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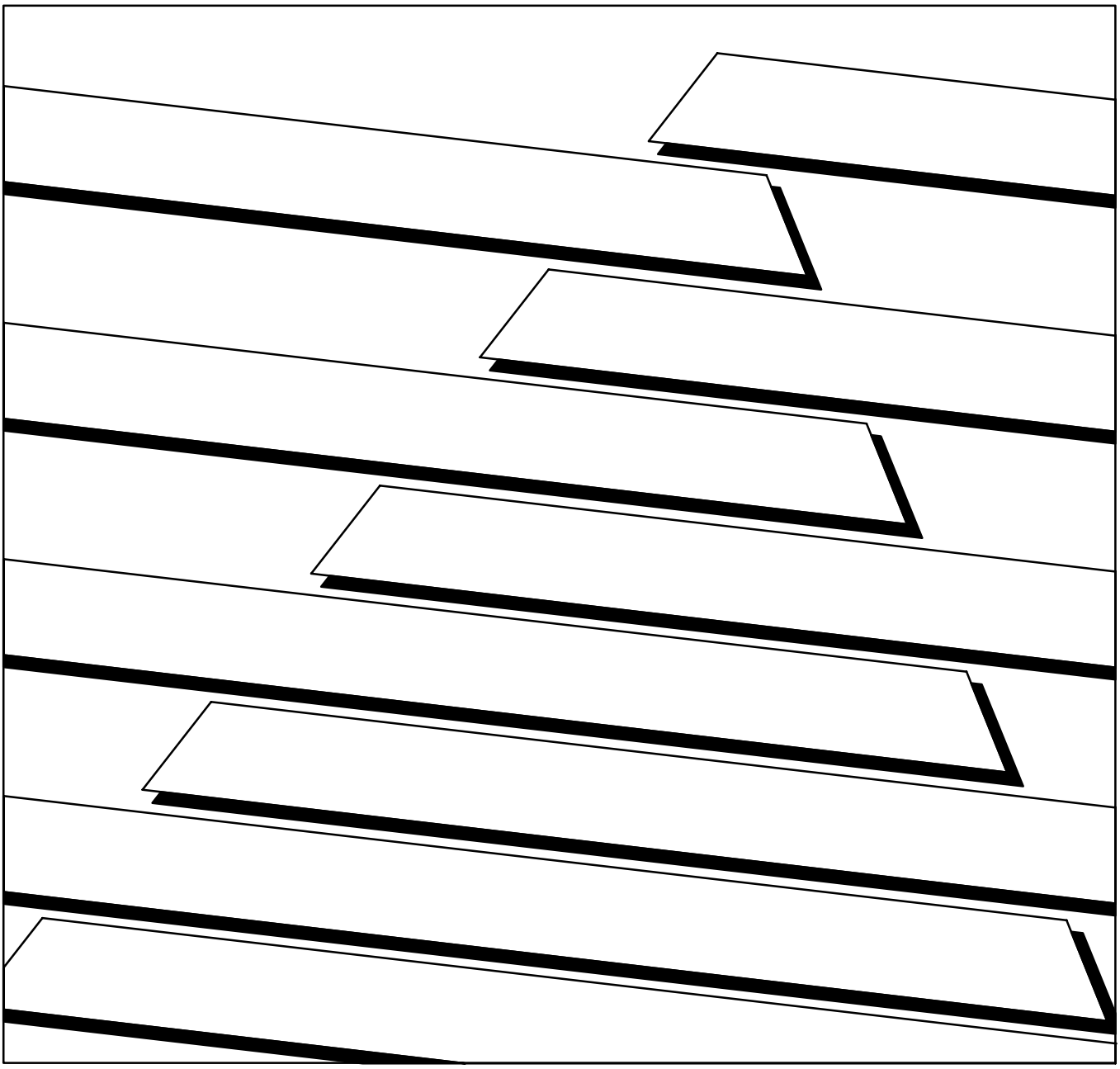
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ALLEN-BRADLEY

Data Highway or Data Highway Plus Asynchronous (RS–232–C or RS–422–A) Interface Module

Cat. No. 1770-KF2)

User Manual



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Chapter 1

Introduction

General

A 1770-KF2 Series B module is a communication interface that links intelligent RS-232-C or RS-422-A (asynchronous) devices to an Allen-Bradley local area network. By setting switches on the KF2, and changing cables, you can direct communications over a Data Highway or a Peer Communication Link (**PCL**). With a 1770-KF2 module, a computer on a PCL can communicate with any PLC-5 node on the network. Other current Allen-Bradley products that communicate over a PCL are the 1784-T50 Industrial Terminal System and the 1785-KA Communication Adapter Module.

The KF2 is designed to operate in a control-room environment on a tabletop. It takes its power from an AC wall outlet, and it gives you a choice of **full-duplex** or **half-duplex** protocol on its asynchronous link. The module has Data Highway compatibility, and it supports all PCL facilities except internetworking.

(Internetworking would indicate that a computer on a PCL could talk to a node on another PCL, or to a station on a Data Highway link. That may be possible in the future, but it isn't right now. A computer on a Data Highway, though, using a 1770-KF2 and a 1785-KA can communicate with PLC-5s on a PCL.)

About This Manual

This manual describes installation, operation, and communication protocols of a 1770-KF2 module; and it assumes that you are already thoroughly familiar with how to program your computer or other intelligent asynchronous device. It does not assume prior knowledge of the Allen-Bradley Data Highway or a Peer Communication Link.

Table 1.A lists related documentation that might be helpful in conjunction with this manual. For more details about the programming and operation of specific Allen-Bradley programmable controllers, refer to the appropriate user's manual for that controller.

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Table 1.A
Related Documentation

Publication Number	Old Publication Number	Title
1770-6.2.1	1770-810	Data Highway Cable Assembly and Installation Manual
1771-6.5.1	1771-801	Communication Adapter Module (Cat. No. 1771-KA2) User's Manual
1771-6.5.15	1771-822	Communication Controller Module (Cat. Nos. 1771-KE, -KF) User's Manual
1771-6.5.8	1771-811	PLC-2 Family/RS-232-C Interface Module (Cat. No. 1771-KG) User's Manual
1775-6.5.1	1775-802	PLC-3 Communication Adapter Module (Cat. No. 1775-KA) User's Manual
1773-6.5.2	1773-801	PLC-4 Communication Interface Module (Cat. No. 1773-KA) User's Guide
1785-6.8.1		PLC-5/15 Processor Manual
1785-6.6.1		PLC-5/15 Assembly & Installation Manual
6226-6.5.1		Industrial Terminal Support Software System Manual
1784-6.5.1		Industrial Terminal (1784-T50) User's Manual
1785-6.5.1		PCL-to-Data Highway Communication Adapter Module (1785-KA) User's Manual

This manual is organized as follows:

- Chapter 2 — Explains basic communication concepts.
- Chapter 3 — Tells how to install a KF2 module.
- Chapters 4, 5, and 6 — Describe the communication protocol used by a KF2 module.
- Chapter 7 — Summarizes error reporting.

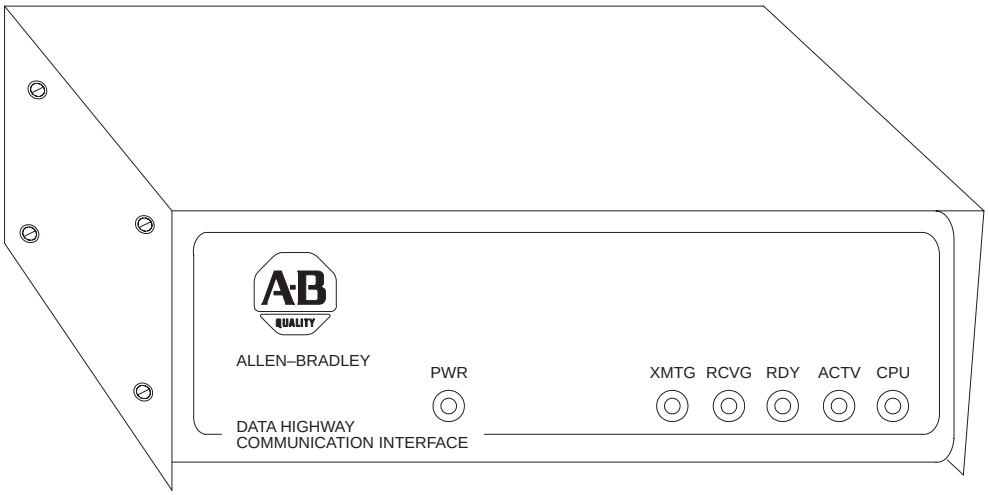
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Module Description

Figure 1.1 shows the 1770-KF2 module's hardware features:

- Diagnostic Indicators
- Connectors for Data Highway and RS-232-C Devices
- Communication Option Switches
- On/Off Switch, Power Plug, Fuse, and Voltage Select Switch

Figure 1.1
1770-KF2 Communication Interface Module



A KF2 also features extensive self-diagnostics. At power-up, tests are run on internal memory, timers, and firmware integrity. Any failure causes the red front-panel CPU indicator to flash. Also, the module continuously checks the memory and firmware during operation.

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Specifications

Table 1.B lists KF2 module specifications.

Table 1.B
KF2 Module Specifications

Specification	Requirements
Communication Rates	• Data Highway: 57,600 bits per second (recommended) • Peer Communication Link: 57,600 bits per second (recommended) • Asynchronous: Switch selectable from 110 to 9.600 bits per second
Functions	• Interface a programmable RS-232-C or RS-422-A compatible device with an Allen-Bradley Data Highway. • Serve as a replacement for a 1771-KD Communication Controller Module.
Location	• Tabletop (or other horizontal surface) • Controlled environment, e.g., office or control room
Communication Ports	• Data Highway: 15-pin male EIA D-connector • Peer Communication Link: 15-pin male EIA D-connector • Data Highway Monitor: 9-pin female EIA D-connector • Asynchronous (RS-232-C/RS-422-A): 25-pin male EIA D-connector
Cabling	• Data Highway: Data Highway Dropline Cable (Cat. No. 1770-CD) • Asynchronous RS-232-C: User-Supplied Data Terminal Interface Cable or Modem Interface Cable • Asynchronous RS-422-A: User-Supplied Data Terminal Interface Cable
Power Requirements	• Selectable: 115 V/60 Hz or 230 V/50 Hz • Watts: 3.5
Ambient Temperature Rating	• 32°F to 113°F (0°C to 45°C) Operational • -40°F to 185°F (-40°C to 85°C) Storage
Ambient Humidity Rating	• 10% to 80% Non-Condensing
Physical	• Size: 10-3/8 in. x 10.0 in. x 3-3/8 in. (263.5 mm x 254 mm x 85.7 mm) • Weight: 6.0 pounds (2.7 Kg)

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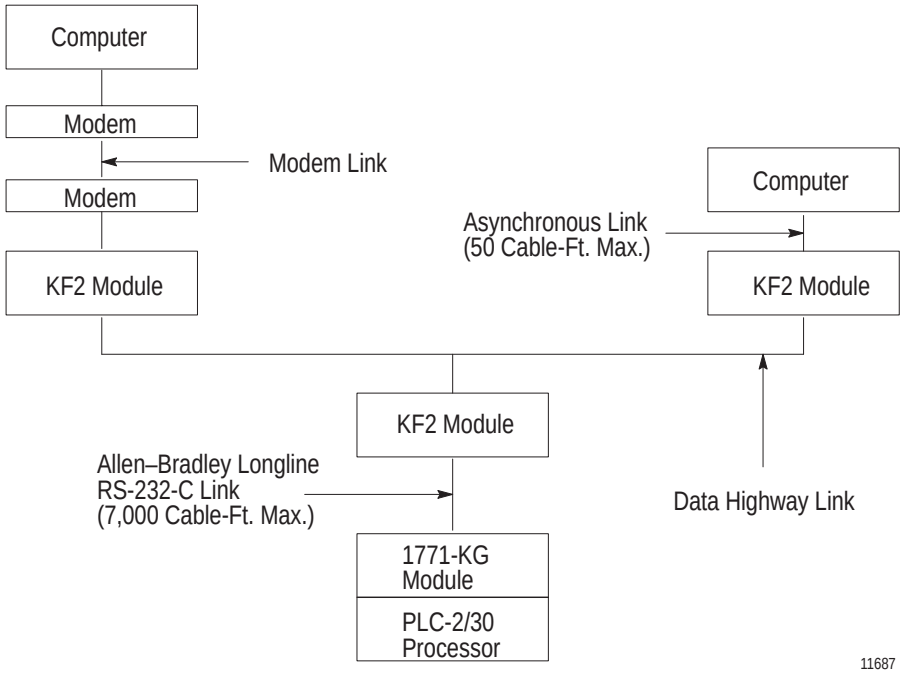
Data Highway Applications

A KF2 module provides either a point-to-point link or a multi-drop link between an Allen-Bradley Data Highway and an intelligent asynchronous device. By "intelligent asynchronous device" we mean any device that complies with RS-232-C or RS-422-A electrical standards and that can be programmed to handle the communication protocol described in Chapters 4 through 6 of this manual. Throughout this manual, we will also use the term "computer" in a general sense to refer to this type of device. Some examples include:

- An Allen-Bradley Advisor 2+™ Color Graphic System
- A PLC-3 Programmable Controller and Connected Communication Adapter Module (Cat. No. 1775-KA)
- A PLC-2 Family Programmable Controller and Connected PLC-2 Family/RS-232-C Interface Module (Cat. No. 1771-KG)
- A PLC-4 Microtrol Programmable Controller and Connected Communication Interface Module (Cat. No. 1773-KA)
- A Variety of Minicomputers and Microcomputers

In point-to-point configuration, the KF2 module connects one intelligent asynchronous device as a single station on a Data Highway. Figure 1.2 illustrates this configuration. Point-to-point links can use either peer-to-peer (full-duplex) or master-slave (half-duplex) communication.

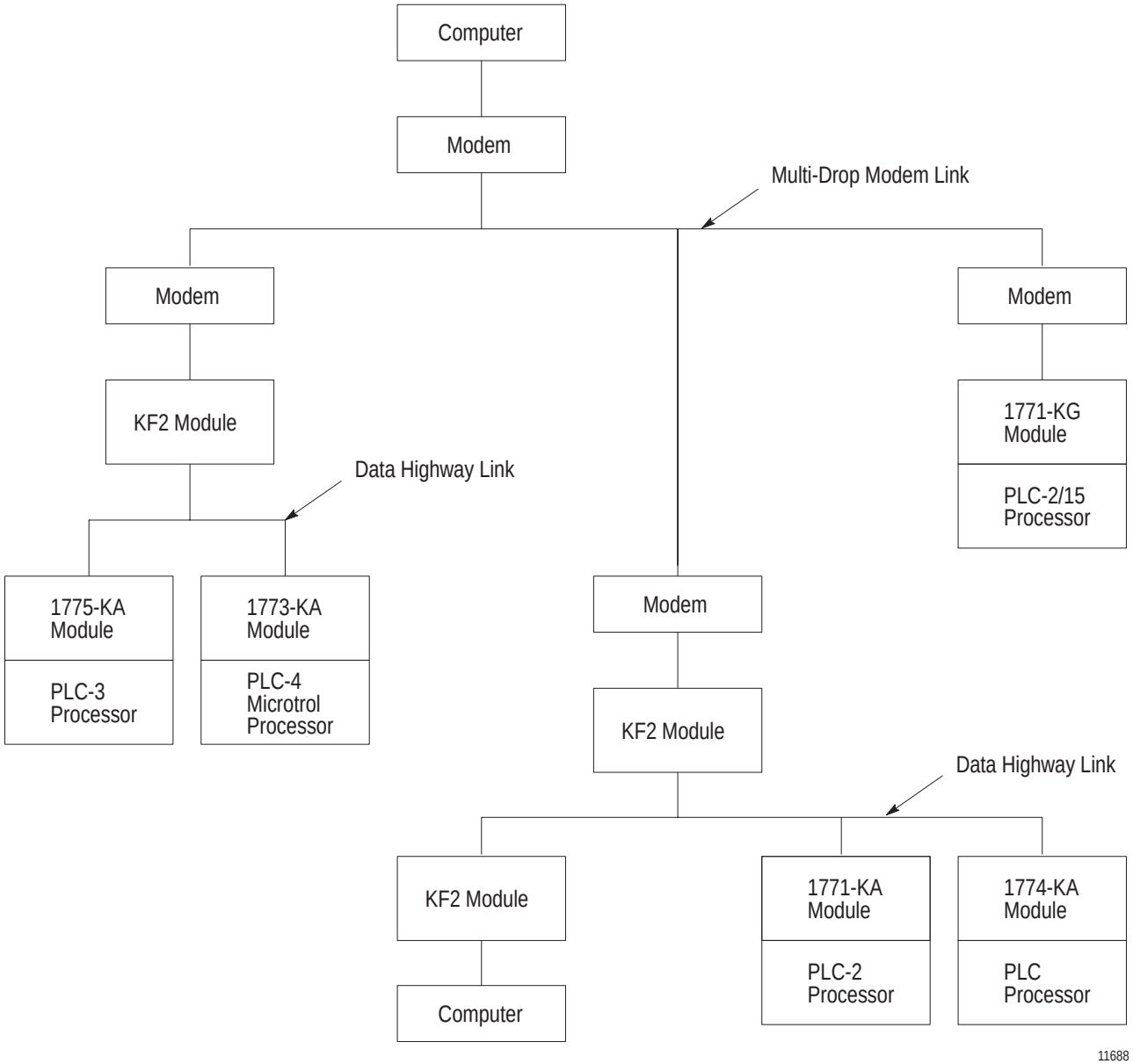
Figure 1.2
Point-to-Point Links



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In a multi-drop configuration, one intelligent asynchronous device connects to several Data Highways through sets of modems and KF2 modules. Figure 1.3 illustrates this type of configuration. If the multi-drop link consists of broadband modems, you can select either peer-to-peer (full-duplex) or master-slave (half-duplex) communication. If the multi-drop link consists of baseband modems, you must use master-slave (half-duplex) communication because baseband modems support only one communication channel.

Figure 1.3
Multi-Drop Link



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In either type of configuration, there are three possible ways you can connect a KF2 module:

- Direct connection to an intelligent asynchronous device if the KF2 module is mounted within 50 cable-feet of an RS-232-C, or within 4,000 cable-feet of an RS-422-A device.
- Direct connection to an Allen-Bradley 1775-KA, 1773-KA, or 1771-KG interface module if the KF2 module is within 50 cable-feet of the other module.
- Modem connection if the KF2 module is within 50 cable-feet of an RS-232-C compatible modem, or within 4,000 cable-feet of an RS-422-A device.

You can also use the 1770-KF2 module to replace a 1771-KD module in an existing application. By properly setting the option switches on the KF2 module, you can make this replacement without having to change any application programs that you were using with the 1771-KD module. Refer to Chapter 3 under “Replacing a 1771-KD Module with a KF2 Module” for switch settings.

PCL Applications

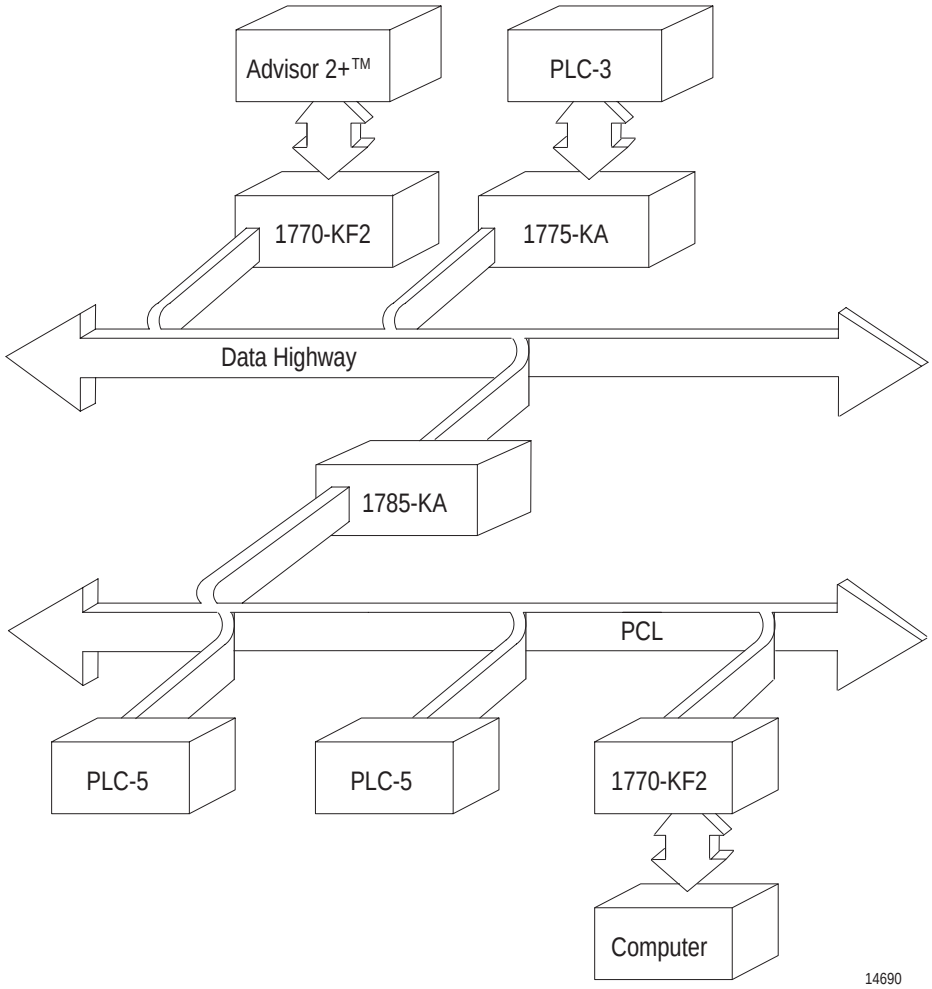
A 1770-KF2 Series B module provides either a point-to-point or multi-drop link between an Allen-Bradley Peer Communication Link (PCL) and an intelligent asynchronous device. You can use a PCL link when you have a small number of PLC-5/15 stations in a local cluster. Typically, a PCL link connects PLC-5/15s that need to communicate with each other frequently. If your system requires more than ten stations, consider breaking it into smaller PCL links connected by a Data Highway to optimize performance.

The KF2 Series B module provides an interface between either:

- an RS-232-C or RS-422-A asynchronous link to Data Highway, or
- an RS-232-C or RS-422-A asynchronous link to a PCL network as shown in Figure 1.4.

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Figure 1.4
A PCL Network Connected to a Data Highway



Important: A 1770-KF2 module on a PCL link cannot access a station on the Data Highway through a 1785-KA module. A KF2 module on the Data Highway, however, can access a station on a PCL link through a 1785-KA.

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Chapter 2

Communication Concepts

General

This chapter presents some of the concepts of communication with the KF2 module. It describes the physical communication links to the module and the various levels of software necessary to make those links work.

A KF2 module connects a computer or programmable controller to an Allen-Bradley local area network (LAN), either Data Highway or Peer Communication Link (PCL). In doing so, the module acts as an interface between two physical communication links:

- Data Highway or PCL, Called “Network Link”
- RS-232-C or RS-422-A, Called “Asynchronous Link”

A Data Highway network provides peer-to-peer communication between the KF2 module and other stations on the Data Highway. It uses a half-duplex (polled) protocol and rotation of link mastership.

A Peer Communication Link provides peer-to-peer communication between the KF2 module and other stations on the PCL. The PCL uses token-passing to control access to the link.

The asynchronous link can provide either peer-to-peer communication through a full-duplex (unpolled) protocol, or master-slave communication through a half-duplex (polled) protocol.

In addition to a physical link layer, communication on either the network link or the asynchronous link involves three levels of software:

- Application Layer
- Network Layer
- Data Link Layer

If you are using a computer on an asynchronous link, you must program all three layers. For A-B programmable controllers, you need program only the application layer; the Data Highway interface modules (or for the PCL, the PLC-5 itself) automatically take care of the other two layers.

The rest of this chapter presents some of the concepts behind the physical communication links and their three software layers. For more details on

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the application and network layers, refer to Chapters 5 and 6. For more on the data link layer of the asynchronous link, refer to Chapter 4 and Appendix D.

Physical Link Layer

The physical link layer is a set of cables and interface modules that work together to provide a channel for communication between the various points, called stations, on the physical link. A station consists of an intelligent programmable device (e.g., PC or computer) and the module or modules that interface it with the physical link.

In this way, the KF2 module allows stations on one link to communicate with stations on the other link. Since these two physical links have different communication protocols, the KF2 module serves mainly as a protocol translator.

Data Highway

The Data Highway and the PCL are both local area networks (LANS) that allow peer-to-peer communication among up to 64 stations. Figure 2.1 illustrates a Data Highway network.

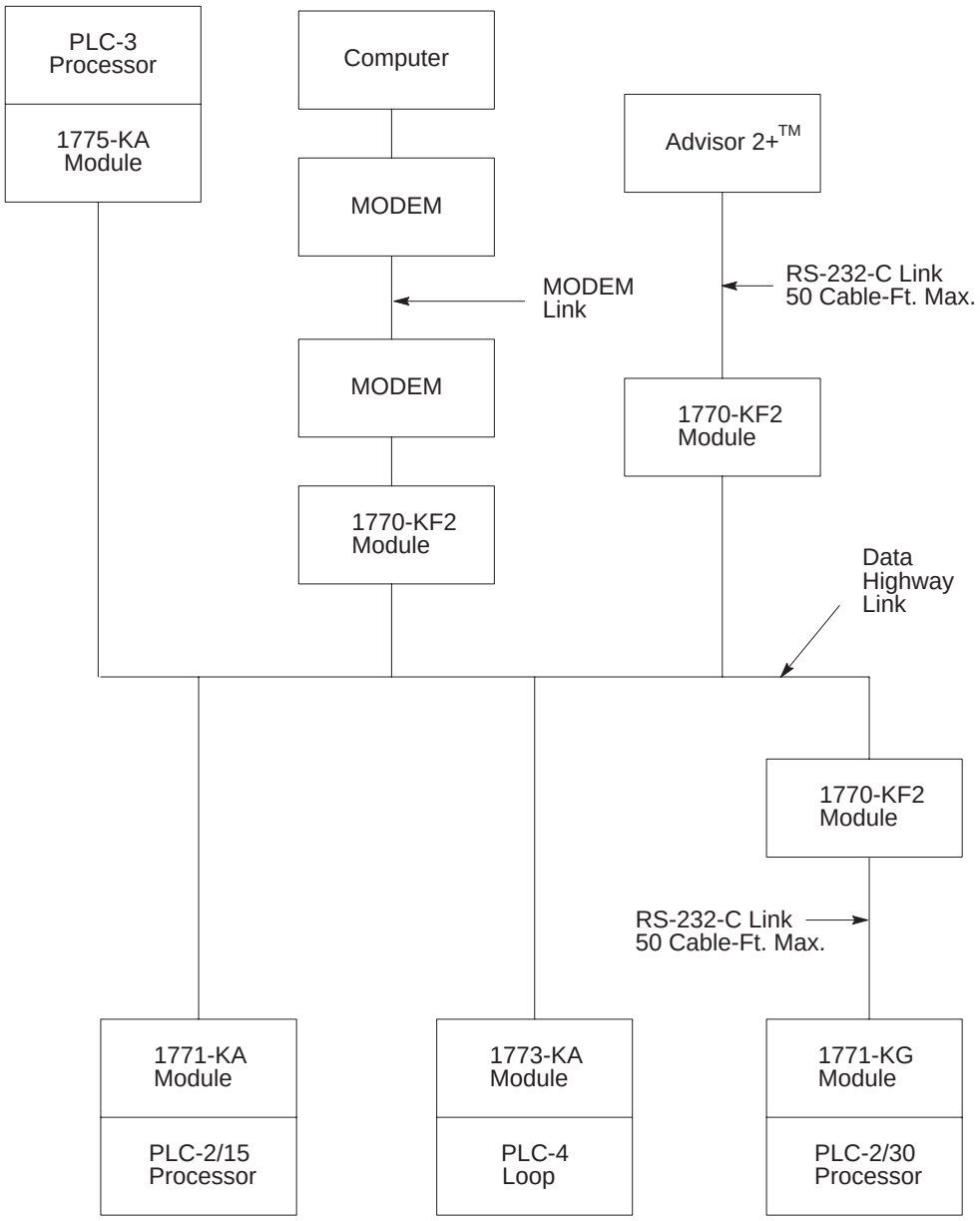
The Data Highway link consists of a trunkline that can be up to 10,000 feet long and droplines that can be up to 100 feet each. Each station is at the end of a dropline.

A Data Highway link implements peer-to-peer communication through a modified token-passing scheme called the floating master. With this arrangement, each station has equal access to become the master. The stations bid for temporary mastership based on their need to send information.

Unlike a master/slave relationship, a floating master relationship does not require the current master to poll each station to grant permission to transmit. Therefore, it provides a more efficient network because there is less overhead per transaction.

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Figure 2.1
Data Highway Network



Stations

A station consists of a computer or PC processor and the module or modules that interface it with the Data Highway link. Within a station that contains a KF2 module, an asynchronous link is required as an auxiliary link to the network. Figure 2.1 shows three such stations.

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One station consists of an Advisor 2+™ Color Graphic System connected to a KF2 module through an RS-232-C link limited to 50 cable-feet. Another station consists of a computer interfacing with a KF2 module through a modem link that is limited only by the nature of the modems themselves.

The third such station consists of a 1771-KG module interfacing a PLC-2/30 processor with a KF2 module through an RS-232-C link limited to 50 cable-feet. If you want a link longer than 50 cable-feet, you can use modems.

PC Programming

All Allen-Bradley PC processors can be connected to a Data Highway through an appropriate station interface module. All of these processors can receive and reply to command messages, and some of them can also transmit command messages. For an explanation of how to program PCs to send and receive messages, refer to the user's manual for the appropriate station interface module.

Computer Programming

The communication protocol for the Data Highway link is transparent to a computer on the network. However, for a computer to send or receive messages through the Data Highway network, it must be programmed to communicate with its KF2 module over an asynchronous link. Chapters 4, 5, and 6 describe the protocol that you must program your computer to use on such an asynchronous link.

Peer Communication Link

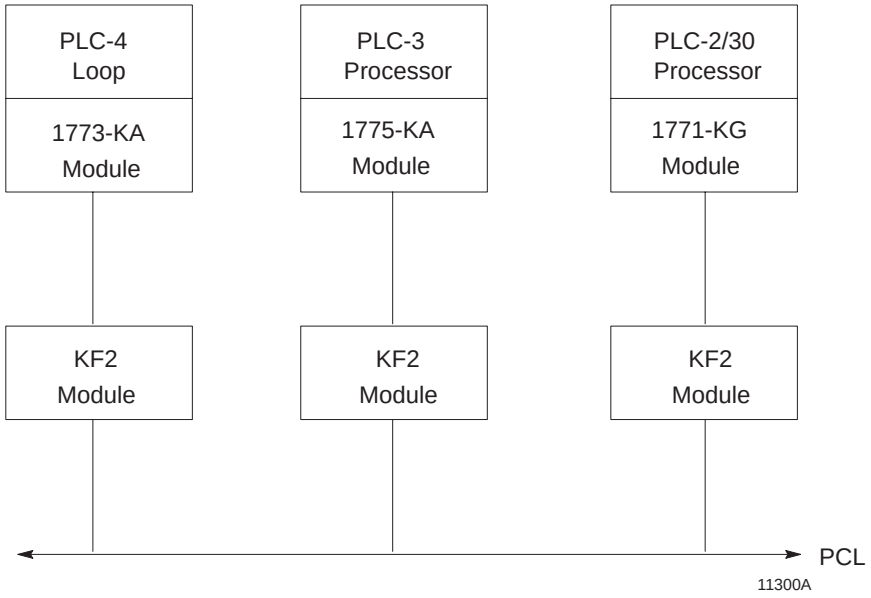
A PCL has much the same topology as the Data Highway, described in the previous chapter; but it is designed for fewer, closely coupled, PCs. The PCL implements peer-to-peer communication with a token-passing scheme to rotate link mastership among the stations connected to that link. Since such a method does not require any polling, it is very time efficient. The PCL also uses timeouts to recover from any fault that disables the station that has the token.

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Stations

A station consists of a computer, or PC processor, and the module or modules that interface it with the PCL. Within a station that contains a KF2 module, an asynchronous link is required as an auxiliary link to the network. PCL networks currently use PLC-5 processors, which interface directly to the PCL; and no station interface module is required. You can, however, connect other PCs, as shown in Figure 2.2.

Figure 2.2
PCL Network Connected to Various PC Processors



Other PCL stations can be computers that interface with the KF2 module either directly or through a modem link, or a PCL-to-Data Highway communication adapter (1785-KA), which you can use to connect a PCL to the Data Highway.

PC Programming

All Allen-Bradley PC processors can receive command messages and reply to them, and some can transmit commands. For an explanation of how to program PCs to send and receive messages, refer to the user's manual for that particular station interface module or, in the case of a PLC-5, the processor itself.

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Computer Programming

The communication protocol for the PCL is transparent to a computer on the network. However, for a computer to send or receive messages through the PCL, it must be programmed to communicate with its KF2 module over an asynchronous link. Chapters 4, 5, and 6 describe the protocol that you must program your computer to use on this link.

Configuration Selection

Figure 2.1 and Figure 2.2 illustrate configurations in which PC stations can communicate with each other and with computers through network ports and asynchronous ports on the station interface modules. Each configuration is useful, depending on your application.

If you want to provide a peer-to-peer communication among many PCs and/or a computer, use a Data Highway network as shown in Figure 2.1. For communication among a small cluster of PCs and a computer, use a PCL as shown in Figure 1.4. For distances longer than the networks provide, you can use an auxiliary longline asynchronous (RS-232-C or RS-422-A) link or a modem link.

A Data Highway link has a communication rate of 57,600 bits per second and a half-duplex (peer-to-peer, polled) protocol. A KF2 asynchronous link is selectable RS-232-C/RS-422-A and has a selectable communication rate up to 9,600 bits per second. It uses a selectable protocol of half-duplex (master-slave polled) or full-duplex (peer-to-peer, unpolled).

A master-slave communication protocol can be selected for any link to a computer. A peer-to-peer communication protocol can be selected only for a point-to-point link or a broadband modem multi-drop link to a computer.

Even with only two stations, you may want a Data Highway or a Peer Communication Link. Either network provides the flexibility of easy reconfiguration or expansion if you want to be able to add more stations later, and it also provides more error checking than an asynchronous link.

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Configuration Considerations

Allen-Bradley manufactures a variety of communication interface modules for different applications:

Communication Interface Module	Cat. No.	Note
PLC Communication Adapter Module	1774-KA	1
PLC-2 Family Communication Adapter Module	1771-KA2	1
PLC-3 Communication Adapter Module	1775-KA	1 & 2
PLC-4 Communication Interface Module	1773-KA	1 & 2
PLC-5/Data Highway Communication Adapter Module	1785-KA	—
PLC-2 Family/RS-232-C Interface Module	1771-KG	2
Communication Controller Modules	1771-KE, -KF	3
Communication Interface Module	1770-KF2B	3

Provides interface between:

1 A PC Processor and a Data Highway Communication Link
2 A PC Processor and an RS-232-C Communication Link
3 A RS-232-C Communication Link and a Data Highway Communication Link

A 1785-KA module interfaces a Data Highway with a Peer Communication Link. The module resides in a 1771 I/O rack and receives its power from the rack's backplane.

A 1771-KE module must be installed in an I/O chassis. The 1771-KD, 1771-KF, and 1770-KF2 are standalone modules. Modules 1771-KE, 1771-KF, and 1770-KF2 provide either peer-to-peer or master-slave communication between an RS-232-C link, or to a modem link, and the Data Highway.

RS-422-A/Data Highway Interface

A 1770-KF2 provides an interface between an RS-422-A communication link and a Data Highway communication link. The 1770-KF2 is functionally identical to the 1771-KF except that it is a desktop module, provides its own power supply, and supports both RS-232-C and RS-422-A communication.

RS-232-C/RS-422-A — PCL Interface

A 1770-KF2 provides an interface between an RS-232-C or RS-422-A asynchronous link and a Peer Communication Link network.

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Software Layers

Each of the physical links just described requires three layers of software to enable communication to take place. The layers are defined as follows:

- **Application Layer** — Controls and executes the actual tasks, or commands, specified in the communication between stations. To program this layer, use the commands described in Chapter 5.
- **Network Management Layer** — Handles queueing, sequencing, routing, and error status reporting for communication. If your physical link contains only Allen-Bradley PCs, you do not have to program this layer. Otherwise, refer to Chapter 5 for a description of how to program this layer for an asynchronous link to a computer.
- **Data Link Layer** — Controls the flow of communication over the physical link by establishing, maintaining, and releasing the communication channel between stations. If your physical link contains only Allen-Bradley PCs, you do not have to program this layer. Otherwise, refer to Chapter 4 for a description of how to program this layer for an asynchronous link to a computer.

Application Layer

The application layer concerns the specific commands that you can program at a given station to cause that station to communicate over the link. This layer is the same for both asynchronous and network links.

The types of commands that a station can transmit and receive vary with the type of processor at that station. Chapter 5 describes the commands that each type of PC processor can transmit or receive. To program your computer to communicate with a PC, use the appropriate command message format shown in Chapter 5.

Message Structures

All messages on a network have the same fundamental structure, regardless of their function or destination. If you could freeze a block while it is in transmission, you would see two types of message bytes:

- Protocol Bytes
- Data Bytes

Protocol bytes are used by the network to get the message to its destination. Data bytes are delivered to the application at the destination.

The methods by which these bytes are filled is determined by the nature of the station from which the transmission block originates. For example, if a transaction originates from a PC station, the station interface module

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automatically fills the protocol bytes. If the transaction originates from a computer station, your computer software must supply the necessary protocol. In both cases, the data bytes contain information supplied by application programs.

Command/Reply Cycle

Any network transaction consists of two messages: a command and a reply.

The two parts provide extra data integrity by ensuring that a required action always returns some sort of status, whether an error code or data. As a frame of reference, the command initiator is always referred to as a **local** station, and a reply initiator is always referred to as a **remote** station. Unless noted otherwise, whether in a network link or an asynchronous link, our reference will be limited to a single local station and a single remote station.

The network layer protocol distinguishes a command from a reply. Obviously, the data area of a command and its corresponding reply depend on the type of command.

Priority

Each message on a Data Highway link is classified as either **high** priority or **normal** priority.

Each message on a PCL is classified as normal priority.

Priority levels of messages determine the order in which stations are polled and allowed to transmit messages. In the polling process, stations with high priority messages will always be given priority over stations with normal priority messages.

You specify the priority level for each command in the message command code. The station that receives a command message must establish the same priority level for its corresponding reply message.

Important: Stations with high priority messages are given priority over stations with normal priority messages throughout the command/reply message cycle. For this reason, a command should be given a high priority designation only when special handling of specific data is

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required. Using an excessive number of high priority commands defeats the purpose of this feature and could delay or inhibit the transmission of normal priority messages.

Command Structures

There are four basis types of command on a Data Highway network or a standalone link:

- Read
- Write
- Diagnostic
- Mode Select

Reads

There are two types of read:

- Physical
- Unprotected

A physical read allows you to read any area of PC memory at a remote station. However, a PC processor cannot originate a physical read command; only a computer can originate a physical read.

An unprotected read can access only the data table area of PC memory. Both computers and PCs can initiate unprotected reads.

Any read can request up to 122 16-bit words of contiguous data from PC memory.

Writes

We can classify write commands both by their application and by their level of memory access.

As an application issue, writes are divided between bit writes and word writes. Bit writes allow the local station to control bits in the data table of a remote station.

Word writes allow the local station to write up to 121 contiguous words of data into the remote station's memory, provided you abide by the restrictions on memory access discussed next.

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As with reads, writes also are classified by the level of access to PC memory. Non-physical writes can access only the data table at a remote PC; physical writes can access all of user memory, including PC program memory.

Non-physical writes can be further subdivided into protected and unprotected. Protected writes can access only specified areas of the remote PC's data table memory. The accessible areas are defined by memory protection rungs in the remote PC's ladder diagram program. Unprotected writes, on the other hand, can access any area of the remote PC's data table.

In most cases, switch settings on the remote station's interface module can disable the module from executing each of these types of write commands.

Diagnostics

Diagnostic commands have to originate from a device other than a PC. You can use these commands to return status information from a remote or local station or to alter some on-board parameters at a station interface module. Diagnostic commands are particularly useful during a start-up or during on-line debugging.

Mode Select

Mode select commands allow you to load a new PC program from a remote computer station. The operation of these commands varies by PC processor type. These commands can be issued only by a computer.

Network Management Layer

The network management layer is concerned with the specifics of conveying a message safely from its source to its destination. This layer is the same for both asynchronous and network links.

If your physical link contains only Allen-Bradley PCs, you do not have to program anything for this layer; the communication interface modules automatically take care of it. If your physical link contains a computer, then refer to Chapter 5 for a description of how to program this layer at the computer station.

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Generally, you need not be concerned with the interaction of station interface modules on the network.

This means that your application programs at the PCs and computers along the network need not involve themselves with interstation protocol, handshaking, or control of the network link. This is all carried out automatically by the station interface modules. However, an understanding of station interaction is useful both to computer programmers and PC programmers. It allows optimum use of network commands and fault diagnostics.

Error Checking

Error codes can be generated at two places: remote station modules and local station interface modules. For codes that are returned from a local station module, two types of condition can exist:

- Application programs use the wrong message format or issue illegal commands.
- The local station cannot complete a transaction due to network problems.

A remote station can return only the codes associated with an application problem at the remote station. Typically, these involve either the PC processor being off-line (in Program mode, for example) or the command trying to access memory areas blocked by either the interface module or the user application program.

In the network layer protocol, command message status is returned in a reply status byte. A value of zero in the status byte indicates successful transmission of the corresponding command. It is up to the local application program to display and act on the value of the returned byte.

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Chapter 3

Installation

General

This chapter explains how to install the 1770-KF2 module. There are four parts to installation:

- Setting Communication Option Switches
- Situating the Module for Operation
- Connecting the Module to the Network and Asynchronous Links
- Observing the Diagnostic Indicators

Please read the first three chapters of this manual carefully before attempting any of the installation steps.

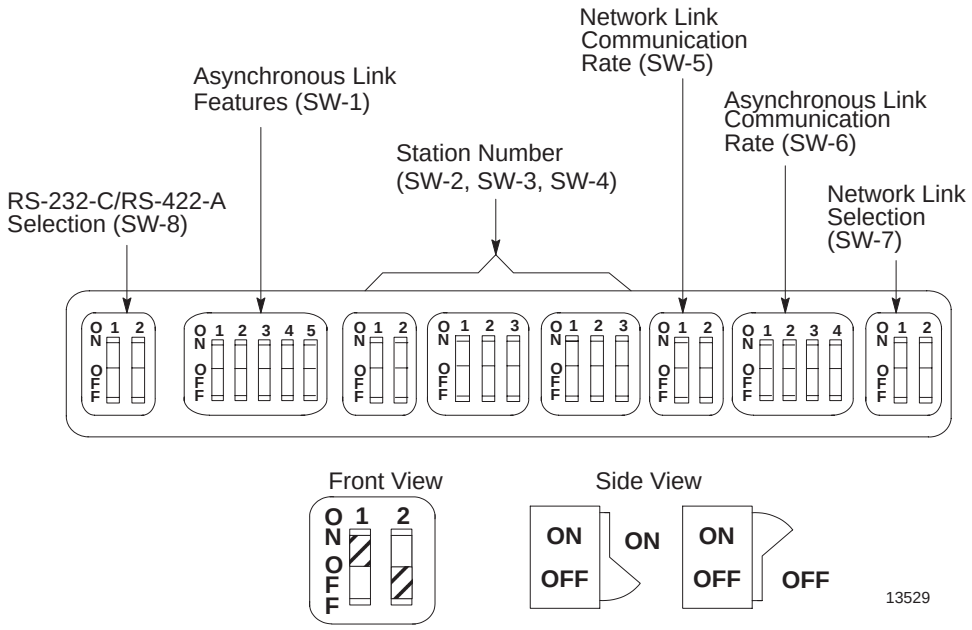
Communication Option Switches

The KF2 module has 8 switch assemblies (Figure 3.1) that enable you to select various communication options. The switch assemblies and their corresponding options are:

Switch Assembly	Communication Option
SW-1	Asynchronous Link Features
SW-2, SW-3, SW-4	Station Number
SW-5	Network Link Communication Rate
SW-6	Asynchronous Link Communication Rate and Diagnostic Commands
SW-7	**Selecting the Network Link**
SW-8	RS-232-C/RS-422-A Selection

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Figure 3.1
Communication Option Switches



Important: The KF2 reads the status of the communication option switches only at power-up, so you must make your selection with the KF2's power off.

Asynchronous Link Features

The following table shows you how to set the asynchronous link features using Switch Numbers 1, 2, and 5.

If You Want to Select Protocol as:	With Error Check as:	With Parity as:	With Embedded Responses:	SW-1				
				1	2	3	4	5
Full Duplex	BCC	None	No	OFF	OFF	N/A	N/A	OFF
Full Duplex	BCC	Even	No	ON	OFF			OFF
Full Duplex	BCC	None	Yes	OFF	ON			OFF
Full Duplex	BCC	Even	Yes	ON	ON			OFF
Half Duplex	BCC	None	No	OFF	OFF			ON
Half Duplex	BCC	Even	No	ON	OFF			ON
Full Duplex	CRC	None	Yes	OFF	ON			ON
Half Duplex	CRC	None	No	ON	ON			ON

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Switch 3 determines whether the asynchronous port of the KF2 module can detect duplicate messages transmitted to it.

If You Want Your Module to:	Set Switch 3:
Detect and Ignore Duplicate Messages	ON
Accept All Messages Regardless of Duplication	OFF

Switch 4 determines whether the module uses and recognizes the following handshaking signals: data set ready, request to send, clear to send, data carrier detect, and data terminal ready.

If You Want the Module's Asynchronous Port to:	Set Switch 4:
Use Handshaking Signals	ON
Ignore Handshaking Signals	OFF

Important: If you select half-duplex, the KF2 uses handshaking signals even if Switch 4 is set OFF.

Station Number

Switch Assemblies SW-2, SW-3, and SW-4 are for setting the network station number of the KF2 module. For the Data Highway, the station number is a 3-digit octal number that identifies the KF2 module as a unique station. Valid station numbers for the KF2 module in Data Highway mode are 010 to 077 and 110 to 376 octal. For a PCL, the station number is 2 digits; set both switches in SW-2 OFF. Valid station numbers for the KF2 in PCL mode are 00 to 77 octal.

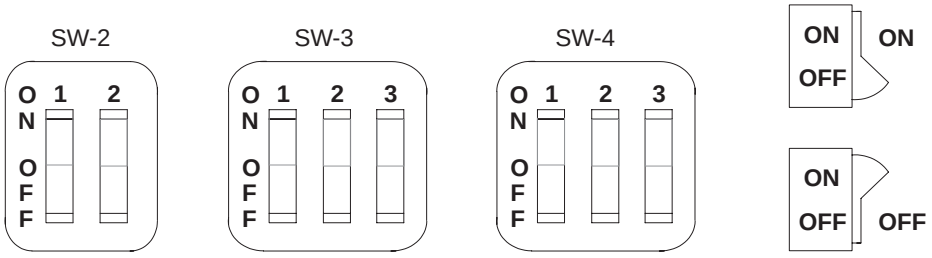
Figure 3.2 shows an example of how to set the KF2 station number to 037 octal. The switches in Assembly SW-2 set the first (left-most) digit of the station number; Switch Assembly SW-3 sets the middle digit; and Switch Assembly SW-4 sets the last (right-most) digit.

Station numbers play an important part in the polling scheme described in Chapter 2. They can also influence the order in which mastership is transferred between network stations. Therefore, we recommend that you always begin numbering stations with the lowest possible number and continue with the next available number in sequence.

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Figure 3.2
Station Number

Switch Groups



First Digit

If You Want to Set This Digit:	Set Switches	
	No. 1	No. 2
0	OFF	OFF
1	OFF	ON
2	ON	OFF
3	ON	ON

Second and Third Digits

If You Want to Set This Digit:	Set Switches		
	No. 1	No. 2	No. 3
0	OFF	OFF	OFF
1	OFF	OFF	ON
2	OFF	ON	OFF
3	OFF	ON	ON
4	ON	OFF	OFF
5	ON	OFF	ON
6	ON	ON	OFF
7	ON	ON	ON

Switch Setting Example: Station No. 037

Switch Group	SW-2		SW-3			SW-4		
Station No. Digits	0		3			7		
Switch No.	1	2	1	2	3	1	2	3
Switch Setting	OFF	OFF	OFF	ON	ON	ON	ON	ON

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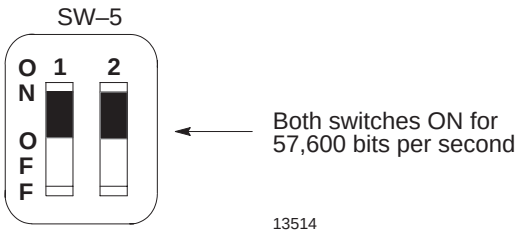
Network Communication Rate

Switch Assembly SW-5 lets you select the communication rate for the KF2 module's network link.

Important: Set both switches ON for a network communication rate of 57,600 bits per second. Be sure to set all modules on the network link for this communication rate.

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Figure 3.3
Switch Settings for Network Link



Asynchronous Communication Rate and Diagnostic Commands

Switch Assembly SW-6 lets you select the communication rate and diagnostic commands for the KF2 module's asynchronous port.

Communication Rate

Set the communication rate switches as shown:

Bits per Second as:	Set Switch: 1	2	3
110	OFF	OFF	OFF
300	ON	OFF	OFF
600	OFF	ON	OFF
1,200	ON	ON	OFF
2,400	OFF	OFF	ON
4,800	ON	OFF	ON
9,600	OFF	ON	ON

Diagnostic Commands

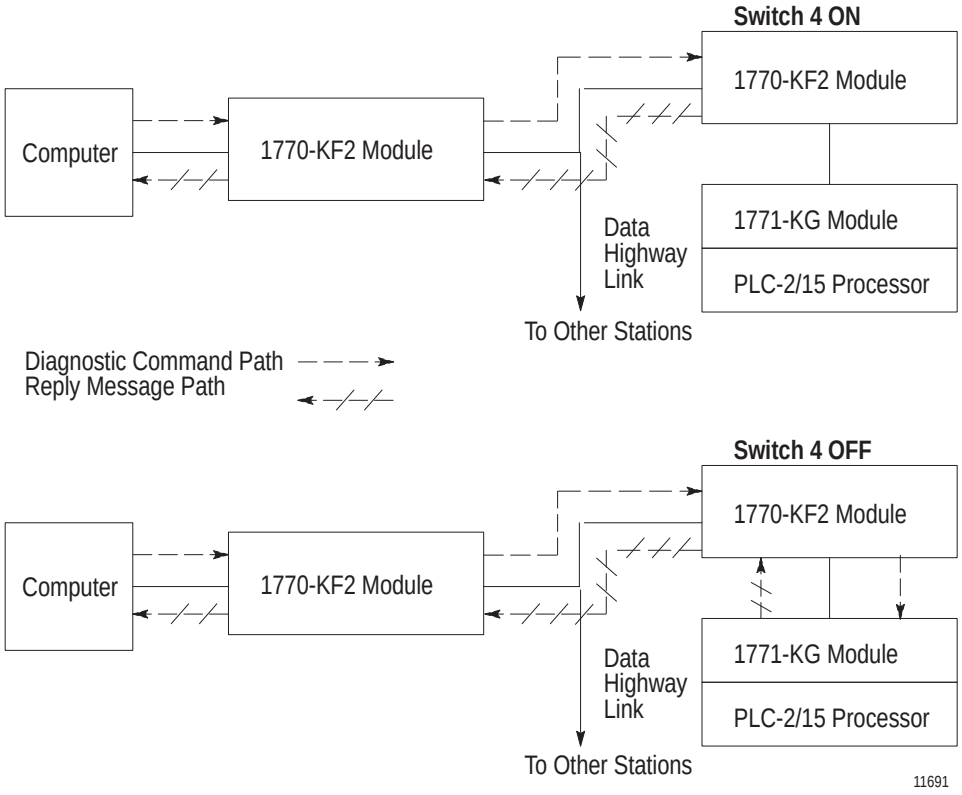
Switch 4 determines how the KF2 module treats diagnostic commands sent to it by a remote Data Highway station. You can connect the asynchronous port of the KF2 module directly to a 1771-KG, 1773-KA, or 1775-KA communication interface module (Figure 1.2). In such applications, you can set Switch 4 so that the KF2 module either executes any received diagnostic commands itself or passes those commands to the other attached communication module.

If You Want Your Module to:	Set Switch 4:
Execute Received Diagnostic Commands	ON
Pass Any Received Diagnostic Commands to the Attached Asynchronous Device	OFF

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Switch 4 relates only to diagnostic commands sent to the KF2 module from a **remote** Data Highway station. Since only computers can transmit diagnostic commands, the remote station must be a computer connected to the Data Highway by means of another KF2 module. At the computer station, the setting of Switch 4 **does not** affect any diagnostic commands that the computer sends to its local KF2 module. The local module always retransmits the command message over the Data Highway without executing it. Figure 3.4 illustrates these concepts.

Figure 3.4
Effect of Switch 4 on Diagnostic Commands



You can have more than one computer station on a network, and one computer can transmit diagnostic commands to the others. At the receiving computer station, if Switch 4 is OFF, the local KF2 module will pass the diagnostic commands to the computer. In such cases, you will have to write computer application programs to handle those commands at the receiving station. If Switch 4 is ON at the receiving station, the local KF2 module itself will execute the incoming diagnostic commands.

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Selecting the Network Link

You use Switch Assembly SW-7, a spare assembly in all Series A modules, to select whether the KF2 treats the network link as a Data Highway or as a PCL.

The following table shows the settings for Switch Assembly SW-7:

For This Network:	Set Switch 1:	Set Switch 2:
Data Highway	OFF	OFF
Peer Communication Link	ON	OFF

Selection of RS-232-C/RS-422-A

Switch Assembly SW-8 lets you select whether the asynchronous interface uses RS-232-C or RS-422-A standard communication.

For Communication Using Standard:	Set Switch 1:	Set Switch 2:
RS-232-C	OFF	ON
RS-422-A	ON	OFF

Important: This is the only option switch that affects KF2 operation after power-up. It changes the voltage applied to the network link connector pins to those required for the standard selected. Set this switch BEFORE power-up.

Replacing a 1771-KD Module with a KF2 Module

By setting the switches properly on the KF2 module, you can use it to replace an older 1771-KD module in an existing application without having to make any changes in your application programs.

In Set Switch Ass'y	Switch No.	Setting
SW-1	1	OFF
	2	Same Setting as 1771-KD Switch (Assembly SW-1, Switch 1)
	3	OFF
	4	OFF
	5	OFF
SW-2	1, 2	Same Setting as 1771-KD Switches (Assembly SW-2, Switches 1 and 2)
SW-3	1, 2, 3	Same Setting as 1771-KD Switches (Assembly SW-3, Switches 1, 2, and 3)
SW-4	1, 2, 3	Same Setting as 1771-KD Switches (Assembly SW-4, Switches 1, 2, and 3)
SW-5	1, 2	Same Setting as 1771-KD Switches (Assembly SW-5, Switches 1 and 2)
SW-6	1, 2, 3	Same Setting as 1771-KD Switches (Assembly SW-6, Switches 1, 2, and 3)
	4	Same Setting as 1771-KD Switch (Assembly SW-1, Switch 5)
SW-7	1, 2	OFF
SW-8	1	OFF
	2	ON

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Important: The asynchronous port of the KF2 module can communicate at a maximum rate of 9,600 bits per second. If your 1771-KD module was set to communicate at a higher rate, then you might have to make some modifications to your RS-232-C link before installing the replacement KF2 module.

Mounting (Placing)

A KF2 module is not actually mounted in the sense that other Allen-Bradley communication modules are. It is simply situated on a surface, like a desktop, near a wall plug for AC power. It is set for 115V operation when it reaches you. Connections to 115V AC and 230V AC are described below.

Place the KF2 module within 100 cable-feet of the Data Highway trunkline. If you are connecting the module directly to an RS-232-C device, you must also mount the module within 50 cable-feet of that device. If you are using a modem link to connect the KF2 module to the asynchronous device, then the module and the device may be as far apart as the modem link will allow. If you are connecting the KF2 directly to an RS-422-A compatible device, you must mount the module within 4,000 cable-feet of that device.

115V AC Operation

The “power select” switch is above the ON/OFF switch on the module’s rear panel. Set this switch to “115.” The power cord (approximately 7’4”), supplied with the module, must be plugged into the receptacle at the right of the ON/OFF switch. Plug the other end of the power cord into any standard 115V AC power outlet. **Switch must be set before power-up**.

230V AC Operation

Set the “power select” switch to “230.” **Do NOT use the power cord supplied with the module**. This cord is not approved for connection to a 230V AC outlet. To guard against electrical shock or fire, the power supply cord must be approved for 230V AC by Underwriters Laboratories or a similarly recognized agency. To mate with the receptacle on the module’s rear panel, the power cord must be terminated in a molded female connector (CEE 22 Standard V).

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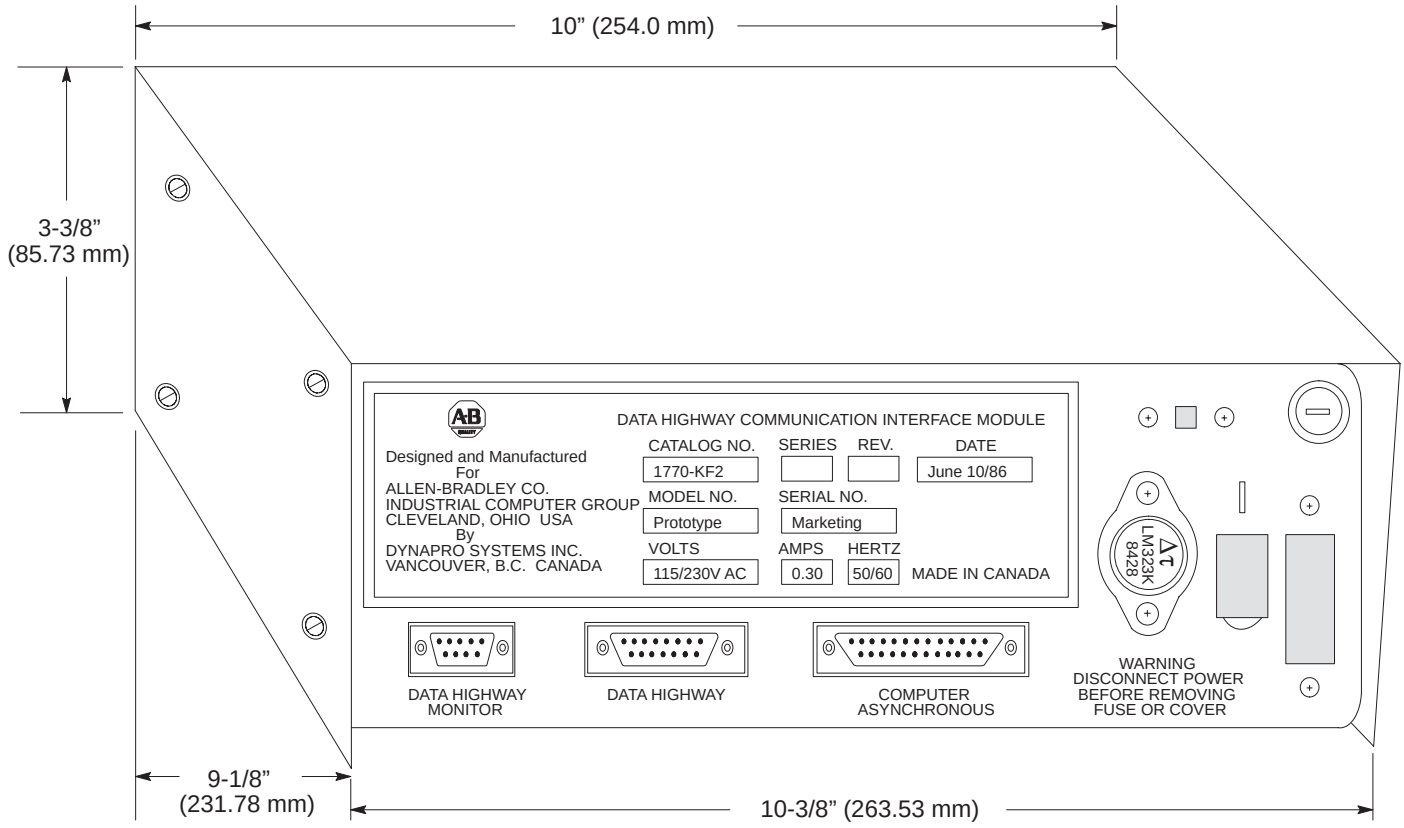
Interface Connections

The KF2 module has 3 connectors on its rear panel (Figure 3.5). The center connector, labeled DATA HIGHWAY, connects to the Data Highway dropline cable. Plug the 15-pin connector of the dropline into the DATA HIGHWAY socket. For connection to the PCL, plug the 15-pin PCL dropline into the Data Highway socket. (For details on how to construct the dropline, refer to Publications 1770-6.2.1 or 1770-2.13.)

The left connector, labeled DATA HIGHWAY MONITOR, is for future product development. Do not make any connections to this socket.

The right connector, labeled COMPUTER ASYNCHRONOUS, connects to an intelligent RS-232-C or RS-422-A compatible device. The rest of this section explains how to make connections to this asynchronous socket.

Figure 3.5
Dimensions of a 1770-KF2 Series B Module



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Mechanical Characteristics

The COMPUTER ASYNCHRONOUS connector on a KF2 module is a male 25-pin D-shell. This connector conforms to the RS-232-C standard and will accommodate any RS-232-C standard cable (see “Cabling”).

Electrical Characteristics

Selection of either RS-232-C or RS-422-A determines the input and output levels of the transmit data and receive data circuits on the asynchronous interface. When RS-232-C standard communication is selected, all signals on the asynchronous interface are driven and received by RS-232-C interface circuits which have a maximum drive capability of 50 cable-feet. When RS-422-A standard communication is selected, the transmit and receive signals only are driven and received by RS-422-A interface circuits which have a maximum drive capability of 4,000 cable-feet. In RS-422-A mode, all other signals except transmit and receive still conform to RS-232-C.

The setting of Communication Option Switch 4 of Switch Group SW-1 determines whether the asynchronous port asserts the handshaking signals or not (see “Asynchronous Link Features”). The handshaking signals are: RTS, CTS, DSR, DCD, and DTR. When Switch 4 of SW-1 is ON, the handshaking signals are used. When RS-422-A communications and handshaking are both selected, handshaking signals are present; but they conform to RS-232-C standards only.

Cabling

Cabling for the asynchronous port of the KF2 module will vary, depending on your application and on whether you are using RS-232-C or RS-422-A communications. The pinouts for the asynchronous connector are as follows:

Signal	Abbreviation	Pin	
		RS-232-C	RS-422-A
Protective Ground		1	1
Transmitted Data	TXD	2	
Received Data	RXD	3	
Request to Send	RTS	4	
Clear to Send	CTS	5	
Data Set Ready	DSR	6	
Signal Ground	GND	7	
Data Carrier Detect	DCD	8	
Data Terminal Ready	DTR	20	
Transmitted Data A	TDA		14
Transmitted Data B	TDB		25
Received Data A	RDA		16
Received Data B	RDB		18

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The definitions of the above signals are:

- TXD carries serialized data. It is an RS-232-C standard output from the module.
- RXD is RS-232-C standard serialized data input to the module.
- RTS is a request from the module to the modem to prepare to transmit. With full-duplex protocol, RTS is always asserted. With half-duplex protocol, it is turned on when the module has permission to transmit; otherwise it is off. It conforms to RS-232-C specifications.
- CTS is a signal from the modem to the module that indicates the carrier is stable and the modem is ready to transmit. The module will not transmit until CTS is on. If CTS is turned off during transmission, the module will stop transmitting until CTS is restored. It conforms to RS-232-C specifications.
- DTR is a signal from the module to the modem to connect to the phone line (i.e., “pick up the phone”). The module will assert DTR all the time except during the phone hang-up sequence. Modems built to American standards will not respond to DTR until the phone rings. Some European modems will always pick up the phone, whether it is ringing or not. The KF2 module will not work with these types of European modems. DTR conforms to RS-232-C specifications.
- DSR is a signal from the modem to the module that indicates the phone is off-hook. (It is the modem’s answer to DTR.) The module will not transmit or receive unless DSR is on. If the modem does not properly control DSR, or if no modem is used, DSR must be jumpered to a high signal at the module’s asynchronous connector. (It can be jumpered to DTR.) DSR conforms to RS-232-C specifications.
- DCD is a signal from the modem to the module to indicate that the carrier from another modem is being sensed on the phone line. It will not be asserted unless the phone is off-hook. Data will not be received at the asynchronous connector unless DCD is on. With full-duplex protocol, the module will not transmit unless DCD is on. If the modem does not properly control DCD, or if a modem is not being used, DCD must be jumpered to DTR at the module. DCD conforms to RS-232-C specifications.
- TDA is the transmitted data signal for RS-422-A output from the module.
- TDB is the differential return signal for TDA for transmitting RS-422-A data.
- RDA is the RS-422-A data input to the module.
- RDB is the differential return signal for RDA.

If you are connecting a KF2 module to an RS-232-C compatible device (e.g., modem or computer), then you must mount the module within 50 cable-feet of that device. For such applications, the module’s GND

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must be connected to the GND of the modem or computer. Note that this type of connection does not provide electrical isolation between the module and the connected device.

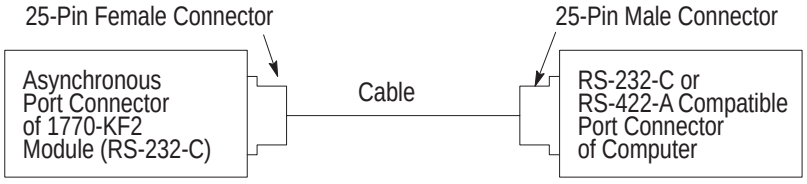
If a connection is made between the KF2 and an RS-422-A compatible device, you can mount the device and the module up to 4,000 cable-feet apart.

Direct Connection to a Computer

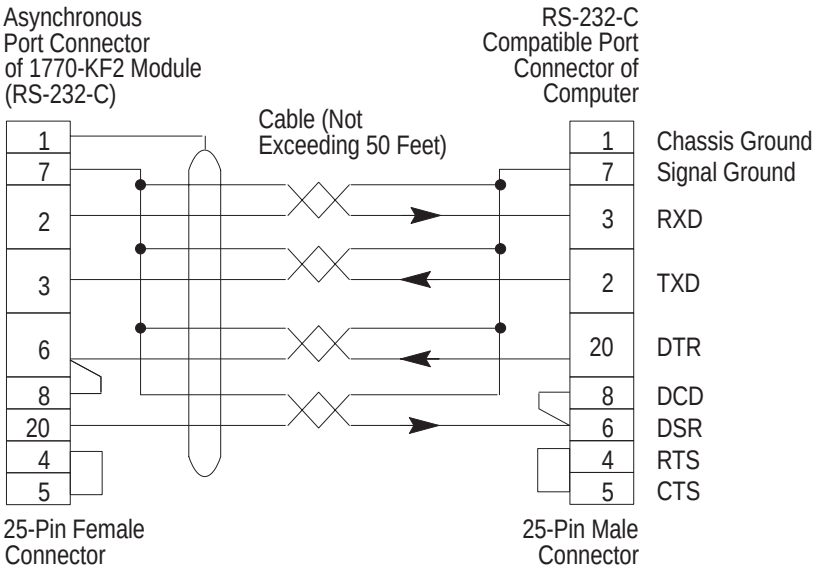
To connect the module directly to a computer, you can construct your own cable according to the wiring diagram in Figure 3.6.A. This cable plugs into the COMPUTER ASYNCHRONOUS connector on the module and the RS-232-C or RS-422-A compatible connector on the computer (Figure 3.6.A). Connect the cable shield at one end only. Be sure that the cable length does not exceed the RS-232-C limit of 50 feet or the RS-422-A limit of 4,000 feet.

Figure 3.6
Connection to a Computer

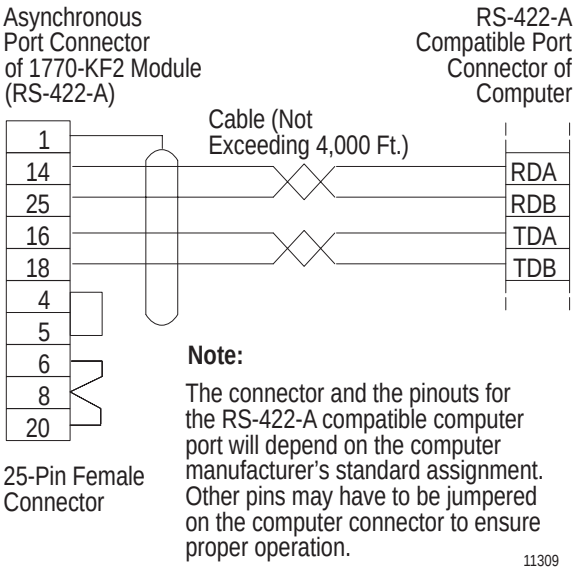
A. Connection Diagram



B. Wiring Diagram for RS-232-C



C. Wiring Diagram for RS-422-A



Note:

The connector and the pinouts for the RS-422-A compatible computer port will depend on the computer manufacturer's standard assignment. Other pins may have to be jumpered on the computer connector to ensure proper operation.

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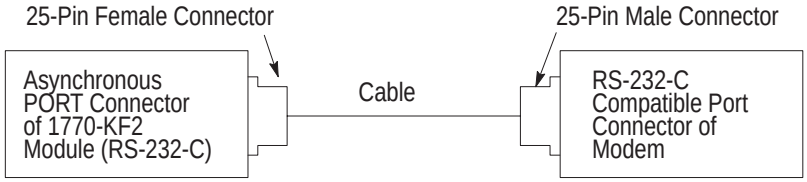
This type of connection includes the DTR signal to allow each end to detect the loss of the other end's ability to communicate. If your computer does not provide the DTR signal, jump Pins 6 and 8 at the KF2 module to Pin 20.

Connection to a Modem

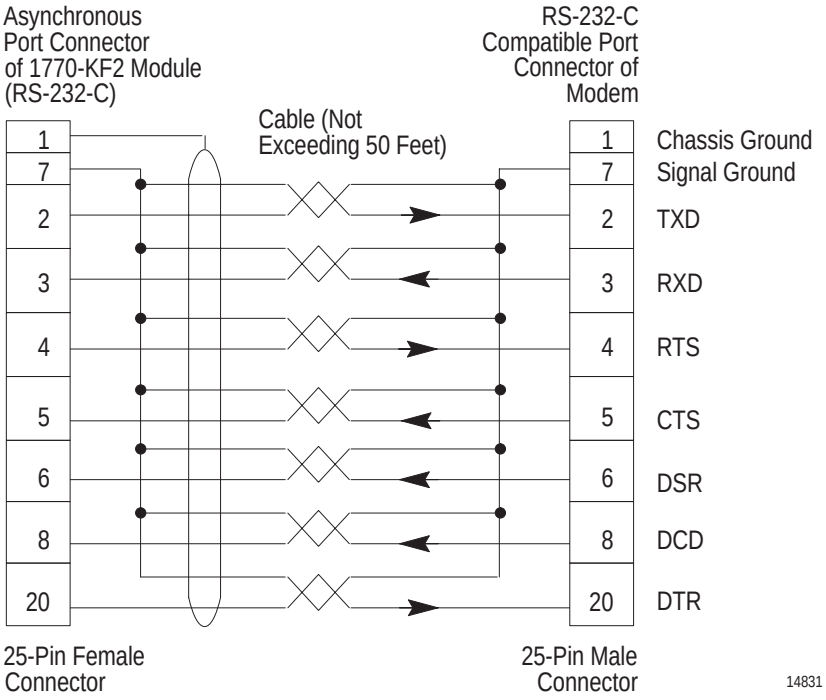
To connect the module to a modem, you can construct your own cable according to the wiring diagram in Figure 3.7. This cable plugs into the COMPUTER ASYNCHRONOUS connector on the module and the RS-232-C compatible connector on the modem (Figure 3.7). Connect the cable shield at one end only. Be sure that the cable length does not exceed the RS-232-C limit of 50 feet.

Figure 3.7
Connection to a Modem

A. Connection Diagram



B. Wiring Diagram



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The module can be connected to standard American dial-up modems and some European modems. Other European standards specify that the DTR signal will make the modem answer the phone whether it is ringing or not, causing the phone always to be "busy." Do not use the module with any type of modem that answers the phone when DTR is asserted, even while waiting for a call.

The types of dial-up network modems that you can use are:

- **Manual:** These are typically acoustically coupled modems. The connection is established by human operators at both ends, who insert the handsets into couplers to complete the connection.
- **DTE-Controlled Answer:** These unattended modems are directly connected to the phone lines. The module serves as the data terminal equipment to control the modem via the DTR, DSR, and DCD signals. The module incorporates timeouts and tests to properly operate these types of modems.
- **Auto-Answer:** These modems have self-contained timeouts and tests and can answer and hang up the phone automatically.

The module has no means of controlling an auto-dial modem, but it can be used in conjunction with a separate auto-dialer.

Connection to Another Communication Module

To learn about a direct RS-232-C communication link with a 1771-KE, -KF, or -KG module, refer to Figure 3.8. To construct the cable, use a 25-pin female connector at the KF2 end and a 15-pin male connector at the other end.

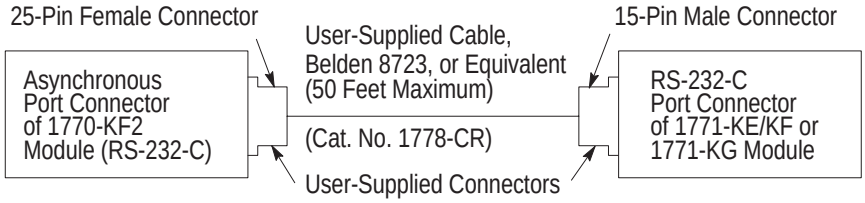
To provide a direct RS-232-C link with a 1773-KA or a 1775-KA module, Figure 3.9, use a 25-pin female connector at the KF2 and a 25-pin male connector at the KA module.

Use Belden 8723 or equivalent cable (available from Allen-Bradley under Cat. No. 1778-CR). Connect the cable shield at one end only. You can make the cable up to 50 feet long.

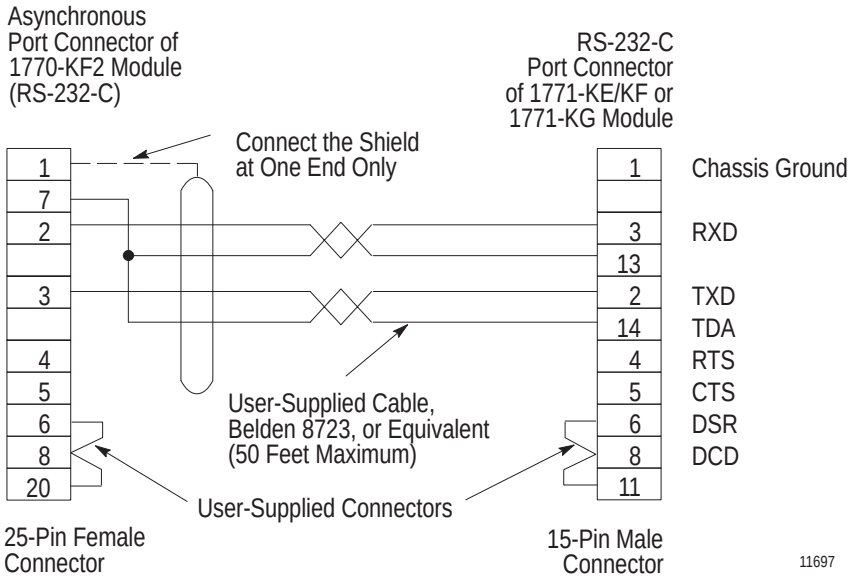
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Figure 3.8
Connection to 1771-KG Module

A. Connection Diagram



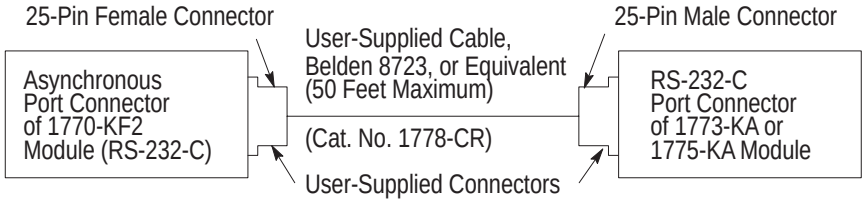
B. Wiring Diagram



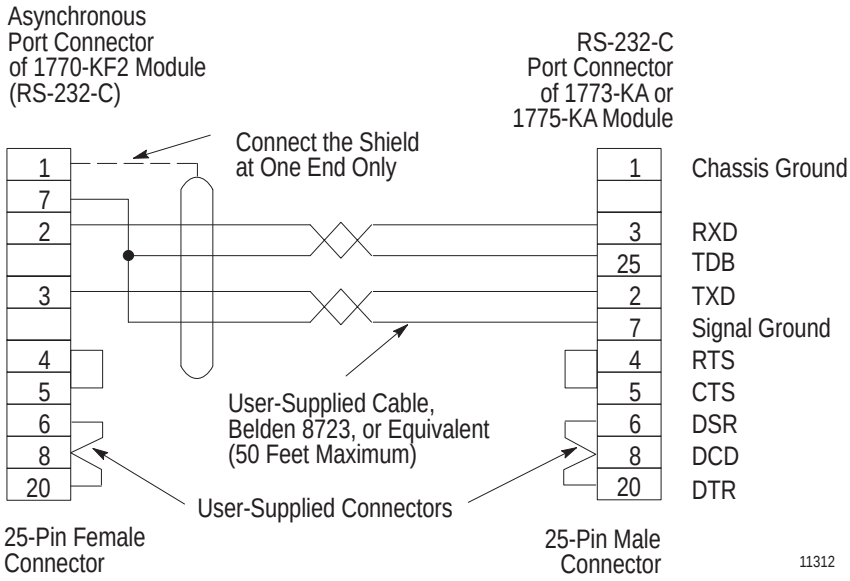
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Figure 3.9
Connection to 1773-KA or 1775-KA Module

A. Connection Diagram



B. Wiring Diagram



Answering

The module continually asserts DTR when it is waiting for a call. Under this condition, the modem will answer a call and assert DSR as soon as it detects ringing. The module does not monitor the RING indicator in the RS-232 interface. Once it detects DSR, the module starts a timer (around 10 seconds) and waits for the DCD signal. When the module detects DCD, communication can start.

If the module does not detect DCD within the timeout, the module turns DTR off. This causes the modem to hang up and break the connection. When the hang-up is complete, the modem turns off DSR. This causes the module to reassert the DTR line and wait for another call. This feature protects access to the phone if someone calling a wrong number reaches this station.

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After detecting DCD, the module continues to monitor the DCD line. If DCD goes off, the module restarts the timeout. If DCD is not restored within the timeout, the module initiates the hang-up sequence. This feature allows the remote station to redial in the event that the connection is lost through a fault in the phone network.

This handshaking is necessary to guarantee access to the phone line. If this handshaking protocol is defeated by improper selection of modem options or by jumpers at the connectors, the modem may still answer a call. But if the connection is lost, the modem will not hang up. It will then be impossible for the remote station to reestablish the connection because it will get a busy signal.

Character Transmission

The module sends data serially over the asynchronous interface, one 8-bit byte at a time. The transmission format conforms to ANSI X3.16, CCITT V.4, and ISO 1177, with the exception that the parity bit is retained while the data length is extended to eight bits.

The transmission format may be summarized as follows:

start bit
data bit 0
data bit 1
data bit 2
data bit 3
data bit 4
data bit 5
data bit 6
data bit 7
even parity bit (optional)
one stop bit

For communication rate see “Asynchronous Communication Rate and Diagnostic Commands” and for parity settings refer to “Asynchronous Link Features.”

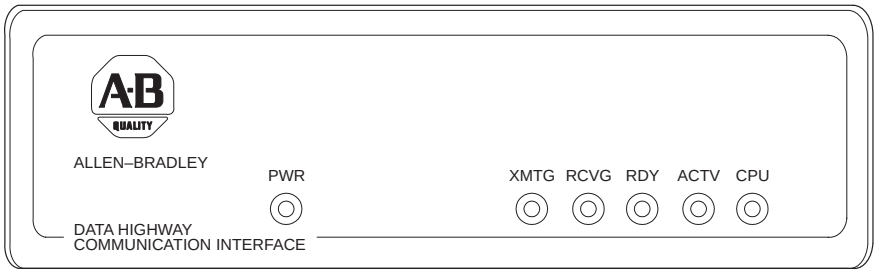
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Diagnostic Indicators

There are 6 LED indicators on the front of a KF2 module (Figure 3.10). These indicators can help you in diagnosing problems with the module's installation and operation. The indicators are:

- PWR - Power On
- XMTG - Transmitting
- RCVG - Receiving
- RDY - Ready to Transmit
- ACTV - Active
- CPU - Module Fault, or DLE NAK Indicator

Figure 3.10
Diagnostic (LED) Indicators



The XMTG light comes on when the KF2 module is current master of the network link and is transmitting a command or reply message.

The RCVG light comes on when the module is receiving a command or reply message from another station on the network link.

If the KF2 is on the Data Highway and the XMTG and RCVG lights are on at the same time, this indicates that the module is current master of the Data Highway and is polling the other stations to transfer mastership.

If the KF2 is on a PCL link and the XMTG and RCVG lights are on at the same time, this means that the module is determining whether there is a new module trying to access the link. This is known as "soliciting a successor."

The RDY light comes on when the module has a message stored in its transmit buffer and it is waiting to acquire mastership of the network link so it can transmit the message.

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The ACTV light remains on as long as the cable between the COMPUTER ASYNCHRONOUS socket and the interfacing asynchronous device is properly connected. This light will appear to flicker whenever characters are being transmitted across the asynchronous link. If this light goes off, check the cable and connectors for possible problems.

The CPU light comes on for about half a second every time the module transmits or receives a DLE NAK protocol sequence (Chapter 4). If this light flickers frequently or stays on, the asynchronous link might need better isolation or noise immunity.

If the KF2 is on a PCL, the CPU light also flashes at about 1 Hz when a duplicate node (two stations with the same station number) is detected and stays on when an internal hardware fault is detected. For more on the KF2 self-diagnostics, see Chapter 1 under “Module Description.”

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Chapter 4

Asynchronous Link Protocols

General

This chapter describes the communication protocol used on the asynchronous link to the KF2 module. If you are connecting a KF2 module to another Allen-Bradley communication interface module (such as a 1771-KG, 1773-KA, or 1775-KA module), you need not be concerned with protocol because the modules automatically take care of it. However, if you are connecting a KF2 module to a computer, then you must program the computer to understand and to issue the proper protocol character sequences, as described in Chapters 4 through 6 of this manual.

Definition of Link Protocol

A link consists of a wire and associated hardware—such as transceivers, UARTs, and error checkers. A link protocol carries a message error-free from one end of the link to the other, or it indicates failure with an error code. Internally it delimits messages, detects and signals errors, retries after errors, and controls message flow. It requires that the link hardware send characters from one end of the wire to the other.

The only purpose of a link protocol is to carry a message intact over a link. It has no concern for the content of the message, the message's function in the operation of higher levels in the system, or the ultimate fate or purpose of the message. Once the message has been reliably carried from one end of the link to the other, the link protocol's concern for that message is ended.

The asynchronous port of the KF2 module can use one of two link protocols, which are:

- Full-Duplex Protocol (for Point-to-Point Communication)
- Half-Duplex Protocol (for Master-Slave Communication)

In general, full-duplex protocol gives faster data throughput but is harder to implement; half-duplex protocol is easier to implement but gives slower data throughput. Each of these protocols is described independently in "Full-Duplex Protocol" and "Half-Duplex Protocol" respectively.

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Important: Some Allen-Bradley documentation might refer to full-duplex and half-duplex protocols as DF1 and polled-mode protocols, respectively.

Full-Duplex Protocol

Full-duplex protocol conforms closely to ANSI X3.28-1976, combining features of Subcategories D1 (data transparency) and F1 (two-way simultaneous transmission with embedded responses).

Full-duplex protocol is used over a point-to-point link that allows two-way simultaneous transmission. It is relatively difficult to implement because it requires a system programmer to use interrupts and multi-tasking techniques. It is intended for high-performance applications where it is necessary to get the highest possible throughput from the available communication medium.

Transmission Codes

Full-duplex protocol is character-oriented; it uses the following ASCII control characters extended to eight bits by adding a zero for Bit 7. See ANSI X3.4, CCITT V.3, or ISO 646 for the standard definition of these characters.

Control Character	Hexadecimal Code
STX (Start of Text)	02
ETX (End of Text)	03
ENQ (Enquiry)	05
ACK (Acknowledge)	06
DLE (Data Link Escape)	10
NAK (Negative Acknowledge)	15

The term “code” is defined for use in the following paragraphs as an indivisible sequence of one or more bytes having a specific meaning to the link protocol. “Indivisible” means that the component characters of a code must be sent one after another with no other characters between them. It does not refer to the timing of the characters.

The following codes are used in full-duplex protocol:

- Control Codes:
  - DLE STX
  - DLE ETX BCC/CRC
  - DLE ACK
  - DLE NAK
  - DLE ENQ

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- Data Codes:
  - Data (single characters having values 00-0F and 11-FF hex)
  - DLE DLE (to represent the value 10 hex)

Codes are grouped into two classes: **message** codes, sent from transmitter to receiver; and **response** codes, sent from receiver to transmitter.

- DLE STX is a message code used to indicate the start of a message.
- DLE ETX BCC/CRC is a message code used to terminate a message.
- Data 00-0F and 11-FF hex are message codes used to encode the corresponding values in the message itself. DLE DLE is a message used to encode the occurrence of the value 10 in the message.
- DLE ENQ is a message code. It requests the retransmission of the last received code.
- DLE ACK, a response code, signals that a message has been successfully received.
- DLE NAK, also a response code, signals that an attempt to transfer a message has failed.

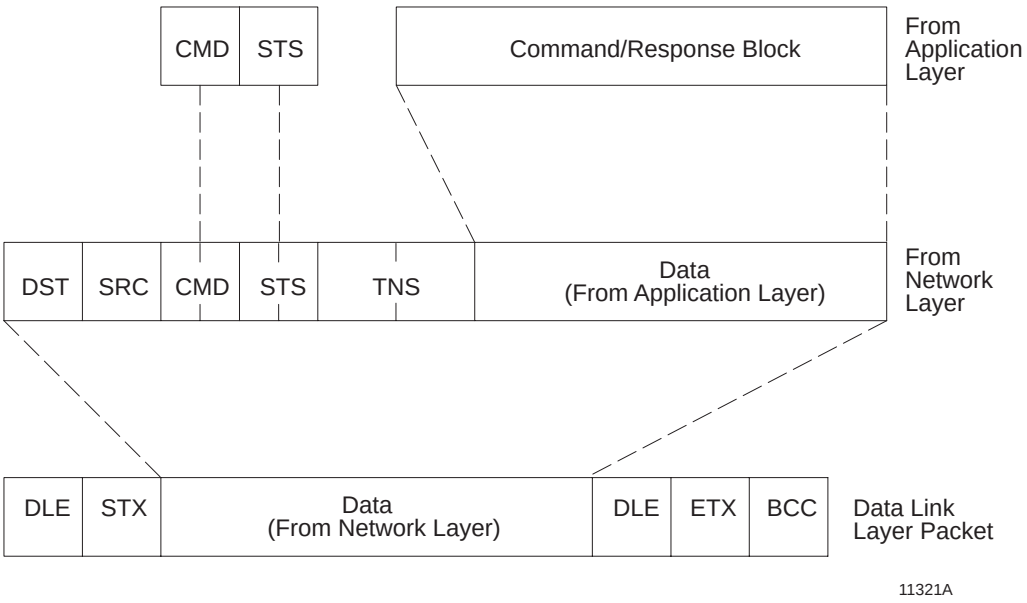
Link-Layer Message Packets

A link-layer message packet starts with a DLE STX and ends in a DLE ETX BCC/CRC, with data codes in between. Data codes can occur only inside a message packet. Response codes can also occur between a DLE STX and a DLE ETX BCC/CRC, but such response codes are not part of the message packet. They are referred to as embedded responses.

Figure 4.1 shows the format of a link-layer message packet for full-duplex protocol, and the layer at which each portion should be implemented. At the end of each message packet is the one-byte BCC field.

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Figure 4.1
Packet Format for Full-Duplex Protocol



Block Check

The block check character (BCC) is a means of checking the accuracy of each message packet transmission. It is the 2's complement of the 8-bit sum (modulo-256 arithmetic sum) of all data bytes between the DLE STX and the DLE ETX BCC. It does not include any other message packet codes or response codes.

Example 1: If a message packet contained the data codes 08, 09, 06, 00, 02, 04 and 03, the message packet codes would be (in hex):

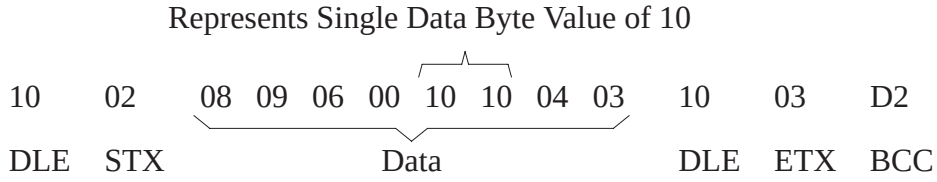
10	02	08 09 06 00 02 04 03	10	03	E0
DLE	STX	Data	DLE	ETX	BCC

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The sum of the data bytes in this message packet is 20 hex. The BCC is the 2's complement of this sum, or E0 hex. This is shown in the following binary calculation:

0010 0000	20 hex
1101 1111	1's complement
+1	
1110 0000	2's complement (E0 hex)

Example 2: To transmit the data value 10 hex, you must use the data code DLE DLE. However, only one of these DLE data bytes is included in the BCC sum. For example, to transmit the values 08, 09, 06, 00, 10, 04, and 03 hex, you would use the following message codes:



In this case, the sum of the data bytes is 2E hex because only one DLE text code is included in the BCC. So the BCC is D2 hex.

The BCC algorithm provides a medium level of data security. It cannot detect transposition of bytes during transmission of a packet. It also cannot detect the insertion or deletion of data values of zero within a packet.

Cyclic Redundancy Check

Calculate the CRC value on the value of the data bytes and the ETX byte (using the polynomial $x^{16} + x^{15} + x^2 + x^0$). To transmit the data value of 10 hex, you must use the data code DLE DLE. However, only one of these DLE data bytes is included in the CRC value. Embedded responses are not included in the CRC value.

At the start of a message packet, the transmitter clears a 16-bit register for the CRC value. As a byte is transmitted, it is exclusive-ORed (with Bit 0 to the right) to the right eight bits of the register. The register is then shifted right eight times with zeros (0s) inserted on the left. Each time a one (1) is shifted out on the right the following binary number is exclusive-ORed with the 16-bit register value:

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1010 0000 0000 0001

As each additional byte is transmitted, it is included in the value in the register the same way. After the ETX value is included in the value in the register and is transmitted, the value in the register is transmitted (right bit first) as the CRC field.

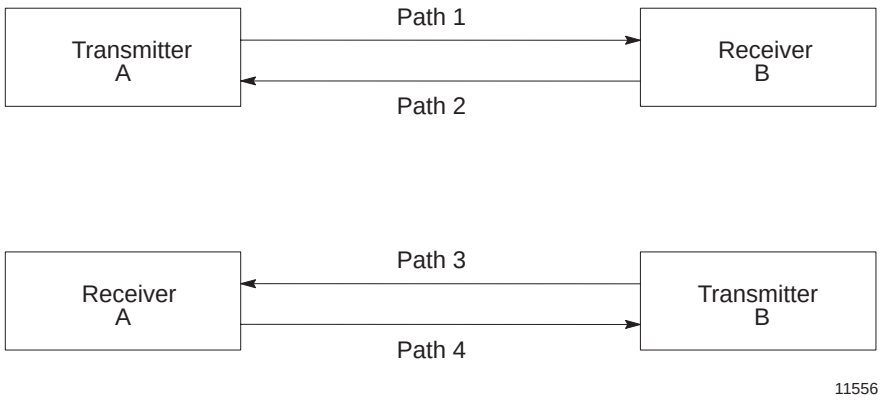
The receiver also calculates the CRC value and compares it to the received CRC value to verify the accuracy of the data received.

Two-Way Simultaneous Operation

On a two-way simultaneous link there are only two physical circuits connecting 4 distinct and independent programs. Referring to the diagram below, Transmitter A and Receiver B manage the transfer of messages from Station A to Station B by sending message packets from A to B and returning responses from B to A. At the same time, Transmitter B and Receiver A carry out the transfer of messages from Station B to Station A by sending message packets from B to A and returning responses from A to B.

Figure 4.2 shows the four independent data paths involved.

Figure 4.2
Data Paths for Two-Way Simultaneous Operation

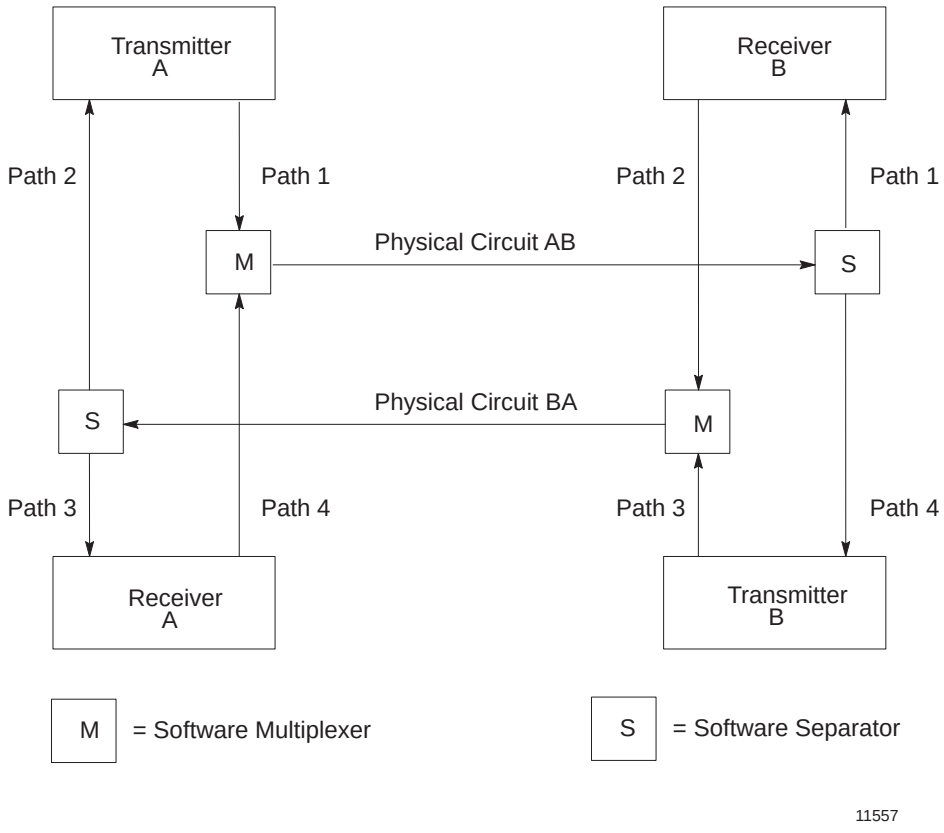


Path 1 carries message codes from A to B; Path 2 carries response codes from B to A; Path 3 carries message codes from B to A; and Path 4 carries response codes from A to B.

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To implement all of these data paths with only two physical circuits, a software multiplexer combines the message codes with the response codes going in the same direction. At the other end of the link a software separator divides the message codes from the response codes. The message codes are sent to the receiver, and the response codes are sent to the transmitter via internal software. On each physical circuit, response codes from a receiver to a transmitter will be seen intermingled with message codes being sent from a transmitter to a receiver. Figure 4.3 shows this implementation.

Figure 4.3
Software Implementation of Data Paths

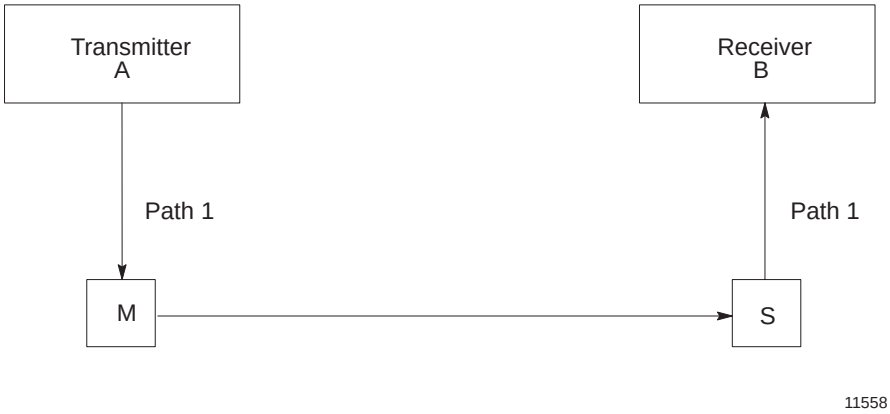


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Figure 4.4 shows Path 1 with unrelated parts of Figure 4.3 removed.

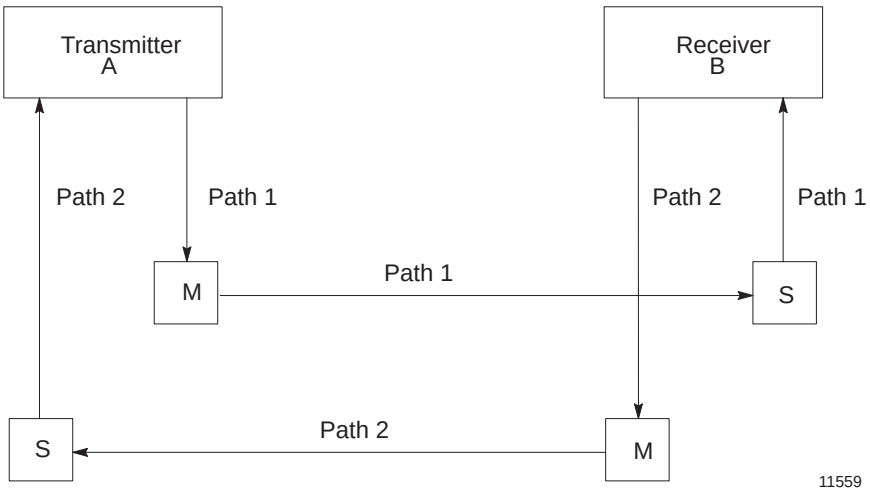
Paths 2, 3, and 4 could be similarly shown.

Figure 4.4
Path 1, Unrelated Parts of Figure 4.3 Removed



The full-duplex protocol is symmetrical; that is, anything that can be said about Transmitter A, Receiver B, and Paths 1 and 2 applies equally to Transmitter B, Receiver A, and Paths 3 and 4. There are actually two independent instances of the protocol operating simultaneously. For simplicity the protocol will be defined on the subsystem that carries messages from A to B, with reference to Figure 4.5.

Figure 4.5
Message Transmission from A to B



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Although the protocols on each subsystem operate independently of each other, there will be a slight interaction as transmission of a message is delayed when a two-character response code is inserted in a stream of message codes. Also, any hardware problem that affects message codes traveling over a hardware circuit will also likely affect response codes on the same circuit.

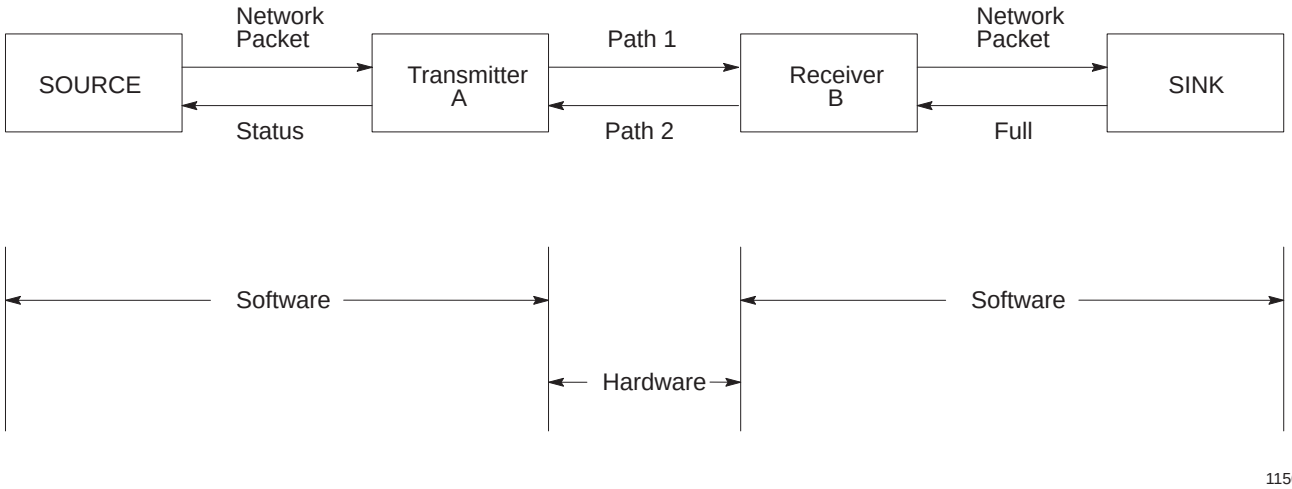
Protocol Environment Definition

To fully define the environment of the protocol, the transmitter needs to know where to get the message it sends; and the receiver must have a means of disposing of messages. These are implementation dependent functions which shall respectively be called the message source and the message sink.

We assume that the message source supplies one message at a time upon request from the transmitter and requires notification of the success or failure of the transfer to Station B before supplying the next message. When the message source is empty, the transmitter waits in an inactive state until a message is available. Whenever the receiver has received a message successfully, it attempts to give it to the message sink. The possibility exists that the message sink will be full. The receiver requires an indication of this.

Figure 4.6 shows this representation of the protocol environment.

Figure 4.6
Protocol Environment



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Message Characteristics

Ideally the link protocol should not be at all concerned with the content or form of the message it is transferring. However, full-duplex protocol places the following restrictions on the messages that are submitted to it for transfer:

1. Minimum size of a valid message is 6 bytes, maximum is 250 bytes.

2. Some protocol implementations (point-to-point links to a 1771-KG module, for example) require that the first byte of a message match the station address. The receiver will ignore messages that do not contain the correct address.

3. As part of the duplicate message detection algorithm, the receiver checks the second, third, fifth, and sixth bytes of each message. There must be a difference in at least one of these bytes between a message and the previous one for it to be recognized as distinct rather than a retransmission of the previous message. If Switch 3 of Switch Group SW-1 if off, the KF2 module does not implement duplicate message detection (see Chapter 3, “Asynchronous Link Features”).

Protocol Definition

Whenever the message source can supply a message and the transmitter is not busy, it sends a message packet on Path 1. It then starts a timeout and waits for a response on Path 2.

When a DLE ACK is received, the message has been successfully transferred. After signaling the message source that the message has been sent, the transmitter proceeds with the next message.

If a DLE NAK is received, the message will be retransmitted. The transmitter restarts the timeout and waits again for a response. This can be repeated several times. There is a user-defined limit to the number of times a message can be retransmitted. If this limit is exceeded, the message source will be signaled of the failure; and the transmitter will proceed with the next message.

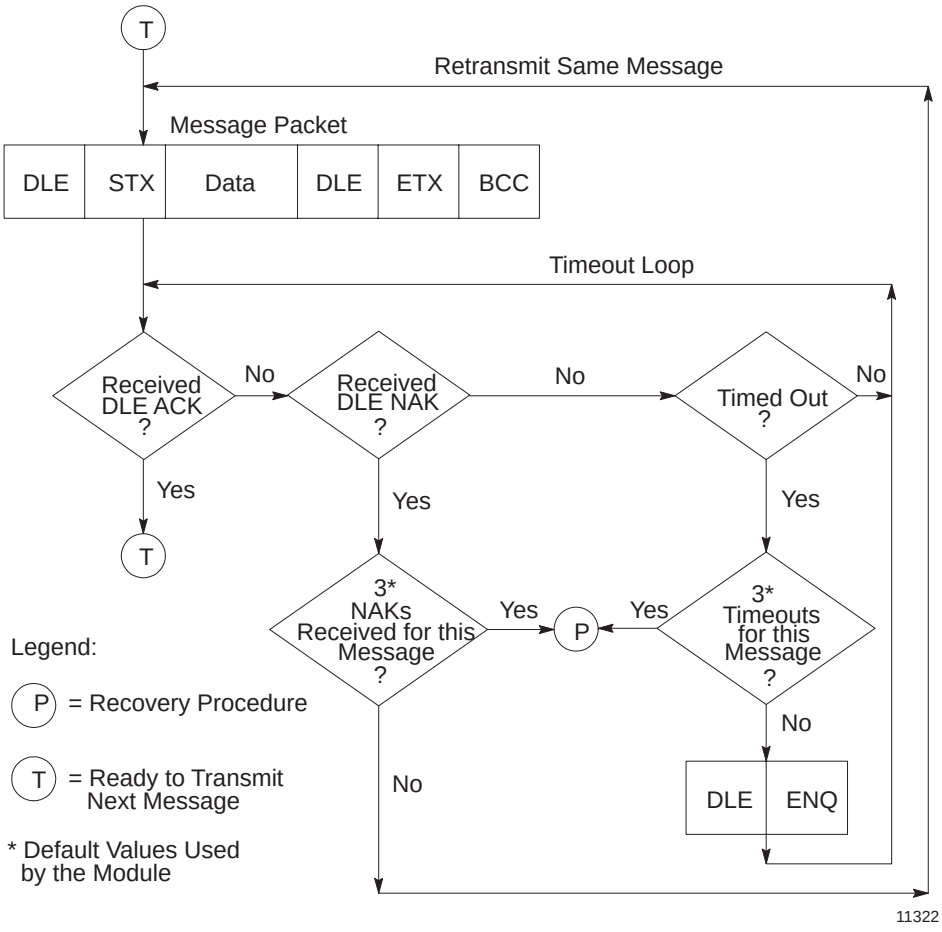
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If the timeout expires before a response is received, the transmitter sends a DLE ENQ on Path 1 to request a retransmission of the last response sent on Path 2. It restarts the timeout and waits for a response.

This too can be repeated several times, and there is a user-defined limit on the number of timeouts that are allowed per message. If the enquiry limit is exceeded, the message source will be signaled that the transmission has failed, and the transmitter proceeds to the next message.

Since there are only two response codes defined, there are no invalid response codes. If the separator returns an invalid response code, the transmitter will ignore it. A more precise and detailed description of the actions of the transmitter appears in Table 4.A in structured English procedures. Figure 4.7 is a flowchart of the software logic for implementing the transmitter.

Figure 4.7
Software Logic for Implementing Transmitter



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Table 4.A
Transmitter for Full-Duplex Protocol

```
TRANSMITTER is defined as
    loop
        Message = GET-MESSAGE-TO-SEND
        Status = TRANSFER (Message)
        SIGNAL-RESULTS  (Status)
    end loop

TRANSFER (Message) is defined as
    initialize NAK-limit and ENQ-limit
    SEND (Message)
    start timeout
    loop
WAIT for response on Path 2 or timeout.

if received DLE ACK then return SUCCESS
else if received DLE NAK then
    if NAK-limit is exceeded then return FAILURE
    else
        begin
            count NAK retries;
            SEND-MESSAGE  (Message);
            start timeout
        end
        end
else if timeout
    if ENQ-limit is exceeded then return FAILURE
    else
        begin
            count ENQ retries;
            send DLE ENQ on Path 1;
            start timeout
        end
        end
    end loop

SEND (Message) is defined as
    begin
        BCC = 0
        send DLE STX on Path 1
        for every byte in the message do
            begin
                add the byte to the BCC;
                send the corresponding data code on Path 1
            end
        send DLE ETX BCC on Path 1
    end

GET-MESSAGE-TO-SEND
    This is an operating-system-dependent interface routine that waits and allows the rest
    of the system to run until the message source has supplied a message to be sent.

SIGNAL-RESULTS
    This is an  implementation-dependent  routine  that  tells the message source of the results
    of the attempted message transfer.

WAIT
    This is an operating-system-dependent  routine that waits for any of several events to
    occur while allowing other parts of the system to run.
```


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Receiver Actions

Since the receiver gets “dirty” input from the physical world, it is more complex and must be capable of responding to many adverse situations. Some of the things that can conceivably happen are listed here:

1. The message sink can be full, leaving the receiver with nowhere to put a message.

2. A message can contain a parity error.

3. The BCC can be invalid.

4. The DLE STX or DLE ETX BCC may be missing.

5. The message can be too long or too short.

6. A spurious control or data code can occur outside a message.

7. A spurious control code can occur inside a message.

8. The DLE ACK response can be lost, causing the transmitter to send a duplicate copy of a message that has already passed to the message sink.

A record of the last response sent on Path 2 is kept. The value of this response is either ACK or NAK. It is initialized to NAK. When a DLE ENQ is received, the receiver sends the value of the last response from this variable.

A record is kept of several message header bytes. If a message has the same header as the previous message, the message is ACKed but discarded.

The receiver ignores all input from Path 1 until a DLE STX or a DLE ENQ is received. If anything other than a DLE STX or DLE ENQ is received on Path 1, the receiver sets the last response variable to a NAK.

If an ENQ is received, the last response is sent on Path 2; and the receiver continues waiting for input.

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If a DLE STX is received, the BCC and the message buffer are reset; and the receiver starts building a message.

While building a message, all data codes are stored in the message buffer and added to the BCC. If the buffer overflows, the receiver continues summing the BCC, but the data is discarded. If a parity, overrun, framing, or modem handshaking error is detected, it is recorded. If any control codes other than a DLE EXT BCC are received, the message is aborted and a DLE NAK sent on Path 2. When the DLE ETX BCC is received, the error flag, the BCC, the message size, and the address (optionally) are all checked. If any of the tests fail, a DLE NAK is sent on Path 2.

If the message is OK, its header is compared to the last message. If it is the same, the message is discarded; and a DLE ACK is sent. (Duplicate message detection is not implemented if Switch 1 of Switch Group SW-1 is turned off.)

If the message is different from the last one, the state of the message sink is tested. If the message sink is full, a DLE NAK is sent; otherwise the message is forwarded to the message sink; the header information is saved for the duplicate message detector; and a DLE ACK is sent.

The procedure for the 1771-KC/KD and 1771-KG (Revision C) modules is different. First, they check the message sink state. If the sink is full, the response is recorded but not sent. The receiver waits for a DLE ENQ on Path 1. If any other code is received, the response is changed from ACK to NAK and the receiver continues waiting for a DLE ENQ. If a DLE ENQ is received, the sink status is checked. If it is still full, the receiver continues waiting. If it is not full, the last response is sent; and the receiver then accepts new messages. This variation is **not** documented in the structured English section found in Table 4.B.

The receiver for the KF2 module is listed in Table 4.B in structured English. Figure 4.8 is a flowchart of the software logic for implementing the receiver.

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Table 4.B
Receiver for Full-Duplex Protocol

```
RECEIVER is defined as
    variables
        LAST-HEADER is 4 bytes copied out of the last good message
        RESPONSE is the value of the last ACK or NAK sent
        BCC is an 8-bit block check accumulator

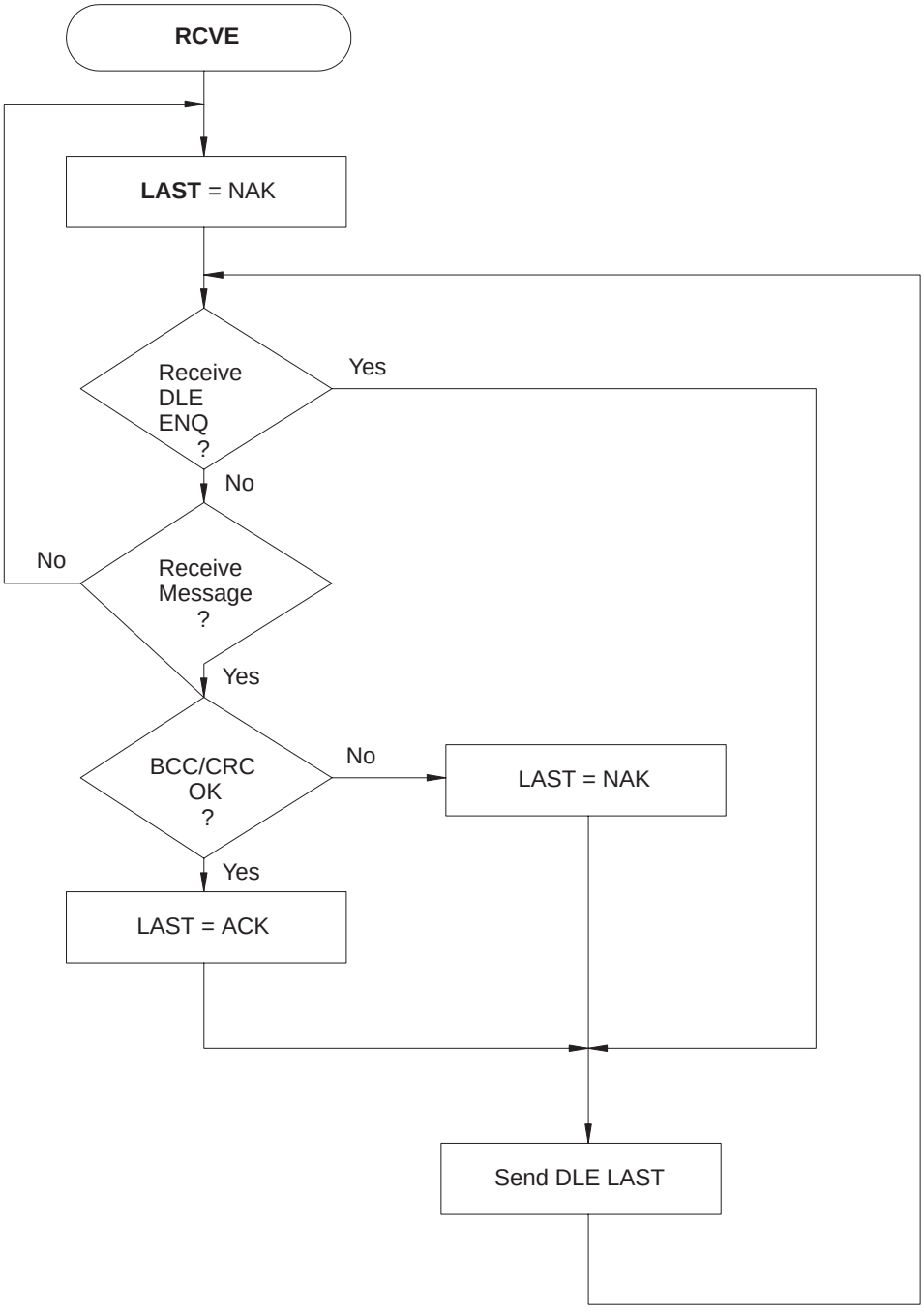
    LAST-HEADER = Invalid
    LAST-RESPONSE = NAK

    loop
        reset parity error flag
        GET-CODE
        if DLE STX then
            begin
                BCC =  0
                GET-CODE
                while it is a data code
                    begin
                        if buffer is not overflowed put data in buffer
                        GET-CODE
                    end
                if the control code is not a DLE ETX then send DLE NAK
                else if error flag is set then send DLE NAK
                else if BCC is not zero then send DLE NAK
                else if message is too small then send DLE NAK
                else if message is too large then send DLE NAK
                else if header is same as last message send a DLE ACK
                else if message sink is full send DLE NAK
                else
                    begin
                        send message to message sink
                        send a DLE ACK
                        save last header
                    end
            end
        else if DLE ENQ then send LAST-RESPONSE
        else LAST-RESPONSE = NAK
    end loop
```

```
GET-CODE is defined as
    loop
        GET-CHAR
        if char is not a DLE
            begin
                add char to BCC
                return the char and data flag
            end
        else
            begin
                GET-CHAR
                if char is a DLE
                    begin
                        add char to BCC
                        return a DLE and a data flag
                    end
                else if char is an ACK or NAK send it to the transmitter
                else if char is an ETX
                    begin
                        GET-CHAR
                        add char to BCC
                        return ETX with a control flag
                    end
                else return character with a control flag
            end
        end loop
GET-CHAR is defined as
    an implementation-dependent function that returns one byte of data from the link interface hardware.
```


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Figure 4.8
Receiver for Full-Duplex Protocol



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Full-Duplex Protocol Diagrams

The following figures show some events that can occur on the various interfaces. Time is represented as increasing from the top of the figure to the bottom. Data bytes are represented by “xxxx”; corrupted data by “???”.

Figure 4.9
Normal Message Transfer

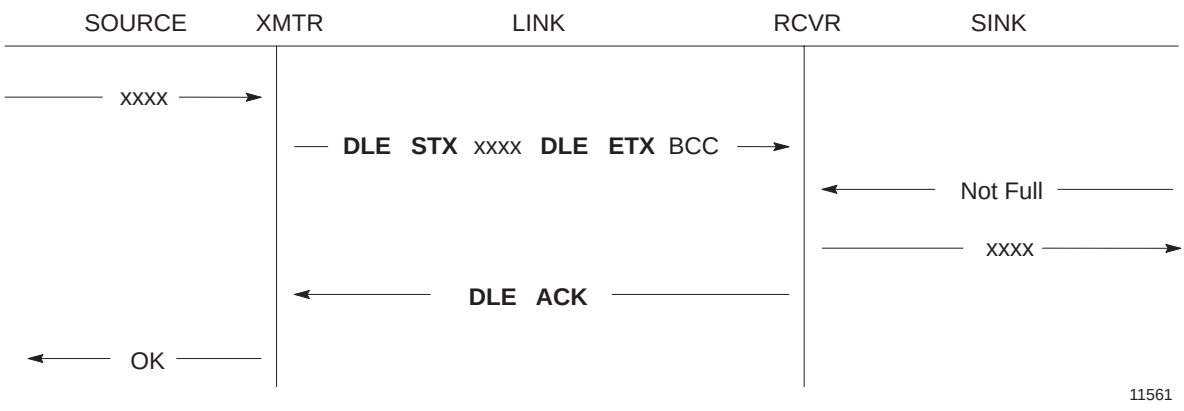
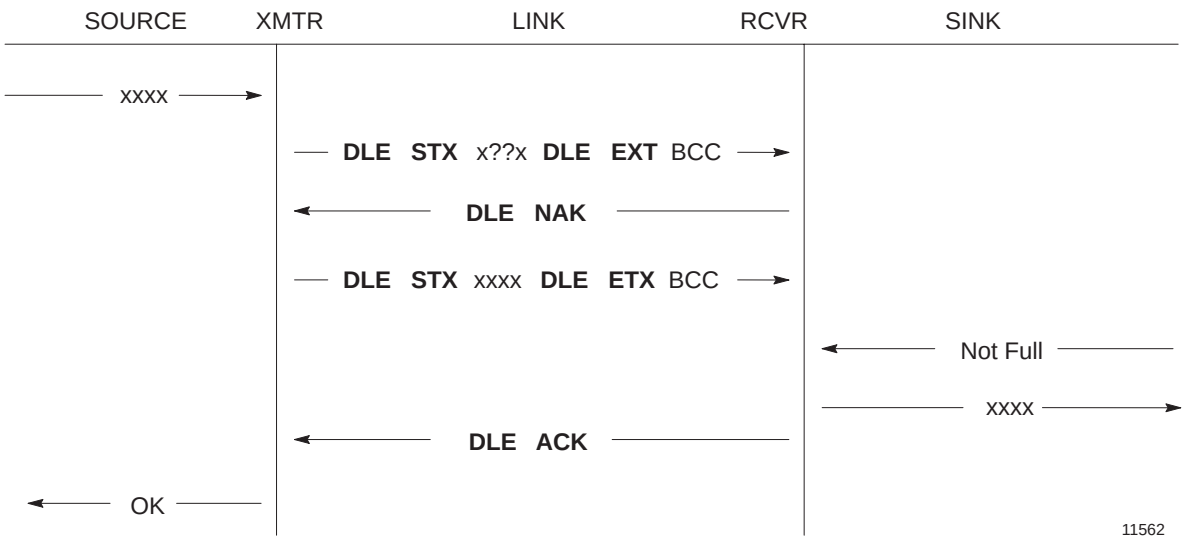


Figure 4.10
Message Transfer with NAK



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Figure 4.11
Message Transfer with Timeout and ENQ

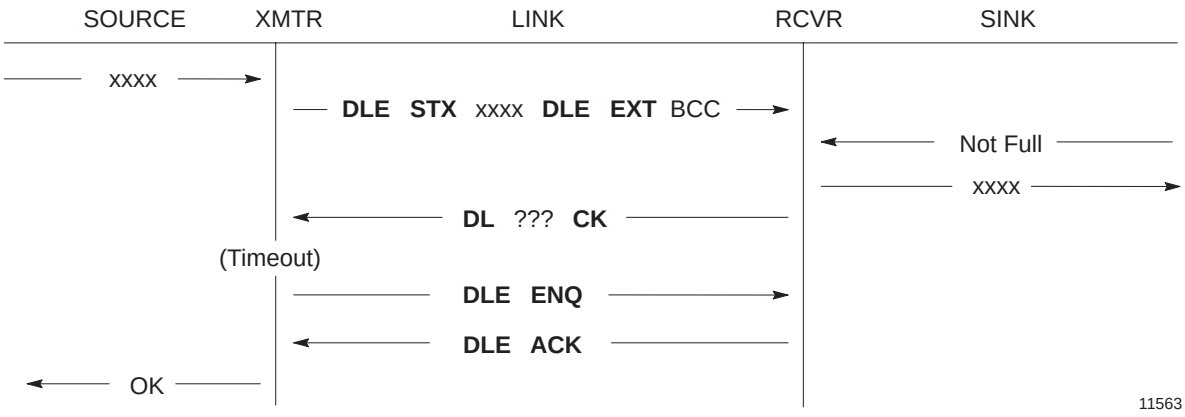
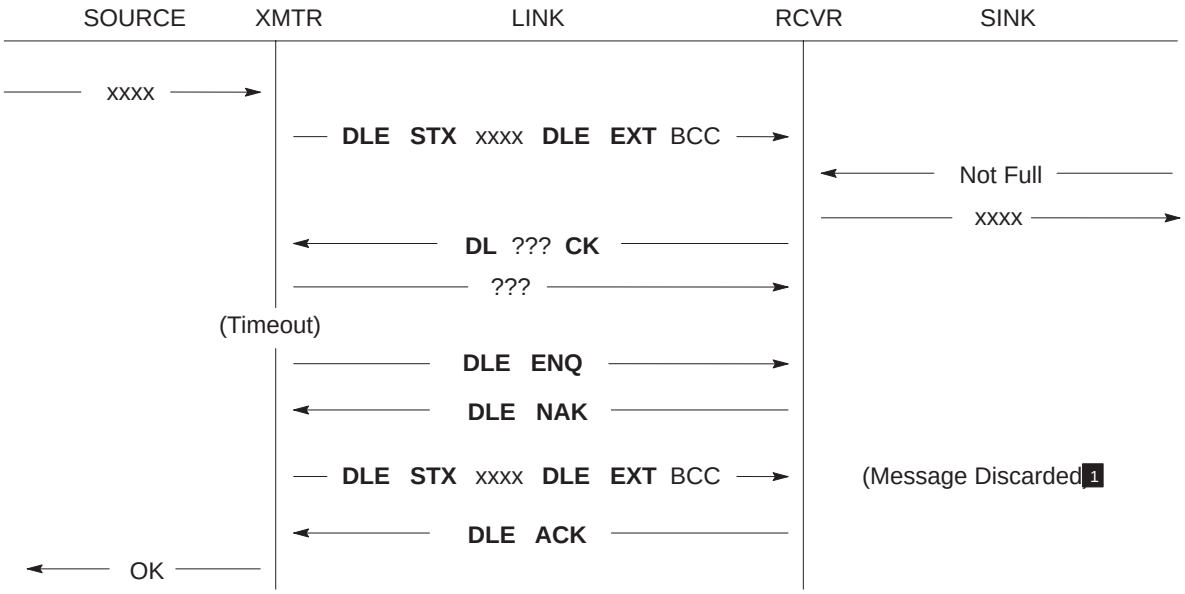


Figure 4.12
Message Transfer with Retransmission

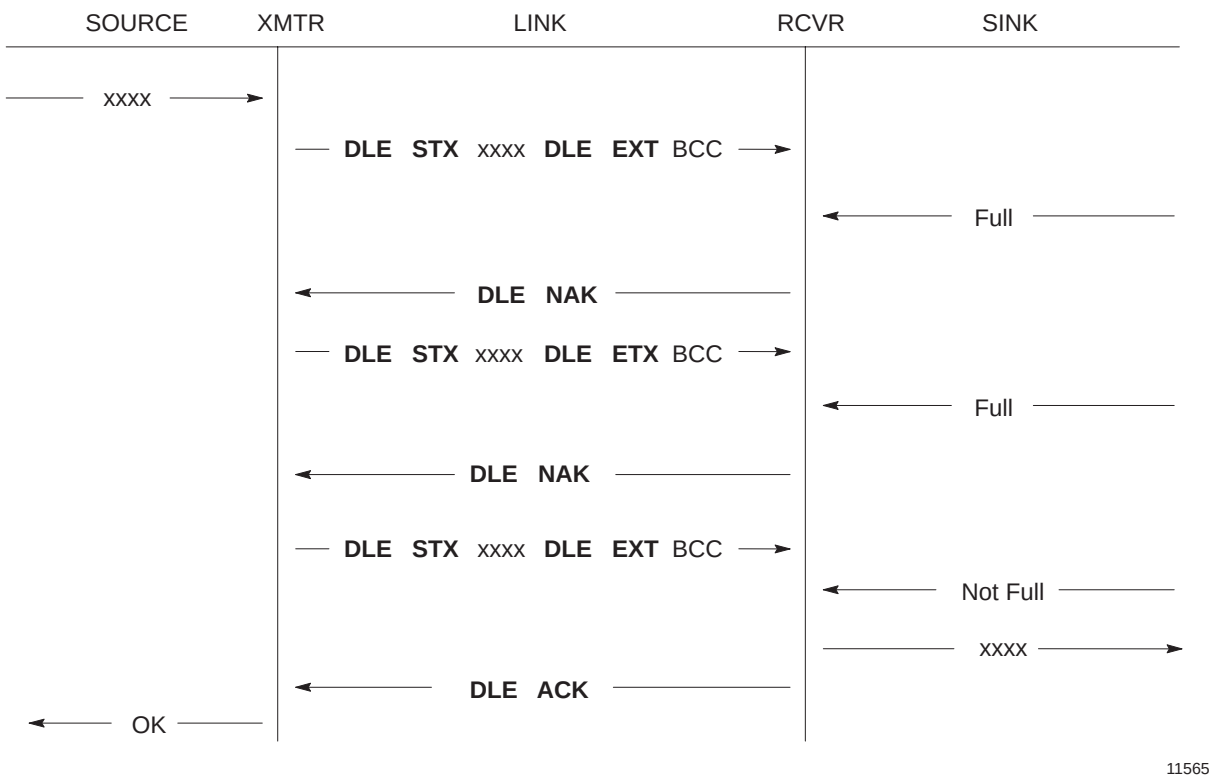


1 Note that this is detected as a duplicate message.

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Figure 4.13
Message Transfer with Message Sink Full



Retransmission occurs when noise hits both sides of the line. This type of noise destroys the DLE ACK while also producing invalid characters at the receiver. The result is that the receiver changes its last response to NAK and the transmitter retransmits the original message. Note that this is detected as a duplicate message if Switch 1 of Switch Group SW-1 is on.

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Examples

If a line monitor were connected to the wires between Stations A and B, and only the A to B subsystem were active, the following would be observed:

Normal Message

```
Path 1:  DLE STX ... DLE ETX BCC          DLE STX .... DLE ETX BCC
Path 2:                          DLE ACK                          DLE ACK
```

Message with Parity or BCC Error and Recovery

```
Path 1:  DLE STX ...xxx.. DLE ETX BCC          DLE STX .... DLE ETX BCC
Path 2:                          DLE NAK                          DLE ACK
```

Message with ETX Destroyed

```
Path 1:  DLE STX .....xxxx [timeout] DLE ENQ          DLE STX .... DLE ETX BCC
Path 2:                                   DLE NAK                          DLE ACK
```

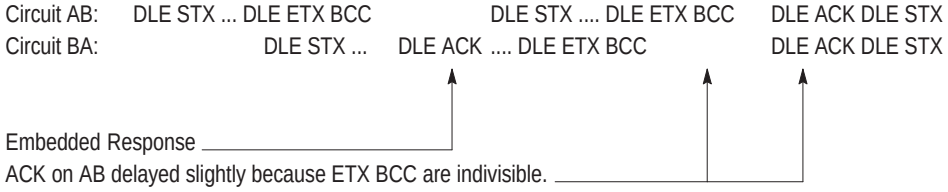
Good Message but ACK Destroyed

```
Path 1:  DLE STX ... DLE ETX BCC          [timeout] DLE ENQ          DLE STX ... etc.
Path 2:                          DL xxx CK                DLE ACK
```

Messages Being Sent in Both Directions

```
Path 1:  DLE STX ... DLE ETX BCC          DLE STX .... DLE ETX BCC          DLE STX
Path 2:                          DLE ACK                          DLE ACK
Path 3:                DLE STX ...          .... DLE ETX BCC                DLE STX
Path 4:                                                          DLE ACK
```

Combined



Embedded Response Option

To simplify the design of the receiver, you can, in some cases, disable transmission of embedded responses by turning off communication option Switch 2 of Switch Group SW-1. If this switch is OFF, the KF2 module's multiplexer will not allow response codes to be sent within a message. Instead, it will delay response codes until after it receives the next DLE ETX BCC.

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Half-Duplex Protocol

Half-duplex protocol is the alternative to full-duplex protocol. You can select half-duplex protocol by setting communication option Switches 1, 2, and 5 of SW-1. Half-duplex protocol is based on full-duplex but extends or redefines several features.

Half-duplex protocol is a multi-drop protocol for one master and one or more slaves. Modems must be used (unless there is only one slave). KF2 modules have slave mode capability only; the master function must be provided by a user-programmed intelligent device.

Half-duplex protocol provides a lower effective utilization of resources than full-duplex, but it is much easier to implement. Its use is indicated by the following:

- Multiple stations and a single computer are connected in a multi-drop configuration using multi-drop modems.
- Half-duplex modems are being used.
- It is desirable to sacrifice throughput in exchange for ease of implementation.

Half-duplex protocol requires the following communication characteristics:

- 8 Bits per Character
- Even Parity
- 1 Stop Bit
- Pass-All Mode (The terminal driver does not translate or respond to control characters.)
- Single Character Buffer (The terminal driver immediately returns each character to the caller.)

Multi-Drop Topology

The intended environment for half-duplex protocol is a multi-drop link with all stations interfaced through half-duplex modems. The actual nature of the link does not matter much, as long as the modems support request-to-send, clear-to-send, and data-carrier-detect signals. If dial-up modems are used, they must also support data-set-ready and data-terminal-ready; otherwise, DSR should be jumpered to DTR.

There may be from 2 to 256 stations simultaneously connected to a single link. Each station has a receiver permanently connected to the circuit and a transmitter that may be enabled or disabled by RTS.

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One station is designated as master, and it controls which station has access to the link. You can use a 1771-KGM PLC-2 Family module as the master, or this function can be performed by your own programmed intelligent device. All other stations are called slaves and must wait for permission from the master before transmitting. Each slave station has a unique station number from 0 to 254.

The master can send and receive messages to and from each station on the multi-drop. The master can send and receive messages to and from every station on highways that are connected to the multi-drop via a KF2 module. If the master is programmed to relay messages, then stations on the multi-drop can engage in peer-to-peer communications. The multi-drop will not easily provide flexible peer-to-peer communication between the multi-drop and connected highways, or between different highways.

Either a two-circuit system (master sends and slaves receive on one circuit, slaves send and master receives on the other), or a one-circuit system (master and slaves send and receive on the same circuit) can be used.

Half-duplex dial-up modems can be used as long as a carrier is detected before the carrier timeout (about 8 seconds). If a carrier is not sensed before the timeout, the module will hang up the phone. Carrier must be sensed at least every 8 seconds to maintain the connection.

Multiple masters are not allowed, except when one acts as a backup to the other and does not communicate unless the primary is shut down.

Transmission Codes

Half-duplex protocol is a character-oriented protocol that uses the following ASCII control characters extended to 8 bits by adding a zero for Bit 7. See ANSI X3.4, CCITT V.3, or ISO 646 for the standard definition of these characters.

Control Character	Hexadecimal Code
SOH (Start of Header)	01
STX (Start of Text)	02
ETX (End of Text)	03
EOT (End of Transmission)	04
ENQ (Enquiry)	05
ACK (Acknowledge)	06
DLE (Data Link Escape)	10
NAK (Negative Acknowledge)	15

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The term “code” means (in the following paragraphs) an indivisible sequence of one or more bytes having a specific meaning to the link protocol. “Indivisible” means that the component characters of a code must be sent one after another with no other characters inserted between them. It does not refer to the timing of the characters. (This definition has less significance than for full-duplex protocol since there is no multiplexing of transmission codes in half-duplex protocol.)

These codes are used in half-duplex protocol:

- Control Codes:
  - DLE SOH
  - DLE STX
  - DLE ETX BCC/CRC
  - DLE ACK
  - DLE NAK
  - DLE ENQ
  - DLE EOT
- Data Codes:
  - DATA (single characters having values 00-0F and 11-FF hex)
  - DLE DLE (to represent the value 10 hex)

DLE SOH indicates the start of a message.

DLE STX separates the link level header from the data field of a message.

DLE ETX BCC/CRC terminates a message.

DATA 00-0F and 11-FF encode the corresponding values in the message itself. DLE DLE encodes the occurrence of the value 10 in the message.

DLE ACK signals that a message has been successfully received.

DLE NAK is used as a global link reset command and can be issued only by the master. It causes all slaves to cancel all messages that are ready to be transmitted to the master. Typically the slave will return the messages to the command originator with an error code.

DLE ENQ starts a poll command.

DLE EOT is used by slaves as a response to a poll when they have no messages to send.

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Link-Layer Packets

Half-duplex protocol uses three types of transmissions:

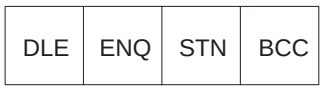
- Polling Packet
- Master Message Packet
- Slave Message Packet

The master station transmits both polling packets and master message packets, while slave stations transmit slave message packets.

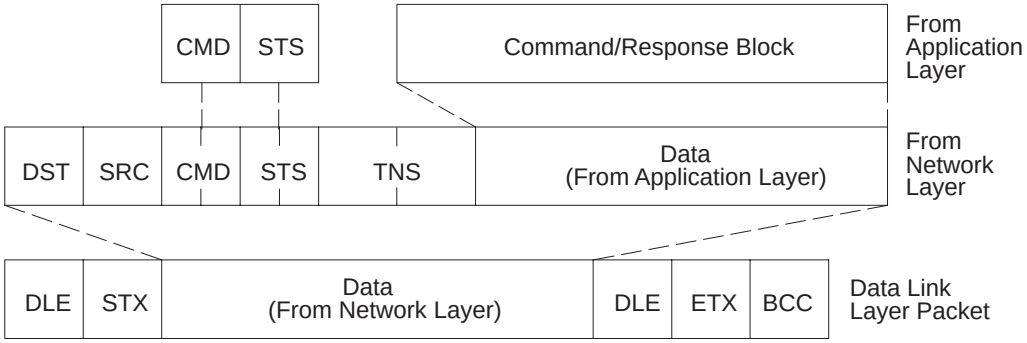
Figure 4.14 illustrates the formats of these packets. Note that the slave message packet has the same format as the full-duplex message packet (see "Link-Layer Message Packets"). The master message packet is the same as the slave message packet except that it is prefixed with DLE SOH and an address code to specify a slave station number.

Figure 4.14
Packet Formats for Half-Duplex Protocol

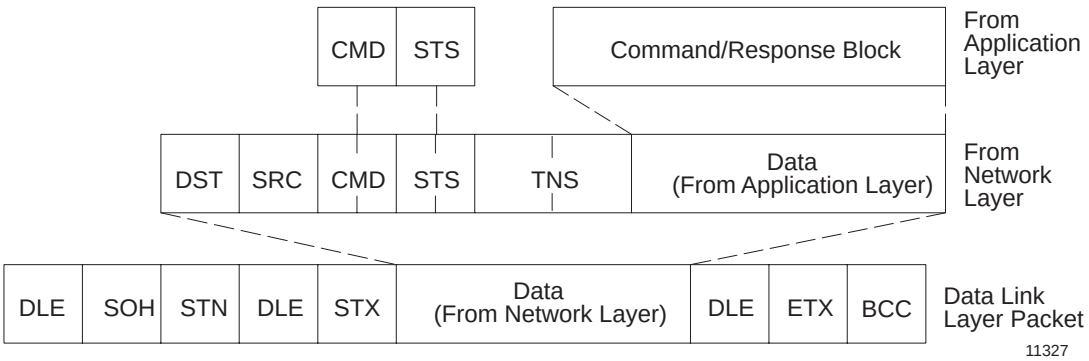
A. Polling Packet



B. Slave Message Link Packet



C. Master Message Link Packet



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At the end of each polling packet there is a BCC byte. At the end of each message packet, there is either a one-byte BCC field or a two-byte CRC field. You can select BCC or CRC through switch settings (see Chapter 3, “Asynchronous Link Features”).

Block Check

The block check character (BCC) is a means of checking the accuracy of each packet transmission. It is the 2’s complement of the 8-bit sum (modulo-256 arithmetic sum) of the slave station number (STN) and all the data bytes in the packet. For polling packets, the BCC is simply the 2’s complement of STN. The BCC does not include any other message packet codes or response codes.

Example 1: If the master station wanted to send the data codes 08, 09, 06, 00, 02, 04, and 03 to Slave Station 20 hex (40 octal), the master message codes would be (in hex):

10	01	20	10	02	08 09 06 00 02 04 03	10	03	C0
DLE	SOH	STN	DLE	STX	Data	DLE	ETX	BCC

The sum of the STN and data bytes in this message packet is 40 hex. The BCC is the 2’s complement of this sum, or C0 hex. This is shown in the following binary calculation:

0100 0000	40 hex
1011 1111	1’s complement
+1	
1100 0000	2’s complement (C0 hex)

Example 2: To transmit the STN or data value 10 hex, you must use the data code DLE DLE. However, only one of these DLE text characters is included in the BCC sum. For example, to transmit the values 08, 09, 06, 00, 10, 04, and 03 hex, a slave station would use the following message codes:

Represents Single Text Value of 10

10	02	08 09 06 00 10 10 04 03	10	03	D2
DLE	STX	Data	DLE	ETX	BCC

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In this case, the sum of the data bytes is 2E hex because only one DLE text code is included in the BCC. So the BCC is D2 hex.

The BCC algorithm provides a medium level of data security. It cannot detect transposition of bytes during transmission of a packet. It also cannot detect the insertion or deletion of data values of zero within a packet.

Cyclic Redundancy Check

Calculate the CRC value on the value of the data bytes and the ETX byte (using the polynomial $x^{16} + x^{15} + x^2 + x^0$). To transmit the data value of 10 hex, you must use the data code DLE DLE. However, only one of these DLE data bytes is included in the CRC value. Embedded responses are not included in the CRC value.

At the start of a message packet, the transmitter clears a 16-bit register for the CRC value. As a byte is transmitted, it is exclusive-ORed (with Bit 0 to the right) to the right eight bits of the register. The register is then shifted right eight times with zeros (0s) inserted on the left. Each time a one (1) is shifted out on the right, the following binary number is exclusive-ORed with the 16-bit register value:

1010 0000 0000 0001

As each additional byte is transmitted, it is included in the value in the register the same way. After the ETX value is included in the value in the register and is transmitted, the value in the register is transmitted (right bit first) as the CRC field.

The receiver also calculates the CRC value and compares it to the received CRC value to verify the accuracy of the data received.

Important: In half-duplex mode there is a BCC on the polling packet regardless of whether BCC or CRC error checking is used on messages.

Master/Slave Transceiver

In each station there is a program associated with the physical link called the transceiver. The master station has a more complex transceiver than the slave, since it must include a polling algorithm. The slave's

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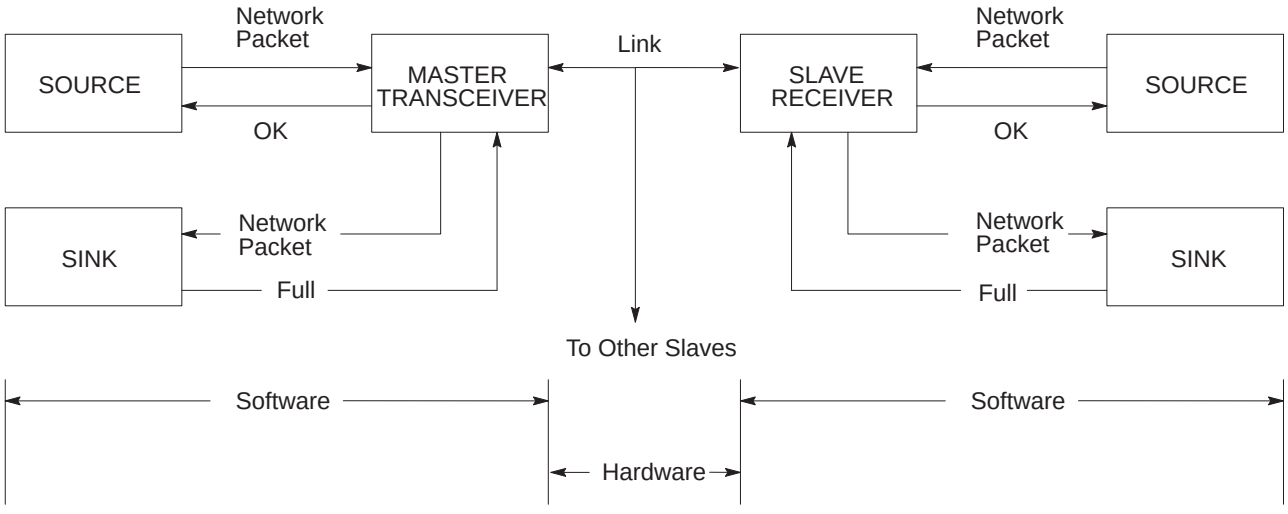
transceiver is illustrated in Figure 4.15, and the master transceiver is illustrated in Figure 4.16.

To fully define the environment of the protocol, the transceiver needs to know where to get the messages it sends and must have a means of disposing of messages it receives. These are implementation-dependent functions that shall respectively be called the message source and the message sink.

We assume that the message source will supply one message at a time upon request from the transceiver and will require notification of the success or failure of transfer before supplying the next message.

When the transceiver has received a message successfully, it will attempt to give it to the message sink. The possibility exists that the message sink will be full. The transceiver requires an indication of this.

Figure 4.15
Slave Transceiver



Message Characteristics

Ideally, the link protocol should not be at all concerned with the content or form of the messages it is transferring. However, half-duplex protocol places the following restrictions on the messages that are submitted to it for transfer:

1. Minimum size of a valid message is 6 bytes, maximum is 250 bytes.

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2. Some protocol implementations require that the first byte of a message match the station address. These receivers will ignore messages that do not contain the correct address. This filtering is not required, since the message sink can also provide the address filtering function.

3. As part of the duplicate message detection algorithm, the receiver checks the second, third, fifth, and sixth bytes of each message. There must be a difference in at least one of these bytes between a message and its predecessor for it to be recognized as distinct rather than a retransmission of the previous message.

Master Polling Responsibilities

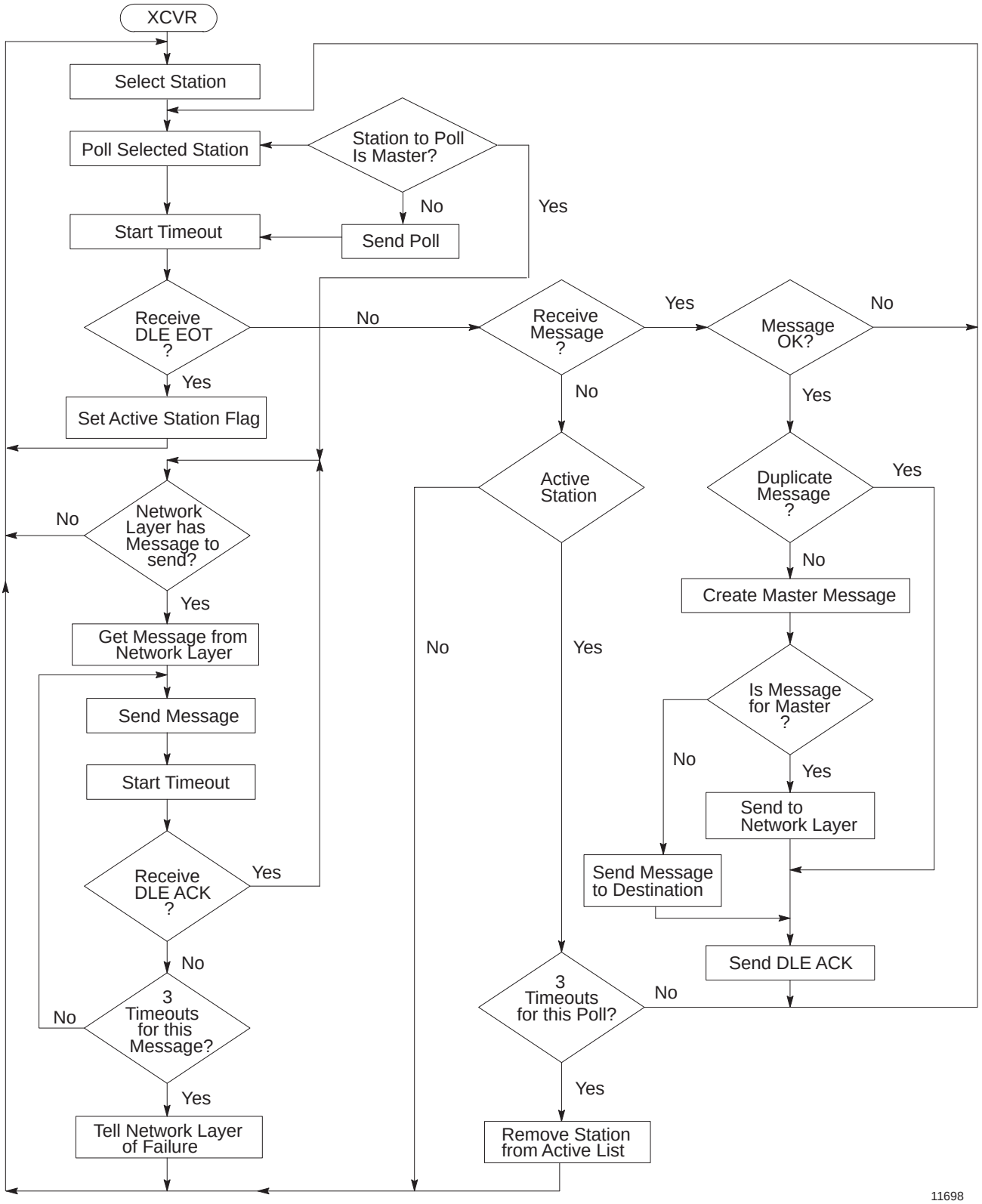
The master polling algorithm may vary depending on the expected flow of traffic through the system.

A simple master that does not expect unsolicited messages continuously polls each slave once in a round-robin fashion. If a message is received, it should be handled, then the next station polled. An alternative scheme would poll each station repeatedly until it was empty and then proceed to the next. Relaying of peer-to-peer messages is best left to the network layer, which is the lowest level of the body of software that includes the message source and sink.

Figure 4.16 is a flowchart of the software logic for implementing half-duplex protocol from the master station's point of view.

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Figure 4.16
Half-Duplex Master Transceiver



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Slave Transceiver Actions

Since the transceiver receives “dirty” input from the physical world, it must be capable of responding to many adverse situations. Some of the things that could conceivably happen are listed below:

1. The message sink can be full, leaving nowhere to put a message.
2. A message can contain a parity error.
3. The BCC can be invalid.
4. The DLE SOH, DLE STX, or DLE ETX BCC may be missing.
5. The message can be too long or too short.
6. A spurious control or data code can occur outside a message.
7. A spurious control code can occur inside a message.
8. The DLE ACK response can be lost, causing the transmitter to send a duplicate copy of a message that has already been passed to the message sink.

The slave is always in a passive mode until it receives a message. While waiting for a message, anything besides the DLE SOH or DLE ENQ is ignored. Note that in a single circuit system the slaves must be able to safely ignore everything sent by other slaves.

If a DLE SOH is received, the BCC and the message buffer are reset. The next code received must be a data code and must equal the station address or 255 (if the station can receive broadcast messages). If there is no match, the station ignores the rest of the message and continues waiting for the start of the message.

If the station address matches, it is added to the BCC. The next code is received and must match DLE STX. If it doesn’t, the station ignores the rest of the message. Otherwise it starts building a message.

While building a message, all data codes are stored in the message buffer and added to the BCC. If the buffer overflows, the receiver continues

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summing the BCC, but the data is discarded. If an error is detected, it is recorded. If any control code other than a DLE ETX BCC is received, the error flag, the BCC, the message size, and the address (optionally) are all checked. If any of the tests fail, the message is ignored.

If the message is OK, its header is compared to the last message. If it is the same, the message is discarded and a DLE ACK is transmitted. If it is different, the new header is saved and the message is sent to the message sink. If the message can be stored, a DLE ACK is sent. If the message sink is full, the message is discarded and not acknowledged.

If while waiting for a message a DLE ENQ is received, the transceiver accepts the next two characters. The last character is read directly from the link, since it is a BCC and is not byte stuffed. If the station address does not match or there is an error, the poll is ignored. If the poll is accepted, there are three possible situations:

1. The transceiver could still be holding a message that it had transmitted previously but had not been ACKed. There is a limit on the number of times each message can be sent. If this limit is exceeded when the poll is received, the message is returned to the message source with an error indication, and the transceiver tries to send the next message from the message source. If the limit is not exceeded, the response to the poll will be to resend the current message.

2. If no message is currently being held, the transceiver tries to get one from the message source. If one is available, the transceiver will initialize its retry counter and transmit it in response to the poll.

3. If no message is available, the response to a poll will be to transmit a DLE EOT.

When a message is transmitted after receiving a poll, its format is identical to a full-duplex message packet. After sending a message, the transceiver will hold the message until a DLE ACK is received, or the number of times the message has been polled exceeds the limit.

When a DLE ACK is received, the message currently held is discarded. When the next poll is received, the next message available from the message source is sent (or a DLE EOT).

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When a DLE NAK is received, the transceiver takes messages from the source until it is empty. Each message will be discarded with an error code sent back to the message source. This can be used by the master to clear up the message source buffers of all slaves after the master has been down.

Half-Duplex Protocol Diagrams

The following figures show some of the events that occur on various interfaces. Time is represented as increasing from the top of the figure to the bottom.

Figure 4.17
Normal Message Transfer

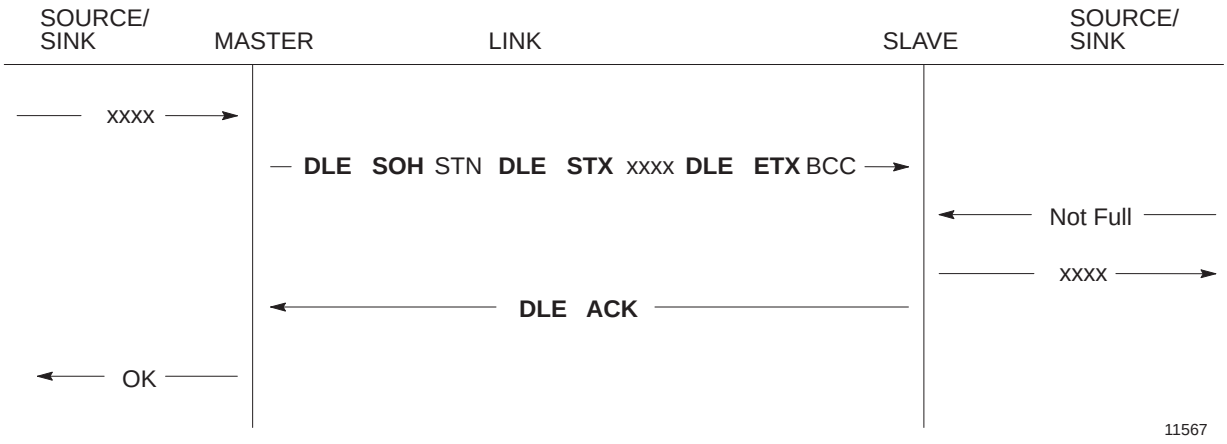
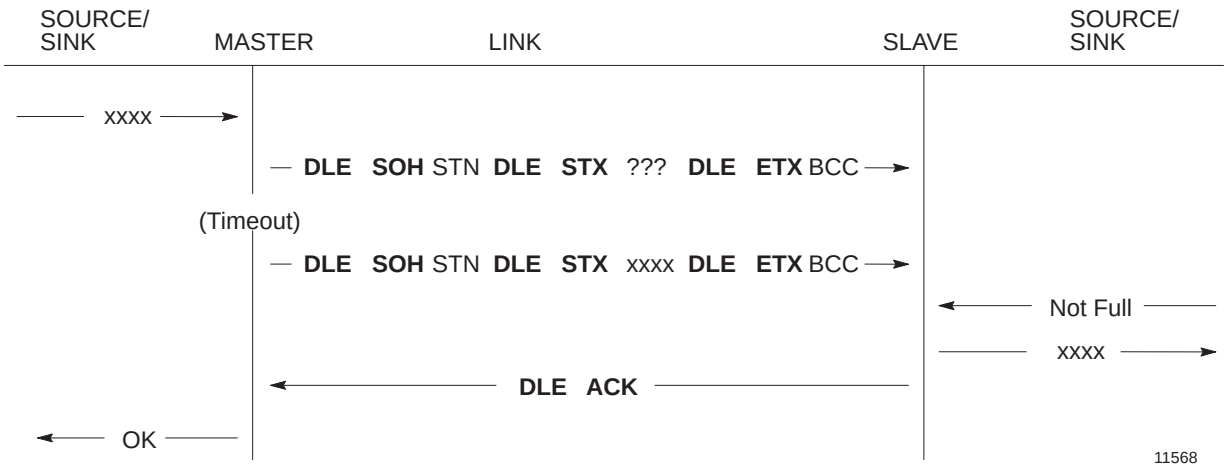


Figure 4.18
Message Transfer with Invalid BCC



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Figure 4.19
Message Transfer with ACK Destroyed

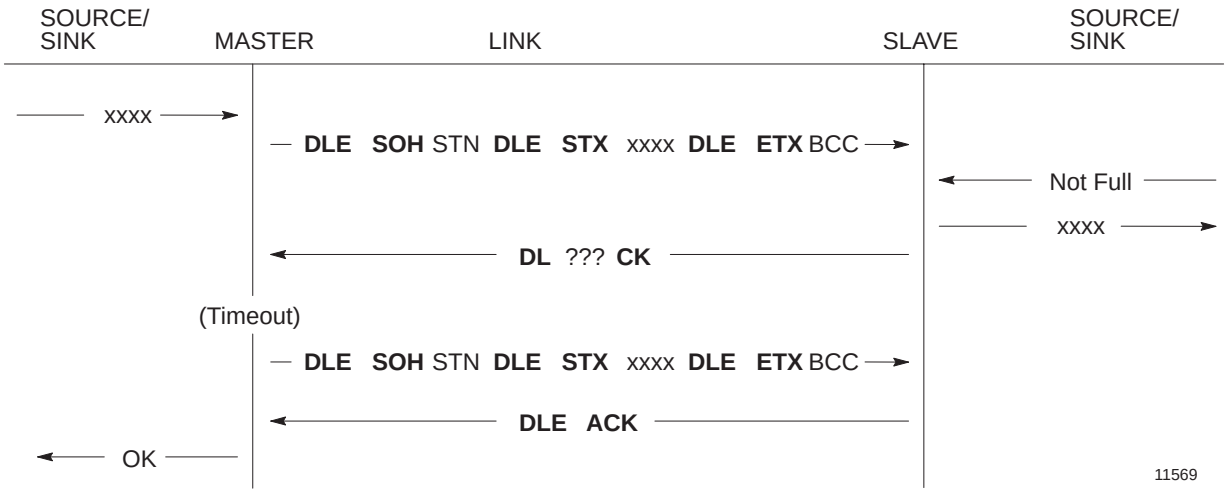


Figure 4.20
Poll with No Message Available

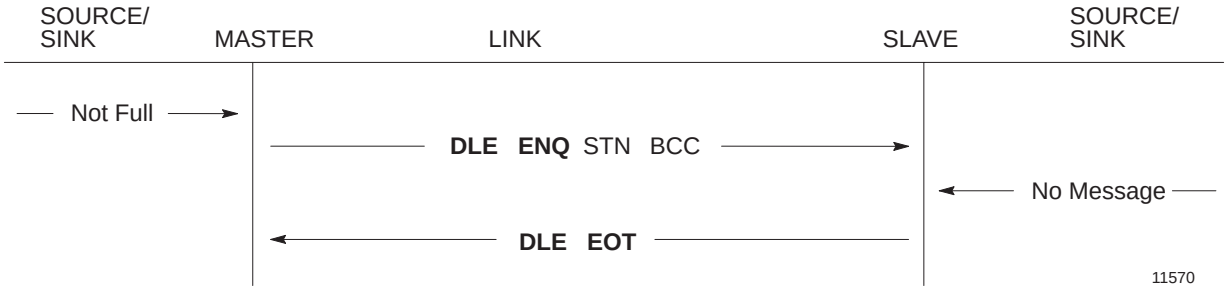
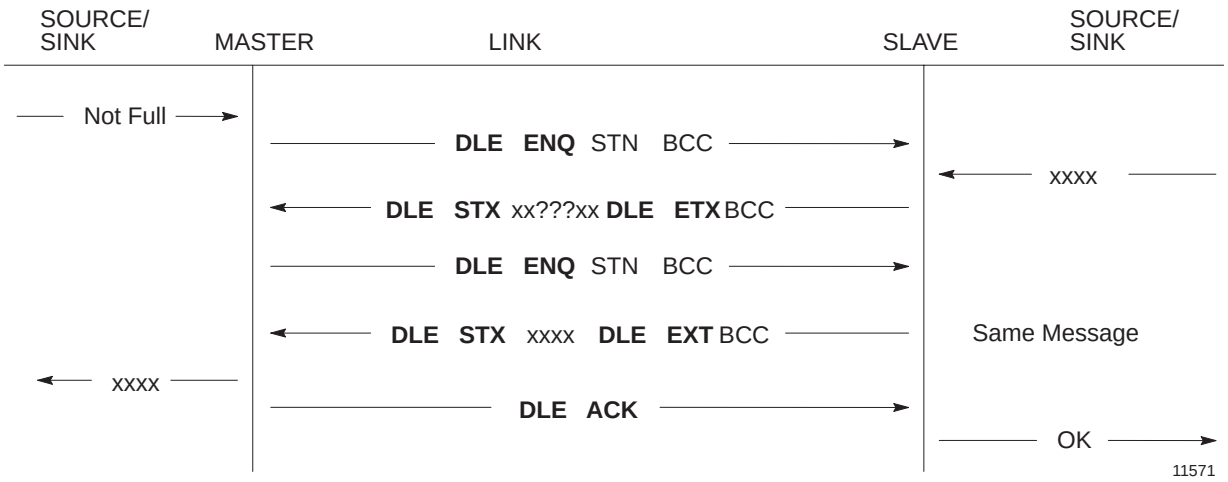


Figure 4.21
Poll with Message Returned



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Figure 4.22
Duplicate Message Transmission

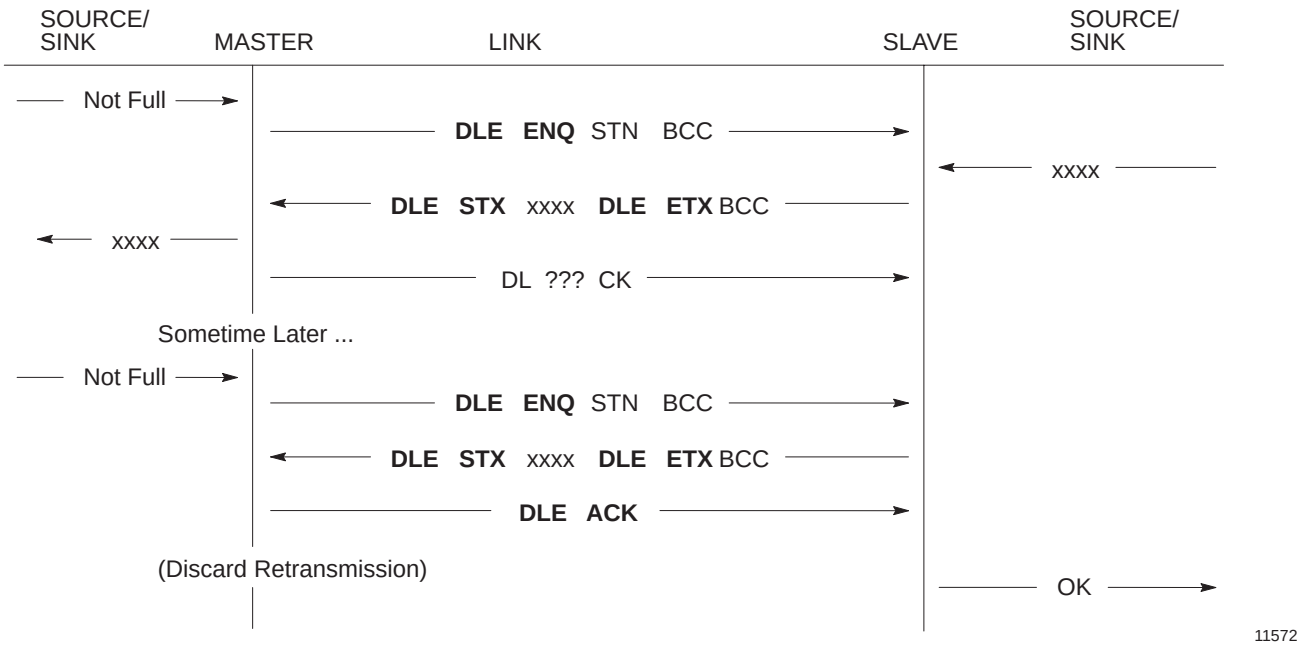
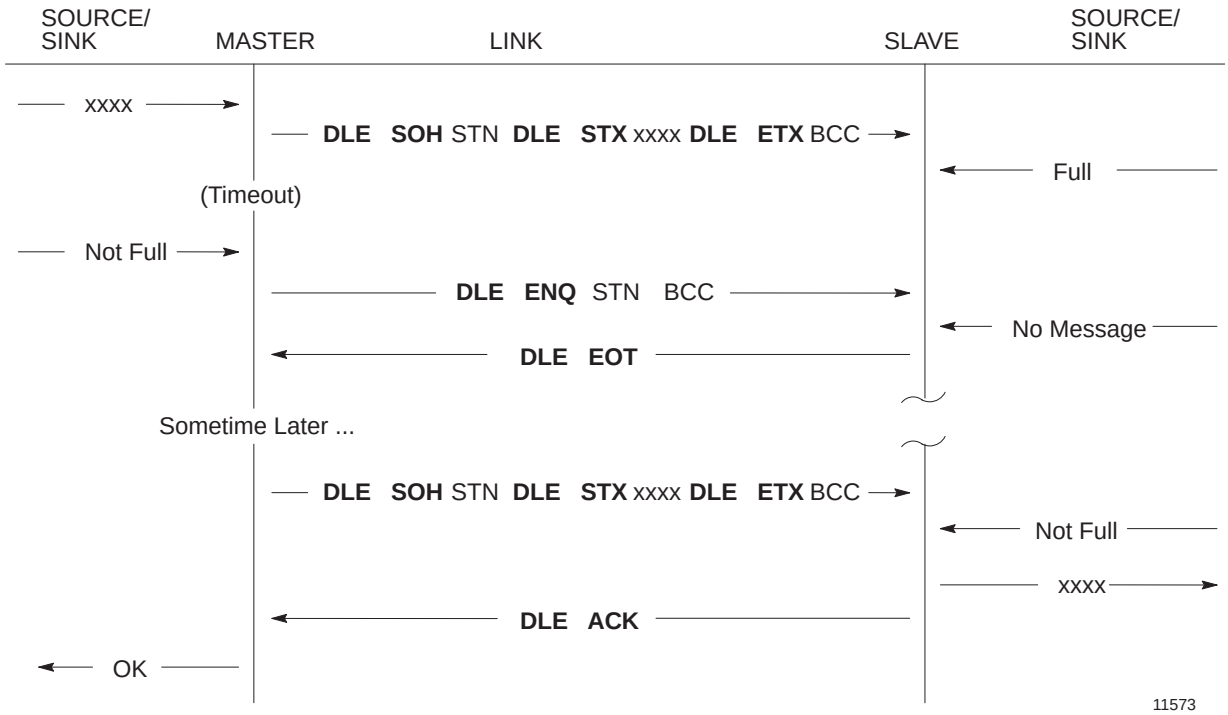
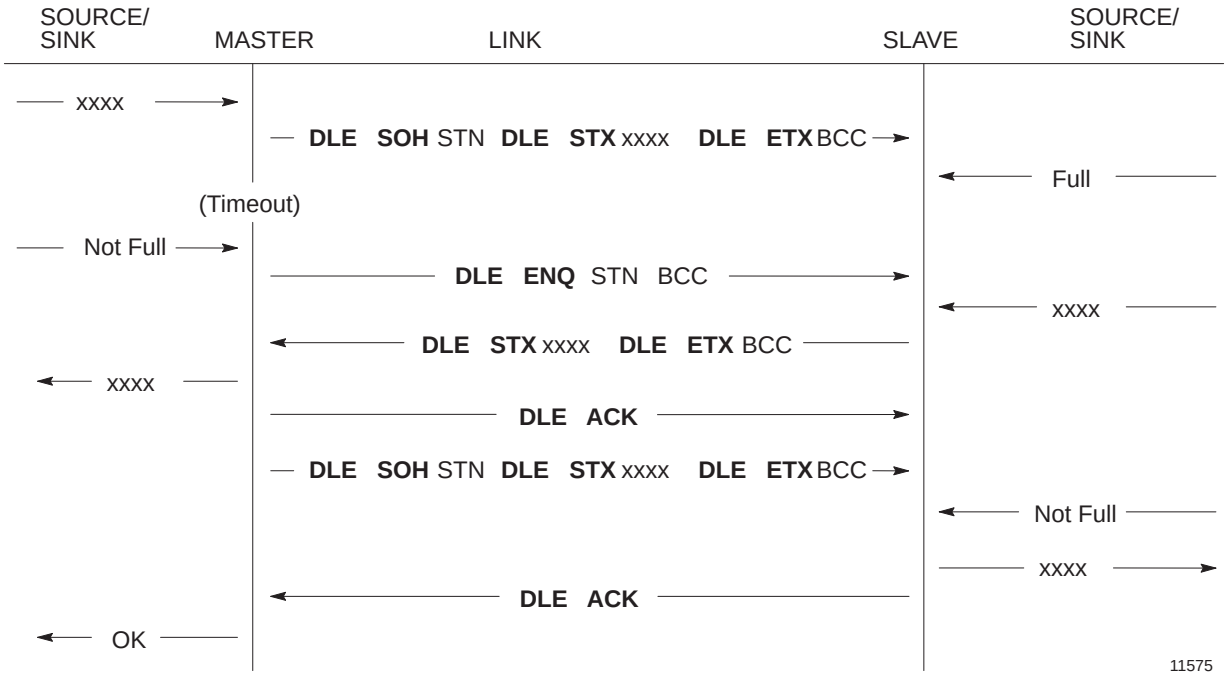


Figure 4.23
Message Sink Full, Case 1



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Figure 4.24
Message Sink Full, Case 2



The message sent for the second poll is the same as the first, since the first transmission was not ACKed. Also, the master should ACK and discard the second message, since it was a retransmission. This means that the master must either poll a station repeatedly until it receives a DLE EOT, without polling any other stations, to be sure it has detected all retransmissions.

If each station is polled only once per cycle, the master must keep a record of the last header from each station, since other stations may transfer messages between retransmissions from a station.

When a station times out, it is a good idea to poll it to see if it is there. If it answers with a DLE EOT to a message, but consistently fails to a ACK a message, its message sink is probably full. If it responds DLE EOT to a poll, you must wait for the buffers to clear.

When a station's message source and sink share a common memory pool, it may be that the message sink "full" indication results from an abundance of messages in the message source, which use up all free pool memory. In this case, the memory can be freed up by receiving messages from the station. Waiting for the memory to clear by the action of the

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station alone may not work, since it could be that the only way to free up space is to send a message to the master.

Line Monitoring

When monitoring half-duplex protocol in two-wire mode, you need to monitor only one line. The example below shows a message sent by the master and a reply sent by the slave in answer to a poll. Slave responses are in boldface.

Message from Master to Slave:

DLE SOH STN DLE STX message DLE ETX BCC **DLE ACK**

Message Sent from Slave to Master in Response to Poll:

DLE ENQ STN BCC **DLE STX message DLE ETX BCC** DLE ACK

Poll with a DLE EOT in Response:

DLE ENQ STN BCC **DLE EOT**

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Chapter 5

Message Packet Formats

General

This chapter describes how your computer application programs should format command and reply messages for transmission over the asynchronous link. It covers both application level and network level functions. Basically, the application layer specifies the contents of messages and initiates their transmissions. The network layer takes the information from the application layer and formats it in a way that is acceptable to the data link layer (Chapter 4).

Application Layer

There are two types of application programs: command **initiators** and command **executors**. These names correspond with the two message types:

- Command Messages — Sent by command initiators to command executors.
- Reply Messages — Sent by command executors in response to command messages received from command initiators.

Each command message requires one reply message.

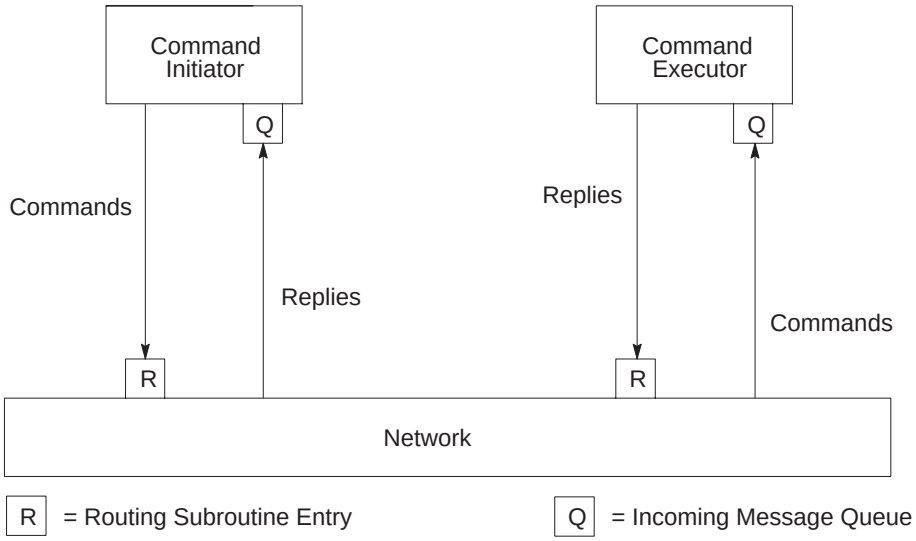
Command initiators specify which command function to execute at a particular destination station. The command executor at that destination station is responsible for interpreting the command message and executing the specified command function. The command executor also issues a reply message for each command it receives. If it cannot execute the received command, the command executor must generate the appropriate error message.

Network Layer

Internally, the KF2 module uses a routing subroutine and a message queue to implement the network layer. When the module receives a message over its asynchronous port, it puts that message in the queue. The routing subroutine then takes the message from the queue and transmits it over the Data Highway link. The module also queues messages received from the Data Highway, and the routing subroutine retransmits those messages over the asynchronous link. Figure 5.1 illustrates this model.

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Figure 5.1
Network Model



Messages do not necessarily arrive at their destination in the same order that they were sent. It is impossible for the network layer to guarantee delivery, and in some cases it may not be possible to provide notification of non-delivery.

In particular, the network layer does not notify the command executor about non-delivery of a reply message. Therefore, it is advisable that your command initiator maintain a timer for each outstanding command message. If the time limit expires before the command initiator receives the corresponding reply to its command, it can either retransmit the same command message or indicate an error condition.

If your network layer software cannot deliver a command message, it should generate a reply message with an error code in it and send that reply to the command initiator. If it cannot deliver a reply message, the network layer software should simply destroy the reply without notification to the command executor.

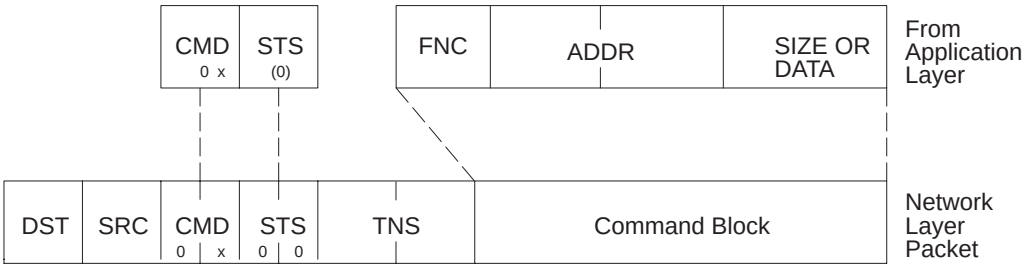
If your link layer software cannot deliver a message over the asynchronous link, it also should return an error message to the command initiator.

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Message Packets

The message bytes contain unsigned binary data from both the application layer and the network layer. Figure 5.2 shows the general format of a command message.

Figure 5.2
Command Message Packet Format



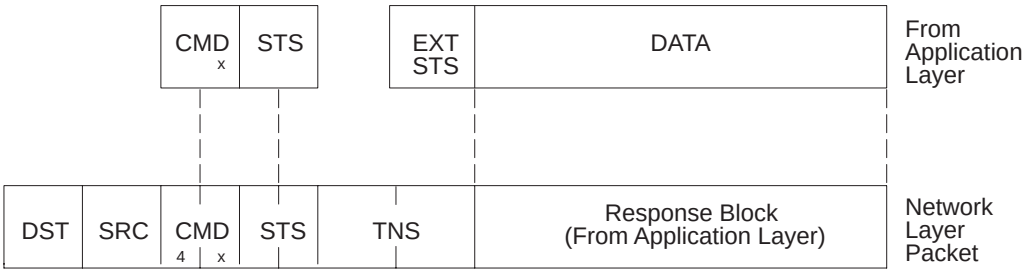
Legend: x = low hex digit of CMD byte supplied by application layer

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Not all command messages have FNC, ADDR, SIZE, or DATA bytes.

Figure 5.3 shows the general format of a reply message. The definitions of these bytes are the same as those for command messages. Not all reply messages have DATA or EXT STS bytes.

Figure 5.3
Reply Message Packet Format



Legend: x = low hex digit of CMD byte supplied by application layer

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Note that the bytes are shown from left to right in the order in which they are transmitted across the link.

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The meanings of the bytes are:

- DST — Destination Station for the Message
- SRC — Source Station of the Message
- CMD — Command Code
- STS — Status Code
- TNS — Transaction Number (2 Bytes)
- FNC — Function Code
- EXT STS — Extended Status Code
- ADDR — Address of Memory Location (2 Bytes Minimum)
- SIZE — Number of Bytes to Be Transferred
- DATA — Data Values Being Transferred by the Message

These bytes are described in more detail below.

DST and SRC

The DST (destination) byte contains the station number of the station that is the ultimate destination of the message. The SRC (source) byte is the station number of the station that originated the message.

The network layer supplies the DST and SRC values. Allowed values for these bytes are 0 to 254 decimal (0 to 376 octal). Note that you can form the DST and SRC bytes of a reply message simply by interchanging the DST and SRC bytes of the corresponding command message.

In application programming of a computer connected to the network by a KF2, the SRC byte should be set to zero. The module will set the byte to its own station number.

CMD and FNC

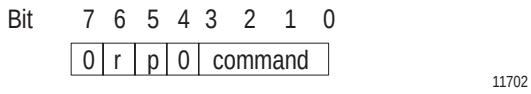
The CMD (command) and FNC (function) bytes together define the activity to be performed by the command message at the destination station. CMD defines the command type; and FNC, if used, defines the specific function under that command type.

Table 5.A lists all the available CMD and FNC codes in hexadecimal notation. The exact format for a particular message depends on the CMD and FNC values. “Message Formats” explains the use of each command or function and gives a detailed description of the message text format for each.

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Figure 5.4 shows the format for the CMD byte itself. Bits 0 through 3 contain the command code. Bits 4 and 7 should always be set to 0. Bit 5 is the priority indicator; set to 0 for normal priority messages and 1 for high priority messages (Chapter 2). Bit 6 is the command/reply indicator; set it to 0 in a command message and 1 in a reply message.

Figure 5.4
CMD Byte Format



Reply messages also contain a CMD byte. To form the CMD value for a reply, the network layer copies the CMD value from the corresponding command message and sets the reply bit (Bit 6) to 1.

The application layer supplies the FNC value and the command code (Bits 0 to 3) of the CMD byte for each command message. The network layer supplies Bits 4 through 7 of the CMD byte.

STS and EXT STS

The STS (status) and EXT STS (extended status) bytes indicate the status of the message transmission. In command messages, the application program should always set the STS value to 0. In reply messages, the STS byte may contain one of the status codes listed in Chapter 7. If the four high bits of that byte are 1s (0F hex), there is extended status information in an EXT STS byte. Otherwise, there is no EXT STS byte. Note that an STS value of 0 in a reply message means “no error.”

In a reply message, the STS byte is divided between application layer and network layer. The network layer uses Bits 0 through 3 of the STS byte to report local errors (those errors that occur when the network layer attempts to transmit a message across the link).

The application layer uses Bits 4 through 7 of the STS byte (and in some cases the EXT STS byte), to report remote errors (those errors that occur when the command executor at the destination station tries to execute the command message). Chapter 7 explains local and remote error codes.

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TNS

A complete transaction consists of a command message transmitted by a PC station. The TNS (transaction) bytes contain a a unique 16-bit transaction identifier. The first byte, RNG, contains the number of the PC program rung that generated the command; and the second, SQN, contains the transmission sequence number. For command messages transmitted by your computer station, your application programs can use the RNG and SQN bytes together to store a single 16-bit transaction number.

For command messages transmitted by a PC station, the station interface module assigns the TNS values. For each command message transmitted by your computer station, your network level software must assign a unique 16-bit transaction number; and a simple way to generate this number is to maintain a 16-bit counter at the network layer. Increment the counter every time your command initiator (application program) creates a new message and store the counter value in the two TNS bytes of the new message.

When the command initiator receives a reply to one of its command messages, it can use the RNG and SQN bytes to tie the reply message to its corresponding command. If the RNG and SQN bytes of a reply message match the RNG and SQN bytes of a command message, then that reply is the appropriate one for that command.

Whenever the command executor receives a command from another station, it should copy the RNG and SQN fields of the command message into the same fields of the corresponding reply message. Do not change the RNG and SQN values in a reply message. If you do, the command initiator will not be able to match its command to the corresponding reply message.

Note that the low byte (least significant bits) of your TNS value will be transmitted across the link before the high byte (most significant bits).

At any instant, the combination of SRC, CMD, RNG, and SQN are sufficient to uniquely identify every message packet in transit. At least one of these fields in the current message must be different than the corresponding field in the last message received by a command executor. If none of these fields is different, the command executor ignores the currently received message. This process is called duplicate message detection.

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ADDR

The ADDR (address) field contains the address of a memory location in the command executor. ADDR specifies the address where the command is to begin executing. For example, if the command is to read data from the command executor, ADDR specifies the address of the first byte of data to be read.

Note that the ADDR field specifies a byte address, not a word address as in PC programming. Chapter 6 explains how to convert PC word addresses to byte addresses.

SIZE

The SIZE byte specifies the number of data bytes to be transferred by a message. This field appears in read commands, where it specifies the number of data bytes that the responding station must return in its reply message. The allowed value for SIZE will vary with the type of command, as indicated in the command formats below.

DATA

The DATA field contains binary data from the application program. The number of data bytes in a message depends on the command or function being executed, as indicated in "Message Formats." Chapter 6 gives some details on the format for the data field.

Message Formats

This section presents the detailed message formats for each type of command and reply message. PLC-5 processors cannot be interfaced directly with the Data Highway; they work only on Peer Communication Link (PCL) networks. To access a PLC-5 from a Data Highway station, join the two networks with a 1785-KA PLC-5/Data Highway adapter module. In this manual, the command message formats are discussed in the same order as Table 5.A:

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Table 5.A
Message Formats

If You Want This Command:	Use This CMD Code:	Use This FNC Code:
Basic Command Set		
Diagnostic Counters Reset	06	07
Diagnostic Loop	06	00
Diagnostic Read	06	01
Diagnostic Status	06	03
Protected Bit Write	02	N/A
Protected Write	00	N/A
Set ENQs	06	06
Set NAKs	06	05
Set Timeout	06	04
Set Variables	06	02
Unprotected Bit Write	05	N/A
Unprotected Read	01	N/A
Unprotected Write	08	N/A
PLC Commands		
Disable Outputs	07	00
Enable Program	07	01
Enable Scan	07	03
Physical Read	04	N/A
Physical Write	03	N/A
PLC-2 Commands		
Enter Download Mode	07	04
Enter Upload Mode	07	06
Exit Download/Upload Mode	07	05
Physical Read	04	N/A
Physical Write	03	N/A
Set Data Table Size	06	08
PLC-3 Commands		
Bit Writes	0F	02
Download Request	0F	05
File Read	0F	04
File Write	0F	03
Physical Read	0F	09
Physical Write	0F	08
Restart Request	0F	0A
Shutdown Request	0F	07
Upload Request	0F	06
Word Range Read	0F	01
Word Range Write	0F	00
PLC-4 Commands		
Allocate	0E	05
Deallocate	0E	06
Initialize Processor	0E	0C
Physical Read	0E	0D
Physical Write	0E	0E
Physical Write with Mask	0E	0F
Set to Program Mode	0E	01
Set to Run Mode	0E	02
Set to Single-Step Test Mode	0E	04
Set to Test Mode	0E	03
PLC-5 Commands		
Download All Request	0F	50
Download Completed	0F	52
Modify PLC-2 Compat. File	0F	5E
Read Bytes Physical	0F	17
Read-Modify-Write	0F	26
Set Processor Mode	0F	3A
Typed Read	0F	68
Typed Write	0F	67
Upload All Request	0F	53
Upload Completed	0F	55
Write Bytes Physical	0F	18
Word Range Read	0F	01
Word Range Write	0F	00

Important: In the example formats that follow, CMD and FNC values are expressed in hexadecimal notation; all other values are in decimal form.

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Basic Command Set

Basic commands include those that can generally be executed by any PC station on the communication link, regardless of the type of PC controller at that station. In some cases, switch settings on the station interface module can disable execution of a particular type of command at that station. For more details, refer to the user's manual for the station interface module.

Basic commands are in two categories:

Privileged:

Computer initiates. PCs execute.

- Diagnostic Counters Reset
- Diagnostic Loop
- Diagnostic Read
- Diagnostic Status
- Set ENQs
- Set NAKs
- Set Timeout
- Set Variables

Non-Privileged:

PC stations and computer can initiate; only PCs can execute (unless the computer is programmed for execution).

- Protected Bit Write
- Protected Write
- Unprotected Bit Write
- Unprotected Read
- Unprotected Write

Diagnostic Counters Reset

This command resets to zero all the diagnostic timers and counters in the station interface module. The diagnostic status command gives the starting address for this block of counters and timers.

Command Format:

DST	SRC	CMD 06	STS	TNS	FNC 07

Reply Format:

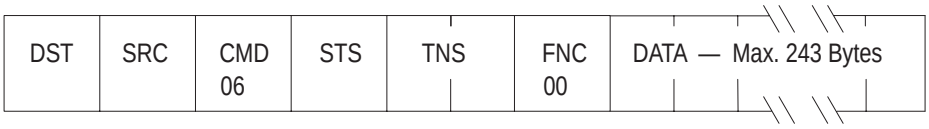
DST	SRC	CMD 46	STS	TNS

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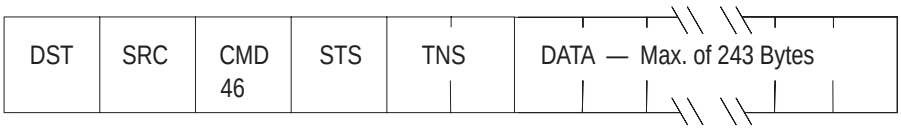
Diagnostic Loop

You can use this command to check the integrity of transmissions over the communication link. The command message transmits up to 243 bytes of data to a station interface module. The receiving module should reply to this command by transmitting the same data back to the originating station.

Command Format:



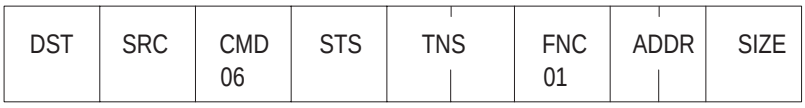
Reply Format:



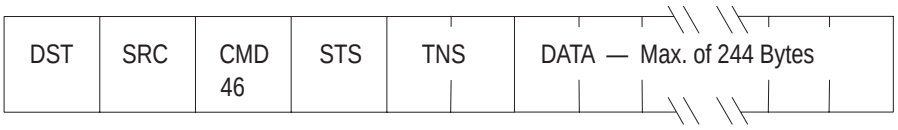
Diagnostic Read

This command reads up to 244 bytes of data from the PROM or RAM of the station interface module. You can use it to read the module's diagnostic timers and counters. Except for the PLC-5, you must use the diagnostic status command to obtain the starting address of the diagnostic counters. The PLC-5 doesn't require that this address be specified, though you must include a dummy value in the ADDR field, which the PLC-5 will ignore.

Command Format:



Reply Format:



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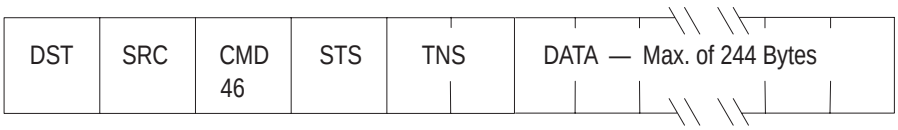
Diagnostic Status

This command reads a block of status information from the station interface module. The reply to this command contains the status information in its DATA field.

Command Format:



Reply Format:



The status information varies with the type of station interface module. Table 5.B describes the contents of the status DATA field for 1771-KA, 1771-KC/KD, 1771-KE/KF, 1770-KF2, 1771-KG, 1774-KA, and 1785-KA modules. Table 5.C lists the status DATA for 1773-KA modules. Table 5.D describes this DATA for 1775-KA modules. Table 5.E describes this DATA for the PLC-5.

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Table 5.B
Contents of Status DATA for 1771-KA2, -KC/KD, -KE/KF; 1770-KF2; 1771-KG, 1774-KA; and 1785-KA Modules

Byte	Bit	Value	Meaning
1	Operating Status of PC Processor — For the 1770-KF2, this byte is always 0. For the 1785-KA, it has one of these values: **0** = Standby Mode **1** = On-Line Mode		
	0-2	0	Program Load Mode
		1	Test Mode
		2	Run Mode
		3	(Not Used)
		4	Remote Program Load
		5	Remote Test
	3	0	Normal
		1	No Communication with PC
	4	0	Normal
		1	Download Mode
	5	0	Normal
		1	Format Error in Communication Zone of PC Program
	6, 7		Always Zero
2	Type of Station Interface Module and Processor **NOTE:** The 1770-KF2 identifies itself as a station interface module with a "3" in Byte 2, Bits 0 to 3 (i.e., as a 1771-KE/KF).		
	0-3	0	1771-KC/KD Module
		1	1771-KA Module
		2	1774-KA Module
		3	1771-KE/KF or 1770-KF2 Module
		4	1771-KG Module
		5	1771-KGM Module
		6	1775-KA, Data Highway Port
		7	1775-KA, RS-232-C Port
		8	1773-KA, Data Highway Port
		9	1773-KA, RS-232-C Port
		10	(Unused)
		11	PLC-5 Processor Interface
		12	(Unused)
		13	(Unused)
		14	Check Interface Module Expansion Byte (Byte 3)
		15	Computer
	4-7	0	PLC Processor
		1	PLC-2 Processor
		2	PLC-2/20 (LP1) Processor
		3	Mini-PLC-2 Processor
		4	PLC-3 Processor
		5	PLC-2/20 (LP2) Processor
		6	PLC-2/15 Processor
		7	PLC-2/30 Processor
		8	PLC-4 Microtrol Processor
		9	(Not Used)
		10	(Not Used)
		11	PLC-5 Processor Interface
		12	(Not Used)
		13	(Not Used)
		14	Check Processor Expansion Byte (Byte 4)
		15	Computer
3-4	Octal Word Address of the Start of PC Program — For the KF2 module, these are always 0. For the 1785-KA module, these are the expansions of the interface module type bits and the processor type bits, respectively. Both have a value of 16.		
5-6	Memory Size (Number of Bytes) for PLC Processors; Zero Otherwise — For the 1785-KA module, this is the starting address of the counters on the link other than the one from which the diagnostic read command was issued.		
7-8	Starting Byte Address of Diagnostic Counters and Timers — For the 1785-KA module, this is the starting address of the counters on the link from which the diagnostic read command was issued.		
9	Series and Revision Level of Station Interface Module **NOTE:** The Series A 1770-KF2 identifies itself as Series "D" in Byte 9, Bits 5 to 7.; Series B KF2 identifies itself as Series E; and so on.		
	0-4	0	Revision A
		1	Revision B, etc.
	5-7	0	Series A
		1	Series B, etc.
10	Settings of the Option Switches on the Station Interface Module — This byte is not used in replies by 1771-KC/KD or -KE/KF modules. For the other modules, the bits of this byte are defined as follows:		
	1771-KA2 MODULE		
	0-1	0	57,600 Bits per Second
		1	Undefined
		2	Undefined
		3	Undefined
	2	0	All Other PLC-2 Family Processors
		1	PLC-2 Processor
	3	0	Protected Commands Enabled
		1	Protected Commands Disabled
	4	0	Unprotected Commands Enabled
		1	Unprotected Commands Disabled
	5	--	Not Used
	6	0	Physical Writes Enabled
		1	Physical Writes Disabled
	7	0	Transmission Unprotected Commands Enabled
		1	Transmission Unprotected Commands Disabled

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Table 5.B Continued
Contents of Status DATA for 1771-KA2, -KC/KD, -KE/KF; 1770-KF2; 1771-KG, 1774-KA; and 1785-KA Modules

Byte	Bit	Value	Meaning
10 Cont'd	**1771-KG MODULE**		
	0	0	Half-Duplex Protocol
		1	Full-Duplex Protocol
	1	0	Physical Writes Enabled
		1	Physical Writes Disabled
	2	0	Unprotected Commands Enabled
		1	Unprotected Commands Disabled
	3	0	Embedded Responses Enabled
		1	Embedded Responses Disabled
	4	0	Even Parity
		1	No Parity
	5-7	0	19,200 bps
		1	9,600 bps
		2	4,800 bps
		3	2,400 bps
		4	1,200 bps
		5	600 bps
		6	300 bps
		7	110 bps
	1774-KA MODULE		
	0	0	Unprotected Commands Enabled
		1	Unprotected Commands Disabled
	1	--	Not Used
	2	0	Physical Writes Enabled
		1	Physical Writes Disabled
	3	0	Transmission of Unprotected Commands Enabled
		1	Transmission of Unprotected Commands Disabled
	4	0	Data Highway Port B Is Connected
		1	Data Highway Port A Is Connected
	5	0	PLC Outputs Held in Last State
		1	PLC Outputs Turned Off
	6-7	0	57,600 bps
		1	76,800 bps
		2	38,400 bps
		3	115,200 bps
	1770-KF2 MODULE		
	0-1	0	57,600 Bits per Second
		1	Undefined
		2	Undefined
		3	undefined
	2	--	Not Used
	3-7		Logical Complement of the State of Option Switch SW-1, Switches 1 through 5
	1785-KA MODULE		
	0	0	57,600 Bits per Second Data Highway Baud Rate Switch
		1	Undefined
	1	0	57,600 Bits per Second PCL Baud Rate Switch
		1	Undefined
	2-3	--	Not Used
	4	--	Not Used
	5	--	Not Used
	6-7	--	Not Used
11	Address of the PCL Active Node Table		
12	(Low Byte First)		

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Table 5.C
Contents of Status DATA for 1773-KA Modules

Byte	Bit	Value	Meaning
1	Operating Status of Controllers on the Loop		
	0	1	If Controller 1 Is Active
	1	1	" Controller 2 "
	2	1	" Controller 3 "
	3	1	" Controller 4 "
	4	1	" Controller 5 "
	5	1	" Controller 6 "
	6	1	" Controller 7 "
	7	1	" Controller 8 "
2	Station Interface Type		
	0-3	8	1773-KA, Data Highway Port
		9	1773-KA, RS-232-C Port
	4-7	8	PLC-4 Microtrol Processor
3-4	Data Highway Port Options		
	0	0	57,600 Bits per Second
		1	Undefined
	1	--	Not Used
	2	0	Privileged Commands Enabled
		1	Privileged Commands Disabled
	3	0	Unprotected Commands Enabled
		1	Unprotected Commands Disabled
	4	0	Protected Commands Enabled
		1	Protected Commands Disabled
	5-7	--	Not Used
	8-15	--	Octal Station Number
5-6	RS-232-C Port Options		
	0	0	Even Parity
		1	No Parity
	1-3	0	19,200 bps
		1	8,600 bps
		2	4,800 bps
		3	2,400 bps
		4	1,200 bps
		5	600 bps
		6	300 bps
		7	110 bps
	4-10	--	Not Used
	11	0	Protected Commands Enabled
		1	Protected Commands Disabled
	12	0	Embedded Responses Enabled
		1	Embedded Responses Disabled
	13	0	Unprotected Commands Enabled
		1	Unprotected Commands Disabled
	14	0	Privileged Commands Enabled
		1	Privileged Commands Disabled
	15	0	Half-Duplex Protocol
		1	Full-Duplex Protocol
7-8	Starting Byte Address of Diagnostic Timers and Counters		
9	Module Series and Revision Level		
	0-4	0	Revision A
		1	Revision B, Etc.
	5-7	0	Series A
		1	Series B, Etc.
10	--	--	Not Used
11-114	Eight 13-byte groups of processor status data, one group for each of eight possible controllers on the loop. If a particular controller on the loop is not active or does not respond to the diagnostic status command, its 13 status bytes will be all zeros. Otherwise, each group of processor status bytes will contain the following:		
	Byte 1		Program ID
	2		Processor ID
	3		Pointer to Start Program
	4		Pointer to End of Available Memory
	5		Size of I/O
	6		Processor Error Code
	7		Error Word Address (Low Byte)
	8		Error Word Address (High Byte)
	9		Processor Mode
	10		Pointer to END Statement (Low Byte)
	11		Pointer to END Statement (High Byte)
	12		Pointer to End of Used Memory (Low Byte)
	13		Pointer to End of Used Memory (High Byte)

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Table 5.D
Contents of Status DATA for 1775-KA Modules

Byte	Bit	Value	Meaning
1	Operating Status of PLC-3 Processor		
	0-1	0	Program Mode
		1	Test Mode
		2	Run Mode
	2	--	Not Used
	3	0	Normal
		1	Major Processor Fault
	4	0	Normal
		1	Shutdown Request
	5	0	Normal
		1	Shutdown in Effect
	6-7	--	Not Used
2	Type of Station Interface		
	0-3	6	1775-KA, Data Highway Port
		7	1775-KA, RS-232-C Port
3	Current Context (Stored in Bits 4 to 7)		
4	Thumbwheel Number		
5-6	Mode Control Word — The logical address of the mode control word is E0.0.0.8.		
7-8	Starting Byte Address of the Diagnostic Counters and Timers — There is a separate block of diagnostic timers and counters for the Data Highway port and the RS-232-C port. The address given here is the one for the port that received the diagnostic status command.		
9	Series and Revision Number of the 1775-KA Module		
	0-4	0	Revision A
		1	Revision B, Etc.
	5-7	0	Series A
		1	Series B, Etc.
10	Not Used		
11-14	The Physical Address of the Unused Word of PLC-3 System Memory — This is the physical address corresponding to the logical address E60.0.0.0.		
15-18	The Total Number of Words in the PLC-3 System Memory (Both Used and Unused) — This is the physical word address that corresponds to the logical address E60.0.0.0.		

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Table 5.E
Contents of Status DATA for PLC-5

Byte	Bit	Value	Meaning
1	Operating Status of PLC-5 Processor		
	0-2	0	Program Load
		1	Not Used
		2	Run Mode
		3	Not Used
		4	Remote Program Load
		5	Remote Test
		6	Remote Run
		7	Not Used
	3	0	Normal
		1	Major Processor Fault
	4	0	Normal
		1	Download Mode
	5	--	Not Used
	6	0	Not Testing Edits
		1	Testing Edits
	7	0	Not Testing Edits
		1	Testing Edits
2	Processor Type		
	0-3	11	PLC-5
	4-7	11	PLC-5
3-6	Size of User Memory (Low Word First, Low Byte First)		
7	Series and Revision of PLC-5		
	0-4	0	Revision A
		1	Revision B, Etc.
	5-7	0	Series A
		1	Series B, Etc.
8	Processor Number on PCL Link		
9	I/O Address — Address of the processor if it is an adapter. If it is a scanner, then value is 0FDH.		
10	I/O and Communication Parameters		
	0	0	Double Density
	1	1	Adapter Mode
	2	1	Module Group 4 Top Half
	5	1	Adapter Is Half Rack
	6	1	PCL at 115K Baud
11-12	Number of Data Table Files (Low Byte First)		
13-14	Number of Program Type Files (Low Byte First)		
15	Forcing Status		
	0	1	Forces Active
	4	1	Forces Are Present in the Tables
16	Memory Protect Indication — Non-Zero means memory is protected.		
17	Bad RAM Indication — Non-Zero means RAM is bad, must be cleared.		

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Protected Bit Write

This command sets or resets individual bits within limited areas of the PC data table memory. Its access is limited by memory access rungs in the communication zone of the PC's ladder diagram program.

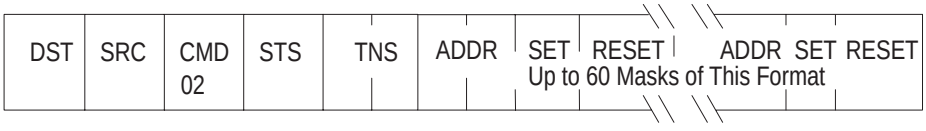
The data field in this packet consists of 4-byte blocks, each of which contains a 16-bit address field, a set mask, and a reset mask. Use the ADDR field to specify the address of the byte to be modified in the PC data table memory. Put the low byte (least significant bits) of the PC address value into the first byte of the ADDR field. Refer to Chapter 6 for more details on how to specify an address value.

Use the SET mask to specify which bits to set to 1 in the addressed PC byte. A 1 in a bit position of the SET mask means to set the corresponding bit in the addressed PC byte to 1; a 0 in a bit position of the SET mask means to leave the corresponding bit in the PC byte unchanged.

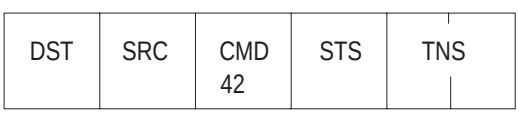
Use the RESET mask to specify which bits to reset to 0 in the addressed PC byte. A 1 in a bit position of the RESET mask means to reset the corresponding bit in the addressed PC byte to 0; a 0 in a bit position of the reset mask means to leave the corresponding bit in the PC byte unchanged.

Note that the interface module at the receiving PC station executes this command by first making a copy of the addressed PC byte. It then sets or resets the appropriate bits and writes the byte back into PC memory. At the same time, the PC processor can be changing the states of the original bits in memory. Because of this, some data bits may unintentionally be overwritten.

Command Format:



Reply Format:

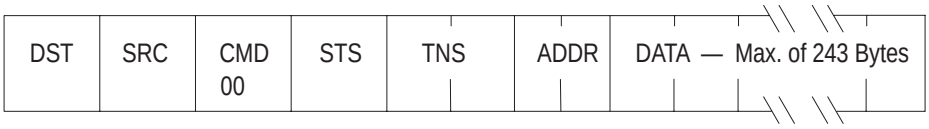


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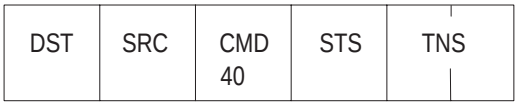
Protected Write

This command writes words of data into limited areas of the PC data table memory. Its access is limited by memory access rungs in the communication zone of the PC's ladder diagram program.

Command Format:



Reply Format:



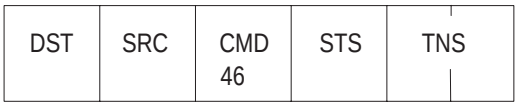
Set ENQS

This command sets the maximum number of ENQs that the station interface module will issue per message transmission. Put the number in the DATA field. The default setting for the KF2 module is 10 ENQs per transmission.

Command Format:



Reply Format:



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Set NAKS

This command sets the maximum number of NAKs that the station interface module will accept per message transmission. Put the number in the DATA field. The default setting for the KF2 module is 3 NAKs per transmission.

Command Format:

DST	SRC	CMD 06	STS	TNS	FNC 05	DATA

Reply Format:

DST	SRC	CMD 46	STS	TNS

Set Timeout

This command sets the maximum amount of time that the station interface module will wait for an acknowledgment to its message transmission. The setting is expressed as the number of cycles of an internal clock, where 40 cycles equals 1 second. Put the number of desired cycles in the DATA field. The default setting for the KF2 module is 128 cycles, or about 3 seconds.

Command Format:

DST	SRC	CMD 06	STS	TNS	FNC 04	DATA

Reply Format:

DST	SRC	CMD 46	STS	TNS

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Set Variables

This command is a combination of the above three commands. It sets the maximum ENQs, NAKs, and timeouts all at once. Put the timeout setting in the first byte of the DATA field, the NAKs setting in the second byte, and the ENQs in the third byte.

Command Format:

DST	SRC	CMD 06	STS	TNS	FNC 02	DATA — 3 Bytes Timeouts NAKs ENQs

Reply Format:

DST	SRC	CMD 46	STS	TNS

Unprotected Bit Write

This command sets or resets individual bits in any area of PC data table memory.

The data field in this packet consists of 4-byte blocks, each of which contains a 16-bit address field, a set mask, and a reset mask. Use the ADDR field to specify the address of the byte to be modified in the PC data table memory. Put the low byte (least significant bits) of the PC address value into the first byte of the ADDR field. Refer to Chapter 6 for more details on how to specify an address value.

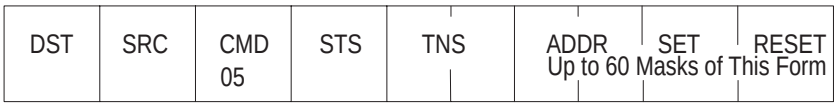
Use the SET mask to specify which bits to set to 1 in the addressed PC byte. A 1 in a bit position of the SET mask means to set the corresponding bit in the addressed PC byte to 1; a 0 in a bit position of the SET mask means to leave the corresponding bit in the PC byte unchanged.

Use the RESET mask to specify which bits to reset to 0 in the addressed PC byte. A 1 in a bit position of the RESET mask means to reset the corresponding bit in the addressed PC byte to 0; a 0 in a bit position of the RESET mask means to leave the corresponding bit in the PC byte unchanged.

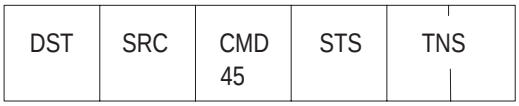
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Note that the interface module at the receiving PC station executes this command by first making a copy of the addressed PC byte. It then sets or resets the appropriate bits and writes the byte back into PC memory. At the same time, the PC processor can be changing the states of the original bits in memory. Because of this, some data bits may unintentionally be overwritten.

Command Format:



Reply Format:



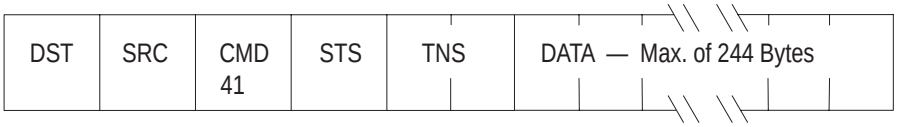
Unprotected Read

This command reads words of data from any area of PC data table memory. Use the SIZE field to specify the number of bytes to be read. To specify a number of PC words, SIZE should be an even value because PC words are two bytes long.

Command Format:



Reply Format:

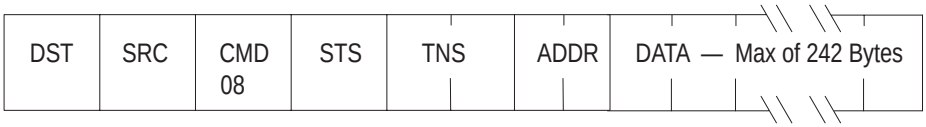


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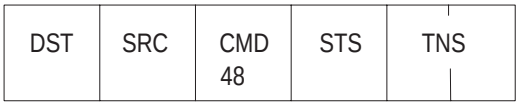
Unprotected Write

This command writes words of data into ay area of PC data table memory. Use the SIZE field to specify the number of bytes to be read. To specify a number of PC words, SIZE should be an even value because PC words are two bytes long.

Command Format:



Reply Format:



PLC Commands

PLC stations can execute all of the commands in the basic command set, except the commands to set NAKs, ENQs, timeouts, and variables. They can also execute the following commands, which apply only to PLC controllers:

- Disable Outputs
- Enable Program
- Enable Scan
- Physical Read
- Physical Write

The above are privileged commands. This means that only a computer can initiate them. Their primary purpose is for uploading and downloading PLC memory.

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Disable Outputs

This command turns off all outputs of the PLC controller. Use this command to disable the PLC's outputs before doing a physical write operation.

Command Format:

DST	SRC	CMD 07	STS	TNS	FNC 00

Reply Format:

DST	SRC	CMD 47	STS	TNS

Enable Program

This command returns control of outputs to the PLC ladder diagram program. Use this command to cancel the effect of the disable outputs command.

Command Format:

DST	SRC	CMD 07	STS	TNS	FNC 01

Reply Format:

DST	SRC	CMD 47	STS	TNS

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Enable Scan

This command restarts the PLC processor's program scanner after a physical write operation has been performed. Note that you must always use the enable scan command to restart the PLC processor after a physical write command.

Command Format:

DST	SRC	CMD 07	STS	TNS	FNC 03

Reply Format:

DST	SRC	CMD 47	STS	TNS

Physical Read

This command reads bytes of data from the PC data table or program memory. Use this command to upload the contents of PLC memory to your computer.

Use the SIZE field to specify the number of bytes to be read. To specify a number of PC words, SIZE should be an even value because PC words are two bytes long.

Command Format:

DST	SRC	CMD 04	STS	TNS	ADDR	SIZE

Reply Format:

DST	SRC	CMD 44	STS	TNS	DATA — Max. of 244 Bytes

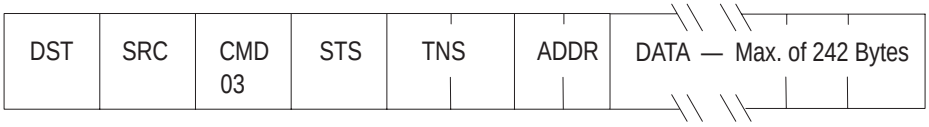
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Physical Write

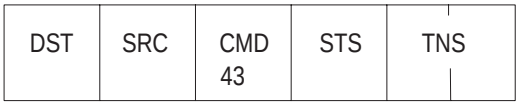
This command writes bytes of data into the PC data table or program memory. Use this command to download a computer file into PLC memory.

Use the SIZE field to specify the number of bytes to be written. To specify a number of PC words, SIZE should be an even value because PC words are two bytes long.

Command Format:



Reply Format:



PLC-2 Commands

PLC-2 stations can execute all of the commands in the basic command set. They can also execute the following commands, which apply only to PLC-2 Family controllers:

- Enter Download Mode
- Enter Upload Mode
- Exit Download/Upload Mode
- Physical Read
- Physical Write
- Set Data Table Size

The above commands are privileged. This means that only a computer can initiate them. Their primary use is for uploading and downloading PLC-2 memory.

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Enter Download Mode

This command puts the PLC-2 processor into the Download mode. Use this command on a PLC-2 station before attempting to send any physical write commands to the station.

Command Format:

DST	SRC	CMD 07	STS	TNS	FNC 04

Reply Format:

DST	SRC	CMD 47	STS	TNS

When you send an Enter Download/Upload mode command, the Industrial Terminal port is disabled until you send an Exit Download/Upload mode command. When the Industrial Terminal port is disabled, it enters the Mode Select State. To leave this state, you will have to manually select a mode at the Industrial Terminal.

If you are using a 1771-KA, Series A, Revision F module, or a 1771-KG, Series A, use the {Enter Download Mode} Command 07, Function 04, shown above, before sending physical read commands.

If you are using a 1771-KA2 module, or a 1771-KG, Series B, use the Enter Upload Command 07, Function 06, shown in the next section, before sending physical read commands.

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Enter Upload Mode

This command puts the PLC-2 processor into the Upload mode. Use this command on a PLC-2 station before attempting to send any physical read commands to the station.

Command Format:

DST	SRC	CMD 07	STS	TNS	FNC 06

Reply Format:

DST	SRC	CMD 47	STS	TNS

When you send an Enter Download/Upload mode command, the Industrial Terminal port is disabled until you send an Exit Download/Upload mode command. When the Industrial Terminal port is disabled, it enters the Mode Select State. In order to leave this state, you will have to manually select a mode at the Industrial Terminal.

Exit Download/Upload Mode

This command takes the PLC-2 processor out of the Upload or Download mode. Use this command to restart the PLC-2 processor after performing an upload or download operation.

If you don't send this command after a Download/Upload mode command, you will have to recycle power at the 1771-KA or 1771-KA2 module to enable Industrial Terminal communication.

Command Format:

DST	SRC	CMD 07	STS	TNS	FNC 05

Reply Format:

DST	SRC	CMD 47	STS	TNS

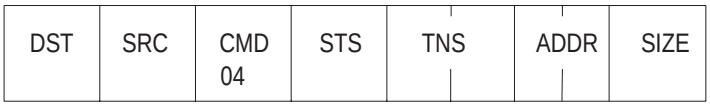
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Physical Read

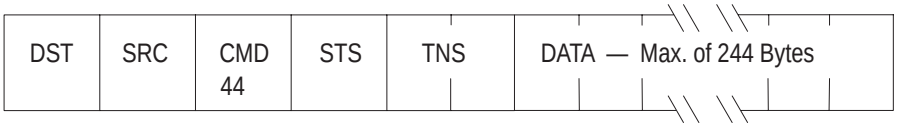
This command reads bytes of data from the PC data table or program memory. Use this command to upload the contents of PLC-2 memory to your computer.

Use the SIZE field to specify the number of bytes to be read. To specify a number of PC words, SIZE should be an even value because PC words are two bytes long.

Command Format:



Reply Format:

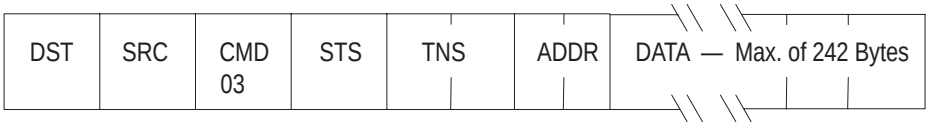


Physical Write

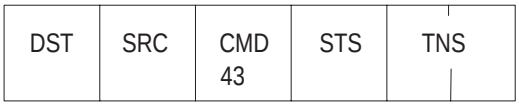
This command writes bytes of data into the PC data table or program memory. Use this command to download the contents of a computer file into PLC-2 memory.

Use the SIZE field to specify the number of bytes to be written. To specify a number of PC words, SIZE should be an even value because PC words are two bytes long.

Command Format:



Reply Format:



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Set Data Table Size

This command sets the data table size for the PLC-2 processor. Use this command immediately before performing any physical writes on the PLC-2 processor.

For the DATA field in this command, enter the number of bytes of memory that you want to allocate to the PLC-2 data table. Since PC words are two bytes long, the DATA value is double the number of words in the PLC-2 data table. The DATA value is also equivalent to the physical address (Chapter 6) of the start of the processor's program memory. To determine allowable data table sizes, refer to the programming manual for the appropriate PLC-2 processor.

Command Format:

DST	SRC	CMD 07	STS	TNS	FNC 03	DATA

Reply Format:

DST	SRC	CMD 47	STS	TNS

PLC-3 Commands

PLC-3 stations can execute all of the commands in the basic command set. They can also execute the following commands, which apply specifically to PLC-3 controllers:

Non-Privileged Commands

- Bit Write
- Word Range Read
- Word Range Write

Privileged Commands

- Download Request
- Physical Read
- Physical Write
- Restart Request
- Shutdown Request
- Upload Request

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Only a computer can initiate privileged commands. Their primary use is for uploading and downloading PLC-3 memory.

Only a computer or another PLC-3 station can initiate the non-privileged PLC-3 commands listed above. Their primary use is for transferring data between two PLC-3 files. Those files may be located in the same PLC-3 processor in two different PLC-3s.

In addition to the message packet fields already described for the basic command set (see "Message Packets"), PLC-3 messages may also contain the following fields:

1. **ASCII SYMBOL** — Contains the ASCII codes for the characters in a PLC-3 symbolic address. Chapter 6 gives more information on the format of symbolic addresses.

2. **PACKET OFFSET** — Contains the word offset between the DATA field of the current message packet and the DATA field of the first packet in the transaction. This offset value appears only in command messages for file transfers, where the complete transaction might require more than one command or reply message packet. The value of PACKET OFFSET is zero for the first packet in a transaction.

3. **PLC-3 LOGICAL ADDRESS** — Contains the logical address of a PLC-3 file or word. Chapter 6 gives more details about the contents of the address field.

4. **PLC-3 PHYSICAL ADDRESS** — Contains the physical address of a PLC-3 word. Chapter 6 gives more details about the contents of this address field.

5. **TOTAL TRANS** — Contains the total number of data words transferred by the current transaction. This is the total number of PLC-3 words to be transferred in the DATA fields of all message packets in the current transaction. TOTAL TRANS appears only in command messages for file transfers, where the transaction might take more than one message packet to complete.

6. **W/F** — Is the word/file symbolic address flag. This one-byte flag specifies whether the symbolic address field following it represents a word address or a file address. The value of W/F is zero if the symbol represents a word address and non-zero if the symbol represents a file address.

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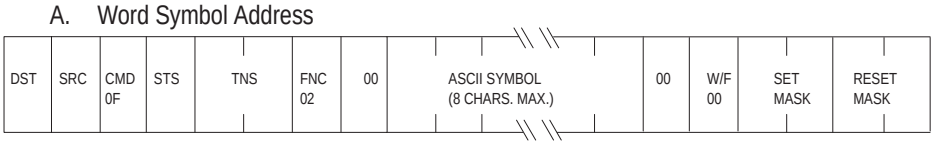
7. WORD OFFSET — Contains the word offset between the desired word and the beginning of the addressed file. The offset is zero for the first word of a file. In word-range read and write commands, this field can be combined with a symbolic file address to specify a word address.

Bit Writes

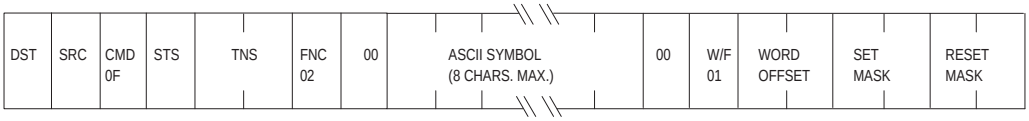
This is a bit write command to modify the bits at the address specified by either a word symbol, a file symbol plus a word offset, or a logical address. This address must point to a word within a file. The function code is 2. Unlike the current unprotected and protected bit writes in the basic command set, this command can change the bits in a single word only.

Command Packet:

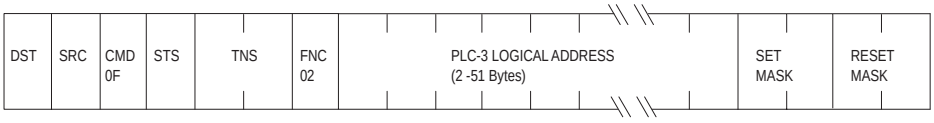
A. Word Symbol Address



B. File Symbol Address Plus Word Offset

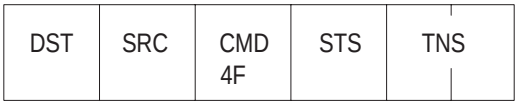


C. Logical Address



Reply Format: (EXT STS Byte Is Optional)

A. Format When Successful Execution



B. Format When Reporting an Error



NOTE:
This is the same as the reply packet format for all current unprotected, protected, and privileged bit writes.

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Download Request

A computer can use this command to inform the 1775-KA module that it wants to do a download. If the 1775-KA module grants the download privilege, the computer may begin issuing physical reads or writes. If a different station already has the download privilege, the second station is denied the privilege.

Command Format:

DST	SRC	CMD 0F	STS	TNS	FNC 05

Reply Format: (EXT STS Byte Optional)

A. Format When Successful Execution

DST	SRC	CMD 4F	STS	TNS

B. Format When Reporting an Error

DST	SRC	CMD 4F	STS	TNS	EXT STS

File Read

This is a read command, starting address of which is either a file symbol or a block address. This starting address must point to a file of words. The function code is 4.

Command Packet:

DST	SRC	CMD 0F	STS	TNS	FNC 04	PACKET OFFSET	TOTAL TRANS	PLC-3 LOGICAL ADDRESS (2-51 Bytes)	SIZE

Reply Format: (EXT STS Byte Is Optional)

A. Format When Successful Execution

DST	SRC	CMD 4F	STS	TNS	DATA — Max. of 244 Bytes or 122 Words

B. Format When Reporting an Error

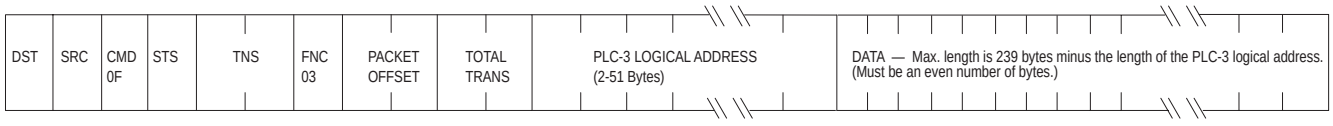
DST	SRC	CMD 4F	STS	TNS	EXT STS

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File Write

This is a write command, starting address of which is either a file symbol or a block address. This starting address must point to a file of words.

Command Packet:



Reply Format: (EXT STS Byte Is Optional)

A. Format When Successful Execution

DST	SRC	CMD 4F	STS	TNS

B. Format When Reporting an Error

DST	SRC	CMD 4F	STS	TNS	EXT STS

Physical Read

This is a read command where the starting address is a PLC-3 physical address. It is used to upload from a PLC-3 to a computer. The destination 1775-KA module will accept this command only after the source station has successfully transmitted a shutdown request.

Command Format:

DST	SRC	CMD 0F	STS	TNS	FNC 09	PLC-3 Physical Address	SIZE

Reply Format: (EXT STS Byte Optional)

A. Format When Successful Execution

DST	SRC	CMD 4F	STS	TNS	DATA — Max. of 244 Bytes or 122 Words

B. Format When Reporting an Error

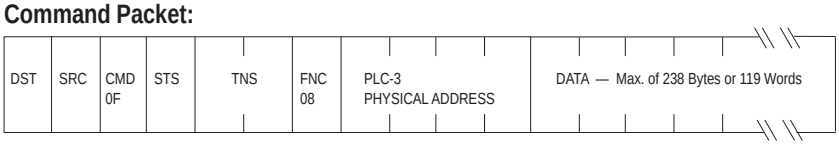
DST	SRC	CMD 4F	STS	TNS	EXT STS

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Physical Write

This is a write command where the starting address is a PLC-3 physical address. It is used to download to a PLC-3 from a computer. The destination 1775-KA module will accept this command only after the source station has successfully transmitted a shutdown request. Function code for this command is 8.

Command Packet:



Reply Format: (EXT STS Byte Is Optional)

A. Format When Successful Execution

DST	SRC	CMD 4F	STS	TNS

B. Format When Reporting an Error

DST	SRC	CMD 4F	STS	TNS	EXT STS

Restart Request

This command is used by the computer to terminate an upload or a download. The computer cannot issue this command until after it has successfully completed an upload or download operation with the destination station. This command causes the 1775-KA module to revoke the upload and download privileges for the source computer station and to initialize a PLC-3 start.

Command Format:

DST	SRC	CMD 0F	STS	TNS	FNC 0A

Reply Format: (EXT STS Byte Optional)

A. Format When Successful Execution

DST	SRC	CMD 4F	STS	TNS

B. Format When Reporting an Error

DST	SRC	CMD 4F	STS	TNS	EXT STS

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Shutdown Request

This command is used by the computer to ask the 1775-KA module to initiate either a PLC-3 shutdown (if the computer has download privileges) or a freeze on file allocations (if the computer has upload privileges). The computer cannot issue this command until it has successfully transmitted an upload or download request to the 1775-KA module.

Command Format:

DST	SRC	CMD 0F	STS	TNS	FNC 07

Reply Format: (EXT STS Byte Optional)

A. Format When Successful Execution

DST	SRC	CMD 4F	STS	TNS

B. Format When Reporting an Error

DST	SRC	CMD 4F	STS	TNS	EXT STS

Upload Request

This command is used by the computer to inform the 1775-KA module that it wants to do an upload. If the module grants the upload privilege, the computer may begin issuing physical reads. If a different station already has the upload privilege, the second station is denied the privilege. The function code is 6.

Command Format:

DST	SRC	CMD 0F	STS	TNS	FNC 06

Reply Format: (EXT STS Byte Optional)

A. Format When Successful Execution

DST	SRC	CMD 4F	STS	TNS

B. Format When Reporting an Error

DST	SRC	CMD 4F	STS	TNS	EXT STS

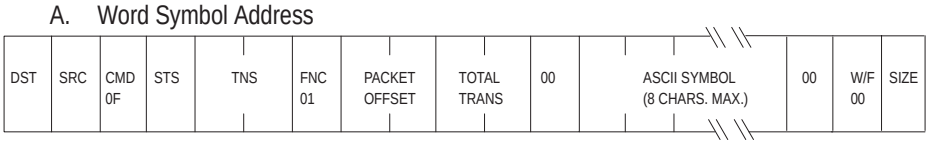
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Word Range Read

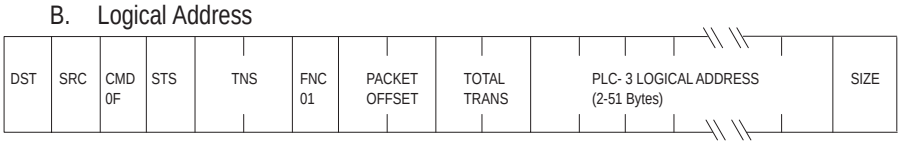
This is a read command whose starting address is either a word symbol, a file symbol plus a word offset, or a block address. This starting address must point to a word in a file. The function code is 1. A special case of this command is the single-word read, where the number of bytes to read is only two bytes (one word).

Command Format:

A. Word Symbol Address

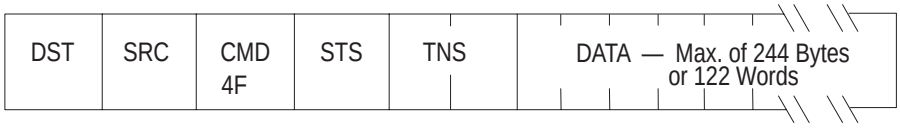


B. Logical Address



Reply Format: (EXT STS Byte Is Optional)

A. Format When Successful Execution



B. Format When Reporting an Error



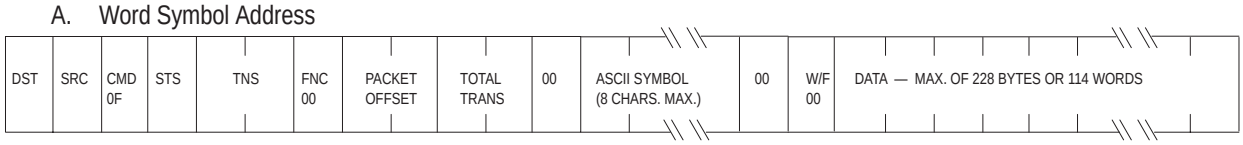
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Word Range Write

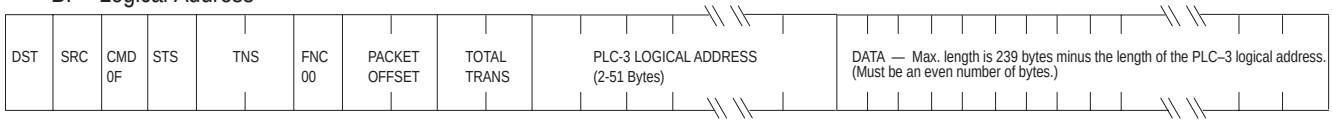
This is a write command whose starting address is either a word symbol, a file symbol plus a word offset, or a logical address. This starting address must point to a word in a file. The function code is 0. A special case of this command is the single-word write, where the number of bytes to read is only one word long.

Command Format:

A. Word Symbol Address

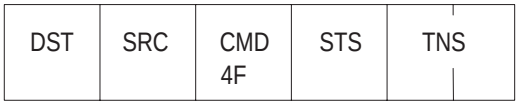


B. Logical Address



Reply Format: (EXT STS Byte Is Optional)

A. Format When Successful Execution



B. Format When Reporting an Error



PLC-4 Commands

PLC-4 stations can execute all of the commands in the basic command set. They can also execute the following commands, which apply only to PLC-4 Microtrols:

- Allocate Processor
- Deallocate Processor
- Initialize Processor
- Physical Read
- Physical Write
- Physical Write with Mask
- Set to Program Load Mode
- Set to Run Mode
- Set to Single-Scan Test Mode
- Set to Test Mode

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The above are privileged commands. This means that only a computer can execute them. Their primary purpose is for uploading and downloading PLC-4 memory.

PLC-4 stations cannot initiate any type of command message.

In addition to the message packet fields already described for the basic command set (see "Message Packets"), PLC-4 messages may also contain a byte called PLC-4 SEL. This field specifies which controller in the PLC-4 Microtrol loop is the ultimate destination of the command message. The allowed values for this field are:

PLC-4 SEL Value	Meaning
0	Selects Controller #1
1	Selects Controller #2
2	Selects Controller #3
3	Selects Controller #4
4	Selects Controller #5
5	Selects Controller #6
6	Selects Controller #7
7	Selects Controller #8

Allocate

This command causes the 1773-KA module to allocate PLC-4 access privileges to the computer station that originated the allocate commands. Once the computer has this access privilege, it can send any of the other privileged commands to the selected PLC-4 controller. No other computer can gain access privileges to the same PLC-4 controller until the privileges of the first computer have been deallocated.

If the 1773-KA module loses power, all access privileges are deallocated.

Command Format:

DST	SRC	CMD 0F	STS	TNS	FNC 07	PLC-4 SEL

Reply Format: (EXT STS Byte Is Optional)

A. Format When Successful Execution

DST	SRC	CMD 4F	STS	TNS

B. Format When Reporting an Error

DST	SRC	CMD 4F	STS	TNS	EXT STS

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Deallocate

This command deallocates access privileges to the selected PLC-4 controller.

Command Format:

DST	SRC	CMD 0E	STS	TNS	FNC 06	PLC-4 SEL

Reply Format: (EXT STS Byte Optional)

A. Format When Successful Execution

DST	SRC	CMD 4E	STS	TNS

B. Format When Reporting an Error

DST	SRC	CMD 4E	STS	TNS	EXT STS

Initialize Processor

This command initializes, or clears, memory in the selected PLC-4 controller. Use this command to clear the data table memory of the controller before downloading to it. The controller must be in Program Load mode and must not be executing any other privileged command.

Command Format:

DST	SRC	CMD 0E	STS	TNS	FNC 07	PLC-4 SEL

Reply Format: (EXT STS Byte Optional)

A. Format When Successful Execution

DST	SRC	CMD 4E	STS	TNS

B. Format When Reporting an Error

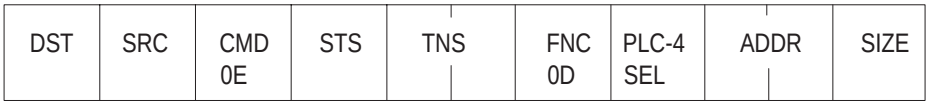
DST	SRC	CMD 4E	STS	TNS	EXT STS

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Physical Read

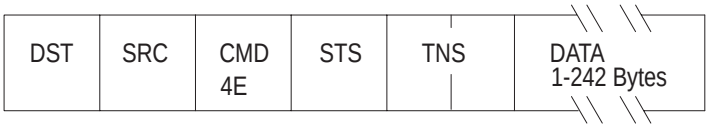
This command reads the specified number of bytes from the memory of the selected PLC-4 controller. Use this command to upload the contents of PLC-4 memory to your computer. The SIZE field contains the number of bytes to be read, and it may have a value from 1 to 242 decimal.

Command Format:

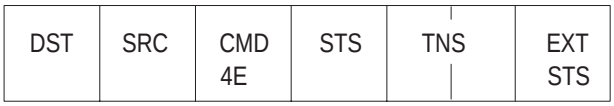


Reply Format: (EXT STS Byte Optional)

A. Format When Successful Execution



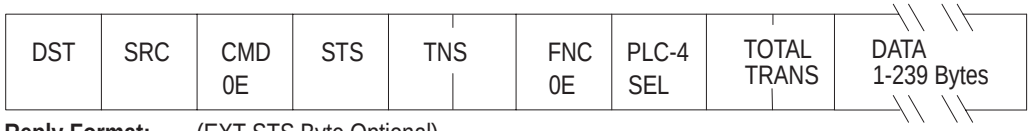
B. Format When Reporting an Error



Physical Write

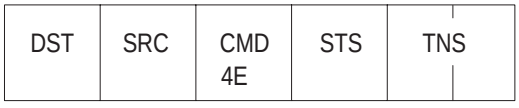
This command writes bytes of data into the memory of the selected PLC-4 controller. Use this command to download data from your computer to the controller. The PLC-4 ADDRESS field contains the physical byte address where the data will begin being written into PLC-4 memory. Refer to Chapter 6 for a description of this physical address.

Command Format:

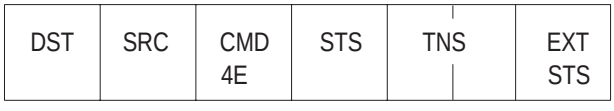


Reply Format: (EXT STS Byte Optional)

A. Format When Successful Execution



B. Format When Reporting an Error



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Physical Write with Mask

This command sets or resets bits in a memory word of the selected controller. The ADDRESS field contains the physical PLC-4 address of the memory word to be modified. Refer to Chapter 6 for a description of physical addresses.

The BIT MASK field specifies which bits in the PLC-4 word are to be modified, and the DATA field specifies whether those bits are to be set or reset. For each bit that is 1 in the BIT MASK, the corresponding bit in the addressed PLC-4 word is set to the same value (1 or 0) as the corresponding bit in the DATA field. For each bit that is 0 in the BIT MASK, the corresponding bit of the addressed PLC-4 word is left unchanged.

Note that you can modify up to 40 PLC-4 words in this way by specifying a series of ADDRESS, DATA, and BIT MASK fields.

Command Format:

DST	SRC	CMD 0E	STS	TNS	FNC 0F	PLC-4 SEL	ADDRESS	DATA	BIT MASK
							(Repeated up to 40 Times)		

Reply Format: (EXT STS Byte Optional)

A. Format When Successful Execution

DST	SRC	CMD 4E	STS	TNS

B. Format When Reporting an Error

DST	SRC	CMD 4E	STS	TNS	EXT STS

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Set to Program Load Mode

This command sets the selected controller to the Program Load mode.

Command Format:

DST	SRC	CMD 0E	STS	TNS	FNC 01	PLC-4 SEL

Reply Format: (EXT STS Byte Optional)

A. Format When Successful Execution

DST	SRC	CMD 4E	STS	TNS

B. Format When Reporting an Error

DST	SRC	CMD 4E	STS	TNS	EXT STS

Set to Run Mode

This command sets the selected controller to the Run mode.

Command Format:

DST	SRC	CMD 0E	STS	TNS	FNC 02	PLC-4 SEL

Reply Format: (EXT STS Byte Optional)

A. Format When Successful Execution

DST	SRC	CMD 4E	STS	TNS

B. Format When Reporting an Error

DST	SRC	CMD 4E	STS	TNS	EXT STS

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Set to Single-Scan Test Mode

This command sets the selected controller to the Single-Scan Test mode.

Command Format:

DST	SRC	CMD 0E	STS	TNS	FNC 04	PLC-4 SEL

Reply Format: (EXT STS Byte Optional)

A. Format When Successful Execution

DST	SRC	CMD 4E	STS	TNS

B. Format When Reporting an Error

DST	SRC	CMD 4E	STS	TNS	EXT STS

Set to Test Mode

This command sets the selected controller to the Test mode.

Command Format:

DST	SRC	CMD 0E	STS	TNS	FNC 03	PLC-4 SEL

Reply Format:

A. Format When Successful Execution

DST	SRC	CMD 4E	STS	TNS

B. Format When Reporting an Error (EXT STS Byte Optional)

DST	SRC	CMD 4E	STS	TNS	EXT STS

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PLC-5 Commands

PLC-5 stations can execute the basic command set with the following exceptions:

- Set ENQs
- Set NAKs
- Set Timeouts
- Set Variables

This section presents the message formats of the PLC-5 command and reply messages. The table below lists the messages in the order they will be discussed:

Message	CMD	FNC
Download All Request	0F	50
Download Completed	0F	52
Modify PLC-2 Compatibility File	0F	5E
Read Bytes Physical	0F	17
Read-Modify-Write	0F	26
Set Processor Mode	0F	3A
Typed Read	0F	68
Typed Write	0F	67
Upload All Request	0F	53
Upload Completed	0F	55
Write Bytes Physical	0F	18
Word Range Read	0F	01
Word Range Write	0F	00

Important: In the example formats that follow, CMD and FNC values are expressed in hexadecimal notation. Other values are given in decimal form.

Important: In addition to the message packet fields already described for the basic command set, PLC-5 messages can also contain the following fields:

1. **PACKET OFFSET** — Contains the word offset between the DATA field of the current message packet and the DATA field of the first packet in the transaction. This offset value appears only in command messages for file transfers, where the complete transaction might require more than one command or reply message packet. Packet offset appears only in command messages for file transfers, where the transaction might take more than one message packet to complete. The value of PACKET OFFSET is zero for the first packet in a transaction.

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2. **PLC-5 LOGICAL BINARY ADDRESS** — Contains the logical address of a PLC-5 file, element, and subelement. Chapter 6 gives more details about the contents of this address field.

3. **PLC-5 LOGICAL ASCII ADDRESS** — Contains the logical address of a PLC-5 file, element, or subelement expressed as a string of ASCII characters. Chapter 6 gives more details about the contents of this address field.

4. **PLC-5 PHYSICAL ADDRESS** — Contains the physical address of a PLC-5 word. Chapter 6 gives more details about the contents of this address field.

5. **TOTAL TRANS** — Contains the total number of data elements transferred by the current transaction. This is the total number of PLC-5 elements to be transferred in the DATA fields of all message packets in the current transaction. The value of PACKET OFFSET is zero for the first packet in a transaction.

Download All Request

Use this command before downloading a complete system to place the processor in a Download mode. A **no privilege** error is returned if the requestor does not have the privilege of placing the processor in a Download mode. This error occurs when:

- the processor is in Run or Remote Run mode (must be in Program or Remote Program mode),
- the processor is being edited, or
- some other station is already downloading to the processor.

The format for this message is as follows:

Command Format:

DST	SRC	CMD 0F	STS	TNS	FNC 50

Reply Format:

DST	SRC	CMD 4F	STS	TNS	EXT STS

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The STS and EXT STS bytes contain status and error code information. For more information on these bytes, see the “Error Codes” section in this document.

Download Completed

Use this command after downloading a complete system to place the processor back in the mode that it was in prior to executing the Download All Request command.

The format for that message is as follows:

Command Format:

DST	SRC	CMD 0F	STS	TNS	FNC 52

Reply Format:

DST	SRC	CMD 4F	STS	TNS	EXT STS

The STS and EXT STS bytes contain status and error code information. For more information on these bytes, see the “Error Codes” section in this document.

Modify PLC-2 Compatibility File

Use this command to change the Compatibility mode file so that communications from a PLC-2 (or a station emulating a PLC-2 type processor) at the given station address will use the file specified in the command. This change in the default file for PLC-2 Compatibility mode remains in effect until this command is issued again to change it. Cycling the power to the PLC-5/15 does not reset the default back to the original file.

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The link ID (presently not used, set it to zero) and the station address are one byte while the file number is two bytes. The format for this message is as follows:

Command Format:

DST	SRC	CMD 0F	STS	TNS	FNC 5E	LINK ID	STATION ADDRESS	FILE NUMBER

Reply Format:

DST	SRC	CMD 4F	STS	TNS	EXT STS

The STS and EXT STS bytes contain status and error code information. For more information on these bytes, see the “Error Codes” section in this document.

Read Bytes Physical

Use this command to perform an Upload Only after anUpload (or Download) All Request has been successfully performed.

Command Format:

DST	SRC	CMD 0F	STS	TNS	FNC 17	1	SIZE

1 The Physical Address is a 4-byte field:

Byte	Physical Address Bit(s)
1	A00 - A07
2	A08 - A15
3	A16 - A23
4	A24 - A31

SIZE: The SIZE byte is a one-byte field that contains the number of bytes to read up to 240 (must be an even number).

Reply Format:

DST	SRC	CMD 4F	STS	TNS	2	DATA (Up to 240 Bytes)

2 This byte will be the Extended Status byte if there is an error; otherwise it will be data at Physical Address, first word, low byte.

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The STS and EXT STS bytes contain status and error code information. For more information on these bytes, see the “Error Codes” section in this document.

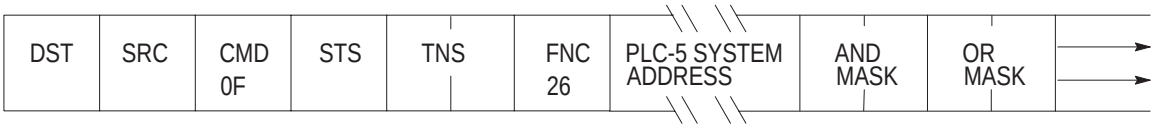
Read-Modify-Write

Use this command to take the contents of each location specified:

- AND them with the appropriate AND mask.
- OR them with the appropriate OR mask.
- Restore them to their location, one word at a time.

The command parameters that follow the FNC byte in the example can be repeated up to a length of 243 bytes.

Command Format:



The PLC-5 system address must point to a word, and can be either a logical binary address or a logical ASCII address with up to 51 bytes of specification.

The AND and OR masks are two bytes each with the low byte first.

Reply Format:



The STS and EXT STS bytes contain status and error code information. For more information on these bytes, see the “Error Codes” section in this document.

Set Processor Mode

Use this command to set the Operating mode of the processor at the next I/O scan. The Operating mode is set to the mode indicated in the flag byte (shown below). A **no privilege** error is returned if the requestor does not

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have the privilege of placing the host in a Download mode. This error occurs when:

- the processor is in Program or Run mode (must be in Remote Program or Remote Run mode),
- the processor is being edited, or
- some other station is already downloading to the processor.

The format for this message is as follows:

Command Format:

DST	SRC	CMD 0F	STS	TNS	FNC 3A	1

1 Flag Byte (Explained Below)

Reply Format:

DST	SRC	CMD 4F	STS	TNS	EXT STS

The STS and EXT STS bytes contain status and error code information. For more information on these bytes, see the “Error Codes” section in this document.

You use the bits in the flag byte of the set processor command as follows:

- Bits 2 through 7 are unused.
- Bits 0 and 1 determine which operating mode is selected.

This table shows the settings of Bits 0 and 1 for each operating mode:

For This Operating Mode:	Bit 1	Bit 0
Program/Load Mode (Processor Idle, I/O Disabled)	0	0
Remote Test Mode (Processor Scanning, I/O Disabled)	0	1
Remote Run Mode (Processor Scanning, I/O Enabled)	1	0
No Change (Only Remote Bit Affected)	1	1

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For example, if you wanted to set the processor to Run mode, your flag byte would look like this:

Bit	76543210
	00000010

Typed Read and Typed Write

Use these commands to:

- read data from the processor starting at the PLC-5 system address plus the packet offset or
- write data to the processor starting at the PLC-5 system address plus the packet offset.

The type of data sent with the Typed Write command must match the file type being written. It is the responsibility of the host to do data type conversions.

The format for the Typed Read message is as follows:

Command Format:

DST	SRC	CMD 0F	STS	TNS	FNC 68	PACKET OFFSET	TOTAL TRANS	PLC-5 SYSTEM ADDRESS	SIZE

Reply Format:

DST	SRC	CMD 4F	STS	TNS	1	2

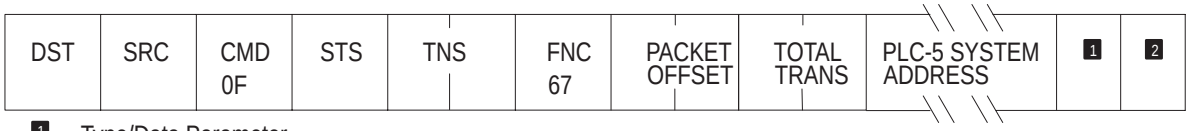
1 Type/Data Parameter

2 Data Bytes — This can be up to 240 bytes long (including the size of the PLC-5 system address).

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The format for the Typed Write message is as follows:

Command Format:



1 Type/Data Parameter

2 Data Bytes — This can be up to 240 bytes long (including the size of the PLC-5 system address and data type information).

Reply Format:



The packet offset, total transaction (in elements), and size (in elements) are all two bytes. The PLC-5 system address can be a logical binary address or a logical ASCII address containing up to 51 bytes of specification.

The STS and EXT STS bytes contain status and error code information. For more information on these bytes, see the “Error Codes” section in this document.

The Typed Read and Typed Write commands for the PLC-5 are similar to the Word Range Read and Word Range Write for the PLC-3. The differences are:

- The PLC-5 Typed Read/Write commands replace the data parameter in the request or response with a type/data parameter.
- The PLC-5 commands use elements, not words (i.e., timer elements return five words, counter elements return three words, etc.).

Table 5.F contains the types of data you can send or receive and the ID value of each:

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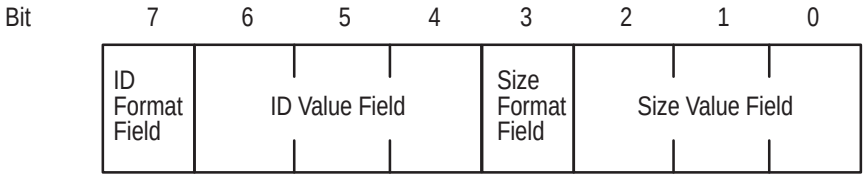
Table 5.F
Data Types/ID Values

Value	Mnemonic	Name
0	END	Last Element Indicator/No Type Specification
1	B	Bit
2	BS	Bit String
3	CS	Byte (or Character) String
4	I	Integer
5	T	Allen-Bradley Timer
6	C	Allen-Bradley Counter
7	R	Allen-Bradley General Control Structure
8	F	IEEE Floating Point
9	A	Array of Similar Elements
15	ADR	Address
16	D	Binary Coded Decimal

You use the type/data parameter to determine:

- the ID value for the type of data you are sending or receiving (ID values in the table above) or
- the number of bytes in the data type you are sending or receiving.

The first byte of the type/data parameter has this format:



Data Type ID

If Bit 7 is a zero (0), the data type ID value is 7 or less (see Table 5.F). The actual ID value for the data type is then contained in the ID Value Field (Bits 4, 5, 6).

If Bit 7 is a one (1), the data type ID value is greater than 7 (see Table 5.F). The ID Value Field (Bits 4, 5, 6) contain the number of bytes (following the parameter byte) which contain the data type ID value.

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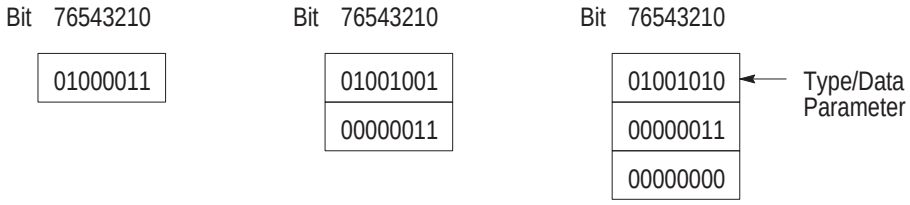
Data Type Size

If Bit 3 is a zero (0), the data type defined in the ID Value Field uses 7 or less bytes for each piece of data. The actual number of bytes the data type uses for each piece of data is then contained in the Size Value Field (Bits 0, 1, 2).

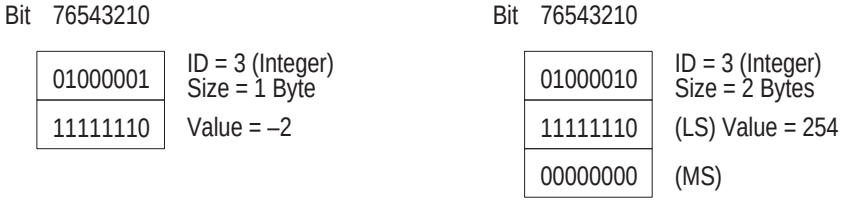
If Bit 3 is a one (1), the data type defined in the ID Value Field uses more than 7 bytes for each piece of data. The Size Value Field (Bits 0, 1, 2) contains the number of bytes which identify the number of bytes the data type uses for each piece of data. These bytes follow the parameter byte and any ID type bytes.

Examples

The order of the bytes is least significant to most significant. One or more most significant bytes containing all zeros are permitted, but the fields thus generated are not different from those that omit these bytes. Thus the following descriptors each have an ID type of 4 (integer) and a size value of 3 bytes:



The following example shows type “I” (integer) type/data parameters:



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The following example shows a type “A” (array) type/data parameter. The array data type includes one descriptor as part of its data field. This descriptor must be counted as part of the data field size:

Bit	76543210	
	10010111	ID in Next 1 Byte Size = 7 Bytes (6 Data Bytes Plus 1 Descriptor Byte)
	00001001	ID = 9 (Array)
	01000010	Integer, Size = 2 Bytes Each
	00000000	Integer 0, (LS) Value = 0
	00000000	(MS)
	11111110	Integer 1, (LS) Value = –2
	11111111	(MS)
	11111111	Integer 2, (LS) Value = 255
	00000000	(MS)

Not all sizes are legal for all formats. The “END” data type always has a size value of zero (0), and the “B” data type will either have a size value of 4 (single precision or 8 (double precision). Each of the Allen-Bradley predefined structures has a fixed size.

Upload All Request

Use this command before uploading a complete system to place the processor in an Upload mode (T50 terminal displays “Download” mode). A **no privilege** error is returned if the programmed device does not have the privilege of placing the processor into an Upload mode. This error occurs when:

- the processor is in Run or Remote Run mode (must be in Program or Remote Program mode),
- the processor is being edited, or
- some other station is already downloading to the processor.

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The message format is as follows:

Command Format:

DST	SRC	CMD 0F	STS	TNS	FNC 53

Reply Format:

DST	SRC	CMD 4F	STS	TNS	EXT STS

The STS and EXT STS bytes contain status and error code information. For more information on these bytes, see the “Error Codes” section in this document.

Upload Completed

Use this command after uploading a complete system to place the processor back to the mode that it was in prior to executing the Upload All Request command.

The format is as follows:

Command Format:

DST	SRC	CMD 0F	STS	TNS	FNC 55

Reply Format:

DST	SRC	CMD 4F	STS	TNS	EXT STS

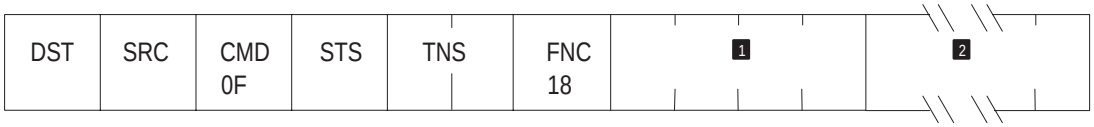
The STS and EXT STS bytes contain status and error code information. For more information on these bytes, see the “Error Codes” section in this document.

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Write Bytes Physical

Use this command to perform a Download Only after a Download (or Upload) All Request has been successfully performed.

Command Format:



1 The Physical Address is a 4-byte field that contains the address you are writing to:

Byte	Physical Address Bit(s)
1	A00 - A07
2	A08 - A15
3	A16 - A23
4	A24 - A31

2 Up to 119 data words can be written with a single command (low byte of the word first).

Reply Format:



The STS and EXT STS bytes contain status and error code information. For more information on these bytes, see the “Error Codes” section in this document.

Word Range Read

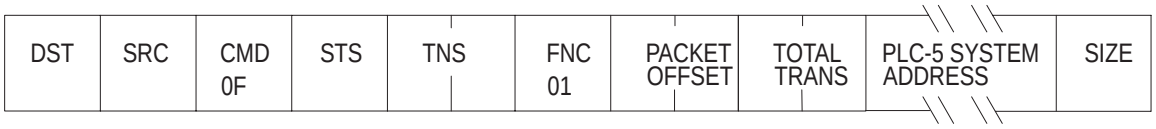
This command is a read command whose starting address is either a logical binary address or a logical ASCII address with up to 51 bytes of specification. This starting address must point to a word or file.

A special case of this command is the single-word read, where the number of bytes to read is two bytes.

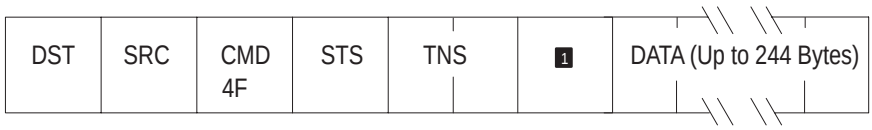
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The packet offset and total transaction are two bytes each, while the size is only one byte. The format is as follows:

Command Format:



Reply Format:



1 This byte will be the Extended Status byte if there is an error; otherwise it will be data at "address + packet offset," first word, low byte.

The STS and EXT STS bytes contain status and error code information. For more information on these bytes, see the "Error Codes" section in this document.

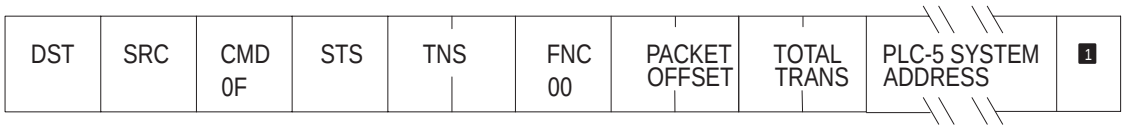
Word Range Write

This command is a write command whose starting address is either a logical binary address or a logical ASCII address with up to 51 bytes of specification. This starting address must point to a word or file.

A special case of this command is the single-word write, where the data field is only one word long.

The packet offset and total transaction are two bytes each. The format is as follows:

Command Format:



1 Data Bytes — This can be up to 239 bytes long (including the size of the PLC-5 system address).

Reply Format:



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Error Codes

Each command has a status (STS) byte in its reply format to indicate:

- if the command was successfully completed (STS equals 00) or
- if there was an error in the completion of the command (STS not equal to 00).

The reply may also use an extended status byte (EXT STS) to define an error if necessary. The following table lists additional status and extended status codes and their meanings (the codes in the table are in hexadecimal):

This Status Code:	With This Extended Status Code:	Means:
01	None	Destination Station Out of Buffer Space
F0	0C	Resource Is Not Available (Someone Has Upload Active)
F0	0D	Resource Is Already Available
F0	0F	No Privilege
F0	11	Incorrect Type Date

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Chapter 6

Data Encoding and Addressing

General

This chapter explains two areas of special concern when you are transmitting messages between computers and PCs:

- Data Encoding
- Addressing Formats

The information contained in this chapter gives some application details that relate to the data and address fields of the message formats in Chapter 5.

Data Encoding

In general, PCs store binary data (1s and 0s) in 16-bit groups called words. If you are looking at this data from a computer, however, you may interpret it in a number of different ways, depending on your application needs.

Number Systems

You may use any one of the following number systems to represent data in your computer application programs:

- Binary
- Binary Coded Decimal
- Decimal
- Hexadecimal
- Octal

You must design your computer application programs to make any necessary conversions from one number system to another. Once you have selected the number system that is best for your applications, try to use only that one system and convert all data values to that base to avoid confusion.

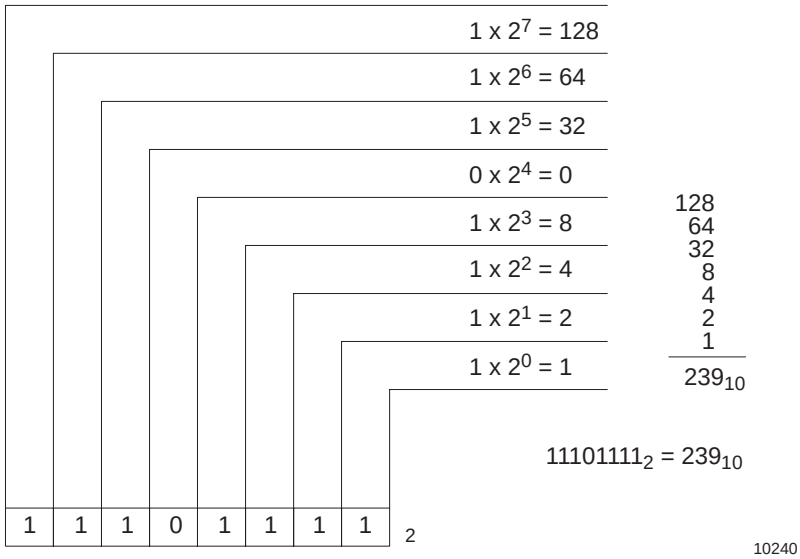
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Binary

The binary number system is probably the simplest to use for computer and PC applications because it is the most natural way to represent data bits. However, since the binary system uses only the digits 0 and 1, it is cumbersome to show values in binary format.

Each digit in a binary number has a certain place value expressed as a power of 2. You can calculate the decimal equivalent of a binary number by multiplying each binary digit by its corresponding place value and then adding the results of the multiplications. Figure 6.1 shows the binary representation of the decimal number 239.

Figure 6.1
Binary Numbers

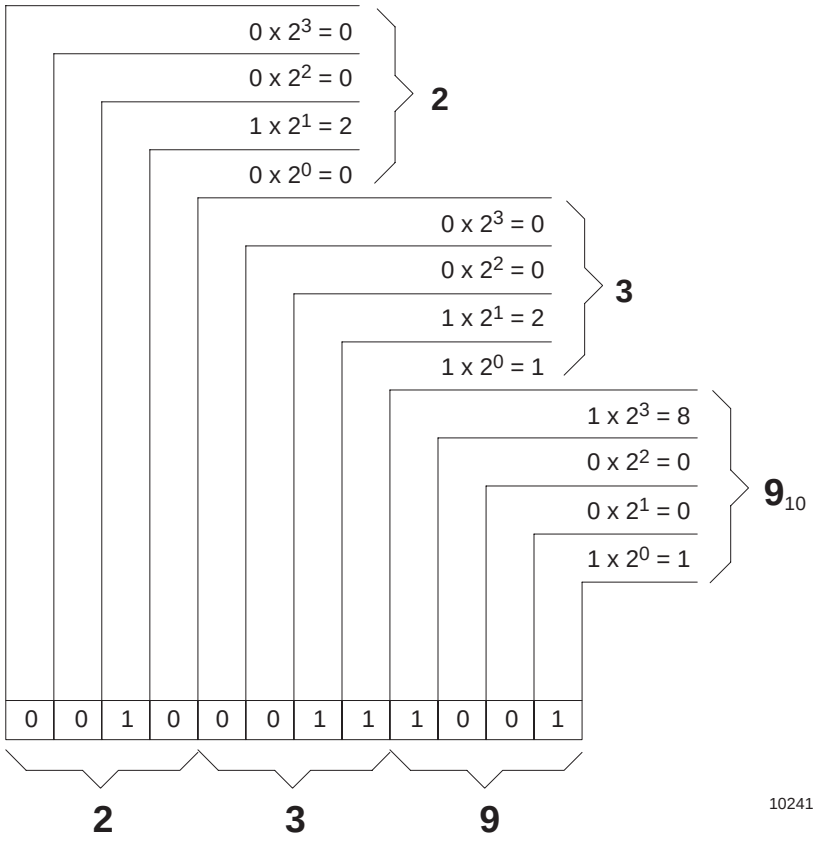


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Binary Coded Decimal

PC data is often represented in binary coded decimal (BCD) form. In this system, each group of four bits in a PC word represents one decimal number between 0 and 9. In this way, each 16-bit word can represent a BCD value between 0 and 9,999. Figure 6.2 shows the BCD representation of the decimal number 239.

Figure 6.2
BCD Representation of Decimal 239

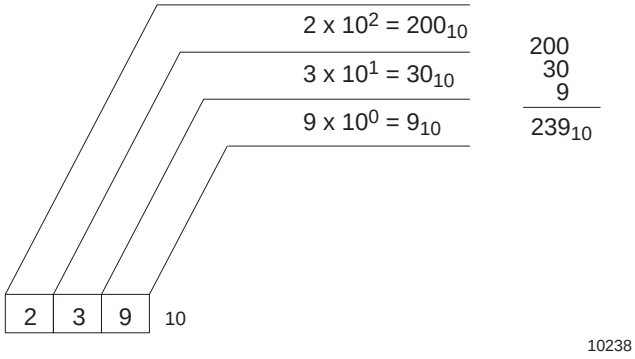


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Decimal

The decimal number system is probably the easiest for us to use because it is the most familiar to us. It uses the common digits 0 through 9, and each digit has a place value that is a power of 10 (Figure 6.3). However, despite the convenience of decimal numbers, it is often easier to convert binary data to a number system other than decimal.

Figure 6.3
Decimal Representation, Number 239



Hexadecimal

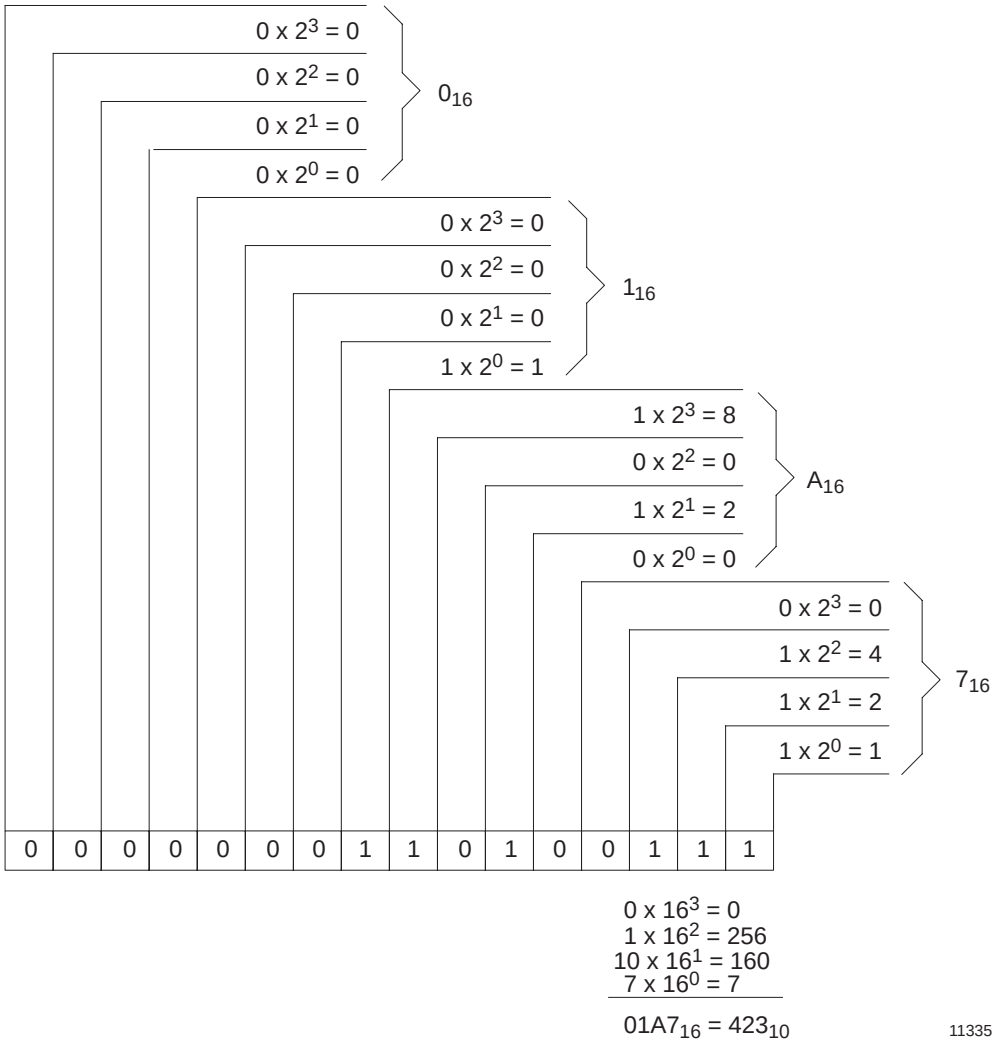
The hexadecimal number system is the most compact way to represent binary data, and it allows for the easiest conversion to and from binary. This system uses a number set of 16 digits: the numbers 0 through 9 and the letters A through F (where the letters A through F are equivalent to the decimal numbers 10 through 15, respectively).

Each group of four data bits represents one hexadecimal digit between 0 and F. In this way, each 16-bit data word can have a hexadecimal value between 0 and FFFF.

Each digit of a hexadecimal number has a place value that is a multiple of 16. To convert a hexadecimal number to its decimal equivalent, multiply each hexadecimal digit by its corresponding place value and add the results of the multiplications. Figure 6.4 shows the hexadecimal representation of the decimal number 423.

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Figure 6.4
Hexadecimal Numbers



Octal

The octal number system is also a relatively easy way to represent binary data. This system uses the eight digits 0 through 7.

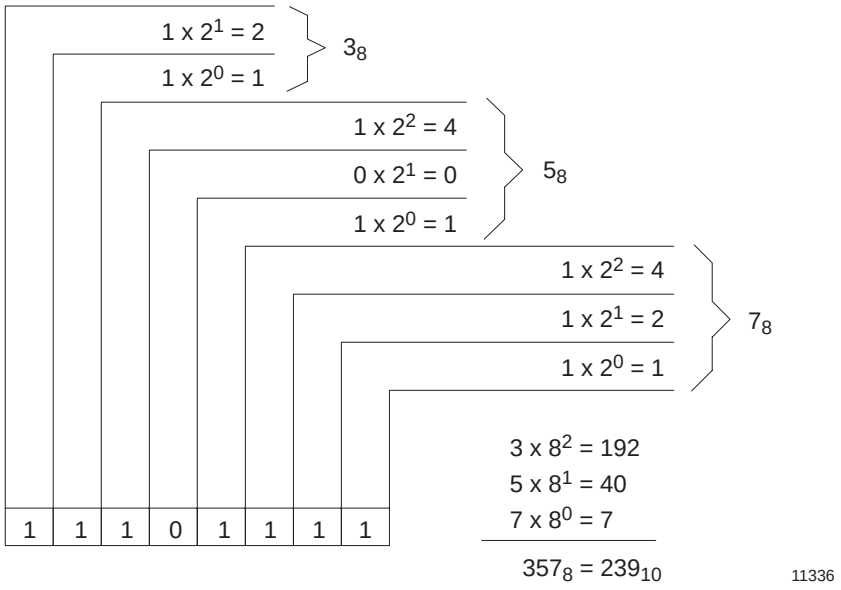
Each group of three data bits represents one octal digit between 0 and 7. This factor presents a slight conversion problem because bytes and words usually contain an even number of bits. Thus, an 8-bit byte can have an octal value between 0 and 377, while a 16-bit word can have an octal value between 0 and 177,777.

Each digit of an octal number has a place value that is a multiple of 8. To convert from octal to decimal, multiply each octal digit by its

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corresponding place value and add the results of the multiplications. Figure 6.5 shows the octal representation of the decimal number 239.

Figure 6.5
Octal Numbers



Order of Transmission

PCs store data in 16-bit (2-byte) words. The bits in these words are numbered (addressed) 0 through 17 octal, going from right to left within a word, as follows:

PC Word

Bits	17	16	15	14	13	12	11	10	07	06	05	04	03	02	01	00

In PC memory, the words are arranged as shown above. However, when the KF2 module transmits data over its asynchronous link, it transmits one byte at a time. The module always transmits the low byte (Bits 00 through 07) of a word before the high byte (Bits 10 through 17) of the same word. Also, the UART transmits the low bit first within a byte. Thus, when a PC word is traveling over the asynchronous link, it will look like this:

	First Byte								Second Byte							
Bits	00	01	02	03	04	05	06	07	10	11	12	13	14	15	16	17

Time →

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This does not present a problem at PC stations on the link because PCs store and retrieve their data in this same order of low byte first. It can, however, require you to do some extra computer application programming to maintain the proper byte and word order in PC data stored in the computer.

Three factors that can influence the ability of your computer to handle PC data are:

- the size of words in your computer's memory,
- the left-to-right or right-to-left ordering of bits within a word in your computer's memory, or
- whether the computer considers the low order byte of a word to have an even or an odd address.

If your computer uses something other than 2-byte, 16-bit words, you should design your application programs to make the proper conversions from PC word addresses to computer word addresses. When stored in a computer, each PC word should start on an even byte boundary.

Figure 6.6.A shows a 16-bit word in PC memory.

Figure 6.6.B shows a 16-bit computer word with right-to-left byte and bit order (as in DEC PDP-11/34 or VAX 11/780). It also represents a 16-bit word in an 8-bit processor (such as Zilog Z-80 or Intel 8086 microprocessor). If your computer has this type of word order, the conversion is straightforward.

Figure 6.6.C shows a 16-bit computer word with left-to-right byte and bit order (as in IBM Series 1). If your computer has this type of word order, the conversion is more complex. You will have to swap bytes into and out of buffers.

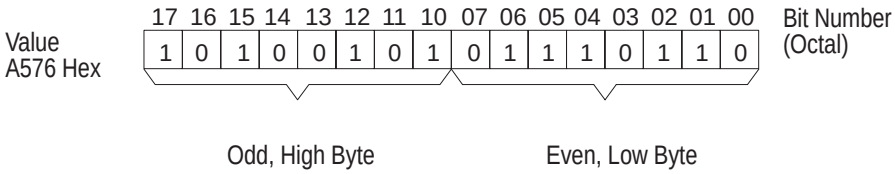
Figure 6.6.D shows a 16-bit computer word with left-to-right byte order and right-to-left bit order (as in Zilog Z 8000 or Motorola 68000 microprocessors). If your computer has this type of word order, your communication driver must handle the task of byte-swapping as it loads data into a buffer. Successive bytes received from the PC must be stored in the following order:

1,0,3,2,5,4,7,6,9,8...

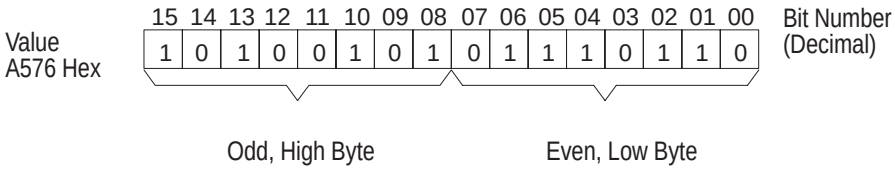
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Figure 6.6
Results of Transmitting Low Byte First

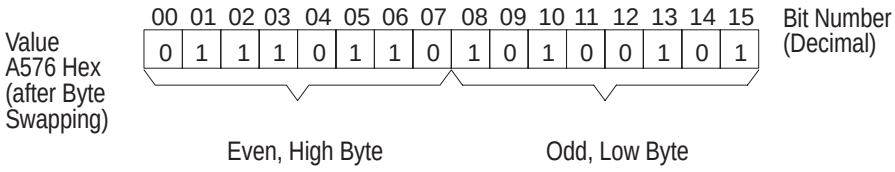
A. PC Word



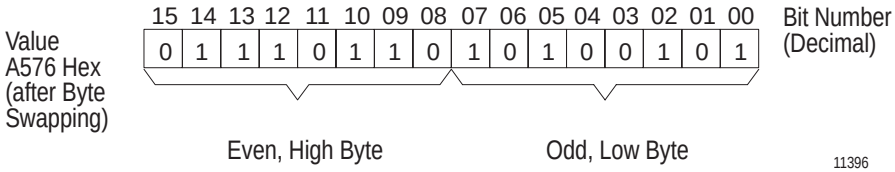
B. 16-Bit Computer Word with Right-to-Left Byte and Bit Order



C. 16-Bit Computer Word with Left-to-Right Byte and Bit Order



D. 16-Bit Computer Word with Left-to-Right Byte Order and Right-to-Left Bit Order



Addressing

There are three types of addressing a computer can use in command messages that it transmits to PC stations:

- Logical
- Physical
- Symbolic

Logical Addressing

You use logical addressing in commands that access PLC data table memory only (non-privileged commands). For example, you use logical

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addressing in a PLC's ladder diagram program to allow it to access its own data table memory.

Due to the differences in PLC memory organization, the logical addressing scheme varies for each controller type.

PLC/PLC-2

PLC and PLC-2 Family controllers access their data tables by using an octal word address. In PLC/PLC-2 command messages, this type of logical word address must be represented as an equivalent byte address. This byte address appears in the 2-byte field labeled ADDR in the message block formats (Chapter 5).

To encode a logical PLC/PLC-2 address, convert the octal word address to whatever number system you are using in your computer application programs. Next, double this converted word address to get the corresponding byte address. Place the result in the ADDR field, low byte first.

For example, to address PLC Word 020, you would first convert the octal value 20 to the desired base. In this example, let's use hexadecimal values. Octal 20 is 10 hex. Doubling this value gives 20 hex for the byte address. You would then code the value 0020 hex in the ADDR field of the message, low byte first. In binary format, ADDR would look like:



Important: PLC and PLC-2 Family controllers use this same logical addressing format when they transmit command messages to another station. If you plan to transmit a command message to your computer from one of these PCs, you should set up a buffer space in your computer to simulate PC memory. You would then have to write computer application programs to accept and execute commands from the PC stations and to translate the ADDR value into the corresponding address in the simulated PC memory.

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PLC-3 and PLC-5

PLC-3 and PLC-5 controllers use a form of logical addressing known as "extended addressing." With extended addressing, you specify the address for each level (or subdivision) of PLC-3 or PLC-5 memory, down to the smallest subdivision you want to access.

With a PLC-3, you can use this method to specify up to 6 levels of extended addressing, which is enough to address any particular word in PLC-3 memory. With a PLC-5, you can specify up to 4 levels of extended addressing, which is enough to address any word in PLC-5 memory.

To send a command message to a PLC-3 station, you would put the extended address in the field labeled "PLC-3 Extended ADDR" in the message block formats (Chapter 5). Figure 6.7 shows an example of how to enter a PLC-3 extended address in logical binary format in this message field.

The first byte in the extended address field is a set of bit flags that indicate which addressing levels are specified in the bytes following the bit flags. If a flag bit is set to 1, the address bytes must contain a specification for the corresponding level of the extended address. If a flag bit is zero, the address bytes should not contain a specification for that addressing level; instead, a default value is assumed.

For Level:	The Default Address Is:
1	3 (Data Table)
2	Current Context
All Others	0

You must always specify the value for the last level of the desired extended address, even if it is the default value.

If the address values can be specified in one byte each, then you can code the values directly. If it takes two bytes to specify an address, then you must use a delimiter byte of value FF hex before each 2-byte address. Any 2-byte value should be encoded low byte first.

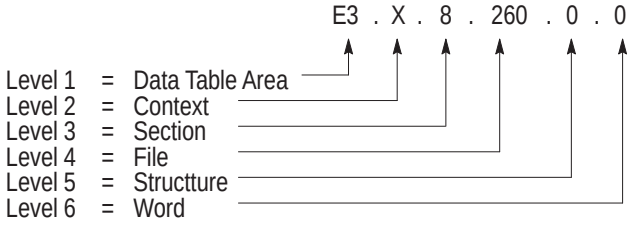
In Figure 6.7, the first byte contains the bit flags to indicate which addressing levels are specified. In this example, only Levels 3, 5, and 6 are specified; default values are used for the other levels.

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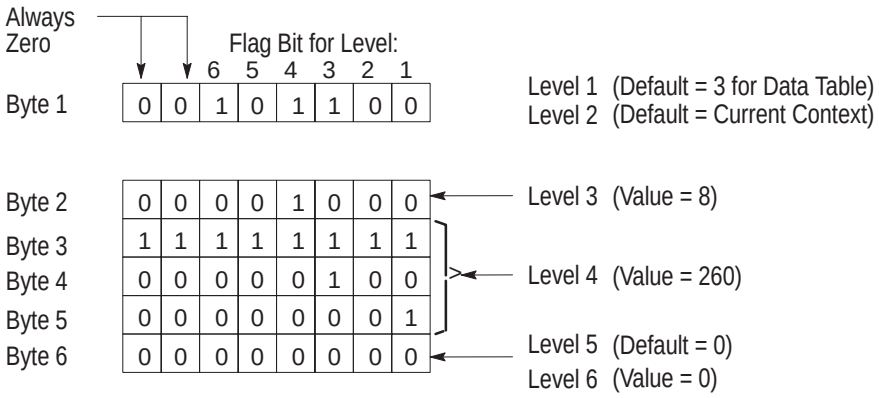
In Figure 6.7, the Level 5 address is 260 (decimal), which is too large to fit in one byte. Therefore, a byte of all 1's is used to delimit the 2-byte address value for this level. The value 260 is then coded low byte first. Note that the last level (Level 6 in this example) must be specified in the address field even though it is equal to the default value of zero.

Figure 6.7
Example of PLC-3 Logical Binary Addressing Format

PLC-3 Extended Address



Logical Addressing Format



Byte 1	Is the flag byte. In this case it indicates that the addresses for Levels 3, 4, and 6 are specified in the bytes that follow. Default values are used for Levels 1, 2, and 5.
Byte 2	Is the value of the Level 3 address.
Byte 3	Is a delimiter that says the next two bytes are one address.
Byte 4	Is the low byte of the Level 4 address .
Byte 5	Is the high byte of the Level 4 address. Note that Bytes 4 and 5 together give a value of 260 for the Level 4 address.
Byte 6	Is the value of the Level 6 address. Even though it is the default value, it must be specified because it is the last level in the desired extended address.

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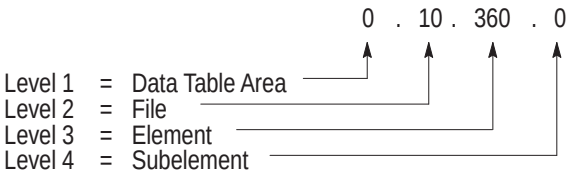
To send a command message to a PLC-5 station, you put the extended address of the station in the field labeled “PLC-5 SYSTEM ADDRESS” in the message block formats of your program. There are two types of logical addressing:

- Logical Binary Addressing
- Logical ASCII Addressing

Figure 6.8 shows the logical binary address you use to access the 360th element in Integer File 10.

Figure 6.9 shows the logical ASCII address to access the 360th element in Integer File 10.

Figure 6.8
PLC-5 Logical Binary Addressing



	Binary								Hex	
Byte 1	0	0	0	0	1	1	1	1	0	F
Byte 2	0	0	0	0	0	0	0	0	0	0
Byte 3	0	0	0	0	1	0	1	0	0	A
Byte 4	1	1	1	1	1	1	1	1	F	F
Byte 5	0	1	1	0	1	0	0	0	6	8
Byte 6	0	0	0	0	0	0	0	1	0	1
Byte 7	0	0	0	0	0	0	0	0	0	0

Byte 1 Is the flag byte. In this case it indicates that the addresses for all levels are specified in the bytes that follow.

Byte 2 Is the value for the Level 1 address (0 for Data Table).

Byte 3 Is the value for the Level 2 address.

Byte 4 Is a delimiter that says the next two bytes are one address.

Byte 5 Is the low byte of Level 3 address.

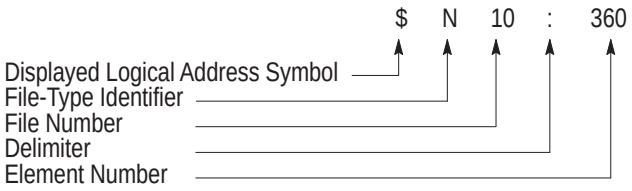
Byte 6 Is the high byte of Level 3 address. Note that Bytes 4 and 5 together give a value of 360.

Byte 7 Is the value for the Level 4 address.

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Figure 6.9
PLC-5 Logical ASCII Addressing



	ASCII	Hex
Byte 1	NUL	0 0
Byte 2	$	2 4
Byte 3	N	4 E
Byte 4	1	3 1
Byte 5	0	3 0
Byte 6	:	3 A
Byte 7	3	3 3
Byte 8	6	3 6
Byte 9	0	3 0
Byte 10	NUL	0 0

Byte 1	Is the null character that tells the PLC that an ASCII address is to follow.
Byte 2	Is an ASCII "$."
Bytes3-9	Are the ASCII address in the PLC-5.
Byte 10	Is a null character that ends the ASCII address specification.

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Important: PLC-3 controllers can also accept PLC/PLC-2 type command messages with the PLC/PLC-2 logical addressing format. Before sending this type of command to a PLC-3 station, you must first allocate a PLC-3 input file (the file number is the same as the PLC/PLC-2's octal station number) to simulate PLC/PLC-2 memory (refer to Publication 1775-6.5.1). In addition, PLC-3 controllers can transmit both PLC-3 and PLC/PLC-2 type command messages, each with its appropriate logical addressing format.

PLC-5 controllers can also accept PLC/PLC-2 type command messages with the PLC/PLC-2 logical addressing format. Before sending this type of command to a PLC-5 station, you must first allocate a PLC-5 file (the file number is the decimal equivalent of the PLC/PLC-2's octal station number) to simulate PLC/PLC-2 memory. In addition, PLC-5 controllers can transmit PLC-5 and PLC/PLC-2 type command messages, each with its appropriate logical addressing format.

Therefore, if you plan to transmit commands from a PLC-3 or a PLC-5 to your computer, you should set up a computer buffer to simulate a PLC-3 or PLC-5 file and write computer application programs that are capable of interpreting all the types of addressing formats that will appear in the command messages.

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PLC-4 Microtrol

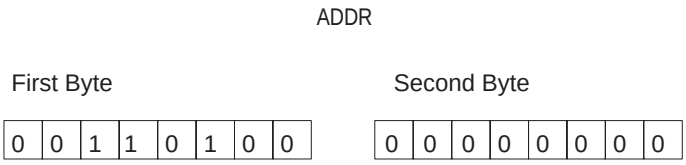
PLC-4 Microtrol controllers use a form of logical addressing that specifies the identification number of the controller in the loop, the section of memory, and the bit address. To specify a PLC-4 logical address in a command message, you would use an appropriate binary code. Note that these binary codes let you address only PLC-4 words, not bits.

PLC-4 controllers can accept only PLC/PLC-2 type non-privileged commands. The binary code for the PLC-4 logical address goes in the 2-byte field labeled ADDR in the PLC/PLC-2 message block formats (Chapter 5). Put the low byte (Bits 0 through 7) of the binary address code into the first byte of ADDR.

For example, suppose we want to address Storage Word 4 in Controller 3 in a PLC-4 Microtrol loop. The binary code for this address is:

00000000 00110100

In the command message that accesses this storage word, the ADDR field would be:



Physical Addressing

Physical addressing is the type of addressing a computer would use to send a privileged command to a PC station. In particular, you would use physical addressing to upload or download PC memory. The recommended procedure for doing this is to use a series of physical read or write commands that begin at Physical Address 0000 and proceed sequentially to the end of PC memory.

Because of the differences in PC memory organization, the physical addressing scheme varies somewhat with controller type.

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PLC

PLC controllers use physical addresses that are exactly the same values as the corresponding logical addresses. Remember that the logical address is a byte address, so the physical address will also be a byte address. For example, the logical byte address of the 17th word in PLC memory is 32 decimal, and the physical address of that word is also 32 decimal.

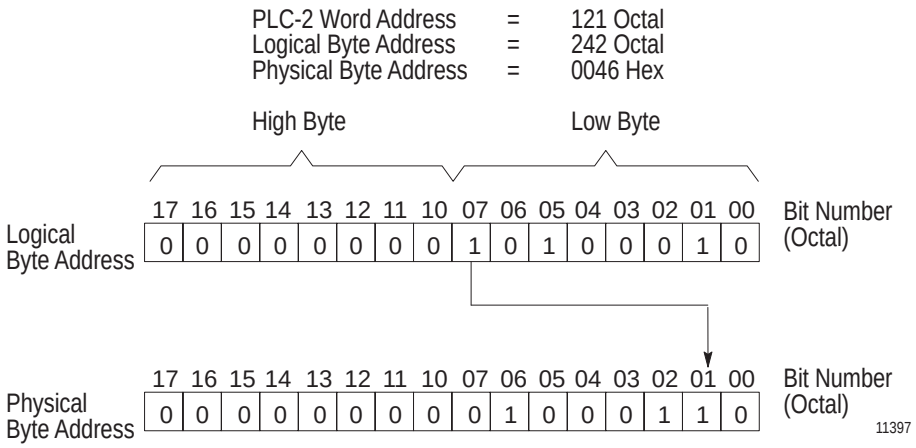
To send a physical read or write command to a PLC station, put the PLC physical address in the ADDR field of the command message format (Chapter 5). Be sure to encode the low byte of the physical address as the first byte in the ADDR field.

PLC-2

PLC-2 controllers use physical addresses that are directly related to the logical addresses. To convert a given logical address to its corresponding physical address, move Bit 7 of the logical address to Bit Position 1 and shift Bits 1 through 6 to the left one position. Figure 6.10 illustrates the conversion process for Logical Word Address 121. Remember that the logical PLC-2 address is a byte address, so the physical address will also be a byte address.

To send a physical read or write command to a PLC-2 station, put the PLC-2 physical address in the ADDR field of the command message format (Chapter 5). Be sure to encode the low byte of the physical address as the first byte in the ADDR field.

Figure 6.10
Converting PLC-2 Logical Addressing to Physical Addressing



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PLC-3 and PLC-5

PLC-3 and PLC-5 controllers use physical addresses that are related to logical addresses by means of pointers. Since no two PLC-3/PLC-5 systems are configured identically, the pointers are not fixed. Therefore, there is no algorithm for converting logical to physical PLC-3 or PLC-5 addresses.

The PLC-3/PLC-5 physical address is a word address. It goes in the 4-byte field labeled “PLC-3 physical ADDR” or “PLC-5 physical ADDR” in the PLC-3/PLC-5 physical read or write command message format (Chapter 5). The format for this physical address field is:

PLC-3/PLC-5 Physical Address

First Byte	A24	A23	A22	A21	A20	A19	A18	A17
Second Byte	0	0	0	0	0	0	0	0
Third Byte	A8	A7	A6	A5	A4	A3	A2	A1
Fourth Byte	A16	A15	A14	A13	A12	A11	A10	A9

In this format, A1 through A24 represent the 1 to 24 bits of the physical address value. For example, to address a command message to Physical Word Address 12,200 decimal (002FA8 hex), you would use the following binary code in the address field:

First Byte	0	0	0	0	0	0	0	0 (Value 00 Hex)
Second Byte	0	0	0	0	0	0	0	0 (Always 00 Hex)
Third Byte	1	0	1	0	1	0	0	0 (Value A8 Hex)
Fourth Byte	0	0	1	0	1	1	1	1 (Value 2F Hex)

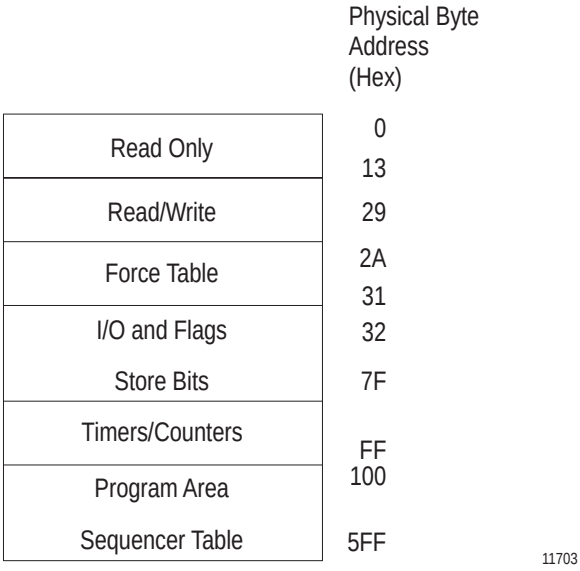
The recommended procedure for uploading or downloading PLC-3 or PLC-5 memory is to begin at Physical Address 0000 and proceed sequentially to the end of memory. Since a single physical read or write command can transfer only about 120 words of data, it will take many such commands to upload or download the entire PLC-3 or PLC-5 memory. Therefore, each successive physical read or write should begin at the next physical address after the one where the previous command stopped.

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PLC-4 Microtrol

PLC-4 Microtrol controllers use physical addresses that begin at 00 for the first word of memory and continue to 5FF hex for the last word of memory. Figure 6.11 is a map of PLC-4 physical memory.

Figure 6.11
PLC-4 Physical Memory



Specifying a physical address in PLC-4 privileged commands requires 3 bytes. The first byte is the identification number for a particular controller in the loop, and it is labeled “PLC-4 SEL” in the command message formats (Chapter 5). The next two bytes contain the physical address of a word in the selected controller’s memory, and they are labeled ADDR in the command message formats (Chapter5). When encoding the physical address, be sure to put the low byte of the address value in the first byte of the ADDR field.

Symbolic Addressing

Symbolic addressing uses ASCII symbols to represent a logical address. Only PLC-3 controllers can accept symbolic addresses. Before using a symbolic address in a message, you must first define the symbol at the PLC-3 or PLC-5 that is to receive the message (refer to Publication 1775-801).

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The symbolic address field can be from 1 to 8 bytes long. The first byte contains the ASCII code for the first character in the symbol name, the second byte contains the ASCII code for the second character, and so on. If the symbol name is more than 8 characters long, encode only the first 8 characters.

To use a symbolic address in a command message, encode the symbol in the field labeled “ASCII symbol” in the command message formats (Chapter 5). Note that the message formats show a byte of value zero (0) before and after the symbolic address field. You must include these zero bytes because they act as delimiters to distinguish the symbolic address from other fields in the message.

Important: PLC-3 controllers can also transmit commands that contain symbolic addresses. If you plan to transmit this type of command message to your computer from a PLC-3 station, then you must write computer application programs that are capable of accepting these commands and interpreting the symbolic addresses.

Logical ASCII Addressing

Logical ASCII addressing is supported only by PLC-5 controllers. ASCII addressing allows you to specify an address in the same form that you use at the programming station, and lets any device communicate with any other device, without knowing the internal memory structure of the target device.

A logical ASCII address starts with an ASCII NULL (0) character and a dollar sign ($) to differentiate it from the symbolic form. The rest of the address then follows, as a string of ASCII characters. The string is terminated with another NULL character. See the example in Figure 6.9 in this chapter.

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Chapter 7

Error Reporting

General

This chapter contains a list of error codes associated with network start-up and run-time situations. The error information is available in three places:

1. the PC application program,
2. the internal error counters in each module, and
3. the STS byte in the header of a message packet.

The first section deals with the PC application program's error word and is the most accessible to you.

The second section lists internal error counters, bytes of information stored in RAM in each Data Highway or PCL module. These numbers can be read only by issuing a diagnostic read command from a device connected to one of the modules that supports an asynchronous port.

"PLC-2/PLC" explains the STS and EXT STS bytes that are contained in a command message. This data is presented as part of the asynchronous protocol and is available only to modules that support this (e.g., KF2 module).

A Brief Note: Error codes pointing to traffic problems or other ambiguous situations should be dealt with only after a troubleshooter has thoroughly **tested the cabling** for shorts and loose connections. Most application problems can be traced initially to bad cabling. What can be very frustrating is that bad cabling does not necessarily mean that a point is completely shorted or completely open. Some traffic may get through (narrowed bandwidth), but the frequency of retries on a given message becomes very high.

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ERROR WORD in User Programming (1771-KG, 1771-KA, 1771-KA2, 1774-KA Modules)

An error code word specified in the header rung is the primary source of explanation for programming problems and run-time problems. Error codes are stored in this word for most events that can be observed by a Data Highway user.

The display of an error code at a given location does not necessarily mean a faulted condition exists on the highway. Due to the nature of the polling algorithm and the built-in retry and recovery procedures, random noise or contention can easily be ignored if normal procedures are followed. For example, Error 89 is primarily an indication of heavy use at one node, rather than a faulted condition. The appearance of a code like Error 89 is then a user application question and should be dealt with by understanding the tradeoffs between performance and node utilization. Obviously prescan errors (1-29) indicate a program problem and should be fixed immediately; but merely trapping and halting on run-time errors, without understanding the relationship of the error to loading factors and node utilization, does not allow efficient operation of the Data Highway.

A troubleshooter should also make full use of the counter (high byte in the error word) to record frequency of errors. This contributes to any application solution that requires redistribution of node traffic.

The error code word is four BCD digits wide. The uppermost digit is not displayed by the Industrial Terminal in the GET instruction in the header rung, but this is the least valuable part of the error code and can often be ignored. If necessary, this number can be easily displayed using GET BYTE and a PUT. The lower two digits are always the error number. Each number indicates a different condition, which is explained in the paragraphs below. The meaning of the upper two digits varies depending on the error number.

There are about 50 different error numbers that can be reduced to two major groups and four minor groups:

- **Pre-Scan Errors:** These are mostly communication zone syntax errors. They are numbered 1 to 29. They are detected as the KA module prescans the communication zone just before it starts scanning start bits.

  No syntax errors are detected in the header rung. If the prescanner does not recognize the header rung it will decide that it is not a header rung and will continue scanning until the end of memory or until it finds a valid header rung.

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Prescan errors always cause the module to turn on the PROG light and enter an error state. When the keylock is turned to PROGRAM, the error state is exited; and the PROG light turned off.

For all prescan errors the upper two digits act as a pointer to the rung containing the error. Rungs are numbered from 1 to 99, then wrap around back to 0 through 99, and so on. The first rung after the header rung is number 1.

If no prescan error is detected, the error code word is set to all zeros at the end of the prescan.

- **Run-Time Errors:** For all run-time errors the first two digits of the code are a modulo 100 error counter. The first error is number 1.

  Except as noted, the module continues operating after recovering from a run-time error.

  Run-time errors are divided into the following groups:

  - **Message Formatting:** Numbered from **30 to 39**. They are detected as a message is being formatted and before it is sent. A few of these errors result in the KA turning on the PROG light and entering the error state.
  - **Reply Errors:** Numbered between **50 and 59** and detected by the local station when a reply is received.
  - **Remote Errors:** Numbered from **80 to 89** and returned in the reply message from the remote station as the result of errors in execution of a message at the remote station. It should be noted that a Data Highway module will continue to generate replies as long as it is functioning properly. These errors are contained in the STS byte of the reply message.
  - **Local Errors:** Numbered **90 to 99** and detected by the local station; they are the result of being unable to properly transmit on the highway.

  Error numbers are listed and explained below:

  01 No longer used. In revisions previous to F for 1771-KA this code could be set as a result of intermittent hard errors on the KA to PC cable.

  02 The prescan aborted because the test codes in RACK 0 are bad. This error should never occur; because if the test codes are ever bad, the PC should fault before the KA ever gets to the prescan.

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03 The KA or KG does not have enough internal memory to store the start bit index. This should only occur if the communication rung is very large. To correct this, the communication zone can be shortened, perhaps by combining commands or windows. It may also occur if a RAM hardware error corrupts the internal memory organization.

04 The first element of a memory access branch is not a GET. This condition can only be detected if no command rungs have yet been detected and if the branch being processed started with a BST. (BST = Branch Start; BND = Branch End)

05 The address field of the first GET in a memory access branch contains an invalid Data Highway station address. The address must be less than 377.

06 The second element of a memory access branch is not a GET.

07 The third element of a memory access branch is not a GET.

08 Invalid window address in memory access branch; the address in the second GET is greater than the third GET.

09 There is something besides a BST or BND after the third GET of a memory access branch.

10 There is something other than a BST or output instruction after a BND in a memory access rung.

11 A rung in the communication zone starts with something besides a BST or an XIC, or the zone contains no command rungs and the terminating rung has been omitted.

12 The start bit address specified for a command rung is in the low byte of a word. Start bits must always be in the 10 to 17 range.

13 The second element of a command rung is not an XIC.

14 The command code (the low digit of the address) of the second XIC in a command rung is invalid.

15 The station address in the second XIC of a command rung is invalid. Station address must be less than 377.

16 An instruction or an opcode other than XIC, XIO, BST, or BND has been encountered in a bit control command rung, or the output element of the rung is incorrect.

17 The third element of a read or write command rung is not a GET.

18 The fourth element of a read or write command rung is not a GET.

19 The fifth element of a read or write command rung is not a GET.

20 The sixth element of a read or write command rung is not a legal output instruction.

21 The start of a command rung is not an XIC, or the terminating rung has been omitted. This error is only generated if valid command rungs precede it.

22 The word containing start/done/error bits is positioned so that it crosses a boundary in the data table. (For example, Start Bit 07710 means that the error bits would be in Word 100, or 17710 means that the error bits would be located in the first word of the program).

23 An unprotected write or bit control command is specified, and the DIP switch that enables sending of unprotected commands is off.

24 Not used in 1771-KA.

25 Not used in 1771-KA.

26 Too many command rungs. A maximum of 255 command rungs can be programmed.

27 The default timeout is too large. Valid timeouts are from 011 to 407 octal. The value 010 causes the timeout to be disabled.

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30 A command rung syntax error has been detected in RUN mode after the prescan. This means that either the communication zone has been altered by on-line editing, hardware problems, or a highway download operation, or that it has been moved by a gap or ungap of a rung before the zone, or by changing the data table size.

31 This will not be generated by Revision F (1771-KA). Previous modules generated this code if the start bit scanner detected a hard error on the PC-to-module cable.

32 The data block of a read or write command is too large to fit in one Data Highway message. This error causes the module to enter an error state.

33 An invalid command code was detected by the start bit scanner. This has the same cause as Error 30. This error causes the module to enter an error state.

34 An invalid station address was detected by the start bit scanner. See Error 30. This error causes the module to enter an error state.

35 The KA attempted to send an unprotected write or bit control command while the DIP switch that enables unprotected commands was off. This can only occur at run-time if the DIP switch that controls this option was changed without removing power from the module.

36 The start bit was turned off after a message was sent but before the done bit, local error, or remote error bit was set. This is the situation that causes the local error to turn on, then off for 85 ms after the start bit is reset. The error code word is set before the local error bit turns on.

37 The start bit was timed out by the automatic module timer before a reply message arrived. This happens for one of the following reasons:

- Noise on the highway causes loss of a message. In this case the message probably will succeed if it is retried.
- The remote station powered down or was disconnected from the highway while it was processing the message. If the message is retried, it should get a 92 error.
- The timeout is too short. The minimum recommended timeout value is 2 seconds. With a resolution of 1 second this allows the actual timeout to occur as soon as 1 second or as late as 2 seconds.
- A highway loading peak caused the timeout to be exceeded. If this is a rare occurrence, it might be acceptable to just retry the message. Small increases (less than 100%) in the timeout should eliminate this problem.
- Malfunction of a highway station is causing it to retain mastership for long periods of time. Check for a station with a faulty receiver, **or a bad highway cable**. The internal diagnostic counters will be most helpful in tracking this one.

50 Not used. Prior to Revision F (1771-KA) this may have occurred if a PC hard error occurred while processing a reply message.

51 The reply message contains an invalid rung number. This should never occur unless PCs are sending messages to a computer program that is not yet functioning properly. This error will not cause the setting of an error bit or done bit.

52 A reply has been received at a PC that cannot send messages because it has no command rungs. This should never occur unless faulty reply messages are sent by a computer under debug. This error will not cause the setting of an error bit or done bit.

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53 A reply message has been received for which the start bit is off. This could mean that the user program turned off the start bit before the done bit came on or that the automatic timeout is too short. This error often follows a 36 or 37 error. This error will not cause the setting of an error bit or done bit.

54 Run-time command rung syntax check failed. This is probably the result of on-line editing. This error will cause the module to enter the error state. See Error 30.

55 Reply received while PROG light is on or during Program mode. This will possibly occur if messages are being executed remotely at the time a run-time syntax check fault occurs or if the keylock is turned to Program mode while messages are being executed. This will not cause the setting of an error bit or done bit.

56 The sequence number in a reply message does not match the one being waited for. This is to be expected if the start bit is turned on, a message is sent, then the start bit is turned off and on again before the done bit is set. This error will not cause the setting of an error bit or done bit.

57 A reply message has an incorrect size. This should not occur except during the debug of a new highway computer program. This will not cause the setting of a done bit or error bit.

81 This error is sent from the remote station if the command message was incorrect. This includes the command code, subcommand code, and size of the command or the requested reply size. This error results in a setting of the remote error bit for the associated rung. This error code corresponds with STS Code 10.

82 Not used for 1771-KA. The meaning of this code has been assigned to verification errors within the host PC. This error code corresponds with STS Code 20.

83 Some condition exists at the remote PC that requires manual intervention. This error code corresponds with STS Code 30.

- The cable between the module and the PC is unplugged.
- The PC is faulted.
- Either results in setting the remote error bit for the associated rung.

84 Execution of a message at the remote station was aborted because of a hard communication error on the cable or on backplane access between the module and the PC. This error results in the setting of the remote error bit for the associated rung. This error code corresponds with STS Code 40.

85 An attempt to access an illegal address in the remote PC has aborted message execution. Illegal accesses may result from:

- Access outside the data table as defined at the remote station.
- Access outside a memory access window (protected commands only).
- Either results in setting the remote error bit for the associated rung. This error code corresponds with STS Code 50.

86 Execution of a command is disabled at the remote station by a DIP switch option. This error results in setting the remote error bit for the associated rung. This error code corresponds with STS Code 60.

87 The remote PC is in PROGRAM or REMOTE PROGRAM mode, the remote KA is in Download mode. This error results in setting the remote error bit for the associated rung. This error code corresponds with STS Code 70.

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88 Execution of protected commands at the remote station is inhibited because its PROG light is on. This error results in setting the remote error bit for the associated rung. This error code corresponds with STS Code 80.

89 The remote station has no memory to store messages. This error will only be signaled after 5 retries at half-second intervals. It indicates that either a very heavy traffic load is being presented to the remote station, or that the dynamic memory of the remote station is corrupted. If the problem clears up after cycling power and does not recur, the cause may be RAM or CPU failures triggered by heat or noise. If the problem recurs repeatedly, the probable cause is too many messages. This error code corresponds with STS Code 90.

91 The RS-232-C port is not connected to a device, or the DSR pin is not being asserted (high = true). This error code corresponds with STS Code 01.

92 The local station cannot confirm delivery of a command message to the remote station. This does not necessarily mean that the message was not sent or that the done bit or remote error bit will not be set. It is possible, but not probable, that the message will be executed at the remote station. The local error bit will be set by this error. If the done or remote error bits are set , they will occur after the local error bit. Reasons for this error include:

- Disconnection of the Data Highway
- Noise on the Highway
- Bad Cabling or Connections
- Remote Station Is Powered Off
- Remote Station Does Not Exist
- Wrong Station Address Is Being Used
- Remote Module Is Faulted
- Some Module on the Highway Is in a “Bus Hog” Condition and Prevents Proper Operation of the Highway

If an Error 92 persists, the internal diagnostic counters should be used to pinpoint the location of the faulty module or cable. This error code corresponds with STS Code 02.

93 This error will occur if the local module, while attempting to send a message, detects another master on the highway. The local error bit for the rung that sent the message will be set. Like Error 92, this error does not mean that the message was not received. It is quite probable that the message will be executed. If it is, the done bit or remote error bit may be set after the local error bit if the start bit stays on. If the start bit is unlatched by the local error bit, a 53 or 56 error may result. Occurrence of this error is probably related to general highway conditions, not to the message or the stations sending and receiving it. The message should be retried. Possible causes of this error are:

- connection of two operating highways,
- connection of a powered up module to an operating highway,
- noise on the highway, or
- bad cabling or connections.

Error 93 is rare but not impossible on a well-functioning highway. If it persists, the internal diagnostic counters should be used to pinpoint the location of the faulty module or cable. This error code corresponds with STS Code 03.

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Local and Remote Error Bits

As a diagnostic tool, these bits are useful to identify the rung that caused an 80- or 90-series error.

The remote error code corresponds with STS Code 03.

The remote error bit indicates that a message was received from the remote station that some condition there prevented successful execution of the message. When a remote error is indicated, there is probably nothing wrong with the local station or with the highway cable. The remote station is most likely working properly. The first causes to investigate are indicated by the various codes.

Setting of a local error bit indicates that the local module is not able to confirm delivery of the command message to the remote station or that the command rung timed out before the reply message arrived. A local error does not necessarily mean that the message was not received at its destination or that it will not be executed.

Error Codes for 1775-KA

This section describes error codes that the 1775-KA module will report to the PLC-3 application program. Errors are of three types:

- Local
- Reply
- Remote

Local errors are those that the 1775-KA module encounters while trying to execute one of its own message procedures.

Reply errors are those that the 1775-KA module inserts in the STS byte of a reply that it generates in response to a command from a remote station.

Remote errors are those that are returned to the 1775-KA module in a reply message from a remote Data Highway station.

Important: The frame of reference in this chapter is the 1775-KA. All error codes listed here result from some action of a 1775-KA.

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Local Error Codes

The 1775-KA module stores local error codes under the user symbol ERROR. Possible local errors are listed below:

Code (If Applies) EXT STS	Code (If Applies) STS	Error Code	Meaning
		32	The size of the local file involved in a file assignment command is greater than 65,535 bytes.
		34	A station number greater than 376 (octal) was specified for the remote address in an assignment command.
		35	Attempt to send unprotected command is invalid.
		37	The per-packet timeout, which can be set through LIST, ran out before a reply was received. This means that the remote station acknowledged (ACK) the command message but did not send the reply in the allotted time. (cf. Error 92)
	02	92	The remote station specified does not acknowledge (ACK) the message. See discussion of Error 92 in "ERROR WORD in User Programming (1771-KG, 1771-KA, 1771-KA2, 1774-KA Modules)."
	04	94	Local port is disabled through LIST.
		112	1. Undefined assignment operator in an assignment statement. 2. Undefined operator in an expression.
		114	Illegal expression syntax.
		115	Illegal unary (prefix) operator in an expression.
		117	Undefined data following a valid address in a CREATE command, or undefined data following a valid symbol in a DELETE command.
		121	Symbol undefined. This will occur if a symbol appears as the source in an assignment command before it is defined as a symbol. For example, a statement of the form: A = A + 6 will give this error if User Symbol "A" has not appeared previously.
		123	System symbol must be a symbolic address. This error will occur if a procedure name is used in place of a symbolic address in an assignment statement or if the system symbol referenced in an assignment doesn't exist.

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Code (If Applies) EXT STS	STS	Error Code	Meaning
		124	Illegal destination in an assignment command. This does not necessarily mean that an assignment command was desired because any command line that doesn't look like anything else is assumed to be an assignment command. Lines that will generate this error include: 5 = 4 + 1 6ASDFGHJ whereas the line: WERTYUI will generate an Error 140 (unrecognized command).
		125	Illegal modifier for the CREATE command. That is, the command was CREATE/... and the ... was other than LOCAL, GLOBAL or a legal abbreviation of one of these.
		126	The CREATE command was specified, but the symbol did not begin with an "@".
		127	"$" missing in CREATE system symbol address.
		129	Attempt to delete non-existent symbol.
		140	Unrecognized or ambiguous command. (cf. Error 124)
		142	Illegal data following GOTO command.
		143	Illegal use of label (e.g., not in a procedure).
		144	Label not found.
		145	Duplicate label. User symbols must be distinct from labels.
		146	Too many nested procedures.
		147	Insufficient privilege for the specified operation. This error can occur when an attempt is made, via the assignment command, to write into a major section of memory in which the 1775-KA module does not have access privileges (namely; Major Section 0, 1, or 2).
		148	Unbalanced parenthesis in expression.
		149	A procedure name was used in a field that required a symbolic address or a user symbol variable.
		150	A label was used in a field that required a symbolic address or a user symbol variable.
		154	Error in reading address for symbol entry.
		156	Illegal symbol in expression.

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Code (If Applies) EXT STS	STS	Error Code	Meaning
		159	Bad level specified in extended address. 1. More than 9 levels were specified in an extended address. 2. Something other than a "(" or a number followed a "." in an extended address.
		160	"$" unrecognized section specifier. An illegal character followed the "$" in an address.
		161	Bad timer or counter specification. 1. The first letter of the data table address is a T, C, or P; but there are not 4 characters in the specification. Incorrect addresses that would cause this error include $TAC:15, $C5:3, $TACCUM:23, etc. 2. The key data table word specifier was 4 characters long and began with a T, C, or P; but it did not match the legal word specifiers (e.g., $TACM:3). 3. There was no colon following a legal word specifier.
		163	Missing colon between file and word.
		164	Illegal word specifier in a data table address.
		165	Illegal context specifier. When an expression determined the context in a data table address,or when the global context (Context 0) was specified in a data table address, a colon followed the context.
		166	Attempt to execute a symbol not defined as a process. The system symbol exists but refers to a symbolic address rather than to a process.
		169	Either the number or the expression following the "/" in an address has a value outside the range 0 to 15 (decimal).
		171	Value specified n a bit assignment statement was other than a zero or a one.
		177	Illegal use of EXIT command.
		178	Illegal use of STOP command.
		179	STOP encountered in procedure.
		188	Attempt to read/write at bad address.
		189	Unable to evaluate the expression in the given base. This will occur, for example, if the argument of a FROM BCD function is not a valid BCD bit pattern. It will also occur when invalid characters occur in numeric values (e.g., "57 + 12X").
		192	Function being used is not defined.

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Code (If Applies) EXT STS	STS	Error Code	Meaning
		194	Expression is too complex.
		199	Attempt to divide by zero.
		200	Bad port specifier. That is, the character following the "#" is other than "H", "h", "M", or "m".
		201	User symbol used as part of remote address specification.
		202	Undefined data following assignment command. This error would occur, for instance, if the modifier UNRPOT were used instead of UNPROT.
		203	Error in remote specification. 1. A character other than "@" or "$" following the station number specification (... = #H045*T...). 2. Something other than EOL, PROT, or UNPROT following a remote source add. (.... = #H012$S5:8 + 9).
		204	Third-party transfer. That is, in an assignment command, both the source and the destination were remote addresses.
		205	Error in evaluating a PLC-2 address, or PLC-2 address greater than 65,535 bytes.
		206	Zero range specified in an assignment command.
		207	Word range specified in destination address.
		208	Destination and source addresses disagree in type.
		209	Not of Data Highway message type.
		210	Use of a non-PLC-3 type address in a local address operand.
		211	In an assignment command, one of the local files does not exist, or the word specified is beyond the end of the file.
		213	A local file exists, but the action specified refers to addresses beyond the end of the file. Possible causes include: 1. In a word assignment statement, the offset is greater than the file size. 2. In a word range assignment statement, the sum of the base address and the offset is greater than the total file size. 3. In a file assignment statement, the destination file is smaller than the source file. If the source file is remote, a single packet will be fetched from the remote station's file.
		214	Local source and destination files differ in size.

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Code (If Applies) EXT STS	STS	Error Code	Meaning
		215	The value resulting from operations specified on the left side of an assignment statement will not fit into the destination specified on the right side. 1. The source is in the H section, and the destination is in the N section; but the number is too large (i.e., outside the range — 32,768 to +32,767). 2. A word is transferred from a binary section (I, O, or B section) to the N or C section and the high-order bit is a 1. 3. The destination is in the D section, but the number is not a valid BCD bit pattern.
		217	More than 8 levels specified in file address.
		218	File size changed between packets of a multi-packet transaction.
		230	Reply packet too small.

Reply Error Codes

The 1775-KA module inserts the reply error code in the STS or EXT STS bytes of any reply message packet it returns to a remote station. For reply errors, there is a direct correlation between the error codes in the STS and EXT STS bytes of reply messages and the error codes stored at the command station. Refer to “PLC-3 and PLC-5” for EXT STS bytes.

The meaning of each error code depends on the command message received from the remote station. The sections below describe the error conditions that the various commands can generate. The error codes are listed according to the decimal value that would be stored at the command initiating station.

When a remote station transmits one of the commands listed below, the local 1775-KA module might issue a reply message that contains one of the error codes listed under that command. Error Codes 81 to 88 appear in the STS byte of the reply message, and Codes 231 to 241 appear in the EXT STS byte. PLC-2 and PLC Family processors can only display error codes contained in the STS byte (80-89). Error codes contained in the EXT STS bytes are only available if either another PLC-3 or computer originates the command message.

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Code (If Applies) EXT STS	STS	Error Code	Meaning
			DIAGNOSTIC READ COMMAND
	10	81	1. A 2-byte ADDR field and a 1-byte SIZE field are missing after the FNC byte in the command message. 2. The number of bytes of data requested in the SIZE field is greater than the maximum number allowed per reply packet (244), or SIZE is 0 (zero).
	50	85	The command is an illegal request to read from the 1775-KA module's backplane window.
			DIAGNOSTIC STATUS COMMAND
	40	84	A backplane error occurred during determination of the physical address of the end of the ladder diagram program or of the end of user memory.
			PLC/PLC-2 WORD WRITE COMMANDS
	10	81	1. A 2-byte ADDR field is expected after the TNS word, but only one byte is present. 2. There is an odd number of data bytes in the command packet. 3. The ADDR value is odd (that is, it does not specify a word address).
	30	83	The local 1775-KA module has executed a shutdown request to the local PLC-3 processor.
	40	84	Local PLC-3 backplane error (either memory parity or timeout/disconnect).
	50	85	1. The destination file does not exist in PLC-3 memory. 2. The destination word does not exist in the destination PLC-3 file. 3. The length of the destination file is greater than 65, 535 words.
	60	86	Local keyswitch setting prohibits writing into desired destination file.
	70	87	The local PLC-3 processor is in Program mode. There may or may not be a major system fault.

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Code (If Applies) EXT STS	STS	Error Code	Meaning
			PLC/PLC-2 READ COMMANDS
	10	81	1. The required 2-byte ADDR field and 1-byte SIZE field are missing in the command message. 2. The ADDR value is odd (that is, it does not specify a word address). 3. The value of SIZE is 0 (zero). 4. The value of SIZE is greater than 244. 5. The SIZE value specifies an odd number of bytes.
	30	83	Same as for PLC/PLC-2 write commands above.
	40	84	Same as for PLC/PLC-2 write commands above.
	50	85	1. Destination file does not exist. 2. Destination file is too small. 3. Source file is more than 65,535 words long.
	70	87	PLC-3 processor is in Program mode.
			PLC/PLC-2 BIT WRITE COMMANDS
	10	81	Incomplete bit description because the number of bytes after the TNSW is not a multiple of 4.
	30	83	Same as for PLC/PLC-2 word write commands above.
	40	84	Same as for PLC/PLC-2 word write commands above.
	50	85	1. Destination file does not exist. 2. Destination bits do not exist in destination file. 3. Length of source file is greater than 65,535 words.
	60	86	Keyswitch setting at local PLC-3 processor prohibits access.
	70	87	Local PLC-3 processor is in Program mode.

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Code (If Applies) EXT STS	STS	Error Code	Meaning
			PLC-3 WRITE COMMANDS
	10	81	1. There are not at least 2 bytes of data after the end of the block address. 2. There is an odd number of data bytes after the end of the block address. 3. Sum of packet offset and size values specifies more than 65,535 words. 4. Sum of packet offset and size is greater than total transaction size.
	30	83	The local 1775-KA module has executed a shutdown request.
	40	84	Backplane error (either memory parity or timeout/disconnect).
	60	86	Keyswitch setting disallows access.
	70	87	Local PLC-3 is in Program mode.
1	F0	231	There is an error in converting the block address (major section > 63, context > 15, or section > 15).
2	F0	232	Three or fewer addressing levels specified in a PLC-3 word address.
3	F0	233	Conversion of a file address to a block address resulted in more than 9 addressing levels.
4	F0	234	Symbolic address not found.
5	F0	235	Symbolic address is of length zero or is longer than 8 bytes.
6	F0	236	1. Destination file not found. 2. Destination address does not point to a word (for word-range writes) or a file (for file writes). 3. Destination address specifies more levels than required. 4. First word of destination location does not exist.
7	F0	237	1. Any word in the total transaction does not exist in the destination file. 2. For a file write, the source and destination files are not the same size.
8	F0	238	Destination file size changed between packets of a multi-packet transaction and became too small for the total transaction.
9	F0	239	There are more than 65,535 words in the source file.

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Code (If Applies) EXT STS	STS	Error Code	Meaning
A	F0	240	Sum of total transaction size and the word level of PLC-3 addressing is greater than 65,535 bytes.
B	F0	241	Source station does not have access to the destination file.
			PLC-3 READ COMMANDS
		81	1. There is more than one byte of data after the byte address. 2. Number of bytes to read is odd. 3. Number of bytes to read is zero. 4. Number of bytes to read is greater than the maximum allowed in a reply packet (244). 5. Sum of packet offset and size of data in words is greater than 65,535 bytes. 6. Sum of packet offset and size of data in words is greater than the total transaction size.
		83	The local 1775-KA module has executed a shutdown request.
		84	Backplane error (memory parity or timeout/disconnect).
		87	Local PLC-3 in Program mode.
1	F0	231	Error in converting the block address (major section > 63, context > 15, section > 15).
2	F0	232	Three or fewer addressing levels specified for a PLC-3 word address.
3	F0	233	Conversion of a file address to a block address resulted in more than 9 addressing levels.
4	F0	234	Symbolic address not found.
5	F0	235	Symbolic address is of length zero or more than 8 bytes.
6	F0	236	1. File not found. 2. Destination address does not have enough levels to specify a PLC-3 word (for word-range reads) or a file (for file reads). 3. The PLC-3 address specifies more levels than required. 4. Word specified by the PLC-3 address does not exist.
7	F0	237	1. Any of the destination words in the destination file do not exist. 2. For a file read, the source and destination files are not the same size.

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Code (If Applies) EXT STS	STS	Error Code	Meaning
8	F0	238	The file size decreased between packets of a multi-packet transaction and became too small for the total transaction.
9	F0	239	File is larger than 65,535 words.
A	F0	240	Sum of total transaction size and PLC-3 address is greater than 65,535 bytes.
			PLC-3 BIT WRITE COMMANDS
	10	81	More than 4 bytes of data exist after the PLC-3 address in the command message.
	30	83	The local 1775-KA module has executed a shutdown request.
	40	84	Backplane error (memory parity or timeout/disconnect).
	60	86	Keyswitch setting disallows access to file.
	70	87	Local PLC-3 in Program mode.
1	F0	231	Error in converting the block address (major section > 63, context > 15, section > 15).
2	F0	232	Three or fewer addressing levels specified for a PLC-3 word address.
3	F0	233	Conversion of a file address to a block address resulted in more than 9 addressing levels.
4	F0	234	Symbolic address not found.
5	F0	235	Symbolic address is of length zero or more than 8 bytes.
6	F0	236	1. File not found. 2. Destination address does not specify a PLC-3 word. 3. The PLC-3 address specifies more levels than required. 4. Word specified by the PLC-3 address does not exist.
9	F0	239	File is larger than 65,535 words.
B	F0	241	Remote station does not have access to the destination file.

Remote Error Codes

Remote error codes are those reported in a reply message from a remote station that received a command message from the local PLC-3 station. These error codes are stored under user symbol ERROR in the local PLC-3 station.

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The meaning of a particular remote error code will vary, depending on the type of communication interface module at the remote station. For example, if the remote station is a PLC-3 processor with a 1775-KA interface module, the remote error codes will have the meanings listed above. For the meanings of other remote error codes, refer to "ERROR WORD in User Programming (1771-KG, 1771-KA, 1771-KA2, 1774-KA Modules)," Errors 80-89.

Internal Error Counters

These counters can be read only by issuing a diagnostic read command from a device connected to one of the modules that support an asynchronous port. Therefore, they are available only to a device that can format the diagnostic commands. A PC user program is unable to initiate a diagnostic command. The counters occupy a block of the module's internal scratch RAM. Most are single byte counters that wrap around to zero when they overflow. They are used to record events of interest for debugging and for longer term reliability analysis.

These counters provide a useful tool for diagnosing problems. If a troubleshooter has available a device that will read the internal error counters of a module, the ACK timeout counter and the false poll counter will be useful for diagnosing bad cabling or a noisy or loaded highway installation. Also useful is the ratio of messages transmitted (successfully returned an ACK from the remote station) versus the commands sent (but not necessarily completed).

Important: Because of differences in revision levels in a given module, and variations from module to module, you must first request the location of these counters by transmitting to the module a diagnostic status command. Then, based on the address returned, the number of the following counters can be used as an offset to calculate the location of the desired counter, or to calculate how many counter values he wants returned. This information is then used to format a diagnostic read command, and the reply from that command will contain the data stored in the counters.

With the PLC-5, you format the diagnostic read command with a dummy value for the address. The reply contains the entire counter block.

The counters are divided into two categories:

- Data Highway or PCL
- Asynchronous

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They apply to activity on their respective links. Obviously, the 1771-KA will have only Data Highway counters. Most modules (including the KF2) will have both. A KF2 can operate on either the Data Highway or the PCL; it has a block of counters for each network.

1771-KA, 1771-KA2, and 1774-KA Data Highway Counters

0. CRC error on ACK.

1. **ACK Timeout:** Counts the number of times that the sender timed out waiting for an acknowledgment. This is a common error and will be one of the first to respond to reflections or low level noise on the highway. It seems to be especially sensitive to problems on longer cables. It will also show up often if the receiver or transmitter circuitry on a module is marginal or if the cable connections are loose.

2. **Contention:** Counts the number of times contention was detected. This will also appear quickly on noisy or overlength cables. This counter corresponds to Error 93. If 93 is a common error on a highway system, then expect 37 (start bit timeout) errors also since any reply that experiences contention will not be retried.

3. **Bad ACK Status:** Counts the number of times the ACK was successfully received but contained a non-zero status code other than memory full. Currently the only other implemented ACK code is buffer overflow. This condition should never occur except when debugging new code.

4. **Returned Messages:** Counts the number of times the highway driver returns a message to sender. Each count corresponds to one local error bit set or one reply message lost.

5. **Transmit/Memory Full:** Counts the number of times that the receiving station's memory was full. Each time this happens the message is placed on a waiting queue for a half second. Each message will be retried five times for memory overflow before it is returned to sender.

6. **Poll Timeout:** Counts the number of times that this station grabbed mastership of the highway because it timed out while waiting to hear a valid frame. On a highway that has just been powered up there should be only one station that has this counter incremented.

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7. **False Poll:** Counts the number of times that this station has tried to relinquish mastership and the station that was expected to take over failed to respond. This happens often on a noisy highway because the noise is mistaken for a poll response, and the wrong station is selected as the next master. When this occurs, the old master resumes polling. It can happen also on a long highway if the poll response is very attenuated and is not picked up by the carrier detect circuit. If the new station does respond, but the old master does not hear it, the old master will record a false poll and continue polling. The new master will start polling also. This usually leads to the second station detecting contention and relinquishing.

8. **Receiver Heard Status:** Counts the number of times that the receiver received a status frame instead of a message frame. This should occur only if a poll timeout is imminent (a master has had mastership for more than 170 ms) and the station has disabled its address recognizer to test for any valid traffic.

9. **Frame Too Small:** Counts the number of frames that were rejected because the header was incomplete. This should be counted only because of undebugged software or in the unlikely event that a bad frame fooled the CRC checker.

10. **Wrong Destination Address:** Counts the number of frames that were rejected because the destination address was incorrect. This can have the same cause as #8. This counter also detects frames that have the same source and destination address.

11. **Receiver/Memory Full:** Counts the number of times that the receiver sent an ACK without first being able to allocate a receive buffer. This will result in a memory overflow error when the next message is received.

12. **Bad Frame Status:** Counts the number of frames that were rejected because of a bad CRC. This error is very common on a noisy highway.

13. **Buffer Overflow:** Counts the number of times a message was received that contained more than 250 bytes.

14. **Memory Overflow:** Counts the number of times a message was received when there was no buffer space allocated for it. This usually follows a memory full error.

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15. **Retransmits:** Counts the number of duplicate frames received. A duplicate frame is sent by a transmitter when it fails to receive an ACK. If the reason it failed to receive an ACK was that the ACK was lost, rather than because the original message was lost, the duplicate is redundant and should be discarded. Any two successive messages between polls that have the same sequence number fields and the same command/reply bit are assumed to be duplicates.

16. **Aborts:** Counts the number of aborts received. The HDLC abort signal is not used on the Data Highway but can be detected by the SIO in certain circumstances. Some stations whose addresses match the ringing pattern after a transmitter shutoff can be particularly susceptible to this error (Stations 36, 76, and 176 for example). These numbers will depend on highway configurations.

17. **Transmitted Messages:** A 16-bit counter that records the number of messages successfully transmitted.

18. Not used.

19. **Received Messages:** A 16-bit counter that records the number of messages successfully received.

20. Not used.

21. **Commands Sent:** A 16-bit counter that records the number of command messages that were successfully generated as a result of a start bit being set. Some of these messages may not be recorded as being transmitted because they were either not successfully sent or because they were sent to the same station that originated them.

22. Not used.

23. **Messages Executed:** A 16-bit counter that records the number of command messages that were received to be executed from the highway. This count does not depend on whether execution was successful. For each message counted as received, a reply message is sent.

24. Not used.

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25. **Replies Received:** A 16-bit counter that records the number of reply messages that were received that resulted in the setting of a done bit or a remote error bit.

26. Not used.

27. **Breaks:** Counts the number of breaks sent to the IT.

28. **Resynchs:** Counts the number of times the PC driver has to resynchronize with the PC. This counter will always count at least one resynch (because of power-up).

29. **IT Errors:** Counts down modulo 5 the number of errors on the KA-to-IT cable. Every time this count reaches zero the KA does a handshake to reset the forced I/O table in the PC.

30. **Undeliverable Replies:** Counts the number of replies that were lost because they could not be delivered over the highway. Undeliverable commands can be signaled to the user, because the "user" is located in PC memory and can always be reached. If a reply message cannot be delivered over the highway, there is no way to signal the user (of that message), who is also over the highway, that this station cannot signal a reply. The local user is not concerned with the problems of the remote user, and can take no meaningful action anyway, so there is not much to do but destroy the message and count it.

1771-KC and 1771-KD Error Counters

NOTE: The intelligent device can read the memory of the 1771-KC it is hooked to by setting the destination equal to the module address.

0. Bad CRC on ACK.

1. **ACK Timeout:** Counts the number of times that the sender timed out waiting for an acknowledgment. This is a common error and will be one of the first to respond to reflections or low level noise on the highway. It seems to be especially sensitive to problems on longer cables. It will also show up often if the cable connections are loose.

2. **Contention:** Counts the number of times contention was detected. This will also appear quickly on noisy or overlength cables. This counter corresponds to Error 93.

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3. **Bad ACK Status:** Counts the number of times the ACK was successfully received but contained a non-zero status code other than memory full.

4. **Returned Messages:** Counts the number of times the highway driver returns a message to sender with a non-zero status code because a reply was not received from a remote station. Each count corresponds to one local error bit set or one reply message lost.

5. **Transmit/Memory Full:** Counts the number of times that the receiving station's memory was full. Each time this happens the message is placed in a waiting queue for a half second. Each message will be retried five times for memory overflow before it is returned to sender.

6. **Poll Timeout:** Counts the number of times this station grabbed mastership of the highway because it timed out while waiting to hear a valid frame. On a highway that has just been powered up there should be only one station that has this counter incremented.

7. **False Poll:** Counts the number of times that this station has tried to relinquish mastership and the station that was expected to take over failed to respond. This happens often on a noisy highway because the noise is mistaken for a poll response, and the wrong station is selected as the next master. When this occurs, the old master resumes polling. It also can happen on a long highway if the poll response is very attenuated and is not picked up by the carrier detect circuit. If the new station does respond but the old master does not hear it, the old master will record a false poll and continue polling; and the new master will start polling also. This usually leads to the second station detecting contention and relinquishing.

8. **Receiver Heard Status:** Counts the number of times that the receiver received a status frame instead of a message frame. This should occur only if a poll timeout is imminent (a master has had mastership for more than 170 ms) and the station has disabled its address recognizer to test for any valid traffic. The probability of errors in #8, 9, and 10 increases substantially.

9. **Frame Too Small:** Counts the number of frames that were rejected because the header was incomplete. This should only be counted because of undebugged software or in the unlikely event that a bad frame fooled the CRC checker.

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10. **Wrong Destination Address:** Counts the number of frames that were rejected because the destination address was incorrect. This can have the same cause as #8. This counter also detects frames that have the same source and destination address.

11. **Receiver/Memory Full:** Counts the number of times that the receiver sent an ACK without first being able to allocate a receive buffer. This will result in a memory overflow error when the next message is received.

12. **Bad Frame Status:** Counts the number of frames that were rejected because of a bad CRC. This error is very common on a noisy highway.

13. **Buffer Overflow:** Counts the number of times a message was received that contained more than 250 bytes.

14. **Memory Overflow:** Counts the number of times a message was received when there was no buffer space allocated for it. This usually follows a “memory full” error.

15. **Retransmits:** Counts the number of duplicate frames received. A duplicate frame is sent by a transmitter when it fails to receive an ACK. If the reason it failed to receive an ACK was that the ACK was lost, rather than because the original message was lost, the duplicate is redundant and should be discarded. Any two successive messages between polls that have the same sequence number fields and the same command/reply bit are assumed to be duplicates.

16. **Aborts:** Counts the number of aborts received. The HDLC abort signal is not used on the Data Highway, but can be detected by the SIO in certain circumstances. Some stations whose addresses match the ringing pattern after a transmitter shutoff can be particularly susceptible to this error (Stations 36, 76, and 176 for example). These numbers will depend on highway configurations.

17. **Transmitted Messages:** A 16-bit counter that records the number of messages successfully transmitted.

18. Not used.

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19. **Received Messages:** A 16-bit counter that records the number of messages successfully received.

20. Not used.

21. Number of ACKs received.

22. Not used.

23. Number of ACKs sent.

24. Not used.

25. Number of NAKs received.

26. Not used.

27. Number of NAKs sent.

28. Not used.

29. **Undeliverable Replies:** Counts the number of replies that were lost because they could not be delivered over the highway. Undeliverable commands can be signaled to the user, because the “user” is located in PC memory and can always be reached. If a reply message cannot be delivered over the highway, there is no way to signal the user (of that message), who is also over the highway, that this station cannot signal a reply. The local user is not concerned with the problems of the remote user, and can take no meaningful action anyway, so there is not much to do but destroy the message and count it.

30. **Timeout Preset**

31. **NAK Preset:** Values set by diagnostic commands or set by default on power-up.

32. **ENQ Preset**

1771-KE/KF, 1770-KF2 (Data Highway Mode) Error Counters

DATA HIGHWAY COUNTERS

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0. Bad CRC or I/O error on ACK. Same causes as bad CRC on messages.

1. **ACK Timeout:** Counts the number of times that the sender timed out waiting for an acknowledgment. This is a common error and will be one of the first to respond to reflections or low-level noise on the highway. It seems to be especially sensitive to problems on longer cables. It will also appear often if the receiver or transmitter circuitry on a module is marginal or if the cable connections are loose.

2. **Contention:** Counts the number of times contention was detected. This will also appear quickly on noisy or overlength cables. This counter corresponds to Error 93.

3. **Bad ACK Status:** Counts the number of times the ACK was successfully received but contained a non-zero status code other than memory full. Currently the only other implemented ACK code is buffer overflow. This condition should never occur except possibly when debugging new computer programs.

4. **Returned Messages:** Counts the number of times the highway driver returns a message to sender. Each count corresponds to one local error bit set or one reply message lost.

5. **Transmit/Memory Full:** Counts the number of times the highway driver returns a message to sender. Each time this happens the message is placed in a waiting queue for a half second. Each message will be retried five times before it is returned to sender.

6. **Poll Timeout:** Counts the number of times this station grabbed mastership of the highway because it timed out while waiting to hear a valid frame. On a highway that has just been powered up there should be only one station that has this counter incremented.

7. **False Poll:** Counts the number of times that this station has tried to relinquish mastership and the station that was expected to take over failed to respond. This happens often on a noisy highway because the noise is mistaken for a poll response, and the wrong station is selected as the next master. When this occurs, the old master resumes polling. It also can happen on a long highway if the poll response is very attenuated and is not picked up by the carrier detect circuit. If the new station does respond but the old master does not

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hear it, the old master will record a false poll and continue polling; and the new master will start polling also. This usually leads to the second station detecting contention and relinquishing.

8. **Receiver Heard Status:** Counts the number of times that the receiver received a status frame instead of a message frame. (This counter will never be incremented because the message size is checked first, and all status messages are too small to be accepted.)

9. **Frame Too Small:** Counts the number of frames that were rejected because they were less than 6 bytes long. This counter will record all status frames that were received by a station that disabled its address recognizer in the second step of the mastership timeout process. This will happen often on a heavily loaded highway.

10. **Wrong Destination Address:** Counts the number of frames that were rejected because the destination address was incorrect. This can have the same cause as #9. This counter also detects frames that have the same source and destination address.

11. **Receiver/Memory Full:** Counts the number of times that the receiver sent an ACK without first being able to allocate a receive buffer. This may result in a memory overflow error when the next message is received.

12. **Bad Frame Status:** Counts the number of frames that were rejected because of a bad CRC. This error is very common on a noisy highway.

13. **Buffer Overflow:** Counts the number of times a message was received that contained more than 250 bytes.

14. **Memory Overflow:** Counts the number of times a message was received when there was no buffer space allocated for it. This usually follows a “memory full” error.

15. **Retransmits:** Counts the number of duplicate frames received. A duplicate frame is sent by a transmitter when it fails to receive an ACK. If the reason it failed to receive an ACK was that the ACK was lost, rather than because the original message was lost, the duplicate is redundant and should be discarded. Any two successive messages between polls that have the same sequence number fields and the same command/reply bit are assumed to be duplicates.

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16. **Aborts:** Counts the number of aborts received. The HDLC abort signal is not used on the Data Highway but can be detected by the SIO in certain circumstances. Some stations whose addresses match the ringing pattern after a transmitter shutoff can be particularly susceptible to this error (Stations 36, 76, and 176 for example). These numbers will depend on highway configurations.

17. **Transmitted Messages:** A 16-bit counter that records the number of messages successfully transmitted.

18. Not used.

19. **Received Messages:** A 16-bit counter that records the number of messages successfully received.

20. Not used.

MODEM CHANNEL COUNTERS

21. 16-bit count of the number of times the station attempted to send a message.

22. Not used.

23. 16-bit count of the number of messages that were successfully transmitted and ACKed.

24. Not used.

25. 16-bit counter of the number of ACKs that were received.

26. Not used.

27. Number of ACKs successfully passed from the receiver's separator to the transmitter.

28. Number of NAKs received.

29. Number of NAKs passed from the separator to the transmitter.

30. Number of timeouts waiting for a response.

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31. Number of ENQs sent.

32. Number of messages that could not be successfully sent.

33. Number of reply messages that could not be forwarded and which were destroyed.

34. 16-bit count of messages received.

35. Not used.

36. 16-bit count of ACKs sent.

37. Not used.

38. Number of NAKs sent.

39. Number of ENQs received.

40. Number of retransmissions received and ACKed. A retransmission is a message that has a transparent word, command, and source that match the previous message.

41. Number of STX (full-duplex mode) or SOH (half-duplex mode) received. This is in effect a count of the number of messages that were started.

42. Number of messages, characters, or message fragments that were ignored.

43. Number of messages that were aborted by receipt of a DLE ENQ.

44. Number of messages that were aborted by the receipt of an unexpected control code other than DLE ENQ.

45. Number of times the DLE ACK response was sent but there was no buffer space for the next message.

46. Number of times DLE NAK was sent because there was no buffer.

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47. Number of broadcast messages received.

48. Number of broadcast messages that were successfully received.

49. Number of messages seen that were not for this station.

50. Number of DLE EOTs sent.

51. Number of calls received.

52. Number of times that phone was hung up by the module.

53. Number of times that DCD was lost.

54. Number of times that the phone was hung up because of a DCD timeout.

1771-KG Error Counters

MODEM CHANNEL COUNTERS

0. 16-bit count of the number of times the station attempted to send a message.

1. Not used.

2. 16-bit count of the number of messages that were successfully transmitted and ACKed.

3. Not used.

4. 16-bit count of the number of ACKs that were received.

5. Not used.

6. Number of ACKs successfully passed from the receiver's separator to the transmitter.

7. Number of NAKs received.

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8. Number of NAKs passed from the separator to the transmitter.

9. Number of timeouts waiting for a response.

10. Number of ENQs sent.

11. Number of messages that could not be successfully sent.

12. Number of reply messages that could not be forwarded and which were destroyed.

13. 16-bit count of messages received.

14. Not used.

15. 16-bit count of ACKs sent.

16. Not used.

17. Number of NAKs sent.

18. Number of ENQs received.

19. Number of retransmissions received and ACKed. A retransmission is a message that has a transparent word, command, and source that match the previous message.

20. Number of STX (full-duplex mode) or SOH (half-duplex mode) received. This is in effect a count of the number of messages that were started.

21. Number of messages, characters, or message fragments that were ignored.

22. Number of messages that were aborted by receipt of a DLE ENQ.

23. Number of messages that were aborted by the receipt of an unexpected control code other than DLE ENQ.

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24. Number of times the DLE ACK response was delayed because of a lack of buffer space for the next message.

25. Number of times reply was changed from ACK to NAK because unexpected characters (any besides DLE ENQ) were received while waiting for memory to free up.

26. Number of broadcast messages received.

27. Number of broadcast messages that were successfully received.

28. Number of messages seen that were not for this station.

29. Number of poll messages received for this station.

30. Number of DLE EOTs sent.

31. Number of calls received.

32. Number of times that phone was hung up by the module.

33. Number of times that DCD was lost.

34. Number of times that the phone was hung up because of a DCD timeout.

INTERVAL EVENT COUNTERS

35. Number of messages routed to RS-232 port.

36. Number of commands routed to command executor.

37. Number of replies routed to reply processor.

38. Number of messages sent to self.

39. Number of routing errors on inbound messages.

40. Number of routing errors on outbound messages.

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41. Number of messages with incorrect network address.

42. 16-bit count of messages sent by command initiator.

43. Not used.

44. 16-bit count of commands received by command executor.

45. Not used.

46. 16-bit count of replies sent by command executor.

47. Not used.

48. 16-bit count of replies received by command initiator.

49. Not used.

50. Number of breaks sent to IT.

51. Number of resynchs sent to PC.

1775-KA Diagnostic Counters

DATA HIGHWAY PORT

0. Bad CRC on acknowledgment.

1. No acknowledgment before timeout occurred.

2. Contention (while master, detected message transmission by another station).

3. Acknowledgment contained an error.

4. Returned message (local errors and lost replies).

5. Waits (no “receive” buffer space at destination station).

6. Poll timeout (master failed).

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7. False polls (failure to transfer).

8. Received acknowledgment when not master.

9. Message size too small (less than 5 bytes).

10. Incorrect DST, or SRC = DST.

11. Memory not available for receive buffer.

12. Received message has bad CRC value.

13. Message too long.

14. Message arrived when no buffer space left.

15. Retransmissions of previously received message.

16. Aborts (result of line nose).

17. Message successfully transmitted.

18. Not used.

19. Message successfully received.

20. Not used.

21. Command messages sent.

22. Not used.

23. Reply messages received.

24. Not used.

25. Command messages received.

26. Not used.

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27. Reply messages sent.

28. Not used.

MODEM CHANNEL COUNTERS

29. Command messages sent.

30. Not used.

31. Reply messages received.

32. Not used.

33. Command messages received.

34. Not used.

35. Reply messages sent.

36. Not used.

37. ACKs received.

38. Not used.

39. ACKs sent.

40. Not used.

41. NAKs received.

42. Not used.

43. NAKs sent.

44. Not used.

45. Undeliverable reply messages.

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46. Computer link timeout (preset to 500 msec).

47. Not used.

48. Maximum number of NAKs accepted per message (preset to 10).

49. Maximum number of ENQs sent per message (preset to 10).

50. Current NAK count.

51. Current ENQ count.

1785-KA Data Highway Diagnostic Counters

Byte No.	
0	Received ACK with bad CRC.
1	Timeout expired with no ACK received.
2	Mastership contention.
3	Error in received ACK.
4	Sum of Bytes 1, 2, and 4.
5	Received a WAK.
6	Master died; we assumed mastership.
7	False Poll: no answer to poll of size = 1.
8	Received an ACK when not master.
9	Received frame too small.
10	Received frame with SRC = DST.
11	Unused.
12	Bad CRC in received frame.
13	Received frame too long.
14	No buffer for received message; WAK sent.
15	Received a retransmission of a frame.
16	Received frame aborted (line noise).
17, 18	Message successfully sent (low byte first).
19, 20	Message successfully received (low byte first).
21, 22	Command successfully sent (low byte first).
23, 24	Reply successfully received (low byte first).
25, 26	Command successfully received (low byte first).
27, 28	Reply successfully sent (low byte first).
29	Reply could not be sent.

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1770-KF2 and 1785-KA PCL Link Error Counters

For the KF2, the block of counters in this section are followed by a block of modem (asynchronous link) counters. They are exactly the same as those in "1771-KE/KF, 1770-KF2 (Data Highway Mode) Error Counters," although in this case, they are numbered starting at 35 rather than at 21.

PCL Diagnostic Counters

Byte No.	
0	Received ACK with bad CRC.
1	Timeout expired with no ACK received.
2	Transmit retries exhausted.
3	NAK/illegal protocol operation received.
4	NAK/bad LSAP received.
5	NAK/no memory received.
6	Received ACK/NAK too short.
7	Received ACK/NAK too long.
8	Something other than an ACK/NAK received.
9	Duplicate tokens found.*
10	Duplicate nodes found.*
11	Token pass timeout.
12	Token pass retries exhausted.
13	Claim token sequence entered.
14	Token claimed.
15	Bad CRC in received frame.
16	NAK/illegal protocol operation sent.
17	NAK/bad LSAP sent.
18	NAK/no memory sent.
19	Received frame too small.
20	Received frame too long.
21	Received a retransmission of a frame.
22	Received frame aborted (line noise).
23, 24	Message successfully sent (low byte first).
25, 26	Message successfully received (low byte first).
27, 28	Command successfully sent (low byte first).
29, 30	Reply successfully received (low byte first).
31, 32	Command successfully received (low byte first).
33, 34	Reply successfully sent (low byte first).
35	Reply could not be sent.
36	Number of active nodes.

***Does not apply for 1770-KF2.**

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PLC-5 Diagnostic Counters

Byte No.	
0	ACK Timeouts
1	NAK No Memory Received
2	Num Claim Tokens
3	NAK No Memory Sent
4	CRC Errors
5	Num Duplicate Packets
6	Token Timeouts
7	Retries
8	Messages Sent High
9	Messages Sent Low
10	Messages Received High
11	Messages Received Low
12	Commands Gen High
13	Commands Gen Low
14	Requests Executed High
15	Requests Executed Low
16	Replies Sent High
17	Replies Sent Low
18	Rack 1 Timeouts
19	Rack 2 Timeouts
20	Rack 3 Timeouts
21	Rack 1 CRC Errors
22	Rack 2 CRC Errors
23	Rack 3 CRC Errors
24	Rack 1 BT Errors
25	Rack 2 BT Errors
26	Rack 3 BT Errors
27	Rack 1 Retries
29	Rack 3 Retries
30	Adapter Timeouts
31	Undeliverable Replies

PLC-2/PLC

The full-duplex protocol (and its half-duplex variation) provides for a message packet that contains a reply to have a status byte reserved in its header. This byte (known as the STS byte) provides information about the execution or failure of the corresponding command that was transmitted from the computer.

A reply that returns zeros in the STS byte means the command was executed at the remote station. Non-zero status can be divided into two categories: remote errors and local errors. Remote errors mean that a command was successfully transmitted by the network controller to another station, but the remote station was unable to execute the command.

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The remote station then formatted a reply with the STS byte containing some error code. Local errors mean that the network controller was unable to transmit the message to the remote station. The local station then turns the command around, stuffs the STS byte with the appropriate error code, and returns it to the sender (computer). The error code format is as follows:

When the error is local, the high nibble (7-4) is zero; and the reference to a particular code is in the low nibble as a hex value. When the error is remote, the low nibble is zero; and the error code is in the high nibble. Since the full-duplex message packet is actually transmitted on the highway itself (in an encapsulated form), the contents of the STS byte is what other (PC) network stations use to generate the error word in the PC application program. To decode the contents of the STS byte, refer in "ERROR WORD in User Programming (1771-KG, 1771-KA, 1771-KA2, 1774-KA Modules)" to error codes (80-8B) for remote errors and error codes (90-97) for local errors

For remote station errors, make sure the error codes correspond to the processor type at that station (either PLC/PLC-2 or PLC-3/PLC-5).

Match the last digit of the error code with value in hex in the appropriate nibble. For example, if the STS byte contains 04H, the low nibble = 4 and the high nibble is 0, indicating a local error. Referring to the local error codes (90-91), 04H matches Error 94 (contention on the highway).

PLC-3 and PLC-5

Important: With PLC-2 Compatibility mode for the 1775-KA, PLC-2 level commands addressed to a PLC-3 will return only errors, as described above; that is, in the STS byte format.

In addition to the above, PLC-3 can also create a second layer of error codes, relative to PLC-3 type commands (CMD byte = 15). If the command is a PLC-3 level command addressed to a remote PLC-3, then the remote error returned from the 1775-KA will have an additional status byte stuffed into the data area called an EXT STS.

If there is a non-zero error value in the EXT STS byte, the STS byte will contain F0H (which, in effect, functions as a flag that there has been an error value generated). If the STS byte is zero, then the EXT STS will also be zero.

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Here is a list of relevant PLC-3 status codes for the **STS** byte and the **EXT STS** byte.

Bits	Hex Value	Meaning
	STS Byte	
04-07	0	Success, no error.
	1	Illegal command or format.
	2	Host has a problem and will not communicate.
	3	Remote station host is not there, disconnected, or shut down.
	4	Host could not complete function due to hardware fault.
	5	Addressing problems or memory protect rungs.
	6	Function disallowed due to command protection selection.
	7	Processor is in Program mode.
	8	Compatibility mode file missing or communication zone problem.
	9	Remote station cannot buffer command.
	A	Not used.
	B	Remote station problem, due to download.
	C	Not used.
	D	Not used.
	E	Not used.
	F	Indicates that there is an error encoded in the EXT STS byte.
	EXT STS Byte	
	0	Not used.
	1	Error in converting block address.
	2	Fewer levels specified in address than minimum for any address.
	3	More levels specified in address than system supports.
	4	Symbol not found.
	5	Symbol is of improper format.
	6	Address doesn't point to something usable.
	7	File is wrong size.
	8	Cannot complete request, situation changed since start of command.
	9	File is too large.
	A	Transaction size plus word address are too large.
	B	Access denied, improper privilege.
	C	Condition cannot be generated.
	D	Condition already exists.
	E	Shutdown could not be executed.
	F	Requestor does not have upload or download access.
	10	Histogram overflow.
	11	Illegal data type.
	12	Bad parameter.
	13	Address reference exists to deleted data table.
	14	-FF not used.

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Appendix A

Switch Settings

General

Here is a reference for switch settings for a 1770-KF2 communication interface module.

Table A.A
Asynchronous Link Features (SW-1)

If You Want to Select Protocol as:	With Error Check as:	With Parity as:	With Embedded Responses:	SW-1				
				1	2	3	4	5
Full Duplex	BCC	None	No	OFF	OFF	N/A	N/A	OFF
Full Duplex	BCC	Even	No	ON	OFF			OFF
Full Duplex	BCC	None	Yes	OFF	ON			OFF
Full Duplex	BCC	Even	Yes	ON	ON			OFF
Half Duplex	BCC	None	No	OFF	OFF			ON
Half Duplex	BCC	Even	No	ON	OFF			ON
Full Duplex	CRC	None	Yes	OFF	ON			ON
Half Duplex	CRC	None	No	ON	ON			ON

If You Want Your Module to:	Set Switch 3:
Detect and Ignore Duplicate Messages	ON
Accept All Messages Regardless of Duplication	OFF

If You Want the Module's Asynchronous Port to:	Set Switch 4:
Use Handshaking Signals	ON
Ignore Handshaking Signals	OFF

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Table A.B
Station Number (SW-2, SW-3, SW-4)

A. First Digit (SW-2)		
	Switch	
Digit	1	2
0	OFF	OFF
1	OFF	ON
2	ON	OFF
3	ON	ON
For a PLC network link, both of these switches must be OFF.		

B. Second and Third Digits (SW-3 and SW-4)			
	Switch		
Digit	1	2	3
0	OFF	OFF	OFF
1	OFF	OFF	ON
2	OFF	ON	OFF
3	OFF	ON	ON
4	ON	OFF	OFF
5	ON	OFF	ON
6	ON	ON	OFF
7	ON	ON	ON

Table A.C
Network Link Baud Rate (SW-5)

	Switch	
Baud Rate	1	2
Undefined	OFF	OFF
57,600	ON	ON
Undefined	ON	OFF
Undefined	OFF	ON

Table A.D
Asynchronous Link Baud Rate and Diagnostic Commands (SW-6)

	Switch		
Baud Rate	1	2	3
110	OFF	OFF	OFF
300	ON	OFF	OFF
600	OFF	ON	OFF
1,200	ON	ON	OFF
2,400	OFF	OFF	ON
4,800	ON	OFF	ON
9,600	OFF	ON	ON

Switch 4:	ON	Execute Diagnostic Command
	OFF	Pass through Diagnostic Command

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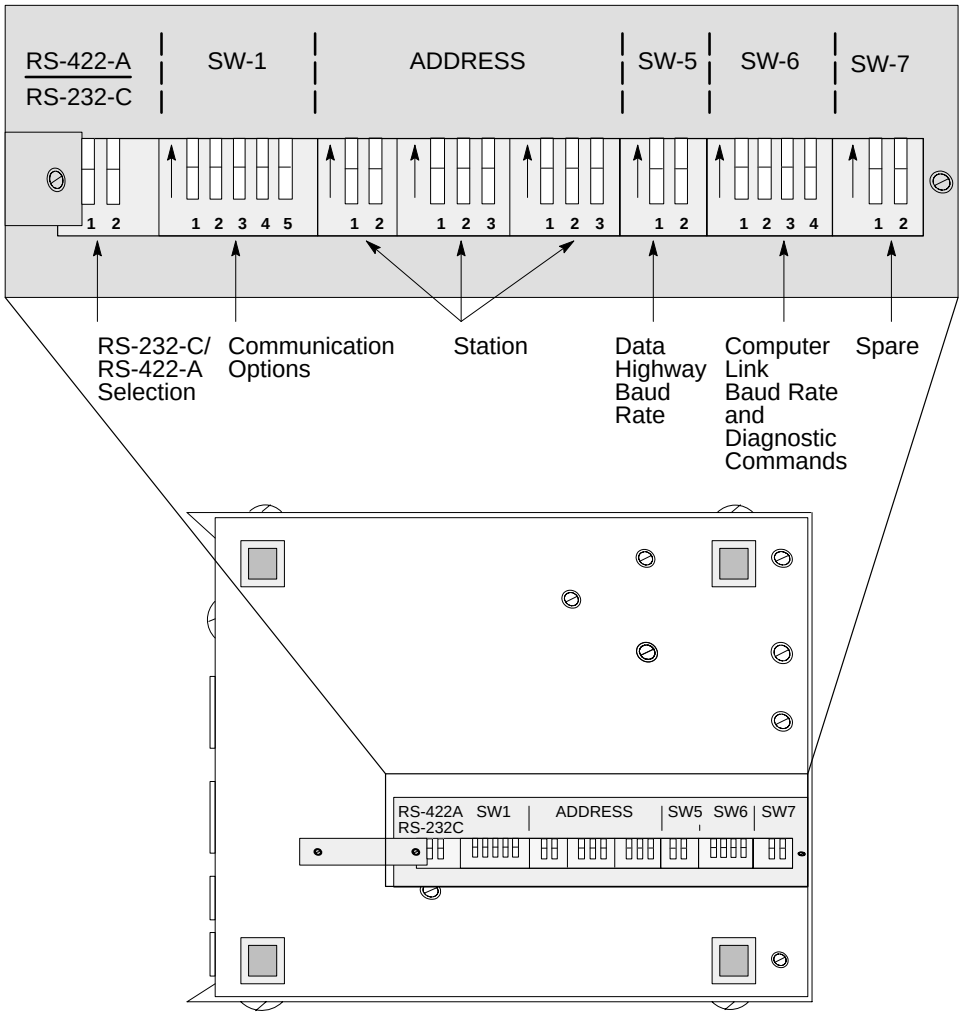
Table A.E
Network Link Selection (SW-7)

Local Area Network	Switch 1	Switch 2
Data Highway	OFF	OFF
Peer Communication Link	ON	OFF

Table A.F
RS-232-C/RS-422-A (SW-8)

Communication Standard	Switch 1	Switch 2
RS-232-C	OFF	ON
RS-422-A	ON	OFF

Figure A.1
Switch Settings



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Appendix **B**

Message Formats

Table B.A
ASCII Codes and Their Numerical Values

Hex	Binary	ASCII	Hex	Binary	ASCII	Hex	Binary	ASCII
00	0000000	NUL	2A	0101010	*	55	1010101	U
01	0000001	SOH	2B	0101011	+	56	1010110	V
02	0000010	STX	2C	0101100	,	57	1010111	W
03	0000011	EXT	2D	0101101	–	58	1011000	X
04	0000100	EOT	2E	0101110	.	59	1011001	Y
05	0000101	ENQ	2F	0101111	/	5A	1011010	Z
06	0000110	ACK	30	0110000	0	5B	1011011	[
07	0000111	BEL	31	0110001	1	5C	1011100	\
08	0001000	BS	32	0110010	2	5D	1011101	]
09	0001001	HT	33	0110011	3	5E	1011110	
0A	0001010	LF	34	0110100	4	5F	1011111	–
0B	0001011	VT	35	0110101	5	60	1100000	\
0C	0001000	FF	36	0110110	6	61	1100001	a
0D	0001101	CR	37	0110111	7	62	1100010	b
0E	0001110	SO	38	0111000	8	63	1100011	c
0F	0001111	SI	39	0111001	9	64	1100100	d
10	0010000	DLE	3A	0111010	:	65	1100101	e
11	0010001	DC1	3B	0111011	;	66	1100110	f
12	0010010	DC2	3C	0111100	<	67	1100111	g
13	0010011	DC3	3D	0111101	=	68	1101000	h
14	0010100	DC4	3E	0111110	>	69	1101001	i
15	0010101	NAK	3F	0111111	?	6A	1101010	j
16	0010110	SYN	40	1000000	@	6B	1101011	k
17	0010111	ETB	41	1000001	A	6C	1101100	l
18	0011000	CAN	42	1000010	B	6D	1101101	m
19	0011001	EM	43	1000011	C	6E	1101110	n
1A	0011010	SUB	44	1000100	D	6F	1101111	o
1B	0011011	ESC	45	1000101	E	70	1110000	p
1C	0011100	FS	46	1000110	F	71	1110001	q
1D	0011101	GS	47	1000111	G	72	1110010	r
1E	0011110	RS	48	1001000	H	73	1110011	s
1F	0011111	US	49	1001001	I	74	1110100	t
20	0100000	SP	4A	1001010	J	75	1110101	u
21	0100001	!	4B	1001011	K	76	1110110	v
22	0100010	”	4C	1001100	L	77	1110111	w
23	0100011	#	4D	1001101	M	78	1111000	x
24	0100100	$	4E	1001110	N	79	1111001	y
25	0100101	%	4F	1001111	O	7A	1111010	z
26	0100110	&	50	1010000	P	7B	1111011	
27	0100111	’	51	1010001	Q	7C	1111100	|
28	0101000	(	52	1010010	R	7D	1111101	
29	0101001	)	53	1010011	S	7E	1111110	~
			54	1010100	T	7F	1111111	DEL

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Appendix C

General Asynchronous Link Error Codes (STS, EXT STS)

Where to Find Asynchronous Link Error Codes

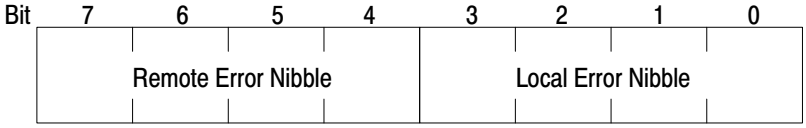
Asynchronous link (RS-232-C) error codes are passed in the link message packets. You can find these codes in the:

- Status (STS) Byte of the Message Packet
- Extended Status (EXT STS) Byte of the Packet (for Some Commands)

The STS Byte

The STS is divided into two nibbles (4 bits):

- The Local Error Nibble
- The Remote Error Nibble



Local STS Error Codes

The local STS error code nibble contains errors found by local asynchronous link layer. The following table contains error codes (in hex) that you may find in the local error code nibble of the STS byte:

This Code	Means
0	Success — No Error
1	Destination Station Out of Buffer Space
2	Remote Station Specified Does not Acknowledge (ACK) the Command Message
3	Duplicate Token Holder Detected
4	Local Port Is Disconnected

Local STS Codes 5 through F (hex) are not used.

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Remote STS Error Codes

The remote STS error code nibble contains errors found by the remote station receiving the command. The following table contains error codes (in hex) that you may find in the remote error code nibble of the STS byte.

This Code	Means
0	Success — No Error
1	Illegal Command or Format
2	Host Has a Problem and Will Not Communicate
3	Remote Station Is Not There, Disconnected, or Shut Down
4	Host Could Not Complete Function Due to Hardware Fault
5	Addressing Problem or Memory Protect Rungs
6	Function Disallowed Due to Command Protection Selection
7	Processor Is in Program Mode
8	Compatibility Mode File Missing or Communication Zone Problem
9	Remote Station Cannot Buffer Command
A	Not Used
B	Remote Station Problem Due to Download
C to E	Not Used
F	There Is an Error in the EXT STS Byte

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The EXT STS Byte

You will have an EXT STS code if your STS code is F0 (hex). The EXT STS has different definitions depending on the command code (type of command). If the command code is:

- 00 to 08 (hex) then there is not an EXT STS byte
- 09 to 0D (hex) then these command codes are not defined so the EXT STS code is not defined
- 0E or 0F (hex) then the codes are defined in the sections below

The following table contains EXT STS codes (in hex) that you may find if the command code is 0E (hex).

This Code	Means
0	Multi-Defined Processors on Ring
1	Processor Is Already Allocated
2	Processor Must be Allocated for This Command
3	Extended Function in Progress
4	Function Not Available in This Processor Command Set
5	Function Not Available in This Processor Mode
6	Processor Number in Program and Hardware Do Not Match
7	Invalid Address
8	Memory Protection Access Violation
9	Invalid Parameter
A	Search Unsuccessful
B	Program Needs to Be Stored — RAM and PROM Do Not Match
C	External EEPROM Is Defective, Cannot Transfer Contents Correctly
D	Invalid User Program
E	Not Used
F	Device Resource Unavailable
10 to 1F	Not Used
20	Processor Already Allocated by Requesting Station
21	Processor Already Allocated by Another Remote Station
22	Processor Not Allocated
23	Data Length Invalid
24	Data Size Too Large
25	Data Size Too Large
26	Data Size Too Small
27	At Least One of the Addresses Points to a Read-Only Area
28	Address Past End of Memory
29	Memory Protected, Address to Program Area Illegal
2A	Memory Protected, Address to Processor Status Area Illegal
2B	Memory Protected, Address to Protected Timer or Counter
2C	Processor Not in Program Mode, Address to Program Area
2D	Address Past “End of Used Memory”
2E	“Program Valid” Bit Not Set in PLC-4 Program ID Byte
2F	Invalid PLC-4 Select Value
30 to 7B	Not Used
7C	PLC-4 Ring Disconnected
7D	No PLC-4 Response
7F	Invalid PLC-4 Select Byte
80 to FF	Not Used

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EXT STS Codes for Command Code 0F (Hex)

The following table contains EXT STS codes (in hex) that you may find if the command code is 0F (hex):

This Code	Means
0	Not Used
1	Error in Converting Block Address
2	Less Levels Specified in Address Than Minimum for Any Address
3	More Levels Specified in Address Than System Supports
4	Symbol Not Found
5	Symbol Is of Improper Format
6	Address Doesn't Point to Something Usable
7	File Is Wrong Size
8	Cannot Complete Request, Situation Has Changed Since Start of Command
9	File Is Too Large
A	Transaction Size Plus Word Address Is Too Large
B	Access Denied, Improper Privilege
C	Condition Cannot Be Generated
D	Condition Already Exists
E	Shutdown Could Not be Executed
F	Requestor Does Not Have Upload or Download Access
10	Histogram Overflow
11	Illegal Data Type
12	Bad Parameter
13	Address Reference Exists to Deleted Data Table
14 to FF	Not Used

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Appendix D

Detailed Flowcharts

General

This appendix presents flowcharts that give **detailed** views of an example of software logic for implementing full-duplex protocol. The flowcharts in Chapter 4 gave you a simplified view of this software logic.

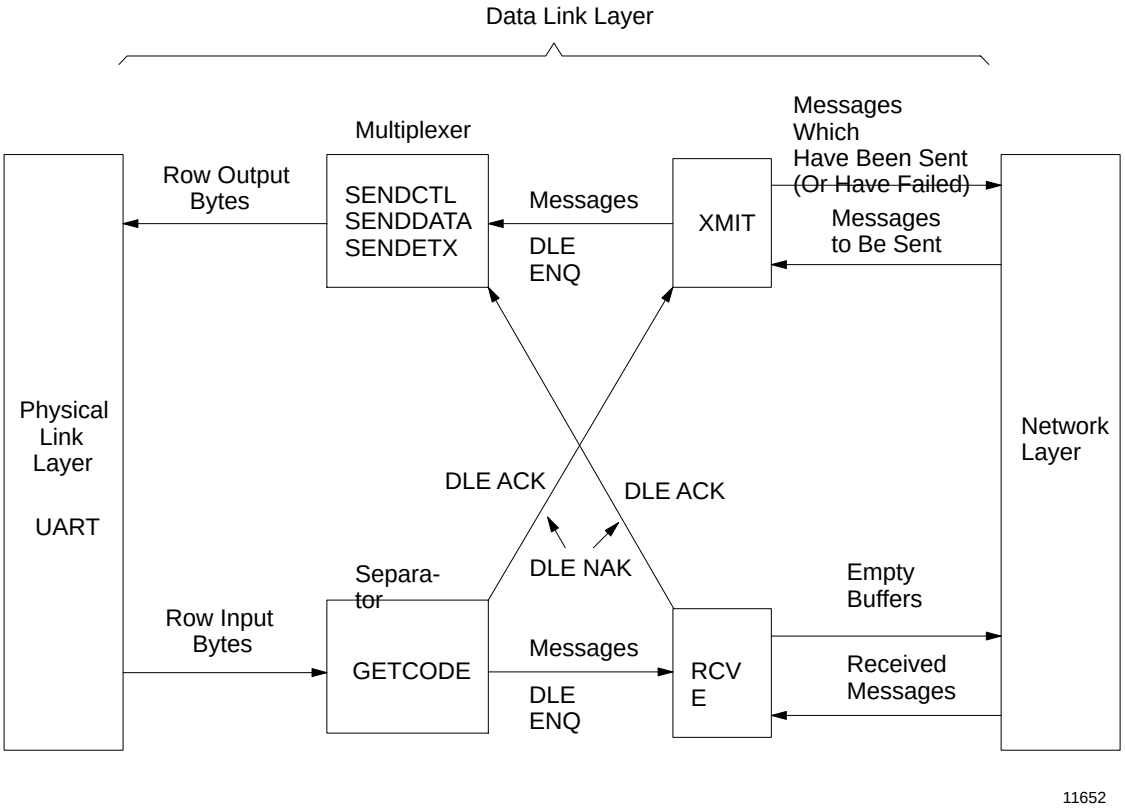
We have not shown any error checking or recovery relating to interaction with the modem handshake driver, a third process. To do this would overly complicate the flowcharts and, in many cases, such error checking and recovery are not needed.

Here is a list of the figures in this appendix:

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D.4	SENDM Subroutine	5
D.5	STARTTIME Subroutine	6
D.6	STOPTIME Subroutine	6
D.7	TIMEOUT Subroutine	7
D.8	GETMSG Subroutine	7
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D.11	SENDCTL Subroutine	10
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D.14	SENDDATA Subroutine	13
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D.26	GETCODE Subroutine	21
D.27	GETRAW Subroutine	22
D.28	SENDNET Subroutine	23
D.29	GETFREE Subroutine	23

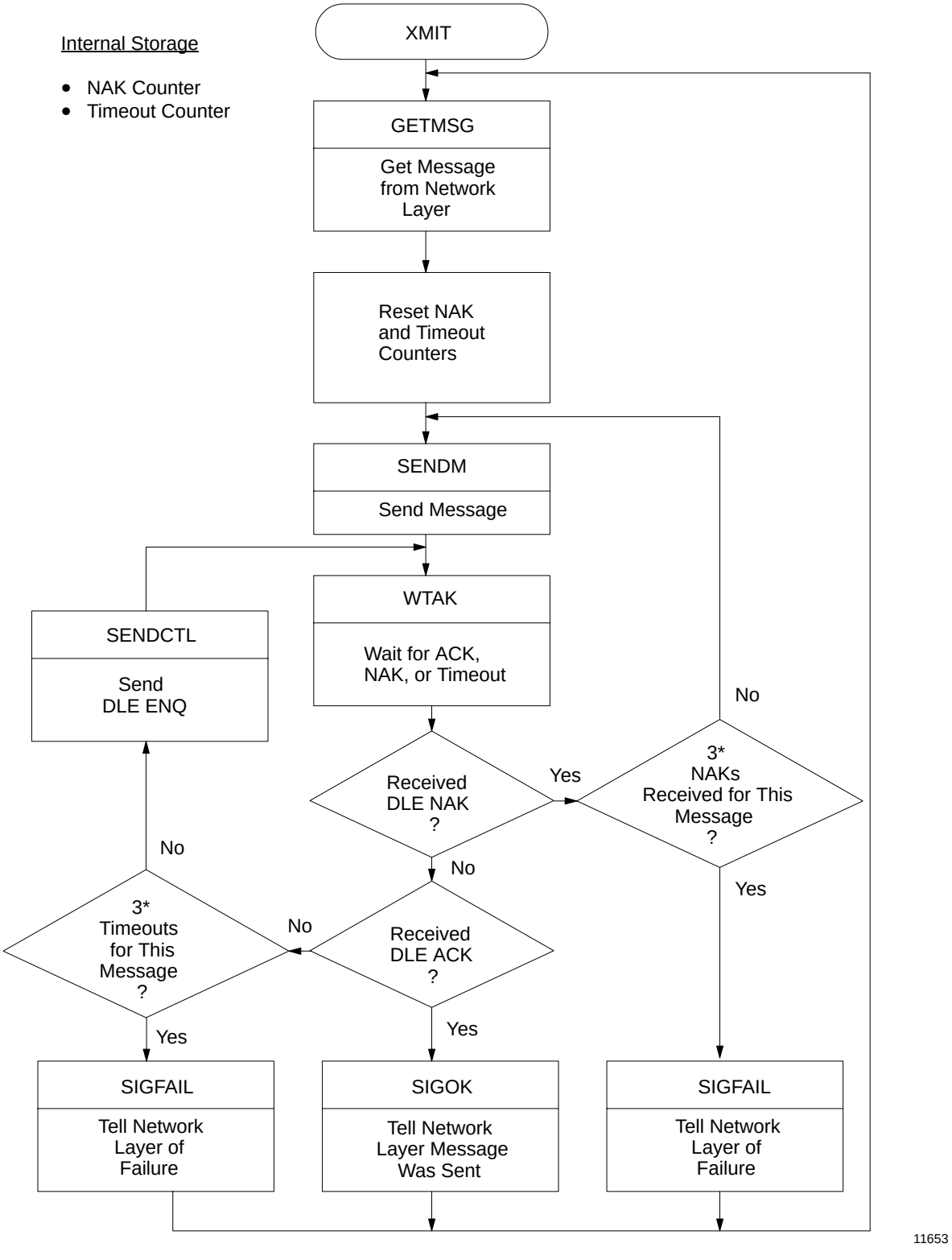
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Figure D.1
Data Flow Diagram for Full-Duplex Protocol



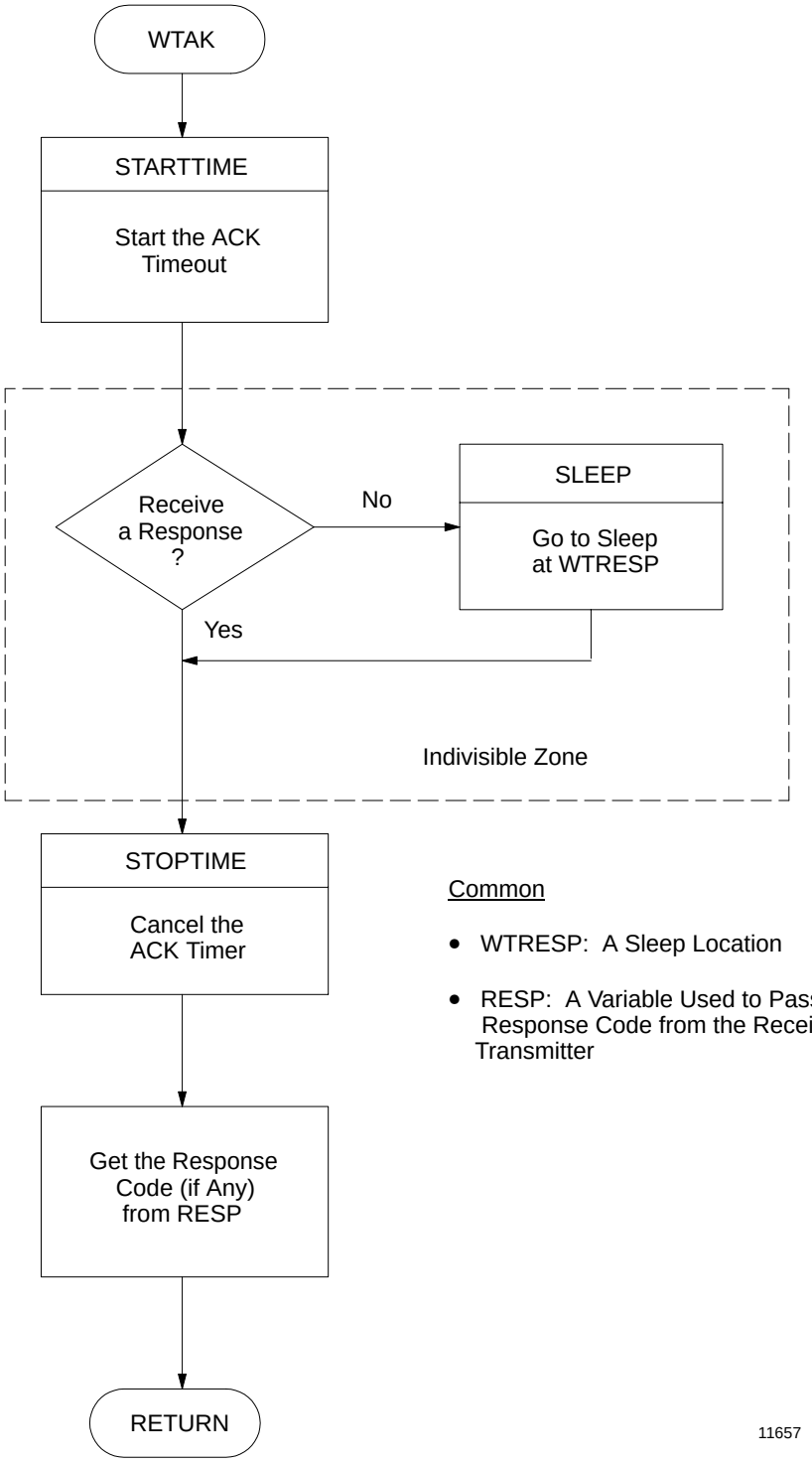
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Figure D.2
Transmitter Routine for Full-Duplex Protocol



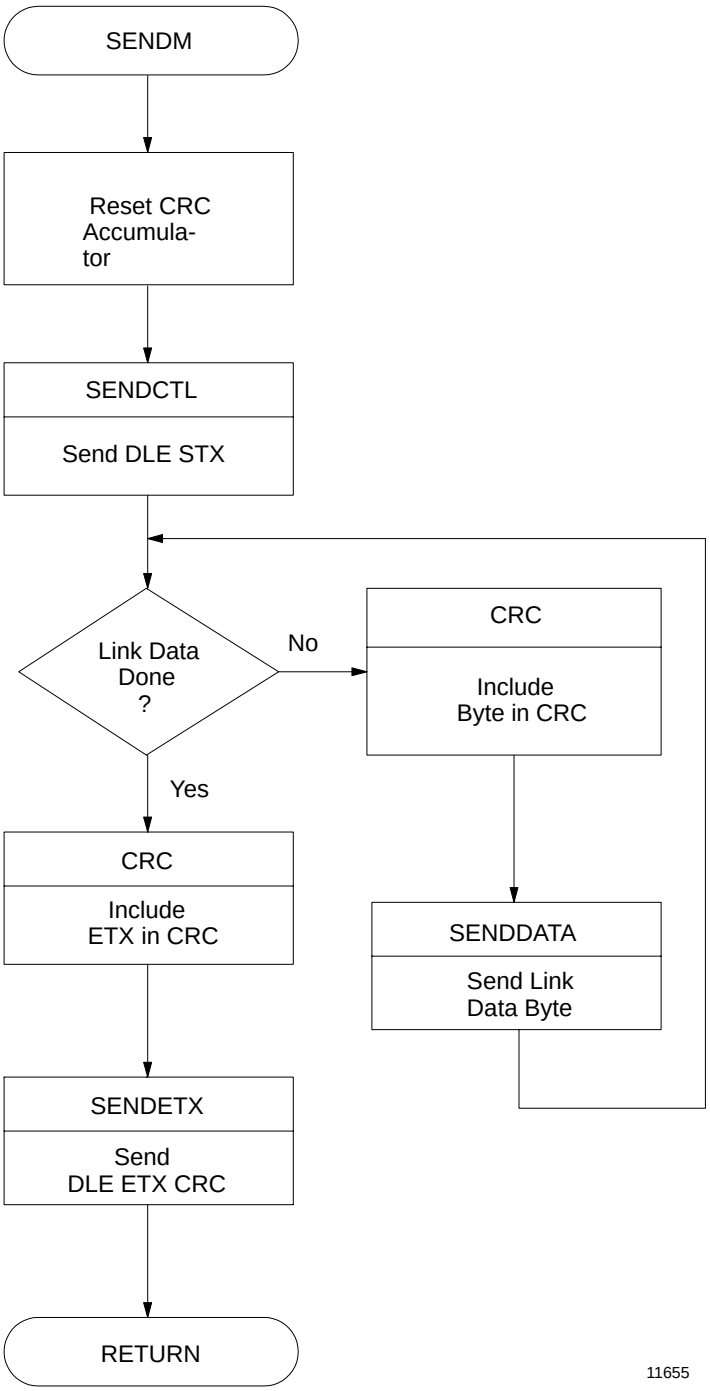
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Figure D.3
WTAK Subroutine



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Figure D.4
SENDM Subroutine



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Figure D.5
STARTTIME Subroutine

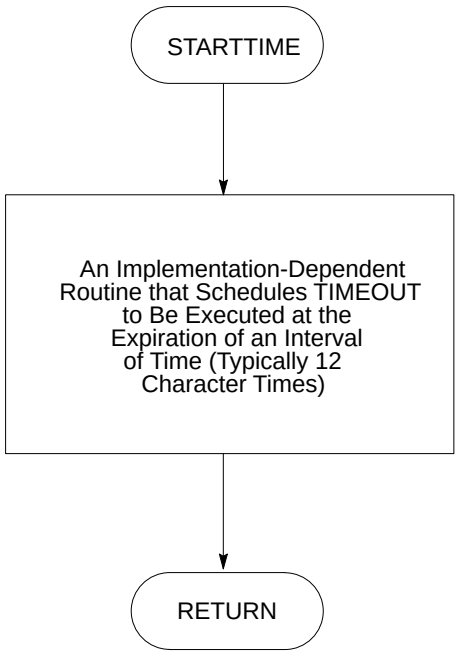
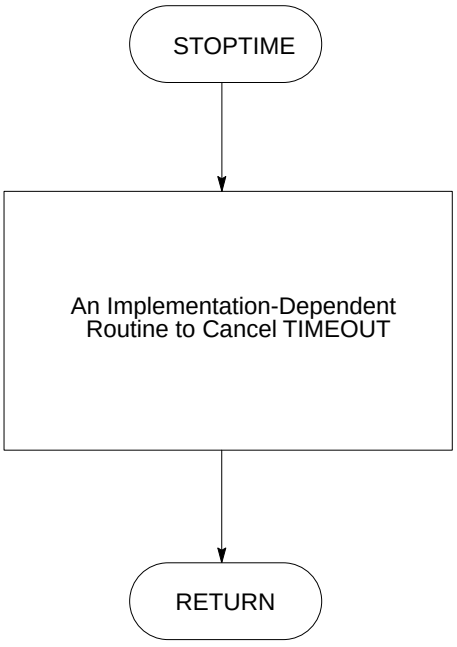
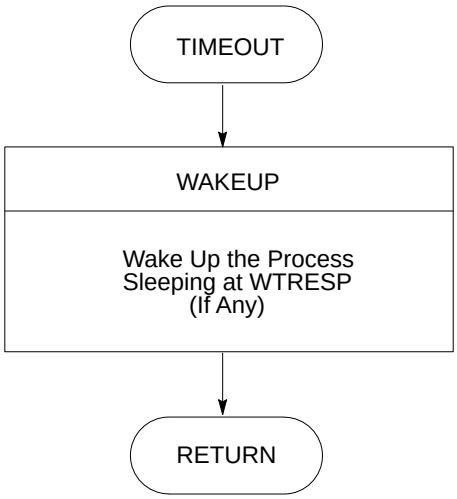


Figure D.6
STOPTIME Subroutine



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Figure D.7
TIMEOUT Subroutine



Scheduled By

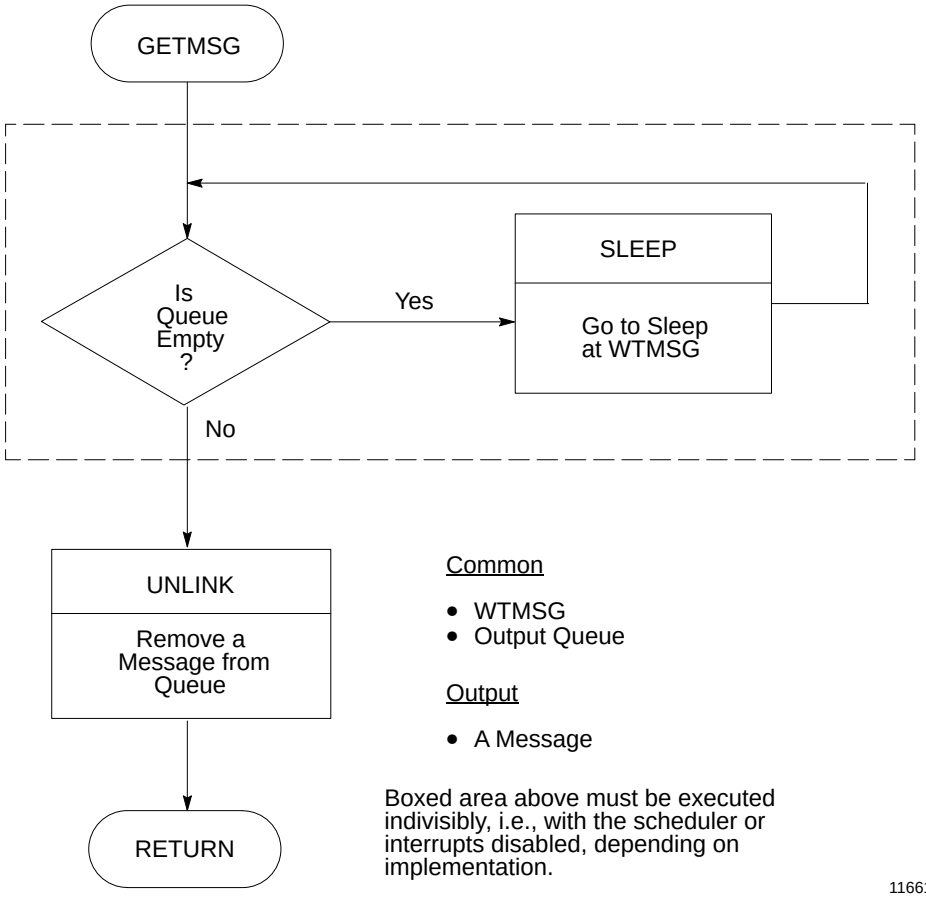
- STARTTIME

Aborted By

- STOPTIME

11660

Figure D.8
GETMSG Subroutine



Common

- WTMSG
- Output Queue

Output

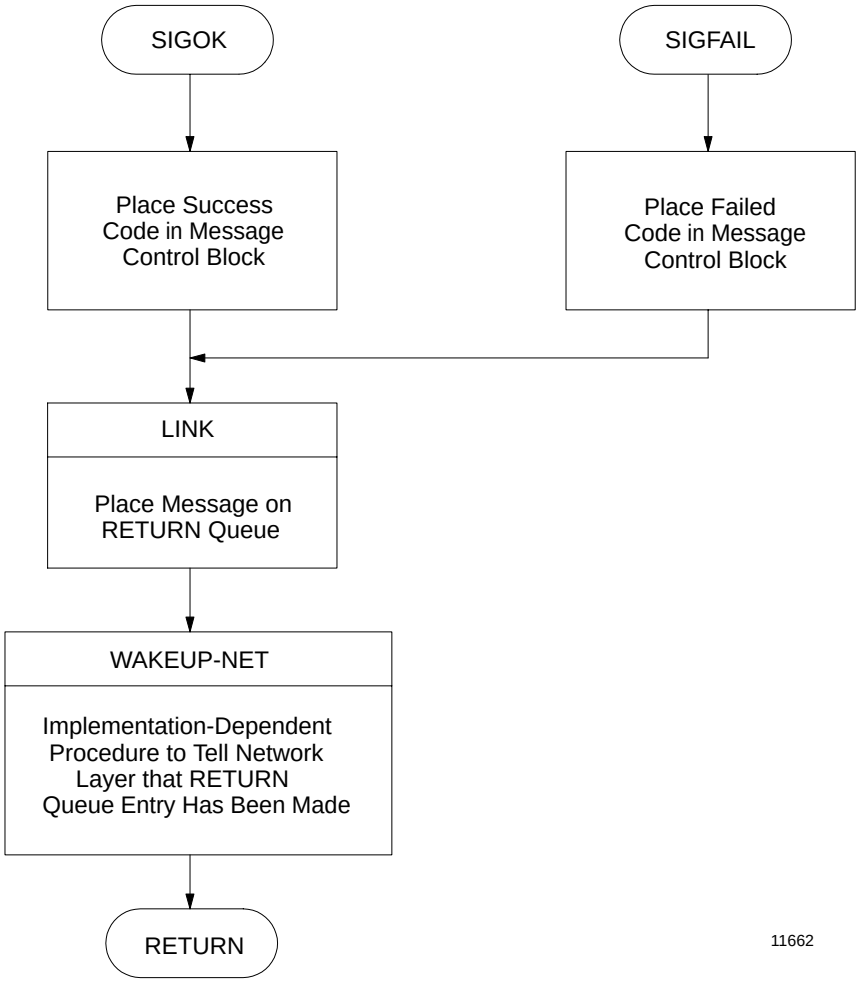
- A Message

Boxed area above must be executed indivisibly, i.e., with the scheduler or interrupts disabled, depending on implementation.

11661

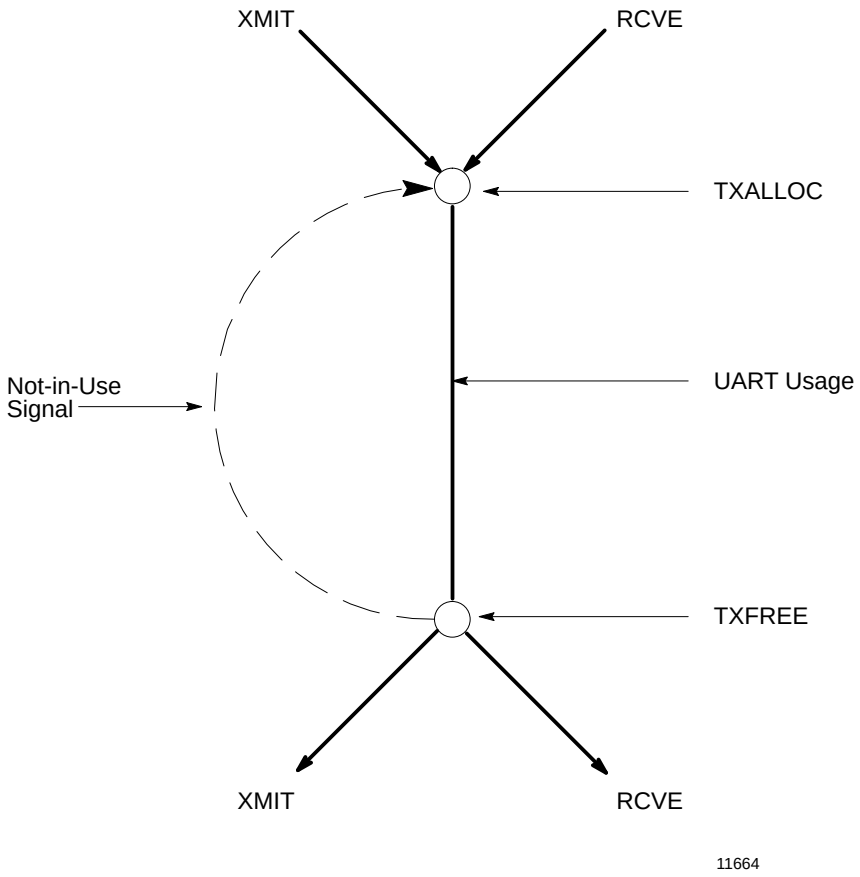
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Figure D.9
SIGOK/SIGFAIL Subroutine



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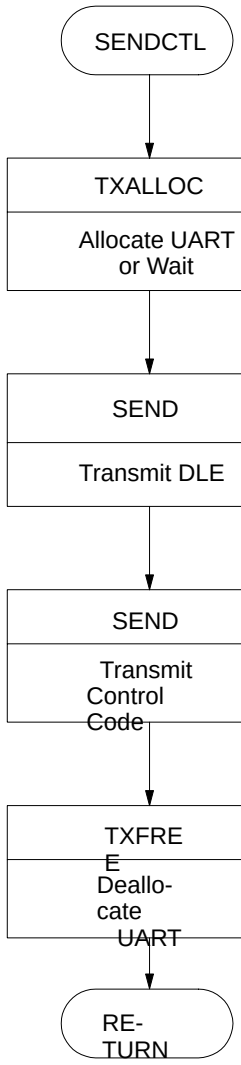
Figure D.10
Sharing the Transmit Side of the UART



Since the transmit side of the UART is shared by the transmit and receive processes, a mutual exclusion mechanism is used to gain sole access during transmission of each indivisible code sequence. The UART is like a small bridge; and the mutual exclusion mechanism is like two flagmen, one at each end of a one-lane bridge. If two heavy trucks (one called XMIT and one called RCVE) come to the bridge at the same time, the flagman on one side lets one truck through and makes the other wait. When the first truck has crossed, the first flagman signals the second flagman, who then allows the second truck to cross. In a similar manner, TXALLOC and TXFREE work together to ensure the XMIT and RCVE do not try to use the UART at the same time.

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Figure D.11
SENDCTL Subroutine



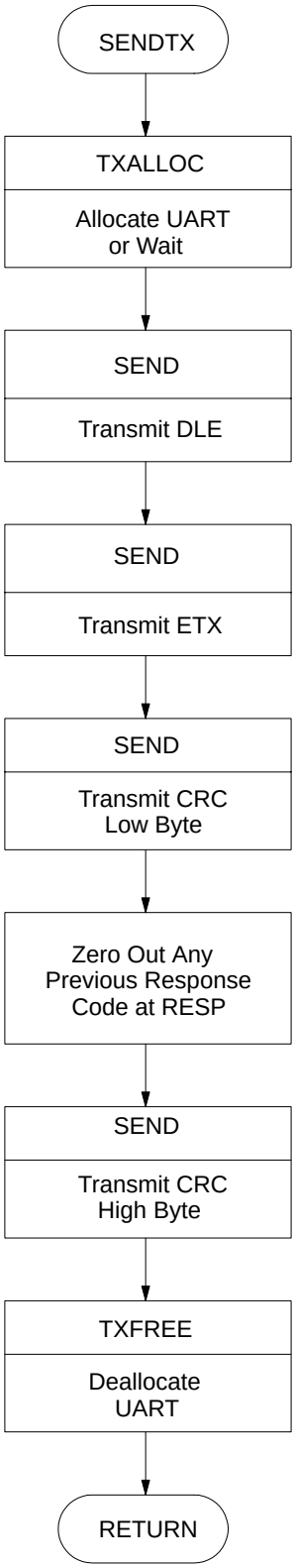
Input

- Control Code

11663

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Figure D.12
SENDTX Subroutine



Input

- CRC

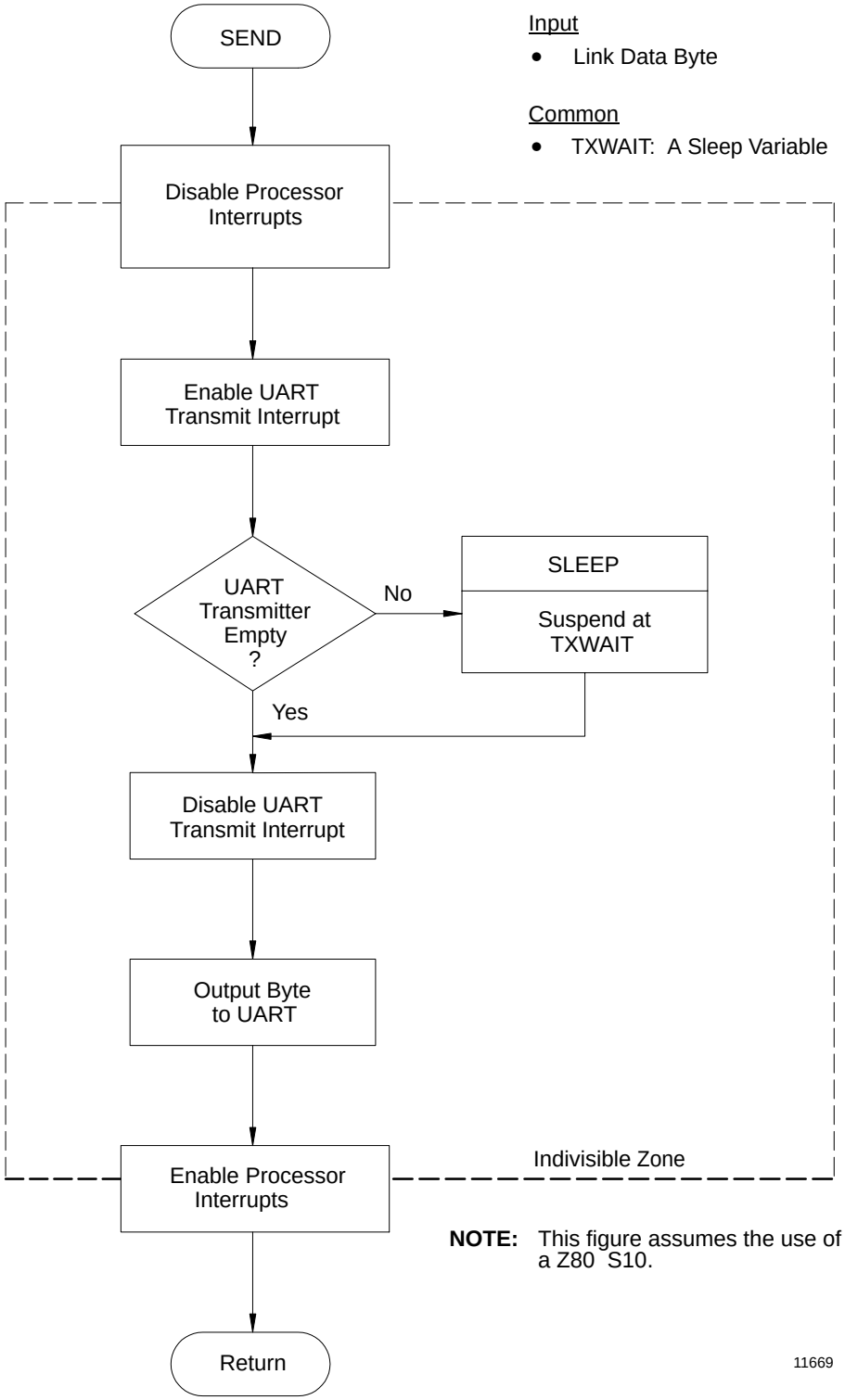
Common

- RESP: The Response Code Variable

11665

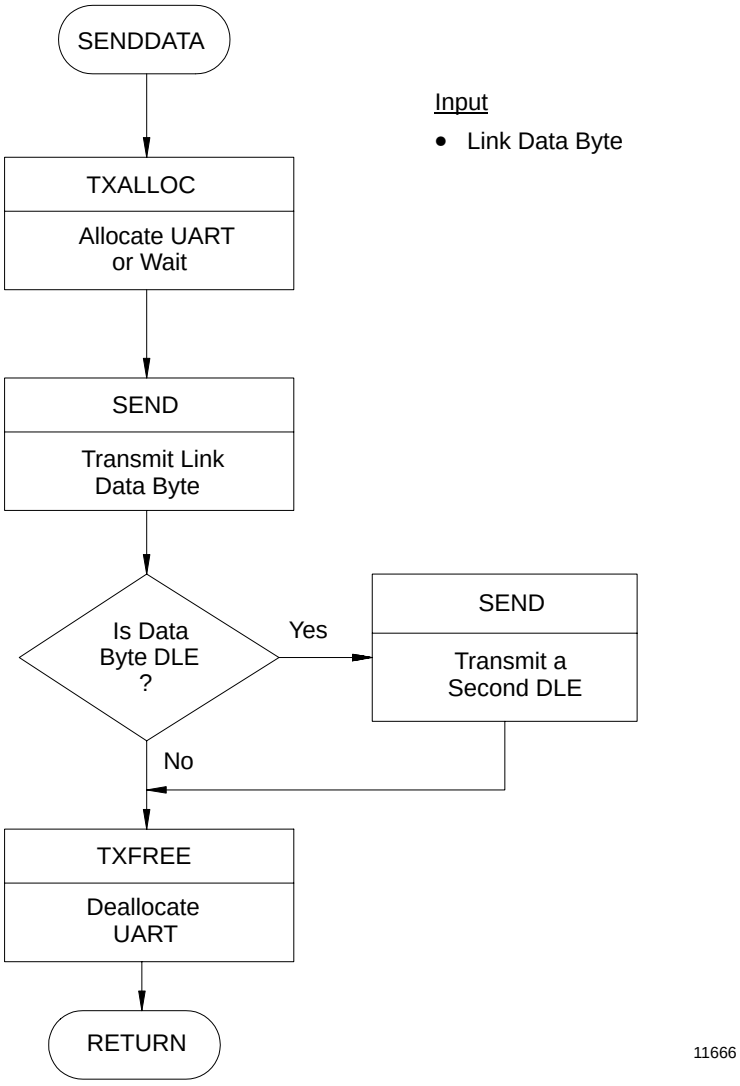
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Figure D.13
SEND Subroutine



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Figure D.14
SENDDATA Subroutine



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Figure D.15
TXALLOC Subroutine

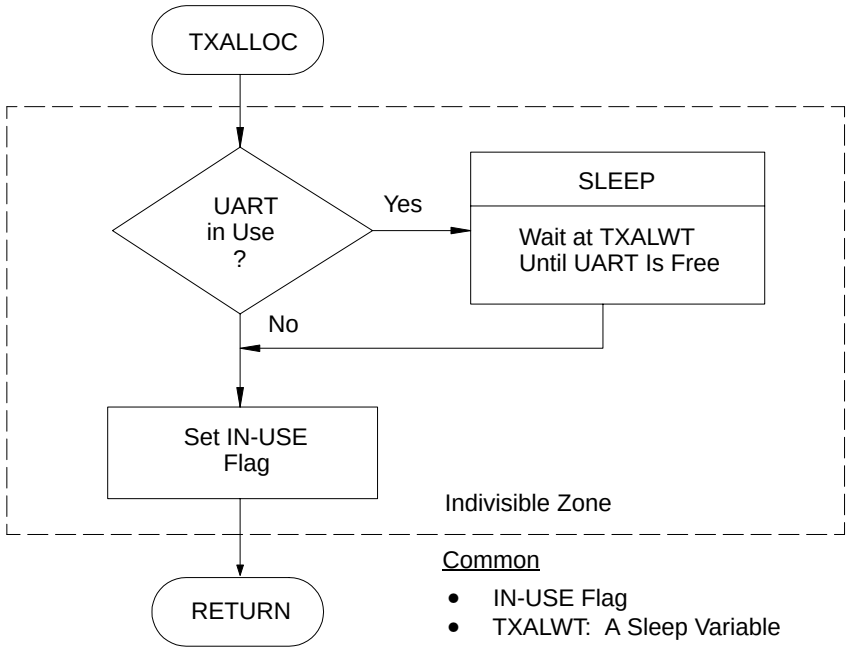
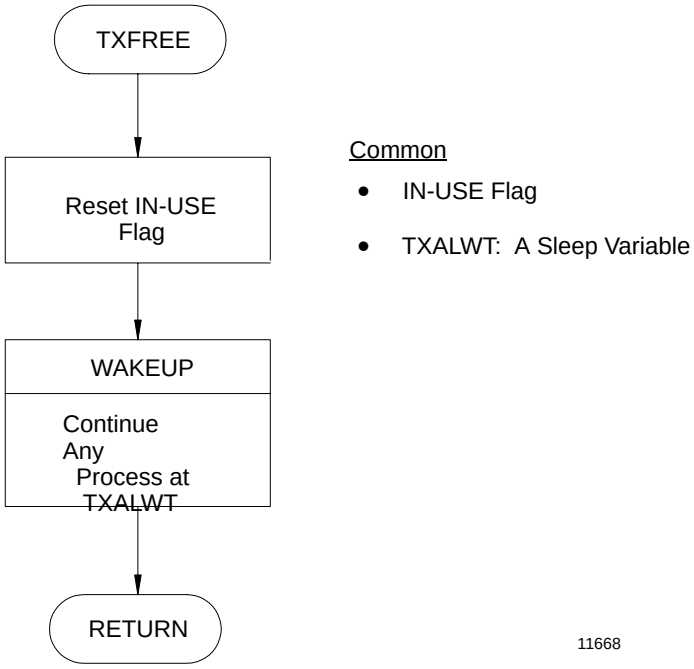
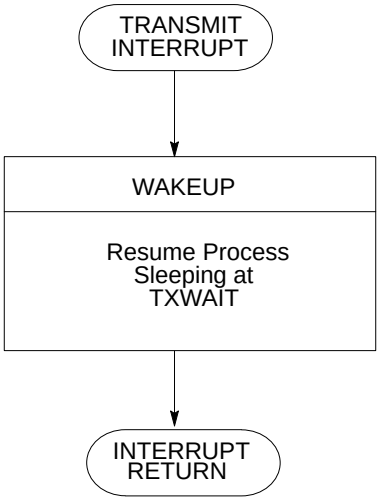


Figure D.16
TXFREE Subroutine



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Figure D.17
TRANSMIT INTERRUPT Subroutine

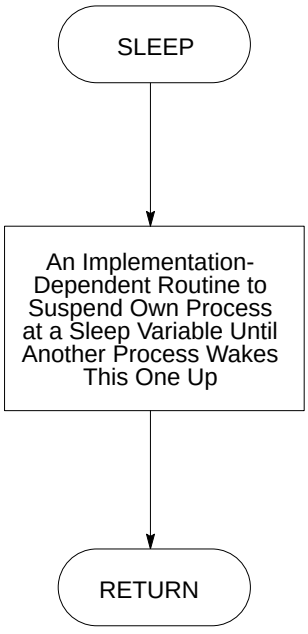


NOTE: This figure assumes the use of a Z80 S10.

NOTE: UART transmit interrupt must be enabled and disabled without affecting the current state of the **receive** and **status interrupt** enable flags.

11670

Figure D.18
SLEEP and WAKEUP Subroutines

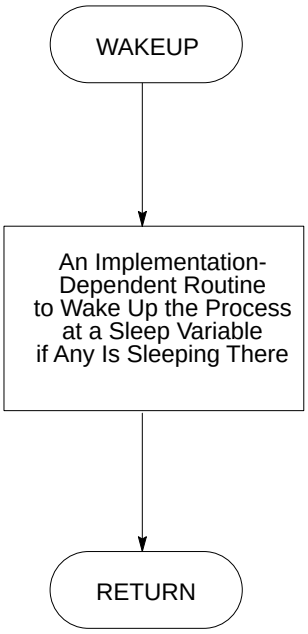


Input

- The address of a Sleep Variable.

Sleep Variables

- Typically an address of a stack or a process or context save area.
- A process can suspend itself and place its address in a Sleep Variable.
- Subsequently another process can wake up the sleeping process by referring to Sleep Variable. When no process is sleeping at a Sleep Variable, a WAKEUP has no effect.



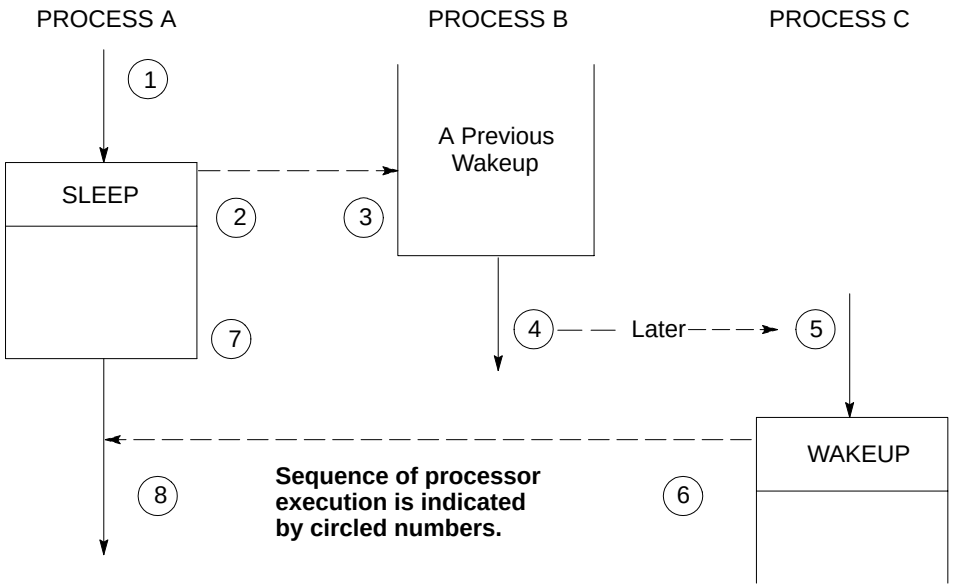
Input

- The address of a Sleep Variable.

11671

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Figure D.19
SLEEP and WAKEUP Interaction



NOTE 1:
SLEEP and WAKEUP are always used in connection with some type of indivisible interprocess interlock. Indivisibility is achieved on many processors (e.g., -Z-80) by disabling processor interrupts. For this reason, SLEEP and WAKEUP assure that interrupts are OFF when they are called. They will always return with interrupts OFF.

The interaction of SLEEP and WAKEUP:

When one process calls SLEEP, the result is a return from a WAKEUP by another process. When a process calls WAKEUP, the result is a return from a call to SLEEP by another process. An interrupt subroutine that calls WAKEUP is viewed as a subroutine of the interrupted process.

In the above example, Process B woke up Process A some time ago. Now, at 1, when A goes to sleep, actual execution resumes after the wakeup call in B at 3 and 4. Sometime later, Process C (at an interrupt, for example) calls WAKEUP at 5. Execution flow proceeds to the instructions at 8 following the call to SLEEP in Process A. The next time A calls SLEEP, the WAKEUP call in C will terminate.

NOTE 2:
This is not the only possible implementation of SLEEP and WAKEUP.

Another implementation would allow a process to call WAKEUP without losing immediate control of the processor. Context switching would be deferred until B itself executed a SLEEP.

A third alternative would cause a context switch if a process performed a WAKEUP on a higher priority process. If a WAKEUP was performed on a lower priority process, the context switch would be deferred until the first process went to SLEEP.

The first alternative is the result of implementing the driver totally at interrupt level. The third alternative would be used if the driver were implemented as tasks-- under a multi-tasking operating system. Such an implementation might be easier but would probably be limited to lower baud rates.

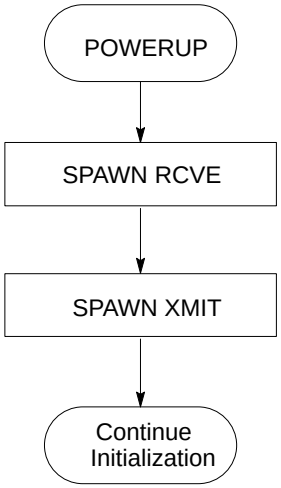
11672

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Figure D.20
POWERUP Subroutine

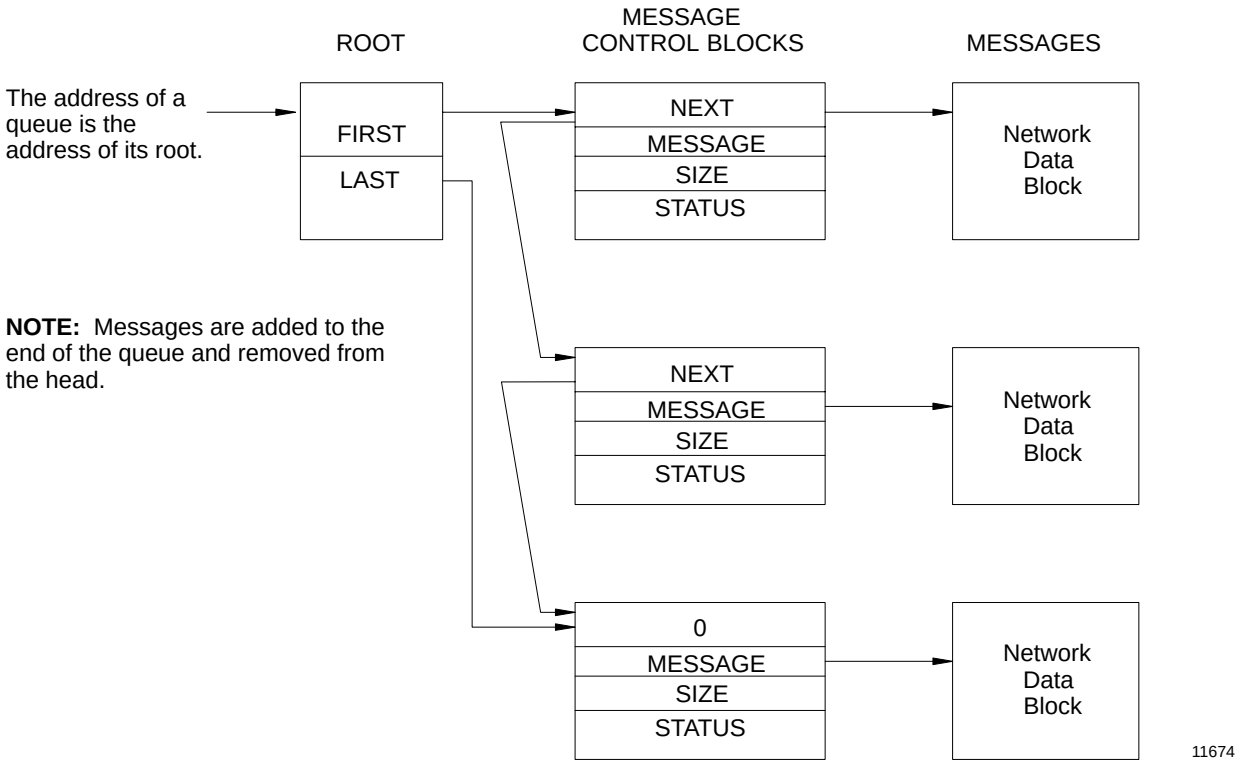
POWERUP

At power-up the Z-80 starts executing code at Location 0. The POWERUP routine starts the XMIT and RCVE processes by executing a SPAWN. A SPAWN is very similar to a WAKEUP, except the corresponding SLEEP is imaginary and is located ahead of the first instruction of the SPAWNed process.



11673

Figure D.21
Message Queue

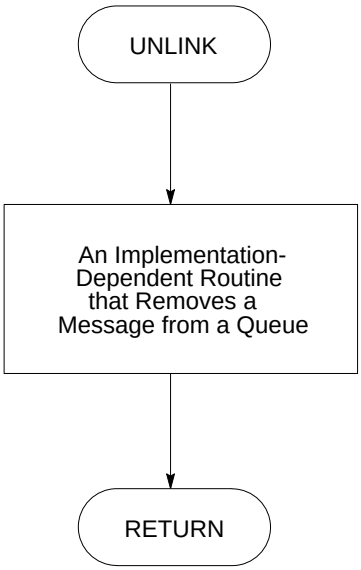


NOTE: Messages are added to the end of the queue and removed from the head.

11674

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Figure D.22
UNLINK Subroutine



Input

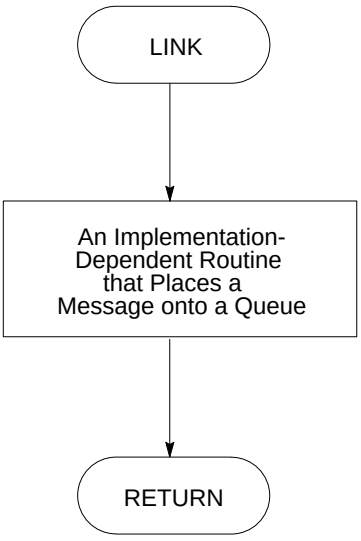
- Address of Queue

Output

- Message Control Block

11675

Figure D.23
LINK Subroutine



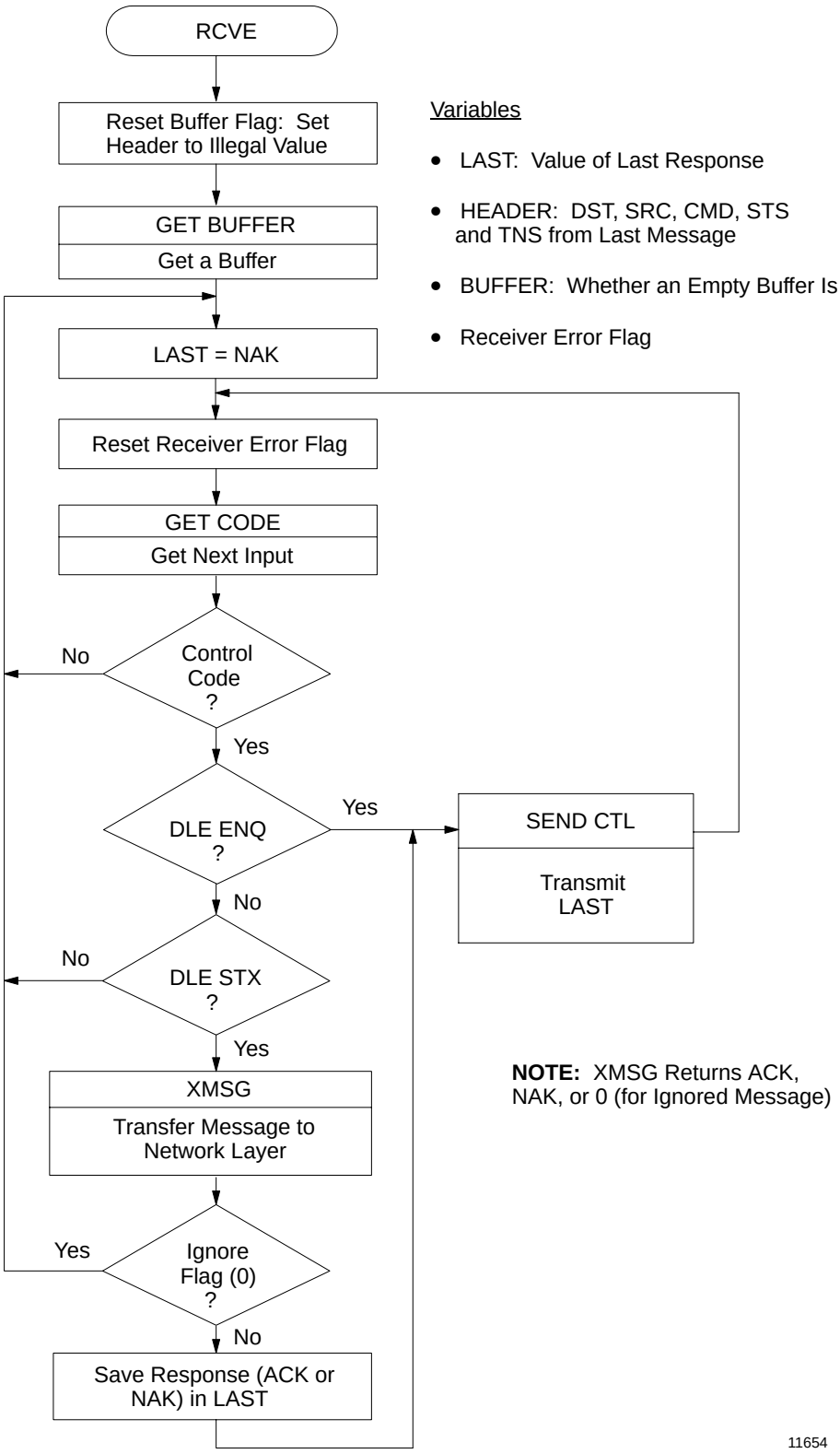
Input

- Address of Queue Message Block

11676

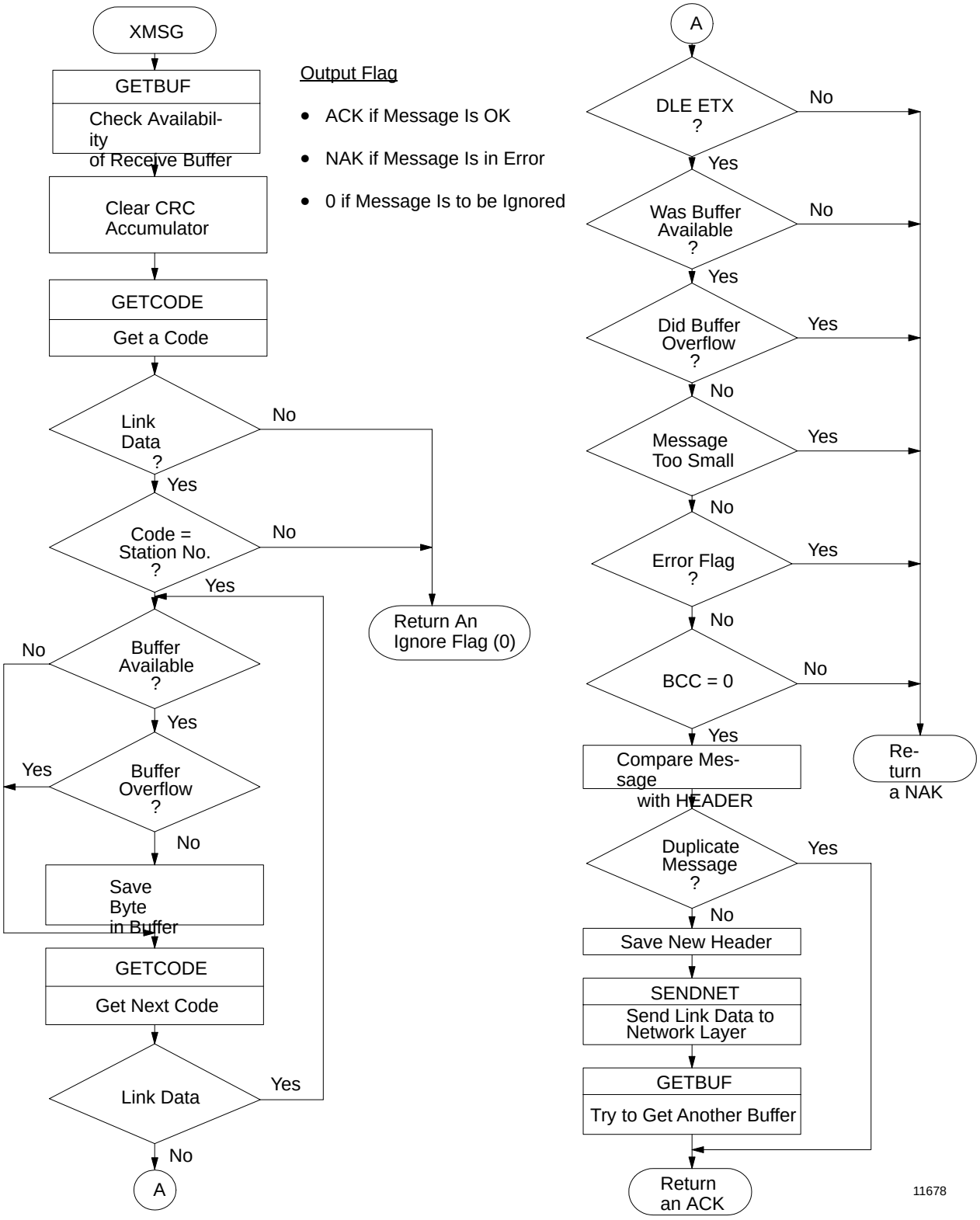
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Figure D.24
Receiver Routine for Full-Duplex Protocol



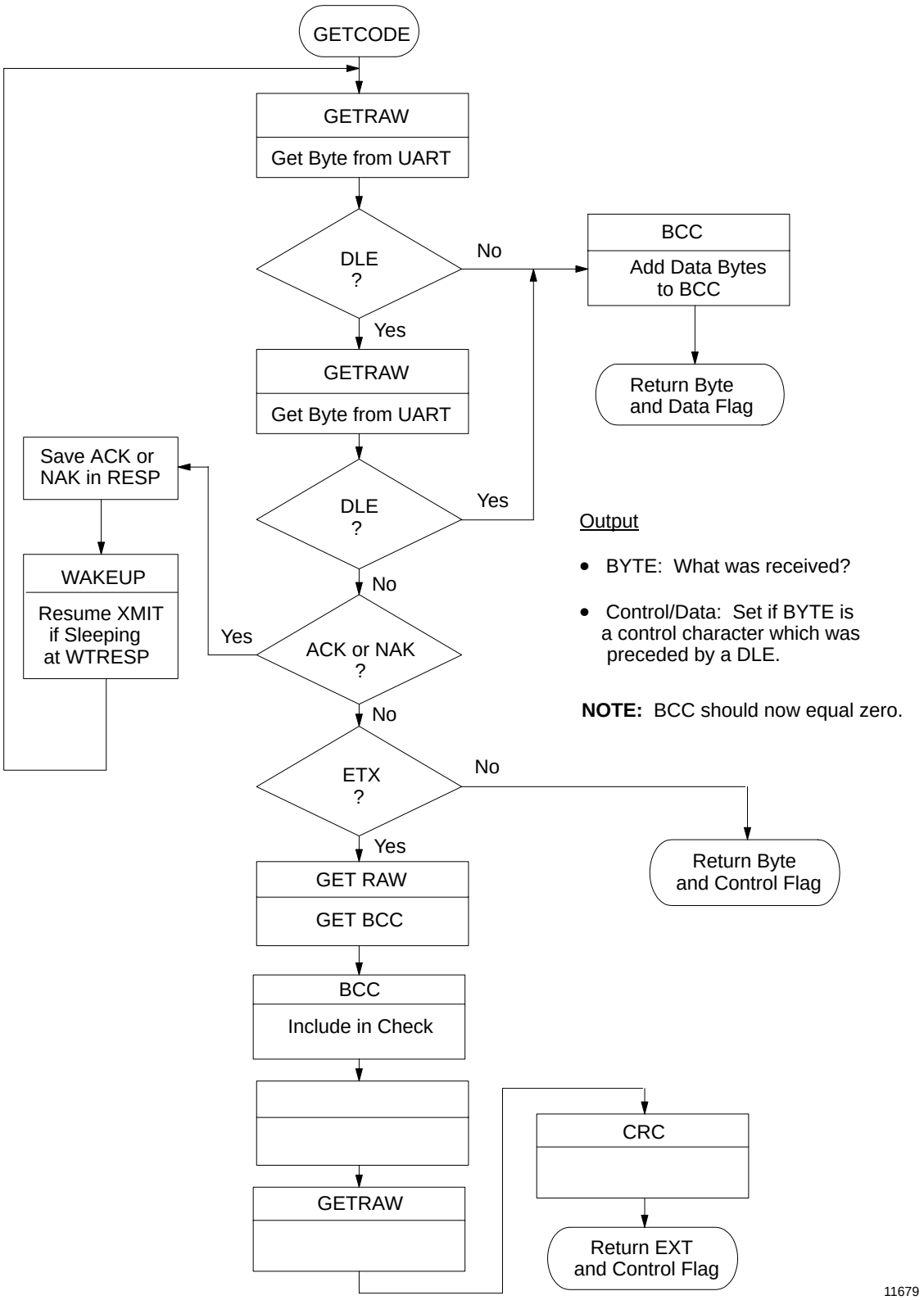
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Figure D.25
XMSG Subroutine



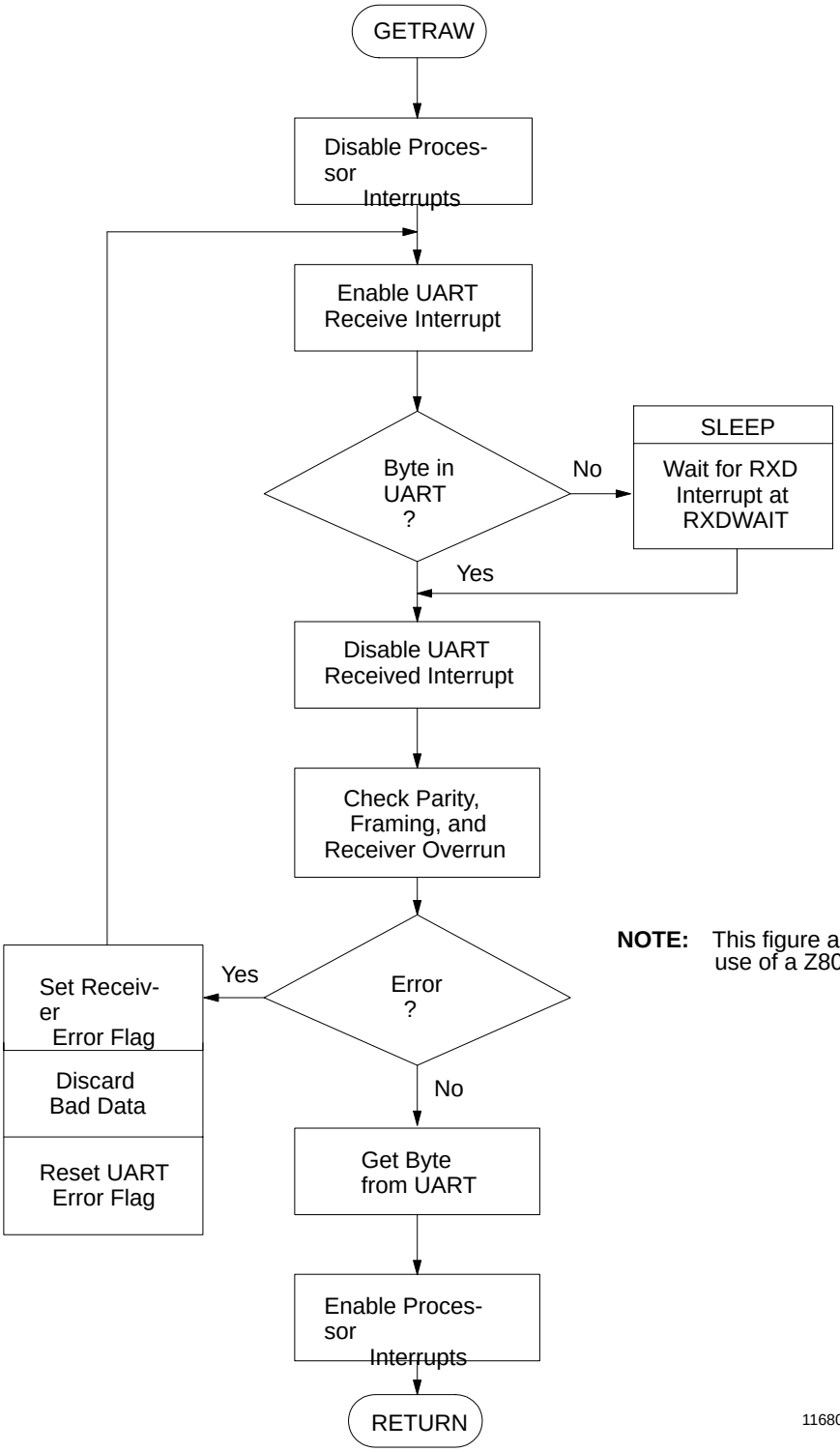
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Figure D.26
GETCODE Subroutine



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Figure D.27
GETRAW Subroutine



NOTE: This figure assumes the use of a Z80 S10.

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Figure D.28
SENDNET Subroutine

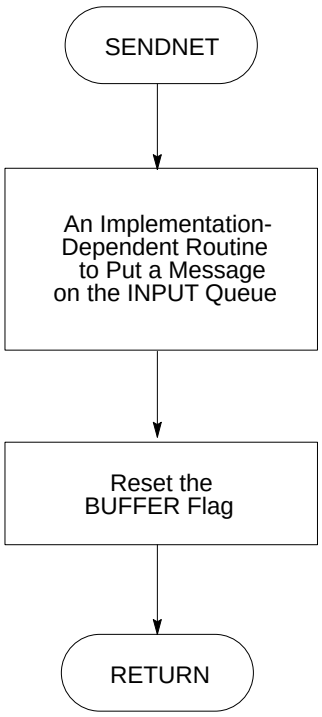
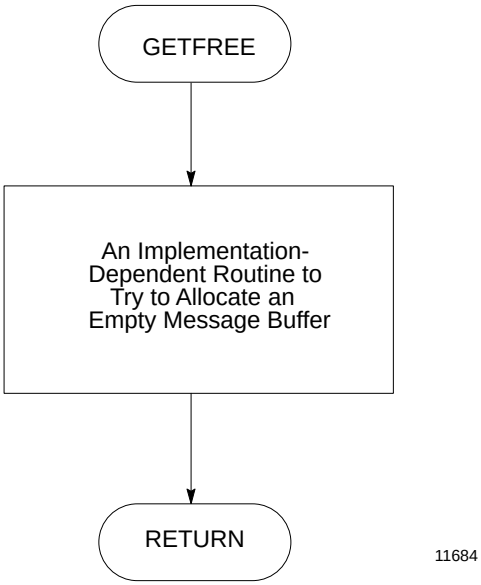


Figure D.29
GETFREE Subroutine



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Appendix E

Data Link Layer

Data Link Layer Operation on Data Highway

The data link layer controls the flow of communication on the physical link by acquiring and releasing access to the communication channel for each station. This layer differs for each type of physical link.

Chapter 4 explains how to program the data link layer for an asynchronous link. The rest of this section describes the data link layer of the Data Highway link.

Note that you do not have to program the data link layer for the Data Highway; the communication interface modules automatically take care of it. The description of it presented here is solely for information purposes.

The protocol that is used between stations on the Data Highway link is a modified low-level implementation of HDLC that features bit stuffing, flag definition, and generation of the cyclic redundancy check (CRC).

Floating Master

Central to the interaction of Data Highway modules is the concept of the floating master. With this arrangement, no single station is permanent master controlling the Data Highway communication link at all times. Instead, each station bids for mastership, based on its need to send command or reply messages. This arrangement has two major features:

- Multiple Masters
- Peer-to-Peer Communication

One advantage of floating master operation is that no single station disables communication on the Data Highway as long as other stations continue to operate. This means that even with disconnection or faulted operation of a module or a processor, communication between other operating station interface modules continues. This minimizes the need for backup in some applications.

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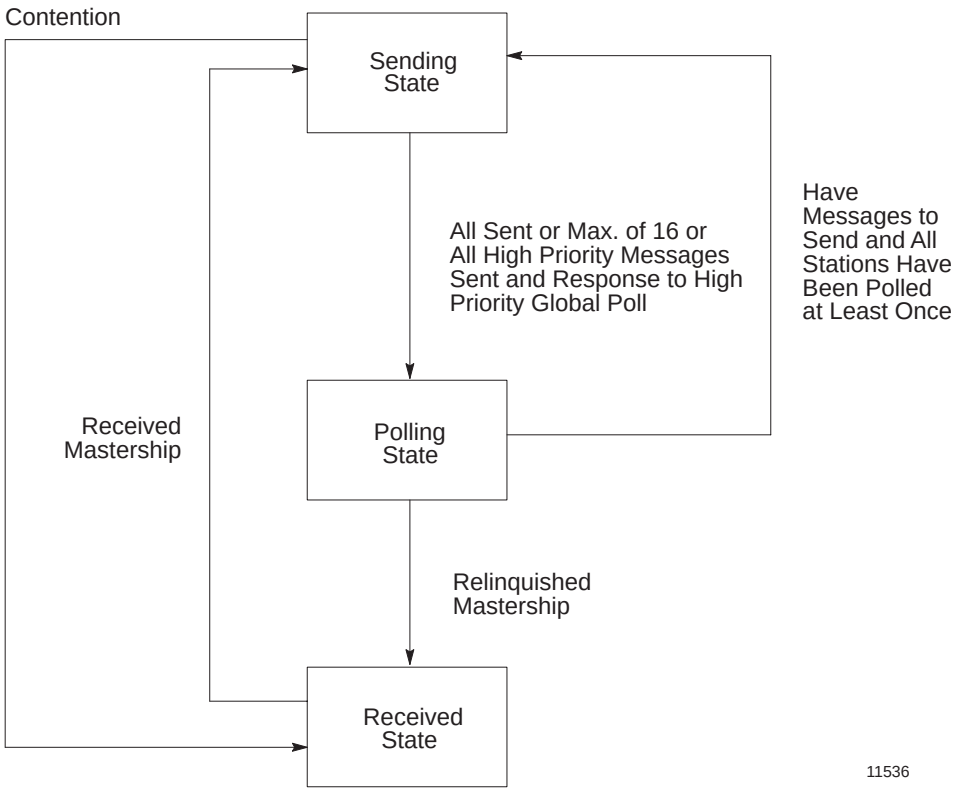
When a station gains control of the Data Highway to transmit messages, it has become a master station. All other station interface modules assume a slave mode. This enables these stations to receive and acknowledge messages sent to them. Basically, a station has three states of operation:

- Transmitting Messages
- Polling to Determine which Station Gets Mastership Next
- Receiving Messages and Polls

Thus, each Data Highway station can transmit and receive both messages and polling sequences.

Figure E.1 shows the change of states at a Data Highway station.

Figure E.1
State Transition at Master Station



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Message Transmission

A station must have mastership of the Data Highway before it can transmit any messages or polling sequences. As part of the data integrity of the highway, all commands must receive a reply before a transaction is considered complete. Since the highway treats commands and replies as the same type of message, it takes at least one change of mastership to complete a single transaction.

Any command has to be formatted in the application program of the local, or transmitting, station. For a PC, the format is part of the PC user program. For a computer, the formatting has to be done as part of the computer program (Chapter 5).

A reply message is generated by a station in response to a command message it receives. The reply message indicates that the command message was received and that the station interface module has completed the sequence of events required of it for command execution. For commands that write data, the reply message indicates that the write operation has been completed at the receiving station.

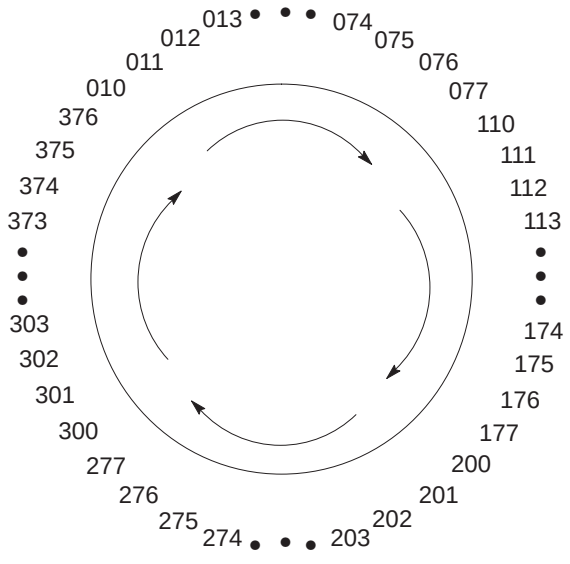
When the replying station is a programmable controller, the reply message is an automatic function of the interface module operation and is transparent to your program. If the replying station is a computer, you must program the computer to formulate the response and the reply message.

Polling

To transfer mastership between stations, the station interface modules use an orderly polling scheme. Normally, mastership passes from one station to another in a round-robin fashion. During installation, you assign each station a unique number between 001 and 376 (octal). Each master passes mastership to the station with the next higher station number that is requesting mastership. All polling arithmetic is performed modulo-256 relative to the station number of the current master. For example, when the master is 200 (octal), Station 220 will receive mastership before Station 177, since 220 is closer in sequence to 200 than is 177. Figure E.2 illustrates this polling scheme.

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Figure E.2
Polling Scheme



The mechanics of the polling algorithm are essentially transparent to you. This is because the communication modules handle this automatically. However, the polling algorithm does lead to the following basic rules that you should follow to optimize your Data Highway performance:

- Number stations sequentially whenever possible.
- Keep the number of high priority messages as low as possible.

Large numbers of high priority messages slow all traffic on the network. In general, you should limit the number of high priority messages to less than 1% of the total traffic on the Data Highway.

Data Security

There are two checks used in Data Highway network message transmission:

- A 16-Bit Cyclic Redundancy Check (CRC) on a Data Highway Link
- An 8-Bit Block Check Character (BCC) or a 16-Bit CRC on an Asynchronous Link

Additionally, you can select a parity check (even parity only) on the asynchronous link.

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A block check is used to detect errors at the link level. You can select a CRC instead of this block check. Any device connected to the asynchronous link must be capable of generating a BCC or a CRC, if used.

A BCC is added to the end of every message block to help detect errors of transmission between station interface modules. The command station generates a BCC by first summing every byte of the text (excluding control characters), then taking the 2's complement of that sum. The result is the BCC. Any final carry-out bit is ignored in the BCC computations.

The receiving station also sums the text bytes, then adds that sum to the BCC to produce zero. Any sum other than zero indicates an error has been made in the transmission and causes the receiving station to respond with DEL ACK.

The CRC is used at the data link layer to validate messages transmitted on the Data Highway link.

The station interface module at the sending station appends the CRC to the message. The CRC is based on the bit pattern of the transmitted message. The receiving station also computes a CRC based on the received data and checks this against the CRC value included with the received message. A discrepancy between the transmitted CRC and the CRC computed by the receiving station indicates some fault in the transmission. If the received and computed CRC values do not agree, the message is not accepted as valid.

Link Disconnect

Floating master operation continues normally as long as all stations share mastership of the Data Highway link. However, if any one station retained continuous control of the communication link due to a fault condition, floating master operation would not be possible and Data Highway communication would be disabled. As a preventive measure against this type of situation, each station interface module has automatic link disconnect circuitry. If a module detects that it is not relinquishing mastership of the Data Highway, this circuitry can disconnect the module from the Data Highway link. The other stations on the Data Highway can then continue to function normally.

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