



GE Fanuc Automation

Programmable Control Products

VersaMax™ I/O and Industrial Networking

Application Guide

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Field Control	Motion Mate	Series Five	VuMaster
GENet	ProLoop	Series One	Workmaster

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How to Use this Guide

Included in this guide are basics of I/O and control, criteria to consider when selecting a network, an assessment of three popular networks (Genius bus, DeviceNet, and Profibus-DP), a procedure for estimating network scan time, and case studies.

- For users unfamiliar with control systems and network structures, start with Chapter 1 for basic I/O terminology and then continue through the guide.
- For users already familiar with control and communication fundamentals, skip to Chapter 5 for information about VersaMax I/O and review Chapters 6 and 7 to help you select your network and estimate network scan time.

Who Are You?

In developing this guide, we assumed that

- ✓ You would like to learn how to integrate VersaMax I/O into an overall system structure that includes a host controller and a network.
- ✓ You are considering one or more of the following networks: Genius, DeviceNet and Profibus-DP.

Contents in Brief

Chapter 1	I/O and Control Basics: Introduces the terminology used to describe I/O and control systems.
Chapter 2	Control Systems: Describes control systems and architectures. Includes how to select a control architecture.
Chapter 3	Communications: Provides a brief introduction to the rules of communication, machine communication, and protocols.
Chapter 4	Networks: Defines networks, introduces the OSI model, describes industrial network types, outlines the differentiating characteristics of industrial networks, and summarizes the benefits of networking.

Preface

- Chapter 5** **VersaMax I/O and Control:** Introduces the VersaMax I/O and Control family. Includes a description of the product structure, an outline of the modules available, and a summary of the features and benefits.
- Chapter 6** **Industrial Network Comparison:** Provides a description of three industrial networks supported by VersaMax I/O – Genius[®], DeviceNet[™], and Profibus-DP. Includes a handy reference chart that compares these three networks.
- Chapter 7** **How to Estimate Network Scan Time:** Provides an outline of the steps to calculate network scan time.
- Chapter 8** **Case Studies:** Provides details on VersaMax I/O applications.
- Appendix A** **Glossary:** Provides brief definitions of basic terms.

Additional Information

www.gefanuc.com: GE Fanuc Web Site

GFK-1503: VersaMax PLC User's Manual

GFK-1504: VersaMax Modules, Power Supplies, & Carriers Manual

GFK-1535: VersaMax Genius[®] Network Interface Unit User's Manual

GFK-1534: VersaMax Profibus-DP Network Interface Unit User's Manual

GFK-1533: VersaMax DeviceNet[™] Network Interface Unit User's Manual

GEK-90486-1: Genius I/O System and Communications Manual

www.profibus.com Profibus Trade Organization Web Site

Profibus-DP Specification: DIN 19-245 PROcess Field BUS Part I




Profibus-DP Specification: DIN 19-245 PROcess Field BUS Part II

DeviceNet Specification: Volume I, Release 2.0

www.odva.org: Open DeviceNet Vendors Association Web Site

Icons Used in this Guide

The following icons are used throughout the guide to call attention to important concepts and information.

Example	Description
	The checkmark icon calls attention to features of VersaMax I/O and Control.
	The book icon cites reference tools.
	This symbol warns the reader that close scrutiny is required.

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Chapter 1

I/O and Control Basics

In this chapter:

- ▲ What is I/O
- ▲ Types of I/O devices
- ▲ What is a controller
- ▲ PLC and PC-based control
- ▲ How a controller communicate with I/O

What is I/O?

The term I/O refers to Input/Output but it has different meanings for different users. In general, I/O is information. It represents the data that is received from sensing devices, such as photo-eyes, pushbuttons, and limit switches, and the commands that are sent to actuating or indicating devices, such as motor starters and solenoid valves. Within the automation industry, I/O is often referred to as the physical elements of the control system that either provide or use this information. Two types of elements within a control system can use I/O information -- Field Devices and I/O Modules.

Field Devices

A field device can be either an input device or an output device. Field input devices are the sensors that provide the controller with information about the state of the machine or process. Field output devices are actuators which perform tasks as instructed by the control system or indicators which report the state of the system. Field devices affect or provide information about one parameter within the system. Field devices can be broken down further into two classifications:

- Digital
- Analog

Digital devices must be in one of two states: on or off.

Digital field input devices may be either on or off; they may not hold an intermediate value. For example, digital positional sensors do not indicate how close an object is but only tell if the object is within a range of positions. Common digital field input devices include limit switches, proximity switches and photoelectric eyes. Common digital field output devices include solenoid valves, relays and motor starters.

Analog devices sense and respond to a range of values.

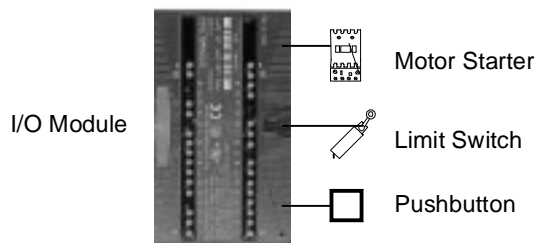
Analog field input devices sense and describe continuous parameters. The information that they provide the controller is given as a range of values, not as an on or off indicator. Common analog field input devices provide the controller with an indication of temperature, pressure, humidity, speed, etc. Analog field output devices respond to a range of output values from the controller. For example, an analog field output actuator will not only open or close a valve, but it can be used to hold the valve in a partially open position. Common analog output signals include motor speed, torque, valve position, air pressure, etc.

I/O Point Count gives a good indication of the size of a control system.

The number of I/O devices used within a control system is often called its “point count”. Digital and analog point counts are typically considered separately. Analog device data requires significantly more manipulation and processing than digital device data. The number of digital and analog points is used to give an indication of the size of a control system.

I/O Modules

I/O modules are the interface through which field devices are connected to the controller. They provide an interface between the electrical signals used in the field devices and the control system electronics. An I/O Module is also used as a concentrating point since it can provide wiring termination locations for many devices in one area.



The communication between the controller and the I/O module takes place in digital format because the processor can operate only on digital information. An analog signal presented to an I/O module is converted to digital form before it is sent to the controller. An Analog to Digital Converter (A/D) is used to assign a digital numerical value to the analog value. The digital value assigned is proportional to the magnitude of the analog signal. The I/O module then communicates the digital value to the controller. The resolution of the digital value assigned is based on the number of binary digits used by the A/D. The reverse operation takes place when a controller is required to output an analog value. Each numerical value calculated by the controller is converted to an analog signal.

- ✓ The VersaMax product line includes a wide variety of I/O Modules.

Examples of I/O Module Types

- DC Voltage Inputs and Outputs
- AC Voltage Inputs and Outputs
- Low Level Analog Inputs (e.g. Thermocouple)
- High Level Analog Inputs and Outputs
- High Speed Counter
- Pulse Train Outputs
- PWM Outputs

Intelligent I/O

Intelligent I/O can communicate diagnostic and status information.

The terms intelligent and non-intelligent I/O have been only loosely defined through industry usage. All I/O must communicate with a controller. The minimum amount of information that must be transferred between an I/O device and a controller is the I/O status or control information. Non-intelligent I/O is able to communicate only this minimum amount of information. Intelligent I/O has the ability to communicate calibration, status or diagnostic messages or to provide operations such as linearization, scaling, etc.

- ✓ VersaMax supports both intelligent and non-intelligent I/O. Intelligent modules include a high speed counter, RTD, and thermocouple I/O.

Intelligent I/O modules can reduce the time required to diagnose fault conditions. For example, a non-intelligent analog input module may report a voltage reading of 0.0 volts. An intelligent analog input module may report the same 0.0-volt reading and include a fault message indicating that the input terminals of the module have been shorted together.

Specialty I/O

- ✓ VersaMax specialty I/O includes a high speed counter module which may be configured as a high speed counter or high speed output module.

Input devices such as bar code readers and output devices like label printers are frequently incorporated into control systems. Closed loop and servo motion control modules help to off-load tasks from the main controller to intelligent I/O modules. Specialty I/O products are broadening the capability of modern control systems.

What is a Controller ?

A controller is an electronic processor which executes a user-developed program utilizing input data and generating output signals to the process. The controller makes logical decisions based on the status of the process along with new data as sensed by the field input devices and timing considerations determined by the resident program. Two basic types of controllers are:

- Programmable Logic Controllers (PLC)
- Personal Computer based Controllers (PC Control)

PLC

A **PLC** is rugged and intended for industrial environments.

PLCs capture all input states at one time to form a 'snap shot' of the system.

A Programmable Logic Controller or PLC is a solid state industrial control system that can be programmed to control a process or machine operation. PLCs have user programmable memory for storage of instructions to implement specific functions such as sequencing, timing, counting, arithmetic, data manipulation, and communication to control machines and processes. PLCs are rugged and intended for industrial environments. They perform operations cyclically. A PLC gathers all of its input information and stores it in an Input Table within the controller's memory. With all data collection taking place simultaneously the controller is given a 'snap shot' of the system at one moment in time. This ensures that an accurate assessment of the present state of the system can be made for the full execution period of the program. The logic decisions are then based on the 'snap shot' of the system along with timing and other criteria as defined within the program. This results in a predictable control result.

As the PLC program is executed the state of each output device is determined and stored in another section of controller memory called the Output Table. The output table stores all of the desired output device states until the final program instruction has been executed. Once the program execution is complete the output table information is transferred to each output device through Output Modules. The PLC then rechecks the input data to begin another cycle.

This process of sequentially reading the inputs, executing the program in memory, and updating the outputs is known generally referred to as a “scan”.

✓ The VersaMax PLC has built-in fault reporting.

Depending on the type of I/O modules and devices used, diagnostic information may also be communicated with the I/O status. The diagnostic data is entered into a separate fault table. As various codes are entered into the fault table system operations are affected through custom application code or by the controller manufacturer’s predetermined response to common faults.

PC Control

PC Control is most effective when both control and operator interface are required.

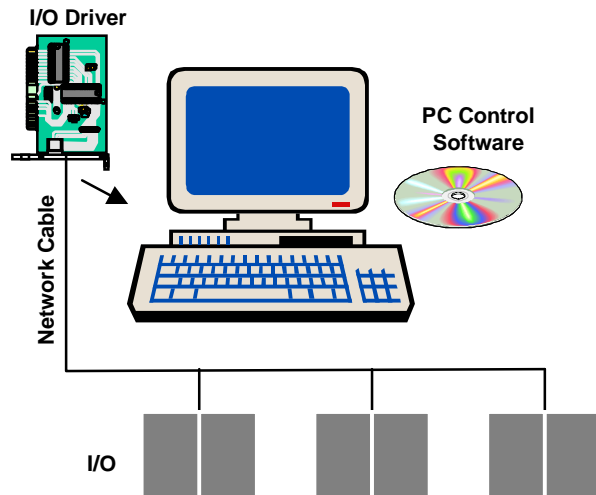
Personal computer-based control, PC Control, is a new and fast growing segment in machine control. What is PC Control? It is an integrated solution comprising operator interface, communications, data processing, and control on a single PC.

Fueling the growth of PC Control is the acceptance of the Windows® NT® operating system and tools such as OLE, DDE, and DLLs which allow open connectivity to other software. The graphical, multi-tasking environment of the PC makes it a particularly effective solution when a graphical user interface is desired. The strength of the PC is in its flexibility and capability to present graphical information to the user.

A PC Control system can be developed around an ‘Industrial PC’ that has been designed to withstand harsh industrial environments. In addition, commercially available PCs without extraordinarily robust electrical designs or construction may be used if the operating environment permits.

The PC Control interface to the inputs and outputs is through an I/O interface driver that is inserted into the backplane of the PC. In most cases, the I/O driver has its own CPU to handle the details of sending and receiving messages on the I/O network. I/O network cable connects the I/O driver to the actual input and output modules in the control system.

- ✓ VersaMax I/O can be controlled from PLC and PC systems.



In a manner similar to that of a PLC, PC Control also requires user-developed programs. These programs can be developed in a number of languages, including SFC, Ladder Diagram, and Function Block Diagram. With PC Control, the logic control engine runs as the highest priority task in a real-time operating system, with the Windows functions running as the lowest priority tasks. The logic control engine scans I/O and executes the control programs developed by the user. Control programs execute during every scan cycle. Windows programs execute only after the control programs have run. This ensures that control programs are not interrupted by Windows applications.

Many suppliers have developed packages that are intended for PC Control including, GE Fanuc PC Control, Taylor, Steeplechase, and Wonderware®. Any host controller that supports Genius, DeviceNet, or Profibus-DP can control VersaMax I/O.

PC Control integrates real-time logic control with Windows, providing users with new options to meet their control needs.

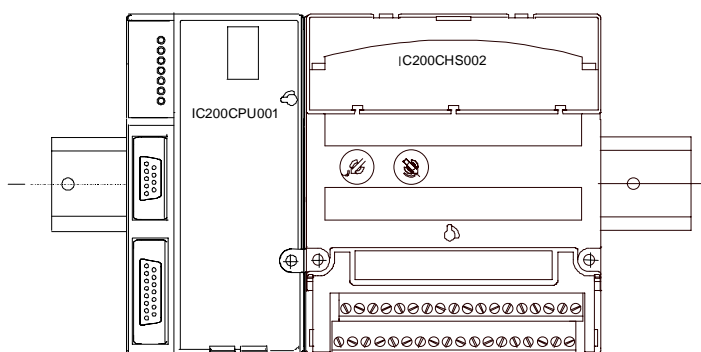
How Does a Controller Communicate with I/O?

There are 3 basic forms of communication between a controller and I/O:

Backplane Communication

✓ VersaMax utilizes I/O carriers to provide fast local backplane communication.

Controllers often provide areas or slots where I/O modules can be connected directly to the controller. The hardware into which the controller and I/O modules are connected is typically called a rack. I/O modules connected in a rack with a controller communicate over a backplane. An alternative means is to add I/O carriers, which provide their own backplane communications, to make up a complete package. Backplanes provide connectors and conductor paths for communication.. Backplanes are often an extension of the bus that the CPU microprocessor uses to communicate with its own peripheral devices. Backplanes provide high-speed communication links but are usually limited in terms of transmission length to the length of the rack in which the modules reside. Communication over a backplane is generally called local communication. PLC CPU communication to its local I/O is typically over a backplane.



Backplane communications on the VersaMax PLC

Backplane Extension Communication

Some controllers provide option modules to extend the capabilities of their standard backplane. Backplane extensions allow additional racks or stations to be added to the CPU.

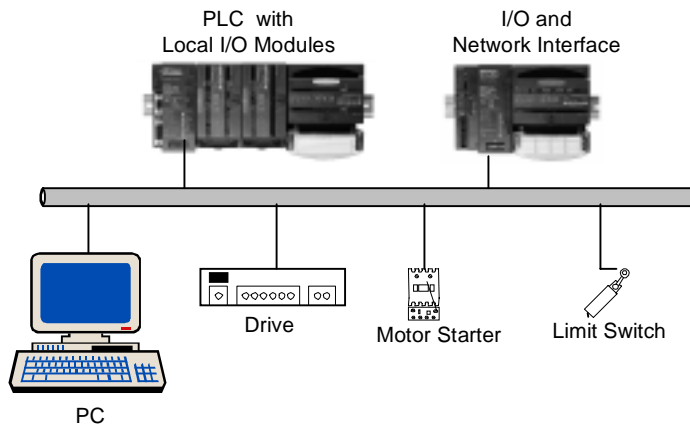
Network Communication

Network protocols define the methods used for communication.

The terms industrial network and fieldbus are generally used interchangeably. The industrial network (fieldbus) protocols define the methods used for communication among network elements. Industrial networks provide bi-directional, real-time communication over a shared media. Each network element has specific electronic components to allow the transfer of data between the elements according to the protocol. Network elements are addressable to give the controllers, I/O devices and I/O modules unique identifying labels.

✓ VersaMax supports network communication with many popular protocols, including Genius, Profibus-DP, and DeviceNet.

Network communication protocols allow controllers to communicate with one another as well as allowing I/O modules to communicate with the controllers. Examples of network communication protocols include Genius, DeviceNet, Profibus-DP, and Ethernet. I/O modules can communicate with a controller in one of two ways: First, network communication intelligence and hardware can be built into the I/O module itself. The second method is to connect the I/O modules through a network interface module which contains the intelligence necessary for network communication. An advantage of the latter method is the I/O is network independent. A comprehensive discussion on network communication techniques follows in Chapter 3.



What Have You Learned?

This chapter introduced the basic terminology used to describe I/O devices and modules. Field devices sense or actuate a single parameter. Examples of I/O devices include push-buttons, pilot lights, solenoid valves, relays, and limit switches. I/O modules provide an interface between the electrical signal levels used by the field I/O devices and those required by the controller.

A controller is an intelligent device that executes program instructions to operate the system in a controllable, predictable manner. Controllers are most common in two forms: PLC and PC-based controllers.

I/O communicates with controllers in one of three basic manners. First, field devices may be connected to I/O modules. The I/O modules can be connected directly to the controller in a rack or station. Communications then takes place across a backplane. Second, backplane extension modules allow I/O modules to be located in racks or stations which are separated from the controller. Third, I/O devices and modules can communicate with a controller over a network. Industrial networks are used to interconnect controlling and field level devices.

Chapter 2

Control Systems

In this Chapter:

- ▲ What is a control system
- ▲ Control system architectures
- ▲ Architecture selection

What is a Control System?

Control systems are made of essentially two types of components:

- Controllers
- I/O

A **control system** combines I/O and control into an overall system that manages the machine or process.

A control system is designed to respond to its input information in a controllable and predictable manner. A system may have one or more controllers but must have at least one input device and one output device. The controller examines the input data and generates output data based on a user-developed program. The program includes instructions that dictate the operation of the control system. Instructions are used to create predictable and controllable event sequences.

Control System Architecture

To design the best control system, engineers need to consider both the I/O system and the control structure before selecting products to meet their unique application needs. Identification of the physical structure or layout of the application, i.e. whether the machine covers a small or large area of the factory, helps to determine whether I/O should be local, remote, distributed, or a combination of these. In many cases, the physical arrangement of the application defines the

optimal I/O strategy. There are two fundamental control system architectures.

- Centralized Control: One controller dictates the system response
- Distributed Control: More than one control processor is used.

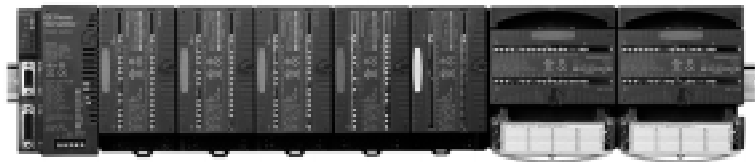
Centralized Control

Centralized control systems have only one controlling device.

Local I/O communicates across the backplane.

Centralized control systems have a single, decision-making controller. The central controller interprets the input data and sends instructions to the actuators and output devices present. Centralized control systems can be further classified according to their I/O structure.

Centralized Control with Local I/O: Centralized applications that involve a physically small area may effectively use a single control system with I/O that is local to the host processor. The I/O modules communicate with the controller directly across the backplane. Each field device is wired directly to an I/O module on the controller backplane, hence this wiring style is often termed “point to point”.

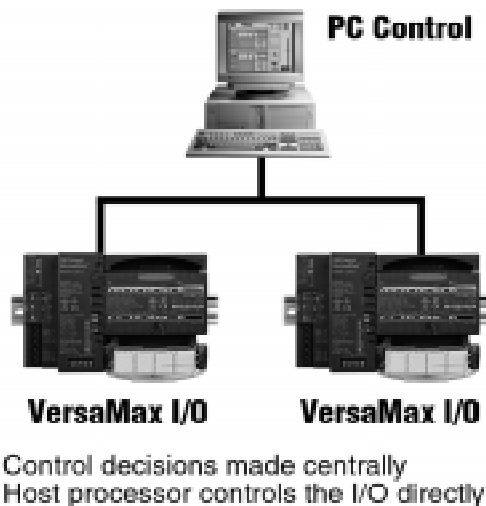


- Single processor
- I/O is integral to the processor

Distributed I/O systems communicate over industrial networks and decrease cost by reducing wiring, installation cost, and panel space.

Centralized Control with Distributed or Remote I/O: In a distributed architecture, I/O modules are placed near the actual field devices and connected over a serial bus structure. The obvious advantage of this structure is a large reduction in wiring and installation costs as well as reduced panel space. A distributed I/O system also offers increased modularity for quick machine setup and easy expansion. Remote I/O is I/O that is separate from the controller, but generally located in one spot. The distributed and remote I/O structures utilize an industrial network interface between the I/O modules and the host controller. The industrial network

provides a communication channel between the controller and the I/O for information and command exchange.

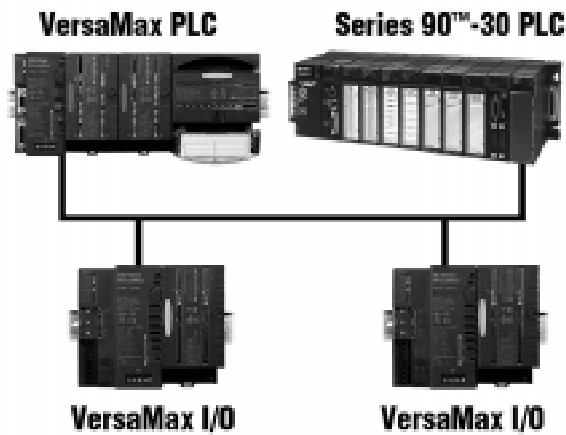


The use of the network can shorten or even eliminate the need for point to point wiring. Distributed I/O systems often incorporate a mixture of local I/O and distributed I/O modules.

Distributed Control

In a distributed control system, each processor often controls its own I/O to maximize the system performance.

Systems utilizing distributed control incorporate more than one processor. These systems split control across several processors with each acting more or less autonomously often with yet another processor coordinating the overall system. The complexity of the control task is not necessarily related to the number of processors. Multiple processors are often used when the task to be performed has a requirement for certain high-speed operations, and the designer does not want to burden the main processor with interrupts to perform these tasks. In other cases, multiple processors are used to perform specialized tasks. Industrial computers, PLCs, or a mixture of these controllers may comprise a distributed control architecture. Industrial networks are used to link the controllers to each other as well as the I/O system. Distributed control architectures generally share information between processors to coordinate the overall control function.



- Distributed processors for fast response
- Host processors coordinate the distributed processors

Architecture Selection

Centralized Control - Local I/O

Local I/O systems are usually the fastest and are best implemented in stand-alone machinery.

Applications that make control decisions centrally from a single controller with I/O that is local to the controller can generally use a centralized control with local I/O architecture. A local I/O structure is best utilized in control systems that are relatively small in size, such as a single machine or individual work cell. A local I/O structure offers high speed response since communication is handled directly through the controller backplane. This architecture is preferred for time critical applications. The VersaMax PLC, with its expandable I/O, provides an efficient and cost-effective solution for systems requiring high speed centralized control with local I/O.

Centralized Control - Distributed I/O

Distributed I/O systems are most beneficial when devices are widely separated.

Applications with a large number of I/O or with long wiring lengths may be better served by distributed I/O. By having distributed I/O modules and devices communicate with the controller through a shared network a great reduction in wiring complexity can be achieved. It should be noted however, that designers need to consider throughput time of the distributed I/O system, which involves input signal conditioning, transmission time over the communication network to the controller, controller response time,

transmission time over the network to the I/O device, and output device actuation time. Transmission delays can add as much as 80 to 100 msec or more – which may or may not be significant in a particular application. The VersaMax PLC supports centralized control of distributed I/O over three networks.

Distributed Control

Distributed control is ideally suited when two or more processes can be logically separated yet need to share resources and information.

The distributed control architecture provides several advantages. It offers the responsive performance of point to point wiring within local areas, yet maintains the flexibility provided by networked resources. Distributed control is an option when two or more processes can be logically separated. Each process may be controlled by an individual processor. By networking the controllers, resources such as printers, operator stations, I/O and status information from individual controllers can be shared for the control of the entire system.

A good example of distributed control is assembly lines. Individual stations can be controlled locally yet the network allows for overall system coordination. The VersaMax PLC supports effective distributed control by networking several PLCs together.

What Have You Learned ?

This chapter defined two types of control systems. Centralized control systems operate under the direction of a single processor while distributed control utilizes more than one controlling processor.

The I/O structure of centralized systems can be categorized into two types: local and distributed.

- Local I/O systems incorporate I/O modules directly into a station or rack with the controller. Local I/O communication is accomplished through the controller backplane. The local I/O structure is better suited for small systems within confined areas.
- Distributed I/O systems utilize network communication technology to place the I/O modules near the actual field devices. Distributed I/O modules are connected over a serial bus structure. Larger, more spacious control systems can be efficiently implemented with the distributed I/O structure.

Control systems using more than one controlling processor are categorized as distributed systems. Distributed control systems typically incorporate a mixture of both local I/O and distributed I/O.

Chapter 3

Communications

In this Chapter:

- ▲ Rules of communication
- ▲ Machine communication
- ▲ Protocols

Rules of Communication

People use rules and guidelines to structure communication.

When people communicate with one another many aspects of communication are taken for granted or performed at a subconscious level. Our mind receives, interprets and reacts to the information that it has been presented. Our communication is guided by a set of rules or criteria that we often do not consciously consider.

Consider for example, communication through speech. To be effective, each message that is conveyed must be correctly interpreted by the recipient. For this to take place we must decide on the language that will be spoken and the level of vocabulary that will be used. We also need to speak at a rate and volume that can be understood by the listener. In addition, we should not interrupt others and we should listen attentively. All of these guidelines may not appear as evident in conversations between two people, but are increasingly important within group discussions. Orderly group discussions require that we identify ourselves and address our intended recipient. Thus far we have assumed that the speaker and listener each knew their role and was abiding by it. If both parties have something that they



wish to communicate, who is granted permission to speak first and how is the permission determined?

Although we often take communication guidelines for granted it should be well understood that effective communication is directed by rules whether they are consciously considered or not.

Machine Communication

Similar to the communication between people, machine communication must follow a prescribed set of rules and guidelines. And while people often vary the rules or guidelines according to the needs of each conversation, machines are not afforded this luxury. The rules governing machine communication are defined by protocols.

Protocols

Communication rules are called protocols.

Protocols define the methods used for communication.

Protocols formally define how communication takes place. There are many different ways machines can communicate and therefore many different communication protocols have been developed. Each protocol defines how communications will take place.

The protocols describe the manner in which electronic devices establish and maintain communication. They describe such characteristics as the physical media used to connect equipment, electrical signaling, and the format of the data transmitted. All of these attributes are described in more detail in later sections of this guide.

What Have You Learned?

This chapter presented an overview of communication fundamentals. Effective machine communication is defined by rules. The rules are called protocols. Each protocol defines how communications will take place.

Chapter 4

Networks

In this Chapter:

- ▲ What is a network
- ▲ What is an industrial network
- ▲ Network benefits
- ▲ Differentiating network characteristics

What is a Network?

A **network** is a system made up of electronic devices that are connected for the purpose of sharing information.

A network is a system of electronic devices that are connected for the purpose of sharing information. Each device on the network is called a node. The physical medium used to interconnect devices on a network is called transmission media. Many different types of networks have been developed to meet specific needs. They were developed to efficiently and cost-effectively handle the amount and type of data that they will most frequently encounter. Each network protocol has different data structures and incorporates different feature sets.

An excellent example of networks is the inter-office local area network for computers and associated peripheral equipment. In addition, networks exist within buildings to control lighting, heating and security systems; telephone systems are also considered networks.

What is an Industrial Network?

Industrial networks are specifically designed for industrial control applications.

Industrial networks, often called fieldbuses, are a subset of networks. They are specifically designed for industrial applications both in terms of their physical attributes as well as their preferred data structure. An industrial network is a bi-directional real-time communication system which allows the exchange of digital

Deterministic behavior enables time predictable responses.

information between field level devices and controlling devices. Industrial networks are, in general, physically and electrically more robust than inter-office computer networks. The cabling used tends to be more resilient with a tough outer jacket. In addition, the connection systems used in industrial networks are generally harder and better able to resist accidental disconnection and environmental conditions.

Many industrial networks are deterministic. Deterministic networks enable communication to occur within a predetermined time interval. Industrial networks value determinism more than other networks as many control systems require real-time response to input data.

Industrial networks allow field level devices and controllers to communicate efficiently with one another. An industrial network is an enabling tool to allow simple and effective use of distributed I/O devices, I/O modules, and distributed control intelligence.

OSI Reference Model

The industrial network concept is based on the Open Systems Interconnection (OSI) reference model. This model divides the various functions that protocols must perform into seven hierarchical layers. In general, industrial networks can be represented by the lower levels of the seven-layer OSI model. The controller's application software manages the upper level functions.

Industrial networks generally address the issues involving the lowest layers of the OSI model. Typically Layers 1, 2 and 3 are addressed in the industrial network protocol while layers 4 and up are handled by the user's application software.

Layer 7 - Application: The user interface.

Layer 6 - Presentation: Determines how information is represented. (data syntax, compression, encryption)

Layer 5 - Session: Organizes and synchronizes communication between applications.

Layer 4 - Transport: Isolates network layers from the application layers.

Layer 3 - Network: Establishes connections between equipment on the network. (message routing, error correction)

Layer 2 - Data Link: Responsible for data transfer between network entities. Includes flow control and error detection.

Layer 1 - Physical: Provides the physical and electrical interface, bit transfer timing, and bus arbitration. (cables, etc.)

An industrial network provides the communication link between distributed I/O and the host controller – PLC, PC, or DCS. The OSI model, including many industrial network standards, was developed openly to allow any suppliers to design and build network compliant components.

Types of Industrial Networks

Each industrial network was developed for a specific data structure and working environment. Industrial networks can be divided into three categories according to their data structure:

- Bit-oriented networks
- Byte-oriented networks
- Message-oriented networks

Bit, Byte and Message-oriented networks are also referred to as Sensor, Device, and Full Function networks respectively. Many industrial networks incorporate features that can support all three data types, but, in general, they are targeted towards one or two structures.

Bit Oriented Networks (Sensor Networks)

Bit-oriented networks can provide fast, deterministic response for simple digital devices, like “smart” limit switches, photo-eyes, and solenoids..

Bit-oriented networks communicate bits of I/O data associated with the status of a sensor. These networks best serve simple sensor systems. The preferred length of an individual message is short, perhaps as short as a single bit. A typical bit-oriented industrial network device is digital, although some protocols support a limited number of analog devices. Complex data structures are not well supported because a higher level of emphasis is placed on predictable, quick response time. Sensor level networks are the simplest to implement but offer limited diagnostic and calibration features. Popular bit-oriented network protocols include Seriplex®, InterBus S, and AS-interface.

Byte-Oriented Networks (Device Networks)

Byte-oriented networks offer increased diagnostic tools and feature sets.

Byte-oriented networks communicate bits of I/O data associated with the status of a device (sensor or actuator). These messages are generally 10 bytes or greater in length. The increased message length, as compared to bit or sensor-level protocol, allows the transfer of several data and diagnostic bytes within a single message. Byte-oriented protocols can therefore support an improved level of

- ✓ VersaMax I/O supports several byte-oriented networks, including Genius, DeviceNet, and Profibus-DP.

diagnostic and status messaging. An increased amount of intelligence located in the field device can also be supported. Remote calibration and data scaling features are supported by device networks.

DeviceNet, Genius and Profibus-DP are all popular Byte-oriented industrial networks. VersaMax I/O supports these three popular protocols.

Message-Oriented Networks (Full Function Networks)

Message-oriented networks are usually not deterministic.

Message-oriented networks are characterized by long streams of data. The increased message sophistication allows advanced diagnostic and status information to be communicated between devices and controllers. Larger, variable message length provides for efficient memory block transfers between controlling devices. Message-oriented networks are seldom deterministic due to their variable message length. They do, however, provide an efficient means of transferring information and are frequently implemented in “Supervisory, Control And Data Acquisition” or SCADA systems. SCADA systems provide a link between the controllers on the plant floor and management computer systems for purposes of real-time data collection.

Common message-oriented industrial networks include Ethernet, Profibus-FMS, Foundation Fieldbus, and LonWorks.

Summary

Understanding your needs and properly selecting the type of industrial network can save both time and money. If your requirements are such that a simple bit-oriented or byte-oriented network will suffice, it is not productive to implement an overly complicated message network. Higher level features only provide benefits when the added functionality is required, or when standardization needs outweigh application considerations.

Network Benefits

Industrial networked systems provide the following benefits over conventional control system architectures:

✓ VersaMax allows you to take full advantage of all the benefits of networking.

- Reduced system cost
- Faster implementation
- Reduced downtime
- Greater system flexibility
- Improved performance

These benefits are derived from a combination of the following features:

Reduced Cabling - A wide variety of devices are available for direct connection to the industrial network . By locating the I/O modules closer to the actual sensors and actuators, shorter wiring lengths can be used for each device. The concentration of I/O information on the network allows for a drastic reduction in cabling. Reduced cabling also implies fewer intermediate termination locations where potential problems may arise. Cost saving are generated from the reduction in wire, terminal blocks, conduit, junction boxes, installation labor and inventory.

Updating I/O is easy because all the required wiring is in place.

Greater Adaptability - Industrial networking technology allows for greater adaptability and ease of component updating or replacement. For example, it is very simple from a hardware point of view to update an I/O device, as the network wiring does not need to be changed. Prior to the use of a network, each device had individual wiring requirements and updating a device meant that additional wiring was needed. The industrial network reduces the need for device or application specific wiring. Updating network compatible devices requires that the controller be made aware of the updated device specifications. In many cases this function can be performed automatically.

Improved diagnostic features locate problems quickly to reduce costly downtime.

Improved Diagnostics - Device error logging, time stamps or messages as simple as which device or I/O point has failed can greatly reduce costly downtime. Intelligent network and diagnostic tools allow a device to be removed from the system automatically. By removing a faulted device, the system can often be kept operational until an operator is able to locate and correct the fault.

By transmitting analog values in digital form across a network, cumulative noise is avoided.

Reduced Signal Degradation - By converting analog signals to digital form closer to the measurement point, the industrial network is able to reduce the amount of analog signal degradation. With local architectures, long wiring lengths can subject analog I/O to high levels of interference. By implementing network technology, the analog to digital converter is moved closer to the point of measurement and the data is transmitted across the network in digital

Interoperable and interchangeable devices expand your supplier options.

Industrial networks enable distributed control.

form. Industrial networks enable error detection and correction so the interference encountered by network wiring does not necessarily affect the analog reading.

Expanded Supplier Selection - Through the use of an industrial network, systems are generally open and not restricted to a single supplier. Many suppliers design and manufacture devices to be interoperable and interchangeable. Intermixing device suppliers creates greater competition and ultimately drives the development of high quality, cost-effective products.

Process Off-loading - Distributing control intelligence enables the network to off-load some of the tasks from the controller(s) to more responsive field-located controllers. Data from specialized local control features such as closed loop control or servo motion control, that do not need to be explicitly known by other devices, can be processed locally rather than transmitted on the network, which yields faster response. By selectively transmitting only required data, the network capacity can be reserved for other tasks. This allows the overall system to be more responsive. In addition, distributed intelligence reduces the complexity of the main controller and enables quicker commissioning time.

VersaMax I/O and Control can help you take advantage of all the benefits of industrial networks.

Network Characteristics

The differentiating characteristics of industrial networks can be described by the following categories:

- Network Access Method
- Communication Structure
- Transmission Media
- Topology and Distance Capability
- System Redundancy
- Network Power
- Transmission Rate and Response Time
- Diagnostic Tools

- Maximum Nodes and I/O Points
- System Cost

Network Access Method

Network Access Method determines which networked device is allowed to produce a message.

The Network Access Method is the process used to determine which device is allowed to transmit information on the media. To avoid interference, only one network device may use the transmission media at any one instant. Although rarely dealt with by the control engineer, a solid understanding of Network Access Methods is beneficial.

There are three popular methods used by industrial networks:

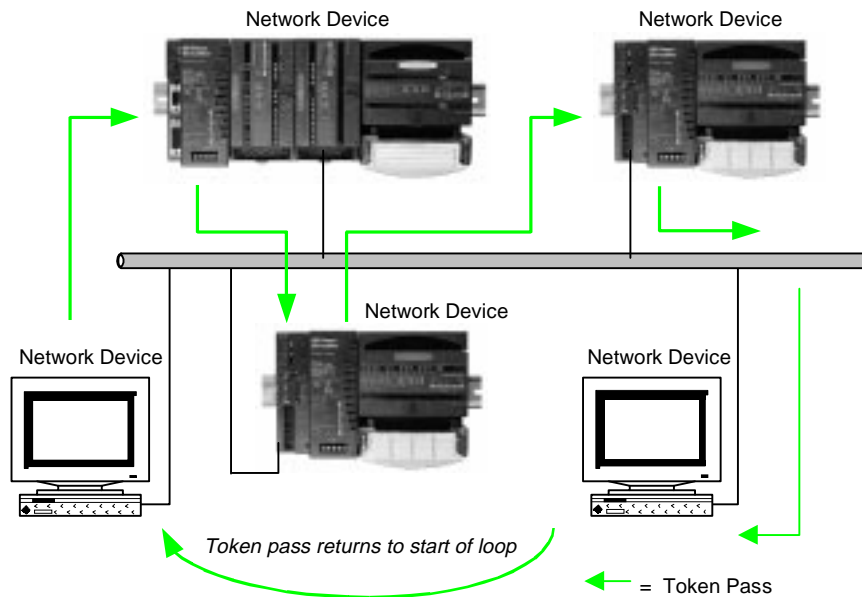
- Token Passing
- Polling
- Collision Detection

Tokens are special messages that grant permission to transmit information on the network media.

Token Passing: Token passing is an access method in which a token, a special message, is passed along the network and each device has a specified amount of time to receive and/or respond to it. The token is used to grant its holder permission to transmit information on the network media. The token is generally rotated through all of the elements on the network. If an element holds the token, it is allowed to originate a message. If an element does not hold the token it is forced to listen to the network media and receive messages without interfering.

✓ The Genius bus is a token passing network.

Usually, the token is held for only a limited amount of time. Once a device receives the token, it may begin to transmit its message. If the complete message has been sent, the token is passed to the next device. If the maximum allowable time has elapsed, the device must stop transmitting, pass the token, and wait for its next turn to continue the message. Since the token is rotated sequentially, a token may be passed to a device when the device does not have a message to transmit. If the device does not wish to produce a message, the token is simply passed to the next device.



The **key to polling** is that the communication with each device takes place one device at a time and in a sequential order.

Profibus-DP utilizes polling.

Polling: Polling is a method whereby each device is polled, or questioned, in sequence to determine if it has data to transmit. This network access method is most commonly implemented in master/slave communication structures. Polling allows a single device to control access to the network. The controlling device may either request information from individual devices or give instructions to those devices. Each slave device is allowed to exchange information with the controller in turn. The slave devices are not permitted to transmit information on the network unless requested to do so by the controller.

Collision Detection: In general, collision detection for industrial networks is referred to as CSMA-NBA. The acronym CSMA stands for Carrier Sense Multiple Access. Carrier Sense refers to the act of testing the network for the presence of the radio frequency carrier signal. Multiple Access simply implies that more than one device has the ability to access or use the network. Although not all networks use a modulated carrier signal, the principles of CSMA are still relevant and the acronym is commonly used.

CSMA systems test the network for use. If the network is unused, the device begins to transmit its message.

CSMA implies that all of the devices on the network have the ability to test the network media to check if it is being used even though they do not necessarily test for the presence of a carrier signal. When a device has a message that it wishes to transmit, it first tests the network for use, and if the network is unused, it begins to

DeviceNet uses CSMA-NBA.

transmit its message. If the network is being used, the device simply waits and re-tests the network at a later time.

NBA refers to Non-destructive Bit-wise Arbitration. If two devices simultaneously test the network when it is free, neither device will sense that the network is busy. Both devices then begin to transmit their messages. The messages will eventually interfere and destroy one another. Non-destructive bit-wise arbitration is the process that forces one of the devices to stop transmitting before the messages are damaged. Bit-wise arbitration determines which of the devices must stop transmitting and it is based on the Media Access Controller Identifications or MAC IDs of the devices.

Selection Criteria

A highly desirable feature of many control systems is deterministic behavior. Token passing and polling network access methods enable deterministic, predictable and repeatable network scan times. Collision detection (CSMA-NBA) network access is less deterministic since individual elements may simultaneously attempt to transmit information and be forced to halt transmission. CSMA-NBA arbitration is used most effectively when devices of different priorities are configured. It can allow faster response to those devices as required.

Communication Structure

The communication structure used by a network determines how each device or controller communicates with other elements on the network. Some structures are hierarchical whereas others communicate as equals (peers). Hierarchical structures grant increased authority to a device or group of devices.

Popular communication structures include:

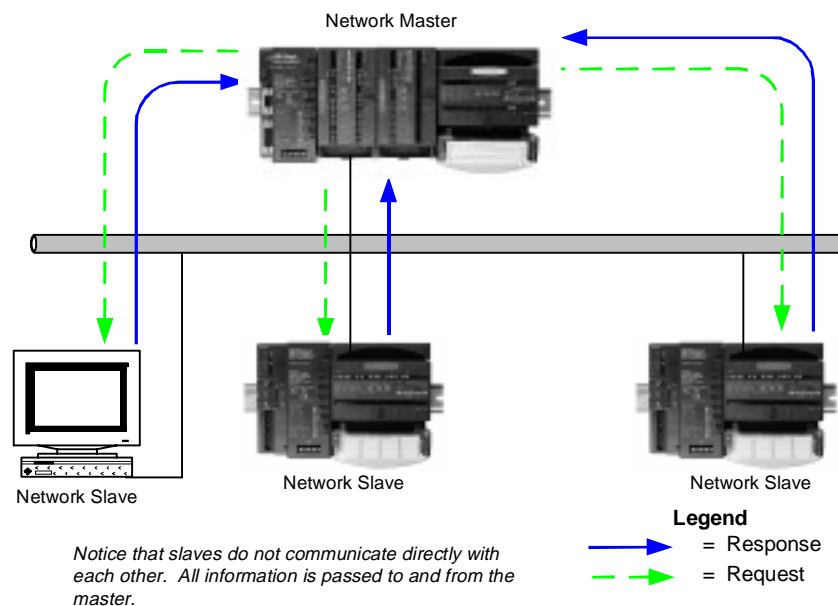
- Master/Slave
- Multi-master
- Peer to Peer

Master/slave systems grant network controlling authority to one device.

Master/Slave: The master/slave communication structure grants special authority to one of the devices on the network. The master has the ability to request information from individual devices

Profibus-DP is a master/slave network with multi-master capability.

(slaves) and slave devices are required to respond to those requests. In a similar manner, if the master commands a slave to perform an action, the slave must follow the directions as given. Slaves can only respond to master requests; they can not initiate communication. The act of sequentially requesting information or instructing each slave device is called polling.



The master/slave structure is similar to the style of communication used in a classroom between a teacher and the students. The teacher (master) may ask a question of or give directions to a specific student (slave). The student is then required to answer the question or comply with the teacher's request. An industry example of master/slave could be demonstrated by the control of a long conveyor system. In this case, a host controller (master) coordinates the actions of multiple devices (slaves) located along the conveyor system and connected by the network.

Broadcast messaging can improve network response.

Some master/slave protocols only allow the master to transmit messages that are intended for single slave use. Each message therefore has one producer (originator of a message) and one consumer (recipient of a message). Such protocols are acceptable in most situations where the network traffic level is not a concern. However, it is common to have several consumers of a single

Master/slave protocols are ideally suited for simple distributed I/O systems.

message. By broadcasting a message to multiple slaves simultaneously, the producer does not need to repeat the message multiple times. Broadcast messaging improves network throughput. Master/slave protocols allowing broadcast style messages may be called multicasting.

Multicasting messages are common in systems where similar information is required from several network devices simultaneously. Broadcast messages are frequently used to communicate system-wide errors, or to request input data from several devices.

Pure master/slave structures are not intended for distributed control applications since a single controller must remain in control of the network at all times.

Selection Criteria

Master/slave structures are typically the simplest to implement. They are ideally suited for applications using centralized control with distributed I/O. The master/slave structure allows a single controller to manage the network. The master is free to request information or to give instructions as it desires. This structure allows for the distribution of I/O modules and devices without overly complicating the control system. Master/slave protocols provide the benefits of networking without requiring extensive configuration or programming.

Multi-master communication structures permit more than one network controller.

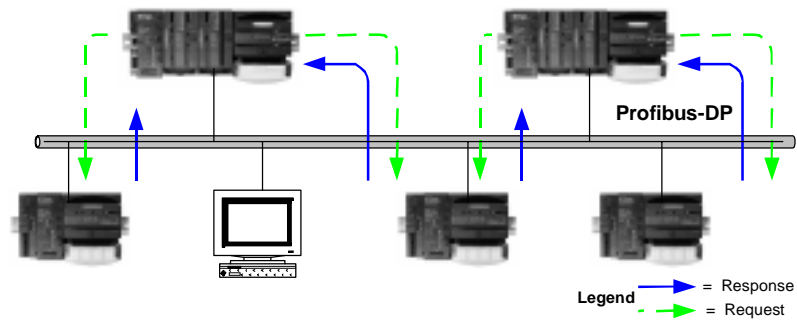
Multi-master: A variation of the master/slave communication structure allows more than one master device to access the network. The masters use the network to control their individual slave devices and for resource sharing but do not concern themselves with all of the devices present. Each master is assigned specific slave devices to control. Although masters typically receive information from all slaves, the slaves are required to respond only to the commands given by their own master.

Multi-master communication structures support distributed control but masters can not share I/O.

Multi-master communication allows the control logic of a system to be divided between several controllers. This division of control logic is the basis of distributed control. Control logic is often implemented more simply and efficiently by breaking it up into segments, each controlled by its own processor. In a distributed control system, each processor often controls its own I/O, with the overall system coordination performed by another processor. By

reducing the amount of logic implemented by each controller, the performance of the system is enhanced.

Network access is often granted to each of the individual masters through token passing arbitration. Each master polls its individual slaves once it has control of the network. When one polling cycle is complete, the token is passed to the next master.



Multi-Master

Selection Criteria

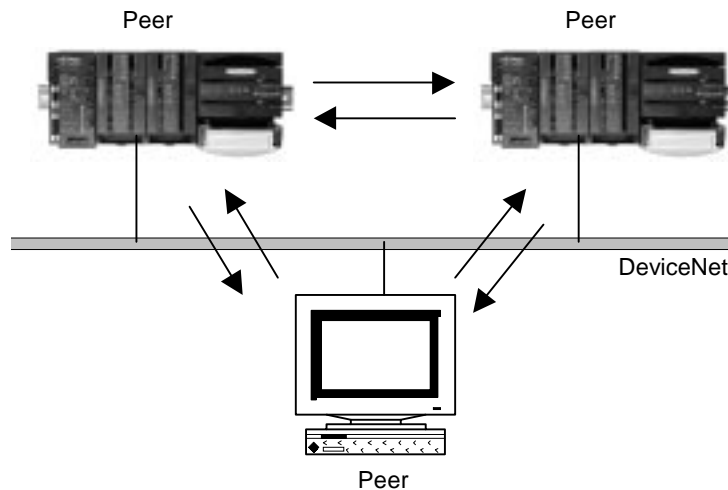
The multi-master communication structure is most common when systems contain two or more processes that are distinctly separate yet periodically need to share resources or information. Since a master may only communicate with its own slave devices, each process must be independent. Status and system-wide parameters may be communicated between masters, but I/O devices can not be shared.

Manufacturing assembly line processes typically implement the multi-master communication structure, provided that a distinct separation can be made between work cells. Multi-master networks can also be used to separate I/O devices which require different update rates or control functions.

Peer to peer communication structures share the responsibilities of network control with all of the devices.

Peer to Peer: Peer to Peer communication structures do not grant controlling status to a single device but share the network through arbitration. Peer to peer networks have no “masters” or slaves. All devices on the network are responsible for the control of network access and timing issues. The peer devices are typically of similar intelligence level and are allowed to both produce and consume each other’s messages. Network access is commonly accomplished with token passing.

DeviceNet is a Peer to Peer network with multi-master capability.



Peer to Peer control areas do not need to be logically separated.

The peer to peer communication structure offers the greatest flexibility in terms of both network access and system control. The flexibility of the peer to peer structure is derived from the fact that masters and slaves are not declared. All devices on the network can gain access to the media. The communication between devices is not restricted.

Selection Criteria

The most significant distinction between the multi-master and peer to peer communication structures is the ability of peers to share I/O devices. The distinct control areas that are required for multi-master applications are not required with peer to peer systems. Distributed control applications, which are not separable into distinct functions, require peer to peer communication structures. Intelligent devices may use the peer to peer communication structure to provide fast, responsive actions for time critical events. Devices can be configured to communicate directly with one another. Examples of peer to peer network applications include pulp and paper mills, metal processing, petrochemical industries and other continuous flow processes.

Transmission Media

The transmission media of a network is the means by which devices are connected. There are two basic aspects of transmission media: the media itself and the electrical signaling used in the media.

Popular transmission media include:

- Copper based Cabling
- Fiber Optic Cables
- Open Air Radio Frequency Communication

Selection Criteria

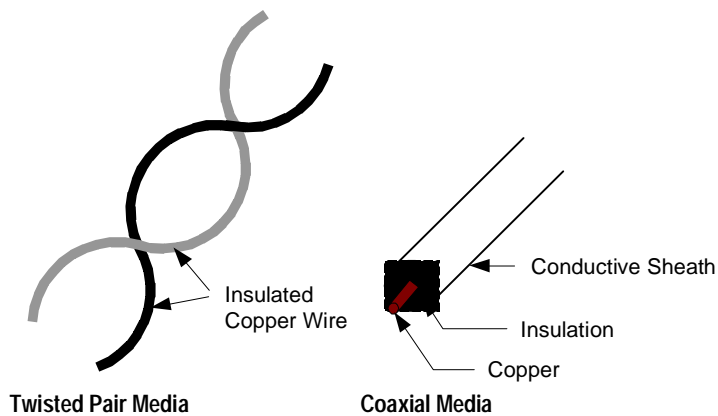
Transmission media selection should be based on its electromagnetic interference immunity, length capability, connector systems, power transmission and cost. The emphasis placed on each of these parameters will vary depending on the environment and application being considered.

Copper media is relatively inexpensive, robust, and simple to use but is less noise immune than fiber optic media.

Copper Based Cabling: Copper wiring is the most popular and least expensive media. Twisted pair cabling and coaxial cabling are the most common copper media types.

A twisted pair is essentially two wires, each insulated and twisted around each other. Twisting pairs increases their rejection of noise and interference. Twisted pair cabling is available with multiple pairs of conductive wires. It is relatively inexpensive in comparison to coaxial cable and other media and is also easy to install, as specialized connectors are typically not required. However, it does lack the noise immunity of other media and can permit destructive “cross-talk” between adjacent cables if runs are closely spaced and parallel for long lengths. Twisted pair cables may be unshielded or shielded depending upon the electrical noise environment in which the system must perform. Shielded twisted pair cable, also called twinaxial cable, uses copper shielding to resist interference from outside sources and offers the advantage of high noise immunity and longer distance capability.

Coaxial cable, a wire surrounded by a shield with a tightly specified impedance, offers improved noise immunity compared to unshielded twisted pair cables. Connector systems, hardware to join devices to the physical media, are commonly required with coaxial cable for such functions as branching and terminations but are readily available at moderate cost.



Selection Criteria

Copper based transmission media are among the most common media used in industrial network systems and provide a reduced cost solution for many applications. The copper media provide advantages in cost savings, simple connection systems, and the ability to transmit operating power to remote devices.

	<u>Twisted Pair</u>	<u>Twinaxial</u>	<u>Coaxial</u>
Distance	Short distance for speed	Moderate distance for speed	Longer distance for speed
Noise Immunity	Low immunity	High immunity	High immunity
Media Cost	Low cost	Medium cost	Medium cost
Installation	Flexible, Easy to install	Flexible, Easy to install	Less flexible, Special connection system required

Fiber optic media is virtually immune to electromagnetic interference, but requires special installation techniques and equipment.

Fiber Optic Systems: For environments where intensive electromagnetic noise can not be avoided or where long cable lengths are required, a fiber optic industrial network may need to be considered. Fiber optic media transmit information in the form of light bursts through a glass or plastic optical channel. Electromagnetic interference has very little or no effect on optical transmission. Fiber optic media are preferred in applications where the network media is exposed to high levels of interference, such as welders, induction furnaces, etc. A disadvantage of fiber optic

media, however, is that it may require costly specialized installation requirements.

Radio Frequency and Modem Systems: Although less common in industrial network applications, radio frequency (RF) and modem communications are supported by some protocols. This media is reserved for extreme distances where several kilometers must be spanned between devices or for mobile applications which prohibit the effective use of cable. It is generally used in specialized applications due to its high cost and complexity.

Selection Criteria

The length capabilities of each media vary according to type, manufacturer, and signaling used. Fiber optic systems typically offer the greatest length capability. Fiber optic cable is also preferable when networks must be run from one building to another, to avoid transient surges from nearby lightning strikes which can permanently damage communication equipment. However, fiber optic transmission media is relatively expensive when compared to copper media.

Fiber optic cabling is rarely used in systems that do not require long lengths and/or noise immunity due to its high cost and specialized connector systems. Optical systems can not transmit power to remote devices. Fiber optic's inability to transmit power removes it from consideration of networks requiring this feature.

	<u>Fiber Optic</u>	<u>RF/Modem</u>
Distance	Longest distance	Longest distance
Noise Immunity	Highest noise immunity	Lowest noise immunity
Media Cost	High cost	High cost
Installation	Least flexible, Special connection system, Fiber preparation	Flexible

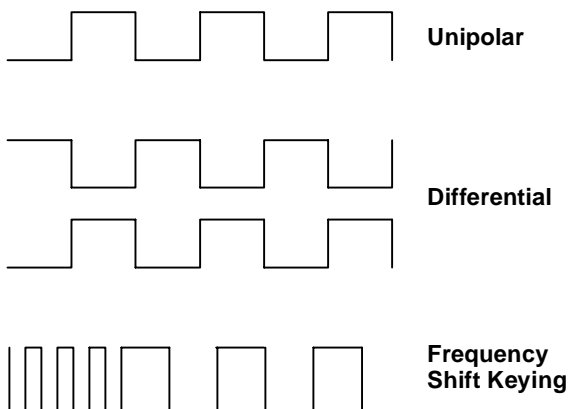
Environmental conditions such as excessive humidity, extreme temperature, or a high vibration level may not adversely affect the transmission media itself but may affect its connector system. Connection points are often viewed as the media's weak area so matching the proper connection system with the environment can avoid needless trouble and downtime.

Selection Criteria

When network media comparisons are made it is important that the equivalent connection systems are included. Connection systems are available for environments with high humidity, extreme temperatures or a high vibration. Connection systems can drastically affect both the price and performance of a system and unbiased comparisons are invaluable.

Electrical Signaling:

The most popular signaling method used in copper media is digital square wave encoding. Digital square waves are waveforms which are not sinusoidal, like standard AC current, but rectangular in shape. Voltage square waves may be unipolar or differentially encoded. Unipolar square waves are formed from voltage as referenced to ground potential in one polarity direction. Ground potential fixes a reference level and voltage excursions are made in either the positive or negative direction to encode digital information. Differential square waves are not necessarily referenced to ground potential but rather are measured as the voltage difference between two signals. Typically each signal wire potential varies in opposite polarity direction to form the total differential signal. Frequency Shift Keying methods are also commonly used both in copper media as well as fiber optic systems. Signals of varying frequency are transmitted onto the media and interpreted by a receiver as binary information.

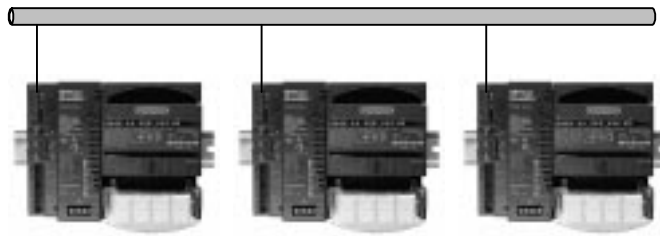


Topology and Distance Capability

The topology of a network describes the shape or form of the network or how individual devices are connected to the network. Popular network topologies include bus, star, and ring.

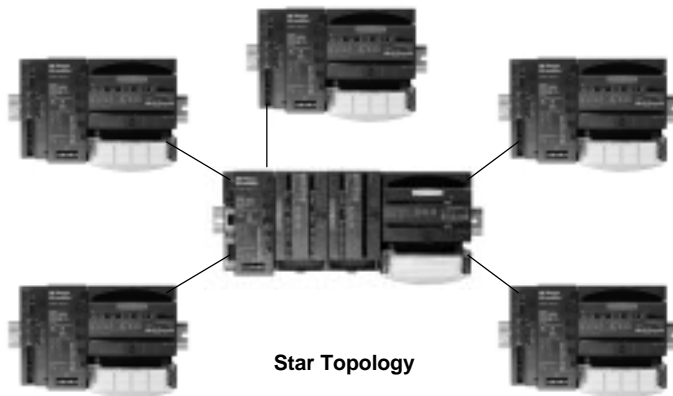
A bus topology describes a system where all devices are connected in parallel to a central cable called a bus or backbone cable. The devices are capable of receiving a signal transmitted by any other another device connected to the network.

Genius, Profibus-DP, and DeviceNet all can support bus topology.



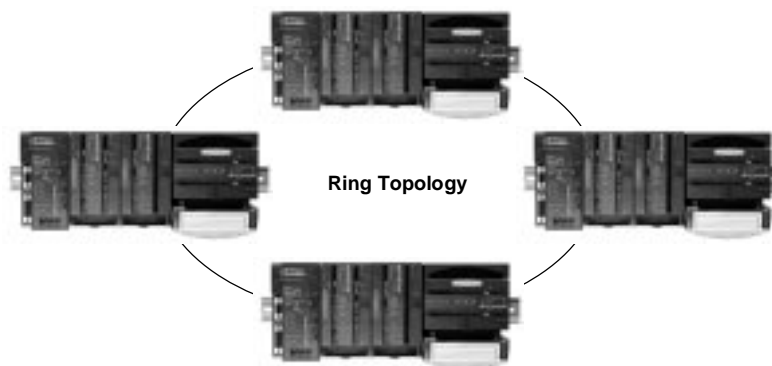
Bus Topology

The star topology describes a system where all of the devices on the network are connected to a central hub which routes messages. The hub serves as a connecting point since all of the devices fan out from this point. Each element on the network is connected directly to the hub and does not need to share the joining network media.

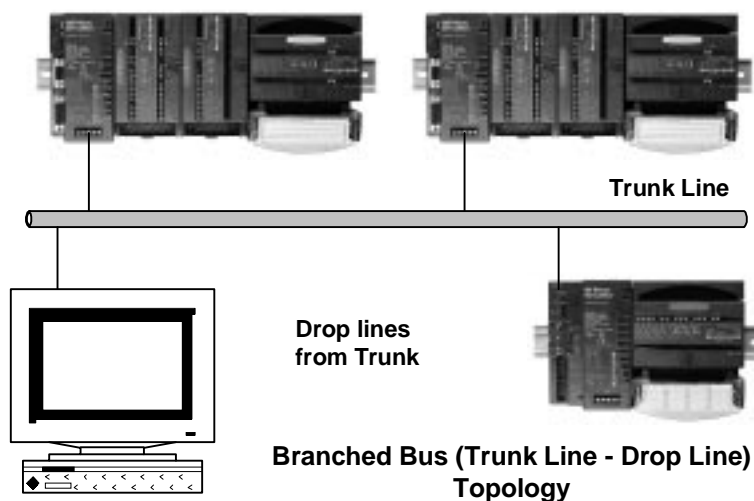


Star Topology

A ring topology describes systems in the shape of a closed loop. Each network device is directly connected to two other devices, one on either side.



Many networks can support a variety, and even an intermixing, of topologies through branching options. Branching and drop length options are often quite restricted and these restrictions should not be taken for granted when considering a potential layout.



⚠ Network length
should be based on
cable length, not
device separation.

From a network's perspective, distances are based on the length of cable between devices and not the physical distance separating the devices. Cable routing has an obvious effect on the total cable length, so if barriers are present which significantly increase the cabling requirement between devices, they need to be considered.

All networks limit both the maximum individual segment length and total overall length of the network media. Both criteria should be considered to ensure that the network will perform reliably.

Selection Criteria

The ideal topology required for an application is determined in part by the physical layout of the control system. Practical considerations such as cable routing and device separations need to be investigated before a topology is selected. Bus and star topologies are the most popular, since they do not require a closed-loop architecture. The star topology typically involves a slightly higher installation cost than a linear bus topology due to the cost of a hub and increased media length. However, the star topology allows for the addition and removal of nodes without shutting down the network.

Branching capabilities are convenient because they provide the designer with a higher degree of flexibility.

System Redundancy

Redundancy can protect your people, equipment, plant and environment.

- ✓ The VersaMax Genius Network Interface Unit supports full media and hardware redundancy.

In certain applications, the process is so critical that a single failure would be intolerable. Typically, designers build redundancy into the system for the CPU -- but neglect the I/O. If a certain output state is vital to the safety or operation of the process, redundancy for the particular I/O must be included in the design. Regardless of whether the CPU is performing correctly or not, it is the I/O device that is sensing inputs and driving outputs -- and a failure in either of these can be as important as a CPU failure.

Full system redundancy incorporates duplicate hardware systems that operate in parallel with one another. In the event of a hardware failure or cable severing, full system functionality should be maintained by the redundant system. Redundant network cabling, when routed via a distinct path along with a duplicate controller, provides an extra measure of protection. Redundancy can protect your people, equipment, plant and environment. It can also help avoid costly downtime.

Selection Criteria

In applications where the consequences of failure are severe, the desired network should include redundancy and failsafe mechanisms. Some network protocols provide the ability to switch between redundant resources in the event of a failure. Redundant resources may include duplicate network cabling, duplicate hardware systems, or both.

A self-healing ring topology is often desirable in systems that require some level of redundant communications. The ring consists of intelligent hubs that can route communications in either direction around the ring. If a hub or a connection fails, the remaining hubs will re-route communications in the other direction.

Hardware redundancy is not easily supported by all networks and should be viewed as an important feature when critical processes are being controlled.

Network Power

Network power is defined as the electricity passed through the network cabling, not for messaging, but to power the network devices. Some devices may be powered solely through the network cabling, which can eliminate the need for separate power sources at each device location.

An understanding of the system layout and device power requirements is required for the proper implementation and management of network power sources. When properly utilized, network power can offer systems a high level of convenience when separate power sources are not located near devices.

Fiber optic network media can not transmit power and therefore can not be used in systems incorporating network power.

⚠ Fiber optic media can not be used to transmit network power.

Selection Criteria

Network power is most advantageous when power sources are not located near field devices. A system with widely distributed I/O, such as a conveyor system, can take advantage of the convenience of network power.

Transmission Rate and Response Time

Transmission rate and response time specifications are commonly misinterpreted parameters. For comparisons to be made in an unbiased fashion, these parameters require close scrutiny.

Transmission rate is the amount of data which can be transmitted over a given time period. It is expressed as a bit rate.

The response time is generally defined as that period of time between the generation of a signal external to the control and the time that an output is generated by the control to cause an action in the process. The control response time includes input signal filtering time, I/O scan time to get the signal to the CPU, time for the processor to act on the input, time to send the signal to the output device, and time for the output device to generate the output signal. For example, it is the delay between pressing a button and its resultant action. Delays in the sensor and actuator add to the actual response time but are not part of the control itself. Control systems that include networks typically have longer response times because data must be transmitted across the network versus a faster, parallel backplane bus. The response time of a networked system is dependent on the number of devices on the network, the amount of data that is transmitted by each device, the data transmission rate, and the speed of the controlling processor.

⚠ Response time estimations must be calculated and are not based solely on data transmission rate.

A network used primarily for discrete control with a limited set of diagnostic features may not need a high transmission rate but may instead require a quicker response time. The response time of a system is not based solely on the transmission rate. Several other factors need to be considered to estimate response time.

A large control system with intelligent analog I/O and increased control sophistication may require an increased transmission rate (bandwidth) for proper operation. However, transmission rate comparisons should be made only when each network is operated in the same manner and under the same conditions.

Transmission overhead reduces the actual data transfer rate of the network.

The longer the transmission media and the larger the number of devices attached to the media, the lower the maximum permissible transmission rate. It should be noted that protocol specifications cite bit transfer rate and do not specify the net “user-data” transfer rate. All protocols transmit “extra” information for functions such as timing, addressing, and error correction. This extra information is commonly called transmission overhead. Since transmission overhead is not user data, the user data transmission rate is lower

than the raw transmission rate. Protocol differences lead to different levels of overhead and therefore different user data transmission rates for the same raw transmission rate. For instance, a master-slave protocol might require several messages, each with overhead, addressing, etc. to gather information from multiple devices and actuate multiple outputs. A peer-to-peer network could be configured to use fewer messages and thus respond more quickly, requiring a lower raw transmission rate to accomplish the same level of functionality.

Microprocessor latency is the time required for a controller to interpret and act upon information presented on the network. Latency can produce inactive moments when the network is not being fully utilized. Processors of different varieties and clock rates do not necessarily respond equally well to network situations, thereby creating varying dormant periods and delays in control response.

The more messages a system requires, the greater the effect microprocessor latency has on the system. In general, multi-master and peer-to-peer messaging require fewer messages and thus will be less susceptible to microprocessor latency.

Useful comparisons are made only when "equivalent" systems are used in similar situations.

Any transfer rate comparison should take into account the differences in overhead usage and processor latency. Other factors such as media length, number of devices, and communication structure, all combine to affect the true data transfer rate and response time.

Transmission rate and response time values, when quoted as mere numbers without clarification, can be very misleading. True data transmission rate and response times vary widely from specification values depending on the network application and environment.

Selection Criteria

It is commonly believed that faster is better. Although this may be true in many situations, the cost associated with higher speed is not warranted for all applications. Transmission rate and response time parameters vary depending on communication structure, topology, media and media length, among other factors. Chapter 7 of this guide is devoted to estimating network scan time. However, before significant weight is placed on network scan time, the designer must fully understand the required response time characteristics of the control system that he or she is designing.

Diagnostic Tools

- ✓ VersaMax I/O offers point level diagnostics to trace problems to individual circuits.

Diagnostic tools and functionality are important aspects to consider, as they can reduce both start-up time and maintenance. Diagnostic information allows network devices to communicate their status. This information can be polled by a controller or reported to the controller automatically when a fault occurs. More sophisticated network protocols typically offer more advanced diagnostic tools. Diagnostic messages may report information on the status of:

- a single I/O point (e.g. open or short circuit)
- an I/O module (e.g. over-temperature, under-voltage, lack of signal or response when polled)
- the transmission media (e.g. high bit error rate, data collisions).

Selection Criteria

The diagnostic tools supported by each network are not equivalent. Even within a particular protocol different diagnostic tool sets will be available depending on the communication structure implemented. Applications also vary in their need for diagnostic features. Applications which are prone to device failure due to environmental conditions or harsh usage may wish to incorporate more advanced diagnostic systems to reduce the time required to troubleshoot problems. Diagnostic systems are also most productive when downtime carries a high cost. The implementation cost of a thorough diagnostic system may be quickly recovered by reduced downtime periods.

Maximum Nodes and I/O Points per Node

A **node** is an addressable device on a network.

A node is an addressable device on a network. There is a limit on the number of nodes allowed on the network media to ensure that the transmission rate and signal levels are maintained. Also commonly included in each protocol specification is the maximum number of discrete or analog I/O points per node. The maximum number of I/O points per node is determined by the maximum message length allowed to be transmitted to or from a node.

System Cost

Factors that contribute to the total system cost include:

- Hardware Components
 - Controllers
 - Network Interfaces
 - I/O Modules
 - Field Devices (both with and without network connectivity options)
- Transmission Media
 - Cabling
 - Connection Systems
- Features Supported (software for both control and diagnostic functions)
- Commissioning Costs
 - Hardware Installation
 - Software Development
- Maintenance Costs

✓ VersaMax I/O can significantly reduce installation and maintenance costs.

The individual costs of the items listed above vary greatly depending on the network selected, topology, transmission media, redundancy, supplier(s), systems integrator, and installation environment. To calculate an unbiased “system” cost, all of the items should be individually totaled and summed.

What have You Learned ?

This chapter described the fundamental aspects of network systems. A network is a system of electronic devices that are connected for the purpose of sharing information. Each device on the network is called a node. An industrial network is a bi-directional real-time communication system which allows the exchange of digital information between field level devices and controlling devices. Popular industrial network protocols are generally classified into three categories -- Bit (Sensor), Byte (Device) and Message-oriented Full Function) networks. This classification is derived from the

typical data structure that is most commonly encountered by each type of network.

The benefits of networked systems over conventional control system architectures include reduced installation cost, faster implementation, reduced downtime, and greater system flexibility.

The differentiating characteristics of industrial networks can be described by the following categories:

- Network Access Method
- Communication Structure
- Transmission Media
- Topology and Distance Capability
- System Redundancy
- Network Power
- Transmission Rate and Response Time
- Diagnostic Tools
- Maximum Nodes and I/O Points
- System Cost

Chapter 5

VersaMax I/O and Control

In this Chapter:

- ▲ Overview of VersaMax I/O and Control
- ▲ Features and benefits
- ▲ Basic system modules
- ▲ Catalog numbers

Overview



The **VersaMax solution** is a family of control products that can be used as I/O, as a PLC, and as distributed control.

VersaMax I/O and Control is a family of products that can be used as universal I/O, as a PLC, and as distributed control for up to 256 local points. With its modular and scalable architecture, intuitive features, and unparalleled ease of use, it helps save machine builders and end users time and money.

- ✓ For higher uptime, VersaMax I/O supports hot insertion which enables the installation or extraction of I/O modules while a machine or process is running and without affecting field wiring.

As a universal I/O, VersaMax I/O connects to a wide variety of PLCs, PC-based control systems, and DCSs via Genius, DeviceNet, and Profibus-DP communications. Designed for industrial and commercial automation, VersaMax I/O provides a common, flexible I/O structure for local and remote control applications requiring up to 256 points per station. VersaMax I/O can be used in standalone applications with a local VersaMax CPU or as a slave.

As a scaleable automation solution, VersaMax I/O combines compactness and modularity for greater ease of use. The 70-mm depth and small footprint of VersaMax I/O enables easy, convenient mounting as well as space-saving benefits. Modules can accommodate up to 32 points of I/O each.

The compact, modular VersaMax products feature a rack-less design and DIN-rail mounting, with up to eight I/O and option modules per station.

VersaMax I/O also provides automatic addressing that can eliminate traditional configuration and the need for hand-held devices. Multiple field wiring termination options -- including IEC box style, spring clamp style, barrier style, and connector style -- provide support for two, three, and four-wire devices.

For faster equipment repair and shorter mean-time-to-repair, a hot insertion feature enables addition and replacement of I/O and communication modules while a machine or process is running and without affecting field wiring.

Features and Benefits of VersaMax I/O

■ Universal I/O

- Utilizes common I/O for a 3-in-one solution as a standalone PLC, remote/distributed I/O, or distributed control system.
- I/O can be connected to a multitude of controllers, including PLCs, PCs, DCS systems and other controllers that connect to the networks supported.

■ Versatile I/O for monitoring and control automation

- Ideal for applications requiring 32-256 points of I/O
- Breadth of I/O -- discrete, analog, mixed, and specialty modules.
- Multitude of wiring options: Field wiring termination options for local and remote wiring provide support for 2, 3, and 4 wire devices.

■ Variety of network interface options

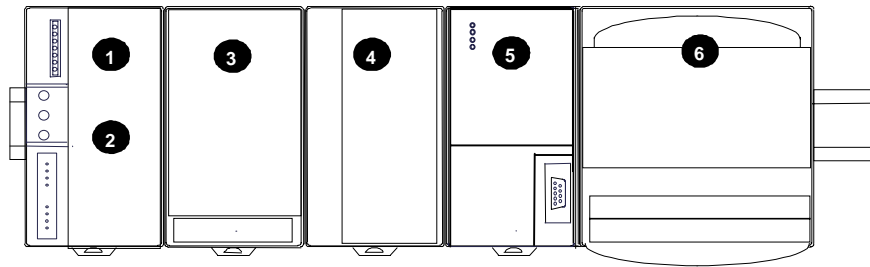
- DeviceNet
- Genius
- Profibus-DP
- Modular and scaleable architecture
 - Compact module size (70mm depth).
 - No rack required. Carriers snap onto a DIN rail – up to 8 modules per station.
 - Removable electronics. Highly reliable I/O carriers with no active components provide field wiring connections, enabling I/O modules to be installed and extracted without disturbing field wiring.
- Easy to use
 - No tools required for installation or extraction of I/O.
 - Automatic addressing of I/O without configuration -- no hand held device is required.
 - Snap-together modules eliminate the need for a rack and cable connections.
 - Hot insertion enables an I/O module to be installed or extracted while the machine or process is running and without affecting field wiring.
- Diagnostics:
 - LEDs display the on/off status of I/O points.
 - Point level electronic short circuit fault indication.
 - Field power LED provides visual indication of user power available for driving outputs.
 - Back-plane power LED indicates power available for each I/O module.

VersaMax Modules

There are six basic types of VersaMax modules:

- **Network Interface Unit (NIU):** Provides slave communications and I/O scanning for a group of up to eight I/O modules. The system host can be any PLC or PC capable of controlling the network.
- **CPU:** Provides local logic, I/O control, and distributed processing. Depending on the network, the CPU may share information with other VersaMax CPUs or command remote VersaMax I/O stations.
- **I/O Modules:** Available in discrete input, discrete output, mixed discrete, analog input, analog output, and mixed analog I/O modules.

- **I/O Carriers and Terminals:** I/O carriers provide mounting, backplane communications, and field wiring for I/O modules.
- **Network Communication Modules:** A DeviceNet master module (Network Control Module, NCM) and Profibus-DP slave module (Network Slave Module, NSM) are available for use in VersaMax CPU systems to provide an interface to the respective networks.
- **Power Supplies:** Provide backplane power for CPU, NIU, communications, and I/O modules.



1 Network Interface Unit with Power Supply

The Network Interface Unit (NIU) interfaces up to 8 VersaMax modules to a host PLC or computer via a communications bus. Three NIUs are available: Genius (IC200GBI001), Profibus-DP (IC200PBI001), and DeviceNet (IC200DBI001).

An AC or DC Power Supply module installs directly on the NIU. The Power Supply provides +5V and +3.3V power to the modules in the station. Additional power supplies can be installed on special booster carriers if needed for systems where the number of modules creates the need for a booster.



See The VersaMax PLC User's Manual (GFK-1503) for additional information on the CPU.

2

CPU

The CPU (IC200CPU001) provides local logic, I/O control, and distributed processing. Each CPU interfaces up to 8 local VersaMax modules. Up to 4K I/O can be accommodated using remote I/O networks.

An AC or DC Power Supply module installs directly on the CPU. The Power Supply provides +5V and +3.3V power to the modules in the station. Additional power supplies can be installed on special booster carriers if needed for systems where the number of modules creates the need for a booster.

3

I/O Module on Connector-Style Carrier

I/O modules are available to suit a wide range of application needs. I/O carriers provide mounting, backplane communications, and field wiring for all types of VersaMax modules. Modules can be installed and removed without disturbing field wiring.

The Connector-Style I/O Carrier (IC200CHS003) provides a 40-pin connector for attaching an I/O cable that connects to interposing terminals. Interposing I/O terminals can be used to provide individual terminals for I/O device wiring. The interposing terminals are available in barrier, IEC box, and spring clamp terminal options.

4

Booster Power Supply

In addition to the power supply installed on the CPU or NIU, one or more additional power supplies can be installed on booster carriers (IC200PWB001) between modules to meet the power requirements of high-current stations. Power supplies provide power through the carrier bases to modules on their right.

5

Network Communication Module

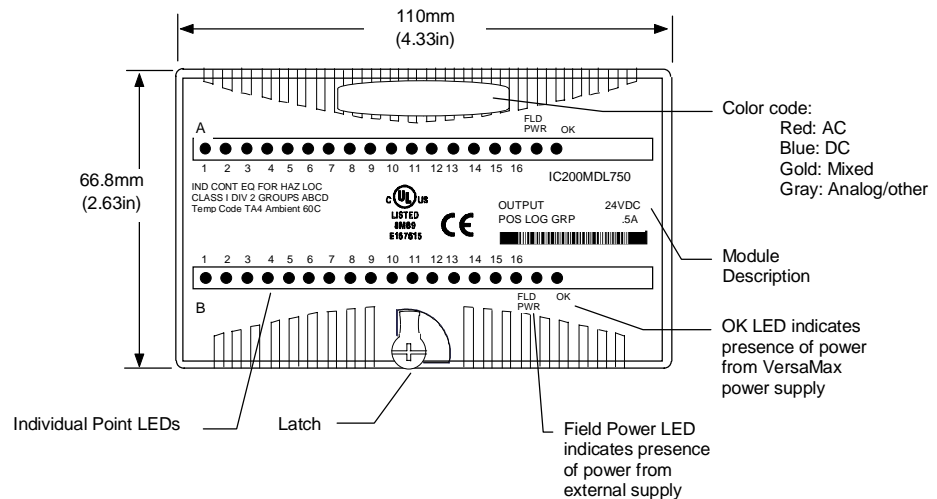
A DeviceNet master module (Network Control Module/NCM, IC200BEM103) and Profibus-DP slave module (Network Slave Module/NSM, IC200BEM002) are available for use in VersaMax CPU systems to provide an interface to the respective networks.

6 I/O Module on Terminal Style I/O Carrier

The Terminal Style I/O Carriers (IC200CHS001, IC200CHS002, IC200CHS005) provide mounting, backplane communications, and field wiring for all types of VersaMax modules. They are available with barrier, IEC box, and spring clamp style terminals for direct connection of field wiring. Additional Auxiliary Terminals (IC200TBM001, IC200TBM002, IC200TBM005) can be used to provide extra wiring terminals if needed.

I/O and Option Modules

VersaMax I/O and option modules are 110mm (4.3in) by 67mm (2.63in) in size. Modules are 50mm (1.956 in) in depth, not including the height of the carrier or the mating connectors.

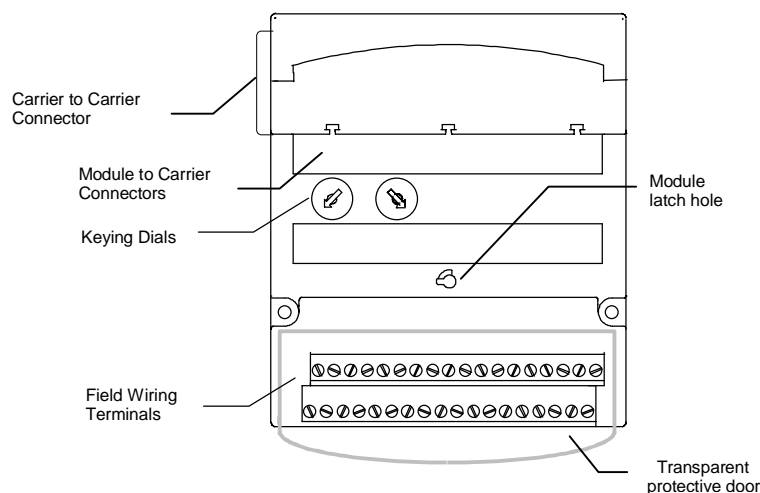


Modules install on individual carriers. The latch on the face of the module is used to secure a module on its carrier. Two keying dials on the underside of the module are factory-set to identify the specific module type. Mating keying on the carrier can be used to assure that the correct module type is installed on a carrier.

Terminal Style I/O Carriers

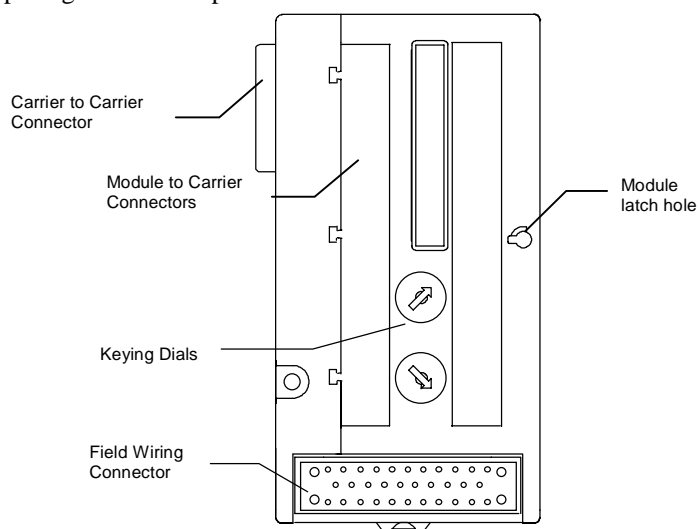
An I/O carrier provides mounting, backplane communications, and field wiring terminals for one I/O module.

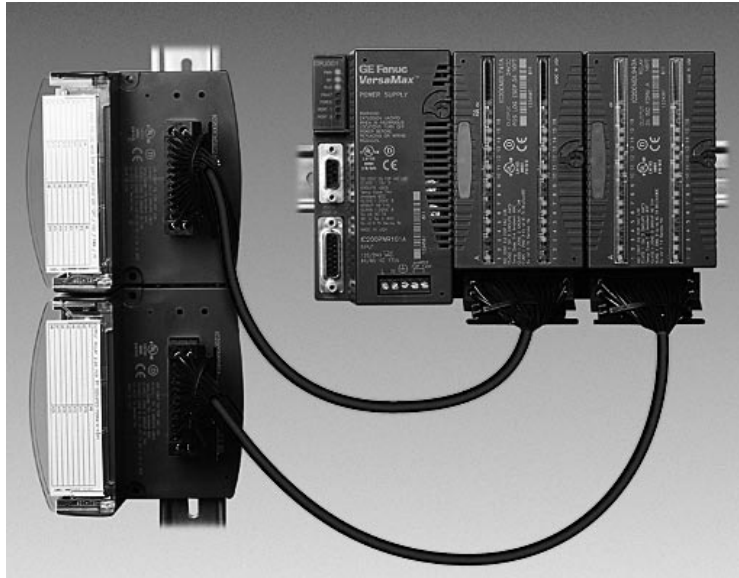
Terminal-style I/O carriers may have IEC box-style or spring-clamp style terminals for direct connection of field wiring. All terminal style I/O carriers are designed for direct connection of field wiring without the use of interposing terminal strips.



Connector Style I/O Carriers

Connector style carriers have a connector for attaching an I/O cable to an interposing terminal strip.



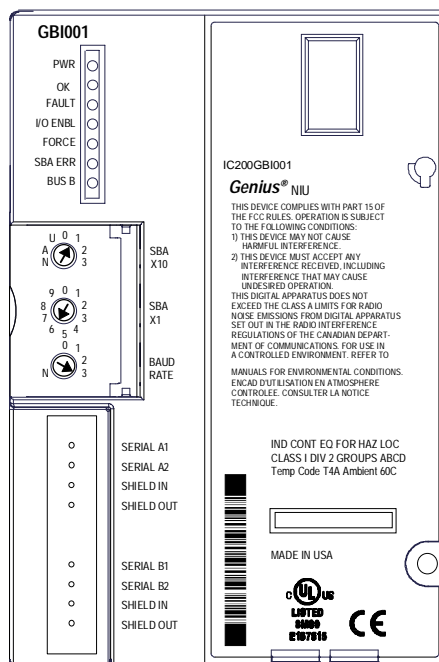


Connector Style I/O Carriers to Interposing Terminals

Genius Network Interface Unit

The VersaMax Genius Network Interface Unit (IC200GBI001) can be used to interface up to eight VersaMax I/O modules to a Genius I/O bus. Together, the NIU and its modules form an I/O station capable of handling up to 128 bytes of discrete and analog input data and 128 bytes of discrete and analog output data. The system host can be any PLC or computer capable of controlling the Genius bus.

The Network Interface Unit installs on a 35mm x 7.5mm DIN rail. A VersaMax power supply module mounts directly on the right-hand side of the NIU. LEDs on the left-hand side indicate the presence of power and show the operating mode and status of the NIU. Three rotary dials beneath a clear protective door are used to configure the NIU's address on the Genius bus and to set its communications baud rate. Removable connectors are used to install single or redundant bus cables. These connectors make it possible to disconnect a bus cable from the NIU without breaking the continuity of the bus, so other devices on the same bus can continue operating. The Genius NIU supports autoconfiguration of I/O modules. VersaMax modules that have software configurable features use their default settings.



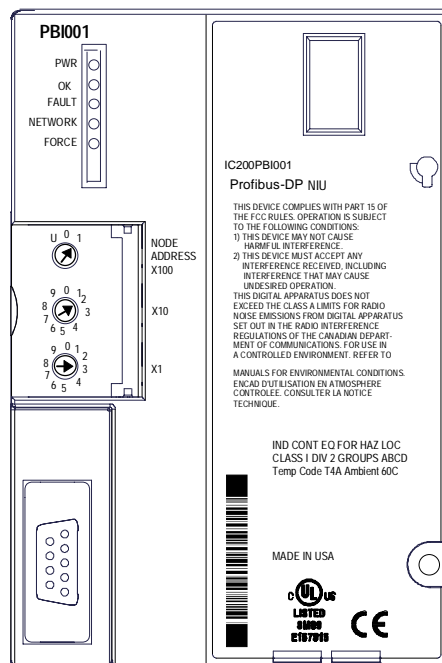
Genius NIU Specifications

Number of Modules	8 per NIU/station
Network inputs per bus scan	128 bytes
Network outputs per bus scan	128 bytes
Discrete Input Memory	1024 points
Discrete Output Memory	1024 points
Analog Input Memory	64 channels
Analog Output Memory	64 channels
Power Consumption	+5V @250mA, +3.3V @10mA
Serial Bus Address	0 to 31
Network data rate	38.4 Kbaud, 76.8 Kbaud, 153.6 Kbaud standard, or 153.6 Kbaud extended.

Profibus-DP Network Interface Unit

The Profibus-DP Network Interface Unit (IC200PBI001) can be used to interface up to eight VersaMax I/O modules to a Profibus network. Together, the NIU and its modules form an I/O station capable of handling up to 375 bytes of I/O data, consisting of up to 244 bytes of discrete and analog input data and up to 244 bytes of discrete and analog output data. The system host can be any device capable of operating as a bus master.

The Network Interface Unit installs on a 35mm x 7.5mm conductive DIN rail. A VersaMax power supply module mounts directly on the right-hand side of the NIU. LEDs on the left-hand side indicate the presence of power and show the operating mode and status of the NIU. Three rotary dials beneath a clear protective door are used to configure the NIU's address on the Profibus network. The 9-pin D-shell connector is used to connect the bus cable. The Profibus-DP NIU supports autoconfiguration of I/O modules. VersaMax modules that have software configurable features use their default settings.

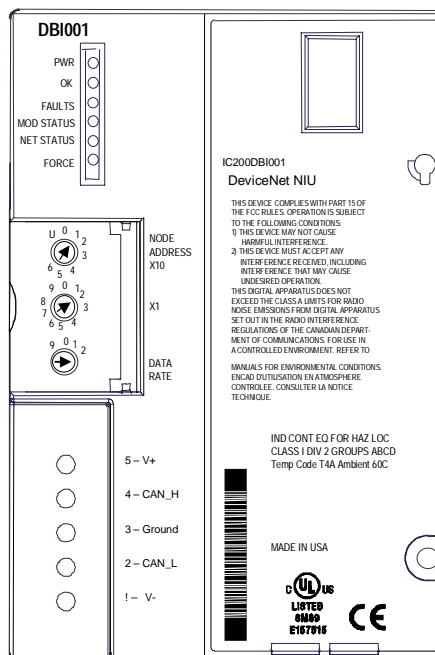


Profibus-DP NIU Specifications

Number of modules	8 per station.
I/O data	Up to 244 bytes of inputs. Up to 244 bytes of outputs. 375 bytes of combined inputs and outputs maximum.
User diagnostic data	5 bytes maximum.
Profibus network address	1 to 125.
Profibus network data rate	9.6Kbaud to 12Mbaud
Indicators (5)	Power LED to indicate power OK LED to indicate health of the NIU Fault LED to indicate presence of faults Network LED to indicate health of the PROFIBUS network Force LED (not used)
Power Consumption	+5V@250mA, +3.3V@10mA

DeviceNet Network Interface Unit

The DeviceNet Network Interface Unit (IC200DBI001) can be used to interface up to 8 VersaMax I/O modules to a DeviceNet network.



The Network Interface Unit installs on a 35mm x 7.5mm DIN rail. A VersaMax power supply module mounts directly on the right-hand side of the NIU. LEDs on the left-hand side indicate the presence of power and show the operating mode and status of the NIU. Three rotary dials beneath a clear protective door are used to configure the NIU's address and data rate on the DeviceNet network. The connector is used to connect the bus cable. The DeviceNet NIU supports autoconfiguration of I/O modules. VersaMax modules that have software configurable features use their default settings.

DeviceNet NIU Specifications

Number of modules	8 per station.
I/O data	Up to 128 bytes of inputs + 2-byte status word Up to 128 bytes of outputs + 2-byte control word.
DeviceNet network address	0 to 63. Default is 63.
DeviceNet network data rate	125K, 250K, 500K baud
Indicators (5)	Power LED to indicate presence or absence of power. OK LED to indicate the status of the NIU powerup. Fault LED to indicate presence of faults. Mod Status LED to indicate the status of the NIU module. Net Status LED to indicate health of the DeviceNet network. Force LED (not used) .

VersaMax Catalog Numbers

Catalog #	Description
Discrete Input Modules	
IC200MDL140	Input 120VAC, 8 Points
IC200MDL141	Input 240VAC, 8 Points
IC200MDL143	Input 120VAC Isolated, 8 Points
IC200MDL144	Input 240VAC Isolated, 4 Points
IC200MDL240	Input 120VAC, 16 Points
IC200MDL241	Input 240VAC, 16 Points
IC200MDL243	Input 120VAC Isolated, 16 Points
IC200MDL244	Input 240VAC Isolated, 8 Points
IC200MDL640	Input 24VDC Pos. Logic, 16 Points
IC200MDL650	Input 24VDC Pos. Logic, 32 Points
Discrete Output Modules	
IC200MDL329	Output 120VAC 0.5 Amp, Isolated 8 Points
IC200MDL330	Output 120VAC 0.5 Amp, Isolated 16 Points
IC200MDL331	Output 120VAC 2.0 Amp, Isolated 8 Points
IC200MDL730	Output 24VDC Pos. Logic 2.0 Amp with Electronic Short Circuit Protection, 8 Points
IC200MDL740	Output 24VDC Pos. Logic 0.5 Amp, 16 Points
IC200MDL741	Output 24VDC Pos. Logic 0.5 Amp with Electronic Short Circuit Protection, 16 Points
IC200MDL742	Output 24VDC Pos. Logic 0.5 Amp with Electronic Short Circuit Protection, 32 Points
IC200MDL750	Output 24VDC Pos. Logic 0.5 Amp, 32 Points
Mixed Discrete Modules	
IC200MDD840	Mixed 24VDC Pos. Logic Input 20 Points / Output Relay 2.0 Amp 12 Points
IC200MDD841	Mixed 24VDC Pos. Log Input 20 Points / Output 24VDC 0.5 Amp 12 Points / High Speed Counter, PWM or Pulse Train Configurable Points
IC200MDD842	Mixed 24VDC Pos. Log Input 16 Points / Output 24VDC 0.5 Amp with Electronic Short Circuit Protection 16 Points
IC200MDD843	Mixed 24VDC Pos. Log Input 10 Points / Output Relay 6 Points
IC200MDD844	Mixed 24VDC Pos. Log Input 16 Points / Output 24VDC 0.5 Amp 16 Points
IC200MDD845	Mixed 24VDC Pos. Log Input 16 Points / Output Relay 2.0 Amp Iso 8 Points
IC200MDD846	Mixed 120VAC Input 8 Points / Output Relay 2.0 Amp Isolated 8 Points
IC200MDD847	Mixed 240VAC Input 8 Points / Output Relay 2.0 Amp Isolated 8 Points

Catalog #	Description
IC200MDD848	Mixed 120VAC Input 8 Points / Output 120VAC 0.5 Amp Isolated 8 Points
Relay Output Modules	
IC200MDL930	Output Relay 2.0 Amp, Isolated Form A 8 Points
IC200MDL940	Output Relay 2.0 Amp, Isolated Form A 16 Points
Analog Input Modules	
IC200ALG230	Analog Input 12 Bit Voltage/Current, 4 Channels
IC200ALG240	Analog Input 16 Bit Voltage/Current Isolated, 8 Channels
IC200ALG260	Analog Input 12 Bit Voltage/Current, 8 Channels
IC200ALG620	Analog Input 16 Bit RTD, 4 Channels
IC200ALG630	Analog Input 16 Bit Thermocouple, 7 Channels
Analog Output Modules	
IC200ALG320	Analog Output 12 Bit Current, 4 Channels
IC200ALG321	Analog Output 12 Bit 0-10V Voltage, 4 Channels
IC200ALG322	Analog Output 12 Bit +/-10V Voltage, 4 Channels
IC200ALG331	Analog Output 16 Bit Voltage/Current Isolated, 4 Channels
Mixed Analog Modules	
IC200ALG430	Analog Mixed 12 Bit Input Current 4 Channels / Output Current 2 Channels
IC200ALG431	Analog Mixed 12 Bit 0-10V Input 4 Channels / Output 0-10V 2 Channels
IC200ALG432	Analog Mixed 12 Bit -10V to +10V Input 4 Channels / Output 2 Channels
I/O Carriers	
IC200CHS001	I/O Carrier, Barrier Style, Field Wiring Interface
IC200CHS002	I/O Carrier, Box Style, Field Wiring Interface
IC200CHS005	I/O Carrier, Spring Clamp Style, Field Wiring Interface
IC200CHS003	I/O Carrier Connector Style, Field Wiring Interface (Requires One
IC200CHS006	Communications Carrier (Genius, DeviceNet, Profibus-DP)
IC200CHS011	I/O Interposing Terminals, Barrier Style, Field Wiring Interface (Requires One Cable and One IC200CHS003)
IC200CHS012	I/O Interposing Terminals, Box Style, Field Wiring Interface (Requires One Cable and One IC200CHS003)
IC200CHS014	I/O Interposing Terminals, Box Style Thermocouple Compensation, Field Wiring Interface (Requires One Cable and One IC200CHS003)
IC200CHS015	I/O Interposing Terminals, Spring Clamp Style, Field Wiring Interface (Requires One Cable and One IC200CHS003)
IC200TBM001	I/O Auxiliary Terminals, Barrier Style, Field Wiring Interface (Required For 2, 3 and 4 Wire Connections)
IC200TBM002	I/O Auxiliary Terminals, Box Style, Field Wiring Interface (Required For 2, 3 and 4 Wire Connections)
IC200TBM005	I/O Auxiliary Terminals, Spring Clamp Style, Field Wiring Interface (Required For 2, 3 and 4 Wire Connections)

Catalog #	Description
Network Interface Units	
IC200GBI001	I/O Network Interface For Genius Bus (Slave)
IC200PBI001	I/O Network Interface For Profibus-DP (Slave)
IC200DBI001	I/O Network Interface For DeviceNet (Slave)
Network Communication Modules	
IC200BEM002	PLC Network Communication Profibus-DP Slave
IC200BEM103	PLC Network Communication DeviceNet Master
CPU	
IC200CPU001	CPU 12K Memory, Two Ports - RS-232 And RS-485
IC200CPU002	CPU 20K Memory, Two Ports - RS-232 And RS-485
Power Supplies	
IC200PWB001	Power Supply Booster Carrier
IC200PWR001	Power Supply 24VDC Input
IC200PWR002	Power Supply with Expanded 3.3VDC 24VDC Input
IC200PWR101	Power Supply 120/240VAC Input
IC200PWR102	Power Supply with Expanded 3.3VDC 120/240VAC Input
Expansion	
IC200ACC201	Expansion Terminator, Qty 1
IC200ACC202	Expansion Connector, Qty 2
IC200CBL600	Cable Expansion Shielded Single Ended, 1M
IC200CBL601	Cable Expansion Shielded 2 Connectors, 1M
IC200CBL602	Cable Expansion Shielded 2 Connectors, 2M
IC200CBL615	Cable Expansion Shielded 2 Connectors, 15M
IC200ERM001	Expansion Receiver Isolated
IC200ERM002	Expansion Receiver Non-Isolated
IC200ETM001	Expansion Transmitter
Cables	
IC200CBL001	Cable, CPU Programming RS-232
IC200CBL002	Cable, Expansion Firmware Upgrade
IC200CBL105	Cable, I/O Non-Shielded 2 Connectors .5m
IC200CBL110	Cable, I/O Non-Shielded 2 Connectors 1.0m
IC200CBL120	Cable, I/O Non-Shielded 2 Connectors 2.0m
IC200CBL230	Cable, I/O Non-Shielded 1 Connector 3.0m
Accessories	
IC200ACC301	I/O Filler
IC200ACC302	I/O Input Simulator
IC200ACC303	I/O Shorting Bar Qty 2
IC200ACC304	I/O Cable Connector Kit Qty 2
Starter Systems	

Catalog #	Description
IC200PKG001	PLC Starter System CPU001
IC200PKG101	I/O Starter System Genius
IC200PKG102	I/O Starter System Profibus-DP
IC200PKG103	I/O Starter System DeviceNet

Chapter 6

Industrial Network Comparisons

In this Chapter:

- ▲ Genius bus
- ▲ DeviceNet
- ▲ Profibus-DP
- ▲ Summary Comparison

Genius Bus

Origin

The Genius bus was developed by GE Fanuc Automation and introduced to the industrial controls market in 1985. GE Fanuc maintains the Genius network protocol. A wide range of Genius-compatible devices have been developed by other companies, providing even greater potential and flexibility for Genius systems.

Communications Overview

The Genius bus is a peer to peer, token passing network.



Additional information can be found in *Genius I/O System and Communications* Manual, GEK-90486-1

The Genius network is a peer to peer, token passing network which also allows multiple master applications. Network access is granted by rotating a token through up to 32 peer elements. Genius networks provide support for both distributed I/O and distributed control systems.

Genius networks can mimic a multi-master communication structure by restricting the capability of its peers. I/O devices broadcast their input conditions on the network media each time they are granted the token. True multi-master structured systems do not have access to all of the I/O information. Genius networks mimic the multi-master structure by forcing controlling devices to ignore slaves that are not assigned to their control.

I/O data and fault messages are automatically transmitted by the nodes. Genius provides two additional, more sophisticated, messaging styles.

- Datagrams

- Global Data

Genius Datagrams communicate data that is not otherwise available through I/O updates.

Datagrams: A datagram is a message from one device on the bus to one or more other devices. Datagrams are not transmitted automatically by devices. Each datagram can be marked as a normal or a high priority message. Datagrams have access to additional information that is not automatically communicated during automatic I/O updates. They allow devices to perform block identification, configuration, diagnostics and on-demand, I/O data captures.

Genius Global data allows repeated data block transfers between network controllers.

Global Data: Global data is data that is automatically sent each bus scan by a network controller to all other CPUs. These messages offer network controllers a simple means to communicate directly with one another. Global data messages transfer data from a block of memory within a network controller into the memory of another network controller. Subsequent global data will overwrite previous messages, therefore the data must be read prior to the next network scan.

Global data is designed to simplify shared data between controllers. By allowing the user to configure data that is automatically and repeatedly transmitted between nodes, global data allows controllers to act as though they share a backplane and/or I/O between them.

Transmission Media and Connection System

The Genius bus uses a shielded twisted-pair wire. Fiber optic modems are also available for use in environments where electromagnetic interference, lightning, or extreme distances may cause problems for the standard twisted pair media. Modems are used to convert between twisted pair and fiber optic signaling.

Genius networking devices are equipped with screw terminal blocks for connecting the bus wiring to the device. Network cabling wires may be stripped back and connected directly to the terminal lugs or prefabricated network cabling systems are available in a variety of lengths.

Topology and Distance Capability

- ✓ Few other industrial networks provide redundancy features at the level supported by the Genius bus.

Genius networks use the bus topology. Devices and controllers are connected together in a daisy-chained fashion with a terminating resistor at each bus end. Branching “T”s, used to generate a Trunk line - Drop line architecture, are restricted to applications where the bus media is fiber optic or the “T” is a very short length of copper cable. Although physically the Genius network structure is bus, its cyclical token passing is more commonly associated with that of a logical ring.

Genius buses can reach up to 1066m (3500 ft) at its highest transmission rate with certain cable types. Bus lengths can be extended to 2286m (7000 ft) by reducing the transmission rate and number of devices supported

System Redundancy

- ✓ The VersaMax Genius NIU supports redundant network media with built-in bus switching capability.

The Genius industrial network is often implemented in systems where communication is critical. Genius allows for full system redundancy to minimize the disturbances caused by faulted hardware or damaged transmission media. Both the network media and network controller can be made redundant. Bus switching and diagnostic features allow the Genius bus to automatically sense and react to fault conditions within devices or to cable breaks.

Network Power

Genius networks do not provide network power for distributed I/O devices, I/O modules, or controllers.

Transmission Rate and Response time

The Genius bus uses token passing media access to assure that the network is highly predictable.

There are four allowable transmission rates in the Genius network protocol. Users may select the transmission rate used, but all devices on the network must operate at the same rate. Genius offers 153.6 kbps (kilo-bits per second) extended, 153.6 kbps standard, 76.8 kbps and 38.4 kbps transmission rates. In electrically noisy environments, 153.6 kbps extended provides improved noise immunity with little effect on network scan time. The Summary Comparison, located at the end of this chapter, provides more detailed information on the available distance and speed options.

The cyclical nature of the Genius bus makes its network scan time an important parameter to consider. The network controller imposes a minimum network scan time of 3ms. Adding I/O modules, scanners or controllers to the network increases the network scan time of a system. Response time is largely determined by network scan times.

Diagnostic Features

The Genius bus supports a wide range of point-level diagnostic features including hardware and wiring fault detection, duplicate address detection, redundant media or hardware switching, and I/O messages such as under or over voltage faults. The diagnostic strength of the Genius bus allows for automatic removal of faulted circuits or devices and allows a technician to quickly diagnose and repair problems.

One fault message may be broadcast per network scan. Each time a network device receives the token, it broadcasts its input data and tests if a previous device has sent a diagnostic message. If a fault message has been sent by another device within the network scan, the second faulted device must wait at least one more scan before it can communicate its message. The token indicates if a node is allowed to send a diagnostic message.

If a device is removed, the network allows a certain time for the device to give up the token, then the next device takes the token. This allows simple detection and accumulation of faulted devices without disrupting the Genius network.

Maximum I/O Allowed

A **Genius node** is an addressable network device.

Genius networks support up to 32 nodes numbered from 0 through 31. A node may consist of a controller, VersaMax family member, or any other Genius bus-enabled device. The maximum amount of I/O data allowed to be communicated over the network is 128 bytes of input and 128 bytes of output data per node. Since at least one controller is required to manage the network, a maximum of 31 nodes is available for distributed I/O. The maximum amount of I/O data per network segment is approximately 4000 bytes of input and 4000 bytes of output data. The maximum amount of permissible I/O data is also limited by the maximum scan time of 400 ms, which can not be exceeded.

DeviceNet

Origin



To learn more about DeviceNet, check out the ODVA website at www.ODVA.org



GE Fanuc is a member of ODVA.

The DeviceNet protocol was developed by Allen-Bradley and introduced to the industrial controls market in 1994. The standard is being maintained by the Open DeviceNet Vendors Association (ODVA). ODVA is a worldwide association of over 285 member companies. The underlying basis for DeviceNet is the differential encoded CAN (Control Area Network) protocol developed in the automotive industry in the mid 1980s.

Communications Overview

DeviceNet supports a wide variety of communication structures including peer to peer, multi-master and master/slave with broadcasting capabilities. These structures allow DeviceNet to fulfill a broad range of control system requirements. A maximum of 64 devices can be connected to a single DeviceNet network without bridging or routing.

Short message length, high node allowance, and network power make DeviceNet a popular choice for distributed I/O networks with primarily discrete devices.

The DeviceNet message field can range from 0 to 8 bytes. The relatively short data length allows messages to be transmitted without excessive overhead. Messages longer than 8 bytes are transmitted by fragmenting the message into several smaller packets. The fragmentation process increases overhead, and therefore reduces data transmission throughput.

DeviceNet supports two types of messaging: Explicit Messaging and I/O Messaging.

- Explicit messages are typically used in a request/response mode between two devices for configuration and diagnostic data transfer. They are commonly of a low priority nature and are not time critical.
- I/O messaging is time critical and of high priority.
 - Strobe messages are a polling request from a master. Strobe messages can be used for communication between two devices or in a multicasting situation where there are several consumers of a single message.
 - Cyclical messaging produces data transfer between devices at regular time intervals. Devices may use cyclical messages to report their status to a master at regular time intervals.
 - Unsolicited messaging allows DeviceNet I/O to report information without token passing or polling. I/O devices or modules can initiate a "Change of State" message when an input condition has changed. Repetitive information is transmitted on the network less frequently, which frees up the available bandwidth. Since an I/O device itself can initiate a message, changed conditions can be communicated without waiting for a periodic token or poll. The repeatable, deterministic nature of polling and token passing is lost by the Change of State messaging style, but it does offer more responsive control when network traffic is light. Well executed Change of State messaging requires increased configuration on the part of the control engineer to ensure that data collisions do not reduce network throughput.

DeviceNet supports unsolicited I/O device initiated messaging.

Transmission Media and Connection Systems

DeviceNet must use a copper based media to transmit network power.

DeviceNet network cabling is limited to copper media as it must be able to transmit power. The media consists of a 5-wire, multi-conductor cable. Two wires form a twisted pair transmission line and are used for network communications while a second pair transmits network power. The fifth conductor forms a shield to reduce the effects of electromagnetic interference. Cabling is available in a variety of current-carrying capacities and a network may include a mixture of high capacity trunk cable and lower capacity cable for individual branch circuits.

DeviceNet has two basic connection system types: An open, inline terminal block and a five pole circular threaded connector.

The open connector is available with inline terminal block style wiring terminations. This connector is plugged directly into a controller or device and is held by small clips. The open connectors are suitable for environments without excessive humidity or vibration levels.

The five pole, circularly arranged connector is available in prefabricated lengths or as field attachable plug ends for odd lengths or cable splicing. Once mated, these connectors are threaded together to provide a robust connection which is better able to resist environmental effects such as moisture or vibration.

Topology and Distance Capability



Additional information can be found in *"DeviceNet Specifications Volume II, Release 2.0"*

DeviceNet network topology is limited to a bus architecture with a restricted amount of branching. This configuration is also commonly referred to as trunkline/dropline. Since a bus topology is required, a terminating resistor is needed at each end of the bus.

The maximum length of the bus is limited by the transfer rate used and the number and accumulated length of droplines used. The main bus can reach a maximum length of 330 ft (100 m) at the highest data rate but can be extended to 1650 ft (500 m) at a reduced transmission rate. Individual branch lengths may not exceed 6 meters and are limited to one network node per drop.

System Redundancy

There are no provisions within DeviceNet specifications for implementing redundancy.

Network Power

Network Power can be a convenient feature when devices are not located near power sources.

The DeviceNet protocol includes specifications to power remote devices through the network cabling. Network power sources supply a nominal 24 Volts DC at a maximum current of 8 Amps. Power sources must be distributed along the network media such that no greater than 8 Amps flows through the network wiring at any point. This is required to ensure adequate heat dissipation is achieved as well as ensure that voltage regulation along the media is maintained within specification limits. Devices can use network power for all of their power requirements or to isolate the network from internal circuitry. The DeviceNet protocol supports the hot insertion or removal of devices.

Transmission Rate and Response Time

DeviceNet supports hot insertion or removal of devices.

Bus and branching length restrictions reduce the transfer rate from a maximum of 500 kbps. A transfer rate of 500 kbps is permitted on bus lengths of 100 meters with 6 meter branches accumulating no more than 39 meters of length. Reducing the transfer rate to 250 or 125 kbps supports increased bus and branch lengths. The Summary Comparison and DeviceNet specifications provide more detailed information regarding transmission rate and trunk/branch length.

Due to DeviceNet's many communication structures, it is difficult to evaluate system determinism. Change of state messaging may offer reduced response time but it is not deterministic. Varying levels of network traffic will affect the probability that the network is free when a device wishes to transmit a change of state message. Master/Slave applications are more repeatable, although not deterministic, and estimating response time involves several assumptions. Multi-master calculations are similar to those required for master/slave applications although their complexity level is increased slightly due to additional hardware timing considerations and varied hardware latency.

Diagnostic Features

The 8-byte data packet size limits system diagnostics to only a few fault messages. Network diagnostic features allow for the automatic removal of a faulted device from the network. Health monitors are available to test the status of field devices.

Several convenient features, such as online configuration utilities, duplicate address detection upon startup, and hot removal/insertion of devices are supported by the DeviceNet protocol. Care should be taken to ensure that individual devices support the desired features, as compliance with convenience options is not enforced. A full profile of the device and its capabilities needs to be included in an Electronic Data Sheet (EDS). An EDS is required to inform the network of a device's presence and its communication requirements.

Maximum I/O Amount

DeviceNet networks can support a maximum of 64 nodes. Nodes can range in complexity from single bit devices, such as a limit switch or solenoid valve, to I/O stations with several I/O modules. The maximum amount of I/O data that can be transferred to or from an individual node is theoretically not limited. Although a theoretical limit does not exist, practical limitations do. Practical limitations are based on the response time requirements of the application.

Profibus-DP

Origin

✓ GE Fanuc is a member of the PTO.

A consortium led by Siemens developed the PROcess Field BUS – Decentralized Peripheral (Profibus-DP) standard and introduced it to the industrial controls market in 1994. The Profibus Trade Organization (PTO) maintains the standard. The PTO has a worldwide membership of over 675 companies.

Communications Overview



For additional information about Profibus-DP, check out the PTO website at www.profibus.com

The primary objective of Profibus-DP is to allow fast, cyclic communication between a master (central controller) and several simple slaves (peripheral devices). The master/slave communication structure is therefore popular with Profibus-DP users. Broadcast messaging to selectable slave groups is permitted within the master/slave structure.

Profibus-DP also supports multi-master communication by allowing

Profibus-DP is most commonly implemented using a master/slave communication structure.

up to three masters on a single network. Media access is controlled through a hybrid system of token passing and polling. Tokens are passed between the multiple masters, allowing each master to poll its individual slaves. The Profibus-DP multi-master communications structure supports some peer to peer functionality. A restricted level of information may be communicated between masters of distinct classification.

All messages transmitted by a slave device are the result of a master's request. Unsolicited slave messages are invalid. Profibus-DP communications take place in cyclical patterns whether master/slave or multi-master structures are in use. Data packets are typically 32 bytes in length, although they may be extended up to 246 bytes.

Transmission Media and Connection Systems

Profibus-DP uses a shielded twisted-pair wire. Fiber optic modems are also available for use in environments where electromagnetic interference, lightning, or extreme distances may cause problems for the standard twisted pair media. Modems are used to convert between twisted pair and fiber optic signaling.

A 9-pin "D" shaped subminiature connector system is most commonly used to connect Profibus-DP equipment to its twisted pair media. Moisture sealed connection systems are also available from several manufacturers.

Topology and Distance Capability



Additional information can be found in the *"PROFIBUS Standard DIN 19245 Parts 1 and 2."*

The Profibus-DP topology is that of the bus. The maximum bus segment length allowed is dependent on the transmission rate selected and ranges from 100m to 1200m. A maximum of three inline repeaters can be used to extend distance capability without affecting the data transmission rate. Inline repeaters can also be used to daisy-chain bus segments, which increases the total number of nodes allowed per bus.

"T" repeaters enable branching options but are not recommended if the data transmission rate is greater than 500 kbps. The bus topology requires line terminators at each bus end.

System Redundancy

Neither standardized methods nor products have been developed to implement redundancy in Profibus-DP networks.

Network Power

Profibus-DP does not provide network power for addressable nodes, although inline repeaters can be powered through network cabling.

Transmission Rate and Response Time

Transfer rates as high as 12 Mbps are possible when bus lengths of 100m or less are used. A 12 Mbps transfer rate can be maintained for bus lengths up to 500m through the use of 3 repeater devices. Essentially, repeaters daisy-chain separate bus segments together to maintain a higher transfer rate, extend the total bus length and increase the allowable number of nodes per bus. Without repeaters, increasing the bus length will require a lower transfer rate to be used. Buses can be extended up to 4800m by reducing the transmission rate to 93.75 kbps or lower. The Summary Comparison as well as the Profibus-DP standard gives more detailed information on the available length and transmission rate options.

The cyclical pattern of the Profibus-DP network enables predictable and repeatable communication. The network scan time can provide a good indication of the system response time to changing inputs. Although cyclic communication strategies allow for network scan time estimations, the individual message lengths are unknown and therefore a guaranteed response time can not be calculated.

Diagnostic Features

Each Profibus-DP master can request diagnostic status from each of its slaves. Status information may contain error flags, device identifications, or device specific errors such as over or under voltage, over temperature, and line break errors. The diagnostic frame is typically less than 32 bytes long although it may be extended to 244 bytes. Duplicate address detection is performed at the time of system start-up by comparing the addresses returned by each device with the controller configuration file. Faulted devices may enter a “Freeze” mode to remove themselves from the network. In a multi-master system, diagnostic information can be shared between the masters.

Maximum I/O Allowed

Nodes are referred to as *stations* in Profibus documentation.

A maximum of 32 nodes can be attached to any Profibus-DP bus segment. Repeaters may be used to link bus segments together to extend bus length and raise the total number of addressable nodes to 127. The maximum amount of I/O data that is supported by the protocol is 30500 bytes (125 nodes, 244 bytes per node).

Summary Comparison

	Genius Bus	DeviceNet	Profibus DP
Communication Structure	Peer to Peer, Multi-master	Peer to Peer, Multi-master, Master/Slave	Multi-master Master/Slave
Network Access Method	Token passing	CSMA with non-destructive bit-wise arbitration	Token passing between masters, Polled slaves
Transmission Media	Shielded Twisted Pair, Fiber-Optic	Shielded Twisted Pair, Fiber-Optic	Shielded Twisted Pair, Fiber-Optic
Network Topology	Bus with limited branching	Bus with limited branching (trunkline/dropline)	Bus with limited branching (trunkline/dropline)
Redundancy	Full media and hardware redundancy supported	Not Supported	Not Supported
Network Power for Node devices	Not supported	Nominal 24 Volt DC	Not Supported
Allowable Nodes (Bridging excluded)	32 nodes	64 nodes	125 nodes total with 3 repeaters (32 nodes per bus segment)
Data Packet Size	2-128 bytes with allowance for message fragmentation	0-8 bytes with allowance for message fragmentation	0-244 bytes per message
Encoding Scheme	Frequency Shift Keying	Digital Square Wave with NRZ differential Encoding	Digital Square Wave with NRZ differential Encoding
Hot Insertion / Addition to Network	Yes	Yes	Only if the slave was included in the master's scan list.

	Genius Bus	DeviceNet	Profibus DP
Isolation from Communication Lines	Yes - 2000 Hi-Pot transformer Isolation	Device specifications vary	Device specifications vary
Duplicate Address Detection	Addresses verified at power-up	Addresses verified at power-up	Comparison to set-up configuration performed
Error Detection / Correction	CRC - retransmission of message if validity not acknowledged by recipient. Bits accepted by a 2 of 3 majority vote.	CRC - retransmission of message if validity not acknowledged by recipient	Varies with selected mode of operation
Transmission Rates with length, branching and repeater limitations	<ul style="list-style-type: none"> - 153.6 kbps up to 1066m bus length - 76.8 kbps up to 1372m bus length - 38.4 kbps with 2286m bus length (limited to 16 devices on bus) 	<ul style="list-style-type: none"> - 500 kbps with 100m trunk and 6 branches - 250 kbps with 250m trunk and 6 branches - 125 kbps with 500m trunk and 6 branches - 500 kbps with < 39m of accumulated branching - 250 kbps with < 78m of accumulated branching - 125 kbps with < 156m of accumulated branching 	<ul style="list-style-type: none"> - 12 Mbps with 100m trunk or 400m trunk using 3 repeaters - 1.5 Mbps with 200m trunk or 800m trunk using 3 repeaters - 500 kbps with 400m trunk or 1200m using 3 repeaters - 187.5 kbps with 600m trunk or 2400m using 3 repeaters - 93.75, 19.2 or 9.6 kbps with 1200m trunk or up to 4800m using 3 repeaters

What Have You Learned ?

This chapter highlighted some of the major characteristics of the industrial networks supported by the VersaMax family. A communications overview was also included for each network. It can not be overstressed that to properly select and implement an industrial network, a clear understanding of the control system and its requirements is essential. An industrial network is an important portion of a control system but it should not limit nor determine the control system operation. It is best to begin by determining the requirements of the control system and working toward the selection of the best network to meet those requirements.

Chapter 7

How to Estimate Network Scan Time

In this chapter:

- ▲ Network scan time versus response time
- ▲ Network scan time jitter
- ▲ Genius bus scan time
- ▲ DeviceNet network scan time
- ▲ Profibus-DP network scan time

Network Scan Time versus Response Time

Network scan time is the interval between successive communications with an individual network device.

Response time is the interval between an input change and the first system output change due to the input change.


The terms network scan time and response time are related but they should not be used interchangeably. Network scan time is relevant only to systems that incorporate network connectivity. Response time is an important parameter to virtually all control systems whether it incorporates an industrial network or not.

Industrial networks allow several devices to share one network media. Since only one device can transmit information on the media at a time, each device must wait until it may transmit. The term network scan time, also called bus scan time, refers to the time interval between successive I/O data transmissions to or from a single device. Since network communication is generally cyclical, network scan time includes a device's transmit, receive, and idle time. For master/slave communication utilizing polling, the network scan time is the interval of time between an individual slave's successive polls. Within token passing networks, the network scan time refers to the time required for all network devices to be granted the token once.

Response time describes the interval of time between an input change and the system-generated response due to that input change. For example, the response time of a system is the time between a button press and the start of the operation controlled by that button. Ideally,

the system response time is short enough that it is not noticeable to the operators or the equipment.

Control systems that do not include a network generally have faster response times. In these systems the response time is generally a function of the controller's processing speed and the amount of information that must be processed.

 **Network communication adds delays to the system response time.**

Systems which include an industrial network have added transmission delays. Information is not transmitted across a network instantaneously. The transmission time across the network is added to the response time of the controller. If the output action needs to be transmitted across the network as well, this delay also adds to the system response time. For a system incorporating an industrial network, its typical response time includes a minimum of at least one network scan interval and usually requires two or more network scans.

Network Scan Time Jitter

Network scan times are dependent on several factors including:


- the number of network nodes used,
- the types of network nodes and amount of data transmitted per node,
- the network transmission rate
- the communication and messaging structures used

Network scan **jitter** describes the amount of variation between successive network scan intervals.

Network scan jitter describes the amount of time variation between network scan intervals. Network scan jitter most commonly arises due to variable message lengths. As message lengths vary from scan to scan, so does the time required to communicate the messages. Non-periodic messages such as fault and unsolicited status messages also affect network scan times. Since diagnostic and fault message lengths vary and are not necessarily communicated with each scan, the network scan interval varies. For these reasons the following procedures only estimate network scan time and can not be considered as absolute.

When an industrial network is started from a powered-down state, nodes typically must "log on". The "logging on" process lengthens the network scan intervals. The additional time required to allow nodes to 'log on' is not considered in this section as it is typically encountered only during start-up situations.

Genius Bus Scan Time

 The following estimation procedure assumes that neither media nor controller redundancy has been implemented.

The Genius bus scan time is dependent on the number of devices and amount of data traffic on the bus. The bus scan time may vary from 3-400ms, but 20-30ms is typical. It cannot be less than 3ms.

The Genius bus scan time contribution for the NIU depends on its I/O data usage. The table below shows the scan time contribution, at each baud rate, for stations with a total of 16, 32, 64, 128, and 256 bytes, when the NIU receives outputs from *only one bus controller at a time*.

To find the scan time contribution for the NIU, follow the procedure below.

Total Amount of Input and Output Data	Contribution time in ms at each baud rate			
	153.6 Kb std	153.6 Kb ext	76.8 Kb	38.4 Kb
16 bytes	2.09	2.16	3.83	7.16
32 bytes	3.24	3.31	6.12	11.74
64 bytes	5.52	5.60	10.69	20.89
128 bytes	10.10	10.17	19.85	39.20
256 bytes (fully-loaded)	19.25	19.32	38.15	75.80

Procedure for Estimating Bus Scan Time

- Find the total number of input bytes and output bytes. (Each analog channels is 2 bytes. Each eight discrete points are one byte).

number of input bytes = _____

number of output bytes = _____

total bytes = _____

- With this total, calculate a scan time contribution using the formula below that corresponds to the Genius bus baud rate.

Formula for 153.6 Kbaud Standard:

$0.943\text{ms} + (0.0715 \times \text{total bytes}) = \text{_____ ms}$

Formula for 153.6 Kbaud Extended:

$1.015\text{ms} + (0.0715 \times \text{total bytes}) = \text{_____ ms}$

Formula for 76.8 Kbaud:

$1.538\text{ms} + (0.143 \times \text{total bytes}) = \text{_____ ms}$

Formula for 38.4 Kbaud:

$2.583\text{ms} + (0.286 \times \text{total bytes}) = \text{_____ ms}$

Timing Responsiveness

If an output in the station is tied to an input in the same station, the output changes state (or value, in the case of an analog output module) within a few milliseconds of the new output being sent from the bus controller to the NIU. (To guarantee that an output changes state, that state must be present for at least one NIU sweep time or one Genius bus scan time, whichever is greater.

The input which is tied to the output responds as soon as any load-effects have settled out and input filtering is completed. This may occur as soon as the NIU's next I/O scan.

If the host is a PLC, an input must be present for at least one PLC sweep time plus one Genius bus scan time plus one NIU sweep time to guarantee its detection by the PLC. If the input changes state only briefly, and then changes again before the input data is sent on the bus, the interim state may be overwritten in the NIU's internal memory by some new input state or value before it can be sent.

Estimating Network Scan Time

To estimate network scan time:

1. Generate a list of all nodes on the network.
2. For all nodes present, excluding VersaMax I/O Stations and Remote I/O scanners, note the contribution to the network scan time from each node as found in the following table. Contribution times must correspond with the network transmission rate selected. The sum of the individual node contribution times serves as an initial estimation of the network scan time.

Node Type	Contribution to Network Scan Time in ms. at each transmission rate			
	153.6 kbps std.	153.6 kbps ext.	76.8 kbps	38.4 kbps
8-point discrete module, inputs only	0.51	0.59	1.18	2.37
8-point discrete module, outputs/combination	0.58	0.66	1.32	2.65
16-point discrete module, inputs only	0.58	0.66	1.32	2.65
16-point discrete module, outputs/combination	0.73	0.80	1.61	3.23
Relay output module	0.73	0.80	1.61	3.23
32-point discrete module, inputs only	0.73	0.80	1.61	3.23
32-point discrete module, outputs/combination	1.01	1.09	2.18	4.37
Analog I/O, RTD, Thermocouple	1.30	1.37	2.75	5.51
High-speed Counter	2.88	2.96	5.91	11.82
Network Controller	1.09	1.16	2.33	4.66
Hand-held Monitor	0.23	0.30	0.61	1.23
Unused Node	0.025	0.050	0.100	0.200
System Message	1.93	1.93	3.86	7.72

Table outlining network scan time contributions for Genius network devices.

- For each VersaMax I/O station and remote scanning node find the total number of input data bytes and output data bytes. Each analog channel is 2 data bytes. Each group of 8 discrete points is 1 data byte. Using the formula corresponding to the transmission rate of the network, calculate each station's contribution to the network scan time.

For 153.6 kbps standard networks the contribution time equals:

$$0.943 + (0.0715 \times \text{total bytes}) = \text{ms}$$

For 153.6 kbps extended networks the contribution time equals:

$$1.015 + (0.0715 \times \text{total bytes}) = \text{ms}$$

For 76.8 kbps networks the contribution time equals:

$$1.538 + (0.143 \times \text{total bytes}) = \text{ms}$$

For 38.4 kbps networks the contribution time equals:

$$2.583 + (0.286 \times \text{total bytes}) = \text{_____ ms}$$


Add the network scan time contributions calculated for each VersaMax I/O station or remote scanner present to the network scan time estimation found in Step 2.

4. Multiple the number of unused node addresses by the contribution time per unused node as found in the table. Add this value to the estimate found in step 3.
5. A system message may be sent automatically. One system message is allowed per network scan interval. The system message may contain fault or status information. Add the system message contribution time to the total network scan time.

The minimum Genius network scan time is 3ms.

By summing the contributions determined within steps 2, 3, 4 and 5 a 'worst-case' estimation of the Genius network scan time is calculated. The network-controller imposes a minimum network scan time of 3ms. Therefore the network scan time can never be less than 3ms regardless of the number of nodes used.

This calculation is a worst case approximation, which includes I/O reporting and fault message communication only. The estimation does not include additional data that is not sent automatically. Any time required for Datagrams used to configure devices and provide additional diagnostic features is not included. Global data messages transferred between multiple network controllers are also not accounted for in the estimation procedure.

 Additional information can be referenced in "*Genius I/O Systems and Communications*".

The procedure used here is intended to provide an estimation of network scan time. This information should be used for the comparison purposes only. More complete network scan time estimation procedures can be found within *Genius I/O Systems and Communications User's Manual* (GEK-90486F-1 Chapter 9 Timing Considerations) published by GE Fanuc Automation.

Genius Bus Example Calculation

To clarify the procedure used to estimate the Genius Bus network scan time the following example has been included. The example network consists of:

- (1) network controller
- (4) 16-point discrete output/combo modules
- (6) 16-point discrete input modules
- (1) VersaMax station with 4 analog channels and 16 discrete pts
- (1) VersaMax station with 8 analog channels and 32 discrete pts
- (1) VersaMax station with 112 discrete points

The selected transmission rate of the network is 153.6 kbps standard.

Using the procedure outlined the estimated network scan time is:

Step 1. Complete list as above.

Step 2. network controller	$(1 \times 1.09 = 1.09)$	1.09
discrete I/O modules	$(4 \times 0.73 = 2.92)$	2.92
discrete input only modules	$(6 \times 0.58 = 3.48)$	<u>3.48</u>

Step Sum	7.49 ms
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Step 3. VersaMax station 01 (8 bytes analog data, 2 bytes discrete data)

$$0.943 + (0.0715 \times 10) = 1.66 \text{ ms}$$

VersaMax station 02 (16 bytes analog data, 4 bytes discrete data)

$$0.943 + (0.0715 \times 20) = 2.37 \text{ ms}$$

VersaMax station 03 (14 bytes discrete data)

$$0.943 + (0.0715 \times 14) = 1.94 \text{ ms}$$

Step Sum	5.97 ms
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Step 4. Unused nodes: $32 - 1 - 4 - 6 - 3 = 18$

$$18 \times 0.025 = 0.45$$

Step Sum	0.45 ms
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Step 5. System Message: 1.93


Step Sum	1.93 ms
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The estimated network scan time of this system is:

$$7.49 + 5.97 + 0.45 + 1.93 = 15.8 \text{ ms}$$

DeviceNet Network Scan Time

DeviceNet allows several communication structures and messaging styles. For each messaging style implemented, a different method of calculating network scan time is required. When different messaging styles are combined on the same network media, accurate network scan times are difficult to calculate and susceptible to higher degrees of scan time jitter.

 This procedure includes only single master systems with polled I/O. It does not allow for multiple masters, strobe, cyclic or change of state messaging.

To facilitate a less complex calculation method and maintain fair comparison with other network scan time estimations only mono-master systems using polled messaging are considered. DeviceNet's strobe, cyclic and change of state messaging styles are assumed to be disabled. The estimation procedure does however include allowances for nodes which produce or consume more than 8 bytes of I/O data.

A finite amount of time is required for each slave to interpret the poll request from the master. It is difficult to estimate the dormant period due to each slave's latency therefore it is assumed that the maximum utilization of the network media is 70 percent. The reduced utilization rate of the media also accommodates data collisions due to request and response interleaving. The assumed network utilization factor has been included in the calculation procedure and serves to increase the network scan time calculated. It provides a more realistic estimation than would be achieved assuming full utilization of the available bandwidth.

Estimating Network Scan Time

To estimate network scan time:

1. Count the number of nodes, not including the master, that are attached to the network. Use the formula below to calculate the total polling request and response overhead transmitted.

For 500 kbps networks the total polling overhead time is:

$$(\text{number of nodes}) \times 0.263 = \text{_____ ms}$$

For 250 kbps networks the total polling overhead time is:

$$(\text{number of nodes}) \times 0.524 = \text{_____ ms}$$

For 125 kbps networks the total polling overhead time is:

$$(\text{number of nodes}) \times 1.049 = \text{_____ ms}$$

2. In order to calculate the amount of I/O data that is transferred on the network each device should be considered separately and then added together for a total data transmission time. The minimum amount of data

transferred per node is 1 byte, therefore all devices must transmit or receive at least one byte of data. Analog channels each contribute 2 bytes of input or output data. The additional overhead required by nodes which transmit or receive more than 8 bytes is considered in step 3 but the I/O data itself should be included here. Using the formula below which corresponds to the transmission rate used, calculate the time required for data transmission.

For 500 kbps networks the data transmission time is:

$$(\text{number of bytes}) \times 0.0223 = \text{_____ ms}$$

For 250 kbps networks the data transmission time is:

$$(\text{number of bytes}) \times 0.0446 = \text{_____ ms}$$

For 125 kbps networks the data transmission time is:

$$(\text{number of bytes}) \times 0.0893 = \text{_____ ms}$$

3. *If all nodes transmit or receive 8 or less bytes of I/O data step 3 is not required and you may continue directly to step 4.* Since individual DeviceNet message fields are a maximum of 8 bytes long I/O nodes which must transmit or receive more than 8 bytes long need to use more than one message to do so. These additional messages produce an increased amount of overhead that must be included in the network scan time estimation. The fragmentation protocol reduces the data field length to 7 bytes. Dividing the total number of I/O bytes required for the node by 7 gives the number of messages that are required. Once again each device should be calculated individually then add the number of additional messages together before applying the formula below.

$$(\text{amount of I/O data required}) \div 7 = \text{_____ messages}$$

Note: Round this number down to an integer or if it is already an integer subtract one from it to leave the number of *additional* messages needed due to fragmentation.

Using the formula below which corresponds to the transmission rate used, calculate the additional overhead time required due to message fragmentation.

For 500 kbps networks the additional overhead due to fragmentation is:

$$(\text{number of additional messages}) \times 0.153 = \text{_____ ms}$$

For 250 kbps networks the additional overhead due to fragmentation is:

$$(\text{number of additional messages}) \times 0.307 = \text{_____ ms}$$

For 125 kbps networks the additional overhead due to fragmentation is:

$$(\text{number of additional messages}) \times 0.614 = \text{_____ ms}$$

4. To estimate the DeviceNet network scan time add the time intervals calculated in steps 1, 2, and 3. The network scan time calculated is in the units of milliseconds.

DeviceNet Example Calculation

To clarify the previously outlined procedure the following example calculations have been included. The network considered is the same as that used to provide the Genius Bus Example Calculation earlier and consists of:

- (1) network controller
- (4) 16-point discrete input/output nodes
- (6) 16-point discrete input only nodes
- (1) VersaMax station with 4 analog channels and 16 discrete pts
- (1) VersaMax station with 8 analog channels and 32 discrete pts
- (1) VersaMax station with 112 discrete points.

The network has a single master node which polls I/O data from the 13 slave nodes. The transmission rate selected for this example is 250 kbps.

Using the procedure outline previously the network scan time is estimated as follows:

Step 1. There are 13 slave nodes present.

$$13 \times 0.524 = 6.812 \text{ ms}$$

$$\text{Step Total} = 6.812 \text{ ms}$$

Step 2. There is 64 bytes of I/O data

$$64 \times 0.0446 = 2.854$$

$$\text{Step Total} = 2.854 \text{ ms}$$

Step 3. Each of the VersaMax stations require the transmission of more than 8 bytes.

VersaMax station 01: 10 bytes

$$10 \div 7 = 1.43 \Rightarrow 1 \text{ additional message}$$

$$1 \times 0.307 = 0.307 \text{ ms}$$

VersaMax station 02: 20 bytes

$$20 \div 7 = 2.86 \Rightarrow 2 \text{ additional messages}$$

$$2 \times 0.307 = 0.614 \text{ ms}$$

VersaMax station 03: 14 bytes

$$14 \div 7 = 2 \Rightarrow 1 \text{ (round down or subtract one)}$$

$$1 \times 0.307 = 0.307 \text{ ms}$$

$$\text{Step Total} = 1.228 \text{ ms}$$

The estimated network scan time of the system is:

$$6.812 + 2.854 + 1.228 = 10.89 \text{ ms.}$$

Profibus-DP Network Scan Time

Profibus network masters are “active stations” while slaves are referred to as “passive stations”

Profibus-DP is a token passing protocol which passes the token between master stations only. Network masters are granted access to control the network media only when they hold the token. Once a master has access to the media it is free to individually poll its slaves. Profibus-DP slaves are polled sequentially by their master. Network masters are referred to as “active stations” within Profibus documentation since they are eligible to possess the token and control the media. Slaves, also called “passive stations”, are not passed the token and hence require polling.

This network scan time estimation procedure assumes that only one network master (active station) is present on the network and that it occupies the highest station address.

For the purpose of estimating the mono-master network scan time, the scan can be broken into 5 time intervals. The *Token Frame* is the transfer time required for the rotation of the token. The *Gap Request* corresponds to the time interval required to search for additional active stations. In mono-master networks this time will elapse without finding additional active stations. A short *Safety Margin* time is added to each scan time to ensure proper communication is insured. The *Offset* time is used to transmit overhead information and is required for each station that is present on the network. The fifth interval is the time required for *I/O data* transfer.

Estimating Network Scan Time

To estimate the network scan time of a mono-master Profibus-DP network:

1. The Token Frame, Gap Request, and Safety margin time intervals are fixed for each transmission rate regardless of the number of stations or amount of I/O data. The total fixed interval is the sum of these three intervals and has been calculated (shaded column) for each available transmission rate in the following chart. Record the total fixed interval corresponding to the transmission rate used.

	Token Frame (ms)	Gap Request (ms)	Safety Margin (ms)	Total Fixed Interval (ms)
12 Mbps	0.006	0.032	0.003	0.041
1.5 Mbps	0.045	0.256	0.002	0.303
500 kbps	0.137	0.787	0.008	0.932
187.5 kbps	0.37	2.10	0.02	2.49
93.75 kbps	0.73	4.20	0.04	4.97
19.2 kbps	3.56	20.50	0.20	24.26
9.6 kbps	7.12	41.00	0.41	48.53

Table outlining the fixed time interval parameters at corresponding transmission rates. All times stated in milliseconds.

- Count the number of stations present on the network including the active station and passive stations. Using the formula corresponding to the network transmission rate being considered, calculate the Total Offset time interval required to transmit all of the stations' overhead data.

For 12 Mbps networks the Total Offset time is:

$$(\text{number of stations}) \times 0.020 = \underline{\hspace{2cm}} \text{ ms}$$

For 1.5 Mbps networks the Total Offset time is:

$$(\text{number of stations}) \times 0.156 = \underline{\hspace{2cm}} \text{ ms}$$

For 500 kbps networks the Total Offset time is:

$$(\text{number of stations}) \times 0.480 = \underline{\hspace{2cm}} \text{ ms}$$

For 187.5 kbps networks the Total Offset time is:

$$(\text{number of stations}) \times 1.28 = \underline{\hspace{2cm}} \text{ ms}$$

For 93.75 kbps networks the Total Offset time is:

$$(\text{number of stations}) \times 2.56 = \underline{\hspace{2cm}} \text{ ms}$$

For 19.2 kbps networks the Total Offset time is:

$$(\text{number of stations}) \times 12.51 = \underline{\hspace{2cm}} \text{ ms}$$

For 9.6 kbps networks the Total Offset time is:

$$(\text{number of stations}) \times 25.02 = \underline{\hspace{2cm}} \text{ ms}$$

3. Count the total number of input and output data bytes. (Each analog channel is 2 data bytes. Each group of 8 discrete points is 1 data byte.) Using the formula corresponding to the network transmission rate used, calculate the Total I/O Data time contribution to the network scan time.

For 12 Mbps networks the Total I/O Data time is:
(number of data bytes) x 0.000874 = _____ ms

For 1.5 Mbps networks the Total I/O Data time is:
(number of data bytes) x 0.00699 = _____ ms

For 500 kbps networks the Total I/O Data time is:
(number of data bytes) x 0.0215 = _____ ms

For 187.5 kbps networks the Total I/O Data time is:
(number of data bytes) x 0.0573 = _____ ms

For 93.75 kbps networks the Total I/O Data time is:
(number of data bytes) x 0.115 = _____ ms

For 19.2 kbps networks the Total I/O Data time is:
(number of data bytes) x 0.560 = _____ ms

For 9.6 kbps networks the Total I/O Data time is:
(number of data bytes) x 1.119 = _____ ms

4. Sum the three values calculated in steps 1, 2, and 3 to approximate the network scan time of the system. The time unit of the estimation is milliseconds.

Note

Multi-master network scan times can be estimated by performing the calculations independently for each active station and its slaves. Summing the network scan times for each active station will then provide an estimation of the total network scan time required for all stations. Additional time will be required for such functions as active station searches and token acknowledgment but generally these do not greatly affect the estimation. For more information on calculating the network scan time for multiple master networks see the Profibus protocol specification DIN 19 245, Part 1, Section 4.2; Cycle and System Reaction Times.

Profibus Example Calculation

To clarify the procedure used to estimate the Profibus-DP network scan time, the following example has been included. To remain consistent with previous example calculations the network consists of 1 active station and 13 passive stations. The total amount of I/O data 64 bytes. The selected transmission rate of the network is 500 kbps.

Using the procedure outlined the estimated network scan time is:

- | | | | |
|---------|---|------------|----------|
| Step 1. | From the table the Total Fixed interval time required for the 500 kbps transmission rate is 0.932 | Step Total | 0.932 ms |
| Step 2. | There are 14 stations on the network
$14 \times 0.480 = 6.720$ | Step Total | 6.720 ms |
| Step 3. | There is 64 bytes of I/O data
$64 \times 0.0215 = 1.376$ | Step Total | 1.376 ms |

The estimated network scan time is:

$$0.932 + 6.720 + 1.376 = 9.03 \text{ ms}$$

Additional Network Scan Time Comparisons

The following table includes estimated network scan times that have been calculated for a variety of sizes and types of industrial networks. The typical transmission rate that has been selected based on the number of nodes required and length restrictions. The estimations have been made assuming that all networks are controlled by a single master which polls individual devices for data. The node counts within the table do not include the controlling node.

	5 Nodes, 4 bytes of I/O data each, 50 m length	15 Nodes, 16 bytes of I/O data each, 250 m length	30 Nodes, 32 bytes of I/O data each, 1000 m length
Genius	153.6 kbps std 7.89 ms	153.6 kbps std 32.80 ms	153.6 kbps std 98.05 ms
DeviceNet	500 kbps 1.76 ms	250 kbps 27.77 ms	Distance too great for DeviceNet
Profibus-DP	1.5 Mbps 1.38 ms	500 kbps 13.77	187.5 kbps 97.18 ms

Table showing typical network scan times for a variety of network sizes.

What Have You Learned ?

The difference in meaning between the two terms 'network scan time' and 'response time' was highlighted at the onset of the chapter. Network scan time is the time interval between successive data transmissions to or from a particular network element. Response time describes the time interval between an input change and the first system output change due to that input change.

This chapter has also outlined procedures to estimate the network scan time of Genius Bus, DeviceNet, and Profibus-DP. Several examples were also included to clarify these calculations.

Chapter 8

Case Studies

This chapter describes the hardware components required and a simplified general procedure to follow when configuring a VersaMax I/O station. The network configurations include both PLC and PC based controlled networks. The scope of work for the case studies includes configuring and adding a VersaMax I/O station to an existing industrial network. Once VersaMax I/O data has been configured and transmitted on the network, the network controller, PC or PLC, has access to the data. With access to VersaMax data, the controller is able to control the VersaMax I/O as required.

Installing VersaMax I/O on a Profibus-DP Network

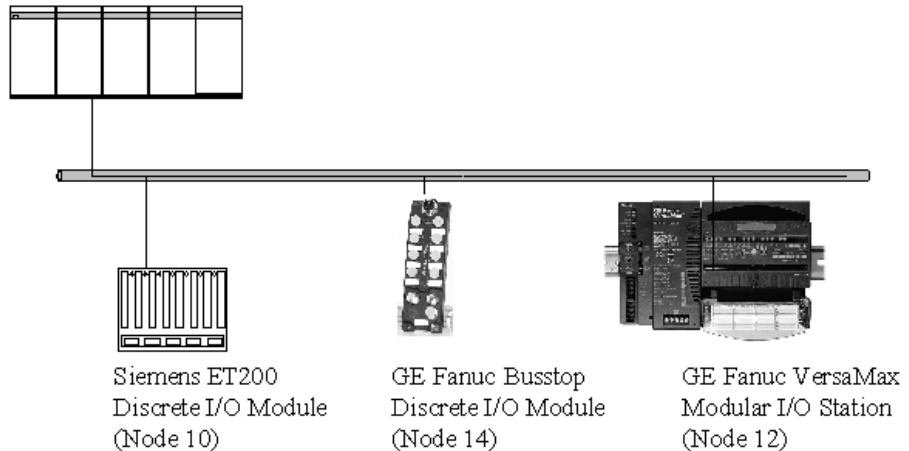
Case Study #1: Siemens S7 PLC Controlled Profibus-DP Network

Introduction

This case study involves incorporating a VersaMax I/O Station in an existing Profibus-DP network. A Siemens S7 315-2 DP PLC controls the Profibus network and its various I/O products. The PLC has built-in functionality to control the network as a Profibus-DP master; therefore, an external or third party network scanner module was not required. Both programming and network configuration was accomplished using Siemens, Step 7 programming software version 4.02.1.

The following diagram illustrates the architecture of the Profibus-DP network

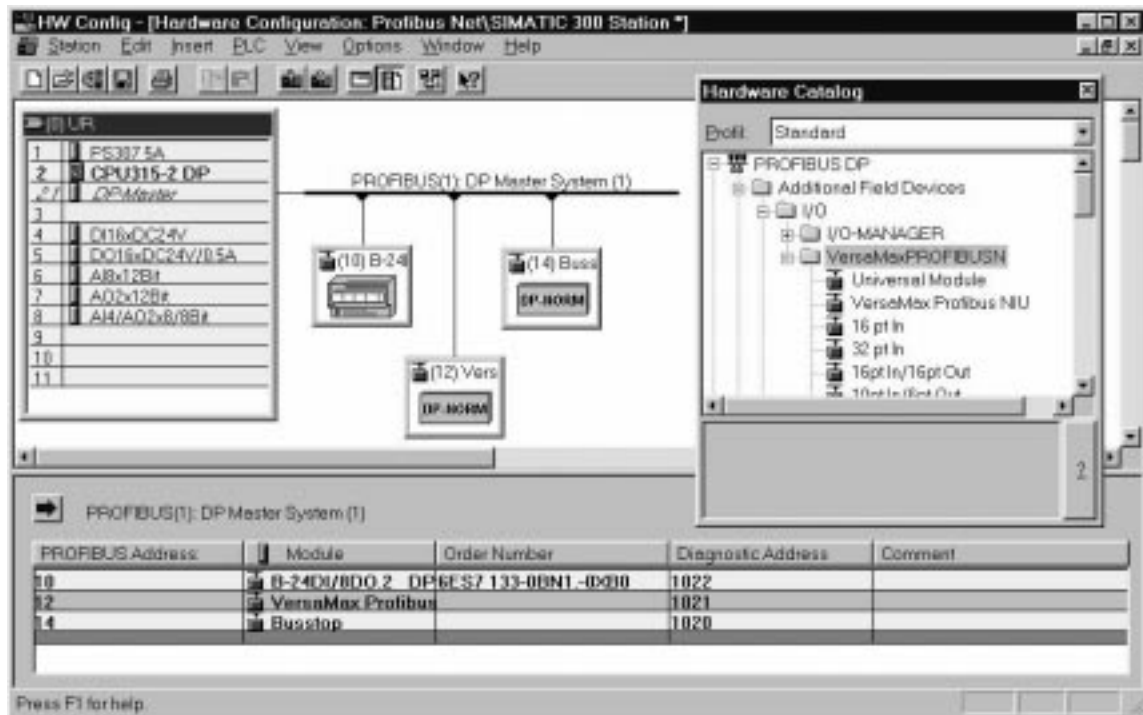
Siemens S7-300 PLC
Profibus DP Master (Node 2)



Integration Procedure

Assuming that a functional network has been installed, wired, and commissioned, the following procedure outlines how to add a VersaMax I/O station to the network. Familiarity with Siemens Step 7 programming software version is also assumed.

1. First, the VersaMax NIU GSD (configuration information) file must be added to the Hardware Catalog Database. Load the S7 programming software. Before opening your project, in the Hardware Configuration Manager, from the Options menu select "Install new DDB File" and direct the installation to the disk area where the required GSD file is stored. This loads the GSD file into the S7 database for later use.
2. Open the existing project, then from within the Hardware configuration manager highlight (select) the Profibus DP master system bar to turn the bar into a solid colored rather than a dashed bar. See figure below.
3. Open the Hardware Catalog by selecting 'Insert' then 'Hardware Component'. Within the Hardware Catalog select 'Profibus DP', followed by 'Additional Field Devices' then 'I/O'. See the following diagram to view the Hardware Catalogue tree structure.



4. Drag the VersaMaxPROFIBUSN folder to the next available line within the Profibus DP Master System table.
5. Use the rotary switches on the top of the VersaMax NIU to set the hardware address of the I/O station. The next step is to inform the S7 master of the node address of the new station. You may also use the 'General' folder tab to give the station a more descriptive name.
6. Within the network line diagram select the new VersaMax station by simply clicking its icon once to reveal an empty station table. Drag and drop the Profibus NIU from the 'Hardware Catalog' window into slot 0 of the table, continue to populate the station with up to 8 additional modules. Both I/O and Diagnostic data addresses are automatically assigned for each module added. The assigned addresses are the exact addresses used within the logic of the PLC program.
7. Download the new configuration to the S7 processor with either the download icon or by selecting 'PLC' followed by 'Download'.
8. Within the controller, logic may be added which uses the newly assigned VersaMax addresses to perform the required functions. Once VersaMax is added to the DP Master's scan list, the control logic is able to control the VersaMax I/O just as it would control local I/O.

Network Bill of Material

QTY	Description	Manufacturer	P/N
1	S7 PLC Processor 315-2 DP	Siemens	6ES7-315-2AF01-0AA0
1	Power Supply 24VDC, 5A	Siemens	6ES7-1EA00-0AA0
2	Signal Module - DI/DO Simulation	Siemens	6ES7-2XH01-0AA0
1	Signal Module – 8 x 12 bit AI	Siemens	6ES7-7KF01-0AB0
1	Signal Module – 2 x 12 bit AO	Siemens	6ES7-5HB01-0AB0
1	Signal Module – 4 x 8 bit AI, 2 x 8 bit AO	Siemens	6ES7-0CE00-0AA0
1	Personal Computer. PII 300 c/w Windows NT Workstation version 4.0 operating system. Required for PLC programming	Various (used Dell)	N/A
1	PC/MPI Programming Cable	Siemens	6ES7-901-2BF00-0AA0
1	Profibus DP Slave I/O Block ET200B - 24VDC, 24I/P, 8O/P	Siemens	6ES7-133-0BN11-0XB0
1	ET200B I/O Screw connector base	Siemens	6ES7-193-0CB10-0XA0
3	Profibus Connector – 9 pin, D-Subminiature	Siemens	6ES7-972-0BB10-0XA0
1	VersaMax Profibus NIU	GE Fanuc	IC200PBI001-AA
1	VersaMax Power Supply	GE Fanuc	IC200PWR102A
4	VersaMax I/O Carrier	GE Fanuc	IC200CHS002A
2	VersaMax Discrete I/O - 24VDC, 16I/P, 16O/P	GE Fanuc	IC200MDD842A
1	VersaMax Analog I/O - Volt/Cur I/P, 4 chan, 16 bit	GE Fanuc	IC200ALG230-AA
1	VersaMax Discrete I/O - 24VDC, 32 point O/P	GE Fanuc	IC200MDL650A
1	Busstop® I/O Block, IP67 Protection - 24VDC, 8I/P, 8O/P	GE Fanuc	IC675PDM881A

QTY	Description	Manufacturer	P/N
1	Profibus eurofast® Cordset	GE Fanuc	IC675PCB005A
1	Busstop Power minifast® Cordset	GE Fanuc	IC675PCB022A
3	Profibus Connector – 9 pin, D-Subminiature	Siemens	6ES7-972-0BB10-0XA0
	Twisted pair network Cabling	Siemens	6XV1 830-0AH10
1	Step 7 Programming Software V4.02.1	Siemens	6ES7 810-4CC03-0YX0
1	GSD Files for all Network nodes	various	

Network Performance

The Profibus Network described above is transmitting 22 bytes of Input / Output data plus an additional 10 bytes of diagnostic / status information between 4 nodes (including the Master). The transmission rate of the network was set to 1.5Mbps.

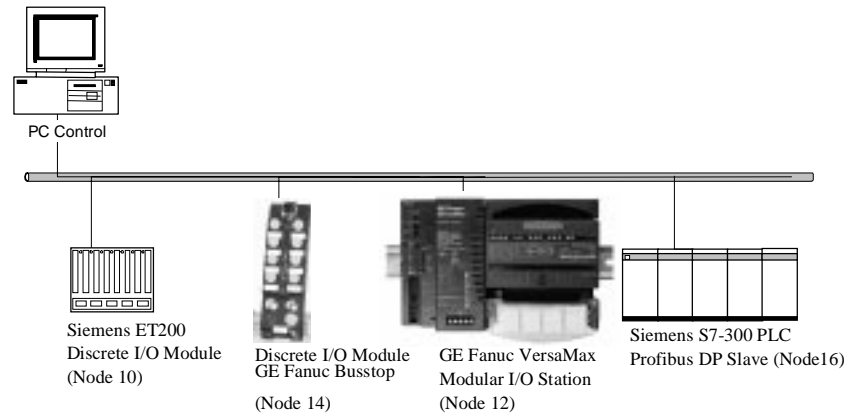
The procedure described previously allows a user to estimate the network scan time of a mono-master Profibus-DP industrial network such as this. The calculation procedure estimates the network scan time as approximately 1.15ms. Using an oscilloscope the network scan time was measured as approximately 1.10ms. The calculated and measured times agree within 5%.

Case #2: GE Fanuc fxControl PC-based Software Controlled Profibus-DP Network

Introduction

This case study incorporates a VersaMax I/O station into an existing Profibus-DP industrial network. The network consists of a computer used as the logic controller of the network. The PC controls the Profibus-DP network via an SST 5136-PFB industrial communication card. The 5136-PFB card occupies one standard ISA slot within the PC. The PC operating system is Microsoft Windows NT Workstation version 4.0. The PC Control software package is the fxControl PC Control software package. The Profibus-DP network configuration was accomplished with COM PROFIBUS V3.3.

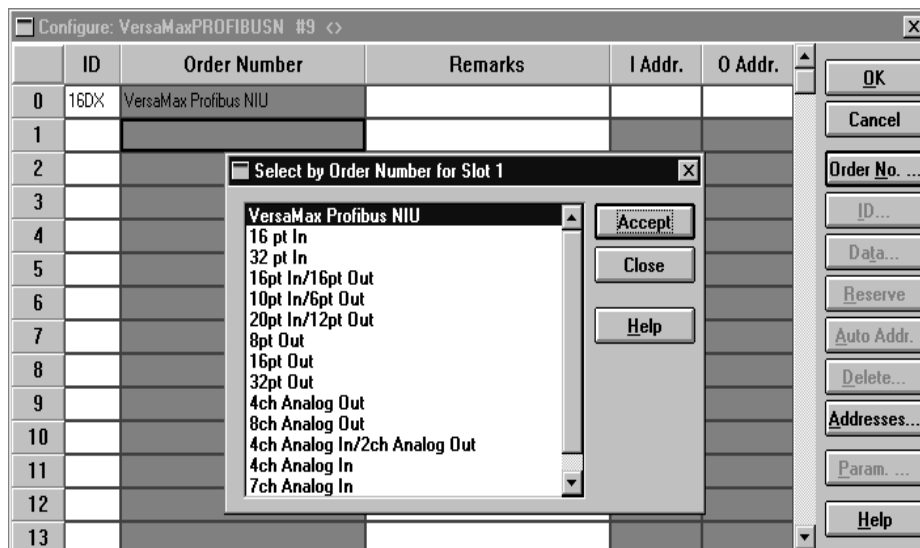
The following diagram illustrates the architecture of the Network



Integration Procedure

The following procedure outlines how to add a VersaMax I/O station to the network. Familiarity with the Com Profibus and the fxControl Development software is assumed.

1. The VersaMax NIU GSD file must first be installed into the Com Profibus software database to configure the VersaMax NIU communication settings.
2. Open the existing COM Profibus project used previously when the network was originally configured.
3. Open the slaves configuration by double clicking the solid colored 'Master' line in the overview of the master systems window. Insert the VersaMax PROFIBUSNIU (from I/O slaves button) and configure the I/O for the VersaMax slave station by selecting the configure button. Populate the I/O station by selecting modules using the 'Order No.' button. Ensure that the first line of the station is the VersaMax Profibus NIU then add up to 8 additional modules as required. See figure below. Save and close the configuration. The Com Profibus file just created will later be used by 'fxControl' as the network configuration file.



4. Use the rotary switches on the top of the NIU to set the hardware address of the I/O station
5. Open the 'fxControl' development project used to create the control system's logic.
6. In the Project tab of the Navigator, right-click on the 'Control I/O Drivers' node and select New Driver. Select the 'Profibus I/O' driver by selecting the Profibus I/O item in the list. Double-click on the card to bring up the Card Setup dialog. Input the NCM database file name (just created by COM Profibus) in the database edit box, or launch the Com Profibus to export an NCM database file. Importing the new NCM file, which now includes the VersaMax configuration information gives 'fxControl' complete access to all of the I/O and Diagnostic data available from the VersaMax station.
7. Run your control project by right-clicking on the Target and selecting 'Run'. Starting the controller activates the Profibus Master scan cycle to read and write data to the Profibus slaves including VersaMax slave.

Network Bill of Material

QTY	Description	Manufacturer	P/N
1	Personal Computer. PII 300 c/w Windows NT Workstation version 4.0 operating system	Various (used Dell)	N / A
1	fxControl Development software	GE Fanuc	PC752FDEPRO
1	fxControl Runtime software	GE Fanuc	PC752FRBPRO
1	Profibus Industrial Communication Interface Card	SST	5136-PFB
1	Com Profibus Version 3.3	Siemens	N / A
1	S7 PLC Processor 315-2 DP	Siemens	6ES7-315-2AF01-0AA0
1	Power Supply 24VDC, 5A	Siemens	6ES7-1EA00-0AA0
2	Signal Module - DI/DO Simulation	Siemens	6ES7-2XH01-0AA0
1	Signal Module – 8 x 12 bit AI	Siemens	6ES7-7KF01-0AB0
1	Signal Module – 2 x 12 bit AO	Siemens	6ES7-5HB01-0AB0
1	Signal Module – 4 x 8 bit AI, 2 x 8 bit AO	Siemens	6ES7-0CE00-0AA0
1	PC/MPI Programming Cable	Siemens	6ES7-901-2BF00-0AA0
1	Profibus DP Slave I/O Block ET200B - 24VDC, 24I/P, 8O/P	Siemens	6ES7-133-0BN11-0XB0
1	ET200B I/O Screw connector base	Siemens	6ES7-193-0CB10-0XA0
3	Profibus Connector – 9 pin, D-Subminiature	Siemens	6ES7-972-0BB10-0XA0
1	VersaMax Profibus NIU	GE Fanuc	IC200PBI001-AA
1	VersaMax Power Supply	GE Fanuc	IC200PWR102A
4	VersaMax I/O Carrier	GE Fanuc	IC200CHS002A

QTY	Description	Manufacturer	P/N
2	VersaMax Discrete I/O - 24VDC, 16I/P, 16O/P	GE Fanuc	IC200MDD842A
1	VersaMax Analog I/O - Volt/Cur I/P, 4 chan, 16 bit	GE Fanuc	IC200ALG230-AA
1	VersaMax Discrete I/O - 24VDC, 32 point O/P	GE Fanuc	IC200MDL650A
1	Busstop® I/O Block, IP67 Protection - 24VDC, 8I/P, 8O/P	GE Fanuc	IC675PDM881A
1	Profibus eurofast® Cordset	GE Fanuc	IC675PCB005A
1	Busstop Power minifast® Cordset	GE Fanuc	IC675PCB022A
	Twisted pair network Cabling	Siemens	6XV1 830-0AH10
1	Step 7 Programming Software V4.02.1	Siemens	6ES7 810-4CC03-0YX0
1	GSD Files for all Network nodes	various	

Network Performance

The Profibus network described above is transmitting 18 bytes of Input / Output data and diagnostic / status information between 5 nodes (including the master station). The transmission rate of the network was set to 1.5Mbps.

The procedure described previously allows a user to estimate the network scan time of a mono-master Profibus-DP industrial network. The calculation procedure estimates the network scan time as approximately 1.21ms. The network scan time was measured as approximately 1.26ms. The estimated and measured times agree within 4 %.

Installing VersaMax in a Genius Network

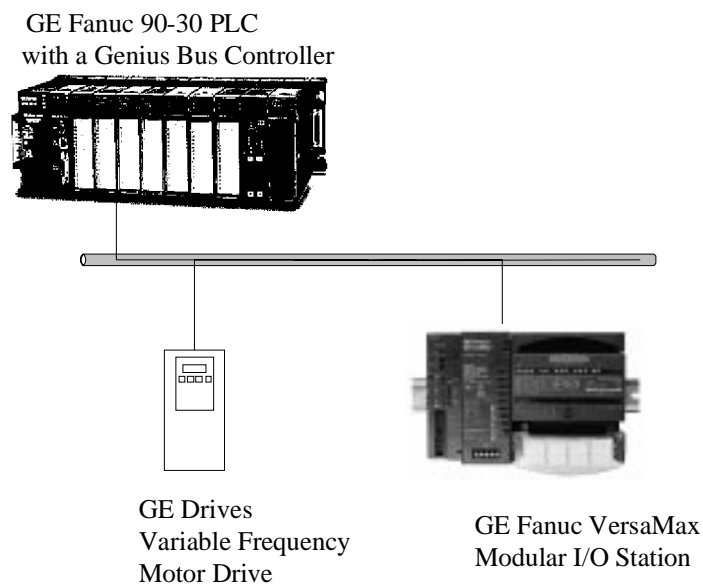
Case Study #3: Series 90-30 PLC controlled Genius Network

Introduction

This case study provides a guideline procedure to configure an industrial network controlled by a Series 90-30 Genius Bus Controller (GBC). The network consisted of a GE Fanuc 90-30 PLC with a Genius Bus Controller module, VersaMax I/O station and a GE AF-300E motor drive.

The network was configured and programmed using the GE Fanuc Logicmaster™ 90-30 programming software, version 9.01.

The following diagram illustrates the network architecture used for this case study.



Integration Procedure

The successful transfer of data on a Genius controlled network requires that all devices on the network (such as the GE AF-300E, VersaMax I/O station and GBC):

- have a unique Serial Bus Address (SBA) that distinguishes it from any other device on the network
- transmit data at the same speed (baud rate)
- have PLC CPU memory allocated to store the I/O data that is received and/or transmitted onto the network.

Individual network components need to be configured to set their baud rate and assign a unique SBA. In the case of the VersaMax NIU all of the required settings are performed with the rotary switches on the top of the unit.

Configuring the GBC using Logicmaster Software

From with the Logicmaster main menu:

1. Select the “Logicmaster 90 Configuration Package”
2. Select the “I/O Configuration” option. This will bring up a screen that displays the PLC backplane with its individual slots.
3. Using the left and right arrow keys, move the highlight to the slot where the Genius Bus Controller is physically to be installed. Select the “Genius” option using the appropriate function key.
4. Select the “GBC” option and the specific catalog number of the GBC you are using. This will then bring up a screen that allows the GBC to be configured. This screen has two separate sections:
 - Bus Controller Module Data – used to configure the GBC parameters,
 - Device Data – used to configure parameters of the devices that are connected to the GBC (over the Genius Bus Network)

Bus Controller Module Data

- i) Set the “Module SBA”. Valid range is 0 to 31. This is the network address of the GBC and typically this is set to 31.
- ii) Set the network “Baud Rate”. All devices on the network must be set to the same transmission rate.
- iii) The “Input Def” parameter determines the events following lost communication. If set to ‘on’, the data last sent by the device will

remain valid in the PLC CPU until communication can be regained. If set to 'off', the data held in the PLC CPU for that device will be reset to zero until communication can be re-established.

- iv) Specify the "S6 Ref" if necessary. This parameter sets the register location in a Series Six or Series Five CPU reserved for the global data transmitted to it by the GBC. A value of zero indicates that no register location is reserved.
- v) Set the memory location of the GBC "Status". The status parameter is used to reserve a 32-bit memory location into which the GBC writes its status. It indicates a memory address that can be used to store a 32-bit number that gives information about the GBC and each device on the network.
- vi) Set the "Out at Start" field to enabled or disabled. Enabling this field allows the device's outputs to be enabled or disabled when the GBC is powered up.

Device Data

The following parameters must be configured for each node attached to the Genius Bus. In general terms, the parameters describe the nodes SBA, the transmission rate to use and the amount of data transferred to and from each node.

- i) Enter the "Device SBA". Valid range is 0 to 31. Each device must have a unique SBA that matches the SBA physically selected on the device.
- ii) Select the "Device Type". This will vary from device to device. In the case of the VersaMax I/O station, this is set to "Generic". Check each device user's manual to determine this setting.
- iii) Specify the "Input 1 Ref" and "Input 2 Ref" starting addresses. These settings specify the starting PLC CPU memory addresses where data from the device will be stored. Once stored, the PLC program has full access to this data. The data from each slave will include both Input Data as well as station diagnostic data
- iv) Specify the "Input Len 1" and "Input Len 2" These values are used in conjunction with "Input Ref 1" and "Input Ref 2", respectively, to indicate the amount of memory needed to store data from the device. If set to zero, then no data is stored; if for example it is set to 4, then four memory locations are used beginning at the specified reference address. If the specified starting address relates to memory location that uses a 16-bit word format to store data, then the specified length refers to the length in words (i.e.: %AI and %AQ memory addresses). If the starting memory location uses a bit format to store data, then this length is in bits (i.e.: %I

and %Q memory addresses). The value of “Input Len 1” added to the value of “Input Len 2” must equal the amount of data supplied by each device.

- v) Specify the “Output1 Ref” and “Output2 Ref” starting addresses. These PLC CPU addresses specify the starting memory addresses of the output information for the device.
- vi) Specify the “Output1 Len” and “Output2 Len” These length settings serve similar purposes as the “Input1 Len” and “Input2 Len” settings. These lengths are applied to the “Output1 Ref” and “Output2 Ref” parameters. Again it should be noted that the value of “Output Len 1” added to the value of “Output Len 2” must equal the amount of data that is output to the device from the PLC.

Network Bill of Material

QTY	Description	Manufacturer	P/N
1	VersaMax Genius NIU	GE Fanuc	IC200GBI001-AA
1	VersaMax Power Supply	GE Fanuc	IC200PWR102A
2	VersaMax Discrete I/O - 24VDC, 16I/P, 16O/P	GE Fanuc	IC200MDD842A
1	VersaMax Analog I/O - Volt/Cur I/P, 4 chan, 16 bit	GE Fanuc	IC200ALG230-AA
1	VersaMax Discrete I/O - 24VDC, 32 point O/P	GE Fanuc	IC200MDL650A
1	Motor Driver	GE Drive	AF-300E
1	Genius Communications option card for GE Drives AF-300E\$	Horner	HE300GEN100
1	Series 90-30 CPU Model 351	GE Fanuc	IC693CPU351
1	10 Slot Backplane	GE Fanuc	IC693CHS391
1	Series 90-30 Programmable Controller Power Supply	GE Fanuc	IC693PWR321
1	Series 90-3- Genius Bus Controller	GE Fanuc	IC693BEM331
1	Discrete Output Module	GE Fanuc	IC693MDL740
1	Discrete Input Module	GE Fanuc	IC693MDL231
2	Discrete Output Module	GE Fanuc	IC693MDL742
1	Logicmaster Programming Software	GE Fanuc	IC641SWP316E

QTY	Description	Manufacturer	P/N
	Twisted Pair Network Cable	Beldon	9463
2	Terminating Resistor (75 ohm)	various	N / A

Network Performance

The case study network included: one Genius Bus Controller, one VersaMax I/O station with 4 analog channels and 96 discrete points, and one GE Drive AF300E\$ AC Motor drive with 12 bytes of input and 12 bytes of output data. The selected transmission rate of the network was 153.6 kbps standard.

Using the procedure outlined previously in this guide, the estimated network scan time was calculated as 8.7ms. During testing the actual network scan time measured was 6.1ms. The difference between the estimated and measured network scan times is 2.6ms. The difference can largely be explained by the system message. The system message, when transmitted, requires approximately 1.9ms. The estimation procedure includes a 1.93 ms allowance for a system message even though a system message is not necessarily transmitted during each bus scan. The procedure is intended to calculate an estimate of “the worst case” or longest bus scan time. The average scan time as measured should be less than the value calculated using the previous procedure.

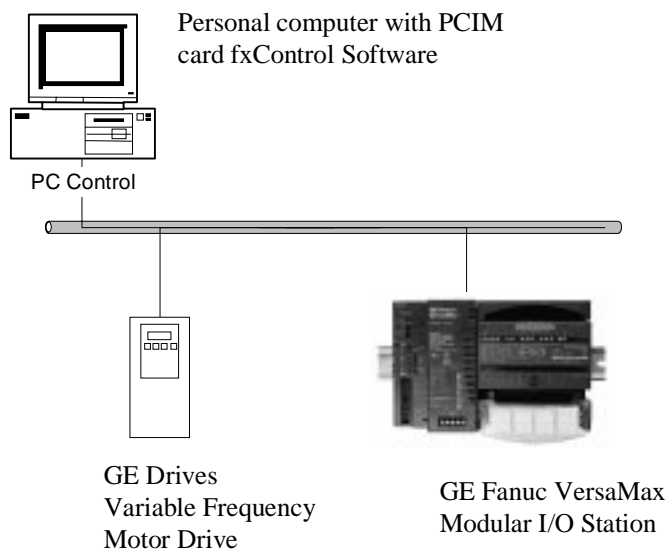
Since the system message is used to initialize and configure devices it was not transmitted when the average scan time was measured. Removing it from the calculation yields an estimated “worst case” bus scan time of 6.8ms. 6.8ms is approximately 10% greater than the measured time of 6.1ms.

Case Study #4: GE Fanuc fxControl PC-based Software Controlled Genius Network

Introduction

This case study incorporates a VersaMax I/O station into a Genius Industrial network that is controlled by a personal computer (PC) running fxControl PC Control software package within a Microsoft Windows NT Workstation environment. The PC controls the Genius network using a GE PC Interface Module (PCIM). The GE PCIM card occupies one full-length ISA slot within the PC.

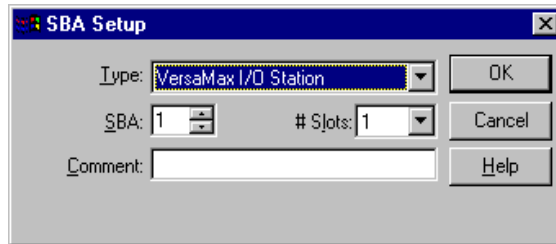
An example network consisting of a PC, VersaMax I/O station and a GE AF-300E motor drive is used to illustrate the configuration procedure required. The following diagram illustrates the simple network architecture that was used.



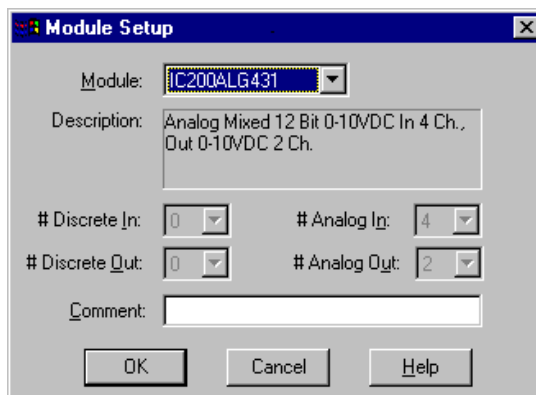
Integration Procedure

The following details describe the procedure required to install a VersaMax I/O station into an existing Genius network. It is assumed that the reader is familiar with Genius networks and the fxControl Software package.

1. Using the 3 selector dials on the Genius NIU, select the communication baud rate and Serial Bus Address (SBA) of the VersaMax node. The baud rate must match the existing rate and the SBA can not be the same as any other node on the existing network.
2. Make the necessary electrical connections to the Serial 1, Serial 2, Shield In, and Shield Out connections on the Genius NIU.
3. Open the 'fxControl' development project used to create the control system's logic.
4. In the Project tab of the Navigator, right-click on the 'Control I/O Drivers' node and select New Driver. Select the 'GE Fanuc Genius I/O' driver.
5. Right-click on the Genius card and select 'Add SBA'. This will produce a window similar to the following:



6. Enter the SBA that was chosen for the new VersaMax I/O node.
7. Once the SBA has been selected, the VersaMax I/O Station node will appear in the Configure I/O Table as shown in Step 3. Select the Slot that appears below the VersaMax I/O Station entry. This will produce a window similar to the following:



8. When you select the module type, the number of inputs and outputs will be filled in for you. This information must be the same as all the inputs and outputs that exist in the VersaMax I/O station. To take advantage of the diagnostic information available from VersaMax this information should be added to the amount of I/O data associated with the node.
9. Save the configuration and Run your project. -With the new configuration the fxControl software engine can now be run with full access to the new addresses declared for the VersaMax node.

Network Bill of Materials

QTY	Description	Manufacturer	P/N
1	Personal Computer. PII 300 c/w Windows NT Workstation version 4.0 operating system	Various (used Dell)	N / A
1	fxControl Development software	GE Fanuc	PC752FDEPRO
1	fxControl Runtime software	GE Fanuc	PC752FRBPRO
1	PC Interface Module (PCIM)	GE Fanuc	IC660ELB922
1	VersaMax Genius NIU	GE Fanuc	IC200GBI001- AA
1	VersaMax Power Supply	GE Fanuc	IC200PWR102A
2	VersaMax Discrete I/O - 24VDC, 16I/P, 16O/P	GE Fanuc	IC200MDD842A
1	VersaMax Analog I/O - Volt/Cur I/P, 4 chan, 16 bit	GE Fanuc	IC200ALG230- AA
1	VersaMax Discrete I/O -	GE Fanuc	IC200MDL650A

QTY	Description	Manufacturer	P/N
	24VDC, 32 point O/P		
1	Variable Frequency Motor Driver	GE Drive	AF-300E
1	Genius Communications option card for GE Drives AF-300ES	Horner	HE300GEN100
	Twisted Pair Network Cable	Beldon	9463
2	Terminating Resistor (75 ohm)	Various	N / A

Network Performance

The Genius network described above had 3 active nodes, one controller and the following I/O nodes:

- 1) GE AF300E drive - six 16 bit inputs and six 16 bit outputs
- 2) VersaMax Node - 32 discrete outputs, 64 discrete inputs and four analog inputs each of which were broken down into 16-bit words.

Using the methods described earlier, the total network scan time was calculated to be 8.78 milliseconds. The actual, measured scan time was found to be 6.02 milliseconds. The calculated scan time includes 1.93 milliseconds for a system message, however, the system message is not necessarily transmitted within each scan. The calculated value is designed to provide a worst case estimate of network scan time. Removing the system message from the calculation produces a scan time estimate of 6.85 milliseconds, which represents an approximation error of 13%.

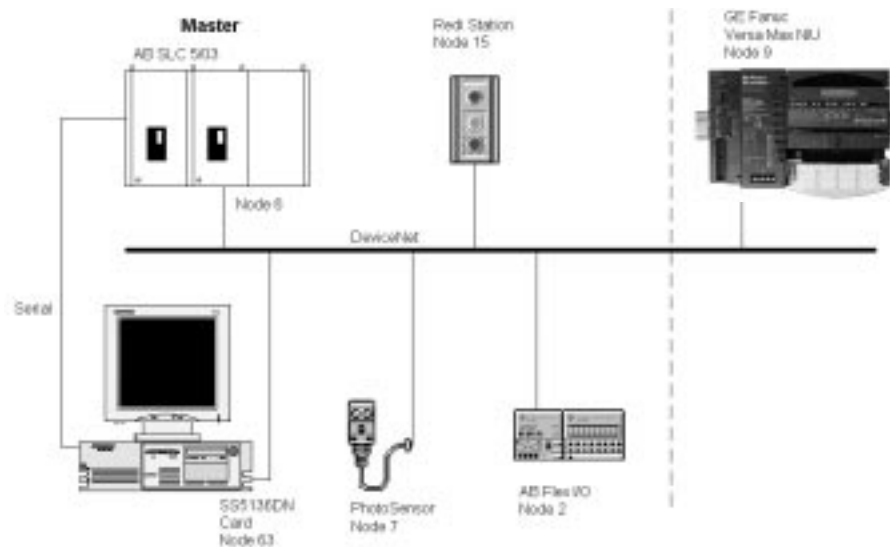
Installing VersaMax in a DeviceNet Network

Case Study #5: Allen-Bradley SLC5 Controlled DeviceNet Network

This section provides a guideline procedure to configure a VersaMax I/O Station in a DeviceNet industrial network. Furthermore, the existing DeviceNet network consists of an Allen Bradley SLC5/03 processor with a DeviceNet scanner module acting as the network master with various other devices as slave nodes.

The scanner module was configured using the DeviceNet Manager software from Rockwell Software (this software is required to develop the 'scan list'). The SLC processor was programmed using RSLogix 500 software version 2.57.00. It is assumed the reader is familiar with these two software packages.

Architecture Diagram

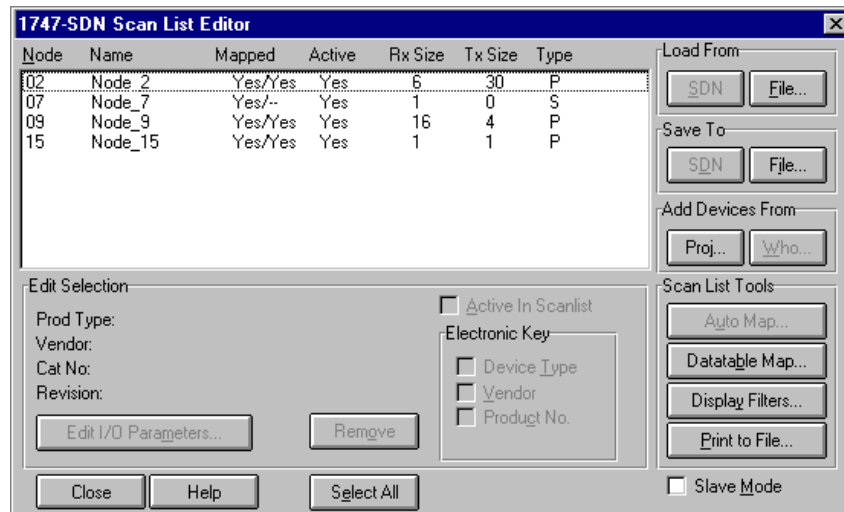


Integration Procedure

The following describes the steps taken to add a VersaMax I/O station to the network.

1. Use the switches on the VersaMax NIU to set the node address and communication rate. Connect the NIU to the network.
2. Within DeviceNet Manager open the existing network project. This file contains the card connection parameters previously used to configure the Scanner module via the SST 5136DN communications card.
3. Under 'Utilities' select 'Install EDS Files', point to the EDS file that has been supplied with the VersaMax NIU. This installs the EDS file into the DeviceNet Manager Database to provide information about the VersaMax NIU to DeviceNet Manager for connection.

4. Under 'Utilities' again, choose 'Start Online Build'. This process will take a moment as the scanner card is polling each node address to test if a device is present. If devices are present the scanner then collects its connection parameters and builds a possible scan list accordingly. The VersaMax node will also be tested and built into the available scan list.
5. Once the available scan list has been built DeviceNet Manager will prompt you to upload the scanner's scan list, choose 'yes'. You will now have a list of all active network devices.
6. To verify the configurations, in the network diagram right click on the bitmap for the VersaMax NIU and choose Edit EDS stub. Verify that the polled connection is enabled and that the correct data exchange is shown.
7. In the network diagram again double click on the 1747 Scanner module to bring up it's configuration. Next click on Edit Scan List. You should now see a list of devices that are to be scanned by the 1747SDN. Choose 'Proj' from within the 'Add Devices from' section of the pop-up window, another network diagram will pop up, drag and drop the VersaMax NIU onto the Scanner's Scan list, and choose Okay. This will result in a table similar to the following.



2. Step 6 included the VersaMax I/O station in the scan list of the 1747SDN. The scanner is now capable of sending and receiving information to and from the station. This step describes the addressing of the information between the scanner module and the SLC processor. You can map the information simply by clicking on the AutoMap button under Scan List Tools shown in the above diagram. To view the addresses selected choose 'Datatable Map'. The Datatable Map shows the arrangement of the information to be used within the logic programming of the SLC.
3. Last, you must choose 'Save to SDN'. This step saves the scanner's scan list and data table mapping to the non-volatile memory of the scanner. The SLC5/03 must be in program mode to save to the scanner module. The connection to the Scanner module is made via a DeviceNet interface card between your programming PC and the DeviceNet network scanner. The configuration of this connection is not described here as this procedure outlines how to add a module to an existing configuration.
4. You should now see the 1747SDN flashing on its LCD panel between the number of its node address and the number 80, meaning the scanner is in IDLE mode. To begin scanning the network, change the SLC processor to run mode. The VersaMax I/O and Diagnostic information is accessible to the SLC program via the scanner module and the DataTable Map settings selected.

Network Bill of Material

QTY	Description	Manufacturer	P/N
1	Programmable Logic Controller SLC 5/03	Allen-Bradley	1747-L532
1	1747 DeviceNet Scanner Module	Allen-Bradley	1747-SDN
1	SLC 4-slot Chassis	Allen-Bradley	1746-A4
1	SLC Power Supply	Allen-Bradley	1746-P1
1	Photo-Sensor with DeviceNet connectivity	Allen-Bradley	42GNU-9000-QD
1	Redi Station	Allen-Bradley	2705-T3DN1A42A
1	Flex I/O DeviceNet Communications Module	Allen-Bradley	1794-ADN
5	Flex I/O Terminal Base	Allen-Bradley	1794-TB3
2	Flex I/O Discrete I/P module	Allen-Bradley	1794-IB16

QTY	Description	Manufacturer	P/N
1	Flex I/O Discrete O/P module	Allen-Bradley	1794-OB16
2	Flex I/O Analog O/P Module	Allen-Bradley	1794-OE4
1	VersaMax DeviceNet NIU	GE Fanuc	IC200DBI001-AA
1	VersaMax Power Supply	GE Fanuc	IC200PWR102A
3	VersaMax I/O Carrier	GE Fanuc	IC200CHS002A
2	VersaMax Discrete I/O - 24VDC, 16I/P, 16O/P	GE Fanuc	IC200MDD842A
1	VersaMax Analog I/O - Volt/Cur I/P, 4 chan, 16 bit	GE Fanuc	IC200ALG230-AA
1	24 Volt Power Supply	Various	N/A
1	RS Logix 500 Version 2.57.00	Rockwell Software	9324-RL0300ENE
1	RS DeviceNet Manager	Rockwell Software	1787-MGR
1	DeviceNet Industrial Communications card	SST	5136DN
1	EDS file for GE Fanuc VersaMax NIU	GE Fanuc	N / A
6	DeviceNet trunk T-Port Tap	Allen-Bradley	1485-P1N5-MN51
4	DeviceNet Open style stub	Allen-Bradley	1485-PM5-C
2	DeviceNet 5-pin drop line	Allen-Bradley	1485-PN5-M5
2	DeviceNet trunk Terminator	Allen-Bradley	1485A-T15

Network Performance

The average network scan time was measured to be 18.0 milliseconds with 59 bytes of data being passed through the DeviceNet network per scan. Using the previously described method, the theoretical average scan time calculated for this network should be approximately 13.0 ms. The calculation procedure requires that all data be passed using a polling connection. Node 7 of this network, the photo eye, does not support polled I/O data transfer therefore its data is passed through a strobe connection. Since a second connection type is required for this network the measured scan time will exceed the calculated value. As can be seen adding a second connection method increases the average scan time of the network significantly. It should also be noted that the DeviceNet scan time calculation can not take into account any idle time that the scanner may produce as this varies between scanners and even model versions of scanners. Idle scanner time can be significant and adds to the overall scan time of the network.

Electronic Data Sheet File

The EDS shown below is that of the VersaMax NIU. It has been included to demonstrate the EDS file format.

```
$ IC200DBI001 DeviceNet Network Interface Unit
Electronic Data Sheet
```

\$ File Description Section

[File]

```
DescText      = "IC200DBI001 EDS File";
CreateDate    = "05-05-1999";
CreateTime    = "10:25:00";
$ModDate      = "00-00-00";
$ModTime      = "00:00:00";
Revision      = "1.0";
```

\$ Device Description Section

[Device]

```
VendCode      = 326;
VendName      = "GE Fanuc Automation";
ProdType      = 12;
ProdTypeStr    = "Communications Adapter";
ProdCode      = 1;
MajRev        = 1;
MinRev        = 100;
ProdName      = "DeviceNet NIU";
Catalog       = "IC200DBI001";
```

[IO_Info]

```
Default = 0x0001;
                                $ Bit mapped (0=None)
                                $ Bit 0 = Poll (Default)
                                $ Bit 2 = Change-of-State

PollInfo=
0x0001,      $ Not OK to Combine w/COS
1,           $ Default Input = Input1
1;           $ Default Output = Output1

COSInfo=
0x0004,      $ Not OK to Combine w/Poll
1,           $ Default Input = Input1
1;           $ Default Output = Output1
```

\$ -- Input Connections --

```

        Input1=
            130,                $ 130 bytes maximum
            0,                  $ all bits are
significant
            0x0005,            $ Poll or COS Connection
            "Status + Data",    $ Name String
            6,                  $ Path Size
            "20 04 24 01 30 03", $ Assy Obj Inst 01
Attr 3
            "DNIU Status and Data"; $ Help String

$ -- Output Connections --

        Output1=
            130,                $ 130 bytes maximum
            0,                  $ all bits are
significant
            0x0005,            $ Poll or COS Connection
            "Control + Data",   $ Name String
            6,                  $ Path Size
            "20 04 24 01 30 03", $ Assy Obj Inst 01
Attr 3
            "DNIU Control and Data"; $ Help String

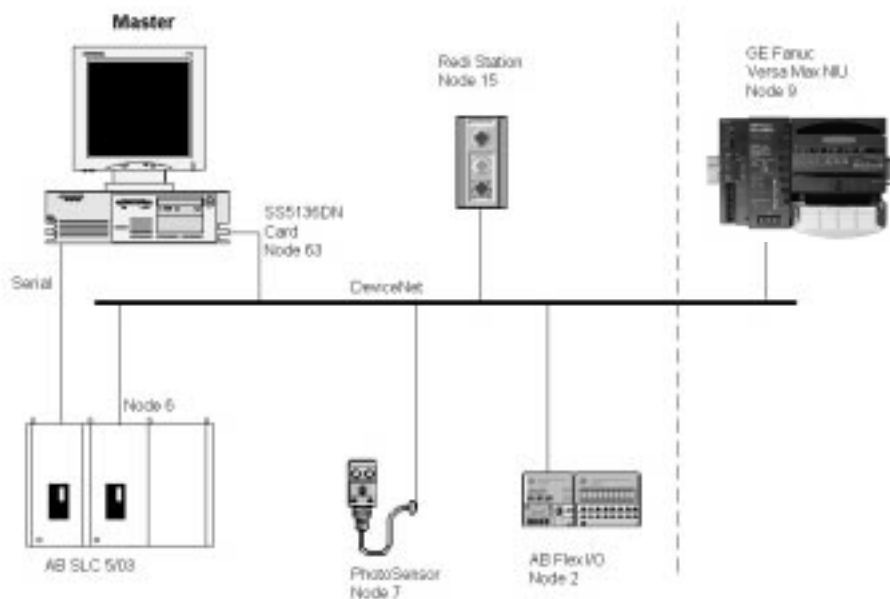
```


Case Study #6: GE Fanuc fxControl PC Controlled DeviceNet Network

This section provides a guideline procedure to configure a VersaMax I/O Station into an existing DeviceNet industrial network. The example network consists of a Personal Computer used as the controller of the network. The PC is using the fxControl PC Control software package operating within the Microsoft Windows NT Workstation environment. The PC gains access to the DeviceNet network via an SST 5136DN industrial communications card. The 5136DN card occupies one ISA slot within the PC. The remaining devices on the network include a photo-sensor, a push-button station and two I/O stations, one of which is to be a VersaMax station.

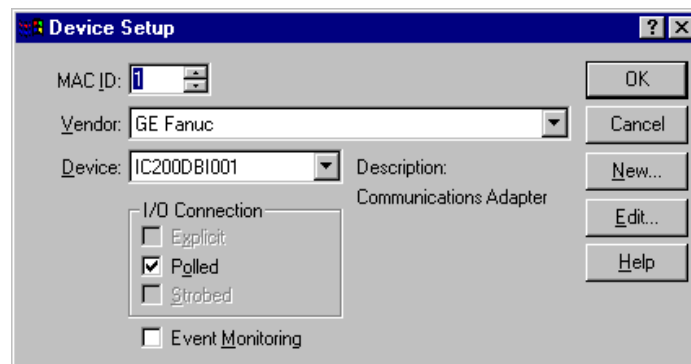
The network was configured using the 'fxControl' development package. DeviceNet Manager software by Rockwell Software was used to configure the 1747-SN node, and the SLC was programmed by means of RS Logix 500 software. It is assumed the reader is familiar with these software packages.

Architecture Diagram



Integration Procedure

1. Set the desired node address of the NIU and communication speed with the switches provided. Connect the NIU to the DeviceNet network media.
2. Determine the amount of input and output data from the modules attached to the NIU. In this study there was 2 bytes input and 2 bytes of output plus 2 additional bytes configuration and diagnostic information that is transmitted both to and from the NIU.
3. Open the 'fxControl' development project used to create the control system's logic.
4. In the Project tab of the Navigator, right-click on the 'Control I/O Drivers' node and select New Driver. Select the 'DeviceNet I/O' driver.
5. In the Project tab of the Navigator, right-click on the 'DeviceNet I/O' driver and select 'Open'.
6. Right-click on the card and select 'Add Device'.



7. From the 'Device Setup' dialog, select GE Fanuc from the Vendor drop-down list.
8. Select your device from the Device drop-down list.
9. Select 'Edit...' to configure this new device.

Edit Device

Vendor: GE Fanuc Automation ID: 326

Device: DeviceNet NIU

Description: Communications Adapter IC200DBI001

Device Type: 12 Code: 1 Check: 0

Terminal Information

Inputs: 2

Outputs: 1

Size: Word

Connection Sizes (Bytes)

	Produced	Consumed
Polled:	4	2
Bit Strobed:	0	0
Explicit Msg:	0	0

OK Cancel Help

10. Insert (or edit) the amount of data transfer required. Again in this example there are 4 bytes of input data coming from VersaMax to the PC Controller, 2 bytes of I/O Data and 2 Bytes of Diagnostic information. In addition, there are 2 bytes of output data.

Once Complete select the OK button to accept the new settings and return to the 'Device Setup' screen.

11. Click on the check box for Polled I/O to enable it.
12. Select the OK button to return to the 'fxControl' development environment.
13. Save the configuration and Run your project. With the new configuration the fxControl software engine can now be run with full access to the new addresses declared for the VersaMax node.

Network Bill of Materials

QTY	Description	Manufacturer	P/N
1	Personal Computer. PII 300 c/w Windows NT Workstation version 4.0 operating system	Various (used Dell)	N / A
1	fxControl Development software	GE Fanuc	IC752FDEPRO
1	fxControl Runtime software	GE Fanuc	IC752FRBPRO
1	DeviceNet Industrial Communications card	SST	5136DN
1	Programmable Logic Controller SLC 5/03	Allen Bradley	1747-L532

QTY	Description	Manufacturer	P/N
1	1747 DeviceNet Scanner Module	Allen Bradley	1747-SDN
1	SLC 4-slot Chassis	Allen Bradley	1746-A4
1	SLC Power Supply	Allen Bradley	1746-P1
2	SLC Discrete I/P Module	Allen Bradley	1746-IB16
1	SLC Discrete O/P Module	Allen Bradley	1746-OB16
1	Photo-Sensor with DeviceNet connectivity	Allen Bradley	42GNU-9000-QD
1	Redi Station	Allen Bradley	2705-T3DN1A42A
1	Flex I/O DeviceNet Communications Module	Allen Bradley	1794-ADN
5	Flex I/O Terminal Base	Allen Bradley	1794-TB3
2	Flex I/O Discrete I/P module	Allen Bradley	1794-IB16
1	Flex I/O Discrete O/P module	Allen Bradley	1794-OB16
2	Flex I/O Analog O/P Module	Allen Bradley	1794-OE4
1	VersaMax DeviceNet NIU	GE Fanuc	IC200DBI001-AA
1	VersaMax Power Supply	GE Fanuc	IC200PWR102A
1	VersaMax I/O Carrier	GE Fanuc	IC200CHS002A
1	VersaMax Discrete I/O - 24VDC, 16I/P, 16O/P	GE Fanuc	IC200MDD842A
1	24 Volt Power Supply	Various	N/A
1	RS Logix 500 Version 2.57.00	Rockwell Software	9324-RL0300ENE
1	RS DeviceNet Manager	Rockwell Software	1787-MGR
1	EDS file for GE Fanuc VersaMax NIU	GE Fanuc	N / A
6	DeviceNet trunk T-Port Tap	Allen Bradley	1485-P1N5-MN51
4	DeviceNet Open style stub	Allen Bradley	1485-PM5-C
2	DeviceNet 5-pin drop line	Allen Bradley	1485-PN5-M5
2	DeviceNet trunk Terminator	Allen Bradley	1485A-T15

Network Performance

The average scan time was found to be 15.2 milliseconds with 58 bytes of data being passed through the DeviceNet network per scan. The theoretical average scan time calculated for this network as calculated by the earlier procedure was 13.0 milliseconds. Once again the calculation procedure does not take into account any idle time produced by the scanner or any of the responding nodes therefore latencies tend to increase the actual scan times achieved.

ADC - Analog to Digital Converter

ASIC - Application Specific Integrated Circuit

Backplane - Communications media between a host controller and its local I/O modules connected directly to the controller.

Bandwidth - Term originated from the frequency band pass region of the network media but has evolved to imply the maximum amount of data that may be passed by a network.

Bridge – a two-port node which, interprets the addressing information and, based on that information, allows or blocks the passage of the message. Routers are used to separate network segments for security or traffic isolation as they restrict messages that are not required by devices in other segments.

Bus Scan Time - Time interval between successive data transmissions to/from a network node.

Bus Terminator - Device used to absorb energy transmitted in the transmission media. The terminator is typically a resistor located at the end of a transmission line segment and is required to minimize energy reflections due to impedance mismatch.

Centralized Control - one controlling processor is responsible for all system functions.

CPU - Central Processing Unit. VersaMax I/O can operate with or without a local VersaMax CPU.

CRC - Cyclic Redundancy Checking – Error checking algorithm which uses redundant data transmitted as part of the original message to ensure correctness.

CSMA / NBA – Carrier Sense Multiple Access / Non-destructive Bit-wise Arbitration. Devices incorporating CSMA/NBA first test the media for the presence of a carrier, which indicates that the media is in use. If the carrier is absent it then begins its transmission. If multiple devices begin transmissions simultaneously, arbitration is based on each device's unique identifier without destroying the identifier.

Device – any instrument or electronic node attached to a network, which has been granted a unique identifying label by the network.

Distributed Control - two or more controlling processors are responsible for system functions.

Distributed I/O - The I/O modules are spread throughout the controlled area. Typically, distributed I/O is interconnected with an industrial network.

Determinism - describes the ability of a system to produce time-predicable responses such that a response time can be calculated not based on probabilistic events.

EDS - Electronic Data Sheet - specification sheet of electronic form which outlines the properties of a field device.

Fieldbus - This term is used interchangeably with the term industrial network. See *Industrial Network*.

Gateway – gateway nodes have the ability to interpret and transform messages between dissimilar network protocols. Gateways are therefore used as a link between dissimilar messages.

Hub(s) – also known as concentrators, do not interpret data but serve as a media splitting point to form a star configuration. Hubs may be passive or active nodes. Active hubs discern, amplify and retransmit bits where as passive hubs simply divide signal strength.

HMI - Human / Machine Interface. Also commonly referred to as an MMI, an HMI is a visual display used to communicate information between human operators and a control system

Industrial Network - A bi-directional, real-time communication system which allows the exchange of digital information between field and controlling devices in an industrial environment.

Interchangeability – describes the ability of a system to accept the replacement of a device with a second device of “equivalent” specification manufactured by another vendor.

Interoperability – The ability of devices manufactured by various vendors to operate simultaneously on the same network system.

kbps - kilo-bits per second, 1024 binary digits per second.

Local I/O - all input and output modules and/or devices are connected directly to the controlling device without network connectivity.

MAC ID – Media Access Controller Identification – a unique hardware address of a device on the network. The device’s MAC ID is used during the arbitration process to resolve bus contention.

Master / Slave - communication where one device has been deemed to be the controller (Master) of the network media and as such controls the message timing and access. Lower intelligence devices (slaves) respond only to the master’s commands and requests for information.

Media Access – systems which permit unsolicited responses require an arbitration means to allow devices access to the media.

Mbaud – The term baud describes a ‘symbol’. The term Mbaud therefore describes 1 million symbols per second. It is generally assumed that the symbol size is understood to be 1 bit although this is not always explicitly the case.

Mbps - Mega-bits per second, 104576 binary digits per second.

MMI - **Man / Machine Interface**. Also commonly referred to as an HMI, an MMI is a visual display used to communicate information between human operators and a control system

Multi-casting – broadcast style messaging where a single message is heard and interpreted by a specific subset of network devices. The subset is defined within the multicast message therefore a single multicast message can have several consumers and can initiate many responses.

Multi-master - communication where multiple masters are present on a single network media. Arbitration rules are required to ensure that each master device periodically receives master-status to allow it access to the media.

NIU - **Network Interface Unit** - Intelligent network device that has the ability to communicate with other devices across an industrial network. Network interface units are slave devices which allow controllers access to I/O modules.

Node - describes a location on the network media where an interconnection can be made.

NCM – **Network Control Module** – Intelligent network device that has the ability to either control an I/O bus or act as a slave device on the bus. NCMs are used in VersaMax I/O in conjunction with a CPU.

NRZ - **Non-Return to Zero**

NSM - **Network Slave Module** - Intelligent network device that has the ability to communicate with other devices across an industrial network. Network slave modules can communicate I/O data but do not provide controlling logic.

ODVA – **Open DeviceNet Vendors Association**. Association of over 285 member companies to maintain and advance the DeviceNet Standard.

Overhead – also known as transmission overhead, describes the header and trailing portion of a transmitted message that does not contain user data. Timing and error detection/correction information are examples of overhead.

PTO – **Profibus Trade Organization**. Association of over 650 member companies to maintain and advance the DeviceNet Standard.

Repeater - a two-port node that discerns the bit levels of an incoming bit stream and retransmits an amplified version of the identical stream. Repeaters do not interpret data but are used to extend the reach of a network.

Router - a router is similar to a bridge but more advanced in that a router has greater than two ports and may direct network traffic to a particular port rather than simply blocking or passing each message.

Peer to Peer - communication between devices of similar intelligence levels where no device enjoys permanent master-status but the media is shared and arbitrated according to a set protocol.

P.I.D. Closed Loop Controller – controller which uses sensor feedback data and the mathematical functions of **Proportional**, **Integral** and **Derivative** gains to apply corrective signal to a system to obtain a desired response from the system.

Polling - The act of sequentially interrogating network elements for input data or dictating output commands

Response Time - Time interval between an input change and the first system output change due to that input change.

SCADA - Supervisory Control And Data Acquisition

Token Passing – media arbitration is accomplished through the passing of a symbolic token between network devices. Each device is allowed to transmit messages only when it holds the token. When a device does not hold the token that device must remain silent.

Topology – describes the physical and/or logical configuration of the network. Common topologies include the bus, star and ring configurations.

Transmission Rate – specification outlining the raw bit transfer rate of a network. The raw bit rate includes overhead plus message data.

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