FAQs

# Bus Systems for Motion Control Applications

## What types of bus systems are available?

Motion control applications need industrial data bus systems to transmit control data to motors and servos and receive feedback from sensors. These buses can have serial, parallel two-wire, or Ethernet-based architecture.

Simple serial buses use the RS-232 Raw ASCII protocol. Parallel two-wire protocols include Control Area Network (CAN) protocols like DeviceNET and CANOpen, as well as RS-485 protocols like Modbus RTU, PROFIBUS, and DMX. EtherCAT, EthernetIP, and ProfiNET are the most widely-used Ethernet-based buses.

## How does a serial bus work?

The RS-232 serial bus design is the oldest bus type and consists of a single wire that daisy-chains one device to the next. This point-to-point architecture is limited to a 10 m distance between devices and to a practical ceiling of a few dozen devices.

Data packets must be sent one at a time down the bus to each device in turn. Consequently, serial buses are limited to the transmission of ASCII data like standard keyboard characters. Simple data like periodic temperature readings can be transmitted quickly with serial buses.

## How does a parallel two-wire bus differ?

Parallel two-wire buses systems consist of two wires connected in parallel to the host and carrying data packets simultaneously to devices or nodes connected to both wires. Theoretically, up to 127 nodes can be connected in this way, but the practical limit is several dozen.

All nodes see all the data on the network, but devices and hosts use bit stuffing to differentiate signals to and from individual devices. Data integrity is ensured with use echo, parity, checksum, or cyclic redundancy checking using a 15-bit or 16-bit polynomial (CRC-15 or CRC-16).

Profibus networks use parallel coaxial cables to achieve network bandwidths up to 12 Mbps (Mbits per second) for 100 m or shorter runs. Other protocols top out at 1 Mbps at distances less than 25 m, although this degrades as distances grow. Typical network cycle times range from 2 ms to 100 ms depending on the protocol, but a 32-bit number transmits in 0.100 ms at 1 Mbps and in as little as 0.014 ms at the 12 Mpbs bandwidth.

One consideration for parallel two-wire buses is that noise on any node affects all nodes, so precautions must be taken near high-EMI devices like high-speed drives.

## What about industrial Ethernet?

Industrial Ethernet's tree topology with switches permits each node to communicate directly with the host. Such a system can theoretically host a few billion nodes, each with its own Internet Protocol (IP) address to facilitate communication with the host PC or PLC. Even with practical limitations, most industrial Ethernet buses can host thousands of nodes. Network traffic is managed by non-deterministic Ethernet collision detection, Ethertype prioritization, or deterministic single packet bit-shift, all with CRC-32 signal integrity checks.

Instead of overall bus length, Ethernet buses are limited by a maximum distance of 100 m between nodes. The isolation of each node makes the overall system relatively immune to noise. At 100 Mbps, Ethernet buses can handle a much higher bandwidth than serial or parallel systems. Cycle times can range from 0.1 to 500 ms. A 32-bit numerical signal can be read in 0.010 ms in this type of network, but users can pay a high implementation cost for the speed.

## Which bus is best for deterministic applications?

Many motion control applications are deterministic. That is, data packets containing instructions for motors or controllers must arrive at a specific time so that motion can occur, with known latency, in concert with other actions.

For example, a six-axis robotic arm has network nodes for each axis' servo and may be in a feedback loop with one or more sensors. Even simpler systems like a load moving on a linear track may employ determinism to ensure position and safety.

EtherCAT, and the less widely used ProfiNET-IRT and Powerlink Ethernet-based bus systems, offer true determinism. EtherCAT uses specialized junction boxes instead of switches in its tree topology to accomplish this.

## Does the amount of data matter?

If a network is carrying less data than its specified bandwidth—say, for a small number of nodes or when the data is simple numeric values—each transmitted packet may carry only a small percentage of useful data. The rest of the bits in the packet are data overhead.

In the case of the 32-bit number, the packet contains 4 bytes of data. Packet sizes vary by protocol, but such a packet would have 96% to 98% in an Ethernet-based network, 60% to 85% overhead in a parallel network, or 33% to 84% overhead on a serial bus.

The effect of data overhead as a percentage of data packet size may be spread over the total number of nodes in an Ethernet-based systems where it is a key factor in bus speed requirements. The speed advantage of faster Ethernet protocols is typically unrealized for fewer than 20 nodes or motion devices.

Below that, a parallel two-wire network may actually be faster for an equivalent amount of data, as well as being less costly and complex to implement. However, parallel systems can't improve their overhead percentages by increasing node count.

## What about the operating environment?

Consider both the physical environment and the ecosystem of existing equipment, which is usually standardized by the OEM. For example, Siemens equipment uses ProfiNET, Beckoff has EtherCAT, and Allen-Bradley uses Ethernet/IP. Compatibility is a major factor in choosing a bus for new equipment.

Environment—especially high temperatures and moisture—matters, too. CANBus and DeviceNET have sealable cabinets and connectors. Sealable accessories for Ethernet-based buses are relatively new, but look for military-grade cabinets, connectors, and cables.

## How can I get help choosing the right bus system?

Industrial buses for motion control are a complex array of products that have evolved over time and for different products. For more guidance on choosing the right bus for your application, consider turning to engineers at a manufacturer of equipment for all bus types, like Moog Inc.

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