HART Protocol Specification

HART Field Communications

Valve Positioner Device Family Specification

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Preface

This proposal intends to be a resolution of many efforts by various groups since 1993. In creating the list of interoperable attributes for actuators, the following guidelines were followed:

- Do not invent the wheel once again, utilize the work already done
- Generate the set of attributes for valves which are useful to end-user independent of the actuator technology used
- Keep HART actuator simple, remove all “nice-to-have” parameters
- If there can be differences in the parameter and corresponding command implementation between the manufacturers, keep the parameter manufacturer-specific
- This proposal is based on the work done by:
- The HART valve WG lead by Pompilio Bermudez, Fisher Controls
- HART valve WG lead by Jim Snowbarger, Fisher Controls
- The HART valve WG lead by Kari Hartikainen, Neles Automation
- Profibus PA valve profile group

Introduction

This is the proposal for interoperable device variables, commands and device status data applicable to valve positioners or similar output devices. The characteristics of a valve positioner is the following.

1. It accepts 4-20 mA control signal from the control system

2. It can measure the position of the valve under control

3. It can control the valve position according to the 4-20 mA control signal

Other type of output devices like I/P transducers can apply part of these interoperable definitions but this is not specifically addressed in this document.

The document is based on the Device Family Command (DFC) proposal which provides the interoperability mechanism for HART rev 6 slaves and masters. DFC mechanism is based on the two basic items: device variables and variable related attributes.

Device variables are defined per device family e.g. temperature variable belongs to temperature device family. HART slave may have multiple device variables but not all of them need to support a device family. For example, valve positioners may measure the device temperature and actuator pressure but the corresponding device variables do not support temperature and pressure device families respectively because the corresponding attributes are not applicable in this case. DFC mechanism provides a HART master a set of commands to identify the number of device variables and those device variables which support DFC based communication. Numbering of the device variables starts always from zero.

Each device variable supporting DFC mechanism includes set of defined mandatory and/or optional attributes (parameters). The attributes are accessible via set of read and write commands defined by the device family group. The reading of all mandatory attributes must be supported but the writing of them may or may not be supported by a slave. The following rules apply in the definition of commands and attributes.

1. Minimize upload time i.e. group attributes into one read command

2. Identify mandatory vs. optional attributes

3. Write one attribute at a time if attributes are not interrelated with equal response codes

4. Mandatory and optional attributes may be mixed in one command

5. Attributes are not dynamic i.e. they cannot change directly nor indirectly without master intervention

The device status data is device variable related and can be accessed via HART rev 6 Universal and Common Practice Commands related to reading of device variables and dynamic variables. Device status data bit mapping is described in Common Tables for each device family. HART rev 6 provides also a Universal Command to identify the DFC related dynamic variables and to interpret the status data provided by the related read commands.

1. SCOPE

This document describes interoperable device variables, commands and device status data applicable to valve positioners or similar output devices. Other type of output devices like I/P transducers can apply part of these interoperable definitions but this is not specifically addressed in this document.

The goal of this proposal is to define a minimum set of common services that will allow plant operation and maintenance personnel to access the normal online operation and status data in addition to minimum set of configuration data of actuators required to setup an actuator device.

Interoperable commands are additional to those existing Universal and Common Practice commands applicable to actuator devices.

The following minimum set of interoperable device family services are defined for valve positioners:

Controlling the valve remotely
Loop current ranging (split range) and loop action (direct/inverse and positioner action)
Setting loop fail action of the positioner (opens/closes valve)
Setting valve setpoint source to provide maintenance vs. operation management
Setting travel rate of change and cutoff
Valve flow characterization
Valve travel limiting and ranging
Activating automatic travel calibration and self-tuning

2. REFERENCES

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

HART Field Communications Protocol Specification. HCF_SPEC-12

Command Summery Specification. HCF_SPEC-99

Universial Command Specification. HCF_SPEC-127

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

3. DEFINITIONS

Calibrated travel - The maximum allowed travel of the valve depending on its mechanical configuration. The calibrated travel is determined during the calibration of the actuator. All the percentage values describing the valve opening and travel configuration are in respect to the calibrated travel of the valve.

Loop current - Typically 4-20 mA control signal to the actuator, which determines the opening of the valve according to the setpoint and travel calibration and configuration. The digital counterpart of the loop current is defined as the percent of the loop current, i.e., 0% equals to 4 mA and 100% equals to 20 mA. Digital loop current value is accessible via Universal Command #1.

4. INTEROPERABLE DEVICE VARIABLES

The interoperable device variables of the valve positioner device family are the following.

Control Value (Mandatory)

Valve Setpoint (Optional)

Target Position (Mandatory)

Valve Position (Optional)

BCalc Value (Optional)

Control Value is a valve control value between 0-100 % where 0 % means the lower range value of the loop current and 100 % the higher range value of the loop current. Control Value is affected by the loop current ranging parameters and thus may not be equal to loop current value. Exception to that is the case in which the Control Value is written digitally using an appropriate Common Practice command (see also section 6.1.4). To support the interoperability with some Common Practice commands applicable to valves and actuators or the interoperability with a digital PID control[1] external to a valve, it is recommended that Control Value is always the Primary Variable for a single interoperable valve positioner device.

Valve Setpoint is a valve control value between 0-100 % where 0 % means minimum opening and 100 % maximum opening determined by the calibrated travel. Valve Setpoint is affected by the Setpoint Configuration parameters and thus may not be equal to Control value.

Target Position is the final setpoint value between 0-100 % used by the valve position controller where 0 % means minimum opening and 100 % maximum opening determined by the calibrated

[1] Digital PID control in this context means the use of HART communication in sending the PID control signal to or receiving a back calculation signal from a HART positioner.

travel. Target Position is affected by the valve characterization, travel rate, travel ranging and travel limiting parameters and thus may not be equal to Valve Setpoint.

Valve Position is the measured position of the valve between the values of 0-100 % where 0 % means minimum opening and 100 % maximum opening determined by the calibrated travel of the valve. Valve position deviation can be derived as (Target Position – Valve Position).

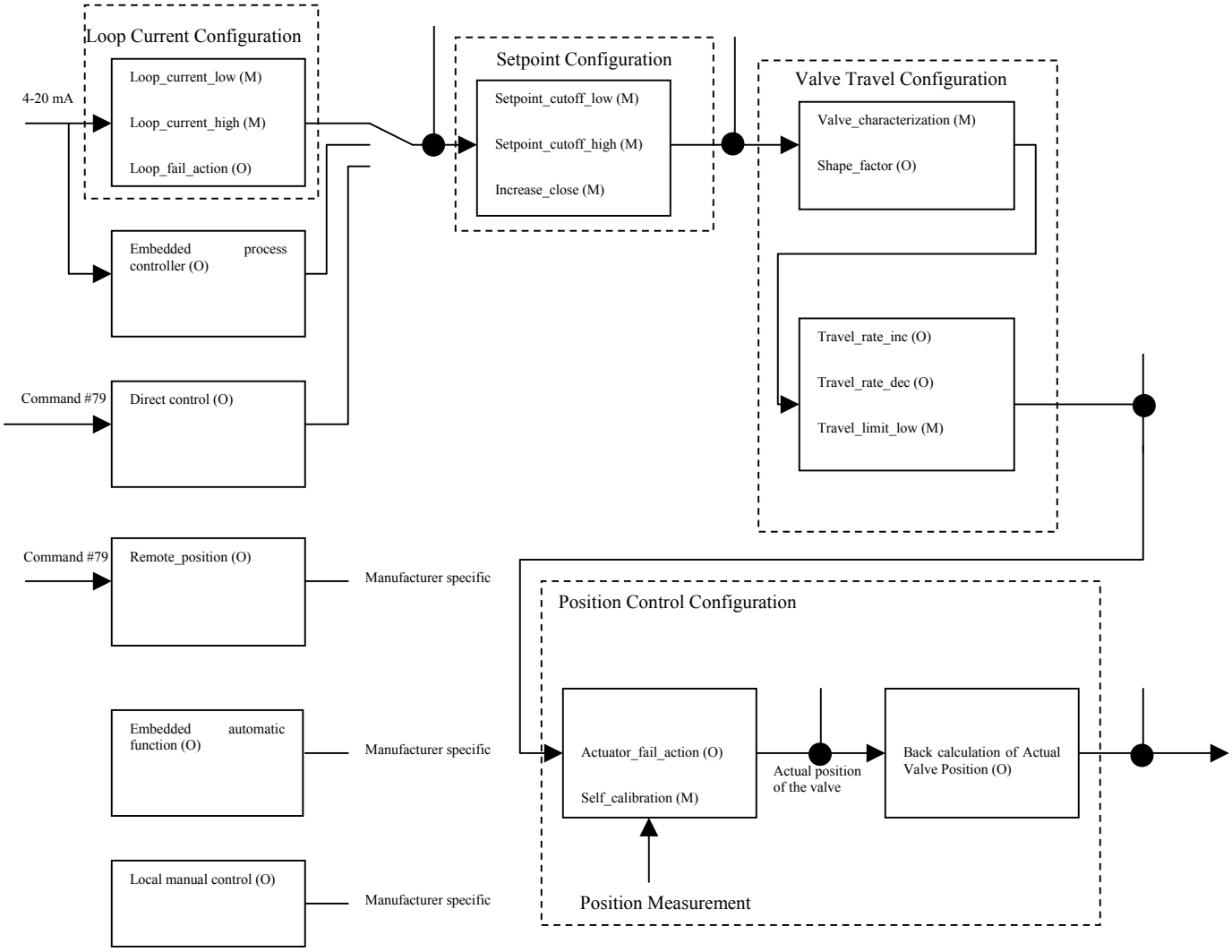
BCalc Value is a value used for back calculation of a PID controller. It is backwards calculated from the Valve Position and is affected by the valve characterization and travel ranging parameters and thus may not be equal to Valve Position.

There are five interoperable device variables in this family. Every device variable should report the valve positioner family code in response to Common Practice Command 54. For more information see Device Family Command Specification.

Because every device variable reports same family code, a HART master cannot identify valve device variables via command 54. A Device Family Command is defined to read the device variable mapping of the valve positioner family.

The block diagram shows the relationship of the device variables and the applicable attributes for valve positioner family type of devices.

5. BLOCK DIAGRAM



Block diagram model of the relationships between device variables and attributes of the valve positioner family type

6. INTEROPERABLE ATTRIBUTES

6.1 Control Value related attributes

6.1.1 Loop_current_low

The value of the loop current in mA which determines the 0% value of Control Value.

6.1.2 Loop_current_high

The value of the loop current in mA which determines the 100% value of Control Value.

6.1.3 Loop_fail_action

Determines the positioner action during the loss of electrical control signal, i.e., the valve motion caused by the positioner or electric actuator in the case of the loss of supply power.

Devices which can not support that attribute like 2 wire single acting positioners should always report ”not used”.

This attribute uses the enumeration of Alarm_selection_code (see Common Table 6) to also use it with Common Practice commands.

Loop_fail_action	Alarm_selection_code
valve opens	High
valve closes	Low
valve stays	Hold last output value
not used	Not Used

6.1.4 Setpoint_source

Determines the control signal source of a valve positioner. The Setpoint Source is the combination of Position Source (MSB) and Control Value Source (LSB). The Target Position Source value always overrides the Valve Setpoint Source value. The Setpoint Source has six bit-coded enumerations.

Setpoint Source	Position Source (MSB)	Control Value Source (LSB)	Description
Loop Current	0000	0000	Valve positioner follows the analog control signal. This is the normal operation mode of a HART valve positioner.
Embedded Process Controller	0000	0001	Valve positioner follows the output of an embedded process control algorithm.
Control Value	0000	0010	Valve positioner follows the digital control signal of a HART capable process controller (see Command #79).

Embedded Automatic Function	0001	XXXX	Valve positioner does not follow the process control signal. An embedded temporary operation function has been activated.
Local Manual Control	0010	XXXX	Valve positioner does not follow the process control signal. The valve position is manually controlled by the means of a local user interface. The valve travel configuration parameters may affect the actual valve position.
Remote Position	0011	XXXX	Valve positioner does not follow the process control signal. The valve position is manually controlled by the means of a HART master (see Command #79). The valve travel configuration parameters may affect the actual valve position.

6.1.5 Internal_setpoint_source

If Setpoint Source is Embedded Process Controller this attribute identifies the actual controller output device variable connected to Control Value variable. If setpoint source value is Loop Current or Control Value the Internal Setpoint Source is Not Used.

6.1.6 Setpoint_shed_time

If Setpoint Source as Control Value is supported, this attribute should also be supported. It determines the time period after which the valve positioner drives the valve into fail-safe position if the Control Value is not updated, i.e., corresponding write command is not issued. If the value of Setpoint Shed Time is zero, no time-out function is applied.

6.2 Valve Setpoint related attributes

6.2.1 Setpoint Cutoff Low

When the Control Value goes below the Setpoint Cutoff Low value (in % of Control Value) the positioner goes to that position which is related to 4 mA.

6.2.2 Setpoint Cutoff High

When the Control Value goes above the Setpoint Cutoff High value (in % of Control Value) the positioner goes to that position which is related to 20 mA.

6.2.3 Increase Close

This attribute determines the relationship of the moving direction of the valve to the setpoint.

Enumerations:
0 = Rising (increasing of Control Value opens the valve)

1 = Falling (increasing of Control Value closes the valve)

6.3 Target Position related attributes

6.3.1 Valve_characterization

The transfer function which can be used to affect the installed flow characteristics of the valve. For example to approximately linearize the installed flow characteristics of equal percentage function one would apply quick opening transfer function. To preserve the installed flow characteristics a linear transfer function should be applied.

Enumerations:

0 = Linear	(Mandatory)
1 = Equal % 1:50	(Optional)
2 = Quick Open 1:50	(Optional)
3 = Custom Table	(Optional)
4 = Equal % 1:25	(Optional)
5 = Quick Opening 1:25	(Optional)
6 = Equal % 1:33	(Optional)
7 = Quick Open 1:33	(Optional)
8 = Hyperbolic (Shape Factor)	(Optional)

If enumeration 8 = Hyperbolic (Shape Factor) is supported the attribute Shape_factor and its commands become mandatory.

6.3.2 Shape_factor

Describes the nearest approximate or exact shape of the valve characterization transfer function based on the hyberbolic function:

$f(x) = x / (S + x (1 – S))$,

where S is shape factor, x is normalized (0-1) input of the transfer function representing Valve Setpoint and f(x) represents an intermediate value before applying travel limits. If $S = 1$, a linear transfer function is applied. If $0 < S < 1$, a quick opening transfer function is applied. If $S > 1$, an equal percentage transfer function is applied. For custom transfer function S is zero.

6.3.3 Characterization Table

Custom Table (11/21/x? points)

There are no Common Practice commands that can be used to read and write the custom transfer function for modifying the installed flow characteristics of a control valve.

Proposal: define own commands or use Block Transfer Commands.

6.3.4 Travel Rate Inc

This attribute can be used to limit the rate of change of the Target Position. It is the configurable time in seconds for a full setpoint span change in opening direction.

6.3.5 Travel Rate Dec

This attribute can be used to limit the rate of change of the Target Position. It is the configurable time in seconds for a full setpoint span change in closing direction.

6.3.6 Travel_limit_low

Lower limit value of Target Position in percent of calibrated travel.

6.3.7 Travel_limit_high

Upper limit value of Target Position in percent of calibrated travel.

6.3.8 Travel_range_low

Lower range value of Target Position related to calibrated travel.

The travel range can be used to rerange the travel of the valve, i.e. to use only a part of the calibrated travel as 100 % travel span. The engineering units of the travel range have to be the same as the calibrated travel (e.g. %, mm, inches, degrees).

6.3.9 Travel_range_high

Upper range value of Target Position related to calibrated travel.

The travel range can be used to rerange the travel of the valve, i.e. to use only a part of the calibrated travel as 100 % travel span. The engineering units of the travel range have to be the same as the calibrated travel (e.g. %, mm, inches, degrees).

6.4 Valve Position related attributes

6.4.1 Self_calibration

Initiates one of the following automatic valve calibration/tuning routines:

0 = automatic travel calibration
1 = automatic tuning
2 = automatic travel calibration and tuning
3 = automatic zero point calibration
4 - 99 = reserved
100 - 254 = manufacturer specific
255 = undefined

The support of the predefined enumerations is optional. A device may use only the manufacturer specific enumerations.

6.4.2 Actuator_fail_action

Determines the actuator action during the loss of power, i.e. the valve motion caused by the pneumatic or electric actuator in the case of loss of supply power.

0 = valve opens
1 = valve closes
3 = valve stays
4-239 = reserved
254 = not used

7. INTEROPERABLE COMMANDS

7.1 Universal and common practice commands for valve positioner family devices

To support the interoperability with some Universal and Common Practice commands applicable to valves and actuators or the interoperability with a digital PID control external to a valve positioner, it is necessary that Control Value is always the Primary Variable for a single interoperable valve positioner device.

Commands #1, #2, #3

This commands should always report the Control Value as PV.

Command #14

This command can be used for reading limit information of the PV.

Transducer Limits and Minimum Span Units Code always reports mA.

Upper Transducer Limit and Lower Transducer Limit report the maximum and minimum analog loop current the device will work with.

Minimum Span is the smallest range that can be used by loop current ranging.

Command #15

This command returns the units and the upper and lower range values for the PV.

It can be used to read the Control Value attributes Loop_current_low and Loop_current_high and Loop_fail_action.

Loop_current_low and Loop_current_high are mapped into Primary Variable Lower Range Value and Primary Variable Upper Range Value. Primary Variable Upper and Lower Range Values Units Code always shows mA.

Loop_fail_action is mapped into Primary Variable Alarm Selection Code.

Command #35

This command is applicable for loop current split-range configuration.

Loop_current_low and Loop_current_high are mapped into Primary Variable Lower Range Value and Primary Variable Upper Range Value. Primary Variable Upper and Lower Range Values Units Code always should be set to mA.

This command does not exclude the valve positioner family specific command Write Loop Action which also includes the positioner action vs. valve motion attribute which is required by some manufacturers to prevent the non-allowed combinations of loop current direct/inverse action and positioner action.

Commands #40, #44, #45 and #46

These commands can be used to trim the loop current input of a valve device. These commands should only be supported by devices that support user-calibration of their current input.

Command #65

This command can be used to rerange any dynamic variable.

Command #79

This command can be used to set any dynamic device variable (depending Setpoint_source).

Commands #80, #81, #82, #83

These commands can be used to manually calibrate the valve travel (0 and 100% opening). These commands should only be supported by devices that support manual calibration of the valve travel.

7.2 Transferring Characterization Tables

For up/download of the characterization table of a control valve Block Transfer Commands can be used.

7.3 Valve positioner family commands

7.3.1 Command #0 Read Valve Positioner Status

All Device Families allow additional status information to be provided to host applications.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Bits	Device Variable related Status (see 8.1)

Byte	Format	Description	
2	Bits	Device Family Status 0	(see 8.2)
3	Bits	Device Family Status 1	(see 8.2)
4	Bits	Device Family Status 2	(see 8.2)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
5	Error	Too Few Data Bytes Received
16	Error	Access Restricted
17	Error	Invalid Device Variable. The Device Variable does not exist in this device
19	Error	Device Variable index not allowed for this command

7.3.2 Command #1 Read Valve Positioner Device Variable Codes

This command reads the device variable numbers of the interoperable device variables of the valve positioner family device.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Unsigned-8	Control Value Variable Number
2	Unsigned-8	Valve Setpoint Variable Number
3	Unsigned-8	Target position Variable Number
4	Unsigned-8	Valve Position Variable Number
5	Unsigned-8	BCalc Value Variable Number

Command-Specific Response Codes

Code	Class	Description
0	Success	No command-specific errors
5	Error	Too few data bytes received
16	Error	Access Restricted
17	Error	Invalid Device Variable Index. The device variable does not exist in this field device.
19	Error	Device Variable Index not allowed for this command

7.3.3 Command #2 Read Valve Positioner Capabilities

This command reports which of the optional attributes are supported by the device.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code

Response Data Bytes

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

Command-Specific Response Codes

Code	Class	Description
0	Success	No command-specific errors
5	Error	Too few data bytes received
16	Error	Access Restricted
17	Error	Access Restricted
19	Error	Access Restricted

Device Family Capabilities 0

Byte	Description
0	Loop_fail_action
1	Internal_setpoint_source
2	Setpoint_shed_time
3	Setpoint_rate_dec and Setpoint_rate_inc
4	Shape_factor
5	Characterization_table
6	Travel_range_low and Travel_range_high
7	Actuator_fail_action

If the corresponding bit in Device Family Capabilities 0 is set the attribute is supported

7.3.4 Command #3 Read Loop Action

This command reads the loop current values (split-range values) corresponding to the valve 0% and 100% opening and the relationship between the loop current and valve opening, i.e., increasing the loop current opens or closes the valve. The command also returns the positioner action in the case of the current loop failure, i.e., loss of loop current. Loop current in mA.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Loop_current_low
5-8	Float	Loop_current_high
9-12	Float	Loop_fail_action

Command-Specific Response Codes

Code	Class	Description
0	Success	
5	Error	
16	Error	
17	Error	
19	Error	

7.3.5 Command #4 Read Setpoint Source

This command reads the setpoint source of a valve positioner. The setpoint source determines the control signal source of the valve.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Bits	Setpoint_source

Command-Specific Response Codes

Code	Class	Description
0	Success	
5	Error	
16	Error	
17	Error	
19	Error	

7.3.6 Command #5 Read Internal Setpoint Source

This command reads the internal source for Valve Setpoint variable in the case of multiple embedded process controllers. It returns the device variable code of the output of embedded process controller. If no embedded process controller is used or is available in the device, Not Used should be returned instead.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Bits	Internal_setpoint_source

Command-Specific Response Codes

Code	Class	Description
0	Success	
5	Error	
16	Error	
17	Error	
19	Error	

7.3.7 Command #6 Read Setpoint Shed Time

This command reads the shed time of the valve positioner when Control Value is written digitally via HART command #79. The shed time determines the time period within which the value of Control Value must be updated, i.e., the coreesponding write command is received by the valve positioner. If the shed time is exceeded, the valve positioner drives the valve into fail-safe position. Shed time in Seconds.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Setpoint Shed Time

Command-Specific Response Codes

Code	Class	Description
0	Success	
5	Error	
16	Error	
17	Error	
19	Error	

7.3.8 Command #7 Read Valve Setpoint Information

This command reads the attributes affecting the calculation of the Valve Setpoint. Setpoint cutoff in % of Control Value.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Setpoint_cutoff_low
5-8	Float	Setpoint_cutoff_high
9	Enumerated	Increase_close

Command-Specific Response Codes

Code	Class	Description
0	Success	
5	Error	
16	Error	
17	Error	
19	Error	

7.3.9 Command #8 Read Valve Travel Information

This command reads the positioner configuration information related to the valve travel. The information includes valve travel rate, travel range and travel limits. If travel range is not supported the device should report NAN. Travel time in Seconds. Travel time in % of calibrated travel.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Travel_rate_dec
5-8	Float	Travel_rate_inc
9	Enumerated	
10-13	Float	Travel_range_low
14-17	Float	Travel_range_high
18-21	Float	Travel_limit_low
22-25	Float	Travel_limit_high

Command-Specific Response Codes

Code	Class	Description
0	Success	
5	Error	
16	Error	
17	Error	
19	Error	

7.3.10 Command #9 Read Flow Characterization Type

This command reads the type of the flow characterization function which modifies the installed flow characteristics of a control valve.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enumerated	Valve_characterization

Command-Specific Response Codes

Code	Class	Description
0	Success	
5	Error	
16	Error	
17	Error	
19	Error	

7.3.11 Command #10 Read Flow Characterization

This command reads the shape of the transfer function which modifies the installed flow characteristics of a control valve. The shape is described by a hyberbolic function.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Shape_factor

Command-Specific Response Codes

Code	Class	Description
0	Unsigned-8	
5	Error	
16	Error	
17	Error	
19	Error	

7.3.12 Command #128 Write Loop Action

This command can be used to set the loop current values (split-range values) corresponding to the lower range value of the loop current and the higher range value of the loop current.

The command can also set the positioner action in the case of the current loop failure, i.e., loss of loop current. The positioner action depends on the mechanical configuration of the control valve assembly and in some cases the contradiction between the Loop Fail Action parameter value and the positioner action may cause the incorrect operation of the control valve.

Some manufacturers may not allow every combinations of loop split-range values and loop fail action values.

Devices which can not support the Loop Fail Action parameter like 2 wire single acting positioners always expect ”not used”. Loop current in mA.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Loop_current_closed
5-8	Float	Loop_current_open
9	Enumerated	Loop_fail_action

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Loop_current_ closed
5-8	Float	Loop_current_open
9	Enumerated	Loop_fail_action

Command-Specific Response Codes

Code	Class	Description
		#1 The combination of loop split-range values and loop fail action is not allowed
0	Success	
5	Error	
7		

7.3.13 Command #129 Write Setpoint Source

This command sets the setpoint source of a valve positioner. The setpoint source determines the control signal source of the valve.

The writing of this attribute may require the pre- and post-transactions of device specific commands.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Bits	Setpoint_source

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Bits	Setpoint_source

Command-Specific Response Codes

Code	Class	Description
?	Error	#1 Present device setting does not accept changing the setpoint source
0	Success	
5	Error	
16	Error	
17	Error	
19	Error	

7.3.14 Command #130 Write Internal Setpoint Source

This command writes the internal source for Valve Setpoint variable in the case of multiple embedded process controllers. It returns the device variable code of the output of embedded process controller. If the device does not support the embedded process controller, standard response code should be given (Command Not Implemented).

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Bits	Internal_setpoint_source

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Bits	Internal_setpoint_source

Command-Specific Response Codes

Code	Class	Description
0	Success	
2	Error	
5	Error	
7	Error	
16	Error	
17	Error	
19	Error	

7.3.15 Command #131 Write Setpoint Shed Time

This command writes the shed time of the valve positioner when Control Value is written digitally via HART command #79. The shed time determines the time period within which the value of Control Value must be updated, i.e., the coreesponding write command is received by the valve positioner. If the shed time is exceeded, the valve positioner drives the valve into fail-safe position. Time in seconds.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Setpoint_shed_time

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Setpoint_shed_time

Command-Specific Response Codes

Code	Class	Description
0	Success	
3	Error	
4	Error	
5	Error	
7	Error	
16	Error	
17	Error	
19	Error	

7.3.16 Command #132 Write Setpoint Cutoff Low

This command writes the lower value of setpoint cutoff. Time in % of Control Value.

CAUTION: Override conflicts will arise between the setpoint cutoff and travel limit configuration. The actual override implementation is manufacturer specific.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Setpoint_cutoff_low

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Setpoint_cutoff_low

Command-Specific Response Codes

Code	Class	Description
0	Success	
3	Error	
4	Error	
5	Error	
7	Error	
16	Error	
17	Error	
19	Error	

7.3.17 Command #133 Write Setpoint Cutoff High

This command writes the upper value of setpoint cutoff.

CAUTION: Override conflicts will arise between the setpoint cutoff and travel limit configuration. The actual override implementation is manufacturer specific.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Setpoint_cutoff_high

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Setpoint_cutoff_high

Command-Specific Response Codes

Code	Class	Description
0	Success	
3	Error	
4	Error	
5	Error	
7	Error	
16	Error	
17	Error	
19	Error	

7.3.18 Command #134 Write Increase Close

This command writes the attribute Increase_close. This attribute determines the relationship of the moving direction of the valve to the setpoint.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enumerated	Increase_close

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enumerated	Increase_close

Command-Specific Response Codes

Code	Class	Description
0	Success	
2	Error	
5	Error	
7	Error	
16	Error	
17	Error	
19	Error	

7.3.19 Command #135 Write Travel Rate Inc

This command writes the attribute Travel_rate_inc. This attribute can be used to limit the rate of change of the Valve Setpoint. Time in seconds.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Setpoint_rate_inc

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Setpoint_rate_inc

Command-Specific Response Codes

Code	Class	Description
0	Success	
3	Error	
4	Error	
5	Error	
7	Error	
16	Error	
17	Error	
19	Error	

7.3.20 Command #136 Write Travel Rate Dec

This command writes the attribute Travel_rate_dec. This attribute can be used to limit the rate of change of the Valve Setpoint. Time in seconds.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Setpoint_rate_dec

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Setpoint_rate_dec

Command-Specific Response Codes

Code	Class	Description
0	Success	
3	Error	
4	Error	
5	Error	
7	Error	
16	Error	
17	Error	
19	Error	

7.3.21 Command #137 Write Travel Range

This command writes the lower and upper values of the valve travel range.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enumerated	Unit Code
2-5	Float	Travel_range_low
6-9	Float	Travel_range_high

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enumerated	
2-5	Float	Travel_range_low
6-9	Float	Travel_range_high

Command-Specific Response Codes

Code	Class	Description
0	Success	
5	Error	
7	Error	

7.3.22 Command #138 Write Travel Limits

This command writes the lower and upper values of valve travel limits. The valve travel is limited between these values under normal operation condition. Units in % of calibrated travel.

CAUTION: Override conflicts will arise between the travel cutoff and travel limit configuration. The actual override implementation is manufacturer specific.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Travel_limit_low
5-8	Float	Travel_limit_high

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Travel_limit_low
5-8	Float	Travel_limit_high

Command-Specific Response Codes

Code	Class	Description
0	Success	
5	Error	
7	Error	

7.3.23 Command #139 Select Flow Characterization Type

This command selects the transfer function which modifies the installed flow characteristics of a control valve. If no modification to the installed flow characteristics is required a linear transfer function should be selected. If the device does not support the selected type, the response Invalid Selection should be given.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enumerated	Valve_characterization

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enumerated	Valve_characterization

Command-Specific Response Codes

Code	Class	Description
0	Success	#1 Invalid Selection
2	Error	
5	Error	
7	Error	
16	Error	
17	Error	
19	Error	

7.3.24 Command #140 Write Flow Characterization

This command sets the shape of transfer function which modifies the installed flow characteristics of a control valve. If no modification to the installed flow characteristics is required a linear transfer function should be set. Shape Factor value should be equal to the selected flow characterization transfer function except for custom 11/21 point transfer function for which Shape Factor value is zero.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Shape_factor

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1-4	Float	Shape_factor

Command-Specific Response Codes

Code	Class	Description
0	Success	
3	Error	
4	Error	
5	Error	
7	Error	
16	Error	
17	Error	
19	Error	

7.3.25 Command #141 Write Actuator Fail Action

This command writes the attribute Actuator_fail_action. Determines the actuator action during the loss of power, i.e. the valve motion caused by the pneumatic or electric actuator in the case of loss of supply power. Some devices are detecting Actuator_fail_action during Self Calibration and therefore may not support writing that attribute.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enumerated	Actuator_fail_action

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enumerated	Actuator_fail_action

Command-Specific Response Codes

Code	Class	Description
0	Success	#1 Device does not support writing that attribute.
2	Error	
5	Error	
7	Error	
16	Error	
17	Error	
19	Error	

7.3.26 Command #142 Activate Self Calibration

This command activates the automatic calibration and/or tuning routine in a valve positioner depending on the selected value of Setpoint Source attribute.

Before starting a self calibration function, the device should set Setpoint Source attribute to indicate the operation of an embedded automatic function and reset it after the self calibration is finished unless the HART master does not that.

It is recommended that a device rejects this command if the value of Setpoint Source attribute is other than Embedded Automatic Function.

If the device does not support the selected type, the response Invalid Selection should be given.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enumerated	Self_calibration

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enumerated	Self_calibration

Command-Specific Response Codes

Code	Class	Description
		#1 Automatic calibration or tuning failed (requires delayed response mechanism implementation)
		#2 Present device setpoint source setting does not accept the local operation
		#3 Invalid Selection
0	Success	
5	Error	
7	Error	

8. INTEROPERABLE STATUS DATA

8.1 Device Variable related status data

Device Variable related status information to be provided with the Device Variables:

The following status bits are defined for **Control Value** device variable:Request Data Bytes

Bit	Format	Description
0	Lower Limit Active	This bit is set if Control Value reaches Loop_current_low.
1	Upper Limit Active	The Target Position does not follow the value of Valve Setpoint.
2	Valve Offline	The Target Position does not follow the value of Valve Setpoint.
3	Valve Simulated	The value of Valve Position is simulated
4	Fail Safe Active	Setpoint_shed_time exceeded
5-7	Reserved	

The following status bits are defined for **Valve Setpoint** device variable:

Bit	Format	Description
0	Lower Limit Active	This bit is set if Valve Setpoint reaches Setpoint_cutoff_low.
1	Upper Limit Active.	This bit is set if Valve Setpoint reaches Setpoint_cutoff_high.
2	Valve Offline	The Target Position does not follow the value of Valve Setpoint.
3	Valve Simulated	The value of Valve Position is simulated
4	Fail Safe Active	Setpoint_shed_time exceeded or Fail Safe activated by embedded functions
5-7	Reserved	

The following status bits are defined for **Target Position** device variable:

Bit	Format	Description
0	Lower Limit Active	This bit is set if travel limit low is applied. The status bit is not set if the MSB value of the Setpoint Source is not equal to 0000.
1	Upper Limit Active.	This bit is set if travel limit high is applied. The status bit is not set if the MSB value of the Setpoint Source is not equal to 0000.
2	Valve Offline	The Target Position does not follow the value of Valve Setpoint.
3	Valve Simulated	The value of Valve Position is simulated
4	Fail Safe Active	Setpoint_shed_time exceeded or Fail Safe activated by embedded functions
5-7	Reserved	

The following status bits are defined for **Valve Position** device variable:

Bit	Format	Description
1	Lower Limit Active.	This bit is set if the decrease of the valve opening is limited because of internal reasons. The status bit is not set if the MSB value of the Setpoint Source is not equal to 0000.
0	Upper Limit Active	This bit is set if the increase of the valve opening is limited because of internal reasons. The status bit is not set if the MSB value of the Setpoint Source is not equal to 0000.
2	Valve Offline	The Target Position does not follow the value of Valve Setpoint.
3	Valve Simulated	The value of Valve Position is simulated
4	Fail Safe Active	Valve is in Fail Safe Position as defined by Actuator_fail_action
5-7	Reserved	

The following status bits are defined for **BCalc Value** device variable:

Bit	Format	Description

Bit	Format	Description
1	Lower Limit Active.	This bit is set if the decrease of the valve opening is limited because of internal reasons. The status bit is not set if the MSB value of the Setpoint Source is not equal to 0000.
0	Upper Limit Active	This bit is set if the increase of the valve opening is limited because of internal reasons. The status bit is not set if the MSB value of the Setpoint Source is not equal to 0000.
2	Valve Offline	The Target Position does not follow the value of Valve Setpoint.
3	Valve Simulated	The value of Valve Position is simulated
4	Fail Safe Active	Valve is in Fail Safe Position as defined by Actuator_fail_action
5-7	Reserved	

8.2 Device Family Status

Device Family Status Information to be provided with Command Read Valve Positioner Status.

If a Status Information is not supported by a device the corresponding bit should be set to 0.

Device Family Status 0

Bit	Format	Description
0	Electrical Hardware Failure	Failure in the electrical part of the device is detected
1	Mechanical Hardware Failure	Failure in the mechanical or pneumatical part of the device is detected
2	Temperature Failure	Internal Temperature too high
3	Memory Error	Failure or checksum error in non volatile device memory detected
4	Feedback failure	Failure in travel pickup system
5	Supply error	Device has detected a loss or shortage of power supply

Bit	Format	Description
6	Local operation active	Device in local control
7	Override active	Override function active (e.g. built-in security contact or function)

Device Family Status 1

Bit	Format	Description
0	Not calibrated	Device has not performed a self calibration
1	Self calibration failed	Self calibration was not successful
2	Selftest active	Device is currently performing selftest or calibration
3	Configuration error	Device has detected an inconsistend configuration
4	Characterizatio n error	Downloaded characterization is invalid
5-7	reserved	

Device Family Status 2

Bit	Format	Description
0	Travel time exceeded	Internal travel time monitoring has exceeded its limits
1	Control loop error	Internal control loop supervision has detected an error
2	Zero point error	Internal supervision has detected a zero point deviation of the valve
3	Torque limit active	Torque limit is exceeded
4	Maintenance required	Internal supervision function has detected the need for maintenance of the device
5	Additional input active	an additional input of the device (e.g.for diagnostic purposes) is active
6-7	reserved	

9. SUMMARY TABLE OF INTEROPERABLE VALVE POSITIONAER ATTRIBUTES

Attribute name	Unit	Type	Implementation
Loop_current_low	mA	Float	Mandatory
Loop_current_high	mA	Float	Mandatory
Loop_fail_action	N/A	Uint8	Optional
Setpoint_source	N/A	Uint8	Mandatory
Internal_setpoint_source	N/A	Uint8	Optional
Setpoint_shed_time	s	Uint8	Optional
Setpoint_cutoff_low	%	Float	Mandatory
Setpoint_cutoff_high	%	Float	Mandatory
Increase_close	N/A	Uint8	Mandatory
Setpoint_rate_dec	s	Float	Optional
Setpoint_rate_inc	s	Float	Optional
Valve_characterization	N/A	Uint8	Mandatory
Shape_factor	N/A	Float	Optional
Characterization_table	%	Array of Floats	Optional
Travel_range_low	Manuf. spec.	Float	Optional
Travel_range_high	Manuf. spec.	Float	Optional
Travel_limit_low	%	Float	Mandatory
Travel_limit_high	%	Float	Mandatory
Self_calibration	N/A	Uint8	Mandatory
Actuator_fail_action	N/A	Uint8	Optional

10. SUMMARY TABLE OF INTEROPERABLE VALVE POSITIONER COMMANDS

Command name	Implementation
Read Valve Positioner Status	Mandatory
Read Valve Positioner Device Variable Codes	Mandatory
Read Valve Positioner Capabilities	Mandatory
Read Loop Action	Mandatory
Read Setpoint Source	Mandatory
Read Internal Setpoint Source	Optional
Read Setpoint Shed Time	Optional
Read Valve Setpoint Information	Mandatory
Read Valve Travel Information	Mandatory
Read Flow Characterization Type	Mandatory
Read Flow Characterization	Optional
Write Loop Action	Optional
Write Setpoint Source	Optional
Write Internal Setpoint Source	Optional
Write Setpoint Shed Time	Optional
Write Setpoint Cutoff Low	Optional
Write Setpoint Cutoff Low	Optional
Write Increase Close	Optional
Write Setpoint Rate Inc	Optional
Write Setpoint Rate Dec	Optional
Write Travel Range	Optional
Write Travel Limits	Optional
Select Flow Characterization Type	Optional
Write Flow Characterization	Optional
Write Actuator Fail Action	Optional
Activate Self Calibration	Mandatory
Abort Self Calibration	Mandatory

ANNEX A. REVISION HISTORY