HART Protocol Specification

Field Communications

Vortex Flow Device Family Specification

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1. SCOPE

This Device Family principally allows the configuration of a vortex 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. VORTEX DEVICE FAMILY - OVERVIEW

Flow is an important measurement in many different applications of the process industry. The vortex method directly measures the volume flow and often the density is used to derive mass flow. The volume flow is the associated Device Variable for the Vortex Flow Device Family. (Command #54, Device Variable Information) The mass flow is not associated with a Device Family. Mass Flow is a derived Device Variable by using the user configured, or calculated density.

Figure 1 – Vortex Device Family Diagram illustrates a typical vortex 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.

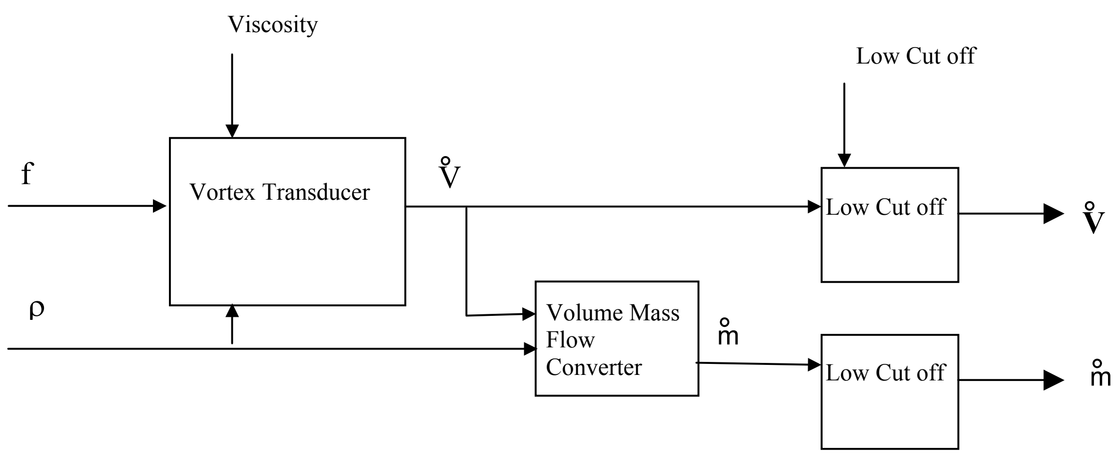

Figure 1 – Vortex Device Family Diagram

The **Vortex Transducer Block** should contain hardware and software components necessary for conditioning and filtering signals necessary for vortex measurement. It also contains the calibration factor (manufacturer specific) in order to receive an accurate volume flow. In a Vortex meter, the shedder bar frequency f is proportional to the volume flow. There is no zero adjustment on vortex flowmeters.

The user input of the viscosity in conjunction with density and volume flow is used to calculate the Reynolds number. The Reynolds number is a measurement quality which can be used for diagnostics.

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

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

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
44 – Write PV Unit	M
50 – Read Dynamic Variable Assignment	M
51 – Write Dynamic Variable Assignment	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 Vortex 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
There is no zero offset in a vortex flow measurement. Therefore only the upper trim point is applicable.(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 Vortex Frequency	M
xxxx – Read Low Flow Cut Off	M for Volume, R for Mass
xxxx – Read Density	R
xxxx – Read Density Unit	R
xxxx – Read Viscosity	R
xxxx – Read Tube Diameter	R
xxxx – Write Low Flow Cut Off	M for Volume, R for Mass
xxxx – Write Density	R
xxxx – Write Density Unit	R
xxxx – Write Viscosity	R
xxxx – Write Tube Diameter	R

Table 2 – Vortex 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 Vortex Family Status (refer to Table 1)
2	Bits	Additional Vortex 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
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

Vortex 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

Code	Class	Description
16	Error	Access Restricted
17 -127		Undefined

6.4 Command xxxx: Read Vortex Frequency

Shedder bar frequency

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	Frequency Unit (Hz)
2 – 5	Float	Vortex Frequency 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 Low Flow Cut Off

In many applications a small flow value shall be suppressed. Therefore a Low Cut Off value for the volume flow (mandatory) and the mass flow (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	Flow Unit
2 – 5	Float	Low Flow 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

6.6 Command xxxx: Read Density (optional)

Mass flow can be derived from volume flow by using the density of the flowing material. Therefore the density 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

Byte	Format	Description
1	Enum	Density Unit
2 – 5	Float	Density 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 Density Unit(optional)

Mass flow can be derived from volume flow by using the density of the flowing material. Therefore the density 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	Density Unit
2 – 5	Float	Density Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors

Code	Class	Description
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

6.8 Command xxxx: Read Viscosity (optional)

The Reynolds number can be derived from the density, the viscosity and volume flow. Therefore the viscosity can be configured. The viscosity unit is fixed to centipoise. The Reynolds number is a measurement quality which can be used for diagnostics.

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	Viscosity Unit
2 – 5	Float	Viscosity 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

Code	Class	Description
16	Error	Access Restricted
17 -127		Undefined

6.9 Command xxxx: Read Tube Diameter (optional)
The tube diameter is used in the calculation of volumetric flow.

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

6.10 Command xxxx: Write Low Flow Cut Off
In many application a small flow value shall be suppressed. Therefore a Low Cut Off value for the volume flow (mandatory) and the mass flow (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	Low Flow Cutoff Unit
2 – 5	Float	Low Flow Cut Off Value

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Low Flow Cutoff Unit
2 – 5	Float	Low Flow 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
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

6.11 Command xxxx: Write Density (optional)

Mass flow can be derived from volume flow by using the density of the flowing material. Therefore the density 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)

Byte	Format	Description
1	Enum	Density Unit
2 – 5	Float	Density Value

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Density Unit
2 – 5	Float	Density 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
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

6.12 Command xxxx: Write Density Units (optional)

Mass flow can be derived from volume flow by using the density of the flowing material. Therefore the density 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	Density Unit Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code

Byte	Format	Description
1	Enum	Density Unit Code

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

6.13 Command xxxx: Write Viscosity (optional)

The Reynolds number can be derived from the density, the viscosity and volume flow. Therefore the viscosity can be configured. The viscosity unit is fixed to centipoise. The Reynolds number is a measurement quality which can be used for diagnostics.

Request Data Bytes

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

Response Data Bytes

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

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors

Code	Class	Description
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

6.14 Command xxxx: Write Tube Diameter (optional)

The tube diameter is used in the calculation of volumetric flow.

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	Error	Value too Large
4	Error	Value too Small

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

7. VORTEX DEVICE FAMILY TABLES

7.1 Table 1: Device Variable and Vortex Family Status

Bit	Vortex Family Variable Status
0xD0	Data Quality of Device Variable
0x30	Limit Status of Device Variable
0x08	More Device Family Status Available
0x04	Sensor Failure (loss of shedder frequency signal)
0x02	Transmitter Failure
0x01	Flow rate is below linear range (Reynolds number too low)

7.2 Table 2: Additional Vortex Family Status

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

ANNEX A. REVISION HISTORY

A1. Revision 1.0 a

Initial Revision.