

First-time FA Networking

**OMRON
FA Networking
Outline**

Introduction

Recent years have brought significant changes to the environments surrounding computers. Due to the low-pricing of personal computers (computers) and their sudden widespread use that accompanies it, this is especially true of computers where, now more than ever, they are being connected to each other and sharing the same data in all departments of the same company. This is not unrelated to the control site. Even progress reports and production histories, documents that have up until now been written and handed in, are now requested to be submitted in a way that the data can be used over again.

Further still, in the present-day control site, where the work requested of everyone is growing more complexly advanced, it is requested that the work be dealt with by instantaneously extracting various kinds of management data from the information obtained by programmable controllers (PLCs).

This book is for those who "have never used multiple PLCs connected together" or who say, "I have used computers before, but when it comes to networking, ...". It explains the basic knowledge necessary for reading catalogs or users manuals. So, by all means, read this book and put it to good use.

There are limitations to the combinations of various software, hardware and FA networking products introduced in this book. In addition, the versions that correspond to each are different as well, so please be sure to inquire about each separately when considering these products.

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Chapter 1 Connections

The World of Networks as Seen From the Control Site

Connecting a Sensor to a PLC: Wiring

Connecting Multiple Sensors to a PLC: Reduced Wiring

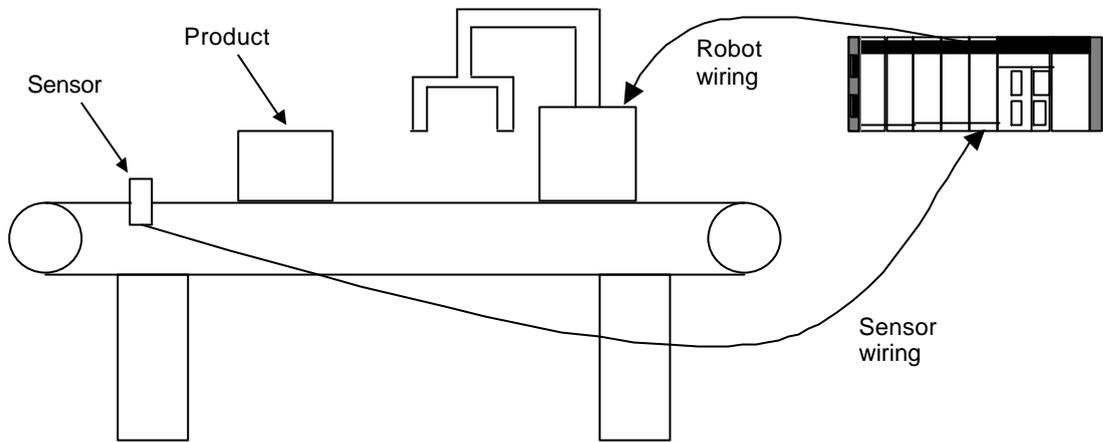
Connecting PLCs to PLCs: Using FA Networks

Connecting PLCs to a Computer in Another Department: To a LAN and to the World

Connecting a Sensor to a PLC: Wiring

Two items that a control site must include are the PLC (programmable controller) and the sensor.

In the following example, when a product passes in front of the optical sensor, the PLC determines the size and sends instructions to the robot.



The work to be done on these objects differs sometimes depending on its size. For times like these, the optical sensor is connected to the I/O unit of the PLC to determine the size of the objects. In accordance with the instructions of the PLC, the robot moves the objects to different lines according to their size.

Wiring a sensor to a PLC, and the PLC to a robot, makes this kind of control possible.

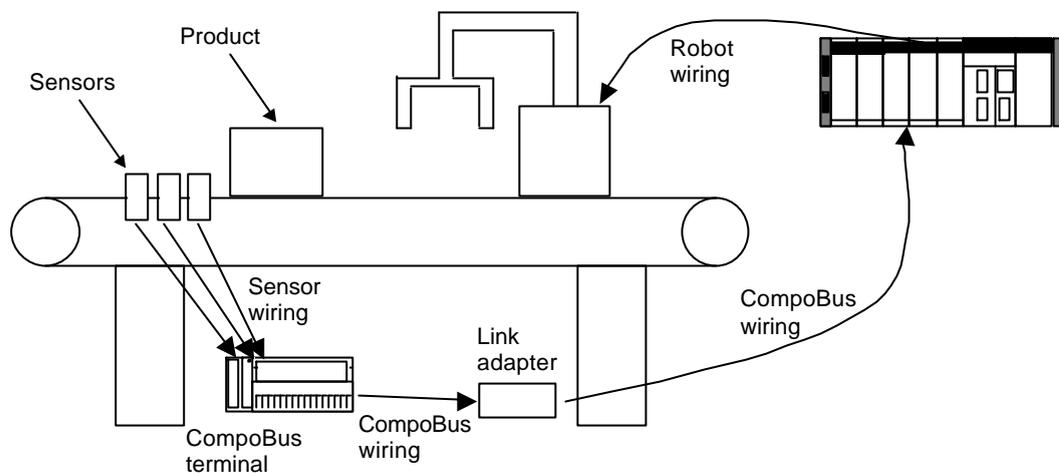
Step-by-step

In the figure above, the PLC determines the size of the objects based on the electrical current from the optical sensor. This flowing and stopping of current is received as a "signal". As this example shows, when the PLC I/O unit is wired one-to-one with the sensor, the electrical current, or lack of current in the wire is the information sent to the PLC. The PLC then tells the robot what to do next, based on the size of the object.

Connecting Multiple Sensors to a PLC - Reduced Wiring

At an actual control site, multiple sensors are connected to one PLC.

PLCs perform complex control operations based on the information from these sensors.



In the past, the I/O terminals of all the sensors have been connected directly to the I/O units of the PLCs. At present, we can wire multiple sensors together, resulting in reduced wiring. OMRON has developed and markets equipment called “**CompoBus**” for reducing the amount of wiring.

In the above figure, signals from several sensors are sent to the PLC through one wire, which is shared by all the sensors. CompoBus is designed for this purpose. There is also something called “DeviceNet” which is a standardization of this idea. Each sensor is connected to a box called a “terminal”. This terminal sends signals according to a pre-determined pattern (protocol). Next, several terminals are connected to a “link adapter”, and this is connected to the PLC. A CompoBus unit is mounted to the PLC in an I/O slot. This unit receives each signal, and determines which sensor is the source, etc. The PLC then performs the appropriate control operation based on the signal received.

Protocol

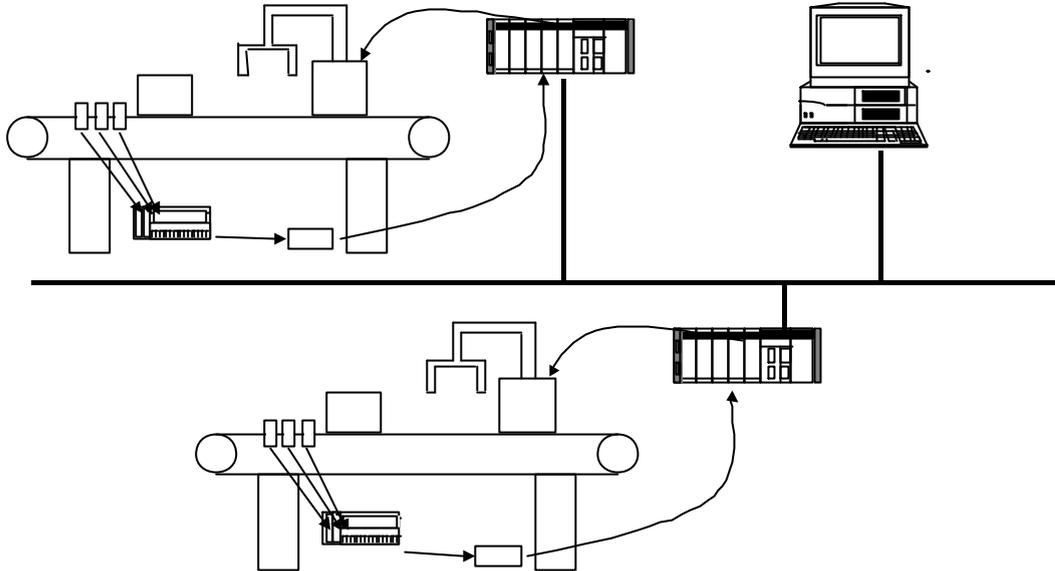
Protocol refers to the patterns and rules for when PLCs and related equipment (including terminals) communicate information back and forth with other equipment, such as computers. For instance, suppose you want to send signals from multiple sensors using one wire. If these sensors each send signals freely, the PLC will not be able to understand. A terminal is used to determine in advance the timing when each sensor sends its signal, and to attach a name to the beginning of a signal so that the PLC will know which sensor sent the signal. These rules are called the protocol.

Step-by-step

In the figure above, the sensors send signals to the CompoBus terminal. The terminal sends the signals through the link adapter to the PLC. The PLC then tells the robot what to do next, based on the information received from the sensors.

Connecting PLCs to PLCs: Using FA Networks

In order to do more complex control, it is necessary to connect multiple PLCs, and have them cooperate with each other. For safety purposes, a person must always monitor the system.



Each of the multiple PLCs that cooperate in the control system must tell the PLC next to it that its work is done. In addition, the person monitoring the system must be informed if an error signal comes from a sensor, in order to prevent an accident. The system can also be automatically shut down, at the same time. The system used to accomplish this automation is called an "FA (factory automation) network". OMRON has developed and markets "Controller Link", which is an FA networking system. Connecting units and support boards for FA networks are installed in each of the PLCs and computers used for monitoring and controlling the system.

Control information is transferred among the PLCs and computers using the FA network. The necessary data is also processed using software so that people can interpret it, and displayed on a computer screen, printed, etc.

OMRON has also developed "PLC Reporter", a software package that processes data from PLCs for people to use.

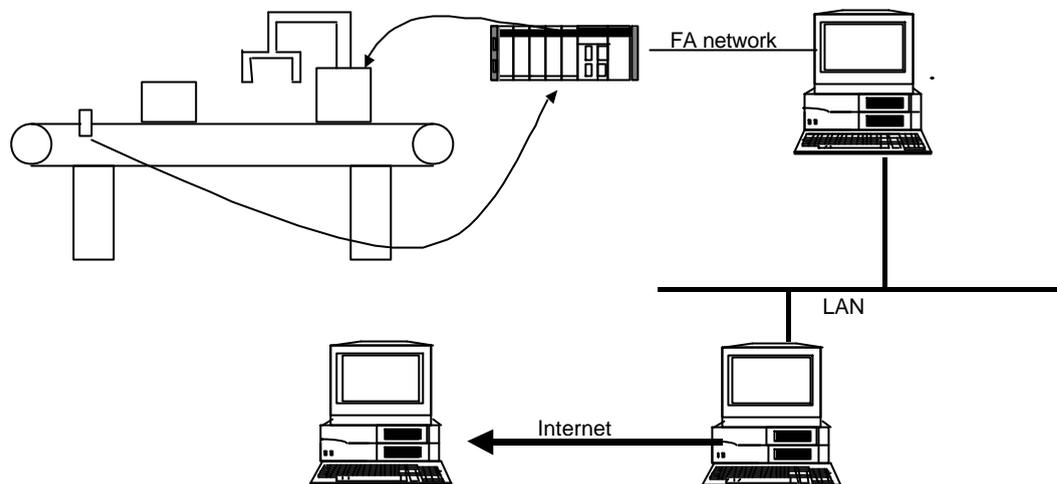
FA Network

This is the system in which PLCs are connected to one another and/or to computers. OMRON has several FA networking products, such as "Controller Link", "SYSMAC LINK" and "Host Link".

Connecting PLCs to a Computer in Another Department: To a LAN and to the World

In Sales and Accounting departments, computers are already being connected together so that work can be done without generating sales vouchers.

Even in the world of FA, examples are increasing where orders sent and received for machinery and accessories are directly sent online to the accounting department without creating vouchers for them.



With OA (office automation) equipment being widely used in sales and accounting, using computers connected to each other (i.e., LAN systems) is becoming the natural thing to do. Companies that have control sites today are beginning to use FA networks connected to LANs of OA equipment. This is because it is possible for the companies' administration departments to see the orders issued from the managing departments for materials, as well as the production volumes. Companies can also exchange control programs with factories overseas using the Internet.

Data from the PLCs is sent through the FA network to computers that control and manage this data. If these computers are also connected to a LAN, the data from the PLCs can also be seen from computers in other departments.

In order to do this, it is necessary to use software that can process the data sent through the FA network into an understandable format.

OMRON has developed and markets software such as the "FinsServer-series" for this purpose.

Internet

This is an enormous computer network that extends throughout the world. Originally it was a network that connected scientific research institutions, but now it is being used for commercial purposes as well. If the computer you are using and the computer you want to communicate with are both connected to the Internet, it is possible to exchange data just as with a company LAN (but the company LAN has limitations in communication speeds and data formats). By this means, control data can be sent to factories located overseas.

LAN

LAN is the abbreviation for local area network. It allows data to be exchanged by computers connected to each other in a limited scope. There are various protocols just as with FA networks. Conforming to these protocols makes it possible to exchange data between different kinds of computers.

Chapter 2 An OMRON FA Network

OMRON: The World of FA Networking

Controller Link

SYSMAC LINK

Ethernet

Host Link

CompoBus

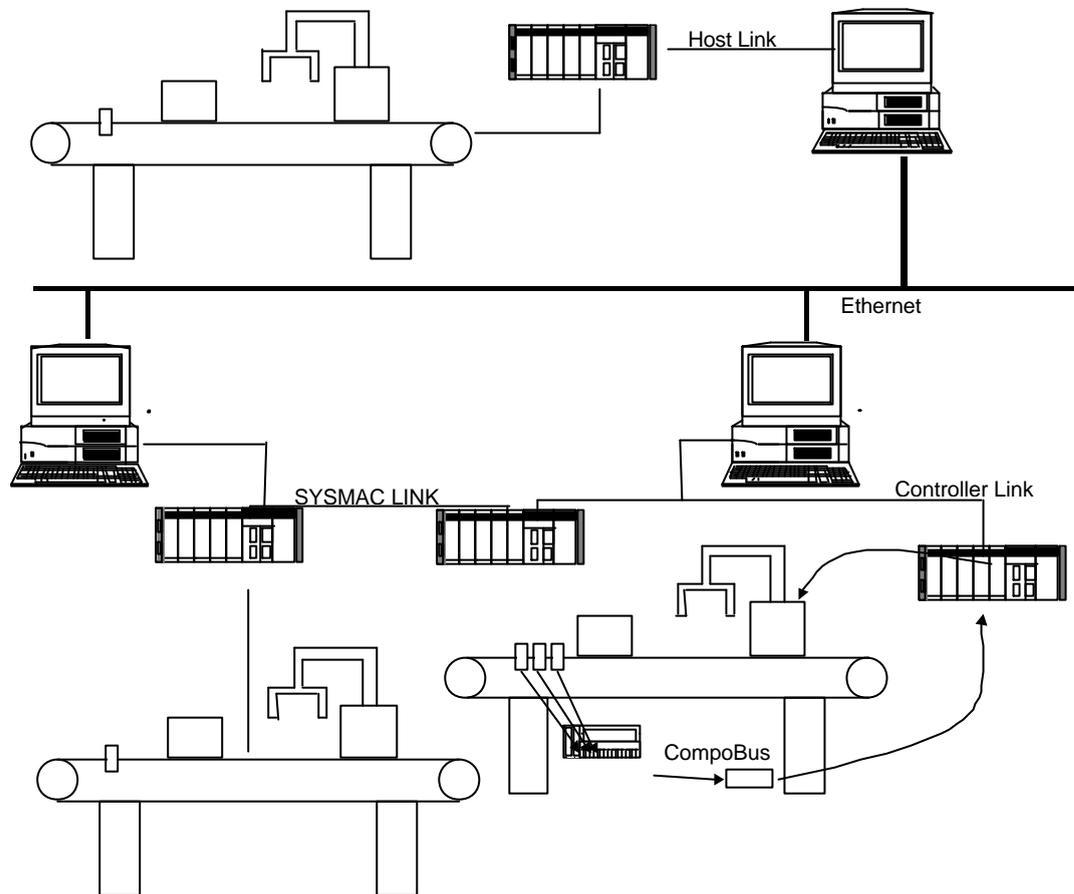
Connecting with Computers

Protocol Macros

OMRON: The World of FA Networking

There are various products available in the world of FA networking that OMRON has made possible.

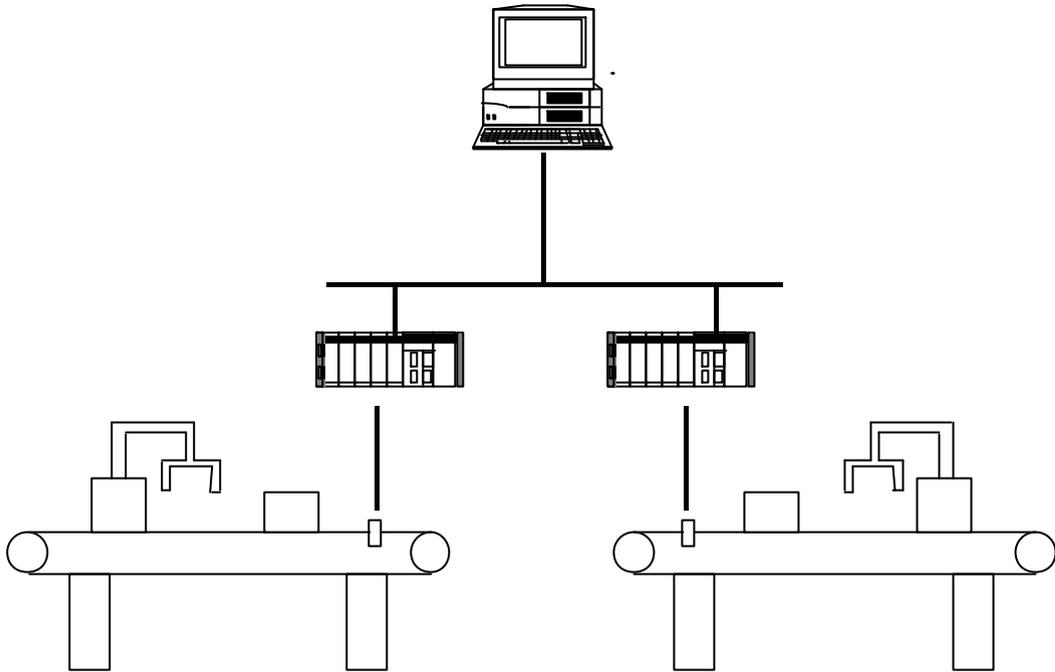
The products introduced below are similar in that they are all used to connect PLCs to each other or to computers, but the specific functions and roles that they each fulfill are different.



Each of these various systems is explained further in this chapter.

Controller Link

Controller Link is the newest OMRON FA network product. It handles larger volumes of data than many of the other FA network products. PLCs are connected to Controller Link using a Controller Link communications module mounted to one of the I/O unit slots of the PLC.



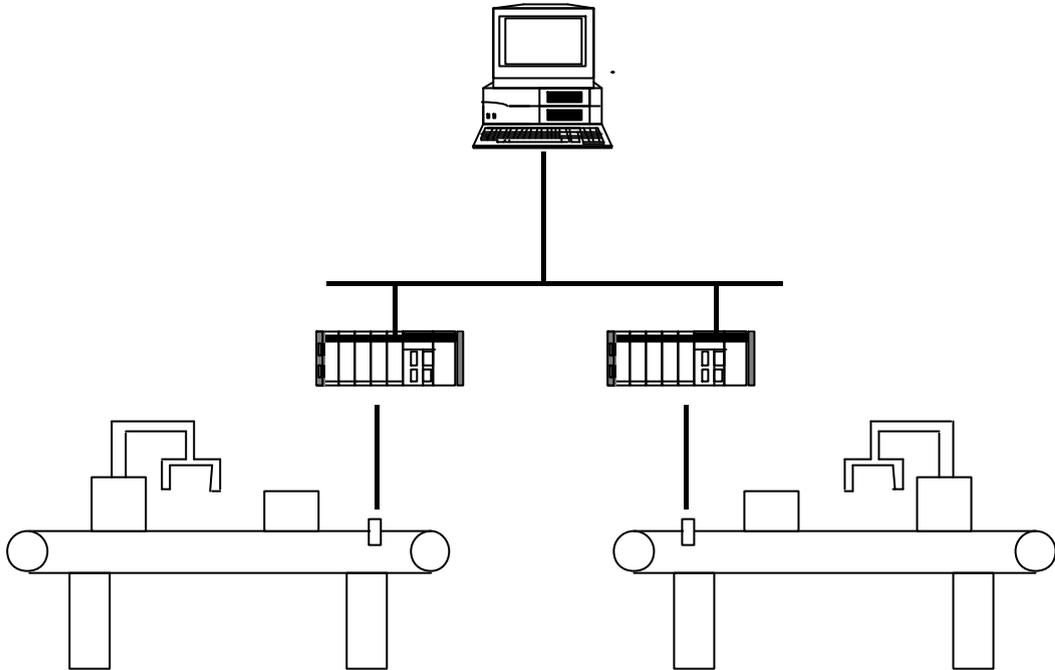
Controller Link has the following features and functions:

- Maximum number of nodes* (maximum number of PLCs and computers that can be connected to a single network layer): 32
- Large capacity data link* function
Transfer data area for each node: up to 1000 words
- RAS (reliability, accessibility, serviceability) functionality
- Network access (method of sending/receiving messages over the network)*: token passing
- Inexpensive, simple connections with twisted-pair cable
- In addition to connections between PLCs (SYSMAC alpha-series, CV-series, CVM1, etc.), the computer support board can also be mounted to the expansion slot of a computer to connect it to the Controller Link system.

*Explained in Chapter 4.

SYSMAC LINK

SYSMAC Link was released to the market in 1993. It provides the high speed and high reliability that are demanded by the FA networking market. PLCs are connected to SYSMAC LINK using a SYSMAC LINK communications module mounted to one of the I/O unit slots of the PLC.



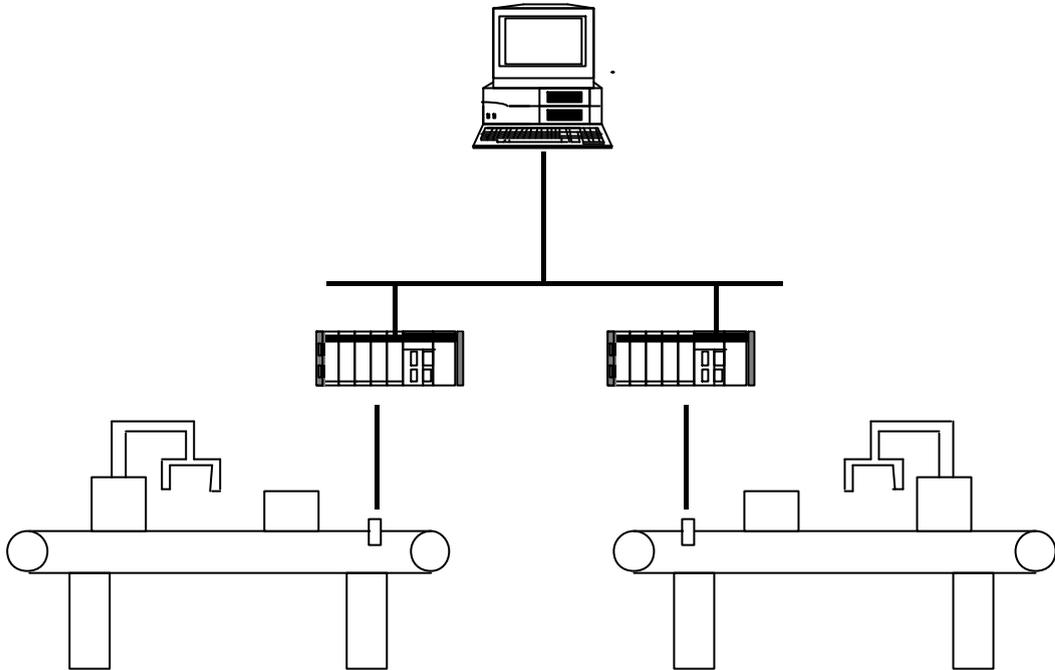
SYSMAC Link has the following features and functions:

- Maximum number of nodes*: 62
- Data link* functionality: up to 254 words of data link data for each node
- Message servicing for data transfer
- RAS functionality
- Network access*: token passing
- High reliability through coaxial cable, or fiber-optic cable connections
- In addition to connections between PLCs (SYSMAC alpha-series, CV-series, CVM1, etc.), the computer support board can also be mounted to the expansion slot of a computer to connect it to the Controller Link system.

*Explained in Chapter 4.

Ethernet

Ethernet is one of the most widely used LAN standards. It was fundamentally an OA network, but is beginning to be used more and more for FA networks, as well. PLCs are connected to Ethernet using an Ethernet communications module mounted to one of the I/O unit slots of the PLC. The computer must also have a commercially available network board mounted.



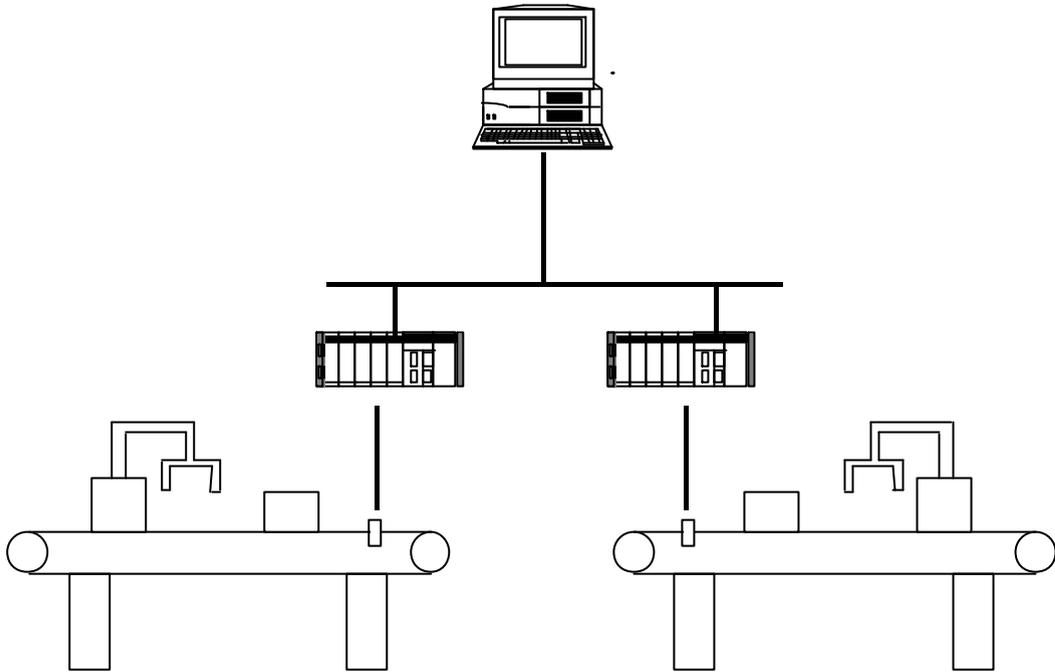
FA networks using Ethernet have the following features and functions:

- Maximum number of nodes: 100
- Coaxial cable, or twisted-pair cable connections
- Network access*: CSMA/CD
- Used for connecting OA and FA networks together
- Because of the difference in network access methods from Controller Link and SYSMAC LINK, Ethernet is not always appropriate for systems where constant data updates are required

*Explained in Chapter 4.

Host Link

Host Link is one of the most fundamental FA networks. It utilizes the RS-232C port that is included as standard on all computers and PLCs, for serial communications. Therefore, including a computer in the network does not require any special support board. Most PLCs are connected to Host Link using a Host Link communications module mounted to one of the I/O unit slots of the PLC. Some PLCs have a built-in Host Link port, and do not require a special module.



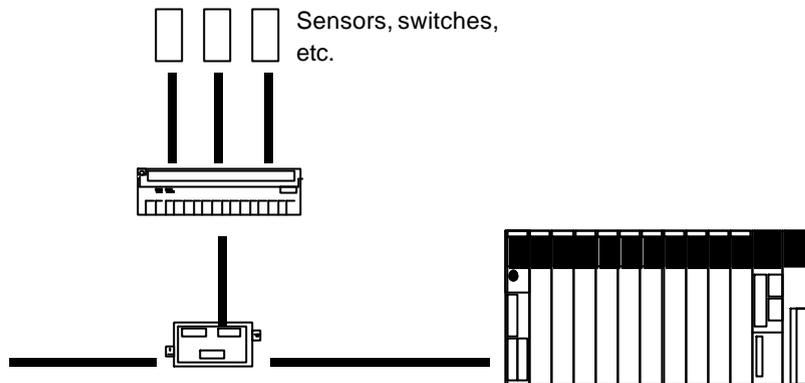
Host Link has the following features and functions:

- Complies with standard RS-232C
- Converting to RS-422/485 enables connection of up to 32 nodes
- Data transfer is not fast, but system configuration/setup is simple, and the costs are very low

CompoBus

CompoBus is a product that simplifies the usually complicated wiring between sensors, switches, etc. and the PLC.

CompoBus is available in two varieties: D and S. CompoBus/D follows the DeviceNet standard, while CompoBus/S is an Omron standard.

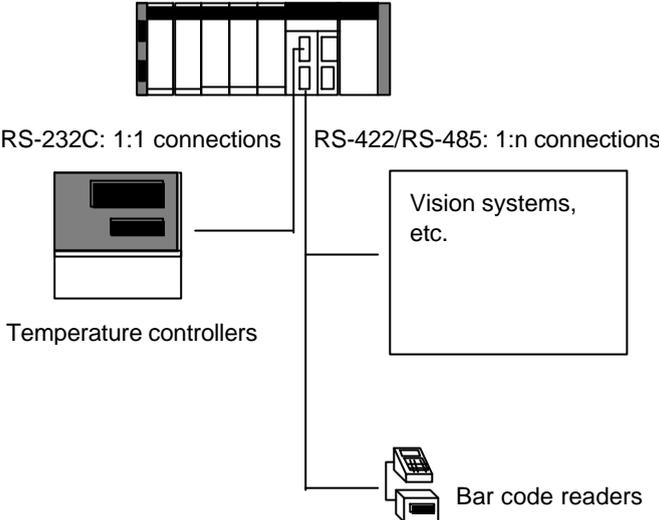


CompoBus has the following features and functions:

- Data transfer speeds up to 500Kbit/s
- At lower data transfer rates, distances can be extended up to 500m
- Connecting all the sensors, etc. with their complex wiring needs through a CompoBus terminal to the PLC greatly reduces wiring effort and cost
- CompoBus/D complies with the DeviceNet standard, enabling connection of third-party DeviceNet products

Protocol Macros

Some of the Omron PLC communication boards have protocol macros. These macros enable communication with various devices without the purchase of special networking equipment. Some of the Omron Temperature Controllers and other peripheral devices are compatible with the protocol macros. Simply performing the protocol settings with the setting software enables communication with the PLC. After that, communications can be performed using the standard ladder diagram program.



Chapter 3 Using an OMRON FA Network to its Fullest

Choosing the Right Software

FA Network Communication

Component Products

PLC Reporter

FinsGateway

Compolet Series

(FinsServer-series DataFlowNavi for Access)

Choosing the Right Software

Using the various systems and products described thus far allows you to obtain the factory floor data in the location you want it.

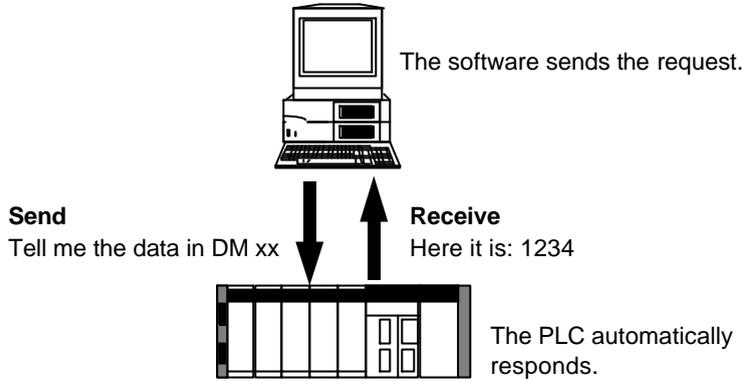
However, obtaining exactly the data you want is not only a matter of hardware. Using the right software to sort, organize, and present the data in the desired manner is also a necessity. Various software packages are available to process the data into just the right form.

Objective	FA Network Used			
	Controller Link	SYSMAC LINK	Host Link	Ethernet
Make graphs and tables with data from the PLC	PLC Reporter			---
Independent development of production instructions, actual data management, etc.	Compolet series			

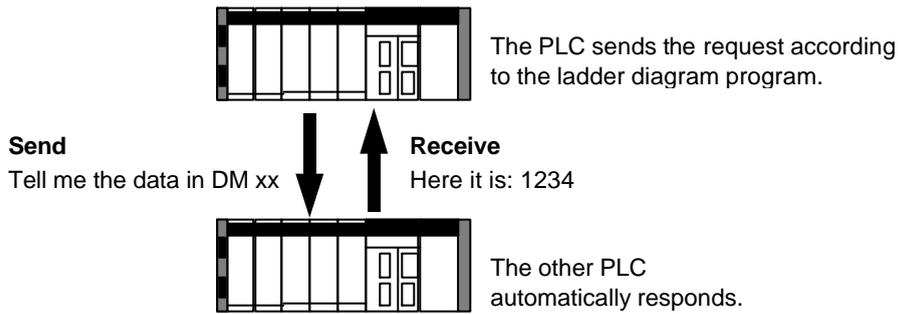
FA Network Communications

Reading PLC data into the computer and writing data to the PLC requires computer software that can send instructions to the PLC and receive/interpret responses. This requires software products such as PLC Reporter that will be described later.

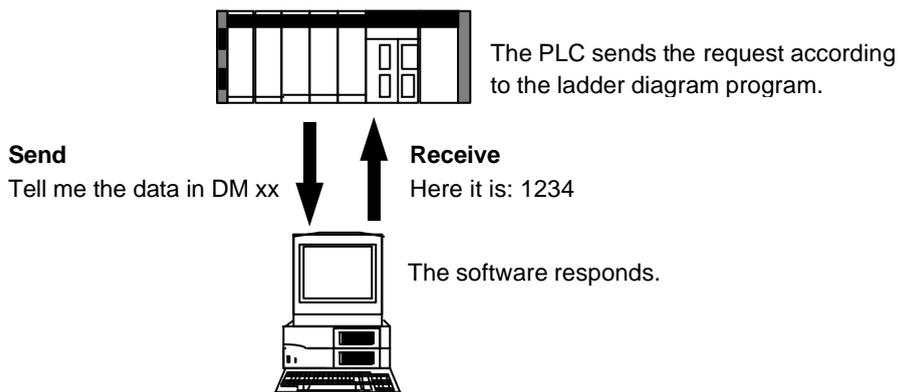
Reading/Writing PLC Data with the Computer



Reading/Writing Data between PLCs



Reading/Writing Computer Data from the PLC



Transferring data between PLCs, or sending data from a PLC to a computer can be done from the ladder diagram program. However, two-way data exchange with a computer requires software in the computer that can communicate with the PLC. This functionality is built into PLC Reporter and the FinsServer-series software packages.

Component Products

PLC Reporter

PLC Reporter is a simple data collection software package. It enables reading PLC data to the computer, and writing PLC data from the computer.

The settings for communicating with the PLC are all made with simple selections from menus. There is no need for any programming.

The biggest feature of this product is that the user is only required to operate the setting menus in PLC Reporter, and the spreadsheet software, Excel.

PLC Reporter is operated through the Excel software, running on Windows98. The data obtained using PLC Reporter is processed in Excel to make graphs and tables.

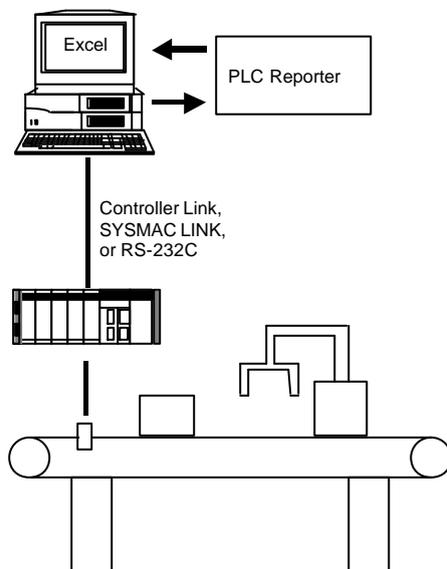
This software is for people who are not expert programmers, or who just want to monitor actual production status and results as simply as possible.

OS

OS stands for operating system. The operating system is what acts as an intermediary between the computer hardware and the application software (i.e., word processing software, spreadsheet software, etc.). It also controls the execution of the application software and its various functions. There are various operating systems on the market, such as Unix, OS2, Windows98, or Windows NT.

PLCs	SYSMAC C/CV-series
FA Networks	Host Link, SYSMAC LINK, Controller Link
Computers	PC/AT-compatible
OS	Windows95/98
Other Software	Excel (Controller Link requires Excel97)

Note: Depending on the exact combination, other restrictions may apply. Ask for details.



The PLC data is sent through any one of the indicated the FA networks, and arrives at the computer. The data is then displayed in the Excel spreadsheet by way of PLC Reporter. Data can also be written to the PLC from the Excel spreadsheet, following the same path in the reverse.

FinsGateway

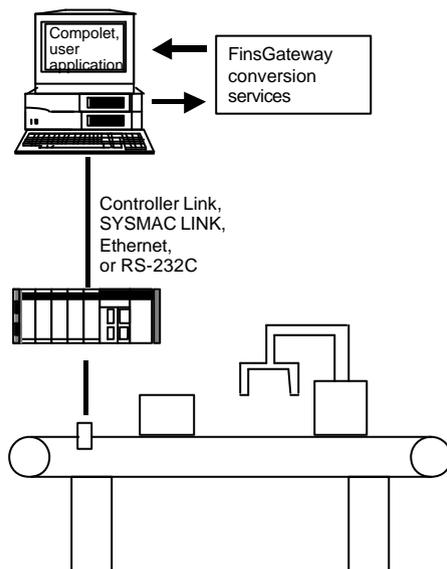
FinsGateway is a communications platform. A communications platform is a central software package that performs data communication/conversion services.

When the data from the PLC is passed through the FA network (i.e., Controller Link, SYSMAC LINK, etc.), it is passed according to the specified protocol, as already explained. This protocol is different for each network. The communications platform (i.e., FinsGateway) converts the data between these differing protocols and the FINS protocol. FINS is a standard protocol to be understood by Omron products. (The means of communicating with FINS is by using FINS commands.)

For example, let's say there is a single computer dedicated to the management and supervision of the production lines in a factory. In order to connect that one computer to the various FA networks in the factory, a network support board for each network must be installed in the computer. The data from each line is gathered into the one computer through the network support board for that network. However, because the protocol is different for each of these networks, the effort required to develop application software to gather all the data from each network would be considerable.

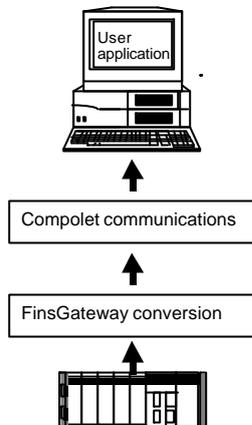
This is where FinsGateway is used to convert between the varying protocols and FINS. This converted data can then be provided to the various application software packages through the FinsServer-series software from Omron.

FinsGateway by itself is just a communications platform. Using it in combination with another FinsServer-series software package is a way to take advantage of its functionality. User-developed applications can also be based on FinsGateway to reduce the effort required for initial development, as well as modification required as the system evolves.



Compolet Series

Compolet runs on top of FinsGateway, and is used for communications between FinsGateway and user applications written in Visual Basic. In order to obtain data from devices outside the computer (PLCs, etc.), and make that data usable and understandable to people, at least three layers of software functionality are required, as shown below.



The PLC data is sent through the FA network, and arrives at the computer. The data is passed from the network support board to FinsGateway, and converted. It is then passed through Compolet to Visual Basic, and displayed on the screen. It is also possible to enter data into a dialog box displayed on the screen, and write the data back into the PLC following the same route in reverse.

Before FinsGateway and Compolet were developed, the user had to develop and maintain all the software except for the network support board driver. (The board driver is the software program that actually works directly with the board hardware, like the OS does for the computer.) For example, even making a simple change in a production line that resulted in an address change at the PLC required rewriting the communications program in the computer. This modification to the program also required knowledge of the communication protocol, and the overall system, etc.

Compared to that old approach, using FinsGateway and Compolet really simplifies both the initial program development effort and the maintenance effort requirements, as well.

PLCs	SYSMAC C/CV-series
FA Networks	Host Link, SYSMAC LINK, Controller Link, Ethernet
Computers	computer/AT-compatible
OS	Windows NT 4.0
Other Software	FinsGateway, Visual Basic, etc.

Note: Depending on the exact combination, other restrictions may apply. Ask for details.

User Applications

User applications are the software programs that users develop to accomplish specific functions for the system being monitored/controlled. It differs from applications such as PLC Reporter, which work with off-the-shelf application programs like Excel. A user application is a software program that the user has developed from the concept stage, including screen design, functionality, processing, etc.

FINS commands are required for Compolet to communicate with FinsGateway. However, knowledge of the FINS commands is not required by the user to take full advantage of Compolet functionality. With the ActiveX control approach employed in Compolet, the already widely used programming language, Visual Basic can be used to develop applications with Compolet, as well. Since Visual Basic also uses ActiveX, communications between Compolet and Visual Basic are easily performed with ActiveX. At present, C-series and CV-series versions of Compolet are available. In the future, Compolet will be expanded to include virtual objects for other products as well.

Visual Basic

Visual Basic is a Microsoft programming language. It enables the development of user application screens for Windows by simply pasting buttons etc. into the dialog boxes.

ActiveX

ActiveX is also provided by Microsoft. ActiveX is the generic name of a technology that allows the execution of application programs over the Internet, or another network. An ActiveX control is one part of this ActiveX technology. It is similar to the fixed means of exchanging data between different applications.

Chapter 4 Main Points of This Book

Unit Numbers

Nodes, Node Numbers

Network Numbers

Routing Tables

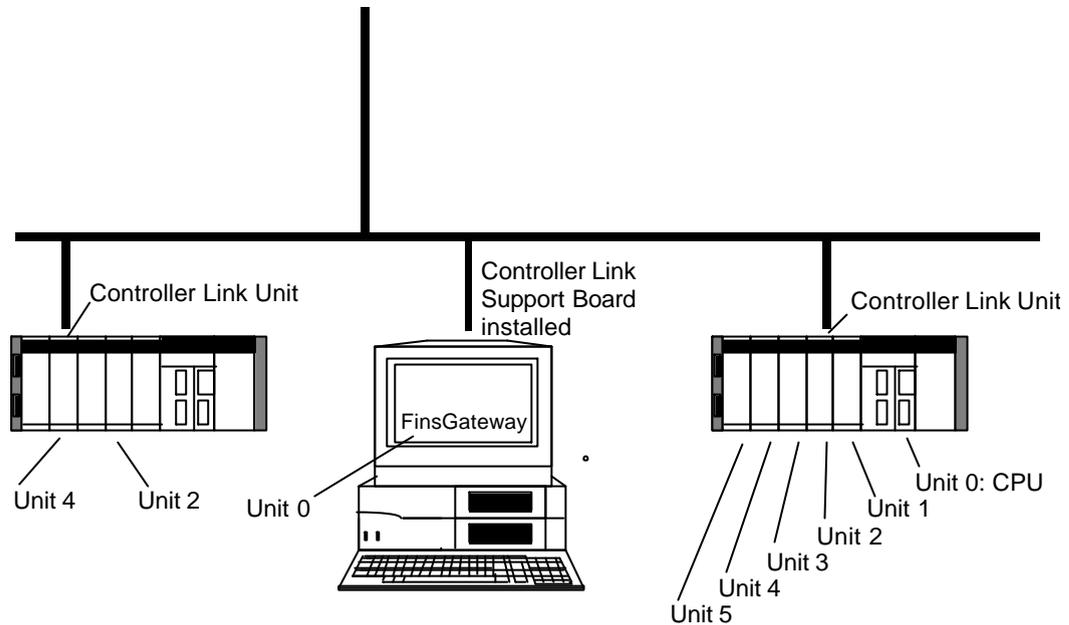
Local Network Numbers, Local Node Numbers

Network Access Methods

Data Links

Unit Numbers

Omron PLCs allow the connection of various modules, called communication units, I/O units, etc. Each of the units mounted to the PLC must be able to be distinguished from the other units to be accessed by other PLCs or computers.



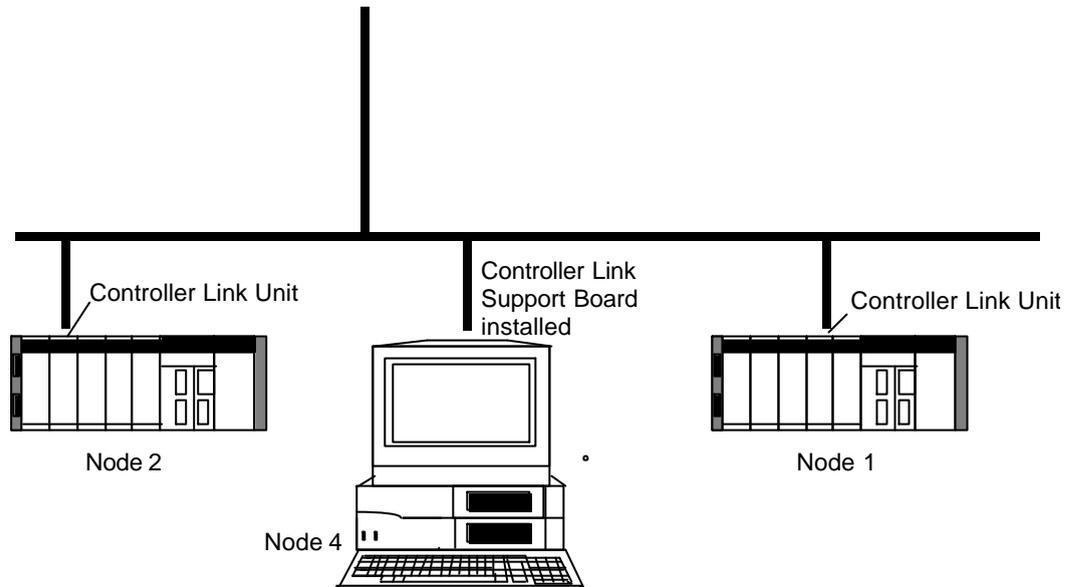
In an Omron FA network, a number is assigned to distinguish each of the units. Communications in an FA network consist mostly of data reading/writing. Data reading/writing is done with the CPU of the PLC. In order to communicate with the CPU of the PLC connected to the network, 0 is specified for the unit number of the CPU.

Nodes, Node Numbers

Omron FA networks can have many PLCs and computers connected. Each PLC and computer connected to the network is called a node. In order to utilize an FA network, it is necessary to distinguish each of the PLCs and computers connected to the network.

A unique number is assigned to each PLC and computer within the network to accomplish this purpose. This number is called a node number, or node address.

Generally, this node number is assigned using a node number switch on the PLC communication units and the computer network support boards.



Host Link Systems

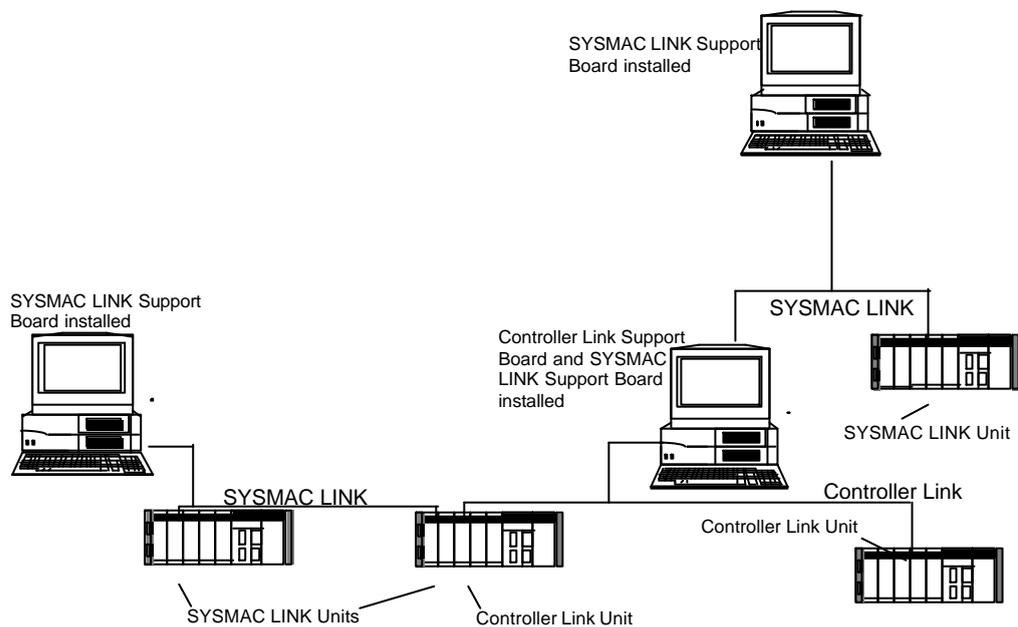
Host Link systems differ in the number assignments. They have a unit number assigned to distinguish the various PLCs. These are different from node numbers in that unit numbers are assigned beginning with 0. Also, the computer acting as the host, does not have a number assigned. The unit numbers assigned for Host Link systems are also different from the unit numbers assigned to the various I/O units mounted to each PLC. The unit numbers of the Host Link system must be unique for each PLC in the system, whereas the unit numbers assigned to the I/O units on the PLC are unique only within that PLC.

Network Numbers

We have already introduced some of the variety of Omron FA network products. These products can be mixed into the same system and used to read/write data from/to PLCs connected to other FA networks.

In order to see the data of a PLC connected to another network, it is necessary to know and identify the specific network where that PLC is connected. In order to establish an identity for each network, a number other than 0 is assigned to each network. This number is called the network number, or network address.

The combined network number and node number are similar to a telephone number. The area code distinguishes one phone number from another phone number that is identical, but in a different area code. In the same manner, the network number distinguishes two node numbers that are identical, but in different networks. The network number must also be registered in the routing table. (Routing tables are explained later in this chapter.)



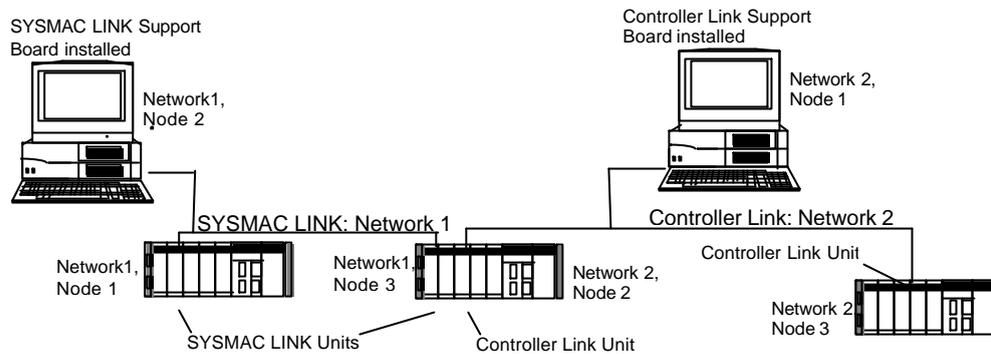
Hopping Networks

Omron FA networks allow data exchange between differing networks. Exchanging data with a PLC or computer in another network is called hopping networks. The number of hops that can be made depends on the PLC. The Omron CV-series PLCs can hop up to three networks.

For example, in the figure shown above, a message could be sent from the computer at the top of the figure to the PLC at the bottom left, by hopping the networks in between.

Routing Tables

The routing table is like a map. It is stored in the PLCs and computers connected to the FA networks. It is basically a table that tells each node what its own network is, and how to hop to other networks. In order to get to another network, the message must first go to the node that is connected to that network, and then be transferred across to the other network. The routing table is set using special software for that purpose. The routing table settings are required when using multiple FA networks connected together. A routing table consists of a local network table, and a remote network table.



Local Network Table

This table is a list showing the network for each communication unit on a PLC with multiple communication units mounted, or a computer with multiple network support boards installed.

Remote Network Table

This table is like a route map. It shows the PLC or computer the best node to use to make a hop to another network. For example, to go from network 2, node 1 to network 1, node 1 of the above system, the message must be sent through network 2, node 2. From there it goes to network 1, and can be sent on to network 1, node 1.

Local Network Number

When one node is sending data to another node on the same network (i.e., it does not need to hop to another network), it is sending to its local network. Each network has a number assigned to it, but 0 (zero) is designated as a special number that always means the local network. If a PLC or computer is only connected directly to one network, it can use the number 0 to mean the local network.

If that node is connected directly to multiple networks, (i.e., if it has multiple communication units, or support boards mounted), it cannot use 0. Because it has multiple local networks, it must use the actual network number to specify which network is intended.

Local Node Number

This is a special node number that always refers back to the node sending the data. The number 0 (zero) is reserved for this purpose.

Advantages of Local Numbers

The main advantage of reserving the number 0 for local network and node specification is for the program developer. Programs can be written to access nodes on the local network, or the data in the local node. These programs can then be used on multiple nodes, without being modified for the changes in network or node numbers.

Network Access Methods

Whether it is an FA network, or an OA LAN, it is necessary to have communication rules for a single line to be used for all the various nodes to communicate with each other. Very generally speaking, there are 2 sets of rules used for these communications. These rules are called the network access methods.

Token-passing Method

This network access method is used in some of the Omron FA networks. In the single communication line, there is something called a token. It is like an electronic ticket. The token is passed through the communication line from node to node. A node waiting to send data must wait to receive an available token. Then, it can send data to another node. If the token already has data for another node, it is busy. The node waiting to send must then wait until the token becomes available. This approach prevents data collisions. It is also possible to calculate about how it will take to be able to send data.

CSMA/CD Method

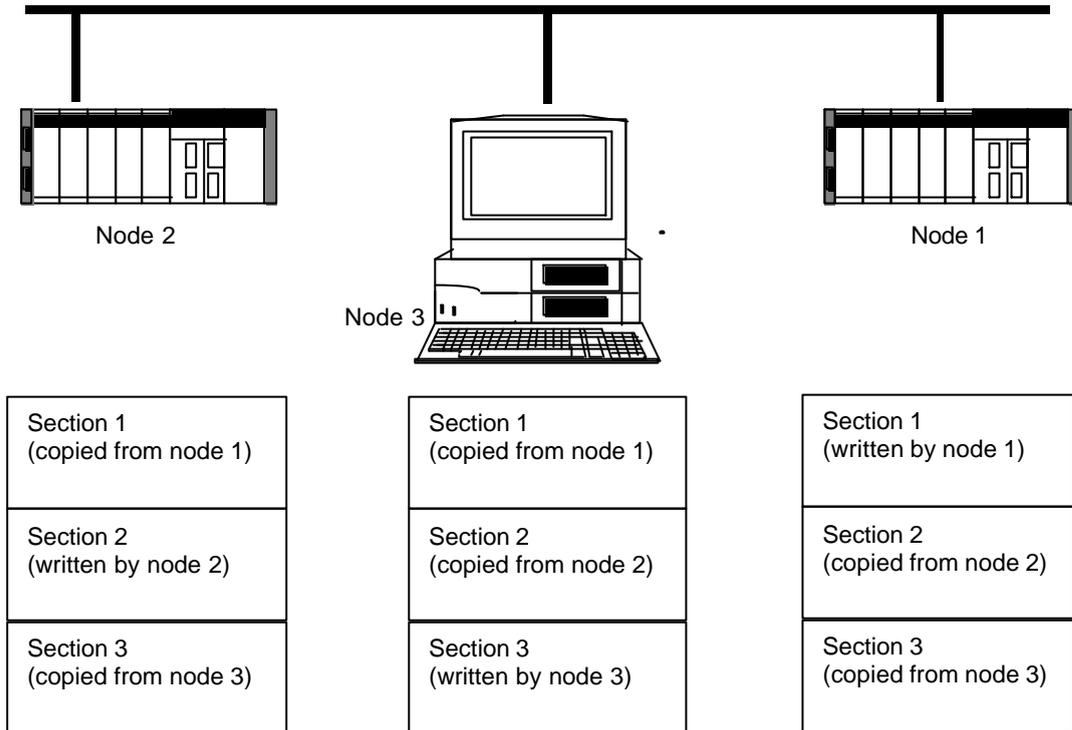
The most common LAN standard is Ethernet. Ethernet uses the CSMA/CD network access method. In this method, each node on the network simply monitors the common communication line. If it needs to send data, and no other node is sending, it sends its data. The result is that if several nodes send their data at once, there is a collision of the data in the communication line. When this happens, the node waits for a little while, then resends. As the number of nodes on the network increases, the length of time it takes to send and receive data also increases.

Data Links

The Omron Controller Link and SYSMAC LINK networks provide an automatic data exchange function that can be utilized without programming. This is called data link.

Data link is a function that automatically copies data between specified nodes, using the DM (data memory) area, or another data area. The memory used for the data link is reserved for that purpose only, and cannot be used for any other purpose. For example, as shown in the figure, nodes 1, 2, and 3 could be assigned to a data link, using sections 1, 2, and 3 of the DM area of each node. In this system, when data is written to section 1 of the memory area by node 1, that data is automatically copied into the same section 1 of the memory areas of nodes 2 and 3.

In the same way, when node 2 writes data to section 2, the data is automatically copied into section 2 of nodes 1 and 3. When node 3 writes to section 3, it is copied into section 3 of nodes 1 and 2.



Using this function enables quick, simple data exchange between nodes that require frequent data updates, without requiring any communication programming. Each of the nodes has the data from the other nodes automatically available within its own memory area.

The user decides what data to write to each section of the specified memory areas. Therefore, there is no concern for data being unexpectedly overwritten.

Data link has some limitations regarding the volume of data, etc., but is a convenient communication function, and is very commonly used.