Communications protocols abound. The most useful are featured in components such as encoders to match application requirements.

Connection guaranteed: Choosing the right sensor interface

Rotary encoders with SAE J1939-compatible interfaces — suitable for vehicle systems.

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During the relatively brief history of electronic motion control systems, a number of communications and networking schemes have been introduced. Not all get equal acceptance in the marketplace, but several are established industry standards, mainly because they offer the right combination of features, performance, and cost to meet the needs of a particular technology or market segment.

That said, when it comes to communications systems for motion control and industrial automation systems, there are no one-size-fits-all solutions. Industrial Ethernet has many advanced features that are valuable to designers of large, complex factory systems. However, for smaller, self-contained applications, simpler technologies such as fieldbuses or point-to-point SSI, bit-parallel, or even analog solutions are useful. Legacy setups can also influence decision making: It may not make economic sense to replace an existing fieldbus network that is still sufficient. Remember: Commitment to a particular communications networking technology should not stand in the way of selecting the best sensors or other devices for a system.

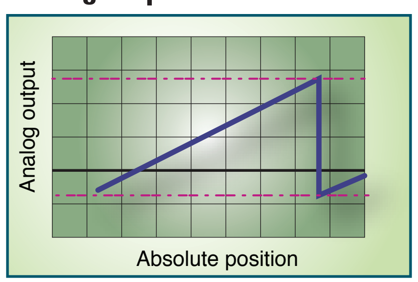
Networking strengths and weaknesses

- Analog interfaces (such as the ratiometric output of potentiometers) can be cost effective for simple control systems. Using point-to-point wiring topology, these are easy to install and provide for quick integration on small networks. For these reasons, installations are common in vehicles, medical equipment, and alternative-energy applications.
- **SSI (Synchronous Serial Interface)** and bit-parallel connections are also based on point-to-point wiring systems, but interface directly to PLCs or other digital controllers. Bit-parallel communications provide speedy communications over short distances. However, the need for individual wires for each bit makes high resolutions impractical.

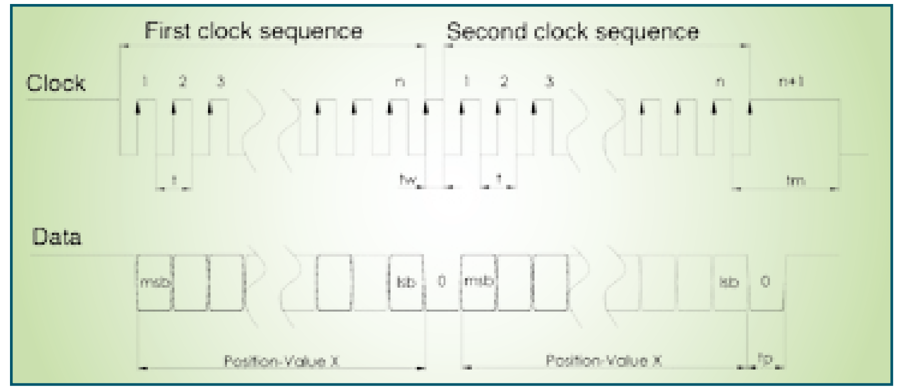
In this case, a fast serial transmission is a better choice. SSI connections use clock rates up to 2 Mhz and work reliably over long distances using differential signal transmission. In addition, the protocol provides basic error detection of broken wires, short circuits, and data inconsistencies. This makes SSI suitable for OEM applications, as it interfaces easily with digital programmable controllers or directly with the serial peripheral interface (SPI) of common microcontrollers.

- **Fieldbus networks** were developed for work cell and factory automation systems. Applications range from conveyors and manufacturing facilities to medical equipment, wind turbines, and solar panels. These networks are based on a bus topology that simplifies wiring together many devices. First developed as physical fieldbus layers were Controller Area Network or *CAN* and Process Field Bus or *PROFIBUS* by Bosch and Siemens, respectively; the De-

Analog output



Voltage or current change proportionally through the measuring range. This range can be set by the user (from less than one turn to multi-turn) for easy installation.



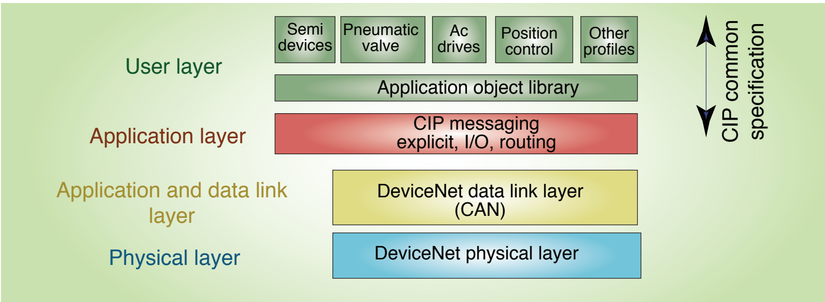
SSI data specification: **Top, a clock signal is sent to the encoder. Bottom, the encoder returns data per the clock.**

Network comparison

Interface	Wiring costs	Sensor costs	Diagnostic functions	Cycle - response time	Ease of installation	Network topology	Safety features
Analog	High	Low	Low	Medium	Easy	Small	No
SSI / bit parallel	High	Low	Low	Fast	Easy	Small	No
Fieldbus	Low	Medium	High	Medium to fast	Medium	Medium to large	Yes
Industrial Ethernet	Low	Medium	High	Medium to fast	Medium	Large	Yes

Wiring costs are for many sensors on one network. Sensor costs are based on a given interface.

DeviceNet protocol stack

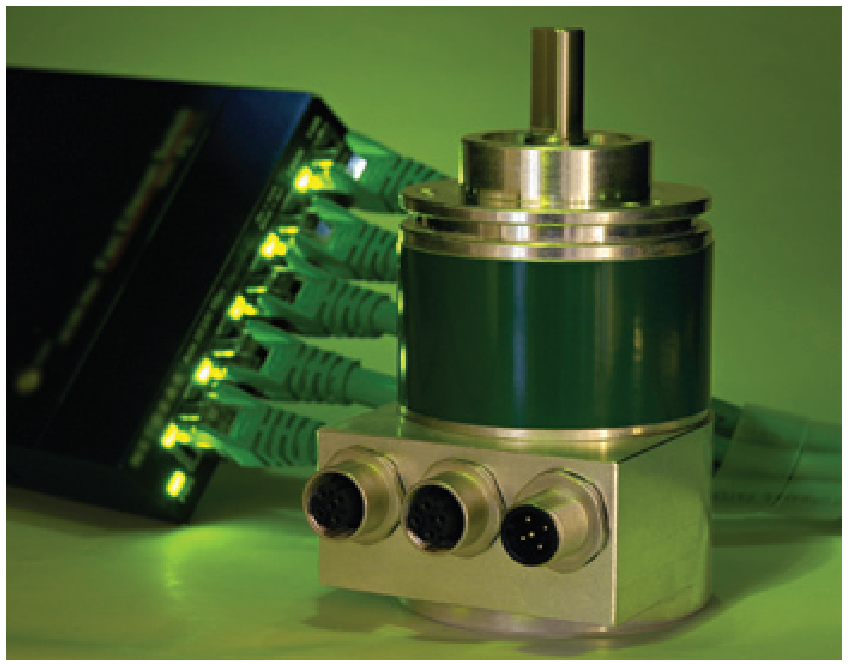


The DeviceNet interface, developed by Allen-Bradley/Rockwell Automation, is commonly used in North America. DeviceNet combines the CAN physical layer and higher-level CIP protocols.

viceNet interface, developed by Allen-Bradley/Rockwell, is commonly used in North America. DeviceNet combines the CAN physical layer and Common Industrial Protocol or *CIP* higher-level protocols. Similarly, SAE's J1939 standard defines a CAN-related technology for vehicular applications. These higher-level interfaces also allow for diagnostics and safety functions.

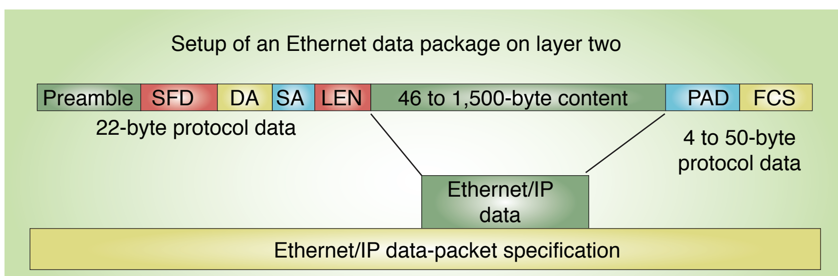
• **Industrial Ethernet** is a relatively recent development in industrial automation and motion control. It uses the same core technology as the millions of commercial and domestic LANs installed around the world — so industrial users can often leverage the enormous base of products and experience accumulated around the Ethernet standards IEEE 802.x. However, factory and mill conditions are often more severe than those in a typical office environment. Moreover, industrial applications often require controls to operate in real time, without the delays in data transmission that can occur in "ordinary" Ethernet networks. For these reasons, Industrial Ethernet systems incorporate special features at both the hardware and software levels to improve robustness and performance. Examples include Profinet, EtherNet/IP, and Ethernet Powerlink. These interfaces are gradually replacing fieldbuses for large-scale applications.

Another benefit: Industrial Ethernet allows for larger networks (with more nodes) and more complex networks than fieldbus technologies. It also allows for *vertical integration*, enabling seamless interfaces between the factory network (Industrial Ethernet) and the enterprise network (office Ethernet). This can be a valuable feature for integrating production, inventory control, and management.



Above: Optical encoders deliver highest resolution: FRABA's POSITAL OPTOCODE rotary encoders use optics for resolution to 65,536 (2^{16}) steps per turn, or 16,384 (2^{14}) revolutions from multi-turn models. The units also feature several interfaces for wide compatibility, including an Ethernet/IP communications interface certified by ODVA — a protocol often most appropriate for common optical-encoder applications.

EtherNet/IP data packet specification: **Industrial Ethernet allows for larger and more complex networks than fieldbus technologies. It also has the potential for vertical integration, enabling seamless interfaces between factory and enterprise (a.k.a. office) networks.**



Electronic adjustment of measuring range

Magnetic rotary encoders with an analog interface are a reliable alternative to traditional potentiometers — a combination suitable for cost-sensitive applications using simple analog-based measurement and control. Specifically, POSITAL MCD encoders use noncontacting Hall-effect sensors to track rotations, so they are more reliable than potentiometers, which can suffer from wear. (In a unique range-adjustment feature, the MCD encoder can be "taught" the rotary positions that correspond to travel limits of the machine to which it is connected.) POSITAL MCD encoders offer 13-bit resolution (8,192 steps per turn). To allow connection to applications typical for these units, these include CANopen and SSI interfaces as well.

Compatibility increases

First-generation networked industrial automation systems were introduced by large equipment vendors seeking competitive advantage by offering end-to-end solutions based on proprietary technologies. However, no single vendor supplies best-in-class equipment for every part of a complex automation system. For this reason, some equipment suppliers now support industrial organizations that promote technology on "open" or vendor-neutral networks.

Technical specifications are published and compatibility standards developed for testing and certifying devices from different vendors. As a result, buyers of industrial automation and motion control equipment can now mix and match components from several suppliers and expect a reasonable level of compatibility. This development allows integration of sophisticated products (such as precision-engineered encoders) into larger systems through standards-compliant interfaces.

Important user and vendor groups include the Open Device Vendors Association (ODVA, www.odva.org), supporters of DeviceNet and Ethernet/IP standards; the CAN in Automation association (CiA, www.can-cia.org), supporters of the CANopen protocols; and the Profibus Nutzerorganisation (PNO, www.profibus.com), supporters of the Profibus and Profinet interfaces.