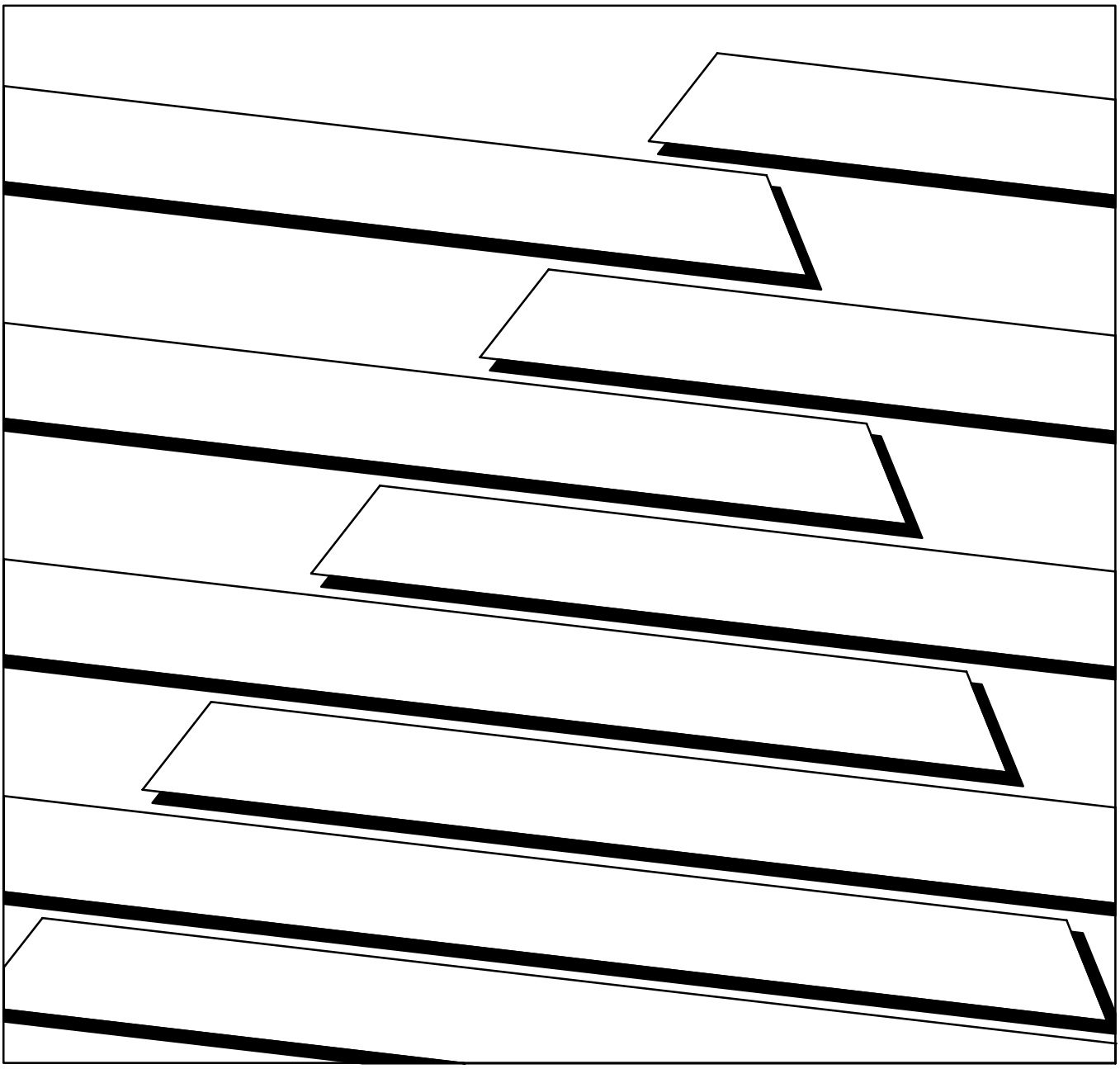
ALLEN-BRADLEY

Smart Transmitter Toolkit

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, Allen-Bradley 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 that 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.

Attention statements help you to:

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

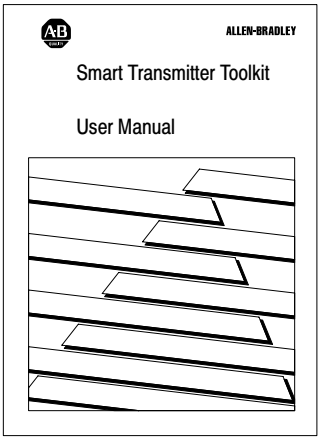
Important: Identifies information that is critical for successful application and understanding of the product.

Table of Contents

Using This Manual

What's In This Preface

This preface describes how to properly and efficiently use this manual.



publication 1770-6.5.21

It tells you about:

- the purpose of this manual
- who should use this manual
- how to use this manual
- terms
- abbreviations
- conventions
- related publications

Purpose of This Manual

Use this manual to install and use the Smart Transmitter Toolkit. Throughout this manual we refer to this utility as the STT subroutine.

Who Should Use This Manual

This manual is intended for use by:

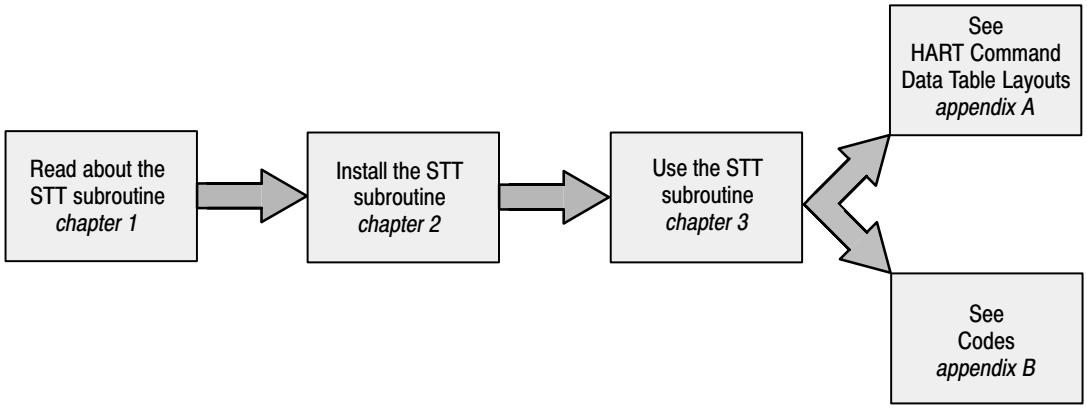
- persons who install Smart Transmitter Interface products, in connection with Allen-Bradley PLC® controllers or other intelligent controllers
- system integrators who design and establish network systems that involve plant floor machinery, programmable controllers, HART® field devices, Smart Transmitter Interface products, and host computers

We assume that you have:

- a strong working knowledge of your plant's process and equipment
- a familiarity with personal computers, MS-DOS® or PC-DOS™, ControlView™, and 6200 programming software

How To Use This Manual

Start by reading about the STT subroutine. Then, follow the instructions in chapter 2 to install the STT subroutine. Finally, use chapter 3 and the appendices to help you incorporate the STT subroutine into your ladder logic.



Terms

Some of the tasks described in this manual assume that you have an acquaintance with basic computer terminology.

For a glossary of terms related to Smart Transmitter Interface products, see the *Smart Transmitter Interface Products (HART Protocol) User Manual*, publication 1770-6.5.19.

Abbreviations

In this manual, we use these abbreviations.

This abbreviation:	is for:
BTR	**B**lock-**t**ransfer **R**ead
BTW	**B**lock-**t**ransfer **W**rite
HART	**H**ighway **A**ddressable **R**emote **T**ransducer
JSR	**J**ump to **S**ubroutine
STT	**S**mart **T**ransmitter **T**oolkit

Conventions

We use these conventions in this manual:

In this manual, we show:	Like this:
prompts and messages	`Press a function key`
literal text that you type	**STT_SUB**
variable text that you type	*filename*
keys that you press	F1
screens that you see	Program Directory
that there is more information about the topic in another manual	

Related Publications

Allen-Bradley Publications

Publication	Publication Number
Smart Transmitter Interface Products (HART Protocol) User Manual	1770-6.5.19
PLC-5® Programming Software Programming Manual	6200-6.4.7

For a list of publications for Allen-Bradley programmable controller products, see the *Automation Group Publication Index*, publication 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

STT Software License

STT is not a licensed software product. It is provided to help you quickly communicate with HART field devices. Please feel free to use this software on any and all machines that you have.

Chapter 1

Introducing The Smart Transmitter Toolkit

What's In This Chapter

This chapter gives you an overview of the Smart Transmitter Toolkit that you received with your Smart Transmitter Interface (cat. no. 1770-HT1).

What's The Smart Transmitter Toolkit

The Smart Transmitter Toolkit (STT) is a PLC-5 ladder logic subroutine utility that saves development time by simplifying the communication among Allen-Bradley PLC-5 processors, Allen-Bradley Smart Transmitter Interfaces, and HART-compliant field devices, such as a smart transmitter or actuator.

✔ The STT subroutine provides a shell that lets you use a PLC processor to communicate with a HART field device, without having detailed knowledge of the HART protocol.

✔ The STT subroutine supports the HART commands that are most commonly used with PLC processors. The STT subroutine does not support vendor-specific HART commands, such as totalization.

✔ STT focuses on digital data that is associated with the HART protocol. Use Allen-Bradley Analog I/O modules to acquire 4-20mA analog data.

✔ STT does not include faceplates or operator interface screens. However, you can configure operator interface software, such as ControlView software, to display/modify data that is received/sent to the STT subroutine.

✔ STT supports:

- HART Universal Commands 0, 1, and 3
- HART Common Practice Commands 35, 38, 43, and 44
- Both long- and short-frame addressing
- Both point-to-point and multi-drop configurations
- Allen-Bradley PLC-5® processors

Important: Do not view STT as a configuration tool. We assume you take the appropriate steps to configure and calibrate the HART field device using either Cornerstone™ software or a hand-held terminal.

HART Universal Commands
The functions performed by these commands are performed by all HART devices.

HART Common-practice Commands
The functions performed by these commands may not be possible for all HART devices.

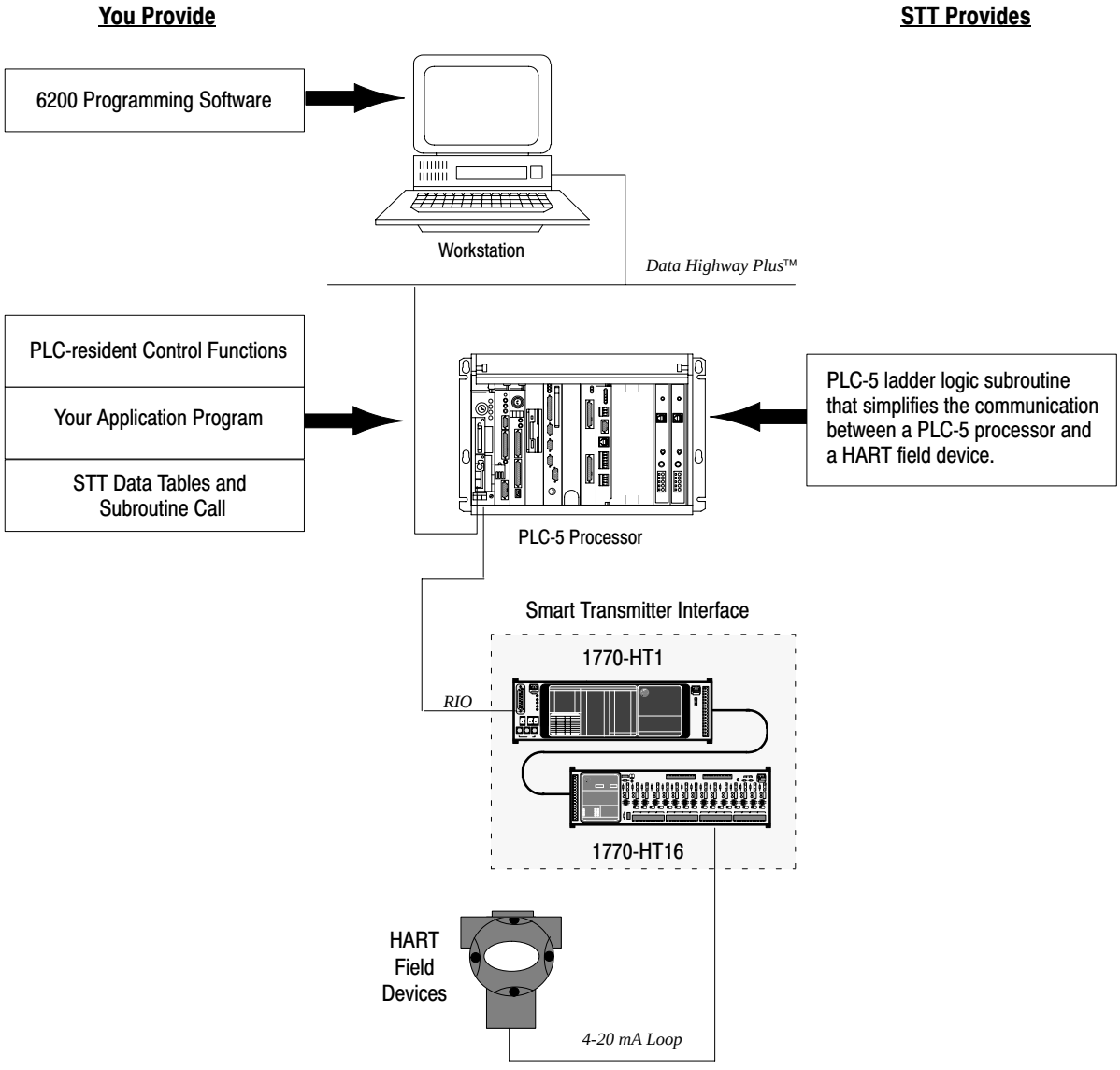
HART Transmitter-specific Commands
Only one or at most a few HART devices implement these functions. The functions performed by these commands allow each device type to implement their own commands for special functions, calibration, and special data handling.

Refer to the product manual for your HART field device for a list of supported commands.

What You Get With The STT Subroutine

The STT subroutine transfers this digital data between the PLC-5 processor and HART field devices:

- Read
  - primary variable and unit
  - primary variable current
  - dynamic variables and unit
  - status information
- Write/modify primary variable range values
- Write primary variable unit
- Reset configuration change flag
- Set primary variable to zero



What You Need to Use The STT Subroutine

You need these hardware and software components to integrate STT with your new or existing PLC-5 processor:

Hardware

- (1 or more) 1770-HT1 Smart Communications Controller(s)
- (1 or more) 1770-HT8 or 177-HT16 Terminal Block(s)
- (1 or more) HART-compliant field device(s)

Software

- PLC-5 6200 Programming Software
- (2 or more) PLC-5 data table files
- (1 or more) PLC-5 programming file(s)
- PLC-5 integer data table file locations N90:0, N90:1, and N90:2

Why You Should Use The STT Subroutine

The STT subroutine greatly simplifies sending and receiving data to and from HART field devices.

Without STT, the ladder developer must:

✔ Format each command from the HART specification using the Smart Transmitter Interface protocol.

✔ Understand HART protocol internals, such as long frame addressing vs. short frame addressing, and byte swapping for word alignment.

✔ Parse HART command responses for data.

✔ Convert IEEE-754 data to floating-point data.

✔ Synchronize BTWs with BTRs.

With STT, the ladder developer must only:

✔ Configure a data block.

✔ Make the appropriate call to the STT subroutine.

How a PLC-5 Processor Communicates With a HART Field Device

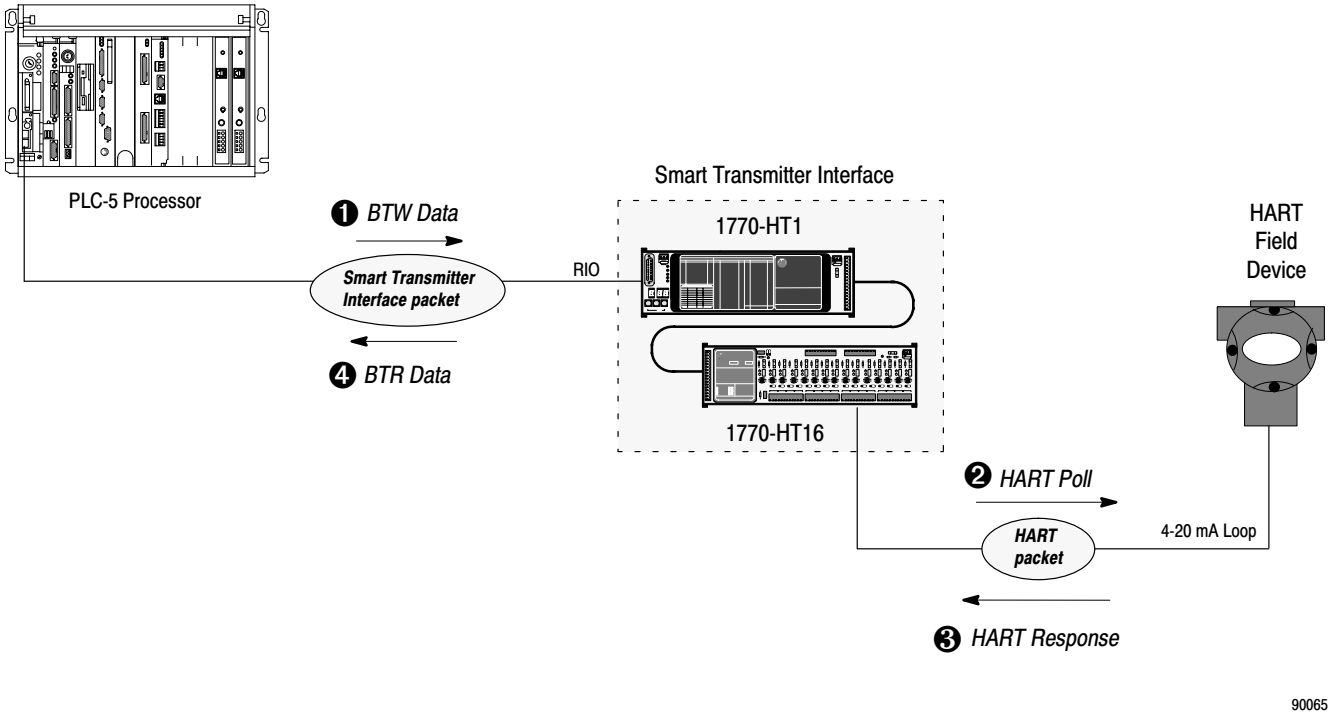
To help explain what the STT subroutine can do for you, let's examine how communication occurs between a PLC processor and a HART field device.

❶ The PLC-5 processor sends a Smart Transmitter Interface packet to the 1770-HT1 as block-transfer write (BTW) data.

❷ The 1770-HT1 forwards the Smart Transmitter Interface packet as a HART packet to the HART field device.

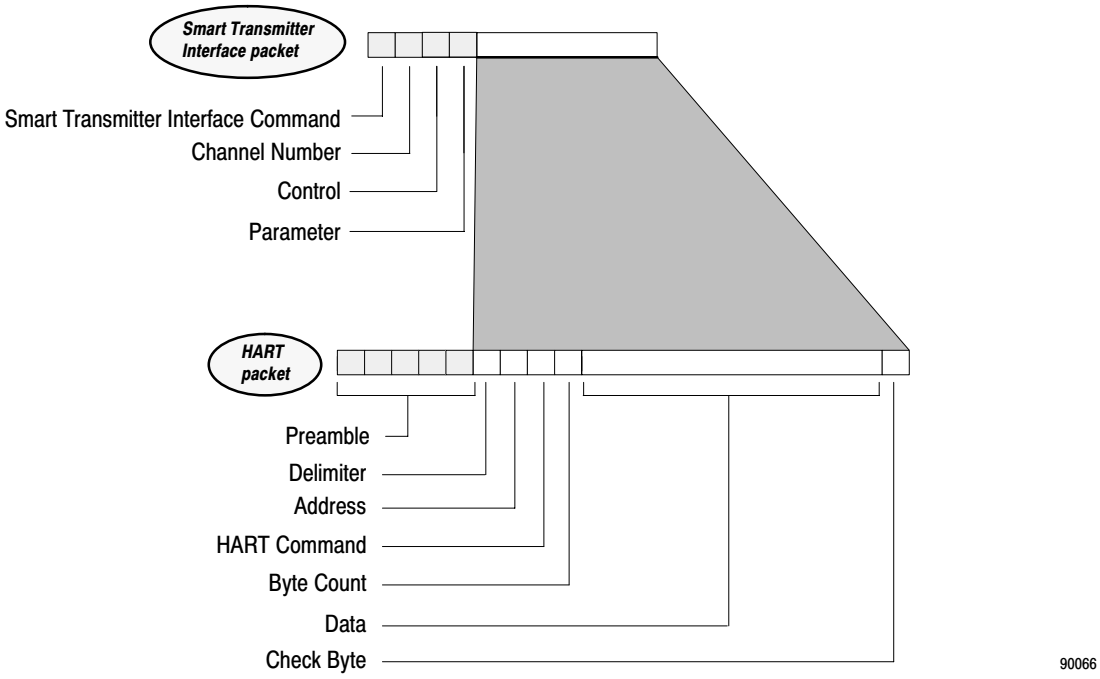
❸ The HART field device receives the HART packet and then responds back to the 1770-HT1 with a HART packet that contains the appropriate HART digital data.

❹ The 1770-HT1 routes the response back to the PLC-5 processor in a Smart Transmitter Interface packet as block-transfer read (BTR) data.



The PLC-5 processor sends and receives data from the 1770-HT1 as Smart Transmitter Interface Packets. The HART field device sends and receives data from the 1770-HT1 as HART packets. The 1770-HT1 converts the packets that it receives to the required format before transmitting the packets to their destination.

This diagram illustrates the relationship between the two packets.



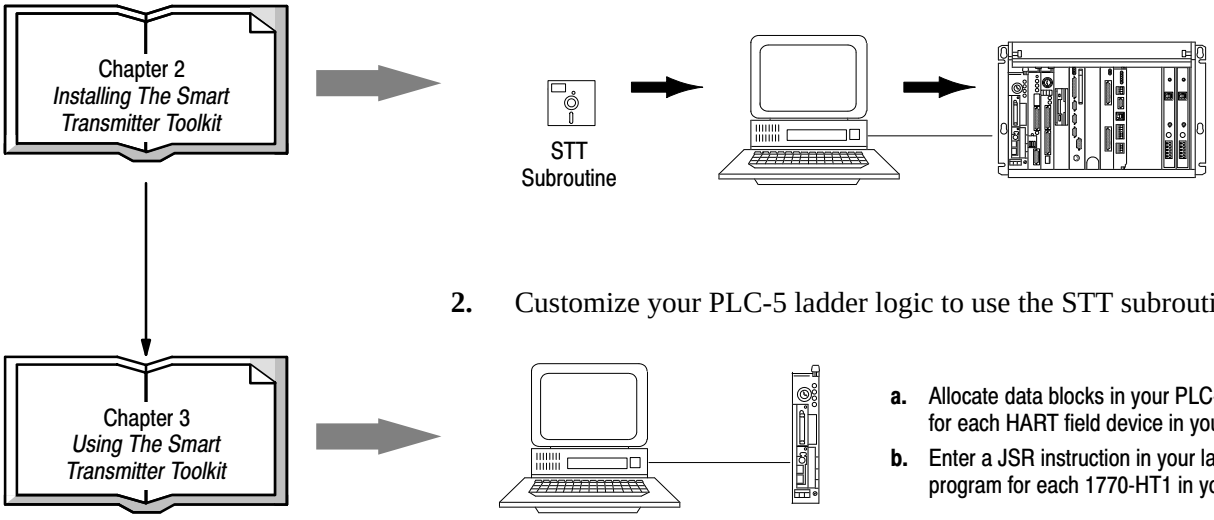
Using a few pieces of data, the STT subroutine creates a Smart Transmitter Interface packet and sends it to the 1770-HT1. The STT subroutine then takes the response from the 1770-HT1 and decodes the Smart Transmitter Interface packet to provide you with useful data.

For more information about communications with Smart Transmitter Interface products, see the *Smart Transmitter Interface Products (HART Protocol) User Manual*, publication 1770-6.5.19.

How You Use The STT Subroutine

We developed the STT Subroutine so that you can easily use a PLC-5 processor to communicate with a HART field device. Here's how easy it is to use STT:

1. Install the STT subroutine into your workstation and PLC-5 processor.



2. Customize your PLC-5 ladder logic to use the STT subroutine.

a. Allocate data blocks in your PLC-5 processor for each HART field device in your system.

b. Enter a JSR instruction in your ladder logic program for each 1770-HT1 in your system.

When you've completed these steps, you're ready to use the STT subroutine.

What to Do Next

Go to chapter 2 to begin installing the Smart Transmitter Toolkit.

Chapter 2

Installing The Smart Transmitter Toolkit

What's In This Chapter

This chapter provides instructions for installing the Smart Transmitter Toolkit (STT).

Important: Use 6200 programming software to install the STT subroutine into your PLC-5 processor. Before you begin, make sure your current program is loaded.

To install the STT subroutine, you will:

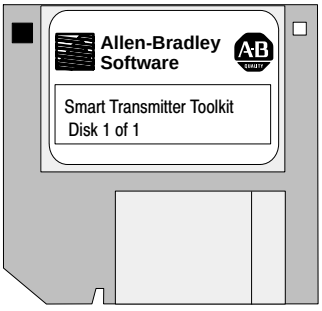
1. Copy the STT subroutine file to the hard drive.
2. Create and name a new program file in your PLC-5 processor.
3. Paste the STT subroutine file into the new program file.
4. Save your work (optional).
5. Change the data table defaults (optional)

   Important: The STT subroutine uses three fixed word addresses: N90:0 through N90:2. When you paste the STT subroutine, these three addresses are created. If these addresses are already in use and cannot be freed up for the STT Subroutine, you need to change the data table defaults. If you need to make these changes, do step 5.

The rest of this chapter contains the instructions for completing these steps.

Before You Begin

You need this diskette to install the STT subroutine:



This diskette contains these paste files:

- STT100.CR5 – the STT subroutine
- STT100E1.CR5 – programming example 1
- STT100E2.CR5 – programming example 2
- STT100E3.CR5 – programming example 3

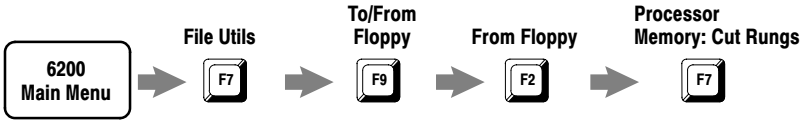
See chapter 3 for an explanation of the programming examples.

Since you install the STT subroutine using 6200 programming software, you may want to obtain a copy of the *PLC-5 Programming Software Programming Manual*, publication 6200-6.4.7.

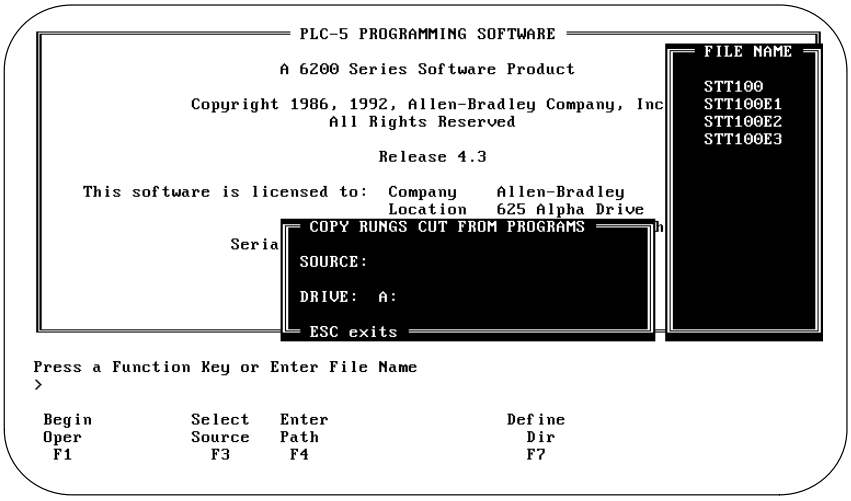
1. Copy STT Subroutine File to the Hard Drive

A. Insert the STT disk into a floppy drive.

B. Start at the 6200 Main Menu and press these keys:



You see:



C. Use the cursor keys to highlight the STT100 file.

D. To select the STT100 file as the source of the copy, press F3 `Select Source`.

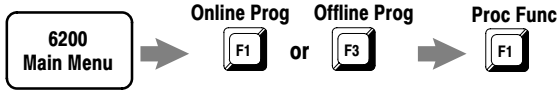
E. To begin the copy, press F1 `Begin Oper`.

The operation is completed.

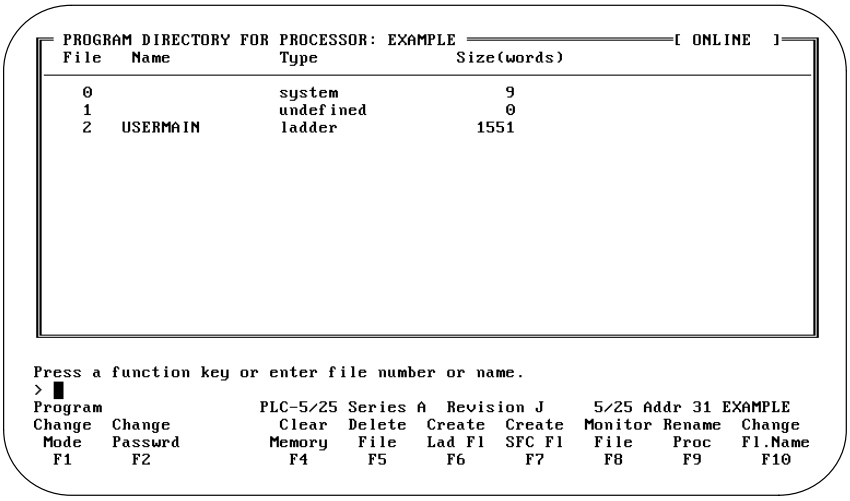
F. To return to the 6200 Main Menu, press Esc Esc .

2. Create and Name a New Program File

A. Start at the 6200 Main Menu and press these keys:



You see:



B. To create a program file, press F6 `Create Lad Fl` and then enter a file number.

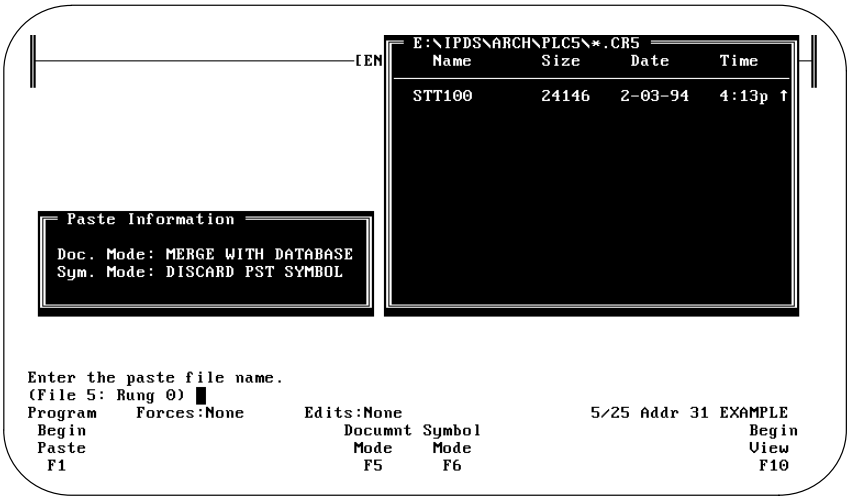
C. To name the file, press F10 `Change Fl Name` and then enter a file name. We recommend that you use the filename **STT_SUB**.

D. To go to the Program Directory, press Esc.

3. Paste The STT Subroutine File

A. Start at the Program Directory and press these keys:

You see:



B. Use the cursor keys to highlight the STT100 file.

C. To begin the paste, press F1 `Begin Paste.`

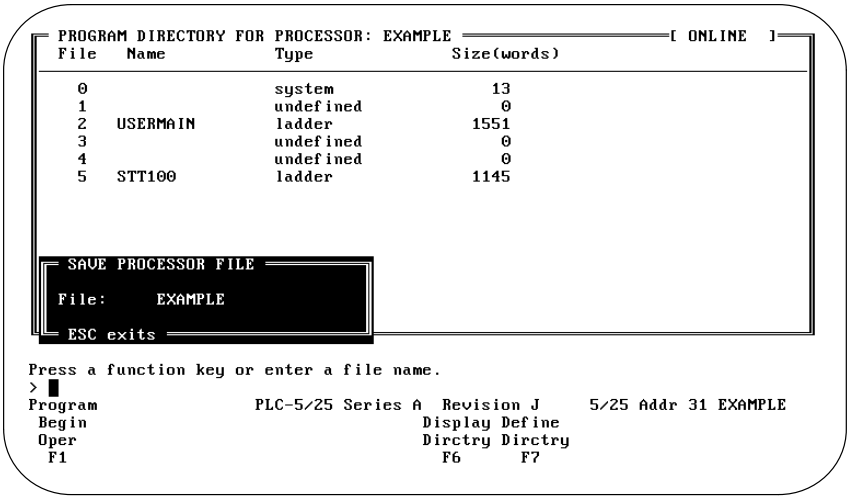
The paste operation takes about 3 minutes. Since the STT subroutine uses indirect addressing, you may hear beeps during the paste operation. This is normal.

D. To return to the Program Directory, press Esc Esc .

4. Save Your Work *(optional)*

A. Start at the Program Directory and press these keys:

You see:



B. If you want to change the name of the file, enter a new name. If you don't enter a new name, the file is saved using the name that you see on the screen.

C. To save the file, press F1 `Begin Oper.`

5. Change The STT Default Data File *(optional)*

You can move the STT subroutine data table file from its default location of N90.

Important: Moving this file increases the chance of making errors while setting up your system and complicates the technical support of the STT subroutine because the file is not in its default location. We recommend that you only attempt this procedure if you are experienced in ladder-logic programming and using 6200 programming software.

The STT subroutine uses indirect addresses in block-transfer instructions. You cannot use 6200 programming software to edit/cut/copy/paste block-transfer instructions that use indirect addressing or to search for file references that use indirect addressing. To move the file, follow these steps:

A. Use the 6200 file utilities to export the processor memory file and comments/symbols. Make sure that you export all the different types of comments (address, rung, instruction, etc.).

- The exported program file has a **.PC5** extension.
- The exported comments/symbols file has a **.TXT** extension.

For more information about using 6200 file utilities, see *PLC-5 Programming Software Programming Manual*, publication 6200-6.4.7.

B. Use an ASCII text editor to make the changes as described below.

Moving the STT Data Table File From N90

a. Edit the .PC5 file
b. Search for all occurrences of integer file number N90 and change to the new integer file number.
c. Save the changes and close the file.
d. Edit the .TXT file.
e. Search for all occurrences of integer file number N90 and change to the new integer file number.
f. Save the changes and close the file.

C. Import the modified processor memory file and comments/symbols file. Use a different name for the imported files to distinguish them from the original files.

What's Next

You are finished installing the STT subroutine. Proceed to the next chapter for instructions on using the STT subroutine in your ladder logic.

Chapter 3

Using The Smart Transmitter Toolkit

What's In This Chapter

Follow the instructions in this chapter to incorporate the STT subroutine into your ladder code and use the HART commands.

1. Create data table files.
2. Provide the STT subroutine inputs
3. Use the STT subroutine status word.
4. Call the STT subroutine.
5. Interpret the STT subroutine outputs.

At the end of this chapter, you'll find some programming examples.

1. Create Data Table Files

Integer word = 16 bits
Floating-point word = 32-bits

In your PLC-5 processor, create one integer and one floating-point file for each HART field device.

- Each integer file must be 150 integer words minimum (0 through 149)
- Each floating-point file must be 20 floating-point words minimum (0 through 19)

In addition, the floating point file must be the data file that immediately follows the integer data file. For example, if the integer file is N10, the floating point file must be F11.

Important: The STT utility uses integer data file N90 for indirect addressing. Do not use this data file for a HART field device data table file.

Since the STT subroutine uses N90:0 and N90:1 for indirect addressing, you must place valid file numbers in N90:0 and N90:1. For example, if you created N10 and F11, you need to place a 10 in data table location N90:0 and an 11 in data table location N90:1.

Following is an explanation of how the data tables are used by the STT subroutine.

Example of Newly Created Integer Data File

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	0	0	0	0	0	0	0	0	0	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	0	0	0	0	0	0	0	0	0	0
N10:40	0	0	0	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0
N10:60	0	0	0	0	0	0	0	0	0	0
N10:70	0	0	0	0	0	0	0	0	0	0
N10:80	0	0	0	0	0	0	0	0	0	0
N10:90	0	0	0	0	0	0	0	0	0	0
N10:100	0	0	0	0	0	0	0	0	0	0
N10:110	0	0	0	0	0	0	0	0	0	0
N10:120	0	0	0	0	0	0	0	0	0	0
N10:130	0	0	0	0	0	0	0	0	0	0
N10:140	0	0	0	0	0	0	0	0	0	0

Integer words 60 through 149 = STT Subroutine Work Area

Integer words 30 through 59 = STT Subroutine Status and Output Area

Integer words 0 through 29 = User Input Area

Example of Newly Created Floating-point Data File

Data Table Report PLC-5/25 Addr 31 Data Table File F11:0

Address	0	1	2	3	4
F11:0	0	0	0	0	0
F11:5	0	0	0	0	0
F11:10	0	0	0	0	0
F11:15	0	0	0	0	0

Floating-point words 10 through 19 = STT Subroutine Output Area

Floating-point words 0 through 9 = User Input Area

2. Provide The STT Subroutine Inputs

All data that is used by the STT subroutine is obtained from the integer and floating point data files that you create for each HART field device. Before you make a call in your ladder logic to the STT, you must put the required data into these data files.

There are two types of input data:

- **Command-specific inputs** are specific for each HART command. See appendix A.
- **Standard inputs** are required for every HART command. This table explains each of the six standard inputs.

Standard Inputs			
Integer	Word 0	I/O Rack Number of 1770-HT1	This integer word contains the I/O rack number of the 1770–HT1 that is connected to the HART field device. Valid values are 1 through 7.
	Word 1	I/O Group Number of 1770-HT1	This integer word contains the I/O group number of the 1770–HT1 that is connected to the HART field device. Valid values are 0, 2, 4, and 6.
	Word 2	Channel Number of HART field device	This integer word contains the channel on the 1770–HT8 or the 1770–HT16 that is wired to the HART field device. Valid values are 1 through 32.
	Word 3	Polling Address of HART field device	This integer word contains the polling address of the HART field device. Use a Rosemount 268 Handheld terminal or Cornerstone software to configure this address. If you are wired: • *point-to-point*, the polling address is 0 (zero). • *multi-drop*, the polling address is 1 through 15. **Note:** Most HART field devices come from the factory with a default polling address of zero.
	Word 4	Smart Transmitter Interface Command Number 16 decimal (10 Hex)	This integer word contains the number of the Smart Transmitter Interface command. Currently, the only supported command is 16. This command indicates that you want to send a HART command to a HART field device. Always place a 16 in word 4 of the integer data file.
	Word 5	HART Command	This integer word contains the number of the HART command that the STT subroutine generates and processes. Valid values are 0, 1, 3, 35, 38, 43, and 44. Every HART command, except 0, requires the HART address returned by HART command 0.

Example: Inputs for HART Command 0

Data Table Report PLC–5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	**4**	**6**	**3**	**0**	**16**	**0**	0	0	0	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	0	0	0	0	0	0	0	0	0	0
N10:40	0	0	0	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

- N10:0 indicates that the 1770–HT1 is located at I/O rack 4.
- N10:1 indicates that the 1770–HT1 is located at I/O group 6.
- N10:2 indicates that the HART field device is wired to channel 3.
- N10:3 indicates that the HART field device has a polling address of 0.
- N10:4 indicates that the Smart Transmitter Interface command is 16 (for STT release 1.00, it is always 16).
- N10:5 indicates that this example is using HART command 0.

3. Use The STT Subroutine Status Word

The STT subroutine status word handshakes with your PLC ladder logic. The STT subroutine status word:

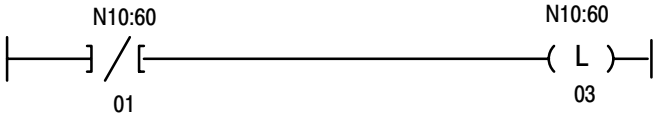
- tells you when the STT subroutine is entered and exited
- tells you when the STT subroutine is enabled and done
- lets you trigger the STT subroutine
- tells you when the STT subroutine errors

The STT status word is integer word 30 of the integer file that is passed in with your JSR instruction. This table shows the bits that are used in the STT subroutine status word.

STT Subroutine Status Word 30		
Bit 0	STT Enter/Exit Bit	Use bit 0 to debug your program. When called, the STT subroutine sets bit 0 to 1. When the STT subroutine exits, the subroutine sets bit 0 to 0. This lets you know when the STT subroutine is entered and exited.
Bit 1	STT Enable Bit	Bit 1 indicates that the STT subroutine is in the middle of processing a HART command.
Bit 2	STT Done Bit	Bit 2 indicates that the STT subroutine is done processing a command. When you make an unconditional call to the STT subroutine, if the subroutine is not already enabled, it sets bit 1 to 1 and bit 2 to 0. When the STT subroutine is done processing a Hart command (successful or not), it sets bit 2 to 1 and bit 1 to 0. When bit 2 is set to 1, you can process the output data that is returned by the STT subroutine.
Bit 3	STT Trigger Bit	Bit 3 is the STT subroutine trigger bit. Use bit 3 to tell the STT subroutine to process the requested command. Even though you call the STT subroutine with an unconditional JSR, it does not process the HART command unless bit 3 is set to 1. When the STT subroutine sees bit 3 set to 1, it processes the request. When the request is first detected, the STT subroutine is enabled and it sets bit 3 to 0.
Bit 4	STT Error Bit	Bit 4 is the STT subroutine error bit. This bit is set if either the BTW or the BTR has failed. Any data, except words 30 and 31, in the output area is invalid if this bit is set.
Bits 5-7	Reserved	Reserved for future use.
Bit 8	STT BTW Retry Bit	Bit 8 indicates that the BTW has returned an error and is being retried by the STT subroutine.
Bit 9	STT BTR Retry Bit	Bit 9 indicates that the BTR has returned an error and is being retried by the STT subroutine.
Bits 10-15	Reserved	Reserved for future use.

Example

In this example, the STT trigger bit is set to 1 if the STT enable bit is set to 0.



4. Call The STT Subroutine

Insert a JSR on an unconditional rung to call the STT subroutine.

The JSR instruction includes one program file number and one input parameter. There are no return parameters.

- The program file number is the program file number where you installed the STT subroutine. For example, if you installed the STT subroutine into program file number 5, the JSR must call program file number 5.
- The input parameter is the integer file number for the current HART field device. For example, if you created N10 and F11 for your HART field device, the input parameter would be 10.

When the STT routine is called by your ladder logic, it generates the specified HART command from the data that you provided in the integer and floating-point data files.

After generating a properly formatted HART command, the STT subroutine executes a BTW followed by a BTR to execute the command just generated. It then reformats the returned data and places the outputs in the locations specific to that HART command. See appendix A for more detail on the command-specific outputs.

Because of the nature of enabling and finishing BTWs and BTRs, it takes three calls minimum to the STT subroutine to obtain the outputs from the HART command. This is a description of the steps that occur in each of the three passes through the STT subroutine.

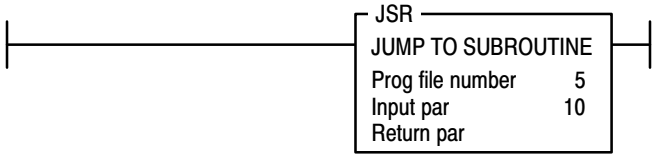
1st Pass
- sets the enter/exit bit to 1
- sets the trigger bit to 0
- sets the enable bit to 1
- generates the HART command specified in integer word 5
- initiates a BTW
- sets the enter/exit bit to 0 and returns

2nd Pass
- sets the enter/exit bit to 1
- finishes the BTW
- initiates a BTR
- sets the enter/exit bit to 0 and returns

3rd Pass
- sets the enter/exit bit to 1
- finishes the BTR
- produces outputs
- sets the done or error bit to 1
- sets the enable bit to 0
- sets the enter/exit bit to 0 and returns

Example

In this example, the JSR calls the STT subroutine unconditionally. The STT subroutine looks for input data in files N10 and F11. However, since this example is using HART command 0, there is no input data in the floating-point file.



5. Interpret The STT Subroutine Outputs

Each HART command returns these outputs:

- **Command-specific outputs** returned for a specific HART command. See appendix A for more detail on the command specific outputs.
- **Standard Outputs** that are returned for every HART command. This table explains each of the seven standard outputs.

Standard Outputs			
Integer	Word 30	STT Subroutine Status Word (*see page 3-4*)	All handshaking with the STT subroutine is done with the STT status word.
	Word 31	STT Subroutine Error Code①	This word contains any error code returned by the STT subroutine.
	Word 32	Smart Transmitter Interface Status Word	On powerup, the Smart Transmitter Interface sets bit 7 to a 1. All other bits are set to 0. Therefore, the value for word 32 is 128 decimal. The STT utility does not provide any way to reset bit 7 to a zero. Therefore, bit 7 is always set to 1 in word 32.
	Word 33	Smart Transmitter Interface Error Code①	This word contains any error code returned by the 1770-HT1.
	Word 34	HART Protocol-Communication Error Code①	This word contains information that pertains to the reception of a message by a device. An error in this word indicates that the HART transmitter detected a communications error and the message was not accepted. The response data is not returned when errors are reported.
	Word 35	HART Command Response Summary Error Code①	This word contains information relative to the execution of a HART command. This error code is command dependent.
	Word 36	HART Field Device Error Code①	This word contains information that pertains to the operating status of the HART device as a whole and is not associated with the completion of any HART command.

① See appendix B for a list of error codes.

Example: Outputs for HART Command 0

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	4	6	3	0	16	0	0	0	0	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	4	0	128	0	0	0	0	0	0	0
N10:40	9858	269	12807	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

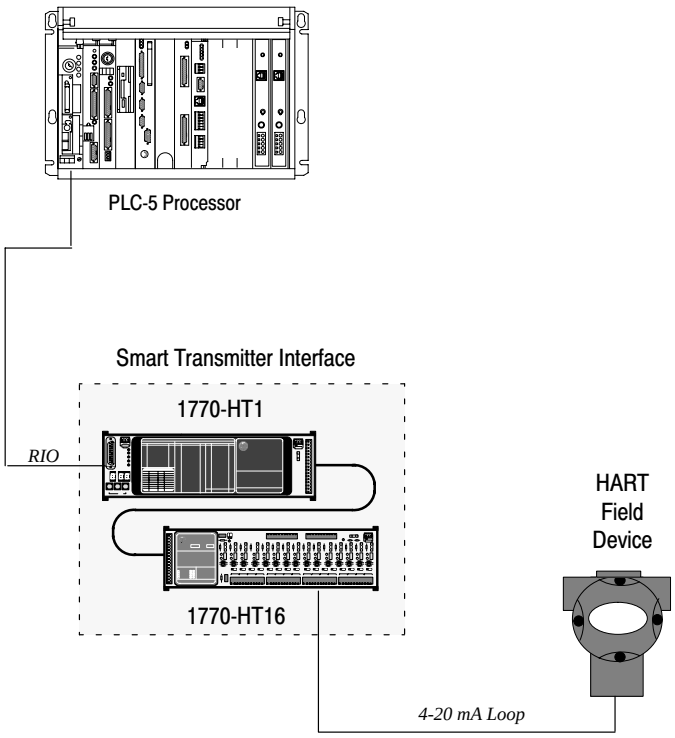
These three integer words are the HART address.

These seven integer words contain the status of the STT subroutine and the communications with the HART field device.

Important: We used this example because every ladder program must have a JSR instruction and all HART communications must start with HART command 0. Every HART command (except HART command 0) requires the HART address.

Programming Example 1: Single HART Device With Single 1770-HT1

In this example, the primary variable is being read continuously from a single HART field device.



Because we're dealing with one device we can execute the JSR with a fixed device data file number. In the course of operation if the device does not respond, we reissue HART command 0 to try and get a new HART address for the device.

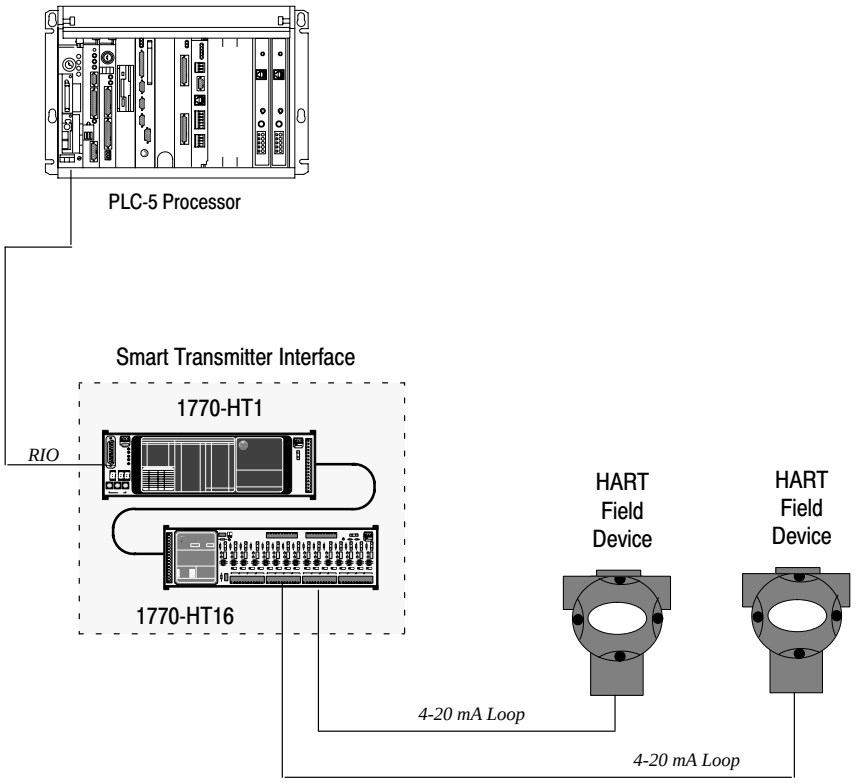
Important: This example assumes that data table files N10 and F11 exist, and N10 is populated with the standard inputs for HART command 0 prior to the execution of this logic. The primary variable value is placed in F11:10 and the primary variable unit code is placed in N10:40.

Example 1 *(continued)*

```
Rung 2:0
STT 1.00 Programming Example 1.
This example reads the primary variable from 1 HART field device wired to 1
1770-HT1.

When the STT subroutine is not enabled, set the STT subroutine trigger bit.
| STT enable                                                          STT trigger |
|   N10:30                                                               N10:30   |
+----]/[-------------------------------------------------------------------(L)-----+
|       1                                                                   3    |

Rung 2:1
Call the STT subroutine unconditionally.
|                                                                 STT             |
|                                                                 Subroutine      |
|                                                              +JSR---------------+ |
+--------------------------------------------------------------+JUMP TO SUBROUTINE+-+
|                                                              |Prog file number 5| |
|                                                              |Input par       10| |
|                                                              |Return par        | |
|                                                              +------------------+ |

Rung 2:2
Only process when the STT subroutine is done.  If the Hart command is 0, copy
the Hart address to the input area and request Hart command 1.  If the device
does not respond (error 33), try getting a new Hart address for the device by
requesting Hart command 0.
|                                      Hart                 Hart              |
| STT Done                             Command #            Address           |
|   N10:30                          +EQU---------------+ +COP---------------+   |
+----] [--------------------------++EQUAL             +++COPY FILE         +++-+
|       2                         ||Source A     N10:5|||Source     #N10:40||| |
|                                 ||                 1|||Dest        #N10:6||| |
|                                 ||Source B         0|||Length           3||| |
|                                 ||                  ||+------------------+|| |
|                                 |+------------------+|     Hart            || |
|                                 |                    |     Command #       || |
|                                 |                    |+MOV---------------+|| |
|                                 |                    ++MOVE               ++| |
|                                 |                     |Source           1| | |
|                                 |                     |                  | | |
|                                 |                     |Dest         N10:5| | |
|                                 |                     |                 1| | |
|                                 |                     +------------------+ | |
|                                 |     Device Not            Hart           | |
|                                 |     Responding            Command #      | |
|                                 |+EQU---------------+  +MOV---------------+| |
|                                 ++EQUAL             +--+MOVE              ++ |
|                                  |Source A    N10:33|  |Source           0|  |
|                                  |                 0|  |                  |  |
|                                  |Source B        33|  |Dest         N10:5|  |
|                                  |                  |  |                 1|  |
|                                  +------------------+  +------------------+  |

Rung 2:3
|                                                                               |
+-------------------------------[END OF FILE]--------------------------------+
|                                                                               |
```

Programming Example 2: Multiple HART Devices With Single 1770-HT1

In this example, the primary variable is read continuously from two HART field devices that are associated with one 1770–HT1 Communications Controller. You will notice that the example reads the primary variable from device 1 and then from device 2. If you want to talk to two HART field devices at the same time, you must use two 1770-HT1s. Example 3 demonstrates reading the primary variable from two HART field devices using two 1770-HT1s.



In this example, we used separate data areas for each device. This forced us to load the device data file number into the JSR input variable prior to making the call to the STT subroutine.

In the course of operation, if either HART field device does not respond, we reissue command 0 to try and get a new HART address for the field device. This example assumes that each device data area is setup with the standard inputs for command 0, prior to the execution of this logic.

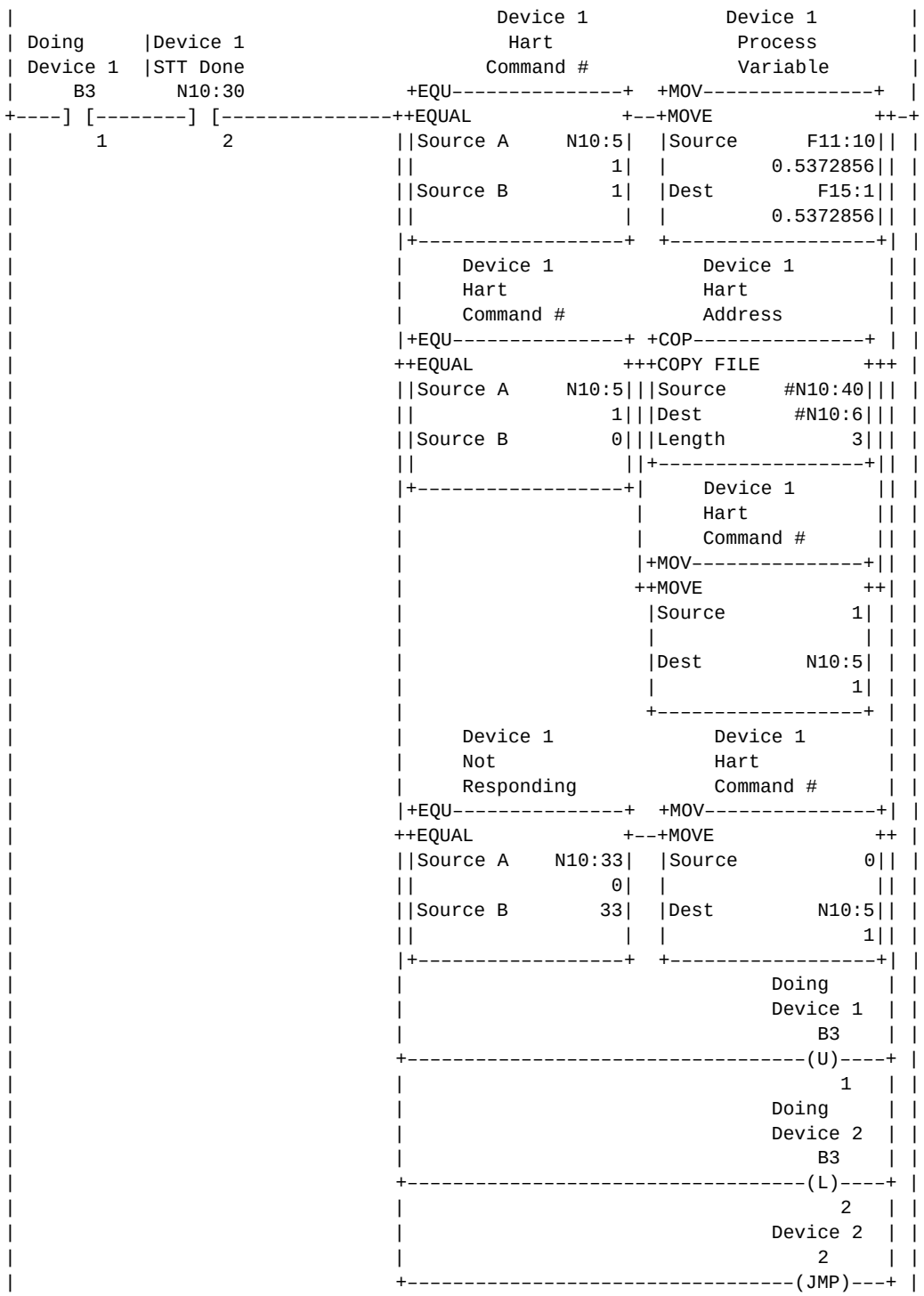
- Device 1 uses N10 and F11
- Device 2 uses N12 and F13
- N14 is the JSR variable
- F15 contains both primary variable values

Example 2 *(continued)*

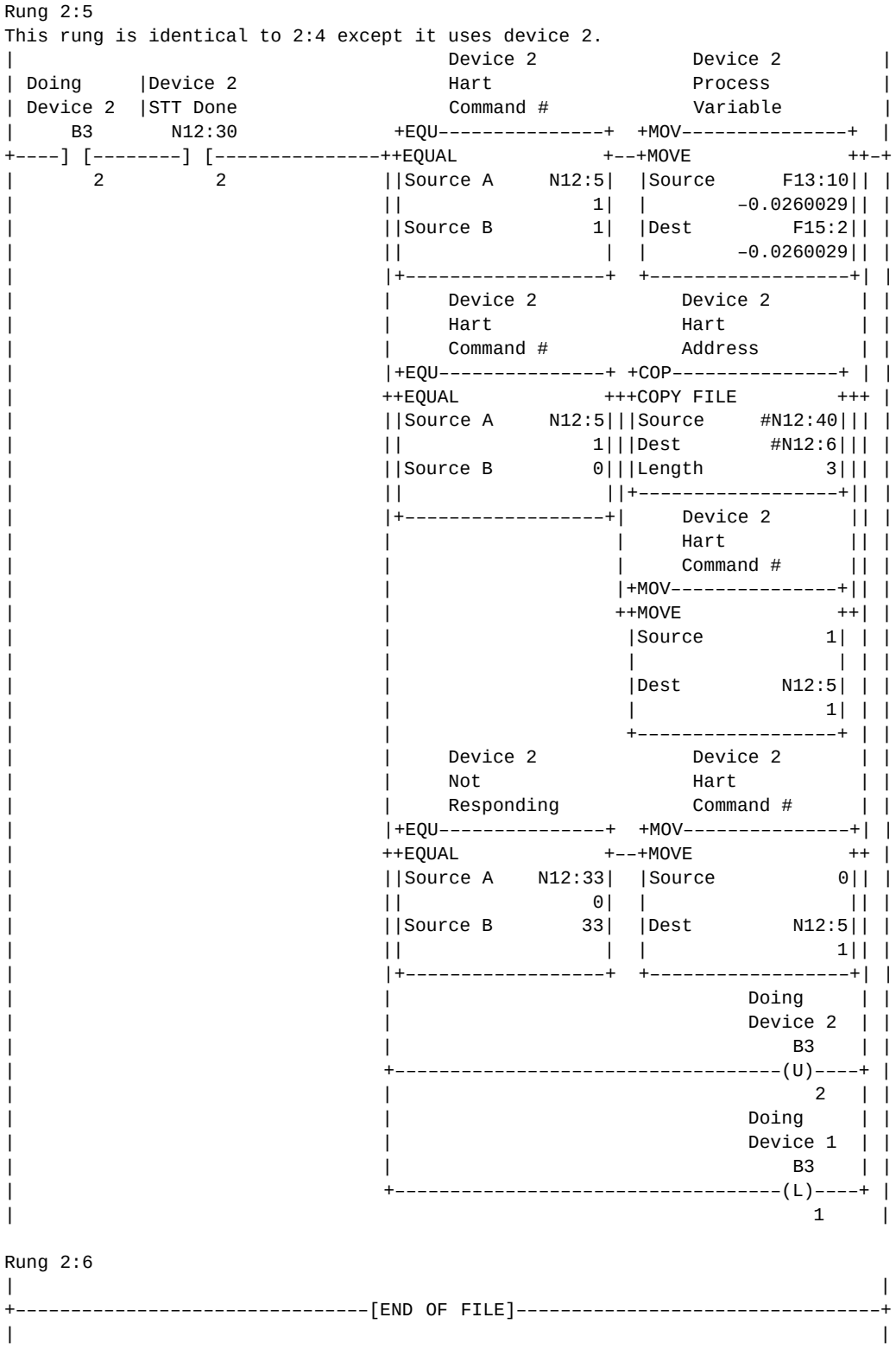
```
Rung 2:0
STT 1.00 Programming Example 2
This example reads the primary variable from 2 HART field devices wired to 1
1770-HT1.

If neither device is current, make device 1 the current device.
| Doing     |Doing                                                    Doing      |
| Device 1  |Device 2                                                 Device 1   |
|     B3         B3                                                     B3     |
+----]/[--------]/[-----------------------------------------------------(L)-----+
|       1          2                                                      1    |

Rung 2:1
Set the device 1 STT subroutine trigger bit and load the JSR input variable for
device 1 processing.
|                                                                  Device 1    |
| Doing     |Device 1                                              STT         |
| Device 1  |STT enable                                            trigger     |
|     B3       N10:30                                              N10:30    |
+----] [--------]/[-----------------------------------+-------------(L)----+-+
|       1          1                                 |                3   | |
|                                                    |     JSR Input      | |
|                                                    |     Variable       | |
|                                                    |+MOV---------------+| |
|                                                    ++MOVE              ++ |
|                                                     |Source          10|  |
|                                                     |                  |  |
|                                                     |Dest         N14:0|  |
|                                                     |                12|  |
|                                                     +------------------+  |

Rung 2:2
This rung is identical to 2:1, except it uses device 2.
|                                                                  Device 2    |
|           |Doing     |Device 2                                   STT         |
| Device 2  |Device 2  |STT enable                                 trigger     |
|     2          B3       N12:30                                    N12:30    |
+---[LBL]-------] [--------]/[---------------------------+-------------(L)----+-+
|                  2          1                         |                3   | |
|                                                       |     JSR Input      | |
|                                                       |     Variable       | |
|                                                       |+MOV---------------+| |
|                                                       ++MOVE              ++ |
|                                                        |Source          12|  |
|                                                        |                  |  |
|                                                        |Dest         N14:0|  |
|                                                        |                12|  |
|                                                        +------------------+  |

Rung 2:3
Call the STT subroutine unconditionally.
|                                                              STT             |
|                                                              Subroutine      |
|                                                          +JSR---------------+ |
+----------------------------------------------------------+JUMP TO SUBROUTINE+-+
|                                                           |Prog file number 5| |
|                                                           |Input par    N14:0| |
|                                                           |Return par        | |
|                                                           +------------------+ |
```

Example 2 *(continued)*

Rung 2:4
Only process when the STT subroutine is done. If the Hart command is 1, copy the primary variable to file F15. If the Hart command is 0, copy the Hart address to the input area and request Hart command 1. If device 1 does not respond (error 33), try getting a new Hart address for device 1 by requesting Hart command 0. Make device 2 the current device.

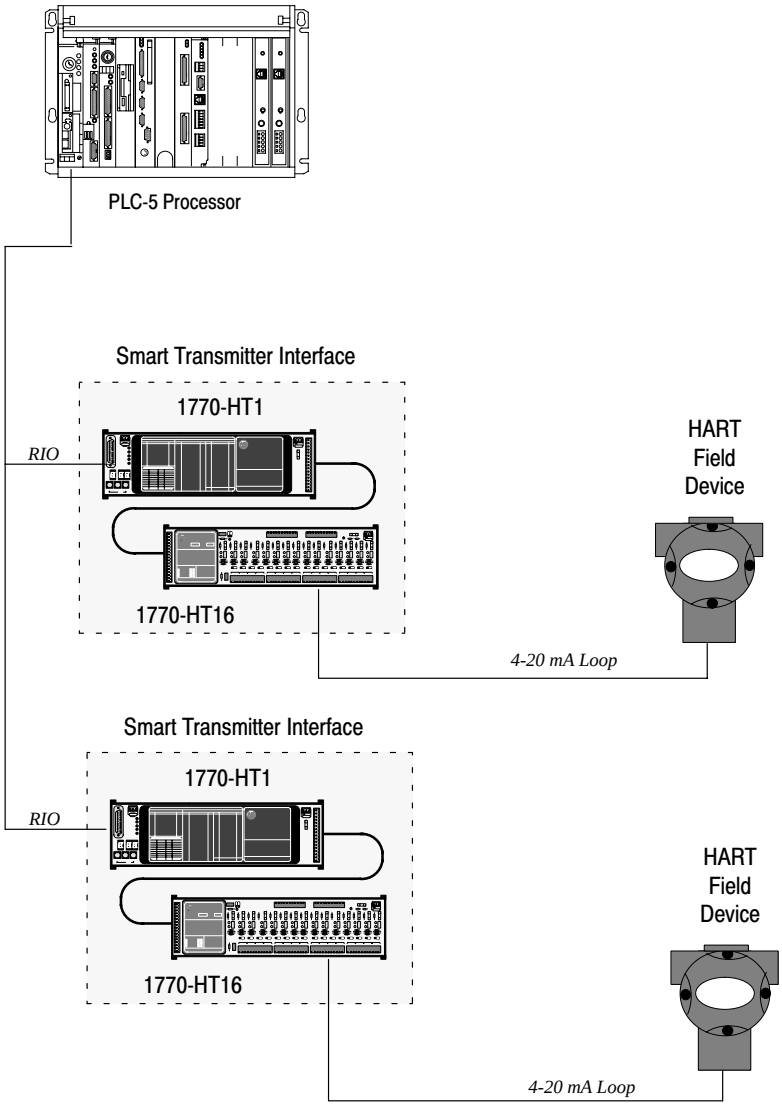


Example 2 *(continued)*



Programming Example 3: Multiple HART Devices With Multiple 1770-HT1s

In this example, the primary variable is read continuously from two HART field devices that are wired to separate 1770-HT1s. Communication with multiple 1770-HT1s can occur asynchronously when calling the STT subroutine.



In the course of operation, if the field device does not respond, we reissue HART command 0 to get the HART address. This example assumes that each device data area is setup with the standard inputs for HART command 0 prior to the execution of this logic.

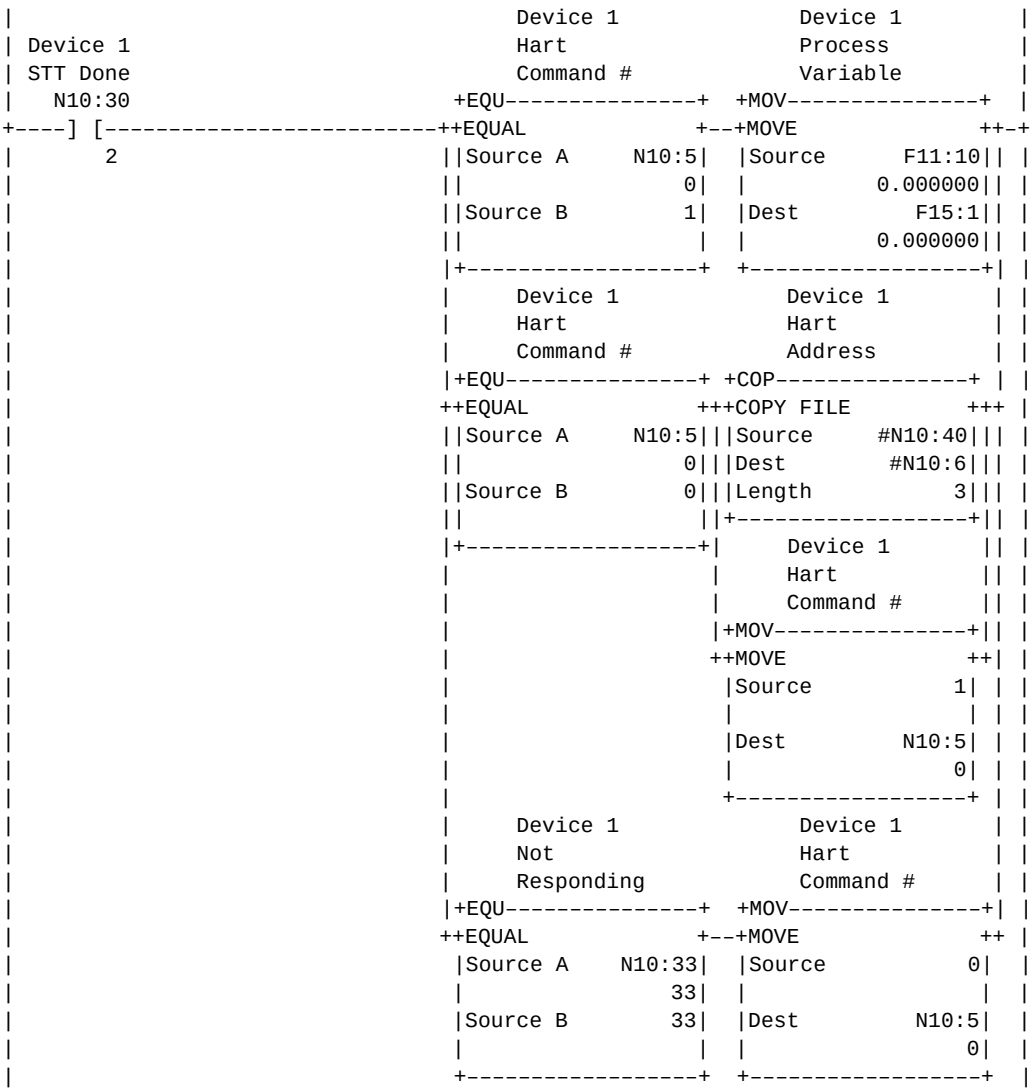
- Device 1 uses N10 and F11
- Device 2 uses N12 and F13
- F15 contains both primary variable values

Example 3 *(continued)*

```
Rung 2:0
STT 1.00 Programming Example 3.
This example reads the primary variable from 2 HART field devices wired to 2
1770-HT1s.

When the STT subroutine is not enabled, set the STT subroutine trigger bit.
|                                                                  Device 1   |
| Device 1                                                         STT        |
| STT enable                                                       trigger    |
|   N10:30                                                           N10:30   |
+----]/[-------------------------------------------------------------(L)-----+
|       1                                                                3    |

Rung 2:1
Call the STT subroutine unconditionally.
|                                                          STT             |
|                                                          Subroutine      |
|                                                      +JSR---------------+ |
+------------------------------------------------------+JUMP TO SUBROUTINE+-+
|                                                      |Prog file number 5| |
|                                                      |Input par       10| |
|                                                      |Return par        | |
|                                                      +------------------+ |
```

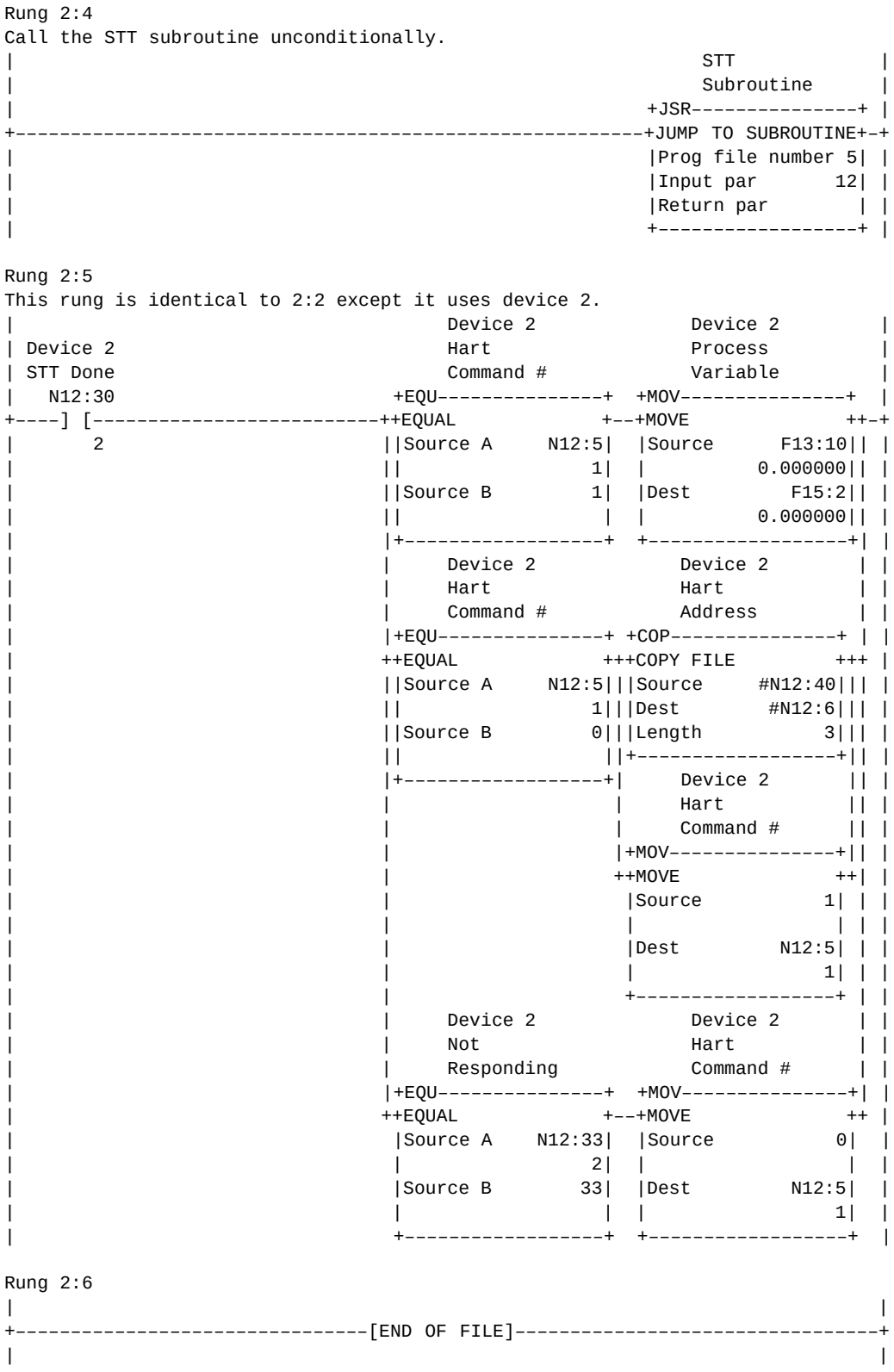
Example 3 *(continued)*

Rung 2:2
Only process when the STT subroutine is done. If the Hart command is 1, copy the primary variable to file F15. If the Hart command is 0, copy the Hart address to the input area and request Hart command 1. If device 1 does not respond (error 33), try getting a new Hart address for device 1 by requesting Hart command 0.



Rung 2:3
This rung is identical to 2:0, except it uses device 2.

Example 3 *(continued)*



Appendix A

HART Command Data Table Layouts

What's In This Appendix

This appendix contains the data table layouts for the HART commands that are supported in the Smart Transmitter Toolkit (STT).

Important: All data table layout examples in this appendix are shown assuming that these conditions exist:

- The 1770-HT1 is located at I/O rack 4 and I/O group 6.
- The HART field device is wired:
  - to channel 3 of a 1770-HT8 or 1770-HT16
  - point-to-point (polling address is 0)
- The HART field device uses a long-frame address.

HART Command 0

Read HART Address

Use this command to read the HART address from a HART field device.

Important: To use STT, you must include this command at least once in your program prior to any calls with other HART commands. This command returns the HART address of the HART field device. The HART address is used in all other HART commands.

Standard Inputs		
Integer	Word 0	I/O Rack Number of 1770-HT1
	Word 1	I/O Group Number of 1770-HT1
	Word 2	Channel Number of HART field device
	Word 3	Polling Address of HART field device
	Word 4	Smart Transmitter Interface Command Number 16 (decimal)
	Word 5	HART Command Number 0

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	4	6	3	0	16	0	0	0	0	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	0	0	0	0	0	0	0	0	0	0
N10:40	0	0	0	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

These six integer words are the standard inputs that are required for each HART command *(see page 3-3)*.

HART Command 0
Read HART Address

Standard Outputs		
Integer	Word 30	STT Subroutine Status Word
	Word 31	STT Subroutine Error Code
	Word 32	Smart Transmitter Interface Status Word
	Word 33	Smart Transmitter Interface Error Code
	Word 34	HART Protocol-Communication Error Code
	Word 35	HART Command Response Summary Error Code
	Word 36	HART Field Device Error Code
Command-specific Outputs		
Integer	Words 40 - 42	HART Address of HART field device

Long Frame HART Address

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	4	6	3	0	16	0	0	0	0	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	4	0	128	0	0	0	0	0	0	0
N10:40	9858	269	12807	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

This is the HART address that is needed as an input to the other HART commands.

These seven integer words are the standard outputs that contain the status of the communications with the HART field device *(see page 3-6)*.

Short Frame HART Address

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	4	6	3	0	16	0	0	0	0	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	4	0	128	0	0	0	0	0	0	0
N10:40	1538	0	0	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

This is the HART address that is needed as an input to the other HART commands.

These seven integer words are the standard outputs that contain the status of the communications with the HART field device *(see page 3-6)*.

HART Command 1

Read Primary Variable

Use this command to read the primary variable and unit code from a HART field device. The primary variable is returned in floating-point format and the unit code is returned as an integer.

Standard Inputs		
Integer	Word 0	I/O Rack Number of 1770-HT1
	Word 1	I/O Group Number of 1770-HT1
	Word 2	Channel Number of HART field device
	Word 3	Polling Address of HART field device
	Word 4	Smart Transmitter Interface Command Number 16 (decimal)
	Word 5	HART Command Number 1
Command-specific Inputs		
Integer	Words 6 - 8	HART Address of HART field device

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	4	6	3	0	16	1	9858	269	12807	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	0	0	0	0	0	0	0	0	0	0
N10:40	0	0	0	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

These six integer words are the standard inputs that are required for each HART command *(see page 3-3)*.

This is the HART address that is returned from HART Command 0 *(see page A-3)*.

HART Command 1
Read Primary Variable

Standard Outputs		
Integer	Word 30	STT Subroutine Status Word
	Word 31	STT Subroutine Error Code
	Word 32	Smart Transmitter Interface Status Word
	Word 33	Smart Transmitter Interface Error Code
	Word 34	HART Protocol-Communication Error Code
	Word 35	HART Command Response Summary Error Code
	Word 36	HART Field Device Error Code
Command-specific Outputs		
Integer	Word 40	Primary Variable Unit Code
Floating-point	Word 10	Primary Variable

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	4	6	3	0	16	1	9858	269	12807	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	4	0	128	0	0	0	0	0	0	0
N10:40	32	0	0	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

This integer word is a command-specific output that contains the unit code for the primary variable *(see page B-5)*.

These seven integer words are the standard outputs that contain the status of the communications with the HART field device *(see page 3-6)*.

Data Table Report PLC-5/25 Addr 31 Data Table File F11:0

Address	0	1	2	3	4
F11:0	0	0	0	0	0
F11:5	0	0	0	0	0
F11:10	20.58	0	0	0	0
F11:15	0	0	0	0	0

This floating-point word is a command-specific output that contains the primary variable.

HART Command 3

Read Dynamic Variables & Primary Variable Current

Use this command to read the primary variable current and up to four predefined dynamic variables from the HART field device.

- The primary variable current always matches the analog output current of the device including alarm conditions and set values.
- The secondary, tertiary, and 4th variables are defined by each device type. For example, the secondary variable is the sensor temperature for the 3051 pressure transmitter.

Standard Inputs		
Integer	Word 0	I/O Rack Number of 1770-HT1
	Word 1	I/O Group Number of 1770-HT1
	Word 2	Channel Number of HART field device
	Word 3	Polling Address of HART field device
	Word 4	Smart Transmitter Interface Command Number 16 (decimal)
	Word 5	HART Command Number 3
Command-specific Inputs		
Integer	Words 6 - 8	HART Address of HART field device

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	4	6	3	0	16	3	9858	269	12807	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	0	0	0	0	0	0	0	0	0	0
N10:40	0	0	0	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

These six integer words are the standard inputs that are required for each HART command *(see page 3-3*).

This is the HART address that is returned from HART Command 0 *(see page A-3)*.

HART Command 3

Read Dynamic Variables & Primary Variable Current

Standard Outputs		
Integer	Word 30	STT Subroutine Status Word
	Word 31	STT Subroutine Error Code
	Word 32	Smart Transmitter Interface Status Word
	Word 33	Smart Transmitter Interface Error Code
	Word 34	HART Protocol-Communication Error Code
	Word 35	HART Command Response Summary Code
	Word 36	HART Field Device Error Code
Command-specific Outputs		
Integer	Word 41	Primary Variable Unit Code
	Word 42	Secondary Variable Unit Code
	Word 43	Tertiary Variable Unit Code
	Word 44	4th Variable Unit Code
Floating-point	Word 10	Primary Variable Current
	Word 11	Primary Variable
	Word 12	Secondary Variable
	Word 13	Tertiary Variable
	Word 14	4th Variable

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	4	6	3	0	16	3	9858	269	12807	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	4	0	128	0	0	0	0	0	0	0
N10:40	0	32	250	250	250	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

These four integer words are the command-specific outputs that contain the unit codes for the variables *(see page B-5)*.

These seven integer words are the standard outputs that contain the status of the communications with the HART field device. *(see page 3-6)*.

Data Table Report PLC-5/25 Addr 31 Data Table File F11:0

Address	0	1	2	3	4
F11:0	0	0	0	0	0
F11:5	0	0	0	0	0
F11:10	7.29	20.58	0	0	0
F11:15	0	0	0	0	0

This floating-point word is a command-specific output that contains the primary variable current.

These four floating-point words are command-specific outputs that contain the variables from the HART field device.

HART Command 35

Write Primary Variable Range Values

Use this command to write new upper and lower primary variable range values to the data memory of the HART field device. This command then outputs the actual upper and lower primary range values from the data memory of the HART field device.

- If the write operation was successful, you should see the same values that you entered.
- If the write operation was unsuccessful, you will see the original values from the data memory of the field device. These values may or may not be the same as the values that you entered. Check the status and error codes.

Standard Inputs		
Integer	Word 0	I/O Rack Number of 1770-HT1
	Word 1	I/O Group Number of 1770-HT1
	Word 2	Channel Number of HART field device
	Word 3	Polling Address of HART field device
	Word 4	Smart Transmitter Interface Command Number 16 (decimal)
	Word 5	HART Command Number 35
Command-specific Inputs		
Integer	Words 6 - 8	HART Address from HART Command 0
	Word 10	Primary Variable Range Values Unit Code
Floating-point	Word 0	Primary Variable Upper Range Value
	Word 1	Primary Variable Lower Range Value

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	4	6	3	0	16	35	9858	269	12807	0
N10:10	32	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	0	0	0	0	0	0	0	0	0	0
N10:40	0	0	0	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

This integer word is a command-specific input and contains the (new) unit code for the primary variable *(see page B-5)*.

These six integer words are the standard inputs that are required for each HART command *(see page 3-3)*.

This is the HART address that is returned from HART Command 0 *(see page A-3)*.

Data Table Report PLC-5/25 Addr 31 Data Table File F11:0

Address	0	1	2	3	4
F11:0	100.0	0.0	0	0	0
F11:5	0	0	0	0	0
F11:10	0	0	0	0	0
F11:15	0	0	0	0	0

These two floating-point words are command-specific inputs that contain the new upper and lower range values for the primary variable.

HART Command 35

Write Primary Variable Range Values

Standard Outputs		
Integer	Word 30	STT Subroutine Status Word
	Word 31	STT Subroutine Error Code
	Word 32	Smart Transmitter Interface Status Word
	Word 33	Smart Transmitter Interface Error Code
	Word 34	HART Protocol-Communication Error Code
	Word 35	HART Command Response Summary Code
	Word 36	HART Field Device Error Code
Command-specific Outputs		
Integer	Word 40	Primary Variable Range Values Unit Code
Floating-point	Word 10	Primary Variable Upper Range Value
	Word 11	Primary Variable Lower Range Value

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	4	6	3	0	16	35	9858	269	12807	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	4	0	128	0	0	0	0	0	0	0
N10:40	32	0	0	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

This integer word is a command-specific output that should contain the unit code that you entered for the primary variable *(see page B-5)*.

These seven integer words are the standard outputs that contain the status of the communications with the HART field device. *(see page 3-6)*.

Data Table Report PLC-5/25 Addr 31 Data Table File F11:0

Address	0	1	2	3	4
F11:0	100.0	0.0	0	0	0
F11:5	0	0	0	0	0
F11:10	100.0	0.0	0	0	0
F11:15	0	0	0	0	0

These two floating-point words are command-specific outputs that should contain the new upper and lower range values that you entered for the primary variable.

HART Command 38

Reset Configuration Change Flag

Use this command to reset the configuration change flag.

Standard Inputs		
Integer	Word 0	I/O Rack Number of 1770-HT1
	Word 1	I/O Group Number of 1770-HT1
	Word 2	Channel Number of HART field device
	Word 3	Polling Address of HART field device
	Word 4	Smart Transmitter Interface Command Number 16 (decimal)
	Word 5	HART Command Number 38
Command-specific Inputs		
Integer	Words 6 - 8	HART address from HART Command 0

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	4	6	3	0	16	38	9858	269	12807	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	0	0	0	0	0	0	0	0	0	0
N10:40	0	0	0	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

These six integer words are the standard inputs that are required for each HART command *(see page 3-3)*.

This is the HART address that is returned from HART Command 0 *(see page A-3)*.

HART Command 38

Reset Configuration Change Flag

Standard Outputs		
Integer	Word 30	STT Subroutine Status Word
	Word 31	STT Subroutine Error Code
	Word 32	Smart Transmitter Interface Status Word
	Word 33	Smart Transmitter Interface Error Code
	Word 34	HART Protocol-Communication Error Code
	Word 35	HART Command Response Summary Code
	Word 36	HART Field Device Error Code

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
N10:0	4	6	3	0	16	38	9858	269	12807	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	4	0	128	0	0	0	0	0	0	0
N10:40	0	0	0	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

These seven integer words are the standard outputs that contain the status of the communications with the HART field device *(see page 3-6)*.

HART Command 43

Set Primary Variable Zero

Use this command to trim the primary variable so that it reads zero with the existing process applied to the HART field device. The resulting offset must be within the limits defined by each device.

Standard Inputs		
Integer	Word 0	I/O Rack Number of 1770-HT1
	Word 1	I/O Group Number of 1770-HT1
	Word 2	Channel Number of HART field device
	Word 3	Polling Address of HART field device
	Word 4	Smart Transmitter Interface Command Number 16 (decimal)
	Word 5	HART Command Number 43
Command-specific Inputs		
Integer	Words 6 - 8	HART Address from HART Command 0

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	4	6	3	0	16	43	9858	269	12807	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	0	0	0	0	0	0	0	0	0	0
N10:40	0	0	0	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

These six integer words are the standard inputs that are required for each HART command *(see page 3-3)*.

This is the HART address that is returned from HART Command 0 *(see page A-3)*.

HART Command 43

Set Primary Variable Zero

Standard Outputs		
Integer	Word 30	STT Subroutine Status Word
	Word 31	STT Subroutine Error Code
	Word 32	Smart Transmitter Interface Status Word
	Word 33	Smart Transmitter Interface Error Code
	Word 34	HART Protocol-Communication Error Code
	Word 35	HART Command Response Summary Code
	Word 36	HART Field Device Error Code

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	4	6	3	0	16	43	9858	269	12807	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	4	0	128	0	0	0	0	0	0	0
N10:40	0	0	0	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

These seven integer words are the standard outputs that contain the status of the communications with the HART field device *(see page 3-6)*.

HART Command 44

Write Primary Variable Units

Use this command to select the units in which the primary variable and the primary variable range will be returned by the HART field device. This command also selects the units for sensor limits and minimum span.

Standard Inputs		
Integer	Word 0	I/O Rack Number of 1770-HT1
	Word 1	I/O Group Number of 1770-HT1
	Word 2	Channel Number of HART field device
	Word 3	Polling Address of HART field device
	Word 4	Smart Transmitter Interface Command Number 16 (decimal)
	Word 5	HART Command Number 44
Command-specific Inputs		
Integer	Words 6 - 8	HART Address from HART Command 0
	Word 10	Primary Variable Unit Code

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	4	6	3	0	16	44	9858	269	12807	0
N10:10	32	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	0	0	0	0	0	0	0	0	0	0
N10:40	0	0	0	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

This integer word is a command-specific input that contains the (new) unit code for the primary variable *(see page B-5)*.

This is the HART address that is returned from HART Command 0 *(see page A-3)*.

These six integer words are the standard inputs that are required for each HART command *(see page 3-3)*.

HART Command 44
Write Primary Variable Units

Standard Outputs		
Integer	Word 30	STT Subroutine Status Word
	Word 31	STT Subroutine Error Code
	Word 32	Smart Transmitter Interface Status Word
	Word 33	Smart Transmitter Interface Error Code
	Word 34	HART Protocol-Communication Error Code
	Word 35	HART Command Response Summary Code
	Word 36	HART Field Device Error Code
Command-specific Outputs		
Integer	Word 40	Primary Variable Unit Code

Data Table Report PLC-5/25 Addr 31 Data Table File N10:0

Address	0	1	2	3	4	5	6	7	8	9
N10:0	4	6	3	0	16	44	9858	269	12807	0
N10:10	0	0	0	0	0	0	0	0	0	0
N10:20	0	0	0	0	0	0	0	0	0	0
N10:30	4	0	128	0	0	0	0	0	0	0
N10:40	32	0	0	0	0	0	0	0	0	0
N10:50	0	0	0	0	0	0	0	0	0	0

This integer word is the command-specific output that should contain the unit code that you entered for the primary variable.

These seven integer words are the standard outputs that contain the status of the communications with the HART field device *(see page 3-6)*.

Appendix B

Codes

What's In This Appendix

This appendix contains the codes that you need to use the STT subroutine.

STT Subroutine Error Codes

Integer Word 31

Code	Definition
1	Block-transfer write (BTW) error
2	Block-transfer read (BTR) error

Smart Transmitter Interface Error Codes

Integer Word 33

General Errors

Code (decimal)	Code (hex)	Definition	Description
0	00	No Error	The Smart Transmitter Interface processed the last received command, and no errors were detected.
1	01	Downloading Firmware	The Smart Transmitter Interface firmware is being upgraded over the RS-232C port. The last received command cannot be processed.
2	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.
3	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

Code (decimal)	Code (hex)	Definition	Description
16	10	Invalid Command	The Smart Transmitter Interface command is invalid and cannot be processed.
17	11	Invalid Channel Number	The Smart Transmitter Interface channel number is invalid. The command cannot be processed.
18	12	Invalid HART Message	The HART packet encapsulated within a Smart Transmitter Interface packet is invalid and cannot be forwarded to a field device.
19	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.
20	14	Invalid Parameter	An invalid parameter is provided with the Smart Transmitter Interface command and so it cannot be processed.
21	15	Invalid Control	An invalid control byte is included with the Smart transmitter Interface command. The command cannot be processed.
22	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

Code (decimal)	Code (hex)	Definition	Description
32	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.
33	21	No Response Received From Device	The Smart Transmitter Interface has not received a response from a field device after exhausting all retry attempts.
34	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.

HART Protocol Communication Error Codes

Integer Word 34

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.

HART Command Response Summary Error Codes

Integer Word 35

Code	HART Command	Code Definition	
0	All①	No command-specific errors	No errors were found in verifying the parameters for this command.
2	All①	Invalid Selection	The code or index was not allowed in this command or for this field device.
5	All①	Too Few Data Bytes Received	The message syntax was proper but the number of bytes contained in the message was less than required to execute the command.
6	All①	Transmitter-Specific Command Error	An error occurred in a HART command for which a Command-Specific Response Code is not defined. Further information on this response code is available in each Transmitter-Specific document.
7	All①	In Write Protect Mode	The field device is Write Protected and cannot accept this write command.
8	All①	Warning: Update Failure	The real-time data returned from the field device has not changed since the last time it was read.
9	35	Lower Range Value too High	The Lower Range Value was above the Upper Sensor Limit.
	43	Applied Process too High	The process applied to the field device was too high.
10	35	Applied Process too Low	The process applied to the field device was too low.
	43	Lower Range Value too Low	The Lower Range Value was below the Lower Sensor Limit.
11	All①	Upper Range Value too High	The Upper Range Value was above the Upper Sensor Limit.
12	All①	Upper Range Value too Low	The Upper Range Value was below the Lower Sensor Limit.
13	All①	Upper and Lower Range Values Out of Limits	Both the Upper and Lower Range Values are beyond their limits.
14	All①	Span too Small	The Span, as determined from the Upper and Lower Range Values, was below the Minimum Span.
16	All①	Access Restricted	The command was rejected due to a condition within the Field Device which would prevent proper execution.
32	All①	Busy	The device is performing a function that cannot be interrupted by this command.
64	All①	Command not implemented	The command was not defined for this device.

① This code applies to all HART commands that are supported by this release of the Smart Transmitter Toolkit: 0, 1, 3, 35, 38, 43, and 44.

HART Field Device Error Codes

Integer Word 36

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 on 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 HART command 48, Read Additional Status Information. **Note:** HART command 48 is not supported by the STT subroutine.
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.

Unit Codes

Integer Words 10 and 40

Code	Units	Recommended Abbreviation
0	Undefined	
1	inches H_2O @ 68 degrees Fahrenheit	InH_20
2	inches Hg @ 0 degrees Celsius	InHg
3	feet H_2O @ 68 degrees Fahrenheit	FtH_20
4	millimeters H_2O @ 68 degrees Fahrenheit	mmH_2O
5	millimeters Hg @ 0 degrees Celsius	mmHg
6	pounds/square inch	psi
7	bars	bars
8	millibars	mbar
9	grams/square centimeter	g/SqCm
10	kilograms/square centimeter	kg/SqCm
11	pascals	PA
12	kilopascals	kPA
13	torr @ 0 degrees Celsius	torr
14	atmospheres	ATM
15	cubic feet/minute	CuFt/min
16	gallons/minute	gal/min
17	liters/minute	l/min
18	imperial gallons/minute	ImpGal/min
19	cubic meters/hour	CuMtr/hr
20	feet/second	ft/s
21	meters/second	mtr/s
22	gallons/second	gal/s
23	million gallons/day	MilGal/day
24	liters/second	l/s
25	million liters/day	MilL/day
26	cubic feet/second	CuFt/s
27	cubic feet/day	CuFt/day
28	cubic meters/second	CuMtr/s
29	cubic meters/day	CuMtr/day
30	imperial gallons/hour	ImpGal/hr
31	imperial gallons/day	ImpGal/day
32	degrees Celsius	degC
33	degrees Fahrenheit	degF
34	degrees Rankine	degR

Code	Units	Recommended Abbreviation
35	Kelvin	Kelvin
36	millivolts	mV
37	ohms	Ohm
38	Hertz	Hz
39	milliamperes	mA
40	gallons	gal
41	liters	liter
42	imperial gallons	ImpGal
43	cubic meters	CuMtr
44	feet	ft
45	meters	meter
46	barrels	bbl
47	inches	in
48	centimeters	cm
49	millimeters	mm
50	minutes	min
51	seconds	sec
52	hours	hr
53	days	day
54	Undefined	
55	centipoise	cpoise
56	microsiemens	uSiemen
57	percent	%
58	volts	v
59	pH	pH
60	grams	grams
61	kilogram	kg
62	metric tons	MetTon
63	pounds	lb
64	short tons (2000 pounds)	ShTon
65	long tons (2240 pounds)	LTon
66	Undefined	
69	Undefined	
70	grams/seconds	g/s
71	grams/minute	g/min

Unit Codes *(continued)*

Integer Words 10 and 40

Code	Units	Recommended Abbreviation
72	grams/hour	g/hr
73	kilograms/second	kg/s
74	kilograms/minute	kg/min
75	kilograms/hour	kg/hr
76	kilograms/day	kg/day
77	metric tons/minute	MetTon/min
78	metric tons/hour	MetTon/hr
79	metric tons/day	MetTon/day
80	pounds/second	lb/s
81	pounds/minute	lb/min
82	pounds/hour	lb/hr
83	pounds/day	lb/day
84	short tons (2000 pounds)/minute	ShTon/min
85	short tons (2000 pounds)/hour	ShTon/hr
86	short tons (2000 pounds)/day	ShTon/day
87	long tons (2240 pounds)/hour	LTon/hr
88	long tons (2240 pounds)/day	LTon/day
89	Undefined	
90	specific gravity units	SGU
91	grams/cubic centimeter	g/CuCm
92	kilograms/cubic meter	kg/CuMtr
93	pounds/gallon	lb/gal
94	pounds/cubic foot	lb/CuFt
95	grams/milliliter	g/ml
96	kilograms/liter	kg/l
97	grams/liter	g/l
98	pounds/cubic inch	lb/CuIn
99	short tons(2000 pounds)/cubic yard	ShTon/CuYd
100	degrees Twaddell	degTwad
101	degrees Brix	degBrix
102	degrees Baume - heavy	degBaum hv
103	degrees Baume - light	degBaum lt
104	degrees API	degAPI
105	percent solids/weight	%sol-wt
106	percent solids/volume	%sol-vol
107	degrees Balling	degBall

Code	Units	Recommended Abbreviation
108	proof/volume	proof/vol
109	proof/mass	proof/mass
110	bushels	bush
111	cubic yards	CuYd
112	cubic feet	CuFt
113	cubic inches	CuIn
114	undefined	
119	undefined	
120	meters/hour	mtr/hr
121	undefined	
129	undefined	
130	cubic feet/hour	CuFt/hr
131	cubic meters/minute	CuMtr/min
132	barrels/second	bbl/sec
133	barrels/minute	bbl/min
134	barrels/hour	bbl/hr
135	barrels/day	bbl/day
136	gallons/hour	gal/hr
137	imperial gallons/second	ImpGal/sec
138	liters/hour	l/hr
139	undefined	
149	undefined	
150	percent steam quality	% Stm Qual
151	feet-in-sixteenths	Ft.In16
152	cubic feet/pound	CuFt/lb
153	undefined	
159	undefined	
160	percent Plato	% plato
161	undefined	
249	undefined	
250	not used	
251	reserved	
252	reserved	
253	special	
254	reserved	
255	reserved	

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