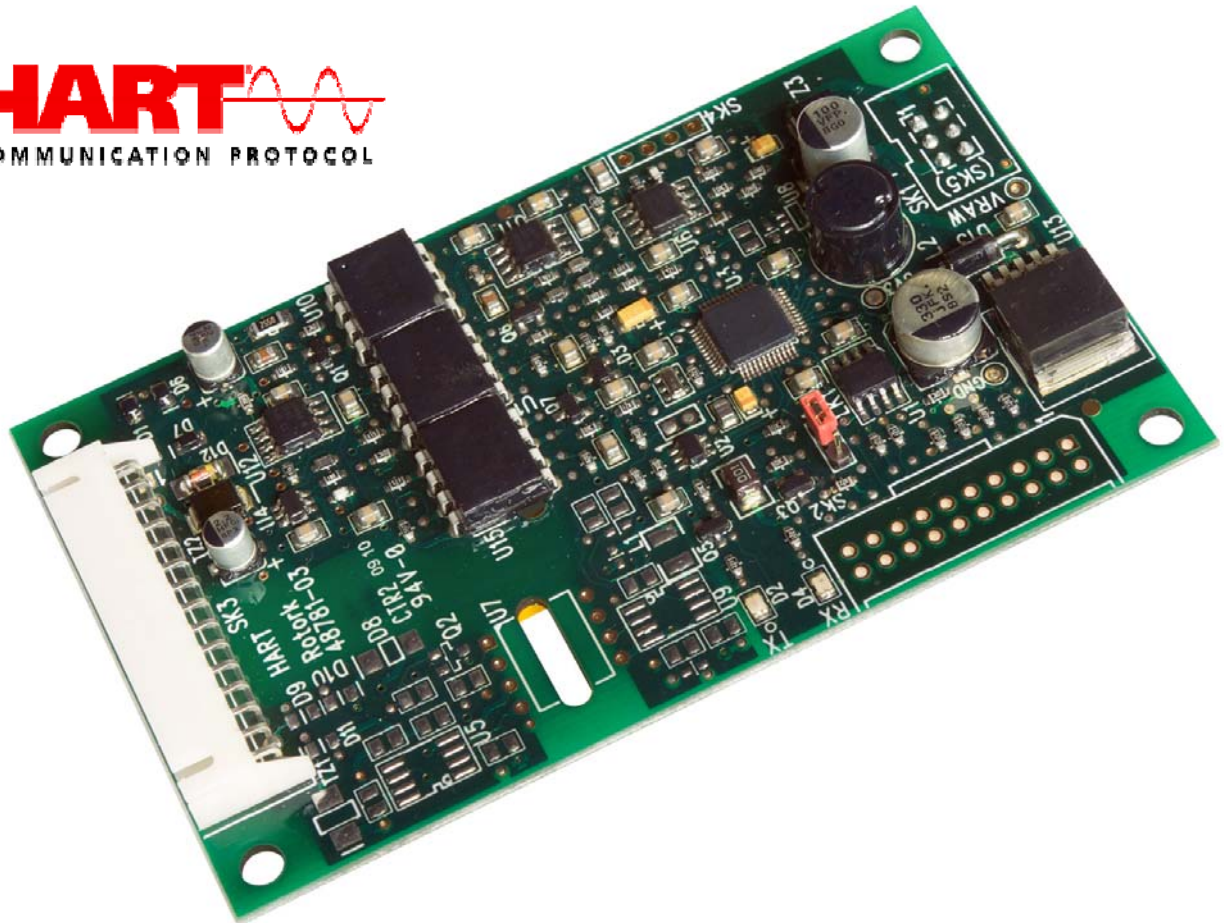




HART Field Unit Technical Manual

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1. INTRODUCTION

1.1 Scope

The Rotork Actuator HART Field Unit (HFU), device revision 1, complies with HART Protocol Revision 7.1. This document specifies all the device specific features and documents for the HART Protocol implementation details (for example, 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 compliment 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 (for example, 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

CVL	Control Valve (actuator) Linear
CVQ	Control Valve (actuator) Quarter (turn)
DTM	Device Type Manager
HART	Highway Addressable Remote Terminal
HFU	HART Field Unit
LRV	Lower Range Value
PV	Primary Variable
QV	Quaternary Variable
SV	Secondary Variable
TV	Tertiary Variable
URV	Upper Range Value

2. PRODUCT OVERVIEW

2.1 General

The Rotork Actuator HART Field Unit allows communication and control of Rotork actuators by a suitable host system with HART capability. Standard shielded twisted pair cable is used to connect the actuators to the host in either point-to-point or multidrop network configurations.

The HFU may be fitted into the Rotork CVL or CVQ electric control valve actuators. The HFU board is fitted within the actuator double-sealed electrical housing and forms an integral part of the actuator.

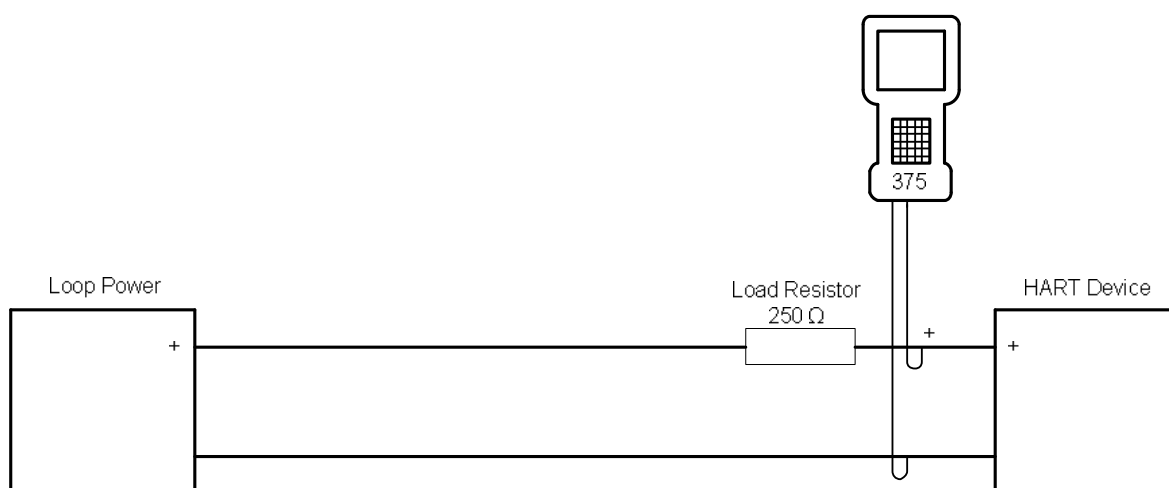
There should be no need to open the electrical housing of the actuator once it leaves the factory. All adjustments and configuration settings of the HFU board may be done over the data highway using a suitable tool, such as the Emerson 375.

The HFU circuitry does not impinge on the actuator control electronics. The actuator itself remains fully self-protecting. The HFU performs the tasks of network interface, actuator data collection and the issuing of some actuator commands.

In normal operation the HFU is controlled by the analog signal demand signal, but it can also be controlled by digital signals. In this way the HFU can command the actuator in which it is fitted to open, stop, close or move to a set position. Commands to carry out these actions will have come from the network, having been generated by a master controller. The actuator then behaves as a slave device to this controller.

Device Description (DD) Files are available on the Rotork website.

A typical HART system configuration setup is shown below:



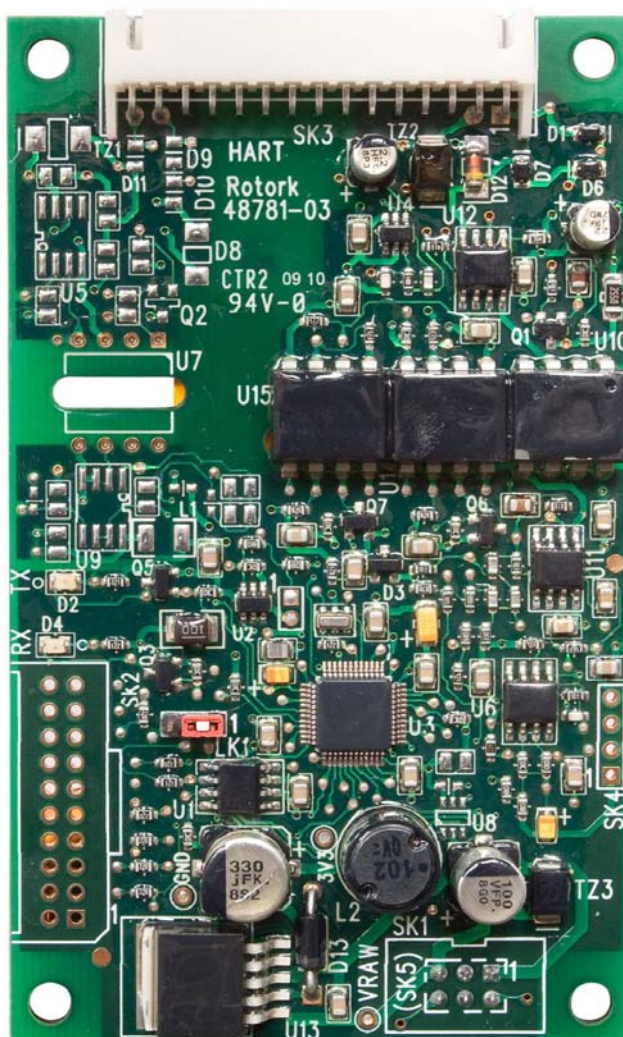
2.2 Mechanical Properties

The HFU board is a single printed circuit board which is fitted beneath the main printed circuit board. It is attached by four nylon screwed pillars, one in each corner.

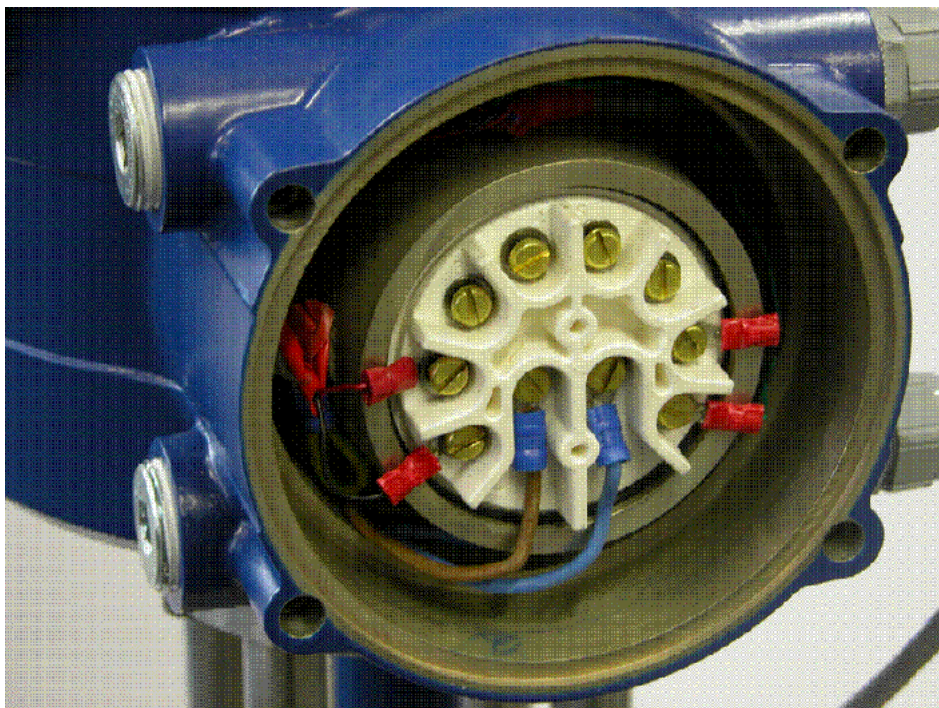
Electrical connection to the network is through SK3, pins 1 and 2, at the top of the picture.

Electrical connection to the main board is through SK5, at the bottom of the picture.

There is one removable link, LK1 (red), which should be left in the position shown below.



3. CONNECTIONS AND SETUP



Network connections are made to Terminals 1 and 2 of the terminal bung. Find a suitable conduit entry and connect the HART cabling with the negative polarity to Terminal 1 and the positive polarity to Terminal 2. These connections are shown in the picture above. Terminals 1 and 2 are on the left hand side of the picture.

General installation and maintenance instructions are found in the P170 manual for the CVL and P175 for the CVQ actuator. Follow the instructions carefully to attach and setup the actuator, which is achieved using Rotork software: Enlight (Bluetooth required), only the HART loop 0% and 100% values can be set up using this tool. The HFU is set up through the network cabling, using a HART master or a configuration tool like the Emerson 375 or by using a generic DTM.

4. ANALOGUE CONTROL SIGNAL

The PV is the actuator's demand position, measured in percent, and is derived from the loop current. Its range is 0% to 100%.

Table 1 – Analogue input characteristics

	Direction	Values (percent of range)	Values
Linear over-range	Down	-3.125 ± 0.1%	3.5 ± 0.01 mA
	Up	+3.125 ± 0.1%	20.5 ± 0.01 mA
Maximum current			23 mA
Multi-Drop current draw			4.0 mA
Lift-off voltage (voltage required at 20.5 mA)			11 V
Effective input resistance*			280 Ω
Capacitance number (terminal to terminal & case capacitance × 5000 pF)			0.6 max

* The effective input resistance is calculated as the slope of a graph of voltage against loop current, across the input range of the device. It is not simply V/I , as the device has a theoretical voltage offset of 5.4 V at zero current.

5. DEVICE VARIABLES

The Device Variables are the loop current and the four Dynamic Variables.

Table 2 – Device Variables

Number	Name	Classification	Units
0	Loop current	Current	mA
1	Demand	Analytical	%
2	Position	Analytical	%
3	Thrust or torque	Analytical	%
4	Position within factory limits	Analytical	%

5.1 Device Variable 0 Loop current

The loop current, measured in milliamps. This is calibrated at the factory, but may be recalibrated by the user using Commands 45 and 46.

5.2 Device Variable 1 Demand

The actuator position demand, measured in percent, and derived from the loop current. This value is relative to the user limits, and so is dependent on the LRV and URV.

It can be set, allowing manual control of the actuator, by Command 79.

5.3 Device Variable 2 Position

The present position of the actuator, measured in percent. This uses the same user-defined range as the demand.

5.4 Device Variable 3 Thrust or torque

The actuator thrust (for a linear actuator) or torque (for a quarter-turn actuator), measured as a percent of rated thrust or torque.

5.5 Device Variable 4 Position within factory limits

This value, measured in percent, indicates the position of the actuator within its full mechanical stroke, determined at the factory.

This is only used to set the actuator's limits, and is not available during normal operation.

Command 79 must be used to set this value, allowing the actuator to be moved anywhere within its physical limits. When in this mode, the normal demand (Device Variable 1) will be unavailable; position will continue to show the normal position, not the position within factory limits.

5.6 Dynamic Variables

Four Dynamic Variables are implemented, with a fixed mapping to the Device Variables shown below:

Table 3 – Dynamic variables

	Device Variable number	Meaning
PV	1	Demand
SV	2	Position
TV	3	Thrust or torque
QV	4	Position within factory limits

6. STATUS INFORMATION

6.1 Field Device Status

The functions of the Field Device Status bits are specified in HCF_SPEC-99. Further details of their implementation are described in Table 4.

Table 4 – Field Device Status bits

Bit	Name	Notes
7	Device Malfunction	Set on loss of communication with the main board.
6	Configuration Changed	Set if changes are made to device configuration.
5	Cold Start	Set when initially powered-up.
4	More Status Available	Set if any Additional Device Status bit is set (see section 6.2).
3	Loop Current Fixed	Set by Command 40.
2	Loop Current Saturated	Set if current goes 0.5 mA outside limits (see Table 1).
1	Non-PV Out of Limits	Not used.
0	PV Out of Limits	Set if PV (demand) goes 3.125% outside limits.

6.2 Command 48 Additional Device Status

Command 48 returns up to 5 bytes of device-specific data. The meaning of the bits in bytes 0 to 3 depends on the family of actuator. Byte 4 is for HART-specific status. Refer to tables 5 and 6.

All bits are for errors only, and are continually updated. Accordingly, if any bit is set, the More Status Available bit (bit 4) of the Field Device Status is set; likewise, if all of the former are clear, then the latter is too.

The More Status Available bit can also be cleared using the procedure added to Command 48 for HART 7. If that is done, any *new* Additional Device Status bit being set will cause the More Status Available bit to be set.

During normal operation, all bits should be zero. All unused bits are set to zero. Extended Device Status bits are not used, so are not affected by any of these bits.

Table 5 – CVA: Alarm status bits

Byte	Bit	Meaning
0	0	Motor Hall sensor: invalid data
	1	Motor Hall sensor: unknown
	2	Thermostat trip
	3	Knob position error
	4	Actuator type unknown
	5	Configuration error
	6	Over back-drive limit: open
	7	Over back-drive limit: closed
1	0	Motor sensor: communications failure
	1	Motor sensor: unknown
	2	Position sensor: magnet failure
	3	Position sensor: communications failure
	4	Position sensor: unknown
	5	Force sensor: out of range
	6	Force sensor: communications failure
	7	Force sensor: unknown
2	0-7	Reserved
3	0	Motor sensor: magnet failure
	1	UPS error
	2	Configuration defaults error
	3	Valve obstruction: opening
	4	Valve obstruction: closing
	5	Actuator stalled
	6	Reserved
	7	Reserved

Table 6 – HART board: Alarm status bits

4	0	Main board not responding
	1-7	Reserved

7. UNIVERSAL COMMANDS

Command 3 returns all four Dynamic Variables, for a total of 24 bytes of response data.

Command 48 returns 9 bytes of data, which includes 5 bytes of device-specific status (see Section 6.2).

8. COMMON-PRACTICE COMMANDS

8.1 Supported Commands

The following common-practice commands are implemented:

Table 7 – Supported common practice commands

35	Write Primary Variable Range Values
40	Enter/Exit Fixed Current Mode
42	Perform Device Reset
45	Trim Loop Current Zero
46	Trim Loop Current Gain
49	Write Primary Variable Transducer Serial Number
79	Write Device Variable

Command 40 (Enter/Exit Fixed Current Mode) simulates a specified input current to the actuator. This mode is cleared by power loss or device reset.

Command 42 (Perform Device Reset) resets the HFU card, but not the main board.

Command 79 (Write Device Variable) only supports Device Variables 1 (demand) and 4 (position within factory limits), and only one of these can be fixed at a time.

8.2 Unsupported Features

This Field Device does not support Burst Mode.

This Field Device does not support Catch Device Variable.

This Field Device does not support Perform Self Test.

This Field Device does not support Extended Device Status.

9. DEVICE-SPECIFIC COMMANDS

The following device-specific commands are implemented:

Table 8 – Device-specific commands

128	Read Software Version
129	Do Not Use
130	Do Not Use
131	Read Current Zero & Span

9.1 Command 128 Read Software Version

Reads the software version and build numbers of the HART board's software.

The string has the form: "M.mm (bbbb)", where "M" is the major revision number (currently 1), "mm" is the minor version number (incremented each time a new version of the software is released), and "bbbb" is the build number (used within Rotork as a reference for each build of the software).

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-12	Latin-1	String containing software version and build numbers

Command-Specific Response Codes

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

9.2 Command 131 Read Current Zero & Span

This reads the current zero (lower endpoint value) and span (upper endpoint value), in milliamps. These are the values set by Commands 45 and 46, respectively, and so correspond to the currents used to calibrate the actuator's ADC, typically 4 and 20 mA.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-3	Float	Current zero (lower endpoint) value in mA
4-7	Float	Current span (upper endpoint) value in mA

Command-Specific Response Codes

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

Appendix 1 Capability Checklist

Manufacturer, model and revision	Rotork Actuator, rev. 1
Device type	Actuator
HART revision	7.1
Device Description available	Yes
Number and type of sensors	1 (internal ADC)
Number and type of actuators	1
Number and type of host side signals	1: 4 – 20 mA analogue
Number of Device Variables	5
Number of Dynamic Variables	4
Mappable Dynamic Variables?	No
Number of common-practice commands	8
Number of device-specific commands	4
Bits of additional device status	33
Alternative operating modes?	Yes
Burst mode?	No
Write-protection?	No

Appendix 2 Fault Configuration

Parameter	Default value
Lower Range Value	0
Upper Range Value	100
PV Units	%

Appendix 3 Device Summary

Manufacturer Name:	Rotork Process Controls
Manufacture ID Code:	110 (6E Hex)
HART Protocol Revision	7.1
Number of Device Variables	5
Physical Layers Supported	FSK
Physical Device Category	Actuator, DC-isolated Bus Device
Model Name(s):	HART Option Board
Device Type Code:	221 (DD Hex)
Device Revision:	1

Appendix 4 General HART Protocol Summary

COMMUNICATION SIGNALS

Traditional analog 4–20mA
Digital FSK, based on the Bell 202 telephone communication standard
Logical “0” frequency 2,200 Hz
Logical “1” frequency 1,200 Hz
Bit rate: 1200 bits per second

DATA INFORMATION

Data update rate:

- Request/response mode—2–3 updates per second
- Optional burst mode—3–4 updates per second

Data byte structure:

- 1 start bit, 8 data bits, 1 odd parity bit, 1 stop bit

Data integrity:

- Two-dimensional error checking (a combination of parity and check sum)
- Status information in every reply message

SIMPLE COMMAND STRUCTURE

Universal	Common to all devices
Common practice	Optional; used by many devices
Device specific	For unique product features

COMMUNICATION MASTERS

- Two communication masters

VARIABLES

- Up to 256 device variables per device
- IEEE 754 floating point format (32 bits) with engineering units

WIRING TOPOLOGIES

- Point to point—simultaneous analog and digital
- Point to point—digital only
- Multidrop network—digital only (up to 63 devices)

CABLE LENGTHS

- Maximum twisted-pair length—10,000 ft (3,048 m)
- Maximum multiple twisted-pair length—5,000 ft (1,524 m)

Cable length depends on the characteristics of individual products and cables.