STANDARD

Common Practice Command Specification

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Attention: Foundation Director
HART Communication Foundation
9390 Research Boulevard
Suite I-350
Austin, TX 78759, USA

Voice: (512) 794-0369
FAX: (512) 794-3904

http://www.hartcomm.org

Use of imperatives in HART Specifications
The key words (imperatives) "must", "required", "shall", "should", "recommended", "may", and "optional" when used in this document are to be interpreted as follows:

Must	**Must**, **Shall**, or **Required** denotes an absolute mandatory requirement. For example, "All HART Field Devices must implement all Universal Commands"
Should	**Should** or **Recommended** indicates a requirement that, given good cause/reason, can be ignored. However, the consequences of ignoring the requirement must be fully understood and well justified before doing so.
May	**May** or **Optional** identifies a requirement that is completely optional and can be supported at the discretion of the implementation. May can be used to identify optional Host Application or Master functionality and, when this is the case, does not imply the function is optional in Field Devices.

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Preface

This preface is included for informational purposes only.

The popularity of the HART Protocol continues to grow along with demand for new capabilities and further standardization. To meet these requirements the Common Practice Command Specification has been enhanced with 18 new commands and several clarifications have been made. This document contains the following additions and enhancements to the Common Practice Command set:

- To provide standardized support for NAMUR NE107 Condensed Status, Commands 523-525 have been added. These commands allow one or more Field Device Status bits or bits in the Command 48 response to be mapped to and drive one of four Condensed Status bits (Failure; Out of Specification; Function Check; or Maintenance Required).
- To facilitate the pre-configuration of I/O Systems, Sub-device Assignment Commands (Commands 528-531) have been added to the Specification.
- Since I/O Systems may be connected to and communicate with several Host Applications commands were added to Event Notification to simplify the management of Event Notifications by I/O Systems. The new commands (Commands 514 and 515) allow a single Host Application to be designated the "Event Manager" responsible for acknowledging Field Device events.
- One of HCF's long-time goals is for systems to use HART communication full-time/continuously. Consequently, digital values are becoming more used. To facilitate systems test, Commands 526 and 527 were added to allow status to be simulated. Simulation of digital process values uses Command 79 (introduced in 2001).
- With the growing number of wired and wireless HART-enabled Field Devices in plants it becomes increasingly important to be able to easily identify the location of the device. This revision of the Common Practice Command Specification adds Commands 516-521 allowing the location of the device being communicated with to be queried.
- Unit code expansion was introduced in 2001 and that expansion is sufficient for most applications, except flow meters. This revision adds Command 522 allowing the classification of a volumetric flow Device Variable to be modified. This adds eight Unit Code Expansion Tables to the Common Tables Specification. Four for liquid flow and four for gas flow. Each table is for either per second, minute, hour, day flow units.
- Historically the Primary Variable (PV) Alarm Code has been the only PV attribute without a standardized Common Practice Command. This omission has been corrected with the addition of Command 100.

Introduction

This preface is included for informational purposes only.

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-13

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

2.3 Related Documents

The following are applicable NAMUR documents:

NAMUR. *Self-Monitoring and Diagnosis of Field Devices*. NE 107

Wikipedia, International System of Units, http://en.wikipedia.org/wiki/International_System_of_Units

Wikipedia, NMEA 0183, http://en.wikipedia.org/wiki/NMEA_0183

Wikipedia, World Geodetic System, http://en.wikipedia.org/wiki/World_Geodetic_System

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 **Ac****q**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-*nn*	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-*nn*	An enumerated value where nn indicates the number of bits in this integer. Only values specified in the *Common Tables Specification* may be used.
Date	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	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

The HART Common Practice Commands enhances interoperability by providing additional standardized, device-independent commands. This subsection logically groups Common Practice Commands and specifies the operation and Standard Operating Procedures (SOPs) for those commands.

While these commands are optional, Host Applications can determine Common Practice Command support by dispatching the commands[1] with no data bytes. The Field Device does not support commands that respond with "Command Not Implemented".

Using exploratory techniques like this many other device capabilities can be determined as well. For example, using Command 54 the entire list of Device Variables supported by the device can be determined.

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

[1] Some commands (e.g., Commands 36, 37, etc.) should not be polled in this fashion as they can adversely affect device operation. Host Application vendors must evaluate all commands for potential negative side affects before polling them to determine Field Device support.

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:
- 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.
- 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[2]:

- Command 41 Perform Self Test
- Command 42 Perform Device Reset
- 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
- Command 512 Read Country Code
- Command 513 Write Country Code

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 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.

[2] Universal Commands 38 and 48 are also Device Management Commands

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.

- Issue Command 81, Read Device Variable Trim Guidelines, to determine the number of applicable trim points and their acceptable limits.
- 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).
- Prompt the user to set the variable input to a value within acceptable limits for the trim point.
- Once set and stable, obtain the exact process variable value from either a calibrator or the user.
- Issue Command 82, Write Device Variable Trim Point. Inform user of any errors.
- 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.
- 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[3].

[3] 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 one or more Dynamic Variables (i.e., the Primary, Secondary, Tertiary, and Quaternary Variables[4]). 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).

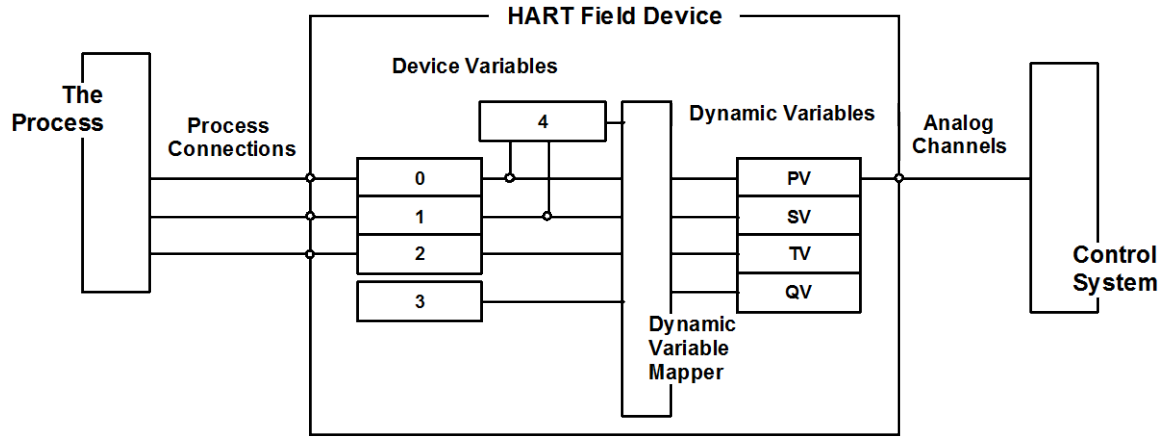

Figure 1 Device Variables and Dynamic Variables

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
- Command 100 Write Primary Variable Alarm Code

[4] These are returned in Universal Command 3, which can be truncated after PV.

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:

- Device Families and engineering units codes are based on information returned by Command 54, Read Device Variable Information.
- Many Masters prefer to use Command 33[5], Read Device Variables, to avoid tracking the Dynamic Variable map (see Command 51).
- 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[6]
- 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 Message 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 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;

[5] Command 9 returns Device Variable Status and Classification. As a result, Host Applications supporting HART 6 or later should use Command 9 whenever possible.

[6] Command 54 must be implemented if Burst Mode is supported

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

- Command 101 Read Sub-device to Burst Message; and
- 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 acquisition 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 a device is configured for burst mode operation (number of burst message active, trigger settings, etc.) the configuration must be retained across power cycles and resets.

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 by a host application or control system. Field devices must correct settings differing from those indicated in Table 1 and indicate "Update Times Adjusted" in its response message.

Table 1. Update Periods[7] 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**

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 recommended 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	0.100s	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[8] (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 Update Periods lapse[9].

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 6.12.2 for more information.

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

[8] For example, if Burst Message 0 is the only Burst Message configure and specified for an update period of 32 seconds it will be published much faster then that on a Token-Passing network. On an FSK-based network the Burst Message may be transmitted 2-3 times per second. If this is faster then the acquisition rate then and "Update Failure" warning Response Code will be returned as well.

[9] For example, Burst Message 1 and 2 could be set to update periods of 2 seconds and 16 seconds respectively. Consequently, Burst Message 1 would be burst most of the time (to meet the Token-Passing Data-Link Layer requirements) with Burst Message 2 being transmitted less often. Depending on the exact timing Burst Message 2 could be aggregated with Burst Message 1 (using Command 78).

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.

The HART Protocol offers two distinct methods to display events: the Field Device Status and the response to Command 48[10].

Event Notification publishes changes in the device's status, independently from data publishing supported in other Burst Mode commands. For Event Specifications, the status included in the Field Device Status byte and the Command 48 response 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 must be transmitted aggregated with Burst Messages when appropriate (e.g., on WirelessHART networks).

The following commands must be implemented if Event Notification is supported:

- 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. 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 for that Event Specification) must be supported[11]. It is highly recommended that 5 transitions be buffered. If more events are detected then can be buffered then the "Event Notification Overflow" bit must be set (see Common Table 30) until all pending event have been acknowledged. Events detected after the event queue for a given Event Specification is full are lost.

Implementation of Status Simulation (see Subsection 6.16) is essential to enable end-end system testing of Host Application response to Event Notification. In other words, the following commands should be implemented if Event Notification is supported:

- Command 526 Write Status Simulation Mode
- Command 527 Simulate Status Bit

[10] All critical status, even those driving Device Family and Device Variable status (e.g., Device Variable fixed), should be reflected in the Command 48 response.

[11] In other words, there must be an event history queue at least three deep for each supported Event Specification.

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[12] using Command 118, Event Notification Control, which also selects the interface the Event Notification should be used on[13].

The Event Notification can be disabled by setting the Event Notification Control Code to 0 (Off)[14].

6.10.2 Handling of Event Notification in a Device

The first occurrence of the event for each Event Specification 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 request 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).

Command 116 is used to specify the bits that may trigger the Event Notification. Command 119 must only return the status bytes 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 currently latched Field Device Status and Command 48 response regardless of which bits are masked[15]. The Time Stamp remains the same until an Acknowledge is 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.

[12] On Token-Passing Networks (only), burst mode must be active for event notifications to be enabled.
[13] Events acknowledgement must be successful only on the interface specified in Command 118.
[14] Events latched when notification is disabled must be retained. No new events are captured once Event Notification is disabled.
[15] If no event is latched the current Configuration Changed Counter, Field Device Status and Command 48 response data must be returned.

6.10.3 Handling Event Notifications in I/O Systems

Event notifications push exceptions toward the plant's Host Applications. An intermediate stop may be an I/O system (see Subsection 6.12). In turn the I/O system maybe a server providing process data and event notifications to multiple clients. The following commands are provided to allow the final Host Application to control and acknowledge event notifications.

- Command 514 Register Event Manager allows a client to register as the Event Manager; and
- Command 515 Read Event Manager Registration Status indicates whether an Event Manager is currently registered with the I/O System.

Since the event notifications are being received by the I/O System and may be forwarded to multiple clients[16] one of the clients should be designated as the "Event Manager". Only one Event Manager is allowed[17]. The Event Manager is responsible for issuing Command 119 to acknowledge the event[18]. Once an Event Manager is registered

- Any client can read currently pending events;
- Only the Event Manager is allowed to acknowledge an event; and
- The I/O System must answer attempts to acknowledge events by clients other than the Event Manager with "Access Restricted"

[16] An I/O System (Server) should cache Command 119 response data from all connected sub-devices for access by its connected Clients.

[17] If there is no event manager is ever registered using Command 514 then any/all clients can acknowledge clear events in the connected sub-devices.

[18] Any client may read (i.e., not acknowledge) the currently pending event at any time (whether an Event Manager is registered or not) by issuing Command 119 with only the event number in the request data.

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.

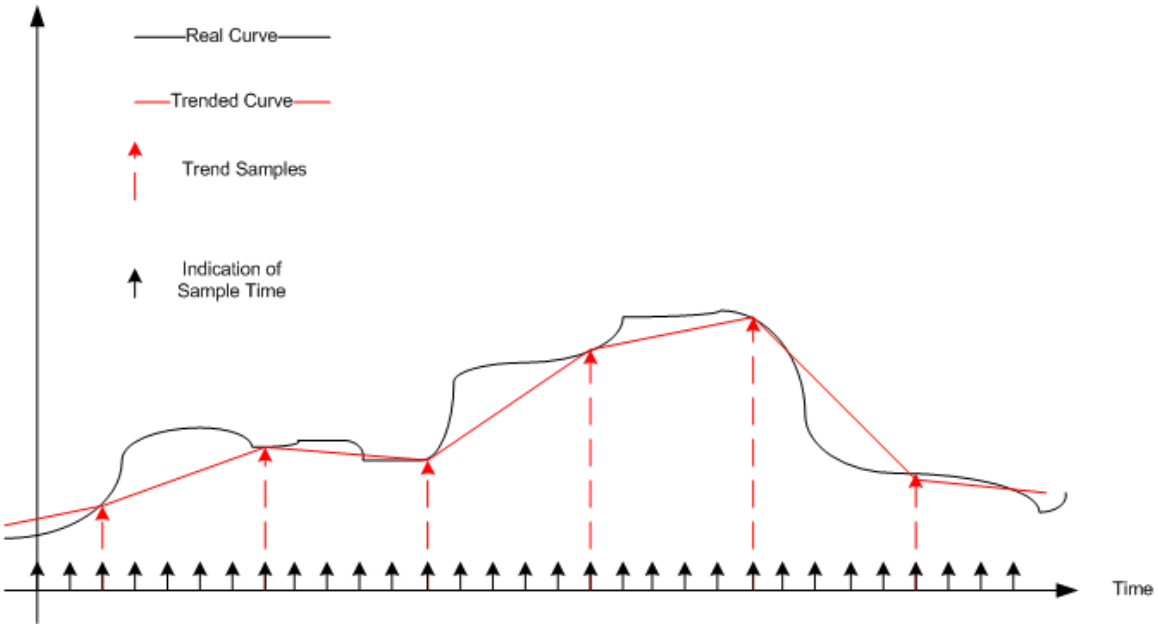

Figure 2: Trending of Process Value

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 acquisition 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 Trend Sample Period .

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 Trend Sample Period. A filtered trend uses a time constant equal to one-third the Trend Sample Period to smooth the data[19]. For the actual behavior of the device, see the device specific documentation. The Trend Sample Period 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 Trend Sample Period) 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 Trend Sample Period is always transmitted.

6.11.5 Burst Mode and Trend

The command Read Trend is a new addition to the possible burst mode commands[20]. 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 Trend Sample Period. Afterwards burst mode is configured to update with 12 times the Trend Sample Period and Read Trend is configured as the burst command. Thus with every burst all values in the trend are transferred. If an overlap is desired, the burst update time can be set to 11 or 10 times the Trend Sample Period.

Trends allow the maximum Trend Sample Period 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 the Burst Update Period is less than 12 times the Trend Sample Period, some previously transmitted trend data will be included in each publication of the Burst Message. The receiving application must ensure that duplicates are filtered out correctly.

[19] Consider a step change in the Device Variable value, this averaging time constant allows the returned Trend Value to reach 95% of the step change in one Trend Sample Period.

[20] When Command 93 is configured to be burst Trend[0] (i.e., the first trend) shall be published by the device.

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; and
- Command 84 Read Sub-Device Identity Summary

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[21], 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.

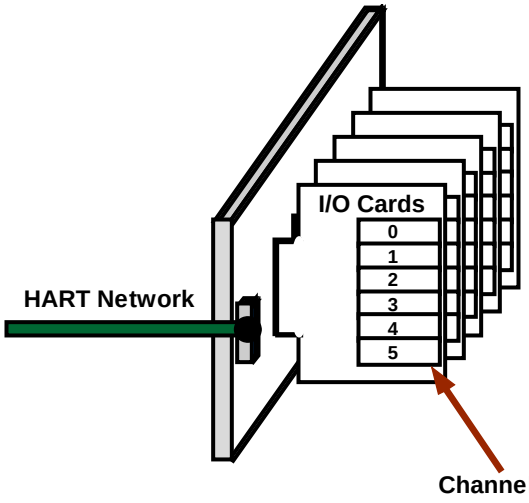

Figure 3. Bridge or I/O System Components

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.

[21] Support for Command 75 is recommended in WirelessHART Gateways (i.e., it is not mandatory in Gateways)

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 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.

In addition, Command 84 must also be supported

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 length of the list is returned in Command 74 and "Number of devices detected " includes the I/O system itself (i.e., the number of devices is always at least 1). The list is as long as there are devices and the list includes the I/O system itself (in index 0). If a device is disconnected or added, the list grows or shrinks as needed.

Any change to this list shall cause the "Sub-Device List Changed" bit to be set in the Command 48 response. An I/O System must contain a "Sub-Device List Changed" bit for both the primary and the secondary Master (plus the Gateway if supporting WirelessHART). All bits are set when Sub-Device list changes[22]. Individual bits are reset upon receiving either Command 74; or Command 84 with a "Sub-device Index" of 0 or 1 only. In other words both Command 74 or Command 84 (index 0 and 1) must reset the appropriate "Sub-Device List Changed" bit.

6.12.2 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 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 is 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.

[22] When "Sub-Device List Changed" bit is set, Host Applications must issue Command 74 to determine the number of Sub-devices followed by multiple Command 84 requests to determine the changes in the Live List. The entire list must be read if the "Sub-Device List Changed" bit becomes set during the read of the Live List (i.e, the Live List can change dynamically).

6.12.3 Non-volatile Sub-Device Assignment

Simple I/O systems retain no knowledge of plant topology and must re-learn which devices are connected after each power loss or Device Reset. More sophisticated I/O systems incorporate a non-volatile Sub-Device Assignment list. Consequently, these I/O systems will contain two lists of Sub-Devices: The Assignment List (representing the expected plant topology); and the Live List (representing the as-found Topology). The commands in this subsection include:

- Command 528 Read Sub-Device Assignment List Information;
- Command 529 Read Sub-Device Assignment;
- Command 530 Write Sub-Device Assignment; and
- Command 531 Transfer Live List to Assignment List

These commands standardize the creation and maintenance of the Assignment list.

I/O Systems are structured as one or more Cards, where each Card can be associated to one or more Channels. This reflects either the physical or logical I/O System topology. In addition, Card and Channels are the Sub-Device addressing mechanism used in (for example) Command 77. The "Live" list of Sub-devices currently connected to the I/O System is read using Command 84.

Sub-Device Assignment allows the topology for an I/O system to be specified and retained across power cycles and Device Reset. This allows (for example) the I/O system to be preconfigured at the factory or the known-good topology to be saved (i.e., which device must be on which card and channel). Upon power-up the I/O System must identify all connected Sub-Devices and place them in the topology as specified in the Assignment List. This is repeated until all connected Sub-Devices have been processed.

The I/O System must set the "Sub-Device Mismatch" (See Common Table 31) status bit in the I/O System Command 48 response if any of the following occur:

- The Sub-Device are not connected to the specified Card and Channel;
- The number of Sub-Devices found is different than the number of Sub-Devices assigned; or
- Any other discrepancies between the Assignment List and the Live List.

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 RTC 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 Requested 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[23]. 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.

[23] Some devices (e.g., wireless) do not support any Analog Channels (or Loop Current)

6.15 Condensed Status Commands

Implementation of all commands in this section is recommended. Implementation of at least Command 523, Command 526 and Command 527, enables compliance with NAMUR NE107.

Field Devices can convey status information to Host Applications in several ways (e.g., Device Variable Status, and via loop current signaling). The status supplied in the Command 48 response provides the most comprehensive summary of Field Device status and health. The Condensed Status Commands in this subsection allow the status bits returned by the Field Device in the Field Device Status Byte and the Command 48 response[24] to be mapped to (and thus summarized by) the Condensed Status bits in the Extended Field Device Status Byte (See Common Table 17). The 4 Condensed Status bits (in priority order) are:

Table 4. NAMUR NE107-compatible Condensed Status

NAMUR Symbol	Name	Description
F	**Failure**	The Field Device has malfunctioned such that one or more Device Variable values (i.e., measurement or control) are invalid or inaccurate.
C	**Function Check**	The Field Device is being serviced and one or more Device Variable values may be (temporarily) frozen or invalid.
S	**Out of Specification**	One or more Device Variable values may have been compromised due to past or present ambient/operating conditions deviating from device requirements.
M	**Maintenance Required**	To ensure continued proper operation maintenance must be performed on the Field Device.

These Condensed Status bits are mutually exclusive (i.e., a maximum of 1 of the 4 bits shall be set at any time). The priority of the Condensed Status bits (from highest to lowest) is Failure, Function Check, Out of Specification, and Maintenance Required. Only the single highest priority of the Condensed Status bit shall be set at any given time and all Condensed Status bits shall be reset when the device is operating normally and within specification.

Extended Device Status is returned in Command 0, 9, 48, 78 and 119 responses. Consequently, identifying the Field Device, monitoring status, or accessing process data also provides Host Applications with updated Condensed Status. More specifically, Hosts Applications receive updated Condensed Status values when:

- Using Command 0 to confirm the device is still present on the network;
- Polling[25] Command 48 or when it is published by the Field Device;
- Accessing process data via Command 9; or
- The Field Device publishes (bursts) an Event Notification.

One or more Field Device Status bits or bits in the Command 48 response drive a given Condensed Status bit[26]. In other words, Field Devices supporting Condensed Status must contain a Condensed Status Mapping Array that must contain one Status Map for each bit in the Field Device Status and each bit in the Command 48 response. The Status Map is an enumeration (see Common Table 70 Condensed Status Mapping Code) that specifies the Condensed Status bit (if any) affected by the corresponding status bit.

[24] All critical status, even those driving Device Family and Device Variable status (e.g., Device Variable fixed), should be reflected in the Command 48 response.

[25] Any change in Condensed Status must set the More Status Available bit in Field Device Status.

[26] When multiple status bits are mapped to a single Condensed Status bit the value of the Condensed Status bit is determined by OR'ing the corresponding status bits together.

The Status Maps in the Condensed Status Mapping Array[27] are each uniquely associated with a status bit starting with the least significant bit of the Field Device Status followed by each bit returned in the Command 48 response. Table 5 specifies the assignment of Condensed Status Mapping Array entries to Field Device Status bits and bits in the Command 48 response.

Field Devices supporting Condensed Status must support Command 523 Read Condensed Status Mapping Array. The Status Map values in the Condensed Status Mapping Array must be preset from the Field Device manufacturer's factory. If this is the only Condensed Status Command supported then mapping must remain fixed for the life of the Field Device.

In addition Field Devices supporting Condensed Status must also support Status Simulation (see Subsection 6.16) and, consequently, the following commands:

- Command 526 Write Status Simulation Mode
- Command 527 Simulate Status Bit

Table 5. Indexes for Status Bits Found in Field Devices

			Assignment of Index to Status Bit							
		Description	**0x01**	**0x02**	**0x04**	**0x08**	**0x10**	**0x20**	**0x40**	**0x80**
		Field Device Status	0	1	2	3	4	5	6	7
Command 48 Response Bytes	0	Device-Specific Status (bytes 0-5 of the Command 48 response)	8	9	10	11	12	13	14	15
	1		16	17	18	19	20	21	22	23
	2		24	25	26	27	28	29	30	31
	3		32	33	34	35	36	37	38	39
	4		40	41	42	43	44	45	46	47
	5		48	49	50	51	52	53	54	55
	6	Extended Field Device Status (see Common Table 17)	56	57	58	59	60	61	62	63
	7	Device Operating Mode (see Common Table 14)	64	65	66	67	68	69	70	71
	8	Standardized Status 0 (see Common Table 29)	72	73	74	75	76	77	78	79
	9	Standardized Status 1 (see Common Table 30)	80	81	82	83	84	85	86	87
	10	Analog Channel Saturated (see Common Table 27)	88	89	90	91	92	93	94	95
	11	Standardized Status 2 (see Common Table 31)	96	97	98	99	100	101	102	103
	12	Standardized Status 3 (see Common Table 32)	104	105	106	107	108	109	110	111
	13	Analog Channel Fixed (see Common Table 28)	112	113	114	115	116	117	118	119
	14	Device-Specific Status (bytes 14-24 of the Command 48 response[28])	120	121	122	123	124	125	126	127
	15		128	129	130	131	132	133	134	135
	16		136	137	138	139	140	141	142	143
	17		144	145	146	147	148	149	150	151
	18		152	153	154	155	156	157	158	159
	19		160	161	162	163	164	165	166	167
	20		168	169	170	171	172	173	174	175
	21		176	177	178	179	180	181	182	183
	22		184	185	186	187	188	189	190	191
	23		192	193	194	195	196	197	198	199
	24		200	201	202	203	204	205	206	207

[27] The length of the Condensed Status Mapping Array can be determined by reading (Universal) Command 48. The array is exactly 8 entries longer than the number of bits returned in the Command 48 response.
[28] Command 48 is truncatable and, consequently, Command 48 may not return one or more of these bytes.

To allow tailoring of the maps to meet user/application requirements, Common Practice Commands are provided to configure the mapping of Field Device Status bits and Command 48 Status bits to Condensed Status. Field Devices that allow user configuration of Condensed Status mapping must support the following commands:

- Command 524 Write Condensed Status Mapping
- Command 525 Reset Condensed Status Map

While Field Devices are not required to support Command 524 and 525, their implementation is strongly recommended. Plant operational requirements, strategies and applications for a Field Device vary wildly. It will be very difficult to impossible to predict in advance a fixed Condensed Status map that will work in all installations. While not a protocol requirement, lack of support for Commands 524 and 525 can be a serious competitive deficiency.

Communication Buffer size

The commands to read and write the Condensed Status Map are indexed commands that allow all or part of the Status Map array to be read. A Field Device may not have a communication buffer long enough to read or write the entire Status Map array in one transaction.

Communication buffer limitation (if a limitation exists) can be determined by issuing Command 523 with "Status Map Index" set to 0 and "Number of Entries to Read" set to the number of Status Maps supported by the Field Device. The maximum number of entries that can be transferred in a single transaction shall be indicated in the "Number of entries actually read" field of the Field Device response.

6.16 Status Simulation

Implementation of all commands in this section is recommended[29].

To allow testing of Host Application response to status changes commands are provided to force the values of status bits returned by the Field Device. These include:

- Command 526 Write Status Simulation Mode is used to enable or disable status simulation; and
- Command 527 Simulate Status Bit allows a Field Device Status bit or a bit in the Command 48 response to be set or reset.

Enabling the Status Simulation Mode allows a Field Device Status bit or a bit in the Command 48 response to be manipulated. Status simulation mode may be changed while the device is Write Protected or Locked. When Status Simulation Mode is switched from Disabled to Enabled:

- All device-initiated changes to Field Device Status and the Command 48 response data shall be disabled[30]; and
- The Status Simulation Active bit must be set (see Common Table 30).

While Status Simulation is enabled Field Device Status bit values and the Command 48 response values shall only be affected upon receipt of Command 527 from the Host Application[31]. Using Command 527 individual bits may be set or reset using the bits index (see Table 5). The device shall react normally to the setting and resetting of status bits including:

- Updating the value of the More Status Available bit;
- Setting/resetting Condensed Status bits;
- Device generated actions responding to status bits being set/reset; and
- Generating Event Notification(s).

All other diagnostic functions are unaffected such as:

- Analog signal alarms;
- Device Malfunction status bit in Device Status;
- Device Variable Status; and
- Device Family Status.

When Status Simulation is switched from Enabled to Disabled:

- The Status Simulation Active bit must be reset (see Common Table 30);
- Field Device Status and the Command 48 response data shall immediately be changed to the currently applicable values (i.e., any bit values forced using Command 527 shall be discarded); and
- Normal device-initiated updates to Field Device Status and the Command 48 response shall resume.

Status Simulation Mode is also exited when power is removed from the device or when a Device Reset is performed.

[29] The commands in this section are mandatory if Condensed Status is supported by the Field Device.
[30] Enabling Status Simulation Mode shall not affect the current values of Field Device Status bits or any value in the Command 48 response.
[31] Any attempt to enable Status Simulation while it is already enabled will have no affect (i.e., "No Command-Specific Errors" shall be returned).

7. COMMANDS

7.1 Command 33 Read Device Variables

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 6).

Table 6. 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

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	PV Damping Value (units of seconds)

Response Data Bytes

Byte	Format	Description
0 - 3	Float	Actual PV 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

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 affect 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	PV Upper and Lower Range Values Units Code (refer to Common Tables Specification)
1 - 4	Float	PV Upper Range Value
5 - 8	Float	PV Lower Range Value

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	PV Upper and Lower Range Values Units Code
1 - 4	Float	PV Upper Range Value
5 - 8	Float	PV 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

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

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

THIS COMMAND IS NOT RECOMMENDED FOR NEW DESIGNS.

This command causes data to be transferred from shadow RAM to nonvolatile memory[32] (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.

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

[32] 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.

7.8 Command 40 Enter/Exit Fixed Current Mode

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 or upon performing a Device Reset.

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

Request Data Bytes

Byte	Format	Description
0 - 3	Float	PV Fixed Current Level (units of milliamperes[33])

Response Data Bytes

Byte	Format	Description
0 - 3	Float	Actual PV Current Level

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

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

7.9 Command 41 Perform Self Test

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

The device must respond to this command immediately and within the Slave Time Out and then reset the device. 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

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.

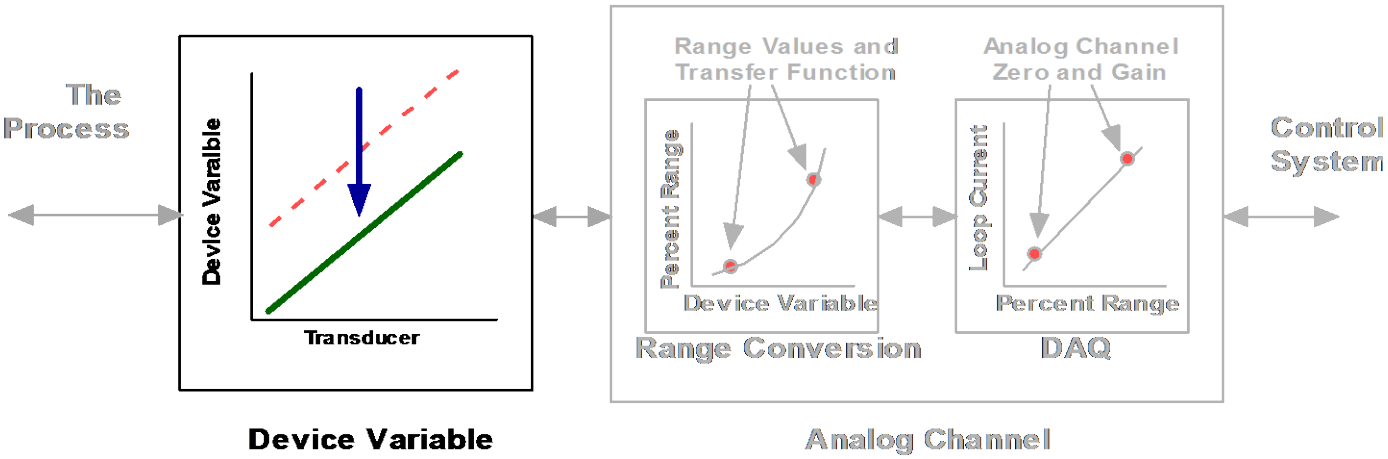

Figure 4 Effect of Set PV Zero Command

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

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	PV Units Code (refer to Common Tables Specification)

Response Data Bytes

Byte	Format	Description
0	Enum	PV 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

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.

Request Data Bytes

Byte	Format	Description
0 - 3	Float	Externally Measured PV Loop Current Level (units of milliamperes[34])

Response Data Bytes

Byte	Format	Description
0 - 3	Float	Actual Measured PV Loop Current 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	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

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

7.14 Command 46 Trim Loop Current Gain

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 PV Loop Current Level (units of milliamperes[35])

Response Data Bytes

Byte	Format	Description
0 - 3	Float	Actual Measured Loop PV 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

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

7.15 Command 47 Write Primary Variable Transfer Function

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	PV Transfer Function Code (see Common Table 3, Transfer Function Codes)

Response Data Bytes

Byte	Format	Description
0	Enum	PV 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

Writes the transducer serial number associated with the Primary Variable.

Request Data Bytes

Byte	Format	Description
0 - 2	Unsigned-24	PV Transducer Serial Number

Response Data Bytes

Byte	Format	Description
0 - 2	Unsigned-24	PV 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

Responds with the Device Variable Numbers that are assigned to the Primary, Secondary, Tertiary, and Quaternary Variables[36]. The Field Device must return all Response Data Bytes. Unsupported Dynamic Variables return "250" (Not Used) as the Device Variable assigned

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

[36] When a Field Device allows the Device Variable returned for a Dynamic Variable to be changed (i.e., mapped) then this command must be supported.

7.19 Command 51 Write Dynamic Variable Assignments

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. In this command Device Variable codes 244-249 are invalid selection (i.e. the device must return "Invalid Selection" Response Code).

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

Trim the selected Device Variable so that it reads zero with the existing process applied to the device[37]. The resulting offset must be within the limits assigned to each 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

[37] Depending on the device's configuration the Device Variable being zeroed may be the Primary Variable.

7.21 Command 53 Write Device Variable Units

Selects the units in which the selected Device Variable[38] will be returned.

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

[38] Depending on the device's configuration the Device Variable may be mapped to the Primary Variable and, consequently, the units for the Primary Variable would be changed.

7.22 Command 54 Read Device Variable Information

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 must 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 Acquisition 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[39]
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[40] (see Common Table 21, Device Variable Classification Codes)
22	Enum	Device Variable Family[41] (see Common Table 20, Device Variable Family Codes).
23-26	Time	Acquisition Period. The Acquisition Period indicates the maximum period between Device Variable updates[42].
27	Bits	Device Variable Properties (see Common Table 65 Device Variable Property Codes)

[39] 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.

[40] If the Device Variable Classification is not supported by this Device Variable then the Field Device must return "0" (Not Yet Implemented).

[41] 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*).

[42] Acquisition Period must return 0xFFFF FFFF if Device Variable is not calculated by the Field Device (i.e., the Device Variable is a setpoint or remote sensor 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

7.23 Command 55 Write Device Variable Damping Value

Writes the damping value controlling the response rate of the selected Device Variable[43]. 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 affected by other commands[44].

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	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.

[43] Command 64 may be used to provide additional damping directly on the analog channel signal itself.

[44] Depending on the device's configuration the Device Variable may be mapped to the Primary Variable (see Command 34)

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.

Writes the transducer serial number associated with a particular Device Variable[45].

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

[45] Depending on the device's configuration the Device Variable may be mapped to the Primary Variable.

7.25 Command 57 Read Unit Tag, Descriptor, Date

THIS COMMAND IS NOT RECOMMENDED FOR NEW DESIGNS. INSTEAD SEE Command 520 Read Process Unit Tag

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

THIS COMMAND IS NOT RECOMMENDED FOR NEW DESIGNS. INSTEAD SEE AND Command 521 Write Process Unit Tag

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

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[46].

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

[46] Field devices must answer all messages and meeting the requirements in the *Token-Passing Data Link Layer Specification* even if the Master Request contains more than 20 Preambles.

7.28 Command 60 Read Analog Channel And Percent Of Range

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[47] 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

[47] When the Device Variable value reaches the Upper (100%) or Lower (0%) Range Value the Analog Channel Level must correspond to the Upper or Lower Endpoint signal level respectively (see Command 70).

7.29 Command 61 Read Dynamic Variables And Primary Variable Analog Channel

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)
21-24	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

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

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

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

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

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 or upon performing a Device Reset.

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 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 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

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

Read the endpoint values for the selected Analog Channel. The Upper Endpoint Value corresponds to 100% range and Upper Range Value from Commands 63 and 65. Similarly the Lower Endpoint Value corresponds to 0% range and the Lower Range Value.

All Field Devices should be capable of operation across a wider range then just the Upper and Lower Endpoints (e.g., for signaling or detecting an alarm). The Upper and Lower Limits are the minimum and maximum values that the Analog Channel is capable of (i.e., where the signal saturates).

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
10 - 13	Float	Analog Channel Upper Limit Value
14 - 17	Float	Analog Channel Lower Limit 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 command temporarily locks a device preventing any changes being made from a local panel or from another Master.

This command will allow a Master[48] to temporarily or permanently lock an 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.

Changing the Lock Code does not affect the Configuration Changed Counter or the Configuration Changed bit. If this Command is supported then Command 76 must also be supported.

Command 38 must allow the Configuration Changed Bit to be reset even if the device is locked.

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 (e.g., Network Manager attempted to lock device)
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

[48] When a Gateway locks a Field Device the "Locked by Primary Master" and "Locked By Gateway" status bits must be set (see Common Table 25).

7.40 Command 72 Squawk

This command causes the addressed device to visually, audibly or mechanically indicate the reception of this command. Squawking begins when this command is received with the "On" control code to allow technicians to identify the actual device being addressed and ceases when the "Off" code is received (or upon power cycle or Device Reset). When the "Squawk Once" code is received the device should temporarily squawk (e.g., for 2 seconds).

7.40.1 Backward Compatibility Requirements

Previously this command contained no request data bytes and Masters repeatedly issued this command. The Field Device must answer these Master requests without returning Response Code 5, Too Few Data Bytes Received. If a command request is received with no request data bytes the Field Device must temporarily squawk and respond with "Squawk Once" in the command response.

Request Data Bytes

Byte	Format	Description
0	Enum-8	Squawk Control (See Common Tables 66 Squawk Control Codes)

Response Data Bytes

Byte	Format	Description
0	Enum-8	Squawk Control

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 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 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 the 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. Any change to this list shall cause the "Sub-Device List Changed" bit to be set in the Command 48 response[49]. In addition, the I/O system should capture devices answering a poll generated by the reception of Command 75 and capture 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 (the count includes the I/O system itself).
5	Unsigned-8	Maximum number of delayed responses supported by I/O System. Must be at least two.
6	Enum-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 a sub-device. Valid range is 2 to 5. 3 retries is default.

[49] An I/O System must contain a "Sub-Device List Changed" each master. All bits are set when Sub-Device list changes and individual bits are reset upon the master issuing Command 74.

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.[50]

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.

[50] I/O Card, Channel, and Polling Address may represent a logical mapping within the I/O System and not the actual physical topology. For example, a WirelessHART Gateway may use these data fields to logically map devices that may not directly correspond to the mesh topology.

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[51]
17 - 20		Undefined
21	Error	Invalid I/O card number
22	Error	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

[51] "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 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 command is used to pass an embedded HART command request to a specific sub-device[52]. 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. The master address and burst mode bit will reflect the values returned by the subdevice in the response to the I/O System.

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)

[52] This command must not be used to send command to 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 - 15		Undefined
16	Error	Access Restricted[53]
17 - 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

[53] "Access restricted" shall only be returned when the I/O system receives Command 77 via one of the sub-device channels.

7.46 Command 78 Read Aggregated Commands

This command allows a host or device to aggregate/encapsulate multiple commands into a single transaction (command) for low overhead, faster communications. Using this command, for example, multiple read commands can be aggregated in one transaction by a host application.

In the request, the number of commands along with the embedded command numbers and their request data bytes are provided. In the reply, the command number, byte count, response code and response data bytes for each command is included. Device status is NOT included in the individual embedded command responses. To directly support Device Family commands and other expanded command numbers, 16bit command number fields are used in both the request and response.

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.

All devices supporting command 78 must support multiple embedded read commands. Any mixture of read commands may be issued by host applications without rejection by the field device. All devices must support embedding of Device Management (read) Commands, Universal (read) Commands, Command 38, and Command 48 in Command 78 requests. A device may support aggregation of read and write commands.

Devices must parse each embedded command in order generating the appropriate response data and Response Code. Each individual embedded response can be Success, Warning or Error (e.g., "Command not Implemented") without affecting the Command 78 Response Code.

If all response data with not fit in the response packet then Response Code 30, "Command Response Truncated" shall be returned and the response must be truncated after the last complete embedded command that can be contained in the response packet. The device shall execute no truncated command (i.e., a command that does not have response data in the reply).

Request Data Bytes

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

Response Data Bytes

Byte	Format	Description
0	Bits	Extended Field Device Status (refer to Common Table 17, Extended Field Device Status)
1	Unsigned-8	Number of commands requested
2-3	Unsigned-16	Command A
4	Unsigned-8	Byte count for Command A
5	Enum-8	Response Code for Command A
6 - A	Unsigned-8	Response Data bytes for Command A

Byte	Format	Description
…	Unsigned-16	Command B
…	Unsigned-8	Byte count for Command B
	Enum-8	Response Code for Command B
…	Unsigned-8	Response Data Bytes for Command B
	…	
…	Unsigned-16	Command N
…	Unsigned-8	Byte count for Command N
	Enum-8	Response Code for Command N
…	Unsigned-8	Response Data Bytes for Command N

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection (e.g., The combination of commands requested cannot be aggregated or "Number of commands" = 0)
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 (e.g., Command 31 or 78)
10-31		Undefined
30	Warning	Command Response Truncated - One or more commands are dropped 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 command allows a Device Variable to be set 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[54] the engineering value or allowing normal operation. For Device Variables automatically calculated by the Field Device, normal operation is also resumed when power is removed from the device or upon performing a device reset. Device Variables not calculated by the Field Device[55] (e.g., Setpoints or remote sensor values) are not considered "forced" and the "Write Device Variable Command Code" is ignored.[56]

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.

If the Field Device is Write Protected or Locked simulation of Device Variables is disabled and any attempt to simulate the Device Variable must return the corresponding Error Response Code. Field Device must not Write Protect or lock Device Variables not calculated by the Field Device.

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[57]
7	Bits	Device Variable status[58]

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

[54] While the Device Variable remains forced Response Code 8, "Update Failure" must be returned whenever the forced value is read by a host. Update Failure is not returned for Device Variables not calculated in the Field Device.

[55] "Device Variable Properties" returned in Command 54 indicates which Device Variables are not calculated by the Field Device.

[56] Device Variable Simulation Active (see Common Table 29) must not be set when Command 79 is used to update Device Variables not calculated in the Field Device.

[57] Forcing a Device Variable value may affect bits in the Device Status byte. For example, the Loop Current may become fixed when this command forces the Device Variable mapped to the Primary Variable. Also Device Variable Simulation Active (see Common Table 29) is set when a Device Variable is forced.

[58] Host Applications must not set any Device Family status bits for Device Variables not supporting a Device Family (i.e., the field device must always reset these bits in this case)

Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection. (e.g., Field Device is locked[59])
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 bits not set.
9		Undefined
10	Error	Invalid Write Device Variable Command Code
11-13		Undefined
14	Warning	Requested value was returned in command response but Rate-of-Change limit was exceeded. Device Variable tracking to value written at maximum rate allowed.[60]
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

[59] Neither "Invalid Selection" or "In Write Protect Mode" must not be returned if the Field Device does not calculate Device Variable.

[60] Subsequent Device Variable reads (e.g., with Command 9) will show actual value as Device Variable changes to the new specified value.

7.48 Command 80 Read Device Variable Trim Points

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 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 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 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 command allows an application to get a summary of all Sub-Devices currently connected to the I/O System (i.e., the "Live" list). 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.

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.

I/O Systems must detect duplicate Long Tags and Unique IDs[61] and set the "Sub-Devices with Duplicate IDs Found" status bit (See Common Table 31). In addition, the "Duplicate ID" Response Code must be returned when the identity of a Sub-Device with a duplicate identity is read.

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[62])
2	Unsigned-8	I/O Card
3	Unsigned-8	Channel
4-5	Unsigned-16	Manufacturer ID
6-7	Unsigned-16	Expanded Device Type Code
8-10	Unsigned-24	Device ID
11	Unsigned-8	Universal Command Revision level.
12 - 43	Latin-1	Long Tag [63]
44	Unsigned-8	Device Revision
45	Enum-8	Device Profile[64] (see Common Table 57)
46 - 47	Enum	Private Label Distributor Code (see Common Table 8, Manufacturer Identification Codes)

[61] I/O Systems should actively communicate with the sub-devices as needed to detect changes in topology and duplicate devices. I/O Systems must at least perform the detection passively by monitoring ongoing communications.

[62] For Index 0 (the I/O System itself), the Card and Channel should be ignored in Host Applications.

[63] For HART 5 devices, the Long Tag field shall return the (unpacked) text in the "Message" attribute as read from Command 12.

[64] If the sub-device does not return Device Profile in its Command 0 response then I/O system must return "Process Automation 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		Undefined
8	Warning	Duplicate ID (Long Tag or Unique ID). This device's long tag is the same as another device's on this I/O Card and Channel; or this device's Unique ID is the same as another device connected to the I/O System.
7 - 127		Undefined

7.53 Command 85 Read I/O Channel Statistics

This is a diagnostic command that the host can use to analyze the communication traffic on the specified channel[65]. The I/O System's Card and Channel number are included to ensure correct propagation of the embedded 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.

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 - 11	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	Error	Invalid Channel number
23 - 31		Undefined
32	Error	Busy (A DR Could Not Be Started)
33 - 127		Undefined

[65] 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.

7.54 Command 86 Read Sub-Device Statistics

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 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 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
4-5	Unsigned-16	Count of ACK messages received from this device
6-7	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 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	Enum-8	Master Mode (0 = Secondary Master; 1 = Primary Master)

Response Data Bytes

Byte	Description	
0	Enum-8	Master Mode

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 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	Unsigned-8	Retry Count. Valid range is 2 to 5.

Response Data Bytes

Byte	Description	
0	Unsigned-8	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
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

7.57 Command 89 Set Real-Time Clock

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		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		Undefined
9	Error	Invalid Date Code Detected
10 - 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

7.58 Command 90 Read Real-Time Clock

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
0-2	Date	Current Date
3-6	Time	Current Time of Day
7-9	Date	Date clock last set[66]
10-13	Time	Time clock last set
14	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

[66] Date and time last set must reflect when Real-Time Clock set irrespective of methodology (e.g., via HART communications, via the Field Device's front panel, etc).

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 command reads the gateway or multiplexer communication statistics for this host system interface[67]. It allows a host system to diagnose communication issues between itself and the communication gateway or multiplexer it is using to access field devices.

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-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

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

[67] 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.

7.63 Command 95 Read Device Communications Statistics

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 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 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

Synchronized Device Actions can be used to trigger the execution of a command. This command reads the current settings for the command to be executed. 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	Action number

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Action number
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

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	Action 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

Response Data Bytes

Byte	Format	Description
1	Unsigned-8	Action 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 100 Write Primary Variable Alarm Code

Selects the behavior of the Primary Variable when an alarm occurs (e.g., drive the PV high).

Request Data Bytes

Byte	Format	Description
0	Enum	PV Alarm Selection Code (see Common Table 6, Alarm Selection Codes). The Alarm Selection Code indicates the action taken by the device under error conditions. For transmitters, the code indicates the action taken by the Loop Current. For Actuators, the action taken by the positioner is indicated.

Response Data Bytes

Byte	Format	Description
0	Enum	PV Alarm Selection 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		Device-Specific Command Error
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

7.69 Command 101 Read Sub-device to Burst Message Map

This command reads which sub-device is mapped to a burst message or event notification[68]. 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.

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)

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

[68] 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

7.70 Command 102 Map Sub-device to Burst Message

This command maps a sub-device to a burst message or event notification[69]. 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

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

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	Error	Invalid Sub-device Index
10 - 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

[69] 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.

7.71 Command 103 Write Burst Period

This command selects the minimum and maximum Update Period of a burst message. The minimum time must be less than or equal to the maximum time. The Update Period shall be selected as specified Subsection 6.9.2. Field devices must correct settings differing from the values in Table 1 and indicate "Update Times Adjusted" in its response message. For wireless devices already in burst mode and a smaller Update Period is requested, if the Network Manager declines to increase the bandwidth then the device shall return "Update Times Adjusted".

In all cases, the target Update Period (corrected, if needed, based on the values in Table 1) must be stored in the Field Device and returned in Command 105.

If the Update Period is set shorter than the Acquisition Period indicated in Command 54 the device may publish the same measurement in multiple burst messages. If multiple Burst Messages are enabled and they all coincide within the same time they must be aggregated together using Command 78[70] 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 Burst Message Number dictates the priority.

Table 7. 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[71]
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.

[70] WirelessHART natively supports command aggregation (i.e., Command 78 should not be used). In addition, Burst message 0 must never be aggregated in Token-Passing networks.

[71] The device must return the Update Time actually in use whether it is the target-value adjusted to meet the requirements in Subsection 6.9.2 or because the actual-value allocated by the Network Manager was less bandwidth then requested. Command 105 must return the target-value.

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

7.72 Command 104 Write Burst Trigger

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". Furthermore, if a device specific command is specified as the burst command then Command 104 may return "Access Restricted" and default to a Trigger Mode of "Continuous". When trigger mode is "Continuous", the Device Variable Classification, Units Code, and Trigger Level should set to NaN (0x7F A0 00 00); Not Classified (0); and Not Used (250), respectively.

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 8). All trigger modes must be supported for all Commands in Table 8 and all Device Variables supported by the Field Device.

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.

Table 8. 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.

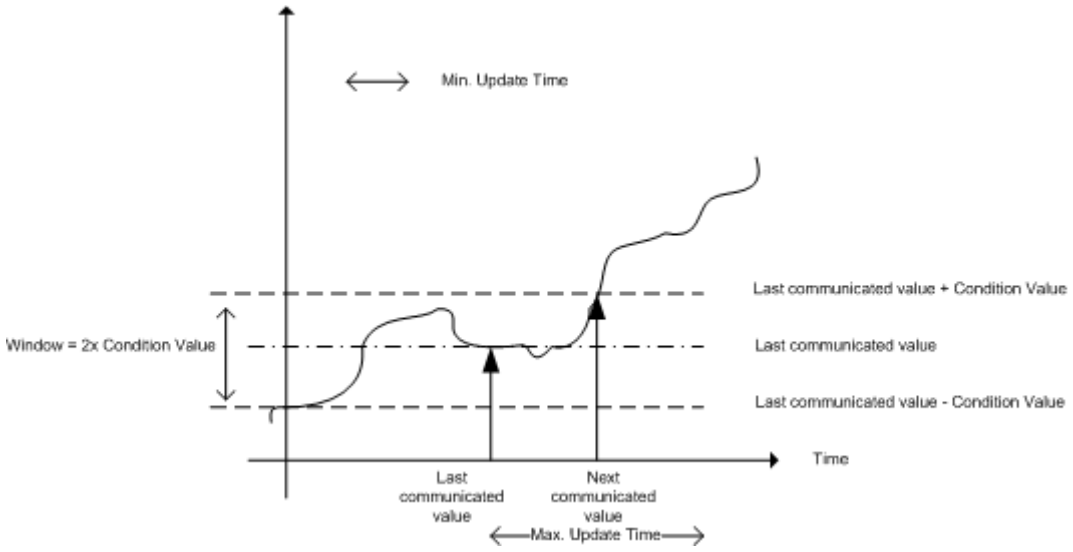

Figure 5. Trigger Mode 1: Windowed

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.

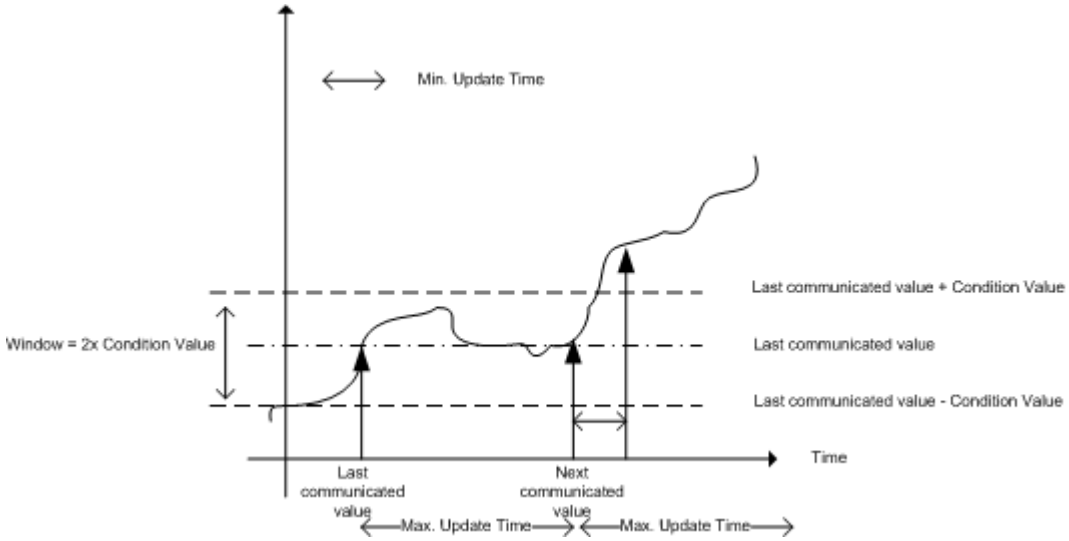

Figure 6: Windowed Condition on Burst with max. Update Time expired

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.

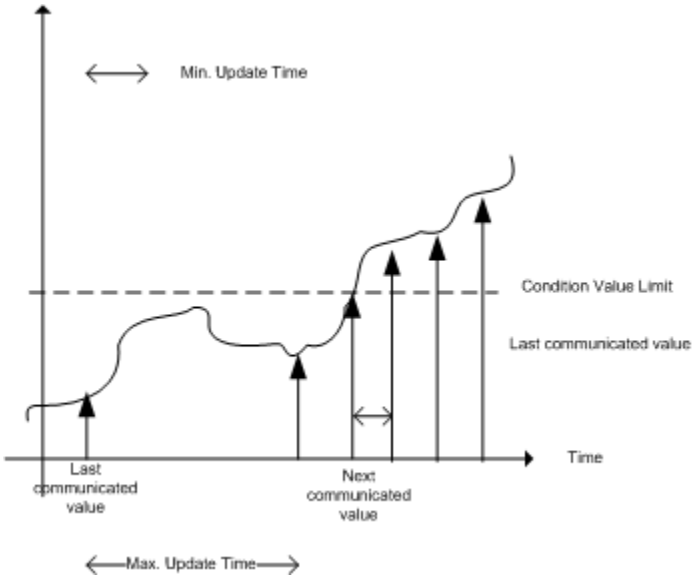

Figure 7: Update Time change on Limit Excess

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 (see Common Table 21. Device Variable Classification Codes)
3	Enum-8	Units Code[72]
4 - 7	Float	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
2	Enum-8	Device Variable Classification for Trigger Level
3	Enum-8	Units Code
4 - 7	Float	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
1-2		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	Burst Condition Conflict (e.g., Device Variable Classification corrected to match Device Variable being triggered on)
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 (Trigger Mode Code requested is not in Common Table 33)
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

[72] The Trigger Units received with this command do not affect the Device Variable Units. The Trigger Level must be returned in the same Trigger Units as received.

7.73 Command 105 Read Burst Mode Configuration

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.

7.73.1 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 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
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[73]
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.

[73] The device must return the Update Time specified. The actual Update Time currently in use may differ based on (for example) the bandwidth allocated by the Network Manager. If the actual and target Update Times differ then the device must set the "Capacity Denied" status and the "More status available" bit in the Device Status byte.

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

7.74 Command 106 Flush Delayed Responses

This command clears all pending delayed responses[74] 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.

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

[74] 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.

7.75 Command 107 Write Burst Device Variables

Selects the Device Variables that will be used by a bursting device to be returned by a Command 9 or 33 in Burst Mode[75]. 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 not "Continuous" 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 "Continuous" (Trigger Mode 0) and publish continuously at the Update Period until it receives another Command 104.

7.75.1 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"[76].

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

[75] Any supported Device Variable must be available to be returned in any Slot without restriction. The Field Device must allow the same Device Variable to be returned in multiple Slots.

[76] Field Device response shall not be truncated, all other Device Variable codes must be set to 250 and Burst Message set to 0.

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
10-15		Undefined
16	Error	Access Restricted
17-127		Undefined

7.76 Command 108 Write Burst Mode Command Number

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 and Command 33 must be supported if it is implemented in the field device. Refer to the device-specific document to determine if additional commands are supported for a specific device type.

If the trigger mode is not "Continuous" 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 "Continuous" (Trigger Mode 0) and publish continuously at the Update Period until it receives another Command 104.

7.76.1 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. 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[77]
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.

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
10-15		Undefined
16	Error	Access Restricted
17-127		Undefined

[77] 16-Bit Command Numbers are used in this Request and Response, except when operating in backward compatibility mode.

7.77 Command 109 Burst Mode Control

This command is used to enter and exit the Burst Mode[78] 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.

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 is unable to obtain any bandwidth to handle the newly enabled Burst Message it must return " No bandwidth available"[79]. If devices is able to obtain less bandwidth then requested it must return "Update Period Increased"[80]. In this case, the target Update Time returned in Command 105 is unchanged (only the actual Update Time internal to the Field Device is affected).

When switching Burst Mode off no delayed response is allowed.

7.77.1 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

[78] This command affects Token-Passing Data Link Layer operation. All Token-Passing Data Link Layer requirements for entering and exiting burst mode must be met.

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

[80] Field Device must continue to publish burst messages (albeit at a reduced rate) as long as some bandwidth is available. While bandwidth is reduced, at each Health Report interval the device must request the target bandwidth (see Command 799).

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 (Some bandwidth available)
9	Error	No bandwidth available.
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

7.78 Command 110 Read All Dynamic Variables

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
8	Warning	Update Failure
9-15		Undefined
16	Error	Access Restricted
17- 27		Undefined

7.79 Command 111 Transfer Service Control

See *Block Transfer Specification*

7.80 Command 112 Transfer Service

See *Block Transfer Specification*

7.81 Command 113 Catch Device Variable

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[81], 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 9 shows the Slot Code assignments for command 1, 2, 3, 9 and 33 responses.

If the Field Device supports Command 113 then Command 114 must also be supported. In addition, the Field Device must support the capture of one or more Device Variables (i.e., the device must have at least one Device Variable that may be used for receiving a setpoint or remote sensor value).

7.81.1 Backward Compatibility Requirements

If a field device receives only 13 data bytes in the request it must assume that a HART 5 or HART 6 host is configuring it. In this case, the device must not return Response Code 5 - "Too Few Data Bytes Received" and must use Byte 7 as the command number to catch. In the response, the command number must be returned in both byte 7 and bytes 13-14.

Table 9. 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)[82]
7	Unsigned-8	31 (0x1F)
8	Unsigned-8	Source Slot Number
9-12	Float	Shed Time (in Seconds) for this mapping.
13-14	Unsigned-16	Source Command Number

[81] Source Slave Address must be ignored if the Capture Mode Code is set to "2" (Catch data from BACK message).

[82] 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.

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	31 (0x1F)r
8	Unsigned-8	Source Slot Number
9-12	Float	Shed Time (in Seconds) for this mapping.
13-14	Unsigned-16	Source Command Number

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		Undefined
8	Warning	Capture Mode Code set to "Catch data from BACK message" (e.g., the Field Device supports WirelessHART).
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

7.82 Command 114 Read Caught Device Variable

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	Least Significant Byte of the Source Command Number
8	Unsigned-8	Source Slot Number
9-12	Float	Shed Time (in Seconds) for this mapping.
13-14	Unsigned-16	Source Command Number

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

7.83 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).

Request Data Bytes

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

Response Data Bytes[83]

Byte	Format	Description
0	Unsigned-8	Event Specification 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[84]
11 - 14	Time	Maximum Update Time
15 - 18	Time	Event De-bounce Interval
19	Bits	Device Status Mask
20 - 44	Bits	Event Mask. The mask for triggering on bits set in the 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

[83] The response is truncated after the last byte that is supported in Command 48

[84] The device must return the Event Notification Retry Time specified. The actual Event Notification Retry Time currently in use may differ based on (for example) the bandwidth allocated by the Network Manager. If the actual and target Event Notification Retry Time differ then the device must set the "Capacity Denied" status and the "More status available" bit in the Device Status byte.

7.84 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 at any point after the Extended Field Device Status byte (byte 6 of Command 48) 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.

The Event Mask in the response is truncated after the last byte that is supported in the target device's Command 48 response. When the event is mapped to a subdevice (using Command 102) the Command 116 response shall always include as many bytes in the requested Event Mask.

Request Data Bytes[85]

Byte	Format	Description
0	Unsigned-8	Event Specification number
1	Bits	Device Status mask
2 - 26	Bits	Event Mask. The mask for triggering on bits set in the Command 48 Response

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Event Specification number
1	Bits	Device Status mask
2 - 26	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

[85] The request is truncated after the last byte that containing a trigger-able event

7.85 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 " Update Period or De-bounce Interval Adjusted"[86] 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. The device must scan for possible events at least twice as fast as specified by the Event De-Bounce Interval.

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 Specification 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 Specification number
1 - 4	Time	Event Notification Retry Time
5 - 8	Time	Maximum Update Time
9 - 12	Time	Event De-bounce Interval

[86] The device must return the Event Notification Retry Time actually in use whether it is the target-value adjusted to meet the requirements in Subsection 6.9.2 or because the actual-value allocated by the Network Manager was less bandwidth then requested. Command 115 must return the target-value.

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 Event Specification number
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

7.86 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[87] (see Common Table 35. Event Notification Control Code).

If the device is unable to obtain any bandwidth to handle the newly enabled Event Notification it must return "No bandwidth available". If devices is able to obtain less bandwidth then requested it must return " Update Times adjusted"[88]. In this case, Command 115 must return the values actually in use.

Request Data Bytes

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

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Event Specification 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	Error	No bandwidth available.
10-13		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

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

[88] Field Device must continue to publish event messages (albeit at a reduced rate) as long as some bandwidth is available. While bandwidth is reduced, at each Health Report interval the device must request the target bandwidth (see Command 799).

7.87 Command 119 Acknowledge Event Notification

This command is used to publish or to acknowledge the Event Notification (see Subsection 6.10). The host will send the data received with an Event Notification to acknowledge the latched event instance currently being published[89] that is associated with the Event Specification number. When the request (Timestamp, Configuration Change Counter, the Device Status, and Command 48 data) matches the currently published Event Notification values, the device will Respond with "Success"[90] and reset the Event Status bits (see Common Table 36 Event Status Codes) accordingly. There may be multiple time-stamped bit transitions and the command will only clear the oldest one (i.e., the one currently being published). The device must return Response Code 8, "Not All Events Cleared", anytime any events are still pending.

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 Specification number
1 - 4	Time	Time when first unacknowledged event was triggered (must be set to 0xFFFFFFFF 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 Specification number
1 - 4	Time	Time when first unacknowledged event was triggered
5 - 6	Unsigned-16	Configuration Changed Counter
7	Bits	Device Status
8 -32	Bits or Enum only	Latched Command 48 data[91]

[89] This command must not be affected by any write protect mechanism. It is essential that Event Notifications can be cleared at any time.

[90] For Field Devices supporting mutlipl HART communication channels any matching acknowledgement must be successful irrespective of the channel the Command 119 request is received on.

[91] 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. Success is also returned when publishing an Event Notification with no events pending (i.e. the Maximum Update timer has lapsed)
1		Undefined
2	Error	Invalid Selection
3-4		Undefined
5	Error	Too Few Data Bytes Received. This shall NOT be generated if only the "Event number" is included in the request data.
6	Error	Device-Specific Command Error
7		Undefined
8	Warning	Not All Events Cleared or (when publishing an Event Notification) one or more event is pending for this or another Event Specification.
9-15		Undefined
16	Error	Access Restricted (I/O System Use only. Request is not from Event Manager)
17 -127		Undefined

7.88 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.

If Command 512 is supported the Field Device must also support Command 513.

Request Data Bytes

Byte	Format	Description
None		

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 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

7.89 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.

The Country Code (for example) changes the language displayed on the Field Device's the local panel.

In some locals it is illegal to allow products to be configured with any non-SI Engineering Units. When "SI Units Restriction" is set to "Unit codes limited to the SI Units only" the Field Device must prevent any non SI Unit code from being written to the device[92].

If Command 513 is supported the Field Device must also support Command 512.

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)

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		Device-Specific Command Error
7	Error	In Write Protect Mode
8		Undefined
9	Error	SI Units Restriction Failed (Not all Units Codes currently configured are SI Compliant)
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

[92] When configured to only accept SI Unit Codes, the Field Device must return "Invalid Selection" in response to any command request to write a non-SI Unit Code.

7.90 Command 514 Register Event Manager

The command allows a master or client to register as the Event Manager. Once registered, only the Event Manager can acknowledge events via I/O Systems.

Request Data Bytes

Byte	Format	Description
0	Enum-8	Event Manager registration control code (see Common Table 67 Event Manager Registration Control Codes)

Response Data Bytes

Byte	Format	Description
0	Enum-8	Event Manager registration control code

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
6-15		Undefined
16	Error	Access Restricted
17-127		Undefined

7.91 Command 515 Read Event Manager Registration Status

The command allows a master or client to determine whether an Event Manager is registered.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Bits-8	Event Manager registration status. (see Common Table 68 Event Manager Registration Status Codes)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
6-15		Undefined
16	Error	Access Restricted
17-127		Undefined

7.92 Command 516 Read Device Location

This command reads the configured location of a device as per WGS84

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-3	Float	Latitude (degrees). A positive value is north and a negative value is south. The absolute value must not be greater than 90.0.
4-7	Float	Longitude (degrees). A positive value is east and a negative value is west. The absolute value must not be greater than 180.0
8	Enum-8	Location method/quality (See Common Table 69. Location Method Codes)
9-12	Float	Altitude (meters) above mean sea level. Above sea level the value is positive, below sea level is negative.

Command-Specific Response Codes

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

7.93 Command 517 Write Device Location

This command writes the location of a device. The geodetic coordinates written with this command shall be with reference to World Geodetic System 84 (WGS 84).

Request Data Bytes

Byte	Format	Description
0-3	Float	Latitude (degrees). A positive value is north and a negative value is south. The absolute value must not be greater than 90.0.
4-7	Float	Longitude (degrees). A positive value is east and a negative value is west. The absolute value must not be greater than 180.0
8	Enum-8	Location method/quality (See Common Table 69. Location Method Codes)
9-12	Float	Altitude (meters) above mean sea level. Above sea level the value is positive, below sea level is negative.

Response Data Bytes

Byte	Format	Description
0-3	Float	Latitude (degrees).
4-7	Float	Longitude (degrees).
8	Enum-8	Location method/quality
9-12	Float	Altitude (meters).

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection (e.g., invalid location method)
3	Error	Passed Parameter Too Large (Latitude greater than +90 or Longitude greater than +180)
4	Error	Passed Parameter Too Small (Latitude less than -90 or Longitude less than -180)
5	Error	Too Few Data Bytes Received
6		Device-Specific Command Error
7	Error	In Write Protect Mode
8 -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

7.94 Command 518 Read Location Description

Reads the 32-byte location description. Plant personnel can use this description to find the device.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-31	Latin-1	Location Description

Command-Specific Response Codes

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

7.95 Command 519 Write Location Description

Write the 32-byte location description. Plant personnel can use this description to find the device.

Request Data Bytes

Byte	Format	Description
0-31	Latin-1	Location Description

Response Data Bytes

Byte	Format	Description
0-31	Latin-1	Location Description

Note: The value returned in the response data bytes reflects the value actually used by the Field 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		Device-Specific Command Error
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

7.96 Command 520 Read Process Unit Tag

Reads the 32-byte Process Unit Tag. Often within a plant there are multiple identical process units. Consequently the Long tag for the devices maybe the same unit to unit. The Process unit tag indicates the process unit this device is associated with and can be (e.g., when maintenance is performed) used to differentiate this unit from other devices with the same Long Tag but installed on a different process unit.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-31	Latin-1	Process Unit Tag

Command-Specific Response Codes

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

7.97 Command 521 Write Process Unit Tag

Writes the 32-byte Process Unit Tag. The Process unit tag indicates the process unit this device is associated with.

Request Data Bytes

Byte	Format	Description
0-31	Latin-1	Process Unit Tag

Response Data Bytes

Byte	Format	Description
0-31	Latin-1	Process Unit Tag

Note: The value returned in the response data bytes reflects the value actually used by the Field 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 (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

7.98 Command 522 Write Volumetric Flow Classification

There are many volumetric measurements and for volumetric flow these are often made using differing time bases (e.g., per Second, per Minute, per Hour, per Day). This command allows the time base for volumetric flow to be changed. This command must only be used for volumetric flow. As per the *Command Summary Specification*, no other Device Variable may change its classifications code without changing the device type of the field device.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Enum-8	The Classification Code for a volumetric flow measurement (See Common Table 21)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum-8	The Classification Code for a volumetric flow measurement

Note: The value returned in the response data bytes reflects the value actually used by the Field 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 (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

7.99 Command 523 Read Condensed Status Mapping Array

This command returns the requested Condensed Status Maps from the Field Device's array of Status Maps. Each Status Map in the array is associated with one of the Field Device Status bits or a bit returned in Command 48. This command reads the currently configured mapping.

Two status map codes (see Common Table 70 Condensed Status Mapping Code) are packed into each byte with the least significant nibble corresponding to the smaller of the two indices into the status map array (e.g., the LSNibble corresponds to status_map_array [k] and the MSNibble status_map_array [k+1], etc.).

"Status Map Index" or "Number of Entries to Read" may be modified and "Set to Nearest Value" Response Code returned[93]. This command shall always return at least two status maps (i.e., Number of Entries to Read shall be at least 2 with Status Map Index adjusted as needed).

Prior to issuing this command, Host Applications should issue Command 48 to determine the length of the status map array. Depending on the length of the Command 48 response; the size of the Field Device response buffer; and Protocol limitations, it may not be possible to read the entire Condensed Status Mapping Array in one transaction. When this is the case Host Application should read successive fragments of the Condensed Status Mapping Array until the entire array has been read.

Host Applications may determine the number of Status Maps that can be read or written (if Command 524 is supported) in one transaction by issuing this command with Status Map Index set to 0 and Number of Entries to Read set to the maximum value supported by the Field Device. If the "Set to Nearest Value" Response Code is returned the maximum number of entries possible in a single transaction must be indicated in the Field Device response (i.e., in the "Number of entries actually read" field) along with the corresponding status map codes.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Starting Status Map Index. This first entry in the Status Map Array to be read (see Table 5 for a list of Status Map Indexes).
1	Unsigned-8	Number of Entries to Read. The total number of Status Map Array entries to be read

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Actual Starting Status Map Index
1	Unsigned-8	Number of entries actually returned ("*n*")[94]
2.0-2.3	Enum-4	1st status map code (i.e., status_map_array [actual_ starting_index +0])
2.4-2.7	Enum-4	2nd status map code
3.0-3.3	Enum-4	3rd status map code
. . .		
(2+(n-2)/2).0 (2+(n-2)/2).3	Enum-4	(*n*-1) status map code
(2+(n-2)/2).4 (2+(n-2)/2).7	Enum-4	*n*th status map code (i.e., status_map_array [actual_starting_index +(*n* -1)])

[93] e.g., some device may require reads to always start at an even-numbered index.

[94] Number of Entries actually returned must always be an even number. The actual start index must be adjusted, as needed, to ensure the last nibble returned is valid (i.e., correlates to a status bit from Field Device Status or a bit returned by Command 48)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Bytes Received
6-7		Undefined
8	Warning	Set to Nearest Possible Value (e.g., requested more mapping entries than available)
9-127		Undefined

7.100 Command 524 Write Condensed Status Mapping

This command maps (or un-maps) status bits to Condensed Status. Each Status Map in the array is associated with one of the bits returned in Field Device Status or in Command 48 response. This command modifies the specified Status Maps. The modified mapping takes effect immediately upon Field Device execution of this command and may result in immediate changes in Condensed Status values.

Two status map codes (see Common Table 70 Condensed Status Mapping Code) are packed into each byte with the least significant nibble corresponding to the smaller of the two indices into the status map array (e.g., the LSNibble corresponds to status_map_array [k] and the MSNibble status_map_array [k+1], etc.).

"Status Map Index" or "Number of entries to write" may be modified and "Set to Nearest Value" Response Code returned[95]. This command must always write at least two status maps (i.e., Number of Entries to write shall be at least 2 with Status Map Index adjusted as needed).

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Starting Status Map index
1	Unsigned-8	Number of entries to write ("*n*")[96]
2.0-2.3	Enum-4	1st status map code (i.e., status_map_array [starting_index +0])
2.4-2.7	Enum-4	2nd status map code
3.0-3.3	Enum-4	3rd status map code
. . .		
(2+(n-2)/2).0 (2+(n-2)/2).3	Enum-4	(*n*-1) status map code
(2+(n-2)/2).4 (2+(n-2)/2).7	Enum-4	*n*th status map code (i.e., status_map_array [starting_index +(*n* -1)])

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Actual Starting Status Map Index
1	Unsigned-8	Number of entries actually returned ("*n*")
2.0-2.3	Enum-4	1st status map code
2.4-2.7	Enum-4	2nd status map code
3.0-3.3	Enum-4	3rd status map code
. . .		
(2+(n-2)/2).0 (2+(n-2)/2).3	Enum-4	(*n*-1) status map code
(2+(n-2)/2).4 (2+(n-2)/2).7	Enum-4	*n*th status map code

Note: The values returned in the response data bytes reflect the value actually used by the Field Device.

[95] e.g., some device may require writes to always start at an even-numbered index

[96] The device will respond with a Buffer Overflow Communication Error if the request data length is longer than the device communication buffers can support. See the *Token-Passing Data-Link Layer Specification* for more information.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection (e.g., one of the mapping codes is invalid)
3-4		Undefined
5	Error	Too Few Data Bytes Received
6		Device-Specific Command Error
7	Error	In Write Protect Mode
8	Warning	Set To Nearest Possible Value[97]
9	Error	Starting Status Map Index must be even value.
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

[97] e.g., the "Actual Starting Status Map Index" or "Number of entries actually returned" was modified in the command response.

7.101 Command 525 Reset Condensed Status Map

This command resets the Condensed Status Map (i.e., the default values for the status maps are written to the Status Map Array). The reset Condensed Status Map takes effect immediately upon Field Device execution of this command and may result in immediate changes in Condensed Status values.

The default values of the status maps for the standardized status are defined in the Common Tables Specification. All other default values are device specific.

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
8-15		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

7.102 Command 526 Write Status Simulation Mode

This command is used to enable and disable Status Simulation Mode. Status Simulation Mode allows end-to-end testing of system response to changes in either the Field Device Status or the Command 48 response. Changes in Status Simulation Mode are not allowed while device is Write Protected or Locked.

When Status Simulation is switched from Disabled to Enabled:

- All device-initiated changes to Field Device Status and the Command 48 response data shall be disabled[98]; and
- The Status Simulation Active bit must be set (see Common Table 30)

While Status Simulation is enabled the Field Device Status and the Command 48 response shall only be affected upon receipt of Command 527 from the Host Application[99]. When Status Simulation is switched from Enabled to Disabled:

- The Status Simulation Active bit must be reset (see Common Table 30);
- Field Device Status and the Command 48 response data shall immediately be changed to the currently applicable values (i.e., any bit values forced using Command 527 shall be discarded); and
- Normal device-initiated updates to Field Device Status and the Command 48 response shall resume.

Status Simulation Mode is also exited when power is removed from the device or when a Device Reset is performed.

Request Data Bytes

Byte	Format	Description
0	Enum-8	Status Simulation Mode Code (see Common Table 71 Status Simulation Mode Codes)

Response Data Bytes

Byte	Format	Description
0	Enum-8	Status Simulation Mode Code

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

[98] Enabling Status Simulation Mode shall not affect the current values of Field Device Status bits or any value in the Command 48 response.

[99] Any attempt to enable Status Simulation while it is already enabled will have no affect (i.e., "No Command-Specific Errors" shall be returned).

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		Device-Specific Command Error
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

7.103 Command 527 Simulate Status Bit

While Status Simulation Mode is enabled, this command allows individual Field Device Status bits or bit in the Command 48 response to be set or cleared[100]. The Field Device must react normally to the setting or resetting of a status bit.[101].

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Index of bit to be simulated (see Table 5)
1	Enum-8	Simulated Value Code (see Common Table 72 Simulated Value Code Codes)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Index of bit to be simulated
1	Enum-8	Simulated Value Code

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

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2		Invalid Selection (e.g., invalid status bit index, bad simulated value code)
3-4		Undefined
5	Error	Too Few Data bytes received
6-15		Undefined
16	Error	Access Restricted (e.g., Status Simulation is disabled, attempt to write Status Simulation Active bit)
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

[100] Simulation of the "Failure"; "Out of Specification"; "Function Check"; and "Maintenance Required" is not allowed.

[101] For example, setting or resetting a bit in the Command 48 response may result in More Status Available being set; the change in state of a Condensed Status bit; or a Status Event (Command 119) being published.

7.104 Command 528 Read Sub-Device Assignment List Information

This command reads the Sub-Device Assignment list properties.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Unsigned-16	Total Number of Sub-devices in the Assignment list (the count includes the I/O system itself).
1	Unsigned-16	Maximum Number of Sub-devices possible in the Assignment list.
2	Bits-8	Sub-device Assignment Status (see Common Table 73 Sub-device Assignment Status Codes). Value returned is the Logical-OR of status for all list entries.

Command Specific Response Codes

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

7.105 Command 529 Read Sub-Device Assignment

This command reads the Assignment list. This command assists in verification of the I/O system configuration (e.g., comparing as-expected with as-found). This command only returns the contents of the Assignment list. It is possible that there are devices in the Live List not currently stored in the Assignment List.

In addition, Sub-device Assignment Status is returned indicating when a Sub-Device Assignment is not found in the Live List returned by Command 84. This status is only valid after the Live List has been created. i.e., the I/O System has been connected to the plant and the connected devices identified.

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	Bits-8	Sub-device Assignment Status (see Common Table 73 Sub-device Assignment Status Codes).
3	Unsigned-8	I/O Card (Index 0 returns 251, "None")
4	Unsigned-8	Channel (Index 0 returns 251, "None")
5-6	Unsigned-16	Manufacturer ID
7-8	Unsigned-16	Expanded Device Type Code
9-11	Unsigned-24	Device ID
12 - 43	Latin-1	Long Tag
44	Unsigned-8	Device Revision

Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 127		Undefined

7.106 Command 530 Write Sub-Device Assignment

Inserts a new Sub-Device or modifies an existing Assignment. I/O systems supporting this command maintains a non-volatile "Sub-device Assignment" list indicating the Sub-Devices[102] that should always be connected to the I/O System and their location in the network topology.

Reception of this command will either overwrite an existing Sub-device Assignment list entry or – when index 0x00 is specified – create a new entry[103]. Entries are identified by:

- Long Tag;
- Long Tag + Expanded Device Type Code (Best Practice); or
- Expanded Device Type Code + Device ID.

Upon command reception the I/O System must review the Sub-Devices in the Assignment List and identify any that match the Sub-Device specified in the command request.

- If specified Sub-Device is unique, then the Subdevice shall be added to the Assignment list;
- Else If Sub-Device is NOT unique and index is 0x00 then "Sub-Device already exists" Response Code is returned;
- Else If Sub-Device is NOT unique and index is NOT 0x00 then the identified Sub-Device Assignment is replaced.

When an Assignment insertion is successful the new entry shall be added to the specified Card and Channel[104] or, if Card and/or Channel is unspecified, added to a Card and Channel of the I/O systems choice.

To delete a device from the Assignment List the Manufacturer ID shall be set to 0xFFFF (along with identifying data for the entry) and be sent to the I/O System. Upon command reception the I/O System must review Assignment List and identify the sub-device to be deleted.

Request Data Bytes

Byte	Format	Description
0-1	Unsigned-16	Sub-device Index. Setting Index to 0x00 will result in device being added to Sub-Device Assignment List.
2	Unsigned-8	I/O Card. If set to 0xFF then Sub-device will be added to Card number of I/O System's choosing.
3	Unsigned-8	Channel. If set to 0xFF then Sub-device will be added to Channel of I/O System's choosing.
4-5	Unsigned-16	Manufacturer ID
6-7	Unsigned-16	Expanded Device Type Code (Ignore if 0x0000-Use Long Tag Only)105
8-10	Unsigned-24	Device ID (Ignore if 0x000`000-Match device using Expanded Device Type Code and Long Tag)
11-42	Latin-1	Long Tag (If all bytes set to 0x00 then match using Expanded Device Type Code and Device ID)
43	Unsigned-8	Device Revision[106]

[102] This Command does not affect the Live List only sets an expectation of what should be in the Live List.
[103] The list ordering is device specific. I/O systems may maintain an ordered list (e.g., by card and channel) or (for example) new entries may be added to the end of the Sub-Device Assignment list.
[104] When specified, multiple Sub-Devices shall be added to the same Card and Channel (i.e., devices may be multi-dropped on the same Channel).
[105] If Expanded Device Type Code set to 0x0000 then Device ID ignored. 0x000000 shall be returned in response as Device ID.
[106] Setting Device Revision to zero (0x00) will allow any Device Revision to be used with no errors.

Response Data Bytes

Byte	Format	Description
0-1	Unsigned-16	Sub-device Index
2	Unsigned-8	I/O Card
3	Unsigned-8	Channel
4-5	Unsigned-16	Manufacturer ID
6-7	Unsigned-16	Expanded Device Type Code (Ignore if 0x0000-Use Long Tag Only)[107]
8-10	Unsigned-24	Device ID (Ignore if 0x000000-Match device using Expanded Device Type Code and Long Tag)
11-42	Latin-1	Long Tag (If all bytes set to 0x00 then match using Expanded Device Type Code and Device ID)
43	Unsigned-8	Device Revision

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

Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection (e.g., bad I/O Card or Channel)
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
9	Error	Sub-Device already exists. Attempt to add new Sub-Device failed[108].
10	Error	Bad device identity. Expanded Device Type Code and Long Tag cannot both be null.
11 - 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

[107] If Expanded Device Type Code set to 0x0000 then Device ID ignored. 0x000000 shall be returned in response as Device ID.
[108] At least the Long Tag must be unique.

7.107 Command 531 Transfer Live List to Assignment List

This command copies the "Live List" returned in Command 84 to the "Assignment List" (i.e. the list returned in Command 529). The entire contents of the Assignment List shall be replaced (i.e. the prior contents of the list are lost/discarded). This ensures the Assignment List (as-left list) matches the Live List (as-found).

The Live List returned in Command 84 is not affected.

Request Data Bytes

Byte	Format	Description
0	Enum-8	Sub-device Assignment Transfer Code (Table 74. Sub-device Assignment Transfer Codes).

Response Data Bytes

Byte	Format	Description
0	Enum-8	Sub-device Assignment Transfer Code
1-2	Unsigned-16	Number of Sub-devices transferred.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 4		Undefined
5	Error	Too Few Data Bytes Received
6-7		Undefined
8	Warning	Duplicate ID (Long Tag or Unique ID). This device's long tag is the same as another device's on this I/O Card and Channel; or this device's Unique ID is the same as another device connected to the I/O System.
9 - 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. 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
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

Blank cells indicate the command is totally optional for that Device Type.

Table 10. Common Practice Command Summary

Command	CC	Device Type				
		FD	BD	WD	WPA	GW
Command 33 Read Device Variables	N	R	R	R	R(L)	
Command 34 Write Primary Variable Damping Value	Y	R	R	R	R(L)	
Command 35 Write Primary Variable Range Values[109]	Y	R	R		M(L)	
Command 36 Set Primary Variable Upper Range Value	Y	R	R			
Command 37 Set Primary Variable Lower Range Value	Y	R	R			
Command 38 Reset Configuration Changed Flag	N	M	M	M	M	M
Command 40 Enter/Exit Fixed Current Mode	N	R	R		M(L)	
Command 41 Perform Self Test	N	R	R	M	M	M
Command 42 Perform Device Reset	N	R	R	M	M	M
Command 43 Set Primary Variable Zero	Y					
Command 44 Write Primary Variable Units	Y	R	R	R		
Command 45 Trim Loop Current Zero	Y	R	R		M(L)	
Command 46 Trim Loop Current Gain	Y	R	R		M(L)	
Command 47 Write Primary Variable Transfer Function	Y					
Command 48 Read Additional Device Status	N	M	M	M	M	M
Command 49 Write Primary Variable Transducer Serial Number	Y					
Command 50 Read Dynamic Variable Assignments	N	R	M	M	M(L)	
Command 51 Write Dynamic Variable Assignments	Y					
Command 52 Set Device Variable Zero	Y					
Command 53 Write Device Variable Units	Y	R	R	R		
Command 54 Read Device Variable Information	N	R	M	M	M(L)	
Command 55 Write Device Variable Damping Value	Y	R	R	R	R(L)	

[109] Allows Device to calculate Percent Range and scale output/input of current loop.

Command	CC	Device Type				
		FD	BD	WD	WPA	GW
Command 56 Write Device Variable Transducer Serial No.	Y					
Command 59 Write Number Of Response Preambles	Y	R	R	M	M	
Command 71 Lock Device	N	R	R	R	R	R
Command 72 Squawk[110]	N	R	R	R	M	
Command 73 Find Device	N	R	R	R	R	
Command 74 Read I/O System Capabilities	N				M	M
Command 75 Poll Sub-Device	N				M	M
Command 76 Read Lock Device State	N	R	R	R	R	R
Command 77 Send Command to Sub-Device	N				M	M
Command 78 Read Aggregated Commands	N			M	M	M
Command 79 Write Device Variable	Y	R	R	M	M(L)	
Command 80 Read Device Variable Trim Points	N	R	R	R	R(L)	
Command 81 Read Device Variable Trim Guidelines	N	R	R	R	R(L)	
Command 82 Write Device Variable Trim Point	Y	R	R	R	R(L)	
Command 83 Reset Device Variable Trim	Y	R	R	R	R(L)	
Command 84 Read Sub-Device Identity Summary	N				M	M
Command 85 Read I/O Channel Statistics	N				M	M
Command 86 Read Sub-Device Statistics	N				M	M
Command 87 Write I/O System Master Mode	Y				M	M
Command 88 Write I/O System Retry Count	Y				M	M
Command 89 Set Real-Time Clock	N	R	R			M
Command 90 Read Real-Time Clock	N	R	R	M	M	
Command 91 Read Trend Configuration	N			R		
Command 92 Write Trend Configuration	Y			R		
Command 93 Read Trend	N			R		
Command 94 Read I/O System Client-Side Communication Statistics	N				R	M
Command 95 Read Device Communications Statistics	N	R	R	R	M	
Command 96 Read Synchronous Action	N					
Command 97 Configure Synchronous Action	Y					
Command 98 Read Command Action	N					
Command 99 Configure Command Action	Y					
Command 100 Write Primary Variable Alarm Code	Y					
Command 101 Read Sub-device to Burst Message Map	N				M	
Command 102 Map Sub-device to Burst Message	Y				M	
Command 103 Write Burst Period	Y		M	M	M	
Command 104 Write Burst Trigger	Y		M	M	M	
Command 105 Read Burst Mode Configuration	N		M	M	M	
Command 106 Flush Delayed Responses[111]	N			M	M	M
Command 107 Write Burst Device Variables	Y		M	M	M	
Command 108 Write Burst Mode Command Number	Y		M	M	M	
Command 109 Burst Mode Control	Y		M	M	M	
Command 111 Transfer Service Control Command 112 Transfer Service					M[112]	M[113]

[110] Strongly Recommended for Wireless Devices

[111] Must be supported if device uses DR

Command	CC	Device Type				
		FD	BD	WD	WPA	GW
Command 113 Catch Device Variable	Y					
Command 114 Read Caught Device Variable	N					
Command 115 Read Event Notification Summary	N		R	M	M	
Command 116 Write Event Notification Bit Mask	Y		R	M	M	
Command 117 Write Event Notification Timing	Y		R	M	M	
Command 118 Event Notification Control	Y		R	M	M	
Command 119 Acknowledge Event Notification	N		R	M	M	
Command 512 Read Country Code	N	R	R	R	R	R
Command 513 Write Country Code	Y	R	R	R	R	R
Command 514 Register Event Manager	N					R
Command 515 Read Event Manager Registration Status	N					R
Command 516 Read Device Location	N			R	R	
Command 517 Write Device Location	Y			R	R	
Command 518 Read Location Description	N			R	R	
Command 519 Write Location Description	Y			R	R	
Command 520 Read Process Unit Tag	N	R	R	R	R	
Command 521 Write Process Unit Tag	Y	R	R	R	R	
Command 522 Write Volumetric Flow Classification	Y					
Command 523 Read Condensed Status Mapping Array	N	R	R	R	R	
Command 524 Write Condensed Status Mapping	Y	R	R	R	R	
Command 525 Reset Condensed Status Map	Y	R	R	R	R	
Command 526 Write Status Simulation Mode	N	R	R	R	R	
Command 527 Simulate Status Bit	N	R	R	R	R	
Command 528 Read Sub-Device Assignment List Information	N					
Command 529 Read Sub-Device Assignment	N					
Command 530 Write Sub-Device Assignment	Y					
Command 531 Transfer Live List to Assignment List	Y					

[112] 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
[113] idem

ANNEX B. REVISION HISTORY

B1. Changes from Revision 9.1 to 10.0

19 new commands have been added (along with several clarifications). Additions include

- Command 100 Write Primary Variable Alarm Code
- Support for Event Managers (Commands 514 and 515);
- Device location commands (Commands 516-521);
- Unit code expansion for flow meters (Command 522 plus proposed tables);
- Support for NAMUR NE107 Condensed Status (Commands 523-525); and
- Commands allowing status simulation (Commands 526 and 527)
- I/O System commands enabling the preconfiguring of Sub-Device Assignments (Commands 528-531)

Closed about 50 issues from HCFTracker

B2. Changes from Revision 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.

B3. Changes from Revision 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.

B4. Changes from Rev 7.1 to Rev 8.0

- 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.
- Added Recommended Use For HART Common Practice Commands section.
- Added Common Practice Trim Commands 80, 81, 82, and 83.
- Added Delayed Response Mechanism Commands 106.
- The descriptions of Command 111 and 112 were moved to the *Block Transfer Specification.*
- Added Command 113, Catch Device Variable.

- 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.
- Changed Command 41, Perform Self Test, to require use of DRM rather than busy.
- Reformatted title page and all tables.
- Changed "BEPROM" to "EEPROM" in Command 39.
- Changed "units as receivei" to "units as received" in Command 35.
- Changed "rounded dr" to "rounder or" in Command 40.
- Replaced all occurrences of "units of mifliampres" with "units of milliamperes".
- Changed "Slot *0, 3-bit" to "Slot 0, 8-bit" in Command 62.
- Replaced all occurrences of "Slot *2" with "Slot 2" and "Slot *3" with "Slot 3".
- 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.
- 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.
- 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.
- 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.
- Added recommendation for number of preambles to Command 59 and the warning that this command only applies to HART FSK.
- Fixed incorrectly scanned characters in Revision Notes.
- "This is a Data Link Layer command" was added to the description of Command 59.
- "This is a Primary Variable Range command" was added to the descriptions of Commands 35,36, and 37.
- "This is a Loop Current command" was added to the descriptions of Commands 40, 45 and 46.
- "This is a Device Management command" was added to the descriptions of Commands 38, 41, 42 and 48.
- "This is a Process Variable Mapping command" was added to the descriptions of Commands 50 and 51.
- "This is a Primary Variable command" was added to the descriptions of Commands 34, 43, 44 and 47.
- "This is a Device Variable command" was added to the descriptions of Commands 33, 52, 53 54, 55, 56, and 79.
- "This is an Analog Channel Support command" was added to the descriptions of Commands 60 and 62-70.
- "This is a Device Variable command" was added to the descriptions of Commands 33, 52, 53 54, 55, 56, and 79.

- Included Response Data Byte 21, Variable Classification, to Command 54 as part of Unit Codes expansion.

B5. 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.

B6. Changes from Rev 6.0 to Rev 7.0

- This revision adds commands for devices with Multiple Analog Outputs and Analog Outputs other than Current.
- Added Changes Pending note to the beginning of the document and "CHANGES PENDING" to the Transfer Service Commands.
- 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"
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"

Page	Line	Change	Text
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"
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".

Page	Line	Change	Text
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"
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"

Page	Line	Change	Text
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…"

B7. Major Modifications from Rev. 5 to Rev. 6

- A decimal point and integer was added to the HART document number.
- This revision adds Burst Mode and Unit Device commands.
- 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
- Added Command #57, Read Unit Tag, Descriptor, Date.
- Added Command #58, Write Unit Tag, Descriptor, Date.
- Added Command #59, Write Number of Response Preamble
- Added Command #108, Write Burst Mode Command Number.
- Added Command #109, Burst Mode Control
- Added Command #110, Read All Dynamic Variables.
- Added Command #111, Transfer Service Control.
- Added Command #112, Transfer Service.
- Increased the maximum Command-Specific Response Code number from 15 to 127 for all commands
- Moved Transmitter Fault from Command Error Summary Bit #4 to Command-Specific Response Code #16 and renamed it Access Restricted.
- 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.
- Changed most occurrences of "transmitter" to "device". (Refer to document Revision 6, D8900072, for detailed information).

B8. Major Modifications from Rev. 4 to Rev. 5

- This Revision incorporates Write Protect Mode and adds Transmitter Variable Commands
- Added Command #50, Read Dynamic Variable Assignments.
- Added Command #51, Write Dynamic Variable Assignments.
- Added Command #52, Set Transmitter Variable Zero.
- Added Command #53, Write Transmitter Variable Units.
- Added Command #54, Read Transmitter Variable Damping Value.
- Added Command #55, Write Transmitter Variable Damping Value.
- Added Command #56, Write Transmitter Variable Sensor Serial Number.

B9. Major Modifications from Initial Rev. 3 to Rev. 4

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