Instruction Manual
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Using Modbus® Protocol with Micro Motion® Transmitters

Micro Motion™

EMERSON™
Process Management

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Using Modbus® Protocol with Micro Motion® Transmitters

July 2002

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• In the U.S.A., phone 1-800-522-6277, 24 hours
• In the Americas outside the U.S.A., phone 303-530-8400, 24 hours
• In Europe, phone +31 (0) 318 549 443
• In Asia, phone 65-770-8155

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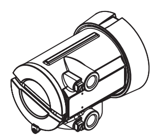
Introduction

1 Before You Begin

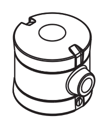
1.1 What this manual tells you

This manual describes the use of Modbus® protocol for configuration, operation, and maintenance of the Micro Motion® flowmeter components that support Modbus protocol.

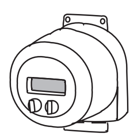
Micro Motion flowmeter components that support Modbus protocol include:



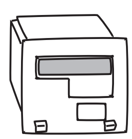
Series 1000 and 2000 transmitters, all versions



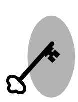
Core processor stand-alone (MVDSolo)



Field-mount Model RFT9739 transmitters, Version 2 and higher



Rack-mount Model RFT9739 transmitters, Version 2 and higher



Keys to using this manual
This manual is a comprehensive reference for using Modbus protocol with Micro Motion transmitters. Tables throughout this manual contain checkmarks (√) that identify the implementations for which each mapped address is available.

Throughout this manual, when binary variables are discussed, a value of 0 represents OFF and a value of 1 represents ON, unless otherwise specified. The term “set” is used to mean writing a value of 1 to the specified coil, and the term “reset” is used to mean writing a value of 0 to the specified coil.

Micro Motion strongly recommends that you make a record of your transmitter configuration. See **Section 1.4**, page 5.

1.2 Organization of this manual

This manual is organized into three major sections:

- Introduction
- Configuration
- Maintenance

Each section contains several chapters. The section name is displayed on the first page of each chapter, above the chapter number.

1.3 How to use this manual

This manual focuses on using Modbus protocol for transmitter configuration, operation, and maintenance. It is not designed as a operations or reference manual for either the sensor or the transmitter. For more detailed information on these components, refer to the manuals supplied with the transmitter or sensor.

This manual describes how to perform setup, configuration, calibration, and troubleshooting procedures using the Modbus protocol. Some procedures are required; others are optional.

Information on using the Modbus protocol is provided in **Chapter 4** and **Appendix B**.

Required procedures

In all cases, you must:

- Enable Modbus protocol (see **Chapter 3**)
- Zero the flowmeter (see **Chapter 18**)

Flowmeter zero establishes flowmeter response to zero flow and sets a baseline for flow measurement.

⚠ CAUTION

Failure to zero the flowmeter at initial startup could cause the flowmeter to produce inaccurate signals.

Zero the flowmeter before putting it into operation. To zero the flowmeter, see **Chapter 18**.

If your flowmeter is on a multidrop network, you must configure its polling address (see **Chapter 5**).

Other procedures

Review **Chapter 6** for configuration information related to your transmitter, option board, and network.

Characterization may or may not be required:

- When a complete flowmeter (transmitter and sensor combination) is ordered, the individual units are characterized for each other at the factory. You may customize the configuration as desired or required by your application.
- If the components are ordered separately, or one component is replaced in the field, the units are not characterized for each other.

These procedures must be performed. You can then customize the configuration as described above.

Additionally, field calibration and related procedures may be required if:
- The application is highly sensitive to density or temperature
- Transmitter outputs must be matched to a specific reference standard, receiver, or readout device

Finally, a master reset sets all values in transmitter memory to pre-characterization factory defaults. Complete reconfiguration of the transmitter is required after a master reset.

⚠ CAUTION

Contact Micro Motion customer support before performing a master reset.

Perform a master reset only after all other options have been explored.

Characterization

Characterization is the process of writing sensor-specific information to the transmitter, for example:
- The flow calibration factor describes a particular sensor's sensitivity to flow.
- Density factors describe a particular sensor's sensitivity to density.
- The temperature calibration factor describes the slope and offset of the equation used for calculating temperature.

If the transmitter is not characterized for the sensor in use, measurement error will result.

Characterization procedures are described in **Chapter 17**.

Calibration

Calibration accounts for performance variations in individual sensors, transmitters, and peripheral devices, for example:
- Flowmeter zeroing establishes flowmeter response to zero flow and sets a baseline for flow measurement.
- Density calibration adjusts factors used by the transmitter in calculating density.
- Temperature calibration adjusts factors used by the transmitter in calculating temperature. Temperature calibration is not recommended.

Field calibration overwrites some or all of the values written during characterization. Calibration procedures are described in **Chapter 18** through **Chapter 21**.

Customizing the configuration

To customize the flowmeter for your application, use the following general procedure.

1. Configure your transmitter with basic information about the sensor (see **Chapter 5**).

2. Configure your transmitter's option boards, outputs, and communications (see **Chapter 6**).

3. Determine what process variable or variables you will measure. A process variable is any of the variables that can be measured by the sensor. The following process variables may be measured (not all flowmeters measure all process variables):
   - Mass flow rate
   - Mass total
   - Mass inventory
   - Volume flow rate
   - Volume total
   - Volume inventory
   - Density
   - Temperature
   - Pressure

   Mass total and volume total are used for "batches." These process variables can be reset to 0. Mass inventory and volume inventory track values over time, across batches, and are typically never reset.

4. Determine what measurement units will be used for the selected process variables. Configure the flowmeter to use these measurement units. (See **Chapter 7** and **Chapter 8**.)

5. Decide how you will read process variable data. You can read the values dynamically from the transmitter registers or you can map them to outputs. You can use both methods, unless you are using MVDSolo, which does not provide outputs.

   If a process variable is mapped to an output, the data are automatically sent to an external device such as a host controller.

6. Adjust the process variable measurements for various field conditions (see **Chapter 10**).

7. If you will use outputs to report process data:
   - Decide which process variable will be mapped to which output.
   - Perform the mapping (see **Chapter 9**).

8. Perform additional output configuration (see **Chapter 11**). Typical configuration includes:
   - Defining fault indicators
   - Defining process controls

9. Review the remainder of this manual and follow instructions for any features that are relevant to your application.

1.4 Recording transmitter configuration

After completing transmitter configuration, you should record the configuration.

If you are using Micro Motion® ProLink II™ Version 1.1 or higher, you can download the transmitter configuration to your computer system. See the ProLink documentation for instructions.

If you do not have ProLink, use the configuration record provided in **Appendix C**.

1.5 What this manual does not tell you

This manual does *not* explain terminology and procedures for using Modbus protocol, or how to use a host controller to communicate with other devices in a Modbus-compatible multidrop network. For detailed information about using Modbus protocol, visit http://www.modicon.com.

This manual does *not* explain transmitter installation or wiring. For information about installation and wiring, see the transmitter and sensor installation manuals. To order manuals, see below.

1.6 Customer service

For customer service, or to order manuals:

- Inside the U.S.A., phone 1-800-522-6277, 24 hours
- In South America, Central America, and North America outside the U.S.A., phone 303-530-8400, 24 hours
- In Europe, phone +31 (0) 318 549 443
- In Asia, phone 65-770-8155
- Visit us on the Internet at http://www.micromotion.com

Introduction

2 Introduction to Modbus Protocol with Micro Motion Transmitters

2.1 About this chapter

This chapter provides an introduction to using Modbus protocol with Micro Motion transmitters.

2.2 Introduction to Micro Motion transmitters

The Micro Motion transmitter is designed to provide fluid process measurement and control. The transmitter works with a Micro Motion sensor to measure mass flow, fluid density, and temperature.

The transmitter emulates a Modbus programmable logic controller (PLC) in an RS-485 multidrop network. The transmitter supports 7-bit American Standard Code for Information Interchange (ASCII) or 8-bit Remote Terminal Unit (RTU) data transmission mode with a subset of read commands, write commands, and diagnostic commands used by most Modbus host controllers.

This manual addresses the use of Modbus protocol with the following transmitter types:

- MVDSolo (core processor stand-alone)
- Series 1000
- Series 2000
- RFT9739

MVDSolo vs. Series 1000 or 2000 transmitter

The core processor is not a transmitter per se. The core processor component stores configuration information, receives signal inputs from the sensor, and processes these inputs to yield process data. The process data are available in core processor memory, for direct access from a host controller.

The core processor can be used without a transmitter. In this case, the core processor communicates directly with an external host. This implementation is called “MVDSolo” if no barrier is installed between the core processor and the external host, or “MVD Direct Connect” if a barrier is installed.

In addition, all Series 1000 and 2000 transmitter implementations include the core processor. The transmitter adds output functionality to the basic core processor functionality. The Series 1000 or 2000 transmitter may also supply a display. No display is provided with MVDSolo.

MVDSolo functions are identical to Series 1000 and 2000 functions except for display and output functions.

Note: The term "MVD®" means "Multi Variable Digital." It refers to the type of processing that is performed in the core processor and Series 1000 or 2000 transmitters. In this manual, MVD is used to refer to the flowmeter implementations that use MVD processing.

Keys to using this manual

- Unless otherwise specified, the term "transmitter" includes the MVDSolo implementation.
- Unless otherwise specified, all references to MVDSolo also apply to MVD Direct Connect.
- References to MVD indicate the Series 1000 and 2000 transmitters and MVDSolo, or the Series 1000 and 2000 transmitters omitting MVDSolo.

Mapped address types

The transmitter emulates Modbus read/write and read-only coils and registers, including all the following types of mapped addresses:

- Read/write ON/OFF memory locations known as "coils"
- Read-only ON/OFF memory locations known as "discrete inputs"
- Read-only 16-bit input registers
- Read/write 16-bit holding registers
- Registers that store pairs of 8-bit ASCII characters
- Register pairs that store 32-bit floating-point values in single precision IEEE 754 format

The mapped 5-digit addresses store and use data types supported by many Modbus PLCs. **Table B-6**, page 287, lists data types according to their mapped addresses and corresponding function codes.

Using some PLCs, you must subtract 1 from the address or starting address.

- When you send a Modbus message that specifies a register, subtract 1 from the address.
- When you send a Modbus message that specifies a series of consecutive registers, subtract 1 from the starting address.

Example

Refer to your PLC documentation to know if this applies to you. If it does:

This Modbus manual specifies 40042 as the address of the holding register that contains the unit for process variables that measure volume flow.

Convert this address to 40041.

Floating-point register pairs and ASCII character strings

Complete configuration, calibration, and flowmeter characterization require use of floating-point values and ASCII characters supported by some Modbus host controllers.

- Floating-point values must be written in a single command to a series of two consecutive registers. More than one value can be written in a single command.
- Character strings must be written in a single command to a series of 4 to 16 consecutive registers, depending on the number of characters specified for the string. More than one character string can be written in a single command.

The transmitter can accept, store, and return 32-bit floating-point values and 8-bit ASCII characters, regardless of the data transmission mode (ASCII or RTU) required by the host controller.

Operation in multidrop network

While operating under Modbus protocol, the transmitter can participate in a multidrop network.

Modbus protocol supports up to 247 transmitters in a multidrop network. Each transmitter must be assigned a unique address within the range specified in **Table 5-3**, page 30. This procedure is described in **Chapter 5**.

To initiate communication with an individual network device, the host controller uses the unique address of the network device. To initiate communication with all the network devices, the host controller uses command 0.

The host controller communicates with a network device by reading data stored in the mapped addresses of the network device, each of which corresponds to a specific memory location in the transmitter's microprocessor. The host controller can query one mapped address or multiple consecutive addresses of a single device, or can broadcast a message to one mapped address or multiple consecutive addresses of all the network devices.

Sensor and transmitter interchangeability

Micro Motion calibrates each transmitter to operate with a particular sensor. However, Modbus protocol enables interchange of transmitters and sensors.

- You can recalibrate the transmitter for accurate measurement of flow, density, and temperature with any compatible Micro Motion sensor.
- You can characterize the flowmeter's sensitivity to mass flow, density, and temperature.

Introduction

3 Implementing Modbus Protocol

3.1 About this chapter

This chapter explains how to configure the transmitter to use Modbus® protocol. The configuration procedure depends on the transmitter.

3.2 RS-485 requirements

All communication using Modbus protocol requires an RS-485 connection. Many, but not all, Micro Motion transmitters have an RS-485 digital output that can be used for this purpose. If an RS-485 digital output is available, it can be used for either a temporary or a permanent connection.

Some Series 1000 and Series 2000 transmitters do not have an RS-485 digital output. In this case, the service port under the transmitter's Warning flap can be used for temporary connections. Because of the location of the service port, this connection is not appropriate for permanent connections. Temporary connections are useful for configuration or troubleshooting purposes.

See **Figure 3-5**, page 16, for a diagram of the RS-485 digital output and service port.

The core processor, which is a component of Series 1000, Series 2000, and MVDSolo installations, also has RS-485 terminals. See **Figure 3-6**, page 18.

3.3 RFT9739 transmitter

The procedure for implementing Modbus protocol with the RFT9739 transmitter depends on the transmitter version. Before you can implement Modbus protocol, you must identify the transmitter version.

There are three versions of the RFT9739 transmitter. You should not have a transmitter that is earlier than Version 2. If the transmitter is earlier than Version 2, contact Micro Motion. (See the back cover of this manual for phone numbers.)

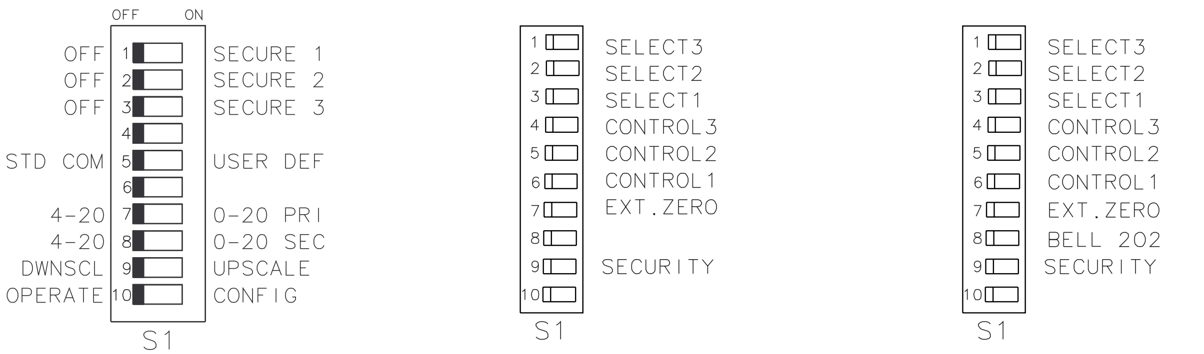
Transmitter version identification

To identify the field-mount RFT9739 transmitter version:

1. Unscrew the cover from the base of the housing.
2. Inside the transmitter is an electronics module, which has terminal blocks for wiring connections. A Version 3 transmitter has an electronics module that is different from older versions. Earlier versions of the module have switches labeled SELECT, CONTROL, and EXT.ZERO. A module for a Version 3 transmitter does not have these labels. For comparison, refer to **Figure 3-1**, page 12.

Figure 3-1. Switches on RFT9739 transmitters

Version 3 transmitters | **Version 2 transmitters (switch 8 not labeled)** | **Earlier versions (switch 8 labeled "BELL 202")**

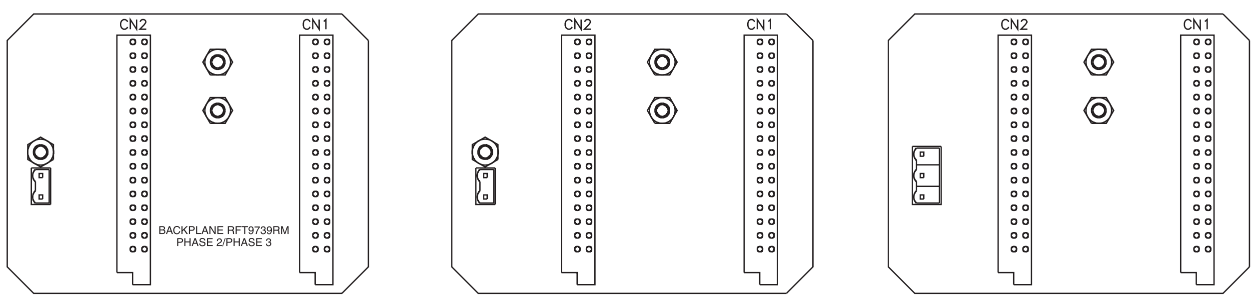


A Version 3 rack-mount RFT9739 transmitter has a back panel that is different from older versions. For comparison, refer to **Figure 3-2**.

- The Version 3 back panel has text between connectors CN1 and CN2 that reads BACKPLANE RFT9739RM PHASE 2/PHASE 3.
- The Version 2 back panel does not have text between connectors CN1 and CN2 to identify the transmitter version.
- Earlier versions have a 3-position power-supply terminal block at connector CN3.

Figure 3-2. Back panels on rack-mount RFT9739 transmitter

Version 3 transmitters | **Version 2 transmitters** | **Earlier versions**



Implementation procedure

To implement Modbus protocol with the RFT9739 transmitter:

1. If possible, place the transmitter on a workbench.

2. Set three communications parameters:
   - Baud rate
   - Parity
   - Protocol

Set the baud rate and parity as appropriate for your network. Set protocol to one of the options that includes Modbus on RS-485. Be sure to select the correct data bits setting – RTU (8 bits) or ASCII (7 bits).

These communications parameters can be set using either of two methods:

- Via switches on the electronics module in the field-mount transmitter or on the control board in the rack-mount transmitter
- Via the front-panel display on the rack-mount transmitter or the optional display on the field-mount transmitter

Refer to the instruction manual that was shipped with the transmitter for detailed instructions.

3. Install the flowmeter, making sure RS-485 wiring is properly connected.
   - For RS-485 wiring from the field-mount transmitter, see *Wiring for field-mount RFT9739 transmitter*, below.
   - For RS-485 wiring from the rack-mount transmitter, see "Wiring for rack-mount RFT9739 transmitter," page 14.

⚠ WARNING

Hazardous voltage can cause severe injury or death.

Shut off the power before wiring the transmitter.

⚠ WARNING

A transmitter that has been improperly wired or installed in a hazardous area could cause an explosion.

- Make sure the transmitter is wired to meet or exceed local code requirements.
- Install the transmitter in an environment that complies with the classification tag on the transmitter.

Wiring for field-mount RFT9739 transmitter

To connect the transmitter to an RS-485 network, use RFT9739 terminals 27 and 26. **Figure 3-3**, page 14, shows how to connect one RFT9739 or multiple RFT9739 transmitters to a host controller for RS-485 serial communication.

- Install twisted-pair, shielded cable, consisting of 24 AWG (0.25 mm²) or larger wire, between the transmitter and an RS-485 communication device. Maximum cable length is 4000 feet (1200 meters).
- Some installations require a 120-ohm, ½-watt resistor at both ends of the network cable to reduce electrical reflections.

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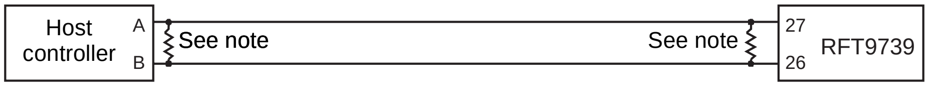
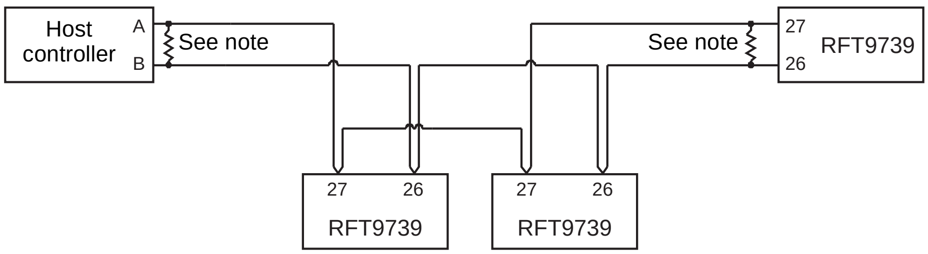
Figure 3-3. RS-485 wiring for field-mount RFT9739 transmitter

One RFT9739 and a host controller



Multiple RFT9739s and a host controller



For long-distance communication, or if noise from an external source interferes with the signal, install 120-ohm ½-watt resistors across terminals of both end devices.

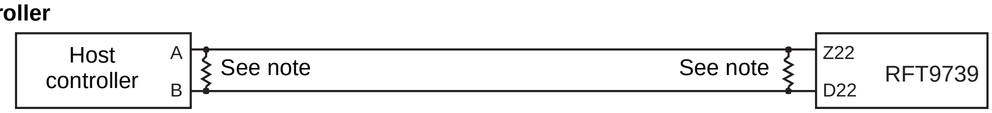
Wiring for rack-mount RFT9739 transmitter

To connect the transmitter to an RS-485 network, use RFT9739 terminals CN2-Z22 and CN2-D22. **Figure 3-4** shows how to connect one RFT9739 or multiple RFT9739 transmitters to a host controller for RS-485 serial communication.

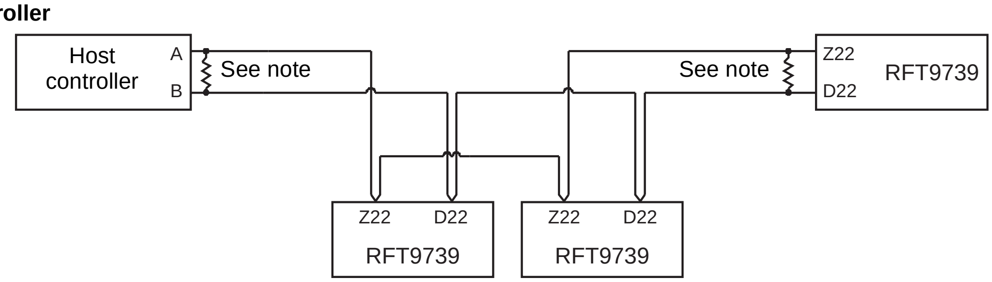
- Install twisted-pair, shielded cable, consisting of 24 AWG (0.25 mm^2) or larger wire, between the transmitter and an RS-485 communication device. Maximum cable length is 4000 feet (1200 meters).
- Some installations require a 120-ohm, ½-watt resistor at both ends of the network cable to reduce electrical reflections.

Figure 3-4. RS-485 wiring for rack-mount RFT9739 transmitter

One RFT9739 and a host controller



Multiple RFT9739s and a host controller



For long-distance communication, or if noise from an external source interferes with the signal, install 120-ohm ½-watt resistors across terminals of both end devices.

3.4 Series 1000 or 2000 transmitter

To implement Modbus protocol with the Series 1000 or 2000 transmitter:

1. Make sure the transmitter has wiring terminals for RS-485 wiring. If the transmitter does not have RS-485 wiring terminals, use the service port under the Warning flap.

2. Referring to the instruction manuals that were shipped with the transmitter and sensor, install the flowmeter.

3. Make sure RS-485 wiring is properly connected. See **Figure 3-5**, page 16.

4. If you are using the service port, the digital communications variables are preset to a baud rate of 38,400, parity of none, 1 stop bit, and address of 111.

5. If you are using the RS-485 terminals, configure the digital communication variables listed in **Table 3-1**, page 17.

   a. If you have ProLink II™ software, refer *to Using ProLink II Software with Micro Motion Transmitters*, and use the software to configure the digital communication variables.
      - Set the address to 1.
      - Click the **Comm** tab.
      - Click one of the two Modbus options under **Protocol**.
      - Click one of the six options under **Baud Rate**.
      - Click one of the three options under **Parity**.
      - Click one of the two options under **Stop Bits.**
      - Click **Apply**.

      Changing the communication settings affects only terminals 5 and 6. It does not affect the mA/Bell 202 terminals (1 and 2) or the service port (terminals 7 and 8).

      If you are communicating with the transmitter via terminals 5 and 6, ProLink II software will lose communication with the transmitter at this point. Change the ProLink II communication settings and re-establish communication.

   b. If you do not have ProLink II software, you can use the HART Communicator (HART 275) or the transmitter display to set the communication variables.

Wiring for Series 1000 or 2000 transmitter

To install RS-485 point-to-point wiring, see **Figure 3-5**, page 16.

- Install twisted-pair, shielded cable, consisting of 24 AWG (0.25 mm²) or larger wire, between the transmitter and an RS-485 communication device. Maximum cable length is 4000 feet (1200 meters).
- Some installations require a 120-ohm, ½-watt resistor at both ends of the network cable to reduce electrical reflections.

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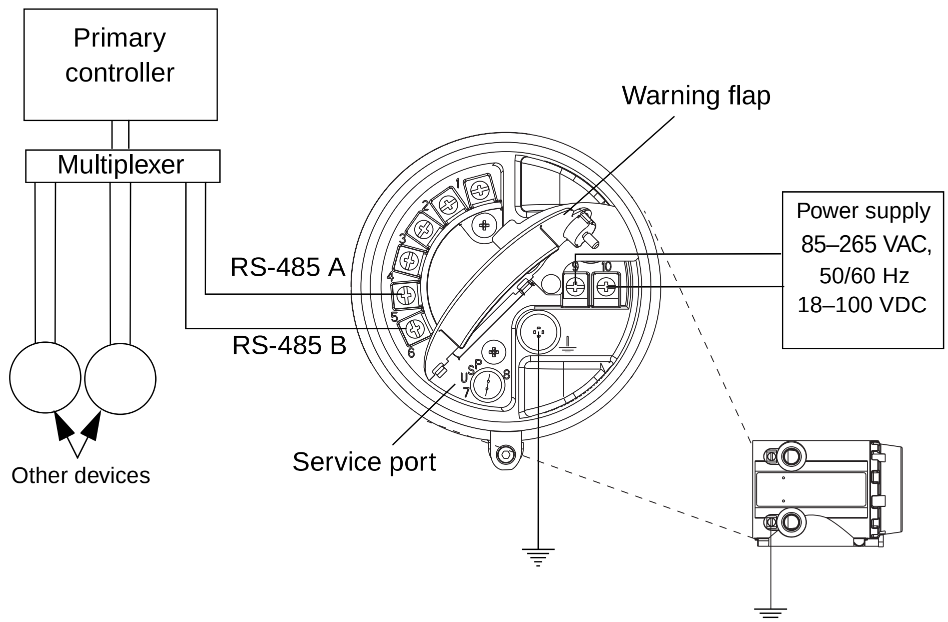
Figure 3-5. RS-485 wiring for Series 1000 or 2000 transmitter



Series 1000 or 2000 digital communication variables

Table 3-1 lists the digital communication variables that control network communications. These variables must be set correctly to enable Modbus communication. If you are connecting through the service port, these variables are detected automatically.

After communication via Modbus protocol has been implemented, you may use the Modbus host controller to change any of the communication settings. To do this, write the integer code of the desired value to the appropriate holding register, as listed in **Table 3-1**.

Note: If you change these values, you may lose your connection and have to re-establish communication. If you have set them incorrectly, you may be unable to re-establish Modbus communication. If this occurs, you will need to reset these variables using another method (for example, the HART Communicator or hardware switches)..

Table 3-1. Series 1000 or 2000 digital communication variable holding registers

Holding register	Integer code	Digital communication protocol codes	Series 1000	Series 2000
41132	0	None	√	√
	1	HART only	√	√
	2	Modbus RTU only	√	√
	3	Modbus ASCII only	√	√
		Digital communication baud rate codes		
41133	0	1200 baud	√	√
	1	2400 baud	√	√
	2	4800 baud	√	√
	3	9600 baud	√	√
	4	19,200 baud	√	√
	5	38,400 baud	√	√
		Digital communication parity codes		
41134	0	None	√	√
	1	Odd parity	√	√
	2	Even parity	√	√
		Digital communication stop bits		
41135	1	1 stop bits	√	√
	2	2 stop bit	√	√

WARNING

Changing communication settings may terminate your Modbus connection.

- Do not change the settings to values that are incompatible with Modbus communication.
- Be prepared to re-establish communication after changing settings.

3.5 MVDSolo

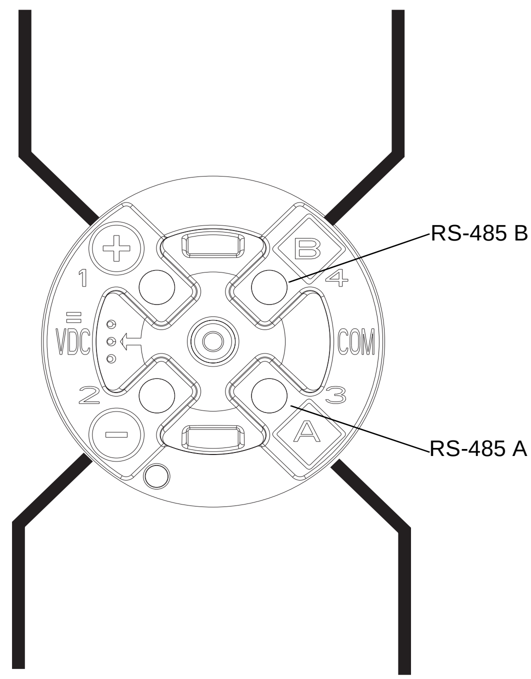
To enable Modbus protocol with MVDSolo:

1. Install twisted-pair, shielded cable, consisting of 24 AWG (0.25 mm²) or larger wire, between MVDSolo and the remote RS-485 communication device. Maximum cable length is 1000 feet (300 meters). See **Figure 3-6**, page 18. For more information, see the sensor manual and *Instructions for 4-Wire Cable and Gland Preparation for Wiring at Core Processor*, available from Micro Motion.

2. Supply power to the core processor, using a “floating” (isolated) DC power supply. See the sensor manual for more information.

No protocol configuration is required: the core processor automatically detects the incoming communications parameters and adjusts.

Figure 3-6. RS-485 wiring for MVDSolo



⚠ WARNING

Be careful to connect the wiring to the correct terminals.

- Accidentally connecting power to the RS-485 terminals of the core processor will damage the core processor.

3.6 Optional communication parameters

Depending on your network and host controller, you may need to change the default transmitter address (all transmitters), or configure the transmitter to communicate with a slower host controller (Series 1000, Series 2000, and MVDSolo only).

Default polling address

The default polling address for all Micro Motion transmitters is 1. You may change this address as desired. If the transmitter is installed on a multidrop network, each device on the network must have a unique polling address.

See **Chapter 6** for instructions on changing the transmitter's polling address.

Additional response time delay

If you have MVDSolo or a Series 1000 or 2000 transmitter, you can configure the transmitter to add a time delay, measured in milliseconds, to each response it sends to a remote controller. To do this, write the appropriate integer value for the additional response time delay to holding register 40522, as listed in **Table 3-2**.

Table 3-2. Additional delay to response holding register

Holding register	Integer value	MVDSolo	Series 1000	Series 2000
40522	• An integer that represents the time required to synchronize communication with a slower host controller • For appropriate values, see **Table 3-3** and the equation above	√	√	√

The register value that you should write is listed in **Table 3-3** and is based on the following equation:

$$\mathit{Register\ Value} = \frac{\mathit{TimeDelay}}{\left[6400\ \mu sec \times \dfrac{1200}{\mathit{Baud\ rate}}\right]}$$

Table 3-3. Register values for additional response time delay

	Baud rate:					
	1200 baud	**2400 baud**	**4800 baud**	**9600 baud**	**19,200 baud**	**38,400 baud**
Time delay	**Register value to be written:**					
800 μsec	—	—	—	1	2	4
1600 μsec	—	—	1	2	4	8
3200 μsec	—	1	2	4	8	16
6400 μsec	1	2	4	8	16	32
12.8 msec	2	4	8	16	32	64

4 Using Modbus Commands

4.1 About this chapter

This chapter explains how to use Modbus commands that are supported by Micro Motion transmitters. The transmitter can use integers, floating-point values, and ASCII character strings.

CAUTION

Using write commands can change transmitter outputs, which can result in measurement error.

Set control devices for manual operation before using write commands. This prevents automatic recording of process data during transmitter configuration.

4.2 Message structure

Modbus commands are composed of function codes and references to addresses in transmitter memory. These addresses contain values that represent process data, transmitter configuration, and so on. **Appendix B** provides reference information for Modbus command structures. If you are using ProLink II software, the Modbus commands are automatically coded and interpreted by the software.

4.3 Memory structures and data types

The types of data written to and returned from the transmitter depend on the capabilities of the host controller. The transmitter can accept, store, and return binary data, integers, floating-point values, and ASCII characters, regardless of the 8-bit RTU or 7-bit ASCII data transmission mode used by the host controller.

Transmitter memory is structured in several different ways:

- Binary data (0/1, OFF/ON) is stored in binary bit units called coils (read/write) or discrete inputs (read-only).
- All other data types are stored in one or more registers. A register is a 16-bit unit of memory.
  - Integer values are stored in holding registers (read/write) or input registers (read-only). Values are unsigned 16-bit integers ranging from 0 to 65535.
  - Floating-point values stored in register pairs, in single precision IEEE 754 format. A register pair may be either read/write or read-only.
  - ASCII values are stored in consecutive registers. Each register holds one pair of 8-bit ASCII characters (16 bits total).

In this manual, these memory structures are identified with 5-digit numbers. The first digit represents the memory type, and the other four identify the specific bit or register of that type. See **Table 4-1**, page 22.

Table 4-1. Memory structures, data formats, and numbering conventions

Name	Memory structure	Access	Data type	Typical use	Identifier
Coil	Bit	Read/write	Binary	Enable/disable functions, set/reset controls	0XXXX
Discrete input	Bit	Read-only	Binary	Store status information	1XXXX
Input register	16-bit register	Read-only	Integer	Store process variable data in integer form	3XXXX
Holding register	16-bit register	Read/write	Integer	Store configuration data, device identification codes, serial numbers	4XXXX
Register pair	16-bit register pair (32 bits total)	Read-only or read/write	Floating point	Store process variable data or configuration data in floating-point format	2XXXX-2XXXY
ASCII register	1 or more consecutive 16-bit registers	Read/write	8-bit ASCII	Store alphanumeric data such as labels for special measurement units.	5XXXX

Integer data support

All Modbus host controllers support integer data, enabling you to perform the following tasks:

- Reading values of process variables
- Reading transmitter status
- Establishing standard engineering units for all process variables
- Scaling integers that represent process variables
- Limited configuration of the transmitter

Integer data can be written to 16-bit holding registers. Integer data include integer codes corresponding to choices from a software menu, and integer values for scaling process variables.

An integer value is written to a holding register using a single command. Multiple values can be written with a single command, if the holding registers are consecutive. If they are non-consecutive, a separate command must be used for each holding register.

Integer values are read using a single command to read a holding register or several consecutive holding registers. You can configure slot addresses to allow you to read multiple non-consecutive holding registers using a single command. See **Chapter 16** for information on configuring slot addresses.

Floating-point data support

Some Modbus-compatible host controllers support floating-point values. Floating-point values are stored in register pairs. Each register pair consists of two consecutive 16-bit registers and can return values as small as 9.999999×10^{-32} or as large as 9.999999×10^{32} with 23-bit resolution, 1-bit sign, and 8-bit exponent. The digital value displayed on a readout depends on the host controller.

The byte order of floating-point values can vary depending on your transmitter:

- If you are using an RFT9739 transmitter, the byte order is fixed.
- If you are using MVDSolo or a Series 1000 or 2000 transmitter, the byte order is configurable.

See **Appendix B** for more information on byte order.

A floating-point value is written to a register pair using a single command. Multiple values can be written with a single command, if the register pairs are consecutive. If they are non-consecutive, a separate command must be used for each pair.

Floating-point values are read using a single command to read a register pair, or several consecutive register pairs. You can configure slot addresses to allow you to read multiple non-consecutive register pairs using a single command. See **Chapter 16** for information on configuring slot addresses.

ASCII data support

Some Modbus-compatible host controllers support ASCII values. ASCII values are stored in ASCII registers. Two 8-bit characters can be stored in each 16-bit register. Character strings must be written in a single command to a series of four to 16 consecutive registers, depending on the number of characters specified for the string. More than one character string can be written in a single command.

Consecutive ASCII registers can be read using a single read command. You can configure slot addresses to allow you to read multiple non-consecutive ASCII registers using a single command. See **Chapter 16** for information on configuring slot addresses.

Reading and writing data

For process variables, the value read from the sensor is available in both floating-point and integer format:
- If you read the input register associated with the process variable, the transmitter will return an integer.
- If you read the floating-point register pair associated with the process variable, the transmitter will return a floating-point value.

Note that there is no necessary correspondence between the identifiers assigned to the floating-point register pair and the input or holding register: The floating-point register pair may be 20195-20196 while the other register is 40039 (a holding register in this case, as denoted by the 4).

Similarly, for certain configuration variables, the value to be stored in transmitter memory is in integer format, while for other configuration variables the value is in floating-point format. In the first case, the value is written to a holding register; in the second case, the value is written to a floating-point register pair.

4.4 Enumerated integers

Some holding registers store *enumerated integers*, which consist of *integer codes*.

Integer codes

Integer codes correspond to options available from a list. The following example describes how to use an integer code:

Example	Establish grams per second (g/sec) as the measurement unit for the mass flow rate. Integer code 70 corresponds to g/sec, and holding register 40039 stores the integer for the mass flow rate unit. Write the integer 70 to holding register 40039. The transmitter will measure and return the mass flow rate in g/sec.

Values dependent on integer codes

Some integer or floating-point values depend on integer codes held elsewhere in the map. The following example describes a variable with a floating-point value that depends on an integer code for a measurement unit.

Example	To establish grams per second (g/sec) as the measurement unit for the mass flow rate, the integer 70 has been written to holding register 40039, as illustrated in the example on page 24. The transmitter should indicate zero flow if the mass flow rate drops below 0.50 g/sec. Register pair 20195-20196 stores the mass flow cutoff for the frequency and digital outputs. Write a value of 0.50 to register pair 20195-20196. The frequency and digital outputs will indicate zero flow if the mass flow rate drops below 0.50 g/sec.

4.5 Linearity and proportion

Proper use of Modbus commands requires an understanding of how the transmitter derives linear outputs that are proportional to the process data it receives.

To calculate an output proportional to process data, the transmitter uses the following equation:

$$y = Ax + B$$

Where:

y = Output level that represents x value of process variable
A = Slope, or proportional change in the output that occurs due to a given change in process variable
x = Value of process variable at output level y
B = Offset, or output when process variable has a value of 0

You can manipulate the linear equation to perform the following tasks:

- Implementing unit conversions and integer scaling of process variables
- Establishing frequency output scaling
- Determining the value of a process variable represented by a milliamp or frequency output
- Calibrating or characterizing the flowmeter for optimal measurement of flow, density, and temperature

Example

A 4-20 mA output represents a density of 0.0000 to 5.0000 grams per cubic centimeter (g/cc). Determine the slope and offset of the output.

$$20\ \mathit{Milliamps} = A(5.0000\ g/cc) + B$$
$$4\ \mathit{Milliamps} = A(0.0000\ g/cc) + B$$

Solve for A:

$$16\ \mathit{Milliamps} = A(5.0000\ g/cc)$$
$$A = \frac{16}{5}$$
$$A = 3.2$$

Solve for B:

$$20\ \mathit{Milliamps} = 3.2(5.0000\ g/cc) + B$$
$$20 - 16 = B$$
$$B = 4$$

The output has a slope of 3.2 (A = 3.2) and an offset of 4 (B = 4).

5 Sensor and Transmitter Information

5.1 Overview

This chapter explains how to write sensor and transmitter information.

Sensor and transmitter information consists of integer data and ASCII character strings that provide data about the flowmeter. You can review or change most, but not all, sensor and transmitter information without affecting operation of the flowmeter. The host controller uses the tag and the polling address to communicate with the transmitter.

With one exception, the procedures described in this chapter are optional. The ability to store sensor information in the transmitter is provided as a convenience to the user.

The exception is network address, or polling address. The default polling address is 1. If your transmitter is installed in a multidrop network, you must specify a unique polling address for the transmitter to enable communication with the controller.

⚠ CAUTION

Writing sensor and transmitter information can change transmitter outputs, which can result in measurement error.

Set control devices for manual operation before writing sensor and transmitter information.

5.2 Sensor description

The core processor can store basic information about the sensor. Holding registers 40047-40051 and 40127-40131 store sensor description data as integer values. Some registers store integer codes corresponding to options available from a list. In some cases, two consecutive registers are combined to store integers larger than 65535.

Sensor serial number

Write the sensor serial number to register pair 40127-40128. The sensor serial number can be found on the metal tag on the sensor housing.

Because the sensor serial number is a 24-bit number, two registers are required. The serial number is stored in the low order 8 bits of register 40127 plus all 16 bits of register 40128. The high order 8 bits of register 40127 must be set to 0. See **Table 5-1**, page 28.

Table 5-1. Sensor serial number register pair

Register	Bits	Value	MVDSolo	Series 1000	Series 2000	RFT9739
40127	High order 8 bits	00000000	√	√	√	√
	Low order 8 bits	First 8 bits of sensor serial number	√	√	√	√
40128	All 16 bits	Last 16 bits of sensor serial number	√	√	√	√

Sensor physical description

Write integer codes describing the sensor to the holding registers listed in **Table 5-2**.

Table 5-2. Sensor information holding registers

Holding register	Integer code	Sensor flange type codes	MVDSolo	Series 1000	Series 2000	RFT9739
40129	0	ANSI 150	√	√	√	√
	1	ANSI 300	√	√	√	√
	2	ANSI 600	√	√	√	√
	5	PN 40	√	√	√	√
	7	JIS 10K	√	√	√	√
	8	JIS 20K	√	√	√	√
	9	ANSI 900	√	√	√	√
	10	Sanitary clamp	√	√	√	√
	11	Union	√	√	√	√
	12	PN 100	√	√	√	
	251	None				√
	252	Unknown	√	√	√	√
	253	Special	√	√	√	√
		FLow tube construction material codes				
40130	3	Hastelloy® C-22	√	√	√	√
	4	Monel	√	√	√	√
	5	Tantalum	√	√	√	√
	6	Titanium	√	√	√	
	19	316L stainless steel	√	√	√	√
	23	Inconel™	√	√	√	
	252	Unknown	√	√	√	√
	253	Special	√	√	√	√
		Flow tube liner material codes				
40131	10	PTFE (Teflon®)	√	√	√	√
	11	Halar	√	√	√	√
	16	Tefzel®	√	√	√	√
	251	None	√	√	√	√
	252	Unknown	√	√	√	√
	253	Special	√	√	√	√
		Sensor type codes				
41139	0	Curved-tube sensor (D, DL, DT, CMF, F-Series, R-Series)		√	√	
	1	Straight-tube sensor (T-Series)		√	√	

5.3 Transmitter description

Some transmitter information is configurable. Other information is not configurable, but can be read by the customer.

Configurable information includes:
- HART polling address (RFT9739 transmitter only)
- Modbus polling address
- HART protocol device tag
- Transmitter final assembly number
- User-specified date
- User-specified messages or descriptions

Non-configurable information includes:
- Transmitter software revision
- Electronics module identifier
- Core processor software revision
- Transmitter output option board

Table 5-3, page 30. and **Table 5-4**, page 31. list the configurable items and the associated holding registers (for integer values) or ASCII registers (for character strings). For each item, write the appropriate value to the specified holding register or ASCII register(s).

Table 5-5, page 32, lists the non-configurable items and the associated input registers. To read these items, read the appropriate input register.

Note: If you are using HART protocol via the Bell 202 physical layer, an address of 0 is required to allow the milliamp output variable to represent a process variable. This may have implications for network layout if you plan to use multiple flowmeters configured for output variables.

Table 5-3. Configurable transmitter information – integer values

Holding register	Description	Integer value	MVDSolo	Series 1000	Series 2000	RFT9739
40047	HART or Modbus polling address	• Any integer from 0 to 15 that identifies this RFT9739 transmitter in a multidrop network • For HART protocol via the Bell 202 physical layer: - An address other than 0 fixes the primary milliamp output at 4 MA - An address of 0 enables the primary milliamp output to represent a process variable		√	√	√[1]
40048	Final assembly number from tag on transmitter housing	High-order register of integer from 0 to 167777215	√	√	√	√
40049		Low-order register of integer from 0 to 167777215	√	√	√	√
40050	Date (day/ month/year)	Day (any integer from 01 to 31)	√	√	√	√
40051		Month (any integer from 01 to 12), multiplied by 256, plus year (any integer from 00 to 99)	√	√	√	√
40313	Modbus polling address	An integer that identifies this transmitter in a Modbus multidrop network: • 1-247 for RFT9739 transmitter • 1-15, 32-47, 64-79, 96-110 for MVDSolo or Series 1000 or 2000 transmitter	√	√	√	√[1]
41187	Core processor I.D.[2, 3]	High order register of 3-byte integer		√	√	
41188		Low-order register of 3-byte integer		√	√	

[1] *Version 3.7 and higher revision RFT9739 transmitters.*
[2] *Must be queried through transmitter. If wiring is direct to core processor, registers 41187 and 41188 do not exist.*
[3] *Same as registers 31187-31188, listed in **Table 5-5**, page 32. If these registers contain a non-zero value, they are read-only. If they contain 0, they can be written to.*

Table 5-4. Configurable transmitter information – character strings

Note

Write character strings as single-write multiples.

Register	Description	ASCII character string	MVDSolo	Series 1000	Series 2000	RFT9739
50068 50069 50070 50071	Device tag	Each register holds 2 characters in an 8-character tag that identifies this transmitter in a HART multidrop network	√	√	√	√
50096 50097 50098 50099 50100 50101 50102 50103	Transmitter description	• Each register holds 2 characters in a 16-character device description or other message • Description is for user information only, and is not used by the transmitter	√	√	√	√
50104 50105 50106 50107 50108 50109 50110 50111 50112 50113 50114 50115 50116 50117 50118 50119	Message	• Each register holds 2 characters in a 32-character message • Message is for user information only, and is not used by the transmitter	√	√	√	√
50425 50426 50427 50428 50429 50430 50431 50432	Sensor description	• Each register holds 2 characters in a 16-character description of the sensor, for example, sensor model number • Sensor description is for user information only, and is not used by the transmitter	√	√	√	

Table 5-5. Non-configurable transmitter information

Input register	Description	Returned integer	MVDSolo	Series 1000	Series 2000	RFT9739
30016	Transmitter software revision	An integer describing the transmitter software revision	√	√	√	√
30121	Identification number from tag on electronics module	1-byte integer that identifies this electronics module	√	√	√	√
30122	Hart protocol device identifier[1]	High-order register of integer from 0 to 167777215	√	√	√	√
30123		Low-order register of integer from 0 to 167777215	√	√	√	√
31137	Core processor software revision	1-byte integer describing software revision for core processor		√	√	
31138	Output option board	0 None 1 Analog I/O 2 FOUNDATION™ Fieldbus, Profibus-PA 3 Intrinsically safe output (IS) 4 Configurable input/output		√	√	
31187	Core processor I.D.[2 3]	High-order register of 3-byte integer		√	√	
31188		Low-order register of 3-byte integer		√	√	

[1] *If wiring is connected to transmitter, returns I.D. of transmitter. If wiring is connected to core processor, returns I.D. of core processor.*
[2] *Must be queried through transmitter. If wiring is direct to core processor, registers 31187 and 31188 do not exist.*
[3] *Same as registers 41187-41188, listed in **Table 5-3**, page 30. If these registers contain a non-zero value, they are read-only. If they contain 0, they can be written to.*

Configuration

6 Outputs, Option Boards, and Communications

6.1 About this chapter

This chapter describes the different outputs that are available with each transmitter, including the different outputs provided by the Series 1000 and 2000 transmitter option boards.

The chapter then discusses how you can use Modbus protocol to configure the Series 2000 option boards. Configurable options include:

- Channel configuration (configurable input/output option boards only)
- Power source (configurable input/output option boards only)
- Frequency output mode (configurable input/output option boards only)
- Frequency output polarity (intrinsically safe option boards or configurable input/output option boards only)
- Configuring the frequency output as a discrete output
- Fieldbus simulation mode (Fieldbus option boards only)
- Profibus-PA station address (Fieldbus option boards with Profibus-PA software loaded only)

This chapter also describes various communication options that may apply to all transmitters, including:

- Changing the polling address and device tag
- Configuring burst mode
- Configuring polling to read external temperature or pressure

Uses of outputs

When you have established your outputs as described in this chapter, you can use them in several ways:

- You can use outputs to report process data to a host controller. Configuration instructions are provided in **Chapter 9**.
- You can use outputs for process control (**Chapter 10**).
- You can use outputs as fault indicators (**Chapter 11**).

6.2 Outputs

Different transmitters have different outputs. Additionally, the Series 1000 and Series 2000 transmitters have option boards, and each option board has different outputs. The specific option board installed in your transmitter will affect the feature set available to you.

Output types

The following terms are used to describe the different output types.

Milliamp (mA)
Outputs an electrical signal that varies in proportion to the value of its assigned process variable.

Frequency
Outputs an electrical pulse at a rate that varies in proportion to the value of its assigned process variable.

Analog
Refers to any output that varies in proportion to its assigned process variable. In this context, “analog” typically refers to the milliamp output.

Discrete
A two-state output, frequently used to report ON/OFF states. Typically implemented as two different steady electrical voltages: 0 (ON) and 15 (OFF). If you have a Series 2000 transmitter with the configurable input/output board, you can reverse these settings (see **Section 6.3**).

RS-485 digital
Communicates digital (numeric) information using a communications protocol, for example, Modbus. The numeric information can be the value of an assigned process variable, or a variety of other data.

Unlike the other outputs discussed here, the RS-485 digital output does not automatically send data. An external device can use this output to query the transmitter.

Outputs, transmitters, and option boards

Table 6-1 lists the outputs supplied with each transmitter and option board. Configuration tables in this manual refer to these option board types.

Table 6-1. Transmitters, option boards, and outputs

	Series 1000		Series 2000			RFT9739
Output	**Analog option board**	**IS option board**	**Analog option board**	**IS option board**	**Configurable IO option board**[1]	
Milliamp	1	1	1	2	1 or 2	2
Frequency	1[2]	1[2]	1[3]	1[3]	0, 1, or 2[4]	1
RS-485 digital	1		1			1
RFT9739 control output						1
Discrete output			0 or 1[5]	0 or 1[5]	0, 1, or 2	
Discrete input					0 or 1	

[1] *See "Series 2000 configurable input/output board," page 35.*
[2] *Always reports same process variable as milliamp output.*
[3] *May report same or different process variable as milliamp output.*
[4] *All frequency outputs report the same process variable. See "Series 2000 configurable input/output board," page 35.*
[5] *Depends on option board configuration.*

6.3 Series 2000 configurable input/output board

The configurable input/output board has three output channels. Channel A is always a milliamp output; channels B and C are configurable, as described in **Table 6-2**.

Channel A always uses an internal power source. Channels B and C may be configured to use either an internal or an external power source. This configuration also controls how the discrete outputs will report ON or OFF.

Additionally, if you configure either channel B or C as a frequency output, you can specify the frequency output mode (phase shift) and polarity of the output.

To configure channels B and C:

1. Write the integer code for the output type to holding register 41167, for channel B, or holding register 41168, for channel C. Output type codes are listed in **Table 6-3.**

Table 6-2. Series 2000 configurable input/output board channel configuration

Holding register	Channel	Output type integer codes		Series 2000
41166	A	0	Milliamp output	√
41167	B	0 1 4	Milliamp output Frequency output Discrete output	√
41168	C	1 4 5	Frequency output Discrete output Discrete input	√

If you specify frequency output for both channel B and channel C (dual pulse), the channel C output is generated from the same signal sent on Channel B. The channel C output is electrically isolated but not independent. This configuration supports phase-shifting, discussed below.

2. Write the integer code for the output power source to holding register 41174, for channel B, or holding register 41175, for channel C. Power source also controls how the discrete outputs (if any) indicate ON/OFF. Power source integer codes are listed in **Table 6-3.** ON/OFF indicators are listed in **Table 6-4**, page 36.

Table 6-3. Series 2000 configurable input/output board power source configuration

Holding register	Channel	Power source integer codes		Series 2000
41174	B	0 1	External Internal	√
41175	C			√

Table 6-4. Series 2000 configurable input/output board discrete output voltages

Power source	State	Voltage	Series 2000
External	ON	15 V	√
	OFF	0 V	√
Internal	ON	0 V	√
	OFF	15 V	√

3. If you configured a frequency output in step 1, write the integer code for the frequency output mode to holding register 41181. Frequency output mode codes are listed in **Table 6-5**.

   If you specified frequency output for both channel B and channel C (dual pulse mode), the frequency output mode specified here applies to both; they cannot be configured independently. If you specified only one frequency output, you must specify 0 (single) here.

Table 6-5. Series 2000 configurable input/output board frequency output mode configuration

Holding register	Frequency output mode integer codes		Series 2000
41181	0	Single	√
	1	Quadrature	
	2	Dual pulse w/ 0° phase shift	
	3	Dual pulse w/ 180° phase shift	
	4	Dual pulse w/ +90° phase shift	
	5	Dual pulse w/ -90° phase shift	

Frequency output mode controls phase-shifting. For example, when you set the outputs for quadrature, forward flow is indicated by a +90° phase shift, and reverse flow is indicated by a -90° phase shift. Quadrature mode is used only for specific Weights and Measures applications where required by law.

4. If you configured a discrete input in step 1, you can configure it to zero the flowmeter or reset a totalizer. Write the integer code of the desired function to holding register 41176, as listed in **Table 6-6**. Then connect a control device to channel C.

Table 6-6. Discrete input assignment codes

Holding register	Integer code	Description	Series 2000[1]
41176	0	None	√
	1	Start flowmeter zero	
	2	Reset mass total	
	3	Reset volume total	
	4	Reset corrected volume total	

[1] Transmitters with the configurable input/output option board only.

6.4 Series 2000 frequency output polarity

If you have the configurable input/output option board with a frequency output configured, or the intrinsically safe option board, you can specify the polarity of the frequency output: active high or active low. The default polarity, active high, is appropriate for most applications. Write the integer code for frequency output polarity to holding register 41197, as shown in **Table 6-7**.

If you set both channels B and C on the configurable input/output board to frequency, this setting applies to both; they cannot be configured separately.

Table 6-7. Series 2000 frequency output polarity configuration

Holding register	Frequency output polarity integer codes		Series 2000
41197	0	Active low	√
	1	Active high	

6.5 Series 2000 discrete output

If you have a Series 2000 transmitter with the analog option board or the intrinsically safe option board, you can configure the frequency output to act as a discrete output. (If you have a Series 2000 transmitter with the configurable input/output board, see **Section 6.3**, page 35.)

To configure the frequency output as a discrete output, write integer code 4 to holding register 41167, as listed in **Table 6-8**.

Table 6-8. Series 2000 discrete output configuration

Holding register	Frequency output assignment integer codes		Series 2000
41167	1	Frequency output	√
	4	Discrete output	

6.6 Configuring communications

The transmitter uses network communications to exchange data with a host controller or similar device, and may also use network communications to poll an external device for temperature or pressure.

Two protocols can be used for network communications:
- HART protocol
- Modbus protocol

In all cases, the transmitter must have a unique address so that it can be queried by external devices.

If HART protocol is used, burst mode may or may not be enabled.

If the transmitter will poll an external device for temperature or pressure, polling must be configured. Polling requires HART protocol.

Polling address

Polling addresses are integers assigned to transmitters to distinguish them from other devices on multidrop networks. Each transmitter on a multidrop network must have a polling address that is different from the polling addresses of other devices on the network. Transmitters can be configured for polling via HART protocol, Modbus protocol, or both.

HART protocol
If HART protocol is used to query the transmitter, it can be identified by its polling address, configured in holding register 40047, or its device tag, configured in ASCII registers 50068-50071. Configure either or both, depending on how external devices will query this transmitter.

To configure the transmitter for HART polling, write the assigned address and/or the assigned device tag to the appropriate register(s), as shown in **Table 6-9**.

Table 6-9. Transmitter polling via HART protocol

Address	Address type	I.D. type	Description	Series 1000	Series 2000	RFT9739
40047	Holding register	Polling address	Valid addresses: 0-15		√	√
50068 50069 50070 50071	ASCII register	Device tag	ASCII character string. Each register holds 2 characters in an 8-character tag.	√	√	√

Transmitters that are polled via HART protocol can have polling addresses of 0–15. Using HART protocol, 0 is a special-purpose polling address that enables the primary mA output to vary according to a process variable. When a transmitter's HART polling address is set to any value other than zero, the primary mA output is fixed at 4 mA.

Modbus protocol
If Modbus protocol is used to query the transmitter:
- For Series 1000 and 2000 transmitters, and for Version 3.7 and higher RFT9739 transmitters, the transmitter is identified by the polling address in holding register 40313.
- For Version 3.6 and lower RFT9739 transmitters, the polling address is configured in holding register 40047.

Valid addresses for Modbus protocol depend on the transmitter type and version, as shown in **Table 6-10**. To configure the polling address for Modbus protocol, write the assigned address to the appropriate holding register, also shown in **Table 6-10**.

Table 6-10. Transmitter polling via Modbus protocol

Holding register	I.D. type	Valid addresses	MVDSolo	Series 1000	Series 2000	RFT9739
40313	Polling address	1-247				√[1]
		1-15, 32-47, 64-79, 96-110	√	√	√	
40047	Polling address	1-15				√[2]

[1] *Version 3.7 and higher.*
[2] *Version 3.6 and lower.*

Burst mode

Burst mode is a specialized mode of communication during which the primary mA output is fixed at 4 mA and the transmitter regularly broadcasts HART digital information. Because no polling by an external host is required, burst mode can provide better performance. Burst mode can be used only if the same process data will be broadcast each time.

Note: The RFT9739 transmitter supports burst mode, but it is not configurable via Modbus.

Burst mode is ordinarily disabled, and should be enabled only if another device on the network requires HART burst-mode communication.

Burst mode does not require specification of a target. Data broadcast in burst mode can be received by any device that is listening.

You can specify several types of process data to be sent via burst mode. The data will be sent out via Bell202 HART at approximately 2-second intervals. The interval is not configurable.

To configure HART burst mode:

1. Enable burst mode by setting coil 00083, as shown in **Table 6-11**.

Table 6-11. HART burst mode control coil

Address	Description	Bit status	Series 1000	Series 2000
00083	HART burst mode is disabled HART burst mode is enabled	0 1	√	√

2. Specify the process data to be sent by writing an integer code to holding register 41165, as shown in **Table 6-12**.

Table 6-12. HART burst mode process data

Holding register	Code	Description	Series 1000	Series 2000
41165	1 2 3 33	Send primary variable Send primary variable current and percent of range Send dynamic variables and primary variable current Send transmitter variables	√	√

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3. If you specified code 33, send transmitter variables, you must additionally specify up to four process variables to be burst. Write integer codes for these process variables to holding registers 41169-41172, as shown in **Table 6-13**.

Table 6-13. HART burst mode code 33 process variables

Holding register	Description	Process variable code		Series 1000	Series 2000
41169	Burst variable 1	0	Mass flow rate	√	√
41170	Burst variable 2	1	Temperature	√	√
41171	Burst variable 3	2	Mass totalizer	√	√
41172	Burst variable 4	3	Density	√	√
		4	Mass inventory		
		5	Volume flow rate		
		6	Volume totalizer		
		7	Volume inventory		

6.7 Polling external device

A Micro Motion transmitter can poll an external device to retrieve information such as temperature or pressure. This can be used for real-time pressure or temperature compensation. Polling is performed using HART protocol.

Configuration for external polling depends on your transmitter type and version. MVDSolo does not support external polling.

Note: Complete implementation of pressure or temperature compensation requires additional steps:
- *See **Chapter 12** for information on Series 1000 or Series 2000 pressure compensation.*
- *See **Chapter 13** for information on RFT9739 pressure compensation.*
- *See **Chapter 14** for information on Series 1000 or Series 2000 temperature compensation.*

Series 1000 and Series 2000 transmitter

A Series 1000 or 2000 transmitter, Version 2 and earlier, can be configured to poll an external HART device for pressure. A Series 1000 or 2000 transmitter, Version 3 and later, can be configured to poll one or two external HART devices, and can poll for pressure or temperature. For example, you may poll device #1 for temperature and device #2 for pressure.

To do this:

1. Write the polling tag of HART device #1 to registers 50298-50301. Write the polling tag of HART device #2 to registers 51140-51153. See **Table 6-14**.

2. Set the polling control code to identify the type of polling control. You can specify a value of 0 (no polling), 1 (polling as a HART primary master), or 2 (polling as a HART secondary master). Write the

Table 6-14. External HART device polling tag

Notes

Write character strings as single-write multiples.

Register	ASCII character strings	Series 1000	Series 2000	RFT9739
50298 50299 50300 50301	Each register holds 2 characters in a string of 8 characters that represent the polling tag for external HART device #1.	√	√	√[1]
51140 51141 51142 51142	Each register holds 2 characters in a string of 8 characters that represent the polling tag for external HART device #2	√[2]	√[2]	

[1] *Version 3 and later transmitters only.*
[2] *Version 3 and later transmitters only.*

polling control code to holding register 40302, for device #1, or to holding register 41144, for device #2. See **Table 6-15**.

If you specify either 1 or 2 for device #1 polling control, you must specify the same value for device #2. If you specify a different value, the transmitter will operate as a HART primary master (polling control type 1) for both devices.

Table 6-15. Polling control type – Series 1000 and 2000

Holding register	External polling device	Integer code	Description	Series 1000	Series 2000
40302	Device #1	0	No polling	√	√
41144	Device #2	1 2	Polling as a HART primary master Polling as a HART secondary master	√[1]	√[1]

[1] *Version 3 and later transmitters only.*

3. Specify the type of external data to be polled by writing the appropriate integer code to holding register 41145, for device #1, or to holding register 41146, for device #2. Transmitter versions 2 and earlier can poll only for pressure. See **Table 6-16**.

Table 6-16. Polled data – Series 1000 and 2000

Holding register	External polling device	Integer code	Description	Series 1000	Series 2000
41145	Device #1	53	Pressure	√	√
41146	Device #2	55[1]	Temperature	√[1]	√[1]

[1] *Version 3 and later transmitters only.*

4. If you are using Version 3 or later of the Series 1000 or 2000 transmitter, skip this step. If you are using Version 2 of the Series 1000 or 2000 transmitter, specify pressure compensation by writing integer code 1 to holding register 41147. See **Table 6-17**, page 42.

Table 6-17. Polling type – Series 1000 and 2000, Version 2 and earlier

Holding register	Integer code	Description	Series 1000	Series 2000
41147	1	Pressure compensation	√[1]	√[1]

[1] *Version 2 and earlier transmitters only.*

RFT9739 transmitter

If you are using the RFT9739 transmitter, you may poll one external device for pressure data. Polling for temperature data is not supported.

To configure polling for pressure data:

1. Write the external HART device polling tag to ASCII registers 50298-50301, as listed in **Table 6-14**, page 41.
2. Set the polling control code to identify the type of polling control. Write the polling control code to holding register 40302, as listed in **Table 6-18**.

Table 6-18. Polling control type – RFT9739

Holding register	External polling device	Integer code	Description	RFT9739
40302	Device #1	0 3 4 5 8	No polling Polling as a HART primary master Polling as a HART secondary master Analog input Modbus	√

6.8 Fieldbus simulation mode

If you have a Series 2000 transmitter with the FOUNDATION Fieldbus option board, Modbus communication is supported via the transmitter's service port. Only one parameter can be set using this method: you can enable or disable Fieldbus simulation mode.

To enable or disable Fieldbus simulation mode, write 0 or 1 to coil 00084, as shown in **Table 6-19**.

Table 6-19. Fieldbus simulation mode control coil

Coil	Bit status	Description	Series 2000
00084	0 1	Fieldbus simulation mode disabled Fieldbus simulation mode enabled	√

A hardware switch is also provided for this option. Refer to the transmitter documentation.

6.9 Profibus-PA station address

If you have a Series 2000 transmitter with the Profibus-PA software loaded, Modbus communication is supported via the transmitter's service port. Only one parameter can be set using this method: you can set the Profibus station address.

To set the Profibus-PA station address, write the new address to holding register 41186, as listed in **Table 6-20**. Valid addresses are 0-126.

Table 6-20. Profibus-PA station address

Holding register	Values	Description	Series 2000
41186	0-126	Profibus station address	√

7 Measurement Units for Process Variables

7.1 About this chapter

This chapter explains how to write and read measurement units that will be used by the transmitter.

⚠ CAUTION

Writing measurement units can change transmitter outputs, which can result in measurement error.

Set control devices for manual operation before writing measurement units. This prevents automatic recording of measurement data during transmitter configuration.

7.2 Using measurement units

The transmitter can simultaneously measure and indicate all the following process variables:

- Mass flow rate
- Mass total
- Mass inventory
- Volume flow rate
- Volume total
- Volume inventory
- Density
- Temperature

Mass total and volume total are used for “batches.” These process variables can be reset to 0. The term “totalizer” is used to refer to these two process variables.

Mass inventory and volume inventory track values over time, across batches, and are typically never reset.

The transmitter can also measure pressure to compensate for the pressure effect on flow and density signals produced by some sensors.

The transmitter supports standard engineering units for all process variables and user-defined special units for mass and volume.

Key to using measurement units
After establishing measurement units as instructed in this chapter, continue using the same units to configure totalizers, outputs, process limits, calibration factors, and characterization factors for process variables.

A totalizer is a mass total or volume total process variable.

7.3 Standard units for mass and volume

To establish standard units of mass and volume, write integer codes representing the desired units to the appropriate holding registers.

Use the holding registers and integer codes listed in **Table 7-1** through **Table 7-4** to establish standard units of mass and volume.

Table 7-1. Mass flow units

Holding register	Integer code	Mass flow unit	MVDSolo	Series 1000	Series 2000	RFT9739
40039	70	Grams/second	√	√	√	√
	71	Grams/minute	√	√	√	√
	72	Grams/hour	√	√	√	√
	73	Kilograms/second	√	√	√	√
	74	Kilograms/minute	√	√	√	√
	75	Kilograms/hour	√	√	√	√
	76	Kilograms/day	√	√	√	√
	77	Metric tons/minute	√	√	√	√
	78	Metric tons/hour	√	√	√	√
	79	Metric tons/day	√	√	√	√
	80	Pounds/second	√	√	√	√
	81	Pounds/minute	√	√	√	√
	82	Pounds/hour	√	√	√	√
	83	Pounds/day	√	√	√	√
	84	Short tons (2000 pounds)/minute	√	√	√	√
	85	Short tons (2000 pounds)/hour	√	√	√	√
	86	Short tons (2000 pounds)/day	√	√	√	√
	87	Long tons (2240 pounds)/hour	√	√	√	
	88	Long tons (2240 pounds)/day	√	√	√	
	253	Special [1]	√	√	√	√

[1] *See "Special units of mass or volume," page 48.*

Measurement Units for Process Variables *continued*

Table 7-2. Mass total and mass inventory units

Holding register	Integer code	Mass total or mass inventory unit	MVDSolo	Series 1000	Series 2000	RFT9739
40045	60	Grams	√	√	√	√
	61	Kilograms	√	√	√	√
	62	Metric tons	√	√	√	√
	63	Pounds	√	√	√	√
	64	Short tons (2000 pounds)	√	√	√	√
	65	Long tons (2240 pounds)	√	√	√	
	253	Special [1]	√	√	√	√

[1] *See "Special units of mass or volume," page 48.*

Table 7-3. Volume flow units

Holding register	Integer code	Volume flow unit	MVDSolo	Series 1000	Series 2000	RFT9739
40042	15	Cubic feet/minute	√	√	√	√
	16	Gallons/minute	√	√	√	√
	17	Liters/minute	√	√	√	√
	18	Imperial gallons/minute	√	√	√	√
	19	Cubic meters/hour	√	√	√	√
	22	Gallons/second	√	√	√	√
	23	Million U.S. gallons/day	√	√	√	
	24	Liters/second	√	√	√	√
	25	Million liters/day	√	√	√	
	26	Cubic feet/second	√	√	√	√
	27	Cubic feet/day	√	√	√	
	28	Cubic meters/second	√	√	√	√
	29	Cubic meters/day	√	√	√	√
	30	Imperial gallons/hour	√	√	√	√
	31	Imperial gallons/day	√	√	√	√
	130	Cubic feet/hour	√	√	√	√
	131	Cubic meters/minute	√	√	√	√
	132	Barrels/second	√	√	√	√
	133	Barrels/minute	√	√	√	√
	134	Barrels/hour	√	√	√	√
	135	Barrels/day	√	√	√	√
	136	U.S. gallons/hour	√	√	√	√[1]
	137	Imperial gallons/second	√	√	√	√[1]
	138	Liters/hour	√	√	√	√[1]
	235	U.S. gallons/day	√	√	√	
	253	Special [2]	√	√	√	√

[1] *Version 3 RFT9739 transmitter only.*
[2] *See "Special units of mass or volume," page 48.*

Table 7-4. Volume total and volume inventory units

Holding register	Integer code	Volume total or volume inventory unit	MVDSolo	Series 1000	Series 2000	RFT9739
40046	40	U.S. gallons	√	√	√	√
	41	Liters	√	√	√	√
	42	Imperial gallons	√	√	√	√
	43	Cubic meters	√	√	√	√
	46	Barrels (42 U.S. gallons)	√	√	√	√
	112	Cubic feet	√	√	√	√
	253	Special[1]	√	√	√	√

[1] *See "Special units of mass or volume," page 48.*

7.4 Special units of mass or volume

A special unit of mass or volume is a user-defined unit that is a modification of existing units. Special units of mass or volume require a base mass or volume unit, a user-provided conversion factor, and a time base. The transmitter can store one special mass unit and one special volume unit.

Key to using special units of mass or volume

- If you write the integer 253 (special) to holding register 40039 (mass flow unit) and integer 253 (special) to holding register 40045 (mass total or inventory unit), both holding registers must represent the same special mass unit.
- If you write the integer 253 (special) to holding register 40042 (volume flow unit) and integer 253 to holding register 40046 (volume total or inventory unit), both holding registers must represent the same special volume unit.

To configure a special mass or special volume unit, follow these steps:

1. If you are configuring a special mass unit for a gas, follow the instructions in "Special units of mass for gases," page 52. If you are configuring a special mass or volume unit for liquids or solids, continue with these steps.
2. Select special as the measurement unit for the mass flow rate, mass total (mass inventory), volume flow rate, or volume total (volume inventory) by writing integer code 253 to holding register 40039, 40042, 40045, or 40046. (See **Table 7-1** through **Table 7-4**.)
3. Write the integer code for the base mass or volume unit to holding register 40132 or 40134, as listed in **Table 7-5**, page 50.
4. Calculate the conversion factor, then write its value to register pair 20237-20238 or 20239-20240, as listed in **Table 7-6**, page 50. The conversion factor is derived as follows:

Measurement Units for Process Variables *continued*

$$x[BaseVolumeUnit(s)] = y[SpecialVolumeUnit(s)]$$

$$ConversionFactor = \frac{x[BaseVolumeUnit(s)]}{y[SpecialVolumeUnit(s)]}$$

5. Write the integer code for the desired base time unit to holding register 40133 or 40135, as listed in **Table 7-7**, page 50.

Example

Configure pints per hour as the special volume flow rate unit for a Series 2000 transmitter.

1. Write the integer 253 (special) to holding register 40042.
2. Pints can be derived from gallons, so gallons will be used as the base volume unit. Write the integer code 40 (gallons) to holding register 40134.
3. Calculate the conversion factor. The conversion factor is the ratio of the base volume unit to the equivalent amount measured in the special volume unit. The equations below show the derivation of the conversion factor.

$$x[BaseVolumeUnit(s)] = y[SpecialVolumeUnit(s)]$$

$$ConversionFactor = \frac{x[BaseVolumeUnit(s)]}{y[SpecialVolumeUnit(s)]}$$

$$ConversionFactor = \frac{1[gal]}{8[pints]}$$

$$ConversionFactor = 0.125$$

In this case, 1 gallon = 8 pints, so the conversion factor is 1/8, or 0.125. Write a value of 0.125 to register pair 20239-20240.

4. Write the integer code 52 (hours) to holding register 40135.

Integer codes for mass or volume base unit

You must convert the special unit to a base unit of mass or volume. Integer codes listed in **Table 7-5**, page 50, enable you to choose one among several standard engineering units as a base for the special mass or volume unit. Write the desired integer code to holding register 40132 or 40134.

Floating-point conversion factor

The conversion factor determines the value of the special unit in terms of the base mass or volume unit. Write the mass or volume conversion factor to the appropriate register pair listed in **Table 7-6**, page 50.

Table 7-5. Base mass and volume units for special mass or special volume units

Holding register	Special unit type	Integer code	Description	MVDSolo	Series 1000	Series 2000	RFT9739
40132	Mass	60	Grams	√	√	√	√
		61	Kilograms	√	√	√	√
		62	Metric tons	√	√	√	√
		63	Pounds	√	√	√	√
		64	Short tons (2000 pounds)	√	√	√	√
		65	Long tons (2240 pounds)	√	√	√	
40134	Volume	40	U.S. gallons	√	√	√	√
		41	Liters	√	√	√	√
		42	Imperial gallons	√	√	√	√
		43	Cubic meters	√	√	√	√
		46	Barrels (42 U.S. gallons)	√	√	√	√
		112	Cubic feet	√	√	√	√

Table 7-6. Special mass or special volume unit conversion factors

Register pair	Floating point value	MVDSolo	Series 1000	Series 2000	RFT9739
20237 20238	Mass conversion factor, where: $\textit{Mass conversion factor} = \dfrac{\textit{Base mass unit}}{\textit{Special mass unit}}$	√	√	√	√
20239 20240	Volume conversion factor, where: $\textit{Volume conversion factor} = \dfrac{\textit{Base volume unit}}{\textit{Special volume unit}}$	√	√	√	√

Integer codes for base time unit

Since the flow rate is the mass or volume of fluid per unit time, the special unit must have a time base. The integer codes listed in **Table 7-7** enable you to choose a standard time base for the special mass or special volume unit. Write the desired integer code to holding register 40133 or 40135.

Table 7-7. Time units for special mass or special volume units

Holding register	Special unit type	Integer code	Description	MVDSolo	Series 1000	Series 2000	RFT9739
40133	Mass	50 51 52 53	Minutes Seconds Hours Days	√	√	√	√
40135	Volume			√	√	√	√

Adding descriptions for special mass or volume units

If the host controller supports ASCII characters, you can write descriptive strings for special flow or total units. Each register holds two ASCII characters in the string that describes the unit.

Special unit character strings for MVDSolo or a Series 1000 or 2000 transmitter can include up to 8 characters. See **Table 7-8**. Special unit character strings for the RFT9739 transmitter can include up to 4 characters. See **Table 7-9**.

Character strings can include spaces if necessary.

Table 7-8. MVDSolo or Series 1000 or 2000 special unit character strings

Note

Write character strings as single-write multiples.

Register	Description	ASCII character string	MVDSolo	Series 1000	Series 2000
50052 50053 50054 50055	Special mass flow unit string	• Each register holds 2 ASCII characters in a string of 8 characters describing the special mass or volume unit • The string can include spaces	√	√	√
50056 50057 50058 50059	Special mass total unit string or special mass inventory unit string		√	√	√
50060 50061 50062 50063	Special volume flow unit string		√	√	√
50064 50065 50066 50067	Special volume total unit string or special volume inventory unit string		√	√	√

Table 7-9. RFT9739 special unit character strings

Note

Write character strings as single-write multiples.

Register	Description	ASCII character string	RFT9739
50052 50053 50054 50055	Special mass flow unit string Special mass flow unit string Space characters Space characters	• Each register holds 2 ASCII characters in a string of 4 characters describing the special mass or volume unit • The character string can include spaces in addition to the space characters that are required	√
50056 50057 50058 50059	Special mass total unit string or special mass inventory unit string Special mass total unit string or special mass inventory unit string Space characters Space characters		√
50060 50061 50062 50063	Special volume flow unit string Special volume flow unit string Space characters Space characters		√
50064 50065 50066 50067	Special volume total unit string or special volume inventory unit string Special volume total unit string or special volume inventory unit string Space characters Space characters		√

Reading special mass or volume values

Values for special mass or volume units can be read as integers (either truncated integers or proportional scaled integers), or as floating-point values, as described in "Reading and writing data," page 23.

A special unit is indicated by a value of 253 in holding register 40042. If an ASCII description has been added, it can be read from the appropriate register or registers.

Example

Pints per hour has been established as the special volume flow rate unit for a Series 2000 transmitter. You have written "PPH" (for *pints per hour*) to registers 50060-50062. You now wish to read the volume flow rate and its measurement unit.

If you read input register 30005, then read holding register 40042, the transmitter returns a truncated integer or a proportional scaled integer representing the volume flow rate, with the integer code 253 to indicate a special volume unit, such as:

32174 253

If you read register pair 20253-20254 and then read registers 50060-50062, the transmitter returns a floating-point value, with the ASCII character string that describes the special volume flow rate unit, such as:

3217.469 PPH

7.5 Special units of mass for gases

The flowmeter measures mass flow of gas or standard volume flow of a gas. Mass flow rate and volume flow rate are related by the density of the gas at a reference condition. To establish a special unit of mass for a gas, determine the density of the gas at a reference temperature, pressure, and composition.

Note: The flowmeter should not be used for measuring actual volume flow of a gas (volumetric flow at line conditions). The flowmeter can be used for measuring volume flow at standard conditions.

To establish a special unit of mass flow for measuring a gas:

1. Establish a special unit of mass flow by writing integer 253 to holding register 40039.

⚠ CAUTION

The flowmeter should not be used for measuring the actual volume of gases.

Standard or normal volume is the traditional unit for gas flow. Coriolis flowmeters measure mass. Mass divided by standard or normal density yields standard or normal volume units.

2. Write the floating-point value of the standard (or normal) density of the gas to register pair 20237-20238. The standard or normal density of the gas depends on a reference temperature, pressure, and composition. For example, since one cubic foot of air has a normal density of 0.075 lb, write a value of 0.075.
3. Write the integer code for the base mass unit to holding register 40132. In this example, since the normal density of the gas is defined in pounds per cubic foot, write the integer 63 (pounds).
4. Write the base time unit for this special unit of mass to holding register 40133. For example, to establish minutes as the base time unit, write the integer 50.
5. You may write an ASCII character string that describes the special unit of mass flow to registers 50052 to 50055. For example, write the character string "SCFM" for *standard cubic feet per minute.*
6. You may write an ASCII character string that describes the special unit of mass total to registers 50056 to 50059. For example, write the character string "SCF" for *standard cubic feet*.

7.6 Density units

The transmitter can measure and indicate density in any of the available standard engineering units listed in **Table 7-10**. Write the selected integer code to holding register 40040.

Key to using density units
After establishing a standard density unit as instructed in this chapter, continue using the chosen density unit to configure density outputs, but use grams per cubic centimeter (g/cc) to configure density limits, calibration factors, and characterization factors.

Table 7-10. Density units

Holding register	Integer code	Density unit	MVDSolo	Series 1000	Series 2000	RFT9739
40040	90	Specific gravity units	√	√	√	√
	91	Grams/cubic centimeter	√	√	√	√
	92	Kilograms/cubic meter	√	√	√	√
	93	Pounds/gallon	√	√	√	√
	94	Pounds/cubic foot	√	√	√	√
	95	Grams/milliliter	√	√	√	
	96	Kilograms/liter	√	√	√	
	97	Grams/liter	√	√	√	
	98	Pounds/cubic inch	√	√	√	
	99	Short tons (2000 pounds)/cubic yard	√	√	√	
	104	Degrees API	√	√	√	√

API feature

If the API feature is enabled, degrees API may be specified for the density unit, To do this, write the integer 104 to holding register 40040, as listed in **Table 7-10**.

If degrees API is specified, the transmitter calculates standard volume for Generalized Petroleum Products according to API-2540. You must configure your transmitter for the API feature, as discussed in **Chapter 14**.

7.7 Temperature units

Use holding register 40041 and integer codes listed in **Table 7-11** to establish the temperature unit.

Table 7-11. Temperature units

Holding register	Integer code	Temperature unit	MVDSolo	Series 1000	Series 2000	RFT9739
40041	32	Degrees Celsius	√	√	√	√
	33	Degrees Fahrenheit	√	√	√	√
	34	Degrees Rankine	√	√	√	√
	35	Kelvin	√	√	√	√

7.8 Pressure units

If you establish a pressure unit, the transmitter can use pressure values to compensate for the effects of pressure on the sensor flow tubes.

- To implement pressure compensation for the RFT9739 transmitter, see **Chapter 13**.
- To implement pressure compensation for MVDSolo or a Series 1000 or 2000 transmitter, see **Chapter 12**.

Most applications do not require pressure compensation.

Use holding register 40044 and the integer codes listed in **Table 7-12** to establish the pressure unit.

Table 7-12. Pressure units

Holding register	Integer code	Pressure unit	MVDSolo	Series 1000	Series 2000	RFT9739
40044	1	Inches water @ 68°F	√	√	√	√
	2	Inches mercury @ 0°C	√	√	√	√
	3	Feet water @ 68°F	√	√	√	√
	4	Millimeters water @ 68°F	√	√	√	√
	5	Millimeters mercury @ 0°C	√	√	√	√
	6	Pounds/square inch	√	√	√	√
	7	Bar	√	√	√	√
	8	Millibar	√	√	√	√
	9	Grams/square centimeter	√	√	√	√
	10	Kilograms/square centimeter	√	√	√	√
	11	Pascals	√	√	√	√
	12	Kilopascals	√	√	√	√
	13	Torr @ 0°C	√	√	√	√
	14	Atmospheres	√	√	√	√

8 Using Process Variables

8.1 About this chapter

This chapter explains how to read process variables.

This chapter also explains how to implement integer scaling for process variables. If the host controller has IEEE 754 floating-point capability, integer scaling is unnecessary.

Keys to using process variables
Before reading process variables, establish measurement units for process variables. See **Chapter 7**.

8.2 Stored values versus returned values

For process variables, the value read from the sensor is available from the transmitter in both floating-point and integer format:

- If you read the floating-point register pair associated with the process variable (register pairs 20247-20248 to 20265-20266), the transmitter will return a floating-point value in single precision IEEE 754 format.
- For Version 3.7 and higher revision RFT9739 transmitters, input registers 30305 to 30312 return binary values that indicate the mass total and volume total. (see **Section 8.4**, page 57).
- If you read the input register associated with the process variable (registers 30002 to 30011), the transmitter will return an integer. This integer may be either a truncated representation of the floating-point value or a scaled integer which retains all of the resolution of the floating-point value. The process of scaling integers is described in **Section 8.5**, page 58.

Resolution of process variables depends on the following factors:

- The measurement units established for the process variable
- The number of bits (16 or 32) in the data. A floating-point register pair consists of two consecutive 16-bit registers, whereas an input register consists of a single 16-bit register
- The integer scaling, if any, implemented for the process variable

Integer or floating-point values of process variables can be read from the addresses listed in **Table 8-1**, page 56. Measurement units for process variables can be read from the addresses listed in **Table 8-2**, page 56.

Table 8-1. Process variable registers

Input register (Returned data format)		Register pair (Returned data format)		Data returned from address	MVDSolo	Series 1000	Series 2000	RFT9739
30002	(Integer)	20247 20248	(Floating-point)	Mass flow rate	√	√	√	√
30003	(Integer)	20249 20250	(Floating-point)	Density	√	√	√	√
30004	(Integer)	20251 20252	(Floating-point)	Temperature	√	√	√	√
30005	(Integer)	20253 20254	(Floating-point)	Volume flow rate	√	√	√	√
40007	(Integer)	20257 20258	(Floating-point)	Pressure				√
30008	(Integer)	20259 20260	(Floating-point)	Mass total	√	√	√	√
30010	(Integer)	20263 20264	(Floating-point)	Mass inventory	√	√	√	√
30009	(Integer)	20261 20262	(Floating-point)	Volume total	√	√	√	√
30011	(Integer)	20265 20266	(Floating-point)	Volume inventory	√	√	√	√

Table 8-2. Measurement unit holding registers

Holding register	Data returned from address	MVDSolo	Series 1000	Series 2000	RFT9739
40039	Mass flow rate unit	√	√	√	√
40040	Density unit	√	√	√	√
40041	Temperature unit	√	√	√	√
40042	Volume flow rate unit	√	√	√	√
40044	Pressure unit	√	√	√	√
40045	Mass total unit or mass inventory unit	√	√	√	√
40046	Volume total unit or volume inventory unit	√	√	√	√

8.3 Floating-point values

If you read process variables from register pairs 20247-20248 to 20265-20266, as listed in **Table 8-1**, the transmitter returns floating-point values in single precision IEEE 754 format.

The transmitter returns a NAN (not-a-number) response or produces fault outputs if any of the following conditions exists:

- Sensor failure
- Input overrange
- Density overrange
- Temperature overrange
- Transmitter electronics failure

For information about alarm conditions, see **Chapter 23**.

Example	Read the mass flow rate and its measurement unit. The mass flow rate is read from register pair 20247-20248. The integer code for the mass flow rate unit is read from holding register 40039. The transmitter returns the following values: 104117.3 75 The floating-point value represents the measured mass flow rate, and the 2-digit integer code represents kilograms per hour (kg/hr). (See **Table 7-1** on page 46 for the integer codes.)

8.4 RFT9739 binary totals

For the Version 3.7 and higher revision RFT9739 transmitter, input registers 30305 to 30312 return binary values that indicate the mass total and volume total.

- Input registers 30305 to 30308 contain the binary mass total.
- Input registers 30309 to 30312 contain the binary volume total.

Table 8-3. RFT9739 binary total input registers

Input register	Data returned from address	RFT9739[1]
30305 30306 30307 30308	• A binary value indicating the mass total in grams: $\frac{\textit{Binary mass total}}{655,360} = \textit{Total in grams}$ • You may read the value using one or several Modbus commands, as desired.	√
30309 30310 30311 30312	• A binary value indicating the volume total in grams: $\frac{\textit{Binary volume total}}{655,360} = \textit{Total in milliliters}$ • You may read the value using one or several Modbus commands, as desired.	√

[1] *Version 3.7 and higher revision RFT9739 transmitters.*

Note: In the equation shown above, 655,360 is an internal conversion factor specific to the RFT9739 transmitter.

8.5 Integer scaling

If you read process variables from input registers 30002 to 30011, the transmitter ordinarily returns a truncated integer, such as 2711 to represent 2711.97 grams per minute, or 1 to indicate a density of 1.2534 gram per cubic centimeter.

⚠ CAUTION

Writing scaled integers can change transmitter outputs, which can result in measurement error.

Set control devices for manual operation before writing scaled integers. This prevents automatic recording of measurement data during transmitter configuration.

Integer scaling causes the transmitter to return integers, accurate to one part in 65536, representing the measured value of the process variable, such as 50000 to represent a mass flow rate of 50 grams per second. Scaled integers amplify and linearize small changes in critical process variables, as illustrated in the following example.

Example

The quality of the process varies widely unless density remains between 1.0000 and 1.200 grams per cubic centimeter (g/cc).

Implement an integer scale that represents 1.0000 g/cc as the integer 10000 and 1.2 g/cc as the integer 12000. A change of 1 in the value of the scaled integers represents a 0.0001 g/cc change in temperature. The integer 12001 represents a density of 1.2001 g/cc

You can implement integer scaling for the following purposes:
- To offset negative values such as subzero temperatures or reverse flow rates, so they can be read as positive integers
- To increase output resolution of values such as density, temperature, pressure, or low flow rates

Keys to using integer scaling
- If the host controller has IEEE 754 floating-point capability, integer scaling is unnecessary.
- For each process variable, establish measurement units that will prevent scaled integers from exceeding the programmed or default maximum integer. See **Chapter 7**.
- To represent high flow rates, totals, or other large values as smaller values, change measurement units. See **Chapter 7**.

Configuring scaled integers

If you configure integer scaling for more than one process variable, the same maximum integer applies to all scaled process variables. Each scaled process variable can have its own offset and scale factor.

To determine a scaled integer proportional to the measured value of a process variable, the transmitter uses a variation of the linear equation presented in **Section 4.5**, page 24. The equation represents a linear correction of the measured value:

$$y = Ax - (B - 32768)$$

Where:

y = Scaled integer returned by transmitter
A = Scale factor for scaled integer values
x = Measured value of process variable
B = Offset for scaled integer values

To configure integer scaling of process variables, follow these steps:

1. Select a maximum integer and write its value to the appropriate holding register. See **Table 8-4**, page 60.
2. Derive a scale factor for each desired process variable and write the values to the appropriate holding registers. See **Table 8-5**, page 61.
3. Derive an offset for each desired process variable and write the values to the appropriate holding registers. See **Table 8-6**, page 62.

Step 1 **Determine maximum integer**

A scaled integer is the value of y in the equation presented above. The maximum integer is the highest integer proportional to a measured value of a process variable.

The default maximum integer is 65534.

Key to using maximum integers
If integer scaling applies to more than one process variable, all scales must share the same maximum integer, but may have different offsets and scale factors.

You can program a maximum integer below the default maximum integer. The maximum integer can accommodate a Honeywell® control system or other data highway. For example, the Honeywell control system allows transmission of integer values from 0 to 9999 or from 0 to 4096.

The overflow integer is defined as the maximum integer plus 1. Therefore, if the maximum integer is 1000, the overflow integer is 1001. If the default maximum integer is used (65534), the overflow integer is 65535.

The default overflow integer is 65535.

The transmitter returns the overflow integer if the measured value of a process variable derives an integer higher than the maximum integer. The transmitter also returns the overflow integer if any of the following alarm conditions exists:

- Sensor failure
- Input overrange
- Density outside sensor limits
- Temperature outside sensor limits
- Transmitter electronics failure

For information about alarm conditions, see **Chapter 23**.

Table 8-4. Maximum integer holding register

Holding register	Integer value	MVDSolo	Series 1000	Series 2000	RFT9739
40018	An integer from 0 to 65534; the term y in the equation: $y = Ax - (B - 32768)$ • The term y is the highest scaled integer proportional to a measured value of a process variable • The same maximum integer applies to all integer scales that are implemented	√	√	√	√

Step 2 Determine scale factor (slope)

The scale factor is the value of A in the equation presented on page 59. The scale factor equals the linear slope of the integers, which are proportional to measured values of the process variable. The scale factor therefore is a ratio that compares the change in the measured value to the proportional change in the value of the scaled integers.

In the following example, the default maximum integer (65534) is assumed.

Example

The integer 0 represents zero flow, and the integer 10000 represents a mass flow rate of 10.000 grams per minute (g/min).

Since a change of 10.000 g/min in the mass flow rate causes a change of 10000 in the value of the scaled integers, the scale factor is 10000/10 = 1000/1 = 1000. The default overflow integer, 65535, indicates a mass flow rate greater than or equal to 65.534 g/min.

Table 8-5. Scale factor holding registers

Holding register	Description	Integer value	MVDSolo	Series 1000	Series 2000	RFT9739
40029	Mass flow scale factor	An integer from 0 to 65535; the term A in the equation: $y = Ax - (B - 32768)$ The term A is a ratio that compares the change in the measured value of a process variable to the proportional change in the value of the scaled integers	√	√	√	√
40030	Density scale factor		√	√	√	√
40031	Temperature scale factor		√	√	√	√
40032	Volume flow scale factor		√	√	√	√
40034	Pressure scale factor		√	√	√	√
40035	Mass total scale factor		√	√	√	√
40036	Volume total scale factor		√	√	√	√
40037	Mass inventory scale factor		√	√	√	√
40038	Volume inventory scale factor		√	√	√	√

Step 3 Determine offset

The offset for scaled integers is the value of B in the equation presented on page 59. The intercept, or the offset minus 32768, equals the value of the process variable that is represented by a scaled integer value of 0. The offset enables scaled integers, which always have positive values, to represent negative values such as a subzero temperature or a reverse flow rate.

Since B (the offset) always has a value from 0 to 65534, the transmitter uses the following equation to derive a positive or negative intercept:

$$Intercept = Offset - 32768$$

- The maximum negative intercept is –32768, where offset = 0.
- The intercept is 0, where offset = 32768.
- The maximum positive intercept is 32767, where offset = 65535.

So, although you write the offset as an integer from 0 to 65535, the process variable can have a value less than, equal to, or greater than 0.

Table 8-6. Offset holding registers

Holding register	Description	Integer value	MVDSolo	Series 1000	Series 2000	RFT9739
40019	Mass flow offset	An integer from 0 to 65535; the term B in the equation: $y = Ax - (B - 32768)$ The term B – 32768 is the integer that represents a value of 0 for the process variable	√	√	√	√
40020	Density offset		√	√	√	√
40021	Temperature offset		√	√	√	√
40022	Volume flow offset		√	√	√	√
40024	Pressure offset		√	√	√	√
40025	Mass total offset		√	√	√	√
40026	Volume total offset		√	√	√	√
40027	Mass inventory offset		√	√	√	√
40028	Volume inventory offset		√	√	√	√

Using integer scaling to define range limits

The maximum integer, offsets, and scale factors establish programmable limits on process variables. Establish an integer scale for programmable limits on process variables according to either of the two methods described below.

Method 1

Follow these steps while referring to **Example 1** and **Example 2**.

1. Use the following equations to set up scaled integer limits corresponding to lower and upper range values of the process variable.

$$\textit{Scale factor} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$\textit{Offset} = (\textit{Scale factor} \times x_1) - y_2 + 32,768$$

   Where:
   x_1 = Lower range value
   x_2 = Upper range value
   y_1 = Maximum integer
   y_2 = An integer (usually 0) with lower value than the maximum integer

2. Write the integer value of y (the maximum integer) to holding register 40018, as listed in **Table 8-4**, page 60.
3. Write the integer value of A (the scale factor) to the appropriate holding register listed in **Table 8-5**, page 61.
4. Write the integer value of B (the offset) to the appropriate holding register listed in **Table 8-6**.

Example 1	The transmitter is connected to a Honeywell TDC3000 control system using a PLC Gateway. The control system engineer sets up an analog input point to bring in volume flow, which enables use of flow limit alarms in the control system. On the control system, an analog input point has limits of 0 to 4095, with any input greater than 4095 indicating a “bad” process variable. The lower range limit is –100 barrels/day. The upper range limit is 300 barrels/day.

1. Set up the maximum integer, if necessary.
2. Set up scaled integer limits corresponding to the lower and upper range values.
3. Determine the scale factor:

$$= \frac{y_2 - y_1}{x_2 - x_1} = \frac{4095 - 0}{300 - (-100)} = \frac{4095}{400} = 10.2375$$

   Since the scale factor must be an integer, round down to 10.

4. Determine the offset:

$$= (\textit{Scale factor} \times x_1) - y_1 + 32,768$$
$$= [10(-100)] - 0 + 32,768$$
$$= -1000 + 32,768$$
$$= 31,768$$

5. The calculated scale factor of 10.2375 was rounded down to 10, so the actual transmitter range will slightly exceed the desired range of –100 to 300. To allow proper scaling of the analog input point data by the Honeywell control system, calculate the actual transmitter range corresponding to scaled integer values of 0 and 4095:

   Lower range value $= x_1 = -100$

   Upper range value

$$= \frac{y_2 - y_1}{\textit{Scale factor}} + x_1 = \frac{4095 - 0}{10} - 100 = 309.5$$

Example 2

Scale the mass flow rate so 0 represents –100 pounds/minute (lb/min) and 30,000 represents 200 lb/min.

Scale factor:

$$
\begin{aligned}
&= \frac{y_2 - y_1}{x_2 - x_1} \\
&= \frac{30,000 - 0}{200 - (-100)} \\
&= \frac{30,000}{300} \\
&= 100
\end{aligned}
$$

Offset:

$$
\begin{aligned}
&= (\textit{Scale factor} \times x_1) - y_2 + 32,768 \\
&= [100 - (-100)] - 0 + 32,768 \\
&= 22,768
\end{aligned}
$$

Method 2

Choose a maximum integer equal to or less than 65534, then use the linear equation presented on page 59 to solve for A (the scale factor) and B (the offset), as shown in **Example 3**.

1. Write the integer value of y (the maximum integer) to holding register 40018, as listed in **Table 8-4**, page 60.
2. Write the integer value of A (the scale factor) to the appropriate holding register listed in **Table 8-5**, page 61.
3. Write the integer value of B (the offset) to the appropriate holding register listed in **Table 8-6**, page 62.

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Example 3	The mass flow rate needs to remain between 30 and 40 grams per minute (g/min). Scale the mass flow rate so 0 represents a flow rate less than or equal to 30.000 g/min, 10,000 represents a flow rate of 40.000 g/min, and 10,001 represents a flow rate greater than 40.000 g/min.

$$10,000 = A(40) - (B - 32,768)$$

$$0 = A(30) - (B - 32,768)$$

Solve for A:

$$10,000 = A(10)$$

$$A = \frac{10,000}{10}$$

$$A = 1000$$

Solve for B:

$$10,000 = 1000(40) - (B - 32,768)$$

$$10,000 = 40,000 - (B - 32,768)$$

$$10,000 = 40,000 + 32,768 - B$$

$$B = 62,768$$

- The maximum integer is 10,000. If the mass flow rate exceeds 40.000 g/min, the transmitter returns the integer 10,001.
- The scale factor is 1000. A change of 1 in the value of the integers represents a change of 0.001 g/min in the mass flow rate.
- The offset is 62,768. If the mass flow rate drops to 30.000 g/min, the transmitter returns a 0.

Configuration

9 Reporting Process Data with Outputs

9.1 About this chapter

This chapter discusses the relationship between process variables, output variables, and outputs. It then describes how to use an output to report process data to an external device such as a host controller. This enables the transmitter to send process data automatically. If this is not configured, the external device must query the transmitter. Mapping a process variable to an output also makes it possible to define events, which are used for process control (see **Chapter 11**).

Outputs that can be used to report process data include:

- Milliamp outputs (one or two, depending on the option board)
- Frequency output

See **Chapter 6** for definitions of the different output types and the outputs available with each transmitter and option board.

This chapter also explains how to read the process variable values, output variables, and present output levels directly; that is, by reading the associated memory registers.

Finally, this chapter discusses the use of 100Hz mode for faster updating of process data. This option is available only with Series 1000 or 2000 transmitters.

Note: MVDSolo does not support procedures that require outputs.

Keys to using outputs to report process data
Before configuring outputs to report process data, establish measurement units for process variables (see **Chapter 7**).

CAUTION

Configuring outputs to report process data can change transmitter outputs, which can result in measurement error.

Set control devices for manual operation before configuring outputs. This prevents automatic recording of process data during transmitter configuration.

9.2 Process variables, output variables, and outputs

Real-time values of process variables are written to transmitter or core processor memory at frequent intervals (6.25-100 Hz; see **Section 9.8**, page 86). These values are stored in input registers or floating-point register pairs, as discussed in **Chapter 4**.

In the transmitter (core processor) memory structure, four output variables are defined. They are called the primary, secondary, tertiary, and quaternary variables (PV, SV, TV, and QV). These output variables have predefined relationships to outputs. However, these output variables always exist, whether or not their designated outputs exist on a specific transmitter or option board. For example, there is always a secondary variable, whether or not there is a secondary milliamp output.

When a process variable is assigned to an output, it is actually being assigned to an output variable; that is, it is being assigned to a particular memory structure. If the designated output exists, the real-time value of the process variable is written to the output variable structure, and then reported through the output. If the designated output does not exist, the value stored in the output's register is 0. (See **Chapter 6** for definitions of the different output types and the outputs available with each transmitter and option board.)

Figure 9-1 displays a diagram of the relationship of process variables, output variables, and outputs.

Note that the quaternary variable does not have a designated output. The quaternary variable is provided because it is frequently convenient to be able to read three or four process variable values at one time using HART protocol. The value of the process variable assigned to the quaternary variable cannot be read using Modbus protocol.

Also note that the RS-485 digital output does not "send" process data automatically. However, it can be used by an external device to read:
- The registers that store process variable data (**Table 9-1**)
- The registers that store the PV, SV, TV, and QV assignments (**Table 9-2**)
- The registers that store the present values of the designated outputs (**Table 9-3**)

Figure 9-1. Process variables, output variables, and outputs

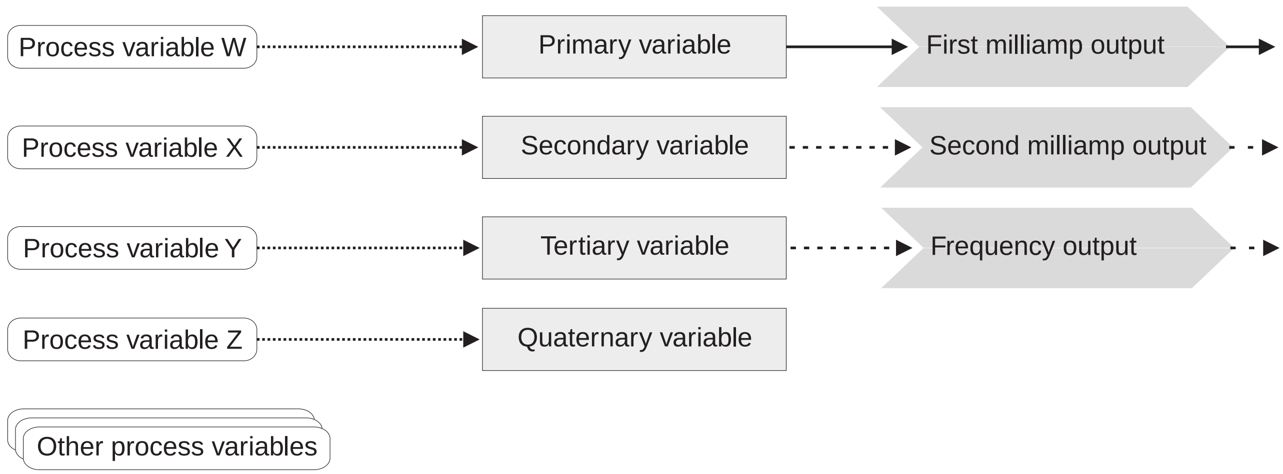

Table 9-1. Process variable registers

Process variable	Input register	Floating-point register pair	Stored value
Mass flow rate	30002	20247-20248	Present value of process variable
Density	30003	20249-20250	
Temperature	30004	20251-20252	
Volume flow rate	30005	20253-20254	
Pressure	40007	20257-20258	
Mass total	30008	20259-20260	
Volume total	30009	20261-20262	
Mass inventory	30010	20263-20264	
Volume inventory	30011	20265-20266	
API: temperature-corrected density	N/A	20235-20236	
API: temperature-corrected volume flow	N/A	20331-20332	

Table 9-2. Output variable assignment registers

Output variable	Input register	Stored value
PV	40012	Assigned process variable
SV	40013	
TV	40014	
QV	40015	

Table 9-3. Output present level registers

Output	Floating-point register pair	Stored value
Primary milliamp	20203-20204 (in milliamps)	Present value of designated output[1, 2]
Secondary milliamp	20213-20214 (in milliamps)	
Frequency	20229-20230 (in Hz)	
QV	N/A (available only through HART protocol)	

[1] *Because the values stored in these registers represent output levels in milliamps or Hz, you must derive the actual value of the process variable through calculation. See **Section 9.5**, page 84, and **Section 9.6**, page 85.*
[2] *If the designated output does not exist, the value in these register pairs is 0.0.*

9.3 Configuring the milliamp outputs

Primary and secondary milliamp outputs go to controllers, PLCs, or recording devices. The primary milliamp output always reports the process variable assigned to the primary variable; the secondary milliamp reports the process variable assigned to the secondary variable.

Note: You can assign a process variable to the secondary variable even if your transmitter or output board does not have a secondary milliamp output. You can also configure output range, low-flow cutoff, and added damping for the secondary variable. These configurations will have no effect in the present, but if a secondary milliamp output is configured at a later time, they will affect the behavior of the secondary output at that time.

Milliamp outputs are analog outputs. That is, the milliamp output varies in proportion to the value of the assigned process variable.

Depending on the transmitter, the milliamp output span may be either 0-20 or 4-20 mA. The lower range value is the process value corresponding to the 0 or 4 mA level. The upper range value is the process value corresponding to the 20 mA level. Between the upper and lower limits, the milliamp output is proportional to the flow of the assigned process variable.

To configure milliamp outputs, follow the steps below.

Step 1 Assign process variables to milliamp outputs

To assign a process variable to a milliamp output, write the desired integer codes to holding registers 40012 and 40013, as listed in **Table 9-4** and **Table 9-5**. The RFT9739 transmitter supports two milliamp outputs; the Series 1000 supports one milliamp output; and the Series 2000 transmitters support either one or two milliamp outputs, depending on output board and configuration. See **Chapter 6**.

Step 2 Define range

The Series 1000 or 2000 milliamp output(s) produce(s) a 4-20 mA current. RFT9739 milliamp outputs can be set to produce either a 0-20

Reporting Process Data with Outputs *continued*

Table 9-4. RFT9739 milliamp output holding registers

<table>
<tr><th>Holding register</th><th>Description</th><th>Integer code</th><th>Process variable</th><th>RFT9739</th></tr>
<tr><td>40012</td><td>Process variable indicated by primary mA output</td><td rowspan="2">0
1
3
5
9
10
11</td><td rowspan="2">Mass flow rate
Flow tube temperature
Density
Volume flow rate
Pressure
Event 1 (see "Configuring RFT9739 events," page 112)
Event 2 (see "Configuring RFT9739 events," page 112)</td><td>√</td></tr>
<tr><td>40013</td><td>Process variable indicated by secondary mA output</td><td>√</td></tr>
</table>

Table 9-5. Series 1000 or 2000 milliamp output holding register

<table>
<tr><th>Holding register</th><th>Description</th><th>Integer code</th><th>Process variable</th><th>Series 1000</th><th>Series 2000</th></tr>
<tr><td>40012</td><td>Process variable indicated by primary mA output</td><td rowspan="2">0
1
3
5
15
16
19
20
47</td><td rowspan="2">Mass flow rate
Flow tube temperature
Density
Volume flow rate
API: temperature-corrected density
API: temperature-corrected (standard) volume flow
API: batch-weighted average corrected density
API: batch-weighted average temperature
Drive gain</td><td>√</td><td>√</td></tr>
<tr><td>40013</td><td>Process variable indicated by secondary mA output</td><td></td><td>√[1]</td></tr>
</table>

[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*

or a 4-20 mA current. To set the span of RFT9739 milliamp outputs, see the instruction manual that was shipped with the transmitter.

The high and low ends of these ranges represent a specific value of the assigned process variable. The default upper range value (URV) and lower range value (LRV) settings are the sensor limits, as listed in **Table 9-6**, page 72.

- If a milliamp output indicates flow, the transmitter uses the flow calibration factor to establish limits on the flow rate. The flow calibration factor is derived from the factory calibration or from a flowmeter characterization.
- If a milliamp output indicates temperature or density, the limit depends on the sensor model. For limits on each sensor model, see the instruction manual that was shipped with the sensor.

To change the URV and LRV:

- To set the URV on the primary or secondary milliamp output, write the process variable value to be represented by 20 mA to register pair 20209-20210 (primary) or 20219-20220 (secondary), as listed in **Table 9-7**, page 73.
- To set the LRV on the primary or secondary milliamp output, write the process variable value to be represented by 0 mA or 4 mA to register pair 20211-20212 (primary) or 20221-20222 (secondary), as listed in **Table 9-7**.

Table 9-6. Sensor limit read-only register pairs

Notes

- The transmitter converts sensor limits listed below to measurement units established for process variables.
- For limits on each sensor model, see the instruction manual that is shipped with the sensor.

Register pair	Description	Returned single precision IEEE 754 floating-point value:	Series 1000	Series 2000	RFT9739
20165 20166	Maximum mass flow rate	• 2 to 25,000 lb/min (27 to 680,250 kg/h) • Depends on flow calibration factor	√	√	√
20167 20168	Maximum temperature	• 842°F (450°C) or lower temperature • Depends on sensor model	√	√	√
20169 20170	Maximum density	• 5.0000 g/cc or lower density • Depends on sensor model	√	√	√
20171 20172	Maximum volume flow rate	• 0.2 to 3000 gal/min (1 to 11,350 l/min) • Depends on flow calibration factor	√	√	√
20173 20174	Minimum mass flow rate	• –2 to –25,000 lb/min (–27 to –680,250 kg/h) • Depends on flow calibration factor	√	√	√
20175 20176	Minimum temperature	• –400°F (–240°C) or higher temperature • Depends on sensor model	√	√	√
20177 20178	Minimum density	• 0.0000 g/cc or higher density • Depends on sensor model	√	√	√
20179 20180	Minimum volume flow rate	• –0.2 to –3000 gal/min (–1 to –11,350 l/min) • Depends on flow calibration factor	√	√	√
20181 20182	Minimum span of mass flow rates	Depends on flow calibration factor and measurement unit for mass flow rate	√	√	√
20183 20184	Minimum span of temperature	• 36°F (20°C) or higher temperature • Depends on sensor model	√	√	√
20185 20186	Minimum span of densities	• 0.1 g/cc or higher density range • Depends on sensor model	√	√	√
20187 20188	Minimum span of volume flow rates	Depends on flow calibration factor and measurement unit for volume flow rate	√	√	√

Keys to setting the milliamp output range

- The programmed lower range value must be higher than the minimum limit for the sensor.
- The programmed upper range value must be lower than the maximum limit for the sensor.
- The programmed span, which equals the difference between the programmed upper and lower range limits, should exceed the minimum span of the sensor for the variable.

Example	
Example	The Series 2000 milliamp output indicates density. Scale the milliamp output so 4 mA represents a density of 0.9000 gram per cubic centimeter (g/cc) and 20 mA represents a density of 1.0000 g/cc. According to **Table 9-6**, the output can be successfully scaled: • The span of 0.1000 g/cc matches the minimum density span for the sensor; • The upper range value of 1.0000 g/cc is less than the sensor upper limit of 5.0000 g/cc; • The lower range value of 0.9000 g/cc is more than the sensor lower limit of 0.0000 g/cc. Write a value of 1.0000 to register pair 20209-20210 (see **Table 9-7**). Write a value of 0.9000 to register pair 20211-20212 (see **Table 9-7**).

Table 9-7. Milliamp output URV and LRV register pairs

Note

Write output limit values in the units that have been configured for the process variable.

Register pair	Single precision IEEE 754 floating-point value	Series 1000	Series 2000	RFT9739
20209 20210	• Highest value of process variable indicated by primary mA output • Value must be lower than value written to register pair 20211-20212	√	√	√
20211 20212	• Lowest value of process variable indicated by primary mA output • Value must be higher than value written to register pair 20209-20210	√	√	√
20219 20220	• Highest value of process variable indicated by secondary mA output • Value must be lower than value written to register pair 20221-20222		√[1]	√
20221 20222	• Lowest value of process variable indicated by secondary mA output • Value must be higher than value written to register pair 20219-20220		√[1]	√

[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*

Internal zero

Internal zero is the output level that represents a value of zero for the assigned process variable. The values in effect for upper and lower limits determine the internal zero output level. Internal zero may be used as a fault indicator (see **Chapter 11**).

Internal zero may be derived from the upper and lower limits using the equations below. In these equations:

- IZ = internal zero
- LRV = configured lower range value (register pair(s) 20211-20212, 20221-20222)
- URV = configured upper range value (register pair(s) 20209-20210, 20219-20220)

For a 0-20 mA span, use the following equation:

$$IZ = \frac{(0 - LRV) \times 20}{(URV - LRV)}$$

For a 4-20 mA span, use the following equation:

$$IZ = \frac{(0 - LRV) \times 16}{(URV - LRV)} + 4$$

Step 3 Set low-flow cutoff

At low flow rates, a milliamp output that indicates flow can become difficult to read, due to rapid changes in the flow rate.

If a milliamp output indicates mass flow or volume flow, you can define a low-flow cutoff for the output. A low-flow cutoff is the lowest flow rate at which the milliamp output indicates non-zero flow. If the flow signal drops below the flow cutoff, the output goes to the current level that indicates zero flow (the configured internal zero value).

The default low-flow cutoff value is 0. To set different low-flow cutoff for a milliamp output, write the desired value to register pair 20207-20208 or 20217-20218, as listed in **Table 9-8**.

Example

The Series 2000 milliamp output indicates mass flow, and has user-defined limits of zero flow at 4 mA and 100 grams per minute (g/min) at 20 mA. The output should go to 4 mA when the mass flow rate goes below 2.00 g/min.

Write a value of 2.00 to register pair 20207-20208. An output of 4.32 mA indicates a mass flow rate of 2.00 g/min. The milliamp output goes to 4 mA if the flow rate drops below 2.00 g/min.

Table 9-8. Milliamp output low-flow cutoff register pairs

Note

Write values in measurement units for mass or volume flow as process variables.

Register pair	Single precision IEEE 754 floating-point value	Series 1000	Series 2000	RFT9739
20207 20208	Flow rate below which primary mA output indicates zero flow	√	√	√
20217 20218	Flow rate below which secondary mA output indicates zero flow		√[1]	√

[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*

Multiple low-flow cutoffs
There are four low-flow cutoffs: the first two apply to the primary and secondary milliamp outputs, the third applies to mass flow, and the fourth applies to volume flow. (See **Chapter 10** for information on configuring the mass flow and volume low-flow cutoffs. The low-density cutoff, also discussed in **Chapter 10**, does not affect the milliamp low-flow cutoffs)

If multiple cutoffs apply to a milliamp output, it is controlled by the highest setting. See the following examples.

Example

- Mass flow has been assigned to the primary milliamp output and to the frequency output.
- A low-flow cutoff of 10 g/sec has been configured for the primary milliamp.
- A low-flow cutoff of 15 g/sec has been configured for mass flow.

As a result:
- If the mass flow rate drops below 15 g/sec, all outputs will report zero flow.

Example

- Mass flow has been assigned to the primary milliamp output and the secondary milliamp output, and also to the frequency output.
- A low-flow cutoff of 15 g/sec has been configured for the primary milliamp output.
- No low-flow cutoff has been configured for the secondary milliamp output.
- A low-flow cutoff of 10 g/sec has been configured for mass flow.

As a result:
- If the mass flow rate drops below 15 g/sec but not below 10 g/sec:
  - The primary milliamp output will report zero flow.
  - Both the secondary milliamp output and the frequency output will report non-zero flow.
- If the mass flow rate drops below 10 g/sec, all outputs will report zero flow

Key to using milliamp output low-flow cutoffs
- Be sure to set the milliamp output low-flow cutoffs in the correct relationship to the mass flow, volume flow, and density cutoffs.
- Be aware that the milliamp low-flow cutoff(s) is in effect only if mass flow or volume flow is assigned to the milliamp output(s). If another process variable (such as temperature or density) is assigned, the low-flow cutoff may still be configured, but will have no effect.

Step 4 Put added damping on outputs

Damping filters the effects of noise and rapid changes in the process variable:

- If damping is not configured, when the process variable changes, the output level changes in response as soon as possible.
- If damping is applied, the output changes gradually, so that the output reaches 63% of the change in the process variable at the end of the time period specified by the damping parameter. In other words, the change in output level is represented by a flatter line (lower slope) or a curve, rather than a sharp increase or decrease.

The transmitter rounds down the selected added damping value to the nearest available programmed filter coefficient. **Table 9-9** and **Table 9-10** list programmed filter coefficients on flow, density, and temperature as indicated by the milliamp outputs.

Example

To compensate for noise from a slow-acting valve, approximately 2 seconds of damping need to be added to the existing 0.8 second of digital damping on the mass flow rate. RFT9739 primary milliamp and frequency outputs indicate the mass flow rate.

Write a value of 2.00 to register pair 20205-20206.

The transmitter damps the frequency output at a filter coefficient of 0.8. After rounding down to the nearest programmed filter coefficient, the transmitter damps the primary milliamp output at approximately 0.8 + 1.6, or 2.4 seconds.

Table 9-9. RFT9739 milliamp output added damping register pairs

		Filter coefficients (in seconds)			
Register pair	**Description**	**Mass or volume flow**	**Temperature**	**Density**	**RFT9739**
20205 20206	Filter coefficient for added damping on primary mA output	0 0.1 0.2	0 2 4	0.5 1 2	√
20215 20216	Filter coefficient for added damping on secondary mA output	0.4 0.8 1.6 3.2 6.4 12.8 25.6 51.2 102.4 204.8 409.6 819.2 1638.4	8 16 32 64 128 256 512 1024 2048 4096 8192 16384 32768	4 8 16 32 64 128 256 512 1024 2048 4096 8192	√

Table 9-10. Series 1000 or 2000 milliamp output added damping register pairs

Register pair	Description	Filter coefficients (in seconds): Mass or volume flow	Temperature	Density	Serles 1000	Serles 2000
20205 20206	Filter coefficient for added damping on primary mA output	0 0.1 0.5 1 2	55 110 220 440	3 7 14 27	√	√
20215 20216	Filter coefficient for added damping on secondary mA output					√[1]

[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*

Multiple damping parameters

There are multiple damping parameters:

- The first two – “added damping” — apply to the primary and secondary milliamp outputs.
- The others apply specifically to mass or volume flow, temperature, or density, and therefore affect any output that is mapped to one of these process variables. See **Chapter 10** for information on configuring these damping parameters.

If multiple damping parameters apply to a milliamp output, the added damping parameter is applied to the already-damped output that results from the first damping parameter.

Example

- A damping value of 1 second has been configured for mass flow.
- Mass flow has been mapped to the primary milliamp output and also to the frequency output.
- An added damping value of 2 seconds has been configured for the primary milliamp output.

As a result:

- A change in mass flow will be reflected in the primary milliamp output over a time period that is greater than 3 seconds. The exact time period is calculated by the transmitter according to internal algorithms which are not configurable.
- The frequency output level changes over a 1-second time period (the mass flow damping value). It is not affected by the added damping value.

Key to using added damping

Be sure to configure the added damping parameters in conjunction with the damping parameters discussed in **Chapter 10**.

9.4 Frequency output

The frequency output goes to a Micro Motion peripheral or to another frequency-based totalizer or flow computer. The frequency output always reports the process variable assigned to the tertiary variable. To configure the frequency output, follow the steps below.

Step 1 Assign a process variable to the output

RFT9739 transmitters

The RFT9739 frequency output indicates either mass flow, mass total, volume flow, or volume total.

- If mass flow is selected, the output produces a frequency proportional to the mass flow rate.
- If mass total is selected, the output produces a given number of pulses per unit mass flow.
- If volume flow is selected, the output produces a frequency proportional to the volume flow rate.
- If volume total is selected, the output produces a given number of pulses per unit volume flow.

The frequency or number of pulses per unit time is always proportional to a flow rate, regardless of the process variable assigned to the frequency output.

To assign a process variable to the RFT9739 frequency output, write the desired integer code to holding register 40014, as listed in **Table 9-11**.

Table 9-11. RFT9739 frequency output variable holding register

Holding register	Integer code	Process variable	RFT9739
40014	0	Mass flow rate	√
	2	Mass totalizer	√
	5	Volume flow rate	√
	6	Volume totalizer	√

Series 1000 transmitters

The Series 1000 frequency output variable depends on the process variable that is assigned by the primary milliamp output, and cannot be reassigned.

- If the milliamp output reports mass flow, the frequency output will also represent mass flow. The output level is proportional to the mass flow rate.
- If the milliamp output reports volume flow, the frequency output will also represent volume flow. The output level is proportional to the volume flow rate.

Series 2000 transmitters

The Series 2000 frequency output can represent mass or volume flow. If the API feature is enabled, it can also represent the temperature-corrected volume flow. The output level is proportional to the flow rate or total.

To assign a process variable to the Series 2000 frequency output variable, write the desired integer code to holding register 40014, as listed in **Table 9-12**.

Table 9-12. Series 2000 frequency output variable holding register

Holding register	Integer code	Process variable	Series 2000
40014	0	Mass flow rate	√
	5	Volume flow rate	√
	16	API: Temperature-corrected (standard) volume flow	√

Step 2 Set the output scaling

After assigning a process variable to the frequency output, you must scale the output. The scaling method depends on the transmitter.

Because the frequency always represents a mass or volume flow rate, the frequency varies proportionally to the flow rate, unless one or more of the following conditions exist(s):

- The flow rate attempts to drive the frequency beyond 15 kHz, causing the frequency to remain fixed at 15 kHz.
- Flow stops or goes below the programmed low-flow cutoff for the mass or volume flow rate.
- Density goes outside a programmed low-density or high-density limit for a time period longer than the slug duration, after which the output goes to 0 Hz.
- A process variable goes outside a programmed limit or sensor limit, causing milliamp outputs and the frequency output to go to their fault output levels.
- A transmitter failure occurs.

Unlike milliamp flow outputs, which can represent zero flow as an output other than 0 mA or 4 mA, the frequency output is always 0 Hz at zero flow.

Series 1000 or 2000 frequency output scaling

To scale the Series 1000 or 2000 frequency output, you must first select the scaling method that will be used.

To select the scaling method, write the desired integer code to holding register 41108, as listed in **Table 9-13**.

Table 9-13. Scaling method holding register

Holding register	Integer code	Scaling method	Series 1000	Series 2000
41108	0	Frequency=flow	√	√
	1	Pulses/unit	√	√
	2	Units/pulse	√	√

Frequency=flow

If integer code 0 was written to holding register 41108, follow these steps to write the flow rate and a corresponding frequency:

a. Select a mass flow rate or volume flow rate that will be represented by a corresponding frequency.
b. Write the frequency that will represent the selected flow rate to register pair 20223-20224, as listed in **Table 9-14**.
c. Write the selected flow rate to register pair 20225-20226, as listed in **Table 9-14**.

Example

The Series 2000 frequency output represents mass flow. Scale the output so 4000 Hz represents a mass flow rate of 400 grams per minute (g/min).

- Write integer code 0 to holding register 41108.
- Write a value of 4000.0 to register pair 20223-20224.
- Write a value of 400.0 to register pair 20225-20226.

One Hz represents a mass flow rate of 0.10 g/min. The maximum frequency of 10 kHz represents a flow rate of 1000 g/min.

Table 9-14. Frequency=flow rate register pairs

Note

Write values in measurement units for process variables. See **Chapter 7**.

Register pair	Single precision IEEE 754 floating-point value	Series 1000	Series 2000
20223 20224	Frequency that represents the mass flow or volume flow rate written to register pair 20225-20226	√	√
20225 20226	Mass flow or volume flow rate that is represented by the frequency written to register pair 20223-20224	√	√

Pulses/unit

If integer code 1 was written to holding register 41108, follow these steps to write the frequency or number of pulses:

a. Choose a frequency or number of pulses that will represent one unit of flow or total.
b. Write the floating-point value of the frequency or number of pulses to register pair 20225-20226, as listed in **Table 9-15**.

Table 9-15. Pulses/unit register pair

Note

Write values in measurement units for process variables. See **Chapter 7**.

Register pair	Single precision IEEE 754 floating-point value	Series 1000	Series 2000
21101 21102	Frequency that represents 1 unit of flow	√	√

Example	The Series 2000 frequency output represents volume flow. Using pulses/unit as the scaling method, scale the output so 10,000 Hz represents a flow rate of 200,000 cubic meters/hour. One cubic meter will be represented by 0.05 pulses. • Write integer code 1 to holding register 41108. • Write a value of floating-point value of 0.05 to register pair 21101-21102. One Hz represents 20 cubic meters/hour. The frequency will vary with the volume flow rate.

Units/pulse
If integer code 2 was written to holding register 41108, follow these steps to write the flow rate or total:

a. Select a mass flow or volume flow rate that will be represented by one Hz or one pulse.
b. Write the floating-point value of the selected flow rate to register pair 21103-21104, as listed in **Table 9-16**.

Table 9-16. Units/pulse register pair

Note

Write values in measurement units for process variables. See **Chapter 7**.

Register pair	Single precision IEEE 754 floating-point value	Series 1000	Series 2000
21103 21104	Flow rate or total that is represented by 1 Hz or 1 pulse	√	√

Example	The Series 2000 frequency output represents mass flow. Using units/pulse as the scaling method, scale the output so 4000 Hz represents a mass flow rate of 400 grams per minute (g/min). • Write integer code 2 to holding register 41108. • Write a floating-point value of 0.10 to register pair 21103-21104. One Hz represents a mass flow rate of 0.10 g/min. The maximum frequency of 10 kHz will represent a flow rate of 1000 g/min.

RFT9739 frequency output scaling

If the output indicates the mass flow rate or volume flow rate, scaling requires writing of frequency and flow rate setpoints, such as 10,000 Hz per 10,000 kilograms/hour.

If the output indicates the mass total or volume total, scaling requires writing of pulses and an equivalent total, such as 1 pulse per kilogram.

To establish the proportional scale of the RFT9739 frequency output, follow these steps:

a. Select a frequency that will represent a flow rate, or a number of pulses that will represent a flow total or inventory.
b. Write the value of the frequency setpoint or number of pulses to register pair 20223-20224, as listed in **Table 9-17**.
c. Select a mass flow rate, volume flow rate, mass total, or volume total that will be represented by the frequency or number of pulses that was selected at step a.
d. Write the value the flow rate or total to register pair 20225-20226, as listed in **Table 9-17**.

Table 9-17. Frequency and flow rate register pairs

Note

- For the frequency setpoint or number of pulses, write the value in Hz or number of pulses.
- For flow rates or totals, write values in measurement units for process variables. See **Chapter 7**.

Register pair	Single precision IEEE 754 floating-point value	RFT9739
20223 20224	Frequency or number of pulses that represents the flow rate, total, or inventory written to register pair 20225-20226	√
20225 20226	Flow rate or total that is represented by the frequency or number of pulses written to register pair 20223-20224	√

Example

The RFT9739 frequency output represents mass flow. Scale the frequency output so 4000 Hz represents a mass flow rate of 400 grams per minute (g/min).

- Write a value of 4000.0 to register pair 20223-20224.
- Write a value of 400.0 to register pair 20225-20226.

One Hz represents a mass flow rate of 0.10 g/min. The maximum frequency of 10 kHz represents a flow rate of 1000 g/min.

Example

The RFT9739 pulse output represents volume total. Scale the pulse output so 10,000 pulses represent an accumulated volume of 200,000 cubic meters.

- Write a value of 10000.0 to register pair 20223-20224.
- Write a value of 200000.0 to register pair 20225-20226.

Each pulse represents 20 cubic meters. The frequency of the pulses will vary with the volume flow rate.

Step 3 Set the pulse width

The frequency output operates in different modes at high and low frequencies.

At high frequencies, the output produces a square wave with an approximate 50% duty cycle. (The ON and OFF states are of approximately equal duration.) High-frequency counters such as frequency-to-voltage converters, frequency-to-current converters, and Micro Motion peripherals usually require such an input.

At low frequencies, the output reverts to a constant pulse width in the ON state, with an OFF state that varies in relationship to the actual frequency. Electromechanical counters and PLCs that have low-scan cycle rates generally use an input with a constant ON state and a varying OFF state. Most low-frequency counters have a specified requirement for the minimum pulse width.

The pulse width defines a crossover frequency:

$$\textit{Crossover frequency} = \frac{1}{2 \times \textit{Pulse width}}$$

Above the crossover frequency, the output has a 50% duty cycle. Below the crossover frequency, the output has a constant ON state (0 V) duration.

- The lowest available crossover frequency is 1 Hz, when the pulse width is 0.500 seconds.
- The highest available crossover frequency is 500 Hz, when the pulse width is 0.001 seconds.

To program the pulse width, write the desired value in seconds to register pair 20227-20228, as listed in **Table 9-18.**

Table 9-18. Pulse width register pair

Register pair	Single precision IEEE 754 floating-point value	Series 1000	Series 2000	RFT9739
20227 20228	Number of seconds for ON (0 V) state of frequency output below crossover frequency • For RFT9739 transmitter, value is 0.001 to 0.500 seconds • For Series 1000 or 2000 transmitter, value is 0.001 to 0.277 seconds	√	√	√

Example	
	The frequency output goes to a totalizer with a specified pulse width requirement of 50 milliseconds. The maximum frequency input to the totalizer is 10 pulses per second. Since 50 milliseconds equals 0.05 second (50 x 0.001), the pulse width is 0.05. According to **Table 9-18**, page 83, register pair 20227-20228 stores the frequency pulse width. Write a value of 0.050 to register pair 20227-20228. The crossover frequency is 1 ÷ (2 x 0.05 second), or 1 ÷ 0.10, which equals 10 Hz. Below 10 Hz, the frequency output will have a 50-millisecond ON state. Above 10 Hz, the frequency output will be a square wave with a 50% duty cycle.

9.5 Reading milliamp output levels

Register pairs 20203-20204 and 20213-20214, listed in **Table 9-19**, store floating-point values representing the amount of electrical current that is being produced by the milliamp outputs.

Table 9-19. Present current level register pair

Register pair	Returned single precision IEEE 754 floating-point value	Series 1000	Series 2000	RFT9739
20203 20204	Amount of current, in milliamps, being produced by primary mA output	√	√	√
20213 20214	Amount of current, in milliamps, being produced by secondary mA output		√[1]	√

[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*

Note: You are actually reading the output level that represents the value of the primary variable and secondary variable. If no process variable has been assigned to the primary or secondary variable, or if the secondary milliamp output does not exist, the value in the associated register is 0.0.

If the register contains a non-zero value, you can determine the value of the process variable from the milliamp output level, as demonstrated in the following example.

Example	The primary milliamp output indicates density in grams per cubic centimeter (g/cc). A 4 mA current represents 0.9000 g/cc, and a 20 mA current represents 1.0000 g/cc. Determine the density when register pair 20203-20204 returns a value of 11.53 mA.

$$20\ \mathit{Milliamps} = A(1.0000\ \mathit{g/cc}) + B$$
$$4\ \mathit{Milliamps} = A(0.90000\ \mathit{g/cc}) + B$$

Solve for A:

$$16\ \mathit{Milliamps} = A(0.10000\ \mathit{g/cc})$$
$$A = \frac{16}{1.0000}$$
$$A = 160$$

Solve for B:

$$20\ \mathit{Milliamps} = \frac{160}{1.0000} + B$$
$$20\ \mathit{Milliamps} = 160 + B$$
$$B = 20\ \mathit{Milliamps} - 160$$
$$B = -140$$

Use the slope, offset, and present current level to determine the measured density.

$$\mathit{Density} = \frac{(y - B)}{A}$$
$$= \frac{11.53 - (-140)}{160}$$
$$= 0.9471$$

The measured density is 0.9471 g/cc at an output of 11.53 mA.

9.6 Reading the frequency output

Register pair 20229-20230 stores a floating-point value representing the frequency in Hz that is being produced by the frequency output.

Read the present frequency in Hz from register pair 20229-20230, as listed in **Table 9-20**, page 86. After scaling the output as instructed on pages 79-82, use the ratio of the frequency per flow rate to determine the flow rate, as demonstrated in the following example.

The frequency returned from register pair 20229-20230 represents a mass or volume flow rate, rather than a total.

Note: You are actually reading the output level that represents the value of the tertiary variable. If no process variable has been assigned to the tertiary variable, if the frequency output does not exist, or if the frequency output is acting as a discrete output, the value in this register pair is 0.0.

Example	The frequency output indicates mass flow. A frequency of 10,000 Hz represents a mass flow rate of 5000 pounds per minute (lb/min). Determine the mass flow rate when register pair 20229-20230 returns a frequency of 7936 Hz. Since 10,000 Hz ÷ 5000 lb/min = 2, the frequency output has a slope of 2. $7936 = 2x$ $\frac{7936}{2} = 3968$ The mass flow rate is 3968 lb/min at a frequency of 7936 Hz.

Table 9-20. Present output frequency register pair

Register pair	Returned single precision IEEE 754 floating-point value	Series 1000	Series 2000	RFT9739
20229 20230	The output frequency, in Hz, proportional to the mass or volume flow rate	√	√	√

9.7 Quaternary variable

A process variable can be assigned to the quaternary output variable. This is useful if the output variables will be queried using HART protocol. However, there is no output to report the value of the quaternary variable and there is no memory register that can be read using Modbus protocol.

Write the desired integer code for the quaternary variable for MVDSolo or a Series 1000 or 2000 transmitter to holding register 40015, as listed in **Table 9-21**. The value of the assigned variable can be read using a HART Communicator.

9.8 100 Hz mode

By default, all process variable values in the transmitter are updated with new process data from the sensor at a rate of 20 Hz. 100 Hz mode specifies that the transmitter will be updated with process data from the sensor at 100Hz, instead of 20Hz.

100 Hz mode can be used for only one process variable. This process variable can be reported to an external device using the milliamp output, the frequency output, or both. Because the process variable is being updated at a faster rate, the output can respond more quickly to changes in the process variable.

Note: If 100 Hz mode is implemented, all other process variables are reported at 6.25 Hz.

Note: 100 Hz mode applies to the update rate between the sensor and the core processor, so that you can specify 100 Hz mode for MVDSolo implementations. This will be useful only if the external device polling the core processor can poll at a rate greater than 20 Hz.

Table 9-21. Quaternary variable holding register

Holding register	Integer code	Process variable	MVDSolo	Series 1000	Series 2000
40015	0	Mass flow rate	√	√	√
	1	Temperature	√	√	√
	2	Mass total	√	√	√
	3	Density	√	√	√
	4	Mass inventory	√	√	√
	5	Volume flow rate	√	√	√
	6	Volume total	√	√	√
	7	Volume inventory	√	√	√
	15	API: Temperature-corrected density	√	√	√
	16	API: Temperature-corrected (standard) volume flow	√	√	√
	17	API: Temperature-corrected (standard) volume total	√	√	√
	18	API: Temperature-corrected (standard) volume inventory	√	√	√
	19	API: Batch-weighted average corrected density	√	√	√
	20	API: Batch-weighted average temperature	√	√	√
	33	API: CTL	√	√	√
	47	Drive gain	√	√	√
	53	Externally read pressure	√	√	√
	55	Externally read temperature	√	√	√

To configure 100 Hz mode:

1. Specify the process variable that will be updated at 100 Hz. To do this, write the integer code for the process variable to holding register 41164, as listed in **Table 9-22**. This process variable should already be assigned to the milliamp output and/or the frequency output.

Table 9-22. 100 Hz mode process variables holding register

Holding register	Integer code	Process variable	Series 1000	Series 2000
41164	0	Mass flow rate	√	√
	1	Temperature	√	√
	2	Mass total	√	√
	3	Density	√	√
	4	Mass inventory	√	√
	5	Volume flow rate	√	√
	6	Volume total	√	√
	7	Volume inventory	√	√
	10	Event 1[1] (see **Chapter 11**)	√	√
	11	Event 2[2] (see **Chapter 11**)	√	√

[1] *Specifies the process variable associated with event 1.*
[2] *Specifies the process variable associated with event 2.*

2. Write the new rate,100, to holding register 40366, as shown in **Table 9-23**, page 88.

Table 9-23. Update rate holding register

Holding register	Update rate	Description	Series 1000	Series 2000
40366	20	All process variables will be updated at 20 Hz.	√	√
	100	Specified process variable will be updated at 100 Hz. All other process variables will be updated at 6.25 Hz.	√	√

Configuration

10 Process Variables and Field Conditions

10.1 About this chapter

This chapter explains how to adapt process variables for field conditions such as low flow, flow direction, and slug flow. Available adaptions include:

- Writing floating-point values to define low-flow cutoffs for mass flow and volume flow
- Writing floating-point values to define low-density cutoff
- Writing integer codes that indicate flow direction
- Writing floating-point values to control damping on flow, temperature, and density
- Writing floating-point values to define slug flow limits

⚠ CAUTION

Writing configuration specifications for process variables can change transmitter outputs, which can result in measurement error.

Set control devices for manual operation before configuring process variables. This prevents automatic recording of process data during transmitter configuration.

Key to using limits on process variables

- Before adapting process variables to field conditions, establish measurement units for process variables. See **Chapter 7**.
- A totalizer is a mass volume, mass inventory, volume total, or volume inventory process variable.

10.2 Low-flow cutoffs for mass flow and volume flow

In some sensor installations, velocity signals from the pickoffs can carry noise caused by a mechanical source, such as a valve or motor. Low-flow cutoffs allow you to filter out noise for either mass flow or volume flow by defining the lowest value of that process variable to be reported.

If the value of the process variable drops below the cutoff value, any output reporting these process variables will indicate zero flow:

- Milliamp outputs go to their internal zero value.
- The frequency output goes to 0 Hz.
- Totalizers stop counting.
- The transmitter indicates zero flow (configured internal zero) during polling from a host controller.

The low-flow cutoffs have a default value of 0.

Key to using low-flow cutoffs
Milliamp outputs have their own low-flow cutoffs. Be sure to set mass flow and volume low-flow cutoffs in the correct relationship to the milliamp output low-flow cutoffs. See **Chapter 9** for information on the milliamp output low-flow cutoffs.

To configure a low-flow cutoff, write the desired value to register pair 20195-20196 or 20197-20198, as listed in **Table 10-1**.

Table 10-1. Low-flow cutoff register pairs

Note

Write cutoff values in measurement units established for mass and volume flow as process variables.

Register pair	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000	RFT9739
20195 20196	Mass flow rate below which totalizers stop counting; associated outputs indicate zero flow	√	√	√	√
20197 20198	Volume flow rate below which totalizers stop counting; associated outputs indicate zero flow	√	√	√	√

Mass, density, and volume interdependencies

Micro Motion flowmeters measure mass flow and density independently, and use those two values to calculate volume flow.

The mass flow low-flow cutoff is not applied to the volume flow calculation. Even if the mass flow drops below the cutoff, and therefore the mass flow indicators go to zero, the volume flow rate will be calculated from the actual mass flow process variable.

However, the density cutoff is applied to the volume flow calculation. Accordingly, if the density drops below its configured cutoff value, the volume flow rate will go to zero. See **Section 10.3**.

Live zero flow

In some situations, you may want to read the actual mass flow rate even when it has dropped below the low-flow cutoff defined above. This value is the "live zero flow" value.

Live zero flow is for diagnostic purposes only. If the mass flow rate drops below the low-flow cutoff, internal totalizers will quit counting, whether or not the operator is reading live zero flow.

Live zero flow can be used for calculating the zero stability portion of the flow measurement error:

$$\textit{\% error in zero stability} = \frac{\textit{Live zero flow}}{\textit{Operating flow rate}} \times 100$$

Read live zero flow from holding register 40297 or from floating-point register pair 20293-20294. See **Table 10-2**.

Table 10-2. Live zero flow registers

Address	Address type	Read-only scaled integer or single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000	RFT9739
40297	Holding register	Calculated flow rate, damped at 12.8 seconds, when flow rate drops below mass flow cutoff				√
20293 20294	Floating point register pair		√	√	√	√

10.3 Low-density cutoff

MVDSolo and Series 1000 and 2000 transmitters have a low-density cutoff. The low-density cutoff specifies the lowest density value to be reported. If the measured density value drops below the cutoff value:

- Any output reporting density will indicate a zero value.
- Any outputs reporting volume will go to zero.
- All volume totalizers will stop counting.

See *Mass, density, and volume interdependencies*, below.

The default low-density cutoff is 0.2. To change this value, write the desired value to register pair 20149-20510, as listed in **Table 10-3**.

Table 10-3. Low-density cutoff register pair

Note

Write cutoff values in measurement units established for density as a process variable.

Register pair	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000
20149 20150	Density value below which outputs representing density or volume indicate zero, and volume totalizers stop counting	√	√	√

Mass, density, and volume interdependencies

Micro Motion flowmeters measure mass flow and density independently, and use those two values to calculate volume flow.

The mass flow low-flow cutoff is not applied to the volume flow calculation. Even if the mass flow drops below the cutoff, and therefore the mass flow indicators go to zero, the volume flow rate will be calculated from the actual mass flow process variable.

However, the density cutoff is applied to the volume flow calculation. Accordingly, if the density drops below its configured cutoff value, the volume flow rate will go to zero.

Key to using low-density cutoffs
Be sure to set the low-density cutoff high enough to maintain the required measurement of volume flow.

10.4 Flow direction

The flow direction parameter controls the behavior of outputs and totalizers under forward flow or reverse flow conditions. **Table 10-4** lists the available settings for the flow direction parameter. Outputs and totalizers then behave as described in **Table 10-6** through **Table 10-11**.

Key to using flow direction
If possible, install the sensor so the arrow on the manifold indicates forward flow. To install the sensor, see the instruction manual that is shipped with the sensor.

For MVDSolo or a Series 1000 or 2000 transmitter, if flow remains above the rate that is defined as the mass low-flow cutoff, bit #4 in holding register 30422 is ON when fluid flows in the same direction as the arrow and OFF when fluid flows in the opposite direction from the arrow, as listed in **Table 10-5**.

To set the flow direction parameter, write the desired integer code to holding register 40017, as listed in **Table 10-4**.

Table 10-4. Flow direction holding register

Holding register	Integer code	Flow direction option	MVDSolo	Series 1000	Series 2000	RFT9739
40017	0	• Forward flow only • For effects of forward flow, see **Table 10-6**	√	√	√	√
	1	• Reverse flow only • For effects of reverse flow, see **Table 10-7**	√	√	√	√
	2	• Bidirectional flow • For effects of bidirectional flow, see **Table 10-8**	√	√	√	√
	3	• Absolute forward/reverse • For effects of absolute forward/reverse flow, see **Table 10-9**	√	√	√	
	4	• Negate – forward only • For effects of negate – forward flow, see **Table 10-10**	√			
	5	• Negate – bidirectional • For effects of negate – bidirectional flow, see **Table 10-11**	√			

Table 10-5. Flow direction status bit

Note

The status bit functions only when the flow rate exceeds the mass flow low-flow cutoff. See page 89.

Address	Address type	Description	Bit status	MVDSolo	Series 1000	Series 2000
30422	Input register	Fluid is flowing in same direction as flow direction arrow on sensor	xxxx xxxx xxx1 xxxx	√	√	√
		Fluid is flowing in opposite direction from flow direction arrow on sensor	xxxx xxxx xxx0 xxxx	√	√	√

Table 10-6. Effect of forward flow

Fluid flow direction	Output or totalizer	If forward flow only is selected	MVDSolo	Series 1000	Series 2000	RFT9739
Fluid flowing in *same direction* as flow arrow on sensor	Milliamp outputs that are not NAMUR-compliant[1]	Output increases as flow rate increases				√
	NAMUR-compliant milliamp outputs	Output increases as flow rate increases		√	√	√
	Frequency output	Output increases as flow rate increases		√	√	√
	Control output[2]	Output is 15 VDC				√
	Totalizers	Flow totals increase	√	√	√	√
	Digital flow rate	Flow is positive	√	√	√	
Fluid flowing in *opposite direction* from flow arrow on sensor	Milliamp outputs that are not NAMUR-compliant[1]	• 4-20 mA output goes to 2 mA • 0-20 mA output goes to 0 mA				√
	NAMUR-compliant milliamp outputs	• 4-20 mA output goes to 3.8 mA • 0-20 mA output goes to 0 mA		√	√	√
	Frequency output	Output remains at 0 Hz		√	√	√
	Control output[2]	Output is 0 VDC				√
	Totalizers	Flow totals remain constant	√	√	√	√
	Digital flow rate	Flow is negative	√	√	√	

[1] *RFT9739 transmitters with software versions lower than 3.8 (shipped before December1999).*
[2] *Control output is configured for flow direction (see **Chapter 11**).*

Table 10-7. Effect of reverse flow

Fluid flow direction	Output or totalizer	If reverse flow only is selected	MVDSolo	Series 1000	Series 2000	RFT9739
Fluid flowing in *same direction* as flow arrow on sensor	Milliamp outputs that are not NAMUR-compliant[1]	• 4-20 mA output goes to 2 mA • 0-20 mA output goes to 0 mA				√
	NAMUR-compliant milliamp outputs	• 4-20 mA output goes to 3.8 mA • 0-20 mA output goes to 0 mA		√	√	√
	Frequency output	Output remains at 0 Hz		√	√	√
	Control output[2]	Output is 15 VDC				√
	Totalizers	Flow totals remain constant	√	√	√	√
	Digital flow rate	Flow is positive	√	√	√	
Fluid flowing in *opposite direction* from flow arrow on sensor	Milliamp outputs that are not NAMUR-compliant[1]	Output increases as flow rate increases				√
	NAMUR-compliant milliamp outputs	Output increases as flow rate increases		√	√	√
	Frequency output	Output increases as flow rate increases		√	√	√
	Control output[2]	Output is 0 VDC				√
	Totalizers	Flow totals increase	√	√	√	√
	Digital flow rate	Flow is negative	√	√	√	

[1] RFT9739 transmitters with software versions lower than 3.8 (shipped before December1999).
*[2] Control output is configured for flow direction (see **Chapter 11**).*

Table 10-8. Effect of bidirectional flow

Fluid flow direction	Output or totalizer	If bidirectional flow is selected	MVDSolo	Series 1000	Series 2000	RFT9739
Fluid flowing in *same direction* as flow arrow on sensor	Milliamp outputs that are not NAMUR-compliant[1]	• Output increases as flow rate increases • 4-20 mA output remains at or above 4 mA				√
	NAMUR-compliant milliamp outputs	• Output increases as flow rate increases • 4-20 mA output remains at or above 4 mA		√	√	√
	Frequency output	Output increases as flow rate increases		√	√	√
	Control output[2]	Output is 15 VDC				√
	Totalizers	Flow totals increase	√	√	√	√
	Digital flow rate	Flow is positive	√	√	√	
Fluid flowing in *opposite direction* from flow arrow on sensor	Milliamp outputs that are not NAMUR-compliant[1]	• Output increases as flow rate increases • 4-20 mA output remains at or above 4 mA				√
	NAMUR-compliant milliamp outputs	• Output increases as flow rate increases • 4-20 mA output remains at or above 4 mA		√	√	√
	Frequency output	Output increases as flow rate increases		√	√	√
	Control output[2]	Output is 0 VDC				√
	Totalizers	Flow totals decrease	√	√	√	√
	Digital flow rate	Flow is negative	√	√	√	

[1] RFT9739 transmitters with software versions lower than 3.8 (shipped before December1999).
*[2] Control output is configured for flow direction (see **Chapter 11**).*

Table 10-9. Effect of absolute forward/reverse flow

Fluid flow direction	Output or totalizer	If absolute forward/reverse flow is selected	MVDSolo	Series 1000	Series 2000
Fluid flowing in *same direction* as flow arrow on sensor	NAMUR-compliant milliamp outputs	• Output increases as flow rate increases • 4-20 mA output remains at or above 4 mA		√	√
	Frequency output	Output increases as flow rate increases		√	√
	Totalizers	Flow totals increase	√	√	√
	Digital flow rate	Flow is positive	√	√	√
Fluid flowing in *opposite direction* from flow arrow on sensor	NAMUR-compliant milliamp outputs	• Output increases as flow rate increases • 4-20 mA output remains at or above 4 mA		√	√
	Frequency output	Output increases as flow rate increases		√	√
	Totalizers	Flow totals increase	√	√	√
	Digital flow rate	Flow is negative	√	√	√

Table 10-10. Effect of negate – forward flow

Fluid flow direction	Output or totalizer	If negate – forward flow is selected	MVDSolo
Fluid flowing in *opposite direction* from flow arrow on sensor	Totalizers	Flow totals increase	√
	Digital flow rate	Flow is positive	√
Fluid flowing in *same direction* as flow arrow on sensor	Totalizers	Flow totals remain constant	√
	Digital flow rate	Flow is negative	√

Table 10-11. Effect of negate – bidirectional flow

Fluid flow direction	Output or totalizer	If negate – bidirectional flow is selected	MVDSolo
Fluid flowing in *opposite direction* from flow arrow on sensor	Totalizers	Flow totals increase	√
	Digital flow rate	Flow is positive	√
Fluid flowing in *same direction* as flow arrow on sensor	Totalizers	Flow totals decrease	√
	Digital flow rate	Flow is negative	√

10.5 Digital damping

You can put digital damping on mass or volume flow, density, or temperature process variables. Digital damping filters the effects of noise and rapid changes in the process variable:

- If damping is not configured, when the process variable changes, the output level changes in response as soon as possible.
- If damping is applied, the output changes gradually, so that the output reaches 63% of the change in the process variable at the end of the time period specified by the damping parameter. In other words, the change in output level is represented by a flatter line (lower slope) or a curve, rather than a sharp increase or decrease.

Digital damping does not affect measurement of the variable. The transmitter implements a selective digital filter on the output.

*Note: An added damping parameter can be configured for the primary and secondary milliamp outputs. This configuration can interact with the digital damping value specified here. See **Chapter 9** for information on the added damping parameter.*

The default digital damping value is 0.8 seconds.

- A value of 0 seconds should be used only for troubleshooting.
- Use values lower than 0.8 for batch runs shorter than 15 seconds.

The transmitter rounds down the programmed damping value to the nearest available filter coefficient.

Key to using digital damping
Be sure to configure the digital damping parameters in conjunction with the added damping parameter discussed in **Chapter 9**.

To establish digital damping on flow, temperature, and density, write the desired filter constants to register pairs 20189-20190 to 20193-20194, as listed in **Table 10-12** and **Table 10-13**.

Example

Put approximately one second of digital damping on mass flow.

According to **Table 10-12**, register pair 20189-20190 stores the filter coefficient for digital damping on the mass or volume flow rate. Write a value of 1.00 to register pair 20189-20190.

The transmitter automatically rounds down the digital damping value to the nearest programmed filter coefficient (0.8).

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Table 10-12. RFT9739 digital damping register pairs

Register pair	Description	Filter coefficients (in seconds)[1]				RFT9739
20189 20190	Filter coefficient for digital damping on mass flow or volume flow	0 0.1 0.2 0.4	0.8 1.6 3.2 6.4	12.8 25.6 51.2 102.4	204.8 409.6 819.2 1638.4	√
20191 20192	Filter coefficient for digital damping on temperature	0 2 4 8	16 32 64 128	256 512 1024 2048	4096 8192 16384 32768	√
20193 20194	Filter coefficient for digital damping on density	0.5 1 2	4 8 16 32	64 128 256 512	1024 2048 4096 8192	√

[1]*Because volume flow measurement is derived from mass and density measurements, set digital damping values accordingly.*

Table 10-13. MVDSolo or Series 1000 or 2000 digital damping register pairs

Register pair	Description	Filter coefficients (in seconds)[1, 2]			MVDSolo	Series 1000	Series 2000
20189 20190	Filter coefficient for digital damping on mass flow or volume flow	0.0 0.1 0.2 0.4	0.8 1.6 3.2 6.4	12.8 25.6 51.2	√	√	√
20191 20192	Filter coefficient for digital damping on temperature	0.0 0.6 1.2	2.4 4.8 9.6	19.2 38.4 76.8	√	√	√
20193 20194	Filter coefficient for digital damping on density	0.0 0.1 0.2 0.4	0.8 1.6 3.2 6.4	12.8 25.6 51.2	√	√	√

[1]*Because volume flow measurement is derived from mass and density measurements, set digital damping values accordingly.*
[2]*When 100 Hz mode is configured, the filter coefficient values are divided by five.*

10.6 Slug flow limits

Density limits enable detection of conditions such as slug flow (the presence of gas slugs in a liquid flow stream). Such conditions cause erratic vibration of the flow tubes, which in turn causes the transmitter to produce inaccurate flow signals.

Because the sensor typically fails to produce accurate signals when a liquid process stream contains more than 1% to 20% gas by volume, the low-density limit should equal 80% to 99% of the lowest process density, depending on the sensor.

The high-density limit allows detection of accumulated solid particles in the flow tubes or cessation of flow tube vibration due to other conditions.

If fluid density goes outside the limits for a an amount of time longer than the slug duration, all the following occur:

- Addresses listed in **Table 10-14**, page 98, indicate slug flow.
- The frequency output goes to 0 Hz.
- Milliamp outputs indicating flow go to a level that represents zero flow.

- Totalizers stop counting until density stabilizes within the slug flow limits.
- On the field-mount RFT9739 transmitter, the diagnostic LED blinks OFF once per second (75% ON, 25% OFF).
- The core processor LED or the display LED is yellow and blinks.

Table 10-14. Slug flow status bits

Address	Address type	Description	Bit status	MVDSolo	Series 1000	Series 2000	RFT9739
30001	Input register	Sensor cannot measure flow due to: • Slug of gas in sensor flow tubes, or • Solid particles in flow tubes	xx1x xxxx xxxx xxxx	√	√	√	√
30126	Input register		1xxx xxxx xxxx xxxx	√	√	√	√
30421	Input register		1xxx xxxx xxxx xxxx	√	√	√	
20245 20246	Floating point register pair		262144.	√	√	√	√

Example	Slug flow occurs in a process in which the density of the liquid consistently remains above 0.9000 grams per cubic centimeter (g/cc). According to **Table 10-15**, register pair 20201-20202 stores the low-density limit. Because the installed sensor fails to produce accurate signals if the liquid contains 10% or more gas by volume, set the low-density limit at 0.8100 g/cc (or 90% of 0.9000 g/cc) by writing a value of 0.8100 to register pair 20201-20202.

Table 10-15. Slug flow register pairs

Note

Write slug flow limits in grams per cubic centimeter, regardless of the measurement unit selected for density as a process variable.

Register pair	Single precision IEEE 754 floating-point value in g/cc	MVDSolo	Series 1000	Series 2000	RFT9739
20199 20200	Density in g/cc above which transmitter indicates slug flow, after slug duration (see **Table 10-16**). Valid range is 0.0 - 10.0 g/cc.	√	√	√	√
20201 20202	Density in g/cc below which transmitter indicates slug flow, after slug duration (see **Table 10-16**). Valid range is 0.0 - 10.0 g/cc.	√	√	√	√

10.7 Slug duration

Before programming a slug duration, write floating-point values of slug flow limits to register pairs 20199-20200 and/or 20201-20202, as instructed in **Section 10.6**.

The slug duration causes flow outputs to hold their last measured value for a set number of seconds after density goes outside the slug flow limits. The slug duration prevents unnecessary inhibition of flow outputs if density momentarily goes outside user-defined limits, then stabilizes within them. In other words, if a slug condition occurs, and clears within the time period specified by slug condition, the alarm condition will clear. However, the fact that the alarm occurred will remain in the alarm log.

Some applications are more vulnerable than others to slug flow. If gas slugs or solid particles typically remain in the flow tubes for a short time, you should configure the transmitter to hold its last measured flow value for up to one minute before indicating zero flow. The slug duration specifies the amount of time the transmitter indicates the last measured flow value.

After setting slug flow limits as instructed on pages 97-98, program a slug duration by writing the desired time period in seconds to register pair 20141-20142, as listed in **Table 10-16**.

Table 10-16. Slug duration register pair

Register pair	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000	RFT9739
20141 20142	During a slug flow condition, the number of seconds, from 0.0 to 60.0, that flow remains at last measured value before outputs go to levels indicating zero flow	√	√	√	√

11 Process Controls

11.1 About this chapter

This chapter explains how to define process controls. Process controls are used to report and specify system behavior under various conditions, for example:

- Fault conditions
- Flowmeter zeroing in process
- Specific flow direction
- Changes in a process variable with respect to a specified value (a setpoint)

Types of system behavior that can be specified include, for example:

- Setting output levels to specific values defined as fault indicators
- Switching output states between ON and OFF
- Starting, stopping, or resetting totalizers

By indicating these conditions through outputs, external devices such as PLCs or control valves can respond to changing process conditions. **Table 11-1**, page 102, and **Table 11-2**, page 102, list the different conditions that can be indicated through outputs.

Note: For complete information on system status, specific diagnostic registers can be read. See ***Chapter 23****.*

This chapter also explains how to enable or disable operator control of various totalizer functions.

CAUTION

Writing process controls can change transmitter outputs, which can result in measurement error.

Set control devices for manual operation before writing process controls. This prevents inappropriate process control actions during transmitter configuration.

Table 11-1. RFT9739 system conditions and indicators

System condition	Milliamp outputs	Frequency output	Control output
Fault condition	√[1]	√[1]	√
Flowmeter zeroing in progress			√
Flow direction			√
Event 1	√		√
Event 2	√		√

[1] *These may be configured via Modbus communications only with Version 2 of the RFT9739 transmitter. To configure these outputs with the Version 3 transmitter, you must use hardware switches. However, after configuration, Version 3 fault indicators operate as described in this manual, and you can use Modbus communications to read the values.*

Table 11-2. MVDSolo or Series 1000 and Series 2000 system conditions and outputs

	MVDSolo	Series 1000 or Series 2000			
System condition	RS-485 output	Milliamp output(s)	Frequency/ pulse output	RS-485 output	Discrete output[1]
Fault condition	√	√	√	√	√
Calibration in progress	√			√	√
Flow direction	√			√	√
Flow switch	√			√	√
Event 1	√			√	√
Event 2	√			√	√
Event 1 or event 2	√			√	√

[1] *Series 2000 transmitters only.*

Key to using process controls
Before writing process controls:
1. Establish measurement units for process variables (see **Chapter 7**).
2. Configure floating-point flow cutoffs and slug flow limits for the frequency output and internal totalizers (see **Chapter 10**).

No outputs available

Even if an output is not available, and therefore no process control can be defined for it, the corresponding memory register can be read. For example, there is no way to map events to outputs in MVDSolo installations. However, you can use Modbus communications to read the registers that hold the event states.

Information on memory registers that contain process control data is provided throughout this chapter.

11.2 Fault outputs

Fault outputs control milliamp outputs and the frequency output when the transmitter cannot accurately measure process variables. Faults can occur for a variety of reasons.

The milliamp and frequency outputs can be used for both fault outputs and process variables simultaneously. For example, the milliamp output may be configured to report volume flow and also to indicate faults. When no fault conditions exist, it will report volume flow; if a fault condition occurs, it will then report the fault, even if the fault is not related to volume flow.

To define fault outputs:

- For a Version 2 RFT9739 transmitter, you can write an integer code that assigns a fault indicator to milliamp outputs and the frequency output. Version 3 RFT9739 transmitters must be configured using hardware switches or the display.
- For a Series 1000 or Series 2000 transmitter, you can write integer codes or floating-point values that assign fault indicators to the milliamp output and the frequency output.
- For MVDSolo or a Series 1000 or Series 2000 transmitter, you can write an integer code that assigns a fault indicator to the RS-485 digital output.
- For a Series 2000 transmitter with a discrete output (configurable input/output option board only), you can write an integer code that assigns a fault indicator to the discrete output.

Key to using fault outputs
Regardless of the fault output that is selected, the transmitter's diagnostic LED, if one exists, will blink red to indicate a fault condition. For RFT9739 transmitters with a display, "ERR" flashes on the display.

Version 2 RFT9739 fault outputs

For the Version 2 RFT9739 transmitter, fault outputs can be configured using Modbus protocol.

Note: Later versions of the RFT9739 transmitter require setting of hardware switches inside the transmitter or using the display. See the instruction manual that was shipped with the transmitter.

You can specify how faults are indicated. For example, you can specify an upscale, downscale, last measured value, or internal zero indicator. Then, if a fault occurs:

- And the setting is upscale:
  - Milliamp outputs produce 22 mA.
  - Frequency outputs produce 15000 Hz.
- And the setting is downscale:
  - Milliamp outputs produce 0 mA, if configured for 0-20 mA span, or 2 mA, if configured for 4-20 mA span.
  - Frequency outputs produce 0 Hz.

- And the setting is last measured value:
  - All outputs hold the last value they produced before the fault condition occurred.
- And the setting is internal zero:
  - Milliamp outputs go to zero (configured internal zero value).
  - Frequency outputs produce 0 Hz.

You can also read fault indicator values from the register pairs listed in **Table 11-8**, page 108.

To select a milliamp and frequency fault output for a Version 2 RFT9739 transmitter, write the desired integer code to holding register 40124, as listed in **Table 11-3**.

⚠ CAUTION

Using last measured value or internal zero can hamper identification of fault outputs.

To make sure fault outputs can be identified, select upscale (integer code 0) or downscale (integer code 1).

Table 11-3. Version 2 RFT9739 fault output holding register

Holding register	Integer code	Description	Fault indicator[1]	RFT9739
40124	0	Upscale	• Milliamp outputs go to 22 mA • Frequency output goes to 15 kHz	√
	1	Downscale	• Milliamp outputs go to 0 mA if they produce a 0-20 mA current, or to 2 mA if they produce a 4-20 mA current • Frequency output goes to 0 Hz	√
	2	Last measured value	• Outputs hold the values measured immediately before the fault condition occurred • Apparent lack of variation in the process variable could indicate a fault	√
	3	Internal zero	• Milliamp outputs go to the setting that represents the zero value for the indicated process variable • Frequency output goes to 0 Hz • A value of 0.0 for the process variable could indicate a fault	√

[1] *To read the values of these outputs directly, you can query the associated input registers or register pairs. See **Chapter 9**.*

MVDSolo or Series 1000 or 2000 fault outputs

For the Series 1000 or 2000 transmitter, you can assign independent fault indicators to the milliamp output(s), the frequency output, and the RS-485 digital output. For MVDSolo, only the RS-485 digital output is available.

You can specify how faults are indicated by the different outputs. For example, you can specify upscale, downscale, or internal zero indicators. For the milliamp outputs, you can also specify fault level (the current level to be produced in fault conditions).

Then, if a fault occurs:

- And the setting is upscale, with a fault level of 22 mA:
  - Milliamp outputs produce 22 mA.
  - Frequency outputs produce 10-15000 Hz.
- And the setting is downscale, with a fault level of 3 mA:
  - Milliamp outputs produce 3 mA.
  - Frequency outputs produce 0 Hz.
- And the setting is internal zero:
  - Milliamp outputs go to zero (configured internal zero).
  - Frequency outputs produce 0 Hz.

Milliamp and frequency outputs

To configure the fault indicator for Series 1000 or 2000 fault outputs, write the appropriate values to the registers that are listed in **Table 11-4**, page 106.

To configure the milliamp fault levels, write the desired current level for the configured fault indicator to the floating-point register pairs that are listed in **Table 11-5**, page 106.

You may configure more than one output as a fault indicator, and you can configure them independently. For example, you could set the primary milliamp output to upscale and the frequency output to internal zero. If no secondary milliamp output or frequency output exists, the configurations are stored and will be applied if the transmitter is reconfigured.

If fault conditions occur:

- The outputs change as described in **Table 11-4**.
- You may also read fault indicator values from the register pairs listed in **Table 11-8**, page 108.

Table 11-4. Series 1000 or 2000 fault output holding registers

Holding register	Output	Integer code	Description	Fault indicator[1]	Series 1000	Series 2000
41113	Primary mA	0	Upscale	Goes to 21-24 mA (see **Table 11-5**)	√	√
41114	Secondary mA	1	Downscale	Goes to 1-3 mA (see **Table 11-5**)		√[2]
		3	Internal zero	• Goes to the setting that represents the zero value for the indicated process variable • A value of 0.0 for the process variable could indicate a fault		
41107	Frequency	0	Upscale	Goes to 10.0-15,000 Hz (see **Table 11-5**)	√	√
		1	Downscale	Goes to 0 Hz (see **Table 11-5**)		
		3	Internal zero	• Frequency output goes to 0 Hz • A value of 0.0 for the flow rate or total could indicate a fault		

[1] *To read the values of these outputs directly, you can query the associated input registers or register pairs. See* ***Chapter 9****.*
[2] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*

Table 11-5. Series 1000 or 2000 fault levels register pairs

Register pair	Output	Fault indicator	Single precision IEEE 754 floating-point value	Series 1000	Series 2000
21109 21110	Primary mA	0 (upscale)	A value between 21.0 and 24.0	√	√
		1 (downscale)	A value between 1.0 and 3.0		
		3 (internal zero)	Configured zero value or 0.0 • A value of 0.0 for the process variable could indicate a fault		
21111 21112	Secondary mA	0 (upscale)	A value between 21.0 and 24.0		√
		1 (downscale)	A value between 1.0 and 3.0		
		3 (internal zero)	Configured zero value or 0.0 • A value of 0.0 for the process variable could indicate a fault		
21105 21106	Frequency	0 (upscale)	A value between 10.0 and 15,000.0	√	√
		1 (downscale)	A value of 0.0		
		3 (internal zero)	A value of 0.0 • A value of 0.0 for the flow rate or total could indicate a fault		

RS-485 digital output

The RS-485 digital output, available with MVDSolo or a Series 1000 or 2000 transmitter, can indicate fault conditions.

To configure a digital fault output, write the desired integer code to holding register 40124, as listed in **Table 11-6**.

CAUTION

Using internal zero or flow zero can hamper identification of fault outputs.

To make sure fault outputs can be identified, select integer code 0, integer code 1, or integer code 3.

Table 11-6. RS-485 digital output holding register

Holding register	Integer code	Description	Digital fault indicator	MVDSolo	Series 1000	Series 2000
40124	0	Upscale	• Process variables go to a value that is greater than the upper limit for the sensor • Totalizing stops	√	√	√
	1	Downscale	• Process variables go to a value that is less than the lower limit for the sensor • Totalizing stops	√	√	√
	2	Internal zero	Outputs go to settings that represent a value of zero for flow, density, and temperature	√	√	√
	3	Not-a-number	• Report maximum scaled integer (input registers) and not-a-number (register pairs)[1] • Totalizing stops	√	√	√
	4	Flow zero	• Flow outputs go to the setting that represents zero flow • Other process variables remain unaffected	√	√	√
	5	None	• Default setting • Status bits will be used for fault detection	√	√	√

[1] *The input registers report the maximum scaled integer value; the floating-point register pairs report not-a-number.*

Last measured value fault timeout

If a fault occurs, outputs can hold their last measured values for the time period specified here, before going to fault levels. The value held is the last value received from the core processor.

For example, if upscale has been selected as the milliamp fault indicator, and the last measured value fault timeout has been set to 20 seconds, the output will hold its last measured value for 20 seconds, then go to its upscale value of 22 mA.

To define the last measured value fault timeout, write an integer value from 1 to 60 seconds to holding register 40314, as listed in **Table 11-7**, page 108

.

Table 11-7. Last measured value fault timeout holding register

Note

Outputs that indicate faults by holding their last measured values will remain unaffected by the fault timeout value.

Holding register	Integer value	MVDSolo	Series 1000	Series 2000
40314	Number of seconds, from 1 to 60, for which outputs hold last measured values before going to fault levels	√	√	√

Reading fault output levels

The real-time output level of the milliamp and frequency outputs can be read from the register pairs listed in **Table 11-8**. In ordinary (non-fault) circumstances, these registers will hold values that represent the real-time values of the assigned process variables. In fault conditions, these registers will hold values that represent the configured fault indicators.

Table 11-8. Output levels register pairs

Register pair	Output	Single precision IEEE 754 floating-point value	Series 1000	Series 2000	RFT9739
20143 20144	Primary mA	Output level, in milliamps	√	√	√
20145 20146	Secondary mA	Output level, in milliamps		√[1]	√
20147 20148	Frequency	Output level, in Hz	√	√	√

[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*

11.3 RFT9739 control output

The RFT9739 control output produces a signal at either of two levels: 15 V (OFF) and 0 V (ON). The control output can indicate flow direction, flowmeter zeroing in progress, faults, event 1 or event 2.

To assign a function to the control output, write its associated integer code to holding register 40015. **Table 11-9** lists the available functions and associated integer codes.

Example

The control output is connected to a controller. A downstream valve needs to remain closed during transmitter zeroing.

According to **Table 11-9**, the integer 1 configures the control output to indicate zero in progress. Write the integer 1 to holding register 40015. The control output will switch ON (go to 0 V) to indicate transmitter zeroing in progress.

Flow direction

If the RFT9739 control output indicates flow direction, the output is low (0 V) when indicating reverse flow, and high (+15 V) when indicating forward flow. At zero flow, the output remains low or high, depending on the flow direction before the flow rate reached zero.

- When configured to indicate flow direction, the RFT9739 control output is affected by the low-flow cutoff. If the flow signal drops below the low-flow cutoff, the output remains low or high, depending on the flow direction before the flow rate reached the cutoff.

- Configure the RFT9739 control output to indicate flow direction if the transmitter is connected to a Micro Motion peripheral device.

Zeroing in progress

If the control output indicates zeroing in progress, the output is low (0 V) when zeroing is in progress, and high (+15 V) at all other times. Whether or not the control output is configured to indicate zeroing in progress, the diagnostic LED on the field-mount RFT9739 is red and remains ON during flowmeter zeroing.

Faults

If the RFT9739 control output indicates faults, the output is low (0 V) when indicating a fault condition, and high (15 V) when indicating normal operation. Whether or not the control output is set to indicate faults, the diagnostic LED on the field-mount RFT9739 is red and blinks 4 times per second to indicate a fault condition. For transmitters with a display, “ERR” flashes on display.

Event 1 and event 2

Assigning event 1 or event 2 to the RFT9739 control output requires output configuration and event parameter configuration. To assign an event to the control output, see **Section 11.6**, page 111.

Table 11-9. RFT9739 control output holding register

Holding register	Integer code	Control output function	RFT9739
40015	0	Forward/reverse flow	√
	1	Zero in progress	√
	2	Faults	√
	3	Event 1 (see **Section 11.6**)	√
	4	Event 2 (see **Section 11.6**)	√

11.4 Series 2000 discrete output

The Series 2000 transmitters can be configured for a discrete output. The Series 2000 transmitter with the configurable input/output option board can be configured for none, one, or two discrete outputs. See **Chapter 6** for instructions on configuring a discrete output.

The discrete output produces a signal at either of two levels. By default, 15 V = OFF and 0 V = ON. These may be reversed depending on board configuration (see **Chapter 6**).

The discrete output can indicate fault condition, calibration in progress, flow direction, flow switch, event 1, event 2, or event 1 or event 2. To assign an indicator to the discrete output:

1. Write the integer code for the discrete output assignment, as listed in **Table 11-10**:
   a. For transmitters with a single discrete output, or for the discrete output configured on channel B, write the integer code to holding register 41151.
   b. For the discrete output configured on channel C, write the integer code to holding register 41153

Table 11-10. Discrete output assignment holding register

Holding register	Discrete output	Integer code	Description	Series 2000
41151	Single DO Channel B[1]	10	Event 1 active	√
		11	Event 2 active	
41153	Channel C[1]	100	Event 1 or event 2 active	
		101	Flow switch indicator	
		102	Forward/reverse indicator	
		103	Calibration in progress	
		104	Fault indicator	

[1] *Transmitters with configurable input/output boards only.*

2. If you assign flow switch to the discrete output, you must specify the flow switch setpoint. To do this, write the setpoint value to register pair 21159-21160. See **Table 11-11**.

Table 11-11. Discrete output flow switch setpoint register pair

Note
Write setpoint value in measurement units established for flow. See **Chapter 7**.

Register pair	Single precision IEEE 754 floating-point value	Series 2000
21159 21160	Any desired value at which discrete output changes state.	√

The flow switch will be triggered when the mass flow rate falls below the value specified here. The flow switch has a 5% hysteresis. For example, if the setpoint is 100 lb/min, the flow switch will be triggered when the flow rate falls below 100 lb/min. It will remain on until a 5% change occurs, in this case, until flow rate rises to 105 lb/min.

Note that your transmitter may provide several ways to use flow rate as a process control:

- You can assign flow switch to a discrete output, as described here.
- You can define event 1 to represent mass flow rate or volume flow rate, and report it through the RS-485 digital output as described in "Configuring Series 1000 or 2000 event," page 116.
- You can define event 1 or event 2 to represent mass flow rate or volume flow rate, and then assign event 1, event 2, or event 1 or event 2 to a discrete output, as described here.

The result will be the same, except that the flow switch and flow switch setpoint described here have the 5% hysteresis described above, while the setpoints defined for events have no hysteresis.

Note: Although it is possible to configure the Series 2000 transmitter with the configurable input/output board for two discrete outputs, and then to configure both discrete outputs to act as a flow switch, it is not useful because both discrete outputs will use the same flow switch setpoint.

Reading discrete output states

You can read the states of the indicators assigned to the discrete outputs by reading discrete inputs 10037-10038 and 10065-10069. Discrete inputs 10037-10038, which report event status, are also used by transmitters that do not have discrete outputs. See **Table 11-12**.

Table 11-12. Discrete output indicator status bits

Address	Description	Bit status	Series 1000	Series 2000
10037	Event 1 is OFF Event 1 is ON	0 1	√	√
10038	Event 2 is OFF Event 2 is ON	0 1	√	√
10065	Event 1 and event 2 are OFF Event 1 or event 2 is ON	0 1		√
10066	Flow direction switch is OFF Flow direction switch is ON	0 1		√
10067	Flow rate indicator is OFF Flow rate indicator is ON	0 1		√
10068	Calibration indicator is OFF Calibration indicator is ON	0 1		√
10069	Fault indicator is OFF Fault indicator is ON	0 1		√

11.5 Events

When an event is assigned to an output, the output functions as an event indicator. An event indicator operates in ON/OFF states, and switches from one state to the other when the assigned process variable reaches a programmed setpoint. The output can go to a valve, PLC, host controller, or other device that controls the process or indicates its status.

Any value of a process variable can serve as the setpoint at which the event indicator switches states.

Event indicators can act as process alarms. For example, a temperature event indicator switches states when the process temperature exceeds the setpoint.

Although event state is automatically sent to the external device through the configured output, event state can also be read from transmitter registers, as discussed in "Reading event states," page 120.

The following outputs can function as event indicators:

- Series 1000 or 2000 discrete outputs
- RFT9739 milliamp outputs
- RFT9739 control output

The RFT9739 transmitter supports two events and two event indicators.

MVDSolo and Series 1000 or 2000 transmitters support two events and one, two, or three event indicators:

- Event status can be read from transmitter registers, as mentioned above. This is the only method available for MVDSolo.
- If you have a transmitter with a discrete output, either event can be reported through that output.
- If you have a transmitter with the configurable input/output board, configured for one or two discrete outputs, you can report event 1, event 2, or event 1 or event 2 through either or both discrete outputs.

Event configuration procedure

The event configuration procedure depends on the transmitter.

RFT9739 event configuration procedure
To define an event for an RFT9739 transmitter, follow the steps on pages 112-116.

Series 1000 or 2000 event configuration procedure
To define an event for a Series 1000 or 2000 transmitter, follow the steps on pages 116-119.

Configuring RFT9739 events

Step 1 Assign process variables to RFT9739 events

Any process variable, including a mass or volume total or inventory, can control the states of an RFT9739 event indicator.

To assign a process variable to event 1 or event 2, write the desired integer code to holding register 40137 or 40138, as listed in **Table 11-13**.

Table 11-13. RFT9739 event process variable holding register

Holding register	Description	Integer code	Process variable	RFT9739
40137	Process variable assigned to event 1	0	Mass flow rate	√
		1	Temperature	
		2	Mass totalizer	
		3	Density	
40138	Process variable assigned to event 2	4	Mass inventory	√
		5	Volume flow rate	
		6	Volume totalizer	
		7	Volume inventory	
		9	Pressure	

Step 2 Configure alarm states for RFT9739 events

With any process variable except a total or inventory assigned to an RFT9739 event, the following conditions determine the alarm state:

- A high alarm is ON if the measured value is equal to or greater than the setpoint. Otherwise, the alarm is OFF.
- A low alarm is ON if the measured value is equal to or less than the setpoint. Otherwise, the alarm is OFF.

With a total or inventory assigned to the event, the value of the setpoint determines when the alarm switches states.

- If the setpoint is positive, and forward flow causes the total or inventory level to increase, the alarm switches states when the total reaches the setpoint.
- If the setpoint is negative, and reverse flow causes the total or inventory level to decrease, the alarm switches states when the total reaches the setpoint.
- Once the totalizer alarm has been activated, the totalizer must be reset. Resetting the totalizer switches a high totalizer alarm OFF or switches a low totalizer alarm ON. To stop, start, or reset mass or volume totalizers, see **Section 11.7**, page 120.

Example	
	Mass total has been assigned to RFT9739 event 1.
	Configure the totalizer alarm to switch OFF when 500 kg of fluid has been loaded.
	With mass total assigned to the event, the low alarm will switch OFF when the mass total equals the setpoint, then will switch ON when the totalizer is reset.
	Write the integer 2 (low) to holding register 40139. The totalizer alarm then will remain OFF until you reset the mass totalizer.

To configure an event indicator as a low or high alarm, write the desired integer code to holding register 40139 or 40140, as listed in **Table 11-14**.

Table 11-14. RFT9739 event alarm-type holding register

Holding register	Event	Integer code	Alarm type	RFT9739
40139	Event 1	1	High alarm	√
40140	Event 2	2	Low alarm	√

Step 3 Configure RFT9739 event setpoints

Any value of the assigned process variable can serve as the setpoint at which the RFT9739 event indicator switches states.

- With mass flow, volume flow, density, temperature, or pressure assigned to the event, the event indicator switches states whenever the setpoint is crossed in either direction.
- With a total or inventory assigned to the event, the event indicator switches states when the setpoint is first achieved. You then must reset the totalizer to reset the event indicator.

Key to using event setpoints

1. Before establishing the setpoint for any process variable, assign a process variable to the event (see page 112).
2. Before establishing the setpoint for a total or inventory, configure the flow direction parameter (see **Chapter 10**).

After assigning a process variable to the event, select an appropriate measured value as the setpoint, then write the value of the setpoint to register pair 20241-20242 or 20243-20244, as listed in **Table 11-15**.

Table 11-15. RFT9739 event setpoint register pairs

Note

Write event setpoint values in measurement units established for process variables.

Register pair	Description	Single precision IEEE 754 floating-point value	RFT9739
20241 20242	Measured value at which event 1 switches states	Any desired value representing the point in the process at which event 1 or event 2 switches states	√
20243 20244	Measured value at which event 2 switches states		√

Example	Mass total has been assigned to RFT9739 event 1. Configure the event to switch OFF when the flowmeter measures an accumulated mass total of 500 kilograms. Since mass total has been assigned to the event, configuring the output as a low alarm causes the event indicator to switch ON when the totalizer is reset, then OFF when the mass total equals the setpoint. Write the integer code 2 (low) to holding register 40139. According to **Table 11-15**, register pair 20241-20242 stores the setpoint for event 1. Write a value of 500.00 to register pair 20241-20242. Since the setpoint is positive, and the output is configured as a low alarm, the event indicator will switch OFF when forward flow amounts to 500 kilograms. The event indicator then will remain OFF until you reset the mass totalizer.

Step 4 Configure RFT9739 outputs as event indicators

To assign an event to an RFT9739 output, write the desired integer code to holding register 40012, 40013, or 40015, as listed in **Table 11-16**.

Table 11-16. RFT9739 event assignment holding register

Holding register	Description	Integer code	Event	RFT9739
40012	Event assigned to primary mA output	10 11	Event 1 Event 2	√
40013	Event assigned to secondary mA output			√
40015	Event assigned to RFT9739 control output	3 4	Event 1 Event 2	√

Step 5 Assign current levels for RFT9739 milliamp outputs

If an RTF9739 milliamp output functions as an event indicator, you must define the amount of current produced by the indicator at its ON and OFF states.

If a milliamp output functions as an event indicator, the output produces the programmed high current level in an ON state, and the low current level in an OFF state. The programmed low current level must be lower than the high current level.

To establish low and high current levels for an RFT9739 milliamp event indicator, write the desired values to register pairs 20209-20210 and 20211-20212 or 20219-20220 and 20221-20222. See **Table 11-17**, page 116.

Example	The RFT9739 primary milliamp output indicates event 2, with density as the process variable. Event 2 is a low alarm. The setpoint is 1.0000 grams per cubic centimeter (g/cc). The output should produce an 18 mA current while density is below the setpoint, then should produce a 10 mA current while density is above the setpoint. • Write a value of 10.00 to register pair 20211-20212. • Write a value of 18.00 to register pair 20209-20210. Since the event indicator is low, it remains ON at 18 mA when density drops below 1.0000 g/cc, then switches OFF and goes to 10 mA when density exceeds 1.0000 g/cc.

Table 11-17. RFT9739 event current-level register pairs

Register pair	Description	Single precision IEEE 754 floating-point value	RFT9739
20211 20212	• Low current level from primary mA output • Event is OFF at low current level	• A value from 0.00 to 20.00 if mA output has a 0-20 mA span • A value from 4.00 to 20.00 if mA output has a 4-20 mA span • High current level must exceed low current level	√
20209 20210	• High current level from primary mA output • Event is ON at high current level		√
20221 20222	• Low current level from secondary mA output • Event is OFF at low current level		√
20219 20220	• High current level from secondary mA output • Event is ON at high current level		√

Configuring Series 1000 or 2000 event

Step 1 Assign a process variable to Series 1000 or 2000 event

Any process variable, including a mass or volume total or inventory, can control the states of the Series 1000 or 2000 event indicators.

To assign a process variable to event 1 or event 2, write the desired integer code to holding register 40137 or 40138, as listed in **Table 11-18**.

Step 2 Configure alarm states for Series 1000 or 2000 event

With any process variable except a total or inventory assigned to a Series 1000 or 2000 event, the following conditions determine the alarm state:

Table 11-18. Series 1000 or 2000 event process variable holding registers

Holding register	Indicator	Integer code	Process variable	Series 1000	Series 2000
40137	Event 1	0	Mass flow rate	√	√
		1	Temperature		
		2	Mass total		
		3	Density		
40138	Event 2	4	Mass inventory	√	√
		5	Volume flow rate		
		6	Volume total		
		7	Volume inventory		
		10-55	Additional process variables[1]		

[1] *For a comprehensive list of process variables that can be assigned to events, see **Appendix A**.*

- A high alarm is ON if the measured value is equal to or greater than the setpoint. Otherwise, the alarm is OFF.
- A low alarm is ON if the measured value is equal to or less than the setpoint. Otherwise, the alarm is OFF.

Example	The Series 2000 discrete output has been configured to report event 1. Temperature has been assigned to the event, and the event is used to control an electronic valve. Under normal operating conditions, the valve is closed (that is, the valve is closed when power is supplied from the discrete output). Configure the discrete output to open the valve if the process temperature exceeds the setpoint. With temperature assigned to the event, a high alarm switches ON when temperature goes above the setpoint. Write the integer 1 (high) to holding register 40139. The alarm will switch ON and produce 0 V output to open the valve when temperature exceeds the setpoint.

With a total or inventory assigned to the event, the value of the setpoint determines when the alarm switches states.

- If the setpoint is positive, and forward flow causes the total or inventory level to increase, the alarm switches states when the total reaches the setpoint.
- If the setpoint is negative, and reverse flow causes the total or inventory level to decrease, the alarm switches states when the total reaches the setpoint.
- Once the totalizer alarm has been activated, the totalizer must be reset. Resetting the totalizer switches a high totalizer alarm OFF or switches a low totalizer alarm ON. To stop, start, or reset mass or volume totalizers, see **Section 11.7**, page 120.

To configure an event indicator as a low or high alarm, write the desired integer code to holding register 40139 or 40140, as listed in **Table 11-19**.

Example	
	Mass total has been assigned to the Series 2000 event 1. Configure an alarm to switch OFF when 500 kg of fluid has been loaded. With mass total assigned to the event, the low alarm will switch OFF when the mass total equals the setpoint, then will switch ON when the totalizer is reset. Write the integer 2 (low) to holding register 40139. The alarm then will remain OFF until you reset the mass totalizer.

Table 11-19. Series 1000 or 2000 event alarm-type holding registers

Holding register	Indicator	Integer code	Alarm type	Series 1000	Series 2000
40139	Event 1	1	High alarm	√	√
40140	Event 2	2	Low alarm		√

Step 3 Configure Series 1000 or 2000 event setpoint

Any value of the assigned process variable can serve as the setpoint at which the event indicator switches states.

- With mass flow, volume flow, density, or temperature assigned to the event, the event indicator switches states whenever the setpoint is crossed in either direction.
- With a total or inventory assigned to the event, the event indicator switches states when the setpoint is first achieved, and you must then reset the totalizer to reset the event indicator.

Key to using event setpoints

1. Before establishing the setpoint for any process variable, assign a process variable to the event (see page 116).
2. Before establishing the setpoint for a total or inventory, configure the flow direction parameter (see **Chapter 10**).

After assigning a process variable to the event, select an appropriate measured value as the setpoint, then write the value of the setpoint to register pair 20241-20242, for event 1, or register pair 20243-20244, for event 2, as listed in **Table 11-20**.

Example	
	Mass total has been assigned to the event. Configure the event to switch OFF when the flowmeter measures an accumulated mass total of 500 kilograms. Since mass total has been assigned to the event, configuring the output as a low alarm causes the event indicator to switch ON when the totalizer is reset, then OFF when the mass total equals the setpoint. Write the integer code 2 (low) to holding register 40139. Write a value of 500.00 to register pair 20241-20242. Since the setpoint is positive, and the output is configured as a low alarm, the event indicator will switch OFF when forward flow amounts to 500 kilograms. The event indicator then will remain OFF until you reset the mass totalizer.

Table 11-20. Series 1000 or 2000 event setpoint register pairs

Note

Write event setpoint values in measurement units established for process variables.

Register pair	Description	Single precision IEEE 754 floating-point value	Series 1000	Series 2000
20241 20242	Measured value at which event 1 switches states	Any desired value representing the point in the process at which event 1 or event 2 switches states	√	√
20243 20244	Measured value at which event 2 switches states		√	√

Step 4 Configure discrete output(s) as event indicators

If your transmitter provides a discrete output (or outputs), event 1, event 2, or event 1 or 2 can be reported through this output. See **Section 11.5**, page 109, for information on configuring the discrete output.

Also, the state of both event 1 and event 2 can be read from transmitter memory, as discussed below.

Reading event states

Read states of event indicators from the discrete inputs or input registers listed in **Table 11-21**.

Table 11-21. Event state status bits

Address	Address type	Description	Bit status	Series 1000	Series 2000	RFT9739
30126	Input register	Event 2 is ON Event 2 is OFF Event 1 is ON Event 1 is OFF	xxxx xxxx xx1x xxxx xxxx xxxx xx0x xxxx xxxx xxxx x1xx xxxx xxxx xxxx x0xx xxxx	√	√	√
30421	Input register	Event 1 is ON Event 1 is OFF Event 2 is ON Event 2 is OFF	xxxx xxxx xx1x xxxx xxxx xxxx xx0x xxxx xxxx xxxx x1xx xxxx xxxx xxxx x0xx xxxx	√	√	
10037	Discrete input	Event 1 is OFF Event 1 is ON	0 1	√	√	√
10038	Discrete input	Event 2 is OFF Event 2 is ON	0 1	√	√	√
10065	Discrete input	Event 1 and event 2 are OFF Event 1 or event 2 is ON	0 1		√	

11.6 Totalizers and inventories

Internal totalizers store mass totals, volume totals, and API totals, in the units configured. Various process control settings allow you to start, stop, and reset totalizers based on process conditions.

Inventories store cumulative (across batch) totals, rather than batch totals. In ordinary use, inventories are not reset. However, if the application changes or the transmitter is reconfigured, it may be appropriate to reset the inventories.

Totalizer functions

The configuration of the transmitter determines totalizer functions.

- **Chapter 8** explains how to query addresses that store values indicating mass or volume quantities.
- **Chapter 9** explains how to assign a totalizer to the frequency output, and how to scale the output so a given number of pulses represents a proportional mass or volume quantity.
- **Chapter 10** explains how low-flow cutoffs, the flow direction parameter, and slug flow limits affect totalizer behavior.
- Page 112 and page 116 explain how to assign a totalizer to an event.

Totalizer controls

Read/write coils enable you to start, stop, and reset totalizers. Additionally, if your transmitter has the configurable input/output board option, you can use the discrete input for some totalizer reset functions.

If you reset totalizers, the frequency output remains unaffected. If you stop totalizers, the frequency output goes to 0 Hz until totalizers are restarted.

Control coils

Table 11-22 lists coils used for controlling totalizers.

Table 11-22. Totalizer control coils

Notes

If a totalizer is assigned to an event, and the totalizer is reset:
- The totalizer event will switch OFF if configured as a high alarm, or will switch OFF if configured as a low alarm
- Discrete inputs 10037 and/or 10038 will switch states to indicate event status

Coil	Coil function	Description	Bit status	MVDSolo	Series 1000	Series 2000	RFT9739
00002	• OFF. All input registers and register pairs listed below hold last measured values • ON. All input registers and register pairs listed below start accumulating totals	Totalizers OFF Totalizers ON	0 1	√	√	√	√
00003	Reset mass, volume, and API reference volume totals in input registers 30008 and 30009 and register pairs 20259-20260, 20261-20262, and 20333-20334	Reset totalizers (momentary)	1	√	√	√	√
00004	Reset mass, volume, and API reference volume inventories in input registers 30010 and 30011 and register pairs 20263-20264, 20265-20266, and 20335-20336			√	√	√	√
00056	Reset mass total in input register 30008 and register pair 20259-20560			√	√	√	
00057	Reset volume total in input register 30009 and register pair 20261-20262			√	√	√	
00058	Reset API reference volume total in register pair 20333-20334			√	√	√	

When totalizers are OFF, totalizer registers hold their most recent values and do not change with changes in the process variables, and the frequency output goes to 0 Hz. When totalizers are ON, their values change according to the changes in the process variables.

Coil 00002 is used to set totalizers to OFF or ON:
- To start totalizers, write a value of 1 to coil 00002.
- To stop totalizers, write a value of 0 to coil 00002.

You can also read coil 00002 to find out if totalizers are ON or OFF.

To reset all totalizers to 0 with one action, write a value of 0 to coil 00003.

You can also reset totalizers independently:

- To reset the RFT9739 mass totalizer, write any integer value to input register 30008.
- To reset the RFT9739 volume totalizer, write any integer value to input register 30009.
- To reset the MVDSolo or Series 1000 or 2000 mass totalizer, write a value of 0 to coil 00056, or write any integer value to input register 30008.
- To reset the MVDSolo or Series 1000 or 2000 volume totalizer, write a value of 0 to coil 00057, or write any integer value to input register 30009.
- To reset the MVDSolo or Series 1000 or 2000 API reference volume totalizer, write a value of 0 to coil 00058.

Totals will go to 0. Event indicators with setpoints representing totals will switch states.

Coils 00003, 00056, 00057, and 00058 return automatically to an OFF state after the totalizers are reset.

Mass and volume totals are held in the registers that are listed in **Table 11-23**.

Key to using totalizer controls

1. To "set" a coil, write a value of 1 to the specified coil.
2. To "reset" a coil, write a value of 0 to the specified coil. In some cases, you can reset a coil by writing any integer value. Be careful to distinguish resetting a coil from resetting a totalizer.
3. Some coils are "momentary." A momentary coil can be set (to 1), but it automatically resets (to 0). Typically, the reset will occur before the operator can retrieve the 1 value from the coil.

Table 11-23. Mass or volume total input registers

Input register	Register pair	Data returned from address	MVDSolo	Series 1000	Series 2000	RFT9739
30008	20259 20260	Mass total	√	√	√	√
30009	20261 20262	Volume total	√	√	√	√

Discrete input

If your transmitter has the configurable input/output option board, you can reset the following totalizers via the discrete input:

- mass total
- volume total
- corrected volume total

See **Chapter 6** for information on configuring the discrete input.

Totalizer security

Modbus protocol enables you to secure totalizer functions in two ways:

- You can prevent the operator from using the Series 1000 or 2000 front-panel display to reset totalizers.
- RFT9739 totalizers can be disabled, depending on the security mode. For information about security for custody transfer, see the instruction manual that is shipped with the transmitter.

Disabling Series 1000 or 2000 totalizer reset from display
To disable resetting of totalizers from the Series 1000 or 2000 display, write a value of 0 to coil 00094, as listed in **Table 11-24**.

Resetting coil 00094 does not affect operation of totalizer control coils that are listed in **Table 11-22**, page 121.

Table 11-24. Series 1000 or 2000 totalizer display coil

Note

Setting coil 00094 does not affect operation of totalizer control coils listed in **Table 11-22**.

Coil	Coil function	Bit status	Series 1000	Series 2000	RFT9739
00094	Totalizers can be reset using display	1	√	√	
	Totalizers cannot be reset using display	0	√	√	

Disabling RFT9739 totalizer controls
RFT9739 totalizer functions can be disabled, depending on the security mode. See **Table 11-25**. For more information about security modes, refer to the instruction manual that is shipped with the transmitter.

Table 11-25. Disabling RFT9739 totalizer controls

Note

Resetting the totalizer has no effect on the mass or volume inventory. For more information, refer to the instruction manual that was shipped with the transmitter.

Function	Performed with	Security mode							
		1	2	3	4	5	6	7	8
Totalizer reset, no flow	Display controls		Disabled		Disabled	Disabled		Disabled	
	Modbus device			Disabled		Disabled	Disabled		
Totalizer controls with flow	Display controls		Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
	Modbus device			Disabled	Disabled	Disabled	Disabled	Disabled	Disabled

Resetting inventories

Mass and volume inventories can be reset in one of several ways:

- To reset mass and volume inventories, write a value of 0 to coil 00004, or write any integer value to input registers 30010 and 30011.
- To reset the mass inventory, write any integer value to input register 30010.
- To reset the volume inventory, write any integer value to input register 30011.

Inventories will go to 0. Event indicators with setpoints representing inventories will switch states.

Coil 00004 resets to an OFF state when the inventories are reset.

Mass and volume inventories are held in the registers that are listed in **Table 11-26**.

Table 11-26. Mass or volume inventory input registers

Input register	Register pair	Data returned from address	Series 1000	Series 2000	RFT9739
30010	20263 20264	Mass inventory	√	√	√
30011	20265 20266	Volume inventory	√	√	√

12 Pressure Compensation – MVD

12.1 About this chapter

This chapter explains how to implement pressure compensation for MVDSolo or a Series 1000 or 2000 transmitter. Most applications do not require pressure compensation.

MVDSolo or a Series 1000 or 2000 transmitter can compensate for the effect of pressure on the sensor flow tubes. Pressure effect is defined as the change in sensor flow sensitivity due to process pressure change away from calibration pressure. Sensors that are affected by pressure are listed in **Table 12-2**, page 127.

If a flowmeter is ordered for an application requiring pressure compensation, the pressure input is configured at the factory. Modbus protocol enables you to change this configuration, or configure the pressure input for flowmeters that were not ordered with pressure compensation.

If your operating pressure is relatively stable, you can write pressure data once (static pressure compensation). If your application is sensitive to differences in operating pressure, you can use external pressure data for real-time pressure compensation. Both methods are described in this chapter.

⚠ CAUTION

Writing pressure compensation variables can change transmitter outputs, which can result in measurement error.

Set control devices for manual operation before writing pressure compensation variables. This prevents automatic recording of process data during transmitter configuration.

12.2 Pressure compensation implementation procedure

To implement pressure compensation, follow steps 1 through 3.

Step 1 Enable pressure compensation

To enable pressure compensation, set coil 00082. See **Table 12-1**.

Table 12-1. Pressure compensation coil

Address	Description	Bit status	MVDSolo	Series 1000	Series 2000
00082	• Pressure compensation is enabled • Pressure compensation is disabled	1 0	√	√	√

Step 2 Write pressure correction factors

You must write a pressure correction factor for flow and a pressure correction factor for density. These values are fixed, and depend on the sensor component of your flowmeter.

The pressure correction factor for flow is the percent change in the flow rate per psi. Write the pressure correction factor for flow to register pair 20267-20268, as listed in **Table 12-2**.

The pressure correction factor for density is change in fluid density in grams per cubic centimeter per psi. Write the pressure correction factor for density to register pair 20269-20270, as listed in **Table 12-2**.

Step 3 If necessary, write a flow calibration pressure value

Register pair 20271-20272 stores a floating-point value that represents the pressure, in psig, at which the flowmeter was calibrated for flow. If your flowmeter was ordered with pressure compensation, Micro Motion used a flow calibration pressure of 20 psig.

Verify that your transmitter contains an appropriate flow calibration pressure value by reading register pair 20271-20272. If it does not (for example, if this value was not set at the factory, or if your flowmeter has been recalibrated for flow), write a single precision IEEE 754 floating-point value representing the calibration pressure, in psi, to register pair 20271-20272, as listed in **Table 12-3**.

Table 12-2. Pressure correction register pairs

Note

Write pressure correction values in psi, regardless of the unit selected for pressure as a process variable.

Register pair	Description	Sensor model[1]	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000
20267 20268	Pressure correction factor for flow	CMF100	0.0002	√	√	√
		CMF200	0.0008			
		CMF300	0.0006			
		CMF400	0.002			
		F050	0.0007	√	√	√
		F100	0.001			
		F200	0.0005			
		D300 standard or Tefzel-lined	0.009	√	√	√
		D600	0.005			
		DL100	0.005			
		DL200	0.009			
20269 20270	Pressure correction factor for density	CMF025	–0.000004	√	√	√
		CMF050	0.000002			
		CMF100	0.000006			
		CMF200	0.000001			
		CMF300	–0.0000002			
		CMF400	–0.000007			
		F025, F050, F100	–0.000007	√	√	√
		F200	0.000004			
		D300 standard or Tefzel-lined	0.00001	√	√	√
		D600	0.0000031			
		DL100	0.000001			
		DL200	0.00001			

[1] *If your sensor is not listed here, it does not require a pressure correction factor for flow or density.*

Table 12-3. Flow calibration pressure register pair

Note

Write the calibration pressure in psi, regardless of the unit selected for pressure as a process variable.

Register pair	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000
20271 20272	Pressure, in psi, at which flowmeter was calibrated for flow	√	√	√

Step 4 Write a pressure value

MVDSolo or a transmitter uses flow and density signals from the sensor and pressure signals from the host controller to compensate for the pressure effect on the sensor.

Static pressure compensation
If your operating pressure does not vary significantly, write the operating pressure value to the transmitter. Write a single precision IEEE 754 floating-point value for gauge pressure to register pair 20451-20452, as listed in **Table 12-4**.

Table 12-4. Gauge pressure register pair

Address	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000
20451 20452	Measured gauge pressure at line conditions	√	√	√

Real-time pressure compensation
If operating pressure varies significantly, use one of the following methods to update the pressure value dynamically:

- Configure the host controller to write a gauge pressure value to core processor memory at regular intervals.
- Configure the transmitter to poll an external HART device for pressure data. This method cannot be used with MVDSolo. Configuration instructions are provided in **Chapter 6**.

Configuration

13 Pressure Compensation – RFT9739

13.1 About this chapter

This chapter explains how to implement pressure compensation for the RFT9739 transmitter. Most applications do not require pressure compensation.

The RFT9739 transmitter can compensate for the effect of pressure on sensor flow tubes. Pressure effect is defined as the change in sensor flow sensitivity due to process pressure change away from calibration pressure. Sensors that are affected by pressure are listed in **Table 13-2**, page 131.

If a flowmeter is ordered for an application requiring pressure compensation, the pressure input is configured at the factory. Modbus protocol enables you to change this configuration, or configure the pressure input for flowmeters that were not ordered with pressure compensation.

⚠ CAUTION

Writing pressure compensation variables can change transmitter outputs, which can result in measurement error.

Set control devices for manual operation before writing pressure compensation variables. This prevents automatic recording of process data during transmitter configuration.

Keys to using RFT9739 pressure compensation

Implement pressure compensation if the operating pressure varies significantly from the pressure at which the flowmeter was calibrated. You can implement pressure compensation in one of two ways:

- For operating pressures that are not stable, by implementing real-time pressure compensation (see page 130).
- For relatively stable operating pressures, by adjusting the calibration factors or meter factors for flow and density (see page 133).

13.2 Real-time compensation

If operating pressure is not stable, you can implement real-time pressure compensation. Real-time pressure compensation requires the following:

- A pressure data receiving method
- Pressure correction factors for flow and density
- A gauge pressure input or an analog pressure input
- A valid calibration pressure value

If the flowmeter has been recalibrated for flow, you can write a floating-point value for the calibration pressure.

Follow the steps below to implement real-time pressure compensation.

Step 1 Pressure data receiving method

Pressure compensation is not available for a Version 2 RFT9739 transmitter. For a Version 3 RFT9739 transmitter, write an integer code to holding register 40302 that defines the method by which the transmitter will receive pressure data. See **Table 13-1**.

Table 13-1. RFT9739 Version 3 pressure data receiving method holding register

Holding register	Integer code	Pressure input	Method of receiving pressure data
40302	0	None	None
	3	HART primary	• Transmitter serves as primary master • Transmitter polls HART-compatible host controller for gauge pressure
	4	HART secondary	• Transmitter serves as secondary master • Transmitter polls HART-compatible host controller for gauge pressure
	6	Analog input	Transmitter receives 4-20 mA input indicating gauge pressure from DP cell connected to pressure input terminals
	8	Modbus	Transmitter receives gauge pressure values from Modbus-compatible host controller

Step 2 Pressure correction factors

For real-time pressure compensation, you must write a pressure correction factor for flow and a pressure correction factor for density. These factors are fixed, and depend on the sensor component of your flowmeter.

The pressure correction factor for flow is the percent change in the flow rate per psi. Write the pressure correction factor for flow to register pair 20267-20268, as listed in **Table 13-2**.

The pressure correction factor for density is change in fluid density in grams per cubic centimeter per psi. Write the pressure correction factor for density to register pair 20269-20270, as listed in **Table 13-2**.

Table 13-2. Pressure correction register pairs

Note

Write pressure correction factors in psi, regardless of the unit selected for pressure as a process variable.

Register pair	Description	Sensor model[1]	Single precision IEEE 754 floating-point value	RFT9739
20267 20268	Pressure correction factor for flow	CMF100	0.0002	√
		CMF200	0.0008	
		CMF300	0.0006	
		CMF400	0.002	
		F050	0.0007	√
		F100	0.001	
		F200	0.0005	
		D300 standard or Tefzel-lined	0.009	√
		D600	0.005	
		DL100	0.005	
		DL200	0.009	
20269 20270	Pressure correction factor for density	CMF025	–0.000004	√
		CMF050	0.000002	
		CMF100	0.000006	
		CMF200	0.000001	
		CMF300	–0.0000002	
		CMF400	–0.000007	
		F025, F050, F100	–0.000007	√
		F200	0.000004	
		D300 standard or Tefzel-lined	0.00001	√
		D600	0.0000031	
		DL100	0.000001	
		DL200	0.00001	

[1] *If your sensor is not listed here, it does not require a pressure correction factor for flow or density.*

Step 3 Pressure input

You must define one of the following pressure inputs:

- Gauge pressure input
- Analog pressure input

Gauge pressure input

If a pressure transmitter connected to a host controller measures gauge pressure at the sensor input, the RFT9739 can use flow and density signals from the sensor and pressure signals from the host controller to compensate for the pressure effect on the sensor.

- In a Modbus network, the host controller downloads pressure values to register 40007 or register pair 20257-20258. This value should be updated as often as required by field conditions and the application.
- In a HART Bell 202 or RS-485 network, the RFT9739 functions as a primary or secondary master by polling the host controller. This value is automatically updated every few seconds. The polling interval is not configurable.

Modbus network. To establish the gauge pressure input, the host controller must write a pressure value to the integer register or floating-point register pair listed in **Table 13-3**. This value represents the measured gauge pressure at line conditions.

- Write a single precision IEEE 754 floating-point value to register pair 20057-20058; or
- Write a scaled integer from 0 to 65534 to holding register 40007. To write a scaled integer, follow these steps:

  1. Establish a measurement unit for pressure, as instructed in **Chapter 7**.
  2. Determine a scale factor and offset for pressure, as instructed in **Chapter 8**.
  3. If integer scaling applies to variables other than pressure, all scaled process variables must share the same maximum integer. If necessary, change the measurement unit, the offset, and/or scale factor, then repeat steps 1 and 2 until the maximum anticipated gauge pressure is less than or equal to the maximum integer for all scaled process variables.
  4. Use the scale factor and offset for pressure to find y in the following equation:

$$x = \frac{y + (B - 32768)}{A}$$

Where:

x = Pressure
y = Scaled integer written to transmitter
B = Offset for scaled integers representing gauge pressure
A = Scale factor for integers representing gauge pressure

Table 13-3. RFT9739 gauge pressure registers

Address	Register type	Integer or floating-point value	RFT9739
40007	Scaled integer	A scaled integer, from 0 to 65534, proportional to the measured gauge pressure at line conditions	√
20257 20258	Floating point	A single precision IEEE 754 floating-point value equal to the measured gauge pressure at line conditions	√

HART network. If the RFT9739 transmitter obtains pressure data by polling an external device, you must configure polling as described in **Chapter 6**.

Analog pressure input

The RFT9739 transmitter has wiring terminals for connections to an analog pressure transmitter. The RFT9739 transmitter or an external source can power the pressure transmitter, which produces a 4-20 mA input signal representing gauge pressure.

- To connect a pressure transmitter to the RFT9739 transmitter, see the instruction manual that is shipped with the transmitter.
- If a flowmeter is ordered for an application requiring pressure compensation, the pressure input is configured at the factory.

To establish an analog pressure input, write single precision IEEE 754 floating-point values that represent the range of pressure values indicated by the pressure input.

- Write the gauge pressure, in psig, represented by the input at 4 mA to register pair 20273-20274, as listed in **Table 13-4**.
- Write the gauge pressure, in psig, represented by the input at 20 mA to register pair 20275-20276, as listed in **Table 13-4**.

Table 13-4. Pressure input register pairs

Note

Write gauge pressure values in psig, regardless of the unit selected for pressure as a process variable.

Register pair	Single precision IEEE 754 floating-point value	RFT9739
20273 20274	Gauge pressure, in psig, indicated by pressure input at 4 mA	√
20275 20276	Gauge pressure, in psig, indicated by pressure input at 20 mA	√

Step 4 Flow calibration pressure

Register pair 20271-20272 stores a floating-point value that represents the pressure, in psig, at which the flowmeter was calibrated for flow. If your flowmeter was ordered with pressure compensation, Micro Motion used a flow calibration pressure of 20 psig.

Verify that your transmitter contains an appropriate flow calibration pressure value by reading register pair 20271-20272. If it does not (for example, if this value was not set at the factory, or if your flowmeter has been recalibrated for flow), write a single precision IEEE 754 floating-point value representing the calibration pressure, in psi, to register pair 20271-20272, as listed in **Table 13-5**.

Table 13-5. Flow calibration pressure register pair

Note

Write the calibration pressure in psi, regardless of the unit selected for pressure as a process variable.

Register pair	Single precision IEEE 754 floating-point value	RFT9739
20271 20272	Pressure, in psi, at which flowmeter was calibrated for flow	√

13.3 Compensation for stable operating pressures

If the process pressure is relatively stable, you can implement pressure compensation without requiring real-time pressure data. The method used depends on your transmitter version:

- For Version 2 transmitters, modify the calibration factors.
- For Version 3 transmitters, modify the meter factors.

Version 2 RFT9739 transmitters

If the sensor is one of the models listed in **Table 13-2**, page 131, and it operates at a relatively constant pressure, modify the flow calibration factor and the density calibration factor as described below.

Step 1 Flow calibration factor

a. Apply the following equation to the first five digits of the flow calibration factor:

$$\text{Flow cal factor}_{new} = \text{Flow cal factor}_{old} \times [1 + K_{\rho flow}(0.01)(P_{meas} - P_{cal})]$$

Where:

$K_{\rho flow}$ = Pressure correction factor for flow (listed in **Table 13-2**)
P_{meas} = Measured pressure, in psig, at sensor inlet
P_{cal} = Pressure at which the flowmeter was calibrated for flow (20 psig for a factory-calibrated meter)

To obtain the *Flow cal factor*$_{old}$ value, read it from the registers listed in **Table 13-6**, or refer to your configuration record. To obtain the P_{meas} value, use any appropriate external method.

The flow calibration factor is a 10-character ASCII value of the form xxx.xxy.yy:

- The first six characters (xxx.xx) represent the flow rate, in grams per second, required to produce 1 µsec of time shift between velocity signals from sensor pickoffs. It is derived from the following equation:

:

$$\text{Flow cal factor}_{new} = \text{Flow cal factor}_{old} \times [1 + K_{\rho flow}(0.01)(P_{meas} - P_{cal})]$$

  This is the only part of the flow calibration factor that should be changed.

- The last four characters (y.yy) represent the temperature coefficient for flow: the change per 100°C in rigidity of flow tubes around twisting axis. This value should not be changed.

b. Write the new flow calibration factor, the *Flow cal factor*$_{new}$ value, to the ASCII registers listed in **Table 13-6**.

Example	A Model CMF300 sensor will operate at 100 psig. After being calibrated for flow at 20 psig, the sensor has a flow calibration factor of 697.624.75. $$\begin{aligned}\text{Flow cal factor}_{new} &= 697.62 \times \{1 + [0.000006 \times (100 - 20)]\}\\ &= 697.62 \times [1 + (0.000006 \times 80)]\\ &= 697.62 \times (1 + 0.00048)\\ &= (697.62 + 1.00048)\\ &= 697.95\end{aligned}$$ The new flow calibration factor, including the 4-character temperature coefficient, is 697.954.75.

Table 13-6. Flow calibration factor character strings

Note

Write character strings as single-write multiples.

Register	ASCII character strings	RFT9739
50072 50073 50074	• Each register holds 2 characters in a string of 6 characters describing the flow rate, in grams per second, required to produce 1 µsec of time shift between velocity signals from sensor pickoffs • If pressure compensation is being implemented, write the character string that is derived from the following equation: $\textit{Flow cal factor}_{new} = \textit{Flow cal factor}_{old} \times [1 + K_{\rho flow}(0.01)(P_{meas} - P_{cal})]$	√
50075 50076	• Each register holds 2 characters in a string of 4 characters describing percent change per 100°C in rigidity of flow tubes around twisting axis • If pressure compensation is being implemented, this value should not be changed	√

Step 2 Density calibration factor

a. Use the following equation to find the density offset (convert pressure to psig for use in this equation):

$$\textit{Density offset} = K_{Pden} \times P_{oper}$$

Where:

K_{Pden} = Pressure correction factor for density (listed in **Table 13-2**, page 131)

P_{oper} = Operating pressure, in psig

To obtain P_{oper}, use any appropriate external method.

b. After finding the density offset, use the following equation to calculate the correct density:

$$Density_{corrected} = Density_{measured} + Density\ offset$$

Example	After being calibrated at the factory at 20 psi, a D300 sensor operating at 220 psig indicates a process density of 0.9958 grams per cubic centimeter (g/cc). $$\text{Density offset} = 0.00001 \times 220 = 0.0022$$ $$\text{Density}_{\text{corrected}} = 0.9958 + 0.0022 = 0.9980\ g/cc$$

c. After calculating the corrected density, use the following equation to adjust the second five digits of the density calibration factor (K2):

$$K2_{new} = \sqrt{(K2_{old}^2 - K1^2) \times \left(\frac{Density_{measured}}{Density_{corrected}}\right) + K1^2}$$

Example	The Version 2 RFT9739 transmitter is connected to a D300 sensor with 316L stainless steel flow tubes. The flowmeter indicates a density of 0.9958 grams per cubic centimeter (g/cc), which has been corrected to 0.9980 g/cc. The first five digits of the density calibration factor (K1) are 09615, and the second five digits (K2) are 13333. Adjust the second five digits of the density calibration factor (K2) to compensate for pressure. $$\text{K2}_{\text{new}} = \sqrt{(13333^2 - 9615^2) \times \left(\frac{0.9958}{0.9980}\right) + 9615^2}$$ $$= \sqrt{(85,320,664 \times 0.9978) + 92,448,225}$$ $$= 13325.9590$$ The new K2 value is 13325.

5. Write the second five digits of the density calibration factor (K2) to register pair 20161-20162, as listed in **Table 13-7**.

Table 13-7. K2 register pair

Register pair	Single precision IEEE 754 floating-point value in microseconds	RFT9739
20161 20162	If pressure compensation is being implemented, write the value that is derived from the following equation: $K2_{new} = \sqrt{(K2_{old}^2 - K1^2) \times \left(\frac{Density_{measured}}{Density_{corrected}}\right) + K1^2}$	√

Version 3 RFT9739 transmitters

If the sensor is one of the models listed in **Table 13-2**, page 131, and it operates at a relatively constant pressure, modify the mass flow and density meter factors as described below. For more information on meter factors, see **Chapter 19**.

Step 1 Mass flow meter factor

a. Apply the following equation to the meter factor for mass flow:

$$Meter\ factor_{new} = Meter\ factor_{old} \times [1 + K_{\rho flow}(0.01)(P_{meas} - P_{cal})]$$

Where:

$K_{\rho flow}$ = Pressure correction factor for flow (listed in **Table 13-2**)
P_{meas} = Measured pressure, in psig, at sensor inlet
P_{cal} = Pressure at which the flowmeter was calibrated for flow (20 psig for a factory-calibrated meter)

To obtain the $Meter\ factor_{old}$ value, read it from the register pair listed in **Table 13-8**, page 138, or refer to your configuration record. To obtain the P_{meas} value, use any appropriate external method.

b. Write the new meter factor for flow, the $Meter\ factor_{new}$ value, to register pair 20279-20280, as listed in **Table 13-8**. You may specify up to four decimal places.

Example	A Model CMF300 sensor will operate at 100 psig. After being calibrated for flow at 20 psig, the sensor has a meter factor for flow of 1.0000. Meter factor$_{new}$ $= 1.0000 \times \{1 + [0.000006 \times (100 - 20)]\}$ $= 1.0000 \times [1 + (0.000006 \times 80)]$ $= 1.0000 \times (1 + 0.00048)$ $= 1.0000 \times 1.0004$ $= 1.00048$ The new meter factor for flow is 1.00048.

Table 13-8. Mass flow meter factor register pair

Register pair	Single precision IEEE 754 floating-point value from 0.8 to 1.2	RFT9739
20279 20280	• Meter factor for mass flow • If pressure compensation is being implemented, write the floating-point value that is derived from the following equation: $\mathit{Meter\ factor}_{new} = \mathit{Meter\ factor}_{old} \times [1 + K_{\rho flow}(0.01)(P_{meas} - P_{cal})]$	√

Step 2 Density meter factor

a. Use the following equation to find the density offset (convert pressure to psig for use in this equation):

$$\mathit{Density\ offset} = K_{Pden} \times P_{oper}$$

Where:

K_{Pden} = Pressure correction factor for density (listed in **Table 13-2**, page 131)

P_{oper} = Measured pressure, in psig, at sensor inlet

To obtain P_{oper}, use any appropriate external method.

b. After finding the density offset, use the following equation to calculate the correct density:

$$\mathit{Density}_{corrected} = \mathit{Density}_{measured} + \mathit{Density\ offset}$$

Pressure Compensation – RFT9739 *continued*

Example	After being calibrated at the factory at 20 psi, a D300 sensor operating at 220 psig indicates a process density of 0.9958 grams per cubic centimeter (g/cc). $\text{Density offset} = 0.00001 \times 220$ $= 0.0022$ $\text{Density}_{\text{corrected}} = 0.9958 + 0.0022$ $= 0.9980\ g/cc$

c. After calculating the corrected density, use the following equation to adjust the meter factor for density:

$$\textit{Meter factor}_{new} = \textit{Meter factor}_{old} \times \frac{\textit{Density}_{corrected}}{\textit{Density}_{measured}}$$

Example	The Version 3 RFT9739 transmitter is connected to a D300 sensor with 316L stainless steel flow tubes. The flowmeter indicates a density of 0.9958 grams per cubic centimeter (g/cc), which has been corrected to 0.9980 g/cc. The first five digits of the density calibration factor (K1) are 09615, and the meter factor for density is 1.0000. Adjust the meter factor for density to compensate for pressure. $\text{Meter factor}_{\text{new}} = 1.0000 \times \frac{0.9980}{0.9958}$ $= 1.0000 \times 1.0022$ $= 1.0022$ The new meter factor for density is 1.0022.

d. Write the new meter factor for density to register pair 20283-20284, as listed in **Table 13-9**, page 140. You may specify up to four decimal places.

Table 13-9. Density meter factor register pair

Register pair	Single precision IEEE 754 floating-point value from 0.8 to 1.2	RFT9739
20283 20284	• Meter factor for density • If pressure compensation is being implemented, write the floating-point value that is derived from the following equation: $$Meter\ factor_{new} = Meter\ factor_{old} \times \frac{Density_{corrected}}{Density_{measured}}$$	√

Configuration

14 Configuring the API Feature

14.1 About this chapter

This chapter provides configuration instructions for the API feature. The API feature enables Correction of Temperature on volume of Liquids, or CTL. In other words, some applications that measure liquid volume flow or liquid density are particularly sensitive to temperature factors, and must comply with American Petroleum Institute (API) standards for measurement.

Information in this chapter applies only to MVDSolo or Series 1000 or 2000 transmitters with the API feature.

Definitions

The following terms and definitions are used in this chapter:

- **API** – American Petroleum Institute, and in this context, the feature that enables CTL
- **CTL** – Correction of Temperature on volume of Liquids. The CTL value is used to calculate the VCF value.
- **TEC** – Thermal Expansion Coefficient
- **VCF** – Volume Correction Factor. The correction factor to be applied to volume process variables. VCF can be calculated after CTL is derived.

14.2 CTL derivation methods

There are two derivation methods for CTL:

- Method 1 is based on observed density and observed temperature.
- Method 2 is based on a user-supplied reference density (or TEC, in some cases) and observed temperature.

Your choice of reference tables, discussed below, will determine the derivation method used.

The following equation is used to calculate CTL:

$$CTL = \frac{\rho_t}{\rho_{tref}} = e^{[-(\alpha_{tref}\Delta T(1 + 0.8(\alpha_{tref}\Delta T)))]}$$

Where:

ρ_t =Operating density
ρ_{tref}=Standard density
tref=User-specified reference temperature
ΔT =Temperature difference from base (standard) temperature (60°F or 15°C)
$\alpha_{tref}=f(k_{(1..n),\rho tref,}T)$ = TEC

14.3 Configuring API

Step 1 Specify reference temperature table.

Specify a reference temperature table, by writing its integer code to holding register 40351, as listed in **Table 14-2**. Choose the table based on the following criteria:

- Different reference temperature tables are based on different reference temperatures: 60°F or 15°C.
- If you specify a 53*x* or 54*x* table, the default reference temperature is 15°C. However, you can change the reference temperature, as recommended in some locations (for example, to 14.0 or 14.5°C).
- If you specify an odd-numbered table (5, 23, or 53), CTL will be derived using method 1 described above. If you specify an even-numbered table (6, 24, or 54), CTL will be derived using method 2 described above.
- The letters *A*, *B*, *C*, or *D* that are used to terminate table names define the type of liquid that the table is designed for:
  - *A* tables are used with generalized crude and JP4 applications.
  - *B* tables are used with generalized products.
  - *C* tables are used with liquids with a constant base density or known thermal expansion coefficient.
  - *D* tables are used with lubricating oils.

Table 14-1 summarizes the reference temperature table options.

Table 14-1. API reference temperature tables

Table	CTL derivation method	Base temperature	Range		
			API	Base density	Relative density
5A	Method 1	60°F, non-configurable	0–100		
5B	Method 1	60°F, non-configurable	0–85		
5D	Method 1	60°F, non-configurable	-10–40		
23A	Method 1	60°F, non-configurable			0.6110–1.0760
23B	Method 1	60°F, non-configurable			0.6535–1.0760
23D	Method 1	60°F, non-configurable	0.8520–1.1640		
53A	Method 1	15°C, configurable		610–1075 kg/m^3	
53B	Method 1	15°C, configurable		653–1075 kg/m^3	
53D	Method 1	15°C, configurable		825–1164 kg/m^3	
			Reference temperature		**Supports**
6C	Method 2	60°F, non-configurable	60°F		Degrees API
24C	Method 2	60°F, non-configurable	60°F		Relative density
54C	Method 2	15°C, configurable	15°C		Base density in kg/m^3

Step 2 Configure temperature unit.

In most cases, the temperature unit used by your reference table should also be the temperature unit configured for the transmitter to use in general processing. To configure °C or °F as the temperature unit, write integer code 32 or 33 to holding register 40041, as listed in **Table 14-3**.

Table 14-2. API reference temperature table holding register

Holding register	Integer code	API reference temperature table	MVDSolo	Series 1000	Series 2000
40351	17	5A	√	√	√
	18	5B	√	√	√
	19	5D	√	√	√
	36	6C	√	√	√
	49	23A	√	√	√
	50	23B	√	√	√
	51	23D	√	√	√
	68	24C	√	√	√
	81	53A	√	√	√
	82	53B	√	√	√
	83	53D	√	√	√
	100	54C	√	√	√

Table 14-3. Temperature units

Holding register	Integer code	Temperature unit	MVDSolo	Series 1000	Series 2000
40041	32	Degrees Celsius	√	√	√
	33	Degrees Fahrenheit	√	√	√

Step 3 Specify reference temperature.

If you did not specify Table 53A, Table 53B, Table 53D, or Table 54D in step 1, skip this step.

If you did specify one of these tables in step 1, you chose 15°C as the reference temperature. If you want to change that reference temperature, write the new reference temperature to register pair 20319-20320, as listed in **Table 14-4.**

Table 14-4. API reference temperature table register pair

Note

Write reference temperature value in measurement units established for temperature as a process variable.

Register pair	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000
20319 20320	Reference temperature for use in CTL calculation.	√	√	√

Step 4 Specify thermal expansion coefficient.

If you did not specify Table 6C, Table 24C, or Table 54C in step 1, skip this step.

If you did specify one of these tables in step 1, you must specify a thermal expansion coefficient. To do this, write the thermal expansion coefficient to register pair 20323-20324, as listed in **Table 14-5**.

Table 14-5. API thermal expansion coefficient register pair

Register pair	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000
20323 20324	Thermal expansion coefficient for use in CTL calculation.	√	√	√

Step 5 Configure temperature compensation.

For the temperature value to be used in CTL calculation:

- If the temperature is known and does not vary significantly, you can specify a static temperature value.
- If the temperature fluctuates, you can specify real-time temperature compensation, using either:
  - Temperature data from the sensor
  - Temperature data from an external temperature measurement device (requires polling)

Note: MVDSolo does not support polling.

To specify static temperature compensation:

1. Write the temperature value to be used to register pair 20049-20450, as listed in **Table 14-6**.
2. Write a 1 to coil 00086, as listed in **Table 14-7**.

Table 14-6. Fixed temperature register pair

Register pair	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000
20449 20450	Temperature value, in °F or °C as configured in step 2	√	√	√

Table 14-7. Enable/disable non-sensor temperature

Coil	Bit status	Description	MVDSolo	Series 1000	Series 2000
00086	0	Non-sensor temperature is disabled. Sensor temperature will be used in CTL calculation.	√	√	√
	1	Non-sensor temperature is enabled. Temperature value in register pair 20449-20450 will be used in CTL calculation.			

To specify real-time temperature compensation using temperature data from the sensor, write a 0 to coil 00086, as listed in **Table 14-7**.

To specify real-time temperature compensation using temperature data from an external temperature measurement device:

1. Configure polling for temperature, as described in **Chapter 6**. The temperature data will be written to register pair 20449-20450.
2. Write a 1 to coil 00086, as listed in **Table 14-7**.

Step 6 Enable the API feature.

Finally, you must enable CTL calculation by setting coil 00072, as listed in **Table 14-8.**

Table 14-8. Enable/disable CTL calculation

Coil	Bit status	Description	MVDSolo	Series 1000	Series 2000
00072	0	CTL calculation is disabled.	√	√	√
	1	CTL calculation is enabled.			

14.4 Using API

The calculated CTL value and related API values may be read from transmitter registers, assigned to transmitter outputs, and displayed on the transmitter display, if one exists. In addition, two VCF alarms may be used.

Reading API and CTL values from registers

Table 14-9 lists the memory registers that contain CTL and related API values.

Table 14-9. CTL data in registers

Register pair	Value	MVDSolo	Series 1000	Series 2000
20325 20326	Temperature-corrected density	√	√	√
20329 20330	Calculated CTL value, in floating-point format.	√	√	√
20331 20332	Temperature/pressure-corrected volumetric flow	√	√	√
20333 20334	Temperature/pressure-corrected volumetric total	√	√	√
20335 20336	Temperature/pressure-corrected volumetric inventory	√	√	√
20337 20338	Weighted average batch observed density	√	√	√
20339 20340	Weighted average batch observed temperature	√	√	√

Assigning API and CTL values to outputs

If you are using a Series 1000 or 2000 transmitter, you can assign various API and CTL values to transmitter outputs. See **Chapter 9** for configuration information.

Displaying CTL values

If your transmitter has the optional display, you can assign CTL and related values to the display. See **Chapter 15** for configuration information.

VCF alarms

When the API feature is enabled, two alarms are automatically enabled. These alarms cannot be mapped to an output; the alarms must be read by an external device such as a host controller. Each alarm is represented by a single bit in input register 30422. Each alarm bit can have a status of 0 (OFF) or 1 (ON). See **Table 14-10**.

Table 14-10. VCF alarm bits

Input register	Bit	Bit type	Bit status	Description	MVDSolo	Series 1000	Series 2000
30422	0	VCF temperature alarm	0	Alarm is off.	√	√	√
	1	VCF density alarm	1	Alarm is on.			

VCF-temperature alarm
If the temperature goes outside the limits defined in the configured API table, a VCF-temperature alarm will occur, and the VCF temperature alarm bit (bit 0) is set to 1.

When the temperature returns to a legal value, the VCF temperature alarm will clear.

VCF-density alarm
If the density goes outside the limits defined in the configured API table, a VCF-density alarm will occur, and the VCF density alarm bit (bit 1) is set to 1.

When the density returns to a legal value, the VCF density alarm will clear.

Configuration

15 Configuring the Display – MVD

15.1 About this chapter

This chapter explains how to configure the display for the Series 1000 or 2000 transmitter.

- The display has operating, offline, and alarm menus.
- For information about operating the display, see the instruction manual that was shipped with the transmitter.

You can use Modbus protocol to:

- Enable or disable display functions
- Configure a password for accessing the offline menu
- Configure the rate at which automatic scrolling will occur
- Assign process variables or diagnostic values to the display

15.2 Enabling and disabling display functions

To disable display functions, or to require a password for access to the offline menu, set the appropriate coils that are listed in **Table 15-1**.

Table 15-1. Display function coils

Coil	Coil status	Bit status	Series 1000	Series 2000
00094	• If coil is OFF, operator can reset totalizers • If coil is ON, operator cannot reset totalizers	0 1	√	√
00095	• If coil is ON, scrolling occurs at the programmed rate (see **Table 15-2**, page 148) • If coil is OFF, scrolling occurs when the operator presses the scroll button (see **Table 15-3**, page 149)	1 0	√	√
00096	• If coil is ON, operator can access offline menu • If coil is OFF, operator cannot access offline menu	1 0	√	√
00097	• If coil is ON, operator can access offline menu without entering password • If coil is OFF, operator must enter password to access offline menu (see **Table 15-4**, page 149)	1 0	√	√
00098	• If coil is ON, operator can access alarm menu • If coil is OFF, operator cannot access alarm menu	1 0	√	√
00099	• If coil is ON: - Operator can read alarm messages - Operator can acknowledge all alarms at once, but cannot individually acknowledge each alarm • If coil is OFF, operator can individually acknowledge each alarm	1 0	√	√

15.3 Operating menu

In the operating menu, the operator can:

- Read measured values of process variables
- Read diagnostic values for flowmeter troubleshooting

You can enable or disable automatic scrolling for the operating menu, set the scroll rate, and assign variables for each line that will be scrolled.

Scroll rate

If you set coil 00095 to ON, automatic scrolling occurs in the operating menu.

To set the scroll rate, write the desired number of seconds from 1 to 10 to holding register 41116, as listed in **Table 15-2**.

To assign variables to the display, see **Table 15-3**.

Table 15-2. Scroll rate holding register

Note

To assign a variable to each line of the display, see **Table 15-3**.

Holding register	Integer value	Series 1000	Series 2000
41116	Number of seconds, from 1 to 10, for which display will show a process variable before scrolling to the next process variable	√	√

Display variables

To assign process variables or diagnostic values to various lines of the display, write the desired integer codes to holding registers 41117-41131, as listed in **Table 15-3**. The display can accommodate up to 15 variables.

- Line 1 always displays the process variable assigned to the primary milliamp output.
- You may assign values to Lines 2-15 as desired. You may assign all, any, or none of them. If nothing is assigned to a display line, that line will be skipped during scrolling.
- You may also assign one process variable or diagnostic value to multiple display lines.

If coil 00095 is set to ON, the display will show a process variable and the corresponding measurement unit for the number of seconds defined for the scroll rate, then will scroll to the next process variable.

If coil 00095 is reset to OFF, the display will scroll only when the operator presses the scroll button.

Table 15-3. Display variable holding registers

Holding register	Description	Code	Process variable or diagnostic value	Series 1000	Series 2000
41117	Line 1 display variable	0	Mass flow rate	√	√
41118	Line 2 display variable	1	Temperature	√	√
41119	Line 3display variable	2	Mass total	√	√
41120	Line 4 display variable	3	Density	√	√
41121	Line 5 display variable	4	Mass inventory	√	√
41122	Line 6 display variable	5	Volume flow rate	√	√
41123	Line 7 display variable	6	Volume total	√	√
41124	Line 8 display variable	7	Volume inventory	√	√
41125	Line 9 display variable	10	Event 1	√	√
41126	Line 10 display variable	11	Event 2	√	√
41127	Line 11 display variable	15	API: temperature-corrected density	√	√
41128	Line 12 display variable	16	API: temperature-corrected (std) volume flow	√	√
41129	Line 13 display variable	17	API: temperature-corrected (std) volume total	√	√
41130	Line 14 display variable	18	API: temperature-corrected (std) volume inventory	√	√
41131	Line 15 display variable	19	API: batch weighted average corrected density		
		20	API: batch weighted average temperature		
		33	API: CTL		
		46	Raw tube frequency		
		47	Drive gain		
		48	Left pickoff amplitude		
		49	Right pickoff amplitude		
		50	Board temperature		
		51	Input voltage	√	√
		52	None		
		53	Externally read pressure		
		55	Externally read temperature		

15.4 Offline menu access

In the offline menu, the operator can:

- Test the transmitter outputs
- Zero the flowmeter
- Configure the RS-485 digital output

You can secure the offline menu in either of two ways:

- To prevent access to the offline menu, reset coil 00096 to OFF.
- To enable the operator to access the offline menu by entering a password:
  1. Set coil 00096 to ON.
  2. Set coil 00097 to ON.
  3. Write an integer value from 0000 to 9999 to holding register 41115, as listed in **Table 15-4**.

Refer to **Table 15-1**, page 147, as required.

Table 15-4. Offline menu password holding register

Holding register	Integer value	Series 1000	Series 2000
41115	A value from 0000 to 9999 that will be entered to access the offline menu	√	√

15.5 Alarm menu access

In the alarm menu, the operator can read and acknowledge alarm messages.

To prevent access to the alarm menu, reset coil 00098 to OFF.

To enable the operator to acknowledge all alarms at once, set coil 00099 to ON. See **Table 15-1**, page 147.

Configuration
16 Slot Addresses – MVD

16.1 About this chapter

This chapter explains how to configure and read slot address sequences for MVDSolo or a Series 1000 or 2000 transmitter.

16.2 Slot addresses and slot address sequences

A slot address is a holding register used specifically to redirect the read command. A slot address sequence is a set of consecutive slot addresses that reference non-consecutive addresses in memory. The slot address sequences are then referenced by a second set of register pairs.

Because the slot addresses are consecutive and the register pairs that reference them are consecutive, they can be read using a single read command. Without slot address sequences, multiple read commands must be issued to read the non-consecutive addresses. This can cause response time problems. Slot addresses are both faster and more convenient than multiple reads.

There are two types of slot addresses sequences:
- The first type is used to reference any set of mapped addresses. Registers are read two at a time, whether the underlying value is stored in a single register or a register pair. The slot address identifies the address of the first register of the two to be read. Slot addresses in this sequence type are in the range 40655-40686, and they are read through register pairs 20687-20688 – 20749-20750.
- The second type is used to reference any set of process variables. Slot addresses in this sequence type are in the range 40751-40782, and they are read through register pairs 20783-20784 – 20845-20846.

You can configure one or more slot address sequences of either type. You must issue a separate read command for each slot address sequence.

Read commands

When you issue a read command 01, 02, 03, or 04, the data field in the query specifies the address at which the read command will start, and the number of addresses (coils or registers) to be read. See the illustrations below.

Using slot address sequences, the start address references the first register in a slot address sequence, rather than the register that contains the process data. The slot address sequence redirects the read command to the appropriate addresses.

Function 01: Read coil status
Function 02: Read discrete input status

Query	Address	Function **01 or 02**	Starting coil	# of coils	Error check

Response	Address	Function **01 or 02**	Byte count*	Coil status byte(s)	Error check

**Byte count is the number of data bits in the coil status byte(s) field.*

Function 03 or 04: Read multiple registers

Query	Address	Function **03 or 04**	Starting register	# of registers	Error check

Response	Address	Function **03 or 04**	Byte count*	Register data bytes	Error check

**Byte count is the number of data bits in the register status byte(s) field.*

16.3 Configuring slot address sequences

To configure a slot address sequence:

1. Determine the values that the read command will return, and the order in which they will be returned.

2. Write consecutive slot addresses to specify the type of information that will be read.

   To specify a mapped address sequence (single register, register pair, or ASCII register):

   a. Write the last four digits of the first address to the first slot address in the sequence. See **Table 16-1** for a list of the holding registers used for mapped addresses. See **Appendix A** for the list of mapped addresses.

      For example, to read register pair 20253-20254, which represents volume flow rate, as the first value in the returned data, write the value 0253 to holding register 40655.

Slot Addresses – MVD *continued*

Table 16-1. Slot address sequence holding registers – mapped addresses

Holding register	Value	MVDSolo	Series 1000	Series 2000
40655	Last four digits of any mapped address	√	√	√
40656	Last four digits of any mapped address	√	√	√
40657	Last four digits of any mapped address	√	√	√
40658	Last four digits of any mapped address	√	√	√
40659	Last four digits of any mapped address	√	√	√
40660	Last four digits of any mapped address	√	√	√
40661	Last four digits of any mapped address	√	√	√
40662	Last four digits of any mapped address	√	√	√
40663	Last four digits of any mapped address	√	√	√
40664	Last four digits of any mapped address	√	√	√
40665	Last four digits of any mapped address	√	√	√
40666	Last four digits of any mapped address	√	√	√
40667	Last four digits of any mapped address	√	√	√
40668	Last four digits of any mapped address	√	√	√
40669	Last four digits of any mapped address	√	√	√
40670	Last four digits of any mapped address	√	√	√
40671	Last four digits of any mapped address	√	√	√
40672	Last four digits of any mapped address	√	√	√
40673	Last four digits of any mapped address	√	√	√
40674	Last four digits of any mapped address	√	√	√
40675	Last four digits of any mapped address	√	√	√
40676	Last four digits of any mapped address	√	√	√
40677	Last four digits of any mapped address	√	√	√
40678	Last four digits of any mapped address	√	√	√
40679	Last four digits of any mapped address	√	√	√
40680	Last four digits of any mapped address	√	√	√
40681	Last four digits of any mapped address	√	√	√
40682	Last four digits of any mapped address	√	√	√
40683	Last four digits of any mapped address	√	√	√
40684	Last four digits of any mapped address	√	√	√
40685	Last four digits of any mapped address	√	√	√
40686	Last four digits of any mapped address	√	√	√

b. Write the last four digits of the first address in the second pair to the next slot address in the sequence. For example, to read the volume flow unit, which is stored in holding register 40042, write the value 0042 to holding register 40656.

   Note that the read command in this case will return the values of both register 40042 and register 40043, even though only register 40042 is required. When the read command is issued, the data returned from register 40043 must be ignored.

c. Continue specifying register pairs in consecutive slot addresses until all required values been configured.

To specify process variable values:

a. Write the integer code representing the first required process variable to the first slot address in the sequence. For example, to read the temperature value, write the integer code 1 to holding register 40751.

   For the integer codes that represent process variables, see **Table 16-2**. For the holding registers that are used for process variable slot addresses, see **Table 16-3**, page 156.

   Note that if you want to read binary mass total or binary volume total, you must specify codes 34 and 35 (for mass) or codes 36 and 37 (for volume) in consecutive slot addresses. See “Reading binary totals” on page 158.

b. Write the integer code representing the second required process variable to the second slot address in the sequence. For example, to read the volume flow in this position, write the integer code 5 to holding register 40752.

c. Continue specifying integer codes in consecutive slot addresses until all required process variables have been configured.

Slot Addresses – MVD *continued*

Table 16-2. Slot address sequences – integer codes for process variables

Holding registers	Codes	Returned single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000
40751-40782	0	Mass flow rate	√	√	√
	1	Temperature	√	√	√
	2	Mass totalizer	√	√	√
	3	Density	√	√	√
	4	Mass inventory	√	√	√
	5	Volume flow rate	√	√	√
	6	Volume totalizer	√	√	√
	7	Volume inventory	√	√	√
	10	Event 1 process variable	√	√	√
	11	Event 2 process variable	√	√	√
	12	Status word 1 (input registers 30419-30420)			
	13	Status word 2 (input registers 30421-30422)			
	14	Status word 3 (input registers 30423-30424)			
	15	API: Temperature-corrected density			
	16	API: Temperature-corrected (standard) volume flow			
	17	API: Temperature-corrected (standard) volume total			
	18	API: Temperature-corrected (standard) volume inventory			
	19	API: Batch-weighted average corrected density			
	20	API: Batch-weighted average temperature			
	33	API: CTL			
	34	High-order doubleword of binary mass total in grams	√	√	√
	35	Low-order doubleword of binary mass total in grams	√	√	√
	36	High-order doubleword of binary volume total in cubic centimeters	√	√	√
	37	Low-order doubleword of binary volume total in cubic centimeters	√	√	√
	38	Raw API: Temperature/pressure-corrected volume total, high-order doubleword			
	39	Raw API: Temperature/pressure-corrected volume total, low-order doubleword			
	46	Raw tube frequency	√	√	√
	47	Drive gain in mA	√	√	√
	49	Left pickoff amplitude in mV	√	√	√
	50	Right pickoff amplitude in mV	√	√	√
	51	Board temperature in °C	√	√	√
	52	Input voltage in V	√	√	√
	53	Externally read pressure			
	55	Externally read temperature			
	100	Event 1 or event 2[1]			
	101	Flow switch indicator[1]			
	102	Forward/reverse indication[1]			
	103	Calibration in progress[1]			
	104	Fault condition indication[1]			

[1] *Available only when mapped to a discrete output. See **Section 11.4**, page 109.*

Table 16-3. Slot address sequence holding registers – process variables

Holding register	Integer value	MVDSolo	Series 1000	Series 2000
40751	Process variable integer code	√	√	√
40752	Process variable integer code	√	√	√
40753	Process variable integer code	√	√	√
40754	Process variable integer code	√	√	√
40755	Process variable integer code	√	√	√
40756	Process variable integer code	√	√	√
40757	Process variable integer code	√	√	√
40758	Process variable integer code	√	√	√
40759	Process variable integer code	√	√	√
40760	Process variable integer code	√	√	√
40761	Process variable integer code	√	√	√
40762	Process variable integer code	√	√	√
40763	Process variable integer code	√	√	√
40764	Process variable integer code	√	√	√
40765	Process variable integer code	√	√	√
40766	Process variable integer code	√	√	√
40767	Process variable integer code	√	√	√
40768	Process variable integer code	√	√	√
40769	Process variable integer code	√	√	√
40770	Process variable integer code	√	√	√
40771	Process variable integer code	√	√	√
40772	Process variable integer code	√	√	√
40773	Process variable integer code	√	√	√
40774	Process variable integer code	√	√	√
40775	Process variable integer code	√	√	√
40776	Process variable integer code	√	√	√
40777	Process variable integer code	√	√	√
40778	Process variable integer code	√	√	√
40779	Process variable integer code	√	√	√
40780	Process variable integer code	√	√	√
40781	Process variable integer code	√	√	√
40782	Process variable integer code	√	√	√

16.4 Reading slot address sequences

To read the slot address sequence:

- For mapped address data, refer to **Table 16-4** and issue a read command that identifies the first register in the sequence and the number of registers to be read. Note that you do not specify the slot address registers directly; instead, you specify the register pair that corresponds to the slot address.

Table 16-4. Slot address sequences – register pairs for mapped addresses

Register pair	Returned single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000
20687 20688	Value of consecutive addresses in holding register 40655	√	√	√
20689 20690	Value of consecutive addresses in holding register 40656	√	√	√
20691 20692	Value of consecutive addresses in holding register 40657	√	√	√
20693 20694	Value of consecutive addresses in holding register 40658	√	√	√
20695 20696	Value of consecutive addresses in holding register 40659	√	√	√
20697 20698	Value of consecutive addresses in holding register 40660	√	√	√
20699 20700	Value of consecutive addresses in holding register 40661	√	√	√
20701 20702	Value of consecutive addresses in holding register 40662	√	√	√
20703 20704	Value of consecutive addresses in holding register 40663	√	√	√
20705 20706	Value of consecutive addresses in holding register 40664	√	√	√
20707 20708	Value of consecutive addresses in holding register 40665	√	√	√
20709 20710	Value of consecutive addresses in holding register 40666	√	√	√
20711 20712	Value of consecutive addresses in holding register 40667	√	√	√
20713 20714	Value of consecutive addresses in holding register 40668	√	√	√
20715 20716	Value of consecutive addresses in holding register 40669	√	√	√
20717 20718	Value of consecutive addresses in holding register 40670	√	√	√
20719 20720	Value of consecutive addresses in holding register 40671	√	√	√
20721 20722	Value of consecutive addresses in holding register 40672	√	√	√
20723 20724	Value of consecutive addresses in holding register 40673	√	√	√
20725 20726	Value of consecutive addresses in holding register 40674	√	√	√
20727 20728	Value of consecutive addresses in holding register 40675	√	√	√
20729 20730	Value of consecutive addresses in holding register 40676	√	√	√
20731 20732	Value of consecutive addresses in holding register 40677	√	√	√
20733 20734	Value of consecutive addresses in holding register 40678	√	√	√
20735 20736	Value of consecutive addresses in holding register 40679	√	√	√
20737 20738	Value of consecutive addresses in holding register 40680	√	√	√
20739 20740	Value of consecutive addresses in holding register 40681	√	√	√
20741 20742	Value of consecutive addresses in holding register 40682	√	√	√
20743 20744	Value of consecutive addresses in holding register 40683	√	√	√
20745 20746	Value of consecutive addresses in holding register 40684	√	√	√
20747 20748	Value of consecutive addresses in holding register 40685	√	√	√
20749 20750	Value of consecutive addresses in holding register 40686	√	√	√

- For process variable data, refer to **Table 16-5**, page 158, and issue a read command that identifies the first register in the sequence and the number of registers to be read. Note that you do not specify the slot address registers directly; instead, you specify the register pair that corresponds to the slot address.

Table 16-5. Slot address sequences – register pairs for process variables

Register pair	Returned single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000
20783 20784	Value of process variable configured in holding register 40751	√	√	√
20785 20786	Value of process variable configured in holding register 40752	√	√	√
20787 20788	Value of process variable configured in holding register 40753	√	√	√
20789 20790	Value of process variable configured in holding register 40754	√	√	√
20791 20792	Value of process variable configured in holding register 40755	√	√	√
20793 20794	Value of process variable configured in holding register 40756	√	√	√
20795 20796	Value of process variable configured in holding register 40757	√	√	√
20797 20798	Value of process variable configured in holding register 40758	√	√	√
20799 20800	Value of process variable configured in holding register 40759	√	√	√
20801 20802	Value of process variable configured in holding register 40760	√	√	√
20803 20804	Value of process variable configured in holding register 40761	√	√	√
20805 20806	Value of process variable configured in holding register 40762	√	√	√
20807 20808	Value of process variable configured in holding register 40763	√	√	√
20809 20810	Value of process variable configured in holding register 40764	√	√	√
20811 20812	Value of process variable configured in holding register 40765	√	√	√
20813 20814	Value of process variable configured in holding register 40766	√	√	√
20815 20816	Value of process variable configured in holding register 40767	√	√	√
20817 20818	Value of process variable configured in holding register 40768	√	√	√
20819 20820	Value of process variable configured in holding register 40769	√	√	√
20821 20822	Value of process variable configured in holding register 40770	√	√	√
20823 20824	Value of process variable configured in holding register 40771	√	√	√
20825 20826	Value of process variable configured in holding register 40772	√	√	√
20827 20828	Value of process variable configured in holding register 40773	√	√	√
20829 20830	Value of process variable configured in holding register 40774	√	√	√
20831 20832	Value of process variable configured in holding register 40775	√	√	√
20833 20834	Value of process variable configured in holding register 40776	√	√	√
20835 20836	Value of process variable configured in holding register 40777	√	√	√
20837 20838	Value of process variable configured in holding register 40778	√	√	√
20839 20840	Value of process variable configured in holding register 40779	√	√	√
20841 20842	Value of process variable configured in holding register 40780	√	√	√
20843 20844	Value of process variable configured in holding register 40781	√	√	√
20845 20846	Value of process variable configured in holding register 40782	√	√	√

Reading binary totals

If you have specified a binary total (codes 34 and 35, or codes 36 and 37) in the slot address sequence, the binary value is stored in two consecutive slot addresses, each slot address representing a register pair. The value returned from these slot addresses is in a special, non-standard, 8-byte floating point format.

When you read the first slot pair, the first register will contain Word 0 and the second register will contain Word 1. When you read the second slot pair, the first register will contain Word 2 and the second register will contain Word 3.

Note: For MVDSolo or Series 1000 or 2000 transmitters, byte order in floating-point registers is configurable (see ***Appendix B****). Binary totals are not affected by byte order.*

To convert the binary code to the total value, follow the steps below.

1. Calculate M:

$$M = [((Word1 \times 65536) + Word2) \times 65536] + Word3$$

2. Set P = Word 0.

3. Calculate as follows:

$$TotalFlow = M \times 2^{(P-47)}$$

4. If you are reading mass flow (codes 34 and 35), this value represents total mass flow in grams. If you are reading volume flow (codes 36 and 37), this value represents total volume flow in cubic centimeters.

Note: Both M and P are twos complement notation. If you are working with negative values (i.e., reverse flow), adjust this method as required.

Example

Reading binary totals

Reading the slot addresses returns the following values:

- Word 0 = 001B (decimal value: 27)
- Word 1 = 75BC (decimal value: 30140)
- Word 2 = D152 (decimal value: 53586)
- Word 3 = 0000 (decimal value: 0)

Calculate M:

$$M = [((30140 \times 65536) + 53586) \times 65536] + 0$$

$$M = 1.2945383 \times 10^{14}$$

P = 27.

Calculate total flow:

$$TotalFlow = 1.2945383 \times 10^{14} \times 2^{(27-47)}$$

$$TotalFlow = 1.2945383 \times 10^{14} \times 2^{(-20)}$$

$$TotalFlow = 1.2945383 \times 10^{14} \times 9.5367432 \times 10^{-7}$$

$$TotalFlow = 123,456,789.125$$

16.5 Examples

Review the following examples of slot address sequences. The first example illustrates a slot address sequence that references mapped addresses. The second example illustrates a slot address sequence that references process variables.

Example

Slot address sequence – mapped addresses

Several times per day, the operator needs to read the following:

- Floating-point volume flow rate
- Volume flow unit
- Floating-point process density
- Density unit

The volume flow rate unit is gallons/minute (integer code 16). The density unit is degrees grams/cubic centimeter (integer code 91).

Configure slot configuration index holding registers 40655 to 40659 so the operator can read the required values by issuing a single read command to register pairs 20687-20688 to 20695-20696.

Referring to the Modbus Mapping Assignments (**Appendix A**), follow these steps:

1. Write the integer value 0253 to holding register 40655. The value represents register pair 20253-20254, which stores the volume flow rate.
2. Write the integer value 0042 to holding register 40656. The value represents holding register 40042, which stores the volume flow unit, plus the value that is stored in the next consecutive register. You must ignore the second value.
3. Write the integer value 0249 to holding register 40658. The value represents register pair 20249-20250, which stores the process density.
4. Write the integer value 0040 to holding register 40659. The value represents holding register 40040, which stores the density unit, plus the value that is stored in the next consecutive register.You must ignore the second value.

If the operator reads register pairs 20687-20688 to 20695-20696, the transmitter returns a series of floating-point values such as:

23.038	16 6	1.091	91 33
(Volume flow rate)	(Volume flow unit plus next register)	(Process density)	(Density unit plus next register)

Example	**Slot address sequence – process variables** Several times per day, the operator needs to read the following: • Temperature in degrees Fahrenheit • Volume flow rate in gallons/minute • Drive gain in milliamps • Left pickoff voltage in millivolts • Right pickoff voltage in millivolts Configure slot process variable index holding registers 40751 to 40755 so the operator can read the values by issuing a single read command to register pairs 20783-20784 to 20791-20792. Follow these steps: 1. Write the integer value 1 to holding register 40751. The value represents the integer codes for temperature. 2. Write the integer value 5 to holding register 40752. The value represents the integer code for volume flow. 3. Write the integer value 47 to holding register 40753. The value represents the integer code for drive gain. 4. Write the integer 49 to holding register 40754. The value represents the integer codes for left pickoff voltage. 5. Write the integer code 50 to holding register 40755. The value represents the integer code for the right pickoff voltage. If the operator reads register pairs 20783-20784 to 20791-20792, the transmitter returns a series of floating-point values such as: 60.09 (Temperature) · 23.038 (Volume flow rate) · 7.009 (Drive gain) · 17087.05 (Left pickoff) · 17087.02 (Right pickoff) Each of these values is returned using the unit that has been configured for the process variable. This example assumes that the required units (as listed above) have already been configured.

Configuration
17 Characterization

17.1 Overview

This chapter explains how to characterize the flowmeter. Characterization consists of writing floating-point values and ASCII character strings that describe sensor sensitivity to flow and density.

- The flow calibration factor describes a particular sensor's sensitivity to flow.
- Density factors describe a particular sensor's sensitivity to density.
- The temperature calibration factor describes the slope and offset of the equation used for calculating temperature.

When a complete flowmeter (transmitter and sensor combination) is ordered, most of the procedures described in this chapter have already been performed. If the components are ordered separately, or one component is replaced in the field, most or all the procedures in this chapter will be required.

Micro Motion ELITE®, F-Series, R-Series, Model D, DT, and DL sensors have the following characterization factors:

- ASCII 10-character flow calibration factor
- Single precision IEEE 754 floating-point density calibration factors
- ASCII 14-character temperature calibration factor

Micro Motion T-Series sensors have their own characterization factors, which should be written using the values that appear on the sensor serial number tag.

CAUTION

Writing characterization variables can change transmitter outputs, which can result in measurement error.

Set control devices for manual operation before writing characterization variables. This prevents automatic recording of process data during transmitter configuration.

Key to characterizing the flowmeter
Values written during characterization override existing flow, density, and temperature factors, and change the current flowmeter calibration.

17.2 Flow calibration factor

The flow calibration factor describes a particular sensor's sensitivity to mass flow. Testing conducted in the Micro Motion Flow Calibration Lab determines the precise value of the flow calibration factor for each sensor, to NIST (National Institute of Standards and Technology) standards.

Transmitter is pre-programmed

If the sensor and transmitter were ordered together as a Coriolis flowmeter, the correct flow calibration factor was programmed into the transmitter at the factory and does not need to be rewritten.

After calibration at the factory, the ASCII character string in registers 50072-50076 represents the flow calibration factor that is on the sensor serial number tag and the flowmeter calibration certificate.

If the flowmeter fails to perform within the accuracy specifications provided by Micro Motion, you might need to perform a field flow calibration, discussed on page 165, or adjust the meter factor, as discussed on page 165 and in **Chapter 19**.

Transmitter is not pre-programmed

If the sensor and transmitter were not ordered together as a Coriolis flowmeter, or if the sensor or transmitter is replaced in the field, you must write the flow calibration factor (8 digits and 2 decimal points) from the sensor serial number tag to registers 50072-50076. The flow calibration factor can also be found on the calibration certificate that was shipped with the sensor. See **Table 17-3**, page 167.

If the flowmeter fails to perform within the accuracy specifications provided by Micro Motion, you might need to perform a field flow calibration, discussed on page 165, or adjust the meter factor, as discussed on page 165.

Flow calibration factor format

The flow calibration factor contains two components: flow rate and temperature coefficient for flow. Flow rate represents the flow, in grams per second, required to produce one microsecond of time shift between signals transmitted by sensor pickoffs. Temperature coefficient for flow represents the percent change in the rigidity of the flow tubes around the twisting axis per 100˚C. These values are fixed and depend on the sensor type. They are listed on the sensor tag.

These two components can be represented as ASCII character strings or as floating-point values.

- In ASCII format, the flow calibration factor consists of 10 ASCII characters, including 8 digits and 2 decimal points. The following ASCII character string is a typical flow calibration factor:

  63.1904.75

  The first six characters (five digits and first decimal point), stored in registers 50072-50074, are the flow rate. In the example calibration factor, the first five digits and first decimal point indicate that, for every detected microsecond of time shift, 63.190 grams of fluid per second flow through the sensor.

The last four characters (three digits and second decimal point), stored in registers 50075-50076, represent the temperature coefficient for flow for the sensor. In the default calibration factor above, the temperature coefficient for flow is set to 4.75.

- In floating-point format, the first five digits and first decimal point (the flow rate) are stored as a floating-point value in register pair 20407-20408. The temperature coefficient for flow is stored as a floating-point value in register pair 20409-20410.

Field flow calibration

If a field flow calibration is performed, and the transmitter is using a pressure input for pressure compensation, you should enter the calibration pressure. Enter the value in psi. Omitting this step may result in less accurate measurements. For information on pressure compensation, see **Chapter 12** or **Chapter 13**.

In the flow calibration procedure, a batch of fluid is run through the sensor, then the weighed amount of fluid in the batch is compared with the measured total that is read from holding register 30008 or 30009.

To perform a flow calibration, follow these steps:

1. Set process control devices for manual operation.
2. Make sure the mass flow meter factor is *1.0000*. To check the meter factor, read the floating-point value from register pair 20279-20280, as listed in **Table 17-1**, and change it as required.

Table 17-1. Mass flow meter factor register pair

Register pair	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000	RFT9739[1]
20279 20280	A value that adjusts flowmeter measurements without changing the flow calibration factor	√	√	√	√

[1] *Does not apply to Version 2 RFT9739 transmitters.*

3. Ensure that the original (pre-calibration) value for flow calibration factor is correct. This value should be stored in transmitter memory, in registers 50072-50076, as listed in **Table 17-3**, page 167. The original flow calibration factor can be found on the calibration certificate that was shipped with the sensor.
4. Zero the flowmeter. The zeroing procedure is described in **Chapter 18**.
5. Set coil 00003 to ON to reset totalizers to zero. See **Table 11-22**, page 121.

6. Run three batches of fluid, resetting the scale and totalizer between batches. For each batch, record the weights indicated by the scale and the totalizer. **Table 17-2** lists registers that store totalizer values.

	$\textbf{Weight}_{scale}$	$\textbf{Weight}_{totalizer}$
First batch	______	______
Second batch	______	______
Third batch	______	______
Total	______	______

Table 17-2. Mass and volume total registers

Input register	Register pair	Data returned from address	MVDSolo	Series 1000	Series 2000	RFT9739
30008	20259 20260	Mass total	√	√	√	√
30009	20261 20262	Volume total	√	√	√	√

7. Divide *Total Weight*$_{scale}$ by *Total Weight*$_{totalizer}$. This is the mass flow meter factor. Record the meter factor:

   Mass flow meter factor ______

8. For MVDSolo or a Series 1000, Series 2000, or Version3 RFT9739 transmitter, write the floating-point mass flow meter factor to register pair 20279-20280, as listed in **Table 17-1**, page 165. *After entering the meter factor, you do not need to perform steps 9 through 11 of this procedure.* For more information on meter factors, see **Chapter 19.**
9. For a Version 2 RFT9739 transmitter, multiply the meter factor from step 7 by the first five digits of the current flow calibration factor. This is the new first five digits of the new flow calibration factor. Record the new flow calibration factor:

   Flow calibration factor ______

10. Write the new flow calibration factor to the appropriate registers:
    - If you are using ASCII format, write the new 10-character string for the flow calibration factor to registers 50072-50076, as listed in **Table 17-3**.
    - If you are using floating-point format, write the new floating-point values to register pairs 20407-20408 and 20409-20410, as listed in **Table 17-4**.

The complete flow calibration factor should have 8 digits and 2 decimal points, as described on page 164.

11. To verify the accuracy of the new flow calibration factor, repeat step 6. The total that is read from holding register 30008 or 30009 should equal the weighed amount of fluid in the batch, within accuracy specifications provided by Micro Motion for the flowmeter.

Table 17-3. Flow calibration factor values – ASCII format

Notes

- Write the flow calibration factor from the sensor serial number tag, or the factor derived from a flow calibration.
- Write character strings as single-write multiples.

Register	Description	ASCII character strings	MVDSolo	Series 1000	Series 2000	Version 2 RFT9739
50072 50073 50074	Flow calibration factor	Each register holds 2 characters in a string of 6 characters describing the flow rate, in grams per second, required to produce 1 µsec of time shift between velocity signals from sensor pickoffs	√	√	√	√
50075 50076	Temperature coefficient for flow	• Each register holds 2 characters in a string of 4 characters describing percent change per 100°C in rigidity of flow tubes around twisting axis • For appropriate values, see the sensor serial number tag.	√	√	√	√

Table 17-4. Flow calibration factor values – floating-point format

Notes

- Write the flow calibration factor from the sensor serial number tag, or the factor derived from a flow calibration.

Register pairs	Description	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000	Version 2 RFT9739
20407 20408	Flow calibration factor	Flow rate, in grams per second, required to produce 1 µsec of time shift between velocity signals from sensor pickoffs	√	√	√	
50075 50076	Temperature coefficient for flow	• Percent change per 100°C in rigidity of flow tubes around twisting axis • For appropriate values, see the sensor serial number tag.	√	√	√	

17.3 Density characterization

Density factors describe a particular sensor's density measurement sensitivity. Testing conducted at the factory determines the precise values of the density factors for each sensor.

Transmitter is pre-programmed

If the sensor and transmitter were ordered together as a Coriolis flowmeter, the correct density factor was programmed into the transmitter at the factory and does not need to be rewritten.

Transmitter is not pre-programmed

If the sensor and transmitter were not ordered together as a Coriolis flowmeter, or if the sensor or transmitter is replaced in the field, you must write density factors to the floating-point register pairs used during a density calibration.

> **CAUTION**
>
> **Density calibration terminology has changed.**
>
> For all sensor other than T-Series, the name of the flowing density factor depends on the ship date of the sensor:
> - For sensors shipped before October 1997, it is called the K3 factor.
> - For sensors shipped after October 1997, it is called the FD factor.

Keys to writing density factors

1. Write all density calibration factors as single precision IEEE floating-point values.
2. **Table 17-5** describes three methods for writing density calibration factors. All factors must be written using the same method. Review the entire section before selecting a method.
3. If you have a Micro Motion T-series sensor, do not use any of these methods. See **Section 17.5**, page 174.

Table 17-5. Methods for writing density factors

Note

- Use the same method for writing all six density factors.
- Do not use any of these methods for characterizing a Micro Motion T-Series sensor (see **Section 17.5**, page 174).

Density factor	Method 1 • Preferred • If possible, use this method	Method 2 Acceptable if D1 and D2 or K1 and K2 are not listed on the sensor tag	Method 3 Acceptable if Method 2 is not possible
Density 1	Write the D1 value from the sensor serial number tag	Perform the density calibration procedure described in **Chapter 18**	Write the D1 value from the sensor tag, or enter 0.0012 if no D1 value is listed
Density 2	Write the D2 value from the sensor serial number tag		Write the D2 value from the sensor tag, or enter 0.998 if no D2 value is listed
Density constant 1	Write the K1 value from the sensor serial number tag		Write the first five digits of the 13-digit density calibration factor from the sensor serial number tag
Density constant 2	Write the K2 value from the sensor serial number tag		Write the second five digits of the 13-digit density calibration factor from the sensor serial number tag
Density constant 3	Write a value of 0 (the factory-default value for K3 for the RFT9739 transmitter)		Write a value of 0 (the factory-default value for K3 for the RFT9739 transmitter)
Flowing density constant	Write the FD from the sensor tag or calibration certificate		Contact Micro Motion for an appropriate FD value
Temperature coefficient	Write the TC value from the sensor serial number tag	• Write the temperature coefficient value from Methods 1 or 3 • If it is not possible to read the sensor tag, contact Micro Motion for appropriate value.	Write the last three digits and decimal point of the 13-digit density calibration factor from the sensor serial number tag

Density 1 and 2

Use the same method for deriving density 1 and density 2 as the method that is used for deriving all other density factors. See **Table 17-5**.

Density 1 (D1)
Density 1 represents the density, in grams per cubic centimeter at line conditions, of the low-density fluid (usually air) used during a 2-point density calibration. Write the appropriate values to register pair 20155-20156, as listed in **Table 17-6**, page 170.

Density 2 (D2)
Density 2 represents the density, in grams per cubic centimeter at line conditions, of the high-density fluid (usually water) used during a 2-point density calibration. Write the appropriate value to register pair 20157-20158, as listed in **Table 17-6**.

Density calibration constants

Use the same method for deriving density constants as the method that is used for deriving all other density factors. See **Table 17-5**.

Density constant 1 (K1)
Calibration constant 1 represents the tube period in microseconds when the flow tubes contain the low-density calibration fluid at line conditions.

Table 17-6. Density 1 and 2 register pairs

Notes

- Write density 1 and density 2 values in grams per cubic centimeter, regardless of the measurement unit established for density as a process variable.
- Use the same method for deriving density 1 and density 2 as the method that is used for deriving all other density factors. See **Table 17-5**, page 169.

Register pair	Single precision IEEE 754 floating-point value in grams per cubic centimeter	MVDSolo	Series 1000	Series 2000	RFT9739
20155 20156	• **Method 1:** D1 from sensor serial number tag • **Method 2:** Density of low-density calibration fluid at line conditions • **Method 3:** D1 from sensor serial number tag, or a value of 0.0012 g/cc if the sensor tag does not list a D1 value	√	√	√	√
20157 20158	• **Method 1:** D2 from sensor serial number tag • **Method 2:** Density of high-density calibration fluid at line conditions • **Method 3:** D2 from sensor serial number tag, or a value of 0.9980 g/cc if the sensor tag does not list a D2 value	√	√	√	√

Write the appropriate value to register pair 20159-20160, as listed in **Table 17-7**.

Density constant 2 (K2)
Calibration constant 2 represents the tube period in microseconds when the flow tubes contain the high-density calibration fluid at line conditions. Write the appropriate value to register pair 20161-20162, as listed in **Table 17-7**.

Third-point density constant (K3) or flowing density constant (FD)
This value represents the corrected tube period in microseconds that is calculated while fluid flows through the sensor at a high flow rate. For sensors that were shipped before October 1997, it is called the K3 constant. For sensors shipped after October 1997, it is called the FD constant.

*Note: This K3 value is not the same as the K3 value for a Micro Motion T-Series sensor. For information on characterizing T-Series sensors, see **Section 17.5**, page 174.*

If you are using an RFT9739 transmitter, version 3.5 or lower, write the K3 or FD value to register pair 20277-20278, as listed in **Table 17-7**.

If you are using an RFT9739 transmitter, version 3.6 or higher, MVDSolo, or a Series 1000 or 2000 transmitter, write the K3 or FD value to register pair 20303-20304, as listed in **Table 17-7**. The 20277-20278 register pair is not used with these transmitters, unless you are performing flowing-density calibration with MVDSolo or a Series 1000 or 2000 transmitter (see **Chapter 18**). In this case, register pair 20277-20278 will be used during the calibration process to store a value required for calibration.

Table 17-7. Density constant register pairs

Note

Use the same method for deriving density calibration constants as the method that is used for deriving all other density factors. See **Table 17-5**, page 169.

Register pair	Method	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000	RFT9739
20159 20160	Method 1	• K1 value from sensor tag	√	√	√	√
	Method 2	• Tube period in µsec measured during low-density calibration	√	√	√	√
	Method 3	• First 5 digits in density calibration factor on sensor tag	√	√	√	√
20161 20162	Method 1	• K2 value from sensor tag	√	√	√	√
	Method 2	• Tube period in µsec measured during high-density calibration	√	√	√	√
	Method 3	• Second 5 digits in density calibration factor on sensor tag	√	√	√	√
20277 20278	Method 1	• A value of 0 (the factory-default value for K3 or FD)				√[1]
	Method 2	• The K3 or FD value measured during a flowing-density calibration				√[1]
		• A density value required during flowing density calibration	√[2]	√[2]	√[2]	
	Method 3	• A value of 0 (the factory-default value for K3 or FD)				√
20303 20304	Method 1	• K3 or FD from the sensor tag or calibration certificate	√	√	√	√[3]
	Method 2	• The FD value measured during a flowing (third-point) density calibration	√	√	√	√[3]
	Method 3	• K3 or FD value obtained by contacting Micro Motion	√	√	√	√[3]

[1] *Version 3.5 and lower only.*
[2] *Do not write unless performing flowing density calibration, as instructed in **Chapter 18**.*
[3] *Version 3.6 and higher only.*

Temperature coefficient for density

Use the same method for deriving the temperature coefficient for density as the method that is used for deriving all other density factors. See **Table 17-5**, page 169.

The temperature coefficient for density represents the percent change in the elasticity of the flow tubes around the bending axis per 100°C. Write the value to register pair 20163-20164, as listed in **Table 17-8**, page 172.

Table 17-8. Density temperature coefficient register pair

Note

Use the same method for deriving density calibration constants as the method that is used for deriving all other density factors. See **Table 17-5**, page 169.

Register pair	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000	RFT9739
20163 20164	• **Method 1:** The TC value from the sensor serial number tag • **Method 2:** - The temperature coefficient value from Methods 1 or 3 - If it is not possible to read the sensor tag, contact Micro Motion for required information. • **Method 3:** The last three digits and decimal point of the 13-digit density calibration factor from the sensor tag	√	√	√	√

17.4 Temperature calibration factor

Temperature characterization is not recommended.

⚠ CAUTION

Temperature characterization could cause measurement error.

Temperature characterization affects flow and density measurements and will require completely recalibrating the flowmeter for flow and density measurement.

Temperature characterization is not recommended.

The temperature calibration factor describes the slope and offset of the equation used for calculating the output level that represents the temperature of the sensor flow tubes. In a Micro Motion flow sensor, a platinum resistance temperature detector (RTD) with a resistance of 100 ohms at 0°C measures the flow tube temperature. The specified temperature accuracy is ±1˚C ± 0.5% of the reading in °C.

The temperature calibration factor represents A and B in the following equation, which expresses a straight-line correction of the linear output indicating flow tube temperature:

$$T_{corrected} = A(T_{measured}) + B$$

Where:

A = Slope
B = Offset

Since the transmitter ordinarily does not correct the measured temperature, $T_{corrected} = T_{measured}$. The linear output therefore has a slope of 1 and an offset of 0. The default temperature calibration factor is:

1.00000T0000.0

- The digits before the placeholder “T” represent the slope of the linear output.

- The digits after the placeholder “T” represent the temperature offset, or the difference between the actual flow tube temperature and the temperature indicated by the output when $T_{measured}$ indicates a temperature of 0°C.

These two components can be represented as ASCII character strings or as floating-point values:

- In ASCII format, the slope is written to ASCII registers 50080-50083, and the offset is written to ASCII registers 50084-50086. The last character of the string must be the placeholder T.
- In floating-point format, the slope is written to register pair 20411-20412, and the offset is written to register pair 20413-20414. The placeholder is not required.

Write the temperature calibration factor to the ASCII registers listed in **Table 17-9** or the register pairs listed in **Table 17-10**.

Table 17-9. Temperature calibration factor – ASCII format

Notes

- Write the default temperature calibration factor, the factor from the serial number tag, or the factor derived from a temperature calibration performed as instructed in **Chapter 18**.
- Write character strings as single-write multiples.

Register	ASCII character strings	MVDSolo	Series 1000	Series 2000	RFT9739
50080 50081 50082 50083	Each register holds 2 characters in a string of 8 characters: • First 7 characters define slope of output representing flow tube temperature. • 8th character is placeholder “T”	√	√	√	√
50084 50085 50086	Each register holds 2 characters in a string of 6 characters defining offset of output representing flow tube temperature.	√	√	√	√

Table 17-10. Temperature calibration factor – floating-point format

Notes

- Write the default temperature calibration factor, the factor from the serial number tag, or the factor derived from a temperature calibration performed as instructed in **Chapter 18**.

Register pair	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000
20411 20412	Slope of output representing flow tube temperature	√	√	√
20413 20414	Offset of output representing flow tube temperature	√	√	√

17.5 Micro Motion T-Series factors

Micro Motion T-Series sensors have their own characterization factors, which should be written using the values that appear on the sensor serial number tag.

Write Micro Motion T-Series characterization factors to the register pairs that are listed in **Table 17-11**.

Table 17-11. Micro Motion T-Series characterization register pairs

Note

Write all Micro Motion T-Series characterization factors from the values on the sensor serial number tag.

Register pair	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000
20505 20506	FTG factor from sensor tag	√	√	√
20507 20508	FFC factor from sensor tag	√	√	√
20513 20514	DTG factor from sensor tag	√	√	√
20515 20516	DFQ1 factor from sensor tag	√	√	√
20517 20518	DFQ2 factor from sensor tag	√	√	√
20155 20156	D1 factor from sensor tag	√	√	√
20157 20158	D2 factor from sensor tag	√	√	√
20159 20160	K1 factor from sensor tag	√	√	√
20161 20162	K2 factor from sensor tag	√	√	√
20303 20304	FD factor from sensor tag	√	√	√
20163 20164	TC factor from sensor tag	√	√	√

18 Calibration

18.1 About this chapter

This chapter explains how to perform calibration procedures.

Calibration accounts for performance variations in individual sensors, transmitters, and peripheral devices. When a transmitter and a sensor are ordered together as a Coriolis flowmeter, they are factory calibrated to produce highly accurate measurements of mass flow, fluid density, and flow tube temperature. However, Modbus protocol supports field calibration, thereby enabling sensors and transmitters to be interchanged. Field calibration might also be required if the application is highly sensitive to density or temperature.

- Flowmeter zeroing establishes flowmeter response to zero flow and sets a baseline for flow measurement.
- Density calibration adjusts calibration factors used by the transmitter in calculating density.
- Temperature calibration, which is not recommended, adjusts calibration factors used by the transmitter in calculating temperature. The procedure for performing a temperature calibration depends on the transmitter.

⚠ CAUTION

During calibration, the flowmeter could produce inaccurate signals.

Set control devices for manual operation before performing calibration procedures.

Keys to performing calibration procedures
- Before performing calibration procedures, establish measurement units for process variables. See **Chapter 7**.
- Zero the transmitter at initial startup, and before performing a flow calibration, as instructed in **Chapter 17**.

18.2 Zeroing the flowmeter

Flowmeter zeroing establishes flowmeter response to zero flow and sets a baseline for flow measurement.

⚠ CAUTION

Failure to zero the flowmeter at initial startup could cause the flowmeter to produce inaccurate signals.

Zero the flowmeter before putting it into operation.

To zero the flowmeter, follow these steps:

1. Prepare the flowmeter for zeroing:
   a. Install the sensor according to the appropriate sensor instruction manual.
   b. Apply power to the transmitter, then allow it to warm up for at least 30 minutes.
   c. Make sure the transmitter is in a security mode that allows flowmeter zeroing.
   d. Run the process fluid to be measured through the sensor until the sensor temperature reading approximates the normal process operating temperature.

2. Close the shutoff valve downstream from the sensor.

3. Fill the sensor *completely* with fluid under normal process conditions of temperature, density, pressure, etc., and ensure zero flow through the sensor.

⚠ CAUTION

Flow through the sensor during flowmeter zeroing will result in an inaccurate zero setting.

Make sure fluid flow through the sensor is *completely* stopped during flowmeter zeroing.

a. Make sure flow through the sensor is completely stopped, then set coil 00005. The transmitter then begins zeroing.
   - Coil 00005 indicates zeroing in progress (ON) or zeroing complete (OFF).
   - Other addresses listed in **Table 18-1** also indicate zeroing in progress.
   - On transmitters with a display, the message screen reads “CAL IN PROGRESS”.
   - If the RFT9739 control output indicates zeroing in progress, the output goes to 15 V.
   - On a field-mount RFT9739 transmitter, the diagnostic LED is red and remains ON.
   - On a Series 1000 or 2000 transmitter with a display, the diagnostic LED is yellow and blinks.

Sensor zeroing requires anywhere from 20 seconds to 2 minutes, depending on the sensor model and the density of the fluid.

To end zeroing before its completion, reset coil 00005.

When zeroing is completed:
- Coil 00005 resets.
- On transmitters with a display, the message screen reads “CALIBRATION COMPLETE”.
- On a field-mount RFT9739 transmitter, the diagnostic LED is red and blinks ON once per second.
- On a Series 1000 or 2000 transmitter with a display, the diagnostic LED is green and blinks.

Table 18-1. Zeroing in progress status bits

Note

If flowmeter zeroing is interrupted, status bits remain ON.

Address	Address type	Description	Bit status	MVDSolo	Series 1000	Series 2000	RFT9739
30126	Input register	Zeroing in progress	x1xx xxxx xxxx xxxx	√	√	√	√
30421	Input register		x1xx xxxx xxxx xxxx	√	√	√	
30423	Input register		1xxx xxxx xxxx xxxx	√	√	√	
20245 20246	Floating point register pair		131072	√	√	√	√
00005	Coil		1	√	√	√	√

Diagnosing zeroing failure

If zeroing fails:
- Discrete input 10026 is set ON.
- The addresses listed in **Table 18-2** also indicate zeroing failure.
- On transmitters with a display, the message screen reads “ZERO TOO HIGH”, “ZERO TOO LOW”, or “ZERO TOO NOISY”.
- On a Series 1000 or 2000 transmitter with a display, the diagnostic LED is red and blinks
- On a field-mount RFT9739 transmitter, the diagnostic LED is red and blinks ON 4 times per second.

The most common sources of zeroing failure are:
- Flow of fluid through sensor during zeroing
- Partially empty sensor flow tubes
- An improperly mounted sensor

Status bits listed in **Table 18-3** indicate sources of zeroing failure.

To clear a zeroing error, re-zero the transmitter after correcting the problem, or cycle power to the transmitter to abort the procedure and return to the previously established zero. You can adjust the programmable zeroing parameters before re-zeroing. See pages 179-181.

Table 18-2. Zeroing failure status bits

Note

If the status bits listed below indicate zeroing failure, the status bits listed in **Table 18-3** can expose the source of the failure.

Address	Address type	Description	Bit status	MVDSolo	Series 1000	Series 2000	RFT9739
30001	Input register	Flowmeter zeroing failed	xxxx 1xxx xxxx xxxx	√	√	√	√
30126	Input register		xxxx xxx1 xxxx xxxx	√	√	√	√
30419	Input register		xxxx xxxx xx1x xxxx	√	√	√	
30421	Input register		xxxx xxx1 xxxx xxxx	√	√	√	
20245 20246	Floating point register pair		8192	√	√	√	√
10026	Discrete input		1	√	√	√	√

Table 18-3. Zeroing failure source status bits

Notes

- If flowmeter zeroing is interrupted, status bits remain ON.
- If register pairs return the status bits listed below, see **Section** for suggestions on how to correct the problem. Then make sure flow is **completely** shut off and the sensor tubes are **completely** filled with fluid, then re-zero.

Address	Address type	Description	Bit status	MVDSolo	Series 1000	Series 2000	RFT9739
30126	Input register	Transmitter zeroing failed/zero value too low	xxxx xx11 xxxx xxxx	√	√	√	√
20245 20246	Floating point register pair		8192 + 16384 = 24576	√	√	√	√
30421	Input register		xxxx xx1x xxxx xxxx	√	√	√	
20245 20246	Floating point register pair	Transmitter zeroing failed/zero value too high	8192 + 32768 = 40960	√	√	√	√
30126	Input register		xxxx x1x1 xxxx xxxx	√	√	√	√
30421	Input register		xxxx x1xx xxxx xxxx	√	√	√	
30126	Input register	Transmitter zeroing failed/zero too noisy	xxxx 1xx1 xxxx xxxx	√	√	√	√
30421	Input register		xxxx 1xxx xxxx xxxx	√	√	√	

Flow signal offset

Register pair 20233-20234 stores a floating-point value that represents the flow signal offset, which is set by the transmitter during flowmeter zeroing. The value is the average time shift, in microseconds, between signals from the sensor pickoffs at zero flow. See **Table 18-4**.

- For the RFT9739 transmitter, register pair 20233-20234 is read-only.
- For the Series 1000 or 2000 transmitter, register pair 20233-20234 is read/write.

Table 18-4. Flow signal offset register pair

Register pair	Single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000	RFT9739
20233 20234	Average time shift in µsec between signals from sensor pickoffs at zero flow	√	√	√	√

Programming flowmeter zero time

Zeroing parameters can be reprogrammed if status bits listed in **Table 18-3** indicate zero value too low, zero value too high, or zero too noisy. A longer zero time might improve the accuracy of the zeroing procedure by increasing the number of measurement cycles or the number of seconds required for zeroing.

During flowmeter zeroing, the transmitter measures the time shift (the time between signals from the sensor's left and right pickoffs) for each measurement cycle, computes the average time shift per cycle, then derives the standard deviation of the average time shift over the zero time.

- For the Series 1000 or 2000 transmitter, zero time is the number of seconds required for flowmeter zeroing. The default zero time is 20 seconds.
- For the RFT9739 transmitter, zeroing time is the number of measurement cycles required for flowmeter zeroing. The default zero time is 2048 cycles (approximately 40 seconds at a tube frequency of 100 Hz).

For the RFT9739 transmitter, if bit status indicates zero too noisy, you can program a standard deviation limit to account for mechanical noise, such as vibrating pumps or other equipment. Mechanical noise can cause zero failure by interfering with signals from the sensor.

RFT9739 standard deviation limit

For the RFT9739 transmitter, the limit of the standard deviation causes the transmitter to zero in one of the following ways:

- When the standard deviation measured by the transmitter converges to a value that is less than the programmed standard deviation limit, the transmitter will zero successfully. The time required for zeroing to be completed will be equal to or less than the configured zero time.
- If the standard deviation measured by the transmitter exceeds, but is not more than 10 times the programmed standard deviation limit, the transmitter will zero successfully, but will continue sampling throughout the entire zero time.
- If the standard deviation measured by the transmitter is more than 10 times the programmed standard deviation limit, the transmitter indicates zero failure and retains the previous zero calibration. This is a fault condition.

The standard deviation limit default value is 0. To change this, write the new value to register pair 20235-20236, as listed in **Table 18-5**.

Read the standard deviation for the last flowmeter zeroing from register pair 20231-20232, as listed in **Table 18-6**.

Table 18-5. Flowmeter zeroing standard deviation limit

Register pair	Read-only single precision IEEE 754 floating-point value	RFT9739
20235 20236	Standard deviation limit	√

Table 18-6. Flowmeter zeroing standard deviation register pairs

Register pair	Read-only single precision IEEE 754 floating-point value	RFT9739
20231 20232	Standard deviation of time shifts at zero flow during previous zero calibration	√

Zero time

The zero time enables zeroing to occur over a shorter or longer time than the default time.

- For the Series 1000 or 2000 transmitter, you can program a zero time of 20 to 150 seconds. If the zero time is not changed, the transmitter will sample the time shift over the number of seconds that is typical for the sensor.
- For the RFT9739 transmitter, you can program a zero time of 100 to 65,535 cycles. If the zero time is not changed, the transmitter will sample the time shift over 2048 measurement cycles (approximately 40 seconds at a flow tube frequency of 100 Hz).

To program the zero time, write the desired number of seconds or desired number of measurement cycles to holding register 40136, as listed in **Table 18-7**.

Example

The RFT9739 transmitter needs to zero in 10 or fewer seconds because flow can be stopped only for this short period of time. Under zero flow conditions, the flow tubes vibrate at a rate of 100 Hz, or 50 measurement cycles per second.

Since 10 seconds x 50 measurement cycles/second = 500, the zero time is 500 measurement cycles. Write a value of 500 to holding register 40136.

The flowmeter will zero in 10 or fewer seconds, depending on the standard deviation and the programmed limit of the standard deviation.

Table 18-7. Flowmeter zero time holding register

Holding register	Integer value	MVDSolo	Series 1000	Series 2000	RFT9739
40136	Any integer from 100 to 65535, equal to maximum number of measurement cycles allowed for zeroing, where: $1\ \textit{Measurement cycle} = 2\ \textit{Tube periods}$ *or* $1\ \textit{Measurement cycle} = \frac{1}{2 \times \textit{Frequency}}$				√
	Any number of seconds, from 20 to 150, equal to the number of seconds allowed for zeroing	√	√	√	

18.3 Density calibration

Fluid density is inversely proportional to the square of the flow tube frequency. Density calibration adjusts the slope and offset of the factors used by the transmitter to calculate density.

Note: Density calibration is not applicable to R-Series sensors.

Density calibration includes the following procedures:
- Low-density calibration
- High-density calibration
- Flowing-density calibration (optional)
- D3 and D4 density calibration (optional, T-Series sensors only)

The first two calibrations, also called two-point density calibration, establish an individual sensor's tube periods at two reference densities, which the transmitter uses to calculate the density of the process fluid at low flow rates.Two-point density calibration is preferably performed under zero flow conditions.

Note: One-point density calibration is an option when two-point calibration is not possible. However, because one-point calibration is performed with only one reference density, two-point calibration is recommended for increased accuracy. If one-point density calibration is required, you may use either the low-density or the high-density calibration procedure.

Flowing-density (third-point or FD) calibration accounts for the effect of flow on the tube period at high flow rates. As the flow rate approaches the maximum flow rate of the sensor, the angular momentum of the fluid can alter the tube period, which causes an increase in the density value measured by the sensor. An increase in the flow rate causes a proportional increase in the angular momentum of the fluid.

FD calibration is desirable if the process exceeds or often approaches the sensor-specific flow rate listed in **Table 18-8**. If the process remains below the listed rate, performing a flowing-density calibration is unnecessary, since angular momentum of the fluid will have a minimal effect on the flow tube frequency.

Note: FD calibration should not be performed for T-Series sensors.

D3 and D4 density calibrations enable fine-tuning of the density calibration. D3 and D4 density calibrations are applicable only to T-Series sensors used with MVDSolo or Series 1000 or 2000 transmitters.

Density unit for calibration

Density calibration requires writing density values in grams per cubic centimeter (g/cc). This may or may not be the unit configured for density. Calibration can proceed regardless of the configured density unit. However, you must write the line-condition density in g/cc.

Table 18-8. Flow rates requiring flowing density calibration

Sensor model		Flow rate in lb/min	Flow rate in kg/h
ELITE® sensor	CMF010	2.5	69
	CMF025	27	720
	CMF050	86	2350
	CMF100	280	7575
	CMF200	1270	34,540
	CMF300	4390	119,600
	CMF400	15,000	409,000
T-Series sensor	T025	25	680
	T050	140	3800
	All T-Series sensors	Flowing density calibration not necessary	
F-Series sensor	F200	2315	63,045
	All other F-Series sensors	Flowing density calibration not necessary	
Model D sensor	D6	0.8	25
	D12	4.5	125
	D25	18	485
	D40 stainless steel	33	900
	D40 Hastelloy® C-22	52	1395
	D65	115	3060
	D100	405	11,010
	D150	1140	31,050
	D300	2705	73,660
	D600	9005	245,520
Model DH sensor	All DH sensors	Flowing density calibration not necessary	
Model DL sensor	DL65	115	3075
	DL100	325	8,780
	DL200	1210	32,950
Model DT sensor	DT65	150	4040
	DT100	315	8460
	DT150	580	15,780

Calibration procedures

To perform density calibration, follow the steps below.

Step 1 Low-density calibration

To perform the low-density calibration:

a. Fill the sensor with a low-density fluid such as air.

b. If possible, shut off the flow. Otherwise, pump the fluid through the sensor at the lowest flow rate allowed by the process.

c. Use any established method to derive an accurate density, in g/cc, for the fluid at line conditions. If air is the low-density calibration fluid, a value in **Table 18-9**, page 184**,** can be used for the density.

d. Write the line-condition density, *in grams per cubic centimeter*, to register pair 20155-20156, as listed in **Table 18-10**, page 184. You must use g/cc even if you have specified a different density unit for process measurement.

e. Set coil 00013 to an ON state. The transmitter measures the tube period and corrects it to 0°C. The transmitter stores the floating-point value of the temperature-corrected tube period in register pair 20159-20160, as listed in **Table 18-10**. The following indicators show low-density calibration in process:
   - Coil 00013 is set to ON.
   - Other addresses listed in **Table 18-11** also indicate low-density calibration in progress.
   - On transmitters with a display, the message screen reads "CAL IN PROGRESS".
   - On a field-mount RFT9739 transmitter, the diagnostic LED is red and remains ON.
   - On a Series 1000 or 2000 transmitter with a display, the diagnostic LED is yellow and blinks.

f. If the calibration fails, retry the calibration. If calibration fails repeatedly, cycle power to the transmitter to clear the error status. The transmitter will then use the old calibration settings. Contact Micro Motion customer support.

Table 18-9. Density of air

	Density in g/cc at:								
Pressure in-Hg (millibar)	**10°C 50°F**	**15°C 59°F**	**20°C 68°F**	**25°C 77°F**	**30°C 86°F**	**35°C 95°F**	**40°C 104°F**	**45°C 113°F**	**50°C 122°F**
25.14 (850)	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0009	0.0009	0.0009
26.62 (900)	0.0011	0.0011	0.0011	0.0010	0.0010	0.0010	0.0010	0.0010	0.0009
28.10 (950)	0.0012	0.0011	0.0011	0.0011	0.0011	0.0011	0.0010	0.0010	0.0010
29.57 (1000)	0.0012	0.0012	0.0012	0.0012	0.0011	0.0011	0.0011	0.0011	0.0011
31.06 (1050)	0.0013	0.0013	0.0012	0.0012	0.0012	0.0012	0.0012	0.0011	0.0011

Table 18-10. Low-density calibration addresses

Note

Enter the density of the low-density calibration fluid in grams per cubic centimeter.

Address	Address type	Value	MVDSolo	Series 1000	Series 2000	RFT9739
20155 20156	Floating point register pair	Density in g/cc of low-density calibration fluid at line conditions	√	√	√	√
00013	Coil	0 Low-density calibration complete 1 Low-density calibration in progress	√	√	√	√
20159 20160	Floating point register pair	Temperature-corrected tube period in µsec when flow tubes contain low-density calibration fluid	√	√	√	√

Table 18-11. Low-density calibration status bits

Note

If the low-density calibration is interrupted, status bits remain ON.

Address	Address type	Description	Bit status	MVDSolo	Series 1000	Series 2000	RFT9739
30126	Input register	Calibration in progress	x1xx xxxx xxxx xxxx	√	√	√	√
30421	Input register	Calibration in progress	x1xx xxxx xxxx xxxx	√	√	√	
		Calibration failure	xxxx xxx1 xxxx xxxx	√	√	√	
30423	Input register	Low-density calibration in progress	x1xx xxxx xxxx xxxx	√	√	√	
00013	Coil	• Low-density calibration in progress • Low-density calibration complete	1 0	√	√	√	√

Step 2 High-density calibration

To perform the high-density calibration:

a. Fill the sensor with a high-density fluid such as water.

b. If possible, shut off the flow. Otherwise, pump the fluid through the sensor at the lowest flow rate allowed by the process. The rate must be less than the flow rate listed in **Table 18-12**, or the calibration will be in error. To ensure stable density, make sure the fluid in the flow tubes remains completely free of gas bubbles during the calibration.

Table 18-12. Maximum low-flow rates for high-density calibration

Sensor model		Maximum flow rate in lb/min	Maximum flow rate in kg/h
ELITE® sensor	CMF010	0.25	6.75
	CMF025	5	135
	CMF050	15	425
	CMF100	62	1700
	CMF200	200	5440
	CMF300	625	17,010
	CMF400	1250	34,090
F-Series sensor	F025	5	135
	F050	15	425
	F100	62	1700
	F200	200	5440
T-Series sensor	T025	1.5	42
	T050	8.5	237
	T075	31	875
	T100	68	1875
	T150	200	5435

Table 18-12. Maximum low-flow rates for high-density calibration *continued*

Model D sensor	D6	0.125	3.25
	D12	0.25	8.25
	D25	1.5	42
	D40	2.75	76
	D65	18	510
	D100	50	1360
	D150	175	4760
	D300	435	11,905
	D600	1560	42,525
Model DH sensor	DH6	0.125	3.25
	DH12	0.25	8.25
	DH25	1.5	42
	DH38	3	85
	DH100	50	1360
	DH150	175	4760
	DH300	435	11,905
Model DL sensor	DL65	15	420
	DL100	50	1360
	DL200	215	5950
Model DT sensor	DT65	18	510
	DT100	50	1360
	DT150	87	2380

c. Use any established method to derive an accurate density, in g/cc, for the fluid at line conditions. If water is the high-density calibration fluid, a value in **Table 18-13**, page 187**,** can be used for the density.

d. Write the line-condition density, *in grams per cubic centimeter*, to register pair 20157-20158, as listed in **Table 18-14**, page 187. You must use g/cc even if you have specified a different density unit for process measurement.

e. Set coil 00014 to an ON state. The transmitter measures the tube period and corrects it to 0°C. The transmitter stores the floating-point value of the temperature-corrected tube period in register pair 20161-20162, as listed in **Table 18-14**. The following indicators show high-density calibration in process:
   - Coil 00014 is set to ON.
   - Other addresses listed in **Table 18-15**, page 188, also indicate high-density calibration in progress.
   - On transmitters with a display, the message screen reads “CAL IN PROGRESS”.
   - On a field-mount RFT9739 transmitter, the diagnostic LED is red and remains ON.
   - On a Series 1000 or 2000 transmitter with a display, the diagnostic LED is yellow and blinks.

f. If the calibration fails, retry the calibration. If calibration fails repeatedly, cycle power to the transmitter to clear the error status. The transmitter will then use the old calibration settings. Contact Micro Motion customer support.

Table 18-13. Density of water

Temperature °F	Temperature °C	Density g/cc	Temperature °F	Temperature °C	Density g/cc	Temperature °F	Temperature °C	Density g/cc
32	0.0	0.9998	56	13.3	0.9994	80	26.7	0.9966
33	0.6	0.9998	57	13.9	0.9992	81	27.2	0.9964
34	1.1	0.9999	58	14.4	0.9992	82	27.8	0.9963
35	1.7	0.9999	59	15.0	0.9991	83	28.3	0.9961
36	2.2	0.9999	60	15.6	0.9991	84	28.9	0.9960
37	2.8	0.9999	61	16.1	0.9989	85	29.4	0.9958
38	3.3	0.9999	62	16.7	0.9989	86	30	0.9956
39	3.9	1.0000	63	17.2	0.9988	95	35	0.9941
40	4.4	1.0000	64	17.8	0.9987	100	38	0.9930
41	5.0	0.9999	65	18.3	0.9986	104	40	0.9922
42	5.6	0.9999	66	18.9	0.9984	113	45	0.9902
43	6.1	0.9999	67	19.4	0.9983	122	50	0.9881
44	6.7	0.9999	68	20.0	0.9982	131	55	0.9857
45	7.2	0.9999	69	20.6	0.9981	140	60	0.9832
46	7.8	0.9999	70	21.1	0.9980	149	65	0.9806
47	8.3	0.9998	71	21.7	0.9980	158	70	0.9778
48	8.9	0.9998	72	22.2	0.9979	167	75	0.9749
49	9.4	0.9998	73	22.8	0.9977	176	80	0.9718
50	10.0	0.9997	74	23.3	0.9975	185	85	0.9686
51	10.6	0.9996	75	23.9	0.9973	194	90	0.9653
52	11.1	0.9996	76	24.4	0.9972	203	95	0.9619
53	11.7	0.9995	77	25.0	0.9970	212	100	0.9584
54	12.2	0.9995	78	25.6	0.9969			
55	12.8	0.9994	79	26.1	0.9968			

Table 18-14. High-density calibration addresses

Note
Enter the density of the high-density calibration fluid in grams per cubic centimeter.

Address	Address type	Value	MVDSolo	Series 1000	Series 2000	RFT9739
20157 20158	Floating point register pair	Density in g/cc of high-density calibration fluid at line conditions	√	√	√	√
00014	Coil	0 High-density calibration complete 1 High-density calibration in progress	√	√	√	√
20161 20162	Floating point register pair	Temperature-corrected tube period in µsec when flow tubes contain high-density calibration fluid	√	√	√	√

Table 18-15. High-density calibration status bits

Note

If the high-density calibration is interrupted, status bits remain ON.

Address	Address type	Description	Bit status	MVDSolo	Series 1000	Series 2000	RFT9739
30126	Input register	Calibration in progress	x1xx xxxx xxxx xxxx	√	√	√	√
30421	Input register	Calibration in progress	x1xx xxxx xxxx xxxx	√	√	√	
		Calibration failure	xxxx xxx1 xxxx xxxx	√	√	√	
30423	Input register	High-density calibration in progress	xx1x xxxx xxxx xxxx	√	√	√	
00014	Coil	• High-density calibration in progress • High-density calibration complete	1 0	√	√	√	√

Step 3 Flowing-density calibration

Performing a flowing-density calibration is desirable if the process exceeds or often approaches the sensor-specific flow rate listed in **Table 18-8**, page 183.

To perform a flowing-density calibration, make sure the low-density and high-density calibration procedures have been performed, then:

a. Compare the maximum flow rate for the process with the sensor-specific value from **Table 18-8**. If the maximum flow rate for the process is less than the sensor-specific value, it is not necessary to perform the flowing-density calibration.

b. Fill the sensor with a process fluid that has a stable density.

c. If possible, shut off the flow. Otherwise, pump the fluid through the sensor at the lowest flow rate allowed by the process. To ensure stable density, make sure the fluid in the flow tubes remains *completely* free of gas bubbles during the calibration.

d. Read the measured density of the fluid from holding register 30003 or floating-point register pair 20249-20250, as listed in **Table 18-16**, page 189.

e. Pump the fluid through the sensor at the highest flow rate allowed by the process. The rate must be greater than the sensor-specific value from **Table 18-8**, or the calibration will be in error. To ensure stable density, make sure the fluid in the flow tubes remains *completely* free of gas bubbles during the calibration.

f. Write the density value, *in grams per cubic centimeter*, that was read in step d to the appropriate register pair, as listed in **Table 18-8**:
   - Series 1000 or Series 2000 transmitter: Write the density value to register pair 20277-20278.
   - RFT9739 transmitter: Write the density value to 20157-20158.

g. Set the appropriate coil to an ON state:
   - For a Series 1000 or 2000 transmitter, set coil 00018.
   - For an RFT9739 transmitter, set coil 00014.

Table 18-16. Read-only density registers

Input register	Register pair	Data returned from address	MVDSolo	Series 1000	Series 2000	RFT9739
30003	20249 20250	Line-condition density	√	√	√	√

During flowing-density calibration, the following indicators show flowing-density calibration in progress:

- Specific status bits are listed in **Table 18-18**, page 190.
- For an RFT9739 transmitter, coil 00014 indicates density calibration in progress (ON) or density calibration complete (OFF).
- For a Series 1000 or 2000 transmitter, coil 00018 indicates density calibration in progress (ON) or density calibration complete (OFF).
- On transmitters with a display, the message screen reads “CAL IN PROGRESS”.
- On a field-mount RFT9739 transmitter, the diagnostic LED is red and remains ON.
- On a Series 1000 or 2000 with a display, the diagnostic LED is yellow and blinks.

Table 18-17. Flowing-density calibration addresses

Notes
Enter the measured density of the fluid in grams per cubic centimeter.

Address	Address type	Value	MVDSolo	Series 1000	Series 2000	RFT9739
20157 20158	Register pair	Line-condition density in g/cc of calibration fluid at zero flow, written at highest flow rate allowed by process • For an RFT9739 transmitter, use register pair 20157-20158 • For MVDSolo or a Series 1000 or Series 2000 transmitter, use register pair 20277-20278				√
20277 20278	Register pair		√	√	√	
00014	Coil	0 RFT9739 calibration complete 1 RFT9739 calibration in progress				√
00018	Coil	0 Series 1000 or 2000 calibration complete 1 Series 1000 or 2000 calibration in progress	√	√	√	
20303 20304	Register pair	Flowing density calibration constant • For a Version 3.5 or lower revision RFT9739 transmitter, use register pair 20277-20278 • For MVDSolo or a Series 1000, Series 2000, or Version 3.6 or higher revision RFT9739 transmitter, use register pair 20303-20304	√	√	√	√
20277 20278	Register pair					√

h. If the calibration fails, retry the calibration. If calibration fails repeatedly, cycle power to the transmitter to clear the error status. The transmitter will then use the old calibration settings. Contact Micro Motion customer support.

Table 18-18. Flowing density calibration status bit

Note

If the flowing-density calibration is interrupted, the status bit remains ON.

Address	Address type	Description	Bit status	MVDSolo	Series 1000	Series 2000	RFT9739
30126	Input register	Calibration in progress	x1xx xxxx xxxx xxxx	√	√	√	√
30421	Input register	Calibration in progress	x1xx xxxx xxxx xxxx	√	√	√	
		Calibration failure	xxxx xxx1 xxxx xxxx	√	√	√	
30423	Input register	Calibration in progress	xxx1 xxxx xxxx xxxx	√	√	√	

Step 4 D3 density calibration

Keys to performing D3 and D4 calibration procedures
Before performing a D3 or D4 calibration, perform both low-density and high-density calibrations.

You may perform a D3 calibration, a D4 calibration, or both.

- The minimum density of the D3 or D4 fluid is 0.6 g/cc.
- The difference between the density of the D3 calibration fluid and the fluid that was used to perform the high-density calibration must be at least 0.1 g/cc.
- The difference between the density of the D4 calibration fluid and the fluid that was used to perform the high-density calibration must be at least 0.1 g/cc.
- If D3 and D4 density calibrations are performed, the difference between the densities of the D3 and D4 calibration fluids must be at least 0.1 g/cc.

To perform the D3 density calibration:

a. Fill the sensor with a fluid that has a density at least 0.6 g/cc. Use any established method to derive an accurate density, in g/cc, for the fluid at line conditions.
   - The density must be at least 0.1 g/cc lower or higher than the density of high-density calibration fluid (see pages 185-188).
   - If a D4 calibration will also be performed, the difference between the densities of the D3 and D4 calibration fluids must be at least 0.1 g/cc.

b. If possible, shut off the flow. Otherwise, pump the fluid through the sensor at the lowest flow rate allowed by the process.

c. Write the line-condition density, *in grams per cubic centimeter*, to register pair 20509-20510, as listed in **Table 18-19**, page 191.

d. Set coil 00044 to ON. The transmitter measures the tube period and corrects it for the density of the calibration fluid. The transmitter stores the floating-point value of the corrected tube period in register pair 20503-20504, as listed in **Table 18-19**. Calibration indicators are as follows:
   - Coil 00044 indicates D3 density calibration in progress (ON) or D3 calibration complete (OFF).
   - Other addresses listed in **Table 18-20** also indicate D3 density calibration in progress.
   - On transmitters with a display, the diagnostic LED is yellow and blinks.

Table 18-19. D3 density calibration addresses

Note

Enter the density of the D3 calibration fluid in grams per cubic centimeter.

Address	Address type	Value	MVDSolo	Series 1000	Series 2000
20509 20510	Floating point register pair	Density in g/cc of D3 calibration fluid at line conditions: • Minimum D3 density is 0.6 g/cc • The density must be at least 0.1 g/cc lower or higher than the high-density calibration fluid density (see pages 185-188) • If a D4 calibration is also performed, the difference between D3 and D4 densities must be 0.1 g/cc	√	√	√
00044	Coil	0 D3 density calibration complete 1 D3 density calibration in progress	√	√	√
20503 20504	Floating point register pair	Corrected tube period in μsec when flow tubes contain D3 calibration fluid	√	√	√

Table 18-20. D3 density calibration status bits

Note

If the D3 density calibration is interrupted, status bits remain ON.

Address	Address type	Description	Bit status	MVDSolo	Series 1000	Series 2000
30421	Input register	D3 density calibration in progress	x1xx xxxx xxxx xxxx	√	√	√
		D3 density calibration failure	xxxx xxx1 xxxx xxxx	√	√	√
30423	Input register	D3 density calibration in progress	xxxx xxxx x1xx xxxx	√	√	√
00044	Coil	• D3 density calibration in progress • D3 density calibration complete	1 0	√	√	√

Step 5 D4 density calibration

To perform the D4 density calibration:

a. Fill the sensor with a fluid that has a density at least 0.6 g/cc. Use any established method to derive an accurate density, in g/cc, for the fluid at line conditions.
   - The density must be at least 0.1 g/cc lower or higher than the density of high-density calibration fluid (see pages 185-188).

- If a D3 calibration will also be performed, the difference between the densities of the D3 and D4 calibration fluids must be at least 0.1 g/cc.

b. Write the line-condition density, *in grams per cubic centimeter*, to register pair 20511-20512, as listed in **Table 18-21**.

c. Set coil 00045 to an ON state. The transmitter measures the tube period and corrects it for the density of the calibration fluid. The transmitter stores the floating-point value of the corrected tube period in register pair 20519-20520, as listed in **Table 18-21**. Calibration indicators are as follows:
   - Coil 00045 indicates D4 density calibration in progress (ON) or D4 density calibration complete (OFF).
   - Other addresses listed in **Table 18-22** also indicate D4 density calibration in progress.
   - The diagnostic LED is yellow and blinks.

Table 18-21. D4 density calibration addresses

Note

Enter the density of the D4 calibration fluid in grams per cubic centimeter.

Address	Address type	Value	MVDSolo	Series 1000	Series 2000
20511 20512	Floating point register pair	Density in g/cc of D4 calibration fluid at line conditions: • Minimum D4 density is 0.6 g/cc • The density must be at least 0.1 g/cc lower or higher than the high-density calibration fluid density (see pages 185-188) • If a D3 calibration is also performed, the difference between D3 and D4 densities must be 0.1 g/cc	√	√	√
00045	Coil	0 D4 density calibration complete 1 D4 density calibration in progress	√	√	√
20519 20520	Floating point register pair	Corrected tube period in μsec when flow tubes contain D4 calibration fluid	√	√	√

Table 18-22. D4 density calibration status bits

Note

If the D4 density calibration is interrupted, status bits remain ON.

Address	Address type	Description	Bit status	MVDSolo	Series 1000	Series 2000
30421	Input register	D4 density calibration in progress	x1xx xxxx xxxx xxxx	√	√	√
		D4 density calibration failure	xxxx xxx1 xxxx xxxx	√	√	√
30423	Input register	D4 density calibration in progress	xxxx xxxx x1xx xxxx	√	√	√
00045	Coil	• D4 density calibration in progress • D4 density calibration complete	1 0	√	√	√

18.4 Temperature calibration

Temperature calibration is not recommended, for two reasons:
- Most applications do not require it.
- It can lead to measurement error if not performed properly.

CAUTION

Temperature calibration can cause measurement error.

Temperature calibration is not recommended.

Temperature calibration, performed while process fluid flows through the sensor at line conditions, adjusts the slope and offset of the equation used for calculating flow tube temperature. Performing a temperature calibration involves using a low-temperature calibration fluid to establish the offset and a high-temperature calibration fluid to establish the slope, then recalibrating the flowmeter for flow and density.

The temperature calibration procedure depends on the transmitter.
- To calibrate the RFT9739 transmitter for temperature, see pages 193-195.
- To calibrate MVDSolo or the Series 1000 or 2000 transmitter for temperature, see pages 196-198.

Temperature unit for calibration

Temperature calibration requires writing temperature values in degrees Celsius (°C). The calibration procedure can proceed if another temperature unit has been configured, as long as values are written in °C.

Keys to performing temperature calibration
You must perform the following steps without interruption:
1. Perform the temperature offset calibration.
2. Perform the temperature slope calibration.
3. For an RFT9739 transmitter, calculate and write the temperature calibration factor.
4. Recalibrate the flowmeter for flow and density measurement.

RFT9739 temperature calibration

Step 1 **Perform the temperature offset calibration**

a. Pump a process fluid through the sensor at the lowest temperature measured during the application.

b. Wait approximately five minutes for the flow tube temperature to stabilize.

c. Use a highly accurate thermometer, temperature sensor, or another device to measure the temperature of the process fluid. Record the temperature *in degrees Celsius* as T_1.

d. Read the temperature of the fluid from holding register 30004 or floating-point register pair 20251-20252, as listed in **Table 18-23**. Record the temperature *in degrees Celsius* as T_2.

Table 18-23. Read-only temperature registers

Input register	Register pair	Data returned from address	RFT9739
30004	20251 20252	Line-condition temperature	√

Step 2 Perform the temperature slope calibration

a. Pump a process fluid through the sensor at the highest temperature measured during the application.

b. Wait approximately five minutes for the flow tube temperature to stabilize.

c. Use a highly accurate thermometer, temperature sensor, or another device to measure the temperature of the process fluid. Record the temperature *in degrees Celsius* as T_3.

d. Read the temperature of the fluid from holding register 30004 or floating-point register pair 20251-20252, as listed in **Table 18-23**, above. Record the temperature *in degrees Celsius* as T_4.

Step 3 Calculate and write the temperature calibration factor

a. Perform the following calculations:

$$T_1 = A(T_2) + B$$

$$T_3 = A(T_4) + B$$

b. Solve for values of A and B, as illustrated in the following example.

Example	
	• At step 1c, the T_1 value equals 20°C. • At step 1d, the T_2 value equals 20.1°C. • At step 2c, the T_3 value equals 80°C. • At step 2d, the T_4 value equals 80.3°C.

$$80 = A(80.3) + B$$
$$20 = A(20.1) + B$$

Solve for A:

$$60 = A(60.2)$$
$$A = \frac{60}{60.2}$$
$$A = 0.99668$$

Solve for B:

$$20 = [20.1(0.99668)] + B$$
$$20 = 20.033268 + B$$
$$B = -0.033268$$

The new temperature calibration factor is 0.99668T–0.033.

c. Write the temperature calibration factor as an ASCII character string to registers 50080 to 50086, as listed in **Table 18-24**. Round off the slope (A) and offset (B) to ensure the placeholder "T" remains in its proper position as the 8th character in the factor (the lower-order character in register 50083).

Table 18-24. Temperature calibration character string

Notes

Write character strings as single-write multiples.

Register	ASCII character strings	RFT9739
50080 50081 50082 50083	Each register holds 2 characters in a string of 8 characters: • First 7 characters represent the slope of the output representing flow tube temperature • 8th character the is placeholder "T"	√
50084 50085 50086	Each register holds 2 characters in a string of 6 characters representing the offset of the output representing flow tube temperature	√

Step 4 Recalibrate the flowmeter

a. Perform the flow calibration procedure described in "Field flow calibration," page 165.

b. Perform the density calibration procedure described in "Density calibration," page 182.

MVDSolo or Series 1000 or 2000 temperature calibration

Step 1 Perform the temperature offset calibration

a. Pump a process fluid through the sensor at the lowest temperature measured during the application.

b. Wait approximately five minutes for the flow tube temperature to stabilize.

c. Use a highly accurate thermometer, temperature sensor, or another device to measure the temperature of the process fluid.

d. Write the line-condition temperature, *in degrees Celsius*, to register pair 20151-20152, as listed in **Table 18-25**.

e. Set coil 00015 to an ON state. The transmitter stores an ASCII character string representing the temperature offset in registers 50084-50086, as listed in **Table 18-25**. Calibration indicators are as follows:
   - Coil 00015 indicates temperature offset calibration in progress (ON) or temperature offset calibration complete (OFF).
   - Other addresses listed in **Table 18-26**, page 197, also indicate temperature offset calibration in progress.
   - On transmitters with a display, the diagnostic LED is yellow and blinks.

Table 18-25. Temperature offset calibration addresses

Note

Enter the temperature of the high-temperature calibration fluid in degrees Celsius.

Address	Address type	Value	MVDSolo	Series 1000	Series 2000
20151 20152	Floating point register pair	Temperature in °C of low-temperature calibration fluid at line conditions	√	√	√
00015	Coil	0 Calibration complete 1 Calibration in progress	√	√	√
50084 50085 50086	Character string	ASCII character string, calculated by transmitter, representing the offset of the temperature output	√	√	√

Table 18-26. Temperature offset calibration status bits

Note

If the temperature offset calibration is interrupted, status bits remain ON.

Address	Address type	Description	Bit status	MVDSolo	Series 1000	Series 2000
30421	Input register	Calibration in progress	x1xx xxxx xxxx xxxx	√	√	√
30423	Input register	Temperature offset calibration in progress	xxxx 1xxx xxxx xxxx	√	√	√
00015	Coil	• Temperature offset calibration in progress • Temperature offset calibration complete	1 0	√	√	√

Step 2 Perform the temperature slope calibration

a. Pump a process fluid through the sensor at the highest temperature measured during the application.

b. Wait approximately five minutes for the flow tube temperature to stabilize.

c. Use a highly accurate thermometer, temperature sensor, or another device to measure the temperature of the process fluid.

d. Write the line-condition temperature, *in degrees Celsius*, to register pair 20151-20152, as listed in **Table 18-27**.

e. Set coil 00016 to an ON state. The transmitter stores an ASCII character string representing the temperature slope in registers 50080-50083, as listed in **Table 18-27**.
- Coil 00016 indicates temperature slope calibration in progress (ON) or temperature slope calibration complete (OFF).
- Other addresses listed in **Table 18-28** also indicate temperature slope calibration in progress.
- The diagnostic LED is yellow and blinks.

Table 18-27. Temperature slope calibration addresses

Note

Enter the temperature of the high-temperature calibration fluid in degrees Celsius.

Address	Address type	Value	MVDSolo	Series 1000	Series 2000
20151 20152	Floating point register pair	Temperature in °C of high-temperature calibration fluid at line conditions	√	√	√
00016	Coil	0 Calibration complete 1 Calibration in progress	√	√	√
50080 50081 50082 50083	Character string	ASCII character string, calculated by transmitter, representing slope of temperature output	√	√	√

Table 18-28. Temperature slope calibration status bits

Note

If the temperature slope calibration is interrupted, status bits remain ON.

Address	Address type	Description	Bit status	MVDSolo	Series 1000	Series 2000
30421	Input register	Calibration in progress	x1xx xxxx xxxx xxxx	√	√	√
30423	Input register	Temperature slope calibration in progress	xxxx x1xx xxxx xxxx	√	√	√
00016	Coil	• Temperature slope calibration in progress • Temperature slope calibration complete	1 0	√	√	√

Step 3 Recalibrate the flowmeter

a. Perform the flow calibration procedure described in "Field flow calibration," page 165.

b. Perform the density calibration procedure described in "Density calibration," page 182.

Maintenance

19 Meter Factors

19.1 About this chapter

This chapter explains how to calculate and write meter factors.

This chapter is not a comprehensive source of information about meter factors. For more information, see *Proving Coriolis Flowmeters,* available from Micro Motion.

⚠ CAUTION

Writing meter factors can change transmitter outputs, which can result in measurement error.

Set control devices for manual operation before writing meter factors.

19.2 Default meter factors

Meter factors adjust the flowmeter measurement without modifying calibration factors. Meter factors apply primarily to proving applications, in which the flowmeter measurement is checked against a calibrated reference. The reference measurement is assumed to be correct.

Three meter factors are provided:
- Mass flow meter factor
- Volume flow meter factor
- Density meter factor

The default value for all meter factors is 1.0000. The value may be changed based on your tests. The valid range for all meter factors is 0.8–1.2.

19.3 Meter factor options

Note: This section applies only to RFT9739 transmitters. If you are using MVDSolo or a Series 1000 or 2000 transmitter, the meter factors can be set independently.

Because volume measurement is derived from mass and density measurements, as shown below, the volume measurement is automatically corrected by the mass and density meter factors.

$$Volume = \frac{Mass}{Density}$$

Accordingly, you can set mass and/or density meter factors, as required, or you can set the volume meter factor, but you cannot set all three:

- If you set a mass or density meter factor, the volume meter factor defaults to 1.0000.
- If you set the volume meter factor, both mass and density meter factors default to 1.0000.

19.4 Calculating the meter factor

The equation used to calculate the meter factor depends on whether the current meter factor is 1.000 or another value. Some applications, such as custody transfer, require that the flowmeter measurement be periodically checked (proved) against a reference. In this case, meter factors are used to validate the stability of a flowmeter's measurements over time. After meter factors have been determined and written, flowmeter measurements are corrected.

Original calculation

If the current meter factor is 1.0000, the meter factor is determined from the following calculation:

$$\textit{Meter factor} = \frac{\textit{Reference device measurement}}{\textit{Flowmeter measurement}}$$

- For a mass flow meter factor, check the flowmeter mass flow measurement against a reference.
- For a density meter factor, check the flowmeter density measurement against a reference.
- For a volume flow meter factor, check the flowmeter volume flow measurement against a reference.

Calculation after proving

If the current meter factor is not 1.0000 (a meter factor has previously been calculated), new meter factors are determined from the following equation:

$$\textit{New meter factor} = \textit{Current meter factor} \times \textit{Meter factor from proving}$$

The following example illustrates the use of meter factors in proving applications.

Example	
	The flowmeter is installed and proved. The flowmeter mass measurement is 250.27 lb, the reference device measurement is 250 lb. A mass meter factor is determined as follows: $$\textit{Mass flow meter factor} = \frac{250}{250.27} = 0.9989$$ Write a floating-point mass flow meter factor of 0.9989 to register pairs 20279-20280. One month later, the flowmeter is proved again. The flowmeter mass measurement is 250.07 lb, the reference device measurement is 250.25 lb. A new mass meter factor is determined as follows: $$\textit{New mass flow meter factor} = 0.9989 \times \frac{250.25}{250.07} = 0.9996$$ Write a floating-point mass flow meter factor of 0.9996 to register pairs 20279-20280.

19.5 Writing meter factors

The register pairs listed in **Table 19-1** store single precision IEEE 754 floating-point values from 0.8 to 1.2. Write the new meter factors to the specified register pairs.

Table 19-1. Meter factor register pairs

Register pair	Single precision IEEE 754 floating-point value from 0.8 to 1.2	MVDSolo	Series 1000	Series 2000	RFT9739
20279 20280	Mass flow meter factor	√	√	√	√
20281 20282	Volume flow meter factor	√	√	√	√
20283 20284	Density meter factor	√	√	√	√

Maintenance

20 RFT9739 Security and Administration

20.1 About this chapter

This chapter explains:

- How to save RFT9739 non-volatile data
- How to set RFT9739 security coils
- How to read Version 3 RFT9739 security event registers
- What happens during a Version 3 RFT9739 security breach

For all RFT9739 versions, security coils enable you to secure selected data for custody transfer or for other purposes.

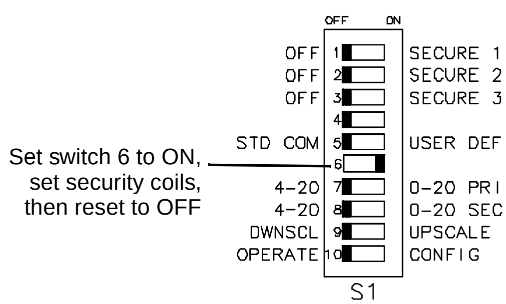
For a Version 3 RFT9739 transmitter, security event registers record the changes that are made to calibration and configuration variables.

For a Version 3 RFT9739 transmitter, a security breach occurs if an operator changes the security status after the transmitter has been configured for security mode 8 (custody transfer mode).

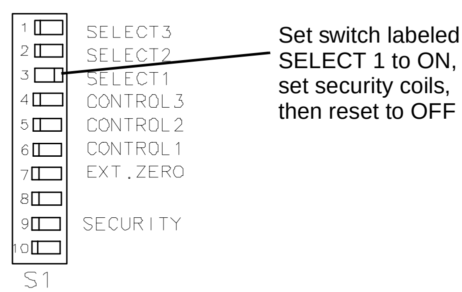
Keys to using RFT9739 security functions

- Before setting Version 2 RFT9739 security coils, set the switch labeled SELECT 1 to ON. After coils have been set, reset the SELECT 1 switch to OFF.
- Before setting Version 3 RFT9739 security coils, set switch 6 (not labeled) to ON. After coils have been set, reset switch 6 to OFF.

Version 3 transmitters



Version 2 transmitters



In some security modes, milliamp output trim, milliamp output test, and frequency output test cannot be performed. Before securing the transmitter, perform milliamp trim and/or test procedures, if necessary. See **Chapter 22** and **Chapter 23**.

20.2 Saving non-volatile data

As you perform configuration and characterization tasks, the transmitter automatically saves data every few seconds. However, at any time, you can save non-volatile data by setting coil 00018. See **Table 20-1**. Coil 00018 is a momentary coil, and will reset to 0 automatically.

Table 20-1. Coil for saving non-volatile data

Coil	Coil function	Bit status	RFT9739
00018	Coil is OFF Coil is ON, non-volatile data are being saved	0 1	√

20.3 Security coils

Security coils enable you to protect all calibration factors, selected registers, or selected coils.

Defining security for all calibration factors

Define security for all calibration factors by setting security coil 00113 or 00125. See **Table 20-2**.

- Coil 00113 prevents reading of calibration factors.
- Coil 00125 write-protects calibration factors.

You may set either or both.

Table 20-2. Calibration factor security coils

Security coil	Function	If ON, coil secures these calibration factors:		RFT9739
00113	Prevent reading	**ASCII registers**		√
00125	Write-protect	50072-50074	Flow calibration factor	√
		50075-50076	Flow temperature coefficient	
		50080-50089	Temperature calibration factor	
		Register pairs		
		20155-20156	Density for low-density calibration	
		20157-20158	Density for high-density calibration	
		20157-20158	Density calibration constant 1	
		20161-20162	Density calibration constant 2	
		20163-20164	Density temperature coefficient	
		20279-20280	Mass flow meter factor*	
		20281-20282	Volume flow meter factor*	
		20283-20284	Density meter factor*	

**Does not apply to Version 2 RFT9739 transmitter.*

Write-protecting selected registers

You can write-protect selected registers by setting security coils 00114 to 00124. See **Table 20-3**.

Table 20-3. Register and register pair security coils

Security coil	If ON, coil write-protects these registers:		RFT9739
00114	**Holding registers**		√
	40012	Primary mA output variable	
	40013	Secondary mA output variable	
	40014	Frequency output variable	
	40039	Mass flow unit	
	40040	Density unit	
	40041	Temperature unit	
	40042	Volume flow unit	
	40044	Pressure unit	
	40045	Mass total unit	
	40046	Volume total unit	
00115	**Holding registers**		√
	40018	Maximum integer	
	40019	Mass flow offset	
	40020	Density offset	
	40021	Temperature offset	
	40022	Volume flow offset	
	40024	Pressure offset	
	40025	Mass total offset	
	40026	Volume total offset	
	40027	Mass inventory offset	
	40028	Volume inventory offset	
	40029	Mass flow scale factor	
	40030	Density scale factor	
	40031	Temperature scale factor	
	40032	Volume scale factor	
	40034	Pressure scale factor	
	40035	Mass total scale factor	
	40036	Volume total scale factor	
	40037	Mass inventory scale factor	
	40038	Volume inventory scale factor	
00116	**Input registers**		√
	30120	Device type code	
	30121	Electronics module identification number	
	Holding registers		
	40048-40049	Final assembly number	
	40050-40051	Date	
	40127-40128	Sensor serial number	
	40129	Sensor flange type	
	40130	Sensor flow tube construction material	
	40131	Sensor flow tube liner material	

Table 20-3. Register and register pair security coils *continued*

Security coil	If ON, coil write-protects these registers:		RFT9739
00117	**Register pairs**		√
	20237-20238	Conversion factor for special mass unit	
	20239-20240	Conversion factor for special volume unit	
	Holding registers		
	40132	Base mass unit	
	40133	Time base for special mass unit	
	40134	Base volume unit	
	40135	Time base for special volume unit	
	ASCII registers		
	50052-50055	Special mass flow unit	
	50056-50059	Special mass total unit	
	50060-50063	Special volume flow unit	
	50064-50067	Special volume total unit	
00118	**Holding register**		√
	40015	Control output variable	
00119	**Holding register**		√
	40017	Flow direction	
00120	**Holding register**		√
	40124	Fault code	
00122	**Register pairs**		√
	20189-20190	Flow rate internal damping	
	20191-20292	Temperature internal damping	
	20193-20194	Density internal damping	
	20195-20196	Mass flow cutoff	
	20197-20198	Volume flow cutoff	
	20199-20200	Slug flow high-density limit	
	20201-20202	Slug flow low-density limit	
00123	**Register pairs**		√
	20235-20236	Flowmeter zeroing standard deviation limit	
	20141-20242	Slug duration	
	20147-20148	Fixed frequency for output test	
	20205-20206	Added damping on primary mA output	
	20207-20208	Flow cutoff for primary mA output	
	20209-20210	High limit for primary mA output variable	
	20211-20212	Low limit for primary mA output variable	
	20215-20216	Added damping on secondary mA output	
	20217-20218	Flow cutoff for secondary mA output	
	20219-20220	High limit for secondary mA output variable	
	20221-20222	Low limit for secondary mA variable	
	20223-20224	Frequency setpoint or number of pulses	
	20225-20226	Proportional flow rate or proportional total	
	20227-20228	Frequency pulse width	
	Holding register		
	40136	Maximum zeroing time	
00124	**Register pair**		√
	20257-20258	Floating point value for pressure	
	Holding register		√
	400047	Scaled integer for pressure	

Write-protecting selected coils

You can prevent reading or setting of selected coils by setting security coils 00126 to 00160. See **Table 20-4**.

Table 20-4. Coil and discrete input security coils

Security coil	If ON, coil prevents reading and setting of these ON/OFF coils:		RFT9739
	Coils		√
00126	00002	Start/stop totalizers	
00127	00003	Reset totals	
00128	00004	Reset inventories	
	Coil		√
00129	00005	Perform flowmeter zeroing	
	Coils		√
00130	00006	Trim primary mA output at 0 mA or 4 mA	
00131	00007	Trim primary mA output at 20 mA	
00132	00008	Trim secondary mA output at 0 mA or 4 mA	
00133	00009	Trim secondary mA output at 20 mA	
00134	00010	Fix current level from primary mA output	
00135	00011	Fix current level from secondary mA output	
00136	00012	Fix frequency from frequency output	
	Coils		√
00137	00013	Perform low-density calibration	
00138	00014	Perform high-density calibration	
00139	00015	Factory use only	
00140	00016	Factory use only	
	Coil		√
00142	00018	Save non-volatile data	
	Coil		√
00144	00020	Perform transmitter test	
	Discrete inputs		√
00145	10021	(E)EPROM checksum failure	
00146	10022	RAM diagnostic failure	
00147	10023	Real-time interrupt failure	
00148	10024	Sensor failure	
00149	10025	Temperature sensor failure	
00150	10026	Flowmeter zeroing failure	
00151	10027	Other failure occurred	
00152	10028	Transmitter initializing/warming up	
00153	10029	Primary variable out of limits	
00154	10030	Secondary or tertiary variable out of limits	
00155	10031	Milliamp output(s) saturated	
00156	10032	Milliamp output(s) fixed for testing or trimming	
00157	10033	Watchdog timer error	
00158	10034	Power reset occurred	
00159	10035	Transmitter configuration changed	
00160	10036	Transmitter electronics failure	

20.4 Version 3 security event registers

For custody transfer applications, security event registers enable you to determine whether the configuration or calibration of a Version 3 RFT9739 transmitter has been changed.

Configuration event register

Versions 3.0 to 3.5 RFT9739 transmitter

Regardless of the security mode, holding register 40295 counts all changes made to these parameters:

- Range values for milliamp outputs
- Variables assigned to milliamp outputs
- Variable assigned to control output
- Mass and volume flow cutoffs
- Internal damping on flow outputs
- Flow direction

Holding register 40295 also counts all attempts to perform:

- Master reset
- Milliamp output trim

Holding register 40295 counts all changes written to the addresses listed in **Table 20-5**, plus all times a master reset is performed.

Performing a master reset does not clear holding register 40295.

Table 20-5. Configuration event holding register, Versions 3.0 to 3.5

Note

Returned value equals number of times master reset has been performed, plus number of changes written to listed registers, plus number of times listed coils have been set to ON

Holding register	Address		Returned value	RFT9739
40295	**Coils**		**Number of times coils have been set to ON**	√
	00006		Trim primary mA output at 0 mA or 4 mA	
	00007		Trim primary mA output at 20 mA	
	00008		Trim secondary mA output at 0 mA or 4 mA	
	00009		Trim secondary mA output at 20 mA	
	Register pairs	+	**Number of times floating-point values have been written**	
	20209-20210		High limit for primary mA output variable	
	20211-20212		Low limit for primary mA output variable	
	20219-20220		High limit for secondary mA output variable	
	20221-20222		Low limit for secondary mA output variable	
	20189-20190		Flow rate internal damping	
	20195-20196		Mass flow cutoff for frequency output and totalizer	
	20197-20198		Volume flow cutoff for frequency output and totalizer	
	Holding registers	+	**Number of times integer codes have been written**	
	40012		Primary mA output variable	
	40013		Secondary mA output variable	
	40015		Control output variable	
	40017		Flow direction for frequency output and totalizers	
		+	**Number of times master reset has been performed**	
		=	**Returned integer value**	

Versions 3.6 and higher revision RFT9739 transmitter
If the operator enters security mode 8, then exits security mode 8 by setting SECURITY 1, SECURITY 2, and SECURITY 3 switches to OFF, a security breach occurs.

During the security breach, the value in holding register 40295 increases by 1 if the operator performs a master reset, performs a milliamp output trim, or changes the parameters that are listed in **Table 20-6**.

The security breach ends when the operator re-enters security mode 8 by resetting SECURITY 1, SECURITY 2, and SECURITY 3 switches to ON. For more information about security modes, see the instruction manual that was shipped with the transmitter.

Performing a master reset does not clear holding register 40295.

Table 20-6. Configuration event holding register, Versions 3.6 and higher

Note

During a security breach, the value in holding register 40295 increases by 1 if the operator performs a master reset or changes any of the configuration parameters that are listed below.

Holding register	Address	Configuration parameter	RFT9739
40295	**Coils**		√
	00006	Trim primary mA output at 0 mA or 4 mA	
	00007	Trim primary mA output at 20 mA	
	00008	Trim secondary mA output at 0 mA or 4 mA	
	00009	Trim secondary mA output at 20 mA	
	Register pairs		
	20209-20210	High limit for primary mA output variable	
	20211-20212	Low limit for primary mA output variable	
	20219-20220	High limit for secondary mA output variable	
	20221-20222	Low limit for secondary mA output variable	
	20189-20190	Flow rate internal damping	
	20195-20196	Mass flow cutoff for frequency output and totalizer	
	20197-20198	Volume flow cutoff for frequency output and totalizer	
	Holding registers		
	40012	Primary mA output variable	
	40013	Secondary mA output variable	
	40015	Control output variable	
	40017	Flow direction for frequency output and totalizers	

Calibration event register

Versions 3.0 to 3.5 RFT9739 transmitter

Regardless of the security mode, holding register 40296 counts all changes made to these parameters:

- Frequency output scaling factors
- Flow calibration factor
- Density calibration factors
- Pressure compensation factors
- Mass or volume flow measurement units
- Meter factors for flow and density

Holding register 40296 also counts all attempts to perform any of these functions:

- Density calibration
- Flowmeter zeroing

Holding register 40296 counts all changes written to the addresses listed in **Table 20-7**.

Performing a master reset does not clear holding register 40296.

Table 20-7. Calibration event holding register, Versions 3.0 to 3.5

Notes

Returned value equals number of changes written to listed registers, plus number of times listed coils have been set to ON.

Holding register	Address		Returned value	RFT9739
40296	**Coil**		**Number of times coils have been set to ON**	√
	00005		Perform auto zero	
	00013		Perform low-density calibration	
	00014		Perform high-density or third-point density calibration	
	Register pairs	**+**	**Number of times floating-point values have been written**	
	20155-20156		Density for low-density calibration	
	20157-20158		Density for high-density calibration	
	20159-20160		Density calibration constant 1	
	20161-20162		Density calibration constant 2	
	20163-20164		Density temperature coefficient	
	20277-20278		Density for third-point density constant	
	20223-20224		Frequency setpoint or number of pulses	
	20225-20226		Flow rate or frequency	
	20267-20268		Pressure correction factor for flow	
	20269-20270		Pressure correction factor for density	
	20271-20272		Flow calibration pressure	
	20279-20280		Mass flow meter factor	
	20281-20282		Volume flow meter factor	
	20283-20284		Density meter factor	
	Holding registers	**+**	**Number of times integer codes have been written**	
	40039		Mass flow rate unit	
	40042		Volume flow rate unit	
	ASCII registers	**+**	**Number of times character strings have been written**	
	50072-50074		Flow calibration factor	
	50075-50076		Flow temperature coefficient	
		=	**Returned integer value**	

Versions 3.6 and higher revision RFT9739 transmitter
If the operator enters security mode 8, then exits security mode 8 by setting SECURITY 1, SECURITY 2, and SECURITY 3 switches to OFF, a security breach occurs.

During the security breach, the value in holding register 40296 increases by 1 if the operator performs any of the calibration tasks or changes any of the parameters that are listed in **Table 20-8**.

The security breach ends when the operator re-enters security mode 8 by resetting SECURITY 1, SECURITY 2, and SECURITY 3 switches to ON. For more information about security modes, see the instruction manual that was shipped with the transmitter.

Performing a master reset does not clear holding register 40296.

Table 20-8. Calibration event holding register, Versions 3.6 and higher

Notes

During a security breach, the value in holding register 40296 increases by 1 if the operator performs any of the calibration procedures or changes any of the parameters that are listed below.

Holding register	Address	Calibration parameter	RFT9739
40296	**Coil**		√
	00005	Perform auto zero	
	00013	Perform low-density calibration	
	00014	Perform high-density or third-point density calibration	
	Register pairs		
	20155-20156	Density for low-density calibration	
	20157-20158	Density for high-density calibration	
	20159-20160	Density calibration constant 1	
	20161-20162	Density calibration constant 2	
	20163-20164	Density temperature coefficient	
	20277-20278	Density for third-point density constant	
	20223-20224	Frequency setpoint or number of pulses	
	20225-20226	Flow rate or frequency	
	20267-20268	Pressure correction factor for flow	
	20269-20270	Pressure correction factor for density	
	20271-20272	Flow calibration pressure	
	20279-20280	Mass flow meter factor	
	20281-20282	Volume flow meter factor	
	20283-20284	Density meter factor	
	Holding registers		
	40039	Mass flow rate unit	
	40042	Volume flow rate unit	
	ASCII registers		
	50072-50074	Flow calibration factor	
	50075-50076	Flow temperature coefficient	

Resetting security event registers

To reset configuration event register 40295 and calibration event register 40296, write a value of 0 to coil 00039. See **Table 20-9**.

Table 20-9. Security event register reset coil

Input register	Condition indicated	Bit status	RFT9739
00039	Values in security event registers have been reset	0	√

20.5 Version 3 security breach

If you temporarily enter a new security mode after entering security mode 8 (custody transfer security mode):

- In response to a query, bit #3 of input register 30126 returns a value of 1 (see **Table 20-10**).
- Internal totalizers stop counting
- The frequency output goes to 0 Hz
- 4-20 mA outputs go to 4 mA
- 0-20 mA outputs go to 0 mA
- If the transmitter has a display, the display reads, "SECURITY BREACH; SENSOR OK"

If you change the RFT9739 configuration, security event registers record changes made to configuration and calibration variables.

The security breach continues, and totalizers and outputs remain inactive, until security mode 8 is re-entered, or until a master reset has been performed. Security event registers are not affected by a master reset.

- For information about security event registers, see **Section 20.4**, page 208.
- To perform a master reset, see the instruction manual that was shipped with the transmitter.

To re-enter security mode 8, see the instruction manual that was shipped with the transmitter.

Table 20-10. Security breach input register

Input register	Condition indicated	Bit status	RFT9739
30126	User attempted to enter another security mode after configuring transmitter for security mode 8 (custody transfer mode)	xxxx xxxx xxxx 1xxx	√

Maintenance

21 Milliamp Output Trim

21.1 About this chapter

This chapter explains how to perform a milliamp trim.

Milliamp output trim adjusts the transmitter's digital-to-analog converter to match primary and secondary milliamp outputs with a specific reference standard, receiver, or readout device.

The current levels used for milliamp output trim depend on the span of the milliamp output.

- If the output produces a 4-20 mA current, trim the output at 4 mA and at 20 mA.
- If the output produces a 0-20 mA current, trim the output at 0 mA and at 20 mA.

⚠ CAUTION

Performing a milliamp output trim changes transmitter outputs, which can result in measurement error.

Set control devices for manual operation before performing a milliamp output trim.

Key to performing milliamp output trim
Milliamp output trim requires a reference device. In most situations, the host controller serves as the reference.

If the reference is connected to the output terminals, leave the output wiring intact. Otherwise, disconnect milliamp output wiring and connect a reference device such as a digital multimeter (DMM) to the appropriate output terminals, as listed in **Table 21-1**, page 214.

21.2 Wiring for output trim

Connect a reference device such as a digital multimeter (DMM) to the transmitter terminals listed in **Table 21-1**.

Table 21-1. Milliamp output terminals

Transmitter	Primary mA output terminals		Secondary mA output terminals		Series 1000	Series 2000	RFT9739
RFT9739 field-mount transmitter	17 18	PV+ PV–	19 20	SV+ SV–			√
RFT9739 rack-mount transmitter	CN2-Z30 CN2-D30	PV+ PV–	CN2-Z28 CN2-D28	SV+ SV–			√
Series 1000 or 2000 transmitter	1 2	4-20 mA + 4-20 mA –	3[1] 4[1]	4-20 mA + 4-20 mA –	√	√	

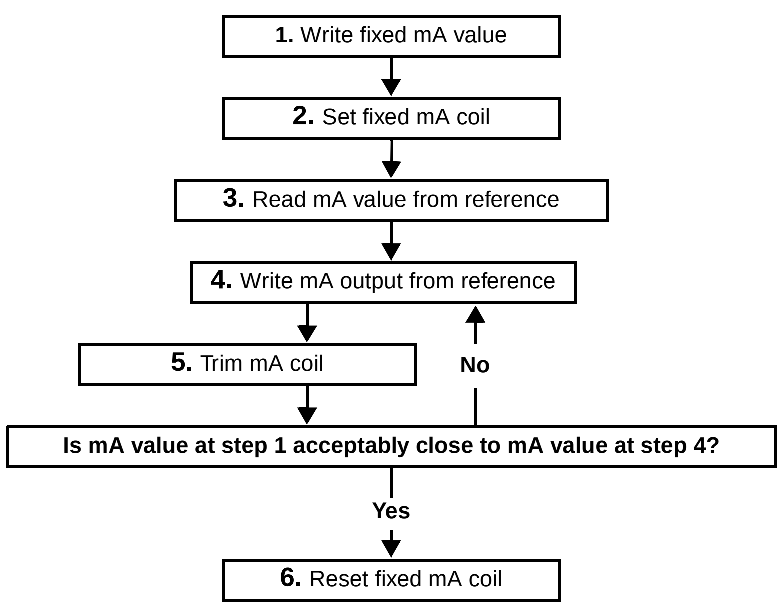
[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*

21.3 Output trim procedure

To perform a milliamp trim, follow these steps *in the described order:*

> **⚠ CAUTION**
>
> **Any deviation from the procedure described below will prevent accurate trimming of the output.**
>
> To avoid an inaccurate milliamp output trim, follow the step-by-step procedure that is described below. **Figure 21-1** is a flow diagram illustrating the correct sequence of steps.

Figure 21-1. Flow diagram: floating-point milliamp output trim



Milliamp Output Trim *continued*

1. Write the fixed mA value for the trim to the appropriate register pair listed in **Table 21-2**.
2. Set the output to produce a fixed current by setting coil 00010 or 00011 to 1, as listed in **Table 21-2**.
3. Read the milliamp output indicated by the reference device.
4. Write the milliamp output that was read at step 3 to the appropriate register pair listed in **Table 21-2**.
5. Trim the output by setting the appropriate coil (00006 through 00009) to 1. (The coil will automatically reset to 0 after the trim has been completed.)
6. Read the milliamp output from the reference device. The output level should match the original milliamp value that was written at step 1.
   - If the reference readout is acceptably close to the value that was written at step 1, reset coil 00010 or 00011 to 0.
   - If the reference readout displays an appreciably different value than the value that was written at step 1, repeat steps 4 and 5.

Table 21-3, page 216, lists addresses that indicate milliamp output trim in progress. During the milliamp output trim:

- On a field-mount RFT9739 transmitter, the diagnostic LED is red and remains ON.
- On a Series 1000 or 2000 transmitter with a display, the diagnostic LED is yellow and blinks.

Table 21-2. Milliamp output trim addresses

Note

Enter trim values in milliamps.

Address	Address type	Description	Value		Series 1000	Series 2000	RFT9739
20143 20144	Floating point register pair	Fixed current for trimming primary mA output	• At step 1, current level (0 mA, 4 mA, or 20 mA) at which output will be trimmed • At step 4, current output from reference device		√	√	√
20145 20146	Floating point register pair	Fixed current for trimming secondary mA output				√[1]	√
00010	Coil	Set primary mA output to produce fixed current written to register pair 20143-20144	0 1	Output will produce variable current Output will produce fixed current	√	√	√
00011	Coil	Set secondary mA output to produce fixed current written to register pair 20145-20146				√[1]	√
00006	Coil	Trim primary mA output at 0 mA or 4 mA	0 1	Output will produce variable current Output will produce fixed current	√	√	√
00007	Coil	Trim primary mA output at 20 mA			√	√	√
00008	Coil	Trim secondary mA output at 0 mA or 4 mA				√[1, 2]	√
00009	Coil	Trim secondary mA output at 20 mA				√[1]	√

[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*
[2] *Only the 4 mA trim value is supported.*

Table 21-3. Milliamp output trim status bits

Note

If the milliamp output trim is interrupted, status bits remain ON.

Address	Address type	Description	Bit status	Series 1000	Series 2000	RFT9739
30001	Input register	Milliamp output trim in progress	xxxx xxx1 xxxx xxxx	√	√	√
30125	Input register	Primary mA output trim in progress	xxxx xxxx xxxx x1xx	√	√	√
30125	Input register	Secondary mA output trim in progress	xxxx xxxx xxxx 1xxx			√
30420	Input register	Primary mA output trim in progress	xxxx xxxx xxxx x1xx	√	√	
30420	Input register	Secondary mA output trim in progress	xxxx xxxx xxxx 1xxx		√[1]	
20245 20246	Floating point register pair	Primary mA output trim in progress	1024	√	√	√
20245 20246	Floating point register pair	Secondary mA output trim in progress	2084		√[1]	√
10032	Coil	Milliamp output trim in progress	1	√	√	√

[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*

Maintenance

22 Output and Transmitter Testing

22.1 About this chapter

This chapter explains how to test milliamp outputs, the frequency output, the discrete output, the discrete input, and the transmitter software.

- Milliamp output testing forces the transmitter to produce a user-specified current output of 1 to 22 mA.
- Frequency output testing forces the transmitter to produce a user-specified frequency output of 0.1 to 15,000 Hz.
- Discrete output testing forces the transmitter to produce a user-specified ON or OFF signal.
- Discrete input testing verifies that the input is being correctly received by the transmitter.
- Transmitter testing verifies proper operation of the electronics and software in the transmitter and core processor.

CAUTION

Performing output and transmitter tests can change transmitter outputs, which can result in measurement error.

Set control devices for manual operation before performing an output or a transmitter test. This prevents automatic recording of process data during testing.

Key to performing output testing

Output testing requires a reference device. In most situations, the host controller serves as the reference.

If the reference device is already connected to the output terminals, leave the output wiring intact. Otherwise:

- Disconnect milliamp output wiring and connect a reference device such as a digital multimeter (DMM) to the appropriate output terminals, as listed in **Table 22-1**, page 218.
- Disconnect frequency output wiring and connect a reference device such as a pulse counter to the frequency output terminals, as listed in **Table 22-5**, page 220.

22.2 Milliamp output test

The current levels used for milliamp output test depend on the span of the milliamp output.

- You can test the Series 1000 or 2000 transmitter output at any current level from 2 to 22 mA.
- You can test an RFT9739 transmitter output at any current level from 1 to 22 mA if it is set to produce a 0-20 mA current.
- You can test an RFT9739 transmitter output at any current level from 2 to 22 mA if is set to produce a 4-20 mA current.

Wiring for milliamp test

Connect a reference device such as a digital multimeter (DMM) to the transmitter terminals listed in **Table 22-1**.

Table 22-1. Milliamp output terminals

Transmitter	Primary mA output terminals		Secondary mA output terminals		Series 1000	Series 2000	RFT9739
RFT9739 field-mount transmitter	17 18	PV+ PV–	19 20	SV+ SV–			√
RFT9739 rack-mount transmitter	CN2-Z30 CN2-D30	PV+ PV–	CN2-Z28 CN2-D28	SV+ SV–			√
Series 1000 or 2000 transmitter	1 2	4-20 mA + 4-20 mA –	3[1] 4[1]	4-20 mA + 4-20 mA –	√	√	

[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*

Milliamp output test procedure – RFT9739 transmitter

To perform a milliamp output test, follow these steps:

1. Write the fixed mA value for the test to the appropriate register pair listed in **Table 22-2**.
2. Set the output to produce a fixed current by setting coil 00010 or 00011 to 1, as listed in **Table 22-2**.
3. Read the actual mA output indicated by the reference device. The output level should match the original mA value entered at step 1. If the reference device indicates a different value than the value entered at step 1, trim the output as instructed in **Chapter 21**.
4. To unfix the output, reset coil 00010 or 00011 to 0.

Table 22-2. Milliamp output test addresses – RFT9739 transmitter

Note

Enter test values in milliamps.

Address	Address type	Description	Value		RFT9739
20143 20144	Floating point register pair	Primary mA output current level	Single precision IEEE 754 floating-point value of current level at which output will be tested		√
20145 20146	Floating point register pair	Secondary mA output current level			√
00010	Coil	Set primary mA output terminals	0 1	Output will produce variable current Output will produce fixed current, at level specified in register pair	√
00011	Coil	Set secondary mA output terminals			√

Milliamp output test procedure – Series 1000 or 2000 transmitter

To perform a milliamp output test, follow these steps:

1. Set the output to produce a fixed current level:
   a. Write the fixed mA value for the test to the appropriate register pair listed in **Table 22-3**. Any non-zero value will produce a fixed current of the specified level. A value of 0 will produce a variable current.
   b. Set the output to produce the fixed current by setting coil 00010 or 00011 to 1, as listed in **Table 22-3**.
2. Read the actual mA output indicated by the reference device. The output level should match the original mA value entered at step 1. If the reference device indicates a different value than the value entered at step 1, trim the output as instructed in **Chapter 21**.
3. To unfix the output:
   a. Write 0 to the appropriate register pair listed in **Table 22-3**.
   b. Set coil 00010 or 00011 to 1.

Table 22-3. Milliamp output test addresses – Series 1000 or 2000 transmitter

Note

Enter test values in milliamps.

Address	Address type	Description	Value	Series 1000	Series 2000
20143 20144	Floating point register pair	Primary mA output current	Single precision IEEE 754 floating-point value	√	√
20145 20146	Floating point register pair	Secondary mA output current	0 = variable current non-zero value = fixed current		√[1]
00010	Coil	Set primary mA output terminals	1	√	√
00011	Coil	Set secondary mA output terminals			√[1]

[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*

Milliamp output test indicators

Table 22-4, page 220, lists addresses that indicate milliamp output test in progress.

During the milliamp output test:

- On a field-mount RFT9739 transmitter, the diagnostic LED is red and remains ON.
- On Series 1000 or 2000 transmitters with a display, the diagnostic LED is yellow and blinks.

Table 22-4. Milliamp output test status bits

Note

If the milliamp output test is interrupted, status bits remain ON.

Address	Address type	Description	Bit status	Series 1000	Series 2000	RFT9739
30001	Input register	Milliamp output test in progress	xxxx xx1x xxxx xxxx	√	√	√
30125	Input register	Primary mA output test in progress	xxxx xxxx xxxx x1xx	√	√	√
30125	Input register	Secondary mA output test in progress	xxxx xxxx xxxx 1xxx		√[1]	√
30420	Input register	Primary mA output test in progress	xxxx xxxx xxxx x1xx	√	√	
30420	Input register	Secondary mA output test in progress	xxxx xxxx xxxx 1xxx		√[1]	
20245 20246	Floating point register pair	Primary mA output test in progress	1024	√	√	√
20245 20246	Floating point register pair	Secondary mA output test in progress	2084		√[1]	√
10032	Coil	Milliamp output test in progress	1	√	√	√

[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*

22.3 Frequency output test

Modbus protocol enables you to test the frequency output at any level from 0.1 Hz to 15 kHz. Frequency output testing requires a frequency counter.

Wiring for frequency output test

To test the output, connect the frequency counter to the transmitter frequency output terminals listed in **Table 22-5**.

Table 22-5. Frequency output terminals

Transmitter	Frequency output terminals		Series 1000	Series 2000	RFT9739
RFT9739 field-mount transmitter	15 16	Freq + Return			√
RFT9739 rack-mount transmitter	CN2-D24 CN2-D26	Freq Return			√
Series 1000 or 2000 transmitter	3 4	+ –	√	√	
	5 6	+ –		√[1]	

[1] *Transmitters with configurable input/output boards only.*

Frequency output test procedure

Register pair 20147-20148 holds a floating-point value that represents the frequency output level. 0.0 specifies a variable output level; any other value specifies a fixed output level at the specified value. After the output level has been changed (by writing a new value to the register pair), it must be enabled by writing a 1 (ON) to coil 00012. Output level is immediately altered, and the coil value automatically resets to 0 (OFF).

To perform a frequency output test, follow these steps:

1. Write any fixed frequency value from 0.1 to 15,000.0 Hz to register pair 20147-20148.

2. Set the output to produce the fixed frequency by setting coil 00012 to 1.
3. Read the frequency output indicated by the reference frequency counter. The output level should match the original frequency that was written at Step 1.
4. After the test is complete, frequency output level must be reset to variable. To do this, write 0.0 to register pair 20147-20148 and write a 1 to coil 00012

Table 22-6 lists the addresses that are used during a frequency output test.

During the frequency output test:

- For a Series 1000 or 2000 transmitter, bit #2 in input register 30423 is set, as listed in **Table 22-7**.
- On a field-mount RFT9739 transmitter, the diagnostic LED is red and remains ON.
- On a Series 1000 or 2000 transmitter with a display, the diagnostic LED is yellow and blinks.

Table 22-6. Frequency output test addresses

Note

Enter test values in Hz.

Address	Address type	Description	Value		Series 1000	Series 2000	RFT9739
20147 20148	Floating point register pair	Fixed frequency for testing frequency output	• During test, single precision IEEE 754 floating-point value of 0.1 to 15,000.0 • After test, a value of 0.0 (enable variable output by setting coil 00012)		√	√	√
00012	Coil	Set frequency output terminals to produce fixed frequency written to register pair 20147-20148	1	Coil is set to enable frequency/output test	√	√	√

Table 22-7. Frequency output test status bit

Note

If the frequency output test is interrupted, status bit remains ON.

Address	Address type	Description	Bit status	Series 1000	Series 2000	RFT9739
30423	Input register	Frequency output test in progress	xxxx xxxx xxxx x1xx	√	√	

22.4 Discrete output test

Modbus protocol enables you to test the discrete output(s), available with some transmitters and option boards.

Note: The Series 2000 transmitter with the configurable input/output board can be configured for a discrete output on channel B, channel C, or both. Other Series 2000 transmitters can be configured for a single discrete output. See ***Chapter 6****.*

To test the discrete output:

1. Connect it to a remote indicator, such as an LED, that turns ON or OFF according to the state of the variable mapped to the discrete output.

2. Configure the discrete output to be a fixed value of either OFF or ON, as listed in **Table 22-8**:
   a. For transmitters with a single discrete output, or for the discrete output configured on channel B, write a 0 or a 1 to holding register 41182.
   b. For the discrete output configured on channel C, write a 0 or 1 to holding register 41183.

Table 22-8. Discrete output state code holding registers

Holding register	Discrete output	Integer value	Description	Series 2000
41182	Single DO Channel B[1]	0 1 255	OFF ON Unfixed	√
41183	Channel C[1]			

[1] *Transmitters with configurable input/output boards only.*

3. Enable the OFF/ON configuration, as listed in **Table 22-9**:
   a. For transmitters with a single discrete output, or for the discrete output configured on channel B, set coil 00046.
   b. For the discrete output configured on channel C, set coil 00047.

Table 22-9. Discrete output forcing coils

Coil	Discrete output	Code	Description	Series 2000
00046	Single DO Channel B[1]	1	Force discrete output as specified in holding register 41182 or 41183	√
00047	Channel C[1]			

[1] *Transmitters with configurable input/output boards only.*

4. Read the indicator connected to the discrete output. The indicator should match the fixed state configured for the discrete output. For example, a warning light should be off or on.

   You can also read bit 4 (transmitters with a single discrete output, or discrete output on channel B), or bit 5 (discrete output on channel C) of input register 30423. See **Table 22-10**.

Table 22-10. Discrete output state code input registers

Input register	Discrete output	Bit	Code	Description	Series 2000
30423	Single DO Channel B[1]	4	0 1	OFF ON	√
	Channel C[1]	5			

[1] *Transmitters with configurable input/output boards only.*

5. Unfix the discrete output, by writing integer code 255 to holding register 41182 or 41183, and setting coil 00046 or 00047.

22.5 Discrete input test

If you have a transmitter with a configurable input/output board, and channel C is configured as a discrete input, you can test the connection between the external input device and the transmitter.

To do this:
1. Set the external input device to OFF.
2. Read bit 0 of input register 30424, as listed in **Table 22-11**. Bit 0 should contain a value of 0.
3. Set the external input device to ON.
4. Read bit 0 of input register 30424. It should now contain a value of 1.

Table 22-11. Series 2000 discrete input state codes

Input register	Bit	Code	Description	Series 2000
30424	0	0 1	OFF ON	√[1]

[1] *Transmitters with configurable input/output boards only.*

22.6 Transmitter test

Modbus protocol enables you to perform a transmitter test to verify proper operation of the transmitter.

To test the transmitter, follow these steps:
1. Set coil 00020 to 1, as listed in **Table 22-12**, page 224. During the transmitter test:
   - Coil 00020 indicates transmitter test in progress.
   - On a field-mount RFT9739 transmitter, the diagnostic LED is red and remains ON.
2. Read the appropriate discrete inputs and registers:
   - For an RFT9739 transmitter, see **Table 22-13**, page 224.
   - For MVDSolo or a Series 1000 or 2000 transmitter, see **Table 22-14**, page 225.
3. If the bits returned from the query indicate any of the listed failures, phone the Micro Motion Customer Service Department:

- In the U.S.A., phone 1-800-522-6277, 24 hours.
- In the Americas outside the U.S.A., phone 303-530-8400, 24 hours.
- In Europe, phone +31 (0) 318 549 443.
- In Asia, phone (65) 770-8155.

4. After the test is complete, reset coil 00020 to 0.

Table 22-12. Transmitter test coil

Coil	Description	Bit status	MVDSolo	Series 1000	Series 2000	RFT9739
00020	• Normal operation • Transmitter test in progress	0 1	√	√	√	√

Table 22-13. RFT9739 failure status bits

Notes

- If the transmitter test is interrupted, status bits remain ON.
- If any of the status bits listed below is ON, the transmitter produces fault outputs as described in **Chapter 11**.
- If diagnostic codes indicate a failure that is listed below, phone the Micro Motion Customer Service Department.

Address	Address type	Type of failure	Bit status	RFT9739
30001	Input register	(E)EPROM checksum failure	xxxx xxxx xxxx xxx1	√
20245 20246	Floating point register pair		1	√
10021	Discrete input		ON	√
30125	Input register		xxxx xxx1 xxxx xxxx	√
20245 20246	Floating point register pair	RAM diagnostic failure	2	√
10022	Discrete input		ON	√
30125	Input register		xxxx xx1x xxxx xxxx	√
30001	Input register	Real-time interrupt failure	xxxx xxxx 1xxx xxxx	√
30125	Input register		1xxx xxxx xxxx xxxx	√
20245 20246	Floating point register pair		128	√
10023	Discrete input		ON	√
30001	Input register	Transmitter electronics failure	xxx1 xxxx xxxx xxxx	√
30126	Input register		xxx1 xxxx xxxx xxxx	√
20245 20246	Floating point register pair		65536	√
10036	Discrete input		ON	√
10033	Discrete input	Watchdog timer error	ON	√
10027	Discrete input	Other failure occurred	ON	√

Table 22-14. MVDSolo or Series 1000 or 2000 failure status bits

Notes

- If the transmitter test is interrupted, status bits remain ON.
- If diagnostic codes indicate a failure that is listed below, phone the Micro Motion Customer Service Department.

Address	Address type	Type of failure	Bit status	MVDSolo	Series 1000	Series 2000
30001	Input register	(E)EPROM checksum failure	xxxx xxxx xxxx xxx1	√	√	√
20245 20246	Floating point register pair		1	√	√	√
10021	Discrete input		ON	√	√	√
30125	Input register	(E)EPROM checksum failure in core processor	xxxx xxx1 xxxx xxxx	√	√	√
30419	Input register		xxxx xxxx xxxx xxx1	√	√	√
30420	Input register		xxxx xxx1 xxxx xxxx	√	√	√
30422	Input register	(E)EPROM checksum failure in Series 1000 or 2000 transmitter	xxxx x1xx xxxx xxxx	√	√	√
30422	Input register	(E)EPROM database corrupt	xx1x xxxx xxxx xxxx	√	√	√
30422	Input register	(E)EPROM powerdown totals corrupt	x1xx xxxx xxxx xxxx	√	√	√
30422	Input register	(E)EPROM program corrupt	1xxx xxxx xxxx xxxx	√	√	√
20245 20246	Floating point register pair	RAM diagnostic failure	2	√	√	√
10022	Discrete input		ON	√	√	√
30125	Input register	RAM diagnostic failure in core processor	xxxx xx1x xxxx xxxx	√	√	√
30419	Input register		xxxx xxxx xxxx xx1x	√	√	√
30420	Input register		xxxx xx1x xxxx xxxx	√	√	√
30422	Input register	RAM diagnostic failure in Series 1000 or 2000 transmitter	xxxx 1xxx xxxx xxxx		√	√
30001	Input register	Real-time interrupt failure	xxxx xxxx 1xxx xxxx	√	√	√
30125	Input register		1xxx xxxx xxxx xxxx	√	√	√
30419	Input register		xxxx xxxx xxxx x1xx	√	√	√
30420	Input register		1xxx xxxx xxxx xxxx	√	√	√
20245 20246	Floating point register pair		128	√	√	√
10023	Discrete input		ON	√	√	√
30001	Input register	Transmitter electronics failure	xxx1 xxxx xxxx xxxx	√	√	√
30126	Input register		xxx1 xxxx xxxx xxxx	√	√	√
30421	Input register		xxx1 xxxx xxxx xxxx	√	√	√
20245 20246	Floating point register pair		65536	√	√	√
10036	Discrete input		ON	√	√	√
10033	Discrete input	Watchdog timer error	ON	√	√	√
30419	Input register	Other failure occurred	xxxx xxxx x1xx xxxx	√	√	√
10027	Discrete input		ON	√	√	√
30423	Input register	Boot sector fault	xxxx xxxx xxxx xxx1	√	√	√
30423	Input register	Software upgrade needed	xxxx xxxx xxxx xx1x	√	√	√

Maintenance

23 Troubleshooting

23.1 About this chapter

This chapter explains how to use diagnostic codes to troubleshoot the flowmeter and the fluid process.

In response to a query, the transmitter can return floating-point, integer, and binary codes that are useful for fault detection, diagnostics, and troubleshooting.

Use diagnostic codes, transmitter fault output levels, and a digital multimeter (DMM) to troubleshoot the flowmeter.

CAUTION

During troubleshooting, the transmitter could produce inaccurate flow signals.

Set control devices for manual operation before troubleshooting the flowmeter. This prevents automatic recording of process data while troubleshooting.

Key to using diagnostic codes
For help using diagnostic codes, refer to **Table 23-1** through **Table 23-3**, pages 228-234. The cited tables list diagnostic codes by address type and list the pages where troubleshooting procedures for each code are described.

23.2 Reading diagnostic codes

You can read diagnostic codes as floating-point values or as binary ON/OFF status bits. The tables throughout this chapter explain the meanings of diagnostic codes when one condition exists. However, diagnostic codes can also indicate multiple conditions.

Reading discrete inputs and input registers

If you read diagnostic codes from any of the mapped addresses listed in **Table 23-1** or **Table 23-2**, each ON bit represents a specific condition. If more than one condition exists, the number and placement of the ON bits indicate the existing conditions.

Example	Determine the multiple conditions that are indicated when input register 30001 returns 1000 0000 0000 0010. In input register 30001, bit #1 indicates the transmitter configuration was changed, and bit #15 indicates a power reset occurred. Since bit #1 and bit #15 are ON, the status bits returned from input register 30001 indicate a power reset occurred and the transmitter configuration was changed.

Table 23-1. Diagnostic discrete inputs

Discrete input	Description	MVDSolo	Series 1000	Series 2000	RFT9739
10021	(E)EPROM checksum error	√	√	√	√
10022	RAM diagnostic error	√	√	√	√
10023	Real-time interrupt failure	√	√	√	√
10024	Sensor failure	√	√	√	√
10025	Temperature sensor failure	√	√	√	√
10026	Flowmeter zeroing failure	√	√	√	√
10027	Other failure occurred	√	√	√	√
10028	Transmitter initializing/warming up	√	√	√	√
10029	Primary variable out of range	√	√	√	√
10030	Non-primary variable out of range	√	√	√	√
10031	Milliamp output(s) saturated		√	√	√
10032	Milliamp output(s) fixed		√	√	√
10033	Watchdog timer error	√	√	√	√
10034	Power reset occurred	√	√	√	√
10035	Transmitter configuration changed	√	√	√	√
10036	Transmitter electronics failure	√	√	√	√
10037	Event 1 status (ON/OFF)	√	√	√	√
10038	Event 2 status (ON/OFF)	√	√	√	√

Table 23-2. Diagnostic input registers

Input register	Description		MVDSolo	Series 1000	Series 2000	RFT9739
30001	Bit #0	(E)EPROM checksum error	√	√	√	√
	Bit #1	Transmitter configuration changed	√	√	√	√
	Bit #2	Sensor failure	√	√	√	√
	Bit #3	Temperature sensor failure	√	√	√	√
	Bit #4	Input overrange	√	√	√	√
	Bit #5	Frequency output saturated		√	√	√
	Bit #6	Transmitter not configured	√	√	√	√
	Bit #7	Real-time interrupt failure	√	√	√	√
	Bit #8	Milliamp output(s) saturated		√	√	√
	Bit #9	Milliamp output(s) fixed		√	√	√
	Bit #10	Density overrange	√	√	√	√
	Bit #11	Flowmeter zeroing failure	√	√	√	√
	Bit #12	Transmitter electronics failure	√	√	√	√
	Bit #13	Slug flow	√	√	√	√
	Bit #14	Transmitter initializing/warming up	√	√	√	√
	Bit #15	Power reset occurred	√	√	√	√
30125	Bit #0	Primary mA output saturated		√	√	√
	Bit #1	Secondary mA output saturated			√[1]	√
	Bit #2	Primary mA output fixed		√	√	√
	Bit #3	Secondary mA output fixed			√[1]	√
	Bit #4	Density overrange	√	√	√	√
	Bit #5	Drive gain overrange	√	√	√	√
	Bit #6	Not used				
	Bit #7	Milliamp input error				√
	Bit #8	(E)EPROM checksum error, core processor or RFT9739	√	√	√	√
	Bit #9	RAM diagnostic error, core processor or RFT9739	√	√	√	√
	Bit #10	Sensor failure	√	√	√	√
	Bit #11	Temperature sensor failure	√	√	√	√
	Bit #12	Input overrange	√	√	√	√
	Bit #13	Frequency output saturated		√	√	√
	Bit #14	Transmitter not configured	√	√	√	√
	Bit #15	Real-time interrupt failure	√	√	√	√

Table 23-2. Diagnostic input registers *continued*

Input register	Description		MVDSolo	Series 1000	Series 2000	RFT9739
30126	Bit #0	Burst mode enabled	√	√	√	√
	Bit #1	Power reset occurred	√	√	√	√
	Bit #2	Transmitter initializing/warming up	√	√	√	√
	Bit #3	Security breach				√
	Bit #4	Display readback error				√
	Bit #5	Event 2 ON	√	√	√	√
	Bit #6	Event 1 ON	√	√	√	√
	Bit #7	Not used				
	Bit #8	Flowmeter zeroing failure	√	√	√	√
	Bit #9	Zero value too low	√	√	√	√
	Bit #10	Zero value too high	√	√	√	√
	Bit #11	Zero too noisy	√	√	√	√
	Bit #12	Transmitter electronics failure	√	√	√	√
	Bit #13	Data loss possible				√
	Bit #14	Calibration in progress	√	√	√	√
	Bit #15	Slug flow	√	√	√	√
30419	Bit #0	(E)EPROM checksum error, core processor	√	√	√	
	Bit #1	RAM test error, core processor	√	√	√	
	Bit #2	Real-time interrupt failure	√	√	√	
	Bit #3	Sensor not vibrating	√	√	√	
	Bit #4	Temperature sensor out of range	√	√	√	
	Bit #5	Calibration failure	√	√	√	
	Bit #6	Other failure occurred	√	√	√	
	Bit #7	Transmitter initializing/warming up	√	√	√	
	Bit #8	Not used				
	Bit #9	Not used				
	Bit #10	Not used				
	Bit #11	Not used				
	Bit #12	Not used				
	Bit #13	Not used				
	Bit #14	Not used				
	Bit #15	Transmitter fault	√	√	√	

Table 23-2. Diagnostic input registers *continued*

Input register	Description		MVDSolo	Series 1000	Series 2000	RFT9739
30420	Bit #0	Primary mA output saturated		√	√	
	Bit #1	Secondary mA output saturated			√[1]	
	Bit #2	Primary mA output fixed		√	√	
	Bit #3	Secondary mA output fixed			√[1]	
	Bit #4	Density overrange	√	√	√	
	Bit #5	Drive overrange	√	√	√	
	Bit #6	Not used				
	Bit #7	External input failure		√	√	
	Bit #8	(E)EPROM checksum failure, core processor	√	√	√	
	Bit #9	RAM diagnostic failure, core processor	√	√	√	
	Bit #10	Sensor not vibrating	√	√	√	
	Bit #11	Temperature sensor failure	√	√	√	
	Bit #12	Input overrange	√	√	√	
	Bit #13	Frequency output saturated		√	√	
	Bit #14	Transmitter not configured	√	√	√	
	Bit #15	Real-time interrupt failure	√	√	√	
30421	Bit #0	Burst mode enabled	√	√	√	
	Bit #1	Power reset occurred	√	√	√	
	Bit #2	Transmitter initializing/warming up	√	√	√	
	Bit #3	Not used				
	Bit #4	Not used				
	Bit #5	Event 2 ON	√	√	√	
	Bit #6	Event 1 ON	√	√	√	
	Bit #7	Sensor/transmitter communication failure	√	√	√	
	Bit #8	Calibration failure	√	√	√	
	Bit #9	Zero value too low	√	√	√	
	Bit #10	Zero value too high	√	√	√	
	Bit #11	Zero too noisy	√	√	√	
	Bit #12	Transmitter electronics failure	√	√	√	
	Bit #13	Data loss possible	√	√	√	
	Bit #14	Calibration in progress	√	√	√	
	Bit #15	Slug flow	√	√	√	

Table 23-2. Diagnostic input registers *continued*

Input register	Description		MVDSolo	Series 1000	Series 2000	RFT9739
30422	Bit #0	API: Temperature outside standard range	√		√	
	Bit #1	API: Line density outside standard range	√		√	
	Bit #2	Line temperature sensor out of range	√	√	√	
	Bit #3	Meter temperature sensor out of range	√	√	√	
	Bit #4	Flow direction (1 = reverse, 0 = forward or zero flow)	√	√	√	
	Bit #5	Not used				
	Bit #6	Not used				
	Bit #7	Not used				
	Bit #8	Not used				
	Bit #9	Transmitter not configured	√	√	√	
	Bit #10	(E)EPROM checksum error		√	√	
	Bit #11	RAM test error		√	√	
	Bit #12	Invalid/unrecognized sensor type	√	√	√	
	Bit #13	(E)EPROM database corrupt, core processor	√	√	√	
	Bit #14	(E)EPROM powerdown totals corrupt, core processor	√	√	√	
	Bit #15	(E)EPROM program corrupt, core processor	√	√	√	
30423	Bit #0	Boot sector fault, core processor	√	√	√	
	Bit #1	Software upgrade needed, core processor		√	√	
	Bit #2	Frequency output fixed		√	√	
	Bit #3	Not used				
	Bit #4	Discrete output #1 status			√[1]	
	Bit #5	Discrete output #2 status			√[2]	
	Bit #6	T-Series D3 calibration in progress	√	√	√	
	Bit #7	T-Series D4 calibration in progress	√	√	√	
	Bit #8	Not used				
	Bit #9	Not used				
	Bit #10	Temperature slope calibration in progress	√	√	√	
	Bit #11	Temperature offset calibration in progress	√	√	√	
	Bit #12	Flowing density calibration in progress	√	√	√	
	Bit #13	High-density calibration in progress	√	√	√	
	Bit #14	Low-density calibration in progress	√	√	√	
	Bit #15	Flowmeter zeroing in progress	√	√	√	

Table 23-2. Diagnostic input registers *continued*

Input register	Description		MVDSolo	Series 1000	Series 2000	RFT9739
30424	Bit #0	Discrete input 1 status (0=OFF, 1=ON)			√[2]	
	Bit #1	Not used				
	Bit #2	Discrete output 1 fixed			√[1]	
	Bit #3	Discrete output 2 fixed			√[2]	
	Bit #4	Not used				
	Bit #5	Not used				
	Bit #6	Security breach				
	Bit #7	Not used				
	Bit #8	Not used				
	Bit #9	Not used				
	Bit #10	Not used				
	Bit #11	Not used				
	Bit #12	Not used				
	Bit #13	Not used				
	Bit #14	Not used				
	Bit #15	Not used				

[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*
[2] *Transmitters with configurable input/output boards only.*

Reading register pairs

If you read diagnostic codes from the register pairs that are listed in **Table 23-3**, page 234, the returned value is in single precision IEEE 754 floating-point format. If multiple conditions exist, the returned value equals the sum of all the values indicating individual conditions.

Multiple conditions exist whenever register pair 20245-20246 returns a value other than a value listed in **Table 23-3**. If multiple conditions exist, the returned value equals the sum of several values that are listed in **Table 23-3**. To determine the conditions indicated by a returned value, follow these steps:

1. Find the highest listed value below the value returned from the query.
2. Divide the returned value by the listed value. The returned value divided by the listed value should equal 1, plus a remainder.
   a. Compare the remainder to the values listed in **Table 23-3**.
   b. Divide the remainder by the highest listed value that is equal to or less than the remainder.
3. The remainder divided by the listed value should equal 1, and might leave a remainder. If the division leaves a remainder, again refer to **Table 23-3**, then divide the remainder by the highest listed value that is equal to or less than the remainder.

4. Continue dividing until the remainder is 0. Each division indicates an existing condition, as demonstrated in the following example.

Example

Determine the multiple conditions that are indicated when register pair 20245-20246 returns a floating-point value of 1572864.

		Quotient		Remainder
1572864 ÷ 1048576	=	1	+	524288
524288 ÷ 524288	=	1	+	0

The returned value of 1572865 = 1048576 + 524288, and indicates the following conditions:

- Power reset occurred, as represented by the value 524288
- Transmitter configuration was changed, as represented by the value 1048576

Table 23-3. Diagnostic register pairs

Register pair	Description		MVDSolo	Series 1000	Series 2000	RFT9739
20245 20246	1	(E)EPROM checksum error	√	√	√	√
	2	RAM diagnostic error	√	√	√	√
	4	Sensor failure	√	√	√	√
	8	Temperature sensor failure	√	√	√	√
	16	Input overrange	√	√	√	√
	32	Frequency output saturated		√	√	√
	64	Transmitter not configured	√	√	√	√
	128	Real-time interrupt failure	√	√	√	√
	256	Primary mA output saturated		√	√	√
	512	Secondary mA output saturated			√[1]	√
	1024	Primary mA output fixed		√	√	√
	2048	Secondary mA output fixed			√[1]	√
	4096	Density overrange	√	√	√	√
	8192	Flowmeter zeroing failure	√	√	√	√
	16384	Zero value too low	√	√	√	√
	32768	Zero value too high	√	√	√	√
	65536	Transmitter electronics failure	√	√	√	√
	131072	Flowmeter zeroing in progress	√	√	√	√
	262144	Slug flow	√	√	√	√
	524288	Power reset occurred	√	√	√	√
	1048576	Transmitter configuration changed	√	√	√	√
	2097152	Transmitter initializing/warming up	√	√	√	√
20285 20286	Raw tube frequency (Hertz)		√	√	√	√[2]
20287 20288	Left pickoff voltage (volts)		√	√	√	√[2]
20289 20290	Right pickoff voltage (volts)		√	√	√	√[2]
20291 20292	Drive gain (& for MVDSolo, Series 1000 or 2000, volts for RFT9739)		√	√	√	√[2]

Table 23-3. Diagnostic register pairs *continued*

20293 20294	Mass flow live zero flow	√	√	√	√[2]
20435 20436	Maximum recorded temperature at sensor	√	√	√	√
20437 20438	Minimum recorded temperature at sensor	√	√	√	√
20439 20440	Average recorded temperature at sensor	√	√	√	√
20463 20464	Maximum recorded temperature at transmitter	√	√	√	√
20465 20466	Minimum recorded temperature at transmitter	√	√	√	√
20467 20468	Average recorded temperature at transmitter	√	√	√	√

[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*
[2] *Version 3 RFT9739 transmitter only.*

23.3 Transmitter diagnostic tools and reference

The transmitter runs continuous self-diagnostics. If self-diagnostics detect a failure, diagnostic codes can indicate the failure. Self-diagnostics allow the transmitter to check its own circuitry.

MVDSolo and Series 1000 and 2000 diagnostic tools

- Both the core processor and the Series 1000 or 2000 transmitter with an optional display have a diagnostic LED that indicates various operating conditions.
- Register pairs 20285-20286 to 20291-20292 (see **Table 23-3**) indicate test point values for the sensor flow tube frequency, velocity signals from the sensor pickoffs, and sensor drive gain.

Version 2 RFT9739 diagnostic tools

- The field-mount RFT9739 transmitter has a diagnostic LED that indicates various operating conditions.
- Test points enable you to use a reference device such as a DMM to troubleshoot problems with the sensor or with cable connections between the sensor and the transmitter.

Version 3 RFT9739 diagnostic tools

- The field-mount RFT9739 transmitter has a diagnostic LED that indicates various operating conditions.
- Register pairs 20285-20286 to 20291-20292 (see **Table 23-3**) indicate test point values for the sensor flow tube frequency, velocity signals from the sensor pickoffs, and sensor drive gain.

Diagnostic LED

If the transmitter has a diagnostic LED, it indicates various operating conditions. **Table 23-3**, page 234, explains the operating conditions indicated by the diagnostic LED.

Test points

Test points for Version 2 field-mount RFT9739 transmitter

The Version 2 rack-mount RFT9739 transmitter does not have hardware or software test points.

Test points for a Version 2 field-mount RFT9739 transmitter are located on the electronics module inside the transmitter housing. The test points are labeled TP1, TP2, and TP3. To read test point values for a Version 2

Table 23-4. Operating conditions indicated by LED

Diagnostic LED status: Series 1000 or 2000 transmitter with display	Diagnostic LED status: MVDSolo Field-mount RFT9739 transmitter	Indicated condition
Is green and remains ON	Is red and blinks ON once per second (75% OFF, 25% ON)	Normal operation
Is yellow and blinks	Is red and remains ON	• Startup and initialization • Flowmeter zeroing in progress • Density calibration in progress • Temperature calibration in progress • Milliamp output trim in progress • Output or transmitter test in progress
Is yellow and blinks	Is red and blinks OFF once per second (75% ON, 25% OFF)	Slug flow
Is red and blinks	Is red and blinks ON 4 times per second	Fault condition
Is yellow or red and remains ON		An alarm message has been acknowledged, but alarm condition has not been cleared
Is green and blinks		An alarm condition has occurred and been cleared, but alarm message has not been acknowledged

field-mount RFT9739 transmitter, use a digital multimeter (DMM) and refer to the RFT9739 transmitter manual.

Test points for other transmitters

You can read test point values for MVDSolo or a Series 1000, Series 2000, or Version 3 RFT9739 transmitter from the register pairs that are listed in **Table 23-5**.

Table 23-5. Test point register pairs

Register pair	Returned single precision IEEE 754 floating-point value	MVDSolo	Series 1000	Series 2000	Version 3 RFT9739*
20285 20286	Frequency of sensor flow tubes in Hz	√	√	√	√
20287 20288	• Velocity signal from left pickoff in V • Voltage value should be within 10% of the value returned from register pair 20289-20290 • Value should be equal to the appropriate value from **Table 23-7**, based on frequency value returned from register pair 20285-20286	√	√	√	√
20289 20290	• Velocity signal from right pickoff in V • Voltage value should be within 10% of the value returned from register pair 20289-20290 • Value should be equal to the appropriate value from **Table 23-7**, based on frequency value returned from register pair 20285-20286	√	√	√	√
20291 20292	• Signal from sensor drive coil in mA • For Series 1000 or 2000 transmitter, value should be stable, from 0-100%	√	√	√	
20291 20292	• Signal from sensor drive coil in V • For RFT9739 transmitter, value should be stable				√

**Does not apply to Version 2 RFT9739 transmitters.*

9-wire cable reference

For installations that include 9-wire cable, each wire is color-coded and must be attached to the correct terminal, as listed in **Table 23-6**.

Table 23-6. 9-wire cable terminal and wire designations

	Transmitter terminal			
Sensor terminal	**Field-mount RFT9739 Model 1000/2000**	**Rack-mount RFT9739**	**Wire color**	**Function**
No connection	0	CN1-Z4	Black	Shields
1	1	CN1-Z2	Brown	Drive +
2	2	CN1-B2	Red	Drive –
3	3	CN1-B6	Orange	Temperature –
4	4	CN1-B4	Yellow	Temperature lead length compensator
5	5	CN1-Z8	Green	Left pickoff +
6	6	CN1-Z10	Blue	Right pickoff +
7	7	CN-Z6	Violet	Temperature +
8	8	CN1-B10	Gray	Right pickoff –
9	9	CN1-B8	White	Left pickoff –

Sensor pickoff values reference

Table 23-7 lists the pickoff values for the different sensors that may be used.

Table 23-7. Sensor pickoff values

Sensor model	Pickoff value
ELITE® Model CMF sensors	3.4 mV per Hz based on sensor flow tube frequency
Model D, DL, and DT sensors	3.4 mV per Hz based on sensor flow tube frequency
Micro Motion® F-Series sensors	3.4 mV per Hz based on sensor flow tube frequency
Model R025, R050, or R100 sensor	3.4 mV per Hz based on sensor flow tube frequency
Model R200 sensor	2.7 mV per Hz based on sensor flow tube frequency
Micro Motion T-Series sensors	0.5 mV per Hz based on sensor flow tube frequency

Nominal resistance values reference

Table 23-8, page 238, lists nominal resistance values for flowmeter circuits.

Excessive drive gain procedures

Table 23-9, page 238, describes the procedures that can be used to correct excessive drive gain.

Faulty 9-wire sensor cabling procedures

Table 23-10, page 239, describes the conditions that indicate faulty 9-wire sensor cabling, and the procedures that can be used to correct the problem.

Table 23-8. Nominal resistance values for flowmeter circuits

- If you are using a D600 or CMF400 sensor, check the sensor documentation for the wire colors and resistance values for your sensor.
- Resistance values increase 0.38675 ohms per °C increase in temperature
- Nominal resistance values will vary 40% per 100°C. However, confirming an open coil or shorted coil is more important than any slight deviation from the resistance values presented below
- Resistance across blue and gray wires (right pickoff circuit) should be within 10% of resistance across green and white wires (left pickoff circuit)
- Actual resistance values depend on the sensor model and date of manufacture
- Readings across wire pairs should be stable. If they are unstable, see **Table 23-9.**

Circuit	Wire colors	Sensor junction box wiring terminals	Nominal resistance range
Drive coil	Brown to red	1 to 2	8 to 2650 Ω
Left pickoff	Green to white	5 to 9	15.9 to 1000 Ω
Right pickoff	Blue to gray	6 to 8	15.9 to 1000 Ω
Temperature sensor RTD	Yellow to violet	4 to 7	100 Ω at 0°C + 0.38675 Ω per °C
Lead length compensator[1]	Yellow to orange	4 to 3	100 Ω at 0°C + 0.38675 Ω per °C
Composite temperature[2]	Yellow to orange	4 to 3	300 Ω at 0°C + 1.16025 Ω per °C

[1] *All currently manufactured sensors except Micro Motion T-Series sensors.*
[2] *Micro Motion T-Series sensors only.*

Table 23-9. Troubleshooting excessive drive gain

Symptom		
Drive gain is unstable	Erratic process density (slug flow) has caused flow tubes to vibrate erratically or stop vibrating	• Monitor density • Change sensor orientation
	Plugged flow tube	Purge flow tubes
	Cavitation or flashing of process fluid	• If possible, increase inlet pressure and/or back pressure • If pump is mounted upstream from sensor, increase distance between pump and sensor
	• Drive board failure • Sensor imbalance • Sensor failure	Phone Micro Motion Customer Service (see page 247 or the back cover for phone numbers)

Table 23-10. Troubleshooting 9-wire cabling

- If you are using a D600 or CMF400 sensor, check the sensor documentation for the wire colors used with your sensor.

Resistance at sensor terminals	Cause	Corrective action(s)
Open or short from green to white	• Moisture in sensor case or junction box • Open or short left pickoff	• If sensor junction box contains moisture, check for leaking junction box, conduit, or conduit seals • If sensor junction box does not contain moisture, return sensor to factory
Open or short from blue to gray	• Moisture in sensor case or junction box • Open or short right pickoff	
Open or short from red to brown	• Moisture in sensor case or junction box • Open or short drive coil	
Open or short from violet to yellow	• Moisture in sensor case or junction box • Open or short lead length compensator	
Open or short from violet to orange	• Moisture in sensor case or junction box • Open or short RTD	
Values are within the ranges listed in **Table 23-8**	Transmitter cannot calculate flow signal offset	• If using volume flow units, verify density measurement • Zero the flowmeter after: - Eliminating pipe stress, vibration, or mechanical noise - Verifying flow calibration - Shutting off flow
	Flow rate outside sensor limit	• Bring flow rate within sensor limit • Monitor flow rate • If using volume flow units, verify density measurement • Verify flow calibration
	• Inappropriate density factors • Process density above 5 g/cc • Erratic process density has caused flow tubes to stop vibrating • Plugged flow tube	• Perform density calibration or density characterization • Bring density within sensor limit • Monitor density • Purge flow tubes
	Temperature outside sensor limit	• Bring temperature within sensor limit • Monitor temperature
Resistance of any wire pair is outside range listed in **Table 23-8**	Incorrect or faulty cable connection	Reconnect sensor cable according to the *9-Wire Cable Preparation and Installation Instruction Manual*
	Sensor failure	Contact Micro Motion Customer Service (see page 247 or the back cover for phone numbers)

23.4 Sensor failure and overrange conditions

If a sensor failure occurs, if the sensor cable is faulty, or if flow, temperature, or density goes outside the sensor limits, one or more of the following diagnostic codes switches ON:

- Sensor failure
- Sensor not responding
- Temperature sensor failure
- Case temperature sensor failure (Micro Motion T-Series sensor only)
- Line temperature sensor failure (Micro Motion T-Series sensor only)
- Temperature sensor out of range
- Temperature overrange
- Density overrange
- Input overrange
- Drive gain overrange

Fault outputs

If diagnostic codes indicate one or more sensor failure or overrange conditions, the transmitter produces fault outputs as described in **Chapter 11**.

Checking wiring

Flowmeter wiring problems are often incorrectly diagnosed as a faulty sensor. At initial startup of the flowmeter, or as part of troubleshooting, check the wiring between the flowmeter components. See your sensor manual for wiring information.

If your flowmeter includes a booster amp or a barrier, additional wiring information is provided in the supplementary installation documentation.

Troubleshooting procedure

The procedure for troubleshooting sensor failure and overrange conditions depends on the transmitter and installation type:

- MVDSolo, Series 1000 or 2000 transmitter
- Version 3 RFT9739 transmitter
- Version 2 field-mount RFT9739 transmitter
- Version 2 rack-mount RFT9739 transmitter

MVDSolo or Series 1000 or 2000 transmitter
If MVDSolo or the Series 1000 or 2000 transmitter indicates sensor failure or overrange conditions and produces fault outputs, follow these steps:

1. Read register pairs 20285-20286 to 20291-20292, as listed in **Table 23-5**, page 236.

2. Compare the returned values with the values described in **Table 23-5** and **Table 23-7**, page 237:
   - If the drive gain is unstable, see **Table 23-9**, page 238.
   - If the value for the left or right pickoff does not equal the appropriate value from **Table 23-7**, based on the sensor flow tube frequency, go to step 3.

3. If you have a 9-wire cable between the sensor and the core processor, disconnect sensor wiring from the intrinsically safe

transmitter terminals that are listed in **Table 23-6**, page 237, then use a DMM to measure resistance between wire pairs.
- If open or short circuits are found, or if measured resistance values are outside the ranges listed in **Table 23-8**, page 238, the sensor cable might be faulty. See **Table 23-10**, page 239.
- If faulty sensor cable is not indicated, go to step 4.

4. Before reconnecting wiring at the transmitter terminals, measure resistance between wire pairs at the sensor junction box. See **Table 23-10**.

5. If troubleshooting fails to reveal why diagnostic codes have switched ON, phone the Micro Motion Customer Service Department. (See page 247 or the back cover for phone numbers.)

Version 3 RFT9739 transmitter
If a Version 3 RFT9739 transmitter indicates sensor failure or overrange conditions and produces fault outputs:

1. Read register pairs 20285-20286 to 20291-20292, as listed in **Table 23-5**, page 236.

2. Compare the returned values with the values described in **Table 23-5** and **Table 23-7**, page 237:
   - If the drive gain is unstable, see **Table 23-9**, page 238.
   - If the value for the left or right pickoff does not equal the appropriate value from **Table 23-7**, based on the sensor flow tube frequency, go to step 3.

3. Disconnect sensor wiring from the intrinsically safe transmitter terminals that are listed in **Table 23-6**, page 237, then use a DMM to measure resistance between wire pairs.
   - If open or short circuits are found, or if measured resistance values are outside the ranges listed in **Table 23-8**, page 238, the sensor cable might be faulty. See **Table 23-10**, page 239.
   - If faulty sensor cable is not indicated, go to step 4.

4. Before reconnecting wiring at the transmitter terminals, measure resistance between wire pairs at the sensor junction box. See **Table 23-10**.

5. If troubleshooting fails to reveal why diagnostic codes have switched ON, phone the Micro Motion Customer Service Department. (See page 247 or the back cover for phone numbers.)

Version 2 RFT9739 transmitter
If the Version 2 RFT9739 transmitter indicates sensor failure or overrange conditions and produces fault outputs, use a digital multimeter (DMM) or other reference device to measure resistance across wire pairs or test points. Refer to the transmitter manual for test procedures, expected values, and suggested actions.

If troubleshooting fails to reveal why diagnostic codes have switched ON, phone the Micro Motion Customer Service Department. (See page 247 or the back cover for phone numbers.)

23.5 Output saturation and process out-of-range conditions

The transmitter returns diagnostic codes identifying process variations outside user-defined or factory-specified limits. Such diagnostic codes can indicate any of the following conditions:

- The process has gone outside a sensor limit on flow, density, temperature, or pressure
- Programmed limits fail to account for normal variations in the process
- Faulty sensor wiring
- Faulty cable between the sensor and the transmitter
- Faulty wiring between the pressure transmitter and the RFT9739 transmitter

Responding to diagnostic codes

Table 23-11 explains how to respond to diagnostic codes indicating the process has gone outside a user-defined or factory-specified limit.

Before performing corrective actions listed in **Table 23-11**, follow the diagnostic procedures that are described earlier in this section.

Table 23-11. Process limit diagnostic codes

Process condition	Indicator address	Indicator address type	Bit status	Corrective action(s)
Flow rate is outside sensor limit	30001	Input register	xxxx xxxx xxx1 xxxx	Alter fluid process
	20245 20246	Floating point register pair	16	
Frequency output saturated	30001	Input register	xxxx xxxx xx1x xxxx	• Rescale frequency output (see **Chapter 9**) • Reduce flow rate
	30125	Input register	xx1x xxxx xxxx xxxx	
	30420	Input register	xx1x xxxx xxxx xxxx	
	20245 20246	Floating point register pair	32	
	10030	Discrete input	ON	
Primary mA output variable out of range	30001	Input register	xxxx xxx1 xxxx xxxx	• Change upper limit for primary mA output variable (see **Chapter 9**) • Alter fluid process
	30125	Input register	xxxx xxxx xxxx xxx1	
	30419	Input register	xxxx xxx1 xxxx xxxx	
	30420	Input register	xxxx xxxx xxxx xxx1	
	20245 20246	Floating point register pair	256	
	10029 10031	Discrete inputs	ON	
Secondary mA output variable out of range	30001	Input register	xxxx xxx1 xxxx xxxx	• Change upper limit for secondary mA output variable (see **Chapter 9**) • Alter fluid process
	30125	Input register	xxxx xxxx xxxx xx1x	
	30419	Input register	xxxx xx1x xxxx xxxx	
	30420	Input register	xxxx xxxx xxxx xx1x	
	20245 20246	Floating point register pair	512	
	10030 10031	Discrete inputs	ON	

Troubleshooting *continued*

Table 23-11. Process limit diagnostic codes *continued*

Process condition	Indicator address	Indicator address type	Bit status	Corrective action(s)
Process density above 5 g/cc	30001	Input register	xxxx x1xx xxxx xxxx	• Change density calibration factors (see **Chapter 17** or **Chapter 18**) • Alter fluid process • Check for symptoms of sensor failure
	30125	Input register	xxxx xxxx xxx1 xxxx	
	30420	Input register	xxxx xxxx xxx1 xxxx	
	20245 20246	Floating point register pair	4096	
Slug flow	30001	Input register	xx1x xxxx xxxx xxxx	• Change slug flow limits (see **Chapter 10**) • Change slug duration (see **Chapter 10**) • Alter fluid process
	30126	Input register	1xxx xxxx xxxx xxxx	
	30421	Input register	1xxx xxxx xxxx xxxx	
	20245 20246	Floating point register pair	262144	
Event 1 ON	10037	Discrete input	ON	• Change event setpoint(s) (see **Chapter 11**) • Alter fluid process
	30126	Input register	xxxx xxxx x1xx xxxx	
	30421	Input register	xxxx xxxx x1xx xxxx	
Event 2 ON	10038	Discrete input	ON	
	30126	Input register	xxxx xxxx xx1x xxxx	
	30421	Input register	xxxx xxxx xx1x xxxx	
Event 1 or event 2 ON	10065	Discrete input	ON	
Pressure input less than 4 mA or greater than 20 mA	30125	Input register	xxxx xxxx 1xxx xxxx	• Set range limits for mA pressure input (see **Chapter 13**) • Check for faulty wiring to or from pressure transmitter • Alter fluid process
Temperature sensor out of range	30419	Input register	xxxx xxxx xxx1 xxxx	• Check temperature sensor function • Alter fluid process
Input overrange	30001	Input register	xxxx xxxx xxxx xxx1	See **Section 23.4**
	30125	Input register	xxx1 xxxx xxxx xxxx	
	30420	Input register	xxx1 xxxx xxxx xxxx	
	20245 20246	Floating point register pair	16	
API: Temperature outside standard range	30422	Input register	xxxx xxxx xxxx xxx1	• Check temperature sensor function • Check wiring between sensor and transmitter • Alter fluid process
API: Density outside standard range	30422	Input register	xxxx xxxx xxxx xx1x	Alter fluid process
Line temperature sensor out of range	30422	Input register	xxxx xxxx xxxx x1xx	• Check temperature sensor function • Check wiring between sensor and transmitter • Alter fluid process
Meter temperature sensor out of range	30422	Input register	xxxx xxxx xxxx 1xxx	• Check temperature sensor function • Alter fluid process

Milliamp output performance

When process variables are out of range, milliamp output performance depends on whether or not the outputs are NAMUR-compliant.

Milliamp output performance is described below. **Figure 23-1**, page 244, illustrates RFT9739 milliamp output performance.

⚠ CAUTION

The RFT9739 milliamp output range has changed.

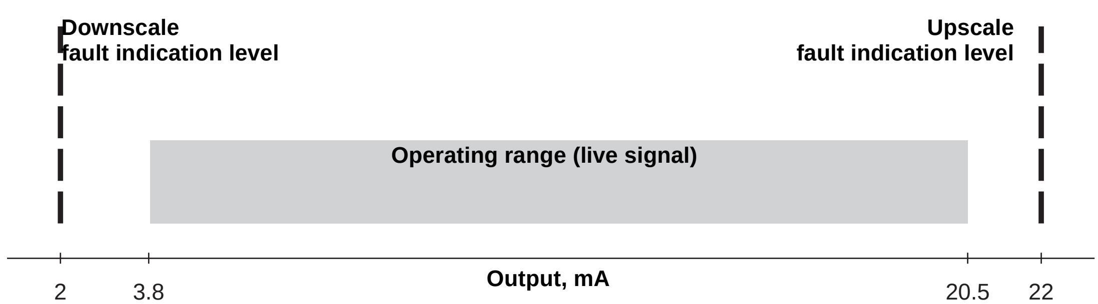
RFT9739 4-20 mA outputs will not produce live signals between 2.0 and 3.8 mA, or between 20.5 and 22 mA.

Systems that rely on milliamp output signals in the ranges listed above might not perform as expected. For RFT9739 transmitters shipped after October 1999, 4-20 mA outputs will saturate at 3.8 and 20.5 mA, unlike previous versions of RFT9739 transmitters.

Reconfigure systems as necessary.

In compliance with the NAMUR NE43 standard:
- The Series 1000, Series 2000, and NAMUR-compliant RFT9739 4-20 mA outputs will produce live signals from 3.8 to 20.5 mA.
- The Series 1000, Series 2000, and NAMUR-compliant RFT9739 4-20 mA outputs will not produce signals between 2.0 and 3.8 mA, or between 20.5 and 22 mA, unless the user has configured the fault level within these ranges.
- The Series 1000 or Series 2000 4-20 mA output will indicate a fault at the level determined by the fault level setting, as described in **Chapter 11**.
- The NAMUR-compliant RFT9739 4-20 mA output will indicate a fault at 2 or 22 mA.

Figure 23-1. Milliamp output performance for RFT9739 transmitter



23.6 Transmitter status bits

Transmitter status bits indicate various operating conditions. Transmitter status bits include:
- Transmitter not configured
- Data loss possible
- Transmitter configuration changed
- Power reset occurred
- Transmitter initializing/warming up

Transmitter not configured

If a master reset is performed on the transmitter, diagnostic codes that are listed in **Table 23-12** indicate the flowmeter requires complete reconfiguration. A master reset returns all transmitter register values to pre-characterization manufacturer's defaults.

Contact Micro Motion customer support before performing a master reset.

Table 23-12. Transmitter not configured status bits

Address	Address type	Bit status	Condition	Corrective action(s)
30001	Input register	xxxx xxxx x1xx xxxx	• Master reset has been performed • Transmitter is not configured	Reconfigure flowmeter (see **Chapter 7** through **Chapter 19**)
30125	Input register	x1xx xxxx xxxx xxxx		
30420	Input register	x1xx xxxx xxxx xxxx		
30422	Input register	xxxx xx1x xxxx xxxx		
20245 20246	Floating point register pair	64		

Data loss possible

If a power fluctuation occurs during configuration of MVDSolo or a Series 1000 or 2000 transmitter, bit #13 in input register 30421 switches ON to indicate the last configuration parameters might not have been saved. See **Table 23-13**.

Table 23-13. Data loss possible status bits

Address	Address type	Bit status	Condition	Corrective action(s)
30126	Input register	xx1x xxxx xxxx xxxx	Power fluctuation occurred during configuration	• Check the last configuration variables that were written (if necessary, see **Chapter 7** through **Chapter 19**) • Rewrite any incorrect variables
30421	Input register	xx1x xxxx xxxx xxxx		

Transmitter configuration changed

Status bits that are listed in **Table 23-14** indicate a Modbus or HART® device has been used to change the transmitter configuration.

Table 23-14. Transmitter configuration changed status bit

Address	Address type	Bit status	Condition	Corrective action(s)
30001	Input register	xxxx xxxx xxxx xx1x	Transmitter configuration was changed using Modbus or HART protocol	• Read configuration • If desired, reconfigure transmitter (see **Chapter 7** through **Chapter 19**) • Clear bits by writing any value to input register 30001, register pair 20245-20246, or discrete input 10035. All addresses are cleared together.
20245 20246	Floating point register pair	1048576		
10035	Discrete input	ON		

Power reset occurred

Status bits that are listed in **Table 23-15** indicate a shutdown, power failure, or brownout, which causes cycling of power to the transmitter.

Table 23-15. Power reset status bits

Address	Address type	Bit status	Condition	Corrective action(s)
30126	Input register	xxxx xxxx xxxx xx1x	• Shutdown • Power failure • Brownout	• Check power supply to transmitter • Check accuracy of totalizers • Clear bits by writing any value to input register 30001, register pair 20245-20246, or discrete input 1003. 4All addresses are cleared together.
30421	Input register	xxxx xxxx xxxx xx1x		
20245 20246	Floating point register pair	524288		
10034	Discrete input	ON		

Transmitter initializing/warming up

Status bits that are listed in **Table 23-16** indicate electronic calibration at startup or after power cycling of the transmitter. For MVDSolo or a Series 1000 or 2000 transmitter, the listed status bits can also indicate a brownout (low-power) condition. After the transmitter has warmed up or the brownout condition ceases, the bits clear and the diagnostic LED indicates normal operation. (See **Table 23-4**, page 236.)

Table 23-16. Transmitter warming up status bits

Address	Address type	Bit status	Condition	Corrective action(s)
30001	Input register	x1xx xxxx xxxx xxxx	• Transmitter warming up at startup • Transmitter warming up after power cycle • Self-test in progress • Brownout condition may exist; check voltages	• If bit clears, no action needed • If bit remains ON, check cable connections from transmitter to sensor
30126	Input register	xxxx xxxx xxxx x1xx		
30419	Input register	xxxx xxxx 1xxx xxxx		
30421	Input register	xxxx xxxx xxxx x1xx		
20245 20246	Floating point register pair	2097152		
10028	Discrete input	ON		

Burst mode enabled

If the transmitter has been configured to send data in burst mode while operating under HART protocol, status bits that are listed in **Table 23-17** switch ON. In burst mode, the transmitter bursts data at regular intervals.

To configure the transmitter to communicate in burst mode, see **Chapter 6**.

Table 23-17. Burst mode enabled status bits

Address	Address type	Bit status	Condition	Corrective action(s)
30126	Input register	xxxx xxxx xxxx xxx1	Burst mode enabled	No action needed
30421	Input register	xxxx xxxx xxxx xxx1		

RFT9739 display readback error (Version 3 only)

If the Version 3 RFT9739 optional display does not properly receive a value that is written to the display, bit #4 in input register 30126 switches ON, as listed in **Table 23-18**. If the bit does not clear within 60 seconds, cycle power to the transmitter to disable the display. Contact the factory to replace a faulty display.

To configure the Version 3 RFT9739 display, see the instruction manual that was shipped with the transmitter.

Table 23-18. Display readback error status bit

Address	Address type	Bit status	Condition	Corrective action(s)
30126	Input register	xxxx xxxx xxx1 xxxx	Version 3 RFT9739 display did not properly receive value	• If bit clears, no action needed • If bit does not clear within 60 seconds, cycle power to transmitter

23.7 Customer service

For technical assistance, phone the Micro Motion Customer Service Department:
- Inside the U.S.A., phone 1-800-522-6277, 24 hours
- In the Americas outside the U.S.A., phone 303-530-8400, 24 hours
- In Europe, phone +31 (0) 318 549 443
- In Asia, phone 65-770-8155

Appendices
A Modbus Mapping Assignments

Table A-1. Read/write coils

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
0 0002	Start/stop totalizers	√	√	√	√	120, 207
0 0003	Reset totals	√	√	√	√	120, 207
0 0004	Reset inventories	√	√	√	√	120, 207
0 0005	Perform flowmeter zeroing	√	√	√	√	176, 207
0 0006	Trim primary mA output at 0 or 4 mA		√	√	√	214, 207
0 0007	Trim primary mA output at 20 mA		√	√	√	214, 207
0 0008	Trim secondary mA output at 0 or 4 mA			√[1]	√	214, 207
0 0009	Trim secondary mA output at 20 mA			√[1, 2]	√	214, 207
0 0010	Fix current level from primary mA output		√	√	√	207, 214, 218
0 0011	Fix current level from secondary mA output			√[1]	√	207, 214, 218
0 0012	Fix frequency from frequency output		√	√	√	220, 207
0 0013	Perform low-density calibration	√	√	√	√	182
0 0014	Perform high-density calibration	√	√	√	√	184
0 0014	Perform third-point density calibration				√	187
0 0015	Perform temperature offset calibration	√	√	√		192, 195
0 0016	Perform temperature slope calibration	√	√	√		193, 196
0 0018	Perform flowing density (FD) calibration	√	√	√		187
0 0018	Save non-volatile data				√	204
0 0020	Perform transmitter test	√	√	√	√	207, 223
0 0039	Reset configuration and calibration registers				√	212
0 0041	Perform reboot	√	√	√	√	—
0 0044	Perform T-Series sensor D3 calibration	√	√	√		189
0 0045	Perform T-Series sensor D4 calibration	√	√	√		190
0 0046	Fix discrete output 1		√	√		222
0 0047	Fix discrete output 2			√[3]		222
0 0056	Reset mass total	√	√	√		120
0 0057	Reset line volume (gross volume) total	√	√	√		120
0 0058	Reset API reference volume total (Standard volume total)	√	√	√		120
0 0081	Enable/disable cryogenic modulus compensation	√	√	√		—
0 0082	Enable/disable pressure compensation	√	√	√		126
0 0083	Enable/disable HART burst mode		√	√		39
0 0084	Enable/disable FOUNDATION Fieldbus simulation mode			√[4]		42
0 0086	Enable/disable Use externally written temperature (20449/20450) for internal calculations	√	√	√		144
0 0094	Enable/disable totalizer reset using display		√	√		147
0 0095	Enable/disable automatic scrolling using display		√	√		147
0 0096	Enable/disable display offline menu		√	√		147

Table A-1. Read/write coils *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
0 0097	Enable/disable offline password for display		√	√		147
0 0098	Enable/disable display alarm menu		√	√		147
0 0099	Enable/disable acknowledge all alarms using display		√	√		147

[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*
[2] *Only the 4 mA trim value is supported.*
[3] *Transmitters with configurable input/output boards only.*
[4] *Transmitters with FOUNDATION Fieldbus option board only.*

Table A-2. RFT9739 security coils

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	RFT9739	See this page:
0 0113	Read protect calibration factors	√	204
0 0114	Write protect output variables and units	√	205
0 0115	Write protect scaled integers	√	205
0 0116	Write protect sensor and transmitter information	√	205
0 0117	Write protect special units factors	√	205
0 0118	Write protect control output variable	√	205
0 0119	Write protect flow direction	√	205
0 0120	Write protect fault code	√	205
0 0121	Write protect fault limit	√	—
0 0122	Write protect output variables	√	205
0 0123	Write protect flowmeter zeroing and process variable limits	√	205
0 0124	Write protect pressure variables	√	205
0 0125	Write protect calibration factors	√	204
0 0126	Write protect coil 00002 (start/stop totalizer)	√	207
0 0127	Write protect coil 00003 (reset totals)	√	207
0 0128	Write protect coil 00004 (reset inventories)	√	207
0 0129	Write protect coil 00005 (perform flowmeter zeroing)	√	207
0 0130	Write protect coil 00006 (trim primary mA output at 4 mA or 0 mA)	√	207
0 0131	Write protect coil 00007 (trim primary mA output at 20 mA)	√	207
0 0132	Write protect coil 00008 (trim secondary mA output at 4 mA or 0 mA)	√	207
0 0133	Write protect coil 00009 (trim secondary mA output at 20 mA)	√	207
0 0134	Write protect coil 00010 (fix primary mA output)	√	207
0 0135	Write protect coil 00011 (fix secondary mA output)	√	207
0 0136	Write protect coil 00012 (fix frequency output)	√	207
0 0137	Write protect coil 00013 (perform low-density calibration)	√	207
0 0138	Write protect coil 00014 (perform high-density calibration)	√	207
0 0142	Write protect coil 00018 (save non-volatile data)	√	207
0 0143	Read/write protect master reset defaults	√	—
0 0144	Read/write protect coil 00020 (perform transmitter self-test)	√	207

Table A-2. RFT9739 security coils *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	RFT9739	See this page:
0 0145	Read protect coil 10021 (EEPROM checksum failure)	√	207
0 0146	Read protect coil 10022 (RAM diagnostic failure)	√	207
0 0147	Read protect coil 10023 (real-time interrupt failure)	√	207
0 0148	Read protect coil 10024 (sensor failure)	√	207
0 0149	Read protect coil 10025 (temperature sensor failure)	√	207
0 0150	Read protect coil 10026 (flowmeter zeroing failure)	√	207
0 0151	Read protect coil 10027 (other failure occurred)	√	207
0 0152	Read protect coil 10028 (transmitter initializing/warming up)	√	207
0 0153	Read protect coil 10029 (primary variable out of range)	√	207
0 0154	Read protect coil 10030 (non-primary variable out of range)	√	207
0 0155	Read protect coil 10031 (milliamp output saturated)	√	207
0 0156	Read protect coil 10032 (milliamp output fixed)	√	207
0 0157	Read protect coil 10033 (watchdog timer error)	√	207
0 0158	Read protect coil 10034 (power reset occurred)	√	207
0 0159	Read protect coil 10035 (transmitter configuration changed)	√	207
0 0160	Read protect coil 10036 (transmitter electronics failure)	√	207

Table A-3. Read-only discrete inputs

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
1 0021	(E)EPROM checksum failure	√	√	√	√	223, 228
1 0022	RAM diagnostic failure	√	√	√	√	223, 228
1 0023	Real-time interrupt failure	√	√	√	√	223, 228
1 0024	Sensor failure	√	√	√	√	227
1 0025	Temperature sensor failure	√	√	√	√	227
1 0026	Flowmeter zeroing failure	√	√	√	√	177, 228
1 0027	Other failure occurred	√	√	√	√	223, 228
1 0028	Transmitter initializing/warming up	√	√	√	√	207, 228, 244
1 0029	Primary variable out of range	√	√	√	√	242, 227
1 0030	Secondary variable out of range	√	√	√	√	242, 228
1 0031	Milliamp output(s) saturated		√	√	√	242, 228
1 0032	Milliamp output(s) fixed		√	√	√	214, 218, 227
1 0033	Watchdog timer error	√	√	√	√	223, 228
1 0034	Power reset occurred	√	√	√	√	228, 244
1 0035	Transmitter configuration changed	√			√	228, 244
1 0036	Transmitter electronics failure	√	√	√	√	223, 227
1 0037	Event 1 status (ON/OFF)	√	√	√	√	111, 120, 228, 242
1 0038	Event 2 status (ON/OFF)	√	√	√	√	111, 120, 228, 242
1 0065	Event 1 or event 2 status (ON/OFF)		√	√		111, 120, 242

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Table A-3. Read-only discrete inputs *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
1 0066	Flow direction switch status (ON/OFF)		√	√		111
1 0067	Flow rate indicator status (ON/OFF)		√	√		111
1 0068	Zero in progress status (ON/OFF)		√	√		111
1 0069	Fault status (ON/OFF)		√	√		111

Table A-4. Floating-point register pairs

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
2 0141 0142	Slug duration (seconds)	√	√	√	√	98, 205
2 0143 0144	Fixed current for primary mA output test (milliamps)		√	√	√	108, 214, 218
2 0145 0146	Fixed current for secondary mA output test (milliamps)			√[1]	√	108, 214, 218
2 0147 0148	Fixed frequency for frequency/output test (Hz)		√	√	√	108, 205, 220
2 0149 0150	Cutoff for density	√	√	√		91
2 0151 0152	Temperature for temperature offset/slope calibrations	√	√	√		195, 196
2 0155 0156	Density for low-density calibration (g/cc)	√	√	√	√	169, 174, 182, 204
2 0157 0158	Density for high-density calibration (g/cc)	√	√	√	√	169, 174, 184, 187, 204
2 0157 0158	Density for flowing-density calibration (g/cc)	√	√	√	√	187, 204
2 0159 0160	Density calibration constant 1 (µsec)	√	√	√	√	169
2 0161 0162	Density calibration constant 2 (µsec)	√	√	√	√	169
2 0163 0164	Density temperature coefficient	√	√	√	√	171
2 0165 0166	High mass flow limit of sensor	√	√	√	√	70
2 0167 0168	High temperature limit of sensor	√	√	√	√	70
2 0169 0170	High density limit of sensor (g/cc)	√	√	√	√	70
2 0171 0172	High volume flow limit of sensor	√	√	√	√	70
2 0173 0174	Low mass flow limit of sensor	√	√	√	√	70
2 0175 0176	Low temperature limit of sensor	√	√	√	√	70
2 0177 0178	Low density limit of sensor (g/cc)	√	√	√	√	70
2 0179 0180	Low volume flow limit of sensor	√	√	√	√	70
2 0181 0182	Mass flow minimum range	√	√	√	√	70
2 0183 0184	Temperature minimum range	√	√	√	√	70
2 0185 0186	Density minimum range	√	√	√	√	70
2 0187 0188	Volume flow minimum range	√	√	√	√	70
2 0189 0190	Flow rate internal damping (seconds)	√	√	√	√	96, 205
2 0191 0192	Temperature internal damping (seconds)	√	√	√	√	96, 205
2 0193 0194	Density internal damping (seconds)	√	√	√	√	96, 205
2 0195 0196	Mass flow cutoff for frequency output and totalizers	√	√	√	√	89, 205

Modbus Mapping Assignments *continued*

Table A-4. Floating-point register pairs *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address		Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
2	0197 0198	Volume flow cutoff for frequency output and totalizers	√	√	√	√	89, 205
2	0199 0200	Slug flow high-density limit (g/cc)	√	√	√	√	97, 205
2	0201 0202	Slug flow low-density limit (g/cc)	√	√	√	√	97, 205
2	0203 0204	Primary mA output present current (milliamps)		√	√	√	68, 84
2	0205 0206	Added damping on primary mA output (seconds)		√	√	√	76, 205
2	0207 0208	Flow cutoff for primary mA output		√	√	√	74, 205
2	0209 0210	Primary variable at 20 mA		√	√	√	70, 115, 205
2	0211 0212	Primary variable at 0 mA or 4 mA		√	√	√	70, 115, 205
2	0213 0214	Secondary mA output present current (milliamps)[1]			√	√	68, 84
2	0215 0216	Added damping on secondary mA output (seconds)[1]			√	√	76, 205
2	0217 0218	Flow cutoff for secondary mA output[1]			√	√	74, 205
2	0219 0220	Secondary variable at 20 mA			√[1]	√	70, 115, 205
2	0221 0222	Secondary variable at 0 mA or 4 mA			√[1]	√	70, 115, 205
2	0223 0224	Frequency setpoint or number of pulses (Hz)		√	√	√	79, 205
2	0225 0226	Flow rate or total represented by frequency or number of pulses		√	√	√	79, 205
2	0227 0228	Frequency pulse width (seconds)		√	√	√	83, 205
2	0229 0230	Frequency output present frequency (Hz)		√	√	√	68, 85
2	0231 0232	Flowmeter zeroing standard deviation				√	179
2	0233 0234	Present flow signal offset at zero flow	√	√	√	√	178
2	0235 0236	Flowmeter zeroing standard deviation limit				√	179
2	0237 0238	Special mass unit conversion factor	√	√	√	√	48, 52, 205
2	0239 0240	Special volume unit conversion factor	√	√	√	√	48, 205
2	0241 0242	Event 1 setpoint	√	√	√	√	114, 118
2	0243 0244	Event 2 setpoint	√	√	√	√	114, 118
2	0245 0246	1(E)EPROM checksum failure	√	√	√	√	233, 242
		2RAM diagnostic failure	√	√	√	√	233, 242
		4Sensor failure	√	√	√	√	233, 242
		8Temperature sensor failure	√	√	√	√	233, 242
		16Input overrange	√	√	√	√	233, 242
		32Frequency output saturated	√	√	√	√	233, 242
		64Transmitter not configured	√	√	√	√	233, 242
		128Real-time interrupt failure	√	√	√	√	233, 242
		256Primary mA output saturated		√	√	√	233, 242
		512Secondary mA output saturated[1]			√	√	233, 242
		1024Primary mA output fixed		√	√	√	233, 242
		2048Secondary mA output fixed[1]			√	√	233, 242
		4096Density overrange	√	√	√	√	233, 242
		8192Flowmeter zeroing failure	√	√	√	√	233, 242
		16384Zero value too low	√	√	√	√	233, 242
		32768Zero value too high	√	√	√	√	233, 242
		65536Transmitter electronics failure	√	√	√	√	233, 242
		131072Flowmeter zeroing in progress	√	√	√	√	233, 242
		262144Slug flow	√	√	√	√	233, 242
		524288Power reset occurred	√	√	√	√	233, 242
		1048576Transmitter configuration changed	√	√	√	√	233, 242
		2097152Transmitter initializing/warming up	√	√	√	√	233, 242

Table A-4. Floating-point register pairs *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
2 0247 0248	Mass flow rate	√	√	√	√	55, 68
2 0249 0250	Density	√	√	√	√	55, 68
2 0251 0252	Temperature	√	√	√	√	55, 68
2 0253 0254	Volume flow rate	√	√	√	√	55, 68
2 0257 0258	Pressure				√	55, 68
2 0259 0260	Mass total	√	√	√	√	55, 68
2 0261 0262	Volume total	√	√	√	√	55, 68
2 0263 0264	Mass inventory	√	√	√	√	55, 68
2 0265 0266	Volume inventory	√	√	√	√	55, 68
2 0267 0268	Pressure correction factor for flow	√	√	√	√	130, 126
2 0269 0270	Pressure correction factor for density	√	√	√	√	130, 126
2 0271 0272	Flow calibration pressure	√	√	√	√	133, 126
2 0273 0274	Pressure input at 4 mA				√	131
2 0275 0276	Pressure input at 20 mA				√	131
2 0277 0278	Density for flowing-density calibration	√	√	√	√[4]	187
2 0277 0278	Constant for third-point density calibration				√[2]	169
2 0279 0280	Mass flow rate meter factor	√	√	√	√[3]	201, 204
2 0281 0282	Volume flow rate meter factor	√	√	√	√	201, 204
2 0283 0284	Density meter factor	√	√	√	√	201, 204
2 0285 0286	Raw tube frequency (Hz)	√	√	√	√[3]	233, 235
2 0287 0288	Left pickoff voltage (millivolts)	√	√	√	√[3]	233, 235
2 0289 0290	Right pickoff voltage (millivolts)	√	√	√	√[3]	233, 235
2 0291 0292	Drive gain (% for MVDSolo, Series 1000, or Series 2000; volts for RFT9739)	√	√	√	√[3]	233, 235
2 0293 0294	Mass flow live zero flow	√	√	√	√[3]	90, 233
2 0303 0304	Flowing-density calibration constant	√	√	√	√[4]	169, 174, 187
2 0319 0320	API reference temperature	√	√	√		143
2 0323 0324	API thermal expansion coefficient	√	√	√		143
2 0325 0326	Temperature-corrected density	√	√	√		145
2 0329 0330	CTL	√	√	√		145
2 0331 0332	Temperature/pressure-corrected volumetric flow	√	√	√		145
2 0333 0334	Temperature/pressure-corrected volumetric total	√	√	√		145
2 0335 0336	Temperature/pressure-corrected volumetric inventory	√	√	√		145
2 0337 0338	Weighted average batch observed density	√	√	√		145
2 0339 0340	Weighted average batch observed temperature	√	√	√		145
2 0407 0408	Flow calibration factor (FCF)	√	√	√		164
2 0409 0410	Temperature coefficient for flow (FT)	√	√	√		164
2 0411 0412	Tempcal slope	√	√	√		172
2 0413 0414	Tempcal offset	√	√	√		172
2 0435 0436	Sensor maximum recorded temperature	√	√	√		233
2 0437 0438	Sensor minimum recorded temperature	√	√	√		233
2 0439 0440	Sensor average recorded temperature	√	√	√		233
2 0449 0450	External temperature input value	√	√	√		144
2 0451 0452	External pressure input value	√	√	√		128
2 0463 0464	Electronics maximum recorded temperature	√	√	√		233
2 0465 0466	Electronics minimum recorded temperature	√	√	√		233
2 0467 0468	Electronics average recorded temperature	√	√	√		233

Modbus Mapping Assignments *continued*

Table A-4. Floating-point register pairs *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address		Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
2	0503 0504	T-Series K3 density constant	√	√	√		189
2	0505 0506	T-Series FTG value	√	√	√		174
2	0507 0508	T-Series FTQ value	√	√	√		174
2	0509 0510	Density for T-Series sensor D3 density calibration	√	√	√		189
2	0511 0512	Density for T-Series sensor D4 density calibration	√	√	√		190
2	0513 0514	T-Series DTG value	√	√	√		174
2	0515 0516	T-Series DFQ1 value	√	√	√		174
2	0517 0518	T-Series DFQ2 value	√	√	√		174
2	0519 0520	T-Series K4 density constant	√	√	√		190
2	0687 0688	Slot 0 configuration variable	√	√	√		157
2	0689 0690	Slot 1 configuration variable	√	√	√		157
2	0691 0692	Slot 2 configuration variable	√	√	√		157
2	0693 0694	Slot 3 configuration variable	√	√	√		157
2	0695 0696	Slot 4 configuration variable	√	√	√		157
2	0697 0698	Slot 5 configuration variable	√	√	√		157
2	0699 0700	Slot 6 configuration variable	√	√	√		157
2	0701 0702	Slot 7 configuration variable	√	√	√		157
2	0703 0704	Slot 8 configuration variable	√	√	√		157
2	0705 0706	Slot 9 configuration variable	√	√	√		157
2	0707 0708	Slot 10 configuration variable	√	√	√		157
2	0709 0710	Slot 11 configuration variable	√	√	√		157
2	0711 0712	Slot 12 configuration variable	√	√	√		157
2	0713 0714	Slot 13 configuration variable	√	√	√		157
2	0715 0716	Slot 14 configuration variable	√	√	√		157
2	0717 0718	Slot 15 configuration variable	√	√	√		157
2	0719 0720	Slot 16 configuration variable	√	√	√		157
2	0721 0722	Slot 17 configuration variable	√	√	√		157
2	0723 0724	Slot 18 configuration variable	√	√	√		157
2	0725 0726	Slot 19 configuration variable	√	√	√		157
2	0727 0728	Slot 20 configuration variable	√	√	√		157
2	0729 0730	Slot 21 configuration variable	√	√	√		157
2	0731 0732	Slot 22 configuration variable	√	√	√		157
2	0733 0734	Slot 23 configuration variable	√	√	√		157
2	0735 0736	Slot 24 configuration variable	√	√	√		157
2	0737 0738	Slot 25 configuration variable	√	√	√		157
2	0739 0740	Slot 26 configuration variable	√	√	√		157
2	0741 0742	Slot 27 configuration variable	√	√	√		157
2	0743 0744	Slot 28 configuration variable	√	√	√		157
2	0745 0746	Slot 29 configuration variable	√	√	√		157
2	0747 0748	Slot 30 configuration variable	√	√	√		157
2	0749 0750	Slot 31 configuration variable	√	√	√		157
2	0783 0784	Slot 0 process variable	√	√	√		157
2	0785 0786	Slot 1 process variable	√	√	√		157
2	0787 0788	Slot 2 process variable	√	√	√		157
2	0789 0790	Slot 3 process variable	√	√	√		157
2	0791 0792	Slot 4 process variable	√	√	√		157
2	0793 0794	Slot 5 process variable	√	√	√		157
2	0795 0796	Slot 6 process variable	√	√	√		157
2	0801 0802	Slot 9 process variable	√	√	√		157

Table A-4. Floating-point register pairs *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
2 0803 0804	Slot 10 process variable	√	√	√		157
2 0805 0806	Slot 11 process variable	√	√	√		157
2 0807 0808	Slot 12 process variable	√	√	√		157
2 0809 0810	Slot 13 process variable	√	√	√		157
2 0811 0812	Slot 14 process variable	√	√	√		157
2 0813 0814	Slot 15 process variable	√	√	√		157
2 0815 0816	Slot 16 process variable	√	√	√		157
2 0817 0818	Slot 17 process variable	√	√	√		157
2 0819 0820	Slot 18 process variable	√	√	√		157
2 0821 0822	Slot 19 process variable	√	√	√		157
2 0823 0824	Slot 20 process variable	√	√	√		157
2 0825 0826	Slot 21 process variable	√	√	√		157
2 0827 0828	Slot 22 process variable	√	√	√		157
2 0829 0830	Slot 23 process variable	√	√	√		157
2 0831 0832	Slot 24 process variable	√	√	√		157
2 0833 0834	Slot 25 process variable	√	√	√		157
2 0835 0836	Slot 26 process variable	√	√	√		157
2 0837 0838	Slot 27 process variable	√	√	√		157
2 0839 0840	Slot 28 process variable	√	√	√		157
2 0841 0842	Slot 29 process variable	√	√	√		157
2 0843 0844	Slot 30 process variable	√	√	√		157
2 0845 0846	Slot 31 process variable	√	√	√		157
2 1101 1102	Frequency output pulses per unit		√	√		79
2 1103 1104	Frequency output units per pulse		√	√		79
2 1105 1106	Frequency output fault setting		√	√		104
2 1109 1110	Primary mA output fault setting		√	√		104
2 1111 1112	Secondary mA output fault setting[1]			√		104
2 1159 1160	Flow rate switch setpoint		√	√		109

[1] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*
[2] *Version 3.5 or lower revision RFT9739 transmitter.*
[3] *Version 3 or higher revision RFT9739 transmitter.*
[4] *Version 3.6 or higher revision RFT9739 transmitter.*

Modbus Mapping Assignments *continued*

Table A-5. Input registers

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
3 0001	Bit #0 (E)EPROM checksum failure	√	√	√	√	223, 228, 242
	Bit #1Transmitter configuration changed	√			√	228, 245
	Bit #2Sensor failure	√	√	√	√	228
	Bit #3Temperature sensor failure	√	√	√	√	228
	Bit #4Input overrange	√	√	√	√	228, 242
	Bit #5Frequency output saturated		√	√	√	228, 242
	Bit #6Transmitter not configured	√	√	√	√	228, 245
	Bit #7Real-time interrupt failure	√	√	√	√	223, 228
	Bit #8Milliamp output(s) saturated		√	√	√	214, 228, 242
	Bit #9Milliamp output(s) fixed		√	√	√	218, 228
	Bit #10Density overrange	√	√	√	√	228, 242
	Bit #11Flowmeter zeroing failure	√	√	√	√	177, 228
	Bit #12Transmitter electronics failure	√	√	√	√	223, 228
	Bit #13Slug flow	√	√	√	√	97, 228, 242
	Bit #14Transmitter initializing/warming up	√	√	√	√	228, 246
	Bit #15Power reset occurred	√	√	√	√	228
3 0002	Mass flow rate scaled integer	√	√	√	√	55, 58, 68
3 0003	Density scaled integer	√	√	√	√	55, 58, 68
3 0004	Temperature scaled integer	√	√	√	√	55, 58, 68
3 0005	Volume flow rate scaled integer	√	√	√	√	55, 58, 68
4 0007	Pressure scaled integer				√	55, 58, 68
3 0008	Mass total scaled integer	√	√	√	√	55, 58, 68
3 0009	Volume total scaled integer	√	√	√	√	55, 58, 68
3 0010	Mass inventory scaled integer	√	√	√	√	55, 58, 68
3 0011	Volume inventory scaled integer	√	√	√	√	55, 58, 68
3 0016	Transmitter software revision (xxxx.x format; 141 = rev14.1)	√	√	√	√	29
3 0120	Device type code	√	√	√	√	—
3 0121	Electronics manufacturer's code identification number	√	√	√	√	29
3 0122	HART device I.D. number – high order register of 3-byte integer	√	√	√	√	29
3 0123	HART device I.D. number – low order register of 3-byte integer	√	√	√	√	29

Table A-5. Input registers *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
3 0125	Bit #0Primary mA output saturated		√	√	√	228, 242
	Bit #1Secondary mA output saturated[1]			√	√	218, 228, 242
	Bit #2Primary mA output fixed		√	√	√	214, 218, 228
	Bit #3Secondary mA output fixed[1]			√	√	214, 218, 228
	Bit #4Density overrange	√	√	√	√	228, 242
	Bit #5Drive gain overrange	√	√	√	√	228
	Bit #6Not used					—
	Bit #7External input error				√	228, 242
	Bit #8(E)EPROM checksum failure, core processor or RFT9739	√	√	√	√	223, 228
	Bit #9RAM diagnostic failure, core processor or RFT9739	√	√	√	√	223, 228
	Bit #10Sensor failure	√	√	√	√	228
	Bit #11Temperature sensor failure	√	√	√	√	228
	Bit #12Input overrange	√	√	√	√	228, 242
	Bit #13Frequency output saturated		√	√	√	228, 242
	Bit #14Transmitter not configured	√	√	√	√	228, 245
	Bit #15Real-time interrupt failure	√	√	√	√	223, 228
3 0126	Bit #0Burst mode enabled		√	√	√	228, 246
	Bit #1Power reset occurred	√	√	√	√	228, 246
	Bit #2Transmitter initializing/warming up	√	√	√	√	228, 246
	Bit #3Security breach				√	212, 228
	Bit #4Display readback error				√	228, 247
	Bit #5Event 2 ON	√	√	√	√	120, 228, 242
	Bit #6Event 1 ON	√	√	√	√	120, 228, 242
	Bit #7Not used					—
	Bit #8Flowmeter zeroing failure	√	√	√	√	177, 228
	Bit #9Zero value too low	√	√	√	√	177, 228
	Bit #10Zero value too high	√	√	√	√	177, 228
	Bit #11Zero too noisy	√	√	√	√	177, 228
	Bit #12Transmitter electronics failure	√	√	√	√	223, 228
	Bit #13Data loss possible	√	√	√	√	228, 245
	Bit #14Calibration in progress	√	√	√	√	176, 182, 228
	Bit #15Slug flow	√	√	√	√	97, 228, 242
3 0295	Security event configuration register				√	—
3 0296	Security event calibration register				√	—
3 0297	Mass flow live zero flow				√[2]	—
3 0305	Most significant word for binary mass total				√[3]	57
3 0306	High-order word for binary mass total				√[3]	57
3 0307	Low-order word for binary mass total				√[3]	57
3 0308	Least significant word for binary mass total				√[3]	57

Modbus Mapping Assignments *continued*

Table A-5. Input registers *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
3 0309	Most significant word for binary volume total				√[3]	57
3 0310	High-order word for binary volume total				√[3]	57
3 0311	Low-order word for binary volume total				√[3]	57
3 0312	Least significant word for binary volume total				√[3]	57
3 0419	Bit #0(E)EPROM checksum error, core processor	√	√	√		223, 228
	Bit #1RAM test error, core processor	√	√	√		223, 228
	Bit #2Real-time interrupt failure	√	√	√		223, 228
	Bit #3Sensor not vibrating	√	√	√		228
	Bit #4Temperature sensor out of range	√	√	√		228, 242
	Bit #5Calibration failure	√	√	√		177, 228
	Bit #6Other failure occurred	√	√	√		223, 228
	Bit #7Transmitter initializing/warming up	√	√	√		228, 246
	Bit #8Primary variable out of limits	√				228, 242
	Bit #9Secondary variable out of limits	√				228, 242
	Bit #10Not used					—
	Bit #11Not used					—
	Bit #12Watchdog error	√				228
	Bit #13Cold start occurred	√				228
	Bit #14Transmitter configuration changed	√				228
	Bit #15Transmitter fault	√	√	√		228
3 0420	Bit #0Primary mA output saturated		√	√		228, 242
	Bit #1Secondary mA output saturated[1]			√		228, 242
	Bit #2Primary mA output fixed		√	√		214, 218, 228
	Bit #3Secondary mA output fixed[1]			√		214, 218, 228
	Bit #4Density overrange	√	√	√		228, 242
	Bit #5Drive overrange	√	√	√		228
	Bit #6Not used					—
	Bit #7External input failure		√	√		228
	Bit #8(E)EPROM checksum failure, core processor	√	√	√		228
	Bit #9RAM diagnostic failure, core processor	√	√	√		228
	Bit #10Sensor not vibrating	√	√	√		228
	Bit #11Temperature sensor failure	√	√	√		228
	Bit #12Input overrange	√	√	√		228, 242
	Bit #13Frequency output saturated		√	√		228, 242
	Bit #14Transmitter not configured	√	√	√		228, 245
	Bit #15Real-time interrupt failure	√	√	√		223, 228

Table A-5. Input registers *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
3 0421	Bit #0Burst mode enabled		√	√		228, 246
	Bit #1Power reset occurred	√	√	√		228, 246
	Bit #2Transmitter initializing/warming up	√	√	√		228, 246
	Bit #3Not used					—
	Bit #4Not used					—
	Bit #5Event 2 ON	√	√	√		120, 228, 242
	Bit #6Event 1 ON	√	√	√		120, 228, 242
	Bit #7Sensor/transmitter communication failure		√	√		228
	Bit #8Calibration failure	√	√	√		177, 182, 228
	Bit #9Zero value too low	√	√	√		177, 228
	Bit #10Zero value too high	√	√	√		177, 228
	Bit #11Zero too noisy	√	√	√		177, 228
	Bit #12Transmitter electronics failure	√	√	√		177, 223, 228
	Bit #13Data loss possible	√	√	√		228, 245
	Bit #14Calibration in progress	√	√	√		176, 182, 195, 228
	Bit #15Slug flow	√	√	√		97, 228, 242
3 0422	Bit #0API: Temperature outside standard range	√	√	√		146, 228, 242
	Bit #1API: Density outside standard range	√	√	√		146, 228, 242
	Bit #2Line temperature sensor out of range	√	√	√		228, 242
	Bit #3Meter temperature sensor out of range	√	√	√		228, 242
	Bit #4Flow direction (1 = reverse, 0 = forward or zero flow)	√	√	√		92, 228
	Bit #5Not used					—
	Bit #6Not used					—
	Bit #7Not used					—
	Bit #8Not used					—
	Bit #9Transmitter not configured	√	√	√		228, 245
	Bit #10(E)EPROM checksum error		√	√		223, 228
	Bit #11RAM test error in transmitter		√	√		223, 228
	Bit #12Invalid/unrecognized sensor type	√	√	√		228
	Bit #13(E)EPROM database corrupt	√	√	√		223, 228
	Bit #14(E)EPROM powerdown totals corrupt	√	√	√		223, 228
	Bit #15(E)EPROM program corrupt	√	√	√		223, 228

Modbus Mapping Assignments *continued*

Table A-5. Input registers *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
3 0423	Bit #0Boot sector fault	√	√	√		223, 228
	Bit #1Software upgrade needed		√	√		223, 228
	Bit #2Frequency output fixed		√	√		220, 228
	Bit #3Not used					—
	Bit #4DO1 status (0=OFF, 1=ON)		√	√		222, 228
	Bit #5DO2 status (0=OFF, 1=ON)[4]			√		222, 228
	Bit #6T-Series D3 calibration in progress	√	√	√		182, 228
	Bit #7T-Series D4 calibration in progress	√	√	√		182, 228
	Bit #8Not used					—
	Bit #9Not used					—
	Bit #10Temperature slope calibration in progress	√	√	√		195, 228
	Bit #11Temperature offset calibration in progress	√	√	√		195, 228
	Bit #12Flowing density calibration in progress	√	√	√		182, 228
	Bit #13High-density calibration in progress	√	√	√		182, 228
	Bit #14Low-density calibration in progress	√	√	√		182, 228
	Bit #15Flowmeter zeroing in progress	√	√	√		176, 228
3 0424	Bit #0Discrete input 1 status (0=OFF, 1=ON)[4]			√		223
	Bit #1Not used					—
	Bit #2Discrete output 1 fixed		√	√		222
	Bit #3Discrete output 2 fixed[4]			√		222
	Bit #4Not used					—
	Bit #5Not used					—
	Bit #6Security breach			√		—
	Bit #7Not used					—
	Bit #8Not used					—
	Bit #9Not used					—
	Bit #10Not used					—
	Bit #11Not used					—
	Bit #12Not used					—
	Bit #13Not used					—
	Bit #14Not used					—
	Bit #15Not used					—
3 1137	Core processor software revision		√	√		29
3 1138	Output option board		√	√		29
3 1187[5 6]	Core processor HART device I.D. number – high order register of 3-byte integer		√	√		29
3 1188	Core processor HART device I.D. number – low order register of 3-byte integer		√	√		29

1 Transmitters with intrinsically safe output boards or configurable input/output boards only.
2 Version 3 RFT9739 transmitter.
3 Version 3.7 or higher revision RFT9739 transmitter.
4 Transmitters with configurable input/output boards only.
5 Must be queried through transmitter. If wiring is direct to core processor, registers 31187 and 31188 do not exist.
6 Same as registers 41187-41188. If these registers contain a non-zero value. they are read-only. If they contain 0, they can be written to.

Table A-6. Holding registers

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
4 0012	Process variable assigned to primary variable	√[1]	√	√	√	68, 70, 112, 205
4 0013	Process variable assigned to secondary variable	√[1]	√[1]	√[1, 2]	√	68, 70, 112, 205
4 0014	Process variable assigned to tertiary variable	√[1]	√	√[1]	√	68, 78, 205
4 0015	Process variable assigned to RFT9739 control output variable				√	108, 112, 205
4 0015	Process variable assigned to quaternary variable	√[1]	√	√		68, 86
4 0017	Flow direction	√	√	√	√	92, 205
4 0018	Maximum integer	√	√	√	√	59, 205
4 0019	Mass flow offset	√	√	√	√	62, 205
4 0020	Density offset	√	√	√	√	62, 205
4 0021	Temperature offset	√	√	√	√	62, 205
4 0022	Volume flow offset	√	√	√	√	62, 205
4 0024	Pressure offset				√	62, 205
4 0025	Mass total offset	√	√	√	√	62, 205
4 0026	Volume total offset	√	√	√	√	62, 205
4 0027	Mass inventory offset	√	√	√	√	62, 205
4 0028	Volume inventory offset	√	√	√	√	62, 205
4 0029	Mass flow scale factor	√	√	√	√	59, 205
4 0030	Density scale factor	√	√	√	√	59, 205
4 0031	Temperature scale factor	√	√	√	√	59, 205
4 0032	Volume flow scale factor	√	√	√	√	59, 205
4 0034	Pressure scale factor				√	59, 205
4 0035	Mass total scale factor	√	√	√	√	59, 205
4 0036	Volume total scale factor	√	√	√	√	59, 205
4 0037	Mass inventory scale factor	√	√	√	√	59, 205
4 0038	Volume inventory scale factor	√	√	√	√	59, 205
4 0039	Standard or special mass flow rate unit	√	√	√	√	46, 48, 55, 205
4 0040	Density unit	√	√	√	√	53, 55, 205
4 0041	Temperature unit	√	√	√	√	54, 55, 142, 205
4 0042	Standard or special volume flow rate unit	√	√	√	√	46, 48, 55, 205
4 0044	Pressure unit				√	54, 55, 205
3 0045	Standard or special mass total or inventory unit[3]	√	√	√	√	46, 48, 55, 205
3 0046	Standard or special volume total or inventory unit[4]	√	√	√	√	46, 48, 55, 205
4 0047	Polling address[5]		√	√	√	29, 37, 280
4 0048	Final assembly number – high order register of 3-byte integer	√	√	√	√	29, 205
4 0049	Final assembly number – low order register of 3-byte integer	√	√	√	√	29, 205
4 0050	Date low order byte: day	√	√	√	√	29, 205
4 0051	Date high order byte: month Date low order byte: year (1900 + x assumed)	√	√	√	√	29, 205
4 0124	RFT9739 fault code				√	103, 205
4 0124	MVD digital output fault code	√	√	√		107

Table A-6. Holding registers *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address		Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
4	0127	Sensor serial number	√	√	√	√	27, 205
4	0128	Sensor serial number	√	√	√	√	27, 205
4	0129	Sensor flange type	√	√	√	√	28, 205
4	0130	Sensor flow tube construction material	√	√	√	√	28, 205
4	0131	Sensor flow tube liner material	√	√	√	√	28, 205
4	0132	Base mass unit	√	√	√	√	48, 52, 205
4	0133	Base time unit for special mass unit	√	√	√	√	48, 52, 205
4	0134	Base volume unit	√	√	√	√	48, 205
4	0135	Base time unit for special volume unit	√	√	√	√	48, 205
4	0136	Maximum zeroing time	√	√	√	√	180, 205
4	0137	Event 1 variable assignment	√	√	√	√	112, 116
4	0138	Event 2 variable assignment	√	√	√	√	112, 116
4	0139	Event 1 type (high=1/low=2)	√	√	√	√	112, 116
4	0140	Event 2 type (high=1/low=2)	√	√	√	√	112, 116
4	0302	Polling control code #1		√	√	√	40, 130
4	0313	Modbus polling address	√	√	√	√[6]	29, 38
4	0314	Last measured value fault timeout	√	√	√		107
4	0351	API 2540 CTL table type (see CTL Code Table)	√	√	√		142
4	0366	DSP calculation update rate (20 Hz or 100 Hz)	√	√	√		86
4	0521	Floating-point byte order	√	√	√		289
4	0522	Additional delay to Modbus response	√	√	√		19
4	0655	Slot 0 configuration index	√	√	√		152, 157
4	0656	Slot 1 configuration index	√	√	√		152, 157
4	0657	Slot 2 configuration index	√	√	√		152, 157
4	0658	Slot 3 configuration index	√	√	√		152, 157
4	0659	Slot 4 configuration index	√	√	√		152, 157
4	0660	Slot 5 configuration index	√	√	√		152, 157
4	0661	Slot 6 configuration index	√	√	√		152, 157
4	0662	Slot 7 configuration index	√	√	√		152, 157
4	0663	Slot 8 configuration index	√	√	√		152, 157
4	0664	Slot 9 configuration index	√	√	√		152, 157
4	0665	Slot 10 configuration index	√	√	√		152, 157
4	0666	Slot 11 configuration index	√	√	√		152, 157
4	0667	Slot 12 configuration index	√	√	√		152, 157
4	0668	Slot 13 configuration index	√	√	√		152, 157
4	0669	Slot 14 configuration index	√	√	√		152, 157
4	0670	Slot 15 configuration index	√	√	√		152, 157
4	0671	Slot 16 configuration index	√	√	√		152, 157
4	0672	Slot 17 configuration index	√	√	√		152, 157
4	0673	Slot 18 configuration index	√	√	√		152, 157
4	0674	Slot 19 configuration index	√	√	√		152, 157
4	0675	Slot 20 configuration index	√	√	√		152, 157
4	0676	Slot 21 configuration index	√	√	√		152, 157
4	0677	Slot 22 configuration index	√	√	√		152, 157
4	0678	Slot 23 configuration index	√	√	√		152, 157
4	0679	Slot 24 configuration index	√	√	√		152, 157
4	0680	Slot 25 configuration index	√	√	√		152, 157
4	0681	Slot 26 configuration index	√	√	√		152, 157
4	0682	Slot 27 configuration index	√	√	√		152, 157

Table A-6. Holding registers *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address		Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
4	0683	Slot 28 configuration index	√	√	√		152, 157
4	0684	Slot 29 configuration index	√	√	√		152, 157
4	0685	Slot 30 configuration index	√	√	√		152, 157
4	0686	Slot 31 configuration index	√	√	√		152, 157
4	0751	Slot 0 process variable index	√	√	√		152, 157
4	0752	Slot 1 process variable index	√	√	√		152, 157
4	0753	Slot 2 process variable index	√	√	√		152, 157
4	0754	Slot 3 process variable index	√	√	√		152, 157
4	0755	Slot 4 process variable index	√	√	√		152, 157
4	0756	Slot 5 process variable index	√	√	√		152, 157
4	0757	Slot 6 process variable index	√	√	√		152, 157
4	0758	Slot 7 process variable index	√	√	√		152, 157
4	0759	Slot 8 process variable index	√	√	√		152, 157
4	0760	Slot 9 process variable index	√	√	√		152, 157
4	0761	Slot 10 process variable index	√	√	√		152, 157
4	0762	Slot 11 process variable index	√	√	√		152, 157
4	0763	Slot 12 process variable index	√	√	√		152, 157
4	0764	Slot 13 process variable index	√	√	√		152, 157
4	0765	Slot 14 process variable index	√	√	√		152, 157
4	0766	Slot 15 process variable index	√	√	√		152, 157
4	0767	Slot 16 process variable index	√	√	√		152, 157
4	0768	Slot 17 process variable index	√	√	√		152, 157
4	0769	Slot 18 process variable index	√	√	√		152, 157
4	0770	Slot 19 process variable index	√	√	√		152, 157
4	0771	Slot 20 process variable index	√	√	√		152, 157
4	0772	Slot 21 process variable index	√	√	√		152, 157
4	0773	Slot 22 process variable index	√	√	√		152, 157
4	0774	Slot 23 process variable index	√	√	√		152, 157
4	0775	Slot 24 process variable index	√	√	√		152, 157
4	0776	Slot 25 process variable index	√	√	√		152, 157
4	0777	Slot 26 process variable index	√	√	√		152, 157
4	0778	Slot 27 process variable index	√	√	√		152, 157
4	0779	Slot 28 process variable index	√	√	√		152, 157
4	0780	Slot 29 process variable index	√	√	√		152, 157
4	0781	Slot 30 process variable index	√	√	√		152, 157
4	0782	Slot 31 process variable index	√	√	√		152, 157
4	1107	Frequency output fault code		√	√		104
4	1108	Frequency output scaling method		√	√		79
4	1113	Primary milliamp output fault code		√	√		104
4	1114	Secondary milliamp output fault code			√[2]		104
4	1115	Display offline password (0000 to 9999)		√	√		149
4	1116	Display scroll rate (1 to 10 seconds)		√	√		148
4	1117	Display variable #1		√	√		148
4	1118	Display variable #2		√	√		148
4	1119	Display variable #3		√	√		148
4	1120	Display variable #4		√	√		148
4	1121	Display variable #5		√	√		148
4	1122	Display variable #6		√	√		148
4	1123	Display variable #7		√	√		148

Table A-6. Holding registers *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
4 1124	Display variable #8		√	√		148
4 1125	Display variable #9		√	√		148
4 1126	Display variable #10		√	√		148
4 1127	Display variable #11		√	√		148
4 1128	Display variable #12		√	√		148
4 1129	Display variable #13		√	√		148
4 1130	Display variable #14		√	√		148
4 1131	Display variable #15		√	√		148
4 1132	RS-485 digital communication protocol setting AIO		√	√		16
4 1133	RS-485 digital communication baud rate AIO		√	√		16
4 1134	RS-485 digital communication parity setting AIO		√	√		16
4 1135	RS-485 digital communication stop bits setting AIO		√	√		16
4 1139	Sensor type code		√	√		28
4 1144	Polling control code #2		√	√		40
4 1145	Polled variable #1 code		√	√		40
4 1146	Polled variable #2 code		√	√		40
4 1147	Polling type code[7]		√	√		40
4 1151	Discrete output 1 assignment		√	√		109
4 1153	Discrete output 2 assignment [8]			√		109
4 1164	100 Hz update rate variable assignment		√	√		86
4 1165	Burst command		√	√		39
4 1166	Output channel A type assignment		√	√		35
4 1167	Output channel B type assignment		√	√		35
4 1168	Output channel C type assignment		√	√		35
4 1169	Burst variable 1		√	√		39
4 1170	Burst variable 2		√	√		39
4 1171	Burst variable 3		√	√		39
4 1172	Burst variable 4		√	√		39
4 1174	Channel B power [3]			√		35
4 1175	Channel C power[5]			√		35
4 1176	Discrete input 1 assignment[8]			√		122
4 1181	Frequency output mode[5]			√		35
4 1182	Discrete output 1 fixed value		√	√		222
4 1183	Discrete output 2 fixed value[5]			√		222
4 1186	Profibus station address (0-126)[9]			√		43
4 1187[10]	Core processor HART device I.D. number – high order register of 3-byte integer		√	√		29
4 1188	Core processor HART device I.D. number – low order register of 3-byte integer		√	√		29
4 1197	Frequency output polarity (0=active low, 1=active high)		√	√		37

[1] *Supported in software even if associated output is not available.*
[2] *Transmitters with intrinsically safe output boards or configurable input/output boards only.*
[3] *Read-only; automatically derived from holding register 40039.*
[4] *Read-only; automatically derived from holding register 40042.*
[5] *Modbus or HART polling address (Version 3.6 or lower RFT9739 transmitter); HART polling address (Version 3.7 or higher RFT9739 transmitter and Series 1000 and 2000 transmitters).*
[6] *Version 3.7 or higher revision RFT9739 transmitter.*
[7] *Release 2.x or lower only.*
[8] *Transmitters with configurable input/output boards only.*
[9] *Transmitters with Profibus-PA software only.*

[10]*Must be queried through transmitter. Same as registers 31187-31188. If these registers contain a non-zero value. they are read-only. If they contain 0, they can be written to.*

Table A-7. ASCII character strings

Note

- Always write character strings as single-write multiples.
- Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739		See this page:
5 0052 5 0053 5 0054 5 0055	Special mass flow unit Special mass flow unit Special mass flow unit Special mass flow unit	√	√	√		Single-write multiple	50, 205
5 0056 5 0057 5 0058 5 0059	Special mass total or mass inventory unit Special mass total or mass inventory unit Special mass total or mass inventory unit Special mass total or mass inventory unit	√	√	√		Single-write multiple	50, 205
5 0060 5 0061 5 0062 5 0063	Special volume flow unit Special volume flow unit Special volume flow unit Special volume flow unit	√	√	√		Single-write multiple	50, 205
5 0064 5 0065 5 0066 5 0067	Special volume total or volume inventory unit Special volume total or volume inventory unit Special volume total or volume inventory unit Special volume total or volume inventory unit	√	√	√		Single-write multiple	50, 205
5 0068 5 0069 5 0070 5 0071	Device tag Device tag Device tag Device tag	√	√	√	√	Single-write multiple	29, 38
5 0072 5 0073 5 0074 5 0075 5 0076 5 0077 5 0078 5 0079	Flow calibration factor Flow calibration factor Flow calibration factor Flow temperature coefficient Flow temperature coefficient Space character Space character Space character	√	√	√	√	Single-write multiple	134, 164, 204
5 0080 5 0081 5 0082 5 0083 5 0084 5 0085 5 0086 5 0087	Temperature calibration slope Temperature calibration slope Temperature calibration slope Temperature calibration slope Temperature calibration offset Temperature calibration offset Temperature calibration offset Space character	√	√	√	√	Single-write multiple	172, 193, 196, 204

Table A-7. ASCII character strings *continued*

Note

- Always write character strings as single-write multiples.
- Page numbers in the farthest right column refer to the pages where you can find information about each address.

Address	Description	MVDSolo	Series 1000	Series 2000	RFT9739		See this page:
5 0096 5 0097 5 0098 5 0099 5 0100 5 0101 5 0102 5 0103	Description Description Description Description Description Description Description Description	√	√	√	√	Single-write multiple	29
5 0104 5 0105 5 0106 5 0107 5 0108 5 0109 5 0110 5 0111 5 0112 5 0113 5 0114 5 0115 5 0116 5 0117 5 0118 5 0119	User message User message User message User message User message User message User message User message User message User message User message User message User message User message User message User message	√	√	√	√	Single-write multiple	29
5 0298 5 0299 5 0300 5 0301	Polling tag name for external device #1 Polling tag name for external device #1 Polling tag name for external device #1 Polling tag name for external device #1		√	√	√	Single-write multiple	40, 42
5 0425 5 0426 5 0427 5 0428 5 0429 5 0430 5 0431 5 0432	Sensor type Sensor type Sensor type Sensor type Sensor type Sensor type Sensor type Sensor type	√	√	√		Single-write multiple	29
5 1140 5 1141 5 1142 5 1143	Polling tag name for external device #2 Polling tag name for external device #2 Polling tag name for external device #2 Polling tag name for external device #2		√	√		Single-write multiple	40

Table A-8. Integer codes

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

		MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
Mass flow unit codes (holding register 40039)						
70	Grams/second	√	√	√	√	46
71	Grams/minute	√	√	√	√	46
72	Grams/hour	√	√	√	√	46
73	Kilograms/second	√	√	√	√	46
74	Kilograms/minute	√	√	√	√	46
75	Kilograms/hour	√	√	√	√	46
76	Kilograms/day	√	√	√	√	46
77	Metric tons/minute	√	√	√	√	46
78	Metric tons/hour	√	√	√	√	46
79	Metric tons/day	√	√	√	√	46
80	Pounds/second	√	√	√	√	46
81	Pounds/minute	√	√	√	√	46
82	Pounds/hour	√	√	√	√	46
83	Pounds/day	√	√	√	√	46
84	Short tons (2000 pounds)/minute	√	√	√	√	46
85	Short tons (2000 pounds)/hour	√	√	√	√	46
86	Short tons (2000 pounds)/day	√	√	√	√	46
87	Long tons (2240 pounds)/hour	√	√	√		46
88	Long tons (2240 pounds)/day	√	√	√		46
253	Special	√	√	√	√	46
Mass totalizer unit codes (holding register 40045)						
60	Grams	√	√	√	√	46
61	Kilograms	√	√	√	√	46
62	Metric tons	√	√	√	√	46
63	Pounds	√	√	√	√	46
64	Short tons (2000 pounds)	√	√	√	√	46
65	Long tons (2240 pounds)	√	√	√		46
253	Special	√	√	√	√	46
Mass inventory unit codes (holding register 40045)						
60	Grams	√	√	√	√	46
61	Kilograms	√	√	√	√	46
62	Metric tons	√	√	√	√	46
63	Pounds	√	√	√	√	46
64	Short tons (2000 pounds)	√	√	√	√	46
65	Long tons (2240 pounds)	√	√	√		46
253	Special	√	√	√	√	46
Base mass unit codes for special mass units (holding register 40132)						
60	Grams	√	√	√	√	49, 52
61	Kilograms	√	√	√	√	49, 52
62	Metric tons	√	√	√	√	49, 52
63	Pounds	√	√	√	√	49, 52
64	Short tons (2000 pounds)	√	√	√	√	49, 52
65	Long tons (2240 pounds)	√	√	√		49, 52

Modbus Mapping Assignments *continued*

Table A-8. Integer codes *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

		MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
Base time unit codes for special mass units (holding register 40133)						
50	Minutes	√	√	√	√	50, 52
51	Seconds	√	√	√	√	50, 52
52	Hours	√	√	√	√	50, 52
53	Days	√	√	√	√	50, 52
Volume flow unit codes (holding register 40042)						
15	Cubic feet/minute	√	√	√	√	46
16	Gallons/minute	√	√	√	√	46
17	Liters/minute	√	√	√	√	46
18	Imperial gallons/minute	√	√	√	√	46
19	Cubic meters/hour	√	√	√	√	46
22	Gallons/second	√	√	√	√	46
23	Million U.S. gallons/day	√	√	√		46
24	Liters/second	√	√	√	√	46
25	Million liters/day	√	√	√		46
26	Cubic feet/second	√	√	√	√	46
27	Cubic feet/day	√	√	√		46
28	Cubic meters/second	√	√	√	√	46
29	Cubic meters/day	√	√	√	√	46
30	Imperial gallons/hour	√	√	√	√	46
31	Imperial gallons/day	√	√	√	√	46
130	Cubic feet/hour	√	√	√	√	46
131	Cubic meters/minute	√	√	√	√	46
132	Barrels/second	√	√	√	√	46
133	Barrels/minute	√	√	√	√	46
134	Barrels/hour	√	√	√	√	46
135	Barrels/day	√	√	√	√	46
136	U.S. gallons/hour	√	√	√	√[1]	46
137	Imperial gallons/second	√	√	√	√[1]	46
138	Liters/hour	√	√	√	√[1]	46
235	U.S. gallons/day	√	√	√		46
253	Special	√	√	√	√	46
Volume totalizer unit codes (holding register 40046)						
40	U.S. gallons	√	√	√	√	46
41	Liters	√	√	√	√	46
42	Imperial gallons	√	√	√	√	46
43	Cubic meters	√	√	√	√	46
46	Barrels (42 U.S. gallons)	√	√	√	√	46
112	Cubic feet	√	√	√	√	46
253	Special	√	√	√	√	46

Table A-8. Integer codes *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

		MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
Volume inventory unit codes (holding register 40046)						
40	U.S. gallons	√	√	√	√	46
41	Liters	√	√	√	√	46
42	Imperial gallons	√	√	√	√	46
43	Cubic meters	√	√	√	√	46
46	Barrels (42 U.S. gallons)	√	√	√	√	46
112	Cubic feet	√	√	√	√	46
253	Special	√	√	√	√	46
Base volume units for special volume units (holding register 40134)						
40	U.S. gallons	√	√	√	√	49
41	Liters	√	√	√	√	49
42	Imperial gallons	√	√	√	√	49
43	Cubic meters	√	√	√	√	49
46	Barrels (42 U.S. gallons)	√	√	√	√	49
112	Cubic feet	√	√	√	√	49
Base time units for special volume units (holding register 40135)						
50	Minutes	√	√	√	√	50
51	Seconds	√	√	√	√	50
52	Hours	√	√	√	√	50
53	Days	√	√	√	√	50
Temperature unit codes (holding register 40041)						
32	Degrees Celsius	√	√	√	√	54
33	Degrees Fahrenheit	√	√	√	√	54
34	Degrees Rankine	√	√	√	√	54
35	Kelvin	√	√	√	√	54
Density unit codes (holding register 40040)						
90	Specific gravity units	√	√	√	√	53
91	Grams/cubic centimeter	√	√	√	√	53
92	Kilograms/cubic meter	√	√	√	√	53
93	Pounds/gallon	√	√	√	√	53
94	Pounds/cubic foot	√	√	√	√	53
95	Grams/milliliter	√	√	√		53
96	Kilograms/liter	√	√	√		53
97	Grams/liter	√	√	√		53
98	Pounds/cubic inch	√	√	√		53
99	Short tons (2000 pounds)/cubic yard	√	√	√		53
104	Degrees API	√	√	√	√	53
Pressure unit codes (holding register 40044)						
1	Inches water at 68° degrees Fahrenheit	√	√	√	√	54
2	Inches mercury at 0° Celsius	√	√	√	√	54
3	Feet water at 68° Fahrenheit	√	√	√	√	54
4	Millimeters water at 68° Fahrenheit	√	√	√	√	54
5	Millimeters mercury at 0° Celsius	√	√	√	√	54
6	Pounds/square inch	√	√	√	√	54

Table A-8. Integer codes *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

		MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
7	Bar	√	√	√	√	54
8	Millibar	√	√	√	√	54
9	Grams/square centimeter	√	√	√	√	54
10	Kilograms/square centimeter	√	√	√	√	54
11	Pascals	√	√	√	√	54
12	Kilopascals	√	√	√	√	54
13	Torr at 0 degrees Celsius	√	√	√	√	54
14	Atmospheres	√	√	√	√	54
Milliamp output variable codes (holding register 40012 or 40013)						
0	Mass flow rate		√	√	√	70
1	Temperature		√	√	√	70
3	Density		√	√	√	70
5	Volume flow rate		√	√	√	70
9	Pressure				√	70
10	Event 1				√	70
11	Event 2				√	70
15	API: Temperature-corrected density		√	√		70
16	API: Temperature-corrected (standard) volume flow		√	√		70
19	API: Batch-weighted average corrected density		√	√		70
20	API: Batch-weighted average temperature		√	√		70
47	Drive gain		√	√		70
Display variable codes (holding registers 41117-41131)						
0	Mass flow rate		√	√		148
1	Temperature		√	√		148
2	Mass totalizer		√	√		148
3	Density		√	√		148
4	Mass inventory		√	√		148
5	Volume flow rate		√	√		148
6	Volume totalizer		√	√		148
7	Volume inventory		√	√		148
15	API: Temperature-corrected density		√	√		148
16	API: Temperature-corrected (standard) volume flow		√	√		148
17	API: Temperature-corrected (standard) volume total		√	√		148
18	API: Temperature-corrected (standard) volume inventory		√	√		148
19	API: Batch-weighted average corrected density		√	√		148
20	API: Batch-weighted average temperature		√	√		148
33	API: CTL		√	√		148
46	Raw tube frequency		√	√		148
47	Drive gain		√	√		148
48	Meter temperature (T-Series)					148
49	Left pickoff amplitude		√	√		148
50	Right pickoff amplitude		√	√		148
51	Board temperature		√	√		148
52	Input voltage		√	√		148
53	Externally read pressure		√	√		148
55	Externally read temperature		√	√		148

Table A-8. Integer codes *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

		MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
Event output variable codes (holding register 40137 or 40138)						
0	Mass flow rate	√	√	√	√	112, 116
1	Temperature	√	√	√	√	112, 116
2	Mass totalizer	√	√	√	√	112, 116
3	Density	√	√	√	√	112, 116
4	Mass inventory	√	√	√	√	112, 116
5	Volume flow rate	√	√	√	√	112, 116
6	Volume totalizer	√	√	√	√	112, 116
7	Volume inventory	√	√	√	√	112, 116
Quaternary variable codes (holding register 40015)						
0	Mass flow rate	√	√	√		86
1	Temperature	√	√	√		86
2	Mass total	√	√	√		86
3	Density	√	√	√		86
4	Mass inventory	√	√	√		86
5	Volume flow rate	√	√	√		86
6	Volume total	√	√	√		86
7	Volume inventory	√	√	√		86
15	API: Temperature-corrected density	√	√	√		86
16	API: Temperature-corrected (standard) volume flow	√	√	√		86
17	API: Temperature-corrected (standard) volume total	√	√	√		86
18	API: Temperature-corrected (standard) volume inventory	√	√	√		86
19	API: Batch-weighted average corrected density	√	√	√		86
20	API: Batch-weighted average temperature	√	√	√		86
33	API: CTL	√	√	√		86
47	Drive gain	√	√	√		86
53	Externally read pressure	√	√	√		86
55	Externally read temperature	√	√	√		86
Event alarm type codes (holding register 40139 or 40140)						
1	High alarm	√	√	√	√	112, 116
2	Low alarm	√	√	√	√	112, 116
Flow direction codes (holding register 40017)						
0	Forward flow only	√	√	√	√	92
1	Reverse flow only	√	√	√	√	92
2	Bidirectional flow	√	√	√	√	92
3	Absolute forward/reverse	√	√	√		92
4	Negate - forward only	√				92
5	Negate - bidirectional	√				92
Process variable and diagnostic codes for slot addresses (holding registers 40751-40782)						
0	Mass flow rate	√	√	√		152
1	Temperature	√	√	√		152
2	Mass totalizer	√	√	√		152
3	Density	√	√	√		152
4	Mass inventory	√	√	√		152

Modbus Mapping Assignments *continued*

Table A-8. Integer codes *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

		MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
5	Volume flow rate	√	√	√		152
6	Volume totalizer	√	√	√		152
7	Volume inventory	√	√	√		152
10	Event 1	√	√	√		152
11	Event 2	√	√	√		152
12	Status word 1 (419/420)	√	√	√		152
13	Status word 2 (421/422)	√	√	√		152
14	Status word 3 (423/424)	√	√	√		152
15	API: Temperature-corrected density	√	√	√		152
16	API: Temperature-corrected (standard) volume flow	√	√	√		152
17	API: Temperature-corrected (standard) volume total	√	√	√		152
18	API: Temperature-corrected (standard) volume inventory	√	√	√		152
19	API: Batch-weighted average corrected density	√	√	√		152
20	API: Batch-weighted average temperature	√	√	√		152
33	API: CTL	√	√	√		152
34	High-order doubleword of binary mass total in grams	√	√	√		152
35	Low-order doubleword of binary mass total in grams	√	√	√		152
36	High-order doubleword of binary volume total in cubic centimeters	√	√	√		152
37	Low-order doubleword of binary volume total in cubic centimeters	√	√	√		152
38	Raw API: Temperature/pressure-corrected volume total, high-order doubleword	√	√	√		152
39	Raw API: Temperature/pressure-corrected volume total, low-order doubleword	√	√	√		152
46	Raw tube frequency	√	√	√		152
47	Drive gain	√	√	√		152
49	Left pickoff amplitude	√	√	√		152
50	Right pickoff amplitude	√	√	√		152
51	Board temperature	√	√	√		152
52	Input voltage	√	√	√		152
53	Externally read pressure	√	√	√		152
55	Externally read temperature	√	√	√		152
100	Event 1 or event 2[2]		√	√		152
101	Flow switch indicator[2]		√	√		152
102	Forward/reverse indication[2]		√	√		152
103	Calibration in progress[2]		√	√		152
104	Fault condition indication[2]		√	√		152

Frequency output variable codes (holding register 40014)

		MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
0	Mass flow rate			√	√	78
2	Mass totalizer				√	78
5	Volume flow rate			√	√	78
6	Volume totalizer				√	78
16	API: Temperature-corrected (standard) volume flow			√		78

Table A-8. Integer codes *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

		MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
Frequency output scaling method codes (holding register 41108)						
0	Frequency=flow		√	√		78
1	Pulses/unit		√	√		78
2	Units/pulse		√	√		78
Control output variable codes (holding register 40015)						
0	Forward/reverse flow				√	108
1	Zero in progress				√	108
2	Faults				√	108
3	Event 1				√	108
4	Event 2				√	108
100 Hz variable codes (holding register 41164)						
0	Mass flow rate	√	√	√		86
1	Temperature	√	√	√		86
2	Mass totalizer	√	√	√		86
3	Density	√	√	√		86
4	Mass inventory	√	√	√		86
5	Volume flow rate	√	√	√		86
6	Volume totalizer	√	√	√		86
7	Volume inventory	√	√	√		86
10	Event 1	√	√	√		86
11	Event 2	√	√	√		86
Flow tube liner material codes (holding register 40131)						
10	PTFE (Teflon)	√	√	√	√	28
11	Halar	√	√	√	√	28
16	Tefzel	√	√	√	√	28
251	None	√	√	√	√	28
252	Unknown	√	√	√	√	28
253	Special	√	√	√	√	28
Sensor type codes (holding register 41139)						
0	Curved-tube sensor (D, DL, DT, CMF, F-Series, R-Series)		√	√		28
1	Straight-tube sensor (T-Series)		√	√		28
Pressure value receiving method codes (holding register 40302)						
0	None				√	130
3	HART primary				√	130
4	HART secondary				√	130
6	Analog input				√	130
8	Modbus				√	130
Version 2 RFT9739 fault output codes (holding register 40124)						
0	Upscale				√	103
1	Downscale				√	103
2	Last measured value				√	103
3	Internal zero				√	103

Table A-8. Integer codes *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

		MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
Analog fault output codes (holding registers 41107 and 41113)						
0	Upscale		√	√		104
1	Downscale		√	√		104
3	Internal zero		√	√		104
4	None		√	√		104
Digital fault output codes (holding register 40124)						
0	Hold at value greater than upper sensor limit, stop totalizing	√	√	√		107
1	Hold at value less than lower sensor limit, stop totalizing	√	√	√		107
2	Drive outputs to zero values of process variables, stop totalizing	√	√	√		107
3	Report not-a-number or maximum scaled integer, stop totalizing	√	√	√		107
4	Drive flow rate to zero value, other process variables remain unaffected	√	√	√		107
5	None (default; use status bits for fault detection)	√	√	√		107
Floating-point byte ordering codes (holding register 40521)						
0	0-1-2-3	√	√	√		289
1	2-3-0-1 (Default)	√	√	√		289
2	1-0-3-2	√	√	√		289
3	3-2-1-0	√	√	√		289
Sensor flange type codes (holding register 40129)						
0	ANSI 150	√	√	√	√	28
1	ANSI 300	√	√	√	√	28
2	ANSI 600	√	√	√	√	28
5	PN 40	√	√	√	√	28
7	JIS 10K	√	√	√	√	28
8	JIS 20K	√	√	√	√	28
9	ANSI 900	√	√	√	√	28
10	Sanitary clamp	√	√	√	√	28
11	Union	√	√	√	√	28
12	PN 100	√	√	√		28
250	Reserved				√	28
251	None	√	√	√	√	28
252	Unknown	√	√	√	√	28
253	Special	√	√	√	√	28
254	Reserved				√	28
255	Reserved				√	28

Table A-8. Integer codes *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

		MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
Flow tube construction material codes (holding register 40130)						
3	Hastelloy C-22	√	√	√	√	28
4	Monel	√	√	√	√	28
5	Tantalum	√	√	√	√	28
6	Titanium	√	√	√		28
19	316L stainless steel	√	√	√	√	28
23	Inconel	√	√	√		28
252	Unknown	√	√	√	√	28
253	Special	√	√	√	√	28
Digital communication protocol codes (holding register 41132)						
0	None		√	√		16
1	HART only		√	√		16
2	Modbus RTU only		√	√		16
3	Modbus ASCII only		√	√		16
Digital communication baud rate codes (holding register 41133)						
0	1200 baud		√	√		16
1	2400 baud		√	√		16
2	4800 baud		√	√		16
3	9600 baud		√	√		16
4	19,200 baud		√	√		16
5	38,400 baud		√	√		16
Digital communication parity codes (holding register 41134)						
0	None		√	√		16
1	Odd parity		√	√		16
2	Even parity		√	√		16
Digital communication stop bits codes (holding register 41135)						
1	1 stop bit		√	√		16
2	2 stop bits		√	√		16
Read-only output board codes (holding register 41138)						
0	None		√	√		—
1	Analog I/O (mA/Frequency/RS-485)		√	√		—
2	Foundation Fieldbus (H1) or Profibus-PA			√		—
3	Intrinsically safe output		√	√		—
4	Configurable input/output			√		—
Polling control option codes (holding register 40302 or 41144)						
0	Do not poll		√	√		40
1	Poll transmitter: HART primary		√	√		40
2	Poll transmitter: HART secondary		√	√		40

Modbus Mapping Assignments *continued*

Table A-8. Integer codes *continued*

Note
Page numbers in the farthest right column refer to the pages where you can find information about each address.

		MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
Polling type option codes (holding register 41147)						
0	None					40
1	Pressure compensation only		√	√		40
3	API only (temperature)		√	√		40
6	Pressure compensation and API (temperature)		√	√		40
Polled variable codes (holding registers 41145-41146)						
53	Externally read pressure		√	√		40
55	Externally read temperature		√	√		40
Output type codes (holding registers 41166-41168)						
0	Milliamp (primary) output		√	√		35
1	Frequency output		√	√		35
2	Digital communications [3]		√	√		35
3	Milliamp (secondary) output [4]			√		35
4	Discrete output		√	√		35
5	Discrete input [5]			√		35
Discrete input assignment codes (holding register 41176)[5]						
0	None			√		122
1	Start sensor zero			√		122
2	Reset mass total			√		122
3	Reset volume total			√		122
4	Reset corrected volume total			√		122
Discrete output assignment codes (holding registers 41151 and 41153)						
10	Event 1 active		√	√		109
11	Event 2 active		√	√		109
100	Event 1 or event 2 active		√	√		109
101	Flow switch indication		√	√		109
102	Forward/reverse indication		√	√		109
103	Calibration in progress		√	√		109
104	Fault condition indication		√	√		109
Power source codes (holding registers 41174-41175)						
0	External		√	√		35
1	Internal		√	√		35
Burst command option codes (holding register 41165)						
1	Read primary variable		√	√		39
2	Read PV current and percent of range		√	√		39
3	Read dynamic variables and PV current		√	√		39
33	Read transmitter variables		√	√		39

Table A-8. Integer codes *continued*

Note

Page numbers in the farthest right column refer to the pages where you can find information about each address.

		MVDSolo	Series 1000	Series 2000	RFT9739	See this page:
Burst variable codes for command 33 (holding registers 41169-41172)						
0	Mass flow rate	√	√	√		39
1	Temperature	√	√	√		39
2	Mass totalizer	√	√	√		39
3	Density	√	√	√		39
4	Mass inventory	√	√	√		39
5	Volume flow rate	√	√	√		39
6	Volume totalizer	√	√	√		39
7	Volume inventory	√	√	√		39
Frequency output mode codes (holding register 41181)[5]						
0	Single			√		35
1	Quadrature			√		35
2	Dual with 0° phase shift			√		35
3	Dual with 180° phase shift			√		35
4	Dual with +90° phase shift			√		35
5	Dual with -90° phase shift			√		35
CTL code table codes (holding register 40351)						
17	Table 5A	√	√	√		142
18	Table 5B	√	√	√		142
19	Table 5D	√	√	√		142
36	Table 6C	√	√	√		142
49	Table 23A	√	√	√		142
50	Table 23B	√	√	√		142
51	Table 23D	√	√	√		142
68	Table 24C	√	√	√		142
81	Table 53A	√	√	√		142
82	Table 53B	√	√	√		142
83	Table 53D	√	√	√		142
100	Table 54C	√	√	√		142
Discrete output state codes (holding registers 41182-41183)						
0	Off		√	√		222
1	On		√	√		222
255	Unfix discrete output		√	√		222

[1] *Version 3 RFT9739 transmitter.*
[2] *Available only when mapped to a discrete output.*
[3] *Transmitters with analog input/output boards only.*
[4] *Transmitters with intrinsically safe output boards and configurable input/output boards only.*
[5] *Transmitters with configurable input/output boards only.*

Appendices

B Reference to Message Framing

B.1 About this appendix

This appendix is a reference to framing Modbus messages for use with a Micro Motion transmitter.

B.2 Polling address

A Micro Motion® transmitter emulates a programmable logic controller (PLC) that communicates with a Modbus-compatible host controller in a multidrop network. Each transmitter has a unique polling address of 1 to 247. The host uses a polling address to initiate communication with one network device, or a command 0 to broadcast a message to all the network devices.

B.3 Mapped addresses

Each transmitter also has mapped addresses similar to PLC coils, discrete inputs, input registers, and holding registers. Such addresses correspond to particular memory locations in the transmitter's microprocessor. The transmitter also has floating-point and packed-character registers mapped to the same locations as input and holding registers. The host communicates by reading data from or writing data to a single location or a series of locations that have consecutive addresses.

Key to using holding registers and input registers
For a given mapped address, the transmitter returns the same data, whether you access the address as a holding register or as an input register.

Example	Temperature is stored in register 0004. It can be read as input register 30004 or holding register 40004. It can be read using Modbus commands 03, 04, or 16 by specifying address 3.

Key to using coils and discrete inputs
For a given mapped address, the transmitter returns the same data, whether you accesses the address as a coil or a discrete input.

Example

Sensor failure status is stored in memory location 0024. It can be read as coil 00024 or as discrete input 10024. It can be read by using Modbus commands 01 or 02 by specifying address 23.

Key to using mapped addresses
A coil or discrete input can have the same mapped address as a holding register or input register. The function code determines the information that is being accessed.

Example

Address 0002 corresponds to start/stop totalizers when accessed as a coil or discrete input using Modbus commands 01, 02, 05, or 15. Address 0002 also corresponds to scaled integer representation of mass flow when accessed as a holding register or input register using Modbus commands 03, 04, or 16.

B.4 Query messages and broadcast messages

The host controller can produce query frames or broadcast frames. Query frames generate a response frame from one network device. Broadcast frames address all the devices, which do not respond. A query/response message includes one query frame and one response frame. A broadcast message includes one broadcast frame. Each frame has an address field, a function field, a data field, and an error check field, regardless of the data transmission mode or data type. See **Table B-1**.

Table B-1. Data transmission fields

Address field	Function field	Data field	Error check field

Broadcast mode and address 0

Any query message with a slave address of 0 is a broadcast message. Only Modbus function codes 5, 6, 8, 15, and 16 are valid in a broadcast message. Every slave device on a multidrop network will receive a broadcast message and perform the requested action, and no slave will respond, which is why no read functions are supported in a broadcast message. Because of its use in broadcast messages, address 0 is not useful as a Modbus slave address. If you assign a non-zero address by

Reference to Message Framing *continued*

writing an integer from 1 to 15 to register 40047, the transmitter will use the assigned address regardless of the protocol.

Address field

In a query frame, the address field contains a transmitter's polling address. In a response frame, the address field contains the polling address of the responding device. In a broadcast frame, the address field contains a 0, which tells the network devices not to reply.

Function field

In a query frame or broadcast frame, the function field contains a function code, which indicates a read command, write command, or diagnostic command to a mapped address or consecutive series of mapped addresses listed in the data field.

In a response frame, the function field contains a function code verifying the device's response to the command. If the most significant bit in the function field is set, the data field contains an exception response explaining any errors encountered processing the command.

The transmitter's mapped addresses use a subset of function codes supported by all Modbus hosts, including the Modicon 984 Enhanced Executive Cartridge. **Table B-2** lists all Modbus function codes, and emphasizes the function codes used by Micro Motion transmitters.

Table B-2. Modbus function codes

Function code	Description	Modicon PLCs 184/384	484	584	884	Micro 84	984	Micro Motion transmitters
01	Read coil status	√	√	√	√	√	√	√
02	Read input status	√	√	√	√	√	√	√
03	Read holding registers	√	√	√	√	√	√	√
04	Read input registers	√	√	√	√	√	√	√
05	Force coil	√	√	√	√	√	√	√
06	Load register	√	√	√	√	√	√	√
07	Read exception status	√	√	√	√	√	√	√
08	Loopback diagnostic	√	√	√	√	√	√	√
09	Program 484							
10	Poll 484							
11	Communication event counter							
12	Communication event log							
13	Program-general							
14	Poll-general							
15	Force multiple coils	√	√	√	√	√	√	√
16	Load multiple registers	√	√	√	√	√	√	√
17	Report device I.D.	√	√	√	√	√	√	√
18	Program							
19	Reset communication link							
20	Read general reference							
21	Write general reference							

The transmitter-supported function codes listed in **Table B-2**, page 281, include read commands, write commands, and diagnostic commands.

- **Read commands** include function codes 01 (read coil status), 02 (read input status), 03 (read holding registers), 04 (read input registers), and 17 (report device I.D.).
- **Write commands** include function codes 05 (force coil), 06 (load register), 15 (force multiple coils), and 16 (load multiple registers).
- **Diagnostic commands** include 07 (read exception status) and 08 (loopback diagnostic).

Table B-3 explains the read commands, write commands, and diagnostic commands supported by the transmitter. The various command types are summarized on pages 283-285.

Table B-3. Explanation of function codes supported by Micro Motion® transmitters

Function code	Command type	Description	Explanation of function code
01	Read	Read coil status	Read ON/OFF status of one coil or consecutive coils
02	Read	Read input status	Read ON/OFF status of one discrete input or consecutive discrete inputs
03	Read	Read holding registers	• Read binary integer values in one holding register or consecutive holding registers • Read floating-point values in one register pair or consecutive register pairs • Read character strings in consecutive ASCII registers
04	Read	Read input registers	Read binary values in one or more input register(s)
05	Write	Force coil	Set coil to a specified ON or OFF state
06	Write	Load register	• Write a binary integer value to a holding register • Write a single precision IEEE 754 floating-point value to a register pair
07	Diagnostic	Read exception status	Read ON/OFF status of status bits that comprise the high-order byte of input register 30125. Micro Motion has programmed these bits to indicate flowmeter status. They include: Bit #0(E)EPROM checksum failure Bit #1RAM diagnostic failure Bit #2Sensor failure Bit #3Temperature sensor failure Bit #4Input overrange Bit #5Frequency overrange Bit #6Transmitter not configured Bit #7Real-time interrupt failure
08	Diagnostic	Loopback diagnostic	Send test message to transmitter to evaluate communication processing
15	Write	Force multiple coils	Set consecutive coils to an ON or OFF state
16	Write	Load multiple registers	• Write binary integer values to consecutive holding registers • Write single precision IEEE 754 floating-point values to consecutive register pairs • Write a single-write multiple character string to consecutive ASCII registers
17	Read	Report device I.D.	Report AA_{hex} device type and ON operating status

Reference to Message Framing *continued*

Function 01: Read coil status
Function 02: Read discrete input status

In the Micro Motion transmitter, functions 01 and 02 perform the same processing and are interchangeable.

Query	Address	Function **01 or 02**	Starting coil	# of coils	Error check
Response	Address	Function **01 or 02**	Byte count*	Coil status byte(s)	Error check

**Byte count is the number of data bits in the coil status byte(s) field.*

Function 03: Read multiple holding registers
Function 04: Read multiple input registers

In the Micro Motion transmitter, functions 03 and 04 perform the same processing and are interchangeable.

Query	Address	Function **03 or 04**	Starting register	# of registers	Error check
Response	Address	Function **03 or 04**	Byte count*	Register data bytes	Error check

**Byte count is the number of data bits in the register status byte(s) field.*

Function 05: Write single coil

Query	Address	Function **05**	Coil address	New coil value	Error check
Response	Address	Function **05**	Coil address	New coil value	Error check

Function 06: Write single holding register or register pair

Query	Address	Function	Register address	New register value	Error check
		06			

Response	Address	Function	Register address	New register value	Error check
		06			

Function 07: Read transmitter status

Query	Address	Function	Error check
		07	

Response	Address	Function	Transmitter status	Error check
		07		

Function 08: Loopback diagnostic

Query	Address	Function	Diagnostic code	Data	Error check
		08			

Response	Address	Function	Diagnostic code	Data	Error check
		08			

Function 15: Write multiple coils

Query	Address	Function	Starting coil	# of coils	Byte count*	Coil data byte(s)	Error check
		15					

Response	Address	Function	Starting coil	# of coils	Error check
		15			

**Byte count is the number of data bits in the coil data byte(s) field.*

Reference to Message Framing *continued*

Function 16: Write multiple holding registers or register pairs

	Address	Function	Starting register	# of registers	Byte count*	Register data byte(s)	Error check
Query		**16**				/ . . . . /	

	Address	Function	Starting register	# of registers	Error check
Response		**16**			

**Byte count is the number of data bits in the register data byte(s) field.*

Function 17: Report slave I.D.

	Address	Function	Starting register	# of registers	Error check
Query		**17**			/ . . . . /

	Address	Function	Starting register	# of registers
Response		**17**		

**Byte count is the number of data bits in the register data byte(s) field.*

Data field

In a query or broadcast frame, the data field contains information that is needed by the slave device to perform the command issued in the function field. In a response frame, the data field contains data collected by the slave in response to a query, or an exception response. A data field can contain values, address references, limits, or exception responses. The function code and the type of data in the query or broadcast frame determine the first number of each mapped address that executes the command. For example, if the function code issues a command to read input registers (function code 04), the data field in the query or broadcast frame would indicate the input register at which the reading should begin and the consecutive number of registers to read.

If a device detects errors while executing a command issued in a query, the most significant bit in the response function field is set, and the data field contains an exception response, which explains why the device cannot execute the command.

- **Table B-4**, page 286, lists all Modbus exception responses, and emphasizes the exception responses used by the transmitter.
- **Table B-5**, page 286, explains the exception responses used by the transmitter.

Table B-4. Modbus® exception responses

Function code	Description	Modicon PLCs 184/384	484	584	884	Micro 84	984	Micro Motion transmitters
01	Illegal function	√	√	√	√	√	√	√
02	Illegal data address	√	√	√	√	√	√	√
03	Illegal data value	√	√	√	√	√	√	√
04	Failure in associated device							
05	Acknowledge							
06	Busy, rejected message	√	√	√	√	√	√	√
07	NAK – Negative acknowledge							

Table B-5. Exception responses supported by Micro Motion® transmitters

Exception response	Description	Explanation of exception response
01	Illegal function	The received message function is not an allowable action for the transmitter
02	Illegal data address	The address referenced in the data field is not an allowable address for the location
03	Illegal data value	The value referenced in the data field is not allowed in the addressed location
06	Busy, rejected message	The device received the message without error, but is engaged in processing a long-duration program command

Error check field

The error check field allows the host and other network devices to check a message for data transmission errors. Electrical noise or other interference can cause a message to change during transmission from one unit to another unit in the network. Error checking assures that the host or other network device does not react to messages that have changed during data transmission.

B.5 Data types

The transmitter supports standard data types used by Modbus-compatible host controllers. The transmitter can use all the following types of data:

- Unsigned 16-bit integers, from 0 to 65535 (registers denoted as 3XXXX or 4XXXX);
- One-byte and 3-byte integers used as device identification codes or serial numbers (registers denoted as 3XXXX or 4XXXX);
- Consecutive pairs of 8-bit ASCII characters, stored one pair per 16-bit register (registers denoted as 5XXXX); and
- Floating-point values in single precision IEEE 754 format (registers denoted as 2XXXX).

The types of data written to and returned from the transmitter depend on the capabilities of the host controller. The transmitter can accept, store, and return integers, floating-point values, and ASCII characters regardless of the 8-bit RTU or 7-bit ASCII data transmission mode used

Reference to Message Framing *continued*

by the Modbus-compatible host controller. **Table B-6** lists the data types supported by the transmitter.

Table B-6. Data types according to function code and mapped address

Note

The first character in the mapped address is for notation purposes only, and might not be the same as the notational convention used by a specific host controller.

Mapped address	Accessible via function codes	Address type	Access	Description
0XXXX	01, 05, 15	Coil	Read/write	Single on/off bit per coil (Boolean)
1XXXX	02	Discrete input	Read-only	Single on/off bit per coil (Boolean)
2XXXX	03, 04, 06, 16	Floating-point register	Read-only and read/write	• Two consecutive 16-bit registers in single precision IEEE 754 format • Mapped to same locations as input registers (3XXXX) and holding registers (4XXXX)
3XXXX	04	Input register	Read-only	• One 16-bit unsigned integer per register • Mapped to same locations as floating-point registers (2XXXX) and ASCII registers (5XXXX)
4XXXX	03, 06, 16	Holding register	Read/write	• One 16-bit unsigned integer per register • Mapped to same locations as floating-point registers (2XXXX) and ASCII registers (5XXXX)
5XXXX	03, 04, 06, 16	ASCII characters	Read/write	• Two ASCII characters per 16-bit register in format compatible with some controllers that use ASCII data transmission mode • Mapped to same locations as input registers (3XXXX) and holding registers (4XXXX)

Data addresses and number of points

Many of the Modbus functions require sending the data start address and/or the number of points in the data field of the Modbus query. Each data start address and number of query are passed in 2 bytes (16 bits), high order byte first. See **Table B-7**.

Table B-7. Data transmission order for start address and number of query

Transmitted first	TRANSMISSION ORDER Transmitted last
High order address	Low order address
High order number of points	Low order number of points

Coils and discrete inputs

Transmitter status bits, security option selections, and transmitter action initiators are provided by the transmitter as discrete inputs or coils.

Transmitter status indication bits, such as *zeroing operation failed*, are read-only. They can be read through the discrete input function 2 or the coil/exception status functions 1 or 7.

Security option selections, used primarily for custody transfer applications, can be read using Modbus functions 1 and 2, and written using Modbus function 5.

Transmitter action initiators, such as *start/stop totalizers*, can be read using Modbus commands 1 and 2, and written using Modbus function 5. Some initiators are "sticky," meaning they will stay in the state that was last written to them, such as *start/stop totalizers*. Other initiators are momentary, meaning they initiate an action when written as ON, and immediately switch back to OFF, such as *reset totalizers*. The third type of initiator is transitory, and will switch to OFF when the action is complete, such as *perform low-density calibration*. *Perform flow zero* is a special case of transitory initiator in that the action can be stopped by writing OFF to the coil prior to its automatic completion by the transmitter.

Writing coils

Coils are written individually or as a group of contiguous values. When written individually with function 5, the data value 65,280 (FF00 HEX) sets the coil ON, and 0 turns the coil OFF. When written as a group of contiguous values using function 15, each bit within the data bytes represents a single coil, with lower addresses represented by lower order bits within the byte. If more than 8 coils are written, the first 8 coils will be written in the first byte, the next 8 coils in the next byte, and so on. The last data byte transmitted may contain fewer than 8 coils, with the high order bit(s) as *don't care*. In each of these cases a 1 turns the coil ON and a 0 turns the coil OFF.

Reading coils and discrete inputs

Coils and discrete inputs are read as a group of one or more contiguous values using functions 1 or 2. Each bit within the data bytes represents a single coil or discrete input, with lower addresses represented by lower order bits within the byte. If more than 8 coils or discrete inputs are read, the first 8 will be read from the first byte, the next 8 from the next byte, and so on. The last data byte read may contain fewer than 8 coils or discrete inputs, with the high order bit(s) equal to 0. In each of these cases, 1 represents ON and 0 represents OFF.

Integer data

Process variable data, scaling of process variable data, status information, and some configuration data are available from the transmitter as integer data. Integer data can be read from Modbus input or holding registers using functions 3 and 4, and written to Modbus holding registers using functions 6 and 16 (although not all integer data can be written).

Registers are transmitted high order byte first. See **Table B-8**.

Table B-8. Data transmission order for integer data

Transmitted first	TRANSMISSION ORDER	Transmitted last
High order data byte		Low order data byte

For functions that support multiple registers, data are transmitted from consecutive registers, beginning with lower addressed registers, then higher-addressed registers.

Some integer data from the transmitter, such as *transmitter serial number*, represent numbers larger than 65,535, which is the largest number that can be represented by a single register. In these cases, the high order 16-bits of the data bytes are transmitted first (i.e. in the lower-addressed register), followed by the lower order data.

ASCII (string) data

String data, such as the *flow calibration factor*, are represented as a consecutive group of ASCII characters. The standard Modbus functions for transmitting input and holding registers (functions 3, 4, 6, and 16) are used for transmitting string data. Each register contains 2 ASCII characters.

When reading and writing string data, partial strings are not permitted by the transmitter. Because of this, string data must be written using command 16.

To accommodate Modbus-compatible hosts more efficiently, such as the Honeywell Serial Interface (SI), string data are padded to even multiples of 4, 8, 16, or 32 characters. To accomplish this padding, the space character is used for data reading from the transmitter, and *don't care* is used for data sent to the transmitter.

Floating point data

Process variable data, status information, and some configuration data are available from the transmitter as floating-point data. The standard Modbus functions for transmitting input and holding registers (functions 3, 4, 6, and 16) are used for transmitting floating-point data. The data are represented in 32-bit IEEE 754 single precision floating-point format.

Data transmission order required by RFT9739 transmitter
The RFT9739 transmitter requires floating-point data to be transmitted in the following order: byte #2, byte #3, byte #0, byte #1.

Floating point data transmission order if integer code 1 is written to holding register 40521

Transmitted first	Transmitted second	Transmitted third	Transmitted last
Byte #2	**Byte #3**	**Byte #0**	**Byte #1**
M M M M M M M M	M M M M M M M M	S E E E E E E E	E M M M M M M M

Where:
S = sign of the mantissa, 1 = negative
E = exponent, biased by 127 decimal in twos complement format
M = mantissa, 23 least significant bits, fractional portion

Data transmission order for MVDSolo or Series 1000 or 2000 transmitter

The Series 1000 or 2000 transmitter can transmit data in the order that is required by the RFT9739 transmitter, or in the order that you specify. To specify a data transmission order other than the order that is required by the RFT9739 transmitter, write integer code 0, 2, or 3 to holding register 40521, as listed in **Table B-9**. See the illustrations, below.

Table B-9. Floating point byte ordering holding register

Holding register	Integer code	Floating-point byte order	MVDSolo	Series 1000	Series 2000
40521	0	0-1-2-3	√	√	√
	1	2-3-0-1 (RFT9739 compatibility)	√	√	√
	2	1-0-3-2	√	√	√
	3	3-2-1-0	√	√	√

Floating point data transmission order if integer code 0 is written to holding register 40521

Transmitted first	Transmitted second	Transmitted third	Transmitted last
Byte #0	**Byte #1**	**Byte #2**	**Byte #3**
S E E E E E E E	E M M M M M M M	M M M M M M M M	M M M M M M M M

Floating point data transmission order if integer code 2 is written to holding register 40521

Transmitted first	Transmitted second	Transmitted third	Transmitted last
Byte #1	**Byte #0**	**Byte #3**	**Byte #2**
E M M M M M M M	S E E E E E E E	M M M M M M M M	M M M M M M M M

Floating point data transmission order if integer code 3 is written to holding register 40521

Transmitted first	Transmitted second	Transmitted third	Transmitted last
Byte #3	**Byte #2**	**Byte #1**	**Byte #0**
M M M M M M M M	M M M M M M M M	E M M M M M M M	S E E E E E E E

Value of floating-point numbers

The value of the floating-point number is obtained as shown in the equation below. The 24-bit mantissa is composed of an assumed most significant bit of 1, a decimal point following the 1, and the 23 bits of the mantissa:

$$S1M \times 2^{E-127}$$

Invalid data, such as *bad process variable*, are represented by the hexadecimal (not a number) value 00 00 7F A0 for the RFT9739 transmitter, or .0 x 7F A 00000 for the Series 1000 or 2000 transmitter.

Reference to Message Framing *continued*

The 4 bytes that represent a floating-point value are stored in two consecutive Modbus input or holding registers.

When reading and writing floating-point data, partial numbers are not permitted by the transmitter. Because of this, floating-point data must be written using command 16.

B.6 Data transmission modes

Modbus protocol allows framing of messages in ASCII or RTU data transmission mode. The equipment that serves as the host determines the mode used by all the devices in the network.

In RTU mode, messages consist of 8-bit binary characters, while in ASCII mode a message consists of 7-bit ASCII characters. To obtain the ASCII mode representation of a message, each 8-bit RTU character is divided into two 4-bit parts: a high order part and a low order part. Each of these 4-bit parts is then converted to its hexadecimal equivalent, and the 7-bit ASCII codes corresponding to the hexadecimal numbers are transmitted. ASCII mode requires approximately twice as many characters as RTU mode because a single 8-bit RTU character equals two 7-bit ASCII characters.

Modbus protocol also has several levels of error checking, including automatic redundancy checks. The data transmission mode determines the form of the redundancy checks: ASCII mode relies on Longitudinal Redundancy Checks (LRC); RTU mode relies on Cyclic Redundancy Checks (CRC).

Table B-10 compares ASCII and RTU data transmission modes.

Table B-10. Comparison of ASCII and RTU data transmission modes

Characteristics of mode	ASCII (7-bit)	RTU (8-bit)
Coding system	Hexadecimal (ASCII printable characters 0-9, A-F)	8-bit binary
Number of bits: Start bits Data bits (least significant first) Optional parity bits (in data field only) Stop bits	 1 7 1 for odd or even parity 1 or 2	 1 8 1 for odd or even parity 1 or 2
Error checking	LRC (Longitudinal Redundancy Checks)	CRC (Cyclic Redundancy Checks)

Message framing in ASCII mode

In the ASCII mode, each frame has a start delimiter, an address field, a function field, a data field, an error check field, and an end delimiter.

The colon character (:) is the start delimiter, and the carriage return (CR) and line feed (LF) are the end delimiter. The line feed also serves as a synchronizing character, which indicates that the transmitting station is ready to receive an immediate response.

ASCII mode allows breaks of up to one second in duration to occur between characters.

Address fields, function fields, and error check fields can contain 2 ASCII hexadecimal characters or 16 bits. The data field contains a multiple of 2 ASCII characters or a multiple of 16 bits. An ASCII character has 1 start bit, 7 data bits, and 1 or 2 stop bits. If parity is used, the data field has a single parity bit. **Table B-11** illustrates an ASCII frame.

Table B-11. ASCII message frame format

Beginning of frame	Address field	Function field	Data field	Error check field	End of frame	Ready to receive response
2-character format						
:	2 characters	2 characters	n x 4 characters	2 characters	Carriage return	Line feed
6-bit format						
:	16 bits	16 bits	n x 16 bits	16 bits	Carriage return	Line feed

Message framing in RTU mode

In the Remote Terminal Unit (RTU) mode of data transmission, each frame has an address field, a function field, a data field, and an error check field. Messages are transmitted as a continuous stream of binary characters.

Messages are terminated when no characters are sent in the time required to transmit 3½ characters. This 3½ character gap time frames each query or response message and synchronizes Modbus RTU communications.

The receiving device monitors the elapsed time between receipt of characters. If the time gap between characters in a frame exceeds the time required to receive 3½ characters, the receiving device flushes the frame and assumes the next byte received will be a polling address.

Address fields and function fields each contain one RTU character. Data fields can contain no characters, or can contain 1 or more RTU characters. Error check fields contain 2 RTU characters. An RTU character has 1 start bit, 8 binary data bits, and 1 or 2 stop bits. If parity is used, the data field has a single parity bit. **Table B-12** illustrates an RTU frame.

Table B-12. RTU message frame format

Elapsed time	Address field	Function field	Data field	Error check field	Elapsed time
Maximum time is time needed to send 3½ characters	(8 bits) 1 character	(8 bits) 1 character	(8 bits + optional parity bit) n x 1 character	(2 x 8 bits) 2 characters	Maximum time is time needed to send 3½ characters

B.7 Error checking

Error checking includes the hardware determination of parity bits, longitudinal redundancy checking for the ASCII mode, and cyclic redundancy checking for the RTU mode.

Hardware determination of parity bits

The Modbus system follows these steps to determine whether it should use 1 or a 0 as the parity bit:

- It adds the number of ones in the data.
- It determines whether the number is even or odd.

Even parity

- In even numbers, the system adds a 0 to retain an even number of ones.
- In odd numbers, the system adds a 1 to create an even number of ones.

For example, in even parity the value 0110 1000 would have a 1 as the parity bit, whereas the value 0110 1010 would have a 0 as the parity bit.

Odd parity

The system adds a 1 or a 0 so the data will have an odd number of ones.

If a message contains two errors, parity sometimes cannot detect the changes. If data transmission distorts 0010 0000 to 0010 0011, the value still will have an odd number of ones. For this reason, the Modbus system provides several error checking levels to ensure the integrity of the data. The system uses redundancy checks to detect multibit errors in which the data has *not* changed. The system automatically performs Longitudinal Redundancy Checks (LRC) on ASCII data and Cyclic Redundancy Checks (CRC-16) on RTU data.

Longitudinal redundancy check sequence for ASCII mode

In ASCII mode, the error check is an 8-bit binary number represented as 2 ASCII hexadecimal characters. The unit that transmits the message divides the hexadecimal characters into 4-bit high order and 4-bit low order binary parts, adds the binary characters without wraparound carry, derives a ones complement of the sum, and then adds 1, thereby deriving a twos complement.

In calculating the LRC, the Modbus system ignores the colon (:) that begins the frame, the carriage return and line feed that end the frame, and all non-ASCII hexadecimal characters.

Example

LRC produced by a host that sends a query to transmitter 02, asking it to read the first 8 logic coils:

Address	0	2	....	0000	0010
Function code	0	1	....	0000	0001
Start add high order part	0	0	....	0000	0000
Start add low order part	0	0	....	0000	0000
Quantity of parts	0	0	....	0000	0000
Read first 8 coils	0	8	....	0000	1000
				0000	1011
			Ones complement	1111	0100
			+1	0000	0001
			Twos complement	**1111**	**0101**
Error check	F	5	....	F	5

The transmitter sums up all received data bytes, including the LRC:

Error check	F	5	....	F	5
Address	0	2	....	0000	0010
Function code	0	1	....	0000	0001
Start add high order part	0	0	....	0000	0000
Start add low order part	0	0	....	0000	0000
Quantity of parts	0	0	....	0000	0000
			Read first 8 coils OK	0000	1000
			Error check	**1111**	**0101**
			SUM	0000	0000

The 8-bit values should all equal zero. The sum can exceed 8 bits, but only the low order bits should be saved.

Cyclic redundancy check for RTU mode

The Modbus system follows these steps to implement the CRC-16 sequence:

1. The system regards the message as one continuous binary number *with its most significant bit (MSB) transmitted first*. (The system regards the message as data bits only, while disregarding start/stop bits and optional parity bits.)
2. The system pre-multiplies X16 by the continuous binary number (shifts it left 16 bits), then divides the resulting product by the polynomial X16 + X15 + X2 + 1 expressed as the binary number 1100 0000 0000 0101.
3. The system ignores the integer quotient digits, then appends the 16-bit remainder to the message (*MSB first*) as the 2 CRC check bytes. (The 16-bit remainder is first initialized to all ones to prevent acceptance of all zeros as a message.)
4. If no errors have occurred, the received message (including the CRC) will leave a remainder of 0 when divided by the polynomial X16 + X15 + X2 + 1. (The receiver recalculates the CRC and compares it to the transmitted CRC.)

Reference to Message Framing *continued*

All arithmetic is performed without carries. The device that serializes the data for transmission *sends the conventional least significant bit (LSB) or farthest-right bit of each character first*. In generating the CRC, the first transmitted bit represents the MSB of the dividend. So, since the arithmetic is performed without carries, assume the MSB is farthest right during computation of the CRC, and the bit order of the generating polynomial is reversed. The MSB of the polynomial is dropped, because it affects the quotient but not the remainder. This yields 1010 0000 0000 0001 (Hex A001). Reversing the bit order does not affect the interpretation of the bit order of characters external to the CRC calculations.

Given these assumptions, the following example illustrates a CRC-16 error check for a read exception status query (function code 07) sent to transmitter 02, with the check bytes formed according to this step-by-step procedure:

1. Load a 16-bit register with all ones.
2. Exclusive OR the first 8-byte with the low order byte of the 16-bit register.
3. Shift the 16-bit register 1 bit to the right.
4. If the flag (the bit shifted out to the right) is a 1, exclusive OR the generating polynomial 1010 0000 0000 0001 with the 16-bit register.
5. If the flag is a 0, again shift the register one bit to the right.
6. Repeat Step 3 until 8 shifts have been performed.
7. Exclusive OR the next 8-byte with the low order byte of the 16-bit register.
8. Repeat Steps 3 through 6 until all message bytes have been exclusive OR'ed with the generating polynomial and then shifted eight times.
9. The 16-bit register contains the 2-byte CRC error check. The error check is added to the message, least significant bytes first.

Table B-13, page 296, illustrates this step-by-step procedure.

Table B-13. Example CRC (read exception status from slave 02)

Step	16-bit register				Flag
Load 16-bit register with all ones	1111	1111	1111	1111	
Message byte: Address 02			**0000**	**0010**	
Exclusive address 02 OR high order byte of 16-bit register	1111	1111	1111	1101	
Shift 1	0111	1111	1111	1110	1
Generating polynomial	1010	0000	0000	0001	
Exclusive generating polynomial OR shift 1	1101	1111	1111	1111	
Shift 2	0110	1111	1111	1111	1
Generating polynomial	1010	0000	0000	0001	
Exclusive generating polynomial OR shift 2	1100	1111	1111	1110	
Shift 3	0110	0111	1111	1111	0
Shift 4	0011	0011	1111	1111	1
Generating polynomial	1010	0000	0000	0001	
Exclusive generating polynomial OR shift 4	1001	0011	1111	1110	
Shift 5	0100	1001	1111	1111	0
Shift 6	0010	0100	1111	1111	1
Generating polynomial	1010	0000	0000	0001	
Exclusive generating polynomial OR shift 6	1000	0100	1111	1110	
Shift 7	0100	0010	0111	1111	0
Shift 8	0010	0001	0011	1111	1
Generating polynomial	1010	0000	0000	0001	
Exclusive generating polynomial OR shift 8	1000	0001	0011	1110	
Message byte: Function code 07 (read exception status)			**0000**	**0111**	
Exclusive function code 07 OR high order byte of 16-bit register	1000	0001	0011	1001	
Shift 1	0100	0000	1001	1100	1
Generating polynomial	1010	0000	0000	0001	
Exclusive generating polynomial OR shift 1	1110	0000	1001	1101	
Shift 2	0111	0000	0100	1110	1
Generating polynomial	1010	0000	0000	0001	
Exclusive generating polynomial OR shift 2	1101	0000	0100	1111	
Shift 3	0110	1000	0010	0111	1
Generating polynomial	1010	0000	0000	0001	
Exclusive generating polynomial OR shift 3	1100	1000	0010	0110	
Shift 4	0110	0100	0001	0011	0
Shift 5	0011	0010	0000	1001	1
Generating polynomial	1010	0000	0000	0001	
Exclusive generating polynomial OR shift 5	1001	0010	0000	1000	
Shift 6	0100	1001	0000	0100	0
Shift 7	0010	0100	1000	0010	0
Shift 8	0001	0010	0100	0001	0
Result	**1**	**2**	**4**	**1**	

Reference to Message Framing *continued*

Add the 16-bit register, with its most significant bits first, to the message. So the error check field now contains the last 16-bit register as the two 8-bit characters 0001 0010 (Hex 12) and 0100 0001 (Hex 41). The transmitted message, including the CRC-16 and shifted to the right, looks like **Table B-14**.

Table B-14. Result of example CRC

Address field	Function field	Error check field	
Hex 02	Hex 07	Hex 41	Hex 12
0000 0010	0000 0111	0100 0001	0001 0010

Appendices

C Configuration Record

C.1 About this appendix

This appendix is designed to serve as a configuration record for the Micro Motion transmitter.

The configuration record is organized to match the chapter structure of this manual. In the configuration record, there is a separate section for the configuration settings discussed or defined in each chapter.

Because not all transmitters have all configuration options, not all fields in the configuration record will apply to your transmitter.

C.2 Configuration record

As you work through this manual, enter your configuration into the configuration record below. You may enter it in any form that is convenient for you. For example, you may choose g/sec as your mass flow unit. You can enter either g/sec or the corresponding integer code (70), or both.

Table C-1. Sensor and Transmitter Information – Chapter 5

Configuration option	Site value
Sensor serial number	______________________
Sensor flange type	______________________
Flow tube material	______________________
Flow tube liner material	______________________
Sensor type	______________________
HART or Modbus polling address	______________________
Assembly number	______________________
Date	______________________
HART protocol device identifier	______________________
Modbus polling address	______________________
Core processor I.D.	______________________
Hart device tag	______________________
Transmitter description	______________________
Message	______________________
Sensor description	______________________

Table C-2. Outputs, Option Boards, and Communications – Chapter 6

Configuration option	Site value		
Configurable IO board			
Channel A	__ Milliamp (non-configurable)		
Channel B	__ Milliamp		
	__ Frequency	Output mode	__ Single
			__ Quadrature
			__ Dual pulse w/ 0° phase shift
			__ Dual pulse w/ 180° phase shift
			__ Dual pulse w/ +90° phase shift
			__ Dual pulse w/ -90° phase shift
	__ Discrete output		
	Power source	__ External	
		__ Internal	
Channel C	__ Frequency	Output mode	__ Single
			__ Quadrature
			__ Dual pulse w/ 0° phase shift
			__ Dual pulse w/ 180° phase shift
			__ Dual pulse w/ +90° phase shift
			__ Dual pulse w/ -90° phase shift
	__ Discrete output		
	__ Discrete input		
	Power source	__ External	
		__ Internal	
Frequency output polarity	__ Active low	__ Active high (default)	
Series 2000 discrete output	__ Frequency output	__ Discrete output	
HART polling address	____________________		
HART device tag	____________________		
Modbus polling address	____________________		
Burst mode	__ Disabled	__ Enabled	__ Primary variable
			__ Primary variable current and percent of range
			__ Dynamic variables and primary variable current
			__ Transmitter variables Variable 1 __________
			Variable 2 __________
			Variable 3 __________
			Variable 4 __________
External polling device #1			
Address	____________________		
Polling control type	__ 0 (no polling)	__ 1 (HART primary master)	__ 2 (HART secondary master)
Polled data	__ Pressure	__ Temperature	
External polling device #2			
Address	____________________		
Polling control type	__ 0 (no polling)	__ 1 (HART primary master)	__ 2 (HART secondary master)

Configuration Record *continued*

Table C-2. Outputs, Option Boards, and Communications – Chapter 6 *continued*

Configuration option	Site value	
Polled data	__ Pressure	__ Temperature
Fieldbus simulation	__ Disabled	__ Enabled
Profibus station address	__ Default	__ Other ____________

Table C-3. Measurement Units for Process Variables – Chapter 7

Configuration option	Site value			
Mass flow unit	__________________	__ Special __________	Base unit	__________________
			Time unit	__________________
			Conversion factor	__________________
			Description	__________________
Mass total/ mass inventory unit	__________________	__ Special __________	Base unit	__________________
			Time unit	__________________
			Conversion factor	__________________
			Description	__________________
Volume flow unit	__________________	__ Special __________	Base unit	__________________
			Time unit	__________________
			Conversion factor	__________________
			Description	__________________
Volume total/ volume inventory unit	__________________	__ Special __________	Base unit	__________________
			Time unit	__________________
			Conversion factor	__________________
			Description	__________________
Density unit	__________________			
Temperature unit	__________________			
Pressure unit	__________________			

Table C-4. Using Process Variables – Chapter 8

Configuration option	Site value	
Maximum integer	__ 65534 (default)	__ Other ____________
Scaled integers		
Process variable #1	__________________	
Scale factor	__________________	
Offset	__________________	
Process variable #2	__________________	
Scale factor	__________________	
Offset	__________________	
Process variable #3	__________________	

Table C-4. Using Process Variables – Chapter 8 *continued*

Configuration option	Site value
Scale factor	________________
Offset	________________
Process variable #4	________________
Scale factor	________________
Offset	________________

Table C-5. Reporting Process Data with Outputs – Chapter 9

Configuration option	Site value		
Milliamp output #1			
Output range	__ 0-20 mA	__ 4-20 mA	
Process variable	________________	URV _________	Low-flow cutoff ____________
		LRV _________	Added damping ____________
Milliamp output #2			
Output range	__ 0-20 mA	__ 4-20 mA	
Process variable	________________	URV _________	Low-flow cutoff ____________
		LRV _________	Added damping ____________
Frequency output			
Process variable	________________		
Scaling method	__ 0 (Frequency=flow)	Frequency	________________
		Flow rate	________________
	__ 1 (Pulses/unit)	Frequency	________________
	__ 2 (Units/pulse)	Flow rate	________________
RFT9739 output scaling	Frequency	________________	
	Flow rate	________________	
Pulse width	________________		
Quaternary variable			
Process variable	________________		
100 Hz mode	__ Enabled	Process variable	________________
	__ Disabled		

Table C-6. Process Variables and Field Conditions – Chapter 10

Configuration option	Site value	
Low-flow cutoffs for totalizers and frequency output		
Mass flow rate	________________	
Volume flow rate	________________	
Low-density cutoff	________________	
Flow direction	__ Forward only	__ Absolute forward/reverse
	__ Reverse only	__ Negate – forward only
	__ Bidirectional	__ Negate – bidirectional
Digital damping	__ Default (.8 sec)	__ Other _________

Table C-6. Process Variables and Field Conditions – Chapter 10 *continued*

Configuration option	Site value
Slug flow	
High density limit	________________
Low density limit	________________
Slug duration	________________

Table C-7. Process Controls – Chapter 11

Configuration option	Site value		
Fault outputs			
RFT9739 Version 2 fault output	__ Upscale	__ Last measured value	
	__ Downscale	__ Internal zero	
mA output #1	__ Upscale	__ Downscale	__ Internal zero
mA output #2	__ Upscale	__ Downscale	__ Internal zero
Frequency/ pulse output	__ Upscale	__ Downscale	__ Internal zero
RS-485 digital output	__ Upscale	__ Internal zero	__ Flow zero
	__ Downscale	__ Not-a-number	__ None
Last measured value period (sec)	__ Default	__ Other ________	
RFT9739 control output	__ Forward/reverse flow		
	__ Zero in progress		
	__ Faults		
	__ Event 1		
	__ Event 2		
Discrete output – Channel B	__ Event 1 active		
	__ Event 2 active		
	__ Event 1 or event 2 active		
	__ Flow switch indicator	Flow switch setpoint	________________
	__ Forward/reverse indicator		
	__ Calibration in progress		
	__ Fault indicator		
Discrete output – Channel C	__ Event 1 active		
	__ Event 2 active		
	__ Event 1 or event 2 active		
	__ Flow switch indicator	Flow switch setpoint	________________
	__ Forward/reverse indicator		
	__ Calibration in progress		
	__ Fault indicator		
RFT9739 Event 1			
Process variable	________________		
Alarm state	__ High	__ Low	
Setpoint	________________		
Output assignment	__ Milliamp output #1	__ Milliamp output #2	__ RFT9739 control output
Current levels	High	________________	
	Low	________________	
RFT9739 Event 2			

Table C-7. Process Controls – Chapter 11 *continued*

Configuration option	Site value		
Process variable	________________		
Alarm state	__ High	__ Low	
Setpoint	________________		
Output assignment	__ Milliamp output #1	__ Milliamp output #2	__ RFT9739 control output
Current levels	High	________________	
	Low	________________	
Series 1000/2000 Event #1			
Process variable	________________		
Alarm state	__ High	__ Low	
Setpoint	________________		
Output assignment	__ none		
	__ discrete output #1 (Channel B)		
	__ discrete output #2 (Channel C)		
Series 2000 Event #2			
Process variable	________________		
Alarm state	__ High	__ Low	
Setpoint	________________		
Output assignment	__ none		
	__ discrete output #1 (Channel B)		
	__ discrete output #2 (Channel C)		
	__ Resettable via display		
Series 1000/2000 totalizers	__ Not resettable via display		
RFT9739 totalizer security mode	________________		
	__ None		
	__ Start sensor zero		
	__ Reset mass total		
	__ Reset volume total		
Discrete input assignment	__ Reset corrected volume total		

Table C-8. Pressure Compensation – MVD – Chapter 12

Configuration option	Site value	
Pressure compensation	__ Disabled	__ Enabled
Pressure correction factor	Flow	________________
	Density	________________
Flow calibration pressure	________________	
Gauge pressure	__ Static____________	
	__ Dynamic	__ Polling
		__ Externally controlled

Configuration Record *continued*

Table C-9. Pressure Compensation – RFT9739 – Chapter 13

Configuration option	Site value			
Pressure value receiving method	__ None __ HART primary __ HART secondary __ Analog __ Modbus			
Pressure correction factor		Flow	___________	___________
		Density	___________	
Analog input	4mA gauge pressure	___________		
	20 mA gauge pressure	___________		
Static pressure value		___________		
Flow calibration pressure		___________		
Flow calibration factor		___________		
Meter factor for flow		___________		
Density calibration factor (K2)		___________		
Meter factor for density		___________		

Table C-10. Configuring the API Feature – Chapter 14

Configuration option	Site value			
Reference temperature table	__ 5A	__ 6C	__ 23D	__ 53B
	__ 5B	__ 23A	__ 24C	__ 53D
	__ 5D	__ 23B	__ 53A	__ 54C
Reference temperature		__ 60°F	__ 15°C	__ Other ___________
Thermal expansion coefficient		___________		
Temperature compensation		__ Static	Value	___________
		__ Real-time	__ Sensor temperature	
			__ External temperature device	
API feature		__ Disabled	__ Enabled	

Table C-11. Configuring the Display – MVD – Chapter 15

Configuration option	Site value	
Coil 00094	__ OFF	__ ON
Coil 00095	__ OFF	__ ON
Coil 00096	__ OFF	__ ON
Coil 00097	__ OFF	__ ON
Coil 00098	__ OFF	__ ON
Coil 00099	__ OFF	__ ON
Scroll rate	___________	

Table C-11. Configuring the Display – MVD – Chapter 15 *continued*

Configuration option	Site value	
Line 1 display variable	________________	
Line 2 display variable	________________	
Line 3 display variable	________________	
Line 4 display variable	________________	
Line 5 display variable	________________	
Line 6 display variable	________________	
Line 7 display variable	________________	
Line 8 display variable	________________	
Line 9 display variable	________________	
Line 10 display variable	________________	
Line 11 display variable	________________	
Line 12 display variable	________________	
Line 13 display variable	________________	
Line 14 display variable	________________	
Line 15 display variable	________________	
Offline menu password	________________	
Alarm menu access	__ Disabled	__ Enabled

Configuration Record *continued*

Table C-12. Slot Addresses – MVD – Chapter 16

Configuration option		Site value	Configuration option		Site value
Slot address sequence holding registers – mapped addresses	40655	____________	Slot address sequence holding registers – process variables	40751	____________
	40656	____________		40752	____________
	40657	____________		40753	____________
	40658	____________		40754	____________
	40659	____________		40755	____________
	40660	____________		40756	____________
	40661	____________		40757	____________
	40662	____________		40758	____________
	40663	____________		40759	____________
	40664	____________		40760	____________
	40665	____________		40761	____________
	40666	____________		40762	____________
	40667	____________		40763	____________
	40668	____________		40764	____________
	40669	____________		40765	____________
	40670	____________		40766	____________
	40671	____________		40767	____________
	40672	____________		40768	____________
	40673	____________		40769	____________
	40674	____________		40770	____________
	40675	____________		40771	____________
	40676	____________		40772	____________
	40677	____________		40773	____________
	40678	____________		40774	____________
	40679	____________		40775	____________
	40680	____________		40776	____________
	40681	____________		40777	____________
	40682	____________		40778	____________
	40683	____________		40779	____________
	40684	____________		40780	____________
	40685	____________		40781	____________
	40686	____________		40782	____________

Table C-13. Characterization – Chapter 17

Configuration option	Site value
Meter factor for mass	________________
RFT9739 Version 2 flow calibration factor	________________
D1	________________
D2	________________
K1	________________
K2	________________
K3	________________
FD	________________
Temperature coefficient for density	________________
Temperature calibration factor	________________
T-Series characterization factors	________________
FTG	________________
FFC	________________
DTG	________________
DFQ1	________________
DFQ2	________________
D1	________________
D2	________________
K1	________________
K2	________________
FD	________________
TC	________________

Table C-14. Calibration – Chapter 18

Configuration option	Site value
RFT9739 standard deviation limit	________
Flowmeter zero time	________
Temperature calibration factor	________

Table C-15. Meter Factors – Chapter 19

Configuration option	Site value
Meter factor	
Mass flow	________
Volume flow	________
Density	________

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Table C-16. RFT9739 Security and Administration – Chapter 20

Configuration option	Site value		Configuration option	Site value	
Calibration factor security coils			**Calibration factor security coils**		
00113	__ OFF	__ ON			
00125	__ OFF	__ ON			
00114	__ OFF	__ ON	00137	__ OFF	__ ON
00115	__ OFF	__ ON	00138	__ OFF	__ ON
00116	__ OFF	__ ON	00139	__ OFF	__ ON
00117	__ OFF	__ ON	00140	__ OFF	__ ON
00118	__ OFF	__ ON	00142	__ OFF	__ ON
00119	__ OFF	__ ON	00144	__ OFF	__ ON
00120	__ OFF	__ ON	00145	__ OFF	__ ON
00121	__ OFF	__ ON	00146	__ OFF	__ ON
00122	__ OFF	__ ON	00147	__ OFF	__ ON
00123	__ OFF	__ ON	00148	__ OFF	__ ON
00124	__ OFF	__ ON	00149	__ OFF	__ ON
00126	__ OFF	__ ON	00150	__ OFF	__ ON
00127	__ OFF	__ ON	00151	__ OFF	__ ON
00128	__ OFF	__ ON	00152	__ OFF	__ ON
00129	__ OFF	__ ON	00153	__ OFF	__ ON
00130	__ OFF	__ ON	00154	__ OFF	__ ON
00131	__ OFF	__ ON	00155	__ OFF	__ ON
00132	__ OFF	__ ON	00156	__ OFF	__ ON
00133	__ OFF	__ ON	00157	__ OFF	__ ON
00134	__ OFF	__ ON	00158	__ OFF	__ ON
00135	__ OFF	__ ON	00159	__ OFF	__ ON
00136	__ OFF	__ ON	00160	__ OFF	__ ON

Table C-17. Reference to Message Framing – Appendix B

Configuration option	Site value
Floating-point data transmission order	__ 0-1-2-3
	__ 2-3-0-1
	__ 1-0-3-2
	__ 3-2-1-0

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