HART® Field Device Specification:

DELTA CONTROLS CORPORATION

MODEL 173 REV 3.0

Document 00-17335, rev. B

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TABLE OF CONTENTS

1. INTRODUCTION

1.1 Scope

The Delta Controls Corporation Level Transmitter, model 173, revision 3 complies with HART Protocol Revision 7.06. This document specifies all the device specific features and documents HART Protocol implementation details (e.g., the Engineering Unit Codes supported). 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 (e.g., the *173 Installation Manual*) 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

ADC	Analog to Digital Converter
CPU	Central Processing Unit (of microprocessor)
DAC	Digital to Analog Converter
EEPROM	Electrically-Erasable Read-Only Memory

1.5 References

HART Smart Communications Protocol Specification. HCF_SPEC-12. Available from the HCF.

173 Installation Manual, Document 00-17303. Available from the Delta Controls Corporation.

2. DEVICE IDENTIFICATION

Manufacturer Name:	Delta Controls Corporation	**Model Name(s):**	173
Manufacture ID Code:	24842 (0x610A)	**Device Type Code:**	58439 (0xE447)
HART Protocol Revision	7.06	**Device Revision:**	3
Number of Device Variables	1		
Physical Layers Supported	FSK		
Physical Device Category	Transmitter, Non-DC-isolated Bus Device		

The 173 consists of an explosion-proof housing mounted on an extractable-under-pressure capacitance probe. The name plate is located on the housing cover and indicates the model name and revision.

3. PRODUCT OVERVIEW

The 173 is a simple two-wire loop-powered level transmitter with a 4-to-20mA output. Measurement is via probe capacitance

The 173 rev. 3 replaces the earlier rev. 2 model, providing improved HART communication capability.

The device measures probe capacitance over the maximum range of 0-2000pF and converts this to a level measurement.

4. PRODUCT INTERFACES

4.1 Process Interface

4.1.1 Sensor Input Channels

The device has two input channels labeled “Probe” and “Comp”. The Probe input measures the sum of the probe capacitance and any interconnecting cable between the probe and the electronics (if any). The Comp input is typically connected to an identical interconnecting cable. The device subtracts the capacitance measured on the Comp terminal from the capacitance measured on the Probe terminal, thus eliminating the interconnecting cable capacitance from the probe measurement. This is done to eliminate accuracy problems that could occur due to cable capacitance changes with temperature. When the electronics are mounted directly to the probe the short interconnecting wire that connects between the electronics and the probe has an insignificant capacitance, and thus the Comp terminal is left unused.

4.2 Host interface

4.2.1 Analog Output: Process Level

The two-wire 4-to-20mA current loop is connected on two terminals marked "Loop+" and "Loop-". Refer to the Installation Manual for connection details.

This is the only output from this transmitter, representing the level 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 number of 1.

A guaranteed linear over-range is provided. Device malfunction can be indicated by down-scale or up-scale current. The direction is selectable by the user; see Section 4.3 below. Current values are shown in the table below.

	Direction	Values (percent of range)	Values (mA or V)
Linear over-range	Down	-1.25%	3.8 mA
	Up	+105.0% ± 1.0%	20.5 mA
Device malfunction indication	Down: less than	-2.5%	3.6 mA
	Up: greater than	+106.25%	21.0 mA
Maximum current		+112.5%	22.0 mA
Multi-Drop current draw			4.0 mA
Lift-off voltage			12 V

4.3 Local Interfaces, Jumpers and Switches

4.3.1 Local Controls and Displays

The field device has a window providing visible access to an LCD display.

4.3.2 Internal Jumpers and Switches

Four pushbuttons are provided to set up operating parameters without connection to an external controller. Detailed information is provided in the 173 Operation Manual.

Variables

4.4 Device Variables

Variable	Meaning	Units	Unit Codes
DV0	PV	ft,m,in,cm,mm,%,undefined	44,45,47,48,49,57,240

4.5 Dynamic Variables

One Dynamic Variable is implemented.

	Meaning	**Units**
PV	Process Variable	ft,m,in,cm,mm,%,undefined

5. STATUS INFORMATION

5.1 Device Status

BIT	Name	Meaning
0	0 Primary Variable out of limits	Set if the Device Variable mapped to PV is out of transducer limits. Range setting by Command 35 does not affect these limits.
1	Non PV out of limits	Set if any of the Device Variables not mapped to PV is out of limits. This bit is formed by OR-ing all out-of-limit informations of DV 0 to 5 except the one mapped to PV.
2	Loop Current Saturated	Set if the analog output 1 (channel 0) current is out of the linear overrange Limits.
3	Loop Current Fixed	Set if analog output 1 (channel 0) current no longer tracks the PV value. Use of any of commands 6, 40, 66 or 79 may cause the current to be fixed.
4	More Status Available	Set whenever any irregularity is detected. Use of Command 48 will read additional details.
5	Cold Start	Set after initial power up and after execution of Command 42. Bit is cleared for each Master individually after recognition of the first command.
6	Configuration	Set when the Field Device configuration is modified. Each Master will

	Changed	clear this bit individually by use of Command 38.
7	Device Malfunction	Set if the Field Device's self-monitoring detected an abnormal condition of class Error. Warnings will not set this bit.

5.2 Extended Device Status

Bit	Name	Meaning
0	Maintenance Required	Device requires maintenance.
1	Device Variable Alert	Some device variable is in an alarm or warning state
2	unused	Bit not supported
3	Failure	Device variable invalid due to malfunction
4	Out of Spec	Condition detected that could affect accuracy (ie ambient temperature)
5	Function Check	Bit not supported
6	Unused	Undefined
7	Unused	Undefined

5.3 Additional Device Status (Command #48)

Command #48 returns 9 bytes of data, with the following status information:

Byte	Bit	Meaning	Class	Device Status Bits Set
0	DEVICE SPECIFIC STATUS			
	0	Probe Out of Limits	WARNING	4
	1	Comp Out of Limits	WARNING	4
	2	Internal Reference 1 Out of Limits	ERROR	4,7
	3	Internal Reference 2 Out of Limits	ERROR	4,7
	4	Temperature Out of Limits	WARNING	4
	5	Not Defined		
	6	Loop Fault Detected	WARNING	4
	7	Not Defined		
1,2,3,4,5	Not Defined			
6	EXENDED DEVICE STATUS			
	0	Device requires maintenance.	WARNING	4
	1	Some device variable is in an alarm or warning state	WARNING	4
	2	Bit not supported		
	3	Bit not supported	ERROR	4,7
	4	Bit not supported	WARNING	4
	5	Bit not supported		
	6,7	Not Defined		
7	Not supported			
8	STANDARD STATUS			
	0,1,2	Bit(s) not supported		
	3	Watchdog reset occurred	WARNING	4
	4,5,6,7	Bit(s) not supported		

"Not Defined" bits are always set to 0.

6. UNIVERSAL COMMANDS

Command #3 returns PV for a total of 9 bytes of response data).

Sensor serial number is Not Defined, and returns 0.

7. COMMON-PRACTICE COMMANDS

7.1 Supported Commands

The following common-practice commands are implemented:

33 Read Device Variables

34 Write Damping Value

35 Write Range Values

40 Enter/Exit Fixed Current Mode

42 Perform Master Reset

44 Write PV Units

45 Trim DAC Zero

46 Trim DAC Gain

48 Read Additional Device Status

54 Read Device Variable Information

59 Write Number of Response Preambles

72 Squawk (Causes Outline Rectangle on LCD for 2 seconds)

100 Write Primary Variable Alarm Code

103 Write Burst Period

104 Write Burst Trigger

105 Read Burst Mode Configuration

107 Write Burst Device Variables

108 Write Burst Mode Command Number

109 Burst Mode Control

7.2 Burst Mode

This Field Device supports three Burst Messages.

The following commands can be represented in a Burst Message:

1 Read Primary Variable

2 Read Loop Current and Percent Of Range

3 Read Dynamic Variables and Loop Current

9 Read Device Variables with Status

33 Read Device Variables

48 Read Additional Device Status

7.3 Catch Device Variable

This Field Device does not support Catch Device Variable.

8. DEVICE-SPECIFIC COMMANDS

The following device-specific commands are implemented:

128 Read Parameter

129 Write Parameter

130 Write Calibration Value

131 Write Calibration Table Entry

8.1 Command #128: READ PARAMETER

Read a device parameter value

Request Data Bytes

Byte	Format	Description
0	Enum	Parameter to read (see section 10.1)

Response Data Bytes

Byte	Format	Description	
0	Enum	Parameter to read	
1	Enum	Datatype (See bytes 3-6)	
2	Enum	Units	
3	Byte	Value	Datatype = 0
3-4	Int[2]	Value	Datatype = 2
3-6	Float	Value	Datatype = 3

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors

Code	Class	Description
2	Error	Invalid selection (of units)
5	Error	Too few data bytes

8.2 Command #129: WRITE PARAMETER

Request Data Bytes

Byte	Format	Description
0	Enum	Parameter to write (see section 10.1)
1	Byte	Byte value to write
1,2	Int	Integer value to write
1,2,3,4	Float	Float value to write

Response Data Bytes

Byte	Format	Description	
0	Enum	Parameter (see section 10.1)	
1	Enum	Datatype (See bytes 3-6)	
2	Enum	Units	
3	Byte	Value	Datatype = 0
3-4	Int[2]		Datatype = 2
3-6	Float		Datatype = 3

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
2	Error	Invalid selection (of units)
5	Error	Too few data bytes

8.3 Command #130: CALIBRATE TABLE VALUE

Calibrate by setting the process level to a known value. Write that value to a calibration point using command 130. Set the process level to a different known value (as far away from the first level as possible). Write that value to a different calibration point using command 130.

Calibration point to write must be less than or equal to the number of active calibration points.
Note: After writing, the device sorts the calibration table in order of level, so you should read all calibration points before calibrating the next point, in case the values were moved to another calibration point.

Request Data Bytes

Byte	Format	Description
0	Byte	Calibration Point to write
1-4	Float	PV to associate with current process level

Response Data Bytes

Byte	Format	Description
0	Byte	Calibration point to write
1-4	Float	PV to associate with current process level
5-8	Float	Net capacitance at current process level

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
2	Error	Invalid selection (of units)
5	Error	Too few data bytes

8.4 Command #131: WRITE CALIBRATION TABLE ENTRY

Use this command to update the calibration table offline.

Request Data Bytes

Byte	Format	Description
0	Byte	Calibration Point to write
1-4	Float	PV to associate with the Calibration Point
5-8	Float	Net Capacitance to associate with the Calibration Point

Response Data Bytes

Byte	Format	Description
0	Byte	Calibration point to write
1-4	Float	PV to associate with the Calibration Point
5-8	Float	Net Capacitance to associate with the Calibration Point

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
2	Error	Invalid selection (of units)
5	Error	Too few data bytes

9. TABLES

9.1 List of Device Parameters (see command 128 & 129)

Parameter	Description (See doc 00-17303 for more information)	Format
0	PV	Float
1	Loop mA	Float
2	Loop %	Float
3	Units	Enum
4	Lower Range Value	Float
5	Upper Range Value	Float
6	Number of Active Calibration Points	Byte
7	Calibration point #1 PV	Float
8	Calibration point #2 PV	Float
9	Calibration point #3 PV (inactive cal pts return NaN)	Float
10	Calibration point #4 PV	Float
11	Calibration point #5 PV	Float
12	Calibration point #6 PV	Float
13	Calibration point #7 PV	Float
14	Calibration point #8 PV	Float
15	Calibration point #9 PV	Float
16	Calibration point #10 PV	Float
18	Calibration point #1 pF	Float
19	Calibration point #2 pF	Float
20	Calibration point #3 pF	Float
21	Calibration point #4 pF	Float
22	Calibration point #5 pF	Float
23	Calibration point #6 pF	Float
24	Calibration point #7 pF	Float
25	Calibration point #8 pF	Float
26	Calibration point #9 pF	Float
27	Calibration point #10 pF	Float
28	Range – 0=2000pF; 1=600pF; 2=200pF	Enum
29	Damping Value (seconds)	Float
30	4mA trim value	Int
31	20mA trim value	Int
32	Alarm Action 0=drive high;1=drive low;2=hold;3=ignore	Enum
33	Polling Address	Byte

Parameter	Description (See doc 00-17303 for more information)	Format
34	Loop Control 0=normal;1=multidrop;2=manual	Enum
35	Probe raw value	Int
36	Comp raw value	Int
37	Internal Reference 1 raw value	Int
38	Internal Reference 2 raw value	Int
39	Probe Capacitance (pF)	Float
40	Comp Capacitance (pF)	Float
41	Net Capacitance (pF)	Float
42	Offset Cal	Float
43	Module Temperature (°C)	Float

10. PERFORMANCE

10.1 Sampling Rates

Typical sampling rates are shown in the following table.

Probe sample rate	3 per second
Comp sample rate	1 per second
Analog output update	3 per second

10.2 Power-Up

On power up, the transmitter goes through an initialization procedure, which takes approximately 2 seconds. During this period, the device will not respond to HART commands, and the analog output is set at 4.0mA.

Fixed-current mode is cancelled by power loss.

10.3 Reset

Command 42 ("Device Reset") causes the device to reset its microprocessor. The resulting restart is identical to the normal power up sequence.

10.4 Self-Test

Continuous self-testing is part of the normal device operation.

10.5 Command Response Times

Minimum	20ms
Typical	50ms
Maximum	100ms *

10.6 Busy and Delayed-Response

The transmitter does not respond with Delayed Response. Changing units (command 44) may cause subsequent commands to respond with BUSY for a few seconds.

10.7 Long Messages

The largest data field used is in the response to Command 9: 66 bytes including the two status bytes.

10.8 Non-Volatile Memory

EEPROM is used to hold the device's configuration parameters. New data is written to this memory immediately on execution of a write command.

10.9 Modes

Fixed current mode is implemented, using Command 40. This mode is cleared by power loss or reset. Another method to affect the loop current is Command 6 with Loop Current Mode parameter set to disabled. This mode setting is not affected by power cycle or reset but has to be changed by execution of Command 6 with Loop Current Mode parameter set to enabled.

10.10 Write Protection

This Field Device does not support write-protection. A hardware switch or jumper cannot be accessed during operation in explosion hazard areas.

10.11 Damping

The damping function has a first order low pass characteristic affecting only the PV and the loop current signal. The device accepts values from 0 to 60 seconds.

ANNEX A. CAPABILITY CHECKLIST

Manufacturer, model and revision	Delta Controls Corporation model 173 Rev 3
Device type	Transmitter
HART revision	7.06
Device Description available	Yes
Number and type of sensors	2 capacitance sensors
Number and type of actuators	0
Number and type of host side signals	1: 4 - 20mA analog
Number of Device Variables	1
Number of Dynamic Variables	1
Mappable Dynamic Variables?	No
Number of common-practice commands	20
Number of device-specific commands	4
Bits of additional device status	8
Alternative operating modes?	No
Burst mode?	Yes
Write-protection?	No

ANNEX B. DEFAULT CONFIGURATION

Parameter	Default value
Lower Range Value	0
Upper Range Value	100
PV Units	%
Damping time constant	4 second
Polling Address	0
Number of response preambles	5

ANNEX C. REVISION HISTORY

A1. Changes from Rev 2.0 to Rev 3.0

Support was added for HART 7.