Modicon Modbus Plus Network Planning and Installation Guide

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AEG SCHNEIDER AUTOMATION
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Preface

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Related Publications

Refer to the following publications for further information about the Modbus Plus network and other Modicon products.

840 USE 100 00	Modicon Quantum Automation Series Hardware Reference Guide
840 USE 101 00	Modicon Ladder Logic Block Library User Guide
840 USE 104 00	Modicon Modbus Plus Network I/O Servicing Guide
890 USE 102 00	Modicon IBM Host Based Devices User s Guide
890 USE 103 00	Modicon Modbus Plus Network BM85 Bridge Multiplexer User s Guide
GM-HBDS-002	Modicon DEC Host Based Devices User s Guide
PI-MBUS-300	Modicon Modbus Protocol Reference Guide

Chapter 1
Introducing the Modbus Plus Network

- ☐ Introducing the Modbus Plus Network
- ☐ Network Terminology
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- ☐ Major Components of the Network
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- ☐ Joining Modbus Plus Networks
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1.1 Introducing the Modbus Plus Network

1.1.1 Modbus Plus Applications

Modbus Plus is a local area network system for industrial control applications. Networked devices can exchange messages for the control and monitoring of processes at remote locations in the industrial plant.

Modicon products supporting Modbus Plus communication include programmable controllers and network adapters. The network is also supported by a variety of products from other manufacturers.

Each Modicon controller can connect to Modbus Plus directly from a port on its front panel. Additional networks can be accessed through Network Option Modules (NOMs) installed in the common backplane.

The network also provides an efficient means for servicing input/output subsystems. Modicon Modbus Plus Distributed I/O (DIO) Drop Adapters and Terminal Block I/O (TIO) modules can be placed at remote I/O sites to allow the application to control field devices over the network link.

1.1.2 Extending the Network

Each network supports up to 64 addressable node devices. Up to 32 nodes can connect directly to the network cable over a length of 1500 ft (450 meters). Repeaters can extend the cable distance to its maximum of 6000 ft (1800 meters) and the node count to its maximum of 64. Fiber optic repeaters are available for longer distances.

1.1.3 Bridging Networks

Multiple networks can be joined through Bridge Plus devices. Messages originated on one network are routed through one or more bridges to a destination on another network. Bridges are applicable to networks in which fully deterministic timing of I/O processes is not a requirement. In a network requiring deterministic I/O timing, messages for DIO/TIO nodes are passed on that network only, and do not pass through bridges.

Modbus and custom RS232/RS485 serial devices can access Modbus Plus through Bridge Multiplexers. Each Bridge Multiplexer provides four configurable serial ports. A serial device can communicate with

Modbus Plus networked devices, as well as with other devices at the serial ports.

1.1.4 Network Example

Figure 1 shows four Modbus Plus networks. A Repeater extends the cable for Network A. Networks A and B are joined by a Bridge Plus.

Networks C and D handle I/O processes. DIO Drop Adapters and Terminal Block I/O modules service the I/O field devices at each site.

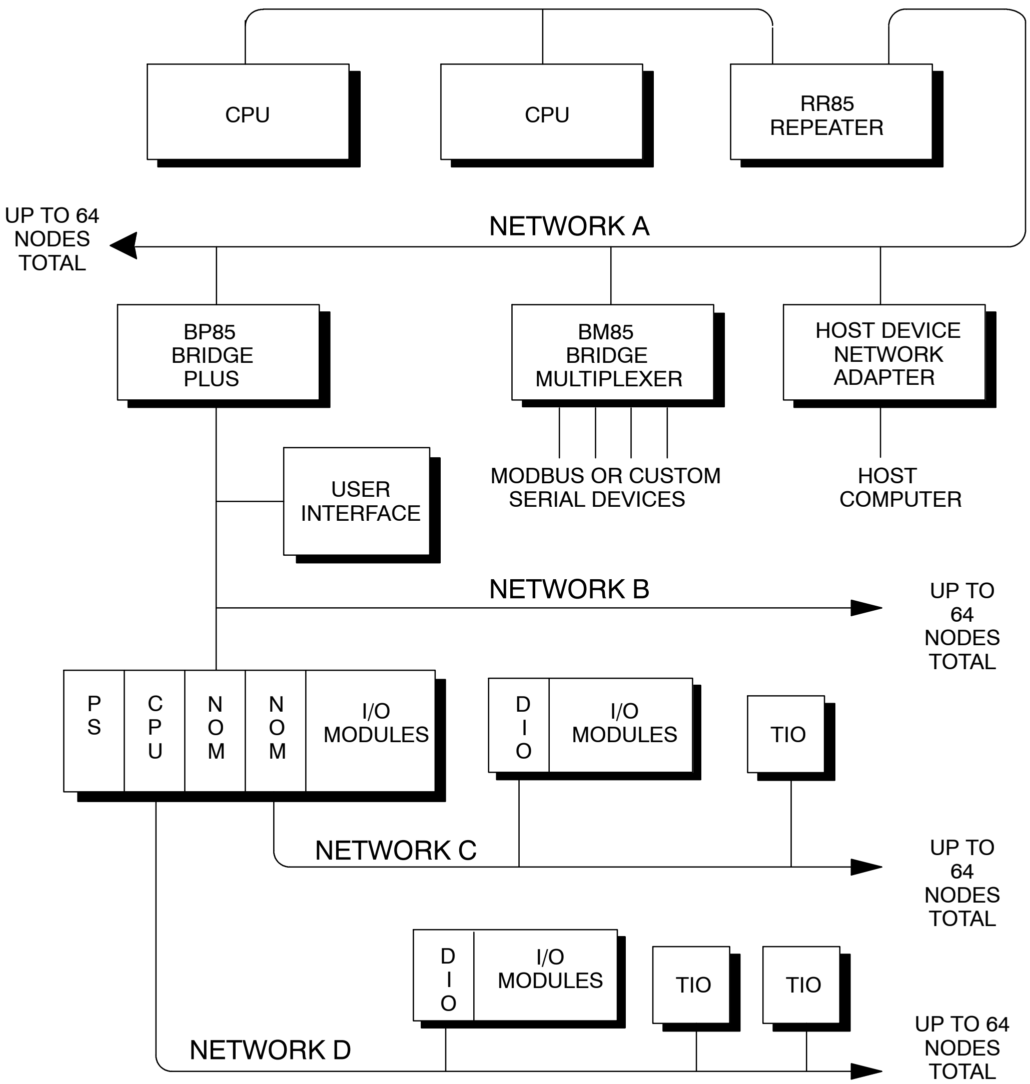


Figure 1 Network Overview

1.2 Network Terminology

The following terms are used in this guide to describe network elements:

Network The grouping of nodes on a common signal path that is accessed by the passing of a token. It consists of one or more cable sections. For example, all of the nodes in Figure 2 are on a *network*.

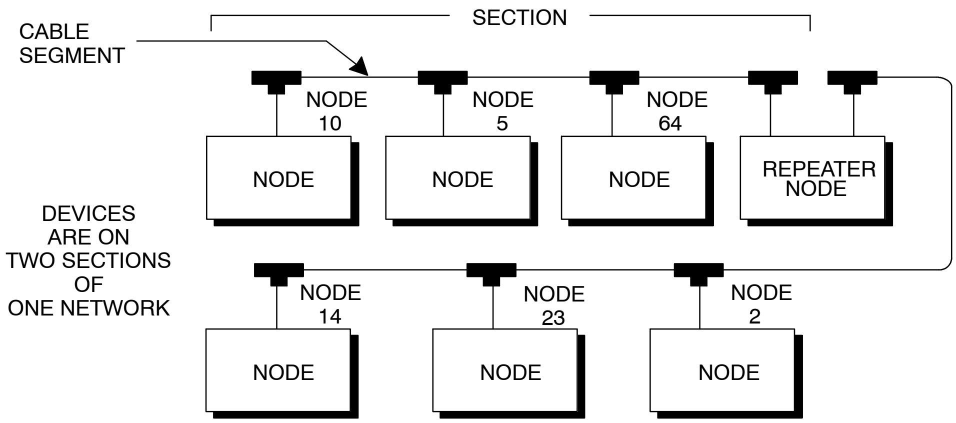


Figure 2 Standard Network Terminology

Section A series of nodes that are joined only by cable segments. The *section's* signal path does not pass through any kind of node device. *Sections* are all part of one network, sharing the same token and address sequence. In Figure 2, the Repeater joins two *sections*. Each *section* can be up to 1500 ft (450 m) long, and can contain up to 32 physical node connections.

Cable Segment A single length of trunk cable between two taps. Taps are passive devices that provide connections for the trunk cable segments. In Figure 2, the cable connection between the nodes at addresses 10 and 5 is through one *cable segment*. Another *cable segment* connects nodes 5 and 64.

On dual-cable networks, two *cable segments* run in parallel between pairs of nodes.

Node Any device that is physically connected to the Modbus Plus cable. Figure 2 shows a network with seven *node* devices. The term applies to any device, whether it is addressable or not. Some *nodes* , like programmable controllers, have addresses and can serve as sources or destinations for messages. The Bridge Plus is a separately addressable *node* on each of its two networks. The Repeater is a *node* on each of two sections, but has no address, serving only to extend the network.

Token A grouping of bits that is passed in sequence from one device to another on a single network, to grant access for sending messages. If two networks are joined by a Bridge Plus, each network has its own *token* that is passed only among the devices on that network.

DIO Network A Distributed I/O (DIO) network is a Modbus Plus network designed primarily for servicing I/O field devices in the application. In its minimum configuration a DIO network consists of one controller (CPU) and one or more drops located at remote sites near to the field devices. Each drop consists of a DIO Drop Adapter installed in a backplane with I/O modules, or a Terminal Block I/O (TIO) module.

In Figure 3, one DIO network contains the CPU, a DIO Adapter, and a TIO module. Two other DIO networks consist of Network Option Modules (NOMs) with DIO Drop Adapters and TIO modules.

Details for designing a Modbus Plus network that is intended primarily for I/O servicing are in the *Modbus Plus Network I/O Servicing Guide.*

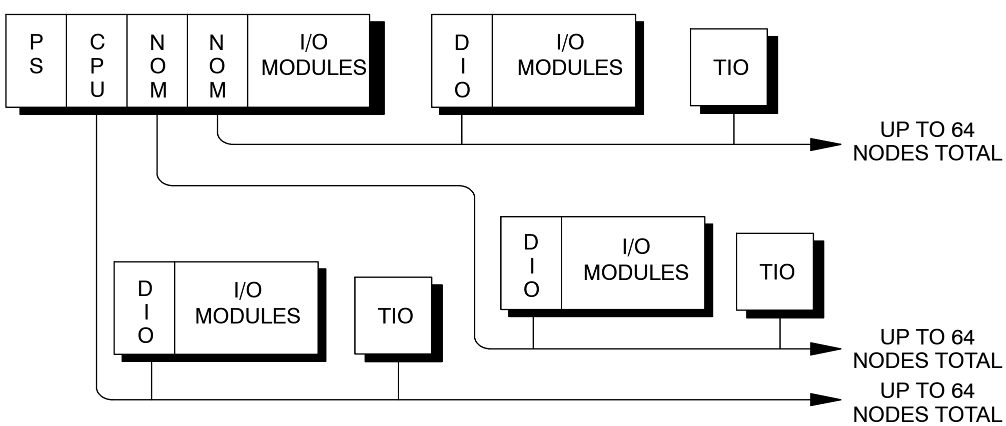


Figure 3 Distributed I/O Network Terminology

1.3 Overview of the Logical Network

Network nodes are identified by addresses assigned by the user. Each node s address is independent of its physical site location. Addresses are within the range of 1 to 64 decimal, and do not have to be sequential. Duplicate addresses are not allowed.

Network nodes function as peer members of a logical ring, gaining access to the network upon receipt of a token frame. The token is a grouping of bits that is passed in a rotating address sequence from one node to another. Each network maintains its own token rotation sequence independently of the other networks. Where multiple networks are joined by bridges, the token is not passed through the bridge device.

While holding the token, a node initiates message transactions with other nodes. Each message contains routing fields that define its source and destination, including its routing path through bridges to a node on a remote network.

When passing the token, a node can write into a global database that is broadcast to all nodes on the network. Global data is transmitted as a field within the token frame. Other nodes monitor the token pass and can extract the global data if they have been programmed to do so. Use of the global database allows rapid updating of alarms, setpoints, and other data. Each network maintains its own global database, as the token is not passed through a bridge to another network.

Figure 4 shows the token sequences in two networks joined by a Bridge Plus.

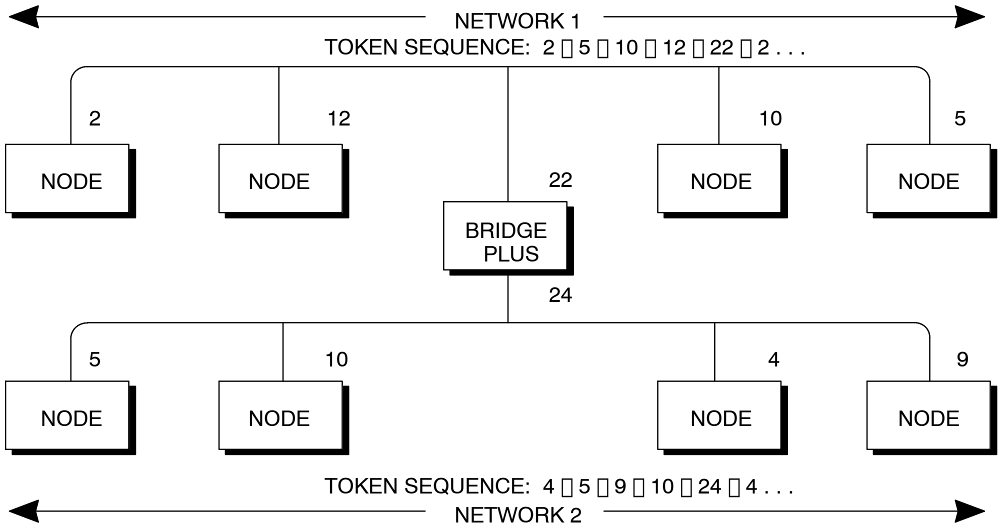


Figure 4 Token Rotation Sequence

1.4 Overview of the Physical Network

The network bus consists of twisted-pair shielded cable that is run in a direct path between successive nodes. The two data lines in the cable are not sensitive to polarity, however a standard wiring convention is followed in this guide to facilitate maintenance.

The network consists of one or more cable sections, with any section supporting up to 32 nodes at a maximum cable distance of 1500 ft (450 m). Sections can be joined by Repeaters to extend the network length and to support up to 64 nodes.

The minimum cable length between any pair of nodes must be at least 10 ft (3 m). The maximum cable length between two nodes is the same as the maximum section length of 1500 ft (450 m).

On dual-cable networks, the cables are known as cable A and cable B. Each cable can be up to 1500 ft (450 m) long, measured between the two extreme end devices on a cable section. The difference in length between cables A and B must not exceed 500 ft (150 m), measured between any pair of nodes on the cable section.

Nodes are connected to the cable by means of a tap device, supplied by Modicon. This provides *through* connections for the network trunk cable, *drop* connections for the cable to the node device, and a grounding terminal.

The tap also contains a resistive termination that is connected by two internal jumpers. The tap at each end of a cable section requires both of its jumpers to be connected to prevent signal reflections. All of the taps that are inline on the cable section require their jumpers to be removed (open).

Figure 5 illustrates a tap at an inline site. Two lengths of trunk cable are installed. When a tap is installed at the end site of a cable section, only one length of trunk cable is routed to the tap. It can enter at either side of the tap. The jumpers are connected to the signal pins at the opposite side of the tap to provide the network termination.

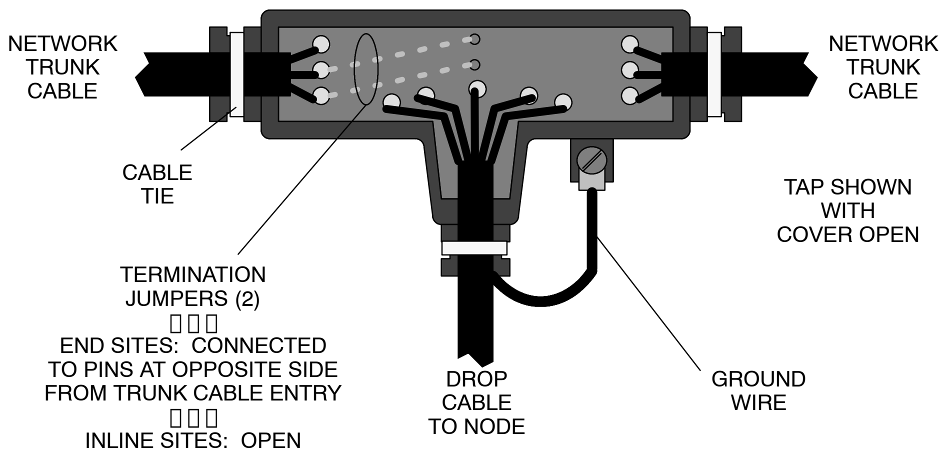


Figure 5 Cable Tap Layout

The next two figures summarize the layout for one section of a network.

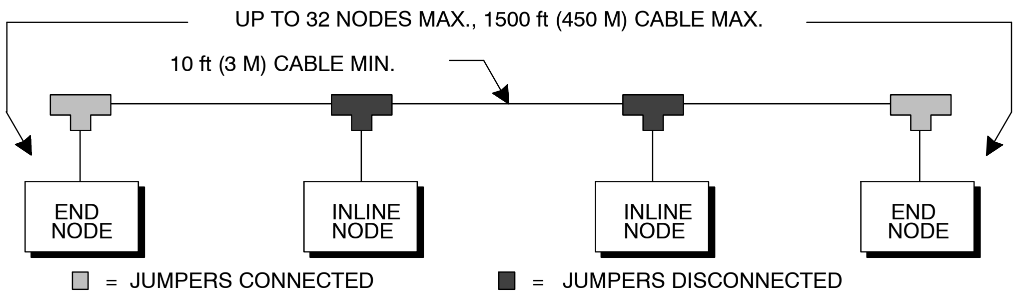


Figure 6 Section Physical Layout (Single Cable)

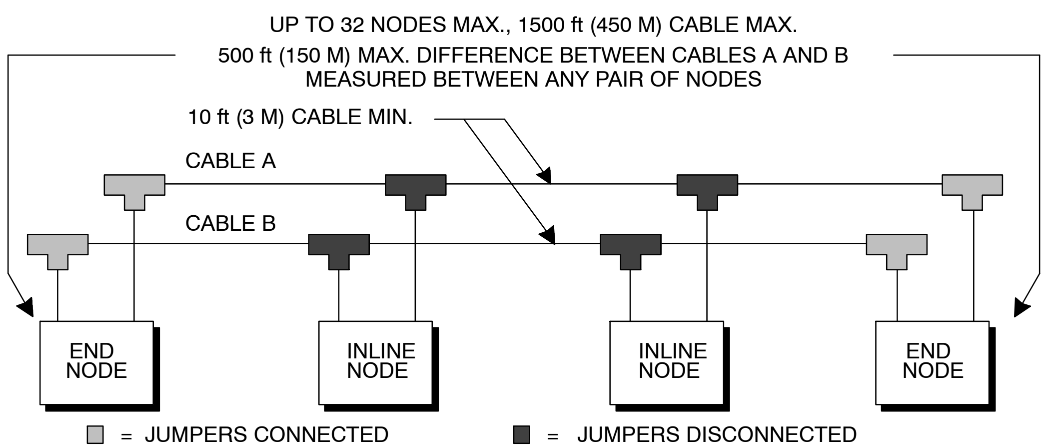


Figure 7 Section Physical Layout (Dual Cables)

1.5 Major Components of the Network

1.5.1 Programmable Controllers

Modicon controllers connect directly to the network bus cable through a dedicated Modbus Plus communication port that is located on the controller assembly. The port allows the controller to communicate with other networked controllers, host computers with network adapters, and DIO drops.

Controller models are available for single-cable and dual-cable network layouts. Contact your Modicon distributor for information about models and part numbers.

Each controller functions as a peer on the network, receiving and passing tokens and messages. The user application program can access registers in the local controller and in the other networked controllers.

Three types of communication are available to the application program for exchanging messages between networked nodes:

- The MSTR function block can be used for transferring, reading and clearing statistics, and accessing the network s global database. The MSTR is a general function for transacting messages with any type of networked node. It is programmed into the user logic program of the controller.

- Peer Cop transfers can be used to move data both globally and with specific nodes. Such transfers are specified in the controller s Peer Cop table during its initial configuration.

- Distributed I/O transfers can be used to move data with DIO Drop Adapter nodes. Such transfers are specified in the controller s DIO Map table during its initial configuration.

Hot Standby Configurations

When two controllers are connected in a redundant (hot standby) configuration, each controller is seen as a separate address on the network. This use of dual addressing allows both controllers to be fully accessed for programming and statistics. If a transfer occurs to the standby controller, the primary and standby addresses are exchanged, maintaining consistent addressing within the application.

Note: The address exchange can cause a momentary delay in communication with the new primary unit while it assumes its place in the network token rotation sequence. This can be a significant factor in the timing of processes using redundant controllers. The application should provide retry capabilities in the other nodes to cover this time.

1.5.2 Network Option Modules

The Network Option Module (NOM) mounts in the backplane with the controller. It allows the user application program, running in the controller, to communicate with an additional Modbus Plus network. The additional network can be configured with controllers, other NOMs, Distributed I/O nodes, or a combination of these devices. One or two NOMs can be mounted in the controller s housing. Power is taken from the power supply module which must also be installed in the housing.

Network Option Modules are available for single-cable and dual-cable network layouts. Contact your Modicon distributor for information about models and part numbers.

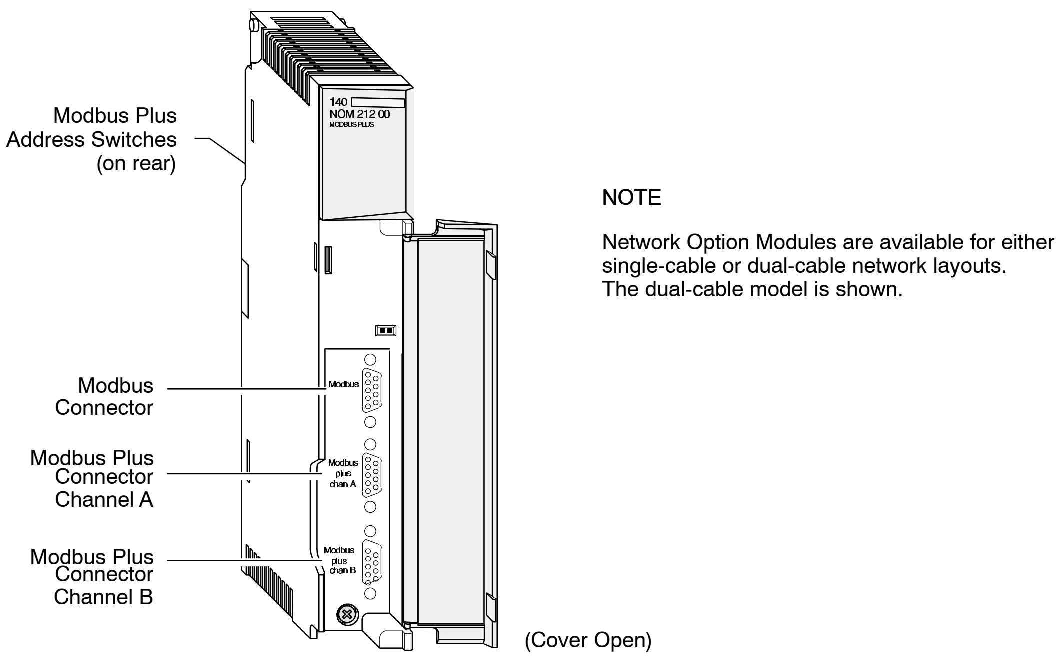


Figure 8 Network Option Module

1.5.3 DIO Drop Adapters

The DIO Drop Adapter mounts in a housing at a remote site, communicating over the housing backplane to the site s I/O modules to service the site s data requirements. The adapter includes a built-in power supply that provides operating power for the I/O modules.

DIO Adapters are available for single-cable and dual-cable network layouts. Contact your Modicon distributor for information about models and part numbers.

Figure 9 shows the front view of a typical DIO Drop Adapter. Specifications are provided in the *Quantum Automation Series Hardware Reference Guide.*

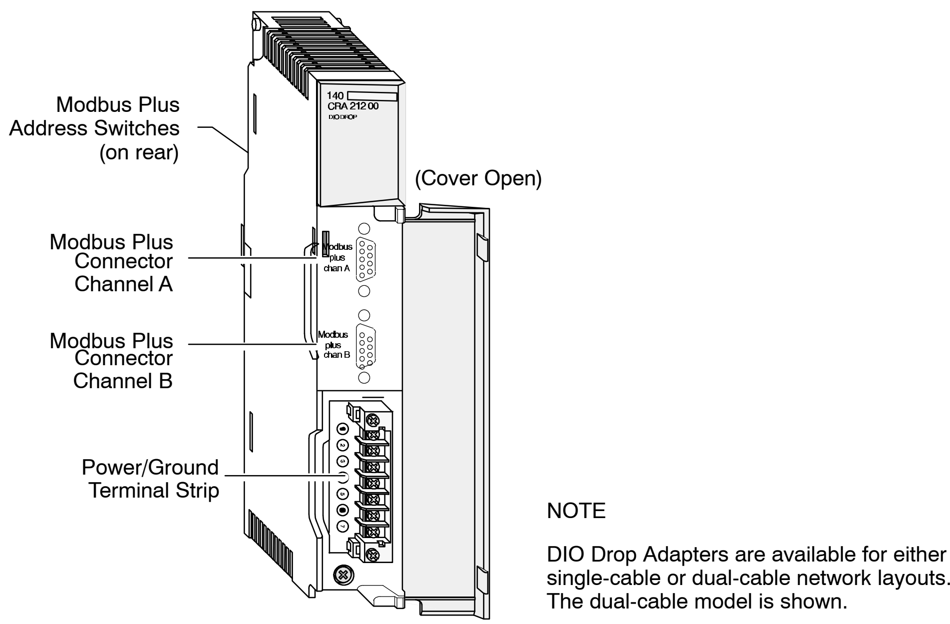


Figure 9 DIO Drop Adapter

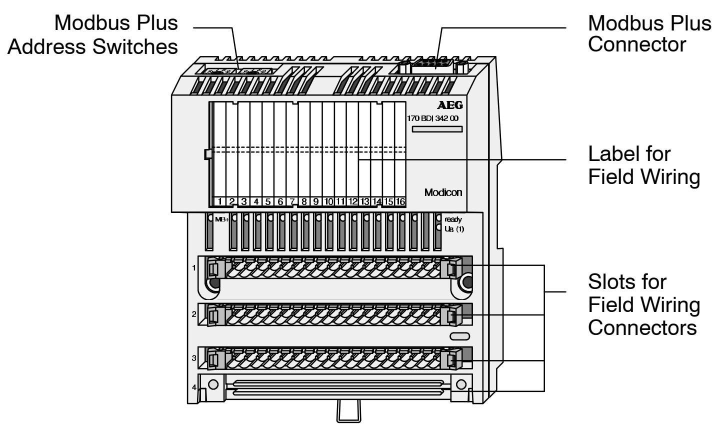
1.5.4 Available Backplanes for DIO Applications

Modicon backplanes are available in sizes from 2 ... 16 slots. The DIO Drop Adapter module occupies one slot, and contains a power supply that furnishes operating power to the housing for I/O modules. The supply s capacity is 3.0 A.

1.5.5 Terminal Block I/O (TIO) Modules

Remote sites can be serviced using Terminal Block (TIO) modules. These compact modules mount directly to a panel or DIN rail, and provide direct wiring connections to field devices at the site.
TIO modules are available for single-cable layouts only, and are not applicable for use in dual-cable layouts.

Figure 10 shows the front view of a typical TIO module. Specifications are in the *Terminal Block I/O Modules Hardware Reference Guide.*



NOTE

TIO modules are available for single-cable layouts only.

Figure 10 TIO Module

1.5.6 Network Adapters for Host Computers

Adapters are available for connecting host computers to the Modbus Plus network. The SA85 Network Adapter connects an IBM AT or compatible product to the network. The SM85 Network Adapter connects an IBM Personal System/2 or compatible product using a MicroChannel bus. The SQ85 connects a DEC MicroVAX II or 3000.

Figure 11 shows an example of the configuration of an SA85 adapter into an IBM AT-compatible host computer.

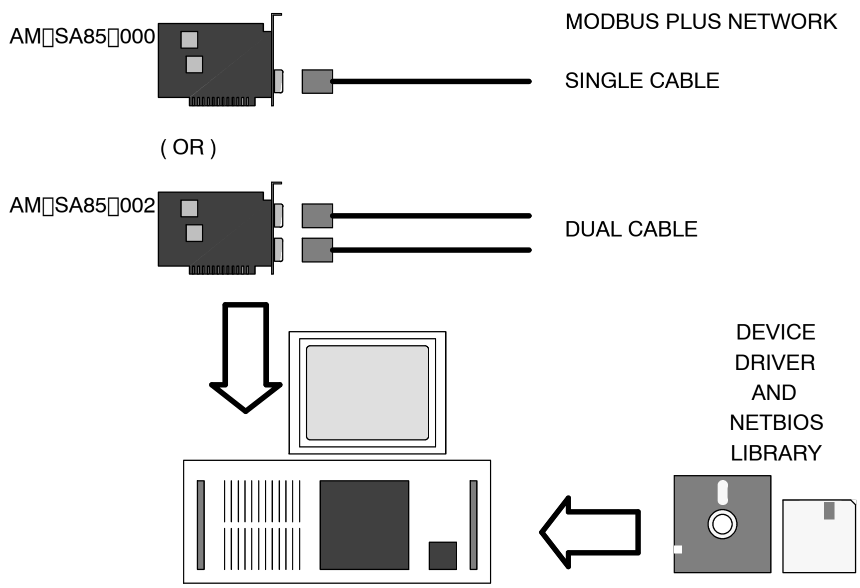


Figure 11 Example of the SA85 and Host Configuration

Adapters are supplied complete with the required device driver, a library of C functions that can be called by the application, a network diagnostic utility, and a set of sample programs. The Modbus Plus network cable connects to a communications port on the adapter.

The adapter s device driver responds to a library of NetBIOS functions that are called from the application program. These allow sending and receiving data packets, sending and receiving global data transactions, and monitoring status.

Applications running in the host computer can read and write references at other nodes. They can also program remote nodes and access the global database.

Typical network adapter applications include:

- □ User interfaces
- □ Control, monitoring, and reporting of remote processes
- □ Program load/record/verify operations
- □ Online programming
- □ Bridging between Modbus Plus and other networks
- □ Testing and debugging of application programs
- □ Running network diagnostic programs.

Modbus commands received from the Modbus Plus network that are addressed to the network adapter can be given to tasks running in the computer. Examples include:

- □ Running a data logging task in the host, accessed by other nodes on the network.
- □ Providing virtual registers for remote controllers.

Each adapter can be separately configured for its use of memory, interrupts, and other parameters. This allows flexibility in using multiple adapters in the same host computer. You can also apply the adapter as a bridge between Modbus Plus and other networks which may be present, including those which may also be using NetBIOS.

Information about installing the network adapters, setting their Modbus Plus parameters, and connecting them to the network, is supplied with the adapters.

1.5.7 BM85 Bridge Multiplexer

The BM85 Bridge Multiplexer provides connection to Modbus Plus for up to four kinds of serial devices. Four BM85 models are available. Two of these connect Modbus devices, or networks of Modbus devices, to the Modbus Plus network. Each of the Modbus ports can be separately configured to support a Modbus master device, slave device, or network of slave devices. Port parameters are also separately configurable.

Two other BM85 models are available for user-defined RS232 or RS485 serial devices. They include a library of C language functions for creating a user application program.

Bridge Multiplexers are available for single-cable and dual-cable network layouts. Contact your Modicon distributor for information about models and part numbers.

1.5.8 BP85 Bridge Plus

The BP85 Bridge Plus allows you to connect two Modbus Plus networks. The routing information in each message allows a node on one network to communicate through the Bridge Plus to a destination node on another network. Up to four bridges can be present in the message path between the source and destination nodes. You can therefore join up to five Modbus Plus networks along a linear path, with any node being able to communicate with any other node.

Bridge Plus devices are not applicable to Modbus Plus DIO networks because those networks transfer data messages as part of the token pass. Tokens are not passed through the Bridge Plus.

Note that the Bridge Plus may still be placed on a DIO network to allow non-DIO messages to be passed to another network. For example, statistical reporting can be handled between a controller on the DIO link and a network adapter in a host processor on another network.

The Bridge Plus contains two ports, for connection to its two networks. It functions as an addressable node on each of the two networks it joins. It contains two sets of address switches, for setting its node address on each network. The two addresses can be set to the same value, or to different values, as they are independent of each other.

Bridge Plus models are available for single-cable and dual-cable network layouts. Contact your Modicon distributor for information about models and part numbers.

1.5.9 RR85 Repeater

The RR85 Repeater allows you to place more than 32 nodes on the network and to increase the cable distance up to an additional 1500 ft (450 m). It functions as an amplifier and signal conditioner to maintain adequate signal levels between its two sections of the network. Up to three Repeaters may be present in the message path between the source and destination nodes. You can therefore join up to four sections along a single linear path. Other configurations are possible and are described later in this chapter.

Contact your Modicon distributor for information about models and part numbers.

In addition to its use in extending the network, the Repeater can be applied in plant environments that have high levels of electrical interference. Repeaters at key points in the cable system can help to maintain an excellent signal to noise ratio on the network.

The Repeater is provided with two ports for connection to the two sections. It is counted as a physical node on each section. The Repeater does not have a network address. It transparently passes tokens and messages as they are received.

When Repeaters are used in dual-cable network layouts, one Repeater must be positioned on each cable at the same point (between the same pair of nodes) as on the other cable. Information is supplied in this guidebook for installing Repeaters.

1.6 How Nodes Access the Network

1.6.1 How Your Application's Layout Affects Node Access

When the network is initialized, each node becomes aware of the other active nodes. Each node builds a table identifying the other nodes. Initial ownership of the token is established, and a token rotation sequence begins. Your choice between laying out your application as one large network, or as several smaller networks, affects the timing of the complete token rotation.

For example, tokens are not passed through Bridge Plus nodes, although messages can be addressed through Bridge Plus nodes to destination nodes. You can therefore construct your networking application as several smaller networks, joined by Bridge Plus nodes. The fast token rotation time in each small network allows rapid transfer of high-priority data, with lower-priority data passing through bridges to other networks. This facilitates time-critical messaging to nodes that are tightly linked in an application.

1.6.2 The Token Rotation Sequence

The token sequence is determined by the node addresses. Token rotation begins at the network's lowest-addressed active node, proceeding consecutively through each higher-addressed node, until the highest-addressed active node receives the token. That node then passes the token to the lowest one to begin a new rotation.

If a node leaves the network, a new token-passing sequence will be established to bypass it, typically within 100 milliseconds. If a new node joins, it will be included in the address sequence, typically within 5 seconds (worst-case time is 15 seconds). The process of deleting and adding nodes is transparent to the user application.

Where multiple networks are joined by bridges, tokens are not passed through a bridge device from one network to another. Each network performs its token passing process independently of the other networks.

1.6.3 Point to Point Message Transactions

While a node holds the token, it sends its application messages if it has any to transmit. Each message can contain up to 100 controller registers (16-bit words) of data. The other nodes monitor the network for incoming messages.

When a node receives a message, it sends an immediate acknowledgment to the originating node. If the message is a request for data, the receiving node will begin assembling the requested data into a reply message. When the message is ready, it will be transmitted to the requestor when the node receives a subsequent token granting it access to transmit.

Nodes can also transact messages containing local and remote operating statistics. These include information such as identification of active nodes, current software version, network activity, and error reporting. If a node transmits a request to read statistics in another node, the entire transaction is completed while the originating node holds the token. The remote node's statistics are imbedded in its acknowledgement. It is not necessary for the remote node to acquire the token to transmit the statistics.

After a node sends all of its messages, it passes the token on to the next node. Protocols for token passing and messaging are transparent to the user application.

1.6.4 Global Database Transactions

When a node passes the token, it can broadcast up to 32 words (16 bits each) of global information to all other nodes on the network. The information is contained in the token frame. The process of sending global data when transmitting the token is controlled independently by the application program in each node.

The global data is accessible to the application programs at the other nodes on the same network. Each node maintains a table of global data sent by every other node on the network. Although only one node accepts the token pass, all nodes monitor the token transmission and read its contents. All nodes receive and store the global data into the table.

The table contains separate areas of storage for each node's global data. Each node's application program can selectively use the global data from specific nodes, while other applications can ignore the data. Each node's application determines when and how to use the global data.

Global database applications include time synchronization, rapid notification of alarm conditions, and multicasting of setpoint values and constants to all devices in a common process. This allows uniform and rapid transmission of global data without having to assemble and transmit separate messages to the individual devices.

Access to a network s global database is available only to the nodes on that network, because the token is not passed through bridge devices to other networks. The user s application can determine which data items are useful to nodes on a remote network, and forward them as necessary.

1.7 Error Checking and Recovery

When a node sends a data message, it expects an immediate acknowledgment of receipt by the destination. If none is received, the node will attempt up to two retries of the message. If the final retry is unsuccessful, the node sets an error which can be sensed by the application program.

If a node detects a valid transmission from another node using the same address, the node becomes silent and sets an error which can be sensed by the application. The node will remain silent as long as the duplicate node continues to participate in the token rotation. If two devices have been inadvertently assigned the same address, the application program can detect the duplication and handle it while the rest of the application continues.

When a node transmits the token, it monitors the network for new activity from its successor. If the node detects no valid activity, it makes one retry to pass the token. If no activity is detected after the retry, the node remains silent. This causes the network to be initialized and a new token sequence to be created.

1.8 Designing for Process Speed

Figure 12 is an example of a hierarchical approach using Bridge Plus devices. The application uses a relatively large count of nodes, but no network contains more than six nodes.

Token access and message handling can be rapid within the networks that are used for the control of time-critical processes. For example, the node count on a given network can be reduced to the minimum that is required for that portion of the application. Node counts on other less-critical networks can be increased.

Message transactions across the bridges are slower than in single networks, because the rotation times of the multiple networks are a factor in receiving data responses from destinations. Because of this, internetwork traffic should be dedicated to transactions that are less critical for timing, such as for data collection and program downloading.

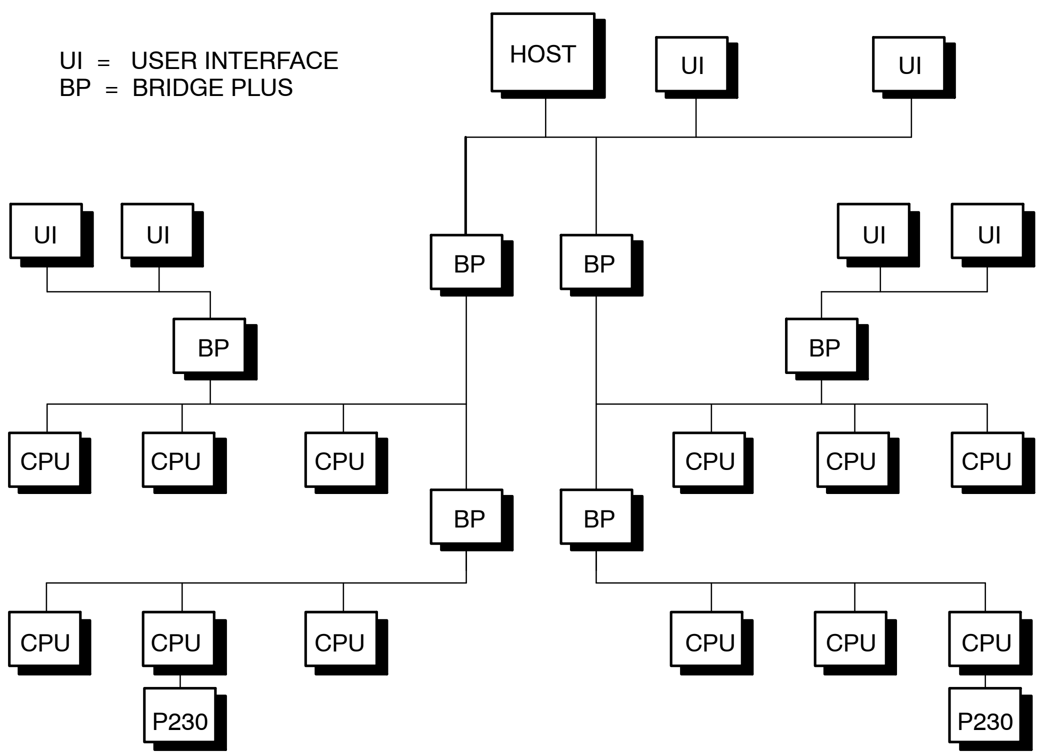


Figure 12 Hierarchical Configuration for Improved Throughput

1.9 Designing for Deterministic I/O Servicing

Figure 13 illustrates a network designed for deterministic timing of I/O processes. The I/O network consists only of the CPU and I/O drops. A User Interface (UI) device is connected to a separate network at the NOM port.

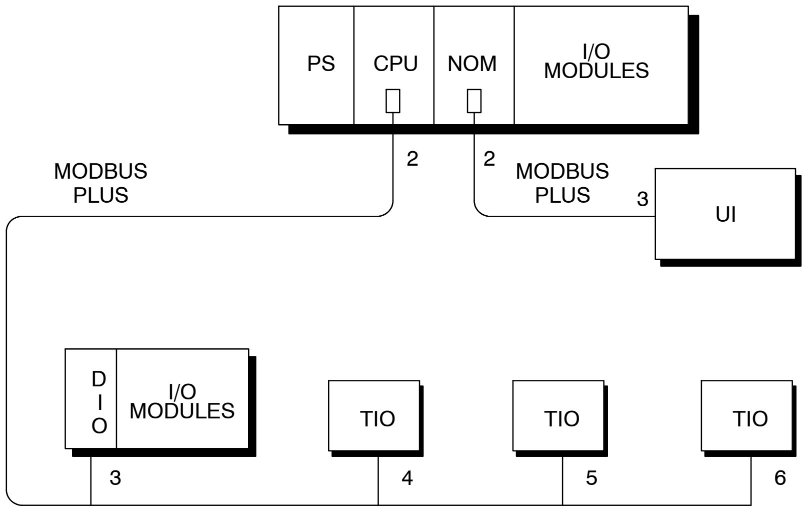


Figure 13 Network for Deterministic I/O Timing

For truly deterministic timing of I/O servicing, reserve the CPU s network for the nodes used in I/O servicing only. If you require a User Interface or other non-I/O device in your application, connect it to a separate network at a NOM port.

Guidelines for designing networks for servicing I/O processes, with estimates of network performance, are provided in the *Modbus Plus Network I/O Servicing Guide.*

1.10 Using Peer Cop

1.10.1 Peer Cop Transactions

Point to point data can be transacted while a node holds the token and during its token pass with Modbus Plus Peer Cop. Up to 500 words (16 bits each) can be directed to specific data references in node devices prior to release of the token, and up to 32 words can be globally broadcast to all nodes as part of the token frame.

Because all nodes monitor the network, each node can extract data that is specifically addressed to that node. All nodes detect the token pass, and can extract global data messages from the token frame. Defined data references (like controller discretes or registers) are used as sources and destinations. For example, a block of registers can be the data source at the transmitting node, and the same block or another block can be the data destination in the receiving node.

The delivery of Peer Cop data to destination nodes is independent of the next address used in the token pass. The token is always passed to the next node in the network s address sequence. The token frame, however, can contain Peer Cop global messages that are unrelated to the next address and which are globally broadcast to all nodes.

Each node is configured through its Modicon panel software to handle Peer Cop data transactions. Nodes must be specifically configured to send and receive the data. Nodes which have not been configured for Peer Cop will ignore the data transactions.

Sending Data

Nodes can be configured to send two kinds of Peer Cop data:

☐ **Global Output** Up to 32 words of data can be broadcast globally from each node to all nodes. Source data references are specified in the node configuration.

☐ **Specific Output** Up to 32 words of data can be transmitted to any specific node. Multiple node destinations can be specified, up to the maximum of 500 data words. Any nodes on the network can be specifically addressed as destinations. A unique block of references can be specified as the data source for each targeted node.

Receiving Data

Nodes can be configured to receive two kinds of Peer Cop data:

- **Global Input** Up to 32 words of global data can be received by each node from each other node on the network. Destination references are specified in the receiving node s configuration. Up to eight blocks of references can be specified, giving up to eight separate destinations for the data received from each source node. The incoming data can be indexed to establish the starting point and length of each block of data to be extracted from the message and delivered to each destination.

- **Specific Input** Up to 32 words of data can be received from any specific node. Each node on the network can be specifically defined as a data source, up to the maximum of 500 data words.

The net effect of using Peer Cop for data transactions is that each sending node can specify unique references as data sources, and each receiving node can specify the same or different references as data destinations. When receiving global data, each node can index to specific locations in the incoming data and extract specific lengths of data from those points. Data is thus transacted rapidly as part of each token pass, and can be directly mapped between data references in the sending and receiving nodes.

Applications can be designed in which alarms and setpoints are transmitted (globally), with required actions by specific nodes also defined (specifically). Because all nodes detect the token passes, Peer Cop global data can be rapidly known to all nodes, with each node s specific data requirements also rapidly known to just that node.

Because Peer Cop data is transacted as part of the token pass, it applies to each network independently of any other networks that are part of the Modbus Plus system. Tokens are not exchanged between networks, because they are not passed through Bridge Plus devices. Each network maintains its own Peer Cop database, with its own system of global broadcasting and specific node addressing.

1.10.2 A Peer Cop Example

Figure 14 shows a network with three nodes that are handling Peer Cop data transfers. Other nodes are also present elsewhere on the network.

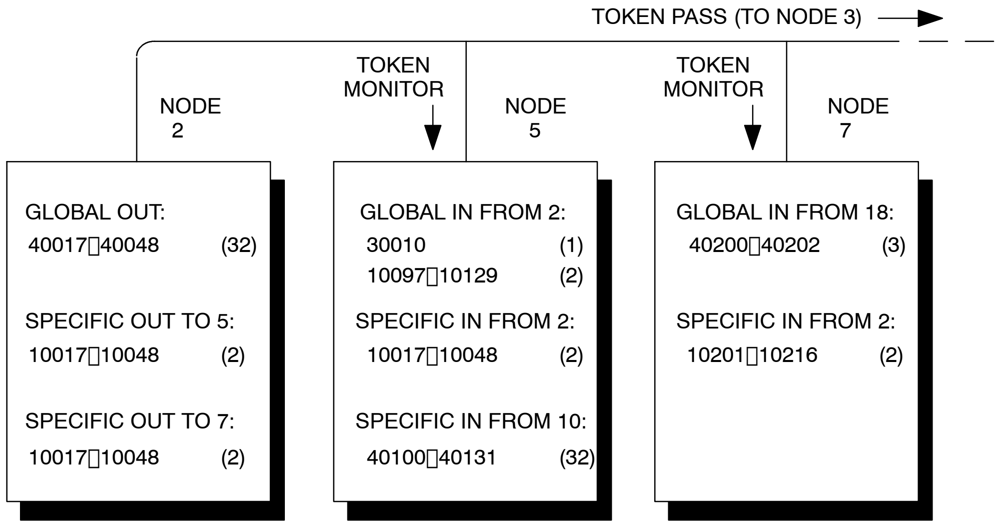


Figure 14 Peer Cop Example

Node 2 currently holds the token and passes it to the next addressed node (node 3). Nodes 5 and 7 monitor the pass and extract data as they have been configured to do.

Node 2 transmits two words of Specific Output for node 5 from its references 10017 ... 10048 (32 bits of discrete reference data, a total of two 16-bit words). It also transmits these same references as Specific Output for node 7. In the token frame, node 2 transmits 32 words of Global Output from its references 40017 ... 40048.

Node 5 has been configured to receive Global Input from node 2. It places one word into its reference 30010, and two words (32 discretes) into references 10097 ... 10129. Node 5 indexes into the 32 words of data and maps its 3 words into these references. Node 5 has also been configured to receive Specific Input from node 2, and places it into references 10017 ... 10048. Note that the application uses identical references for this data in nodes 2 and 5. The references could have been different if required.

Node 7 has not been configured to receive Global Input from node 2, and ignores it. The node receives Specific Input and maps it to its references 10201 ... 10216.

Other References Ignored Node 5 is also configured to receive Specific Input from node 10, and node 7 is configured to receive Global Input from node 18. These other references are not involved in the transactions from node 2. Nodes 5 and 7 could also be configured to make output transactions when they pass the token.

1.1 1 Expanding the Network

1.1 1.1 Linear Expansion

The simplest network configuration consists of two or more nodes connected to a single section. Figure 15 shows four nodes connected in a basic dual-cable configuration.

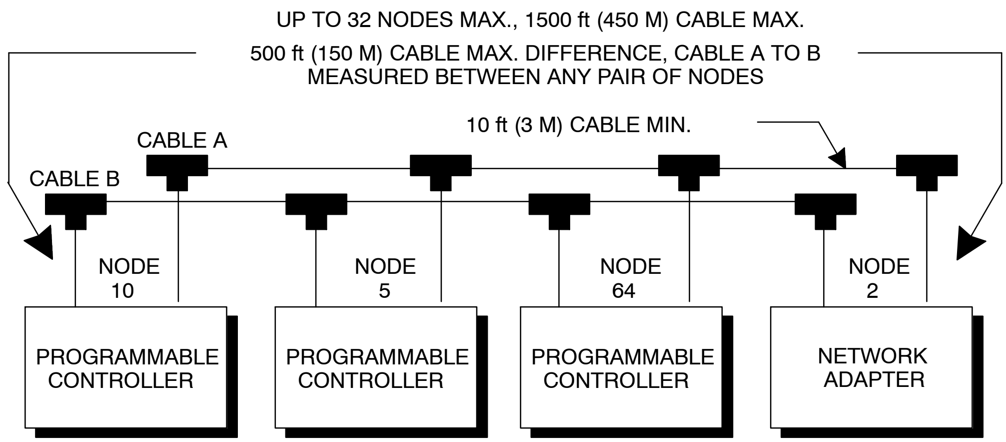


Figure 15 Basic Configuration Example

The basic configuration in Figure 15 will satisfy the network requirements if all of the following specifications are met:

- ☐ Not more than 32 nodes are connected to the network cable
- ☐ The total end-to-end length of each network cable is 1500 ft (450 m) or less
- ☐ The difference in length between cables A and B is 500 ft (150 m) or less, between any pair of nodes
- ☐ The length of each cable segment (between a pair of nodes) is 10 ft (3 m) or more
- ☐ The proper type of impedance termination is used at each node site (tap's internal jumpers removed at inline sites, and installed at end sites).

1.1 1.2 Using RR85 Repeaters

If your network requires more than 1500 ft (450 m) of cable, or more than 32 nodes, you can install RR85 Repeaters to expand the network. The repeaters must be sited so that no single section of the network exceeds the maximum length of 1500 ft (450 m) of cable, and no single section contains more than 32 nodes.

Up to three repeaters can be present in the cable path between any two nodes that will communicate with each other. As each cable section can be up to 1500 ft (450 m) in length, and you can have up to three repeaters between a pair of nodes, the maximum length between any pair of nodes in a linear configuration will be 6000 ft (1800 m).

Figure 16 shows the maximum linear configuration using RR85 Repeaters.

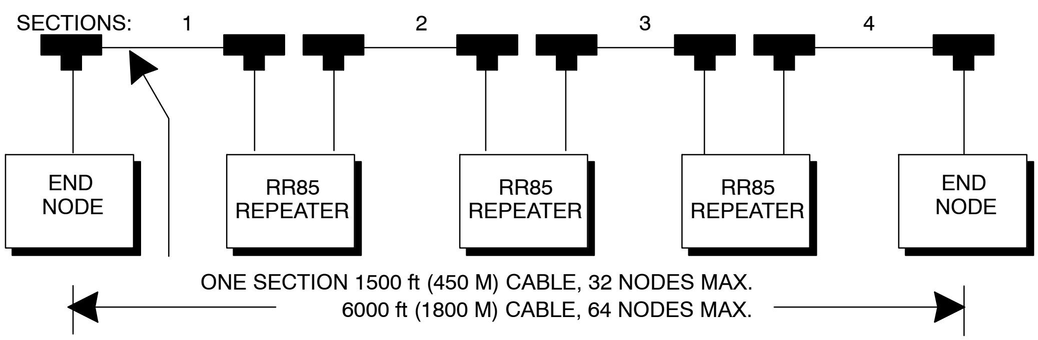


Figure 16 Maximum Linear Configuration of a Single Network

1.1 1.3 Expanding Dual-cable Networks

On dual-cable networks, repeaters must be placed between the same node devices, maintaining a logical symmetry to the two cable paths. Figure 17 illustrates this.

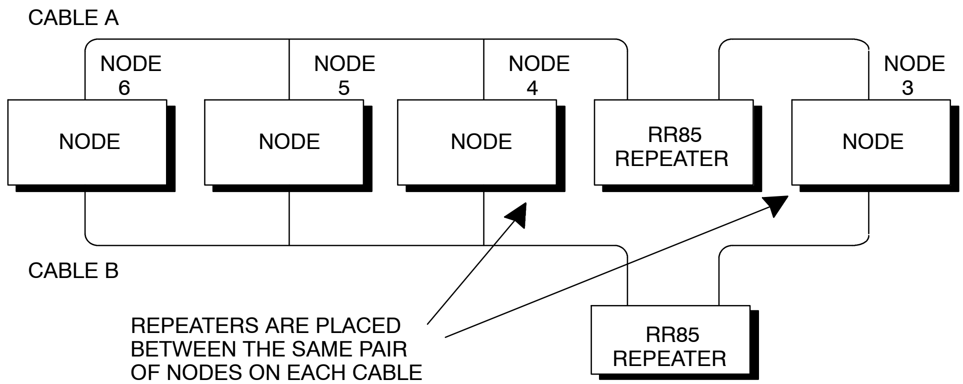


Figure 17 Placing Repeaters on Dual-cable Networks

This configuration is proper because the two repeaters are placed between the same nodes. Placing a repeater on one path, without a repeater at the corresponding point on the other path, is not a proper configuration. Note that the two physical cable lengths can be different, provided the logical symmetry of the network is maintained.

1.1 1.4 Non-Linear Expansion

You can connect RR85 Repeaters to create multiple paths, so long as each section is run along a linear path (no branches to the cable). In effect, you can use RR85 Repeaters to create the equivalent of *star* or *tree* configurations. This can be useful where a linear configuration may not be practical due to the layout of your plant facility.

Figure 18 shows an example of non-linear network expansion using RR85 Repeaters. This is a legal configuration because it satisfies the network requirements:

- Not more than 32 nodes are present on any single section
- Each section is a linear cable path of 1500 ft (450 m) or less
- Not more than three RR85 Repeaters are present in the cable path between any pair of nodes.

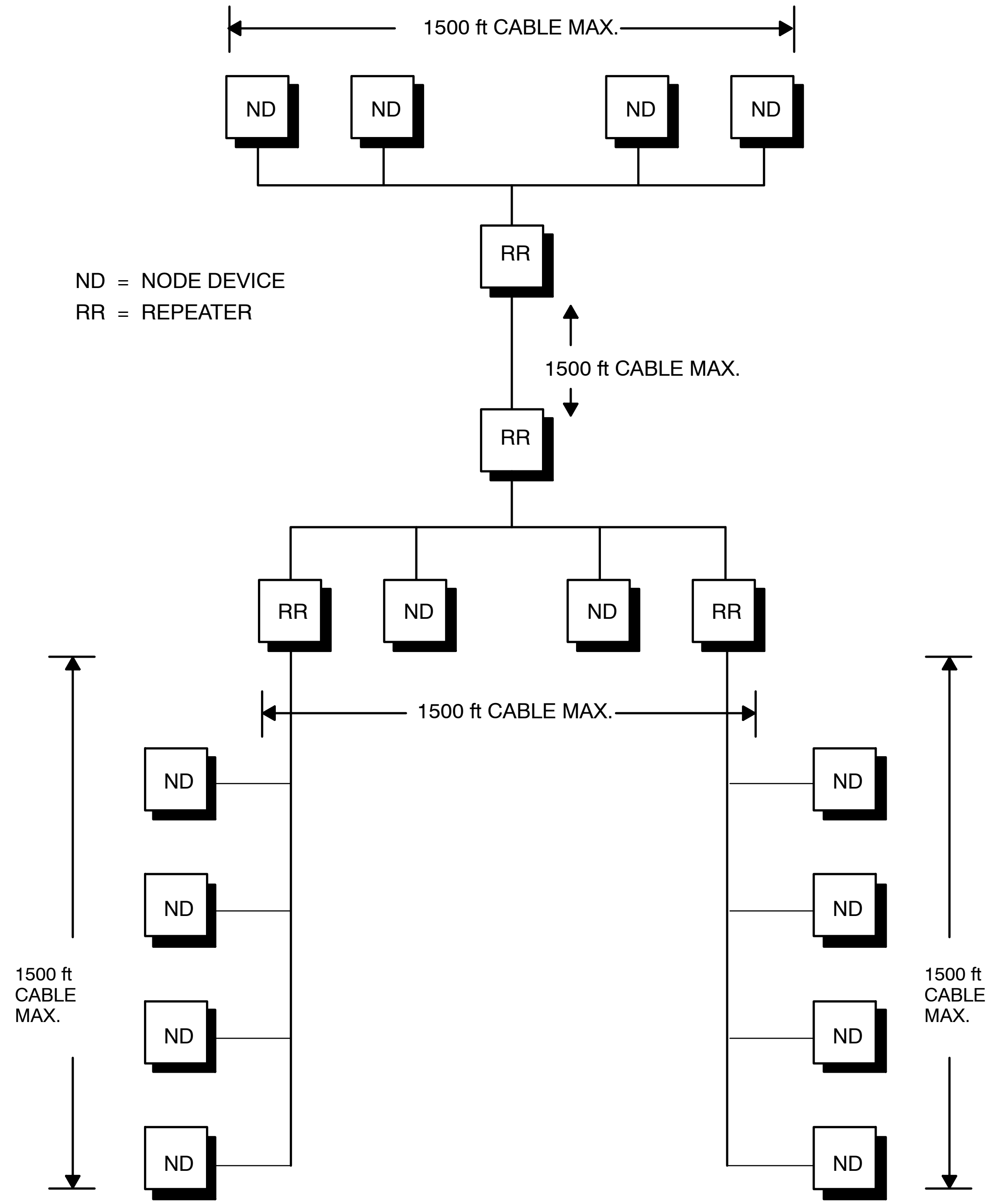


Figure 18 Non-Linear Expansion

1.12 Joining Modbus Plus Networks

1.12.1 How the Bridge Plus Operates

The BP85 Bridge Plus device connects as a node on each of two Modbus Plus networks. The Bridge operates as an independent node on each network, receiving and passing tokens according to each network s address sequence. Bridge Plus devices are not applicable to networks used for Distributed I/O applications.

Figure 19 shows three networks (A, B, and C) joined by a pair of Bridge Plus devices. The figure shows a single-cable network for simplicity. The Bridge Plus also supports dual-cable layouts. One Bridge appears on network A at node address 22, and on network B at node 25. The other Bridge is on network B at node 20, and on network C at node 20. Note that each Bridge s two network addresses are entirely separate, and can be set uniquely for each network.

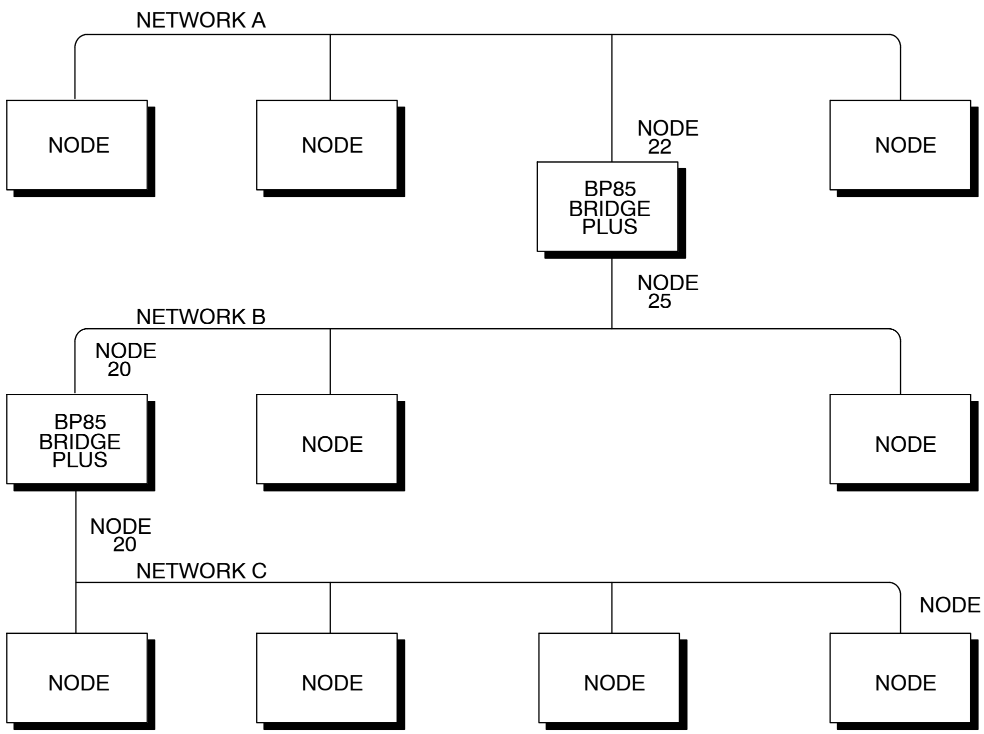


Figure 19 Message Routing Through Multiple Networks

If a data message intended for a remote node is received at one of the Bridge s ports, the Bridge stores the message, and then forwards it to a node address on the next network as soon as it has received the token to transmit on that network.

Each message frame contains routing information that allows it to be passed through successive Bridges to a final destination node on a remote network. The routing path is specified when the message is created by the user s application program. Messages can be routed to a final destination up to four networks away from the originating node. Figure 20 shows an example of the routing path field in a typical message frame.

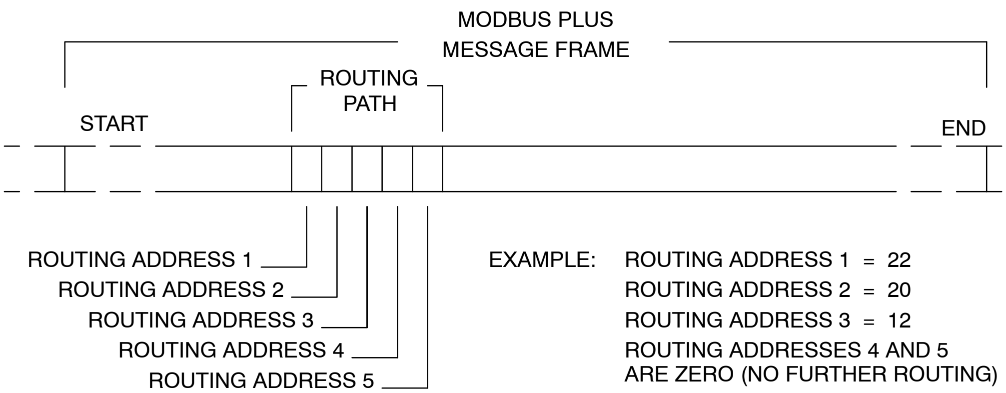


Figure 20 Message Frame Routing Path Field

The examples in Figure 19 and Figure 20 illustrate routing through three networks. If a message originates at node 5 on network A, and is intended for node address 12 on network C, the message will be forwarded as described below.

- The first routing address contains the Bridge address (22) on the originating node s network. The message will be sent to this Bridge by the originating station.
- The second routing address contains the Bridge address (20) on the next network. Note that the first Bridge is at node 25 on this network. When node 25 acquires the token, the message will be forwarded from node 25 to node 20.
- The third routing address contains the address of the destination node (12) on the final network. The rest of the routing path field will contain zeros, indicating that no further forwarding is needed.

When the first Bridge (22) receives the original message, it examines the routing field and determines that routing is required to its other network port (the next address in the field is not a zero). The Bridge removes its address from the routing field, shifting the remaining addresses in the field one place to the left and zero-filling the field from the right. This places the next routing address (20) into position 1 of the field. When the Bridge receives the token to transmit on network B, it passes the message to node address (20) on that network.

The second Bridge (20) processes the message in the same manner, removing its own address from the routing field and shifting the remaining addresses one place to the left. Node 12 becomes the final destination, as all the remaining contents of the field are now zeros. When the token is received, the Bridge sends the message to node 12.

1.12.2 Using the Bridge Plus

Although adding many nodes to one network is a legal configuration, you might find that message throughput is unacceptably slow due to the time required for passing the token. By organizing your application into more compact groups of nodes, you can improve throughput.

Figure 21 shows a basic hierarchical approach using Bridge Plus devices. With this approach, separate networks contain the devices that must communicate rapidly in an industrial process. Bridge Plus devices join the networks to provide process information and supervisory control.

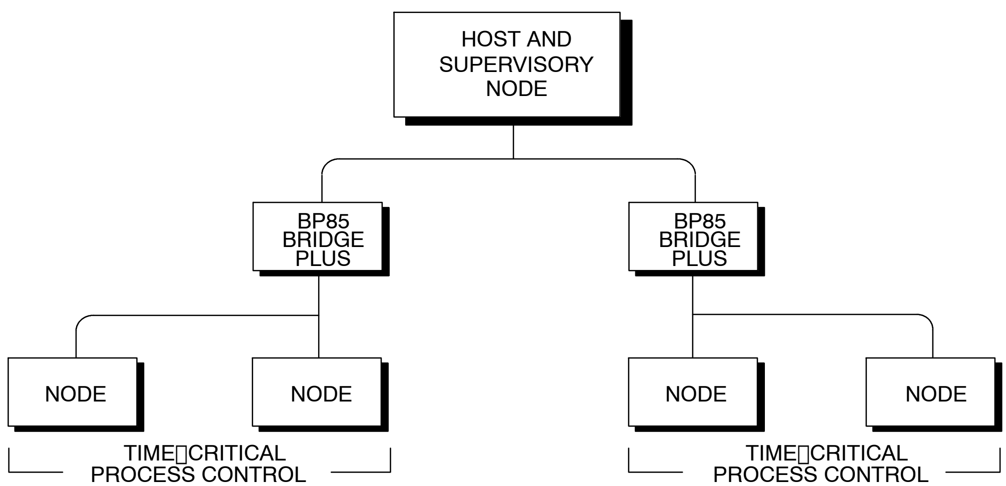


Figure 21 Basic Hierarchical Configuration

The types of devices used in your application determine how many Modbus Plus networks you can join.

- You can address a programmable controller destination on a remote network that is up to four networks away from the originating node (that is, with four bridges in the message path).
- Host-based network adapters can be addressed up to three networks away (through three bridges).
- A single Modbus slave device at a Bridge Multiplexer port can also be addressed up to three networks away. A slave device that is part of a Modbus network at a Bridge Multiplexer port can be addressed up to two networks away (through two bridges).

1.13 Bridging Modbus Plus and Serial Devices

1.13.1 How the Bridge Multiplexer Operates

The BM85 Bridge Multiplexer device operates as a standard Modbus Plus node, receiving and passing tokens in the network s address sequence. It provides four serial port connections to allow Modbus Plus nodes to communicate with serial devices. BM85 models are available for support of Modbus, RS232, and RS485 serial devices.

1.13.2 Modbus Configurations

Each Modbus port can be configured to support a master device, slave device, or a network of up to 32 slave devices. Selection of ASCII or RTU mode, baud rate, parity, stop bits, link timeout value, and function code conversion is also configurable.

Figure 22 illustrates four types of Modbus devices connected to a Bridge Multiplexer.

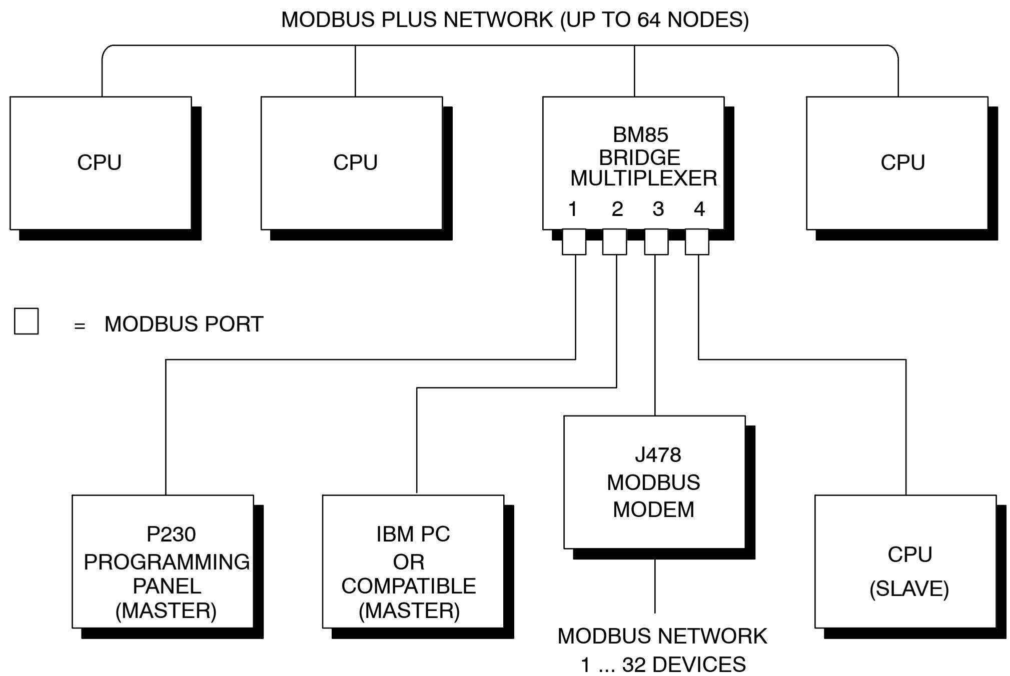


Figure 22 Modbus Devices Multiplexed to Modbus Plus

Modbus master devices connected to the Bridge Multiplexer can access any controller node on the Modbus Plus network, including nodes on remote networks through Bridge Plus devices. A master device can also access a slave device connected to another port on the local Bridge Multiplexer, or one connected to a remote Bridge Multiplexer node on Modbus Plus.

Modbus slave devices can be accessed by a master at the local Bridge Multiplexer, or by a master at a remote Bridge Multiplexer node, or by program functions in your Modbus Plus application.

For example, in Figure 22 the Modbus master devices connected to ports 1 and 2 of the Bridge Multiplexer can attach to: (a) any controller on the Modbus Plus network; (b) any slave device on the modem network at port 3; or (c) the slave controller at port 4. Application program function blocks in the controllers on Modbus Plus can access: (a) the slave devices on the modem network at port 3; and (b) the controller at port 4. Each Modbus port can be configured for the communication mode (ASCII / RTU) and parameters suitable for its port devices.

1.13.3 Modbus Port Mapping

Each Modbus port has an address mapping table that allows messages and commands received at the port to be routed as needed. The table converts the Modbus address in the message to a routing path, allowing it to be routed to a device on the local Modbus Plus network, to a device on another Modbus Plus network, or to a device at another Modbus port. The mapping table allows the devices to be uniquely addressed, even when two or more ports have devices using the same Modbus address.

For example, in Figure 23 both ports 1 and 3 have networks of Modbus slave devices. Devices on the two networks can have the same addresses. Commands or messages originated at the controllers on Modbus Plus can be routed to a unique device on either of the two Modbus networks. Similarly, the Modbus master device at port 2 can attach to a unique device on either network.

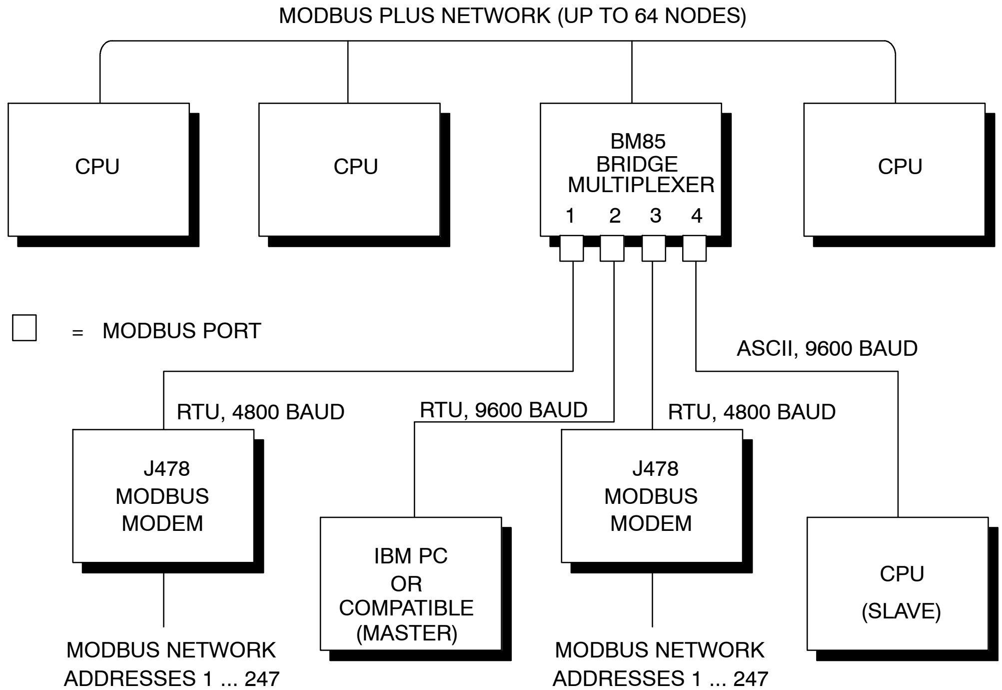


Figure 23 Unique Device Addressing and Parameters

If a Modbus Plus networked controller or Modbus master device needs to perform a lengthy command sequence to one of the Modbus networked devices, the Bridge Multiplexer can acknowledge the command and then handle it locally at the Modbus port. The Bridge Multiplexer will perform a polling process with the destination device and return a final response when the command action has been completed. This frees the network at the port for further transactions with other devices in the application.

1.13.4 RS232 and RS485 Configurations

Two BM85 models can be programmed by the user to support custom RS232 or RS485 applications. Both of the models can be downloaded with a user application image across Modbus Plus.

The user creates the application program on an IBM PC/AT compatible, using software development tools supplied with the BM85. These require the use of a Borland C/C++ development environment which must be supplied by the user.

The application can then be downloaded using a utility supplied with the development tools. The download host can be connected to Modbus Plus by a Modicon SA85 (ISA/AT bus) or SM85 (Microchannel bus) network adapter.

The download image contains all of the internal operating code to be used in the BM85. It provides the protocols for the serial devices to establish communication with other devices: handshaking, protocol translation, packaging of messages, buffer space, data conversion, and error handling.

The image can contain all of the serial port parameters (for example, baud rates and parity) as fixed parameters. The image could also provide a local protocol (default parameters and a menuing system) for the user to locally configure the parameters through a terminal at one of the serial ports.

The BM85 can operate as a fully-programmed Modbus Plus coprocessor in the user application. It can locally manage processes at its serial ports, initiating or responding to Modbus Plus nodes as needed for higher-level status reporting and control. Library functions are provided for creating multiple tasks within the BM85 s application program, and for assigning and arbitrating the tasks.

The BM85 application development tools include:

- A Borland C/C++ run-time startup routine
- An object library of BM85 utility routines, including functions for managing multiple tasks within the BM85 application
- A Modbus Plus data transfer utility routine
- A header file containing function prototypes
- A compiled demonstration program, with source code, showing examples of the use of functions in a typical application
- Test utilities, including source code, that exercise BM85 hardware
- The download utility for loading the application to the BM85.

The software development tools are supplied on both 3.5-inch and 5.25-inch high-density diskettes.

Figure 24 summarizes the layout of port devices in a typical BM85 user-programmed application.

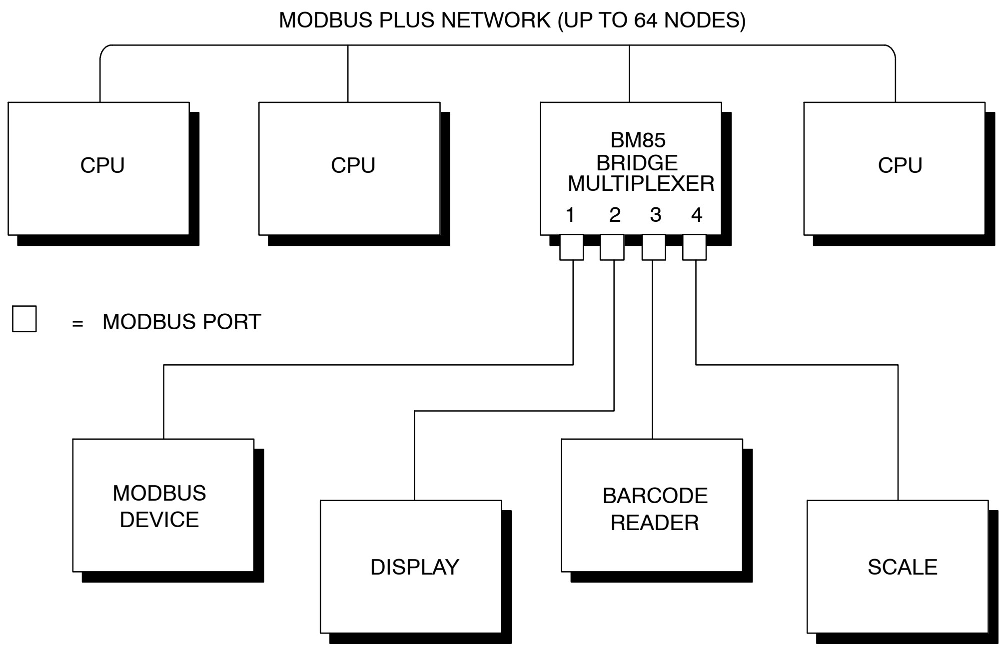


Figure 24 User-programmed BM85 Application

As shown in the figure, a Modbus master or slave device could also be attached at a serial port if the user-defined code in the BM85 included a Modbus protocol handler.

Chapter 2 Elements of Network Planning

- An Overview of Network Planning
- Defining the Network Components
- Defining the Network Layout

2.1 An Overview of Network Planning

You should consider the following factors in the layout of your Modbus Plus network:

- You can design your control system from a wide range of controller performance features. You can choose your system layout from many variations in distributed control, local and remote input/output systems, and user interfaces. A major factor determining your Modbus Plus networking requirement will be your definition of the types, quantities, and site locations of the programmable control components required for your application.
- Planning of your overall programmable control system is beyond the scope of this document. For further information refer to the books for Modicon controllers listed in the *Related Publications* section in the front of this book.
- If you intend that your network will primarily service I/O processes, you should refer to the *Modbus Plus Network I/O Servicing Guide* for further information to assist you in your design. That book gives guidelines and performance estimates for those kinds of applications.
- Typically, you will be defining the site locations of your system components according to your process flow and work cell layout. Your network design should support your requirements for the transfer of information between those processes. Your design should also accommodate any host or supervisory computer involved in the job of monitoring the process activity, loading configuration and recipe files, retrieving statistics, and providing reports.
- Your network layout should provide ready access for debugging your application and for future maintenance. Plan to include extra inline taps and drop cables at convenient points. You will be able to use them for connecting a device to monitor the network activity and collect statistics, without having to disconnect some active device. This service access will also allow you to temporarily connect, test, and debug future devices as you expand your networking application.

Your planning should include preparation of documents that describe the network plan. These should support ordering of materials, installation of the network, and future maintenance. Worksheet examples are provided in this guidebook. You ll also find blank worksheets. You can make photocopies of them for use in documenting your network.

2.1.1 Preparing a Network Plan

This chapter provides a focus for planning your Modbus Plus network requirements and layout. Planning elements include:

- ☐ Defining the network media components. These include the network trunk cable, taps, and drop cables.
- ☐ Defining the network layout. This includes defining environmental requirements, estimating cable run and cut lengths, and providing access for future maintenance.
- ☐ Defining the network device setup parameters. Certain kinds of devices require a network node address and other parameters to be set in hardware switches or in a software configuration. Your planning should include defining the specific setup parameters for each networked device.

Network devices requiring the specification of setup parameters include:

- ☐ **Programmable Controllers** You must define each controller s network node address. If you will use its Modbus to Modbus Plus bridge mode, you must set port parameters for its Modbus port. Setup information is supplied with each controller.
- ☐ **Network Option Modules** You must define each Network Option Module s node address and its slot position in the backplane.
- ☐ **D IO Drop Adapters and TIO Modules** You must define the node address for each of these devices in your application.
- ☐ **Host-Based Network Adapters** You must define the Network Adapter board s network node address and memory window address. You will also have to edit your host computer s CONFIG.SYS file. Setup information is supplied with each adapter.
- ☐ **Bridge Multiplexers** You must define each Bridge Multiplexer s network node address. You must also define the communication parameters for each serial port that will be used in your application. Setup information is supplied with each adapter.
- ☐ **Repeaters** No special setup information is required for Repeaters. This guidebook provides installation information.

- **Bridge Plus** You must define a network node address for each of the Bridge Plus device s two network ports. This guidebook provides setup and installation information.

2.2 Defining the Network Components

Figure 25 summarizes the components of the network cable system.

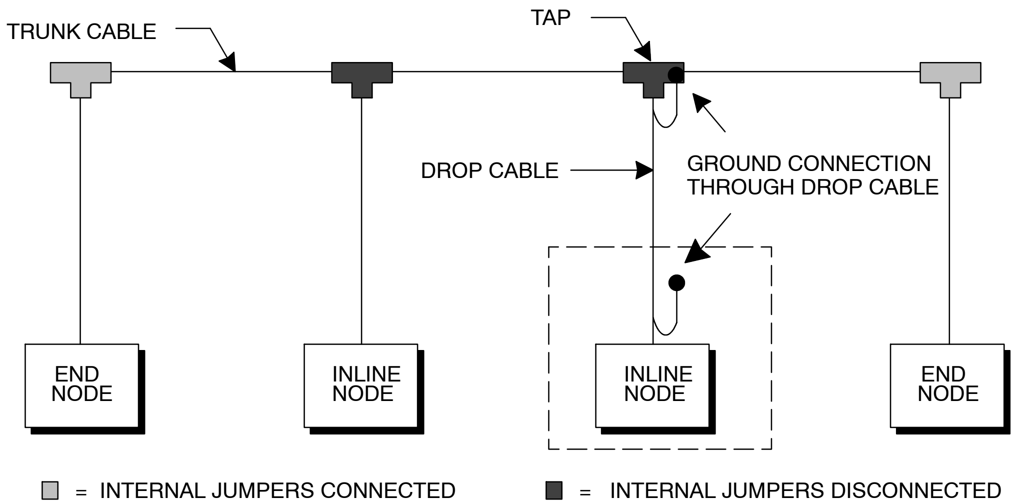


Figure 25 Network Cable System Components

For ordering information, contact Modicon Customer Service at the following telephone numbers. Ask for Customer Service Order Entry.

- North America: (800) 468-5342
- International: (508) 794-0800

2.2.1 Modbus Plus Trunk Cable

Cable specified for Modbus Plus trunk use is available from Modicon as the following part numbers:

Length of Cable on Reel	Part Number
100 ft (30.5 m)	490NAA27101
500 ft (152.5 m)	490NAA27102
1000 ft (305 m)	490NAA27103
1500 ft (457 m)	490NAA27104
5000 ft (1525 m)	490NAA27106

Your cable will run directly between the network device locations. Each cable segment must be a continuous run between the taps at two locations. The use of splices, splitters, or any other configurations such as *star* or *tree* configurations, is not allowed. The only allowed media components are the network cable and taps.

You will typically plan your cable runs according to the horizontal distances between sites. When you order trunk cable, you will be ordering it by reels of fixed length. Order reels of sufficient length to allow continuous runs between the network devices.

2.2.2 Modbus Plus Drop Cables

A drop cable is used at each site to connect between the tap and a network node device. The cable is preassembled with a 9-pin D connector on one end for connection to the node device. The other end is open for connection to the tap. Cables are available in two lengths with the following Modicon part numbers:

Length of Cable	Part Number
8 ft (2.4 m)	990NAD21110
20 ft (6 m)	990NAD21130

You should plan to order a sufficient quantity of drop cables and taps to allow extra ones for service access and spares.

2.2.3 Modbus Plus Tap

A tap is required at each site on the trunk cable to provide connections for the trunk cable and drop cable. Its Modicon part number is 990NAD23000.

You should plan to order a sufficient quantity of taps and drop cables to allow extra ones for service access and spares.

2.2.4 Modbus Plus Cable Impedance Termination

Each tap contains an internal terminating resistor that can be connected by two jumpers. Two jumper wires are included in the tap package, but are not installed. At the taps at the two ends of a cable section, you must connect both of the jumpers to provide the proper terminating impedance for the network. Taps at inline sites must have both jumpers removed. Chapter 1 describes the meaning of cable sections, end and inline sites.

The impedance is maintained regardless of whether a node device is connected to the drop cable. Any connector can be disconnected from its device without affecting the network impedance.

2.2.5 Modbus Plus Network Grounding

Each tap has a grounding screw for connection to the site panel ground. Modicon drop cables have a grounding lug in the cable package. This must be installed on the cable and connected to the grounding screw on the tap.

The node device end of the drop cable has a lug which must be connected to the node device s panel ground. The network cable must be grounded through this connection at each node site, even when the node device is not present. The ground point must not be left open. No other grounding method can be used.

For a full description of Modicon controller system grounding requirements, refer to the documents listed in the *Related Publications* section of this guide.

2.3 Defining the Network Layout

2.3.1 Component Locations

The maximum cable length allowed for the network section from end to end is 1500 ft (450 m). Up to 32 nodes can be connected within this length. The maximum length includes the total set of cable runs, including all horizontal runs and vertical cable drops to the networked devices. On dual-cable networks, the difference in length between cables A and B must not exceed 500 ft (150 m) between any two nodes on the same cable section. This is explained in more detail on the next page.

The minimum length allowed between any two points is 10 ft (3 m). If two devices are closer than this, you must include extra cable to attain the minimum cable length.

2.3.2 Environmental Requirements

You should select a cable routing method that will protect the cable from physical damage and potential electrical interference sources.

Avoid areas of high temperature, moisture, vibration, or other mechanical stress. Secure the cable where necessary to prevent its weight and the weight of other cables from pulling or twisting the cable. Plan the cable layout to use cable ducts, raceways, or other structures for protecting the cable. These structures should be dedicated for signal wiring paths, and should not contain power wiring.

Avoid sources of electrical interference that can induce noise into the cable. Use the maximum practicable separation from such sources.

Follow these cable routing guidelines for electrical protection:

- Maintain a minimum separation of 3.3 ft (1 m) from the following equipment: air conditioners, elevators, escalators, large blowers, radios, televisions, intercom and security systems, fluorescent, incandescent, and neon lighting fixtures.

- Maintain a minimum separation of 10 ft (3 m) from the following equipment: power wiring, transformers, generators, and alternators.

- ☐ In addition to the minimum separation, if the cable must cross power wiring carrying over 480 volts, it must cross only at a right angle. The cable must not run parallel to the power wiring.

2.3.3 Adding Service Connectors

In addition to the drop cables to the network node devices required for your application, you should provide one or more drops to allow for service access to the active network.

You should include at least one drop at a location that will allow connection of a device for future monitoring and servicing, without disconnecting some active device. This can also assist in debugging your application at the present time and for future expansion.

Caution: Before you connect or disconnect any device on an active network, you should be aware of its effect on network timing. See Chapter 3 for further information about predicting network throughput and node dropout latency time.

2.3.4 Dual-Cable Length Considerations

Designing your network as a dual-cable layout can give you increased protection against communication errors caused by cable breakage or excessive electrical interference. If a fault occurs on either cable path, the node devices can continue processing error-free messages on the alternate path.

To minimize the chance of simultaneous interference or damage to both cables, you should route the two cables through separate areas of your plant site. Typically this will require you to plan different lengths for the two cable paths between successive nodes. Additional considerations apply when the two cable lengths will not be the same.

Between any two nodes on the same cable section, the difference between the lengths of cables A and B must not exceed 500 ft (150 m). Figure 26 shows an example of an illegal configuration. Even though the two cable lengths between nodes 1 ... 4 are identical at 1200 ft (360 m), several illegal lengths exist in this configuration.

- ☐ Between nodes 1 and 2, the difference in lengths between cables A and B is 600 ft (180 m). This exceeds the maximum allowable difference of 500 ft (150 m).

☐ Between nodes 2 ... 4, the difference between cables A and B is also 600 ft (180 m). This exceeds the maximum allowable difference of 500 ft (150 m).

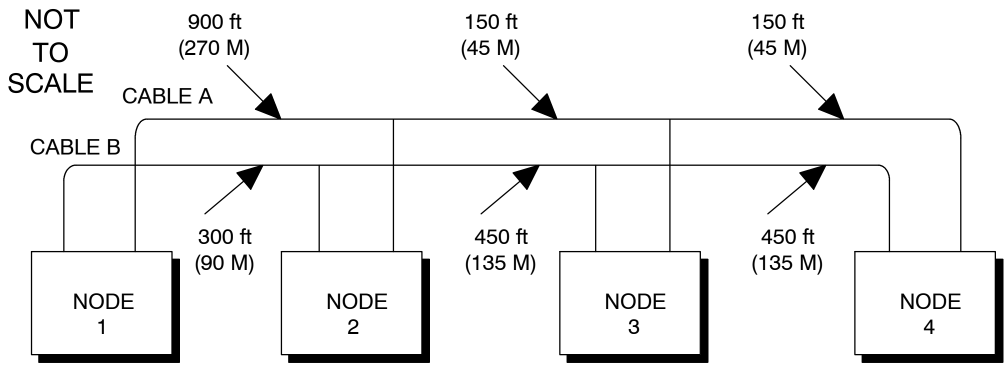


Figure 26 Dual-Cable Layout: Illegal Lengths

Note that the cable A-to-B difference only applies to node connections on the same cable section. If node 4 were a Repeater or Bridge Plus, for example, the cables on the other side of that node would be totally independent of the cables in Figure 26, for measurement purposes.

2.3.5 Estimating Cable Run Distances

Your cable layout planning should provide information to the installers that will show the cut length of each segment in the cable run. Before the cable is cut at each drop location, the following factors should be considered:

☐ The cable routing must provide for installation of strain reliefs to prevent the cable s weight from pulling on its connector at the node device. The cable should be routed adjacent to a frame, panel, or other stable structure to properly secure strain reliefs against its weight. Allow sufficient cable length for this routing.

☐ You must provide a service loop at each node device to allow future servicing of the device without placing stress on the cable or connector. A service loop of 6 in (15 cm) minimum radius is adequate for most panel mounting layouts.

Chapter 3
Estimating Network Performance

☐ Overview
☐ Factors for Planning
☐ How Devices Interact on the Network
☐ Factors That Affect Performance
☐ Communication Paths and Queueing
☐ Reading and Writing with the MSTR
☐ A Sample MSTR Communication
☐ Getting and Clearing Statistics
☐ Reading and Writing Global Data
☐ Loading Effects in Your Application
☐ Predicting Token Rotation Time
☐ Formula for Calculating Token Rotation
☐ Predicting MSTR Response Time
☐ Estimating Throughput (With MSTR)
☐ Estimating Throughput (With Peer Cop)
☐ Predicting Node Dropout Latency Time
☐ Estimating Latency for Small and Large Networks
☐ Planning for Ring Join Time
☐ Precautions for Hot Standby Layouts
☐ Guidelines for a Single Network
☐ Guidelines for Multiple Networks
☐ Sample Communications Across Networks

□ A Summary of Network Planning

3.1 Overview

This chapter describes the major factors you should consider as you plan the layout of your Modbus Plus network. It explains how you can use MSTR and Peer Cop methods for communicating in your application, and shows how your use of these methods affects network performance. It gives examples of message handling between nodes, and presents guidelines for predicting the performance of single and multiple networks.

3.1.1 Your Network Performance Goal and Options

Your Goal

The goal of your planning is to achieve a network design that meets your needs for information transfer among the devices in your application. The network s message handling capacity must be sufficient to assure that each device has the data it needs, within the timing requirements of your application and with margins for safety. The network design must also be able to support future modifications and expansion to your application.

Each device presents unique requirements for obtaining data from the other devices. Data requirements can range from occasional updates of statistics to nearly continuous exchanges of large blocks of information. Control applications that interact between nodes require a network design that provides fast responses to requests for data.

When multiple devices share the same network, each device s data requirements should not be viewed as being isolated from the requirements of the other devices. Each device has a need for access to the network token. The length of time each device needs to transmit its application messages affects the network s token rotation time, and therefore also affects the network s access for the other devices. Responses to data requests are also determined by the processing speeds of the devices, such as the scantimes of programmablecontrollers and the efficiency with which their application programs have been designed. The network should be viewed as an interactive array of devices, in which overall performance is affected by the physical count of nodes, their combined data requirements, and their data handling capabilities.

Your Options You can plan your network application as a single network, with a linear arrangement of nodes. You can also plan it as multiple networks that are joined in a layered or hierarchical configuration. The choices you make will be determined by your data requirements between the nodes. Nodes which must exchange significant amounts of data that is critical to the timing of some process should be positioned on a compact network, with a bridge serving to forward less-criticaldata to devices on other networks.

Consider also how much of the data should be handled through read/write message transactions between the nodes, and how much through global database transactions. If your application requires that devices must maintain multiple concurrent transactions with other devices, consider how many data paths can be opened within the devices.

As you choose your design options, your estimation of total throughput for your network application should be conservative. When you estimate average performance, be aware that events in your application will occur asynchronously, and will place heavier loads on the network at various times. Instantaneous throughput between devices in a time-critical process must remain within safety margins, even with worst case loading.

By understanding the factors that affect your network s performance, and your options for device selection and programming, you can achieve a network design that meets the goals for your current application and future needs.

3.1.2 Design Options for I/O Servicing

If you are designing your network primarily for servicing I/O field devices through DIO Drop Adapters and TIO modules, you will have several important factors to consider.

Your network must service the I/O processes at a rate of speed that is sufficient to control them efficiently and without excessive delay. In general, the network s I/O servicing rate will depend upon the amount of nodes you employ, and the average message size. In addition, the determinism or repeatability of the I/O servicing rate will be affected by the types of node devices you connect to the network.

To assist you in planning for both of these factors (the speed of timing for data transfers, and the repeatability of that timing), a guidebook is available for network applications that are intended for I/O servicing. See the *Modbus Plus Network I/O Servicing Guide* for further details.

3.2 Factors for Planning

When you plan an industrial communications strategy that will integrate various control systems and computer products, you ll need to consider the kinds of applications you will implement, their information requirements, and their control devices. Your planning should be at three levels: (1) Network Applications; (2) Information Requirements; and (3) Transaction Requirements. Factors to consider are listed below.

3.2.1 Network Applications

Consider the types of applications you will require for your network:

Process Data Acquisition	Local and Remote Programming
Supervisory Control	Program Archiving, Upload, and Download
User Interfaces	Database Generation for Management Reports
Statistical Process Control	Connectivity to Other Types of Networks
Statistical Quality Control	

3.2.2 Information Requirements

Consider the kinds of information that must be handled in each application and between applications:

Process data between interactive nodes	Supervisory control and information for user interfaces
Downloading of recipes and control programs	Data conversion to computer databases
Production and quality statistics and reports	Process device diagnostics and maintenance reports

Consider the quantities of each type of information and their throughput requirements.

How much data must be transferred between devices per unit of time

3.2.3 Transaction Requirements

Consider the types and quantities of message transactions that must occur between networked devices. Make a chart showing your planning for each transaction:

Originating Node	Network Number	Device Description
	Node Address	Device Type
Receiving Node	Network Number	Device Description
	Node Address	Device Type
Communication	Purpose	Frequency of Enabling
	Priority	Number of Registers
	Sent Under What Conditions	Response Time Needed

3.3 How Devices Interact on the Network

Multiple data transfer and programming operations can occur concurrently on anetwork. As an example, consider the network in Figure 27. This example shows five nodes on a single network. In practice, the network could contain up to its full complement of 64 nodes, and additional networks could be connected through Bridge Plus devices.

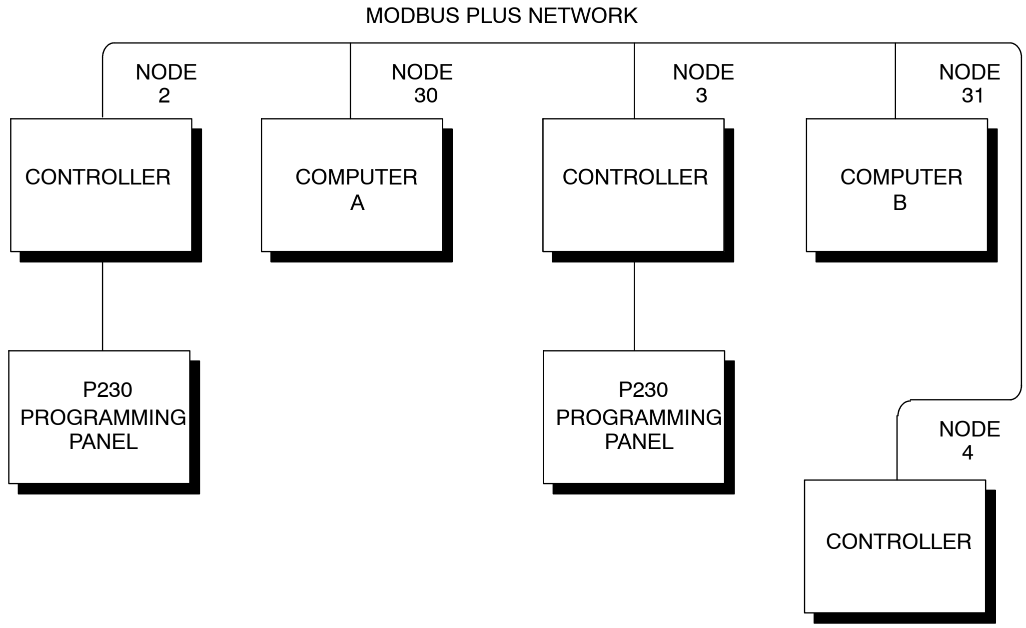


Figure 27 Concurrent Multiple Operations

Control processes can be in progress between various nodes while plant personnel are actively programming, archiving, and diagnosing the devices from different locations.

Examples of operations which can be occurring concurrently on this network include:

- ☐ Data transfers in progress between controllers 2 and 4
- ☐ Computer A operating as a user interface obtaining data from controllers 2 and 4

- Computer B in a programming or load/record/verify operation with controller 3
- Plant personnel accessing any node from the P230 programming panels using the controllers built-in Modbus to Modbus Plus bridge mode.

3.4 Factors That Affect Performance

3.4.1 Handling Multiple Operations

The time that is required for a node to respond to a request for data is affected by the count of nodes on the network, by the number of active transactions in each node, and by each node s instruction handling capability (scan time). The way in which you program your application also will affect the response time.

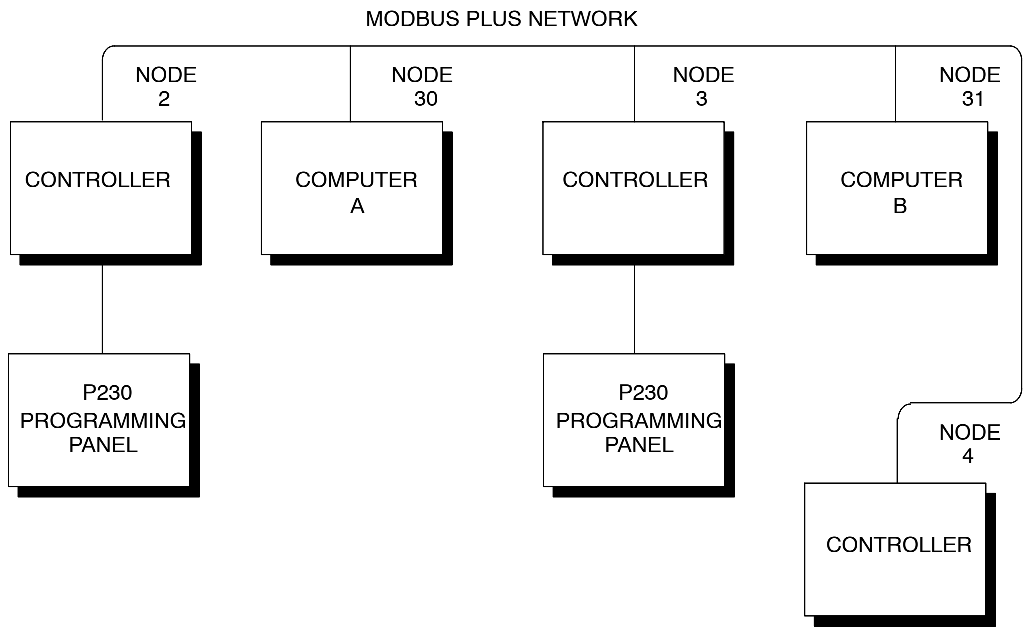


Figure 28 Handling Multiple Operations

Consider the Multiple Operations example again (see Figure 28.) Data transfers are in progress between controllers 2 and 4. Computer A is operating as a user interface obtaining data from controllers 2 and 4. These two operations can be considered to be the ones that are most critical for timing, because they are handling application data in real time. These operations are also interactive, because the application uses Computer A as an interface accessing data in the controllers 2 and 4. Data paths and application program instructions must be provided in these controllers for servicing the user interface, in addition to servicing their mutual data requirements.

Two additional operations are occurring on the network. Computer B is in a programming or load/record/verify operation with controller 3. Plant personnel accessing any node from the P230 programming panels using the controllers built-in Modbus to Modbus Plus bridge mode. These operations are handling data that is not currently used in the application. Their activity on the network will, however, affect the response times for the first two operations. For example, the network s token must be held for a period of time by Computer B and controller 3 while they transact the necessary data. If this operation terminates, and these nodes have no other immediate operations, each will retain the token for only a minimum time before passing it. (Methods for estimating token rotation time are presented later in this chapter.)

3.4.2 Planning Your Application Program

The way in which you program your application will also affect network performance. For example, the approximate time required between two controllers to request data and receive it is:

- One token rotation time for network access to send the request
- One scan time in the receiving controller to process the request
- One token rotation time for network access to send the response
- Two scan times in the initiating controller to process the response

If data were transferred as a global transaction, it is received by multiple nodes during a single token pass. The approximate time for this is:

- One token rotation time for network access to send the global data
- One scan time in each receiving controller to process the global data

Your choice of polling or unsolicited transactions will greatly affect network performance. If you construct your application program using polling techniques, you will force the network to handle some quantity of transactions that do not return data. This will tend to increase the aggregate amount of network traffic, and will diminish the ability of the network devices to manage their data paths and to acquire the token.

Rather than using polling techniques, you can gain improved message throughput by implementing event-driven read or write operations between the devices. Receiving devices can be prepared for unsolicited data by having their applications sample flag bits (bits that are written by the incoming data, and cleared by a subsequent scan), or by using transaction counters or other similar methods.

3.5 Communication Paths and Queueing

With multiple devices processing messages asynchronously on the network, it becomes possible for an individual device to have several concurrent transactions in process. The peer processor in each device maintains multiple communication paths of various types. It opens a path when a transaction begins, keeps it open during the transaction, and closes it when the transaction terminates. When the path is closed, it becomes available to another transaction.

Both the originating and destination devices open paths and maintain them until the transaction completes. If the transaction passes through Bridge Plus devices to access a destination on another network, each bridge opens and maintains a path at each of its two network ports. Thus a logical path is maintained between the originating and destination devices until the transaction is finished.

3.5.1 Path Types

Each Modbus Plus device has the following types of paths:

- *Data Master Path* for data reads and writes and for get and clear remote statistics, originated in the device
- *Data Slave Path* for data reads and writes as they are received in the device
- *Program Master Path* for programming commands originated in the device
- *Program Slave Path* for programming commands as they are received in the device.

Each path is independent of the others. Activity in one path does not affect the performance of the other paths.

3.5.2 Path Quantities

The following paths are available in the various types of Modbus Plus devices:

	CPU	BM85	BP85	SA85/SM85
Data Master	5	4	8	8
Data Slave	4	4	8	8
Program Master	1	4	8	8
Program Slave	1	4	8	8

Data Master Paths in Controllers

Five Data Master paths are provided in controllers. Of these, one path is reserved for use by the controller s Modbus port in the bridge mode between Modbus and Modbus Plus. The remaining four paths are reserved for use by MSTR functions in the controller s application program.

3.5.3 Queueing

If all Data Slave paths are active in a device, incoming transactions will be queued. Transactions will remain queued until a path is available, and will then be removed from the queue and given the path. A final data response is not returned to your application until a full path is available from origin to destination.

When the destination node removes a transaction from its queue, it must acquire the token and request the command again from the originating node. The originator will respond with the command while the destination has the token. This process occurs automatically, eliminating the need for polling between the origination and destination in your application.

BP85 Bridge Plus Queueing

Messages which must pass through multiple bridges will be queued (if necessary) within the first bridge, but will not be queued within any subsequent bridges in the transaction path. Figure 29 shows an example.

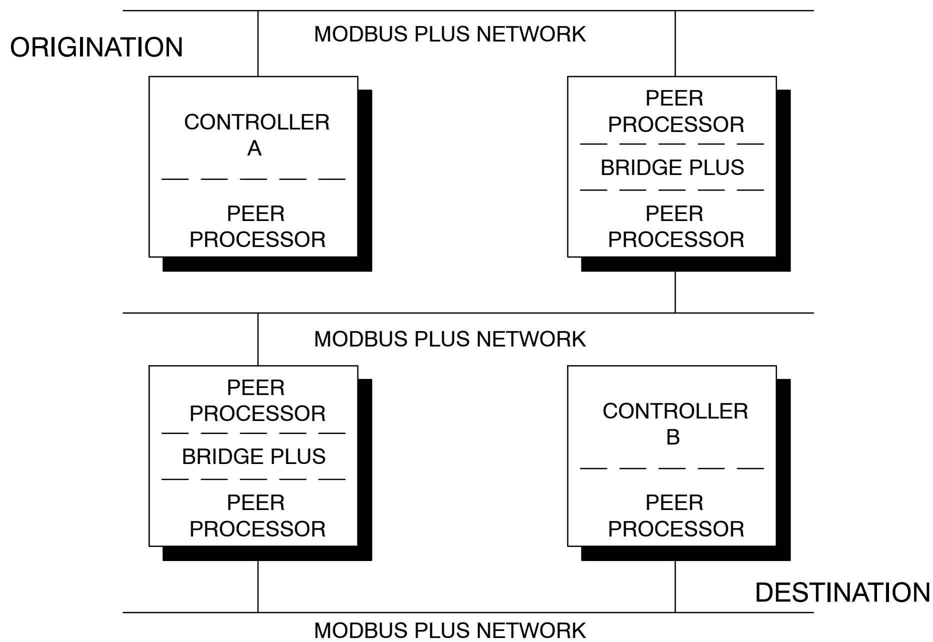


Figure 29 BP85 Bridge Plus Queueing

A message from controller A to controller B must pass through two Bridge Plus devices. If a path is not available in the first bridge, the message will be queued and given a path when one is available. If the second bridge does not have a path when it receives the message, the message will not be queued further. An error code will be returned from the second bridge and can be sensed by the application program in controller A.

Transactions are handled in this way to prevent excessive delays between requests and responses in your application. This situation should occur rarely, and is caused by high message loading within the bridge.

3.6 Reading and Writing with the MSTR

The MSTR instruction is a ladder logic function that provides access to the Modbus Plus network. Its format is shown in Figure 30.

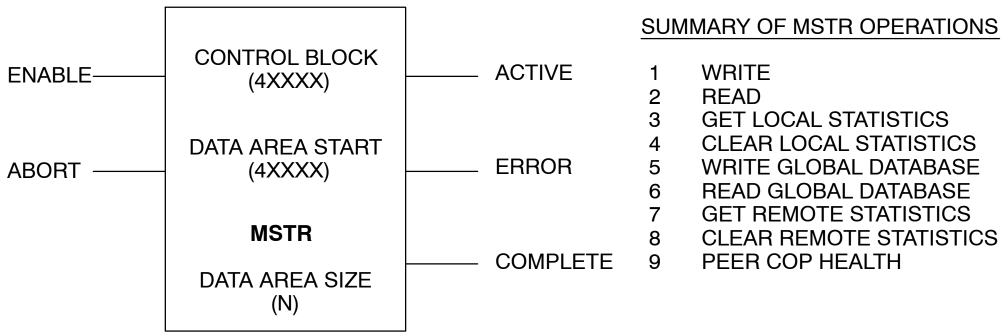


Figure 30 MSTR Function Format

A complete description of how you can program your application using the MSTR is provided in the *Modicon Ladder Logic Block Library User Guide* (840 USE 101 00)). This overview will assist you in following the sample communication on the next page.

The Control Block is a 4*x* reference that is the starting register in a block of nine consecutive registers. These registers define the intended actions and Modbus Plus routing for the communication. Their contents are unique for each type of operation.

For example, in a data Read or Write operation, the Control Block layout is as follows:

Register	Content	
4x	Operation Type	1 = Write
		2 = Read
4x + 1	Storage for Returned Error Status Code (if an error occurs)	
x + 2	Data Block Length	4
4x + 3	Start of the Data Area in the Destination Device	
4x + 4	Modbus Plus Routing Path 1	
4x + 5	Modbus Plus Routing Path 2	
4x + 6	Modbus Plus Routing Path 3	
4x + 7	Modbus Plus Routing Path 4	
4x + 8	Modbus Plus Routing Path 5	

The Control Block register at 4*x* + 2 specifies the length of the data area for the read or write operation. For example, if this register contains a value of 32 decimal, that many registers of data will be transferred in the operation.

The Control Block register at 4*x* + 3 defines the starting location of the data buffer in the destination device. Its contents are an offset value (not an absolute address). For example, a value of 1 specifies reference 40001 in a programmable controller. The offset can be incremented in successive MSTR operations to move large areas of data.

Data Area Start is a 4*x* reference that is the starting register in a block of upto100 consecutive registers that will be used as the local data buffer in the Read or Write. If the operation is a Read, the incoming data from the destination device will be stored into this buffer. For a Write, the buffer contents will be sent to the destination device.

Data Area Size is an absolute value in the range 1 ... 100 decimal. It specifies the maximum quantity of registers to be allocated for the MSTR function s data area.

3.7 A Sample MSTR Communication

Every Modbus Plus device has a peer processor that controls network communication. Collectively the peer processors in all of the networked devices establish and maintain the token rotation, the transmission and receipt of messages, and acknowledgements. In a programmable controller, the peer processor transfers message data to and from the MSTR functions in your ladder logic.

Figure 31 shows two controllers on a Modbus Plus network. Here is an estimate of the time required for a Read operation.

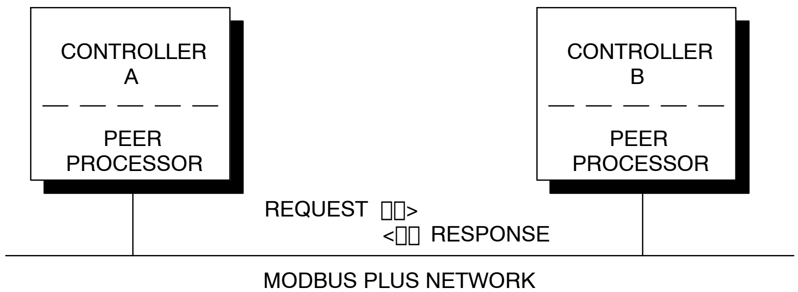


Figure 31 Sample READ Communication

During the ladder logic scan in unit A, an MSTR block is executed that specifies a Read request to unit B. At the end of the block execution, the Read request is sent to the peer processor in unit A. The following events occur:

Step 1 When the peer processor in unit A acquires the network token, it transmits the Read request. When the request is received by the peer processor in unit B, it sends an immediate acknowledgement.

Step 2 At the end of the ladder logic scan in unit B, the incoming transactions are handled. The peer processor in unit B is ready with the data response to the Read request.

Step 3 When the peer processor in unit B acquires the token, it sends the data response to unit A. The peer processor in unit A sends an immediate acknowledgement.

Step 4 At the end of the ladder logic scan in unit A, the incoming transactions are handled. The transaction is complete at the next solve time of the MSTR function in unit A. Data registers will be written, and the MSTR function s COMPLETE output goes ON.

The time required to process the complete communication would be:

Event	Time Range	Average Time	Worst Case Time
1	0 ... 1 token rotation	1/2 token rotation	1 token rotation
2	0 ... 1 scan, unit B	1/2 scan, unit B	1 scan, unit B
3	0 ... 1 token rotation	1/2 token rotation	1 token rotation
4	0 ... 2 scans, unit A	1 scan, unit A	2 scans, unit A

If the scan time in unit B is much shorter than the token rotation time, unit B can create the data response and have it ready before the token reaches unit B s peer processor. On the other hand, if a Data Slave path is not free in unit B, the request will be queued by that unit s peer processor and will wait until a Data Slave path is free.

The frame format of ModbusPlus messages and the timing elements within transactions are described in detail in Appendix A.

3.8 Getting and Clearing Statistics

3.8.1 Local Device Statistics

When you issue commands to Get Local Statistics or Clear Local Statistics, the action is handled by the local device s peer processor. No transaction occurs on the Modbus Plus network. The operation is completed by the end of the MSTR function execution in the local device. Figure 32 illustrates a Get Local Statistics operation in controller A.

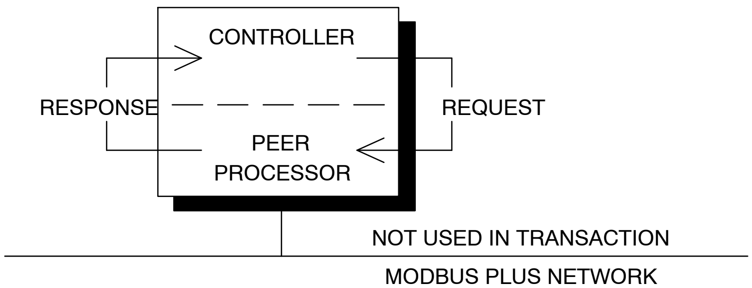


Figure 32 Sample GET LOCAL STATISTICS

3.8.2 Remote Device Statistics

When you issue commands to Get Remote Statistics or Clear Remote Statistics, the action is handled by the destination device s peer processor. Timing of the transaction is affected by the network token rotation time and the scan time of the originating device. The scan time of the destination device is not a factor.

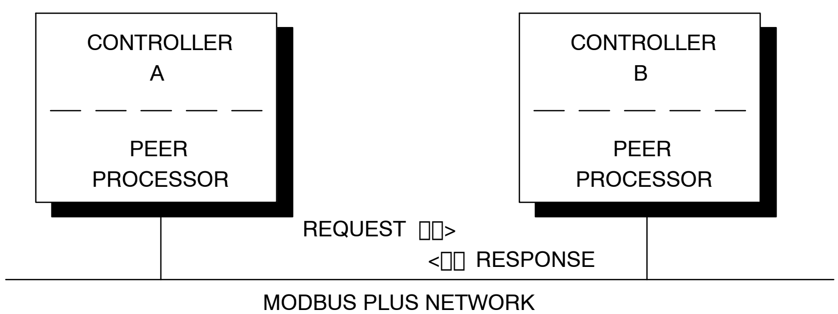


Figure 33 Sample GET REMOTE STATISTICS

The time required to process the complete communication would be:

Time Range	Average Time	Worst Case Time
0 ... 1 token rotation	1/2 token rotation	1 token rotation
0 ... 2 scans, unit A	1 scan, unit A	2 scans, unit A

3.9 Reading and Writing Global Data

3.9.1 Passing Global Data Between Nodes

Up to 32 registers of global data can be included in the network token frame as it is passed between nodes. In the node currently holding the token, an MSTR function can be programmed to include global data in the next token pass. The global data will be read into the peer processors of the other nodes on the same network, and will update the storage area in those nodes. Global data is not passed through bridges from one network to the next.

The application program in each node can have an MSTR programmed to read all or a certain portion of the global data. Nodes accept global data without waiting for paths or queueing.

Figure 34 shows a sample global database pass.

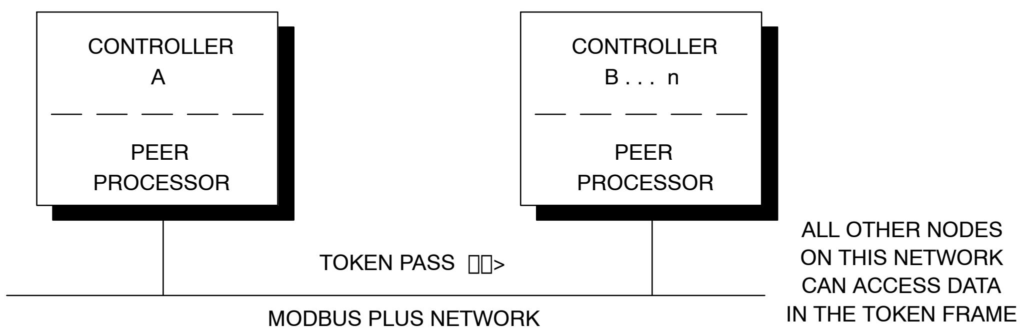


Figure 34 Sample Global Database Pass

During the ladder logic scan in unit A, an MSTR block is enabled that specifies a Write Global Database operation. At the end of the block execution, the global data is sent to the peer processor in unit A. The following events occur:

Step 1 When the peer processor in unit A acquires the network token, it transmits any other application messages it has pending, and then passes the token. Every other node on the network reads the global data contained in the token frame and places a copy of it in its peer processor.

Step 2 each other controller on the same network, an MSTR function programmed to Read Global Database can read the new global data.

The time required to process the complete communication would be:

Event	Time Range	Average Time	Worst Case Time
1	0 ... 1 token rotation	1/2 token rotation	1 token rotation
2	0 ... 1 scan, unit B ... n	1/2 scan, unit B	1 scan, unit B

3.10 Loading Effects in Your Application

During the application, each node on the network can have a different number of paths constantly being opened, held active, and closing. This is a dynamic process that is affected by the count of nodes and the amount of message traffic between them.

If some nodes have most of their paths active at any given moment, and others do not, the nodes with the heavy path loading will hold the token longer as they process data. The token will move more slowly through heavily loaded nodes, and more quickly through those that are lightly loaded.

The effect on an individual MSTR function in your application will be quicker completion during light network loading, and slower completion under heavy loads. Even though the origination and destination nodes in the MSTR operation may have light path loading, the network token must still pass through the other nodes. If their loading is heavy, the net effect will be a slower token rotation time, affecting both the sending and response of a data request.

Appendix A provides further details about the token holding times in nodes that are fully loaded with active transactions and queueing.

3.10.1 MSTR Data Path Handling Under Loading

When you program multiple MSTR functions in a controller s ladder logic, they will be handled according to loading conditions as follows:

☐ *At the source* . If more than four MSTR functions are enabled at any time (through their ENABLE inputs), the first four scanned will go active using the MSTR Data Master paths available in the controller. The other MSTR functions will not be serviced, but will wait for free paths. Your design of the ladder logic program controls the sequencing of the MSTR functions.

☐ *At the destination.* If the destination controller has all of its Data Slave paths currently active, the next data transactions will be queued until paths are available. This queue will be processed at the approximate rate of four transactions per scan of the controller. MSTR functions in originating controllers will wait, with their paths held open, until a final data response is returned from the destination.

During dequeueing at the destination, the receiving node will request the command again from the originating node when the receiving node acquires the network token. The command is reissued and received while the receiving node holds the token.

This process eliminates the need for continual polling, reducing the overhead in your application and the loading that would be caused by polling on the network. It does, however, tend to add some loading and to decrease the overall message throughput. By adopting techniques to minimize queueing, such as logically grouping the nodes on each network, using global data transactions, and packing more data into fewer MSTR transactions, you can achieve fast response times and high data rates in your process.

3.10.2 Modbus Port Data Path Handling Under Loading

The dedicated Data Master path for a controller s Modbus port in bridge mode is always available. Transactions are given to the peer processor as received from the master device connected to the port, and are transmitted when the token is acquired.

Data Slave paths in the receiving device will be queued as necessary if multiple messages are initiated to the same device.

3.10.3 Program Path Handling Under Loading

Program Master and Program Slave paths are not queued. Only one programmer can have access to a controller at any given time. An attempt to attach a second programmer will return an error message to that device.

3.1 1 Predicting Token Rotation Time

Figure 35 shows a graph of token timing as a function of the network node count and message loading. The graph was constructed with a network containing Modicon programmable controllers. Message loading ranges from zero (the token pass only) to maximum loading (each controller has all four MSTR Data Master paths on, with each path passing 100 registers, and with global data passing 32 registers).

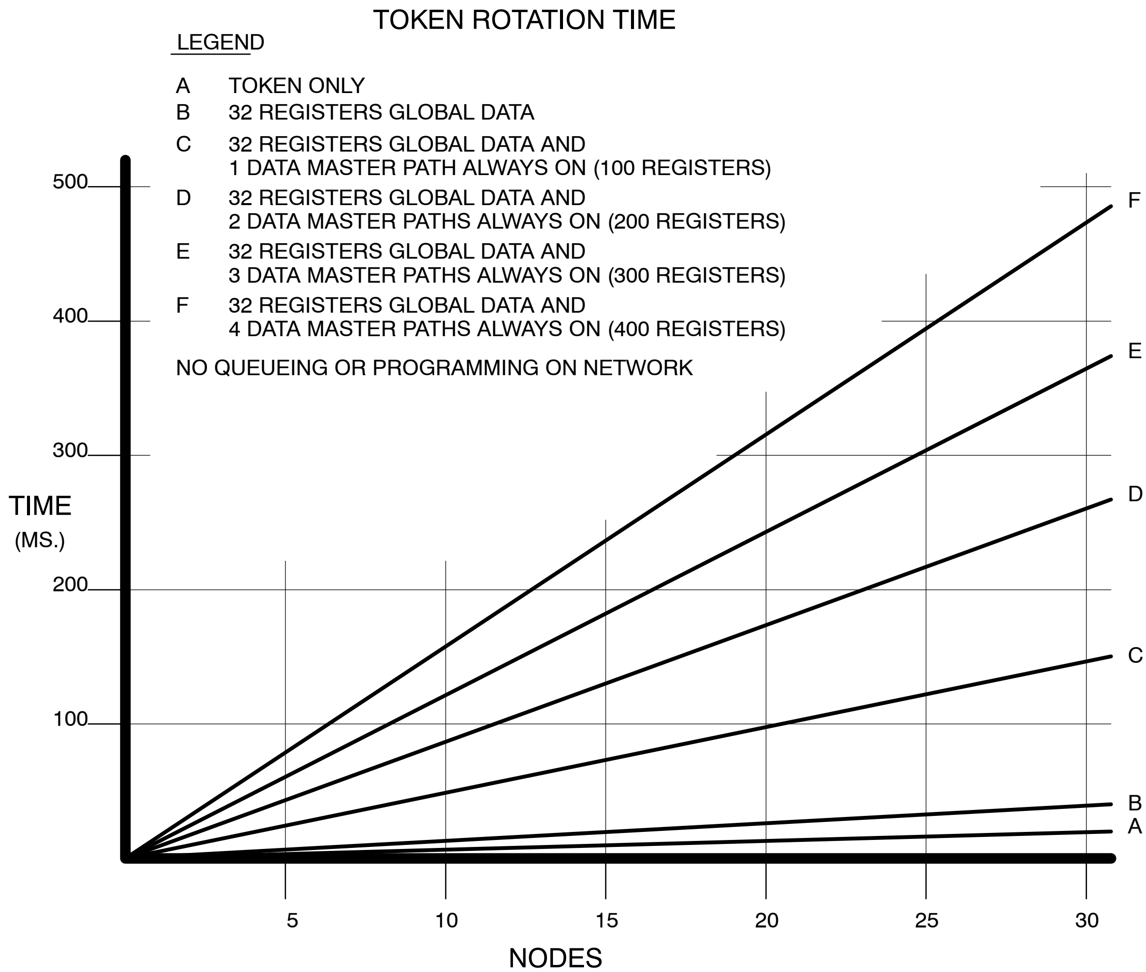


Figure 35 Token Rotation Time

The token rotation times shown in the figure are for data transactions, with no queueing at the destination nodes and with no remote programming concurrently in progress. Rotation times can be expected to be longer if some nodes must hold the token for a longer time to process queued transactions or remote programming.

Token rotation time will be slightly reduced when less than 100 registers of data are moved in each path, however this improvement will be marginal for most applications. Optimum throughput can be expected by using relatively few Data Master paths (and enabled MSTR functions) at a time, with each path moving as much data as possible.

3.12 Formula for Calculating Token Rotation

The formula for calculating the average token rotation time is:

$$TR = (2.08 + 0.016 * DMW) * DMP + (0.19 + 0.016 * GDW) * GDN + 0.53 * N$$

where:

- TR is the average token rotation time in ms
- DMW is the average number of words per Data Master path used in the network (maximum 100 for controllers)
- DMP is the number of Data Master paths used continuously in the network (see the two notes below)
- GDW is the average number of global data words per message used in the network (maximum 32)
- GDN is the number of nodes with global data transmitted in the network
- N is the number of nodes on the network

Note: When counting Data Master paths, consider the ratio between the network s token rotation time and the device s scan time. The way in which you count paths depends upon which of these two times is the faster.

For example.consider twocases in which an MSTR is enabled every scan, and the scan time is 20 ms.

- *Faster token* If the token rotation time is estimated at 10 ms, count the Data Master path use as 0.5 path. The ratio (10/20) shows the use is one half path.
- *Faster scan* If the token rotation time is estimated at 50 ms, count the Data Master path use as 1.0 path. Even though the ratio (50/20) is greater than unity, the use will never be more than one path.

Note: First estimate of the token rotation time and then refine it after you perform the calculation. Use the chart in Figure 35 to make the estimate.

For example, if an MSTR block will be timed to execute every 500 ms, and the token rotation time is estimated as 50 ms, you can estimate the Data Master path use as 0.1 path (50/500). After you calculate the actual token time from the formula, review your initial estimate. If the actual time is not close to 50 ms, refine your estimate and recalculate the path use.

3.13 Predicting MSTR Response Time

When you have calculated the average token rotation time on the network, you can predict the average time for a response to an MSTR data request. The response time will not include factors such as queueing or error conditions on the network. The time will be based on a request/response transaction on a single network. The average response time is the sum of the following times:

- 1 token rotation time
- 1 scan time of the requesting unit
- 1/2 scan time of the responding unit

The worst case response time would be:

- 2 token rotation times
- 2 scan times of the requesting unit
- 1 scan time of the responding unit

If the scan time of the responding unit is much shorter than the network's token rotation time, it is possible for the unit to create the data response and have it ready in the peer processor before the network token arrives at the unit. In this case the response would be transmitted when the token is received. The scan time of the responding unit can be removed from the timing calculation.

Figure 36 shows an example of a network of six nodes, with the planned loading. In this example, nodes 1 ... 4 will transmit using MSTR functions and global data as shown in the figure. Nodes 5 and 6 will not send data in this application but will use the global data when they receive it.

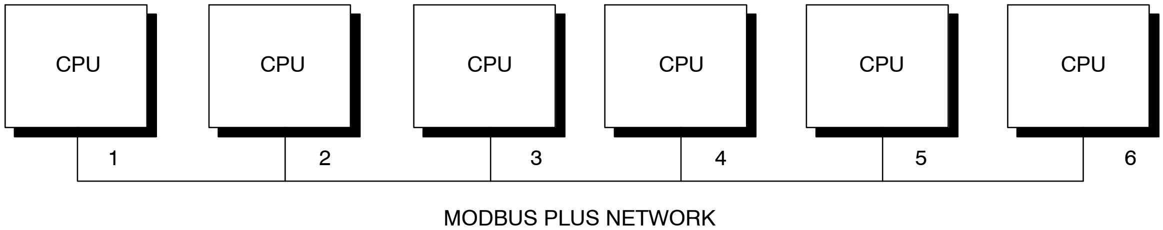


Figure 36 Predicting Response Time

Planning Loading

Originating Node	Type of Communication		Receiving Node
1	MSTR always ON	50 registers	2
	MSTR ON for 500 ms	100 registers	3
	MSTR always ON	75 registers	4
2	MSTR always ON	100 registers	1
	MSTR always ON	75 registers	4
3	Global Data ON	16 registers	All
	MSTR always ON	75 registers	4
4	Global Data ON	32 registers	All

Guidelines are provided on the next page for calculating the time required for obtaining data.

The following steps can be used to calculate the data response time for an MSTR, and the acquisition time for global data.

1. Find the average token rotation time

Apply the formula from Section 3.12:

$$TR = (2.08 + 0.016 * DMW) * DMP + (0.19 + 0.016 * GDW) * GDN + 0.53 * N$$

$$DMW = (50 + 100 + 75 + 100 + 75 + 75) / 6 = 79 \text{ words}$$

$$DMP = (1 + 20/500 + 1 + 1 + 1 + 1) = 5.04 \text{ paths}$$

$$GDW = (16 + 32) / 2 = 24 \text{ words}$$

$$GDN = (1 + 1) = 2 \text{ nodes}$$

$$N = 6 \text{ nodes}$$

$$TR = (2.08 + 0.016*79) * 5.04 + (0.19 + 0.016 * 24) * 2 + 0.53 * 6 = 21.18 \text{ ms}$$

2. Calculate the MSTR response time

If all units have a scan time of 20 ms, then:

Average response time	1 token rotation time	21.18 ms
	1 scan time of the requesting unit	20 ms
	1/2 scan time of the responding unit	10 ms
	Total	51.18 ms
Worst case response time	2 token rotation times	42.36 ms
	2 scan time of the requesting unit	40 ms
	1 scan time of the responding unit	20 ms
	Total	102.36 ms

3. Calculate the global data acquisition time

Each unit s time to receive data from another unit s Global Data Write would be:

Average time	1/2 token rotation time	10.59 ms
	1/2 scan time of the receiving unit	10 ms
	Total	20.59 ms
Worst case time	1 token rotation time	21.18 ms
	1 scan time of the receiving unit	20 ms
	Total	41.18 ms

3.14 Estimating Throughput (W ith MSTR)

Figure 37 shows a graph of the throughput per node as a function of the node count. The data rate is the quantity of registers that can be transferred per second of time. The graph was constructed with a network containing Modicon programmable controllers, with each controller s message loading at maximum (each controller has all four MSTR Data Master paths on, with each path passing 100 registers).

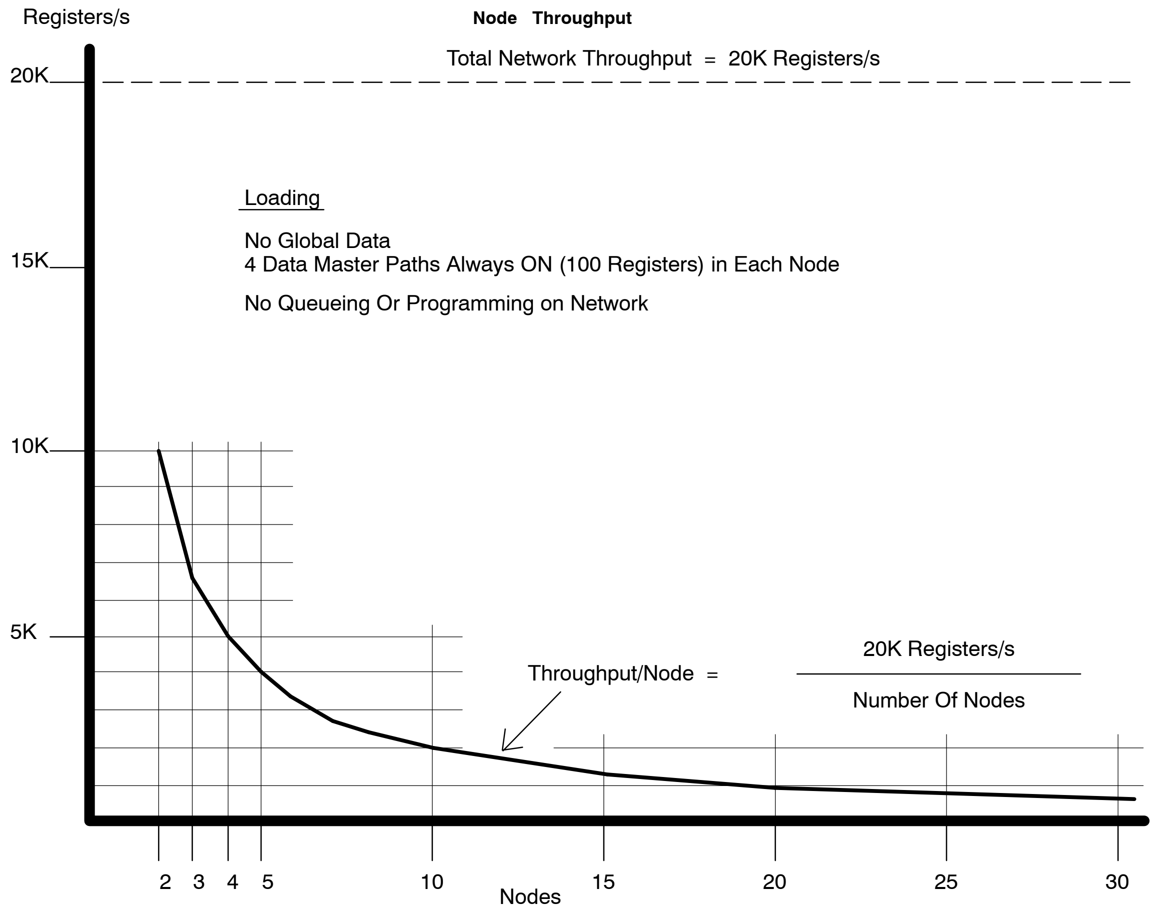


Figure 37 Node Throughput

The throughput shown in the figure is for data transactions, with no global data, no queueing at destinations, and with no remote programming concurrently in progress.

Note that the network s capacity is 20,000 registers/s. The throughput for any node is 20,000 registers/s divided by the count of nodes on the network.

3.14.1 Grouping Nodes Logically for Increased Throughput

Each node s throughput is a factor of the network s node count and network loading, as shown in Figure 37. Consider how your node devices must communicate to the other nodes. Plan each network in your application as an integrated system of devices and application programs that will achieve the required throughput.

Instead of constructing a single network with a large node count, you can realize improved throughput by integrating smaller, more compact networks through bridges. Note that you can include two or more bridges on the same network as a way to pass data quickly to multiple remote networks. Allow margins for instantaneous loading.

Compact networks should consist of nodes that need to communicate time-critical information with one another. Bridges serve to pass any lower-priority information to devices on remote networks. Using bridges in an application in which all nodes must communicate time-critical information will not improve throughput. When you plan your application, consider the communication requirements between each pair of devices. Prioritize the communication requirements so that you can determine the best grouping of nodes. This will also assist you later when you construct MSTR functions in your application program.

3.15 Estimating Throughput (With Peer Cop)

3.15.1 Estimating Total Communication Time

With Peer Cop communication, data can be sent to specific nodes during token passes. Nodes using Peer Cop can transmit Specific Output data to one or more destinations. The destination nodes can be set to receive Specific Input data from selected sources.

If the sending and receiving nodes have scan times that are significantly shorter than the network s token rotation time, data can sent from a source node, and a response received back to that node, within a total communication time that is a fraction of the token rotation time. An example is shown below.

The total communication time between Specific Output and Specific Input in a controller can be estimated using the following formula (times in ms):

One scan time, sending controller
\+ Specific output time, sending controller
\+ % of token rotation time, sending node to receiving node
\+ Specific input time, receiving controller
\+ One scan time, receiving controller

Total communication time between specific output and specific input

Percent of token rotation time is the portion of the network s total token rotation time that elapses between the sending node s release of the token and the receiving node s release of the token. Figure 38 shows a network at the start of a Peer Cop transaction between two controllers.

In Figure 38, Controller A has the token, with Peer Cop Specific Output traffic for Controller B. Two other nodes exist in the network s address sequence between Controllers A and B.

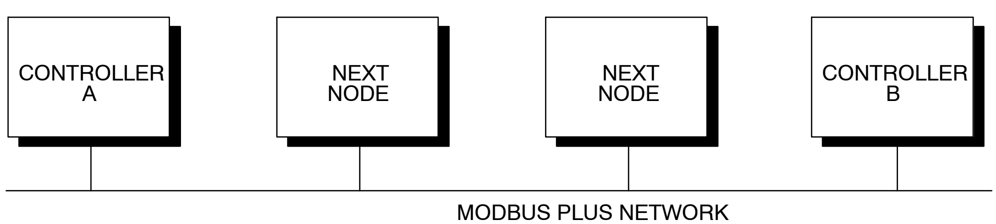


Figure 38 Example: Estimating Peer Cop Performance

The sending node A transmits its Specific Output data, containing Peer Cop data to receiving node B. Node B receives this traffic immediately as Specific Input data, and acts upon it during its next scan. The token now passes through the intervening nodes before it is passed to node B. Node B retains the token while it handles any non Peer Cop traffic.

Before node B releases the token to the next node in the address sequence, it sends the Peer Cop response data (as Specific Output) for node A. Node A receives the data immediately (as Specific Input) and handles the data during its next scan.

In this communication the elapsed time for the transaction is the time between the data transmission from node A (when node B begins to act on its data) and the transmission from node B (when node A begins to act on its data). Because this actual time may vary somewhat for subsequent communications between A and B (due to variable token-holding times in the intervening nodes) it is convenient to estimate the time as a percent of network token rotation time as expressed in the formula above.

3.15.2 Estimating Specific Input and Specific Output Times

Specific Input and Specific Output times for processing data in a node with Peer Cop can be estimated using the following formula (time in ms):

Specific Input/Output Time = .530 + .001(words * 16)

For example, if 200 words of data are sent:

Specific Input/Output Time = .530 + .001(200 * 16) = 3.73

3.15.3 An Example of Peer Cop Performance

Here is an example of a complete Peer Cop data transaction timing.

Consider a network that has an average token rotation time of 100 ms. Two controllers are involved in the transaction, each with a scan time of 20 ms. The percent of token rotation time between the two nodes is 30%, for a time of 30 ms.

	One scan time, sending controller	20.00
+	Specific output time, sending controller	3.73
+	% of token rotation time, sending node to receiving node	30.00
+	Specific input time, receiving controller	3.73
+	One scan time, receiving controller	20.00
	Total	77.46 ms

3.16 Predicting Node Dropout Latency Time

3.16.1 How the Network Handles Node Dropouts

All active nodes maintain a *member node* table that identifies other nodes in the ring. When a node holds the token and completes its message traffic, it passes the token. The token is always passed to the next active node in an ascending address sequence. If the *next* node has left the network since its last token pass, a network timeout occurs during the attempt to pass the token. The remaining nodes detect this timeout, and begin to create a new address sequence that will bypass the missing node.

In the process of creating the new address sequence, all nodes try to reclaim the token, with the lowest-addressed node invariably claiming and holding it. During this process, each node builds a new member node list that re-establishes the sequence. When the ring is re-established the token rotation begins again at the lowest address. This process is handled automatically by the remaining nodes and is transparent to the user application, except for the time interval required to reconstitute the network ring.

This time interval can be calculated separately for each node that remains in the ring. It represents the time during which the node will not be processing any data messages. It is called the Node Drop Out Latency time (NDOL), and is expressed in ms. Nodes can be removed from the network by some fault or by design in the application, for example for scheduled maintenance on the field devices at the node location. Possibly several nodes might drop out simultaneously due to an area power failure. Network designers should become familiar with typical latency times for reconstituting the network with the remaining nodes, and should provide appropriate methods of handling them in their application programs.

3.16.2 The Latency Formula

The formula for calculating node drop out latency (NDOL) produces two time values. One time applies to nodes with addresses below the address of the drop-out node. The other time applies to nodes with addresses higher than that of the drop-out node. (If several nodes drop out simultaneously, the address of the lowest drop-out is used.)

Addresses below the drop-out

This general formula is used to calculate the NDOL for each node with an address lower than that of the lowest drop-out node. This time is abbreviated $NDOL_{(L)}$, where $_{(L)}$ is the address of any remaining node.

$$NDOL_{(L)} = 80 + 4(\text{lowest node address}) + (\text{qty of nodes remaining} - 1) + 5(\text{quantity of nodes dropped} - 1)$$

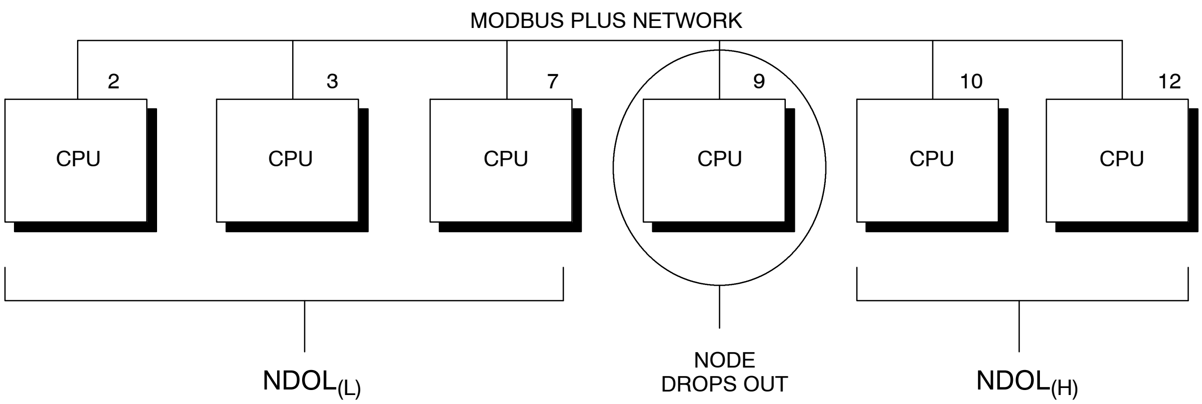
Addresses above the drop-out

This general formula is used to calculate the NDOL for each node with an address higher than that of the lowest drop-out node. This time is abbreviated $NDOL_{(H)}$, where $_{(H)}$ is the address of any remaining node.

$$NDOL_{(H)} = NDOL_{(L)} + (\text{one token rotation time})$$

The resulting times for both $NDOL_{(L)}$ and $NDOL_{(H)}$ are in ms.

Figure 39 summarizes the use of the two NDOL formulas.



$$NDOL_{(L)} = 80 + 4(\text{lowest node address}) + (\text{qty of nodes remaining} - 1) + 5(\text{qty of nodes dropped} - 1)$$

$$NDOL_{(H)} = NDOL_{(L)} + (\text{one token rotation time})$$

Figure 39 Predicting Node Dropout Latency Time

3.17 Estimating Latency for a Small Network

Here is an example for estimating drop-out latency in a small network of programmable controller nodes. Peer Cop transfer of Specific Input and Specific Output data is used.

The network is structured as follows:

- ☐ 10 nodes, Programmable Controllers addressed 2 ... 11
- ☐ Node 2 has an output of 2 registers to each of the other nine nodes (a total of 2 * 9 = 18 registers)
- ☐ Nodes 3 ... 11 each will input 2 registers and output 2 registers
- ☐ Scan time of each controller is 10 ms

Normal Transaction Time

The example shows the normal response time for a transaction from node 11 to node 2, which is processed by node 2 and then returned to node 11. A similar transaction is shown between nodes 9 and 2.

Abnormal Transaction Time Due to Node Dropout

The example shows the abnormal time for the same two transactions in the case of node 10 dropping out while node 11 holds the token.

The example includes the calculation of the following times:

Times Calculated

- ☐ The token transmission time (the time required for any node to transmit its data during the token pass)
- ☐ The token rotation time
- ☐ The $NDOL_{(L)}$ and $NDOL_{(H)}$ times
- ☐ The normal response times (minimum and maximum) for communication between two nodes before a drop-out occurs
- ☐ The abnormal response times (minimum and maximum) between the same two nodes with the latency interval included.

Abbreviations

$TTT_{(n)}$	Token Transmission Time (for node n)
TRT	Token Rotation Time
$NDOL_{(n)}$	Node Drop Out Latency (for node n)
$TN_{(n)}$	Response Time, Normal (for node n)
$TA_{(n)}$	Response Time, Abnormal (for node n)

Calculations

$TTT_{(n)}$ = (Token Pass Time: .530 + Specific Output Time: .530 +.001(Qty of Nodes Communicated * Qty of Registers * 16))

$TTT_{(2)}$ = (.530 + .530 + .001(9 * 2 * 16)) = 1.348 ms
$TTT_{(3...11)}$ = (.530 + .530 + .001(1 * 2 * 16)) = 1.092 ms
TRT = $TTT_{(2)}$ + 9($TTT_{(3...11)}$) = 11.18 ms

Normal Response Time (minimum):

$TN_{(9)}$ = (1 scan node 9) + $TTT_{(9)}$ +(1 scan node 2) + $TTT_{(2)}$ = 10 + 1.092 + 10 + 1.348 = 22.44 ms
$TN_{(11)}$ = same as node 9

Normal Response Time (maximum):

$TN_{(9)}$ = (1 scan node 9) + 2(TRT) + (2 scans node 2)
= 10 + 2(11.18) + 20
= 52.36 ms
$TN_{(11)}$ = same as node 9

Node 10 drops out, causing the following latencies:

$NDOL_{(9)}$ = 80 + 4(2) + (9−1) + 5(1−1) = 96 ms
$NDOL_{(11)}$ = $NDOL_{(9)}$ + 11.18 = 107.18 ms

The dropout would create these abnormal minimum response times:

$TA_{(9)}$ = 22.44 + 96 = 118.44 ms
$TA_{(11)}$ = 22.44 + 107.18 = 129.62 ms

The dropout would create these abnormal maximum response times:

$TA_{(9)}$ = 52.36 + 96 = 148.36 ms
$TA_{(11)}$ = 52.36 + 107.18 = 159.54 ms

3.18 Estimating Latency for a Large Network

Here is an example for estimating drop-out latency in a large network of programmable controller nodes. Peer Cop transfer of Specific Input and Specific Output data is used.

The network is structured as follows:

- 32 nodes, Programmable Controllers addressed 2 ... 33
- Nodes 2 and 3 act as Masters, each controlling 15 nodes which act as Slaves
- Each Master sends a total of 480 words 32 words to each of its Slave nodes
- Each Slave sends 32 words to its respective Master
- Scan time of each Master controller is 30 ms; scan time of each Slave is 15 ms

Normal Transaction Time

The example shows the normal response time for a transaction from node 31 to its Master node, which is processed by the Master node and then returned to node 31. The example also shows a similar transaction between nodes 33 and its Master node.

Abnormal Transaction Time Due to Node Dropout

The example shows the abnormal time for the same two transactions in the case of node 32 dropping out while node 33 holds the token.

Times Calculated

The example includes the calculation of the following times:

- The token transmission time (the time required for any node to transmit its data during the token pass)
- The token rotation time
- The $NDOL_{(L)}$ and $NDOL_{(H)}$ times
- The normal response times (minimum and maximum) for communication between two nodes before a drop-out occurs
- The abnormal response times (minimum and maximum) between the same two nodes with the latency interval included

Abbreviations

$TTT_{(n)}$	Token Transmission Time (for node n)
TRT	Token Rotation Time
$NDOL_{(n)}$	Node Drop Out Latency (for node n)
$TN_{(n)}$	Response Time, Normal (for node n)
$TA_{(n)}$	Response Time, Abnormal (for node n)

Calculations

$TTT_{(n)}$ = (Token Pass Time: .530 + Specific Output Time: .530 +.001(Qty of Nodes Communicated * Qty of Registers * 16))

$TTT_{(master)} = (.530 + .530 + .001(15 * 32 * 16)) = 8.74$ ms
$TTT_{(slave)} = (.530 + .530 + .001(1 * 32 * 16)) = 1.57$ ms
$TRT = 2(TTT_{(master)}) + 30(TTT_{(slave)}) = 64.52$ ms

Normal Response Time (minimum):

$TN_{(slave)}$ = (1 scan Master node) + $TTT_{(master)}$ + (1 scan Slave node) + $TTT_{(slave)}$
= 30 + 8.74 + 15 + 1.57 = 55.31 ms

Nodes 31 and 33 have this minimum normal response time.

Normal Response Time (maximum):

$TN_{(slave)}$ = (1 scan Master node) + 2(TRT) + (2 scans Slave node)
= 30 + 2(64.52) + 30
= 189.04 ms

Nodes 31 and 33 have this maximum normal response time.

Node 32 drops out, causing the following latencies:

$NDOL_{(31)} = 80 + 4(2) + (31 - 1) + 5(1 - 1) = 118.0$ ms
$NDOL_{(33)} = NDOL_{(31)} + 64.52 = 182.52$ ms

The dropout would create these abnormal minimum response times:

$TA_{(31)} = 55.31 + 118.0 = 173.31$ ms
$TA_{(33)} = 55.31 + 182.52 = 237.83$ ms

The dropout would create these abnormal maximum response times:

$TA_{(31)} = 189.04 + 118.0 = 307.04$ ms
$TA_{(33)} = 189.04 + 182.52 = 371.56$ ms

3.19 Planning for Ring Join Time

Nodes can be connected to the network while it is active, dynamically joining into the address sequence. A node that was previously inactive due to a power-down state can join the active ring upon its power-up. The network automatically senses the presence of the new node and begins to include it in the address sequence.

In most cases a node joins under the direct control of the user for example, when a new node is connected to the network cable, or when a connected node has been without power, and is then manually powered up. This case is illustrated in Figure 40.

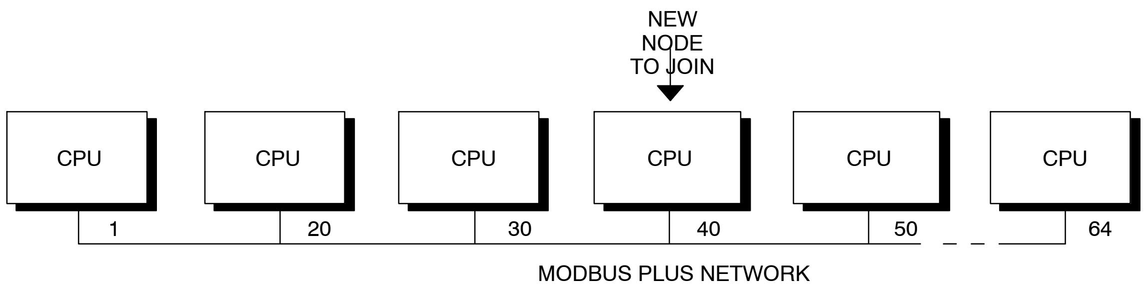


Figure 40 Planning for Ring Join Time

The amount of time that is required for a node to join the address sequence (the *ring*) is a function of a message counter and *next-try* node address that are maintained mutually by all nodes that are present. The count and next-try address are passed with the token from node to node.

For a given node, the counter increments with each message that is sent by the node. Only when the counter reaches a value of at least 64 does the node invite the node with the next-try address to join, at which time the message counter is reset to zero. The next-try address is incremented with each attempt to allow a new node to join. Neither the counter nor the next-try address are accessible to the user application.

For example, consider the network shown in Figure 40. Node 40 has been absent, and is ready to join now. Regardless of which node holds the token, only when the network message counter reaches 64 and the next-try address reaches 40 will the current node invite node 40 to join the ring. As node 40 joins, all other nodes will add its address to their member list. However, each time a next-try node address is invited to join and does not do so, approximately 2 ms must elapse before its absence can be assumed and the token passed to the next node.

The worst-case event occurs when node 64 wants to join at the moment the node that currently holds the token has a message count of 1 and a next-try address of 1 also. A minimum of 64 x 64 messages must pass before node 64 can be invited to join.

The average latency for this case is approximately 6 ... 7 s. Worst-case time is approximately 15 s. Because the actual timing is beyond the direct control of the application, the network planner should provide for worst-case timing to handle the event of a new node joining the ring.

3.19.1 Adding or Deleting Nodes

When you plan your network application you should provide adequate safeguards for the effects of nodes dropping out and rejoining the network ring. You can provide programming in each node s application that will safely suspend the node s activity, or that causes an orderly shutdown of the processes controlled by the node.

You should consider the inclusion of a dedicated node that monitors the network activity and reports on the status of your application. This can assist you in determining the origin of a condition in which several nodes are programmed to shut down if proper data is not received from one or more other nodes. With the monitoring node, you can more easily identify the node which started the shutdown sequence.

If you use one or more spare (open) drop cables and connectors at selected sites as points for temporarily connecting a network monitoring device, you should be aware of the effects on network timing when you add or delete that device on an active network. Adding the new node causes an increase in the network s token rotation time, reducing the overall data throughput. Deleting the node causes dropout latency times.

Caution: Before you connect or disconnect any device on an active network, you should be aware of its effect on network timing. Use the formulas in this chapter to estimate your network s token rotation time, data throughput, and node dropout latency time. Apply sufficient margin to your timing to provide for worst-case conditions, such as multiple nodes leaving or rejoining the network due to area power faults.

3.20 Precautions for Hot Standby Layouts

A case exists in which a node can leave the network and rejoin it without the control of the user application. This can occur when two nodes are connected in a hot standby configuration, as shown in Figure 41.

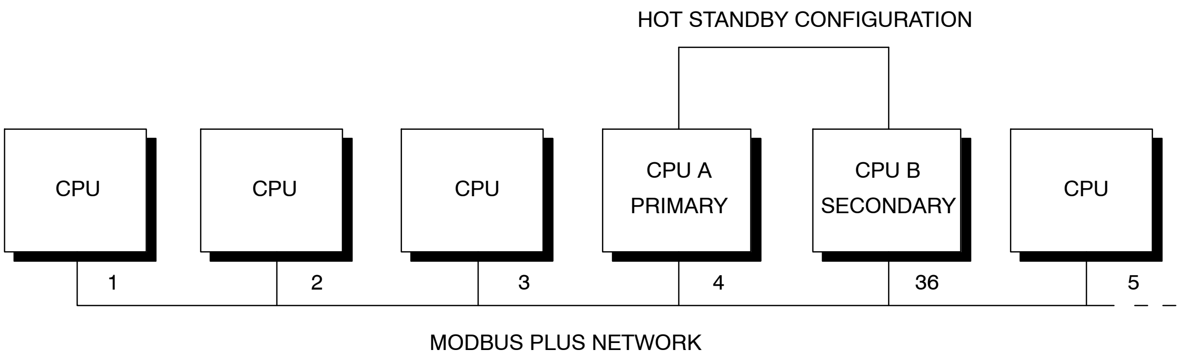


Figure 41 Hot Standby Ring Join Time

Programmable Controllers connected in hot standby each have a network address. Both nodes are active, with the two addresses offset by 32, as shown in Figure 41. As long as no transfer occurs between the primary and secondary controllers, the token is passed in the network s usual ascending address sequence.

If a hot standby transfer occurs, CPU B assumes the primary role and CPU A becomes the secondary. To maintain consistency in application programming among the nodes, CPUs A and B must also exchange node addresses. For this to occur, both nodes must momentarily leave the network and then rejoin it after the transfer has taken place. At that point CPU B (the new primary) then continues as node address 4, handling its traffic with the other nodes in the manner that you programmed for node 4.

Both nodes must be separately invited to rejoin through the ring-join process outlined on the previous page. This requires the use of an internal message counter and next-try address that are maintained by the network nodes and which are beyond the control of the user application.

Caution: In the worst-case timing for this event, as much as 15 s can be required for the ring to be reconstituted with the nodes in place at their new addresses. This can occur in a network of any size, if node address 64 is one of the nodes attempting to join at the same moment that the message counter and next-try addresses are both at a value of 1.

In most cases the time will be significantly less than this maximum amount, however the network planner should account for this worst-case event in the design of the network layout and programming of the node applications.

3.21 Guidelines for a Single Network

3.21.1 Using MSTR Functions

Each controller on the network should have a maximum of four MSTR functions active at the same time. Plan to have an MSTR function transferring large quantities of registers (up to 100 maximum per MSTR), rather than multiple MSTRs transferring small amounts of registers. You can easily use Block instructions in your ladder logic program to produce the block of contiguous registers required for each MSTR.

Here are two timing examples. Each example is taken from a network with 16 nodes, without global data being passed.

- Example 1: Every node has four MSTR functions active at all times. Each MSTR is writing 50 registers. The average token rotation time is 193 ms.

- Example 2: Every node has two MSTR function active at all times. Each MSTR is writing 100 registers. The average token rotation time is 126 ms.

Note that the same total quantity of data is being moved in the two examples. By using fewer MSTRs to move the data, the second example gives a 67 ms (about 35%) improvement in the average token rotation time.

3.21.2 Using Peer-to-Peer Communication Techniques

Use peer-to-peer passing of data where applicable, rather than master-slave polling. For example, in a master-slave process you can have a user interface device perform polling of your process control devices to determine if status updates are necessary. Using a peer-to-peer technique, you can have each process device initiate messages to the user interface device as events happen in the process. This reduces the total quantity of transactions on the network, improving network performance.

Destination devices must be able to sense the presence of new data and handle it before more data is received. One way to do this is to have each destination device maintain a *write status* register for each other device that can originate data to that application. When new data is sent, this status register is written into in addition to the data registers that are written. A *new data ready* sentinel bit can be set by the write operation, and can be reset by the local application when the data is extracted and used. Other bits in the status register can indicate the data block length, target task, and other information. Additional registers can be used for this purpose if required.

The destination device s software can handle missed events internally on a timeout basis, rather than by polling, and still manage orderly shutdowns. Plan your application from the start to use effective techniques for throughput.

3.21.3 Using the Global Database

You can broadcast up to 32 registers using the network s global database, with up to 64 nodes receiving this data during the current token pass. This can be most effective in data acquisition and alarm handling, in which many devices can react quickly to a single transmission of data.

The MSTR Write Global Database function executes upon release of the token by the initiating node. The MSTR Read Global Database function executes during the scan of each receiving node, making the data available immediately to the node s application.

3.21.4 Security Considerations in Node Addressing

Modbus Plus nodes can be addressed within the range 1 ... 64 decimal. For security purposes, consider limiting the range to between 2 and 64 (you probably will not require all 64 addresses on a single network).

In non-networked applications, many users have traditionally attached to a local controller by identifying it as device 1. If a person tried to do this with a controller operating in its bridge mode, a remote controller at node address 1 could be attached and possibly started, stopped, or programmed. Avoiding the use of address 1 prevents inadvertent attaches by persons who may be unfamiliar with a controller s bridge mode.

3.21.5 Selecting Node Addresses for Best Throughput

Consider assigning network node addresses to the various devices in a manner that supports efficient message handling. If your network consists of multiple nodes with heavy traffic occurring at one node, your choice of node addressing can affect the token rotation time and data rate.

For example, consider a network of 12 nodes, with an average token rotation time of 100 ms. The nodes are addressed from 2 ... 13, with no gaps in the address sequence. In the application, nodes 2 and 3 are initiating many transactions to node 4. As the token passes to node 4, that node might not have had enough time to scan and process all of its message traffic. Node 4 might have to wait for a later rotation of the token in order to send its data responses to the initiating nodes.

By assigning a higher node address to the receiving node, for example address 12, the device can use the time during which the token is passing through the other nodes to process its traffic. By the time the token arrives, a data response can be ready.

The time saved in each transaction is the difference between the time for a full rotation (nodes 2, 3, 4 ... 13, 2, 3, 4) and the time for a partial rotation (nodes 2, 3 ... 12).

3.21.6 Consistency in Node Addressing

Use a consistent method for identifying node addresses. This will facilitate development of your application program and make future expansion easier to plan. For example, use addresses in the range 2 ... 19 to identify programmable controller nodes, addresses 20 ... 29 for bridges, and addresses in the 30's for host-based network adapters.

Using addresses 20 ... 24 for Bridge Plus devices, with addresses 2 ... 9 for controllers, allows you to use Implicit Addressing in your application. Appendix B has examples of message routing using this and other addressing methods.

Note that you can use the same networkaddress at both networkports of a Bridge Plus. When using hot-standby controllers, remember the address offset of 32 between the primary and standby unit. Avoid duplicating addresses on the same network.

3.21.7 Remote Programming

Online programming of nodes while network data transactions are in progress does not reduce the network's data transfer rate. Devices maintain program master and slave paths that are separate from their data paths. Some programming commands, like the Search command, do increase the scan time of controllers. When these commands are being executed the data rate (registers per second for active MSTR functions) may be reduced in the controller.

For security, the Memory Protect keyswitch on programming panels should always be set to the ON position when programming is not in progress.

3.21.8 Controlling the Sequencing of MSTR Functions

When you use multiple MSTR functions in a controller, each MSTR acquires its own Data Master path which is maintained open until its transaction terminates. The paths are independent of each other. A transaction can be started on one path, and another transaction can be started some time later on a second path. Their completions are determined by other devices on the network.

If your application needs to complete the MSTR functions sequentially, use logic to monitor the COMPLETE outputs before enabling other MSTR functions.

3.21.9 Optimizing Node Counts

Consider separating a device application into two or more devices to avoid queueing. For example, if you expect heavy queueing within one controller because of a high concentration of traffic from other nodes, consider employing two nodes instead. Although the additional node count adds slightly to the token rotation time, the opportunity for parallel processing without queueing makes data available more quickly as the token is received in each of the two nodes.

3.21.10 Prioritizing and Compressing Data

Plan the data transactions in your application so that only needed information is sent. Process the data before transmission, condensing it into larger messages if possible. Reduce the amount of data messages to be sent, or reduce the frequency at which they have to be sent.

Schedule the data to be sent on a timed basis rather than on every scan of a controller, to reduce the loading on the network. Time the transmissions to the intervals at which the receiving device needs the information.

3.21.1 1 Selecting Bridge Multiplexer Port Modes

The four Modbus ports on Bridge Multiplexers can be separately configured for either ASCII or RTU communications. RTU mode provides significantly better throughput than ASCII for a given baud rate. Plan to configure the ports for RTU mode, using the highest baud rate possible for your Modbus devices.

3.22 Guidelines for Multiple Networks

If your application s data rate requirements are not met between nodes on a single network, consider the use of bridges to join smaller networks. The grouping of nodes on each network requires determination of which nodes must communicate at high data rates with other nodes. Time-critical control data should be handled between nodes on the same network. Bridging should be used for less critical tasks like data acquisition, load-record-verify operations, and remote programming.

Modbus Plus networks that are joined by bridges will have separate token rotations. When a message passes through a bridge to another network, the other network s token rotation time will be a factor in communication timing. In general, messages sent through bridges will take longer to complete than messages sent between nodes on a single network. Note also that global data is not passed through bridges.

Peer Cop and Distributed I/O data is transacted on a single network only. It does not pass through bridges. Bridges are not applicable to networks employing Peer Cop data transfers, nor to networks in DIO applications.

3.22.1 Bridge Communication Paths

Figure 42 shows the structure of communication paths within a bridge. It illustrates the amount of paths that are available in each direction.

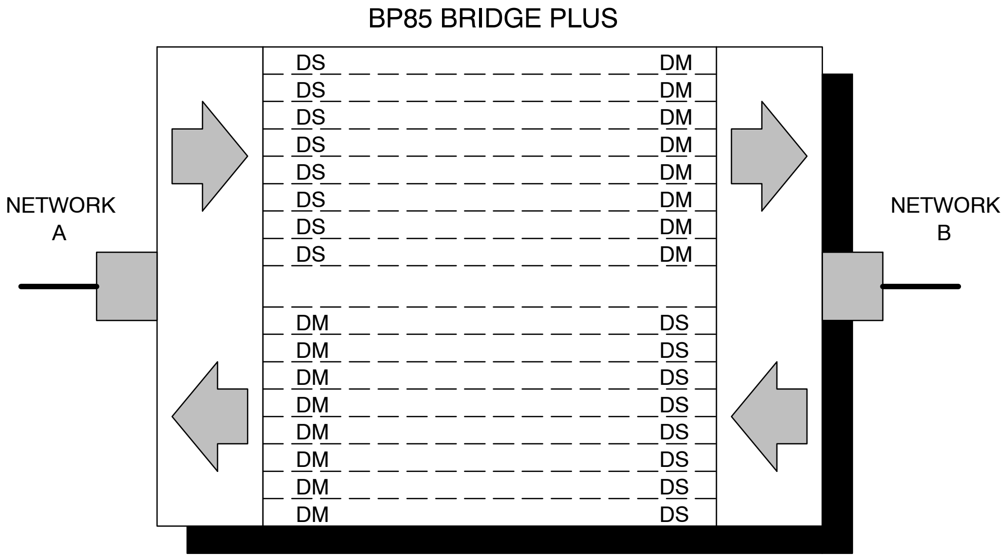


Figure 42 Bridge Communication Paths

The bridge contains eight independent Data Master paths and eight independent Data Slave paths for each of its two network ports. Messages received at the network A port with destinations on network B or beyond are given Data Slave paths on network A, and then passed to Data Master paths at the network B port. In the other direction, incoming messages at network B are given Data Slave paths at that port and Data Master paths at network A.

As each message is allocated one slave path and one master path in the bridge, up to eight messages can be routed from each network to the other without queueing.

When all eight paths are in use in a given direction, other incoming messages will queue in the bridge, unless they have previously been routed through another bridge. Messages that have already been passed through a bridge will cause an error response when they are received at the second bridge. The error response will be returned to the error status register of the originating MSTR function, and can be tested by the application program. This prevents tieing up paths in the originating device due to excessive queueing. MSTRs can be temporarily released (using their ABORT inputs), and their Data Master paths given to other MSTRs.

3.22.2 Using Multiple Bridges Between Networks

If your application will have heavy traffic between networks, you can use two or more bridges to increase the number of paths and to reduce or eliminate queueing. Figure 43 shows an example.

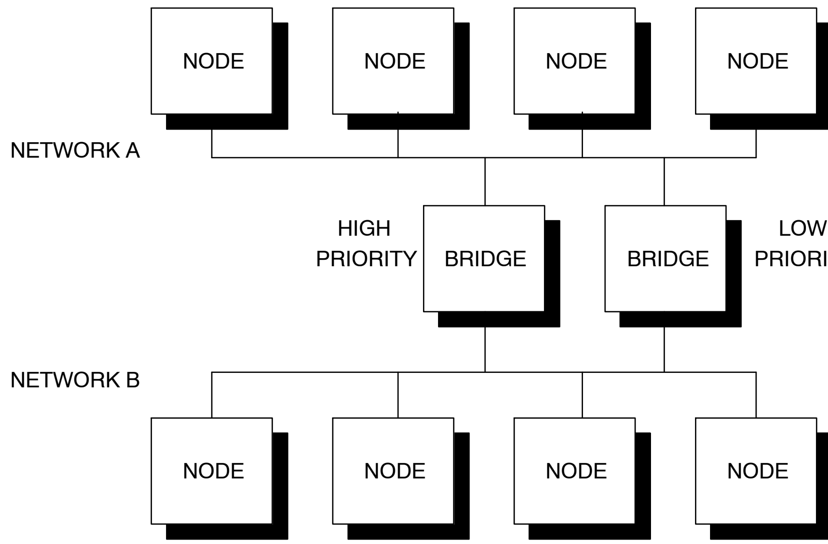


Figure 43 Multiple Bridging Between Networks

You can plan your application so that high priority messages are passed through a dedicated bridge. Design the message flow so that the bridge always has available paths. Low priority messages can be allowed to queue in the other bridge.

Note: Data Master paths will remain busy in the originating nodes while messages are queued in the bridge.

3.23 Sample Communications Across Networks

Figure 44 shows two controllers on separate Modbus Plus networks joined by a bridge. Each controller has its own peer processor. The bridge has a separate peer processor for each network. Each network has a separate token rotation pattern and timing.

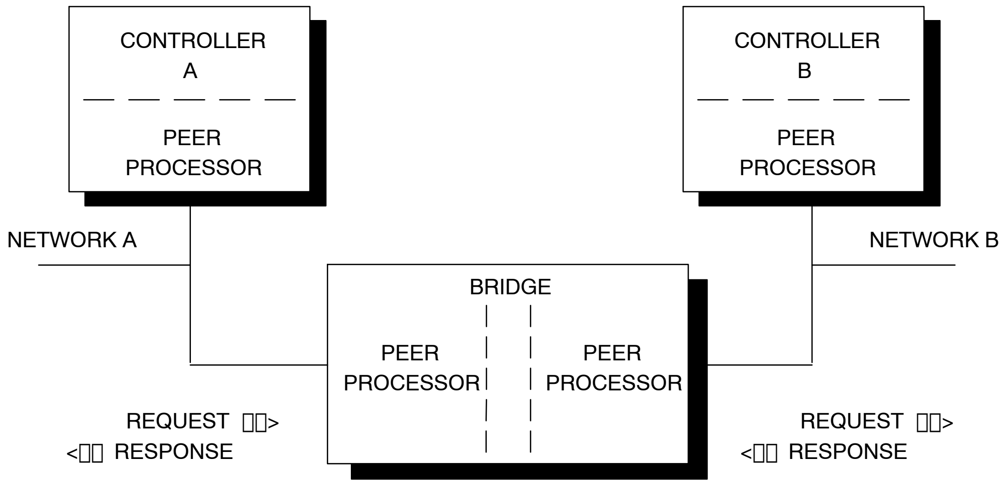


Figure 44 Sample READ Communication Across Networks

During the ladder logic scan in unit A, an MSTR block is executed that specifies a read request to unit B. At the end of the block execution, the read request is sent to the peer processor in unit A. The following events occur:

Step 1 When the peer processor in unit A acquires the network token, it transmits the read request. The peer processor in the bridge sends an immediate acknowledgement.

Step 2 When the bridge has the token on network B, it transmits the read request to unit B. The peer processor in unit B sends an immediate acknowledgement to the bridge.

Step 3 At the end of the ladder logic scan in unit B, the incoming transactions are handled. The peer processor in unit B is ready with the data response to the read request.

Step 4 When the peer processor in unit B acquires the token, it sends the data response to the bridge. The peer processor in the bridge sends an immediate acknowledgement.

Step 5 When the bridge has the token on network A, it transmits thedataresponse to unitA. The peer processor in unit A sends an immediate acknowledgement.

Step 6 At the end of the ladder logic scan in unit A, the incoming transactions are handled. The transaction is complete at the next solve time of the MSTR function in unit A. Data registers will be written, and the MSTR function s COMPLETE output goes ON.

The time required to process the complete communication would be:

Event	Time Range	Average Time	Worst Case Time
1	0 ... 1 token rotation, net A	1/2 token rotation, net A	1 token rotation, net A
2	0 ... 1 token rotation, net B	1/2 token rotation, net B	1 token rotation, net B
3	0 ... 1 scan, unit B	1/2 scan, unit B	1 scan, unit B
4	0 ... 1 token rotation, net B	1/2 token rotation, net B	1 token rotation, net B
5	0 ... 1 token rotation, net A	1/2 token rotation, net A	1 token rotation, net A
6	0 ... 2 scans, unit A	1 scan, unit A	2 scans, unit A

If the scan time in unit B is much shorter than the token rotation time, unit B can create the data response and have it ready before the token reaches unit B s peer processor. On the other hand, if a data path is not free in either the bridge or in unit B, the request will be queued by that unit s peer processor and will wait until a path is free.

3.24 A Summary of Network Planning

3.24.1 Analyzing Your Needs

Analyze your application s data communication requirements prior to laying out your network or writing your programming. Make a simple chart to guide your planning. Include the following items for each communication:

Originating Node	Network Number	Device Description
	Node Address	Device Type
Receiving Node	Network Number	Device Description
	Node Address	Device Type
Communication	Purpose	Frequency of Enabling
	Priority	Number of Registers
	Sent Under What Conditions	Response Time Needed

3.24.2 Finding Opportunities for Increasing Performance

As you enter your needs on your planning chart, look for the following opportunities to improve performance by reducing network loading:

- ☐ Carefully examine the purpose of each communication and group of registers to ensure that the communication and data are needed.
- ☐ Try to group multiple communications between two nodes into fewer transactions.
- ☐ Try to reduce the frequency at which reads or writes are enabled. Remember that the maximum frequency of enabling MSTRs is once per scan.
- ☐ Look for receiving controller nodes that have more than four potential transactions being sent to them these nodes might have queueing. Especially look for types of communications that have high priority, and which are to be sent to nodes that might have queueing.
- ☐ Use peer-to-peer passing of data where applicable, rather than master-slave polling.

- Reduce queueing by reducing the number of communications to a controller node, or by reducing the frequency of enabling communications, so that only four reads or writes are handled by the receiving controller; consider having the receiving node originate some transactions (this will use its Data Master paths, freeing Data Slave paths).

Chapter 4 Documenting the Network Layout

- ☐ Documenting Your Network Layout
- ☐ Your Planning Worksheets
- ☐ Defining Your Node Requirements
- ☐ Topology Planning Worksheet
- ☐ Estimating Cable Lengths
- ☐ Reviewing Your Topology Plan
- ☐ Detailing the Network Layout
- ☐ Network Planning Worksheet
- ☐ Cable Routing Worksheet
- ☐ Materials Summary Worksheet

4.1 Documenting Your Network Layout

Your planning should include the preparation of documents that describe your network node requirements, setup parameters, installation materials, cable routing, and labeling. Provide information to support the following kinds of activity:

- Ordering the proper types and quantities of node devices and network materials
- Routing and installing the network cable
- Identifying, labeling, and installing the network components
- Setting up the network addresses and other device parameters
- Expanding, modifying, and servicing the network and network devices.

4.2 Worksheets for Network Planning

Five kinds of worksheets are provided in this book to assist you in your network planning. This chapter shows examples of their use.

Appendix C provides blank worksheets. You can make photocopies as needed for documenting your network layout. Some copiers can enlarge thesize of thesheets if that is moresuitable.

Here are your five types of worksheets:

Node Planning Worksheet
Use this sheet to list the communications requirements and setup parameters of each node device in your application.

Topology Planning Worksheet
Use this sheet to define each network s layout and the interconnection of multiple networks.

Network Planning Worksheet
Use this sheet to itemize the trunk cable length, tap, drop cable, and labeling requirements at each node site.

Cable Routing Worksheet
Use this sheet to show the routing of the network trunk cable through the node sites in your facility.

Materials Summary Worksheet
Use this sheet to summarize your network devices, cable components, supporting materials, and tools requirements for ordering purposes.

4.3 Defining Your Node Requirements

Before you document your network layout, make a list of your requirements for each node device. Include the node address, device type, site location, application, setup parameters, and a summary of the communications to be sent and received.

Include all the necessary setup parameters for each type of device. For example, if the device is a controller, define its free-running timer location to identify the registers that will be used for Modbus address mapping. For a host-based network adapter, define its memory base address and driver parameters. For a Bridge Multiplexer, define its attached Modbus devices, Modbus port parameters, and Modbus address mapping.

An example of a Node Planning Worksheet is shown in Figure 45. You can adapt this worksheet to your requirements, adding other fields of information as needed. If a node will have several applications, you may want to use separate worksheets for showing the types of communication that will be used in each application.

When you have defined each node s requirements, use the network worksheets in the rest of this chapter to document your network layout, cable routing, and materials.

MODBUS PLUS NETWORK
NODE PLANNING WORKSHEET

FACILITY / AREA : *PAINT* PROJECT NAME : *MOD #1* DATE : *6-6-96*

NETWORK NUMBER : *1* PROJECT ENGR : *P. GREEN* TEL : *2742*

NODE ADDRESS : *2* MAINTENANCE : *V. WHITE* TEL : *3824*

1. DEVICE :

TYPE	DESCRIPTION	SITE LOCATION
CPU 213 03	*PROGRAMMABLE CONTROLLER*	*PAINT #1 PANEL 5A*

2. APPLICATION :

PAINT MOD #1

3. SETUP PARAMETERS :

N/A

4. COMMUNICATIONS ORIGINATED :

NETWORK	NODE	PRIORITY	PURPOSE	TYPE OF COMMUNICATION	AMOUNT OF DATA	RESPONSE TIME NEEDED
1	*3*	*1*	*INIT LOAD*	*READ DATA*	*50 REGS*	*150 MS.*
1	*10*	*1*	*PARAMS 1*	*READ DATA*	*100 REGS*	*250 MS.*
1	*10*	*2*	*PARAMS 2*	*READ DATA*	*75 REGS*	*200 MS.*

5. COMMUNICATIONS RECEIVED :

NETWORK	NODE	PRIORITY	PURPOSE	TYPE OF COMMUNICATION	AMOUNT OF DATA	RESPONSE TIME NEEDED
1	*3*	*1*	*ALARMS*	*READ GLOBAL*	*16 REGS*	*50 MS.*
1	*10*	*2*	*PROC STATS*	*READ DATA*	*50 REGS*	*100 MS.*

NOTES :

Figure 45 Example: Node Planning Worksheet

4.4 Topology Planning Worksheet

Figure 46 is an example of a completed Topology Planning Worksheet. The example shows two networks that are interconnected by a BP85 Bridge Plus. Each device s network node address, type, application, and site location are listed.

Top of Worksheet

If applicable, identify the plant facility or area, network, and project. Show how to contact the responsible project engineer and maintenance person.

Network Topology Area

Lay each network out in a linear path for clarity. Use an END symbol to show the two physical ends of each network section. Make four entries to identify each node device. Use the following legend:

Entry Number	Entry Content	Meaning
First	Node number	The device s address on the network
Second	Device type	The device s model number
Third	Application	The title of the device s application or use
Fourth	Location	The device s site location in your facility

Use additional entries as needed to further identify each node in your application.

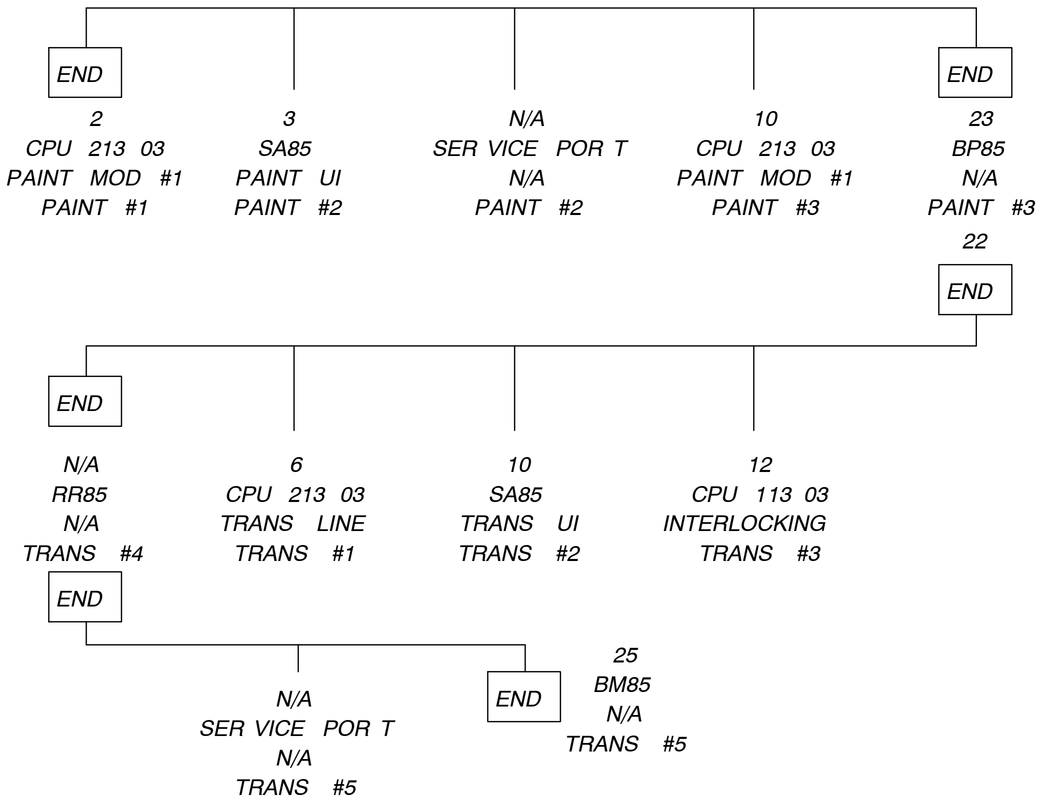
MODBUS PLUS NETWORK
TOPOLOGY PLANNING WORKSHEET

FACILITY / AREA : *PAINT*

PROJECT NAME : *MOD #1* DATE : *6-6-96*

PROJECT ENGR : *P. GREEN* TEL : *2742*

MAINTENANCE : *V. WHITE* TEL : *3824*



LEGEND : FIRST ENTRY: NODE NUMBER
SECOND ENTRY: DEVICE TYPE
THIRD ENTRY: APPLICATION
FOURTH ENTRY: LOCATION

END — END SITE OF NETWORK SECTION

NOTES :

Figure 46 Example: Topology Planning Worksheet

4.5 Estimating Cable Lengths

After defining the network topology, consider the required cable lengths between nodes. You can enter the estimated cable lengths onto the topology planning worksheet. This information will be required for the detailed planning worksheets you will be using next.

For dual-cable network planning, note that the point of the two cable runs is to minimize the potential for communication loss through interference or damage to either cable. Therefore you should plan for proper physical separation of the cables at all points except for where they connect to a network node device.

Use a facility grid or floor plan to estimate the cable lengths. Account for all horizontal runs, vertical rises, and required clearances from interference sources. A walkthrough to confirm your estimates is best.

4.6 Reviewing Your Topology Plan

Review your topology planning worksheet after you estimate the cable lengths. Revise it if necessary to account for the minimum and maximum cable length requirements. For example, if you have estimated a cable length of less than 10 ft (3 m) between a pair of nodes, you must revise your plan to meet this minimum length requirement.

If you have estimated a distance of more than 1500 ft (450 m) between two nodes, or if you are using more than 32 nodes on one cable section, you must revise your plan to include at least one RR85 Repeater device in the cable path.

When you have completed your topology planning, you can proceed to the detailed worksheets in the rest of this chapter.

4.7 Detailing the Network Layout

4.7.1 Overview of Your Detailed Planning Worksheets

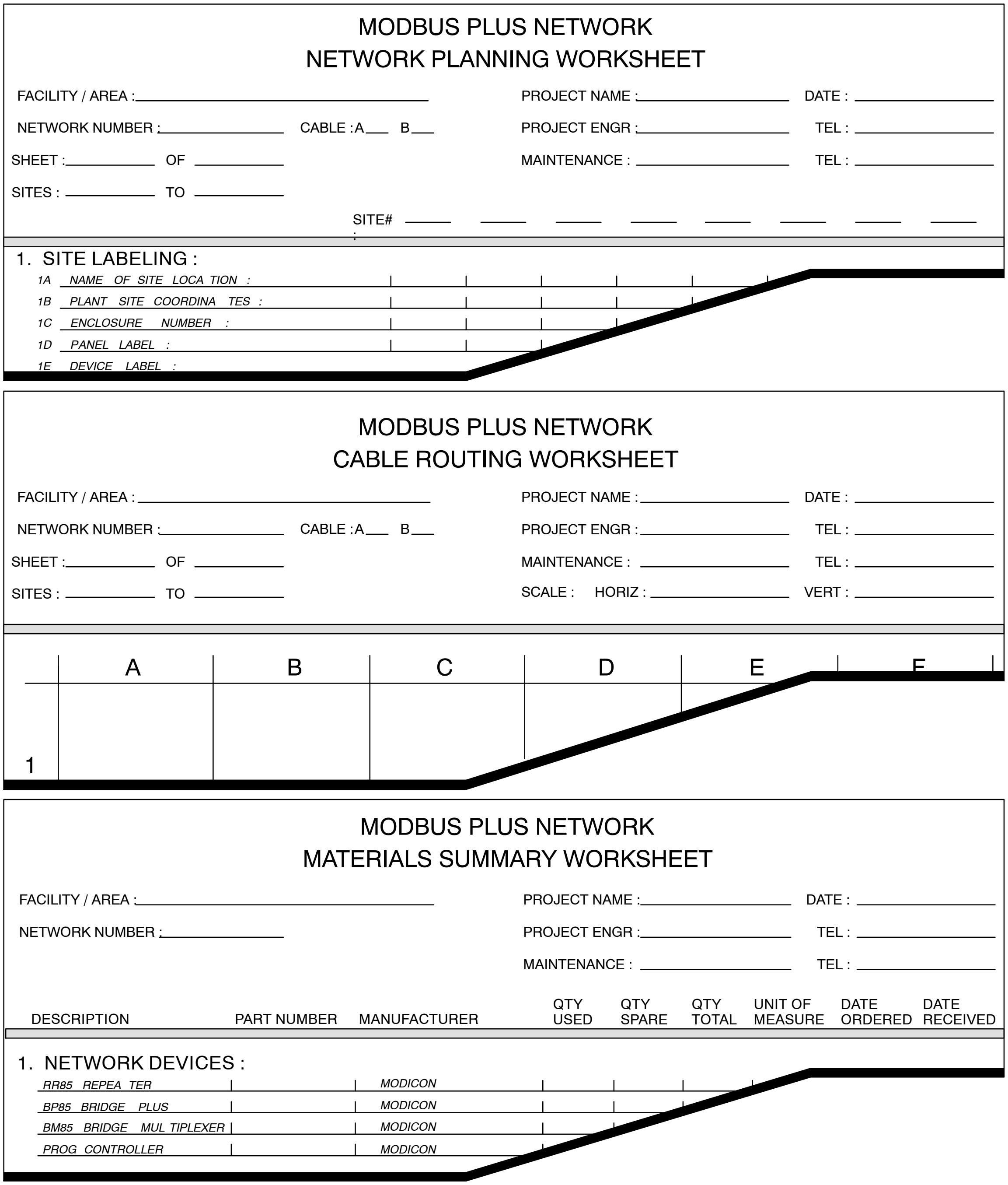
You have three worksheets to document your detailed planning. Examples are described in the following pages.

Figure 47 shows an overview of the three worksheets:

Network Planning Worksheet
This worksheet details the layout of your network: your cable lengths, taps, and node devices; your labeling of panels, cables, and connectors.

Cable Routing Worksheet
This worksheet details the routing of your cable through the sites of your plant facility.

Materials Summary Worksheet
This worksheet summarizes your network materials requirement before placing orders: node devices, trunk cable, drop cables, taps, labels, installation hardware, tools and test equipment.



MODBUS PLUS NETWORK
NETWORK PLANNING WORKSHEET

FACILITY / AREA : ________ PROJECT NAME : ________ DATE : ________
NETWORK NUMBER : ________ CABLE : A___ B___ PROJECT ENGR : ________ TEL : ________
SHEET : ________ OF ________ MAINTENANCE : ________ TEL : ________
SITES : ________ TO ________
SITE# : ______ ______ ______ ______ ______ ______ ______ ______

1. SITE LABELING :
1A NAME OF SITE LOCATION :
1B PLANT SITE COORDINATES :
1C ENCLOSURE NUMBER :
1D PANEL LABEL :
1E DEVICE LABEL :

MODBUS PLUS NETWORK
CABLE ROUTING WORKSHEET

FACILITY / AREA : ________ PROJECT NAME : ________ DATE : ________
NETWORK NUMBER : ________ CABLE : A___ B___ PROJECT ENGR : ________ TEL : ________
SHEET : ________ OF ________ MAINTENANCE : ________ TEL : ________
SITES : ________ TO ________ SCALE : HORIZ : ________ VERT : ________

	A	B	C	D	E	F
1						

MODBUS PLUS NETWORK
MATERIALS SUMMARY WORKSHEET

FACILITY / AREA : ________ PROJECT NAME : ________ DATE : ________
NETWORK NUMBER : ________ PROJECT ENGR : ________ TEL : ________
MAINTENANCE : ________ TEL : ________

DESCRIPTION	PART NUMBER	MANUFACTURER	QTY USED	QTY SPARE	QTY TOTAL	UNIT OF MEASURE	DATE ORDERED	DATE RECEIVED
1. NETWORK DEVICES :								
RR85 REPEATER		MODICON						
BP85 BRIDGE PLUS		MODICON						
BM85 BRIDGE MULTIPLEXER		MODICON						
PROG CONTROLLER		MODICON						

Figure 47 Overview of Planning Worksheets

4.8 Network Planning Worksheet

Each network planning worksheet can document up to eight sites. Use additional worksheets as required. Figure 48 is an example of a completed Network Planning Worksheet. The example shows a network of four nodes (two controllers, one SA85 Network Adapter, and one BP85 Bridge Plus), plus one additional tap and drop cable for future service access.

Note: You can use this worksheet for: (a) a single-cable network; (b) each cable on a dual-cable network; or (c) both cables on a dual-cable network.

Single-cable network Enter the complete information in all areas of the sheet.

Dual-cable network, each cable Use a separate planning sheet for each cable. Check CABLE A or CABLE B as appropriate in the top area of the sheet. Enter the Site Labeling and Cable Length information for the cable. In the Device Type area, you should enter the network device types (except for RR85 Repeaters) only once, on the CABLE A sheet. You should enter the RR85 Repeaters on both sheets (RR85 Repeaters are used on both cables).

Dual-cable network, both cables Check both CABLE A and CABLE B in the top area of the sheet. In the Site Labeling area, use a labeling method that will properly identify each cable. In the Cable Length area, make sure to enter the total length for both cables, including the service loops on both cables.

Top of Worksheet

If applicable, identify the plant facility or area, network, and project. Show how to contact the responsible project engineer and maintenance person.

Site Labeling

Provide a labeling method for identifying network components. Enter site names into line 1A, such as department names or floor/room numbers. If a grid locator system is used, enter site coordinates into line 1B. If a device enclosure or cabinet is used, identify it in line 1C. Enter further information into lines 1D through 1G to identify each site s mounting panel, device, and incoming/outgoing cable runs.

Trunk Cable and Taps

Estimate the length of the cable between sites. Each segment except the first has a cable run from the previous site (line 2A). A service loop in included (line 2B) to eliminate pulling or twisting of the cable. Include all vertical routing (such as runs between floor levels), and all horizontal routing (such as bends around ventilating shafts). Add these lengths and enter their total into line 2C. Multiply this times 1.1 (providing an additional 10 percent) for finished dressing of the cable, and enter this final length into line 2D. This is the cut length for each segment.

Make sure that the minimum length that will result between any pair of nodes will be 10 ft (3 m) or more. Make sure that the combined lengths between all nodes on a cable section will be 1500 ft (450 m) or less.

Enter an X into line 2E for each site, showing that a tap is to installed. At the two end sites on the network section, enter an X into line 2F to show that the tap s termination jumpers are to be installed.

Drop Cables

Enter an X into line 3A or 3B for the drop cable at each site. Ensure that the drop cable is long enough to allow a service loop for maintenance.

Device Type

Specify the device to be installed at each site. For programmable controllers, enter the model number into line 4E. For host network adapters enter the model number (SA85, SM85, etc) into line 4F. For other devices, enter the model number or an X into the appropriate line (4A through 4K) for each site. Include at least one access point (line 4A) at a convenient site for future service.

MODBUS PLUS NETWORK
NETWORK PLANNING WORKSHEET

FACILITY / AREA : *PAINT*   PROJECT NAME : *MOD #1*   DATE : *6-6-96*

NETWORK NUMBER : *1*   CABLE : A ✓ B ___   PROJECT ENGR : *P. GREEN*   TEL : *2742*

SHEET : *1* OF *1*   *NOTE 2.*   MAINTENANCE : *V. WHITE*   TEL : *3824*

SITES : *1* TO *5*

SITE# :	1	2	3	4	5			
1. SITE LABELING :	PAINT	PAINT	PAINT	PAINT	PAINT			
1A NAME OF SITE LOCATION :	#1	#2	#2	#3	#3			
1B PLANT SITE COORDINATES :	B5	B3	B3	C2	C2			
1C ENCLOSURE NUMBER :	N/A	N/A	N/A	N/A	N/A			
1D PANEL LABEL :	5A	6A	6C	12A	12A			
1E DEVICE LABEL :	5A1	6A3	N/A	12A2	12A3			
1F CABLE FROM PREVIOUS SITE, LABEL :	N/A	6A3A	6C3A	12A2A	12A3A			
1G CABLE TO NEXT SITE, LABEL :	5A1AA	6A3AA	6C3AA	12A2AA	12A3AA			
2. TRUNK CABLE AND TAPS :								
2A CABLE RUN FROM PREVIOUS SITE, LENGTH :	N/A	160	58	140	25			
2B SERVICE LOOP AT THIS SITE (2M/6FT) :	N/A	6	6	6	6			
2C RUN LENGTH (SUM OF 2A AND 2B) :	N/A	166	64	146	31			
2D CUT LENGTH (MULTIPLY 2C TIMES 1.1) :	N/A	183	71	161	35			
2E TAP, 990NAD23000 :	X	X	X	X	X			
2F TERMINATION JUMPERS INSTALLED IN TAP :	X				X			
3. DROP CABLES :								
3A DROP CABLE, 2.4M/8FT, 990NAD21 110 :		X	X					
3B DROP CABLE, 6M/20FT, 990NAD21 130 :	X			X	X			
4. DEVICE TYPE :								
4A SERVICE ACCESS POINT CONNECTOR :			X					
4B RR85 REPEATER:								
4C BM85 BRIDGE MULTIPLEXER :								
4D BP85 BRIDGE PLUS :					X NOTE 1.			
4E PROGRAMMABLE CONTROLLER (MODEL NO.):	213 03			213 03				
4F HOST NETWORK ADAPTER (MODEL NO.):		SA85						
4G NETWORK OPTION MODULE (MODEL NO.):								
4H DIO DROP ADAPTER (MODEL NO.):								
4I TIO MODULE (MODEL NO.):								
4J								
4K								

NOTES :

1. SITE 5: BP85 CONNECTS BETWEEN NETWORKS #1 AND #2. COUNT ONLY ONCE IN MATERIALS SUMMARY.

2. CABLES: THIS WORKSHEET SHOWS CABLE LENGTHS FOR CABLE A. USE SEPARATE WORKSHEET FOR CABLE B.

Figure 48 Example: Network Planning Worksheet

4.9 Cable Routing Worksheet

Wherever possible, obtain a site layout for your plant facility and use it to plot your network cable routing. If no drawing is available, use the Cable Routing Worksheet in this guide. Adapt the blank worksheet in Appendix C as needed for your network cable path.

Figure 49 shows an example of a completed Cable Routing Worksheet. The example shows a network of four nodes, plus one additional connector for future service access. The site locations correspond to those shown on the Network Planning Worksheet.

☞ **Note:** You can use this worksheet for: (a) a single-cable network; (b) each cable on a dual-cable network; or (c) both cables on a dual-cable network.

Single-cable network Show the cable routing.

Dual-cable network, each cable Use a separate planning sheet for each cable. Check CABLE A or CABLE B as appropriate in the top area of the sheet. Show the cable routing. You can use a different grid scale for each cable, if appropriate.

Dual-cable network, both cables Check both CABLE A and CABLE B in the top area of the sheet. Show the cable routing for both cables. Make sure to mark the sheet so that each cable (A or B) is properly identified over its entire run.

Top of Worksheet

If applicable, identify the plant facility or area, network, and project. Show how to contact the responsible project engineer and maintenance person.

You can enter grid scale dimensions at the top of the worksheet to plot your cable routing. You can use separate dimensions horizontally (grids A ... F) and vertically (grids 1 ... 5). For example, each grid can represent a square site area such as 10 m X 10 m, or a rectangular area such as 10 m X 50 m. If you wish, you can leave the scale blank and mark each cable run length directly onto the worksheet.

You can also make multiple copies of this worksheet, and use a relatively small scale on some sheets to show local placement of devices and cables. Use a larger scale on another sheet to show the overall network layout.

Worksheet Grid Areas

Draw the cable routing path into these areas. Provide sufficient information to enable installers to properly route the cable between site locations. The following type of information will be useful:

- ☐ The area name or department of each site location to which the cable is to be routed
- ☐ The identification label of the device enclosure, cabinet, or mounting panel at each site location
- ☐ The identification label of the networked device at each site location
- ☐ The cable routing path between site locations
- ☐ The cable routing method, such as through new or existing cable troughs, raceways or conduits
- ☐ Any additional cable installation information, such as separation from interference sources, mounting of strain reliefs, and other methods of securing and protecting the cable.

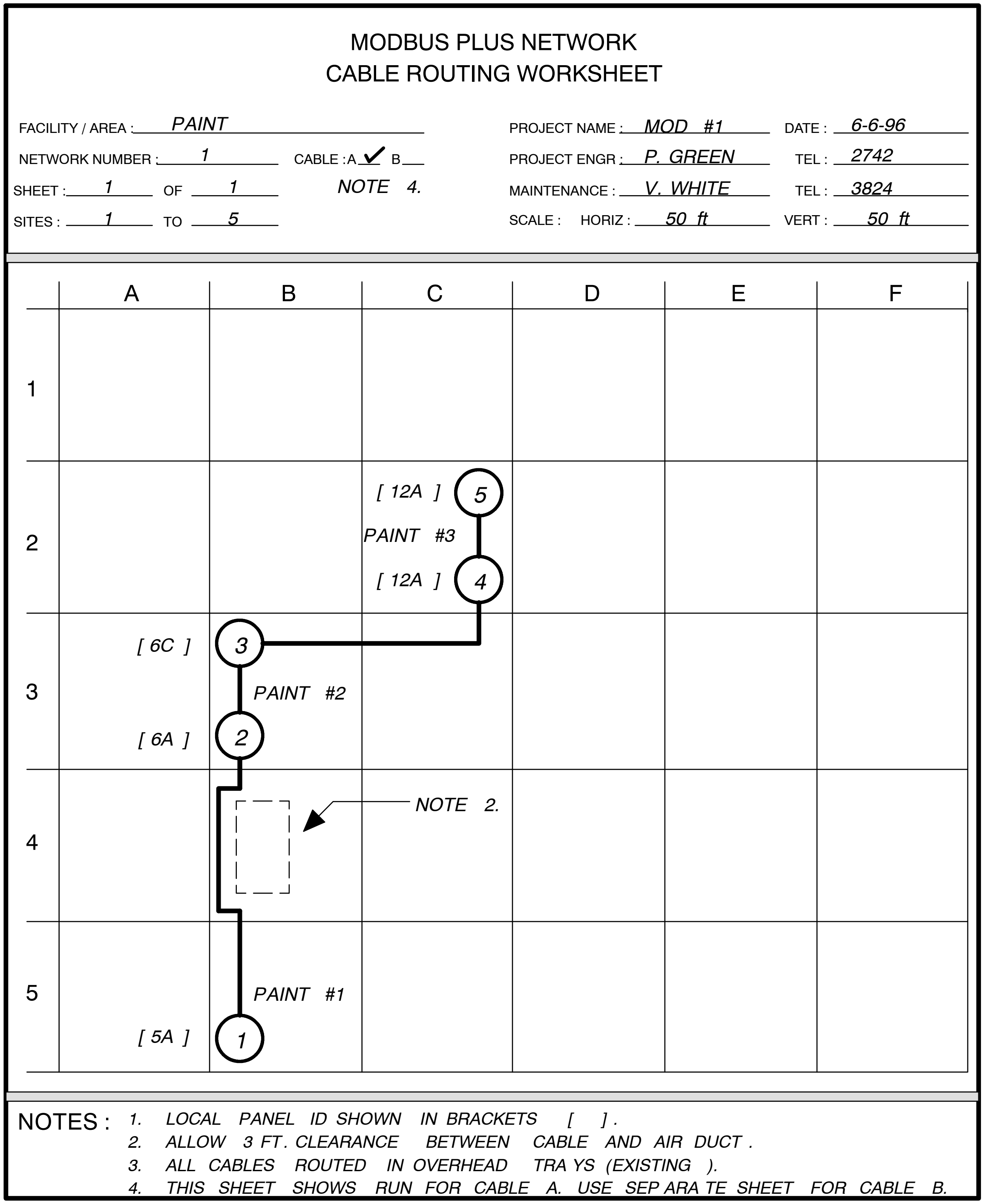


Figure 49 Example: Cable Routing Worksheet

4.10 Materials Summary Worksheet

When your planning of the network layout and cable routing is complete, you can use the Materials Summary Worksheet to list the required components and start an ordering process. Use the worksheet to list the types of materials, part numbers, manufacturers/sources, and quantities to be ordered. Some items are already listed to start your planning. Enter any additional items into the blank lines provided.

Use additional worksheets if more space is needed. If you are planning multiple networks, you can use one worksheet for each network and then summarize your requirements on a final worksheet.

Dual-cable Networks

Your final worksheet should contain the total of all materials you will be specifying and ordering for both cable runs. Note that RR85 Repeaters are used separately on each cable. Where an RR85 is used between nodes on one cable run, another RR85 must appear between the same nodes on the other cable run.

Figure 50 is an example of a completed MaterialsSummary Worksheet. It lists materials for a network of four nodes (two programmable controllers, one SA85 Network Adapter, and one BP85 BridgePlus), plus one additional connector for future service access. The example also shows provisions for service spares.

Top of Worksheet

If applicable, identify the plant facility or area, network, and project. Show how to contact the responsible project engineer and maintenance person.

Network Devices

Summarize the devices that will be connected to the network. For programmable controllers, list the model numbers and quantities of each type.

Avoid duplication when summarizing your device requirements. When you include an RR85 Repeater to join two network sections, make sure to count that device only once. Note that separate RR85 Repeaters are used on each cable on a dual-cable system. When you include a BP85 Bridge Plus to join two networks, count thedevice only once.

Trunk Cable and Taps

Summarize the amount of cable that will be required. Convert the network cable length into standard reel lengths of 100, 500, or 1000 ft.

If cable will be ordered as two or more reels, specify reel lengths that will allow you to run continuous cable segments between sites, without splices. On dual-cable layouts, make sure that this requirement is met for each cable run.

Summarize the amount of taps that will be required.

Drop Cables

Summarize the drop cables in each size that will be required.

Labels

Summarize the types and quantities of labels that will be required to properly identify the network components for installation and future servicing.

Installation Hardware

Enter the types and quantities of hardware items that will be required to install, secure, and support the network cable and devices.

Tools/Test Equipment

Enter the types and quantities of tools and test equipment that will be required to install and test the network.

MODBUS PLUS NETWORK
MATERIALS SUMMARY WORKSHEET

FACILITY / AREA : *PAINT* PROJECT NAME : *MOD #1* DATE : *6-6-96*

NETWORK NUMBER : *1* PROJECT ENGR : *P. GREEN* TEL : *2742*

NOTE 1. MAINTENANCE : *V. WHITE* TEL : *3824*

DESCRIPTION	PART NUMBER	MANUFACTURER	QTY USED	QTY SPARE	QTY TOTAL	UNIT OF MEASURE	DATE ORDERED	DATE RE-CEIVED
1. NETWORK DEVICES :								
RR85 REPEATER		MODICON				EACH		
BP85 BRIDGE PLUS	NW-BP85-002	MODICON	1	1	2	EACH	6-6-96	
BM85 BRIDGE MULTIPLEXER		MODICON				EACH		
PROG CONTROLLER	CPU 213 03	MODICON	2	1	3	EACH	6-6-96	
HOST NETWORK ADAPTER	AM-SA85-002	MODICON	1	1	2	EACH	6-6-96	
NETWORK OPTION MODULE		MODICON				EACH		
DIO DROP ADAPTER		MODICON				EACH		
TIO MODULE		MODICON				EACH		
2. TRUNK CABLE AND TAPS: *NOTE 2.*								
MBPLUS TRUNK CABLE	490NAA27102	MODICON	2	–	2	REEL	6-6-96	
MBPLUS TAP	990NAD23000	MODICON	10	2	12	EACH	6-6-96	
3. DROP CABLES : *NOTE 2.*								
MBPLUS DROP (2.4M/8FT)	990NAD21 110	MODICON	4	1	5	EACH	6-6-96	
MBPLUS DROP (6M/20FT)	990NAD21 130	MODICON	6	1	7	EACH	6-6-96	
4. LABELS : *NOTE 2.*								
PANEL	R–321	LIDCO	3	–	3	KIT	6-6-96	
DEVICE	R–330	LIDCO	1	–	1	KIT	6-6-96	
CABLE	R–787	LIDCO	2	–	2	KIT	6-6-96	
CONNECTOR	R–212	LIDCO	1	–	1	KIT	6-6-96	
5. INSTALLATION HARDWARE : *NOTE 2.*								
STRAIN RELIEFS	SR5–74	COMPSCO	36	4	40	EACH	6-6-96	
CLAMPS, WIRE	WC3–24	COMPSCO	40	5	45	EACH	6-6-96	
6. TOOLS / TEST EQUIPMENT :								

NOTES : *1. THIS SHEET IS FOR NETWORK #1. USE SEPARATE SHEET FOR NETWORK #2.*
2. INCLUDES MATERIALS FOR BOTH CABLES A AND B.

Figure 50 Example: Materials Summary Worksheet

Chapter 5
Installing the Network Cable

5.1 Overview of the Cable Installation

This chapter describes how to install the network trunk and drop cables. It is intended primarily for the installer, but can also be useful to the network planner in estimating installation time and labor requirements. It also provides an overview of tap connections to assist the network planner. Each tap package includes detailed instructions for the tap installer.

You will be performing the following actions to install and check the cable:

- ☐ Install a tap at each network node site. Mount it close enough to the node device to allow the drop cable to be installed with a sufficient service loop. Drop cables are available in lengths of 2.5 m (8 ft) and 6 m (20 ft).

- ☐ At each tap location except the two ends of the section of trunk cable, make sure that both of the internal jumpers are disconnected and removed inside the tap. Chapter 1 describes the meaning of a trunk cable section.

- ☐ At the tap locations at the two ends of the section of trunk cable, connect both of the internal jumpers inside the tap. This chapter describes how to connect the jumpers.

- ☐ Route the trunk cable in accordance with the layout diagram described in Chapter 4, and connect it to the taps. Include a small service loop at the tap connection to eliminate any pulling or twisting of the cable.

- ☐ Connect the proper length of drop cable to each tap. Connect the ground wire on the drop cable to the tap grounding screw and node device panel ground.

- ☐ Label the trunk cable segments and drop cables to assist in future maintenance.

- ☐ Inspect the cable run and check the cable s continuity before connecting it to the network node devices.

5.2 Tools and Test Equipment Required

The following tools and test equipment are required to install and check the network components:

- ☐ Wire cutter to cut the cable segments
- ☐ Wire stripper or knife to remove the cable jacket
- ☐ Flat screwdriver for connecting the drop cable ground lugs
- ☐ Insertion tool for pressing wires into the tap terminals. The tool is available from AMP Incorporated, P.O. Box 3608, Harrisburg, PA 17105-3608 USA (part number 552714-3), or your local Modicon product representative (part number 043509383).
- ☐ Ohmmeter for checking the cable continuity.

If possible, avoid the use of cable pulling tools by laying the cable directly into overhead troughs or raceways. This will minimize potential stretching or cutting damage. If a pulling tool is used, follow the manufacturer's guidelines and avoid excessive force in pulling the cable.

5.3 Before You Start

Before routing the cable you should have a cable routing diagram that shows:

- ☐ Site locations of network node devices
- ☐ Routing paths of each cable segment
- ☐ Cable segment distances and cut lengths
- ☐ List of materials required (length of trunk cable, quantities of taps, drop cables, cable ties, adhesive labels, and other materials as needed)

Chapter 4 describes how to prepare this diagram. If you cannot obtain such a diagram, you must observe all the precautions described in this guide for physical and electrical protection of the cable during installation.

Caution: Failure to provide proper physical protection of the cable can cause damage to the cable conductors or insulation. Failure to provide proper electrical protection of the cable can result in excessive interference induced from adjacent circuits. This can cause degraded network performance.

5.4 Routing the Cables

Figure 51 shows typical cable routing of the network trunk cable between tap locations. The figure also shows cable drops to several node devices and a service access point.

Note: The tap s internal termination jumpers are connected at the two end sites of a cable section, and disconnected and removed at each inline site on the cable section. Chapter 1 describes the meaning of a cable section.

If you are installing cables for a dual-cable network, the two cables should be identified as Cable A and Cable B. Each of the cables should be routed using the methods shown in Figure 51.

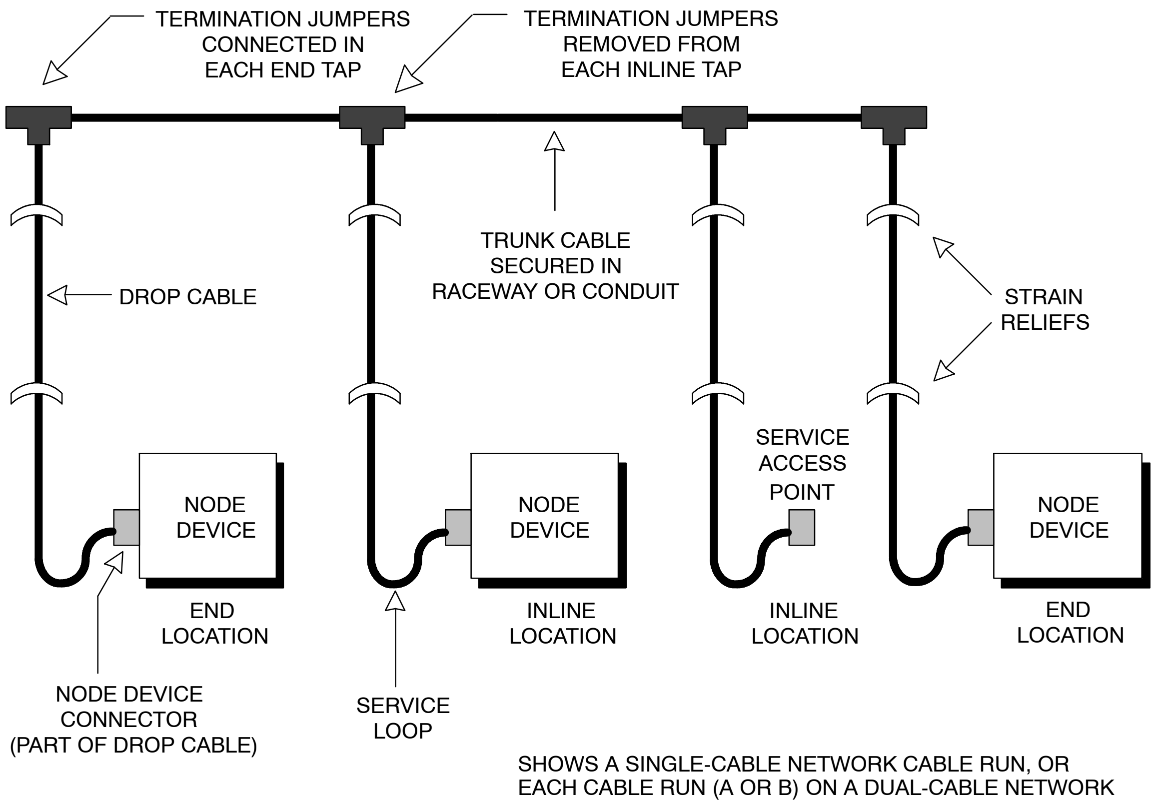


Figure 51 Typical Cable Routing

Refer to Figure 51. Route the cable between the site locations of the node devices. Guidelines for cable routing are described below. For dual-cable routing, follow these guidelines for each cable.

- ☐ Use a continuous length of trunk cable between locations. Do not use any splices.
- ☐ In dual-cable installations, make sure that each trunk cable, tap, and drop cable is properly marked so that it can be positively identified as belonging to Cable A or Cable B over the entire end-to-end length of the network.
- ☐ At each tap location, allow sufficient trunk cable length for a service loop to prevent pulling or twisting the cable.
- ☐ For each drop cable, provide a service loop to allow the connector to be connected and disconnected at the network node device without any strain on the cable. A service loop of 6 in (15 cm) minimum radius is adequate for most installations.
- ☐ Install cable ties or clamps on each trunk cable segment as required for strain reliefs, to prevent the cable from pulling on the tap.
- ☐ Install cable ties or clamps on each drop cable as required for strain reliefs, to prevent the cable from pulling on the tap or node device connector.
- ☐ Use additional ties or clamps as required to secure each cable from flexing or other damage in areas of mechanical motion devices and traffic.

5.5 Mounting the Taps

Before mounting each Tap, install the supplied grounding screw and nut into the Tap as shown in Figure 52.

Before connecting any wiring to a Tap, mount the Tap at a location near its node device panel. The Tap must be near enough to the node device to allow the drop cable to reach the node device with a service loop. See Figure 51 for an example of the drop cable routing.

The location must also be accessible for installing the trunk and drop cables, and for future maintenance. Figure 52 shows the Tap s outer and mounting dimensions.

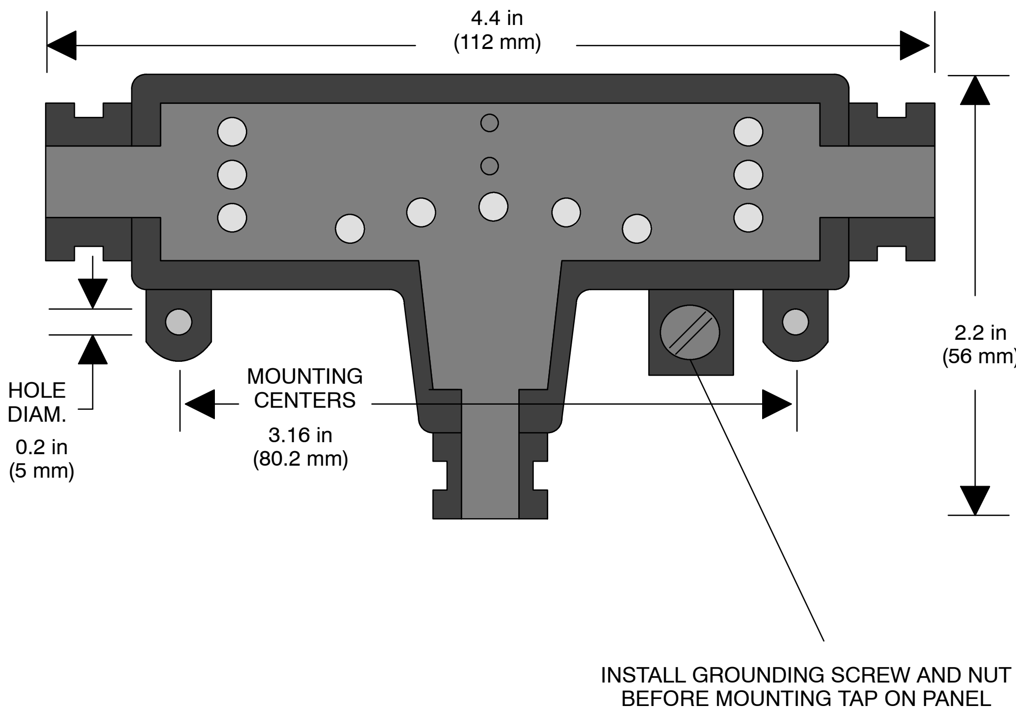


Figure 52 Tap Layout (Cover Open)

5.6 Connecting the Trunk Cables

5.6.1 Cable Entry and Jumpers (Taps at Inline Sites)

At each inline site, two lengths of trunk cable will be installed. The cable to the *right side* of the previous tap must connect to the *left side* of this tap. The cable to the *left side* of the next tap must connect to the *right side* of this tap. The two jumpers must be removed (see Figure 53).

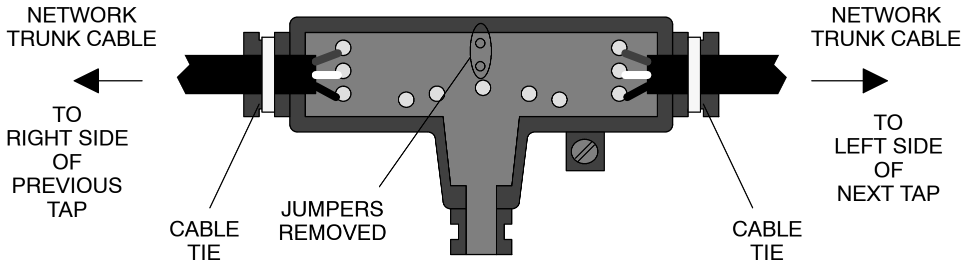


Figure 53 Trunk Cable Connections and Jumpers Removed (Inline Sites)

5.6.2 Cable Entry and Jumpers (Taps at End Sites)

At the two end sites on the cable section, one length of trunk cable will be installed. It can be connected to either side of the tap. The two jumpers must be installed between the center posts and the lower two posts at the side of the tap opposite from the cable (see Figure 54).

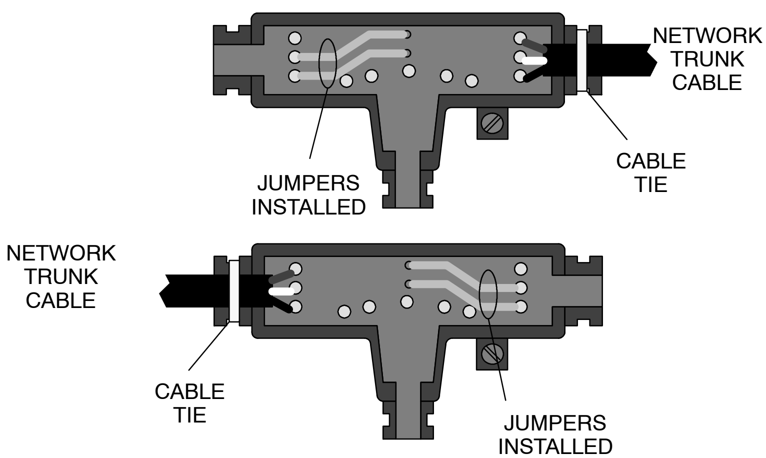


Figure 54 Trunk Cable Connections and Jumpers Installed (End Sites)

5.6.3 Connecting the Wires

Detailed instructions for making the connections are enclosed in each tap package. Below is a general description of the connections.

Trunk cable is connected as shown in Figure 55. The terminals are marked as follows:

Terminal	Meaning	Wire Color
GND	Network Bus, Ground	Shield
W	Network Bus, White	WHITE
BLK	Network Bus, Blue or Black	BLUE or BLACK

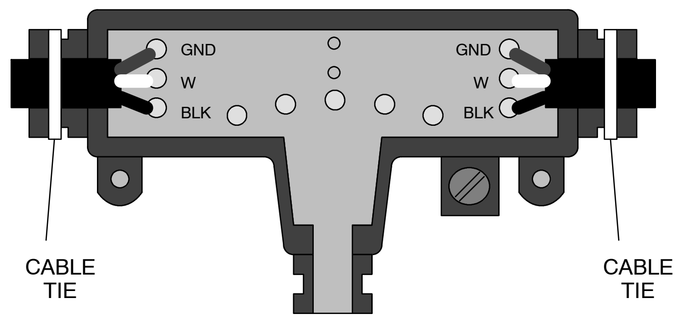


Figure 55 Trunk Cable Connections

Figure 56 shows how to connect each wire. (A) Do not strip the wire. Place the wire into the terminal slot so that the end of the wire is flush with the inside of the terminal. (B) Using the proper insertion tool, press the wire into the terminal. (C) Plastic caps are supplied with the Tap. Press a plastic cap down fully into the terminal.

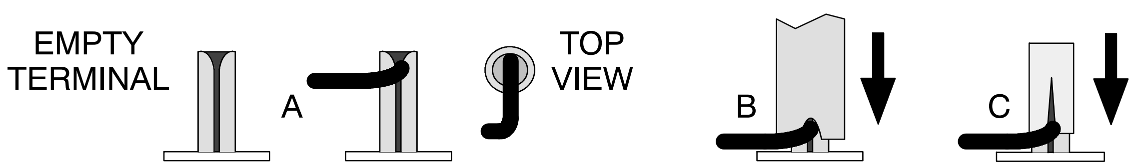


Figure 56 Wire Terminal Connection (Detail)

5.7 Connecting the Drop Cable

5.7.1 Connecting the Signal Wires

Detailed instructions for making the connections are enclosed in each tap package. Below is a general description of the connections.

The drop cable contains two sets of twisted-pair signal wires with separate shield wires. It also has an outer shield drain wire. This is a total of seven wires.

- One set of wires is color-coded WHITE and ORANGE, with a bare shield wire
- The other set is WHITE and BLUE, with a bare shield wire

Before connecting the wires, make sure you have identified the two sets of twisted-pair wires. The two white wires are not interchangeable. When you connect the wires, you must connect each wire to its proper terminal.

Insert the cable into the tap and secure it with a cable tie. Viewing the tap as shown in Figure 57, connect the wires. The terminals are marked as follows, from left to right:

Terminal	Location	Wire Color
O	Left	ORANGE
W	Left center	WHITE
GND	Center	Shields (both sets of wires)
W	Right Center	WHITE
BLU	Right	BLUE

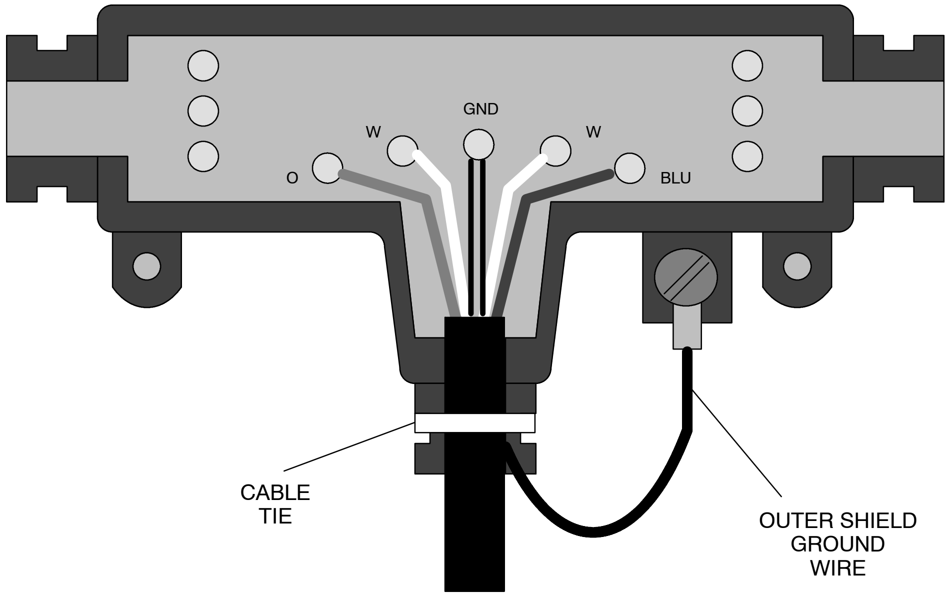


Figure 57 Drop Cable Connections

Figure 58 shows how to connect each wire. (A) Do not strip the wire. Place the wire into the terminal slot so that the end of the wire is flush with the inside of the terminal. (B) Using the proper insertion tool, press the wire into the terminal. (C) Plastic caps are supplied with the Tap. Press a plastic cap down fully into the terminal.

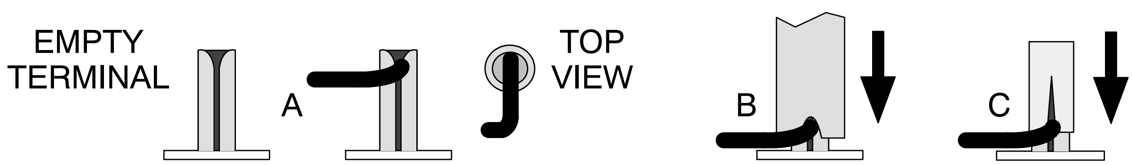


Figure 58 Wire Terminal Connection (Detail)

5.7.2 Connecting the Outer Shield Wire

Install a ground lug on the outer shield drain wire. Tightly crimp or solder the lug to the wire. Connect the lug to the tap s grounding screw as shown in Figure 57.

5.8 Grounding

At each tap, ensure that the drop cable's ground wire is connected to the tap's grounding screw.

The tap's grounding path should be separate from paths used for motors, generators, welders, and other high-current industrial devices. No other ground wires (from other devices) should be connected to the tap's grounding screw.

At the node device end of the drop cable, the drop cable's ground wire must be connected to the panel ground at the node site. This ground connection must be made even if there is no node device connected to the drop cable connector at the site.

5.9 Labeling

After the cable is installed, label the cable segments for ease in future maintenance of the network. Adhesive labels are available commercially for cable identification.

If a cable layout diagram exists for the installation, label each segment in accordance with the diagram. If a diagram does not exist, refer to the examples in Chapter 2 and prepare a diagram showing the cable segments and method of identifying them for future service. Then label the segments accordingly.

Affix the labels to the cables at each network node drop. Place them at a point that will be visible to maintenance personnel.

Complete the network installation labeling by properly labeling each site s cabinet or enclosure, device mounting panel, and device.

Notify the person who will be responsible for future maintenance of the network, and deliver the network documents to that person. It is suggested you do a walking tour with that person through the network sites to produce familiarity with the network layout.

5.10 Checking the Cable Installation

This section describes how to visually inspect the cable and check its end-to-end electrical continuity.

5.10.1 Inspecting the Cable Installation

☐ The cable runs should agree with the physical and electrical protection requirements in Chapter 2.

☐ The cable runs should agree with the network cable routing diagram as described in Chapter 2.

☐ The tap at each of the two end drop sites on each section of the network should have its two internal termination jumpers connected; they must be connected between the two center posts and the W and B posts at the side of the tap opposite from the trunk cable connection.

☐ The tap at each inline drop site should have its two internal termination jumpers disconnected and removed.

☐ Service loops should exist on the trunk cable at each tap service loops should exist on each drop cable at the node device end of the cable.

☐ Each tap should have the drop cable s ground wire connected to its grounding screw; the drop cable s ground wire should also be connected to the panel grounding point at the node device site.

☐ Adequate strain reliefs should be installed on the cable at each drop.

☐ All identification labels should be in place and properly marked.

5.10.2 Checking the Cable Continuity

☐ Before checking continuity, disconnect all network cable connectors from the node devices. Leave the drop cable ground lugs connected to their site panel grounds.

☐ At any node device connector, measure the resistance between pins 2 and 3 (the signal pins). The resistance should be in the range 60 ... 80 Ω, which includes the cable wire resistance.

☐ At each node device connector, check for an open circuit between pin 2 (a signal pin) and pin 1 (the outer shield pin). Then check between pin 3 (a signal pin) and pin 1. An open circuit should exist for both checks.

☐ At each node device connector, check the continuity between pin 1 (the outer shield pin) and the plant ground point on the local site panel or frame. Direct continuity should be present.

If your checks do not agree with these results, inspect the cable and all connections for damage or miswiring, and correct the condition.

Figure 59 shows the point-to-point wiring connections for a cable system with two end sites and one inline site.

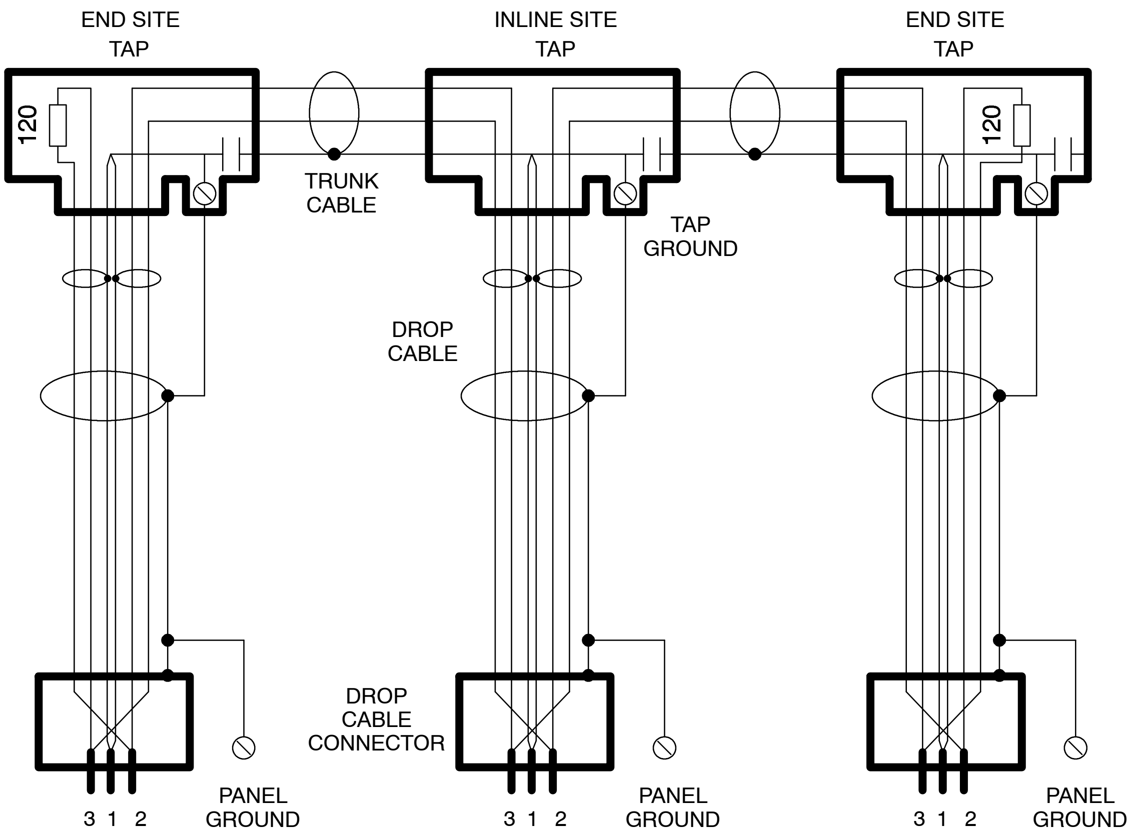


Figure 59 Typical Cable System: Point-to-Point Connections

Chapter 6
Connecting an RR85 Repeater

6.1 Mounting Methods

As supplied, the RR85 Repeater s bottom surface is fitted with pads for mounting on a horizontal surface, such as a shelf or platform. The unit is supplied also with brackets for bolting it to a vertical panel.

The Repeater is supplied with a power cable of 6 ft (2 m) length. You must provide either 110 ... 120 VAC or 220 ... 240 VAC single-phase power. The power cable connects to a socket on the rear panel. Grounding is supplied through the power cable.

The Repeater has a set of network indicators located on its top surface, near the front of the unit. These indicate the communication status of the two links of the network that are connected to the Repeater. Your choice of mounting method should include provision of access to the device for observing these indicators. You should also locate the unit for easy access to its rear panel power and network cable connectors, and for future servicing.

6.1.1 Horizontal Mounting

For mounting on a horizontal surface, place the unit at or below eye level to allow viewing the network indicators. Secure it to the surface to prevent it from shifting its position. Do not allow the unit to pull or strain on the network cables and power cable.

The mounting brackets supplied with the unit for vertical panel mounting can also be used to secure the unit on a horizontal surface.

6.1.2 Vertical Mounting

For vertical mounting, use the brackets supplied with the unit for bolting to a panel. The brackets have tabs that insert into slots provided on the Repeater s bottom panel. No additional hardware is required for securing the brackets to the Repeater. You will have to furnish hardware for bolting the Repeater brackets to your panel. Four bolts are required. Typically, standard 1/4-20 (10 mm) bolts or equivalent will be satisfactory.

The Repeater s indicators will usually be readable at or slightly above eye level when the unit is installed in the vertical position.

6.2 Mounting Dimensions

Mounting dimensions for the Repeater are shown in Figure 60. The figure shows the outer dimensions of the device, plus the total panel space required for the device with its vertical mounting brackets installed.

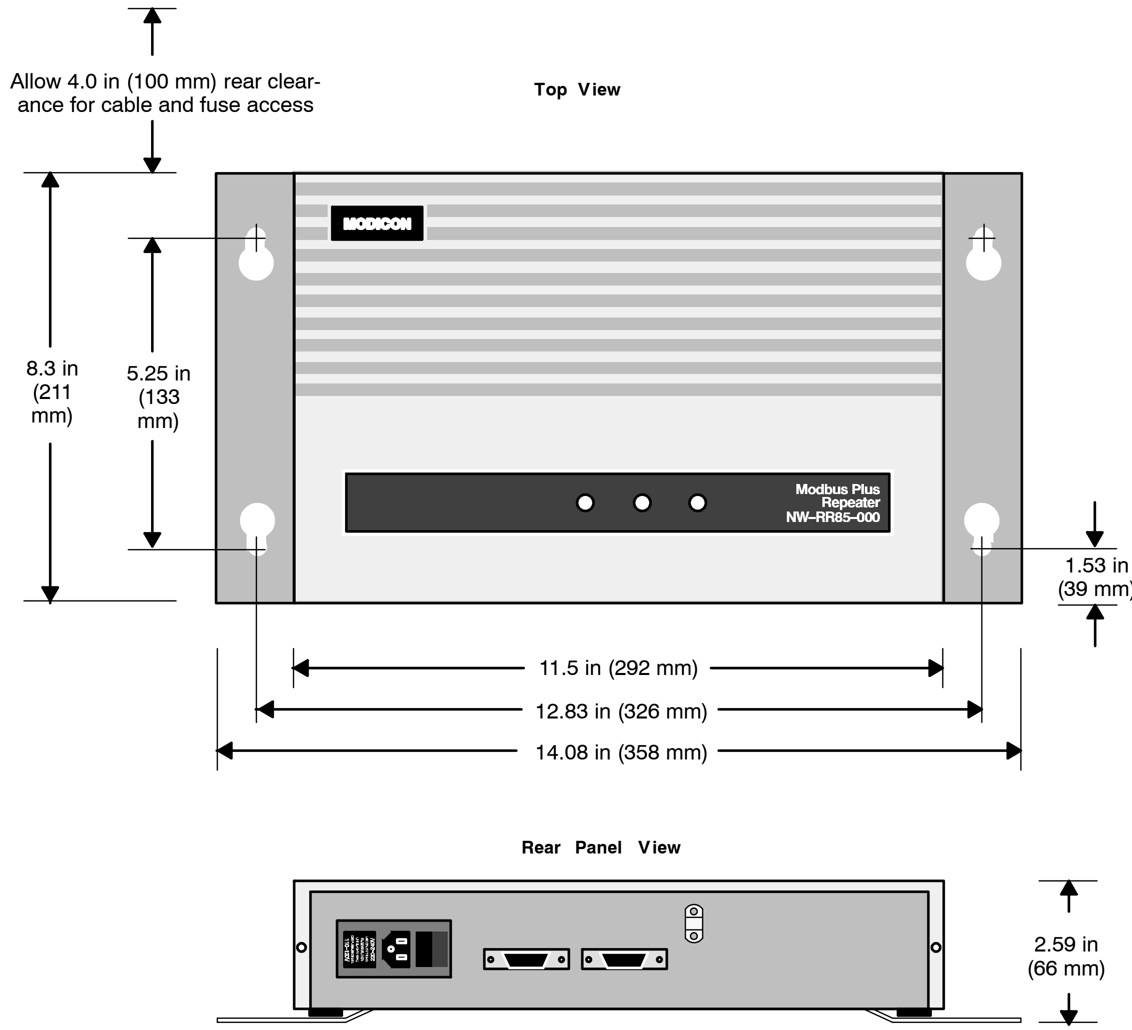


Figure 60 RR85 Repeater Mounting Dimensions

6.3 Installing the Repeater

Caution: If you are replacing a Repeater on an active Modbus Plus network, the communication between the two links of the network will be temporarily disabled as you disconnect the old device and connect the new one. The network signal path passes through the Repeater via its two rear panel connectors. This path will be interrupted as you disconnect the cables from the ports.

Always plan for an orderly shutdown of your control process if necessary , while you replace a Repeater on an active network.

6.3.1 Mounting the Repeater

Mount the Repeater on the horizontal or vertical surface using the guidelines described earlier in this chapter. Make sure you have proper access to the rear panel connectors and power switch.

6.3.2 Connecting Power

The power cable supplied with the Repeater is keyed for North American 110/120 VAC power outlets. If necessary, install a different plug on the cable for the power source at your site.

Refer to Figure 61. On the rear panel of the Repeater, set the power selector plug to the 110/120 VAC or 220/240 VAC position for the power source at your site. To do this, remove the power selector plug by prying under its tab using a small screwdriver. Set the plug to the proper voltage position as shown on the plug body, then reinsert it.

Rear Panel View

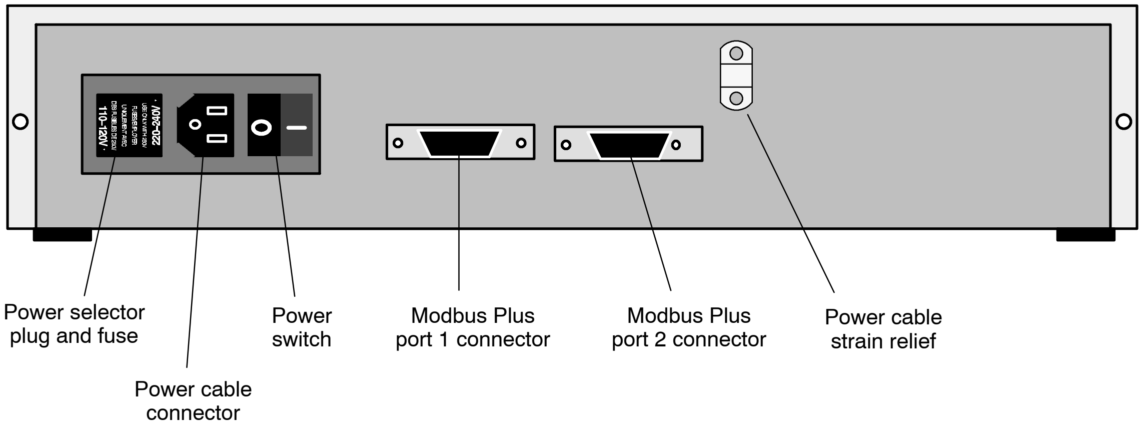


Figure 61 RR85 Repeater Rear Panel View

Set the main power switch on the Repeater s rear panel to the 0 position (power OFF). Plug the Repeater s power cable into the socket provided on the Repeater s rear panel. Secure the power cable under the strain relief. Plug the cable into the power source.

Using a continuity tester, verify the Repeater chassis is grounded to the site ground.

Set the Repeater s main power switch to the 1 position (power ON). The unit s POWER OK indicator should illuminate.

6.3.3 Connecting the Network Cables

Two sections of network trunk cable should already have been run to the Repeater site, representing the two links of the network that will be joined by the Repeater. Each set of cables should already have a network tap and a drop cable with connector installed. If the cables and connectors are not in place, install them as described in Chapter 5 of this guide.

Each of the cable segments should be labeled to identify the link to which it connects. If you are following a network layout diagram, it should show which cable connector is to be mated to each Repeater rear panel connector.

If the cable segments are not labeled, or if you do not have a network layout diagram, you can still connect the cables to the Repeater and test your installation. The two rear panel ports of the Repeater operate identically. When you have connected the cables, document your connection to facilitate future maintenance.

Refer to Figure 61. Connect the two cable connectors to the Repeater s rear panel connectors. If the network links are active, the unit s MODBUS PLUS PORT 1 and MODBUS PLUS PORT 2 indicators should begin flashing.

6.4 Reading the Network Indicators

The layout of the Repeater indicators is shown in Figure 62.

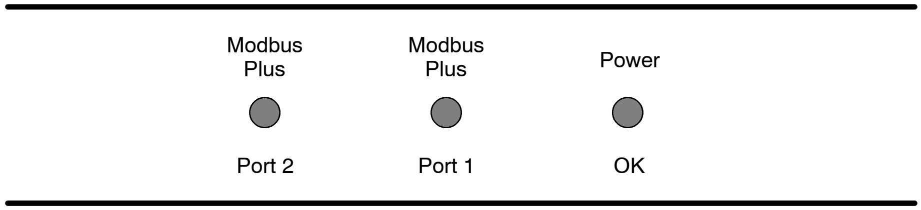


Figure 62 RR85 Repeater Indicators

The POWER OK indicator illuminates steadily when the Repeater has normal power from the AC line and its internal power supply is operating normally.

The Repeater has two indicators that show the communication status at its two Modbus Plus ports. Each port s indicator flashes when a transmission occurs at the port.

The intensity of each port indicator reflects the relative rate of transmission at the port. As the indicator illuminates during transmission, this in turn reflects the relative amount of network activity received at the opposite port. For example, if the Port 2 indicator is brightly illuminated, indicating that this port is highly active, it shows that a high level of activity is being received from the network section at Port 1.

If a port indicator fails to illuminate, or is illuminated only dimly, it can indicate a very low level of activity on the opposite port s cable.

6.5 RR85 Repeater Specifications

RR85 Repeater Specifications

Description	Name	RR85 Modbus Plus Network Repeater
	Part Number	NW-RR85-000
Physical Characteristics	Height	2.59 in (66 mm)
	Width	11.50 in (292 mm), unit only 14.08 in (358 mm), with mounting brackets
	Depth	8.30 in (211 mm)
	Weight	5.5 lbs (2.5 kg) net
		6.5 lbs (3.0 kg) shipping
Power	Requirements	115/230 VAC +15%. 47 ... 63 Hz, 10 W
	Access	Rear panel power connector with ON/OFF switch
	Fuse	1.0 A, 3 AG SB
Environmental	Temperature	0 ... 60 degrees C, operating
		-40 ... +80 degrees C, storage
	Humidity	0 ... 95%, non-condensing
	Altitude	10,000 ft (3 km), maximum
	EMI, Radiated Susceptibility	MIL STD 461B RS03
	EMI, Conducted Susceptibility	MIL STD 461B CS03
Network Connections	Rear Panel Connectors	Mate with Modbus Plus drop cables

Chapter 7
Connecting a BP85 Bridge Plus

- ☐ Mounting Methods
- ☐ Dimensions (Panel/Shelf Models)
- ☐ Dimensions (Rack Mount Model)
- ☐ Setting the Modbus Plus Addresses
- ☐ Connecting the Power Cables
- ☐ Connecting the Network Cables
- ☐ Applying Power
- ☐ Reading the Network Indicators
- ☐ Attaching Port Identification Labels
- ☐ Specifications

7.1 Mounting Methods

BP85 models are available for mounting on a horizontal shelf or vertical panel, or for installation into a standard 19 inch rack.

Your choice of a mounting method should provide access for observing the front panel indicators. You should also provide access to the unit's rear panel for setting the switches, connecting the cables, and servicing.

7.1.1 Horizontal or Vertical Mounting

Models for horizontal or vertical mounting are fitted with pads on their bottom surface, and are supplied with mounting brackets. The brackets can be used to secure the unit to the horizontal shelf or vertical panel.

No additional hardware is needed for attaching the brackets to the BP85. You will have to furnish hardware for bolting the brackets to your panel or shelf. Four bolts are required. Typically, standard 1/4–20 (10 mm) bolts or equivalent will be satisfactory.

7.1.2 Rack Mounting

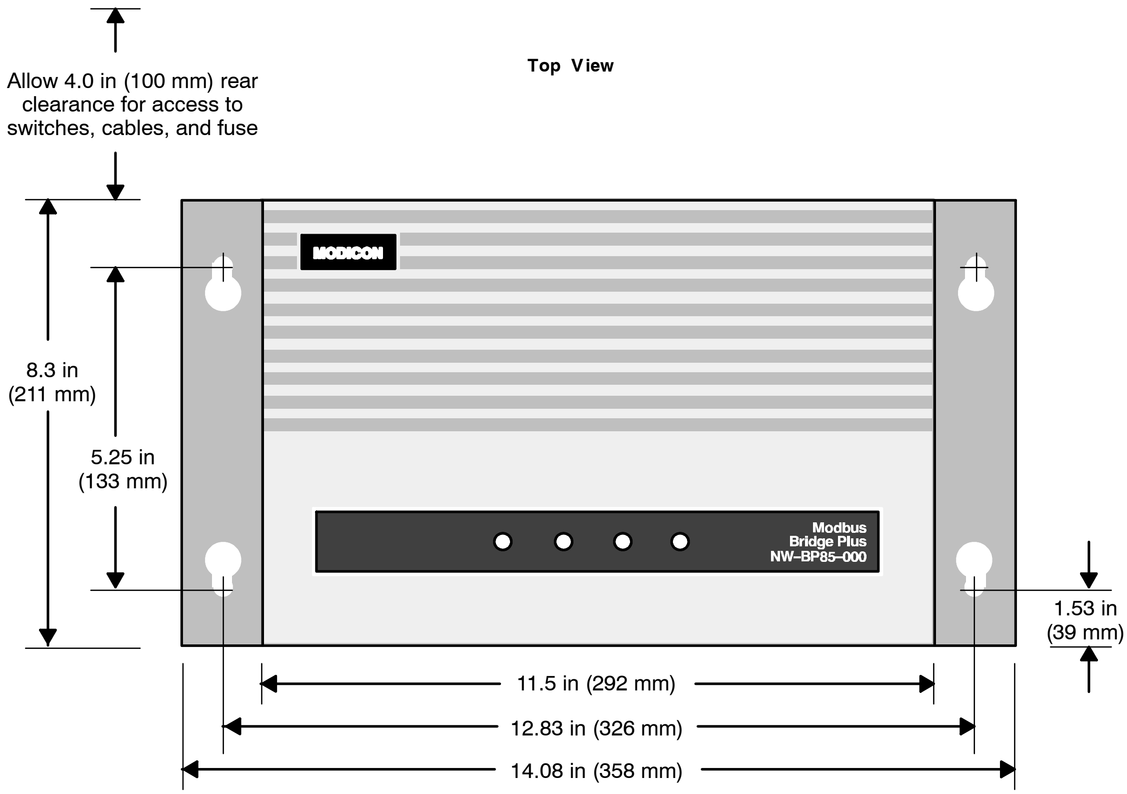
Rack-mount models are designed for installation into a standard 19-inch rack. You must furnish the hardware for bolting the unit to your rack. Four bolts are required.

The BP85 unit can support itself in the rack by its front mounting bolts. It is light enough that you do not have to provide rear support within the rack.

7.1.3 Bridge Plus Models

Part Number	Mounting Method	Operating Power (Nominal)	Modbus Plus Network Cable
NW-BP85-000	Panel or Shelf	115/230 Vac or 24 Vdc	Single
NW-BP85-002	Panel or Shelf	115/230 Vac or 24 Vdc	Single or Dual
NW-BP85D002	19 in Rack	125 Vdc or 24 Vdc	Single or Dual

7.2 Dimensions (Panel /Shelf Models)



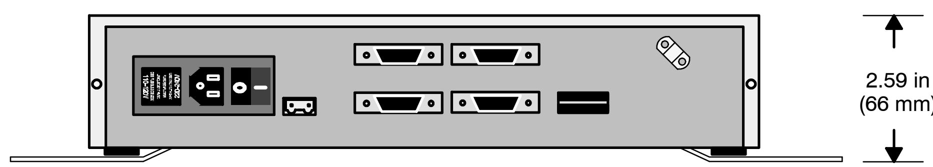


Figure 63 BP85 Bridge Plus Dimensions (Panel/Shelf Models)

7.3 Dimensions (Rack Mount Model)

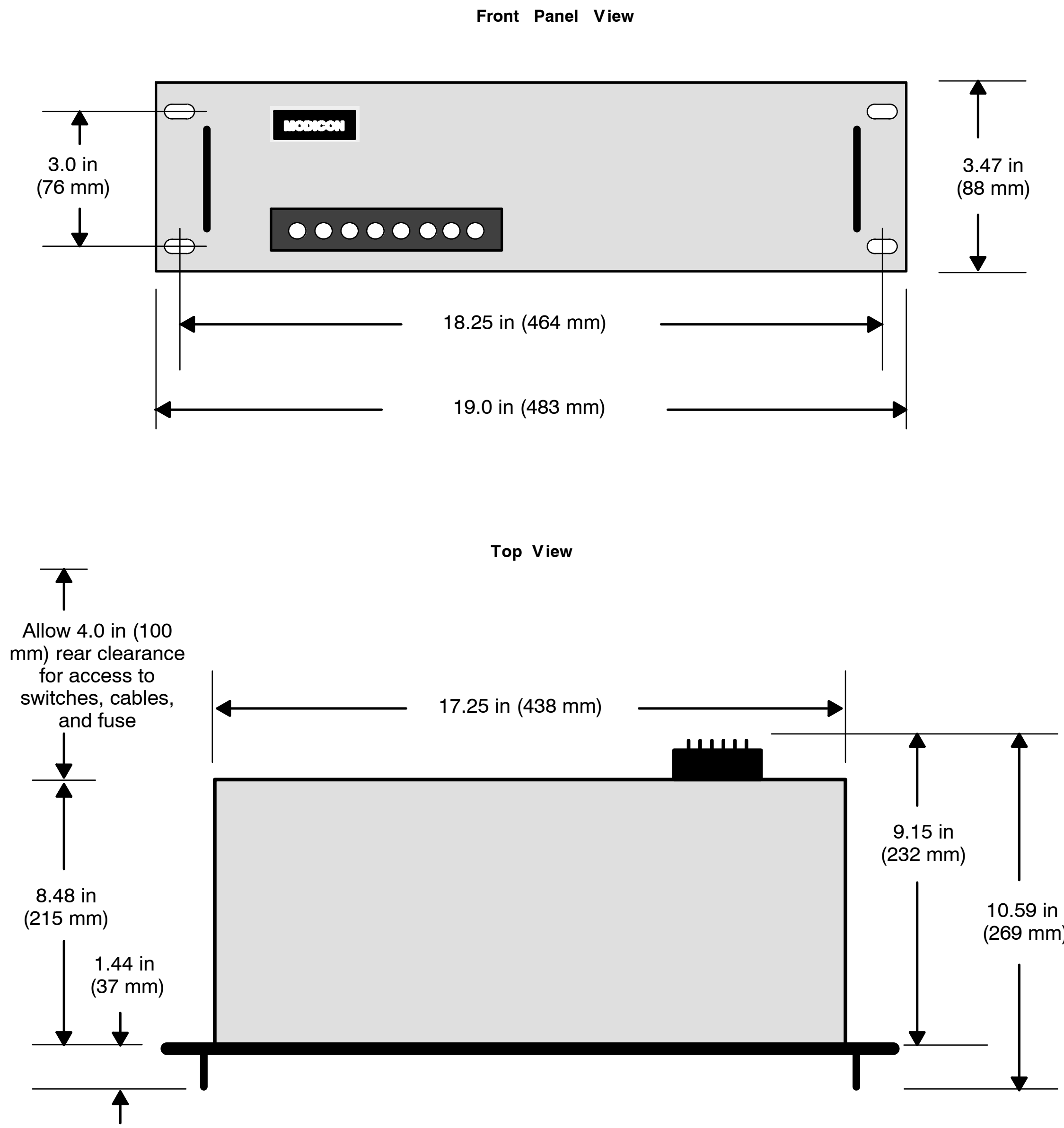


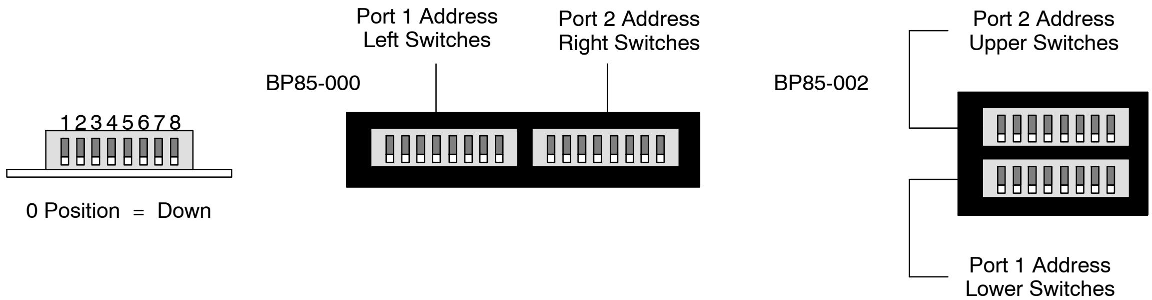
Figure 64 BP85 Bridge Plus Dimensions (Rack Mount Model)

7.4 Settin g the Modbus Plus Addresses

Before you apply power to the BP85, you must set the unit s network addresses in two groups of switches on the unit s rear panel.

Because the BP85 serves two networks, it has a set of port connectors for each network and an associated group of switches for assigning the unit s address on each network. Figure 66 shows the switch locations. Figure 65 shows the switch setup combinations and resulting addresses.

Set each group of switches to the BP85 s address on the network that will be connected to the port connector. The network address will be one higher than the binary value you set into switches 1 ... 6. Switches 7 and 8 are not used.



Address	Switch Position 1	2	3	4	5	6	7	8	Address	Switch Position 1	2	3	4	5	6	7	8
1	0	0	0	0	0	0	□	□	33	0	0	0	0	0	1	□	□
2	1	0	0	0	0	0	□	□	34	1	0	0	0	0	1	□	□
3	0	1	0	0	0	0	□	□	35	0	1	0	0	0	1	□	□
4	1	1	0	0	0	0	□	□	36	1	1	0	0	0	1	□	□
5	0	0	1	0	0	0	□	□	37	0	0	1	0	0	1	□	□
6	1	0	1	0	0	0	□	□	38	1	0	1	0	0	1	□	□
7	0	1	1	0	0	0	□	□	39	0	1	1	0	0	1	□	□
8	1	1	1	0	0	0	□	□	40	1	1	1	0	0	1	□	□
9	0	0	0	1	0	0	□	□	41	0	0	0	1	0	1	□	□
10	1	0	0	1	0	0	□	□	42	1	0	0	1	0	1	□	□
11	0	1	0	1	0	0	□	□	43	0	1	0	1	0	1	□	□
12	1	1	0	1	0	0	□	□	44	1	1	0	1	0	1	□	□
13	0	0	1	1	0	0	□	□	45	0	0	1	1	0	1	□	□
14	1	0	1	1	0	0	□	□	46	1	0	1	1	0	1	□	□
15	0	1	1	1	0	0	□	□	47	0	1	1	1	0	1	□	□
16	1	1	1	1	0	0	□	□	48	1	1	1	1	0	1	□	□
17	0	0	0	0	1	0	□	□	49	0	0	0	0	1	1	□	□
18	1	0	0	0	1	0	□	□	50	1	0	0	0	1	1	□	□
19	0	1	0	0	1	0	□	□	51	0	1	0	0	1	1	□	□
20	1	1	0	0	1	0	□	□	52	1	1	0	0	1	1	□	□
21	0	0	1	0	1	0	□	□	53	0	0	1	0	1	1	□	□
22	1	0	1	0	1	0	□	□	54	1	0	1	0	1	1	□	□
23	0	1	1	0	1	0	□	□	55	0	1	1	0	1	1	□	□
24	1	1	1	0	1	0	□	□	56	1	1	1	0	1	1	□	□
25	0	0	0	1	1	0	□	□	57	0	0	0	1	1	1	□	□
26	1	0	0	1	1	0	□	□	58	1	0	0	1	1	1	□	□
27	0	1	0	1	1	0	□	□	59	0	1	0	1	1	1	□	□
28	1	1	0	1	1	0	□	□	60	1	1	0	1	1	1	□	□
29	0	0	1	1	1	0	□	□	61	0	0	1	1	1	1	□	□
30	1	0	1	1	1	0	□	□	62	1	0	1	1	1	1	□	□
31	0	1	1	1	1	0	□	□	63	0	1	1	1	1	1	□	□
32	1	1	1	1	1	0	□	□	64	1	1	1	1	1	1	□	□

Figure 65 BP85 Network Address Switch Settings

7.5 Connecting the Power Cables

Caution: If you are replacing a Bridge Plus on an active network, the communication between the networks served by the Bridge Plus will be temporarily disabled as you disconnect the old device and connect the new one. Always plan for an orderly shutdown of your control process if necessary, while you replace a Bridge Plus on an active network.

AC/DC Models

AC/DC models are supplied with a power cable of 6 ft (2 m) length for operation from 110–120 Vac or 220–240 Vac single-phase power. The cable connects to a socket on the rear panel. Grounding is through the cable. The ac line switch is located on the rear panel. The unit contains an ac line fuse that is accessible on the rear panel.

These models can also operate from an external 24 Vdc source. Power connects to a socket on the rear panel. Grounding is through the cable. The dc source must be switched and fused externally to the unit.

DC/DC Models

DC/DC models operate from a 125 Vdc or 24 Vdc source. Power connects to a terminal strip on the rear panel. A grounding terminal is provided. The dc source must be switched and fused externally to the unit.

7.5.1 Connecting AC Power

Set the BP85 power switch to the 0 (power OFF) position. Connect the BP85 to the power source. Test the connection by setting the power switch to 1 (power ON). The POWER indicator should illuminate.

Before connecting the network cables, set the power switch to the 0 (power OFF) position. The POWER indicator should not be lit.

7.5.2 Connecting DC Power

Set the external dc power source to OFF. Connect the BP85 to the source. Test the connection by setting the dc power source to ON. The POWER indicator should illuminate.

Before proceeding with the connection of the network cables, set the dc power source to OFF. The POWER indicator should not be lit.

7.5.3 Before You Apply Power

Do not apply power to the BP85 until you have completed the setup of the unit s network address switches for both networks. The settings will be sensed by the unit when power is applied.

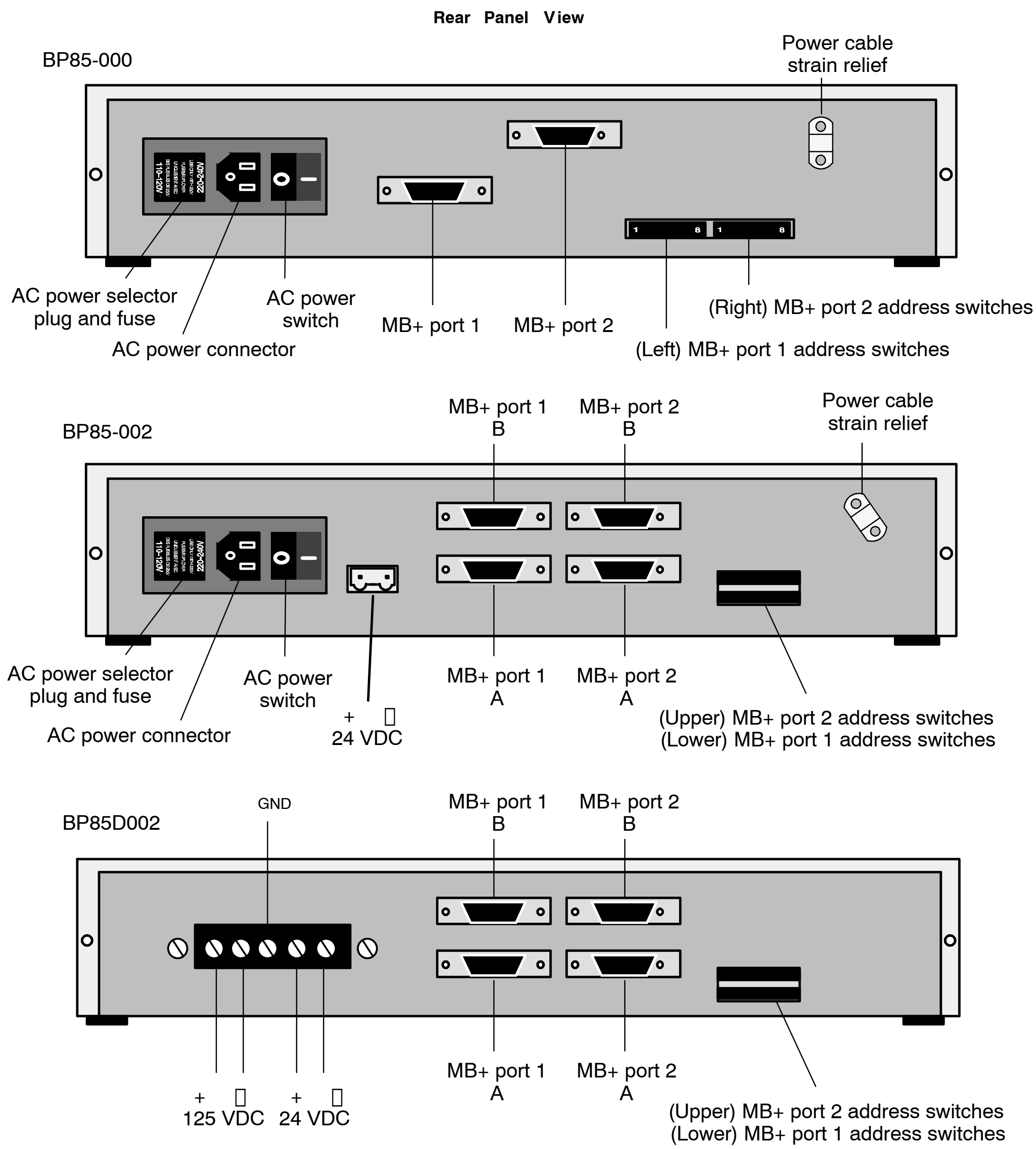


Figure 66 BP8 5 Bridge Plus Connectors

7.6 Connecting the Network Cables

If the cables and connectors are not in place, install them as described in Chapter 5 of this guide. If the network cables are not labeled, contact the person who is responsible for the network planning and layout before proceeding. When you have this information, connect the cables as described below.

Caution: If the network cables are not labeled, or if you do not have a layout diagram showing which cable is to be connected to each connector on the Bridge Plus, you should not connect the cables until you obtain this information. The Bridge Plus connectors have dedicated network addresses that you have set in the unit s address switches. Incorrect connection of the cables can cause a disruption of communication on the networks.

Refer to Figure 66. Connect the network cable connectors to the connectors provided on the Bridge Plus s rear panel. If the networks are active, the unit s MODBUS PLUS PORT 1 and MODBUS PLUS PORT 2 indicators should begin flashing.

☐ **Connecting Single-cable Units on Single-cable Networks:**
If you are installing a single-cable unit (BP85-000) on networks that have a single cable, you will have two cables to connect to your BP85. Connect the cables to the Port 1 and Port 2 connectors. Secure each connector by tightening its two screws.

☐ **Connecting Dual-cable Units on Dual-cable Networks:**
If you are installing a dual-cable unit (BP85-002) on a dual-cable network, you will have four cables to connect to your BP85. Each network should have two cables, labeled A and B. Connect the cables to the connectors on the BP85 rear panel. Secure each connector by tightening its two screws.

☐ **Connecting Dual-cable Units on Single-cable Networks:**
If you are installing a dual-cable unit (BP85-002) on networks that have a single cable, you will have two cables to connect to your BP85. Connect the cables to the Port 1 A and Port 2 A connectors. Plug two Terminating Connectors (AS-MBKT-185) into the Port 1 B and Port 2 B connectors. Secure each connector by tightening its two screws.

7.7 Applying Power

After you have set the address switches to the desired network addresses, and have connected the network cables, you can apply main power to the BP85.

AC Power

If you are using AC power, set the power switch on the BP85 rear panel to the 1 position (power ON).

DC Power

If you are using DC power, switch in on from its external source.

The BP85 s POWER OK indicator should illuminate. When the unit completes its internal diagnostic tests, the READY indicator should illuminate.

7.8 Reading the Network Indicators

The layout of the Bridge Plus indicators is shown in Figure 67.

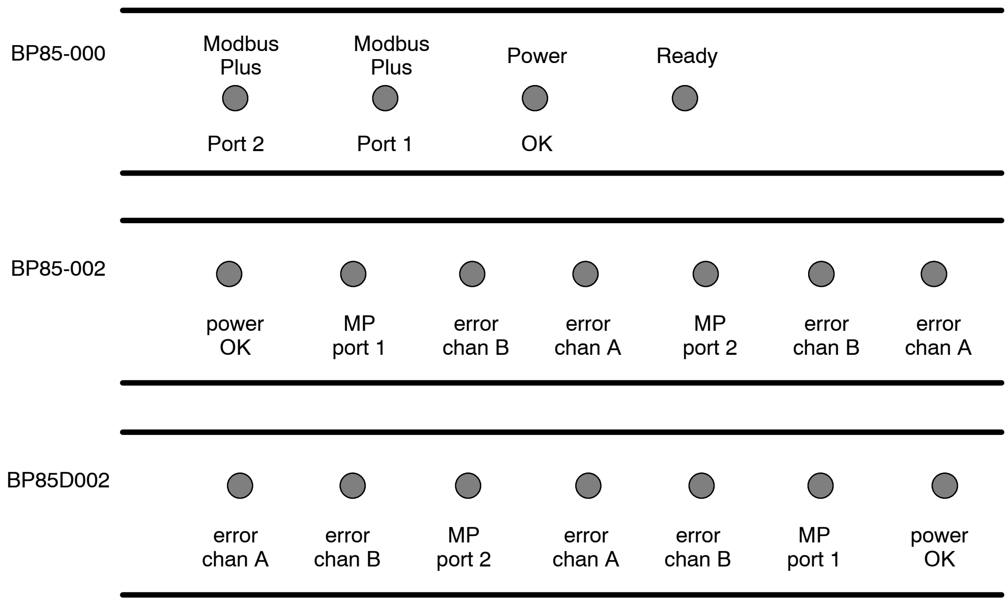


Figure 67 BP85 Bridge Plus Indicators

POWER OK illuminates when the BP85 has normal power from the source. READY (NW-BP85-000 only) illuminates when the BP85 has successfully completed its internal diagnostics.

ERROR CHAN A and ERROR CHAN B show the fault status on the two cable paths for each network. If an indicator blinks momentarily, it indicates that a message error was detected on the path. A steady ON state indicates a hard fault either in the cable or in a node device connected to the cable.

PORT 1 and PORT 2 show the communication status at the two Modbus Plus network ports. Status is shown by flashing a repetitive pattern. The patterns are:

- **Six flashes/s** This is the Bridge Plus s normal operating state. All nodes on the network should be flashing this pattern. If a port indicator is OFF continuously, the Bridge Plus is not transmitting at that port.

- **One flash/s** The Bridge Plus node is offline after just being powered up, or after hearing a message from another node with the same network address (duplicate addresses are not allowed). In this state, the node monitors the network and builds a table of active nodes and token-holding nodes. It remains in this state for five seconds, then attempts to go to its normal operating state.

- **Two flashes, then OFF for 2 s** The Bridge Plus node is hearing the token being passed among other nodes, but is never receiving the token. Check the network link for an open or short circuit, or defective termination.

- **Three flashes, then OFF for 1.7 s** The Bridge Plus node is not hearing any other nodes. It is periodically claiming the token, but finding no other node to which to pass it. Check the network link for an open or short circuit, or defective termination.

- **Four flashes, then OFF for 1.4 s** The Bridge Plus node has heard a valid message from another node that is using the same address as this node. The node remains offline in this state as long as it continues to hear the duplicate address. If the duplicate address is not heard for five seconds, the node then changes to the pattern of one flash every second.

7.9 Attaching Port Identification Labels

Two sets of Modbus Plus port labels are supplied with your Bridge Plus. Each set contains two labels. One set is used to identify the Modbus Plus networks and node addresses at the device's port connectors. The other set is a spare.

The labels are designed to provide ready information to persons who will maintain the network in the future. Enter the Modbus Plus network numbers and network addresses you have assigned to the Bridge Plus. Place the labels on the unit so that they can readily identify the network and node address at each port connector. Figure 68 shows examples.

Figure 68 Modbus Plus Port Labels

7.10 BP85 Bridge Plus Specifications

BP85 Bridge Plus Specifications (Panel/Shelf Models)

Description	Name	BP85 Modbus Plus Network Bridge
	Part Number	NW-BP85-000 (Single Cable)
		NW-BP85-002 (Dual Cables)
Physical Characteristics	Height	2.59 in (66 mm)
	Width	11.50 in (292 mm), unit only 14.08 in (358 mm), with mounting brackets
	Depth	8.30 in (211 mm)
	Weight	5.5 lbs (2.5 kg) net
		6.5 lbs (3.0 kg) shipping
AC Power	Requirements	115/230 VAC +15%. 47 ... 63 Hz, 10 W
	Access	Rear panel power connector with ON/ OFF switch
	Fuse	1.0 A, 3 AG SB
DC Power (NW-BP85-002 only)	Requirements	24 VDC +15%
		10 W
	Access	Rear panel power connector, requires external ON/OFF switch
	Fuse	Requires external 1.0 A Fast-blow fuse
Environmental	Temperature	0 ... 60 degrees C, operating
		-40 ... +80 degrees C, storage
	Humidity	0 ... 95%, non-condensing
	Altitude	10,000 ft (3 km), maximum
	EMI, Radiated Susceptibility	MIL STD 461B RS03
	EMI, Conducted Susceptibility	MIL STD 461B CS03
Network Connections	Rear Panel Connectors	Mate with Modbus Plus drop cables

BP85 Bridge Plus Specifications (Rack Mount Model)

Description	Name	BP85 Modbus Plus Network Bridge
	Part Number	NW-BP85D002 (Dual Cables)
Physical Characteristics	Height	3.47 in (88 mm)
	Width	19.0 in (483 mm)
	Depth	8.48 in (215 mm)
	Weight	6.5 lbs (3.0 kg) net
		7.5 lbs (3.5 kg) shipping
DC Power	Requirements	105 ... 140 VDC or 24 VDC +15%
		10 W
	Ground Leakage	1 mA @ 140 VDC
	Input Current	41 mA @ 125 VDC
	Inrush Current	6 A @ 125 VDC typical
	Access	Rear panel terminal strip, requires external ON/OFF switch
	Fuse	24 VDC: Requires external 1.0 A Fast-blow fuse
		125 VDC: Requires external 2.0 A Slow-blow fuse
Environmental	Temperature	0 ... 60 degrees C, operating
		−40 ... +80 degrees C, storage
	Humidity	0 ... 95%, non-condensing
	Altitude	10,000 ft (3 km), maximum
	EMI, Radiated Susceptibility	IEC 801-3, level 3
	Surge Withstand, Fast Transient	IEC 801-4, level 3
	Surge Withstand, Oscillatory Wave	IEEE 472
	Surge Transients	IEEE 801-5, level 3
	Electrostatic Discharge	IEEE 801-2, level 3
Reliability	Service Life	5 years
	MTBF	50,000 hours minimum @ 30 degrees C, assuming fixed grund and component stress within maximum specifications
Network Connections	Rear Panel Connectors	Mate with Modbus Plus drop cables

Appendix A Modbus Plus Transaction Elements

- Transaction Timing Elements
- The Message Format HDLC Level
- The Message Format MAC Level
- The Message Format LLC Level

A .1 Transaction Timing Elements

A .1.1 Token Holding Time

Eachnode holds the networktoken for a minimumlength of time ifit has notransactions. The minimum token time is approximately 530 microseconds. The token will be held for a longer time depending upon the quantity and size of pending transactions.

Typical times are shown in the charts below. Each chart shows the types of transactions the device can handle, how many concurrent transactions are available, and the times required to process single and multiple paths.Times are shownfor smallandlargesizes of transactions. All times are in milliseconds.

A .1.2 Worst Case Timing Examples

Note that the token holding times shown in the right column are worst case times, with all of the device s paths active, with all paths moving the full amount of data, and with full queueing. With proper design of your network these times should not occur in practice.

The only types of transactions that you should consider for calculating the loading on a properly designed network are the Data Master paths and Data Slave paths, with occasional queueing.

You should plan your network layout and application programming so as to avoid the worst case times. Use the formulas in Chapter 3 to predict response times under various loading conditions. That chapter also provides guidelines for designing your network so as to avoid or minimize queueing in your application.

Controllers

	Two Registers			100 Registers	
Transaction Type	**Available Transactions**	**One Transaction**	**All Transactions**	**One Transaction**	**All Transactions**
MSTR DM path	4	1.4	5.6	3.0	12.0
DS path	4	1.4	5.6	3.0	12.0
Dequeue transaction to slave path	4	1.4	5.6	3.0	12.0
PM path	1	1.4	1.4	3.0	3.0
PS path	1	1.4	1.4	3.0	3.0
	Totals	8.4	21.0	18.0	45.0

SA85 and SM85 Network Adapters

	Two Registers			125 Registers	
Transaction Type	**Available Transactions**	**One Transaction**	**All Transactions**	**One Transaction**	**All Transactions**
DM path	8	1.4	11.2	3.4	27.2
DS path	8	1.4	11.2	3.4	27.2
Dequeue transaction to slave path	8	1.4	11.2	3.4	27.2
PM path	8	1.4	11.2	3.4	27.2
PS path	8	1.4	11.2	3.4	27.2
	Totals	7.0	56.0	17.0	136.0

BP85 Bridge Plus Devices

	Two Registers			125 Registers	
Transaction Type	**Available Transactions**	**One Transaction**	**All Transactions**	**One Transaction**	**All Transactions**
DM path	8	1.4	11.2	3.4	27.2
DS path	8	1.4	11.2	3.4	27.2
Dequeue transaction to slave path	8	1.4	11.2	3.4	27.2
PM path	8	1.4	11.2	3.4	27.2
PS path	8	1.4	11.2	3.4	27.2
	Totals	7.0	56.0	17.0	136.0

BM85 Bridge Multiplexers

	Two Registers			100 Registers	
Transaction Type	**Available Transactions**	**One Transaction**	**All Transactions**	**One Transaction**	**All Transactions**
MSTR DM path	4	1.4	5.6	3.0	12.0
DS path	4	1.4	5.6	3.0	12.0
Dequeue transaction to slave path	4	1.4	5.6	3.0	12.0
PM path	4	1.4	5.6	3.0	12.0
PS path	4	1.4	5.6	3.0	12.0
	Totals	7.0	28	15.0	60.0

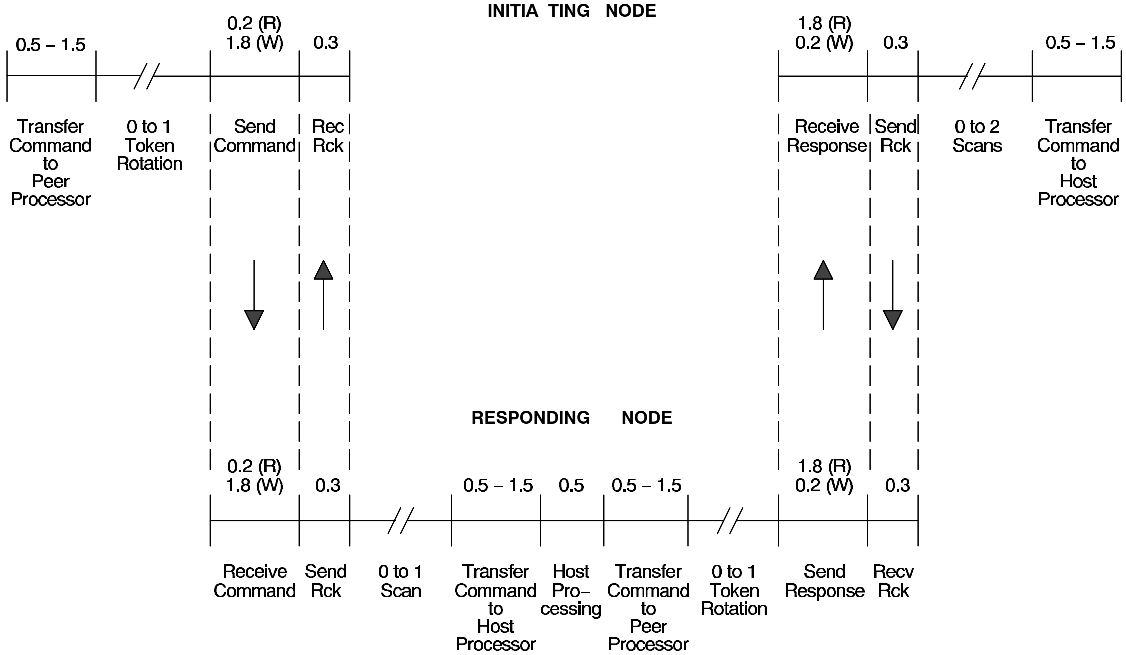
A.1.3 Data Response Time

When a node's application program initiates a transaction, the time required for a data response to be returned to the application depends upon several factors: the internal timing of the initiating node, the token rotation and transmission timing on the network, and the internal timing of the responding node.

Figure 69 illustrates the elements of one READ or WRITE transaction as it occurs in initiating and responding controller nodes. The transaction is moving 100 registers of data. Where the times differ between operations, the READ transaction timing is shown with an (R) and the WRITE timing with a (W).

Timing starts when an MSTR is enabled in the initiating node. The transaction is finished when the MSTR function's COMPLETE output is ON. In the case of the READ, registers will be updated in the initiating node at that time.

The token rotation time of the network and the scan times of the devices will usually predominate in the end-to-end timing of the transaction. The other timing elements are typically much shorter than the token rotation and scan times. The graphs and formulas in Chapter 3 include all of the timing elements in the diagram. You should use the material in that chapter for predicting response times and throughput in your network design.



NOTES

TRANSACTION EXAMPLE IS FOR MODICON PROGRAMMABLE CONTROLLERS

DATA LENGTH IS 100 REGISTERS

ALL TIMING IS IN MILLISECONDS

ALL TIMING IS APPROXIMATE (NOT TO SCALE)

(R) = READ,   (W) = WRITE

Figure 69   Timing Elements of a READ or WRITE Transaction

A .2 The Message Format HDLC Level

Messages appearing on the network contain three levels of protocol to handle the processes of synchronization, routing, transferring data, and checking for errors. The message format satisfies the network HDLC, MAC, and LLC level protocols.

Figure 70 illustrates the High-level Data Link Control (HDLC) level format of a typical message transmitted from a networked controller. The format at the other levels is shown on the following pages.

HDLC LEVEL:

	PREAMBLE AA	OPENING FLAG 7E	BDCST ADDRESS FF	MAC / LLC FIELD	FCS CRC-16	CLOSING FLAG 7E
LENGTH:	1	1	1		2	1

Figure 70 Typical Message Format

A .2.1 HDLC Fields

At the HDLC level, the network protocol defines the beginning and end of the message frame, and appends a frame check sequence for error checking. The message contains the following HDLC level fields:

Preamble
One byte, 0xAA (hexadecimal AA, or alternating ONES and ZEROS).

Opening Flag
One byte, 0x7E (one ZERO, six ONES, one ZERO).

Broadcast Address
One byte, 0xFF (eight ONES). These contents specify that all nodes are to receive the frame. Each node will then parse the frame s MAC level contents to recognize its address as the intended destination.

MAC/LLC Data

This field specifies the MAC level control packet for token-related operations, and contains both the MAC and LLC level packets for data-message related operations.

If the message relates to the token-passing operation of the network, the field will contain only the MAC level information necessary to identify a successor. If the message contains data, the field will contain both MAC and LLC level information.

The MAC and LLC level packets are detailed on the following pages.

Frame Check Sequence

Two bytes containing the CRC-16 frame error checksum.

Closing Flag

One byte, 0x7E (one ZERO, six ONES, one ZERO).

A .3 The Message Format — MAC Level

At the Medium Access Control (MAC) level, the network protocol defines the message destination and source nodes, and controls the passing of tokens.

Figure 71 illustrates the MAC level format of a message containing a Modbus command. The Modbus command is imbedded in the LLC field of the frame.

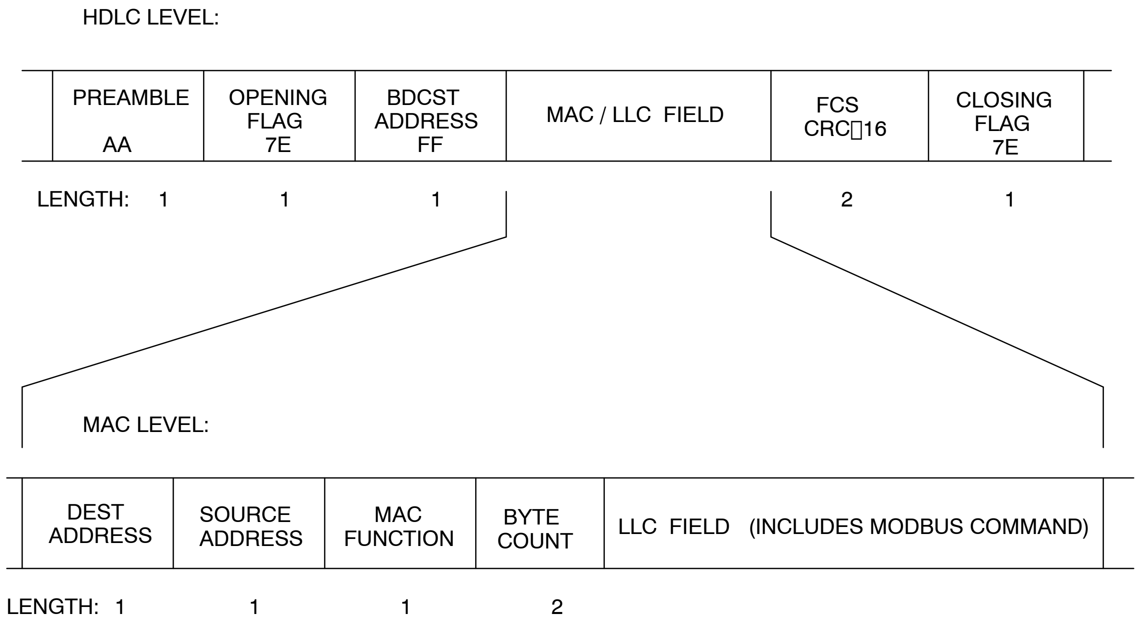


Figure 71 MAC Level Message Format

A .3.1 MAC Fields

The message contains the following MAC level fields:

Destination Address
The address of the node intended to receive the message, in the range of 1 to 64. Additional information identifying the message transaction in the node's application is contained in the LLC level packet.

Source Address
The address of the node originating the message, in the range of 1 to 64.

MAC Function Code
This field defines the action to be performed at the MAC level by the destination.

Byte Count
This field defines the quantity of data bytes to follow in the message.

LLC Data
This field contains the LLC level packet, which includes the Modbus command. The LLC field is detailed on the next page.

A .4 The Message Format – LLC Level

At the Logical Link Control (LLC) level, the message contains the data field to be transferred, such as the Modbus command. It also contains additional routing and message control fields.

Figure 72 illustrates the LLC level format of a message containing a Modbus command.

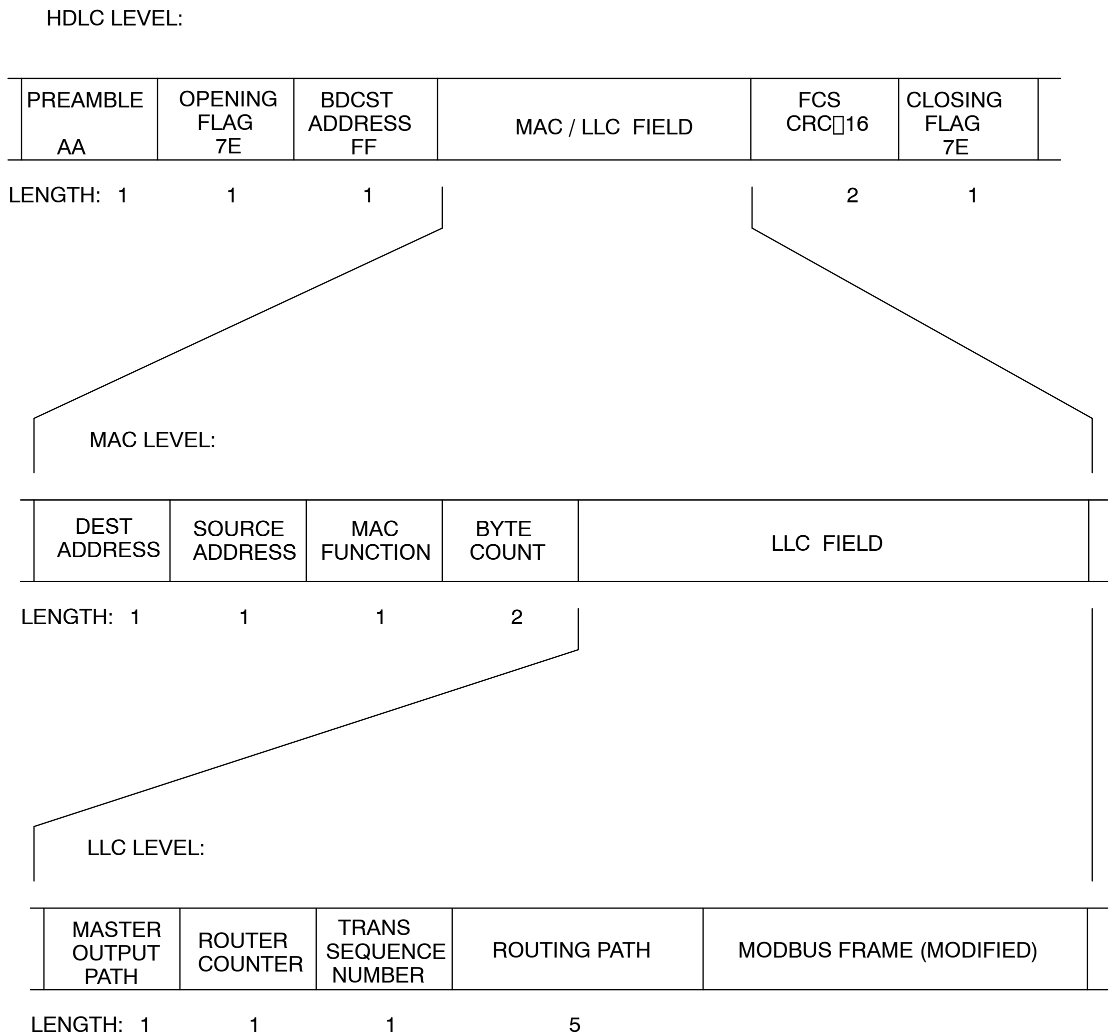


Figure 72 LLC Level Message Format

A.4.1 LLC Fields

The message contains the following LLC level fields:

Master Output Path
One byte identifying the originating node's output path for transmission of the message. Although each controller has one physical port for access to the network, it maintains multiple logical paths internally for sending and receiving messages. This allows multiple transactions to remain queued within the controller while it completes communications with other controllers. The controller will reserve the specified path until its transactions on that path are completed.

Router Counter
This field counts the number of Bridge Plus devices traversed, to control message queueing. Messages are queued in the first bridge only.

Transaction Sequence
One byte identifying the transaction between the source and destination. Multiple messages associated with a single transaction contain a value which remains constant while the transaction is active.

If a source initiates a message requesting data from a destination, the returned data message will include the same transaction sequence value. If the source initiates a message requesting data from a destination, and then aborts the transaction before receiving the data, the source can initiate a new message with the same destination without waiting for returned data for the aborted transaction. The two messages will have different transaction sequence values. When returned data is received from the destination, the transaction sequence value in the received message will identify the data as being either from the aborted transaction or from the newly initiated one.

Routing Path
This field is implemented as follows:

For messages to programmable controller nodes on Modbus Plus: each non-zero byte except the last specifies routing through a Bridge Plus to another network. The last non-zero byte specifies the destination controller's node address (1-64).

For messages to SA85 Host Based Device nodes: each byte up to and including the device's node address specifies routing to the device. Bytes following the node address byte can be used by the host application to specify application tasks running in the host.

For messages to a single Modbus slave device connected to a Bridge Multiplexer port: each non-zero byte except the last two specifies routing through a Bridge Plus to another network. The last two non-zero bytes specify the Bridge Multiplexer s node address (1-64) and Modbus port (1-4), respectively.

For messages to a Modbus networked slave device connected to a Bridge Multiplexer port: each non-zero byte except the last three specifies routing through a Bridge Plus to another network. The last three non-zero bytes specify the Bridge Multiplexer s node address (1-64), Modbus port (1-4) and slave address (1-247), respectively.

Modbus Frame (Modified)

This field contains the Modbus command originated by the controller, or by a Modbus master device connected to the controller. Data in a Modbus response message would also be contained in this field.

The field contents are the same as the original Modbus message, with two exceptions:

- The Modbus slave address is stripped from the contents. It appears in the Modbus Plus MAC level destination field.
- The Modbus CRC/LRC error check is stripped from the contents. Error checking is performed on the entire message in the Modbus Plus HDLC level CRC-16 field.

Appendix B
Message Routing

☐ The Modbus Plus Message Routing Path

☐ Modbus Address Conversion

☐ Controller Bridge Mode Routing

☐ Bridge Multiplexer Routing

B .1 The Modbus Plus Message Routing Path

A single Modbus Plus network can have up to 64 addressable node devices, with each device having a unique address of between 1 and 64. Multiple networks can be joined through Bridge Plus devices. Devices address each other across Bridge Plus devices by specifying routing paths of five bytes, with each byte representing an address on the next network. This routing method allows nodes in other networks to be addressed up to four networks away from the originating node.

The routing path is imbedded in the Modbus Plus message frame as it is sent from the originating node:

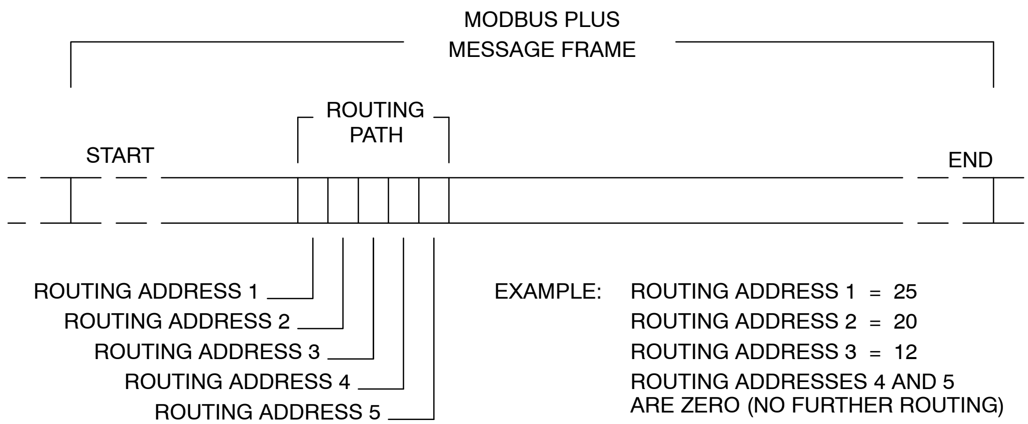


Figure 73 Message Frame Routing Path Field

Figure 73 illustrates message routing to a programmable controller through three networks that are joined by Bridge Plus nodes. Using the routing addresses in the figure, the message will first be routed to node 25, a Bridge Plus on the local network. That node forwards the message on to the Bridge Plus at address 20 on the second network. The second Bridge Plus forwards the message to its final destination, node address 12 on the third network. The zero contents of bytes 4 and 5 specify that no further routing is needed.

Programmable Controllers

For programmable controllers, the last non-zero byte in the message routing specifies the network node address of the controller (1 to 64).

Host-Based Network Adapters

For host-based network adapters, the routing bytes specify the network routing to the adapter s node address. Then, any bytes following the adapter s own address can be used by the internally by the adapter application program (for example, to route messages to specific tasks within the application). Routing details are provided in the guidebook for each host-based device.

Bridge Multiplexers

For bridge multiplexers, the routing field contents are specific to the type of device being addressed.

For a single slave device at a Modbus port, two bytes are used to address the device. The next-to-last non-zero byte addresses the multiplexer node (1 to 64). The last non-zero byte specifies the port (1 to 4), and therefore the single device.

For a networked Modbus slave device, three bytes are used to address the device. The third byte from the last non-zero byte addresses the multiplexer node (1 to 64). The next-to-last non-zero byte specifies the Modbus port (1 to 4). The last non-zero byte specifies the Modbus address of the slave device (1 to 247).

B .2 Modbus Address Conversion

Modbus devices use addresses of one byte in the range 1 ... 255. Modbus Plus nodes are addressed in the range 1 ... 64, with five bytes of routing imbedded in each Modbus Plus message.

Modbus messages received at the Modbus port of a programmable controller in bridge mode must be converted to the five-byte routing path used on Modbus Plus. Modbus messages received at a Bridge Multiplexer Modbus port must also be converted.

The Modbus address in the message determines the final routing over Modbus Plus. Figure 74 compares the methods used by programmable controllers in bridge mode and Bridge Multiplexers for converting Modbus addresses.

Programmable controllers convert the address using the methods shown in Figure 74. Bridge Multiplexers first compare the address to an internal table of Modbus Plus paths, using routing from the table if a match is found. If a match is not found in the table, the methods shown in Figure 74 are used.

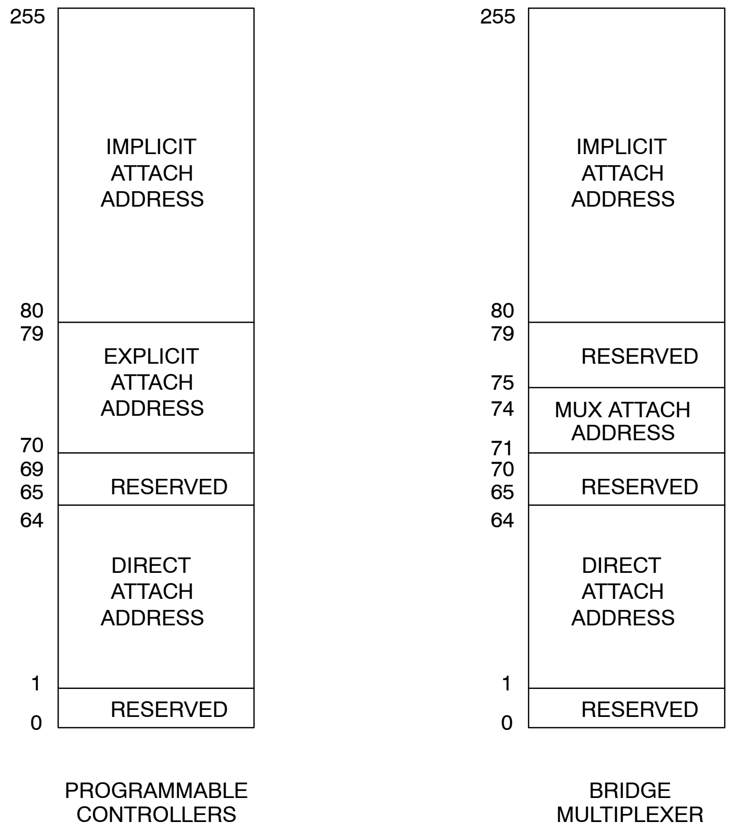


Figure 74 Modbus to Modbus Plus Address Conversion

Note that the addressing methods for both devices are identical except for addresses in the range 70 ... 79. Addressing is described in detail on the following pages.

B .3 Controller Bridge Mode Routing

If a Modbus message is received at the Modbus port of a controller that is set to bridge mode, the address (in the range 1 ... 255) is converted as shown in Figure 75.

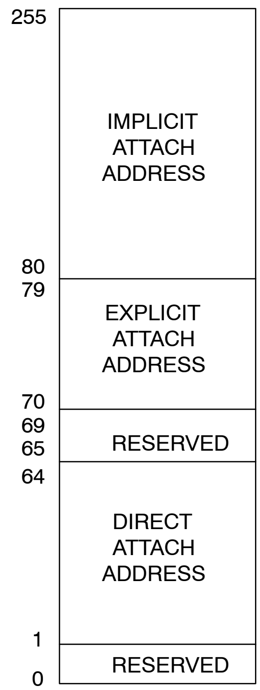


Figure 75 Controller Bridge Mode Address Conversion

1 ... 64

If the address is in the range 1 ... 64 (Direct Attach Address), the message is routed to the specific node address 1 ... 64 on the local Modbus Plus network.

70 ... 79

If the address is in the range 70 ... 79 (Explicit Attach Address), it causes the controller to access an address map table stored in a set of holding (4*x*) registers. These registers are located immediately following the Free-Running Timer Register in user logic (you must therefore implement the Timer in your logic program). Modbus addresses in this range thus become pointers to the routing table, which contains ten stored routing paths for Modbus Plus.

The routing path pointed to by the Modbus address is applied to the message. Each path is five bytes in length:

	4*x*	Free-Running Timer
70	4*x* + 1	Routing Path 1, byte 1
	4*x* + 2	Routing Path 1, byte 2
	4*x* + 3	Routing Path 1, byte 3
	4*x* + 4	Routing Path 1, byte 4
	4*x* + 5	Routing Path 1, byte 5
71	4*x* + 6	Routing Path 2, byte 1
	. . .	. . .
	4*x* + 50	Routing Path 10, byte 5

80 ... 255

If the address is in the range 80 ... 255 (Implicit Attach Address), it will be divided by 10. The quotient and remainder of the division will become the first two bytes of the five byte routing path. The remaining three bytes of the routing path will always be zeros. This addressing method allows two levels of addressing across Modbus Plus networks.

B .4 Bridge Multiplexer Routing

Modbus Address Map

If a Modbus message is received at a BM85 Modbus port, the address (1 ... 255) is compared to an internal Modbus Address Map table for the port. The map table contains up to 64 addresses, each pointing to a five-byte routing path. If an address match is found in the table, the routing path is applied to the message. If the first byte is in the range 1 ... 64, the message is routed out on Modbus Plus. If the first byte is zero, the message goes to a Modbus port (1 ... 4) specified in byte two. If that port has a single slave device, the remaining three routing bytes should be zeros. If the port has a network of slave devices, byte three is the slave address.

If a match is not found in the table, address conversion proceeds as in Figure 76.

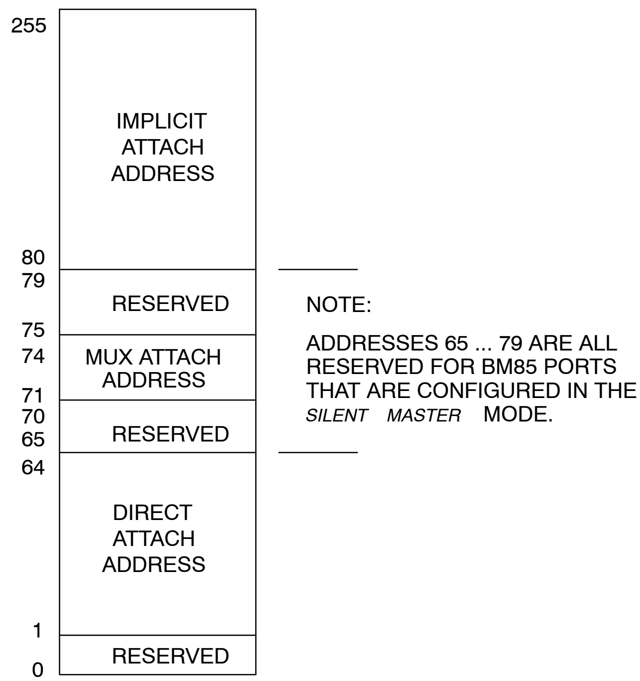


Figure 76 Bridge Multiplexer Address Conversion

1 ... 64

If the address is in the range 1 ... 64 (Direct Attach Address), the message is routed to the specific node address 1 ... 64 on the local Modbus Plus network.

71 ... 74

If the address is in the range 71 ... 74 (MUX Attach Address), the message is routed to a single Modbus device at one of the Bridge Multiplexer s Modbus ports. Addresses 71 ... 74 specify ports 1 ... 4, respectively.

80 ... 255

If the address is in the range 80 ... 255 (Implicit Attach Address), it will be divided by 10. The quotient and remainder of the division will become the first two bytes of the five byte routing path. The remaining three bytes will always be zeros. This addressing method allows two levels of addressing across Modbus Plus networks.

***Silent Master* Ports**

A BM85 serial port can be configured as a *Silent Master* port. A network with one master and a set of slave devices can be connected to the port. The master can initiate communication with a local slave device or across Modbus Plus. The slave device addresses must be unique. They must not be the same as a node address (1 ... 64) on the BM85 s local network, and they must not exist as entries in the mapping table for the port. Addresses 65 ... 79 are reserved.

B .4.1 Routing Examples

Figure 77 illustrates message routing across two networks.

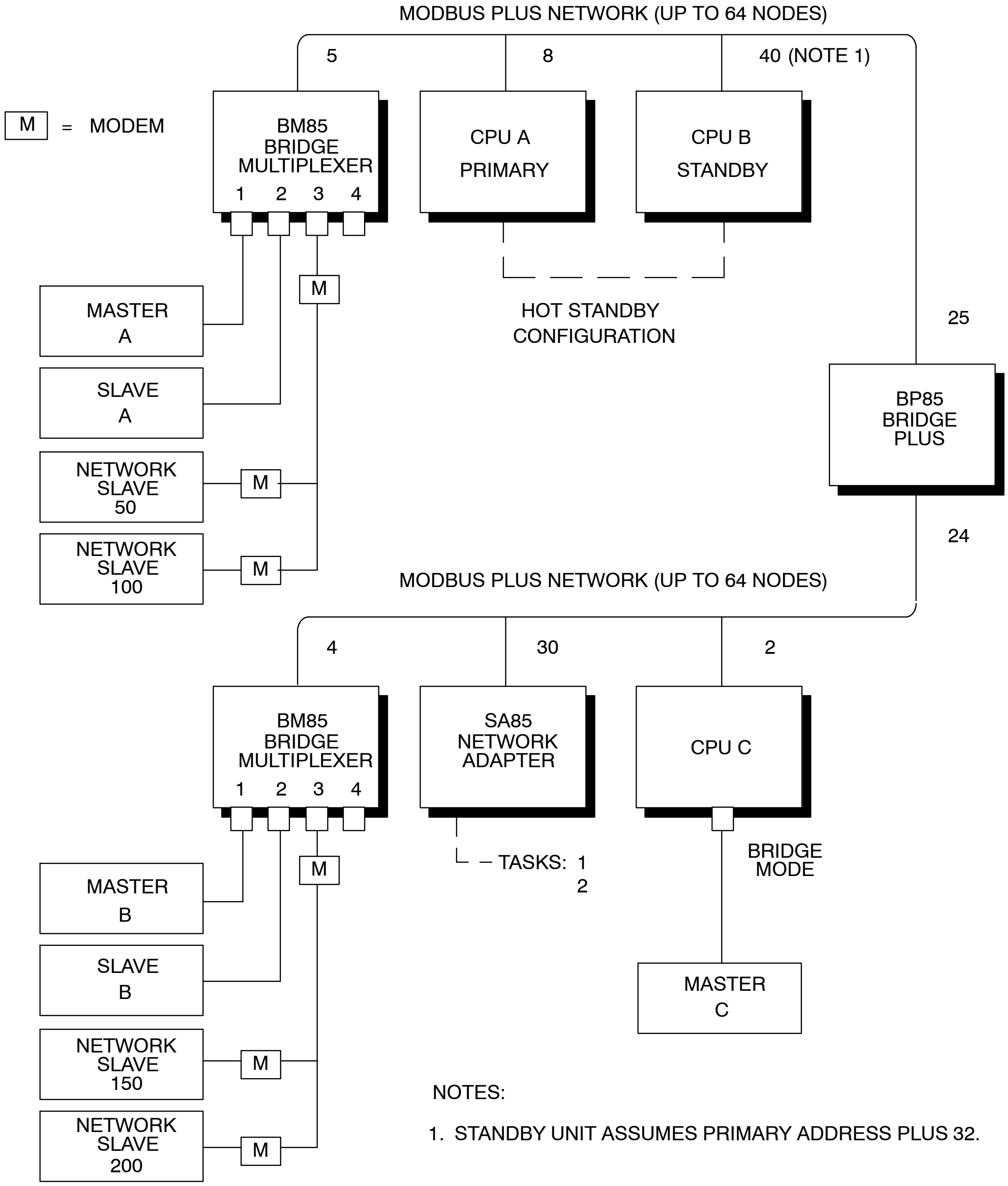


Figure 77 Routing Examples

Here are examples of routing between peer, master, and slave devices.

From	To	Routing Path				
CPU A (Primary)	Slave A	5	2	0	0	0
	50	5	3	50	0	0
	CPU C	25	2	0	0	0
	SA85 (Task 1)	25	30	1	0	0
	Slave B	25	4	2	0	0
	200	25	4	3	200	0
CPU C	SA85 (Task 2)	30	2	0	0	0
	Slave B	4	2	0	0	0
	200	4	3	200	0	0
	CPU A (Primary)	24	8	0	0	0
	CPU B (Standby)	24	40	0	0	0
	100	24	5	3	100	0
SA85	Slave B	4	2	0	0	0
	150	4	3	150	0	0
	CPU C	2	0	0	0	0
	CPU A (Primary)	24	8	0	0	0
	50	24	5	3	50	0

If Masters A, B, and C are programming panels such as the Modicon P230, they can attach to various devices using Direct, Implicit, or MUX addressing, or mapped routing:

From	To	Address		Routing Method	
Master A	CPU A (Primary)	8	Attach	Direct	8 0 0 0 0
	Slave A	72	Attach	MUX	Internal Path
	CPU C	252	Attach	Implicit	252/10 = 25 2 0 0 0
	50	50	Attach	Mapped	0 3 50 0 0
	200	200	Attach	Mapped	25 4 3 200 0
Master B	CPU C	2	Attach	Direct	2 0 0 0 0
	Slave B	72	Attach	MUX	Internal Path
	CPU A (Primary)	248	Attach	Implicit	248/10 = 24 8 0 0 0
	200	200	Attach	Mapped	0 3 200 0 0
	50	100	Attach	Mapped	24 5 3 50 0
Master C	CPU A (Primary)	248	Attach	Implicit	248/10 = 24 8 0 0 0
	CPU B (Standby)	71	Attach	Mapped	24 40 0 0 0
	Slave A	72	Attach	Mapped	24 5 2 0 0
	Slave B	73	Attach	Mapped	4 2 0 0 0
	150	74	Attach	Mapped	4 3 150 0 0

Appendix C
Planning Worksheets

This appendix provides blank worksheets that you can use for planning your Modbus Plus network.

- □ Node Planning Worksheet
- □ Topology Planning Worksheet
- □ Network Planning Worksheet
- □ Cable Routing Worksheet
- □ Materials Summary Worksheet

C.1 Using the Worksheets

Use these worksheets to plan the layout of your network and to coordinate the ordering of materials.

You can make photocopies of these worksheets as needed. Some copiers are capable of expanding the size of your copies for greater detail.

Examples of completed worksheets are provided in Chapter 4.

Node Planning Worksheet
Use this worksheet to plan the device type, setup and configuration parameters, and communications traffic at each node on your network. Use a separate worksheet for each node.

Topology Planning Worksheet
Use this worksheet to plan the top-level layout of your network. Summarize each node s address, device type, application, and site location. If you are using multiple networks, this worksheet can show how they are interconnected.

Network Planning Worksheet
Use this worksheet to detail the device type, length of trunk cable, tap, drop cable, and method of labeling at each physical site location on your network. Each worksheet has space for eight site locations. Use additional worksheets as needed to describe your network.

Cable Routing Worksheet
Use this worksheet for planning the individual sections of your network, or for planning the entire network, depending on the horizontal and vertical scales you want to use. You can use multiple copies of this worksheet for your planning. Use a small scale on some sheets to show local placement of devices and cables. Use a larger scale on another sheet to show the overall network cable layout throughout your plant.

Materials Summary Worksheet
Use this worksheet to summarize your materials requirements prior to ordering. Be sure to order cable in proper spool sizes to allow continuous runs between sites without splices. If you are specifying a dual-cable network with RR85 Repeaters, be sure to order separate Repeaters for each cable run.

MODBUS PLUS NETWORK
NODE PLANNING WORKSHEET

FACILITY / AREA : ______________________ PROJECT NAME : ____________ DATE : ____________

NETWORK NUMBER : ____________ PROJECT ENGR : ____________ TEL : ____________

NODE ADDRESS : ____________ MAINTENANCE : ____________ TEL : ____________

1. DEVICE :

TYPE *DESCRIPTION* *SITE LOCATION*

2. APPLICATION :

3. SETUP PARAMETERS :

4. COMMUNICATIONS ORIGINATED :

NETWORK	NODE	PRIORITY	PURPOSE	TYPE OF COMMUNICATION	AMOUNT OF DATA	RESPONSE TIME NEEDED

5. COMMUNICATIONS RECEIVED :

NETWORK	NODE	PRIORITY	PURPOSE	TYPE OF COMMUNICATION	AMOUNT OF DATA	RESPONSE TIME NEEDED

NOTES :

Figure 78 Node Planning Worksheet

NOTES :

Figure 79 Node Planning: Notes

MODBUS PLUS NETWORK
TOPOLOGY PLANNING WORKSHEET

FACILITY / AREA : ______________________

PROJECT NAME : ______________ DATE : ______________

PROJECT ENGR : ______________ TEL : ______________

MAINTENANCE : ______________ TEL : ______________

LEGEND : FIRST ENTRY: NODE NUMBER
SECOND ENTRY: DEVICE TYPE
THIRD ENTRY: APPLICATION
FOURTH ENTRY: LOCATION

END — END SITE OF NETWORK SECTION

NOTES :

Figure 80 Topology Planning Worksheet

NOTES :

Figure 81 Topology Planning: Notes

MODBUS PLUS NETWORK
NETWORK PLANNING WORKSHEET

FACILITY / AREA : ____________________ PROJECT NAME : __________ DATE : __________

NETWORK NUMBER : __________ CABLE : A ___ B ___ PROJECT ENGR : __________ TEL : __________

SHEET : ________ OF ________ MAINTENANCE : __________ TEL : __________

SITES : ________ TO ________ SITE: ____ ____ ____ ____ ____ ____ ____ ____

1. SITE LABELING :

1A NAME OF SITE LOCA TION :								
1B PLANT SITE COORDINA TES :								
1C ENCLOSURE NUMBER :								
1D PANEL LABEL :								
1E DEVICE LABEL :								
1F CABLE FROM PREVIOUS SITE, LABEL :								
1G CABLE TO NEXT SITE, LABEL :								

2. TRUNK CABLE AND TAPS :

2A CABLE RUN FROM PREVIOUS SITE, LENGTH :								
2B SER VICE LOOP AT THIS SITE (2M/6FT) :								
2C RUN LENGTH (SUM OF 2A AND 2B) :								
2D CUT LENGTH (MUL TIPL Y 2C TIMES 1.1) :								
2E TAP, 990NAD23000 :								
2F TERMINA TION JUMPERS INST ALLED IN TAP :								

3. DROP CABLES :

3A DROP CABLE, 2.4M/8FT , 990NAD21 110 :								
3B DROP CABLE, 6M/20FT , 990NAD21 130 :								

4. DEVICE TYPE :

4A SER VICE ACCESS POINT CONNECT OR :								
4B RR85 REPEATER:								
4C BM85 BRIDGE MUL TIPLEXER :								
4D BP85 BRIDGE PLUS :								
4E PROGRAMMABLE CONTROLLER (MODEL NO.):								
4F HOST NETWORK ADAPTER (MODEL NO.):								
4G NETWORK OPTION MODULE (MODEL NO.):								
4H DIO DROP ADAPTER (MODEL NO.):								
4I TIO MODULE (MODEL NO.):								
4J								
4K								

NOTES :

Figure 82 Network Planning Worksheet

NOTES :

Figure 83 Network Planning: Notes

MODBUS PLUS NETWORK
CABLE ROUTING WORKSHEET

FACILITY / AREA : ______________________ PROJECT NAME : ____________ DATE : ____________

NETWORK NUMBER : ____________ CABLE : A ___ B ___ PROJECT ENGR : ____________ TEL : ____________

SHEET : __________ OF __________ MAINTENANCE : ____________ TEL : ____________

SITES : __________ TO __________ SCALE : HORIZ : ____________ VERT : ____________

	A	B	C	D	E	F
1						
2						
3						
4						
5						

NOTES :

Figure 84 Cable Routing Worksheet

NOTES :

Figure 85 Cable Routing: Notes

MODBUS PLUS NETWORK
MATERIALS SUMMARY WORKSHEET

FACILITY / AREA : ______________________ PROJECT NAME : __________ DATE : __________

NETWORK NUMBER : ______________ PROJECT ENGR : __________ TEL : __________

MAINTENANCE : __________ TEL : __________

DESCRIPTION	PART NUMBER	MANUFACTURER	QTY USED	QTY SPARE	QTY TOTAL	UNIT OF MEASURE	DATE ORDERED	DATE RECEIVED
1. NETWORK DEVICES :								
RR85 REPEATER		MODICON				EACH		
BP85 BRIDGE PLUS		MODICON				EACH		
BM85 BRIDGE MULTIPLEXER		MODICON				EACH		
PROG CONTROLLER		MODICON				EACH		
HOST NETWORK ADAPTER		MODICON				EACH		
NETWORK OPTION MODULE		MODICON				EACH		
DIO DROP ADAPTER		MODICON				EACH		
TIO MODULE		MODICON				EACH		
2. TRUNK CABLE AND TAPS:								
MBPLUS TRUNK CABLE		MODICON				REEL		
MBPLUS TAP	990NAD23000	MODICON				EACH		
3. DROP CABLES :								
MBPLUS DROP (2.4M/8FT)	990NAD21 110	MODICON				EACH		
MBPLUS DROP (6M/20FT)	990NAD21 130	MODICON				EACH		
4. LABELS :								
PANEL								
DEVICE								
CABLE								
CONNECTOR								
5. INSTALLATION HARDWARE :								
STRAIN RELIEFS								
6. TOOLS / TEST EQUIPMENT :								

NOTES :

Figure 86 Materials Summary Worksheet

NOTES :

Figure 87 Materials Summary: Notes

Appendix D
Installing Custom Cable Systems

- ☐ Overview
- ☐ Tools and Test Equipment Required
- ☐ Before You Start
- ☐ Routing the Cable
- ☐ Installing Cable Connectors on Dual-cable Runs
- ☐ Installing Connectors With the Tool
- ☐ Installing Connectors Without the Tool
- ☐ Grounding
- ☐ Labeling Cables
- ☐ Checking the Cable Installation

D.1 Overview

This chapter describes how to install the network cable system without the use of Modicon taps and drop cables. This method uses *inline* and *terminating* connectors that are available from Modicon. It is intended primarily for the installer, but can also be useful to the planner in estimating time and labor requirements.

You will be performing the following actions to install and check the cable:

- □ Route the cable in accordance with the layout diagram described in Chapter 4.
- □ At each cable drop location except the two extreme ends, connect the cable signal conductors and shield to an *inline* connector.
- □ At the cable drop locations at the two extreme ends, connect the cable signal conductors and shield to a *terminating* connector.
- □ If the network node devices are installed, check that each one is grounded to a proper site ground.
- □ Label the cable segments to assist in future maintenance.
- □ Inspect the cable run and check the cable s continuity before connecting it to the network node devices.

D .2 Tools and Test Equipment Required

An installation tool (Modicon part number AS-MBPL-001) is available for installing connectors on the cable. Use of this tool will make the installation much easier to perform compared to the use of common hand tools only. It will also ensure positive electrical contact between connectors and the network cable. Contact Modicon for information about obtaining this tool.

The following additional tools and test equipment are required to install and check the cable:

- Wire cutter to cut the cable segments
- Wire stripper or knife to remove the cable jacket
- Flat screwdriver for assembling cable connectors
- Voltohmmeter for checking the cable continuity.

If possible, avoid the use of cable pulling tools by laying the cable directly into overhead troughs or raceways. This will minimize potential stretching or cutting damage. If a pulling tool is used, follow the manufacturer s guidelines and avoid excessive force in pulling the cable.

D.3 Before You Start

Before routing the cable you should have a cable routing diagram that shows:

- □ Site locations of network node devices
- □ Routing paths of each cable segment
- □ Cable segment distances and cut lengths
- □ List of materials required (length of cable, quantities of inline connectors, terminating connectors, cable ties, adhesive labels, and other materials as needed).

Chapter 4 describes how to prepare this diagram. If you cannot obtain such a diagram, you must observe all the precautions described in this guide for physical and electrical protection of the cable during installation.

Caution: Failure to provide proper physical protection of the cable can cause damage to the cable conductors or insulation. Failure to provide proper electrical protection of the cable can result in excessive interference induced from adjacent circuits. This can cause degraded network performance.

D .4 Routing the Cable

Figure 88 shows typical cable drops to several network node devices and a service access point connector.

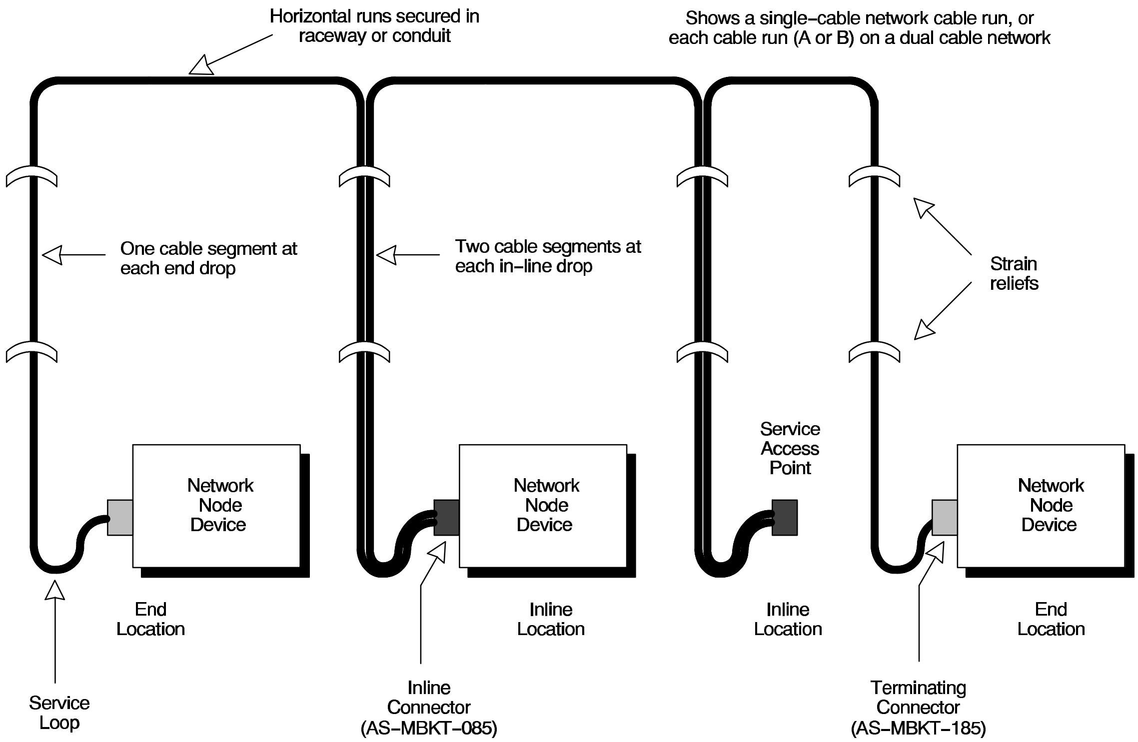


Figure 88 Typical Cable Drops

Refer to Figure 88. Route the cable between the site locations of the network node devices. Guidelines for cable routing are described below. For dual-cable routing, follow these guidelines for each cable.

- ☐ Use a continuous length of cable between locations. Do not use any kind of taps or splices.
- ☐ Two cable segments are routed to each inline drop location: one segment from the previous drop, and one segment to the next drop.
- ☐ One cable segment is routed to the last drop at each end of the network.

- ☐ At each drop, allow sufficient cable for a service loop and strain reliefs.
- ☐ At each drop, provide a service loop to allow the cable to be connected and disconnected from the network device without strain on the cable. A service loop of 6 in (15 cm) minimum radius is adequate for most installations.
- ☐ Two cable ties are provided with each cable connector for use as strain reliefs. Use one of these at each drop to secure the cable to a panel or other stable assembly, to prevent the cable s weight from pulling on the connector. The other strain relief will be used on the connector.
- ☐ Use additional ties as required to secure the cable from flexing or other damage in areas of mechanical motion devices and traffic.
- ☐ If you are installing cables for a dual-cable network, the two cables should be identified as Cable A and Cable B.
- ☐ Make sure that each cable is properly marked so that it can be positively identified as Cable A or Cable B over the entire end-to-end length of the network.

D.5 Installing Connectors on Dual-Cable Runs

At each inline device site, an Inline Connector (AS-MBKT-085) must be installed on both Cable A and Cable B. At the two device sites at the extreme ends of the network, a Terminating Connector (AS-MBKT-185) must be installed on both cables.

An individual connector is always wired to segments on the same cable only, never to both cables. Cable A and Cable B should remain independent through their entire runs.

For example, a connector may connect to two segments on Cable A. A separate connector may connect to two segments on Cable B. The same connector should never connect cables A and B together.

Make sure to properly label each connector (A or B) so that it can be connected to the proper port (A or B) on the node device when it is installed at the site.

D.6 Installing Connectors With the Tool

A tool is available from Modicon (part number AS-MBPL-001) for installing the connectors on your network cable. Use of this tool will ensure a positive connection between the cable and connector. The tool is illustrated in Figure 89.

If you are not using this tool, skip the instructions below. Go to page 229.

Figure 89 Modbus Plus Connector Installation Tool

D.6.1 Before You Start

Make sure you have the proper type of connector for each point on the network cable:

Connector type AS-MBKT-185 (light grey) must be installed at the two end points. Two connectors are contained in the Modicon kit with this part number.

Connector type AS-MBKT-085 (dark grey) must be installed at each inline point. One connector is contained in the kit with this part number.

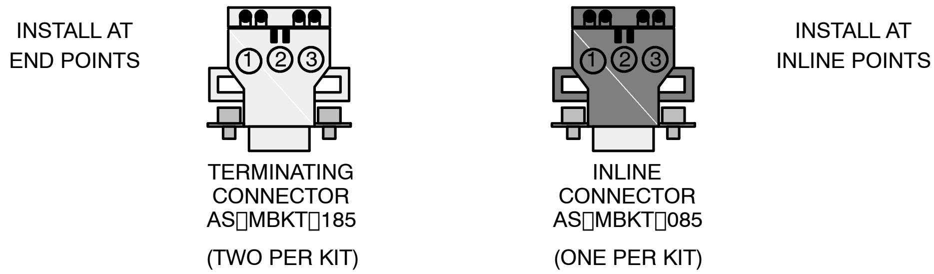


Figure 90 Modbus Plus Connectors

You will need the following additional tools: electrician's knife; wire stripper; small flat-blade screwdriver; ohmmeter with a low-resistance range (0 ... 200 Ω).

You will also need to know which type of network device (type of Modicon 984 controller or other device) is to be installed at each point on the cable. The connector wiring direction will depend on the type of device installed.

D.6.2 Overview of the Connector Installation

Each connector requires seven kinds of action:

- ☐ Preparing the cable
- ☐ Placing the connector into the tool
- ☐ Determining the wiring direction
- ☐ Placing the wires into the connector
- ☐ Replacing the cap
- ☐ Seating the wires and installing the cap screw
- ☐ Completing the connection

D .6.3 Preparing the Cable

Remove three inches (7.5 cm) of the cable s outer jacket and shields as shown in Figure 91 below. This will expose the cable s two signal wires and drain wire.

Strip approximately 1/4 inch (6 mm) of the insulation from the end of each signal wire. This will allow you to check wiring continuity to the connector s pins.

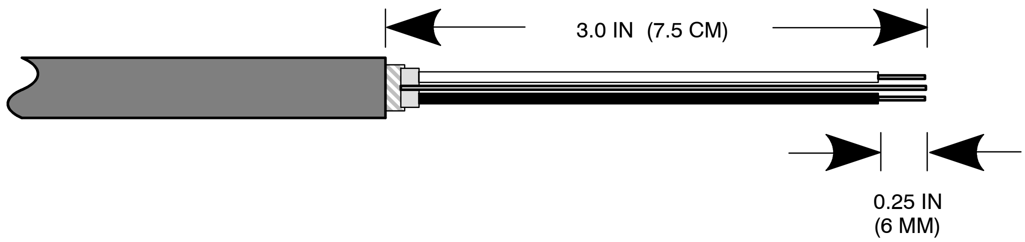


Figure 91 Preparing the Cable

D .6.4 Placing the Connector into the Tool

Select the proper connector as described in **Before You Start** . Remove the screw that secures the connector cap, and remove the cap. Retain the cap and screw for reassembly.

Open the tool and place the connector into the cutout as shown in Figure 92 below.

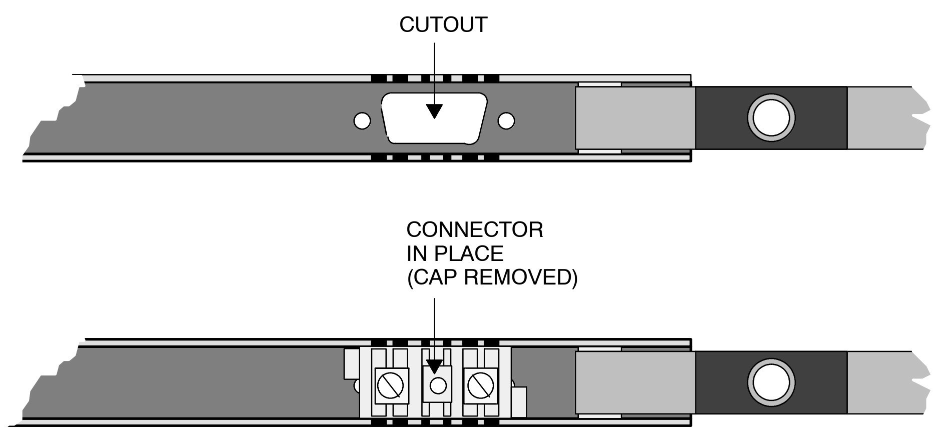


Figure 92 Placing the Connector into the Tool

D.6.5 Determining the Wiring Direction

The wires must be inserted into the connector in the proper direction for the type of device to be installed at the site. The tool is labeled with the proper wire direction for various network devices. Determine the wire direction for the device at the present site.

Figure 93 shows an example of the wire direction for a Modicon 984-685 or 984-785 controller.

If the device is not listed on the tool, the wires can be inserted from either direction. In this case, choose the best direction according to the manner in which the cable is routed to the device.

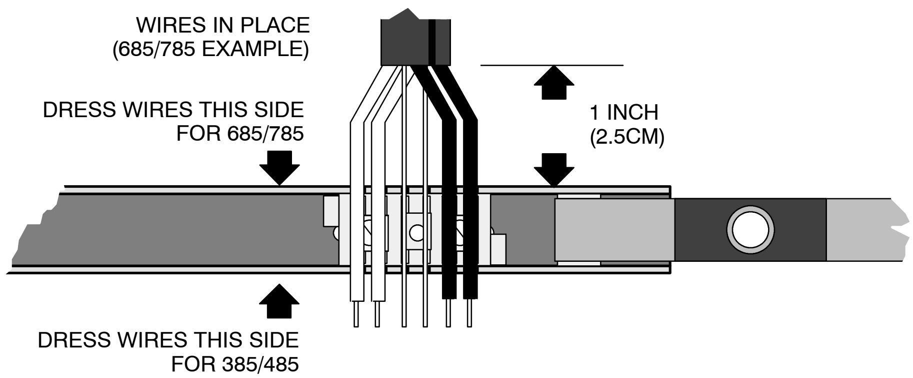


Figure 93 Determining the Wiring Direction

D.6.6 Placing the Wires into the Connector

One cable (three wires) will be connected to the connector at each of the two extreme end sites. Two cables (six wires) will be connected at each inline site.

Observing the proper wire direction, place the wires into the slots of the tool as in Figure 93 above. Make sure the white wires are toward the handle end of the tool and the blue or black wires are toward the pivot end.

When the white and blue or black wires have been inserted, insert the bare drain wires into the center slots of the tool. Make sure the drain wires do not contact any other terminal.

D.6.7 Replacing the Cap

Carefully replace the cap as shown in Figure 94 below. Make sure the cap is properly aligned to fit over the wiring terminals. Do not install the cap screw yet.

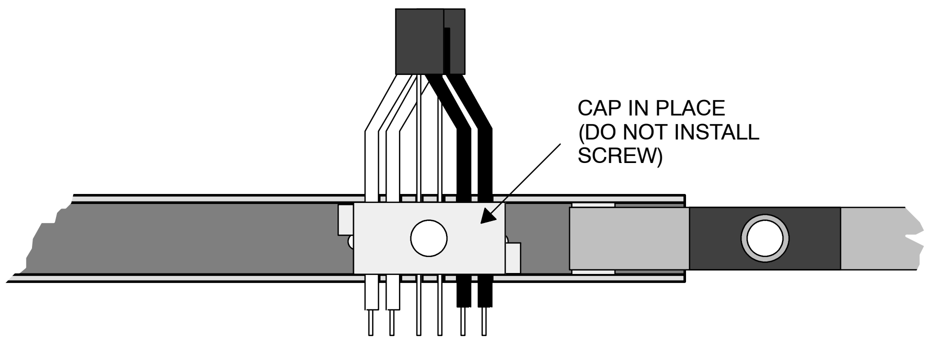


Figure 94 Replacing the Cap

D.6.8 Seating the Wires and Installing the Cap Screw

Close the tool firmly to seat the wires into the connector terminals as shown in Figure 95 below. Close the tool completely against its stop tab. While holding the tool closed, insert the cap screw through the hole provided in the tool and tighten it into the connector with a screwdriver.

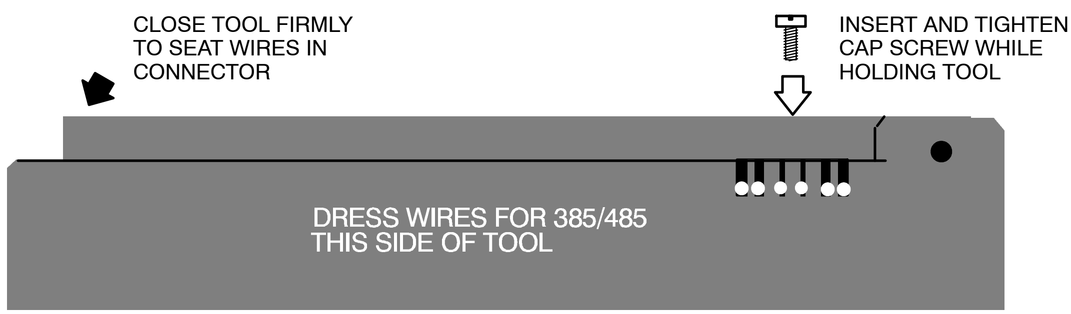


Figure 95 Seating the Wires and Installing the Cap Screw

D.6.9 Completing the Installation

Checking Wiring Continuity

Open the tool, and remove the connector and cable. Locate pins 1, 2, and 3 of the connector as shown in Figure 96.

Using an ohmmeter set to a low-resistance range, verify that direct continuity (zero ohms) exists between each white wire and pin 3. Verify direct continuity between each blue or black wire and pin 2. Verify direct continuity between each bare drain wire and pin 1.

If an improper connection has been made, and you have already installed one or both of the connectors at the two ends of the network cable, it is possible to read either 60 or 120 ohms resistance between a blue or black or white wire and its pin. Make sure you have direct continuity (zero ohms) between each wire and its proper pin.

Verify that no continuity (an open circuit) exists between each white wire and each drain wire. Verify that no continuity exists between each blue or black wire and each drain wire.

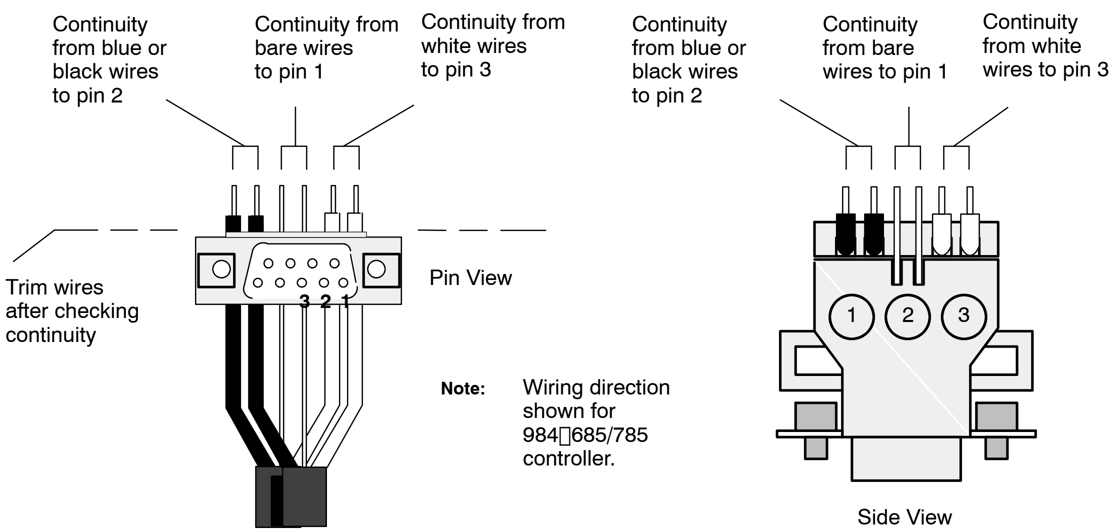


Figure 96 Checking Wiring Continuity

Trim the Wires

If continuity is normal, trim the excess lengths of wire so that they are flush with the side of the connector. If continuity is not normal, repeat the installation procedure with a new connector.

Installing the Cable Tie

Using one of the cable ties supplied with the connector, tie the cable tightly to one of the connector s side tabs. This will prevent damage in future handling of the connector.

D .6.10 What to Do Next

Install the remaining connectors on the cable by repeating the steps in these instructions.

After installing all of the connectors, follow the guidelines for observing the cable **Grounding** precautions, and for **Labeling** the cable installation, in this chapter.

Check the entire cable installation visually and electrically as described in **Checking the Cable Installation**, in this chapter.

D.7 Installing Connectors Without the Tool

If you are using the Modbus Plus connector installation tool (AS-MBPL-001), do not follow the instructions below. Go to the instructions in the previous part of this chapter, **Installing Connectors With the Tool**.

If you are not using the installation tool, continue with the instructions below.

D.7.1 Before You Start

Make sure you have the proper type of connector for each point on the network cable:

Connector type AS-MBKT-185 (light grey) must be installed at the two end points.
Two connectors are contained in the Modicon kit with this part number.

Connector type AS-MBKT-085 (dark grey) must be installed at each inline point.
One connector is contained in the kit with this part number.

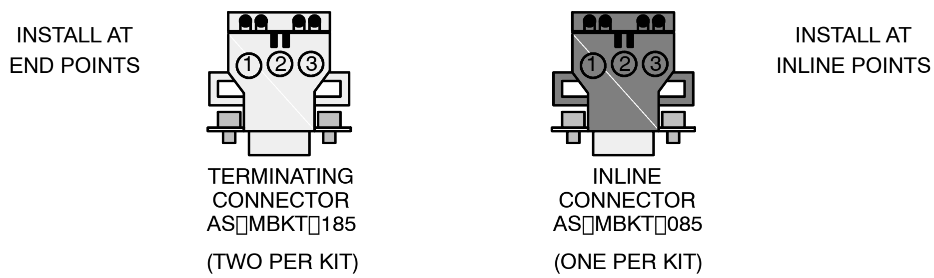


Figure 97 Modbus Plus Connectors

You will need the following tools: electrician s knife; wire stripper; small flat-blade screwdriver; ohmmeter with a low-resistance range (0-200 ohms).

You will also need to know which type of network device (type of Modicon 984 controller or other device) is to be installed at each point on the cable. The connector wiring direction will depend on the type of device installed.

D.7.2 Overview of the Connector Installation

Each connector requires six kinds of action:

- ☐ Preparing the cable
- ☐ Identifying the connector terminals
- ☐ Connecting the wires
- ☐ Inspecting the connection
- ☐ replacing the cap
- ☐ Completing the connection

D.7.3 Preparing the Cable

Remove 3 in (7.5 cm) of the cable s outer jacket and shields as shown in Figure 98 below. This will expose the cable s two signal wires and drain wire.

Strip approximately 1/4 in (6 mm) of the insulation from the end of each signal wire. This will allow you to check wiring continuity to the connector s pins.

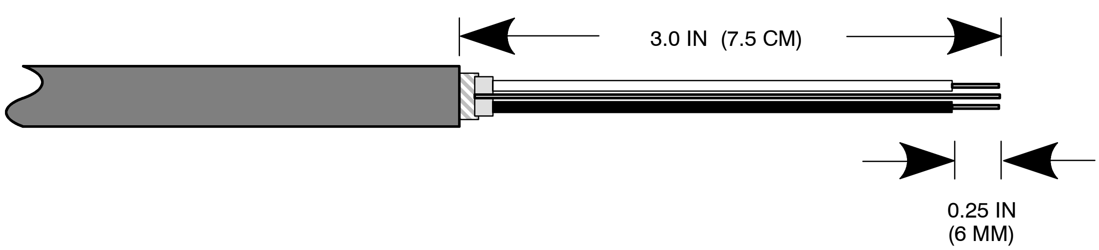


Figure 98 Preparing the Cable

D .7.4 Identifying the Terminals

Refer to Figure 99. Remove the screw that secures the connector cap. Remove the cap to expose the wiring terminals. Note the terminal numbers (1, 2, 3) marked on each side of the connector.

Caution: The connector terminals have sharp edges. Use caution when handling the connector .

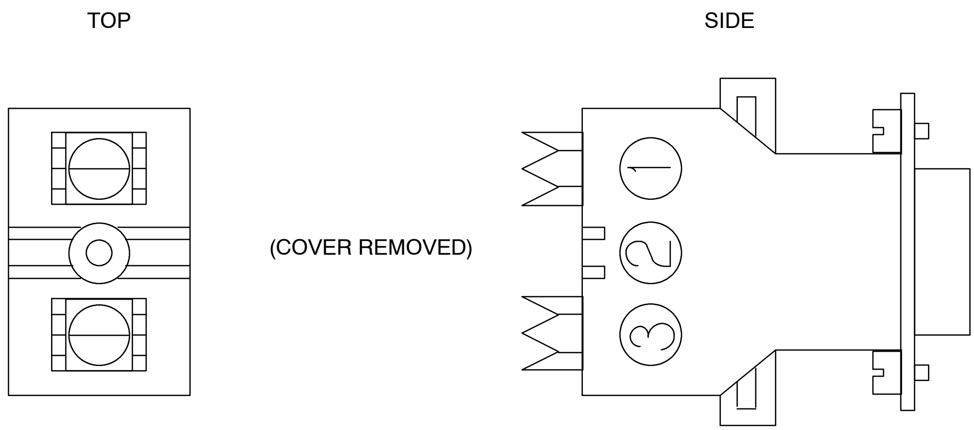


Figure 99 Identifying the Terminals

D .7.5 Connecting the Wires

Refer to Figure 100. All wires will be routed into one side of the connector. The wiring direction depends upon the type of device to be installed at the site, as shown in the figure. If a device is not listed, the wires can be routed into either side of the connector.

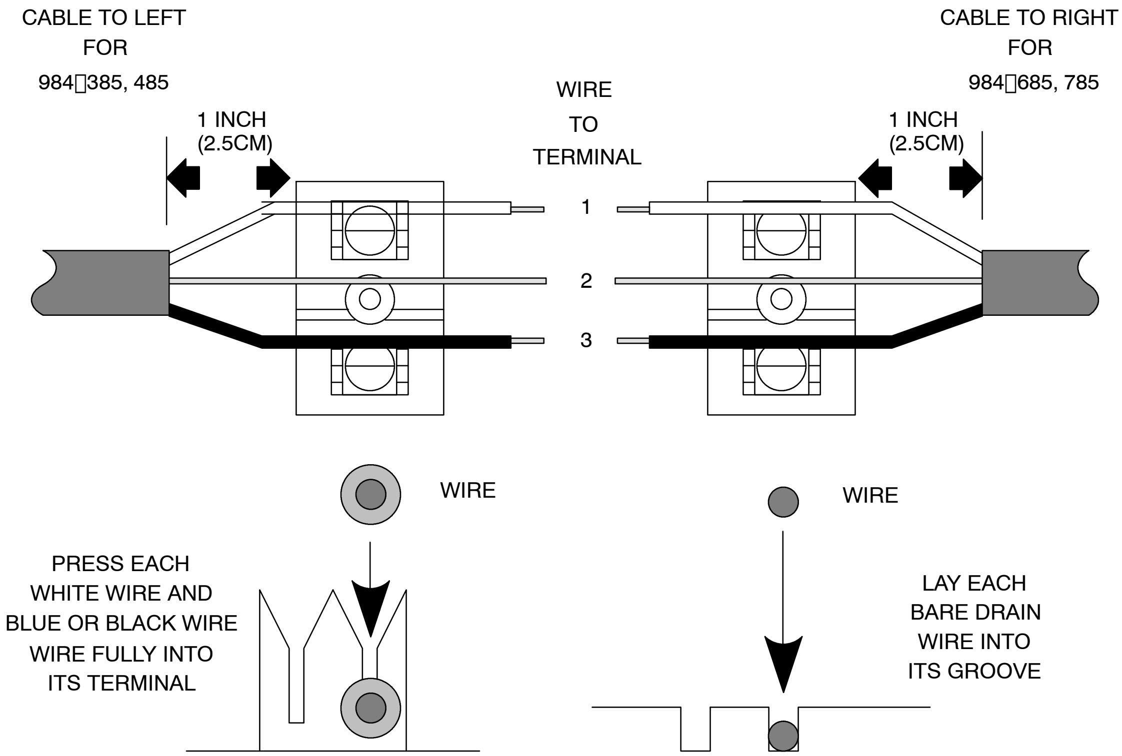


Figure 100 Connecting the Wires

Refer again to Figure 100. Note the wire color that will connect to each terminal. The white wire will connect to terminal 1, the bare drain wire to terminal 2, and the blue or black wire to terminal 3.

To connect a white, blue, or black wire, lay it across the top of its terminal with the cable's outer jacket approximately one inch (2.5 cm) away from the connector. Using the connector cap as a tool, press the wire fully into its terminal. When the wire is fully inserted, it will bottom into its terminal as shown in Figure 100.

After connecting each wire, check continuity between the wire conductor and terminal. Check this with an ohmmeter between the exposed end of the wire and the terminal.

Lay the drain wire over terminal 2 (the center contact area). Do not allow the wire to contact any other terminal. Make sure the drain wire is into its groove in the connector body as shown in Figure 100.

If you are connecting an inline site, refer to Figure 101. Connect the second cable to the connector as shown in the figure. Use the same methods for connecting and checking the wiring as for the first cable.

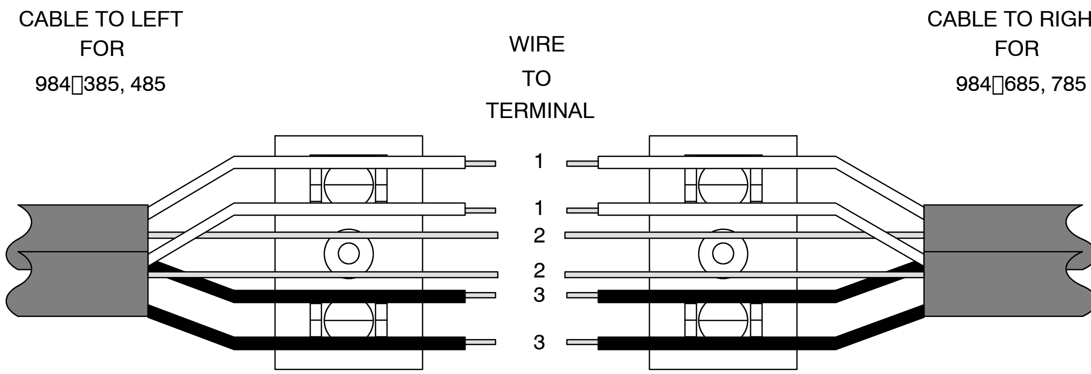


Figure 101 Connecting the Second Cable (Inline Sites Only)

D .7.6 Inspecting the Connection

Visually inspect the completed connection:

- □ The wire colors are correct: White at terminal 1, Bare at terminal 2, and Blue or Black at terminal 3
- □ All wires are routed straight through the channels in the connector
- □ All wires are inserted completely into the channels in the connector
- □ The bare drain wire is not frayed, and is not touching either terminal 1 or terminal 3.

D .7.7 Replacing the Cap

When all the wires are in correctly placed in the connector, you can replace the connector cap. Taking care not to dislodge any wire, fit the connector cap to the connector body. Tighten the cap screw to secure the cap.

D.7.8 Completing the Installation

Checking Wiring Continuity

Locate pins 1, 2, and 3 of the connector as shown in Figure 102.

Using an ohmmeter set to a low-resistance range, verify that direct continuity (zero ohms) exists between each white wire and pin 3. Verify direct continuity between each blue or black wire and pin 2. Verify direct continuity between each bare drain wire and pin 1.

If an improper connection has been made, and you have already installed one or both of the connectors at the two ends of the network cable, it is possible to read either 60 or 120 ohms resistance between a blue or black or white wire and its pin. Make sure you have direct continuity (zero ohms) between each wire and its proper pin.

Verify that no continuity (an open circuit) exists between each white wire and each drain wire. Verify that no continuity exists between each blue or black wire and each drain wire.

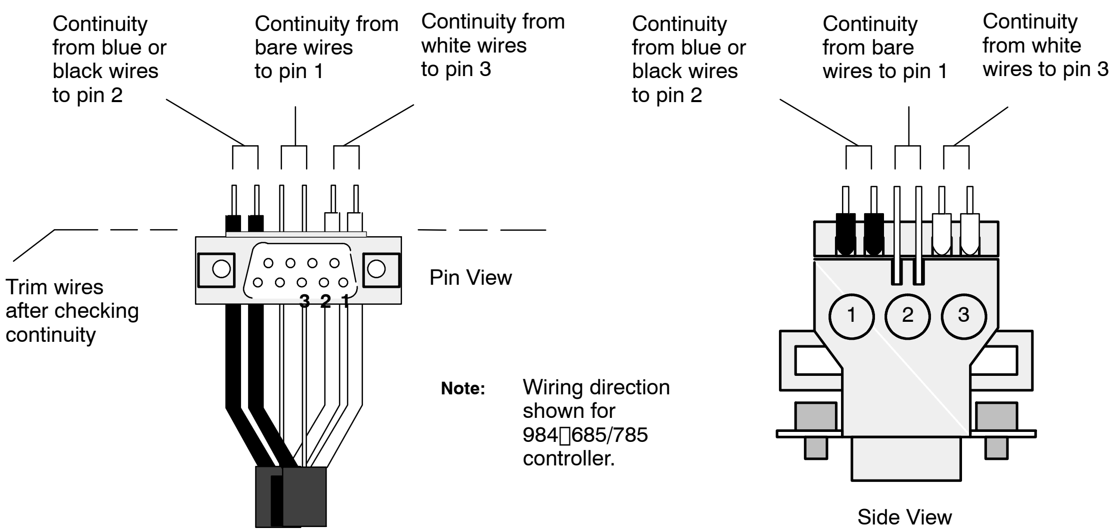


Figure 102 Checking Wiring Continuity

Trim the Wires

If continuity is normal, trim the excess lengths of wire so that they are flush with the side of the connector. If continuity is not normal, repeat the installation procedure with a new connector.

Installing the Cable Tie

Using one of the cable ties supplied with the connector, tie the cable tightly to one of the connector s side tabs. This will prevent damage in future handling of the connector.

D .7.9 What to Do Next

Install the remaining connectors on the cable by repeating the steps in these instructions.

After installing all of the connectors, follow the guidelines for observing the cable **Grounding** precautions, and for **Labeling** the cable installation, in this chapter.

Check the entire cable installation visually and electrically as described in **Checking the Cable Installation**, in this chapter.

D.8 Grounding

All three conductors of the cable (signal wires and shield) should remain isolated from the panel grounding connection at each drop location. Grounding systems should connect to the network device, not to the network cable.

If the network devices are installed, make sure each one has its grounding terminal and frame properly connected to the plant grounding system. The grounding path should be separate from paths used for motors, generators, welders, and other high-current industrial devices.

D .9 Labeling

After the cable is installed, label the cable segments for ease in future maintenance of the network. Adhesive labels are available commercially for cable identification.

If a cable layout diagram exists for the installation, label each segment in accordance with the diagram. If a diagram does not exist, refer to the examples in Chapter 2 and prepare a diagram showing the cable segments and method of identifying them for future service. Then label the segments accordingly.

Affix the labels to the cables at each network node drop. Place them at a point visible to maintenance personnel.

Complete the network installation labeling by properly labeling each site s cabinet or enclosure, device mounting panel, and device.

Notify the person who will be responsible for future maintenance of the network, and deliver the network documents to that person. It is suggested you do a walking tour with that person through the network sites to produce familiarity with the network layout.

D.10 Checking the Cable Installation

This section describes how to visually inspect the cable and check its end-to-end electrical continuity.

D.10.1 Inspecting the Cable Installation

☐ The cable runs should agree with the physical and electrical protection requirements in Chapter 2.

☐ The cable runs should agree with the network cable routing diagram as described in Chapter 2.

☐ Each inline drop site should have two cables, connected to one inline connector (dark grey).

☐ The two end drop sites on each section of the network should each have one cable, connected to a terminating connector (light grey).

☐ The cable direction (left or right) into each connector should be correct according to the type of device to be installed at each site.

☐ Each connector should be tightly secured to its cable(s) by a cable tie.

☐ Adequate strain reliefs should be installed on the cable at each drop.

☐ All identification labels should be in place and properly marked.

D.10.2 Checking the Cable Continuity

☐ These continuity checks are applicable to cable installations that use only the components described in this Appendix. These checks do not apply to installations that use the tap and drop cable components described in Chapter 5.

☐ Before checking continuity, all cable connectors should be disconnected from the network devices.

☐ At any connector, measure the resistance between pins 2 and 3 (the signal pins). Measure this at the connector s external pins, not at its internal wiring terminals. This should be in the range of 60 to 80 ohms, which includes the cable wire resistance.

☐ At one end connector, connect a jumper between pin 2 (a signal pin) and pin 1 (the shield pin). At the other end connector, check for continuity between pin 2 and pin 1. Continuity should be present.

☐ Leaving the meter connected as above, remove the jumper. Again check the continuity between pin 2 and pin 1. It should be an open circuit.

☐ At any connector, check the continuity between pin 1 and the plant ground point on the local site panel or frame. It should be an open circuit.

If your checks do not agree with these results, inspect the cable and connectors for damage or miswiring, and correct the condition.

Glossary

acknowledgement
An LLC frame that indicates that a data frame has been received correctly.

address
On a network, the identification of a station. In a frame, a grouping of bits that identifies the frame s source or destination.

ASCII
American Standard Code for Information Interchange. A digital coding of alphanumeric and control characters as established by the American National Standards Institute.

baud rate
The speed of data transmission in serial data communications, approximately equal to the number of code elements (bits) per second.

bit
Binary Digit. The smallest unit of data, which can at any time be in one of two possible states, represented by a value of 0 or 1.

bridge
A device that interconnects two or more networks.

Bridge Multiplexer
A Modicon device that interconnects a Modbus Plus network with up to four Modbus devices or networks, or up to four RS232 or RS485 serial devices. See **Co-Processor** .

Bridge Plus
A Modicon device that interconnects two Modbus Plus networks.

broadband
A network communications method supporting multiple data transmission channels, using frequency division multiplexing.

bus
An electrical channel used to send or receive data.

carrierband
A network communications method in which information is transmitted using a single transmission channel. See **broadband**.

channel
The communication pathway between two or more devices.

coaxial cable
A two conductor cable in which an inner conductor is the signal path and an outer conductor is a shield. A dielectric separates the two conductors.

Co-Processor
Bridge Multiplexer models BM85S232 and BM85S485. These models contain a user-defined application program that can independently control processes at their four serial ports, accessing Modbus Plus nodes only as required.

CRC
Cyclic Redundancy Checking. An error detection method in which a sending station computes a mathematical value derived from the frame s contents, and sends it as an HDLC field in the frame. The receiving station recomputes the value as it receives the frame, and compares it to the received value. If the two values are equal, the frame is assumed to have been received without error.

data frame
An LLC frame containing data to be transferred between devices.

Data Link Layer
In the OSI model, the layer that provides services for transferring frames of data between nodes of a network. Defined by the IEEE 802.2 standard. At this layer, a sending device assembles data into a message packet with addresses and information for error checking, handles tokens for accessing the network, and sends the

packet to the Physical Layer for transmission. Its two logical entities are the MAC and LLC sublayers. See **MAC** and **LLC**.

DIO

See **Distributed I/O.**

DIO Drop Adapter

See **DIO Adapter**.

Distributed I/O

A Modbus Plus network that consists of hardware components that are specifically designed for high-speed control of Input/Output devices at remote sites in an industrial process. Each DIO network has one Programmable Controller or one Modbus Plus Network Option Module that operates as the master controlling node on the network. The DIO network also has one or more DIO Adapters, placed at the remote plant sites. Up to 64 nodes can be present on each DIO network, exchanging messages during the passing of token frames.

download

The transfer of a program from one device to another for execution.

drop cable

A cable used to connect a networked node device to a tap on the trunk cable. Drop cables are available in various lengths from Modicon. See **tap.**

duplicate frame

A frame received twice because an acknowledgement was lost.

end delimiter

A field that defines the end of a message.

EIA

Electronic Industries Association.

field

A logical grouping of contiguous bits that convey one kind of information, such as the start or end of a message, an address, data, or an error check.

frame

A logical grouping of contiguous bits for transmission; a message.

frame check sequence

A code that is used to determine whether a frame was received correctly.

frame descriptor

A part of the host computer s buffer structure that links transmitted or received data frames to appropriate priority queues. Frame Descriptors contain MAC frame parameters, frame status, and pointers.

Global Input

A type of data input received by a node using Peer Cop data transfers. Nodes using Peer Cop can be configured to receive up to 32 16-bit words of Global Input data from each of up to 64 source nodes, up to a maximum total of 500 words. Incoming data from each source node can be indexed into up to eight fields for delivery into separate data destinations in the receiving node.

Global Output

A type of data output sent by a node using Peer Cop data transfers. Nodes using Peer Cop can be configured to send up to 32 16-bit words of Global Output data, which is globally broadcast to all active nodes on the network. Destination nodes can be configured to accept or ignore incoming data from specific source nodes.

HDLC

High-level Data Link Control. The part of the device that performs the protocols for defining the beginning and end of a frame, synchronizing the frame between sender and receiver, providing CRC error checking, and defining the portion of the received information that is to be checked by the CRC.

host computer

A computer which controls other computers and devices. In an industrial process with networking, the host computer specifies the current requirements for the operation of remote nodes, and is the destination for summary data reports about the performance of the process.

IEC

International Electrical Commission.

IEEE

Institute of Electrical and Electronics Engineers.

ISO

International Standards Organization.

LAN

Local Area Network. An interconnection of devices in which data is transferred without the use of public communications services. Modbus Plus is an example of a LAN for controlling and monitoring industrial processes.

layer

In the OSI Model, a portion of the structure of a device which provides defined services for the transferring of information. See **Data Link Layer** and **Physical Layer** .

LLC

Logical Link Control. The part of the device that performs the protocols for identifying users of the network and for providing reliable frame delivery. The LLC handles the framing and checking of messages.

MAC

Medium (or Media) Access Control. The part of the device that performs the protocols for sharing the network with other devices. The MAC handles the queueing and transmission of outgoing LLC level messages, address recognition for incoming messages, and resolution of access contentions.

MAP

Manufacturing Automation Protocol. A network protocol that allows devices or cells within an industrial environment to communicate with each other.

master

A networked device which controls other devices to which it connects. It initiates transactions, and schedules and transmits tasks to a slave device. See **slave** .

medium

The entire cable system: the network cable, taps, connectors, and terminators.

Modbus

An industrial networking system that uses RS232 serial master-slave communications at data transfer rates of up to 19.2 k baud.

Modbus Plus

An industrial networking system that uses token-passing peer-to-peer communications at data transfer rates of one megabits per second. The network medium is shielded twisted-pair cable.

Modbus II

An industrial networking system that uses token-passing peer-to-peer communications at data transfer rates of five megabits per second. The network medium is coaxial cable.

modem

Modulator/demodulator. A device that conditions digital data for transmission along an analog signal path, or conditions input signals received from the path for use as digital data.

network

The interconnection of devices sharing a common data path and protocol for communication. On Modbus Plus, the devices share in the passing of a common token frame to gain sequential access for sending messages.

Network Option Module

A hardware module that is mounted into a common backplane together with a Programmable Controller, communicating with the controller over the backplane. The module connects to the Modbus Plus network and provides the central point for communication between the controller s application program and the node devices on the network.

node

A device that has a direct point of access to a communications network. On Modbus Plus, any device that is physically connected to the network.

OSI Model

Open Systems Interconnection Model. A reference standard describing the required performance of devices for data communication. Produced by the International Standards Organization.

Peer Cop

A method of peer-to-peer communication between networked devices in which data is transferred as part of the passing of tokens between nodes. Each node passes the token in the network s address sequence, and can be configured to transmit data in addition to the token. All nodes monitor the token passes, and can be configured to extract data from them. Nodes are setup for Peer Cop transfers as part of their initial configuration, and continue using Peer Cop as long as they are active on the network.

Four kinds of Peer Cop communication can be transacted during each token pass: see **Global Input, Global Output, Specific Input,** and **Specific Output.**

peer-to-peer communication

A communication between networked devices in which any device can initiate data transfer. The method used by devices conforming to the OSI Model. Also the method used on Modbus Plus.

Physical Layer

In the OSI model, the layer that provides the physical connection and signalling means between nodes of a network. Defined by the IEEE 802.4 standard.

port

The external connector on a device at which the network cable is attached.

protocol

A set of rules used mutually by two or more devices to communicate.

Repeater

A Modicon device that interconnects two sections of a Modbus Plus network.

routing path

In Modbus Plus, the sequence of device node addresses through which a message will be routed to its final destination.

routing path field

In a Modbus Plus message frame, a group of five bytes that specify the addresses of the devices in the message routing path.

RS232

An EIA standard that defines signal requirements and cable connections for serial data communications.

section

A contiguous grouping of cable segments, together with their node devices, connected directly to form a signal path that does not pass through any Repeater. The minimum length of a section can be 10ft (3m), the same as one segment. The maximum length can be 1500 ft (450 m). One section supports up to 32 nodes. Repeaters can be used to join two sections for greater cable lengths and more nodes. See **segment**.

segment

The combination of: a continuous length of trunk cable connecting a pair of taps; the two taps; and the drop cables between the two taps and their node devices. One or more segments form a section of the network. See **section** and **tap.**

serial port

An communication port at which data is transferred one bit at a time.

slave

A networked device which is controlled by another device. Slave devices do not initiate data transactions. They respond to commands or requests initiated by a master device. See **master** .

slot time

The amount of time representing the worst case time any station on the network must wait for a response from another station. It is based upon the response time of the network s slowest station and the bus propagation delay.

Specific Input

A type of data input received by a node using Peer Cop data transfers. Nodes using Peer Cop can be configured to receive up to 32 16-bit words of Specific Input data from each of up to 64 source nodes, up to a maximum total of 500 words. Nodes can be configured to accept or ignore incoming data from specific source nodes.

Specific Output

A type of data output sent by a node using Peer Cop data transfers. Nodes using Peer Cop can be configured to send up to 32 16-bit words of Specific Output data to each of up to 64 destination nodes, up to a maximum total of 500 words.

splitter

A passive device that allows a cable to be routed into multiple paths with essentially equal signal amplitude in each path. Not used with Modbus Plus.

start delimiter

A field that defines the start of a frame, occurring after the signal has been detected and synchronized by the receiving node. See **end delimiter** .

system

A set of hardware devices and their associated software capable of performing the functions of information processing and device control without significant dependence on other equipment.

tap

A passive electrical device that joins segments of the trunk cable, or terminates the trunk cable at its two end sites. It also provides a connection for the drop cable to the node device at the tap site. See **terminator** .

terminator

A resistive load placed at the end of a cable to prevent data signals from reflecting back into the data path. The signals are terminated with the same impedance as the characteristic impedance of cable system. On Modbus Plus, each tap contains a terminating resistor with two jumpers. The termination is effective when the jumpers are installed. The tap at each of the two ends of the cable section has its terminating jumpers installed. The tap at each inline point has them removed. See **section** .

token

In data transmission, a frame passed on a network that gives a networked device the current authority to transmit.

token bus

A network access method between two or more devices in which the procedure for sending data is based upon the passing of a token for access to the network. See **token** .

transaction

The complete and successful transfer of a message between networked devices.

trunk

The main element of the cable system that interconnects the network nodes. On Modbus Plus, the trunk cable runs directly between pairs of taps.

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