ALLEN-BRADLEY

Smart Transmitter Interface Products (HART® Protocol)

Cat. Nos. 1770-HT1, 1770-HT8, 1770-HT16

User Manual

Important User Information

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The illustrations, charts, sample programs and layout examples shown in this guide are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation, the Allen-Bradley Company, Inc. does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

Allen-Bradley Publication SGI-1.1, "Safety Guidelines for the Application, Installation and Maintenance of Solid State Control" (available from your local Allen-Bradley office) describes some important differences between solid-state equipment and electromechanical devices which should be taken into consideration when applying products such as those described in this publication.

Throughout this manual we use notes to make you aware of safety considerations:

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage or economic loss.

Attentions help you:

- identify a hazard
- avoid the hazard
- recognize the consequences

Important: Identifies information that is especially important for successful application and understanding of the product.

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Preface

Purpose of the Manual

This manual shows you how to use the Smart Transmitter Interface products with Allen-Bradley programmable controllers and other intelligent host computers. It describes how to install and configure the Smart Transmitter Interface products, as well as how to perform trouble-shooting procedures.

Organization of the Manual

This manual contains five chapters and three appendices. They address the following topics:

Chapter	Topics Covered
Chapter 1: Introducing the Smart Transmitter Interface	overview of the Smart Transmitter Interface; introduction to the HART protocol, and features and benefits of using them
Chapter 2: Installing the Smart Transmitter Interface	installation procedure, power supply requirements and connection instructions
Chapter 3: Configuring the Communications Controller	the communication parameters and how to set them on the Communications Controller
Chapter 4: Communicating with the Smart Transmitter Interface	Smart Transmitter Interface data routing and protocol conversion, communication terms, HART and Smart Transmitter Interface data packets, PLC-5 programming example, and serial host communication with the Smart Transmitter Interface
Chapter 5: Troubleshooting	diagnosing communications problems
Appendix A: Product Specifications	technical specifications for 1770-HT1, HT8 and HT16, and HART communications specifications
Appendix B: DF1 Diagnostic Command Support	diagnostic commands for use on the RS-232C link between a host processor and the Communications Controller
Appendix C: Cable Length and Power Supply Requirements	cable length requirements between the Communications Controller and the Terminal Blocks, and power supply requirements

How to Use This Manual

This manual explains the features, functions and specifications of three products designed to provide communication between Allen-Bradley products and HART® field devices. These products are:

- Communications Controller Cat. No. 1770-HT1

- 8 Channel Terminal Block Cat. No. 1770-HT8
- 16 Channel Terminal Block Cat. No. 1770-HT16

Audience

This manual is intended for use by:

- persons installing Smart Transmitter Interface products, in connection with Allen-Bradley PLC controllers or other intelligent controllers
- system integrators who are designing and establishing network systems involving plant floor machinery, programmable controllers, HART field devices, Smart Transmitter Interface products and host computers
- maintenance personnel who maintain such systems and who must locate, define and correct problems arising during their day-to-day operation

Related Publications

Allen-Bradley Publications

Publication	Reference Number and Date
Allen-Bradley Data Highway/Data Highway Plus™ /DH485 Communication Protocol and Command Set Reference Manual	1770-6.5.16, November 1991
Analog Input Module User Manual cat. no. 1771-IFE	1771-6.5.90, September 1991
ControlView Core User Manual	6190-6.5.1, November 1992
PLC-5 Family Programmable Controllers Hardware Installation Manual	1785-6.6.1
PLC-5 Programming Software	6200-6.4.7
6008-SI IBM™ PC Scanner User's Manual	6008-6.5.3

A complete list of publications relating to ControlView and its options is available in the ControlView Core User Manual. For a list of publications on Allen-Bradley programmable controller products refer to the Allen-Bradley publication index (SD499).

HART Publications

Publication	Reference Number and Date
HART – Smart Communications Protocol Specification	Revision 5.1, January 4, 1991 Rosemount, Inc. Document No. D9000047, Revision A

Related Products

The Smart Transmitter Interface Products create a communication interface between programmable controllers and HART field devices. They are compatible with HART field devices and with hand-held terminals capable of supporting the physical and data link layers of the HART protocol.

Glossary of Terms and Abbreviations

This manual uses the following terms as defined below.

Actuator: any one of several field devices that provide control functions using a 4-20mA input control signal. Actuators that support the HART protocol are designated as being “smart”.

BTR: Block Transfer Read

BTW: Block Transfer Write

Clear: (a bit) equal to 0

Hand-held terminal: a smart terminal product capable of functioning as either a primary or secondary master to one single HART device, using the HART protocol; this terminal allows the operator to monitor and configure the HART field device (e.g. Rosemount 268)

HART: **H**ighway **A**ddressable **R**emote **T**ransducer

HART field device: a transducer or actuator that supports the HART protocol

- 4-wire: refers to a HART field device drawing power from an external power source
- 2-wire: refers to a HART field device drawing power from the 4-20 mA loop

HART protocol: a protocol that provides digital communication over an industry-standard 4-20 mA process control loop at the same time as the value of a process control variable is being transmitted as a 4-20 mA signal

Host Processor: the programmable controller or host computer (generally a PC) connected to the Communications Controller over the RIO, or the host computer connected to the Communications Controller’s RS-232 port

mA: milliamp; one-thousandth of an Ampere

Multidrop: multiple HART field devices (to a maximum of 15), connected in parallel, per channel on a terminal block

PLC: Programmable Logic Controller; an Allen-Bradley programmable controller

Point-to-point: one HART field device per channel on a terminal block

RIO: **R**emote **I**nput **O**utput link that supports remote, time-critical, I/O and control communications between a master PLC controller and its remote I/O and adapter mode slave processors

Transducer/Transmitter: any one of several field devices that can measure pressure, temperature, level, flow, density or other process control variables, and then transmit the value of that variable as a 4-20 mA signal. Transducers that support the HART protocol are designated as being “smart”.

Chapter 1

Introducing the Smart Transmitter Interface

This chapter provides an overview of the Smart Transmitter Interface products, a brief introduction to the HART protocol and a description of the different system architectures which can be implemented. It also describes the features and benefits of using the Smart Transmitter Interface and lists some of the products that are compatible with the 1770-HT1, 1770-HT8 and 1770-HT16.

Product Overview

The Smart Transmitter Interface products provide a communication interface between Allen-Bradley PLC controllers or host computers and HART field devices (transmitters, transducers and actuators). These products give host processors access to the digital information encoded with the 4-20 mA analog process control signal. The digital information can be passed to and from the host processor using either a remote I/O (RIO) or an RS-232C port.

A Smart Transmitter Interface consists of one Communications Controller (1770-HT1), and one or more Terminal Blocks (1770-HT8 or 1770-HT16). These products can be mounted on a DIN rail in a control cabinet and the field wiring brought directly to the Terminal Blocks.

1770-HT1 Communications Controller

The 1770-HT1 Communications Controller receives commands from a host processor and passes them on, via the 1770-HT8/16 Terminal Blocks, to HART field devices. Responses from the HART field devices go through the Terminal Blocks to the Communications Controller and then on to the host processor.

The Communications Controller communicates through its Remote I/O or RS-232C port to the host processor. The combination of hardware and software used by the host determines which port is used.

Use the Remote I/O port (labelled RIO in Figure 1.1) with the following:

- a programmable controller as host processor using ladder logic to perform block transfer reads and writes. On the DH+ network the programmable controller can connect to a computer running software applications, such as ControlView, to monitor and supervise the ongoing processes.

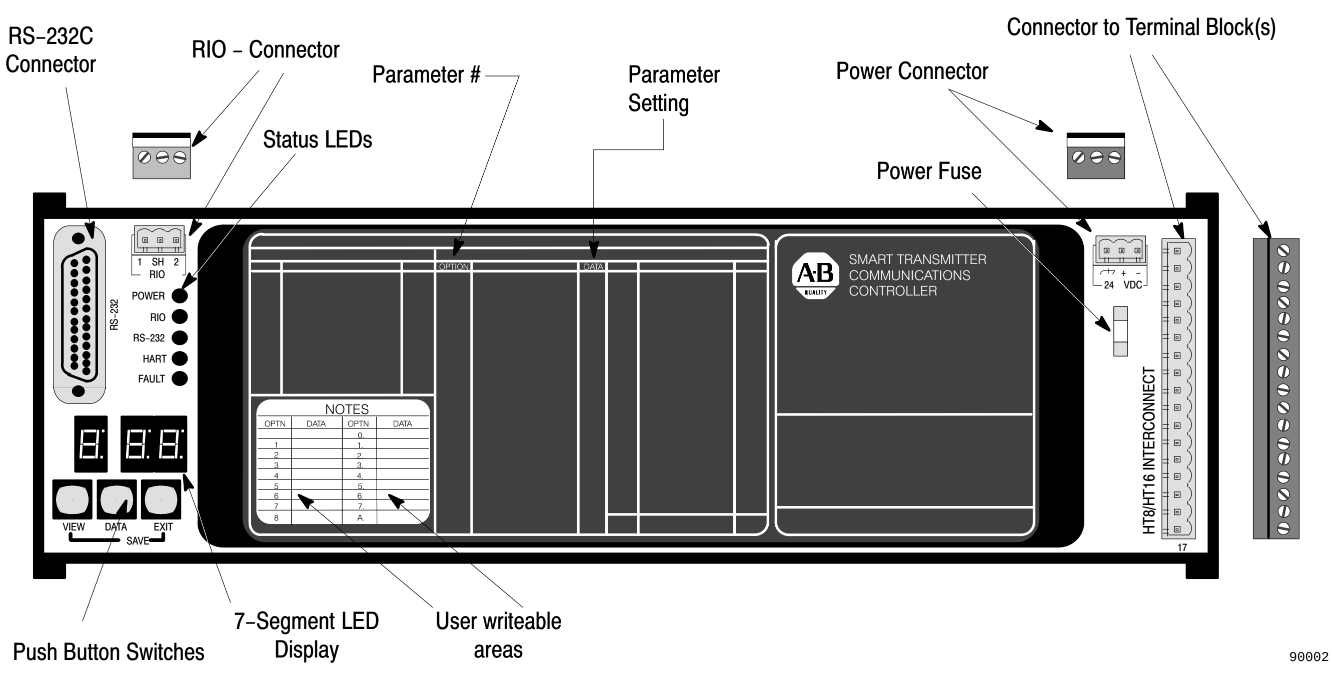
- a programmable controller with Allen-Bradley's pass-through functionality connected to a host computer on the DH+ network running application software to initiate communications

Use the RS-232C port (labelled RS-232 in Figure 1.1) with the following:

- a host computer using Allen-Bradley DF1 protocol, connected to the Communications Controller by an RS-232 cable (if the distance is less than 50 feet)
- a host computer using Allen-Bradley DF1 protocol, connected to the Communications Controller by telephone lines and modems

The Communications Controller requires an external 24 VDC power supply. It provides a multiplexed, 32 channel interface to the Terminal Blocks. All of the Remote I/O and RS-232C communications parameters are set on the Communications Controller using push buttons and a seven segment LED display.

Figure 1.1
1770-HT1 Communications Controller



1770-HT8/16 Terminal Block

The Terminal Blocks pass both analog and digital signals to and from the HART field devices. The analog signal is passed on to devices such as the Allen-Bradley 1771-IFE Analog I/O module. The digital signal is routed to the Communications Controller.

Each Terminal Block provides either 8 (1770-HT8) or 16 (1770-HT16) channels. Each channel has connection points for HART field devices and Analog I/O modules, loop fuses and loop power selection jumpers. Any combination of 8 and 16 channel Terminal Blocks can be used to make up the 32 channel maximum. The board address jumpers (see Figure 1.2 and Figure 1.3) indicate to the Communications Controller which set of channels a particular Terminal Block will use. These are set when the Terminal Block is installed (see Chapter 2).

Figure 1.2
1770-HT8 8 Channel Terminal Block

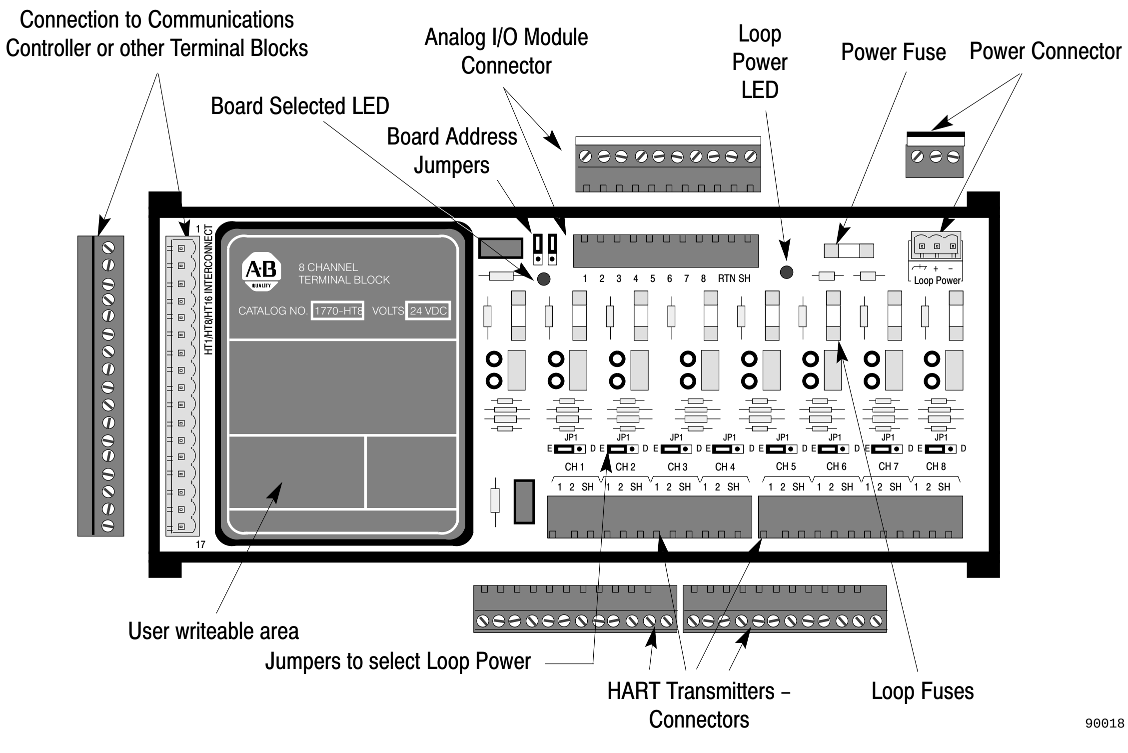
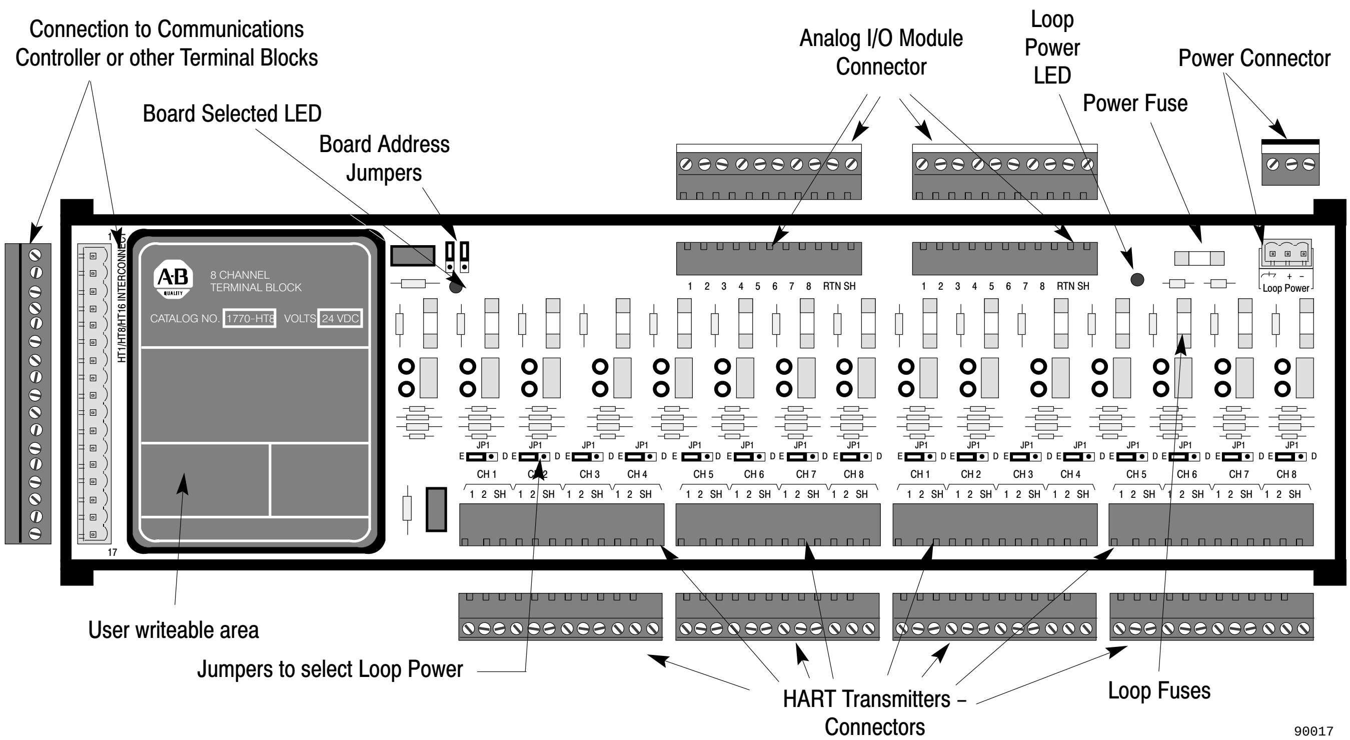


Figure 1.3
1770-HT16 16 Channel Terminal Block

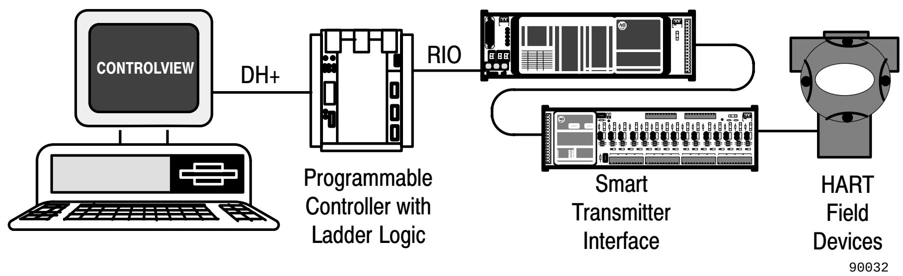


The Remote I/O Port of the Communications Controller

Programmable Controller Host Communications

Using programmable controller ladder logic to initiate Block Transfer Writes and Reads (BTW and BTR), data can be sent to and received from the HART field devices. A host computer on the DH+ network running application programs (such as ControlView) can read and display the data which the programmable controller has obtained from the HART field devices. (See Figure 1.4)

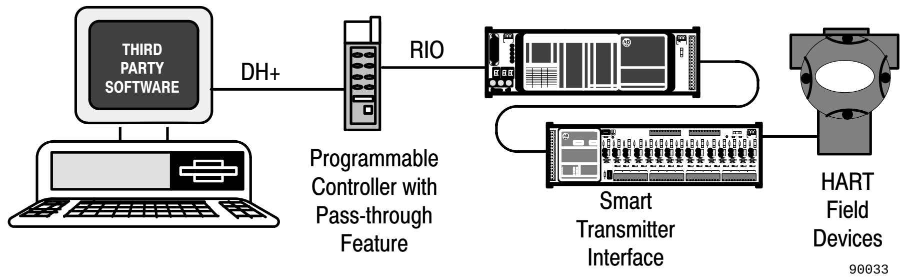
Figure 1.4
Smart Transmitter Interface with Programmable Controller Host



DH+ Host Communications (Using Programmable Controller Pass-through)

Data can also be sent to and received from HART field devices using the pass-through feature of the programmable controller to initiate Block Transfer Reads and Writes (BTR and BTW). No dedicated programmable controller ladder logic programs are required when the pass-through feature is used. A host computer on the DH+ network, running programs with pass-through support, can be used to communicate with the HART field devices.

Figure 1.5
Smart Transmitter Interface with DH+ Host
(Using Pass-through)



The RS-232C Port of the Communications Controller

The RS-232C port on the Communications Controller allows the HART field devices to communicate with either a local host or, via modem, a remote host.

Full Duplex Communications

With DF1 full duplex systems, you can communicate directly to a single Smart Transmitter Interface. No programmable controllers are necessary—just a computer running the appropriate software, the HART field devices, and the Smart Transmitter Interface between them. The host computer and the Smart Transmitter Interface should be connected with either an RS-232 cable for distances equal to or less than 50 feet, or two modems for distances greater than 50 feet. (See Figure 1.6 and Figure 1.7.) This gives end users with less complex applications, inexpensive access to HART field devices and to the advantages of the HART protocol.

Figure 1.6
Full Duplex Communication with no Modem

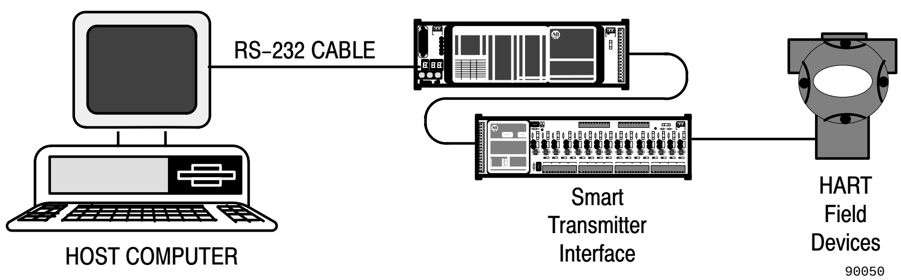
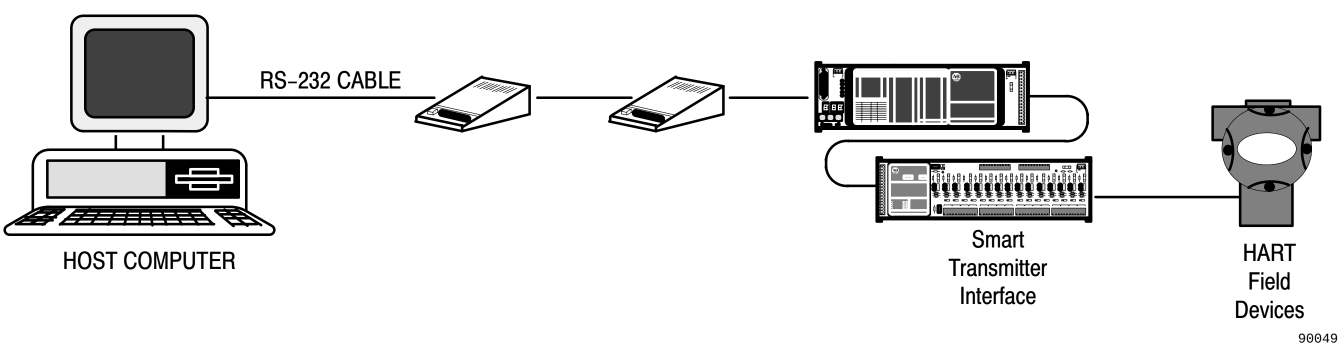


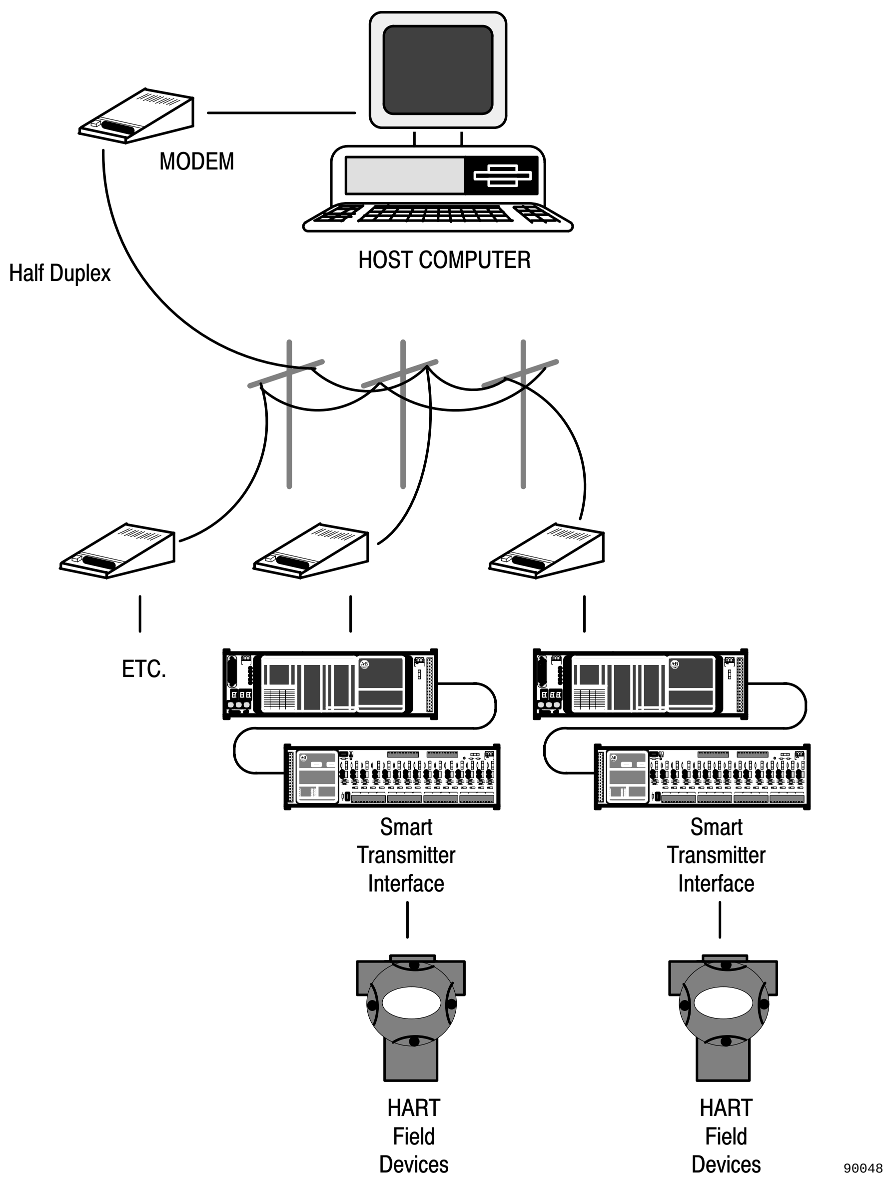
Figure 1.7
Full Duplex with Modems



Half Duplex Communications

DF1 half duplex systems can be considerably more extensive. The host computer can communicate via modems to a number of Smart Transmitter Interfaces spread out over great distances. Once again, though programmable controllers can certainly be a part of such a network, they are not required, and any host with third party software can be used with the Smart Transmitter Interface.

Figure 1.8
Half Duplex Communications with Modems

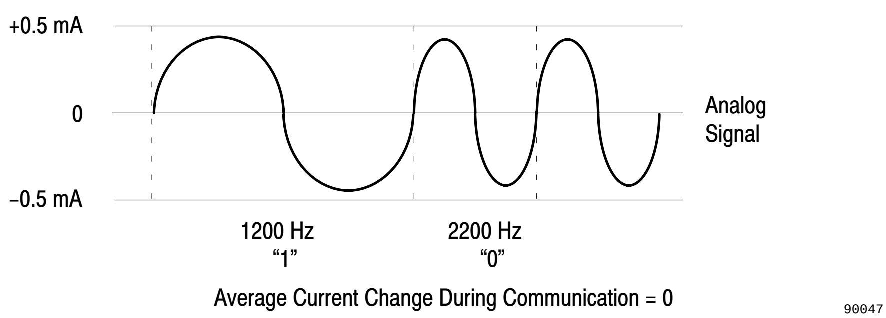


The HART Protocol

The HART field communications protocol carries digital information with the analog signal over industry-standard 4-20 mA process control loops. Both the digital and analog signals occur simultaneously on the same loop wiring without disrupting the process signal.

The HART protocol uses the Frequency Shift Keying technique, based on the Bell 202 communication standard. Digital communication is accomplished by superimposing a frequency signal over the 4-20 mA current, as shown in Figure 1.9. Two individual frequencies, 1200 and 2200 Hz, represent the digits 1 and 0. The sine wave formed by the two frequency levels has an average value of zero, so digital communication takes place without disruption to the analog signal.

Figure 1.9
Analog and Digital Signals on 4-20 mA Current



Field devices (transducers, actuators) can use the HART protocol to transmit or receive a process variable as a 4-20 mA analog signal at the same time as they are transmitting or receiving device or process data (e.g. smart pressure, temperature, density, etc.) as a modulated digital signal. The analog signal, with its faster update rate, can be used for control, while the digital signal can be used for diagnostic, maintenance and additional process data. Communication can be in either poll/response or burst transmission mode.

The HART protocol supports digital communication from both a control system and a hand-held communications device. It also allows multidrop networking by which several smart HART field devices can be connected to a single twisted-pair wire, and can operate over leased telephone lines.

The HART Protocol and the Smart Transmitter Interface

Each Communications Controller can communicate with a maximum of 32 channels via the 1770-HT8 and 1770-HT16 Terminal Blocks. As all channels are multiplexed, communications can only occur over one channel at a time. Each channel can have one HART field device connected to it in point-to-point mode, or up to 15 devices in a multidrop network. The host addresses these channels using channel numbers 0–31 (decimal).

The Communications Controller in the Smart Transmitter Interface receives HART protocol commands from the host processor (via Remote I/O or RS-232C connection) and routes these commands (via the Terminal Blocks) to the HART field devices. The Smart Transmitter Interface receives responses from the HART field devices and transmits the responses to the host when it polls for them.

In both multidrop and point-to-point networks each device has a unique address that is included in every HART message. A device picks up messages destined to it via this unique address.

When the Terminal Block receives the composite digital/analog signal from the HART field devices, it filters out the digital portion of the signal (see Appendix A for more information on the filtering circuitry), and passes the analog portion on to an Allen-Bradley Analog I/O module, such as the 1771-IFE. The Analog I/O module decodes the analog data and passes it along to the programmable controller.

At the same time, the Terminal Block reads the digital portion of the signal and multiplexes it to the Communications Controller. The Communications Controller embeds the digital data into messages conforming to the RIO or DF1 protocol format, and passes it to the appropriate host processor and its application program in one of three ways:

- to a programmable controller via the remote I/O link
- to a computer via the RS-232C port
- to a host on the Data Highway Plus network via the pass-through feature of an Allen-Bradley PLC-5 family programmable controller

Important: You cannot have more than one DH+ host computer using the pass-through feature or more than one RS-232C host.

Poll/Response Mode

The HART protocol supports two modes of digital communications, poll/response and burst. In poll/response mode the host processor requests information from (polls) the smart device. Both point-to-point and multidrop networks can employ this mode.

When the host processor sends a request or control information to the HART field devices, the Smart Transmitter Interface reads the routing information in the header portion of the data. It then strips the header off the message and sends the data down the appropriate channel to the HART device. Responses from the HART devices are returned to the host processor when the host polls for them.

If there are no more messages to be forwarded, the Smart Transmitter Interface stays on the last used channel and watches the traffic. This allows higher throughput if consecutive messages are sent to the same channel.

Burst Mode

In burst mode the HART field device continuously transmits digital data to the Communications Controller in burst monitor mode without the need for request messages from the host. This mode cannot be used with multidrop networks.

In burst monitor mode, the host processor sends the Smart Transmitter Interface a list of all the channels whose devices are preset to burst mode. If the list changes, the host must provide a new list. The Smart Transmitter Interface continuously monitors the channels on the list in order, returning to the first as soon as the last has been checked. The data collected from the burst channels is stored in a Burst Data table. The latest information on any channel is sent to the host processor upon request.

While in burst monitor mode, the Smart Transmitter Interface still responds to requests from the host to poll any channel. When the polling is complete, it resumes monitoring the burst channels.

Features of the Smart Transmitter Interface

The Smart Transmitter Interface (1770-HT1 and 1770-HT8/16) features include:

- remote I/O port for interface to programmable controllers (RIO scanners) and DH+ hosts
- RS-232C port for interface to serial hosts
- 7-segment display and push buttons for communications configuration

- clips for DIN rail mounting
- connections to 32 HART field devices in point-to-point configuration
- point to point and multidrop wiring support
- poll and response or burst digital transmission mode support
- connector for providing loop power
- interface to Analog I/O modules with 4-20 mA loop support
- 2 wire and 4 wire transmitters supported

Benefits of Using the Smart Transmitter Interface

The benefits of using the Smart Transmitter Interface to take advantage of the HART protocol include the following:

- extend programmable controller use in the process area by enabling Allen-Bradley PLCs to communicate with HART field devices, thus allowing process monitoring with ControlView or similar applications software

  Because of the added intelligence supplied by the HART field devices, and the wide range of accurate data available from such devices, (pressure, temperature, level, flow and density, among others), automated processes can be monitored accurately over considerable distances.

- reduce downtime and installation time through remote wiring verification, remote transmitter programming and simple retrofitting capabilities of HART field devices

  Many HART devices are “smart” enough to tell you what is wrong with them, and how they can be readjusted by remote programming. They can be, in effect, remote diagnostic tools, as well as remote repair units. Maintenance becomes simpler and less costly since you no longer need to send technicians out to the field to perform these tasks manually.

- add Smart device capabilities to existing analog systems while maintaining existing devices

  You can add the Smart Transmitter Interface to an existing 4-20 mA system without having to change the wiring, thus reducing installation time and expense. Digital capabilities can be gradually implemented, including digital process variables monitoring, without modifying field devices.

- perform configuration and diagnostics of HART field devices using third party software and the pass-through feature

Compatibility

The Smart Transmitter Interface Products create a communication interface between programmable controllers and HART field devices. (See Figure 1.10.)

The Smart Transmitter Interface is compatible with HART field devices and with hand-held terminals capable of supporting the physical and data link layers of the HART protocol.

Host computers can be any 100% PC compatible computers.

The following products have been tested in connection with the Smart Transmitter Interface:

PLC-5 Family

- PLC-5/11
- PLC-5/15
- PLC-5/20
- PLC-5/25
- PLC-5/30
- PLC-5/40
- PLC-5/60
- PLC-5/250

You can connect one or more Smart Transmitter Interfaces directly to a PLC-5 Remote I/O Port (in scanner mode) along with other I/O racks. In addition, the Smart Transmitter Interface can also be connected to other remote I/O scanner modules such as the 1771-SN I/O Subscanner module. For details about which programmable controllers support the pass-through feature, contact your A-B representative.

HART Field Devices

- ABB Kent Taylor K-SC
- ABB Kent Taylor K-ST

- Fischer & Porter 50XM1000B
- Micro Motion RFT9739
- Moore Products 340B
- Princo 50PL4610
- Rochester Instrument System SC-6500
- Rosemount 1151S
- Rosemount 3001C
- Rosemount 3001S
- Rosemount 3044C
- Rosemount 3051C
- Rosemount 8712C
- Rosemount 8800
- Rosemount 9712
- Rosemount Analytical 2054pH
- Smar LD301

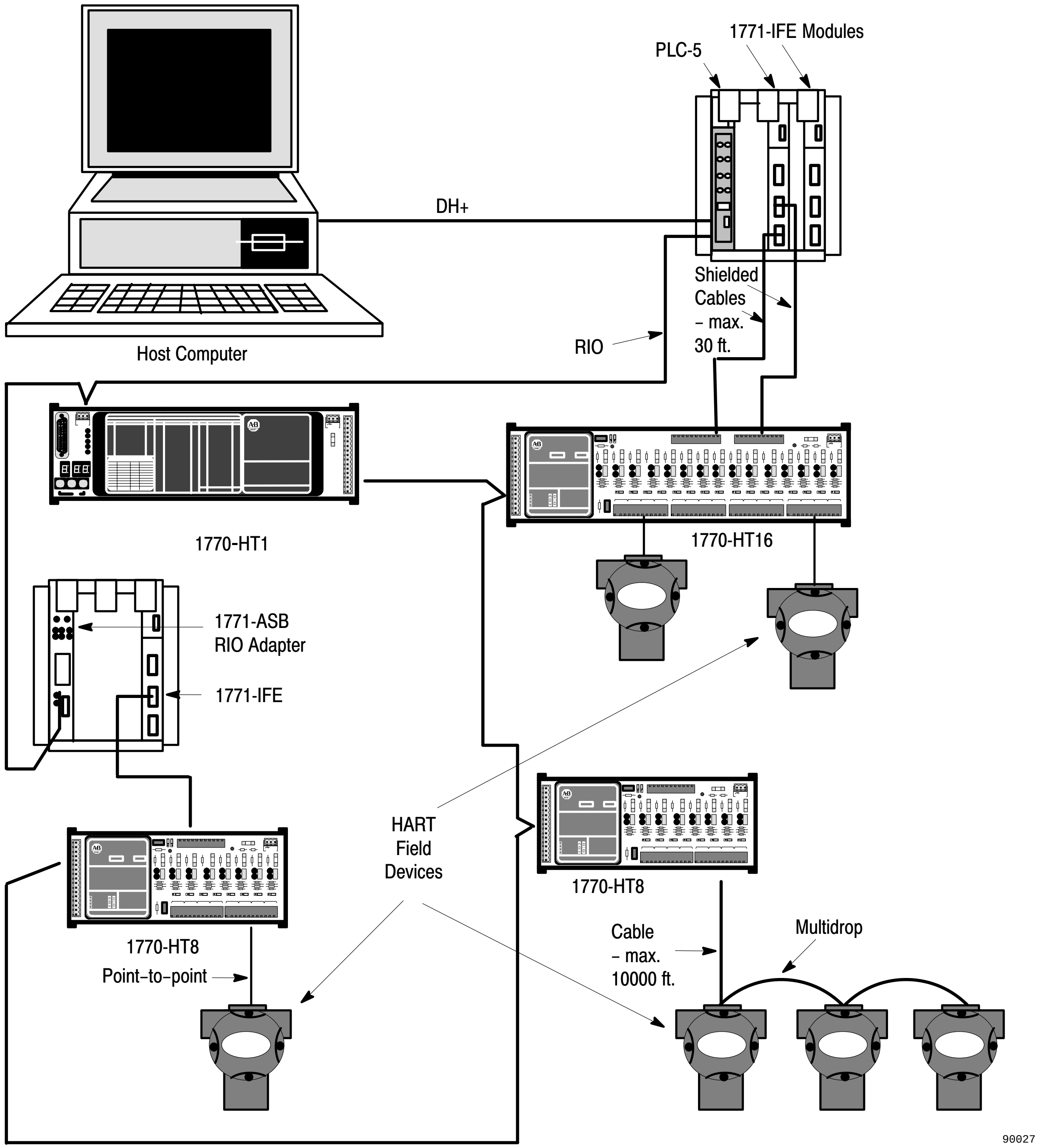
Analog I/O Devices

- 1771-IE05
- 1771-IF
- 1771-IFE

Hand Held Terminal

- Rosemount Model 268 Smart Family Interface

Figure 1.10
A Typical Network



Chapter 2

Installing the Smart Transmitter Interface Products

This chapter explains how to install the Smart Transmitter Interface products. It includes the following information:

- an overview of the general installation procedure
- how to connect the Communications Controller and Terminal Blocks to each other so they can communicate
- how to connect Terminal Blocks to Analog I/O and HART field devices
- system grounding requirements
- power supply requirements and connections for the Communications Controller and Terminal Blocks
- how to provide power for HART field devices through the Terminal Blocks
- how to connect the Communications Controller to the host processor

Before You Begin

Before installing the Smart Transmitter Interface you should:

- determine where the Communications Controller and Terminal Blocks are to be placed

  The Terminal Blocks should be mounted in the same equipment cabinet as the Analog I/O modules to which they are to be connected. The distance between a given Terminal block and its HART field devices must conform to the HART Protocol specifications and meet the requirements in Appendix C.

- review your setup to ensure that the maximum cable length between the Communications Controller and the Terminal Blocks is not exceeded. See the section *Connecting the Communications Controller to the Terminal Blocks* for details.
- calculate the power requirements of the Communications Controller (1770-HT1), the Terminal Blocks (1770-HT8/16) and the HART field devices

Electrostatic Damage

Electrostatic discharge can damage semiconductor devices inside the Smart Transmitter Interface products. To guard against electrostatic damage, observe the following precautions:

- wear an approved wrist strap grounding device, or touch a grounded object to rid yourself of electrostatic charge before handling the products
- keep the products in their static-shield bags when not in use

Overview of the Installation Procedure

The general procedure for installing the Smart Transmitter Interface products is as follows:

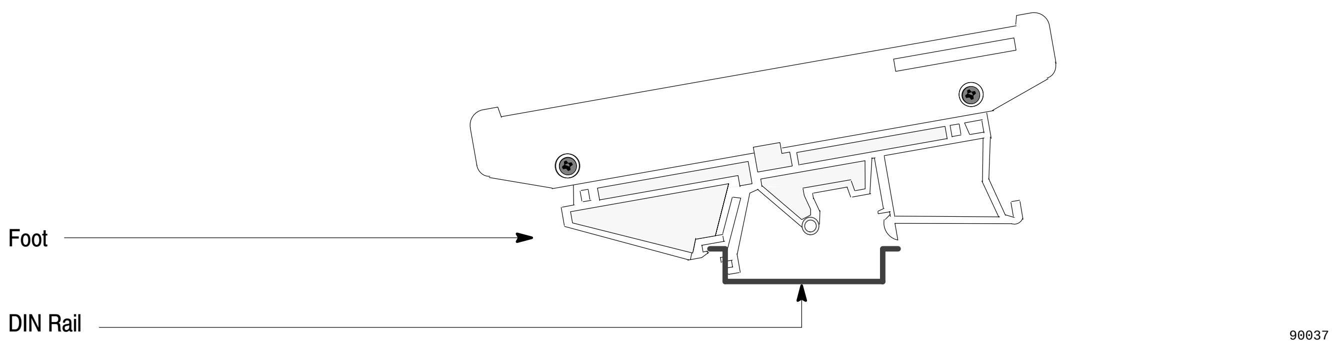
1. Mount the Communications Controller and the Terminal Blocks in their appropriate equipment cabinet (or cabinets).
2. Connect the Communications Controller to the Terminal Blocks and set the board address jumpers on the Terminal Blocks.
3. Connect the Terminal Blocks to I/O modules (1771 I/O devices) and HART field devices.
4. Establish the necessary ground connections.
5. Connect the Communications Controller and Terminal Blocks to a power supply.
6. Configure the communications parameters on the Communications Controller as detailed in Chapter 3.
7. Connect the Communications Controller to the host through the RIO or RS-232C port.

Mounting Smart Transmitter Interface Products in a Cabinet

Mount the Terminal Blocks in the same equipment cabinet as the Analog I/O modules to which they will be connected. This ensures the integrity of the 4-20 mA analog signal being received by the Analog I/O module.

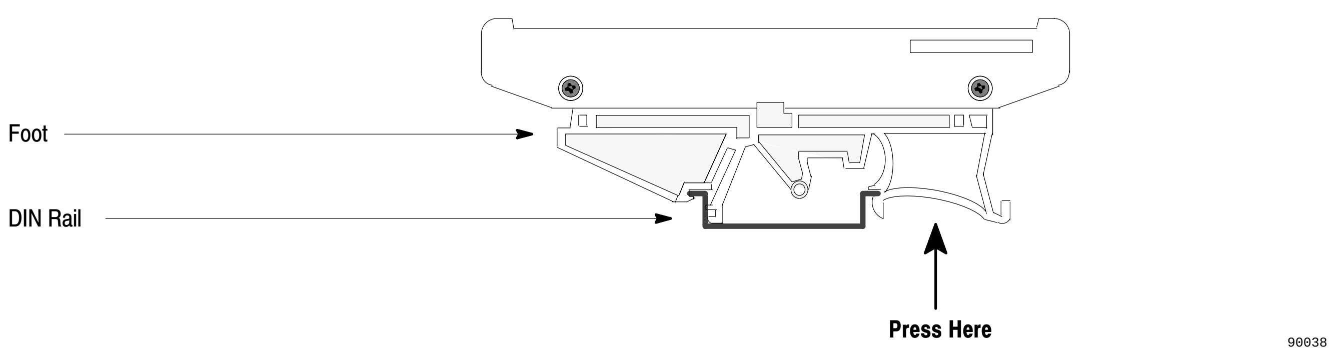
Each unit of the Smart Transmitter Interface is equipped with two plastic feet designed to attach to an EN 50 022 or EN 50 035 DIN rail. Using these feet, clip the unit(s) to the DIN rail in the desired position (Figure 2.1). The units can be mounted in any orientation—horizontally, vertically, diagonally, etc.

Figure 2.1
Mounting on a DIN Rail



To release the feet from the rail, press on the plastic as shown in Figure 2.2 so that the clip is pulled back far enough to release the unit.

Figure 2.2
Releasing From a DIN Rail



Connecting the Communications Controller to the Terminal Blocks

The Communications Controller can support a maximum of 32 HART channels via the Terminal Blocks. Use any of the following combinations:

- one or two 16 Channel Terminal Blocks (1770-HT16)
- one, two, three or four 8 Channel Terminal Blocks (1770-HT8)
- one 16 Channel Terminal Block and one or two 8 Channel Terminal Blocks

Digital Communications Cables

The connecting cables should be shielded multi-conductor cables with 8 twisted 20-24 AWG wire pairs. These are not supplied with the Smart Transmitter Interface. Belden #9508 (24 gauge) or # 85168 cable (20 gauge) or equivalent is recommended. Line 1 is shield, line 2 power and lines 3 to 17 are control.

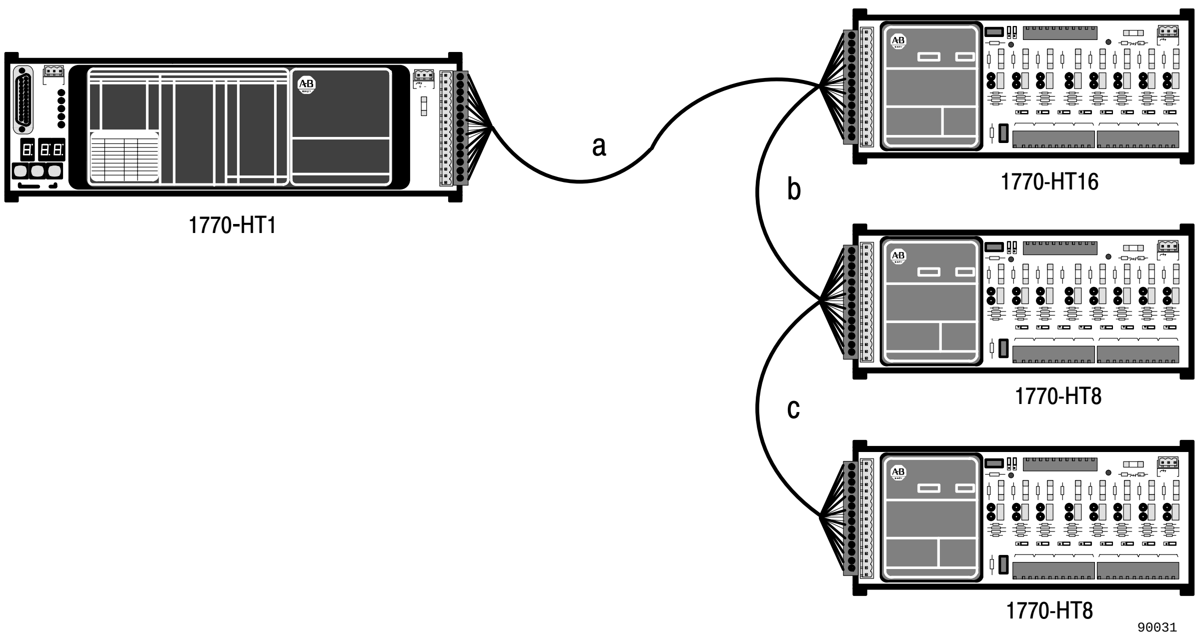
The connections between the Communications Controller and the Terminal Blocks can be either a linear or star topography. You can use any combination of linear/star connections as long as you adhere to the cabling length requirements.

If your particular setup requires cable lengths greater than the ones indicated in Figure 2.3 to Figure 2.5 or is substantially different, refer to Appendix C.

Linear Connection

For linear connection the cables go from the 17 pin connector on the Communications Controller to the connector on the first Terminal Block. Another cable of the same kind leads from the connector on the first Terminal Block to the connector on the second Terminal Block, from there to the connector on the third Terminal Block, and so on.

Figure 2.3
Example 1: Linear Connection



Example 1 assumes that the modules (HT1, HT16 and two HT8's) are installed in separate cabinets. The maximum cable lengths allowed for the setup shown in this example are given in the table below.

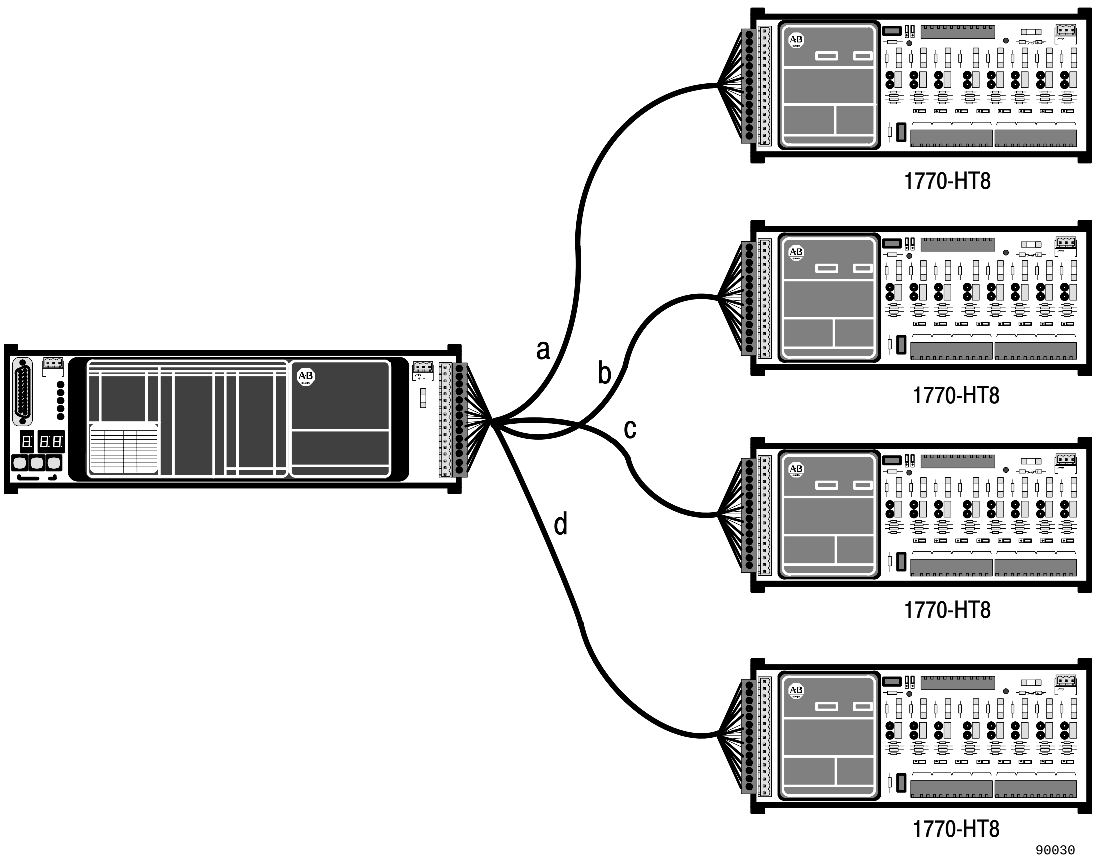
Cable Size	Cable a	Cable b	Cable c
Belden # 85168	250 ft	250 ft	250 ft

If you are using a linear arrangement, the connector at the Communications Controller will have one set of 17 wires leading out of it. The connector at each Terminal Block (except the last one) will have two sets of wires in the same holes: the one coming from the previous connection, (either the Communications Controller or the previous Terminal Block), and the one leading to the next Terminal Block.

Star Connection

For star connection the cables to each Terminal Block lead to the connector on the Communications Controller directly. If you are using a star arrangement, the connector at the Communications Controller will have as many sets of wires leading into it as there are Terminal Blocks. The connector at each Terminal Block will have only one set of wires, leading directly back to the Communications Controller.

Figure 2.4
Example 2: Star Connection



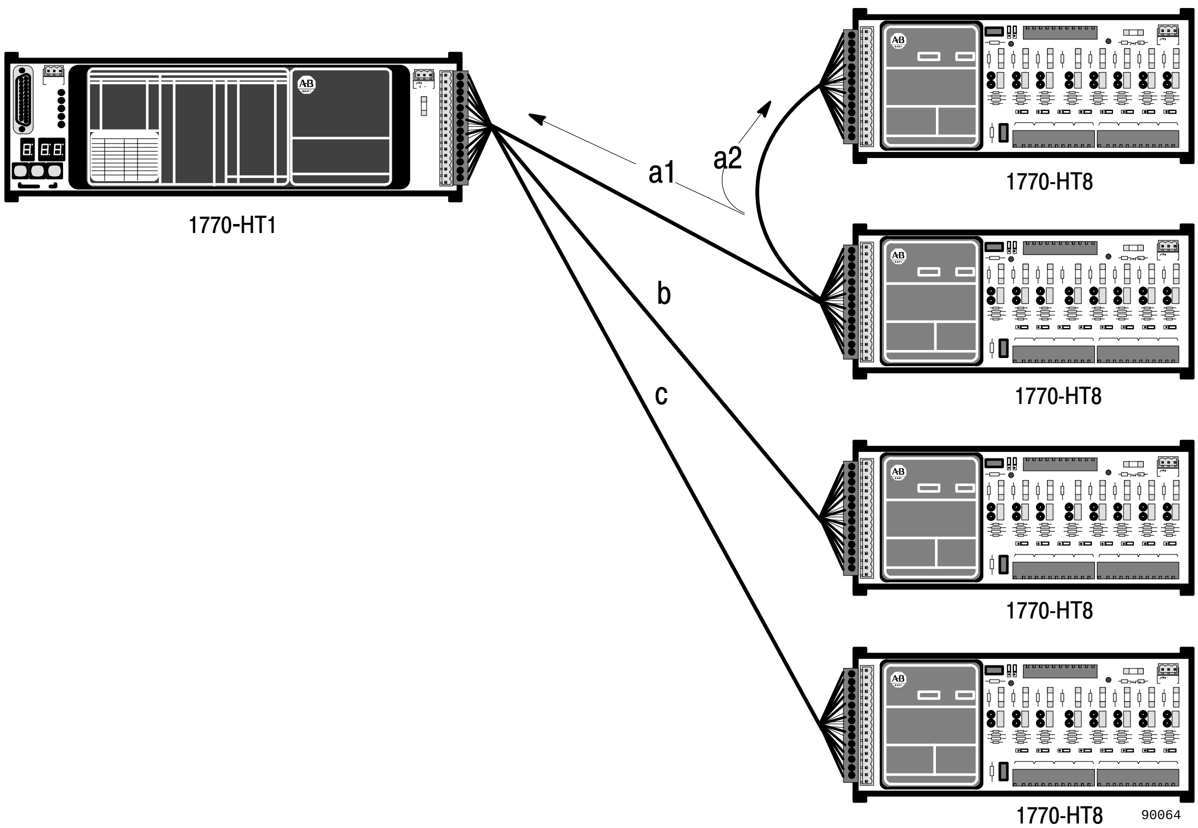
Example 2 assumes that the modules (HT1, and four HT8's) are installed in separate cabinets. The table below gives one example of possible cable lengths.

Cable Size	Cable a	Cable b	Cable c	Cable d
Belden #85168	250 ft	250 ft	250 ft	250 ft

Star/Linear Connection

Example 3 shows a setup where a combination of star and linear connections are used. In this example, two HT8's are joined in a linear connection by cable **a** (a1 and a2) and the other two HT8's are joined to the HT1 in a star connection by cables **b** and **c**.

Figure 2.5
Example 3: Star/linear Connection



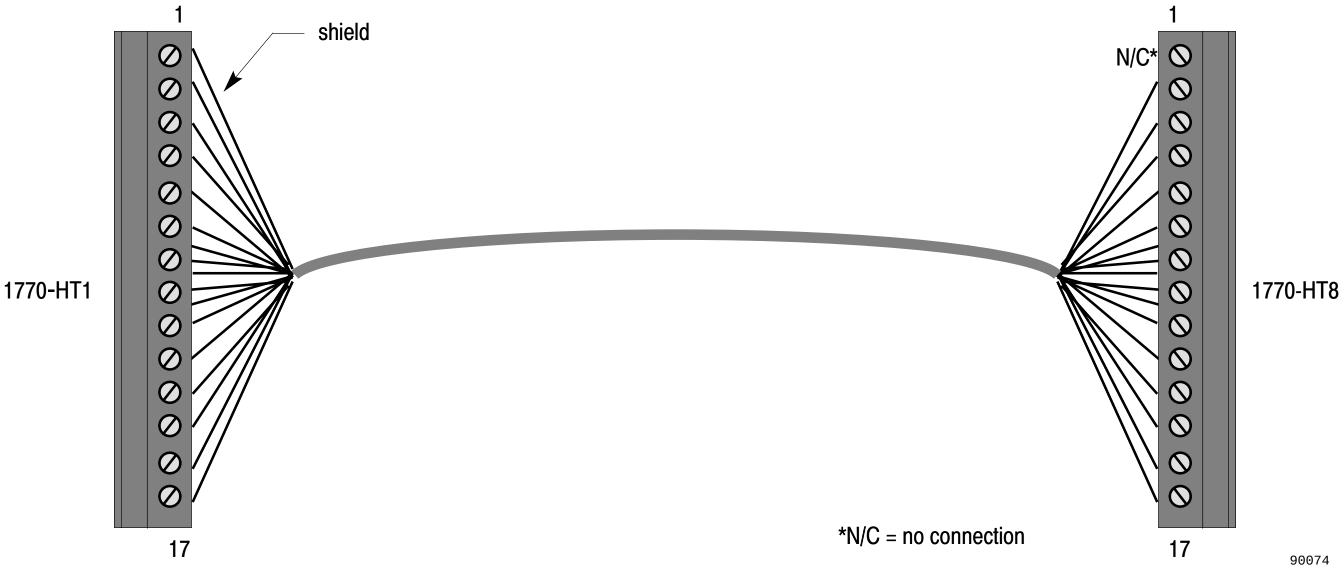
Cable Size	Cable a1	Cable a2	Cable b	Cable c
Belden #85168	250 ft	200 ft	200 ft	100 ft

Connector and Pinout

Attach the 17 position Phoenix COMBICON plugs (supplied) to each end of the cable (see Figure 2.6) then plug them into the units. Use the bare wire for chassis ground (to be connected at one end only, preferably to the Communications Controller end). Use only one twisted pair for each ± pair of signals. The colors in the table below are intended as examples only. You can use any pair you like for any pair of signals. The pinout for the connector is in the table below.

Signal	Pin	Examples of Colors
Chassis Ground	1 (Shield)	Bare Silver
+24 VDC	2 (Power)	Red and White twisted pair; Red is VDC, White is Ground (see Appendix C)
Signal Ground	3 (Control)	
+ Transmit Enable	4 (Control)	Red and Black twisted pair; Red is +, Black is –
– Transmit Enable	5 (Control)	
+ Channel Select 1	6 (Control)	Blue and Black twisted pair Blue is +, Black is –
– Channel Select 1	7 (Control)	
+ Channel Select 2	8 (Control)	White and Black twisted pair; White is +, Black is –
– Channel Select 2	9 (Control)	
+ Channel Select 3	10 (Control)	Orange and Black twisted pair; Orange is +, Black is –
– Channel Select 3	11 (Control)	
+ Channel Select 4	12 (Control)	Brown and Black twisted pair; Brown is +, Black is –
– Channel Select 4	13 (Control)	
+ Channel Select 5	14 (Control)	Green and Black twisted pair; Green is +, Black is –
– Channel Select 5	15 (Control)	
+ HART Tx/Rx	16 (Control)	Yellow and Black twisted pair; Yellow is +, Black is –
– HART Tx/Rx	17 (Control)	

Figure 2.6
Attaching Plugs to the Digital Communications Cable



Setting the Board Address Jumpers

The Communications Controller can handle up to 32 HART channels via the Terminal Blocks. However, since the 32 channels can be divided among as many as four separate terminal blocks, the Communications Controller needs to know where one Terminal Block ends and the next begins. That is, it needs to know which of the 32 channels belong to which individual Terminal Block, and whether it is an 8 or a 16 channel block.

Each Terminal Block has a set of board address jumpers located just to the right of the black cover near the top edge of the board (see Figure 1.2 and Figure 1.3). To set a jumper block, lift the black jumper off the pins it is currently on, re-position it, then push into place. (See Figure 2.7.) Set the board address jumpers as shown in Figure 2.8.

Figure 2.7
Jumper and Pins

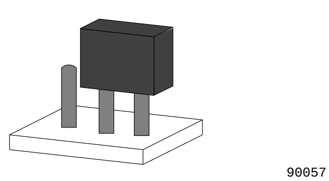


Figure 2.8
Terminal Block Board Address Jumpers

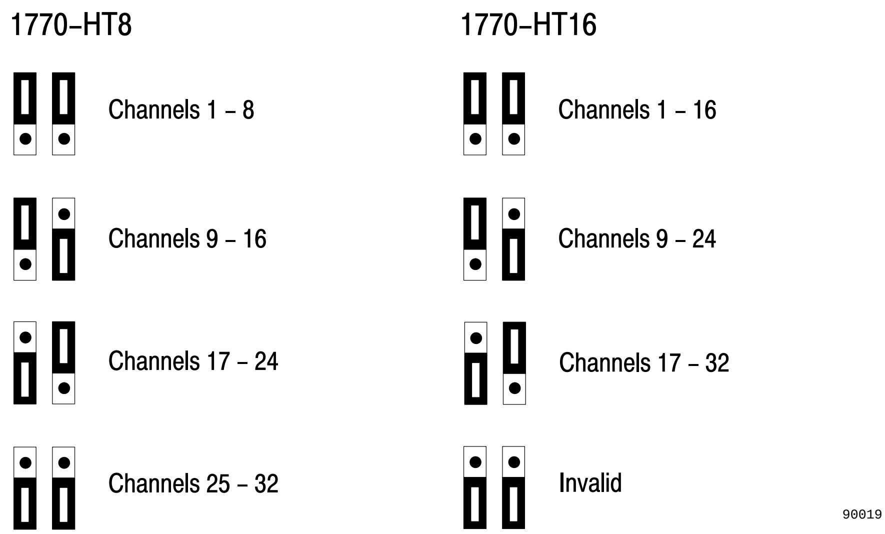
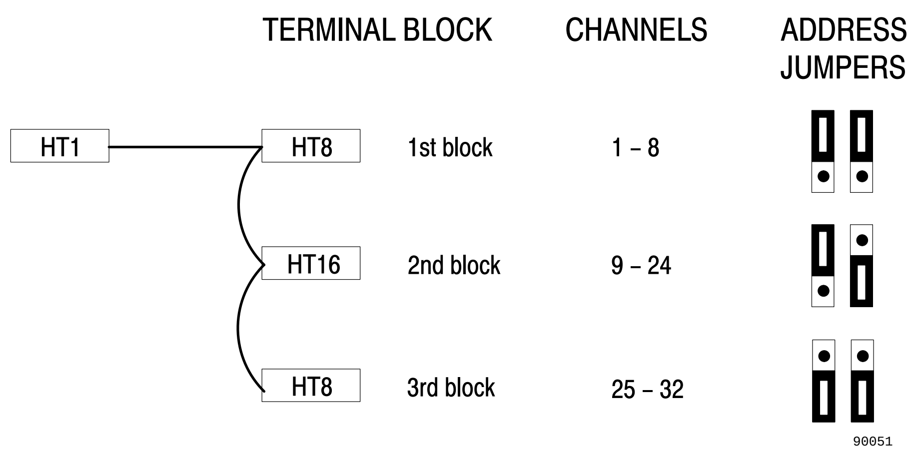


Figure 2.9
Example Terminal Block Channel Setup



Marking the Terminal Block Labels

On the label on top of each Terminal Block is a place in the lower left hand corner to record how you have configured the board address jumpers. The jumper address configuration options for the unit are listed (3 options for the 16 channel block and 4 for the eight channel block). Mark the box to indicate which configuration you have used for this Terminal Block. (See Figure 1.2 and 1.3.) Use a pencil so you can erase the marking if you change the configuration.

Connecting the Terminal Blocks to I/O and HART Field Devices

As shown in Figure 1.10, a Terminal Block can be connected to Analog I/O devices such as the 1771 IFE module, and to HART field devices. In addition, a hand held terminal can be connected to the Terminal Block for communication with HART field devices.

Connecting to 1771 I/O Devices

Attach the wires from the 1771 Analog I/O devices to the 10 position Phoenix COMBICON plugs supplied with the Terminal Block. Insert the plug(s) into the 10 position Phoenix COMBICON connectors on the upper edge of the Terminal Block (see Figure 2.10). The 1771-HT8 has one connector; the 1771-HT16 has two. Figure 2.11 shows a 1771-IFE connected to a Terminal Block. The cable between them must be no longer than 30 feet. Single ended Analog I/O devices are recommended.

Figure 2.10
Connecting the Terminal Block to an Analog I/O Module

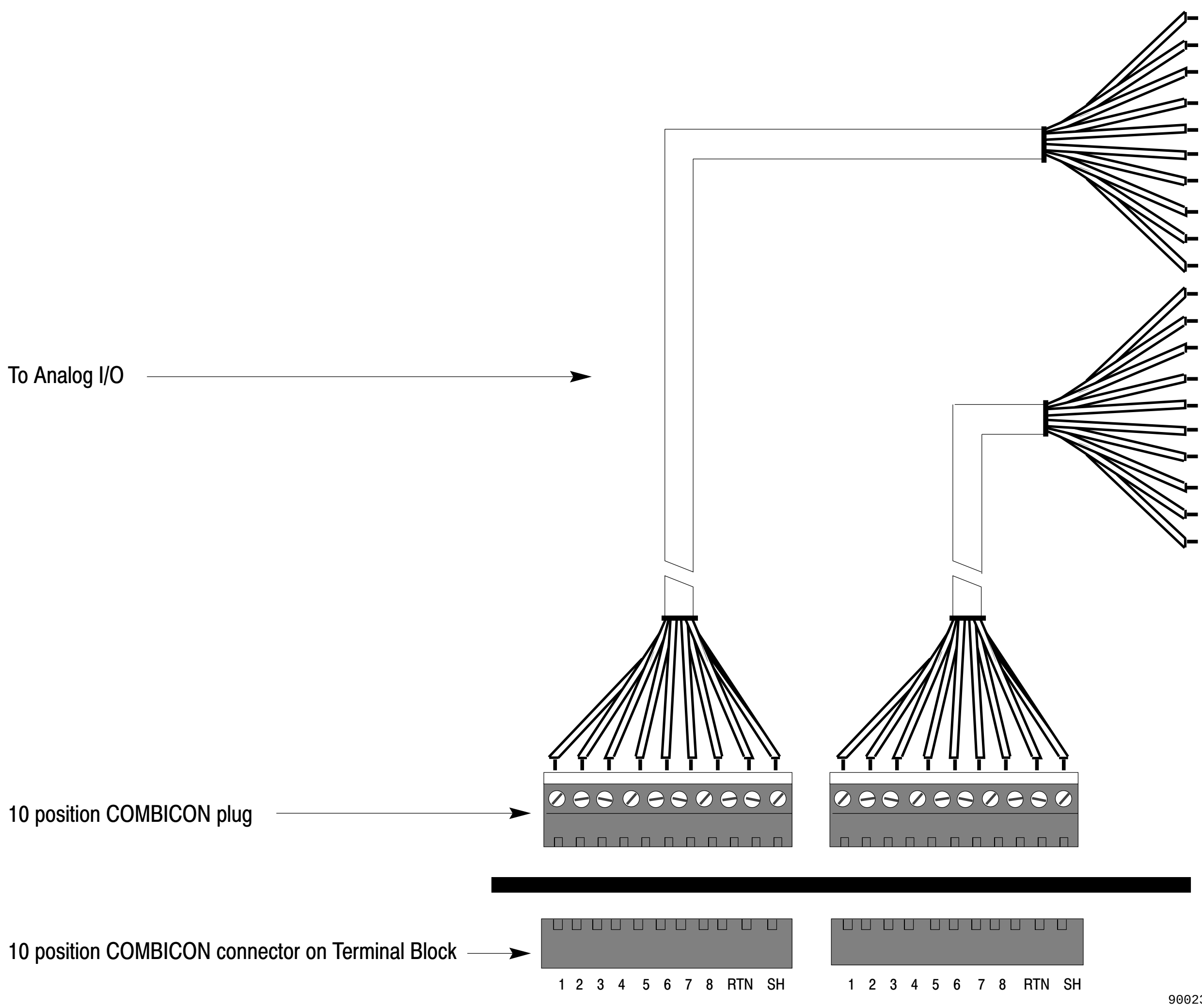
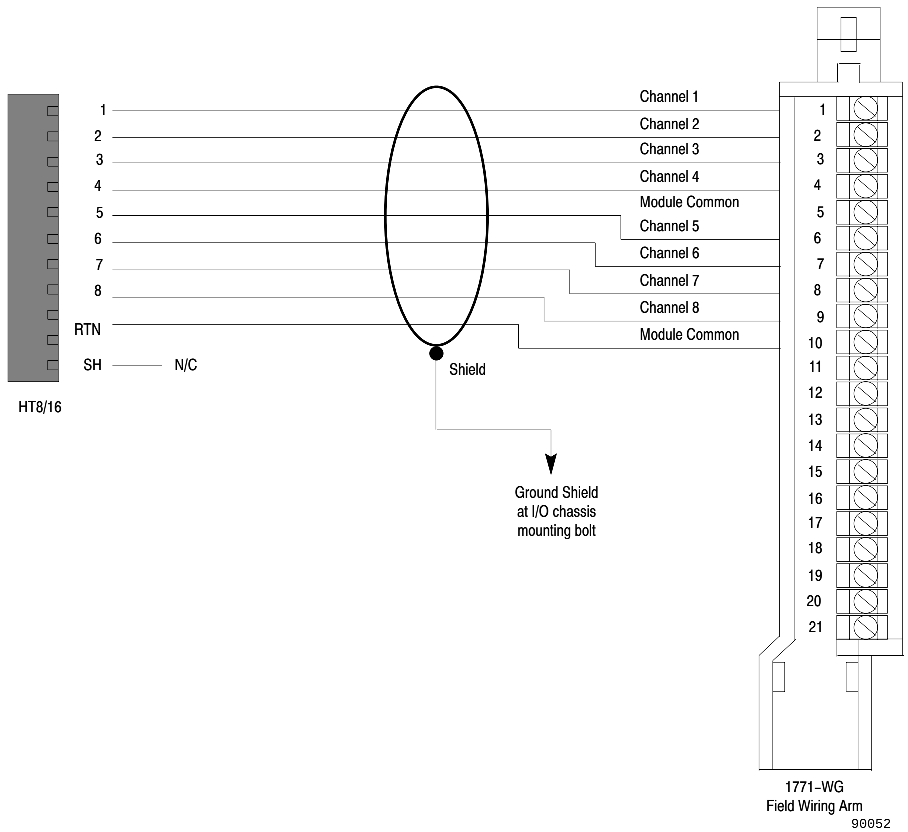


Figure 2.11
1771-IFE Connection Example

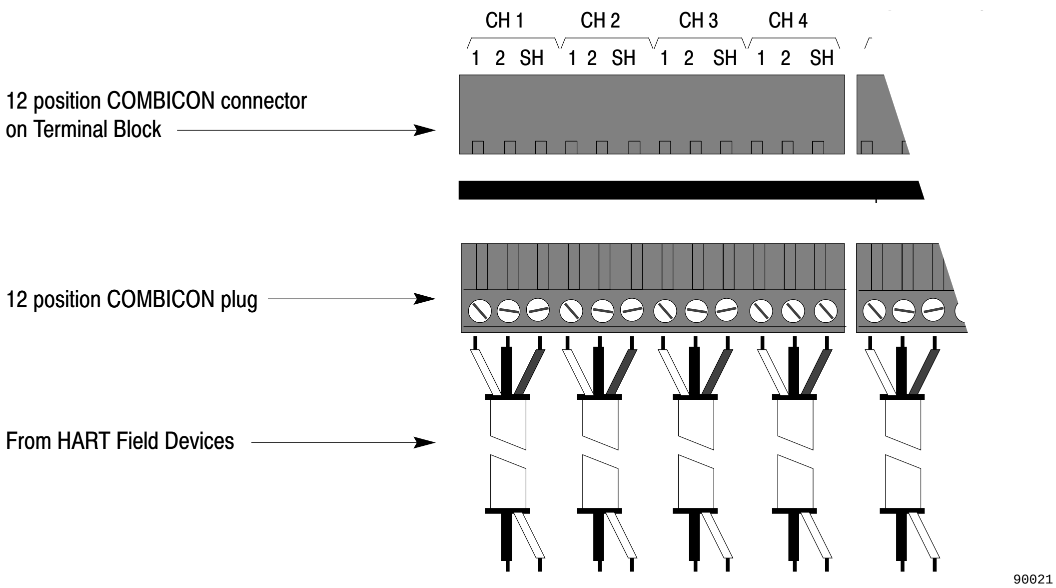


Connecting to HART Field Devices

To connect a HART field device to a Terminal Block attach the wires from the HART field device to a 12 position Phoenix COMBICON plug supplied with the Terminal Block. Insert the plug into the 12 position Phoenix COMBICON connector on the lower edge of the Terminal Block (see Figure 2.12). The 1770-HT8 has two of these connectors; the 1770-HT16 has four. HART field devices can be connected to the Terminal Block in either a point-to-point or multidrop connection.

For 2-wire transmitters connect the positive (+) terminal of the transmitter to position 2 on the Terminal Block, and the negative (–) terminal of the transmitter to position 1 on the Terminal Block. For 4-wire transmitters connect the positive terminal on the transmitter to position 1 on the Terminal Block and the negative terminal on the transmitter to position 2 on the Terminal Block.

Figure 2.12
Connecting HART Field Devices to the Terminal Block



Point-to-point Connection

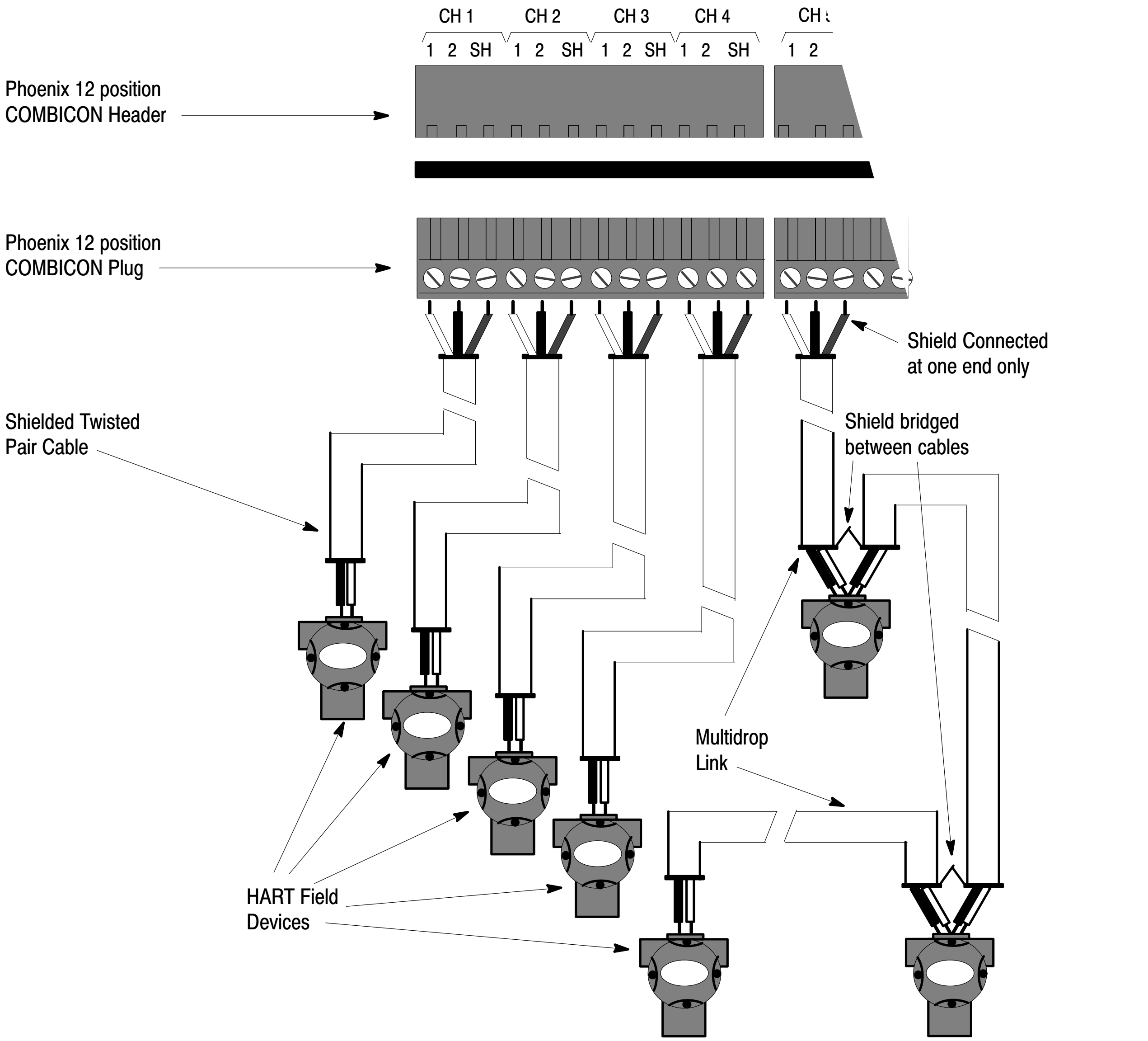
A point-to-point connection exists when only one HART field device is connected to any particular Terminal Block channel. This arrangement allows the transmission of both analog and digital data to and from the HART field device.

Multidrop Connection

A maximum of 15 HART field devices can be connected to each channel on the Terminal Block in a multidrop network. A multidrop connection supplies only digital data through the Terminal Block. See Figure 1.10 and Figure 2.13 for illustrations of both point-to-point and multidrop connections.

Any channel on the Terminal Block can be used for either point-to-point or multidrop networking, and the same Terminal Block can support both at the same time without any special settings or configuration of the hardware.

Figure 2.13
Point-to-point and Multidrop Connections



Connecting a Hand Held Terminal

Because the HART protocol supports up to two digital communication masters at one time, you can use a hand-held terminal to communicate with the HART field devices without disrupting their connection to the Terminal Blocks.

To do this, attach the clips of your hand held terminal to either end of the resistor on the Terminal Block that corresponds to the channel to which you wish to connect. (See Figure 2.14.) igure 2.15 and Figure 2.16 show the channels and their corresponding resistors.

Figure 2.14
Connecting the Hand Held Terminal

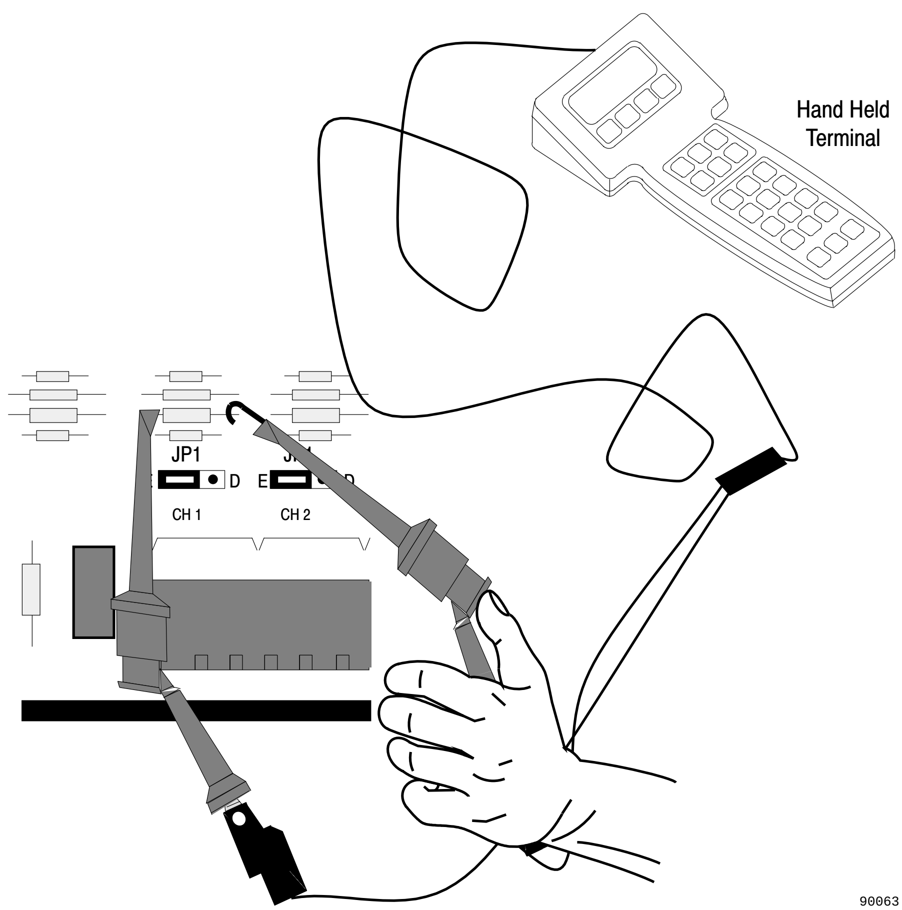


Figure 2.15
HT8 Terminal Block Channels and Corresponding Resistors

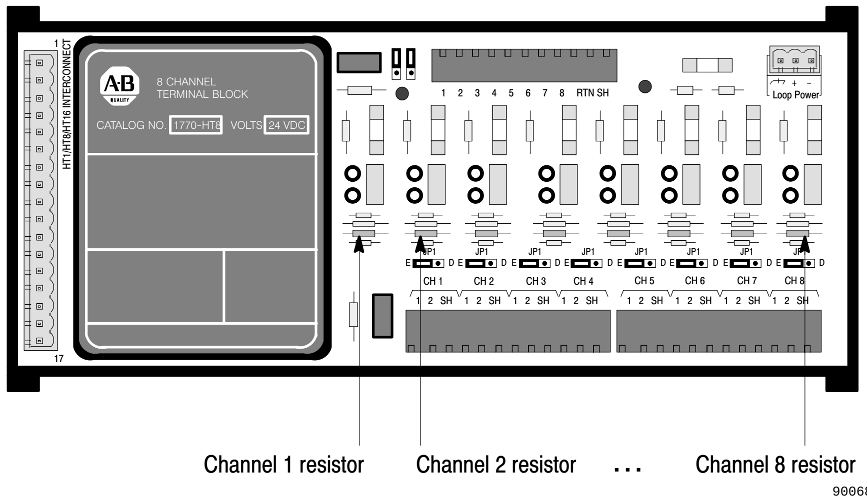
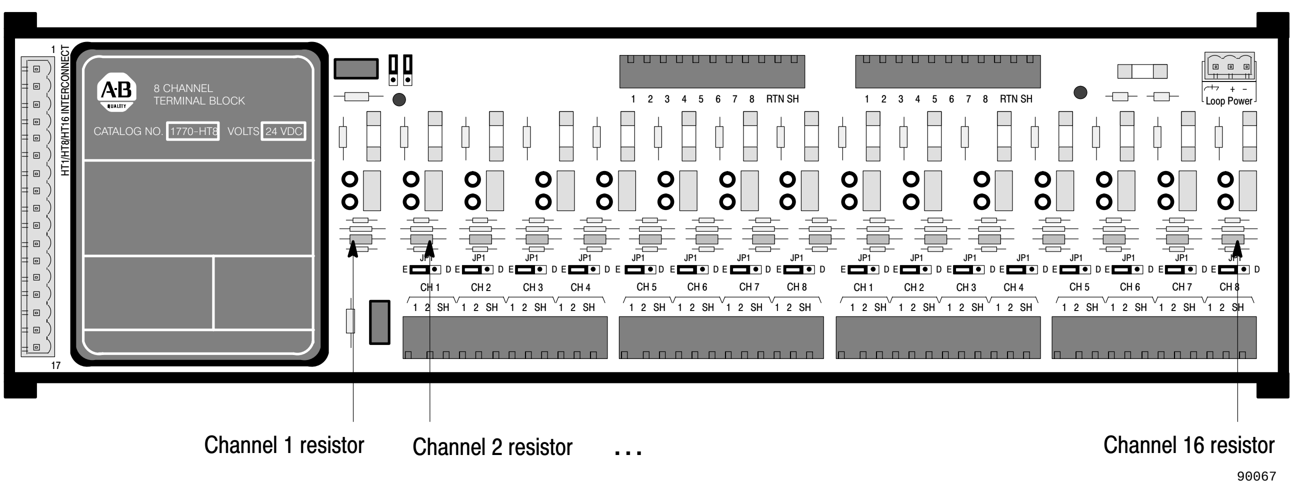


Figure 2.16
HT16 Terminal Block Channels and Corresponding Resistors



Grounding

Grounding the Communications Controller and Terminal Block Chassis

Because the Communications Controller and the Terminal Blocks can be as far as 1000 feet apart it is best to ground each unit locally. To ground the Communications Controller, connect a wire from the Earth Ground terminal of its 3 position COMBICON power connector (see Figure 2.18) to the local ground bus.

Ground each Terminal Block in the same way and insert the plug in the power connection header for loop power (see Figure 2.19). Each Terminal Block must be grounded in this way regardless of whether or not it is to provide 4-20 mA loop power for HART field devices.

Grounding the HART Field Device Cable Shield

Connectors to the HART field devices on the Terminal Blocks are internally grounded to the power connector. Once the power connector is properly grounded, these connectors are also properly grounded.

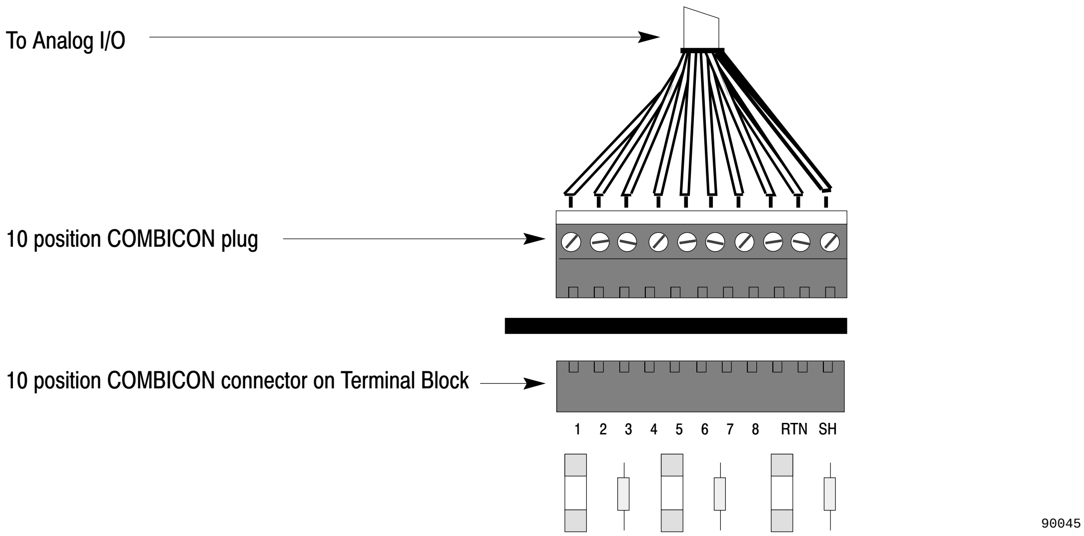
Grounding the Analog I/O Cable Shield

Important: The shield connection in the cable between the Terminal Blocks and the Analog I/O modules must be grounded at one end only. The cable must not be more than 30 feet long.

If the Analog I/O module is a 1771-IFE module, ground the shield connection to the chassis of the 1771-IFE as shown in the documentation for that module. Do not ground the shield to the Terminal Block connector.

If the Analog I/O module is of another kind, and grounding at that end is not feasible, you must first connect the cable's shield wire to the position on the Terminal Block plug marked SH for Shield (see Figure 2.17).

Figure 2.17
Grounding Analog I/O



Supplying Power to the Communications Controller and Terminal Blocks

The Communications Controller requires an external 24 VDC power supply with ± 1% voltage regulation. The power supply must provide the Communications Controller with 200 mA of current. It must also provide an additional 100 mA of current for each Terminal Block that is connected to the Communications Controller. For example, the setup in Figure 2.3 requires a 24 VDC power supply that can provide at least 500 mA. Please refer to Appendix C if your cable length requirement exceeds those shown in Figure 2.3 to Figure 2.5. For recommended power supplies see Appendix C, Table C.A.

Fuses for the Communications Controller

Overload protection for external power is provided by a 1 Amp user-replaceable fuse located immediately below the power connector on the Communications Controller. The fuse is UL 198G and CSA 22.2, No. 59 rated, 5mm x 20mm, 250V fast acting.

Connecting Power to the Communications Controller

To connect the power supply to the Communications Controller:

1. Turn the power supply off.

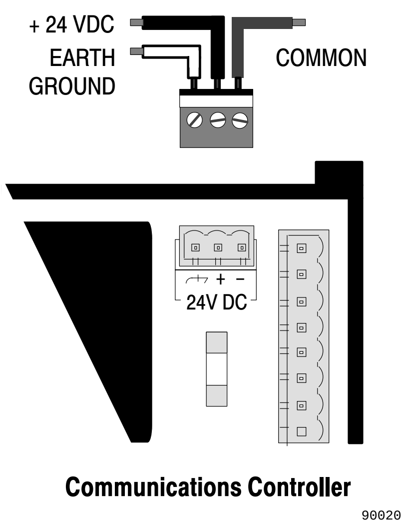
2. Attach the 3 position Phoenix COMBICON plug (supplied) to the output cable of the power supply.

3. Insert the plug into the power connection header on the upper right corner of the Communications Controller (Figure 2.18).

4. Turn the power supply on.

Important: Be sure to turn the power off while connecting the cables.

Figure 2.18
Connecting the Power Supply to the Communications Controller



Supplying Loop Power for HART Field Devices

HART field devices are of two types:

- those that draw power from the 4–20 mA loop (2 wire transmitters)
- those that require an external power supply (4 wire transmitters)

The HT8/16 Terminal Blocks support both types, and they can be mixed on the same Terminal Block. Each channel on the Terminal Block has a jumper block associated with it, JPn. The ‘n’ is the number of the channel (1 to 8 or 1 to 16). This jumper block indicates the type of HART transmitter connected to the channel in question.

If a HART field device is a four wire transmitter it must be connected to its own external power supply and the jumper on the Terminal Block for the channel in question set to D (disable).

If a HART field device is a two wire transmitter it can be powered through the Transmitter Block. This requires that the Terminal Block be connected to an external power supply by the power connection header in the upper right corner of the block. See Figure 2.19. The jumper on the Terminal Block for the channel must be set to E (enable).

Set Jumper JP to this position	For this type of HART transmitter
D (Disable loop supply)	External power supply
E (Enable loop supply)	Power drawn from the 4-20 mA loop

Power Supply Requirements

The external power supply required to power the HART field devices may be from 24 to 32 VDC. The exact power supply needed depends on the type of HART field device and the length and gauge of the cable connecting it to the Terminal Block. For example, a 24 VDC ± 0.1% power supply with a 1 Ampere output would be adequate to supply loop power to 32 Rosemount 3051C or 3044C field devices over a 20 gauge, or larger, cable with a length of 1000 feet or less. See Appendix C for further details.

Fuses for the Terminal Blocks

One fuse on the Terminal Block (either the 1770-HT8 or 1770-HT16) is for the external power supply providing loop power to HART field devices through the Terminal Block. It is located immediately to the left of the power connector. The 1770-HT8 requires a 0.25 Amp fuse and the 1770-HT16 requires a 0.5 Amp fuse. Both fuses should be UL 198G and CSA 22.2, No. 59 rated, 5mm x 20mm, 250V fast acting.

Connecting the Power Supply for Loop Power

To connect the power supply to the Terminal Block.

1. Turn the power supply off.

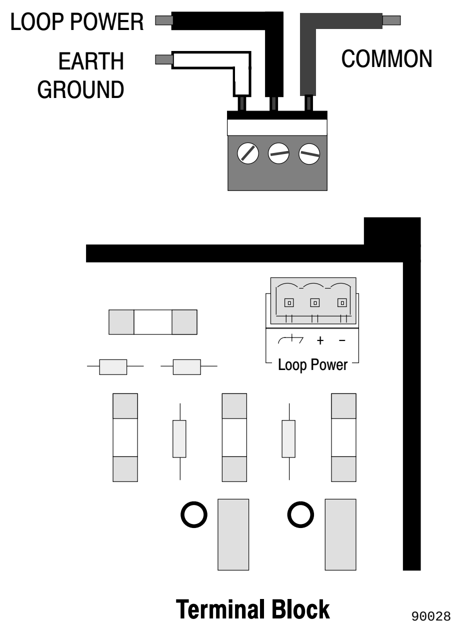
2. Attach the 3 position Phoenix COMBICON plug supplied with the product to the output cable of the power supply.

3. Insert the plug into the power connection header on the upper right corner of the Terminal Block (Figure 2.19).

4. Turn the power supply on.

Important: The loop power and ground common wires are only needed if the HART field devices connected to the Terminal Blocks draw power from the 4-20 mA current loop instead of from their own individual power supplies. The earth ground wire is needed, whether or not loop power is being supplied.

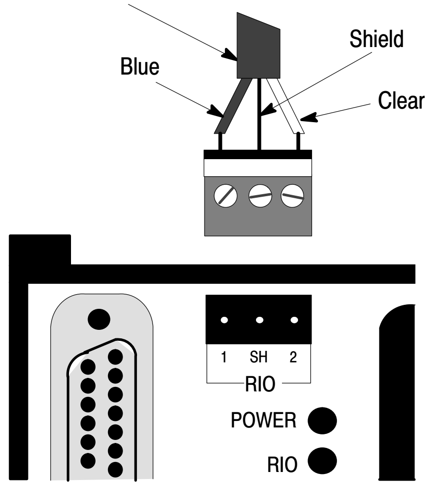
Figure 2.19
Connecting an External Power Supply to a Terminal Block for Loop Power to HART Field Devices



Connecting the Communications Controller to the RIO Host

The RIO connector is a 3 position Phoenix COMBICON connector located at the left end of the unit, just to the right of the DB-25 connector, at the top edge of the board (see Figure 2.20). Attach the matching plug (supplied with the Communications Controller) to the RIO cable. Insert the plug into the connector to make the RIO connection.

Figure 2.20
RIO Connector



The pinout is:

Signal	Label	Cable
A1	1	Blue wire
A2	SH	Shield
A3	2	Clear wire

Use Twinaxial Cable (1770-CD) for the RIO connections. Maximum length for the cable depends on the baud rate:

For this baud rate:	Maximum cable length is:
57600	10,000 feet (3,048 m)
115200	5,000 feet (1,524 m)
230400	2,500 feet (762 m)

Termination

Terminate the farthest physical nodes on the RIO link with a 150 or 82 Ohm termination resistor. If the Communications Controller is the last device on the RIO link, connect a 1/2 watt resistor across pins 1 and 2 of the plug. The value of the resistor depends on the Remote I/O baud rate:

For this baud rate:	Use this terminating resistor:	Allen-Bradley Part Number
57600	150Ω	#740018-29
115200	150Ω	#740018-29
230400	82Ω	#740018-23

Activity Indicator

If the RIO LED is:	The RIO link is:
Off	Inactive
On	Active, normal communication is in progress
Flickering	Communications established, but not active

Connecting the Communications Controller to the RS-232C Host

A single, full or half duplex, RS-232C serial port using the DF1 protocol provides communications with the host processor. This connector is located at the left end of the Communications Controller (see Figure 1.1). The 1770-HT1 is configured as a DTE (Data Terminal Equipment).

RS-232C Baud Rates

Baud rates supported are 300, 600, 1200, 2400, 4800, 9600 and 19200.

Cables

Cabling for the RS-232C connector of the Communications Controller will vary depending on your application.

Use Belden #8723 (or equivalent) cable to construct a cable to connect the Communications Controller to a computer.

Important: The length must not exceed 50 feet, and the cable shield must be connected to chassis ground (using Pin 1) at the Communications Controller end only. If the length required exceeds 50 feet, a modem or line driver must be used. In addition, if multiple Communications Controllers are connected to the host processor modems must be used to isolate the signals.

Activity Indicator

The green LED RS-232 indicator, located to the upper left of the black cover on the 1770-HT1 (see Figure 1.1), flickers when the Communications Controller is receiving data over the RS-232C interface.

Connector and Pinout

The RS-232C interface connector at the Communications Controller end is a DB-25 male connector with the following EIA (Electronics Industries Association) pinout.

Table 2.A
RS-232C Connector Pinouts

Signal	Abbreviation	I/O	Direction	Pin Number	Meaning
Chassis Ground		N/A	–	1	The cable shield must be connected to chassis ground at one end only. It is recommended that you do this at the Communications Controller end.
Transmit Data	TXD	O	Output	2	RS-232C serialized data output from the Communications Controller.
Receive Data	RXD	I	Input	3	RS-232C serialized data input to the Communications Controller.
Request to Send	RTS	O	Output	4	A request from the Communications Controller 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 Communications Controller has permission to transmit, otherwise it is off.
Clear to Send	CTS	I	Input	5	A signal from the modem to the Communications Controller that indicates the carrier is stable and the modem is ready to transmit. The Communications Controller will not transmit until CTS is on. If CTS is turned off during transmission, the Communications Controller will stop transmitting until CTS is restored.
Data Set Ready	DSR	I	Input	6	A signal from the modem to the Communications Controller that indicates the phone is off-hook. It is the modem's answer to DTR. The Communications Controller will not transmit or receive unless DSR is on. If the modem does not control DSR properly, DSR must be jumpered to a high signal at the Communications Controller. (It can be jumpered to DTR.)
Signal Ground	GND	N/A	–	7	Signal ground – a reference point for the data signals.
Data Carrier Detect	DCD	I	Input	8	A signal from the modem to the Communications Controller 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 by the Communications Controller unless DCD is on. With full duplex protocol, the Communications Controller will not transmit unless DCD is on. If the modem does not control DCD properly, DCD must be jumpered to DTR at the module.
Data Terminal Ready	DTR	O	Output	20	A signal from the Communications Controller to the modem to connect to the phone line (i.e., "pick up the phone"). The Communications Controller will assert DTR all the time except during the phone hang-up sequence. Modems built to North American standards will not respond to DTR until the phone rings. The Communications Controller will not work correctly with modems which always pick up the phone upon receiving DTR, whether the phone is ringing or not.

The connector you use at the computer end of the cable depends on whether or not your application makes use of handshake signals, whether or not you are connecting to a 9 pin serial port for an IBM AT, and whether or not your computer uses standard IBM pinouts. The following diagrams, Figure 2.21 through Figure 2.26, are for IBM computers with either 9 or 25 pin connectors. If your computer has a different pinout, construct a cable using the appropriate signal names for your computer.

If you are not using handshake signals, use the three wire connections shown in Figure 2.21 or Figure 2.22.

Figure 2.21
Three Wire Connection to IBM Computer (25 pin)

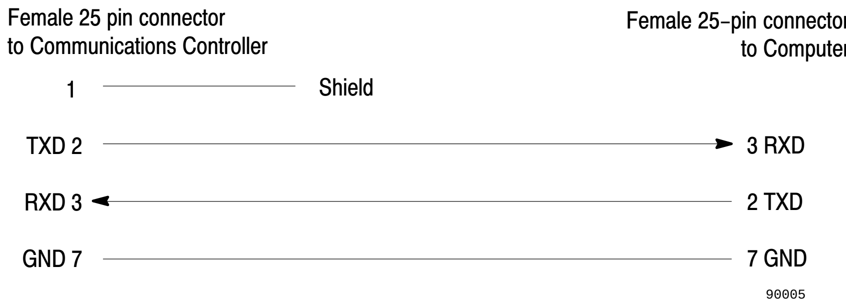
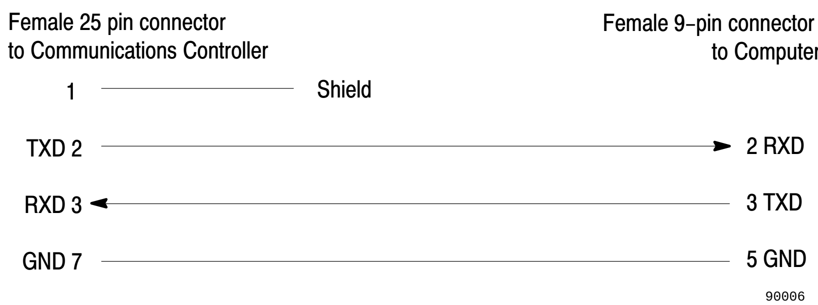


Figure 2.22
Three Wire Connection to IBM Computer (9 pin)



If your computer requires active DSR and CTS signals, add jumpers to the computer connections as shown in Figure 2.23 and Figure 2.24.

Figure 2.23
Jumper Positions for DSR and CTS Lines (25 pin)

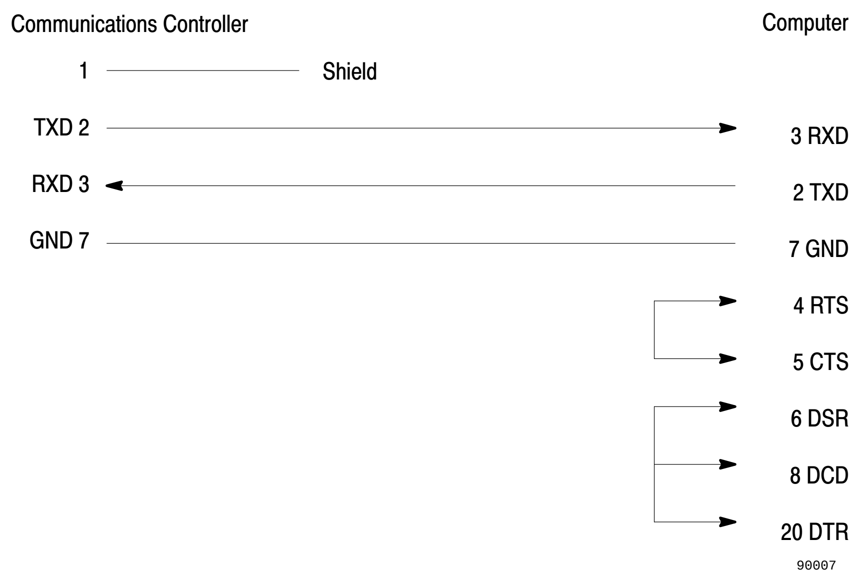
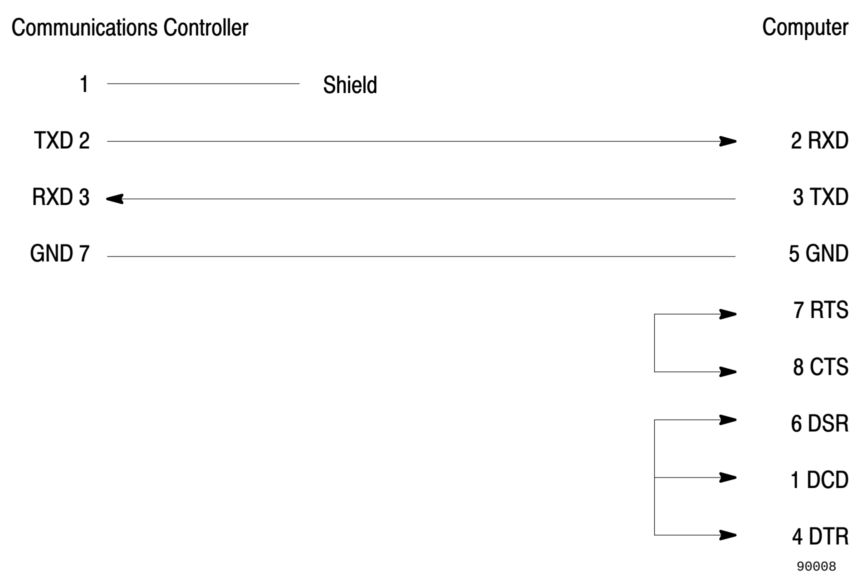


Figure 2.24
Jumper Positions for DSR and CTS Lines (9 pin)



If you are using handshake signals with your computer, use the connection shown in Figure 2.25 or Figure 2.26.

Figure 2.25
Connection to IBM Computer with Handshake Signals (25 pin)

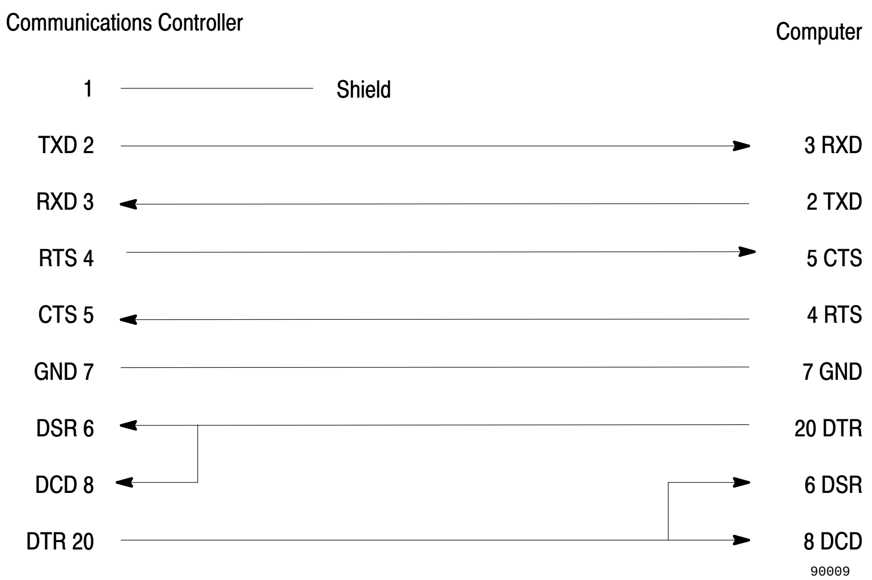
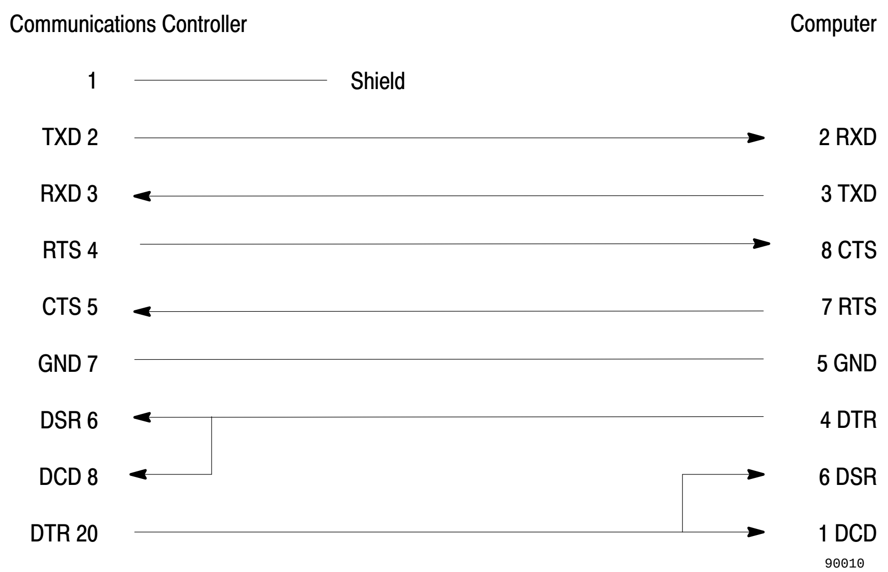


Figure 2.26
Connection to IBM Computer with Handshake Signals (9 pin)



Modem Connections

The Communications Controller can be connected to a modem via a direct 25-pin to 25-pin cable, which you must construct using Belden #8723 (or equivalent) cable.

Important: The length of the cable must not exceed 50 feet, and the cable shield must be connected to chassis ground (using Pin 1) at the Communications Controller end only.

Figure 2.27
Connection between a Communications Controller RS-232C Serial Port and a Modem

The Communications Controller can be connected to any standard asynchronous dial-up modem.

Important: Some modems are designed to respond to the DTR signal by answering the phone whether it is ringing or not. Since the Communications Controller asserts DTR at all times except during the hang-up sequence, the phone would always appear to be busy. Do not use the Smart Transmitter Interface with any type of modem that answers the phone as soon as DTR is asserted.

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 Smart Transmitter Interface serves as the data terminal equipment to control the modem via the DTR, DSR and DCD signals. The Smart Transmitter Interface incorporates timeouts and tests to operate these types of modems properly.

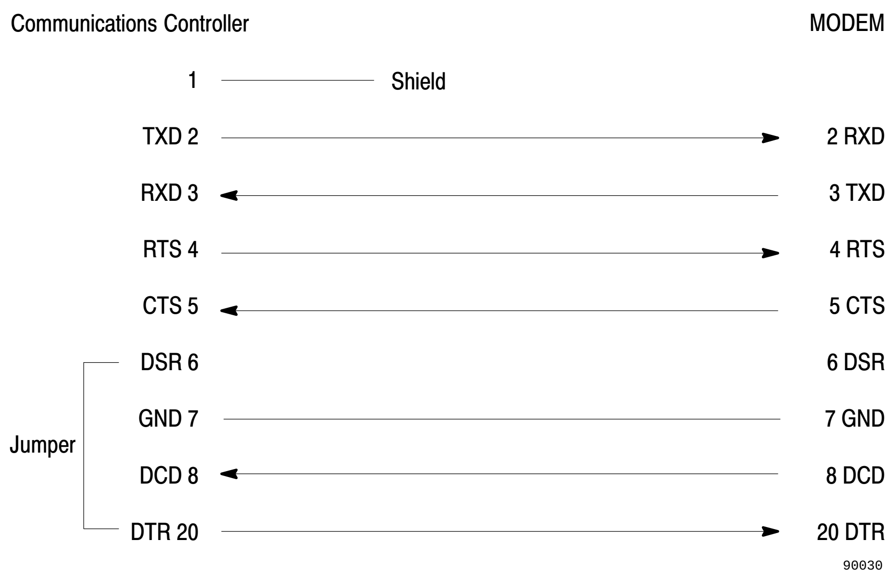
- Auto-Answer: these modems have self-contained timeouts and test, and can answer and hang up the phone automatically.

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

If your application requires the use of leased lines, you will probably not be using a dial-up modem. Some non-dial-up modems are designed to assert a continuous DSR signal, a situation that would leave the Communications Controller waiting forever for communication with the modem.

To avoid this, construct your cable with the jumper indicated in Figure 2.28.

Figure 2.28
Connection between a Communications Controller and a Modem (Other than a Dial-up Modem)



Chapter 3

Configuring the Communications Controller

This chapter explains the communication parameters of the Communications Controller and describes how to set them. System integrators need this information to configure the Communications Controller for the host system.

Overview of Configuration Procedures

The Communications Controller has two modes of operation, *run mode* and *configuration mode*. During normal operation, the Controller functions in run mode. When the Controller is in configuration mode you can change the communication parameters using the push buttons and displays located at its left end. Any changes you make to the parameter settings do not take effect until they are saved, which returns the Communications Controller to run mode. While in configuration mode the Communications Controller continues to communicate over its ports according to its previous settings.

Important: Verify all parameter settings before connecting the Communications Controller to your network. Incorrect settings may cause unreliable and unpredictable operation of the network.

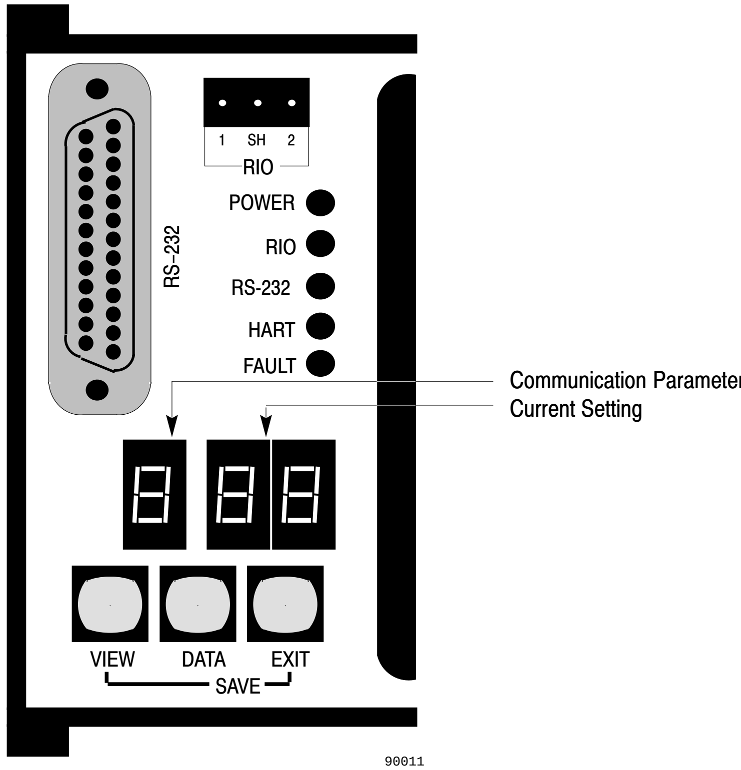
Parameter settings are saved in non-volatile memory so that you do not lose them even if power to the Communications Controller is interrupted. Whenever the Communications Controller is in run mode, the seven segment display is off to conserve power.

Important: If the Communications Controller displays symbols other than those shown in this chapter, it is malfunctioning. Contact your A-B representative to arrange to return the unit for servicing.

Displays

Figure 3.1 shows the configuration displays on the left end of the Communications Controller. The left display (one digit) shows the number of the communication parameter being configured. The two right displays (two digits) show the current setting for that parameter. Communication parameters are configured in two menus, a *main menu* for basic parameters, and a *sub-menu* for more advanced parameters for the RS-232C port.

Figure 3.1
Configuration Display and Push Buttons



Push Buttons

Figure 3.1 shows three push buttons labelled **VIEW**, **DATA**, and **EXIT**. The operation of these buttons is described in Table 3.A.

Table 3.A
Push Button Operation

Pressing this button or button combination:	Performs this task:
VIEW	In run mode, takes the Communications Controller into configuration mode. This is the only button that has a function in run mode. In configuration mode, cycles through the possible communication parameters (displayed on the left digit). If you hold the button down for more than 1 second, the parameter number will advance automatically.
DATA	In configuration mode, cycles through the possible communication settings for the parameter shown on the left. The data is displayed on the right two digits. If you hold the button down for more than 1 second, the settings will advance and accelerate automatically. When the left display shows 9, press DATA to enter the sub-menu.
EXIT	In configuration mode, from the main menu, returns the Controller to run mode **without** saving any changes. The change in mode takes effect when the button is released. From the sub-menu, returns to the main menu.
VIEW + EXIT	In configuration mode, saves all configuration changes, and returns the Communications Controller to run mode from either menu. The Communications Controller will begin operating with the new configuration as soon as it returns to run mode.
VIEW + DATA	In configuration mode, resets all communication parameters to their factory defaults (see Table 3.B and Table 3.C). The changes do not take effect until the configuration is saved, and the Communications Controller returns to run mode—i.e. until **VIEW** and **EXIT** are pressed simultaneously.

Configuration Step by Step

Before configuring the Communications Controller, you should determine the parameters settings your network requires. If they differ from the factory defaults shown in Table 3.B and Table 3.C, use the following procedure to change them. While you are changing the parameters in configuration mode, the Communications Controller continues to communicate over its ports. The changed parameter settings do not take effect until they are saved and the Communications Controller returns to run mode.

Enter Configuration Mode

1. Press the **VIEW** button to enter configuration mode. The first parameter number is displayed on the left display, with its current setting in the right two displays.

Configure Basic Parameters

2. Each time you press the **VIEW** button, the parameter number in the left display advances, and the parameter's current setting appears in the right display.

Press the **VIEW** button as often as necessary or hold it down until the desired parameter is reached.

3. Once the desired parameter is displayed, press the **DATA** button to cycle through the available settings.

4. When you have reached the desired data setting, you can press **VIEW** to display the next parameter and its current setting or go to step 7 to save the change and exit configuration mode.

Repeat steps 2 through 4 until the basic parameter settings meet your requirements.

Configure Advanced RS-232C Parameters

5. To enter the sub-menu press **VIEW** until parameter 9 appears in the left display, then press **DATA**.

When you are in the sub-menu, the decimal to the right of the parameter number lights up to distinguish this menu from the main menu.

6. Use the **VIEW** and **DATA** buttons, as described in steps 2 to 4 to review and modify the advanced parameter settings.

You can press **EXIT** to return to the main menu from the sub-menu, if necessary. This does not end the configuration session and you may go back to the sub-menu as described in step 5.

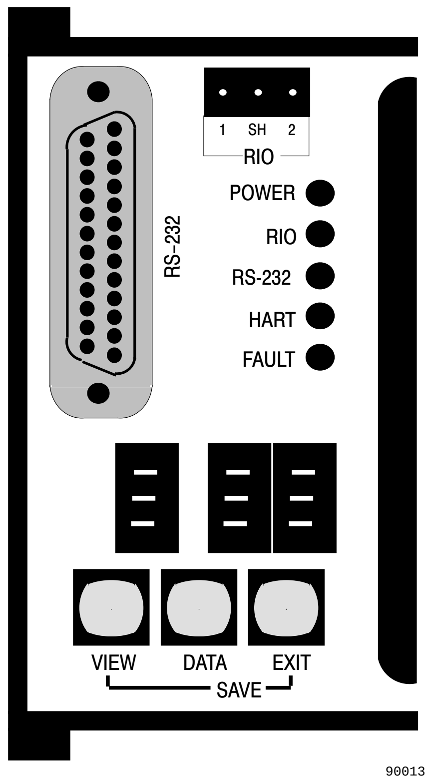
Save and Exit

7. To save the new data and exit configuration mode, press the **VIEW** and **EXIT** buttons simultaneously. All parameters in both the main menu and the sub-menu will be saved in non-volatile memory, and the Controller will return to run mode. This ends the configuration session.

If the save is successful, each display will show three dashes (see Figure 3.2) for a period of two seconds. When the Communications Controller returns to run mode, the new configuration takes effect immediately, and the displays turn off.

Important: If you change any of the RIO parameters (see Table 3.B) and then press **VIEW** and **EXIT**, the display cycles through the numbers 1–3 after showing the three dashes. This indicates that the Communications Controller has saved the new parameters in non-volatile memory, and then gone through a reset cycle to bring the new parameters into effect.

Figure 3.2
Successful Save Display



If the save is not successful, the Communications Controller is malfunctioning. The left display will show hardware fault number 6 (see Table 5.C) and the fault indicator will light. If this happens you should contact your A-B representative.

Exit Without Saving

Press only the **EXIT** button while in the **main menu** to take the Communications Controller out of configuration mode and into run mode without saving any changes. This ends the configuration session and the previous settings will remain in effect.

Pressing only the **EXIT** button while in the sub-menu takes the Communications Controller back to the main menu. You can move between the two menus as much as you need to during any given configuration session.

Important: If the Communications Controller is left inactive (i.e., with no buttons pressed) in configuration mode for 3 minutes, it returns to run mode. Any changes made since going into configuration mode will not be saved. Also, if power to the Communications Controller is interrupted while in configuration mode, any changes made will not be saved.

Setting Factory Defaults

Pressing the **VIEW** and **DATA** buttons simultaneously when in configuration mode resets all parameters in both menus to their factory defaults. When this button combination is pressed, the Communications Controller displays the first parameter and its factory default.

Like any other changes, the factory default parameters are not saved until the **VIEW** and **EXIT** buttons are pressed simultaneously. If only the **EXIT** button is pressed, the Communications Controller returns to run mode without changing the parameters to their factory defaults.

Communication Parameters

For normal operation, you must configure the basic communication parameters. For special communication needs you can configure the advanced communication parameters, which provide more flexibility in the RS-232C operation of the Communications Controller.

Basic Parameters

The basic communication parameters are divided into two groups:

- those that control the Remote I/O link
- those that control the RS-232C link

The parameter number is shown in the left display with the current setting in the two right displays.

Table 3.B describes each basic communication parameter and its valid settings.

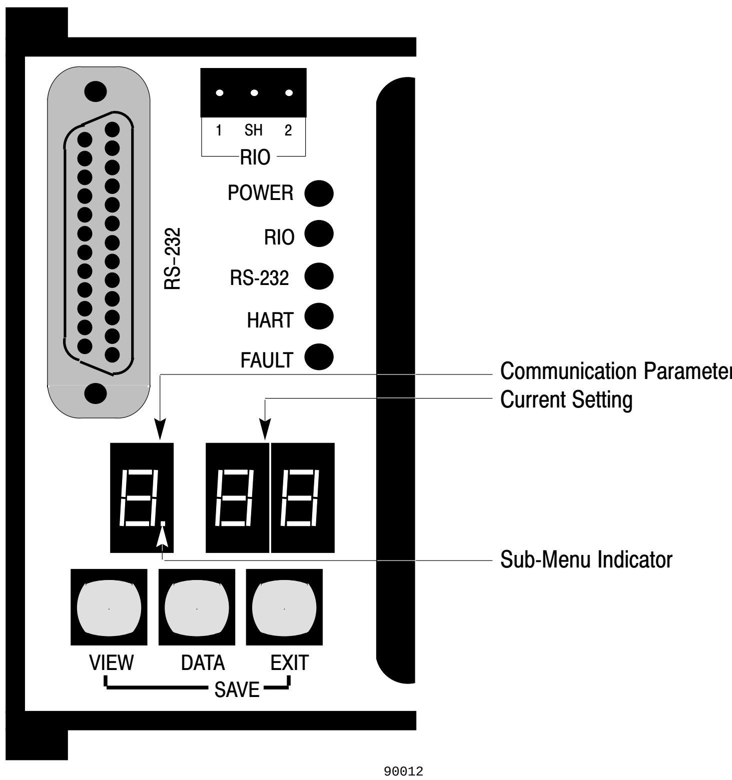
Table 3.B
Main Menu: Basic Communication Parameters

Parameter Number	Parameter	Description	Factory Default
RIO Parameters			
0	Rack Address	Defines the address of the rack containing the Communications Controller. Valid choices are Programmable Logic Controller dependent; maximum is 77 (octal).	01
1	Starting Module Group	Defines the address of the Communications Controller within the rack. Valid choices are 00, 02, 04, 06	00
2	Last Module	Is this the last module in the current rack? No (00), Yes (01) To save time in RIO communications, and to make sure all modules in a rack are read, be sure only the last logical module in each rack is configured as Yes.	No (00)
3	Baud Rate	Sets the baud rate (the speed in bits/second at which data is transferred) of the link between the Communications Controller and Remote I/O scanner. Possible rates are 57.6 (57), 115.2 (11), 230.4 (23) Kbits/s	57.6 (57)
RS-232C Parameters			
4	RS-232C Baud Rate	Sets the baud rate of the link between the Communications Controller and the RS-232C port of the host computer. The host computer and the Communications Controller must be set to the same baud rate. Possible rates are 300 (03), 600 (06), 1200 (12), 2400 (24), 4800 (48), 9600 (96), 19200 (19) Bits/s	9600 (96)
5	RS-232C Parity	Parity of the characters on the RS-232C link. The host computer and the Communications Controller must have the same parity setting. Parity can be None (00), Even (01), or Odd (02).	None (00)
6	DF1 Protocol	Sets the DF1 protocol as being either: Full-duplex (00) or Half-duplex (01).	Full Duplex (00)
7	Error Detection	Two forms of error checking are available on the RS-232C link: BCC Block Check Code (00) or CRC16 Cyclic Redundancy Check (01). The application program running on the host computer must use the same error detection as the Communications Controller. Refer to your application's documentation to determine what error detection it is using, and set the Communications Controller to the same setting.	BCC (00).
8	Station Address	The station address of this Communications Controller on the RS-232C link. Valid addresses are 00–77 (octal) inclusive.	00
Other Parameters			
9	Sub-menu Parameters	Lets you into the sub-menu when the DATA key is pressed, to set the advanced communication parameters; the data display will show two dashes. See the section below on Advanced communication parameters for more information.	N/A
A	Series and Revision	Displays the series and revision level of the Communications Controller. The first digit shows the series (A–J), the second the revision (A–J). For example, Series A Revision B is displayed as AB. You cannot set this value.	N/A

Advanced RS-232C Communication Parameters

The advanced communication parameters for the RS-232C link are located in the sub-menu. When parameter 9, the sub-menu entry parameter, is shown on the left display, the right display shows dashes. Press the **DATA** button to enter the sub-menu and display the sub-menu parameter numbers. The number on the left changes from 9 to 0, and its decimal point lights up, remaining lit as long as you are in the sub-menu.

Figure 3.3
Sub-Menu Indicator



Once in the sub-menu, you select and change parameters in the same manner as in the main menu, using the **VIEW** and **DATA** buttons. When the last sub-menu parameter is reached, you can press **VIEW** to go back to the first sub-menu parameter.

As described previously, you can press the **EXIT** button alone to return to the main menu or press **VIEW** and **EXIT** simultaneously to save all changes and return the Communications Controller to run mode.

Table 3.C describes each advanced (sub-menu) communication parameter and its valid settings.

Table 3.C
Sub-Menu: Advanced RS-232C Communication Parameters

Parameter Number	Parameter	Description	Factory Default
0.	Number of Retries	Number of allowable retries per attempt on the RS-232C link: Valid numbers are 00 (no retries per attempt) to 10 (10 retries per attempt).	02
1.	DF1 ACK Timeout	The time to wait for an acknowledgement (ACK) from the host computer. The timeout is from 0.1 to 5 seconds in 0.1 second increments (1–50). To calculate the timeout, multiply the number in the display by 0.1 second. For example, a setting of 14 means 14 x 0.1 = 1.4 seconds.	1 second (10)
2.	Flow Control	Determines whether modem handshake lines are used for flow control: Disabled (00), Enabled (01). Flow control is normally enabled when communicating with a modem.	Disabled (00)
3.	CTS to TX Delay	The delay between the Clear to Send (CTS) signal and the start of transmission (half duplex only). The delay is from 0 seconds to 0.99 seconds in 10 ms (0.01 second) increments (00–99). To calculate the delay, multiply the number in the display by 0.01 seconds. For example, a setting of 48 means 48 x 0.01 = 0.48 seconds. This parameter only takes effect when the Controller is in half duplex mode and handshaking is enabled. It is only required when communicating with radio modems that require a delay after exerting the CTS signal. Refer to your modem manual for this information.	No delay (00)
4.	End of Message to RTS Off	The delay between the end of a message and the Communications Controller setting Request to Send (RTS) inactive. The delay is from 0 seconds to 0.99 seconds, in 10 ms (0.01 second) increments (00–99). To calculate the delay, multiply the number in the display by 0.01 seconds. For example, a setting of 50 means 50 x 0.01 seconds = 0.50 seconds. This parameter is only required when communicating with modems that require a delay between sending the last character and raising the RTS signal. Refer to your modem manual for this information. This parameter only takes effect when the Communications Controller is in Half-Duplex DF1 mode, and handshaking is enabled.	No delay (00).
5.	Duplicate Message Detection	Determines whether duplicate message detection is enabled: Disabled (00), Enabled (01). If enabled, the Communications Controller will acknowledge and discard duplicate messages.	Enabled (01)

Verifying the Communication Parameters

Before connecting the Communications Controller to your network, cycle through the parameter settings and verify that they are correct for your network. If you have made no changes to the default settings they should appear in the displays.

When you connect the Communications Controller to your network and turn it on, the displays cycle through the numbers 1–3 and then turn off. If your parameters are correctly configured, and the Controller is connected to the RIO link, the RIO LED on the Controller lights up. If the RIO LED flashes instead of glowing steadily, make sure that only the last module in the rack has its Last Module parameter set to Yes.

Once you initiate active communication on the DF1 link, the RS-232 Activity LED flashes to reflect communication activity. If this fails to happen, check the RS-232C parameters (Table 3.B, Parameters 4–8, and Table 3.C) or the RS-232C cable.

If the displays show symbols other than those shown in this chapter, the Controller is malfunctioning. You should contact your A-B representative to arrange to return the unit for servicing.

For more information on troubleshooting see Chapter 5.

Marking the Communications Controller Label

When you have configured and verified the communication parameters, record the configuration on the label on top of the unit. In the lower left hand corner of the label is a section entitled Notes. This lists the parameter number (OPTN) for the main menu and sub-menu options and provides space for the current settings (DATA). Mark these in with a pencil so they can be changed if the configuration changes. (See Figure 1.1.)

Chapter 4

Communicating with the Smart Transmitter Interface

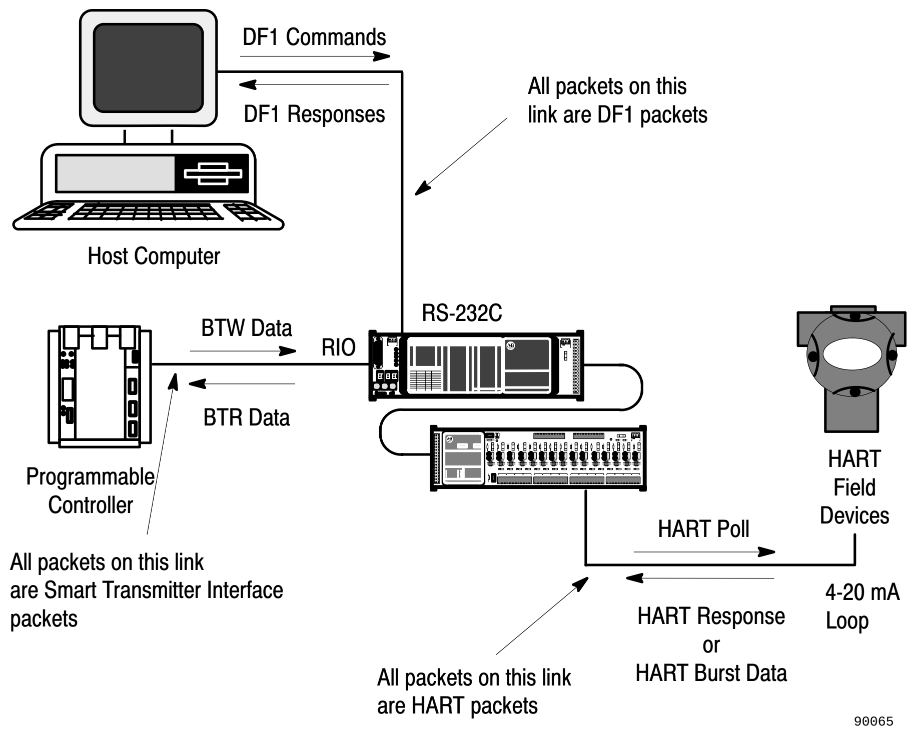
This chapter provides programming information for communication between host processors (programmable controllers and host computers) and HART field devices via the Smart Transmitter Interface. It includes:

- explanations of the data routing and protocol conversion functions of the Smart Transmitter Interface
- definitions of relevant communication terms
- descriptions of HART and Smart Transmitter Interface data packets
- a PLC-5 programming example that illustrates the use of these packets for communicating between programmable controllers and HART field devices
- an explanation of serial communications with the Smart Transmitter Interface
- a brief note on using Data Highway Plus hosts with the Smart Transmitter Interface

Data Routing and Protocol Conversion

The Smart Transmitter Interface routes data packets between host processors and HART field devices as illustrated in Figure 4.1. Programmable controllers send and receive Smart Transmitter Interface packets on the RIO link. Host computers send and receive DF1 packets on the RS-232C link. The Smart Transmitter Interface converts the packets from the host processor into packets conforming to the HART protocol (by extracting the HART data and adding preambles) and relays them to the specified HART field device. When it receives a packet from a HART field device, the Smart Transmitter Interface converts it into the packet format appropriate to the host processor and sends it on when required. The Smart Transmitter Interface and HART field devices send and receive HART packets over the 4-20 mA loops.

Figure 4.1
System Data Flows with a Smart Transmitter Interface



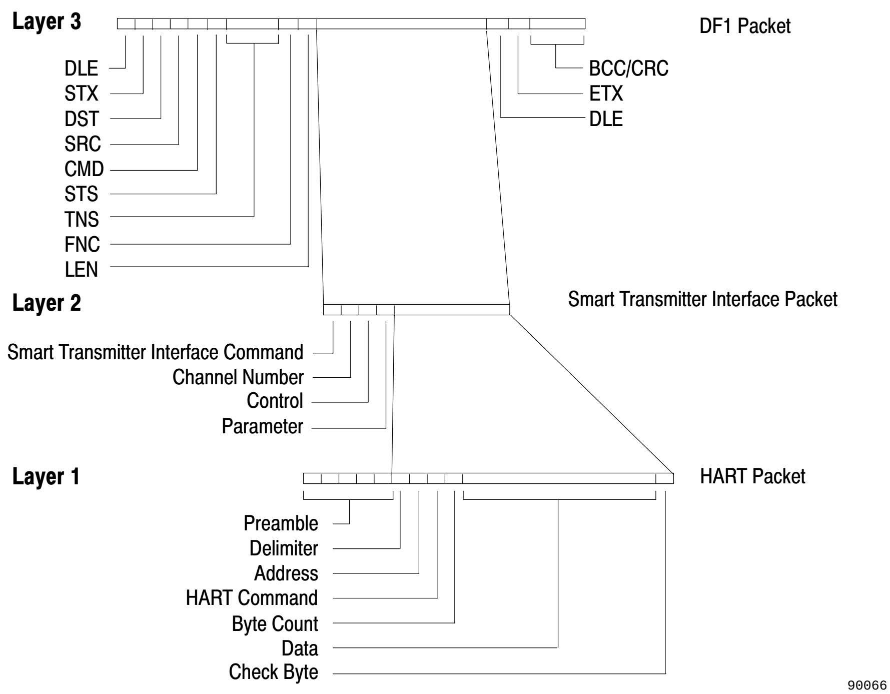
Data Routing In Poll and Response Mode

A Smart Transmitter Interface operating in the Poll and Response mode receives packets as Block Transfer Write (BTW) data from a programmable controller and forwards those packets as HART polls to the field device. When the field device responds, the Smart Transmitter Interface routes that response to the programmable controller as data in a Block Transfer Read (BTR). The Smart Transmitter Interface receives similar packets from, and sends them to the host processor on the RS-232C link in the form of DF1 commands and responses instead of Block Transfer Writes and Reads.

Data Routing in Burst Monitor Mode

In Burst Monitor mode the Smart Transmitter Interface watches specified channels for HART burst data from field devices and places this data in a Burst Data table. Programmable controllers request this data via a BTW to the Smart Transmitter Interface which returns the data from the Burst Data Table in a BTR. Host computers request and receive this data via DF1 commands and responses rather than BTWs and BTRs.

Figure 4.2
Layered Nature of Protocols



Protocol Conversion

The Smart Transmitter Interface receives data in one of three protocols: HART, Smart Transmitter Interface and DF1. Figure 4.2 illustrates the layered nature of these three protocols as transmitted from a host computer. Here the DF1 packet contains the Smart Transmitter Interface packet, which in turn, contains the HART packet. The Smart Transmitter Interface converts all received packets to the required format before transmitting them to their destination. As mentioned previously, when sending a packet to a HART field device, it adds preamble bytes. When sending a packet to the host processor the Smart Transmitter Interface attaches a four byte header. The contents of these bytes are explained in the sections describing the various packets.

Definition of Terms

Table 4.A summarizes the definitions of relevant communications terms used with the Smart Transmitter Interface.

Table 4.A
Definitions of Communications Terms

Term	Definition
Block Transfer Read (BTR)	A programmable controller ladder logic instruction to obtain data (formatted as Smart Transmitter Interface packets) from the Smart Transmitter Interface over the RIO link.
Block Transfer Write (BTW)	A programmable controller ladder logic instruction to send data (formatted as Smart Transmitter Interface packets) to the Smart Transmitter Interface over the RIO link.
Burst Data Table	An internal table maintained by the Smart Transmitter Interface which stores the latest HART Burst Data received on a monitored channel.
DF1 Protocol	An Allen-Bradley proprietary protocol which defines the format of data packets transmitted over an RS-232C link.
DF1 Packet	A data packet formatted according to the DF1 protocol.
DF1 Command	A DF1 packet transmitted by a host computer to the Smart Transmitter Interface.
DF1 Response	A DF1 packet transmitted by the Smart Transmitter Interface to a host computer.
HART Protocol	A communications protocol defining the format of data packets transmitted between the Smart Transmitter Interface and HART field devices.
HART Packet	A data packet formatted according to the HART Protocol.
HART Poll	A HART Packet sent by the Smart Transmitter Interface to a field device to poll or write data to it.
HART Response	A HART Packet sent by the field device to the Smart Transmitter Interface in response to a HART Poll.
HART Burst Data	An unsolicited HART Packet sent periodically by a field device to the Smart Transmitter Interface.
Smart Transmitter Interface Protocol	A communications protocol defining the format of data packets transmitted between a programmable controller and the Smart Transmitter Interface.
Smart Transmitter Interface Packet	Data packets formatted according to the Smart Transmitter Interface Protocol.
Frame	Frame is another word for packet used extensively in Rosemount HART documentation.

HART Poll Packets

The Smart Transmitter Interface transmits HART Poll packets to field devices using the format illustrated in Figure 4.3 and Figure 4.4. The host processor provides data for all fields except the preamble. If you are using a programmable controller as host processor, you provide data for the HART device via Block Transfer Writes to the Smart Transmitter Interface. If you are using a computer as host processor, you provide the data by using the computer's software to send DF1 commands to the Smart Transmitter Interface.

Preamble

The preamble is a number of hexadecimal FF characters that precede all frames sent to the HART field device. The size depends on the field devices being used, but it can be from 2 to 32 hexadecimal. The default is 10. The Smart Transmitter Interface inserts the required preamble before each packet or frame transmission to the HART device. This is done automatically so you do not have to program the host processor to do this.

HART Delimiter

This is a one-byte field that is used to identify the frame type. Set the frame type as STX (010) to identify this packet as a HART poll. Also, indicate whether a short or long frame address follows this byte, by specifying hexadecimal 02 for a short frame address or hexadecimal 82 for a long frame address.

HART Address

The Smart Transmitter Interface addresses HART field devices using either a short or long frame address format (as specified by the HART Delimiter byte). A short frame address is one byte long and contains a polling address from 0 to 15. A long frame address is five bytes long and includes a unique 38 bit identifier encoded within each field device by the manufacturer.

HART field device addressing is device dependent. Some devices do not support long frame addressing while others only recognize short frame addressing for HART Command #0. In this situation, use HART Command #0 to determine the long frame address, and then use long frame addressing for all other HART commands. Consult the documentation provided with your field device for details about the addressing formats it supports.

Figure 4.3
HART Poll Packets - Smart Transmitter Interface to HART Field Device (Short Frame Format)

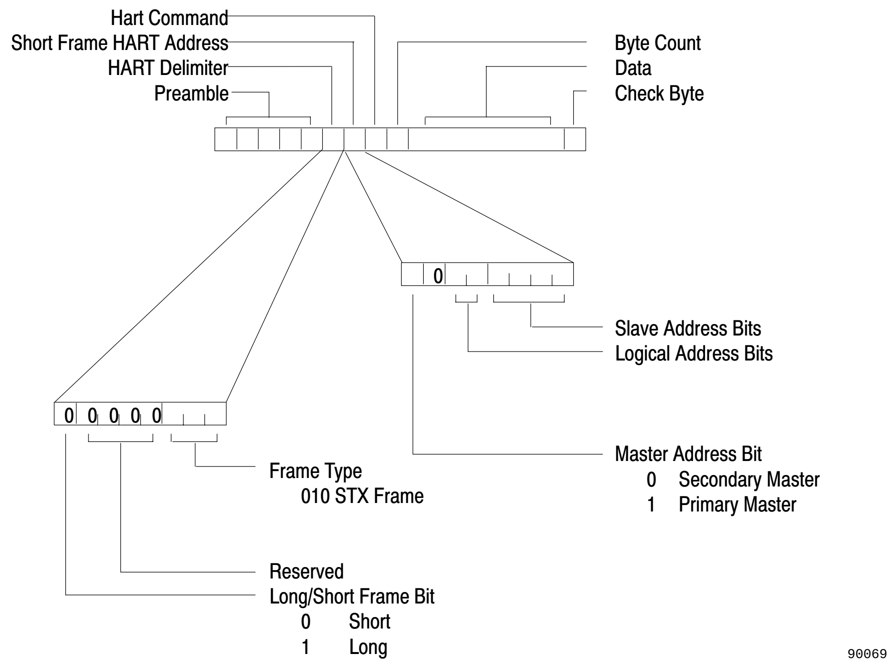
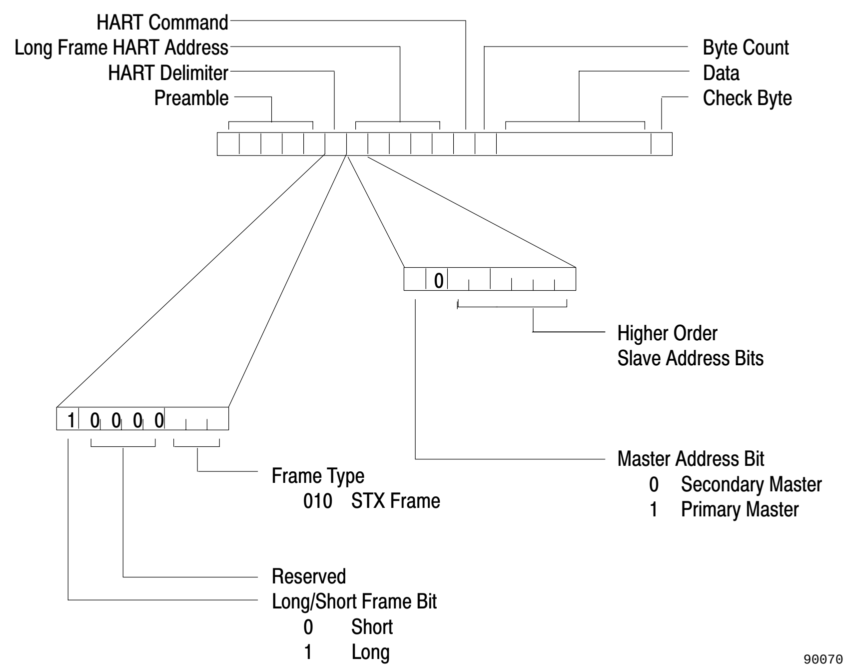


Figure 4.4
HART Poll Packets - Smart Transmitter Interface to HART Field Device (Long Frame Format)



Short Frame Address Field

This one-byte field contains three bit fields: the master address bit, the logical address bits and the slave address bits. The master address bit differentiates between packets sent from a primary or secondary master. Set this bit to 0 so the Smart Transmitter Interface operates in the preferred mode of primary master. For those applications requiring a secondary master set this bit to 1. Since master mode changes at the Smart Transmitter Interface are dynamic for each message, you can change this bit for successive messages.

Important: A link to a HART field device can have only one primary and one secondary master.

Two logical address bits define the addresses of up to four logical devices within one HART field device. You should clear these bits for most field devices.

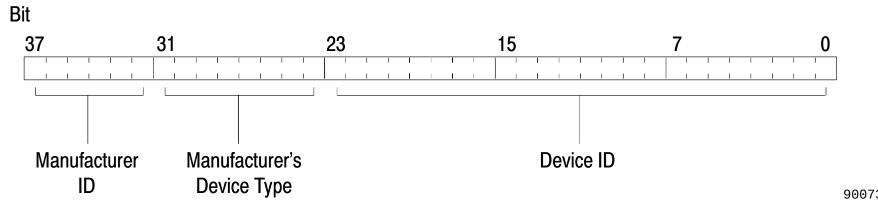
The slave address bits range from decimal 0 to 15. Most applications with point-to-point HART links require a slave address of 0. However, HART field devices only recognize polling addresses of 1 to 15 when placed into multi-drop mode and assigned a polling address using HART Command #6.

When the field device is on a point-to-point link, set this field to hexadecimal 80 for a primary master or hexadecimal 00 for a secondary master. On a multi-drop link, set this field to a value in the range hexadecimal 80 to hexadecimal 8F for a primary master and hexadecimal 00 to hexadecimal 0F for a secondary master.

Long Frame Address Field

This five-byte field contains two bit fields: the master address bit, and a 38 bit device address. The master address bit is defined as for short frame address fields. Figure 4.5 illustrates the format of the 38 bit device address. Use HART Command #0 and short frame addressing (as illustrated in the programmable controller programming example later in this chapter) to determine this address.

Figure 4.5
Unique 38 Bit Device Identifier



HART Command

This one-byte field specifies the HART command that is to be sent by the Smart Transmitter Interface to the field device. Many commands are device dependent. Table 4.B lists some universal commands supported by all field devices. Consult the documentation provided with the device for details. Set this field to a device recognizable command before sending the packet to the Smart Transmitter Interface.

Table 4.B
Representative HART Universal Commands

Universal Command (Decimal)	Description	Expected Response
#0	Read Unique Identifier	Unique 38 bit device identifier, revision levels, number of preambles required
#1	Read Primary Variable	Primary variable in floating point (IEEE 754 format)
#2	Read Primary Variable Current and Percent of Range	Primary variable in milliamperes and %
#3	Read Dynamic Variables and Primary Variable Current	Primary variable and up to 4 predefined dynamic variables
#6	Write Polling Address	Assigned polling address - short form
#11	Read Unique Identifier Associated with Tag	Unique 38 bit device identifier, revision levels, number of preambles required

Byte Count

This one-byte field indicates the number of bytes to follow this field excluding the check byte. Valid values are 0 to 113. Insert the number of bytes required for this packet before transmitting it.

Data

This field specifies a number of data bytes associated with the command number given in the command field. Set the number of data bytes to the appropriate value for the command in question. The valid range is from 0 to 113. Only use this field when you are writing data to the HART device.

Check Byte

The Smart Transmitter Interface calculates the value of this field and transmits it to the field device as the last byte of a packet. The field device verifies the integrity of the received data packet by checking this byte. Since the Smart Transmitter Interface calculates this byte, you can set this field to a null (00).

HART Response and Burst Data Packets

Field devices transmit HART Response packets or HART Burst Data packets to the Smart Transmitter Interface using the format illustrated in Figure 4.6 and Figure 4.7. The Smart Transmitter Interface removes the preamble bytes and sends the remaining fields to the host processor. With a programmable controller use BTRs to accomplish. With a computer use DF1 Responses to receive data from the Smart Transmitter Interface.

Preamble

All frames transmitted by field devices are preceded by a number of hexadecimal FF bytes which are called the preamble to the frame. As the Smart Transmitter Interface handles all preamble bytes, the host processor does not receive them.

HART Delimiter

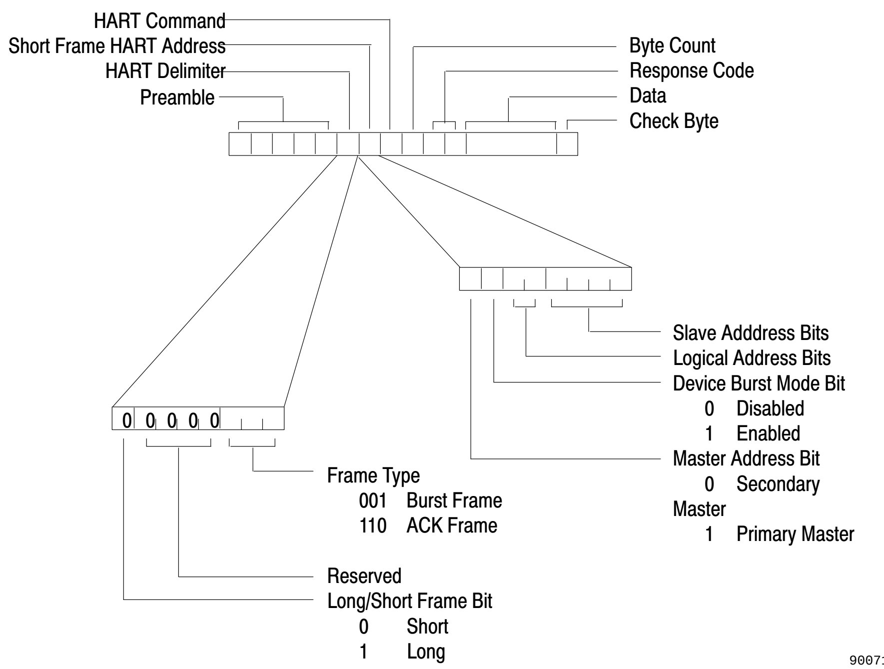
This one-byte field encodes the HART frame as either an ACK or Burst frame. An ACK frame indicates a response packet while a Burst frame indicates a burst packet from a field device. One bit of this field specifies whether a short frame or long frame address follows this byte.

In poll and response mode you will receive hexadecimal 06 for a short frame address or hexadecimal 86 for a long frame address. In burst mode, when the host processor is receiving data from the Smart Transmitter Interface’s Burst Data table, this field will contain hexadecimal 01 for a short frame address or hexadecimal 81 for a long frame address.

HART Address

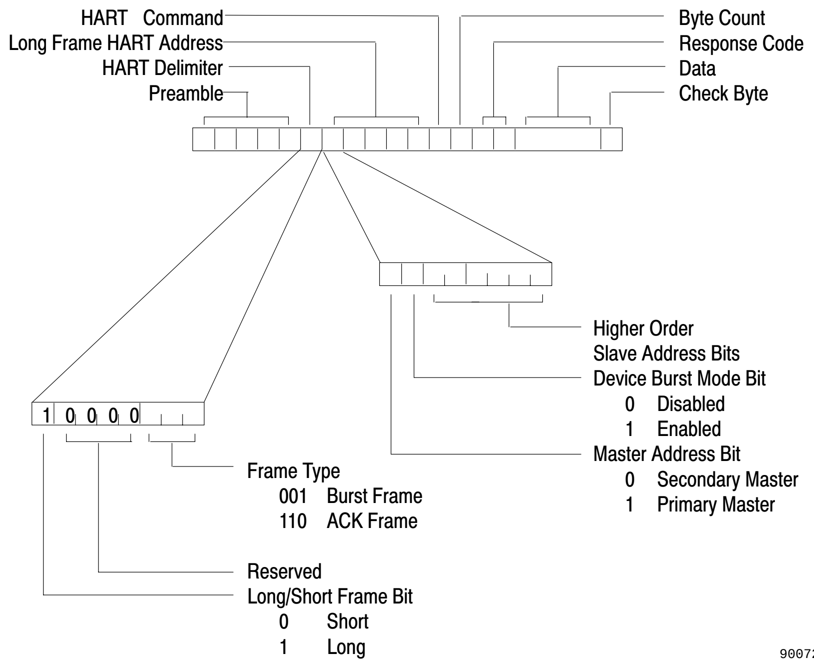
When field devices respond to HART polls they send packets with the same short or long frame address format used in the poll. The field device sets or clears the master address bit depending on which master the response is for. If the device is also bursting data, it sets the burst mode address bit; otherwise it clears this bit. You must program the host processor to verify that the address field in a HART Response packet is correct before it processes the remaining data in the packet.

Figure 4.6
HART Response or Burst Data Packets - HART Field Device to Smart Transmitter Interface (Short Frame Format)



When the host processor requests data from the Burst Data table, the packet that is received contains either a short frame or long frame address, depending on the field device which sent that data to the Smart Transmitter Interface. The master address bit may also be in either state, as field devices alternate this bit between primary and secondary master when bursting data.

Figure 4.7
HART Response of Burst Data Packets - HART Field Device to Smart Transmitter Interface (Long Frame Format)



HART Command

This one-byte field echoes the HART command being responded to. This is either the last command sent to the device, or the HART command for which burst data is being transmitted by the device. Program the host processor to verify that this field contains the correct command before it processes the remaining data in the packet.

Byte Count

This one-byte field indicates the number of bytes to follow this field excluding the check byte. Valid values are 2 to 113. It indicates to the host processor the size of the received data field.

Response Code

This two-byte code contains the HART field device status as sent by that device. Field devices detecting a communications error set the most significant bit (bit 7) of the first byte and identify the error in the other seven bits as shown in Table 4.C. If the last message was received without error, the field device will clear bit 7 and return a device dependent response code in the other seven bits.

The second byte of this response code returns the operating status of HART field devices as indicated in Table 4.D. This byte may default to 0 when a communications error occurs as indicated by bit 7 of the first byte being set.

Important: The host processor should ignore any values in the data field when a communications error is detected.

Table 4.C
HART Protocol - Communication Error Code

Bit	Error Code	Description
7	Communications Error	If set, the field device has detected a communications error. Bits 0 - 6 indicate the type of error.
6	Vertical Parity Error	The parity of one or more of the bytes received by the HART field device is incorrect.
5	Overrun Error	At least one byte of data in the receive buffer of the HART field device was over-written before it was read.
4	Framing Error	The stop bit of one or more bytes received by the HART field device was not detected.
3	Longitudinal Parity Error	The longitudinal parity calculated by the HART field device does not match the longitudinal parity byte at the end of the packet.
2	Reserved	Set to 0.
1	Buffer Overflow	The packet is too long for the receive buffer of the HART field device.
0	Undefined	Not defined at this time.

Table 4.D
HART Field Device Error Codes

Bit	Error Code	Description
7	Field Device Malfunction	An internal hardware error or failure has been detected by the HART field device.
6	Configuration Changed	A write or set command has been executed by the HART field device.
5	Cold Start	Power has been removed and reapplied resulting in the reinstallation of the setup information. The first HART command to recognize this condition automatically resets this flag. This flag may also be set following a master reset or self test.
4	More Status Available	More status information is available and can be read using command #48, Read Additional Status Information.
3	Primary Variable Analog Output Fixed	The analog and digital outputs for the primary variable are held at their requested value. They will not respond to the applied process.
2	Primary Variable Analog Output Saturated	The analog and digital outputs for the primary variables are beyond their limits and no longer represent the true applied process.
1	Non-Primary Variable Out of Limits	The process applied to a sensor, other than that of the Primary Variable, is beyond the operating limits of the device. To identify the variable, use command #48, Read Additional Status Information.
0	Primary Variable Out of Limits	The process applied to the sensor for the primary variable is beyond the operating limits of the device.

Data

This field contains the number of bytes of response data associated with the command number specified in the command field. An application on the host processor can use this data as required.

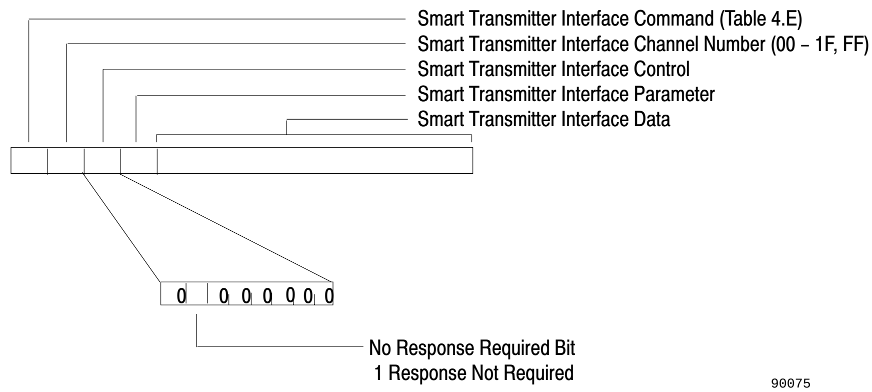
Check Byte

This one byte field contains a check byte which the Smart Transmitter Interface uses to verify the validity of data received from the field device. If the Smart Transmitter Interface detects a bad check byte, it resends HART polls to the device until either a valid response is received or the maximum number of retries have occurred.

Smart Transmitter Interface Packets Received by the Smart Transmitter Interface

Figure 4.8 illustrates the format of Smart Transmitter Interface packets received by the Smart Transmitter Interface. The programmable controller data files or host computer data buffers are formatted similarly for transmission of data to the Smart Transmitter Interface. An optional Smart Transmitter Interface Data field follows a required four-byte header. The host processor places HART packets in the Smart Transmitter Interface Data field when sending HART commands to a field device.

Figure 4.8
Smart Transmitter Interface Packets - Programmable Controller or Host Computer to Smart Transmitter Interface



Smart Transmitter Interface Command

The first byte of the header contains one of the valid commands listed in Table 4.E. This command indicates to the Smart Transmitter Interface how the remaining data in the header and the optional Smart Transmitter Interface Data field should be processed.

Smart Transmitter Interface Channel

The second byte of the header contains the channel number that the host processor wants to address. Each Smart Transmitter Interface supports up to 32 channels. Address each of these using the hexadecimal numbers 00 to 1F. For commands intended for the Smart Transmitter Interface, rather than a particular channel, use hexadecimal FF in this field.

Important: Address value hexadecimal 00 represents channel 1, address value hexadecimal 01 represents channel 2, ..., address value hexadecimal 1F represents channel 32.

Table 4.E
Valid Smart Transmitter Interface Commands from the Programmable Controller or Host Computer

Command Number (Hex)	Smart Transmitter Interface Command	Description
00	No Operation	Command is ignored by the Smart Transmitter Interface. A No Error response is sent if requested by the host.
01	Enable Poll and Response Mode	Puts the Smart Transmitter Interface into Poll and Response mode
02	Enable Burst Monitor Mode	Puts the Smart Transmitter Interface into Burst Monitor mode where it begins monitoring all channels listed in the Smart Transmitter Interface Data portion of the message for bursting HART data.
10	Send Message to Device	Directs the Smart Transmitter Interface to forward the message to the channel specified in the Smart Transmitter Interface Channel byte.
11	Read Burst Data	Directs the Smart Transmitter Interface to respond with the latest data stored in the Burst Data Table for the channel specified in the Smart Transmitter Interface Channel byte.
20	Set Number of Preambles	Sets the number of preamble bytes used for the channel specified in the Smart Transmitter Interface Channel byte.
21	Set Number of Retries	Sets the number of retries before declaring No Response on the channel specified in the Smart Transmitter Interface Channel byte.
30	Read Status and Statistics	Directs the Smart Transmitter Interface to return a set of statistics for the channel specified in the Smart Transmitter Interface Channel byte.
31	Reset Statistics Counters	Directs the Smart Transmitter Interface to reset all the statistics counters to 0.
32	Read ID	Directs the Smart Transmitter Interface to return the series and revision information.

Smart Transmitter Interface Control

The third byte of the header provides control information to the Smart Transmitter Interface. If you are using a programmable controller application to send a BTW followed by a BTR, clear bit six (set bit 6 to 0) in this field. If your application sends only a BTW and it does not require a response message from the Smart Transmitter Interface, then set bit six to 1 in this field. When bit six is set, the Smart Transmitter Interface does not expect a BTR to be sent immediately after the BTW, and so it does not hold responses in its queue waiting for a BTR. When using a host computer you would normally clear all bits. If you do not require a response (when using hexadecimal Smart Transmitter Interface Commands 00, 01, 02, 20, 21 or 31) set bit six to 1.

The other bits in this byte are used for communication between host computers residing on the Data Highway Plus and the Smart Transmitter Interface. This communication requires special software on the host computer and can only occur with programmable controllers which support “pass through” functionality.

ATTENTION: You must program the host processor to clear all bits except for bit six in this byte. Your application may operate in an unpredictable and unreliable manner if this is not done.

Smart Transmitter Interface Parameter

The last byte of the header provides an additional parameter required by the Smart Transmitter Interface commands hexadecimal 10, 20 and 21. If you are not using any of these commands set this field to 0 as indicated in Table 4.G.

Smart Transmitter Interface Data

Smart Transmitter Interface commands hexadecimal 2 and 10, require this extended data field to provide additional information to the Smart Transmitter Interface. When not required, the Smart Transmitter Interface ignores any data received in this field.

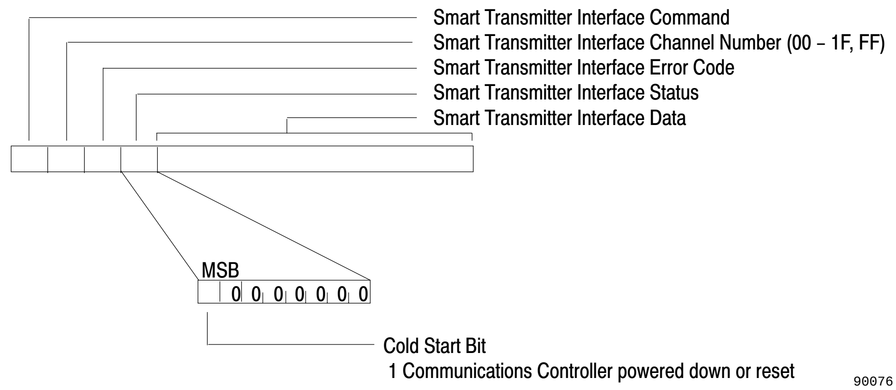
Smart Transmitter Interface Packets Sent by the Smart Transmitter Interface

Figure 4.9 illustrates the format of Smart Transmitter Interface packets transmitted by the Smart Transmitter Interface to the host processor. These packets are similar those sent by the host processor.

Smart Transmitter Interface Command

This byte contains the number for the Smart Transmitter Interface command which the Smart Transmitter Interface is sending to the host processor.

Figure 4.9
Smart Transmitter Interface Packets - Smart Transmitter Interface to Programmable Controller or Host Computer



Smart Transmitter Interface Channel

In this field, the Smart Transmitter Interface echoes the channel number associated with the response it is sending.

Smart Transmitter Interface Error Code

In this field, the Smart Transmitter Interface places the error codes it is returning, as described in Table 4.F.

Smart Transmitter Interface Status

The most significant bit in this field is used as a cold start bit. On powerup the Smart Transmitter Interface sets it (to 1). It remains set until the Smart Transmitter Interface receives an Enable Poll and Response mode command (hexadecimal 01) or an Enable Burst Monitor mode command (hexadecimal 02). All other bits are set to 0.

When this bit changes state from 0 to 1, it indicates to the host processor that power was cycled to the Smart Transmitter Interface leaving it in Poll and Response mode with an empty Burst Data Table, the number of preambles for all channels set to 10 and the number of retries for all channels set to 3.

Upon detecting this condition, you should reinitialize the Smart Transmitter Interface as required for your application.

Table 4.F
Smart Transmitter Interface Error Codes

Error Code (hex)	Definition	Description
General Errors		
00	No Error	The Smart Transmitter Interface processed the last received command, and no errors were detected.
01	Downloading Firmware	The Smart Transmitter Interface firmware is being upgraded over the RS-232C port. The last received command cannot be processed.
02	No Corresponding BTW	The Smart Transmitter Interface received a BTR but does not know what data is being requested. All BTRs must be preceded by a BTW indicating what response to return in a BTR.
03	Command Still in Progress	The Smart Transmitter Interface is still obtaining the HART Response from a field device and cannot respond with the requested data. The programmable controller should reissue the BTR request to obtain the response.
Command Errors		
10	Invalid Command	The Smart Transmitter Interface command is invalid and cannot be processed.
11	Invalid Channel Number	The Smart Transmitter Interface channel number is invalid. The command cannot be processed.
12	Invalid HART Message	The HART packet encapsulated within a Smart Transmitter Interface packet is invalid and cannot be forwarded to a field device.
13	Invalid Channel List	The channel list provided with the Enable Burst Monitor Mode command contains an invalid entry or is incorrectly terminated. The command cannot be processed.
14	Invalid Parameter	An invalid parameter is provided with the Smart Transmitter Interface command and so it cannot be processed.
15	Invalid Control	An invalid control byte is included with the Smart transmitter Interface command. The command cannot be processed.
16	Invalid DF1 Packet Length	The length of the DF1 packet is not consistent with the length specification in that packet. The command cannot be processed.
Device Errors		
20	Burst Mode Device Not Communicating	The Smart Transmitter Interface is not receiving burst data from a field device in burst mode. Either Burst mode has been turned off in the field device or it is too busy to send burst table data. The error code is cleared once the Smart Transmitter Interface receives new burst data from the device.
21	No Response Received From Device	The Smart Transmitter Interface has not received a response from a field device after exhausting all retry attempts.
22	No Valid Burst Data	The Smart Transmitter Interface does not have data in its Burst Monitor Table for the requested channel. Either the Smart Transmitter Interface was not commanded to monitor the channel for burst data, or the field device is not in burst mode.

Smart Transmitter Interface Data

Certain Smart Transmitter Interface commands require this extended data field to provide additional data to the host processor. When not required this field is not sent by the Smart Transmitter Interface.

Valid Smart Transmitter Interface Commands and Responses

Table 4.G summarizes the valid combinations of Smart Transmitter Interface commands you can send via the programmable controller or host computer to the Smart Transmitter Interface.

Table 4.G
Valid Command Combinations

Command	Smart Transmitter Interface Command (hex)	Smart Transmitter Interface Channel (hex)	Smart Transmitter Interface Parameter (hex)	Smart Transmitter Interface Data
General Commands				
No Operation	00	00	00	Not required
Enable Poll and Response Mode	01	FF	00	Not required
Enable Burst Monitor Mode	02	FF	00	List of burst channels
Device Commands				
Send Message to Device	10	00 - 1F	Set bit 0 for no BTR Response Delay	HART poll
Read Burst Data	11	00 - 1F	00	Not required
Setting Commands				
Set Number of Preambles	20	00 - 1F, FF	02 - 20	Not required
Set Number of Retries	21	00 - 1F, FF	00 - 0F	Not required
Diagnostic Commands				
Read Status and Statistics	30	00 - 1F, FF	00	Not required
Reset Statistics Counters	31	FF	00	Not required
Read ID	32	FF	00	Not required

No Operation (hexadecimal command 00)

The Smart Transmitter Interface performs "no operation" when it receives this command. Use it to simplify your programmable controller ladder logic by issuing BTWs and BTRs in pairs, and using this command when no specific information is required from the Smart Transmitter Interface. When the programmable controller requests a BTR response after the BTW sending hexadecimal command 00, the Smart Transmitter Interface responds with "No Error".

Enable Poll and Response Mode (hexadecimal command 01)

This command puts the Smart Transmitter Interface into Poll and Response mode. Data from any bursting HART field devices is ignored in this mode.

Enable Burst Monitor Mode (hexadecimal command 02)

This command puts the Smart Transmitter Interface into Burst Monitor mode. In this mode the Smart Transmitter Interface monitors the channels specified in the Smart Transmitter Interface Data field, for bursting data. For example, if hexadecimal channels 05, 07 and 1E are to be monitored, then the Smart Transmitter Interface Data field should contain the four bytes: "05 07 1E FF". The channel list must be terminated with hexadecimal FF. You must still set each of the HART field devices into burst mode before any Burst Data packets can be received by the Smart Transmitter Interface.

When the Smart Transmitter Interface is monitoring the bursting field devices in a "round-robin" fashion, the received data is placed into the Burst Data table. You can access this data by sending a Read Burst Data command (hexadecimal 11) to the Smart Transmitter Interface.

Send Message to Device (hexadecimal command 10)

Use this command to send a HART poll to a field device on the specified channel. The HART poll is placed in the Smart Transmitter Interface Data field. The Smart Transmitter Interface returns field device responses as data in a BTR or DF1 Response. The field device response is passed on as is except for the leading preambles, which are removed.

The field device response may not be available for several hundred milliseconds, so if you wish an immediate response to a BTR, set bit 0 of the Smart Transmitter Interface Parameter field. The Smart Transmitter Interface will then respond immediately to a BTR with either a HART field device response, if available, or a Smart Transmitter Interface Error Code hexadecimal 03. This error code indicates that the Smart Transmitter Interface is still attempting to obtain the field device response. When the programmable controller receives a Smart Transmitter Interface Error Code hexadecimal 03, it should retry the BTR until either the field device response is available or a communications failure is reported.

Your host computer cannot use bit 0 of the Smart Transmitter Interface Parameter field in the above fashion. Rather, the host computer should wait until either the field device responds or a communications failure occurs. In either case, the Smart Transmitter Interface will send a response message to the host computer as specified by the DF1 protocol.

Read Burst Data (hexadecimal command 11)

Use this command to read HART burst data from the Burst Data table. This table contains the latest data available from the bursting device on the specified channel. Send the command via a BTW or DF1 packet. The data is returned in the next BTR or DF1 packet.

The Smart Transmitter Interface Data field in the response will contain a HART Burst Data packet. If the Smart Transmitter Interface fails to receive data from a bursting device it returns Smart Transmitter Interface Error code hexadecimal 20 along with the response. If the data is not available in the channel table because burst data has never been received for this channel, then Smart Transmitter Interface returns Error code hexadecimal 22 in the response.

Set Number of Preambles (hexadecimal command 20)

Use this command to set the number of preambles transmitted by the Smart Transmitter Interface before sending a HART poll to a field device. The default number of preambles is 10, but some devices require fewer and others require additional preambles to operate reliably. Use as few as possible: the communications bandwidth to a field device increases if you reduce this number. The number of preambles from (2 to 32) for the specified channel is defined in the Smart Transmitter Interface Parameter field. If the specified channel is hexadecimal FF, then the number of preambles for all 32 channels is changed to the number in the Smart Transmitter Interface Parameter field.

Set Number of Retries (hexadecimal command 21)

Use this command to set the number of retries (from 0 to 15) the Smart Transmitter Interface attempts for a specified channel when a field device fails to respond to the initial HART Poll command. The default number of retries is 3. The number of retries is specified in the Smart Transmitter Interface Parameter field of the header. Placing hexadecimal FF in the Smart Transmitter Interface Channel field results in the specified number of retries being assigned to every channel.

Read Status and Statistics (hexadecimal command 30)

Use this command to request that the Smart Transmitter Interface return data containing status and statistics for the specified channel. Table 4.H illustrates the format of this information in the Smart Transmitter Interface Data field. If the specified channel is hexadecimal FF, then data for the Smart Transmitter Interface is returned in the Smart Transmitter Interface Data field formatted as in Table 4.I. Either response is returned to the programmable controller via the next BTR, or to a host computer via a DF1 Response.

Reset Statistics Counters (hexadecimal command 31)

Use this command to direct the Smart Transmitter Interface to reset all the statistics counters to 0, so that the counters can be initialized to known values.

Read ID (hexadecimal command 32)

Use this command to direct the Smart Transmitter Interface to return a data packet containing an ID code. The programmable controller can access this data on the next BTR issued, while a host computer will receive this response as specified by the DF1 protocol. Table 4.J shows the response format.

Table 4.H
Response to Read Channel Status and Statistics

Byte	Description
1	Channel status Bit #0 - 0 = channel not in Burst Monitor Mode scan list 1 = channel in Burst Monitor Mode scan list Bit #1 - 0 = last attempt to poll field device was successful 1 = last attempt to poll field device including retries failed Bits #2 - #7 - reserved
2	Reserved and set to 0
3	Number of preambles for channel
4	Number of retries for channel
5, 6	Number of messages transmitted on this channel including retries Byte 5 - low byte Byte 6 - high byte
7, 8	Number of messages received on this channel Byte 7 - low byte Byte 8 - high byte
9, 10	Number of time-outs on this channel Byte 9 - low byte Byte 10 - high byte
11, 12	Number of invalid messages received on this channel Byte 11 - low byte Byte 12 - high byte
13, 14	Reserved
15, 16	Reserved

Table 4.I
Response to Read Module Status and Statistics

Byte	Description
1	Smart Transmitter Interface Status Bits 0,1 - Smart Transmitter Interface Mode 00 = Poll and Response Mode 01 = Burst Monitor Mode 10 - Reserved 11 = Reserved Bit 2 - RAM Test 0 = passed 1 = failed Bit 3 - ROM Test 0 = passed 1 = failed Bits 4-7 - Reserved
2	Reserved
3, 4, 5, 6	Device communication status with 1 bit per channel 0 = last attempt to poll field device was successful 1 = last attempt to poll field device including retries failed Byte 3 - Bit #7 = Channel 32 ... Bit #0 = Channel 25 Byte 4 - Bit #7 = Channel 24 ... Bit #0 = Channel 17 Byte 5 - Bit #7 = Channel 16 ... Bit #0 = Channel 9 Byte 6 - Bit #7 = Channel 8 ... Bit #0 = Channel 1
7, 8, 9, 10	Channel in Burst Monitor Mode scan list with 1 bit per channel 0 = channel not in scan list 1 = channel in scan list Byte 7 - Bit #7 = Channel 32 ... Bit #0 = Channel 25 Byte 8 - Bit #7 = Channel 24 ... Bit #0 = Channel 17 Byte 9 - Bit #7 = Channel 16 ... Bit #0 = Channel 9 Byte 10 - Bit #7 = Channel 8 ... Bit #0 = Channel 1
11, 12	Number of BTW requests received on RIO link Byte 11 - low byte Byte 12 - high byte
13, 14	Number of BTW data blocks received from programmable controller Byte 13 - low byte Byte 14 - high byte
15, 16	Number of BTW data blocks received via pass-through of programmable controller Byte 15 - low byte Byte 16 - high byte
17 - 42	Reserved

**Table 4.J
Response to Read ID Command**

Data Byte	description	Status reply
1	Mode/Status Byte	00 (No Modes)
2	Interface/Processor Type	EE (Extended)
3	Extended Interface Type	34 DF1 on RS-232 in Full Duplex mode 36 DF1 on RS-232 in Half Duplex mode
4	Extended Processor Type	57
5	Series/Revision Bits 0-4: Bits 5-7:	 0 = Revision A 1 = Revision B, etc. 0 = Series A 1 = Series B, etc.
6 - 16	Bulletin Name (in ASCII)	"1770-HT1 "
17 - 24	Reserved	0

Programmable Controller Communication with HART Field Devices

Programmable Logic Controllers communicate with HART field devices using block transfers over the RIO link to the Smart Transmitter Interface. Commands are sent in the form of a Block Transfer Write (BTW), while responses are received via a Block Transfer Read (BTR).

The Smart Transmitter Interface expects BTWs and BTRs in pairs with the BTW preceding the BTR. If the Smart Transmitter Interface receives a BTR without a preceding BTW, it will return a Smart Transmitter Interface Error Code hexadecimal 02 (see Table 4.F). The one exception occurs when the programmable controller specifically indicates that no response is required. To do this, set bit 6 of the Smart Transmitter Interface Control byte (see Figure 4.8). In this case, the next transfer should be another BTW.

You must program the programmable controller to execute the BTW and BTR instructions to transfer data between the programmable controller and the HART field device. You can fix both the BTW and BTR data file lengths at the largest values required by your application because the Smart Transmitter Interface does not interpret extra BTW data and pads out BTR data blocks with zeros. Figure 4.10 and Table 4.K show an example PLC-5 ladder logic program with its required data files.

Figure 4.10
Example PLC-5 Ladder Logic

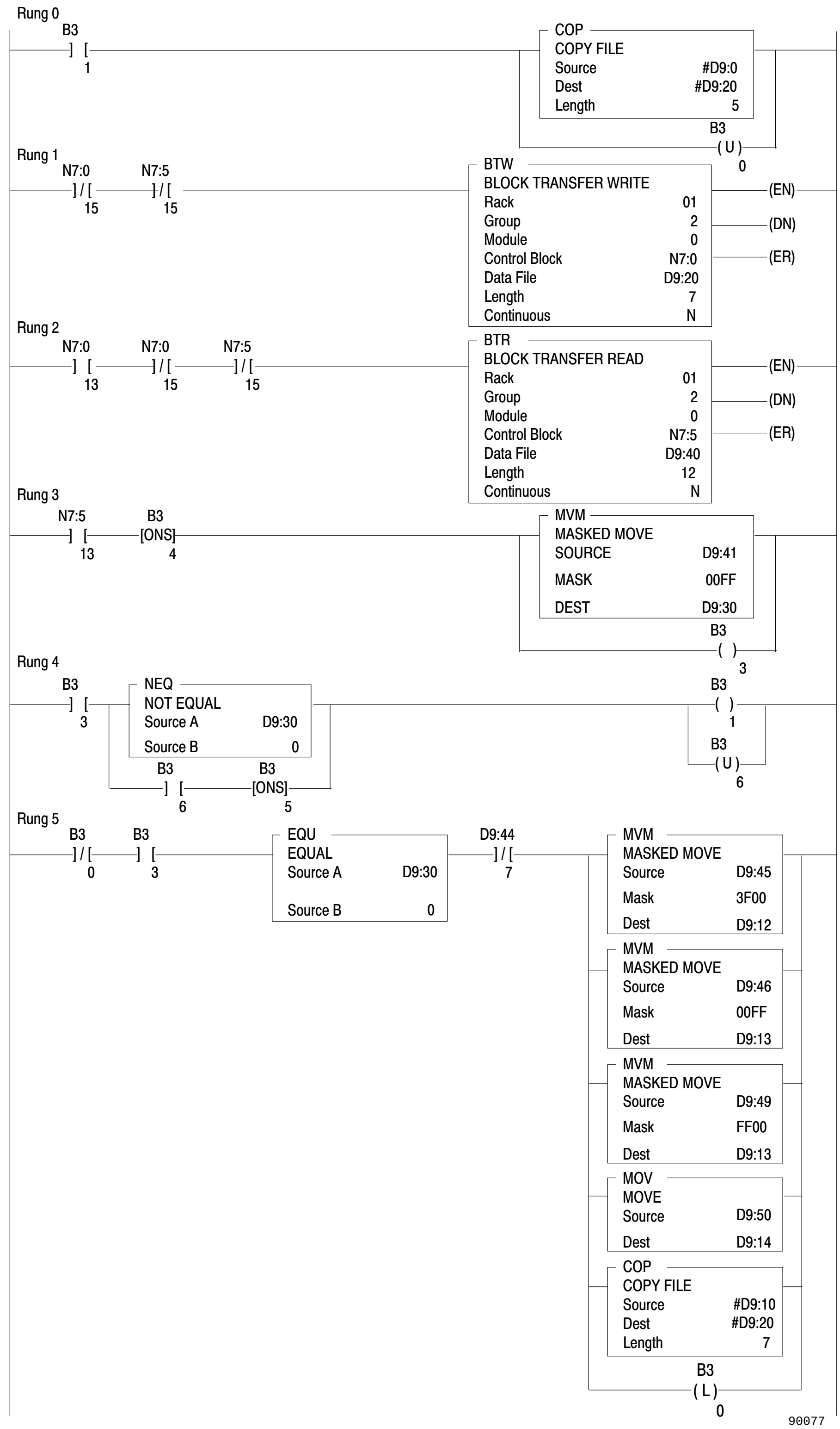


Table 4.K
PLC-5 Data Tables for Example Program

Address	15	Data		0
B3:0	0000	0000	0000	0000

Address	0	1	2	3	4	5	6	7	8	9
D9:00	0110	0000	8002	0000	0000	0000	0000	0000	0000	0000
D9:10	0110	0000	8082	0000	0000	0001	0000	0000	0000	0000
D9:20	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
D9:30	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
D9:40	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
D9:50	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000

ATTENTION: The BTR command must have a data file length between 1 and 63. Zero is reserved for hosts on the Data Highway Plus which use the pass through functionality of the programmable controller.

This program assumes that the Smart Transmitter Interface is configured for rack 1, group 2 and the HART field device is connected to channel 2 of the Terminal Block. HART command #0 is first sent to a field device to obtain its long frame address. Then the program continually sends HART command #1 to the field device and obtains its response. If the Smart Transmitter Interface returns a non-zero error code in the Smart Transmitter Interface Error Code, the PLC-5 program sends HART command #0 and repeats the above cycle. You can also force the programmable controller to resend HART command #0 by clearing bit B3:0.

The rungs in Figure 4.10 perform the following functions:

- Rung 0: Sets up the BTW data for a short frame HART command #0 and clears B3:0 to indicate that the long frame address must be initialized.
- Rung 1: Performs the BTW if no previous BTW or BTR is active.
- Rung 2: Performs the BTR if no previous BTW or BTR is active and if the BTW is completed.
- Rung 3: Moves the Smart Transmitter Interface Error Code received from the Smart Transmitter Interface to D9:30 and sets B3:3 to indicate that the data received in the BTR is valid.

- Rung 4: Sets B3:1 if a non-zero error code was received from the Smart Transmitter Interface. This forces rung 0 to be true on the next scan so that HART command #0 will be sent to the field device. A check is also made on B3:6 which you can set if you wish to restart the cycle by sending HART command #0 to the field device.

- Rung 5: Checks that all data is valid and if so sets up the HART command #1 using the response to HART command #0 to determine the long frame address. Bit B3:0 is also set to indicate that the long frame address is initialized.

Table 4.L and Table 4.M illustrate BTW data for HART command #0, while Table 4.N and Table 4.O show the response received as BTR data. Table 4.P through Table 4.S illustrate the data for HART command #1.

Table 4.L
Programmable Controller to Smart Transmitter Interface - BTW Data Short Frame Format for HART Command 0

Octal Bits	17	16	15	14	13	12	11	10	07	06	05	04	03	02	01	00
Decimal Bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Word 00	Smart Transmitter Interface Channel Number								Smart Transmitter Interface Command							
Word 01	Smart Transmitter Interface Parameter								Smart Transmitter Interface Control							
Word 02	HART Address								HART Delimiter							
	Mas Adr	0	Logical Address		Slave Address				Lng Frm	0	0	0	0	Frame Type		
Word 03	Byte Count								HART Command							
Word 04	0	0	0	0	0	0	0	0	Check Byte							

Table 4.M
Example BTW Data Offset at D9:00 - Short Frame Format for HART Command 0

Address	0	1	2	3	4
D9:00	0110	0000	8002	0000	0000

Short Frame Word Contents - Programmable Controller to Smart Transmitter Interface (Offset at D9:00)

- Word 00: Smart Transmitter Interface command hexadecimal 10 (low byte); Smart Transmitter Interface channel hexadecimal 01 (high byte).

- Word 01: Smart Transmitter Interface control hexadecimal 00 indicating a response is required from the Smart Transmitter Interface (low byte); Smart Transmitter Interface parameter hexadecimal 00 (high byte).
- Word 02: HART delimiter hexadecimal 02 indicating an STX frame with a short frame address (low byte); HART short frame address hexadecimal 80 indicating primary master, and logical and slave addresses 0 (high byte).
- Word 03: HART command hexadecimal 00 (low byte); HART packet byte count of hexadecimal 00 (high byte).
- Word 04: HART packet check byte set to 0 (low byte); zero padding (high byte).

Table 4.N
Smart Transmitter Interface to Programmable Controller - BTR Data Short Frame Format for Response to Hart Command 0

Octal Bits	17	16	15	14	13	12	11	10	07	06	05	04	03	02	01	00
Decimal Bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Word 00	Smart Transmitter Interface Channel Number								Smart Transmitter Interface Command							
Word 01	Smart Transmitter Interface Status								Smart Transmitter Interface Error Code							
Word 02	HART Address								HART Delimiter							
	Mas Adr	Bur Mde	Logical Address		Slave Address				Lng Frm	0	0	0	0	Frame Type		
Word 03	Byte Count								HART Command							
Word 04	HART Response Code															
	Second Byte Count								First Byte							
Word 05	Manufacturer Identification Code								1	1	1	1	1	1	1	0
Word 06	Number of Preambles								Manufacturer's Device Type Code							
Word 07	Transmitter Specific Revision								Universal Command Revision							
Word 08	Hardware Revision								Software Revision							
Word 09	Device ID (Most Significant Byte)								Flags							
Word 10	Device ID (Least Significant Byte)								Device ID Middle Byte							
Word 11	0	0	0	0	0	0	0	0	Check Byte							

Table 4.O
Example BTR Data Offset at D9:40 - Short Frame Format for HART Command 0

Address	0	1	2	3	4	5	6	7	8	9
D9:40	0110	8000	8006	0E00	0000	26FE	060D	0205	5001	0000
D9:50	1115	0009								

Short Frame Word Contents - Smart Transmitter Interface to Programmable Controller (Offset at D9:40)

- Word 00: Smart Transmitter Interface command is hexadecimal 10 (low byte); Smart Transmitter Interface channel is hexadecimal 01 (high byte).

- Word 01: Smart Transmitter Interface error code is hexadecimal 00 indicating no errors (low byte); Smart Transmitter Interface status is hexadecimal 80 indicating the Smart Transmitter Interface has been reset (high byte).

- Word 02: HART delimiter is hexadecimal 06 indicating an ACK frame with a short frame address (low byte); HART short frame address is hexadecimal 80 indicating primary master, burst mode disabled, logical and slave address of 0 (high byte).

- Word 03: HART command is hexadecimal 00 (low byte); HART packet byte count is hexadecimal 0E indicating 14 bytes of data between this byte count and the check byte (high byte).

- Word 04: first byte of HART response code is hexadecimal 00 indicating no communications errors (low byte); second byte of HART response code is hexadecimal 00 indicating no device errors (high byte).

- Word 05: Hexadecimal FE (low byte); Manufacturer's Identification code hexadecimal 26 for Rosemount (high byte).

- Word 06: Manufacturer's device type code is hexadecimal 0D for a 3044C temperature transmitter (low byte); minimum number of preambles required by the device is hexadecimal 06 (high byte).

- Word 07: Revision Level of the Universal Command Document implemented in this device is hexadecimal 05 (low byte); revision level of the Transmitter-Specific Document implemented in this device is hexadecimal 02 (high byte).

- Word 08: Software revision level of this device is hexadecimal 01 (low byte); hardware revision level of this device is hexadecimal 50 (high byte).

- Word 09: HART hexadecimal flag assignment is 00 (low byte); most significant byte of 24 bit device identification number is hexadecimal 00 (high byte).
- Word 10: middle byte of 24 bit device identification number is hexadecimal 15 (low byte); least significant byte is hexadecimal 11 (high byte). The 24 bit device ID is hexadecimal 001511.
- Word 11: HART packet check byte received is hexadecimal 09 (low byte); zero padding (high byte).

Table 4.P
Programmable Controller to Smart Transmitter Interface - BTW Data Long Frame Format for HART Command 1

Octal Bits	17	16	15	14	13	12	11	10	07	06	05	04	03	02	01	00
Decimal Bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Word 00	Smart Transmitter Interface Channel Number								Smart Transmitter Interface Command							
Word 01	Smart Transmitter Interface Parameter								Smart Transmitter Interface Control							
Word 02	HART Address								HART Delimiter							
	Mas Adr	0	Manufacturer Identification Code						Lng Frm	0	0	0	0	Frame Type		
Word 03	Device ID (Most Significant Byte)								Manufacturer's Device Type							
Word 04	Device ID (Least Significant Byte)								Device ID (Middle Byte)							
Word 05	Byte Count								HART Command							
Word 06	0	0	0	0	0	0	0	0	Check Byte							

Table 4.Q
Example BTW Data Offset at D9:10 - Long Frame Format for HART Command 1

Address	0	1	2	3	4	5	6
D9:10	0110	0000	A682	000D	1115	0001	0000

Long Frame Word Contents - Programmable Controller to Smart Transmitter Interface (Offset at D9:10)

- Word 00: Smart Transmitter Interface Command is hexadecimal 10 (low byte); Smart Transmitter Interface Channel is hexadecimal 01 (high byte).

- Word 01: Smart Transmitter Interface Control is hexadecimal 00 indicating a response is required from the Smart Transmitter Interface (low byte); Smart Transmitter Interface Parameter is hexadecimal 00 (high byte).
- Word 02: HART delimiter is hexadecimal 82 indicating an STX frame with a long frame address (low byte); HART long frame address is hexadecimal A6 indicating primary master, and a manufacturer's identification code of hexadecimal 26 for Rosemount (high byte).
- Word 03: Manufacturer's device type code is hexadecimal 0D for a 3044C temperature transmitter (low byte); most significant byte of 24 bit device identification number is hexadecimal 00 (high byte).
- Word 04: middle byte of 24 bit device identification number is hexadecimal 15 (low byte); least significant byte is hexadecimal 11 (high byte).
- Word 05: HART command is hexadecimal 01 (low byte); HART packet byte count is hexadecimal 00 (high byte).
- Word 06: HART packet check byte set to 0 (low byte); zero padding (high byte).

Table 4.R
Smart Transmitter Interface to Programmable Controller- BTR Data Long Frame Format for Response to HART Command 1

Octal Bits	17	16	15	14	13	12	11	10	07	06	05	04	03	02	01	00
Decimal Bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Word 00	Smart Transmitter Interface Channel Number								Smart Transmitter Interface Command							
Word 01	Smart Transmitter Interface Status								Smart Transmitter Interface Error Code							
Word 02	HART Address								HART Delimiter							
	Mas Adr	Bur Mde	Manufacturer Identification Code						Lng Frm	0	0	0	0	Frame Type		
Word 03	Device ID (Most Significant Byte)								Manufacturer's Device Type							
Word 04	Device ID (Least Significant Byte)								Device ID (Middle Byte)							
Word 05	Byte Count								HART Command							
Word 06	HART Response Code															
	Second Byte								First Byte							
Word 07	Primary Variable (Most Significant Byte)								Primary Variable Units							
Word 08	Primary Variable (3rd Most Significant Byte)								Primary Variable (2nd Most Significant Byte)							
Word 09	Check Byte								Primary Variable (Least Significant Byte)							

Table 4.S
Example BTR Data Offset at D9:40 - Long Frame Format for HART 1 Command

Address	0	1	2	3	4	5	6	7	8	9
D9:40	0110	8000	A686	000D	1115	0701	0000	4220	3991	B356

Long Frame Word Contents - Smart Transmitter Interface to Programmable Controller (Offset at D9:40)

- Word 00: Smart Transmitter Interface Command is hexadecimal 10 (low byte); Smart Transmitter Interface Channel is hexadecimal 01 (high byte).
- Word 01: Smart Transmitter Interface Error Code is hexadecimal 00 indicating no errors (low byte); Smart Transmitter Interface Status is hexadecimal 80 indicating the Smart Transmitter Interface has been reset (high byte).

- Word 02: HART delimiter is hexadecimal 86 indicating an ACK frame with a long frame address (low byte); HART long frame address is hexadecimal A6 indicating primary master, burst mode disabled, and the manufacturer's identification code of hexadecimal 26 for Rosemount (high byte).
- Word 03: manufacturer's device type code is hexadecimal 0D for a 3044C temperature transmitter (low byte); most significant byte of 24 bit device identification number is hexadecimal 00 (high byte).
- Word 04: middle byte of 24 bit device identification number is hexadecimal 15 (low byte); least significant byte is hexadecimal 11 (high byte).
- Word 05: HART command is hexadecimal 01 (low byte); HART packet byte count is hexadecimal 07 indicating 7 bytes of data between this byte count and the check byte (high byte).
- Word 06: first byte of HART response code is hexadecimal 00 indicating no communications errors (low byte); second byte of HART response code is hexadecimal 00 indicating no device errors.
- Word 07: primary variable units are hexadecimal 20 for degrees Celsius (low byte); most significant byte of IEEE 754 primary variable is hexadecimal 42 (high byte).
- Word 08: second most significant byte of IEEE 754 primary variable is hexadecimal 91 (low byte); third most significant byte of IEEE 754 primary variable is hexadecimal 39 (high byte).
- Word 09: least significant byte of IEEE 754 primary variable is hexadecimal 56 (low byte); HART packet check byte received is hexadecimal B3 (high byte).

Serial Communication with the Smart Transmitter Interface

Serial communication between an RS-232C host and the Smart Transmitter Interface is carried out using Allen-Bradley's proprietary DF1 protocol. DF1 is a full or half duplex protocol designed to carry messages intact over a link. The protocol delimits messages, detects and signals errors, retries after errors and controls message flow.

In a typical network as discussed in this manual, the host computer is the master station and the Smart Transmitter Interface is the slave.

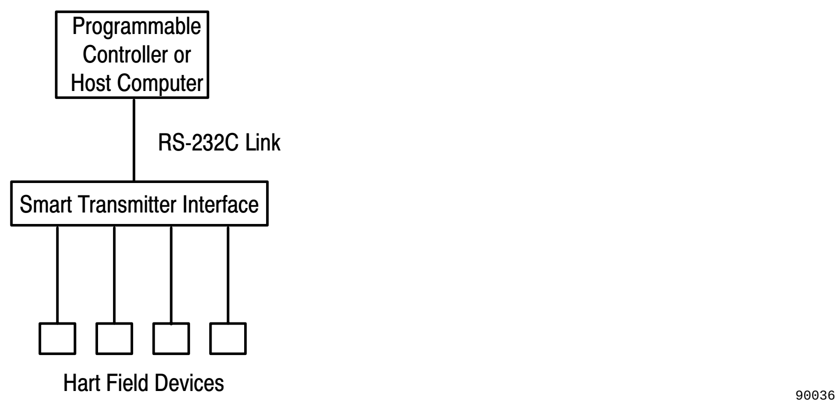
For a complete description of the DF1 protocol, you should see the Data Highway/Data Highway Plus/DH-458 Protocol and Command Set Manual.

Full Duplex

Full duplex protocol:

- is a direct link that allows simultaneous two-way transmission
- requires a system programmer to use interrupts and multi-tasking techniques
- is intended for high performance applications where maximum data throughput is necessary
- gives faster data throughput than half duplex, but is more difficult to implement

Figure 4.11
Full Duplex Network



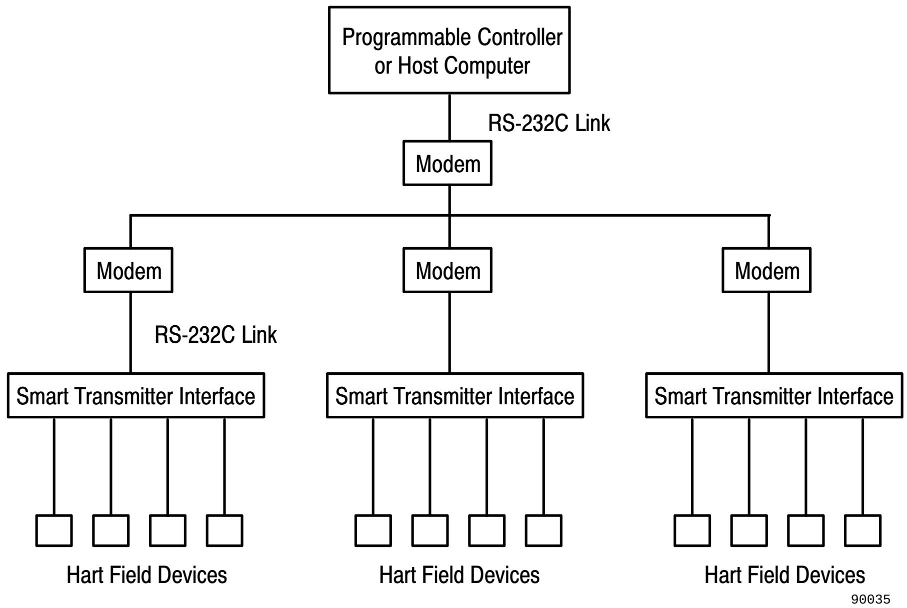
Half Duplex

Half duplex protocol:

- is a protocol for one host processor and one or more field devices. (You must use modems if there is more than one Smart Transmitter Interface).
- allows only one host processor or field device to transmit at any one time
- provides a less effective utilization of resources than full duplex, but is easier to implement

Half duplex protocol can be used on a point-to-point link, but more usually operates on a link with all nodes interfaced through half duplex modems. There may be from 0 to 63 decimal nodes simultaneously connected to a single link.

Figure 4.12
Half Duplex Network



One node is designated as the master, and controls which node has access to the link. All other nodes are slaves and must wait for permission from the master before transmitting. In the Smart Transmitter Interface network, the host computer is the master and the Smart Transmitter Interface is the slave.

With half duplex protocol, you can use:

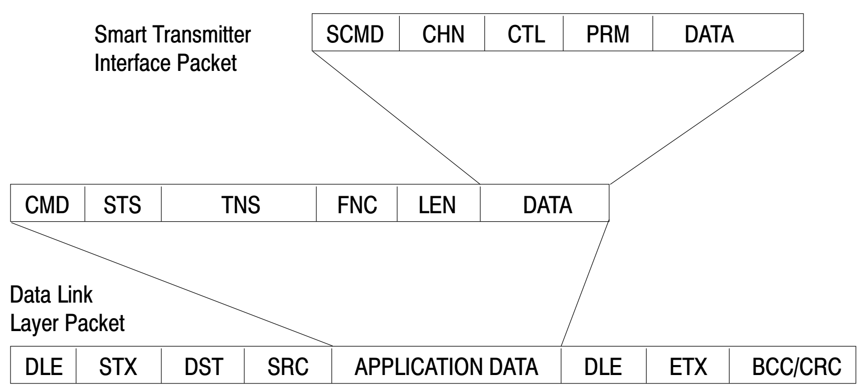
- a two-circuit system - the master sends and slaves receive on one circuit, slave send and master receives on the other
- a one-circuit system - master and slaves send and receive on the same circuit

DF1 Packet Formation

In full duplex mode, the host computer and Smart Transmitter Interface can transmit and receive simultaneously. Once the Smart Transmitter Interface receives a command, it can send the response to the host as soon as it is available, without waiting for the host to request the response with a separate command. Figure 4.13 and Figure 4.14 illustrate the format and give an example of a full duplex DF1 command.

In half duplex mode, the master station controls which station can transmit. The master station must also issue poll requests to the Smart Transmitter Interface before the Smart Transmitter Interface will send a response. Figure 4.15 and Figure 4.16 illustrate the format and an example of a half duplex DF1 Command.

Figure 4.13
Full Duplex DF1 Packet sent by a Host Computer to the Smart Transmitter Interface



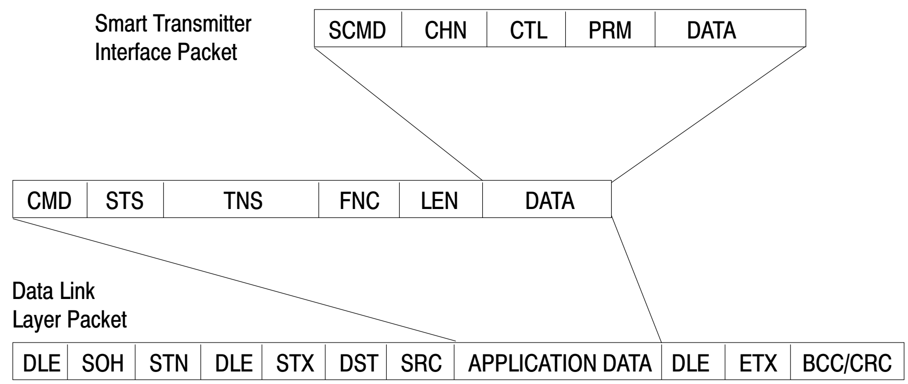
Since message is from host to Smart Transmitter Interface
- DLE = data link escape control character (“10” hex)
- STX = start of text control character (“02” hex)
- DST = Smart Transmitter Interface station address in hexadecimal
- SRC = host station address in hexadecimal
- CMD = “OF” hexadecimal
- STS = Status byte
- TNS = transaction number (2 bytes)
- FNC = “95” hexadecimal
- LEN = length of Smart Transmitter Interface Packet in bytes
- SCMD = Smart Transmitter Interface Command
- CHN = Smart Transmitter Interface Channel
- CTL = Smart Transmitter Interface Control
- PRM = Smart Transmitter Interface Parameter
- ETX = end of text control character (“04” hex)
- BCC/CRC = Block Check or CRC bytes

9007

Figure 4.14
Example Full Duplex DF1 Command - Enable Poll and Response Mode

DLE	STX	DST	SRC	CMD	STS	TNS		FNC	LEN	Smart Transmitter Interface Packet				DLE	ETX	BCC
10	02			OF	00			95	04	01	FF	00	00	10	03	

Figure 4.15
Half Duplex DF1 Packet sent by a Host Computer to the Smart Transmitter Interface



Since message is from host to Smart Transmitter Interface
- DLE = data link escape control character (“10” hex)
- SOH = start of header control character (“01” hex)
- STN = Smart Transmitter Interface station address in hexadecimal
- STX = start of text control character (“02 hex”)
- DST = Smart Transmittter Interface station address in hexadecimal
- SRC = host station address in hexadecimal
- CMD = “OF” hexadecimal
- STS = status byte
- TNS = tranxaction number (2 bytes)
- FNC = “95” hexadecimal
- LEN = length of Smart Transmitter Interface Packet in bytes
- SCMD = Smart Transmitter Interface Command
- CHN = Smart Transmitter Interface Channel
- CTL = Smart Transmitter Interface Control
- PRM = Smart Transmitter Interface Parameter
- ETX = end of text control character (“03” hex)
- BCC/CRC = Block Check or CRC bytes

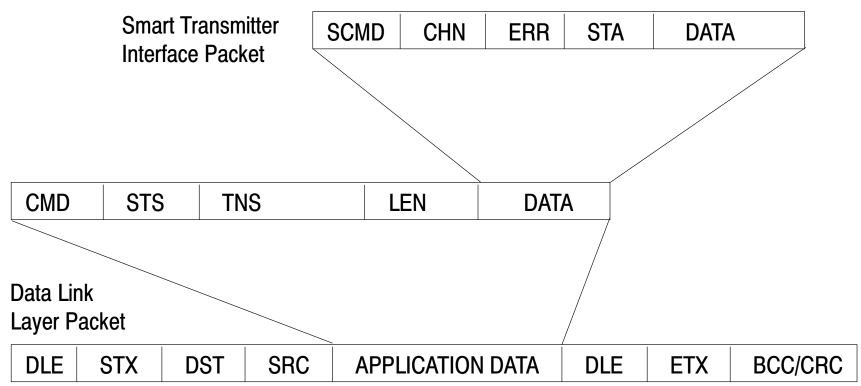
90079

Figure 4.16
Example Half Duplex DF1 Command - Enable Poll and Response Mode

DLE	SOH	STN	DLE	STX	DST	SRC	CMD	STS	TNS		FNC	LEN	Smart Transmitter Interface Packet				DLE	ETX	BCC
10	01		10	02			0F	00			95	04	01	FF	00	00	10	03	

In both full duplex and half duplex mode the DF1 responses from the Smart Transmitter Interface are identical. These responses are sent immediately by the Smart Transmitter Interface in full duplex mode. However, in half duplex mode the host must first send a poll to the Smart Transmitter Interface before it will send the DF1 Response. Figure 4.17 and Figure 4.18 illustrate the format and an example of these responses.

Figure 4.17
DF1 Packet sent by the Smart Transmitter Interface to a Host Computer



Since message is from host to Smart Transmitter Interface

- DLE = data link escape control character (“10” hex)
- STX = start of text control character (”02”hex)
- DST = host station address in hexadecimal
- SRC = Smart Transmitter Interface station address in hexadecimal
- CMD = “4F” hexadecimal
- STS = status byte
- TNS = transaction number (2 bytes)
- LEN = length of Smart Transmitter Interface Packet in bytes
- SCMD = Smart Transmitter Interface Command
- CHN = Smart Transmitter Interface Channel
- ERR = Smart Transmitter Interface Error Code
- STA = Smart Transmitter Interface Status
- ETX = end of text control character (“03” hex)
- BCC/CRC = Block Check or CRC bytes

90080

Figure 4.18
DF1 Response - Enable Poll and Response Mode

DLE	STX	DST	SRC	CMD	STS	TNS		LEN	Smart Transmitter Interface Packet				DLE	ETX	BCC
10	02			4F	00			04	01	FF	00	00	10	03	

Command 0F with FNC 95 and command 06 as described in Appendix B are the only commands supported by the Smart Transmitter Interface.

Consult the Data Highway/Data Highway Plus/DH-485 Protocol and Command Set Manual for the additional information required to successfully implement both full and half duplex communications with the Smart Transmitter Interface.

Data Highway Plus and the Smart Transmitter Interface

The Smart Transmitter Interface supports one Data Highway Plus host using the pass-through functionality supported by some Allen-Bradley programmable controllers. This host requires using proprietary Allen-Bradley Interchange Software. For further information on using the Smart Transmitter Interface with such a host, you should contact your Allen-Bradley representative.

Chapter 5

Troubleshooting

To aid in troubleshooting, this chapter tells you how to interpret the indicators (status LEDs and seven-segment LED displays) on the Communications Controller (1770-HT1) and the Terminal Blocks (1770-HT8/16).

If you are unable to save new configurations successfully, the left display will display hardware fault 6, and the Fault LED on the front will light up. This indicates a malfunction in the module. If the displays show symbols other than those shown in this chapter, this also indicates that the module is malfunctioning. In both cases contact your A-B representative.

Interpreting the Terminal Block LEDs

The LEDs on the front panel of the Terminal Blocks can help you diagnose problems during installation and operation.

Table 5.A
Terminal Block LED Indicators

LED:	State	Probable Cause	Recommended Action
LOOP POWER (green)*	ON	Normal operation	None
	OFF	No power	Replace fuse if blown Ensure wiring to power connector is correct
	FLASHING	Intermittent contact	Inspect power connector wiring for loose wire
BOARD SELECTED (green)	ON	Normal operation	None (will light up when any channel on the board is being addressed by the Communications Controller; default address on powerup is logical address #1)
	OFF	Not selected	None**

* Depends upon a loop power supply being connected to the Terminal Block.

**If communicating but the light is off, check the wiring between the Communications Controller and the Terminal Block.

Interpreting the Communications Controller Status LEDs

There are five status LEDs on the front panel of the Communications Controller. These indicators can help you diagnose problems with the module's installation and operation.

Table 5.B
Communications Controller LED Indicators

LED:	State	Probable Cause	Recommended Action
POWER (green)	ON	Normal operation	None
	OFF	No power	Replace fuse if blown Ensure wiring to power connector is correct
	FLASHING	Intermittent contact	Inspect power connector wiring for loose wire
RIO (green)	ON	Normal operation	None
	OFF	Remote I/O fault	Ensure wiring to remote connector is correct Verify RIO communication parameter settings (See Chapter 3)
	FLASHING	Not transmitting data	Verify RIO communication parameter settings Ensure only the last logical module in the rack has its Last Module parameter set to Yes Ensure that programmable controller is in RUN mode
RS-232 (green)	FLASHING	Normal operation	None (once you initiate active communications on the RS-232C link, this LED flashes to reflect communication activity)
	OFF	No communication	Check the RS-232C parameters (Table 3.B, parameters 4-8; Table 3.C, and the cable connections and pinouts
HART (green)	FLASHING	Normal operation	None (the Communications Controller is receiving information from the HART field devices)
	OFF	No communication	Replace HART field device if faulty Verify wiring from Communication Controller to Terminal Blocks and from Terminal Blocks to HART field device Ensure power is being supplied to the HART field device Ensure LOOP POWER jumper on the Terminal Block (Jpn) is correctly set Ensure Terminal Block Board Address jumpers are correctly set
FAULT (red)	ON	A fault has been detected	See Table 5.C
	OFF	Normal operation	None

Important: The RS-232 and HART LED indicators always stay off if there is no communication activity on the communication channel.

Interpreting the Communications Controller Numeric Displays

The numeric displays are used to indicate hardware fault conditions. When the fault indicator is lit, the left display will show a number indicating the type of hardware fault. Table 5.C gives a description of the faults.

Table 5.C
Hardware Faults

This number:	Indicates this fault:	Meaning
1	Processor Fault	A hardware fault was detected in the processor. This is a major fault. Return the Communications Controller for servicing.
2	Flash EPROM Fault	The checksum stored in the Flash EPROM does not match the actual checksum for it. This indicates bad cells in the Flash EPROM. This is a major fault. Return the Communications Controller for servicing.
3	RAM Fault	The static RAM cannot be reliably written to. This is a major fault. Return the Communications Controller for servicing.
4	Stuck Button Detected	One or more push buttons are stuck on. This could be caused by a mechanical problem with the buttons, or by an object pressing on the push buttons. If the cause is mechanical, the Communications Controller should be returned for servicing. Otherwise, remove the pressure from the push buttons to clear the fault condition. The Communications Controller will continue to communicate when this fault is detected, but configuration will not be possible.
5	Flash EPROM Write Fault	The Flash EPROM could not be burned correctly during download of new firmware. This is a major fault. Return the Communications Controller for servicing.
6	Serial EEPROM Major Fault	The Smart Transmitter Interface was unable to write the new configuration to the EEPROM. This is a major fault. Return the Communications Controller for servicing.
7	Serial EEPROM Minor Fault	On power up, the Smart Transmitter Interface detected invalid configuration data in the EEPROM. The Smart Transmitter Interface recovered by writing the factory default configuration to the EEPROM. You must power the module off and back on, and then reconfigure it. This is not a major fault, but if the problem persists, return the Communications Controller for servicing.
8	Power Failure	The power supply voltage is below the minimum rating for the Communications Controller. The Communications Controller will continue to communicate when this fault is detected, but configuration will not be possible.
9	Remote I/O Fault	A hardware fault was detected in the Remote I/O Interface. This is a major fault. Return the Communications Controller for servicing.

Appendix A

Product Specifications

Communications Controller (1770-HT1)

RS-232 Interface

Start Bits	1
Data Bits	8
Parity	None, Even, Odd
Stop Bits	1
Baud Rates	300, 600, 1200, 2400, 4800, 9600, 19200
Connector	DB-25P (male)
Output	RS-232C
Protocol	Allen-Bradley DF1

RIO Interface

Baud Rates	57600, 115200, 230400
Rack Size	1/4 rack
Connector	Phoenix COMBICON header and plug – 3 position
Cable	Standard “blue hose” shielded twisted-pair cable (Belden 9463)
Cable Length	10,000 ft. (3,048 m) - 57.6 kbaud 5,000 ft. (1,524 m) - 115.2 kbaud 2500 ft. (762 m) - 230.4 kbaud
Output	Allen-Bradley RIO
Termination	150 or 82 ohm resistors on last nodes of RIO link (depending on baud rate)
Protocol	Allen-Bradley RIO

Terminal Block (1770-HT8/16) Interface

Channels	supports 32 multiplexed HART 4-20 mA current loops
Connector	Phoenix COMBICON header and plug – 17 position, 12-24 AWG
Cable	maximum 1000 ft. (304.8 m) standard shielded cable with 8 twisted pairs (Belden 9508 or Belden 85168)
Output	24 VDC, differential channel select, differential transmit enable, differential half-duplex HART transmit/receive
Protocol	HART Master Device – Revision 7.1 HART Physical Layer Specification, Revision 7.0 HART Data Link Layer Specification

Electrical

DC Input Voltage	24 VDC $\pm$1% (600 mA maximum load)
Fuse	UL 198G and CSA 22.2, No. 59 rated, 5mm x 20mm, 1.0 Amp., 250V, fast acting
Connector	Phoenix COMBICON header and plug 3 position, 12-24 AWG
Power Consumption	4.8 watts maximum

Physical

Dimensions	4.3” (10.9 cm) wide x 14.0” (35.6 cm) long x 2.7” (6.9 cm) high
Weight	1.8 lb (0.8 kg) approximate
Mounting	DIN rail (EN 50 022 or EN 50 035)

Environmental

Operating temperature	0°C to 60°C (32°F to 140°F)
Storage temperature	–40°C to 60°C (–40°F to 140°F)
Operating humidity	5% to 95% (non-condensing)

8 Channel Terminal Block (1770-HT8)

1770-HT1 Interface

Connector	Phoenix COMBICON header and plug – 17 position, 12-24 AWG
Input	24 VDC, differential channel select signals, differential transmit enable, differential half-duplex HART transmit/receive

4-20 mA Current Loop Interfaces (see Figure A.1)

Channels	eight 4-20 mA current loops
I/O Module Connector	Phoenix COMBICON header and plug 10 position, 1 set, 12-24 AWG
I/O Module Cable Length	30 foot (9 m) maximum between the Terminal Block and the Analog I/O module
Field Device Connector	Phoenix COMBICON header and plug 12 position, 2 sets, 12-24 AWG
Loop Fuses	UL 198G and CSA 22.2, No. 59 rated, 5mm x 20mm, 0.1 Amp., 250V, fast acting

Electrical

DC Input Voltage	24 - 32 VDC for 4-20 mA current loops if required
DC Current	Maximum of 0.2A or as required for all 4-20 mA current loops connected
Fuse	UL 198G and CSA 22.2, No. 59 rated, 5mm x 20mm, 0.25 Amp., 250V, fast acting
Connector	Phoenix COMBICON header and plug 3 position, 12-24 AWG
Power Consumption	4.8 watts maximum or as required for all 4-20 mA current loops connected

Physical

Dimensions	4.3” (10.9 cm) wide x 9.9” (25 cm) long x 2.7” (6.9 cm) high
Weight	1.3 lb (0.6 kg) approximate
Mounting	DIN rail (EN 50 022 or EN 50 035)

Environmental

Operating temperature	0°C to 60°C (32°F to 140°F)
Storage temperature	–40°C to 60°C (–40°F to 140°F)
Operating humidity	5% to 95% (non-condensing)

16 Channel Terminal Block (1770-HT16)

1770-HT1 Interface

Connector	Phoenix COMBICON header and plug – 17 position, 12-24 AWG
Input	24 VDC for control electronics, differential channel select signals, differential transmit enable, differential half-duplex HART transmit/receive

4-20 mA Current Loop Interfaces (see Figure A.1)

Channels	sixteen 4-20 mA current loops
I/O Module Connector	Phoenix COMBICON header and plug 10 position, 2 sets, 12-24 AWG,
I/O Module Cable Length	30 foot (9 m) maximum between the Terminal Block and the Analog I/O module
Field Device Connector	Phoenix COMBICON header and plug 12 position, 4 sets, 12-24 AWG
Loop Fuses	UL 198G and CSA 22.2, No. 59 rated, 5mm x 20mm, 0.1 Amp., 250V, fast acting

Electrical

DC Input Voltage	24 - 32 VDC for 4-20 mA current loops if required
DC Current	Maximum of 0.4A or as required for all 4-20 mA current loops connected
Fuse	UL 198G and CSA 22.2, No. 59 rated, 5mm x 20mm, 0.5 Amp., 250V, fast acting
Connector	Phoenix COMBICON header and plug 3 position – 12-24 AWG
Power Consumption	9.6 watts maximum or as required for all 4-20 mA current loops connected

Physical

Dimensions	4.3” (10.9 cm) wide x 15.5” (39 cm) long x 2.7” (6.9 cm) high
Weight	1.8 lb (0.8 kg) approximate
Mounting	DIN rail (EN 50 022 or EN 50 035)

Environmental

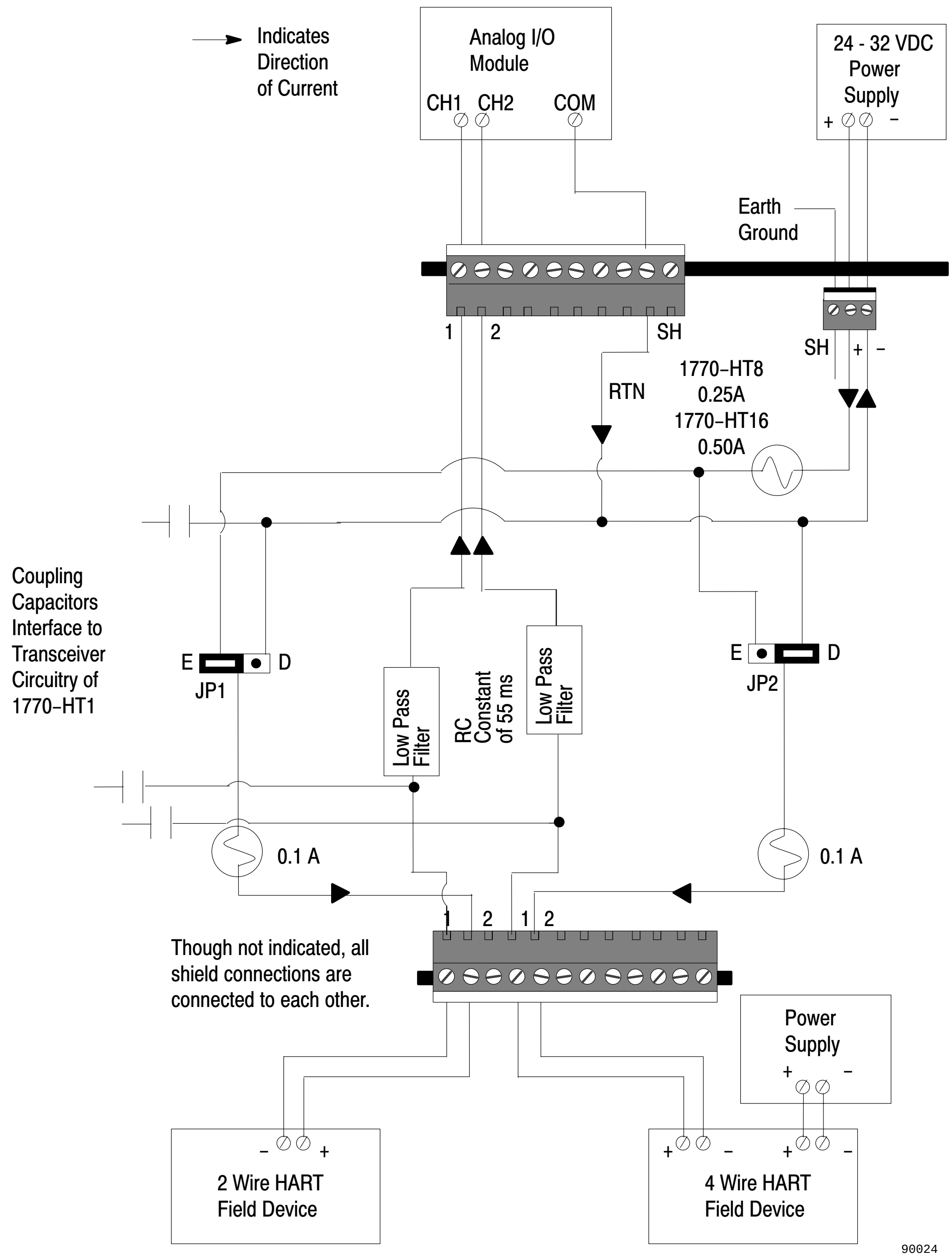
Operating temperature	0°C to 60°C (32°F to 140°F)
Storage temperature	–40°C to 60°C (–40°F to 140°F)
Operating humidity	5% to 95% (non-condensing)

HART Communications Specifications

The communications specifications conform to HART Field Communications protocol.

Method of communication	Frequency Shift Keying (FSK) Bell 202 Modem Standard with respect to baud rate and digital ”1” and ”0” frequencies
Baud rate	1200 bps
Digital ”0” frequency	2200 Hz
Digital ”1” frequency	1200 Hz
Data byte structure	1 start bit, 8 data bits, 1 odd parity bit, 1 stop bit
Maximum multidropped devices	15
Maximum process variable per smart device	256
Maximum communication masters	2

Figure A.1
Loop Power Selection



Appendix B

DF1 Diagnostic Command Support

The information in this appendix deals only with RS-232C DF1 communications, between the host processor and the Communications Controller.

Diagnostic Command Support

The Communications Controller interprets and responds to the following diagnostic commands from the host processor:

Table B.A
Communications Controller Diagnostic Commands

Description	Command Byte	Function Code (hex)
Diagnostic Loop	06	00
Diagnostic Read Counters	06	01
Diagnostic Status	06	03
Reset Diagnostic Counters	06	07

Diagnostic Loop

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

Figure B.1
Diagnostic Loop Command Format

1 byte	1 byte	2 bytes	1 byte	243 bytes max
CMD 06	STS	TNS	FNC 00	DATA

Figure B.2
Diagnostic Loop Reply Format

1 byte	1 byte	2 bytes	243 bytes max
CMD 46	STS	TNS	DATA

Diagnostic Read

This command reads the diagnostic counters from the Communications Controller. The format of these counters is given below. The address and size fields can have any value (but they must be included).

Figure B.3
Diagnostic Read Command Format

1 byte	1 byte	2 bytes	1 byte	2 bytes	1 byte
CMD 06	STS	TNS	FNC 01	ADDR 0000	SIZE 00

Figure B.4
Diagnostic Read Reply Format

1 byte	1 byte	2 bytes	10 bytes
CMD 46	STS	TNS	DATA

Table B.B contains the diagnostic read reply values for the Smart Transmitter Interface:

Table B.B
Diagnostic Read Reply Values

1	Total RS-232C packets received, low byte
2	Total RS-232C packets received, high byte
3	Total RS-232C packets transmitted, low byte
4	Total RS-232C packets transmitted, high byte
5	Number of RS-232C retries
6	Number of RS-232C packets where the retry limit was exceeded
7	Number of RS-232C NAKs sent
8	Number of RS-232C NAKs received
9	Number of RS-232C bad messages received
10	Number of RS-232C line errors

Diagnostic Status

This command requests a block of status information from a RS-232C device. The reply contains the information in its DATA field. The status information varies from device to device. The Communications Controller’s status block is given in Table 4.J.

Figure B.5
Diagnostic Status Command Format

1 byte	1 byte	2 bytes	1 byte
CMD 06	STS	TNS	FNC 03

Figure B.6
Diagnostic Status Reply Format

1 byte	1 byte	2 bytes	24 bytes
CMD 46	STS	TNS	DATA

Diagnostic Counter Reset

This command resets the diagnostic counters listed in Table B.B.

Figure B.7
Diagnostic Counter Reset Command Format

1 byte	1 byte	2 bytes	1 byte
CMD 06	STS	TNS	FNC 07

Figure B.8
Diagnostic Counter Reset Reply Format

1 byte	1 byte	2 bytes
CMD 46	STS	TNS

Appendix C

Cable Length and Power Supply Requirements

This appendix discusses cabling requirements between the Terminal Blocks and the Communications Controller for control signals and 24VDC power, explains how to determine when a separate 24VDC power supply is needed for a Terminal Block and describes how to connect it. It also provides further details about supplying 4-20mA loop power to 2 wire HART field devices from a Terminal Block.

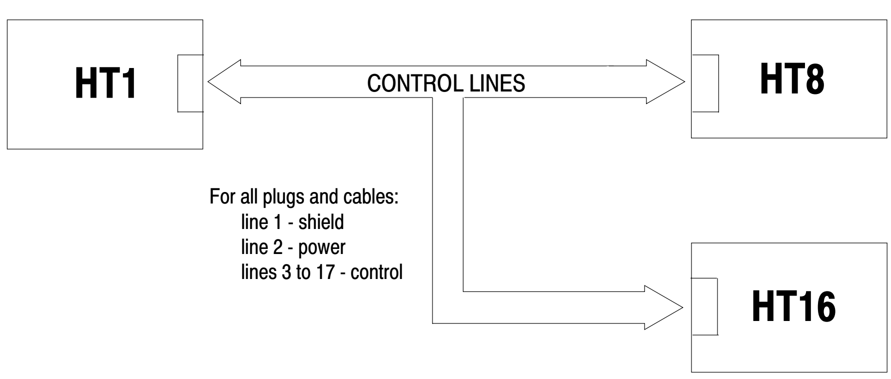
Cabling Requirements Between the Communications Controller and the Terminal Blocks

The digital communications cable carries both the control signals and power for the Terminal Blocks. To carry the control signal clearly, the length of cable between the Communications Controller and all Terminal Blocks added together must not exceed 1000 feet. How the modules are connected (star, linear or a combination) does not change this requirement.

The 1000 foot maximum cable length applies only to the control signals. When power (24 VDC) is being supplied over the cable to the Terminal Blocks, the maximum cable length is further restricted because of the power drawn by the Terminal Blocks. The exact length allowed depends upon the number of Terminal Blocks being powered, the gauge of wire being used and the wiring configuration.

The simplest cabling scheme between the Terminal Blocks and Communications Controller (Figure C.1.) is one where the Smart Transmitter Interface products can be placed close enough together for the cable to carry both control signals and power. See Chapter 2, Figure 2.3 to Figure 2.5 for examples.

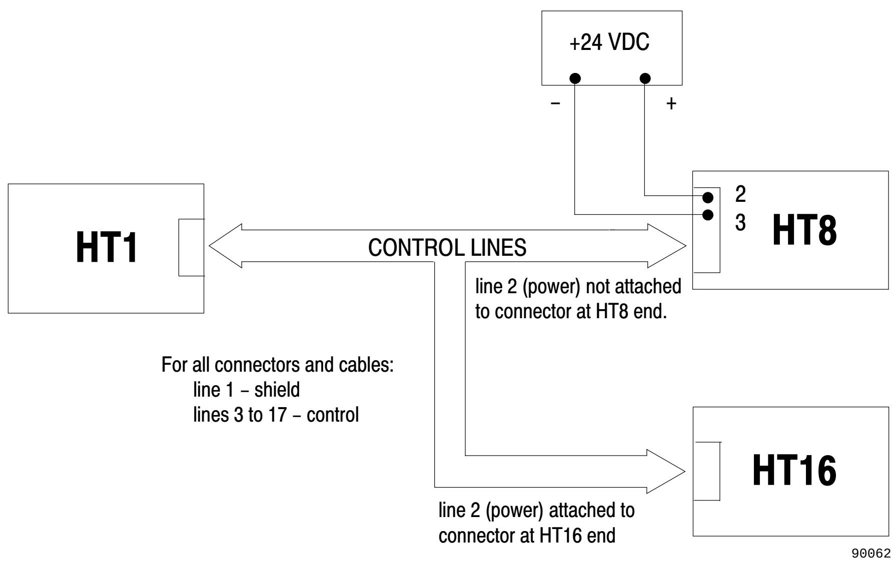
Figure C.1
Cable Carrying Control Signals and Power



If the Terminal Blocks are to receive power via the cable, the power cable length requirements explained below must be adhered to. If a Terminal Block is too far from the Communications Controller to meet these cabling requirements, an external 24 VDC power supply must be used. In any given Smart Transmitter Interface installation, there may be some Terminal Blocks receiving power from the Communications Controller via the cable, and others receiving power from an external power supply.

Figure C.2 shows an example installation with a 1770-HT16 Terminal Block close enough to the Communications Controller to receive power via the cable and a 1770-HT8 Terminal Block requiring an external power supply. If you are not using line 2 of the digital communications cable for power to a particular Terminal Block, do not connect that wire to its connector.

Figure C.2
Power Provided to a Terminal Block by an External Power Supply

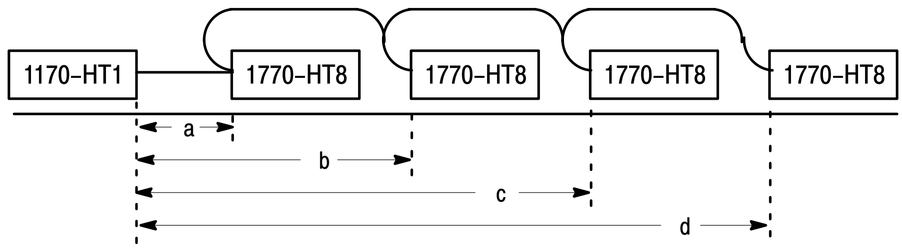


Important: No matter which method you choose, the total length of the digital communications cable between the Communications Controller and all the Terminal Blocks must not exceed 1000 feet (300 meters).

Maximum Power Cable Lengths

Figure C.3 gives the formula for determining maximum power cable lengths and illustrates its application in a linear connection configuration of four 1770-HT8 units. If fewer units are used, the variables that do not apply (D, C etc.) are set to 0.

Figure C.3
Determining Maximum Cable Lengths for Linear Connection



Control Signals

Total cable lengths <= 1000 ft
or <= 305 m

+24 VDC Power — Pin 2

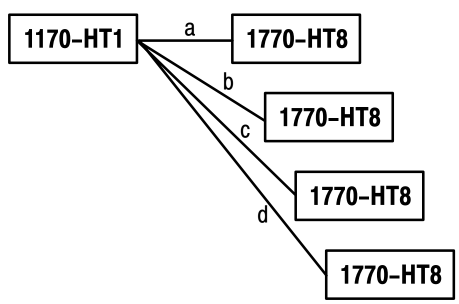
a + b + c + d <= 1000 / (0.065 * R)
where R = cable resistance per 1000 ft

or a + b + c + d <= 1/(0.065 * R)
where R = cable resistance per meter

90055

Figure C.4 illustrates the formula as it applies to a star connection configuration in which each Terminal Block is wired directly to the Communication Controller with its own cable.

Figure C.4
Determining Maximum Cable Lengths for Star Connection



Channel Select and Data Signals

a + b + c + d <= 1000 ft
or a + b + c + d <= 305 m

+24 VDC Power — Pin 2

a, b, c, and d <= 1000 / (0.065 * R)
where R = cable resistance per 1000 ft

or a, b, c, and d <= 1/(0.065 * R)
where R = cable resistance per meter

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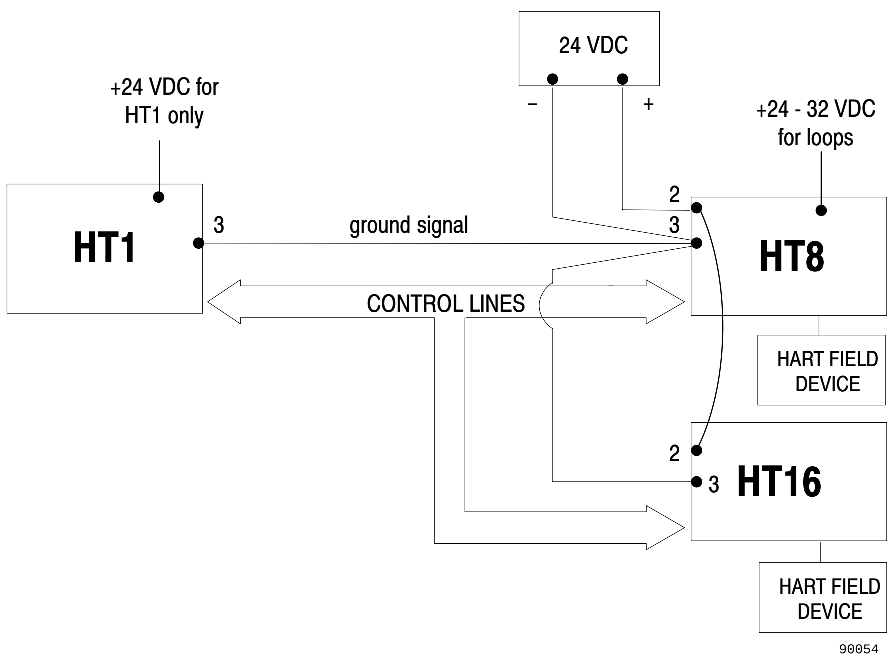
Using a Separate Power Supply for a Terminal Block

One way of overcoming the maximum power length restrictions required to carry power to the Terminal Blocks is to use a local power supply at the site of the Terminal Blocks, rather than providing 24 VDC via the cable between the Communications Controller and the Terminal Blocks. This power supply must be connected to pins 2 (+) and 3 (–) of the 17 position connector.

Important: No matter how the Terminal Blocks are powered, the total length of the digital communications cable between the Communications Controller and all the Terminal Blocks must not exceed 1000 feet (300 meters) and a signal ground must still connect the Communications Controller and the Terminal Blocks at pin 3 via the cable in order to provide a common ground reference.

Figure C.5
Using a Separate Power Supply



Connecting Power to the Terminal Blocks

To connect an external 24 VDC power supply to a Terminal Block do the following:

1. Make sure the power supply is turned off.

2. Connect the wire from the positive terminal in the power supply to pin 2 in the 17 pin connector on the cable.

3. Connect the wire from the negative terminal in the power supply to pin 3 in the 17 pin connector on the cable.

4. Insert the connector on the cable into the 17 pin connector header on the Terminal Block.

5. Turn on the power to the power supply.

Cabling and Power Supply Requirements for Loop Power

If loop power is to be supplied to HART field devices via a Terminal Block, several factors have to be accounted for in the calculation of the voltage required of the external 4-20 mA power supply. These include:

- the supply voltage required by the HART field device (varies from device to device)
- the wire gauge and length of the 4-20 mA loop
- the DC resistance of the Terminal Block in relation to the 4-20 mA current loop
- the voltage drop across one of the Terminal Block's diodes

These factors have been incorporated in the following formula :

$$V_{supply} = V_{device} + (2 \times i \times l \times r) + 514.25 \times i + 0.25$$

where:

l is the cable length in feet
i is the maximum loop current
r is the cable resistance per foot.

This formula was used to calculate the voltages required of power supplies for the Rosemount 3051 and 3044 with different cable lengths and wire gauge. The 3051 requires 10.5 volts and the 3044 requires 12.5.

Table C.A
Typical Supply Voltages

Cable Length (ft)	Wire Gauge AWG	Supply Voltage 3051	Supply Voltage 3044
100	16	21.8	23.8
	20	21.8	23.8
	24	21.9	23.9
500	16	21.9	23.9
	20	22.0	24.0
	24	22.3	24.3
1000	16	22.0	24.0
	20	22.2	24.2
	24	22.8	24.8
1500	16	22.1	24.1
	20	22.5	24.5
	24	23.4	25.4
2000	16	22.2	24.2
	20	22.7	24.7
	24	23.9	25.9
5000	16	22.7	24.7
	20	24.0	26.0
	24	27.0	29.0
10000	16	23.6	25.6
	20	26.1	28.1
	24	*	*

* 24 AWG is limited to 5000 feet by HART specifications

Table C.B
Recommended Power Supplies

Voltage	Amperage	Manufacturer	Part Number
24 VDC	2.1 Amp	Acopian	A24MT210
	3.5 Amp	Acopian	A24MT350
	1.5 Amp	Phoenix Contact	CM 90-PS-110/230 VAC/24 DC/1.5
	2.0 Amp	Phoenix Contact	CM 125-PS-110/230 VAC/24 DC/2
28 VDC	2..1 Amp	Acopian	A28MT210
	3.0 Amp	Acopian	A28MT300
30 VDC	2.1 Amp	Acopian	A30MT210
	3.0 Amp	Acopian	A30MT300

Symbols

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