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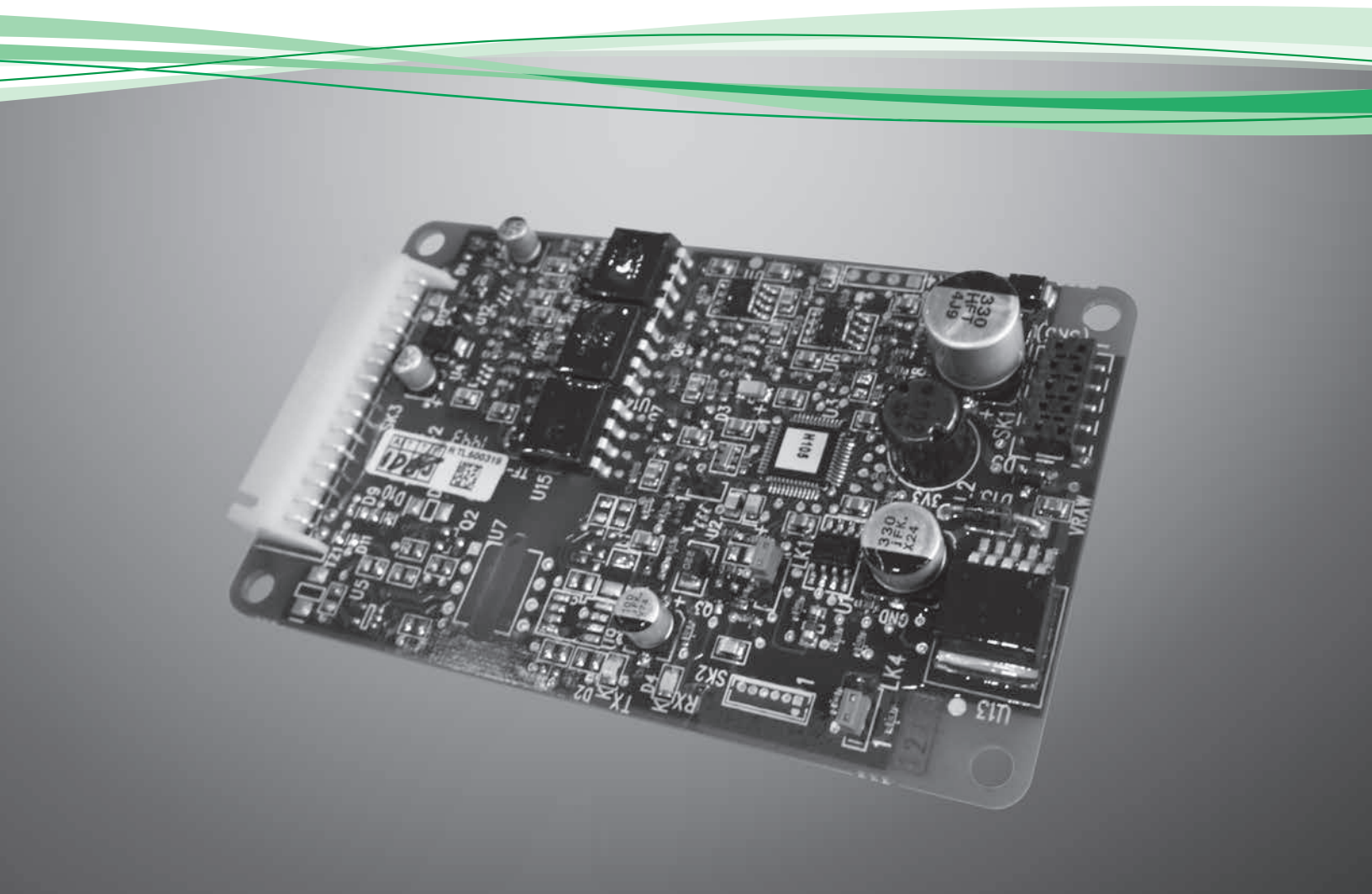
CK range

HART Actuator Field Unit
Technical Manual

HART® COMMUNICATION PROTOCOL



Modular Design Electric Valve Actuators

Note 1:

The information in this manual relates to the following firmware releases:

HART firmware version V105.

HART DD Files versions, Device Revision 2 (DEV_REV 2) and Device Description File revision 3 (DD_REV 3).

CK main Board software version V101 (Control Board) and V102 (HMI).

The manual can be used with other versions, but be aware that there may be differences.

Note 2:

The HART module described in this manual is suitable for inclusion into the Centork Centronik ranges of actuator: CKC (Isolating Duty) and CKRC (Modulating Duty).

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Glossary

Abbreviations

ADC	Analogue to Digital Converter
CKC	Isolating Duty CK actuator
CKRC	Modulating Duty CK actuator
DD	Device Description
DCS	Distributed Control System
DTM	Device Type Manager
FSK	Frequency Shift Keying
HART	Highway Addressable Remote Terminal
HFU	HART Field Unit
PV	Primary Variable
QV	Quaternary Variable
SV	Secondary Variable
TV	Tertiary Variable
URV	Upper Range Value

References

PUB111-004 Centork CK Centronik Start up guide

PUB111-005 Centork CK Centronik full configuration manual

PUB111-006 Centork CK Centronik *Bluetooth*® setting tool manual

PUB111-007 Centork CK Centronik range safe use manual

HART protocol specification version 7

Notes for Centork

There are two models of the Centork that can use the HART Network; The CKC standard duty actuator and the CKRC modulating duty actuator. These two models are interchangeable when talking about HART: this manual refers to both. Centronik is the term applied to a Centork actuator that has an optional electronic control system in it. This is required for HART use.

The Centork/Centronik can be fitted with either a DSM (Digital Switching Mechanism) or a MSM (Mechanical Switching Mechanism). The DSM can report analogue torque values (0-120%) and position (0-100%). The MSM will only report torque as minimum (0%) or maximum (tripped), it does not report any intermediate values. It also only reports position as fully closed, fully open or intermediate (mid-travel).

There is an optional potentiometer that can be fitted to the MSM which allows it to report position (0-100%), which means that the position features can be used, however, this does not include the torque.

The optional potentiometer must be fitted for full HART functionality.

If there is any uncertainty about what the model is, please consult the wiring diagram which will show which option is fitted

Introduction

The Centork 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.

This document 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.

Fig. 1: The Centronik.

1 PRODUCT OVERVIEW

The Centork Actuator HART Field Unit allows communication and control of Centork 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 Centork CKc and CKRC electric actuators. The HFU board is fitted within the actuator electrical housing and forms an integral part of the actuator. 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.

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 made using Centork 'Accent' software for the PC or using the actuator HMI and the Centork setting tool. Accent software can be downloaded from the Centork web site. Some 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 Handheld tools.

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 (end of travel or intermediate positions). Commands to carry out these actions will have come from the HART 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 configuration system, with a handheld tool:

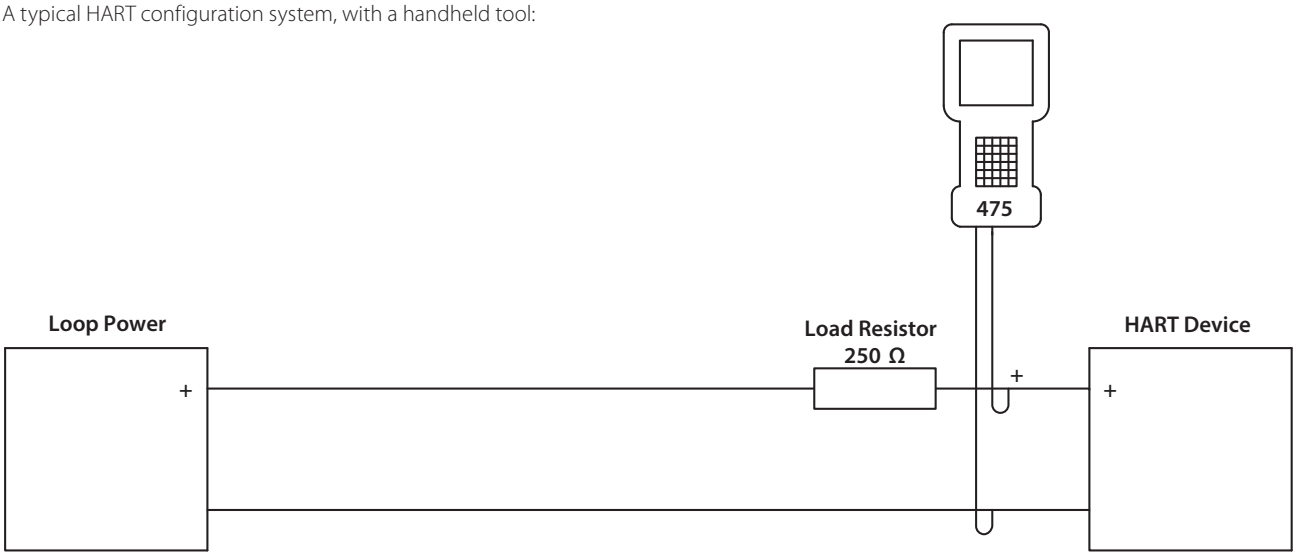
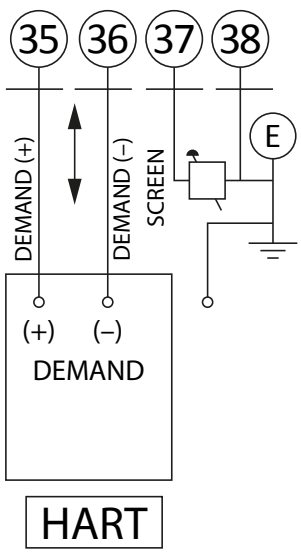


Fig. 2: Typical HART set up with Handheld tool

1.1 Connections and Setup



Network connections are made to the terminals of the actuator as defined in the wiring diagram. Shown here is a typical arrangement used in standard wiring diagrams, in this case HART connections here are made to terminals 35 (+) and 36 (-) of the terminal bung. The wiring diagram should be checked to confirm the correct terminal numbers and to confirm which terminal has positive and which terminal has negative polarity.

General installation and maintenance instructions are found in the relevant actuator manuals PUB111-004 (Centork CK Centronik Start up guide), PUB111-005 (Centork CK Centronik full configuration manual), PUB111-006 (Centork CK Centronik *Bluetooth*® setting tool manual) and PUB111-007 (Centork CK Centronik range safe use manual).

Follow the instructions carefully to attach and setup the actuator, which is achieved using the Centork setting tool. 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 475 or by using a generic DTM.

2 HFU CARD PROPERTIES

2.1 Mechanical Properties

The HFU board is a single printed circuit board which is fitted to the main actuator printed circuit board.

Electrical connection to the network is through SK3, pins 1 and 2.

Electrical connection to the main board is through SK5 (fitted to the underside of the PCB).

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

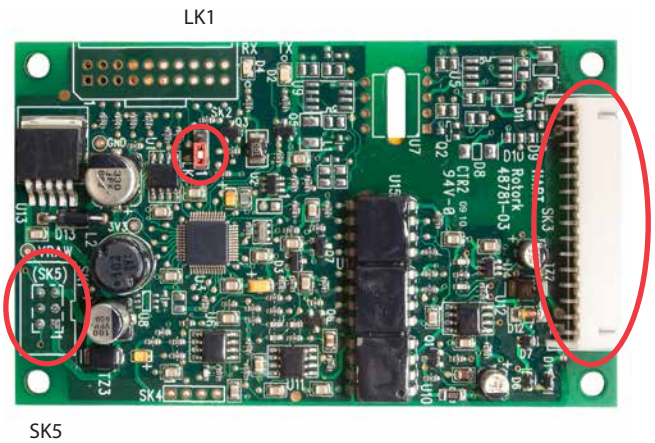


Fig 3 : The HART Field Unit, showing the network connector

2.2 Electrical Properties

The HFU does not sit in the main control path for the actuator and does not affect the actuator control integrity.

The HART fieldbus data highway connections are fully isolated from the actuator electronics.

2.3 Operation and Storage

The HFU is designed to be stored in the actuator and operated within the same environment as the actuator.

The constraints are:

- Operating temperature: -40 °C to +70 °C
- Storage temperature: -50 °C to +85 °C
- Relative Humidity: 5% to 95% (<50 °C) non-condensing

Refer to actuator manuals for environmental range applicable for the particular actuator type.

3 FITTING THE HART OPTION CARD

3.1 Inside a CKc or CKRC Actuator

The HFU is suitable for fitting into CKc actuators with P000.000 and K000.0000 series wiring diagrams and CKRC with P000.1000 and K000.1000 series wiring diagrams. The connections and fitting in a CKRC are the same as the CKc so the following information effectively relates to both actuator types. The HFU is normally located in the first option board slot inside the electrical housing, using Main PCB connection SK2. When fitted with an HFU, the wiring diagram will have a '6' in the 3rd character for example P0**6**0.0000.

The Interface card must be correctly profiled and loaded with the appropriate connectors to match the actuator. The illustration below shows the location of the cards in the Centronik unit.

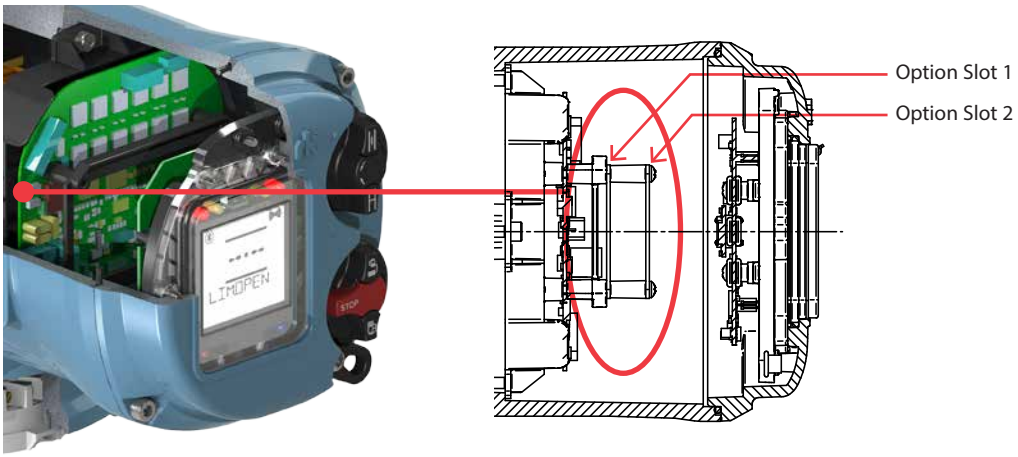


Fig 4: The HART option card located in a Centronik unit.

Within the actuator the remote inputs are always present and are conditioned by the auxiliary mask setting. The HFU can control the 4 Digital Outputs (Relays) on the main actuator card and 4 additional Digital Outputs, if the Extra relay card is fitted into the actuator. The Centronik can accommodate 2 option cards, the second option card fits on top of the first card, as shown above.

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.

4.1 Analogue Control Signal Loss

For a demand input of 4ma down to 2ma (this level is not adjustable), the HART card will send a zero percent, set point command to the Actuator, thus driving it to 0%. If the signal drops below 2ma, after about a short delay (approx 1 sec), the HART card sends a loss of comms indication to the Actuator. This causes the Actuator to starts its Loss of comms timeout timer (this can be set to 0s). When it expires, the configured loss of comms action is initiated. The timeout and action to take are set in the appropriate Actuator settings. if the analogue signal is reapplied (i.e. above 2ma), the actuator will follow the analogue signal again. Signal / Comms loss only applies to the analogue control signal and not the digital signals.

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 Torque

The actuator torque, measured as a percent of rated 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. For the CK this is the same as the Primary Variable.

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 (this is identical to PV)

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 or when an NE107 failure is triggered.
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 or if any of the NE107 diagnostic flags are triggered.
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 Extended Device Status

The functions of the Extended Device Status bits are specified in HCF_SPEC-127. Further details of their implementation are described in Table 5.

Table 5 – Extended Device bits

Bit	Name	Notes
7-6	Unused	Unused
5	NE107 Function Check	This bit is set if the status has occurred and the NE107 Function Check mask is set in the actuator
4	NE107 Out of Specification	This bit is set if the status has occurred and the NE107 Out of Specification mask is set in the actuator
3	NE107 Failure	This bit is set if the status has occurred and the NE107 Failure mask is set in the actuator
2	Critical Power Failure	Unused
1	Device Variable Alert	Unused
0	NE107 Maintenance Required	This bit is set if the status has occurred and the NE107 Maintenance Required mask is set in the actuator

6.3 Command 48 Additional Device Status

Command 48 returns up to 6 bytes of device-specific data. The meaning of the bits in bytes is defined in Table 6.

Bytes 0-3 are for errors only, and are continually updated. Accordingly, if any of these bits are set and the appropriate Namur mask bit is also set to a category (see section Setup: NE107 Setup), the More Status Available bit (bit 4) of the Field Device Status is set; if all of these error bits are clear (zero), then the More Status Available Bit will be clear too.

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.

Bytes 4-5 are status bits which are useful for diagnostic purposes, these bits being set will **not** cause the More Status Available bit (bit 4) of the Field Device Status to be set.

The More Status Available bit can 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.

Table 6 – Alarm status bits

Byte	Bit	Meaning
0	0	reserved
	1	Local Control Fault
	2	Power Fault
	3	Thermostat Tripped
	4	reserved
	5	reserved
	6	Hi Hi Trip Service Alarm (Hi Hi Torque level exceeded)
	7	Hi Trip Service Alarm (Hi Torque level exceeded)
1	0	Valve Error
	1	reserved
	2	Monitor Relay
	3	Control Fail
	4	Actuator Fail
	5	Communications Fail
	6	Hardware Option Fail
	7	Partial Stroke Error
2	0	reserved
	1	Actuator Stalled
	2	DSM Service Required
	3	End of Travel Timer (expired)
	4	Fieldbus Fault
	5	24VDC Customer Supply Fail
	6	reserved
	7	Wrong Direction
3	0-7	Reserved
4	0	Output Moving
	1	Close Limit Switch active
	2	Open Limit Switch active
	3	Moving Closed
	4	Moving Open
	5	Remote Control mode
	6	Local Stop
	7	Local Control Mode
5	0	Hand Operation
	1	Partial Stroke (in progress)
	2	Main board communications loss
	3	Reserved
	4	Digital input 1 status
	5	Digital input 2 status
	6	Digital input 3 status
	7	Digital input 4 status

7 UNIVERSAL COMMANDS

The universal commands are supported as listed below, for example: command 3 returns the loop current and all four Dynamic Variables with their unit code, for a total of 24 bytes of response data.

Table 7 – Universal command list

Command	Description
0	Read Unique Identifier
1	Read Primary Value
2	Read PV Current and percentage of range
3	Read dynamic variable and PV current
4	Reserved
5	Reserved
6	Write polling address
7	Read loop configuration
8	Read dynamic variable class
9	Read device variables with status
10	Reserved
11	Read unique identifier associated with tag
12	Read message
13	Read tag, descriptor and date
14	Read primary variable transducer information
15	Read Device Information
16	Read final assembly number
17	Write message
18	Write tag, descriptor and 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

8 COMMON-PRACTICE COMMANDS

8.1 Supported Commands

The following common-practice commands are implemented:

Table 8 – Supported common practice commands

34	Write Primary Variable Damping Values
35	Write Primary Variable Range Values
40	Enter/Exit Fixed Current Mode
42	Perform Device Reset (HART option card only)
45	Trim Loop Current Zero
46	Trim Loop Current Gain
49	Write Primary Variable Transducer Serial Number
79	Write Device Variable
523	Read Condensed Status Mapping Array
524	Write Condensed Status Mapping Array
525	Reset Condensed Status Map
526	Write status simulation mode
527	Simulate status bit

Command 34 (Write Primary Variable Damping Value) accepts a damping value of up to 250 s.

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. Refer to the HART specification for more details. For this function, the request bytes are as follows:

Byte	Format	Description
0	U8	Device variable code = 01 (demand)
1	U8	Write variable command code: 0 = normal mode (control by analogue), 1 = fixed value – you have to put this back to 0 to return to normal analogue control.
2	Enum	Units code, for % = 57dec (39hex)
3-6	Float	Floating point number representing 0.00% to 100.00% For example: 0% = 00 00 00 00 25% = 41 C8 00 00 hex 50% = 42 48 00 00 hex 75% = 42 96 00 00 hex 100% = 42 C8 00 00 hex
7	Bits	Device Variable Status

Once you have enabled control via command 79, you can check it is under control of this digital command by reading the control mode using command 133, it is also possible to revert back to analogue control use command 132. For details of these 2 commands see sections later in this document.

Command 523 (Read Condensed Status Mapping Array) Reads the status for the indexes 0-63.

Command 524 (Write Condensed Status Mapping Array) only supports writing to indexes 8-39 inclusive.

Command 525 (Write Status Simulation mode) Sets the device into simulation mode.

Command 526 (Simulate Status Bit) allows the indexes 8-39 inclusive to be written and simulated.

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 9 – Device-specific commands

128	Read Software Version
131	Read Current Zero & Span
132	Command digitally – for multi-drop HART applications
133	Read Control mode
134	Write Relay control

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: "vMmm+(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
0-11	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 132 Control digitally

Enables the actuator to be controlled with a digital input.

Request Data Bytes

Byte	Format	Description
0	Unsigned 8bit	ACTCON register (see below)

Response Data Bytes

Byte	Format	Description
0	Unsigned 8bit	ACTCON register (see below)

Table 10 – ACTCON Register

Bit	Command	Description
0	Stop	This will Stop the actuator
1	Close	This will operate the actuator in the close direction
2	Open	This will operate the actuator in the open direction
3	ESD	This will cause the actuator to ESD
4	Partial stroke	This will initiate a partial stroke test
5	Force Digital Position	This bit must be set to allow digital control bits above to operate the actuator. It **must** be reset once digital control is no longer required. The reset of this bit could cause movement of the actuator if the demand current is not the equal to the present position.

For example a value of 0x22 will sent the actuator closed. To reset back to analogue control send 0x00.

9.4 Command 133 HART Control Mode

Reads the present control mode of the HART board.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
1	Enum	HART control mode enumeration – see Table 11.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
2	Error	Invalid poll address selection
5	Error	Too few data bytes received
6	Error	Transmitter specific command error
73	Error	Incorrect function response

The response is an enumerated value indicating the mode of control see Table 11.

Table 11 – HART control mode enumeration Register

Mode		
Value	**Mode**	**Comment**
0	AI Control	This is the normal operating mode in which the actuator responds to changes in value of the 4-20mA analogue input.
1	Digital Position	This mode is entered and exited using command 79. The actuator enters this mode when the primary variable is put into forced mode. The actuator will respond to the forced primary value. It leaves this mode when the primary value is returned to normal. When in this mode the primary variable returns a NaN value.
2	Digital position within factory limits.	This mode is entered and exited using command 79. The actuator enters this mode when the quaternary variable is put into forced mode. The actuator will respond to the forced quaternary value. It leaves this mode when the quaternary value is returned to normal. In this mode the primary value returns a NaN value.
3	Discrete	This mode is entered and exited using command 132. When in this mode the actuator responds to the commands issued using command 132. When in this mode the primary variable returns a NaN value.

9.5 Command 134 Write Relay Control

This command can be used to digitally control the relays within the actuator using the transmitted data. CK actuators are fitted with relays 1-4 as standard, 5 to 8 are optional extras – refer to the wiring diagram to check how many are fitted. Relays 9 to 16 are not available on the CK range.

The relays need to be set up as the function 'Digital output' in the actuator (DIGIT.OUT on the actuator menu).

Request Data Bytes

Byte	Format	Description
1	Unsigned-8	Set Relays register Low (see Table 12)
2	Unsigned-8	Set Relays register High (see Table 12)
3	Unsigned-8	Reset Relays register Low (see Table 12)
4	Unsigned-8	Reset Relays register High (see Table 12)

Response Data Bytes

Byte	Format	Description
1	Unsigned-8	Set Relays register Low
2	Unsigned-8	Set Relays register High
3	Unsigned-8	Reset Relays register Low
4	Unsigned-8	Reset Relays register High

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 bytes
6-72		Undefined
73	Error	Incorrect function response
74	Error	Invalid Data
75	Error	Wrong number of data bytes

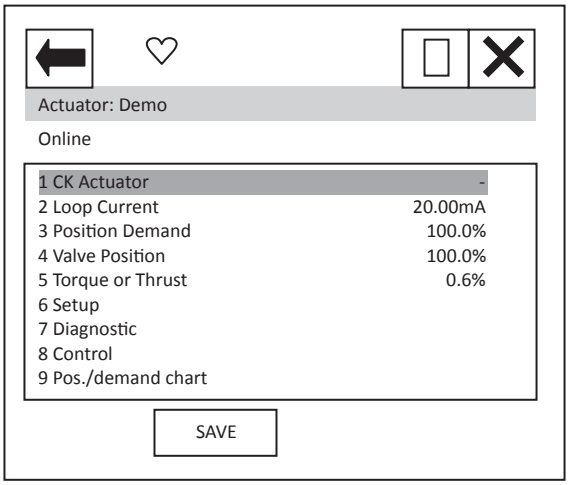
Table 12 – HART Relay control Register

Relay Control Data		
Byte No.	**Function**	**Comment**
1	Set Relays 1-8	Setting one of these bits will cause the corresponding relay to be set as long as the same bit is not set in the Reset relay data. (Note that the relay must be set for digital control in the actuator).
2	Set Relays 9-16	Not Available.
3	Reset Relays 1-8	Setting one of these bits will cause the corresponding relay to be reset as long as the same bit is not set in the Set relay data. (Note that the relay must be set for digital control in the actuator).
4	Reset Relays 9-16	Not Available.

10 DD FILE, EMERSON HANDHELD TOOLS SCREEN SHOTS

The DD file describes the HART device. There are 2 sets of DD files available; for use by a DCS and for use by the Emerson handheld tools. The following pages show screen shots from the Emerson handheld tools, indicating the data and functions that can be accessed using the DD files. Also shown are views likely to be seen using the DCS.

10.1 Top Menu



When the items 2 to 5 are selected, the display changes to show the data selected.

Item 1 'CK Actuator' indicates the type of actuator.

Item 2 'Loop current' displays the instantaneous value of the current, as measured by the HFU.

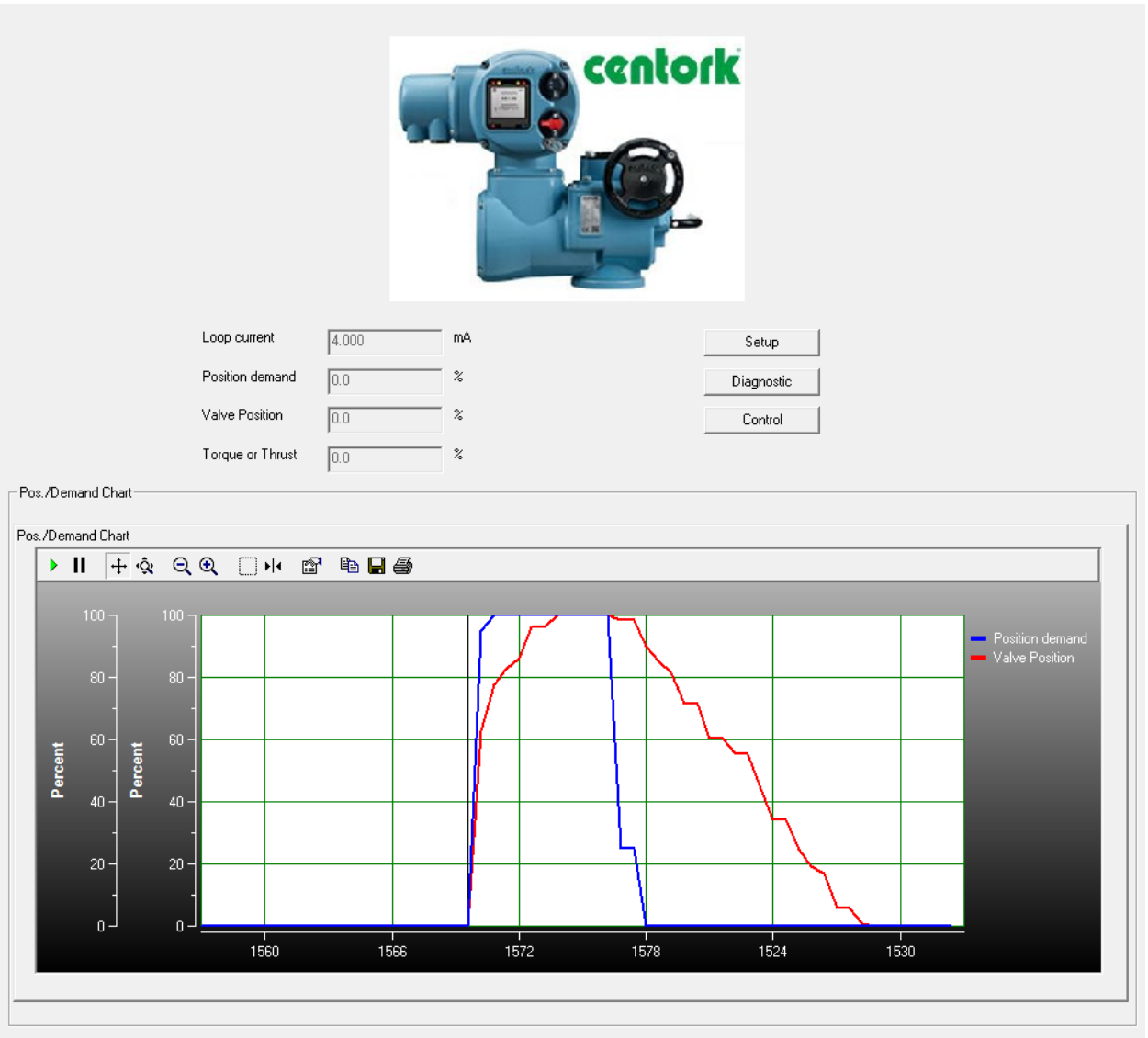
Item 3 'Position demand' displays the percent (%) demand that the current is representing.

Item 4 'Valve position' displays the valve position.

Item 5 'Torque or Thrust' displays the torque or thrust present at the output of the actuator.

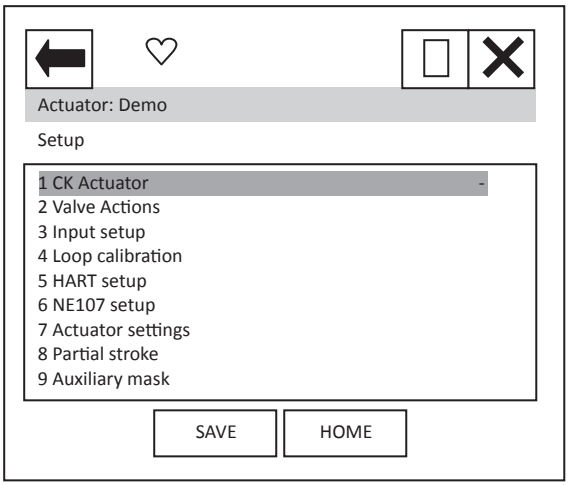
Selection of items 6 to 9 will bring up new menus, detailed in the following sections.

View of **Top Menu** within DCS:



10.2 Setup

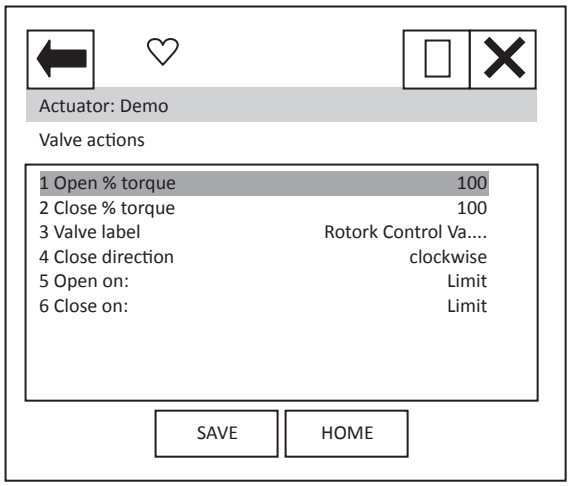
From the top menu, selecting 'Setup' will display the following menu:



Item 1 'CK Actuator' indicates the type of actuator.

When the items 2 to 9 are selected, new pages are displayed.

Setup: **Valve actions**



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

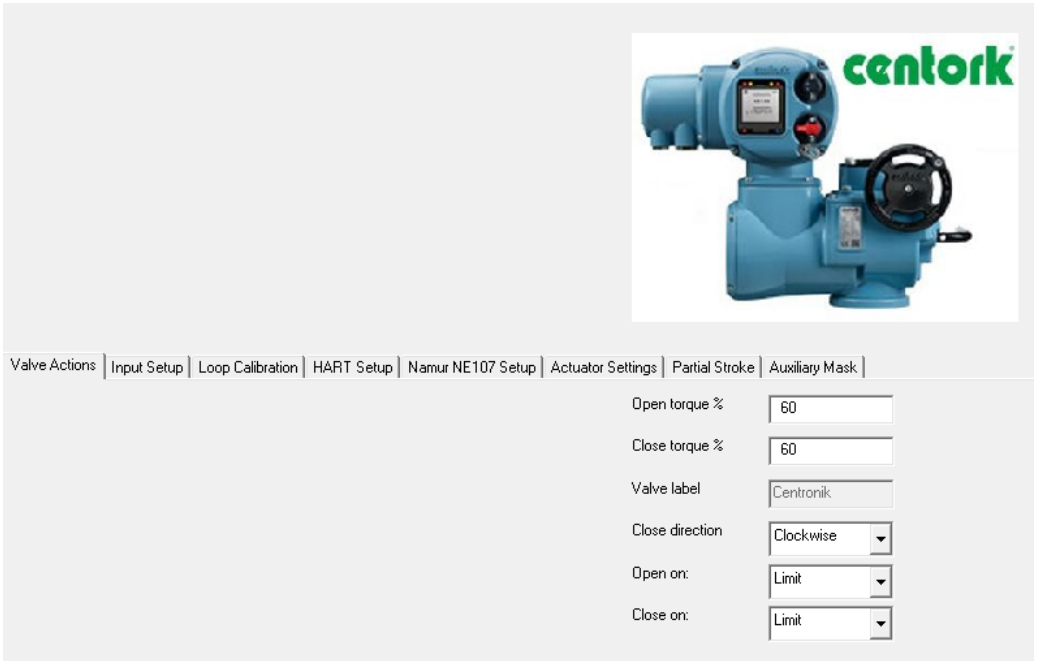
Items 1 and 2 Open and Close torque; can be modified between 40 and 100%.

Item 3 cannot be modified.

Item 4 can be modified between clockwise or anti-clockwise.

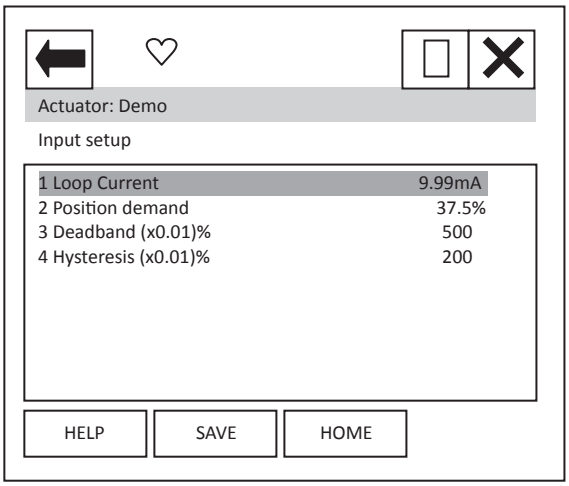
Items 5 and 6 can be modified between Limit and Torque

View of **Valve Actions** tab within DCS:



DD File, Emerson Handheld Tools Screen Shots

Setup: **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.

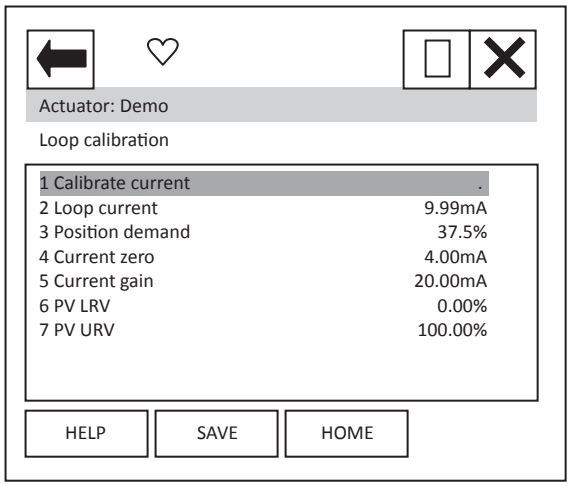
Item 2 'Position demand' displays the % demand that the current input signal is representing.

Item 3 'Deadband' – displays the deadband applied to the demand signal; can be modified between the range 0 (0%) and 1500 (15.00%) in 0.01% increments.

Item 4 'Hysteresis' – displays the hysteresis applied to the demand signal; can be modified between the range 0 (0%) and 1500 (15.00%) in 0.01% increments.

View of **Input Setup** tab within DCS:

Setup: **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.

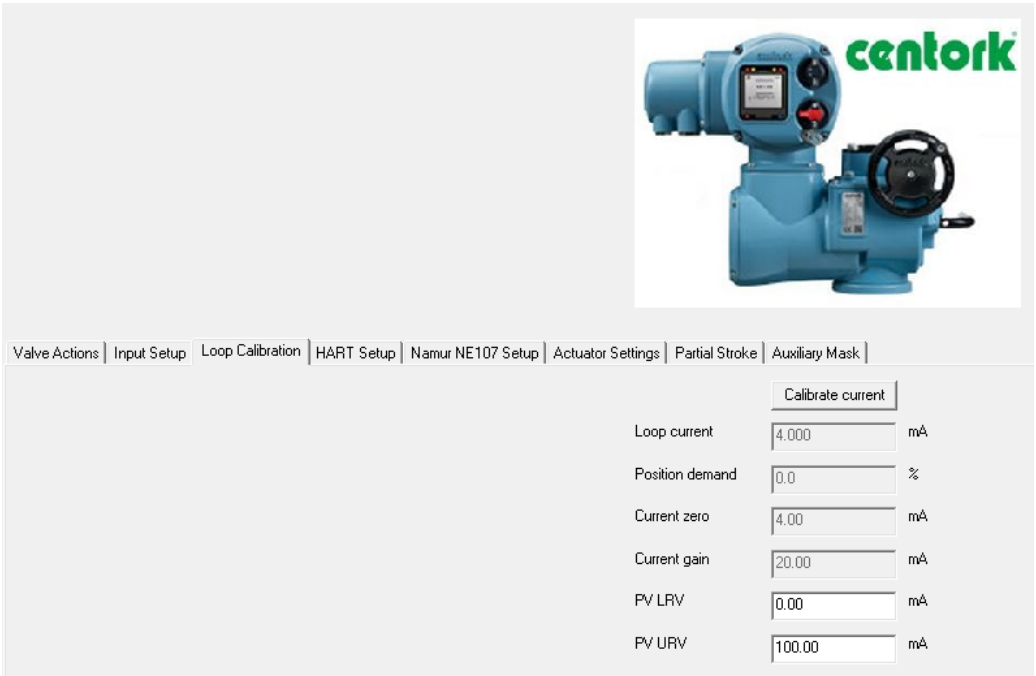
Item 4 'Current zero' displays current zero setting; not modifiable.

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.

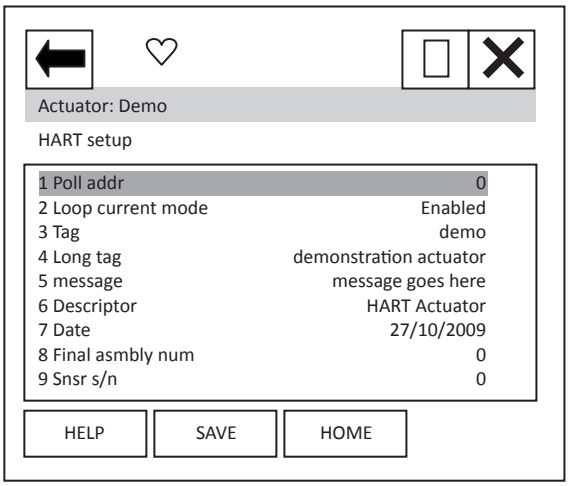
Item 7 'PV URV' shows the HART Primary Value Upper Range Value; can be modified.

View of **Loop Calibration** tab within DCS:



DD File, Emerson Handheld Tools Screen Shots

Setup: **HART setup**



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

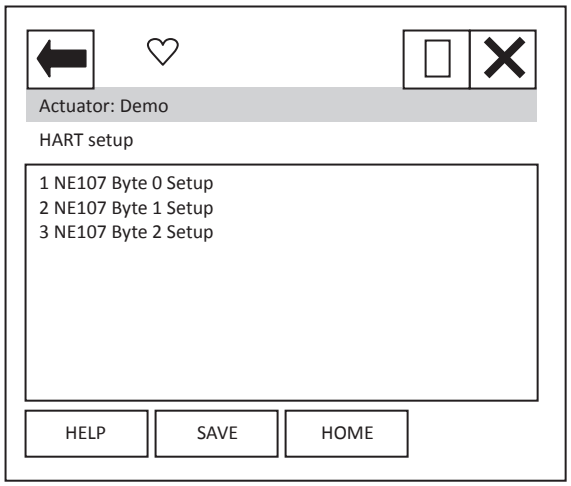
Item 1 'Poll addr' displays the HART address of the device; can be changed in the range 0-63.

Item 2 'Loop current mode' can be enabled or disabled. When disabled the actuator will not position to the analogue signal, but the unit can be commanded to a position via command 79 – see section 8. Care should be taken when changing to disabled as the actuator may move.

Items 3 to 9 are all text fields that can be modified by the user.

View of **HART Setup** tab within DCS:

Setup: **NE107 Setup**



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

These 3 pages are used to set up which alarms bits will cause the NE107 status bits to be set. For each bit listed in Table 13, the user is able to select one of the following actions:

1. No effect – default
2. **Maintenance required**
3. Reserved
4. **Failure**
5. **Out Of Spec.**
6. **Function Check**
7. Not defined
8. Reserved

The 4 actions highlighted are the NE107 status bits.

View of **NE107 Setup** tab within DCS:

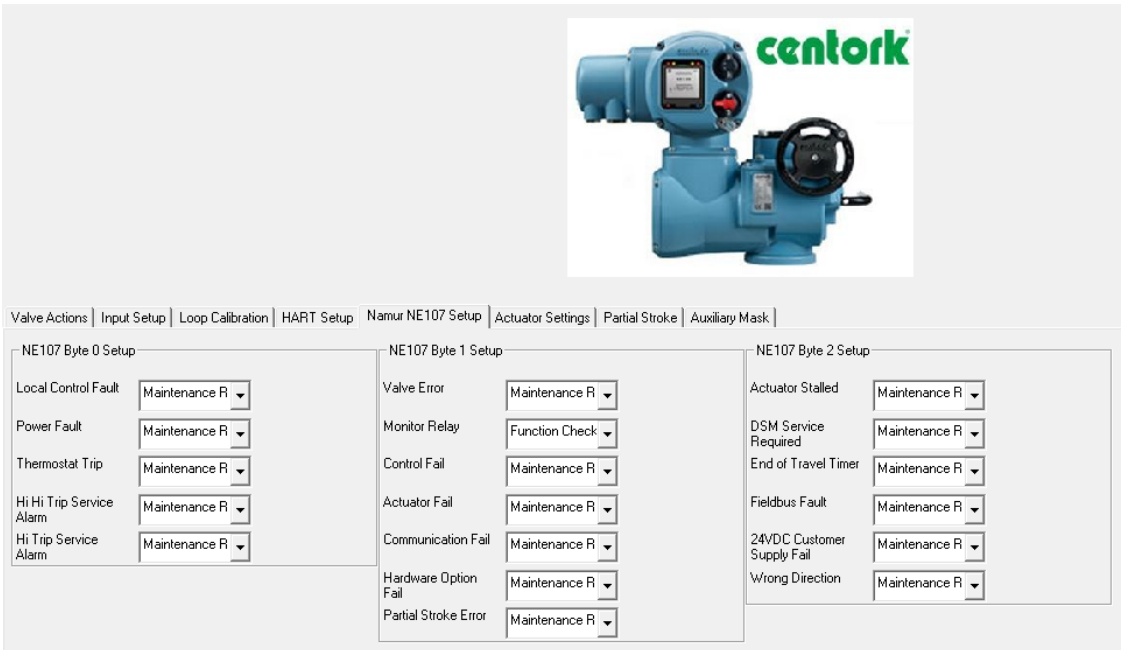


Table 13 – NE107 Diagnostics Bits, Set up

	Bit	Description
Byte 0 Setup	1	reserved
	2	Local Control Fault
	3	Power Fault
	4	Thermostat Tripped
	5	reserved
	6	reserved
	7	Hi Hi Trip Service Alarm (Hi Hi Torque level exceeded)
	8	Hi Trip Service Alarm (Hi Torque level exceeded)
Byte 1 Setup	1	Valve Error
	2	reserved
	3	Monitor Relay
	4	Control Fail
	5	Actuator Fail
	6	Communications Fail
	7	Hardware Option Fail
	8	Partial Stroke Error
Byte 2 Setup	1	reserved
	2	Actuator Stalled
	3	DSM Service Required
	4	End of Travel Timer (expired)
	5	Fieldbus Fault
	6	24VDC Customer Supply Fail
	7	reserved
	8	Wrong Direction

For example: A user requires NE107 Failure indication for faults within the actuator positioner and in the local controls, but treats the actuator being in Local, valve obstructed or High torque as requiring someone to go and check the device. If the thermostat trips the user would like an Out of spec alarm to be raised as the device is being used out of its specification and finally for Hi Hi torque the user wants to call in maintenance. For this set up, the following set up would apply:

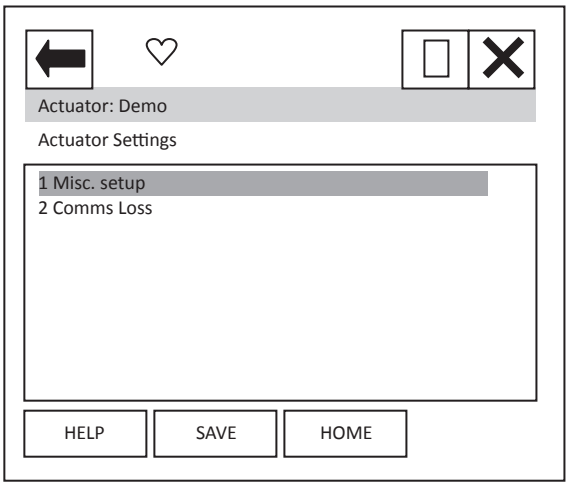
Table 14 – NE107 Diagnostics Bits, Example set up

	Description	Action
Byte 0 Setup	reserved	No effect
	Local Control Fault	**Failure**
	Power Fault	No effect
	Thermostat Tripped	**Out of Spec**
	reserved	No effect
	reserved	No effect
	Hi Hi Trip Service Alarm (Hi Hi Torque level exceeded)	**Maintenance**
	Hi Trip Service Alarm (Hi Torque level exceeded)	**Function Check**
Byte 1 Setup	Valve Error	**Function Check**
	reserved	No effect
	Monitor relay	**Function Check**
	Control Fail	No effect
	Actuator Fail	No effect
	Communications Fail	No effect
	Hardware Option Fail	No effect
	Partial Stroke Error	No effect
Byte 2 Setup	reserved	No effect
	Actuator Stalled	No effect
	DSM Service Required	**Failure**
	End of Travel Timer (expired)	No effect
	Fieldbus Fault	No effect
	24VDC Customer Supply Fail	No effect
	reserved	No effect
	Wrong Direction	No effect

With these settings the bits defined in the Diagnostics page condensed data (see later) will be set if one of the enabled bits above is set i.e. NE107 Failure will be ON if either there is a local control fault OR an actuator positioner fault.

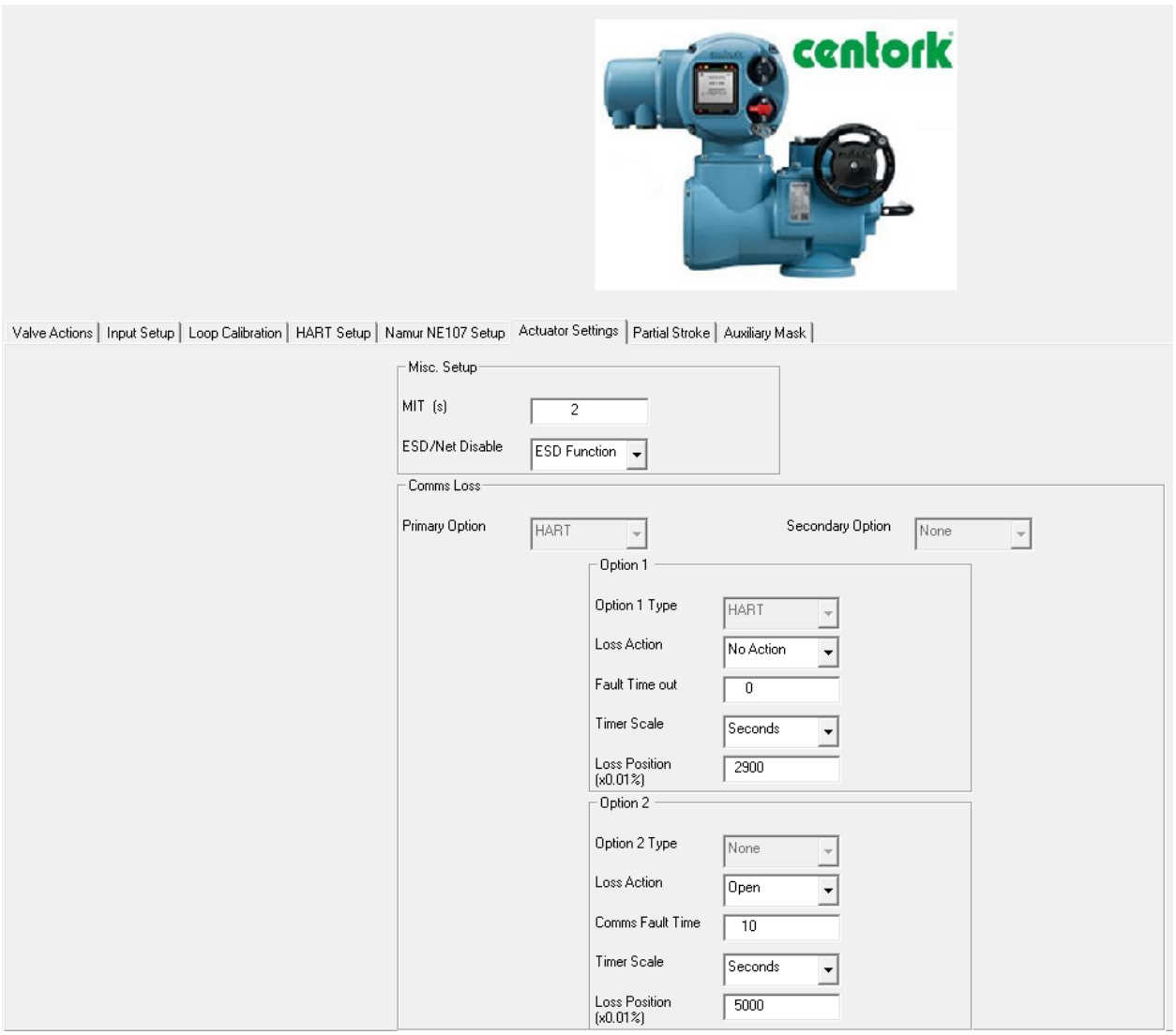
DD File, Emerson Handheld Tools Screen Shots

Setup: **Actuator Settings**

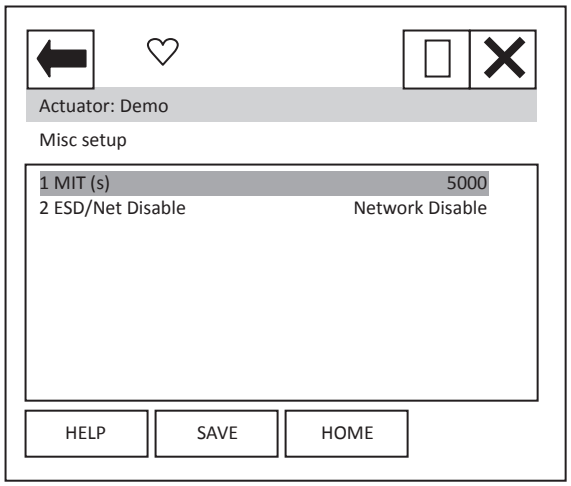


When the items 1 to 2 are selected, new pages are displayed.

View of **Actuator Settings** tab within DCS:



Setup: **Actuator Settings, Misc setup**



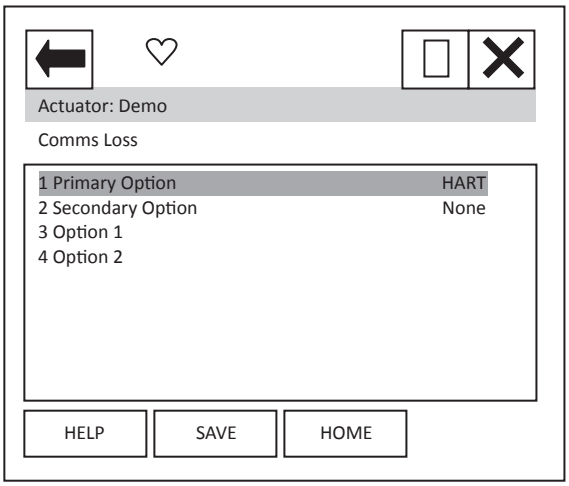
Each item can be selected, viewed, and modified where appropriate.

Item 1 'MIT' displays the Motion Inhibit Timer used in positioning, can be modified between 0 and 255seconds, **the scale is milli seconds** therefore 5000 is 5 seconds.

Item 2 'ESD/Net Disable' displays the function setting for the ESD auxiliary input. Can be set to either the ESD function OR to operate as a network command disable signal.

DD File, Emerson Handheld Tools Screen Shots

Setup: **Actuator Settings, Comms Loss**

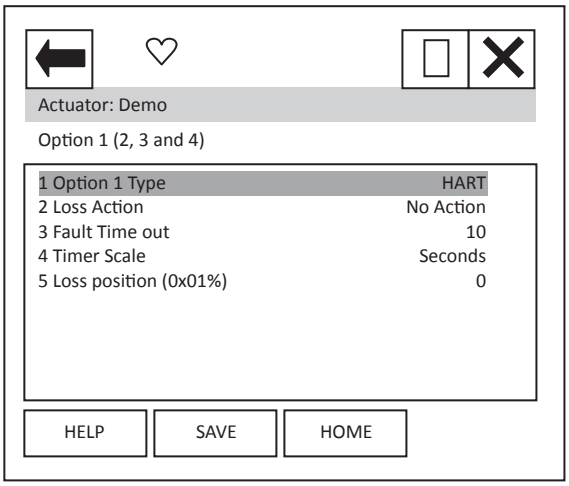


Item 1 'Primary Option' shows the option card that has been selected as source 1 in the CK menu.

Item 2 'Secondary Option' shows the option card that has been selected as source 2 in the CK menu.

When the items 3 to 4 are selected, new pages are displayed to show the Comms loss settings of the option cards fitted. The CK can have up to 2 option cards fitted. It should be noted that only the card that is in control, as defined by the control source selection parameter in the CK, will cause the action to be taken on loss of signal.

Setup: **Actuator Settings, Comms Loss (Option 1 and 2)**



Item 1 'Option 1 Type' shows the option card that is listed as option 1 in the CK options fitted menu.

Item 2 'Loss Action' enables the loss of 4-20mA signal action to be set up. Choices are No Action, Open, Close, Stop and Position.

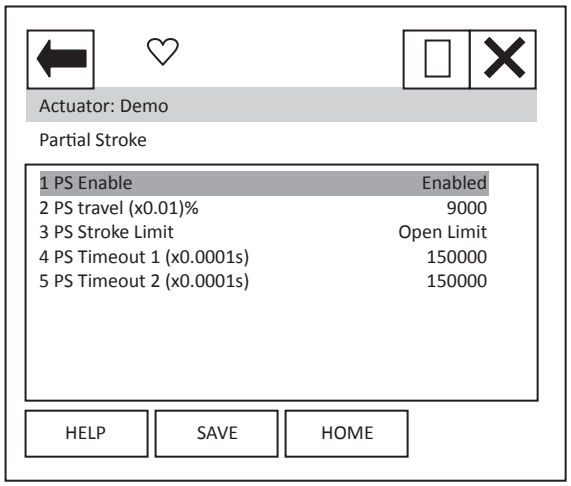
Item 3 'Fault Time out' enables the timeout for the action to be taken on loss of 4-20mA signal to be set up. Range dependent on item 4.

Item 4 'Timer Scale' enables the timeout scale to be set to either Seconds or milli-Seconds.

Item 4 'Loss Position' enables the position value to be entered, for use when the Loss Action of 'Position' has been selected.
Range is 0.00 to 100.00%.

The menu for Option 2 is identical.

Setup: **Partial Stroke**



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

Item 1 'PS Enable' enables the Partial Stroke feature to be enabled and disabled.

Item 2 'PS travel (x0.01)%' enables the position to which the unit will travel on activation of a partial stroke command to be set up. Range is 0-100% in 0.01% steps.

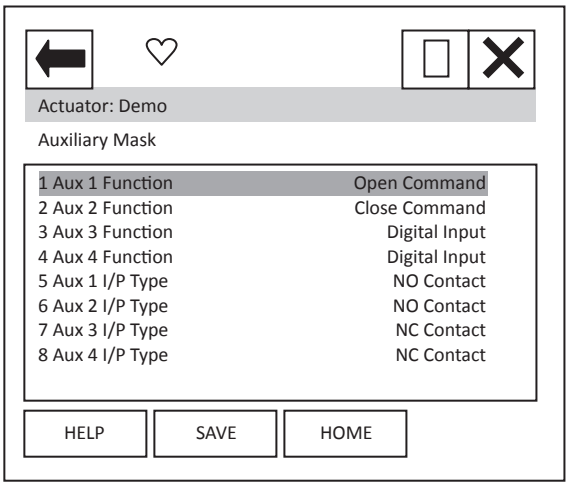
Item 3 'PS Stroke Limit' enables the position of the actuator from which the partial stroke command can be activated to be set up. Either the open or the close limit.

Item 4 and 5 'PS Timeout 1/2 (x0.0001s)' enables the timeout for reaching the position (Timeout 1) then returning to the limit (Timeout 2) to be set up.

View of **Partial Stroke** tab within DCS:

DD File, Emerson Handheld Tools Screen Shots

Setup: **Auxiliary Mask**

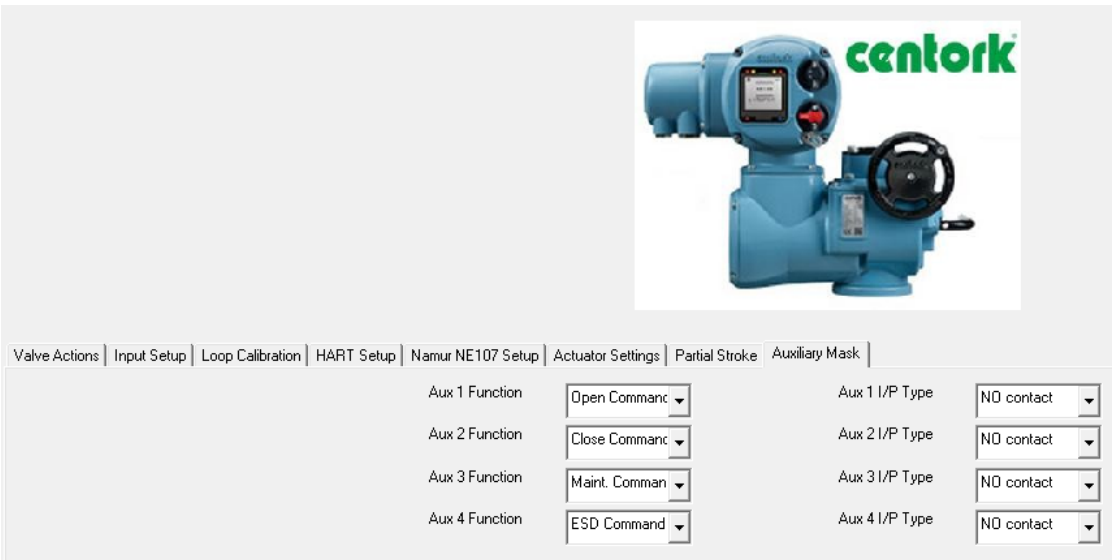


Each item can be selected, viewed, and modified where appropriate.

Items 1 to 4 'Aux 1/2/3/4 Function' enables the function of the Auxiliary inputs to be set up. Either to be a digital input or to a command

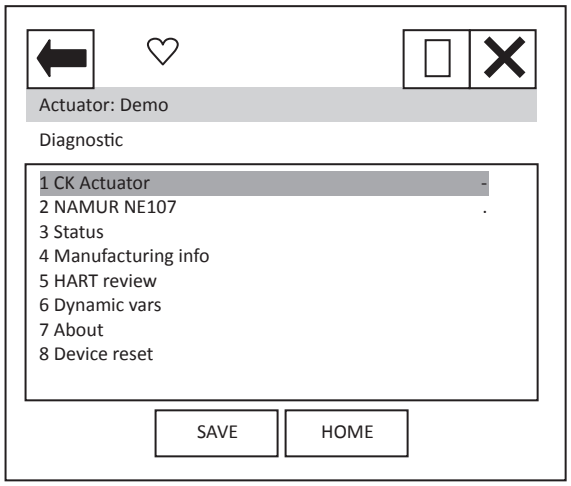
Items 8 to 8 'Aux 1/2/3/4 I/P Type' enables the contact type of the Auxiliary inputs to be set up. Either NO (Normally Open) of NC (Normally Closed).

View of **Auxiliary Mask** tab within DCS:



10.3 Diagnostics

From the top menu, selecting 'Diagnostics' will display the following menu:

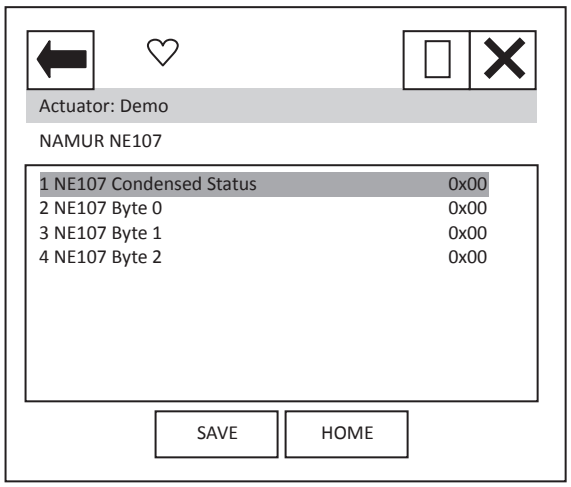


Item 1 'CK Actuator' indicates the type of actuator

When the items 2 to 7 are selected, new pages are displayed.

Item 8 'Device reset' will cause a device reset (HART option card only).

Diagnostic: **NAMUR NE107**

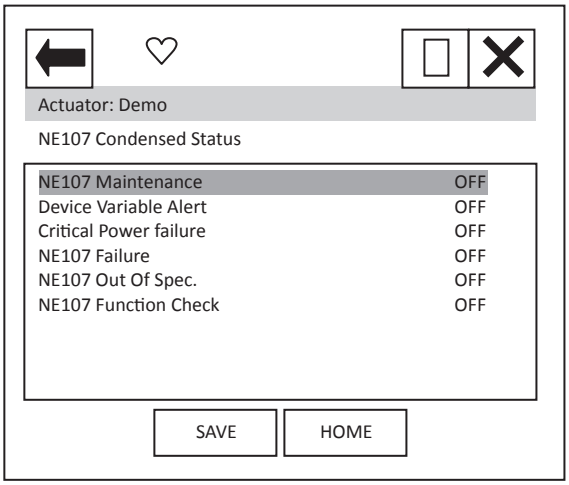


When the items 1 to 4 are selected, new pages are displayed.

Items 2 to 4 select pages which are identical to Status NE107 Alarm Status 0 to 2 – see status section.

DD File, Emerson Handheld Tools Screen Shots

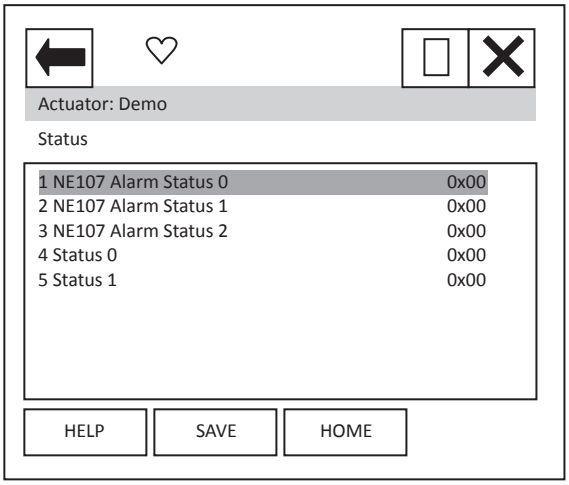
Diagnostic: **NAMUR NE107, NE107 Condensed Status**



These items indicate the status of the alarms bits.

The NE107 bits will be set as 'ON', if one of the alarm bits, that has been associated to the alarm in the NE107 setup section, has activated.

Diagnostic: **Status**

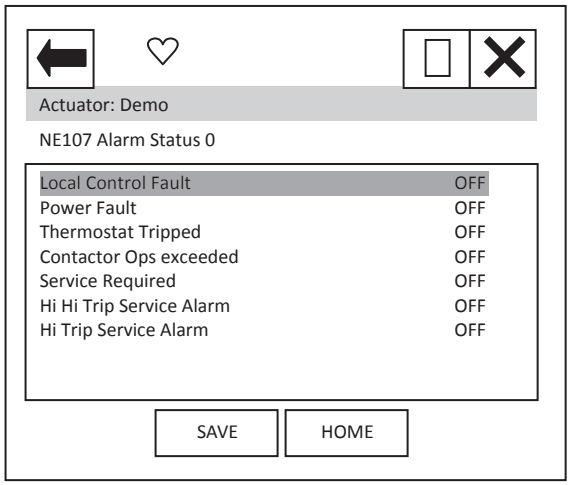


When the items 1 to 5 are selected, new pages are displayed.

The NE107 items show the status of the alarms bits that are associated to the NE107 diagnostics function.

Status 0 and 1 are status indication bits.

Diagnostic: **Status, NE107 Alarm Status 0**



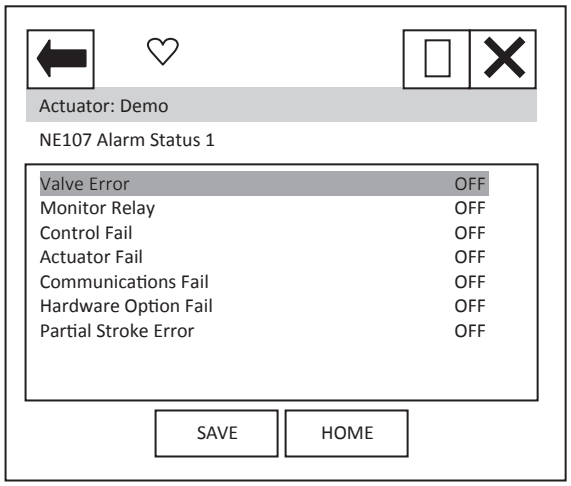
'Local Control Fault' indicates that there is a fault in the actuator's local controls.

'Power Fault' indicates that there is a fault in the actuator's power supply.

'Thermostat tripped' indicates that the actuators motor thermostat has tripped.

'Hi Hi Trip Service Alarm' and 'Hi Trip Service Alarm' indicates that the levels set for the Hi Hi and Hi torque levels have been exceeded.

Diagnostic: **Status, NE107 Alarm Status 1**



'Valve Error indicates that the actuator has tripped/stopped on torque due to an obstruction in the valve.

'Monitor relay' indicates that the actuator monitor relay has tripped – see actuator manual for details.

'Control fail' and 'Actuator Fail' indicates that the actuator has experienced a control or actuator failure.

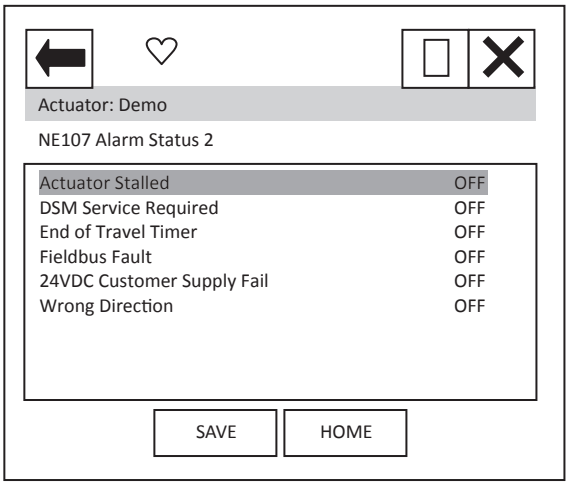
'Communications Fail' indicates that the network card is not able to communicate on the network.

'Hardware Option Fail' indicates a problem with the option card.

'Partial Stroke Error' indicates a failure in the partial stroke test.

DD File, Emerson Handheld Tools Screen Shots

Diagnostic: **Status, NE107 Alarm Status 2**



'Actuator stalled' indicates that the actuator has stalled.

'DSM Service Required' indicates a fault in the Digital Switch Mechanism.

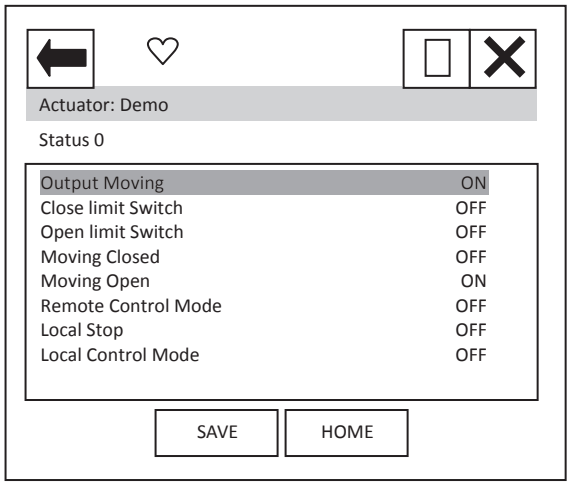
'End of Travel Timer' indicates that there has been excessive travel beyond a limit.

'Fieldbus Fault' indicates a fault with the network card.

'24VDC Customer Supply Fail' indicates a fault with the supply available to the customer.

'Wrong Direction' indicates that the actuator has operated in the incorrect direction.

Diagnostic: **Status, Status0**



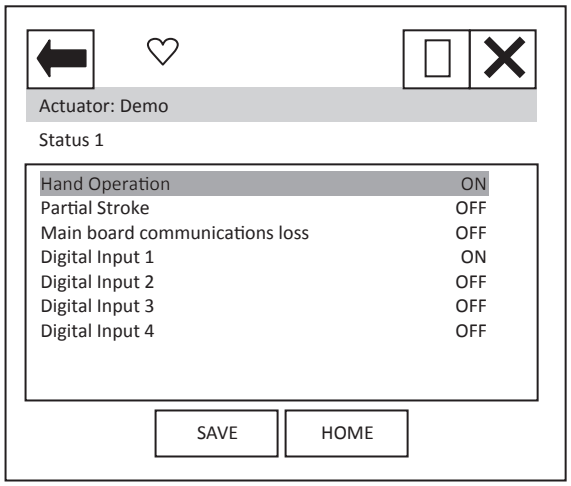
'Output Moving' indicates that the actuator is currently moving.

'Close limit Switch' and 'Open limit Switch' indicate if the actuator is at its close or open position limit.

'Moving Closed' and 'Moving Open' indicates if the actuator is operating the valve in the closing or opening direction.

'Remote Control Mode', 'Local Stop' and 'Local Control Mode' indicate the position that the actuator control selection knob is in.

Diagnostic: **Status, Status1**



'Hand Operation' indicates that the actuator is currently moving under manual / hand control.

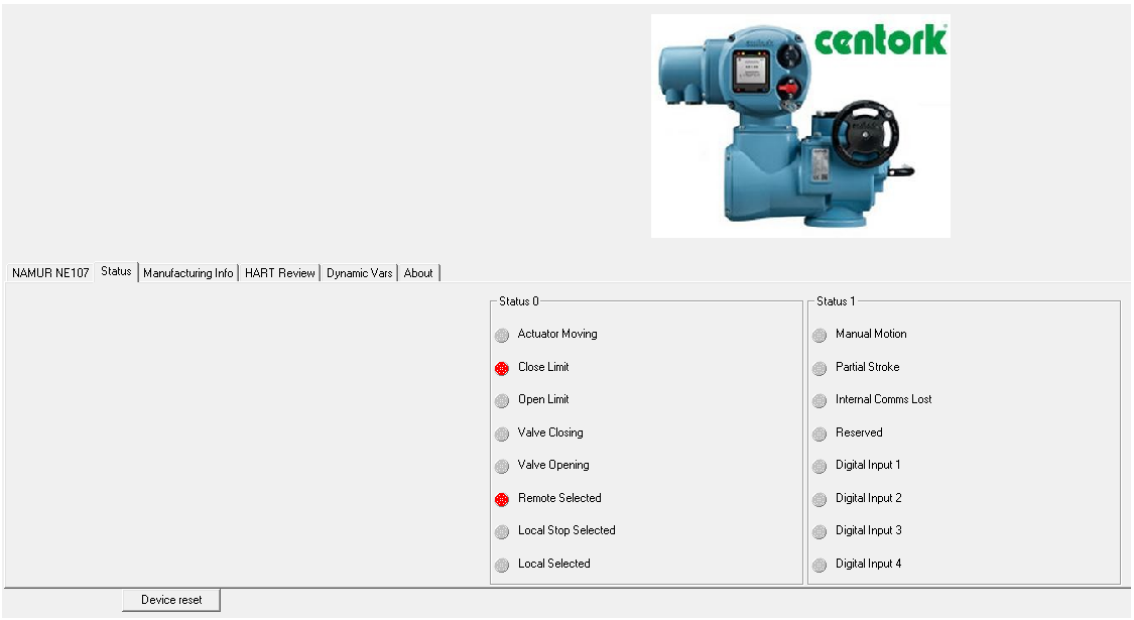
'Partial stroke' indicates the actuator is performing a partial stroke test.

'Main board communications loss' indicates an internal actuator communication problem.

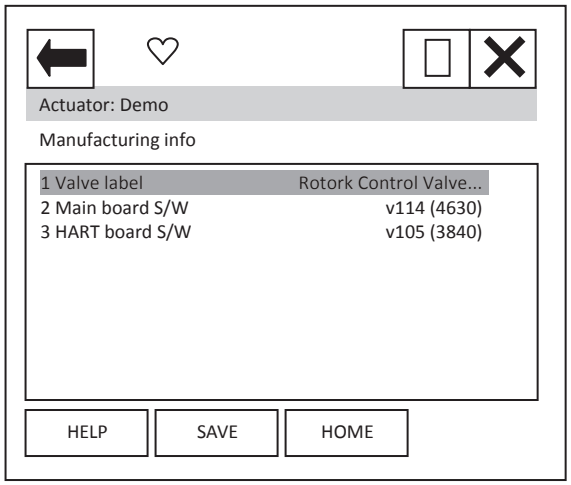
'Digital input 1/2/3/4' indicates the status of the actuator hardwired digital inputs.

DD File, Emerson Handheld Tools Screen Shots

View of **NAMUR NE107 and Status tab** within DCS:



Diagnostic: **Manufacturing info**



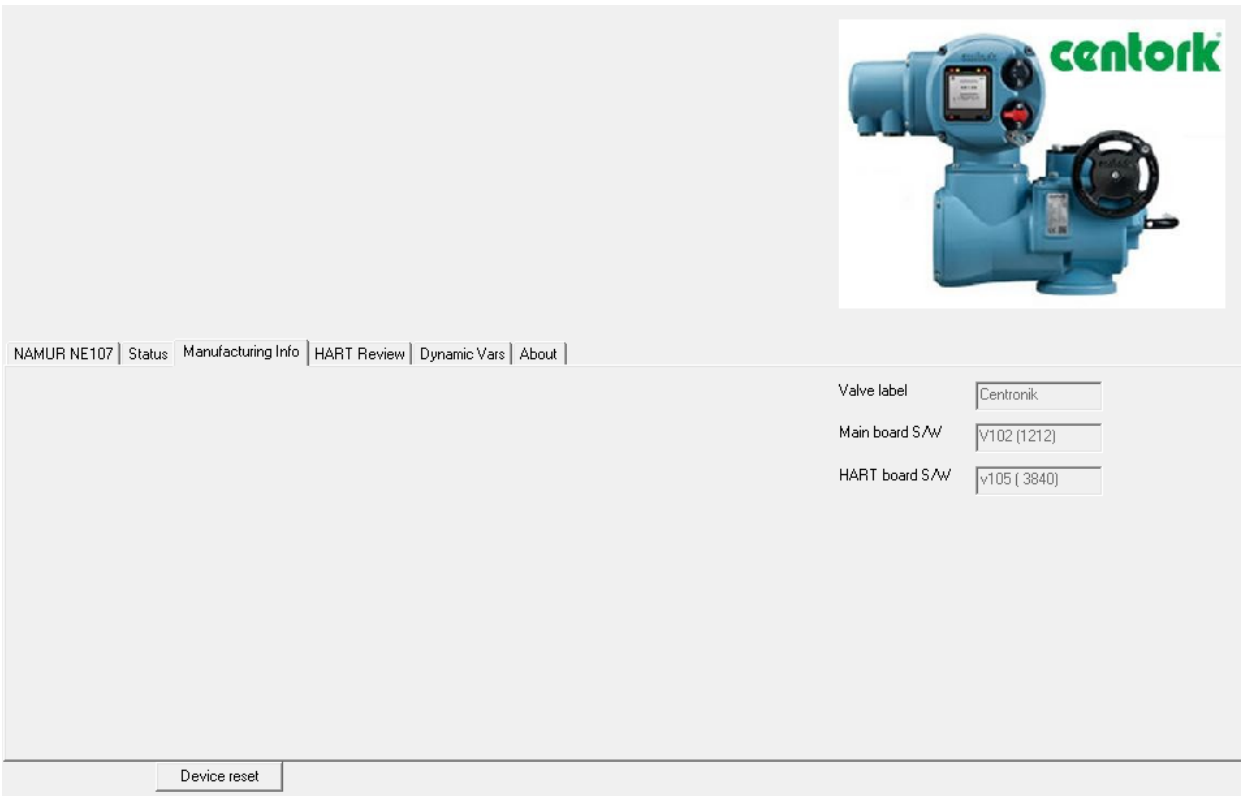
Each item can be selected and viewed.

Item 1 is the valve label.

Item 2 is the main board software version number.

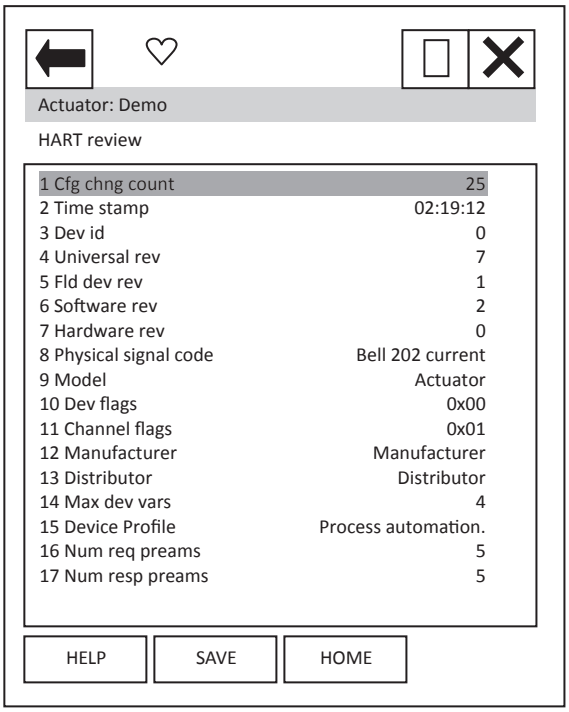
Item 3 is the HART board software version number.

View of **Manufacturing info** tab within DCS:



DD File, Emerson Handheld Tools Screen Shots

Diagnostic: **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.

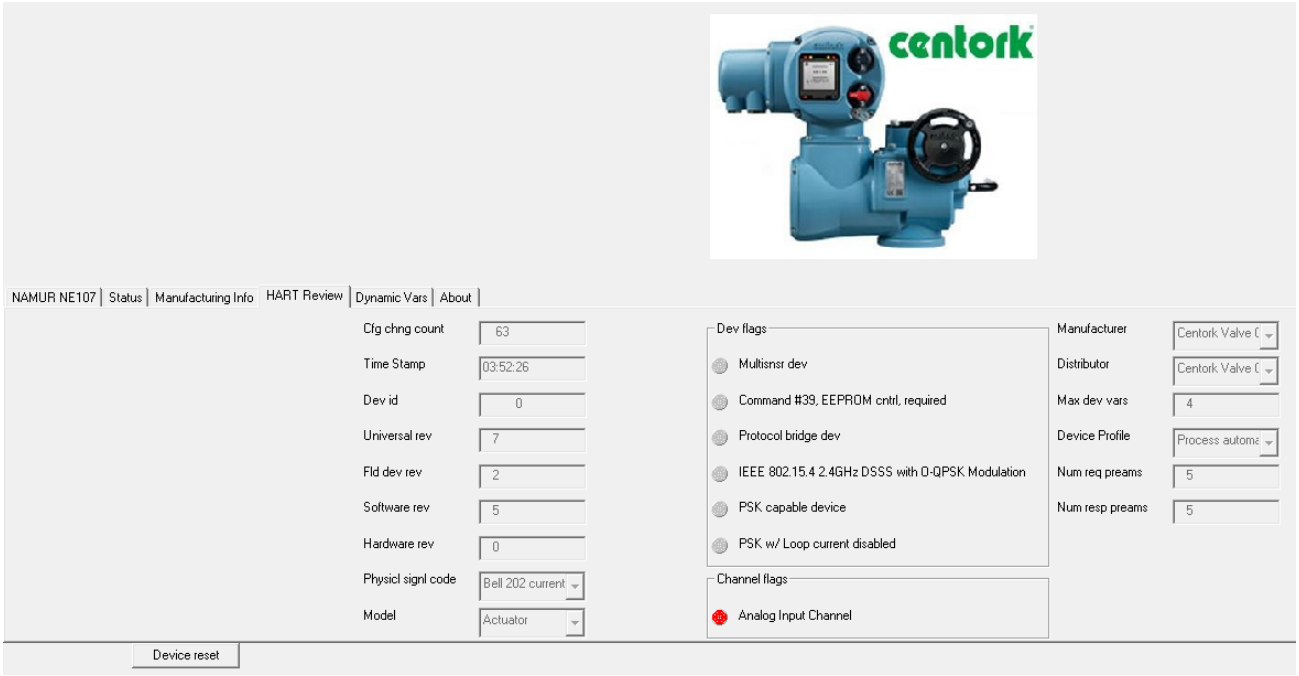
Item 14 indicates the maximum number of variables on the HART device i.e. PV etc.

Item 15 indicates the device profile.

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

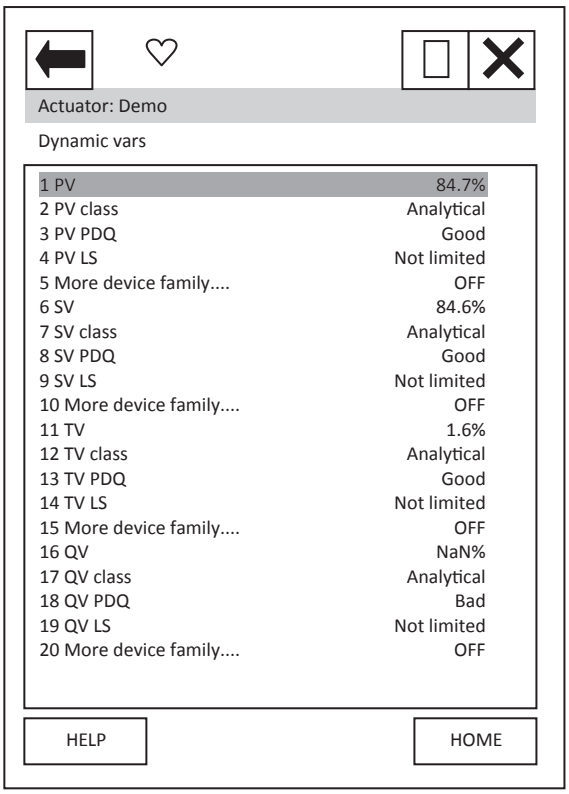
DD File, Emerson Handheld Tools Screen Shots

View of **HART review** tab within DCS:



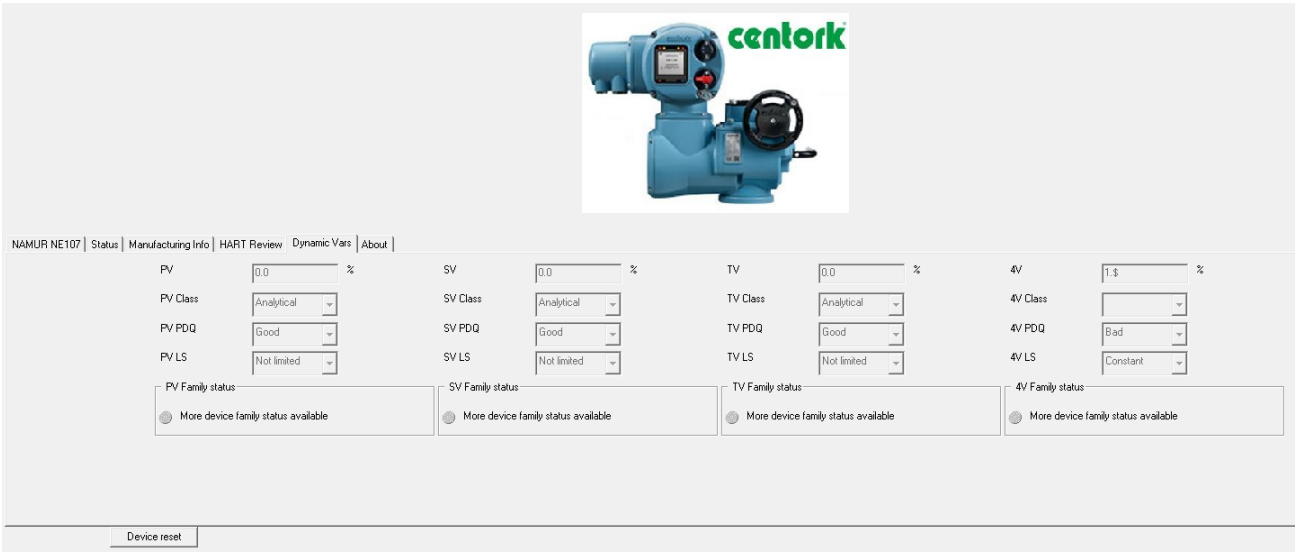
DD File, Emerson Handheld Tools Screen Shots

Diagnostic: **Dynamic vars**

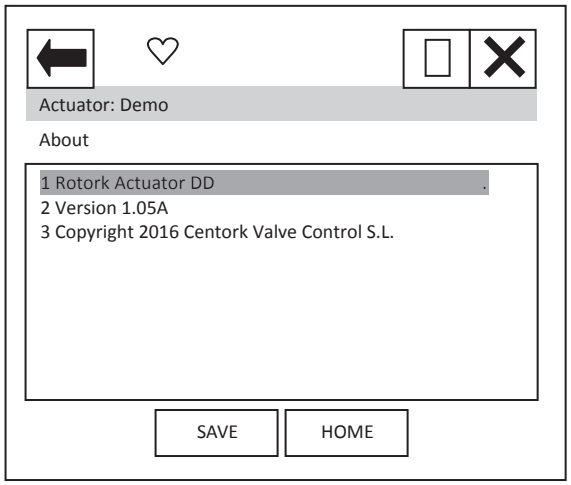


This page details information about the dynamic variables. Each item can be selected and viewed.

View of **Dynamic vars** tab within DCS:

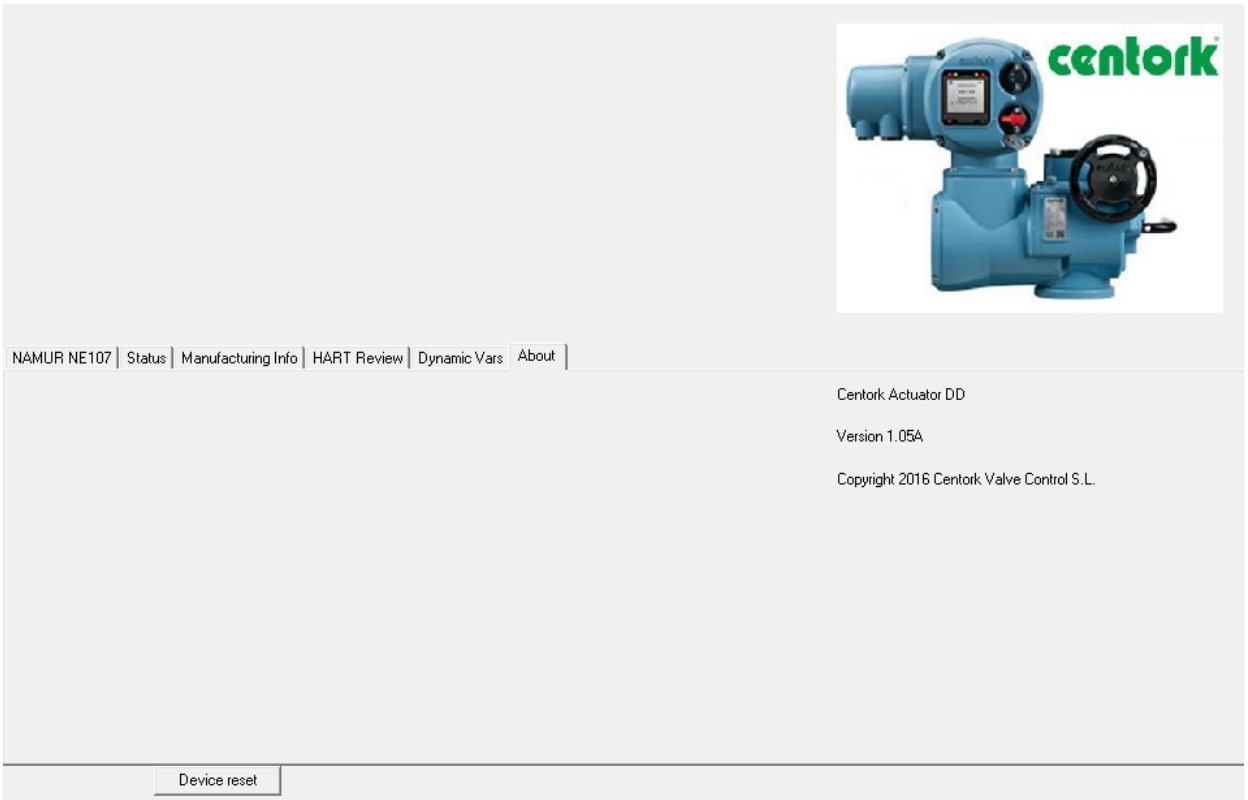


Diagnostic: **About**



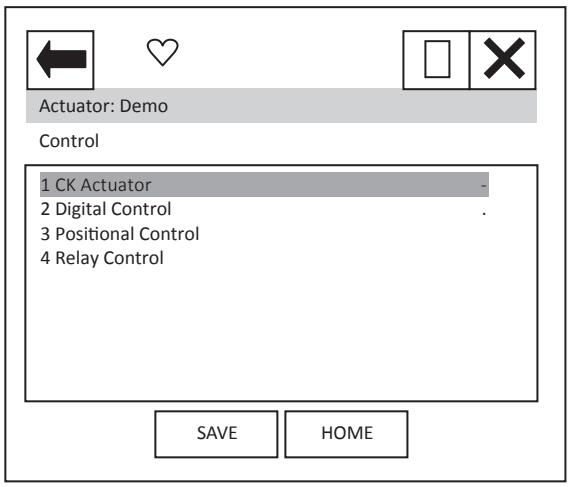
Device Description About box.

View of **About** tab within DCS:



10.4 Control

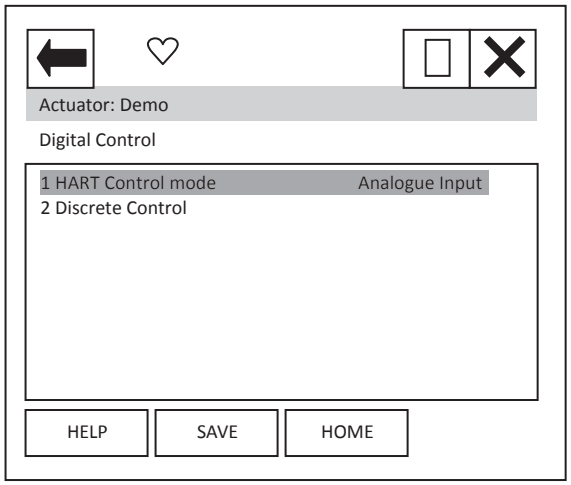
From the top menu, selecting 'Control' will display the following menu:



Item 1 'CK Actuator' indicates the type of actuator

When the items 2 to 4 are selected, new pages are displayed.

Control: **Digital Control**



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

Item 1 'HART Control mode' displays the mode that is currently in control. It can either be 'Analogue Input', 'Discrete' or Digital position'.

Analogue Input indicates that the unit is being controlled with the 4-20mA analogue input supply.

Discrete indicates that the discrete mode of control is enabled and the actuator can be controlled using discrete open/close/stop etc. commands.

Digital position indicates that control is via a digital position command and the actuator can be controlled using a digital position command in the range 0.0 to 100.0%.

Item 2 selects a new page where the actuator can be operated discretely. Only one command should be selected at one time. The commands available are: Stop, Close, Open, ESD, Partial Stroke Test and Enable Digital Control. Commands will not action unless the 'Enable Digital Control' item is also selected. For example, to operate the actuator in the open direction:

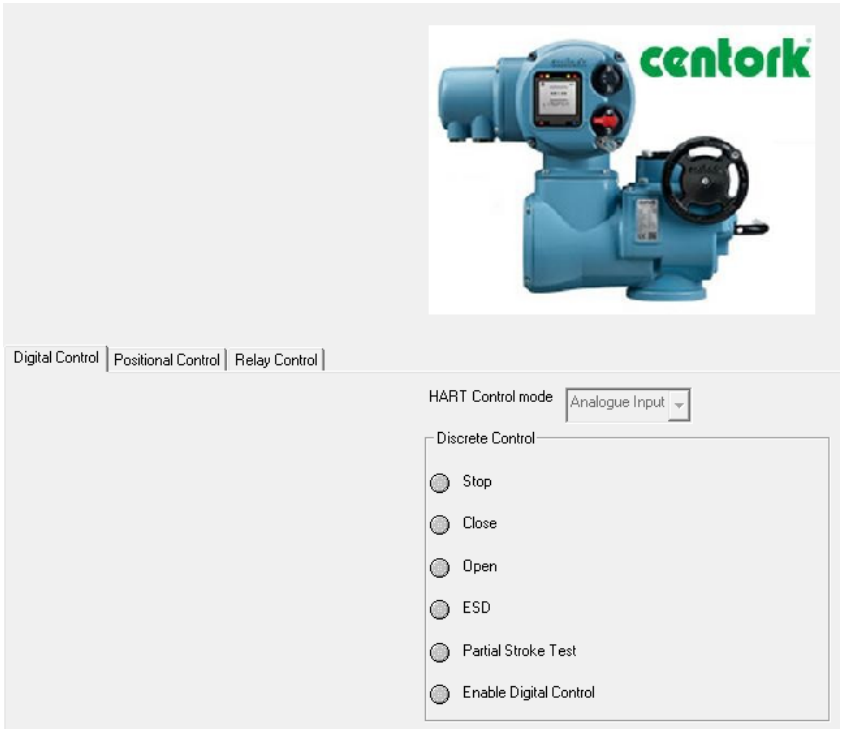
1. Select the Discrete Control page
2. Set the Open row item to 'ON' using the touch screen button displayed at the bottom of the screen
3. Set the 'Enable Digital Control' row item to 'ON' using the same button
4. Ensure all other rows are 'OFF'
5. Select the Enter button to return you to the previous screen
6. You will notice a '*' next to the Discrete Control item – this indicates there is data to send for this feature. Select the 'SEND' button.
7. The actuator will operate and you will notice that the HART control mode will change to Discrete.

To operate in the close direction repeat above instructions ensuring that Open is set to 'OFF' and Close is set to 'ON'

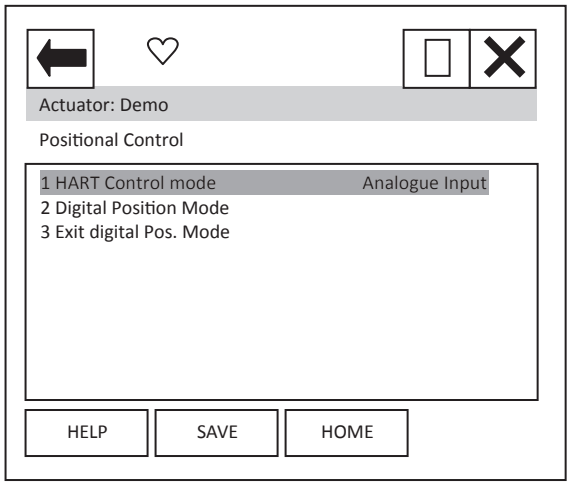
To exit Discrete control mode, the Enable Digital Control row item must be set to 'OFF', the data entered and sent. NOTE that the HART card will return to Analogue Input mode and the actuator may immediately move if the analogue input signal is different to the position that the actuator is at.

DD File, Emerson Handheld Tools Screen Shots

View of **Digital Control** tab within DCS:



Control: **Positional Control**



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

Item 1 'HART Control mode' as previous menu item.

Item 2 Selecting this item will start a method which guides the user to enter the digital positioning mode. The sequence is:

1. On selection, the display changes to 'Entering Forced Mode' at this point the user can Abort or select OK to enter this mode.

On selection of OK the user is warned that the card will be removed from automatic mode – this means that the analogue Input is no longer in control. Again the user can choose to Abort or select OK to carry on.

2. The final page, again has the option to Abort, but selecting OK will enable the user to enter a position value. The Actuator will run to the position selected.
3. To exit this mode select Abort at any page.

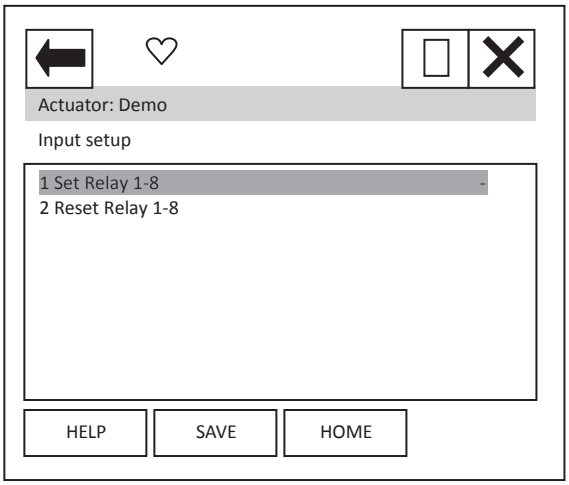
NOTE: On Aborting, the HART card will return to Analogue Input mode and the actuator may immediately move if the analogue input signal is different to the position that the actuator is at.

Item 3 May be required to exit the digital positioning mode should the handheld tool be disconnected at any time, resulting in the HART card remaining in the digital positioning mode. Selecting this item will return the unit to Analogue Input mode.

View of **Positional Control** tab within DCS:

DD File, Emerson Handheld Tools Screen Shots

Control: **Relay Control**



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

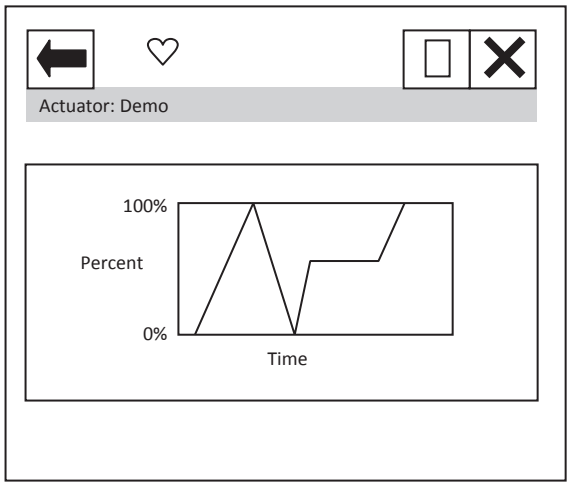
Items 1 to 2 enable the user to operate the 'extra' relays (if fitted) within the actuator. There are 2 sets of items to select for each relay, to activate the relay select the 'Set Relay' item that contains the relay to be set, then change the relays state to 'ON'. To reset the same relay the same item will need to be set to 'OFF' AND, the associated 'Reset Relay' item must be set to 'ON'. To again operate the same relay the 'Reset Relay' item needs to be returned to 'OFF' before selecting on for the 'Set Relay' item.

NOTE: The wiring diagram should be checked to confirm which relays are present within the actuator.
The CK can have up to 8 relays fitted.

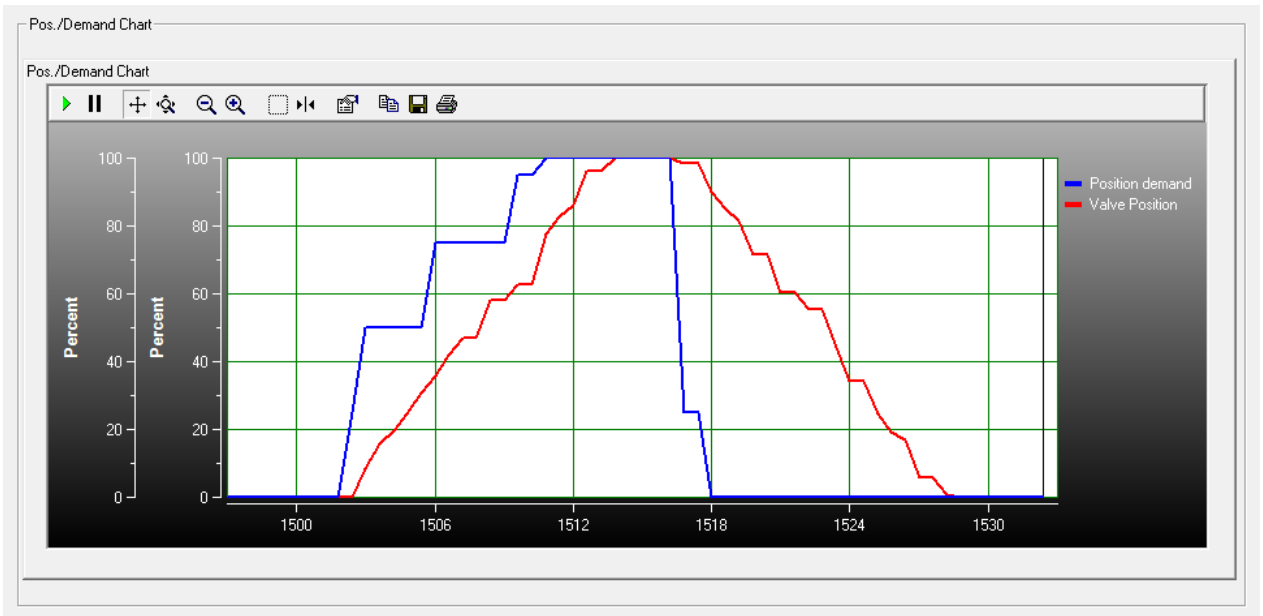
View of **Relay Control** tab within DCS:

10.5 Pos / Demand chart

From the top menu, selecting 'Pos./demand chart' will display the chart of position demand or valve position against time. This will only display if the handheld tool has a graphics license.



View of **Position and demand** tab within DCS:



Appendix

Appendix 1 – Capability Checklist

Manufacturer, model and revision	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	5
Bits of additional device status	39
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 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
Default Address	0

Appendix

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
- EEE 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.

Notes

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