HART Protocol Specification

Field Communications

Coriolis Flow Device Family Specification

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1. SCOPE

This Device Family principally allows the configuration of a coriolis flow measurement to be determined. The properties are common to many flow applications including volume flow and mass flow.

2. REFERENCES

2.1 HART Field Communications Protocol Specifications

These documents published by the HART Communication Foundation are referenced throughout this specification:

HART Field Communications Protocol Specification. HCF_SPEC-12

Command Summary Specification. HCF_SPEC-99

Common Practice Command Specification HCF_SPEC-151

Device Families Command Specification. HCF_SPEC-160

Totalizer Device Family Specification. HCF_SPEC-160.10

Common Tables Specification. HCF_SPEC-183

Command Response Code Specification. HCF_SPEC-307

2.2 Related HART Documents

The HART Protocol Specifications frequently reference the manufacturers' device-specific document. Device-specific documents are developed and controlled by the respective manufacturer and should follow the requirements of the following HART Communication Foundation document:

Requirements for Device Specific Documentation. HCF_LIT-18

2.3 Related Documents

The following documents provide background information relevant to flow measurement and this device family:

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3. DEFINITIONS, SYMBOLS AND ACRONYMS

Terms used in this document and defined in *HART Field Communications Protocol Specification* include: Delayed Response, Delayed Response Mechanism, Device Variable, Busy, DR_CONFLICT, DR_DEAD, DR_INITIATE, DR_RUNNING, Floating Point, Request Data Bytes, Response Data Bytes, Response Message, Units Code

Device Family, or Device Family Specification — The definition of the properties, diagnostics and commands required to manage a Device Variable. The Device Family specification includes all the mandatory and optional properties necessary to configure the corresponding class of process connections.

4. CORIOLIS FLOW DEVICE FAMILY - OVERVIEW

Flow is an important measurement in many different applications of the process industry. The coriolis method directly measures the mass flow and very often also the density. A temperature measurement is typically integrated for compensation purpose. By means of the density the volume flow can be derived. The mass flow is the mandatory device variable and is associated with the Coriolis Flow Device Family. (Command #54, Device Variable Information) The density, the temperature and the volume flow are recommended Device Variables that are not associated with a Device Family.

Figure 1 – Coriolis Flow Device Family Diagram illustrates a typical coriolis flow device family diagram. It is a simplified view because the scope of this document is to use this diagram to show the benefits of using device family definitions for implementing of devices. But it can be used as a guideline for implementation of such a device. It normally contains other modules like filtering and converters, etc.

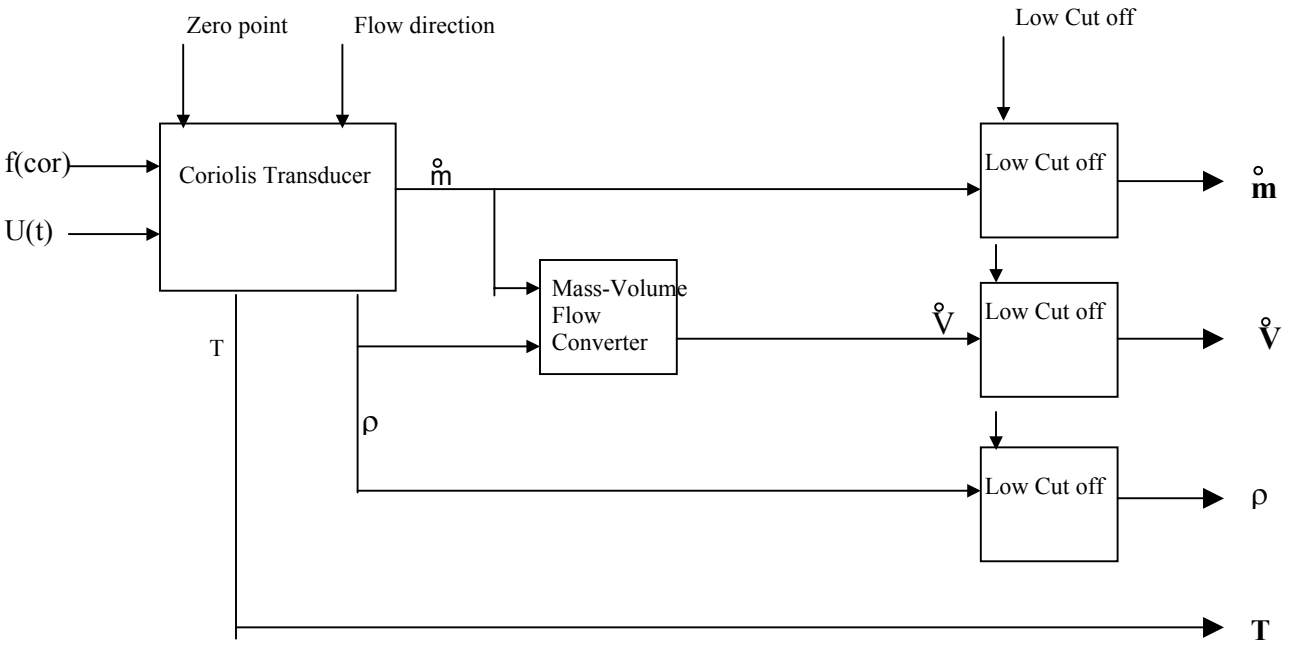

Figure 1 – Coriolis Flow Device Family Diagram

The **Coriolis Transducer Block** should contain hardware and software components necessary for conditioning and filtering signals necessary for coriolis measurement. It also contains the zero point correction and calibration factor (manufacturer specific) in order to receive an accurate mass flow. In a Coriolis meter the coriolis force causes a phase shift of the frequency f(cor). The phase shift is

proportional to the mass flow.
Additionally the density can be derived from the frequency f(cor) by applying adequate signal processing and calibration methods. For compensation purpose a temperature measurement can be integrated.

Volume flow can be derived from mass flow by using the density of the flowing material. (**Mass Volume Flow Converter Block**)

In many applications a small process value shall be suppressed. Therefore a **Low Cut Off** value can be configured for the mass flow, volume flow and the density.

5. COMMON PRACTICE COMMANDS

5.1 Overview Common Practice Commands

Command	M=Mandatory, R=Recommended
33 – Read Device Variables	R
34 – Write PV Damping	M
35 – Write PV Range Values	M
36 – Write PV Upper Range Value	M
37 – Write PV Lower Range Value	M
38 – Reset Configuration Changed Flag	M
43 – Set PV Zero	R
44 – Write PV Unit	M
50 – Read Dynamic Variable Assignment	M
51 – Write Dynamic Variable Assignment	R
52 – Set Device Variable Zero	R
53 – Write Device Variable Unit	M
54 – Read Device Variable Information	M
55 – Write Device Variable Damping	M
79 – Write Device Variable	R
80 – Read Device Variable Trim Points	R
81 – Read Device Variable Trim Guidelines	R
82 – Write Device Variable Trim Point	R
83 – Reset Device Variable Trim	R

Table 1 – Common Practice Commands for Coriolis Flow Device Family

5.2 Mandatory Common Practice Commands

5.2.1 Reading the Mapping of the Dynamic Variables

Common Practice Command #50 – Read Dynamic Variable Assignment must be supported. This enables a master to learn which Device Variable is mapped to PV, SV, TV and QV.

5.2.2 Setting the Engineering Unit for the Flow Device Variable

Each Device Variable that belongs to the Flow Device Family must support Common Practice Command #53 – Write Device Variable Unit. If this variable can be mapped to PV or is always mapped to PV Command #44 – Write PV Unit is also required.

5.2.3 Setting the Damping

Command #55 – Write Device Variable Damping and #34 – Set PV Damping (only if the Flow Device Variable is mapped to PV) must be supported.

5.2.4 Ranging Commands for PV

If the Flow Device Variable can be mapped to PV the Command 35 – Write PV Range Values, #36 Set PV Upper Range Value and #37 Set PV Lower Range Value must be supported.

It must be possible that the Upper Range Value can be below the Lower Range Value. This will result in an inverse characteristic of the Analog Output.

5.2.5 Reset Configuration Changed Flag

Devices that have at least one Device Variable that belongs to the Flow Family must support Command #38 – Reset Configuration Changed Flag.

5.3 Recommended Common Practice Commands

5.3.1 Reading the Device Variables

Common Practice Command #33 – Read Device Variables is recommended. This enables a master to read up to four Device Variables.

5.3.2 Writing the Mapping of the Dynamic Variables

Common Practice Command #51– Write Dynamic Variable Assignment is recommended. This enables a master to configure which Device Variable is mapped to PV, SV, TV and QV.

5.3.3 Setting the Device Variable Zero

The Command #52 – Set Device Variable Zero and #43 – Set PV Zero (only if the Flow Device Variable is mapped to PV) can be used to compensate for offsets in the flow measurement. A Flow Device Variable can also support a two step trim procedure. This is achievable by using commands #80 - #83.

5.3.4 Writing a Device Variable

Common Practice Command #79 – This enables a master to write a Device Variables.

6. COMMANDS

6.1 Overview

Command	M=Mandatory, R=Recommended
xxxx – Read Flow Status	M
xxxx – Read Family Revision	M
xxxx – Read Low Cut Off	M for Mass, R for Volume and Density
xxxx – Read Flow Direction	R
xxxx – Read Tube Diameter	R
xxxx – Read Zero Point	R
xxxx – Write Low Cut Off	M for Mass, R for Volume and Density
xxxx – Write Flow Direction	R
xxxx – Write Tube Diameter	R
xxxx – Write Zero Point	R

Table 2 – Coriolis Flow Device Family Commands

6.2 Command xxxx: Read Flow Status (Mandatory)

All Device Families allow additional status information to be provided to host applications. This Device Family Status is in addition to the Device Variable Status information provided with all Device Variables and Dynamic Variables.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Bits	Device Variable and Coriolis Flow Family Status (refer to Table 1)
2	Bits	Additional Coriolis Flow Family Status (refer to Table 2)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection

Code	Class	Description
3 – 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 – 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

6.3 Command xxxx: Read Family Revision

Coriolis Family Revision Number.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Unsigned-8	Family Revision

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

6.4 Command xxxx: Read Low Flow Cut Off

In many application a small flow or density value shall be suppressed. Therefore a Low Cut Off value for the mass flow (mandatory), the volume flow (optional) and the density (optional) can be configured.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Device Variable Unit
2 – 5	Float	Low Cut Off Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

6.5 Command xxxx: Read Flow Direction (optional)

The Flow Direction determines whether the mass or volume flow value is negated.

Request Data Bytes

Byte	Format	Description

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Flow Direction (refer to Table 3)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

6.6 Command xxxx: Read Tube Diameter (optional)

The tube diameter can be configured.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Tube Diameter Unit
2 – 5	Float	Tube Diameter Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

6.7 Command xxxx: Read Zero Point (optional)

The offset at zero flow rate.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Zero Point Unit
2 – 5	float	Zero Point

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined

Code	Class	Description
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

6.8 Command xxxx: Write Low Cut Off

In many applications a small flow or density value shall be suppressed. Therefore a Low Cut Off value for the mass flow (mandatory), the volume flow (optional) and the density (optional) can be configured.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Device Variable Unit
2 – 5	Float	Low Cut Off Value

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Device Variable Unit
2 – 5	Float	Low Cut Off Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3	Error	Value too Large
4	Error	Value too Small
5	Error	Too Few Data Bytes Received

Code	Class	Description
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

6.9 Command xxxx: Write Flow Direction (optional)

The Flow Direction determines whether the mass or volume flow value is negated.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Flow Direction (refer to Table 3)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Flow Direction (refer to Table 3)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

6.10 Command xxxx: Write Tube Diameter (optional)

The tube diameter can be configured.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Tube Diameter Unit
2 – 5	Float	Tube Diameter Value

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Tube Diameter Unit
2 – 5	Float	Tube Diameter Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

6.11 Command xxxx: Write Zero Point (optional)

The offset at zero flow rate.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Zero Point Unit

Byte	Format	Description
2 – 5	float	Zero Point

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Zero Point Unit
2 – 5	float	Zero Point

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3	Error	Value too Large
4	Error	Value too Small
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

7. CORIOLIS FLOW DEVICE FAMILY TABLES

7.1 Table 1: Device Variable and Coriolis Flow Family Status

Bit	Coriolis Flow Family Variable Status
0xD0	Data Quality of the Device Variable
0x30	Limit Status of the Device Variable
0x08	More Device Family Status Available
0x04	Reserved
0x02	Transmitter Failure
0x01	Coriolis Frequency not stable (bad process conditions like very high viscosity, inhomogeneous medium, cavitations, gas bubbles, tube partially filled or empty)

7.2 Table 2: Additional Coriolis Flow Family Status

Bit	Additional Coriolis Flow Family Status
0x01	Reserved
0x02	Reserved
0x04	Reserved
0x08	Reserved
0x10	Manufacturer Specific
0x20	Manufacturer Specific
0x40	Manufacturer Specific
0x80	Manufacturer Specific

7.3 Table 3: Flow Direction

Code	Flow Direction
0	Positive
1	Negative
2-239	Reserved
240-249	Manufacturer Specific
251	None
252	Unknown
253	Special

ANNEX A. REVISION HISTORY

A1. Revision 1.0 a

Initial Revision.