

MULTIPLE PROTOCOLS FOR VALVE ACTUATOR CONNECTIVITY



EIM CONTROLS



WHICH PROTOCOL IS BEST FOR YOUR APPLICATION?

This document provides a brief description of each protocol, along with EIM's implementation of that protocol. Each implementation is given a cost-to-performance ratio rating. These ratings, related to electric valve actuators, are for general guidance *only* and may be considered subjective because they are the sole judgement of EIM Company, Inc. (based on installed cost, including equipment cost, cabling cost, complexity of integration/support, other required support equipment, data rates, data throughput, available data and control, security, and redundancy).



Based in Missouri City near Houston, Texas, EIM has been manufacturing electric motor valve actuators since 1949 ...

EIM introduced the first valve actuator network controller at the ISA Show in 1985 and registered the trade name “Controlinc” (pronounced Control-link) at that time. EIM soon expanded the Controlinc valve actuator network system with the addition of popular communication protocols and network masters—making network connectivity easier than ever.

Cost-effective valve control solutions are now possible for any size installation, thanks to Controlinc’s easy integration into your preferred control system. Integration with other networked field devices (such as transducers and other actuators) is also made easy through many available protocols.

COMMUNICATION ADAPTER MODULES

EIM Controls’ Controlinc Model 320, introduced in 1992, was designed with a Communication Adapter Module (CAM) concept for the support of multiple protocols and network topologies. This concept was expanded with the high-performance Model 320A.

By plugging in a CAM, any EIM valve actuator with Controlinc 320A may be upgraded to one of the supported protocols. *Any EIM 2000 series valve actuator manufactured over the past 20 years can be retrofitted with EIM’s popular M2CP control package, Controlinc, and any one of the supported protocols.*

Available protocols include Modbus RTU, Modbus Plus, Ethernet TCP/IP with encapsulated Modbus, DeviceNet, Foundation Fieldbus, Profibus DP, LonWorks, and AS-i. EIM can supply all field components necessary to support the valve actuator network with the selected protocol. Turnkey SCADA system integration with process control, report generation, and MMI/HMI software can be supplied through a third-party system integrator.



PROFILE: Modbus RTU offers a low installed cost for EIM actuator network systems ranging from a few nodes to hundreds of nodes. It's supported by most major actuator manufacturers and SCADA, DCS, and PLC systems.



COMMUNICATION & TOPOLOGY: Typical networks use RS-485 on twisted, shielded-pair cable. The EIA RS-485 standard (which is for parallel-connected bus networks on twisted-pair cable) limits distance to 4,000 feet (1,200 meters) with 32 nodes. EIM Controls' E>Net extends the number of units to a maximum of 254 at a wire distance of over 50 miles (>81,000 meters).



Other suitable media include fiber optics, telephone, and radio; maximum distance and number of nodes are both affected by media, topology, and baud rate. Baud rate is influenced by network media. Typical RS-485 wire networks use 9.6K and 19.2K baud. Baud rates up to 115.2K baud are possible on wired networks using expensive twin axial cable at limited distances.

Topologies include bus, E>Net, ring, redundant bus, redundant rings, and redundant E>Net. Networks may be a combination of bus and E>Net with trunk lines and drop lines with branching. EIM Controls' E>Net allows multiple topologies within the same network.

PERFORMANCE & SECURITY: Modbus is a master-slave protocol that limits system performance to the "medium" category. Lower performance of the protocol is overcome by using EIM's Network Master. Encoding security is poor, due to use of async NRZ. However, CRC-16 error check with limited message packets of 6 to 32 bytes provides very good security.



EIM Controlinc 320A actuator controller has a slave response delay of only 8mS. This allows master-slave transactions in less than 20mS at 9.6K baud. The 320A controller performs report-by-exception processing, thereby distributing processing and offloading the master. EIM Controls' Network Master enhances system performance 6 to 8 times, using report-by-exception and priority scanning. (Moving actuators are given priority over non-moving actuators with interlace scanning.) Data concentration at the network master simplifies system integration.

BOTTOM LINE: Due to the lower cost of interface equipment, the number of possible devices per network, as well as network topologies and redundancy, the installed cost for Modbus RTU is one of the lowest compared to other supported protocols.



MODBUS RTU

The most widely used protocol for valve actuator networks.



LOW COST-TO-PERFORMANCE RATIO

PROFILE: Modbus Plus provides high-speed, top-level connectivity to SCADA, DCS, and PLC equipment with gateways to Modbus RTU devices. It is normally used to integrate valve actuator network masters on the same high-level network with PLCs and computer equipment. (Direct connection to valve actuators is not supported.)



COMMUNICATION & TOPOLOGY: EIM Controls' Modbus Plus Network Master is based on a Modicon/Schneider BM85 Bridge Multiplexer running EIM's network master software. This network master has the same features as the Modbus masters, including report-by-exception, priority scanning, and data concentration. All connected Modbus Plus devices have common access to valve actuator data and control. The master also supports EIM Controls' E>Net with multiple network topologies, including rings with network fault detection and fault location.



Modbus Plus allows up to 64 nodes, where the network master is one node with up to 250 valve actuators. This allows very large systems with thousands of actuators, all using the same function codes. Modbus Plus devices may be distributed over a distance of 1,600 feet (500 meters) while supporting

wired Modbus valve actuator networks with distances of over 264,000 feet (81,000 meters) each. Redundancy is supported at both the field network and Modbus Plus network levels.

PERFORMANCE & SECURITY: Modbus Plus is a peer-to-peer network running at 1 Megabaud (1 Mbps). Large blocks of valve commands and data to and from the network master may be transported to any other Modbus Plus connected device at high speed. High-speed master block transfers allow fast execution of process control running on PLC or DCS systems, and also allow fast updates to operators at MMIs.



High data security is provided at the Modbus Plus level by higher level encoding in addition to CRC-16 error check of Modbus.

BOTTOM LINE: Due to the lower cost of network master equipment and a wide support of network topologies including redundancy, the installed cost for Modbus Plus is lower than all the other protocols.



MODBUS PLUS

Good solution for small to very large valve actuator systems with thousands of nodes.



LOW COST-TO-PERFORMANCE RATIO

ETHERNET

Direct connection allows integration of valve actuators into the plant-wide Ethernet network.

PROFILE: Ethernet TCP/IP with encapsulated Modbus provides direct communication with popular SCADA and DCS systems. It can even provide access from anywhere in the world via a Web browser on the World Wide Web.



COMMUNICATION & TOPOLOGY: High-speed network connectivity allows the actuator to share the same network as the plant computers—while remaining a slave to a host system (or systems) anywhere on the network. Multi-master systems allow sharing of all information and also allow control from multiple locations.



Each valve actuator is assigned an IP address, just like other computers on the network. Baud rates up to 10 Megabaud (10 Mbps) are supported with direct connection to wired networks. Backbones or other segments of the network may be supported by fiber optics, just like any plant-wide Ethernet installation. (Due to the limited distance and single-node interface of Ethernet, powered hubs are required to distribute the network to the actuators. Redundant networks are not supported.)

PERFORMANCE & SECURITY: Although there is no limit to the number of actuator nodes, Ethernet wire and hub network topology is not recommended for large systems in harsh industrial environments where process control security is important. Typical applications are confined within a small plant, such as water filtration, wastewater treatment, pump stations, etc.



Ethernet is ideally suited for small, widely distributed clusters of valves such as pipeline compressors or pump stations. Security is provided with both Ethernet and CRC-16 with the encapsulated packets.

BOTTOM LINE: Due to installation limitations and a higher equipment cost, Ethernet's installed cost is much higher than some protocols with full redundancy.



HIGH COST-TO-PERFORMANCE RATIO

DEVICENET

Enables direct connection of high-speed, high-security networks to valve actuators.

PROFILE: DeviceNet allows the integration of EIM valve actuators into the same network with transducers and other actuators with tight coupling with PLC or other process control systems. It provides very fast process control response to keep pace with the process.



COMMUNICATION & TOPOLOGY: Up to 63 actuators may be connected to a wired network using special 4-wire cable with power down the cable. Maximum distance of a wired network is 1,600 feet (500 meters). Typical systems use distributed PLCs on a higher-level network and DeviceNet networks connected to the PLCs. Using this arrangement, very large systems with thousands of actuators and sensors may be supported.



PERFORMANCE & SECURITY: DeviceNet is based on Bosch's CAN protocol, which employs a very high security encoding method in addition to data error checking. All DeviceNet devices have good network diagnostics, although redundancy is seldom supported. The high-security encoding allows baud rates of 125K, 250K, and 500K baud in harsh industrial environments.



BOTTOM LINE: Although the valve actuator is always a slave, DeviceNet supports peer-to-peer and multi-master communications. Most DeviceNet networks are installed as a single bus without redundancy, although installed cost is much greater than some protocols with full redundancy. Due to limitations of wired networks and the higher cost of required cable, installed cost for DeviceNet is much higher than some other protocols with full redundancy.



MEDIUM COST-TO-PERFORMANCE RATIO

PROFILE: EIM actuators, which are certified by the Fieldbus Foundation, provide direct connection to the fieldbus with guaranteed interoperability with other devices. Although Foundation Fieldbus provides peer-to-peer communications and multiple schedulers, process control systems seldom stand alone. (Most systems are installed with a master process controller such as a DCS.) However, with Fieldbus, the process can continue to run should the DCS or its link go down.



COMMUNICATION & TOPOLOGY: EIM valve actuators with Foundation Fieldbus have most of the features of the Modbus systems, including on/off block valve control, modulating/positioner control, extra discrete and analog I/O for monitoring, and control of other devices connected directly to the actuator.



Each network can have up to 32 devices with power down the cable if intrinsically safe devices are not connected to the same network. Networks may extend up to 6,000 feet (1,900 meters). Up to four repeaters may be used to extend distance. Typical systems are made up of DCS distributed process units with Fieldbus host support for multiple networks. This allows for systems with multiple networks that can support hundreds of devices.

Fieldbus systems seldom support redundancy.

PERFORMANCE & SECURITY: EIM valve actuators support a single H1 network connection. H1 runs at a fixed baud rate of 31.25K baud on twisted, unshielded cable. Due to the large amount of overhead processing required by the protocol, Foundation Fieldbus performance is the slowest of all other supported protocols.



Foundation Fieldbus has very good security due to its use of Manchester encoding. High security encoding and error checking provides high data security in noisy industrial environments.

BOTTOM LINE: Due to the protocol's complexity (which necessitates large memory usage and overhead processing and a limited number of nodes per network), installed cost for Fieldbus is one of the highest of all supported protocols, even when compared to some systems with full redundancy.



FOUNDATION FIELDBUS

Allows integration of multiple vendor devices, including transducers and actuators, in a stand-alone process.



HIGH COST-TO-PERFORMANCE RATIO

PROFILE: Profibus DP allows actuators to be integrated with other transducer and control devices—including computer equipment—on the same network. Networks are self-configuring, making integration easier than with some other protocols.



EIM actuators with Profibus support most of the features available on the Modbus units. (This includes on/off block valve and modulating/positioner control and extra I/O.) However, ring networks and redundancy are not supported.

COMMUNICATION & TOPOLOGY: Networks are normally installed as parallel buses using RS-485. Up to 126 nodes may be connected to one bus. Distance is limited to 4,000 feet (1,200 meters). Repeaters may be used to extend distance. Baud rates up to 12 Megabaud (12 Mbps) at



325 feet (100 meters) are supported. Baud rate is affected by network media and topology. Heavy loaded bus networks with spurs (branches) may require baud rate reduction. Other media, such as fiber optics, may be used to extend distance while maintaining high baud rates.

PERFORMANCE & SECURITY: Typical systems consist of a valve actuator network connected directly to a PLC or DCS. Multiple DCS process controllers or a network of PLCs may support multiple networks, allowing support of hundreds of actuators in one system. Although the valve actuator is always a slave on the network, Profibus supports peer-to-peer communications. Good data security is provided by Profibus' encoding method and error checking. Good network diagnostics is provided by all connected devices.



BOTTOM LINE: Although installed cost is not the most expensive, it is more expensive than some other protocols with full redundancy.



PROFIBUS DP

Direct connection of Profibus DP to EIM valve actuators provides a high-performance network control system.



MEDIUM COST-TO-PERFORMANCE RATIO

LONWORKS

Ideal solution for retrofits where existing cable does not meet needs of other protocols.

PROFILE: May be used with almost any type wire, including some power lines. Echelon's LON protocol has one of the highest-security encoding methods ever developed. This allows high data rates at long distances or communication over low-grade wire, or in extremely noisy industrial environments. A third-party device attaches to the conduit entry of any existing actuator, providing automation networking through existing wiring. New actuators may be equipped with the same communication device for new installations or for expansion of existing retrofitted installations.

Gateways are available for conversion to other protocols for easy integration with most SCADA, DCS, and PLC equipment.

COMMUNICATION & TOPOLOGY: Does not support all control and data as most of the other protocols, but has the advantage of multi-media networking with high performance and high security. Supports up to 32,000 nodes per network.

Networks may be widely distributed, with domain managers controlling clusters of devices within a local area.

Baud rates range from 9.6K baud over power lines with 55db loss or about 200 feet (62 meters) to 78K baud on unshielded, twisted-pair cable up to 4,500 feet (1,400 meters) with 64 nodes to a maximum of 1.25 Megabaud (1.25 Mbps) at 1,500 feet (460 meters) with 64 nodes.

PERFORMANCE & SECURITY: LonWorks supports both master/slave and peer-to-peer activity with multi-master capability. The actuator is always a slave to a host device. Extensive software to support network configuration and to interface with other equipment makes system integration one of the easiest in the industry. (The same LonWorks device may be used to automate actuators from multiple vendors in the same system.)

LonWorks has one of the highest security encoding methods, offering superior data security in harsh industrial environments.

BOTTOM LINE: Although this protocol is used predominantly to solve networking problems other protocols can't handle, it has a reasonable installed cost compared with others.



MEDIUM COST-TO-PERFORMANCE RATIO

ACTUATOR SENSOR INTERFACE (AS-i)

Ideally suited for combining pneumatic and electric actuators on the same network.

PROFILE: Systems support 124 discrete I/O points per bus. Typical installations use gateways or PLCs to support multiple AS-i networks, allowing support of thousands of I/O points.

AS-i also supports discrete sensors, but is not suited for analog-type transducers. It provides only discrete control of valve actuators, and is therefore not suited for modulating or positioning service.

A key benefit is the fast scan time of 5mS per bus of 31 nodes with 4 points per node. This provides tight coupling with process control equipment to keep pace with the process.

COMMUNICATION & TOPOLOGY: AS-i is a very simple protocol allowing self-configuring network systems and easy integration with other equipment. It is normally converted to another protocol, such as Modbus, Profibus, etc., for interface with high-level networks for SCADA, DCS, and PLCs.

AS-i is a master-slave protocol with cyclic polling of each node at a typical rate of 150uS per node. Data switching frequency is 167KHz. A fixed data packet of 16 bits is exchanged on each polling cycle. The 16-bit data packet contains only 4 usable data bits (either discrete inputs or discrete outputs). Addresses are set by the master or handheld setup device. No termination resistors are required, allowing devices to be added anywhere in the network.

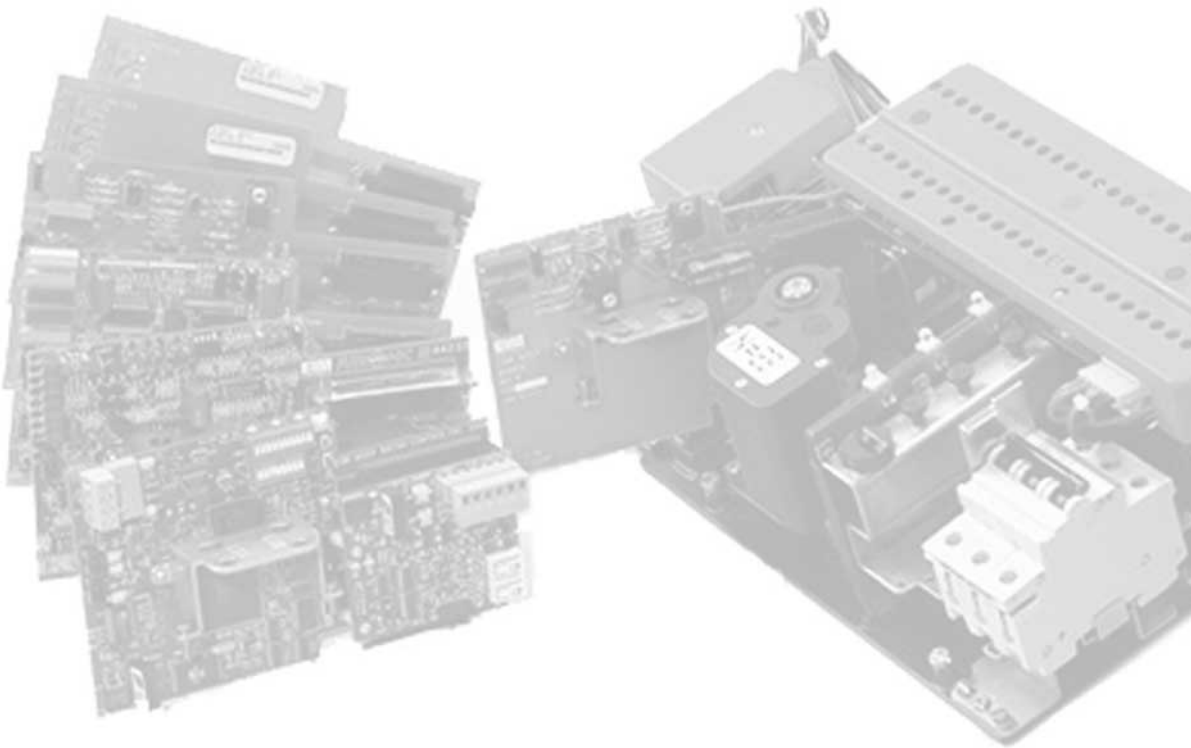
Typical installations use two nodes per electric actuator with 4 inputs and 4 outputs. This limits the number of electric actuators to 15 per bus. Inputs are used for actuator status of Close Limit, Open Limit, Selector Switch in Remote, and Monitor Relay Alarm. Discrete outputs are used for actuator command of Close, Open, and ESD. Since Stop command may be when neither Close nor Open commands are active, a fourth output may be used for other purposes.

PERFORMANCE & SECURITY: Its encoding method provides high data security—but only one parity bit is used for error checking, due to its very small data packet of 16 bits. Network topology is 24VDC power down the cable with parallel connected nodes on a bus, star, spurs, etc. The maximum number of nodes is 31. Maximum cable length with 31 nodes is 325 feet (100 meters) using untwisted, unshielded, 2-wire cable. Repeaters may be used to extend network distance. EIM provides screw terminal connections, so AS-i yellow, flat, insulation displacement cable is not required.

BOTTOM LINE: AS-i was designed for the lowest level of network automation. Although it appears to have great throughput performance compared to other protocols, it has severely limited data and control functions, limiting its applications.



LOW COST-TO-PERFORMANCE RATIO



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and Reliability**

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