Installation, Operation and Maintenance Manual
MDE 254 Rev. 0
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Bettis XTE3000

HART Bus Module

BETTIS™

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Table of Contents

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Section 1: Introduction

The XTE HRT2000v4 Module is an electronic module that allows Bettis XTE3000 actuator to connect to a HART serial communication line. The module complies with HART Protocol Revision 7.2. The XTE HRT2000v4 is equipped with a microprocessor, which allows it to be controlled by a program stored internally. It works as a pure bus interface and does not affect the actuator control integrity. It is installed inside the actuator housing and the communication interface is powered from the actuator power supply module. The HART hardware modem is located on the module board, while fully isolating the data lines from the actuator electronics.

Section 2: Operation and Storage

The module is designed to work and to be stored in the same environment of the actuator.

Section 3: Communication Features

Communication Protocol:	HART Protocol Revision 7.2
Electrical Interface:	4 - 20 mA analog loop, 2 wire communication
HART Signal:	Digital FSK Frequency Shift Keying (Bell 202 standard)
Logical “0” frequency:	2,200 Hz
Logical “1” frequency:	1,200 Hz
Data Rate:	Request / response mode – 2/3 updates per second Optional burst mode – 3/4 updates per second
Data Transmission:	Master / Slave and Burst communication modes
Data Byte Structure:	1 start bit, 8 data bits, 1 odd parity bit, 1 stop bit
Command Structure:	

Type of Command	**Structure**
Universal	Common to all devices
Common practice	Optional; used by many devices
Device specific	For unique product features

HART Topology:	Point to point, Multidrop, Series Connection
Cable Lengths:	Maximum twisted pair length — 10,000 ft. (3,048 m) Maximum multiple twisted pair length — 5,000 ft. (1,524 m)
Electrical Power:	Bus powered Max voltage 36 V Min voltage 0 V
Device Type:	Actuator
Device Impedance:	Low Impedance
Temperature:	-40 °C, +85 °C
Reversed Polarity Protection:	Present
EMC Protections:	According to generic standard for industrial environments EN61000-6-2 and EN 61000-6-4
Manufacturer ID Code:	183 (B7 HEX)
Device Type Code:	126 (7E HEX)

Section 4: HART Module

The module consists in a single PCB that is installed inside the actuator housing. It is connected to the XTE3000 base card via strip connector.

The internal wiring connects the HART data lines to the actuator terminal board.

Figure 1 Top Side

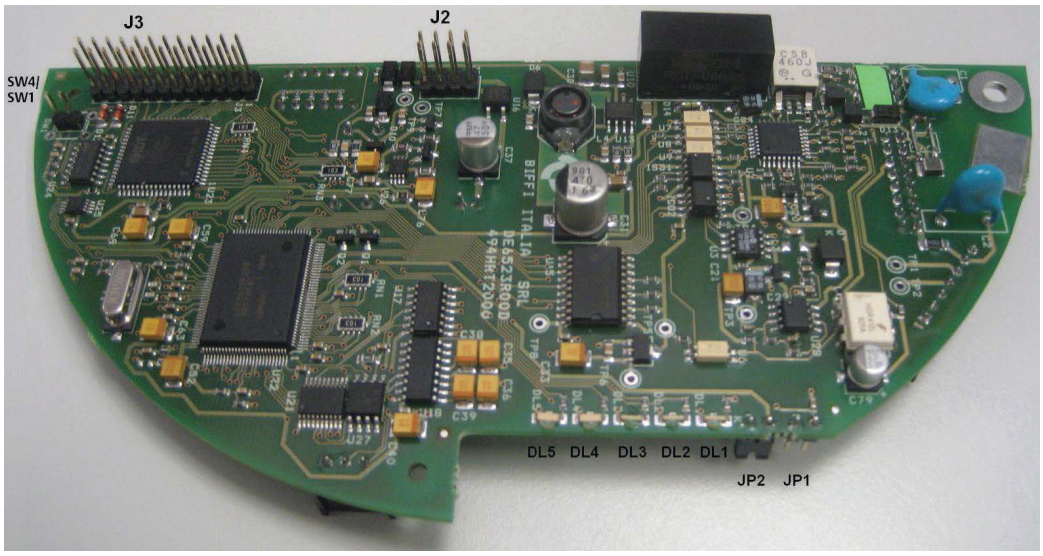
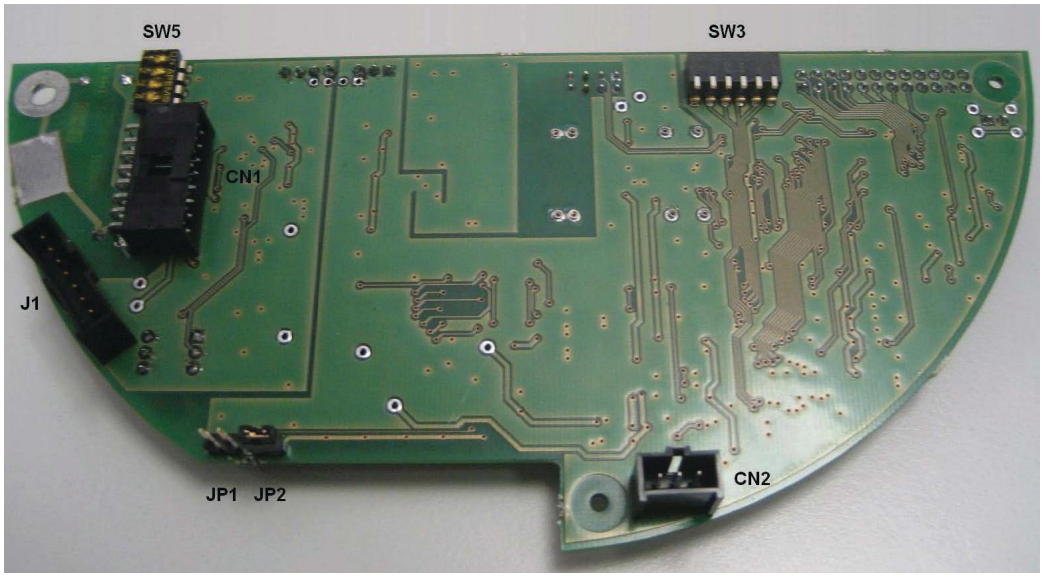


Figure 2 Bottom Side



4.1 On Board Indications and Jumpers

Five LEDs are mounted on the HRT2000v4 rev. 1 to give the following indications for the field service. LEDs indicators are active only when jumper JP2 is closed.

DL1 (green) Power Supply:	ON: when the HRT2000v4 module is correctly powered from the main power supply. OFF: when the HRT2000v4 module is not correctly powered from the power supply.
DL2 (green) HART Communication:	ON: Data Message received or transmit from HRT2000v4 interface. OFF: Silence between Data HART messages.
DL3 (green) 4 - 20 mA Setup:	ON: Setup active (SW3 pin 6 in ON). OFF: Setup not active (SW3 pin 6 in OFF)
DL4 (red) 4 – 20 mA Input Level:	ON: Alarm, input level too low (< 2 mA). OFF: No Alarms
DL5 (red) Data Area Empty:	ON: when Data Area on interface card is not yet loaded. OFF: when Data Area is completely loaded. BLINK: when Data Area is being read from base card.
JP1:	Program jumper. Used to download new firmware on microcontroller (Manufacturer use only).
JP2:	LEDs Jumper. Short this jumper to power LEDs (Default ON).
SW4 / SW1:	Pin Reset. Short this jumper to reset the HRT2000v4 module.

4.2 On Board Settings

The HRT2000v4 module is provided of dip switches to change the hardware settings of the module. The below settings are normally done in factory. Change settings only if authorized from manufacturer.

- 4 - 20 mA SETUP

  This procedure describes how to set the 4 - 20 mA limits for the HART Card Interface.

  - 4 mA: connect 4 mA to HART+ and HART-. Move SW3 pin 5 in ON. Move SW3 pin 6 in ON. Wait 2 seconds. Move SW3 pin 6 and then pin 5 in OFF to store 4 mA setting in data flash memory.
  - 20 mA: connect 20 mA to HART+ and HART-. Move SW3 pin 4 in OFF. Move SW3 pin 6 in ON. Wait 2 seconds. Move SW3 pin 6 and then pin 4 in OFF to store 20 mA setting in data flash memory.

- Filter ON / OFF

  To select analog filter type, follow the below procedure:

  - Filter OFF: Move SW3 pin 6 in ON. Move SW3 pin 3 in ON. Wait 2 seconds. Move SW3 pin 6 in OFF to store OFF filter selection.
  - Filter ON (default): Move SW3 pin 6 in ON. Move SW3 pin 3 in OFF. Wait 2 seconds. Move SW3 pin 6 in OFF to store ON filter selection.

- Default configuration (Manufacturer use only)

  To select default factory settings, follow the below procedure:

  Switch off the power supply to the card. Move SW3 pin 1 to 6 in ON and then switch on power supply. Default configuration is stored in data flash memory. Move SW3 pin 1 to 6 in OFF.

  Be careful, this procedure clears all configurations selected before. In particular, the 4 - 20 mA settings are changed and Configuration Change Counter is reset.

- Wiring mode

  This procedure describes how to set HART Wirings for the HRT2000v4 Interface (see Section 5.1).

  — Point to Point: Move SW5 pin 1 and 2 in OFF. Move SW5 pin 3 and 4 in ON.

  — Split Range: Move SW5 pin 1 and 2 in OFF. Move SW5 pin 3 and 4 in ON.

  — Multidrop: Move SW5 pin 1 and 2 ON. Move SW5 pin 3 and 4 in OFF.

See Section 11 for the Polling address, Device ID number and Mode.

See also Section 8, Universal Command 6 (Write Polling Address).

4.3 Analog Control Signal

Maximum Current: 20.8 mA

Minimum Current: 2 mA

Multidrop Current: 4 mA

The following values are measured according to the HCF_TEST-2 rev 2.2.

Input Impedence: 495 Ohm (in loop control mode)

Input Capacitance: 30,000 pF (in loop control mode)

4.4 Process Variables

PV:	Analog 4 - 20 mA signal in % (position request in loop enable mode)
PV loop current:	Analog 4 - 20 mA input signal in mA
SV:	Actuator position in % of opening
TV:	Actuator torque in % of nominal torque (+ in closing, - in opening)
QV:	Temperature of electronics (°C)

Section 5: HART Protocol Previews

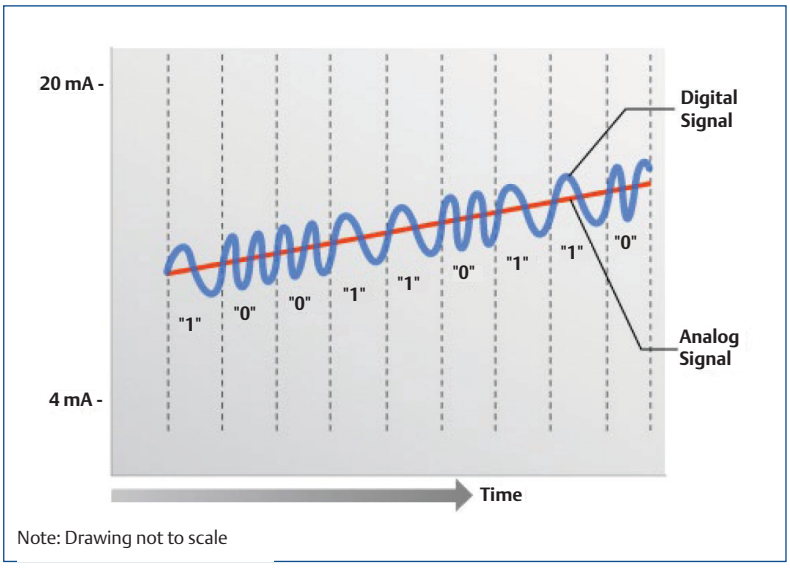
The HART bus combines the familiarity of using the 4 - 20 mA signals with the benefits of the bus technology. In fact, by means of the simultaneous analog and digital signals, additional information can be carried out on the same pair of wires together with the analog 4 - 20 mA signal. The digital communication signal has a response time of approximately 2 - 3 data updates per second without interrupting the analog signal.

HART is typically a request-response communication protocol, which means that during normal operation (2 - 3 data updates per second), each field device communication is initiated by a host communication device. Two hosts can connect to each HART loop. The primary host is generally a distributed control system (DCS), programmable logic controller (PLC), or a personal computer (PC). Our actuator interface is a field device.

The XTE HRT2000v4 Module support the optional burst communication mode. Burst mode enables faster communication (3 - 4 data updates per second). In burst mode, the host instructs the field device to continuously broadcast a standard HART reply message (e.g. the value of the process variable). The host receives the message at the higher rate until it instructs the device to stop bursting.

The HART Communication Protocol is based on the Bell 202 telephone communication standard and operates using the frequency shift keying (FSK) principle. The digital signal is made up of two frequencies 1,200 Hz and 2,200 Hz representing bits 1 and 0, respectively. Sine waves of these two frequencies are superimposed on the direct current analog signal cables to provide simultaneous analog and digital communications. Because the average value of the FSK signal is always zero, the 4 - 20 mA analog signal is not affected.

Figure 3 Digital over Analog



More information about HART are in the official website http://www.hartcomm.org.

5.1 HART Wirings

According to HART specification, the following working modes are available: point to point, split range, and multidrop.

The selection is done according to the Table 1below by means of the dip switches SW5 on the HART module.

Table 1.

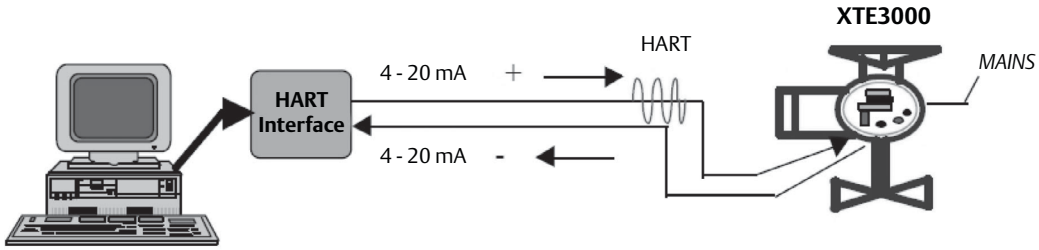
SW5 pin 1	SW5 pin 2	SW5 pin 3	SW5 pin 4	Connections Mode
OFF	OFF	ON	ON	Point to Point
OFF	OFF	ON	ON	Split Ranging
ON	ON	OFF	OFF	Multidrop

NOTE: The factory configuration is POINT to POINT.

- **POINT TO POINT**

  In Point to Point mode, the 4 - 20 mA signal is used to communicate one process variable, while additional process variables, configuration parameters, and other device data are transferred digitally using the HART Protocol. The 4 - 20 mA analog signal is not affected by the HART signal and can be used for control. The HART communication digital signal gives access to secondary variables and other data that can be used for operations, commissioning, maintenance, and diagnostic purposes. See Figure 4 below.

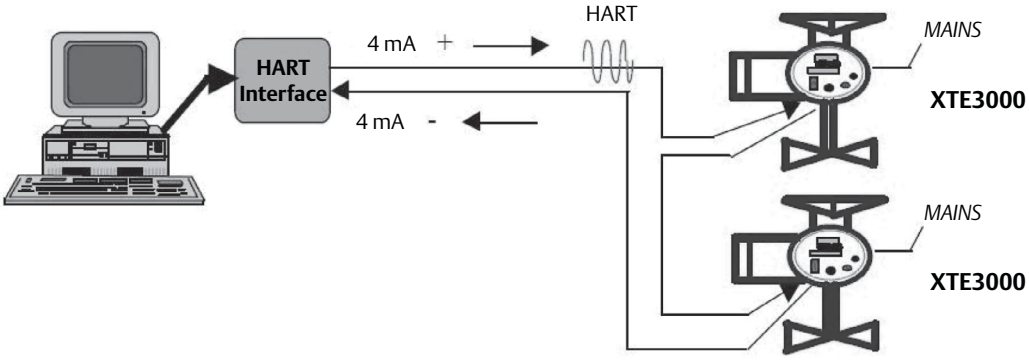
Figure 4



- **SPLIT RANGING**

  Split Range Control is a single control loop divided into two or more independent final control elements such as valves acting in different directions or in different steps. The field devices are connected in series in the same 4 - 20 mA current loop, each field device must have a unique polling address, different from each other in the range 0 - 15.

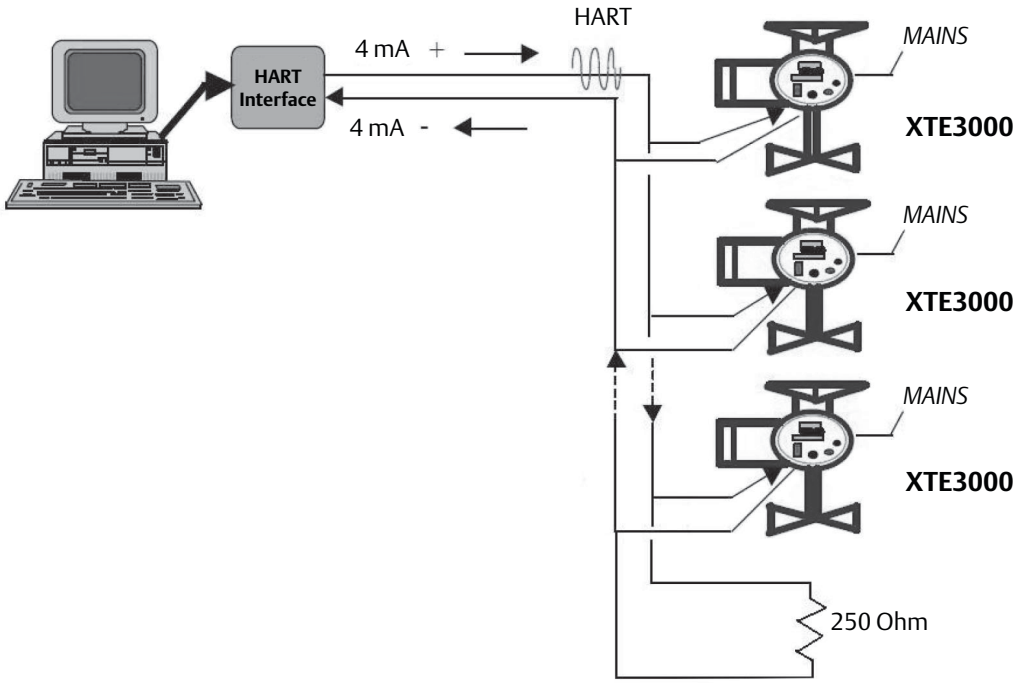
Figure 5



- **MULTIDROP**

  The Multidrop Mode requires only a single pair of wires and can control up to 16 devices connected in parallel. All process values are transmitted digitally. In Multidrop mode, each field device must have a unique polling address, different from each other in the range 0 - 15. The current of the loop is fixed to a minimum value (typically 4 mA).

Figure 6



To work in Multidrop Mode, the XTE HRT2000v4 module need to set SW5 pin 1 and 2 ON, pin 3 and 4 OFF. It needs also to place a 250 Ohm resistance between the terminals HART+ and HART- of the last actuator to close the 4 - 20 mA current loop.

Alternatively, only in the last actuator of 4 - 20 mA current loop, set SW5 pin 1 and 2 OFF, pin 3 and 4 ON. In this case, it is not necessary to add the 250 Ohm resistance to close the 4 - 20 mA loop. The other actuators of the loop must have SW5 pin 1 and 2 ON and pin 3 and 4 OFF.

See also Section 8 (Universal command 6 and Device variable 3) and Section 11 for the configuration of Mode (Loop enable or Multidrop) and Polling Address.

Section 6: Wiring and Installation

In general, the installation practice for HART communicating devices is the same as conventional 4 - 20 mA instrumentation. Individually shielded twisted pair cable, either in single-pair or multi-pair varieties is the recommended wiring practice. Unshielded cables may be used for short distances if ambient noise and cross-talk will not affect communication. The minimum conductor size is 0.51 mm diameter (#24 AWG) for cable runs less than 1,524 m (5,000 ft.) and 0.81 mm diameter (#20 AWG) for longer distances.

6.1 Cable length

Most installations are well within the 3,000 m (10,000 ft.) theoretical limit for HART communication. However, the electrical characteristics of the cable (mostly capacitance) and the combination of connected devices can affect the maximum allowable cable length of a HART network. Table 2 below shows the effect of cable capacitance and the number of network devices on cable length. The table is based on typical installations of HART devices in non-IS environments, i.e. no miscellaneous series impedance. Detailed information for determining the maximum cable length for any HART network configuration can be found in the HART Physical Layer Specifications.

Table 2.

N. network devices	65 pF/m	95 pF/m	160 pF/m	225 pF/m
1	2,769 m	2,000 m	1,292 m	985 m
5	2,462 m	1,815 m	1,138 m	892 m
10	2,154 m	1,600 m	1,015 m	769 m
15	1,846 m	1,415 m	892 m	708 m

NOTE: Cable Capacitance – pF/m Cable Length – m

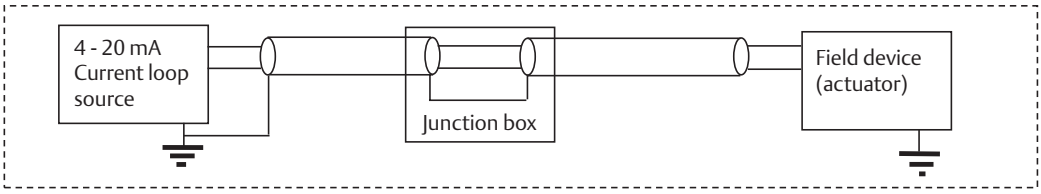
Recommended Minimum Conductor Size (Diameter):

- Below 1,785 m (5,000 ft.) total length: #24 AWG (0.51 mm diameter).
- Above 1,785 m (single pair) total length: #20 AWG (0.81 mm diameter).

6.2 Shielding and Grounding

The cable shield must be grounded at one point only. This is usually done in the control room or near to the source of the current loop. Ground connection may alternatively occur in a junction box or other suitable location in the field area. The cable shield is usually left open at the field device.

Figure 7



Other grounding modes can be used if the coupling and the EMI do not damage the HART digital signal. More information can be viewed on the HART FSK Physical Layer Specification.

Section 7: HART Commands

The HART Command Set provides uniform and consistent communication for all field devices. The command set includes three classes: Universal, Common Practice, and Device Specific (refer to Table 3). Host applications may implement any of the necessary commands for a particular application.

- **UNIVERSAL**

  All devices using the HART Protocol must recognize and support the universal commands. Universal commands provide access to information useful in normal operations (e.g. read primary variable and units).

- **COMMON PRACTICE**

  Common Practice commands provide functions implemented by many, but not necessarily all HART communication devices.

- **DEVICE SPECIFIC**

  Device Specific commands represent functions that are unique to each field device. These commands access setup and calibration information, as well as information about the construction of the device. Information on Device Specific commands is available from device manufacturers.

Table 3.

Universal Commands	Common Practice Commands	Device Specific Commands
• Read Unique Identifier • Read Primary Variable • Read Loop Current and Percent of Range • Read Dynamic Variables and Loop Current • Write Polling Address • Read Loop Configuration • Read Dynamic Variable Classifications • Read Device Variables with Status • Read Unique Identifier Associated with Tag • Read Message • Read Tag, Descriptor, Date • Read Primary Variable Transducer Information • Read Device Information • Read Final Assembly Number • Write Message • Write Tag, Descriptor, Date • Write Final Assembly Number • Read Long Tag • Read Unique Identifier Associated with long Tag • Write Long Tag • Reset Configuration Changed Flag • Read Additional Device Status	• Perform Device Reset • Read Device Variable Inform • Write Number of Response Preamble • Read Device Communications Statistics • Write Burst Period • Write Burst Trigger • Read Burst Mode Configuration • Write Burst Device Variables • Write Burst Mode Command Number • Burst Mode Control	• Write Device Variable Value • Read Array • Write Array

All slave response messages return two Command Status bytes in the first two bytes of the Data field. The first byte is multiplexed and contains either the Communication Status (most significant bit is set) or the Response Code (most significant bit is reset). The second byte of a slave response message always contains Field Device Status.

The Response Data Bytes are not returned if a communications or command error is reported in the Command Status Bytes.

The Communication Status is returned if a communication error is detected by the field device.

Table 4.

Bit Mask	Communication Status Definition
0x80	**1** – This bit is always set to indicate a communication error.
0x40	**Vertical Parity Error** – The parity of one or more of the bytes received by the device was not odd.
0x20	**Overrun Error** – At least one byte of data in the receive buffer of the UART was overwritten before it was read.
0x10	**Framing Error** – The Stop Bit of one or more bytes received by the device was not detected by the UART.
0x08	**Longitudinal Parity Error** – The Longitudinal Parity calculated by the device did not match the Check Byte at the end of the message.
0x04	**Reserved** – always 0
0x02	**Buffer Overflow** – The message was too long for the receive buffer of the device.
0x01	**Reserved** – always 0

If no communication errors are detected, the first byte in the Data Field contains the Response Code. The Response Code describes the result of the executed command.
The Response Code is encoded as a 7-bit enumeration (between 0 and 127).

There are 3 Classification Response Codes:

- **Notification**: The command sent by the Master is executed properly by the Slave.
- **Warning**: The command sent by the Master is executed with the deviation as described in the response.
- **Error**: The command sent by the Master was not properly completed and the Response Code indicates the reason.

See the appropriate Response Code Table for each command.

The second data byte in a Slave-to-Master frame is a bit field table that represent the current operating status of the slave.

Table 5.

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

NOTE:

- Device Malfunction bit is set if a generic alarm or warning is active, maintenance operation is required, one or more device variables are not loaded by the logic card or Main Voltage alarm is active.
- Configuration Changed bit is set if one or more parameters are modified by a HART command.
- Cold Start bit is set after a power on or reset operation has occurred.
- More Status Available bit is set if additional device status data bytes are changed.
- Loop Current Fixed bit is set if Loop Current Mode is disabled.
- Loop Current Saturated, Non-Primary Variable Out of Limits, Primary variable Out of Limits bits are not used. These bits are always set to 0.

Section 8: HART Command Set

8.1 Universal Commands

Table 6.

No.	Command Description
0	Read Unique Identifier
1	Read Primary Variable
2	Read Loop Current and Percent of Range
3	Read Dynamic Variables and Loop Current
6	Write Polling Address
7	Read Loop Configuration
8	Read Dynamic Variable Classifications
9	Read Device Variables with Status
11	Read Unique Identifier Associated with Tag
12	Read Message
13	Read Tag, Descriptor, Date
14	Read Primary Variable Transducer Information
15	Read Device Information
16	Read Final Assembly Number
17	Write Message
18	Write Tag, Descriptor, Date
19	Write Final Assembly Number
20	Read Long Tag
21	Read Unique Identifier Associated with long Tag
22	Write Long Tag
38	Reset Configuration Changed Flag
48	Read Additional Device Status

8.1.1 Command #0: Read Unique Identifier

This command returns identity information about the field device including: Device Type, Revision Levels, and Device ID.

Table 7. Request Data Bytes

Byte	Format	Description
None		

Table 8. Response Data Bytes

Byte	Format	Description
0	Unsigned-8	"254" – Fixed Value
1 - 2	Enum	Expanded Device Type Code (see Section 8.4, Table 119)
3	Unsigned-8	3 = Minimum number of preambles required for the request message from the Master to the Slave
4	Unsigned-8	7 = HART Protocol Major Revision
5	Unsigned-8	Device Revision
6	Unsigned-8	Software Revision
7	Unsigned-5	MSB (5 bits) – Hardware Revision
7	Enum	LSB (3 bits) – Physical Signaling Code (see Section 8.4, Table 126)
8	Bits	Flag Assignement (see Section 8.4, Table 127)
9 - 11	Unsigned-24	Device ID
12	Unsigned-8	Minimum Number of preambles to be sent with the response message from the Slave to the Master.
13	Unsigned-8	Maximum Number of Device Variables.
14 - 15	Unsigned-16	Configuration Change Counter
16	Bits	Extended Field Device Status (see Section 8.4, Table 129)
17 - 18	Enum	Manufacturer Identification Code (see Section 8.4, Table 124)
19 - 20	Enum	Private Label Distributor Code (see Section 8.4, Table 124)
21	Enum	Device Profile (see Section 8.4, Table 134)

Table 9. Command-Specific Response Codes

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

8.1.2 Command #1: Read Primary Variable

This command returns the Primary Variable value with its Unit Code. The Primary Variable (PV) is the percentage corresponding to the Loop Current signal.

Table 10. Request Data Bytes

Byte	Format	Description
None	-	-

Table 11. Response Data Bytes

Byte	Format	Description
0	Enum	Primary Variable Unit Codes (see Section 8.4, Table 120)
1 - 4	Float	Primary Variable

Table 12. Command-Specific Response Codes

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

8.1.3 Command #2: Read Loop Current and Percent of Range

This command reads the Loop Current and its associated Percent of Range.

Table 13. Request Data Bytes

Byte	Format	Description
None	-	-

Table 14. Response Data Bytes

Byte	Format	Description
0 - 3	Float	Primary Variable Loop Current (units of mA)
4 - 7	Float	Primary Variable Percent of Range (units of percent)

Table 15. Command-Specific Response Codes

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

8.1.4 Command #3: Read Dynamic Variables and Loop Current

This command reads the Loop Current and the four Dynamic Variables: the position request (PV – Primary Variable), the actuator position (SV – Secondary Variable), the output torque (TV – Tertiary Variable), the internal actuator temperature (QV – Quaternary Variable).

Table 16. Request Data Bytes

Byte	Format	Description
None	-	-

Table 17. Response Data Bytes

Byte	Format	Description
0 - 3	Float	Primary Variable Loop Current (units of mA)
4	Enum	Primary Variable Units Code (see Section 8.4, Table 120)
5 - 8	Float	Primary Variable
9	Enum	Secondary Variable Units Code (see Section 8.4, Table 120)
10 - 13	Float	Secondary Variable
14	Enum	Tertiary Variable Units Code (see Section 8.4, Table 120)
15 - 18	Float	Tertiary Variable
19	Enum	Quaternary Variable Units Code (see Section 8.4, Table 120)
20 - 23	Float	Quaternary Variable

Table 18. Command-Specific Response Codes

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

8.1.5 Command #6: Write Polling Address

This command permits to write the Polling Address and the Loop Current mode to the field device.

Table 19. Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Polling Address of Device
1	Enum	Loop Current Mode (see Section 8.4, Table 128)

Table 20. Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Polling Address of Device
1	Enum	Loop Current Mode (see Section 8.4, Table 128)

Table 21. Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1	-	Undefined
2	Error	Invalid Poll Address Selection
3 - 4	-	Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8 - 11	-	Undefined
12	Error	Invalid Mode Selection
13 - 15	-	Undefined
16	Error	Access Restricted
17 - 31	-	Undefined
32	Error	Busy
33 - 127	-	Undefined

8.1.6 Command #7: Read Loop Configuration

This command reads the Polling Address and the Loop Current mode.

Table 22. Request Data Bytes

Byte	Format	Description
None	-	-

Table 23. Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Polling Address of Device
1	Enum	Loop Current Mode (see Section 8.4, Table 128)

Table 24. Command-Specific Response Codes

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

8.1.7 Command #8: Read Dynamic Variable Classifications

This command reads the classification associated with the Dynamic Variables.

Table 25. Request Data Bytes

Byte	Format	Description
None	-	-

Table 26. Response Data Bytes

Byte	Format	Description
0	Enum	Primary Variable Classification (see Section 8.4, Table 131)
1	Enum	Secondary Variable Classification (see Section 8.4, Table 131)
2	Enum	Tertiary Variable Classification (see Section 8.4, Table 131)
3	Enum	Quaternary Variable Classification (see Section 8.4, Table 131)

Table 27. Command-Specific Response Codes

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

8.1.8 Command #9: Read Device Variables with Status

This command allows a Master to request the value and status of up to 8 Device or Dynamic Variables.

If the Field Device receives 1, 2, 3, 4, 5, 6, or 7 Request Data Bytes, it returns only the corresponding number of Device Variables.

Table 28.

No. of Device Variables Requested	No. of Request Data Bytes	No. of Response Data Bytes
1	1	13
2	2	21
3	3	29
4	4	37
5	5	45
6	6	53
7	7	61
8	8	69

Table 29. Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Slot 0: Device Variable Code (see Section 9.1)
1	Unsigned-8	Slot 1: Device Variable Code (see Section 9.1)
2	Unsigned-8	Slot 2: Device Variable Code (see Section 9.1)
3	Unsigned-8	Slot 3: Device Variable Code (see Section 9.1)
4	Unsigned-8	Slot 4: Device Variable Code (see Section 9.1)
5	Unsigned-8	Slot 5: Device Variable Code (see Section 9.1)
6	Unsigned-8	Slot 6: Device Variable Code (see Section 9.1)
7	Unsigned-8	Slot 7: Device Variable Code (see Section 9.1)

Table 30. Response Data Bytes

Byte	Format	Description
0	Bits	Extended Field Device Status (see Section 8.4, Table 129)
1	Unsigned-8	Slot 0: Device Variable Code (see Section 9.1)
2	Enum	Slot 0: Device Variable Classification (see Section 8.4, Table 131)
3	Enum	Slot 0: Unit Code (see Section 8.4, Table 120)
4 - 7	Float	Slot 0: Device Variable Value
8	Bits	Slot 0: Device Variable Status (see Section 9.2)
9	Unsigned-8	Slot 1: Device Variable Code (see Section 9.1)
10	Enum	Slot 1: Device Variable Classification (see Section 8.4, Table 131)
11	Enum	Slot 1: Units Code (see Section 8.4, Table 120)
12 - 15	Float	Slot 1: Device Variable Value
16	Bits	Slot 1: Device Variable Status (see Section 9.2)
17	Unsigned-8	Slot 2: Device Variable Code (see Section 9.1)
18	Enum	Slot 2: Device Variable Classification (see Section 8.4, Table 131)
19	Enum	Slot 2: Units Code (see Section 8.4, Table 120)
20 - 23	Float	Slot 2: Device Variable Value
24	Bits	Slot 2: Device Variable Status (see Section 9.2)
25	Unsigned-8	Slot 3: Device Variable Code (see Section 9.1)
26	Enum	Slot 3: Device Variable Classification (see Section 8.4, Table 131)
27	Enum	Slot 3: Units Code (see Section 8.4, Table 120)
28 - 31	Float	Slot 3: Device Variable Value
32	Bits	Slot 3: Device Variable Status (see Section 9.2)

Byte	Format	Description
33	Unsigned-8	Slot 4: Device Variable Code (see Section 9.1)
34	Enum	Slot 4: Device Variable Classification (see Section 8.4, Table 131)
35	Enum	Slot 4: Units Code (see Section 8.4, Table120)
36 - 39	Float	Slot 4: Device Variable Value
40	Bits	Slot 4: Device Variable Status (see Section 9.2)
41	Unsigned-8	Slot 5: Device Variable Code (see Section 9.1)
42	Enum	Slot 5: Device Variable Classification (see Section 8.4, Table 131)
43	Enum	Slot 5: Units Code (see Section 8.4, Table 120)
44 - 47	Float	Slot 5: Device Variable Value
48	Bits	Slot 5: Device Variable Status (see Section 9.2)
49	Unsigned-8	Slot 6: Device Variable Code (see Section 9.1)
50	Enum	Slot 6: Device Variable Classification (see Section 8.4, Table 131)
51	Enum	Slot 6: Units Code (see Section 8.4, Table 120)
52 - 55	Float	Slot 6: Device Variable Value
56	Bits	Slot 6: Device Variable Status (see Section 9.2)
57	Unsigned-8	Slot 7: Device Variable Code (see Section 9.1)
58	Enum	Slot 7: Device Variable Classification (see Section 8.4, Table 131)
59	Enum	Slot 7: Units Code (see Section 8.4, Table 120)
60 - 63	Float	Slot 7: Device Variable Value
64	Bits	Slot 7: Device Variable Status (see Section 9.2)
65 - 68	Time	Slot 0: Data Time Stamp

Table 31. Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1	-	Undefined
2	Error	Invalid Selection
3 - 4	-	Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	-	Undefined
8	Warning	Update Failure
9 - 13	-	Undefined
14	Warning	Dynamic Variables Returned for Device Variables
15	-	Undefined
16	Error	Access Restricted
17 - 29	-	Undefined
30	Warning	Command Response Truncated
31 - 127	-	Undefined

8.1.9 Command #11: Read Unique Identifier Associated with Tag

This command returns identity information about the field device including: Device Type, Revision levels, and Device ID.

Table 32. Request Data Bytes

Byte	Format	Description
0 - 5	Packed	Tag

Table 33. Response Data Bytes

Byte	Format	Description
0	Unsigned-8	"254" – Fixed Value
1 - 2	Enum	Expanded Device Type Code (see Section 8.4, Table 119)
3	Unsigned-8	3 = Minimum number of preambles required for the request message from the Master to the Slave
4	Unsigned-8	7 = HART Protocol Major Revision
5	Unsigned-8	Device Revision
6	Unsigned-8	Software Revision
7	Unsigned-5	MSB (5 bits) – Hardware Revision
7	Enum	LSB (3 bits) – Physical Signaling Code (see Section 8.4, Table 126)
8	Bits	Flag Assignement (see Section 8.4, Table 127)
9 - 11	Unsigned-24	Device ID
12	Unsigned-8	Minimum Number of preambles to be sent with the response message from the Slave to the Master.
13	Unsigned-8	Maximum Number of Device Variables.
14 - 15	Unsigned-16	Configuration Change Counter
16	Bits	Extended Field Device Status (see Section 8.4, Table 129)
17 - 18	Enum	Manufacturer Identification Code (see Section 8.4, Table 124)
19 - 20	Enum	Private Label Distributor Code (see Section 8.4, Table 124)
21	Enum	Device Profile (see Section 8.4, Table 134)

Table 34. Command-Specific Response Codes

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

8.1.10 Command #12: Read Message

This command reads the Message contained within the field device.

Table 35. Request Data Bytes

Byte	Format	Description
None	-	-

Table 36. Response Data Bytes

Byte	Format	Description
0 - 23	Packed	Message

Table 37. Command-Specific Response Codes

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

8.1.11 Command #13: Read Tag, Descriptor, Date

This command reads the Tag, Descriptor and Date contained within the field device. Only Tag is read by this command. Tag and Long Tag are completely separate data items.

Table 38. Request Data Bytes

Byte	Format	Description
None	-	-

Table 39. Response Data Bytes

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

Table 40. Command-Specific Response Codes

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

8.1.12 Command #14: Read Primary Variable Transducer Information

This command reads the Transducer Serial Number, Limits / Minimum Span Units Code, Upper Transducer Limit, Lower Transducer Limit, and Minimum Spar for the Primary Variable Transducer.

Table 41. Request Data Bytes

Byte	Format	Description
None	-	-

Table 42. Response Data Bytes

Byte	Format	Description
0 - 2	Unsigned-24	Transducer Serial Number
3	Enum	Transducer Limits and Minimum Span units Code (see Section 8.4, Table 120)
4 - 7	Float	Upper Transducer Limit
8 - 11	Float	Lower Transducer Limit
12 - 15	Float	Minimum Span

Table 43. Command-Specific Response Codes

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

8.1.13 Command #15: Read Device Information

This command reads the alarm selection code, transfer function code, range values units code, upper range value, Primary Variable lower range value, damping value and write protect code.

Table 44. Request Data Bytes

Byte	Format	Description
None	-	-

Table 45. Response Data Bytes

Byte	Format	Description
0	Enum	PV Alarm Selection Code (see Section 8.4, Table 122)
1	Enum	PV Transfer Function Code (see Section 8.4, Table 121)
2	Enum	PV Upper and Lower Range Values Units Code (see Section 8.4, Table 120)
3 - 6	Float	PV Upper Range Value
7 - 10	Float	PV Lower Range Value
11 - 14	-	PV Damping Value (units of seconds)
15	Enum	Write Protect Code (see Section 8.4, Table 123)
16	Enum	Reserved. "250"
17	Bits	PV Analog Channel Flags (see Section 8.4, Table 132)

Table 46. Command-Specific Response Codes

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

8.1.14 Command #16: Read Final Assembly Number

This command reads the final assembly number associated within the field device. The Final Assembly Number is used for identifying the materials and electronics that comprise the field device.

Table 47. Request Data Bytes

Byte	Format	Description
None	-	-

Table 48. Response Data Bytes

Byte	Format	Description
0 - 2	Unsigned-24	Final Assembly Number

Table 49. Command-Specific Response Codes

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

8.1.15 Command #17: Write Message

This command permits to write the Message into the field device.

Table 50. Request Data Bytes

Byte	Format	Description
0 - 23	Packed	A Message string used by the Master for record keeping.

Table 51. Response Data Bytes

Byte	Format	Description
0 - 23	Packed	Message string

Table 52. Command-Specific Response Codes

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

8.1.16 Command #18: Write Tag, Descriptor, Date

This command permits to write the Tag, Descriptor and Date into the field device. Only the Tag is written here. The Tag and Long Tag are completely separate data items.

Table 53. Request Data Bytes

Byte	Format	Description
0 - 5	Packed	Tag
6 - 17	Packed	Descriptor used by the Master for record keeping
18 - 20	Date	A Date Code used by the Master for record keeping

Table 54. Response Data Bytes

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

Table 55. Command-Specific Response Codes

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

8.1.17 Command #19: Write Final Assembly Number

This command permits to write the Final Assembly Number into the field device.

Table 56. Request Data Bytes

Byte	Format	Description
0 - 2	Unsigned-24	Final Assembly Number

Table 57. Response Data Bytes

Byte	Format	Description
0 - 2	Unsigned-24	Final Assembly Number

Table 58. Command-Specific Response Codes

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

8.1.18 Command #20: Read Long Tag

This command reads the Long Tag. Only the Long Tag is read here. The Tag and Long Tag are completely separate data items.

Table 59. Request Data Bytes

Byte	Format	Description
None	-	-

Table 60. Response Data Bytes

Byte	Format	Description
0 - 31	Latin-1	Long Tag

Table 61. Command-Specific Response Codes

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

8.1.19 Command #21: Read Unique Identifier Associated with Long Tag

This command returns identity information about the field device including: the Device Type, revision levels and Device ID.

Table 62. Request Data Bytes

Byte	Format	Description
0 - 31	Latin-1	Long Tag

Table 63. Response Data Bytes

Byte	Format	Description
0	Unsigned-8	"254" – Fixed Value
1 - 2	Enum	Expanded Device Type Code (see Section 8.4, Table 119)
3	Unsigned-8	3 = Minimum number of preambles required for the request message from the Master to the Slave
4	Unsigned-8	7 = HART Protocol Major Revision
5	Unsigned-8	Device Revision
6	Unsigned-8	Software Revision
7	Unsigned-5	MSB (5 bits) – Hardware Revision
7	Enum	LSB (3 bits) – Physical Signaling Code (see Section 8.4, Table 126)
8	Bits	Flag Assignement (see Section 8.4, Table 127)
9 - 11	Unsigned-24	Device ID
12	Unsigned-8	Minimum Number of preambles to be sent with the response message from the Slave to the Master.
13	Unsigned-8	Maximum Number of Device Variables.
14 - 15	Unsigned-16	Configuration Change Counter
16	Bits	Extended Field Device Status (see Section 8.4, Table 129)
17 - 18	Enum	Manufacturer Identification Code (see Section 8.4, Table 124)
19 - 20	Enum	Private Label Distributor Code (see Section 8.4, Table 124)
21	Enum	Device Profile (see Section 8.4, Table 134)

Table 64. Command-Specific Response Codes

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

8.1.20 Command #22: Write Long Tag

This command allows a Master to write the Long Tag into the field device. Only the Long Tag is written here. The Tag and Long Tag are completely separate data items.

Table 65. Request Data Bytes

Byte	Format	Description
0 - 31	Latin-1	Long Tag

Table 66. Response Data Bytes

Byte	Format	Description
0 - 31	Latin-1	Long Tag

Table 67. Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 4	-	Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8 - 15	-	Undefined
16	Error	Access Restricted
17 - 31	-	Undefined
32	Error	Busy
33	Error	Delayed Response Initiated
34	Error	Delayed Response Running
35	Error	Delayed Response Dead
36	Error	Delayed Response Conflict
37 - 127	-	Undefined

8.1.21 Command #38: Reset Configuration changed Flag

This command allows a Master to reset the Configuration Change Flag into the field device.

Table 68. Request Data Bytes

Byte	Format	Description
0 - 1	Unsigned-16	Configuration Change Counter

Table 69. Response Data Bytes

Byte	Format	Description
0 - 1	Unsigned-16	Configuration Change Counter

Table 70. Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 5	-	Undefined
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8	-	Undefined
9	Error	Configuration Change Counter Mismatch
10 - 15	-	Undefined
16	Error	Access Restricted
17 - 127	-	Undefined

8.1.22 Command #48: Read Additional Device Status

This command returns the device status information, device specific status information, Extended Device Status, Device Operating Mode and Standardized Status.

Table 71. Request Data Bytes

Byte	Format	Description
0 - 5	Bits or Enum	Device-Specific Status
6	Bits	Extended Device Status
7	Bits	Device Operating Mode
8	Bits	Standardized Status 0
9	Bits	Standardized Status 1
10	Bits	Analog Channel Saturated
11	Bits	Standardized Status 2
12	Bits	Standardized Status 3
13	Bits	Analog Channel Fixed
14	Bits or Enum	Device-Specific Status

NOTE: See Table on the next page for details.

Table 72. Response Data Bytes

Byte	Format	Description
0 - 5	Bits or Enum	Device-Specific Status
6	Bits	Extended Device Status
7	Bits	Device Operating Mode
8	Bits	Standardized Status 0
9	Bits	Standardized Status 1
10	Bits	Analog Channel Saturated
11	Bits	Standardized Status 2
12	Bits	Standardized Status 3
13	Bits	Analog Channel Fixed
14	Bits or Enum	Device-Specific Status

NOTE: See Table on the next page for details.

Table 73. Command-Specific Response Codes

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

Table 74. Request and Response Data Field Details

Byte	Bit	Meaning	Class	Device Status Bits Set
0	-	Reserved	-	-
1	-	Reserved	-	-
2	-	Reserved	-	-
3	-	Reserved	-	-
4	-	Reserved	-	-
5	-	Reserved	-	-
6	0	Maintenance Required	Warning	4, 7
	1	Device Variable Alert	Warning	4, 7
	2	Not used	-	-
	3	Not used	-	-
	4	Not used	-	-
	5	Not used	-	-
	6	Not used	-	-
	7	Not used	-	-
7	-	Reserved – Not used	-	-
8	0	Not used	-	-
	1	Not used	-	-
	2	Not used	-	-
	3	Not used	-	-
	4	Not used	-	-
	5	Not used	-	-
	6	Electronic Defeat	Error	4, 7
	7	Not used	-	-
9	-	Not used	-	-
10	-	Not used	-	-
11	-	Not used	-	-
12	-	Not used	-	-
13	-	Not used	-	-
14	0	Generic Warning	Warning	4
	1	Generic Alarm	Error	4, 7
	2	Remote Control Not Available	-	4
	3	Not used	-	-
	4	Not used	-	-
	5	Not used	-	-
	6	Not used	-	-
	7	Not used	-	-

Bytes 0 - 5 are reserved for manufacturer use; they are always set to 0.
“Maintenance Required” bit is set to 1, if the date of the next maintenance operation is reached.
“Device Variable Alert” bit is set to 1, if one or more variable values is not correctly loaded by the device.
“Electronic Defeat” bit is set to 1, if the actuator is not correctly supplied.
“Generic Alarm” bit is set to 1, if one or more alarms are active.
“Generic Warning” bit is set to 1, if one or more warnings are active.
“Remote Control Not Available” bit is set to 1, if the actuator cannot be remotely controlled. The bit is to 1 when the Monitor relay is to 0.
“Not used” bits and bytes are always set to 0.

8.2 Common Practice Commands

The following common practice command are implemented:

Table 75.

No.	Command Description
42	Perform Device Reset
54	Read Device Variable Information
59	Write Number of Response Preambles
95	Read Device Communications Statistics
103	Write Burst Period
104	Write Burst Trigger
105	Read Burst Mode Configuration
107	Write Burst Device Variables
108	Write Burst Mode Command Number
109	Burst Mode Control

8.2.1 Command #42: Perform Device Reset

This command resets the field device. This is equivalent to cycling the power off and then back on to the field device. The field device may not respond to subsequent commands until the reset is complete.

Table 76. Request Data Bytes

Byte	Format	Description
None	-	-

Table 77. Response Data Bytes

Byte	Format	Description
None	-	-

Table 78. Command-Specific Response Codes

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

8.2.2 Command #54: Read Device Variable Information

This command reads the Transducer Serial Number, the Limits, Damping Value and Minimum Span of the selected Device Variable along with the corresponding engineering units.

Table 79. Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Section 9.1)

Table 80. Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Section 9.1)
1 - 3	Unsigned-24	Device Variable Transducer Serial Number
4	Enum	Device Variable Limits / Minimum Span Units Code (see Section 8.4, Table 120)
5 - 8	Float	Device Variable Upper Transducer Limit
9 - 12	Float	Device Variable Lower Transducer Limit
13 - 16	Float	Device Variable Damping Value
17 - 20	Float	Device Variable Minimum Span
21	Enum	Device Variable Classification (see Section 8.4, Table 131)
22	Enum	Device Variable Family (see Section 8.4, Table130)
23 - 26	Time	Update Time Period

Table 81. Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1	-	Undefined
2	Error	Invalid Selection
3 - 4	-	Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15	-	Undefined
16	Error	Access Restricted
17 - 31	-	Undefined
32	Error	Busy
33 - 127	-	Undefined

8.2.3 Command #59: Write Number of Response Preambles

This command sets the number of asynchronous 0xFF preambles 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.

Table 82. Request Data Bytes

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

Table 83. Response Data Bytes

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

Table 84. Command-Specific Response Codes

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

8.2.4 Command #95: Read Device Communication Statistics

This command returns the field device communication statistics: the number of STX messages received by the device, the number of ACK messages sent by the device and the number of BACK sent by the device.

Table 85. Request Data Bytes

Byte	Format	Description
None	-	-

Table 86. Response Data Bytes

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

Table 87. Command-Specific Response Codes

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

8.2.5 Command #103: Write Burst Period

This command selects the minimum and maximum update period of a burst message. The minimum time must be less than or equal to the maximum time. The update time shall be selected as specified in Table 88 below:

Table 88.

< 0.5 second Not Allowed	8 seconds
0.5 second (default)	16 seconds
1 second	32 seconds
2 seconds	60 – 3,600 seconds (any value)
4 seconds	> 3,600 seconds Not Allowed

The device corrects settings differing from these values and indicates “Update Times Adjusted” in its response message.

Table 89. Request Data Bytes

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

Table 90. Response Data Bytes

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

Table 91. Command-Specific Response Codes

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

8.2.6 Command #104: Write Burst Trigger

This command configures the trigger that forces publishing of the Burst Message. Four trigger modes are supported: Continuous (default), Windowed, Rising, and Falling.

Continuous Mode: This burst message is sent when the update period is exceeded.

Windowed Mode: This trigger value must be a positive number and is the symmetric window around the last communicated value. The burst message being published after the window was exceeded.

Rising Mode: This burst message is published when the source value exceeds the threshold established by the trigger value.

Falling Mode: This burst message is published when the source value falls below the trigger value.

In all cases, the burst message is triggered when the maximum update time is in Command 103 is exceeded.

Table 92. Burst Message Trigger Source

Command	Trigger Source Value
1	PV (Position Request)
2	Loop Current Percent Range
3	PV (Position Request)
9	Device Variable in Slot 0

Table 93. Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message
1	Enum	Burst Trigger Mode Selection Code (see Section 8.4, Table 133)
2	Enum	Device Variable Classification for Trigger Level (see Section 8.4, Table 131)
3	Enum	Units Code (see Section 8.4, Table 120)
4 - 7	Float	Trigger Level

Table 94. Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message
1	Enum	Burst Trigger Mode Selection Code (see Section 8.4, Table 133)
2	Enum	Device Variable Classification for Trigger Level (see Section 8.4, Table 131)
3	Enum	Units Code (see Section 8.4, Table 120)
4 - 7	Float	Trigger Level

Table 95. Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1	-	Undefined
2	Error	Invalid Selection
3	Error	Passed Parameter Too Large
4	Error	Passed Parameter Too Small
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8	-	Undefined
9	Error	Invalid Burst Message
10	-	Undefined
11	Error	Invalid Device Variable Classification
12	Error	Invalid Units Code

Code	Class	Description
13	Error	Invalid Burst Trigger Mode Selection Code
14 - 15	-	Undefined
16	Error	Access Restricted
17 - 31	-	Undefined
32	Error	Busy (A Delayed Response could not be initiated)
33	Error	Delayed Response Initiated
34	Error	Delayed Response Running
35	Error	Delayed Response Dead
36	Error	Delayed Response Conflict
37 - 127	-	Undefined

8.2.7 Command #105: Read Burst Mode Configuration

This command reads the Burst Mode configuration from the field device including: the Burst Mode Control Code, the command to be burst and a list of the Device Variables to be transmitted, the burst minimum and maximum update time and the condition for the maximum update time.

Table 96. Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Message

Table 97. Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Mode Control Code (see Section 8.4, Table 125)
1	Unsigned-8	Command Number of the response message to be transmitted
2	Unsigned-8	Device Variable Code assigned to Slot0 (see Section 9.1)
3	Unsigned-8	Device Variable Code assigned to Slot1 (see Section 9.1)
4	Unsigned-8	Device Variable Code assigned to Slot2 (see Section 9.1)
5	Unsigned-8	Device Variable Code assigned to Slot3 (see Section 9.1)
6	Unsigned-8	Device Variable Code assigned to Slot4 (see Section 9.1)
7	Unsigned-8	Device Variable Code assigned to Slot5 (see Section 9.1)
8	Unsigned-8	Device Variable Code assigned to Slot6 (see Section 9.1)
9	Unsigned-8	Device Variable Code assigned to Slot7 (see Section 9.1)
10	Unsigned-8	Burst Message
11	Unsigned-8	Total Number of Burst Messages
12 - 15	Time	Update Time in 1/32 of a millisecond
16 - 19	Time	Maximum Update Time in 1/32 of a millisecond
20	Enum	Burst Trigger Mode Code (see Section 8.4, Table 133)
21	Enum	Device Variable Classification for Trigger Value (see Section 8.4, Table 131)
22	Enum	Units Code (see Section 8.4, Table 120)
23 - 26	Float	Trigger Value

Table 98. Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 5	-	Undefined
6	Error	Device-Specific Command Error
7 - 8	-	Undefined
9	Error	Invalid Burst Message
10 - 31	-	Undefined
32	Error	Busy
33 - 127	-	Undefined

8.2.8 Command #107: Write Burst Device Variables

This command selects the Device Variables that will be used by a bursting device to be return by a Command 9 in Burst Mode.

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

Table 99. Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code assigned to Slot 0 (see Section 9.1)
1	Unsigned-8	Device Variable Code assigned to Slot 1 (see Section 9.1)
2	Unsigned-8	Device Variable Code assigned to Slot 2 (see Section 9.1)
3	Unsigned-8	Device Variable Code assigned to Slot 3 (see Section 9.1)
4	Unsigned-8	Device Variable Code assigned to Slot 4 (see Section 9.1)
5	Unsigned-8	Device Variable Code assigned to Slot 5 (see Section 9.1)
6	Unsigned-8	Device Variable Code assigned to Slot 6 (see Section 9.1)
7	Unsigned-8	Device Variable Code assigned to Slot 7 (see Section 9.1)
8	Unsigned-8	Burst Message

Table 100. Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code assigned to Slot 0 (see Section 9.1)
1	Unsigned-8	Device Variable Code assigned to Slot 1 (see Section 9.1)
2	Unsigned-8	Device Variable Code assigned to Slot 2 (see Section 9.1)
3	Unsigned-8	Device Variable Code assigned to Slot 3 (see Section 9.1)
4	Unsigned-8	Device Variable Code assigned to Slot 4 (see Section 9.1)
5	Unsigned-8	Device Variable Code assigned to Slot 5 (see Section 9.1)
6	Unsigned-8	Device Variable Code assigned to Slot 6 (see Section 9.1)
7	Unsigned-8	Device Variable Code assigned to Slot7 (see Section 9.1)
8	Unsigned-8	Burst Message

Table 101. Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1	-	Undefined
2	Error	Invalid Selection
3 - 4	-	Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8	Warning	Burst Condition Conflict
9	Error	Invalid Burst Message
10 - 127	-	Undefined

8.2.9 Command #108: Write Burst Mode Command Number

This command selects the response message that the device transmits while in Burst Mode.

Table 102. Request Data Bytes

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

Table 103. Response Data Bytes

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

Table 104. Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1	-	Undefined
2	Error	Invalid Selection
3 - 4	-	Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8	Warning	Burst Condition Conflict
9	Error	Invalid Burst Message
10 - 127	-	Undefined

The following command can be represented in burst messages:

Table 105.

No.	Command Description
1	Read Primary Variable
2	Read Loop Current and Percent of Range
3	Read Dynamic Variables and Loop Current
9	Read Device Variables with status
48	Read Additional Device Status

8.2.10 Command #109: Burst Mode Control

This command is used to enter and exit the Burst Mode on the field device.

Table 106. Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Mode Control Code (see Section 8.4, Table 133)
1	Unsigned-8	Burst Message

Table 107. Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Burst Mode Control Code (see Section 8.4, Table 133)
1	Unsigned-8	Burst Message

Table 108. Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1	-	Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7	Error	In Write Protect Mode
8	Warning	Update Period Increased
9	Error	Insufficient bandwidth
10 - 15	-	Undefined
16	Error	Access Restricted
17 - 31	-	Undefined
32	Error	Busy (Delayed Response could not be initiated)
33	Error	Delayed Response Initiated
34	Error	Delayed Response Running
35	Error	Delayed Response Dead
36	Error	Delayed Response Conflict
37 - 127	-	Undefined

8.2.11 Catch Device Variable

This device does not support Catch Device Variable.

8.3 Device Specific Commands

The following Device-Specific commands are implemented:

Table 109.

No.	Command Description
129	Write Device Variable Value
130	Read Array
131	Write Array

8.3.1 Command #129: Write Device Variable Value

This command allows forcing the value of one variable.

Table 110. Request Data Bytes

Byte	Format	Description
0	Enum	Device Variable Code (see Section 9.1)
1 - 4	-	Device Variable Value

Table 111. Response Data Bytes

Byte	Format	Description
0	Enum	Device Variable Code (see Section 9.1)
1 - 4	-	Device Variable Value

Table 112. Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1	-	Undefined
2	Error	Invalid Selection
3 - 4	-	Undefined
5	Error	Too few data bytes received
6	Error	Illegal Device Variable Value
7	Error	In Write Protect Mode
8 - 127	-	Undefined

If a master tries to write a read only variable, Response Code 7 (“In Write Protect Mode”) is generated.

NOTE

If Loop Current Mode is active, Open Command (b0), Close Command (b1), Stop Command (b2), Positioner Enabled (b4) in Device Variable Code 0 are always set to 0 even if No Command Specific errors.

8.3.2 Command #130: Read Array

Reads the value of one actuator array data.

Table 113. Request Data Bytes

Byte	Format	Description
0	Enum	Array Code (see Section 10)

Table 114. Response Data Bytes

Byte	Format	Description
0	Enum	Array Code (see Section 10)
1 - 28	ASCII	Array Value

Table 115. Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1	-	Undefined
2	Error	Invalid Selection
3 - 4	-	Undefined
5	Error	Too few data bytes received
6 - 31	-	Undefined
32	Error	Device Busy
33 - 127	-	Undefined

8.3.3 Command #131: Write Array

This command allows forcing the value of one array data.

Table 116. Request Data Bytes

Byte	Format	Description
0	Enum	Array Code (see Section 10)
1 - 28	ASCII	Array Value

Table 117. Response Data Bytes

Byte	Format	Description
0	Enum	Array Code (see Section 10)
1 - 28	ASCII	Array Value

Table 118. Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4	-	Undefined
5	Error	Too few data bytes received
6	-	Undefined
7	Error	In Write Protect Mode
8 - 16	-	Undefined
17	Error	Invalid Array Code
18 - 31	-	Undefined
32	Error	Device Busy
33 - 127	-	Undefined

If a master tries to write a read only array, response code 7 (“In Write Protect Mode”) is generated.

8.4 Common Tables

Table 119. Expanded Device Type Codes

Expanded Device Code (Hex)	Description	Company Name
B77E	HRT2000v4	Bettis
B705	HRTIMVS2000	Bettis

NOTE: Other manufacturer devices are not listed.

Table 120. Engineering Unit Codes

Code	Description
32	Degrees Celsius
38	Hertz
39	Milliamperes
51	Seconds
57	Percent
58	Volts
251	None

NOTE: Only Unit Codes used by HRT2000v4 are listed.

Table 121. Transfer Function Codes

Code	Transfer Function Description
0	Linear
1	Square Root
2	Square Root Third Power
3	Square Root Fifth Power
4	Special Curve
5	Square
230	Discrete (Switch)
231	Square Root Plus Special Care
232	Square Root Third Power Plus Special Curve
233	Square Root Fifth Power Plus Special Curve
240 - 250	Not Used
251	None
252	Unknown
253	Special

Table 122. Alarm Selection Codes

Code	Alarm Selection Description
0	High
1	Low
239	Hold Last Output Value
240 - 250	Not Used
251	None
252	Unknown
253	Special

Table 123. Write Protect Codes

Code	Physical Signal Definition
0	No – No Write Protected
1	Yes – Write Protected
250	Not used
251	None
252	Unknown
253	Special
253	Special

Table 124. Manufacturer Identification Codes

Code (Dec)	Code (Hex)	Company Name
183	00B7	Bettis

NOTE: Other manufacturers are not listed.

Table 125. Burst Mode Control Codes

Code	Burst Mode Control Definition
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

NOTE: Only codes 0 and 1 are supported by HRT2000v4 field device.

Table 126. Physical Signalling Codes

Code	Physical Signal Definition
0	Bell 202 current
1	Bell 202 voltage
2	RS-485
3	RS-232
4	Wireless
6	Special

Table 127. Flag Assignments

Code	Flag Assignment Definition
00	Undefined
01	Multi-Sensor Field Device
02	Eeprom Control
04	Protocol Bridge Device
08	IEEE 802.15.4 2.4GHz DSS with O-QPSK Modulation
10 - 20	Undefined
40	C8psk Capable Field Device
80	C8psk In Multi-Drop Only

Table 128. Loop Current Mode Codes

Code	Loop Current Mode Description
0	Disabled
1	Enabled

Table 129. Extended Device Status Codes

Code	Description
00	Undefined
01	**Maintenance Required.** This bit is set to indicated that, while the device has not malfunctioned, the Field Device requires maintenance.
02	**Device Variable Alert.** This bit is set if any Device Variable is in Alarm or Warning State. The host should identify the Device Variable(s) causing this to be set using the Device Variable Status indicators.
04	**Critical Power Failure.** For devices that can operate from stored power. This bit is set when that power is becoming critically low.
08 - 80	Undefined

Table 130. Device Variable Family Codes

Code	Device Variable Family
0 - 3	Reserved
4	Temperature
5	Pressure
6	Valve / Actuator
7	Simple PID Control
8	pH
9	Conductivity
10	Totalizer
11	Level
12	Vortex Flow
13	Mag Flow
14	Coriolis Flow
132 - 249	Reserved
250	Not Used

Table 131. Device Variable Classification Codes

Code	Device Variable Classification
0	Device Variable Not Classified
1 - 63	Reserved
64	Temperature
70	Time
80	Frequency
83	EMF (Electromagnetic Unit of Electric Potential)
91	Valve Actuator

NOTE: Only Classification Codes used by HRT2000v4 are listed.

Table 132. Analog Channel Flags

Code	Flag Definition
0x01	This Analog Channel is a Field Device analog input channel. In other words, the Field Device has an ADC connected to this channel when this bit is set.

Table 133. Burst Message Trigger Modes

Code	Burst Message Trigger Mode 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.

Table 134. Device Profile Code

Code	Device Profile Code Description
1	HART Process Automation Device
2	HART Discrete Device
3	Hybrid: Process Automation + Discrete
4	I/O System
129	WirelessHART Process Automation Device
130	WirelessHART Discrete Device
131	WirelessHART Hybrid: Process Automation + Discrete
132	WirelessHART Gateway
141	WirelessHART Process Adapter
142	WirelessHART Discrete Adapter
144	WirelessHART-Enable Handheld / Portable Maintenance Tool

Section 9: Device Variables

9.1 List of Device Variables

Table 135.

Dev. Var.	Description	Classification	Unit Code	R/W	Min	Max	Type
0	Commands	Not Classified	None	W	0		ENUM_BIT
1	Status 1	Not Classified	None	R	0		ENUM_BIT
2	Status 2	Not Classified	None	R	0		ENUM_BIT
3	Position Request	Valve Actuator	Percent	W	0.0	100.0	FLOAT
4	Dead Band	Valve Actuator	Percent	RW	0.1	25.5	FLOAT
5	Motioh Inhibit Time	Time	Seconds	RW	1	255	FLOAT
6	Alarms 1	Not Classified	None	R	0		ENUM_BIT
7	Alarms 2	Not Classified	None	R	0		ENUM_BIT
8	Warnings	Not Classified	None	R	0		ENUM_BIT
9	Act. Log - Opening Time	Time	Seconds	R	0	65535	FLOAT
10	Act. Log - Closing Time	Time	Seconds	R	0	65535	FLOAT
11	ESD Action	Valve Actuator	None	RW	0	4	ENUM
12	ESD Percent	Valve Actuator	Percent	RW	0	100	FLOAT
13	2 Speed Timer - Close Dir. Status	Valve Actuator	None	RW	0	1	ENUM
14	2 Speed Timer - Close Dir. Start Pos.	Valve Actuator	Percent	RW	0	100	FLOAT
15	2 Speed Timer - Close Dir. Stop Pos.	Valve Actuator	Percent	RW	0	100	FLOAT
16	2 Speed Timer - Close Dir. On Time	Time	Seconds	RW	2	200	FLOAT
17	2 Speed Timer - Close Dir. Off Time	Time	Seconds	RW	1	200	FLOAT
18	2 Speed Timer - Open Dir. Status	Valve Actuator	None	RW	0	1	ENUM
19	2 Speed Timer - Open Dir. Start Pos.	Valve Actuator	Percent	RW	0	100	FLOAT
20	2 Speed Timer - Open Dir. Stop Pos.	Valve Actuator	Percent	RW	0	100	FLOAT
21	2 Speed Timer - Open Dir. On Time	Time	Seconds	RW	2	200	FLOAT
22	2 Speed Timer - Open Dir. Off Time	Time	Seconds	RW	1	200	FLOAT
23	Fail Safe Action	Valve Actuator	None	RW	0	4	ENUM
24	Fail Safe Delay	Time	Seconds	RW	0	255	FLOAT
25	Fail Safe Position	Valve Actuator	Percent	RW	0	100	FLOAT
26	Power Supply Type	Valve Actuator	None	R	0	2	ENUM
27	Power Supply Voltage	EMF	Volts	R	10	1000	FLOAT
28	Power Supply Frequency	Frequency	Hertz	R	50	60	FLOAT
244	Percent Range	Not Classified	Percent	R	0	100	FLOAT
245	Loop Current	Not Classified	mA	R			FLOAT
246	PV - Position Request	Not Classified	Percent	R	0.0	100.0	FLOAT
247	SV - Actuator Position	Not Classified	Percent	R	0.0	100.0	FLOAT
248	TV - Torque	Not Classified	Percent	R	-127	128	FLOAT
249	QV - Temperature	Temperature	Celsius	R	-127	128	FLOAT

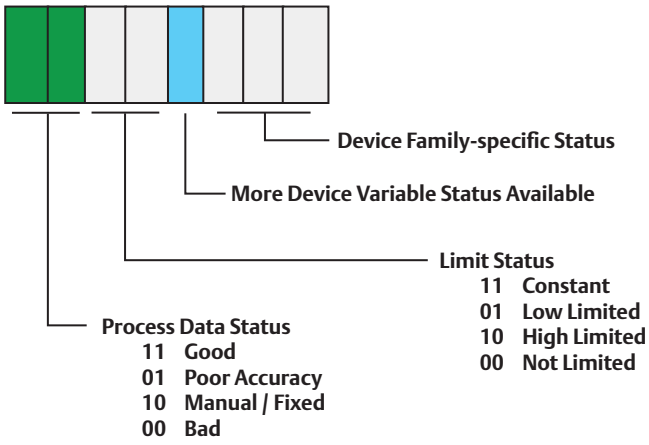
It's not possible to map dynamic variables.

9.2 Device Variable Status Byte

All cyclical process data include a Device Variable Status byte.

The most significant two bits (bits 7 and 6) of every Device Variable Status byte return the overall status of the Device or Dynamic Variable value. The next two bits (bits 5 and 4) indicate whether the Device Variable value is limited. These four bits provide useful status about the Device Variable's value. The content of the lower 4 bits depend on the Device Variable Family. Each Device Family can have its own Device Family-specific Status defining the least significant bits. If set bit 3 indicates the additional Device Family-specific status is available via the appropriate Device Family Command.

Figure 8



HRT2000v4 does not provide Device Family-specific Status for Dynamic and Device Variables, therefore last 4 bits are always set to 0.

9.3 Device Variable 0: Commands

This variable permits to send a command to the actuator. It is a bit_enumerated variable; the possible values are:

Table 136.

Bit	Description	Value
b0	Open Command	ON = 1, OFF = 0
b1	Close Command	ON = 1, OFF = 0
b2	Stop Command	ON = 1, OFF = 0
b3	ESD / PST Command	ON = 1, OFF = 0
b4	Enable Positioner	ON = 1, OFF = 0
b5	Interlock Open Command	ON = 1, OFF = 0
b6	Interlock Close Command	ON = 1, OFF = 0
b7 - b31	Not Defined	ON = 1, OFF = 0

Commands Open, Close, Stop, Enable Positioner of Device variable 0 work only in LOOP DISABLE mode and Multidrop. The commands ESD/PST, Interlock Open, and Interlock Close are always available.

In LOOP ENABLE mode, the commands Open, Close, Stop, Enable Positioner are always cleared.

Open: the command sends an open command to actuator. The command is memorized in the HART module interface and will be reset by Stop command or end of travel in opening.

Close: the command sends a close command to actuator. The command is memorized in the HART module interface and will be reset by Stop command or end of travel in closing.

Stop: the command stops actuator movement.

Example of sequence of Open commands:

- Set Open command
- Clear open command
- Set Stop command to stop actuator in intermediate position
- Clear Stop command before setting a new Open or Close command

If both commands Open and Close are set the actuator stops.

ESD / PST Command: It generates an ESD / PST command to actuator and overrides any other existing command (as the hardwired ESD does).
See “Appendix B.1 Multiple Functionality of ESD Command and Status” for details.

Enable Positioner: The command enables control of actuator by digital HART position request in the range 0.0 - 100.0. The Open, Close, Stop commands are disabled.

Interlock Open Command: It inhibits the open movement (as the hardwired command does).
See “Appendix B.2 Multiple Functionality of Interlock Command” for details.

Interlock Close Command: It inhibit the close movement (as the hardwired command does).
See “Appendix B.2 Multiple Functionality of Interlock Command” for details.

9.4 Device Variable 1: Actuator Status (1)

This variable describes the status of the actuator. It's a bit_enumerated variable, it's not possible to write this data. The possible values are:

Table 137.

Bit	Description
b0	Close Limit
b1	Open Limit
b2	Closing
b3	Opening
b4	ESD / PST Active
b5	Local Selector in REMOTE
b6	Local Selector in LOCAL
b7	Local Selector in OFF
b8	Interlock Open Active
b9	Interlock Close Active
b10	Fail Safe Action Active
b11	Reserved
b12	Reserved
b13	Reserved
b14	Reserved
b15	Reserved
b16	Monitor Relay
b17	Motion Inhibited
b18	DIN1
b19	DIN2
b20	DIN3
b21	DIN4
b22	DIN5
b23	DIN6
b24	AUX in Open
b25	AUX in Close
b26	AUX in Stop
b27	AUX in Bus-on
b28	Hardwired Mode Active
b29	Positioner Active
b30	Reserved
b31	Reserved

9.5 Device Variable 2: Actuator Status (2)

This variable describes the status of the actuator. It's a bit_enumerated variable, it's not possible to write this data. The possible values are:

Table 138.

Bit	Description
b0	Reserved
b1	Local Configuration
b2	Reserved
b3	Reserved
b4	Reserved
b5	Close Travel Available
b6	Open Travel Available
b7	Reserved
b8	Pos >= xx
b9	Pos <= yy
b10	Reserved
b11	Reserved
b12	Reserved
b13	Reserved
b14	Reserved
b15	Reserved
b16	Intermediate Position
b17	Interlock in Progress
b18	Moving
b19	Alarms
b20	Warnings
b21	Reserved
b22	Reserved
b23	Reserved
b24	Reserved
b25	Reserved
b26	Reserved
b27	Reserved
b28	Reserved
b29	Reserved
b30	Reserved
b31	Reserved

9.6 Device Variable 3: Position Request

This variable permits to drive the actuator in a desired position when Loop Current Mode is Disabled or HART topology is Multidrop.

9.7 Device Variable 4: Dead Band

This variable sets the percentage of the maximum position error without electrical commands.

9.8 Device Variable 5: Motion Inhibit Time

This variable indicates the length of the delay time between two motor cycles.

9.9 Device Variable 6: Actuator Alarms (1)

This variable shows the alarms status of the actuator. It's is a bit_enumerated variable, it's not possible to write this data. The possible values are:

Table 139.

Bit	Description
b0	Motor Thermostat
b1	Hi-Hi Torque in opening
b2	Hi-Hi Torque in closing
b3	Reserved
b4	Reserved
b5	Hi-Hi Temperature
b6	Position Sensor
b7	Speed Sensor
b8	Main Voltage
b9	K1 Contactor
b10	K2 Contactor
b11	Configuration
b12	Hardware
b13	Low battery
b14	Lost phase
b15	Request signal
b16	Hi-Hi Torque in intermediate position
b17	Jammed in closing
b18	Jammed in opening
b19	Direction test fail
b20	Mid travel alarm OP
b21	Mid travel alarm CL
b22	Reserved
b23	Reserved
b24	Alarm Extended #1
b25	Alarm Extended #2
b26	Alarm Extended #3

Bit	Description
b27	Alarm Extended #4
b28	Alarm Extended #5
b29	Alarm Extended #6
b30	Alarm Extended #7
b31	Alarm Extended #8

9.10 Device Variable 7: Actuator Alarms (2)

This variable shows the alarm status of the actuator. This is a bit_enumerated variable, it's not possible to write this data. The possible values are:

Table 140.

Bit	Description
b0	Reserved
b1	NACK Motherboard
b3 - b31	Reserved

9.11 Device Variable 8: Actuator Warnings

This variable shows the warning status of the actuator. This is a bit_enumerated variable, it's not possible to write this data. The possible values are:

Table 141.

Bit	Description
b0	Hi Torque in opening
b1	Hi Torque in closing
b2	Hi Temperature
b3	Main Voltage
b4	Contactor Cycles
b5	Maintenance Request
b6	Motor Current
b7	Wrong Stroke Limits
b8	Stop in Remote
b9	Hi Torque in Intermediate Position
b10	Reserved
b11	Reserved
b12	Reserved
b13	Reserved
b14	Reserved
b15	Reserved
b16	Warning Extended #1: Time PST Value Failed
b17	Warning Extended #2: Time RET Value Fixed
b18	Warning Extended #3: OV-TR Value Failed
b19	Warning Extended #4: PST Cycle Aborted
b20 - b31	Reserved

9.12 Device Variable 9: AL – Opening Time

This variable indicates the duration of the last stroke in opening. It's not possible to write this variable.

9.13 Device Variable 10: AL – Closing Time

This variable indicates the duration of the last stroke in closing. It's not possible to write this variable.

9.14 Device Variable 11: ESD Action

This variable defines the action to run in case of an ESD command. This is an enumerated variable; the possible values are:

Table 142.

Value	Description
0	Off: Function Disabled
1	Close
2	Open
3	Stay-Put
4	Go to position

9.15 Device Variable 12: ESD Percent

This variable defines the position to drive the actuator when the ESD action (Device Variable 18) is programmed to "Go to position".

9.16 Device Variable 13: 2SP – Close Direction Status

This variable indicates the status of the timer function in closing direction. This is an enumerated variable, the possible values are:

Table 143.

Value	Description
0	Off
1	On

9.17 Device Variable 14: 2SP – Close Direction Start Position

This variable indicates the position where the timer function start during a stroke in closing.

9.18 Device Variable 15: 2SP – Close Direction Stop Position

This variable indicates the position where the timer function stop during a stroke in closing.

9.19 Device Variable 16: 2SP – Close Direction ON Time

This variable indicates the ON time of motor in 2 Speed Timer operation in close direction.

9.20 Device Variable 17: 2SP – Close Direction OFF Time

This variable indicates the OFF time of motor in 2 Speed Timer operation in close direction.

9.21 Device Variable 18: 2SP – Open Direction Status

This variable indicates the status of the timer function in opening direction. This in an enumerated variable, the possible values are:

Table 144.

Value	Description
0	Off
1	On

9.22 Device Variable 19: 2SP – Open Direction Start Position

This variable indicates the position where the timer function start during a stroke in opening.

9.23 Device Variable 20: 2SP – Open Direction Stop Position

This variable indicates the position where the timer function stop during a stroke in opening.

9.24 Device Variable 21: 2SP – Open Direction ON Time

This variable indicates the ON time of motor in 2 Speed Timer operation in open direction.

9.25 Device Variable 22: 2SP – Open Direction OFF Time

This variable indicates the OFF time of motor in 2 Speed Timer operation in open direction.

9.26 Device Variable 23: Fail Safe Action

This variable indicates the action to run in case of 4 - 20 mA input signal failure. This in an enumerated variable, the possible values are:

Table 145.

Value	Description
0	Off: Function Disabled
1	Close
2	Open
3	Stay-Put
4	Go to Position

9.27 Device Variable 24: Fail Safe Delay

This variable indicates the delay time before running the fail safe action (Device Variable 30).

9.28 Device Variable 25: Fail Safe Position

This variable indicates the position to drive the actuator when the fail safe action (Device Variable 30) is programmed to “Go to position”.

9.29 Device Variable 26: Power Supply Type

This variable indicates the actuator power supply type. This is an enumerated variable, it’s not possible to write this data. The possible values are:

Table 146.

Value	Description
0	AC 3 Ph
1	AC 1 Ph
2	DC

9.30 Device Variable 27: Power Supply Voltage

This variable indicates the actuator power supply voltage. It's not possible to write this variable.

9.31 Device Variable 28: Power Supply Frequency

This variable indicates the actuator power supply frequency. It's not possible to write this variable.

9.32 Device Variable 244: Percent Range

This variable indicates the percentage corresponding to the Loop Current signal. It's not possible to write this variable.

9.33 Device Variable 245: Loop Current

This variable indicates the value of the analog input current. It's not possible to write this variable.

9.34 Device Variable 246: Primary Variable

This variable indicates the percentage corresponding to the Loop Current Signal. It's not possible to write this variable.

9.35 Device Variable 247: Secondary Variable

This variable indicates current position of the actuator. It's not possible to write this variable.

9.36 Device Variable 248: Tertiary Variable

This variable indicates the current torque measured by the actuator. It's not possible to write this variable.

9.37 Device Variable 249: Quaternary Variable

This variable indicates the internal temperature of the actuator. It's not possible to write this variable.

Section 10: Array Codes

Table 147.

Code	Description
0	Name Plate – Serial Number
1	Name Plate – Actuator Size
2	Name Plate – WD
3	Name Plate – Enclosure
4	Name Plate – Certificate
5	Name Plate – Lubricant
6	Motor Data – Motor Code
7	Valve Data – Tag Name
8	Valve Data – Serial Number
9	Valve Data – Valve Manufacturer
10	Valve Data – Break to Open Torque
11	Valve Data – Break Steam Thrust
12	Valve Data – Valve Coupling Type
13 - 255	Undefined

Section 11: Configuration via Local Interface of XTE3000

The HRT2000v4 interface allows the XTE3000 to connect to a HART fieldbus. Here below are described the facilities available in the view and setup menu of XTE3000.

11.1 BUS Control

- DIN 1 - DIN 6: By this routine, it is possible to choose the condition associated to command 128, Device Variable 1 (actuator status) bits 7 - 12. Here below is the list of the available conditions:

Table 148.

STATUS / ALARM		
• open limit • closed limit • position <= xx % • position >= yy % • closing • opening • motor running • blinker • mid-travel position • local selected	• remote selected • local stop active • ESD signal on • manual operation • motor over-temperature • over-torque • over-torque in OP • over-torque in CL • valve jammed • warnings	• valve jammed in OP • valve jammed in CL • ow battery (if present) • mid travel alarm in CL/OP • EFS in manual • PST failed • MAINS only AS8 • EFS mid-travel

The factory setting is: DIN 1 = mid-travel position, DIN 2 = local stop active, DIN 3 = motor over-temperature (motor thermostat alarm), DIN 4 = over-torque (hi-hi torque alarm), DIN 5 = valve jammed alarm, DIN 6 = mid-travel alarm in OP / CL

- **Node:** Use this function to enter the polling address node. Each device must have its address. Each address must be associated to one only device. The available address range is from 0 to 63. Set 0 in point to point mode. Set address from 0 to 15 in multidrop mode.
- **Mode:** The available options are loop enable, loop disable and multidrop. Select loop enable in point to point mode and split range and if the actuator is controlled by the analog 4 - 20 mA (PV). Use loop disable in point to point and split range mode and if the actuator is controlled by the digital HART signal (see Device Variable 3). Use loop disable or multidrop in multidrop mode. Mode can be set also by the HART Universal Command 6.
- **Device number ID:** Use this function to set the HART device number ID. The number is normally set in factory and should not be changed. The Device Number ID must be unique for each field device.

Configuration procedure:

- Move the local selector to OFF and then press simultaneously OPEN and STOP. Select the language and then enter the password according to the instructions “entering the set-up mode”. When the message of display is “SET-UP MODE OK?” press YES. Press YES to select actuator set-up menu, press NO to scroll the list of available routines and then press YES to select the routine BUS.
- Press NO if the conditions DIN1 is correct. Press YES to change. Press NO to change condition to switch, press TES to select.
- Repeat the previous procedure for DIN 2 up to DIN 6.
- Press YES if the configured value of the polling node address (ADDRESS) is correct (from 1 to 63), or press NO to change, then press YES.
- Press YES if the configured value of the MODE (Loop current enable, loop current disable, multidrop) is correct, or press NO to change, then press YES.
- Press YES to confirm the configured Device number.

View procedure:

- Move the local selector to OFF and then press simultaneously OPEN and STOP. Select the language and then enter the password according to the instructions “entering the view mode”. When the message of display is “VIEW MODE OK?” press YES. Press YES to select actuator set-up menu, press NO to scroll the list of available routines and then press YES to select BUS.
- Press YES to scroll the list of BUS parameters.

11.2 Positioner Function

The function is available only on the modulating actuators. The value 0.0 of position request, received from bus, corresponds to close request and the value 100.0 corresponds to open request. The XTE3000 compares the present position % of the actuator with the position request % received from the bus (analog 4 - 20 mA HART current loop or digital HART signal), and if the difference is greater than the dead band, the actuator is driven to reach the new requested position.

The following options can be configured via either bus or local operator interface:

- **Dead band:** Configurable from 0.1% to 25.5% of the maximum position error (difference among position request % and present position %). The configured value should be great enough to avoid “hunting” effect of the actuator.
- **Motion inhibit time:** It allows adjusting the length of the delay time between two cycles of the motor. It can be configured from 1 to 255 seconds and allows to set the maximum number of start / hour of electrical motor.

Configuration procedure:

- Move the local selector to OFF and then press simultaneously OPEN and STOP. Select the language and then enter the password according to the instructions “entering the set-up mode”. When the message of display is “SET-UP MODE OK?” press YES. Press YES to select actuator set-up menu, press NO to scroll the list of available routines and then press YES to select POSITIONER.
- Press YES if the configured value of the Dead Band is correct (from 0.1 to 25.5% of position error), or press NO to change, then press YES.
- Press YES if the configured value of the Motion Inhibit Time is correct (from 1 to 255 seconds), or press NO to change, then press YES.

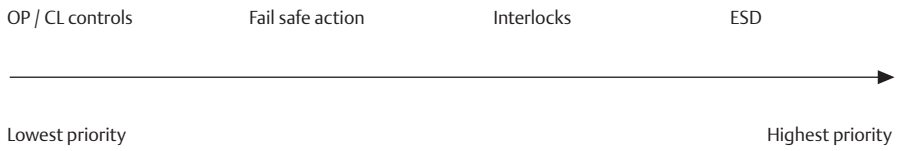
View procedure:

- Move the local selector to OFF and then press simultaneously OPEN and STOP. Select the language and then enter the password according to the instructions “entering the view mode”. When the message of display is “VIEW MODE OK?” press YES. Press YES to select actuator set-up menu, press NO to scroll the list of available routines and then press YES to select the routine (POSITIONER).
- Press YES to scroll the list of parameters.

11.3 Fail Safe Function

This function is available only if enabled in the restricted menu of actuator. It allows configuring the action of the actuator in case of loss of the 4 - 20 mA signal HART current loop. The action takes place only if the local selector is in REMOTE. When the 4 - 20 mA HART current loop restores, also the actuator restores at its normal functioning. The fail safe function can be configured via either bus or local operator interface.

The hardwired controls ESD and INTERLOCKS override the Fail Safe action according to the following diagram.



The following options can be configured:

- Fail safe action: open, close, stay-put, go to position %, no action (OFF)
- Delay time before than the fail safe action takes place (delay = 10 seconds + configured value)

Configuration procedure:

- Move the local selector to OFF and then press simultaneously OPEN and STOP. Select the language and then enter the password according to the instructions “entering the set-up mode”. When the message of display is “SET-UP MODE OK?” press YES. Press YES to select actuator set-up menu, press NO to scroll the list of available routines and then press YES to select FAIL SAFE.
- Press YES if the configured ACTION is correct (open, close, stay-put, go to position xx%, off), or press NO to change, then press YES.
- Press YES if the configured value of the DELAY is correct (from 0 to 255 seconds), or press NO to change, then press YES.

View procedure:

- Move the local selector to OFF and then press simultaneously OPEN and STOP. Select the language and then enter the password according to the instructions “entering the view mode”. When the message of display is “VIEW MODE OK?” press YES. Press YES to select actuator set-up menu, press NO to scroll the list of available routines and then press YES to select the routine (FAIL-SAFE).
- Press YES to scroll the list of parameters.

11.4 Viewing Transmission Info

The following procedure allows seeing the most significant info relevant to the bus data transmission:

- Move the local selector to OFF or REMOTE and then press YES until the display shows NODE REPORT. Press NO to exit or press YES to scroll the list of transmission info.

64 Byte: Information about the HRT2000v4 Interface

Config. change: Configuration changing counter

STX: Number of valid messages transmitted (max before counter reset 65535)

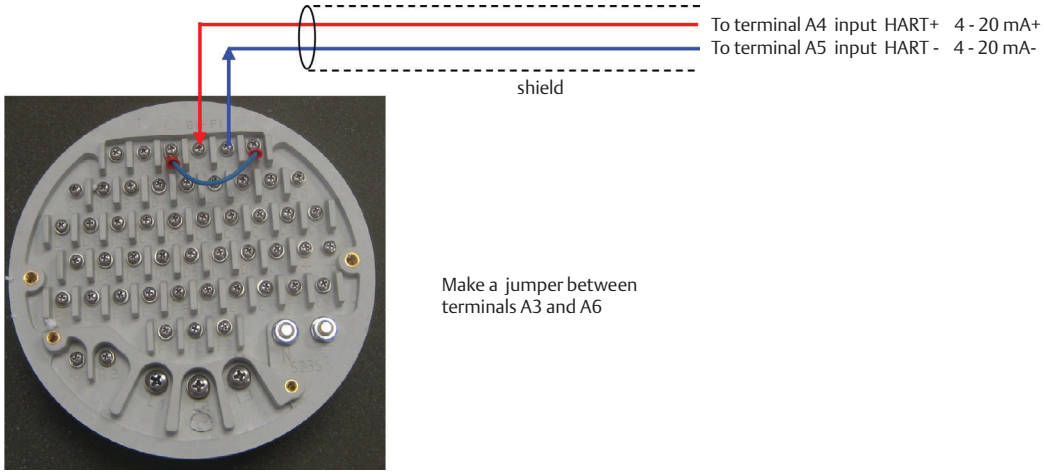
ACK: Number of valid messages received (max before counter reset 65535)

BACK: Number of valid Burst messages transmitted (max before counter reset 65535)

NODE RESET: Not Used

11.5 Actuator Terminal Board

Figure 9

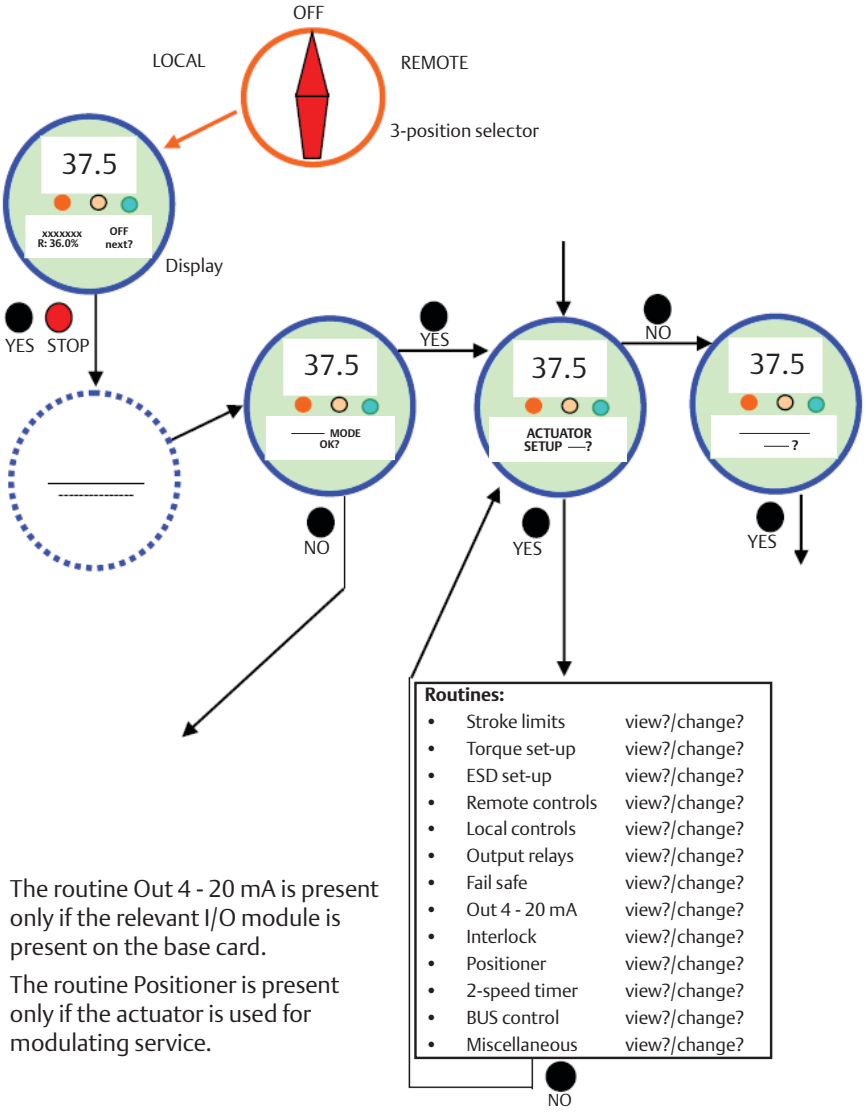


11.6 Bus Signal Failure Indication

In case of loss of 4 - 20 mA signal, a warning is generated. It is signalled by the flashing of the relevant ALARM / WARNING LED and by indication on the local 2 lines /16 characters display.

See Figure 10 for the list of routines available in the XTE3000 view or setup menu.

Figure 10



1. The routine Out 4 - 20 mA is present only if the relevant I/O module is present on the base card.
2. The routine Positioner is present only if the actuator is used for modulating service.

Section 12: Certificate of Registration

HART® REGISTERED

Certificate of Registration
HCF Verified

Biffi Italia s.r.l. — Manufacturer	HRT2000v4 — Product Name / Model Number
0000B7 — Manufacturer ID (Hex)	0002 — Device Type (Hex)
7.2 — HART Protocol Revision	1.0 — Device Revision
1 — Hardware Revision	1.0 — Software Revision
09/15/2010 — Test Date	HCF — Verification Method

The above device has successfully met the quality assurance conditions to be called "HART REGISTERED" and was found to be consistent with the requirements specified by HART Field Communication Protocol

Registration Number: L2-06-1000-073 Registration Issue Date: 09/15/2010 HCF QA Approval:

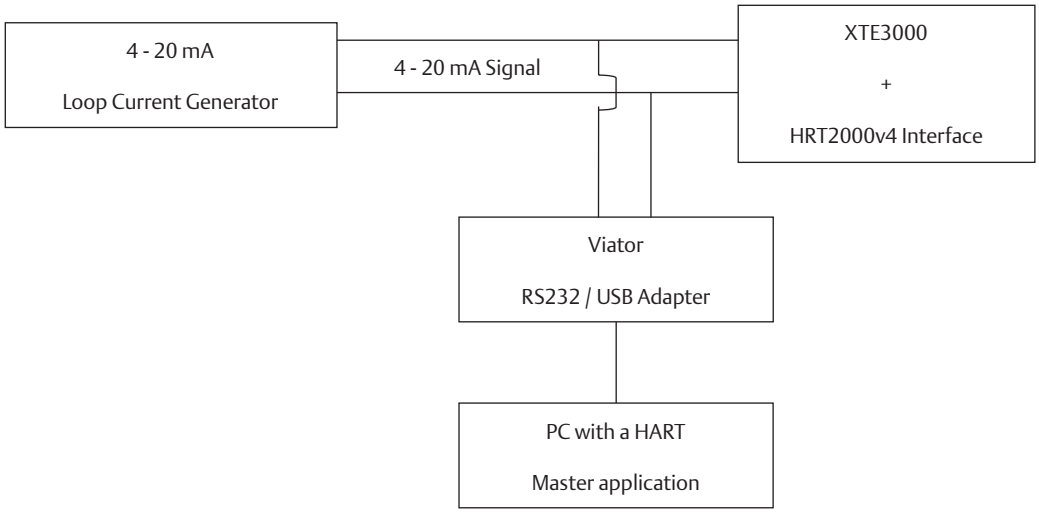
HART COMMUNICATION FOUNDATION

HART® is a registered trademark of the HART Communication Foundation

DD Files and other information are available on HART official website: http://www.hartcomm.org/

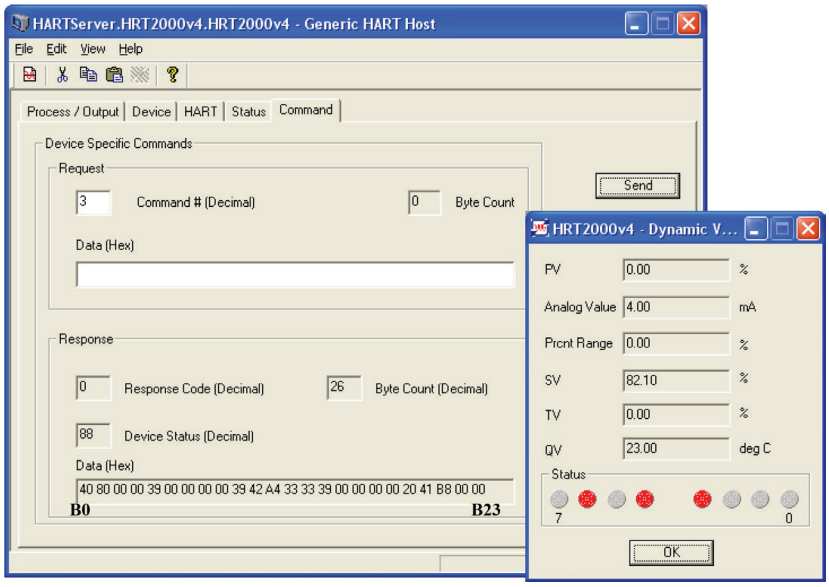
Appendix A: HART Command 3 Communication Example

Figure A-1 Block Diagram



See Section 11.5 for Terminal Board Connections.

Figure A-2 Example of HART Command 3 Communication with Dynamic Variables Values (decimal)



The windows on the right shows the decimal value of Dynamic Variables and the Field Device Status; this window can be selected from “View -> Dynamic Variables”.

The command sent by the master is Universal Command 3 – Read Dynamic Variables.
The response from the slave is a frame with the following values:

Table A-1.

Data Bytes	Description	Values (Hex)	Values (Dec)*
0 - 3	Loop Current (mA)	40 80 00 00	4.00
4	PV Units Code	39	57 = Percent
5 - 8	PV Value	00 00 00 00	0.0
9	SV Units Code	39	57 = Percent
10 - 13	SV Value	42 A4 33 33	82.1
14	TV Units Code	39	57 = Percent
15 - 18	TV Value	00 00 00 00	0.0
19	QV Units Code	20	32 = Degrees Celsius
20 - 23	QV Value	41 B8 00 00	23.0

NOTE: *Converted using IEEE-754 (IEC 559)

Appendix B:

This addendum explains some functionality introduced with base card Firmware version 7.00.
If revision of base card is less than 7.00, this addendum is not relevant.

B.1 Multiple Functionality of ESD Command and Status

The ESD command and status can assume the meaning of PST signal, based on type of actuator and setting of “ESD Input Mode” parameter.

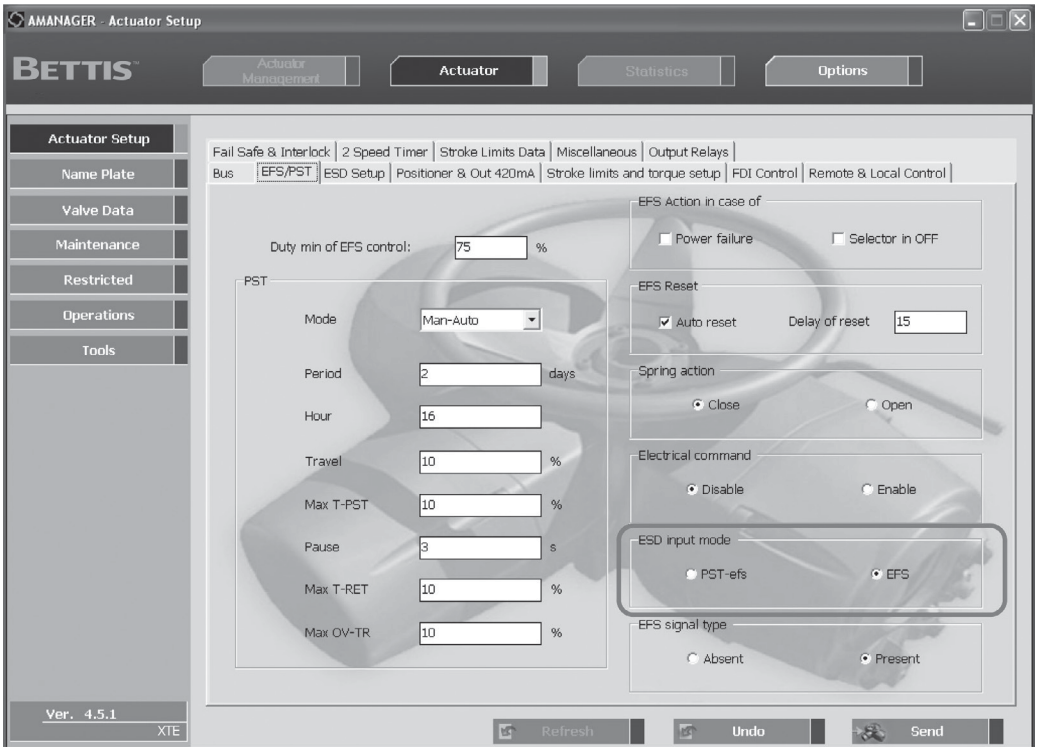
The following Table explicit its functionality:

Table B-1.

ACTUATOR MODEL	ESD INPUT MODE PARAMETER	ESD COMMAND FUNCTIONALITY	ESD STATUS FUNCTIONALITY
XTE	PST-efs	Electrical ESD	ESD IN PROGRESS
XTE	EFS	Electrical ESD	ESD IN PROGRESS
EFS	PST-efs	PST	PST IN PROGRESS
EFS	EFS	Spring ESD	ESD IN PROGRESS

The ESD input mode parameter can be set on “Actuator Setup” menu of local control or AManager software (see Figure below):

Figure B-1



B.2 Multiple Functionality of Interlock Command and Status

In case of XTE actuator, the Interlock command can assume the meaning of PST signal, based on type of actuator and setting of “interlock mode” parameter.

The following Table explicit its functionality:

Table B-2.

ACTUATOR	INTERLOCK MODE	INTERLOCK COMMAND FUNCTIONALITY
XTE	STANDARD	INTERLOCK
XTE	ADVANCED	PST
EFS	STANDARD	INTERLOCK
EFS	ADVANCED	INTERLOCK

The “interlock mode” parameter is available on restricted menu, accessible with manufacturer login access.

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