HART **Protocol Specification**
Field Communication

HART®
COMMUNICATION FOUNDATION

Totalizer Device Family Specification

HCF_SPEC-160.10, Revision 1.0

Release Date: 05 November, 2002

PRELIMINARY

Release Date: 05 November, 2002

Document Distribution / Maintenance Control / Document Approval

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1. SCOPE

This Device Family principally allows the configuration of a totalizer block to be determined. The properties are common to many applications to integrate (totalize, accumulate) a rate or another quantity (e.g. flow rate or power) to the corresponding integral (e.g. volume, mass). For instance totalizers are typically implemented in flow devices to totalize a volume or mass flow to a volume or a mass quantity. If a device presents more than one Device Variable, the Input Selector (optional) selects which one is totalized.

The following Common Practice Commands are mandatory:

- Command #53: Write Device Variable Units
- Command #44: Write Primary Variable Units (only if totalizer value can be mapped to PV)
- Command #79: Write Device Variable (Sets Totalizer to a value)
- Command #54: Read Device Variable Information

The following Device Family Parameters are mandatory:

- Fail Safe Behavior (e.g. Run, Hold, Memory)
- Totalizer Mode (e.g. Balanced, Positive Only, Negative Only, Absolute, Hold)
- Direction (determines to add or subtract the totalizer input)
- Totalizer family status
- Specific definitions in the Device Variable Status (e.g. Totalizer run-over zero for batch application, Internal overflow of totalizer)

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

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 a totalizer block and this device family:

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. OVERVIEW

The Totalizer Block integrates another Device Variable over time.

Figure 1. Totalizer Device Family Diagram illustrates a typical totalizer 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 a totalizer block.

The units for the rate and for the totalized quantity have to be of the same type. (e.g. if channel is a mass flow (kg/s), the totalized quantity have to be a mass kg, g, ton, ...). The unit of the totalized quantity is the integral or compatible (compatible means: g, kg, ton, ... are compatible) to the integral of the unit of the device variable.

The totalizer function can be tailored for different applications using the configuration parameters. (for example: fail-safe behavior)

The Input Selector determines the Device Variable to be totalized. If there is only one Device Variable, that can be totalized, the Input Selector is fixed. Then the Input Selector can only be read and not written.

The Device Variable is providing the rate information to the totalizer, which processes this input in different stages depending on the settings of the control parameters. After passing the first two blocks, which are defining the fail-safe behavior and the operation of the function block, the actual function block algorithm is entered.

In figure 1, the block "Integrator" accumulates the rate, which represents the measured rate for a specific time interval Δt, to a total quantity. The integration time interval Δt is in general specific to a certain transmitter. Further it might be constant or it might depend on certain parameters of the transmitter or even the magnitude or the rate. The parameter Direction determines whether the incoming value is added or subtracted to the totalizer.

For batching applications a bit in the device status is set when the totalizer runs over zero. Optionally this bit is used to drive a Relay. By configuration the Relay can be inverted and forced.

Typically, the totalized value is stored at the event of a power failure by the device in a non-volatile memory and recovered after a following power-up.
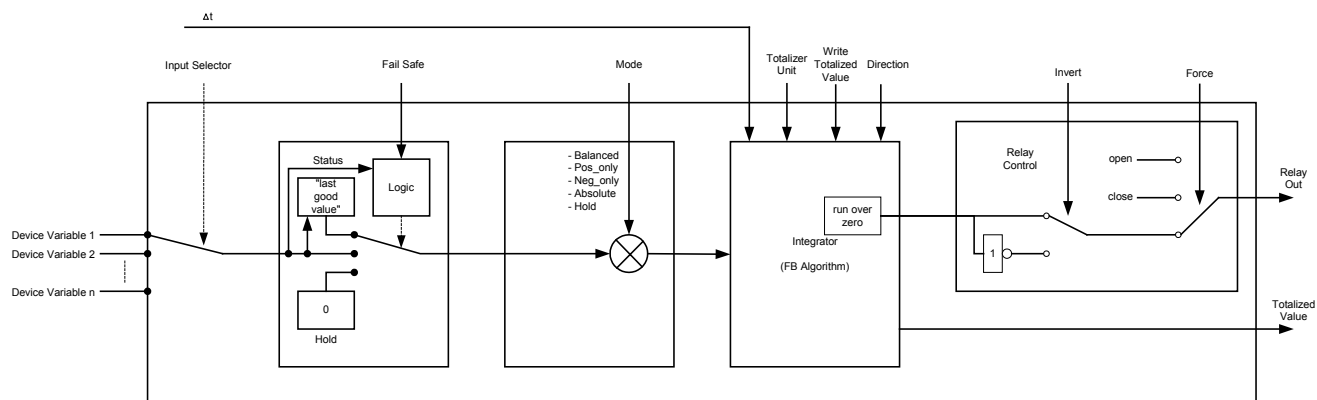
Figure 1. Totalizer Device Family Diagram

4.1 Write Totalizer (command #79)

Writing a value (re)sets the totalizer immediately to that value.
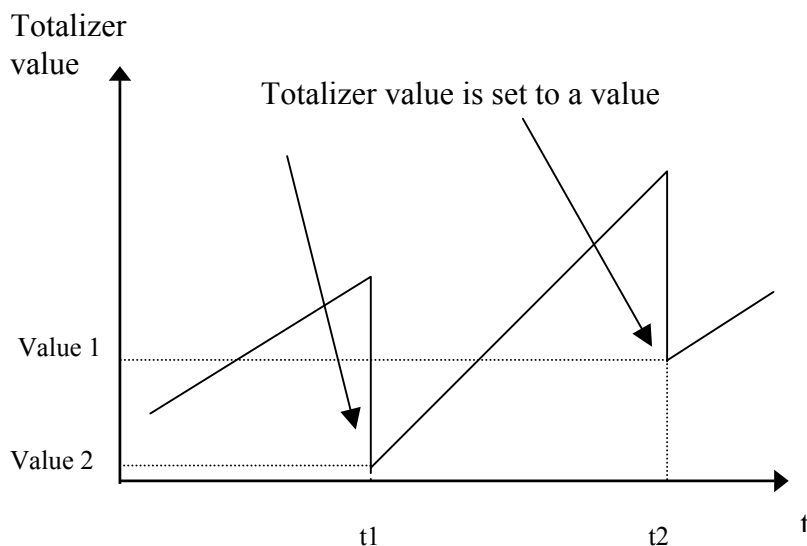
Figure 2. Preset Totalizer Diagram

The next 2 figures show some typical applications.

The totalizer is reset to 0 in order to integrate the quantity from that time. In this case the flow rate creates a positive increment on the Totalizer.

Totalizer value is set to zero.
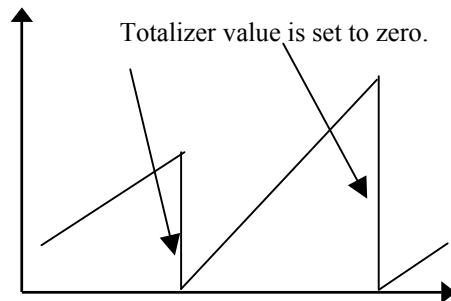
Figure 3. Totalizer counts quantity from zero

The totalizer is set to a value <> 0 in order to count down to zero. In this case the flow rate creates a decrement on the Totalizer.

Totalizer is set to a value and counts down.
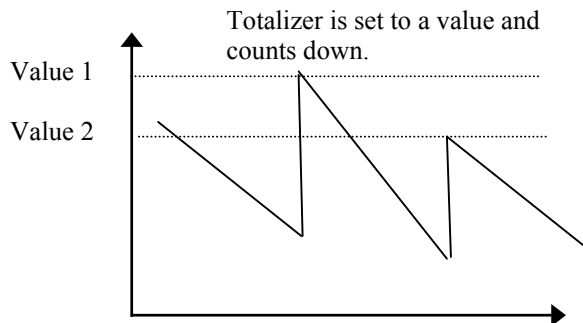
Value 1

Value 2

Figure 4. Totalizer counts fixed quantity to zero

Alternatively the totalizer can be preset to a negative value. Then a positive increment leads to count over zero.

4.2 Usage of Totalizer run-over zero (for example: Batch applications)
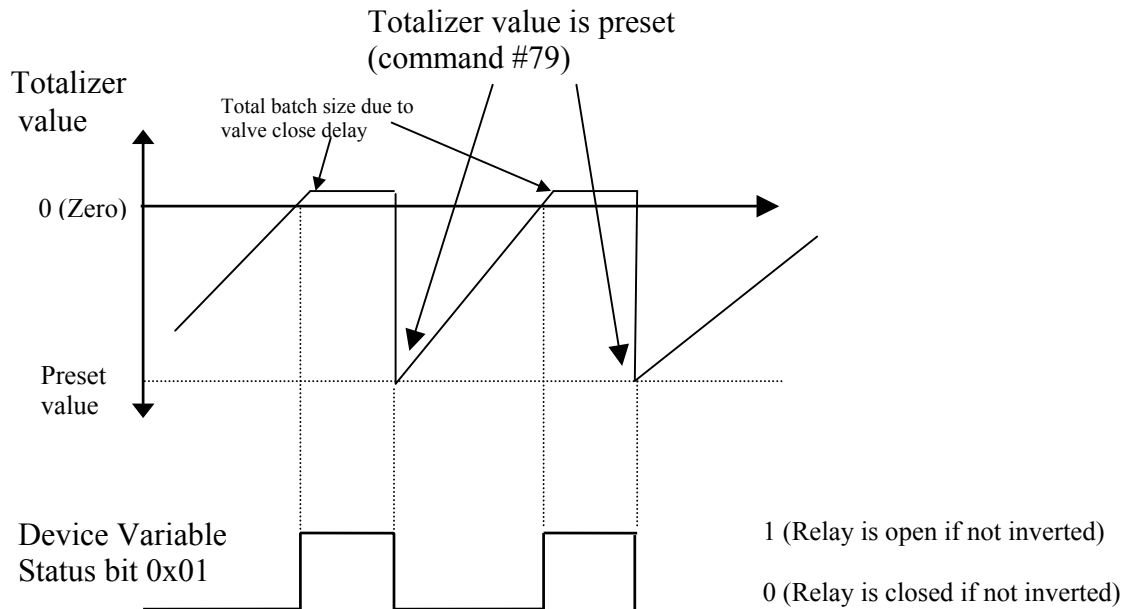
Figure 5. Totalizer Run Over Zero Behavior

The Totalizer is preset to a negative value. The flow rate creates a positive increment. At run over zero the corresponding bit in the Device Variable Status is set to signal the batch amount. In a typical application the valve will close. By presetting the Totalizer the Run Over Zero Bit is reset.

The total batch size due to valve close delay can be calculated by adding the set point and final totalizer value. In that way the set point can be used (manually or automatically) to compensate for the speed at which the valve closes.

5. COMMANDS

5.1 Overview

Command	M=Mandatory, R=Recommended
2560 – Read Totalizer Status	M
2561 – Read Totalizer Configuration	M
2562 – Read Relay Configuration	R
2688 – Write Totalizer Fail Safe Behavior	M
2689 – Write Totalizer Mode	M
2690 – Write Direction	M
2691 – Write Input Selector	R
2692 – Write Force Relay	R
2693 – Write Invert Relay	R

Table 1 – Totalizer Device Family Commands

5.2 Command 2560 Read Totalizer 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	Totalizer Status (refer to Table 1)
2	Bits	Additional Totailzer 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

5.3 Command 2561 Read Totalizer Configuration (Mandatory)

This command reads the configuration of the Totalizer Block in respect of fail safe behavior and mode.

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 Definition Revision
2	Unsigned-8	Device Variable Code of selected Variable for Input
3	Enum	Totalizer Fail Safe Behavior (refer to table 3)
4	Enum	Totalizer Mode (refer to table 4)
5	Enum	Direction (refer to table 5)

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

5.4 Command 2562 Read Relay Configuration (Optional)
This command reads the configuration of the Relay.

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	Force Relay (refer to table 6)
2	Unsigned-8	Invert Relay (refer to table 7)

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 – 15		Undefined
16	Error	Access Restricted
17 –127		Undefined

5.5 Command 2688 Write Totalizer Fail Safe Behavior (Mandatory)

This command writes the Fail Safe Behavior of the Totalizer Block.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Totalizer Fail Safe Behavior (refer to table 3)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Totalizer Fail Safe Behavior (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 – 15		Undefined
16	Error	Access Restricted
17 –127		Undefined

5.6 Command 2689 Write Totalizer Mode (Mandatory)

This command writes the configuration of the Totalizer Mode.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Totalizer Mode (refer to table 4)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Totalizer Mode (refer to table 4)

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 – 15		Undefined
16	Error	Access Restricted
17 –127		Undefined

5.7 Command 2690 Write Direction (Mandatory)

The parameter Direction determines whether the incoming value is added or subtracted to the totalizer.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Direction (refer to table 5)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Direction (refer to table 5)

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 – 15		Undefined
16	Error	Access Restricted
17 –127		Undefined

5.8 Command 2691 Write Input Selector (Optional)

This command writes which Device Variable of another Device Family is selected as Input for the Totalizer Block.

Request Data Bytes

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

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Unsigned-8	Device Variable Code of selected Variable for Input

Command-Specific Response Codes

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

5.9 Command 2692 Write Force Relay (Optional)

This command forces the Relay to open or close.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Unsigned-8	Force Relay (refer to table 6)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Unsigned-8	Force Relay (refer to table 6)

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 – 15		Undefined
16	Error	Access Restricted
17 –127		Undefined

5.10 Command 2693 Write Invert Relay (Optional)

This command negates the Relay.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Unsigned-8	Invert Relay (refer to table 7)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Unsigned-8	Invert Relay (refer to table 7)

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 – 15		Undefined
16	Error	Access Restricted
17 –127		Undefined

6. TOTALIZER DEVICE FAMILY TABLES

6.1 Table 1: Device Variable and Totalizer Family Status

Bit	Totalizer Family Variable Status
0xD0	Data Quality of the Device Variable; It is used to show when the Totalizer is in Fail Safe due to bad input.
0x30	Limit Status of the Device Variable; It is used to show an internal over- or underflow of the Totalizer.
0x08	More Device Family Status Available
0x04	Transmitter Failure
0x02	Unit mismatch between input device variable and totalizer unit
0x01	Totalizer value run-over zero (for batch applications); this bit should be reset when totalizer value is written with preset value

6.2 Table 2: Additional Totalizer Family Status

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

6.3 Table 3: Totalizer Fail Safe Behavior

Code	Fail Safe Behavior
0	Run: Totalization is continued using the input value despite bad or uncertain status
1	Hold: Totalization is stopped during bad or uncertain status of incoming values
2	Memory: Totalization is continued based on the last incoming value with good status
3...239	Reserved
240 – 249	Manufacturer Specific
251	None
252	Unknown

Code	Fail Safe Behavior
253	Special

6.4 Table 4: Totalizer Mode

Code	Totalizer Mode
0	Balanced: True arithmetic Totalization of the incoming rate value
1	Positive Only: Totalization of positive incoming rate values only
2	Negative Only: Totalization of negative incoming rate values only
3	Absolute: Totalization of absolute incoming rate value
4	Hold: Totalization stopped
5...239	Reserved
240 – 249	Manufacturer Specific
251	None
252	Unknown
253	Special

6.5 Table 5: Direction

Code	Totalizer Mode
0	Totalizer adds the flow quantity
1	Totalizer subtracts the flow quantity
2...239	Reserved
240 – 249	Manufacturer Specific
251	None
252	Unknown
253	Special

6.6 Table 6: Force Relay

Code	Force Relay Mode
0	Normal (not forced)
1	Force Relay to open
2	Force Relay to close
2...239	Reserved

Code	Force Relay Mode
240 – 249	Manufacturer Specific
251	None
252	Unknown
253	Special

6.7 Table 7: Invert Relay

Code	Invert Relay Mode
0	No Invertation
1	Invertation
2...239	Reserved
240 – 249	Manufacturer Specific
251	None
252	Unknown
253	Special

ANNEX A.   REVISION HISTORY

A1.   Revision 1.0 a
Initial Revision.