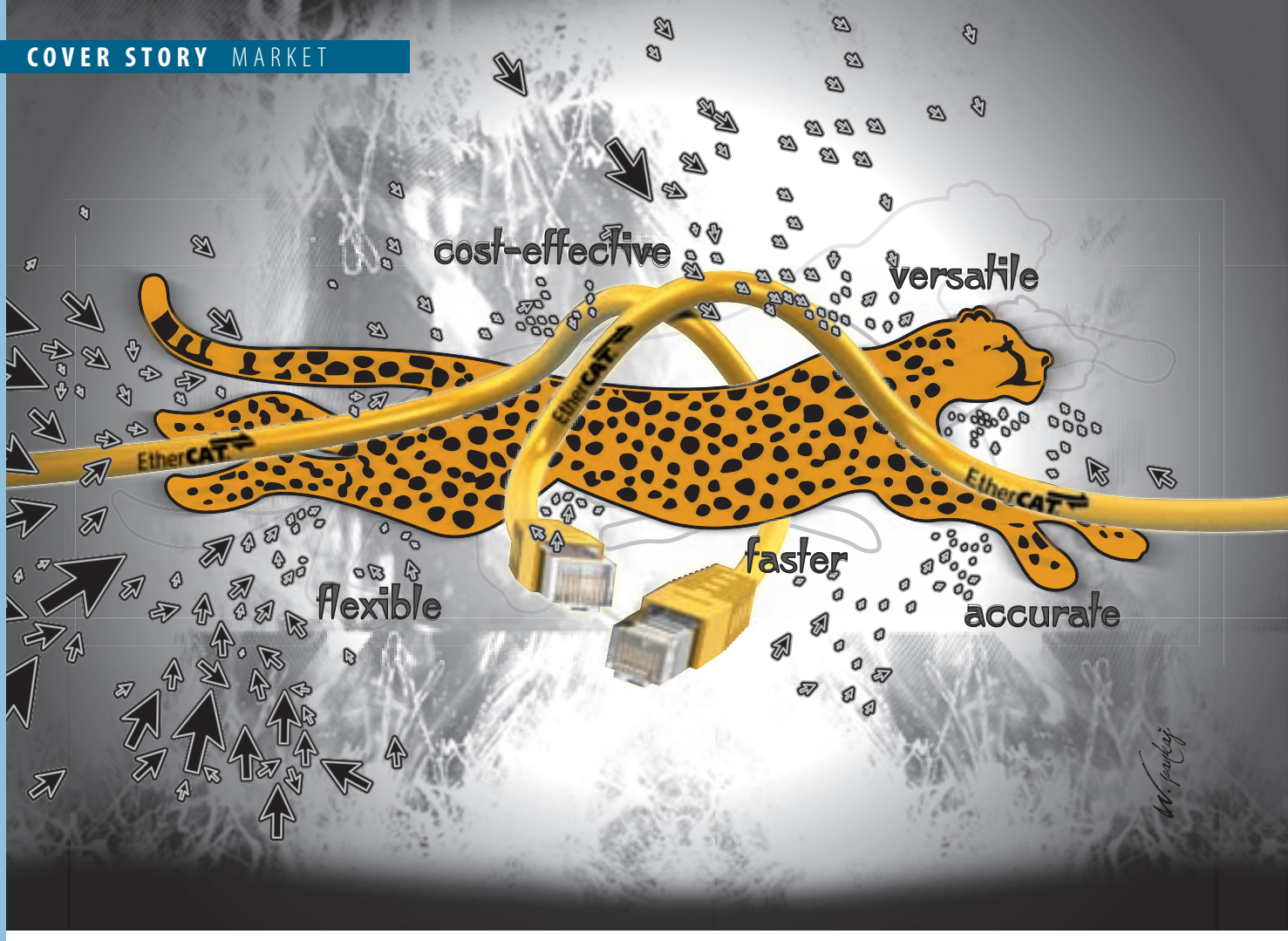

Propelling towards the future

Ethernet has been widely approved and accepted above the fieldbus level, but has advantages to offer at the I/O level too

"Why yet another Ethernet approach?"... the short, but concise answer is: "EtherCAT takes a different route and is currently by far the most powerful Ethernet approach, and the one that is best tailored to automation requirements!" A sound, technically substantiated response is presented in this article.

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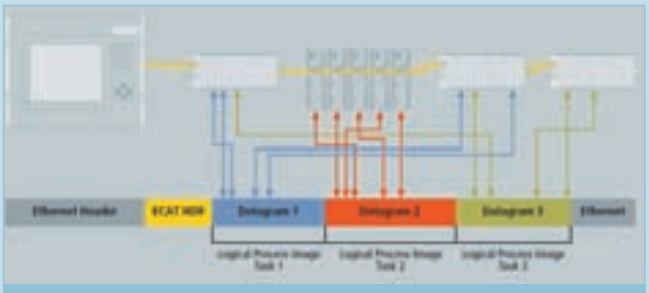
While Moore's Law (doubling of performance approximately every 2 years) has remained valid over recent years, and will continue to apply in future, for PC-based control systems, no significant further development has occurred for fieldbusses. Instead, the majority of fieldbus organisations and 'large' automation companies chose Ethernet as the future extension or replacement for 'proprietary' fieldbus technology, and associated standards were developed.

Fieldbuses have become an integrated component of automation technology. They have been tried and tested and are now widely established. It was fieldbus

EtherCAT makes internet capabilities available at I/O level

EtherCAT cable



EtherCAT functional principle

technology that enabled the wide-scale application of PC-based control systems. While the performance of controller CPUs, particularly for IPCs is increasing rapidly, conventional fieldbus systems tend to represent 'bottlenecks' that limit the performance control systems can achieve. An additional factor is the layered control architecture consisting of several subordinate (usually cyclic) systems: the actual control task, the fieldbus system and perhaps local expansion buses within the I/O system or simply the local firmware cycle in the peripheral device. Reaction times are typically three to five times higher than the controller cycle time – an unsatisfactory solution.

Above the fieldbus system level, i.e. for networking controllers, Ethernet has already been the state-of-the-art for some time. What is relatively new is its application at the drive or I/O level, in areas that were dominated by classical fieldbus systems in the past. The main requirements for this type of application are high real-time capability, suitability for small data quantities, and naturally cost-effectiveness. EtherCAT meets these requirements and at the same time makes internet technologies available at the I/O level.

Ethernet at I/O level

Ethernet features which make it less suitable for automation technology applications should be considered very carefully and circumvented wherever possible. The main differences between the different approaches for adapting Ethernet to automation technology can be found in these Ethernet features:

- High overhead for communication with devices that have to exchange small quantities of data frequently
- High connection costs per device compared with classic fieldbus nodes (transformer, PHY, MAC and required processor performance)
- Lack of real-time capability which, on closer inspection, is caused by slow runtimes in the software stacks, rather than by the fact that Ethernet is used as the transmission medium
- Ethernet now commonly uses a star topology, although this is rather unfavourable when it comes to system wiring and can lead to excessive cabling effort or highly cascaded communication dependencies.

EtherCAT functional principle

By applying the unique functional principle of 'Processing on the Fly', EtherCAT technology overcomes the inherent limitations of other industrial Ethernet solutions: while earlier the Ethernet packet was received, then interpreted and process data was then copied at every device; now the EtherCAT slave devices read the data addressed to them while the frame passes through the node. Similarly, input data is inserted while the telegram passes through. The frames are hardly delayed at all. The frame sent by the master is passed through to the next device until it reaches the end of the segment (or branch). The last device detects an open port and therefore sends the frame back to the master.

An EtherCAT frame comprises the data of many devices, both in sending and receiving direction within one Ethernet frame. The usable data rate increases to over 90 per cent. The full-duplex features of 100BaseTX are fully utilised, so that effective data rates of more than 100 Mbit/s (>90 per cent of 2 x 100 Mbit/s) can be achieved. But what are the resulting EtherCAT features? More importantly, what are the end user benefits of these features?

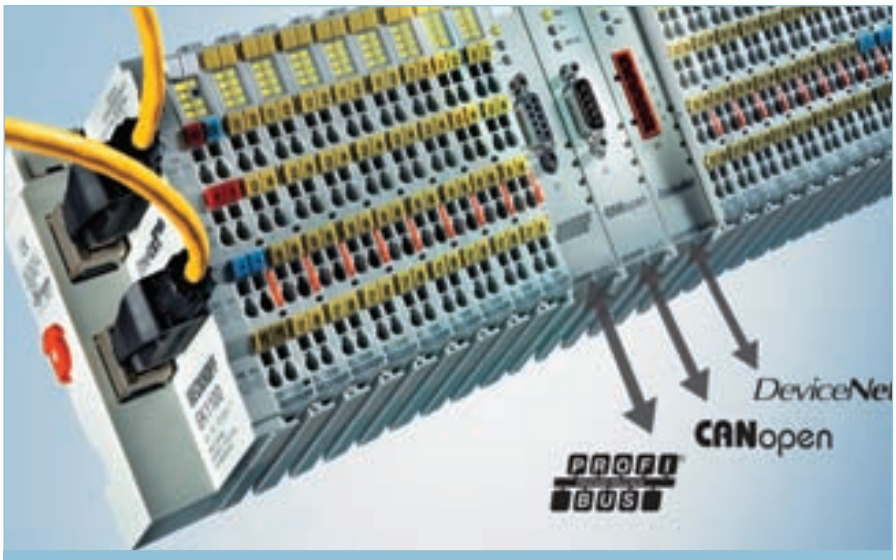
Better efficiency

EtherCAT is not substantially faster than traditional fieldbus systems, but is the fastest among the industrial Ethernet solutions. Typical EtherCAT cycle times are 50 to 250 µs, while traditional fieldbus systems take 5 to 15 ms for an update. EtherCAT makes the processing power of an industrial PC available for the application, and faster controls provide more accurate results.

A leading injection moulding machine manufacturer reported that by using EtherCAT they could reduce the part weight variation and thus the wall thickness of the plastic cup and hence save material worth over $1,80,000 per machine and year. Closed loop controls are not the only ones to benefit from faster communications, in many applications there are so called transitions, where one has to wait for the part to arrive, the cylinder to reach its end position, or the pressure to reach a certain threshold. With a faster network, the waiting times are reduced and the throughput of the machine or plant is increased also increasing the efficiency by some per cent.

Synchronisation accuracy

EtherCAT is not only fast, but also very precise, thanks to the distributed clock measurement values can be sampled and outputs set in a synchronised manner network wide and with a jitter substantially smaller than one microsecond. In most cases the deviation is even below 100 nanoseconds. >



EtherCAT I/O modules and fieldbus gateways

This accuracy is ideal for synchronised motion control applications and for integration of measurement tasks within the same network.

Inexpensive technology

EtherCAT is inexpensive on one hand as there are software implemented masters on standard Ethernet ports, on the other the highly integrated yet low cost slave controller chips. The cabling also saves money, since EtherCAT does not require switches or other active infrastructure components and uses standard cabling and connectors. Even the engineering effort is reduced, since network tuning is not required any more and since the diagnostic feature of the technology provides exact error localisation and thus less trouble shooting time.

Besides low chip and hardware costs, a crucial factor for low component prices is worldwide acceptance of the technology, wide choice of products and thus competition among the suppliers. EtherCAT is supported by the EtherCAT Technology Group (ETG), with over 1100 member companies from 47 countries. EtherCAT also has the fastest adoption rate among the industrial Ethernet technologies. The product guide on the ETG website already features over 200 entries with over 500 products, and many more products are about to enter the market.

Flexibility and migration

EtherCAT networks have no practical limitations on topology: line, star, tree, redundant ring or any other topology can be selected with up to 65,535 nodes per segment. In case the 100 metre distance between two nodes is not sufficient, fibre optic cables are used. Even wireless technologies can be integrated. Hot connect allows connection and disconnection of nodes during runtime.

EtherCAT is so fast that classical fieldbus systems can be integrated easily. Already 19 different systems are supported. With these components one can integrate existing devices into an EtherCAT network and also realise interfaces to neighbouring or higher level systems. Migration from previous systems is facilitated and at the same time the complex interface variety of the central controllers is omitted: other systems are simply integrated via EtherCAT, and not any more via PCI, cPCI, PCIe and so on.

Safety and automation

Conventionally, safety functions are implemented separately from the automation network, either via hardware or using dedicated safety bus systems. Safety over EtherCAT enables safety-related communication and control communication on the same network. The safety protocol is based on the application layer of EtherCAT, without influencing the lower layers. It is certified according to IEC 61508 and meets the requirements of safety integrity level (SIL) 3.

With EtherCAT networks, there is no need for manual address settings via dip-switch, rotary switch or similar means at every device: at boot-up, the addresses are assigned automatically. Even if devices are added later, the original addresses can be kept. EtherCAT masters can also feature automatic topology recognition and compare the actual network configuration with the one expected by the application program. After device replacement, all parameters can be downloaded automatically.

Open for future

Almost every fieldbus and Ethernet technology claims to be open. With EtherCAT, openness does not only mean international standardisation (IEC, ISO), availability of commercial as well as shared and open source master and slave software and chips from several suppliers, but also free of charge implementation support, clear guidelines regarding interoperability, master and slave implementations for a large variety of operating systems and controllers, openness of the configuration tools also for third party devices and specifications also for the application interfaces.

The EtherCAT technology is not only fully Ethernet-compatible, but also characterised by particular openness 'by design' the protocol can transport other Ethernet-based services and protocols on the same physical network. Such internet technologies are tunnelled via the EtherCAT protocol, so that the real-time characteristics are not impaired. All internet technologies can therefore also be used in the EtherCAT environment: integrated web servers, e-mail, FTP transfer, etc.

Versatility

EtherCAT is characterised by outstanding performance, very simple wiring and openness for other protocols. EtherCAT sets new performance standards and provides, thanks to Ethernet and Internet technologies, optimum vertical integration. With EtherCAT topology ›

considerations are a matter of the past – and no expensive infrastructure components are required.

EtherCAT is versatile: master-to-slave, slave-to-slave and master-to master communication is supported. Safety over EtherCAT is available as well. EtherCAT makes Ethernet down to the I/O level technically feasible and economically sensible. Maximum utilisation of the large bandwidth offered by Ethernet and outstanding real-time characteristics at low costs are outstanding features of this network. Remember that a network can never be too fast or just too expensive, too difficult to handle or too proprietary.

Conclusion

In automation technology, there is currently a trend to use Ethernet also at the field level. Various approaches promise high bandwidth, low costs, simplified vertical integration, utilisation of standard components from the office sector and low configuration and diagnostic effort, and all that combined with the required real-time capability.

EtherCAT takes a different route and combines the advantages of fieldbus technology with the otherwise indisputable advantages of the Ethernet world. The available bandwidth is almost fully utilised, and the costs are reduced to a simple ASIC connection in the EtherCAT device. Standard components are used where they are in fact standard - in the control and not in the 2-bit I/O terminal. EtherCAT does not require IP addresses, and configuration is automatic – controlled by the master using simple algorithms. Vertical integration is nevertheless available. Devices requiring an IP address can have one and are then integrated fully transparently in the network.

EtherCAT enables high-performance machine controls to be realised, capable to exchange many distributed signals with cycle times significantly below 100 µs. Moreover, the system is just as suitable for cost-effective control applications where cycle times three orders of magnitude larger are sufficient, e.g. building automation with 100 ms. In this case, any commercially available PC or any controller with integrated Ethernet port can be used as a master. EtherCAT therefore offers a unified, powerful communication basis for the entire automation sector. The same system technology can be used from 'small' PLCs for less than Rs 7000 to high-performance CNC. ■

INDUSTRIAL ETHERNET SEMINAR

ETG is organising a series of seminars in Nov 2009 at various locations, that specifically address end users as well as device vendors and system integrators to learn about EtherCAT technology. You are invited to attend.

Locations

Ahmedabad : Nov 2, 2009
Bangalore : Nov 3, 2009
Chennai : Nov 4, 2009
Pune : Nov 5, 2009
Mumbai : Nov 6, 2009

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