

HART Field Device Specification PR 5437/6437 Device Revision 2

Version Revision: V6R0

Document Summary:

This document explains the HART commands and features implemented in the PR 5437 and PR 6437 transmitters, device revision 2.

PR 5437/6437 are temperature transmitters supporting both 4-20 mA current loop signalling and HART 7 wired FSK communication.

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1. Introduction

1.1 Scope

Temperature transmitters PR 5437 and PR 6437 manufactured by PR electronics A/S complies with HART Protocol Revision 7.6. This document specifies all the device specific features and documents HART Protocol implementation details. The functionality of this Field Device is described sufficiently to allow its proper application in a process and its complete support in HART capable host applications.

1.2 Purpose

This specification is designed to complement other documentation by providing a complete, unambiguous description of this Field Device from a HART Communication perspective.

1.3 Who Should Use This Document?

The specification is designed to be a technical reference for HART capable Host Application Developers, System Integrators and knowledgeable End Users. It also provides functional specifications (e.g., commands, enumerations and performance requirements) used during Field Device development, maintenance and testing. This document assumes the reader is familiar with HART Protocol requirements and terminology.

1.4 Abbreviations and Definitions

CJC	Cold Junction Compensation
CN	Capacitance Number, capacitance as a multiple of 5000 pF
CRC	Cyclic Redundancy Check
DAC	Digital to Analog Converter
DD	Device Description
DTM	Device Type Manager
DV	Device Variable
LIN	Linearization
PV	Primary Variable
RTD	Resistance Temperature Detector
SV	Secondary Variable
TC	Thermo coupler
Safe State	The Safe State is either <3.6mA or >21mA which is the alarm currents defined by NAMUR NE43.

1.5 References

1. HART Communication Protocol Specification (HCF_SPEC-13, Revision 7.6)
2. Universal Command Specification (HCF_SPEC-127, Revision 7.1)
3. Common Practice Command Specification (HCF_SPEC-151, Revision 11.0)
4. Common Tables Specification (HCF_SPEC-183, Revision 24.0)
5. Command Response Code Specification (HCF_SPEC-307, Revision 6.0)
6. FSK Physical Layer Specification (HCF_SPEC-054, Revision 9.1)
7. Token-Passing Data Link Layer Specification (HCF_SPEC-81, Revision 9.0)
8. Network Management Specification (HCF_SPEC-085, Revision 2.0)
9. Command Summary Specification (HCF_SPEC-99, Revision 10.0)
10. Device Families Command Specification (HCF_SPEC-160, Revision 1.1)
11. Temperature Device Family Specification (HCF_SPEC-160.4, Revision 3.0 Draft E)
12. NAMUR Recommendation NE-107

2. Device Identification

Manufacturer Name:	PR electronics A/S	Model Name:	PR 5437 / PR 6437
Manufacture ID Code:	109 (6D Hex)	Device Type Code:	230 (E6 Hex)
HART Protocol Revision	7.6	Device Revision:	2
Number of Device Variables	16		
Physical Layers Supported	FSK		
Physical Device Category	Transmitter		

Figure 1: *Device Identification Summary Table*

The name plate is located on the side of the housing.

3. Product Overview

The device is a loop powered temperature transmitter:

PR 5437 is for mounting in a DIN43729 form B-housing.

PR 6437 is for mounting on a DIN rail, the housing encloses one or two PR 5437 devices, the only difference is the product name and the housing.

- PR 6437 single channel:
Encloses a single PR 5437 device in a DIN-rail housing.
- PR 6437 dual channel:
Encloses two PR 5437 devices in a DIN-rail housing, the two internal PR 5437 share no electrical connections inside the housing and they may therefore be used in two separate current loops or in the same current loop using HART multidrop mode.

Configuration and monitoring of measurements and output signal and status can be done using HART[®]-protocol. The device shall be isolated from input to output to eliminate effects from sensor elements leaking to surroundings at high temperatures.

Input can be configured to measure mV, Thermocouples with cold junction compensation, Pt100 sensors or other RTD/resistance sensors with 2-, 3- or 4-wire compensation. It is possible to measure average or differential and other values on based on two inputs.

The analogue output signal is a standard 4-20 mA current signal corresponding to the Primary Value. It can be configured to indicate sensor error by up or downscaling.

4. Product Interfaces

4.1 Process Interface

4.1.1 Sensor Input Channels

PR 5437: Device has 7 terminals for connection of one or two inputs, the terminals are marked 3, 4, 5, 6, 7, 8 and 9.

PR 6437 single / dual: Device has 8 terminals for connection of one or two inputs, the terminals are marked 41, 42, 43, 44, 51, 52, 53 and 54.

Refer to the Installation Manual for connection details for PR 5437 and PR 6437 single and dual channel.

The supported input types are:

- RTD sensor temperature measurement.
- TC sensor temperature measurement.
- Potentiometer 0 - 100 % position.
- Linear resistance measurement.
- Linear voltage measurement, both bipolar and unipolar.

RTD sensors and linear resistance measurements:

One or two inputs may be connected.

Each input may be connected using 2, 3 or 4 wires depending on the need for cable resistance compensation.

TC sensor and linear voltage measurements:

One or two inputs may be connected.

Each TC sensor may use an external RTD sensor (Pt100 or Ni100) for cold junction compensation. The external compensation sensor may be connected using 2, 3 or 4 wires depending on the need for cable resistance compensation.

TC sensors may alternatively use the internal RTD sensor, which is mounted near the sensor terminals, for cold junction compensation.

Finally, a configurable fixed temperature value may be used for cold junction compensation.

Potentiometer measurements:

A potentiometer may be connected using 3, 4 or 5 wires depending on the need for cable resistance compensation. The measurement returns the potentiometer scale position in the range 0 - 100 %

Dual input features:

If two inputs delivering the same output (temperature, voltage or resistance) are mounted, it is possible to read out the following in addition to the individual input values:

- Average of the two input measurements.
- Difference between the two input measurements.
- Redundant measurement, measurement continues as long as any of the two inputs are working without sensor errors.

4.1.2 Output Channels

This device has no process output channels.

4.2 Host Interface

4.2.1 Analog Output

The two-wire 4-to-20 mA current loop is connected to these terminals:

PR 5437: Terminals 1 (+) and 2 (-).

PR 6437 single channel: Terminals 11 (-) and 12 (+).

PR 6437 dual channel: Channel 1: Terminals 11(-) and 12 (+).
 Channel 2: Terminals 21 (-) and 22 (+).

Refer to the Installation Manual for connection details.

This is the only output from this transmitter, representing the process temperature measurement, linearized and scaled according to the configured range of the instrument. This output corresponds to the Primary Variable. HART Communication is supported on this loop. This device has a CN of 1.

A guaranteed linear over-range is provided.

Device malfunction can be indicated by down-scale.

	Direction	Values (percent of range)	Values (mA or V)
Linear over-range	Down	-1.25 %	3.8 mA
	Up	+103.1%	20.5 mA
Device malfunction indication	Down: Less than	-3.1%	3.5 mA
Maximum current		+118.8%	23.0 mA
Multi-Drop current draw			4.0 mA
Lift-off voltage			N/A

Figure 2: Analog Output Characteristics

4.2.2 Discrete Output

The device has no discrete host outputs.

4.2.3 Analog Input

The device has no analog host inputs.

4.2.4 Discrete Input

The device has no discrete host inputs.

4.3 Local Interfaces, Jumpers and Switches

4.3.1 Local Controls and Displays

The device has no external local controls or displays.

PR 5437: The device has one bi-color LED (red/green) visible on the top of the DIN43729 form B-housing (PR 5437) or on the front (PR 6437). See 7.1.1 for detailed status indication.

PR 6437 single channel: One bi-color LED is mounted on the front of the DIL rail housing.

PR 6437 dual channel: Two bi-color LEDs are mounted on the front of the DIL rail housing.

4.3.2 Internal Jumpers and Switches

PR 5437: Write Protection:

The device has an internal jumper to enable Write Protection, see 12.10.2.

Namur NE43, Safe State output current:

The device has an internal jumper that selects the output current at Safe State, if inserted, the output current will go above 21 mA as specified in Namur NE43. If not inserted, the current will go below 3.6mA as specified in Namur NE43.

Note:

a) The jumper has no effect if device has entered a Safe State that can be reset automatically i.e. without repower, output current is always < 3.6 mA.

See description in chapter 7.3, specifically table column "To Reset".

b) The jumper may not be used in SIL mode, output current is always < 3.6 mA.

PR 6437 single channel: The Write Protection and Namur NE43 jumpers are available on the front of the DIN-rail housing.

PR 6437 dual channel: No jumpers are available for any of the channels.

Refer to the Installation Manual for details.

5. Device Variables

The device exposes 16 device variables.

- DV 0: Input 1 (temperature, voltage, resistance...)
- DV 1: Input 2 (temperature, voltage, resistance...)
- DV 2: CJC 1, Input 1 CJC temperature, only valid if Input 1 is a TC sensor.
- DV 3: CJC 2, Input 2 CJC temperature, only valid if Input 2 is a TC sensor.
- DV 4: Average Input 1 and Input 2.
- DV 5: Difference Input 1 - Input 2.
- DV 6: Difference Input 2 - Input 1.
- DV 7: Absolute difference (Input 1 - Input 2).
- DV 8: Minimum (Input 1, Input 2).
- DV 9: Maximum (Input 1, Input 2).
- DV 10: Input 1 with Input 2 as backup.
- DV 11: Input 2 with Input 1 as backup.
- DV 12: Average with Input 1 or 2 as backup.
- DV 13: Minimum with Input 1 or 2 as backup.
- DV 14: Maximum with Input 1 or 2 as backup.
- DV 15: Electronics Temperature

DV 1 and DV 3 through 14 are only valid for dual input measurements.

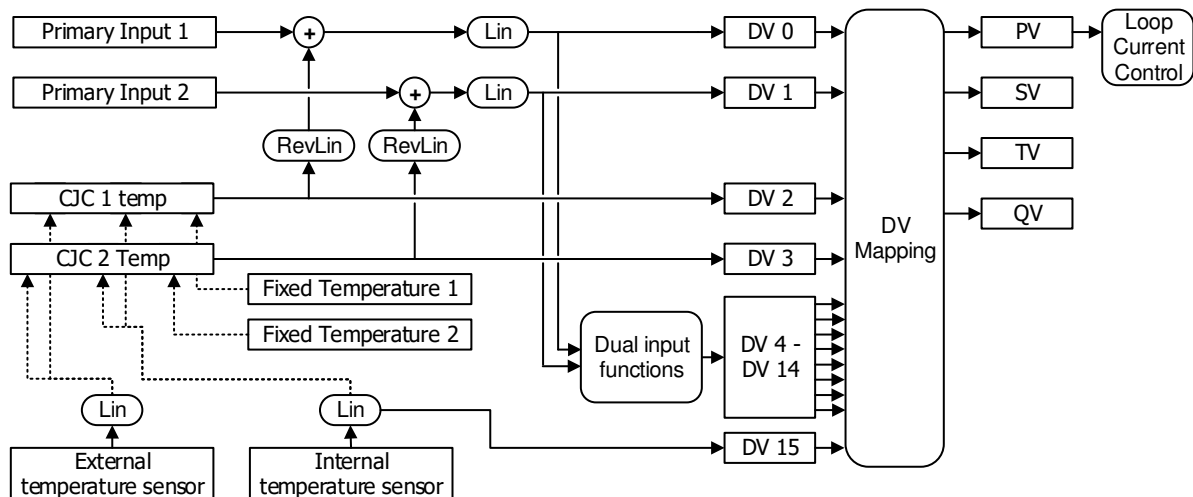


Figure 3: Overview of device variables and dynamic variables

See the Product Manual for more details about configuration and connection..

5.1 Device Variable 0: Input 1

DV 0 must be configured in all measurement modes.

DV 0 holds the status and value of input 1 measurement. Depending on the configuration, the value is linearized, trimmed, damped and compensated using CJC temperature measurement or compensated for cable resistance.

Device Variable Properties	
Number:	0
Name:	Input 1
Classification:	0: Not Classified
Unit Codes.	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status 1025: Read Temperature Configuration 1026: Read Thermocouple Configuration 1152: Write Temperature Probe Type 1155: Select Cold Junction Compensation Type 1556: Write Manual Cold Junction Temperature

Figure 4: *Summary of Device Variable 0 Properties*

5.2 Device Variable 1: Input 2

DV1 holds the status and value of input 2 measurement.

Depending on the configuration, the value is linearized, trimmed, damped and compensated using CJC temperature measurement or compensated for cable resistance.

For single-input measurements, DV1 temperatureProbeType must be configured to "None".

Device Variable Properties	
Number:	1
Name:	Input 2
Classification:	0: Not Classified
Unit Codes.	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status 1025: Read Temperature Configuration 1026: Read Thermocouple Configuration 1152: Write Temperature Probe Type 1155: Select Cold Junction Compensation Type 1556: Write Manual Cold Junction Temperature

Figure 5: *Summary of Device Variable 1 Properties*

5.3 Device Variable 2: CJC 1

When Input 1 is configured as a TC temperature sensor, the CJC temperature is available from DV 2. DV 2 is not valid for any other input type.

Depending on the configuration, DV 2 holds:

- CJC temperature measured using the external RTD temperature sensor.
- CJC temperature measured using the internal RTD sensor located at the terminals.
- A fixed CJC temperature configured by the user.

Device Variable Properties	
Number:	2
Name:	CJC 1
Classification:	0: Not Classified
Unit Codes.	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status

Figure 6: *Summary of Device Variable 2 Properties*

5.4 Device Variable 3: CJC 2

When Input 2 is configured as a TC temperature sensor, the CJC temperature is available from DV 3. DV 3 is not valid for any other input type.

Depending on the configuration, DV 3 holds:

- CJC temperature measured using the external RTD temperature sensor.
- CJC temperature measured using the internal RTD sensor located at the terminals.
- A fixed CJC temperature configured by the user.

Device Variable Properties	
Number:	3
Name:	CJC 2
Classification:	0: Not Classified
Unit Codes.	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status

Figure 7: *Summary of Device Variable 3 Properties*

5.5 Device Variable 4: Average Input 1 and Input 2

DV 4 holds the average of input 1 and input 2 values.

Average = (input 1 value + input 2 value) / 2.

DV 4 status indicates sensor error if either Input 1 or 2 indicate error.

DV 4 is only valid for dual input measurements.

Example:

- DV 0 is configured as TC type K with internal CJC compensation, unit code is 32 (Celsius)
- DV 1 is configured as RTD Pt100, unit code is 32 (Celsius)
- DV 4 is now valid and holds the average of Input 1 and Input 2 temperatures in Celsius.

Device Variable Properties	
Number:	4
Name:	Average Input 1 and Input 2
Classification:	0: Not Classified
Unit Codes.	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status

Figure 8: Summary of Device Variable 4 Properties

5.6 Device Variable 5: Difference Input 1 - Input 2

DV 5 holds the difference between Input 1 and Input 2 values.

Difference = (Input 1 value - Input 2 value)

DV 5 status indicates sensor error if either Input 1 or 2 indicate error.

DV 5 is only valid for dual input measurements, see details and examples for DV 4.

Device Variable Properties	
Number:	5
Name:	Difference Input 1 - Input 2
Classification:	0: Not Classified
Unit Codes.	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status

Figure 9: Summary of Device Variable 5 Properties

5.7 Device Variable 6: Difference Input 2 - Input 1

DV 6 holds the difference between Input 2 and Input 1 values.

Difference = (Input 2 value - Input 1 value)

DV 6 status indicates sensor error if either Input 1 or 2 indicate error.

DV 6 is only valid for dual input measurements, see details and examples for DV 4.

Device Variable Properties	
Number:	6
Name:	Difference Input 2 - Input 1
Classification:	0: Not Classified
Unit Codes.	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status

Figure 10: *Summary of Device Variable 6 Properties*

5.8 Device Variable 7: Absolute Difference

DV 7 holds the absolute difference between Input 1 and Input 2 values.

Difference = | Input 2 value - Input 1 value |.

DV 7 status indicates sensor error if either Input 1 or 2 indicate error.

DV 7 is only valid for dual input measurements, see details and examples for DV 4.

Device Variable Properties	
Number:	7
Name:	Absolute difference
Classification:	0: Not Classified
Unit Codes.	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status

Figure 11: *Summary of Device Variable 7 Properties*

5.9 Device Variable 8: Minimum

DV 8 holds the minimum of Input 1 and Input 2 values.

DV 8 status indicates sensor error if either Input 1 or 2 indicate error.

DV 8 is only valid for dual input measurements, see details and examples for DV 4.

Device Variable Properties	
Number:	8
Name:	Minimum
Classification:	0: Not Classified
Unit Codes.	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status

Figure 12: *Summary of Device Variable 8 Properties*

5.10 Device Variable 9: Maximum

DV 9 holds the maximum of Input 1 and Input 2 values.

DV 9 status indicates sensor error if either Input 1 or 2 indicate error.

DV 9 is only valid for dual input measurements, see details and examples for DV 4.

Device Variable Properties	
Number:	9
Name:	Maximum
Classification:	0: Not Classified
Unit Codes.	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status

Figure 13: *Summary of Device Variable 9 Properties*

5.11 Device Variable 10: Input 1 with Input 2 as Backup

DV 10 holds Input 1 value when Input 1 is OK.

DV 10 holds Input 2 value when Input 1 indicates error and Input 2 is OK.

DV 10 indicates only sensor error if both Input 1 and 2 indicate error.

DV 10 is only valid for dual input measurements, see details and examples for DV 4.

Backup function is only active if Sensor Error detection is enabled.

Device Variable Properties	
Number:	10
Name:	Input 1 with Input 2 as backup
Classification:	0: Not Classified
Unit Codes.	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status

Figure 14: *Summary of Device Variable 10 Properties*

5.12 Device Variable 11: Input 2 with Input 1 as Backup

DV 11 holds Input 2 value when Input 2 is OK.

DV 11 holds Input 1 value when Input 2 indicates error and Input 1 is OK.

DV 11 indicates only sensor error if both Input 1 and 2 indicate error.

DV 11 is only valid for dual input measurements, see details and examples for DV 4.

Backup function is only active if Sensor Error detection is enabled.

Device Variable Properties	
Number:	11
Name:	Input 2 with Input 1 as backup
Classification:	0: Not Classified
Unit Codes.	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status

Figure 15: *Summary of Device Variable 11 Properties*

5.13 Device Variable 12: Average with Input 1 or 2 as Backup

DV 12 holds the average of Input 1 and Input 2 values if Input 1 and 2 both are OK.

Average = (Input 1 value + Input 2 value) / 2.

DV 12 holds Input 1 value when Input 2 indicates error and Input 1 is OK.

DV 12 holds Input 2 value when Input 1 indicates error and Input 2 is OK.

DV 12 indicates only sensor error if both Input 1 and 2 indicate error.

DV 12 is only valid for dual input measurements, see details and examples for DV 4.

Backup function is only active if Sensor Error detection is enabled.

Device Variable Properties	
Number:	12
Name:	Average with Input 1 or 2 as backup
Classification:	0: Not Classified
Unit Codes:	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status

Figure 16: *Summary of Device Variable 12 Properties*

5.14 Device Variable 13: Minimum with Input 1 or 2 as Backup

DV 13 holds the minimum of Input 1 and Input 2 values if Input 1 and 2 both are OK.

DV 13 holds Input 1 value when Input 2 indicates error and Input 1 is OK.

DV 13 holds Input 2 value when Input 1 indicates error and Input 2 is OK.

DV 13 indicates only sensor error if both Input 1 and 2 indicate error.

DV 13 is only valid for dual input measurements, see details and examples for DV 4.

Backup function is only active if Sensor Error detection is enabled.

Device Variable Properties	
Number:	13
Name:	Minimum with Input 1 or 2 as backup
Classification:	0: Not Classified
Unit Codes.	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status

Figure 17: *Summary of Device Variable 13 Properties*

5.15 Device Variable 14: Maximum with Input 1 or 2 as Backup

DV 14 holds the maximum of Input 1 and Input 2 values if Input 1 and 2 both are OK.

DV 14 holds Input 1 value when Input 2 indicates error and Input 1 is OK.

DV 14 holds Input 2 value when Input 1 indicates error and Input 2 is OK.

DV 14 indicates only sensor error if both Input 1 and 2 indicate error.

DV 14 is only valid for dual input measurements, see details and examples for DV 4.

Backup function is only active if Sensor Error detection is enabled.

Device Variable Properties	
Number:	14
Name:	Maximum with Input 1 or 2 as backup
Classification:	0: Not Classified
Unit Codes.	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status

Figure 18: *Summary of Device Variable 14 Properties*

5.16 Device Variable 15: Electronics Temperature

DV 15 holds the Electronics Temperature.

Device Variable Properties	
Number:	15
Name:	Electronics Temperature
Classification:	0: Not Classified
Unit Codes.	Ref. Common Tables, table 2 (HCF_SPEC-183)
Device Family:	4: Temperature Device Family
Device Family Commands:	1024: Read Temperature Status

Figure 19: *Summary of Device Variable 14 Properties*

6. Dynamic Variables

Four dynamic variables are supported, PV, SV, TV and QV.

Using HART commands, these may be assigned to any Device Variable (DV 0 - 15) in any combination. The Device variable mapped to PV controls the loop current.

7. Status Information

7.1 Device Status

The device supports all bits described in HCF_SPEC-99, Table 12:

Bit #:	Definition:	LED status:
0:	("Primary Value Out Of Limits") is set when the device variable mapped to PV is beyond its operating limits.	Flashing red
1:	("Non-Primary Value Out Of Limits") is set when any other device variable is beyond its operating limits.	Flashing red
2:	("Loop Current Saturated" is set when the loop current has reached the Current Output Upper Limit (UL) or Output Lower Limit (LL) as configured with command #147, and is no longer corresponding to the PV value.	Flashing red
3:	("Loop Current Fixed") is set when the analogue output current is being simulated or disabled.	Flashing red
4:	("More Status Available") is set whenever any failure is detected. Command #48 gives further detail in Device Specific Status Byte 0 through 5.	See 7.3
5:	("Cold Start") is set only in the first response after the device has been reset or repowered.	No impact
6:	("Configuration Changed") is set if the configuration has changed since last reception of command# 38 (seen from same master type, Primary- or Secondary Master).	No impact
7:	("Malfunction") is set if the device has detected a serious error or failure that compromises device operation. The loop current will (unless incapable) enter the Safe State value. Command #48 gives further detail in Device Specific Status Byte 0 through 5.	See 7.3

7.1.1 LED Indication

A bicolor red and green LED also indicate the device status.

The LED is lit green constantly when the device is operating normally, providing a "Device OK" indication.

If an error is diagnosed, the LED is either flashing red or constantly lit red.

See above for detailed specifications

7.2 Extended Device Status

The device supports the Extended Device Status specified in HCF_SPEC-183, Table 17:

- Bit 0: Maintenance Required (0x01).
This bit is set when a sensor error is detected by the device. The parameter "Device Specific Status Byte 0" returned by command 48 shows for which input the error was detected.
- Bit 1: Device Variable Alert (0x02)
This bit is set if any of the device variables are out of limits.
Use command 9 "Read Device Variables With Status" to determine for which device variables the alert was detected.

This bit is set when any of the device status bits “PV Values of Of Limits” and “Non-PV Values of Of Limits” are set.

Bit 2 – 7: Not used by device.

7.3 Additional Device Status (Command #48)

The device supports the following bytes of the command 48 request and response.

Byte #	Parameter	Description	Analog output current	LED status	HART resp. byte #2	Class NE-107	To reset NOTE 1	
0	Device Specific Status Byte #0	Status during normal operation: ^{NOTE 2} Bit0: Primary sensor 1 error Bit1: Primary sensor 2 error (only if Input 2 enabled) Bit2: CJC for sensor 1 error (only if used) Bit3: CJC for sensor 2 error (only if used) Bit5: Dual input: Sensor drift alarm (only if enabled)	Enters the configured sensor error value ^{NOTE 3}	Flashing red	"More Status" is set	F	Auto	
		Bit6: Dual input: Backup sensor OK, main sensor error Bit7: Dual input: Backup sensor error, main sensor OK	No impact	Flashing red		M		
		Bit4: Not used	No impact	No impact	No Impact	N.A.		
1	Device Specific Status Byte #1	Status during normal operation: Bit0: Configuration not supported by device.	Value will be held (freeze)	Flashing red	"More Status" is set	C	Auto	
			After 1-2 sec. enters Safe State	Lights red		F	Auto ^{NOTE 4}	
		Bit1: Internal electronics temperature alarm	Normal mode	No impact		Flashing red	S	Auto
			SIL Mode	Safe State	Lights red	"Malfunction" is set	F	Re-power
		Bit2: Minimum supply voltage not reached			Off	No Impact	C	Auto ^{NOTE 5}
		Bit3: Attempting or failed to enter SIL mode			Lights red	"More Status" is set	C	Auto ^{NOTE 6}
Bit4-7: Not used		No impact	No impact	No Impact		N.A.		
2	Device Specific Status Byte #2	Critical device errors: Bit0: Error in communication with Input CPU Bit3: Input CPU reconfiguration failed Bit4: Supply voltage too low ^{NOTE 7} Bit5: Loop current read back error Bit6: Supply voltage too high ^{NOTE 7}	Safe State	Lights red	"Malfunction" is set	F	Re-power	
		Bit1: Not used Bit2: Not used Bit7: Not used	No impact	No impact		No Impact		N.A.

3	Device Specific Status Byte #3	Critical device errors: Bit0: Error in data verification after writing to EEPROM Bit1: CRC16 error in cyclic test of EEPROM Bit2: Error in EEPROM communication Bit4: CRC16 error in cyclic test of program code in FLASH Bit5: Exception error during code execution Bit6: Watchdog Reset Executed	Safe State	Lights red	"Mal-function" is set	F	Re-power
		Bit 3 and 7: Not used	No impact	No impact	No Impact		N.A.
4	Device Specific Status Byte #4	Critical device errors: Bit0: Internal RTD sensor error Bit1: CRC16 error in cyclic test of safe-domain RAM contents Bit2: Stack integrity error Bit4: CRC16 error in factory data in FLASH Bit5: RAM cell error Bit6: Safe domain RAM integrity error Bit7: CRC16 error in input CPU configuration	Safe State	Lights red	"Mal-function" is set	F	Re-power
		Bit 3 Not used	No impact	No impact	No Impact		N.A.
5	Device Specific Status Byte 5	Critical measuring errors: Bit0: Drift error, reference voltage FVR Bit1: Drift error, reference voltage VREF Bit2: Drift error, primary Input 1 Bit3: Drift error, primary Input 2 Bit4: Drift error, ground voltage offset to terminal 3	Safe State	Flashing red	"More Status" is set	F	Auto NOTE 8
		Bit 5-7: Not used	No impact	No impact	No Impact		N.A.
6	Extended Field Device Status	See chapter 7.2					
7	Device Operating Mode	See HCF_SPEC-183, Table 14: Operating Mode Codes. Bit0 – 7: Not used					
8	Standardized Status 0	See HCF_SPEC-183, Table 29: Standardized Status 0 Bit0: Device Variable Simulation Active Bit4: Not used Bit5: Not used Bit7: Device Configuration Locked or Write Protected	No impact	No impact	No Impact		N.A.
		Bit1: Non Volatile Memory Defect (any NVM error) Bit2: Volatile Memory Defect (any RAM error) Bit3: Watchdog Reset Executed (from byte#3, bit#6) Bit6: Electronic Defect (any device error)	Safe State	Lights red	"Mal-function" is set	F	Re-power
9	Standardized Status 1	See HCF_SPEC-183, Table 30: Standardized Status 1	No impact	No impact	No Impact		N.A.

	Status 1	Bit0: Status Simulation Active Bit1-2: Not supported Bit3-7: Not used				
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Figure 20: Parameters for command 48

- NOTE 1:** Some errors with “Safe State” can automatically clear this state again, see column “To Reset”:
 “Auto”: Analog output is fixed < 3.6 mA, Namur NE43 HW jumper setting is not used.
 Device clears automatically Safe State and resumes operation if problem ceases.
 “Repower”: Analog output is controlled by Namur NE43 HW jumper (< 3.6 mA or > 21.0 mA):
 Device must be repowered to clear error.
 See description of jumpers in 4.3.2.
- NOTE 2:** Sensor errors are only detected if Sensor Error detection for broken- or shorted sensor errors are enabled.
- NOTE 3:** A detected sensor error will only force the analog output value to the sensor error value if the failing input (Input 1 or Input 2) is directly, or indirectly (e.g. as Average or Difference), mapped to PV (and analog output).
- NOTE 4:** “Configuration not supported by device” is set if configuration parameters are conflicting.
 Safe State is cleared automatically as soon as a HART or Modbus command removes the conflict.
- NOTE 5:** “Minimum supply voltage not reached” is always set after power on and is cleared automatically when internal supply voltage “Vdigital” gets inside valid range. Once cleared, this state is never set again.
- NOTE 6:** “Attempting or failed to enter SIL mode” indicates that SIL mode is not yet active, either because device is still evaluating configuration or because evaluation has failed because a password or a configuration parameter still need to be entered.
 Safe State is cleared automatically, either when device finally enters SIL mode or when user decides to go back to normal mode.
- NOTE 7:** Internal supply voltages “Vshunt” and “Vdigital” are measured and range checked with regular intervals and device enters permanent Safe State if any of these are outside range.
 Voltages may be outside range due to internal circuit errors, however, low voltage also may be caused by a low external loop supply voltage.
- NOTE 8:** “Drift Error” indicates that an internal voltage measurement has failed range check. Internal ground, sensor or reference voltages are checked with regular intervals for safety, however a check may in rare cases also fail if a sensor input is connected incorrectly.
 Safe State is cleared automatically when correct connection is made and range check is OK.

8. Universal Commands

Universal commands are implemented according to HCF_SPEC-127.

HART commands using Device Variable as parameters accept DV 0 – DV 15 unless otherwise noted.

Cmd #	Description	Comments
0	Read Unique Identifier	-
1	Read Primary Variable	-
2	Read Loop Current And Percent Of Range	-
3	Read Dynamic Variables And Loop Current	The number of response bytes is always 24: - Loop current - Primary value (PV) - Secondary value (SV) - Tertiary value (TV) - Quaternary value (QV)
6	Write Polling Address	-
7	Read Loop Configuration	-
8	Read Dynamic Variable Classifications	-
9	Read Device Variables with Status	The device supports up to 8 DVs in command 9. If more than 8 DVs are requested, 8 DVs and response code 30 (Response Truncated) are returned.
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	-

9. Common-Practice Commands

9.1 Supported Commands

The following common practice commands are supported by the device, refer to HCF_SPEC-151 for more details.

HART commands using Device Variable as parameters accept values DV0 to DV15 unless otherwise noted.

Cmd #	Description	Comments
33	Read Device Variables	-
34	Write Primary Variable Damping Value	Valid range is [0.0 – 60.0] Value = 0.0: No damping. Value > 0.0: Damping enabled.
35	Write Primary Variable Range Value	Valid range for unit code is [1..169, 220...240]
36	Set Primary Variable Upper Range Value	-
37	Set Primary Variable Lower Range Value	-
40	Enter/Exit Fixed Primary Variable Current Mode	-
42	Perform Device Reset	-
43	Set Primary Variable Zero	-
44	Write Primary Variable Units	Valid range for unit code is [1..169, 220...240]
45	Trim Loop Current Zero	-
46	Trim Loop Current Gain	-
49	Write Primary Variable Transducer Serial Number	-
50	Read Dynamic Variable Assignments	-
51	Write Dynamic Variable Assignments	-
52	Set Device Variable Zero	Applicable only for DV 0 - 1.
53	Write Device Variable Units	Valid range for unit code is [1..169, 220...240]
54	Read Device Variable Information	-
55	Write Device Variable Damping Value	Valid range is [0.0 – 60.0] Value = 0.0: No damping. Value > 0.0: Damping enabled.
56	Write Device Variable Transducer Serial No.	-Applicable only for DV 0 - 3
59	Write Number Of Response Preambles	-
71	Lock Device	-
76	Read Lock Device State	-
78	Read Aggregated Commands	The device only supports aggregation of read commands and command 40 and 42.
79	Write Device Variable	Valid range for unit code is [1..169, 220...240]
80	Read Device Variable Trim points	Applicable only for DV 0 - 1
81	Read Device Variable Trim Guidelines	Applicable only for DV 0 - 1
82	Write Device Variable Trim points	Applicable only for DV 0 - 1 Valid range for unit code is [1..169, 220...240]
83	Reset Device Variable Trim points	Applicable only for DV 0 - 1
89	Set Real-Time Clock	The device has no battery backed-up real-time circuit, the timestamp set using command 89 and returned in commands 9, 90 and 93 will be reset to 00:00 January 1st 1900 after a device reset.

90	Read Real-Time Clock	See comment for command 89.
91	Read Trend Configuration	Device has one trend configuration, number 0.
92	Write Trend Configuration	See comment for command 91.
93	Read Trend	The trend buffer holds 12 values. See comment for commands 89 and 91.
95	Read Device Communications Statistics	-
103	Write Burst Period	Valid range for Burst Message is [0 - 2]
104	Write Burst Trigger	Valid range for Burst Message is [0 - 2] Valid range for unit code is [1..169, 220..240]
105	Read Burst Mode Configuration	Valid range for Burst Message is [0 - 2].
106	Flush Delayed Responses	-
107	Write Burst Device Variables	Valid range for Burst Message is [0 - 2].
108	Write Burst Mode Command Number	Valid range for Burst Message is [0 - 2].
109	Burst Mode Control	Valid range for Burst Message is [0 - 2].
115	Read Event Notification Summary	Event Spec. No. must have value "0".
116	Write Event Notification Bit Mask	Event Spec. No. must have value "0".
117	Write Event Notification Timing	Event Spec. No. must have value "0".
118	Event Notification Control	Event Spec. No. must have value "0".
119	Acknowledge Event Notification	Event Spec. No. must have value "0".
526	Write Status Simulation Mode	-
527	Simulate Status Bit	-

Figure 21: Common Practice Commands

The following temperature device family specific commands are supported by the device, refer to HCF_SPEC-160.4 for more details.

Cmd #	Description	Comments
1024	Read Temperature Status	Applicable for DV 0 - 15
1025	Read Temperature Configuration	Applicable only for DV 0 - 1
1026	Read Thermocouple Configuration	Applicable only for DV 0 - 1
1027	Read Callendar-Van Dusen Coefficients	Applicable only for DV 0 - 1
1028	Read Custom RTD Resistance	Applicable only for DV 0 - 1 PtX/NiX: $10 \leq x \leq 10.000$ Cux: $5 \leq x \leq 1.000$
1152	Write Temperature Probe Type	Applicable only for DV 0 - 1
1155	Select Cold Junction Compensation Type	Applicable only for DV 0 - 1
1156	Write Manual Cold Junction Temperature	Applicable only for DV 0 - 1
1157	Write Temperature Callendar Van Dusen Coefficients	Applicable only for DV 0 - 1
1159	Write Custom RTD Resistance	See command 1028

Table 22: Temperature Device Family Specific Commands

The following Temperature Probe Types are supported by the device, refer to HCF_SPEC-160.4 for more details.

Probe type#	Description
1	Ohms
2	kiloOhms
3	Calibrated RTD - Cal Van Dusen
4	Potentiometer
5-9	Not supported
10	RTD Pt x - IEC751, $10 \leq x \leq 10.000$ ^{NOTE1}
11	RTD Pt 50 - IEC751
12	RTD Pt 100 - IEC751
13	RTD Pt 200 - IEC751
14	RTD Pt 500 - IEC751
15	RTD Pt 1000 - IEC751
16-19	Not supported
20	RTD Pt x - JIS C1604-81, $10 \leq x \leq 10.000$ ^{NOTE1}
21	RTD Pt 50 - JIS C1604-81 ($R_{100}/R_0 = 1.3916$)
22	RTD Pt 100 - JIS C1604-81 ($R_{100}/R_0 = 1.3916$)
23	RTD Pt 200 - JIS C1604-81 ($R_{100}/R_0 = 1.3916$)
24-69	Not supported
70	RTD Ni x - DIN43760, $10 \leq x \leq 10.000$ ^{NOTE1}
71	RTD Ni 50 - DIN 43760
72	RTD Ni 100 - DIN 43760
73	RTD Ni 120 - DIN 43760
74	RTD Ni 1000 - DIN 43760
75-79	Not supported
80	RTD Cu x - ECW No. 15, $5 \leq x \leq 1.000$ ^{NOTE1}
81	RTD Cu 10 - ECW No. 15 ($\alpha = 0.00427$)
82	RTD Cu 100 - ECW No. 15 ($\alpha = 0.00427$)
83-102	Not supported
103	RTD Cu 50 - GOST 6651-1994 ($\alpha = 0.00426$)
104	RTD Cu 50 - GOST 6651-2009 ($\alpha = 0.00428$)
105	RTD Cu 100 - GOST 6651-2009 ($\alpha = 0.00428$)
106	RTD Pt 50 - GOST 6651-2009 ($\alpha = 0.00391$)
107	RTD Pt 100 - GOST 6651-2009 ($\alpha = 0.00391$)
108	RTD Cu 100 - GOST 6651-1994 ($\alpha = 0.00426$)
109	RTD Cu x - GOST 6651-1994 ($\alpha = 0.00426$) ^{NOTE1}
110	RTD Ni x - GOST 6651-2009 ($\alpha = 0.00617$) ^{NOTE1}
111	RTD Ni 50 - GOST 6651-2009 ($\alpha = 0.00617$)
112	RTD Ni 100 - GOST 6651-2009 ($\alpha = 0.00617$)
113-127	Not supported
128	Micro-Volts bipolar
129	Milli-Volts bipolar
130	Volts bipolar
131	TC Type B - IEC 584
132	TC Type W5 - ASTM E 988
133	TC Type W3 - ASTM E 988
134	TC Type E - IEC 584
135	Not supported
136	TC Type J - IEC 584
137	TC Type K - IEC 584
138	TC Type N - IEC 584
139	TC Type R - IEC 584
140	TC Type S - IEC 584
141	TC Type T - IEC 584
142	TC Type L - DIN 43710
143	TC Type U - DIN 43710
144-147	Not supported
148	TC Type Lr - GOST 3044-84
149-159	Not supported
160	RTD Cu x - GOST 6651-2009 ($\alpha = 0.00428$) ^{NOTE1}

161-179	Not supported	
180	RTD Pt x – GOST 6691-2009 ($\alpha = 0.00391$)	NOTE1
181-237	Not supported	
238	Custom Linearization	(CUSTOM SPECIFIC)
239	Micro-Volts unipolar	(CUSTOM SPECIFIC)
240	Milli-Volts unipolar	(CUSTOM SPECIFIC)
241	Volts unipolar	(CUSTOM SPECIFIC)
242-250	Not supported	
251	None	
	NOTE1: The x value corresponds to the custom RTD resistance value. See command 1028/1159	

Table 23: *Probe Types Supported in command #1152*

9.2 Burst Mode

The following HART commands can be send in burst frames:

Cmd #	Description	Comments
1	Read Primary Variable	-
2	Read Loop Current And Percent Of Range	-
3	Read Dynamic Variables And Loop Current	-
9	Read Device Variable With Status	The device supports up to 8 DVs in command 9.
33	Read Device Variables	-
48	Read Additional Device Status	-
119	Acknowledge Event Notification	-

Table 24: *Commands that can be send in burst frames*

The device supports configuration of maximum 3 burst messages.

9.3 Catch Device Variable

This device does not support Catch Device Variable.

10. Device-Specific Commands

The following device specific HART commands are implemented.

Cmd #	Description
142	Read Cable Resistance
143	Write Cable Resistance
144	Read Special Polynomial
145	Write Special Polynomial
146	Read Current Output Range Values
147	Write Current Output Range Values
148	Read Device Serial Number
150	Read Sensor Error Values
151	Write Sensor Error Values
152	Write Protection Control
154	Reset DAC Trim
155	Read DV Measurement Range Value
156	Write DV Measurement Range Value
157	Read Device Variable Max-Min
158	Read Range Check Configuration
159	Write Range Check Configuration
160	Read Mains Noise Filter
161	Write Mains Noise Filter
165	Read Sensor Drift Monitor
166	Write Sensor Drift Monitor
167	Read runtime meter
168	Read runtime thresholds
169	Read runtime Min/Max
170	Read CvD Linearization Parameters
171	Write CvD Linearization Parameters
172	Read Config Reserved State
173	Read SIL information
174	Read cable resistance
175	Read Modbus Settings
176	Write Modbus Settings
179	Reset to Factory Default Configuration
180	Read External CJC settings
181	Write External CJC settings
182	Read Device Variant

183	Read Write Protect Status
184	Read non-linearized values for input 1 and 2
190	Read Extension Device Status
191	Read Extension Device Parameters
192	Write Extension Device Parameters
193	Read Non-volatile Extension Device Parameters
194	Write Non-volatile Extension Device Parameters
195	Generate Safety Configuration Report
196	Read Safety Configuration Report
197	Validate Safety Configuration Report CRC

Table 25: *Device specific commands*

10.1 Command 142 Read Entered Cable Resistance

Reads the cable resistance for 2-wire RTD/Linear Resistance and 3-wire potentiometer measurement configuration.

This value is the total resistance in the two wires connecting the sensor to the device.

Example:

If the Pt100 sensor is connected to the device using two wires, each with the resistance 5 Ohm, the cable resistance must be configured to 10 Ohm.

The “entered” cable resistance is a value the user has determined using calculation or using measuring equipment, the value is configured using HART command 143.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (only DV0 and DV1 supported)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1 – 4	Float	Entered Cable Resistance value [Ohm]

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection (Cable Resistance Config Code)
3 – 4		Undefined
5	Error	Too Few Data Bytes Received
6 – 127		Undefined

10.2 Command 143 Write Entered Cable Resistance

Write entered total cable resistance for 2-wire RTD/Linear Resistance and 3-wire potentiometer measurement configuration.

This value is the total resistance in the two wires connecting the sensor to the device.

Example:

If the Pt100 sensor is connected to the device using two wires, each with the resistance 5 Ohm, the cable resistance must be configured to 10 Ohm.

The entered cable resistance may be a calculated value or a value measured using other equipment such as an Ohm-meter.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (only DV0 and DV1 supported)
1 – 4	Float	Entered Cable Resistance value [Ohm]

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1 – 4	Float	Entered Cable Resistance value [Ohm]

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection (Device Variable Code)
3 – 4		Undefined
5	Error	Too Few Data Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8		Undefined
9	Error	Resistance Value Outside Valid Range
10 – 15		Undefined
16	Error	Access Restricted
17 – 127		Undefined

10.3 Command 144 Read Custom Linearization

Cust. Lin. Data Code: Controls which part of polynomial to read, refer to Table 30:

Custom linearization Data Code

Cust. Lin. Data: Polynomial coefficients, table linearization points and other data. Up to 40 data bytes, depends on the value of Custom Linearization Data Code. If less than 40 data bytes are used the message is truncated.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Custom Linearization Data Code
1	Unsigned-8	Device Variable Code (only DV0 and DV1 supported)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Custom Linearization Data Code
1	Unsigned-8	Device Variable Code
2 – 41	Unsigned-8	Custom Linearization Data

Command-Specific Response Codes

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

10.4 Command 145 Write Custom Linearization Data

Cust. Lin. Data Code: Controls which part of polynomial to write, refer to Table 30:
Custom linearization Data Code

Cust. Lin. Data: Polynomial coefficients, table linearization points and other data. Up to 40 data bytes, depends on the value of Custom Linearization Data Code. If less than 40 data bytes are used the message is truncated.

Note:

Configuration parameters for Table, Spline and Polynomial Linearization share the same memory locations. I.e. configuration parameters for Custom Linearization Data Code 0-16 will overwrite parameters written for Code 19-23 and vice versa.

A custom linearization needs to fulfill some basic requirements:

- The linearization needs to be monotonic (that is always increasing or always decreasing)
- For Thermocouple custom linearization of type spline CJC compensation is not supported
- For Thermocouple custom linearization CJC compensation is only supported if the Y range covers the CJC range

There is no internal validity check of a custom linearization and the user is encouraged to make a test to ensure that the functionality is as expected.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Custom Linearization Data Code
1	Unsigned-8	Device Variable Code (only DV0 and DV1 supported)
2 – 41	Unsigned-8	Custom Linearization Data

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Custom Linearization Data Code
1	Unsigned-8	Device Variable Code
2 – 41	Unsigned-8	Custom Linearization Data

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

10.5 Command 146 Read Current Output Range Values

Reads the loop current output range values.

The Current Output 0% Range Value is allowed to be higher than Current Output 100% Range Value, enabling the device to be operated with a reversed output. The output limit values however cannot be reversed, since Current Output Lower Limit always reflects the physical lowest saturation level and the Current Output Upper Limit always reflects the physical highest saturation level.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0 – 3	Float	Current Output at 100%, Upper Range Value (URV) The output current corresponding to PV upper range value.
4 – 7	Float	Current Output at 0%, Lower Range Value (LRV) The output current corresponding to PV lower range.
8 – 11	Float	Current Output Upper Limit (UL) The level where the output current will saturate in the positive direction.
12 – 15	Float	Current Output Lower Limit (LL) The level where the output current will saturate in the negative direction.

Command-Specific Response Codes

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

10.6 Command 147 Write Current Output Range Values

Writes the loop current output range values, see command 146 for details.

Request Data Bytes

Byte	Format	Description
0 – 3	Float	Current Output at 100%, Upper Range Value (URV) The output current corresponding to PV upper range value. Range: 3.5 – 23.0 mA
4 – 7	Float	Current Output at 0%, Lower Range Value (LRV) The output current corresponding to PV lower range. Range: 3.5 – 23.0 mA
8 – 11	Float	Current Output Upper Limit (UL) The level where the output current will saturate in the positive direction. Range: 3.5 – 23.0 mA
12 – 15	Float	Current Output Lower Limit (LL) The level where the output current will saturate in the negative direction. Range: 3.5 – 23.0 mA

Response Data Bytes

Byte	Format	Description
0 – 3	Float	Current Output at 100%, Upper Range Value (URV) The output current corresponding to PV upper range value.
4 – 7	Float	Current Output at 0%, Lower Range Value (LRV) The output current corresponding to PV lower range.
8 – 11	Float	Current Output Upper Limit (UL) The level where the output current will saturate in the positive direction.
12 – 15	Float	Current Output Lower Limit (LL) The level where the output current will saturate in the negative direction.

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	Error	Upper Limit higher than maximum allowed value (UL > maximum)
9	Error	Lower Limit lower than minimum allowed value (LL < minimum)
10	Error	Upper Limit lower than Lower Limit (UL < LL)
11	Error	Upper Range Value higher than Upper Limit (URV > UL)
12	Error	Lower Range Value higher than Upper Limit (LRV > UL)
13	Error	Upper Range Value lower than Lower Limit (URV < LL)

14	Error	Lower Range Value lower than Lower Limit (LRV < LL)
15		Undefined
16	Error	Access Restricted
17 – 127		Undefined

10.7 Command 148 Read Device Serial number

Reads the serial number stored in the device.

This is the complete serial number as printed on the housing.

The buffer format for a PR serial numbers with N digits is:

- Most significant digit is stored in byte 0 and least significant digit in byte N-1.
- Unused bytes N through 23 are padded with space characters, hex value 0x20.

Example:

Serial number 131612345 is stored as:

ASCII: [131612345]

HEX: [0x31, 0x33, 0x31, 0x36, 0x31, 0x32, 0x33, 0x34, 0x35, 0x20, 0x20, . . . , 0x20]

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0 – 23	Latin-1	Device Serial number.

Command-Specific Response Codes

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

10.8 Command 150 Read Sensor Error Values

Reads the loop current values that will be applied to the analog loop when sensor errors are detected. Possible sensor errors are “broken sensor” and “short-circuited sensor”, the Sensor Error Config Code indicates which sensor errors the device, should test for.

See Table 27: *Sensor Error Config Code*.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Error Config Code
1 – 4	Float	Current output for short-circuited sensor
5 – 8	Float	Current output for broken sensor

Command-Specific Response Codes

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

10.9 Command 151 Write Sensor Error Values

Writes the loop current values that will be applied to the analog loop when sensor errors are detected. Possible sensor errors are “broken sensor” and “short-circuited sensor”, the Sensor Error Config Code indicates which sensor errors the device, should test for.

See Table 27: *Sensor Error Config Code*.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Error Config Code
1 – 4	Float	Current output for short-circuited sensor Range: 3.5 – 23.0 mA
5 – 8	Float	Current output for broken sensor Range: 3.5 – 23.0 mA

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Error Config Code
1 – 4	Float	Current output for short-circuited sensor
5 – 8	Float	Current output for broken sensor

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 – 4		Undefined
5	Error	Too Few Data Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8		Undefined
9	Error	Shorted Sensor Value Too High
10	Error	Shorted Sensor Value Too Low
11	Error	Broken Sensor Value Too High
12	Error	Broken Sensor Value Too Low
13 – 15		Undefined
16	Error	Access Restricted
17 – 127		Undefined

10.10 Command 152 Write Protection Control

This command has several functions; the parameter Write Protection Control Code indicates the function to execute:

1. Enable or disable write protection and/or change the password.
2. Switch HART protocol
3. Enable SIL mode

10.10.1 Write protection

All data bytes are transmitted in request and response.

In all cases, the Active Password in byte[1..8] shall be verified before the command is executed, response code 1 (Incorrect Password) is returned if verification fails.

The Default Active Password when the device, leaves the manufacturer is '*****', this value can be changed by the user.

The Universal Active Password "00002008" shall always be accepted, this value cannot be changed. The Universal Active Password shall only be used when the Active Password has been lost and needs to be reset to a known value.

When changing the password, use only Latin-1-characters that can be entered and displayed on any terminal.

10.10.2 Switch HART protocol

The switching of the HART Major Protocol Revision, between HART 5 and HART 7, is activated by this command.

- 1.) Switching from HART 5 to HART 7:
 - a. Write protect the device and set the New Password to "HARTREV7"
 - b. Write enable the device using the Active Password "-CHANGE-"
- 2.) Switching from HART 7 to HART 5:
 - a. Write protect the device and set the New Password to "HARTREV5"
 - b. Write enable the device using the Active Password "-CHANGE-"

After switching the protocol, the password will be reset to the Default Active Password ("*****") and the device will be reset and started in the updated mode, with write protection disabled.

After a switch from HART 7 to HART 5, the configuration will be set to the factory default configuration.

Note: The Configuration Changed Flags and Configuration Changed Counter are cleared by this command only after a switch from HART 7 to HART 5.

10.10.3 Enable / Disable SIL mode

If SIL is enabled i.e. the *SIL Enable Control Code* = 1, all safety related parameters must be configured as described in the safety manual (e.g. Write Protection shall be enabled, Polling Address shall be 0 etc.). If not, SIL will not be enabled and the command will respond with RC #12 – Invalid Mode Selection.

Note: The Configuration Changed Flags and Configuration Changed Counter are NOT updated by this command. See HCF_SPEC-99 chapter 5.1.2 for information on Latin-1 character set.

See Table 28: *Write Protection Control Code* and Table 34: *SIL Enable Control Code*.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Write Protection Control Code
1 – 8	Latin-1	Active Password
9 – 16	Latin-1	New Password (dummy value transmitted when not changing password)
17	Unsigned-8	SIL Enable Control Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Write Protection Control Code
1 – 8	Latin-1	Active password
9 – 16	Latin-1	New password (dummy value transmitted when not changing password)
17	Unsigned-8	SIL Enable Code

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1	Error	Incorrect Password
2 – 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error (Invalid character in new password)
7 – 8		Undefined
9	Error	Switching to this protocol version not allowed for this device.
10 – 11		Undefined
12	Error	Invalid Mode Selection
13 – 15		Undefined
16		Access Restricted
17 – 127		Undefined

10.11 Command 154 Reset DAC Trim

The loop current trim configured using common practice commands 45 and 46 is reset back to factory default.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
None		

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 – 6		Undefined
7	Error	In Write Protect Mode
8 – 17		Undefined
16		Access Restricted
17 – 127		Undefined

10.12 Command 155 Read DV Measurement Limits

Read the Measurement Limits for the individual inputs, Input 1 or Input 2.

For temperature input types the unit of the values is the currently configured DV unit i.e. °C, °F etc.

For other input types, the unit of the values corresponds the selected Probe Type, e.g. for Probe Type 128: *Micro Volts bi-polar* the unit is μV , for Probe Type 2: *kiloOhms* the unit is kOhm etc.

Only exception is Probe Type 237: Potentiometer, where the unit is Ohm and the Limit value indicates the total potentiometer resistance.

The valid range depends on the transducer type. Refer to Product Data Sheet for details about supported transducer types.

If the signal from the applied sensor is exceeding these limits and the input limit check is enabled, the analog output current will be set to the value *Input Limits Error Value*. See Command 158.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (only DV0, and DV1 supported)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (only DV0, and DV1 supported)
1 – 4	Float	DV Upper Measurement Limit Value
5-8	Float	DV Lower Measurement Limit Value

Command-Specific Response Codes

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

10.13 Command 156 Write DV Measurement Limits

Writes the Measurement Limits for the individual inputs.

For more information, see Command 155 Read DV Measurement Limits.

Dependent on the wanted measurement (PV assignment) the limits should be set to support the configured PV Range.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (only DV0, and DV1 supported)
1 – 4	Float	DV Upper Measurement Limit Value
5-8	Float	DV Lower Measurement Limit Value

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (only DV0, and DV1 supported)
1 – 4	Float	DV Upper Measurement Limit Value
5-8	Float	DV Lower Measurement Limit Value

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

10.14 Command 157 Read/Reset Device Variable Max-Min

Read or reset the minimum and maximum values the Device Variable Value has had since the last time the Max-Min registers were reset.

See Table 29: *Max Min Control Code*.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Unsigned-8	Max-Min Control Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Unsigned-8	Max-Min Control Code
2 – 5	Float	Device Variable Max Value. Value in DV units
6 – 9	Float	Device Variable Min Value. Value in DV units

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 – 127		Undefined

10.15 Command 158 Read Limit Check Configuration

Reads the Limit Check configuration and the loop current values that will be applied to the analog output current when inputs (DV0 or DV1) is outside measurement limits, or if output signal is outside limits.

If Input Limit Check is enabled, and the Device Status bit “Primary Value Out Of Limits” (see 7.1) is set, this will be indicated as an error on the analog output current. This bit is set when an input mapped to PV exceeds either of the input limits configured in the DV Measurement Limits (see command # 155 and #156). The bit is also set if a input out of range is indirectly mapped to PV (e.g. Average or Difference).

If Output Limit Check is enabled, and the Device Status bit “Loop Current Saturated” (see 7.1) is set, this will be indicated as an error on the analog output current. This bit is set if the calculated analog output value exceeds either of the Current Output Lower Limit or Current Output Upper Limit (see command #146 and #147).

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Limit Check Configuration Value Input Limit Check Output Limit Check : Enabled: Enabled: 0: No No 1: Yes No 2: No Yes 3: Yes Yes 4-255: undefined
1 – 4	Float	Input Limit Error Value Current output if Input Limits Check is enabled and limits exceeded Range 3.5 to 23 mA
5 – 8	Float	Output Limit Error Value Current output if Output Limit Check is enabled and limits exceeded Range 3.5 to 23 mA

Command-Specific Response Codes

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

10.16 Command 159 Write Limit Check Configuration

See command 158 for details.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Limit Check Configuration Value Input Limit Check Output Limit Check : Enabled: Enabled: 0: No No 1: Yes No 2: No Yes 3: Yes Yes 4-255: undefined
1 – 4	Float	Input Limit Error Value Current output if Input Limit Check is enabled and limits exceeded Range 3.5 to 23 mA
5 – 8	Float	Output Limit Error Value Current output if Output Limit Check is enabled and limits exceeded Range 3.5 to 23 mA

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Limit Check Configuration Value Input Limit Check Output Limit Check : Enabled: Enabled: 0: No No 1: Yes No 2: No Yes 3: Yes Yes 4-255: undefined
1 – 4	Float	Input Limit Error Value
5 – 8	Float	Output Range Error Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection (Limit Check Configuration)
3 – 4		Undefined
5	Error	Too Few Data Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8		Undefined

9	Error	Input Limit Error Value Too High
10	Error	Input Limit Error Value Too Low
11	Error	Output Limit Error Value Too High
12	Error	Output Limit Error Value Too Low
13 – 15		Undefined
16	Error	Access Restricted
17 – 127		Undefined

10.17 Command 160 Read Mains Noise Filter

Reads the frequency for the mains noise suppression filter.

The filter suppresses the noise that originates from the mains AC supply and the filter must be configured to suppress either 50 Hz or 60 Hz, depending on what is used at the installation site. If the wrong frequency is selected for suppression it may cause unpredictable variations in the device analog output current and the DV values.

See Table 26: *Mains Noise Suppression Filter Code*

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Mains Noise Suppression Frequency Code

Command-Specific Response Codes

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

10.18 Command 161 Write Mains Noise Filter

Writes the frequency for the mains noise suppression filter.

The filter suppresses the noise that originates from the mains AC supply and the filter must be configured to suppress either 50 Hz or 60 Hz, depending on what is used at the installation site. If the wrong frequency is selected for suppression it may cause unpredictable variations in the device analog output current and DV values.

See Table 26: *Mains Noise Suppression Filter Code*

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Mains Noise Suppression Frequency Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Mains Noise Suppression Frequency Code

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection (Mains Noise Suppression Frequency Code)
3 – 4		Undefined
5	Error	Too Few Data Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8 – 15		Undefined
16	Error	Access Restricted
17 – 127		Undefined

10.19 Command 165 Read Sensor Drift Monitor

Read configuration for sensor drift monitor.

During dual input operation the process values measured by Input 1 and Input 2 are compared regularly and if the absolute value of the difference $|\text{Input 1} - \text{Input 2}|$ exceeds a configured limit for a configured time period, an alarm is raised.

If the difference $|\text{Input 1} - \text{Input 2}|$ is lower than the same limit, the alarm is cleared and the timer is reset.

The Sensor drift monitor function can be configured independently from and at the same time as the dual input functions.

Sensor drift monitor controls a status bit in command 48.

Sensor drift monitor may be configured to control the analog output loop current.

See Table 31: ***Sensor Drift Config Code***.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Drift Config Code.
1 – 4	Float	Sensor Drift Limit. If $ \text{Input 1} - \text{Input 2} $ exceeds this limit an alarm is raised. Range: > 0.0
5 – 8	Unsigned-32	Sensor Drift Timeout in seconds. Alarm is raised when limit is exceeded permanently for this period. Range: 0 - 86400 sec (~24 hours)
9 – 12	Float	Analog output for Sensor Drift Alarm Range: 3.5 – 23.0 mA

Command-Specific Response Codes

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

10.20 Command 166 Write Sensor Drift Monitor

Configure sensor drift monitor.

See 10.19 for more details.

See Table 31: *Sensor Drift Config Code*.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Drift Config Code.
1 – 4	Float	Sensor Drift Limit. Alarm is raised if $ \text{Input1} - \text{Input2} $ exceeds this limit. Range: > 0.0
5 – 8	Unsigned-32	Sensor Drift Timeout in seconds. Alarm is raised when limit is exceeded permanently for this period. Range: 0 - 86400 sec (~24 hours)
9 – 12	Float	Analog output for Sensor Drift Alarm Range: 3.5 – 23.0 mA

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Sensor Drift Config Code.
1 – 4	Float	Sensor Drift Limit. Alarm is raised if $ \text{Input1} - \text{Input2} $ exceeds this limit. Range: > 0.0
5 – 8	Unsigned-32	Sensor Drift Timeout in seconds. Alarm is raised when limit is exceeded permanently for this period. Range: 0 - 86400 sec (~24 hours)
9 – 12	Float	Analog output for Sensor Drift Alarm Range: 3.5 – 23.0 mA

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection (Sensor Drift Config Code)
3 – 4		Undefined
5	Error	Too Few Data Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8	Error	Illegal value for Sensor Drift Alarm.
9	Error	Illegal value for Sensor Drift Limit
10	Error	Illegal value for Sensor Drift Timeout
11 – 15		Undefined

16	Error	Access Restricted
17 – 127		Undefined

10.21 Command 167 Read Runtime Meter

Reads one of the runtime meters.

The runtime meters serve as a recording mechanism in the device for monitoring operating hours of the transmitter electronics and the connected sensors. The operating time of the transmitter electronics, and its connected sensors are each recorded using 9 distinct ambient temperature intervals, forming a histogram of operating time at each interval.

The operating time is stored in NVM for every passing hour.

Only the operating time recorded for the connected sensors can be manually reset, or automatically by changing the input-type in the device configuration.

See Table 32: *Runtime Meter Code.* & Table 33: *Runtime Meter Control Code*

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Runtime Meter Code.
1	Unsigned-8	Meter Control Code.

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Runtime Meter Code.
1	Unsigned-8	Meter Control Code.
2 – 5	Unsigned-32	Meter value for range 1, in seconds
6 – 9	Unsigned-32	Meter value for range 2, in seconds
10 – 13	Unsigned-32	Meter value for range 3, in seconds
14 – 17	Unsigned-32	Meter value for range 4, in seconds
18 – 21	Unsigned-32	Meter value for range 5, in seconds
22 – 25	Unsigned-32	Meter value for range 6, in seconds
26 – 29	Unsigned-32	Meter value for range 7, in seconds
30 – 33	Unsigned-32	Meter value for range 8, in seconds
34 – 37	Unsigned-32	Meter value for range 9, in seconds

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 – 7		Undefined
8	Warning	Meter cannot be reset
9 – 127		Undefined

10.22 Command 168 Read Runtime Thresholds

Reads the used thresholds for one of runtime meters.

See Command 167 Read Runtime Meter.

See Table 32: *Runtime Meter Code*.

See HCF_SPEC-183 for definition of Unit Codes.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Runtime Meter Code.

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Runtime Meter Threshold Code.
1	Unsigned-8	Unit Code.
2 – 5	Float	Threshold for discriminating range 1 & 2
6 – 9	Float	Threshold for discriminating range 2 & 3
10 – 13	Float	Threshold for discriminating range 3 & 4
14 – 17	Float	Threshold for discriminating range 4 & 5
18 – 21	Float	Threshold for discriminating range 5 & 6
22 – 25	Float	Threshold for discriminating range 6 & 7
26 – 29	Float	Threshold for discriminating range 7 & 8
30 – 33	Float	Threshold for discriminating range 8 & 9

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 – 127		Undefined

10.23 Command 169 Read Runtime Min/Max

Reads the min/max measurement for selecting meter range, of one of the runtime meters.

See Command 167 Read Runtime Meter.

See Table 29: *Max Min Control Code* & Table 32: *Runtime Meter Code*.

See HCF_SPEC-183 for definition of Unit Codes.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Runtime Meter Code.
1	Unsigned-8	Max Min Control Code.

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Runtime Meter Code.
1	Unsigned-8	Max Min Control Code.
2	Unsigned-8	Unit Code
3 – 6	Float	Minimum value for selected runtime meter
7 – 10	Float	Maximum value for selected runtime meter

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 – 7		Undefined
8	Warning	Min Max Value Cannot Be Reset.
9 – 127		Undefined

10.24 Command 170 Read CvD Linearization Parameters

Read parameters for Callendar–van Dusen (CvD) Pt100 sensor linearization.

RTD Pt100 temperature measurements are normally done using a generic parameter set programmed into the field device. However, in order to improve accuracy, the properties for the specific sensor element in use may be programmed into the field device using the CvD parameter set.

CvD parameters may be entered using one of two alternative formats:

- R0, A, B, C coefficients.
- R0, α , β , δ (alpha, beta, delta) coefficients.

Both formats are equally valid and the field device converts internally between the two formats as needed. The parameter sets (R0, A, B, C) or (R0, α , β , δ) are usually obtained from the certificate delivered with the sensor element from the sensor element manufacturer.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code Determines the input: 0: DV 0 refers to Input 1. 1: DV 1 refers to Input 2.
1	Unsigned-8	CvD Control Code. Determines the parameter set used in this command: 0: R0, A, B, C 1: R0, α , β , δ (alpha, beta, delta).

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code Determines the input: 0: DV 0 refers to Input 1. 1: DV 1 refers to Input 2.
1	Unsigned-8	CvD Control Code. Determines the parameter set used in this command: 0: R0, A, B, C 1: R0, α , β , δ (alpha, beta, delta).
2 – 5	Float	R0, resistance at 0 °C.
6 – 9	Float	A or α
10 – 13	Float	B or β
14 – 17	Float	C or δ

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors

1		Undefined
2	Error	Invalid Selection (invalid DV code or CvD Control Code)
3 – 4		Undefined
5	Error	Too Few Data Bytes Received
6 – 127		Undefined

10.25 Command 171 Write CvD Linearization Parameters

Write parameters for Callendar–van Dusen (CvD) Pt100 sensor linearization.

CvD parameters may be entered using one of two alternative formats:

- R0, A, B, C coefficients.
- R0, α , β , δ (alpha, beta, delta) coefficients.

See command 170 Read CvD Linearization Parameters for more details.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code Determines the input: 0: DV 0 refers to Input 1. 1: DV 1 refers to Input 2.
1	Unsigned-8	CvD Control Code. Determines the parameter set used in this command: 0: R0, A, B, C 1: R0, α , β , δ (alpha, beta, delta).
2 – 5	Float	R0, resistance at 0 °C.
6 – 9	Float	A or α
10 – 13	Float	B or β
14 – 17	Float	C or δ

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code Determines the input: 0: DV 0 refers to Input 1. 1: DV 1 refers to Input 2.
1	Unsigned-8	CvD Control Code. Determines the parameter set used in this command: 0: R0, A, B, C 1: R0, α , β , δ (alpha, beta, delta).
2 – 5	Float	R0, resistance at 0 °C.
6 – 9	Float	A or α
10 – 13	Float	B or β
14 – 17	Float	C or δ

Command-Specific Response Codes

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

2	Error	Invalid Selection (invalid DV code or CvD control code)
3 – 4		Undefined
5	Error	Too Few Data Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8	Error	Invalid CvD parameter value (R0, A, B, C, alpha, beta or delta)
9 – 15		Undefined
16	Error	Access Restricted
17 – 127		Undefined

10.26 Command 172 Read Config Reserved State

Reads the “Config Reserved State”.

While the configuration is reserved by the Extension Interface, any HART write command will respond with RC#6: “Access Restricted”.

While processing HART write commands, the Config Reserved State will have the value 1, meaning that the configuration is reserved by the HART interface. This prevents the Extension Interface to gain write access to the configuration while downloading configurations using HART.

The configuration will be reserved by HART interface until 3 seconds after the last successful HART write command is received.

This functionality does not interfere with Lock or Write Protection, configured with HART command #71 and #152 respectively.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Config Reserved State Holds the current reservation status of the Configuration Data: 0: Configuration is not reserved 1: Configuration is reserved by the HART interface 2: Configuration is reserved by the Extension Interface

Command-Specific Response Codes

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

10.27 Command 173 Read SIL Information

Read parameters for valid SIL mode verification.

Consult the Safety Manual for detailed information on validating SIL configuration.

See HCF_SPEC-99 chapter 5.1.2 for information on Latin-1 character set.

See Table 34: *SIL Enable Control Code*.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	SIL Enable Control Code
1-2	Unsigned-16	Reserved
3-6	Latin-1	Configuration Status Result of configuration check by SIL rated SW: "FAIL": No valid configuration has been received "OPEN": Actual configuration is NOT locked (non-SIL) "LOCK": Actual configuration is locked (SIL validated) "INIT": Initial status when load/check is in progress

NOTE: The string value of Configuration Status shall be shown unchanged to the operator/user. The described string values forms 32 bit security codes and may therefore not exist in any non-SIL SW parts, e.g. DD's, DTM's etc.

Command-Specific Response Codes

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

10.28 Command 174 Read Cable Resistance

Read the resistance in the wires connecting the device with a RTD/Ohm sensor.

Cable resistance may be due to long cables or corrosion in connectors and is automatically compensated for by the device in order to determine the correct sensor resistance.

Values returned by this command are valid for these input types:

- Linear resistance.
- RTD sensor.
- Potentiometer.
- TC sensor, cable resistance in connection to an external RTD sensor used for CJC.

The value 0.0 Ohm is returned if cable resistance compensation is not enabled for an input.

A constant resistance value is returned for 2 wire measurements.

2 wire measurement:

Resistances in 1st and 2nd wire are not measured but are constant values that are measured and configured by the user.

3 wire measurement:

Resistance in 1st wire is measured using 3rd wire. Resistance in 2nd wire cannot be measured and is therefore replaced by an extra measurement of the resistance in the 1st wire.

4 wire measurement:

Resistance in 1st and 2nd wire is measured using 3rd and 4th wire.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0 – 3	Float	Input 1 or external CJC sensor, resistance in 1st wire [Ohm]
4 – 7	Float	Input 1 or external CJC sensor, resistance in 2nd wire [Ohm]
8 – 11	Float	Input 2, resistance in 1st wire [Ohm]
12 – 15	Float	Input 2, resistance in 2nd wire [Ohm]

Command-Specific Response Codes

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

10.29 Command 175 Read Modbus Settings

Read the configuration of the Modbus settings for the Extension Port communication.

To facilitate different equipment/host systems that complies to the Modbus standard it is possible to configure the detailed setting of baud-rate, parity, number of stop-bits etc. since the Modbus standard does not dictate these.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Enable Modbus communication control code. (0 = No,1 = Yes) If disabled, the device ignores all frames sent from a Modbus master and the only way to re-enable Modbus communication is by HART.
1	Unsigned-8	Modbus Baud-rate control code. The baud value used for Modbus communication. See Table 35: <i>Modbus Baud-rate Control Code</i>
2	Unsigned-8	Reserved
3	Unsigned-8	Modbus Parity control code. Configures parity check on Modbus frames. (0 = No parity check, 1 = Check for EVEN parity, 2 = Check for ODD parity)
4	Unsigned-8	Number of Stop-bits. Configures the number of stop-bits in Modbus frames. Range: 1..2
5	Unsigned-8	Modbus address. Configures the Modbus address. Range: 1..247 (Address 0 is broadcast address)
6 – 7	Unsigned-16	Modbus Response Delay. Configures minimum delay for Modbus response in ms. Range: 0..1000

Command-Specific Response Codes

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

10.30 Command 176 Write Modbus Settings

Write the configuration of the Modbus settings for the Extension Port communication.

See command 175 for more details on the parameters.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Enable Modbus communication control code. (0 = No,1 = Yes)
1	Unsigned-8	Modbus Baud-rate control code. See Table 35: Modbus Baud-rate Control Code
2	Unsigned-8	Reserved
3	Unsigned-8	Modbus Parity control code. (0 = None, 1 = EVEN, 2 = ODD)
4	Unsigned-8	Number of Stop-bits. Range: 1..2
5	Unsigned-8	Modbus address. Range: 1..247 (Address 0 is broadcast address)
6 – 7	Unsigned-16	Modbus Response Delay. Configures minimum delay for Modbus response in ms. Range: 0..1000 ms.

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Enable Modbus communication control code. (0 = No,1 = Yes)
1	Unsigned-8	Modbus Baud-rate control code. See Table 35: Modbus Baud-rate Control Code
2	Unsigned-8	Reserved
3	Unsigned-8	Modbus Parity control code. (0 = None, 1 = EVEN, 2 = ODD)
4	Unsigned-8	Number of Stop-bits. Range: 1..2
5	Unsigned-8	Modbus address. Range: 1..247 (Address 0 is broadcast address)
6 – 7	Unsigned-16	Modbus Response Delay. Configures minimum delay for Modbus response in ms. Range: 0..1000 ms.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection (Invalid Modbus address)
3 – 4		Undefined
5	Error	Too Few Data Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8		Undefined
9	Error	Invalid Enable Modbus control code
10	Error	Invalid baud-rate control code

11	Error	Invalid parity control code
12	Error	Invalid number of Stop-bits.
13	Error	Modbus Response delay too high
14- 15		Undefined
16	Error	Access Restricted
17 - 127		Undefined

10.31 Command 179 Reset to Factory Default Configuration

The configuration is overwritten with a predetermined configuration, loaded at production time.

NOTE: If the device was delivered with a specifically ordered configuration, this will be overwritten!

When the loading is done, the device will automatically reset.

The execution of this command may take a relatively long period of time to complete, and the device will not respond to subsequent commands until the reset is complete.

Parameter "Configuration Reset Code" must have value 1, all other values are reserved for future use.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Configuration Reset Code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Configuration Reset Code

Command-Specific Response Codes

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

10.32 Command 180 Read External CJC Settings

Reads the configuration of the external CJC sensor.

See Table 36: *External CJC sensor Code*

The Cable Resistance value is the total resistance in the two wires connecting the external CJC sensor to the device. Since only one external CJC sensor can be connected, this is common for both Input 1 and Input 2 if any/both are configured to TC with external CJC.

Request Data Bytes

Byte	Format	Description
none		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	External CJC sensor Code
1	Unsigned-8	Number of wires for the external CJC sensor
2-5	float	Cable Resistance for the external CJC sensor [Ohm]

Command-Specific Response Codes

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

10.33 Command 181 Write External CJC Settings

Writes the configuration of the external CJC sensor

See 10.32 Command 180 Read External CJC Settings for details.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	External CJC sensor Code
1	Unsigned-8	Number of wires for the external CJC sensor
2-5	float	Cable Resistance for the external CJC sensor [Ohm]

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	External CJC sensor Code
1	Unsigned-8	Number of wires for the external CJC sensor
2-5	float	Cable Resistance for the external CJC sensor [Ohm]

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection (Invalid External CJC sensor Code)
3 – 4		Undefined
5	Error	Too Few Data Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8		Undefined
9	Error	Resistance Value Outside Valid Range
10	Error	Invalid number of wires
11– 15		Undefined
16	Error	Access Restricted
17 – 127		Undefined

10.34 Command 182 Read Device Variant

Read the device variant name and features/capability supported.

Request Data Bytes

Byte	Format	Description
none		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Number of Inputs, 0 = 1 Input; 2 = 2 Inputs)
1	Unsigned-8	Input Variant Code. See Table 37: <i>Input Variants Code</i>
2	Unsigned-8	SIL Supported, 0 = No, 1 = Yes
3	Unsigned-8	Puck Variant Code. See Table 39: <i>Puck Variants Code</i>
4	Unsigned-8	Communication Variants Code. See Table 40: <i>Communication Variants Code</i>
5 – 28	Latin-1	Device Type Name.
29	Unsigned-8	CJC Variant Code See Table 38: <i>CJC Variants Code</i>

Command-Specific Response Codes

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

10.35 Command 183 Read Write Protect status

Reads if write protection from HW (jumper) or SW (password) is active, see Common Table 7, Write Protect Codes.

The write protection status, and thereby the Write Protect Code responded in command #15, is a logical OR of the SW Write Protect Status and HW Write Protect Status, see 12.10.

Request Data Bytes

Byte	Format	Description
none		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	SW Write Protect Status, (password): 0= Not Write Protected, 1 = Write Protected
1	Unsigned-8	HW Write Protect Status: 0= Not Write Protected, 1 = Write Protected

Command-Specific Response Codes

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

10.36 Command 184 Read non-linearized values for Input 1 and 2

Read the non-linearized values for Input 1 and 2.

This table shows the content of these values

Probe type	Unit	Additional description
Ohm, kOhm	Ω	
Potmeter	%	
μ V and μ V Bipolar	μ V	
mV and mV Bipolar	μ V	
V and V Bipolar	μ V	
RTD (Ptx, Cux, Nix)	Ω	
TC	μ V	The CJC compensated voltage
Callender Van Dusen	Ω	
Custom linearization	Depending on custom input type μ V, Ω or %	

The values can be seen as raw values, they are not trimmed and lacks the damping and some filtering that is used for the device variables.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0 – 3	Float	Input 1 non-linearized value (unit see above)
4 – 7	Float	Input 2 non-linearized value (unit see above)

Command-Specific Response Codes

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

10.37 Command 190 Read Extension Device Status

Read the status of the device attached to the Extension Port.

The Extension Device Available indicates if there is any compatible device currently attached to the Extension Port within the last 2 seconds.

The Extension Device Id indicates the ID of the device attached.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Extension Device Available, 0 = No, 1 = Yes
1-2	Unsigned-16	Extension Device Id

Command-Specific Response Codes

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

10.38 Command 191 Read Extension Device Parameters

Read parameters for the device attached to the Extension Port.

The Extension Device ID must be checked and the corresponding description of the Extension Device parameters must be used to determine the content of the parameters.

If the Offset + Number of bytes exceed 64, the Response Code 2, Invalid Selection, will be returned.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Offset. First byte in parameter set to read
1	Unsigned-8	Number of Bytes to read from parameter set

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Offset. First byte in parameter set to read.
1	Unsigned-8	Number of Bytes read from parameter set
2	Unsigned-8	Extension Device Available, 0 = No, 1 = Yes
3-4	Unsigned-16	Extension Device Id
5-n	Unsigned-8	Parameter set - bytes (0-63)

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 – 127		Undefined

10.39 Command 192 Write Extension Device Parameters

Write parameters for the device attached to the Extension Port.

The device parameters must correspond to the description of the Extension Device parameters content for the actual Extension Device Id.

If the Offset + Number of bytes exceed 64, the Response Code 2, Invalid Selection, will be returned.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Offset. First byte in parameter set to write
1	Unsigned-8	Number of Bytes to write to parameter set
4-n	Unsigned-8	Parameter set - bytes (0-63)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Offset. First byte in parameter set written.
1	Unsigned-8	Number of Bytes written to parameter set
4-n	Unsigned-8	Parameter set - bytes (0-63)

Command-Specific Response Codes

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

10.40 Command 193 Read Non-volatile Extension Device Parameters

Read the parameters Non-volatile stored for the device attached to the Extension Port.

The Extension Device ID must be checked and the corresponding description of the Extension Device parameters must be used to determine the content of the data.

If the Offset + Number of bytes exceed 64, the Response Code 2, Invalid Selection, will be returned.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Offset. First byte in parameter set to read
1	Unsigned-8	Number of Bytes to read from parameter set

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Offset. First byte in parameter set to read.
1	Unsigned-8	Number of Bytes read from parameter set
2-3	Unsigned-16	Extension Device ID (for the stored parameter set)
4-n	Unsigned-8	parameter set bytes (0-63)

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 – 127		Undefined

10.41 Command 194 Write Non-volatile Extension Device parameters

Write Non-volatile stored parameters for the device attached to the Extension Port.

The Extension Device ID must correspond to the description of the Extension Device parameters content.

If the Offset + Number of bytes exceed 64, the Response Code 2, Invalid Selection, will be returned.

Request Data Bytes

Byte	Format	Description
------	--------	-------------

0	Unsigned-8	Offset. First byte in parameter set to write
1	Unsigned-8	Number of Bytes to write to parameter set
2-3	Unsigned-16	Extension Device Id
4-n	Unsigned-8	Parameter set - bytes (0-63)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Offset. First byte in parameter set written.
1	Unsigned-8	Number of Bytes written to parameter set
2-3	Unsigned-16	Extension Device Id
4-n	Unsigned-8	Parameter set - bytes (0-63)

Command-Specific Response Codes

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

10.42 Command 195 Generate Safety Configuration Report

The device will start the generation of a report showing all Safety Related Configuration Parameters and their value using a "human readable" ASCII text (ISO-Latin1) format. Consult the Safety Manual for detailed information on validating SIL configuration.

Request Data Bytes

Byte	Format	Description
none		

Response Data Bytes

Byte	Format	Description
------	--------	-------------

none

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
5	Error	Too Few Data Bytes Received
6 - 7		Undefined
8	Warning	e.g. Report generation has already been started but not finished yet
9 – 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 – 127		Undefined

10.43 Command 196 Read Safety Configuration Report

This command is used to readout the safety relevant configuration parameters using a “human readable” format (ISO-Latin1). A maximum of 123 characters can be read in one command 196 request. Due to the fact, that not all parameter can be transmitted at once, the request parameter includes an index to identify the current parameter set.

Master Operation:

The master starts with parameter index = 0 and keeps incrementing the index until all characters has been read.

All received characters can be displayed to the user, as either a full text report or one (scrolling) line at a time. Each set of parameter and value are separated using “\n”, or new line, characters (ASCII #0x0A), e.g.:

```
01 InputType 1: Pt100IEC\n
03 NumWires 1: 3\n
..
..
42 LowLim 1: -200.000 degC\n
43 UpLim 1: 850.000 degC\n
..
```

Consult the Safety Manual for detailed information on validating SIL configuration.

Request Data Bytes

Byte	Format	Description
0 - 1	Unsigned-16	Start-index (first character in Configuration Report)
2 - 3	Unsigned-16	Length (number of bytes to read in Configuration Report), maximum 123

Response Data Bytes

Byte	Format	Description
0 - 1	Unsigned-16	Start-index (first character read in Configuration Report)
2 - 3	Unsigned-16	Length (number of bytes read in Configuration Report)
4 - 5	Unsigned-16	Number of total bytes in Configuration Report (ASCII String)
6 – (length+6)	ISO LATIN	Safety parameter set

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection (invalid Start-index or Number of bytes)
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6 - 8		Undefined
9	Error	Configuration Report generation in progress (Wait until finished)
10	Error	No valid Configuration Report (Generate Safety Configuration Report was not executed)
11 – 127		Undefined

10.44 Command 197 Validate Safety Configuration Report

If the CRC is not correct, or if there is not a valid SIL configuration, SIL mode will not be activated. The Configuration Status must be read to verify if SIL mode is activated.

The command will respond with RC #9 – Device is not in proper mode, if SIL Enable Control Code is not set to SIL operation mode.

Consult the Safety Manual for detailed information on validating SIL configuration.

Request Data Bytes

Byte	Format	Description
0 - 1	Unsigned-16	CRC16 value of Configuration Report (ASCII)

Response Data Bytes

Byte	Format	Description
0 - 1	Unsigned-16	CRC16 value of Configuration Report (ASCII)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1 - 4		Undefined
5	Error	Too Few Data Bytes Received
6 - 8		Undefined
9	Error	Device is not in proper mode. (Sil operation mode is not enabled)
10 - 127		Undefined

11. Tables

11.1 Mains Noise Suppression Filter Code Table

Main Noise Suppr. Filter Code	Description
0	50 Hz noise is suppressed
1	60 Hz noise is suppressed

Table 26: *Mains Noise Suppression Filter Code*

11.2 Sensor Error Config Code Table

Sensor Error Config Code	Description
0	No test is performed
1	Test for broken sensor
2	Test for short circuited sensor
3	Test for broken sensor and for short circuited sensor
4 – 255	Undefined

Table 27: *Sensor Error Config Code*

11.3 Write Protection Control Code Table

Write Protection Control Code	Description
0	Enable write protection
1	Disable write protection
2	Set new Password and... Enable write protection
3	Set new Password and... Disable write protection
4 – 255	Undefined

Table 28: *Write Protection Control Code*

11.4 Max Min Control Code Table

Max Min Control Code	Description
0	Reset max/min registers
1	Do not reset max/min registers
2 – 255	Undefined

Table 29: Max Min Control Code

11.5 Custom Linearization Data Code Table

Special polynomial code	Format	Description
0	5 Float	Polynomial 1 coefficients
1	5 Float	Polynomial 2 coefficients
2	5 Float	Polynomial 3 coefficients
3	5 Float	Polynomial 4 coefficients
4	5 Float	Polynomial 5 coefficients
5	1 Float	Maximum limit for polynomial 1 (Ohm / μ V / % /)
6	1 Float	Maximum limit for polynomial 2 (Ohm / μ V)
7	1 Float	Maximum limit for polynomial 3 (Ohm / μ V)
8	1 Float	Maximum limit for polynomial 4 (Ohm / μ V)
9	1 Float	Maximum limit for polynomial 5 (Ohm / μ V)
10	1 Float	Minimum limit for total polynomial (Ohm / μ V)
11	1 Float	Minimum limit for total polynomial (PV units)
12	1 Float	Maximum limit for total polynomial (PV units)
13	1 Float	Minimum span (PV units)
14	4 Float	Polynomial for CJC, only valid for TC (byte 2:5= a_3 , byte 6:9= $a_2, ..a_1, .. A_0$) Note: This dataset is used only when configuring TC measurements.
15	-	Undefined
16	1 byte	Number of polynomials
17	3 bytes	Sensor Serial Number
18	1 byte	PV unit code
19	8 floats	Linearization Table XY Points 1-4 in the order X1, Y1, X2, Y2, X3, Y3, X4, Y4.
20	8 floats	Linearization Table XY Points 5-8 ordered as for XY Points 1-4.
21	8 floats	Linearization Table XY Points 9-12 ordered as for XY Points 1-4.

22	8 floats	Linearization Table XY Points 13-16 ordered as for XY Points 1-4.
23	8 floats	Linearization Table XY Points 17-20 ordered as for XY Points 1-4.
24	8 floats	Linearization Table XY Points 21-24 ordered as for XY Points 1-4.
25	8 floats	Linearization Table XY Points 25-28 ordered as for XY Points 1-4.
26	8 floats	Linearization Table XY Points 29-32 ordered as for XY Points 1-4.
27	8 floats	Linearization Table XY Points 33-36 ordered as for XY Points 1-4.
28	8 floats	Linearization Table XY Points 37-40 ordered as for XY Points 1-4.
29	8 floats	Linearization Table XY Points 41-44 ordered as for XY Points 1-4.
30	8 floats	Linearization Table XY Points 45-48 ordered as for XY Points 1-4.
31	8 floats	Linearization Table XY Points 49-52 ordered as for XY Points 1-4.
32	8 floats	Linearization Table XY Points 53-56 ordered as for XY Points 1-4.
33	8 floats	Linearization Table XY Points 54-60 ordered as for XY Points 1-4.
34	1 byte	Number of active Linearization XY Points (2..60)
35	1 byte	Linearization Type 0: Polynomial Linearization (Polynomial Coefficients are used) 1: Table Linearization (XY Points are used) 2: SPLINE linearization (Y Points are used)
36	1 byte	Input Type 0: Resistance, with input (X-values) in Ω 1: Voltage Bipolar, with input (X-values) in μV 2: Voltage Unipolar, with input (X-values) in μV 3: Potentiometer, with input (X-values) in gg 4: Current Bipolar, with input (X-values) in μA , reserved for future use 5: Current Unipolar, with input (X-values) in μA , reserved for future use 6: Thermo-couple, with input (X-values) in μV (CJC range applies)
37	1 float	Minimum input limit for SPLINE linearization (Ohm / μV / % /)
38	1 float	Maximum input limit for SPLINE linearization (Ohm / μV / % /)
39	8 floats	SPLINE Table Y points 1-8 in the order Y1, Y2, Y3, Y4, Y5, Y6, Y7, Y8
40	8 floats	SPLINE Table Y points 9-16 in the ordered as for Y points 1-8
41	8 floats	SPLINE Table Y points 17-24 in the ordered as for Y points 1-8
42	8 floats	SPLINE Table Y points 25-32 in the ordered as for Y points 1-8
43	8 floats	SPLINE Table Y points 33-40 in the ordered as for Y points 1-8
44-53	-	Undefined
54	1 byte	Number of active SPLINE Y points (3..40)
55 – 255	-	Undefined

Table 30: Custom linearization Data Code

11.6 Sensor Drift Config Code

Sensor Drift Config Code	Description
0	Sensor Drift Monitor is disabled.
1	WARNING

	All device variables are updated as usual. Analog output loop current is updated as usual. Display indicates Sensor Drift Alarm. HART status bit indicates Sensor Drift Alarm
2	ERROR As for WARNING except: Analog output is forced to the configured level.
3 – 255	Undefined

Table 31: Sensor Drift Config Code

11.7 Runtime Meter Code

Runtime Meter Code	Description
0	Electronics Runtime Meter
1	Input 1 Runtime Meter
2	Input 2 Runtime Meter
3 – 255	Undefined

Table 32: Runtime Meter Code

11.8 Runtime Meter Control Code

Runtime Meter Code	Description
0	Reset Runtime Meter
1	Do Not Reset Runtime Meter
2 – 255	Undefined

Table 33: Runtime Meter Control Code

11.9 SIL Enable Control Code Table

SIL Enable Control Code	Description
0	Normal operation mode (no SIL restrictions applies)
1	SIL operation mode. All restrictions described in Safety Manual applies
2 – 255	Undefined

Table 34: SIL Enable Control Code

11.10 Modbus Baud-rate Control Code Table

Modbus Baud-rate Control Code	Description
0	2400 baud
1	4800 baud
2	9600 baud
3	19200 baud
4	38400 baud

5	57600 baud
6	115200 baud
7 – 255	Undefined

Table 35: *Modbus Baud-rate Control Code*

11.11 External CJC sensor Code Table

External CJC sensor Code	Description
0	Pt100 sensor (IEC751)
1	Ni100 sensor (DIN43760)
2 – 255	Undefined

Table 36: *External CJC sensor Code*

11.12 Input Variants Code Table

Input Variants Code (Values can be bitwise OR'ed)	Description
0x01, Bit 0	TC capability (the device can measure Thermo-Couple sensors)
0x02, Bit 1	RTD capability (the device can measure RTD sensors)
0x04, Bit 2	Voltage capability (the device can measure Linear Voltage)
0x08, Bit 3	Potentiometer capability (the device can measure Potentiometers)
0x10, Bit 4	Current Capability (the device can measure Linear Current)
0x20, Bit 5	LinR Capability (the device can measure Linear Resistance)
0xC0, Bit 6-7	Reserved for future use (always 0)

Table 37: *Input Variants Code*

11.13 CJC Variants Code Table

CJC Variants Code (Values can be bitwise OR'ed)	Description
0x01, Bit 0	Internal CJC capability (Thermo-Couple sensors can use the internal CJC sensor)
0x02, Bit 1	External CJC capability (Thermo-Couple sensors can use an externally connected CJC sensor)
0xFC, Bit 2-7	Reserved for future use (always 0)

Table 38: *CJC Variants Code*

11.14 Puck Variants Code Table

Puck Variants Code (Values can be bitwise OR'ed)	Description
0x01, Bit 0	Board mounted CJC Sensor. This is used when one or two 5437 "pucks" are mounted on a motherboard inside a 6437 DIN rail housing.
0x02, Bit 1	Board mounted Current Shunt

0x04, Bit 2	Additional Board Resistance
0xF8, Bit 3-7	Reserved for future use (always 0)

Table 39: *Puck Variants Code*

11.15 Communication Variants Code Table

Communication Variants Code (Values can be bitwise OR'ed)	Description
0x01, Bit 0	HART5 communication possible
0x02, Bit 1	HART7 communication possible
0x04, Bit 2	PROFibus PA communication possible
0xF8, Bit 3-7	Reserved for future use (always 0)

Table 40: *Communication Variants Code*

12. Performance

12.1 Sampling Rates

The input sample update intervals depends on the measurement mode configured for Input 1 and Input 2:

Measurement mode	Update interval [msec]						
	DV 0	DV 1	DV 2	DV 3	DV 4 - DV 14	DV 15	Analog output
Single input: Input 1: RTD, Lin. Resistance or Voltage	100	-	-	-	-	100	10
Single input: Input 1: TC	100	-	100	-	-	100	10
Single input: Input 1: Potentiometer	100	-	-	-	-	100	10
Dual inputs: Input 1 and Input 2: RTD, Lin. Resistance or Voltage	100	100	-	-	100	100	10
Dual inputs: Input 1 and Input 2: TC	100	100	100	100	100	100	10
Dual inputs: Input 1: TC Input 2: RTD	100	100	100	-	100	100	10
Dual inputs: Input 1 and Input 2: Potentiometer	100	100	-	-	100	100	10

Table 41: Input Sample Intervals

The loop current is updated every 10 msec.

12.2 Power-Up

At power-on, the loop current is initialized to 3.5 mA while the input A/D circuit is configured according to the previously saved configuration. After approx. 2.75 seconds, the loop current will change to a value determined by the process or, if an error has been detected, to a fixed value depending on error type and user configuration.

12.3 Reset

Command 42 ("Device Reset") causes the device to reset its microprocessor.

Command 179, or a change from HART7 to HART5 using command 152, will reset the configuration to the default configuration (stored during production), and then reset the device. The resulting restart is identical to the normal power up sequence.

12.4 Self Test

The device does not implement HART command 41 "Perform Self Test".

The device executes permanently self test procedures in the background without affecting measurements or HART communication. If any problem is detected, the Device Status bits "Device Malfunction" and "More Status Available" are set and will be returned to the host in the next HART command response.

The command 48 response indicates the error that has been detected, see chapter 7.5 "Additional Device Status" for details about the errors that can be detected.

12.5 Command Response Times

Minimum	0 msec
Typical	5 msec
Maximum	60 msec

12.6 Busy and Delayed-Response

Response code "Busy" is never returned from the device.

"Delayed Response" is not supported by the device.

12.7 Long Messages

The longest response is a response to cmd 196 "Read Safety Configuration Report". This response can be 131 bytes including response code, device status and 129 data bytes.

12.8 Non-Volatile Memory

The device has two locations for storage of non-volatile data:

1024 bytes in FLASH memory are reserved for data initialized at the factory, such as calibration parameters and serial number. This data cannot be changed after the device has left the factory.

2048 bytes in EEPROM memory are reserved for storage of configuration data and runtime meters, this data is updated each time the user changes configuration using HART commands.

Both FLASH and EEPROM memory sections are protected by a 16 bit CRC checksum. The CRC is validated with regular interval and the Device Status will indicate if an error is detected. See chapter 12.4 "Self Test" for more details.

12.9 Modes

12.9.1 Output simulation mode

Fixed current mode is implemented using command 40. This mode is cleared by power loss or reset.

12.9.2 Input simulation mode

Device variable values and status can be set to fixed values using command 79. This mode is cleared by power loss or reset.

12.9.3 SIL mode

The device can operate in SIL mode. When operating in SIL mode certain configuration and operating restrictions are applied. Mandatory procedures for entering and exiting SIL mode must also be followed strictly. See the PR 5437/6437 Safety Manual for more information.

The following HART commands and the related interactions with the user, supports the procedures specified in the PR 5437/6437 Safety Manual.

Entering SIL mode/Validating all safety related Parameters:

When "Enter SIL mode" is requested by the user:

1. Prompt the user to accept: "Device will enter SIL mode - has all relevant parameters been configured correctly according to the required safety application?"
2. Prompt user for existing password (default "*****") and prompt for a new password
3. Send command #152 with the passwords, "Enable write protection" and the "SIL operation mode" code
4. Reset the device by issuing HART command #42
5. Clear any previously requested Safety Report (screen, buffers etc.)
6. Request the Safety Configuration Report by issuing HART command #195
7. Read the Safety Configuration Report, or a part of it, by issuing HART command #196
8. Show the report as received, or a part of it, to the user and prompt the validation of the report ("Accept" or "Cancel")
9. Repeat step 7 and 8 until all parameters has been shown and accepted, or until the user has canceled the operation (because of wrong parameter values)
10. If all the parameters have been accepted by the user, send command #197 with a CRC16 calculation of all characters in the entire Safety Configuration Report (including separation characters)

11. Send command #173 and show the responded SIL status (as received) to the user.
12. Prompt the user to accept the showed SIL Status.

Exiting SIL mode

When "Exit SIL mode" is requested by the user:

1. Prompt the user to accept: "Device will exit SIL mode?"
2. Prompt user for existing password (default "*****")
3. Send command #152 with the passwords and the "Normal operation mode" code
4. Send command #173 and show the responded SIL status (as received) to the user
5. Prompt the user to accept the showed SIL Status.

12.10 Write Protection

Write protection is provided and is activated in either of two ways:

12.10.1 By Software (password)

Write protection is controlled using the device specific command 152 "Write Protection Control". When write protection is enabled, no "write" commands are accepted regardless of the "Write Protect" Hardware Jumper position.

See description of HART command 152 for details about how to enable and disable write protection and how to change the password.

12.10.2 By Hardware (jumper)

If a hardware jumper is set in position "Write Protect" no, "write" commands are accepted regardless if disabled by software.

ANNEX A. CAPABILITY CHECKLIST

Manufacturer, model and revision	PR electronics, PR 5437, rev. 2 PR electronics, PR 6437, rev. 2
Device type	Transmitter
HART revision	7.6
Device Description available	Yes
Number and type of inputs	2 external resistance or voltage inputs: - RTD temperature sensor - Thermo couple temperature sensor - Linear voltage/resistance 1 external CJC temperature sensor: - RTD Pt100 IEC751 or Ni100 DIN43760 2 external potentiometer 1 internal sensor for CJC temperature
Number and type of actuators	0
Number and type of host side signals	1: 4 - 20 mA analog
Number of Device Variables	16
Number of Dynamic Variables	4
Mappable Dynamic Variables?	DV0 - 15 may be mapped to PV, SV, TV and QV using HART commands.
Number of common-practice commands	58
Number of device-specific commands	44
Bits of additional device status	45
Alternative operating modes?	No
Capture Device Variables	No
Trending	Yes
Burst mode	Yes

ANNEX B. DEFAULT CONFIGURATION

This is how the device is configured when it leaves the factory:

Parameter	Value
Measurement mode	Single input (Input 1) 3-wire RTD Pt100 temperature measurement
Device Variable Units	DV 0, DV15: °C.
Upper and Lower Range	Lower Range Value: 0.0 °C Upper Range Value : 150.0 °C Lower Input Limit: -20 °C Upper Input Limit: 170 °C
Device Variable Mapping	PV mapped to DV 0 (Input 1) SV mapped to DV 0 TV mapped to DV 0 QV mapped to DV 15 (Electronics Temperature)
Loop Current Trim	Loop Current Zero Offset: 0.0 Loop Current Gain: 1.0
Device Variable Damping	All device variables: 0.0 (Disabled)
Trending	Disabled
Burst mode	Disabled
Write protection	Disabled Password: "*****" (8 times asterisk)
Polling Address	0
Preambles in response	5
Sensor error detection	Detection of shorted sensor: Active Detection of broken sensor: Active Loop current if sensor shorted: 3.5 mA Loop current if sensor broken: 23.0 mA
Mains Noise Suppression	50 Hz is suppressed.
Modbus enabled	Enable
Modbus Baud-rate	115200
Modbus Parity check	EVEN
Modbus Stop-bits	1
Modbus Response Delay	0
Modbus Slave Address	1

Table 42: Factory default Configurations

ANNEX C. UNIT CODES

The device supports these unit codes:

Unit code value	Description
1 – 169, 220 – 239	<p>These values are defined in HCF_SPEC-183, Revision 24.0.</p> <p>DV unit codes are configured using HART command 53, Write Device Variable Units.</p> <p>Other HART write-commands, for example command 35 “Write Primary Variable Range Value”, may include a unit code. If this unit code is a temperature (Celsius, Fahrenheit, Rankine, Kelvin) then the temperature value will be converted accordingly before being saved in the device. If this unit code is not a temperature, no conversion is made.</p> <p>HART read-commands return always a value in the DV unit no matter the unit used when writing the value.</p>
240	micro Volts (Device specific value)

Table 43: *Unit codes*

ANNEX D. HART COMMAND RESPONSE CODES

General

HART Command	Response Code
All known commands	0 - Success
Unknown commands	64 - Command not implemented

Universal Commands

HART Command	Response Code
0	-
1	8 - Update failure
2	8 - Update failure
3	8 - Update failure
6	2 - Invalid selection 5 - Too few data bytes received 7 - In write protect mode 12 - Invalid mode selection 16 - Access restricted
7	-
8	-
9	2 - Invalid selection 5 - Too few data bytes received 8 - Update failure 30 - Command response truncated
11	-
12	-
13	-
14	-
15	-
16	-
17	5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted
18	5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted
19	5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted
20	-
21	-
22	5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted
38	5 - Too few data bytes received 9 - Configuration change counter mismatch 16 - Access restricted
48	5 - Too few data bytes received 14 - Status bytes mismatch

Common Practice Commands

HART Command	Response Code
31	5 - Too few data bytes received
(Extended commands)	20 - The extended command number was less than 512

33	<ul style="list-style-type: none"> 2 - Invalid selection 5 - Too few data bytes received 8 - Update failure
34	<ul style="list-style-type: none"> 3 - Passed parameter too large 4 - Passed parameter too small 5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted
35	<ul style="list-style-type: none"> 5 - Too few data bytes received 7 - In write protect mode 9 - Lower range value too high 10 - Lower range value too low 11 - Upper range value too high 12 - Upper range value too low 13 - Upper and lower values out of limits 14 - Span too small 16 - Access restricted 18 - Invalid units code 29 - Invalid Span
36	<ul style="list-style-type: none"> 7 - In write protect mode 9 - Applied process too high 10 - Applied process too low 14 - Span too small 16 - Access restricted 29 - Invalid Span
37	<ul style="list-style-type: none"> 7 - In write protect mode 9 - Applied process too high 10 - Applied process too low 14 - New lower range value pushed 16 - Access restricted
40	<ul style="list-style-type: none"> 3 - Passed parameter too large 4 - Passed parameter too small 5 - Too few data bytes received 7 - In write protect mode 11 - Loop current not active 16 - Access restricted
42	<ul style="list-style-type: none"> 16 - Access restricted
43	<ul style="list-style-type: none"> 7 - In write protect mode 9 - Applied process too high 10 - Applied process too low 16 - Access restricted
44	<ul style="list-style-type: none"> 2 - Invalid selection 5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted
45	<ul style="list-style-type: none"> 3 - Passed parameter too large 4 - Passed parameter too small 5 - Too few data bytes received 7 - In write protect mode 9 - Incorrect loop current mode or value 11 - Loop current not active 16 - Access restricted
46	<ul style="list-style-type: none"> 3 - Passed parameter too large 4 - Passed parameter too small 5 - Too few data bytes received 7 - In write protect mode 9 - Incorrect loop current mode or value 11 - Loop current not active 16 - Access restricted
49	<ul style="list-style-type: none"> 5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted

50	-
51	<ul style="list-style-type: none"> 2 - Invalid selection 5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted
52	<ul style="list-style-type: none"> 2 - Invalid selection 5 - Too few data bytes received 7 - In write protect mode 9 - Applied process too high 10 - Applied process too low 16 - Access restricted
53	<ul style="list-style-type: none"> 5 - Too few data bytes received 7 - In write protect mode 11 - Invalid device variable code 12 - Invalid units code 16 - Access restricted
54	<ul style="list-style-type: none"> 2 - Invalid selection 5 - Too few data bytes received
55	<ul style="list-style-type: none"> 2 - Invalid selection 3 - Passed parameter too large 4 - Passed parameter too small 5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted
56	<ul style="list-style-type: none"> 2 - Invalid selection 5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted
59	<ul style="list-style-type: none"> 3 - Passed parameter too large 4 - Passed parameter too small 5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted
71	<ul style="list-style-type: none"> 5 - Too few data bytes received 10 - Invalid lock code 11 - Cannot lock device 16 - Access restricted
76	-
78 (Aggregated commands)	<ul style="list-style-type: none"> 5 - Too few data bytes received 9 - Invalid command requested 30 - Command response truncated
79	<ul style="list-style-type: none"> 2 - Invalid selection 5 - Too few data bytes received 7 - In write protect mode 8 - Device family status bit not set 10 - Invalid write device variable code 16 - Access restricted 17 - Invalid device variable index 18 - Invalid units code 19 - Device variable not allowed for this command
80	<ul style="list-style-type: none"> 5 - Too few data bytes received 17 - Invalid device variable index 19 - Device variable not allowed for this command
81	<ul style="list-style-type: none"> 5 - Too few data bytes received 17 - Invalid device variable index 19 - Device variable not allowed for this command
82	<ul style="list-style-type: none"> 2 - Invalid selection 3 - Passed parameter too large 4 - Passed parameter too small 5 - Too few data bytes received 7 - In write protect mode 11 - Trim error

	<ul style="list-style-type: none"> 16 - Access restricted 17 - Invalid device variable index 18 - Invalid units code 19 - Device variable not allowed for this command
83	<ul style="list-style-type: none"> 5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted 17 - Invalid device variable index 19 - Device variable not allowed for this command
89	<ul style="list-style-type: none"> 2 - Invalid selection 3 - Passed parameter too large 5 - Too few data bytes received 7 - In write protect mode 9 - Invalid date code detected 16 - Access restricted
90	-
91	<ul style="list-style-type: none"> 5 - Too few data bytes received 11 - Invalid trend number
92	<ul style="list-style-type: none"> 2 - Invalid selection 3 - Passed parameter too large 4 - Passed parameter too small 5 - Too few data bytes received 7 - In write protect mode 11 - Invalid trend number 16 - Access restricted 17 - Invalid device variable index
93	<ul style="list-style-type: none"> 5 - Too few data bytes received 8 - Trend not active 11 - Invalid trend number
95	-
103	<ul style="list-style-type: none"> 5 - Too few data bytes received 7 - In write protect mode 8 - Update times adjusted 9 - Invalid burst message 16 - Access restricted
104	<ul style="list-style-type: none"> 3 - Passed parameter too large 4 - Passed parameter too small 5 - Too few data bytes received 7 - In write protect mode 9 - Invalid burst message 11 - Invalid device variable classification 12 - Invalid units code 13 - Invalid burst trigger mode selection code 16 - Access restricted
105	9 - Invalid burst message
106	16 - Access restricted
107	<ul style="list-style-type: none"> 2 - Invalid selection 5 - Too few data bytes received 7 - In write protect mode 8 - Burst condition conflict 9 - Invalid burst message 16 - Access restricted
108	<ul style="list-style-type: none"> 2 - Invalid selection 5 - Too few data bytes received 7 - In write protect mode 9 - Invalid burst message 16 - Access restricted
109	<ul style="list-style-type: none"> 2 - Invalid selection 5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted
115	2 - Invalid selection

	5 - Too few data bytes received
116	2 - Invalid selection 5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted
117	5 - Too few data bytes received 7 - In write protect mode 8 - Update periode or debounce interval adjusted 9 - Invalid burst message 16 - Access restricted
118	2 - Invalid selection 5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted
119	2 - Invalid selection 5 - Too few data bytes received 8 - Not all events cleared
526	2 - Invalid selection 5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted
527	2 - Invalid selection 5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted

Temperature Device Family Commands

HART Command	Response Code
1024	5 - Too few data bytes received 17 - Invalid device variable index
1025	5 - Too few data bytes received 17 - Invalid device variable index 19 - Device variable index not allowed for this command
1026	5 - Too few data bytes received 17 - Invalid device variable index 19 - Device variable index not allowed for this command
1027	5 - Too few data bytes received 17 - Invalid device variable index 19 - Device variable index not allowed for this command
1028	5 - Too few data bytes received 17 - Error Invalid Device Variable Index. The Device Variable does not exist in this field device. 19 - Error Device Variable index not allowed for this command
1152	2 - Invalid selection 5 - Too few data bytes received 7 - In write protect mode 9 - Unsupported probe type 10 - Invalid number of wires 16 - Access restricted 17 - Invalid device variable index 19 - Device variable index not allowed for this command
1155	5 - Too few data bytes received 7 - In write protect mode 9 - Invalid cold junction compensation code 16 - Access restricted 17 - Invalid device variable index 19 - Device variable index not allowed for this command
1156	5 - Too few data bytes received 7 - In write protect mode 9 - CJC temperature too high 10 - CJC temperature too low

	<ul style="list-style-type: none"> 16 - Access restricted 17 - Invalid device variable index 18 - Invalid units code 19 - Device variable index not allowed for this command
1157	<ul style="list-style-type: none"> 5 - Too few data bytes received 7 - In write protect mode 9 - Coefficient A invalid 10 - Coefficient B invalid 11 - Coefficient C invalid 12 - Coefficient R0 invalid 16 - Access restricted 17 - Invalid device variable index 18 - Invalid units code 19 - Device variable index not allowed for this command
1159	<ul style="list-style-type: none"> 3 - Passed parameter too large 4 - Passed parameter too small 5 - Too few data bytes received 7 - In write protect mode 16 - Access restricted 17 - Invalid device variable index. 19 - Device variable index not allowed for this command

Table 44: *Response codes*



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