HART Protocol Specification

Field Communications

Magnetic Inductive Flow Device Family Specification

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1. SCOPE

This Device Family principally allows the configuration of a magnetic inductive 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. MAGNETIC INDUCTIVE FLOW DEVICE FAMILY - OVERVIEW

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

Figure 1 – Magnetic Inductive Device Family Diagram illustrates a typical magnetic inductive 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.

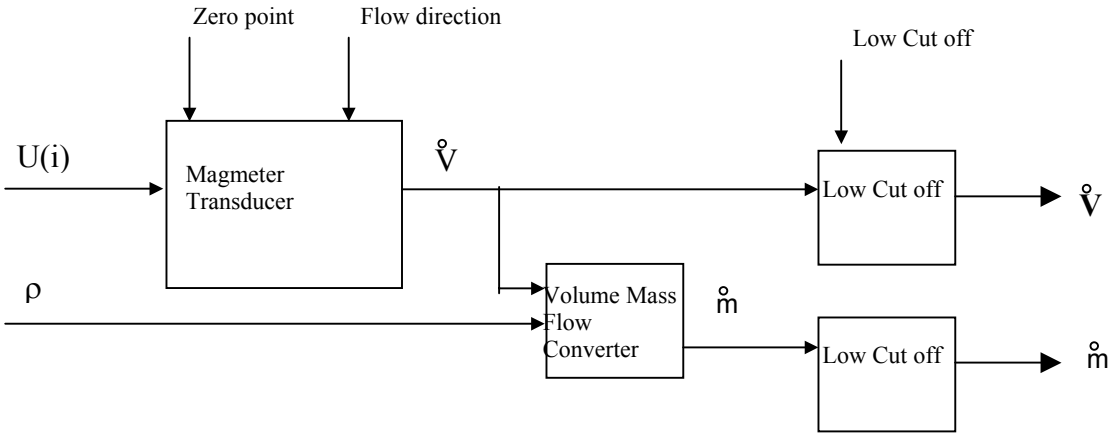

Figure 1 – Magnetic Inductive Device Family Diagram

The **Magmeter Transducer Block** should contain hardware and software components necessary for conditioning and filtering signals necessary for magnetic inductive measurement. It also contains the zero point correction and calibration factor (manufacturer specific) in order to receive an accurate volume flow. In a Magmeter the inductive voltage U(i) is proportional to the volume flow.

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

In many application 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
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 Magmeter 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 Flow Cut Off	M for Volume, R for Mass
xxxx – Read Density	R
xxxx – Read Flow Direction	R
xxxx – Read Density Unit	R
xxxx – Read Tube Diameter	R
xxxx – Read Coil Frequency	R
xxxx – Read Zero Point	R
xxxx – Write Low Flow Cut Off	M for Volume, R for Mass
xxxx – Write Density	R
xxxx – Write Flow Direction	R
xxxx – Write Density Unit	R
xxxx – Write Tube Diameter	R
xxxx – Write Coil Frequency	R
xxxx – Write Zero Point	R

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

Magmeter 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 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)

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

6.5 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
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

6.6 Command xxxx: Read Flow Direction (optional)

The Flow Direction determines whether the volume or mass 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)

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

6.7 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
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 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

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

6.9 Command xxxx: Read Coil Frequency (optional)

The magnetic coils are pulsed at a specified 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	Coil Frequency Unit
2 – 5	float	Coil Frequency

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: 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
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 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

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

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	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 (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

6.13 Command xxxx: Write Flow Direction (optional)

The Flow Direction determines whether the volume or mass 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

Byte	Format	Description
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

6.14 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
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

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

6.15 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
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

6.16 Command xxxx: Write Coil Frequency (optional)

The magnetic coils are pulsed at a specified frequency.

Request Data Bytes

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

Response Data Bytes

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

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
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

6.17 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
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. MAGMETER DEVICE FAMILY TABLES

7.1 Table 1: Device Variable and Magmeter Family Status

Bit	Magmeter Family Variable Status
0xD0	Data Quality of Device Variable
0x30	Limit Status of Device Variable
0x08	More Device Family Status Available
0x04	Transmitter Failure
0x02	Empty Pipe (tube partially filled or empty)
0x01	Coil Current out of tolerance

7.2 Table 2: Additional Magmeter Family Status

Bit	Additional Magmeter 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.