Coriolis
Mass Flow Meters

Coriolis Flow Meter

HART® Bidirectional Communication Protocol Data Access

Badger Meter

CRL-UM-01858-EN-01 (September 2016)

User Manual

CONTENTS

ABOUT THIS MANUAL

Definitions

DD	Device Description
HART	Highway Addressable Remote Transducer
HOST	Host System, typically the master (i.e. handheld device)
PV	Primary Variable
SV	Secondary Variable
TV	Tertiary Variable
FV	Fourth Variable

Scope

This document describes the supported features of HART and how these features are related to the Coriolis. This document also discusses special considerations and the type of data that is accessible over HART. This document is intended for readers who have a general understanding of the HART protocol. For further information regarding the HART protocol please refer to *www.hartcomm.org*.

The Coriolis HART communication card supports Universal Command Revision 7. This document is intended to complement other documentation for the RCT1000 Coriolis mass flow meter and the RCTX transmitter.

INTRODUCTION

HART protocol provides the means for sending and receiving digital information across analog wires. HART is a bidirectional communication protocol that provides data access between intelligent field instruments (like the Coriolis) and host systems (like the Emerson Field Communicator). HART technology is a master/slave protocol, which means that a field device only speaks when spoken to by a master. The Coriolis operates as a slave device. In order to connect with the Coriolis using the HART protocol, the HART communication card is required. As an accessory module to the Coriolis RCTX transmitter, the HART communication card allows access to many of the Coriolis measurements and configuration data using the analog wires. In addition, the HART communication card allows for real-time control and monitoring of the Coriolis.

The Device Description (DD) files for the Coriolis are located on *www.hartcomm.org* under *Product Catalog* > *All Products* > *Coriolis*. These files describe the supported features and functions of the Coriolis with respect to HART. The DD includes details of menus and graphic display features to be used by host applications in order to access all parameters and data in the Coriolis. These files describe what parameters are accessible and should be installed in host systems.

INSTALLATION

The HART communications board is compatible with RCTX transmitters. The board can be ordered on the Coriolis transmitter with the communication option "H". Analog output 1 (Iout 1) becomes the HART signal output once the HART card is installed.

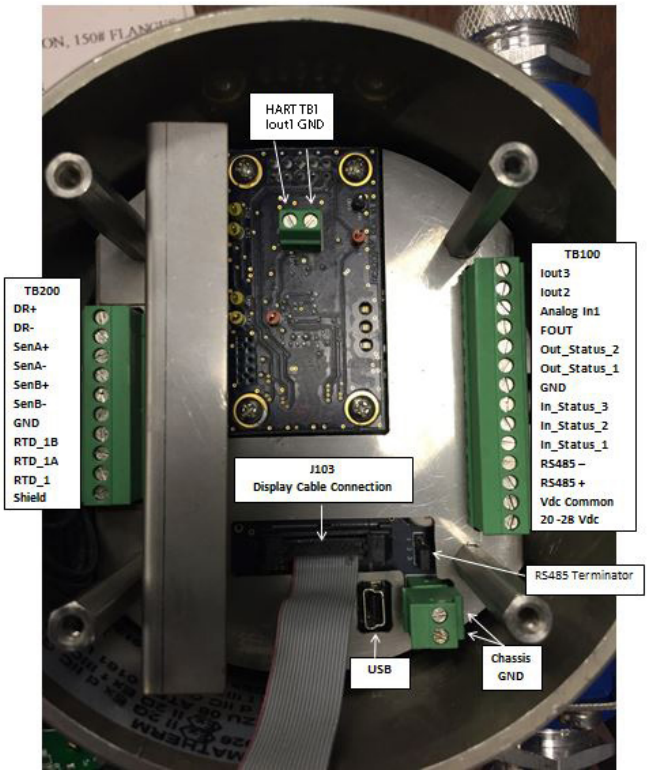

Figure 1: Wiring reference: RCTX with display shown with display board removed for clarity

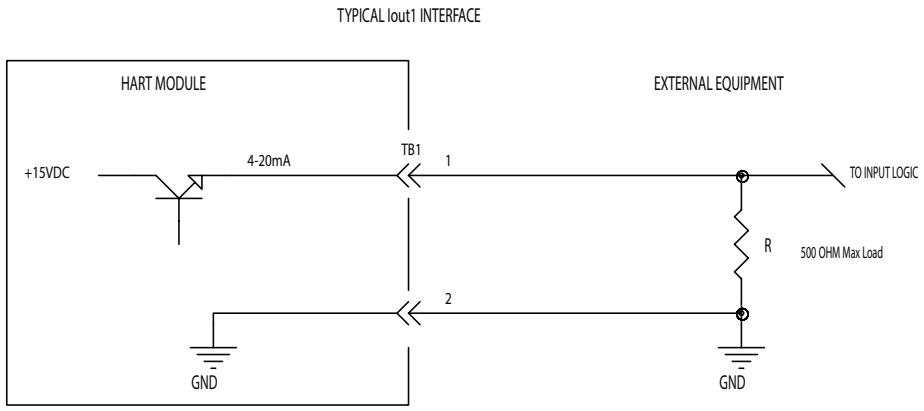

Figure 2: Typical Iout1 interface

1	Resistor	250 Ohm
2	Accessory board	HART
3	External device	HART modem or other HART device
4	Terminal block	TB1 Analog I/O connections

HART Configuration

The transmitter is shipped with HART communications fully configured. If the settings were modified after receiving the transmitter, they can be reprogrammed following the steps below. Engineer (PW3) level access is required to change the default settings.

ComPr2 is the parameter for the HART protocol for the option card:

1. Navigate to *SET UP* > *SYSTEM IO* > *COM PORTS* and press **Enter**.
2. To change the protocol selection, scroll to parameter *ComPr2* and press **Enter**.
3. Press **Up** or **Down** to scroll through the options. Scroll to *HART* and press **Enter**.
4. Press **Enter** for a long press to save the change, or press **Exit** for a long press to cancel the edit(s) and return to the *COM PORTS* parameter screen.

HART Address

To change the HART address default settings, engineer (PW3) level access is required.

PollAdd is the parameter for the HART device address:

1. Navigate to *SET UP* > *SYSTEM IO* > *COM PORTS*.
2. To change the HART device address, scroll to parameter *PollAdd* and press **Enter**.
3. Press **Up** for a long press to move the cursor to the correct digit.
4. Press **Up** and **Down** to increment the address number.
5. Press **Enter** for a long press to save the change, or press **Exit** to cancel the edit(s) and return to the *COM PORTS* parameter screen.

Current Output

The parameter *IOut1* must be enabled for the HART communications board. This output may be independently set by the user, via software or keypad, for any range between 0…22 mA with 4…20 mA being the default. The maximum load (loop) impedance for the output is 500 Ω.

Normally the *Iout1* output is set for mass flow. However, this can represent other parameters. In these cases, the units of measure are (appropriately) different.

The *Home* screen>*SET UP*>*SYSTEM IO* menu contains the current output channel *CURRENT1 SETUP.*

Table 3 **describes Current Output 1 setup.**

Parameter	Description
IOut1	Current output on current channel 1
ID	Parameter ID
EN	Enable current channel 1
IVluMn	Current value associated with minimum flow
IvluMx	Current value associated with maximum flow
VluMn	Parameter value associated with minimum flow
VluMx	Parameter value associated with maximum flow
TstOut	Tests current channel 1 output
+AltI1	Enables alternate current on current channel 1 output

CORIOLIS AND HART COMMANDS

HART protocol has three categories of commands: Universal, Common Practice and Device-Specific. The Coriolis HART communication card supports some Universal commands, Common Practice and Device-Specific commands. Universal commands supported include:

Universal Commands

Command Number	Universal Command Description
0	Read Unique Identifier
1	Read Primary Variable
2	Read Current and Percent of Range
3	Read Current and Four Dynamic Variables
6	Write Polling Address
7	Read Loop Configuration
8	Read Dynamic Variable Class
9	Read Device Variables with Status
11	Read Unique Identifier Associated with Tag
12	Read Message
13	Read Tag, Descriptor, Date
14	Read PV Sensor Information
15	Read Output Information
16	Read Final Assembly Number
17	Write Message
18	Write Tag, Descriptor, Date
19	Write Final Assembly Number
20	Read Long Tag
21	Read Unique Identifier Associated with Long Tag
22	Write Long Tag

Typically, these commands are used by advanced users of HART or the usage of these commands is embedded within the DD files. With the use of the HART universal commands, device variables and dynamic variables are accessible. Device and dynamic variables are defined later. For further understanding of the format and function of the HART Universal Commands please refer to HART protocol documentation.

Universal Command 0 Read Unique Identifier

Byte	Description	Value
1	Manufacturer ID	189 = Badger Meter Europe
2	Device type ID	03 = RCTX Coriolis Transmitter
13	Maximum number of device variables	4
16, Bit 4	Failure detected	Set when any failure is detected

Device Variables

Device Variable: Mass Flow Rate

Shows the calculated and filtered mass flow rate.

Number:	0	**Name:**	Mass Flow Rate
Classification:	72, Mass Flow	**Unit Code:**	kg/s, kg/m, kg/h, g/m, lb/s, lb/m, lb/h, oz/m

Device Variable: Mass Totalizer

Shows the totalized mass.

Number:	1	**Name:**	Mass Totalizer
Classification:	71, Mass	**Unit Code:**	kg, lb, t (metric tons), oz

Device Variable: Temperature 1

Shows the temperature of the media. Temperature is calculated from the resistance changed of the RTD (Pt-100) device mounted in the sensor.

Number:	2	**Name:**	Temperature 1
Classification:	64, Temperature	**Unit Code:**	°C, °F, °R, °K

Device Variable: Density

Shows the calculated density of the media. Density is calculated of the resonant frequency change of the sensor.

Number:	3	**Name:**	Density
Classification:	73, Density	**Unit Code:**	g/s, kg/m^3, lb/ft^3, lb/gal

Dynamic Variables

Four dynamic variables are implemented.

	Name	Description	Units
PV	Mass Flow Rate	Mass Flow Rate	kg/s, kg/m, kg/h, g/m, lb/s, lb/m, lb/h, oz/m
SV	Mass Totalizer	Totalized mass	kg, lb, t (metric tons), oz
TV	Temperature	Temperature 1	°C, °F, °R, °K
FV	Density	Density	g/s, kg/m^3, lb/ft^3, lb/gal

Fixed Dynamic Variables

Dynamic Variable	Dynamic Variable Number	Name
PV	0	Mass Flow Rate
SV	1	Totalized mass
TV	2	Temperature 1
FV	3	Density

Status Information

Device Status

Bit 4 ("More Status Available") is set whenever any failure is detected. Command 48 gives further detail.

Common Practice Commands

Supported Commands

ID	Description
33	Read Device Variables
35	Write Primary Variable Range Values
38	Reset Configuration Changed Flag
42	Perform Device Reset
44	Write Primary Variable Units
48	Read Additional Device Status
54	Read Device Variable Information **Note:** Limits and damping are not used
73	Find Device

Burst Mode

This Field Device does not support Burst Mode.

Catch Device Variable

This Field Device does not support Catch Device Variable.

Command 42 Perform Device Reset

For further details, see *"Troubleshooting" on page 26*.

Command 48 Additional Device Status

Command 48 returns 25 bytes of data, with the following status information:

Byte	Bit	Meaning	Class	Device Status Bit Set
0	System Error Summary			
	0	Low value alarm, Frequency or pulse out error	Warning, error	
	1	High value alarm	Warning	
	2	Too high or low baud rate	Warning	
	3	Always 0	None	
	4	Current or frequency outputs exceeds the software limits	Error	
	5	Current or frequency outputs exceeds the hardware limits	Warning	
	6	Parameters restored or saved to flash, flash backup cleared, slug in flow error, password protected item was written	Status, Warning, Error	
	7	No sensor connected, resonant frequency, temperature error, low sensor warning or driver overflow	Error	4, 7

Byte	Bit	Meaning	Class	Device Status Bit Set
1	System Status Bits			
	0	Not used		
	1	Zero calibration is running	Status	
	2	Measurement is running	Status	
	3	Mass/Volume totalizers are running	Status	
	4	Batching is in progress	Status	
	5	Not used		
	6	Not used		
	7	Not used		
2	Digital Input			
	0	Digital in 1 (1 = active)	Status	
	1	Digital in 2 (1 = active)	Status	
	2	Digital in 3 (1 = active)	Status	
	3	Digital in 4 (1 = active)	Status	
	4	Not used		
	5	Not used		
	6	Not used		
	7	Not used		
3	Digital outputs			
	0	Digital out 4 (1 = active)	Status	
	1	Digital out 3 (1 = active)	Status	
	2	Digital out 2 (1 = active)	Status	
	3	Digital out 1 (1 = active)	Status	
	4	Green LED is on (1 = active)	Status	
	5	Red LED is on (1 = active)	Status	
	6	Not used		
	7	Not used		
4	Not used byte. Always 0x00			
5	Not used byte. Always 0x00			
6	Extended Device Status. Always 0x00			
	0	Maintenance required	Not used	
	1	Device Variable Alert	Not used	
	2	Critical Power Failure	Not used	
	3	Failure	Not used	
	4	Out of Specification	Not used	
	5	Function Check	Not used	
	6	Not used		
	7	Not used		
7	Reserved. Always 0x00			

Byte	Bit	Meaning	Class	Device Status Bit Set
8	Standardized Status 0			
	0	Device Variable Simulation Active	Not used	
	1	Non-Volatile Memory Defect	Not used	
	2	Volatile Memory Defect	Not used	
	3	Watchdog Reset Executed	Not used	
	4	Power Supply Condition Out of Range	Not used	
	5	Environmental Condition out of Range	Not used	
	6	Electronic Defect	Not used	
	7	Device Configuration Locked. Set if none of the passwords are set	Status	
9	Standardized Status 1. Always 0x00			
	0	Status Simulation Active	Not used	
	1	Discrete Variable Simulation Active	Not used	
	2	Event Notification Overflow	Not used	
	3	Not used		
	4	Not used		
	5	Not used		
	6	Not used		
	7	Not used		
10	Analog Channel Saturated			
	0	Analog Channel 1 Current1 output > 24mA or < 0mA	Status	
	1	Analog Channel 2 Current2 output > 24mA or < 0mA	Status	
	2	Analog Channel 3 Current3 output > 24mA or < 0mA	Status	
	3	Analog Channel 4	Not used	
	4	Not used		
	5	Not used		
	6	Not used		
	7	Not used		
11	Standardized Status 2. Always 0x00			
	0	Sub-Device List Changed	Not used	
	1	Duplicated Master Detected	Not used	
	2	Sub-Device Mismatch	Not used	
	3	Sub-Device with Duplicated IDs Found	Not used	
	4	Stale Data Notice	Not used	
	5	Not used		
	6	Not used		
	7	Not used		

Byte	Bit	Meaning	Class	Device Status Bit Set
12	Standardized Status 3. Always 0x00			
	0	Capacity Denied	Not used	
	1	Reserved	Not used	
	2	Bandwidth allocation pending	Not used	
	3	Block Transfer Pending	Not used	
	4	Radio Failure	Not used	
	5	Not used		
	6	Not used		
	7	Not used		
13	Analog Channel Fixed			
	0	Analog Channel 1 Alternate Current1 enabled	Status	
	1	Analog Channel 2 Alternate Current2 enabled	Status	
	2	Analog Channel 3 Alternate Current3 enabled	Status	
	3	Analog Channel 4 Alternate Frequency1 enabled	Status	
	4	Not used		
	5	Not used		
	6	Not used		
	7	Not used		
14	Device-Specific Status-1: Error level 1			
	0	Low Limit (A)	Status	
	1	Low Limit (B)	Status	
	2	Low Limit (C)	Status	
		Low Limit (D)	Status	
	4	Low Limit (E)	Status	
	5	Low Limit (F)	Status	
	6	Frequency out error	Status	
	7	Pulse out error	Status	
15	Device-Specific Status-2: Error Level 2			
		High Limit (A)	Status	
		High Limit (B)	Status	
		High Limit (C)	Status	
		High Limit (D)	Status	
	4	High Limit (E)	Status	
	5	High Limit (F)	Status	
	6	Not used		
	7	Not used		

Byte	Bit	Meaning	Class	Device Status Bit Set
16	Device-Specific Status-3: Error Level 3			
	0	No answer from slave transmitter	Status	
	1	Too Low Baud Rate	Status	
	2	Too High Baud Rate	Status	
	3	Not used		
	4	Not used		
	5	Not used		
	6	Not used		
	7	Not used		
17	Device-Specific Status-4: Error Level 4. Always 0x0			
18	Device-Specific Status-5: Error Level 5			
	0	Current 1 Output Low	Status	
	1	Current 2 Output Low	Status	
	2	Current 3 Output Low	Status	
	3	Frequency Output Low	Status	
	4	Current 1 Output High	Status	
	5	Current 2 Output High	Status	
	6	Current 3 Output High	Status	
	7	Frequency Output High	Status	
19	Device-Specific Status-6: Error Level 6			
	0	Current 1 Out of HW limits	Status	
	1	Current 2 Out of HW limits	Status	
	2	Frequency Out of HW Limits	Status	
	3	Always 0		
	4	Driver Integration = 0	Status	
	5	Current 3 Out of HW limits	Status	
	6	PID controller Integration = 0	Status	
	7	Zero flow error	Status	
20	Device-Specific Status-7: Error Level 7			
	0	Data Logger Active	Status	
	1	Parameters Restored from Flash Memory	Status	
	2	Parameters Backup to Flash Memory	Status	
	3	Access to Parameter Denied	Status	
	4	Backup Flash Memory Cleared	Status	
	5	Application Program Disabled	Status	
	6	Slug Mass Flow	Status	
	7	Backup Flash Memory Overflow	Status	

Byte	Bit	Meaning	Class	Device Status Bit Set
21	Device-Specific Status-8: Error Level 8			
	0	Measurement Error (No sensor signal)	Status	
	1	Resonant Frequency Error	Status	
	2	Temperature Error	Status	
	3	No Answer from Interface CPU	Status	
	4	Sensor Coil Voltage Warning	Status	
	5	Driver Overflow Error	Status	
	6	0, Not used		
	7	Constants Changed Warning	Status	
22	Device-Specific Status-9: Always 0x00			
23	Device-Specific Status-10: Always 0x00			
24	Device-Specific Status-11: Always 0x0			

Device-Specific Commands

There are a total of 253 Device Parameters that can be accessed through these Device-Specific Commands.

Device-specific commands are mainly for accessing many of the Coriolis data parameters, including configuration, identity and diagnostic parameters. Much of the data accessible with device specific commands is accessed through the use of the DD files. The DD files provide all the necessary information for data management within the Coriolis. Installing and using the DD files in the applications host is the most convenient method for communicating to the Coriolis over HART.

The following Device-Specific commands are implemented:

- Command 128 Write Floating Point Type Device Parameter
- Command 129 Write String Type Device Parameter
- Command 130 Write Byte Type Device Parameter
- Command 131 Write Unsigned Integer Type Device Parameter
- Command 132 Read Floating Point Type Device Parameter
- Command 133 Read String Type Device Parameter
- Command 134 Read Byte Type Device Parameter
- Command 135 Read Unsigned Integer Type Device Parameter

The data types of the parameters are described in the *RCT1000 Coriolis User Manual*.

Command 128 Write Floating Point Type Device Variable

Writes a floating point type device variable to the field device.

Request Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-16	Device Variable Code	Floating point type parameter identification code
2	Unsigned-8	Units Code	Current unit
3-6	Float	Device Variable Value	New value of parameter

Response Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-16	Device Variable Code	Parameter identification code
2	Unsigned-8	Units Code	Current unit
3-6	Float	Device Variable Value	Parameter value.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
2	Error	Invalid selection. The selected transmitter variable is not byte type
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	In Write Protect Mode (The necessary password is not set)

Command 129 Write String Type Device Variable

Writes a string point type device variable to the field device.

Request Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-16	Device Variable Code	String type parameter identification code
2-N	String	Device Variable Value	New value of parameter

Response Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-8	Device Variable Code	Parameter identification code
2-N	String	Device Variable Value	Parameter value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
2	Error	Invalid selection. The selected transmitter variable is not byte type
5	Error	Too Few Data Bytes Received
6	Error	In Write Protect Mode (the necessary password is not set)

Command 130 Write Byte Type Device Variable

Writes a byte type device variable to the field device.

Request Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-16	Device Variable Code	Parameter identification code
2	Unsigned-8	Value	New value of parameter

Response Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-16	Device Variable Code	Parameter identification code
2	Unsigned-8	Value	New value of parameter

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
2	Error	Invalid selection. The selected transmitter variable is not byte type
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	In Write Protect Mode (The necessary password is not set)

Command 131 Write Unsigned Integer Type Device Variable

Writes an unsigned integer type device variable to the field device.

Request Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-16	Device Variable Code	Parameter identification code
2	Unsigned-16	Value	New value of parameter

Response Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-16	Device Variable Code	Parameter identification code
2	Unsigned-16	Value	New value of parameter

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
2	Error	Invalid selection. The selected transmitter variable is not byte type
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	In Write Protect Mode (The necessary password is not set)

Command 132 Read Floating Point Type Device Variable

Reads a floating point type device variable from the field device.

Request Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-16	Device Variable Code	Floating point type parameter identification code

Response Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-16	Device Variable Code	Parameter identification code
2	Unsigned-8	Units Code	Current unit
3-6	Float	Device Variable Value	Parameter value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
2	Error	Invalid selection. The selected transmitter variable is not floating point type
5	Error	Too Few Data Bytes Received

Command 133 Read String Type Device Variable

Reads a string type device variable from the field device.

Request Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-16	Device Variable Code	String type parameter identification code

Response Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-16	Device Variable Code	Parameter identification code
2-N	Float	Device Variable Value	Parameter value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
2	Error	Invalid selection. The selected transmitter variable is not string type
5	Error	Too Few Data Bytes Received

Command 134 Read Byte Type Device Variable

Reads a byte type device variable from the field device. (0x00 to 0xFF)

Request Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-16	Device Variable Code	Parameter identification code

Response Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-16	Device Variable Code	Parameter identification code
2	Unsigned-8	Device Variable Value	Parameter value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
2	Error	Invalid selection. The selected transmitter variable is not byte type
5	Error	Too Few Data Bytes Received

Command 135 Read Unsigned Integer Type Device Variable

Reads an unsigned integer type device variable from the field device. (0x000 to 0xFFFF)

Request Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-16	Device Variable Code	Parameter identification code

Response Data Bytes

Byte	Format	Description	RCT1000 Parameter
0-1	Unsigned-16	Device Variable Code	Parameter identification code.
2	Unsigned-16	Device Variable Value	Parameter value.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
2	Error	Invalid selection. The selected transmitter variable is not unsigned integer type
5	Error	Too Few Data Bytes Received

ADDITIONAL FEATURES

RCTX Security

Write Protection

Write-protection is provided and controlled by entering passwords from the keypad/display menu system. With HART, the password does not expire and the default setting is the engineering level. Refer to the *System Password* section in the *RCT1000 Coriolis User Manual*.

Fixed Current Mode (Multi-Drop)

The Coriolis provides an active analog output. This means it is the source of the analog signal. When placing the meter into fixed current mode, the Coriolis shall fix the output current to 4 mA regardless of the primary variables value (that is, Flow Rate). During this condition the device status bit 3 (PV Analog Channel Fixed) is set.

To place the meter into fixed current mode, the polling address must be non-zero. This is a HART specific parameter. The HART polling address can be accessed via *Setup>Com Ports* the Coriolis menu structure. With reference to the HART DD, this parameter is located at *Configuration > Hart > Hart Output > Poll Addr*.

Each meter to be commissioned for multi-drop should exercise the following procedure. The default polling address for all HART communication cards is 0.

1. Turn off power to all meters to be commissioned for HART multi-drop mode.

   IMPORTANT

   As a result of the Coriolis having an active analog output, only five Coriolis meters can be configured for multi-drop mode within the same network.
2. Wire the meters in parallel as shown in *Figure 3*:

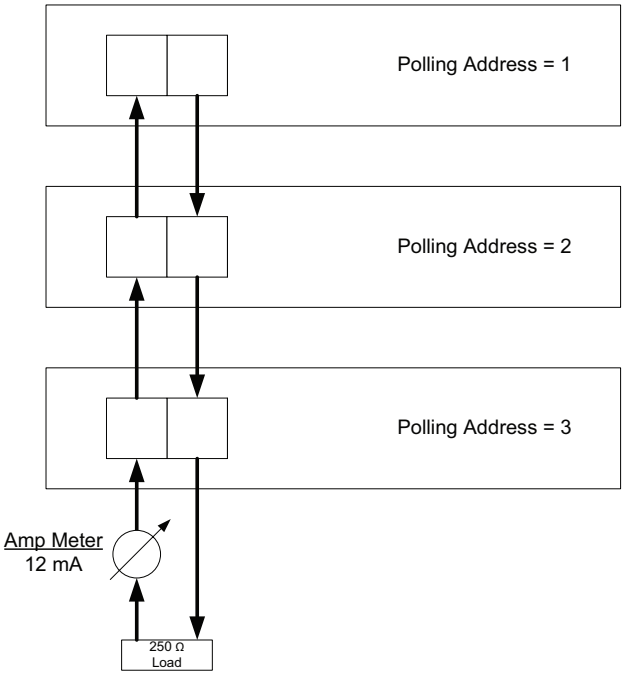

Figure 3: Wiring meters in parallel

3. Turn on power to one of the meters.
4. Change the polling address to desired address. As a suggestion, it may be desirable to change the installation data while changing the polling address. Installation data can provide additional means for identifying the meter on the HART network.
5. Repeat this procedure until all nodes on the HART multi-drop network are configured with a non-zero and unique polling address.

MANUFACTURER-SPECIFIC UNITS

The following Manufacturer-Specific Unit codes are defined and used in the current firmware.

Unit Code	Description	Note
240	Number	DIM_NONE (0), Unit = 0
241	Kilohertz	DIM_FREQUENCY (5), Unit = 1
242	Megahertz	DIM_FREQUENCY (5), Unit = 2
243	Ounce per minute	DIM_MASSFLOW (8), Unit = 7
244	Driver voltage	DIM_DRIVECODE(6), Unit =2 Slope = 5.7V / 4096
245	Timeout in milliseconds	DIM_TIMEOUT(15), Unit = 0
246	Millimeters per second	DIM_VELOCITY (16), Unit = 0
247	Stoke	DIM_KVISCOSITY (18), Unit = 0
248	Poise	DIM_DVISCOSITY (1), Unit = 0
249	not used yet	—

Sensor Type Codes

The following sensor types are available for the RCT1000 transmitter:

Model	No.	Nominal Line and Equivalent Pipe Size Number	Number of Flow Tubes	Flow Range	
				lb/min	kg/hr
RCS-005	0	1/4 in., 1/16 in.	1	0…0.5	0…13.6
RCS-008	1	1/4 in., 3/32 in.	1	0…2	0…55
RCS-018	2	1/2 in., 3/16 in.	2	0…20	0…544
RCS-025	3	1/2 in., 1/4 in.	2	0…40	0…1088
RCS-050	4	1/2 in., 1/2 in.	2	0…220	0…5987
RCS-100	5	1 in.	2	0…1000	0…27,216
RCS-200	6	2 in.	2	0…1700	0…46,266
RCS-300	7	3 in.	2	0…5200	0…141,520

Number Unit Codes

ID	Unit	Conversion
240	Number (Unit less number)	= 1 * x + 0

Phase Unit Codes

ID	Unit	Conversion
51	s, seconds	= 1 * x + 0
71	ms, milliseconds	= 10E3 * x + 0
171	µs, microseconds	= 10E6 * x + 0

Temperature Unit Codes

ID	Unit	Conversion
32	°C, degrees Celsius	= 1 * x + 0
33	°F, degrees Fahrenheit	= 1.8 * x + 32
34	°R, degrees Rankine	= 1.8 * x + 491.7
35	K, Kelvin	= 1 * x + 273.15

Voltage Unit Codes

ID	Unit	Conversion
58	V, volts	= 1 * x + 0
36	mV, millivolts	= 10E3 * x + 0

Time Unit Codes

ID	Unit	Conversion
51	s, seconds	= 1 * x + 0
50	min, minutes	= (1/60)* x + 0
52	h, hours	= (1/3600) * x + 0

Frequency Unit Codes

ID	Unit	Conversion
38	Hz, hertz	= 1 * x + 0
241	kHz, kilohertz	= 10E3 * x + 0
242	MHz, megahertz	= 10E6 * x + 0

Mass Flow Unit Codes

ID	Unit	Conversion
73	kg/s, kilograms per second	= 1 * x + 0
74	kg/min, kilograms per minute	= 60 * x + 0
75	kg/h, kilograms per hours	= 3600 * x + 0
71	g/min, grams per minute	= 60000 * x + 0
80	lb/s, pounds per second	= 2.2046 * x + 0
81	lb/min, pounds per minute	= 1.32276E+2 *x + 0
82	lb/h, pounds per hour	= 7.93656E+3 * x + 0
242	oz/min, ounces per minute	= 2.11644E+3 * x = 0

Percentage Unit Codes

ID	Unit	Conversion
240	Number (0.0 - 1.0 = 0% - 100%)	= 1 * x + 0
57	%, percent	= 100 * x + 0

Mass Unit Codes

ID	Unit	Conversion
61	kg, kilograms	= 1 * x + 0
63	lb, pounds	= 2.2046 * x + 0
62	t, metric tons	= 1E-3 * x + 0
125	oz, ounces	= 3.5274E+1 * x + 0

Density Unit Codes

ID	Unit	Conversion
91	g/cu.cm^3 (g/mL), grams per cubic centimeter	= 1 * x + 0
92	kg/m^3, kilograms per cubic meter	= 1E3 * x + 0
94	lb/ft^3, pounds per cubic foot	= 6.242796E+1 * x + 0
93	lb/gal, pounds per gallon	= 3.5274E+1 * x + 0

Driver Level Unit Codes

ID	Unit	Conversion
240	Number (0.0 – 4095.0)	= 1 * x + 0
57	%, Percent of 4095	= (100.0/4095.0) * x + 0
243	vac, Approximate AC voltage	= 5.7/4095.0* x + 0

Current Unit Codes

ID	Unit	Conversion
39	milliamperes	= 1 * x + 0
244	amperes	= 1E-3 * x + 0

Volume Unit Codes

ID	Unit	Conversion
41	l, liters	= 1 * x + 0
43	m^3, cubic meters	= 1E-3 * x + 0
40	gal, gallons	= 0.264172* x + 0
46	bbl, barrels	= 0.006289803* x + 0
112	Ft^3, cubic feet	= 0.035135 * x + 0

Volumetric Flow Rate Unit Codes

ID	Unit	Conversion
41	l/s, liters per second	= 1 * x + 0
17	l/min, liters per minute	= 60 * x + 0
138	l/h, liters per hour	= 3600 * x + 0
177	l/d, liters per day	= 86400* x + 0
131	m^3/min, cubic meters per minute	= 0.06 * x + 0
19	m^3/h, cubic meters per hour	= 3.6 * x + 0
29	m^3/d, cubic meters per day	= 86.4 * x +0
22	gps, gallons per second	= 0.26417 * x + 0
16	gpmin, gallons per minute	= 15.8504 * x + 0
136	gph, gallons per hour	= 951.022 * x + 0
133	bbl/min, barrels per minute	= 0.377389 * x + 0
134	bbl/h, barrels per hour	= 2.264339E+1 * x + 0
135	bbl/d, barrels per day	= 5.434413E+2 * x + 0
15	ft^3/min, cubic feet per minute	= 2.1189 * x + 0
130	ft^3/h, cubic feet per minute	= 127.134 * x +0

Timeout Unit Codes

ID	Unit	Conversion
245	ms, milliseconds	= 1 * x + 0

Velocity Unit Codes

ID	Unit	Conversion
21	m/s, meters per second	= 1 * x + 0
20	ft/s, feet per second	= 3.28084* x + 0
246	mm/s, millimeters per second	= 1000 * x + 0

Pressure Unit Codes

ID	Unit	Conversion
7	bars	= 1 * x + 0
6	psi, pounds per square inch	= 14.5038 * x + 0
14	atm, atmospheres	= 0.986923 * x + 0
12	kPa, kilopascals	= 100.0 * x + 0
2	inHg, inches of mercury at 0 degrees C	= 29.530 * x + 0
5	mmHg, millimeters of mercury at 0 degrees C	= 750.062 * x + 0
172	cmHg, centimeters of mercury at 0 degrees C	= 75.062 * x + 0
10	kg/cm^2, kilograms per square centimeters	= 1.0195 * x + 0

Resistance Unit Codes

ID	Unit	Conversion
37	Ω, ohms	= 1 * x + 0
163	kΩ, kilo ohms	= 1.0E-3 * x + 0
170	MΩ, mega ohms	= 1.0E-6 * x + 0

Modes

Modes	Value	Enumeration
Density Mode	1	Basic
	2	API Gravity
	3	Degrees Baume
	4	Gas at Reduced Conditions
	5	Normalized Liquid Density
	6	Net Oil Computer
Enable Reverse Flow	0	Disabled
	1	Enabled
Net Flow Mode	0	No Net Flow
	1	Difference Flow
	2	Sum Flow
Driver A Mode	0	Turned off
	1	Coil A
	2	Coil B
	3	Coil A+B
	4	Inverted Coil A
	5	Inverted Coil B
Driver B Mode	0	Off
	1	Coil A
	2	Coil B
	3	Coil A+B
	4	Inverted Coil A
	5	Inverted Coil B
Driver Source	0	Coil A
	1	Coil B
	2	Coil A+B
Hammer Mode	0	Off
	1	Square Wave Sweep
	2	Sine Wave Sweep
	3	Square Wave at Last Know Frequency
	4	Sine Wave at Last Know Frequency

Modes	Value	Enumeration
Sensor Size	0	RCS005
	1	RCS008
	2	RCS018
	3	RCS025
	4	RCS050
	5	RCS100
	6	RCS200
	7	RCS300
Sensor Material	0	316L
	1	C22
	2	Nickel
	3	Quartz
BRIX Mode	0	Off
	1	Solid Calculation
	2	Soluble Calculation
PID Hold	0	Last out
	1	Alt Current #1
	2	Alt Current #2
	3	Alt Current #3
PID Enable	0	Disabled
	1	Enabled
Enable Test Current	0	Disabled
	1	Enabled
Enable Test Freq	0	Disabled
	1	Enabled
Pulse Mode	0	Frequency
	1	Pulse
	2	PWM

DEVICE DESCRIPTION

The device descriptions, located on *www.hartcomm.org* under *Product Catalog* > *All Products* > *Coriolis*, can be installed into host systems such as the Emerson 475 Field Communicator.

Periodically, the device description monitors the attached device for non-zero status codes (universal command 48). These codes inform the user of the status of the Coriolis. If the status of the Coriolis does not clear, these informational dialogs will continue to be presented. To reduce the amount of dialogs, correct the state of the meter or configure the host to ignore these non-zero status codes.

In addition, performing changes to the meter's configuration generates a "configuration changed" status dialog. This bit must be manually cleared to prevent future display of this dialog. This can be done within the DD file by navigating to *Coriolis>Advanced>Miscellaneous>Service>Reset Config Change* or separately issuing universal command 38.

TROUBLESHOOTING

Powerup

On power up, the transmitter goes through a self-test procedure, which takes approximately 2 seconds. During this period, the device will not respond to HART commands, and the analog output is set at 4.0 mA.

When the self-test is satisfactorily completed the transmitter checks whether a sensor is connected. If the sensor is found then the transmitter tries to start the vibration of the sensor tubes.

Once the sensor is started the transmitter is fully operational. The estimated start time delay is 3 seconds.

Regardless of the sensor found and started the transmitter answers the HART commands.

Self-Test

The self-test procedure is executed at power up, following Command 42 (Device Reset). The self-test includes:

- Microprocessor
- RAM
- Flash backup (configuration backup)
- Sensor

The self-test takes about 3 seconds. If the battery backed up RAM would be different from the configuration saved to flash memory then "Items restores" warning message is shown then the battery backup RAM will be overwritten with the last saved configuration from the flash backup.

Symptom	Solution
Using DD files, not able to change values with the handheld	—
Unable to communicate with the meter over HART	Check the wiring. Verify load is above minimum required resistance of 250 Ohms. Verify the loop current is within range, especially if configured for multi-drop. Verify that the RCTX transmitter is configured for HART protocol in PrCom2 and baud rate is the default 38400 (internal communications between main board and communication card).
The configuration error flag is set	To eliminate this condition and any concerns regarding this condition, it is advisable to reset the Coriolis. This can be done by issuing the RESET command in the Advanced>Miscellaneous>Service menu. Shortly thereafter the Coriolis resets and the communication card image updates to match the Coriolis image. Then re-verify all configuration data is as desired.
Analog current is always 4 mA	Verify the meter is not configured for multi-drop mode. A meter configured for multi-drop mode will have a non-zero polling address. Set the polling address to zero. Verify flow rate is non-zero. Flow rate is directly proportional to the analog current. Fixed current mode is automatically turned on if fatal sensor error is detected.
Cannot write over HART	Verify security settings are not set for write protection.

HART CERTIFICATION

HART® REGISTERED

Certificate of Registration
FieldComm Group Verified

Badger Meter Manufacturer	RCTX Product Name
00BD Manufacturer ID (Hex)	BD03 Expanded Device Type (Hex)
7 HART Protocol Revision	03 Device Revision (Hex)
04 Hardware Revision (Hex)	71 Software Revision (Hex)
04/29/2016 Test Date	FieldComm Group Verification Method

The above product has successfully completed the validation process and meets the requirements to be “HART REGISTERED”.

“HART REGISTERED” products conform to GB/T 29910.1-6-2013 and IEC 61158 standards.

Registration Number: L2-06-1000- 544 Registration Issue Date: August 29, 2016 Approval: T. H. Mastus

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