THE CHALLENGE FOR INDUSTRIAL ETHERNET

Ethernet technology has been around for over 30 years, so it's natural to think it could play a role in industrial automation applications. Position feedback devices have historically used Analog signals (voltage or current) or dedicated fieldbus networks such as CANbus, Profibus or Devicenet for communication at the device level with motion controllers. Meanwhile, control-level networks are used to manage communication within the factory between controllers which may then go through a gateway before reaching the corporate Ethernet network. How do you meet the connectivity demands in the factory while addressing the real-time performance needs for motion control? Can this be achieved with common network architecture?

The challenge for Industrial Ethernet networks in Automation is achieving the required speed and determinism. Typically, the Ethernet packets exchanged on a network do not come with consistent delivery times at the level required for automation applications. In addition, the requirements vary with different types of components. Drives and other high-speed devices, for example, may require update times of 1 millisecond or faster. Other devices, such as controllers or terminals may only need 10-100 millisecond updates. Advances in the standards and real-time products for determinism on Industrial Ethernet have enabled adoption for motion control applications. Industrial Ethernet adoption in the factory has grown considerably as it offers the shielding and robustness for harsh manufacturing environments. These solutions follow the IEC 61158-2 for the physical layer and IEC 61784-1,-2 standards for measurement and control profiles, and are open for a variety of devices to adopt.

FLAVORS OF INDUSTRIAL ETHERNET

Suppliers of absolute, linear position sensors now offer a variety of Industrial Ethernet protocols such as EtherCAT, EtherCAT, and Ethernet Powerlink. These offer different network topologies such as star or ring topologies. The main differences in the protocols are how they achieve the network traffic switching and timing for determinism. Selecting a linear position sensor with Industrial Ethernet has the advantage of converging factory automation components on a common network, as well as providing device features such as multi-position capability (up to 20 simultaneous position readings) and advanced diagnostics.
THE EVOLUTION OF INDUSTRIAL ETHERNET PROTOCOLS

EtherCAT evolved from CANopen with the standard managed by the ETG (EtherCAT Technology Group). It uses its own Ethernet hardware to achieve the best cycle time performance. Although not based on standard Ethernet hardware and software protocols, it achieves the fastest performance of the available Industrial Ethernet varieties with cycle times down to 100 microseconds.

Ethernet Powerlink also evolved from CANopen and is managed by the EPSG (Ethernet Powerlink Standardization Group). It uses standard Ethernet hardware with a network of hubs along with its own data protocol transported in the Ethernet frame to provide determinism. The frame is divided into an isochronous and asynchronous portion to achieve cycle times down to 200 microseconds.

The EtherNet/IP protocol was developed by Rockwell Automation and is managed by the ODVA (Open DeviceNet Vendors Association). The technology is built using the Common Industrial Protocol (CIP) which defines profiles for many types of industrial devices including drives, sensors, and controllers. EtherNet/IP, which evolved from DeviceNet, and ProfiNet, which evolved from Profibus, are the most widely adopted Industrial Ethernet protocols with roughly 1/3 of the available nodes each.

A CLOSER LOOK AT ETHERNET/IP

In order to achieve real-time capability, Ethernet/IP divides communication into explicit and implicit message types. Explicit messaging via Transmission Control Protocol (TCP) is used for client-server type information such as diagnostics and configuration. Implicit messaging via User Datagram Protocol (UDP) is used for critical, real-time I/O data such as linear position feedback. The Quality of Service (QoS) feature in Ethernet/IP ensures that implicit messages are prioritized in packet delivery. An important step for setting up an Ethernet/IP network for industrial automation is ensuring that your components are already tested for conformance by the ODVA. The ODVA provides a Declaration of Conformity (DOC) for every product that complies with the requirements for Ethernet/IP and makes them available on their website (www.odva.org). The Conformance Testing helps to minimize configuration issues that might otherwise arise...just look for the Ethernet/IP Conformance Tested logo.

Users can implement linear or ring topology depending on the fault tolerance requirements for the application. Linear topology is simpler and is conducive to applications with a linear layout, such as conveyors. Ring topology adds fault tolerance capability by rerouting traffic within when a link failure occurs. The Ring Supervisor monitors the response as it beacons, and reconfigures the network within milliseconds if a link is broken. Some devices offer Device-Level-Ring (DLR) capability to directly connect to the ring rather than to an external switch. The switch is essentially embedded directly into the device. This provides device-level network re-routing and failure point identification to improve reliability and network recovery time.

One of the advantages of Ethernet/IP is the ease for adding new devices to the network. Adding a device, such as a linear position sensor, to a network is as simple as setting the IP address, attaching the sensor to your network, and configuring the controller parameters. With the R-Series Ethernet/IP Linear Position Sensor from MTS, each sensor comes from the factory with BOOTP and DHCP modes active as well as a unique MAC ID. A tool such as Rockwell’s BOOTP/DHCP Server program is used to assign an IP address to the unique MAC ID printed on the sensor label. When the sensor is then powered up on the network, it will begin broadcasting its MAC ID and be added to the network. The BOOTP/DHCP can then be disabled to permanently store the IP address the sensor’s EEPROM. The final step is adding the sensor as a device in the controller configuration software, and adjusting any parameters specific to the device. Linear position sensors have a number of parameters that can be configured via software such as resolution, measuring direction, multi-position capability, and velocity averaging.

These are just some examples of Industrial Ethernet technology for linear position sensors. Advancements in Ethernet/IP such as CIP Sync and CIP Motion continue to expand the range of real-time applications suitable for this technology. The primary benefits of Industrial Ethernet are connectivity, performance, reliability, and diagnostics. The choices for a design engineer are primarily determined by the network requirements (response time, number of nodes or axes), measurement requirements (speed, accuracy) and interfaces available for the selected motion controller.

HOW MAGNETOSTRICTION WORKS

Magnetostriiction is a term that describes the tendency of some materials to change shape, constrict or elongate in the presence of a magnetic field. Normally, a material’s magnetic domains are randomly oriented. If a magnetic field is applied, those domains will align, causing a change in shape or lengthening.

A magnetostriective position sensor takes advantage of this effect by inducing a mechanical wave or strain pulse (as shown below) in a specially-designed magnetostriective wire called a waveguide. The time of flight of this pulse is measured and can be equated to distance because the speed of traverse is very constant and repeatable. The pulse is created by momentarily causing the interaction of two magnetic fields.
One magnetic field originates from a permanent magnet, which passes along the outside of the sensor tube. The other electromagnetic field, encompassing the entire length of the waveguide, is created when a current interrogation pulse is applied to the waveguide.

At the interaction point between these two magnetic fields a torsional strain pulse is produced, that travels at the speed of sound in the specialized waveguide alloy (about 3.55 microseconds per centimeter of travel) along the waveguide path until the pulse’s arrival is detected at the head or mode converter end of the sensor.

The position of the magnet is determined precisely by measuring the elapsed time between the creation of the current pulse and the arrival of the strain pulse. That information is converted either to a duty cycle derived analog signal or is read as a serial or bus signal by the user’s controller. As a result, accurate non-contacting position sensing is achieved with absolutely no wear to any of the sensing elements. The strain pulse is small, on the order of 20 to 30 microstrain, resulting in virtually no fatigue of the waveguide.

ABOUT MTS SENSORS:

MTS Sensors, a division of MTS Systems Corp., is the global leader in the development and production of magnetostrictive linear-position and liquid-level sensors.

MTS Sensors Division is continually developing new ways to apply Temposonics® magnetostrictive sensing technology to solve critical applications in a variety of markets worldwide. With facilities in the U.S., Germany, Japan, and China, MTS Sensors Division is an ISO 9001 certified supplier committed to providing customers with innovative sensing products that deliver reliable position sensing solutions.