Application Report:

Encoders and interface
Fieldbus compared to Industrial Ethernet - from a sensor expert’s point of view

Contrary to initial persuasion, up to now there is no standard fieldbus but almost 50 different systems with deterministic characteristics regarding technical functions, application and popularity. But not every bus fits industrial use (fig. 1).

Fig. 1: Encoder installed at a straightening machine in a sheet metal processing application. Multiturn absolute encoders with modular bus covers for convenient mounting and cost-effective maintenance have proven reliable even in harsh environments.

Fig. 1a: Even when already docked the bus cover enables function-relevant parameterization or parameter verification. In sheet metal processing the easy-to-mount encoders – here with Profibus interface – are applied as position sensors in an automated manufacturing process, for example tool positioning or precise straightening of sheet metal.

Reliable, established systems well suited for rugged encoder applications are Profibus, Interbus, CAN, CANopen, DeviceNet and also latest interface technology enabling a network on Ethernet level (fig. 2).

Fig. 2a: Nearly no industry that does not rely on fieldbus communication - whether food and beverage, packaging or material handling.

Fig. 2b: Construction sites often provide only confined space, reason why at truck-mounted concrete pumps often only two support legs are extended. The operating range at the supported side of the vehicle is safely monitored by CANopen encoders. (Photograph: Schwing GmbH)

The bus interface truly applied in the end does mainly depend on the already prevailing control topology. Efficiency and safety are primary conditions for the generation of renewable energy. High-performance fieldbus interfaces (fig.
3a) are of substantial significance in wind power stations.

Fig. 3a: Efficiency and safety are prerequisites for the generation of renewable energy. High-performance fieldbus interfaces are of substantial significance in wind power stations.

**Profibus and Interbus**

Profibus (Process Field Bus) was adopted by Siemens and the Profibus User Organisation founded in 1989 and meanwhile is internationally standardised in line with IEC 61158. The DP (decentralized periphery) variation is mainly used in process automation. Data transmission media is a two wire twisted pair with shield. Also transmission by fiber-optic interface is feasible. Baumer recognized the trend at an early point and since 1995 they have been offering encoders featuring the corresponding interface protocols DPV0 and DPV2. Same applies to Interbus that also was intended as rapid sensor/actuator communication medium for process data transmission in industrial use. Cabling is by five pair twisted wire with shield and also here a fiber-optic bus network is feasible. Phoenix Contact and the Interbus-Club where Baumer has been a member of since 1992 were mainly committed in the development.

**CAN, CANopen, DeviceNet and SAE J1939**

By Controller Area Network (CAN) several peer components (nodes) are networked by two wire bus. CAN protocol was developed in 1983 by Bosch for use in automobiles as a communication system with Anti-lock brakes. Thanks to high interference immunity, low costs and real-time capability CAN commercialized for industrial use in automation, textile machinery, lift control and farming equipment. CANopen based on CAN bus protocol proved very well suited for transmission of small amounts of data and high-speed synchronisation. The CANopen communication protocol developed by CIA (CAN-in-Automation User Association) was standardized in line with European standard EN 50325-4 at the end of 2002. First encoders providing a CANopen interface have been applied – mainly in Europe - since 1995 with meanwhile increasing demand in North America and Asia. However, especially in North America another CAN based bus system is very popular: DeviceNet - once developed by Allen Bradley (a company of Rockwell Automation) and now managed as public industrial network by ODVA (Open Device Vendor Association).

CAN SAE J1939 protocol is the commercial automobile bus standard developed by the Society of Automotive Engineers (SAE) and is also applied for ships, railway vehicles, agricultural machinery and large generators. Furthermore SAE J1939 serves as basis for the international standards NMEA 2000 (Navy) and ISO 11783 (ISO bus for agricultural machinery) so that the protocol stack can be utilized also in these applications (fig. 3b).

Meanwhile a large configuration variety of corresponding encoders is available. Dependable operation in harsh environments or in contact with aggressive media: Fieldbus encoders in protective stainless steel housings have proven well suited and reliable for many years in food and beverage industry, harbour logistics or mining applications (fig. 4).
Fig. 4: Dependable operation despite harsh environments or aggressive media: Fieldbus encoders in protective stainless steel housings have proven reliable for many years in food and beverage industry, harbour logistics or mining applications.

Absolute Encoders with Ethernet-based interfaces: EtherCat...

Ethernet well established in office applications has been conquering industry for a fairly long time by combining high performance with user-friendly handling. Industrial Ethernet interfaces as EtherCAT, Profinet, PowerLink or Ethernet/IP (fig. 5) have been conquering the domain of encoders with increasing importance.

Fig. 5a: Latest trend: Opened industrial fieldbus protocols up to Ethernet communication level.

No matter which one may dominate the market on the long run – flexible encoder concepts support all four. EtherCAT is an open Ethernet-based fieldbus system characterized by high performance in conjunction with convenient handling. On the long run it provides a big potential to replace „classic“ fieldbus systems. Based on Ethernet capacities, EtherCAT is even capable of efficient transmission of small amounts of data.

Fig. 5b: Fieldbus and Ethernet protocols are open standards where multivendor application is visualized by busspecific logos. User organisations ensure standard compliance and provide international platforms for exchanging knowhow and ideas.

EtherCAT is an open technology supported by the EtherCAT Technology Group and standardized in line with IEC at the beginning of 2005. Corresponding Baumer encoders (fig. 6) are available on the market.

Fig. 6: The characteristic M12 connector outputs provided at the modular bus cover are the link between interface and Ethernet communication level.

Typical applications can be found at presses and punching machines in automotive industry. More Industrial Ethernet solutions managed by other user associations went through a similar history:

...Profinet, Powerlink and Ethernet/IP

Profinet is the open Industrial Ethernet standard of Profibus and Profinet International (PI) for automation. Profinet uses TCP/IP and IT standards, is real-time Ethernet and enables fieldbus system integration. The Profinet concept...
features a modular structure so that users can select the cascading functions themselves. They differ essentially because of the type of data exchange to fulfil the partly very high requirements of speed.

Ethernet PowerLink is an open protocol in compliance with Ethernet standard IEEE 802.3 and designed for use in automation applications for real-time process data exchange within microseconds. Ethernet PowerLink was introduced by Austrian automation company B&R and standardized by the opened user and producer-group EPSG (Ethernet PowerLink Standardization Group) as a public standard.

Ethernet/IP (Ethernet Industrial Protocol, often shortly called EIP) is an Ethernet-based fieldbus system developed by Allen-Bradley. The protocol later was handed over to Open DeviceNet Vendor Association (ODVA) to be managed as a public standard and to ensure multivendor system interoperability. In 1998 a ControlNet research group introduced a protocol intended to replace the existing public application protocol Common Industrial Protocol by Ethernet. Based on this protocol and with the support of ControlNet International (CI), Open DeviceNet Vendor Association (ODVA) and Industrial Ethernet Association (IEA) Ethernet/IP became a public industrial standard in March 2000. From 2002 to 2006 more than one million devices featuring this interface were sold. About 150 manufacturers among the ODVA support this bus protocol and of course meanwhile many encoders provide this interface.

The world of sensors has been shaped by multiple fieldbus and Ethernet interfaces, a trend we expect to enhance. Baumer keeps up by elaborating a concept to implement relevant interface technologies serving the need for extra safety like CANopen Safety, Profinet Safety and further branch-specific communication protocols like CANopen Lift (fig. 7) developed and promoted by the lift construction industry and supported by “CAN in Automation” (CiA).

The modular bus cover concept: Improved flexibility and reduced stocks

The fairly big diversity of common bus systems sometimes is quite an obstacle. Mechanical engineering and plant manufacturers must consider different customer requirements when choosing a bus system. Modular bus encoder designs provide the vital benefits of quick and easy mounting together with improved maintenance and service. Baumer absolute multiturn encoders are available as modular configurations where several modular bus covers accommodating the respective fieldbus interface are simply docked to the basic solid or hollow shaft encoder (figures 8a, 8b). The benefits are obvious: Simplified wiring, improved flexibility and stock reductions since the interchangeable bus cover is simply docked to the basic encoder. Furthermore, encoder and bus interface allow individual replacement resulting in improved maintenance. Both encoder and bus cover offer numerous diagnostic functions for preventive maintenance to ensure optimum system availability. The user may choose between bus covers with Profibus-DP, CANopen, DeviceNet, SSI, or fiber-optic interface as well as high-speed EtherCAT. New in the Baumer encoder range is an encoder featuring Profibus-DP-V2 interface for clock-synchronous parallel transmission of data output by several encoders at the same time.

But the Baumer encoders are even capable of more. Baumer multiturn absolute encoders utilize the well-established Non-Contact-Encoder-Principle without any mechanicals gears and other components that are subject to wear and tear. They are also available as hollow shaft configuration (fig. 9) with optional hollow shaft diameters up to 50,8 mm for easy mounting straight on the shaft. Thanks to high-integration technology the number of components is down to a minimum what is an important aspect in reliability. They are capable of rotation speeds up to 12.000 rpm, utilize a 36 bit resolution and endure operating temperatures between –40 and +100°C.
Fig. 8a: By the modular bus cover concept different basic encoder configurations can be combined with the individually required interface. Result: Reduced stocks as well as improved maintenance and flexibility.

Fig. 8b: A big plus to flexibility by virtue of an interchangeable fieldbus interface concept: The modular bus cover can be docked to different basic encoder configurations.

Fig. 9: Multiturn absolute encoders utilize the well established Non-Contact-Encoder-Principle without any mechanical gears and other components that are subject to wear and tear. They are also available as hollow shaft configuration with optional hollow shaft diameters up to 50.8 mm for easy mounting straight on the shaft.