

User's Manual 0300217-01 Rev. A

Compact™ I/O Isolated HART Analog Module

Catalog Number: 1769sc-OF4IH



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Preface

Read this preface to familiarize yourself with the rest of the manual. This preface covers the following topics:

- Who should use this manual
- How to use this manual
- Related publications
- Conventions used in this manual
- Rockwell Automation support

Who Should Use This Manual

Use this manual if you are responsible for designing, installing, programming, or troubleshooting control systems that use Allen-Bradley Compact™ I/O and/or compatible controllers, such as MicroLogix 1500 or CompactLogix.

How to Use This Manual

As much as possible, we organized this manual to explain, in a task-by-task manner, how to install, configure, program, operate and troubleshoot a control system using the 1769sc-OF4IH.

Related Documentation

The table below provides a listing of publications that contain important information about MicroLogix 1500 systems.

Document Title	Document Number
MicroLogix™ 1500 User Manual	1764-UM001A-US-P
1769 Compact Discrete Input/Output Modules Product Data	1769-2.1
MicroLogix™ 1500 System Overview	1764-SO001B-EN-P
Compact™ I/O System Overview	1769-SO001A-EN-P
CompactLogix User Manual	1769-UM007B-EN-P
Allen-Bradley Programmable Controller Grounding and Wiring Guidelines	1770-4.1

If you would like a manual, you can:


- Download a free electronic version from the internet at www.theautomationbookstore.com
- Purchase a printed manual by:
 - Contacting your local distributor or Rockwell Automation representative
 - Visiting www.theautomationbookstore.com and placing your order
 - Calling 1.800.963.9548 (USA/Canada) or 001.330.725.1574 (Outside USA/Canada)

Conventions Used in This Manual

The following conventions are used throughout this manual:

- Bulleted lists (like this one) provide information not procedural steps.
- Numbered lists provide sequential steps or hierarchical information.
- *Italic* type is used for emphasis
- **Bold** type identifies headings and sub-headings



- Attention  Are used to identify critical information to the reader

Chapter 1

Module Overview

This chapter describes the 1769sc-OF4IH isolated HART analog output module. The module provides four isolated current outputs with HART communication.

Included is information about:

- The module's hardware and diagnostic features
- An overview of the system and module operation
- Compatibility

Section 1.1 General Description

The OF4IH is a four channel isolated module that allows each channel to be configured independently for either 0 to 20mA or 4 to 20mA with or without HART communication. The module converts the digital value stored in each channel's output command word (i.e. output words 0 to 3) to an analog current signal. If HART is enabled on a specific channel, the user also has the ability to send and receive HART communication to and from the connected HART device. HART data is sent and received using the module's input and output image table. Over-range/under-range detection and indication is also provided by the module for each channel..

The table below lists the output ranges for the module.

Table 1-1

Current Output Types
0 to 20mA
4mA to 20mA

Section 1.2 Data Formats

The data format can be configured for:

- Engineering units
- Scaled-for-PID
- Percent of full-scale
- Raw/proportional data

Section 1.3 Hardware Features

The module contains a removable terminal block. Each channel has a dedicated ground which is isolated from the remaining channels by 500VDC.

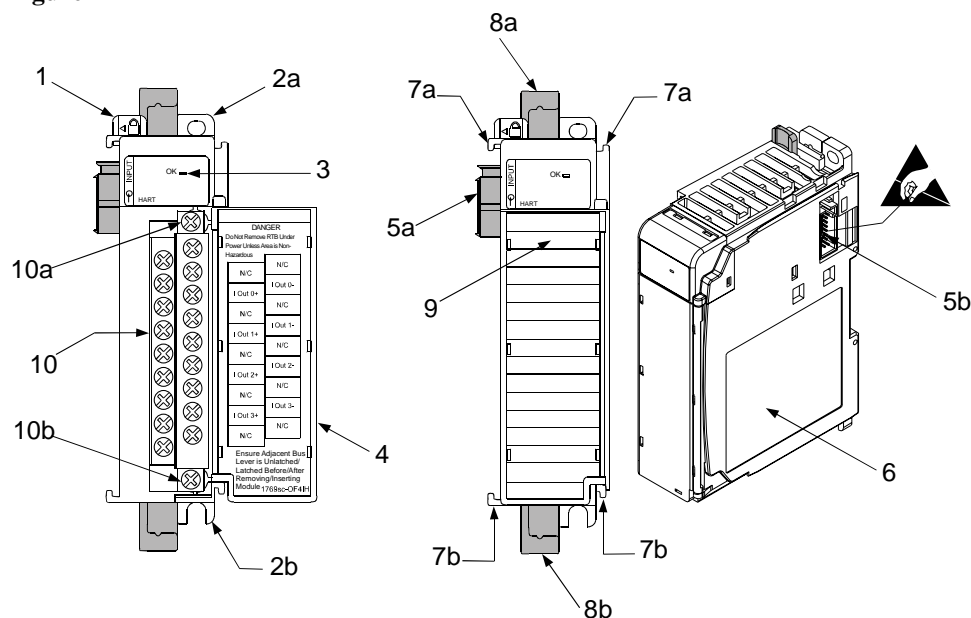


Attention

Do not short the channel grounds together unless you plan to remove the channel to channel isolation.

Module configuration is done via the controller's programming software. In addition, some controllers support configuration via the user program. In either case, the module configuration is stored in the memory of the controller. Refer to your controller's user manual for more information. The illustration below shows the module's hardware features.

Figure 1-1



Item	Description
1	bus lever
2a	upper panel mounting tab
2b	lower panel mounting tab
3	module status LED
4	module door with terminal identification label
5a	movable bus connector (bus interface) with female pins
5b	stationary bus connector (bus interface) with male pins
6	nameplate label
7a	upper tongue-and-groove slots
7b	lower tongue-and-groove slots
8a	upper DIN rail latch
8b	lower DIN rail latch

- 9 write-on label for user identification tags
- 10 removable terminal block (RTB) with finger-safe cover
- 10a RTB upper retaining screw
- 10b RTB lower retaining screw

1.3.1 General Diagnostic Features

The module contains a diagnostic LED that helps you identify the source of problems that may occur during power-up or during normal channel operation. The LED indicates both status and power. Power-up and channel diagnostics are explained in Chapter 9 Diagnostics and Troubleshooting.

Section 1.4 System Overview

The modules communicate to the controller through the bus interface. The modules also receive 5 and 24V dc power through the bus interface.

1.4.1 System Operation

At power-up, the module performs a check of its internal circuits, memory, and basic functions. During this time, the module status LED remains off. If no faults are found during power-up diagnostics, the module status LED is turned on.

After power-up checks are complete, the module waits for valid channel configuration data. If an invalid configuration is detected, the module generates a configuration error. Once a channel is properly configured and enabled, it continuously converts the output command value (i.e. output words 0 to 3) to a proportional analog signal that is within the output range selected for that channel.

Each time a channel command value is read by the output module, that data value is tested by the module for an over-range or under-range condition. If such a condition is detected, a unique bit is set in the channel status word. The channel status word is described in Section 6.3 Input Data File.

Using the module image table, the controller reads the two's complement binary converted input data from the module. This typically occurs at the end of the program scan or when commanded by the control program. If the controller and the module determine that the data transfer has been made without error, the data is used in the control program.

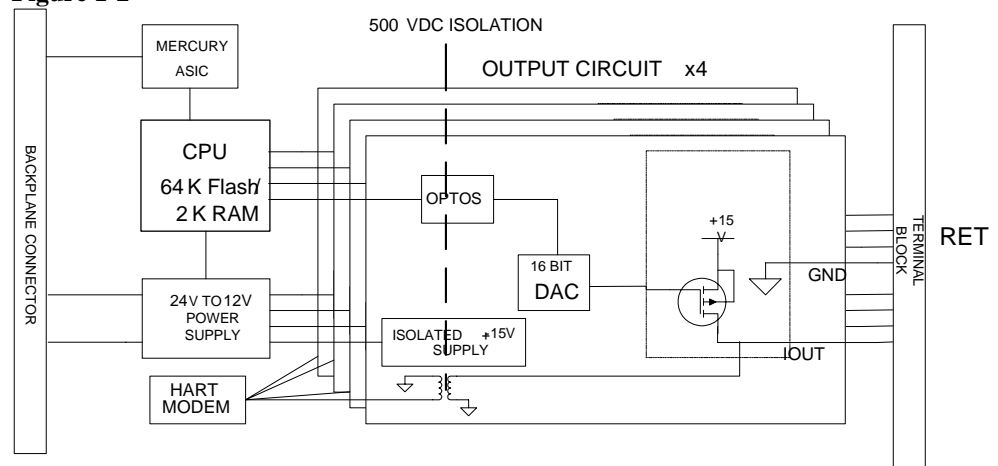
Section 1.5 Module Operation

When the module receives a new command value from the output image, the module's circuitry converts the digital value to an analog current signal using a DAC (Digital to Analog Converter). The resulting signal is made available for the specific channel via the removable terminal block. If HART is enabled on a channel, the HART data is acquired by means of an onboard HART modem.

Note: *The HART data is sent and received asynchronously from the analog acquisition process and therefore does not directly effect the analog update time.*

See the block diagram below.

Figure 1-2



The module is designed to support up to 4 isolated channels which can be independently configured for current, or current with HART.

The HART data, if enabled, is converted directly to a block of twenty controller input tags. The data within this block of twenty tags is multiplexed. For information on HART and how to demultiplex the HART data, refer to Chapter 7.

Chapter 2

Quick Start for Experienced Users

Section 2.1 Before You Begin

This chapter can help you get started using the 1769sc-OF4IH isolated HART analog output module. We base the procedures here on the assumption that you have an understanding of Allen-Bradley controllers. You should understand electronic process control and be able to interpret the ladder logic instructions required to generate the electronic signals that control your application.

Because it is a start-up guide for experienced users, this chapter does not contain detailed explanations about the procedures listed. It does, however, reference other chapters in this book where you can get more information about applying the procedures described in each step.

If you have any questions or are unfamiliar with the terms used or concepts presented in the procedural steps, always read the referenced chapters and other recommended documentation before trying to apply the information.

Section 2.2 Required Tools and Equipment

Have the following tools and equipment ready:

- Medium blade or cross-head screwdriver
- Analog output device
- Shielded, twisted-pair cable for wiring (Belden™ 8761 or equivalent for current outputs)
- Controller (for example, a MicroLogix™ 1500 or CompactLogix™ controller)
- Programming device and software (for example, RSLogix 500™ or RSLogix 5000™)

Section 2.3 What You Need To Do

This chapter covers:

1. Ensuring that your power supply is adequate
2. Attaching and locking the module
3. Wiring the module
4. Configuring the module
5. Going through the startup procedure
6. Monitoring module operation

Step 1: Ensure that your 1769 system power supply¹ has sufficient current output to support your system configuration.

Reference

Chapter 3 (Installation and Wiring)

The modules maximum current draw is shown below:

5V dc	24V dc
180 mA	180 mA

NOTE: The module cannot be located more than 8 modules away from the system power supply.

Step 2: Attach and lock the module.

Reference

Chapter 3 (Installation and Wiring)

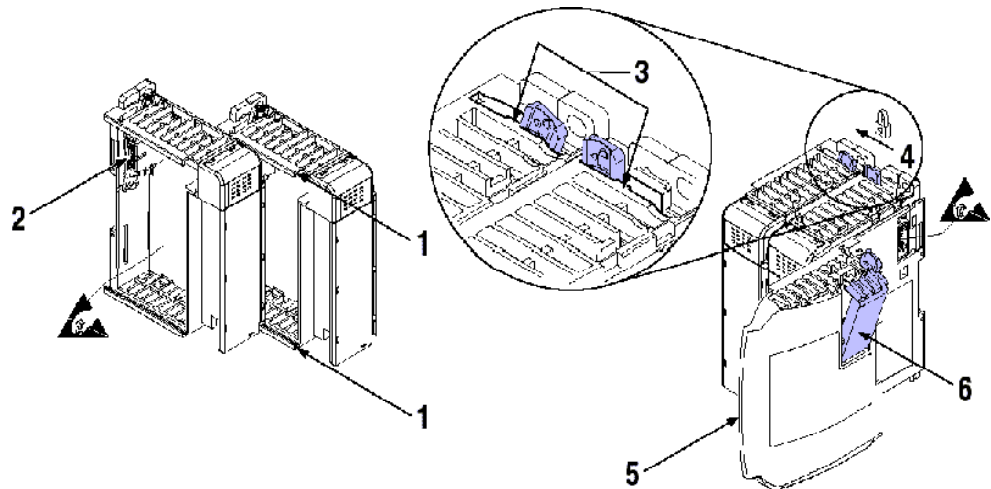
Remove power before removing or inserting this module. If you remove or insert a module with power applied an electrical arc may occur.

NOTE: The module can be panel or DIN rail mounted. Modules can be assembled before or after mounting.



Attention

Remove power before removing or inserting this module. If you remove or insert a module with power applied an electrical arc may occur.



1. Check that the bus lever of the module to be installed is in the unlocked (fully right) position.
2. Use the upper and lower tongue-and-groove slots (1) to secure the modules together (or to a controller).
3. Move the module back along the tongue-and-groove slots until the bus connectors (2) line up with each other.
4. Push the bus lever back slightly to clear the positioning tab (3). Use your fingers or a small screwdriver.

¹ The system power supply could be a 1769-PA2, -PB2, -PA4, -PB4, or the internal supply of the MicroLogix 1500 packaged controller.

5. To allow communication between the controller and module, move the bus lever fully to the left (4) until it clicks. Ensure it is locked firmly in place.
6. Attach an end cap terminator (5) to the last module in the system by using the tongue-and-groove slots as before.
7. Lock the end cap bus terminator (6).



Attention

When attaching I/O modules it is very important that the bus connectors are securely locked together to ensure proper electrical connection.



Attention

A 1769-ECR or 1769-ECL right or left end cap respectively must be used to terminate the end of the 1769 communication bus.

Step 3: Wire the module. Reference

Chapter 3 (Installation and Wiring)

Follow the guidelines below when wiring the module.

General

- Power and output wiring must be in accordance with Class 1, Division 2 wiring methods, Article 501-4(b) of the National Electric Code, NFPA 70, and in accordance with the authority having jurisdiction.
- Channels are isolated from one another by $\pm 500V$ dc maximum.
- Route field wiring away from any other wiring and keep it as far as possible from sources of electrical noise, such as motors, transformers, contactors, and ac devices. As a general rule, allow at least 15.2 cm (6 in.) of separation for every 120V of power.
- Routing field wiring in a grounded conduit can reduce electrical noise.
- If field wiring must cross ac or power cables, ensure that they cross at right angles.

Terminal Block

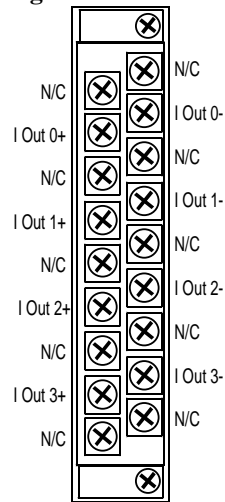
- For current output devices, use Belden 8761 shielded, twisted-pair wire (or equivalent) to ensure proper operation and high immunity to electrical noise.
- To ensure optimum accuracy, limit overall cable impedance by keeping a cable as short as possible. Locate the module as close to input devices as the application permits.

Grounding

- This product is intended to be mounted to a well-grounded mounting surface such as a metal panel. Additional grounding connections from the module's mounting tabs or DIN rail (if used) are not required unless the mounting surface cannot be grounded.
- Keep cable shield connections to ground as short as possible.
- Ground the shield drain wire at one end only. The preferred location is as follows.
- Refer to *Industrial Automation Wiring and Grounding Guidelines*, Allen-Bradley publication 1770-4.1, for additional information.

The terminal block layout is shown below:

Figure 2-1



Step 4: Configure the module for the proper controller.

Reference

Chapter 4 (Configuring the OF4IH for CompactLogix Using RSLogix 5000) or Chapter 5 (Configuring the OF4IH for a MicroLogix 1500 Using RSLogix 500)

Step 5: Configure the module.

Reference

Chapter 6 (Module Data, Status, and Channel Configuration)

The configuration file is typically modified using the programming software compatible with your controller. It can also be modified through the control program, if supported by the controller. See Section 6.4 Module Configuration Configuration for more information.

Step 6: Go through the startup procedure.

Reference

Chapter 9 (Diagnostics and Troubleshooting)

1. Apply power to the controller system.
2. Download your program, which contains the Isolated HART module configuration settings, to the controller.
3. Put the controller in Run mode. During a normal start-up, the module status LED turns on.

NOTE: *If the module status LED does not turn on, cycle power. If the condition persists, contact your local distributor or Spectrum Controls for assistance.*

Step 7: Monitor the module status to check if the module is operating correctly**Reference**

Chapter 9 (Diagnostics and Troubleshooting)

Module and channel configuration errors are reported to the controller. These errors are typically reported in the controller's I/O status file. Channel status data is also reported in the module's input data table, so these bits can be used in your control program to flag a channel error.

Chapter 3

Installation and Wiring

This chapter explains how to:

- Determine the power requirements for the module
- Avoid electrostatic damage
- Install the module
- Wire the module's terminal block
- Wire output devices

Section 3.1 Compliance to European Union Directives

This product is approved for installation within the European Union and EEA regions. It has been designed and tested to meet the following directives.

3.1.1 EMC Directive

The 1769sc-OF4IH module is tested to meet Council Directive 89/336/EEC Electromagnetic Compatibility (EMC) and the following standards, in whole or in part, documented in a technical construction file:

- EN 50081-2 EMC – Generic Emission Standard, Part 2 - Industrial Environment
- EN 50082-2 EMC – Generic Immunity Standard, Part 2 - Industrial Environment

This product is intended for use in an industrial environment.

3.1.2 Low Voltage Directive

This product is tested to meet Council Directive 73/23/EEC Low Voltage, by applying the safety requirements of EN 61131-2 Programmable Controllers, Part 2 – Equipment Requirements and Tests. For specific information required by EN61131-2, see the appropriate sections in this publication, as well as the following Allen-Bradley publications:

- Industrial Automation, Wiring and Grounding Guidelines for Noise Immunity, publication 1770-4.1
- Automation Systems Catalog, publication B113

3.1.3 CE Safety

This product is designed to, and verified compliance with, European Union Safety Standards:

- EN61131-2
- EN61010-1

Section 3.2 Power Requirements

The module receives power through the bus interface from the +5V dc/ +24V dc system power supply. The maximum current drawn by the module is shown in the table below.

Module Current Draw	at 5V dc	at 24V dc
	180 mA	180 mA

Section 3.3 General Considerations

Compact I/O is suitable for use in an industrial environment when installed in accordance with these instructions. Specifically, this equipment is intended for use in clean, dry environments (Pollution degree 2¹ and to circuits not exceeding Over Voltage Category II² (IEC 60664-1)³

3.3.1 Hazardous Location Considerations

This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D or non-hazardous locations only. The following WARNING statement applies to use in hazardous locations.



- **EXPLOSION HAZARD**
- **Substitution of components may impair suitability for Class I, Division 2.**
- **Do not replace components or disconnect equipment unless power has been switched off or the area is known to be non-hazardous.**
- **Do not connect or disconnect components unless power has been switched off or the area is known to be non-hazardous.**
- **This product must be installed in an enclosure.**
- **All wiring must comply with N.E.C. article 501-4(b).**

3.3.2 Prevent Electrostatic Discharge



- Electrostatic discharge can damage integrated circuits or semiconductors if you touch analog I/O module bus connector pins or the terminal block on the output module. Follow these guidelines when you handle the module:
- Touch a grounded object to discharge static potential.**
 - Wear an approved wrist-strap grounding device.**
 - Do not touch the bus connector or connector pins.**
 - Do not touch circuit components inside the module.**
 - If available, use a static-safe work station.**
 - When it is not in use, keep the module in its static-shield bag.**

¹ Pollution Degree 2 is an environment where, normally, only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation shall be expected.

² Over Voltage Category II is the load level section of the electrical distribution system. At this level transient voltages are controlled and do not exceed the impulse voltage capability of the product's insulation.

³ Pollution Degree 2 and Over Voltage Category II are International Electrotechnical Commission (IEC) designations.

3.3.3 Remove Power



Remove power before removing or inserting this module. When you remove or insert a module with power applied, an electrical arc may occur. An electrical arc can cause personal injury or property damage by:

- **Sending an erroneous signal to your system’s field devices, causing unintended machine motion**
- **Causing an explosion in a hazardous environment**

- **Electrical arcing causes excessive wear to contacts on both the module and its mating connector and may lead to premature failure.**

3.3.4 Selecting a Location

Reducing Noise

Most applications require installation in an industrial enclosure to reduce the effects of electrical interference. Analog outputs are highly susceptible to electrical noise. Electrical noise coupled to the analog outputs will reduce the performance (accuracy) of the module.

Group your modules to minimize adverse effects from radiated electrical noise. Consider the following conditions when selecting a location for the analog module. Position the module:

- Away from sources of electrical noise such as hard-contact switches, relays, and AC motor drives
- Away from high voltage conductors

In addition, route shielded, twisted-pair analog input wiring away from any high voltage I/O wiring.

Reducing Heat

To avoid complications when operating in ambient temperatures in excess of 55 degrees C, the following recommendations should be followed. Position the module:

- Away from heat sources such as transformers, variable frequency drives, and cabinet heaters.
- Avoid installing the module adjacent to modules which generate over 4 W of heat, such as the 1769-HSC. The table below lists modules which should be avoided if possible:

Table 3-1 (Modules To Avoid)

Module Catalog	Max Thermal Dissipation
1769-ADN	4.7
1769-HSC	6.2
1769-IQ32	4.8
1769-OW16	4.8
1769-OB32	4.5

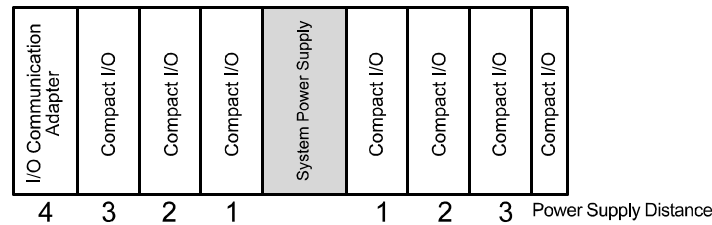
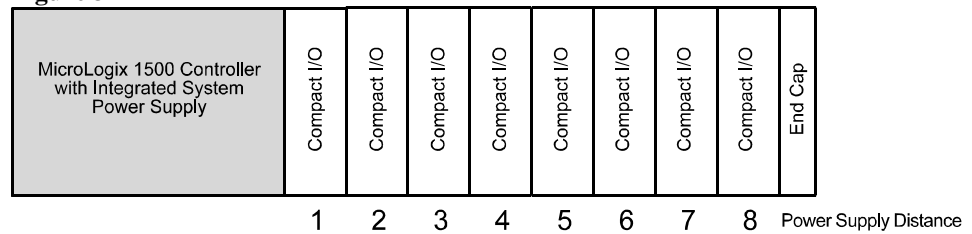


If the OF4IH is to be installed adjacent to one of the modules listed in the table above and the ambient temperature is in excess of 55°C, then derating of the module is required to avoid thermal shutdown. Assume the thermal dissipation of the OF4IH to be 2W fixed plus an additional 0.5W per channel. For example, if the OF4IH is to be installed adjacent to the 1769-HSC, no more than 2 channels should be used on the OF4IH.

Power Supply Distance

You can install as many modules as your power supply can support. However, all 1769 I/O modules have a power supply distance rating. The maximum I/O module rating is 8, which means that a module may not be located more than 8 modules away from the system power supply.

Figure 3-1

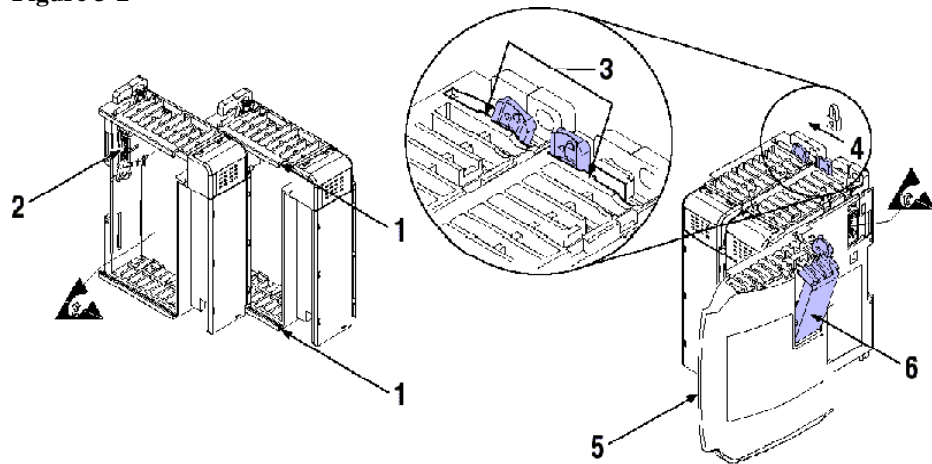


**Section 3.4
System Assembly**

The module can be attached to the controller or an adjacent I/O module before or after mounting. For mounting instructions, see Panel Mounting Using the Dimensional Template, or DIN Rail Mounting. To work with a system that is already mounted, see Replacing a Single Module within a System.

The following procedure shows you how to assemble the Compact I/O system.

Figure 3-2



1. Disconnect power.
2. Check that the bus lever of the module to be installed is in the unlocked (fully right) position.

NOTE: *If the module is being installed to the left of an existing module, check that the right-side adjacent module's bus lever is in the unlocked (fully right) position.*

3. Use the upper and lower tongue-and-groove slots (1) to secure the modules together (or to a controller).
4. Move the module back along the tongue-and-groove slots until the bus connectors (2) line up with each other.
5. Push the bus lever back slightly to clear the positioning tab (3). Use your fingers or a small screwdriver.
6. To allow communication between the controller and module, move the bus lever fully to the left (4) until it clicks. Ensure it is locked firmly in place.



Attention

When attaching I/O modules, it is very important that the bus connectors are securely locked together to ensure proper electrical connection.

7. Attach an end cap terminator (5) to the last module in the system by using the tongue-and-groove slots as before.
8. Lock the end cap bus terminator (6).



Attention

A 1769-ECR or 1769-ECL right or left end cap respectively must be used to terminate the end of the bus.

Section 3.5 Mounting



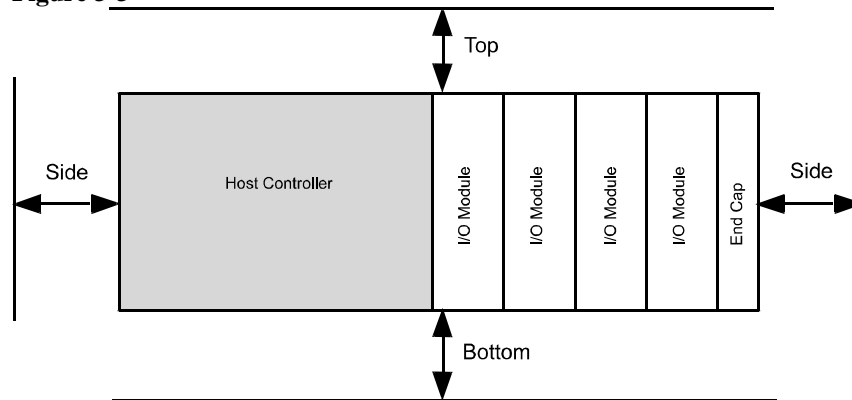
Attention

During panel or DIN rail mounting of all devices, be sure that all debris (metal chips, wire strands, etc.) is kept from falling into the module. Debris that falls into the module could cause damage at power up.

3.5.1 Minimum Spacing

Maintain spacing from enclosure walls, wireways, adjacent equipment, etc. Allow 50 mm (2 in.) of space on all sides for adequate ventilation, as shown below:

Figure 3-3

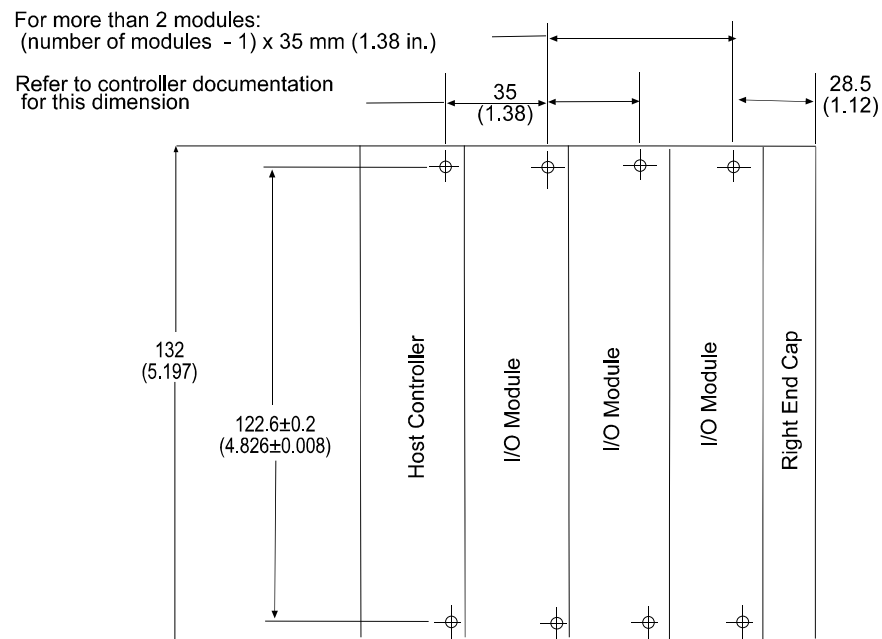


3.5.2 Panel Mounting

Mount the module to a panel using two screws per module. Use M4 or #8 panhead screws. Mounting screws are required on every module.

Panel Mounting Using the Dimensional Template

Figure 3-4



Note: All dimensions are in mm (in.).
 Hole spacing tolerance is ± 0.4 mm
 (0.016 in.).

Panel Mounting Procedure Using Modules as a Template

The following procedure allows you to use the assembled modules as a template for drilling holes in the panel. If you have sophisticated panel mounting equipment, you can use the dimensional template provided on the previous page. Due to module mounting hole tolerance, it is important to follow these procedures:

1. On a clean work surface, assemble no more than three modules.
2. Using the assembled modules as a template, carefully mark the center of all module-mounting holes on the panel.
3. Return the assembled modules to the clean work surface, including any previously mounted modules.
4. Drill and tap the mounting holes for the recommended M4 or #8 screw.
5. Place the modules back on the panel, and check for proper hole alignment.
6. Attach the modules to the panel using the mounting screws.

NOTE *If mounting more modules, mount only the last one of this group and put the others aside. This reduces remounting time during drilling and tapping of the next group.*

7. Repeat steps 1 to 6 for any remaining modules.

3.5.3 DIN Rail Mounting

The module can be mounted using the following DIN rails:

- 35 x 7.5 mm (EN 50 022 - 35 x 7.5), or
- 35 x 15 mm (EN 50 022 - 35 x 15).

Before mounting the module on a DIN rail, close the DIN rail latches. Press the DIN rail mounting area of the module against the DIN rail. The latches will momentarily open and lock into place.

Section 3.6 Replacing a Single Module within a System

The module can be replaced while the system is mounted to a panel (or DIN rail). Follow these steps in order:

1. Remove power. See important note at the beginning of this chapter.
2. On the module to be removed, remove the upper and lower mounting screws from the module (or open the DIN latches using a flat-blade or phillips-style screwdriver).
3. Move the bus lever to the right to disconnect (unlock) the bus.
4. On the right-side adjacent module, move its bus lever to the right (unlock) to disconnect it from the module to be removed.
5. Gently slide the disconnected module forward. If you feel excessive resistance, check that the module has been disconnected from the bus, and that both mounting screws have been removed (or DIN latches opened).

NOTE: *It may be necessary to rock the module slightly from front to back to remove it, or, in a panel-mounted system, to loosen the screws of adjacent modules.*

6. Before installing the replacement module, be sure that the bus lever on the module to be installed and on the right-side adjacent module or end cap are in the unlocked (fully right) position.
7. Slide the replacement module into the open slot.
8. Connect the modules together by locking (fully left) the bus levers on the replacement module and the right-side adjacent module.
9. Replace the mounting screws (or snap the module onto the DIN rail).

Section 3.7 Field Wiring Connections & System Wiring Guidelines

Consider the following when wiring your system:

General

- Power and output wiring must be in accordance with Class 1, Division 2 wiring methods, Article 501-4(b) of the National Electric Code, NFPA 70, and in accordance with the authority having jurisdiction.
- Channels are isolated from one another by ± 500 Vdc maximum.
- Route field wiring away from any other wiring and as far as possible from sources of electrical noise, such as motors, transformers, contactors, and ac devices. As a general rule, allow at least 15.2 cm (6 in.) of separation for every 120V of power.
- Routing field wiring in a grounded conduit can reduce electrical noise.
- If field wiring must cross ac or power cables, ensure that they cross at right angles.
- If multiple power supplies are used with analog millivolt inputs, the power supply commons must be connected.

Terminal Block

- For voltage and current sensors, use Belden 8761 shielded, twisted-pair wire (or equivalent) to ensure proper operation and high immunity to electrical noise.
- To ensure optimum accuracy, limit overall cable impedance by keeping a cable as short as possible. Locate the module as close to input devices as the application permits.

Grounding

- This product is intended to be mounted to a well-grounded mounting surface such as a metal panel. Additional grounding connections from the module's mounting tabs or DIN rail (if used) are not required unless the mounting surface cannot be grounded.
- Keep cable shield connections to ground as short as possible.
- Ground the shield drain wire at one end only. The typical location is as follows.
- If it is necessary to connect the shield drain wire at the module end, connect it to earth ground using a panel or DIN rail mounting screw.
- Refer to Industrial Automation Wiring and Grounding Guidelines, Allen-Bradley publication 1770-4.1, for additional information.

Noise Prevention

- To limit the pickup of electrical noise, keep analog signal wires as far as possible from power and load lines.
- If noise persists for a device, try grounding the opposite end of the cable shield. (You should only ground one end at a time.)

3.7.2 Terminal Door Label

A removable, write-on label is provided with the module. Remove the label from the door, mark your unique identification of each terminal with permanent ink, and slide the label back into the door. Your markings (ID tag) will be visible when the module door is closed.

3.7.3 Removing and Replacing the Terminal Block

When wiring the module, you do not have to remove the terminal block. If you remove the terminal block, use the write-on label located on the side of the terminal block to identify the module location and type.

Figure 3-5



To remove the terminal block, loosen the upper and lower retaining screws. The terminal block will back away from the module as you remove the screws. When replacing the terminal block, torque the retaining screws to 0.46 Nm (4.1 in-lbs).

3.7.4 Wiring the Finger-Safe Terminal Block

When wiring the terminal block, keep the finger-safe cover in place.

1. Loosen the terminal screws to be wired.
2. Route the wire under the terminal pressure plate. You can use the bare wire or a spade lug. The terminals accept a 6.35 mm (0.25 in.) spade lug.

NOTE: *The terminal screws are non-captive. Therefore, it is possible to use a ring lug [maximum 1/4 inch o.d. with a 0.139 inch minimum i.d. (M3.5)] with the module.*

3. Tighten the terminal screw making sure the pressure plate secures the wire.

Recommended torque when tightening terminal screws is 0.68 Nm (6 in-lbs).

NOTE: *If you need to remove the finger-safe cover, insert a screwdriver into one of the square, wiring holes and gently pry the cover off. If you wire the terminal block with the finger-safe cover removed, you may not be able to put it back on the terminal block because the wires will be in the way.*

Wire Size and Terminal Screw Torque

Each terminal accepts up to two wires with the following restrictions:

Wire Type	Wire Size	Terminal Screw Torque	Retaining Screw Torque
Solid Cu-90°C (194°F)	#14 to #22 AWG	0.68 Nm (6 in-lbs)	0.46 Nm (4.1 in-lbs)
Stranded Cu-90°C (194°F)	#16 to #22 AWG	0.68 Nm (6 in-lbs)	0.46 Nm (4.1 in-lbs)

3.7.5 Wiring the Module

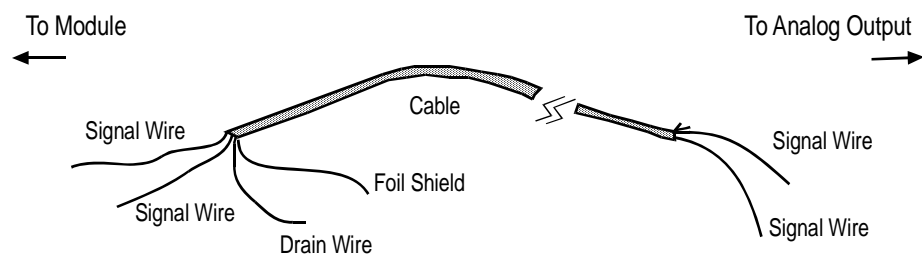


Attention

Before wiring any module, disconnect power from the system power supply.

After the module is properly installed, follow the wiring procedure below, using the proper cable, Belden 8761.

Figure 3-6



To wire your module follow these steps.

1. At each end of the cable, strip some casing to expose the individual wires.
2. Trim the signal wires to 2-inch (5 cm) lengths. Strip about 3/16 inch (5 mm) of insulation away to expose the end of the wire.



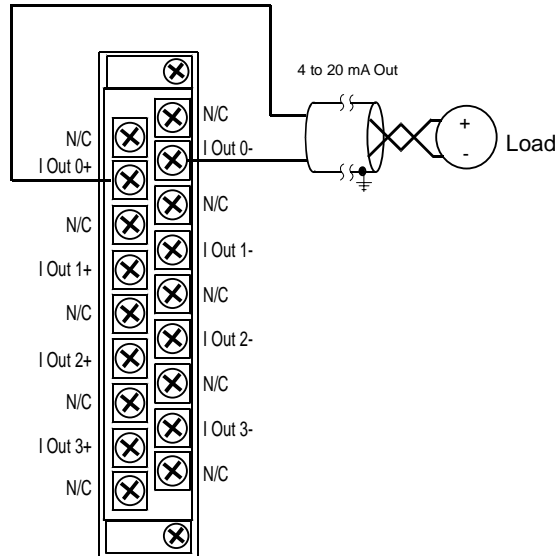
Attention

Be careful when stripping wires. Wire fragments that fall into a module could cause damage at power up.

3. At one end of the cable, twist the drain wire and foil shield together, bend them away from the cable, and apply shrink wrap. Then earth ground at the preferred location based on the type of sensor you are using. See Grounding for more details.
4. At the other end of the cable, cut the drain wire and foil shield back to the cable and apply shrink wrap.
5. Connect the signal wires to the terminal block. Connect the other end of the cable to the analog output device.
6. Repeat steps 1 through 5 for each channel on the module.

3.7.6 Wiring Diagram

Figure 3-7



3.7.7 Calibration

The isolated HART module is initially calibrated at the factory.

Chapter 4

Configuring the OF4IH for CompactLogix Using RSLogix 5000

This chapter explains how to incorporate the OF4IH module into a CompactLogix system using RSLogix 5000 programming software. The process of incorporating your HART module into the CompactLogix system is similar to the process needed to add an Allen-Bradley module. You will use your RSLogix 5000 programming software to install and configure your HART module.

The module is not currently in the RSLogix 5000 I/O pick list, so you will need to copy and paste information from a sample project that can be obtained from our website at (www.spectrumcontrols.com). You may also choose to build onto the sample project itself. The sample project contains the module profile, user defined data types, configuration tags, input tags, output tags, and ladder samples needed to configure each HART module. This chapter will discuss the process of copying the bits and pieces from the sample project. The topics discussed in this chapter include:

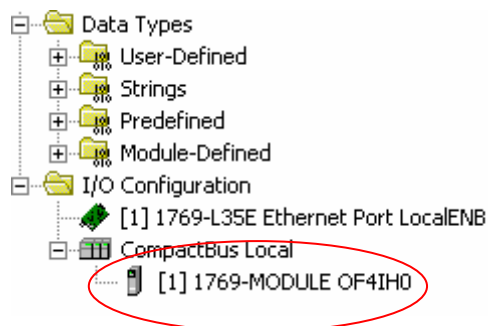
- Setting up the generic profile
- Understanding user defined data types
- Adding the controller and program tags
- Using the provided ladder sample

Section 4.1

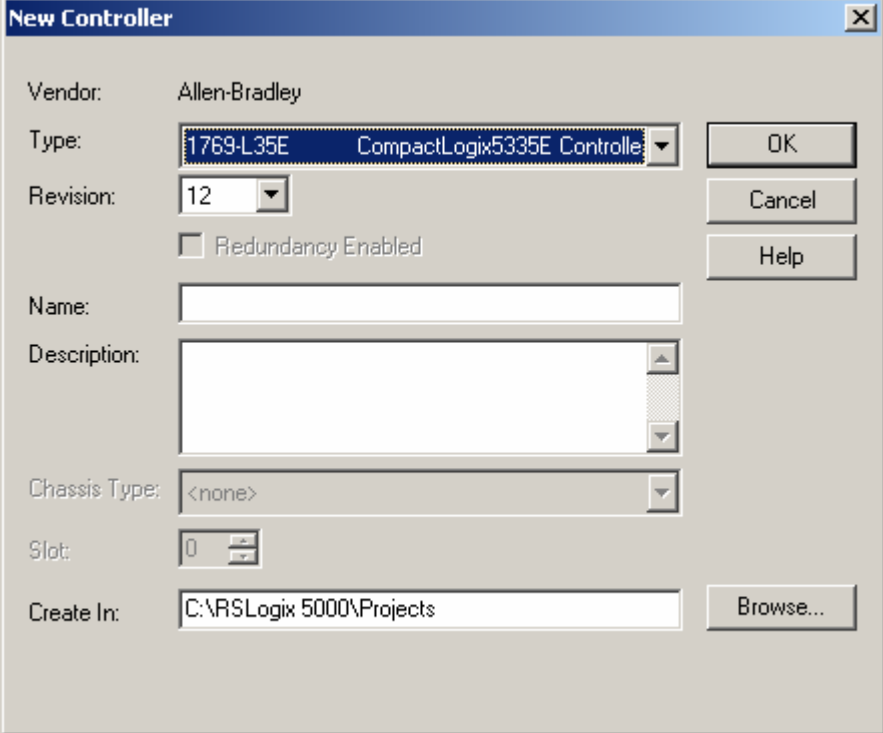
Setting up the Generic Profile

The generic profile defines the module for the CompactBus, so that the right number of input, output and configuration words are reserved. To configure the generic profile you can use the profile already created in the sample project, see Figure 4-1, or follow the procedures outlined below.

Figure 4-1 (Pre-Defined Generic Profile)



1. Create a new RSLogix 5000 project file. Click on the new project icon or on the FILE pull-down menu and select NEW. The following screen appears:

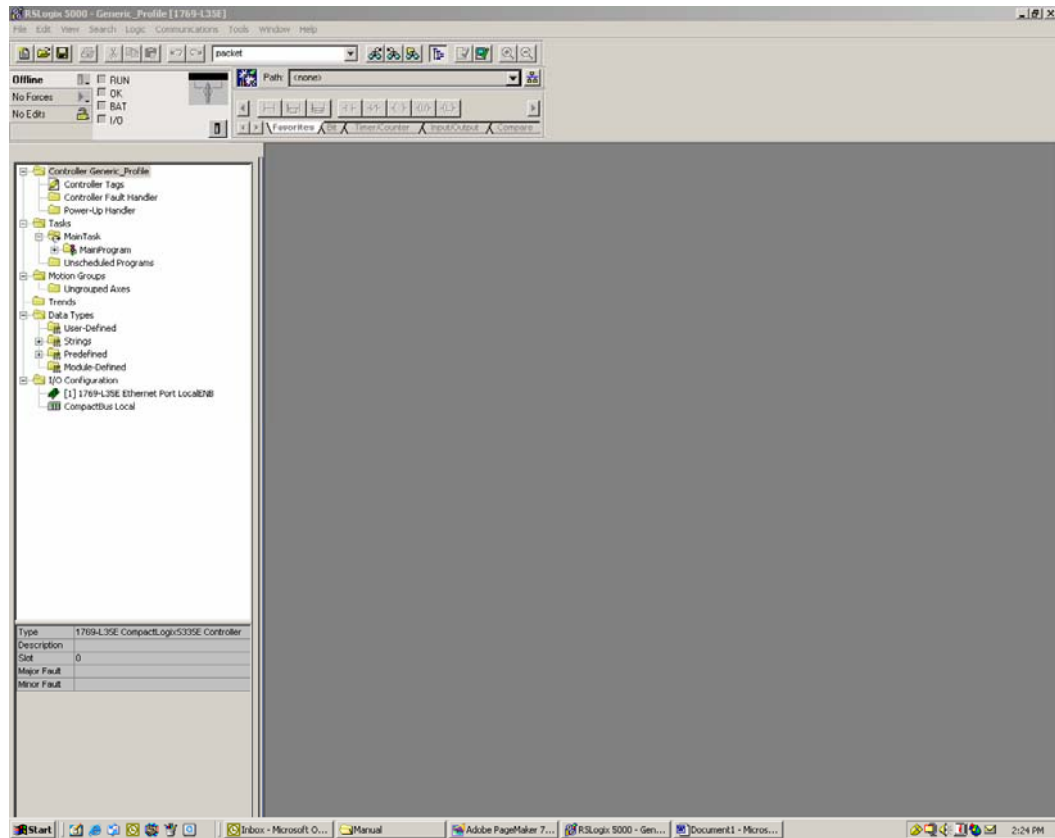
Figure 4-2

The screenshot shows the 'New Controller' dialog box with the following fields and options:

- Vendor: Allen-Bradley
- Type: 1769-L35E CompactLogix5335E Controller (dropdown menu)
- Revision: 12 (dropdown menu)
- Redundancy Enabled
- Name: (text input field)
- Description: (text input field)
- Chassis Type: <none> (dropdown menu)
- Slot: 0 (spin box)
- Create In: C:\RSLogix 5000\Projects (text input field)
- Buttons: OK, Cancel, Help, Browse...

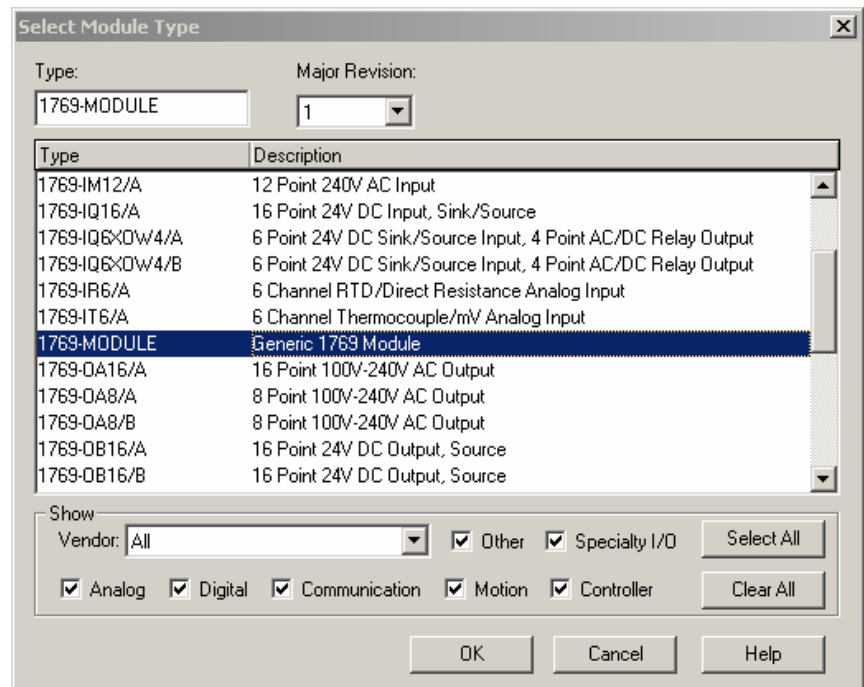
2. Choose your controller type and enter a name for your project, then click OK. The following main RSLogix 5000 screen appears:

Figure 4-3



- In the ControllerOrganizer on the left of the screen, right click on “[0]CompactBus Local”, select New Module, and the following screen appears:

Figure 4-4



- This screen is used to narrow your search for I/O modules to configure into your system. With the initial release of the CompactLogix5320 controller, this screen only includes the “Generic 1769 Module”. Click the OK button and the following default Generic Profile screen appears:

Figure 4-5

- First, select the Comm Format (“Data – INT” for the 1769sc-OF4IH), then fill in the name field. For this example, “OF4IH” is used to help identify the module type in the Controller Organizer. The Description field is optional and may be used to provide more details concerning this I/O module in your application.

The slot number must be selected next, although it will begin with the first available slot number, 1, and increments automatically for each subsequent Generic Profile you configure. For this example, the 1769sc-OF4IH HART module is located in slot 1.

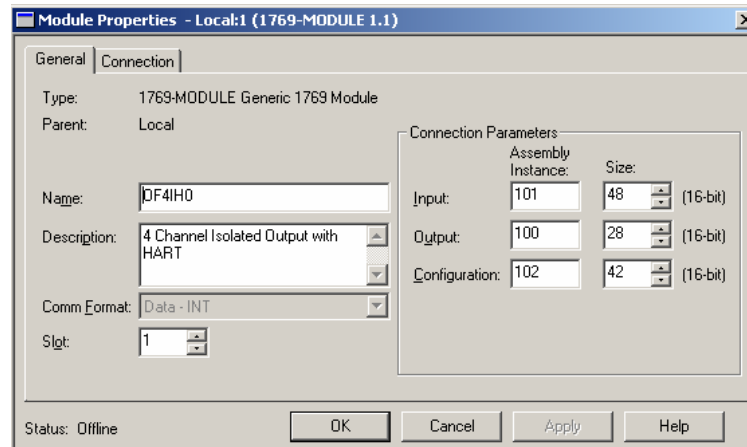
The Comm Format, Assembly Instance and Size values are listed in the following table for the 1769sc-OF4IH HART module:

Table 4-1 (Generic Profile Parameters)

1769 I/O Module	Comm Format	Parameter	Assembly Instance	Size (16-Bit)
OF4IH	Data-INT	Input	101	48
		Output	100	28
		Config	102	42

- Enter the Assembly Instance numbers and their associated sizes for the 1769sc-OF4IH module into the Generic Profile. When complete, the Generic Profile for a 1769sc-OF4IH module should look like the following:

Figure 4-6



- At this point you may click “Finish” to complete the configuration of your I/O module.

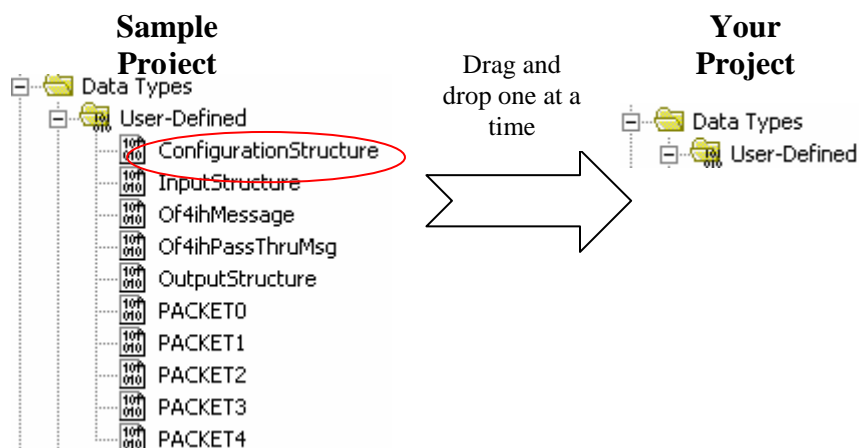
Configure each I/O module in this manner. The CompactLogix5320 controller supports a maximum of 8 I/O modules. The valid slot numbers to select when configuring I/O modules are 1 through 8.

Section 4.2 User Defined Data Types

The sample project contains *user defined data types* which define the structure for tags used within the project. The data types organize the HART data returned by the module and are referenced throughout this manual, so it is highly recommended that these data types be used whenever possible.

Select the data type you wish to copy from the *Controller Organizer* and paste it into your project under *user defined data types*. See figure below.

Figure 4-7 (Copying Data Types)



Attention

The user defined data types should be copied before copying the tags or ladder.

The table below gives a brief description of each data type.

Table 4-2 (User Defined Data Type Descriptions)

User Defined Data Type	Description
ConfigurationStructure	Defines the structure for the configuration tags used to configure the module. ¹
GetDeviceInfoStructure	Defines the structure of the HART data returned by the module when the module specific command, <i>Get Device Information</i> , is sent to module. ²
OF4IHMessage	This data type defines the structure for tags used to send messages to and from the module using the paging scheme. ²
OF4IHPassThruMsg	Defines the structure for tags used to send HART pass through messages to and from the module. ²
InputStructure	Defines the structure for the input tags returned by the module. ¹
OutputStructure	Defines the structure for the output tags used by the module. ¹
Packet0	Defines the data structure for HART packet 0. HART packet zero contains device information for the connected HART device. ²
Packet1	Defines the data structure for HART packet 1. HART packet 1 is used to display the four dynamic variables for the selected HART device. ²
Packet2	Defines the data structure for HART packet 2. HART packet 2 is used to display the slot variables for the connected HART device. ²
Packet3	Defines the data structure for HART packet 3. HART packet 3 displays the ASCII message for the connected HART device. ²
Packet4	Defines the data structure for HART packet 4. HART packet 4 contains the extended status for the connected HART device. ²

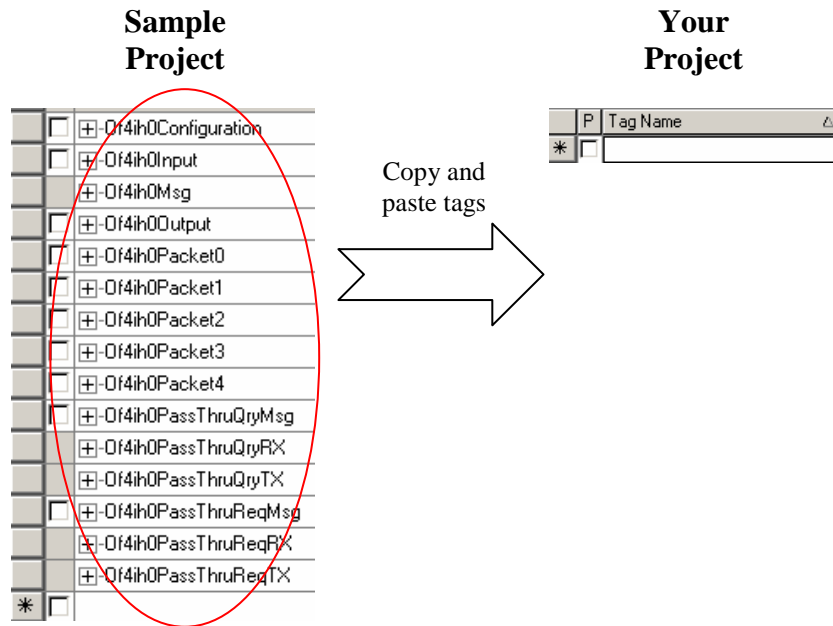
Section 4.3 Project Tags

The project tags were created to simplify the configuration of the module as well as reduce confusion related to using only the module local tags. The tags defined in the sample project utilize the *user defined data types* described in the previous section.

The tags from the controller scope should be copied to your project before the tags contained in the individual program sections. Open the controller tags on the sample project and select the *edit* tags mode. Grab the tags you want to copy by using the left mouse button and dragging. See figure below.

¹ Refer to Chapter 6 for more details.

² Refer to Chapter 7 for more details.

Figure 4-8 (Copying Controller Tags)

After copying the controller tags you can copy the program tags next. Follow the same procedure shown in Figure 4-8.

The figures below show examples of the configuration tags, input tags and output tags. Refer to Chapter 6 for information on how to configure the module and or reading the input data. Refer to Chapter 7 for information regarding HART packet tags and pass-through tags.

Figure 4-9 (Configuration Tags)

[-] 014ih0Configuration	{...}	{...}		ConfigurationStructure
[+] 014ih0Configuration.Ch0ConfigWord0	2#1000_0000_0000_0000		Binary	INT
[+] 014ih0Configuration.Ch0ConfigWord1	2#0000_0001_0000_0001		Binary	INT
[+] 014ih0Configuration.Ch0FaultValue	4000		Decimal	INT
[+] 014ih0Configuration.Ch0ProgramdbleValue	4000		Decimal	INT
[+] 014ih0Configuration.Ch0LowClamp	0		Decimal	INT
[+] 014ih0Configuration.Ch0HighClamp	0		Decimal	INT
[+] 014ih0Configuration.Ch0RampRate	0		Decimal	INT
[+] 014ih0Configuration.Ch0Reserved	0		Decimal	INT
[+] 014ih0Configuration.Ch1ConfigWord0	2#0000_0000_0000_0000		Binary	INT
[+] 014ih0Configuration.Ch1ConfigWord1	2#0000_0000_0000_0000		Binary	INT
[+] 014ih0Configuration.Ch1FaultValue	0		Decimal	INT
[+] 014ih0Configuration.Ch1ProgramdbleValue	0		Decimal	INT
[+] 014ih0Configuration.Ch1LowClamp	0		Decimal	INT
[+] 014ih0Configuration.Ch1HighClamp	0		Decimal	INT
[+] 014ih0Configuration.Ch1RampRate	0		Decimal	INT
[+] 014ih0Configuration.Ch1Reserved	0		Decimal	INT
[+] 014ih0Configuration.Ch2ConfigWord0	2#0000_0000_0000_0000		Binary	INT
[+] 014ih0Configuration.Ch2ConfigWord1	2#0000_0000_0000_0000		Binary	INT
[+] 014ih0Configuration.Ch2FaultValue	0		Decimal	INT
[+] 014ih0Configuration.Ch2ProgramdbleValue	0		Decimal	INT
[+] 014ih0Configuration.Ch2LowClamp	0		Decimal	INT
[+] 014ih0Configuration.Ch2HighClamp	0		Decimal	INT
[+] 014ih0Configuration.Ch2RampRate	0		Decimal	INT
[+] 014ih0Configuration.Ch2Reserved	0		Decimal	INT
[+] 014ih0Configuration.Ch3ConfigWord0	2#0000_0000_0000_0000		Binary	INT
[+] 014ih0Configuration.Ch3ConfigWord1	2#0000_0000_0000_0000		Binary	INT
[+] 014ih0Configuration.Ch3FaultValue	0		Decimal	INT
[+] 014ih0Configuration.Ch3ProgramdbleValue	0		Decimal	INT
[+] 014ih0Configuration.Ch3LowClamp	0		Decimal	INT
[+] 014ih0Configuration.Ch3HighClamp	0		Decimal	INT
[+] 014ih0Configuration.Ch3RampRate	0		Decimal	INT
[+] 014ih0Configuration.Ch3Reserved	0		Decimal	INT
[+] 014ih0Configuration.Pad	0		Decimal	INT
[+] 014ih0Configuration.HartConfig	2#0000_0001_1111_1111		Binary	INT
[+] 014ih0Configuration.Ch0SlotVariable01	0		Decimal	INT
[+] 014ih0Configuration.Ch0SlotVariable23	0		Decimal	INT
[+] 014ih0Configuration.Ch1SlotVariable01	0		Decimal	INT

Figure 4-10 (Input Tags)

[-] 014ih0Input	{...}	{...}		InputStructure
[+] 014ih0Input.StatusWord0	2#0000_0000_0000_0000		Binary	INT
[+] 014ih0Input.StatusWord1	2#0000_0000_0000_0000		Binary	INT
[+] 014ih0Input.Ch0Data	4000		Decimal	INT
[+] 014ih0Input.Ch1Data	-32767		Decimal	INT
[+] 014ih0Input.Ch2Data	-32767		Decimal	INT
[+] 014ih0Input.Ch3Data	-32767		Decimal	INT
[+] 014ih0Input.HartData	{...}	{...}	Decimal	SINT[40]
[+] 014ih0Input.MsgSlaveControl	16#0101		Hex	INT
[+] 014ih0Input.MsgResponseSize	16		Decimal	INT
[+] 014ih0Input.MsgResponseBuffer	{...}	{...}	Decimal	SINT[40]

Figure 4-11 (Output Tags)

[-] Of4ih00Output	{...}	{...}		OutputStructure
+ Of4ih00Output.Ch00OutputValue	4000		Decimal	INT
+ Of4ih00Output.Ch10OutputValue	0		Decimal	INT
+ Of4ih00Output.Ch20OutputValue	0		Decimal	INT
+ Of4ih00Output.Ch30OutputValue	0		Decimal	INT
+ Of4ih00Output.HartSuspendAndAlarmUnlatch	0		Decimal	INT
+ Of4ih00Output.HartPacketJustScanned	0		Decimal	INT
+ Of4ih00Output.MsgMasterControl	16#0101		Hex	INT
+ Of4ih00Output.MsgRequestSize	3		Decimal	INT
+ Of4ih00Output.MsgRequestBuffer	{...}	{...}	Decimal	SINT[40]

Section 4.4 Sample Project Ladder

The ladder contained in the sample project is used to perform several different operations. The *main* routine in the *MainProgram* is used to copy data from the user defined tags to the module local tags. This data includes input, output and configuration settings for the module.

The *OF4IH0_Packet_Data* routine in the *MainProgram* contains the ladder that demultiplexes the HART data for each individual packet. Refer to Section 7.2 HART Packet

Data for more information on HART and the HART packets.

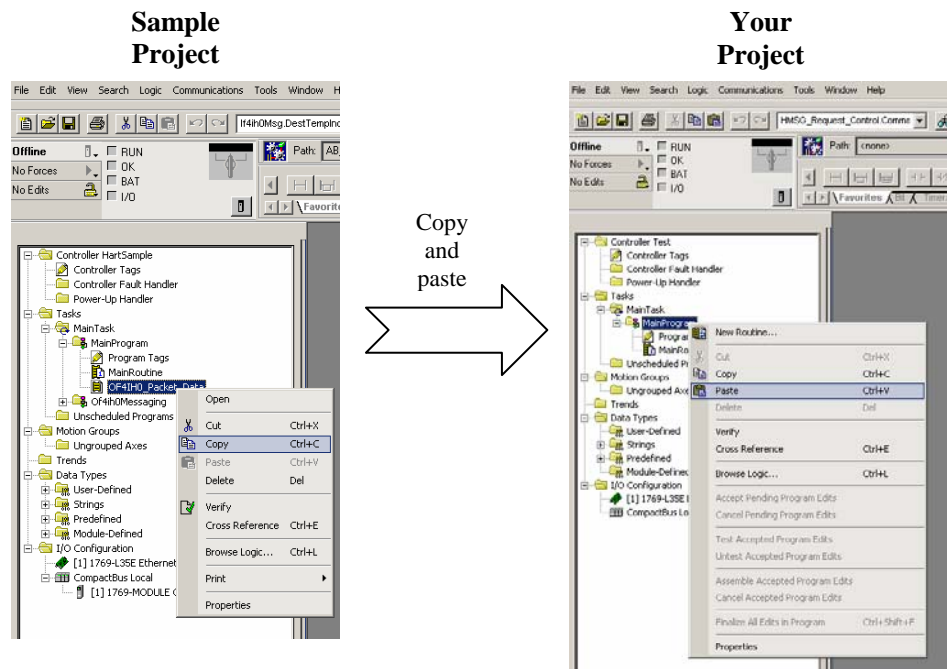
The *OF4IH0Messaging* program contains several routines needed to send and receive HART messages to and from the module and the connected HART devices.

To copy any of the ladder, programs or routines, follow the procedure below:

1. Select the program or routine.
2. Right mouse click and select copy.
3. Go to your project and select the appropriate program or task to place the new routine or program.
4. Right mouse click and select paste.

The figure below outlines this procedure:

Figure 4-12 (Copying Routines or Programs)



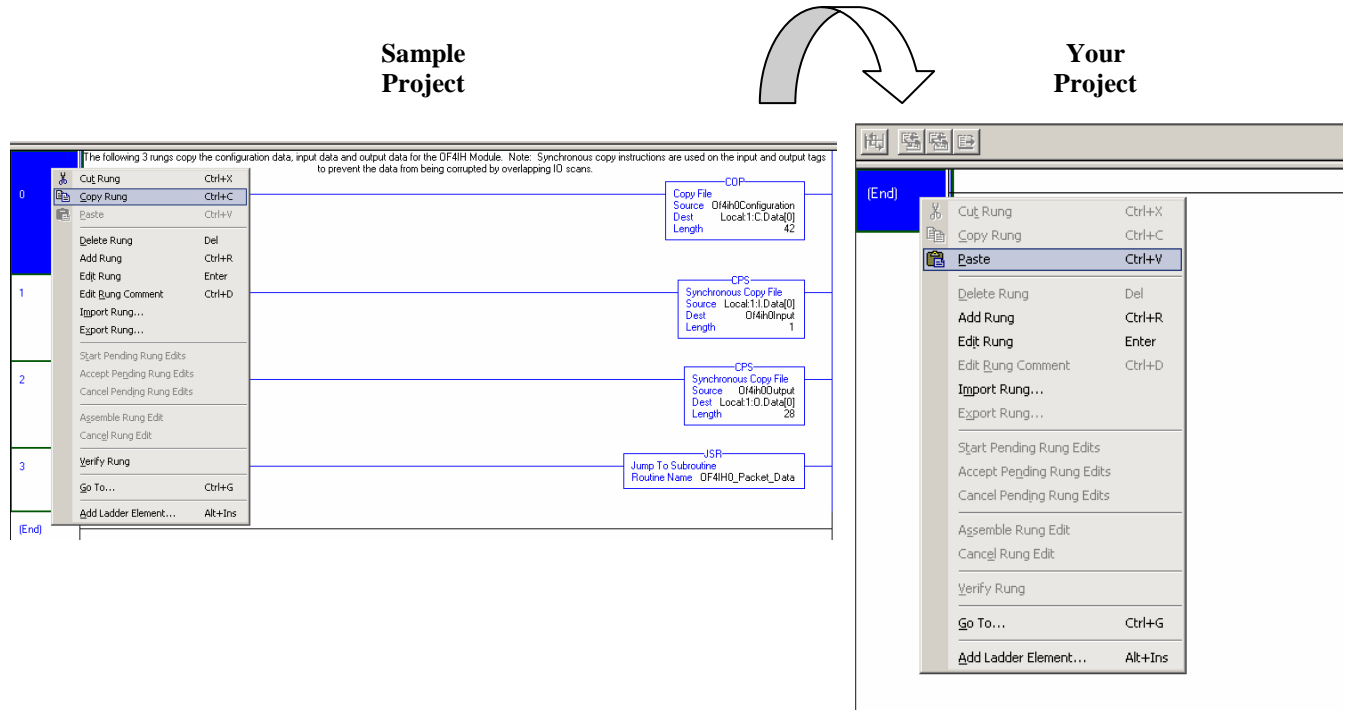
You can follow a similar procedure for copying ladder as well.

1. Open the routine that contains the ladder you want to copy.
2. Select the rungs to copy.
3. Right mouse click and select copy.
4. Open the routine in your project where you wish to paste the new rungs.

5. Right mouse click and select paste.

The figure below demonstrates this procedure:

Figure 4-13 (Copying Ladder)



Chapter 5

Configuring the OF4IH for a MicroLogix 1500 Using RSLogix 500

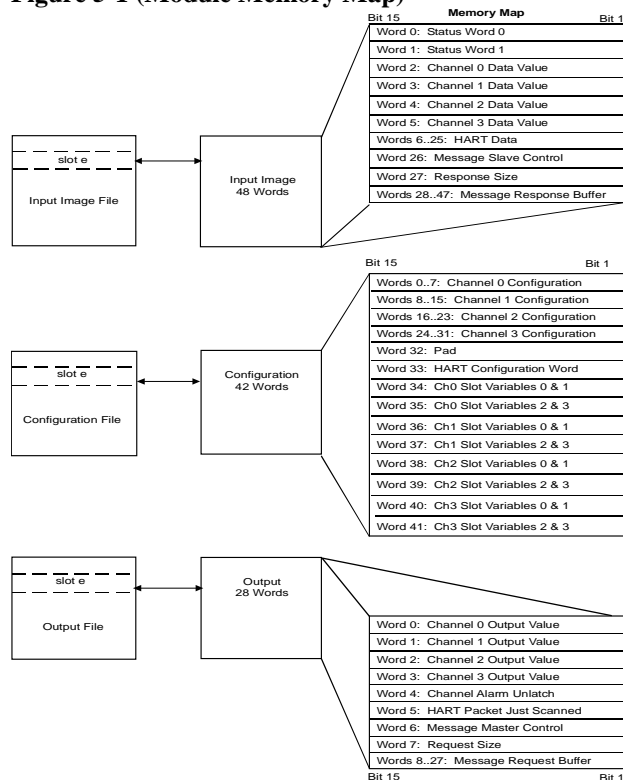
This chapter examines the 1769sc-OF4IH module's addressing scheme and describes module configuration using RSLogix 500 and a MicroLogix 1500 controller. This chapter will cover the following:

- Module Addressing
- Configuring the OF4IH in a MicroLogix 1500 System
- Using the Ladder Sample

Section 5.1 Module Addressing

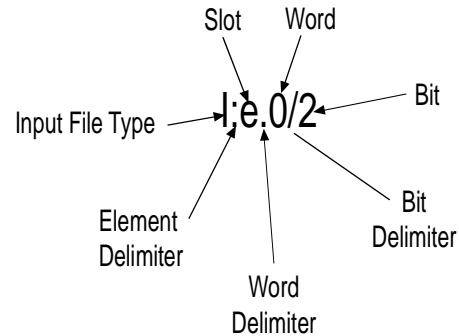
The following memory map shows the input, output, and configuration image tables for the module. Detailed information on the image table is located in Chapter 6.

Figure 5-1 (Module Memory Map)



For example, to obtain the general status for channel 2 of the module located in slot e, use address I:e.0/2.

Figure 5-2 (Address Example)



NOTE: The end cap does not use a slot address.

Section 5.2 Configuring the 1769sc-OF4IH in a MicroLogix 1500 System

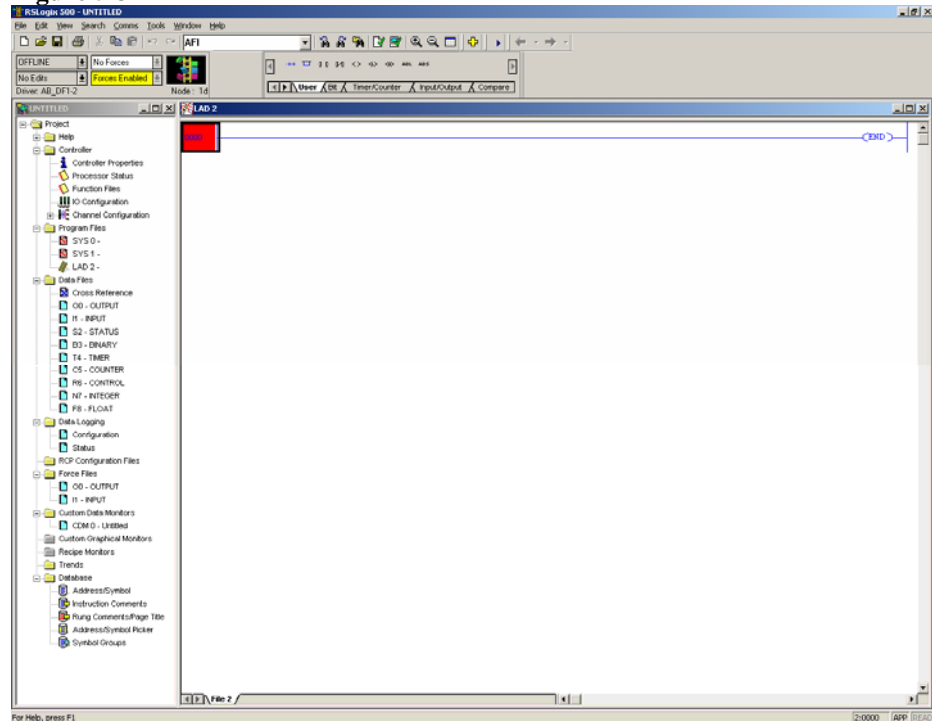
This example takes you through configuring your 1769sc-OF4IH isolated HART analog output module with RSLogix 500 programming software, assumes your module is installed as expansion I/O in a MicroLogix 1500 system, and that RSLinx™ is properly configured and a communications link has been established between the MicroLogix processor and RSLogix 500.



It is recommended that a 1764-LRP series C processor with firmware version 5 or higher be used. The LRP processor supports floating point files, which is required to read floating point data from the OF4IH.

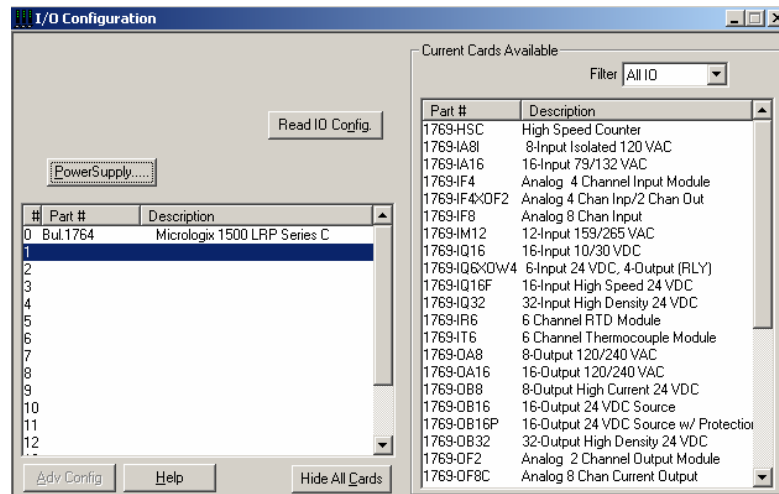
Start RSLogix and create a MicroLogix 1500 application. The following screen appears:

Figure 5-3



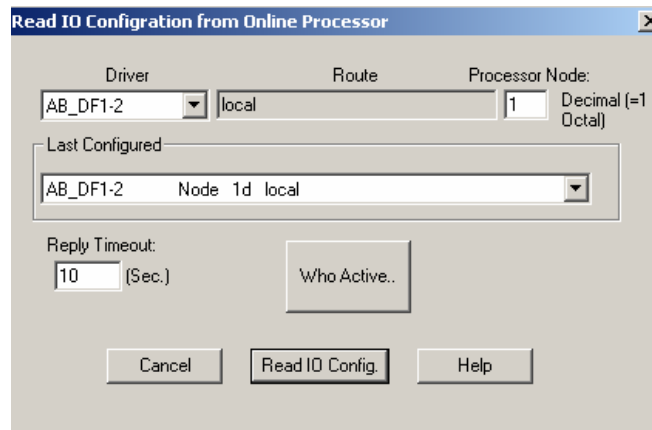
While offline, double-click on the IO Configuration icon under the controller folder and the following IO Configuration screen appears.

Figure 5-4

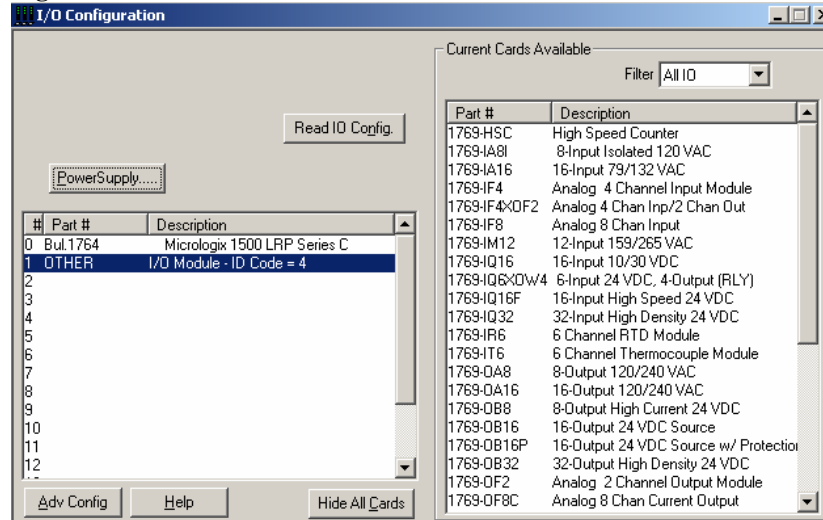


This screen allows you to manually enter expansion modules into expansion slots, or to automatically read the configuration of the controller. To read the existing controller configuration, click on the Read IO Config button.

A communications dialog appears, identifying the current communications configuration so that you can verify the target controller. If the communication settings are correct, click on Read IO Config.

Figure 5-5

The actual I/O configuration is displayed. In this example, a second tier of I/O is attached to the MicroLogix 1500 processor.

Figure 5-6

The 1769sc-OF4IH module is installed in slot 1. To configure the module, double-click on the module/slot. The general configuration screen appears.

Figure 5-7

Module #1: OTHER - I/O Module - ID Code = 5

Expansion General Configuration | Generic Extra Data Config

Vendor ID: 58

Product Type: 10

Product Code: 5

Series/Major Rev/Minor Rev: A

Input Words: 48

Output Words: 28

Extra Data Length: 42

Ignore Configuration Error:

OK Cancel Apply Help

**Attention**

When using the read IO configuration feature in RSLogix, you need to manually enter 42 into the “extra data length” field.

To configure the module select the Generic Extra Data Configuration tab. Enter the decimal equivalent of each configuration word. There are a total of 42 words that need to be configured altogether. The module default settings are used if all the configuration words are left at zero.

Figure 5-8

Module #1: OTHER - I/O Module - ID Code = 5

Expansion General Configuration | Generic Extra Data Config

Offset

0	8000	101	4000	4000	0
5	0	0	0	0	0
10	0	0	0	0	0
15	0	0	0	0	0
20	0	0	0	0	0
25	0	0	0	0	0
30	0	0	0	105	0
35	0	0	0	0	0
40	0	0	0	0	0

Hex/BCD Radix

OK Cancel Apply Help

NOTE: For a complete description of each of these parameters and the choices available for each of them, refer to Chapter 6.

Section 5.3

Using the Ladder Sample

To get started we recommend that you use the provided MicroLogix 1500 sample project. Refer to Chapter 8 for the sample project or visit our website at (www.spectrumcontrols.com).

The sample project contains nine different subroutines which are used to perform various HART related tasks. The following list describes the function of each subroutine within the project file.

Table 5-1 (Ladder Routines)

Routine	Description
MAIN	The main routine is the starting point for the ladder program.
PACKETS	The “packets” routine is used to demultiplex the HART data from the input file to individual integer files, so that the data can be viewed or used within the ladder program. This routine is called from the MAIN routine.
MSG_TO_MOD	This routine is used to send and receive messages to and from the module. Refer to Chapter 7 for more details regarding sending and receiving messages. This routine is called from the HART_MSG routine.
SRC_CHECK	Calculates the checksum for a message sent to the module one page at a time. This routine is called from the MSG_TO_MOD routine.
DEST_CHECKSUM	This routine calculates the checksum for a message received from the module one page at a time. This routine is called from the MSG_TO_MOD routine.
HART_MSG	This routine composes HART messages that will be sent to the module/field transmitter. This routine is called from the MAIN routine.
WORD_BYTE	Converts word data to its byte equivalent. This routine is called from the HART_MSG routine.
HART_CHECK	Calculates the checksum for the HART message being sent to the module/field device. This routine is called from the HART_MSG routine.
BYTE_WORD	Converts byte data to its word equivalent. This routine is called by the HART_MSG routine.

You have the choice to either use the sample project or copy and past the pieces you need from the project.

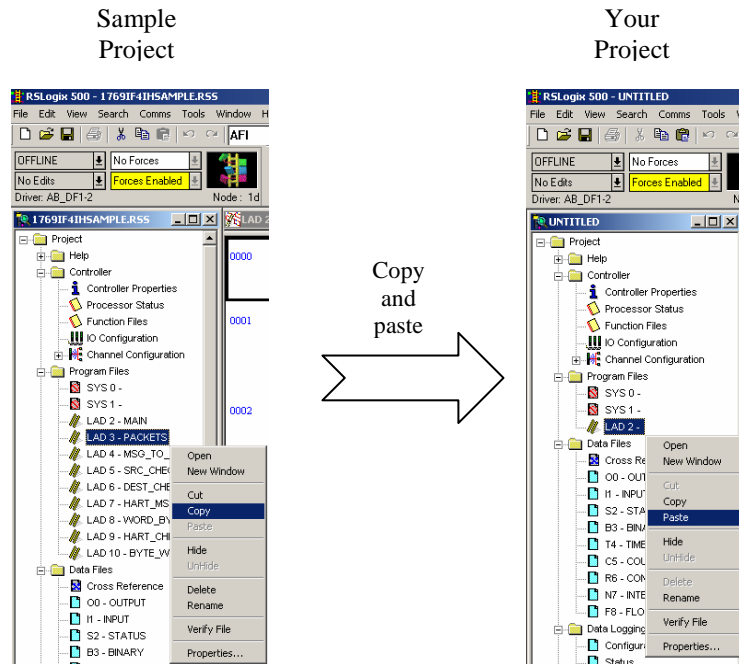
5.3.1 Copying Subroutines from the Sample Project

To copy subroutines from the sample project to your project, follow the steps below:

1. Open the sample project and your project.
2. Select the subroutine you wish to copy.
3. Right mouse click and select copy.
4. Go to your project and select where you would like to place the new routine.

5. Right mouse click and select paste.

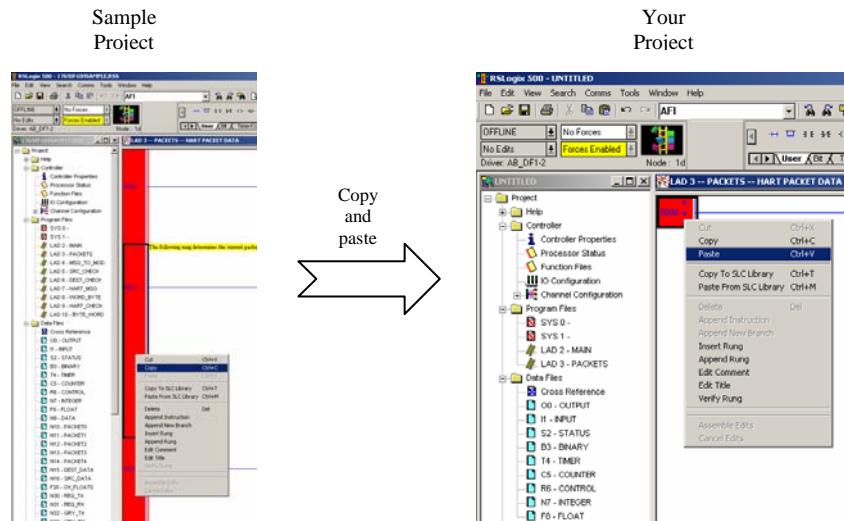
Figure 5-9 (Copying Routines)



5.3.2 Copying Ladder from the Sample Project

To copy ladder, follow the procedure below:

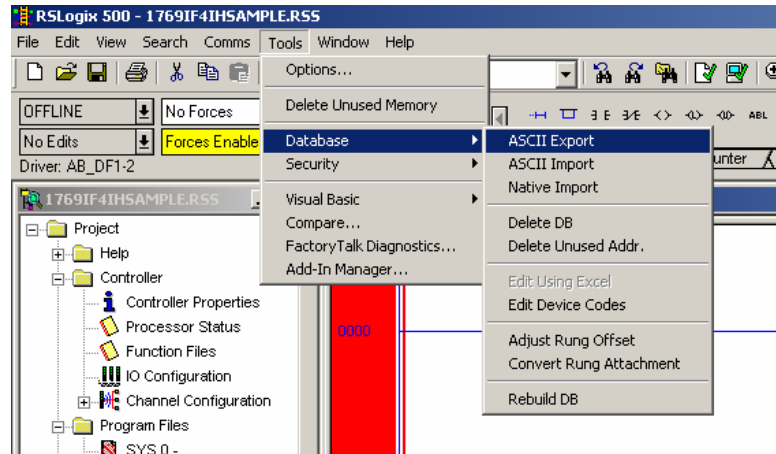
1. Open the sample project and your project
2. Open the routine that you wish to copy the ladder from.
3. Select the rungs by clicking the left mouse button. To select more rungs, select the first rung you wish to copy and while holding the shift key, select the last rung you wish to copy.
4. Right mouse click and select copy.
5. Open the routine in your project where you wish to place the new rungs.
6. Select the paste point by left mouse clicking.
7. Right mouse click and select paste.

Figure 5-10 (Copying Ladder)

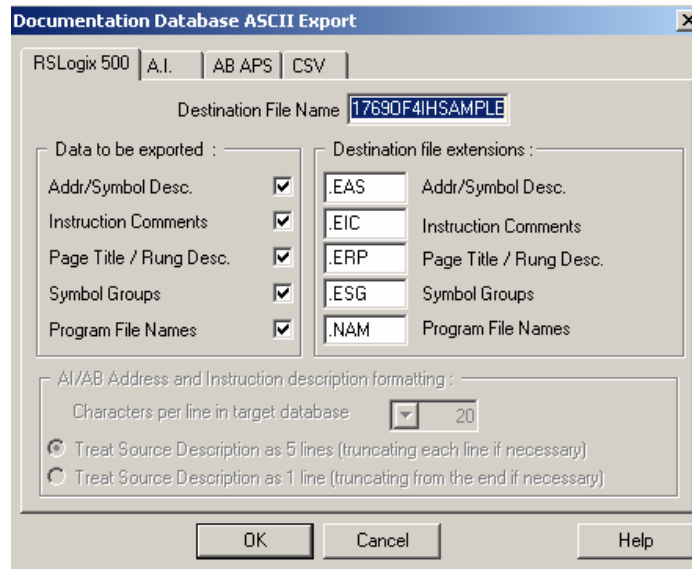
5.3.3 Importing Tag Database and Rung Comments

After copying the subroutines and or the ladder, you may wish to import the tags and rung comments. Follow the procedure below to import the tag database and rung comments:

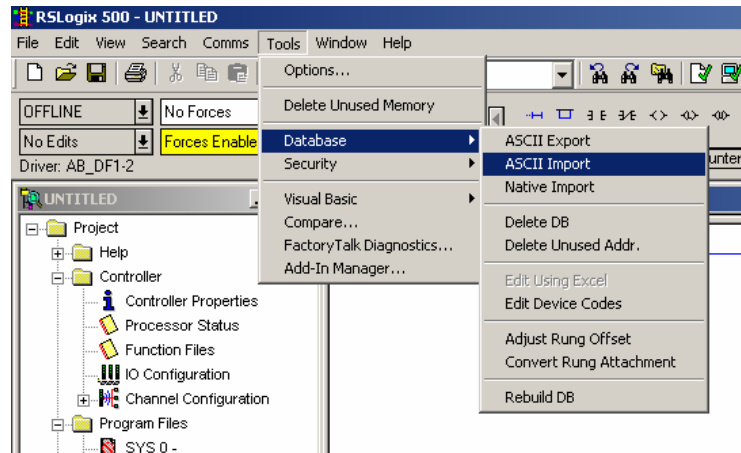
1. Open the sample project and your project.
2. In the sample project, go to the tools menu, select database, and then select ASCII export. See image below:



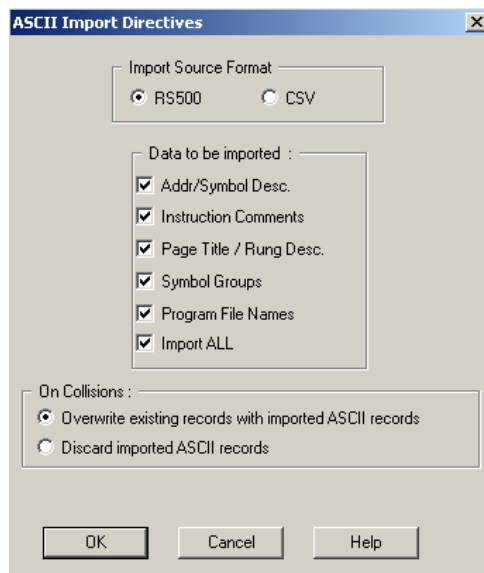
- After selecting ASCII export the following screen appears:



- Select the RSLogix 500 tab and press the OK button.
- Select the location for the export file.
- In your project, go to the tools menu, select database, and select ASCII import. See image below:



7. After selecting ASCII import the following screen should appear:



8. Select the RSLogix 500 radio button and leave everything else at default. After making your selections, press the OK button.
9. Select the export file from steps 4 and 5 and press the open button. You may be prompted for multiple files depending on the selections you made in step 8.

Chapter 6

Module Data, Status, and Channel Configuration

After installing the 1769sc-OF4IH isolated HART output module, you must configure it for operation, usually using the programming software compatible with the controller (for example, RSLogix 500 or RSLogix 5000). Once configuration is complete and reflected in the ladder logic, you need to operate the module and verify its configuration.

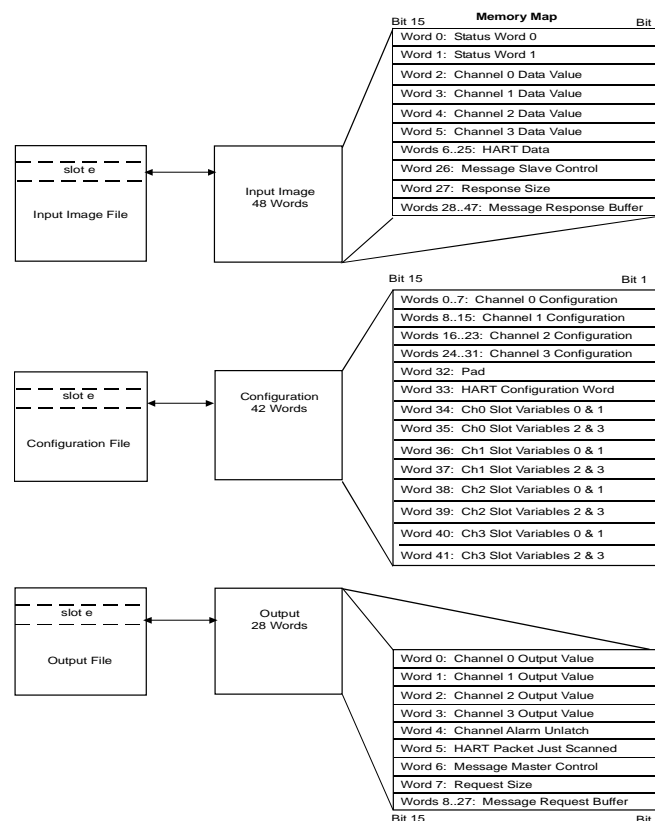
This chapter contains information on the following:

- Module memory map
- Accessing input image file data
- Configuring channels
- Determining effective resolution and range
- Determining module update time

Section 6.1 Module Memory Map

The module uses forty eight input words for data and status bits (input image), twenty eight output words, and forty two configuration words.

Figure 6-1 (Module Memory Map)



NOTE: Not all controllers support program access to the configuration file. Refer to your controller's user manual.

Section 6.2 Accessing Input Image File Data

The input image file represents data words and status words. Words 0 and 1 contain status information for the four channels including process alarms and over and under range flags. Input words 2 through 5 hold an echo of the analog output value for channels 0 through 3 respectively. Words 6 through 25 include the HART packet data. Refer to Chapter 7 for information on how to demultiplex the HART packet data. Input word 26 holds the message control. Word 27 holds the message response size. Words 28 through 47 hold the message response buffer. Refer to Section 7.3 for more information regarding input words 28 through 47.

You can access the information in the input image file using the programming software configuration screen. For information on configuring the module in a MicroLogix 1500 system using RSLogix 500, see Chapter 5; and for the CompactLogix using RSLogix 5000, see Chapter 4.

Section 6.3 Input Data File

The input data file allows you to access module input data for use in the control program, via word and bit access. The data table structure is shown in the table below.

Table 6-1 (Module Input Image)

Word/Bit ¹	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	OS3	OS2	OS1	OS0	Not Used								S3	S2	S1	S0
1	L3	H3	U3	O3	L2	H2	U2	O2	L1	H1	U1	O1	L0	H0	U0	O0
2	Channel 0 Command Value															
3	Channel 1 Command Value															
4	Channel 2 Command Value															
5	Channel 3 Command Value															
6..25	HART Packet Data															
26	Message Slave Control															
27	Message Response Size															
28..47	Message Response Buffer															

(1) Changing bit values is not supported by all controllers. Refer to your controller manual for details.

6.3.1 General Status Bits S0 to S3 (Word 0)

Bits S0 through S3 of word 0 contain the general status information for channels 0 through 3, respectively. If set (1), this bit indicates an error (over- or under-range, or output held).

6.3.2 Out of Service Status Bits OS0 to OS3 (Word 0)

Bits SO0 through SO3 of word 0 indicate whether the associated channel is *out of service* (i.e. automatic HART acquisition is suspended).

Note: A channel that is placed out-of-service (i.e. Suspended) will automatically resume service after three minutes, as long as no pass-through commands are issued before the three minutes expires.

6.3.3 Over-Range Flag Bits O0 to O3 (Word 1)

Over-range bits for channels 0 through 3 are contained in word 1. They apply to all output types. When set (1), the over-range flag bit indicates an output signal that is at the maximum of its normal operating range for the represented channel or sensor. The

module automatically resets (0) the bit when the data value falls below the maximum for that range.

Note: This bit can also be set if the high clamp value is reached or exceeded. The bit will automatically clear when the channel command value¹ drops below the high clamp value.

6.3.4 Under-Range Flag Bits U0 to U3 (Word 1)

Under-range bits for channels 0 through 3 are contained in word 1. They apply to all output types. When set (1), the under-range flag bit indicates an output signal that is at the minimum of its normal operating range for the represented channel or sensor. The module automatically resets (0) the bit when the under-range condition is cleared and the data value is within the normal operating range.

Note: This bit can also be set if the low clamp value is reached or exceeded. The bit will automatically clear when the channel command value¹ exceeds the low clamp value. Refer to section 6.4.5 for more details.

6.3.5 Channel X² Command Value Echo (Words 2 to 5)

Data words 2 through 5 correspond to channels 0 through 3 respectively and contain the current command value¹ stored in the module's RAM memory for the associated channel. These input words can be used as a handshake to verify that the module has received the correct command value for the associated channel. The command value is defined in section 6.5.1.

6.3.6 HART Packet Data (Words 6 to 25)

This block of twenty words contains the multiplexed HART packet data for all four channels.³

6.3.7 Message Slave Control (Word 26)

The *message slave control* word controls how data is returned from the module after sending a message using output words 6 through 27³.

6.3.8 Message Reply Size (Word 27)

The *message response size* indicates the number of bytes returned by the module after sending a message using output words 6 through 27³.

6.3.9 Message Reply Buffer (Words 28...47)

After sending a message to the module, the response data for the message is stored in the *message response buffer*³.

¹ Module output words 0 through 3 for channel 0 through 3, respectively.

² X refers to channel number 0 through 3

³ For more details refer to Chapter 7

Section 6.4 Module Configuration

After module installation, you must configure operation details, such as output type, data format, etc., for each channel. Configuration data for the module is stored in the controller configuration file, which is both readable and writable.

The default value of the configuration data is represented by zeros in the data file. The structure of the channel configuration file is shown below.

Table 6-2a (Module Configuration)

Word	Bit																Function
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	EC	Reserved			SV3	SV2	SV1	SV0	SIU	SIO	LA	ER	FM	PM	HI	PFE	Ch0 General Settings
1	Reserved				Data Format				Reserved				Output Type				Ch0 Output type and Data Format
2	Channel 0 Fault Value																Ch0 Fault Value
3	Channel 0 Program Idle Value																Ch0 Program Idle Value
4	Channel 0 Low Clamp Value																Ch0 Low Clamp Value
5	Channel 0 High Clamp Value																Ch0 High Clamp Value
6	Channel 0 Ramp Rate Value																Ch0 Ramp Rate Value
7	Reserved																Not Used (Set to Zero)
8	EC	Reserved			SV3	SV2	SV1	SV0	SIU	SIO	LA	ER	FM	PM	HI	PFE	Ch1 General Settings
9	Reserved				Data Format				Reserved				Output Type				Ch1 Output type and Data Format
10	Channel 1 Fault Value																Ch1 Fault Value
11	Channel 1 Program Idle Value																Ch1 Program Idle Value
12	Channel 1 Low Clamp Value																Ch1 Low Clamp Value
13	Channel 1 High Clamp Value																Ch1 High Clamp Value
14	Channel 1 Ramp Rate Value																Ch1 Ramp Rate Value
15	Reserved																Not Used (Set to Zero)
16	EC	Reserved			SV3	SV2	SV1	SV0	SIU	SIO	LA	ER	FM	PM	HI	PFE	Ch2 General Settings
17	Reserved				Data Format				Reserved				Output Type				Ch2 Output type and Data Format
18	Channel 2 Fault Value																Ch2 Fault Value
19	Channel 2 Program Idle Value																Ch2 Program Idle Value
20	Channel 2 Low Clamp Value																Ch2 Low Clamp Value
21	Channel 2 High Clamp Value																Ch2 High Clamp Value
22	Channel 2 Ramp Rate Value																Ch2 Ramp Rate Value
23	Reserved																Not Used (Set to Zero)
24	EC	Reserved			SV3	SV2	SV1	SV0	SIU	SIO	LA	ER	FM	PM	HI	PFE	Ch3 General Settings
25	Reserved				Data Format				Reserved				Output Type				Ch3 Output type and Data Format

Table 6-2b (Module Configuration)

Word	Bit																Function
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
26	Channel 3 Fault Value																Ch3 Fault Value
27	Channel 3 Program Idle Value																Ch3 Program Idle Value
28	Channel 3 Low Clamp Value																Ch3 Low Clamp Value
29	Channel 3 High Clamp Value																Ch3 High Clamp Value
30	Channel 3 Ramp Rate Value																Ch3 Ramp Rate Value
31	Reserved																Not Used (Set to Zero)
32	Set to Zero																Pad (16 Bit Alignment)
33	Reserved	PA	EH3	EH2	EH1	EH0	Handle Timeout										HART Configuration Word
34	Channel 0 HART Slot Variables 0 & 1																Defines Slot Variables
35	Channel 0 HART Slot Variables 2 & 3																Defines Slot Variables
36	Channel 1 HART Slot Variables 0 & 1																Defines Slot Variables
37	Channel 1 HART Slot Variables 2 & 3																Defines Slot Variables
38	Channel 2 HART Slot Variables 0 & 1																Defines Slot Variables
39	Channel 2 HART Slot Variables 2 & 3																Defines Slot Variables
40	Channel 3 HART Slot Variables 0 & 1																Defines Slot Variables
41	Channel 3 HART Slot Variables 2 & 3																Defines Slot Variables

6.4.1 Channel X¹ General Settings (Words 0, 8, 16, 24)

Allows the user to enable or disable channels, set the analog output level for each channel in the event of a PLC fault, or enable HART slot variables for a given channel.

Table 6-3 (Channel General Settings)

To Select		Make these bit settings															
		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PFE (Program/Idle to Fault Enable)	Disable																0
	Enable																1
HI (Hold for Initialization)	Disable																0
	Enable																1
PM (Program Mode)	Hold Last State																0
	User Defined																1
FM (Fault Mode)	Hold Last State																0
	User Defined																1
ER (Enable Ramping)	Disable																0
	Enable																1
LA (Latch Alarms)	Disable																0
	Enable																1
SIO (System Interrupt High Clamp, Over Range Alarm)	Disable																0
	Enable																1
SIU (System Interrupt Low Clamp, Under Range Alarm)	Disable																0
	Enable																1
Enable Slot Variable 0	Disable																0
	Enable																1
Enable Slot Variable 1	Disable																0
	Enable																1
Enable Slot Variable 2	Disable																0
	Enable																1
Enable Slot Variable 3	Disable																0
	Enable																1
Reserved	Set to Zero		0	0	0	1											
Channel Enable	Disable	0															
	Enable	1															

¹ Where X is the channel number

PFE (Program/Idle to Fault Enable)

If a system currently in program/idle mode faults, this setting determines whether the program/idle or fault value is applied to the output. If the selection is enabled [the bit is set (1)], the module applies the fault value. If the selection is disabled [the bit is reset (0)], the module applies the program/idle mode data value. The default setting is disabled.

Note: Not all controllers support this function. Refer to your controller's user manual for more details.

HI (Hold for Initialization)

Hold for Initialization causes outputs to hold their present state until the value commanded by the controller matches the value or is within a percentage of the value being commanded by the module. The value being commanded by the module is reflected in the Input file words 2 through 5; the channel data value words for channels 0 through 3 respectively.

If Hold for Initialization is selected, outputs will hold if any of the three conditions occur:

- Initial connection is established after power-up
- Communications re-established after a communications fault
- There is a transition from Program mode to run mode.

PM (Program Mode)

This parameter determines whether the output channel will hold the last state of the output signal or go to a user defined value during a transition from running mode to program mode.

Note: The user defined value is defined by configuration words 3, 11, 19, and 27 for channels 0 through 3 respectively.

FM (Fault Mode)

This parameter determines whether the output channel will hold the last state of the output signal or go to a user defined value during a transition from running mode to fault mode.

Note: The user defined value is defined by configuration words 2, 10, 18, and 26 for channels 0 through 3 respectively.

ER (Enable Ramping)

When enabled, the analog signal for the associated channel will increment and decrement at predefined rate whenever the channel data value changes.

LA (Latch Alarm)

The *latch alarm* feature enables process alarms (i.e. Over Range, Under Range, Clamp High, etc.) to be latched during an alarm condition.

Note: A specific bit in the output image file must be set to clear the associated alarm latch condition. See Section 6.5 Output Data File.

SIO (System Interrupt High Clamp, Over Range Alarm)

When the SIO feature is enabled, a high clamp or over range alarm will trigger a system interrupt within the PLC. This feature allows an immediate response from the system when an analog output channel is commanded to exceed the user defined clamp limit.

¹ Entering a value of zero allows the module to automatically select the fastest allowed RTS rate.

SIU (System Interrupt Low Clamp, Under Range Alarm)

When the SIU feature is enabled, a low clamp or under range alarm will trigger a system interrupt within the PLC. This feature allows an immediate response from the system when an analog output channel is commanded to exceed the user defined clamp limit.

Note: Not all controllers support this function. Refer to your controller's user manual for more details.

SV0...SV3 (Slot Variables 0 to 3)

Enables HART slot variables 0 through 3 for the selected channel.

Note: Slot variables are not supported by all HART devices.

Note: Slot codes must be enabled in sequential order. For example, SV0 (Enabled), SV1 (Disabled), and SV2 (Enabled), is not a valid configuration. In this case, all three slot variables would be enabled.

Reserved

Must be set to Zero

EC (Enable Channel)

This bit allows the user to enable or disable the channel.

6.4.2 Channel X¹ Output Type and Data Format (Words 1, 9, 17, 25)

This section of the configuration allows the user to define the output type (i.e. 0 to 20mA or 4 to 20 mA) and the data format for the associated channel. See table below.

Table 6-4 (Output Type and Data Format)

To Select		Make these bit settings																
		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Output Type	0 to 20mA															0	0	0
	4 to 20mA															0	0	1
Reserved	Set To Zero									0	0	0	0	0				
Data Type	Raw/Proportional						0	0	0									
	Engineering Units						0	0	1									
	Scaled for PID						0	1	0									
	Percent Range						0	1	1									
Reserved	Set To Zero	0	0	0	0	0												

Output Type

Allows the user to configure the output type and range for the associated channel.

Note: To enable HART you must select the 4 to 20 mA range.

Reserved

Reserved for future expansion and should be set to zero.

Data Format

This selection allows the user to define the channel's data format for any of the following:

- Raw/Proportional Data**
 The raw/proportional data format provides the best resolution of all the supported data formats.

If you select the raw/proportional data format for a channel, the output command word³ will be a number between -32767 and +32767. For example, if

a 4 to 20 mA output type is selected, 4 mA corresponds to -32767 counts and 20 mA corresponds to +32767.

- **Engineering Units**

When using this data format, the module scales the output command word³ to the actual engineering values for the selected output type. Values are expressed with an assumed decimal place. Refer to Table 6-8 (Data Formats).

The resolution for the selected data format is dependent on the output type selected.

- **Scaled-for-PID**

The PID algorithm for the MicroLogix 1500 and other Allen-Bradley controllers (i.e. SLC) utilize an engineering range of 0 to 16383. The *scaled for PID* format allows the programmer to assign the output command word³ for the selected channel directly to the PID instruction's CV variable, thus eliminating the need for further scaling.

- **Percent Range**

The output command word³ for the selected channel is scaled using a range of 0 to +10000 counts. For example, if a 4 to 20 mA output type is selected, 4 mA corresponds to 0 counts and 20 mA corresponds to +10000 counts.

Note: 10000 counts represent 100.00 percent.

Table 6-5 (Data Formats)

Output Type	Engineering	Scaled For PID	Proportional Counts	Percent
0 – 20 mA	0 to 20000	0 to 16383	-32767 to 32767	0 to +10000
4 – 20 mA	4000 to 20000	0 to 16383	-32767 to 32767	0 to +10000

Reserved

Reserved for future expansion and should be set to zero.

6.4.3 Fault Value (Words 2, 10, 18, 26)

During a processor fault condition, the associated output channel will be driven to this value.

Note: The range of this value is defined by the data format selected for the channel.

6.4.4 Program/Idle Value (Words 3, 11, 19, 27)

During a processor program or idle mode, the associated output channel will be driven to this value.

Note: The range of this value is defined by the data format selected for the channel.

6.4.5 Low Clamp Value (Words 4, 12, 20, 28)

The low clamp value determines the minimum analog signal that will be applied to the associated channel.

Note: If the channel command value¹ is less than or equal to the low clamp value, the under range status bit, for the associated channel, will be set.

¹ Module output words 0 through 3 for channel 0 through 3, respectively.



Attention

The low clamp value must be less than the high clamp value or a module fault will be generated. If both the low clamp and high clamp values are left at zero, the output is clamped using the end points of the associated channel's defined output range

6.4.6 High Clamp Value (Words 5, 13, 21, 29)

The high clamp value determines the maximum analog signal that will be applied to the associated channel.

Note: If the channel command value¹ is greater than or equal to the high clamp value, the over range status bit, for the associated channel, will be set.



Attention

The low clamp value must be less than the high clamp value or a module fault will be generated. If both the low clamp and high clamp values are left at zero, the output is clamped using the end points of the associated channel's defined output range

6.4.7 Ramp Rate Value (Words 6, 14, 22, 30)

The ramp rate value defines the rate at which the output will change state once a channel is commanded to a new value. The ramp rate is defined in terms of the selected range/format in units per second. For example, in the 0 to 20mA DC range and percent of full scale format, a ramp rate of 1000 is 10%/second or a maximum of 1mADC per second. The following table describes the minimum ramp rate that can be applied for all output range/types and output data formats.

Table 6-6 (Minimum Allowed Ramp Rates)

Output Data Format Output Range/Type	Total Counts in Full Scale	Number of Counts for Every 1% of Ramp Rate	Real Units / Second for Every 1% of Ramp Rate
Proportional Counts			
0 to 20mA	65534	655	0.2 mA/Sec
4 to 20mA	65534	655	0.16mA/Sec
Engineering Units			
0 to 20mA	21000	210	0.2 mA/Sec
4 to 20mA	17800	178	0.16mA/Sec
Scaled for PID			
0 to 20mA	16383	164	0.2 mA/Sec
4 to 20mA	16383	164	0.16mA/Sec
Percent of Full Scale			
0 to 20mA	10000	100	0.2 mA/Sec
4 to 20mA	10000	100	0.16mA/Sec

Note: If you enter a ramp rate value that is less than the minimum specified in the table above, a module fault will be generated.

Note: The number of counts entered for a channel's ramp rate may be equal to 0 only if ramping is not enabled for the channel.

6.4.8 Spare (Words 7, 15, 23, 31)

Reserved for future expansion

6.4.9 Pad (Word 32)

16 bit alignment (Set to Zero)

6.4.10 HART Configuration Word (Word 33)

Word 33 is used to configure module properties like enabling and disabling HART, setting a HART handle time for HART messaging, and selecting one of three scanning schemes for HART pass-through messages. The table below shows the available settings for word 33.

To Select	Handle Timeout	Make these bit settings															
		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CH0 HART Enable	Disable																0
	Enabled																1
CH1 HART Enable	Disable								0								
	Enabled								1								
CH2 HART Enable	Disable							0									
	Enabled							1									
CH3 HART Enable	Disable							0									
	Enabled							1									
Pass-Through Scheme	Two Channel Scans			0	0												
	Once Per Module Scan			0	1												
	Every Channel Scan			1	0												
Reserved	Set to Zero	0	0														

Handle Timeout

There is a handle timeout associated with the final reply message. After the module obtains the requested information from the HART device, it will start the Handle Timeout timer. The reply message will be kept in memory during the Handle Timeout period. After the timeout occurs or after the message is retrieved by the pass-through response query command, the storage buffer will be discarded, and another pass through message will be serviced without being rejected. Handle Timeout is in the range of 1 to 255 seconds.

Channel HART Enable (Bits 8, 9, 10, 11)

These bits allow the user to enable HART on channels 0 through 3, respectively.

Pass-Through Scheme

The pass-through scheme determines how often the pass through commands are serviced.

- Two Channel Scans: Pass-through serviced once every two channel scans
- Once Per Module Scan: Pass-through serviced once per module scan
- Every Channel Scan: Pass-through serviced once every channel scan

Note: *The pass-through scheme can increase the HART packet update time if pass-through messages are serviced every channel scan.*

6.4.11 Channel X¹ HART Slot Variables 0 & 1 (Words 34, 36, 38, 40)

This word defines HART slot variables 0 and 1 for the selected channel. The first byte defines slot variable 0 and the second defines slot variable 1. The variable is defined as a hexadecimal value between 0 and FF.

The HART slot variable is a floating point value that represents a device specific variable defined by the manufacturer for the connected HART field device. This is an optional configuration setting and is not supported by all HART field devices.

For more information regarding slot variables, refer to Section 7.2.

¹ Where X is the channel number (0 to 3)

6.4.12 Channel X¹ HART Slot Variables 2 & 3 (Words 35, 37, 39, 41)

This word defines HART slot variables 2 and 3 for the selected channel. The first byte defines slot variable 2 and the second defines slot variable 3.

The HART slot variable is a floating point value that represents a device specific variable defined by the manufacturer for the connected HART field device. This is an optional configuration setting and is not supported by all HART field devices.

For more information regarding slot variables, refer to Section 7.2.

Section 6.5 Output Data File

The output data file is used to command the analog signal for each channel as well as controlling features which include, clearing process alarms, suspending HART acquisition, and managing HART messages to and from HART field devices. The data table structure is shown in the table below.

Table 6-7 (Output Data File)

Word/Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Channel 0 Command Value															
1	Channel 1 Command Value															
2	Channel 2 Command Value															
3	Channel 3 Command Value															
4	HS3	HS2	HS1	HS0	Reserved			UL3	UH3	UL2	UH2	UL1	UH1	UL0	UH0	
5	Packet Just Scanned															
6	Message Master Control															
7	Message Request Size															
8..27	Message Request Buffer															

6.5.1 Channel X¹ Command Value

The command value is used to control the analog output signal for each channel. The command value is entered in engineering units defined by the channel's selected data format and output type. Refer to section 6.4.2 for more details regarding data format and output type.

6.5.2 Unlatch Process High Alarms UH0 to UH3 (Word 4)

UH0 through UH3 will unlatch the high process alarms for channels 0 through 3 respectively. Refer to section 6.4.1 for more information regarding setting the alarm latch function. To unlatch the high process alarm on a given channel, set the unlatch bit to 1.

Note: Setting the unlatch process alarm bit will not clear the alarm latch if the conditions that generated the alarm are still present.

Note: It is up to the user to keep the unlatch bit set until verification that the process alarm bit has cleared. When the process alarm bit has cleared the user can then clear the unlatch process alarm bit.

Note: The module will not latch the high process alarm if a transition from "no alarm condition" to "alarm condition" occurs while the unlatch high process alarm bit is set.

6.5.3 Unlatch Process Low Alarms UL0 to UL3 (Word 4)

UL0 through UL3 will unlatch the low process alarms for channels 0 through 3 respectively. Refer to section 6.4.1 for more information regarding setting the alarm latch function. To unlatch the low process alarm on a given channel, set the associated unlatch alarm bit to 1.

Note: Setting the unlatch process alarm bit will not clear the alarm latch if the conditions that generated the alarm are still present.

Note: It is up to the user to keep the unlatch bit set until verification that the process alarm bit has cleared. When the process alarm bit has cleared the user can then clear the unlatch process alarm bit.

Note: The module will not latch the low process alarm if a transition from “no alarm condition” to “alarm condition” occurs while the unlatch low process alarm bit is set.

6.5.4 Hart Suspend HS0 to HS3 (Word 4)

HS0 to HS3 are used to suspend all HART acquisition, except Pass-through messages, on channels 0 through 3 respectively. To suspend HART acquisition, set the associated channel suspend bit to 1. Normal HART acquisition will resume when the bit is cleared.

Note: A channel that is placed out-of-service (i.e. Suspended) will automatically resume service after three minutes, as long as no pass-through commands are issued before the three minutes expires.

6.5.5 Packet Just Scanned (Word 5)

When demultiplexing HART data from the module, this output word can be used to speed up the acquisition process by overriding the automatic 500ms acquisition delay between packets.¹ To override the delay, the *packet just scanned* word needs to be populated with word six from the input data file on each scan of the ladder program. Input word six contains the channel and packet number just scanned.

Note: Input word six is the first word of twenty which contains the multiplexed HART data for each channel.

6.5.6 Message Master Control (Word 6)

This word is used to control the data flow of a message sent to the module. These messages include module commands such as HART pass-through, HART suspend and resume, and get device information.¹

6.5.7 Message Request Size (Word 7)

The *message request size* determines the size of the message, in bytes, that will be sent to the module.¹

6.5.8 Message Request Buffer (Words 8...27)

The *message request buffer* contains the data making up the message that will be sent to the module.¹

¹ Refer to Chapter 7 for more details.

Section 6.6 Determining Module Update Time

The module update time is defined as the time required for the module to receive the command value and convert it to an equivalent analog output signal for all enabled channels.

6.6.1 Module Update Time

HART Enabled	HART Disabled
12 ms	10 ms

Chapter 7

Enabling and Using HART on the 1769sc-OF4IH

This chapter outlines the detailed settings and configuration related to HART communication for the 1769sc-OF4IH module. These settings determine how the module acquires HART data.

The chapter is broken down into the following sections:

- Configuring the module for HART
- HART Packet Data
- Sending and Receiving Messages
- Module Specific Commands
- HART protocol overview



Attention

The ladder samples and tags referenced in this chapter were created for the Compact Logix controller using RSLogix 5000 software, see Chapter 4. If you plan on using a MicroLogix 1500 controller, refer to Chapter 5.

Section 7.1 Configuring the Module for HART

7.1.1 Configuring the OF4IH Module for (Hart Acquisition/Communication)

In order for HART to be active on any given channel, the channel configuration must contain the following basic settings:

- The channel must be enabled for HART by selecting the appropriate HART enable bit in the Of4ih0Configuration.HartConfig tag.

Figure 7-1

+ Of4ih0Configuration.Pad		0
+ Of4ih0Configuration.HartConfig	2#0000_1111_1111_1111	
+ Of4ih0Configuration.Ch0SlotVariable01		0
+ Of4ih0Configuration.Ch0SlotVariable23		0
+ Of4ih0Configuration.Ch1SlotVariable01		0

- The channel must be configured for 4 to 20 mA by setting the correct bits in the Of4ih0Configuration.ChX¹⁵ConfigWord1.

¹⁵ X = Channel Number 0 through 3

Figure 7-2

- Of4ih0Configuration	{...}
+ Of4ih0Configuration.Ch0ConfigWord0	2#1000_0000_0000_0000
+ Of4ih0Configuration.Ch0ConfigWord1	2#0000_0001_0000_0001
+ Of4ih0Configuration.Ch0FaultValue	4000
+ Of4ih0Configuration.Ch0ProgramIdleValue	4000



Attention

HART throughput time can be improved by disabling HART communication on unused channels or channels that include non-HART devices.

Section 7.2 HART Packet Data

7.2.1 How the Module Connects to a Field Device

The HART output module behaves as a HART master in which case the field device is considered the slave. In other words, the master must initiate the communication with the field device and the device simply replies with an appropriate response. Any given channel may have a master, a secondary master (hand held configuration tool), and a slave connected simultaneously. Please see Figure below.

Figure 7-3



Attention

Hart multi-drop is not supported by the OF4IH.

The HART module communicates to the controller using the input and output image. Data communicated over the input and output image are transmitted at a rate that is

controlled by the PLC. The rate at which data is communicated to the compactbus is adjustable by using the RPI (Requested Packet Interval). The data passed via the input and output image include, analog data, module status, HART data, and module specific commands.

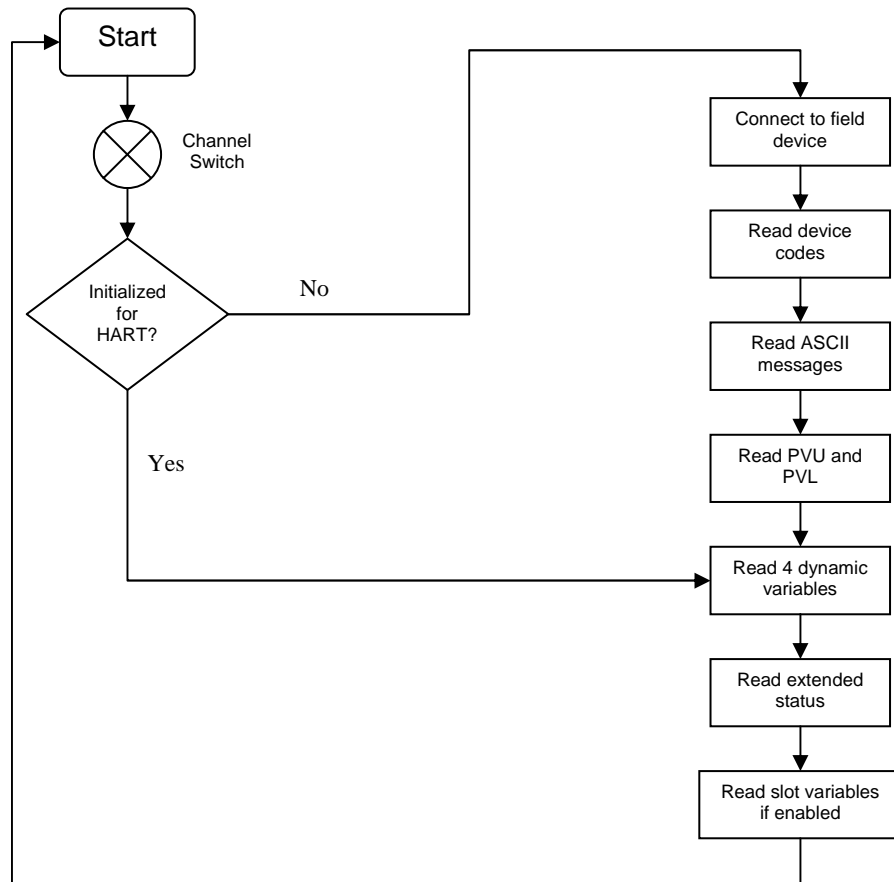
Module specific commands include the HART pass-through commands, HART suspend, HART resume, and the get HART device information command.

Gathering HART data is accomplished using two processes **auto acquisition**, and or using the **module specific commands**.

7.2.2 Auto Acquisition

When a channel is configured for HART, the module will automatically search and establish a connection to any HART field device wired to the channel. Once the module establishes a connection it will begin to acquire HART data, including device specific codes (i.e. Manufacturer ID, serial number, etc.), the four dynamic variables, extended device status, slot variables (if enabled), and any stored ASCII message descriptor that may be present. The HART data retrieved automatically by the module is then displayed in the input image (Of4ih0Input.HartData) and is accessible by ladder logic. The HART data will update, on average, every 3.5 seconds if all four channels are enabled for HART. The module initiates the connection by sending a string of HART commands to the field device. Please see figure below.

Figure 7-4 (Auto Acquisition Flow)



The data that is collected from the process described in Figure 7-4 (Auto Acquisition Flow) is buffered to the module RAM memory. Since the amount of data returned from the auto-acquisition process is extensive, the data is multiplexed into five separate

packets and for each individual channel. The multiplexed data can be read from a 40 byte array which is located in the OF4IH0Input.HartData tag. The multiplexed data is demultiplexed using ladder and stored in five different arrays which are structured using packets zero through four. The packets are defined as “user defined data types” and can be seen in Table 7-1 through Table 7-5.

Table 7-1 (HART Packet 0)

Tag Name	Data Type	Style	Description
If4ih0Packet0	Packet0[4,1]	NA	Two dimensional array containing packet 0 data for all 4 channels.
If4ih0Packet0[X,0] ¹	Packet0	NA	Packet 0 data for channel X
If4ih0Packet0[X,0].HartChannelID	INT	BIN	Bits 0 to 3: Channel number (0 – 3). Bit 4: Searching/Initializing HART device Bit 5: HART communication failure or device not found Bit 6: Pass-through message pending (ready) Bit 7: Unused (0) Bits 8 to 10: Packet ID Bit 11 through 15: Unused
If4ih0Packet0[X,0].ManufacturerID	SINT	DEC	HART device Manufacturer ID
If4ih0Packet0[X,0].DeviceType	SINT	DEC	HART device type code
If4ih0Packet0[X,0].NumPreambles	SINT	DEC	Minimum number of preambles the device requires.
If4ih0Packet0[X,0].UniversalCmdCode	SINT	DEC	HART Universal command set 5.0
If4ih0Packet0[X,0].XmitterRev	SINT	DEC	HART Transmitter specific revision
If4ih0Packet0[X,0].SwRev	SINT	DEC	HART device software revision number
If4ih0Packet0[X,0].HwRev	SINT	DEC	HART device hardware revision number
If4ih0Packet0[X,0].HartFlags	SINT	BIN	HART flags
If4ih0Packet0[X,0].RangeUnits	SINT	DEC	Units code for range parameter
If4ih0Packet0[X,0].DeviceSerialNumber	SINT[3]	HEX	HART device ID number
If4ih0Packet0[X,0].DeviceTag	SINT[8]	ASCII	8 character device tag
If4ih0Packet0[X,0].DeviceDescriptor	SINT[16]	ASCII	

¹ X represents the module channel number (0 to 3)

Table 7-2 (HART Packet 1)

Tag Name	Data Type	Style	Description
If4ih0Packet1 ¹	Packet1[4,1]	NA	Two dimensional array containing packet 1 data for all 4 channels.
If4ih0Packet1[X,0] ¹	Packet1	NA	Packet 1 data for channel X
If4ih0Packet1[X,0].HartChannelID	INT	BIN	Bits 0 to 3: Channel number (0 – 3). Bit 4: Searching/Initializing HART device Bit 5: HART communication failure or device not found Bit 6: Pass-through message pending (ready) Bit 7: Unused (0) Bits 8 to 10: Packet ID Bit 11 through 15: Unused
If4ih0Packet1[X,0].HartCommStatus	SINT	BIN	HART communication status byte. Refer to appendix D for more details.
If4ih0Packet1[X,0].HartDevStatus	SINT	BIN	HART device status byte. Refer to appendix D for more details.
If4ih0Packet1[X,0].HartPV	REAL	FLOAT	HART Primary Variable
If4ih0Packet1[X,0].HartSV	REAL	FLOAT	HART Secondary Variable
If4ih0Packet1[X,0].HartTV	REAL	FLOAT	HART Tertiary Variable
If4ih0Packet1[X,0].HartFV	REAL	FLOAT	HART Fourth Variable
If4ih0Packet1[X,0].HartPVUnits	SINT	DEC	HART Primary Variable units code
If4ih0Packet1[X,0].HartSVUnits	SINT	DEC	HART Secondary Variable units code
If4ih0Packet1[X,0].HartTVUnits	SINT	DEC	HART Tertiary Variable units code
If4ih0Packet1[X,0].HartFVUnits	SINT	DEC	HART Fourth Variable units code
If4ih0Packet1[X,0].PV_Assignment	SINT	DEC	HART Primary Variable code
If4ih0Packet1[X,0].SV_Assignment	SINT	DEC	HART Secondary Variable code
If4ih0Packet1[X,0].TV_Assignment	SINT	DEC	HART Tertiary Variable code
If4ih0Packet1[X,0].FV_Assignment	SINT	DEC	HART Fourth Variable code
If4ih0Packet1[X,0].RangeLow	REAL	FLOAT	Low transmitter range for analog signal in engineering units
If4ih0Packet1[X,0].RangeHi	REAL	FLOAT	High transmitter range for analog signal in engineering units
If4ih0Packet1[X,0].Pad	SINT[4]	DEC	Packet pad (32 bit alignment)

¹ X represents the module channel number (0 to 3)

Table 7-3 (HART Packet 2)

Tag Name	Data Type	Style	Description
If4ih0Packet2	Packet2[4,1]	NA	Two dimensional array containing packet 2 data for all 4 channels.
If4ih0Packet2[X,0] ¹	Packet2	NA	Packet 2 data for channel X
If4ih0Packet2[X,0].HartChannelID	INT	BIN	Bits 0 to 3: Channel number (0 – 3). Bit 4: Searching/Initializing HART device Bit 5: HART communication failure or device not found Bit 6: Pass-through message pending (ready) Bit 7: Unused (0) Bits 8 to 10: Packet ID Bit 11 through 15: Unused
If4ih0Packet2[X,0].Slot0Data	REAL	Float	Variable for slot 0
If4ih0Packet2[X,0].Slot1Data	REAL	Float	Variable for slot 1
If4ih0Packet2[X,0].Slot2Data	REAL	Float	Variable for slot 2
If4ih0Packet2[X,0].Slot3Data	REAL	Float	Variable for slot 3
If4ih0Packet2[X,0].Slot0Units	SINT	DEC	Slot 0 units code
If4ih0Packet2[X,0].Slot1Units	SINT	DEC	Slot 1 units code
If4ih0Packet2[X,0].Slot2Units	SINT	DEC	Slot 2 units code
If4ih0Packet2[X,0].Slot3Units	SINT	DEC	Slot 3 units code
If4ih0Packet2[X,0].Slot0Assignment	SINT	DEC	Slot 0 variable code
If4ih0Packet2[X,0].Slot1Assignment	SINT	DEC	Slot 1 variable code
If4ih0Packet2[X,0].Slot2Assignment	SINT	DEC	Slot 2 variable code
If4ih0Packet2[X,0].Slot3Assignment	SINT	DEC	Slot 3 variable code
If4ih0Packet2[X,0].Pad	SINT[12]	DEC	Packet pad

¹ X represents the module channel number (0 to 3)

Table 7-4 (HART Packet 3)

Tag Name	Data Type	Style	Description
If4ih0Packet3	Packet3[4,1]	NA	Two dimensional array containing packet 3 data for all 4 channels.
If4ih0Packet3[X,0] ¹	Packet3	NA	Packet 3 data for channel X
If4ih0Packet3[X,0].HartChannelID	INT	BIN	Bits 0 to 3: Channel number (0 – 3). Bit 4: Searching/Initializing HART device Bit 5: HART communication failure or device not found Bit 6: Pass-through message pending (ready) Bit 7: Unused (0) Bits 8 to 10: Packet ID Bit 11 through 15: Unused
If4ih0Packet3[X,0].Message	SINT[32]	ASCII	32 character message
If4ih0Packet3[X,0].Pad	SINT[4]	DEC	Pad 32 bit alignment.

¹ X represents the module channel number (0 to 3)

Table 7-5 (HART Packet 4)

Tag Name	Data Type	Style	Description
If4ih0Packet4	Packet4[4,1]	NA	Two dimensional array containing packet 4 data for all 4 channels.
If4ih0Packet4[X,0].HartChannelID	INT	BIN	Bits 0 to 3: Channel number (0 – 3). Bit 4: Searching/Initializing HART device Bit 5: HART communication failure or device not found Bit 6: Pass-through message pending (ready) Bit 7: Unused (0) Bits 8 to 10: Packet ID Bit 11 through 15: Unused
If4ih0Packet4[X,0].Date	SINT[3]	DEC	Stored date in the field device
If4ih0Packet4[X,0].FinalAssemblyNumber	SINT[3]	DEC	The final assembly number is used for identifying the materials and electronics that comprise the field device.
If4ih0Packet4[X,0].ExtendedStatus	SINT[24]	DEC	The extended status returned by HART command 48
If4ih0Packet4[X,0].Pad	SINT[3]	DEC	Pad 32 bit alignment

¹ X represents the module channel number (0 to 3)

Note: *Not all of the HART data that is returned by the process outlined in Figure 7-4 (Auto Acquisition Flow) gets passed to the packets. In order to access the data that is not passed to the packets, you must execute the appropriate HART message using the pass-through command, which will be discussed later in this chapter.*

The ladder determines which packet to copy the data to, by monitoring the state of bits 0, 1, 2 and 8, 9, 10, found in the first two bytes of the OF4IH0Input.HartData tag. Bits 0, 1, 2 determine the current channel being scanned and bits 8, 9, and 10 determine the packet number. The ladder example, shown in Figure 7-5, performs this operation.

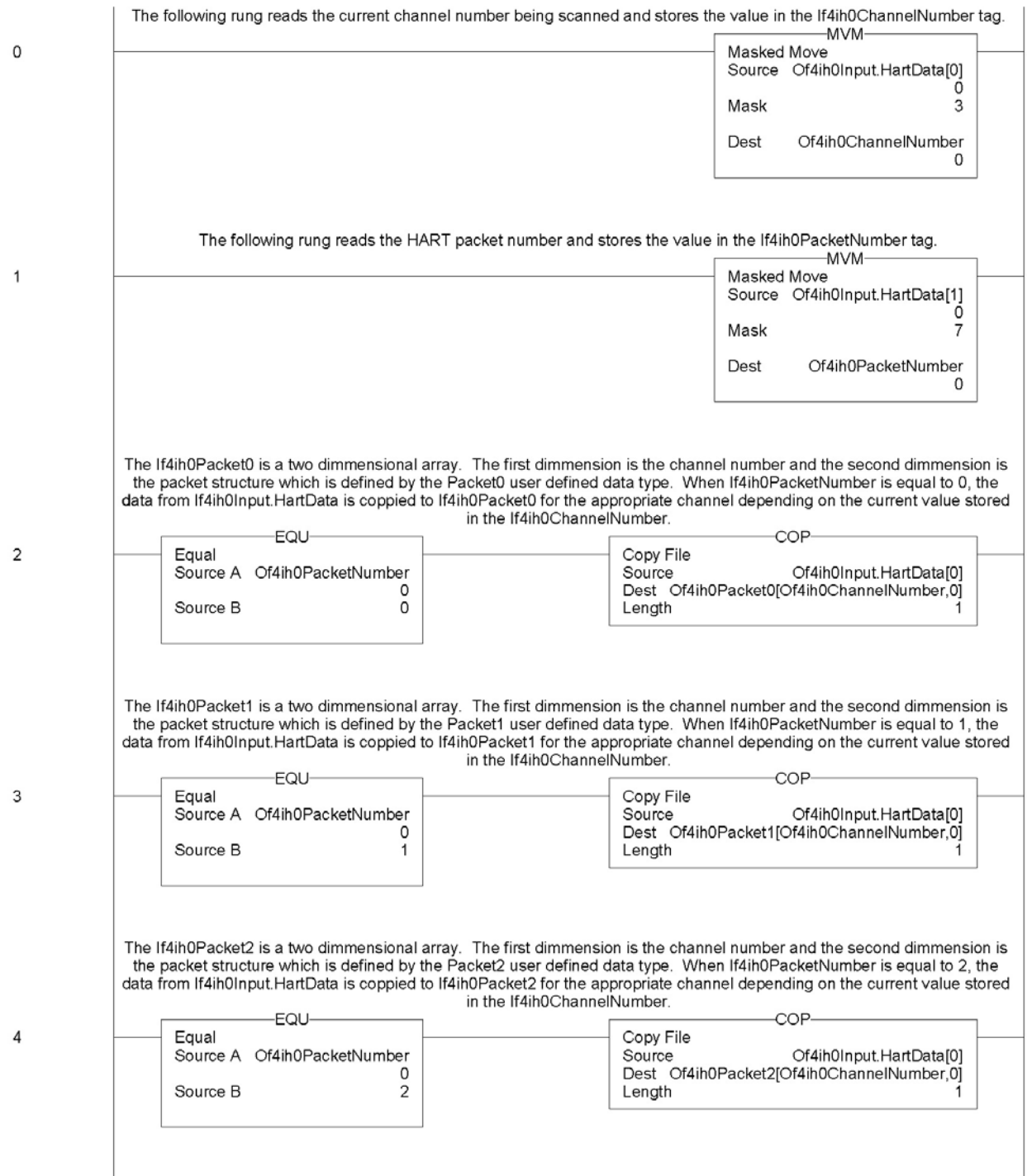
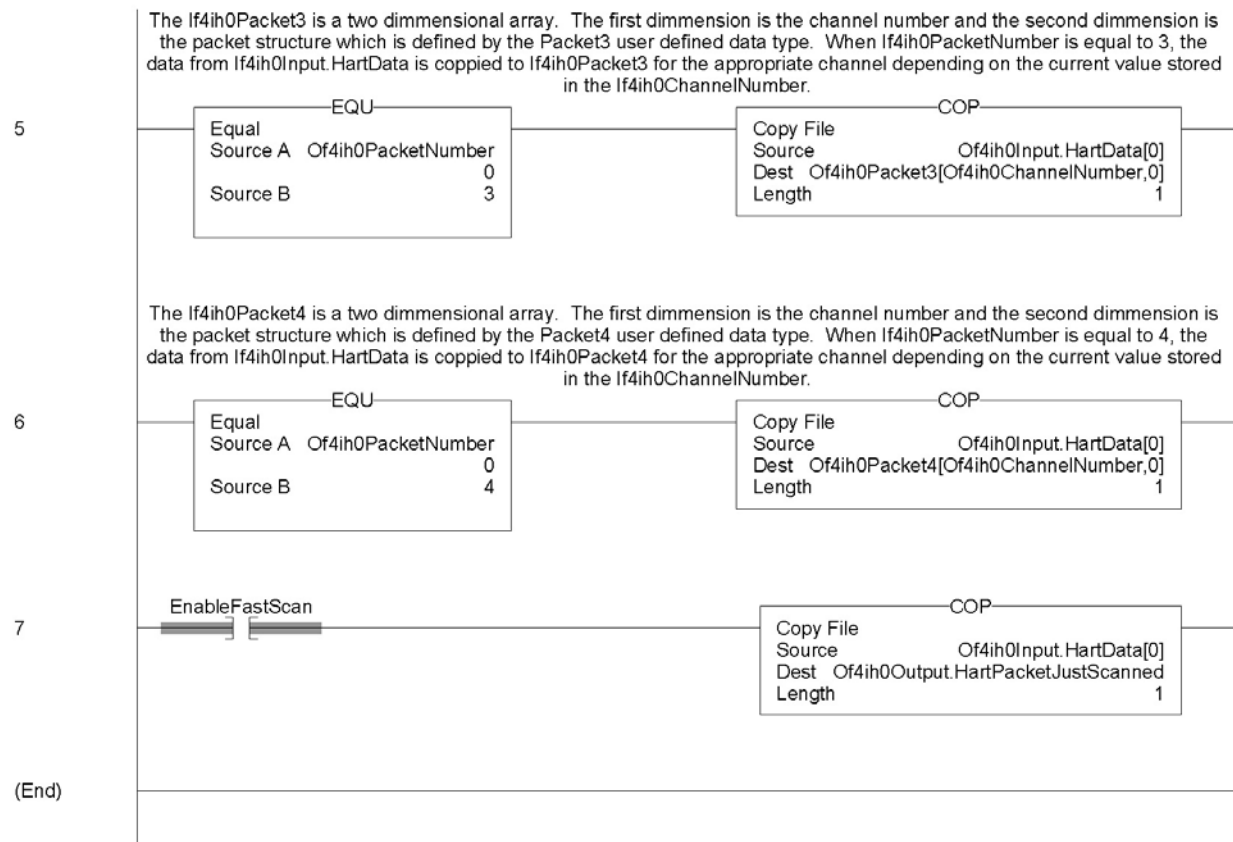
Figure 7-5 (Packet Ladder)

Figure 7-5 (Packet Ladder Continued)

Note: The ladder in Figure 7-5 can be found in the project sample file located on our website at (www.spectrumcontrols.com)

7.2.3 Packet Interval

The delay between two consecutive packets is called the packet interval. The default time for the packet interval is 500 ms. This delay is controlled by the module.

The user has the ability to reduce the packet interval by utilizing output word 1 (*HART Packet Just Scanned*) in the output image. See Table 7-6 (Module Output Table).

Copying the packet number just scanned to output word 1 allows the module to switch to the next packet before the 500 ms delay expires. See Figure 7-5.

Note: The amount of time saved using this method depends on the scan time of the ladder and the update time of each individual HART transmitter.

Section 7.3 Sending and Receiving Messages

Sending messages to and from the module is accomplished using a paging scheme. This paging scheme uses the module's input and output words to transfer data between the controller and the module, 38 bytes at a time (i.e. one page at a time). The paging scheme is utilized to minimize the number of bytes sent and received at one time from the module's input and output image. The maximum message size is 257 bytes.

7.3.1 Module Output Tags Used For Messaging

The OF4IH module utilizes 28 words for sending messages and controlling data flow. The table below shows the output image for the OF4IH module. For more detail regarding module output image, refer to Section 6.5.

Table 7-6 (Module Output Table)

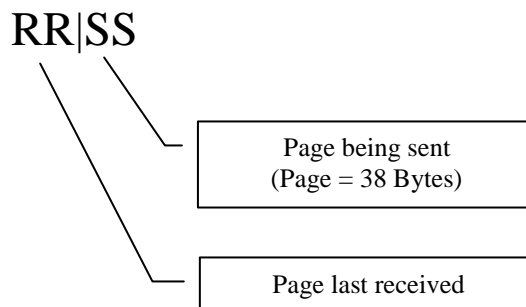
Word/Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Channel 0 Command Value															
1	Channel 1 Command Value															
2	Channel 2 Command Value															
3	Channel 3 Command Value															
4	HS3	HS2	HS1	HS0	Reserved			UL3	UH3	UL2	UH2	UL1	UH1	UL0	UH0	
5	Packet Just Scanned															
6	Message Master Control															
7	Message Request Size															
8..27	Message Request Buffer															

Word 6 (Message Master Control)

The *message master control* initiates the paging process and controls the flow of data to and from the module. The data flow control is accomplished by using the *message master control* with the *message slave control* to manage which pages are being sent and what direction the page is going, that is, whether the page is being sent to the module or read from the module.

Figure 7-6

Message Master/Slave Control (Hex)



Note: Setting the Message Master Control word to zero resets the paging logic within the module and allows the next message to be processed.

Word 7 (Message Request Size)

The message request size is the total number of bytes being sent to the module (not just the current page).

Words 8...27 (Message Request Buffer)

The message request buffer contains the data being sent to the module for the current page (up to 38 bytes).

7.3.2 Module Input Tags Used For Messaging

The module utilizes 48 input words to receive messages and control data flow. The table below shows the input words used by the module. Refer to Chapter 6 for more information regarding input words 0 through 48.

Table 7-7 (Module Input Table)

Word/Bit ¹	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	OS3	OS2	OS1	OS0	Not Used								S3	S2	S1	S0
1	L3	H3	U3	O3	L2	H2	U2	O2	L1	H1	U1	O1	L0	H0	U0	O0
2	Channel 0 Command Value															
3	Channel 1 Command Value															
4	Channel 2 Command Value															
5	Channel 3 Command Value															
6..25	HART Packet Data															
26	Message Slave Control															
27	Message Response Size															
28..47	Message Response Buffer															

(1) Changing bit values is not supported by all controllers. Refer to your controller manual for details.

Word 26 (Message Slave Control)

Again, the *message slave control* is used with the *message master control* to manage which pages are being sent and what direction the page is going, that is, whether the page is being sent to the module or read from the module. Refer to Figure 7-6 for the layout. The *message slave control* is also used to indicate if a message was rejected by the module. If a message is rejected, the lower 8 bits will be set (i.e. FF Hex) in the *message slave control*. In the event the message is rejected, the *message response buffer* will display a fault code in the first byte followed by a checksum in the second. The table below lists the possible responses:

Table 7-8 (Paging Error Codes)

Error Code	Description
1	A page was sent out of sequence.
2	While processing page 2,3,etc. The message size was different than it was for page 1.
3	The message size given exceeds the max allowed.
4	The message page data checksum is not correct.

Word 27 (Message Response Size)

The *message response size* indicates the total number of bytes being returned by the module.

Words 28...47 (Message Response Buffer)

The *message response buffer* contains the response data for the current page up to thirty eight bytes at a time.

7.3.3 Processing a Message

To complete a message from beginning to end, follow the steps listed below:

1. Store the message you wish to send to the module in an array. Remember the message can be up to 257 bytes long, so make the array large enough.
2. Copy the first page of data, up to 38 bytes, to the *message request buffer*. If the number of bytes is odd, the last byte in the last word will be padded with a zero.
3. Calculate the checksum of the message by taking the exclusive OR of all the words within the page (19 max). Place the result into the last word of the message (i.e. word # 20 if a full page).
4. Enter the size of the message to be sent to the module into the *message request size* output word.
5. Add a 1 to the lower nibble of the *message master control* word (i.e. 0001Hex). The *message master control* should be zero when the message is started.
6. Wait for the module to reply that it has received the page without error, by monitoring the second nibble of the *message slave control* (i.e. 0100).

If the lower nibble contains FF, stop the process because the data is corrupted. The first byte in the *message response buffer* will contain the paging error code. Refer to Table 7-1 for a description of the errors.

7. Check to see if there are more pages to send by comparing the bytes sent to the *message request size*. If so, repeat steps 2 through 6. If not, go to step 8.
8. Monitor the lower nibble of the *message slave control* to see if the first page of the response data is ready (0101).
9. Copy the first page of the response data from the *message response buffer* to a temporary array.
10. Take the exclusive OR of all the words within the page (19 max) with the exception of the last word which is the checksum. Compare the calculated checksum with the checksum stored in the last byte. If they are equal, go to step 11. If they are not, stop the process because the data is corrupted.
11. Check to see if there is more response data remaining by comparing the bytes received to the *message response size*. If so, repeat steps 8 through 10. If not, the message is finished. To send another message clear the *message master control* and repeat the process.

A graphical representation of the process can be seen in Figure 7-7 and Figure 7-8.

Figure 7-7 Sending Message

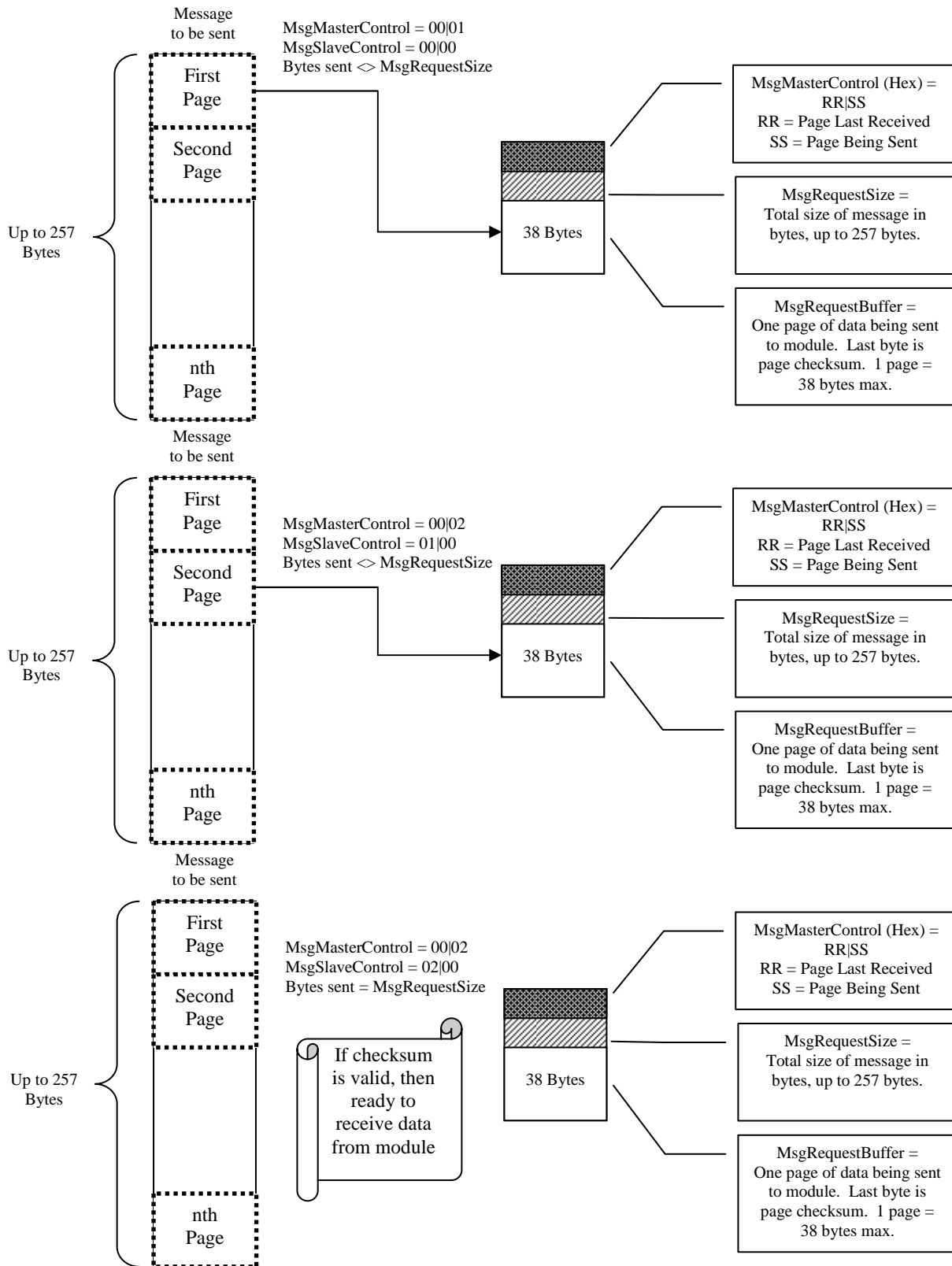


Figure 7-8 Receiving Message

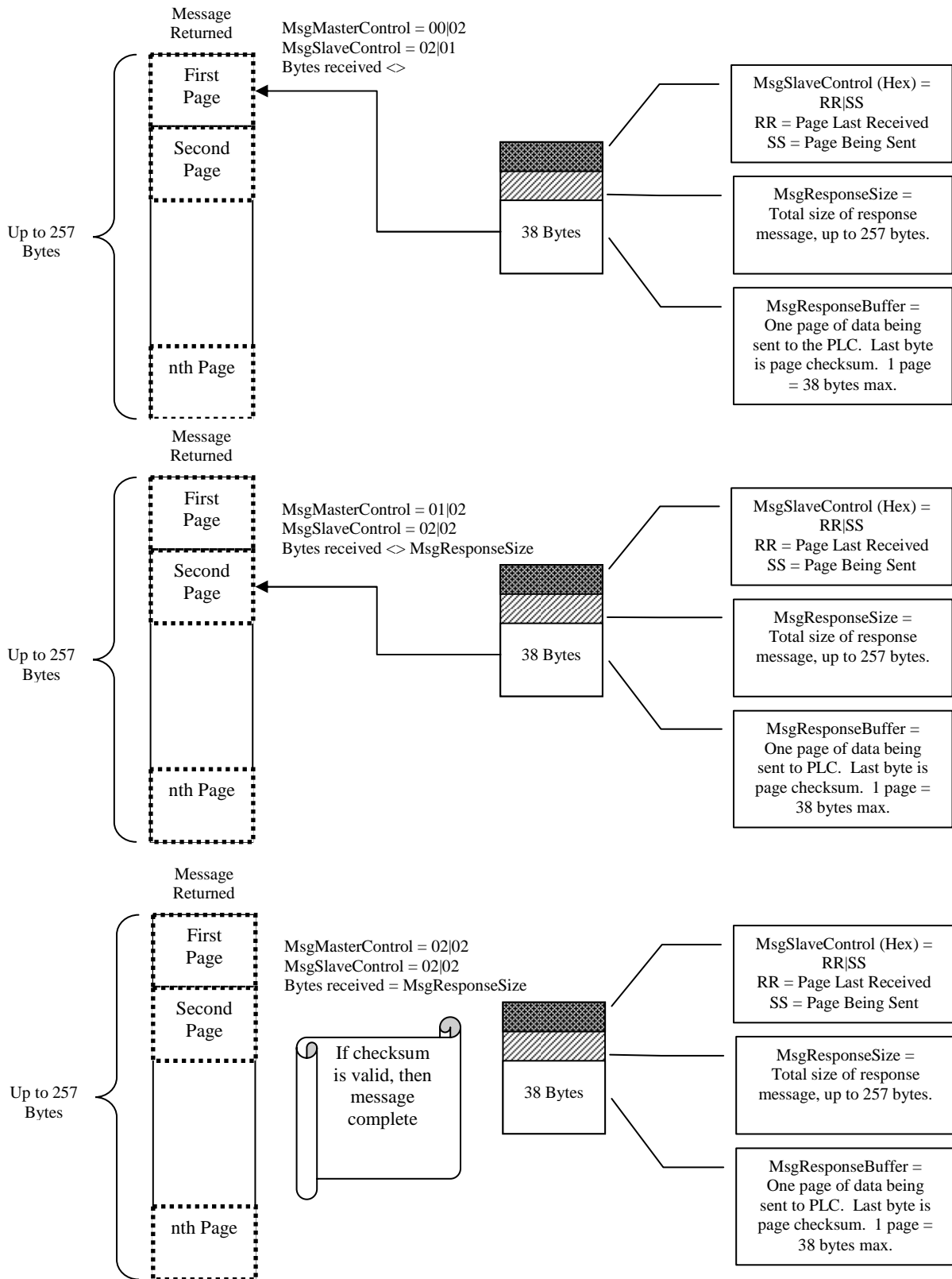


Figure 7-9a (Message Ladder)

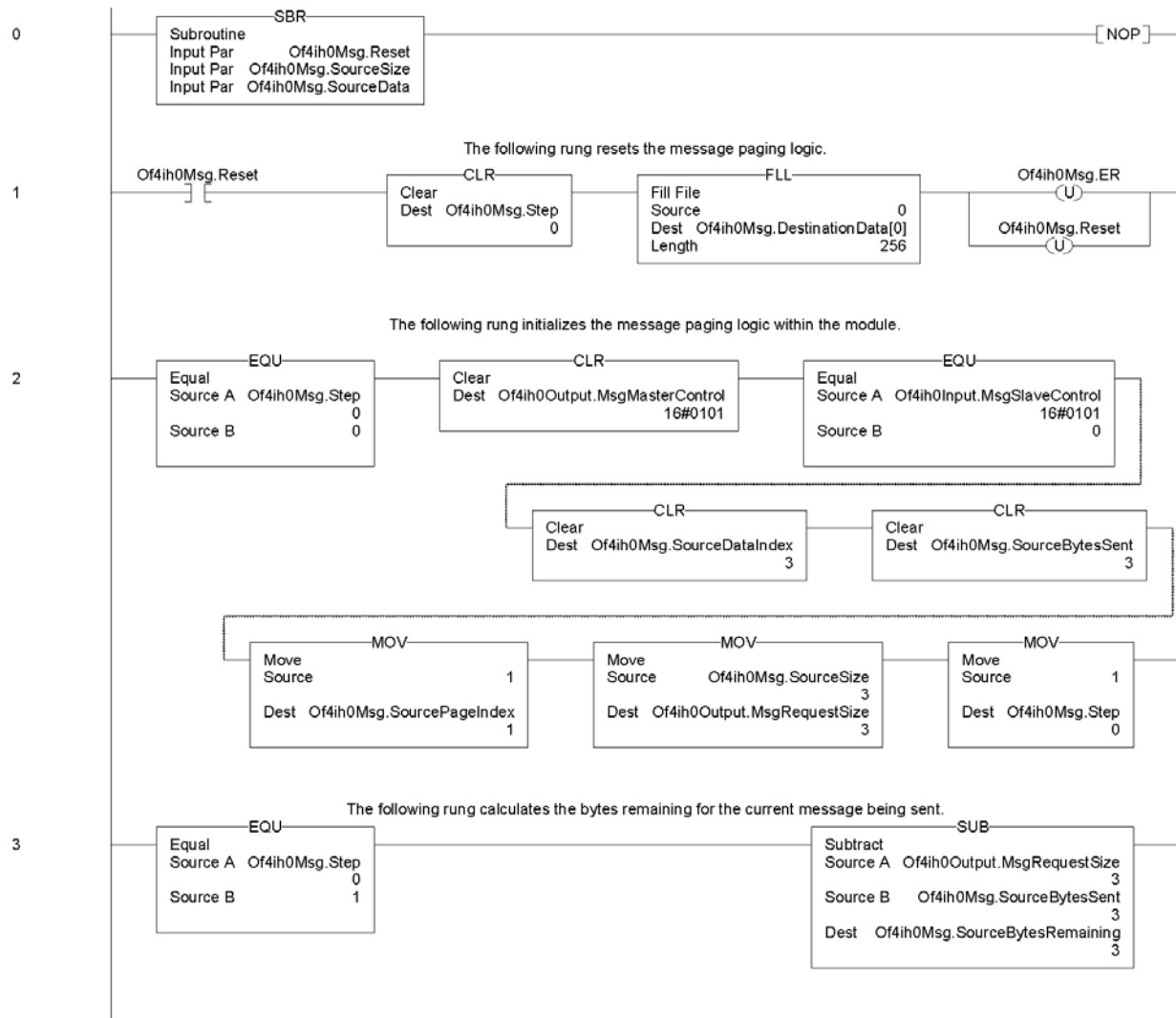


Figure 7-9b

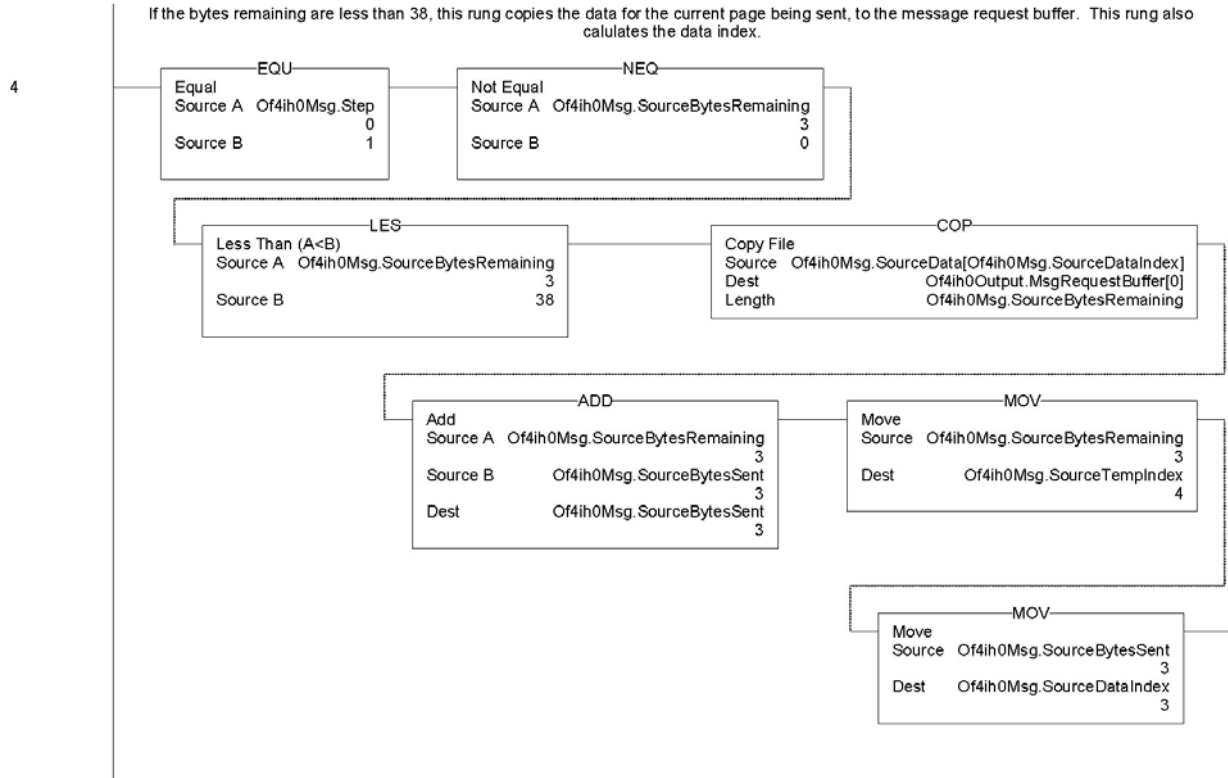


Figure 7-9c

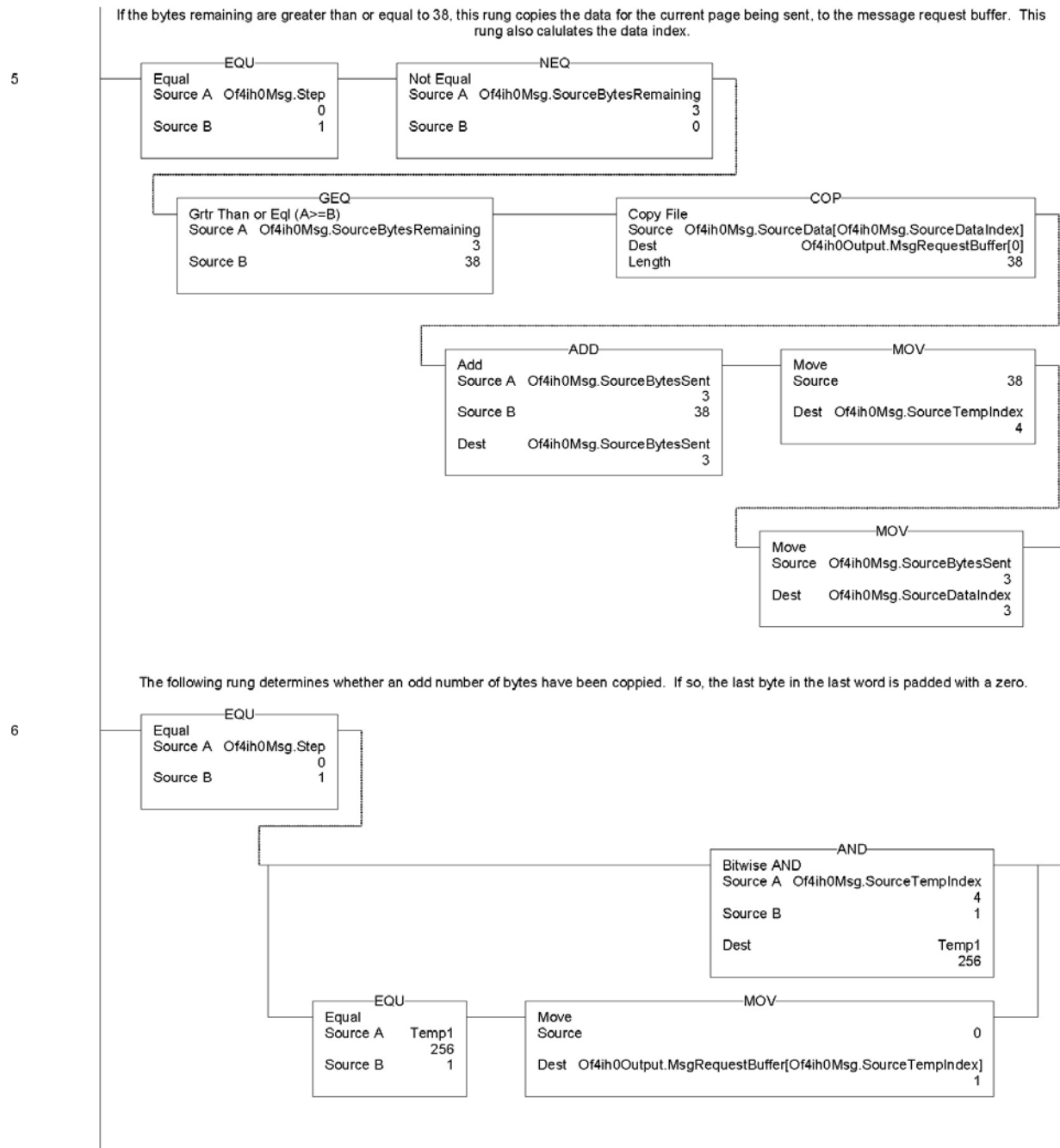


Figure 7-9d

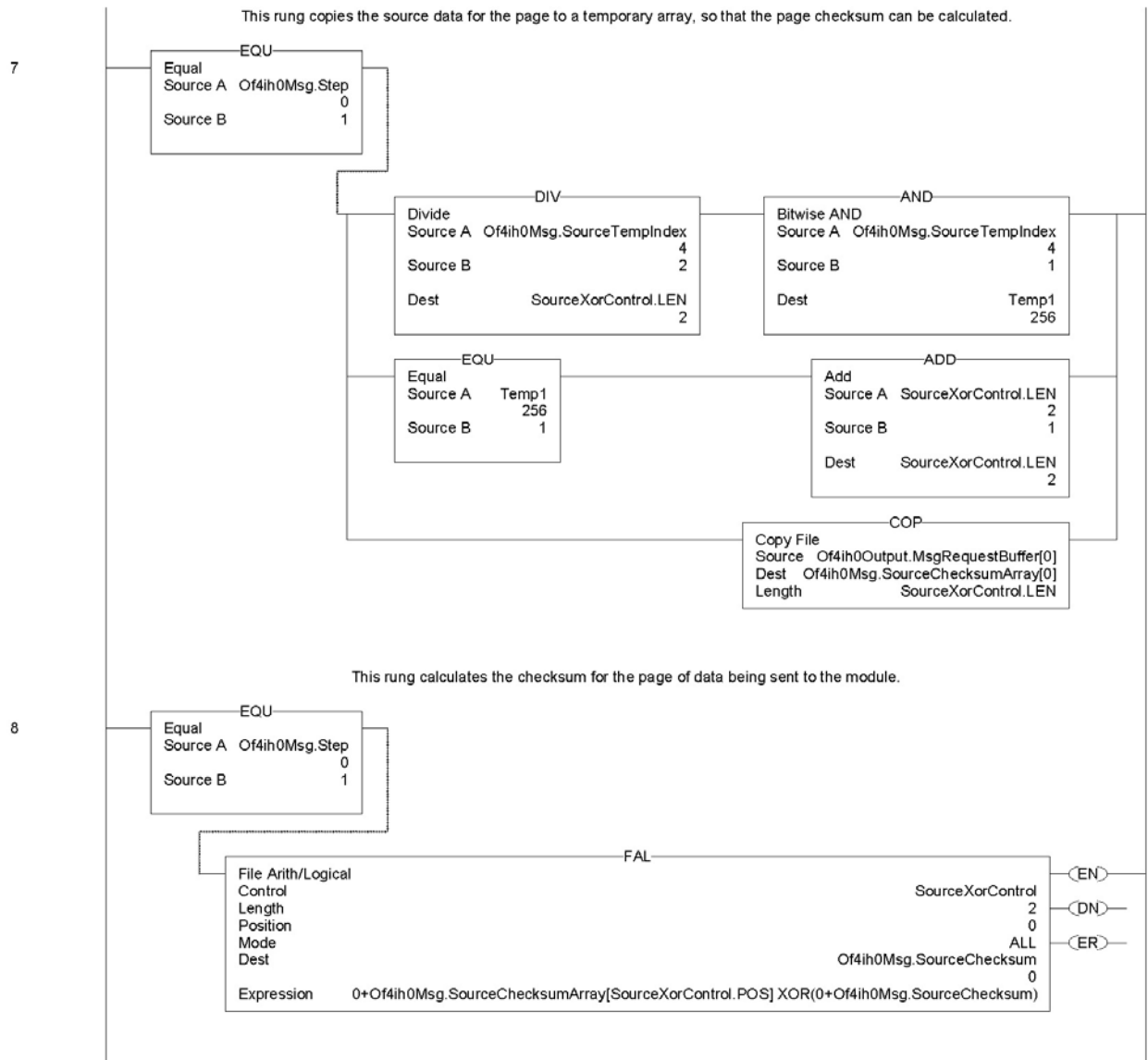


Figure 7-9e

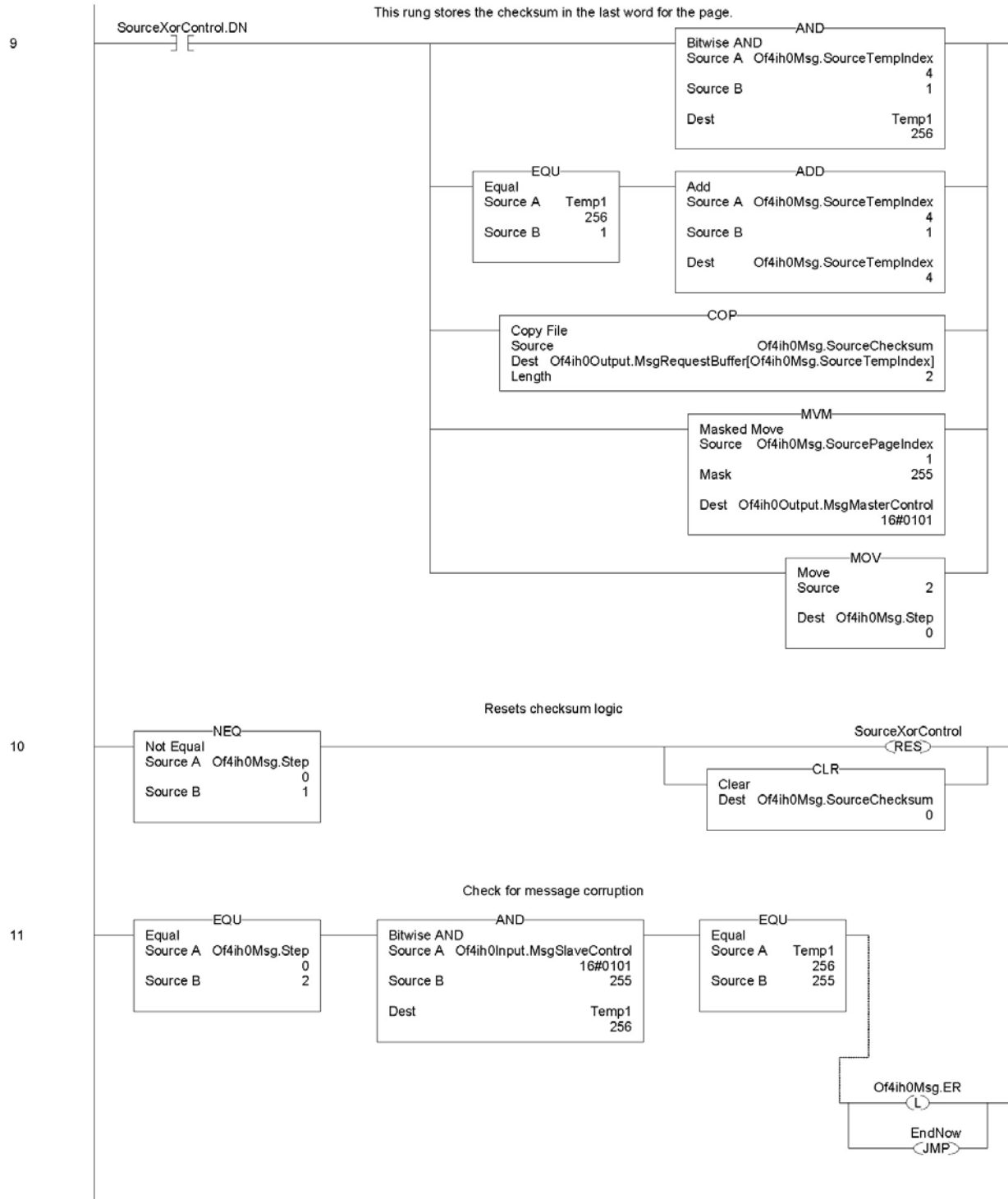


Figure 7-9f

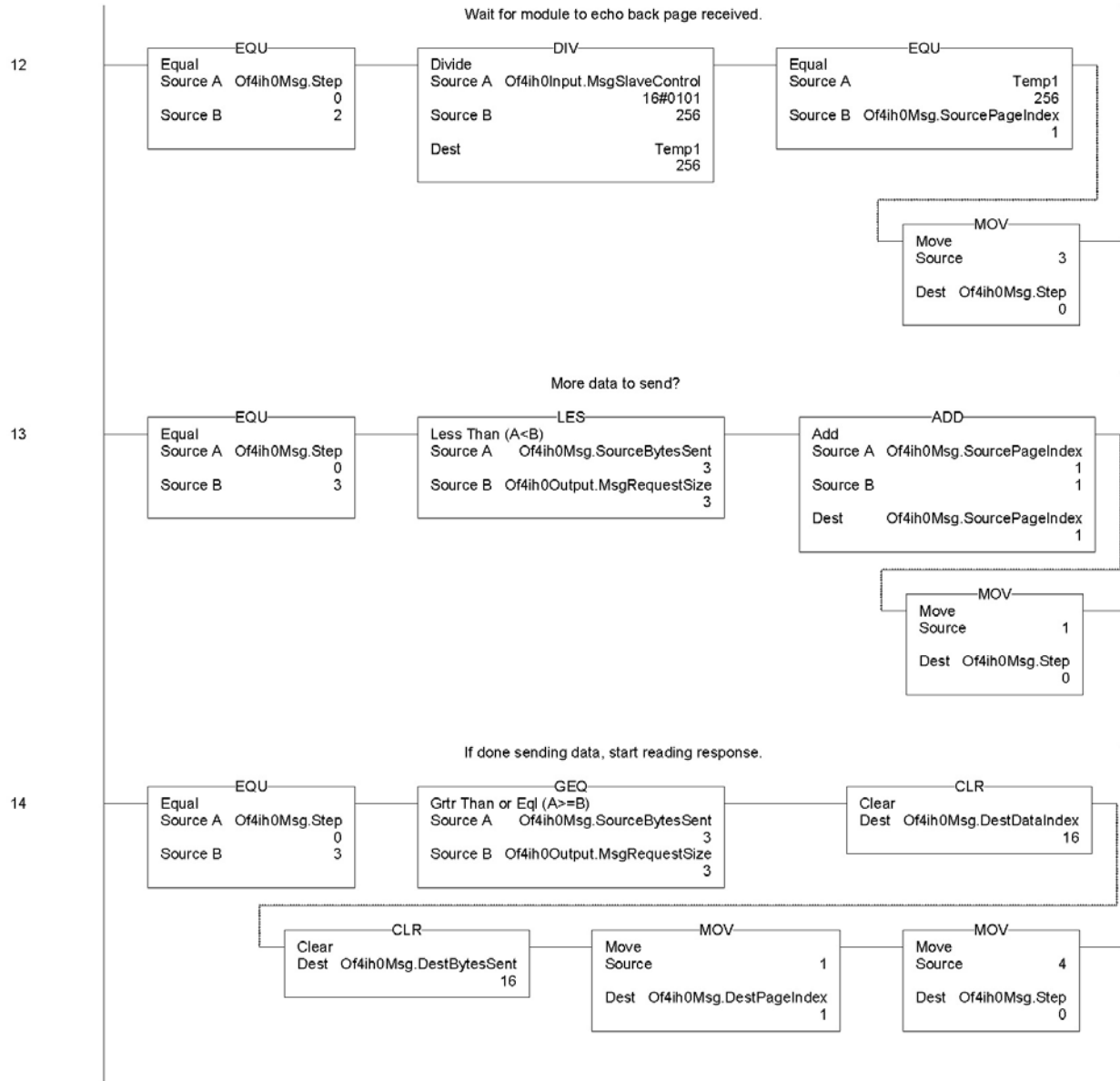


Figure 7-9g

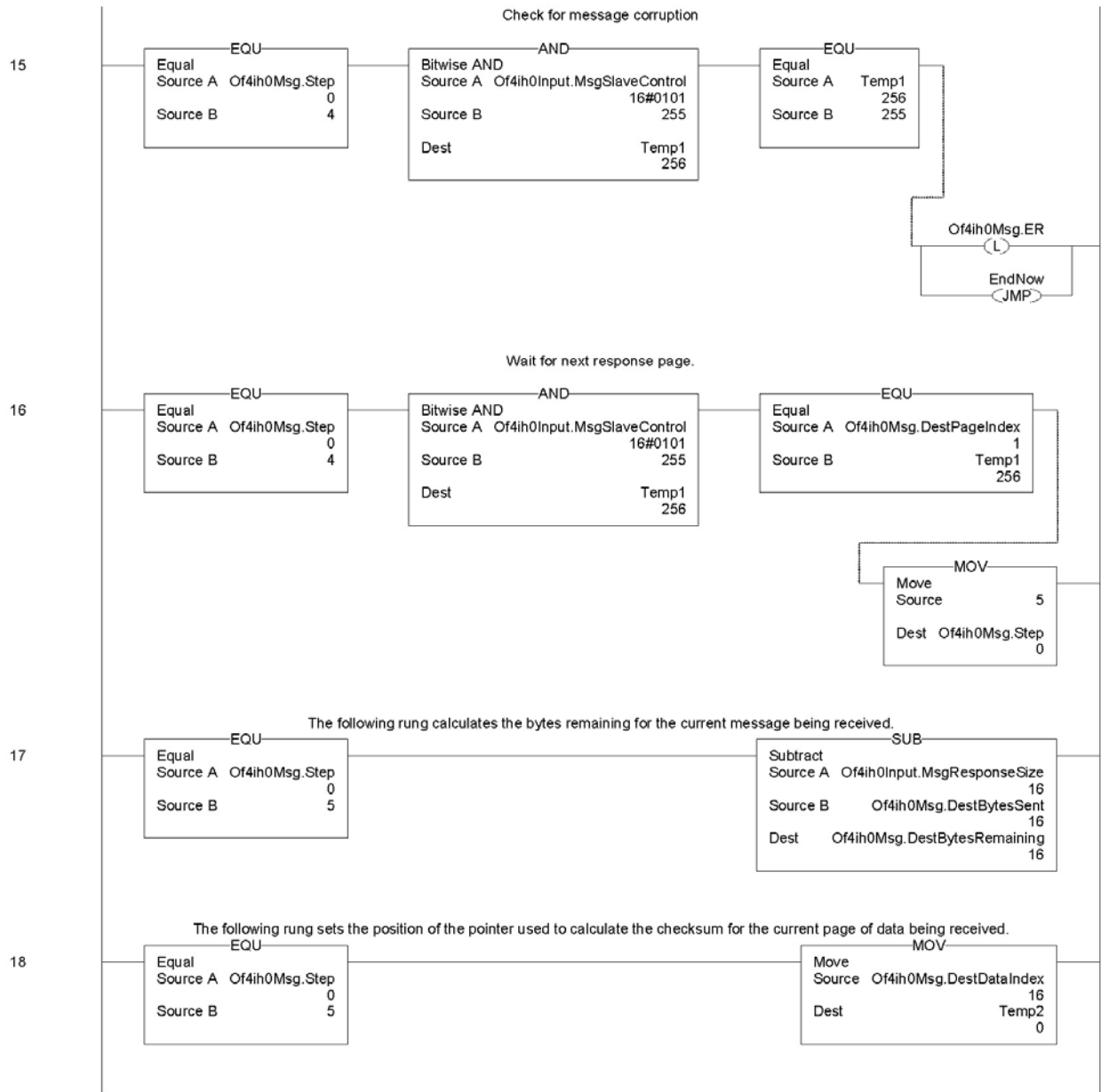


Figure 7-9h

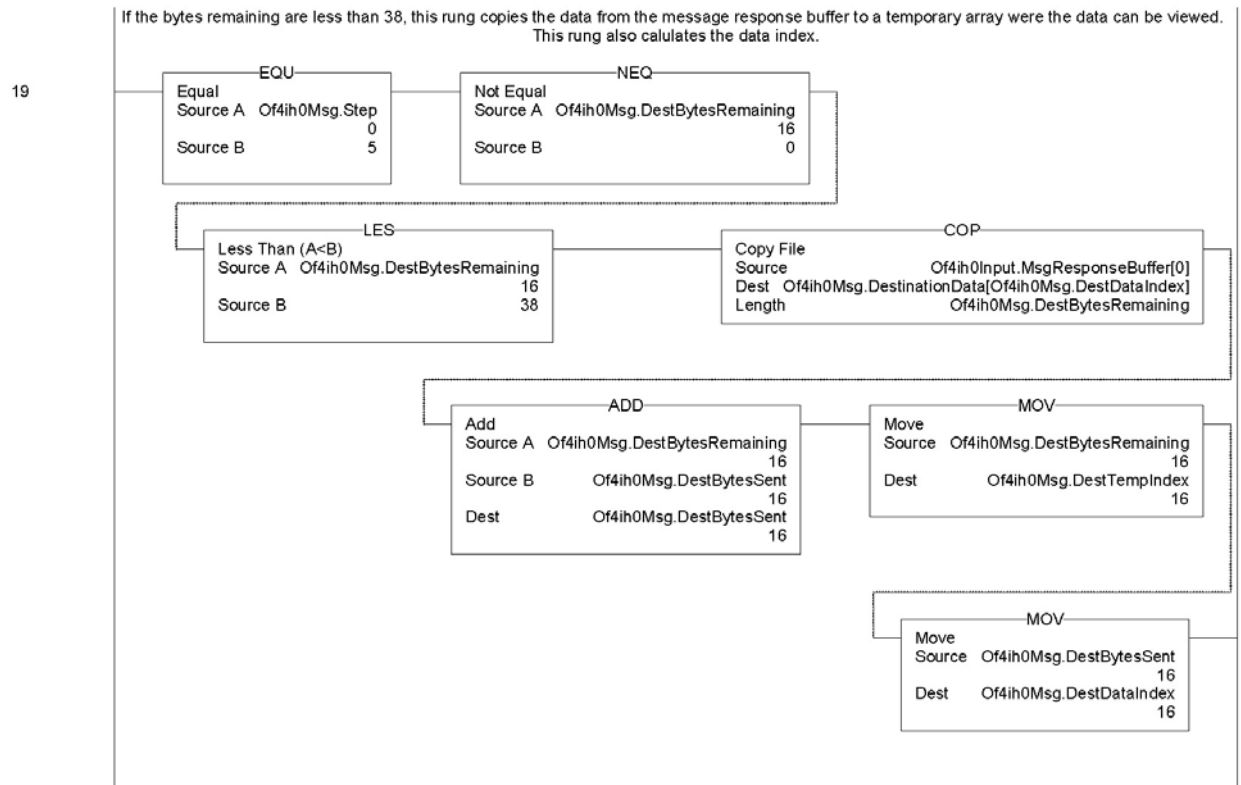


Figure 7-9i

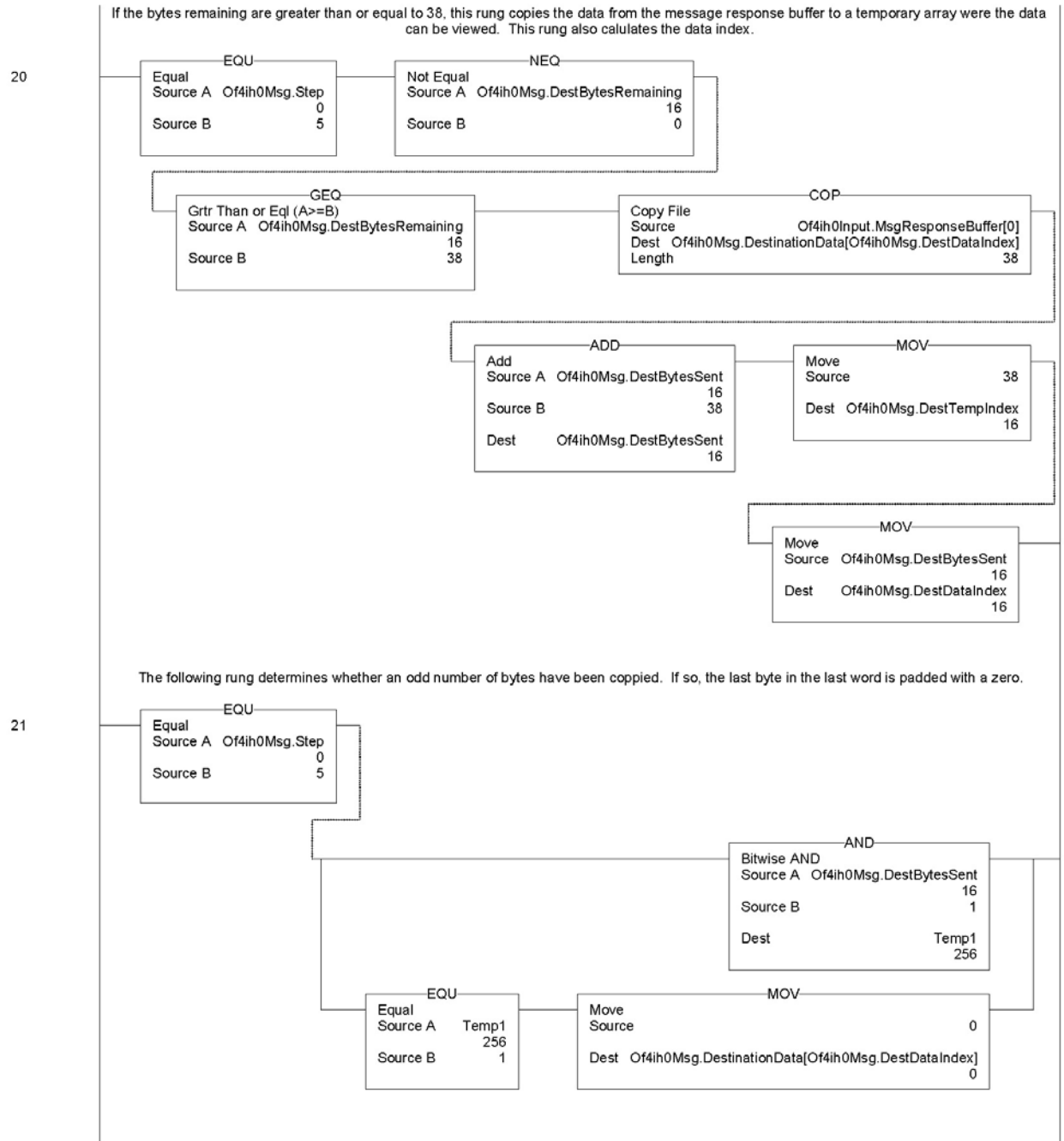


Figure 7-9j

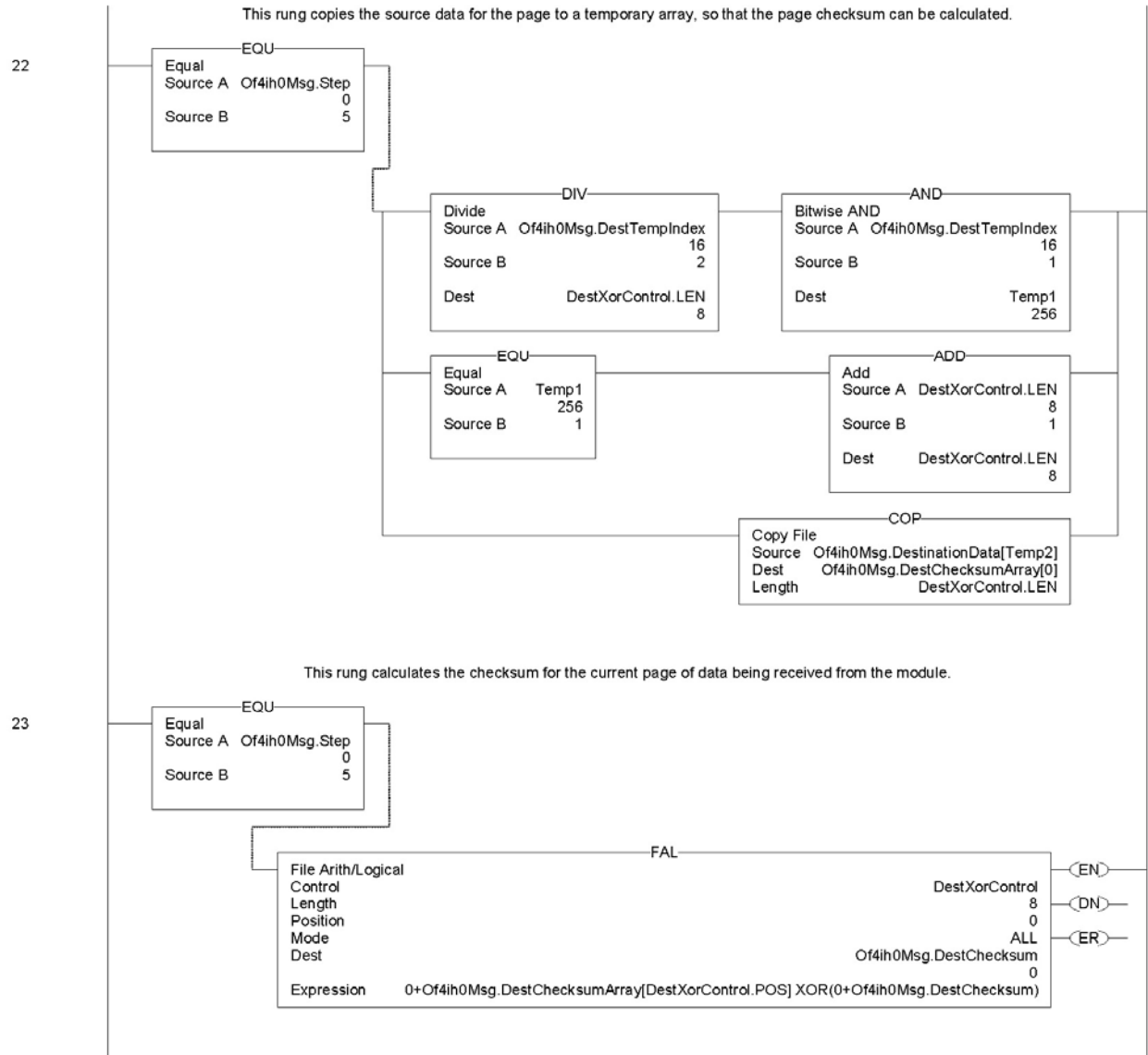


Figure 7-9k

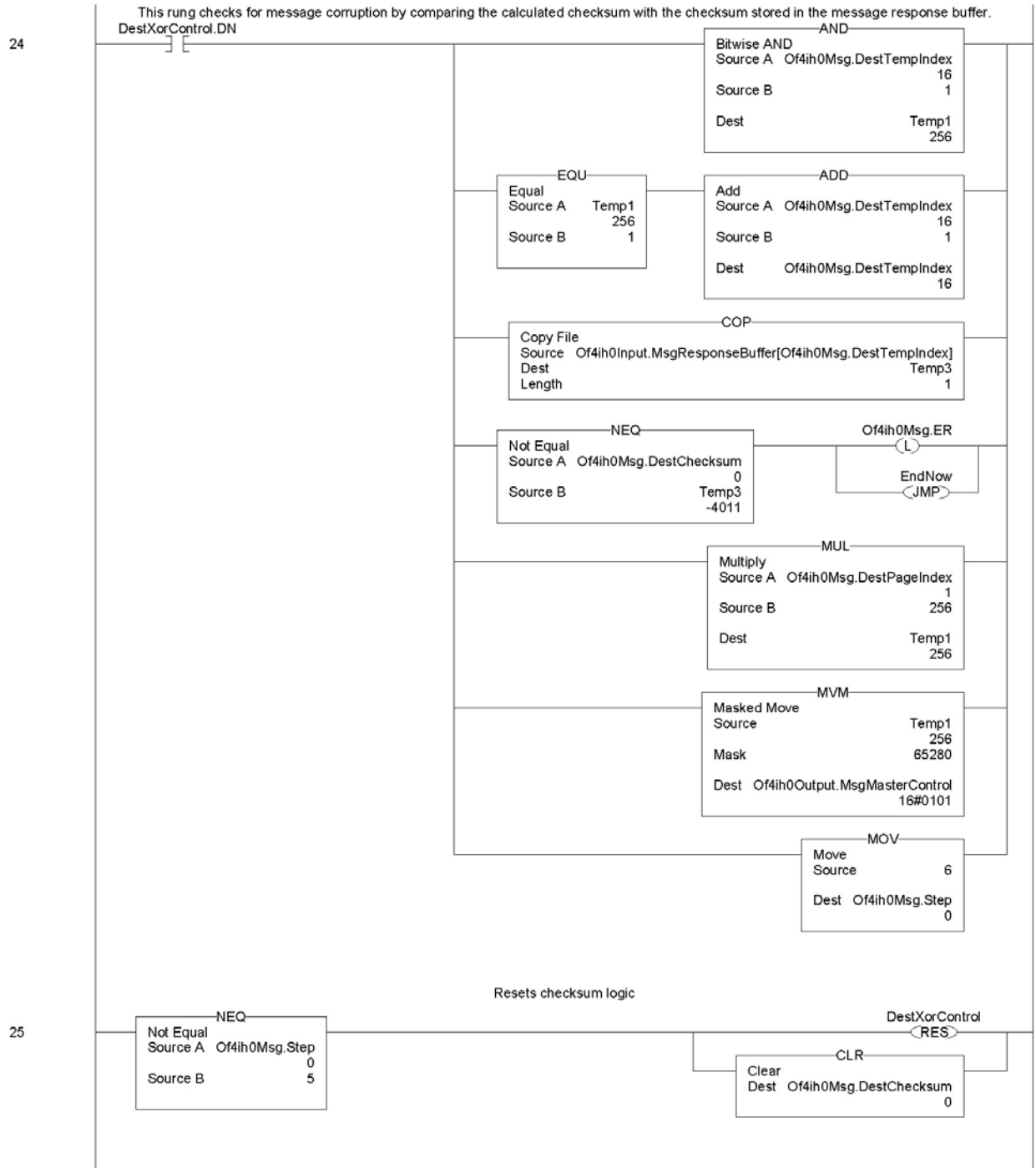
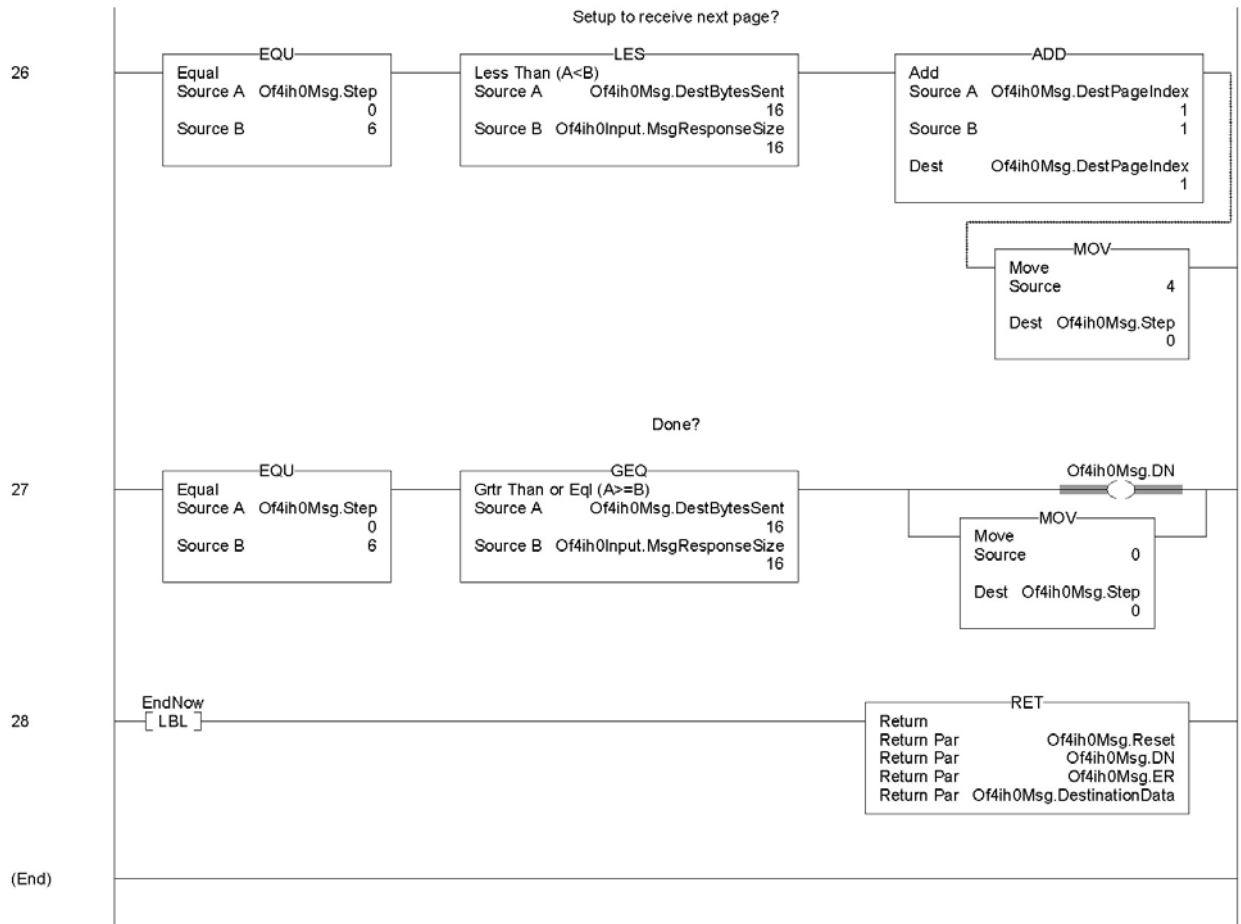


Figure 7-91

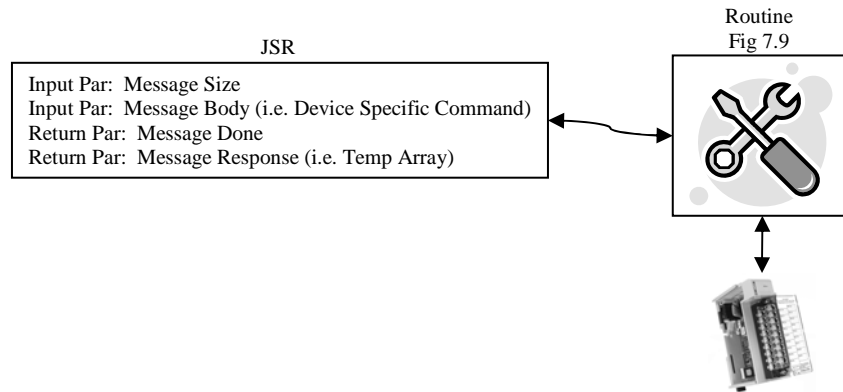


Section 7.4 Module Specific Commands

The HART output module uses module specific commands. Module specific commands include the HART pass-through, HART suspend and resume, and get HART device information. The commands are passed to the module using the input and output image. Since some messages can be as long as 257 bytes, the data is transported to and from the module 40 bytes at a time using the paging scheme described in the previous section.

The module specific command and accompanying data is passed to the routine in Figure 7-9 using a JSR instruction with parameters. When the routine is executed it will send the message to the module. The response data, if any, is also converted by this routine and stored in a temporary array where it can be used within the ladder program. See figure below.

Figure 7-10 (Message Flow)



The tables on the following pages show the format for each module specific command.

7.4.1 Get HART Device Information

The *Get HART Device Information* command is used to gather the device specific information for the connected HART device. The data that is retrieved can be seen in Table 7-11. The information that is gathered by this command is similar to the information gathered from the auto-acquisition process. The key difference is that the *Get HART Device Information* command pulls the data that has been stored in the module RAM and not directly from the field device.

Table 7-9 (Get HART Device Information Command)

HART Get Device Information – command message packet structure		
Get currently cached Device Information for a given channel.		
Field	Value	Definition
HART Channel Number	0x00 – 0x03 (1 byte)	Module input channel number for HART command
Command Number	0x03 (1 byte)	The command number to obtain HART device information

Table 7-10 (Response If Device Information Is Not Available)

HART Get Device Information - reply packet structure		
Field	Value	Definition
HART Channel Number	0x00 – 0x03 (1 byte)	Module input channel number for HART command
Status	(1 byte) 34 = DR_RUNNING 35 = DR_DEAD (bad request)	Command status
Count	(1 byte)	Set to 1
Handle	0	Fill byte of zero to keep command response common among all replies.

Table 7-11 (Response When Device Information Is Available)

HART Get Device Information - reply packet structure		
Field	Value	Definition
HART Channel Number	0x00 – 0x03 (1 byte)	Module input channel number for HART command
Status	00 = SUCCESS	Command status
Count	(1 byte)	Number of data bytes to following.
HART ManufacturerIDCode	(1 byte)	CMD#0, Byte 1
HARTDeviceTypeCode	(1 byte)	CMD#0, Byte 2
HARTPreamble	(1 byte)	CMD#0, Byte 3
HARTUnivCmdCode	(1 byte)	CMD#0, Byte 4
HARTTransSpecRev	(1 byte)	CMD#0, Byte 5
HARTSoftwareRevision	(1 byte)	CMD#0, Byte 6
HARTHardwareRevision	(1 byte)	CMD#0, Byte 7
HARTFlags	(1 byte)	CMD#0, Byte 8
Pad for 32 bit alignment	(1 byte)	
HARTDeviceIDNumber	(3 bytes) Device ID number	CMD#0, Bytes 9-11
Pad for 32 bit alignment	(1 byte)	
HARTTag	(8 bytes unpacked ASCII)	CMD#13, Bytes 0-5
HARTDescriptor	(16 bytes unpacked ASCII)	CMD#13, Bytes 6-17
HARTDate	(3 bytes)	CMD#13, Bytes 18-20
Pad for 32 bit alignment	(1 byte)	
HARTFinalAssemblyNumber	(3 bytes)	CMD#16, Bytes 0-2
Pad for 32 bit alignment	(1 byte)	
HARTMessage	(32 bytes unpacked ASCII)	CMD#12, Bytes 0-23
HARTPVCode	(1 byte)	CMD#50, Bytes 0, 0xff if not supported
HARTSVCode	(1 byte)	CMD#50, Bytes 1, 0xff if not supported
HARTTVCode	(1 byte)	CMD#50, Bytes 2, 0xff if not supported
HARTQVCode	(1 byte)	CMD#50, Bytes 3, 0xff if not supported
HARTPVUnits	(1 byte)	CMD#3, Byte 4
HARTSVUnits	(1 byte)	CMD#3, Byte 9, 0 if not present
HARTTVUnits	(1 byte)	CMD#3, Byte 14, 0 if not present
HARTQVUnits	(1 byte)	CMD#3, Byte 19, 0 if not present
HARTSlot0Units	(1 byte)	CMD#33, Byte 1, 0 if not present Output module use only.
HARTSlot1Units	(1 byte)	CMD#33, Byte 7, 0 if not present Output module use only.

HART Get Device Information - reply packet structure		
Field	Value	Definition
HARTSlot2Units	(1 byte)	CMD#33, Byte 13, 0 if not present Output module use only.
HARTSlot3Units	(1 byte)	CMD#33, Byte 19, 0 if not present Output module use only.
HARTPVLowerRange	(4 bytes – Floating Point Value)	CMD#15, Bytes 3-6
HARTPVUpperRange	(4 bytes – Floating Point Value)	CMD#15, Bytes 7-10
Pad for 32 bit alignment	(3 bytes)	

The command status, the second byte in the reply packet for the module specific command, can return three different responses, SUCCESS, RUNNING and DEAD. These responses echo the state of the module at the time the command is sent. The conditions for each response are as follows:

SUCCESS will be sent back when all of the following conditions are met:

- Command and HART Channel number are both valid.
- HART channel device information is available.

RUNNING will be sent back when all of the following conditions are met:

- Command and HART Channel number are both valid.
- HART channel is enabled and communication has been established, meaning at least the device addressing information is available.
- HART channel is already in the state of gathering device information. Reply will be sent back without additional events triggered.

DEAD will be sent back if any of the following conditions is true:

- Command or HART Channel number is invalid
- HART channel is not enabled
- HART communication has not been established, meaning that the 5-byte unique address has not been determined yet.
- All other conditioned not generating RUNNING or SUCCESS.

7.4.2 HART Channel Suspension and Resume

Sometimes referred to as "Out of Service" and "In Service" respectively, these commands can be utilized to suspend or resume operation of an enabled HART channel. When a suspend HART command is sent, the HART module will keep the current HART configuration information and stop all communication processes on the selected channel. However, there are overriding conditions such as a configuration change which can cause the HART function to reset. Normal HART operation will resume if the resume HART command is sent to the module during a HART suspension.

Note: The HART suspend and resume can be initiated by setting a bit in the output image. Refer to Chapter 6 for more details.

Note: If the resume command is received, without previously receiving a suspension command, it will be ignored.

Note: The selected channel will resume normal HART operations three minutes after the suspension command has been received by the module. Pass-through for that channel resets the timer to 3 minutes.

Table 7-12 (HART Suspend/Resume)

HART Channel Suspend/Resume command request – command message packet structure

Field	Value	Definition
HART Channel Number	0x00 – 0x03 (1 byte) 0xFF (-1) Apply to all 8 channels	Enabled HART channel number
Command Number	(1 byte) 0x05: Suspend (Set service mode) 0x06: Resume (Reset service mode)	The command number to suspend or resume

Table 7-13 (HART Suspend/Resume Reply)

HART Channel Suspend/Resume command request – reply packet structure		
Field	Value	Definition
HART Channel Number	0x00 – 0x03 (1 byte) 0xFF (-1) Apply to all 8 channels	Echo of the HART channel number received
Status	(1 byte) 00 = SUCCESS 35 = DR_DEAD	Command status
Count	(1 byte)	Set to 1
Handle	0	Fill byte of zero to keep command response common among all replies.

The command status, the second byte in the reply packet for the module specific command, can return two different responses, SUCCESS, and DEAD. These responses echo the state of the module at the time the command is sent. The conditions for each response are as follows:

SUCCESS will be sent back under the following conditions:

- Command and HART Channel number are both valid.
- HART channel number is an enabled channel.
- The identified HART channel finished all of the start-up connection process.
- The I/O module will not be checking for matching set of suspend/resume commands. This means, if already suspended, and receives another suspend, SUCCESS will be returned still. Similarly if the system is operating as normal, and receives a resume command, it will ignore the command and continue operation. This state of operation will not be maintained after power-up or when configuration changes.

DEAD will be sent back if any of the following conditions is true:

- Command and HART Channel number are both valid.
- HART channel is not enabled.
- HART communication has not been established, meaning that the 5-byte unique address has not been determined yet, or the module is still obtaining device information.
- All other conditioned not generating SUCCESS.

7.4.3 HART Pass-Through Command

The HART Pass-Through Command can be used to send any HART command including universal, common practice or device specific, directly to a field device. The module in this case could be considered a HART bridge. There can be two (2) instances of a HART pass-through message being serviced, meaning the pass-through message queue is 2 deep. The HART pass-through response will be queued the moment the command is received, if the queue spaces are not already in use, and be dispatched after at least a full

scan is done. In other words, after servicing a pass-through, the HART module will make sure all enabled HART channels have updated variable values before another pass-through is placed into service.

All HART pass-through commands require a series of messages to be exchanged. First, a pass-through command request must be sent to the HART module to initiate the pass-through command. The HART module will respond to the command request with a command request reply that includes a handle that can be used to obtain the pass-through message response. Once the handle is received, the user may issue a Get Command Query to obtain the status of the pass-through command and the pass-through command response data, if it is available.

There is a handle timeout associated with the final reply message. After the HART module obtains the requested information from the HART device, it will start a handle timeout timer. Refer to Chapter 6 for information regarding how to set the handle timeout. The reply message will be kept persistent during the handle timeout period. When the handle timeout timer expires the reply message will be discarded, and another pass through message will be serviced without being rejected. The user defined handle timeout is in the range of 1 to 255 seconds.



Attention

If the HART message being sent or received using the pass-through command contains floating point values, the order of the bytes must be reversed.

Depending on the HART command, the data contained within the HART message may include floating point numbers or double integers. If a floating point or double integer is contained within the HART message, the user must be aware that the order of the bytes that make up the float or double will need to be reversed. The reason for this is related to how the bytes are stored in the Controllogix processor.

The Controllogix processor stores the bytes in memory in a format referred to as "little-endian". Little-endian is an order in which the "little end" (least significant value in the sequence) is stored first (at the lowest storage address). However, HART devices transmit the byte data in the reverse order or as you may have guessed "big-endian". Refer to Chapter 8 for a ladder sample demonstrating the process of swapping the order of the bytes.

Table 7-14 (HART Pass -Through Request Command)

HART pass through command request – command message packet structure		
Field	Value	Definition
HART Channel Number	0x00 – 0x03 (1 byte)	Module input channel number for HART command
Command Number	0x01 (1 byte)	The command number to issue a HART pass-through command.
HART Command	N bytes N = Length of message – 2 Contents are as follows: Start or Delimiter (1 byte): 0x82 Long form Address (5 bytes) HART Command number (1 byte) Request Data Count (1 byte) Data (“Request Data Count” bytes) Checksum (XOR of all bytes from delimiter on. Delimiter is included)	The actual HART command PDU

Table 7-15 (HART Pass-Through Request Reply)

HART pass through command request – reply packet structure		
Field	Value	Definition
HART Channel Number	0x00 – 0x03 (1 byte)	Module input channel number for HART command
Status	(1 byte) 32 = Busy (Queue is already full). 33 = DR_INITIATE 35 = DR_DEAD (bad request)	Command status
Count	(1 byte)	Set to 1
Handle	(1 byte) 0 (bad when status is DR_DEAD) 1-255 (good)	The handle for command complete query

The command status, the second byte in the reply packet for this module specific command, can return two different responses, INITIATE, and DEAD. These responses echo the state of the module at the time the command is sent. The conditions for each response are as follows:

INITIATE will be sent back under the following conditions:

- Command and HART Channel number are both valid.
- HART channel is enabled and communication has been established, meaning at least the device addressing information is available.
- Handle is available, meaning no pending handle is still active.
- HART channel is doing regular data sampling only. No pending device information gathering is active.
- No pending pass-through handle is active, meaning handle timeout has not occurred yet.
- Device address and delimiter are valid.
- Received CIP word count is large enough for the entire command packet.

DEAD will be sent back if any of the following conditions are true:

- Command or HART Channel number is invalid.
- HART channel is not enabled.
- HART communication has not been established, meaning that the 5-byte unique address has not been determined yet.
- The channel is currently updating device information. Theoretically, pass-through command can be safely accepted after successfully receiving Command 0, but for simplicity, we'll track update of the device information as a whole.
- All other conditioned not generating INITIATE.

After the pass-through response is sent with a valid handle and a response value indicating (33) INITIATE, the user can retrieve the data associated with the handle using the following command message.

Table 7-16 (HART Pass-Through Query Command)

HART pass through command complete query - command message packet structure		
Field	Value	Definition
HART Channel Number	0x00 – 0x03 (1 byte)	Module input channel number for HART command
Command Number	0x0C (1 byte)	The command number
Handle	(1 byte) 1-255	The handle from command request reply

If the data associated with the handle is not yet available, or invalid, the following reply message will be returned.

Table 7-17 (HART Pass-Through Query Reply NOT SUCCESS)

HART pass through command complete query - reply packet structure		
Field	Value	Definition
Unconnected Message Header		
HART Channel Number	0x00 – 0x07 (1 byte)	Module input channel number for HART command
Status	(1 byte) 34 = DR_RUNNING 35 = DR_DEAD (bad request)	Command status
Count	(2 bytes) (Command Number 0x0C)	Length of Handle + HART Response Data in bytes (if Success)
Handle	(1 byte)	The handle from command complete query

When data associated with the buffer becomes available, meaning a "success" response, the reply will be formatted as follows:

Table 7-18 (HART Pass-Through Query Reply SUCCESS)

HART pass through command complete query - reply packet structure		
Field	Value	Definition
Unconnected Message Header		
HART Channel Number	0x00 – 0x07 (1 byte)	Module input channel number for HART command
Status	(1 byte) 00 = SUCCESS	Command status
Count	(1 byte) (Command Number 0x04) (2 bytes) (Command Number 0x08, 0x0C)	Length of Handle + HART Response Data in bytes (if Success)
Handle	1-255	The handle from command complete query
HART Command Response Data	Size is the entire HART device response size in bytes. The size does not include preambles bytes.	The HART device's response to the command (if Success)

The command status, the second byte in the reply packet for the module specific command, can return three different responses, SUCCESS, RUNNING and DEAD. These responses echo the state of the module at the time the command is sent. The conditions for each response are as follows:

SUCCESS will be sent back under the following conditions:

- Command and HART Channel number are both valid.
- HART channel is enabled.
- Command handle matches currently active handle and the handle is in the HOLD state.
- After replying with a SUCCESS, the handle will become inactive, thus allowing for next pass-through or host initiated update of device information.

RUNNING will be sent back under the following conditions:

- Command and HART Channel number are both valid.
- HART channel is enabled.
- Command handle matches currently active handle.
- HART channel is already in the state of handling a pass-through command. Reply will be sent back without additional events triggered.

DEAD will be sent back if any of the following conditions are true:

- Command or HART Channel number is invalid.
- HART channel is not enabled.
- HART communication has not been established, meaning that the 5-byte unique address has not been determined yet.
- All other conditioned not generating RUNNING or SUCCESS. Examples are: invalid handle, handle timed out, channel under device information gathering, and etc.

The following ladder demonstrates how to perform the pass-through request and query process.

Figure 7-11a (Pass-Through Ladder)

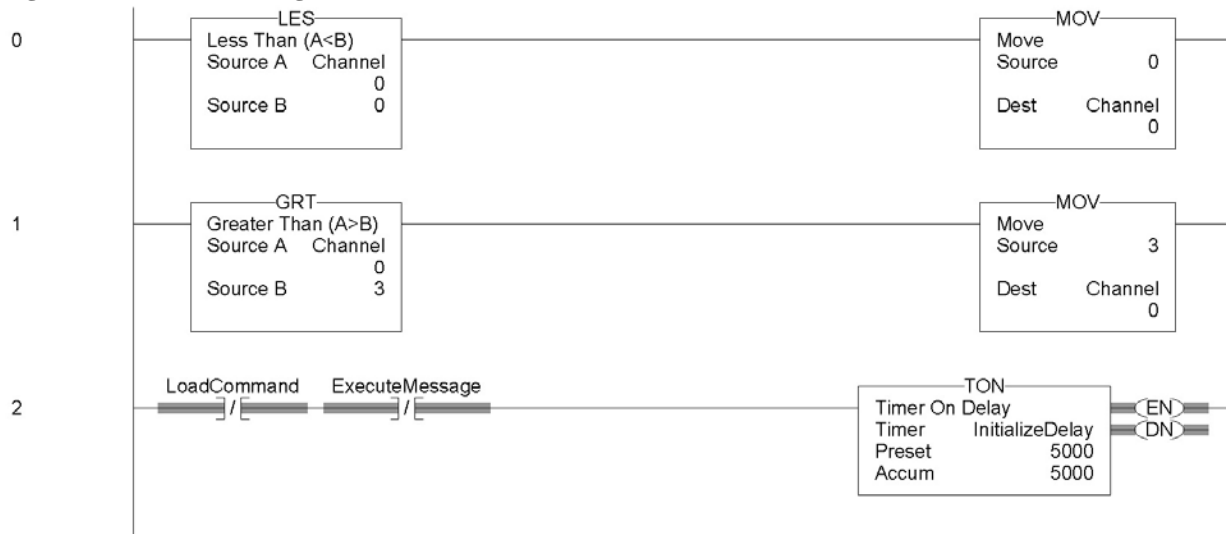


Figure 7-11b

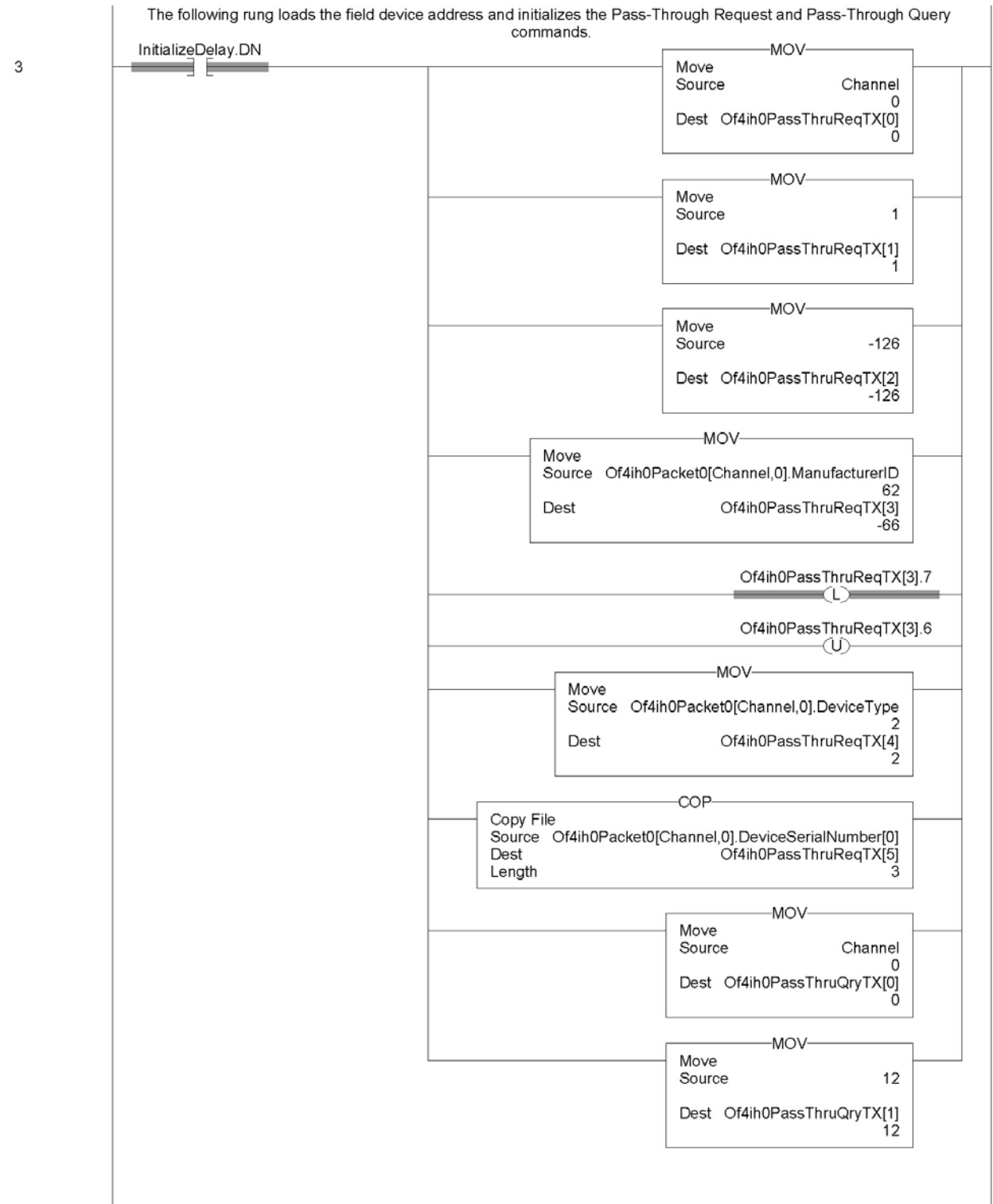


Figure 7-11c

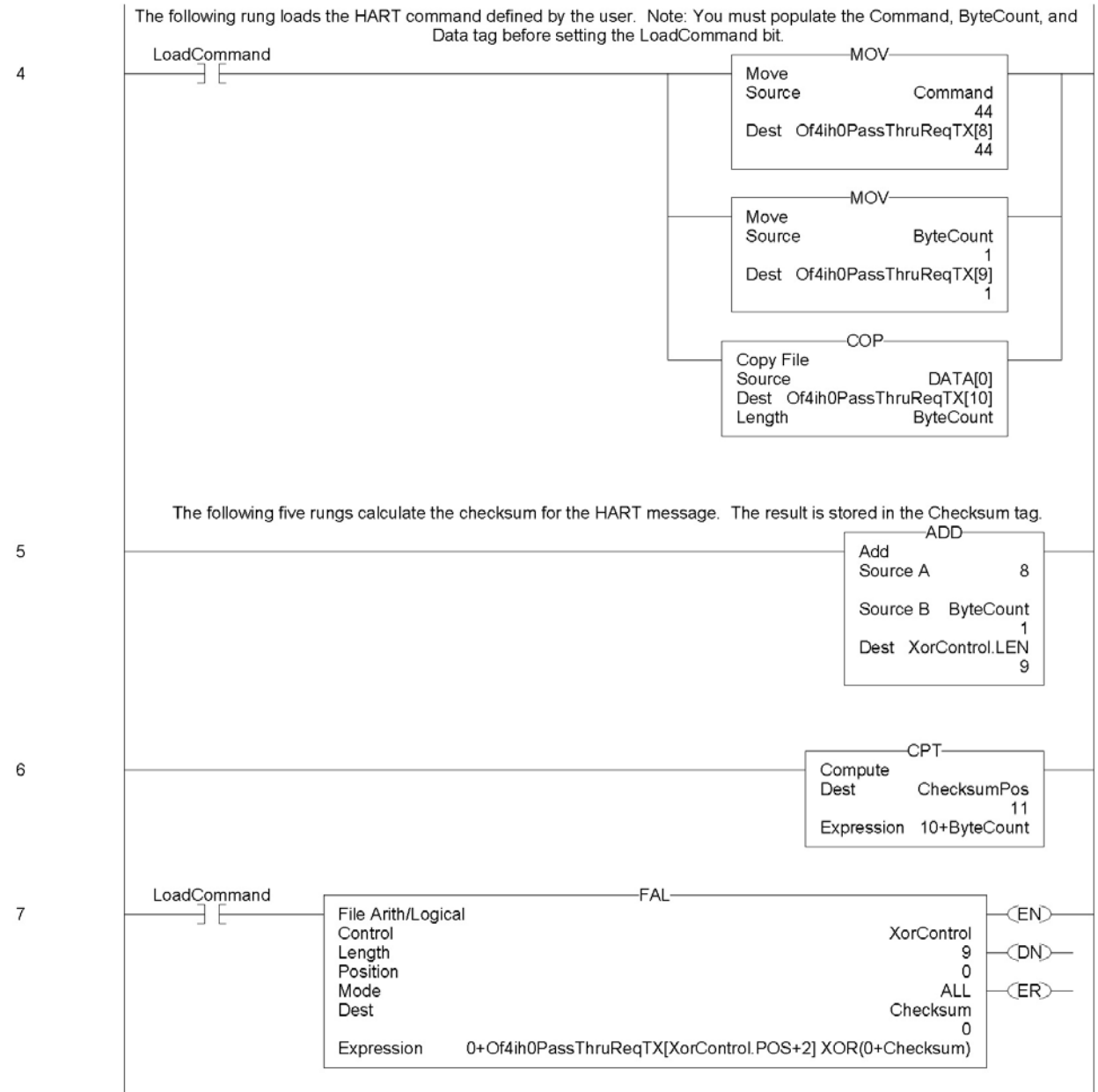


Figure 7-11d

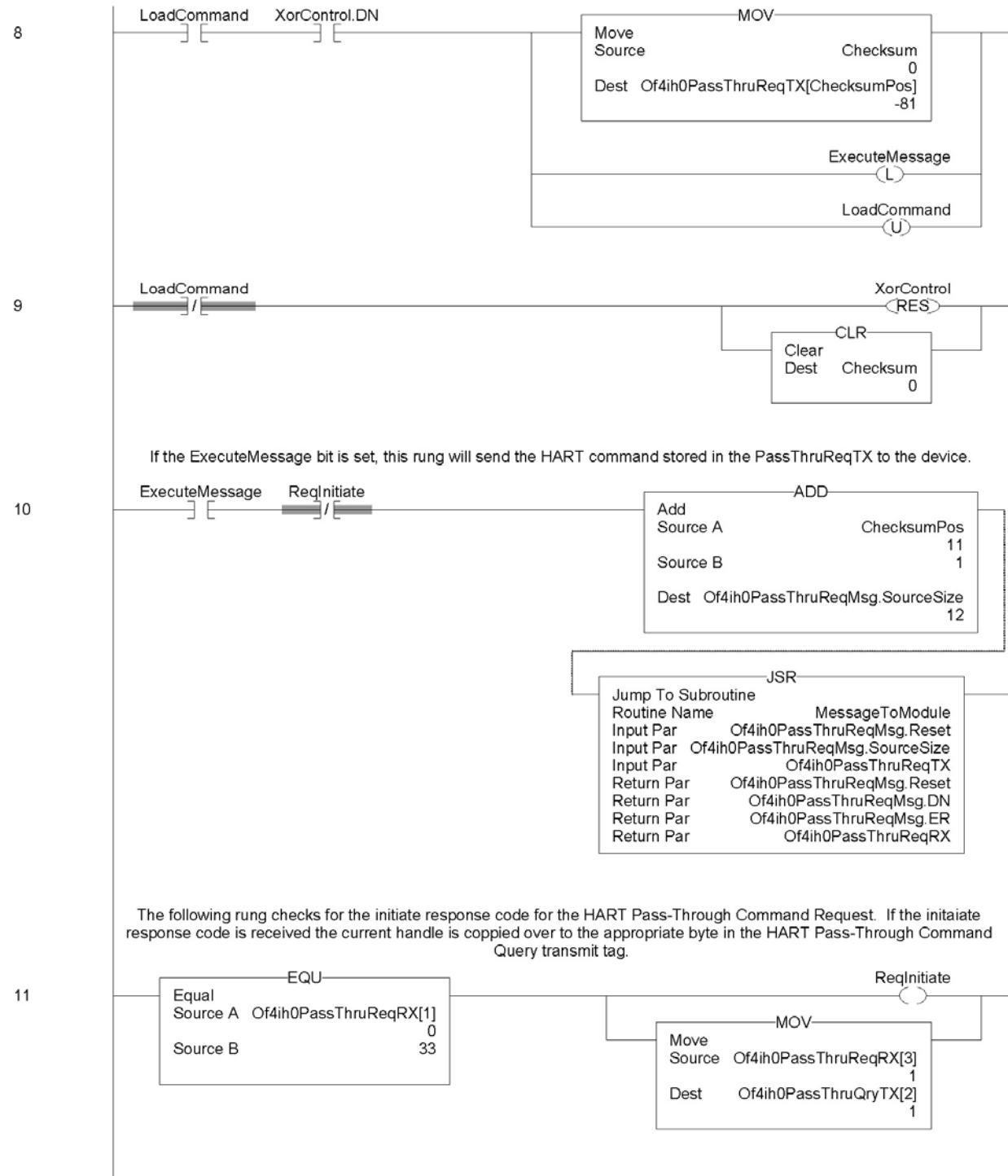


Figure 7-11e

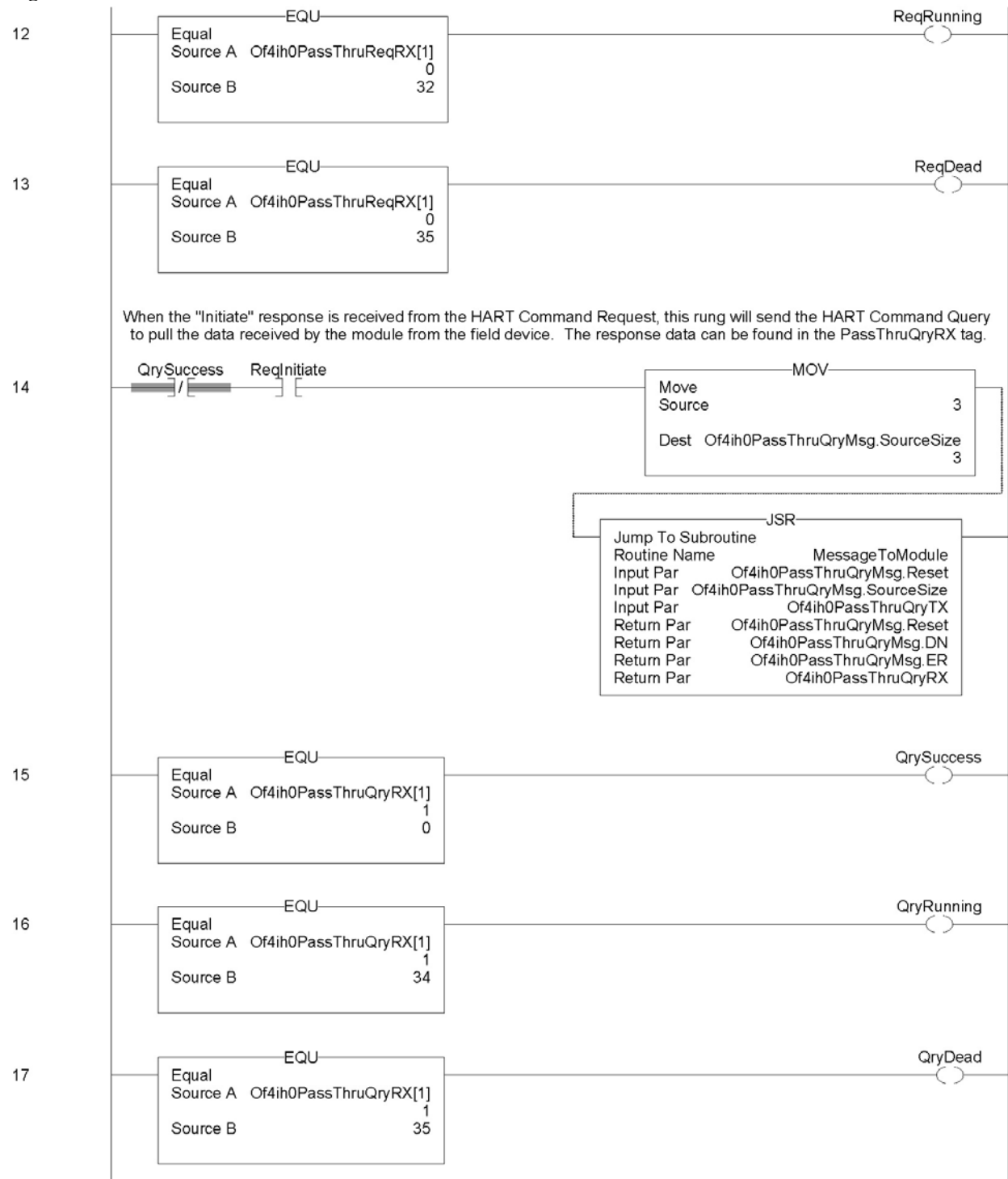
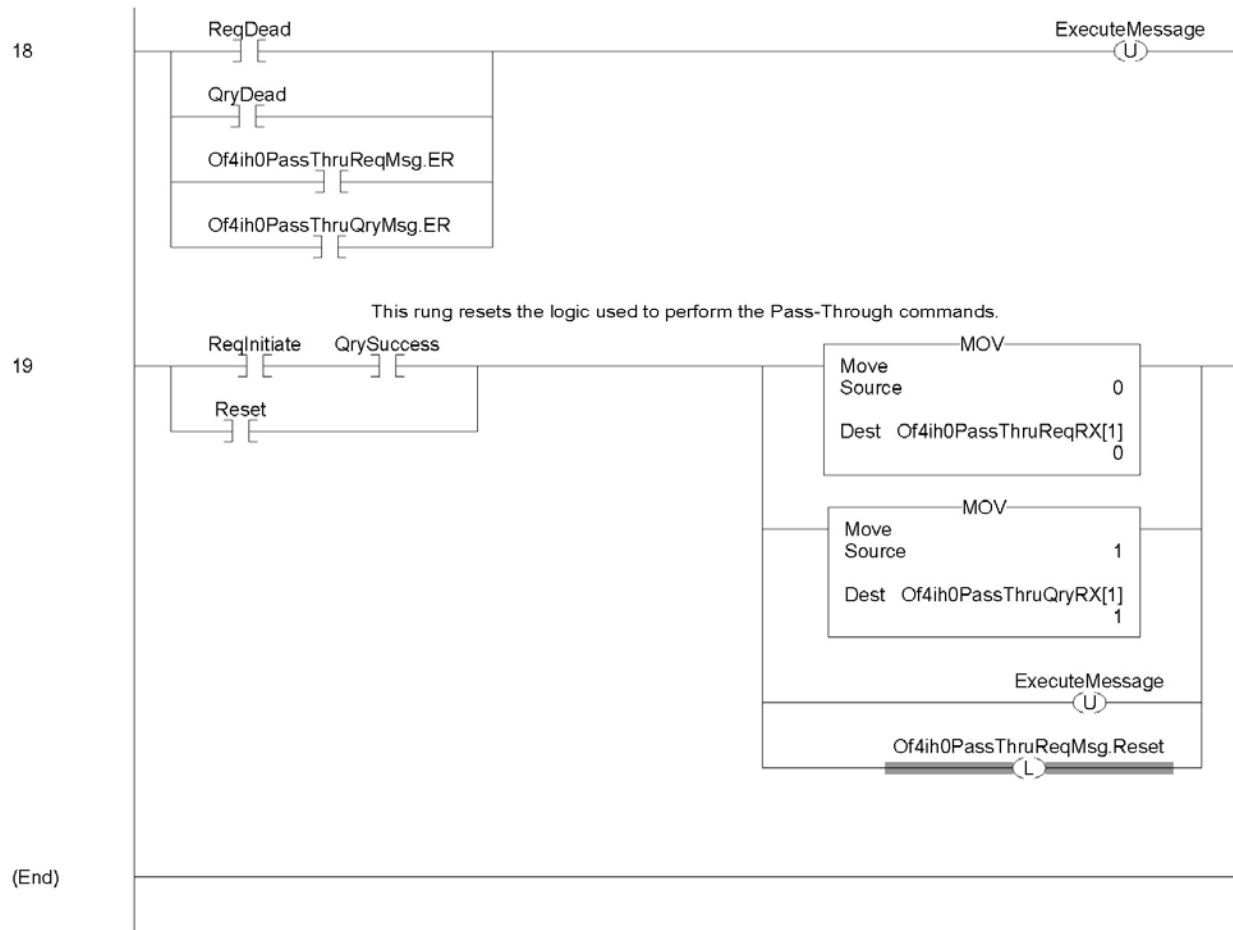


Figure 7-11f



Note: The ladder in Figure 7-11 can be found in the project sample file located on our website at (www.spectrumcontrols.com)

Section 7.5 HART Protocol Overview

In order to read and write HART commands to and from the field device reliably using the OF4IH, you must have a basic knowledge of the HART protocol. This section will explain in detail the various pieces that make up the HART message and how to formulate the message and send it to the field device using the module specific Pass-Through command, which was described earlier in this chapter.

7.5.1 Message Format

HART protocol specifies a message structure as follows:

Figure 7-12 (HART Message Structure)

Preamble	Start Character	Address	Command	Byte Count	Status	Data	Checksum
----------	-----------------	---------	---------	------------	--------	------	----------

Note: The HART protocol supports two different formats, long and short frame. Older HART instruments (up to HART revision 4) used a short frame format. In this format, the address of the slave device is either 0, for non-multidrop devices using the 4-20mA current signal, or 1-15 for multidrop devices.

HART revision 5 introduced the long frame format. In this format, the address of a slave device is a worldwide, unique 38-bit number derived from the manufacturer code, the device type code, and the device identification number. The long frame format provides extra security against acceptance of commands meant for other devices, due to external interference or excessive crosstalk. The OF4IH supports only the long frame format.

Each item of the message structure shown above is explained as follows.

Preamble

The preamble consists of three or more hexadecimal FF characters (all 1s) allowing the receiving modem to get its frequency-detection circuits synchronized to the signal after any pause in transmission.

Note: The preamble does not need to be included in the HART message when using the module specific Pass-through command. The Pass-through command already includes the preamble.

Start Character

The start character in a HART message has various values, indicating which frame format is being used, the source of the message, and whether a field device is in burst mode. The possible definitions are shown in the table below.

Table 7-19 (Start Character Definition)

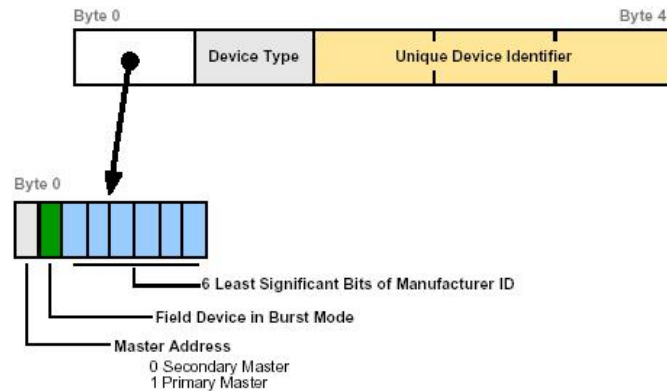
	Short Frame	Long Frame
Master to slave	02 (Hex)	82 (Hex)
Slave to master	06 (Hex)	86 (Hex)
Burst mode from slave	01 (Hex)	81 (Hex)

Address

The address field contains both the host and field device addresses for the message. These may be contained in a single byte (short frame format) or in five bytes (long frame format). Since the module presently only supports the long frame form, we will omit the

discussion of the short frame form. In either format, the single-bit address of the master is the most significant. Only two masters are allowed for example, a control system and a hand-held communicator. The most significant bit of the address field differentiates these two hosts. Primary masters such as the OF4IH use address 1, and secondary masters such as handhelds use address 0. Please see figure below.

Figure 7-13 (Long Frame Address)



Note: *The OF4IH does not support burst mode.*

The 1 byte Device Type code is allocated and controlled by the manufacturer. The 3 byte Device Identifier is similar to a serial number in that each device manufactured with the same Device Type Code must have a different Device Identifier. The OF4IH automatically pulls for the device specific codes using the Auto-acquisition process. The device specific codes that are acquired using this process can be seen in Table 2.

Command

The command byte contains an integer (0 to hex FF or decimal 257) that represents one of the HART commands. Code 254 is defined as an expansion code and is followed by another byte allowing more than 256 different commands to be defined if necessary. The received command code is echoed back by the slave device in its reply.

There are three categories of commands: universal commands, which all HART devices must implement; common practice commands, which should be used if the particular function is provided; and device specific commands, which are for functions more or less unique to a particular slave device.

Byte Count

The byte count portion of the message contains an integer value representing the number of bytes that form the remainder of this message excluding the checksum. In other words, the byte count determines the length of the data and status.

Status

Status is included only in reply messages from a slave. It consists of two bytes of bit-coded information. The first byte indicates communication errors, if any. Otherwise if communication was good, this byte may indicate the status of the received command such as a busy device, or a command not recognized. The second status byte indicates the operational state of the slave device. A properly operating slave device will have both status bytes set to logical zero. The meaning of the individual status bits can be found in Appendix D.

Data

This portion of the HART message contains the data, if any, for the command. Not all commands or responses contain data. For those that do, up to 25 bytes can be included. Data may be in the form of unsigned integers, floating point numbers, or ASCII character strings. The number of bytes of data and the data format used for each item are specified for each HART command.

Checksum

The checksum byte contains the exclusive-or (longitudinal parity) of all the bytes that precede it in the message starting with the Start Character. This provides a further check on transmission integrity, beyond the parity check on the 8 bits of each individual byte.

7.5.2 Sending a HART Command to a Field Device via Pass-through

Now that you're familiar with the bits and pieces that make up a HART message, the next step will be to formulate a message and successfully send the message to the field device using the pass-through command. The first step is to formulate the message and populate the source tag Of4ih0PassThruReqTX. This tag is used in the ladder sample shown in Figure 7-11.

Table 7-20

Tag Name	Value in Hex	Description
HART_PASS_THRU_REQ_TX[0]	00	HART channel
HART_PASS_THRU_REQ_TX[1]	01	Pass-through command designator
HART_PASS_THRU_REQ_TX[2]	82	Start charcter
HART_PASS_THRU_REQ_TX[3]	BE	Long address byte 0
HART_PASS_THRU_REQ_TX[4]	02	Long address byte 1
HART_PASS_THRU_REQ_TX[5]	0C	Long address byte 2
HART_PASS_THRU_REQ_TX[6]	77	Long address byte 3
HART_PASS_THRU_REQ_TX[7]	37	Long address byte 4
HART_PASS_THRU_REQ_TX[8]	23	HART command = 35 decimal
HART_PASS_THRU_REQ_TX[9]	09	Byte count
HART_PASS_THRU_REQ_TX[10]	20	Range units code = 32 decimal
HART_PASS_THRU_REQ_TX[11]	44	Upper Range value (This is a floating point value = 600.0) Note: The bytes are in reverse order.
HART_PASS_THRU_REQ_TX[12]	16	
HART_PASS_THRU_REQ_TX[13]	00	
HART_PASS_THRU_REQ_TX[14]	00	
HART_PASS_THRU_REQ_TX[15]	C3	Lower Range value (This is a floating point value = -150.0) Note: The bytes are in reverse order.
HART_PASS_THRU_REQ_TX[16]	16	
HART_PASS_THRU_REQ_TX[17]	00	
HART_PASS_THRU_REQ_TX[18]	00	
HART_PASS_THRU_REQ_TX[19]	FF	Checksum

The HART message string, shown in Table 7-20, performs HART command 35 (write range values). Once the tags are populated with the HART message, the message can be sent using the ladder in Figure 7-9. The reply for the HART command will be found in the Of4ih0PassThruQryRX tag. The response message should look like the table shown below.

Table 7-21

Tag Name	Value in Hex	Description
HART_PASS_THRU_QRY_RX[0]	00	HART channel
HART_PASS_THRU_QRY_RX[1]	00	Command Status
HART_PASS_THRU_QRY_RX[2]	15	Length of handle + HART response data (Byte 1)
HART_PASS_THRU_QRY_RX[3]	0	Length of handle + HART response data (Byte 2)
HART_PASS_THRU_QRY_RX[4]	02	Message handle
HART_PASS_THRU_QRY_RX[5]	86	Start character
HART_PASS_THRU_QRY_RX[6]	BE	Long address byte 0
HART_PASS_THRU_QRY_RX[7]	02	Long address byte 1
HART_PASS_THRU_QRY_RX[8]	0C	Long address byte 2
HART_PASS_THRU_QRY_RX[9]	77	Long address byte 3
HART_PASS_THRU_QRY_RX[10]	37	Long address byte 4
HART_PASS_THRU_QRY_RX[11]	23	HART command = 35 decimal
HART_PASS_THRU_QRY_RX[12]	0B	Byte count = 11 decimal
HART_PASS_THRU_QRY_RX[13]	00	Status Byte 0
HART_PASS_THRU_QRY_RX[14]	00	Status Byte 1
HART_PASS_THRU_QRY_RX[15]	20	Range units code = 32 decimal
HART_PASS_THRU_QRY_RX[16]	44	
HART_PASS_THRU_QRY_RX[17]	16	Upper Range value (This is a floating point value = 600) Note: The bytes are in reverse order.
HART_PASS_THRU_QRY_RX[18]	00	
HART_PASS_THRU_QRY_RX[19]	00	
HART_PASS_THRU_QRY_RX[20]	C3	
HART_PASS_THRU_QRY_RX[21]	16	Lower Range value (This is a floating point value = -150) Note: The bytes are in reverse order.
HART_PASS_THRU_QRY_RX[22]	00	
HART_PASS_THRU_QRY_RX[23]	00	
HART_PASS_THRU_QRY_RX[24]	F9	Checksum

Chapter 8

Programming Examples

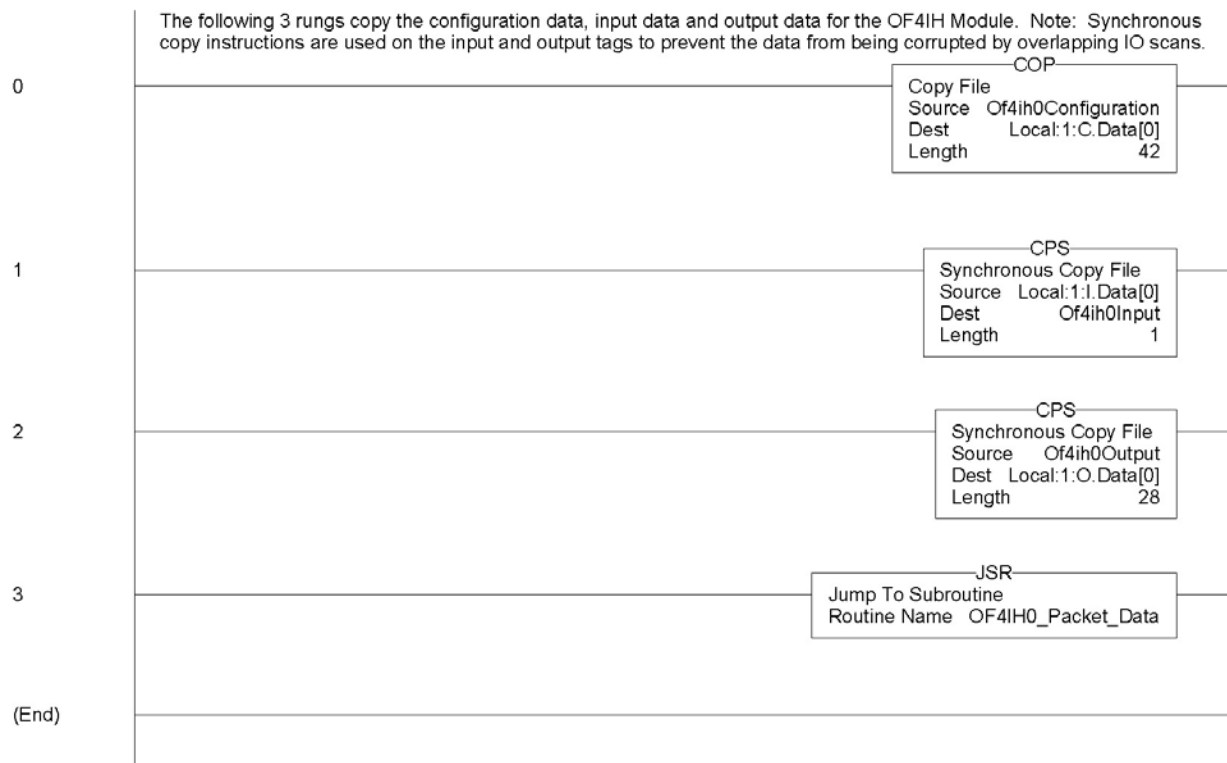
This chapter provides ladder samples for general and advanced applications using the 1756sc-OF4IH module. Ladder samples for both the CompactLogix and MicroLogix 1500 PLC are discussed in this chapter.

Section 8.1 CompactLogix

8.1.1 Initializing the OF4IH Module

The following rungs demonstrate how to initialize the module using copy instructions to copy data from user defined tags to the module local tags. Refer to Chapter 4 for more details.

Figure 8-1 (Initialization)



Note: The ladder in Figure 8-1 can be found in the sample project which can be downloaded from our website at (www.spectrumcontrols.com).

8.1.2 Reset/Reconfig

The following rungs of ladder demonstrate how to either reset the module (Backplane connection will be broken) or reconfigure the module without breaking the connection.

Figure 8-2 (Reset)

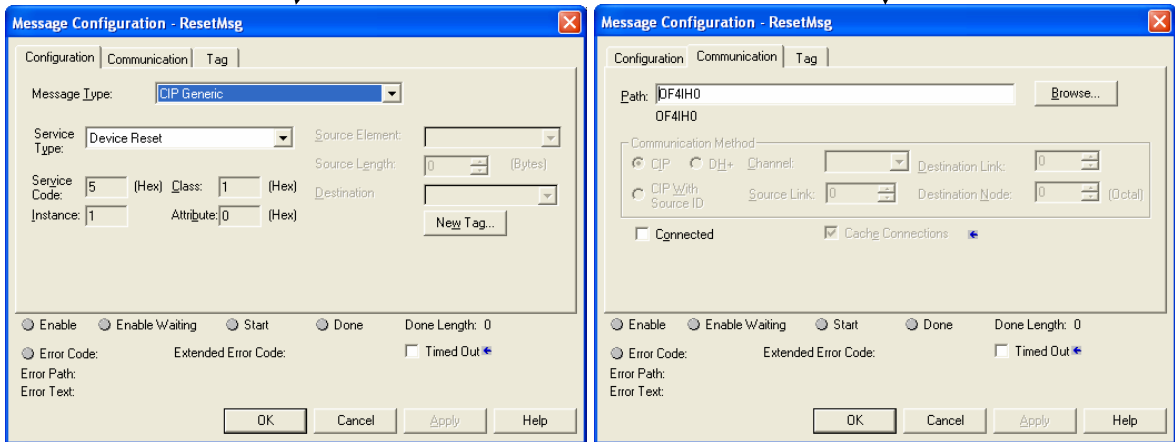
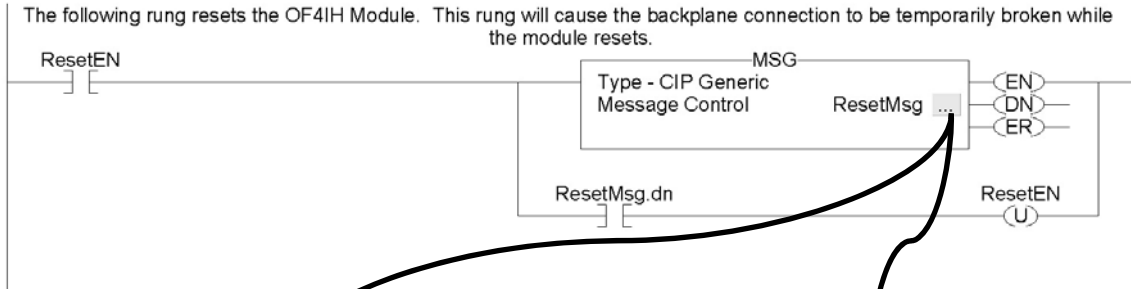
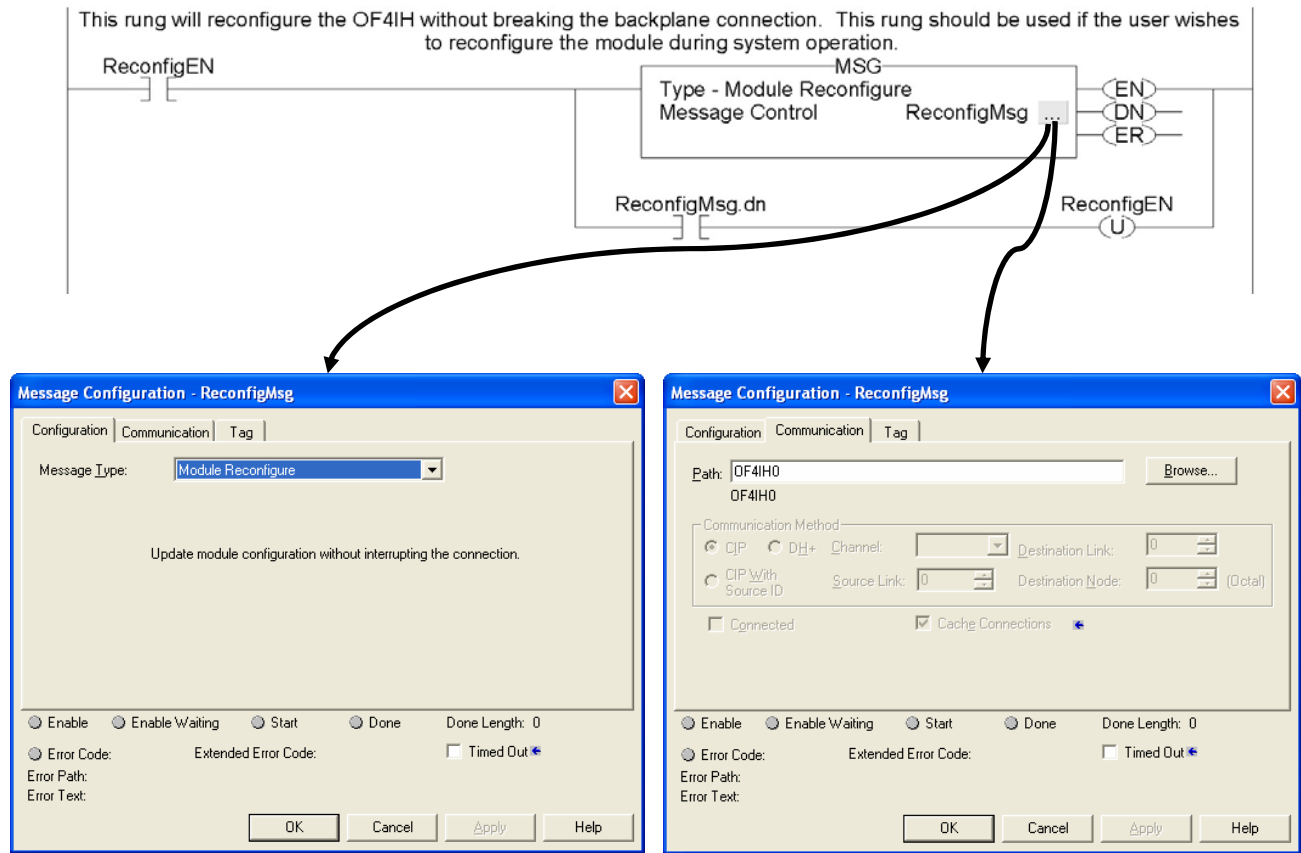


Figure 8-3 (Reconfig)



8.1.3 Demultiplexing the HART Data

The following ladder demonstrates how to demultiplex the data from the input tag OF4IH0Input.HartData.

Figure 8-4a (Demultiplexing)

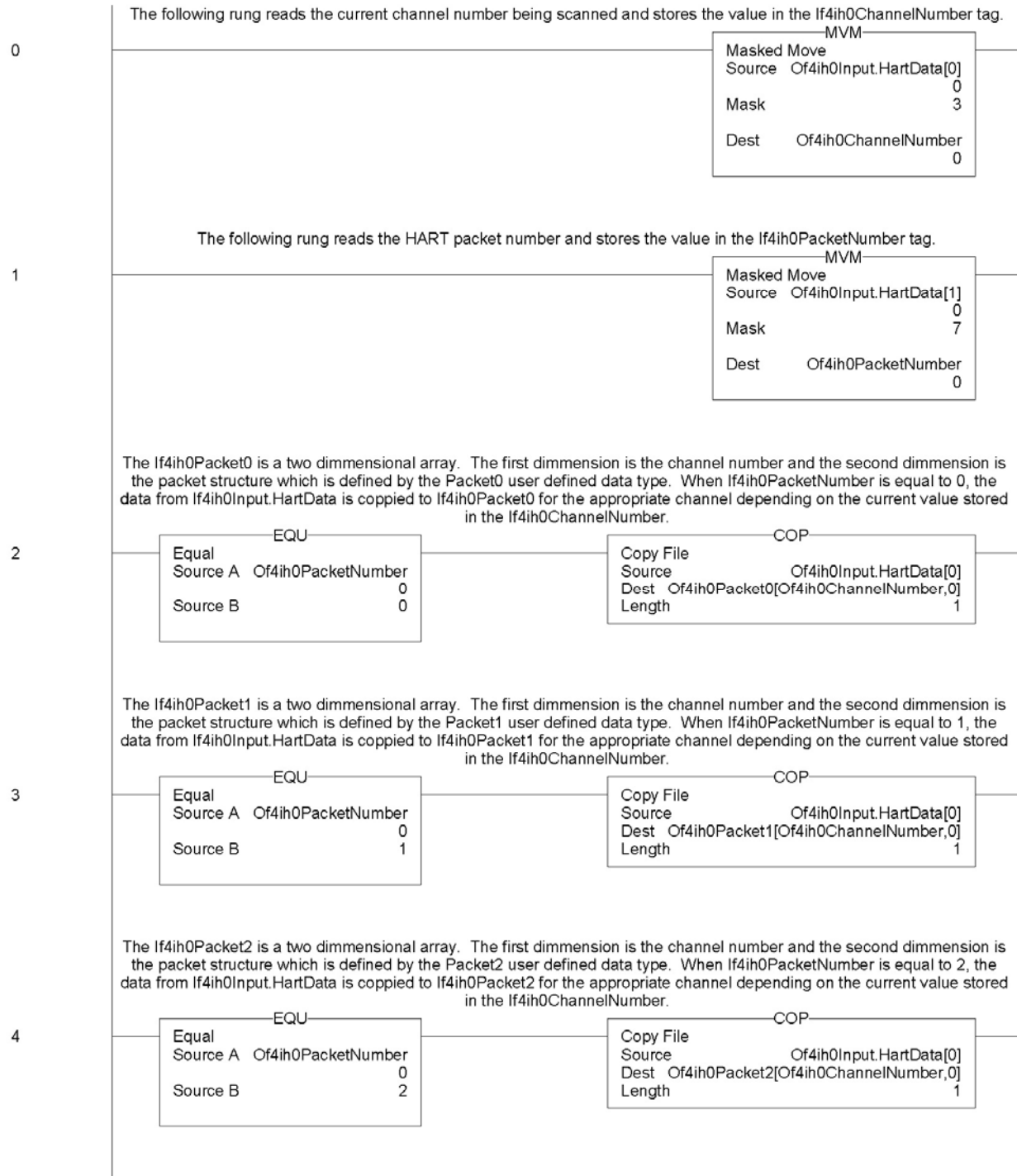
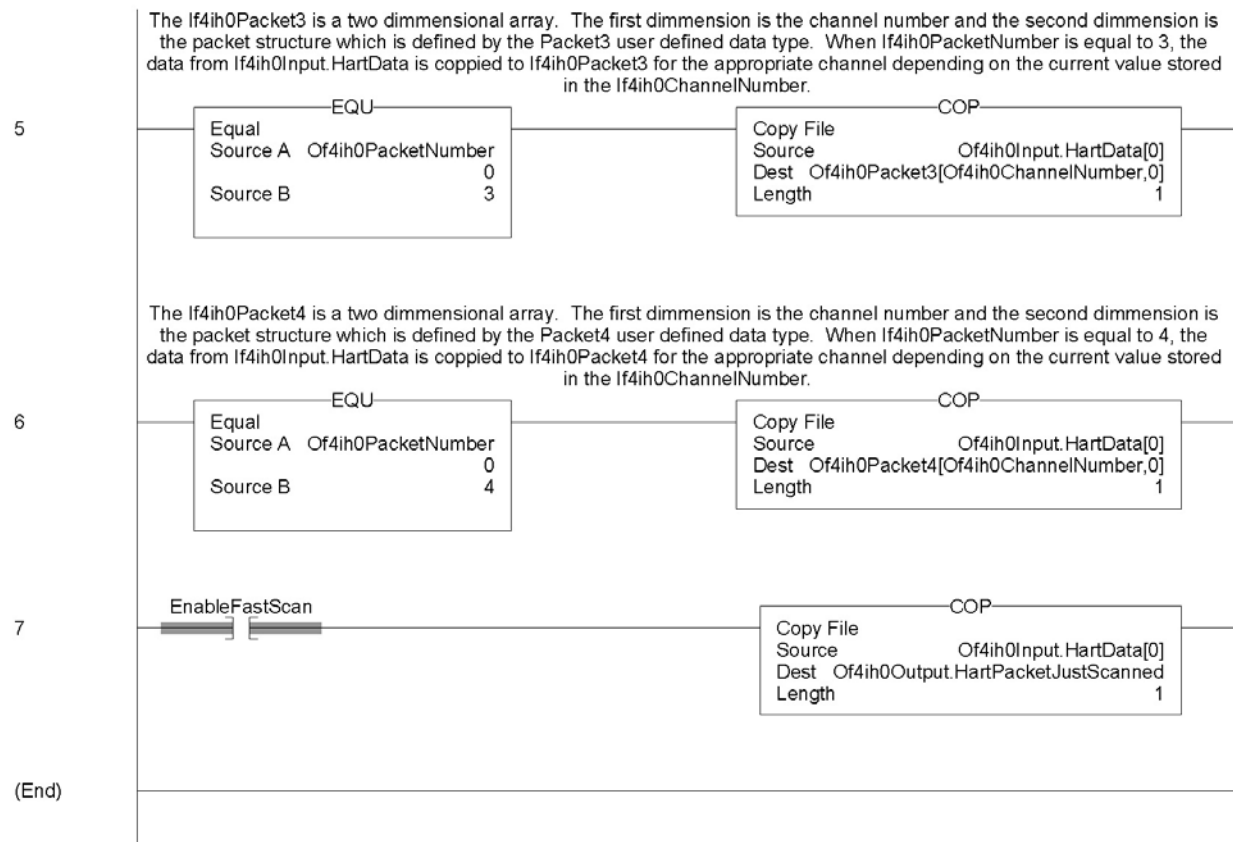


Figure 8-3b



Note: The ladder in Figure 8-3 can be found in the sample project which can be downloaded from our website at (www.spectrumcontrols.com).

8.1.4 Sending a Message To the Module

The following ladder is used to send a message to the module (i.e. Module command such as HART Pass-Through). For more information refer to Chapter 7.

Figure 8-5a (Messaging)

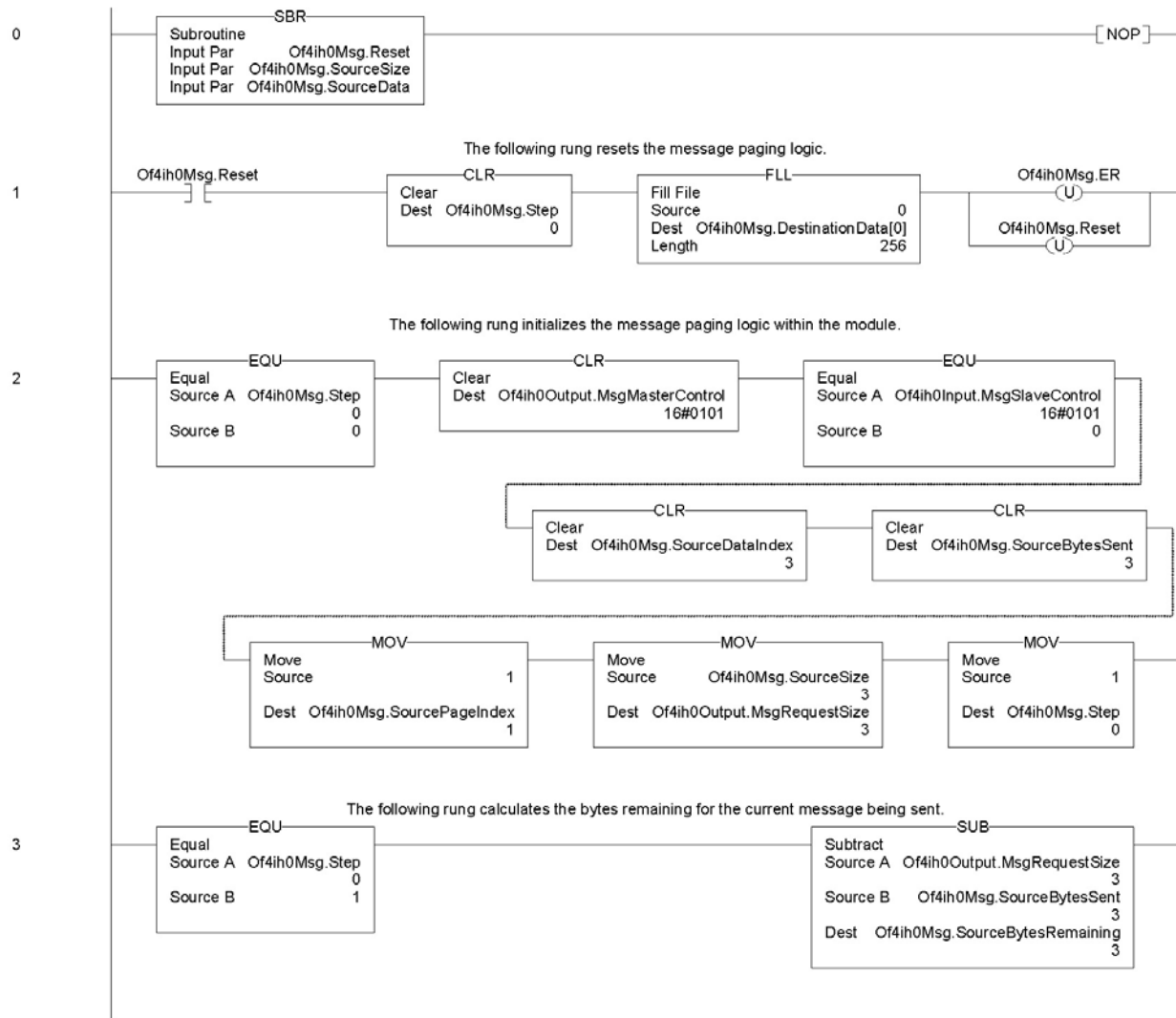


Figure 8-4b

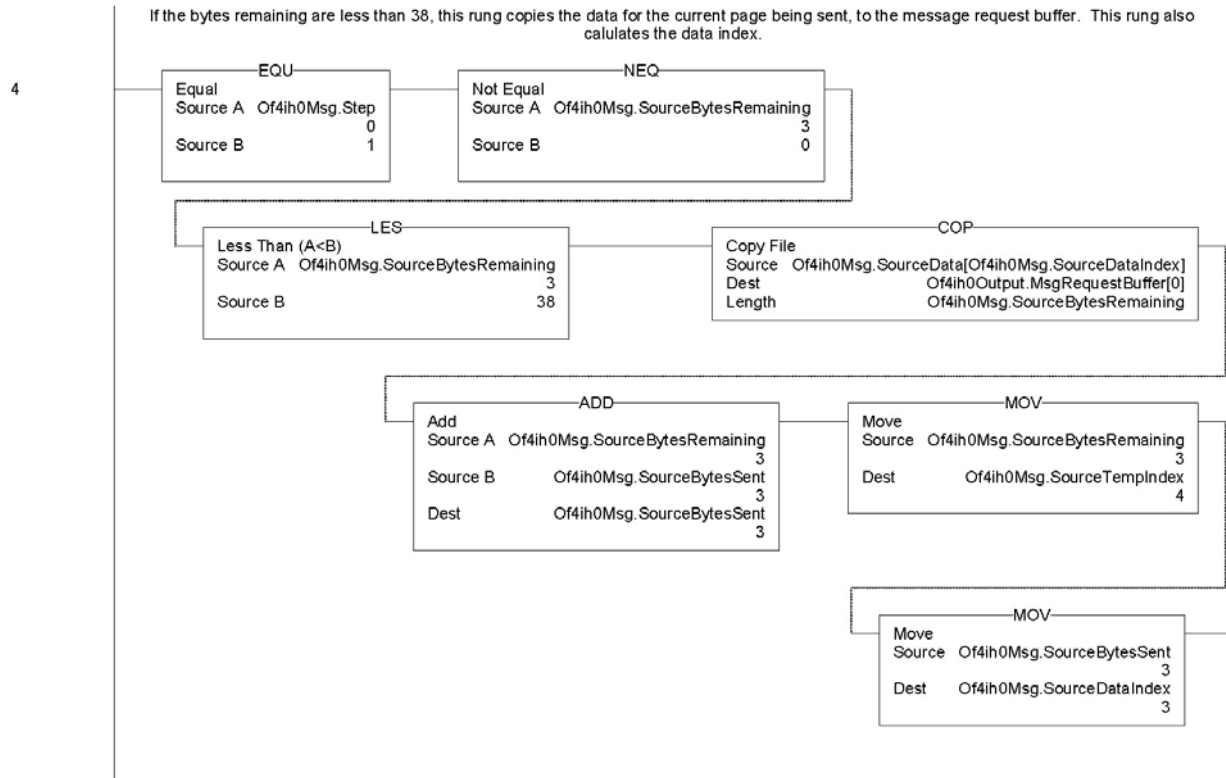


Figure 8-4c

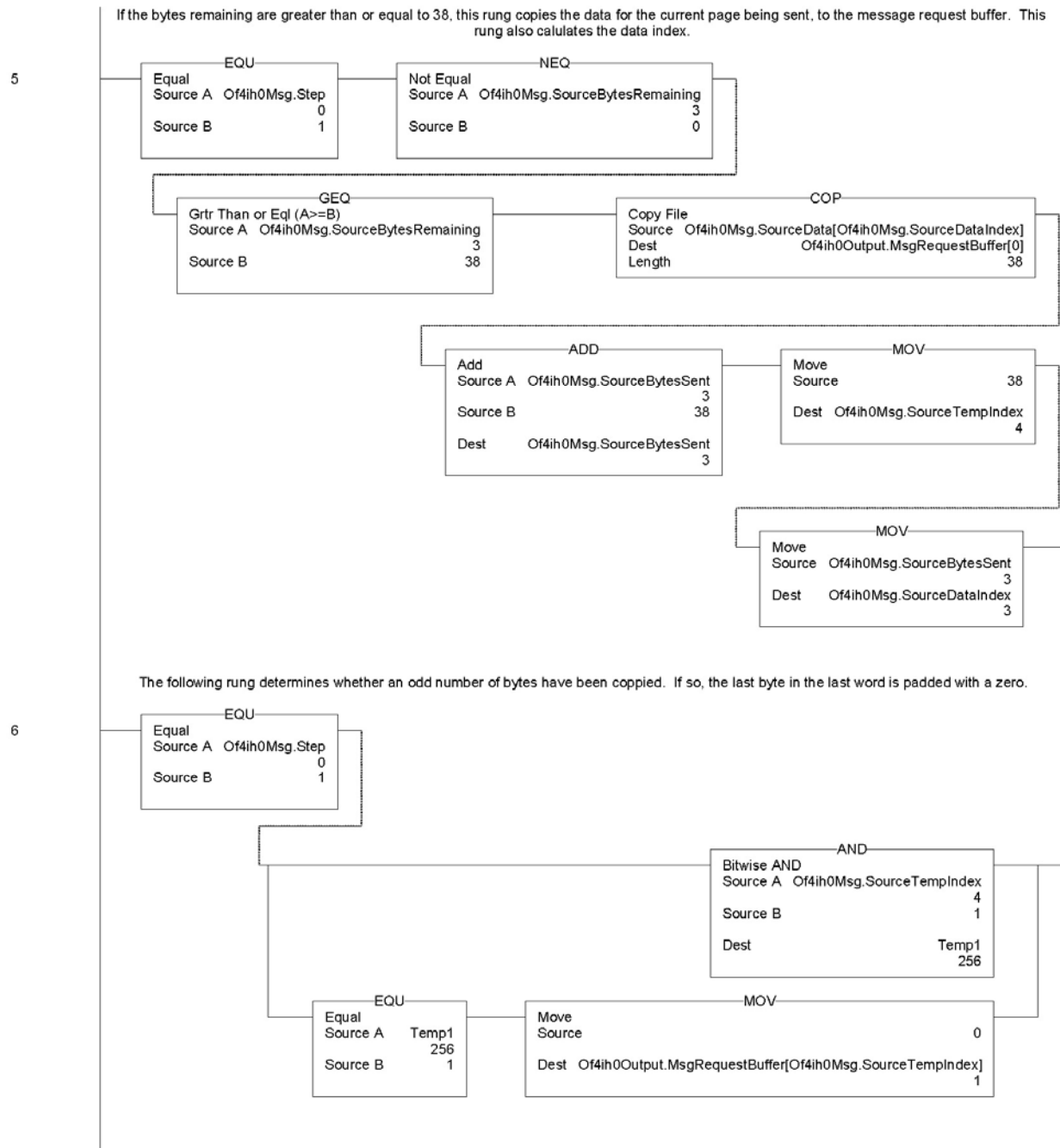


Figure 8-4d

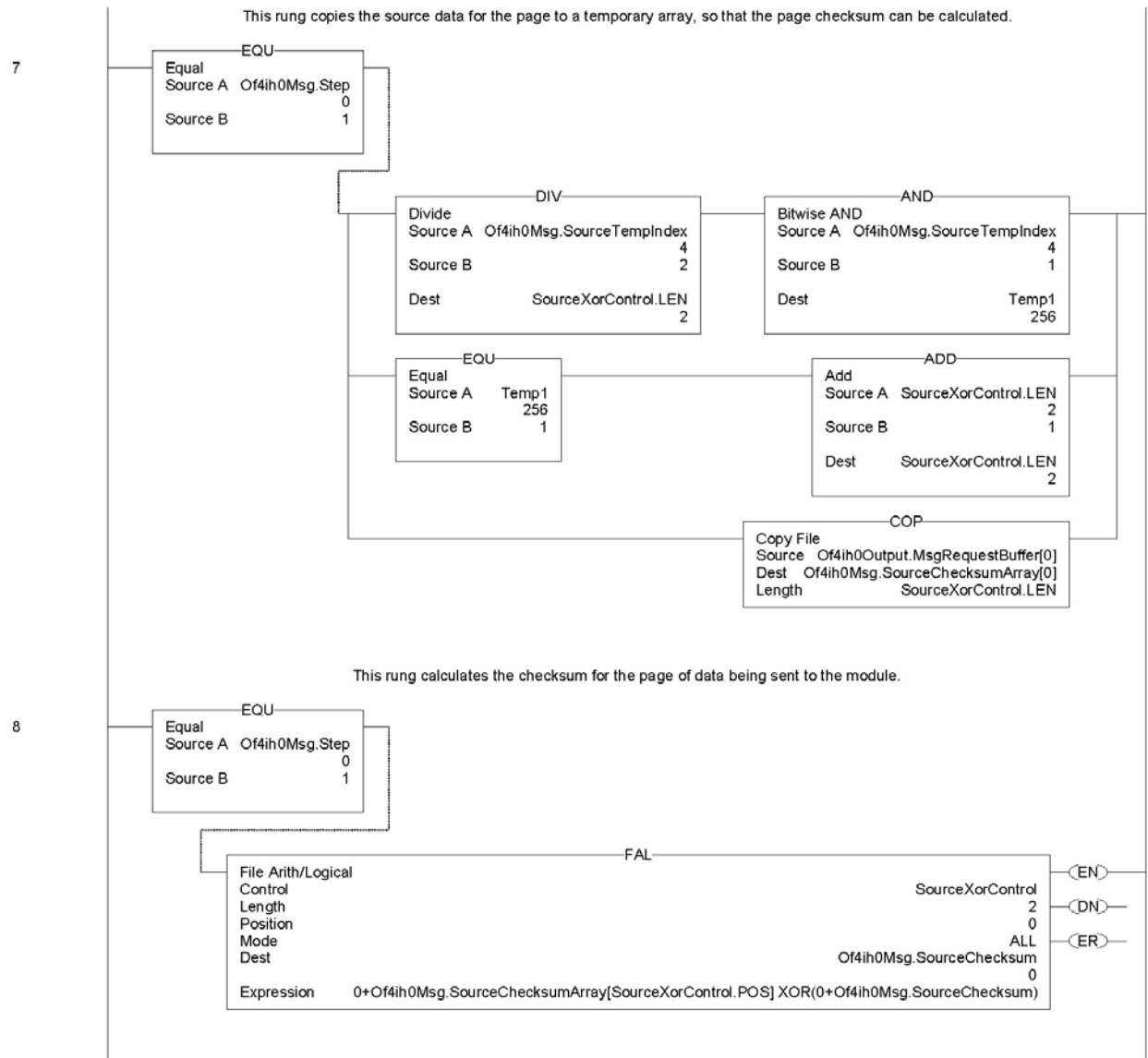


Figure 8-4e

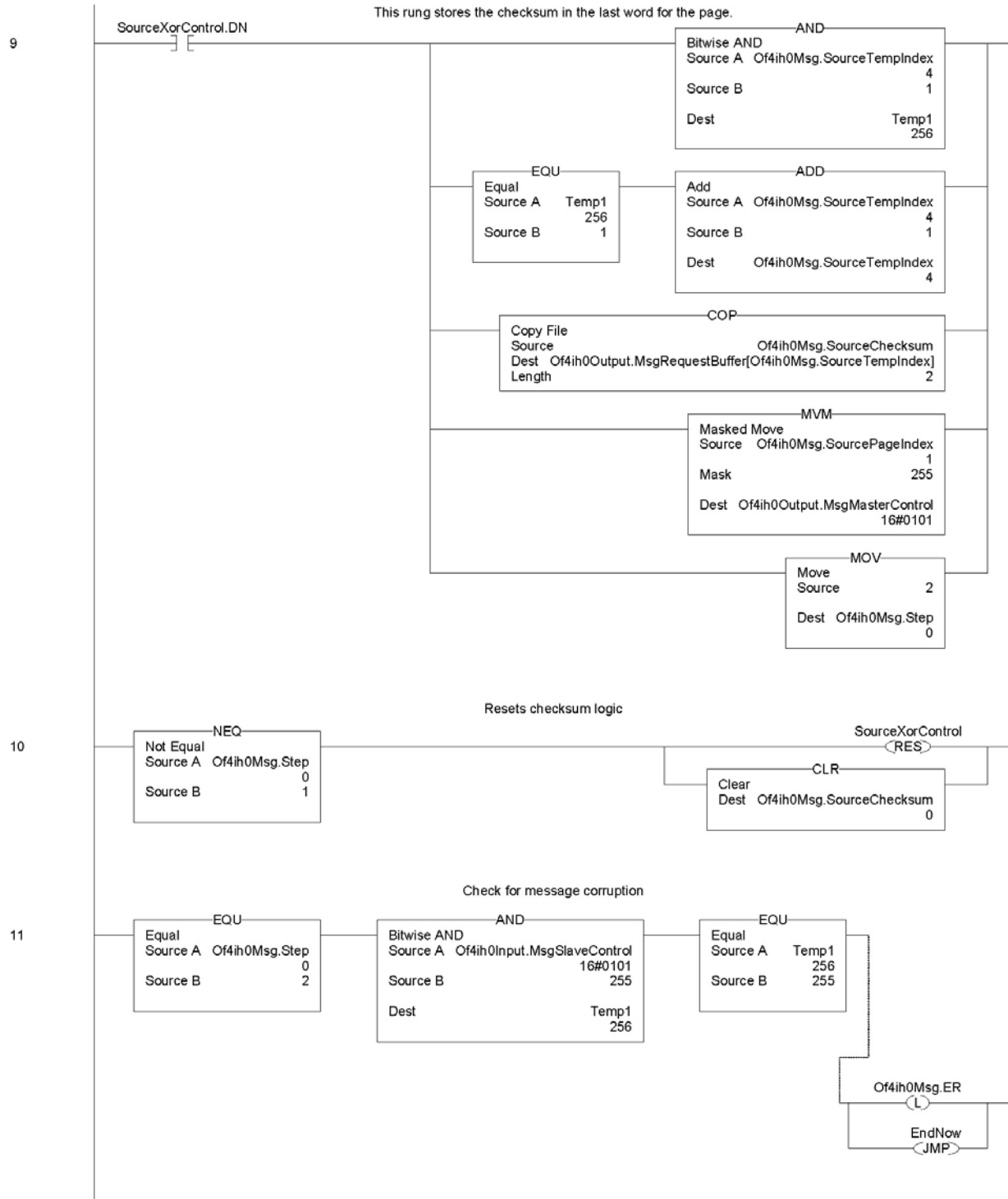


Figure 8-4f

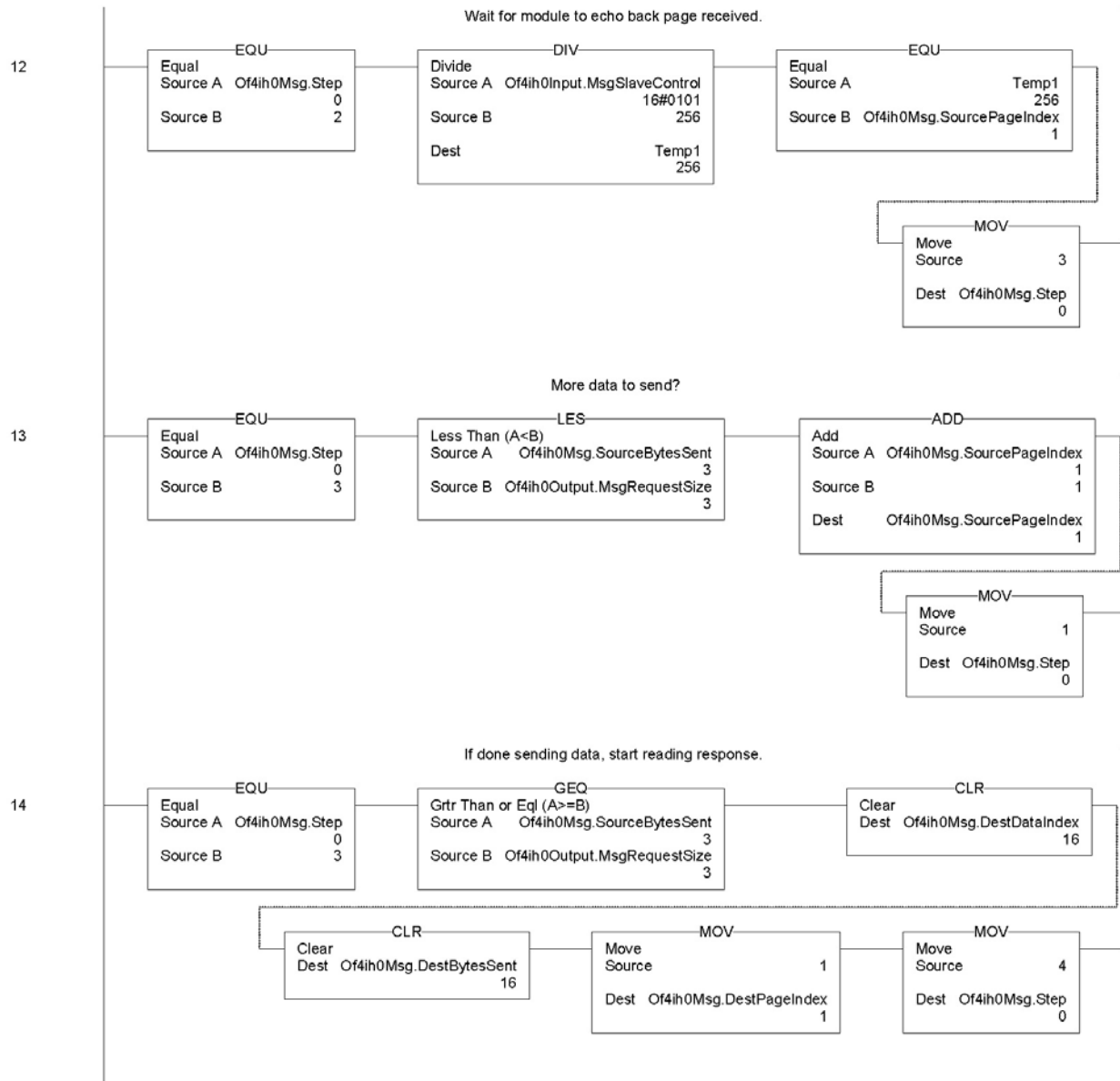


Figure 8-4g

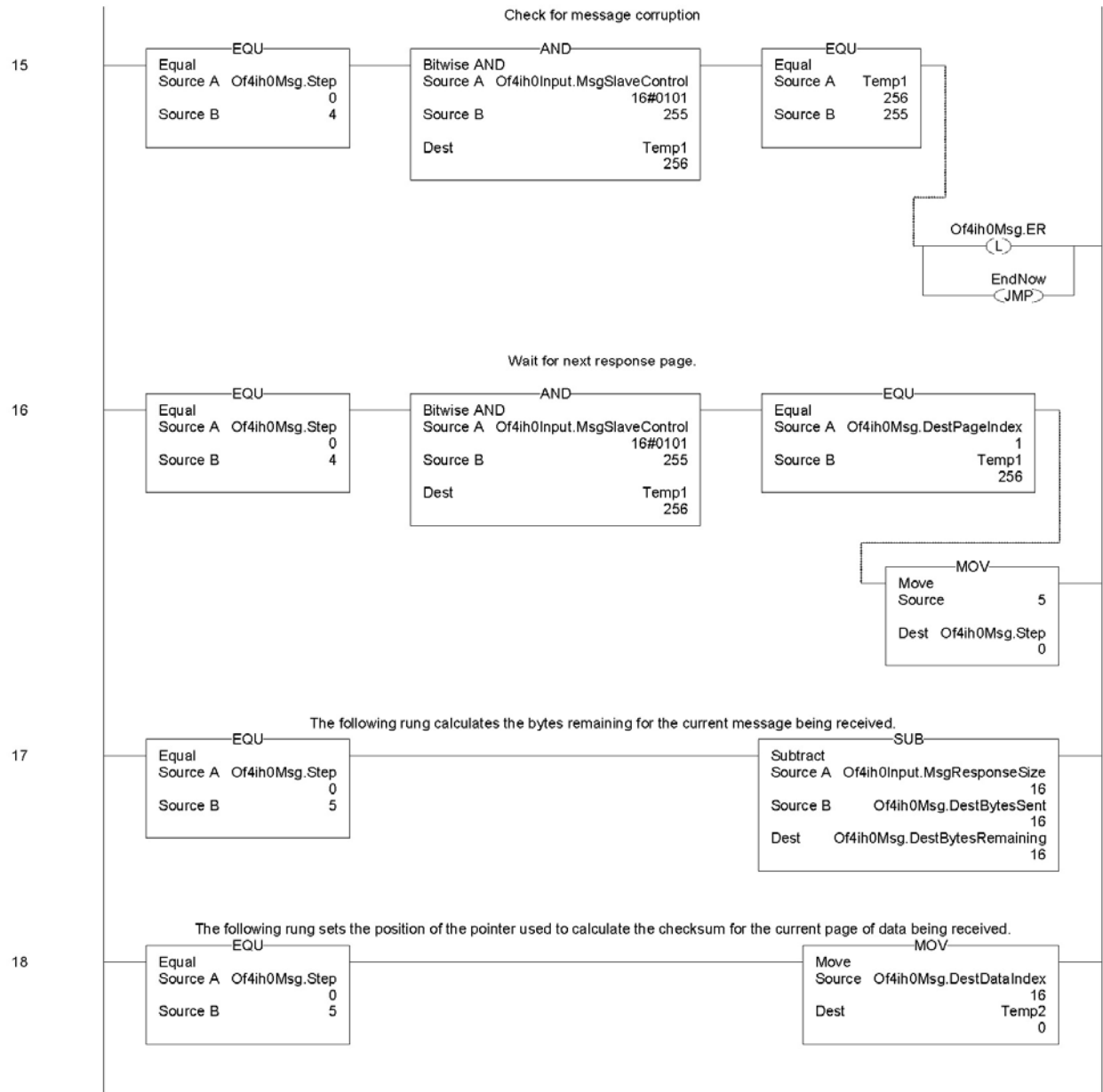


Figure 8-4h

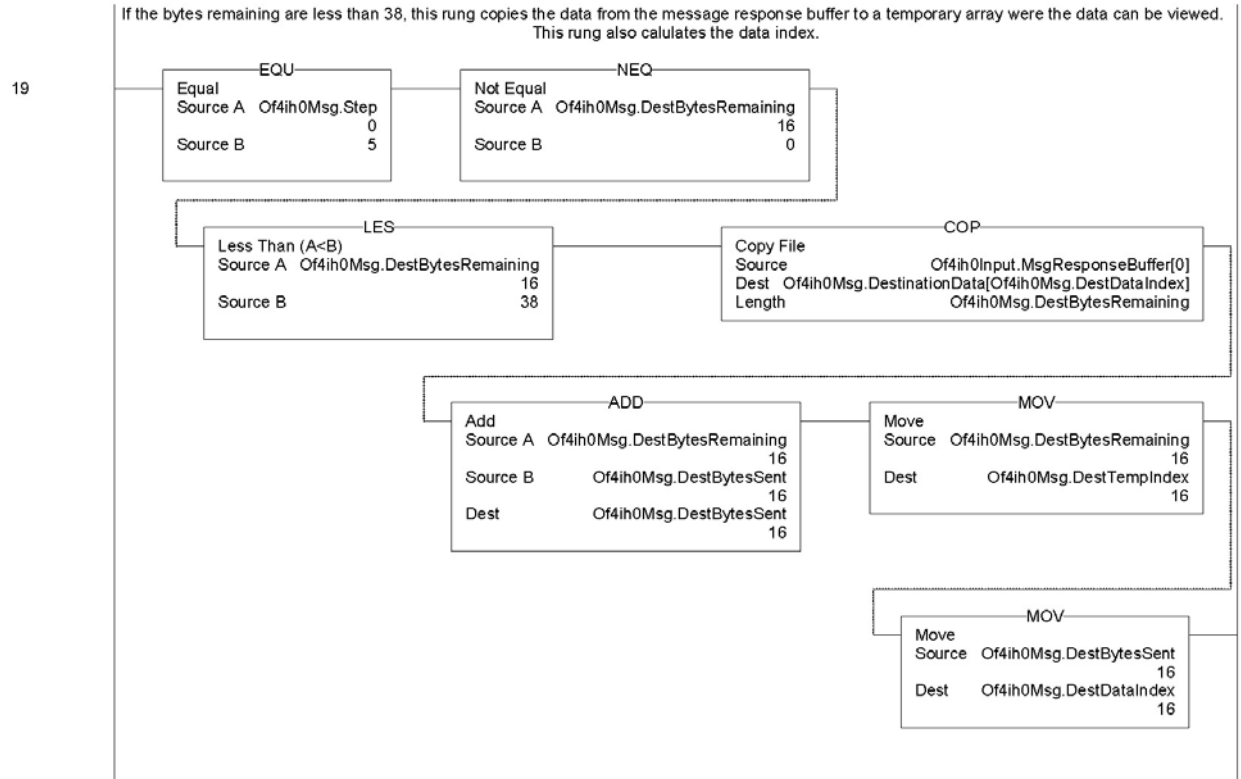


Figure 8-4i

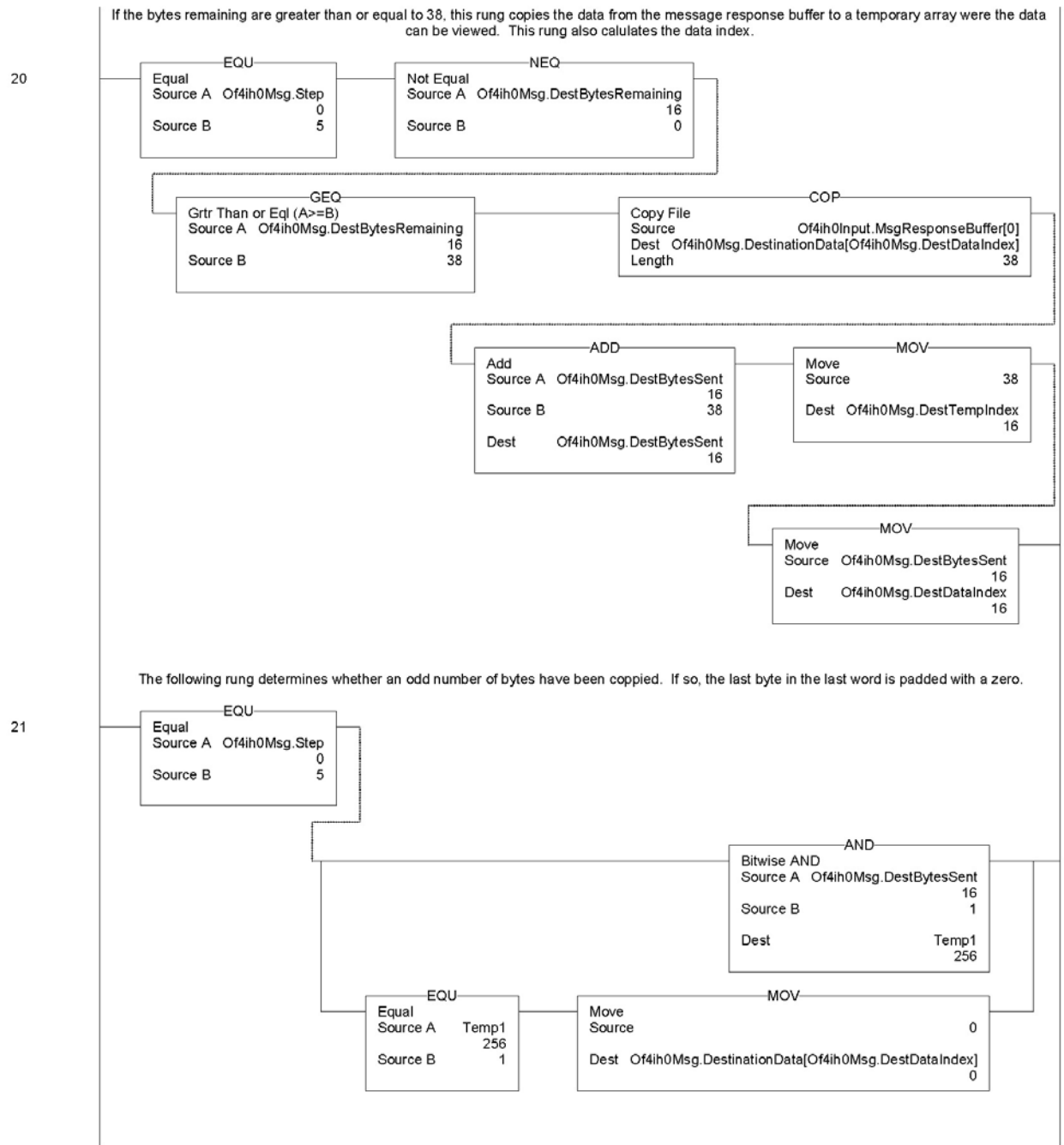


Figure 8-4j

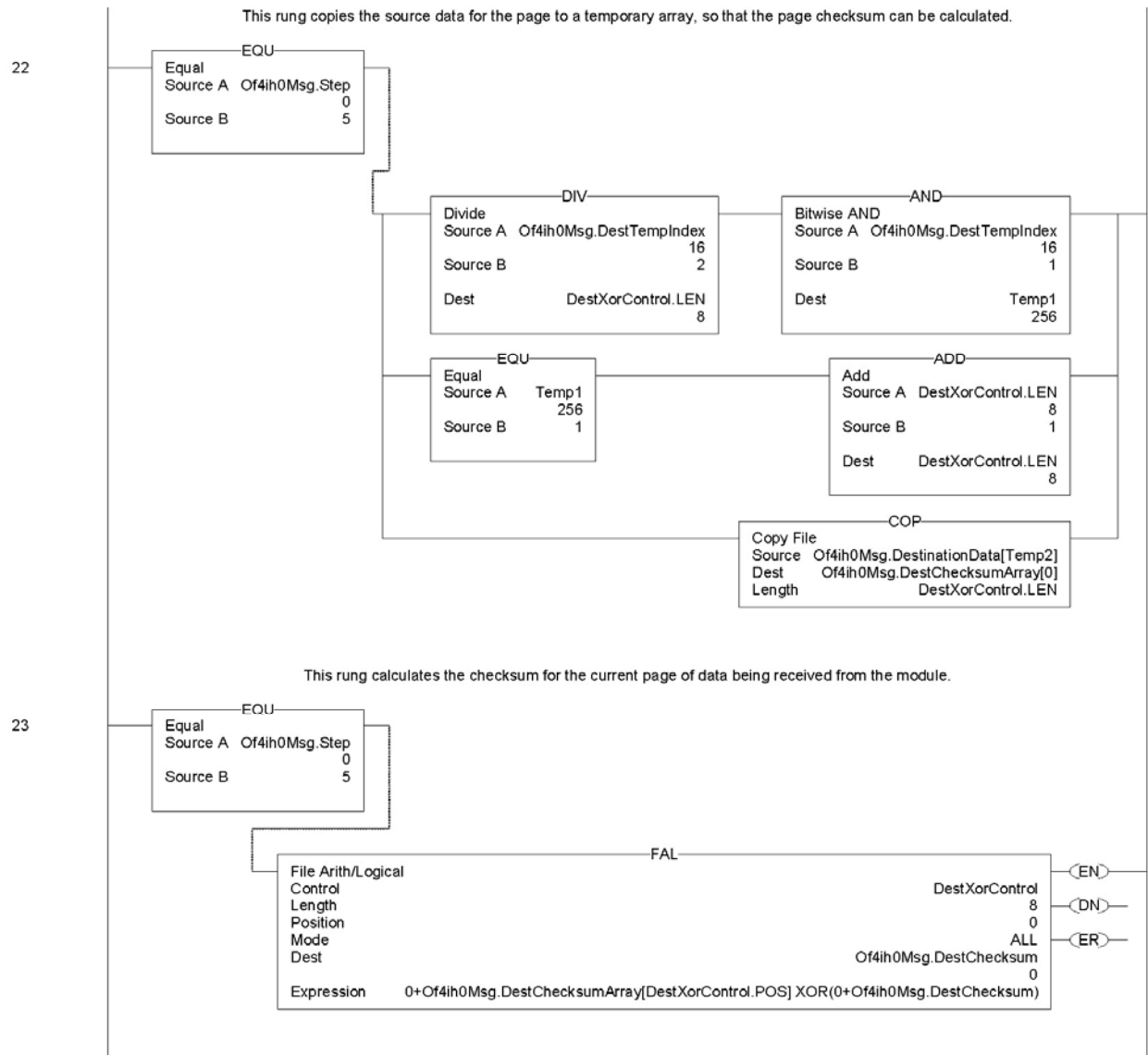


Figure 8-4k

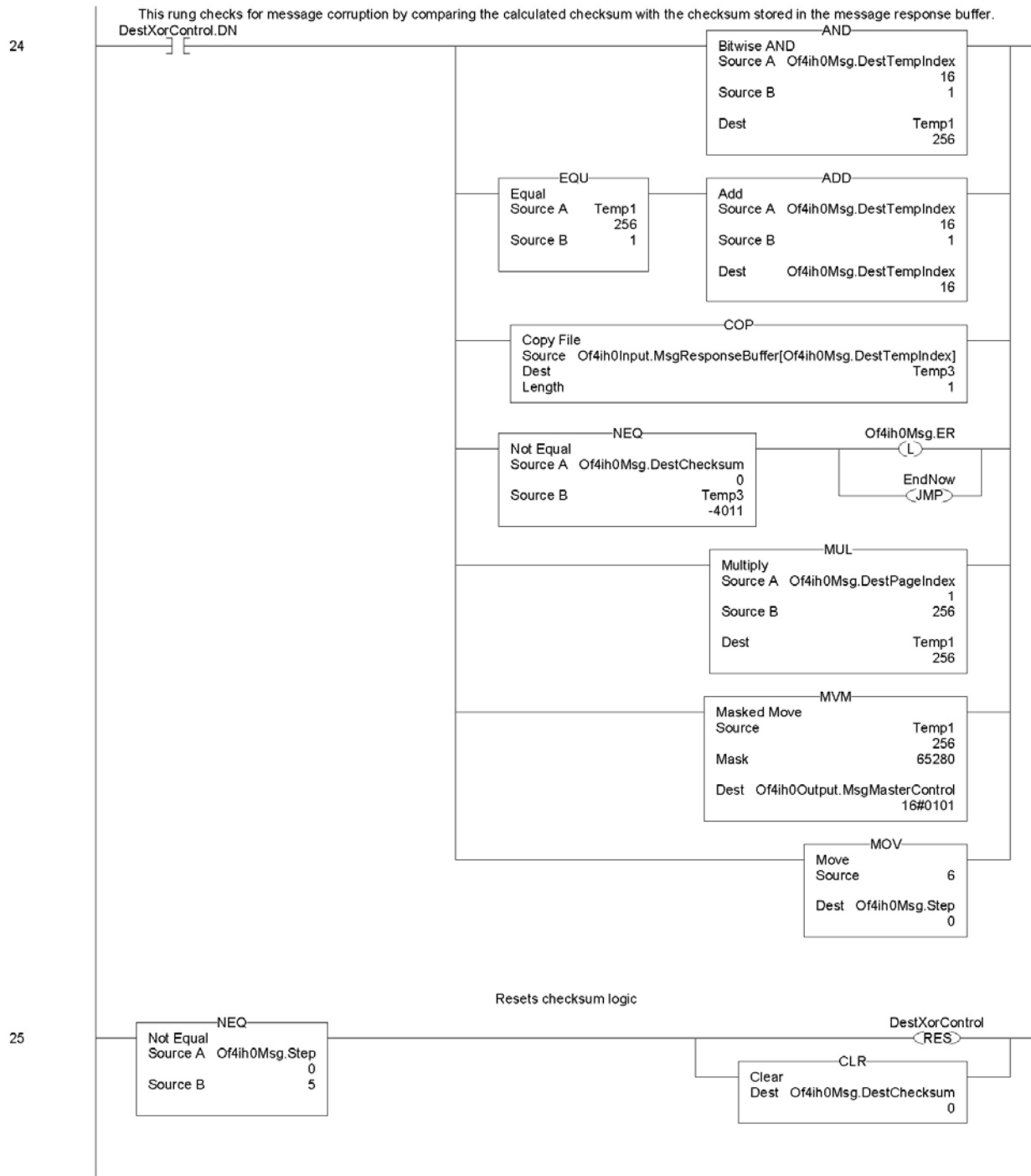
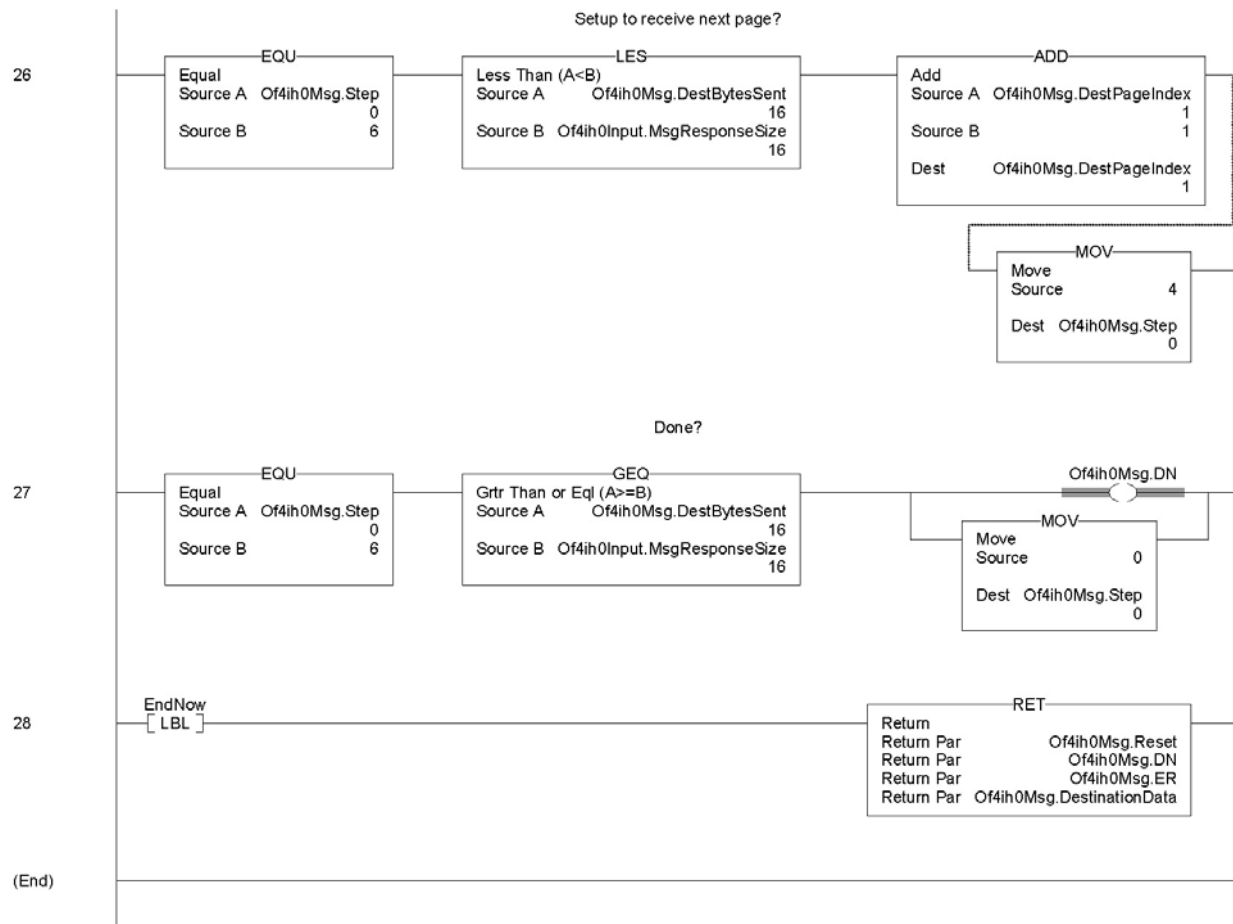


Figure 8-4I



Note: The ladder in Figure 8-4 can be found in the sample project which can be downloaded from our website at (www.spectrumcontrols.com).

8.1.5 HART Pass-Through

The following ladder is used to send HART messages to a connected field device by using the module pass-through command. For more information refer to Chapter 7.

Figure 8-6a (Pass-Through HART Message)

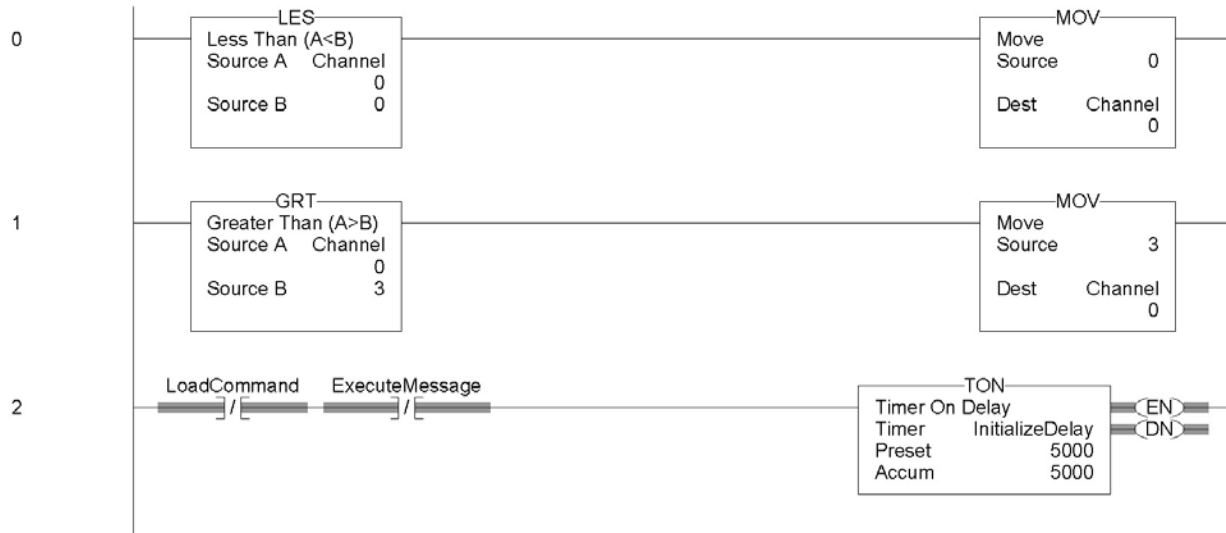


Figure 8-5b

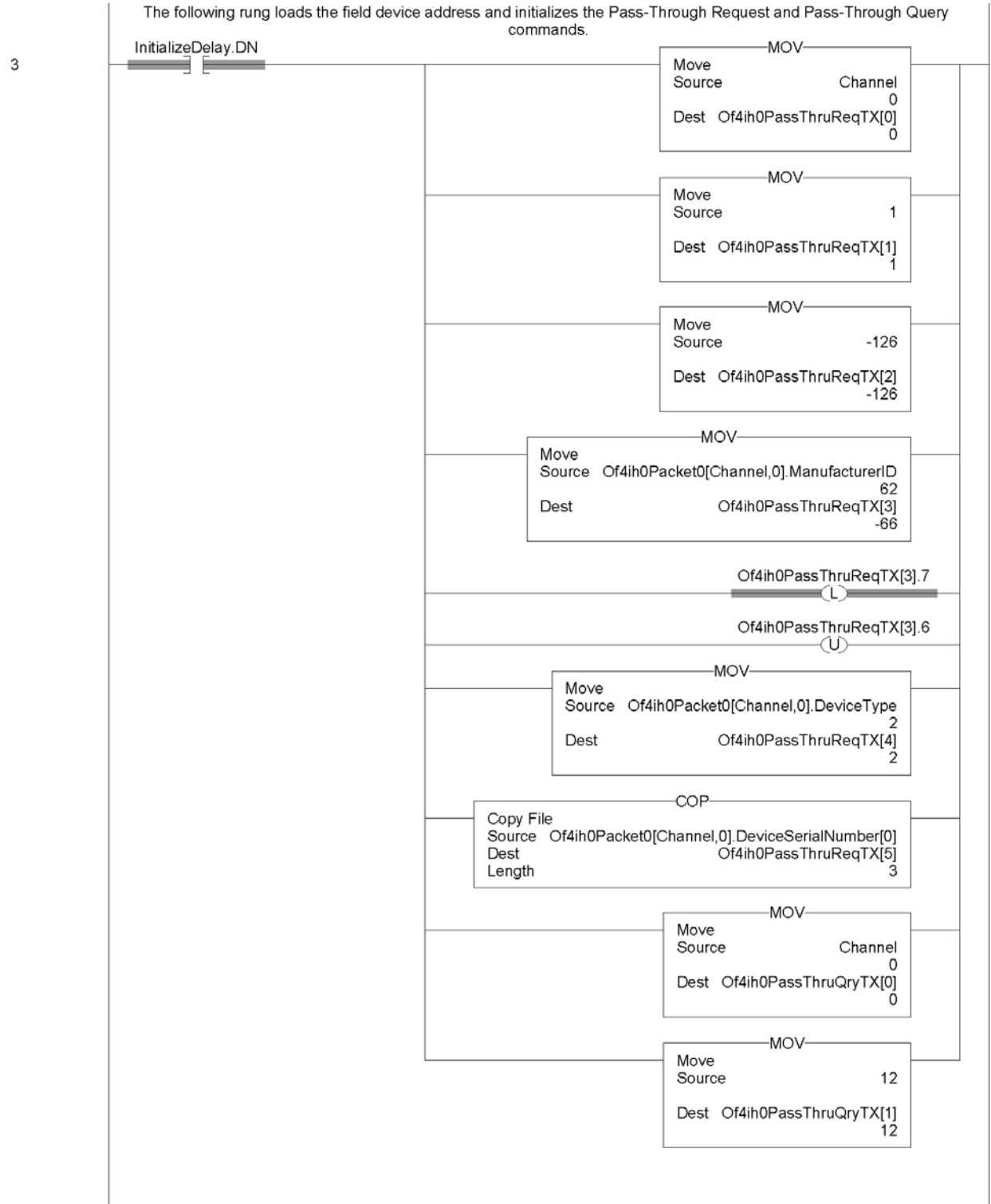


Figure 8-5c

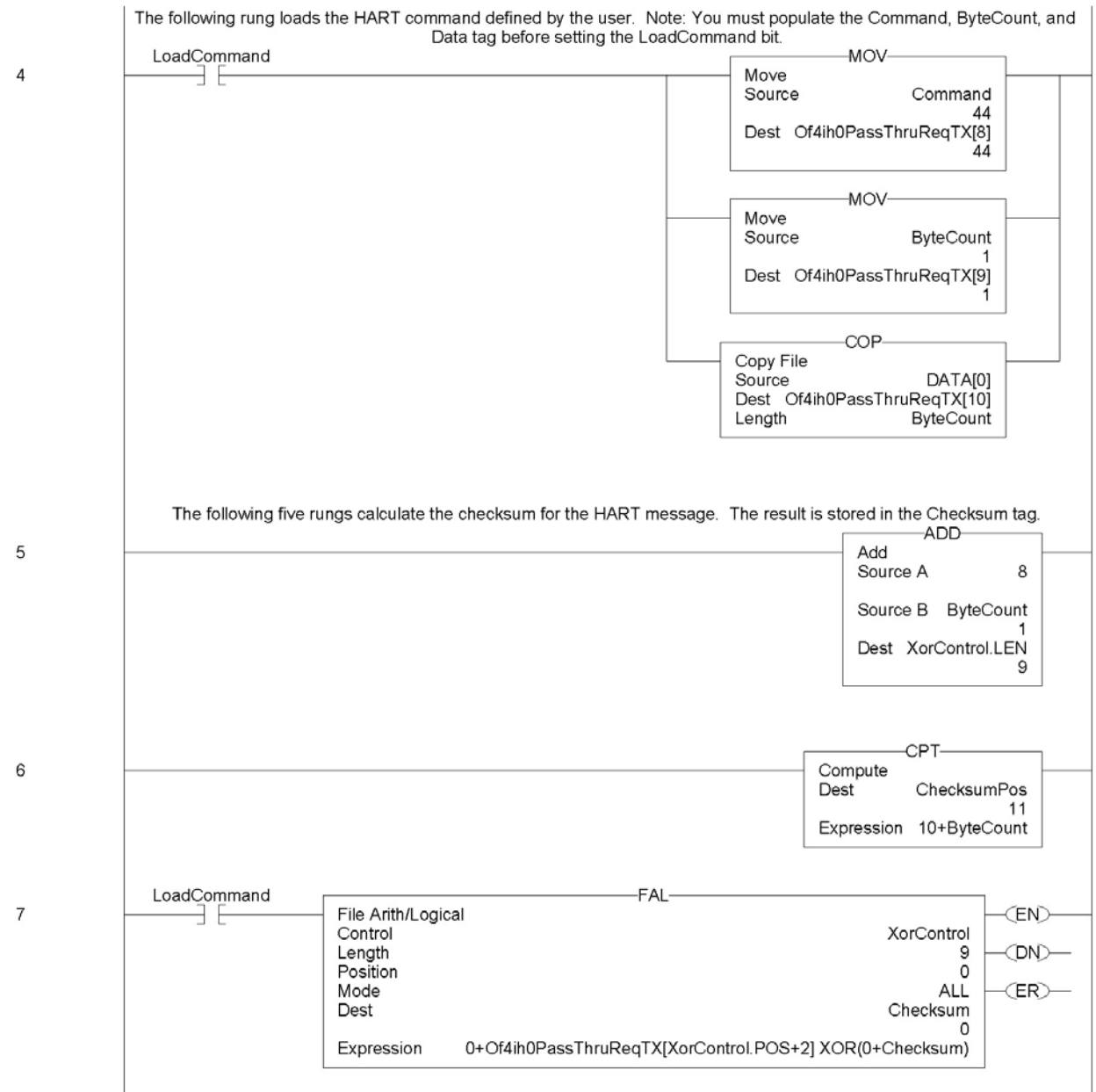


Figure 8-5d

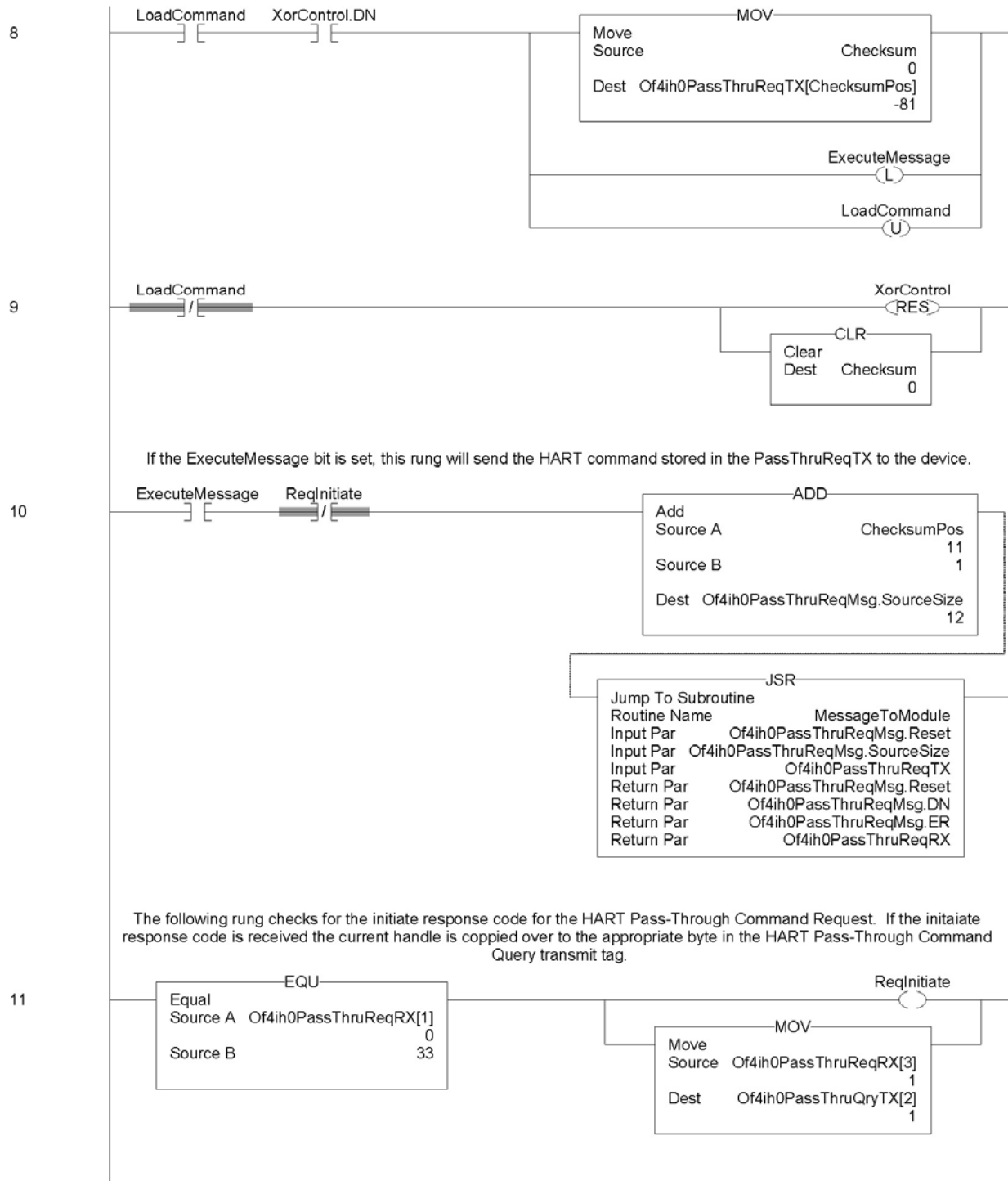


Figure 8-5e

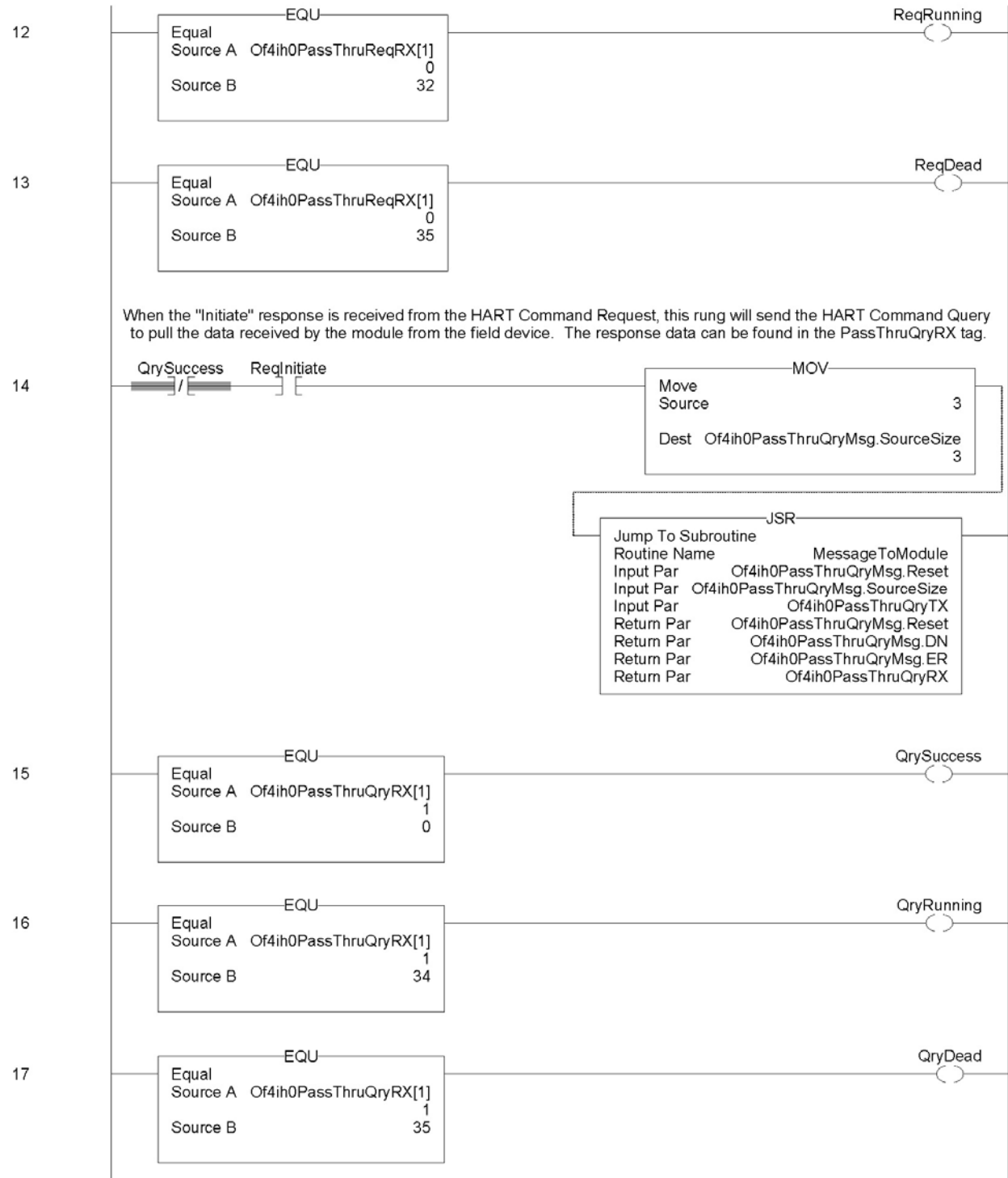
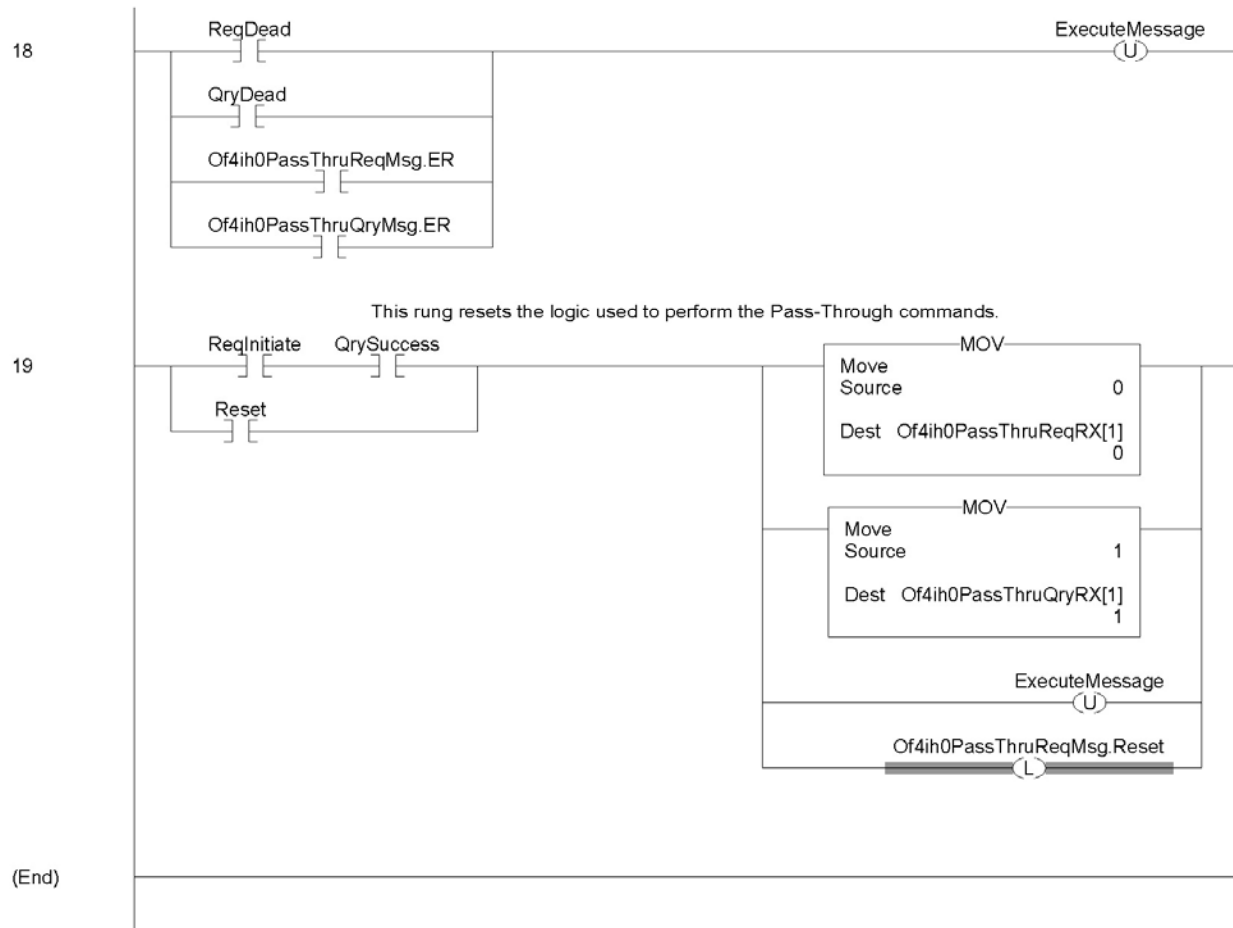


Figure 8-5f



8.1.6 Swap Byte Order

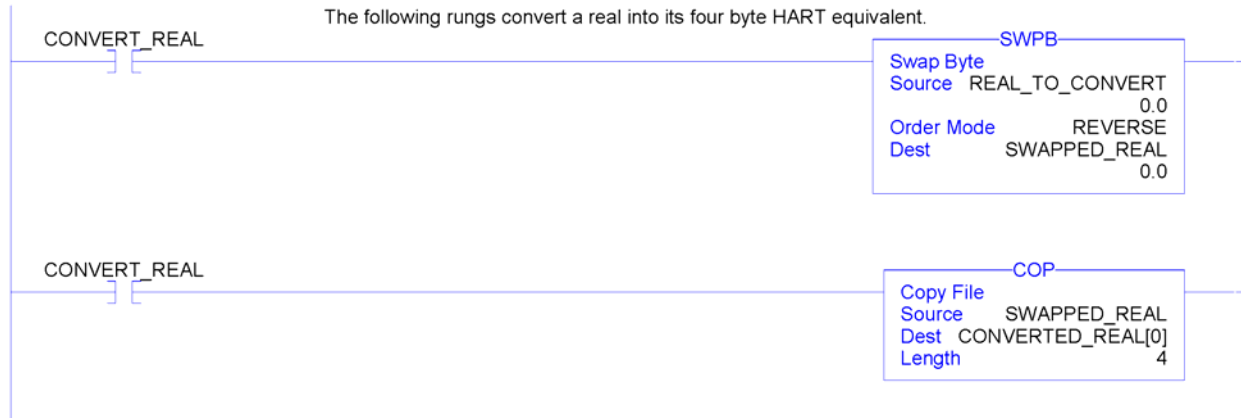
This ladder sample demonstrates how to reverse the order of the bytes for a floating point tag and then convert it to 4 consecutive SINT tags, so that it can be used in a HART message.



Attention

If the HART message being sent or received using the pass-through command contains floating point values, the order of the bytes must be reversed.

Figure 8-7 (Change Byte Order)



8.1.7 Converting Unpacked ASCII to Packed ASCII

Packed ASCII is a HART-specific 6-bit character code representing a subset of the ASCII character code set (see table below). Produced by compressing four packed ASCII characters into three 8-bit bytes, packed ASCII strings must be a multiple of 4 characters (3 bytes) and must be padded out to the end of the data item with space characters. For example, 4 space characters at the end of a string would appear as the 3 bytes: 0x82, 0x08 and 0x20.

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	P	Q	R	S	T	U	V	W	X	Y	Z	[\]	^	_
2	SP	!	"	#	\$	%	&	'	()	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?

Note: Most significant hexadecimal digit top to bottom; least significant left to right.

Construction of Packed ASCII characters:

Constructing a packed ASCII string is a simple matter of discarding the most significant two bits from each character and compressing the result:

1. Truncate Bits 6 and 7 of each ASCII character.
2. Pack four, 6 bit-ASCII characters into three bytes.
3. Repeat until the entire string is processed.

The algorithm can be implemented in ladder by masking and shifting four 6-bit characters into a double word register then moving the three bytes into the packed ASCII string.

Reconstruction of ASCII characters:

Unpacking packed ASCII strings requires flipping some bits in addition to uncompressing the string itself. To unpack a packed ASCII string:

1. Unpack the four, 6-bit ASCII characters.
2. For each character, place the complement of bit 5 into bit 6.
3. For each character, reset bit Bit 7 to zero.
4. Repeat until the entire string is processed.

This algorithm can be implemented by loading three bytes into a 24-bit register and shifting the four 6-bit characters into the string. Parse the resulting character to flip bit 6 as needed.

The ladder sample starting on the next page demonstrates how to pack 4 unpacked ASCII characters into 3 bytes.

Figure 8-8a (Packed ASCII)

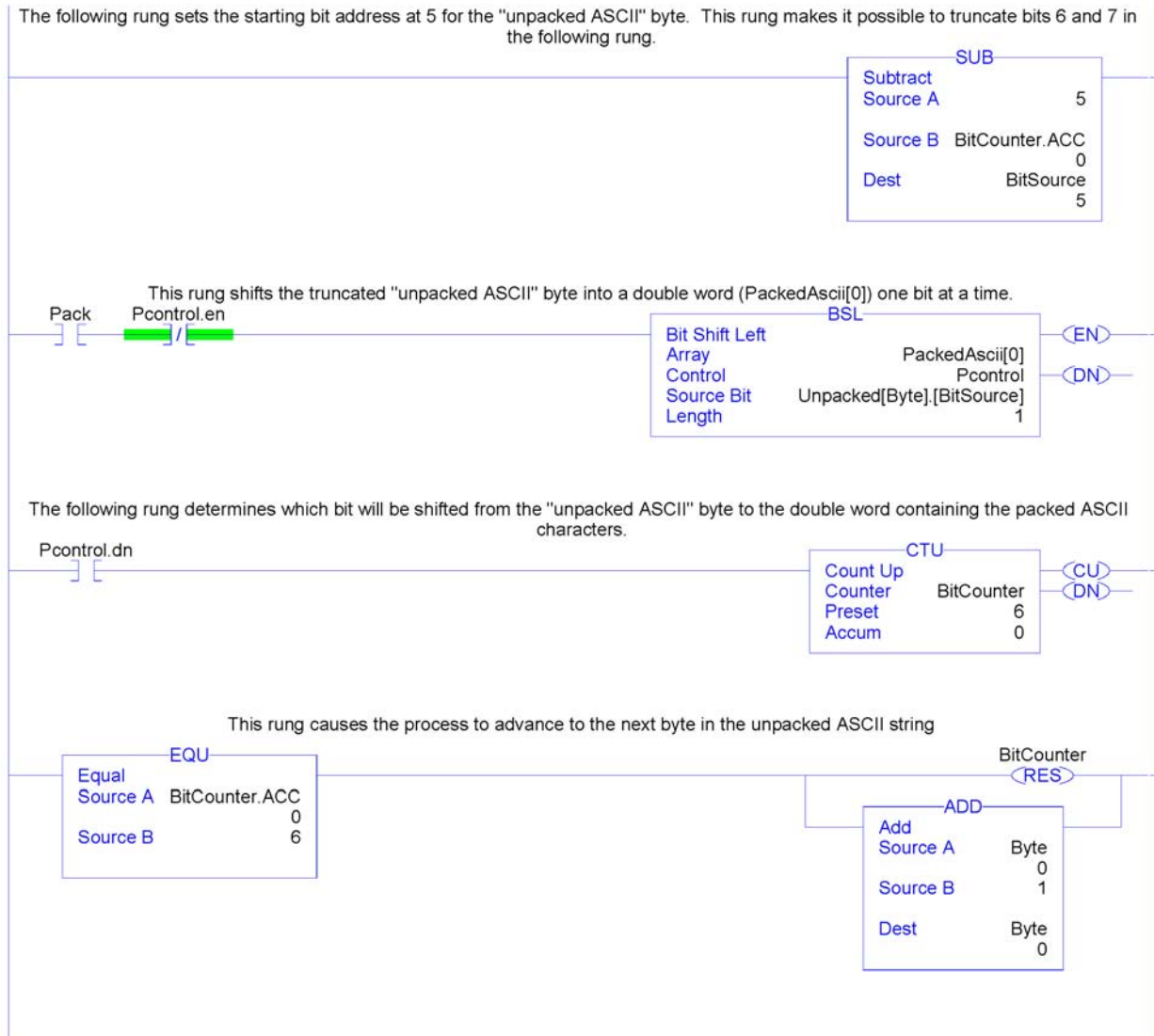
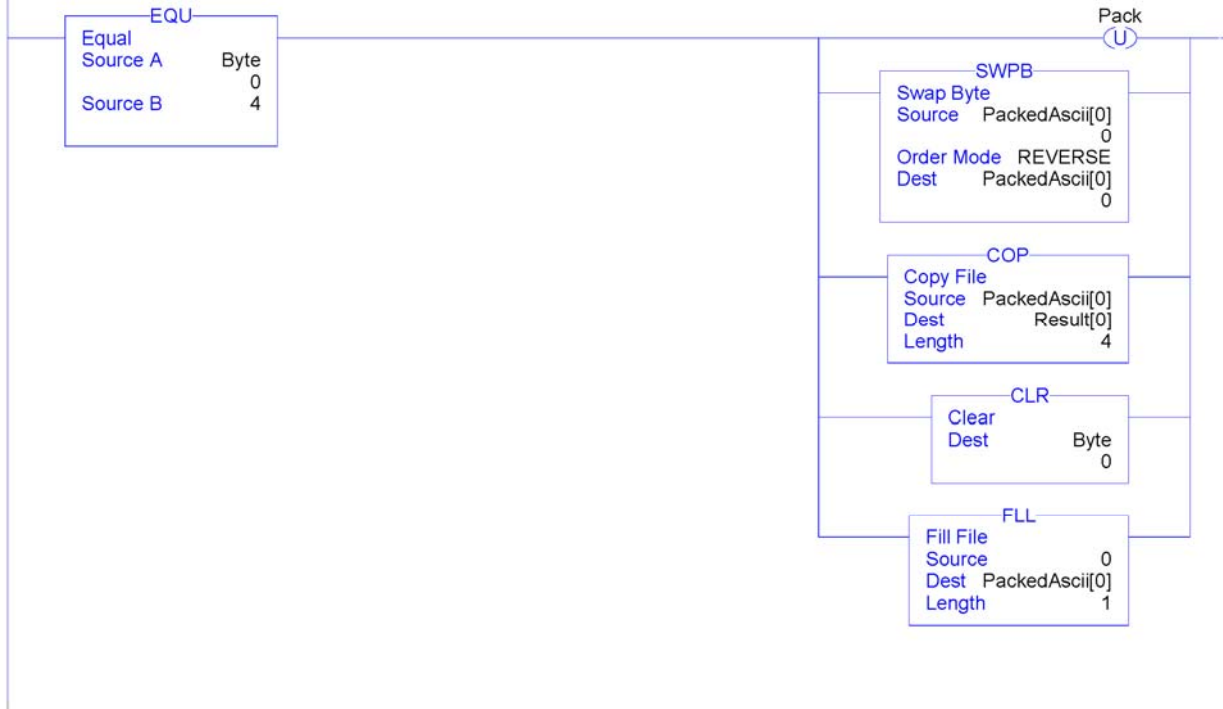


Figure 8-7b

After all four bytes have been packed this rung stops the packing process, resets the ladder and copies the result into a 4 byte array (Result). Note: The first byte in the result is 0 and should be ignored.



Section 8.2

MicroLogix 1500

The following ladder samples provide a working HART solution for the MicroLogix 1500 when used with the OF4IH module. The following table briefly describes each routine in the project file.



Attention

It is recommended that a 1764-LRP series C processor with firmware version 5 or higher be used. The LRP processor supports floating point files, which is required to read floating point data from the OF4IH.

Table 8-1 (Routine Description)

Routine	Description
MAIN	The main routine is the starting point for the ladder program.
PACKETS	The “packets” routine is used to demultiplex the HART data from the input file to individual integer files, so that the data can be viewed or used within the ladder program. This routine is called from the MAIN routine.
MSG_TO_MOD	This routine is used to send and receive messages to and from the module. Refer to Chapter 7 for more details regarding sending and receiving messages. This routine is called from the HART_MSG routine.
SRC_CHECK	Calculates the checksum for a message sent to the module one page at a time. This routine is called from the MSG_TO_MOD routine.
DEST_CHECKSUM	This routine calculates the checksum for a message received from the module one page at a time. This routine is called from the MSG_TO_MOD routine.
HART_MSG	This routine composes HART messages that will be sent to the module/field transmitter. This routine is called from the MAIN routine.
WORD_BYTE	Converts word data to its byte equivalent. This routine is called from the HART_MSG routine.
HART_CHECK	Calculates the checksum for the HART message being sent to the module/field device. This routine is called from the HART_MSG routine.
BYTE_WORD	Converts byte data to its word equivalent. This routine is called by the HART_MSG routine.

8.2.1 MAIN Routine

The main routine is the starting point for the ladder program.

Figure 8-9 (Main Routine)



8.2.2 PACKETS Routine

The “packets” routine is used to demultiplex the HART data from the input file to individual integer files, so that the data can be viewed or used within the ladder program. This routine is called from the MAIN routine.

Figure 8-10a (Packets Routine)

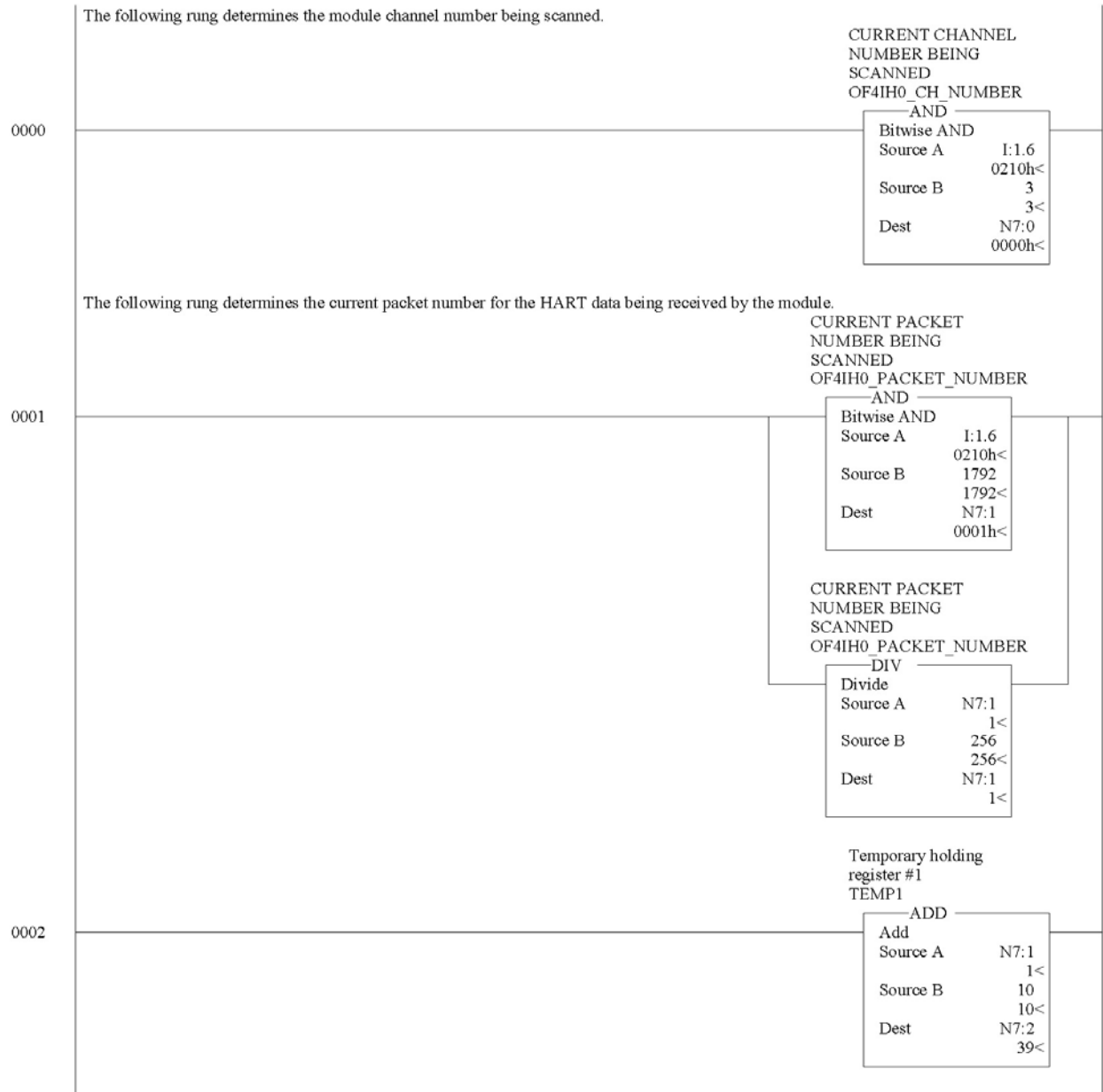


Figure 8-10b

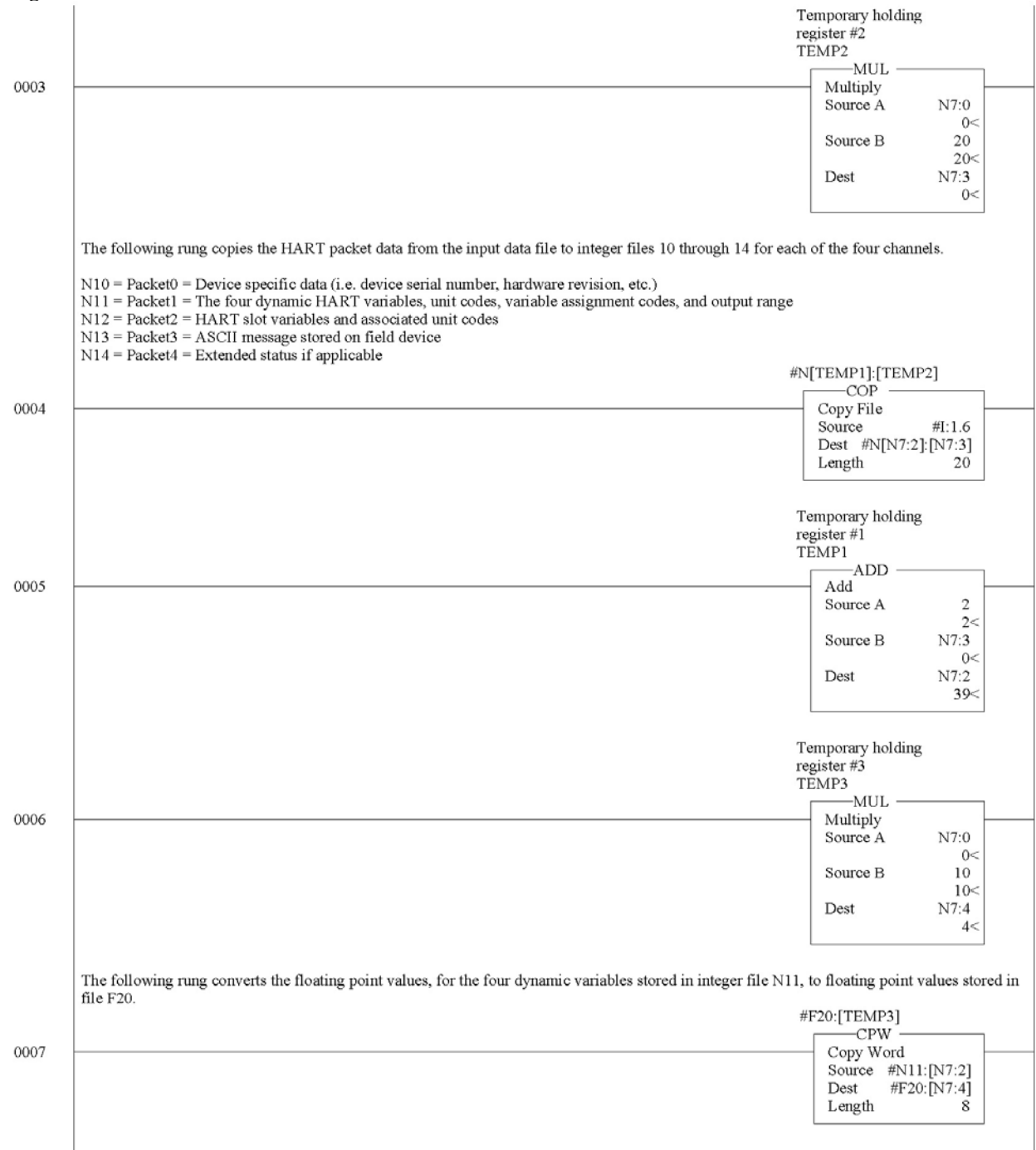
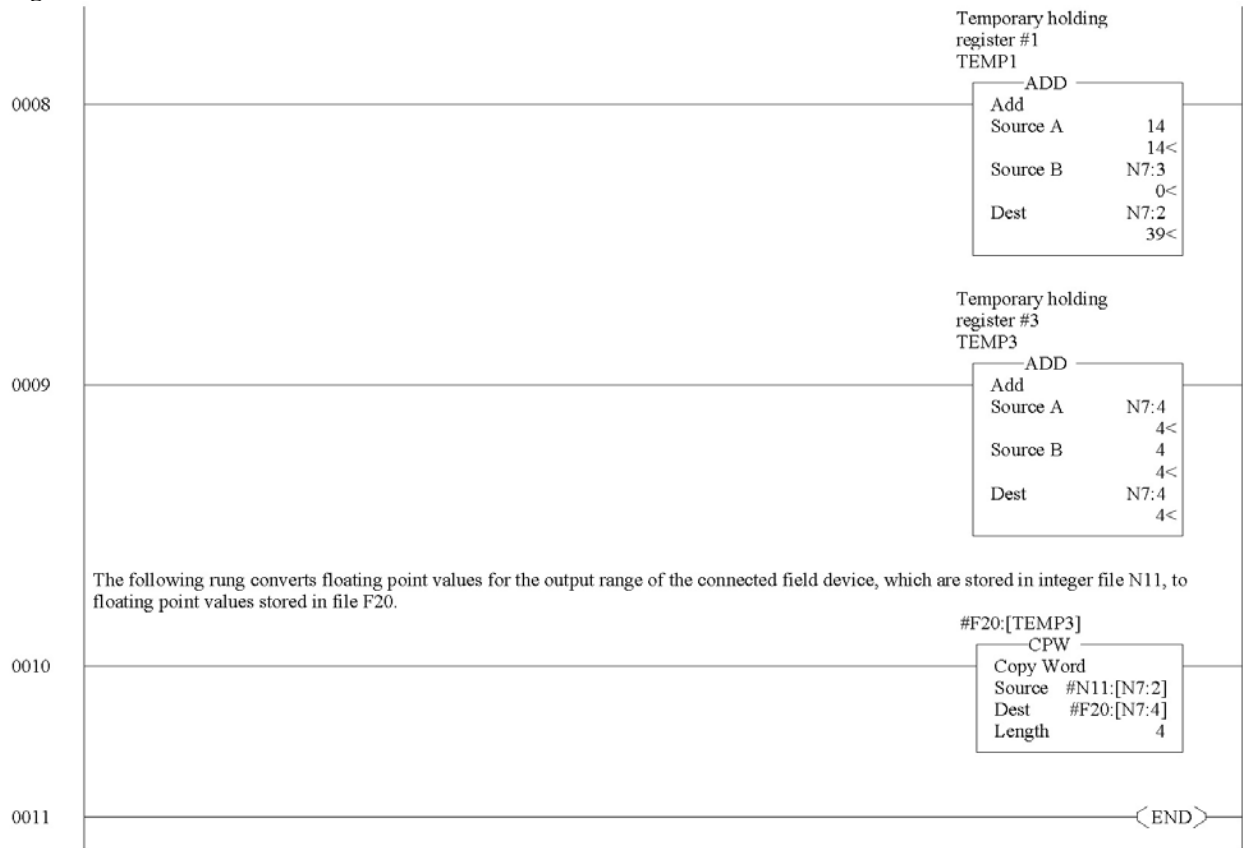


Figure 8-10c



8.2.3 MSG_TO_MOD Routine

This routine is used to send and receive messages to and from the module. Refer to Chapter 7 for more details regarding sending and receiving messages. This routine is called from the HART_MSG routine.

Figure 8-11a (Message to Module)

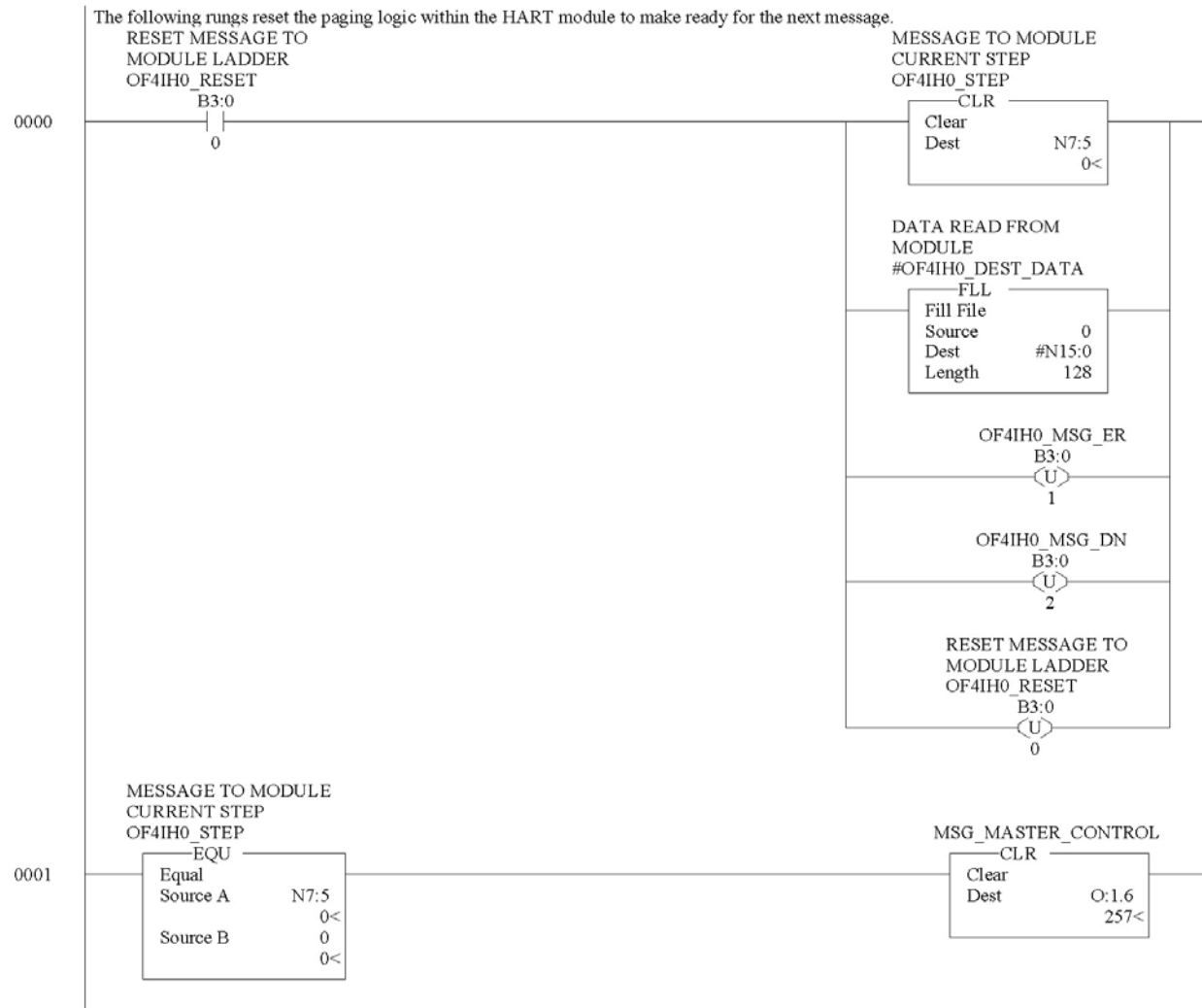


Figure 8-11b

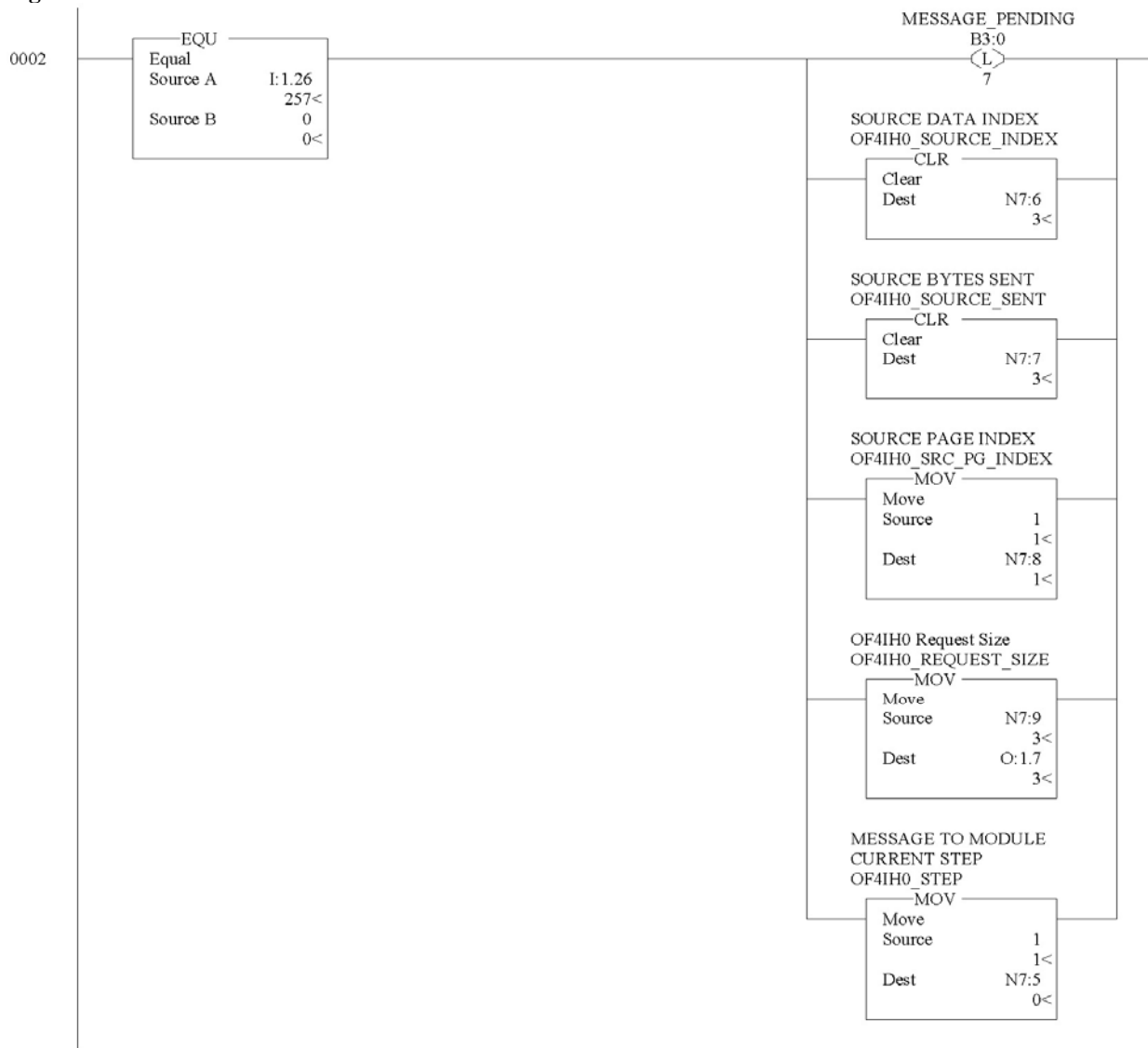


Figure 8-11c

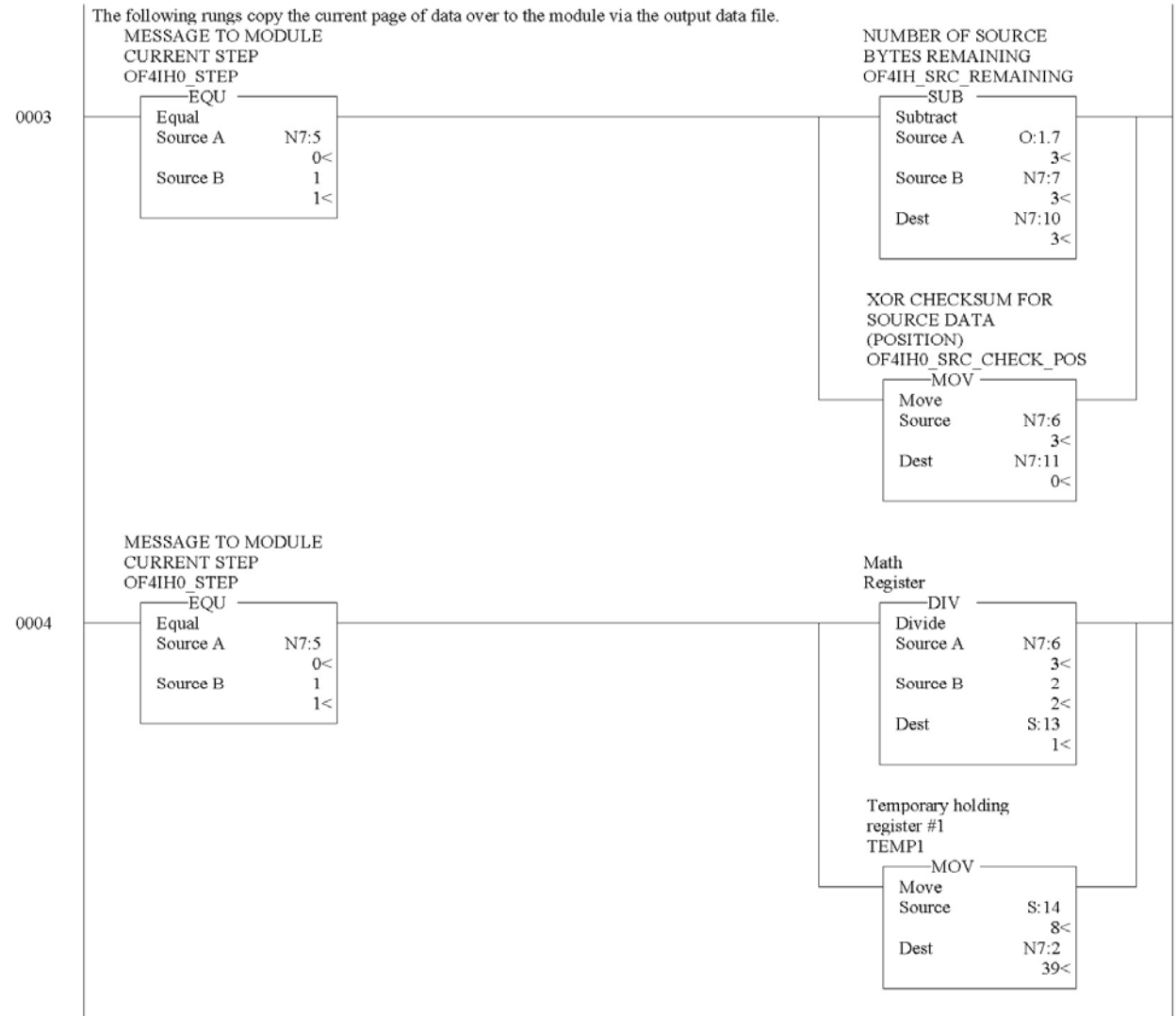


Figure 8-11d

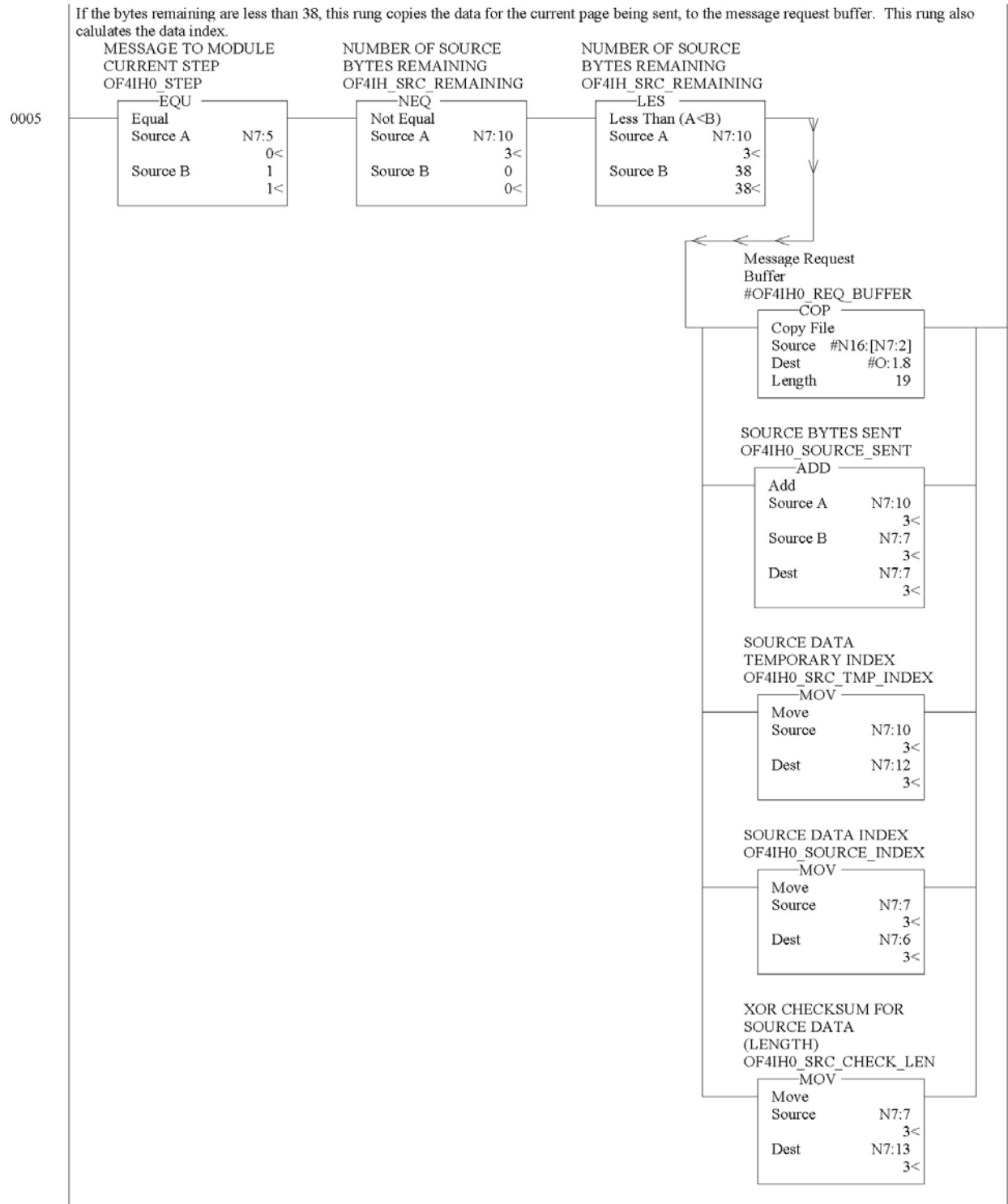


Figure 8-11e

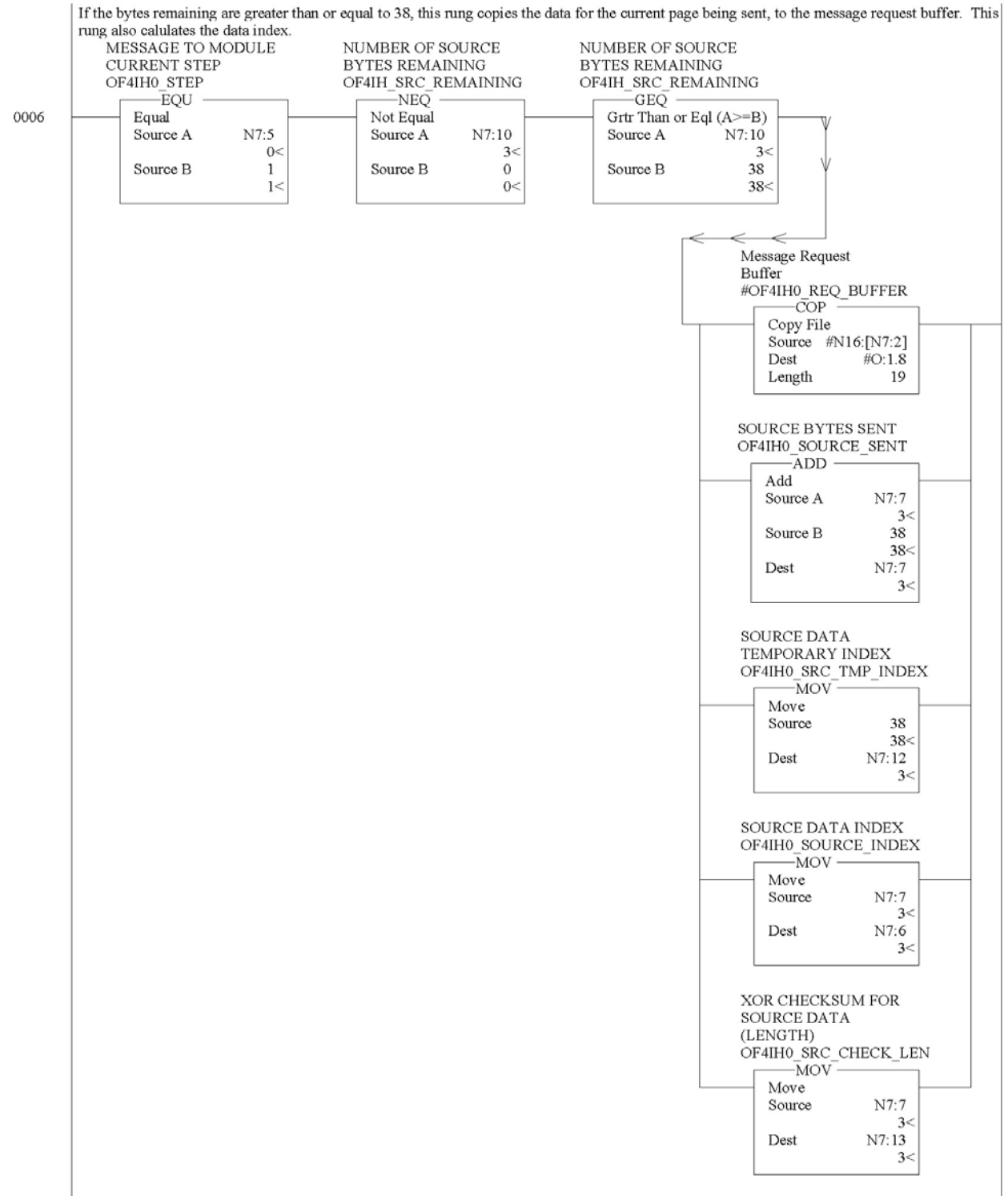


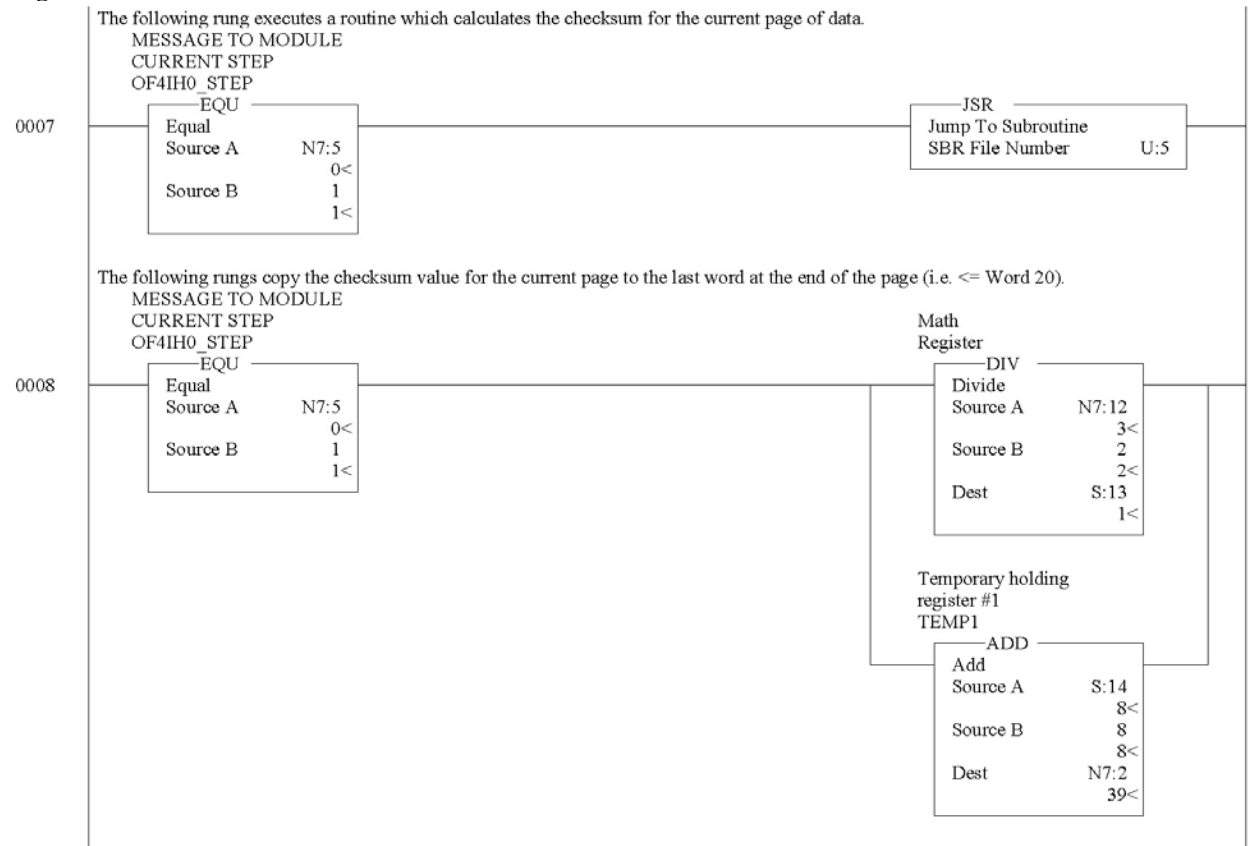
Figure 8-11f

Figure 8-11g

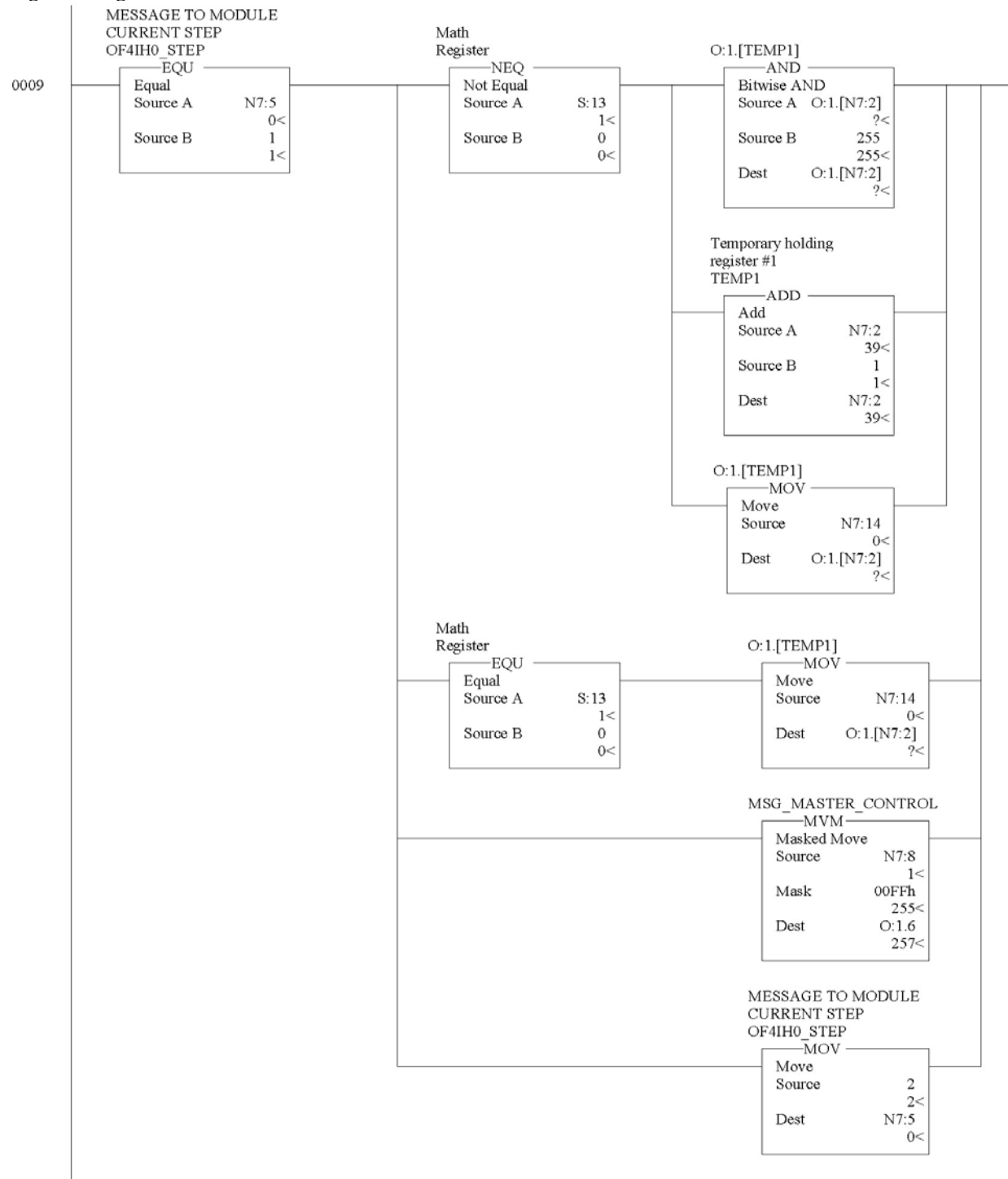


Figure 8-11h

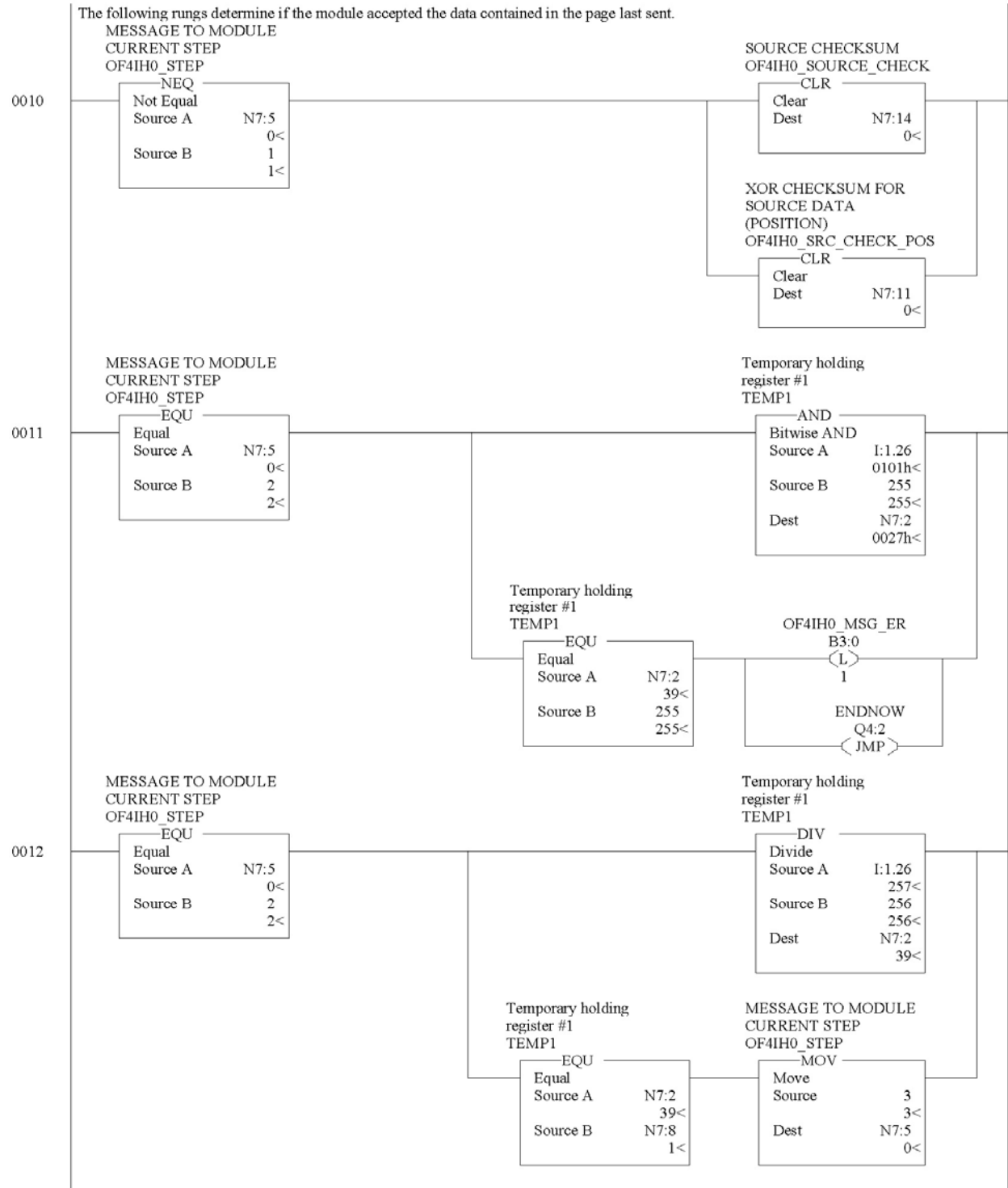


Figure 8-11i

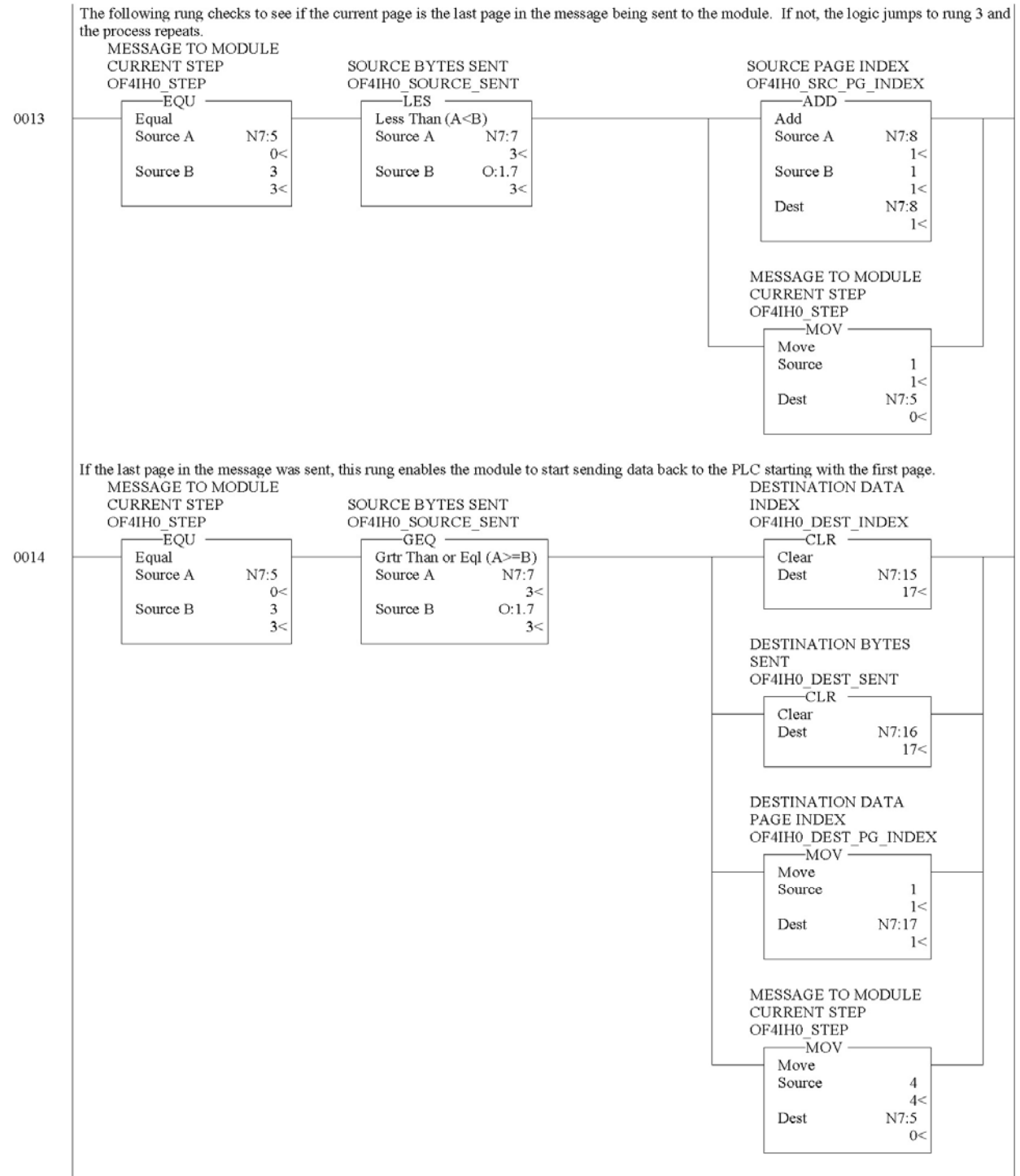


Figure 8-11j

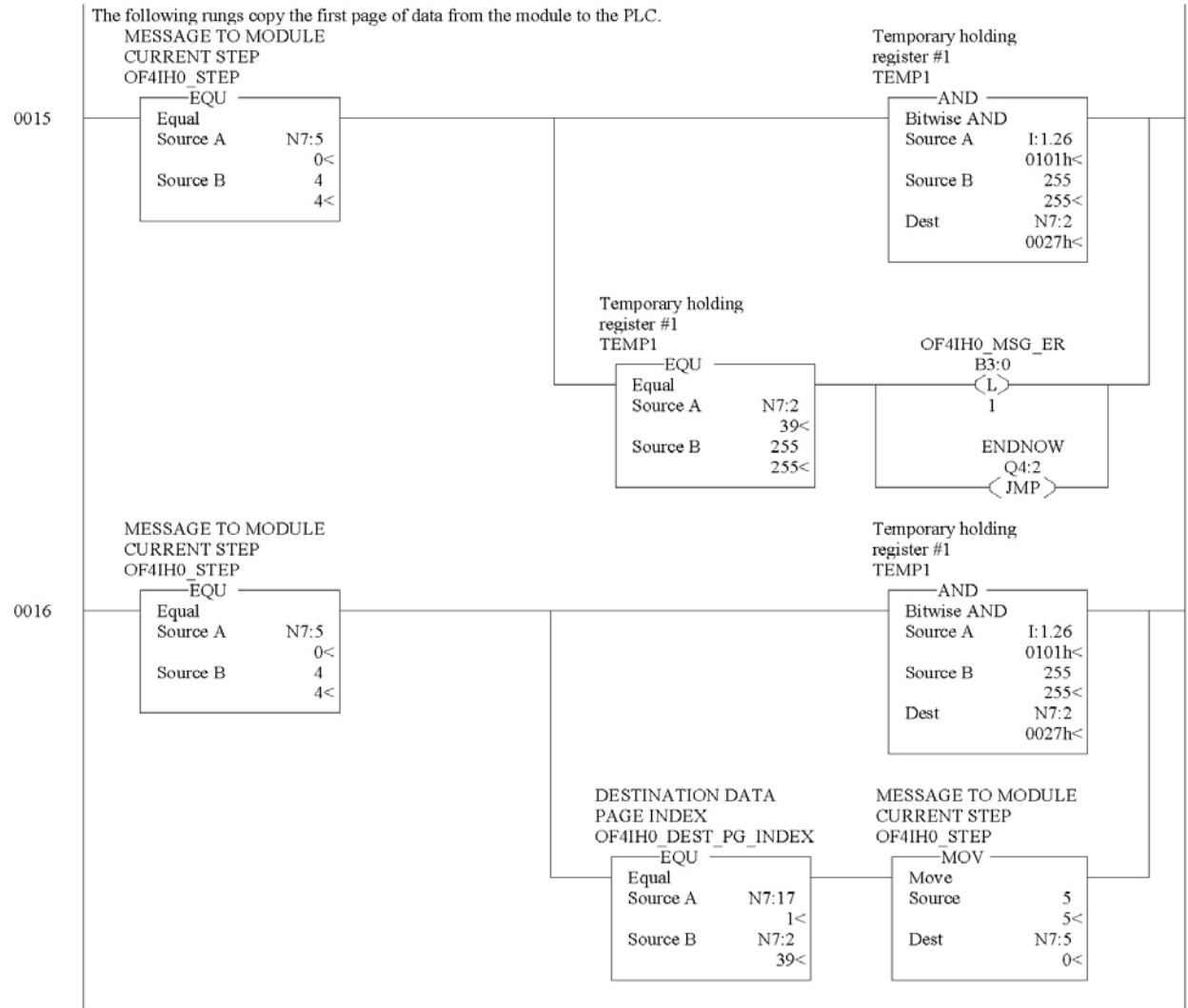


Figure 8-11k

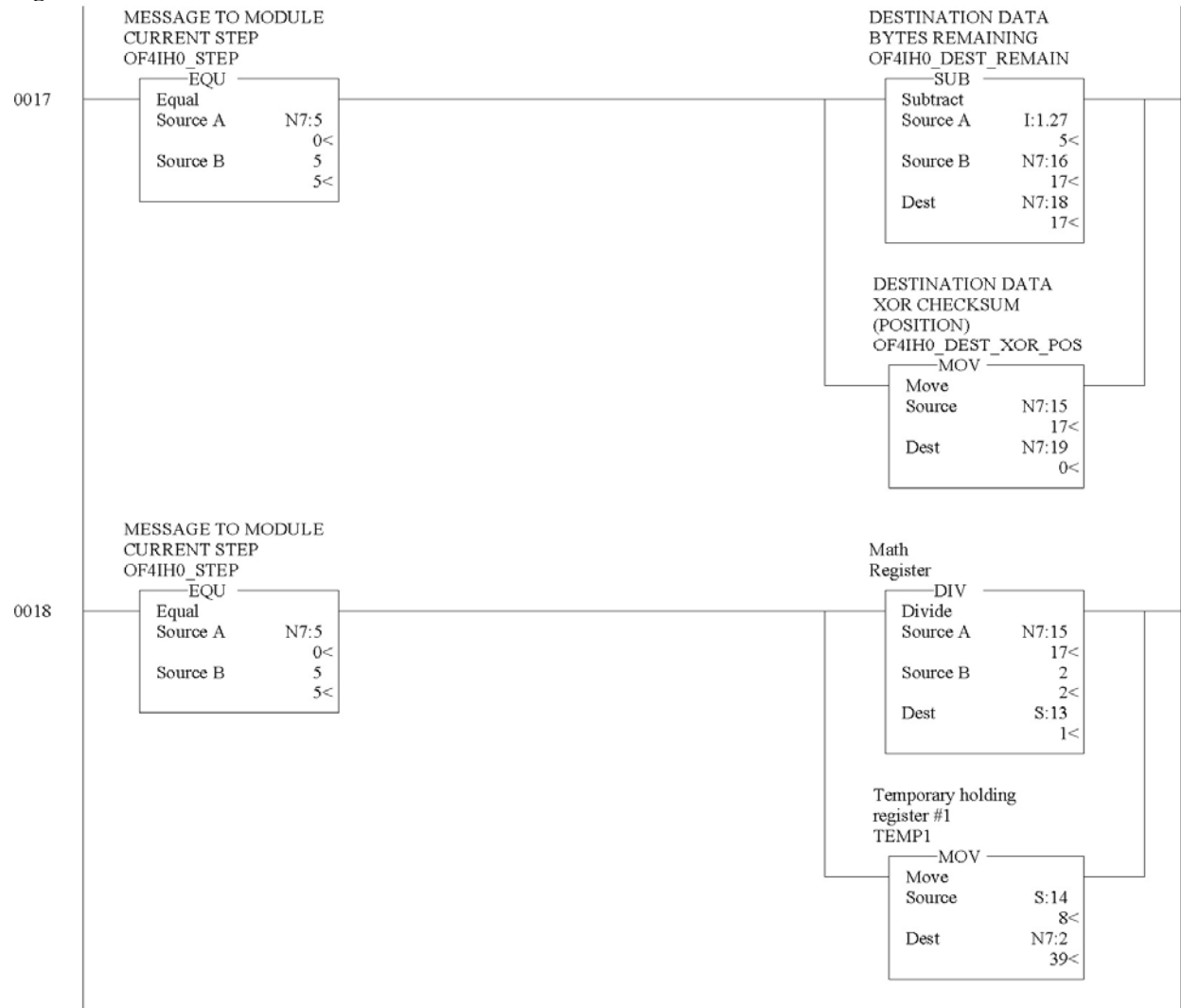


Figure 8-111

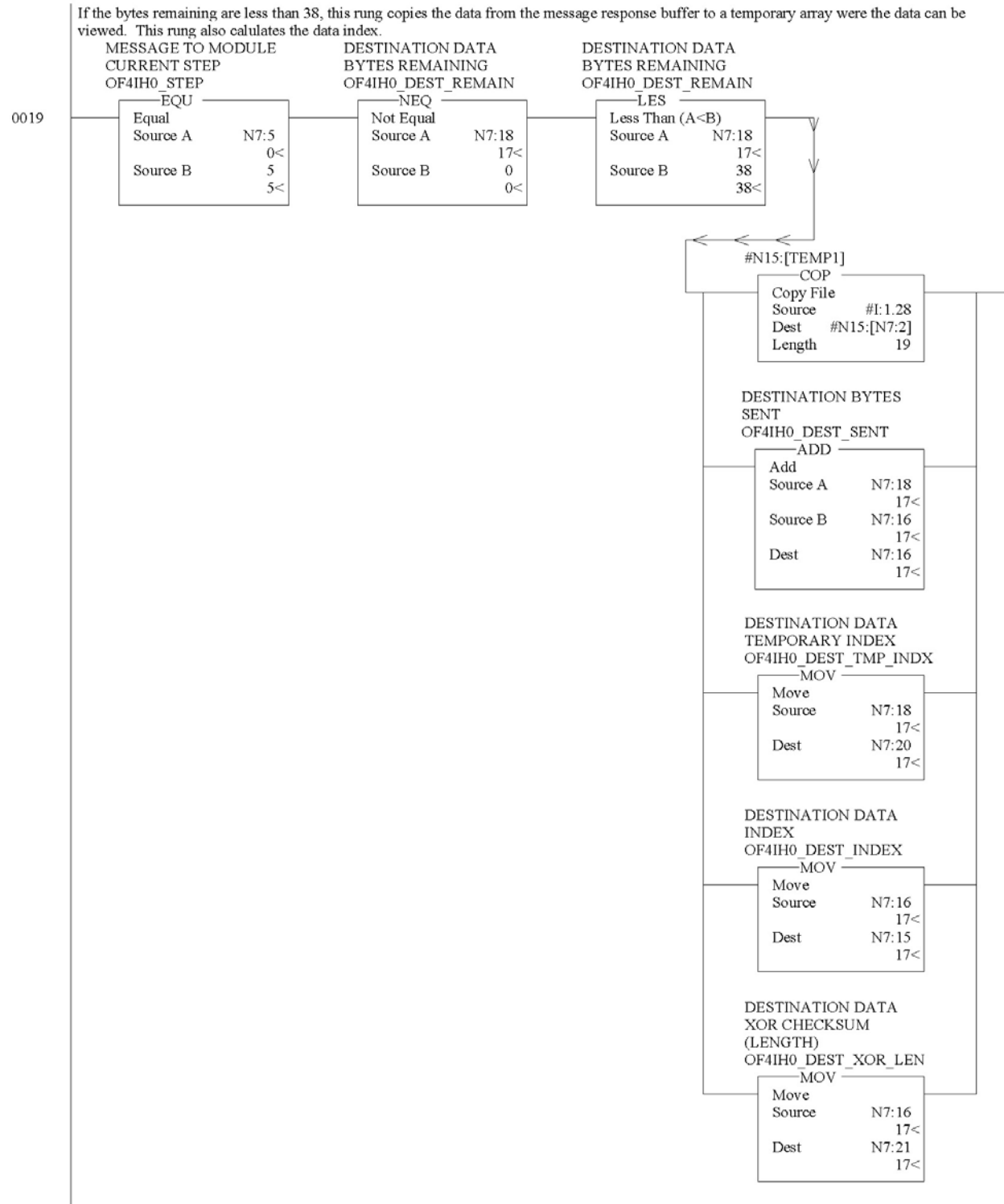


Figure 8-11m

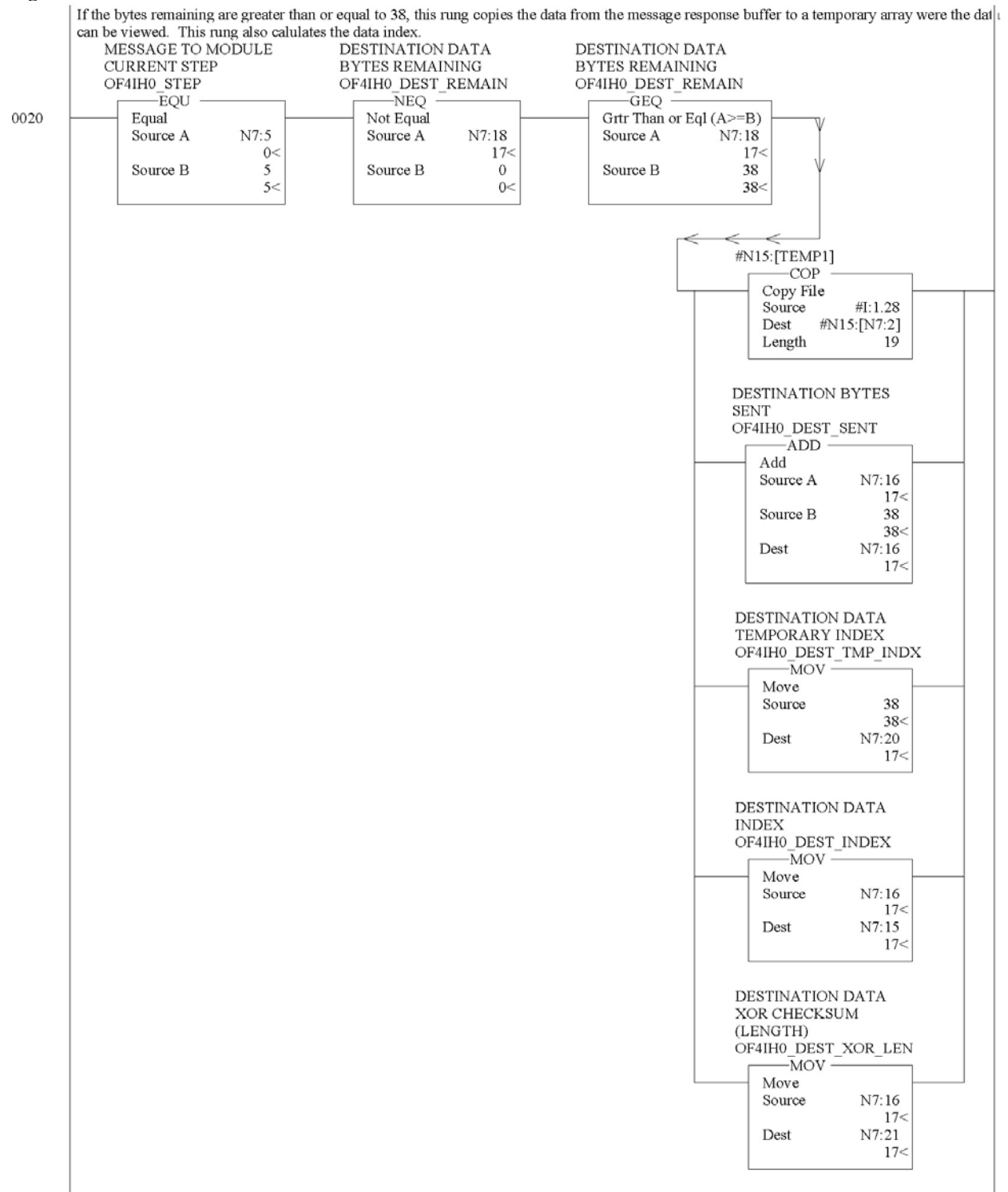


Figure 8-11n

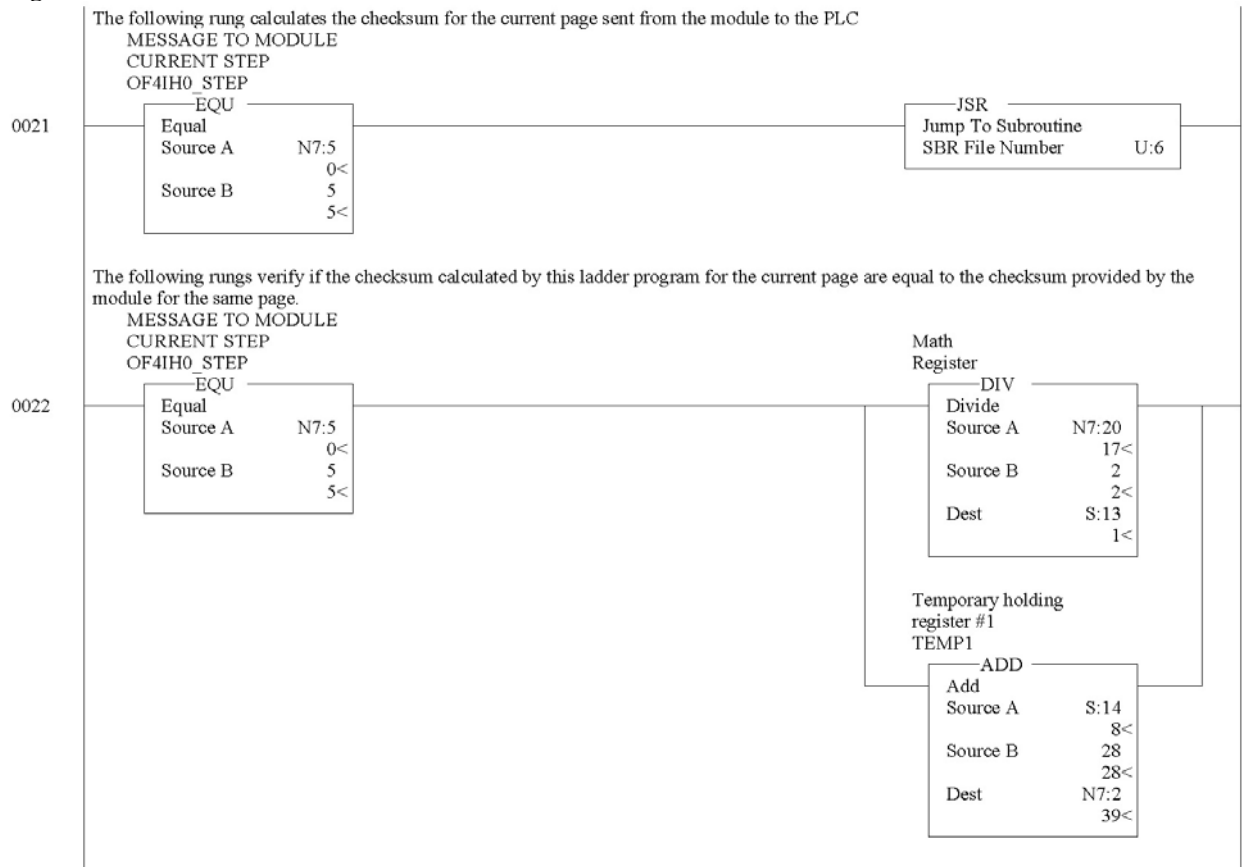


Figure 8-11o

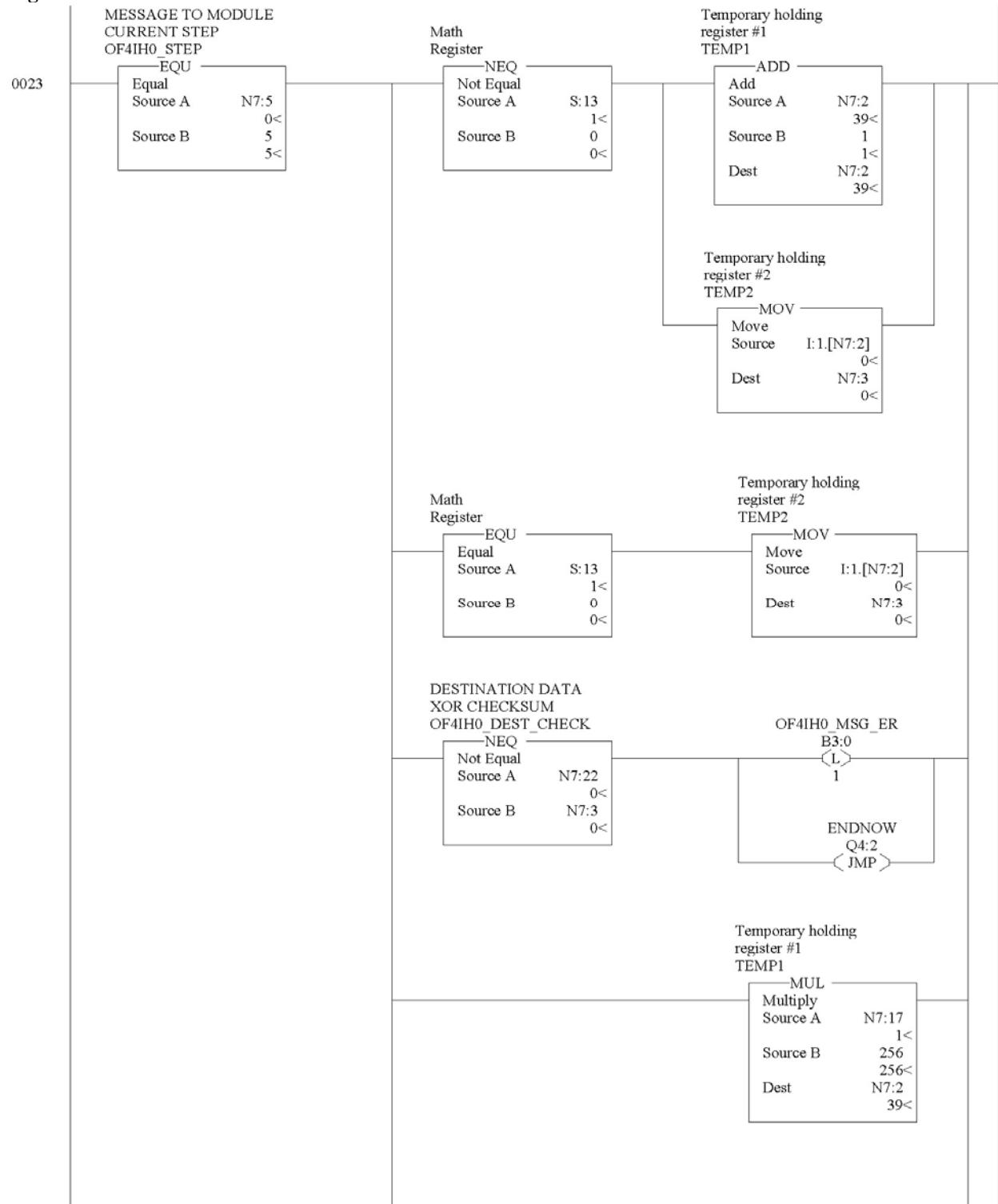


Figure 8-11p

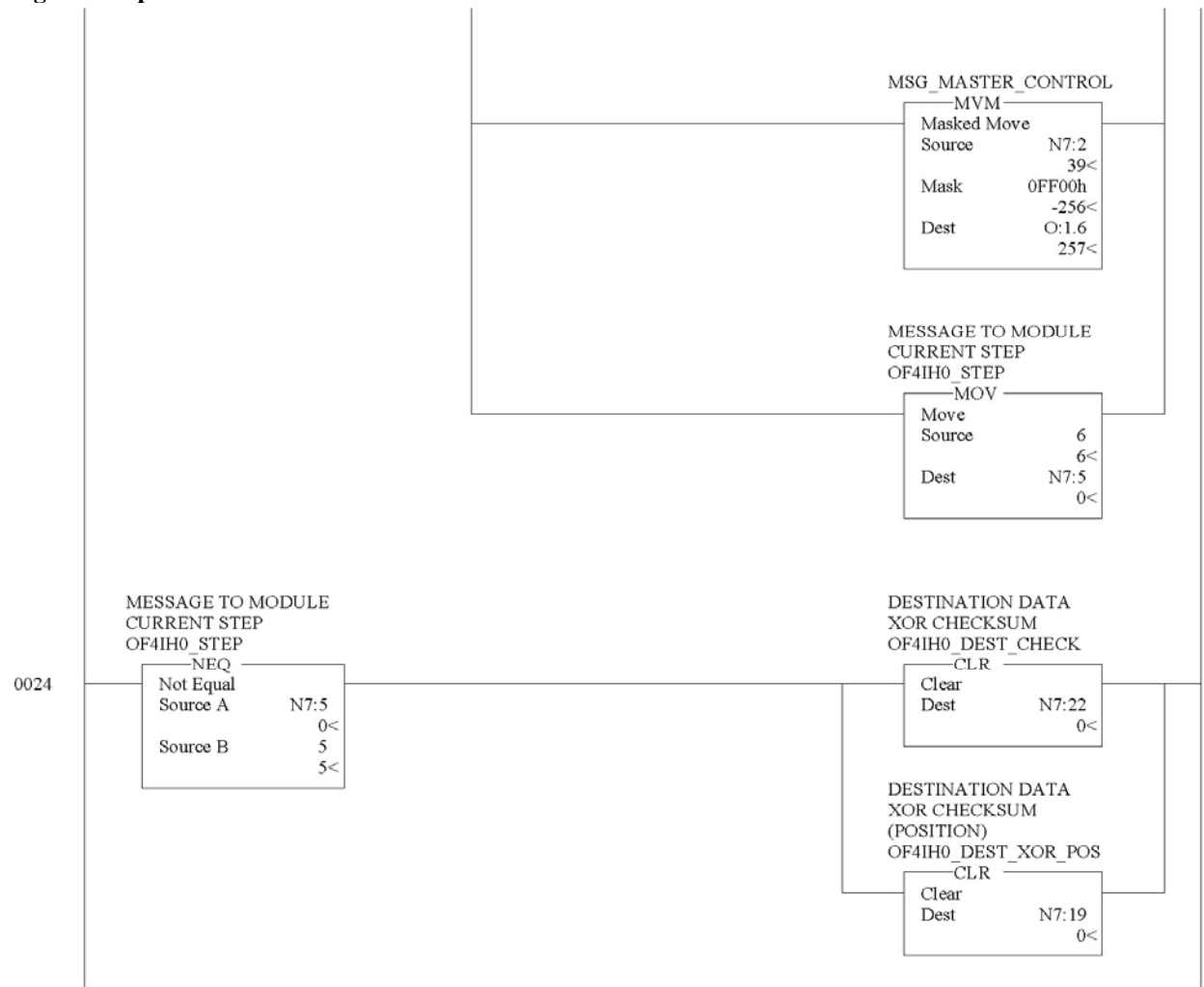
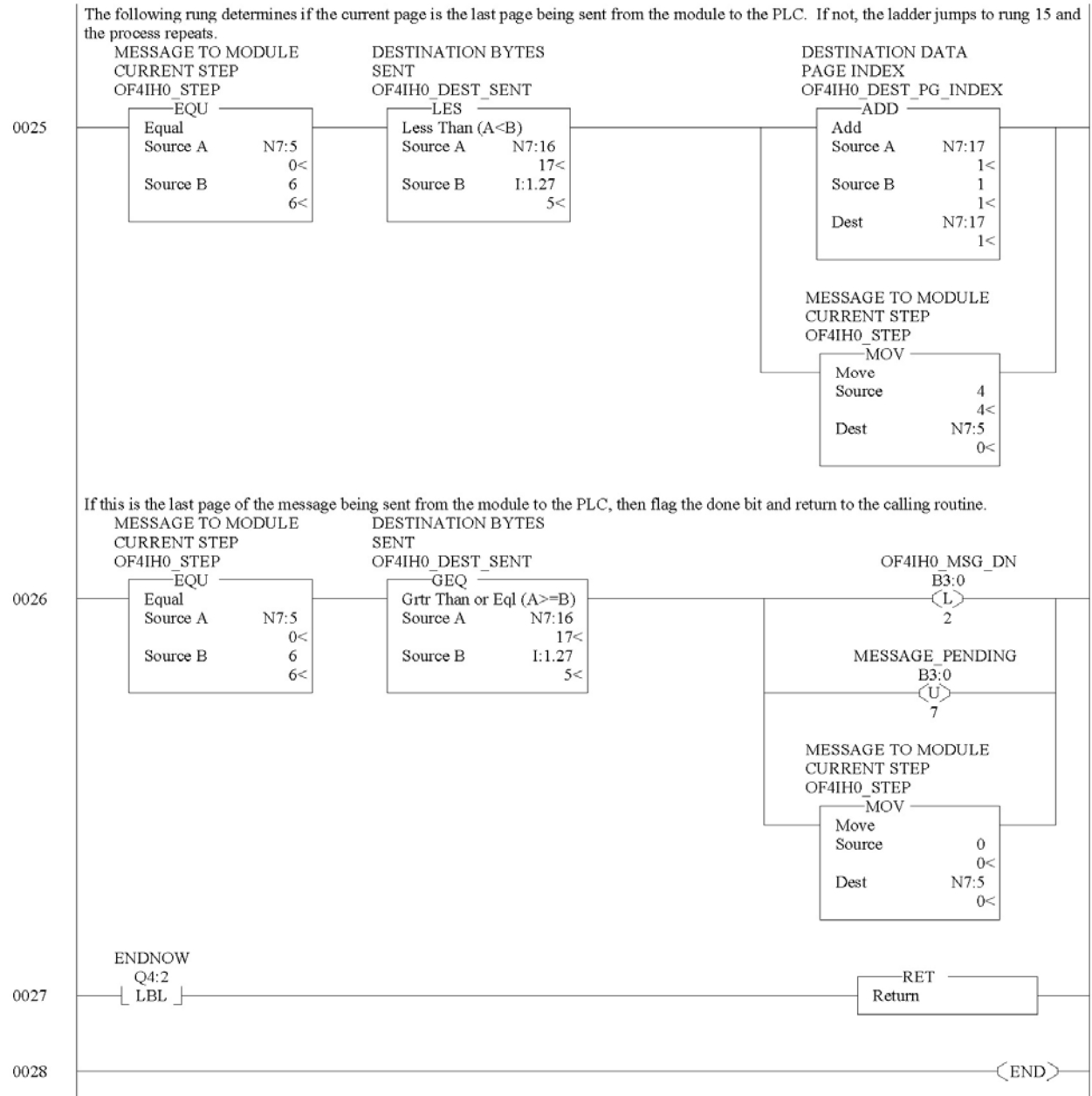


Figure 8-11q



8.2.4 SRC_CHECK Routine

Calculates the checksum for a message sent to the module one page at a time. This routine is called from the MSG_TO_MOD routine.

Figure 8-12a (Source Checksum)

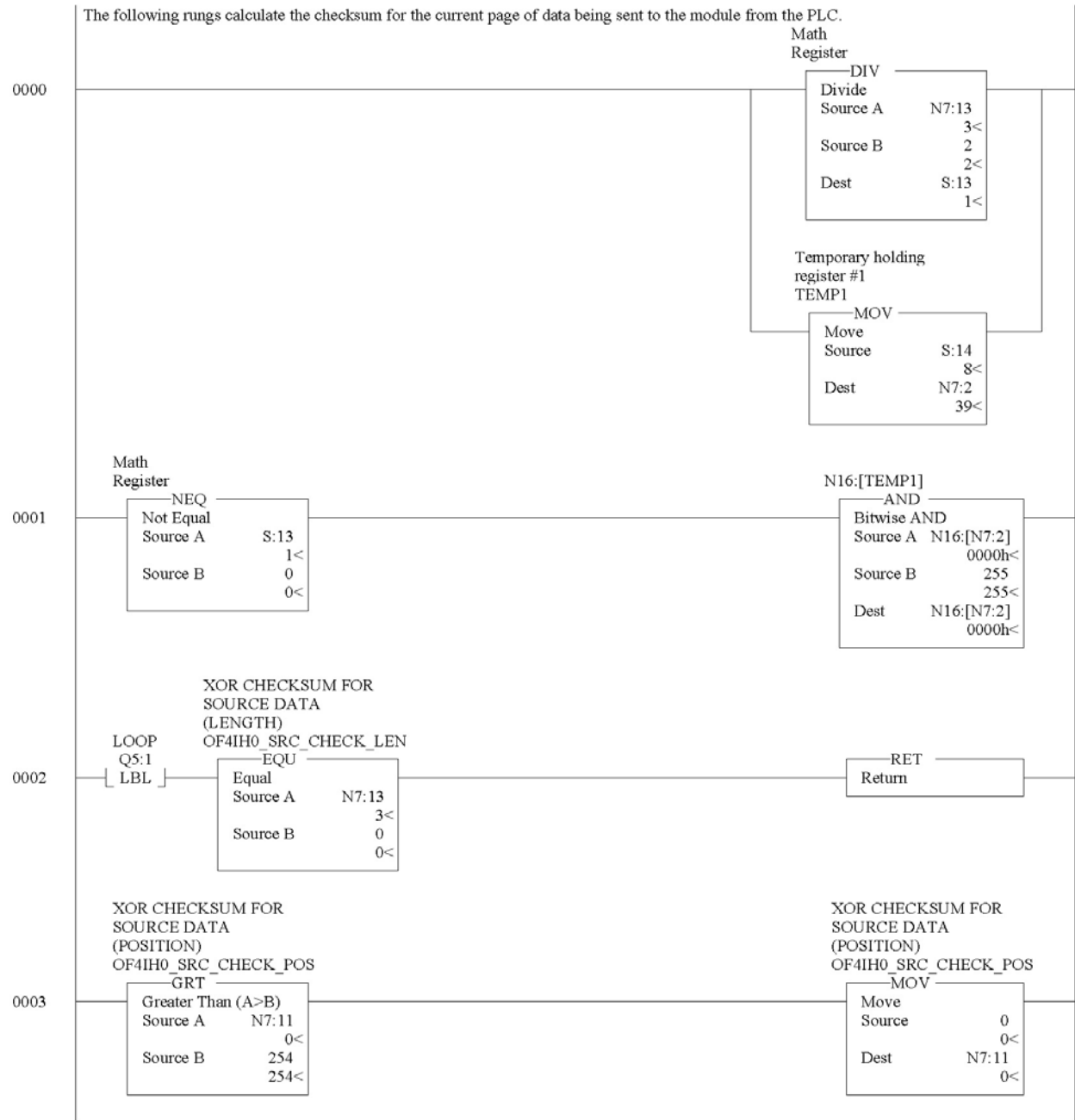
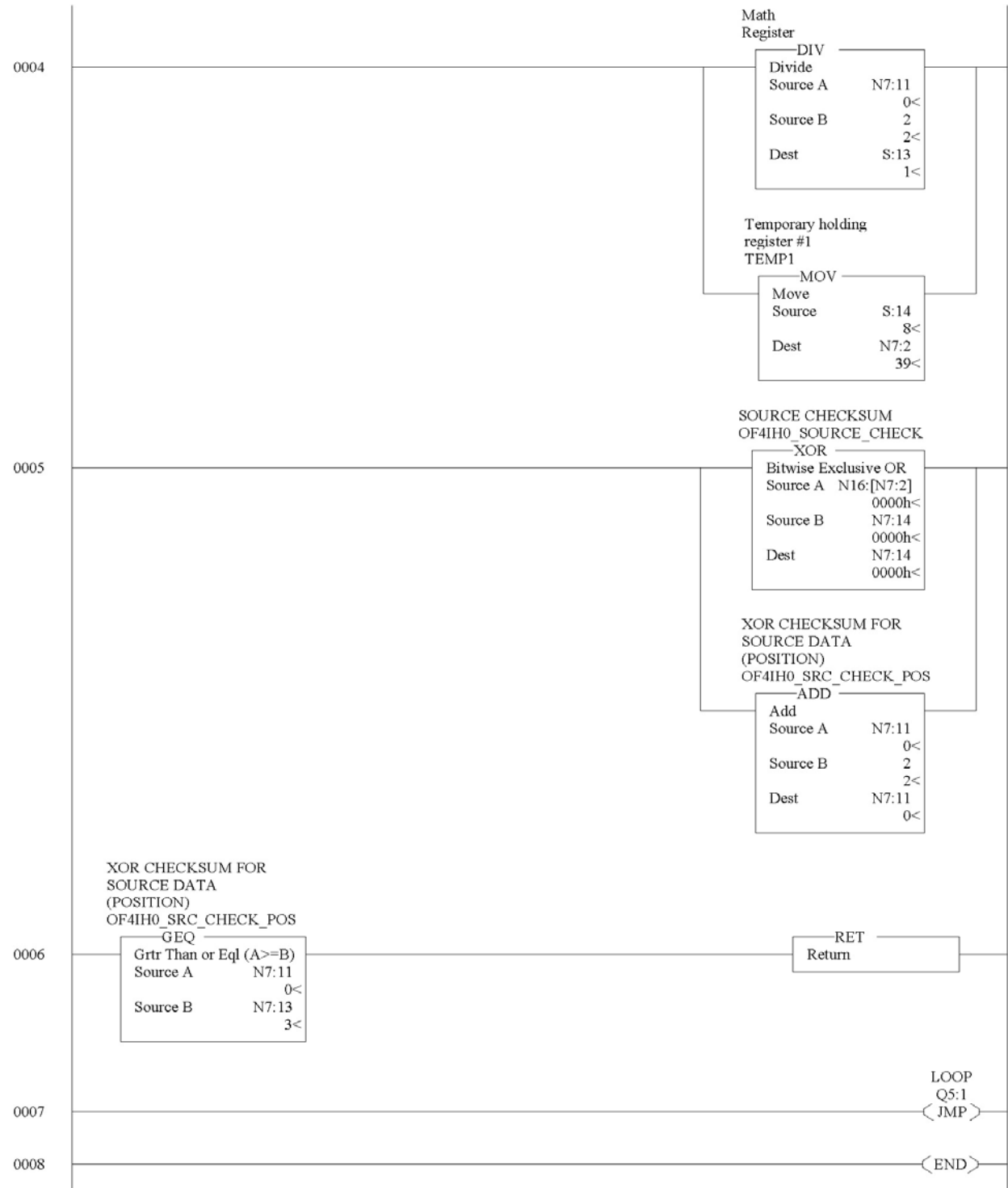


Figure 8-12b



8.2.5 DEST_CHECKSUM Routine

This routine calculates the checksum for a message received from the module one page at a time. This routine is called from the MSG_TO_MOD routine.

Figure 8-13a (Destination Checksum)

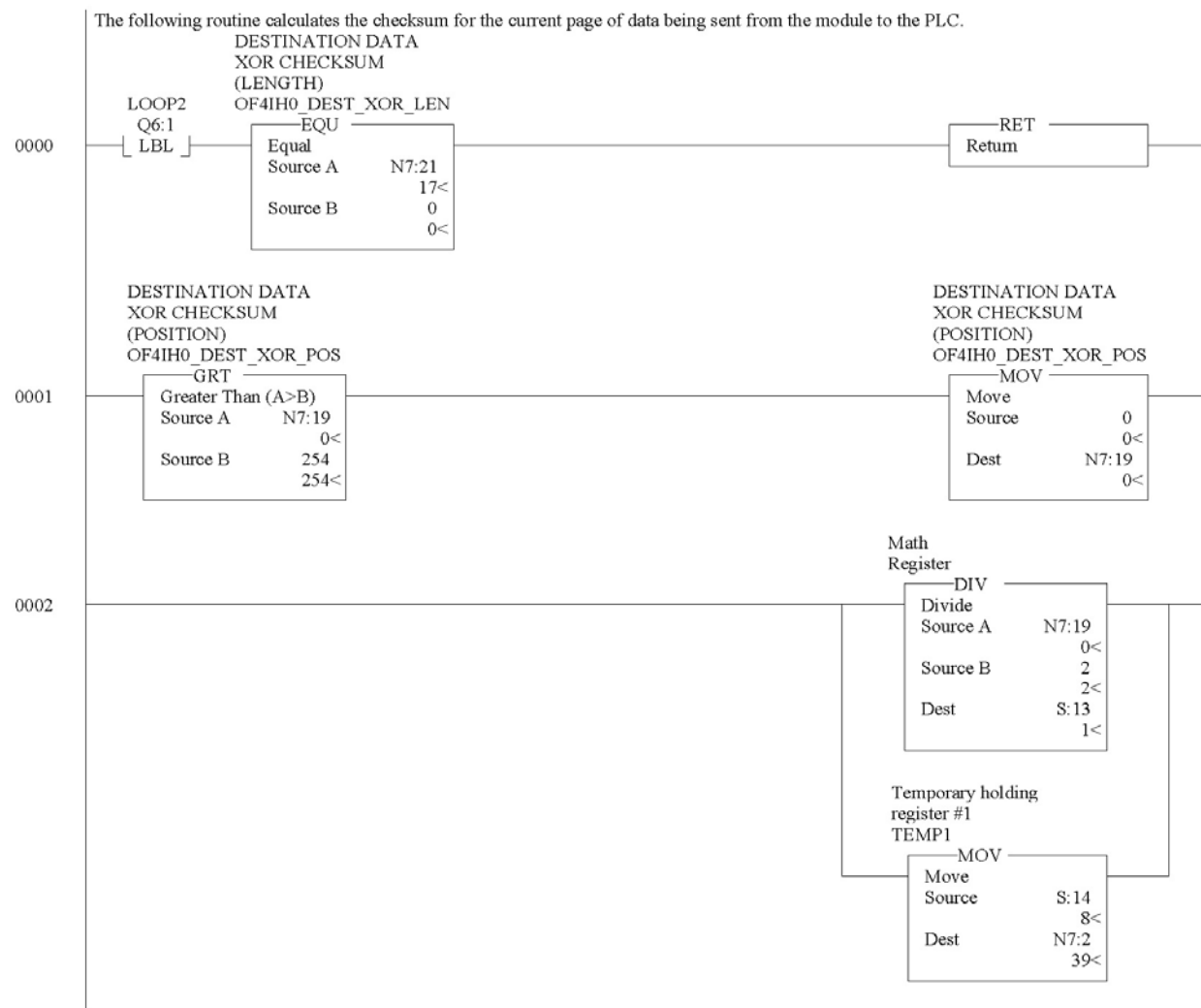
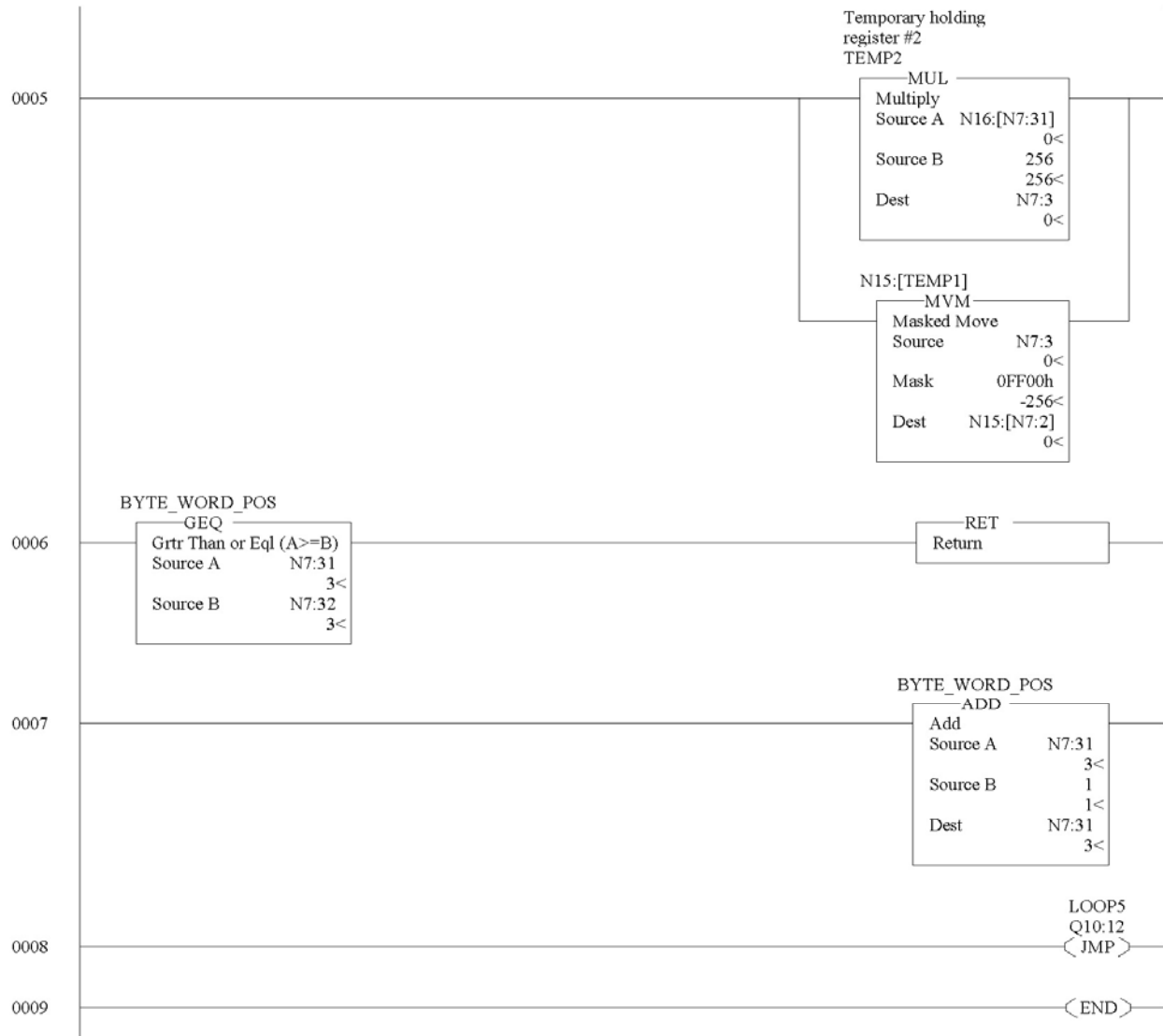


Figure 8-13b



8.2.6 HART_MSG Routine

This routine composes HART messages that will be sent to the module/field transmitter. This routine is called from the MAIN routine.

Figure 8-14a (HART Message)

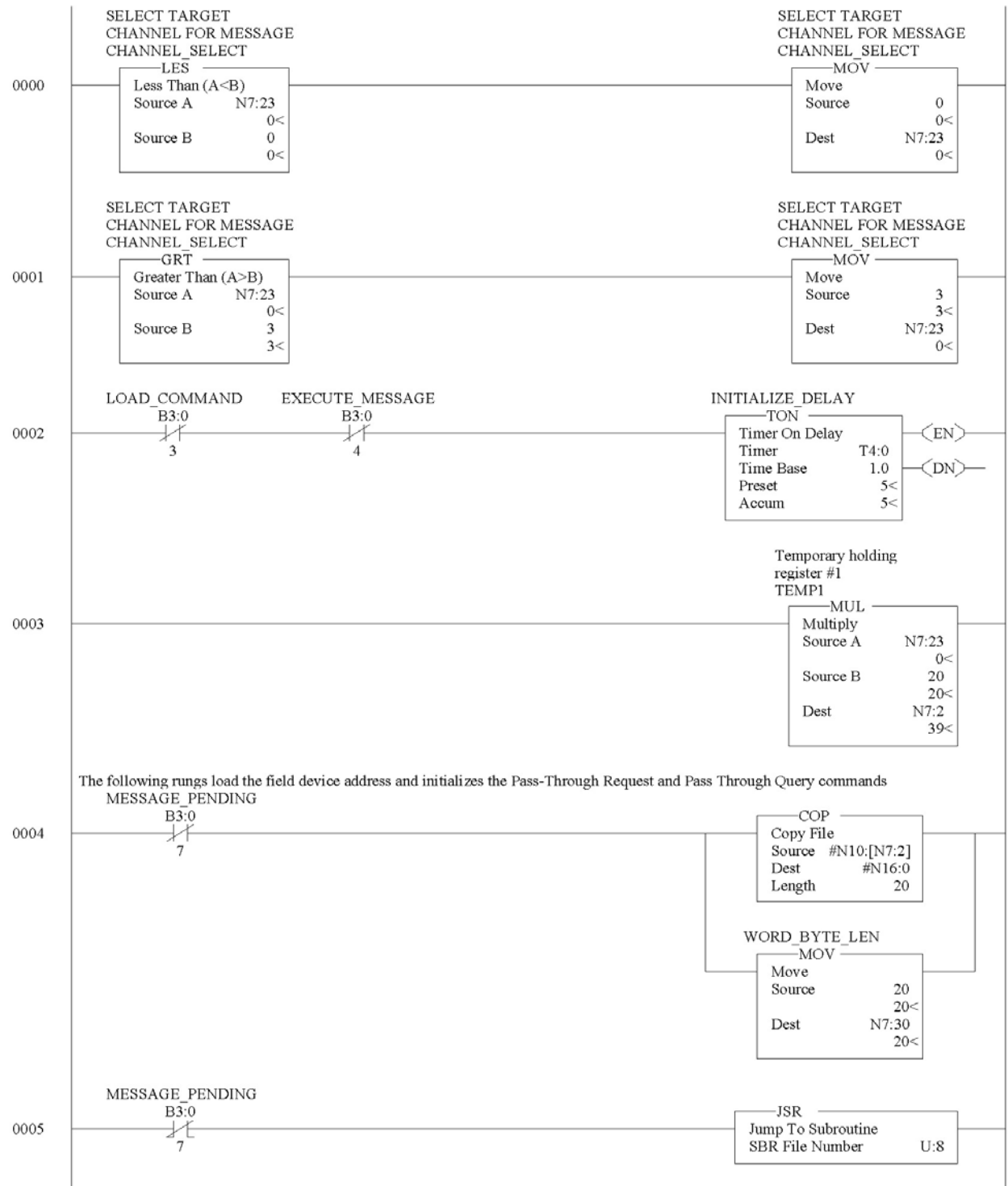


Figure 8-14b



Figure 8-14c

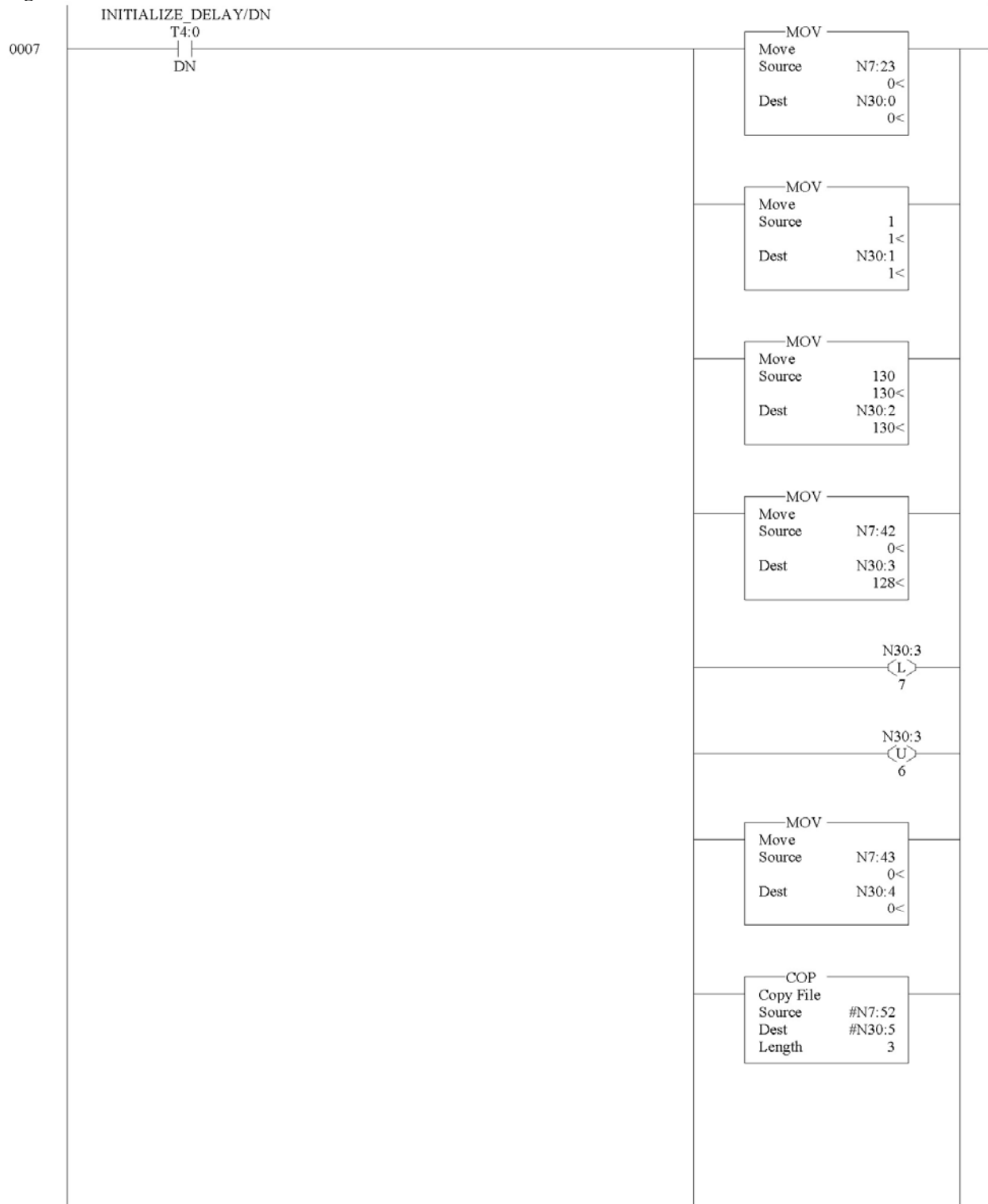


Figure 8-14d

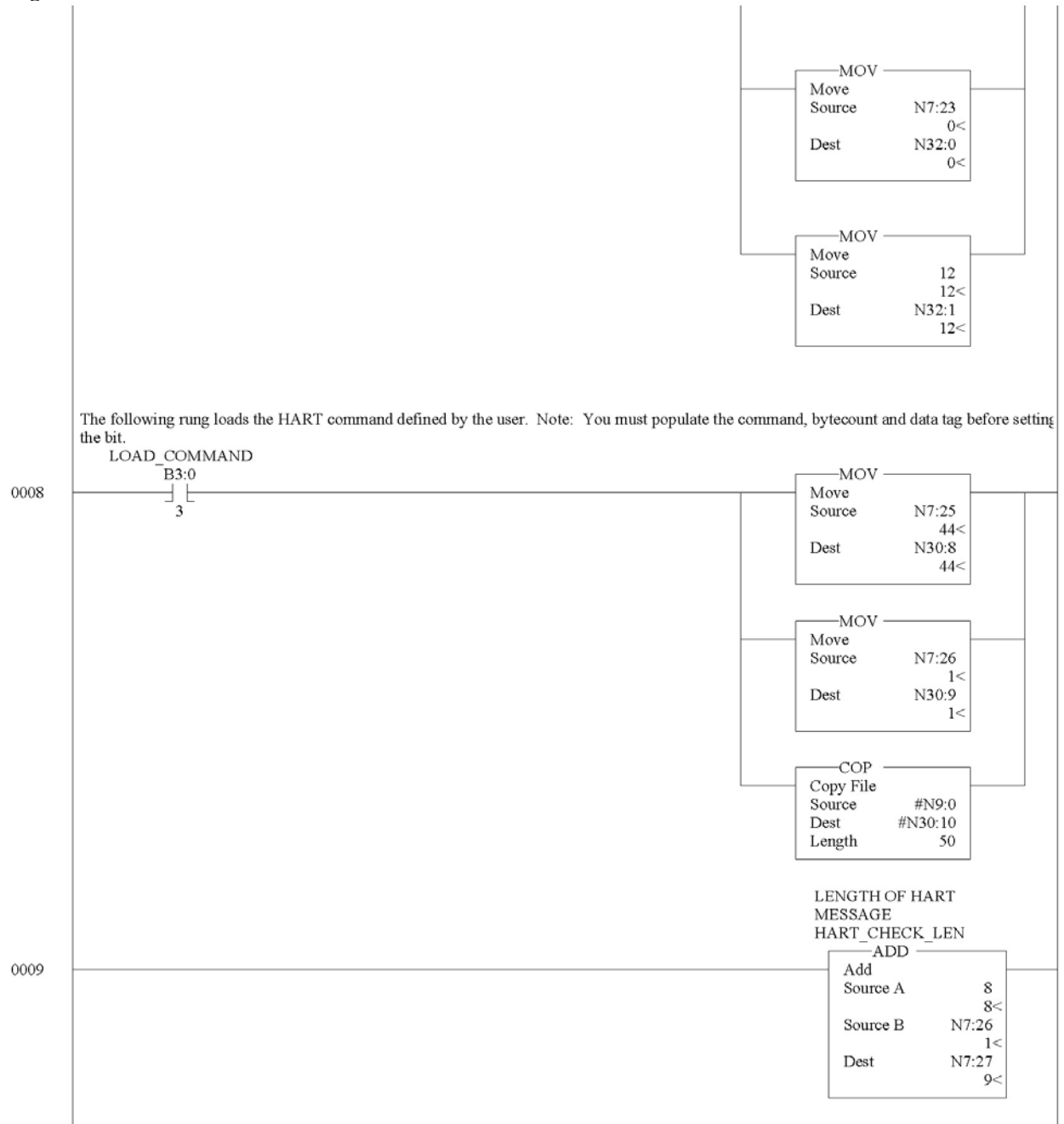


Figure 8-14e

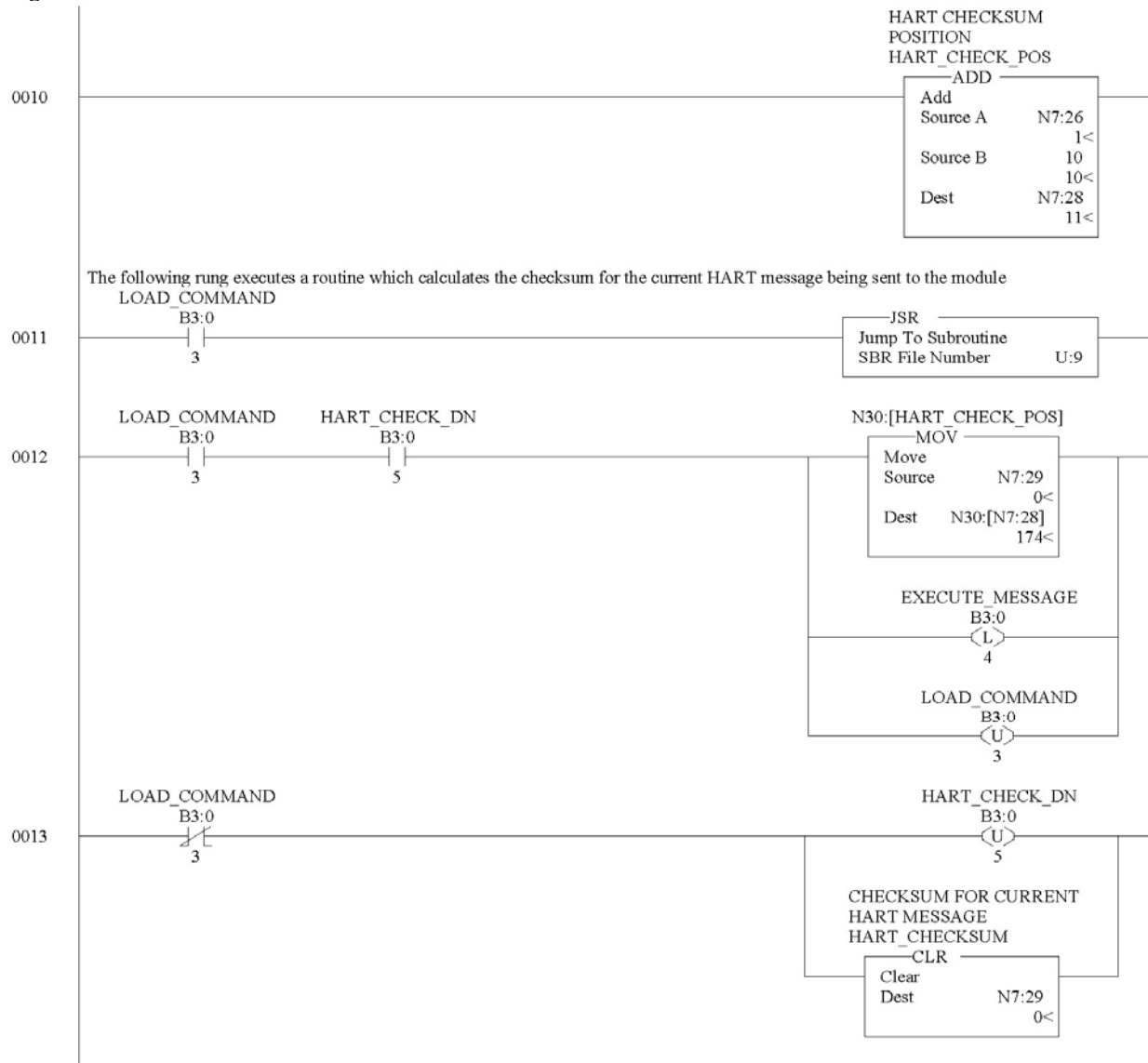


Figure 8-14f

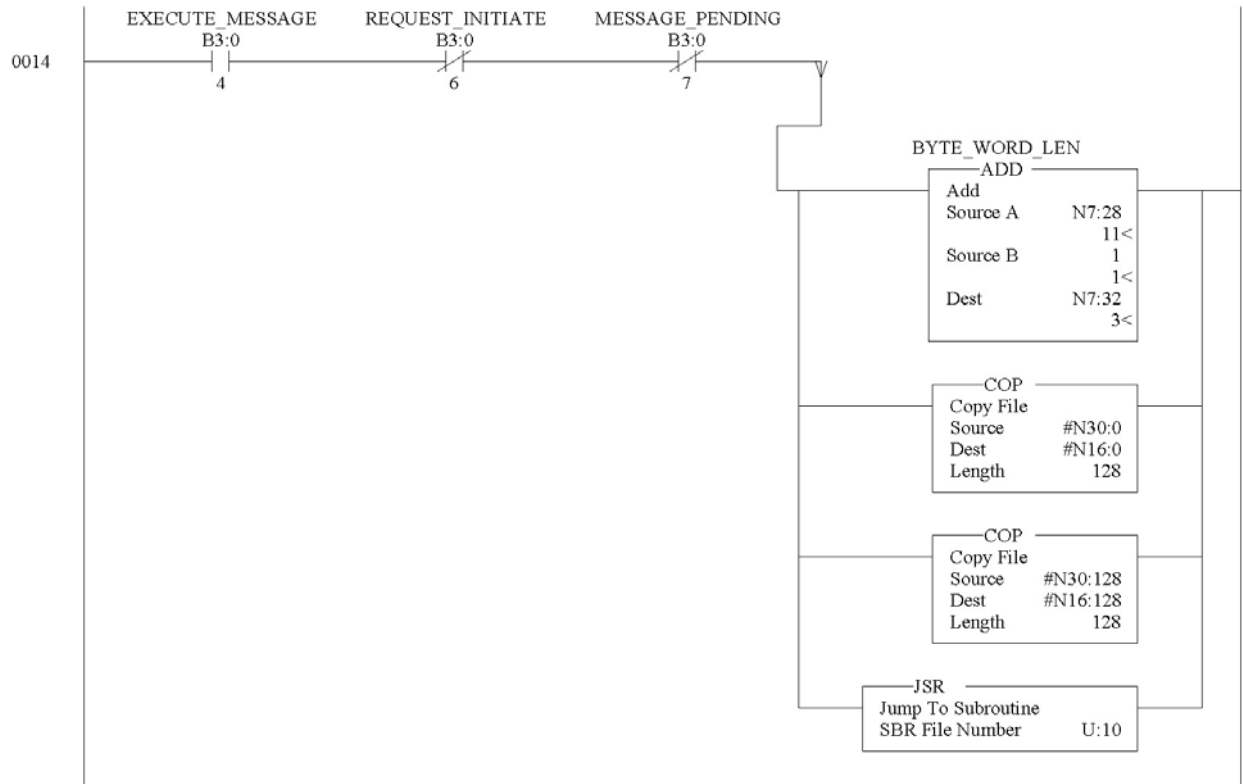


Figure 8-14g

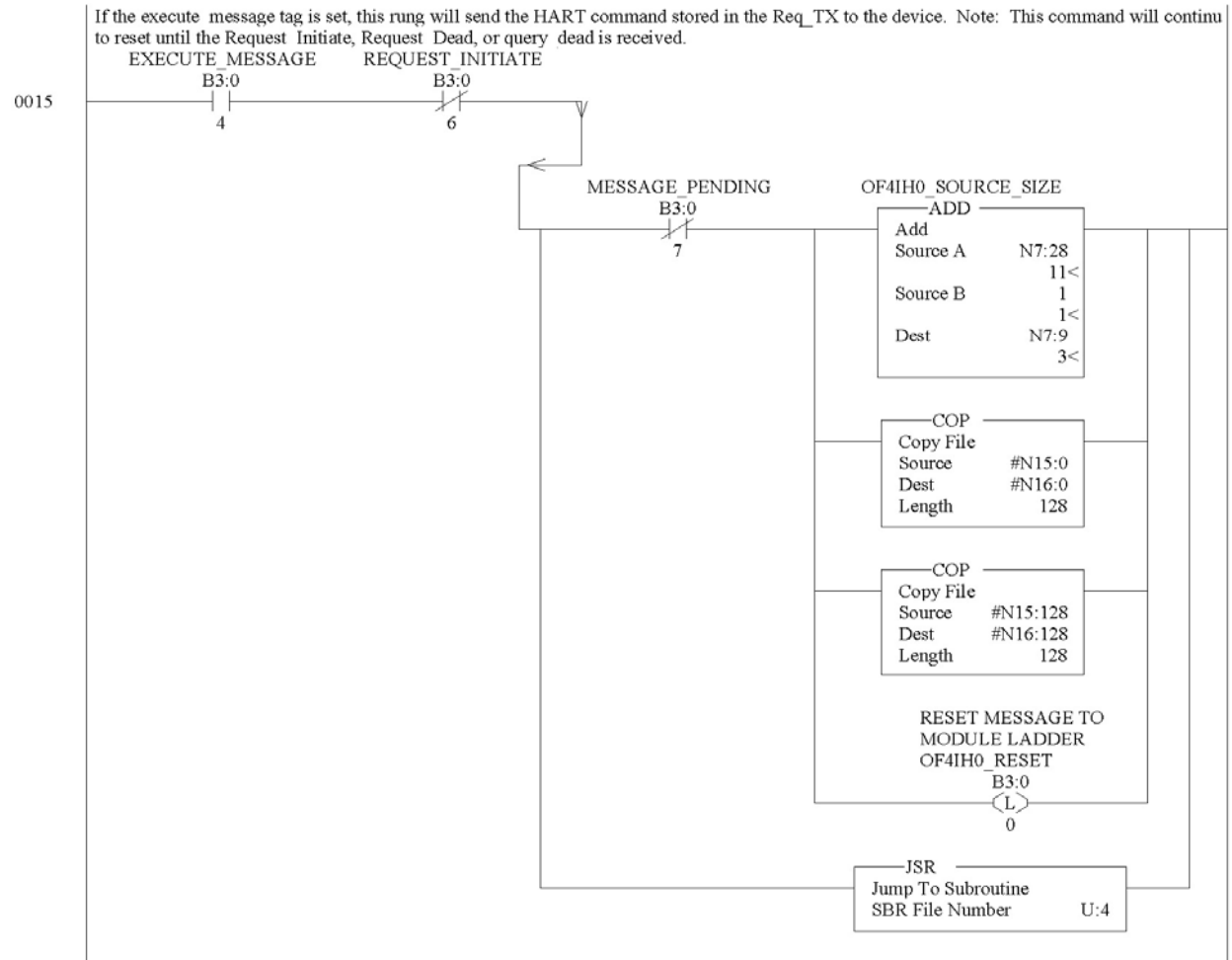


Figure 8-14h

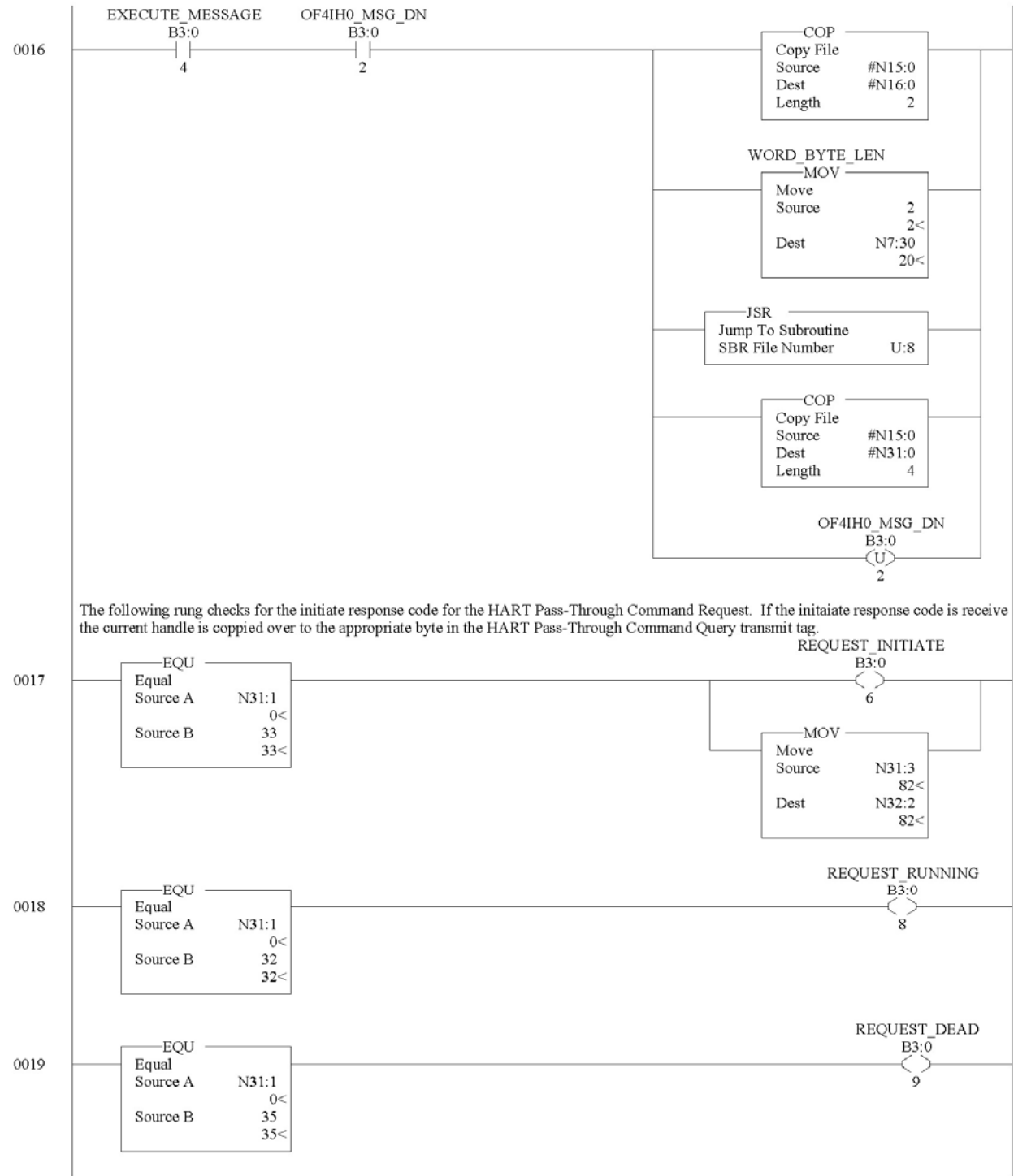


Figure 8-14i

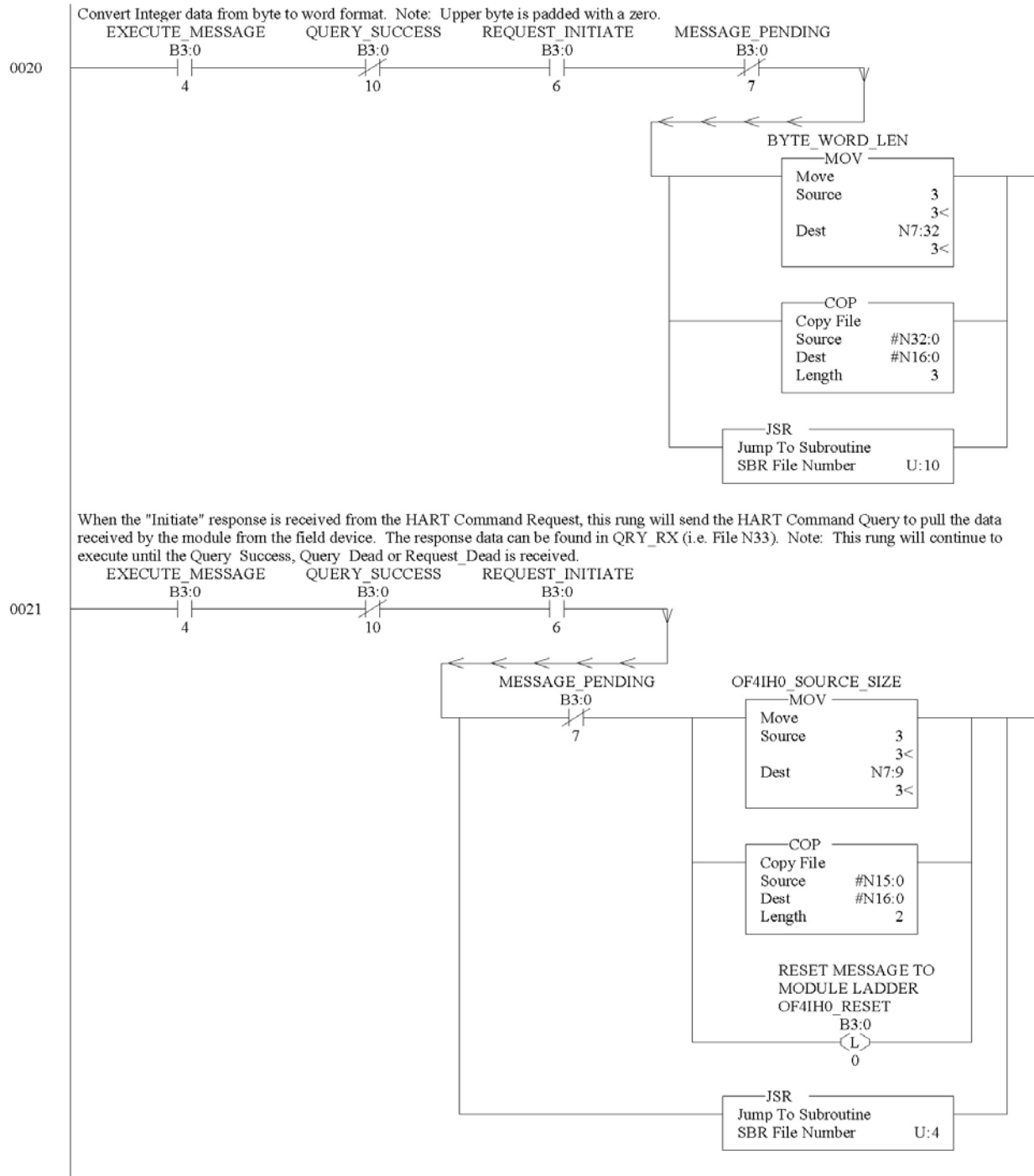


Figure 8-14j

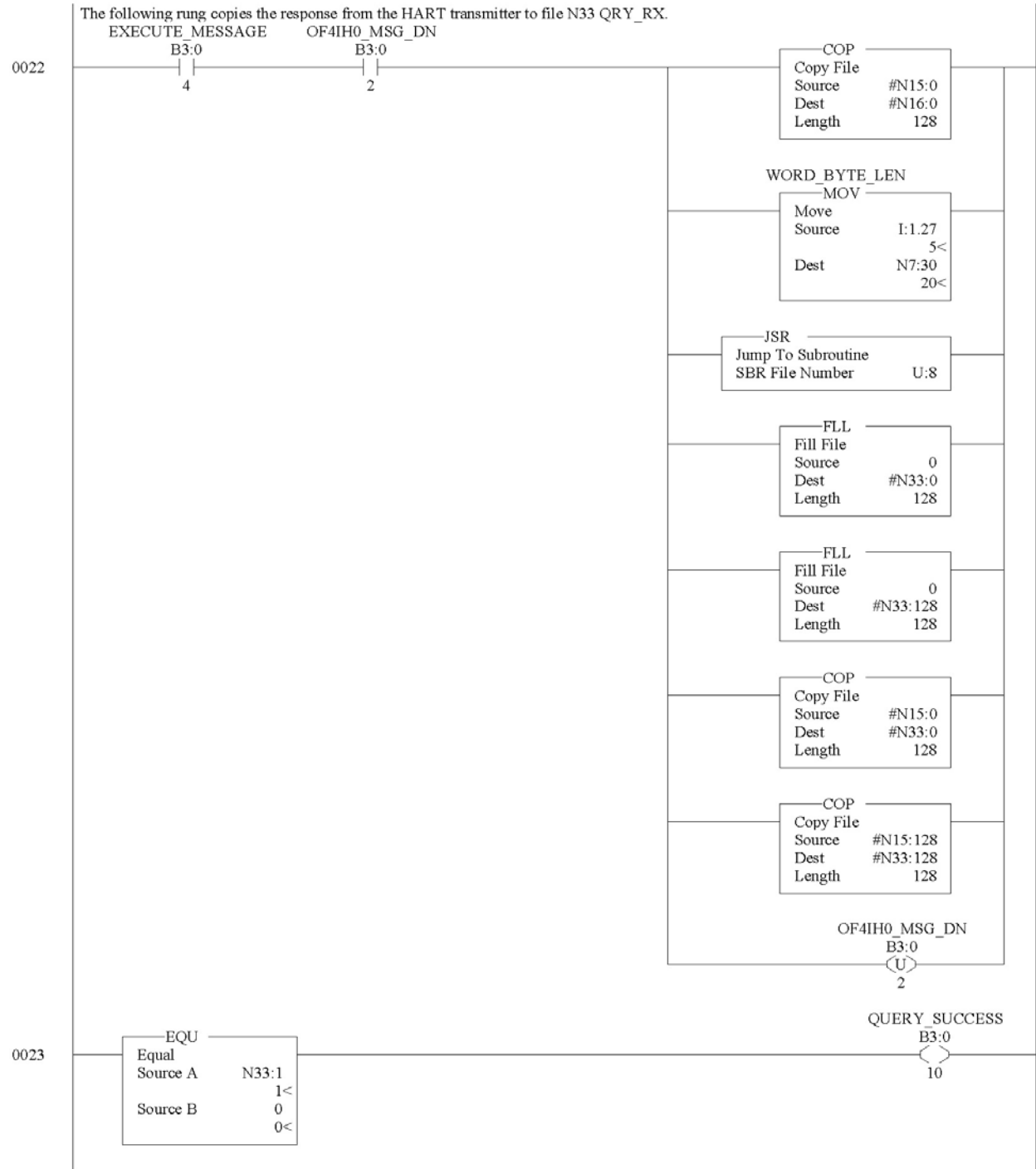
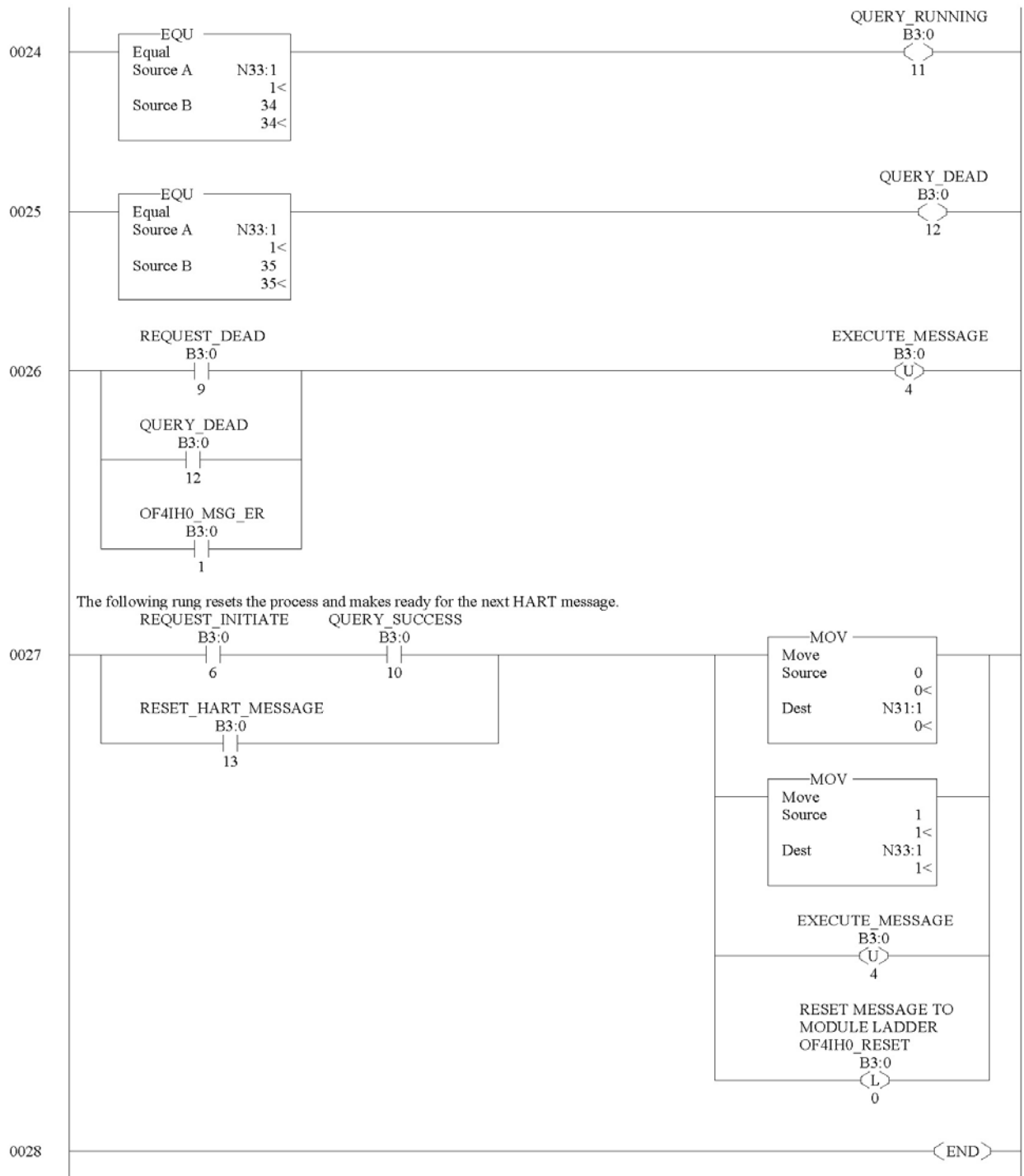


Figure 8-14k



8.2.7 WORD_BYTE Routine

Converts word data to its byte equivalent. This routine is called from the HART_MSG routine.

Figure 8-15a (Word to Byte)

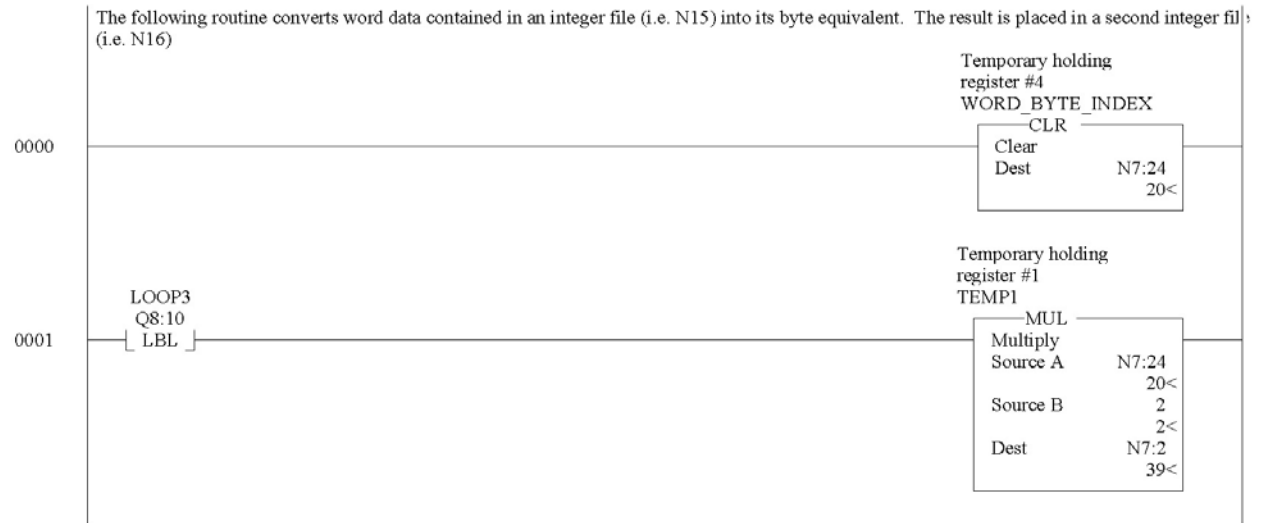


Figure 8-15b

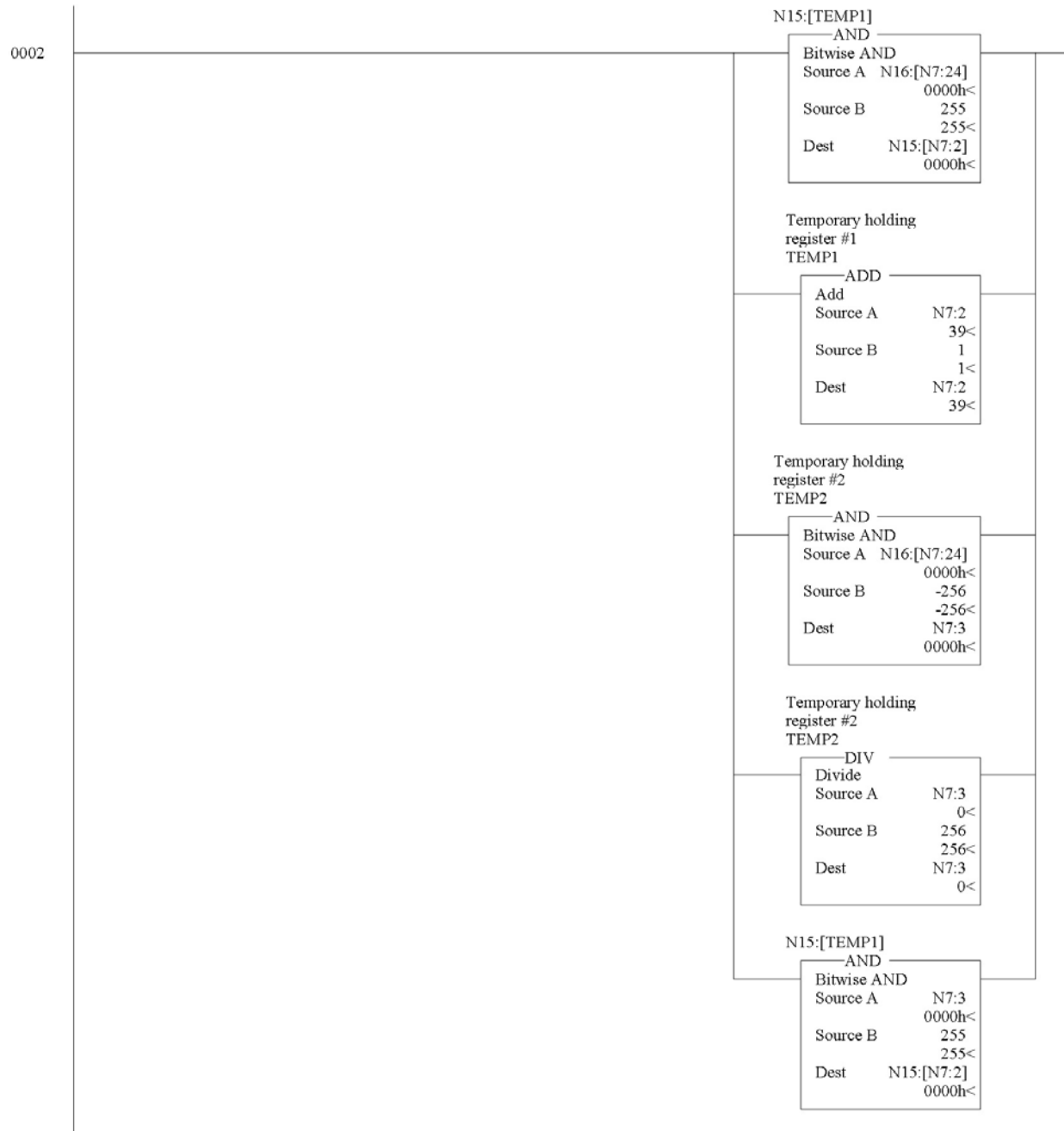
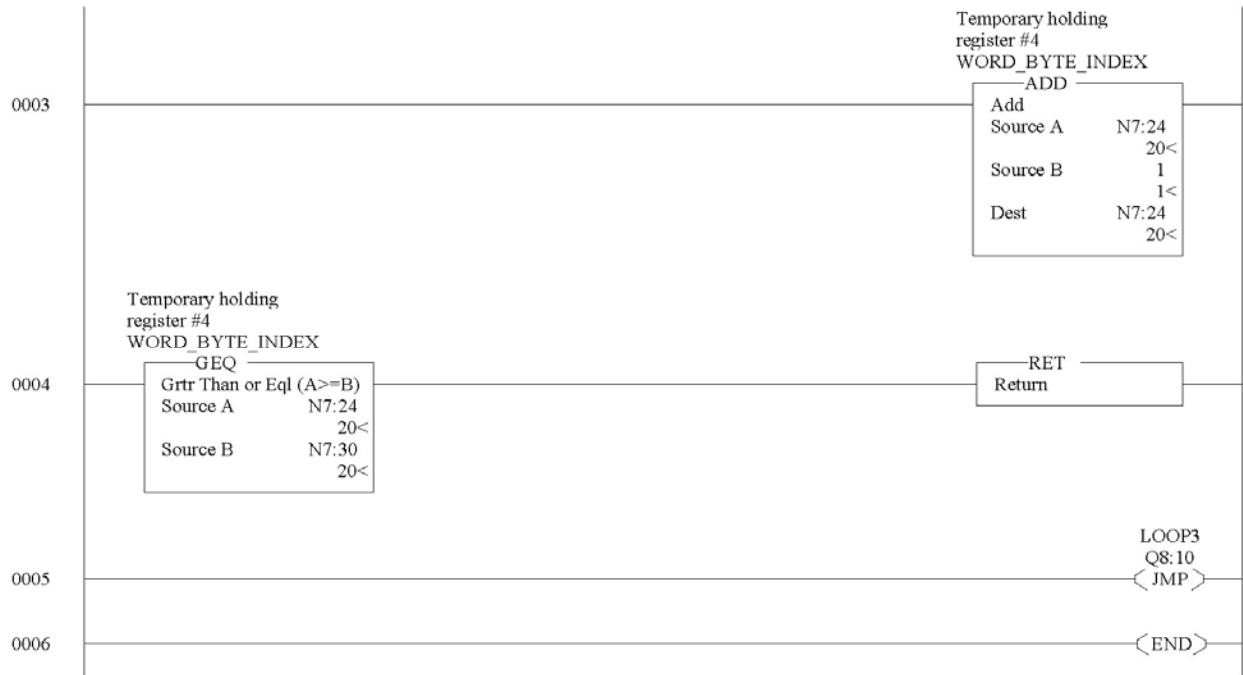


Figure 8-15c



8.2.8 HART_CHECK Routine

Calculates the checksum for the HART message being sent to the module/field device.
This routine is called from the HART_MSG routine.

Figure 8-16a (HART Checksum)

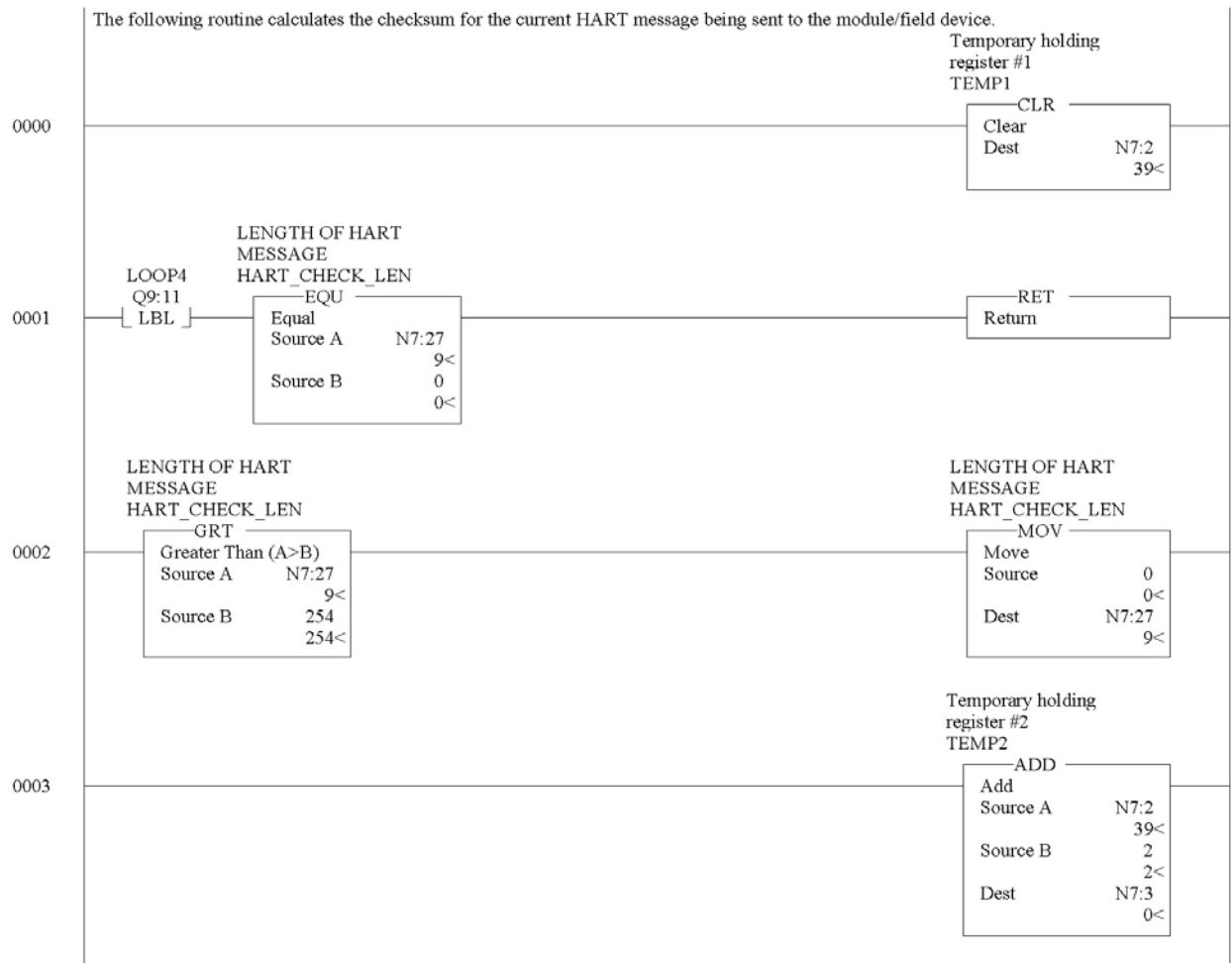
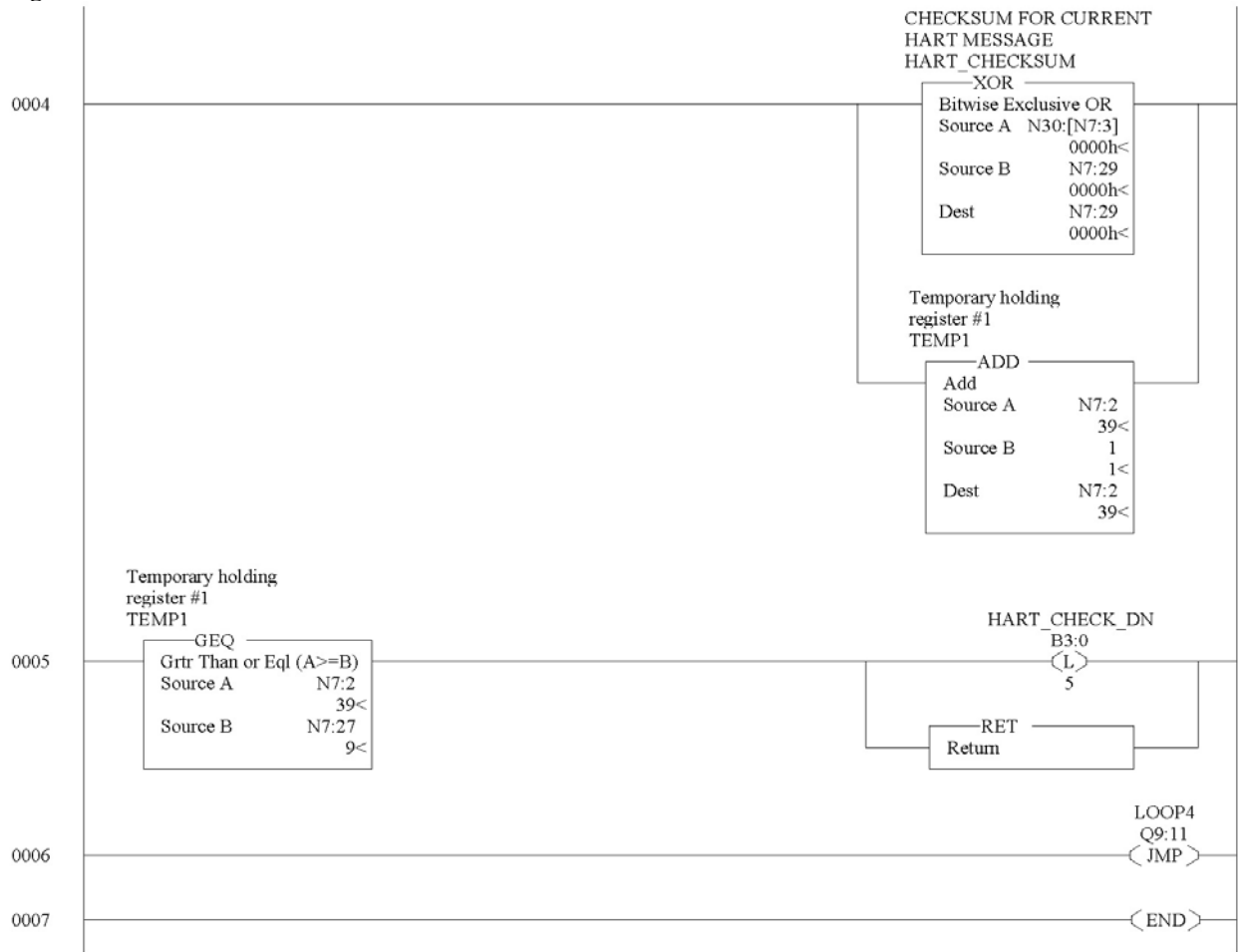


Figure 8-16b



8.2.9 BYTE_WORD Routine

Converts byte data to its word equivalent. This routine is called by the HART_MSG routine.

Figure 8-17a (Byte to Word)

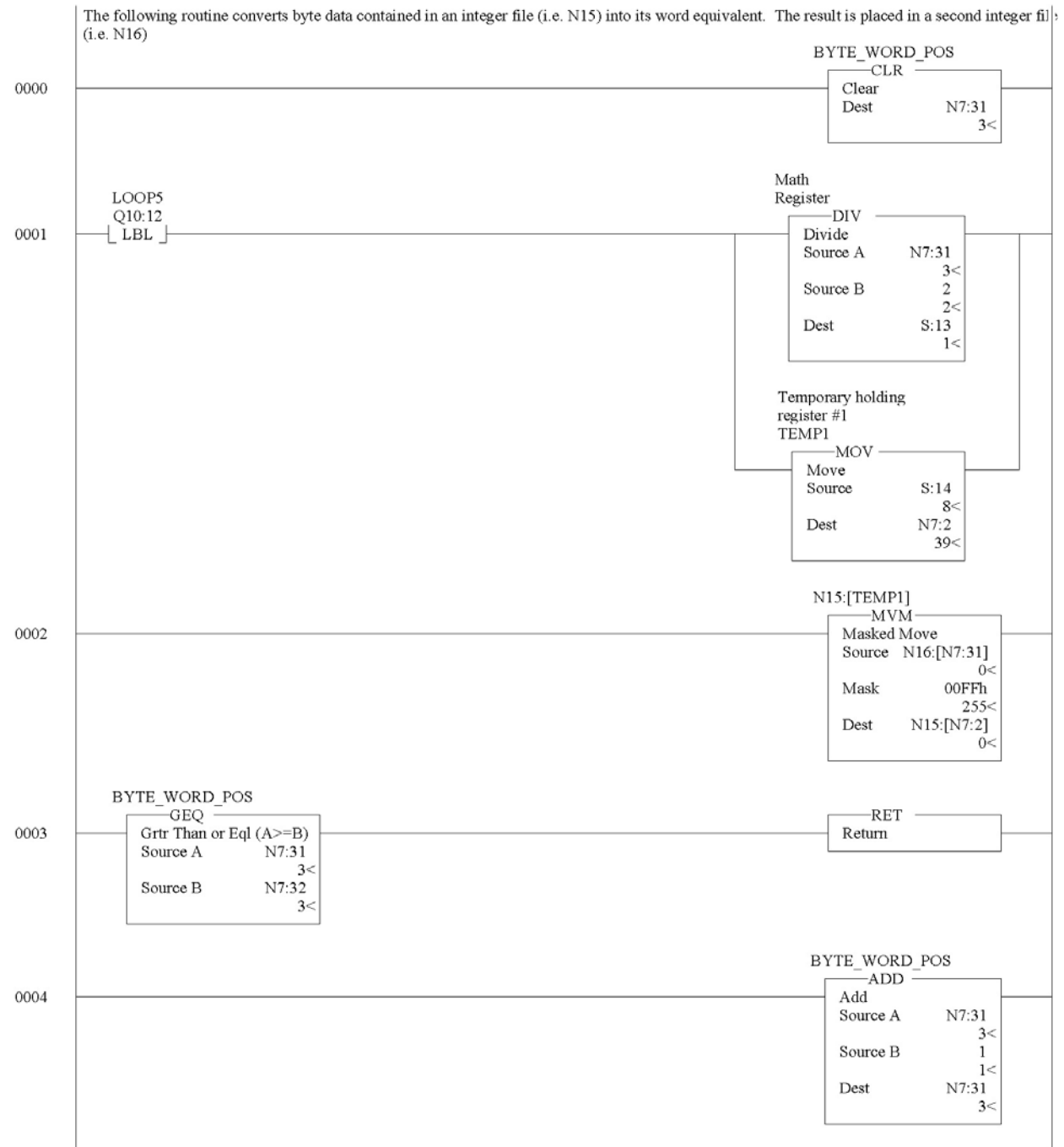
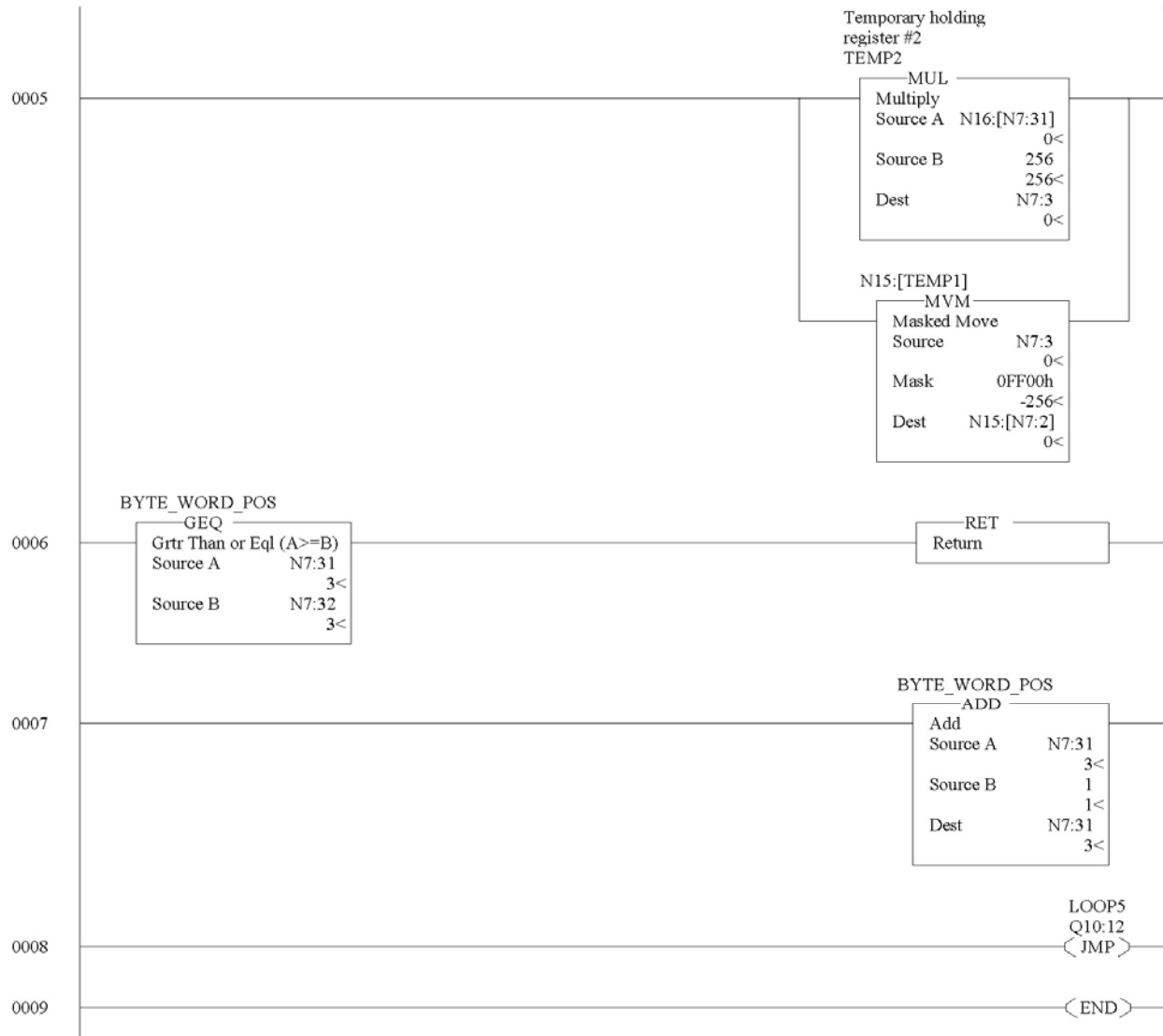


Figure 8-17b



Chapter 9

Diagnostics and Troubleshooting

This chapter describes troubleshooting the isolated HART output module. This chapter contains information on:

- Safety considerations while troubleshooting
- Internal diagnostics during module operation
- Module error codes
- Contacting Spectrum Controls, Inc. for technical assistance

Section 9.1 Safety Considerations

Safety considerations are an important element of proper troubleshooting procedures. Actively thinking about the safety of yourself and others, as well as the condition of your equipment, is of primary importance.

The following sections describe several safety concerns you should be aware of when troubleshooting your control system.



Attention

Never reach into a machine to actuate a switch because unexpected motion can occur and cause injury. Remove all electrical power at the main power disconnect switches before checking electrical connections or inputs/ outputs causing machine motion.

9.1.1 Indicator Lights

When the green LED on the module is illuminated, it indicates that power is applied to the module and that it has passed its internal tests.

9.1.2 Stand Clear of Equipment

When troubleshooting any system problem, have all personnel remain clear of the equipment. The problem could be intermittent, and sudden unexpected machine motion could occur. Have someone ready to operate an emergency stop switch in case it becomes necessary to shut off power.

9.1.3 Program Alteration

There are several possible causes of alteration to the user program, including extreme environmental conditions, Electromagnetic Interference (EMI), improper grounding, improper wiring connections, and unauthorized tampering. If you suspect a program has been altered, check it against a previously saved master program.

9.1.4 Safety Circuits

Circuits installed on the machine for safety reasons, like over-travel limit switches, stop push buttons, and interlocks, should always be hard-wired to the master control relay. These devices must be wired in series so that when any one device opens, the master

control relay is de-energized, thereby removing power to the machine. Never alter these circuits to defeat their function. Serious injury or machine damage could result.

Section 9.2 Module Operation vs. Channel Operation

The module performs diagnostic operations at both the module level and the channel level. Module-level operations include functions such as power-up, configuration, and communication with a 1769 bus master, such as a MicroLogix 1500 controller, 1769-ADN DeviceNet Adapter, or CompactLogix controller.

Channel-level operations describe channel related functions, such as data conversion and over- or under-range detection.

Internal diagnostics are performed at both levels of operation. When detected, module error conditions are immediately indicated by the module status LED. Both module hardware and channel configuration error conditions are reported to the controller. Channel over-range or under-range conditions are visible in the module's input data table. Module hardware errors are typically reported in the controller's I/O status file. Refer to your controller manual for details.

Section 9.3 Power-up Diagnostics

At module power-up, a series of internal diagnostic tests are performed. If these diagnostic tests are not successfully completed, the module status LED remains off and a module error is reported to the controller.

Table 9-1 (LED Status)

If module status LED is:	Indicated condition	Corrective action:
On	Proper Operation	No action required
Off	Module Fault	Cycle power. If condition persists, replace the module. Call your local distributor or Spectrum Controls for assistance.

Section 9.4 Channel Diagnostics

When an output channel is enabled, the module performs a diagnostic check to see that the channel has been properly configured. In addition, the channel is tested on every scan for configuration errors, over-range and under-range conditions.

9.4.1 Invalid Channel Configuration Detection

Whenever a channel configuration word is improperly defined, the module reports an error. See Table 9-4 for a description of module errors.

9.4.2 Over or Under-Range Detection

Whenever a channel is commanded to an output level outside of the defined operating range, an over-range or under-range error is indicated in input data word 1. Possible causes of an out-of-range condition include:

- The output device is faulty.
- The field wiring may be faulty.
- The *low clamp* or *high clamp* values have been exceeded

Section 9.5 Non-critical vs. Critical Module Errors

Non-critical module errors are typically recoverable. Channel errors (over-range or under-range errors) are non-critical. Non-critical error conditions are indicated in the module input data table.

Critical module errors are conditions that may prevent normal or recoverable operation of the system. When these types of errors occur, the system typically leaves the run or program mode of operation until the error can be dealt with. Critical module errors are indicated in Table 9-4 (Extended Fault Codes).

Section 9.6 Module Error Definition Table

Analog module errors are expressed in two fields as four-digit Hex format with the most significant digit as “don’t care” and irrelevant. The two fields are “Module Error” and “Extended Error Information”. The structure of the module error data is shown below.

Table 9-2 (Module Error Table)

"Don't Care" Bits				Module Error			Extended Error Information								
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hex Digit 4				Hex Digit 3			Hex Digit 2				Hex Digit 1				

9.6.1 Module Error Field

The purpose of the module error field is to classify module errors into three distinct groups, as described in the table below. The type of error determines what kind of information exists in the extended error information field. These types of module errors are typically reported in the controller’s I/O status file. Refer to your controller manual for details.

Table 9-3 (Module Error Types)

Error Type	Module Error Field Value Bits 11 through 9 (binary)	Description
No errors	000	No error is present. The extended error field holds no additional information.
Hardware Errors	001	General and specific hardware error codes are specified in the extended error information field.
Configuration Errors	010	Module-specific error codes are indicated in the extended error field. These error codes correspond to options that you can change directly. For example, the input range or input filter selection.

9.6.2 Extended Error Information Field

Check the extended error information field when a non-zero value is present in the module error field. Depending upon the value in the module error field, the extended error information field can contain error codes that are module-specific or common to all 1769 analog modules.

Note: If no errors are present in the module error field, the extended error information field is set to zero.

Hardware Errors

General or module-specific hardware errors are indicated by module error code 001. See Table 9-4 (Extended Fault Codes).

Configuration Errors

If you set the fields in the configuration file to invalid or unsupported values, the module generates a critical error.

Table 9-4 (Extended Fault Codes) lists the possible module-specific configuration error codes defined for the module.

Section 9.7 Error Codes

The table below explains the extended error code.

Table 9-4 (Extended Fault Codes)

Error Type	Hex Equivalent	Module Error Code	Extended Error Information Code	Error Description
No error	X000	000	0 0000 0000	No error
Hardware-Specific Error	X216	001	0 0001 0110	Watchdog reset error
	X220	001	0 0010 0000	Critical code failure
	X221	001	0 0010 0001	Failed calibration/critical EEPROM failure
Module-Specific Configuration Error	X401	010	0 0000 0001	Channel 0 Invalid Output Range
	X402	010	0 0000 0010	Channel 1 Invalid Output Range
	X403	010	0 0000 0011	Channel 2 Invalid Output Range
	X404	010	0 0000 0100	Channel 3 Invalid Output Range
	X405	010	0 0000 0101	Channel 0 Invalid Data Format
	X406	010	0 0000 0110	Channel 1 Invalid Data Format
	X407	010	0 0000 0111	Channel 2 Invalid Data Format
	X408	010	0 0000 1000	Channel 3 Invalid Data Format
	X409	010	0 0000 1001	Channel 0 Invalid Fault Value.
	X40A	010	0 0000 1010	Channel 1 Invalid Fault Value.
	X40B	010	0 0000 1011	Channel 2 Invalid Fault Value.
	X40C	010	0 0000 1100	Channel 3 Invalid Fault Value.
	X40D	010	0 0000 1101	Channel 0 Invalid Idle Value.
	X40E	010	0 0000 1110	Channel 1 Invalid Idle Value.
	X40F	010	0 0000 1111	Channel 2 Invalid Idle Value.
	X410	010	0 0001 0000	Channel 3 Invalid Idle Value.
	X411	010	0 0001 0001	Channel 0 Invalid Clamps.
	X412	010	0 0001 0010	Channel 1 Invalid Clamps.
	X413	010	0 0001 0011	Channel 2 Invalid Clamps.
	X414	010	0 0001 0100	Channel 3 Invalid Clamps.
	X415	010	0 0001 0101	Channel 0 Invalid Ramp Rate.
	X416	010	0 0001 0110	Channel 1 Invalid Ramp Rate.
	X417	010	0 0001 0111	Channel 2 Invalid Ramp Rate.
	X418	010	0 0001 1000	Channel 3 Invalid Ramp Rate.
X419	010	0 0001 1001	Channel 0 Config word 0 Illegal bits set	
X41A	010	0 0001 1010	Channel 1 Config word 0 Illegal bits set	
X41B	010	0 0001 1011	Channel 2 Config word 0 Illegal bits set	
X41C	010	0 0001 1100	Channel 3 Config word 0 Illegal bits set	
X41D	010	0 0001 1101	Channel 0 Config word 1 Illegal bits set	
X41E	010	0 0001 1110	Channel 1 Config word 1 Illegal bits set	
X41F	010	0 0001 1111	Channel 2 Config word 1 Illegal bits set	
X420	010	0 0010 0000	Channel 3 Config word 1 Illegal bits set	
X421	010	0 0010 0001	Channel 0 Illegal HART Passthrough rate.	
X422	010	0 0010 0010	Channel 1 Illegal HART Passthrough rate.	
X423	010	0 0010 0011	Channel 2 Illegal HART Passthrough rate.	
X424	010	0 0010 0100	Channel 3 Illegal HART Passthrough rate.	

Section 9.8 Module Inhibit Function

Some controllers support the module inhibit function. See your controller manual for details.

Whenever the 1769sc-OF4IH module is inhibited, the module continues to provide information about changes at its outputs to the 1769 CompactBus master (for example, a CompactLogix controller).

Appendix A

Module Specifications

Electrical Specifications

Number of Channels	4 single isolated outputs with HART	
Output Ranges	0 to 20.0 mA and 4 to 20mA	
Output Load	750 ohm max.	
Resolution	16 bits over full design range (0-21.24mA)	
Full Scale Settling Time	<2.9ms to 63% of full scale	
Analog Output Update Rate	10ms update of all 8 channels	
Differential Nonlinearity	+/-0.05% full scale based on 4-20mA range.	
Output Ripple	+/-0.05%, or better full scale 0-50kHz	
Repeatability	+/-0.05% full scale	
Max Inductive Load	0.1mH	
Output Impedance	> 1 Megohm	
Accuracy	Temperature	Accuracy (% Full Scale)
	25°C	0.35%
	0 to 60°C	0.55%
Calibration	Modules will be factory-calibrated.	
ISOLATION VOLTAGE	710VDC terminal block to back plane continuous 710VDC Channel to Channel continuous 710VDC terminal block to Frame Ground continuous	
Maximum Backplane Current draw	180mA @ 5VDC, 180mA @ 24VDC	
Thermal Dissipation	4.2 W at 21.0 mA current all channels with 250ohm minimum load.	
Maximum Slot Distance	8 for backplane +24V	
Overvoltage Protection	+24V continuous on any current output	
Power on/off channel glitch	Under +/- 1V for 2ms. Target: +/-0.5V spike for <5ms	
Open and Short Ckt Protection	Yes, continuous. (EN61131-2 requirement)	

Environmental Specifications

Shock & Vibration (op)	Class III
Shock Unpackaged (op)	Class III, Cat. I
Operating Temperature	0 to 60 Degree C ¹
Storage Temperature	-40 to 85 Degree C
Humidity/Pressure	5 to 95% RH (non cond.)

Regulatory Compliance

UL 508

UL 1604

UL-C Class 1, Div2 Group A, B, C, D (CSA Equiv.)

CE compliance to EN 61010-1 and EN 61131-2, EN55011, EN50082-2, and EN61000-6-

¹ Avoid installing the module adjacent to modules with heat dissipation greater than 4 Watts when the ambient temperature is in excess of 55°C. See *Section 3.3.4 Selecting a Location*, for more details.

Appendix B

HART Universal and Common Practice Commands

COMMAND NUMBER AND FUNCTION	DATA IN COMMAND (TYPE)	DATA IN REPLY	(TYPE)
0 Read unique identifier	none	Byte 0 "254" (expansion) Byte 1 manufacturer identification code Byte 2 mfr's device type code Byte 3 number of preambles Byte 4 universal command revision Byte 5 transmitter-specific cmd revision Byte 6 software revision Byte 7 hardware revision (H) Byte 8 device function flags (B) Byte 9-11 device ID number	
1 Read primary variable	none	Byte 0 PV units code Byte 1-4 primary variable (F)	
2 Read current and percent of range	none	Byte 0-3 current (mA) (F) Byte 4-7 percent of range (F)	
3 Read current and four (predefined) dynamic variables	none	Byte 0-3 current (mA) (F) Byte 4 PV units code Byte 5-8 primary variable (F) Byte 9 SV units code Byte 10-13 second variable (F) Byte 14 TV units code Byte 15-18 third variable (F) Byte 19 FV units code Byte 20-23 fourth variable (F)	
6 Write polling addr.	Byte 0 polling address	as in command	
11 Read unique ident. associated with tag	Byte 0-5 tag (A)	as command 0	
12 Read message	none	Byte 0-23 message (A)	
13 Read tag, descriptor, date	none	Byte 0-5 tag (A) Byte 6-17 descriptor (A) Byte 18-20 date (D)	
14 Read PV sensor information	none	Byte 0-2 sensor serial number Byte 3 units code for sensor limits and min span Byte 4-7 upper sensor limit (F) Byte 8-11 lower sensor limit (F) Byte 12-15 minimum span (F)	
15 Read output information	none	Byte 0 alarm select code Byte 1 transfer function code Byte 2 PV/range units code Byte 3-6 upper range value (F) Byte 7-10 lower range v (F) Byte 11-14 damping value (sec) (F) Byte 15 write-protect code Byte 16 private-label distributor code	
16 Read final assembly number	none	Byte 0-2 final assembly number	
17 Write message	Byte 0-23 message (A)		
18 Write tag, descriptor, date	Byte 0-5 tag (A) Byte 6-17 descriptor (A) Byte 18-20 date (D)	as in command	
19 Write final assembly number	Byte 0-2 final assembly number	as in command	

COMMAND NUMBER AND FUNCTION	DATA IN COMMAND	(TYPE)	DATA IN REPLY	(TYPE)
51 Write dynamic variable assignments	Byte 0 Byte 1 Byte 2 Byte 3	PV transmitter variable code SV transmitter variable code TV transmitter variable code FV transmitter variable code	as in command	
52 Set transmitter variable zero	Byte 0	transmitter variable code	as in command	
53 Write transmitter variable units	Byte 0 Byte 1	transmitter variable code transmitter var. units code	as in command	
54 Read transmitter variable information	Byte 0	transmitter variable code	Byte 0 transmitter variable code Byte 1-3 transm. var. sensor serial number Byte 4 transm. var. limits units code Byte 5-8 transm. variable upper limit (F) Byte 9-12 transm. variable lower limit (F) Byte 13-16 transm. var. damping value (sec)(F)	
55 Write transmitter variable damping value	Byte 0 Byte 1-4	transmitter variable code transmitter variable damping value (sec) (F)	as in command	
56 Write transmitter variable sensor serial number	Byte 0 Byte 1-3	transmitter variable code transmitter variable sensor serial number	as in command	
57 Read unit tag, descriptor, date	none		Byte 0-5 unit tag (A) Byte 6-17 unit descriptor (A) Byte 18-20 unit date (D)	
58 Write unit tag, descriptor, date	Byte 0-5 Byte 6-17 Byte 18-20	unit tag (A) unit descriptor (A) unit date (D)	as in command	
59 Write number of response preambles	Byte 0	number of response preambles	as in command	
108 Write burst mode command number	Byte 0	burst mode command number	as in command	
109 Burst mode control	Byte 0	burst mode control code (0 = exit, 1 = enter)	as in command	
110 Read all dynamic variables	none		Byte 0 PV units code Byte 1-4 PV value (F) Byte 5 SV units code Byte 6-9 SV value (F) Byte 10 TV units code Byte 11-14 TV value (F) Byte 15 FV units code Byte 16-19 FV value (F)	

*Data types:**A ASCII string (packed 4 characters per 3 bytes)**B Bit-mapped flags (bit 0 = multisensor device; bit 1 = EEPROM control required)**D Date (day, month, year—1900)**F Floating point (4 bytes IEEE 754)**H Integers xxxxx yyy (xxxxx = hardware rev., yyy = physical signalling code)**Unmarked items are 8-, 16- or 24-bit integers*

First byte:

BIT 7 = 1 COMMUNICATION ERRORS:	
Bit 6	parity error
Bit 5	overrun error
Bit 4	framing error
Bit 3	checksum error
Bit 2	(reserved)
Bit 1	rx buffer overflow
Bit 0	(undefined)

Second byte:

Bit 7	
Bit 6	
Bit 5	
Bit 4	all 0
Bit 3	
Bit 2	
Bit 1	
Bit 0	

First byte:

BIT 7 = 0 COMMAND ERRORS:	
Bits 6 to 0 (not bit-mapped):	
0	no command-specific error
1	(undefined)
2	invalid selection
3	passed parameter too large
4	passed parameter too small
5	too few data bytes received
6	transmitter-specific command error
7	in write-protect mode
8-15	command-specific errors (see Table 4 below)
16	access restricted
32	device is busy
64	command not implemented

Second byte:

Bit 7(hex 80)	device malfunction
Bit 6	configuration changed
Bit 5	cold start
Bit 4	
Bit 3	output current fixed
Bit 2	analog output saturated
Bit 1	variable (not primary) out of limits
Bit 0	primary variable out of limits

Hex equivalents are shown, assuming only a single status indication is present.

These codes have different meanings for different commands. The following table lists some of these meanings. Refer to the full HART specification for information on which codes and meanings are used with each command.

TABLE 4-4. Command-Specific Error Codes.

CODE	MEANING
8	Update Failed Update In Progress Set to Nearest Possible Value
9	Applied Process Too High Lower Range Value Too High Not In Fixed Current Mode
10	Applied Process Too Low Lower Range Value Too Low MultiDrop Not Supported
11	In MultiDrop Mode Invalid Transmitter Variable Code Upper Range Value Too High
12	Invalid Unit Code Upper Range Value Too Low
13	Both Range Values Out of Limits
14	Pushed Upper Range Value Over Limit Span Too Small

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Getting Technical Assistance

Note that your module contains electronic components which are susceptible to damage from electrostatic discharge (ESD). An electrostatic charge can accumulate on the surface of ordinary plastic wrapping or cushioning material.

In the unlikely event that the module should need to be returned to Spectrum Controls, please ensure that the unit is enclosed in approved ESD packaging (such as static-shielding / metallized bag or black conductive container). Spectrum Controls reserves the right to void the warranty on any unit that is improperly packaged for shipment.

For further information or assistance, please contact your local distributor, or call the Spectrum Controls technical Support at:

USA - 425-746-9481

Declaration of Conformity

Available upon request



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