STANDARD

Common Practice Command Specification

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Addendum To
Common Practice Command Specification (HCF_SPEC-151)

May 21, 2008

Since release of the HART Communication Protocol Revision 7.0 Specifications in September 2007, HCF staff and Technical Working Groups updating and developing test specifications have closely scrutinized the Protocol Specifications. Any anomalies, errors or omissions discovered in the Specifications have been identified, tracked and resolved. Changes, clarifications and corrections resulting from the anomalies discovered and resolved during this process are detailed in this addendum.

This addendum provides developers with the most current, accurate and up-to-date information on the HART 7 Specifications. Each change is detailed below by Subsection and brief explanation of the change. All changes described in this addendum are mandatory. HART-enabled product implementations must comply with the Specification corrections and clarifications described in this addendum.

Subsection 6.9.2 / Table 2
For IEEE STD 802.15.4 also 0.1s should be allowed (for small fast networks). Consequently, Table 2 must be modified as follows:

Table 2. Minimum Update Rates Allowed by Physical Layer

Physical Layer	Minimum Value	Default Period
FSK	0.500s	N/A
PSK	0.100s	N/A
RS-485	0.100s	N/A
IEEE STD 802.15.4-2006	0.100s	60s

Subsection 6.10
The number of events that must be captured must be specified. Consequently, the last paragraph in Subsection 6.10 must be modified as follows:

The device must retain Event Notification Settings through a Device Reset, Self Test or the power being removed and reapplied. While event transitions do not need to be retained through power cycles at least 3 transitions (the current event being published using Command 119 and 2 more that are buffered) must be supported. It is highly recommended that 5 transitions be buffered.

Subsection 7.46 Command 78 Read Aggregated Commands

In Command 78, the byte numbering in the Response is incorrect 0. Consequently, the byte numbering is as follows:

Response Data Bytes

Byte	Format	Description
0	Bits-8	Extended Field Device Status (refer to Common Table 17, Extended Field Device Status)
1	Unsigned-8	Number of commands requested
2-3	Unsigned-16	Cmd A
4	Unsigned-8	Byte count for Cmd A
5 - A	Unsigned-8	Data bytes for Cmd A (including command's Response Code)
…	Unsigned-16	Cmd B
…	Unsigned-8	Byte count for Cmd B
…	Unsigned-8	Data Bytes for Cmd B (including command's Response Code)
	…	
…	Unsigned-16	Cmd N
…	Unsigned-8	Byte count for Cmd N
…	Unsigned-8	Data Bytes for Cmd N (including command's Response Code)

Subsection 7.52 Command 84 Read Sub-Device Identity Summary

The use of the configuration changed bit to indicate communication problems with sub-devices is inappropriate. Command 48 Status must be used for this purpose. Consequently, the first paragraph of the requirements in Command 84 must be changed to read:

This command allows an application to get a summary of the sub-devices connection to the I/O system. The I/O System must maintain a list of connected sub-devices and the summary information in this command. Any change to this list shall cause the "Sub-Device List Changed" bit to be set in the Command 48 response.

Subsection 7.56 Command 88 Write I/O System Retry Count

"Passed parameter too small" must be allowed in Command 88. Consequently, the response code is changed to the following:

Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 2		Undefined
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8 - 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

Subsection 7.57 Command 89 7.57 Command 89 Set Real-Time Clock

"Invalid Selection " must be allowed in Command 89. Consequently, the response code is changed to the following:

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection (Time-set code)
3	Error	Passed Parameter Too Large
4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8 - 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

Subsection 7.58 Command 90 Read Real-Time Clock

In Command 90, the byte numbering in the Response is off by 1, they must start at byte 0. Consequently, the byte numbering is as follows:

Response Data Bytes

Byte	Format	Description
0-2	Date	Current Date
3-6	Time	Current Time of Day
7-9	Date	Date clock last set
10-13	Time	Time clock last set
14	Bits	RTC Flags (see Common Table 42)

Subsection 7.62 Command 94 Read I/O System Client-Side Communication Statistics

The data types of the statistics in Command 94 are misstated. Consequently, the response data should read as follows:

Response Data Bytes

Byte	Format	Description
0-3	Unsigned-32	Number of messages received through this host system interface
4-7	Unsigned-32	Number of messages returned to this host system
8-11	Unsigned-32	Number of requests forwarded to IO system
12-15	Unsigned-32	Number of responses returned from the IO system

Subsection 7.68 Command 101 Read Sub-device to Burst Message Map

Mapping of Event Notifications of Wired HART 7 devices is necessary for the adapter. This will be accomplished by setting the MS Bit of the burst message. Consequently the following changes must be made to Command 101:

This command reads which sub-device is mapped to a burst message or event notification. The sub-device is indicated by the sub-device index. The Read Sub-Device Identity Summary command can be used to obtain additional information about the sub-device.

The device sourcing the Burst Message must be tracked using the device's Unique ID. This mapping persists even if the ordering of the sub-device list becomes reordered. In addition, if communication with the device is currently lost then 0xFFFF shall be returned as the sub-device index.

Note: The MSBit of the Burst Message is set to indicate the mapping of an event notification. In other words, if bit 7 of the burst message is set then it is an event notification

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message (If MSBit set then Event Notification)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message (If MSBit set then Event Notification)
1-2	Unsigned-16	Sub-device Index (Index 0 indicates the I/O System itself)

Subsection 7.69 Command 102 Map Sub-device to Burst Message
The following modifications to Command 102 must be made:

- Mapping of Event Notifications of Wired HART 7 devices is necessary for the adapter. This will be accomplished by setting the MS Bit of the burst message.
- "In Write Protect " must be allowed in Command 102.
- Since the Sub-device Index can vary, Burst mapping is to the specified device's Unique ID.

Consequently the following changes must be made to Command 102:

This command maps a sub-device to a burst message or event notification. While the sub-device is specified in this command using the sub-device index, the mapping of the Event or the Burst Message is to the device's Unique ID. The mapping is retained across power cycles and resets. The Read Sub-Device Identity Summary command can be used to obtain additional information about the sub-device

Note: The MSBit of the Burst Message is set to indicate the mapping of an event notification. In other words, if bit 7 of the burst message is set then it is an event notification

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message (If MSBit set then Event Notification)
1-2	Unsigned-16	Sub-device Index (Index 0 indicates the I/O System itself)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message (If MSBit set then Event Notification)
1-2	Unsigned-16	Sub-device Index (Index 0 indicates the I/O System itself)

Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection (Burst Message)
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-specific command error
7	Error	In Write Protect Mode
8		Undefined
9		Invalid Sub-device Index
7 - 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

Subsection 7.71 Command 104 Write Burst Trigger
For I/O systems, the burst message can originate from the sub-device. Consequently the first three paragraphs must be improved and a note added as follows:

This is a Burst Mode Command.

This command configures the trigger that forces publishing of the Burst Message. The trigger modes are defined in Common Table 33, Burst Mode Trigger Mode Codes. Unless otherwise configured by this command a Burst Message shall assume a Trigger Mode of "Continuous" and a Trigger Value of 0.00. Furthermore, if a device specific command is specified as the burst command then Command 104 must return "Access Restricted" and the defaults to a Trigger Mode of "Continuous".

These trigger modes allow the device to be configured to defer the publishing of the Burst Message beyond the Update Period in Command 103. In all cases, the Burst message is triggered when the Maximum Update Time in Command 103 is exceeded. In addition, the trigger source is also specified and is normally the first process value returned in the command (see Table 6).

Note: For I/O systems when the burst message is originating in the sub-device, If the engineering units are changed in the sub-device then the burst message must be published with the Update Period specified in Command 103. In other words the data must be published the same as if the trigger conditions are met.

Subsection 7.72 Command 105 Read Burst Mode Configuration
The Protocol must be able to support publishing of 16 bit commands. In addition, for response byte 11, "Total Number of Burst Messages", refers to the number supported by the I/O system (not the number active). Consequently, Command 105 must be modified to read as follows:

This command allows the Burst Mode configuration to be read. The Field Device responds with whether the Field Device is in Burst Mode; the command to be burst and a list of Device Variables to be transmitted, the burst minimum and maximum update time and the condition for the maximum update time.

7.72.1 Backward Compatibility Requirements
If the device receives a Request without data bytes the device may not respond with Response Code 5 - "Too Few Data Bytes Received" but must assume that it is read from a HART 6 master. The Device will return the configuration of Burst Message 0 and the LSByte of the burst command number must be returned in response data byte 1 (instead of 31)

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Mode Control Code (see Common Table 9, Burst Mode Control Codes)
1	Unsigned-8	31 (0x1F) - Command Number Expansion Flag (Note: If there are no request data bytes then this byte must return the LSByte of the burst command number).
2	Unsigned-8	Device Variable Code assigned to Slot 0 (see Device Variable Codes Table in appropriate device-specific document)
3	Unsigned-8	Device Variable Code assigned to Slot 1 (see Device Variable Codes Table in appropriate device-specific document)
4	Unsigned-8	Device Variable Code assigned to Slot 2 (see Device Variable Codes Table in appropriate device-specific document)
5	Unsigned-8	Device Variable Code assigned to Slot 3 (see Device Variable Codes Table in appropriate device-specific document)
6	Unsigned-8	Device Variable Code assigned to Slot 4 (see Device Variable Codes Table in appropriate device-specific document)
7	Unsigned-8	Device Variable Code assigned to Slot 5 (see Device Variable Codes Table in appropriate device-specific document)
8	Unsigned-8	Device Variable Code assigned to Slot 6 (see Device Variable Codes Table in appropriate device-specific document)
9	Unsigned-8	Device Variable Code assigned to Slot 7 (see Device Variable Codes Table in appropriate device-specific document)
10	Unsigned-8	Burst Message
11	Unsigned-8	Maximum number of Burst Messages supported by the device
12-13	Unsigned-16	Extended Command Number
14-17	Time	Update Time in 1/32 of a millisecond
18-21	Time	Maximum Update Time in 1/32 of a millisecond
22	Enum-8	Burst Trigger Mode Code
23	Enum-8	Device Variable Classification for Trigger Value
24	Enum-8	Units Code
25-28	Float	Trigger Value

Note: If a slot is not configured to transmit a Device Variable that slot must return "250" (Not Used). If Command 9 is to be burst then the slot's Device Variable code must meet the requirements found in Command 9.

Subsection 7.75 Command 108 Write Burst Mode Command Number
It must be possible to burst 16 bit command numbers. Consequently the command must be modified to read as follows:

This command selects the response message that the device transmits while in Burst Mode. Command 1, 2, 3, 9, and 48 shall be supported in all devices implementing Burst Mode. Refer to the device-specific document to determine if additional commands are supported for a specific device type.

Note: 16-Bit Command Numbers are used in this Request and Response, except when operating in backward compatibility mode.

If the trigger mode is non-zero in Command 104 and the trigger source's Device Variable Classification does not match for the new command number the new command number will be accepted and Response Code "Burst Condition Conflict" will be returned. The field device must correct the classification, unit codes, reset to Trigger Mode 0 and publish continuously at the Update Period until it receives another Command 104.

7.75.1 Backward Compatibility Requirements
If a field device receives only one data byte in the request it must assume that the device is being configured by a HART 5 or HART 6 host. The device shall assume burst message 0 is being configured. Furthermore it shall treat the request as a single byte command number and respond with only a single byte in the response. The device must not return Response Code 5 - "Too Few Data Bytes Received".

The field device shall not return "Burst Condition Conflict" but it will reconfigure the attributes associated with Command 104.

Request Data Bytes

Byte	Format	Description
0-1	Unsigned-16	16-bit Command Number of the response message to be transmitted
2	Unsigned-8	Burst Message

Response Data Bytes

Byte	Format	Description
0-1	Unsigned-16	16-bit Command Number of the response message to be transmitted
2	Unsigned-8	Burst Message

Note: The value returned in the response data bytes reflects the value actually used by the device.

Subsection 7.84 Command 117 Write Event Notification Timing
The minimum scan rate for event detection must be specified and be proportional to the de-bounce interval. Consequently the fourth paragraph in the command specification must be modified as follows:

The Event De-bounce Interval sets the minimum time period over which the bit must remain changed (i.e., the time the event must persist) in a device before the Event Notification is sent. The device must scan for possible events at least twice as fast as specified by the Event De-Bounce Interval.

Subsection 7.87 Command 512 Read Country Code

In Command 512, the byte numbering in the Response is off by 1, they must start at byte 0. In addition the Country code data type is Latin-1. Consequently, the response data is modified as follows:

Response Data Bytes

Byte	Format	Description
0-1	Latin1	Country Code. The two letter country code in accordance with ISO 3166
2	Enum-8	SI Units Only (See Common Table 54. SI Units Control Code)

Subsection 7.88 Command 513 Write Country Code

In Command 512, the byte numbering in the Response is off by 1, they must start at byte 0. In addition the Country code data type is Latin-1. Consequently, the request and response data is modified as follows:

Request Data Bytes

Byte	Format	Description
0-1	Latin-1	Country Code. The two letter country code in accordance with ISO 3166
2	Enum-8	SI Units Restriction (See Common Table 54. SI Units Control Code)

Response Data Bytes

Byte	Format	Description
0-1	Latin-1	Country Code. The two letter country code in accordance with ISO 3166
2	Enum-8	SI Units Restriction (See Common Table 54. SI Units Control Code)

ANNEX. Configuration Changed and Common Practice Command Use Table

The following table summarizes the Common Practice commands that must be supported by different types of devices and whether a given command affects the Configuration Changed bit and counter.

Device Type abbreviations are as follows:

FD	Field Device	**WPA**	Wireless Process Adapter
BD	Burst Device	**GW**	Gateway as Slave
WD	Wireless Device		

The abbreviations in the columns are:

Y	Yes. The Configuration Changed bit and counter are affected	**M(L)**	Mandatory if Loop current is supported
N	No. The Configuration Changed bit and counter are un-affected	**R**	Recommended. Device should implement the command
M	Mandatory. Device must implement the command	**R(L)**	Recommended if Loop current is supported

Table. Common Practice Command Summary

Command		Notes	CC	Device Type				
No.	**Description**			**FD**	**BD**	**WD**	**WPA**	**GW**
33	Read Device Variables		N	R	R	R	R(L)	
34	Write Primary Variable Damping Value		Y	R	R	R	R(L)	
35	Write Primary Variable Range Values	Allows Device to calculate Percent Range and scale output/input of current loop.	Y	R	R		M(L)	
36	Set Primary Variable Upper Range Value		Y	R	R			
37	Set Primary Variable Lower Range Value		Y	R	R			
38	Reset Configuration Changed Flag		N	M	M	M	M	M
40	Enter/Exit Fixed Current Mode		N	R	R		M(L)	
41	Perform Self Test		N	R	R	M	M	M
42	Perform Device Reset		N	R	R	M	M	M
43	Set Primary Variable Zero		Y					
44	Write Primary Variable Units		Y	R	R	R		
45	Trim Loop Current Zero		Y	R	R		M(L)	
46	Trim Loop Current Gain		Y	R	R		M(L)	
47	Write Primary Variable Transfer Function		Y					
48	Read Additional Device Status		N	M	M	M	M	M
49	Write Primary Variable Transducer Serial Number		Y					
50	Read Dynamic Variable Assignments		N	R	R	R	R(L)	
51	Write Dynamic Variable Assignments		Y					
52	Set Device Variable Zero		Y					

Command		Notes	CC	Device Type				
No.	Description			FD	BD	WD	WPA	GW
53	Write Device Variable Units		Y	R	R	R		
54	Read Device Variable Information		N	R	M	M	M(L)	
55	Write Device Variable Damping Value		Y	R	R	R	R(L)	
56	Write Device Variable Transducer Serial No.		Y					
59	Write Number Of Response Preambles		Y	R	R	M	M	
71	Lock Device		N	R	R	R	R	R
72	Squawk	Strongly Recommended for Wireless Devices	N	R	R	R	R	
73	Find Device		N	R	R	R	R	
74	Read I/O System Capabilities		N				M	M
75	Poll Sub-Device		N				M	M
76	Read Lock Device State		N	R	R	R	R	R
77	Send Command to Sub-Device		N				M	M
78	Read Aggregated Commands		N			M	M	M
79	Write Device Variable		Y	R	R	M	M(L)	
80	Read Device Variable Trim Points		N	R	R	R	R(L)	
81	Read Device Variable Trim Guidelines		N	R	R	R	R(L)	
82	Write Device Variable Trim Point		Y	R	R	R	R(L)	
83	Reset Device Variable Trim		Y	R	R	R	R(L)	
84	Read Sub-Device Identity Summary		N				M	M
85	Read I/O Channel Statistics		N				M	M
86	Read Sub-Device Statistics		N				M	M
87	Write I/O System Master Mode		Y				M	M
88	Write I/O System Retry Count		Y				M	M
89	Set Real-Time Clock		N	R	R			M
90	Read Real-Time Clock		N	R	R	M	M	
91	Read Trend Configuration		N			R		
92	Write Trend Configuration		Y			R		
93	Read Trend		N			R		
94	Read I/O System Client-Side Communication Statistics		N				R	M
95	Read Device Communications Statistics		N	R	R	R	M	
96	Read Synchronous Action		N					
97	Configure Synchronous Action		Y					
98	Read Command Action		N					
99	Configure Command Action		Y					
101	Read Sub-device to Burst Message Map		N				M	
102	Map Sub-device to Burst Message		Y				M	
103	Write Burst Period		Y		M	M	M	

Command		Notes	CC	Device Type				
No.	Description			FD	BD	WD	WPA	GW
104	Write Burst Trigger		Y		M	M	M	
105	Read Burst Mode Configuration		N		M	M	M	
106	Flush Delayed Responses	Must be supported if device uses DR	N			M	M	M
107	Write Burst Device Variables		Y		M	M	M	
108	Write Burst Mode Command Number		Y		M	M	M	
109	Burst Mode Control		Y		M	M	M	
111	Transfer Service Control	Only as proxy for connected device, Implementation of Block Transfer is recommended if bulk data must be transferred. If block transfer changes device's configuration the CC is set						
112	Transfer Service						M	M
113	Catch Device Variable		Y					
114	Read Caught Device Variable		N					
115	Read Event Notification Summary		N		R	M	M	
116	Write Event Notification Bit Mask		Y		R	M	M	
117	Write Event Notification Timing		Y		R	M	M	
118	Event Notification Control		Y		R	M	M	
119	Acknowledge Event Notification		N		R	M	M	
512	Read Country Code		N	R	R	R	R	R
513	Write Country Code		Y	R	R	R	R	R

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Preface

This preface is included for informational purposes only.

The popularity of the HART protocol has encouraged the development of a variety of HART capable devices. Devices such as multiplexers, repeaters, positioners, PID controllers, and calibrators put new demands on the Protocol. Consequently, a number of areas of the HART Protocol have been enhanced and updated to meet these new demands. This document contains the following additions and enhancements to the Common Practice Command set:

- Command 38 is now mandatory. The Configuration Changed Counter should be included and match the device's current value before the Configuration Changed bit is reset.

- Command 48 is now Mandatory. Command 48 was modified to allow the More Status Available bit to be reset.

- Primarily to facilitate the development of WirelessHART Adapters, Sub-device and I/O System support was improved (see Commands 77, 84-88, 101, 102). These improvements are applicable to a wide range of product in addition to WirelessHART.

- To improve the ability of devices to provide trending of a process data value the Trend Capture Commands have been added (See Commands 91-93)

- HART 6 (and earlier) used burst mode to change the operation of the Token-Passing Data-Link and to publish data. Beginning with this version of the Protocol these two functions are separated. As a result, more than one command response can be published. The resulting improved Burst Mode and Publishing Capabilities are incorporated into the existing burst mode commands and two commands (Commands 103, 104) have been added.

- In addition to publishing process data in burst messages Event Notification is now supported using Commands 115-119.

- Many applications require data and actions to have a time associated with them. To support these applications Real-Time Clock support has been added (see Commands 89, 90)

- The synchronization of sampling performed by multiple devices is now possible (see Commands 96, 97)

Introduction

The principle objective of the HART Protocol is to establish standards that allow host applications and field devices from differing companies to work with each other as a system. Furthermore, even if a system component is replaced with a similar device from another company, the system should still function properly. Accordingly, HART promotes interoperability in many ways:

- Compatibility with the 4-20mA loop allows a HART device to work with existing plant systems;
- Providing a well defined Physical Layers for devices to communicate over;
- Specifying Data Link Layer framing, error detection and bus arbitration requirements to ensure the integrity of communications; and
- Requiring all devices to support all Universal Commands

The HART Common Practice Commands enhances interoperability by providing additional standardized, device-independent commands. These commands are optional and some, all, or none may be implemented in a Field Device. Common Practice Commands provide a set of functions that are widely applicable to many devices (unlike Universal Commands, which must be implemented by all devices). Some Common Practice Commands are used by nearly all devices, while some are used only by certain classes of devices.

Designers of Field Devices have the choice of using device-specific or Common Practice Commands for some of their features. Designers are strongly encouraged to use Common Practice Commands rather than device-specific commands wherever possible. Common Practice Commands are preferable over device-specific commands in that they allow Hosts to create one common interface supporting many Field Devices instead of a custom interface for every Field Device. Using Common Practice Commands allows a Slave to communicate with a larger number and many more types of Host applications.

1. SCOPE

The *Common Practice Command Specification* is an Application Layer specification and, accordingly, builds on the Application Layer Requirements found in the *Command Summary Specification.* Conformance to all requirements of the *Command Summary Specification* is a prerequisite to conforming to this specification.

This specification contains both the definitions and the recommended usage of Common Practice Commands. Common Practice Commands, if used, must be implemented exactly as specified. Many Common Practice Commands refer to tables from the *Common Tables Specification*. When Common Tables are referenced, the tables must be used exactly as specified. This document supersedes all previous revisions.

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

Data Link Layer Specification. HCF_SPEC-81

Command Summary Specification. HCF_SPEC-99

Universal Command Specification. HCF_SPEC-127

Common Tables Specification. HCF_SPEC-183

Block Data Transfer Specification. HCF_SPEC-190

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

3. DEFINITIONS

Definitions for terms can be found in *HART Field Communications Protocol Specification.* Terms used throughout the *Common Practice Command Specification* include: Analog Channel, ASCII, Bridge Device, Data Link Layer, Delayed Response, Delayed Response Mechanism, Device Variable, Busy, DR_CONFLICT, DR_DEAD, DR_INITIATE, DR_RUNNING, Dynamic Variable, Fixed Current Mode, Floating Point, Host, ISO Latin-1, Master, Multidrop, Not-A-Number, Packed ASCII, Preamble, Request Data Bytes, Response Data Bytes, Response Message, Slave, Slave Time-Out, Sub-Device, Time Constant, Trim, Units Code

Some other terms used only within the context of the *Common Practice Command Specification* are:

Analog Channel Number	A number that refers to a particular analog input or output channel. Analog Channel Numbers start at 0. The first analog channel corresponds to the Primary Variable.
Slot	A placeholder to which is assigned a Device Variable.
I/O System	A device, accessed by an application via the HART Protocol, which supports multiple connections to underlying HART-enabled sub-devices.
Shed Time	The time between the last good message reception and the assumption of digital communication failure is called the Shed Time

4. SYMBOLS/ABBREVIATIONS

ADC	**A**nalog-to-**D**igital **C**onverter
DAC	**D**igital-to-**A**nalog **C**onverter.
DAQ	**D**ata **Acq**uisition. This refers to a devices specific ADC or DAC
DR	**D**elayed **R**esponse.
EEPROM	**E**lectrically **E**rasable **P**rogrammable **R**ead **O**nly **M**emory. Non-volatile memory that is alterable by the Field Device without the use of external programming apparatus.
LRV	**L**ower **R**ange **V**alue. Defines the relationship between a Dynamic Variable value and an Analog Channel lower endpoint (e.g. 4.00mA).
LSB	**L**east **S**ignificant **B**yte. The LSB is always the last byte transmitted over a HART data link.
LTL	**L**ower **T**ransducer **L**imit. The digital value that defines the minimum reliable and accurate value of a Dynamic or Device Variable .
MSB	**M**ost **S**ignificant **B**yte. The MSB is always the first byte transmitted over a HART data link.
URV	**U**pper **R**ange **V**alue. Defines the relationship between a Dynamic Variable value and an Analog Channel upper endpoint (e.g. 20.0mA).
UTL	**U**pper **T**ransducer **L**imit. The digital value that defines the maximum reliable and accurate value of a Dynamic or Device Variable.

5. DATA FORMAT

In command specifications, the following key words are used to refer to the data formats. For more information about these formats, see the *Command Summary Specification*.

Bits	Each individual bit in the byte has a specific meaning. Only values specified by the command may be used. Bit 0 is the least significant bit.
Enum	An enumerated value. Only values specified in the *Common Tables Specification* may be used.
Date	The Date consists of three 8-bit binary unsigned integers representing, respectively, the day, month, and year minus 1900. Date is transmitted day first followed by the month and year bytes.
Time	The Time consists of a unsigned 32-bit binary integer with the least significant bit representing 1/32 of a millisecond (i.e., 0.03125 milliseconds).
Float	An IEEE 754 single precision floating point number. The exponent is transmitted first followed by the most significant mantissa byte.
Latin-1	A string using the 8-bit ISO Latin-1 character set. Latin-1 strings are padded out with zeroes (0x00).
Packed	A string consisting of 6-bit alpha-numeric characters that are a subset of the ASCII character set. This allows four characters to be packed into three bytes. Packed ASCII strings are padded out with space (0x20) characters.
Unsigned-*nn*	An unsigned integer where *nn* indicates the number of bits in this integer. Multi-byte integers are transmitted MSB - LSB.

6. APPLICATION OF COMMON PRACTICE COMMANDS

6.1 Data Link Layer Commands

Implementation of all commands in this section is recommended.

Some commands within the Common Practice Command set that support Data Link Layer operation. These commands support the establishment of a communication connection between the Master and the Field Device, and modifying the FSK preamble length. Commands in this group include:

- Command 59 Write Number Of Response Preambles
- Command 72 Squawk
- Command 73 Find Device

6.2 Primary Variable Range Commands

Implementation of Command 35, Write Primary Variable Range Values, is recommended.

The Primary Variable is always associated with the first Analog Channel of a device. Since the 4-20mA signal conveys a single dynamic value using the analog signal, these Common Practice Commands allow the relationship between the analog signal and the Primary Variable digital value to be defined. The commands in this group are:

- Command 35 Write Primary Variable Range Values
- Command 36 Set Primary Variable Upper Range Value
- Command 37 Set Primary Variable Lower Range Value

6.2.1 Rerange Procedures

These Common Practice Commands support two methods for setting the Primary Variable URV and LRV.

- The first technique uses Command 35, Write Primary Variable Range Values, to set the URV and LRV. The engineering units need not be the same as the Primary Variable units and this command does not change the Primary Variable Units.
- The second technique reranges the Field Device based on process conditions:
    1. Adjust the process until the Primary Variable matches the desired LRV (the zero). Use Command 37, Set Primary Variable Lower Range Values, to set the LRV.
    2. Adjust the process until the Primary Variable matches the desired URV (the span). Use Command 36, Set Primary Variable Upper Range Value, to set the URV.

6.3 Loop Current Commands

Implementation of all commands in this section is recommended.

Supporting the analog 4-20mA Loop Current is a traditional requirement for HART compatible Field Devices. The commands in this section allow loop current values to be simulated and allows the Field Device's perceived loop current value to be calibrated.

Commands in this section should be used by both transmitters and actuators since both devices:

- Connect to the analog current loop;
- Need to simulate or force a Loop Current value; and
- Should support the calibration of their Loop Current value.

With respect to the Loop Current, the only difference between a transmitter and an actuator is that the Loop Current value is what a transmitter thinks it is outputting and what an actuator believes it is measuring.

The following are the Loop Current related commands:

- Command 40 Enter/Exit Fixed Current Mode
- Command 45 Trim Loop Current Zero
- Command 46 Trim Loop Current Gain

6.3.1 Loop Current Trim Procedure

The 4-20mA loop transmits a single Dynamic Variable value (the Primary Variable) using an analog signal. As a result, there must be agreement between the Master and Slave Loop Current values. The Loop Current commands allow the Master to force a Loop Current value in the Field Device and to perform a two point (zero and span) calibration of the Field Device's Loop Current value. Since the procedure for calibrating a transmitter is slightly different from actuator, the procedures for each are listed separately.

Procedure for Transmitters

In this procedure, the transmitter controls the Loop Current generally using a DAC. A suitable reference, like a digital multi-meter, is used to calibrate the transmitter's output. The Master's Loop Current measurement could be used as the reference.

1. Use Command 40, Enter/Exit Fixed Current Mode, to set the current to the device's minimum value. 4.00mA is usually used as the zero trim point.
2. Using the reference instrument's measured value, set the zero trim of the device using Command 45, Trim Loop Current Zero. The device trims its calibration and returns its Loop Current value. This may be slightly different from the value the Master sent the device due to rounding or truncation.

3. Use Command 40, Enter/Exit Fixed Current Mode, to set the current to the device's maximum value. 20.00mA is normally used as the span trim point.
4. Using the value measured by the reference, trim the span of the device with Command 46, Trim Loop Current Gain.
5. Repeat steps 1-4 as needed to gain the accuracy desired. Once the Loop Current is calibrated, return the device to normal operation by issuing Command 40, Enter/Exit Fixed Current Mode with a value of 0.0. This takes the device out of fixed current mode.

Procedure for Actuators

In this procedure, the Master or a reference controls the Loop Current and the actuator measures that current. A suitable reference, like a digital multi-meter, is used to calibrate the actuator input. Alternatively, the Master's Loop Current value could be used as the reference.

1. Using the appropriate Loop Current source, set the current to the device's minimum value, usually 4.00mA as the zero trim point.
2. Using the reference instrument's measurement value, set the zero trim of the device using Command 45, Trim Loop Current Zero. The device trims its calibration and returns its Loop Current value. This may be slightly different from the value the Master sent the device due to rounding or truncation.
3. Using the appropriate Loop Current source, set the current to the device's maximum value, normally 20.00mA is used as the span trim point.
4. Using the value measured by the reference, trim the span of the device using Command 46, Trim Loop Current Gain.
5. Repeat steps 1-4 until the desired accuracy is achieved.

6.4 Device Management Commands

Implementation of all commands in this section is recommended.

The Common Practice Commands support routine device management functions, like forcing a self test or performing a device reset. Commands in this group include:

- Command 38 Reset Configuration Changed Flag
- Command 41 Perform Self Test
- Command 42 Perform Device Reset
- Command 48 Read Additional Device Status

  Note: Command 38 and Command 48 were formerly optional and are now mandatory. All devices must implement Commands 38 and 48.

- Command 71 Lock Device
- Command 76 Read Lock Device State
- Command 89 Set Real-Time Clock
- Command 90 Read Real-Time Clock
- Command 95 Read Device Communications Statistics

6.4.1 Performing Self Test

Occasionally an operator may want to perform a self test on a device to confirm the devices integrity. The procedure is:

1. The Host sends Command 41, Perform Self Test, to initiate the self-test. The Slave must answer within the Slave Time Out.
2. The Slave must answer Command 41, Perform Self Test, and begin its self test. Self test may take a relatively long time to complete. During the self-test, the field device must continue to communicate. However, it is allowed to answer "Busy" to most commands received during this interval. Identity commands must be answered with "Success". All network communications on wireless devices must remain fully operational (e.g., packet routing must continue). The Master must not disconnect from the device as the result of issuing Command 41.
3. Once the Master has confirmed the completion of the self-test, the Master should send a Command 48, Read Additional Device Status, to return diagnostics information generated by the Self Test.

Masters must not generate spurious error messages or disconnect from the Field Device while the Self Test is in progress or disconnect from the Field Device while the Self Test is in progress.

6.4.2 Locking the Device to Allow Exclusive Access

In some cases, technicians have been using the local panel on a Field Device simultaneous to a HART Master configuring the Field Devices. When this happens, the HART Master cannot guarantee the accuracy of the data items presented to the user. This command allows a HART Master to have exclusive access while configuring or calibrating a Field Device. The normal use of Command 71, Lock Device is:

1. Issue Command 71 to ensure exclusive access during configuration.
2. Configure the device as needed. While locked the device returns Response Code 16, Access Restricted, to any write commands from the other Masters or the Gateway. Network Management commands are never locked out.
3. Issue Command 38, Reset Configuration Changed Flag. This will allow the Master to easily determine if the device configuration is ever changed by monitoring the Device Status Byte.
4. Issue Command 71 to restore access to the other Master and the device's front panel.

6.5 Transducer Trim Commands

Implementation of all commands in this section is recommended.

This section includes four commands to allow the adjustment or "trim" of a Device Variable. This allows a measurement to be trimmed linearly, assuming the measurement has already been corrected for the transducer characteristics. Transducer characterization is considered a device-specific operation and is beyond the scope of this Specification. Furthermore, transducer and device characterization is not generally possible in a field environment. Commands in this group include:

- Command 80 Read Device Variable Trim Points
- Command 81 Read Device Variable Trim Guidelines
- Command 82 Write Device Variable Trim Point
- Command 83 Reset Device Variable Trim

6.5.1 Transducer Trim Procedure

Adjustment of a Device Variable reading is one of the most common functions that instruments must support. The commands in this section constitute a trim procedure that is applicable to a variety of instruments, both transmitters and actuators.

1. Issue Command 81, Read Device Variable Trim Guidelines, to determine the number of applicable trim points and their acceptable limits.
2. Issue Command 80, Read Device Variable Trim Points, to retrieve the last trim points used. These should be used as default values for a new trim operation. If the value supports a two point trim, then perform the low trim first (step 3-6).
3. Prompt the user to set the variable input to a value within acceptable limits for the trim point.
4. Once set and stable, obtain the exact process variable value from either a calibrator or the user.
5. Issue Command 82, Write Device Variable Trim Point. Inform user of any errors.
6. If a DR_INITIATE response is received, then resend the identical trim command until the operations is completed. Once completed, inform the user of the results.
7. If the variable supports a two-point trim and the low trim is completed successfully, repeat steps 3 through 6 for the upper trim point.

   Note: Some devices may only support an upper trim point (see Common Table 22, Trim Point Codes)

6.6 Mapping Process Variables Commands

Implementation of Command 50 is recommended.

All HART compatible Field Devices are required to return the Primary, Secondary, Tertiary, and Quaternary Variables. These are collectively called the Dynamic Variables. In addition, all HART compatible Field Devices contain Device Variables. Simple Field Devices may use only Dynamic Variables and not expose the underlying Device Variables at the Protocol Application Layer interface. In simple devices the mapping of Device Variables to Dynamic Variables is fixed. More sophisticated devices allow this mapping to be configured (see Figure 1).

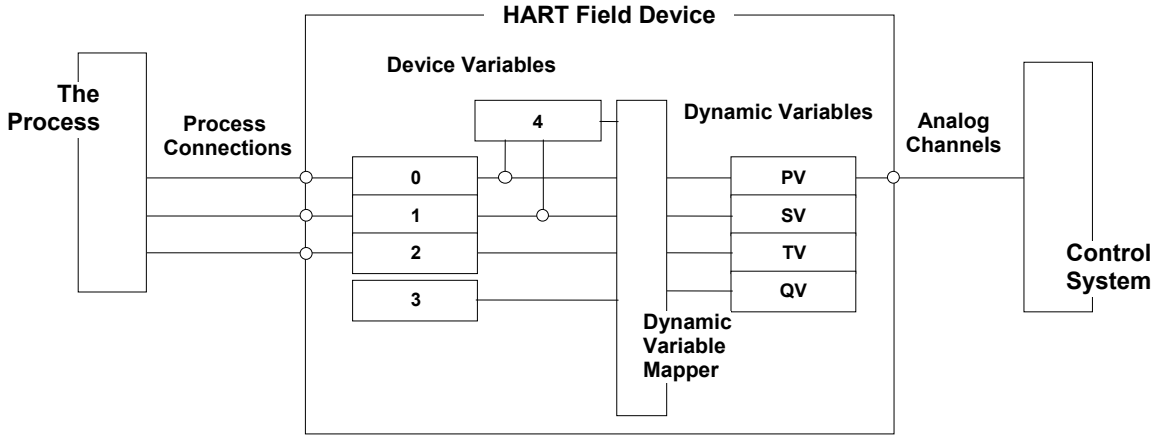

Figure 1 Device Variables and Dynamic Variables

In effect, a Dynamic Variable is convenient way to access a collection of data items comprised of an Analog Channel connected to a Device Variable. The following commands manage the mapping of the connection between the Device Variable and a Dynamic Variable (i.e., an Analog Channel). They allow the mapping to be read and, if supported by the device, changed. The commands in this section are:

- Command 50 Read Dynamic Variable Assignments
- Command 51 Write Dynamic Variable Assignments

6.7 Primary Variable Commands

Implementation of Commands 34 and 44 is recommended.

Due to its connection to Loop Current, the Primary Variable is an essential Application Layer data item. Consequently, there are Common Practice Commands supporting the configuration of the Primary Variable. Commands in this group include:

- Command 34 Write Primary Variable Damping Value
- Command 43 Set Primary Variable Zero
- Command 44 Write Primary Variable Units
- Command 47 Write Primary Variable Transfer Function
- Command 49 Write Primary Variable Transducer Serial Number

6.8 Device Variable Commands

Implementation of Commands 33, 53-55, and 79 is recommended.

Device Variables represent the device's connection to the process. While simple devices may not expose their Device Variables, all HART compatible Field Devices contain them. Several important features of the HART Protocol rely on Device Variables:

1. Device Families and engineering units codes are based on information returned by Command 54, Read Device Variable Information.
2. Many Masters prefer to use Command 33, Read Device Variables, to avoid tracking the Dynamic Variable map (see Command 51).

   Note: Command 9 returns Device Variable Status and Classification. As a result, HART 6 compatible Hosts should use Command 9 whenever possible.

3. Command 79, Write Device Variable Command, allows Device Variables to be forced. This is used to test data acquisition and control in Master applications.

The commands in this section are:

- Command 33 Read Device Variables
- Command 52 Set Device Variable Zero
- Command 53 Write Device Variable Units
- Command 54 Read Device Variable Information
- Note: Command 54 must be implemented if Burst Mode is supported
- Command 55 Write Device Variable Damping Value

- Command 56 Write Device Variable Transducer Serial No.
- Command 79 Write Device Variable
- Command 113 Catch Device Variable
- Command 114 Read Caught Device Variable

6.9 Burst Mode Commands

Implementation of These Commands is Strongly Recommended.

The protocol supports the publishing of cyclical process data using "Burst" messaging. In this mode, a device is instructed to publish the response to a command continuously without any further Master or Host action. If a Field Device supports Burst Mode then all of Commands 103-105 and Commands 107-109 must be implemented. Furthermore, devices implementing burst mode must support at least 3 Burst Messages. The commands in this section are:

- Command 101 Read Sub-device to Burst Message MapCommand 103 Write Burst Period;
- Command 104 Write Burst Trigger;
- Command 105 Read Burst Mode Configuration;
- Command 107 Write Burst Device Variables;
- Command 108 Write Burst Mode Command Number; and
- Command 109 Burst Mode Control;

In addition, two commands are designed specifically for I/O systems and WirelessHART Adapters. These are:

- Command 101 Read Sub-device to Burst Message Map;
- Command 102 Map Sub-device to Burst Message;

Each Burst Message must allow a different configuration. In other words, each Burst Message may be a different command, trigger, update period, set of Device Variables etc. The device must retain Burst Mode Settings through a Device Reset, Self Test or the power being removed and re-applied.

All masters must arbitrate correctly, when a burst-mode device is present. In addition, masters are **strongly recommended** to use Burst Mode for cyclical data acquisition and control.

6.9.1 Configuring A Device For Burst Mode Operation

The procedure a Master should follow to place a Field Device into burst mode is as follows:

1. The command response is configured using Command 108, Write Burst Mode Command Number. Commands 1, 2, 3, 9 and 48 must be available for publishing and Command 33 must be supported if it is implemented in the field device.
2. For Commands 9 and 33, Command 107, Write Burst Device Variables, is used to assign Device Variables to the response data slots. Command 9 supports up to 8 slots and Command 33 supports up to 4.
3. Use Command 54 to determine the update rates for the desired Device Variables. Use Command 103 to set the Update Period and Maximum Update Period for publishing the Burst Message (see Subsection 6.9.2). The Data-Link requirements may result in the Burst Message being published more frequently than the Update Period.
4. Set the Trigger Mode for the Burst Message using Command 104. Burst Messages may be configured to publish continuously or based on a Trigger Level. The Burst Message will always be published at least as often as the Maximum Update Period.
5. Issuing Command 109, Burst Mode Control, will enter or exit Burst Mode. While in Burst Mode, the Slave will begin transmitting the responses to the command number set by Command 108 based on the Data-Link requirements and the properties configured using the other Burst Mode Commands.

Once the device is in burst mode, Command 108 can be used to change the burst command response. A device may take one burst response before the response changes to the new command number. Other Burst Mode Commands may also be used to adjust burst mode operation on-the-fly.

On WirelessHART networks, multiple, pending Burst Messages should be aggregated into a single transaction. If the burst messages will not fit in a single transaction then they must be sent in their separate transactions. WirelessHART natively supports command aggregation (i.e., Command 78 is not required).

6.9.2 Update Periods

The update periods may be programmed as indicated in Table 1. Field devices must correct settings differing from these values and indicate "Set to Nearest Value" in its response message.

Table 1. Update Periods Allowed (in Seconds)

< 0.100 Not Allowed	**0.500**	**4.000**	**32.000**
0.100	**1.000**	**8.000**	**60-3600 (Any Value)**
0.250	**2.000**	**16.000**	**> 3600 Not Allowed**

Note: The Update Periods determine only the communication rate. The acquisition period may be higher or lower. The Update Period for a device variable can be read using command 54.

Furthermore, the settings are constrained based on the Physical Layer being used for publishing the Burst Message (see Table 2). The table also shows the default update period. For Token-Passing based Physical Layers the default update rate is determined by the Data-Link Layer requirements.

Table 2. Minimum Update Rates Allowed by Physical Layer

Physical Layer	Minimum Value	Default Period
FSK	0.500s	N/A
PSK	0.100s	N/A
RS-485	0.100s	N/A
IEEE STD 802.15.4-2006	0.250s	60s

The update period is set to the rate is dictated by process and application requirement and often this may be larger then the minimum. However, on a Token-Passing Data-Link, Burst Messages are used both to publish data and to pass the token. Consequently, a burst transaction must be generated every time the burst mode device has the token (See the *Token-Passing Data-Link Layer Specification*). When multiple Burst Messages are enabled, the device must transmit the Burst Message with the shortest period the majority of the time and transmit the other Burst Message as their periods lapse.

6.9.3 Burst Mode Support in I/O Systems

I/O systems should support Burst Messaging over the HART Network connection to its master (i.e., the client application). To enable publishing of Burst Messages from Sub-devices, Command 101 and Command 102 are provided. See Subsection 6.12 for more information.

6.10 Event Notification

Event notification requires, and is built upon, Burst Mode operation. If Burst Mode is supported then all commands in this section should be supported. Furthermore, Event Notification must be disarmed while the device is not in Burst Mode.

The HART Protocol offers two distinct methods to display events: the device status and the Common Practice Command 48.

Event Notification publishes changes in the device's status, independently from data publishing supported in other Burst Mode commands. For events the status included in the Device Status byte, Extended Device Status byte and Command 48 can be used. It is possible to specify a limited set of

bits that will trigger event notification. Event Notifications have a low priority but require a time stamp in order to indicate the first time when a notification occurred.

The primary difference between Event Notification and Burst Messages is that Event Notifications are not required for monitoring or control and rather infrequent. Event Notifications will be transmitted aggregated with Burst Messages when appropriate (e.g., on WirelessHART networks).

The following commands control Event Notification operation:

- **Command 115** is used to determine the configuration of the Event Notification.
- **Command 116** selects the bits that can trigger an Event Notification.
- **Command 117** controls the timing of Event Notifications.
- **Command 118** is used to enable or disable Event Notification
- **Command 119** is used to acknowledge the Event Notification

The device must retain Event Notification Settings through a Device Reset, Self Test or the power being removed and reapplied.

6.10.1 Configuring Event Notification

The procedure a Master should follow to configure Event Notifications is as follows:

1. Use Command 116, Write Event Notification Bit Mask, to set the bits whose change will trigger an Event Notification.
2. The Retry Maximum Update, and De-bounce Interval associate with the event are configured using Command 117, Write Event Notification Timing.
3. The Event Notification is activated with a write of Event Notification Control Code using Command 118, Event Notification Control, which also selects the interface the Event Notification should be used on.

The Event Notification can be disabled by setting the Event Notification Control Code to 0 (Off).

Note: On Token-Passing Networks, burst mode must be actively for evento notifications to be enabled.

6.10.2 Handling of Event Notification in a Device

The first occurrence of the event is captured and Time Stamped. The Event Notification is generated and the Command 119 response transmitted. Command 119 is transmitted repeatedly at the rate indicated by the Retry Period until a Command 119 requests acknowledges the event.

To prevent spurious Event Notifications the De-bounce Interval is configured. This defines the amount of time that a condition must persist before the Event Notification is sent out.

When no event was triggered within the Maximum Update Period the device shall publish the Command 119 response one time only to each Master (for Token-Passing Networks) and one time to the Gateway (For WirelessHART networks).

The latest values for Device Status, the Configuration Change Counter and the Command 48 response bytes are always included in the Command 119.

Command 116 is used to identify the bits that may trigger the Event Notification. Command 119 must only return the status byte received when the Event Mask was established using Command 116 (i.e., Command 116 may be truncated). The bytes returned in Command 119 must reflect the current Device Status and Command 48 Data is sent regardless of which bits are masked. The Time Stamp remains the same until an acknowledge was received. If an Acknowledge was received the Time Stamp is set to the time when the Acknowledge was performed.

Event Notification and Time Stamps are not required to be maintained through power cycles or a device reset.

6.11 Data Trending Support

Trending allows the collection of monotonically spaced data samples for a specified Device Variable to be acquired. This allows faster sampling rates to be achieved and allows the Device Variable to read less often.

Data Trending is intended to reduce the number of transmissions to get data from a device. This can be useful for monitoring applications that do not need to get all data with low latency.

Devices supporting the commands in this Subsection must support one ring buffer at least 12 samples in length. The ring buffer is updated with samples of the desired Device Variable value at the rate indicate by the sample period.

A device may provide more than one trend and each is completely independent. The trends may be sourced from the same or different Device Variables each at the same or differing sample rates. Figure 2 shows an example where the trend is taken each fifth measurement. The Process Values are shown in black, the trend in red.

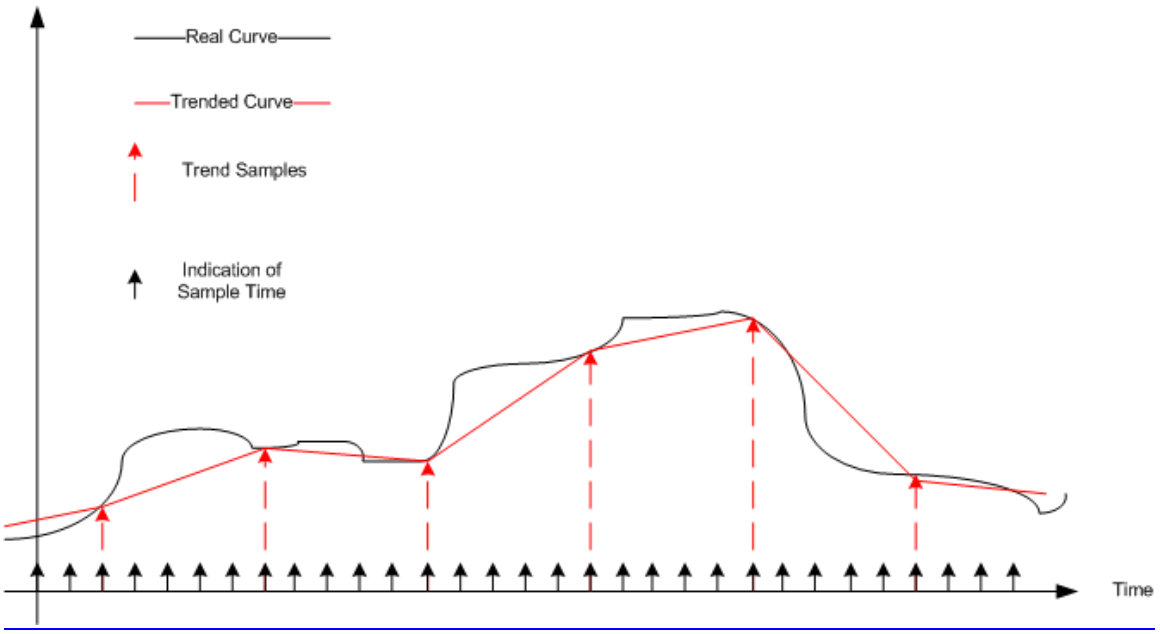

Figure 2: Trending of Process Value

This trend information is not intended to be used for acquiring a long set of measurements at higher data rates that might be used for vibration analysis. For this purpose the block transfer mechanism shall be utilized.

To avoid ambiguity the maximum interval between two values in a trend is limited to 2h.

The fastest update rate for each device variable is accessible via Command 54, Read Device Variable Information

When a Trend is not used it shall transmit when read NaN(0x7FA00000) for the values and as status bad-fixed (0x30) along with the appropriate Response Code.

6.11.1 Determining Trend Support

A host should send Command 91 - "Read Trend Configuration" with the Trend Number set to 0 to the device. If the device responds with any other Response Code than 64 - "Command not Implemented" the device supports trends. Command 91 will return the configuration of Trend 0.

6.11.2 Determining the Number of Trends in a Device

Once Trend Support is determined, the host can issue command 91 - "Read Trend Configuration" with incremented Trend Numbers. The device will reply with Response Code 11 - "Invalid Trend Number" when the first illegal Trend Number is reached. The host will also obtain the current configurations of the Trends in the device with each successful Command 91 response.

6.11.3 Configuring a Trend

When a trend is configured, the host will use Command 92 - "Write Trend Configuration". It contains the Trend Number, the Trend Control Code with the Device Variable that shall be used for the trend (see Common Table 37), and the update interval.

If the Trend is configured to store single data points then only the value that was read during the occurrence of the sampling will be kept in the ring buffer. If Average Trending is enabled the device must average the values that were taken during the update interval. A filtered trend uses a time constant equal to one-third the sample period to smooth the data. For the actual behavior of the device, see the device specific documentation. The sampling rate might be connected to the actual update period that can be set for Burst Mode.

When a change in configuration is detected (change of Trend Control Code, Device Variable or Update Interval) the device will clear the ring buffer and initialize all values to NaN (0x7FA00000) and the status set to BAD-Fixed (0x30) before starting the trend.

6.11.4 Using a Trend

To access the data from a device command 93 - "Read Trend" can be issued. The start point for the trend and the update interval is always transmitted.

6.11.5 Burst Mode and Trend

The command Read Trend is a new addition to the possible burst mode commands. This can be used on wireless networks to reduce the number of transmissions for monitoring applications.

For this purpose, the trend is configured with the desired update time. Afterwards burst mode is configured to update with 12 times the update time of the trends and Read Trend is configured as the burst command. Thus with every burst all trend elements are transferred. If an overlap is desired, the burst update time can be set to 11 or 10 times the trend update time.

Trends allow the maximum Update Interval between two consecutive values to be up to 2h. Burst Mode requires a message at least once an hour. Therefore the maximum period between two trend values should be 5 minutes or less. If period is longer then during each Burst Message that contains the trend older values of the trend will be sent in the transmission. The receiving application must ensure that duplicates are filtered out correctly.

6.12 I/O System and Sub-Device Commands

The Protocol allows communication to multiple devices via an intermediate Bridging Device or I/O System. The intermediate I/O systems are identified by setting `Protocol_Bridge_Device` (bit 2) in the `Flags` byte of Identity Commands. The Protocol allows the devices connected to an I/O System to be identified by a master using:

- Command 74 Read I/O System Capabilities;
- Command 75 Poll Sub-Device;

Commands are sent to the Sub-device using

- Command 77 Send Command to Sub-Device

An I/O System, as defined in this specification, must implement Commands 74, 75, 77.

Figure 3 shows Application Layer view of the "I/O System" architecture supported by the Protocol. In this figure, "HART Network" refers to any legal HART Communication channel (wired or wireless). Example I/O systems include: a HART compatible field device that contains a single Sub-device that is an optional card, the device could be a complete remote I/O system, or the I/O system could be a WirelessHART Adapter.

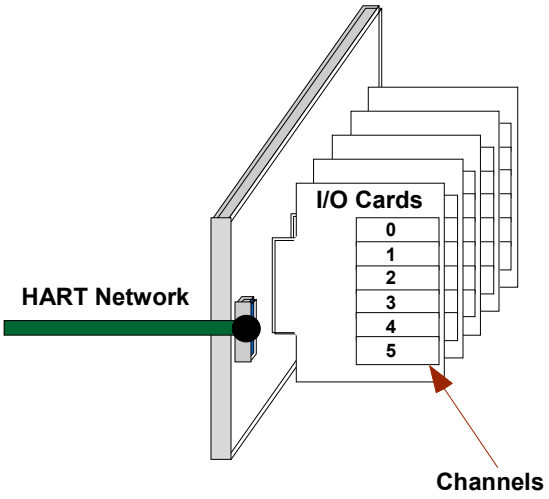

Figure 3. Bridge or I/O System Components

I/O systems appear to HART network like any other device. However, an I/O system must have one or more I/O Cards. Each I/O card in turn must contain one or more sub-network channels and each of these channels must support 1 or more sub-devices. Command 74 allows the master to read the maximum values for each of these data items (I/O Cards, Channels, Sub-Devices). This information, returned in Command 74, allows the master to poll (starting with I/O Card 0, Channel 0) all combinations of I/O Cards, Channels and sub-device polling addresses to identify connected sub-devices. Once identified, Command 77 is used for further communication to the sub-device.

6.12.1 I/O Systems Supporting HART-enabled Channels

If the Sub-devices are connected to the I/O system via a HART Communication channel then the following commands must be implemented.

- Command 84 Read Sub-Device Identity Summary
- Command 85 Read I/O Channel Statistics;
- Command 86 Read Sub-Device Statistics;
- Command 87 Write I/O System Master Mode;
- Command 88 Write I/O System Retry Count; and
- Command 94 Read I/O System Client-Side Communication Statistics.

The I/O systems are strongly recommended to implement the burst mode commands discussed in Subsections 6.9 and 6.12.2.

I/O Systems support two means for identifying sub-devices. The first is via physical connection (e.g., Commands 74, 75, and 77). Commands using this technique are generally used by Data-Link and Network level communications for the physical routing of packets.

The other approach is via a list of all the connected sub-devices. Commands 84 and 86 use this technique to simplify access by, for example, maintenance, configuration, and diagnostic applications. The list is as long as there are devices and, if a device is disconnected or added, the list grows or shrinks as needed.

6.12.2 Burst Mode Support in I/O Systems

I/O systems (See Subsection) should support Burst Messaging over the HART Network connection to its master (i.e. the client application). To enable publishing of Burst Messages from Sub-devices two commands are provided:

- Command 101 Read Sub-device to Burst Message Map; and
- Command 102 Map Sub-device to Burst Message.

Burst Messages from I/O system is based on the Message Map. I/O systems should support at least 3 Burst Messages for each Sub-device. Each Burst Message in the I/O system is mapped to a Sub-device. When the Burst Message is published from or on behalf of the Sub-device, the command is embedded in a Command 77 response. The Sub-device address embedded in the Command 77 response data field along with the device's data. To the recipient of the Burst Message the response appears the same as if it originated from the Sub-Device.

I/O systems should support generation of Burst Messages from all Sub-devices even if the Sub-devices themselves do not support Burst Mode.

6.13 Synchronized Device Actions

Synchronous Actions are used to defer a device activity or action to a specified, future time. The Action could be to simply synchronously sample a single measurement (i.e., a Device Variable), triggering a (e.g., vibration) waveform acquisition, an automatic calibration cycle, or some device specific procedure. In addition, this allows measurements or other operations performed by multiple devices to be synchronized.

If Synchronous Actions are supported then the device must support the "Read Real-Time Clock" command and either the "Set Real-Time Clock"" or the "Write UTC Time Mapping" command.

Four commands are used to synchronize device actions:

- Command 96 Read Synchronous Action
- Command 97 Configure Synchronous Action
- Command 98 Read Command Action
- Command 99 Configure Command Action

Command 97 is used to configure the operation. The action can be capturing a Device Variable value or executing the indicated Command. This configuration consists of setting the Action Control, Device Variable, Command Number Date and Time. Table 3 shows the configuration of the Action Control, Device Variable and Command Number to get the desired Action.

Table 3. Configuring Device Actions

Action	Action Control		Device Variable	Command
	Command	One-Shot		
Delayed or synchronous execution of a command	Set	Set	251	Command to be executed
Repeat Command Execution Daily	Set	Reset	251	Command to be executed
Synchronous Sampling of a Device Variable	Reset	Set	Device Variable Code	0xFFFF
Repeat Sampling of a Device Variable Daily	Reset	Reset	Device Variable Code	0xFFFF

The Date and Time fields specify the time-based trigger for the specified action. When the trigger fires the indicated action is performed. If "One-Shot" bit is reset in the Action Control field then the synchronous action will be performed daily at the specified time of day and repeat continuously. For repetitive actions, the Action is repeated daily at the Time specified. The Date field must be ignored. The Response to Command 97 contains the Date and Time of day set to the resolution of the internal clock of the device. If the time is adjusted the Warning – "Sampling Time Adjusted" will be returned.

Command 99 allows the Requeste Data for the command being triggered to be preset. Command 99 has fields for the command number to be triggered and the command's Request Data. Consequently, when triggering a command almost any kind of device action can be managed (e.g., synchronously sampling vibration waveforms, automatic calibrations cycles).

6.14 Analog Channel Support Commands

All HART devices support Analog Channel 0 corresponding to the Loop Current. These commands must be implemented if the field device supports additional Analog Channels (inputs to or outputs from the Field Device). Such Analog Channels include voltage, current or frequency inputs or outputs used to communicate setpoints or device variables.

The following commands are used if the Field Device supports additional Analog Channels:

- Command 60 Read Analog Channel And Percent Of Range
- Command 62 Read Analog Channels
- Command 63 Read Analog Channel Information
- Command 64 Write Analog Channel Additional Damping Value
- Command 65 Write Analog Channel Range Values
- Command 66 Enter/Exit Fixed Analog Channel Mode
- Command 67 Trim Analog Channel Zero
- Command 68 Trim Analog Channel Gain
- Command 69 Write Analog Channel Transfer Function
- Command 70 Read Analog Channel Endpoint Values

6.14.1 Using Analog Trim Commands

Some devices support more Analog Channels then just the Loop Current. The Analog Channel may be an input to or output from the Field Device. For these devices, the Analog Trim Commands allow Master to calibrate individual Analog Channels. The trim procedure is similar to the one used in Section 6.3.1.

1. Use Command 66, Enter/Exit Fixed Analog Output Mode, to set the analog output to the lower endpoint value.
2. Command 67, Trim Analog Output Zero, can then be used to send the Zero value.
3. Use Command 66 to set the analog output to the upper end point value.
4. Command 68, Trim Analog Output Gain, can then be used to send the gain value.
5. Exit Fixed Output Mode by resending Command 66 with the analog output value of NAN and any Units Code.

7. COMMANDS

7.1 Command 33 Read Device Variables

This is a Device Variable Command.

This command allows a Master to request the value of up to four Device Variables. In other words, a Master may request only 1, 2, 3 or 4 Device Variables. Each slot will accept any Device Variable supported by the device. The Field Device must answer these Master requests without returning Response Code 5, Too Few Data Bytes Received. If the Field Device receives 1, 2 or 3 Request Data Bytes it must return only the corresponding number of Device Variables (see Table 4).

Table 4. Command 33 Response Based on Number of Device Variables Requested

No. of Device Variables Requested	No. of Request Data bytes	No. of Response Data Bytes
1	1	6
2	2	12
3	3	18
4	4	24

Other command requirements include:

- When a Device Variable requested is not supported in the Field Device, then the corresponding Value must be set to "0x7F, 0xA0, 0x00, 0x00", and the Units Code must be set to "250", Not Used.

- This command is capable of Burst Mode Operation and is configured with Command 107, Write Burst Mode Device Variables.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Slot 0: Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Unsigned-8	Slot 1: Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
2	Unsigned-8	Slot 2: Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
3	Unsigned-8	Slot 3: Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Slot 0: Device Variable Code (see Device Variable Code Table in appropriate device-specific document)
1	Enum	Slot 0: Units Code (refer to Common Tables Specification)
2 - 5	Float	Slot 0: Device Variable Value
6	Unsigned-8	Slot 1: Device Variable Code (see Device Variable Code Table in appropriate device-specific document)
7	Enum	Slot 1: Units Code (refer to Common Tables Specification)
8 - 11	Float	Slot 1: Device Variable Value
12	Unsigned-8	Slot 2: Device Variable Code (see Device Variable Code Table in appropriate device-specific document)
13	Enum	Slot 2: Units Code (refer to Common Tables Specification)
14 - 17	Float	Slot 2: Device Variable Value
18	Unsigned-8	Slot 3: Device Variable Code (see Device Variable Code Table in appropriate device-specific document)
19	Enum	Slot 3: Units Code (refer to Common Tables Specification)
20 - 23	Float	Slot 3: Device Variable 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		Undefined
8	Warning	Update Failure
9 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

Note: When a Field Device receives 1, 2, or 3 request data bytes it must answer the Master request without returning Response Code 5, Too Few Data Bytes Received.

7.2 Command 34 Write Primary Variable Damping Value

This is a Primary Variable Command.

The Primary Variable Damping Value represents one time constant. In other words, the output response to a step input reaches 63% of final steady-state value after this time has elapsed. The damping value written by this command affects the PV Transducer Domain's digital value (see the *Command Summary Specification*).

Depending on the role of PV in the Field Device, the associated values in the Analog Channel Domain may be affected as well. For a transmitter, both the Loop Current and digital values of the Primary Variable utilize this time constant. For an actuator, only the response of the Primary Variable digital value is damped. The damping applied to these values may be also affected by other commands (See Command 64).

Some devices implement only discrete damping values (e.g., 1, 2, 4). The value received with the command may be rounded or truncated by the device. The response message will return the actual value used by the device. A warning is issued if value is truncated or rounded.

Request Data Bytes

Byte	Format	Description
0 - 3	Float	Primary Variable Damping Value (units of seconds)

Response Data Bytes

Byte	Format	Description
0 - 3	Float	Actual Primary Variable Damping Value (units of seconds)

Note: The value returned in the response data bytes reflects the rounded or truncated value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 2		Undefined
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8	Warning	Set To Nearest Possible Value
9 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.3 Command 35 Write Primary Variable Range Values

This is a Primary Variable Range Command.

Defines the relationship between the Loop Current 4.00 and 20.0mA points and the Primary Variable value. The Upper Range Value of the Primary Variable is independent of the Lower Range Value. Most devices allow the Upper Range Value of the Primary Variable to be lower than its Lower Range Value, enabling the device to be operated with reverse action. The device-specific document will indicate if this capability has not been implemented.

The Primary Variable Range Units received with this command do not effect the Primary Variable Units of the device. The range values will be returned in the same units as received.

For a transmitter, the Range Values allow the Primary Variable value to be converted to a percent for transmission via the Loop Current. For an actuator, the Range Values allow the Loop Current to be converted to a percent for use by the actuator (e.g., to use as the actuator setpoint).

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Upper and Lower Range Values Units Code (refer to Common Tables Specification)
1 - 4	Float	Upper Range Value
5 - 8	Float	Lower Range Value

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Upper and Lower Range Values Units Code (refer to Common Tables Specification)
1 - 4	Float	Upper Range Value
5 - 8	Float	Lower Range Value

Note: The value returned in the response data bytes reflects the rounded or truncated value actually used by the device.

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	Error	In Write Protect Mode
8	Warning	Set To Nearest Possible Value (Upper or Lower Range Pushed)
9	Error	Lower Range Value Too High
10	Error	Lower Range Value Too Low
11	Error	Upper Range Value Too High
12	Error	Upper Range Value Too Low
13	Error	Upper and Lower Range Values Out Of Limits
14	Warning	Span Too Small (Device Accuracy May Be Impaired)
15		Undefined
16	Error	Access Restricted
17		Undefined
18	Error	Invalid Units Code
19 - 28		Undefined
29	Error	Invalid Span
30 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.4 Command 36 Set Primary Variable Upper Range Value

This is a Primary Variable Range Command.

The current Primary Variable value is written to the Upper Range Value. A change in the Upper Range Value must not effect the Lower Range Value. This action is identical to pushing the SPAN button on many Field Devices.

Most devices allow the Upper Range Value of the Primary Variable to be lower than its Lower Range Value, enabling the device to be operated with a reversed output. The device-specific document will indicate if this capability has not been implemented.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
None		

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 5		Undefined
6	Error	Device-specific Command Error
7	Error	In Write Protect Mode
8	Warning	Set To Nearest Possible Value (Upper Range Value Pushed)
9	Error	Applied Process Too High
10	Error	Applied Process Too Low
11 - 13		Undefined
14	Warning	Span Too Small (Device Accuracy May Be Impaired)
15		Undefined
16	Error	Access Restricted
17 - 28		Undefined
29	Error	Invalid Span
30-31		Undefined
32	Error	Busy
33 - 127		Undefined

7.5 Command 37 Set Primary Variable Lower Range Value

This is a Primary Variable Range Command.

The current Primary Variable value is written to the Lower Range Value. A change in the Lower Range Value will shift the Upper Range Value proportionately so that the span remains constant. This action is identical to pushing the ZERO button on many Field Devices.

When a change pushes the Upper Range Value past either transducer limit, the Upper Range Value saturates and Response Code 14, Warning: New lower range value pushed upper range value over transducer limit, is returned. When the Lower Range Value pushes the Upper Range Value over the transducer limit and the resulting span is less than the Minimum Span, either Response Code 9, Applied Process Too High, or 10, Applied Process Too Low, is returned.

Most devices allow the Upper Range Value to be lower than the Lower Range Value, enabling the device to be operated with a reversed output. The device-specific document will indicate if this capability has not been implemented.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
None		

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 5		Undefined
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8		Undefined
9	Error	Applied Process Too High
10	Error	Applied Process Too Low
11 - 13		Undefined
14	Warning	New Lower Range Value Pushed
15		Undefined
16	Error	Access Restricted
17 - 28		Undefined
29	Error	Invalid Span
30-31		Undefined
32	Error	Busy
33 - 127		Undefined

7.6 Command 38 Reset Configuration Changed Flag

See the *Universal Command Specification*.

7.7 Command 39 EEPROM Control (Not Recommended)

THIS COMMAND IS NOT RECOMMENDED FOR NEW DESIGNS.

This command causes data to be transferred from shadow RAM to nonvolatile memory (burn) or from nonvolatile memory to shadow RAM (restore). Shadow RAM is volatile memory that holds a copy of EEPROM. It is used as a temporary staging area for writing to and reading from EEPROMs.

The Field Device Malfunction Bit, Bit 7 of the Device Status Byte, will be set if an EEPROM checksum error is detected. When this occurs, Command 48, Read Additional Device Status, should be used to obtain specific information. Refer to the device-specific document to determine the error checking implemented by each device type.

A Master should only burn the EEPROM after a session rather then after every write command issued. For burn requests, the burn may not begin until the response that acknowledges the receipt of the command has been sent. When errors occur in these cases, Bit 7 of the Device Status Byte, will be set in the response of subsequent commands.

Note: This command does not increment the Configuration Change Counter because this command only stores the configuration into non-volatile memory. This command (in of itself) does not change the Field Devices configuration.

Request Data Bytes

Byte	Format	Description
0	Enum	EEPROM Control Code 0 Burn EEPROM 1 Restore Shadow RAM 2 - 249 Undefined

Response Data Bytes

Byte	Format	Description
0	Enum	EEPROM Control Code 0 Burn EEPROM 1 Restore Shadow RAM 2 - 249 Undefined

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	Error	In Write Protect Mode
8 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.8 Command 40 Enter/Exit Fixed Current Mode

This is a Loop Current Command.

The device is placed in Fixed Current Mode with the Loop Current set to the value received. The value returned in the response data bytes reflects the rounded or truncated value actually used by the device. A level of '0' exits the Fixed Current Mode. Fixed Current Mode is also exited when power is removed from device.

The Response Data Bytes always indicates the actual current level used by the Field Device.

Request Data Bytes

Byte	Format	Description
0 - 3	Float	Fixed Current Level (units of milliamperes)

Response Data Bytes

Byte	Format	Description
0 - 3	Float	Actual Current Level (units of milliamperes)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 2		Undefined
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8 - 10		Undefined
11	Error	Loop Current Not Active (Device in Multidrop Mode)
12 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.9 Command 41 Perform Self Test

This is a Device Management Command.

Initiates the Self Test function in the device. Refer to the device-specific document for the diagnostics performed and the results available through Command 48, Read Additional Device Status. The execution of this command may take a relatively long time to complete. During the self test the field device must continue to communicate. However, it is allowed to answer "Busy" to all commands received during this interval.

The Loop Current may not reflect the process while the Self test is executing. A master must not generate spurious error messages or disconnect from the Field Device while the Self Test is in progress.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
None		

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 5		Undefined
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.10 Command 42 Perform Device Reset

This is a Device Management Command.

The device must respond to this command immediately and within the Slave Time Out and then reset the microprocessor. This is equivalent to cycling the power off and then back on to the Field Device.

The execution of this command may take a relatively long period of time to complete. The device may not respond to subsequent commands until the reset is complete. Refer to the device-specific document for specific implementation details.

A Master must be prepared for the device's reaction to this command. The Field Device may not respond during the Device Reset. This may look like communications with the Field Device was lost. In addition, the Loop Current may not reflect the process while the Device Reset is executing. A master must not generate spurious error messages or disconnect from the Field Device while the Device Reset is in progress.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
None		

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 5		Undefined
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 -127		Undefined

7.11 Command 43 Set Primary Variable Zero

This is a Primary Variable Command.

Trim the Primary Variable so that it reads zero with the existing process applied to the device. The resulting offset must be within limits defined by each device. The span of the Primary Variable remains constant. This command does not affect or interact with the Upper or Lower Range Values. Figure 4 depicts the effect of this command on the Primary Variable.

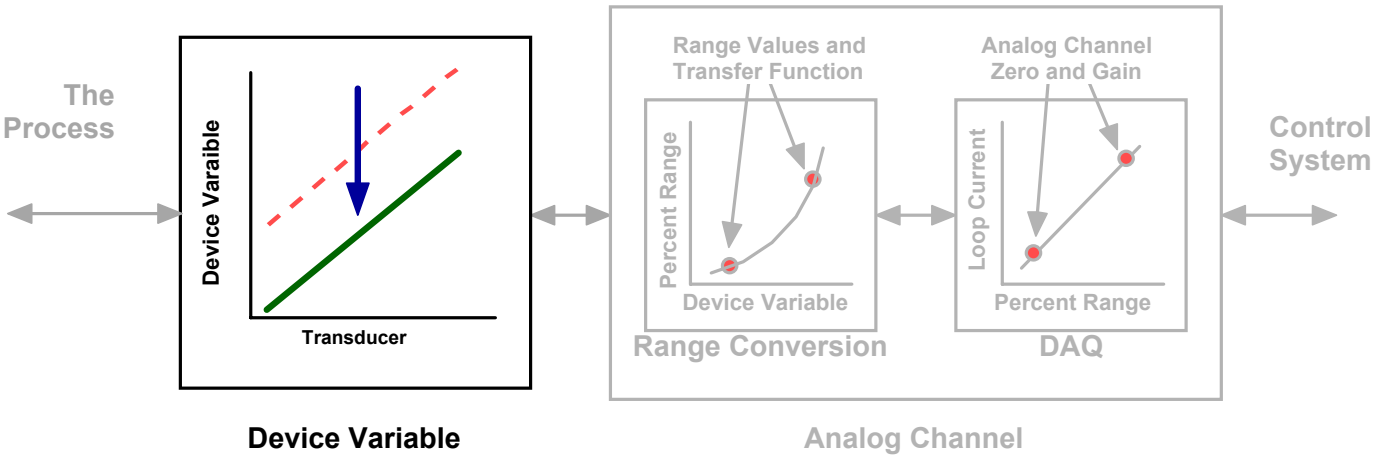

Figure 4 Effect of Set PV Zero Command

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
None		

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 5		Undefined
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8		Undefined
9	Error	Applied Process Too High
10	Error	Applied Process Too Low
11 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.12 Command 44 Write Primary Variable Units

This is a Primary Variable Command.

Selects the units in which the Primary Variable and its range will be returned. This command also selects the units for transducer limits and minimum span.

Request Data Bytes

Byte	Format	Description
0	Enum	Primary Variable Units Code (refer to Common Tables Specification)

Response Data Bytes

Byte	Format	Description
0	Enum	Primary Variable Units Code (refer to Common Tables Specification)

Note: The value returned in the response data bytes reflects the value actually used by the device.

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	Error	In Write Protect Mode
8 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.13 Command 45 Trim Loop Current Zero

This is a Loop Current Command.

Trim the zero or lower endpoint value of the Loop Current exactly to its minimum. This trim is typically performed by adjusting the Loop Current to 4.00 milliamperes and sending the measured value to the Field Device. In response the Field Device trims its calibration of the Loop Current to match the value received from the Master. The value sent with the command may be rounded or truncated by the device. The response data bytes contain the value from the request as used by the device.

Response Code 9, Incorrect Loop Current Mode or Value, will be returned if the device is not in the proper mode to allow the Loop Current to be calibrated or if the current is not set to exactly the minimum value.

Note Voltage Mode Field Devices use "Volts DC" as their engineering units for "Loop Current" rather then milliamps

Request Data Bytes

Byte	Format	Description
0 - 3	Float	Externally Measured Loop Current Level, units of milliamperes

Response Data Bytes

Byte	Format	Description
0 - 3	Float	Actual Measured Loop Current Level, units of milliamperes

Note: The value returned in the response data bytes reflects the rounded or truncated value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 2		Undefined
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8		Undefined
9	Error	Incorrect Loop Current Mode or Value
10		Undefined
11	Error	Loop Current Not Active (Device in Multidrop Mode)
12 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.14 Command 46 Trim Loop Current Gain

This is a Loop Current Command.

Trim the gain or upper endpoint value of the Loop Current exactly to its maximum. This trim is typically performed by adjusting the Loop Current to 20.00 milliamperes. In response, the Field Device trims its calibration of the Loop Current to match the value received from the Master. The value sent with the command may be rounded or truncated by the device. The response data bytes contain the value from the request as used by the device.

Response Code 9, Incorrect Loop Current Mode or Value, will be returned if the device is not in the proper mode to allow the Loop Current to be calibrated or if the current is not set to exactly the maximum value.

Note Voltage Mode Field Devices use "Volts DC" as their engineering units for "Loop Current" rather then milliamps

Request Data Bytes

Byte	Format	Description
0 - 3	Float	Externally Measured Loop Current Level (units of milliamperes)

Response Data Bytes

Byte	Format	Description
0 - 3	Float	Actual Measured Loop Current Level (units of milliamperes)

Note: The value returned in the response data bytes reflects the rounded or truncated value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 2		Undefined
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8		Undefined
9	Error	Incorrect Loop Current Mode or Value
10		Undefined
11	Error	Loop Current Not Active (Device in Multidrop Mode)
12 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.15 Command 47 Write Primary Variable Transfer Function

This is a Primary Variable Command.

Selects the transfer function to be used between the Loop Current and the Primary Variable's digital value.

Request Data Bytes

Byte	Format	Description
0	Enum	Transfer Function **Code** (see Common Table 3, Transfer Function Codes)

Response Data Bytes

Byte	Format	Description
0	Enum	Transfer Function Code (see Common Table 3, Transfer Function Codes)

Note: The value returned in the response data bytes reflects the value actually used by the device.

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	Error	In Write Protect Mode
8 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.16 Command 48 Read Additional Device Status

See the *Universal Command Specification*.

7.17 Command 49 Write Primary Variable Transducer Serial Number

This is a Primary Variable Command.

Writes the transducer serial number associated with the Primary Variable.

Request Data Bytes

Byte	Format	Description
0 - 2	Unsigned-24	Primary Variable Transducer Serial Number

Response Data Bytes

Byte	Format	Description
0 - 2	Unsigned-24	Primary Variable Transducer Serial Number

Note: The value returned in the response data bytes reflects value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.18 Command 50 Read Dynamic Variable Assignments

This is a Process Variable Mapping Command.

Responds with the Device Variable Numbers that are assigned to the Primary, Secondary, Tertiary, and Quaternary Variables. The Field Device must return all Response Data Bytes. Unsupported Dynamic Variables return "250" (Not Used) as the Device Variable assigned

Note: When a Field Device allows the Device Variable returned as PV to be changed (i.e., mapped) then this command must be supported.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable assigned to the Primary Variable (see Device Variable Code Table in appropriate device-specific document)
1	Unsigned-8	Device Variable assigned to the secondary variable (see Device Variable Code Table in appropriate device-specific document)
2	Unsigned-8	Device Variable assigned to the tertiary variable (see Device Variable Code Table in appropriate device-specific document)
3	Unsigned-8	Device variable assigned to the quaternary variable (see Device Variable Code Table in appropriate device-specific document)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 5		Undefined
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

7.19 Command 51 Write Dynamic Variable Assignments

This is a Process Variable Mapping Command.

Assigns Device Variables to the Primary, Secondary, Tertiary, and Quaternary Variables. Each Dynamic Variable will accept any Device Variable Code defined by the device.

7.19.1 Backward Compatibility Requirements

Previously this command was truncatable. In other words, an older Master may only map 1, 2, 3 or 4 Dynamic Variables. The Field Device must answer these Master requests without returning Response Code 5, Too Few Data Bytes Received.. If the Field Device receives 1, 2 or 3 Request Data Bytes, it must return all Response Data Bytes. The slots unspecified by the Master request may return any valid Device Variable in the Field Device. Unsupported Dynamic Variables return "250" (Not Used) as the Device Variable assigned

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable assigned to the Primary Variable (see Device Variable Code Table in appropriate device-specific document)
1	Unsigned-8	Device Variable assigned to the Secondary Variable (see Device Variable Code Table in appropriate device-specific document)
2	Unsigned-8	Device Variable assigned to the Tertiary Variable (see Device Variable Code Table in appropriate device-specific document)
3	Unsigned-8	Device Variable assigned to the Quaternary Variable (see Device Variable Code Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable assigned to the Primary Variable (see Device Variable Code Table in appropriate device-specific document)
1	Unsigned-8	Device Variable assigned to the Secondary Variable (see Device Variable Code Table in appropriate device-specific document)
2	Unsigned-8	Device Variable assigned to the Tertiary Variable (see Device Variable Code Table in appropriate device-specific document)
3	Unsigned-8	Device Variable assigned to the Quaternary Variable (see Device Variable Code Table in appropriate device-specific document)

Note: The value returned in the response data bytes reflects the value actually used by the device.

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	Error	In Write Protect Mode
8 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.20 Command 52 Set Device Variable Zero

This is a Device Variable Command.

Trim the selected Device Variable so that it reads zero with the existing process applied to the device. The resulting offset must be within the limits assigned to each variable.

Note: Depending on the device's configuration the Device Variable being zeroed may be the Primary Variable.

Request Data Bytes

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

Response Data Bytes

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

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	Error	In Write Protect Mode
8		Undefined
9	Error	Applied Process Too High
10	Error	Applied Process Too Low
11 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.21 Command 53 Write Device Variable Units

This is a Device Variable Command.

Selects the units in which the selected Device Variable will be returned.

Note: Depending on the device's configuration the Device Variable may be mapped to the Primary Variable.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Device Variable Units Code (refer to Common Tables Specification).

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Device Variable Units Code (refer to Common Tables Specification).

Note: The value returned in the response data bytes reflects the value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8 - 10		Undefined
11	Error	Invalid Device Variable Code
12	Error	Invalid Units Code
13 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.22 Command 54 Read Device Variable Information

This is a Device Variable Command.

Responds with the transducer serial number, the Limits, Damping Value, and Minimum Span of the selected Device Variable along with the corresponding engineering units. The engineering units returned by this command will be the same as the Device Variable's engineering units .

The device must update the Device Variable at least once in the interval indicated by the Update Time Period

Note: This Command must be supported if the device supports Burst 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 (see Device Variable Codes Table in appropriate device-specific document)
1 - 3	Unsigned-24	Device Variable Transducer Serial Number
4	Enum	Device Variable Limits/Minimum Span Units Code (refer to Common Tables Specification).
5 - 8	Float	Device Variable Upper Transducer Limit
9 - 12	Float	Device Variable Lower Transducer Limit
13 - 16	Float	Device Variable Damping Value
17 - 20	Float	Device Variable Minimum Span
21	Enum	Device Variable Classification (see Common Table 21, Device Variable Classification Codes)
22	Enum	Device Variable Family (see Common Table 20, Device Variable Family Codes).
23-26	Time	Update Time Period. The Update Time Period indicates the maximum period between Device Variable updates

Note 1: The Transducer Serial Number will be set to zero when it does not apply to the selected Device Variable. The other parameters will be set to "0x7F, 0xA0, 0x00, 0x00" or "250" (Not Used) when they are not applicable.

Note 2: If the Device Variable Classification is not supported by this Device Variable then the Field Device must return "0" (Not Yet Implemented)

Note 2: If the Device Variable Family is not supported by this Device Variable then the Field Device must return "250" (Not Used) and the least significant bits of Device Variable Status must be set to 0 (see the *Command Summary Specification*).

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
17-31		Undefined
32	Error	Busy
33-127		Undefined

7.23 Command 55 Write Device Variable Damping Value

This is a Device Variable Command.

Writes the damping value controlling the response rate of the selected Device Variable. The damping value represents one time constant. In other words, the output response to a step input reaches 63% of final steady-state value after this time has elapsed. For a transmitter, the analog output channel values (e.g. the Loop Current) are damped as well as the Device Variable's digital value. For an actuator, only the response of the Device Variable's digital value is damped. The damping applied to these values may be also effected by other commands.

Note: Command 64 may be used to provide additional damping directly on the analog channel signal itself.

Some devices implement only discrete damping values (e.g., 1, 2, 4). The value received with the command may be rounded or truncated by the device. The response message will return the actual value used by the device. A warning is issued if value is truncated or rounded.

Note: Depending on the device's configuration the Device Variable may be mapped to the Primary Variable (see Command 34)

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1 - 4	Float	Device Variable Damping Value (units of seconds)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1 - 4	Float	Device Variable Damping Value (units of seconds)

Note: The value returned in the response data bytes reflects the rounded or truncated value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8	Warning	Set to Nearest Possible Value
9 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.24 Command 56 Write Device Variable Transducer Serial No.

This is a Device Variable Command.

Writes the transducer serial number associated with a particular Device Variable.

Note: Depending on the device's configuration the Device Variable may be mapped to the Primary Variable.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1 - 3	Unsigned-24	Device Variable Transducer Serial Number

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1 - 3	Unsigned-24	Device Variable Transducer Serial Number

Note: The value returned in the response data bytes reflects the rounded or truncated value actually used by the device.

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	Error	In Write Protect Mode
8 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.25 Command 57 Read Unit Tag, Descriptor, Date (Not Recommended)

THIS COMMAND IS NOT RECOMMENDED FOR NEW DESIGNS.

This command reads the tag, descriptor, and date of the unit device and not that of an individual transducer. A unit device is typically common hardware that supports multiple transducers.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0 - 5	Packed	Unit Tag
6 - 11	Packed	Unit Descriptor
18 - 20	Unsigned-24	Unit Date (respectively day, month, year-1900)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 5		Undefined
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

7.26 Command 58 Write Unit Tag, Descriptor, Date (Not Recommended)

THIS COMMAND IS NOT RECOMMENDED FOR NEW DESIGNS.

This command writes the tag, descriptor, and date to the unit device and not an individual transducer. A unit device is typically common hardware that supports multiple transducers.

Request Data Bytes

Byte	Format	Description
0 - 5	Packed	Unit Tag
6 - 17	Packed	Unit Descriptor
18 - 20	Date	Unit Date Code

Response Data Bytes

Byte	Format	Description
0 - 5	Packed	Unit Tag
6 - 17	Packed	Unit Descriptor
18 - 20	Date	Unit Date Code

Note: The value returned in the response data bytes reflects the value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.27 Command 59 Write Number Of Response Preambles

This is a Data Link Layer Management Command. Command 59 only applies to asynchronous Physical Layers like the HART FSK Physical Layer.

This command sets the number of asynchronous 0xFF preamble bytes to be sent by a device before the start of a response message. This number includes the two preambles used to detect the start of message. This value may be set to no smaller then 5 and no greater then 20.

Note: Field devices must answer all messages and meeting the requirements in the *Data Link Layer Specification* even if the Master Request contains more than 20 Preambles.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Number of preambles to be sent with the response message from the Slave to the Master

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Number of preambles to be sent with the response message from the Slave to the Master

Note: The value returned in the Response Data Bytes reflects the value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 2		Undefined
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8	Warning	Set To Nearest Possible Value
9-15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.28 Command 60 Read Analog Channel And Percent Of Range

This is an Analog Channel Support Command.

Read the Analog Level and Percent of Range of the selected Analog Channel. The Analog Level always matches the associated physical Analog Channel of the device, including alarm conditions and set values. The Analog Level always matches the value that can be measured by an externally connected reference meter.

7.28.1 Percent of Range (Transmitters)

Percent of Range always follows the associated Device Variable value, including alarm conditions and set values. The Upper and Lower Range Values maps the Dynamic Variable value to the Percent of Range. Percent of Range is not limited to values between 0% and 100%, but tracks the Device Variable to the Transducer Limits.

7.28.2 Percent of Range (Actuators)

Percent of Range always follows the Analog Level even if is set to a value. The Upper and Lower Range Values maps the Analog Level to the Percent of Range. As a result the Percent of Range is not limited to values between 0% and 100%, but tracks the Analog Level to Transducer Limits when they are defined.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)
1	Enum	Analog Channel Units Code (refer to Common Tables Specification)
2 - 5	Float	Analog Channel Level
6 - 9	Float	Analog Channel Percent of Range (units of percent)

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		Undefined
8	Warning	Update Failure
9 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

7.29 Command 61 Read Dynamic Variables And Primary Variable Analog Channel (Not Recommended)

THIS COMMAND IS NOT RECOMMENDED FOR NEW DESIGNS.

Read the Primary Variable's Analog Channel Level and up to four predefined Dynamic Variables. The Primary Variable Analog Channel Level always matches the physical Primary Variable Analog Channel of the device including alarm conditions and set values. The Secondary, Tertiary, and Quaternary Variables are defined by each device type.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Enum	Primary Variable Analog Channel Units Code (refer to Common Tables Specification)
1-4	Float	Primary Variable Analog Level
5	Enum	Primary Variable Units Code (refer to Common Tables Specification)
6-9	Float	Primary Variable
10	Enum	Secondary Variable Units (refer to Common Tables Specification)
11-14	Float	Secondary Variable
15	Enum	Tertiary Variable Units Code (refer to Common Tables Specification)
16-19	Float	Tertiary Variable
20	Enum	Quaternary Variable Units Code (refer to Common Tables Specification)
21-23	Float	Quaternary Variable

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 5		Undefined
6	Error	Device-Specific Command Error
7		Undefined
8	Warning	Update Failure
9 - 15		Undefined
16	Error	Access Restricted
17-127		Undefined

7.30 Command 62 Read Analog Channels

This is an Analog Channel Support Command.

Read selected Analog Channel Levels. Each slot will accept any Analog Channel Number Code defined by the device.

7.30.1 Backward Compatibility Requirements

Previously this command was truncatable. In other words, an older Master may only request 1, 2, 3 or 4 Analog Channels. The Field Device must answer these Master requests without returning Response Code 5, Too Few Data Bytes Received. If the Field Device receives 1, 2 or 3 Request Data Bytes, it must return all Response Data Bytes. The slots unspecified by the Master request may return any valid Analog Channel in the Field Device even if it duplicates information from a previous slot.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code assigned to Slot 0 (see Analog Channel Number Codes Table in appropriate device-specific document)
1	Unsigned-8	Analog Channel Number Code assigned to Slot 1 (see Analog Channel Number Codes Table in appropriate device-specific document)
2	Unsigned-8	Analog Channel Number Code assigned to Slot 2 (see Analog Channel Number Codes Table in appropriate device-specific document)
3	Unsigned-8	Analog Channel Number Code assigned to Slot 3 (see Analog Channel Number Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code in Slot 0 (see Analog Channel Number Codes Table in appropriate device-specific document)
1	Enum	Slot 0 Units Code (refer to Common Tables Specification)
2-5	Float	Slot 0, Level of selected Analog Channel
6	Unsigned-8	Analog Channel Number Code in Slot 1 (see Analog Channel Number Codes Table in appropriate device-specific document)
7	Enum	Slot 1 Units Code (refer to Common Tables Specification)
8-11	Float	Slot 1, Level of selected Analog Channel
12	Unsigned-8	Analog Channel Number Code in Slot 2 (see Analog Channel Number Codes Table in appropriate device-specific document)
13	Enum	Slot 2 Units Code (refer to Common Tables Specification)
14-17	Float	Slot 2, Level of selected Analog Channel
18	Unsigned-8	Analog Channel Number Code in Slot 3 (see Analog Channel Number Codes Table in appropriate device-specific document)
19	Enum	Slot 3 Units Code (refer to Common Tables Specification)
20-23	Float	Slot 3, Level of selected Analog Channel

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		Undefined
8	Warning	Update Failure
9 - 127		Undefined

7.31 Command 63 Read Analog Channel Information

This is an Analog Channel Support Command.

Read the configuration of the Analog Channel including: the Alarm Selection Code, Transfer Function Code, Range Units Code, Upper Range Value, Lower Range Value, and Damping Value.

The damping value is applied to the Analog Channel in addition to the damping of the associated Device or Dynamic Variable.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)
1	Enum	Analog Channel Alarm Selection Code (see Common Table 6, Alarm Selection Codes)
2	Enum	Analog Channel Transfer Function Code (see Common Table 3, Transfer function Codes)
3.	Enum	Analog Channel Upper and Lower Range Values Units Code (refer to Common Tables Specification)
4 - 7	Float	Analog Channel Upper Range Value
8 - 11	Float	Analog Channel Lower Range Value
12 - 15	Float	Analog Channel Damping Value (units of seconds)
16	Bits	Analog Channel Flags (see Common Table 26, Analog Channel Flags)

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
17-31		Undefined
32	Error	Busy
33-127		Undefined

7.32 Command 64 Write Analog Channel Additional Damping Value

This is an Analog Channel Support Command.

Write the additional damping value for the selected Analog Channel.

The additional damping value represents one time constant. In other words, the output response to a step input is 63% of final steady-state value after this time has elapsed. For a transmitter, only the response of the analog output (e.g. the Loop Current) is damped. For an actuator, the response of the associated Device Variable or Dynamic Variable (e.g. the Primary Variable's digital value) is damped as well. The damping applied to these values may be also effected by other commands.

Some devices implement only discrete damping values (e.g., 1, 2, 4). The value received with the command may be rounded or truncated by the device. The response message will return the actual value used by the device. A warning is issued if value is truncated or rounded.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)
1 - 4	Float	Analog Channel Additional Damping Value (units of seconds)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)
1 - 4	Float	Analog Channel Additional Damping Value (units of seconds)

Note: The value returned in the response data bytes reflects the rounded or truncated value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3		Passed Parameter Too Large
4		Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8	Warning	Set to Nearest Possible Value
9 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.33 Command 65 Write Analog Channel Range Values

This is an Analog Channel Support Command.

Write the Range Values for the selected Analog Channel. The Upper Range Value is independent of the Lower Range Value.

The units of the range received with this command do not effect the units of Dynamic or Device Variables. The Range Values will be returned in the same units as received.

Most devices allow the Upper Range Value to be lower than the Lower Range Value, enabling the device to be operated with a reversed output. The device-specific document will indicate if this capability has not been implemented.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)
1	Enum	Analog Channel Upper and Lower Range Values Units Codes (refer to Common Tables Specification)
2 - 5	Float	Analog Channel Upper Range Value
6 - 9	Float	Analog Channel Lower Range Value

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)
1	Enum	Analog Channel Upper and Lower Range Values Units Codes (refer to Common Tables Specification)
2 - 5	Float	Analog Channel Upper Range Value
6 - 9	Float	Analog Channel Lower Range Value

Note: The value returned in the response data bytes reflects the rounded or truncated value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8	Warning	Set To Nearest Possible Value (Upper or Lower Range Pushed)
9	Error	Lower Range Value Too High
10	Error	Lower Range Value Too Low
11	Error	Upper Range Value Too High
12	Error	Upper Range Value Too Low
13	Error	Upper And Lower Range Values Out Of Limits
14	Warning	Span Too Small (Device Accuracy May Be Impaired)
15	Error	Invalid Analog Channel Code Number
16	Error	Access Restricted
17 - 27		Undefined
28	Error	Invalid Range Units Code
29	Error	Invalid Span
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.34 Command 66 Enter/Exit Fixed Analog Channel Mode

This is an Analog Channel Support Command

The device's Analog Channel level is fixed to the value received. The value returned in the response data bytes reflects the rounded or truncated value actually used by the device. A level containing "0x7F, 0xA0, 0x00, 0x00", with any Units Code exits the Fixed Analog Channel Mode. Fixed Analog Channel Mode is also exited when power is removed from device.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)
1	Enum	Analog Channel Units Code (refer to Common Tables Specification)
2 - 5	Float	Fixed Analog Channel Level

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)
1	Enum	Analog Channel Units Code (refer to Common Tables Specification)
2 - 5	Float	Fixed Analog Channel Level

Note: The value returned in the response data bytes reflects the rounded or truncated value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 2		Undefined
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8 - 10		Undefined
11	Error	In Multidrop Mode
12	Error	Invalid Units Code
13 - 14		Undefined
15	Error	Invalid Analog Channel Code Number
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.35 Command 67 Trim Analog Channel Zero

This is an Analog Channel Support Command

This command trims the zero or lower endpoint value of the selected Analog Channel so that the Analog Channel value matches the connected meter reading. The value sent with the command may be rounded or truncated by the device. The Response Data Bytes contain the value from the request as used by the device.

Use Command 66, Enter/Exit Fixed Analog Channel Mode, to set the Analog Channel exactly to the lower endpoint value before using this command. Response Code 9, Not in Proper Analog Channel Mode, will be returned if the Fixed Analog Channel Mode has not been entered or the Analog Channel is not set exactly to the lower endpoint value.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)
1	Enum	Analog Channel Units Code (refer to Common Tables Specification)
2 - 5	Float	Externally Measured Analog Channel Level

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)
1	Enum	Analog Channel Units Code (refer to Common Tables Specification)
2 - 5	Float	Actual Analog Channel Level

Note: The value returned in the response data bytes reflects the rounded or truncated value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 2		Undefined
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8		Undefined
9	Error	Not In Proper Analog Channel Mode
10		Undefined
11	Error	In Multidrop Mode
12	Error	Invalid Units Code
13 - 14		Undefined
15	Error	Invalid Analog Channel Code Number
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.36 Command 68 Trim Analog Channel Gain

This is an Analog Channel Support Command

This command trims the gain or upper endpoint value of the selected Analog Channel so that the Analog Channel value matches the connected meter reading. The value that is sent with the command may be rounded or truncated by the device. The response data bytes contain the value from the request as used by the device.

Use Command 66, Enter/Exit Fixed Analog Channel Mode, to Set the Analog Channel exactly to the upper endpoint value before using this command. Response Code 9, Not In Proper Analog Channel Mode, will be returned if the Fixed Analog Channel Mode has not been entered or the Analog Channel is not set exactly to the upper endpoint value.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)
1	Enum	Analog Channel Units Code (refer to Common Tables Specification)
2 - 5	Float	Externally Measured Analog Channel Level

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)
1	Enum	Analog Channel Units Code (refer to Common Tables Specification)
2 - 5	Float	Externally Measured Analog Channel Level

Note: The value returned in the response data bytes reflects the rounded or truncated value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 2		Undefined
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8		Undefined
9	Error	Not In Proper Analog Channel Mode
10		Undefined
11	Error	In Multidrop Mode
12	Error	Invalid Units Code
13 - 14		Undefined
15	Error	Invalid Analog Channel Code Number
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.37 Command 69 Write Analog Channel Transfer Function

This is an Analog Channel Support Command

Select the transfer function for the selected Analog Channel of the device.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)
1	Enum	Analog Channel Transfer Function Code (see Common Table 3, Transfer Function Codes)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)
1	Enum	Analog Channel Transfer Function Code (see Common Table 3, Transfer Function Codes)

Note: The value returned in the response data bytes reflects the rounded or truncated value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8 - 12		Undefined
13	Error	Invalid Transfer Function Code
14		Undefined
15	Error	Invalid Analog Channel Code Number
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.38 Command 70 Read Analog Channel Endpoint Values

This is an Analog Channel Support Command

Read the endpoint values for the selected Analog Channel.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog Channel Number Code (see Analog Channel Number Codes Table in appropriate device-specific document)
1	Enum	Analog Channel Upper and Lower Endpoint Values Units Code (refer to Common Tables Specification)
2 - 5	Float	Analog Channel Upper Endpoint Value
6 - 9	Float	Analog Channel Lower Endpoint 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
17-31		Undefined
32	Error	Busy
33-127		Undefined

7.39 Command 71 Lock Device

This is a Device Management Command

This command temporarily locks a device preventing any changes being made from a local panel or from another Master.

This command will allow a Master to temporarily or permanently lock a instrument while the device is being configured or calibrated. Once the procedure is complete the Master device must restore normal operation. If the lock is temporary then normal (unprotected) operation is also resumed when power is removed from device or upon performing a device reset.

Request Data Bytes

Byte	Format	Description
0	Enum	Lock Code (see Common Table 18, Lock Device Codes)

Response Data Bytes

Byte	Format	Description
0	Enum	Lock Code (see Common Table 18, Lock Device Codes)

Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device Specific Command Error
7-9		Undefined
10	Error	Invalid Lock Code
11	Error	Cannot Lock Device
12-15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.40 Command 72 Squawk

This is a Data Link Layer Management Command.

This command causes the addressed device to visually, audibly or mechanically indicate the reception of this command. Masters should repeatedly issue this command to allow technicians to identify the actual device being addressed.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
None		

Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-5		Undefined
6	Error	Device Specific Command Error
7-8		Undefined
9	Error	Unable to Squawk (e.g, no local operator interface)
10-15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.41 Command 73 Find Device

This is an I/O System Command and an Identity Command (see the *Command Summary Specification*).

This command may be issued using either the device's long frame address or the Broadcast Address. Slaves implementing this command must only respond when physically/mechanically armed. For example, the technician presses a special button or combination of buttons that indicate the Slave is to answer this command.

Returns identity information about the Field Device including: the Device Type, revision levels, and Device ID. The address in the Response Message is the same as the request.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Same as Command 0.

Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 127		Undefined

7.42 Command 74 Read I/O System Capabilities

This is an I/O System Command

This command reads the guidance a Host needs to identify an I/O system's sub-devices. Devices supporting this command must have byte 8 (`Flags`), bit #2 (`Protocol Bridge Device`) of the Identity Commands set in there response.

I/O systems may contain one or more I/O Cards. Each I/O Card may in turn support one or more Channels with, possibly, several sub-devices. The data items in this command should contain information allowing Masters to minimize the time necessary to identify sub-devices.

Cards and channels are numbered from 0. For example, the host application must poll from zero to (Maximum Number of I/O Cards - 1). While not all cards may be present, the I/O system must return the Maximum Number of I/O Cards that are supported by the I/O system.

The Maximum Number of Channels per I/O Card indicates the maximum number of Channels that may be found on any card currently found in the I/O system. Each card must support each channel in the range 0 to *n* such that *n* is equal to Maximum Number of Channels - 1.

The I/O System must maintain a list of connected sub-devices and indicates the number of connected Sub-devices in this command. The I/O System must identify connected devices using the mechanisms specified in the Network Management Specification. In addition the I/O system should capturing devices answering a poll generated by the reception of Command 75 and capturing devices communicating with another master connected to the field side of the I/O system to ensure an accurate count of the sub-devices connected.

If the I/O system does not have a physical HART Communication channel to the sub-device then the master Mode and Retry Count must return 250 "Not Used".

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Maximum Number of I/O Cards (must be greater then or equal to 1).
1	Unsigned-8	Maximum Number of Channels per I/O Card (must be greater then or equal to 1).
2	Unsigned-8	Maximum Number of Sub-Devices Per Channel (must be greater then or equal to 1).
3 - 4	Unisigned-16	Number of devices detected.
5	Unsigned-8	Maximum number of delayed responses supported by I/O System. Must be at least two.
6	Unsigned-8	Master Mode for communication on channels . 0 = Secondary Master; 1 = Primary Master (default)
7	Unsigned-8	Retry Count to use when sending commands to an sub-device. Valid range is 2 to 5. 3 retries is default.

Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 5		Undefined
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17-31		Undefined
32	Error	Busy
33-127		Undefined

7.43 Command 75 Poll Sub-Device

This command is issued to identify an I/O system's sub-devices. Host applications use this command to vary the I/O Card number, Channel number and Sub-Device Polling Address to walk through the possible connections and identify all the sub-networks and sub-devices.

When successful, this command returns identity information for the sub-device. Discovered devices are communicated with using Command 77 Send Command to Sub-Device

Since it is not expected that this command will complete in the allowed response time on the network, the delayed response mechanism will be used by the I/O System. The I/O System must automatically retry the command to the field device (up to the Retry Count) if a valid response is not received.

When possible, the I/O System should use Response Code 9, "No Sub-Device Found" to expedite sub-device identification and minimize Master polling time.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	I/O Card
1	Unsigned-8	Channel
2	Unsigned-8	Sub-Device Polling Address

Response Data Bytes

Same as Command 0.

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
7-8		Undefined
9	Error	No Sub-Device Found
10 - 15		Undefined
16	Error	Access Restricted
17 - 20		Undefined
21	Error	Invalid I/O card number
22		Invalid Channel number
23 - 31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

Note: "Access restricted" shall only be returned when the I/O system receives Command 75 via one of the sub-device channels.

7.44 Command 76 Read Lock Device State

This is a Device Management Command

This command reads the current state of the Lock Device. Lock Device allows a Master to temporarily prevent another master of the local operator interface from changing an instruments configuration or calibration.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Bits	Lock Status (see Common Table 25, Lock Device Status)

Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-5		Undefined
6	Error	Device Specific Command Error
7-15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.45 Command 77 Send Command to Sub-Device

This is an I/O System Command

This command is used to pass an embedded HART command request to a specific sub-device. The I/O System's Card and Channel number are included to ensure correct propagation of the embedded command.

The I/O System must first check the command against the Master Mode. If the command format is for the wrong master, the I/O System must correct the master address. In addition, the I/O System must ensure there are an adequate number of preambles (i.e., at least 5) indicated in the embedded command, transmit the preambles, then transmit the balance of the command request. The Check Byte of the embedded command is calculated by the I/O System

Since it is not expected that this command will complete in the allowed response time on the network, the delayed response mechanism will be used by the I/O System. The I/O System must automatically retry the command to the field device (up to the Retry Count) if a valid response is not received. Once the response is received from the field device the preambles are discarded and the balance of the transaction is returning to the host.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	I/O Card
1	Unsigned-8	Channel
2	Unsigned-8	Transmit Preamble Count. Valid range is 5 to 20.
3	Unsigned-8	Delimiter of embedded command
4-n	Unsigned-8 or Unsigned-40	Address field of embedded command. This field is 1 or 5 bytes long
	Unsigned-8	Command of embedded command
	Unsigned-8	Byte Count of embedded command
	Unisgned-8 [ ]	Data field of embedded command (array of bytes)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	I/O Card
1	Unsigned-8	Channel
2	Unsigned-8	Delimiter of embedded command
3-n	Unsigned-8 or Unsigned-40	Address field of embedded command. This field is 1 or 5 bytes long
	Unsigned-8	Command of embedded command
	Unsigned-8	Byte Count of embedded command
	Unisgned-8 [ ]	Data field of embedded command (array of bytes)

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 - 20		Undefined
21	Error	Invalid I/O card number
22	Error	Invalid Channel number
23	Error	Sub-device Response Too Long
24 - 31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.46 Command 78 Read Aggregated Commands

HART compatible devices have been limited historically to a single read command per transaction. For example, if Device Variable 0 and the Percent Range is required continuously then Command 9 could be burst and the host application would be required to poll Command 2 separately.

Using this command, multiple read commands can be aggregated in one transaction. In the request, the number of commands along with the embedded command numbers and their request data bytes are provided. In the reply, the response for each command is included. To directly support Device Family commands and other expanded command numbers, 16bit command number fields are used.

This command allows a device to aggregate/encapsulate multiple commands into a single command for faster command reads. In addition, the command may also be automatically constructed to combine multiple pending Burst Messages. For example, Command 78 could be burst and contain both Command 2 and Command 9. Burst Message 0 must never be aggregated.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Number of commands requested
1 - 2	Unsigned-16	Cmd A
3	Unsigned-8	Byte count for Cmd A
4 - *i*	Unsigned-8 [ ]	Data bytes for Cmd A
…	Unsigned-16	Cmd B
…	Unsigned-8	Byte count for Cmd B
…	Unsigned-8 [ ]	Data Bytes for Cmd B
	…	
…	Unsigned-16	Cmd N
…	Unsigned-8	Byte count for Cmd N
…	Unsigned-8	Data Bytes for Cmd N

Response Data Bytes

Byte	Format	Description
0	Bits	Extended Field Device Status (refer to Common Table 17, Extended Field Device Status)
0	Unsigned-8	Number of commands requested
0-1	Unsigned-16	Cmd A
2	Unsigned-8	Byte count for Cmd A
3 - A	Unsigned-8	Data bytes for Cmd A (including command's Response Code)
…	Unsigned-16	Cmd B
…	Unsigned-8	Byte count for Cmd B
…	Unsigned-8	Data Bytes for Cmd B (including command's Response Code)
	…	
…	Unsigned-16	Cmd N
…	Unsigned-8	Byte count for Cmd N
…	Unsigned-8	Data Bytes for Cmd N (including command's Response 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		Undefined
8	Warning	Update Failure
9	Error	Invalid Command requested
10-31		Undefined
30	Warning	Command Response Truncated - One or more commands are droped in the response.
10-31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.47 Command 79 Write Device Variable

This is a Device Variable Command.

This command allows a Device Variable to be temporarily forced to a fixed value.

The Host selects the Device Variable and Engineering Value to write. The Write Device Variable Code controls the operation of the Field Device either forcing the engineering value or allowing normal operation. For Device Variables automatically calculated by the Field Device, normal operation is resumed when power is removed from the device or upon performing a device reset.

Note 1: A Field Device must initiate a Delayed Response if the change in the Device Variable's value exceeds the Rate-of-Change Limit. This DR will continue until the new Device Variable value can be reached. See the PID Device Family for more information.

Note 2: While the Device Variable remains forced Response Code 8, "Update Failure" must be returned whenever the forced value is read by a host. This signals (e.g., a HART 5) master to detect this condition.

Note 3: Forcing a Device Variable value may affect bits in the device status byte. For example, the Loop Current may become fixed when using this command to force the Device Variable mapped to the Primary Variable in a transmitter.

Note4: Host Applications must not Device Family status bits for Device Variables not supporting a Device Family (i.e., the field device always reset these bits in this case)

The Device Variable Units Code received with this command does not affect the Device Variable Units of the Field Device. The Device Variable value will be returned in the same units as received.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Write Device Variable Command Code (see Common Table 19, Write Device Variable Codes)
2	Enum	Units Code (refer to Common Tables Specification)
3-6	Float	Device Variable value
7	Bits	Device Variable status

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Write Device Variable Command Code (see Common Table 19, Write Device Variable Codes)
2	Enum	Units Code (refer to Common Tables Specification)
3-6	Float	Device Variable value
7	Bits	Device Variable status

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	Error	In Write Protect Mode
8	Warning	Device Family status bit not set.
9		Undefined
10	Error	Invalid Write Device Variable Code
11-15		Undefined
16	Error	Access Restricted
17	Error	Invalid Device Variable Index. The Device Variable does not exist in this Field Device.
18	Error	Invalid Units Code
19	Error	Device Variable index not allowed for this command.
20-31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.48 Command 80 Read Device Variable Trim Points

This is a Transducer Trim Command.

This command reads the last successful trim points. If this Device Variable does not support a trim operation, then both the upper and lower trim points will be set to Not-A-Number. If the Device Variable supports only a single trim point, then the upper trim point will be set to Not-A-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 (see Device Variable Codes Table in appropriate device-specific document)
1	Unsigned-8	Trim Points Units Code (refer to Common Tables Specification)
2 -5	Float	Lower or Single Trim Point (the most recent value used for the lower trim point)
6 - 9	Float	Upper Trim Point (the most recent value used for the upper trim point)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7-16		Undefined
17	Error	Invalid Device Variable Index. The Device Variable does not exist in this Field Device.
18		Undefined
19	Error	Device Variable index not allowed for this command.
20-31		Undefined
32	Error	Busy
33-127		Undefined

7.49 Command 81 Read Device Variable Trim Guidelines

This is a Transducer Trim Command.

This command reads the information that a Host will need to guide a user through a correct selection of trim points. If the Device Variable supports only a single trim point, the lower trim point values are interpreted as the single trim point. The limits of the upper trim point and the minimum differential must be set to Not-A-Number.

If the Device Variable cannot be trimmed, the device should implement this command with Byte 1 (number of trim points supported) set to 0. The floating point values must then be set to Not-A-Number and the Units Code set to Not Used.

Request Data Bytes

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

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable guidelines to read (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Trim points supported (see Common Table 22, Trim Point Codes).
2	Enum	Trim Points Units Code (refer to Common Tables Specification)
3 - 6	Float	Minimum Lower Trim Point Value (no value lower than this will be accepted by the instrument during a low trim procedure)
7 - 10	Float	Maximum Lower Trim Point Value (no value higher than this will be accepted by the instrument during a low trim procedure)
11 - 14	Float	Minimum Upper Trim Point Value (no value lower than this will be accepted by the instrument during a high trim procedure)
15 - 18	Float	Maximum Upper Trim Point Value (no value higher than this will be accepted by the instrument during a high trim procedure)
19 - 22	Float	Minimum Differential (minimum acceptable difference between upper and lower trim points)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7-16		Undefined
17	Error	Invalid Device Variable Index. The Device Variable does not exist in this Field Device.
18		Undefined
19	Error	Device Variable index not allowed for this command.
20-31		Undefined
32	Error	Busy
33-127		Undefined

7.50 Command 82 Write Device Variable Trim Point

This is a Transducer Trim Command.

This command performs a calibration adjustment for the indicated Device Variable. The trim point that is sent in this command must represent the presently applied process variable value. On receipt of this command, the device will check the value for validity (within acceptable limits), then attempt to adjust the indicated point in its calibrated calculation so that the resulting digital process value matches the value supplied in the command.

If the device cannot complete the trim calculation within the time allowed by the Data Link Layer for a response, the device must use the delayed response mechanism to inform the Master that calibration is proceeding.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable to trim (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Trim Point (see Common Table 22, Trim Point Codes)
2	Enum	Trim Point Units Code (refer to Common Tables Specification)
3 - 6	Float	Trim Point Value (the presently applied process value for this Device Variable)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable to trim (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Trim Point (see Common Table 22, Trim Point Codes)
2	Enum	Trim Point Units Code (refer to Common Tables Specification)
3 - 6	Float	Trim Point Value (the presently applied process value for this Device Variable)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	Device Specific Command Error
7	Error	In Write Protect Mode
8		Undefined
9	Error	Applied Process Too High
10	Error	Applied Process Too Low
11	Error	Trim Error, Excess Correction Attempted
12		Undefined
13	Error	Computation Error, Trim Values Were Not Changed
14	Warning	Span Too Small
15		Undefined
16	Error	Access Restricted
17	Error	Invalid Device Variable Index. The Device Variable does not exist in this Field Device.
18	Error	Invalid Units Code
19	Error	Device Variable index not allowed for this command.
20-31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.51 Command 83 Reset Device Variable Trim

This is a Transducer Trim Command.

This command allows the user to reset the Device Variable to the default factory trim.

Request Data Bytes

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

Response Data Bytes

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

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	Undefined
7	Error	In Write Protect Mode
8-15		Undefined
16	Error	Access Restricted
17	Error	Invalid Device Variable Index. The Device Variable does not exist in this Field Device.
18		Undefined
19	Error	Device Variable index not allowed for this command.
20-31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.52 Command 84 Read Sub-Device Identity Summary

This is an I/O System Command

This command allows an application to get a summary of the sub-devices connection to the I/O system. The I/O System must maintain a list of connected sub-devices and the summary information in this command. Any change to this list shall cause the configuration changed bit to be set.

The I/O System captures this summary information by identifying connected devices using the mechanisms specified in the *Network Management Specification*, any devices answering a poll generated by the reception of Command 75, or any device identified during communication by another master connected to the field side of the I/O system.

The I/O system is responsible for obtaining the Long tag from the connected device.

Request Data Bytes

Byte	Format	Description
0-1	Unsigned-16	Sub-device Index

Response Data Bytes

Byte	Format	Description
0-1	Unsigned-16	Sub-device Index (Index 0 returns the I/O system Identity)
2	Unsigned-8	I/O Card (Index 0 returns 251, "None")
3	Unsigned-8	Channel (Index 0 returns 251, "None")
4-5	Unsigned-16	Manufacturer ID
6-7	Unsigned-16	Expanded Device Type Code
8-10	Unsigned-25	Device ID
11	Unsigned-8	Universal Command Revision level.
12 - 43	Latin-1	Long tag

Note: For HART 5 devices, the Long Tag field shall return the text in the "Message" attribute as read from Command 12.

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 - 127		Undefined

7.53 Command 85 Read I/O Channel Statistics

This is an I/O System Command

This is a diagnostic command that the host can use to analyze the communication traffic on the specified channel. The I/O System's Card and Channel number are included to ensure correct propagation of the embedded command.

Note: Marginal designs may not continuously monitor each channel. Consequently, the counts of burst messages and traffic to the other master may not reflect all of the communications that have transpired.

The statistics are volatile and reset to zero only on power-up. After that, the statistics shall only be incremented and must not be reset. All counts must wrap to zero on overflow.

Only if the I/O system is performing its startup or device reset functions, this command can reply with a BUSY response code.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	I/O Card
1	Unsigned-8	Channel

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	I/O Card
1	Unsigned-8	Channel
2 - 3	Unsigned-16	Count of STX messages sent by the I/O system on this channel.
4 - 5	Unsigned-16	Count of ACK messages received.
6 - 7	Unsigned-16	Count of OSTX messages received. (messages from other master).
8 - 9	Unsigned-16	Count of OACK messages received. (replies to other master).
10 - 12	Unsigned-16	Count of BACK messages received (addressed to either master).

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 - 20		Undefined
21	Error	Invalid I/O card number
22		Invalid Channel number
23 - 31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33 - 127		Undefined

7.54 Command 86 Read Sub-Device Statistics

This is a I/O System Command

The I/O system must maintain statistics for its communication with the connected sub-devices. These statistics are accessed by host applications using this command.

The statistics are volatile and reset to zero only on power-up. After power-up, the statistics shall only be incremented and must not be reset. All counts must wrap to zero on overflow.

Request Data Bytes

Byte	Format	Description
0-1	Unsigned-16	Sub-device Index

Response Data Bytes

Byte	Format	Description
0-1	Unsigned-16	Sub-device Index (Index 0 returns statistics for the I/O system itself)
2-3	Unsigned-16	Count of STX messages sent to this device
3-4	Unsigned-16	Count of ACK messages received from this device
5-6	Unsigned-16	Count of BACK messages received from this device

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 - 127		Undefined

7.55 Command 87 Write I/O System Master Mode

This is an I/O System Command

This command sets the I/O System's Data-Link Layer operation on all channels as either primary or secondary master mode.

Request Data Bytes

Byte	Description
0	Master Mode (0 = Secondary Master; 1 = Primary Master)

Response Data Bytes

Byte	Description
0	Master Mode (0 = Secondary Master; 1 = Primary Master)

Note: The value returned in the response data bytes reflects the value actually used by the device.

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	Error	In Write Protect Mode
8 - 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

7.56 Command 88 Write I/O System Retry Count

This is an I/O System Command

This command sets the number of times that the I/O System must retry a command to a field device if a valid response is not received.

Request Data Bytes

Byte	Description
0	Retry Count. Valid range is 2 to 5.

Response Data Bytes

Byte	Description
0	Retry Count.

Note: The value returned in the response data bytes reflects the value actually used by the device.

Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 2		Undefined
3	Error	Passed parameter too large
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8 - 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

7.57 Command 89 Set Real-Time Clock

This is a Device Management Command.

This Command serves two purposes:

- If the Time-set Code is 0 (see Common Table 38) the device will answer in the Response with the internal time at which the request was received. In this case, the command is used to determine the round trip time for the transaction.

- If the Time-set Code is 1 the device will use the sent time and set its Real-Time Clock to have the same value. It will also use the received time as last time when synchronization occurred (see Command 90).

Normally a host should send this command multiple times while measuring average latency. Each time the host will adjust the Time of Day value compensating for the communication latency. This will be repeated until communication latency affects are characterized and its affect on setting the Real-Time Clock is minimized. To improve the consistency of the latency estimates, Command 89 transmits two extra bytes in the request to compensate for transmission of the Response Code and Device Status in the response packet.

This command should not be implemented in WirelessHART devices.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Time-set Code (see Common Table 38, Time-set Code)
1 - 3	Date	Date Code to set device's Real-Time Clock
4 - 7	Time	Time of Day to set device's Real-Time Clock
8 - 9	Unsigned-16	Should be set to 0. Two bytes to ensure request and response take equal amounts of time (compensates for transmission time of Response Code and Device Status in response)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Time-set Code (see Common Table 20, Synchronize Operation Code)
1 - 3	Date	Date Code to set device's Real-Time Clock
4 - 7	Time	Time of Day to set device's Real-Time Clock

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 2		Undefined
3	Error	Passed Parameter Too Large
4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8 - 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

7.58 Command 90 Read Real-Time Clock

This is a Device Management Command.

Read the Real-Time Clock including the current time as estimated by the device and the last time the clock was set. The device must answer with the internal time at which the request was received.

If the clock has not been set then the last time set must be initialized to midnight (00:00) 01 January, 1900.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
1 - 3	Date	Current Date
4 - 7	Time	Current Time of Day
8 - 10	Date	Date clock last set
11 - 14	Time	Time clock last set
15	Bits	RTC Flags (see Common Table 42)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 5		Undefined
6	Error	Device-Specific Command Error
7 - 127		Undefined

7.59 Command 91 Read Trend Configuration

This command reads the configuration of a selectable trend. It returns the current state of a trend, the update interval and the respective device variable.

Request Data Bytes

Byte	Format	Description
0	Unsigned 8	Trend number

Response Data Bytes

Byte	Format	Description
0	Unsigned 8	Trend number
1	Unsigned 8	Total number of Trends supported
2	Enum	Trend Control Code (See Common Table 37)
3	Unsigned 8	Device Variable Code
4-7	Time	Trend sample interval (maximum is 2h: one trend per day)

Command Specific Response Codes

Code	Class	Description
0	Success	No command specific errors
1 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 10		Undefined
11	Error	Invalid Trend Number
12 - 127		undefined

7.60 Command 92 Write Trend Configuration

This command writes the complete configuration of one trend and it writes all three parameters at the same time to transfer the configuration of a trend consistently.

When a change in configuration is detected (change of Trend Control Code, Device Variable or Update Interval), the device will clear the ring buffer and initialize all values to NaN (0x7FA00000) and the status set to BAD-Fixed (0x30) before starting the trend (see Subsection 6.11).

Request Data Bytes

Byte	Format	Description
0	Unsigned 8	Trend number
1	Enum	Trend Control Code (see Common Table 37)
2	Unsigned 8	Device Variable code
3 - 6	Time	Trend sample period (maximum is 2h to allow one trend per day, i.e. 0x0DBBA000)

Response Data Bytes

Byte	Format	Description
0	Unsigned 8	Trend number
1	Enum	Trend Control Code
2	Unsigned 8	Device Variable code
3 - 6	Unsigned 32	Trend sample period

Command Specific Response Codes

Code	Class	Description
0	Success	No command specific errors
1		Undefined
2	Error	Invalid selection (trend control code)
3	Error	Passed parameter too large (trend update period)
4	Error	Passed parameter too small (trend update period)
5	Error	Too few data bytes received
6	Error	Device-Specific Command Error
7	Error	In write protect mode
8	Warning	Set to nearest possible value (trend update period)
9 - 10		Undefined
11	Error	Invalid trend number
13 - 15		Undefined
16	Error	Access restricted
17	Error	Invalid device variable index
18 - 127		Undefined

7.61 Command 93 Read Trend

This command is intended to read one trend. It consists of the trend number, the device variable code, unit and classification, time stamp of first measurement and update time and the last 12 trend values.

When the trend is not enabled the device shall return the data last collected with the corresponding date and time (see Subsection 6.11). The Response Code shall be set to 8 - Trend not Active.

Request Data Bytes

Byte	Format	Description
0	unsigned 8	Trend number

Response Data Bytes

Byte	Format	Description
0	Unsigned 8	Trend Number
1	Unsigned 8	Device Variable Code
2	Enum	Device Variable Classification
3	Enum	Device Variable Unit Code
4-6	Date	Date Stamp Of Trend Value 0
7-10	Time	Time Stamp Of Trend Value 0
11-14	Time	Sample Interval
15-18	Float	Trend Value 0 (newest value)
19	Bits	Trend Value 0 Status (see *Command Summary Specification*)
20-23	Float	Trend Value 1
24	Bits	Trend Value 1 Status
25-28	Float	Trend Value 2
29	Bits	Trend Value 2 Status
30-33	Float	Trend Value 3
34	Bits	Trend Value 3 Status
35-38	Float	Trend Value 4
39	Bits	Trend Value 4 Status
40-43	Float	Trend Value 5
44	Bits	Trend Value 5 Status
45-48	Float	Trend Value 6
49	Bits	Trend Value 6 Status
50-53	Float	Trend Value 7
54	Bits	Trend Value 7 Status
55-58	Float	Trend Value 8
59	Bits	Trend Value 8 Status

60-63	Float	Trend Value 9
64	Bits	Trend Value 9 Status
65-68	Float	Trend Value 10
69	Bits	Trend Value 10 Status
70-73	Float	Trend Value 11
74	Bits	Trend Value 11 Status

Command Specific Response Codes

Code	Class	Description
0	Success	No command specific errors
1 - 4		Undefined
5	Error	Too few data bytes received
6	Error	Device-specific command error
8	Warning	Trend not active
9 - 10		Undefined
11	Error	Invalid trend number
12 - 127		Undefined

7.62 Command 94 Read I/O System Client-Side Communication Statistics

This is an I/O System Command

This command reads the gateway or multiplexer communication statistics for this host system interface. It allows a host system to diagnose communication issues between itself and the communication gateway or multiplexer it is using to access field devices.

Note: Command 85 can be used to retrieve statistics on a particular IO channel of the gateway or multiplexer as well as command 86 can be used to gather statistics for a particular device attached to the IO.

If an I/O System has more than 1 communication interface (e.g. wireless and wired) then the statistics are returned for the interface that the request was received on.

The statistics are volatile and reset to zero only on power-up. After that, the statistics shall only be incremented and must not be reset. All counts must wrap to zero on overflow.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-3	Unsigned-16	Number of messages received through this host system interface
4-7	Unsigned-16	Number of messages returned to this host system
8-11	Unsigned-16	Number of requests forwarded to IO system
12-15	Unsigned-16	Number of responses returned from the IO system

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-5		Undefined
6	Error	Device-specific command error
7-15		Undefined
16	Error	Access restricted
17-127		Undefined

7.63 Command 95 Read Device Communications Statistics

This is a Device Management Command

A device should maintain statistics for its communication interface(s). These statistics are accessed using this command. The statistics are volatile and reset to zero only on power-up. After that, the statistics shall only be incremented and must not be reset. All counts must wrap to zero on overflow.

If a device has more than 1 communication interface (e.g. wireless and wired) then the statistics are returned for the interface that the request was received on.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0 - 1	Unsigned-16	Count of STX messages received by this device
2 – 3	Unsigned-16	Count of ACK messages sent from this device
4 – 5	Unsigned-16	Count of BACK messages sent from this device

Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-5		Undefined
6	Error	Device-specific command error
7 - 127		Undefined

7.64 Command 96 Read Synchronous Action

This is a Synchronized Device Action Command

This Command reads the current settings for the specified Action. The Action Control field specifies whether the action is execution of a command or the sampling of a Device Variable. Date and time indicate when the action will be (or was) triggered.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Action number

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Action number
1	Unsigned-8	Total number of Action
2	Bits-8	Action Control (See Common Table 41, Synchronous Action Control)
3	Unsigned-8	Device Variable Code. If action executing a command, the Device Variable code must be set to 251, "None".
4-5	Unsigned-16	Command Number. If action is sampling a Device Variable, the Command Number must be set to 0xFFFF.
6-8	Date	Trigger Date
9-12	Time	Trigger Time

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
7-127		Undefined

7.65 Command 97 Configure Synchronous Action

This is a Synchronized Device Action Command

This Command configures the specified Action. The Action Control field (See Common Table 41, Synchronous Action Control) specifies whether the action is:

- Execution of a command or the sampling of a Device Variable;
- A "one-Shot" action or repeated daily; and
- Enables or disables the Action.

Date and time indicate when the action will be triggered. The Response will always contain the Time of day set to the resolution of the internal clock of the device. If the time is adjusted the Warning – "Sampling Time Adjusted" will be returned.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Action number
1	Bits-8	Action Control (See Common Table 41, Synchronous Action Control)
2	Unsigned-8	Device Variable Code. If action executing a command, the Device Variable code must be set to 251, "None".
3-4	Unsigned-16	Command Number. If action is sampling a Device Variable, the Command Number must be set to 0xFFFF.
5-7	Date	Trigger Date
8-11	Time	Trigger Time

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Action number
1	Unsigned-8	Action Control
2	Unsigned-8	Device Variable
3-4	Unsigned-16	Command
5-7	Date	Trigger Date
8-11	Time	Trigger Time

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	Error	In Write Protect Mode
8	Warning	Sampling Time Adjusted
9	Error	Bad Trigger Action
10	Error	Invalid Date
11	Error	Invalid Time
12	Error	Invalid Device Variable
13	Error	Command Number Not Supported
14-15		Undefined
16	Error	Access Restricted
17-31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37-127		Undefined

7.66 Command 98 Read Command Action

This is a Synchronized Device Action Command

Synchronized Device Actions can be used to trigger the execution of a command. This command reads the current settings for the command to be executers. In the response, the command number is embedded along with the command's request data bytes. To directly support Device Family commands and other expanded command numbers, 16bit command number fields are used.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Sample trigger action

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Sample trigger action
1-2	Unsigned-16	Command Number to be triggered at later time
3	Unsigned-8	Byte count
4 - *i*	Unsigned-8 [ ]	Data bytes for Command being configured

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
6-127		Undefined

7.67 Command 99 Configure Command Action

This is a Synchronized Device Action Command

Synchronized Device Actions can be used to trigger the execution of a command. The command configures the target command. In the request, the target command's number and request data bytes are embedded. To directly support Device Family commands and other expanded command numbers, 16bit command number fields are used.

Request Data Bytes

Byte	Format	Description
1	Unsigned-8	Sample trigger action
2-3	Unsigned-16	Command Number to be triggered at later time
3	Unsigned-8	Byte count
4 - *i*	Unsigned-8 [ ]	Data bytes for Command being configured

Response Data Bytes

Byte	Format	Description
1	Unsigned-8	Sample trigger number
2-3	Unsigned-16	Command Number to be triggered at later time
3	Unsigned-8	Byte count
4 - *i*	Unsigned-8 [ ]	Data bytes for Command being configured

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection (Command Number)
3-4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8	Warning	Set To Nearest Possible Value (Date or Time)
9	Error	Bad Trigger Action
10	Error	Bad Command Data
11-12		Undefined
13	Error	Command Number Not Supported
14-15		Undefined
16	Error	Access Restricted
17-31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37-127		Undefined

7.68 Command 101 Read Sub-device to Burst Message Map

This is an I/O System and Burst Mode Command

This command reads which sub-device is mapped to a burst message. The sub-device is indicated by the sub-device index. The Read Sub-Device Identity Summary command can be used to obtain additional information about the sub-device

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message
1-2	Unsigned-16	Sub-device Index (Index 0 indicates the I/O System itself)

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 - 127		Undefined

7.69 Command 102 Map Sub-device to Burst Message

This is an I/O System and Burst Mode Command

This command maps a sub-device to a burst message. The sub-device is indicated by the sub-device index. The Read Sub-Device Identity Summary command can be used to obtain additional information about the sub-device

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message
1-2	Unsigned-16	Sub-device Index (Index 0 indicates the I/O System itself)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message
1-2	Unsigned-16	Sub-device Index

Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection (Burst Message)
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-specific command error
7-8		Undefined
9		Invalid Sub-device Index
7 - 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

7.70 Command 103 Write Burst Period

This is a Burst Mode Command.

This command selects the minimum and maximum update period of a burst message. The minimum time must be less then or equal to the maximum time. The update time shall be selected as specified Subsection 6.9.2. Field devices must correct settings differing from these values and indicate "Set to Nearest Value" in its response message.

If multiple Burst Messages are enabled and they all coincide within the same time they are aggregated together using Command 78 to concatenate the messages (see Subsection 6.9.1). The Burst Messages with the highest priority will be concatenated first up to the maximum number of bytes that the respective Data Link Layer allows. The priority is dictated by the Burst Message Number.

Note: WirelessHART natively supports command aggregation (i.e., Command 78 should not be used.

Note: Burst message 0 must never be aggregated in TDMA networks.

Table 5. Burst Message Priorities

Priority	Burst Messages
Highest	Burst Message 0
	Burst Message 1
	Burst Message 2
	…
	Burst Message n
	…
	Device Status Event
Lowest	Command 48 Event

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message
1 - 4	Time	Update Period in 1/32 of a millisecond. Update Period must not exceed 3600 seconds. The device must publish data at this rate as long as the trigger conditions in Command 104 are met.
5 - 8	Time	Maximum Update Period in 1/32 of a millisecond (not to exceed 3600 seconds). The device must publish at this rate when the trigger conditions configured in Command 104 are not met.

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message
1 - 4	Time	Update Period in 1/32 of a millisecond
5 - 8	Time	Maximum Update Period in 1/32 of a millisecond

Note: The value returned in the response data bytes reflects the value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-specific command error
7	Error	In Write Protect Mode
8	Warning	Update Times Adjusted
9	Error	Invalid Burst Message
10 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.71 Command 104 Write Burst Trigger

This is a Burst Mode Command.

This command configures the trigger that forces publishing of the Burst Message. Four trigger modes are supported: Continuous, Windowed, Rising, and Falling (see Common Table 33, Burst Mode Trigger Mode Codes). Unless otherwise configured by this command a Burst Message shall assume a Trigger Mode of "Continuous" and a Trigger Value of 0.00.

These trigger modes allow the device to be configured to defer the publishing of the Burst Message beyond the Update Period in Command 103. In all cases, the Burst message is triggered when the Maximum Update Time in Command 103 is exceeded. In addition, the trigger source is also specified and is normally the first process value returned in the command (see Table 6).

Table 6. Burst Message Trigger Source

Command	Trigger Source Value	Command	Trigger Source Value
1	PV	9	Device Variable in Slot 0
2	Percent of Range	33	Device Variable in Slot 0
3	PV		

When in "Windowed" mode, the Trigger Value must be a positive number and is the symmetric window around the last communicated value. Figure 5 illustrates the Burst Message being published after the window was exceeded.

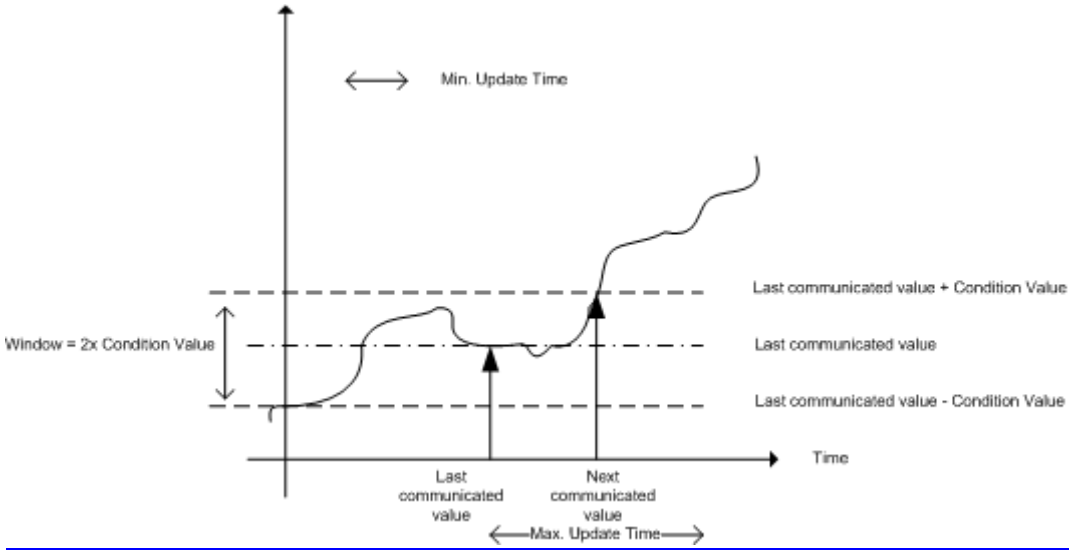

Figure 5. Trigger Mode 1: Windowed

Figure 6 illustrates that even if the value does not deviate beyond the window a Burst Message is still published when the Max Update Period is exceeded.

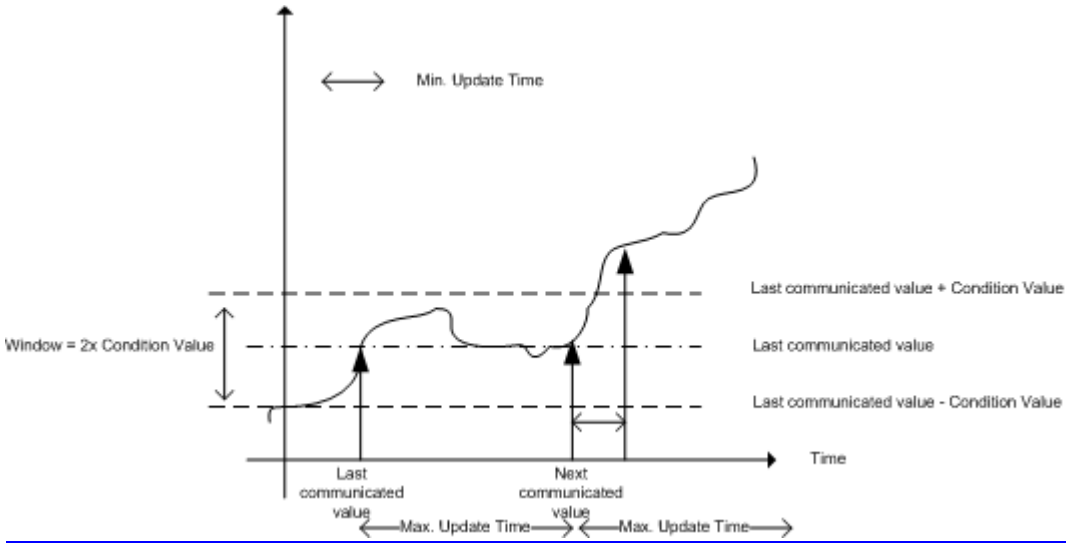

Figure 6: Windowed Condition on Burst with max. Update Time expired

In "Rising" mode, the Burst Message must be published when the source value exceeds the threshold established by the trigger value. Figure 7 shows that the update time changes once the limit is exceeded. Burst messages are published at the rate indicated by the Update Period as long as the source value remains above the trigger value. If the value falls below the trigger value, the update time will drop to the Maximum Update Period.

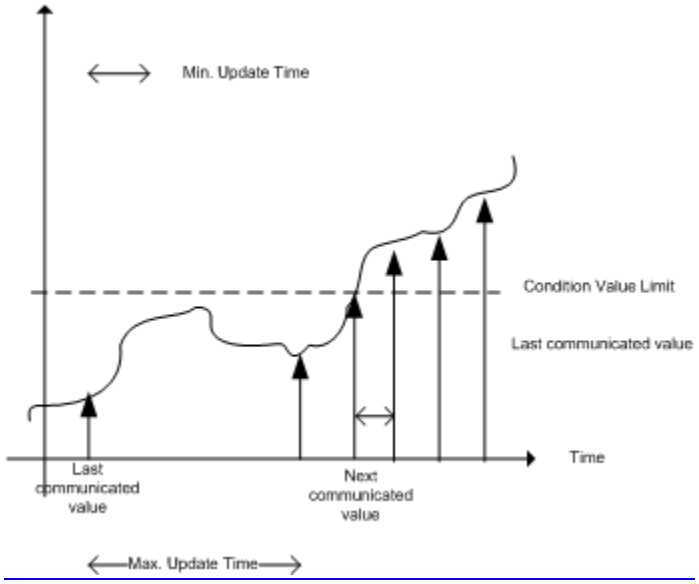

Figure 7: Update Time change on Limit Excess

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message
1	Enum-8	Burst Trigger Mode Selection Code (see Common Table 33, Burst Mode Trigger Mode Codes)
2	Enum-8	Device Variable Classification for Trigger Level
3	Enum-8	Units Code
4 - 7	Float-32	Trigger Level

Note: If Command 2 is selected the Device Variable Classification must be 0 and the Engineering Units "Percent" (0x39 or 57 decimal).

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message
1	Enum-8	Burst Trigger Mode Selection Code (see Common Table 33, Burst Mode Trigger Mode Codes)
2	Enum-8	Device Variable Classification for Trigger Level
3	Enum-8	Units Code
4 - 7	Float-32	Trigger Level

Note: The value returned in the response data bytes reflects the value actually used by the device.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8		Undefined
9	Error	Invalid Burst Message
10		Undefined
11	Error	Invalid Device Variable Classification
12	Error	Invalid Units Code
13	Error	Invalid Burst Trigger Mode Selection Code
13 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.72 Command 105 Read Burst Mode Configuration

This is a Burst Mode Command.

This command allows the Burst Mode configuration to be read. The Field Device responds with whether the Field Device is in Burst Mode; the command to be burst and a list of Device Variables to be transmitted, the burst minimum and maximum update time and the condition for the maximum update time.

7.72.1 Backward Compatibility Requirements

If the device receives a Request without data bytes the device may not respond with Response Code 5 - "Too Few Data Bytes Received" but must assume that it is read from a HART 5 or HART 6 master. The Device will return the configuration of Burst Message 0.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Mode Control Code (see Common Table 9, Burst Mode Control Codes)
1	Unsigned-8	Command Number of the response message to be transmitted
2	Unsigned-8	Device Variable Code assigned to Slot 0 (see Device Variable Codes Table in appropriate device-specific document)
3	Unsigned-8	Device Variable Code assigned to Slot 1 (see Device Variable Codes Table in appropriate device-specific document)
4	Unsigned-8	Device Variable Code assigned to Slot 2 (see Device Variable Codes Table in appropriate device-specific document)
5	Unsigned-8	Device Variable Code assigned to Slot 3 (see Device Variable Codes Table in appropriate device-specific document)
6	Unsigned-8	Device Variable Code assigned to Slot 4 (see Device Variable Codes Table in appropriate device-specific document)
7	Unsigned-8	Device Variable Code assigned to Slot 5 (see Device Variable Codes Table in appropriate device-specific document)
8	Unsigned-8	Device Variable Code assigned to Slot 6 (see Device Variable Codes Table in appropriate device-specific document)
9	Unsigned-8	Device Variable Code assigned to Slot 7 (see Device Variable Codes Table in appropriate device-specific document)
10	Unsigned-8	Burst Message
11	Unsigned-8	Total number of Burst Messagea
12-15	Time	Update Time in 1/32 of a millisecond
16-19	Time	Maximum Update Time in 1/32 of a millisecond
20	Enum-8	Burst Trigger Mode Code
21	Enum-8	Device Variable Classification for Trigger Value
22	Enum-8	Units Code
23-26	Float-32	Trigger Value

Note: If a slot is not configured to transmit a Device Variable that slot must return "250" (Not Used). If Command 9 is to be burst then the slot's Device Variable code must meet the requirements found in Command 9.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-5		Undefined
6	Error	Device-specific command error
7-8		Undefined
9	Error	Invalid Burst Message
10-32		Undefined
32	Error	Busy
33-127		Undefined

7.73 Command 106 Flush Delayed Responses

This command clears all pending delayed responses for the Master that issues the command. Delayed responses currently running that must not be interrupted or aborted may be completed (see the manufacturer's device specific document for details). If this is the case, then the Slave must respond with Response Code 8, Warning: All but running delayed responses flushed.

THIS COMMAND MUST BE IMPLEMENTED IF THE DELAYED RESPONSE MECHANISM IS SUPPORTED.

Note: Devices should always support a minimum of two DR buffers (one for each Master). If only one DR buffer is supported then this command must flush the DR buffer even if it is in use by the other Master.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
None		

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors, All Flushed
1-5		Undefined
6	Error	Device-specific command error
7		Undefined
8	Warning	All but running delayed responses flushed
9-15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

7.74 Command 107 Write Burst Device Variables

This is a Burst Mode Command

Selects the Device Variables that will be used by a bursting device to be returned by a Command 9 or 33 in Burst Mode. The master will always send 9 data bytes in the request to set the value. Unused slots will be set to the value 250 - "Not Used". The first slot with the value 250 - "Not Used" determines where the Command 9 or Command 33 response will be truncated.

Command 33 only accepts up to 4 slots (i.e., slots 0-3) and the others should be set by the host to 250 - "Not Used". In either case the field device shall ignore the settings for slots 4-7 when publishing Command 33.

The last byte indicates which Burst Message this command applies to.

If the trigger mode is non-zero in Command 104 and the trigger source's Device Variable Classification does not match the new Slot 0 Device Variable the new values will be accepted and Response Code "Burst Condition Conflict" will be returned. The field device must correct the classification, unit codes, reset to Trigger Mode 0 and publish continuously at the Update Period until it receives another Command 104.

7.74.1 Backward Compatibility Requirements

For backward compatibility a field device must assume that it is configured by a HART 5 or HART 6 host when it receives only 1, 2, 3 or 4 Device Variables . In such a case the device shall not return Response Code 5 - "Too Few Data Bytes Received" instead it must treat the message as a configuration of the first Burst Message with all other Device Variables set to 250 - "Not Used".

The field device shall not return "Burst Condition Conflict" but it will reconfigure the attributes associated with Command 104.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code assigned to Slot 0 (see Device Variable Codes Table in appropriate device-specific document)
1	Unsigned-8	Device Variable Code assigned to Slot 1 (see Device Variable Codes Table in appropriate device-specific document)
2	Unsigned-8	Device Variable Code assigned to Slot 2 (see Device Variable Codes Table in appropriate device-specific document)
3	Unsigned-8	Device Variable Code assigned to Slot 3 (see Device Variable Codes Table in appropriate device-specific document)
4	Unsigned-8	Device Variable Code assigned to Slot 4 (see Device Variable Codes Table in appropriate device-specific document)
5	Unsigned-8	Device Variable Code assigned to Slot 5 (see Device Variable Codes Table in appropriate device-specific document)
6	Unsigned-8	Device Variable Code assigned to Slot 6 (see Device Variable Codes Table in appropriate device-specific document)
7	Unsigned-8	Device Variable Code assigned to Slot 7 (see Device Variable Codes Table in appropriate device-specific document)
8	Unsigned-8	Burst Message

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code assigned to Slot 0 (see Device Variable Codes Table in appropriate device-specific document)
1	Unsigned-8	Device Variable Code assigned to Slot 1 (see Device Variable Codes Table in appropriate device-specific document)
2	Unsigned-8	Device Variable Code assigned to Slot 2 (see Device Variable Codes Table in appropriate device-specific document)
3	Unsigned-8	Device Variable Code assigned to Slot 3 (see Device Variable Codes Table in appropriate device-specific document)
4	Unsigned-8	Device Variable Code assigned to Slot 4 (see Device Variable Codes Table in appropriate device-specific document)
5	Unsigned-8	Device Variable Code assigned to Slot 5 (see Device Variable Codes Table in appropriate device-specific document)
6	Unsigned-8	Device Variable Code assigned to Slot 6 (see Device Variable Codes Table in appropriate device-specific document)
7	Unsigned-8	Device Variable Code assigned to Slot 7 (see Device Variable Codes Table in appropriate device-specific document)
8	Unsigned-8	Burst Message

Note: The value returned in the response data bytes reflects the value actually used by the device.

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	Error	In Write Protect Mode
8	Warning	Burst Condition Conflict
9	Error	Invalid Burst Message
10-127		Undefined

7.75 Command 108 Write Burst Mode Command Number

This is a Burst Mode Command

This command selects the response message that the device transmits while in Burst Mode. Command 1, 2, 3, and 9 shall be supported in all devices implementing Burst Mode. Refer to the device-specific document to determine if additional commands are supported for a specific device type.

If the trigger mode is non-zero in Command 104 and the trigger source's Device Variable Classification does not match for the new command number the new command number will be accepted and Response Code "Burst Condition Conflict" will be returned. The field device must correct the classification, unit codes, reset to Trigger Mode 0 and publish continuously at the Update Period until it receives another Command 104.

7.75.1 Backward Compatibility Requirements

If a field device receives only one data byte in the request it must assume that it is configured by a HART 5 or HART 6 host and treat is as if the first Burst Message was configured. In this case the device must not return Response Code 5 - "Too Few Data Bytes Received".

The field device shall not return "Burst Condition Conflict" but it will reconfigure the attributes associated with Command 104.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Command Number of the response message to be transmitted
1	Unsigned-8	Burst Message

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Command Number of the response message to be transmitted
1	Unsigned-8	Burst Message

Note: The value returned in the response data bytes reflects the value actually used by the device.

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	Error	In Write Protect Mode
8	Warning	Burst Condition Conflict
9	Error	Invalid Burst Message
10-127		Undefined

7.76 Command 109 Burst Mode Control

This is a Burst Mode Command.

This command is used to enter and exit the Burst Mode on the device's Token-Passing or TDMA Data-Link (see Common Table 9, Burst Mode Control Codes).

The response data bytes for Command 9, Read Primary Variable, or the command number selected with Command 108, Write Command Number To Burst, will be transmitted while in Burst Mode.

Note: This command affects Data Link Layer operation. All Data Link Layer requirements for entering and exiting burst mode must be met.

The Response Codes for the Delayed Response Mechanism may only be used when enabling publishing on the TDMA Data-Link. A delayed response is only initiated if the device does not have enough capacity currently scheduled to the WirelessHART Gateway. If the device determines that there is not enough capacity available to handle the newly enabled Burst Message it must return "Insufficient Bandwidth".

When switching Burst Mode off no delayed response is allowed.

Note: If a WirelessHART field device joins the network and is denied the required capacity it will set the bit "Capacity Denied" in the Standardized Status (see Command 48 and Common Table 32). Capacity Denied can be the result of Burst Message or Event capacity demands.

7.76.1 Backward Compatibility Requirements

To maintain backward compatibility, the device shall only respond with "Too Few Data Bytes Received" (Response Code 5) if no request data bytes are received. If only one byte is received and the Burst Mode Control Code is greater then 1 then the device must respond with "Too Few Data Bytes Received".

When the Burst Message number is not included the device must assume that Burst Message 0 is being activated or deactivated for publishing on the Token-Passing Data-Link. (When a single request byte is received only Burst Mode Control Codes 0 and 1 are valid.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Mode Control Code (see Common Table 9, Burst Mode Control Codes)
1	Unsigned-8	Burst Message

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Mode Control Code (see Common Table 9, Burst Mode Control Codes)
1	Unsigned-8	Burst Message

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	Error	In Write Protect Mode
8	Warning	Update Period Increased
9	Error	Insufficient bandwidth.
10-15		Undefined
16	Error	Access Restricted
17-31		Undefined
32	Error	Busy (Delayed Response could not be initiated)
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37-127		Undefined

7.77 Command 110 Read All Dynamic Variables (Not Recommended)

THIS COMMAND IS NOT RECOMMENDED FOR NEW DESIGNS.

Read up to four predefined Dynamic Variables. The Secondary, Tertiary, and Quaternary Variables are defined by each device type.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Enum	Primary Variable Units Code (refer to Common Tables Specification)
1-4	Float	Primary Variable
5	Enum	Secondary Variable Units Code (refer to Common Tables Specification)
6-9	Float	Secondary Variable
10	Enum	Tertiary Variable Units Code (refer to Common Tables Specification)
11-14	Float	Tertiary Variable
15	Enum	Quaternary Variable Units Code (refer to Common Tables Specification)
16-19	Float	Quaternary Variable

Note: Response Data Bytes are truncates after last variable supported by each device type.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 5		Undefined
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8	Warning	Update Failure
9-15		Undefined
16	Error	Access Restricted
17- 27		Undefined

7.78 Command 111 Transfer Service Control

See *Block Transfer Specification*

7.79 Command 112 Transfer Service

See *Block Transfer Specification*

7.80 Command 113 Catch Device Variable

This is a Device Variable Command.

This command instructs a Field Device to listen to command responses from another Slave device. Data from the specified device and command is captured and mapped to a local Device Variable. This allows data from a specific Slave to be used as an input to calculations being performed in another device.

The Master supplies the receiving Slave device with the source Slave address, the command number and the slot number of the variable to read. When a response is observed, matching the specified address and command number, the value captured is stored into the specified Device Variable and used for internal calculations. Table 1 shows the Slot Code assignments for command 1, 2, 3, and 33 responses.

Table 7 Slot Code Mappings for Common Burst Commands

	Command				
Slot	**1**	**2**	**3**	**9**	**33**
1	PV	Loop mA	PV	Slot 1	Slot 1
2		Pct Range	SV	Slot 2	Slot 2
3			TV	Slot 3	Slot 3
4			QV	Slot 4	Slot 4
5				Slot 5	
6				Slot 6	
7				Slot 7	
8				Slot 8	

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Destination Device Variable (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Capture Mode Code (see Common Table, 23 Capture Mode Codes).
2-3	Unsigned-16	Source Slave Expanded Device Type Code (Slave Address **Byte** 0-1)
4-6	Unsigned-24	Source Slave Device ID (Slave Address **Byte** 2-4)
7	Unsigned-8	Source Command Number
8	Unsigned-8	Source Slot Number
9-12	Float	Shed Time (in Seconds) for this mapping.

Note 1: The Source Slave Device ID may be set to all 0x00's to indicate any Field Device matching the Manufacturer ID and Device Type is to act as the data source.

Note 2: Source Slave Address must be ignored if the Capture Mode Code is set to "2" (Catch data from BACK message)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Destination Device Variable
1	Enum	Capture Mode Code
2-6	Unsigned-40	Source Slave Address
7	Unsigned-8	Source Command Number
8	Unsigned-8	Source Slot Number
9-12	Float	Shed Time (in Seconds) for this mapping.

Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device Specific Command Error
7-9		Undefined
10	Error	Invalid Capture Mode Code
11	Error	Invalid Slot Number
12	Error	Command Number Not Supported
13-15		Undefined
16	Error	Access Restricted
17	Error	Invalid Device Variable Index. The Device Variable does not exist in this Field Device.
18		Undefined
19	Error	Device Variable index not allowed for this command.
20-31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.81 Command 114 Read Caught Device Variable

This is a Device Variable Command.

This command reads the current Catch Device Variable settings for a Device Variable.

If this Device Variable is not being caught from the HART network, then the Capture Mode Code must return 0x00 ("Normal Device Variable Operation"). The other data items must return the last value written by the Host.

The Source Slave Address, Source Command Number, Source Slot Number default to zero if never written by the Master. The Shed Time defaults to 0x7F, 0xA0, 0x00, 0x00 if never written by a Master.

Request Data Bytes

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

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Destination Device Variable (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Capture Mode Code (see Common Table, 23 Capture Mode Codes).
2-6	Unsigned-40	Source Slave Address
7	Unsigned-8	Source Command Number
8	Unsigned-8	Source Slot Number
9-12	Float	Shed Time (in Seconds) for this mapping.

Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device Specific Command Error
7-16		Undefined
17	Error	Invalid Device Variable Index. The Device Variable does not exist in this Field Device.
18		Undefined
19	Error	Device Variable index not allowed for this command.
20-31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.82 Command 115 Read Event Notification Summary

This command reads the configuration of the Event Notification. This command can be truncated after the last byte in the Event Mask. The Event Mask is the indicates which bits in the Device Status Byte (Configuration Changed must be always reported) and the device's Command 48 response will trigger a notification (see Subsection 6.10).

Note: The response is truncated after the last byte that is supported in Command 48

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Event number (i.e. the index of the Event to read)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Event number
1	Unsigned-8	Number of events supported. For most devices this is one. I/O Systems and WirelessHART Adapters (*WirelessHART Device Specification*) support (generally) one per sub-device.
2.7-2.4	Bits-4	(Most Significant 4 Bits) Event Status (see Common Table 36. Event Status Codes)
2.3-2.0	Enum	(Least Significant 4 bits) Event Notification Control Code (see Common Table 35. Event Notification Control Code)
3 - 6	Time	Time when first unacknowledged event was triggered (must be set to 0xFFFFFFFF when no events are pending)
7 - 10	Time	Event Notification Retry Time
11 - 14	Time	Maximum Update Time
15 - 18	Time	Event De-bounce Interval
19 - 44	Bits	Event Mask. The concatenation of the mask for triggering on bits set in Device Status and Command 48 Response

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 - 127		Undefined

7.83 Command 116 Write Event Notification Bit Mask

This command sets the Event Mask that is used to trigger an Event Notification (see Subsection 6.10). For each bit set in the Event Mask, any change in the corresponding Device Status or Command 48 Response bit's value triggers an event notification. The command is truncatable and the bits in any of the device's Command 48 response bytes that are truncated shall assume a bit mask value of zero. In other words, any byte not included shall not trigger an event notification. Furthermore, the truncated bytes shall not be included in the notification generated using the Command 119 response.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Event number
1 - 27	Bits	Event Mask. The concatenation of the mask for triggering on bits set in Device Status and Command 48 Response

Note: The request is truncated after the last byte that containing a trigger-able event

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Event number
1 - 27	Bits	Event Mask

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	Error	In Write-protect Mode
8-15		Undefined
16	Error	Access Restricted
17-127		Undefined

7.84 Command 117 Write Event Notification Timing

This command requires implementation of Burst Mode.

This set the timing parameters for event notification. This includes the notification retry period, the maximum update period and De-bounce Interval associated with the event.

The retry and maximum update periods shall be selected as specified in Subsection 6.9.2. Field devices must correct settings differing from these values and indicate "Set to Nearest Value" in its response message. The retry period must be less then or equal to the maximum update period.

The Event De-bounce Interval sets the minimum time period over which the bit must remain changed (i.e., the time the event must persist) in a device before the Event Notification is sent.

If the Update Periods or De-bounce Interval do not conform to the allowed values the device will set adjust them accordingly and return the corrected values along with the Response Code 8 - "Update Period or De-bounce Interval Adjusted".

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Event number
1 - 4	Time	Event Notification Retry Time
5 - 8	Time	Maximum Update Time
9 - 12	Time	Event De-bounce Interval

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Event number
1 - 4	Time	Event Notification Retry Time
5 - 8	Time	Maximum Update Time
9 - 12	Time	Event De-bounce Interval

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8	Warning	Update Period or De-bounce Interval Adjusted
9	Error	Invalid Burst Message
10-15		Undefined
16	Error	Access Restricted
17-31		Undefined
32	Error	Busy (Delayed Response could not be initiated)
33	Error	DR Initiate
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37-127		Undefined

7.85 Command 118 Event Notification Control

This command is used to enable or disable Event Notification on the device's Token-Passing or TDMA Data-Link (see Common Table 35. Event Notification Control Code).

Note: If a WirelessHART field device joins the network and is denied the required capacity it will set the bit "Capacity Denied" in the Standardized Status (see Command 48 and Common Table 32). Capacity Denied can be the result of Burst Message or Event capacity demands.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Event number
1	Unsigned-8	Even Notification Control Code (see Common Table 35)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Event number
1	Unsigned-8	Event Notification Control 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	Error	In Write Protect Mode
8	Warning	Update Times adjusted
9-13		Undefined
14	Warning	Update Rate uncertain - only allowed when not connected to the network.
15		Undefined
16	Error	Access Restricted
32	Error	Busy (Delayed Response could not be initiated)
33	Error	DR Initiated - only allowed when enabling events in a device connected to a WirelessHART Network.
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37-127		Undefined

7.86 Command 119 Acknowledge Event Notification

This command is used to acknowledge the Event Notification (see Subsection 6.10). The host will send the data received with an Event Notification. If the Configuration Change Counter, the Device Status, Command 48 data and timestamp match the current values, the device will Respond with "Success" and reset the Event Status bits (see Common Table 36 Event Status Codes) accordingly. Since there may be multiple time-stamped bit transitions the command may only clear the oldest one. In that case, Response Code 8 " Not All Events Cleared" must be returned.

Note: This is a write command but must not be affected by any write protect mechanism. It is essential that Even Notifications can be cleared at any time.

The command is truncated after the last byte received when setting the Event Mask (see Command 116). If any bytes beyond those provided in Command 116 are received the command request they are ignored and not returned in the command response.

This command may be issued with only the event number in the request data. When this occurs, the device returns the current latched event data (Time, Configuration Changed Counter, Device Status and Command 48 data).

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Event number
1 - 4	Time	Time when first unacknowledged event was triggered (must be set to -1 when no events are pending)
5 - 6	Unsigned-16	Configuration Changed Counter
7	Bits	Device Status
8 -32	Bits or Enum only	Command 48 data

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Event number
1 - 4	Time	Time when first unacknowledged event was triggered (must be set to -1 when no events are pending)
5 - 6	Unsigned-16	Configuration Changed Counter
7	Bits	Device Status
8 -32	Bits or Enum only	Command 48 data (Note: Contains latched data and may not match current Command 48 response data)

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. This shall only be generated if the event number is not in the request data.
6	Error	Device-Specific Command Error
7		Undefined
8	Warning	Not All Events Cleared
9-15		Undefined
16-127		Undefined

7.87 Command 512 Read Country Code

This command is included to allow implementations to identify the country of (intended) installation locale. A HART compatible device may use this to tailor its operation for compliance with local regulations. This command reads the device's (intended) installation locale.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
1-2	Unsigned-8	Country Code. The two letter country code in accordance with ISO 3166
3	Enum-8	SI Units Only (See Common Table 54. SI Units Control Code)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-5		Undefined
6	Error	Device Specific Command Error
7-127		Undefined

7.88 Command 513 Write Country Code

This command is included to allow implementations to identify the country of (intended) installation locale. A HART compatible device may use this to tailor its operation for compliance with local regulations. This command writes the device's (intended) installation locale.

Request Data Bytes

Byte	Format	Description
1-2	Unsigned-8	Country Code. The two letter country code in accordance with ISO 3166
3	Enum-8	SI Units Restriction (See Common Table 54. SI Units Control Code)

Response Data Bytes

Byte	Format	Description
1-2	Unsigned-8	Country Code. The two letter country code in accordance with ISO 3166
3	Enum-8	SI Units Restriction (See Common Table 54. SI Units Control 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		Undefined
7	Error	In Write Protect Mode
8-15		Undefined
16	Error	Access Restricted
17-31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37-127		Undefined

ANNEX A. REVISION HISTORY

A1. Changes from 9.0 to 9.1

The changes in this revision include adding an addendum and reformatting the front page of the document to reflect the new HCF logo.

A2. Changes from 8.0 to 9.0

Significant additional functionality and commands were added in this version. Most of the enhancements were to support WirelessHART. In the process any functionality required that could also benefit wired installations were added in the Common Practice Specification. The net result is improved capability in the Protocol as a whole.

Additions include

- Improved Sub-device and I/O system support (Commands 77, 84-88, 101, 102)
- Real-Time Clock Support (Commands 89, 90)
- Trend Captures (Commands 91-93)
- Enhance Burst Mode and Publishing Capabilities (Commands 103, 104) Improvements to all other Burst Mode commands.
- Event Notification using, for example, the Burst Mode communication channel (Commands 115-119)
- Synchronizing the sampling performed by multiple devices (Commands 120, 121)
- Commands 38 and 48 are now Mandatory.

A3. Changes from Rev 7.1 to Rev 8.0

1. These new sections were added as part of the format revisions for all HART Protocol Specification documents: Scope, Reference, Definitions, Symbols/ Abbreviations, Data Format, Application of Common Practice Commands.
2. Added Recommended Use For HART Common Practice Commands section.
3. Added Common Practice Trim Commands 80, 81, 82, and 83.
4. Added Delayed Response Mechanism Commands 106.
5. The descriptions of Command 111 and 112 were moved to the *Block Transfer Specification.*
6. Added Command 113, Catch Device Variable.
7. Added Delayed Response Error Codes to Commands Number: 34-37, 39, 41, 43-47, 49, 51, 52, 53, 55, 56, 59, 64, 65, 67, 68, 69, 105, 107, 108.
8. Changed Command 41, Perform Self Test, to require use of DRM rather than busy.
9. Reformatted title page and all tables.
10. Changed "BEPROM" to "EEPROM" in Command 39.

11. Changed "units as receivei" to "units as received" in Command 35.
12. Changed "rounded dr" to "rounder or" in Command 40.
13. Replaced all occurrences of "units of mifliampres" with "units of milliamperes".
14. Changed "Slot *0, 3-bit" to "Slot 0, 8-bit" in Command 62.
15. Replaced all occurrences of "Slot *2" with "Slot 2" and "Slot *3" with "Slot 3".
16. Replaced "Table III" with "Table 3", "Table VI" with "Table 6", "Table X" with "Table 10", "Table XII" with "Table 12", "Table XIII" with "Table 13", and "Table XIV" with "Table 14" in all applicable commands.
17. Replaced "Primary Variable Analog Output" with either "Loop Current" or "Analog Channel' as was appropriate in Commands 40, 45, 46, 69 and 70. The universality of these substitutions merited change bars only appear when the command name was effected.
18. Replaced "Enter/Exit Fixed Variable Current Mode" with "Enter/Exit Fixed Current Mode" in Commands 40, 45, 46, 69 and 70. The universality of these substitutions merited change bars only appear when the command name was effected.
19. Replaced "transmitter" with "device" to demonstrate applicability of commands to many device types. The universality of this substitution merited change bars only appear when the command name was effected.
20. Added recommendation for number of preambles to Command 59 and the warning that this command only applies to HART FSK.
21. Fixed incorrectly scanned characters in Revision Notes.
22. "This is a Data Link Layer command" was added to the description of Command 59.
23. "This is a Primary Variable Range command" was added to the descriptions of Commands 35,36, and 37.
24. "This is a Loop Current command" was added to the descriptions of Commands 40, 45 and 46.
25. "This is a Device Management command" was added to the descriptions of Commands 38, 41, 42 and 48.
26. "This is a Process Variable Mapping command" was added to the descriptions of Commands 50 and 51.
27. "This is a Primary Variable command" was added to the descriptions of Commands 34, 43, 44 and 47.
28. "This is a Device Variable command" was added to the descriptions of Commands 33, 52, 53 54, 55, 56, and 79.
29. "This is an Analog Channel Support command" was added to the descriptions of Commands 60 and 62-70.
30. "This is a Device Variable command" was added to the descriptions of Commands 33, 52, 53 54, 55, 56, and 79.
31. Included Response Data Byte 21, Variable Classification, to Command 54 as part of Unit Codes expansion.

A4. Changes from Rev 7.0 to Rev 7.1

The document was translated from an ASCII text document to Microsoft Word. As a result of this translation the document format was altered. No changes were made to document content.

A5. Changes from Rev 6.0 to Rev 7.0

1. This revision adds commands for devices with Multiple Analog Outputs and Analog Outputs other than Current.
2. Added Changes Pending note to the beginning of the document and "CHANGES PENDING" to the Transfer Service Commands.
3. Summarized Release Notes from Rev 5 to Rev 6.0 - Final.

Page	Line	Change	Text
TP	4	Replace	"6.0 - Final" by "7.0 - Final"
TP	5	Replace	"8 February" by "3 May"
TP	6	Replace	"8 February" by "3 May"
1	7	Replace	"15 February" by "3 May"
1	7	Insert	"This command is capable of Burst Made…"
5	4	Insert	"Primary Variable"
5	7	Insert	"The damping applied to these outputs may be…"
5	19	Insert	"PV PV"
5	24	Insert	"Primary Variable"
5	24	Replace	"IEEE 754" by "IEEE 754"
5	32	Insert	"PV PV"
5	37	Insert	"Primary Variable"
6	2	Replace	"RANGE VALUES" by "PRIMARY VARIABLE RANGE VALUES"
6	4	Insert	"The Primary Variable Upper Range Value is…"
6	46	Delete	"RANGE UPPER UPPER UNITS RANGE RANGE VALUE…"
7	10	Replace	"Data Byte 5 - 8." by "Data Byte 5 - 8."
8	2	Insert	"PRIMARY VARIABLE"
8	2	Delete	"Push SPAN Button)"
8	5	Insert	"to the Primary Variable"
8	6	Insert	"Primary Variable"
8	7	Insert	"primary Variable"
8	7	Insert	"Primary Variable"
8	11	Insert	"Primary Variable"
8	12	Insert	"Primary Variable"
9	2	Insert	"PRIMARY VARIABLE"
9	2	Delete	"(Push ZERO Button)"
9	6	Insert	"to the Primary Variable"
9	7	Insert	"Primary Variable"
9	8	Insert	"Primary Variable"
9	9	Insert	"Primary Variable"
9	10	Insert	"Primary Variable"
9	11	Insert	"Primary Variable"
9	12	Insert	"Primary Variable"
9	_4	Insert	"Primary Variable"

Page	Line	Change	Text
9	15	Insert	"Primary Variable"
9	16	Insert	"Primary Variable"
9	17	Insert	"Primary Variable"
9	20	Insert	"Primary Variable"
9	21	Insert	"Primary Variable"
11	9	Replace	"checksum"' by "checkless"
13	2	Insert	"PRIMARY VARIABLE"
13	4	Insert	"Primary Variable"
13	5	Replace	"Analog Out put" by "Primary Variable Current"
13	8	Replace	"Level" by "A level"
13	9	Insert	"Primary Variable"
13	9	Insert	"Primary Variable"
13	15	Replace	"CURR CURR" by "PV PV CURR CURR LEVEL LEVEL"
13	21	Replace	"Output" by "Primary Variable"
13	30	Replace	"CURR CURR" by "PV PV CURR CURR LEVEL LEVEL"
13	36	Replace	"Output" by "Primary Variable"
17	4	Insert	"Primary Variable"
17	6	Insert	"Primary Variable"
17	6	Insert	"Primary Variable"
18	2	Insert	"PRIMARY VARIABLE CURRENT"
18	4	Replace	"4 milliampere point" by "Lower Endpoint"
18	4	Insert	"Primary Variable Analog output so that the…13
18	7	Replace	"so that the…" by "of a 4 to 20 (milliampere…"
18	12	Insert	"Primary Variable"
18	13	Replace	"4.0 milliamperes" by "the minimum value of…"
18	13	Insert	"Primary Variable"
18	17	Rep Lace	"4.0 milliamperes." by "the minimum value."
18	23	Rep Lace	"CURR CURR" by "p" PV CIRR CRIR LEVEL LEVEL"
18	31	Replace	"Output Current1 IEEE…" by "Primary Variable…"
18	38	Replace	"CURR CURR" by "PV PV CURR CURR LEVEL LEVEL"
18	43	Replace	"0utput Current, IEEE" by "Primary Variable"
20	2	Insert	"PRIMARY VARIABLE CURRENT
20	4	Replace	"20 milliampere point" by "Upper Endpoint"
20	4	Insert	"Primary Variable Analog Output so that the…"
20	7	Replace	"so that the…" by "0f a 4 to 20 milliampere…"
20	12	Insert	"Primary Variable"
20	13	Replace	"20.0 milliamperes" by "the maximum value of…"
20	13	Insert	"Primary Variable"
20	17	Replace	"20.0 milliamperes." by "the maximum value…"
20	25	Replace	"CURR CURR" by "PV PV CURR CURR LEVEL LEVEL"
20	31	Replace	"Output Current 1" by "Primary Variable Current…"
20	41	Replace	"CURR CURR" by "PV PV CURR CURR LEVEL LEVEL"
20	47	Replace	"Output Current," by "Primary Variable Current…"
22	2	Insert	"PRIMARY VARIABLE"
22	4	Replace	"output" by "Primary Variable Analog output"
22	10	Insert	"PV"
22	15	Insert	"Primary Variable"
22	25	Insert	"PV"
22	30	Insert	"Primary Variable"

Page	Line	Change	Text
23	5	Replace	"Code Bytes." by "Codes."
23	8	Insert	"Transmitter-Specific"
23	22	Replace	'#24" by "95"
23	23	Insert	"XMTR XMTR SPEC SPEC"
23	27	Replace	"#0 #24" by "#0 #5 #7 OPER OPER MODE MODE #…"
24	2	Replace	'#24 Additional…" by "#5 Transmitter-…"
24	7	Insert	"#24 Additional…" by "#5 Transmitter"
25	10	Insert	"PV PV".
25	_6	Insert	"Primary Variable"
25	23	Insert	"PV PV".
25	29	Insert	"Primary Variable"
31	10	Insert	"Code".
31	11	Insert	"Code"
32	5	Delete	"and"
32	5	Replace	"Value" by "Value, and Minimum Span".
33	13	Replace	"XMTR UPPER UPPER VAR…" by XMTR XMTR XMTR…"
33	50	Insert	"#17 #18 #19 #20 XMTR XMTR VAR VAR MIN MIN…"
34	10	Replace	"Limits" by "Limit/Minimum Span"
34	15	Delete	"Upper"
34	15	Insert	"Upper"
34	18	Delete	"Lower"
34	18	Insert	"Lower"
34	24	Insert	"Data Byte #17 - #20 Transmitter Variable
40	4	Replace	"Writes" by "writes"
42	4	Insert	'This is a Data Link Layer Management Command."
43	2	Insert	"COMMAND #60 READ ANALOG OUTPUT AND PERCENT OF…"
43	4	Insert	"Read the Analog output Level and Percent of…"
45	2	Insert	"COMMAND #61 READ DYMAMIC VARIABLES AND P. V."
45	4	Insert	"Read the Primary Variable Analog Output Level…"
45	13	Replace	"DATA BYTES #0 BURST…" by "NONE"
45	18	Insert	"#1 #2 #3 #4"
45	19	Replace	"BURST MODE SELECT…" by "PV PV PV ANALOG…"
46	37	Replace	"1 Undefined 2…" by "1 - 5 Undefined"
46	43	Replace	"7 In Write Protect Mode…" by "7 Undefined 8…"
46	46	Replace	"8" by "9"
47	2	Insert	"COMMAND #62 READ ANALOG OUTPUTS"
47	4	Insert	"Read selected Analog Output Levels. Each slot…"
52	2	Insert	"COMAND #63 READ ANALOG OUTPUT INFORMATION"
52	4	Insert	"Read the Alarm Selection Code, Transfer…"
55	2	Insert	"COMMAND #64 WRITE ANALOG OUTPUT ADDITIONAL
55	4	Insert	"Write the Additional Damping Value for the…"
57	2	Insert	"COMMAND #65 WRITE AMOG OUPUT RANGE VALUES"
57	4	Insert	"Write the Range Values for the selected…"
57	6	Move	"The Upper Range Value is independent of the…" from page 6 Line 4
57	8	Replace	"Primary" by "Dynamic or Transmitter"
57	24	Delete	"#1 #2 #3 #4"
57	25	Insert	"ANALOG OUTPUT NUMBER CODE #1 #2 #3 #4 #5 ANALOG…"
59	42	Replace	"17" by "29"

Page	Line	Change	Text
60	2	Insert	"COMMAND #66 ENTER/EX1T FIXED ANALOG OUTPUT MODE"
60	4	Insert	"The device is placed in the Fixed Analog…"
62	1	Insert	"COMMAND #67 TRIM ANALOG OUTPUT ZERO"
62	3	Insert	"Trim the Zero of the selected Analog Output…"
64	2	Insert	"COMMAND #68 TRIM ANALOG OUTPUT GAIN"
64	4	Insert	"'Trim the Gain of the selected Analog Output
66	2	Insert	"COMMAND #69 WRITE ANALOG OUTPUT TRANSFER…"
66	4	Insert	"Select the Transfer Function for the selected…"
72	2	Move	"CDMMAND #108 WRITE BURST MODE COMAND NUMBER" from page 41 line 2
72	2	Insert	"40."
72	4	Insert	"This is a Data Link Layer Management Command."
73	2	Move	"COMMAND #109 BURST MODE CONTR0L This command…" from page 42 line 2
73	2	Insert	"41."
73	5	Replace	"response message" by "Response Data Bytes"
73	9	Insert	"REQUEST DATA BYTES DATA BYTES #0 BURST MODE…"
74	2	Move	"COMMAND #110 READ ALL DYNAMIC VARIABLES Read…" from page 43 line 2
74	2	Insert	"42."
76	2	Move	"COMMAND #111 TRANSFER SERVICE CONTROL This is…" from page 45 line 2
76	4	Replace	"command" by "Command."
76	2	Insert	"43."
76	12	Insert	"#2…#31"
76	33	Insert	"OPT OPT"
76	34	Insert	"DATA DATA"
76	35	Insert	"BYTE BYTE"
76	36	Insert	"#0 #29"
76	46	Insert	"Data Byte #2 - #31 Optional Data as required…"
77	5	Replace	"transmission (Slave/…" by "Transmission"
77	6	Insert	"(Slave/Host) [See Note]"
77	11	Insert	"17 - 29 Undefined 30 Warning: End of…"
78	2	Move	"COMMAND #112 TRANSFER SERVICE This is a Data…" from page 46 line 2
78	2	Insert	"44"
78	4	Replace	"command." by "Command."
70	13	Replace	"transmission (Slave/…" by "Transmission"
79	15	Replace	"2 Control frame pending by "(Slave to Master)…"
79	22	Insert	"17 - 29 Undefined 30 Warning: End of Transmission…"

A6. Major Modifications from Rev. 5 to Rev. 6.0 - Final

1. A decimal point and integer was added to the HART document number.
2. This revision adds Burst Mode and Unit Device commands.
3. This revision also adds a command to write the Device Identification Number for Extended Frame Format and a command to select the Number of Response Preamble
4. Added Command #57, Read Unit Tag, Descriptor, Date.
5. Added Command #58, Write Unit Tag, Descriptor, Date.
6. Added Command #59, Write Number of Response Preamble
7. Added Command #108, Write Burst Mode Command Number.
8. Added Command #109, Burst Mode Control
9. Added Command #110, Read All Dynamic Variables.
10. Added Command #111, Transfer Service Control.
11. Added Command #112, Transfer Service.
12. Increased the maximum Command-Specific Response Code number from 15 to 127 for all commands
13. Moved Transmitter Fault from Command Error Summary Bit #4 to Command-Specific Response Code #16 and renamed it Access Restricted.
14. Changed Command-Specific Response Code #5 from Invalid Byte Count to Too Few Data Bytes Received and removed it from commands with no Request Data Bytes.
15. Changed most occurrences of "transmitter" to "device". (Refer to document Revision 6, D8900072, for detailed information).

A7. Major Modifications from Rev. 4 to Rev. 5

1. This Revision incorporates Write Protect Mode and adds Transmitter Variable Commands
2. Added Command 50, Read Dynamic Variable Assignments.
3. Added Command #51, Write Dynamic Variable Assignments.
4. Added Command #5l, Set Transmitter Variable Zero.
5. Added Command #53, Write Transmitter Variable Units.
6. Added Command #54, Read Transmitter Variable Damping Value.
7. Added Command #55, Write Transmitter Variable Damping Value.
8. Added Command #56, Write Transmitter Variable Sensor Serial Number.

A8. Major Modifications from Initial Rev. 3 to Rev. 4

1. This revision adds Update in Progress to Command #48 and adds a command to write the Transducer Serial Number.