FLOWSERVE

USER INSTRUCTIONS

MX/QX HART Field Unit

FCD LMENIM2340-01 – 06/16

Installation
Operation
Maintenance

Experience In Motion

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1 Introduction

1.1 Purpose

This manual explains how to install and operate the MX/QX HART field unit. Actuators containing the HART field unit may be connected by a standard instrumentation twisted-pair cable to form a HART communication system network. The HART network employs a bi-directional communication protocol, operating at 1200 bits/sec, that provides data access between intelligent actuators and host control/monitoring systems. In addition to a digital signal, the network simultaneously provides a 4-20 mA analog signal that is proportional to the field unit's primary measured value. This system allows a host system such as a distributed control system (DCS) to control and monitor the actuators, including the acquisition of status and alarm data from each MX/QX.

1.2 How to Use This Manual

Each section provides the MX/QX HART user with information on installing and operating the MX/QX HART field unit.

Section	Title	Description
1	Introduction	Details user safety and knowledge requirements, system capabilities and features.
2	System Components	Focuses on the description of the HART system hardware and software components.
3	Installation and Configuration	Provides details for installing and configuring a field unit.
4	Associated Documents	Provides a list of documents on related subjects for additional MX/QX and HART system information.
5	How to Order Parts	This section provides part numbers and ordering contact information.
Appendix A	Wiring Diagram	Detail wiring connections to the MX/QX field unit.
Appendix B	HART Data Formats	Listing of HART parameters and descriptions.
Appendix C	Enumeration and Bit Field Tables	Explains field device bit masking information.
Appendix D	Setting Date and Time	Defines real-time clock configuration settings.
Appendix E	Command Response Codes	Listing of response codes for all universal and common HART commands.

1.3 User Safety

Safety notices in this manual detail precautions the user must take to reduce the risk of personal injury and damage to the equipment. The user must read and be familiar with these instructions before attempting installation, operation, or maintenance. Failure to observe these precautions could result in serious bodily injury, damage to the equipment, warranty void, or operational difficulty. User must follow local and state safety regulations.

Safety notices are presented in this manual in three forms:

☠ **WARNING:** Refers to personal safety. Alerts the user to potential danger. Failure to follow warning notices could result in personal injury or death.

⚠ **CAUTION:** Directs the user's attention to general precautions that, if not followed, could result in personal injury and/or equipment damage.

NOTE: Highlights information critical to the user's understanding of the operator's installation and operation.

1.4 User Knowledge

It is recommended that the user read this manual in its entirety before the MX/QX HART equipped actuator is installed and operated.

The user needs to have a fundamental knowledge of electronics and microprocessor concepts. An understanding of valve actuators and digital control systems is beneficial to the field unit user. Refer to the Glossary for terms used throughout this manual.

The following websites have documents on HART and electric actuators: www.hartcomm.org and www.flowserve.com

For HART technology and cabling information, refer to the following documents:

HART Communication Protocol Specification: **HCF_SPEC-13**
HART Communication FSK Physical Layer Specification: **HCF_SPEC-54**
HART Communication Command Summary Specification: **HCF_SPEC-99**
HART Communication Universal Command Specification: **HCF_SPEC-127**
HART Communication Common Practice Command Specification: **HCF_SPEC-151**
HART Communication Common Tables: **HCF_SPEC-183**

1.5 MX/QX HART System Capabilities and Features

Limitorque's HART field unit conforms to the HART Communication Protocol Specification (Document HCF_SPEC-13). The device is suitable for use on point-to-point and multi-drop network topologies. The communication system theoretically supports up to 26 actuators connected in a multi-drop network.

The MX/QX HART field unit fits in the actuator in the sealed electrical housing. Adjustments to the MX/QX HART settings must be made from the configuration SETUP menu.

The MX/QX HART field unit may command its actuator to:

Open
Stop
Close
Move to a set position
Perform an emergency shutdown operation
Read and control relays
Perform partial stroke test
Monitor analog inputs and position
Monitor modes and alarms

Commands to the unit come over the network from the host system, which may be:

- Personal Computer (PC)
- Distributed Control System (DCS)
- Programmable Logic Controller (PLC)
- Field Device Tool (FDT) w/Device Type Manager (DTM)
- Some other microprocessor-based device

A HART field device is an intelligent device within the actuator that can send multiple digital device variables to the control system over a 4-20 mADC analog signal loop. The device provides control and self-test capabilities, which allow abnormal conditions to be easily and immediately identified before an unplanned shutdown occurs.

Additional features and capabilities are:

- The system reduces the cost of wiring and installation – existing wiring and multi-drop connections can be used.
- The devices are interoperable – devices from different suppliers can communicate with one another on the same network.

1.5.1 General Network Specification

System Specifications:

Communications using the HART Communication Foundation Protocol

Network Specificationss:

- Point-to-point and multi-drop topologies
- Master/slave communication
- Simultaneous 1200 bps digital communication without 4-20 mADC signal interruption
- Up to two masters per network (primary and secondary)
- Burst mode for continuous message broadcasting

MX/QX HART Unit Specification:

The field unit mounts in the actuator and is software-controlled in order to allow functionality of:

- Dynamic Variables PV, SV, QV and TV
- Device Variables: Position Setpoint, Measured Position, Torque, Motor Temperature and Compartment Temperature
- Network Communication
- Device-Specific Commands

System Host Specifications:

The HART master is the network system host, and can be a personal computer (PC), distributed control system (DCS), programmable logic controller (PLC), or another microprocessor-based device. The HART protocol allows for up to two masters (primary and secondary) per network loop. Secondary masters, such as handheld communicators, can be used without interrupting communications between the primary master and field devices.

2 System Components and Installation

2.1 Introduction

This section is an overview of the components used in the HART system and their installation. The MX/QX HART unit is installed in the MX or QX actuator, as shown in Figures 2.1 and 2.2. The network cable connects to the HART unit at the actuator terminal block. The network cable connects to the distributed control system, which usually acts as the host.

2.2 Hardware

2.2.1 MX/QX Electronic Actuators

The MX/QX actuators control the opening and closing of valves. The MX is a multi-turn valve, while the QX is a quarter-turn valve actuator. Both actuators are designed for operation of ON-OFF and modulating valve applications.

The MX/QX features include the following:

- Non-intrusive setup
- Separately sealed terminal compartment
- Patented absolute encoder for valve position sensing (no battery required)
- Graphical LCD for indication and calibration
- Sophisticated electronic control, monitoring, and diagnostic capabilities with patented LimiGard™ technology

NOTE: Recommended storage procedures for the MX are detailed in Bulletin LMENIM2306, MX Maintenance and Spare Parts Manual. QX procedures are detailed in Bulletin LMENIM3306, QX Maintenance and Spare Parts Manual. Failure to comply with recommended procedures will void the warranty. For longer-term storage, contact Limitorque for procedure and recommendations.

Figure 2.1a – MX-05 Actuator

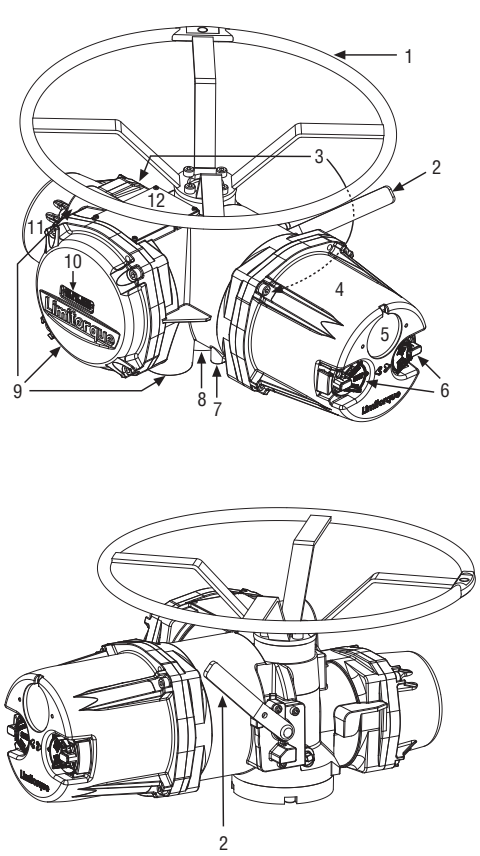


Figure 2.1b – QX-05 Actuator

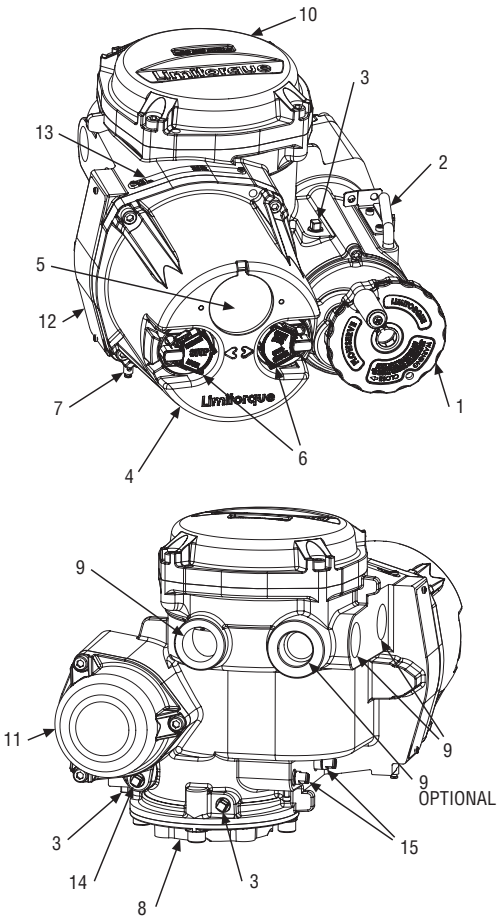


Table 2.1a – MX Actuator Components

Item	Description
1	Handwheel
2	Declutch lever
3	Oil fills (dotted arrow depicts fill on declutch side)
4	Controls compartment (field unit location)
5	LCD display
6	Control knobs
7	Ground lug
8	Thrust/torque base
9	Conduit entries
10	Terminal compartment
11	Electric motor
12	Nameplate

Table 2.1b – QX Actuator Components

Item	Description
1	Handwheel
2	Declutch lever (QX-05)
3	Oil fill
4	Controls cover
5	LCD display
6	Control knob
7	Ground lug
8	Baseplate
9	Conduit entry
10	Terminal compartment
11	Motor
12	Certification nameplate
13	Tag nameplate
14	Oil plug
15	Stem nut stops

2.2.2 MX/QX HART Interface Board

The MX/QX HART field unit interface board is installed in the actuator controls compartment (Figures 2.1 & 2.2 and Tables 2.1 & 2.2). This unit permits the actuator to be controlled by a DCS or other network host over the HART network.

The following commands and feedback information are transmitted through this unit:

- OPEN, CLOSE and STOP commands
- ESD (Emergency Shutdown) commands
- Partial Stroke Test commands
- Unit output torque (0-100% rating)
- Go-to-position commands
- Actuator status, alarm and diagnostic messages
- User analog input feedback

2.2.3 Network Host

The HART network is a master/slave communication protocol. Communication to each slave (MX/QX field device) is initiated by a master (system host device). Two masters can connect to each HART loop. Normally, the primary master is a DCS, PLC, or PC. If desired, a handheld communicator or PC can serve as the secondary master.

2.2.4 Network Cable

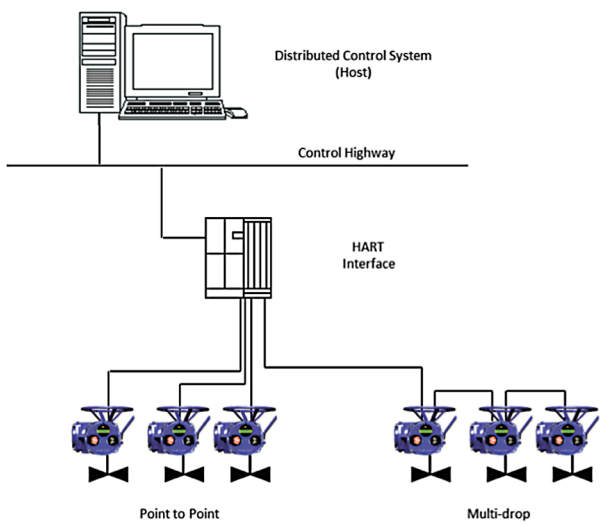
Network cabling should be in accordance with the HART Communication Foundation guidelines. In general, wiring for HART devices is the same as for conventional 4-20 mA instrumentation. It is recommended to use individually shielded twisted pair cable. The minimum conductor size is 0.51mm diameter (#24 AWG) for cable runs less than 1500 meters (5000 ft.), and 0.81mm diameter (#20 AWG) for distances up to the 3000 meter (10 000 ft.) theoretical limit for HART communication. Please note that the electrical characteristics of the cable, especially capacitance, and the number of network field devices can affect the maximum allowable cable length.

To prevent signal loop interference, tie all cable shields together and ground at only one point.

2.2.5 Typical HART Network Configuration

A typical MX/QX HART system is shown below:

Figure 2.2 – Typical HART System With a DCS Host



2.3 Network Cabling Topologies

There are two main topologies for MX/QX HART networks:

Point-to-point One field device connected to the bus (network)

Figure 2.3 – Point-to-Point Topology (Host Powered)

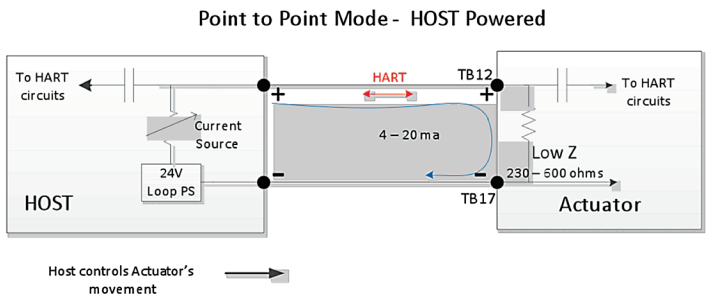
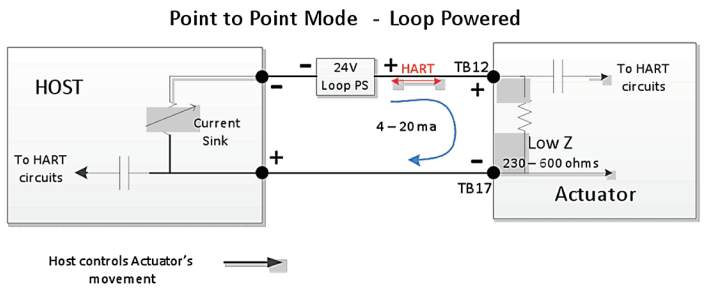


Figure 2.4 – Point-to-Point Topology (Loop Powered)



Multi-drop Multiple field devices connected to the bus (network)

Figure 2.5 – Multi-drop Topology (Host Powered)

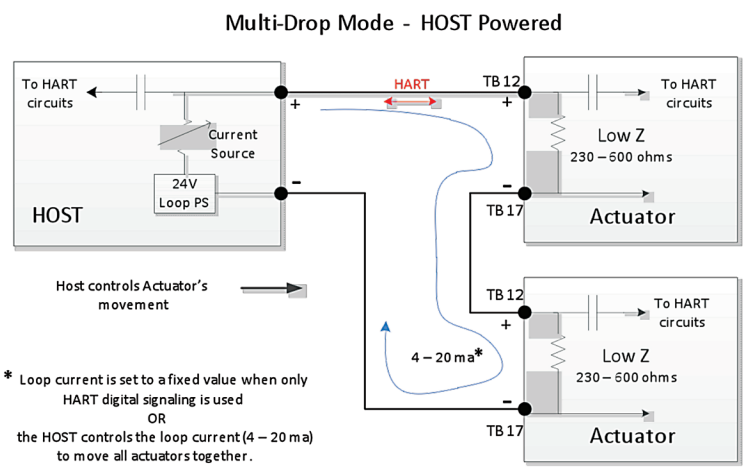
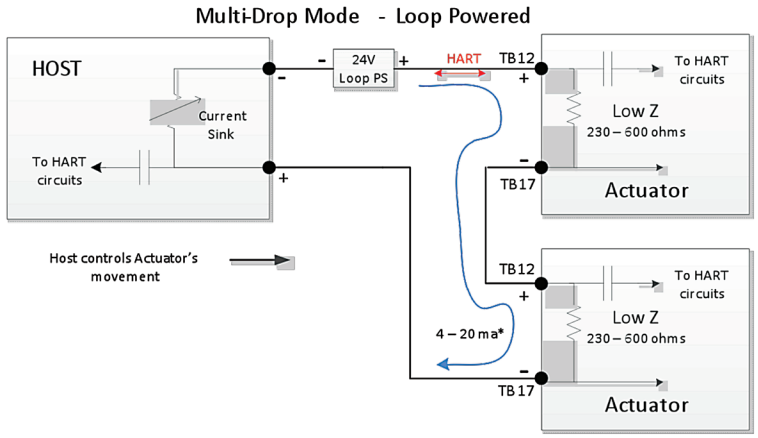


Figure 2.6 – Multi-drop Topology (Loop Powered)



2.4 Site and Network Cable Preparation

2.4.1 Site Preparation

Prepare the site and associated equipment for operation of the MX/QX HART actuators as follows:

1. Prepare a detailed site plan consisting of the following:
   - Actuator locations and tag numbers
   - Junction boxes, terminal strip locations and tag numbers
   - Power supplies/conditioners
   - Provide free access to the MX/QX control panel and terminal block for setup, configuration and troubleshooting.
2. Prepare the cable and label all wires.
3. Install power and control wires in separate conduits.
4. Install and verify earth grounds. The cable shields should be tied together and grounded at only one point. The single ground point is typically located at or near the system host device.

2.4.2 Network Cable Preparation

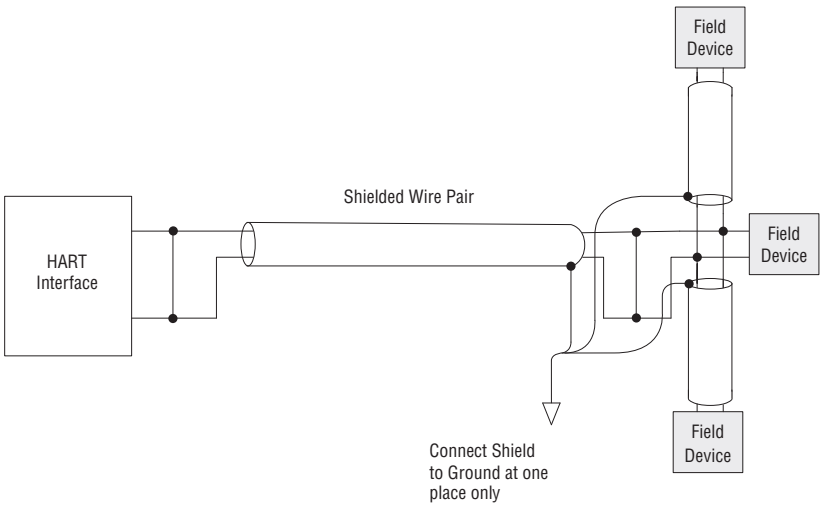
Care must be taken during cable preparation:

- When stripping the insulation, use wire strippers that do not nick the wire.
- Use crimp ferrules to prevent stranded wires from getting loose and shorting to other wires.
- Use vibration-resistant wiring terminals that hold the ferrule securely.

2.4.2.1 Network Cable Connection to the MX/QX HART Unit

The field device is connected to the network through the MX/QX terminal block. The network cable is connected to the terminal block shown in Figure 2.7.

Figure 2.7 – Connecting Network Cable to MX/QX Terminal Block



Connect the network cables to the MX/QX terminal block as shown in Figures 2.3 – 2.6. Refer to Appendix A for unit wiring diagram.

Connect the cable shields to each other inside the unit. Do not connect them to the unit in any way. The network shield should be grounded at only one place in the network. If it is desired to ground the entire network shield at the actuator, then install a jumper cable from terminal 3 to earth ground or ground lug.

NOTE: The MX/QX HART device is sensitive to polarity. The cables should be labeled to indicate polarity, and polarity should be maintained through all connection points.

2.5 MX/QX HART Device Installation and Setup

2.5.1 MX/QX HART Device Installation

The MX/QX HART field unit is located in the controls compartment. It has four standoffs and mounts on top of the main processor board. Multiple Input/Output (I/O) option boards may also be present. If present, the I/O board will be on top of the MX/QX HART unit. For installation instructions, refer to the MX Maintenance and Spare Parts Manual, LMENIM2314 or the QX Maintenance and Spare Parts Manual, LMENIM3314.

2.5.2 MX/QX HART Device Setup

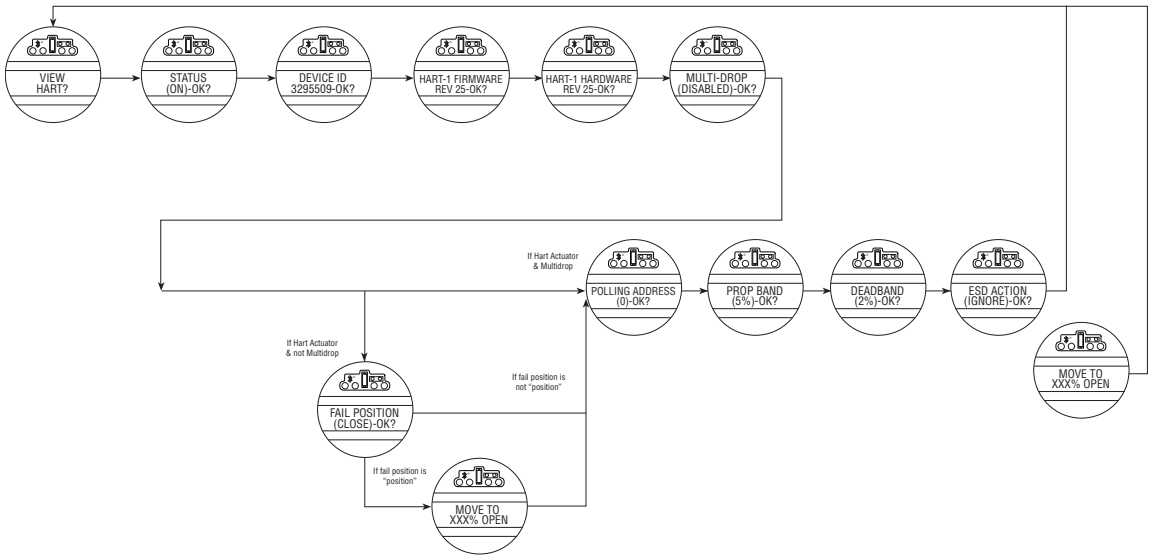
The MX/QX HART option enables the actuator to be controlled by a HART communications signal. If the option has been purchased, it is automatically enabled.

NOTE: If the HART option has not been purchased, the screens for changing HART will not be available. To add the HART option, please consult Limitorque service at (434) 528-4400.

Figure 2.8 illustrates the setup sequence. For proper operation, the correct mode must be selected.

To set up the MX or QX HART device, enter the Setup mode as detailed in Installation and Operation Manual Bulletins LMENIM2306 for the MX and LMENIM3306 for the QX;

Figure 2.8 – MX/QX HART Setup Sequence



NOTE: This menu is displayed after the actuator and HART board have been powered up together at least one time.

1. Proceed through Setup to the CHANGE HART? display. Select YES to get to the STATUS display.
2. STATUS enables the user to change from the default condition to turn on and off the network control capability of the actuator. Select NO to change the setting or YES to get to the next display. (Default = ON)
3. MULTI-DROP (ENABLED) or (DISABLED) allows the user to select the desired network topology. To change the setting, select NO until the required option is displayed. Select YES if the setting is correct to go to the next display.

NOTE: Changing the topology also requires that the network be wired correctly for the selected topology.

NOTE: If MULTI-DROP ENABLED was chosen, skip to step 5. Otherwise, FAIL POSITION display is shown. In multi-drop mode the input is digital only (write PV over network), so there is no analog fail action.

4. FAIL POSITION allows the user to configure the action desired upon loss of the analog input signal. The selections are CLOSE, OPEN, STOP and POSITION. Select the desired setting and proceed to the next display.

NOTE: If POSITION is chosen as the action, a MOVE TO display will be shown where the user can select the desired position between 0 and 100% open, in one percent increments, by selecting NO until the desired position is selected. Select YES once the setting is correct to go to the next display.

5. POLLING ADDRESS allows the user to set the HART polling address of the unit. Point-to-Point units are typically set to address 0, and Multi-drop units are typically set from 1-63. HART 5 masters will always set Point-to-Point units to address 0.
6. SAVE SETTINGS allows the user to save the settings and make them active. This can result in a change in the hardware configuration on the HART board to support the change in configuration. Select NO to return to STATUS (step 2) and change settings. Select YES to save the HART configuration settings and go to additional network settings.

NOTE: The configuration set in steps 1-6 will not be saved if the user does not select YES for SAVE SETTINGS.

7. CHANGE PROP/DEADBAND allows for the setting of proportional band and deadband. Proportional band is the range of errors between the position and demand signal that will produce reduced speed (pulsing). The default value is 5%. To change from default, select NO until the required value is displayed. The value is adjustable between 1% and 100%, in 1% increments. The default deadband value is 2%. For error signals less than this, no motion occurs. The deadband should be wide enough to prevent "hunting" of the actuator but as low as possible to give adequate response to changes in the error signal. To change from the default, select NO to adjust the value between 1% and 50%, in 1% increments to suit the application.
8. ESD ACTION allows a network ESD function to be enabled after the ESD configuration has been established for the unit. This network ESD can be selected to do one of the following: ignore the command (NONE), CLOSE, OPEN, STOP or POSITION the actuator. To change from the default setting, select NO until the required option is displayed. Select YES if the setting is correct to go to the next display.

NOTE: If POSITION is chosen as the action, a MOVE TO display will be shown where the user can select the desired position between 0 and 100% open, in one percent increments, by selecting NO until the desired position is selected. Select YES once the setting is correct to go to the next display.

2.6 Installation Verification

2.6.1 Network Cabling Installation Verification

After installation is complete and prior to operation, inspect the network cable and its connection to each field device.

NOTE: Units should be disconnected from power. The network should be disconnected from the host device.

Check for the following:

1. There should not be:
   - Nicks in the insulation - this can cause a short to the grounded shield.
   - Cut strands in a stranded conductor - this can cause a poor connection and eventually an open circuit.
2. The shield/drain wire should only be grounded at one point in the segment to avoid ground loop problems.
3. The ground/earth connection should be at true ground potential and effective at all times. See step No. 5 in Section 2.4.1, Site Preparation.

2.6.2 MX/QX HART Device Installation Verification

Verify the field device is installed as follows:

1. Enter the Setup mode as detailed in Installation and Operation Manual Bulletins LMENIM2306 for the MX or LMENIM3306 for the QX.
2. In the Setup mode, use the black control knob to select YES to the main menu selection. VIEW DIAGNOSTICS?
3. Select YES to the display VIEW HARDWARE STATUS?
4. Select YES to scroll through the menu selections. The LCD will read HART BOARD 1 (OK) - NEXT? if installed.

NOTE: If the HART BOARD 1 (OK)? does not appear, contact Limitorque for assistance.

5. To return to the normal display, use the black knob to select either LOCAL or REMOTE.

2.7 Configuration Confirmation

Field device operation cannot be verified until the complete HART system is operational. However, routine checks can be performed to verify many functions.

2.7.1 Checking Connections

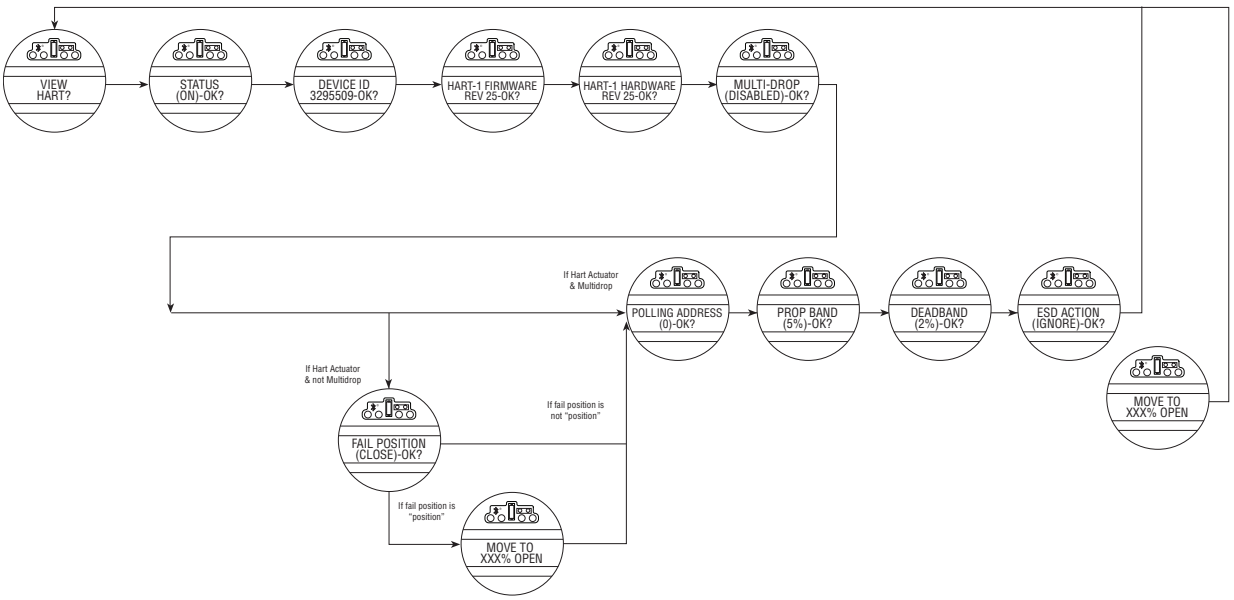
Verify that all connections, including data wires, shield ground, digital inputs (optional), digital outputs (optional), and analog inputs are in accordance with MX/QX wiring diagrams and MX/QX HART device diagrams in Appendix A.

2.7.2 View Settings

Refer to Installation and Operation Manual Bulletins LMENIM2306 for the MX and LMENIM3306 for the QX to access the view settings menu. Verify the settings as follows:

1. From the VIEW SETTINGS display, scan to the VIEW HART? display
2. From VIEW HART? display, select YES and check that the HART status is ON. This confirms that HART is enabled.
3. From HART STATUS display, select YES to go to next display, which is DEVICE ID. This is the Unique Device ID of the HART device.
4. If the MX/QX contacts are to be controlled via the network to control external equipment, from the VIEW HART? display, select NO and obtain the VIEW STATUS AND ALARM CONTROL? display. Verify that the digital outputs, S1a, S1b, S2a, S2b are set for “Network” controlled.

Figure 2.9 – MX/QX HART View Settings Sequence

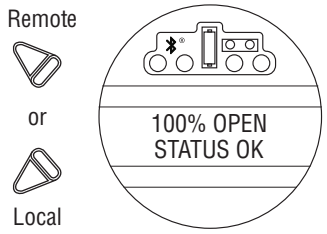


2.7.3 Checking the Normal Display

Place the selector switch in LOCAL or REMOTE position. The valve position will be indicated at the top of the LCD. STATUS OK or HARDWARE FAILURE should be indicated at the bottom of the LCD display.

- If STATUS OK is displayed, then the HART board hardware is OK.
- If HARDWARE FAILURE and HART-1 FAILED or HART-1 NOT PRESENT is displayed, no communication is occurring. This could be due to a number of factors. Check all local connections and configurations. If these are correct and the HARDWARE FAILURE is still displayed, then the solution to this problem must await full system commissioning.

Figure 2.10 – Normal Display



2.8 MX/QX HART Device Description and Device Type Manager Files

In the Host system, the configuration device can use Device Description (DD) files to configure a HART system without having the devices online. Please refer to your host system documentation for the files that are needed. The Device Type Manager (DTM) file provides an interface between the actuator's specific application software and a Network Host Station's Field Device Tool (FDT) frame. The DTM can be integrated into FDT frame applications to allow users to perform offline and online parameterization, configuration, and status and diagnostic retrieval. The DD files are downloaded from the HART Communication Foundation website (www.hcfcomm.org) into the DCS workstation or host device.

In addition, the DD and DTM files can be downloaded from the Flowserve Limitorque website: www.flowserve.com

3 Software

3.1 HART Protocol

The system uses the HART protocol to communicate over the HART network with other HART devices. The HART protocol is a master/slave communication service for process control devices. HART digital signaling is an extension of conventional analog signaling allowing the network signal to ride on the 4-20 mADC analog process signal. It uses 1200 bps binary phase-continuous Frequency-Shift-Keying (FSK), where a high frequency current is superimposed on a low-frequency (typically 4-20 mADC) analog current.

3.2 HART Parameters

Table 3.1 – HART Parameters

Parameter	Value
HART Version	7.3
Expanded Device Type = Manufactuer ID + Device Type	0x3008
Physical Layer Supported	FSK
Physical Device Catagory	Actuator
Maximum Number of Burst Messages	3
Maximum Number of Event Messages	1
Size of the Event Queue	6
Maximum Number of Trends	2
Size of the Trend Buffer	12
Default Number of Preambles[1]	5

3.2.1 Analog Input Ratings

Table 3.2 – Analog Input Ratings

Maximum current[2]	30.0 mA
Maximum voltage	50 V
Current over-range (Primary Variable Out of Limits)	
	Analog Input > 21 mA
	Analog Input < 3 mA (HART communication may fail, if Analog Input <2 mA.)
Multi-drop current draw	Approximately 2 mA

1. Field Device must have minimum 5 preambles, and maximum 20 preambles.
2. The analog input is automatically bypassed, if the maximum loop current is reached. The field device will continue to check the circuit for overload on a periodic basis, and will restore the connection if the overload clears.

3.2.2 Field Device Status

The Field Device Status is contained in the second data byte in a Slave-to-Master frame as a bit field table. It indicates the current operating status of the field device as a whole and is not associated with the completion of any command.

Table 3.3 – Field Device Status

Bit Mask	Description
0x01	**Primary Variable Out of Limits** – The PV is beyond its operating limit.
0x02	**Non-Primary Variable Out of Limits** – A device variable not mapped to PV is beyond its operating limits.
0x04	**Loop Current Saturated** – The loop current has reached its upper (or lower) endpoint limit and cannot increase (or decrease) any further.
0x08	**Loop Current Fixed** – The loop current is being held at a fixed value and is not responding to process variations.
0x10	**More Status Available** – More status information is available via Command 48, Read Additional Status Information.
0x20	**Cold Start** – A power failure or Device Reset has occurred.
0x40	**Configuration Changed** – An operation was performed that changed the device's configuration.
0x80	**Device Malfunction** – The device detected a serious error or a failure that compromises device operation.

3.3 Dynamic Variables

The Limitorque HART actuator device supports the following Dynamic Variables:

Table 3.4 – Supported Dynamic Variables

Variable Code	Variable	Direction	Physical Interface
0	PV (Primary Variable)	input	Analog current input – Analog Channel 0
1	SV (Secondary Variable)	output	None
2	TV (Tertiary Variable)	output	None
4	QV (Quaternary Variable)	output	None

3.4 Device Variables

3.4.1 Supported Device Variables

The Limitorque HART actuator device supports the following Device Variables:

Table 3.5 – Supported Device Variables

Variable Code	Variable	Direction	Unit Code	Device Variable Classification	Device Variable Family	Range
0	Position setpoint	input	% (57)	Not Classified (0)	Valve/Actuator (6)	0-100
1	Current position	output	% (57)	Not Classified (0)	Not Used (250)	0-100
2	Torque	output	% (57)	Not Classified (0)	Not Used (250)	0-100
3	Motor temperature	output	°C (32), °F (33)	Temperature (64)	Not Used (250)	Not Limited
4	Compartment temperature	output	°C (32), °F (33)	Temperature (64)	Not Used (250)	Not Limited

3.4.2 Device Variable Mapping

Device Variables may be mapped to the Dynamic Variables according to the following table:

Table 3.6 – Mapping of Device Variables to Dynamic Variables

Variable Code	Dynamic Variable	Direction	Default Device Variable	Device Variables which may be mapped to the Dynamic Variable
0	PV	input	Position Setpoint	Position Setpoint
1	SV	output	Current Position	Current Position or Torque
2	TV	output	Motor Temperature	Current Position, Torque, Motor Temperature or Compartment temperature
3	QV	output	Compartment Temperature	Current Position, Torque, Motor Temperature or Compartment temperature

No single Device Variable may be mapped to more than one Dynamic Variable.

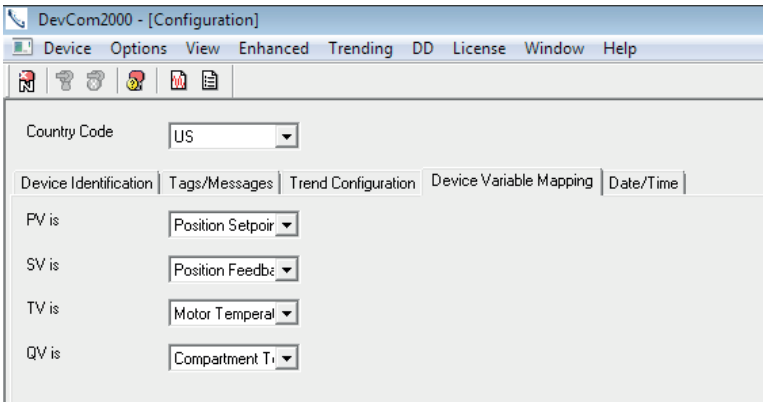
For Example:

Valid Mapping:
PV = DV0
SV = DV1
TV = DV3
QV = DV4

Invalid Mapping:
PV = DV0
SV = DV1
TV = DV1
QV = DV4

If you try to map two Dynamic Variables to the same Device Variable, the command will return response code 2 “invalid selection”. The Device Variables may be mapped from the DD menu Device Setup->Wired HART Board->Configuration-> Device Variable Mapping as follows:

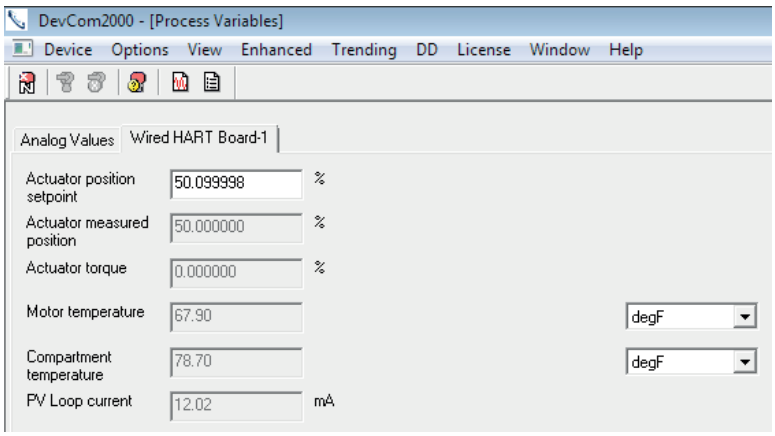
Figure 3.1 – Device Variable Mapping Setup



3.4.3 Device Variable Units

Device Variables 0, 1, and 2 have fixed units that may not be changed. Device Variables 3 and 4 have units that may be interchanged between °C and °F the default is °F. For Device Variables 3 and 4, the units may be changed from the DD menu Process Variables->Wired HART Board as follows:

Figure 3.2 – Device Variable Units



3.5 Supported HART Commands

The following Universal and Common HART commands are supported by the Limitorque MX/QX HART device. See Appendix B for more information on HART data formats such as: Packed, Latin-1, Date and Time. See Appendix C for more information on "Enum" or "Bits" formats. See Appendix E for more information on valid Response Codes for each command.

3.5.1 Universal Commands

Table 3.7 – HART Universal Commands

Command		Request Data Bytes			Response Data Bytes		
No.	Description	Byte	Format	Description	Byte	Format	Description
0	Read Unique Identifier				0 1-2 3 4 5 6 7 7 8 9-11 12 13 14-15 16 17-18 19-20 21	Unsigned-8 Enum Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-5 Enum Bits Unsigned-24 Unsigned-8 Unsigned-8 Unsigned-16 Bits Enum Enum Enum	254" Expanded Device Type = 0x3008 Min. number of request preambles = 5 HART Protocol Major Rev. = 7 Device Rev. Level Software Rev. Level (5 MSB) Hardware Rev. Level (3 LSB) Physical Signaling Code=0 Device Flag Assignment = 1 Device ID (unique for given device type) Min. number of response preambles=5 Max. number of device variables = 5 Configuration Change Counter Extended Field Device Status: 0=OK, 1=Maintenance req'd, 2=Device Alert Manufacturer Identification Code = 0x0030 Private Label Distributor Code = 0x0030 Device Profile = 1
1	Read Primary Variable				0 1-4	Enum Float	Primary Variable Units = 57 (%) Primary Variable
2	Read Loop Current And Percent Of Range				0-3 4-7	Float Float	Primary Variable Loop Current (mA) Primary Variable % Of Range
3	Read Dynamic Variables And Loop Current				0-3 4 5-8 9 10-13 14 15-18 19 20-23	Float Enum Float Enum Float Enum Float Enum Float	Primary Variable Loop Current (mA) Primary Variable Unit Code Primary Variable Secondary Variable Unit Code Secondary Variable Tertiary Variable Units Code Tertiary Variable Quaternary Variable Unit Code Quaternary Variable
6	Write Polling Address	0 1	Unsigned-8 Enum	Polling Address of Device Loop Current Mode	0 1	Unsigned-8 Enum	Polling Address of Device (0-63) Loop Current Mode
7	Read Loop Configuration				0 1	Unsigned-8 Enum	Polling Address of Device (0-63) Loop Current Mode

Command		Request Data Bytes			Response Data Bytes		
No.	**Description**	**Byte**	**Format**	**Description**	**Byte**	**Format**	**Description**
8	Read Dynamic Variable Class		Read Dynamic Variable Class		0 1 2 3	Enum Enum Enum Enum	Primary Variable Class Secondary Variable Class Tertiary Variable Class Quaternary Variable Class
9	Read Device Variables with Status	0 1 2 3 4 5 6 7	Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8	Slot 0: Device Variable Code Slot 1: Device Variable Code Slot 2: Device Variable Code Slot 3: Device Variable Code Slot 4: Device Variable Code Slot 5: Device Variable Code Slot 6: Device Variable Code Slot 7: Device Variable Code	0 1 2 3 4-7 8 9 10 11 12-15 16 17 18 19 20-23 24 25 26 27 28-31 32 33 34 35 36-39 40 41 42 43 44-47 48 49 50 51 52-55 56 57 58 59 60-63 64 65-68	Bits Unsigned-8 Enum Enum Float Bits Unsigned-8 Enum Enum Float Bits Unsigned-8 Enum Enum Float Bits Unsigned-8 Enum Enum Float Bits Unsigned-8 Enum Enum Float Bits Unsigned-8 Enum Enum Float Bits Unsigned-8 Enum Enum Float Bits Time	Extended Field Device Status: 0=OK, 1=Maintenance req'd, 2=Device Alert Slot 0: Device Variable Code Slot 0: Device Variable Classification Slot 0: Units Code Slot 0: Device Variable Value Slot 0: Device Variable Status Slot 1: Device Variable Code Slot 1: Device Variable Classification Slot 1: Units Code Slot 1: Device Variable Value Slot 1: Device Variable Status Slot 2: Device Variable Code Slot 2: Device Variable Classification Slot 2: Units Code Slot 2: Device Variable Value Slot 2: Device Variable Status Slot 3: Device Variable Code Slot 3: Device Variable Classification Slot 3: Units Code Slot 3: Device Variable Value Slot 3: Device Variable Status Slot 4: Device Variable Code Slot 4: Device Variable Classification Slot 4: Units Code Slot 4: Device Variable Value Slot 4: Device Variable Status Slot 5: Device Variable Code Slot 5: Device Variable Classification Slot 5: Units Code Slot 5: Device Variable Value Slot 5: Device Variable Status Slot 6: Device Variable Code Slot 6: Device Variable Classification Slot 6: Units Code Slot 6: Device Variable Value Slot 6: Device Variable Status Slot 7: Device Variable Code Slot 7: Device Variable Classification Slot 7: Units Code Slot 7: Device Variable Value Slot 7: Device Variable Status Slot 7 data time stamp
11	Read Unique Identifier Associated With Tag	0-5	Packed	Tag	0 1-2 3 4 5 6 7 7 8 9-11 12 13 14-15 16 17-18 19-20 21	Unsigned-8 Enum Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-5 Enum Bits Unsigned-24 Unsigned-8 Unsigned-8 Unsigned-16 Bits Enum Enum Enum	"254" Expanded Device Type = 0x3008 Min. number of request preambles = 5 HART Protocol Major Rev. = 7 Device Rev. Level Software Rev. Level (5 MSB) Hardware Rev. Level (3 LSB) Physical Signaling Code=0 Device Flag Assignment = 0 Device ID (unique for given device type) Min. number of response preambles=5 Max. number of device variables = 5 Configuration Change Counter Extended Field Device Status: 0=OK, 1=Maintenance req'd, 2=Device Alert Manufacturer Identification Code = 0x0030 Private Label Distributor Code = 0x0030 Device Profile = 1
12	Read Message				0-23	Packed	Message
13	Read Tag, Descriptor, Date				0-5 6-17 18-20	Packed Packed Date	Tag Descriptor Date Code
14	Read Primary Variable Transducer Information				0-2 3 4-7 8-11 12-15	Unsigned-24 Enum Float Float Float	Transducer Serial Number Transducer Limits and Minimum Span Units Code = 57 (%) Upper Transducer Limit Lower Transducer Limit Minimum Span
15	Read Device Information				0 1 2 3-6 7-10 11-14 15 16 17	Enum Enum Enum Float Float Float Enum Enum Bits	PV Alarm Selection Code = 250 (not used) PV Transfer Function Code = 0 (Linear) PV Upper and Lower Range Values Units Code PV Upper Range Value PV Lower Range Value PV Damping Value (seconds) Write Protect Code = 251 (none) Reserved = 250 (not used) PV Analog Channel Flags = 0x01

Command		Request Data Bytes			Response Data Bytes		
No.	**Description**	**Byte**	**Format**	**Description**	**Byte**	**Format**	**Description**
16	Read Final Assembly Number				0-2	Unsigned-24	Final Assembly Number
17	Write Message	0-5 6-17 18-20	Packed Packed Date	Tag Descriptor used by the master for record keeping A date code used by the master for record keeping (E.G. Last or Next Calibration Date)	0-23	Packed	Message String
18	Write Tag, Descriptor, Date	0-5 6-17 18-20	Packed Packed Date	Tag Descriptor used by the master for record keeping A date code used by the master for record keeping (E.G. Last or Next Calibration Date)	0-5 6-17 18-20	Packed Packed Date	Tag Descriptor Date Code
19	Write Final Assembly Number	0-2	Usigned-24	Final Assembly Number	0-2	Usigned-24	Final Assembly Number
20	Read Long Tag				0-31	Latin-1	Long Tag
21	Read Unique Identifier Associated With Long Tag	0-31	Latin-1	Long Tag	0 1-2 3 4 5 6 7 7 8 9-11 12 13 14-15 16 17-18 19-20 21	Unsigned-8 Enum Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-5 Enum Bits Unsigned-24 Unsigned-8 Unsigned-8 Unsigned-16 Bits Enum Enum Enum	"254" Expanded Device Type = 0x3008 Min. number of request preambles = 5 HART Protocol Major Rev. = 7 Device Rev. Level Software Rev. Level (5 MSB) Hardware Rev. Level (3 LSB) Physical Signaling Code=0 Device Flag Assignment = 0 Device ID (unique for given device type) Min. number of response preambles=5 Max. number of device variables = 5 Configuration Change Counter Extended Field Device Status: 0=OK, 1=Maintenance req'd, 2=Device Alert Manufacturer Identification Code = 0x0030 Private Label Distributor Code = 0x0030 Device Profile = 1
22	Write Long Tag	0-31	Latin-1	Long Tag	0-31	Latin-1	Long Tag
38	Reset Configuration Changed Flag	0-1	Usigned-16	Configuration Changed Counter[3]	0-1	Usigned-16	Configuration Changed Counter[3]
48	Read Additional Device Status	0-5 6 7 8 9 10 11 12 13 14-21[4]	Bits Bits Bits Bits Bits Bits Bits Bits Bits Bits	Device-Specific Status 0 Extended Device Status Device Operating Mode Standardized Status 0 Standardized Status 1 Analog Channel Saturated Standardized Status 2 Standardizes Status 3 Analog Channel Fixed Device-Specific Status 1	0-5 6 7 8 9 10 11 12 13 14-21	Bits Bits Bits Bits Bits Bits Bits Bits Bits Bits	Device-Specific Status 0 Hardware Faults bytes 0-3 Main Board Status bytes 4-5 Extended Device Status Device Operating Mode Standardized Status 0 Standardized Status 1 Analog Channel Saturated Standardized Status 2 Standardizes Status 3 Analog Channel Fixed Device-Specific Status 1 Hardware Warnings bytes 14-17 Device Status bytes 18-21 Not Used bytes 22-24)[4]

3.5.1.1 Command 48 Data

The "More Status Available" bit in Device Status will be set if any bit in the following command 48 data is set, which previously was not set:

- DeviceSpecificStatus_0 (bytes 0-3 only – hardware faults)
- ExtendedDeviceStatus
- StandardizedStatus
- AnalogChannelSaturated
- AnalogChannelFixed
- DeviceSpecificStatus_1 (bytes 14-17 – hardware warnings)
- DeviceSpecificStatus_1 (Bits 6,7 & 14: Local Knob in LOCAL, Local Knob in STOP, CSE is in Local/Stop)

NOTE: DeviceSpecificStatus_0, bytes 4-5 (main board status information) is provided only for additional information but these bits will not trigger More Status Available, as these are not considered faults or warnings. DeviceSpecificStatus_1, bytes 18-21 (device status information) is provided only for additional information but these bits will not trigger More Status Available, as these are not considered faults or warnings.

3. Upon receiving this command the device shall compare the counter value received in this command with the device's current value. If they do not match then the device will return Response Code 9 "configuration change counter mismatch" and not reset the configuration change counter.
4. HART specification allows up to 25 bytes for this command. However, it also states that "the response data bytes returned are truncated after the last status byte supported by the Field Device". Therefore we only return 22 bytes of data in our response. If the master sends a request with more than 22 bytes of data, our device will still respond, but the extra bytes beyond those supported will be ignored

Command 48 can also be used to clear the “More Status Available”. When the device receives command 48 it compares the Request Data Bytes to the current value; if there is an exact match it clears the “More Status Available bit corresponding to the requesting device (Primary Master, Secondary Master, Gateway, etc.). If there is not an exact match or too few bytes are received then the More Status Available bit remains unchanged. Extra Bytes beyond those supported by the device are ignored.

Table 3.8 HART Defined Status Bits

Extended Device Status (Common Table 17)		Supported
Bit	**Description**	
0	Maintenance Required	Yes
1	Device Variable Alert	No
2	Critical Power Failure	No
3	Failure	No
4	Out of Specification	No
5	Function Check	No
6	-	
7	-	

Standardized Status 0 (Common Table 29)		Supported
Bit	**Description**	
0	Device Variable Simulation Active	No
1	Non-Volatile Memory Defect	Yes
2	Volatile Memory Defect	No
3	Watchdog Reset Executed	Yes
4	Power Supply Conditions Out of Range	No
5	Environmental Conditions Out of Range	No
6	Electronic Defect	No
7	Device Configuration Locked	Yes

Analog Channel Saturated (Common Table 27)		Supported
Bit	**Description**	
0	Analog Channel 1	Yes
1	Analog Channel 2	No
2	Analog Channel 3	No
3	Analog Channel 4	No
4	-	
5	-	
6	-	
7	-	

Analog Channel Fixed (Common Table 28)		Supported
Bit	**Description**	
0	Analog Channel 1	Yes
1	Analog Channel 2	No
2	Analog Channel 3	No
3	Analog Channel 4	No
4	-	
5	-	
6	-	
7	-	

Table 3.9 MX/QX Defined Status Bits

Device-Specific Status 0 – CMD 48 Bytes 0-3 : Hardware Faults	
Bit	**Description**
	Hardware Faults – these bits will trigger More Status Available bit
0	Main board to HART board communication loss
1	Reserved
2	Valve Jam
3	Over Torque in Close direction
4	Over Torque in Open direction
5	Phase Lost
6	Motor Temperature
7	Encoder Fault
8	Main board RAM error
9	Main board FLASH error
10	Main board EEPROM error
11	Reserved
12	Knob Failure
13	Limigard Fault
14	Contactor Fault
15	Power Board
16	Digital Out Board 1 (R1-R4 & RM) board fault
17	Digital Out Board 2 (R5-R8) board fault
18	Reserved
19	Analog Board 2 Fault
20	Reserved
21	Reserved
22	Motor Controller Fault
23	Reserved
24	Oil Over Temperature (arctic units)
25	Close Torque Timer Expired
26	Open Torque Timer Expired
27	HART Board 1 Fault
28	Reserved
29	HART Board 1 memory fault
30	Reserved
31	Future

Device-Specific Status 0 – CMD 48 Bytes 4-5 : Main Board Status	
	Main Board Status – these bits will not trigger More Status Available bit
0	Main board Self-test Ongoing (1=ongoing, 0=finished)
1	Main board Self-test Ok (1=succeeded, 0=failed; only valid if “Self-test ongoing = 0”
2	Future
3	Future
4	Future
5	Future
6	Future
7	Future
8	Future
9	Future
10	Future
11	Future
12	Future

13	Future
14	Future
15	Future

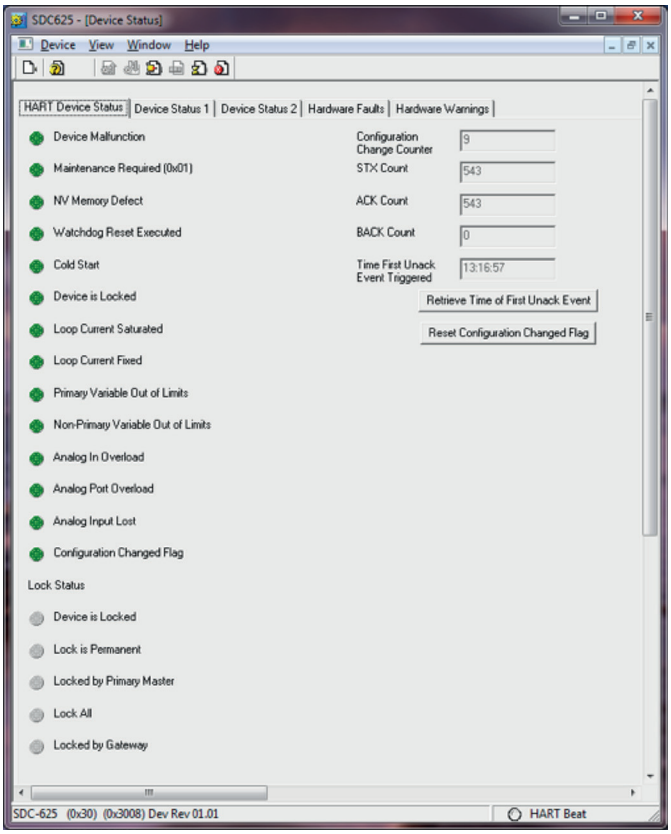
Device-Specific Status 1 – CMD 48 Bytes 14-17 : Hardware Warnings	
Bit	**Description**
Hardware Warnings – these bits will trigger More Status Available bit	
0	Phase Sequence Reversed
1	Encoder Warning
2	Motor Temperature Warning
3	Analog Input 1 Lost (main board mA input)
4	Analog Input 2 lost (Hart board 1 mA input)
5	Reserved
6	Maintenance Required
7	Modulating Position Control (MPC) Halted
8	Future
9	Future
10	Future
11	Future
12	Future
13	Future
14	Future
15	Future
16	Future
17	Future
18	Future
19	Future
20	Future
21	Future
22	Future
23	Future
24	Future
25	Future
26	Future
27	Future
28	Future
29	Future
30	Future
31	Future

Device-Specific Status 1 – CMD 48 Bytes 18-21 : Device Status	
Bit	**Description**
	Device Status – these bits will not trigger More Status Available bit
0	Valve Fully Open
1	Valve Fully Closed
2	Stopped in Mid-Travel
3	Opening Remotely
4	Closing Remotely
5	Local Knob in REMOTE
6	Local Knob in LOCAL
7	Local Knob in STOP
8	Opening in Local mode
9	Closing in Local mode

10	Open Inhibit Active
11	Close Inhibit Active
12	ESD Conflict
13	Inhibit Conflict
14	CSE is in Local/Stop
15	Network ESD Active
16	Local ESD Active
17	Valve Manually Moved
18	Open Torque Switch
19	Open Limit Switch
20	Close Torque Switch
21	Close Limit Switch
22	Reserved
23	In Remote Configuration Mode
24	Future
25	Future
26	Future
27	Future
28	Future
29	Future
30	Future
31	Future

The command 48 diagnostic data can be viewed from the DD menu Diagnostics->Information->Device Status as follows:

Figure 3.3 – HART Diagnostics Data



3.5.2 Common Commands

Table 3.10 Common Commands

Command		Request Data Bytes			Response Data Bytes		
No.	Description	Byte	Format	Description	Byte	Format	Description
33	Read Device Variables	0 1 2 3	Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8	Slot 0: Device Variable Code Slot 1: Device Variable Code Slot 2: Device Variable Code Slot 4: Device Variable Code	0 1 2-5 6 7 8-11 12 13 14-17 18 19 20-23	Unsigned-8 Enum Float Unsigned-8 Enum Float Unsigned-8 Enum Float Unsigned-8 Enum Float	Slot 0: Device Variable Code Slot 0: Units Code Slot 0: Device Variable Value Slot 1: Device Variable Code Slot 1: Units Code Slot 1: Device Variable Value Slot 2: Device Variable Code Slot 2: Units Code Slot 2: Device Variable Value Slot 3: Device Variable Code Slot 3: Units Code Slot 3: Device Variable Value
35	Write Primary Variable Range Values[5]	0 1-4 5-8	Unsigned-8 Float Float	Upper and Lower Range Values Units Code Upper Range Value Lower Range Value	0-3 4-7	Float Float	Primary Variable Loop Current (mA) Primary Variable % Of Range
36	Set Primary Variable Upper Range Value[6]						
37	Set Primary Variable Lower Range Value[7]						
40	Enter/Exit Fixed Current Mode	0-3	Float	Fixed Current Level (units of milliamperes)	0-3	Float	Fixed Current Level (units of milliamperes)
41	Perform Self Test[8]						
42	Perform Device Reset[9]						
45	Trim Loop Current Zero[10]	0-3	Float	Externally Measured Loop Current Level (units of milliamperes)	0-3	Float	Actual Measured Loop Current Level (units of milliamperes)[11]

Command		Request Data Bytes			Response Data Bytes		
No.	**Description**	**Byte**	**Format**	**Description**	**Byte**	**Format**	**Description**
46	Trim Loop Current Gain[12]	0-3	Float	Externally Measured Loop Current Level (units of milliamperes)	0-3	Float	Actual Measured Loop Current Level (units of milliamperes)[13]
49	Write Primary Variable Transducer Serial Number[14]	0-2	Unsigned-24	Primary Variable Transducer Serial Number	0-2	Unsigned-24	Primary Variable Transducer Serial Number
50	Read Dynamic Variable Assignments[15]				0 1 2 3	Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8	Device Variable Assigned to the Primary Variable Device Variable Assigned to the Secondary Variable Device Variable Assigned to the Tertiary Variable Device Variable Assigned to the Quaternary Variable
51	Write Dynamic Variable Assignments	0 1 2 3	Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8	Device Variable Assigned to the Primary Variable Device Variable Assigned to the Secondary Variable Device Variable Assigned to the Tertiary Variable Device Variable Assigned to the Quaternary Variable	0 1 2 3	Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8	Device Variable Assigned to the Primary Variable Device Variable Assigned to the Secondary Variable Device Variable Assigned to the Tertiary Variable Device Variable Assigned to the Quaternary Variable
53	Write Device Variable Units[16]	0 1	Unsigned-8 Enum	Device Variable Code Device Variable Units Code	0 1	Unsigned-8 Enum	Device Variable Code Device Variable Units Cod
54	Read Device Variable Information	0	Unsigned-8	Device Variable Code	0 1-3 4 5-8 9-12 13-16 17-20 21 22 23-26	Unsigned-8 Unsigned-24 Enum Float Float Float Float Enum Enum Time	Device Variable Code Device Variable Transducer Serial Number Device Variable Limits/Minimum Span Units Code Device Variable Upper Transducer Limit Device Variable Lower Transducer Limit Device Variable Damping Value Device Variable Minimum Span Device Variable Classification Device Variable Family Update Time Period [17]
56	Write Device Variable Transducer Serial No.	0 1-3	Unsigned-8 Unsigned-24	Device Variable Code Device Variable Transducer Serial Number	0 1-3	Unsigned-8 Unsigned-24	Device Variable Code Device Variable Transducer Serial Number
59	Write Number of Response Preambles[18]	0	Unsigned-8	Number of preambles	0	Unsigned-8	Number of preambles
60	Read Analog Channel and Percent of Range	0	Unsigned-8	Analog Channel Number Code	0 1 2-5 6-9	Unsigned-8 Enum Float Float	Analog Channel Number Code [19] Analog Channel Units Code = 39 (mA) Analog Channel Level Analog Channel Percent of Range[20]
63	Read Analog Channel Information	0	Unsigned-8	Analog Channel Number Code	0 1 2 3 4-7 8-11 12-15 16	Unsigned-8 Enum Enum Enum Float Float Float Bits	Analog Channel Number Code Analog Channel Alarm Selection Code = 250 (not used) Analog Channel Transfer Function Code = 0 (linear) Analog Channel Upper/Lower Range Values Units Code = 57 (%) Analog Channel Upper Range Value Analog Channel Lower Range Value Analog Channel Damping Value (seconds) Analog Channel Flags
65	Write Analog Channel Range Values[21]	0 1 2-5 6-9	Unsigned-8 Enum Float Float	Analog Channel Number Code Analog Channel Upper/ Lower Range Values Units Code Analog Channel Upper Range Value Analog Channel Lower Range Value	0 1 2-5 6-9	Unsigned-8 Enum Float Float	Analog Channel Number Code Analog Channel Upper/ Lower Range Values Units Code = 57 (%) Analog Channel Upper Range Value Analog Channel Lower Range Value
66	Enter/Exit Fixed Analog Channel Mode	0 1 2-5	Unsigned-8 Enum Float	Analog Channel Number Code Analog Channel Units Code Fixed Analog Channel Level[22]	0 1 2-5	Unsigned-8 Enum Float	Analog Channel Number Code Analog Channel Units Code = 39 (mA) Fixed Analog Channel Level[23]
67	Trim Analog Channel Zero	0 1 2-5	Unsigned-8 Enum Float	Analog Channel Number Code Analog Channel Units Code Externally Measured Analog Channel Level	0 1 2-5	Unsigned-8 Enum Float	Analog Channel Number Code Analog Channel Units Code = 39 (mA) Fixed Analog Channel Level[23]
68	Trim Analog Channel Gain	0 1 2-5	Unsigned-8 Enum Float	Analog Channel Number Code Analog Channel Units Code Externally Measured Analog Channel Level	0 1 2-5	Unsigned-8 Enum Float	Analog Channel Number Code Analog Channel Units Code = 39 (mA) Fixed Analog Channel Level[23]
71	Lock Device	0	Enum	Lock Code	0	Enum	Lock Code
76	Read Lock Device State				0	Enum	Lock Status

Command		Request Data Bytes			Response Data Bytes		
No.	**Description**	**Byte**	**Format**	**Description**	**Byte**	**Format**	**Description**
78	Read Aggregated Commands[24]	0 1-2 3 4-i …….. …….. …….. …….. …….. ……..	Unsigned-8 Unsigned-16 Unsigned-8 Unsigned-8[] Unsigned-16 Unsigned-8 Unsigned-8[] Unsigned-16 Unsigned-8 Unsigned-8[]	Number of commands requested Cmd A Byte count for Cmd A Data bytes for Cmd A Cmd B Byte count for Cmd B Data bytes for Cmd B …… Cmd N Byte count for Cmd N Data bytes for Cmd N	0 1 2-3 4 5-A …….. …….. …….. …….. …….. …….. …….. ……..	Bits Unsigned-8 Unsigned-16 Unsigned-8 Unsigned-8[] Unsigned-8 Unsigned-16 Unsigned-8 Unsigned-8[] …… Unsigned-8 Unsigned-16 Unsigned-8 Unsigned-8[]	Extended Field Device Status: 0=OK, 1=Maintenance req'd, 2=Device Alert Number of Commands Requested Cmd A Byte count for Cmd A Data bytes for Cmd A (including commands response code) Cmd B Byte count for Cmd B Data bytes for Cmd B (including commands response code) …… Cmd N Byte count for Cmd N Data bytes for Cmd N (including commands response code)
79	Write Device Variable	0 1 2 3-6 7	Unsigned-8 Enum Enum Float Bits	Device Variable Code Write Device Variable Command Code Units Code Device Variable Value Device Variable Status	0 1 2 3-6 7	Unsigned-8 Enum Enum Float Bits	Device Variable Code Write Device Variable Command Code Units Code Device Variable Value Device Variable Status
89	Set Real Time Clock[25]	0 1-3 4-7 8-9	Unsigned-8 Date Time Unsigned-16	Time set code[26] Date Code Time of Day 0x0000[27]	0 1-3 4-7	Unsigned-8 Date Time	Time set code Date Code Time of Day
90	Read Real Time Clock[28]				0-2 3-6 7-9 10-13 14	Date Time Date Time Bits	Current Date Current Time of Day Date Clock last set Time Clock last set RTC Flags
91	Read Trend Configuration[29]	0	Usigned-8	Trend Number	0 1 2 3 4-7	Unsigned-8 Unsigned-8 Enum Unsigned-8 Time	Trend Number Total number of Trends supported Trend Control Code Device Variable Code Trend sample interval [30]
92	Write Trend Configuration[31]	0 1 2 3-6	Unsigned-8 Enum Unsigned-8 Time	Trend Number Trend Control Code Device Variable Code Trend sample interval [30]	0 1 2 3-6	Unsigned-8 Enum Unsigned-8 Time	Trend Number Trend Control Code Device Variable Code Trend sample interval
93	Read Trend[32]	0	Usigned-8	Trend Number	0 1 2 3 4-6 7-10 11-14 15-18 19 20-23 24 25-28 29 30-33 34 35-38 39 40-43 44 45-48 49 50-53 54 55-58 59 60-63 64 65-68 69 70-73 74	Unsigned-8 Unsigned-8 Enum Enum Date Time Time Float Bits Float Bits Float Bits Float Bits Float Bits Float Bits Float Bits Float Bits Float Bits Float Bits Float Bits	Trend Number Device Variable Code Device Variable Classification Device Variable Unit Code Date Stamp Of Trend Value 0 Time Stamp of Trend Value 0 Sample Interval Trend Value 0 (newest value) Trend Value 0 Status Trend Value 1 Trend Value 1 Status Trend Value 2 Trend Value 2 Status Trend Value 3 Trend Value 3 Status Trend Value 4 Trend Value 4 Status Trend Value 5 Trend Value 5 Status Trend Value 6 Trend Value 6 Status Trend Value 7 Trend Value 7 Status Trend Value 8 Trend Value 8 Status Trend Value 9 Trend Value 9 Status Trend Value 10 Trend Value 10 Status Trend Value 11 Trend Value 11 Status
95	Read Device Communications Statistics[33]				0-1 2-3 4-5	Unsigned-16 Unsigned-16 Unsigned-16	Count of STX messages received by this device Count of ACK messages received by this device Count of BACK messages received by this device.
103	Write Burst Period[34]	0 1-4 5-8	Unsigned-8 Time Time	Burst Message Update Period[35] Maximum Update Period [36]	0 1-4 5-8	Unsigned-8 Time Time	Burst Message Update Period[37] Maximum Update Period[37]
104	Write Burst Trigger[34]	0 1 2 3 4-7	Unsigned-8 Enum-8 Enum-8 Enum-8 Float	Burst Message[38] Burt Trigger Mode Selection Code Device Variable Classification for Trigger Level Units Code Trigger Level	0 1 2 3 4-7	Unsigned-8 Enum-8 Enum-8 Enum-8 Float	Burst Message Burt Trigger Mode Selection Code Device Variable Classification for Trigger Level Units Code Trigger Level

Command		Request Data Bytes			Response Data Bytes		
No.	**Description**	**Byte**	**Format**	**Description**	**Byte**	**Format**	**Description**
105	Read Burst Mode Configuration[34]	0	Unsigned-8	Burst Message	0 1 2 3 4 5 6 7 8 9 10 11 12-13 14-17 18-21 22 23 24 25-28	Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-16 Time Time Enum-8 Enum-8 Enum-8 Float	Burst Mode Control Code 31 (0x1F) Command Number Extension Flag[39] Device Variable Code Slot 0[40] Device Variable Code Slot 1 Device Variable Code Slot 2 Device Variable Code Slot 3 Device Variable Code Slot 4 Device Variable Code Slot 5 Device Variable Code Slot 6 Device Variable Code Slot 7 Burst Message Maximum Number of Burst Messages Extended Command Number Update Time (1/32 of a millisecond) Maximum Update Time (1/32 of a millisecond) Burst Trigger Mode Code Device Variable Classification for Trigger Value Units Code Trigger Value
106	Flush Delayed Responses[34]						
107	Write Burst Device Variables[34]	0 1 2 3 4 5 6 7 8	Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8	Device Variable Code Slot 0 Device Variable Code Slot 1 Device Variable Code Slot 2 Device Variable Code Slot 2 Device Variable Code Slot 4 Device Variable Code Slot 5 Device Variable Code Slot 6 Device Variable Code Slot 7 Burst Message	0 1 2 3 4 5 6 7 8	Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8 Unsigned-8	Device Variable Code Slot 0[40] Device Variable Code Slot 1 Device Variable Code Slot 2 Device Variable Code Slot 2 Device Variable Code Slot 4 Device Variable Code Slot 5 Device Variable Code Slot 6 Device Variable Code Slot 7 Burst Message
108	Write Burst Mode Command Number[34]	0-1 2	Unsigned-16 Unsigned-8	Command Number of the response message to be transmitted[41] Burst Message	0-1 2	Unsigned-16 Unsigned-8	Command Number of the response message to be transmitted Burst Message
109	Burst Mode Control[42]	0 1	Unsigned-8 Unsigned-8	Burst Mode Control Code Burst Message	0 1	Unsigned-8 Unsigned-8	Burst Mode Control Code Burst Message
115	Read Event Notification Summary[43]	0	Unsigned-8	Event number = 0[44]	0 1 2.7-2.4 2.3-2.0 3-6 7-10 11-14 15-18 19-44	Unsigned-8 Unsigned-8 Bits-4 Enum Time Time Time Bits	Event Number Number of events supported MS 4 Bits of Event Status LS 4 Bits of Event Notification Control Code Time when first unacknowledged event was triggered[45] Event Notification Retry Time Maximum Update Time Event De-bounce Interval Event Mask[46]
116	Write Event Notification Bit Mask[43]	0 1-27	Unsigned-8 Bits	Event Number = 0[44] Event Mask [47]	0 1-27	Unsigned-8 Bits	Event Number = 0 Event Mask
117	Write Event Notification Timing[43]	0 1-4 5-8 9-12	Unsigned-8 Time Time Time	Event Number = 0[44] Event Notification Retry Time Maximum Update Time[48] Event De-bounce Time	0 1-4 5-8 9-12	Unsigned-8 Time Time Time	Event Number = 0 Event Notification Retry Time Maximum Update Time Event De-bounce Time
118	Event Notification Control[43]	0 1	Unsigned-8 Unsigned-8	Event Number = 0[44] Event Notification Control Code	0 1	Unsigned-8 Unsigned-8	Event Number = 0 Event Notification Control Code
119	Acknowledge Event Notification[43]	0 1-4 5-6 7 8-32	Unsigned-8 Time Unsigned-16 Bits Bits	Event Number = 0[44] Time when first unacknowledged event was triggered Configuration Changed Counter Device Status Command 48 Data	0 1-4 5-6 7 8-32	Unsigned-8 Time Unsigned-16 Bits Bits	Event Number = 0 Time when first unacknowledged event was triggered [49] Configuration Changed Counter Device Status Command 48 Data
512	Read Country Code				1-2 3	Unsigned-8 Enum-8	Country Code[50] SI Units Only
513	Write Country Code	1-2 3	Unsigned-8 Enum-8	Country Code[50] SI Units Only	1-2 3	Unsigned-8 Enum-8	Country Code[50] SI Units Only

5. 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).
6. Issuing this command will write the current Primary Variable value to the Upper Range Value.
7. Issuing this command will write the current Primary Variable value to the Lower Range Value.
8. The Loop Current may not reflect the process while the Self test is executing. A master must not generate spurious error messages or disconnect form the Field Device while the Self test is in progress.
9. This is equivalent to cycling the power off and then back on to the Field Device. Communication with the network will be temporarily lost. The device will not respond to subsequent commands until the reset is complete. 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.
10. 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. 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.

11. The value returned in the response data bytes reflects the rounded or truncated value actually used by the device for the Zero value.
12. This trim is typically performed by adjusting the Loop Current to 20.00 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. 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.
13. The value returned in the response data bytes reflects the rounded or truncated value actually used by the device for the Gain value.
14. Command 56 write device variable transducer serial number can also be used to write the PV transducer serial number if device variable code 0 (position setpoint) is used.
15. See Section 3.4 Device Variables for more information on Device Variables and mapping. Note: the Device Variable Assignment is made by the Device Variable Code (0-4).
16. Note: only Device Variables 3 and 4 may have their units code changed. See 3.4.3 Device Variable Units for more information. Response Code 11 "Invalid Device Variable Code" will be returned if an invalid Device Variable Code is requested (Device Variable codes 0-4). Response Code 12 "Invalid Units Code" will be returned if the units code is not valid for the given Device Variable Code.
17. The update time period indicates the maximum period between Device Variable updates.
18. This command sets the number of asynchronous 0xFF preamble bytes to be sent by a device before the start of a response message. This value may be set to no smaller than 5 and no greater than 20.
19. There is one analog channel with analog channel number code of 0 which is linked to the Primary Variable.
20. Percent of Range always follows the Analog Level even if it 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.
21 The Upper Range Value may be set lower than the Lower Range Value, enabling the device to be operated with a reversed signaling polarity.
22. A level containing NAN or "0x7F, 0xA0, 0x00, 0x00", with any units code exits the fixed analog channel mode. The device will also exit fixed analog channel mode when power is removed from the device or the device is reset.
23. The value returned in the response data bytes reflects the rounded or truncated value actually used by the device.
24. This command can be used to receive multiple read commands in one read for faster command reads.
25. 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 effect on setting the real time clock is minimized.
26. See Appendix D for additional details on how this command works dependent upon this code.
27. 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).
28. Reads 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.
29. See section "3.2 HART Parameters" for maximum number of trends and trend buffer size.
30. Maximum is 2 hour; one trend per day i.e. 0x0DBBA000
31. 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.
32. When the trend is not enabled the device shall return the data last collected with the corresponding date and time. The Response Code shall be set to 8 – Trend not Active.
33. The communications statistics are volatile and reset to zero only on power-up or board reset. All counts must wrap to zero on overflow.
34. Please see sections "3.5.3 Burst Messages" for configuration details of Burst Mode.
35. 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.
36. In 1/32 of a millisecond – Maximum update period must not exceed 3600 seconds. The device must publish at this rate when the trigger conditions configured in command 104 are not met.
37. The value returned in the response data bytes reflects the value actually used by the device. If the update time had to be adjusted by the device, the response will reflect the adjusted value. See section "3.5.3 Burst Messages" for more information about update rates.
38. If command 2 "Read Loop Current and Percent of Range" is selected the Device Variable Classification must be 0 and the Engineering Units "Percent" (0x39 or 57 decimal).
39. Note: if there are no request data bytes then this byte must return the LS Byte of the burst command number.
40. 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.
41. See section "3.5.3 Burst Messages" for a list of commands supported for Burst Messaging. Note: if the trigger mode is non-zero in command 104 (not Continuous) 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 8 "Burst Condition Conflict" will be returned. The HART device shall correct the classification, correct the unit codes, and reset the trigger mode to 0 (Continuous) and publish continuously at the update period until it receives another command 104.
42. See section "3.5.3 Burst Messages" for more information on configuring Burst Messages. Note: This command affects Data Link Layer operation. All Data Link Layer requirements for entering and exiting burst mode must be met.
43. See section "3.5.4 Event Notification" for more information about Event Notifications.
44. The MX/QX Hart device supports one Event Notification which is identified as Event Notification Number 0.
45. The value shall be set to 0xFFFFFFFF when no events are pending.
46. This is the concatenation of the mask for triggering on bits set in Device Status and Command 48 Response. The command can be truncated after the last byte in the Event Mask.
47. The concatenation of the mask for triggering on bits set in Device Status and Command 48 Response. The request is truncated after the last byte containing a trigger-able event. Bytes that are truncated assume a bit mask value of zero. Therefore, 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.
48. The return and update times must be selected as specified in section "3.5.4.3 Update Periods". The retry period must be less than or equal to the maximum update period.
49. Value will be set to -1 when no events are pending.
50. The two letter country code in accordance with ISO.

3.5.3 Burst Messages

In this mode, the Limitorque MX/QX field device will publish the response to a command continuously without any further Master or Host action. All masters must arbitrate correctly when a burst-mode field device is present on the loop.

There must be only one burst mode device active on the communication link at any given time. This is because the Master must adapt its operation to ensure correct bus arbitration, because the token passing sequence is fundamentally changed.

3.5.3.1 Update Periods

The host application or control system may set the update periods for the Limitorque MX/QX field device to the following allowed values: 0.5, 1.0, 2.0, 4.0, 8.0, 16.0, 32.0, and 60-3600 seconds.

If a setting is requested that is different from those indicated above, the HART device must correct the setting and send response code 8 “Update Times Adjusted” in its response message. The update time returned in the response message will reflect the adjusted update time the device is using.

When enabling burst messaging, the device takes control of the Token Passing Layer bursting out the default burst message with no less than “Link Grant Time” (approximately 75 ms) between bursts. This Link Grant Time allows another master to take over the bus and transmit a message. If only one burst message is enabled, it is the default burst message. If more than one burst message is enabled, the burst message with the shortest update period is the default burst message.

On a Token Passing Data-Link burst, messages are used both to publish data and to pass the token. Therefore, the default burst message will always burst with approximately 75 ms between bursts, regardless of what value is set for the “Update Period” of the default burst message. If more than one burst message is enabled, the other (not default) burst messages will be burst based on their Update and Max Update Periods.

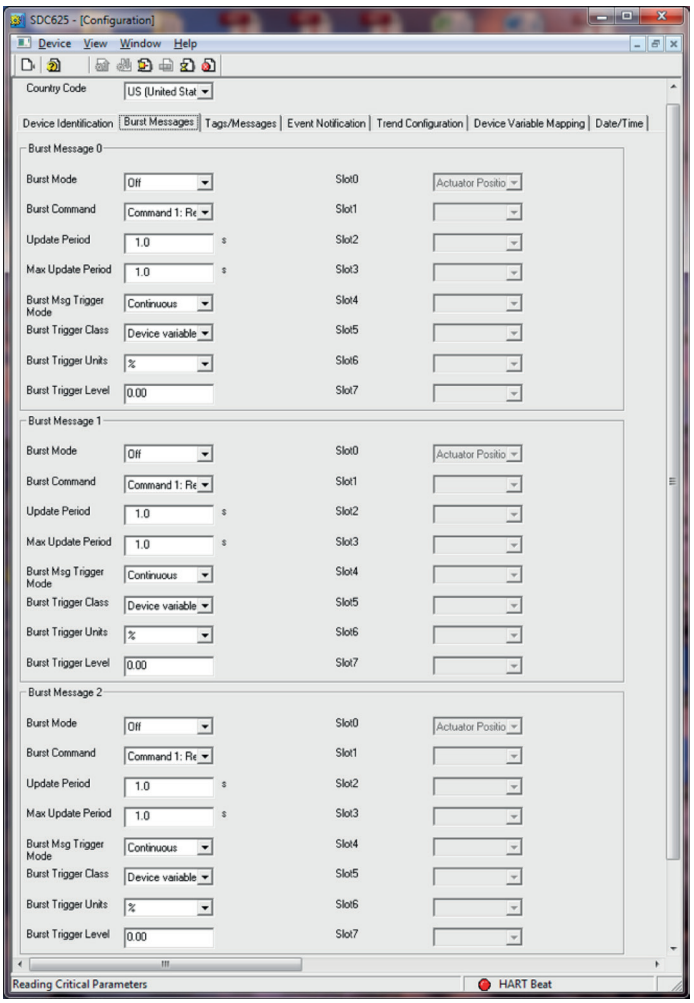
3.5.3.2 Commands Supported for Burst Message

- Command 1 Read Primary Variable
- Command 2 Read Loop Current and Percent of Range
- Command 3 Read Dynamic Variables and Loop Current
- Command 9 Read Device Variables With Status
- Command 33 Read Device Variables
- Command 48 Read Additional Device Status
- Command 93 Read Trend

3.5.3.3 Configuring a Device for Burst Mode Operation

Burst messages can be configured from the DD menu Device Setup->Wired Hart Board->Configuration->Burst Messages as follows:

Figure 3.4 – Burst Messages



The burst mode configuration (number of messages active, trigger settings, etc.) will be retained across power cycles and resets.

3.5.3.4 Burst Message Trigger Mode

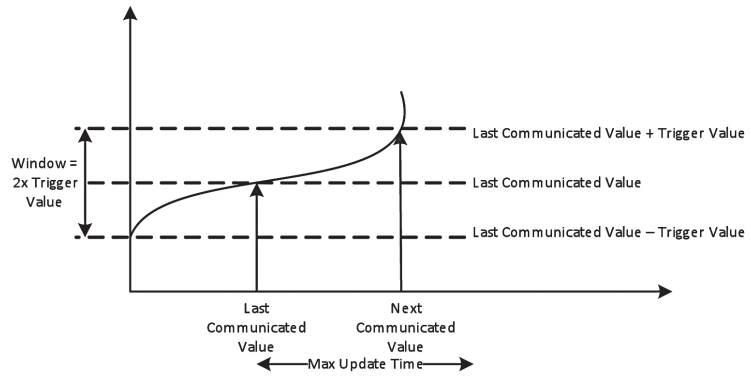
Table 3.11 Trigger Source for Burst Message Commands

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

3.5.3.5 Burst Trigger Mode

In Window Mode the trigger value must be a positive number and is the symmetric window around the last communicated value.

Figure 3.5 – Trigger Mode 1 "Windowed"



Even if the value does not deviate beyond the window, a Burst Message will be published when the max update period is exceeded.

In Rising Mode, the Burst Message is published when the source value exceeds the trigger value. 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.

In Falling Mode, the Burst Message is published when the source value drops below the trigger value. Burst Messages are published at the rate indicated by the update period, as long as the source value remains below the trigger value. If the value exceeds the trigger value, the update time will drop to the maximum update period.

In the On-Change Mode, the Burst Message is published when the value in the message changes. If the value does not change, the Burst Message will be published at the maximum update period.

3.5.4 Event Notification

Event Notification requires Burst Mode operation; therefore, at least one burst message must be enabled for event notification to occur. The HART protocol provides two distinct methods for displaying events:

- Field Device Status
- Command 48 response

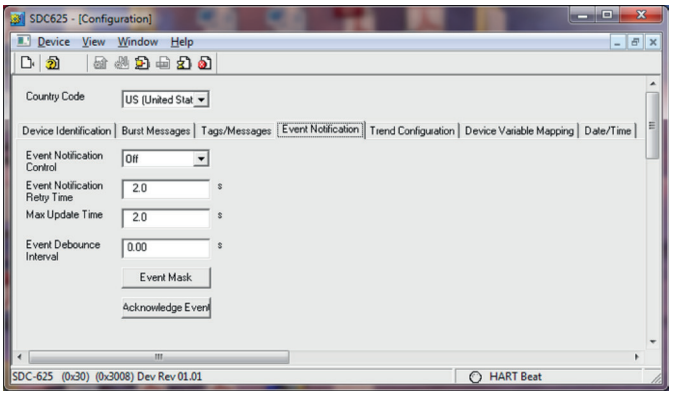
Event Notification publishes changes in the device's status, independently from other data published in other Burst Messages. Bits from the Field Device Status and the command 48 response data may be selected using a bit mask to send Event Notifications. This allows the Event Notification to be limited to specific bits.

The device shall retain Event Notification Settings through a device reset, self-test or power-cycle. However, Event Notification and Time Stamps are not maintained through power cycles or a device reset. The MX/QX HART device supports an event history queue of five events for the configured Event Notification. If more events are detected than can be buffered, then the "Event Notification Overflow" bit in Standardized Status 1 (see section 3.5.1.1 Command 48 Data) shall be set until all pending events have been acknowledged. Events detected after the event queue is full are lost.

3.5.4.1 Configuring Event Notification

Event Notification can be configured from the DD menu Device Setup->Wired Hart Board->Configuration-> Event Notification as follows:

Figure 3.6 – Event Notification



The Event Mask allows the user to select those bits from Field Device Status and Command 48 data which they want to trigger and event. When the user clicks the “Event Mask” button, the following menu will appear, allowing them to select the event triggers:

Figure 3.7 – Event Mask

3.5.4.2 Handling of Event Notifications

The MX/QX HART device detects a change in the selected bit from high to low, and low to high. Therefore, any change in a bit, either to set it or clear it, will generate an event. The first occurrence of the event (change in any of the selected/masked bits) is latched and Time Stamped. The event notification shall be sent repeatedly with a period of ‘Event Notification Retry Period’ until the event is Acknowledged by the Master. The Time Stamp shall remain the same until an Acknowledge is received from the Host/Master. Once an Acknowledge is received, the Time Stamp shall be set to

the time when the Acknowledge was performed. If no event is latched the current Configuration Chagned Counter, Field Device Status, and Command 48 response data shall be sent repeatedly with a period of 'Maximum Update Period'. The event message is aggregated with the default burst message. The event message is sent to both masters (in two consecutive burst cycles, like any burst message. HCF_SPEC-151, 6.10.2).

The Event Notification De-bounce Interval is used to prevent spurious event notifications, and defines the amount of time that a condition must persist before the Event Notification is sent out.

3.5.4.3 Update Periods

The host application or control system may set the update periods for the Limitorque MX/QX field device to the following allowed values: 0.5, 1.0, 2.0, 4.0, 8.0, 16.0, 32.0, and 60-3600 seconds.

If a setting is requested that is different from those indicated above, the HART device must correct the setting and send response code 8 "Update Times Adjusted" in its response message. The update time returned in the response message will reflect the adjusted update time the device is using.

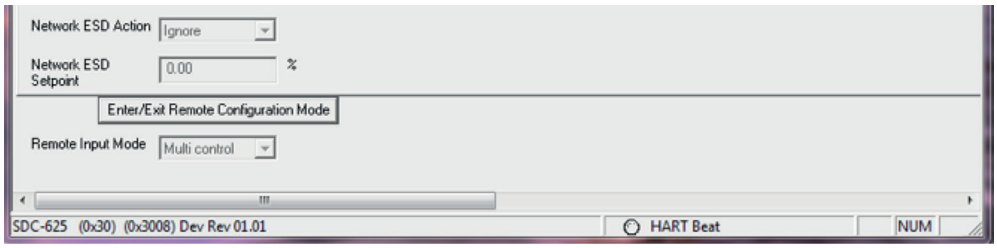
3.6 Device-Specific Commands

3.6.1 Remote Configuration Mode

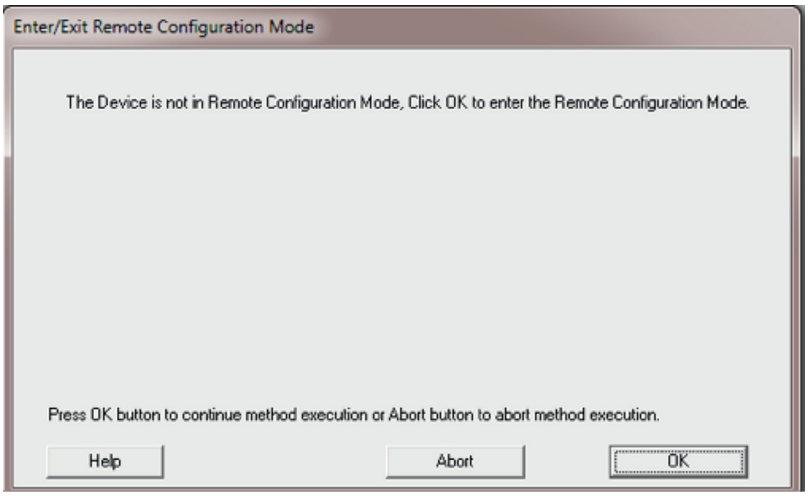
Some device-specific commands require the unit be "In Remote" (Remote-Stop-Local Knob is in the Remote position) and/or "Remote Configuration Mode". If those commands are issued when the unit is not "In Remote" and/or "Remote Configuration Mode", response code 16 "Access Restricted" will be returned.

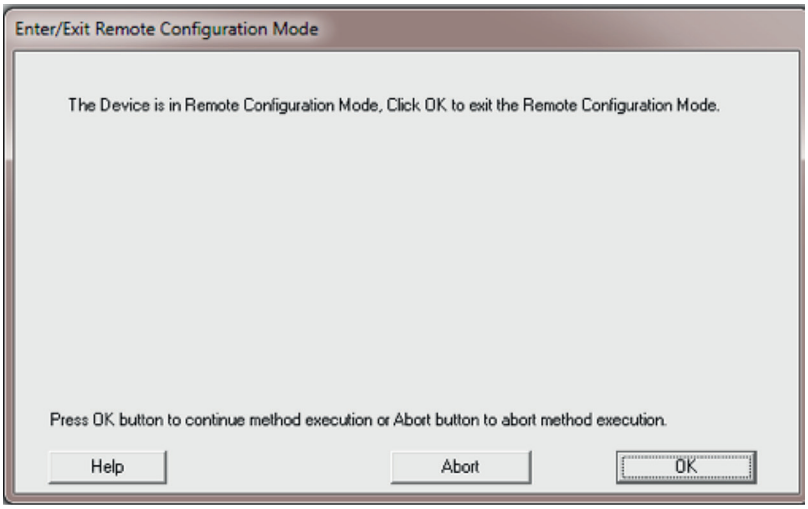
Remote Configuration Mode can be entered or exited using the button located at the bottom of the configuration menu. For example, at the bottom of the ESD Settings configuration menu:

Figure 3.8 – Remote Configuration Modes (3 figures)



When the button is clicked, it will provide a new window that gives you the current status of Remote Configuration Mode and asks if you wish to change it:





The Remote Configuration Mode is used to ensure the unit is not moving during a change of configuration, as this can be dangerous. If a move command is received while in Remote Configuration Mode, the unit will complete the last write and exit Remote Configuration Mode and take the move action. The unit must first be placed in “remote configuration mode” and remain in this mode while these write configuration commands occur to ensure proper operation of the unit. It is intended that the “write” Device-Specific commands which write unit configuration be used only during commissioning of the unit, and not during normal process control.

If the unit is in “remote configuration mode” and any of the following occur, it will exit the “remote configuration mode” upon completion of writing the configuration to EEPROM:

- Control knob is moved from REMOTE to LOCAL or STOP
- Network or discrete/local ESD become active
- A discrete open, close or stop command is received by the unit
- A network open, close or stop command is received by the unit

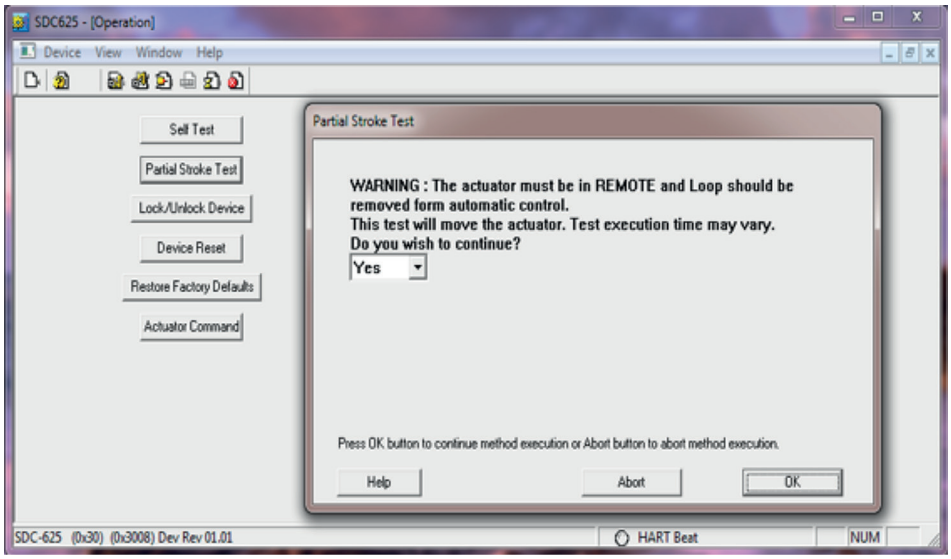
While the unit is in “remote configuration mode”, it will ignore the “position setpoint” value of the HART board and not move the actuator, until the “remote configuration mode” is exited.

3.6.2 Partial Stroke Test

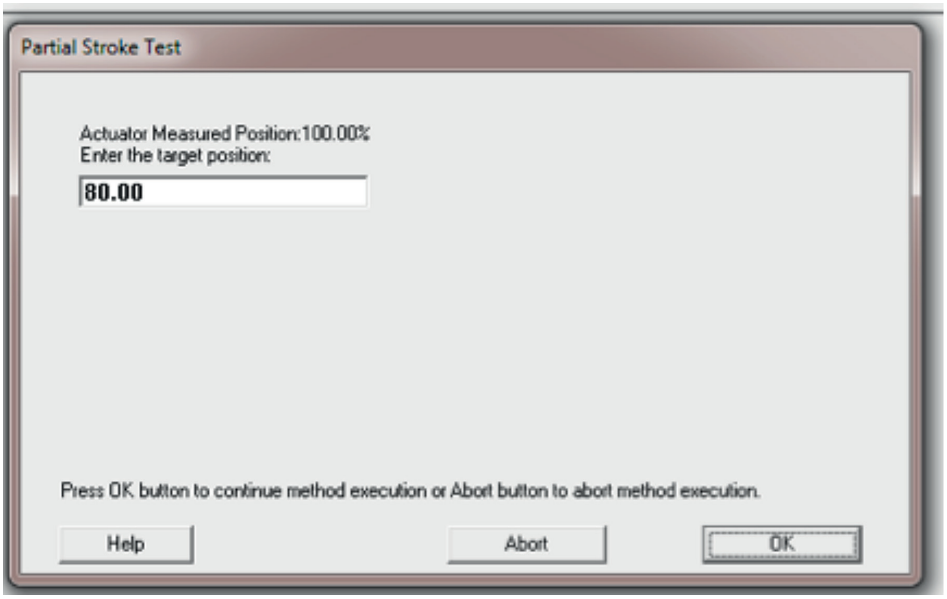
The actuator must be “in REMOTE” and not in “Remote Configuration Mode”. The Partial Stroke Test will not start if the unit is not in the correct configuration or has any system faults. Once the Partial Stroke Test starts, the actuator will display “PST ACTIVE” and move to the given target. Upon reaching the target, the actuator will return to the starting position. If any system faults are encountered during the transition to target and back, the actuator will stop at the position where the fault occurred, the PST ACTIVE display will be cleared, and the test results will indicate failed. Command 48 (or Device-Specific command 149) can be used to obtain more details on what fault occurred. The process should not be controlling the unit while the Partial Stroke Test is active (i.e., the loop current should be constant and not changing).

The Partial Stroke Test may be initiated from the DD menu Diagnostics->Operation as follows:

Click the Partial Stroke Test button and the following warning will be displayed:

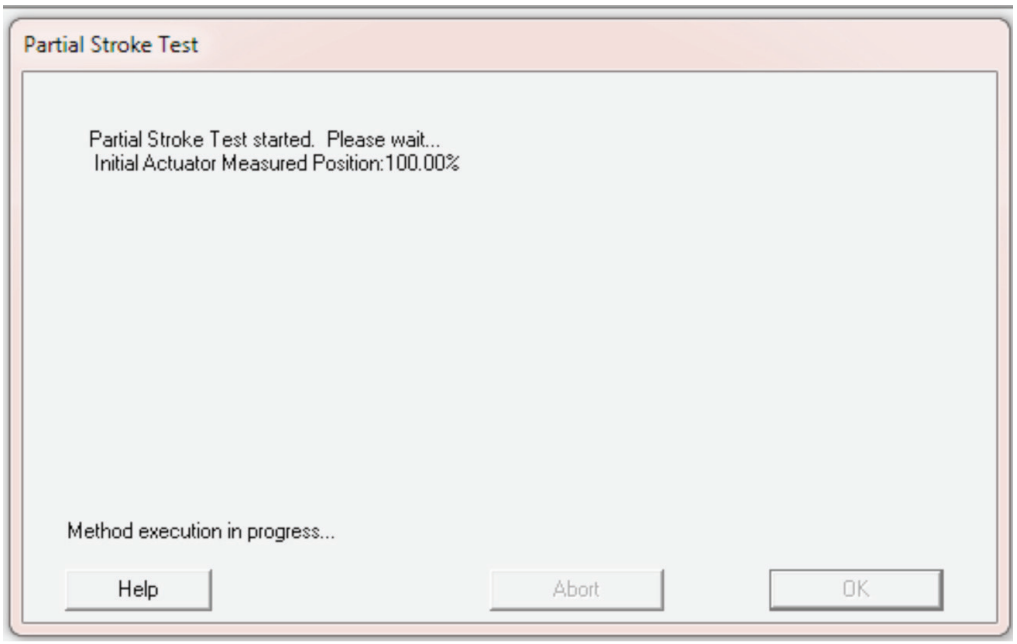


Click OK (with Yes) selected to continue.

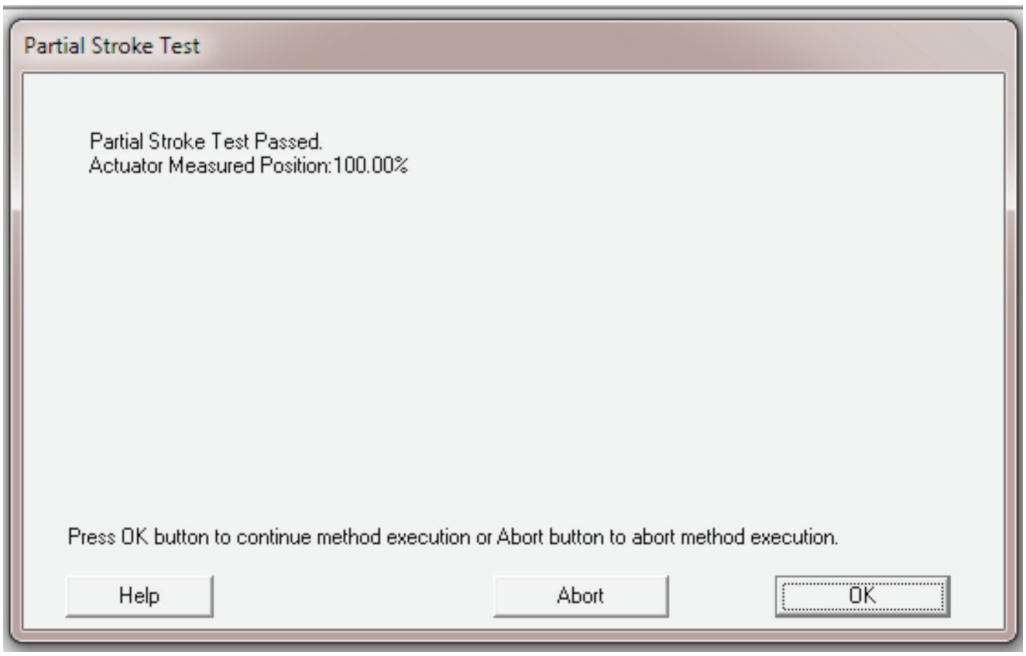


Enter the target position you wish the actuator to move to (it will return to the start position after it reaches the target position). The current start position is displayed as “Actuator Measured Position”

The following will be displayed while the PST is in progress:



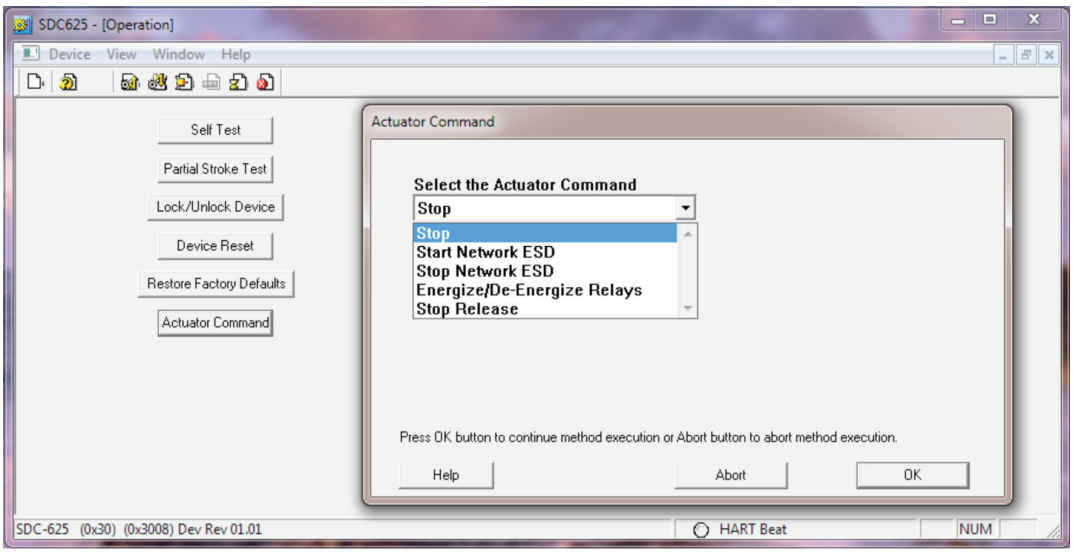
Once the test completes, the test results will be displayed. The following figure shows a passing test.



If the test failed, “Partial Stroke Test Failed” would be displayed and further information on the failure can be found by reviewing the DD menu Diagnostics->Information->Device Status.

3.6.3 Actuator Commands

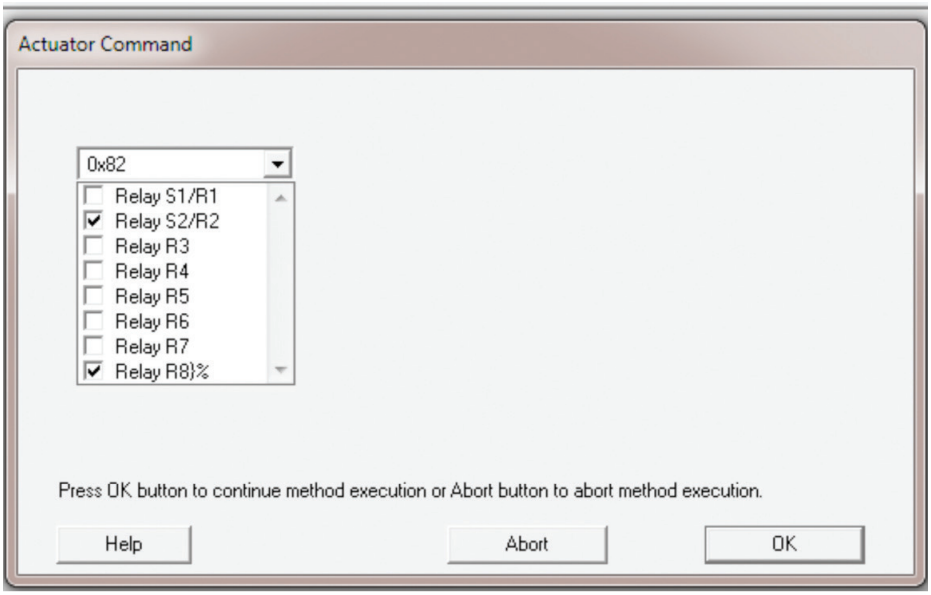
Some common network functions can be issued by using Actuator Commands from the DD menu Diagnostics-> Operation and clicking on the Actuator Command button as follows:



The Stop and Stop Release commands require the unit be in Remote; if not, in remote response code 16 “Access Restricted” will be returned. The Stop command is used like a network stop and will halt the unit from reacting to the PV value. The Stop Release command will remove the network stop and resume normal operation.

The Start Network ESD command will activate a Network ESD, and the unit shall take the action configured for Network ESD and indicate NW ESD ACTIVE on the LCD. The Stop Network ESD command will deactivate the Network ESD and resume normal operation.

The Energize/De-Energize Relays command will allow the customer to set the state of the relays if and only if the relay is configured for “Network Control”. When these commands are selected a new window will open, allowing the user to select which relays to energize (those with a check in the check box will be energized, those with no check in the check box will
be de-energized).

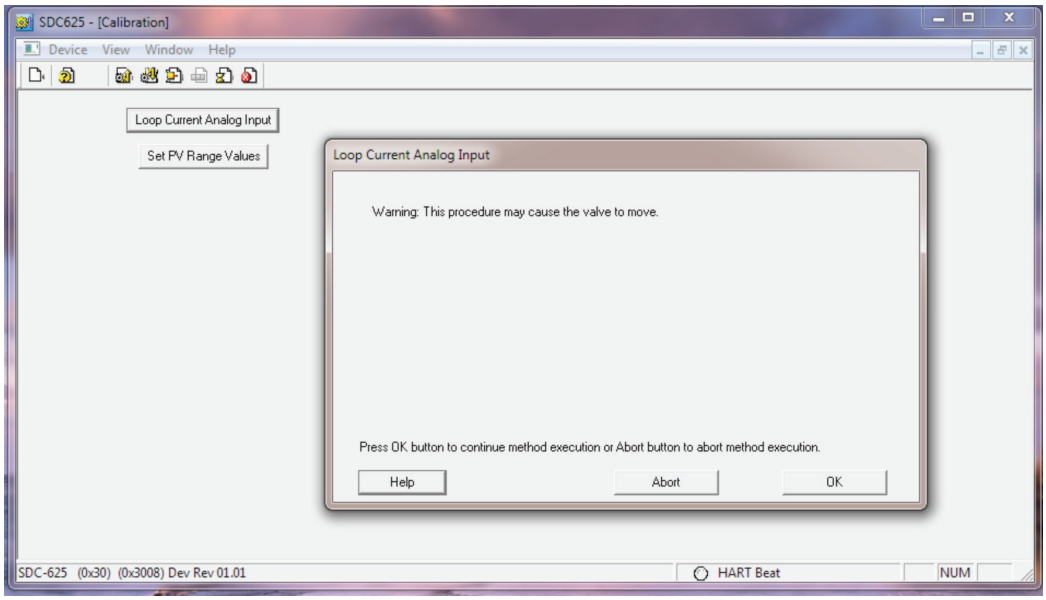


3.7 Calibration

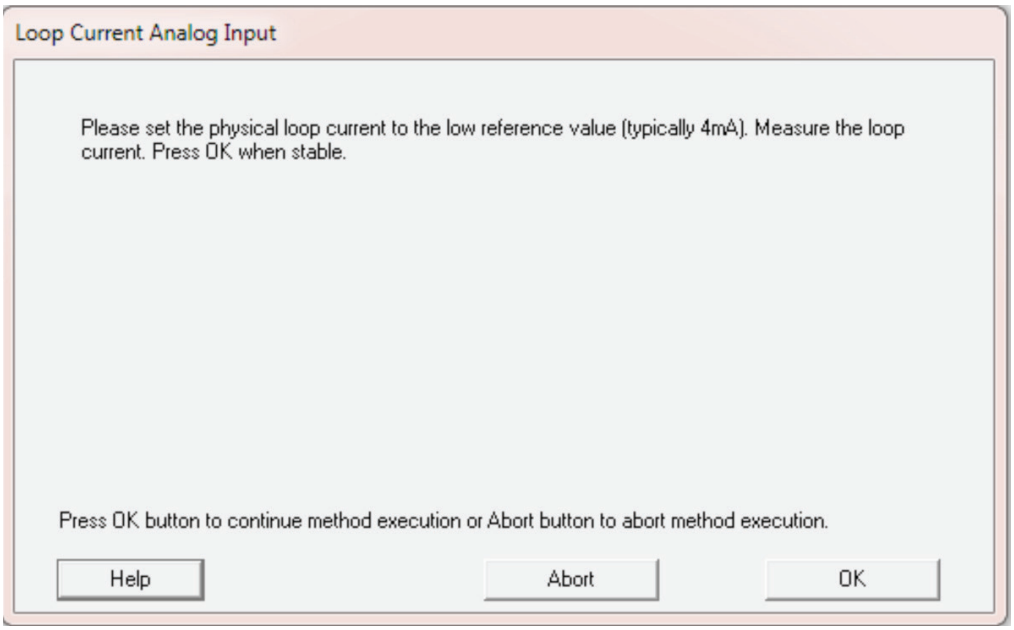
3.7.1 Loop Current Trim Procedure

The Loop Current may be calibrated from the DD menu Device Setup->Wired HART Board->Calibration as follows:

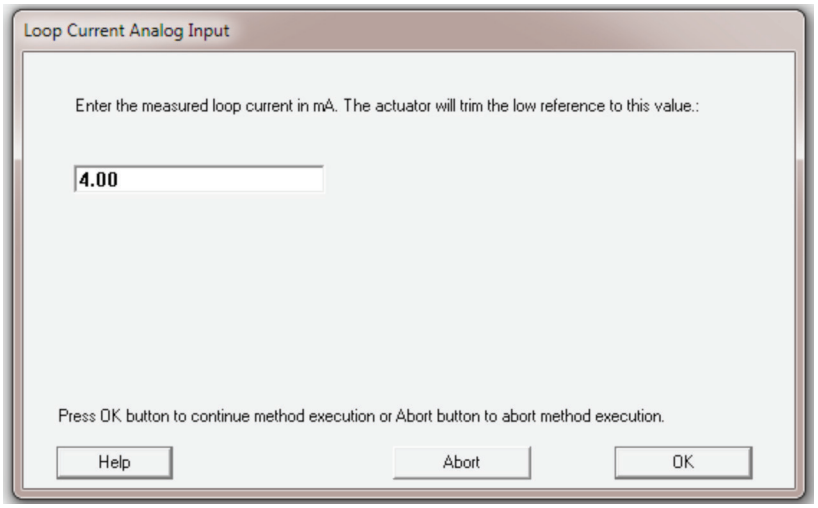
Click on the Loop Current Analog Input button. You will receive a warning that changing the calibration may cause the unit to move.



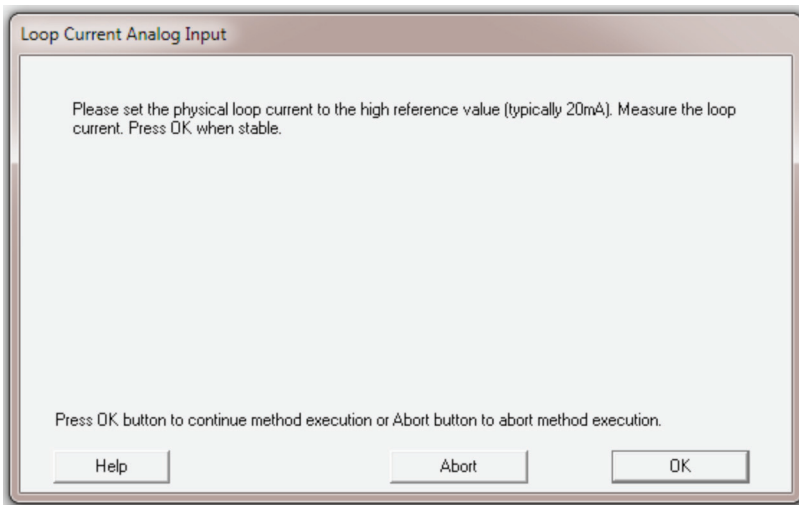
Click OK if it is OK to continue with calibration.



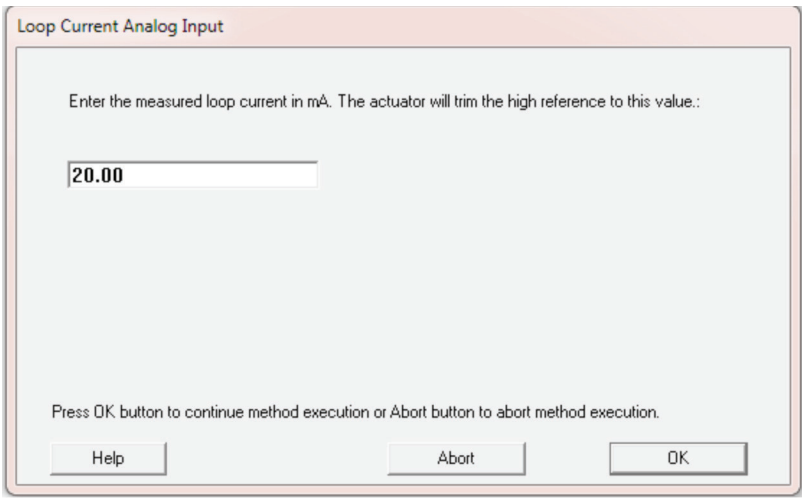
Set the Analog Input Loop Current to the low reference value (typically 4 mA, but can be set between 2-7 mA) and then click OK.



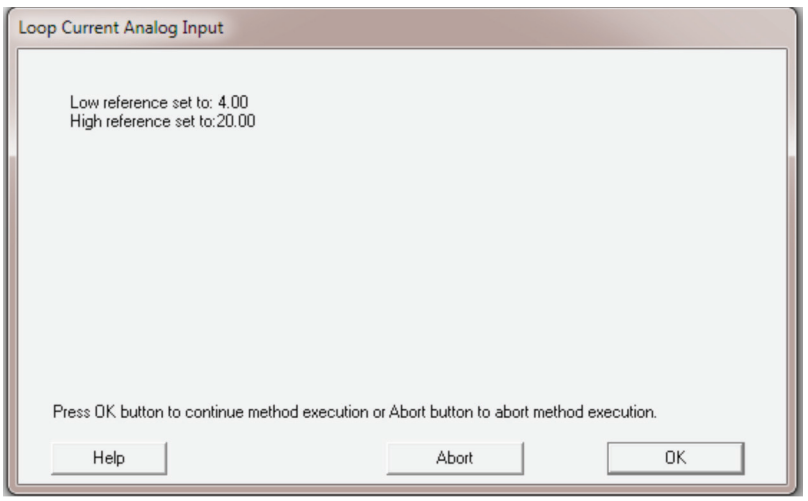
Enter the measured value of the loop current in mA that was applied in the previous step.



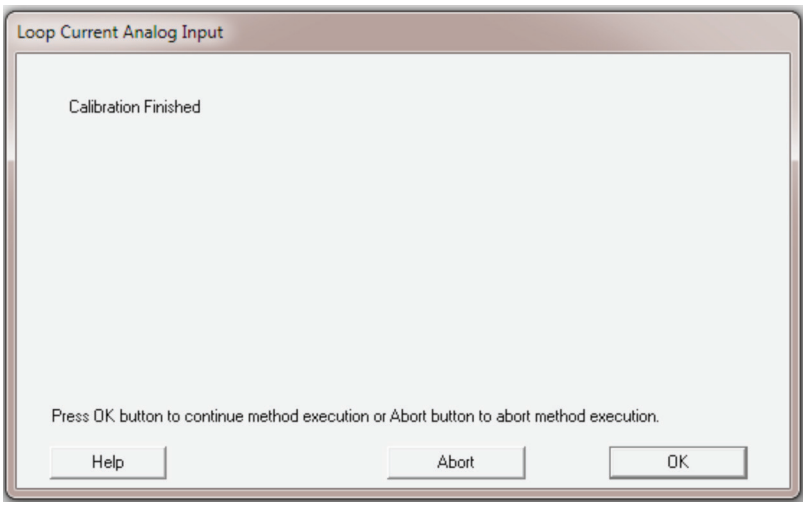
Set the Analog Input Loop Current to the high reference value (typically 20 mA, but can be set between 12-28 mA) and then click OK.



Enter the measured value of the loop current in mA that was applied in the previous step.



A verification of the reference values that were set will be displayed. Click OK to complete the calibration.



Calibration is complete; click OK to exit the method.

3.7.2 Re-range Procedure

The PV Upper and Lower Range values can be calibrated by clicking the Set PV Range Values button on the DD menu Device Setup->Calibration. This calibration defines the relationship between the zero and gain Loop Current values and the Primary Value.

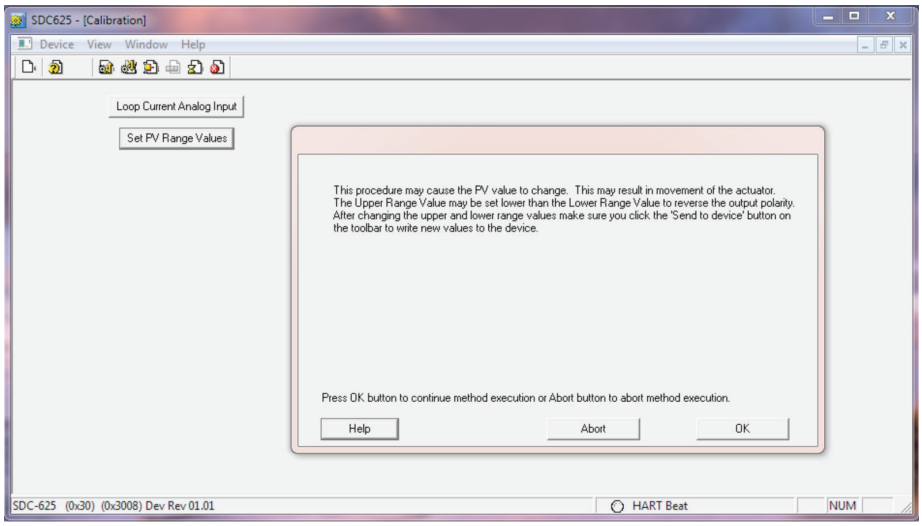
Standard:
Set Upper Range value to 100%, and Lower Range Value to 0%
Zero = 4 mA -> lower range = 0% open; Gain = 20 mA -> upper range = 100% open
To reverse the polarity of the signal the user may set the Upper Range value lower than the Lower Range value.

Reversed:

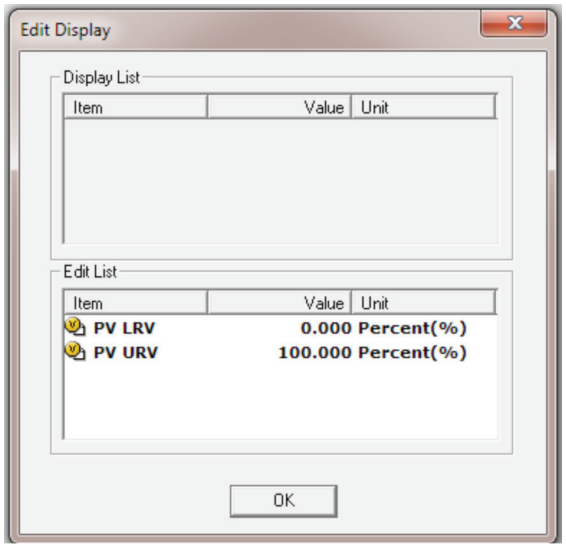
Set Upper Range value to 0%, and Lower Range Value to 100%
Zero = 4 mA = lower range = 100% open, gain = 20 mA = Upper Range = 0% open

The signal may also be limited to a smaller range, for example:
Set the Upper Range value to 80%, and the Lower Range Value to 0%
Zero = 4 mA = lower range = 0% open, gain = 20 mA = Upper Range = 80% open

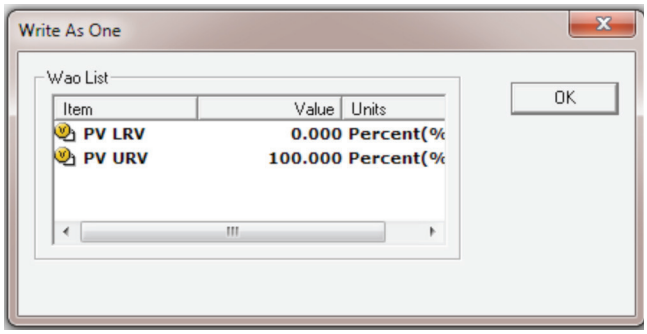
When the Set PV Range Values button is clicked, a warning is given that this may cause the actuator to move:



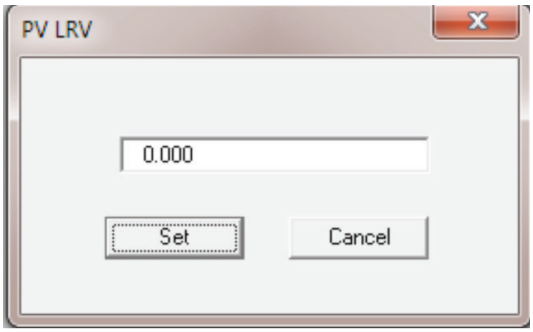
Click OK to continue with calibration of ranges.



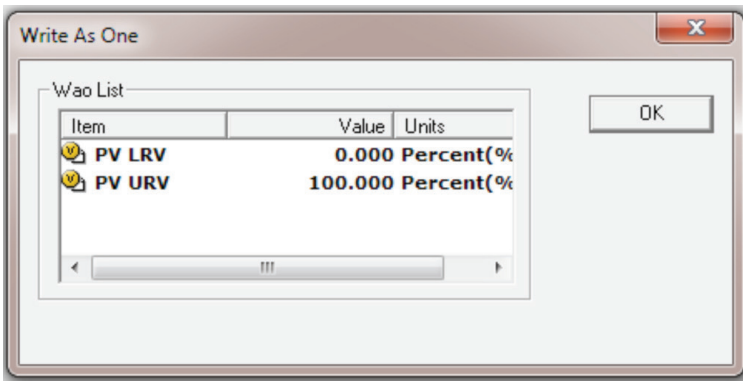
The current Lower (LRV) and Upper (URV) ranges are shown. To change the range value, click on the item to be changed; a new window will open, allowing the user to set both limits at the same time.



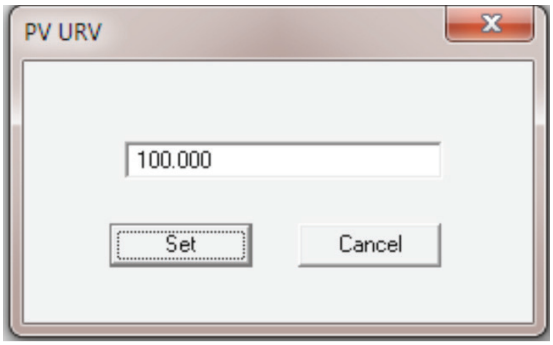
To change the lower range value, click on PV LRV item; a new window will open, allowing the user to enter the value.



Enter the new LRV value and click on the Set button.



To change the upper range value, click on a PV URV item; a new window will open, allowing the user to enter the value.



Enter the new URV value and click on the Set button.

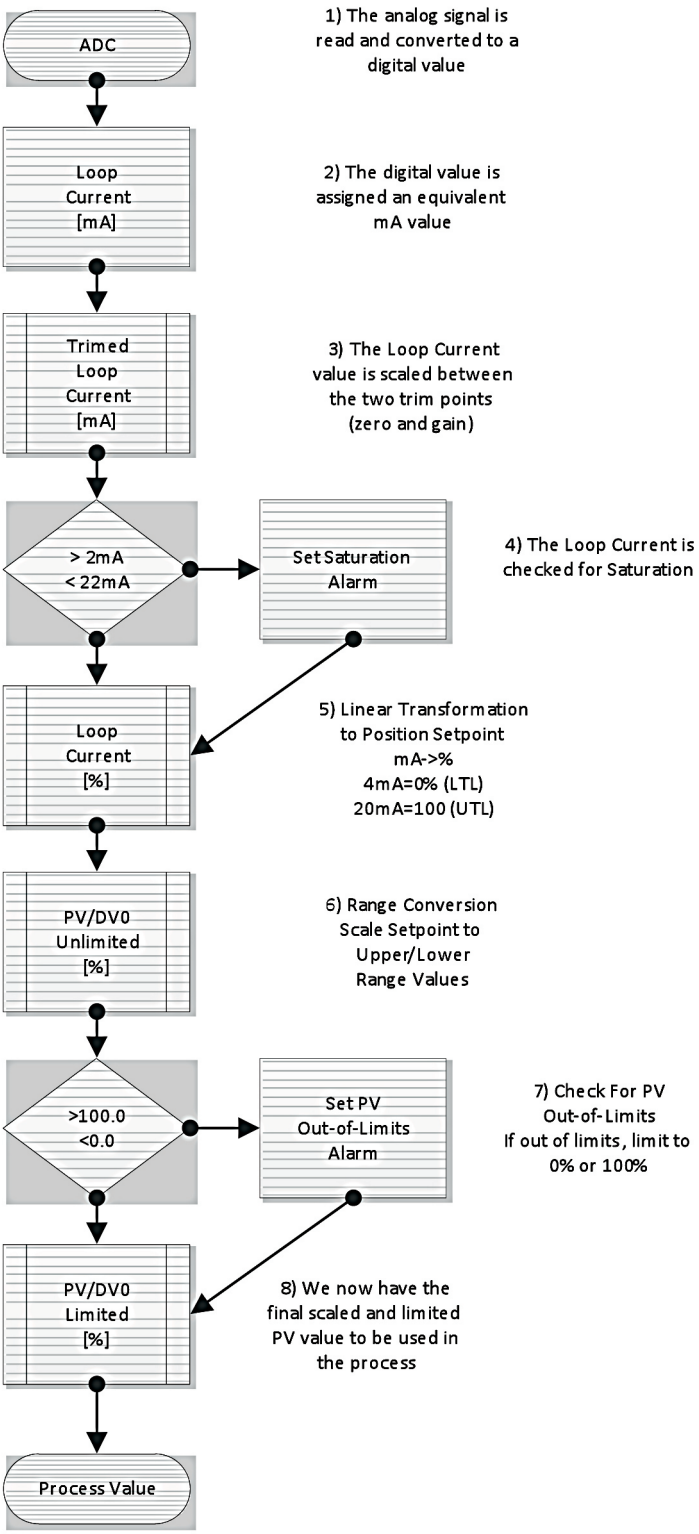
3.7.3 Analog Signal to Primary Variable Process Flow

The following Figure 3.2 shows the process flow used to convert the analog input signal to a positions setpoint target value for the PV.

1. The analog signal is read by the ADC and converted to a digital value
2. The digital value is assigned an equivalent mA value based on fixed internal values
3. The loop current value is now scaled between the zero and gain trim points
   a. The gain trim value can be set from the DD menu Device Setup->Wired HART Board->Calibration
   b. The zero trim value can be set from the DD menu Device Setup->Wired HART Board->Calibration
   c. The loop current value can be set to a fixed value for simulation from the DD menu Process Variables-> Wired HART Board
4. The loop current is checked for saturation and the appropriate alarms are set or cleared
   a. The Field Device Status bit “Loop Current Saturated” will be set/cleared
5. The Upper and Lower Transducer limits (fixed) are used to do a linear transformation to convert the loop current to position setpoint value in percent open. (4 mA = 0% PV – Lower Transducer Limit, 20 mA = 100% PV – Upper Transducer Limit)
   a. The analog channel level and percent range can be read using command 60 with channel number 0 (which is the loop current)
6. The Upper and Lower Range scaling set by the customer is applied to the Primary Variable. This may reverse the signal polarity, or limit the range.
   a. The Upper Range Value can be set from the DD menu Device Setup->Wired HART Board->Calibration
   b. The Lower Range Value can be set from the DD menu Device Setup->Wired HART Board->Calibration
   c. The PV can be forced to a fixed value for simulation from the DD menu Process Variables->Wired HART Board; it is also used to write the PV value when in Multi-drop mode
7. The PV value is checked for Out-of-Limits and the appropriate alarms are set or cleared
   a. The Field Device Status bit “Primary Variable Out of Limits” will be set/cleared
   b. The PV value will be limited to the Upper or Lower Range value if it is detected to be out of limits

8. The PV value is now ready to be used in the process
    a. Command 1 can be used to read the primary variable

Figure 3.9 – Analog Signal to Primary Variable Process Flow



4 Associated Documents

Additional information can be found in the following documents:

MX Actuator	
Quick Start-Up Instructions (MX Actuators)	Limitorque Bulletin LMENIM2310
MX Installation and Operation Manual	Limitorque Bulletin LMENIM2306
Protection, Control and Monitoring Features of MX Electric Actuators	Limitorque Bulletin LMENTB2300
MX Maintenance and Spare Parts Manual	Limitorque Bulletin LMENIM2314

QX Actuator	
Quick Start-Up Instructions (QX Actuators)	Limitorque Bulletin LMENIM3313
QX Installation and Operation Manual	Limitorque Bulletin LMENIM3306
Protection, Control and Monitoring Features of QX Electric Actuator	Limitorque Bulletin LMENIM2300
QX Maintenance and Spare Parts Manual	Limitorque Bulletin LMENIM3314

5 How to Order Parts

To order parts or obtain further information about your Limitorque MX/QX HART field unit, contact your local Limitorque distributor sales office, or:

FLOWSERVE CORPORATION
FLOW CONTROL DIVISION,

Limitorque Actuation Systems
5114 Woodall Road
P.O.Box 11318
Lynchburg, VA 24506-1318

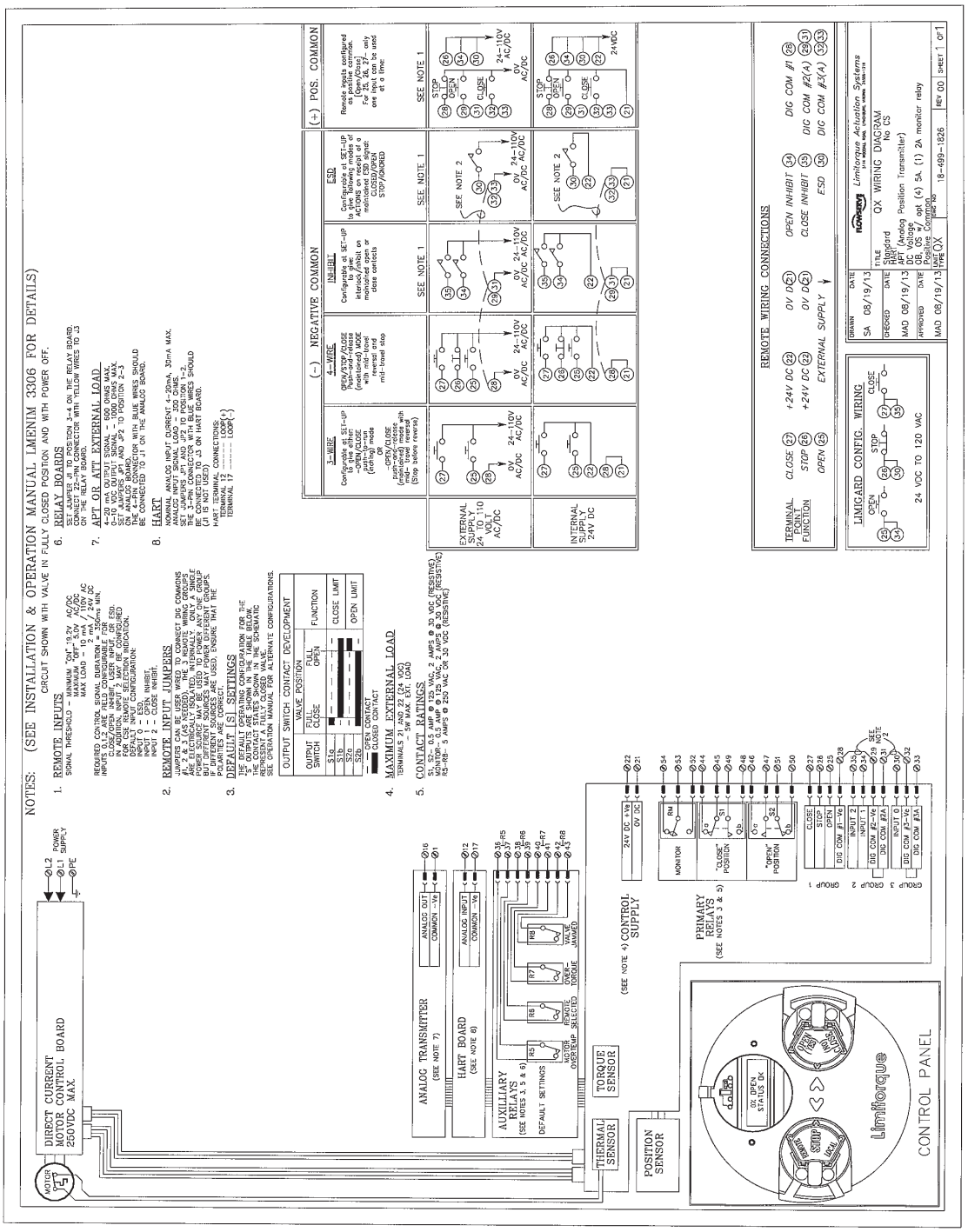
Phone (434) 528-4400
Fax (434) 845-9736

To find the Limitorque distributor or sales office near you, go to http://www.limitorque.com

All inquiries or orders must be accompanied by the following information supplied on the actuator nameplate:

1. Unit size
2. Order number
3. Serial number

Appendix A – Wiring Diagrams



Appendix B – HART Data Formats

Type	Format
Bits	Each individual bit in the byte has a specific meaning. Only values specified by the command may be used. Bit 0 is the least significant bit.
Date	The Date consists of three 8-bit binary unsigned integers representing, respectively, the day, month, and year minus 1900. Date is transmitted day first followed by the month and year bytes.

Enum Enum-8	An integer enumeration with each numeric value having a specific meaning. Only values specified in "Appendix C – Enumeration and Bit Field Tables" are used.
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 zeros (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.
Time	An unsigned 32-bit binary integer with the least significant bit of the time value representing 1/32 of a millisecond (i.e. 0.03125 milliseconds). When time data types are used to represent time of day they indicate the number of 1/32 of milliseconds since midnight. Time can span in excess of 37 hours. When a longer span is required the field device should use time in conjunction with a Date.

Appendix C – Enumeration and Bit Field Tables

Extended Field Device Status

Bit Mask	Description
0x00	Status OK
0x01	Maintenance Required: This bit is set to indicate that, while the device has not malfunctioned, the Field Device requires maintenance.
0x02	Device Variable Alert: This bit is set if any Device Variable is in an Alarm or Warning State. The host should identify the Device Variable(s) causing this to be set using the Device Variable Status Indicators.
0x04	Critical Power Failure: Not Used
0x08	Failure: Not Used
0x10	Out of Specification: Not Used
0x20	Function Check: Not Used

Units Code:

Temperature	
Unit Code	Description
32	Degrees Celsius
33	Degrees Fahrenheit
39	Milliamperes

Miscellaneous	
Unit Code	Description
57	Percent

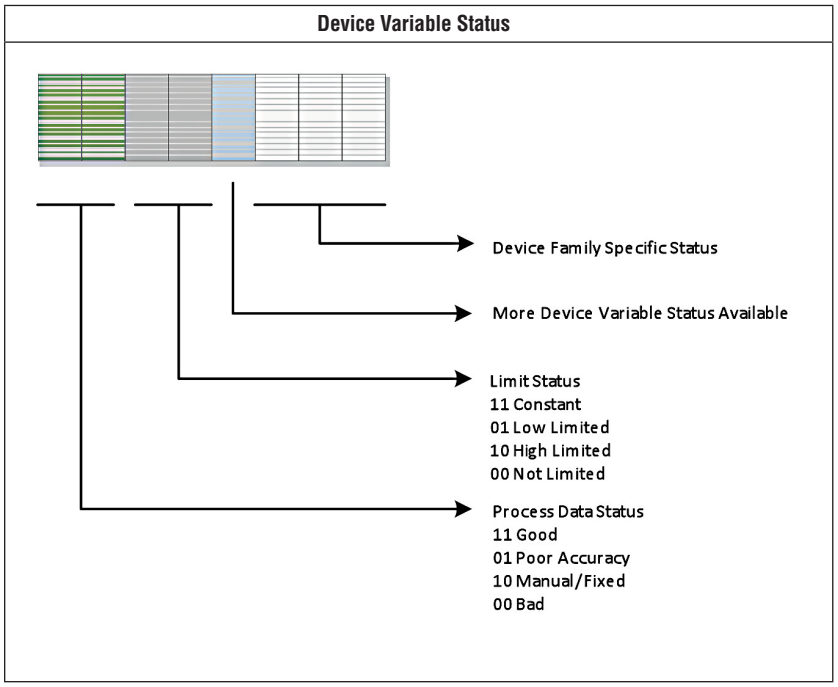
Loop Current Mode	
Code	Loop Current Mode Description
0	Signaling Disabled (Multi-drop)
1	Signaling Enabled (Point-to- Point)

Variable Classification	
Code	Device Variable Classification
0	Device Variable Not Classified
64	Temperature

Device Variable Family	
Code	Device Variable Family

6	Valve/Actuator
250	Not Used

Figure 5.1 – Device Variable Status Byte Format



Write Protect Code	
Code	Device Variable Classification
0	No – Not Write Protected
1	Yes – Write Protected
251	None (Write Protect Mode not supported)

Analog Channel Alarm Selection Code	
Code	Alarm
250	Not Used

Analog Channel Transfer Function Code	
Code	Transfer Function
0	Linear
250	Not Used

Analog Channel Flags	
Flag	Description
0x01	When set this analog channel is a Field Device analog input channel.

Lock Code	
Code	Lock Device Description
0	Unlocked
1	**Lock – Temporary** (i.e., Device Reset or Power Loss releases the lock). Only the locking Master can unlock.
2	**Lock – Permanent** (i.e., Device Reset or Power Loss does not affect the lock). Only the locking Master can unlock.

3	**Lock All** – No changes in the device's configuration, by any master, are allowed. In addition, Device Reset or Power Loss does not affect the lock. Any Master can unlock.

Lock Status	
Bit Mask	Lock Device Description
0x01	**Device Locked.** Must be set if any lock is asserted in the Field Device.
0x02	**Lock is Permanent.** Must be set if lock does not clear on Device Reset or Power Loss.
0x04	**Locked by Primary Master** (Reset if Secondary Master). Must be set if locked by the Primary Master or Gateway.
0x08	**Configuration Locked** and cannot be changed by any application. Must be set if "Lock All" code is received.
0x10	**Locked by Gateway.** Must be set (along with "Locked by Primary Master") if locked by Gateway.

Device Variable Command Code	
These codes indicate whether the Device Variable's engineering value is forced to a fixed value or is in normal operation.	
Code	Transfer Function
0	Normal
1	Fixed

RTC Flags	
Flag	Description
0x01	**Non-Volatile Clock.** When set the device contains a battery-backed clock. In this case the clock does not need to be reset if there is a power loss.
0x02	**Clock Uninitialized.** The real-time clock has never been set with the date and time. For example, the clock is volatile and power was removed from and restored to the device.

Trend Control Code	
Code	Description
0	**Disable**
1	**Enable Single Data Point Trending**
2	**Enable Filtered Trending** – The sample is filtered using a time constant equal to one-third the trend sample period.
3	**Enable Average Trending** – The value is obtained by dividing the sum of all samples in the period by the total number of samples.

Burst Message Trigger Mode Selection Code	
Code	Description
0	**Continuous** – The burst message is published continuously at (worst case) the minimum update period.
1	**Window** – The burst message is triggered when the source value deviates more than the specified trigger value.
2	**Rising** – The burst message is triggered when source value rises above the specified trigger value.
3	**Falling** – The burst message is triggered when the source value falls below the specified trigger value.
4	**On-Change** – The burst message is triggered when any value in the message changes.

Burst Mode Control Code	
Code	Description
0	Off
1	Enable Burst on Token-Passing Data Link Layer Only
2	Enable Burst on TDMA Data-Link Layer Only
3	Enable Burst on TDMA and Token-Passing Data Link Layers
250	Reserved
251	Reserved
252	Reserved

253	Reserved

Event Status	
Flag	Description
0x01	Configuration Changed Event Pending
0x02	Device Status Event Pending
0x04	More Status Available Event Pending

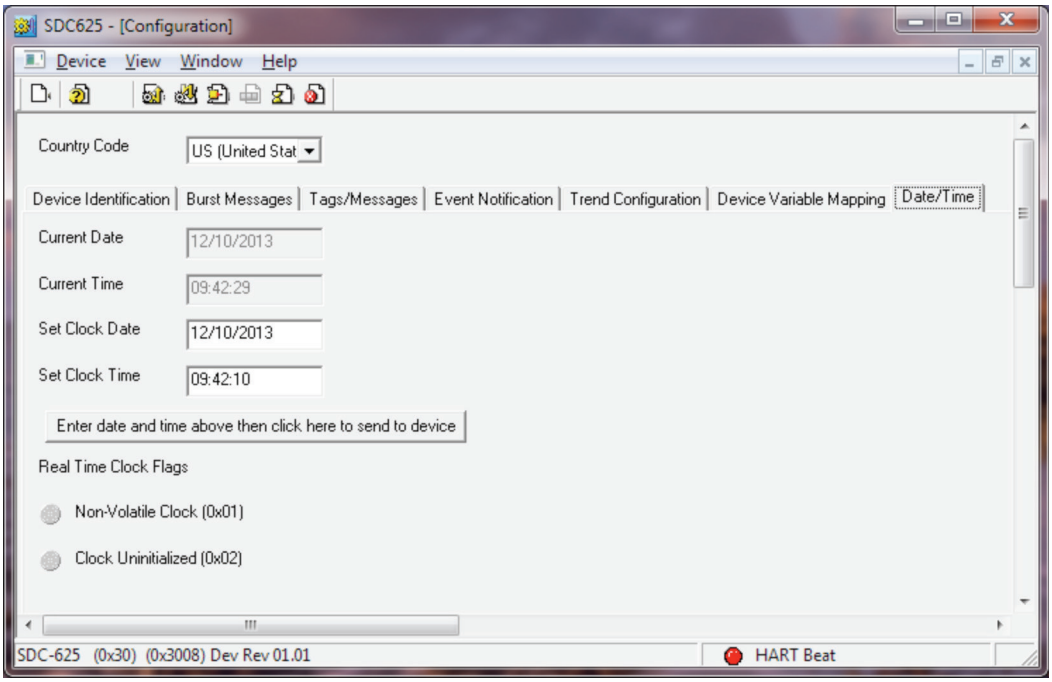
Event Notification Control Code	
Code	Description
0	Off
1	Enable Event Notification on Token-Passing Data Link Layer Only
2	Enable Event Notification on TDMA Data-Link Layer Only
3	Enable Event Notification on TDMA and Token-Passing Data Link Layers

SI Units Control Code	
Code	Description
0	No restrictions (default)
1	Unit codes limited to the SI Units only

Appendix D – Setting Data and Time

Normally a host should send command 89 Set Real Time Clock multiple times while measuring average latency. This will be repeated until communication latency affect are characterized and its effect on setting the Real-Time clock is minimized.

The time and date can be set from the DD menu Device Setup->Wired HART Board-> Configuration->Data/Time as follows:



The MXa/QX HART Device does not support a Non-Volatile Clock, therefore, if power is lost or the unit resets, the date and time are lost and must be reset.

Appendix E – Command Response Codes

NOTE: DR is Delayed Response

Command		Response Code		
No.	**Description**	**Code**	**Class**	**Description**
Universal Commands				
0	Read Unique Identifier	0 1-127	Success N/A	No Command-Specific Errors Undefined
1	Read Primary Variable	0 1-5 6 7 8 9-15 16 17-127	Success N/A Error N/A Warning N/A Error N/A	No Command-Specific Errors Undefined Device-Specific Command Error Undefined Update Failure Undefined Access Restricted Undefined
2	Read Loop Current And Percent Of Range	0 1-5 6 7 8 9-15 16 17-127	Success N/A Error N/A Warning N/A Error N/A	No Command-Specific Errors Undefined Device-Specific Command Error Undefined Update Failure Undefined Access Restricted Undefined
3	Read Dynamic Variables And Loop Current	0 1-5 6 7 8 9-15 16 17-127	Success N/A Error N/A Warning N/A Error N/A	No Command-Specific Errors Undefined Device-Specific Command Error Undefined Update Failure Undefined Access Restricted Undefined

Command		Response Code		
No.	**Description**	**Code**	**Class**	**Description**
6	Write Polling Address	0 1 2 3-4 5 6 7 8-11 12 13-15 16 17-31 32 33-127	Success N/A Error N/A Error Error Error N/A Error N/A Error N/A Error Undefined	No Command-Specific Errors Undefined Invalid Poll Address Selection Undefined Too Few Data Bytes Received Device-Specific Command Error In Write Protect Mode Undefined Invalid Mode Selection Undefined Access Restricted Undefined Busy Undefined
7	Read Loop Configuration	0 1-15 16 17-127	Success N/A Error N/A	No Command-Specific Errors Undefined Access Restricted Undefined
8	Read Dynamic Variable Class	0 1-15 16 17-127	Success N/A Error N/A	No Command-Specific Errors Undefined Access Restricted Undefined
9	Read Device Variables with Status	0 1 2 3-4 5 6 7 8 9-13 14 115 16 17-29 30 31-127	Success N/A Error N/A Error Error N/A Warning N/A Warning N/A Error N/A Warning Undefined	No Command-Specific Errors Undefined Invalid Selection Undefined Too Few Data Bytes Received Device-Specific Command Error Undefined Update Failure Undefined Dynamic Variables Returned for Device Variables Undefined Access Restricted Undefined Command Response Truncated Undefined
11	Read Unique Identifier Associated With Tag	0 1-127	Success N/A	No Command-Specific Errors Undefined
12	Read Message	0 1-15 16 17-31 32 33-127	Success N/A Error N/A Error N/A	No Command-Specific Errors Undefined Access Restricted Undefined Busy Undefined
13	Read Tag, Descriptor, Date	0 1-15 16 17-31 32 33-127	Success N/A Error N/A Error N/A	No Command-Specific Errors Undefined Access Restricted Undefined Busy Undefined
14	Read Primary Variable Transducer Information	0 1-15 16 17-31 32 33-127	Success N/A Error N/A Error N/A	No Command-Specific Errors Undefined Access Restricted Undefined Busy Undefined
15	Read Device Information	0 1-15 16 17-31 32 33-127	Success N/A Error N/A Error N/A	No Command-Specific Errors Undefined Access Restricted Undefined Busy Undefined
16	Read Final Assembly Number	0 1-15 16 17-31 32 33-127	Success N/A Error N/A Error N/A	No Command-Specific Errors Undefined Access Restricted Undefined Busy Undefined
17	Write Message	0 1-4 5 6 7 8-15 16 17-31 32 33-127	Success N/A Error Error Error N/A Error N/A Error N/A	No Command-Specific Errors Undefined Too Few Data Bytes Received Device-Specific Command Error In Write Protect Mode Undefined Access Restricted Undefined Busy Undefined

Command		Response Code		
No.	Description	Code	Class	Description
18	Write Tag, Descriptor, Date	0	Success	No Command-Specific Errors
		1-4	N/A	Undefined
		5	Error	Too Few Data Bytes Received
		6	Error	Device-Specific Command Error
		7	Error	In Write Protect Mode
		8	N/A	Undefined
		9	Error	Invalid Date Code Detected
		10-15	N/A	Undefined
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined
19	Write Final Assembly Number	0	Success	No Command-Specific Errors
		1-4	N/A	Undefined
		5	Error	Too Few Data Bytes Received
		6	Error	Device-Specific Command Error
		7	Error	In Write Protect Mode
		8-15	N/A	Undefined
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined
20	Read Long Tag	0	Success	No Command-Specific Errors
		1-15	N/A	Undefined
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined
21	Read Unique Identifier Associated With Long Tag	0	Success	No Command-Specific Errors
		1	N/A	Undefined
22	Write Long Tag	0	Success	No Command-Specific Errors
		1-4	N/A	Undefined
		5	Error	Too Few Data Bytes Received
		6	Error	Device-Specific Command Error
		7	Error	In Write Protect Mode
		8-15	N/A	Undefined
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33	Error	DR Initiated
		34	Error	DR Running
		35	Error	DR Dead
		36	Error	DR Conflict
		37-127	Error	Undefined
38	Reset Configuration Changed Flag	0	Success	No Command-Specific Errors
		1-4	N/A	Undefined
		5	Error	Too Few Data Bytes Received
		6	Error	Device-Specific Command Error
		7	Error	In Write Protect Mode
		8	N/A	Undefined
		9	Error	Configuration Change Counter Mismatch
		10-15	N/A	Undefined
		16	Error	Access Restricted
		17-127	N/A	Undefined
48	Read Additional Device Status	0	Success	No Command-Specific Errors
		1-4	N/A	Undefined
		5	Error	Too Few Data Bytes Received
		6	Error	Device-Specific Command Error
		7	N/A	Undefined
		8	Warning	Update in Progress
		9-13	N/A	Undefined
		14	Warning	Status Bytes Mismatch
		15	N/A	Undefined
		16	Error	Access Restricted
		17-127	N/A	Undefined
Common Commands				
33	Read Device Variables	0	Success	No Command-Specific Errors
		1	N/A	Undefined
		2	Error	Invalid Selection
		3-4	N/A	Undefined
		5	Error	Too Few Data Bytes Received
		6	Error	Device-Specific Command Error
		7	N/A	Undefined
		8	Warning	Updated Failure
		9-15	N/A	Undefined
		16	Error	Access Restricted
		17-127	N/A	Undefined

Command		Response Code		
No.	**Description**	**Code**	**Class**	**Description**
35	Write Primary Variable Range Values	0	Success	No Command-Specific Errors
		1	N/A	Undefined
		2	Error	Invalid Selection
		3-4	N/A	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	N/A	Undefined
		16	Error	Access Restricted
		17	N/A	Undefined
		18	Error	Invalid Units Code
		19-28	N/A	Undefined
		29	Error	Invalid Span
		30-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined
36	Set Primary Variable Upper Range Value	0	Success	No Command-Specific Errors
		1-5	N/A	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	N/A	Undefined
		14	Warning	Span Too Small (Device Accuracy May be Impaired)
		15	N/A	Undefined
		16	Error	Access Restricted
		17-28	N/A	Undefined
		29	Error	Invalid Span
		30-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined
37	Set Primary Variable Lower Range Value	0	Success	No Command-Specific Errors
		1-5	N/A	Undefined
		6	Error	Device-Specific Command Error
		7	Error	In Write Protect Mode
		8	N/A	Undefined
		9	Error	Applied Process Too High
		10	Error	Applied Process Too Low
		11-13	N/A	Undefined
		14	Warning	New Lower Range Value Pushed
		15	N/A	Undefined
		16	Error	Access Restricted
		17-28	N/A	Undefined
		29	Error	Invalid Span
		30-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined
40	Enter/Exit Fixed Current Mode	0	Success	No Command-Specific Errors
		1-2	N/A	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	N/A	Undefined
		11	Error	Loop Current Not Active (Device in Multi-drop Mode)
		12-15	N/A	Undefined
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined
41	Perform Self Test	0	Success	No Command-Specific Errors
		1-5	N/A	Undefined
		6	Error	Device-Specific Command Error
		7-15	N/A	Undefined
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined
42	Perform Device Reset	0	Success	No Command-Specific Errors
		1-5	N/A	Undefined
		6	Error	Device-Specific Command Error
		7-15	N/A	Undefined
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined

Command		Response Code		
No.	**Description**	**Code**	**Class**	**Description**
45	Trim Loop Current Zero	0	Success	No Command-Specific Errors
		1-2	N/A	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	N/A	Undefined
		9	Error	Incorrect Loop Current Mode or Value
		10	N/A	Undefined
		11	Error	Loop Current Not Active (Device in Multi-drop Mode)
		12-15	N/A	Undefined
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined
49	Write Primary Variable Transducer Serial Number	0	Success	No Command-Specific Errors
		1-4	N/A	Undefined
		5	Error	Too Few Data Bytes Received
		6	Error	Device-Specific Command Error
		7	Error	In Write Protect Mode
		8-15	N/A	Undefined
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined

Command		Response Code		
No.	**Description**	**Code**	**Class**	**Description**
50	Read Dynamic Variable Assignments	0 1-5 6 7-15 16 17-127	Success N/A Error N/A Error N/A	No Command-Specific Errors Undefined Device-Specific Command Error Undefined Access Restricted Undefined
51	Write Dynamic Variable Assignments	0 1 2 3-4 5 6 7 8-15 16 17-31 32 33-127	Success N/A Error N/A Error Error Error N/A Error N/A Error N/A	No Command-Specific Errors Undefined Invalid Selection Undefined Too Few Data Bytes Received Device-Specific Command Error In Write Protect Mode Undefined Access Restricted Undefined Busy Undefined
53	Write Device Variable Units	0 1-4 5 6 7 8-10 11 12 13-15 16 17-31 32 33-127	Success N/A Error Error Error N/A Error Error N/A Error N/A Error N/A	No Command-Specific Errors Undefined Too Few Data Bytes Received Device-Specific Command Error In Write Protect Mode Undefined Invalid Device Variable Code Invalid Units Code Undefined Access Restricted Undefined Busy Undefined
54	Read Device Variable Information	0 1 2 3-4 5 6 7-15 16 17-31 32 33-127	Success N/A Error N/A Error Error N/A Error N/A Error N/A	No Command-Specific Errors Undefined Invalid Selection Undefined Too Few Data Bytes Received Device-Specific Command Error Undefined Access Restricted Undefined Busy Undefined
56	Write Device Variable Transducer Serial No.	0 1 2 3-4 5 6 7 8-15 16 17-31 32 33-127	Success N/A Error N/A Error Error Error N/A Error N/A Error N/A	No Command-Specific Errors Undefined Invalid Selection Undefined Too Few Data Bytes Received Device-Specific Command Error In Write Protect Mode Undefined Access Restricted Undefined Busy Undefined
59	Write Number of Response Preambles	0 1-2 3 4 5 6 7 8 9-15 16 17-31 32 33-127	Success N/A Error Error Error Error Error Warning N/A Error N/A Error N/A	No Command-Specific Errors Undefined Passed Parameter Too Large Passed Parameter Too Small Too Few Data Bytes Received Device-Specific Command Error In Write Protect Mode Set to Nearest Possible Value Undefined Access Restricted Undefined Busy Undefined
60	Read Analog Channel and Percent of Range	0 1 2 3-4 5 6 7 8 9-15 16 17-127	Success N/A Error N/A Error Error N/A Warning N/A Error N/A	No Command-Specific Errors Undefined Invalid Selection Undefined Too Few Data Bytes Received Device-Specific Command Error Undefined Update Failure Undefined Access Restricted Undefined

Command		Response Code		
No.	Description	Code	Class	Description
63	Read Analog Channel Information	0	Success	No Command-Specific Errors
		1	N/A	Undefined
		2	Error	Invalid Selection
		3-4	N/A	Undefined
		5	Error	Too Few Data Bytes Received
		6	Error	Device-Specific Command Error
		7-15	N/A	Undefined
		16	Error	Access Restricted
		17-127	N/A	Undefined
65	Write Analog Channel Range Values	0	Success	No Command-Specific Errors
		1-4	N/A	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	N/A	Undefined
		28	Error	Invalid Range Units Code
		29	Error	Invalid Span
		17-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined
66	Enter/Exit Fixed Analog Channel Mode	0	Success	No Command-Specific Errors
		1-2	N/A	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	N/A	Undefined
		11	Error	In Multi-drop Mode
		12	Error	Invalid Units Code
		13-14	N/A	Undefined
		15	Error	Invalid Analog Channel Code Number
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined
67	Trim Analog Channel Zero	0	Success	No Command-Specific Errors
		1-2	N/A	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	N/A	Undefined
		9	Error	Not in Proper Analog Channel Mode
		10	N/A	Undefined
		11	Error	In Multi-drop Mode
		12	Error	Invalid Units Cod
		13-14	N/A	Undefined
		15	Error	Invalid Analog Channel Code Number
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined
68	Trim Analog Channel Gain	0	Success	No Command-Specific Errors
		1-2	N/A	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	N/A	Undefined
		9	Error	Not in Proper Analog Channel Mode
		10	N/A	Undefined
		11	Error	In Multi-drop Mode
		12	Error	Invalid Units Cod
		13-14	N/A	Undefined
		15	Error	Invalid Analog Channel Code Number
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined

Command		Response Code		
No.	**Description**	**Code**	**Class**	**Description**
71	Lock Device	0	Success	No Command-Specific Errors
		1-4	N/A	Undefined
		5	Error	Too Few Data Bytes Received
		6	Error	Device-Specific Command Error
		7-9	N/A	Undefined
		10	Error	Invalid Lock Code
		11	Error	Cannot Lock Device
		12-15	N/A	Undefined
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33	Error	DR Initiated
		34	Error	DR Running
		35	Error	DR Dead
		36	Error	DR Conflict
		37-127	N/A	Undefined
76	Read Lock Device State	0	Success	No Command-Specific Errors
		1-5	N/A	Undefined
		6	Error	Device-Specific Command Error
		7-15	N/A	Undefined
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined
78	Read Aggregated Commands	0	Success	No Command-Specific Errors
		1	N/A	Undefined
		2	Error	Invalid Selection
		3-4	N/A	Undefined
		5	Error	Too Few Data Bytes Received
		6	Error	Device-Specific Command Error
		7	N/A	Undefined
		8	Warning	Update Failure
		9	Error	Invalid Command Request
		10-29	N/A	Undefined
		30	Warning	Command Response Truncated – One or more commands are dropped in the response
		31	N/A	Undefined
		32	Error	Busy
		33	Error	DR Initiated
		34	Error	DR Running
		35	Error	DR Dead
		36	Error	DR Conflict
		37-127	N/A	Undefined
79	Command 79 Write Device Variable	0	Success	No Command-Specific Errors
		1	N/A	Undefined
		2	Error	Invalid Selection
		3-4	N/A	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	N/A	Undefined
		10	Error	Invalid Write Device Variable Command Code
		11-13	N/A	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.
		15	N/A	Undefined
		16	Error	Access Restricted
		17	Error	Invalid Device Variable Index
		18	Error	Invalid Units Code
		19	Error	Device Variable Index not allowed for this command
		20-31	N/A	Undefined
		32	Error	Busy
		33	Error	DR Initiated
		34	Error	DR Running
		35	Error	DR Dead
		36	Error	DR Conflict
		37-127	N/A	Undefined
89	Set Real Time Clock	0	Success	No Command-Specific Errors
		1	N/A	Undefined
		2	Error	Invalid Selection (Time-set code)
		3	Error	Passed Parameter Too Large
		4	N/A	Undefined
		5	Error	Too Few Data Bytes Received
		6	Error	Device-Specific Command Error
		7	Error	In Write Protect Mode
		8-15	N/A	Undefined
		16	Error	Access Restricted
		17-127	N/A	Undefined
90	Read Real Time Clock	0	Success	No Command-Specific Errors
		1-5	N/A	Undefined
		6	Error	Device-Specific Command Error
		7-127	N/A	Undefined

Command		Response Code		
No.	Description	Code	Class	Description
91	Read Trend Configuration	0	Success	No Command-Specific Errors
		1-4	N/A	Undefined
		5	Error	Too Few Data Bytes Received
		6	Error	Device-Specific Command Error
		7-10	N/A	Undefined
		11	Error	Invalid Trend Number
		12-127	N/A	Undefined
92	Write Trend Configuration	0	Success	No Command-Specific Errors
		1	N/A	Undefined
		2	Error	Invalid Selection
		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	N/A	Undefined
		11	Error	Invalid Trend Number
		12-15	N/A	Undefined
		16	Error	Access Restricted
		17	Error	Invalid Device Variable Index
		18-127	N/A	Undefined
93	Read Trend	0	Success	No Command-Specific Errors
		1-4	N/A	Undefined
		5	Error	Too Few Data Bytes Received
		6	Error	Device-Specific Command Error
		7	N/A	Undefined
		8	Warning	Trend not Active
		9-10	N/A	Undefined
		11	Error	Invalid Trend Number
		12-127	N/A	Undefined
95	Read Device Communications Statistics	0	Success	No Command-Specific Errors
		1-5	N/A	Undefined
		6	Error	Device-Specific Command Error
		7-127	N/A	Undefined
103	Write Burst Period	0	Success	No Command-Specific Errors
		1-4	N/A	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	N/A	Undefined
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33	Error	DR Initiated
		34	Error	DR Running
		35	Error	DR Dead
		36	Error	DR Conflict
		37-127	N/A	Undefined
104	Write Burst Trigger	0	Success	No Command-Specific Errors
		1-2	N/A	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
		9	Error	Invalid Burst Message
		10	N/A	Undefined
		11	Error	Invalid Device Variable Classification
		12	Error	Invalid Units Code
		13	Error	Invalid Burst Trigger Mode Selection
		14-15	N/A	Undefined
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33	Error	DR Initiated
		34	Error	DR Running
		35	Error	DR Dead
		36	Error	DR Conflict
		37-127	N/A	Undefined
105	Read Burst Mode Configuration	0	Success	No Command-Specific Errors
		1-5	N/A	Undefined
		6	Error	Device-Specific Command Error
		7-8	N/A	Undefined
		9	Error	Invalid Burst Message
		10-31	N/A	Undefined
		32	Error	Busy
		33-127	N/A	Undefined

Command		Response Code		
No.	Description	Code	Class	Description
106	Flush Delayed Responses	0 1-5 6 7 8 9-15 16 17-31 32 33-127	Success N/A Error N/A Warning N/A Error N/A Error N/A	No Command-Specific Errors Undefined Device-Specific Command Error Undefined All but running delayed responses flushed Undefined Access Restricted Undefined Busy Undefined
107	Write Burst Device Variables	0 1 2 3-4 5 6 7 8 9 10-15 16 17-127	Success N/A Error N/A Error Error Error Warning Error N/A Error N/A	No Command-Specific Errors Undefined Invalid Selection Undefined Too Few Data Bytes Received Device-Specific Command Error In Write Protect Mode Burst Condition Conflict Invalid Burst Message Undefined Access Restricted Undefined
108	Write Burst Mode Command Number	0 1 2 3-4 5 6 7 8 9 10-15 16 17-127	Success N/A Error N/A Error Error Error Warning Error N/A Error N/A	No Command-Specific Errors Undefined Invalid Selection Undefined Too Few Data Bytes Received Device-Specific Command Error In Write Protect Mode Burst Condition Conflict Invalid Burst Message Undefined Access Restricted Undefined
109	Burst Mode Control	0 1 2 3-4 5 6 7 8 9 10-15 16 17-31 32 33 34 35 36 37-127	Success N/A Error N/A Error Error Error Warning Error N/A Error N/A Error Error Error Error Error N/A	No Command-Specific Errors Undefined Invalid Selection Undefined Too Few Data Bytes Received Device-Specific Command Error In Write Protect Mode Update Period Increased (some bandwidth available) No bandwidth available Undefined Access Restricted Undefined Busy DR Initiated DR Running DR Dead DR Conflict Undefined
115	Read Event Notification Summary	0 1 2 3-4 5 6 7-127	Success N/A Error N/A Error Error N/A	No Command-Specific Errors Undefined Invalid Selection Undefined Too Few Data Bytes Received Device-Specific Command Error Undefined
116	Write Event Notification Bit Mask	0 1 2 3-4 5 6 7 8-15 16 17-127	Success N/A Error N/A Error Error Error N/A Error N/A	No Command-Specific Errors Undefined Invalid Selection Undefined Too Few Data Bytes Received Device-Specific Command Error In Write Protect Mode Undefined Access Restricted Undefined
117	Write Event Notification Timing	0 1-4 5 6 7 8 9 10-15 16 17-31 32 33 34 35 36 37-127	Success N/A Error Error Error Warning Error N/A Error N/A Error Error Error Error Error N/A	No Command-Specific Errors Undefined Too Few Data Bytes Received Device-Specific Command Error In Write Protect Mode Update Period or De-bounce Interval Adjusted Invalid Event Specification number Undefined Access Restricted Undefined Busy DR Initiated DR Running DR Dead DR Conflict Undefined

Command		Response Code		
No.	**Description**	**Code**	**Class**	**Description**
118	Event Notification Control	0	Success	No Command-Specific Errors
		1	N/A	Undefined
		2	Error	Invalid Selection
		3-4	N/A	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	N/A	Undefined
		14	Warning	Update Rate Uncertain – only allowed when not connected to the network
		15	N/A	Undefined
		16	Error	Access Restricted
		17-31	N/A	Undefined
		32	Error	Busy
		33	Error	DR Initiated
		34	Error	DR Running
		35	Error	DR Dead
		36	Error	DR Conflict
		37-127	N/A	Undefined
119	Acknowledge Event Notification	0	Success	No Command-Specific Errors
		1	N/A	Undefined
		2	Error	Invalid Selection
		3-4	N/A	Undefined
		5	Error	Too Few Data Bytes Received
		6	Error	Device-Specific Command Error
		7	N/A	Undefined
		8	Warning	Not All Events Cleared or (when publishing an Event Notification) one or more event is pending for this Event Notification
		9-15	N/A	Undefined
		16	Error	Access Restricted
		17-127	N/A	Undefined
512	Read Country Code	0	Success	No Command-Specific Errors
		1-5	N/A	Undefined
		6	Error	Device-Specific Command Error
		7-127	N/A	Undefined
513	Write Country Code	0	Success	No Command-Specific Errors
		1	N/A	Undefined
		2	Error	Invalid Selection
		3-4	N/A	Undefined
		5	Error	Too Few Data Bytes Received
		6	N/A	Undefined
		7	Error	In Write Protect Mode
		8	N/A	Undefined
		9	Error	SI Units Restriction Failed (Not all Units Codes currently configured are SI Compliant)
		10-15	N/A	Undefined
		16	Error	Access Restricted
		17-31	N/A	Busy
		32	Error	Undefined
		33	Error	DR Initiated
		34	Error	DR Running
		35	Error	DR Dead
		36	Error	DR Conflict
		37-127	N/A	Undefined

FLOWSERVE

Flowserve Corporation
Flow Control

United States
Flowserve Limitorque
5114 Woodall Road
P.O. Box 11318
Lynchburg, VA 24506-1318
Phone: 434-528-4400
Fax: 434-845-9736

England
Flowserve Limitorque
Euro House
Abex Road
Newbury
Berkshire, RG14 5EY
United Kingdom
Phone: 44-1-635-46999
Fax: 44-1-635-36034

Japan
Limitorque – Nippon Gear Co., Ltd.
Asahi-Seimei Bldg. 4th Floor
1-11-11 Kita-Saiwai, Nishi-Ku
Yokohama-Shi, (220-0004)
Japan
Phone: 81-45-326-2065
Fax: 81-45-320-5962

Canada
Flowserve Limitorque
120 Vinyl Court
Woodbridge, Ontario L4L 4A3
Canada
Phone: 905-856-4565
Fax: 905-856-7905

Singapore
Limitorque Asia, Pte., Ltd.
12, Tuas Avenue 20
Singapore 638824
Phone: 65-6868-4628
Fax: 65-6862-4940

China
Limitorque Beijing, Pte., Ltd.
RM A1/A2
22/F, East Area, Hanwei Plaza
No. 7 Guanghua Road, Chaoyang District
Beijing 100004, Peoples Republic of China
Phone: 86-10-5921-0606
Fax: 86-10-6561-2702

India
Flowserve Limitorque
No. 10-12, THE OVAL, Third floor
Venkatnarayana Road
T. Nagar, Chennai 600 017
Phone: 91-44-2432-8755
and 91-44-2432-4801
Fax: 91-44-2432-8754

To find your local Flowserve representative, visit www.flowserve.com, www.limitorque.com or call USA 1 800 225 6989.

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Flowserve Corporation
Flow Control

United States
Flowserve Limitorque
5114 Woodall Road
P.O. Box 11318
Lynchburg, VA 24506-1318
Phone: 434-528-4400
Fax: 434-845-9736

England
Flowserve Limitorque
Euro House
Abex Road
Newbury
Berkshire, RG14 5EY
United Kingdom
Phone: 44-1-635-46999
Fax: 44-1-635-36034

Japan
Limitorque – Nippon Gear Co., Ltd.
Asahi-Seimei Bldg. 4th Floor
1-11-11 Kita-Saiwai, Nishi-Ku
Yokohama-Shi, (220-0004)
Japan
Phone: 81-45-326-2065
Fax: 81-45-320-5962

Canada
Flowserve Limitorque
120 Vinyl Court
Woodbridge, Ontario L4L 4A3
Canada
Phone: 905-856-4565
Fax: 905-856-7905

Singapore
Limitorque Asia, Pte., Ltd.
12, Tuas Avenue 20
Singapore 638824
Phone: 65-6868-4628
Fax: 65-6862-4940

China
Limitorque Beijing, Pte., Ltd.
RM A1/A2
22/F, East Area, Hanwei Plaza
No. 7 Guanghua Road, Chaoyang District
Beijing 100004, Peoples Republic of China
Phone: 86-10-5921-0606
Fax: 86-10-6561-2702

India
Flowserve Limitorque
No. 10-12, THE OVAL, Third floor
Venkatnarayana Road
T. Nagar, Chennai 600 017
Phone: 91-44-2432-8755
and 91-44-2432-4801
Fax: 91-44-2432-8754