HART® Field Device Specification:

3-Sci Ltd, Wi-Corr Bond Revision 1

Document 1, Rev' 1.2

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Author: Richard Caldwell
3-Sci Ltd
Fareham Innovation Centre
Fareham
Hampshire
SO240EE
UK

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1. INTRODUCTION

1.0 Scope

The 3-Sci Wi-Corr Ultrasonic Thickness gauge transmitter, model 1, revision 1 complies with HART Protocol Revision 7.0. 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.

1.1 Purpose

This specification is designed to compliment other Wi-Corr documentation available from 3-Sci by providing a complete, unambiguous description of this Field Device from a HART Communication perspective

1.2 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.

1.3 Abbreviations and definitions

EEPROM	Electrically-Erasable Read-Only Memory
Pt1000	1000-ohm Platinum (temperature sensor)
ROM	Read-Only Memory

1.4 References

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

INST-EX-006-Wi-Corr-Bond-Datasheet_Rev*x*.pdf

'(INST-S-005) Wi-Corr - Instructions for Installation and Use in Explosive atmospheres vx.y.pdf
INST-EX-006-Wi-Corr-Bond-Datasheet_Revx.pdf

(INST-NC-003) Wi-Corr Corrosion Transmitter User Manual_Rev1.8.pdf

2. DEVICE IDENTIFICATION

Manufacturer Name:	3-Sci Ltd	**Model Name(s):**	**Wi-Corr Bond**
Manufacture ID Code:	24858 (611A)hex	**Device Type Code:**	58455 E457 hex
HART Protocol Revision	7.0	**Device Revision:**	1
Number of Device Variables	16		
Physical Layers Supported	FSK, TDMA-Wireless Mesh		
Physical Device Category	Maintenance Port		

Wi-Corr Bond is a designed to mount on pipes or vessels with straps or banding. The name plate is located on the top and lower side of the unit and indicates the model name and revision.

3. PRODUCT OVERVIEW

Wi-Corr Trend is a battery powered, Wireless HART ultrasonic thickness and temperature transmitter, with an FSK Maintenance Port.

External thickness probe and/or a thermocouple temperature sensing element is/are required.

The Wi-Corr Bond is a sister product to Wi-Corr Clamp and Wi-Corr CUI devices.

Data monitoring may be performed using 3-Sci's Wi-Corr Trend Software suite.

Figure 1: Wi-Corr Unit

4. PRODUCT INTERFACES

4.0 Process Interface

4.0.1 Sensor Input Channels

Two physical sensor inputs are provided.

1: The Ultrasonic Sensor is fitted with a reverse polarity TNC connector, this should be carefully mated with the socket marked “ULTRASONIC SENSOR” and tightened moderately.

The measurements taken from this connector are linked to the HART Primary Variable of the device.

2: The Temperature Sensor socket is marked “TEMPERATURE SENSOR”. Insert the plug gently, aligning the connector key with the plug key before tightening the outer threaded plug.

The measurements taken from this connector are linked to the HART Secondary Variable of the device.

Refer to the Installation Manual for further detail.

An additional internal temperature sensor is included that performs simple environmental monitoring, this is reported as Device Variable 12.

4.1 Host interface

All communication with the host is performed via either the Maintenance Port or Wireless HART signalling. The Maintenance Port is only to be connected in a safe non explosive atmosphere, it is marked ‘**HART PORT’** Refer to the Installation Manual for connection details.

4.2 Local Interfaces, Jumpers And Switches

4.2.1 Local Controls And Displays

This device has no external local controls or displays.

4.2.2 Internal Jumpers And Switches

The only internal connection available to the user is the HART Maintenance Port. The programming connectors are for factory use only. Refer to the Installation Manual for details.

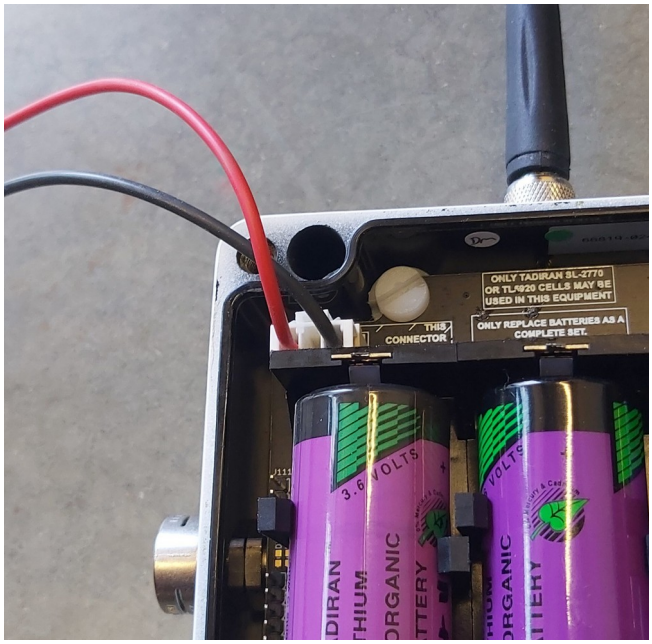

Figure 2: Maintenance Port connector location

5. DEVICE VARIABLES

This Field Device exposes 16 Device Variables.

5.0 Device Variable 0 System Verification Indicator

This has no units and is simply an indicator of whether the internal algorithms are confident of the supplied data.

A value of 1 indicates all is well with the data. A poor result may be caused by such things as poor probe bonding etc.

Further investigation of the other data is recommended if this equals zero.

5.1 Device Variable 1 Measurement Uncertainty

This value presents an estimate of the Uncertainty in the Primary Variable's value in mm.

5.2 Device Variable 2 Pipe Thickness

This is the calculated thickness of the metal to which the ultrasonic sensor is attached in mm.

It is the Primary Variable.

5.3 Device Variable 3 Pipe Temp

It is an indication of the temperature, in degrees C, of the metal to which the main ultrasonic sensor is attached.

It is the Secondary Variable.

5.4 Device Variable 4 AGC Value

It is an indication of the gain used in an internal amplifier used in the calculation of the Primary Variable.

5.5 Device Variable 5 AGC Tries

It is an indication of the performance of an internal amplifier used in the calculation of the Primary Variable.

5.6 Device Variable 6 Calculated Speed of Sound

This provides an estimate of the speed of sound in the attached metal, in m/s.

5.7 Device Variable 7 First Pulse arrival time (us)

This value records the arrival of the first ultrasonic signal.

5.8 Device Variable 8 Front wall echo (maximum) arrival time (sample)

This value records the arrival of another ultrasonic signal. It has no units, it is simply the sample number.

5.9 Device Variable 9 Back wall echo (minimum) arrival time (sample)

This value records the arrival of another ultrasonic signal. It has no units, it is simply the sample number.

5.10 Device Variable 10 First pulse magnitude

This value records the size of the main ultrasonic signal. It has no units.

5.11 Device Variable 11 Back wall echo magnitude

This value records the size of the one of the reflected ultrasonic signals. It has no units.

5.12 Device Variable 12 Ambient temperature

This is the temperature, in degrees C, recorded inside the Wi-Corr Electronics Enclosure. It is only accurate to +-1 C.

5.13 Device Variable 13 Charge used data

This is an estimate of the charge used by the internal radio module in units of milli-Coulombs.

5.14 Device Variable 14 Readings Counter

This is a record of how many ultrasonic readings have been taken.

5.15 Device Variable 15-Echo Ratio

This is simply the ratio of Device Variables 8 and 9.

5.243 Battery Life

An estimate of the expected remaining number of days of battery life.

Dynamic Variable	Device variable	Variable Name	Units	Dev Var Class
	0	System Verification Indicator	noUnits	Not Classified
Quaternary	1	Measurement Uncertainty	mm	Length
Primary	2	Pipe Thickness	mm	Length
Secondary	3	Pipe Temp	C	Temperature
	4	AGC Value	noUnits	Not Classified
	5	AGC Tries	noUnits	Not Classified
	6	Calculated Speed of Sound	m/s	Velocity (Speed)
	7	First Pulse arrival time (us)	us	Time
	8	Front wall echo (maximum) arrival time (sample)	noUnits	Not Classified
	9	Back wall echo (minimum) arrival time (sample)	noUnits	Not Classified
	10	First pulse magnitude	noUnits	Not Classified
	11	Back wall echo magnitude	noUnits	Not Classified
	12	Ambient temperature	C	Temperature
	13	Charge used data	milli-Coulomb (240)	Not Classified
	14	Readings Counter	noUnits	Not Classified
Tertiary	15	Echo Ratio	noUnits	Not Classified

Table 1: Device Variables and their Properties

6. DYNAMIC VARIABLES

Four Dynamic Variables are implemented.

	Meaning	Units
PV	Thickness of attached material	mm
SV	Temperature of attached material	^{0}C
QV	Measurement uncertainty	mm
TV	Echo Ratio	-

The ultrasonic thickness is based upon the time of flight of an ultrasonic pulse and the temperature of the attached material. The Measurement Uncertainty figure gives a degree of confidence in the presented thickness figure, it is calculated by analysis of the observed ultrasonic signal.

The Echo Ratio is also a good indicator of the quality of the bond between the ultrasonic sensor and the attached material.

No smoothing is applied to the data.

Data returned over the Wireless interface is a correct representation of the latest data.

For data returned over Maintenance Port the data is taken from the previous reading request with the Response Code set appropriately. At boot up reading is taken whenever power is applied to the unit such that the first data request gives valid information.

7. STATUS INFORMATION

7.0 Status Information(Command #48)

Command #48 returns 13 bytes of data, with the following status information:

Byte	Format	Meaning
0	Enumeration	Errors (Table 2)
1:4	bits	Warnings (Table 3)
5	0	Not Used
6		Extended Device Status (refer to Common Table 17 Extended Device Status Information)
7		Device Operating Mode (refer to Common Table 14 Operating Mode Codes)
8		Standardized Status 0 (refer to Common Table 29)
9		Standardized Status 1 (refer to Common Table 30)
10		Analogue Channel Saturated (refer to Common Table 27)
11		Standardized Status 2 (refer to Common Table 31)
12		Standardized Status 3 (refer to Common Table 32)

Table 2: Command 48 Error Code Enumeration

Error Code	Description
1	Ultrasonic signal too large. Amplifier overload.
2	Ultrasonic signal too small. Check ultrasonic sensor connection.
3	Wall thickness exceeds measurement range.
4	Thickness under range. Minimum thickness – 3mm.
5	Battery voltage low. Replace battery.
6	Averaging failure.
7	Memory not cleared. Power control failure.
8	Parameter outside expected range.
9	Sensor Board Failed To Respond.
10	Back Wall Echo too small. Improve sensor bonding to pipe.
11	Front Wall Echo too small or late arrival. Retry measurement. Potential sensor problem

Table 3: Command 48 Warning Code Bitmask

bit	Description
0	Observation #0: Electromagnetic or acoustic interference detected.. Move cabling away from potential noise source, Contact 3-Sci if persists.
1	Warning #1: Signal energy between echoes. Potential sensor damage or metal thickness below system minimum. Validate via Full Waveform or contact 3-Sci
2	Warning #2: Early arrival of front wall echo. Possible hardware problem or transmitter configured for different sensor type.
3	Warning #3: Late arrival of front wall echo. Possible hardware problem or transmitter configured for different sensor type
4	Observation #4: Increased 'Measurement Uncertainty' value. Calculation method discrepancy. Optionally validate via Full Waveform.
5	Observation #5: Gain at minimum level
6	Observation #6: Small amplitude of primary echo in relation to secondary echo. Increased 'Measurement Uncertainty' value.
7	Observation #7: Primary echo amplitude smaller than ideal. Monitor 'Measurement Uncertainty' value for increases.
8	Observation #8: Two back wall echoes or slopes are of comparable magnitude. Lowest thickness recorded. Monitor 'Measurement Uncertainty' value for increases
9	Observation #9: Two primary echoes or slopes are of comparable magnitude. Monitor 'Measurement Uncertainty' value for increases.
10	Warning #10: Amplification setting saturated primary echo. Retry measurement.
11	Warning #11: Small front wall echo. Retry measurement.
12	Observation #12: Small back wall echo indicates imperfect adhesive or clamped installation. Increased measurement uncertainty
13	Observation #13: Large variation in averaged thicknesses, indicative of a poor adhesive bond. Increased 'Measurement Uncertainty' value.
14	Warning #14: Temperature of pipe outside of operational range
15	Observation #15: Measurement technique – Back Wall Echo Multiple.
16	Warning #16: Wireless unit operational temperature range exceeded
17	Warning #17: Temperature Probe Not Connected

"Not used" bits are always cleared to 0.

These bits are set or cleared whenever a reading is taken, by Command 41: self-test, a Reset from Command 42 and at unit power up.

7.1 Device Status

Bit 4 ("More Status Available") is set whenever any of the Error Code bits in the Command 48 (Byte 0) response are altered.

Command #48 gives further detail. (See Section 7.0.)

'Field Device Malfunction' is set when any of the Error Code bits are set in Byte 0 of the Command 48 response.

7.2 Extended Device Status

Critical Power Failure is set when the battery voltage falls below 9v.

8. UNIVERSAL COMMANDS

Command #3 returns PV, SV, QV and TV (for a total of 24 bytes of response data).

Any measurement data returned over the WIRED/MAINTENANCEPORT interface will have the ‘Update Failure (8)’ Response Code set. Data returned over the WIRELESS interface will be the latest available.

A reading is taken upon power up.

All units are metric.

9. COMMON-PRACTICE COMMANDS

9.0 Supported Commands

The following common-practice commands are implemented:

38 Reset "Configuration Changed" Flag

41 Perform Device Self-Test

42 Perform Master Reset

48 Read Additional Device Status

50 Dynamic Variable Assignments

54 Read Device Variable Information

59 Write Number Of Response Preambles

78 Read Aggregated Commands

79 Write Device Variable

90 Read Real-Time Clock

103 Write Burst Period

104 Write Burst Trigger

105 Read Burst Mode Configuration

106 Flush Delayed Responses116

107 Write Burst Device Variables

108 Write Burst Mode Command Number

109 Burst Mode Control

115 Read Event Notification Summary

116 Write Event Notification Bit Mask

117 Write Event Notification Timing

118 Event Notification Control

119 Acknowledge Event Notification

526 Write Status Simulation Mode

527 Simulate Status Bit

The Real Time Clock is set by the Mesh Network and so will not be set when there is no connection to the wireless network.

Command #48 returns 13 bytes of data. (See Section 7.0.)

9.1 Burst Mode

This Field Device supports Burst Mode.

Commands 1, 2, 3, 9, 33 and 48 can be contained in Burst messages.

3-Sci DOES NOT recommend the use of Burst Mode in any circumstances other than for very short periods, for example during sensor installation.

Burst Mode will SEVERELY reduce the expected battery life of the device.

If automatic readings are required, contact 3-Sci to access the Wi-Corr Trend Software Suite.

9.2 Catch Device Variable

This Field Device does not support Catch Device Variable.

10. DEVICE-SPECIFIC COMMANDS

The following device-specific commands are implemented:

10.0 Command #129: Enable / Disable Write Protect.

A single request byte of any value greater than 0 will enable Write Protect mode.

A value of zero will will disable Write Protection and return the device to normal operation.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Value != 0 Enables Write Protect Mode

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	0: Write Protect Disabled 1: Write Protect Enabled

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
5		Too Few Data Bytes Received

11. TABLES

11.0 Sensor Type Codes

12. PERFORMANCE

12.0 Sampling Rates

Time taken to take a thickness reading.

Minimum	3 seconds
Maximum	8 second

No averaging is performed between one reading and the next.

12.1 Power-Up

On power up, the transmitter goes through a self-test procedure and takes a single boot up reading(see section 12.3), which takes approximately 9 seconds. During this period, the device will not respond to HART commands.

12.2 Reset

Command 42 ("Device Reset") causes the device to reset its microprocessor and any connection to the Wireless HART mesh network. The resulting restart is identical to the normal power up sequence. (See Section 12.1.)

12.3 Self-Test

The self-test procedure is executed at power up, following Command 41 ("Self-Test") or Command 42 ("Device Reset").

The self-test acts in the same way as requesting any of the Device or Dynamic variables. The device effectively self tests on every reading to assure data validity.

This self-test takes between 3 and 8 seconds. During self-test following power-up or reset the device will not respond to HART commands.

12.4 Command Response Times

Minimum	20ms
Typical	150ms
Maximum	240ms

Commands with a physically longer packet will take longer to process, as will any commands that require communication with wither EEPROM memory or the radio module.

12.5 Busy and Delayed-Response

The transmitter may respond with Delayed-Response over the wireless network while a reading is being taken and the data is traversing the wireless network.

12.6 Long Messages

The largest data field used is in the response to Command 21: 34 bytes including the two status bytes.

12.7 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.

12.8 Write Protection

Write-protection is provided, by using the device specific Command 129.

ANNEX A. CAPABILITY CHECKLIST

Manufacturer, model and revision	3-Sci Ltd Wi-Corr Bond rev. 1
Device type	Transmitter
HART revision	7.0
Device Description available	Yes
Number and type of sensors	2 external: 1 thickness and 1 temperature sensor
Number and type of actuators	0
Number and type of host side signals	-
Number of Device Variables	16
Number of Dynamic Variables	4
Mappable Dynamic Variables?	No
Number of common-practice commands	24
Number of device-specific commands	1
Bits of additional device status	104
Alternative operating modes?	No
Burst mode?	Yes
Write-protection?	Yes

ANNEX B. DEFAULT CONFIGURATION

Parameter	Default value
Lower Range Value	3.15mm
Upper Range Value	25.4mm
PV Units	mm
Sensor type	3-Sci Piezo thickness sensor, Pt1000
Number of wires	2
Damping time constant	-
Fault-indication jumper	-
Write-protect jumper	-
Number of response preambles	5

ANNEX C. REVISION HISTORY

Revision 1.0 April 2020

Everything May Change

Revision 1.1 February 2021

More Status Available bit is only triggered by Error bits, not Warning bits.

Typos.

Revision 1.2 Oct' 2021

Typos, page numbering fix.
