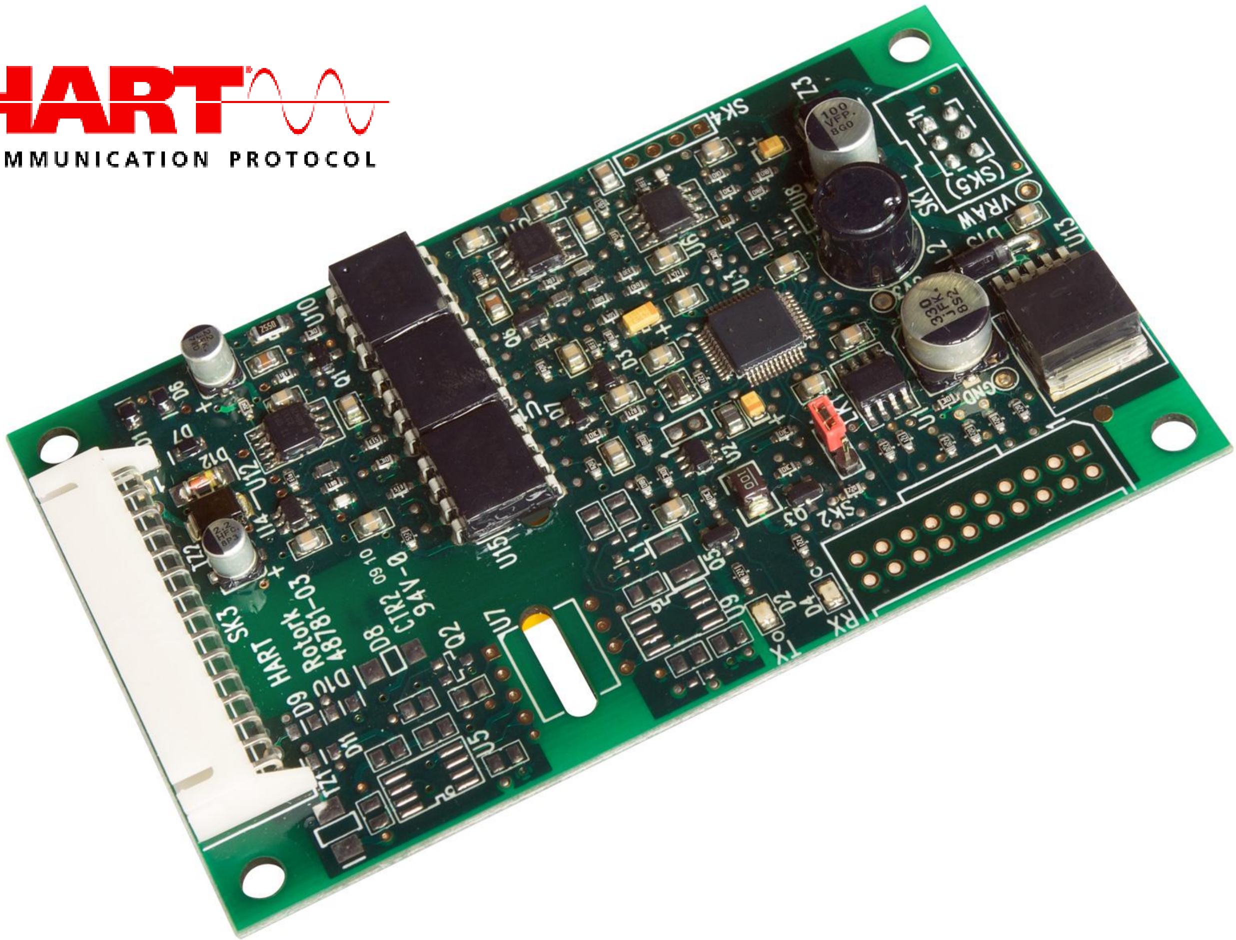
rotork®

HART COMMUNICATION PROTOCOL



CVA HART Field Unit
Technical Manual

Publication PUB092-002-00_0513

Note 1:
The information in this manual relates to HART firmware version V103. DD Files versions, Device_rev 1 and DD_revision 1.

Note 2:
The HART module described in this manual is suitable for inclusion into the CVA range of actuators.

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LIST OF TABLES

The appendices contain useful reference material:

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

ADC	Analogue to Digital Converter
CVL	Control Valve (actuator) Linear
CVQ	Control Valve (actuator) Quarter (turn)
DD	Device Description
DCS	Distributed Control System
DTM	Device Type Manager
FSK	Frequency Shift Keying
HART	Highway Addressable Remote Terminal
HFU	HART Field Unit
LRV	Lower Range Value
PDA	Personal Digital Assistant
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.

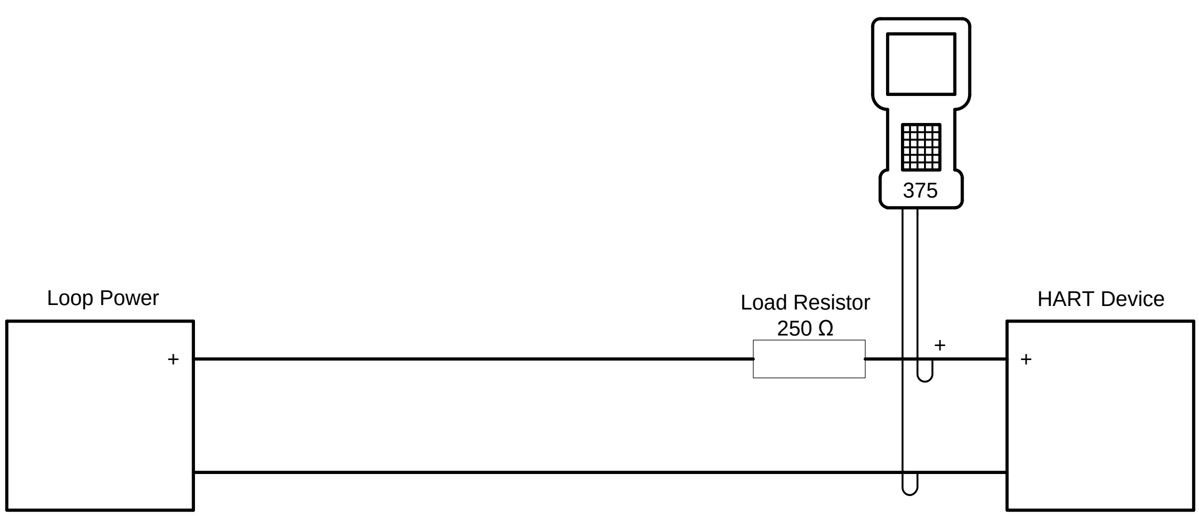
The HFU may be fitted into the Rotork CVL or CVQ electric control valve actuators. The HFU board is fitted within the actuator double-sealed electrical housing and forms an integral part of the actuator.

There should be no need to open the electrical housing of the actuator once it leaves the factory. All actuator adjustments and configuration settings may be done using Rotork 'Enlight' software for the PC or PDA, this software is downloadable from the Rotork web site. The actuator settings and the HART specific 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 the HART digital signal. In this way, the HFU can command the actuator in which it is fitted 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 behaves as a slave device to this controller. Device Description (DD) Files for the HFU are available on the Rotork web site.

A typical HART system configuration setup is shown below:



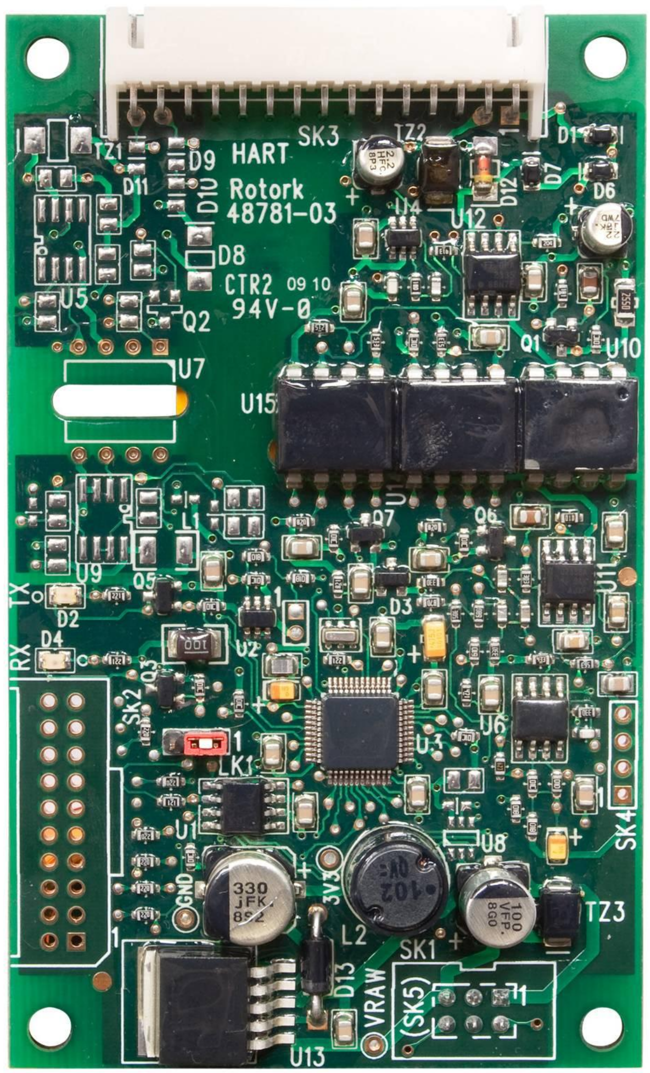
2.2 Mechanical Properties

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.

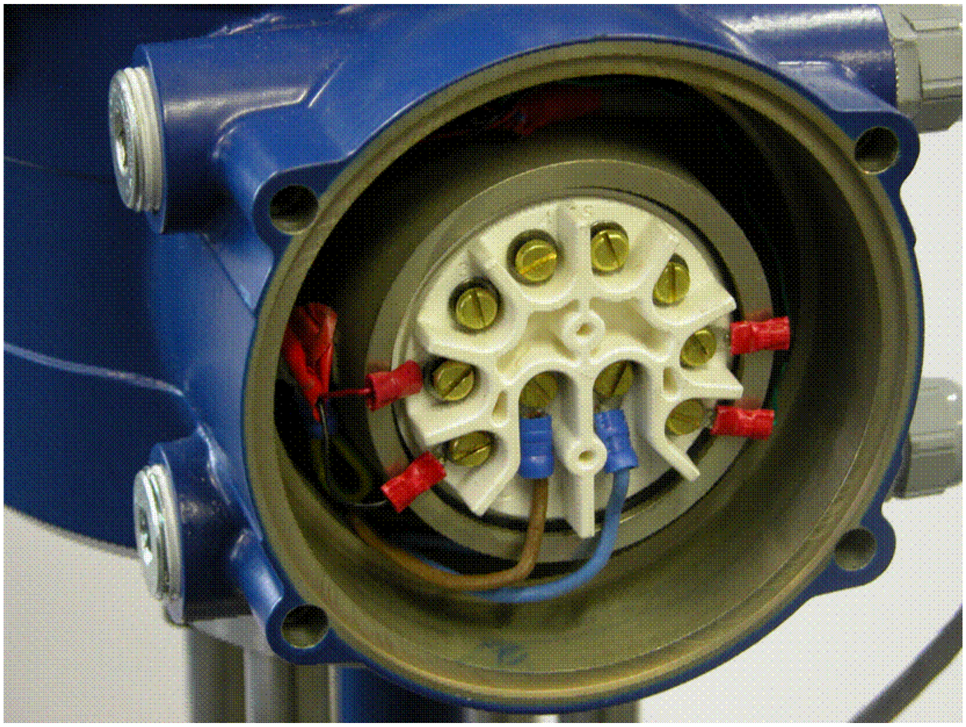
Electrical connection to the network is through SK3, pins 1 and 2, at the top of the picture.

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 PUB042-003 (formerly P170) manual for the CVL and PUB042-004 (formerly P175) for the CVQ actuator. Follow the instructions carefully to attach and setup the actuator, which is achieved using Rotork Enlight software, using Bluetooth communications. Only the HART loop 0% and 100% values can be set up using this tool. The other HFU settings can be made through the network cabling, using a HART master, 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 can 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; if all of the error bits are clear (zero), then the More Status Available Bit will be clear too.

The More Status Available bit can also be cleared by reading command 48 and writing the data back using command 48. 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	Control Knob in Stop position
	7	Control Knob in Test position

Table 6 – HART board: Alarm status bits

4	0	Main board not responding
	1-7	Reserved

7. UNIVERSAL COMMANDS

Command 3 returns the loop current and all four Dynamic Variables with their unit code, 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	Read Status Data
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

9.3 Command 129 Read Status Bits Version

Reads the actuator status bits within the HFU. The data is returned in a 16 bit register described in Table 9.

Request Data Bytes

Byte	Format	Description
0-1	Unsigned 16bit	Functional block: Value 0200
2	Unsigned 8bit	Data index: Value 00

Response Data Bytes

Byte	Format	Description
0-1	Unsigned 16bit	Functional block: Value 0201
2	Unsigned 8bit	Data index: Value 00
3-4	16 Bits	Data read

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
2	Error	Invalid selection
72	Error	Time out
73	Error	Communications loss
1, 3-71 and 74-127	-	Reserved

Table 9 – Actuator Status Register

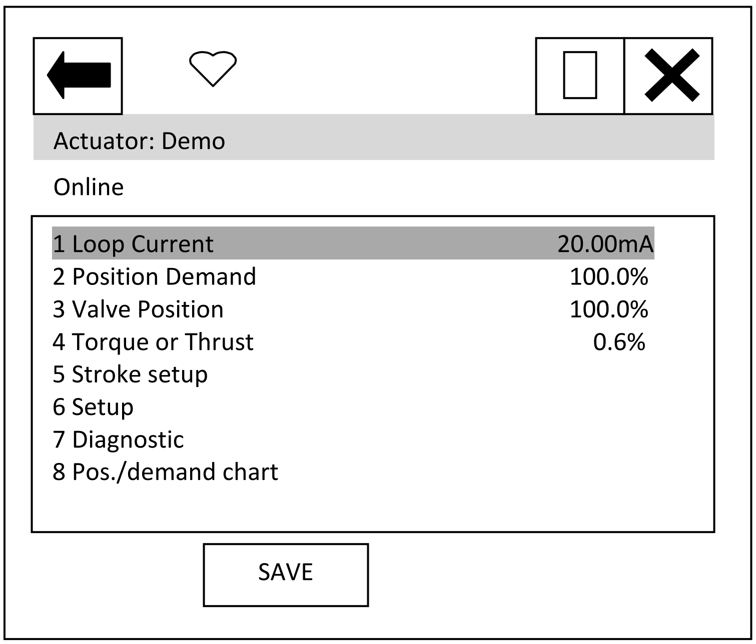
Bit	Meaning
0	Set high when the relay is energised
1	Set high when the valve is obstructed whilst closing
2	Set high when the valve is obstructed whilst opening
3	Set high when a fault (non critical) is present
4	Set high when a fault is present
5	Set high when the closing back drive limit is seen
6	Set high when the opening back drive limit is seen
7	Set high when the thrust limit whilst closing is seen
8	Set high when the thrust limit whilst opening is seen
9	Set high when the actuator is at the open limit
10	Set high when the actuator is at the closed limit
11	Set high when the local controls are in the stop position
12	Set high when the local controls are set to the run position
13	Set high when the local controls are set to the test position
14	Set high when the 4-20mA signal is lost (goes below 1mA)
15	Set high when the actuator is stalled - has moved less than 1% for 10 seconds)

10. DD FILE, EMERSON 375 SCREEN SHOTS

The DD file describes the HART device. There are 2 DD files available on the Rotork web site, one for use by a DCS and one for use by the Emerson 375. The following pages show screen shots from the Emerson 375, indicating the data and functions that can be accessed using the DD files. Refer to the CVA technical manuals PUB042-003 (CVL) and PUB042-004 (CVQ) for more details of the features shown. The DD file pages have the same functions as the pages in Enlight described in the CVA technical manuals.

10.1 Top Menu

When the items 1 to 4 are selected, the display changes to show the data selected.



Item 1 ‘Loop current’ displays the instantaneous value of the current, as measured by the HFU.

Item 2 ‘Position demand’ displays the percent (%) demand that the current is representing.

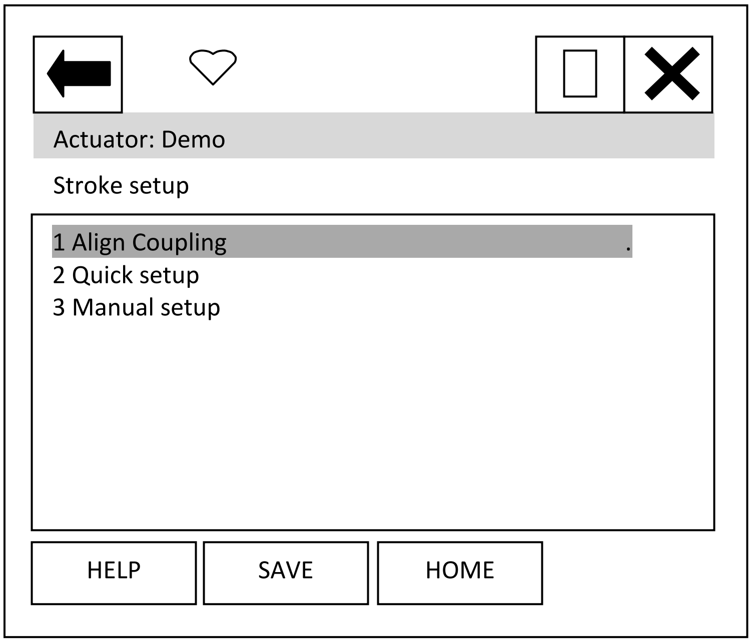
Item 3 ‘Valve position’ displays the valve position.

Item 4 ‘Torque or Thrust’ displays the torque or thrust present at the output of the actuator.

Selection of items 5 to 8 will bring up new menus, detailed in the following sections.

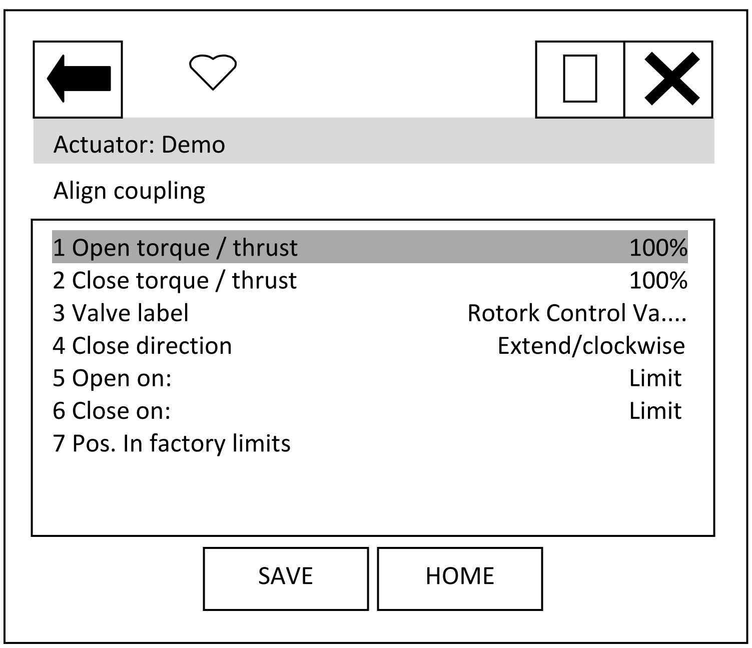
10.2 Stroke setup

From the top menu, selecting 5 ‘Stroke setup’ will display the following menu:



When the items 1 to 3 are selected, new pages are displayed.

Stroke setup: **1 Align coupling**



Each item can be selected, viewed, and modified where appropriate:

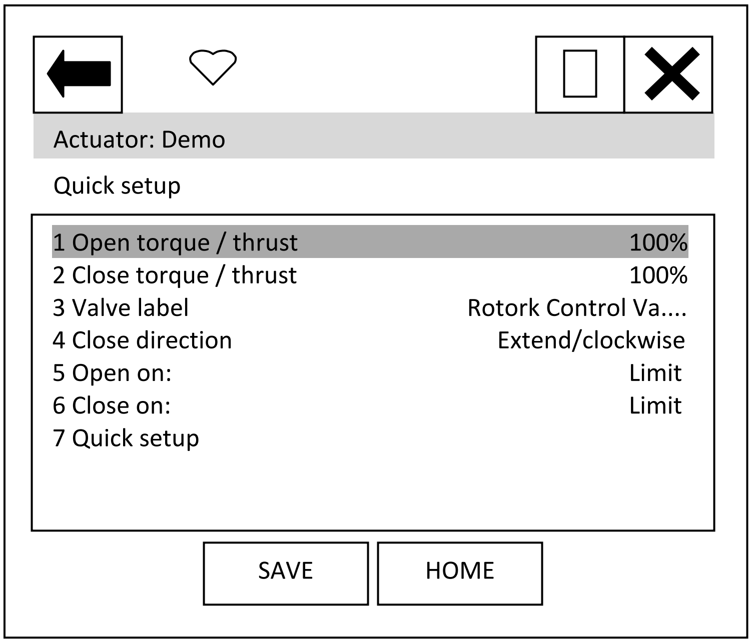
Items 1 and 2 Open and Close torque / thrust; can be modified between 41 and 100%.

Items 3 and 7 cannot be modified.

Item 4 can be modified between Extend/clockwise or Retract/ anti-clock.

Items 5 and 6 can be modified between Limit or Torque / Thrust.

Stroke setup: **2 Quick setup**

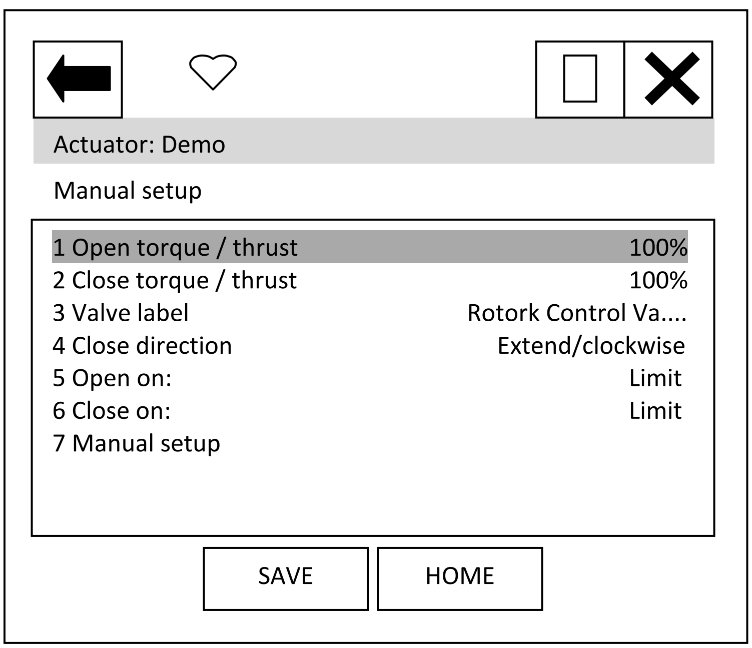


Each item can be selected, viewed, and modified where appropriate:

Items 1 to 6 are as per ‘Align coupling’.

Item 7 ‘Quick setup’, follow on screen instructions for setting up the device.

Stroke setup: **3 Manual setup**



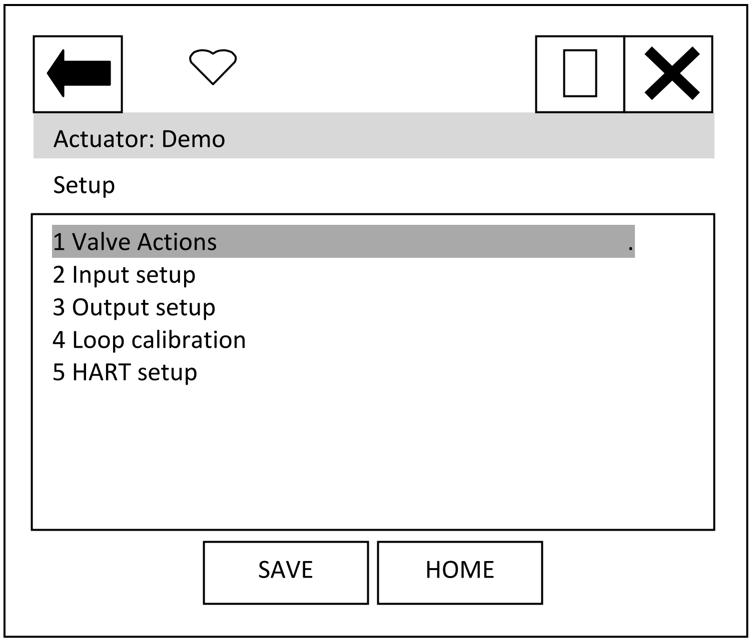
Each item can be selected, viewed, and modified where appropriate:

Items 1 to 6 are as per ‘Align coupling’.

Item 7 ‘Manual setup’, follow on -screen instructions for setting up the device.

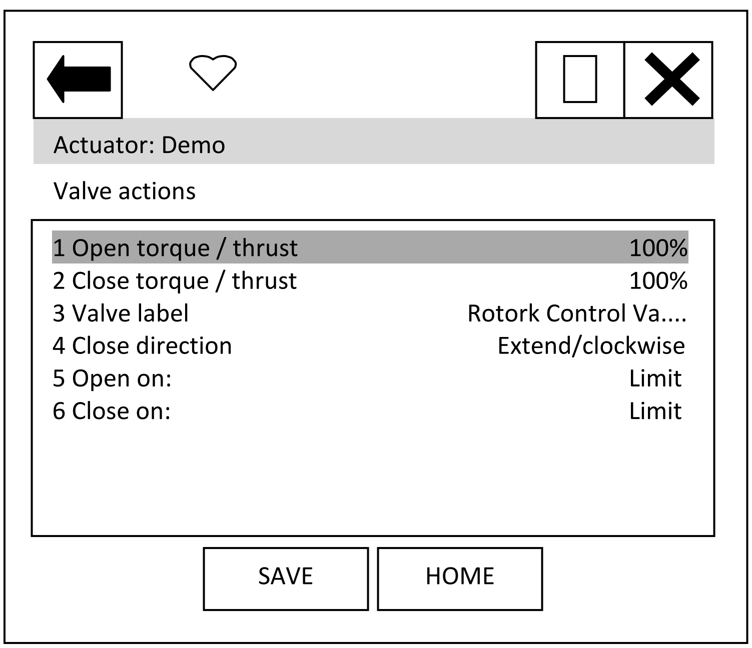
10.3 Setup

From the top menu, selecting 6 ‘Setup’ will display the following menu:



When the items 1 to 5 are selected, new pages are displayed.

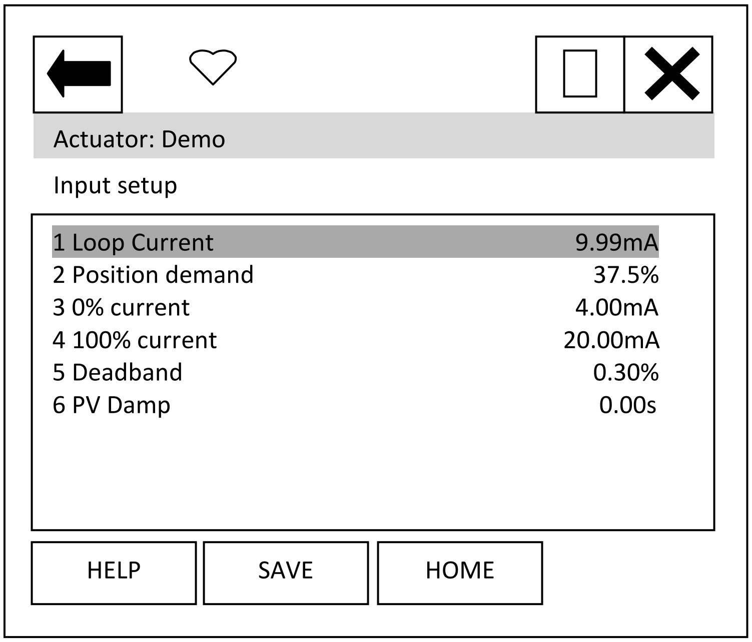
Setup: **1 Valve actions**



Each item can be selected, viewed, and modified where appropriate:

Items 1 to 6 are as per ‘Align coupling’.

Setup: **2 Input setup**



Each item can be selected, viewed, and modified where appropriate.

Item 1 ‘Loop current’ displays the instantaneous value of the loop current as measured by the HFU.

Item 2 ‘Position demand’ displays the % demand that the current input signal is representing.

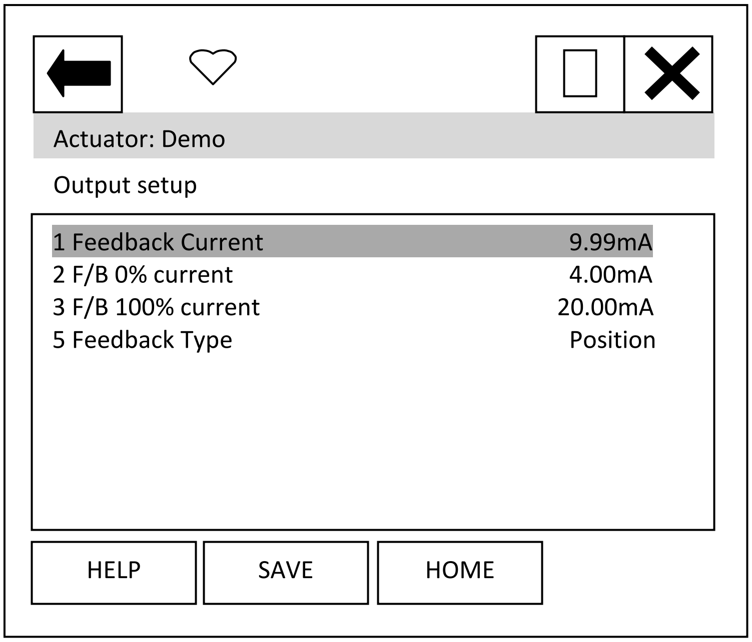
Item 3 ‘0% current’ displays the mA demand signal required for positioning to 0%; can be modified.

Item 4 ‘100% current’ displays the mA demand signal required for positioning to 100%; can be modified.

Item 5 ‘Deadband’ – displays the deadband applied to the demand signal; can be modified between the range 0.00% and 15.00% in 0.01% increments.

Item 6 ‘PV damp’ – displays the Primary Value Damping value; when selected can be modified in 0.01s increments.

Setup: **3 Output setup**



Each item can be selected, viewed, and modified where appropriate.

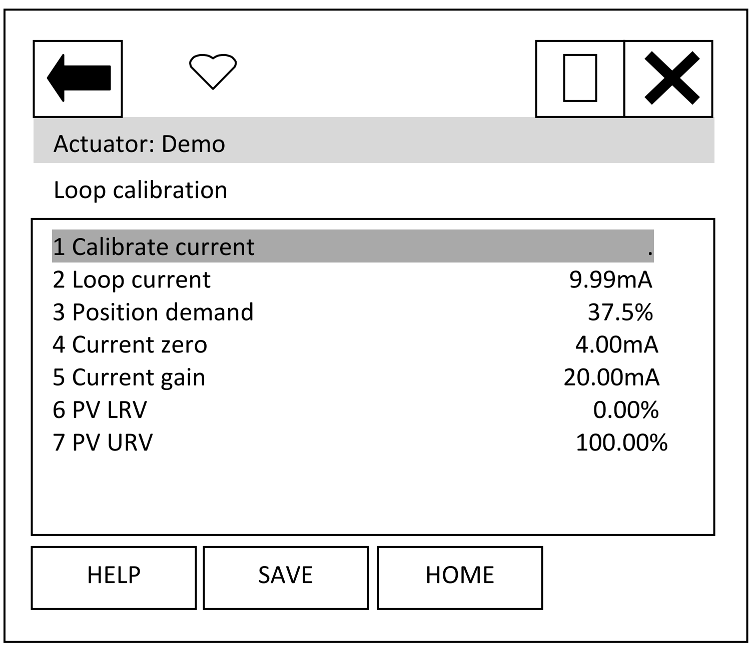
Item 1 ‘Feedback current’ displays the instantaneous value of the feedback signal.

Item 2 ‘F/B 0% current’ displays the value of the Feedback current for 0% position; can be modified.

Item 3 ‘F/B 100% current’ displays the value of the Feedback current for 100% position; can be modified.

Item 4 ‘Feedback type’ displays the feedback source; can be modified between Position or Torque / Thrust.

Setup: **4 Loop calibration**



Each item can be selected, viewed, and modified where appropriate.

Item 1 ‘Calibrate current’ displays the function to calibrate the loop current.

Item 2 ‘Loop current’ displays the instantaneous value of the current as measured by the HFU.

Item 3 ‘Position demand’ displays the percent (%) demand that the current is representing.

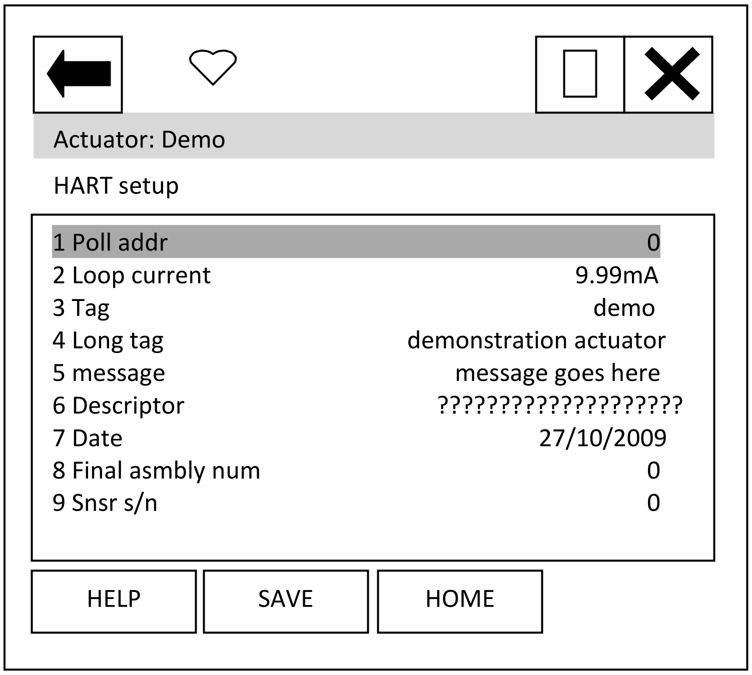
Item 4 ‘Current zero’ displays current zero setting; not modifiable.

Item 5 ‘Current gain’ displays current gain settings; not modifiable.

Item 6 ‘PV LRV’ shows the HART Primary Value Lower Range Value; can be modified.

Item 7 ‘PV URV’ shows the HART Primary Value Upper Range Value; can be modified.

Setup: **5 HART setup**



Each item can be selected, viewed, and modified where appropriate.

Item 1 ‘Poll addr’ displays the HART address of the device; can be changed in the range 0-63.

Item 2 ‘Loop current’ displays the instantaneous loop current.

Item 3 ‘Tag’ shows the tag of the device; text field that can be modified.

Item 4 ‘Long tag’ shows the long tag of the device; text field that can be modified.

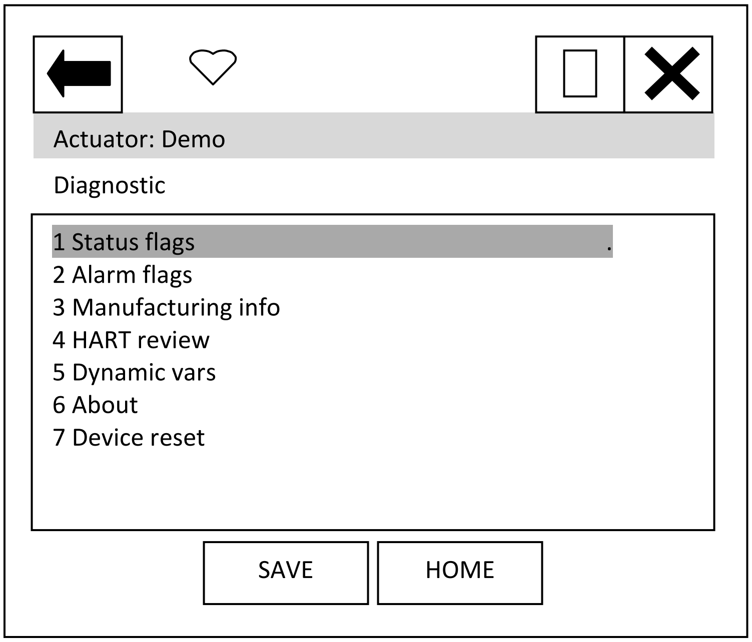
Item 5 ‘Date’ text field that can be modified.

Item 6 ‘Final asmbly num’ text field that can be modified.

Item 7 ‘Snsr s/n’ text field that can be modified.

10.4 Diagnostics

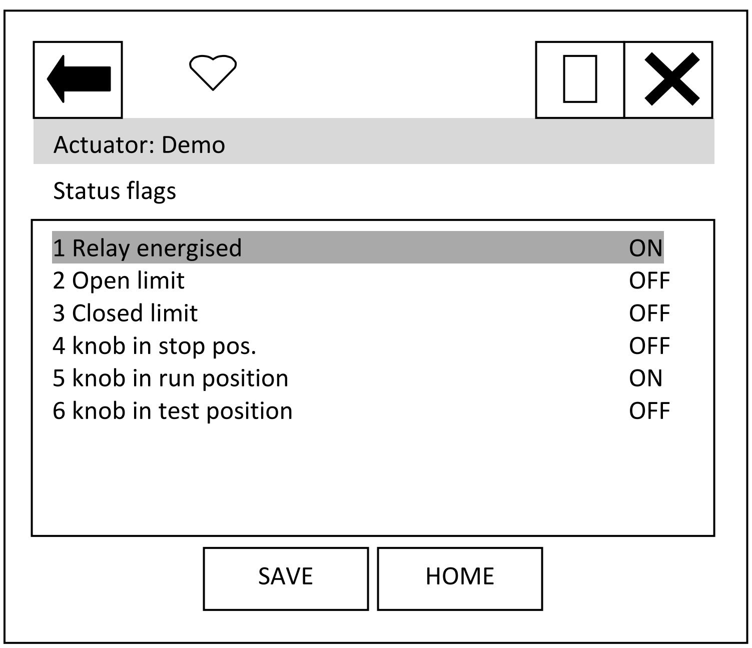
From the top menu, selecting 7 ‘Diagnostics’ will display the following menu:



When the items 1 to 6 are selected, new pages are displayed.

Item 7 ‘Device reset’ will cause a device reset.

Diagnostic: **1 Status flags**



Each item can be selected and viewed.

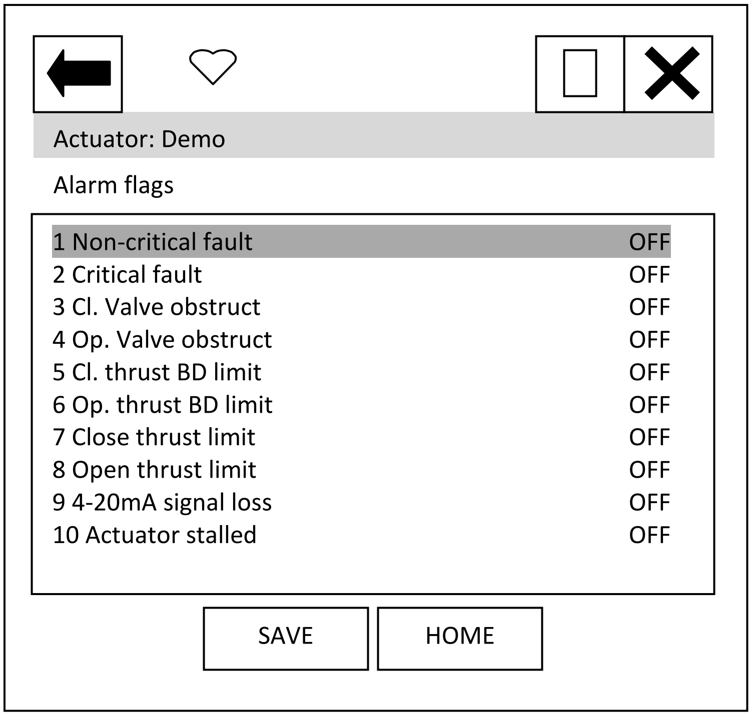
Item 1 ‘Relay energised’ when this item is ‘ON’ it indicates that the CVA is capable of being remotely controlled.

Item 2 ‘Open limit’ indicates if the actuator is at its open limit.

Item 3 ‘Closed limit’ indicates if the actuator is at its close limit.

Items 4-6 indicate the position that the actuator control knob is in.

Diagnostic: **2 Alarm flags**



Each item can be selected and viewed.

Items 1 and 2 indicate if the fault is non-critical or critical.

Items 3 and 4 indicate if the valve is obstructed in the close or open directions.

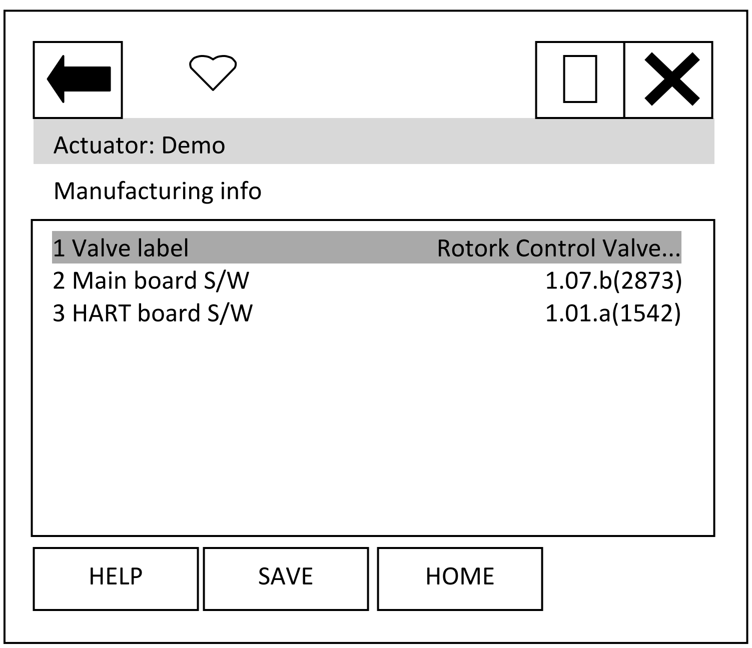
Items 5 and 6 indicate if the close or open back drive thrust limit is reached.

Items 7 and 8 indicate if the close or open back thrust limit is reached.

Item 9 indicates if the 4-20mA signal has been lost. This is unlikely to be seen as loss of signal and will result in the loss of HART communications.

Item 10 indicates if the actuator has stalled.

Diagnostic: **3 Manufacturing info**



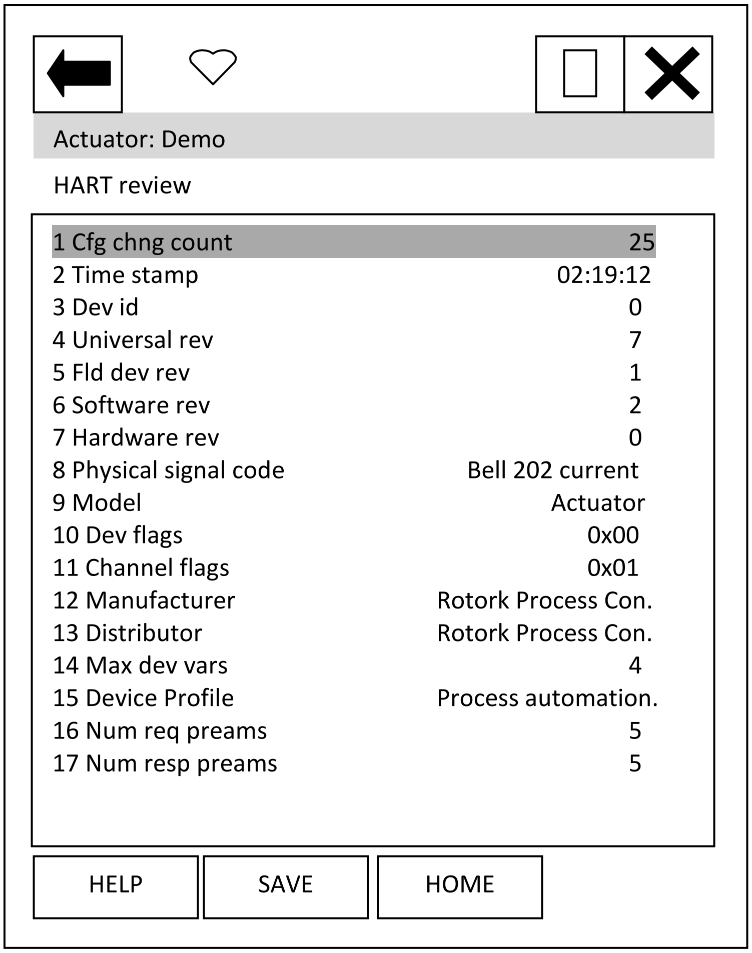
Each item can be selected and viewed.

Item 1 is the valve label.

Item 2 is the CVA main board software version number.

Item 3 is the HART board software version number.

Diagnostic: **4 HART review**



Each item can be selected and viewed.

Item 1 indicates the number of times a configuration change has been made.

Item 2 ‘Time Stamp’ this timer is reset to zero every time the HART device is reset. Every 24 hours it rolls over.

Items 3-7 indicate revisions of the HART device.

Item 8 shows the physical layer code.

Item 9 ‘Model’ indicates the model type for the device – ‘Actuator’.

Items 10 and 11 are HART related flags.

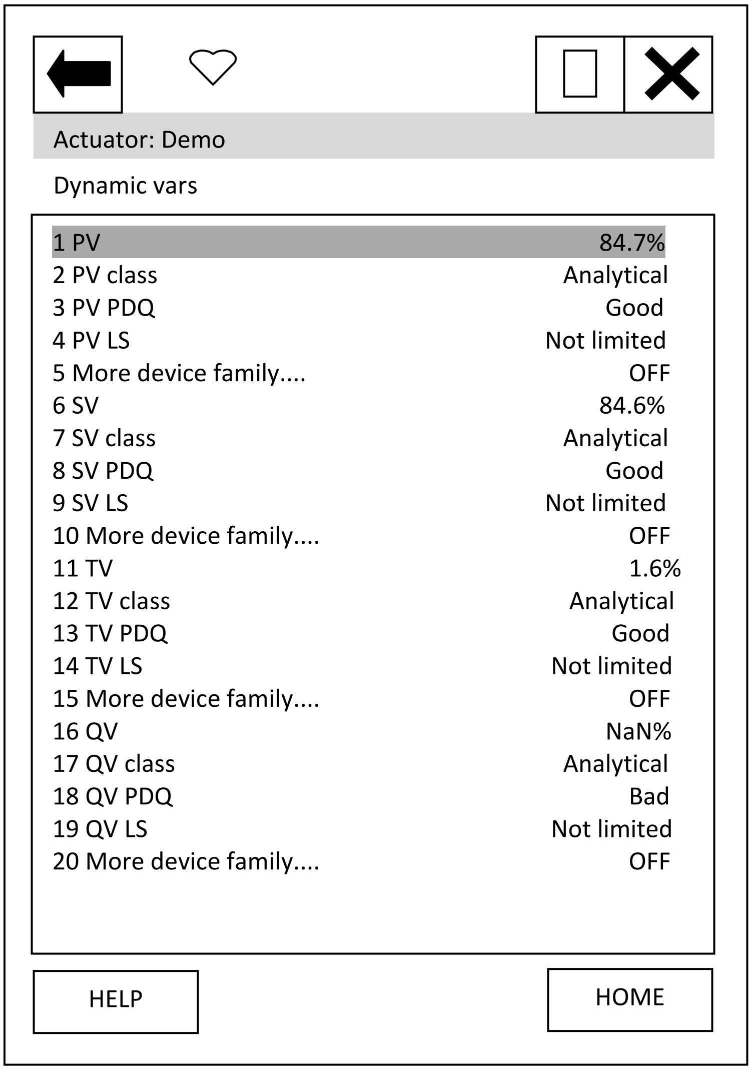
Items 12 and 13 indicate the manufacturer and the distributor of the device.

Item 14 indicates the maximum number of variables on the HART device i.e. PV etc.

Item 15 indicates the device profile.

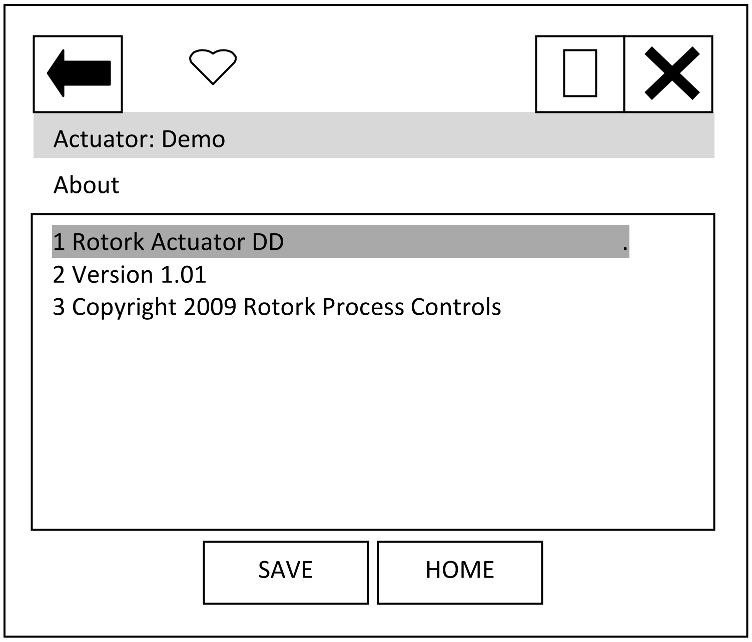
Items 16 and 17 indicate the number of pre-ambles expected for request and response messages.

Diagnostic: **5 Dynamic vars**



This page details information about the dynamic variables. Each item can be selected and viewed.

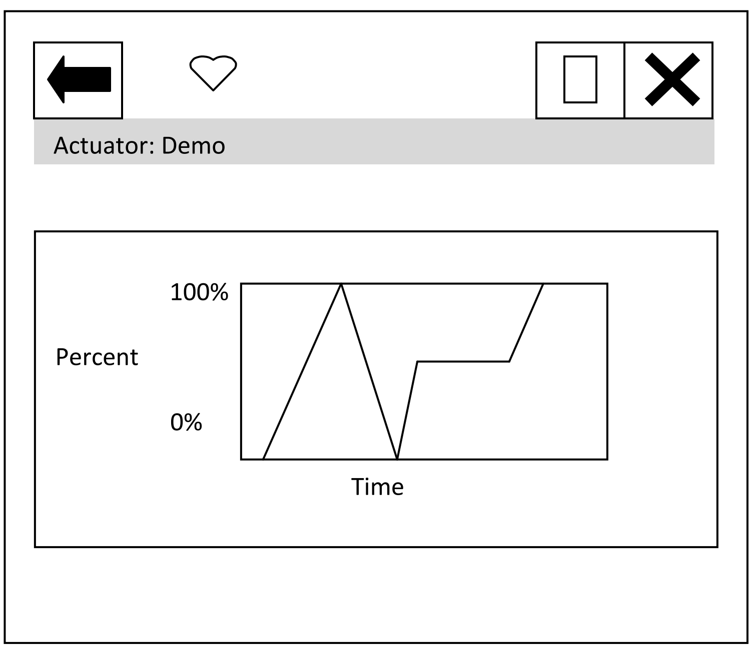
Diagnostic: **6 About**



Device Description About box.

10.5 Pos / Demand chart

From the top menu, selecting 8 ‘Pos./demand chart’ will display the chart of position demand or valve position against time.



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 Default Configuration

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

Appendix 3 Device Identification

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.

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Rotork reserves the right to amend and change specifications without prior notice.

Published data may be subject to change

UK
Rotork PLC

Tel: +44 (0) 1225 733 200
Fax: +44 (0) 1225 333 467
e-mail: mail@rotork.co.uk

USA
Rotork Process Controls

Tel: +1 (414) 461 9200
Fax: +1 (414) 461 1024
e-mail: rpcinfo@rotork.com