How to Select a Motion Control Network

Proper Network Selection Maximizes Reliability and Speed While Simplifying Operation and Maintenance

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Overview

If a machine or a robot needs motion control, odds are the automation system will use a high-speed digital motion control network. These networks provide a host of benefits that have been well documented over the past few years—but designing these networks requires care in order to simultaneously attain high reliability, maximum speed, low cost and ease of operation and maintenance.

Many motion control applications are speed critical, with faster speeds resulting in higher throughput. But as speed increases, motion control network design details become ever more important. This article will show how to maximize motion control network reliability and speed, guarantee operability among motion control components, minimize cost and ensure ease of operation and maintenance.

High Speed Equals Maximum Throughput

Most every modern digital motion control network is Ethernet-based, but significant differences exist at the protocol level and within the communication hardware included with each motion component. Typically, each motion component will have a communications chip that enables it to talk to other components in the network. The protocol and the chip work together to optimize communications for the particular task at hand, in this case motion control. When evaluating different Ethernet-based motion control networks, it's critical to check that all of the key requirements listed in Table 1 are met.

Motion control network requirements

1.	Reliability
2.	High speed
3.	Availability of design tools
4.	Wide selection of interoperable components
5.	Ease of operation and maintenance
6.	Hot plug and play

Table 1

The most important requirements for a motion control network are reliability and high speed. Most modern motion control networks are very reliable in terms of minimal component failure, so operational reliability depends on other factors, namely error checking and quick recovery from any errors. These features are critical as they allow parts to be produced correctly. High speed is important because it results in maximum throughput. Simply put, more speed equals more parts produced.

Machine or robot motion control commands are typically sent from a main controller to motion control components. These commands include information such as the desired position, velocity and/or torque. In turn, the motion control components often send data back to the main controller to indicate actual motion control parameters. To ensure guaranteed high speed, all data should arrive quickly and intact. In rare instances where data becomes corrupt or lost, the network should detect the problem and respond accordingly.

A prime example of this is a CNC application. A CNC relies on the correct data to arrive at the motion control components so that the cutting tool will cut the correct shape. If any data is missed, the CNC will either use the motion data from the previous packet, or make a best guess by extrapolating the information based on previous data points (Figure 1). This missed data will ultimately manifest itself in the machined product.

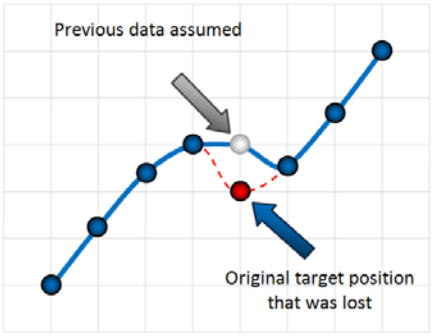

Figure 1: Data isn't correct in a motion control network without a data resend feature

A quick solution to missed data would be simple—just have the machine completely stop when there is any kind of error, and start over. The drawback to this approach is that the machine will have to be restarted many times if the system is sensitive to noise or has other operating issues that cause frequent data losses.

A better solution would be to use a communication network that incorporates a method of automatically resending data should any data become corrupt. The Mechatrolink motion control network, for example, checks to make sure that all motion control components receive data sent by the main controller, and this is done immediately after the initial data send.

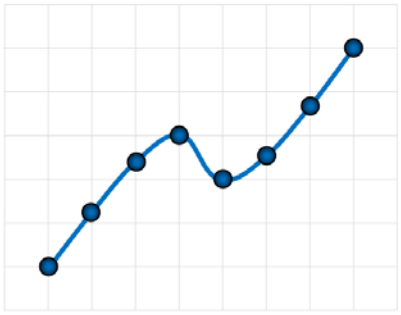
Figure 2: Data is correct in a Motion control network with a data resend feature

If any of the motion control components received corrupt data, the Mechatrolink motion control network will resend the data for only the components that received corrupt data. The new data is sent within the same cycle as the original data, with the resent data now located at the end of the data stream (Figure 2).

Because resent data is included within the same communications cycle, maximum possible recovery speed is assured. This data resend feature is extremely useful for guaranteeing correct data arrival every communications cycle, and allows the system to operate especially well in noisy environments.

Designing for Speed

When discussing Ethernet-based communications such as Mechatrolink, Sercos, ProfiNet, and EtherNet/IP, it's understood that the operating speed is 100Mbps. But actual application speed depends on how quickly the motion control system can perform consecutive operations, which is driven by the cycle time.

The two most important variables that determine the cycle time are the amount of data that is sent to each motion control component, and the total number of components. Most, if not all, Ethernet-based motion control networks allow the amount of control data sent to each motion control component to be changed according to the application requirements.

But one hidden factor that tends to be a mystery in many Ethernet-based motion control networks is actual speed under operating conditions, taking into account all of the variables that determine cycle time. Some motion control network organizations, among them Mechatrolink,

provide a utility that allows the user to input the network architecture and calculate cycle time (Figure 3).

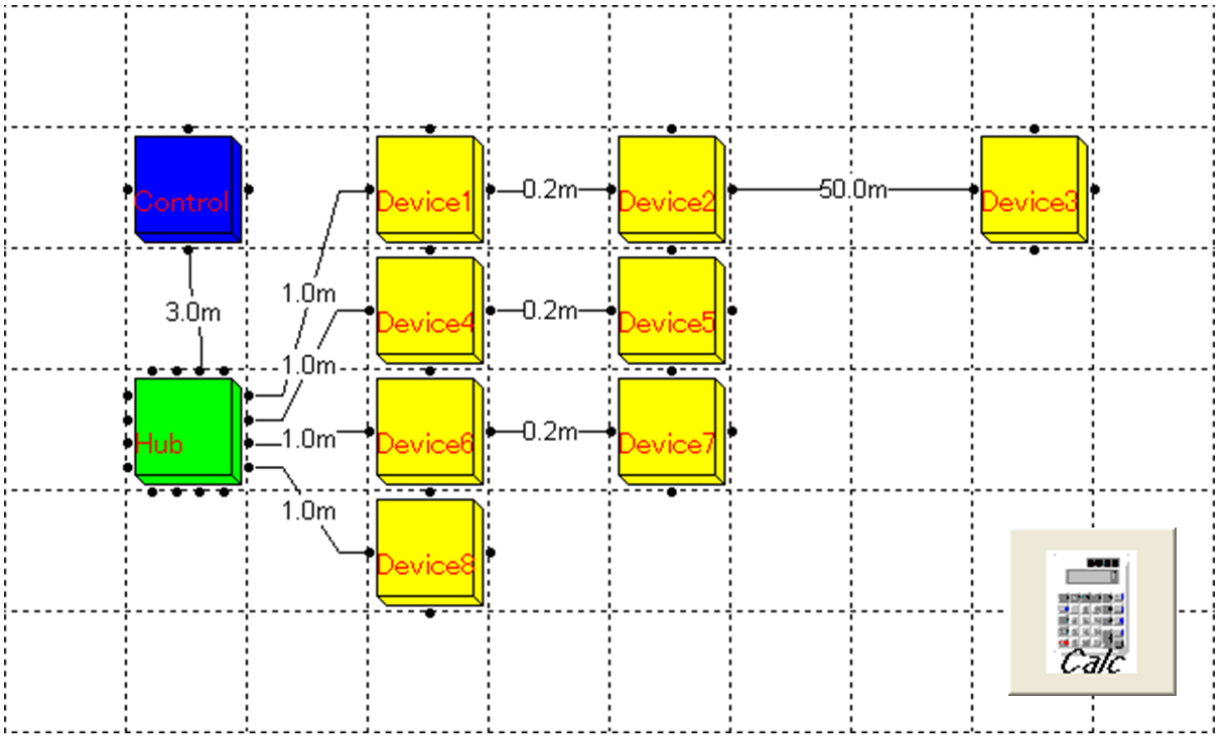

Figure 3: The Mechatrolink motion control network provides a utility to determine minimum cycle time and resulting highest possible speed.

The Mechatrolink cycle time utility takes into account the amount of data sent to each motion control component, the total number of components, the length of the communication cables between, the use of hubs, and all Mechatrolink chip delays. This utility guarantees that the designed motion control network architecture is operable at the desired speed. Machine and robot builder customers demand not only high performance, but also ease of use.

Compatibility is Key

Another requirement that must be met when selecting a motion control network is availability of interoperable components. Most machine and robot builders have preferred suppliers for their automation components, and it's critical to ensure that these components are guaranteed to be seamlessly interoperable in an integrated motion control system.

The goal of interoperability is to erase all doubts about integration issues. Ethernet-based motion control network organizations typically offer a conformance test to check if components can comply with the communications protocol. It's also common policy for the organization to prohibit the use of the communication technology's logo on the component unless the conformance test has been passed. Table 2 shows a partial list of suppliers with conforming components for Mechatrolink, a leading motion control network.

For example, a machine or robot automation system might include a main controller, remote I/O, a vision system and servo motor drives. Best performance and lowest price for such a system could result from mixing and matching different vendors. Motion control networks with a wide variety of available interoperable components enable the desired freedom of choice, resulting in the best automation system for the application.

Even when care is taken in component selection during the design phase, actual commissioning could reveal that one particular component isn't a good fit. Maybe the selected remote I/O isn't performing as expected, or maybe the vision system in question has limitations not evident in initial design. Availability of a wide variety of interoperable components allows needed changes to be made without affecting the viability of the rest of the automation system.

The ability of Ethernet to simultaneously carry multiple protocols may seem to offer an opportunity for virtually unlimited mixing and matching of communications protocols and automation components, but mixing protocols can cause problems.

An Ethernet-based motion control network is less prone to problems when there is only one protocol as compared to using two or more communication protocols. Some Ethernet-based motion control networks have two built-in protocols with the first acting as a carrier for the second. Fortunately, this isn't the case with many well-known motion control networks such as Mechatrolink, Sercos, ProfiNet, and EtherNet/IP.

All of these networks feature one complete protocol, and all use conformance testing and authorize use of their logo only on components that have passed the conformance tests. This results in guaranteed interoperability when designing a motion control network that uses components from different vendors.

Ease of Operation and Maintenance

Another key factor when selecting a motion control network is ease of operation and maintenance. As previously discussed, the right motion system network can increase uptime and ease operation through automated error detection and recovery.

When maintenance is required, hot plug and play saves time and money. A standard maintenance procedure in many plants is to shut down an entire production line in order to perform maintenance on just one section of a machine or robot. This procedure is required with networks that require a restart when any part of the communications system is disconnected, or when any communications error is detected.

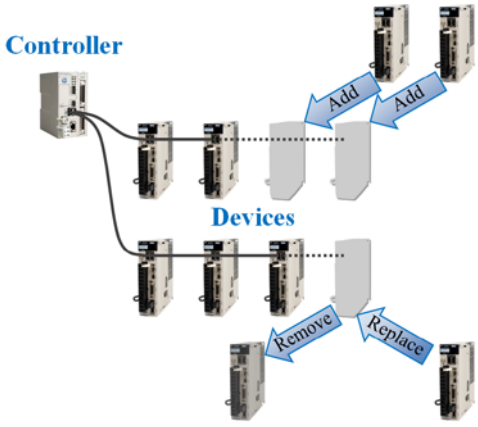

Figure 4: With hot plug and play, the motion control network remains active as components are added or replaced.

A more effective maintenance procedure is to allow the machine or robot to stay on by using the concept of hot plug and play. Many Ethernet-based motion system networks including Mechatrolink, Sercos, ProfiNet and EtherCAT offer hot plug and play capability. This allows motion control components to be added or replaced without interrupting communications among the main controller and other components (Figure 4).

Implementation of the network architecture becomes simple when there's a wide range of products to choose from that are guaranteed to be interoperable. Maintenance and modifications to the automation system are simplified when the motion control components can be swapped in and out while the machine is running. Ethernet-based motion control networks such as Mechatrolink and others include all these features—making network implementation, operation and maintenance effective and efficient.

The requirements listed in Table 1 provide a blueprint for the selection of the right motion control network for your particular application. The relative importance of each requirement will depend on particular characteristics of your application. Selecting the right motion control network will ensure that your machine or robot produces parts correctly with maximum speed.