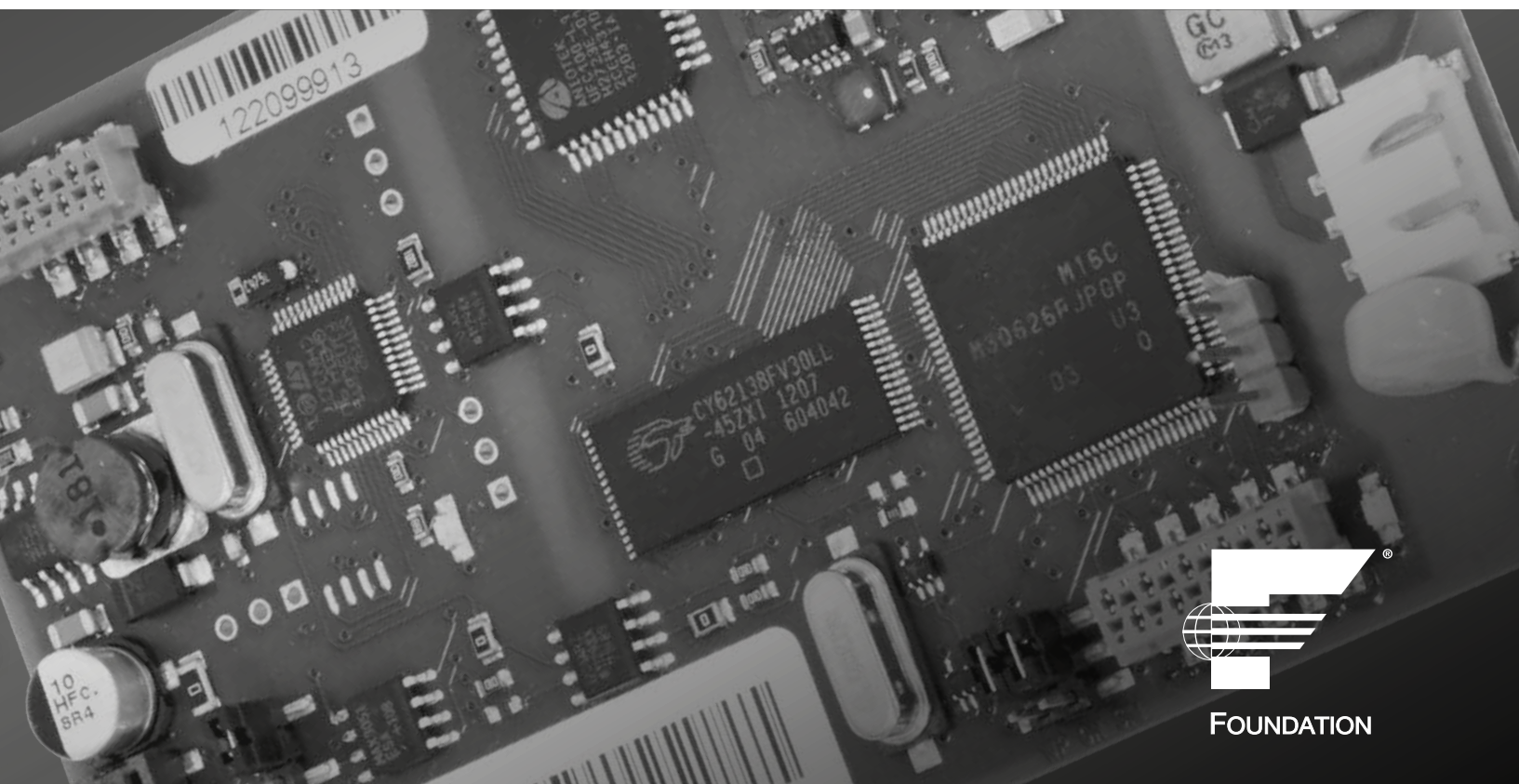


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Mk3 Foundation Fieldbus Option Card

Technical Manual



FOUNDATION

- Note 1:** Throughout this manual the Foundation Fieldbus may be abbreviated to FF.
- Note 2:** Throughout this manual the FF Interface Card may simply be referred to as the FF CP card.
- Note 3:** The information in this manual relates to the FF CP card firmware/hardware versions: M3.1 or A4.2/T1.4/H1.0 or newer.
- Note 4:** The screen dumps used in the manual have generally be taken from a National Instruments FF configurator tool's screen. Other configurator tools may show the same data on a different set of screens.
- Note 5:** This manual is to be used in conjunction with the relevant actuator setting manual and assumes a pre-existing level of knowledge of using both FF and the particular actuator type. It is advised that the relevant technical manual is read before attempting to set-up FF within the actuator.
- Note 6:** The FF CP card described in this manual contains static-sensitive devices. Suitable precautions, such as wearing an earthed anti-static wrist strap, should be taken before handling the card. It should be kept in an anti-static bag or box while it is not fitted within an actuator.

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Glossary of Terms

| | |
|--|---|
| Automatic (AUTO) | A possible mode of a function block which means the block runs its algorithms, producing data at its inputs or outputs. |
| Basic Device | A basic device is any device not having the capability to control communications on an H1 fieldbus segment. |
| Back calculation output (BKCAL_OUT) | This parameter is available on output function blocks, and provides a feedback mechanism to control blocks such as PID. |
| Capabilities File | A file describing the communication objects in a fieldbus device. A configuration device can use Device Description (DD) Files and Capabilities Files to configure a fieldbus system without having the fieldbus devices online. |
| Cascade (CAS) | A possible mode of a function block which refers to an input derived from the output of another function block. |
| Device Description (DD) | A machine-readable description of all the blocks and block parameters of a device. |
| Fieldbus | The digital, two-way, multi-drop communication links. |
| Fieldbus Interface Card (FIC) | The option card fitted to the actuator which provides the communications interface between the DCS and the actuator. |
| Function Block (FB) | Also known as standard function block. This is a named block consisting of one or more inputs and outputs. These are built into fieldbus devices to achieve the desired control functionality. The FF CP has Analogue Input (AI), Analogue Output (AO), Digital Input (DI), Digital Output (DO), Control Selector (CS) and PID control (PID). |
| H1 | A term used to describe a FF highway operating at 31.25 kbit/sec. |
| Initialization Manual (IMAN) | The forward path to a physical output is broken and the output is tracking the downstream block. This will result in the control action being suspended. |
| Interoperability | The capability for a device from one manufacturer to interact with that of another manufacturer, on a fieldbus network, without loss of functionality. |
| Input/Output Options | This parameter is contained within output function blocks and (IO_OPTS) allows different parameters to appear at various connection points. |
| Link Active Scheduler (LAS) | One Link Master (LM) device functions as the fieldbus LAS at any one time. The LAS is the Fieldbus device that is currently controlling access to the Fieldbus. A device that is responsible for keeping a link operational. The LAS executes the link schedule, circulates tokens, distributes time, and probes for new devices. |
| Local Override (LO) | A possible mode of a function block where the block can only be monitored, and no changes can occur to its set points. |
| Manual (MAN) | A possible mode of a function block where the final element is manually input by a user, as opposed to being controlled by its algorithms. |
| Out Of Service (OOS) | A possible mode of a function block which means the block does not run its internal algorithms and cannot be used. |
| Process Variable (PV) | A process variable is a condition of the process fluid (a liquid or gas) that can change the manufacturing process in some way. Common process variables include pressure, temperature, flow rate, etc. |
| Readback | This is the parameter in an output function block which indicates the actual feedback of a process, as opposed to the desired value. |
| Remote Cascade (RCAS) | A possible mode of a function block which refers to an input derived from non-function block outputs. |
| Resource Block (RB) | A block that describes the characteristics of the fieldbus device such as; the device name, manufacturer and serial number. |
| Schedules | Communication events that occur at the same time during each control cycle. The schedule defines when Function Blocks (FBs) execute and when data/status information is published on the bus. |

| | |
|---|--|
| Segment | A Foundation Fieldbus network is made up of devices connected by a serial bus. This serial bus is called a segment (also known as a link). A section of an H1 fieldbus that is terminated in its characteristic impedance. Segments can be linked by Repeaters to form a longer H1 fieldbus. Each Segment can include up to 32 H1 devices. |
| Transducer Block (TB) | A block that is an interface to the physical, sensing hardware in the device. It also performs the digitising, filtering, and scaling conversions needed to present input data to function blocks, and converts output data from function blocks. The block decouples the Function Blocks from the local input/output (I/O) functions required to read the limit switches and command the actuator to move. |
| Virtual Communication Relationship (VCR) | Preconfigured or negotiated connections between virtual field devices on a network. The quantity of VCRs able to be handled by an H1 gateway, or Link Master usually determines the number of devices on an FF highway. |
| Virtual Field Device (VFD) | The virtual field device is a model for remotely viewing data described in the object dictionary. The services provided by the Fieldbus Messaging Specification allow you to read and write information about the object dictionary, read and write the data variables described in the object dictionary, and perform other activities such as uploading or downloading data and invoking programs inside a device. |

Abbreviations

| | |
|--------------|--|
| AI | Analogue Input (Blocks AI1, AI2) |
| AO | Analogue Output (Block AO) |
| BTST | Bluetooth Setting Tool |
| CFF | Common File Format |
| Comms | Communications |
| CP | Common Protocol |
| CS | Control Selector Block |
| DCS | Distributed Control System |
| DD | Device Description |
| DI | Digital Input (Blocks DI1, DI2, DI3, DI4, DI5) |
| DO | Digital Output (Blocks DO1, DO2, DO3, DO4) |
| DSM | (Actuator) Digital Switch Mechanism |
| DTM | Device Type Manager |
| ESD | Emergency Shut Down |
| FB | Function Block |
| FDT | Field Device Tool |
| FF | Foundation Fieldbus |
| FIC | Fieldbus Interface Circuit |
| HIST | Host Interoperability Support Test |
| ITK | Interoperability Test Kit |
| LAS | Link Active Scheduler |
| LM | Link Master |
| MSM | (Actuator) Mechanical Switch Mechanism |
| NIC | Network Interface Circuit |
| PCS | Process Control System |
| PDA | Personal Digital Assistant |
| PID | Proportional, Integral, Derivative; A type of function block which refers to a closed loop control algorithm |
| PST | Partial Stroke Test |
| RAM | Random Access Memory |
| RB | Resource Block |
| ROM | Read Only Memory |
| SW | Software |
| TB | Transducer Block |
| VCR | Virtual Communication Relationship |

Supporting Documents

Available from the Fieldbus Foundation, Austin, Texas.

- Technical Overview of Foundation Fieldbus FD-003 (all parts)
- Wiring and Installation 31.25 kbit/s AG-140

1. Introduction

This manual is designed to be an aid to commissioning and will assist with achieving a successful integration of Rotork's FF product into a DCS's FF network. Correct installation should ensure a lifetime of trouble free use. This is not a manual on how to use FF. Due to the complex nature of the protocol, Rotork strongly recommends users attain a sufficient level of FF competency prior to attempting any FF commissioning work.

The FF CP option card is the third evolutionary step in Rotork's Foundation Fieldbus journey. It has been certified as conforming to the open fieldbus standard IEC 61158 and is suitable for use on an FF H1 highway. The H1 highway uses two copper wires to both carry the digital messages and to supply power to all the devices connected on the highway. As such it is necessary to have a suitable power supply and termination filter on the highway for the FF nodes to function.

The current version of the FF card may be fitted into any of the current Rotork Controls' actuator product range. The FF card is an integral part of the actuator in which it is housed and is fitted within the main electrical housing. This electrical housing need never be opened once the actuator leaves the assembly plant. All adjustments to the settings for the FF card may be made via the Foundation data highway using a suitable network configuration tool. There is no external marking on the actuator to show the FF card serial number since the whole module may be replaced if it should fail.

The FF card's circuits do not impinge on the actuator control electronics; the actuator itself remains fully self-protecting. The card performs the tasks of IEC 61158 interface, actuator data collection and the issuing of actuator commands.

The FF CP card may command the actuator into which it is fitted to open, stop, close, perform an ESD operation, perform a partial stroke operation or move to a set position. Commands to the module come from the network and may be generated in another actuator or device on the network using peer to peer, publisher/subscriber communication. Additionally, digital and analogue status information relating to the actuator is published for the other devices to read.

For a quick start guide see Section 8.



Fig 1.1: Some of the actuators which use the FF CP card

1. Introduction *continued*

1.1 General

The FF CP card is capable of performing the following functions:

- a) Link Master/Link Active Scheduler
- b) Basic Device

The in-built function blocks vary in availability between the different actuator types. The input and output blocks are used to link to the transducer block and tie to the available actuator functions. For example the AI block associated with actuator torque measurement is only available in the DSM actuator type. The following table lists the function blocks and their related availability in each actuator type.

| Function Block Type |
|--|
| Resource Block – System information |
| Transducer Block – Device configuration |
| Digital Inputs |
| DI 1 Closed limit or multistate |
| DI 2 Open limit or multistate |
| DI 3 Selector in remote or multistate |
| DI 4 General alarm or multistate |
| DI 5 Actuator moving or multistate |
| Digital Outputs |
| DO 1 Open or multistate |
| DO 2 Close or multistate |
| DO 3 Stop or multistate |
| DO 4 Single bit selectable or multistate |
| Analogue Inputs |
| AI 1 Analogue position feedback |
| AI 2 Torque/Thrust |
| Analogue Output |
| AO Desired position (set point command) |
| Controllers |
| PID (3 term controller) |
| Control Selector |

2. FF Card Properties

2.1 Mechanical Properties

The FF CP card consists of a single network interface card that fits directly to the main actuator control PCB. It consists of two isolated parts, the actuator interface and the network interface.

Network Interface

This carries the FF highway connections and the processor handling the data highway communication and function blocks. The Network Interface contains the FF connector (SK3), polarised to prevent incorrect insertion. This connects to the three wire loom routed to the terminal compartment of the actuator. Power for the Network Interface is taken from the FF highway.

Actuator Interface

The primary connection to the actuator circuits is by a multi-pin connector on the base of Interface Card. The PCB design ensures it may only be fitted in the correct polarisation. The Actuator Interface on the FF CP card is powered from within the actuator.

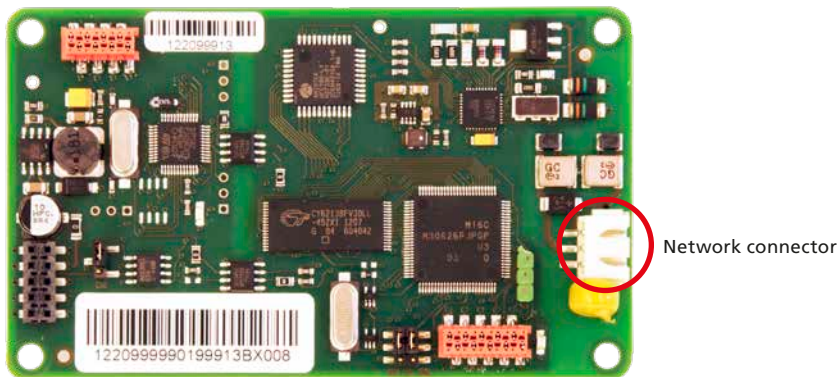


Fig 2.1: The FF card, showing the network connector

2. FF Card Properties *continued*

2.2 Electrical Properties

The FF CP card does not sit in the main control path for the actuator and does not affect the actuator control integrity.

Internally stored programs control the processors on the module. The Network Interface processor software may be updated by connecting a suitable test cable and loading the new code directly, but this cannot be done in the field. The FF system allows all settings for the data highway and module communication functions to be held in non-volatile memory on the Network Interface Card.

The FF data highway connection is fully isolated from the actuator electronics.

2.3 Operation and Storage

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

The constraints are:

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

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

3. Fitting the FF CP Card

3.1 Inside a Rotork Actuator

3.1.1 Inside an IQ3/IQT3 actuator

The FF CP card is suitable for fitting into IQ3 actuators. When factory-fitted, their wiring diagrams will contain an 'F', e.g. 100F2000. The FF CP can be located in one of 2 or 4 option 'slots' located on the back of the control module PCB, housed in the electrical cover. There are 2 slots for directly connecting the option module to the control module and where those slots are already filled, the option card can be fitted on top of the existing modules. The modules can be stacked 2 high where a 'deep' electrical cover is fitted.

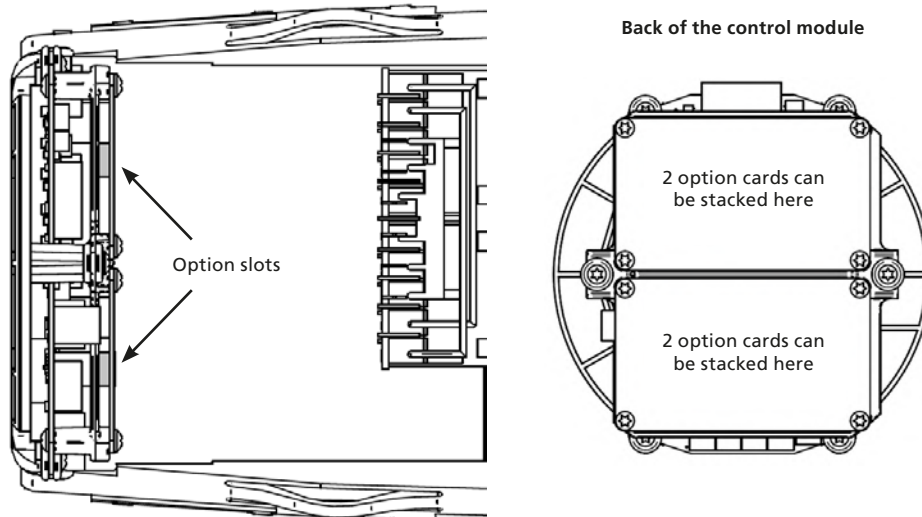


Fig 3.1: The FF CP card's location behind the control module in an IQ3

With the IQ3 actuators, the remote inputs are always present (they are conditioned by the control board) and there is an option to include Digital Outputs from relay contacts. If the FF CP is required to operate the 4 digital outputs that can be controlled from the card, then an Extra Relay Indication card associated with these outputs must be fitted into another option slot in the actuator.

The FF CP is connected to the control module by a 10 way header (SK2). The wiring harness from the actuator terminal bung connects the FF H1 highway field connections to SK3.

3. Fitting the FF CP Card *continued*

Replacing or fitting an FF CP option card

The FF CP card should be replaced or fitted only in a suitable environment. The actuator must be made electrically safe before opening any covers. The electrical housing cover should be removed after unscrewing the four 6mm Allen machine screws. Unplug the electrical housing loom from the control board and remove the cover. Unplug the grey ribbon cable from the edge of the control board and unplug the black plastic carrier frame from the frame legs. Unplug the loom from the FF card. Unscrew the Torx 20 screws holding the FF card into the frame and carefully unplug the FF card from the control board. The replacement board is fitted in the reverse order to removal. The wiring harness connectors are polarised so that only the correct one will fit its mating part on the circuit boards. Don't forget to re-connect the grey ribbon cable to the edge of the control board.

If the operation is to fit an FF CP card for the first time, then the necessary wiring loom must be added to the internal wiring harness of the actuator. The actuator wiring diagram shows the connectors and harness used. The wiring harness is fitted inside the actuator before attempting to fit the FF CP. This requires that you remove the terminal bung, which is held in place by a large circlip. Be careful to attach the wiring loom to the correct terminals, which are numbered. Re-fit the terminal bung.

Once the loom is in place, connect it to the FF CP, then fit the FF CP to the actuator main board connector. Attach the FF CP to the frame, using the Torx 20 screws.

Once the module is fitted, the actuator should be re-assembled.

Once power is applied, the field unit parameters should be checked and corrected, where necessary.

Some FF TB parameters can be set and adjusted either by using the Infra-red and Bluetooth setting tools or by Insight 2 using *Bluetooth*®. The parameter setting procedure is covered by the IQ3 Full configuration, status and monitoring user manual, PUB002-040-00, available on the Rotork web site, <https://www.rotork.com/en/documents/publication/8953>.

3. Fitting the FF CP Card *continued*

3.1.2 Inside an SI3 actuator

The FF CP is suitable for fitting into SI3 actuators. When factory-fitted, the network connections will be as in the diagram below:

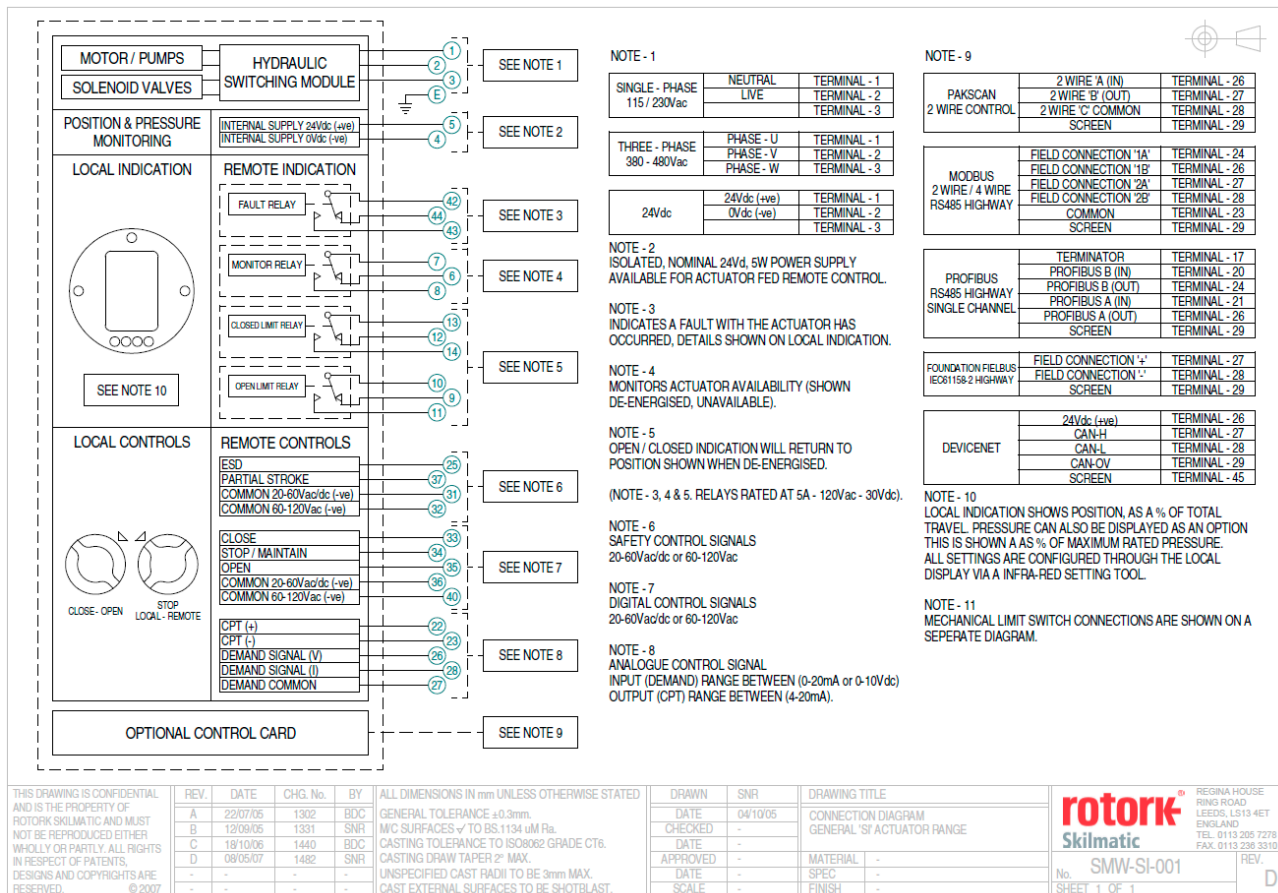


Fig 3.2: The SI3 highway interface connection table

The internal layout of the actuator will be similar to that of the IQ3, when considering installation of the FF CP, as above.

3. Fitting the FF CP Card *continued*

3.1.3 Inside a CVA actuator

The FF CP is suitable for fitting into CVA actuators. When factory-fitted, the wiring diagram will be CXX-80 (where X can be any value). This details the option card connections to the terminal bung. The FF CP module is fitted in the only option board slot inside the CVA electrical housing – on the underside of the Main PCB assembly. The FF CP should be replaced or fitted only in a suitable environment.

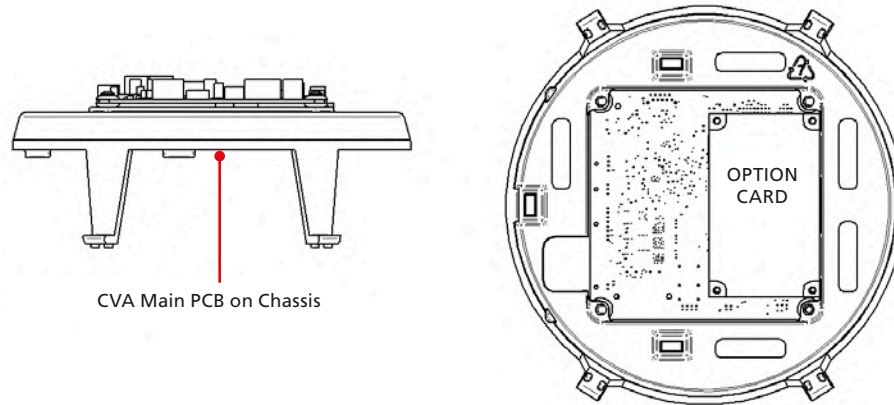


Fig 3.3: The FF CP located on the underside of the control PCB in a CVA actuator

To fit an FF CP card, begin by removing power from the actuator and wait until the LED on the selector knob stops illuminating. This may take several minutes if a reserve power pack of capacitors is fitted.

Remove the six M10 machine screws from the upper cover and lift it off carefully, while removing its ribbon cable connector from the socket on the Main PCB.

Remove the various wiring looms from the sockets on the edges of the Main PCB, noting carefully where they attach. Each connector is different to avoid error.

Remove the Main PCB in its plastic chassis by gently pushing the chassis legs inwards to release them from a groove in the actuator housing.

Fit the FF CP to the underside of the Main PCB using the hardware supplied with the FF CP card.

The wiring loom from the actuator terminal bung connects the FF H1 field connections to SK3. If a new card is being fitted as an upgrade, then the actuator will need to have the loom fitted. Remove the terminal bung by removing the circlip and gently pulling the bung. Attach the loom and replace the bung.

The FF CP is connected to the control module by a header, SK2.

The FF CP in the CVA must be enabled. This would usually be done during factory test, but may be required to be completed on site for conversions to FFs or if a replacement card is fitted. To enable the card, the Rotork PDA software Enlight (downloadable from the Rotork web site) is required to be used to change parameter 34. It must be read and then have 2048 decimal added to it.

This procedure is best performed by a Rotork Engineer.

3. Fitting the FF CP Card *continued*

3.1.4 Inside a CMA actuator

The FF CP is suitable for fitting into CMA actuators, wiring diagrams MXX-FX (where X can be any value) detail the option card connections on the terminal strip. The FF CP module is fitted in the only option board slot inside the CMA electrical housing.

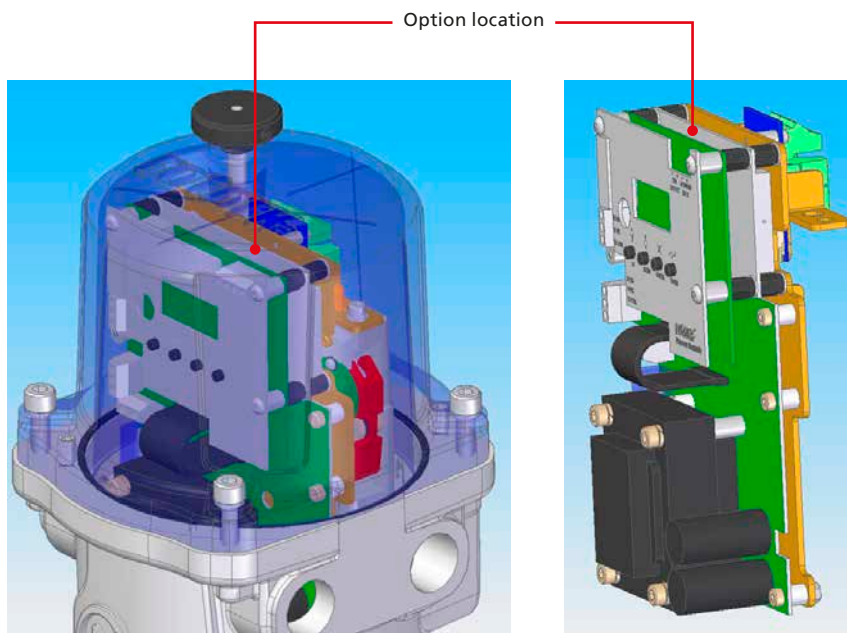


Fig 3.4: The FF CP located in a CMA actuator

The FF CP should be replaced or fitted only in a suitable environment. The actuator must be made electrically safe before opening any covers. The electrical housing cover should be removed after unscrewing the four 6mm Allen machine screws.

The FF CP should be fitted in the position shown in the illustrations above. It plugs into the control board at the 10-way header, which is SK2 on the FF CP board. There is a wiring loom which brings the FF H1 network connection to SK3 on the FF CP.

Connection details are shown in the illustrations on the next page.

The CMA actuator will need configuring, so that it is aware that control from the field is through the FF CP card. This is done by accessing the menu structure as shown in the CMA Installation and Maintenance manual, PUB094-003, found on the Rotork web site.

3. Fitting the FF CP Card *continued*

3.1.5 Inside a K range actuator

The FF CP is suitable for fitting into K-Range actuators; wiring diagrams similar to 1612ZFD detail the option card connections. The FF CP module is fitted in the only option board slot inside the K-Range electrical housing.

SK2 on the FF CP card plugs directly onto SK9 on the Main card, while a terminal bung loom brings the FF highway signals to SK3.

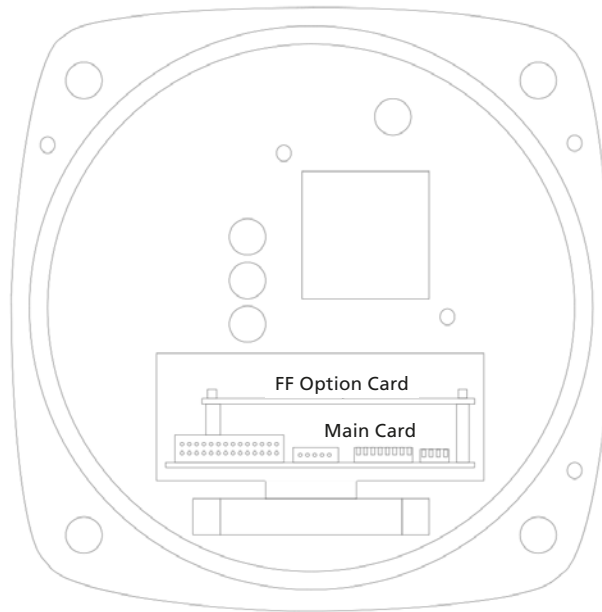


Fig 3.5: The FF card located in a K-range actuator

The FF card should be replaced or fitted only in a suitable environment. The actuator must be made electrically safe before opening any covers. The electrical housing cover should be removed after unscrewing the four 8mm Allen machine screws.

The FF card is attached to the main card by three plastic pillars, with one metal pillar, Torx 20 screw and a fibre washer; as shown in the illustration above.

If an actuator is having the FF fitted for the first time, then the terminal bung loom must also be fitted. The terminal numbers will be found in the appropriate wiring diagram, which should be included in the fitting kit.

3. Fitting the FF CP Card *continued*

3.1.6 Inside a CK actuator

The FF CP card is suitable for fitting into CKc/CKRc actuators with Px5xxxxx and Kx5xxxxx 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 FF CP card is normally located in the first option board slot inside the electrical housing, using Main PCB connection SK2.

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.

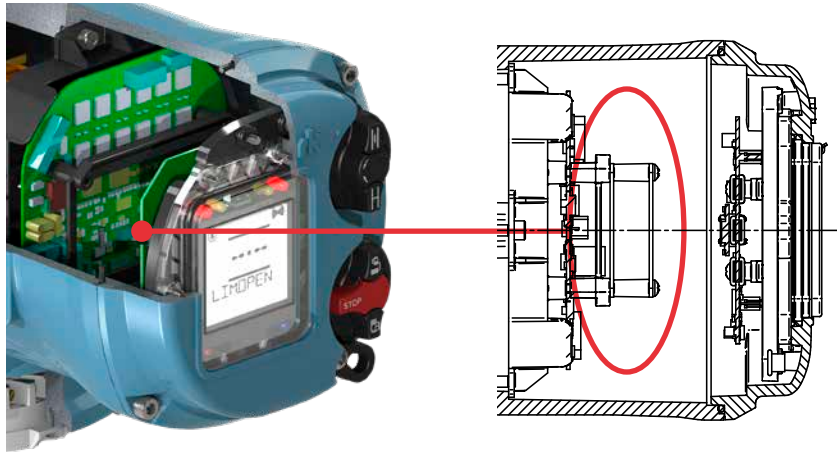


Fig 3.6: The FF CP card located in a Centronik unit

Within the actuator the remote inputs are always present (they are conditioned by the FF CP card) and there is an option to include Digital Outputs from relay contacts. If the FF CP card is required to operate the 4 digital outputs that can be controlled from the card, then the Extra Relay Indication card associated with these outputs must be fitted into the actuator. The following table describes the wiring harnesses and their function in the Centork actuator.

| FF card Socket | Wiring Harness |
|----------------|--------------------------------|
| SK2 | Power and CANbus from actuator |
| SK3 | FF H1 highway connection |

3.2 Replacing or Fitting an FF CP Option Card

The FF card should be replaced or fitted only in a suitable environment. The actuator must be made electrically safe before opening any covers.

⚠ WARNING: Removal of certain covers will void warranty, it is advised that a Rotork approved engineer perform this function.

Suitable anti-static precautions should be taken, as the actuator circuitry contains static-sensitive components.

If an upgrade kit has been purchased please carefully follow the instructions given in the documentation provided. It will also be necessary to have the relevant actuator maintenance manual to hand when adding a new card.

The electrical housing cover should be removed and the existing FF card carefully unplugged from its main connector. The Interface card will be attached to the Main PCB mounting ring by four screws, which are T20 (or T15 if two cards are present). Once removed from the main connector the wiring loom connectors should be removed. The replacement board is fitted in the reverse order to removal. The wiring harnesses are polarised so that only the correct one will fit its mating part on the circuit board.

If the operation is to fit an FF card for the first time then the necessary wiring looms must be added to the internal wiring harness of the actuator. The actuator wiring diagram shows the connectors and harnesses used. The wiring harnesses are fitted inside the actuator before attempting to fit the FF card. Once the looms are in place connect them to the FF card, then fit the card to the actuator control board/main board connector.

Once the module is fitted the actuator should be re-assembled. If an option card is fitted into an actuator after it has left the factory then the actuator needs to be set-up to use this card in the software, the card will not do anything until this has been done. This can be done using the local HMI or Insight but ideally needs to be done by a Rotork service engineer. This is not necessary if a card is being replaced with the same type of card, e.g. replacing an FF with a new FF card.

It is advisable to check the software version numbers are the same between the new and old card to ensure consistent operation. It is also advisable to check the ITK revision of the old FF card as it may be necessary to modify the new FF card's ITK revision. If this needs to be done, see Appendix F.

3.3 Socket, LED and Jumper Functions of the FF Card

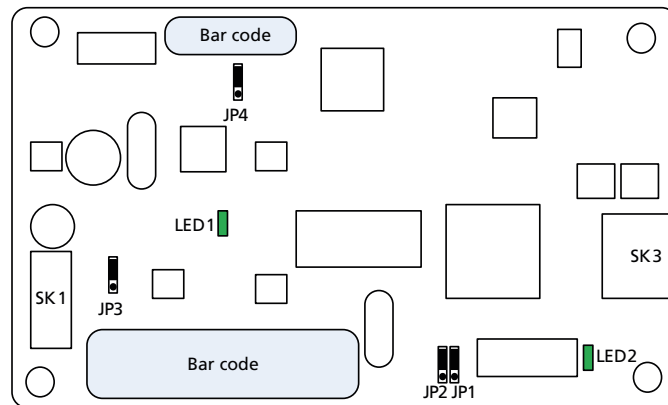


Fig 3.7: Network interface card – jumper and LED functions

The FF CP card includes two connectors (SK1 and SK3), two LED indicators (LED1 and 2) and four jumpers, (JP1 – 4). The position of these jumpers should not normally require alteration from the factory default positions. The illustration shows the default positions. The LEDs can be used to help with system diagnostics in some cases.

The function of each connector, LED and jumper is as follows:

- SK1** This socket connects the FF CP card to the actuator's control PCB via a CANbus highway.
- SK3** This socket connects the FF CP card to the FF highways via the actuator's terminal bung connections.

Note there are two other connectors which are used to program the FF CP card and which are not described in this document.

- LED 1** Indicates the FF CP Card is communicating with the actuator's control PCB.
- LED 2** When flashing, this Indicates there is an active connection to the fieldbus highway.
When on (i.e. not flashing), this indicates the fieldbus highway power is present.

3. Fitting the FF CP Card *continued*

JP1, Simulation Mode Jumper

In simulation mode, the user is permitted to write to primary input/output actuator variables through the status and value attributes normally written to by the transducer block. With JP1 'On' a function block may have its simulation 'active' parameter enabled. When JP1 is 'Off' the primary actuator variables are not write enabled. The normal position is 'Off', as shown on the schematic above. See the appendix section for more information on simulation mode operation.

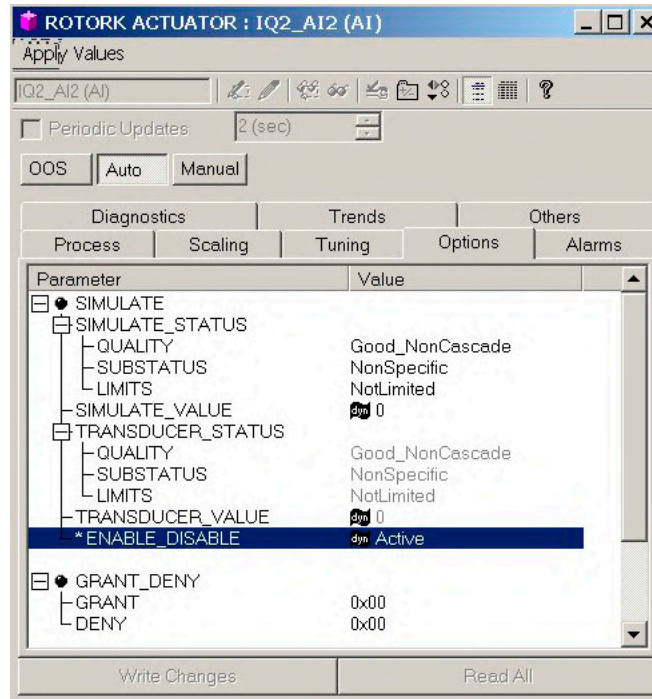


Fig 3.8: Simulate has been activated in the AI function block

JP2, Hard-Write Lock

A setting can be made in the 'FEATURE_SEL' parameter of the Resource block which prevents the writing/changing of all configuration parameters in the FF CP card. If the FEATURE_SEL is set to 'Hard W Lock', the jumper function becomes write protect 'On' and 'Off'. (See Section 6.1 Resource Block). The normal position is 'Off' as shown above.

JP3, CANbus Terminator

This must be left in the "Off" position as shown in Fig 3.7.

JP4, Slot 0/1 Selector

In Fig 3.7, this is shown in the slot 0 position. The jumper is moved to the slot 1 position when two FF CP cards are fitted into the same actuator and one of them already has slot 0 selected.

4. IEC 61158 Data Highway and Connections

4.1 Data Highway

The Foundation Fieldbus network is based on the IEC 61158 data highway using copper conductors. The network also carries the power used to supply each node on the network. In the case of the FF card, the FF interface is powered from the fieldbus network. Only two wires are used for the data highway and these carry both the data signal and the module power. The actuator interface card is powered from the actuator itself and the card can only report actuator data when both the FF highway and actuator are powered up.

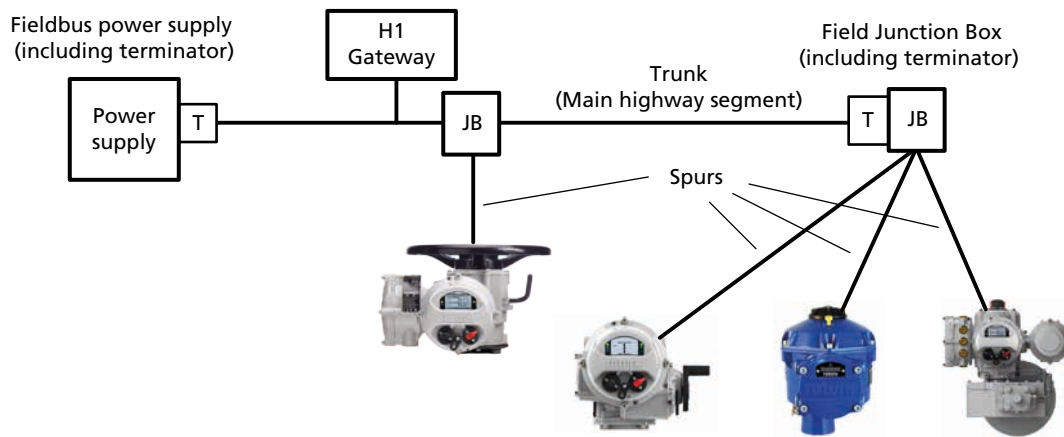


Fig 4.1: Typical Foundation data highway

The data highway must be terminated with proper balancing devices at either end. The highway can use spur or stub connections to the devices but it is recommended to keep any stub lengths to a minimum for successful operation. The length of the highway and number of devices connected will vary from project to project. The standard permits up to 32 devices before a repeater in the highway must be used, however it's extremely unlikely that this many devices will be connected to a highway. Similarly, the standard calls for a maximum segment length of 1900 metres before a repeater must be used. On a 1900 metre highway, the stipulated maximum length for a stub with one actuator is 120 metres. The data highway cable type is given by the Foundation as 'type A'. A typical example of this type of cable is Belden 3076F.

| Cable Specification | Type A Cable (e.g. Belden 3076F) |
|---------------------|---|
| Type | 2 cores, twisted pair plus overall screen |
| Shielding | Minimum 90% copper shielding, braid or foil |
| Size | 18 AWG (0.8 mm ²) |
| Resistance | 24 Ohms/km max |
| Nominal Capacitance | 80 pF/m |

4.2 Fieldbus Power Supply

The FF card takes power from the H1 data highway. This means the internal function blocks are available for control connection between devices even when the actuator has no power.

The power is taken from a special DC power supply connected onto the network through a suitable filter. The power consumption of each FF node on the network is 20 mA and the absolute minimum voltage at the actuator terminals is 9 volts. The power supply has to contain an inductive network to prevent attenuation of the fieldbus signal by the low impedance of the power supply itself. The inductive network in the power pack makes sure that its equivalent impedance is quite high at the 31.25 kbits/sec frequency whilst still allowing a DC current to be drawn for the line-powered devices.

Since each node on the fieldbus consumes power from the DC supply, great care must be taken in the design of the installation. The design must ensure that the volt drop from the power pack to the actuator still leaves at least 9V (absolute minimum) for the FF card and ideally at least 10 Volts. The actuators can withstand a maximum voltage of 32V from the power pack and since the current consumption is virtually constant, a simple Ohm's law calculation can be used to determine the potential at each point in the network. On power up there is no additional inrush current, i.e. the inrush current value is the same as the nominal.

The Foundation fieldbus wiring guide (AG -140) provides examples of how to calculate the voltage at each point.

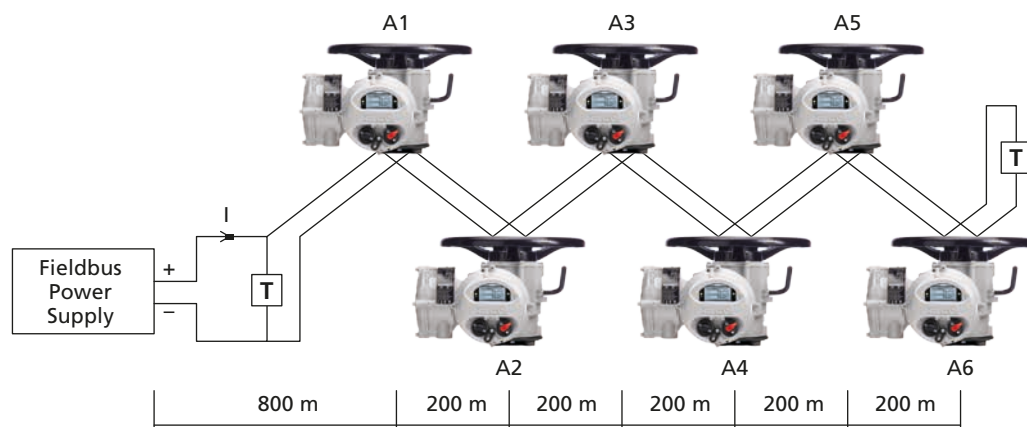


Fig 4.2: Calculating the voltage drop

4. IEC 61158 Data Highway and Connections *continued*

Example of voltage drop calculation:

Assume the cable is **Type A** (24 Ohm per km per conductor), the resistance of each 1000 metre pair is $24 \times 2 = 48$ Ohms per km.

The current drawn by each node A1 to A6 is 20 mA.

| | | |
|---------------------------------|--|---------------|
| Voltage drop power supply to A1 | = current x resistance | |
| | = $(6 \times 0.020) \times (0.8 \times 48)$ | = 4.6 volts |
| Voltage drop A1 to A2 | = $(5 \times 0.020) \times (0.2 \times 48)$ | = 0.96 volts |
| Voltage drop A2 to A3 | = $(4 \times 0.020) \times (0.2 \times 48)$ | = 0.768 volts |
| Voltage drop A3 to A4 | = $(3 \times 0.020) \times (0.2 \times 48)$ | = 0.576 volts |
| Voltage drop A4 to A5 | = $(2 \times 0.020) \times (0.2 \times 48)$ | = 0.384 volts |
| Voltage drop A5 to A6 | = $(1 \times 0.020) \times (0.2 \times 48)$ | = 0.192 volts |
| Total system volt drop | = $4.6 + 0.96 + 0.768 + 0.576 + 0.384 + 0.192$ | = 7.48 volts |

If the power supply is a 24 V unit, then the voltage at actuator A6 will be $(24 - 7.48) = 16.52$ volts which is within the specified limits.

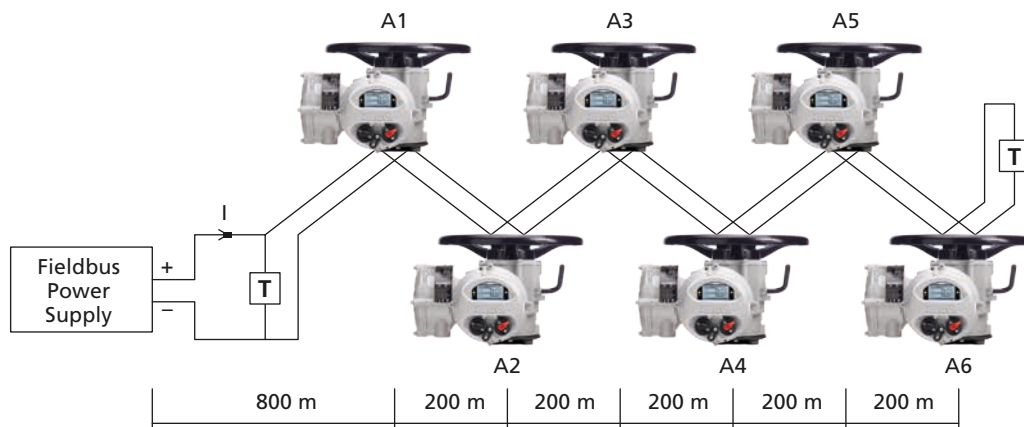


Fig 4.3: Voltage drop example

Whilst we have shown the power supply at one end of the segment, they can be fitted to the middle of the network. This would reduce the voltage drop.

4.3 Termination Network

Each highway must be terminated correctly at the two ends of the data highway. The terminator comprises at least one resistor and capacitor in series and they provide a characteristic impedance of 100 Ohm at 39 kHz. They need not be placed on the absolute ends of the highway but should be on the ends of the main trunk section. They are usually incorporated inside the field junction box.

There are no highway termination facilities inside the actuator itself.

5. The Actuator Input and Output Signals

The FF CP card provides feedback data about its status and that of the actuator to the Foundation highway. This data is contained in the Transducer function block and is fully listed in the section on Function Blocks. The actuator is normally controlled by signals from the Foundation highway connecting to the Output blocks and the Transducer block. There are local controls on the actuator itself and there is the possibility to wire in direct contacts to control the movement. This section explains the primary data available and the meaning of the signals generated by the actuator.

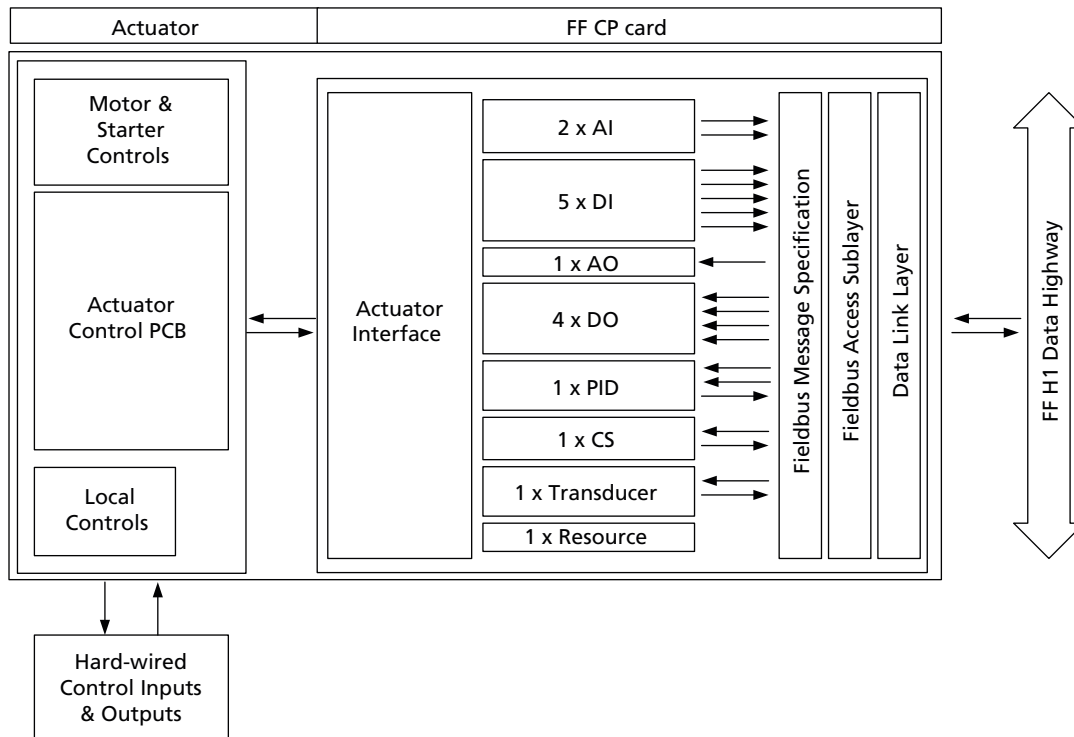


Fig 5.1: Actuator and FF CP card block diagram

Input signals are those returned by the actuator to the network about the status of the actuator and valve whilst output signals are those used to command the actuator to move or operate its internal relays. An actuator control signal such as a command to open is an output, whilst a reported status such as open limit switch reached is a feedback input.

5. The Actuator Input and Output Signals *continued*

5.1 Controls

The FF CP card can be used to control the actuator and position the valve. The valve may be moved fully closed, fully open or to an intermediate position. Additionally, the actuator can make the valve adopt an Emergency Shut Down position and in some actuators perform a partial stroke test. Most actuator types can be prevented from moving by the presence of an Interlocking signal from another device on the plant. The actuator may also be operated from its local controls or by hard-wired direct contact inputs. Note that to do this the Auxiliary Mask must be correctly set.

As well as controlling the actuator the FF CP can also be used to operate 4 discrete output relays when the actuator is fitted with a relay card, assuming the DO block itself isn't in IMAN, LO or OOS.

The control commands have three potential sources:

- Foundation Fieldbus generated commands
- Actuator Local Controls
- Direct Hard-wired input controls

The full list of commands is shown in the table. The actuator types show whether the command is applicable to that actuator type.

| Command | IQ3, IQT3 & SI3 | CVA & CMA | CK | K |
|---|-----------------|-----------|----------------|---|
| Foundation Network | | | | |
| Open | ✓ | ✓ | ✓ | ✓ |
| Close | ✓ | ✓ | ✓ | ✓ |
| Stop | ✓ | ✓ | ✓ | ✓ |
| Emergency Shut Down | ✓ | ✓ | ✓ | ✓ |
| Analogue Position Demand | ✓ | ✓ | ✓ | ✓ |
| Partial Stroke | ✓ | X | ✓ | X |
| Relay 1 output | ✓ ^① | X | ✓ ^① | X |
| Relay 2 output | ✓ ^① | X | ✓ ^① | X |
| Relay 3 output | ✓ ^① | X | ✓ ^① | X |
| Relay 4 output | ✓ ^① | X | ✓ ^① | X |
| Local Actuator Controls | | | | |
| Open | ✓ | X | ✓ | ✓ |
| Close | ✓ | X | ✓ | ✓ |
| Stop | ✓ | X | ✓ | ✓ |
| Direct Hard-Wired Inputs | | | | |
| Open | ✓ | X | ✓ | ✓ |
| Close | ✓ | X | ✓ | ✓ |
| Stop/Maintain | ✓ | X | ✓ | ✓ |
| Emergency Shut Down/Net disable | ✓ | X | ✓ | ✓ |
| Open Interlock (active prevents opening) | ✓ | X | ✓ | ✓ |
| Close Interlock (active prevents closing) | ✓ | X | ✓ | ✓ |

Note: ^① – Requires an extra relay board to be fitted.

Fig 5.2: Available command options

5. The Actuator Input and Output Signals *continued*

The FF commands operate on the Transducer block through Digital Output (DO) blocks that are already connected in the default configuration. The network commands will operate the actuator provided:

- Local/Local Stop/Remote selector is in 'Remote' (or "Run" in a CVA).
- Foundation commands are not inhibited by the 'Inhibit/HW_DI-4' input parameter setting and HW_DI-4 condition
- No interlock is active
- There is no active hard-wired control input or FF control input present
- No alarm condition prevents the actuator from moving
- The Transducer and Resource blocks are in AUTO

Open A digital command to cause the actuator to open to the fully open position as indicated by the Open limit switch. Under correct operation the actuator stops either when the open limit switch is reached, when the torque exceeds the value set and the open limit switch has been reached, or a new command is sent over the network.

Close A digital command to cause the actuator to close to the fully closed position as indicated by the Close limit switch. Under correct operation the actuator stops either when the close limit switch is reached, when the torque exceeds the value set and the close limit switch has been reached, or a new command is sent over the network.

Note: Many multi-turn actuators are set to open until the open limit switch is reached and close until the closing on torque switch trips, but it is dependent on the type of valve. The quarter turn actuators normally operate 90-degree valves, use stop-bolts on the actuator or gearbox, and stop when these are reached. The control room indication is always taken from the end of travel limit switch settings

Stop With no other command present, this digital command causes an actuator motor that is running to stop.

Emergency Shut Down A digital command that causes the actuator to drive to its Emergency position. There are settings within the actuator to determine if this is a closed, open or stay-put action.

Analogue Position Demand This function is only available over the Foundation network. To initiate Analogue Position Control this bit must be set to 1 and all other actuator control bits must be set to 0. This enables the AO block to function. The actuator will then move to within the deadband of whatever position value has been set in the AO block output parameter (range 0-100%, resolution 0.1%).
Provided limited range positioning is not invoked, the values 0% and 100% written to the AO output parameter produce a special case output where the command is revised so as to fully close the valve to its tight shut-off position (0%) and to fully open the valve (100%).

Note: The following functions are not an option with all actuators, see Fig: 5.2.

Partial Stroke The actuator will move the valve to an intermediate position and back to the start position provided it is at the correct end of travel position when the command is issued. The end to start from and the amount of travel are selected by parameters in the transducer block.

Relay Output 1 to 4 These 4 commands are used to energise and de-energise the internal relays on the additional relay board (if fitted). (These outputs are referred to as S5-S8 in the standard actuator documentation when there is no FF CP card in the actuator). The resulting outputs can be used for operating other equipment such as a pump or indication light. The actuator itself is not able to control these relays directly from the main board when the FF CP card is fitted; they may only be controlled by the DO blocks. They will maintain their last state if power is removed from the actuator. On restoration of power, the relays will be reset to their de-energised condition.

5. The Actuator Input and Output Signals *continued*

5.1.2 Foundation control using DO blocks only

Discrete action control is achieved using the DO blocks in the FF CP card. Each DO block output has a value between 0 and 255. If the host DCS system uses its 'Boolean Fan In' function, most of the discrete controls can be achieved using one DO block – see table below. The selected block is put in service and the appropriate value sent to its output. Only one value is permitted at a time in each block. If Boolean functions are not available, then several blocks may need to be used to achieve the desired control actions.

| DO Block Output Actions | | | | | | | | |
|-------------------------|---|-------|-------|----------|----------|-------|-------|-------|
| Block No. | Bit 0 | Bit 1 | Bit 2 | Bit 3 | Bit 4 | Bit 5 | Bit 6 | Bit 7 |
| DO 1 | Close | Open | Stop | ESD | Position | RLY 1 | RLY 2 | RLY 3 |
| DO 2 | Open | Close | Stop | ESD | PST | RLY 1 | RLY 2 | RLY 3 |
| DO 3 | Stop | Close | Open | Position | RLY 1 | RLY 2 | RLY 3 | RLY 4 |
| DO 4 Mode 0 | Position | Close | Open | ESD | RLY 1 | RLY 2 | RLY 3 | RLY 4 |
| DO 4 Mode 1 | ESD | Close | Open | Position | RLY 1 | RLY 2 | RLY 3 | RLY 4 |
| DO 4 Mode 2 | RLY 1 | Close | Open | ESD | Position | RLY 2 | RLY 3 | RLY 4 |
| DO 4 Mode 3 | PST | Close | Open | ESD | RLY 1 | RLY 2 | RLY 3 | RLY 4 |
| DO 4 Mode 4 | Analogue block control (AO) only | | | | | | | |
| DO 4 Mode 5 | 0 = Close, 1 = Open, any other value Stop | | | | | | | |
| DO 4 Mode 6 | Position | PST | Close | Open | Stop | ESD | RLY 1 | RLY 2 |

Fig 5.4: DO block options

- Select Multiple/Single bit control in the Transducer block
- Enable the appropriate DO blocks
- If DO 4 is being used, set its mode in the Transducer block

The Transducer block includes parameters to select single or multiple bit support.

- If multiple bit support is available (using Boolean Fan In) **only one block may be used**.
- If single bit control is selected, all four blocks can be used but each block uses Bit 0 only.

The action of DO 4 is selected using the mode control parameter in the Transducer block.

5.1.3 Foundation control using the AO block only

In order to place the FF CP card into position control mode, so that the AO block output values determine the actuator position, it is necessary to set the Control Mode in the Transducer block to Mode 4. The actuator will then use the value of the AO block output as the setpoint for the internal positioner and the actuator will move to the setpoint (subject to the status of the Local and Hard-wired controls, the Interlocks and the actuator deadband and hysteresis settings). Output block DO 4 does not need to be added to the schedule and can remain set Out of Service (OOS).

- Set the Mode Control in the Transducer block to Mode 4
- Set the positioner parameters (hysteresis, deadband, motion inhibit time etc.)

If the AO output is set to 0% and limited range positioning is not being used (selected via the Transducer block), the actuator will operate as though a 'close' command had been sent. Similarly, if the AO output is set to 100% under these conditions, the actuator will interpret the instruction as an 'open' command.

Note that when limited range positioning is used and the actuator is in the range from fully closed to the 0% position, an AO command of 0% will not be acted upon. Likewise, if the actuator is in the range from fully open to the 100% position, an AO command of 100% will not be acted upon. See Section 6.2.4 for more information on limited range positioning.

5. The Actuator Input and Output Signals *continued*

5.1.4 Foundation control using both DO and AO blocks

With mixed position control using the AO and discrete (open/stop/close/ESD) control using the DO blocks, the control settings must be carefully observed. Discrete actions will take priority over the Position requests.

The single/multiple bit control option for the discrete controls has to be determined. When Boolean Fan In is available, multiple bit control is set and a single DO block is used for the open/stop/close discrete control actions. The DO block chosen must also include a condition to select Position Control.

With single bit control each discrete action requires a DO block to be enabled and the Position option is in DO 4 which must be set to Mode 0.

When the AO value is to be adopted for the valve position, the control scheme must select the DO block to be in its Position value. With multiple blocks DO 4 must be set to '1', all the others being '0'. As soon as the discrete control changes to 'Position', the AO output value becomes the desired actuator position and the position controller will move the valve.

- DO control values of Open/Stop/Close/ESD have priority over the AO value
- The DO value must equal 'Position Control' for the AO value to become active

The position controller will be subject to the considerations mentioned in 5.1.3 with regard to 0% and 100% values.

5.1.5 The 'S' contacts (RLY 1 to RLY 4) controlled by the DO blocks

Note: This option is not available on all actuator types, see Fig 5.2.

The actuator has four 'S' contact outputs that may be configured to report the status of the actuator with signals such as Open Limit, Closed Limit etc. These are identified as S1 to S4.

In addition, an optional additional relay board can be fitted with four more relays. The status of these relays is then adjusted by Foundation DO block commands on outputs Relay 1 to Relay 4. Setting the appropriate DO block output to the value corresponding to the relay will energise the relay whilst the output from the DO is present. Setting a different value will de-energise the relay. Note that these relays are latching and, if energised, will not change state when the actuator power is removed. On restoration of power the relays will be reset to their de-energised condition.

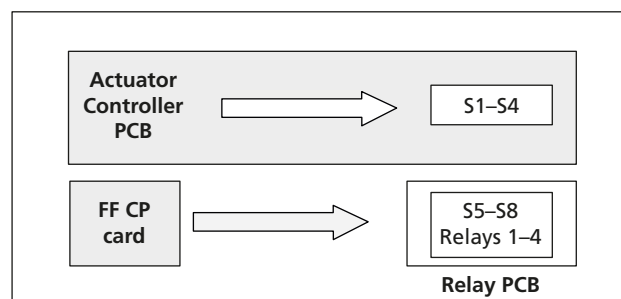


Fig 5.5: Actuator relay outputs

5.1.6 Foundation network control disable feature

Note: This option is not available on all actuator types, see Fig 5.2.

It is possible to set the ESD/HW_DI-4 input so that the actuator ignores open, stop, close, ESD, PST and position control signals sent over the Foundation network. If the HW_DI-4 ESD/Net Disable parameter in the Transducer block is set to '1' then when the ESD input connection is detected as being logic 1, Foundation control is not allowed. This feature is dependent of the Auxiliary mask setting and can be configured as an NO or NC input. When the HW_DI-4 ESD/Net Disable parameter is set to '1', no hard-wired ESD will be available.

5. The Actuator Input and Output Signals *continued*

5.2 Discrete Input Status Feedback

The FF CP card has DI (Discrete Input) function blocks that may be used to report the valve and actuator status over the network. The conventional contact indications are also available from the actuator limit switches and indication contacts.

Each DI block output has a value between 0 and 255. If the host DCS system uses its 'Boolean Fan Out' function, the returned value may be decoded into 8 individual bits, where each bit represents a single piece of feedback data. If the DCS does not have this facility, then the state of the first bit in each DI will be represented by 0 = not true and 1 = true. The complete list of DIs and the function of the individual bits is indicated in Section 5.2.1. The table below indicates which signals are available from each actuator type.

| DI Function: Block Number/Bit Number | | | | | Status Feedback | IQ3, IQT3 & SI3 | CVA & CMA | CK | K |
|---|-------|-------|-------|-------|------------------------------|--------------------|--------------|-----|-----|
| 1 / 0 | 2 / 1 | | | | Close Limit | ✓ | ✓ | ✓ | ✓ |
| 1 / 1 | 2 / 0 | | | | Open Limit | ✓ | ✓ | ✓ | ✓ |
| 1 / 2 | | | | 5 / 0 | Actuator Moving | ✓ | ✓ | ✓ | ✓ |
| 1 / 3 | 2 / 3 | | | | Running Closed | ✓ | ✓ | ✓ | ✓ |
| 1 / 4 | 2 / 2 | | | | Running Open | ✓ | ✓ | ✓ | ✓ |
| 1 / 5 | | 3 / 0 | | | Remote selected | ✓ | ✓ | ✓ | ✓ |
| 1 / 6 | | 3 / 1 | | | Local Stop selected | ✓ | ✓ | ✓ | ✓ |
| 1 / 7 | | 3 / 2 | | | Local selected | ✓ | ✓ | ✓ | ✓ |
| | 2 / 4 | | | | Not in Remote | ✓ | ✓ | ✓ | ✓ |
| | 2 / 5 | | 4 / 0 | | General Alarm | ✓ | ✓ | ✓ | ✓ |
| | 2 / 6 | | | | Valve Obstructed | ✓ | ✓ | ✓ | ✓ |
| | 2 / 7 | | | | Valve Jammed | ✓ | ✓ | ✓ | ✓ |
| | | 3 / 3 | | | Moving Inhibited | ✓ | ✓ | ✓ | ✓ |
| | | 3 / 4 | | 5 / 5 | Open Interlock active input | ✓ | ✓ | ✓ | ✓ |
| | | 3 / 5 | | 5 / 6 | Close Interlock active input | ② | ② | ② | ② |
| | | 3 / 6 | | | Position Control Enabled | ✓ | ✓ | ✓ | ✓ |
| | | 3 / 7 | | | Slow Mode | ① | ① | ① | ① |
| | | | 4 / 1 | | Thermostat Tripped | ✓ | ✓ | ✓ | ✓ |
| | | | 4 / 2 | | Monitor Relay | ✓ | ✓ | ✓ | ✓ |
| | | | 4 / 3 | | Valve Obstructed/Jammed | ✓ | ✓ | ✓ | ✓ |
| | | | 4 / 4 | | Part Stroke Error | ✓ | ✓ | ✓ | ✓ |
| | | | 4 / 5 | | Valve Moving by Hand | ✓ | ✓ | ✓ | ✓ |
| | | | 4 / 6 | | Battery Low | ✓ | N/A | N/A | N/A |
| | | | 4 / 7 | | Watchdog Recovery | ✓ | ✓ | ✓ | ✓ |
| | | | | 5 / 1 | Hard-Wired HW_DI-1 | ✓ | N/A | N/A | N/A |
| | | | | 5 / 2 | Hard-Wired HW_DI -2 | ✓ | N/A | N/A | N/A |
| | | | | 5 / 3 | Hard-Wired HW_DI -3 | ✓ | N/A | N/A | N/A |
| | | | | 5 / 4 | Hard-Wired HW_DI -4 | ✓ | N/A | N/A | N/A |
| | | | | 5 / 7 | Partial Stroke in Progress | ✓ | ✓ | ✓ | ✓ |

Notes: ① - This bit is reported when within the slow mode band, but does not affect the actuator. Slow mode is not an option in some of the actuators.
② - This bit indicates the state of the Hardwired Partial stroke input.

5. The Actuator Input and Output Signals *continued*

5.2.1 Discrete Inputs

| | |
|-------------------------|--|
| Close Limit | This data bit indicates that the actuator has reached the closed position. The limit switch should be set slightly within the actual valve stroke to allow for torque seating or overshoot on closing without damaging the valve. The data bit will remain true (1) even if the position is passed through or exceeded. |
| Open Limit | This data bit indicates that the actuator has reached the open position. The limit switch should be set slightly within the actual valve stroke to allow for torque seating or overshoot on opening without damaging the valve. The data bit will remain true (1) even if the position is passed through or exceeded. |
| Actuator Moving | Whenever the actuator position is changing due to the motor running or in the case of the IQ or IQT if the output drive is moving, this bit will be set true (1). |
| Running Closed | Whenever the actuator motor contactor used to drive the actuator in the closing direction is energised this bit will be true (1). |
| Running Open | Whenever the actuator motor contactor used to drive the actuator in the opening direction is energised this bit will be true (1). |
| Remote Selected | This bit is true (1) when the actuator three-position Remote/Local Stop/Local selector is in the Remote position. The selector must be in this position for Foundation control to be permitted. |
| Local Stop | The actuator three-position selector passes from Local to Remote or Remote to Local through the Local Stop position. The switch can also be placed in Local Stop. When the switch is in the Local Stop position this bit will be true (1). Remote control of the actuator is not possible when the selector is in this position. |
| Local Selected | This bit is true (1) when the actuator three-position Remote/Local Stop/Local selector is in the Local position. Remote control of the actuator is not possible when the selector is in this position. |
| Not In Remote | This bit is true (1) when the actuator three-position Remote/Local Stop/Local selector is not in the Remote position. The selector will be in either the Local or Local Stop position. Remote control of the actuator is not possible when the selector is in this position. |
| General Alarm | If any of the following conditions are true this bit will be true (1): Thermostat tripped Monitor Relay Valve Obstructed Valve Jammed Manual Movement |
| Valve Obstructed | This bit will be true (1) if the actuator stops in mid-travel when not expected to do so after receiving a command to move. If the actuator torque exceeds the trip value set during commissioning, then the motor will stop and motion will cease. The reason for the actuator stopping will be the high torque due to an obstruction and not a 'Stop' signal or reaching the desired setpoint position. The bit will remain true (1) until the actuator position changes by 2% or more. |

Note: Attempting to restart the actuator to move towards the obstruction (even if the obstruction no longer exists) is not possible, the actuator will not restart. The actuator must be electrically reversed away from the obstruction before attempting to continue in the original direction.

5. The Actuator Input and Output Signals *continued*

Valve Jammed

This bit will be true (1) if the actuator is stationary at the end of travel and fails to move away from the seat of the valve when a network command requests it to do so. The actuator will trip on excessive torque due to the valve being jammed in the seat. The FF CP card fails to see movement and reports this status after the time set in the associated Transducer block parameter during set-up.

The bit will remain true (1) until the actuator position changes by 2% or more.

Note: Attempting to restart the actuator to move out of the seated position is not possible. The actuator must be reversed before it will run in the same direction again. The jammed seat must first be released manually before electrical control is attempted. The problem may be overcome by adjusting the actuator torque setting, which is designed to provide extra power on leaving the seated position.

Moving Inhibited

This bit will be true (1) when the Motion Inhibit Timer is active or the Interrupter Timer is active, or both are active.

The Motion Inhibit Timer is used in position control to prevent the actuator from exceeding its prescribed number of starts per hour, or to reduce the effects of hunting during closed-loop control.

The Interrupter Timer can be used over part or the entire actuator stroke to slow down the effective speed of valve travel.

When under network control, the control signal does not need to be re-applied when this bit is true, as the control action will continue once the time has elapsed.

Open Interlock

The input contact to the Open Interlock is monitored. Whenever the input contact is closed this bit will be true (1). If the actuator is not using the interlock function, then this input can be used as a digital status feedback for a plant signal not associated with the actuator. If the interlock circuit is being used, then permission must be granted before the actuator can be opened. The presence of this bit will indicate that opening is permitted and permission is granted.

Close Interlock

The input contact to the Close Interlock is monitored. Whenever the input contact is closed this bit will be true (1). If the actuator is not using the interlock function then this input can be used as a digital status feedback for a plant signal not associated with the actuator. If the interlock circuit is being used, then permission must be granted before the actuator can be closed. The presence of this bit will indicate that closing is permitted and permission is granted.

Position Control Enabled

This bit will be true (1) when a Position command is being actioned. This data can be used to indicate that positioning mode has control of the actuator.

Thermostat

If the temperature of the motor windings rises above the thermostat trip value, the thermostat contact will open and this signal will be present (1). There are no adjustments for the temperature at which the thermostat trip operates. The motor will be stopped if the thermostat trips. Only once the motor (or transformer) has cooled down and the thermostat has reset itself can a new Remote, Host or Local command to move the actuator be carried out. A setting on the actuator main board allows the ESD command to override the thermostat. The bit will remain set at logic 1 until the thermostat resets itself.

Monitor Relay

This signal is true (1) when actuator remote control is not available. The actuator Monitor Relay status is a composite signal for several alarms. This signal will be set true if the actuator selector is in Local or Local Stop (not in Remote) or if the thermostat trips.

Note on an IQ3/IQT3 actuator the Monitor Relay can be set to trigger on "Available" or "Alarm". When set to Alarm, Local or Local Stop won't cause a monitor Relay Alarm – see Section 2.2 of PUB002-040: <http://www.rotork.com/master-popup/8953/>

The mains supply is always monitored and if one of the three phases is lost, this bit is set. If the actuator is operated from a single phase supply and this is lost, then communications with the actuator will also be lost. Where a 3-phase supply is used, if the phase associated with the control circuits is lost then communications with the actuator will be lost.

5. The Actuator Input and Output Signals *continued*

| | |
|--------------------------------|---|
| Valve Obstructed/Jammed | This bit is a combination of the Valve Obstructed and the Valve Jammed bits. If either is true this bit will be true (1). |
| Valve Moving by Hand | <p>The manual movement of the valve is reported as true (1) if the actuator is moved by the handwheel away from the last position. The percentage of travel required to trip the indication is set in the associated parameter in the Transducer block during set-up.</p> <p>The bit will remain true (1) until the actuator is moved electrically by either the local controls or a network command.</p> |
| Digital Input HW_DI-1 | This bit reports the status of the contact connected to the actuator hard-wired Open terminals. The input can be used to control the actuator or simply to report the status of a plant feedback signal. The function is set in the Auxiliary Input Mask parameter, which determines whether the bit is reported as true (1) for a closed contact or an open contact and whether the input controls the actuator or not. Note that the input is always reported even when it is also controlling the actuator. |
| Digital Input HW_DI-2 | This bit reports the status of the contact connected to the actuator hard-wired Close terminals. The input can be used to control the actuator or simply to report the status of a plant feedback signal. The function is set in the Auxiliary Input Mask parameter, which determines whether the bit is reported as true (1) for a closed contact or an open contact and whether the input controls the actuator or not. Note that the input is always reported even when it is also controlling the actuator. |
| Digital Input HW_DI-3 | This bit reports the status of the contact connected to the actuator hard-wired Stop/Maintain terminals. The input can be used to control the actuator or simply to report the status of a plant feedback signal. The function is set in the Auxiliary Input Mask parameter, which determines whether the bit is reported as true (1) for a closed contact or an open contact and whether the input controls the actuator or not. Note that the input is always reported even when it is also controlling the actuator. |
| Digital Input HW_DI-4 | <p>This bit reports the status of the contact connected to the actuator hard-wired ESD terminals. The input can be used to control the actuator or simply to report the status of a plant feedback signal. The function is set in the Auxiliary Input Mask parameter, which determines whether the bit is reported as true (1) for a closed contact or an open contact and whether the input controls the actuator or not. Note that the input is always reported even when it is also controlling the actuator.</p> <p>A configuration feature also allows HW_DI-4 to be set to act as a 'Disable Fieldbus Control' input. In this mode, when the input is applied (irrespective of the Auxiliary Mask setting) the actuator cannot be controlled over the network. This can be useful during plant commissioning to prevent unwanted valve movement.</p> |

5.2.2 Discrete Inputs reporting the FF CP card condition

| | |
|-----------------------------------|--|
| Watchdog Recovery | The FF CP card's watchdog automatically resets the processor if it is tripped. This bit will be true (1) following a watchdog trip for the time period set in the associated watchdog timeout parameter. |
| Part Stroke Error | <p>In order to perform a partial stroke of the valve, the starting position is specified as either the open limit or the close limit. If the actuator is commanded to perform a partial stroke when it is not in the correct starting position or when it is in a mid-position, this error is generated and the bit will be set (1).</p> <p>There is a timer associated with Partial Stroke that is set in the Transducer block during set-up. It must be set to a value long enough to cover a successful part stroke operation from end to mid-position and back to the end. If the actuator fails to complete the partial stroke within the time set, then this bit will be true (1).</p> <p>Once set, the Part Stroke Error bit will be reset to 0 when the actuator next moves at least 2% by either a manual or automatic operation.</p> |
| Partial Stroke in Progress | When the actuator is performing a partial stroke this bit is true (1). Once the action is complete the bit is reset (0). If the partial stroke is interrupted by a new command then the bit will be reset. |

5. The Actuator Input and Output Signals *continued*

5.3 Actuator Analogue Input Feedback

The FF CP card includes two Analogue Input blocks, AI 1 and AI 2, which are used to report information about the valve and actuator. These blocks are connected to the Transducer block in the default configuration.

| Function Block Number | Analogue Feedback | IQ3, IQT3 & SI3 | CVA & CMA | CK | K |
|-----------------------|--------------------------------------|-----------------|-----------|----|-----|
| AI 1 | Valve Position | ✓ | ✓ | ✓ | ✓ |
| AI 2 | Actuator Instantaneous Torque/Thrust | ✓ | ✓ | ✓ | N/A |

Valve Position

The current valve position is reported as an Integer Value in the range 0.0 to 100.0% in block AI 1.

The actuators automatically scale the valve position value reported from the setting of the limit switches. This scaling is retained in EEPROM when the actuator power is removed.

If Limited Range Positioning is invoked by setting the appropriate parameters, then the reported valve position 0.0 to 100.0% follows the limited range of valve travel.

Torque

The currently developed torque value is reported in block AI 2 in the range 0 to 120% representing the percentage of actuator rated torque generated.

6. Function Blocks

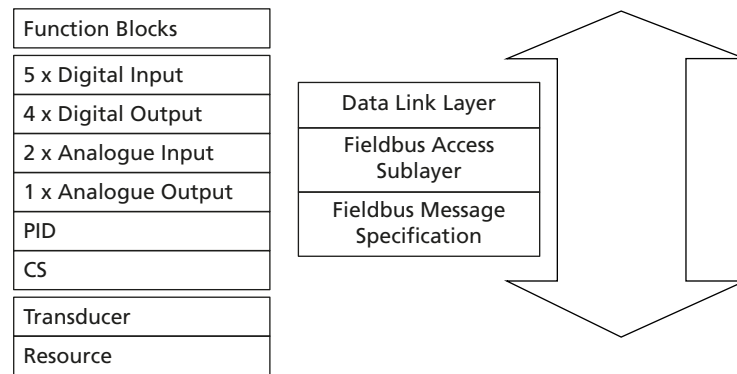


Fig 6.1: Function blocks within the FF CP card

Function blocks provide the heart of the Foundation Fieldbus system. Each device on a network includes at least one Transducer block and a Resource block to allow the equipment to be configured to operate on the network.

The FF CP card includes 16 blocks, of which one is the Resource block and one is the Transducer block. The remaining 14 input and output blocks are used to control and collect data from the actuator.

In order to make the FF CP easier to use, all of the parameters in the blocks are already defined. The Foundation requires certain parameters to be set to specific default values. The actuator controller will require the alteration of some of these when a particular function block is to be used. The values can be altered using a suitable configuration tool. Some of the network communications link location data (VCR coding) are already defined, as required by the Foundation specifications. Publisher and Subscriber function blocks have VCR values assigned, as described in the DD file. The pre-assigned connections that are fixed include:

- The two AI blocks to the two analogue input variables in the actuator
- The AO block to the resident analogue output positioner in the actuator
- The four DO blocks to the digital outputs for controlling the open/close actions of the actuator
- The five DI blocks to the digital inputs for reporting actuator status to the network

Many of the features of the function blocks are provided in order to allow the system to automatically identify and use these blocks. The Fieldbus specification FF-890 to FF-892 defines all aspects of the function blocks. In practice, the user needs to know very little about the internal workings of the blocks, as the Capabilities file lists all the available features. A suitable configuration tool such as that supplied by National Instruments can be used to set up all the tag names and operation of the blocks in the complete system. The contents of the blocks can also be examined using a configuration tool. Most DCS systems include configuration utilities for Foundation Fieldbus devices.

Each block must have its own unique tag name allocated during system configuration and each block has at least three modes it can be in, which show its availability on the system (OOS – Out Of Service, Auto – local set point used for the primary output value algorithm, CAS – set point value from the Cas input is used for the primary output value algorithm).

6. Function Blocks *continued*

6.1 Resource Block

Every Fieldbus device includes a resource block that describes to the host controller the system resources the device needs. This block contains data that is specific to the FF CP card itself. There are no links to this block and there is no function schematic. All the standard Resource Block parameters are included, with the addition of read only data shown in the following table that is specific to the FF CP card.

| Index | Parameter | Description | Units | Class |
|-------|-------------------|---|-------|-------|
| 1 | ITK_VER | ITK version tested to | None | RO |
| 2 | SW_REV | Firmware revision of FIC | None | RO |
| 3 | MB_REV | Main or Interface board firmware revision | None | RO |
| 4 | DEVICE_STATUS1 | Special device status parameters | None | RO |
| 5 | DEVICE_STATUS2 | Special device status parameters | None | RO |
| 6 | DEVICE_STATUS3 | Special device status parameters | None | RO |
| 7 | DEVICE_STATUS4 | Special device status parameters | None | RO |
| 8 | DEVICE_STATUS5 | Special device status parameters | None | RO |
| 9 | ACT_DEVICE_STATUS | Special device status parameters | None | RO |

Indexes 1 to 3 contain information for ITK test and Rotork firmware version control.

Indexes 4 to 9 give information on the current status of the various function blocks and the actuator control interface as shown below.

Index 4: DEVICE_STATUS1

| Bit | Title | Description |
|-----|---------------------------|------------------------------------|
| 0 | Simulate enable jumper on | The Simulation enable switch is ON |
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | RB in OOS mode | The Resource block is OOS |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | EEPROM failure | The EEPROM has failed on the FIC |
| 9 | | |
| 10 | | |
| 11 | | |
| 12 | | |

6. Function Blocks *continued*

Index 5: DEVICE_STATUS2

| Bit | Title | Description |
|-----|--------------------------------------|---|
| 0 | No response from Actuator controller | There is a communications failure between the Fieldbus and actuator |
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | Checksum error | Checksum error on the FIC |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | TB in OOS mode | Transducer block is in OOS mode |
| 9 | | |
| 10 | | |
| 11 | | |

Index 6: DEVICE_STATUS3

| Bit | Title | Description |
|-----|-------------------------|--------------------------------|
| 0 | AI 1 in OOS mode | AI 1 is in Out of Service mode |
| 1 | AI 1 in MAN mode | AI 1 is in Manual mode |
| 2 | AI 1 in Simulate active | AI 1 simulation is active |
| 3 | | |
| 4 | AI 2 in OOS mode | AI 2 is in Out of Service mode |
| 5 | AI 2 in MAN mode | AI 2 is in Manual mode |
| 6 | AI 2 in Simulate active | AI 2 simulation is active |
| 7 | | |
| 8 | DI 1 in OOS mode | DI 1 is in Out of Service mode |
| 9 | DI 1 in MAN mode | DI 1 is in Manual mode |
| 10 | DI 1 in Simulate active | DI 1 simulation is active |
| 11 | | |
| 12 | DI 2 in OOS mode | DI 2 is in Out of Service mode |
| 13 | DI 2 in MAN mode | DI 2 is in Manual mode |
| 14 | DI 2 in Simulate active | DI 2 simulation is active |
| 15 | | |
| 16 | DI 3 in OOS mode | DI 3 is in Out of Service mode |
| 17 | DI 3 in MAN mode | DI 3 is in Manual mode |
| 18 | DI 3 in Simulate active | DI 3 simulation is active |
| 19 | | |
| 20 | DI 4 in OOS mode | DI 4 is in Out of Service mode |
| 21 | DI 4 in MAN mode | DI 4 is in Manual mode |
| 22 | DI 4 in Simulate active | DI 4 simulation is active |
| 23 | | |
| 24 | DI 5 in OOS mode | DI 5 is in Out of Service mode |
| 25 | DI 5 in MAN mode | DI 5 is in Manual mode |
| 26 | DI 5 in Simulate active | DI 5 simulation is active |
| 27 | | |

6. Function Blocks *continued*

Index 7: DEVICE_STATUS4

| Bit | Title | Description |
|-----|-------------|-----------------------------|
| 0 | PID1 in OOS | PID block is Out of Service |
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | PID1 Bypass | PID1 has bypass active |
| 5 | | |
| 6 | | |
| 7 | | |

Index 8: DEVICE_STATUS5

This index is reserved for future use.

Index 9: ACT_DEVICE_STATUS

| Bit | Title | Occurs When | Action Required | Effect |
|-----|-------------------------------|--|--|--|
| 0 | DO block control conflict | Usage of more than one DO block. (When support for multiple bits is selected this is not allowed). | Check for multiple DO blocks in service, when multiple bit support is selected in TB, and not in mode 4 – (AO only control). | FIC Actuator operation suspended. |
| 1 | Incorrect control of DO block | Single bit support has been selected, but multiple bits are being received. | Check for multiple bits being set in DO blocks when only single bit support is selected in TB. | FIC Actuator operation suspended. |
| 2 | Controls contention | More than one actuator control bit is currently active. | Check for more than one bit being true in the actuator digital control register. | FIC Actuator operation suspended. |
| 3 | Actuator interface offline | The actuator is powered down or there is a fault between the Fieldbus and Actuator interface. | No communications between the actuator control/main PCB and the FIC. | Actuator operation not possible over FF network. |
| 4 | FF is overridden | FF control of actuator is currently disabled. | Actuator status is Local or Local Stop and/or HW_DI-4 net disable function is switched on and active. | Actuator operation not possible over FF network. |

6.2 Transducer Block

The Transducer Block is at the heart of the function block structure in the FIC. It contains all of the information with regards to setup and control of the actuator as well as its status feedback and provides the link between standard function blocks and the actuator mechanisms. Links between the actuator hardware and transducer block are already made to allow the user to access defined settings for the device.

The links between the Transducer block and the Input/Output function blocks are also defined and may not be altered. Data may be read from the parameters but not all parameters permit write commands. Writes are limited to the parameters used to set up the actuator control functions.

Before the actuator is used, the settings associated with its performance must be adjusted to match the application for the valve. These settings are contained in parameters within the Transducer block.

On installing the card,

- The default values in the table will be present
- Parameter values should be adjusted to allow for the desired control of the actuator

6.2.1 Transducer block parameters

The table lists all the parameters in the Transducer block. Many of these are required by the Foundation standards and are necessary for the card to operate on the highway. In addition, the block contains many more parameters that are actuator or set-up related. The parameters are categorised as follows:

| Index | Description |
|------------|--|
| 1-23/93-95 | FF specific parameters/standard requirements |
| 24-29 | Status feedback from the actuator – text format |
| 30-36 | Status feedback from the actuator – numerical format |
| 37-49 | Discrete and analogue output values to the actuator |
| 50-63 | Actuator parameter setup |
| 64 | Status feedback – date format |
| 65-66 | FF parameter setup |
| 67-92 | Actuator Datalogger information |

The parameters contained in the table below have the following attributes:

- Range is the range of the parameter. Where 'value' is stated, then this is the decimal value. Where 'bits' are stated, then these are bit parameters starting at bit 0
- Default is the default value for the parameter
- Units are the unit type for the parameter (E – enumeration, S – String)
- Class is whether the parameter is read-only (RO) or read-write (RW)

Note: The Transducer Block **MUST** be placed in **OUT OF SERVICE MODE (OOS)** before changes can be made to the **Control Mode or Discrete Block Control parameters**.

6. Function Blocks *continued*

| Index | Parameter | Description | Range | Default | Units | Class |
|-------|---------------------------------|---|---|---------|-------|-------|
| 1 | ST_REV | Revision level of the static data | Positive | 0 | None | RO |
| 2 | TAG_DESC | User description of the intended application of the block | 32 characters | Null | N/A | RW |
| 3 | STRATEGY | Used to identify grouping of blocks | | 0 | None | RW |
| 4 | ALERT_KEY | ID No. of the plant unit | 1 to 255 | 0 | None | RW |
| 5 | MODE_BLK | Actual, target, permitted, and normal modes of the block | | OOS | N/A | RW |
| 6 | BLOCK_ERR Block Error Status | FF specific parameter: | | | None | RO |
| 7 | UPDATE_EVT | Alert is generated by any change to the static data | | | N/A | RW |
| 8 | BLOCK_ALM | Alarm for all problems in the block | | | N/A | RO |
| 9 | TRANSDUCER_DIRECTORY | Directory that specifies the number and starting indices of the transducers | | | None | RO |
| 10 | TRANSDUCER_TYPE | Identifies the transducer | | 100 | E | RO |
| 11 | XD_ERROR | Error Codes | | 0 | None | RO |
| 12 | COLLECTION_DIRECTORY | FF specific parameter | | | None | RO |
| 13 | ACT_MAN_ID | Manufacturer ID, i.e. Rotork | 0xFF01 | 65281 | E | RO |
| 14 | ACT_MODEL | Actuator model number/type | Value/type: 0 – Unknown (default) 2 – A, AQ, Q, Integral 6 – IQ 8 – IQT 9 – EH 10 – Skilmatic 11 – Multiport 12 – CVL 13 – CVQ 14 – Rompak 17 – IQ3 18 – IQT3 20 – CMA 21 – SI3 22 – K range 23 – CK2 | 0 | None | RW |
| 15 | ACT_SN | Actuator serial number | | Null | None | RW |
| 16 | ACT_DEVICE_STATUS | Rotork parameter | Copy of Resource block parameter | 0 | None | RO |
| 17 | XD_CAL_LOC | Calibration Location | | Null | None | RW |
| 18 | XD_CAL_DATE | Calibration Date | | 0 | None | RW |
| 19 | XD_CAL_WHO | Person Who calibrated | | Null | None | RW |
| 20 | VALVE_MAN_ID | Valve Manufacturer's ID | | Null | None | RW |
| 21 | VALVE_MODEL_NUM | Valve Manufacturer's Model | | Null | None | RW |
| 22 | VALVE_SN | Valve Manufacturer's SN | | Null | None | RW |
| 23 | VALVE_TYPE | Valve Manufacturer's SN | | Null | None | RW |
| 24 | ACTUATOR_CONTROL | Final Fieldbus command to actuator interface | Value: 0 – No Command 1 – Stop command 2 – Close command 4 – Open command 8 – ESD command 16 – Position Control 32 – Partial stroke Any other value - Controls contention | N/A | None | RO |
| 25 | ACTUATOR_CONDITION | Actual actuator condition | Value: 0 – Fully closed 1 – Fully open 2 – Moving closed 3 – Moving open 4 – Stopped mid travel (not open, closed or moving) 5 – Unknown | N/A | None | RO |

6. Function Blocks *continued*

| Index | Parameter | Description | Range | Default | Units | Class |
|-------|---------------------------|---|---|---------|-------|-------|
| 26 | SELECTOR_CONDITION | Selector switch condition | Value: 0 – In Remote 1 – In Local Stop 2 – In Local 3 – In Test - CVA 4 – In Run - CVA | N/A | None | RO |
| 27 | ALARM_CONDITION | Actuator alarm condition | Value: 0 – No alarms 1 – General alarm | N/A | None | RO |
| 28 | CONTROL_WARNING | Interlock condition | Value: 0 – No interlocks 1 – No Open 2 – No Close 3 – No movement | N/A | None | RO |
| 29 | Auxiliary input status | Status of Auxiliary inputs | 0x00-0x0F | N/A | None | RO |
| 30 | PRIMARY_VALUE_POSITION | Actuator position feedback | 0.0 – 100.0% | N/A | % | RO |
| 31 | PRIMARY_VALUE_TORQUE | Actuator torque feedback | 0 – 120% | N/A | % | RO |
| 32 | PRIMARY_VALUE_DI1 | Discrete input 1 feedback | Hexadecimal 0-0xFF | N/A | None | RO |
| 33 | PRIMARY_VALUE_DI2 | Discrete input 2 feedback | Hexadecimal 0-0xFF | N/A | None | RO |
| 34 | PRIMARY_VALUE_DI3 | Discrete input 3 feedback | Hexadecimal 0-0xFF | N/A | None | RO |
| 35 | PRIMARY_VALUE_DI4 | Discrete input 4 feedback | Hexadecimal 0-0xFF | N/A | None | RO |
| 36 | PRIMARY_VALUE_DI5 | Discrete input 5 feedback | Hexadecimal 0-0xFF | N/A | None | RO |
| 37 | FINAL_VALUE_AO | Requested valve position & status written by the Function Block | 0.0-100.0% | N/A | % | RO |
| 38 | FINAL_VALUE_RANGE | The High and Low range limit values | 0.0-100.0% | 0-100 | % | RO |
| 39 | FINAL_VALUE_CUTOFF_HI | Cut-off levels for output | 0 to +Inf | +Inf | | RW |
| 40 | FINAL_VALUE_CUTOFF_LO | Cut-off levels for output | 0.0 | 0 | | RW |
| 41 | LOCAL_FINAL_VALUE_AO | Position Read back Value | 0.0-100.0% | N/A | % | RO |
| 42 | FINAL_VALUE_DO1 | DO Output Value | Hexadecimal 0-0xFF | 0 | None | RO |
| 43 | LOCAL_FINAL_VALUE_DO1 | DO Read back Value | Hexadecimal 0-0xFF | 0 | None | RO |
| 44 | FINAL_VALUE_DO2 | DO Output Value | Hexadecimal 0-0xFF | 0 | None | RO |
| 45 | LOCAL_FINAL_VALUE_DO2 | DO Read back Value | Hexadecimal 0-0xFF | 0 | None | RO |
| 46 | FINAL_VALUE_DO3 | DO Output Value | Hexadecimal 0-0xFF | 0 | None | RO |
| 47 | LOCAL_FINAL_VALUE_DO3 | DO Read back Value | Hexadecimal 0-0xFF | 0 | None | RO |
| 48 | FINAL_VALUE_DO4 | DO Output Value | Hexadecimal 0-0xFF | 0 | None | RO |
| 49 | LOCAL_FINAL_VALUE_DO4 | DO Read back Value | Hexadecimal 0-0xFF | 0 | None | RO |
| 50 | Min Position | LRP Min position | 0-100% | 0 | % | RW |
| 51 | Max Position | LRP Max position | 0-100% | 100 | % | RW |
| 52 | Deadband | Deadband value | 0.0-25.5% | 5.0 | % | RW |
| 53 | Hysteresis | Hysteresis value | 0.0-25.5% | 2.0 | % | RW |
| 54 | Slow mode range | Range to use slow mode | 0-100% | 5 | % | RW |
| 55 | MIT | Motion inhibit timer | 0-255s | 3 | S | RW |
| 56 | Comms lost action | Action on comms loss | Value: 0 – No Action 1 – Open 3 – Close 5 – Stop 7 – Position Any other value = off | 0 | None | RW |
| 57 | Comms lost position | Position on loss of comms | 0-100% | 0 | % | RW |
| 58 | Comms Fault timer | FF bus power loss timer | 0-255s | 10 | S | RW |
| 59 | Auxiliary Mask (Function) | Monitor or Control N/O or N/C contacts | 0x00-0xFF | 0x0F | None | RW |
| 60 | HW_DI-4 ESD/Net disable | Selector for ESD function or Network disable | 0 – ESD function 1 – Network disable | 0 | None | RW |
| 61 | Partial stroke % travel | % position to travel to for partial stroke | 0-100% | 95 | % | RW |
| 62 | Partial stroke limit | Start position for partial stroke | 0 – Close limit 1 – Open limit | 1 | None | RW |
| 63 | Partial stroke timeout | Maximum time for partial stroke to take | 0- 7200s | 300 | S | RO |

6. Function Blocks *continued*

| Index | Parameter | Description | Range | Default | Units | Class |
|-------|-----------------------------------|--|--|----------------------|-------|-------|
| 64 | Partial Stroke Status | Indicates the date and time for partial stroke test success and failures | 2 Date fields: Partial Stroke Success Partial stroke Failure (MM/DD/YY HH:MM:SS) | 01/01/72 00:00:00 | Time | R |
| 65 | Control mode | Used for selecting DO4 function | Value: 0 – Positioning mode 1 – ESD 2 – S5 relay operate 3 – Partial stroke with DO control only 4 – AO only 5 – Two-wire control 6 – Partial stroking with AO and DO control | 0 | None | RW |
| 66 | Discrete block control | Used to select multiple bit support for discrete blocks | Bit: 0 – Multiple support 1 – Single support 2 – AO only DI Multiple support 3 – AO only DI Single support | 0 | None | RW |
| 67 | Close Torque Set | Datalogger Data | 0 – 120% | N/A | % | RO |
| 68 | Open Torque Set | Datalogger Data | 0 – 120% | N/A | % | RO |
| 69 | Torque at 0% - open direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 70 | | | | | | |
| | Torque at 10% - open direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 71 | Torque at 20% - open direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 72 | Torque at 30% - open direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 73 | Torque at 40% - open direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 74 | Torque at 50% - open direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 75 | Torque at 60% - open direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 76 | Torque at 70% - open direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 77 | Torque at 80% - open direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 78 | Torque at 90% - open direction | Datalogger Data Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 79 | Torque at 100% - open direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 80 | Torque at 0% - close direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 81 | Torque at 10% - close direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 82 | Torque at 20% - close direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 83 | Torque at 30% - close direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 84 | Torque at 40% - close direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 85 | Torque at 50% - close direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 86 | Torque at 60% - close direction | Datalogger Data Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 87 | Torque at 70% - close direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 88 | Torque at 80% - close direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 89 | Torque at 90% - close direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 90 | Torque at 100% - close direction | Datalogger Data – latest value | 0 – 120% | N/A | % | RO |
| 91 | Close Contactor counts (Double) | Datalogger Data | 0-4294967296 | 0 | None | RO |
| 92 | Open Contactor counts (Double) | Datalogger Data | 0-4294967296 | 0 | None | RO |
| 93 | Primary Value Position Unit | FF specific parameter | 0-0xFFFF | 1342 | % | RO |
| 94 | Primary Value Torque Unit | FF specific parameter | 0-0xFFFF | 1342 | % | RO |
| 95 | Supported Modes | FF specific parameter | Bits: (OOS, Man, and Auto) | N/A | None | RO |
| 96 | SI only, Partial stroke timeout 1 | Out Time 1 | 0-7200 seconds | 300 | S | RO |
| 97 | SI only, Partial stroke timeout 2 | Out Time 2 | 0-7200 seconds | 300 | S | RO |
| 98 | SI only, Partial stroke timeout 3 | Return Time 1 | 0-7200 seconds | 300 | S | RO |
| 99 | SI only, Partial stroke timeout 4 | Return Time 2 | 0-7200 seconds | 300 | S | RO |

6.2.2 Changing the settings in the Transducer block

The functional operation of the actuator can be modified over the Foundation Fieldbus by editing the Transducer Block. Note that changes to some parameters can only be made when this block is in the 'Out Of Service' mode (OOS). Using a Configuration Tool such as the NI Configurator, there are two ways in which the parameters can be modified:

- Direct changes to parameter values. Clicking each writable parameter reveals a drop-down menu from which the desired value can be selected. Parameters not available for editing are shown greyed out. The changes made must then be downloaded to the FF01 actuator using the "write changes" button.
- Editing the Transducer Block using 'Methods'. The Method provides a step-by-step prompted entry dialogue that automatically presents each user-changeable parameter for modification. Non-changeable parameters are not shown. This 'Method' of Transducer Block editing simplifies the search for specific values required for editing as shown below and is carried out 'On Line' to the actuator.

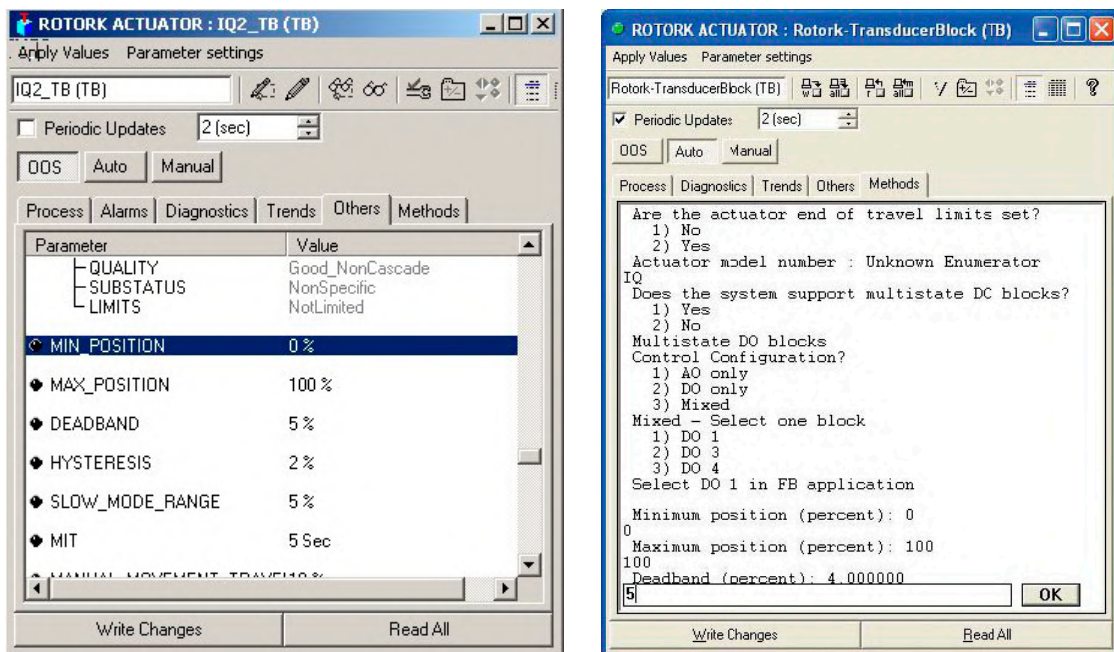


Fig 6.2: Editing the Transducer block

6. Function Blocks *continued*

6.2.3 Editing the Foundation specific parameters 1-23 and 99

These parameters include settings that will be specific to the application and the method of control adopted for the network as a whole. Some are related to standard FF functions and are not described here. Completing the fields listed below will assist on site diagnostics on the installed system by relaying field data to the control room.

| | | |
|----------|-----------------|---|
| Index 2 | TAG_DESC | Enter the tag number allocated to the device |
| Index 14 | ACT_MODEL | Select the type of actuator that the FF CP card is fitted into from the list |
| Index 15 | ACT_SN | The actuator serial number should be entered in this field. The serial number appears on the actuator label |
| Index 20 | VALVE_MAN_ID | The name of the valve manufacturer may be entered |
| Index 21 | VALVE_MODEL_NUM | The valve manufacturer's model number may be entered |
| Index 22 | VALVE_SN | The valve serial number should be entered in this field |
| Index 23 | VALVE_TYPE | For example – Gate, Butterfly, may be entered |

6.2.4 Editing the actuator setup parameters 50–66

The actuator control performance is determined by a number of settings in this group of parameters. When using direct editing of these parameters, close attention should be paid to the function of each. Entering unsuitable values may result in difficulty in controlling the actuator. The parameters are described with their Index numbers.

Index 50 and 51 Limited Range Position Minimum and Maximum

These parameters are used to define the positions in the range of valve travel that will be reported as 0 to 100% if the whole travel from the closed position to the open position is not used. In addition, the position demand set-point output value will also be modified to follow this limited range.

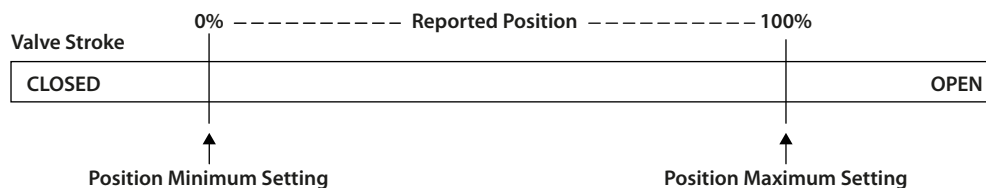


Fig 6.3: Limited range position control and reporting

It is possible to make the position data reported and the position controller relate to a reduced span of actual valve travel. In this mode the position data relates to the reduced portion of the valve stroke. This is sometimes used where the valve is required to have a 0% position (or 100% position) that is not the same as the fully closed position (or fully open position). These parameters define the actual limited range of valve travel that will be used for the position reporting and control by the positioner. Note that the digital open and close commands will still make the valve travel over its full stroke. The special case analogue commands of 0% and 100% that would otherwise cause the actuator to travel to the limit switch or torque off positions are inhibited if values other than 0 and 100 are set in these parameters.

The values inserted relate to the maximum total valve travel between closed and open and represent the point in the full stroke which will now be used for the limited stroke 0 and 100 values.

Index 52 and 53 Deadband and Hysteresis

When using position control by sending a value to the Actuator Position DV set-point, there are a number of parameters used to tune the position controller and reduce the possibility of damage to the actuator. These two parameters are set to prevent hunting around the set-point due to high inertia of the valve. They will require adjustment for each specific application. In addition, the Motion Inhibit Timer is used to ensure the actuator does not carry out an excessive number of starts in a given period.

- **Deadband**

The control used for the positioner is proportional only. The FF CP card will run the actuator to within the deadband of the desired position and then it stops. As the actuator and valve combination have some inertia, there is a possibility that the desired position may be overrun and the positioner will then reverse the direction of travel to make the valve adopt the desired position. This overshoot and return may continue for a number of cycles and is known as hunting, the valve and actuator combination will hunt around the set-point if the inertia is high. To prevent this from happening there is a Deadband setting whereby, once the actuator enters the deadband the motor will be stopped. For example, a 5% deadband will cause the motor to be stopped once the actual position is within 5% of the desired position. The inertia will then bring the actual position nearer the desired position.

The deadband is the allowable error around the set-point.

- **Hysteresis**

In addition to the deadband a second setting, Hysteresis, further refines the performance of the position controller. The positioner will run the actuator towards the set-point DV until the actual position is within the deadband minus the Hysteresis setting. This has the effect of instructing the actuator to stop when it is nearer the DV. The actuator will not restart unless it overshoots and runs outside the deadband or a new command places the new desired position outside the deadband. The Hysteresis is the amount of movement inside the deadband permitted before the motor stops.

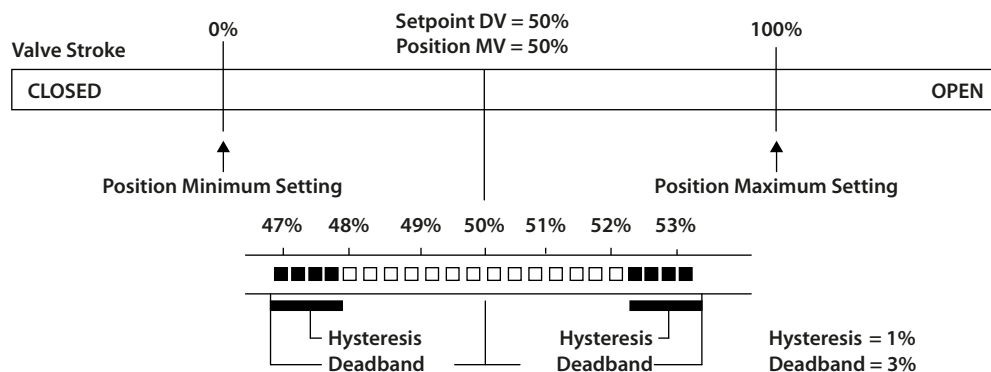


Fig 6.4: Deadband and hysteresis settings

Index 54 **Slow Mode Range**

This parameter is currently only applicable to IQT actuators. The Slow Mode Range sets the deviation between the set-point and current position in positioning mode inside which the actuator motor will slow to minimum speed.

If the set-point (DV) is 50% and the setting for this parameter is 10%, then when the actuator moves within the range 40% to 60% the motor will adopt low speed. The actuator does not use slow mode for digital (Open/Close) commands.

Index 55 **MIT (Motion inhibit timer)**

The Motion Inhibit Timer setting is the period that must elapse between consecutive starts of the actuator motor when in positioning mode. The idle period can be used to prevent the actuator motor from exceeding its rated number of starts per hour. In addition, when tuning the valve positioner, the setting can be used to allow the plant dynamics to stabilise between valve movements.

Index 56 to 58 **Comms Failure – Action on loss of signal**

This is a Rotork feature that is common for all our network products. The feature is used to enable the user to set a position to which the actuator is required to go or to take no action at all if the FF CP card loses communication with the network. If enabled, a timer is used to determine how long the actuator should wait before carrying out the pre-set action:

- **Communications Lost Action (56)**

The Action on Loss of Comms parameter defines the actuator action that will result after the time set for the Comms Fault Timer (parameter 58) if there is no network communication activity detected by the FF CP card.

- **Communications Lost Position (57)**

The setting in this parameter determines the position in the range 0 to 100% that the actuator will move to if the FF card's communications stop being received, provided the Action on Loss of Comms (parameter 56) is set to 'Position'. No action will be taken unless the communications stop for a period equal to or greater than the setting in the Comms Fault Timer (parameter 58).

- **Communications Fault Timer (58)**

The Comms Fault Timer setting determines the number of seconds that the FF card's communication must be absent for before the setting for the Fault Mode will be carried out.

Note: Parameters 56 to 58 relate to how the actuator's control/main PCB responds to a loss of comms. With FF there is also the ability to set a comms fail response on the output blocks of the FF card itself. This is the "Fault state to value". If this is selected, and the fieldbus block goes into "faultstate", the value in the fault state value register will be used by the function block. As an example, if the upstream block connected to the AO block has problem this will put the AO block in fault state – if the fault state value is 50, then the actuator will be sent to 50%.

Extreme care is recommend when using both the "action on loss of signal" and "fault state to value" settings in order to avoid a potential conflict.

Index 59 Auxiliary Mask (Function)

This parameter relates to the IQ3/IQT3/SI3/CK actuators only and allows the auxiliary inputs (Open, Stop, Close, ESD) to be set to control the actuator or simply report their status. In addition, it allows the sense of the input (open or closed contact) that is reported as true (1) to be set. Actuator control always requires a true (1) input signal. The status of the inputs is always reported over the network and they can be used to report associated plant inputs instead of controlling the actuator. The register should be considered in its binary format using the low order byte. The number has the binary form $x^7x^6x^5x^4, y^3y^2y^1y^0$, requiring 8 bits. Each bit in the high order nibble, $x^7x^6x^5x^4$, either enables or disables the associated input for control of the actuator. The bits in the low order nibble, $y^3y^2y^1y^0$, determine if the input reports a closed contact as a '1' or an open contact as a '1'.

To allow an input to act as a control signal its associated bit in the high order nibble must be set to a '1' in the mask. To allow a closed contact to be reported as a '1' then its associated bit in the low order nibble must be set to '1' in the mask.

| Bit | Position | Value | Function |
|-----|----------|-------|---|
| 7 | X^7 | 0 | Disable ESD input as command |
| | | 1 | Enable ESD input as command |
| 6 | X^6 | 0 | Disable Stop/Maintain input as command |
| | | 1 | Enable Stop/Maintain input as command |
| 5 | X^5 | 0 | Disable Close input as command |
| | | 1 | Enable Close input as command |
| 4 | X^4 | 0 | Disable Open input as command |
| | | 1 | Enable Open input as command |
| 3 | Y^3 | 0 | Report closed contact on ESD input as '0' |
| | | 1 | Report closed contact on ESD input as '1' |
| 2 | Y^2 | 0 | Report closed contact on Stop/Maintain input as '0' |
| | | 1 | Report closed contact on Stop/Maintain input as '1' |
| 1 | Y^1 | 0 | Report closed contact on Close input as '0' |
| | | 1 | Report closed contact on Close input as '1' |
| 0 | Y^0 | 0 | Report closed contact on Open input as '0' |
| | | 1 | Report closed contact on Open input as '1' |

The following examples show how the Auxiliary Input Mask settings can be applied.

| | Most Significant Bit | | | | Least Significant Bit | | | |
|------------------|----------------------|---------------------|----------------------|---------------------|-----------------------|----------------|----------------|----------------|
| | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| | X^7 | X^6 | X^5 | X^4 | Y^3 | Y^2 | Y^1 | Y^0 |
| | Enable HW_DI-4 ESD | Enable HW_DI-3 Stop | Enable HW_DI-2 Close | Enable HW_DI-1 Open | Invert HW_DI-4 | Invert HW_DI-3 | Invert HW_DI-2 | Invert HW_DI-1 |
| Example 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| Example 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Example 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

- **Example 1** The default value of '15' (0000,1111 binary or 0F hex) makes all 4 inputs report closed contacts as true (1) and none of the inputs will operate the actuator.
- **Example 2** The value 255 (1111,1111 binary or FF hex) makes all 4 inputs report closed contacts as true (1) and all the inputs control the actuator in their predefined way.
- **Example 3** The value 0 (0000,0000 binary or 00 hex) makes all 4 inputs report open contacts as true (1) and none of the inputs will operate the actuator.

Index 60 HW_DI-4 ESD/Net Disable

In the IQ3/IQT3/SI3/CK actuator this input determines the mode of operation for the ESD/HW_DI-4 remote input. The input can be used either to disable control of the actuator from the FF network, or to act as an ESD/digital input. When this setting is made 'Active' the input will disable FF control of the actuator when the contact input is detected as being logic 1. This feature is dependent of the Auxiliary mask setting and can be configured as an NO or NC input. When the HW_DI-4 ESD/Net Disable parameter is set to '1', no hard-wired ESD will be available.

Index 61 to 64 Partial Stroke

The actuator may be instructed to perform a partial stroke that causes the valve to be moved from one end position to an intermediate position and return to the original position. If the action takes longer than the pre-set time then a timeout indication is given, showing there is a fault.

- **Partial Stroke % Travel**

This parameter sets the position to travel to when a Partial Stroke command is carried out. The partial stroke can be initiated from either the open or the closed position of the valve. The target position can be any value in the range 1-100% where 1 % is near the closed position. Note that the desired value to which the actuator is required to move must be outside the deadband setting.

- **Partial Stroke Limit**

This parameter is used to set two values. The most significant bit in the register is used to determine the starting position which can be either the open position (1) or closed position (0) for the valve.

- **Partial Stroke Timeout**

The time in which the partial stroke must be successfully completed.

- **Partial Stroke Status**

Indicates the time and date for partial stroke test success and failures. There are 2 fields within this parameter, one for success and one for failure. The parameters are in date and time format.

6. Function Blocks *continued*

6.2.5 Editing the control parameters 65–66

Index 65 Control mode

Most control schemes will be executed using the multiple bit function provided by a single DO block. DO 1 to DO 3 have a fixed set of 8 bits each that will suit most applications using discrete control. However, if analogue control alone is being used, or there are some special requirements for the control action, or single bit control is being used, DO 4 may need to be used in one of its mode settings.

Function Block DO 4 can be configured so that the function of the individual control bits is changed to suit a user's preferred control scheme. The following options are available:

| DO 4 Mode | Value | Type | Function of Bit 0 |
|-----------|-------|----------|---|
| 0 | 0 | POS | 1 = Position control enable |
| 1 | 1 | ESD | 1 = Emergency shut down |
| 2 | 2 | S5 RELAY | 1 = Set S5 |
| 3 | 3 | PST | 1 = Partial stroke enable – DO only control |
| 4 | 4 | AO ONLY | None (Analogue only) |
| 5 | 5 | TWO WIRE | 0 = Close/1 = Open |
| 6 | 6 | POS | 1 = Position control enabled * |

***Note: Mode 6 allows position control and PST, when used in multistate mode. Mode 0 doesn't have a PST in multistate and mode 3 doesn't have position control in multistate.**

Index 66 Discrete block control

This parameter is used to set the way the card's DO blocks will be used. Most systems will be able to support Boolean Fan In functions and consequently the DCS can use a single DO block for all the discrete controls (Open/Stop/Close). This provides for much higher efficiency on the Foundation highway. In this condition the setting for the parameter will be 0 (multiple bit support).

For those systems where each DO block performs a single function (e.g. DO 1 = Close) and several blocks are used for the discrete control, it is necessary to set this parameter to 1 (single bit support).

- **Multiple Support**

Systems using the multiple state of a single DO block, with only one DO block selected for use. (Unused DO blocks must be left OOS) Only one DO block may be used if this mode is selected. Note however, multiple DI blocks can be used.

This is multiple bit support.

- **Single Support**

Systems using only bit 0 from each DO block and using several DO blocks to obtain discrete control. Only one bit (bit 0) may be used from each DO block in this mode.

This is single Bit support.

Note that changes to this parameter will also affect the DIs.

6.3 Analogue Input Blocks

The FF CP card includes two Analogue Input (AI) blocks.

- **AI 1 Valve Current Position Output (analogue % value)**

The % 'Open' value (position) of the valve. The range is 0.0-100.0% and the end values relate to the close (0%) and open (100%) position limit switches. Actual resolution is 0.1%.

- **AI 2 Valve Current Torque/Pressure Output (analogue % value)
IQ3/IQT3/SI3 and CVA only**

The instantaneous % torque value throughout the valve stroke. The range is 0-120%, with a resolution of 1%.

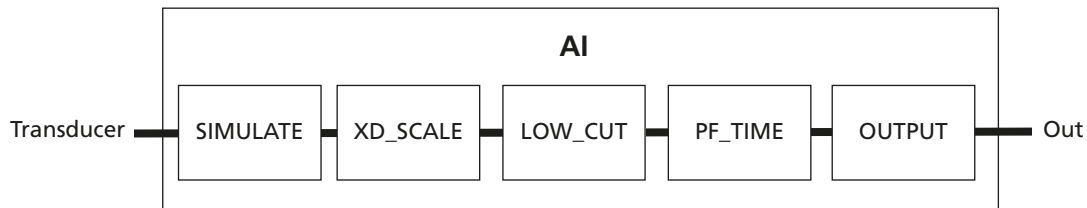


Fig 6.5: Analogue Input function block

On installing the card, the following settings will apply:

- The connections to the Transducer block are fixed and in place
- The Mode control is standard (Auto, Man, OOS)
- The Alarms are disabled
- AI 1 is channel number 1 (this must not be changed)
- AI 2 is channel number 2 (this must not be changed)

6.4 Discrete Input Blocks

There are five Discrete Input Blocks (DI) included on the FF CP card. These DIs are preconfigured to read back information from actuator. The description of each reported data bit is included in Section 5.

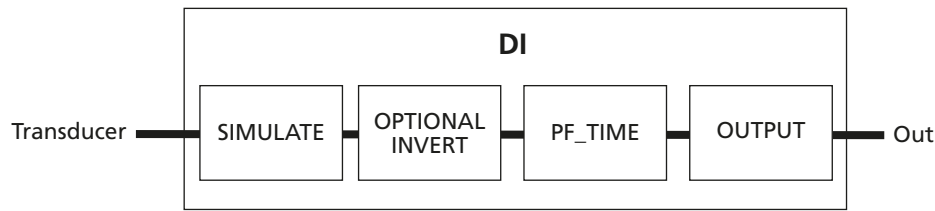


Fig 6.6: Discrete Input function block

The value reported by each DI block is in the range 0-255. This can be split into 8 discrete binary values, allowing 8 different signals to be reported within each block. The host DCS will need to decode the number into its binary parts using a Boolean Fan In function. In this way the operator can access a large number of discrete signals using a minimum number of function blocks.

If the host system is not able to support the Boolean function, the first bit in each block represents a different actuator feedback signal and all 5 blocks can be used to transmit 5 bits of discrete data.

The use of Boolean functions will maximise the data transmitted with the minimum of network resources.

The bit information contained in the first bit of each block is as follows:

- **DI 1** Single bit (bit 0) status = Actuator at Close Limit
- **DI 2** Single bit (bit 0) status = Actuator at Open Limit
- **DI 3** Single bit (bit 0) status = Actuator selector in Remote
- **DI 4** Single bit (bit 0) status = Actuator has a General Alarm
- **DI 5** Single bit (bit 0) status = Actuator is moving

The information from each block is shown below.

| Block | Bit | Operation |
|-------|----------|--|
| DI 1 | 0 | Close limit |
| | 1 | Open limit |
| | 2 | Actuator moving |
| | 3 | Actuator closing |
| | 4 | Actuator opening |
| | 5 | Selector In Remote (Selector in "Run" on a CVA) |
| | 6 | Selector In Local Stop (Selector in "Stop" on a CVA) |
| | 7 | Selector In Local (Selector in "Test" on a CVA*) |
| DI 2 | 0 | Open limit |
| | 1 | Close limit |
| | 2 | Actuator opening |
| | 3 | Actuator closing |
| | 4 | Not in remote (Selector not in "Run" on a CVA) |
| | 5 | General alarm |
| | 6 | Valve obstructed |
| | 7 | Valve jammed |
| DI 3 | 0 | Selector In remote (Selector in "Run" on a CVA) |
| | 1 | Selector In Local Stop (Selector in "Stop" on a CVA) |
| | 2 | Selector In Local (Selector in "Test" on a CVA*) |
| | 3 | MIT/Interrupter active |
| | 4 | Open interlock active |
| | 5 | Close interlock active |
| | 6 | Position control enabled |
| | 7 | Slow mode |

| Block | Bit | Operation |
|-------|----------|-------------------------|
| DI 4 | 0 | General alarm |
| | 1 | Thermostat tripped |
| | 2 | Monitor relay |
| | 3 | Valve obstructed/jammed |
| | 4 | Partial stroke alarm |
| | 5 | Manual movement |
| | 6 | Battery low |
| | 7 | Watchdog recovery/fail |
| DI 5 | 0 | Actuator moving |
| | 1 | HW_DI-1- open input |
| | 2 | HW_DI-2- close input |
| | 3 | HW_DI-3- stop maintain |
| | 4 | HW_DI-4- ESD input |
| | 5 | Open interlock active |
| | 6 | Close interlock active |
| | 7 | Partial stroking |

On installing the card, the following settings will apply:

- The Mode control is standard (Auto, Man, OOS)
- DI 1 is channel number 3 (this must not be changed)
- DI 2 is channel number 4 (this must not be changed)
- DI 3 is channel number 5 (this must not be changed)
- DI 4 is channel number 6 (this must not be changed)
- DI 5 is channel number 7 (this must not be changed)

Note: *When the CVA selector knob is in "Test" the "Local" bit is not true, but the monitor relay bit is.

6.5 Analogue Output Block

There is one Analogue Output (AO) block in the FF CP that is designed to allow the valve under control to be positioned to a specific value over its position range of 0.0-100.0%.

- **A0 1** The % set point (position) of the valve. The range is 0.0-100.0% and the end values relate to the close (0%) and open (100%) position limit switches. Actual resolution is 0.1%, but the practical resolution is 1%. Positioning accuracy is dependent upon deadband and hysteresis settings.

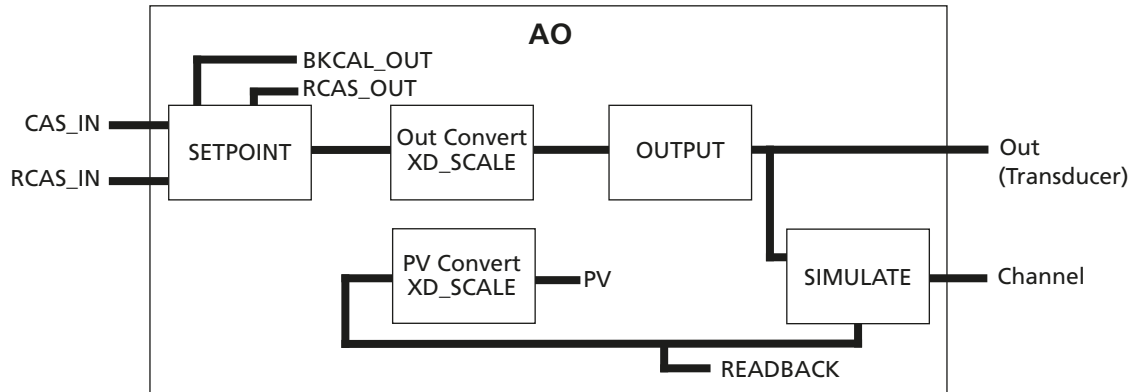


Fig 6.7: Analogue Output function block

On installing the card, the following settings will apply:

- The output connections to the Transducer block are fixed and in place
- The Mode control is standard (Auto, Man, LO, OOS)
- When the actuator Local/Remote selector is not in the Remote position the block will adopt LO mode
- The IO_OPTS must be set to PV for BKCal_Out
- In the resource block set Feature select to Out_Readback
- AO is channel number 8 (this must not be changed)

For the correct operation of the AO block, the setting IO_OPTS = PV for BKCal_Out should be performed in the function block during the configuration of the Foundation Fieldbus. This setting is found within the AO function block dialogue box in the options folder, as shown in Fig 6.8. Setting it to this value ensures that the BKCal_Out value follows the actual valve position if the actuator is moved manually, by the local controls or by other electrical means.

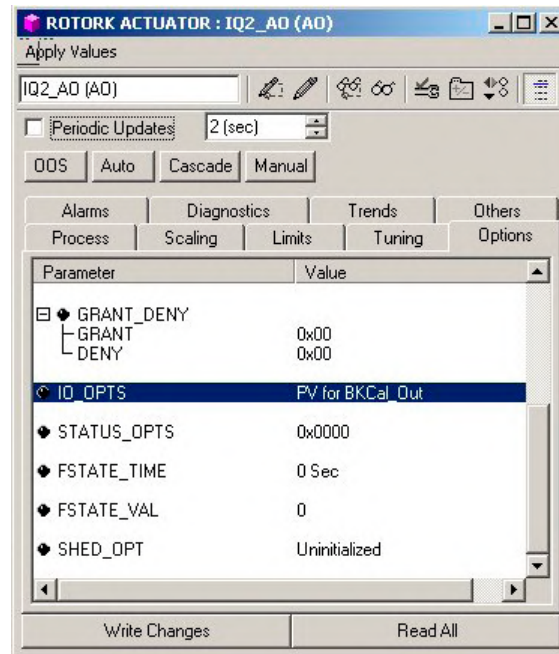


Fig 6.8: Setting IO_OPTS to PV for BKCal_Out

The AO block acts as a positioner for the valve and actuator. The positioning action is initiated by setting the DO function to Position Control Enable through the DO blocks, or by setting the Control Mode (Transducer block parameter 65) to AO only. Each time the positioner is enabled, the actuator will move to the value set in the AO block, provided the actuator Local/Remote selector is in the Remote position.

Note: The block option for IO_OPTS must be set to PV for BKCal_Out for correct operation of a control or positioning function. The AO block will only control the actuator position when the DO setting is for Position Control Enable or the appropriate Transducer block parameter is set for AO only mode.

6.6 Discrete Output Blocks

Discrete (Open/Stop/Close) control of the actuator, or mixed discrete and analogue position control is possible provided the FF CP card is set up correctly in the Transducer block and the correct settings are applied. There are 4 Discrete Output (DO) blocks in the FF card that allow the actuator to be moved. In addition, when the optional relay output board is fitted, the status of the four relays may be controlled.

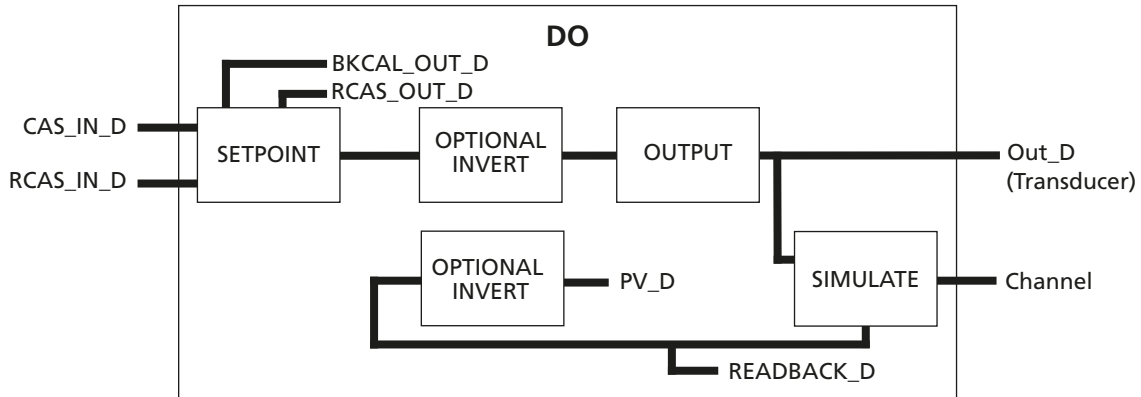


Fig 6.9: Discrete Output function block

As with the DI blocks, the DO blocks make use of all 8 bits within each block. The actuator will respond to values between 0 and 255 sent via one DO block when multiple support is selected, or to the value of the first bit (0/1) when single bit and one or more DO blocks are used. Single or multiple bit discrete use is selected using parameter 70 in the transducer block. When multiple bit support is selected only one of the DO blocks may be used for discrete control. If control using DO 4 is adopted it is necessary to set the mode for this block using parameter 65 in the transducer block.

On installing the card, the following settings will apply:

- The output connections to the Transducer block are fixed and in place
- The Mode control is standard (Auto, Man, LO, OOS)
- When the actuator Local/Remote selector is not in the Remote position the block will adopt LO mode
- The IO_OPTS should be set to PV_D for BKCal_Out_D
- DO 1 is channel number 9 (this must not be changed)
- DO 2 is channel number 10 (this must not be changed)
- DO 3 is channel number 11 (this must not be changed)
- DO 4 is channel number 12 (this must not be changed)

Where multiple support is selected, only one DO should be set to Auto. All other DO blocks must be set to Man or OOS.

6. Function Blocks *continued*

6.6.1 Multiple block – single bit control

- **DO 1** Bit 0 = 'Close'
- **DO 2** Bit 0 = 'Open'
- **DO 3** Bit 0 = 'Stop'
- **DO 4** Bit 0 = selected by mode – see below

| Mode | Bit 0 Function |
|------|----------------------------------|
| 0 | Position Control Enable * |
| 1 | ESD |
| 2 | Set/reset relay 1 |
| 3 | Partial Stroke * |
| 4 | Not Applicable (AO only control) |
| 5 | 0= close, 1 = open |
| 6 | Position Control Enable * |

*** Note:**

1. Mode 0 and mode 6 offer the same control in single bit support.
When used in multistate support, mode 6 provides both position control enable and PST options in the same block.
2. The DO4 block options will appear as shown in Fig 6.10.

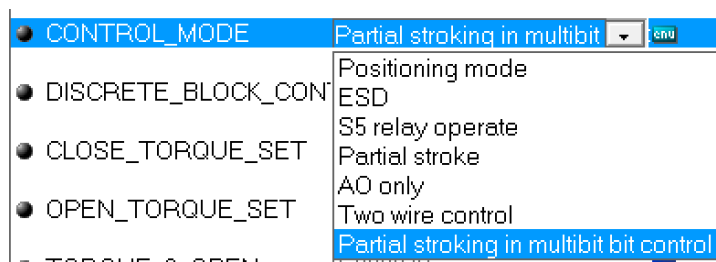


Fig 6.10: DO4 options as shown in the TB

Note: Mode 6 bit 0 is position control enable.

6. Function Blocks *continued*

6.6.2 Single block – multiple bit control

The table below identifies the function of each bit in the available DO block when multiple bit control is selected. PV_D comes from READBACK from the appropriate 'status inputs'. The bold text in the read-back column below indicates bits that only echo the command operation. The italic text in the operation and read-back column show the function of the block for the multiple block mode described previously.

| Block | Bit | Operation | Read-back |
|------------------------|-----|--------------------------------|--|
| DO 1 | 0 | <i>Close</i> | <i>Close limit</i> |
| | 1 | Open | Open limit |
| | 2 | Stop | Actuator not moving |
| | 3 | ESD | ESD |
| | 4 | Position control enable | Position control enabled |
| | 5 | Set relay 1 | relay 1 set |
| | 6 | Set relay 2 | relay 2 set |
| | 7 | Set relay 3 | relay 3 set |
| DO 2 | 0 | <i>Open</i> | <i>Open limit</i> |
| | 1 | Close | Close limit |
| | 2 | Stop | Actuator not moving |
| | 3 | ESD | ESD |
| | 4 | Partial stroke | Partial stroking |
| | 5 | Set relay 1 | relay 1 set |
| | 6 | Set relay 2 | relay 2 set |
| | 7 | Set relay 3 | relay 3 set |
| DO 3 | 0 | <i>Stop</i> | <i>Actuator not moving</i> |
| | 1 | Close | Close limit |
| | 2 | Open | Open limit |
| | 3 | Position control enable | Position control enabled |
| | 4 | Set relay 1 | relay 1 set |
| | 5 | Set relay 2 | relay 2 set |
| | 6 | Set relay 3 | relay 3 set |
| | 7 | Set relay 4 | relay 4 set |
| DO 4 Mode 0: | 0 | <i>Position control enable</i> | <i>Position control enabled</i> |
| | 1 | Close | Close limit |
| | 2 | Open | Open limit |
| | 3 | ESD | ESD |
| | 4 | Set relay 1 | relay 1 set |
| | 5 | Set relay 2 | relay 2 set |
| | 6 | Set relay 3 | relay 3 set |
| | 7 | Set relay 4 | relay 4 set |
| DO 4 Mode 1: | 0 | <i>ESD</i> | <i>ESD</i> |
| | 1 | Close | Close limit |
| | 2 | Open | Open limit |
| | 3 | Position control enable | Position control enabled |
| | 4 | Set relay 1 | relay 1 set |
| | 5 | Set relay 2 | relay 2 set |
| | 6 | Set relay 3 | relay 3 set |
| | 7 | Set relay 4 | relay 4 set |
| DO 4 Mode 2: | 0 | <i>Set relay 1</i> | <i>relay 1 set</i> |
| | 1 | Close | Close limit |
| | 2 | Open | Open limit |
| | 3 | ESD | ESD |
| | 4 | Position control enable | Position control enabled |
| | 5 | DO-6 relay set | relay 2 set |
| | 6 | DO-7 relay set | relay 3 set |
| | 7 | DO-8 relay set | relay 4 set |

6. Function Blocks *continued*

| Block | Bit | Operation | Read-back |
|------------------------|--------------------------------------|--|---|
| DO 4 Mode 3: | 0 1 2 3 4 5 6 7 | <i>Partial stroking</i> Close Open ESD Set relay 1 Set relay 2 Set relay 3 Set relay 4 | <i>Partial stroking enabled</i> Close Open ESD relay 1 set relay 2 set relay 3 set relay 4 set |
| DO 4 Mode 4: | | N/A (used for AO only control) | N/A |
| DO 4 Mode 5: | | Value. 0 – Close 1 – Open Any other value sends Stop command. | Value. 0 – Close 1 – Open |
| DO 4 Mode 6: | 0 1 2 3 4 5 6 7 | <i>Position control enable</i> Partial stroking Close Open Stop ESD Set relay 1 Set relay 2 | <i>Position control enabled</i> Partial stroking enabled Close limit Open limit Actuator not moving ESD relay 1 set relay 2 set |

Note: Ensure that parameters 65 (Control Mode) and 66 (Discrete Block Control) in the Transducer block are set for the type of control and DO 4 mode required.

6.7 PID Control Block

The actuator includes a standard three-term PID controller block for use in a control loop. The inputs and outputs of this block are not directly linked to the actuator Transducer block. This allows the PID controller to be used for controlling devices other than the actuator. With a PID function, as long as an error exists between the set point (desired value) and the measured value feedback (process variable), the controller will change the output in a direction to reduce the error.

The way in which the output changes is influenced by the actual error value, the time it is present and the rate of change it undergoes. The PID settings applied integrate the error with respect to time (RESET value), apply a proportional gain on the error (GAIN) and differentiate the rate of change in the error (RATE); all these actions are combined to produce the OUTPUT.

- **PID** A stand-alone 3-term controller within the actuator.

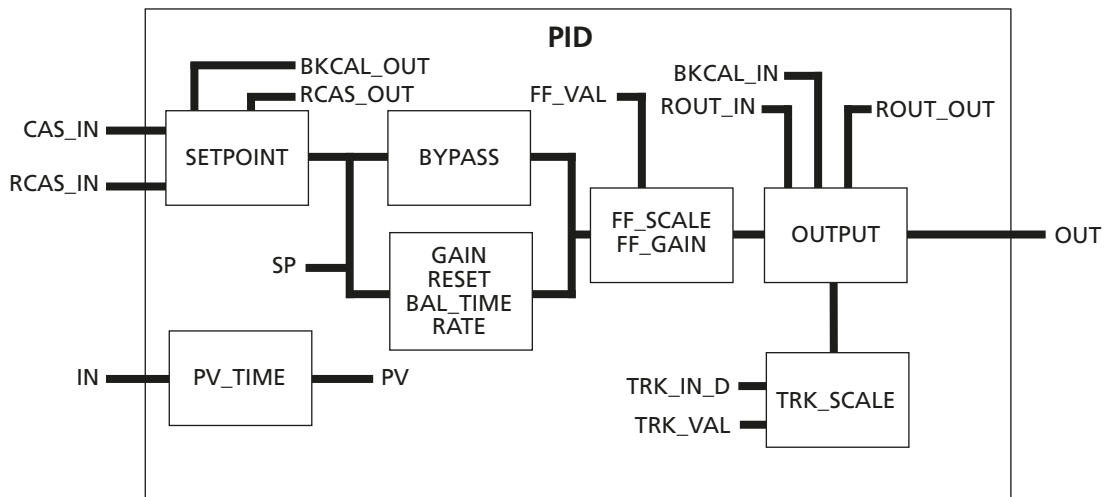


Fig 6.11: PID function block

The PID block must be connected and set up before it can be used. It is not pre-connected to any input or output of the actuator transducer block and may be freely connected into a control loop. The scheduler is used to allocate a time slot for the control algorithm to execute.

6.8 Control Selector Block

The actuator includes a standard control selector block intended to select one of two or three control signals in a manner determined by SEL_TYPE. The inputs and outputs of this block are not directly linked to the actuator transducer block. This allows the Control Selector to be used for selecting control for devices other than the actuator. When the block is in auto mode the control selector block picks the input based on SEL_TYPE, if there are only 2 inputs connected the selection is made between those two, if 3 are connected the selection is based on the 3 inputs. When the block is in Man – no input is selected, the last value is maintained until the block is put back into Auto. Whilst in this mode the output can be set manually.

Note: In Auto mode, when any of the connected SEL_1, SEL_2 or SEL_3 inputs have Bad status during block execution, the block transitions its actual mode to Man. When the Bad SEL_1, SEL_2 or SEL_3 input transitions back to Good status, the block resumes Auto operation.

SEL_TYPE can have the values High, low or Middle. When High is selected the input with the highest value will be picked for the control selector primary output - OUT, when Low is selected; the lowest value and when Middle selected; the middle value.

- **CS** A stand-alone Control Selector within the actuator.

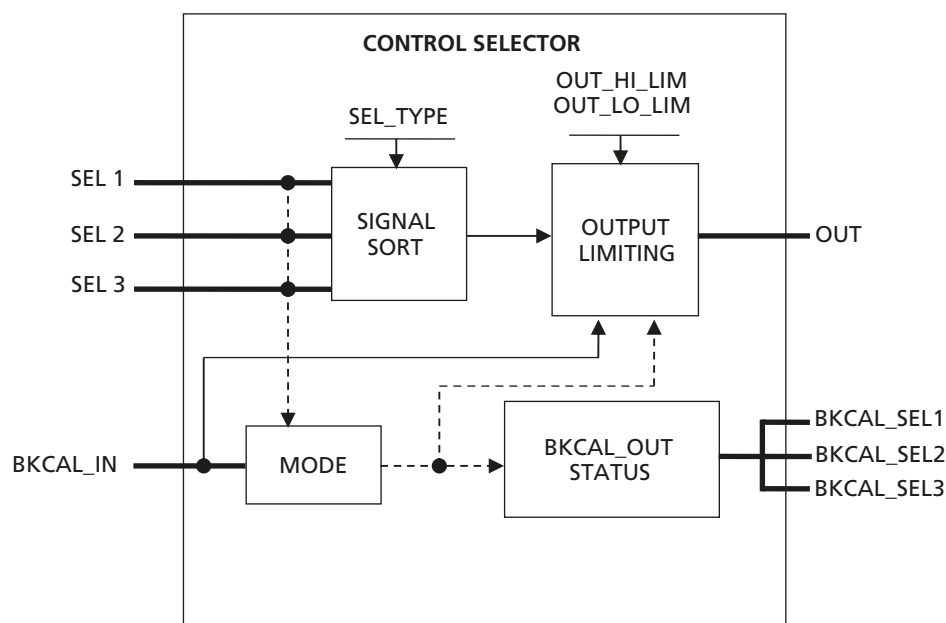


Fig 6.12: CS function block

- BKCAL_IN is the analogue input value and status from a downstream block's BKCAL_OUT output that is used for backward output tracking for bumpless transfer.
- SEL_1, 2 and 3 are the first, second and third input values to the selector.
- BKCAL_SEL1, 2 and 3 are the selector output value associated with SEL_1, 2 and 3 respectively for backward output tracking to an upstream function block.
- OUT is the output value and status.

7. Link Active Scheduler (LAS)

Foundation devices may be either Basic or Link Master (LM) devices.

- Basic units do not have the ability to hold the timing schedule for scanning the nodes and cannot act as system controllers.
- Every network requires at least one LM to control the network communications. An LM that is in control of the communications is known as a Link Active Scheduler (LAS). There can only be one LAS on each FF H1 highway.

All Rotork FF CP cards are supplied set to operate as a Basic device but can be configured to be LMs. When configured as LMs they are capable of assuming network control by switching automatically to become the LAS when the highway LAS goes offline. This option must be checked during commissioning and may be configured as enabled or disabled.

Note:

1. There is limit to the number of VCRs that can be supported by an LAS device. It may be the H1 gateway (LAS) has a larger VCR capacity than the LM (backup LAS). This could lead to problems if the number of VCRs is too great and the LM assumes the LAS role.
2. There can be more than one LM on a highway, up to a maximum of eight, but only one will be the LAS device at any one time. The LMs assume control in the order of their ascending addresses. When initially setting up a system using FF CP cards that are in Link Master mode, it is essential to connect the actuators to the bus after the configuration utility is started or after the DCS gateway port is connected. If an actuator in Link Master mode is connected first, it will automatically become the LAS (Active Scheduler device) and the DCS H1 gateway will be unable to gain full control of the network.

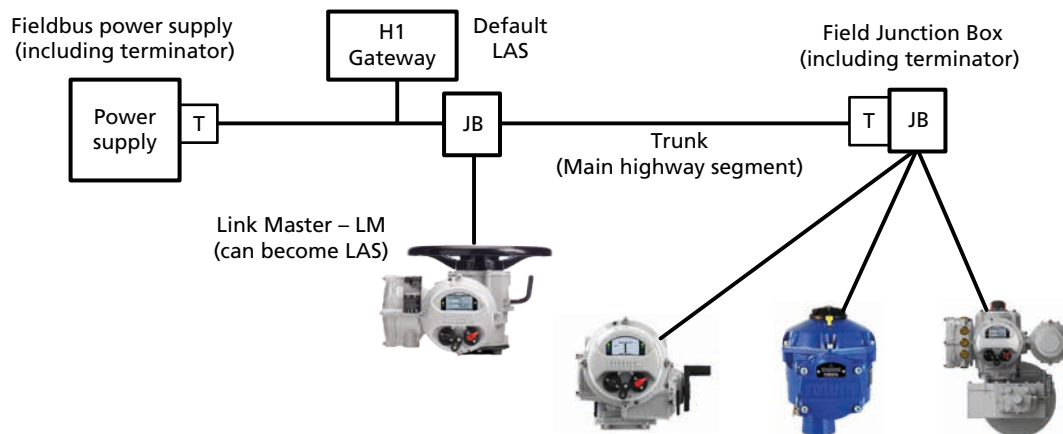


Fig 7.1: Link Active Scheduler – one per network plus Link Master (back-up LAS)

7. Link Active Scheduler (LAS) *continued*

In order to change the FF01 CP card from a Basic unit to an LM a suitable configuration tool or dialogue tool must be used.

If the NI FF configurator tool is used it's simply a matter of a right mouse click on the device tag, select "Change device type" and clicking "Yes" to "Change to Link Master?".

It will then be necessary to cycle the FF highway power to this card for the change to have an effect.

This approach can also be used to convert an LM to a Basic device.

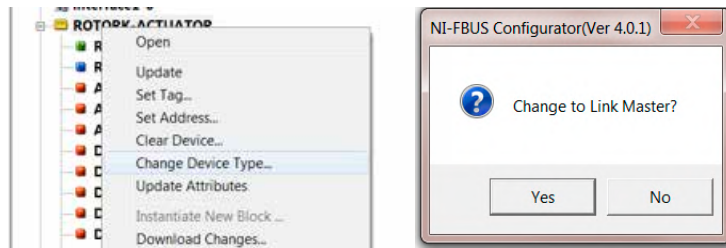


Fig 7.2: Using the NI FF Configurator Tool to change the FF card's device type

As an alternative, open the database using a dialog tool and modify the parameter contained in the Management Information Base (MIB).

The parameter to be altered resides in the MIB type of VFD. The class is called

BOOT_OPERAT_FUNCTIONAL_CLASS

This class can have two values:

- 01 = Basic Unit
- 02 = Link Master

This method cannot be used to change from a Basic to an LM as it's read only in Basic mode, however, it can be used to modify from an LM to a Basic device. In this case, edit the parameter value and download the setting to obtain the desired function. The type of functionality available can also be read in the parameter

DLME_BASIC_CHARACTERISTICS / DL_OPERAT_FUNCTIONAL_DEVICE_CLASS

A value of 1 indicates a basic unit whilst a 2 indicates a Link Master.

7. Link Active Scheduler (LAS) *continued*

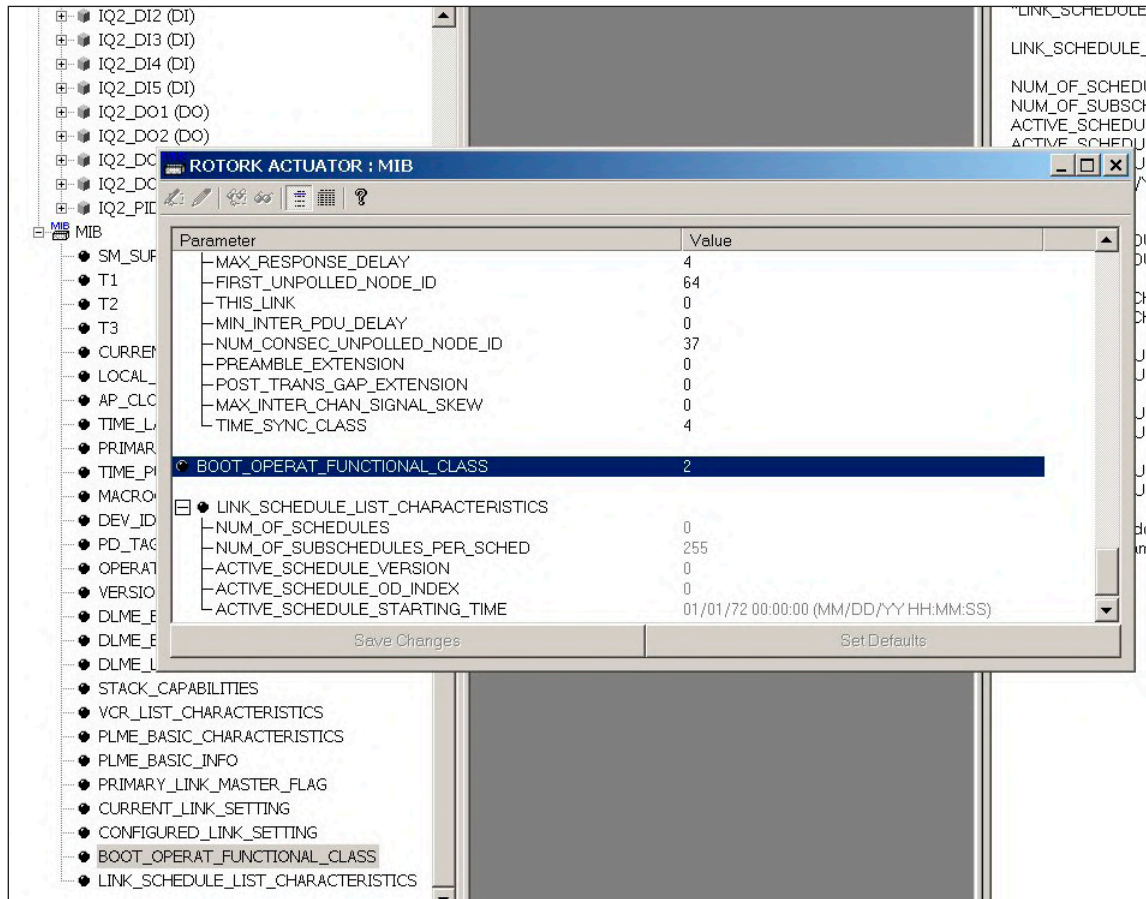


Fig 7.3: Management Information Base (MIB) showing BOOT_OPERAT_FUNCTIONAL_CLASS

Once the LM type has been selected, the configuration tool can be used to download the system configuration. The schedule will reside in all the Link Masters and be executed by the one that is active, the Link Active Scheduler. Should the LAS fail, then any of the remaining Link Master units is able to take the role of LAS. This is usually the LM with the lowest address.

7.1 Creating a Schedule

In order to use any Function Block, with the exception of the Resource Block and the Transducer Block, the required blocks must be placed in a 'Function Block Application' using a suitable configuration tool. This ensures the blocks are processed by the LAS in the correct way, allowing them to publish data when required. Note that blocks do not have to be interconnected at this stage.

Once a control strategy has been worked out, the individual function blocks for all network devices distributed across the network can be interconnected using the DCS or a configuration tool. The configuration process also includes formatting the schedule for the execution of the function blocks. Many configuration tools include the facility to create and alter the schedule, which is downloaded to the system by the host or configuration system.

The individual function blocks each require a time slice of the total execution cycle in which to operate. The execution times required for each block type in the FF CP card are as indicated in the table:

| Function Block | Execution Time (mSec) |
|----------------------|-----------------------|
| Analogue Input (AI) | 50 |
| Analogue Output (AO) | 50 |
| Digital Input (DI) | 50 |
| Digital Output (DO) | 50 |
| Controller (PID) | 100 |
| Controller (CS) | 50 |

Note:

- 1. When constructing an application with interconnected function blocks it is recommended by the Foundation that at least 50% of the total cycle time is left free to allow for the background bus activities to be performed. Failure to follow this guideline may result in the incorrect functioning of the downloaded schedule.**

7. Link Active Scheduler (LAS) *continued*

7.2 Connecting the Blocks

The function blocks used to execute the control strategy must be connected. The interconnection of the blocks requires the use of a suitable Configuration tool.

All the blocks in the FF CP card are already instantiated and ready for use. The mode for control actions using the AO or DO blocks must be set in the transducer block.

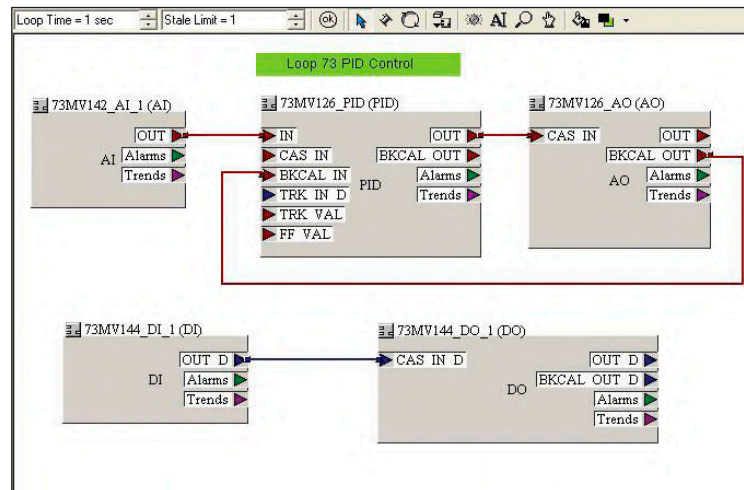


Fig 7.4: Interconnecting blocks to form a control scheme using a 'wiring tool'

7.3 Downloading the Schedule

When downloading a schedule it is essential that any previously downloaded schedule is cleared. Failure to do this may result in the FF card not functioning as expected.

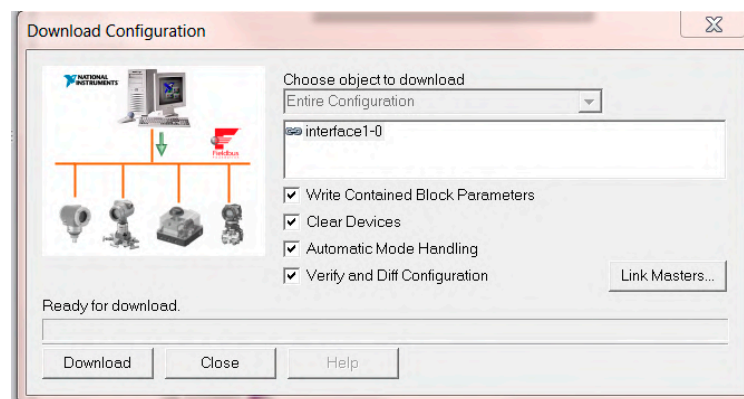


Fig 7.5: When downloading a new schedule ensure any previously loaded schedules are cleared

7.4 Optimising the Downloaded Schedule

A downloaded schedule should consume no more than 50% of the highway's macro-cycle time. Failure to adhere to this guideline may result in the FF card not functioning as expected.

It might be possible to increase the macro-cycle period if the 50% threshold isn't met with the DCS's default macro-cycle time. However, if this increase in time isn't acceptable to the customer, the only remaining option would be to manually optimise the schedule. This can be done by clicking on the schedule objects and dragging them to the desired time position. Most DCS systems allow this sort of manual intervention.

The basic rules of manual optimisation are:

- Only one telegram can be on the highway at any one time
- Within an individual FF node, only one block execution can occur at any one time

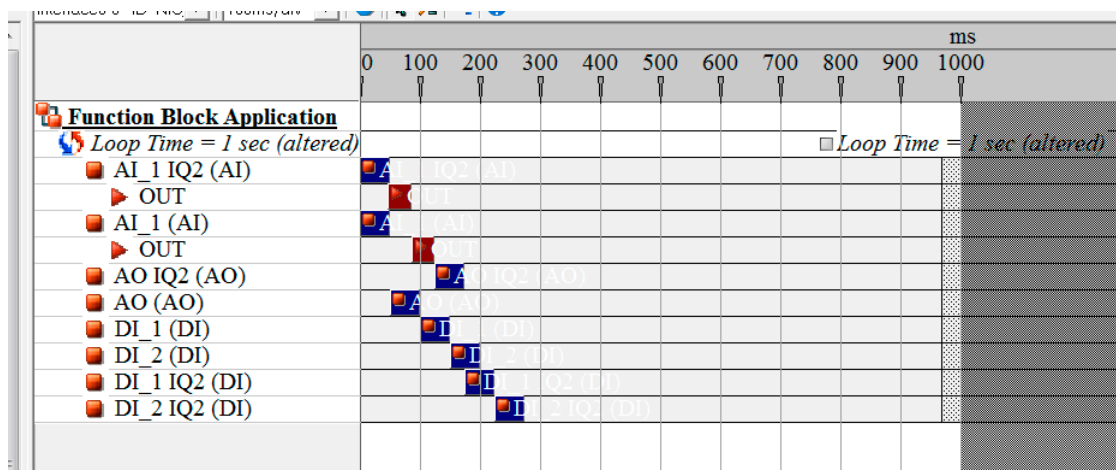


Fig 7.6: Example of a downloaded schedule

8. Setting Up the FF CP Card (Quick Start Guide)

Both the actuator's control parameters and the FF card's parameters must be set up correctly to achieve the desired control. This section assumes the FF card is fitted an IQ3/IQT3 actuator, but the procedure will be similar for other Rotork FF enabled actuators.

The two key FF parameters are: the Control Mode [DO 4 function] & Discrete Block control. These reside in the Transducer Block and can only be accessed via the FF highway. They can only be altered when the Transducer Block is in OOS mode.

There are some actuator positioning parameters that can be checked/set using the Rotork setting tool.

- Section 8.1 lists the parameters that can be accessed along with their default values. Note most of the FF card's parameters, including the control mode and block control, cannot be accessed via this method.

The Insight II software can also be used to access the actuator's control parameters.

- Section 8.2 shows screen dumps of the relevant pages. Note the FF card's control mode and block control parameters cannot be accessed via this method.

The parameters can also be set-up up over the FF highway using an Emerson 375/475 hand-held communicator or a National Instruments Configurator Tool or a similar FF configuration tool. In all cases the action of the module may be set using either the step-by-step instructions in the "Methods" tab, in the Transducer Block or by manual alterations to the parameter list in the Transducer block.

- Section 8.3 outlines the "Methods" approach.
- Section 8.4 describes the manual alteration approach for control block settings.
- Section 8.5 describes the manual alteration approach for feedback block settings.
- Section 8.6 lists the control parameters available in the Transducer Block.
- Section 8.7 shows the TB control parameters available via the DTM/FDT.

Once the configuration of the function blocks has been completed, this must be downloaded to the actuator. If a "Configurator tool" has been used to modify the setting and a number of actuators are required to have the same settings, the configuration file can be saved and copied to several differently tagged devices in turn.

8. Setting Up the FF CP Card (Quick Start Guide) *continued*

8.1 Setting Up with the Setting Tool

The actuator includes a communication port for setting the actuator performance, limit switches etc. via the Setting Tool. This communication link can be used to set some, but not all, of the actuator specific Transducer Block parameters. The parameters will be supplied set to their factory default values. These should still be checked with a configuration tool to ensure optimum actuator and network compatibility. Refer to the relevant actuator's "Full Configuration Manual" to see the access route through the actuator menu screens to reach the settings that affect the FF CP card.

The Transducer block parameters that may be set by using the Setting Tool are listed below. The available range for the deadband setting when using the setting tool is less than the range found using the configuration tools.

| FF TB Parameter | Description | Range | Default Value |
|-----------------|--------------------------------|---|---------------|
| 50 | Limited Range Position Minimum | 0 – 100% | 0% |
| 51 | Limited Range Position Maximum | 0 – 100% | 100% |
| 52 | Deadband | 0.0 – 9.9% | 5.0% |
| 53 | Hysteresis | 0.0 – 9.9% | 2.0% |
| 55 | Motion Inhibit Time | 0 – 255 sec | 5 sec |
| 59 | Comms loss action | 0 – No Action 1 – Open 3 – Close 5 – Stop 7 – Position Any other value = off | 0 |
| 60 | Comms lost position | 0-100% | 0 |
| 61 | Comms Fault timer | 0-255s | 10 |
| 62 | Auxiliary Mask (Function) | 0x00-0xFF | 0x0F |

Note: Parameters may only be altered by the setting tool if the actuator control knob is set to the Local or Local Stop position.

8. Setting Up the FF CP Card (Quick Start Guide) *continued*

8.2 Insight 2

This software can be used to configure and view the settings and configuration of the Rotork actuator. It can be freely downloaded from the Rotork website. It designed to be run from a Windows computer and connects to the actuator using Bluetooth. Please see the relevant Rotork technical manual for more details.

With the FF highway power applied, the FF card's firmware/hardware revisions can be identified via this tool. V3.1/M1.4/ H1.1 (or greater) shows the FF card has a switchable ITK revision capability. This is useful when the actuator is being used on installations where ITK6.1 is not supported.

Note: The FF card's ITK revision cannot be changed via Insight.
The "Control mode" and "Discrete block control" cannot be changed via Insight.

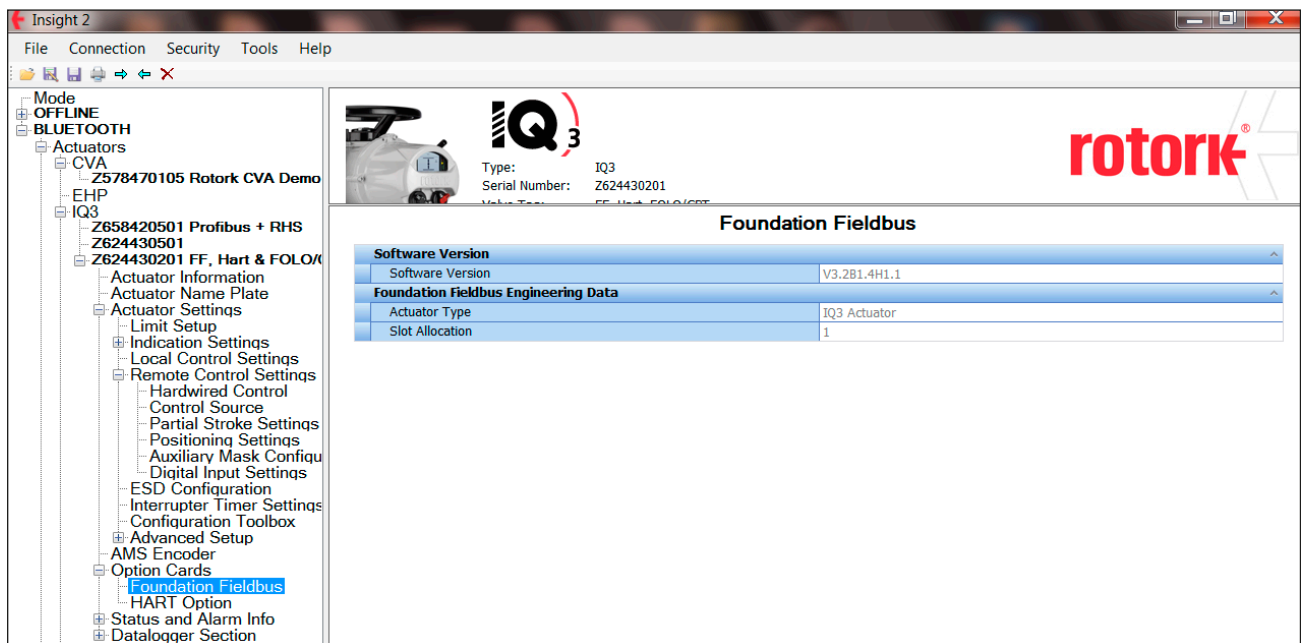


Fig 8.1: Insight Software, connected to an IQ3 actuator, showing the FF card's data

Insight can be used to set some, but not all, of the FF01 Transducer block parameters. The Foundation Fieldbus page, shown above, only allows viewing of the three parameters.

8. Setting Up the FF CP Card (Quick Start Guide) *continued*

Other control parameters can be both viewed and modified. Ideally any changes should still be checked with an FF configuration tool to ensure optimum actuator and network compatibility. Figures 8.2 and 8.3, below, illustrate the access route through the actuator menu screens to reach the settings that affect the TB in the FF CP card.

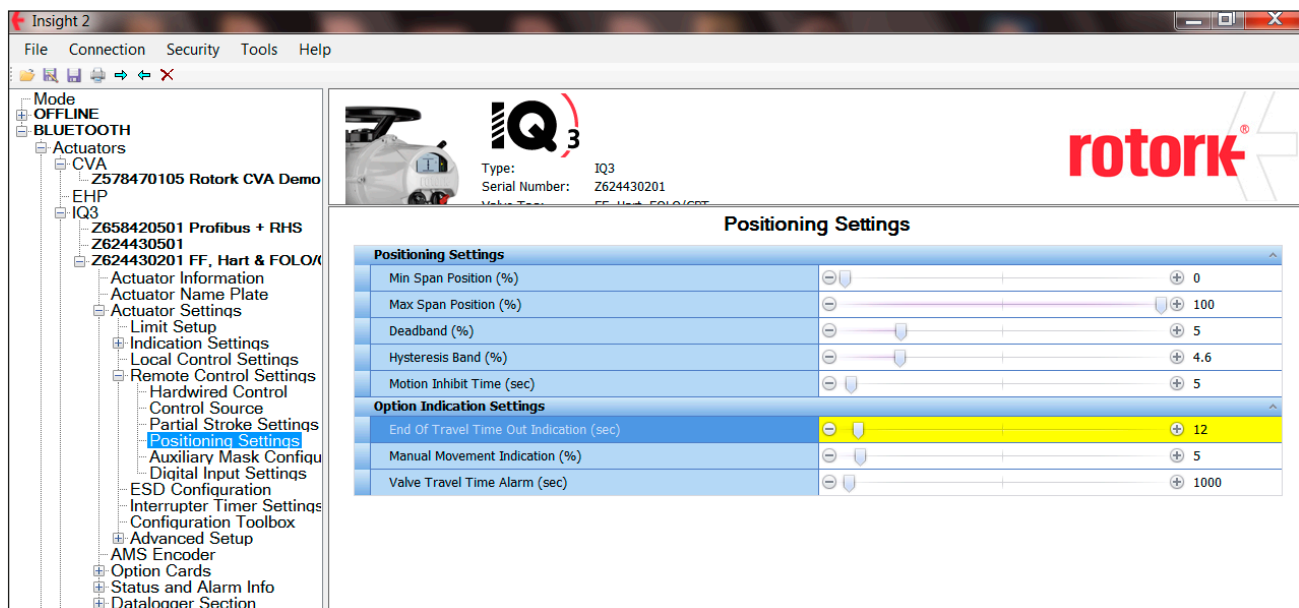


Fig 8.2: Actuator positioning settings

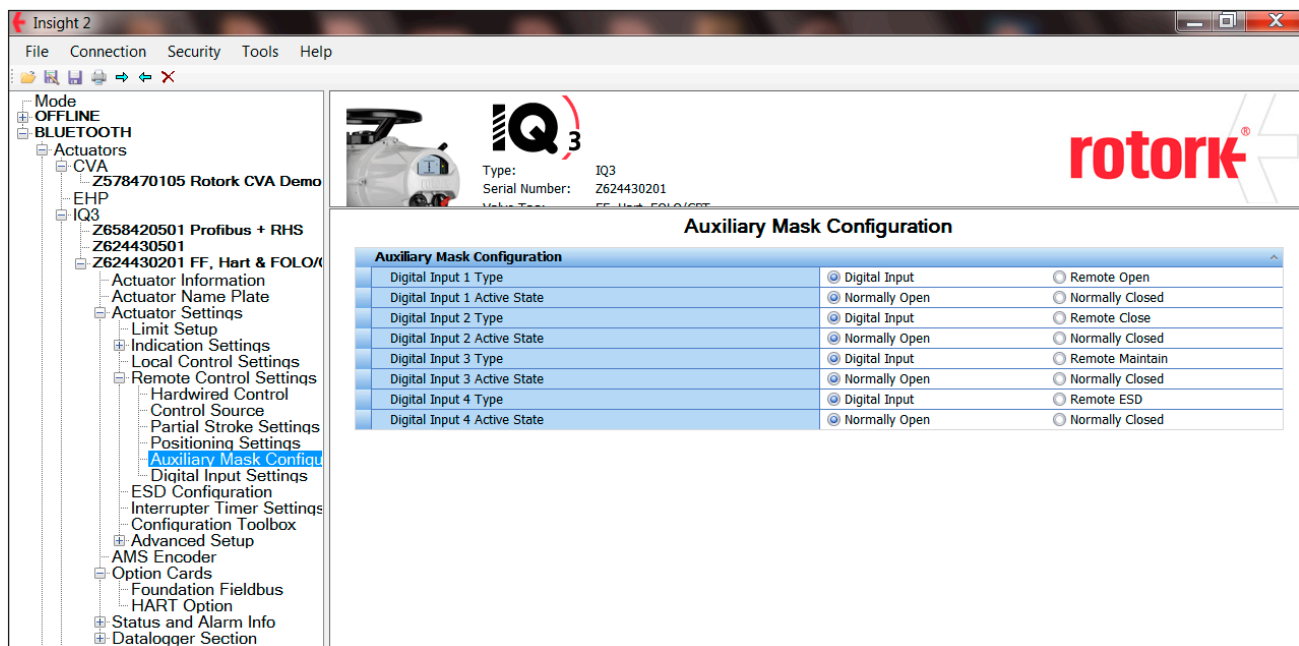


Fig 8.3: Actuator auxiliary input mask settings

8. Setting Up the FF CP Card (Quick Start Guide) *continued*

8.3 Methods

The recommended way to set up the control and reporting function of the FF CP card is to use the Methods editor.

The Methods tab on the Transducer block allows access to a sequence of questions that set up all the actuator control parameters as they are answered. When the Methods editor is used, ALL the questions must be answered, even if there is no change required to the default values.

The Methods editor ensures that all the necessary parameters are set before the actuator is used for control of the plant. The most critical decision that has to be made is for Discrete Block Control, where either multistate or single bit support can be chosen.

Note: If Multistate control is chosen only one DO block can be set to Auto and downloaded to the actuator as part of a project schedule.

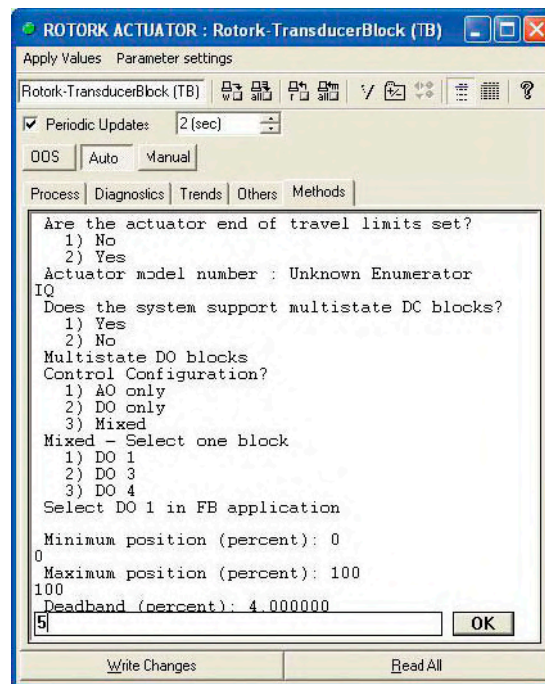


Fig 8.4: Setting the module using Methods from the Transducer block

8.4 Control Output Function Block Settings

Depending on the actual function blocks used in the application there will be different requirements for some of the Transducer block settings. All of the Transducer block parameters are described in Section 6.2. This section shows the most popular settings that can be adopted for control of the actuator.

The action of including the function blocks in the application declares to the LAS those instances to be included in the exchange of information. All the available function blocks need not be added to the application, but those not included will not provide their information to the fieldbus.

- In normal operation, both the Resource and Transducer Blocks must be in **Auto Mode** for control to take place.
- When multistate is selected, the desired Digital Output control block also needs to be placed in **Cascade/Auto Mode**.
- All other DO blocks should be placed in **OOS Mode**.
- **If either the control mode and/or discrete block are modified via the Transducer Block, it must be set to OOS prior to the modification for the changes to be accepted. Once accepted, the Transducer Block must be returned to Auto.**

In order for a configuration tool such as those supplied by SMAR, NI and Yokogawa to parameterise the Actuator Fieldbus Card, the correct Device Definition files need to be loaded in to the configuration environment. These files are freely available for download from <https://www.rotork.com/en/products-and-services/control-networks/foundation-fieldbus/foundation-fieldbus-literature>

The Foundation Fieldbus control of the actuator can be:

- Analogue only using just position demand set-point commands.
- Discrete only using just digital Open/Stop/Close commands.
- Mixed Discrete/Position using both position demand set-point and digital commands.

8. Setting Up the FF CP Card (Quick Start Guide) *continued*

8.4.1 Analogue Only control

Uses AO block only – no discrete control permitted.

| Transducer Block Settings | |
|----------------------------------|---|
| Param. 52 – Deadband | Set between 0-25.5% (typically 5%) |
| Param. 53 – Hysteresis | Set between 0-25.5% (typically 2%) |
| Param. 55 – Motion Inhibit Timer | Set between 0-255 seconds (typically 3 sec) |
| Param. 65 – Control Mode | Set to mode 4 - AO Only |
| Analogue Output Block Settings | |
| IO_OPTS | Must be set to PV for BKCal_Out |

Note: If the control mode parameter is modified, the TB must be set to OOS prior to the modification for the changes to be accepted. Once accepted, the Transducer Block must be returned to Auto.

8.4.2 Discrete Only control

Uses one or more DO blocks – no AO position (%) control permitted. The support available from the DCS will determine how many blocks are required. Where DCS Boolean Fan-In functions are available, multiple support mode can be chosen but, if this option is chosen, only one DO block can be used.

- **Multiple Bit Support**

Systems using the multiple state of a single DO block, with only one DO block selected for use. (Unused DO blocks must be left OOS). Only one DO block may be used if this mode is selected. The block selected will depend on the actual discrete control functions required. In most cases DO 1 or DO 2 will be the most useful.

| Transducer Block Settings | |
|------------------------------------|--|
| Param. 65 – DO 4 Mode | Set either 0,1,2,3,5 or 6 if this block, DO 4, is used |
| Param. 66 – Discrete Block Control | Set Multiple to use Boolean Fan In and one DO block |

- **Single Bit Support**

Systems using only bit 0 from each DO block and using up to four DO blocks to obtain discrete control. Only the first bit, i.e. bit 0, may be used from each DO block in this mode.

| Transducer Block Settings | |
|------------------------------------|--|
| Param. 65 – DO 4 Mode | Set either 0,1,2,3,5 or 6 if this block, DO 4, is used |
| Param. 66 – Discrete Block Control | Set Single to use only values of 0/1 in all DO blocks |

Note: If either the DO4 control mode and/or discrete block control are modified, the TB must be set to OOS prior to the modification for the changes to be accepted. Once accepted, the Transducer Block must be returned to Auto.

8. Setting Up the FF CP Card (Quick Start Guide) *continued*

8.4.3 Mixed analogue and discrete control

Uses the AO block and one or more DO blocks.

- **Multiple Bit Support**

Systems using the multiple state of a single DO block, with only one DO block selected for use. (Unused DO blocks must be left OOS). Only one DO block may be used if this mode is selected. The block selected will depend on the actual discrete control functions required. In most cases DO 1 will be the most useful.

| Transducer Block Settings | |
|------------------------------------|--|
| Param. 52 – Deadband | Set between 0-25.5% (typically 5%) |
| Param. 53 – Hysteresis | Set between 0-25.5% (typically 2%) |
| Param. 55 – Motion Inhibit Timer | Set between 0-255 seconds (typically 3 sec) |
| Param. 65 – D0 4 Mode | Set either 0,1,2,3,5 or 6 if this block, DO 4, is used |
| Param. 66 – Discrete Block Control | Set Multiple to use Boolean Fan In and one DO block |
| Analogue Output Block Settings | |
| IO_OPTS | Must be set to PV for BKCal_Out |

- **Single Bit Support**

Systems using only bit 0 from each DO block and using several DO blocks to obtain discrete control.

Only one bit (bit 0) may be used from each DO block in this mode.

| Transducer Block Settings | |
|------------------------------------|---|
| Param. 52 – Deadband | Set between 0-25.5% (typically 5%) |
| Param. 53 – Hysteresis | Set between 0-25.5% (typically 2%) |
| Param. 55 – Motion Inhibit Timer | Set between 0-255 seconds (typically 3 sec) |
| Param. 65 – D0 4 Mode | Set either 0,1,2,3,5 or 6 if this block, DO 4, is used |
| Param. 66 – Discrete Block Control | Set Single to use only values of 0/1 in several DO blocks |
| Analogue Output Block Settings | |
| IO_OPTS | Must be set to PV for BKCal_Out |

Note: If either the DO4 control mode and/or discrete block control parameters are modified, the TB must be set to OOS prior to the modification for the changes to be accepted. Once accepted, the Transducer Block must be returned to Auto.

8.4.4 Hard-wired inputs - Aux Input function

If hard-wired Auxiliary inputs are required, either to control the actuator, or simply as digital status feedback signals, the Auxiliary input Mask (Index 59) will need to be set in the Transducer Block to ensure the sense and function of the inputs provide the desired control action.

8.5 Status Feedback Function Block Settings

The current status of actuator position, active control functions and fieldbus availability are reported in several parameters of the transducer block and through the Discrete Input and Analogue Input blocks. The only settings that need be considered are those for limited range positioning.

8.5.1 Analogue position and torque data

Before the actuator can accurately report the position of the valve the actuator Open and Closed limits must be set and the actuator moved between the fully open (100%) and fully closed (0%) positions. If the Fieldbus reported positions are required to be a proportion of the available stroke, this reduced band can be set in the transducer block using indices 50 and 51.

| Transducer Block Settings | |
|---------------------------|-----------------------------------|
| Param. 50 – Min Position | Set between 0-100% (usually 0%) |
| Param. 51 – Max Position | Set between 0-100% (usually 100%) |

8.5.2 Discrete Input data

The Discrete Input blocks provide actuator status information. This can be read either as a single bit read from all five DI function blocks or multiple bit reads from one or more blocks, if required.

The following example shows a monitoring configuration where only a single bit read is available.

- **DI 1** bit 0 = Actuator at Close Limit
- **DI 2** bit 0 = Actuator at Open Limit
- **DI 3** bit 0 = Actuator selector in Remote
- **DI 4** bit 0 = Actuator has a General Alarm
- **DI 5** bit 0 = Actuator is moving

The Host DCS will monitor the OUT_VALUE of each of the DI blocks. Each block will be examined for the change in value from 0 to 1 to detect the present status.

The following example shows a monitoring configuration using multiple bit reads from DI 1.

- **DI 1** bit 0 = Actuator at Close Limit
- **DI 1** bit 1 = Actuator at Open Limit
- **DI 1** bit 2 = Actuator is Moving
- **DI 1** bit 3 = Actuator is Closing
- **DI 1** bit 4 = Actuator is opening
- **DI 1** bit 5 = Actuator selector in Remote
- **DI 1** bit 6 = Actuator in Local Stop
- **DI 1** bit 7 = Actuator in Local

When using multiple bit reads from a single byte the DI will show a numeric value based on the combined binary values of each bit at logic 1. For example, the number 52 in the OUT_D VALUE parameter of DI 1 would denote the actuator has Remote selected and is Moving in the open direction, i.e. bits 2, 4 and 5 are true.

8.6 Default Settings

| Transducer Block | | | |
|------------------|--------------------------------|---|--|
| Param. No. | Description | Range | Default Setting |
| 50 | Limited Range Position Minimum | 0-100% | 0% |
| 51 | Limited Range Position Maximum | 0-100% | 100% |
| 52 | Deadband | 0.0-25.5% | 5.0% |
| 53 | Hysteresis | 0.0-25.5% | 2.0% |
| 54 | Slow Mode Range | 0-100% | 5% |
| 55 | Motion Inhibit Time | 0-255s | 5 sec |
| 56 | Action on Loss of Comms | Value: 0 – No Action 1 – Open 3 – Close 5 – Stop 7 – Position Any other value = off | 0 (No action) |
| 57 | Comms Lost Position | 0-100% | 0% |
| 58 | Comms Fault Timer | 0-255s | 10 sec |
| 59 | Aux Input Mask | 0x00-0xFF | 0F |
| 60 | ESD HW_DI-4/Net Disable | 0- ESD function 1- Network disable | 0 |
| 61 | Part stroke % travel position | 0-100% | 90% |
| 62 | Part stroke limit | 0 – Close limit 1 – Open limit | 1 |
| 63 | Part stroke timeout | 0-7200 seconds | 300 sec |
| 64 | Partial stroke status | 2 Date fields: Partial Stroke Success Partial stroke Failure (MM/DD/YY HH:MM:SS) | 01/01/72 00:00:00 |
| 65 | Control Mode [DO 4 function] | Value: 0 – Positioning mode 1 – ESD 2 – S5 relay operate 3 – Partial stroke (DO) 4 – AO only 5 – Two-wire control 6 – Positioning mode | 0 Note: 1. Not all actuator types support partial stroking. 2. Mode 6 offers both position control and partial stroking in multibit support. |
| 66 | Discrete Block control | Bit: 0 – Multiple support 1 – Single support | 0 |

8. Setting Up the FF CP Card (Quick Start Guide) *continued*

8.7 Using the DTM (with FDT)

Rotork's DTM is downloadable via <http://www.rotork.com/document/index/versions/masterID/55353/>

Rotork does not supply a Comm DTM nor does it supply an FDT. These must be purchased from another vendor.

This approach enables the major TB parameters to be configured.

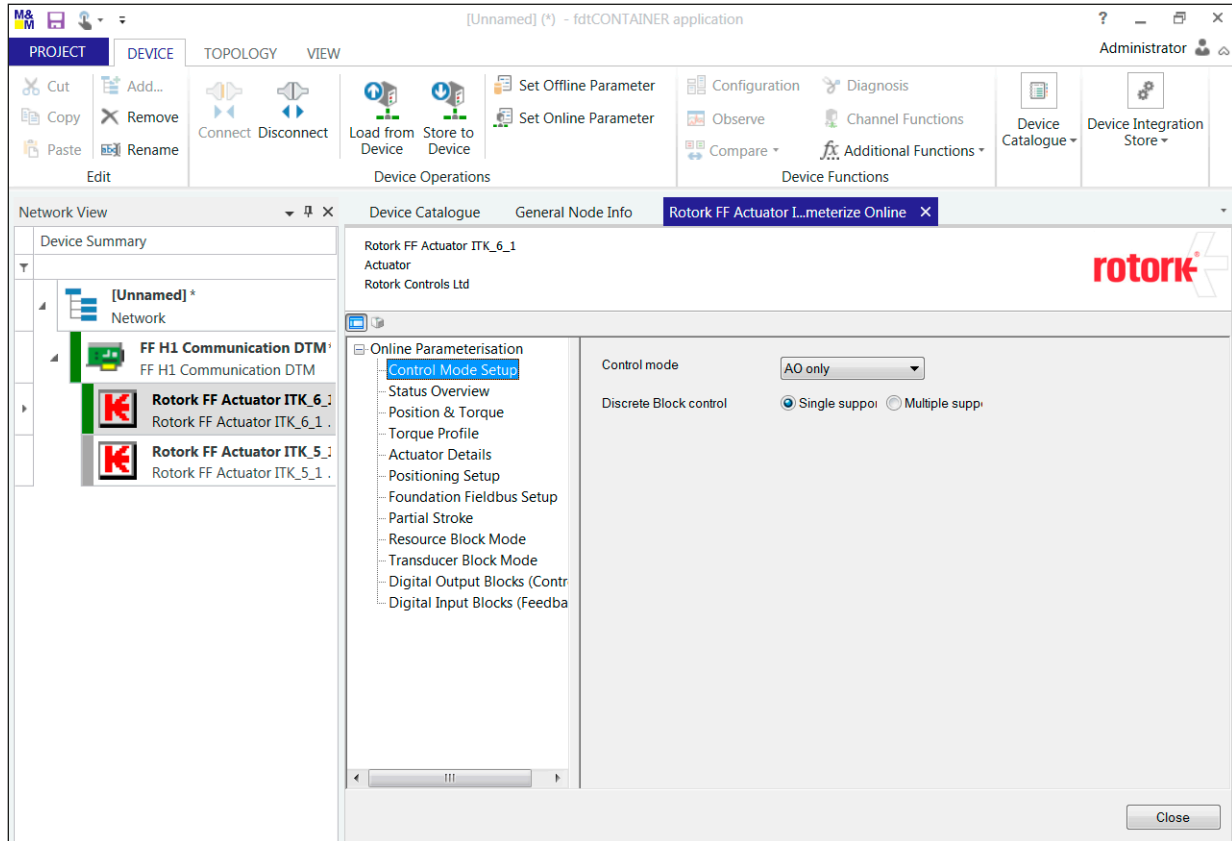


Fig 8.5: Setting the control mode and discrete block control

8. Setting Up the FF CP Card (Quick Start Guide) *continued*

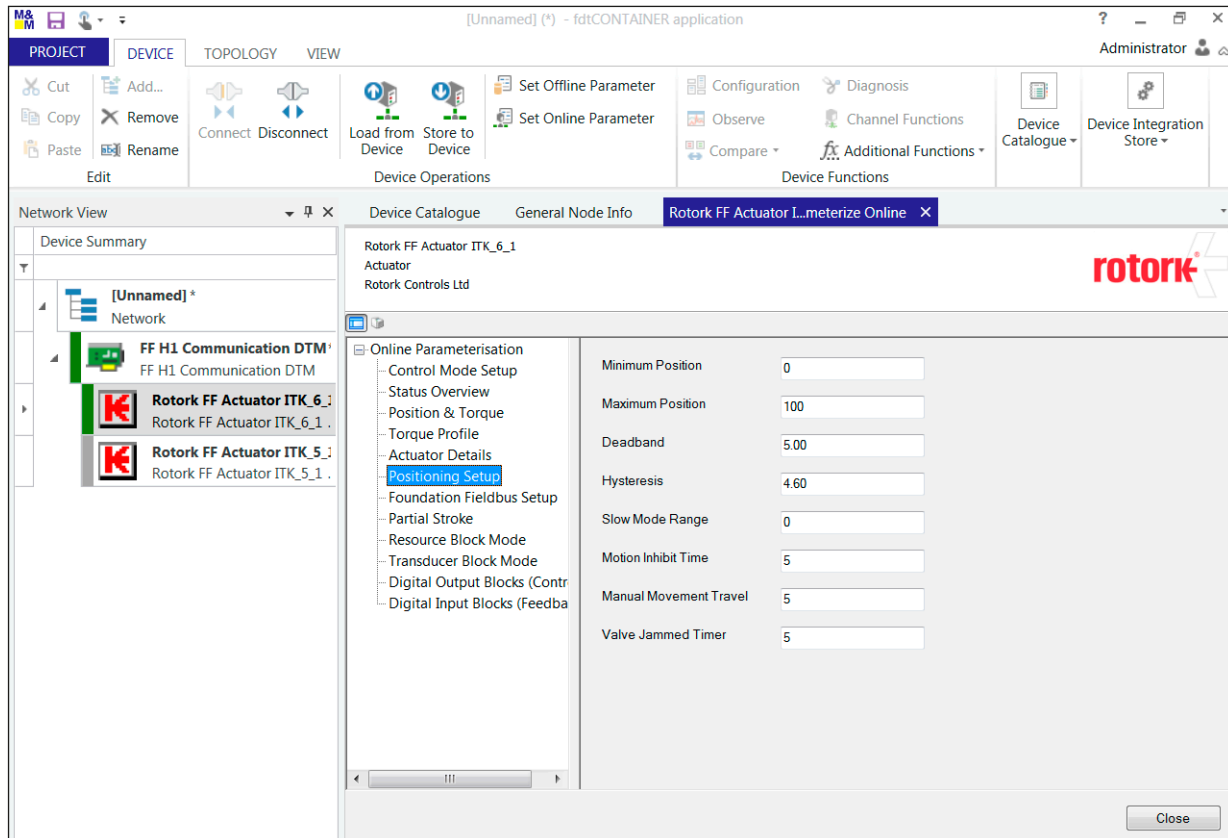


Fig 8.6: Setting the actuator positioning parameters

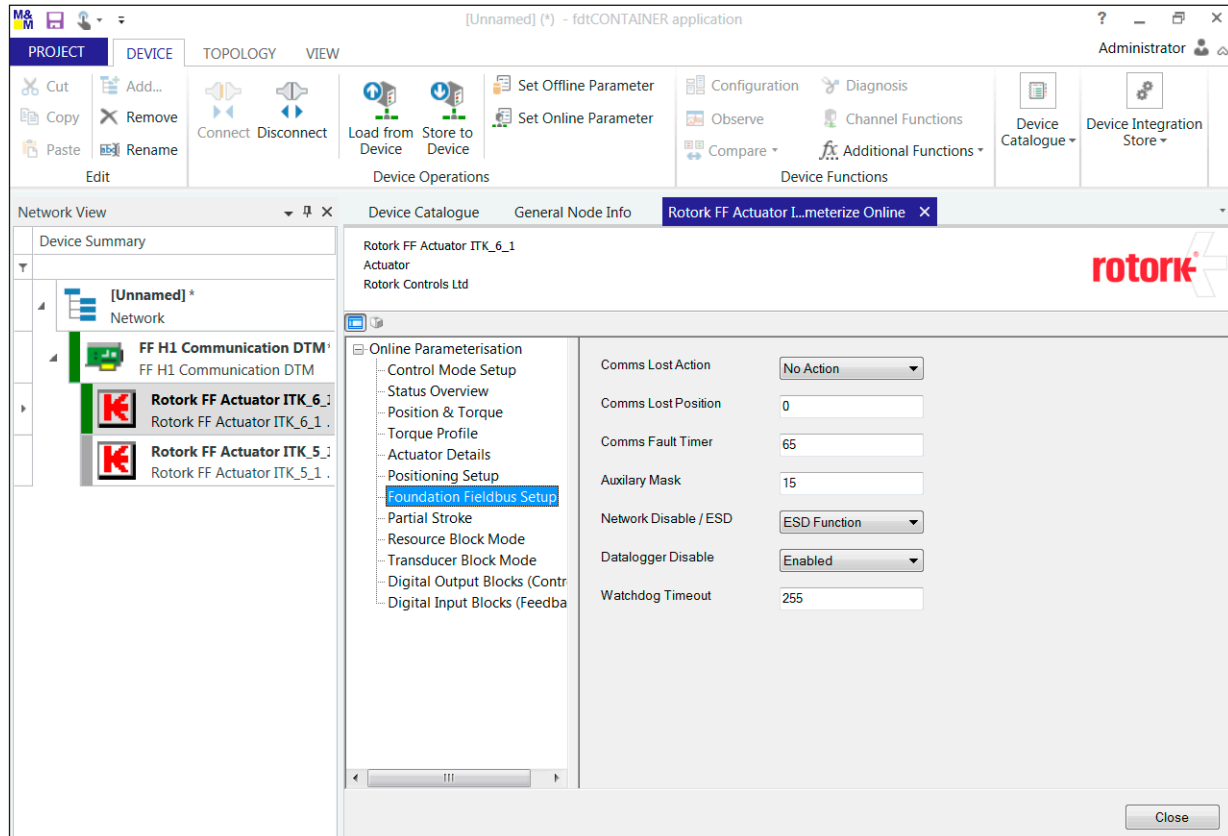


Fig 8.7: Setting the FF control parameters

9. The FF CP Card Firmware and DD Files

9.1 Firmware

The firmware embedded in the processors in the network interface and also on the actuator interface is contained in reprogrammable memory devices. These are Flash upgradeable devices and require special equipment for their contents to be altered.

Should the FF CP card require reprogramming, other than changing the ITK revision, it will be necessary to return the card to Rotork.

9.2 Device Description Files

The FF CP card operates in conjunction with Foundation Fieldbus compliant Device Description files. It has been tested and verified as part of the certification process to ensure compatibility with the Foundation standards.

From time to time there may be revisions to these files to allow enhancements to the module to become effective. Where these enhancements are related to the actuator itself, there may not be a full retest of the module by the Foundation.

The Rotork web site is regularly maintained and always contains the latest version of the DD files for the module. These may be newer than those posted by the Foundation on their web site. We recommend downloading the latest version from our web site at <https://www.rotork.com/en/products-and-services/control-networks/foundation-fieldbus/foundation-fieldbus-literature>

When downloading these files, please take great care to ensure the files are compatible with the ITK version of Fieldbus card with which they will be used.

In some cases, the application may require downloading additional special files from the DCS vendor's web site. Please check with the DCS web site for these files.

| File | File Name | ITK Version |
|--------------------|---------------------|-------------|
| Capabilities File | 010101.cff | 6.1 |
| Symbol File | 0101.SY5 / 0101.SYM | 6.1 |
| Device Description | 0101.FF5 /0101.FFO | 6.1 |

Appendix A – Handling Fault Conditions

Foundation Fieldbus blocks have a large number of parameters which influence the way in which the actuator responds to commands from the Fieldbus. In the event that communications are lost to the actuator, a number of these parameters are available to allow a predictable and deterministic reaction.

The example below shows how an action may be configured to determine how a Digital Output Block will react on the loss of the cascade input to the block.

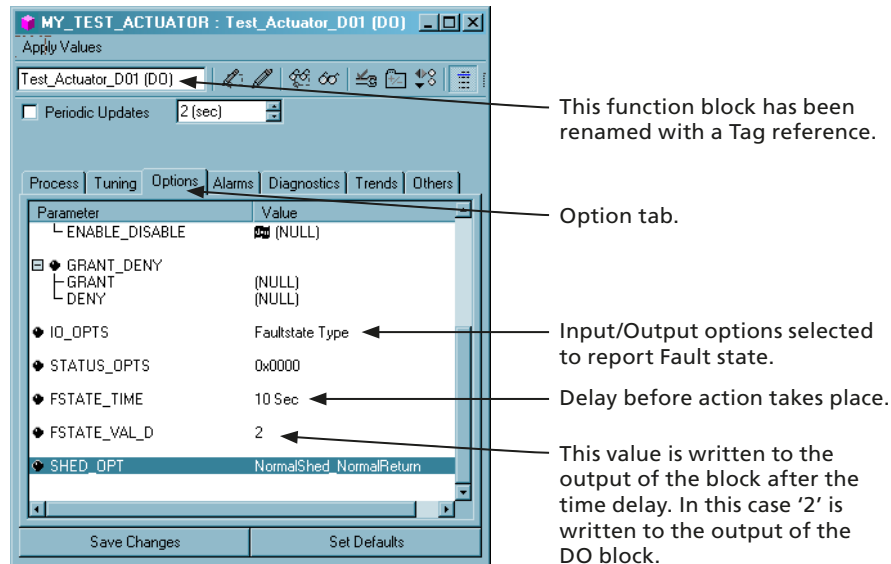


Fig A.1: Settings dialogue, as seen in National Instruments NI-FBUS Configurator

This type of configuration is possible for all of the DO and AO blocks in the actuator.

Appendix B – Function Block Mode – LO

The status of each of the Function blocks can be read by the Host system.

Each block has a minimum of three states taken from the list below:

- OOS – Out Of Service
- AUTO – Automatic
- CAS – Cascade
- MAN – Manual
- IMAN – Initialise Man mode (Not a permanent condition)

Output blocks may have one other state which is LO – Local. For this to appear, the blocks must be part of the downloaded configured Function block application.

This mode is entered when the actuator selector switch is either in the Local Stop or Local position, i.e. when the Monitor Relay bit is true. This mode is also entered when the network disable feature is chosen for HW_DI-4. See Section 5.1. The blocks can also adopt this mode if an illegal data type is presented to an input.

LO is displayed as shown in the NI Configuration tool. This status can be read by a HOST application.

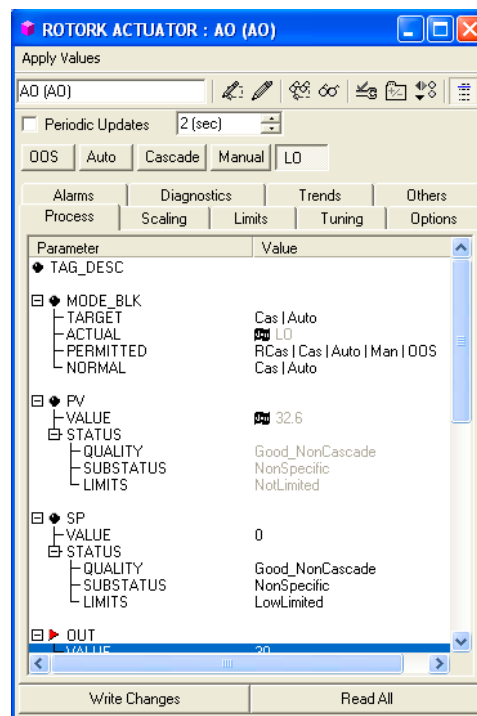


Fig B.1: Example of LO as seen in an AO block

In the example for the AO block shown above, values may still be written to the Output of the block. If the actuator is returned to the Remote Operation state, and the output value is outside the deadband of the actuator, the valve will be moved to the new position.

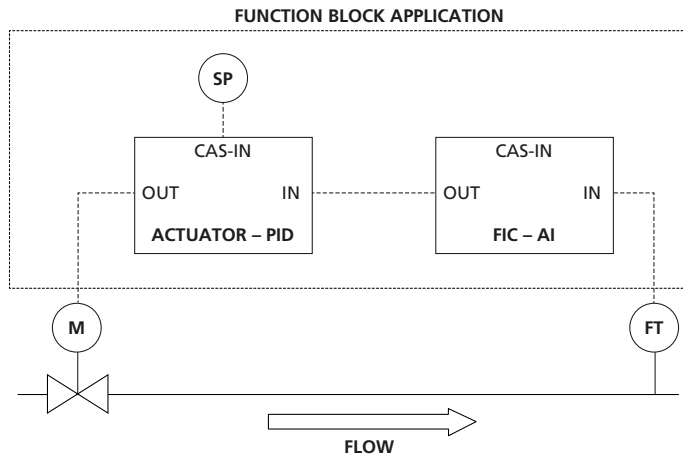


Diagram of the PID Function Block showing the relationship of the various parameters

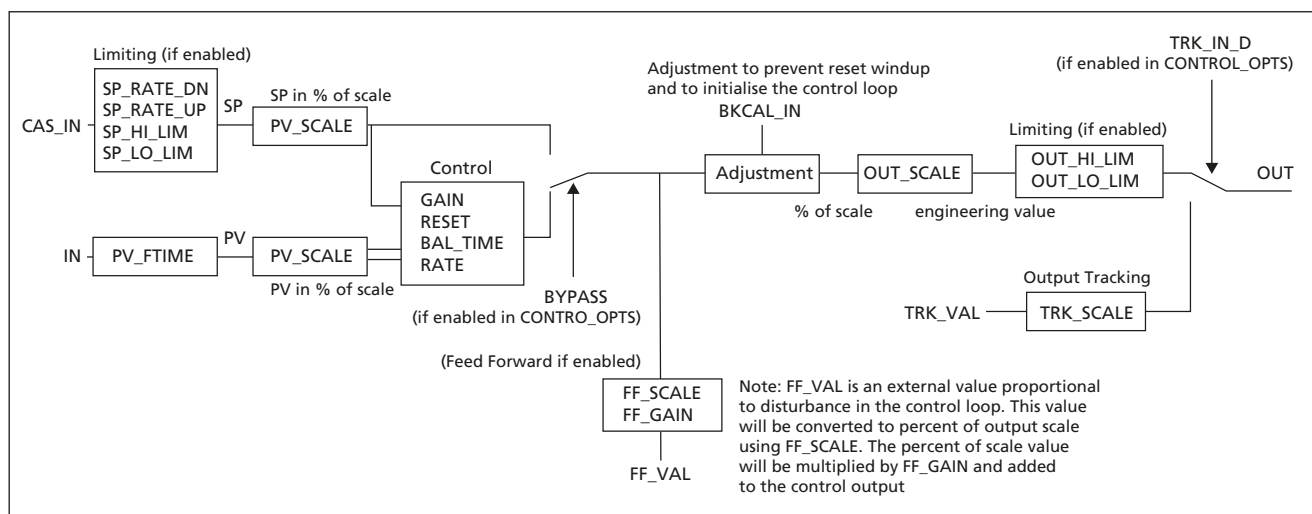


Fig C.1: PID example

The diagram above illustrates the settings available in the PID such as PV_SCALE (Process variable scaling factor) and the interdependencies that occur with, in this case, PV and SP. By using the block diagram it should be possible to 'scale' the PID to achieve the required control regime.

The function block application which might be configured for this application is shown below. In this case the National instruments configurator has been used.

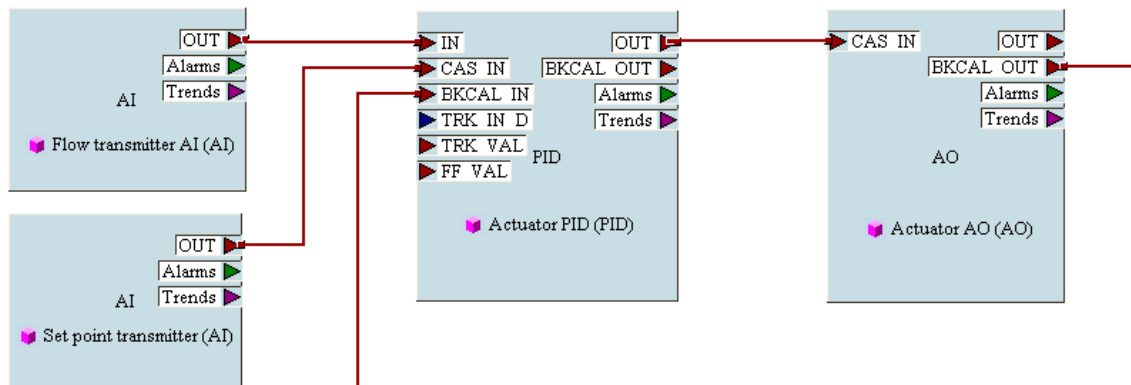


Fig C.2: Setting the FF control parameters

This dialogue box is used to adjust the scaling of the parameters supplied to, or derived through, the processing of the control loop.

In the block diagram of the PID function block, these values can be seen and their relationship to the control algorithm.

The choice of the correct scaling and engineering units is important in the correct operation of the block.

If (NULL) is being shown the FF CP card is not receiving data from the actuator control PCB, possibly due to the actuator being powered off.

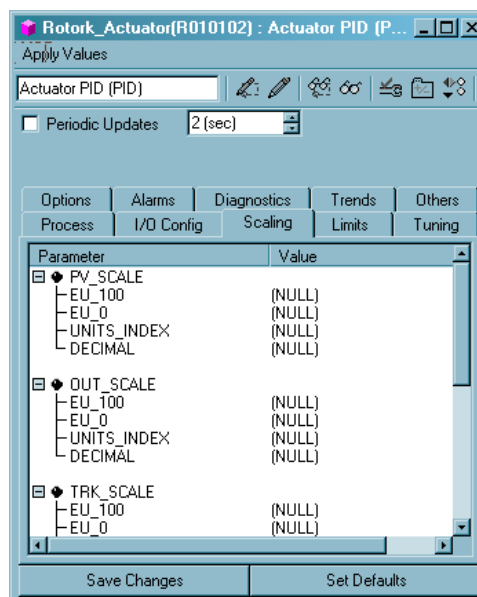


Fig C.3: The PID function block

Familiar tuning constants can be seen in this dialogue block together with others specific to this implementation of a PID block. For full information on the operation, configuration and tuning of PID loops, all the relevant loop component manufacturer's information should be referred to.

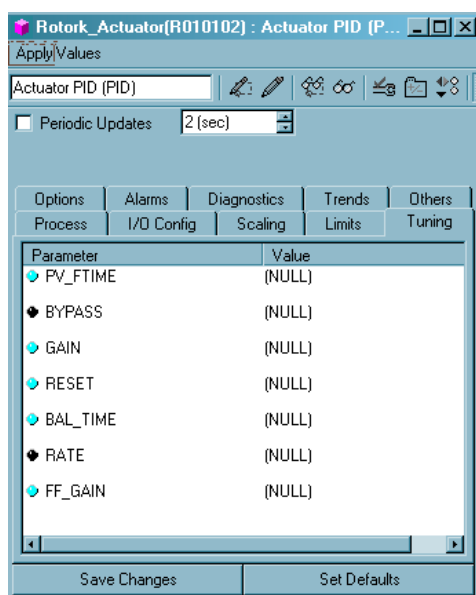


Fig C.4: The PID block's tuning parameters

D.1 Basic Fieldbus Function Blocks

| Function block | Quantity | Execution Time (ms) |
|-----------------------------|----------|---------------------|
| Transducer Block (TB) | 1 | N/A |
| Resource Block (RB) | 1 | N/A |
| Analogue Input (AI) | 2 | 50 |
| Digital Input (DI) | 5 | 50 |
| PID, PI, I Controller (PID) | 1 | 100 |
| Analog Output (AO) | 1 | 50 |
| Discrete Output (DO) | 4 | 50 |
| Control Selector (CS) | 1 | 50 |

D.2 Channel Allocation

| | |
|-------------------|------------|
| AI 1 (Position %) | Channel 1 |
| AI 2 (Torque %) | Channel 2 |
| DI 1 | Channel 3 |
| DI 2 | Channel 4 |
| DI 3 | Channel 5 |
| DI 4 | Channel 6 |
| DI 5 | Channel 7 |
| AO | Channel 8 |
| DO 1 | Channel 9 |
| DO 2 | Channel 10 |
| DO 3 | Channel 11 |
| DO 4 | Channel 12 |

Note: Do not change the channel allocation of the blocks from these default values, as incorrect channel number allocation can cause incorrect actuator operation.

D.3 Segment Information

| | |
|---|---|
| Device ID | 00FF010003:Rotork-Ver3:YYWWSSSSS YY-year WW-week number SSSSS - unique serial number |
| Baud Rate | 31.25K |
| Device Address | 34 |
| LAS capable | Yes |
| Quiescent current draw (mA) | 20 |
| Communicating current draw (mA) | 20 |
| Power up current draw (mA), includes inrush | 20 |
| Upgrade power draw (mA) | N/A |
| Operating voltage Min (V) | 9 |
| Operating voltage Max (V) | 32 |
| Minimum transmit level (V pk-pk) | 750mV |
| Device Minimum receive level (V pk-pk) | 150mV |
| Device Capacitance | 9nF |
| Polarity sensitive | No |
| Max number of VCRs | 20 |
| Device Type (DEV_TYPE) | 03 |
| Device revision (DEV_REV) | 01 |
| DD revision (DD_REV) | 01 |
| DD revision | 0101.FF5 /.FFO and 0101.SY5 / .SYM |
| CFF Revision | 010101.CFF |
| ITK revision | ITK6 |
| Manufacturer ID | 0xFF01 (65281) |

Appendix E – NAMUR NE 107 – Guidelines for Setting Up

NAMUR NE 107 is a set of guidelines for reducing alarm flooding by allowing filtering of the diagnostic data from the field. Developed as a specification for self-diagnosing field devices, it offers alarms that are categorised into four standardised statuses:

| Allocation | Description | Alarm |
|------------|----------------------|---------------------------|
| MAINT | Maintenance required | N107 Maintenance |
| OFF SPEC | Out of specification | N107 Out of Specification |
| CHECK | Function check | N107 Function Check |
| FAIL | Failure | N107 Failure |

The Fieldbus Foundation has been collaborating with NAMUR and have adopted NAMUR's NE-107 recommendations as part of the Foundation fieldbus Diagnostics Profile Specification (FF-912).

With the ITK6 FF option, Namur NE 107 diagnostics support has been implemented in all Rotork actuators that support the FF CP option card as a set of status and alarm bits which can be allocated to one of 4 alert levels. The actual function of each bit is actuator specific.

E.1 Background info

The following diagram from the Fieldbus Foundation shows how polling and broadcast diagnostic alarms are enabled:

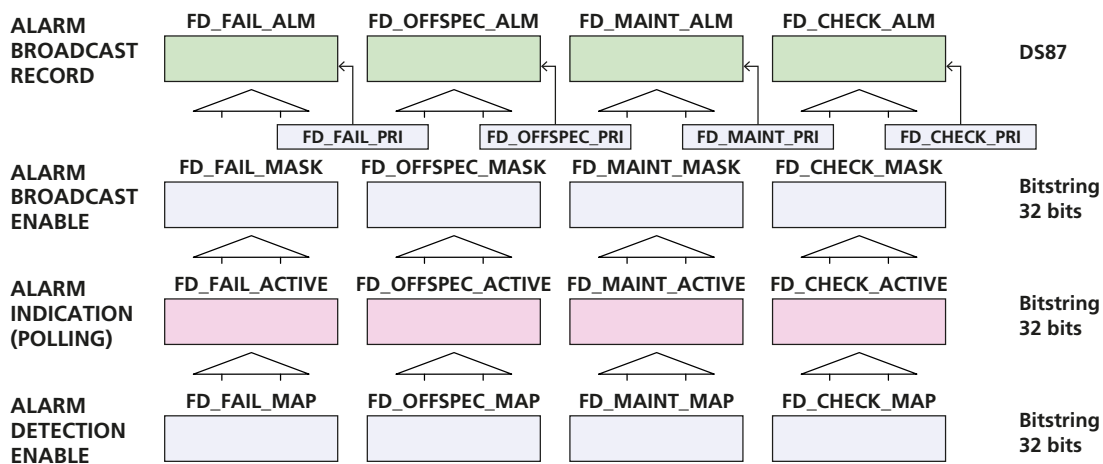


Fig E.1: The Namur 107 – enabling of polling and broadcast alarms

Starting from the bottom of the above diagram:

- The FD_...._MAP parameters are set to generate the FD_...._ACTIVE polling alarms
- The FD_...._MASK can also be set to mask out the FD_...._ALM broadcast alarms
- The broadcast alarms require priority FD_...._PRI to be enabled

The Rotork device has a number of alarms that can be selected for each diagnostic level, these are selected in the MAP and you can see which ones are then active in the ACTIVE parameter.

The MAP parameter can also be set up in the Actuator NAMUR 107 menu, in the Assets section – refer to Section 5.6 in the Rotork publication PUB002-040 available on the Rotork web site. <http://www.rotork.com/master-popup/8953/>

The picture below shows how the selectable items are displayed on the NI configurator tool – all the following screen shots are from the NI configurator:

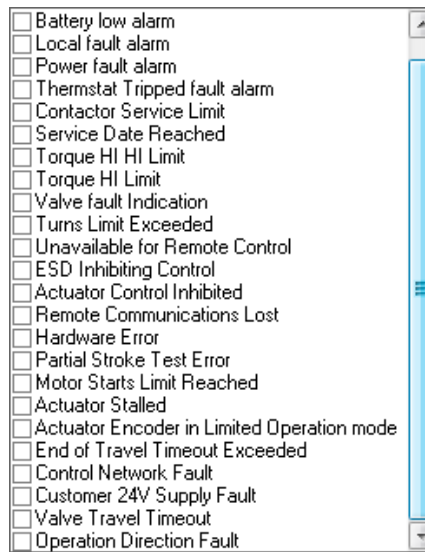


Fig E.2: The Namur 107 list of items to be monitored

The ITK6 fieldbus device Resource block default Diagnostics settings are as follows:

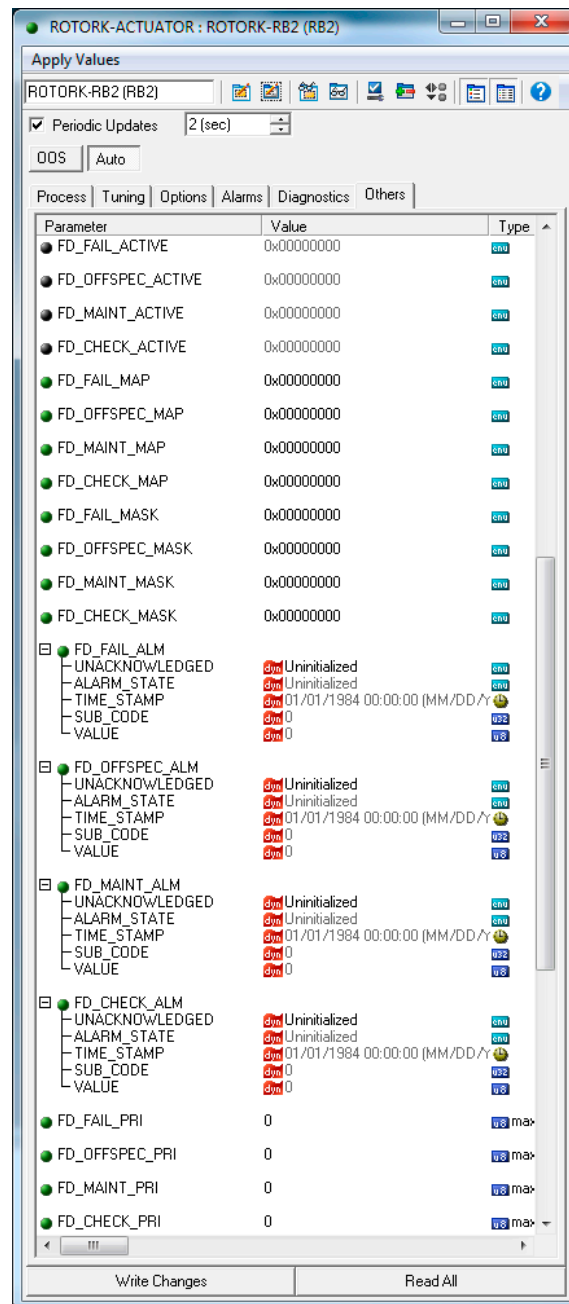


Fig E.3: The RB's Namur 107 settings

E.2 Test set up for FD_..._ACTIVE

The easiest alarm to raise is the ‘unavailable for Remote Control’ alarm. This will be active if the actuator control knob is set to Local or Local Stop. The picture below shows the control knob in the remote position which will show no alarm:



Fig E.4: The front of an IQ3/IQT3 showing actuator control knobs

For the basic test, only the FD_FAIL_MAP will be set to enable the activation of the FD_FAIL_ACTIVE polling alarm. The settings are made as follows:

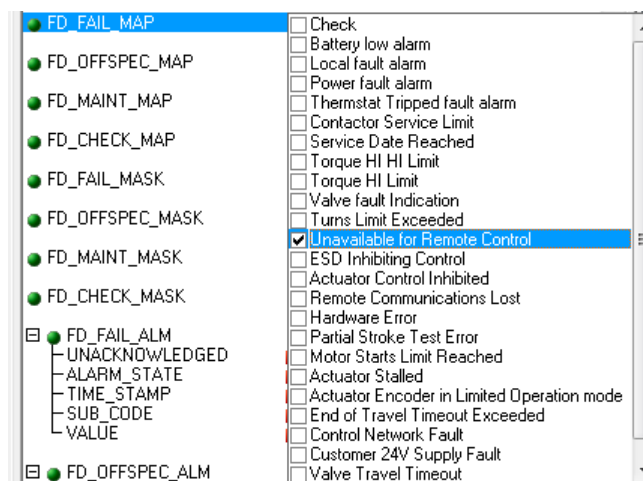


Fig E.5: Setting the “Unavailable for remote control” alarm

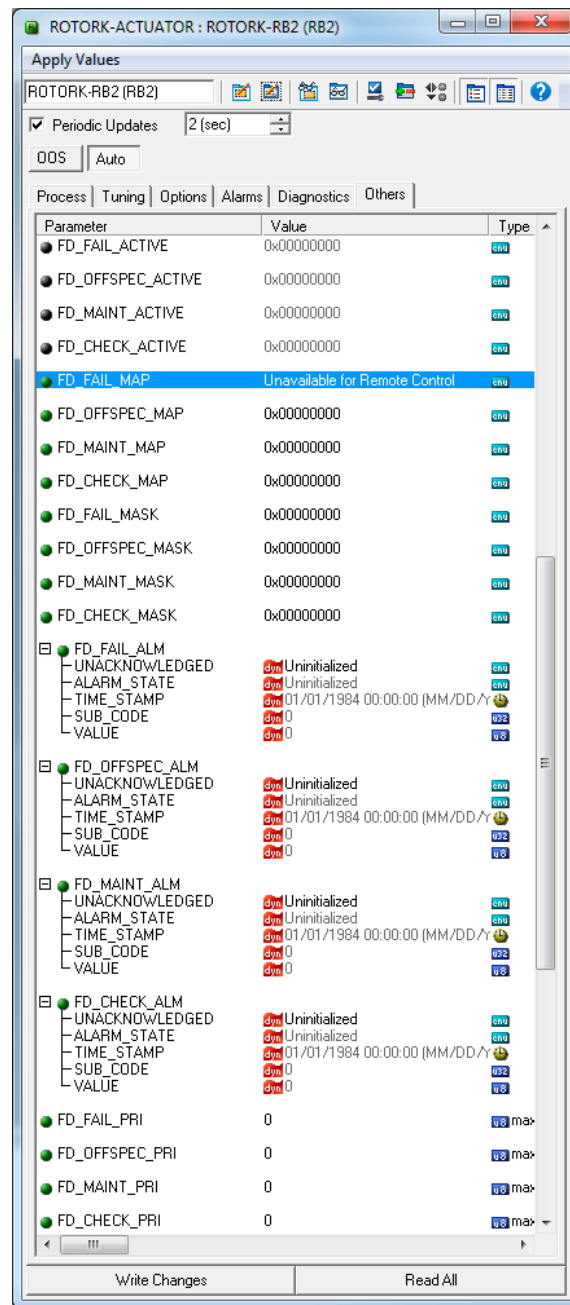


Fig E.6: Checking the Namur "FD_FAIL_MAP" status

When the control knob is set to local or local stop the actuator will be unavailable for remote control.



Local Stop



Local Control

The following will be shown for FD_FAIL_ACTIVE:



Fig E.7: Checking the Namur active alarm status in the RB

Setting the control knob back to the remote position will remove the active alarm.

E.3 Test set up for FD_...._ALM

To enable the broadcast alarms (FD_FAIL_ALM) the FD_FAIL_PRI will need to be set up with a priority level.

The setting is made as shown:



Fig E.8: Setting the priority level



Fig E.9: Alarm state reported



Fig E.10: Alarm state cleared

If there is a need to mask out an alarm and stop it from generating a broadcast alarm the FD_...._MASK setting is required to be set up:

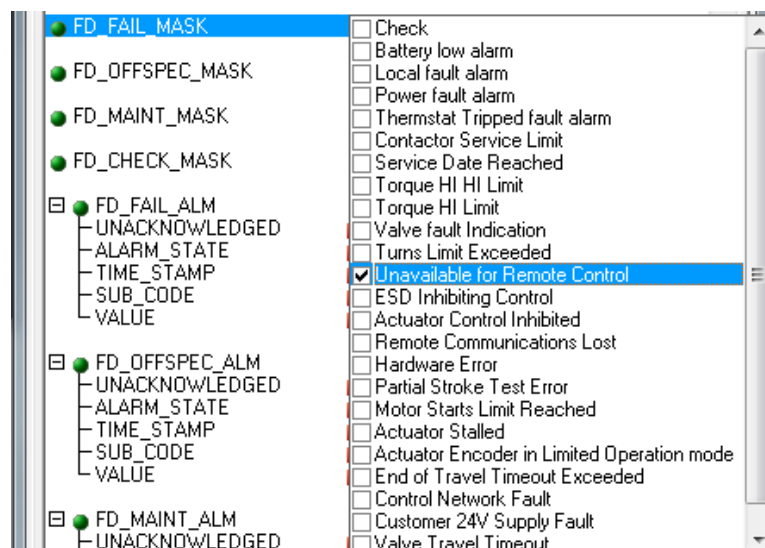


Fig E.11: Setting the mask

Setting the bit above will prevent the alarms from being broadcast, but will not stop the alarm from being available to poll (ACTIVE).

Appendix F – Changing the ITK Revision

1. Using a setting tool with an IQ3/IQT3/SI3 via the Foundation Field bus menu item

NB. This procedure requires:

- Actuator User Interface PCB firmware to be at least version V113
- Foundation fieldbus software version to be at least V/M3.1B1.4H1.1
- The FF highway to be both connected and powered up
- The actuator's mains power to be applied
- At least a service engineer level password to change the ITK revision

In order to see what the current ITK version is, it is necessary to have a correctly powered Foundation Fieldbus network connected to the actuator. Without the network applied, the menu item will show, as default, ITK4.6 although this may not be the ITK version of the card.

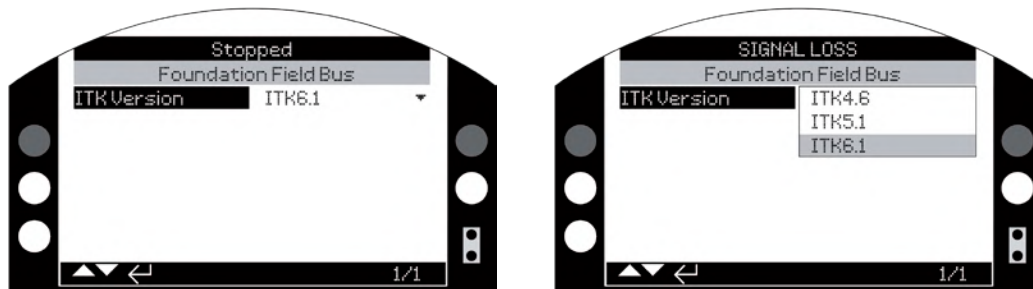


Fig F.1: Changing the ITK rev via the HMI on an IQ3/IQT3/SI3 actuator

Once the correct password has been entered, a different ITK version can be selected and entered. Once done, it is necessary to restart the Rotork Foundation Fieldbus card to enable the setting to take effect. This can be done by cycling the power on the fieldbus network or disconnecting the fieldbus connection to the Rotork Foundation Fieldbus card. Alternatively, if an NI Configurator Tool is connected, restart the processor as shown in Section 3.

Please note the EEPROM is cleared during this operation so the restart process could take a couple of minutes to complete.

Restarting the processor does not delete the tag names nor any project schedule that the card may have.

If you're unfamiliar with using a setting tool, go to Section 2 of this appendix.

2. Using a National Instruments (NI) Configurator tool

NB. This procedure requires:

- The FF card's software version to be at least V/M3.1B1.4H1.1
- The FF highway to be both connected and powered up
- The actuator's mains power to be applied
- The NI configurator tool to be running and have all versions of Rotork's ITK DD files, downloadable via: <https://www.rotork.com/en/products-and-services/control-networks/foundation-fieldbus/foundation-fieldbus-literature>

In order to see what the current ITK version is, select the Resource Block and click on the "Others" tab. Scroll down to the bottom of the page.

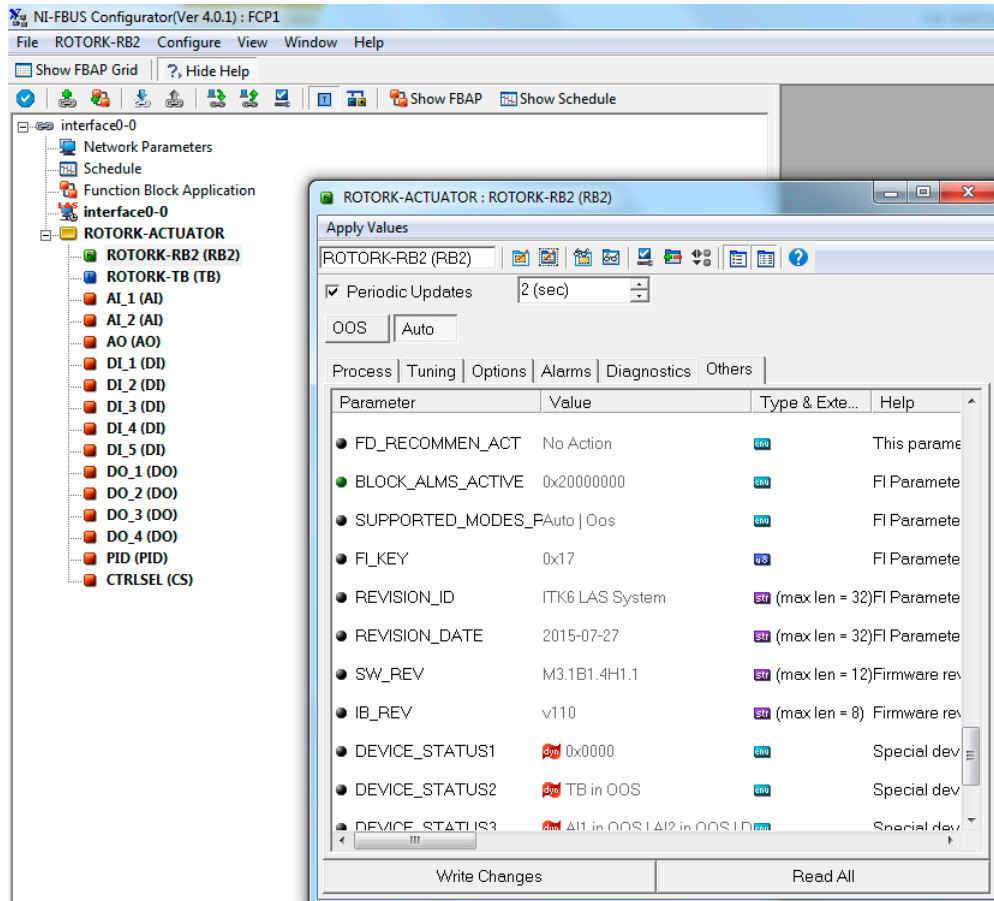


Fig F.2: Changing the ITK rev via the NI FF Configurator Tool on an IQ3/IQT3/IS13 actuator

On this page, the ITK and firmware revision are shown:

- The FF card's ITK rev (REVISION_ID) is listed as ITK6, i.e. in our card this is ITK 6.1, as only the major revision version is shown.
- The card's firmware rev (SW_REV) is shown as M3.1B1.4H1.1. Note that on an IQ3/IQT3 actuator's LCD screen this will be shown as V3.1B1.4H1.

Then click on the “Diagnostics” tab and highlight “VALUE_5” in the “TEST_RW” area.

To change the ITK rev enter the value 0x46, 0x51 or 0x61 and click on “Write Changes”.

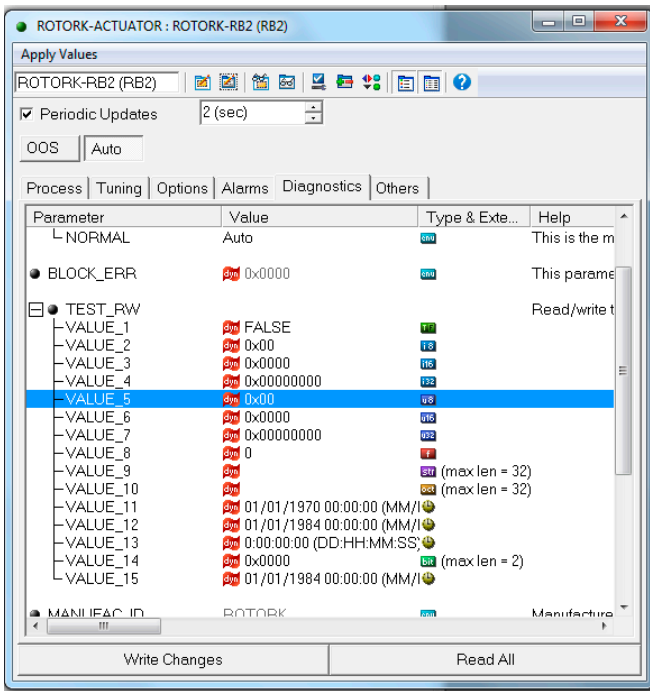


Fig F.3: Access the RB, diagnostics tab

For this value to be taken by the FF card it will need to be reset. To do this, click on “Options” and on the RESTART line, select “Processor” and “Write Changes”.

If an error message appears, click on OK. This will restart the processor and clear the EEPROM, so the restart process could take up to a couple of minutes to complete.

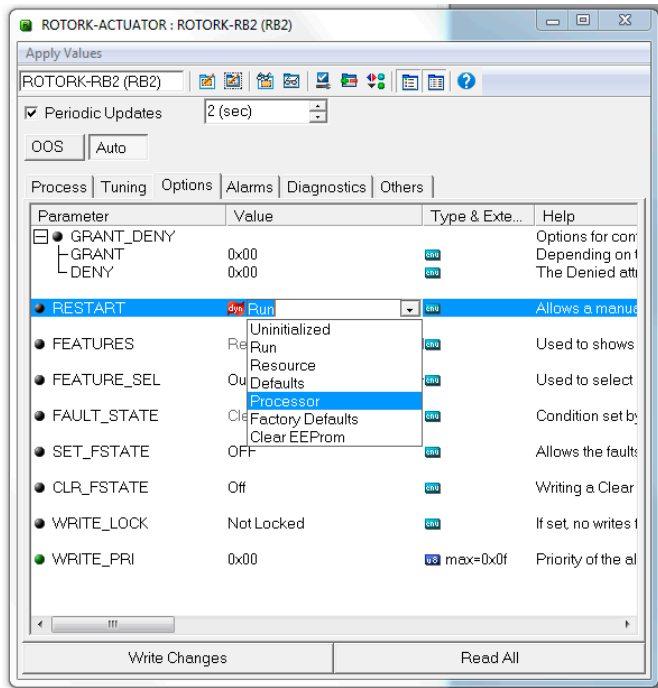


Fig F.4: Restart the processor

Restarting the processor doesn't delete the tag names nor any project schedule that the card may have.

When the card re-starts it will create a new FF entry in the NI Configurator tool's list of devices.

Delete the old entry by right-clicking on the original actuator tag (now marked by an error symbol, as shown below) and selecting "Delete".

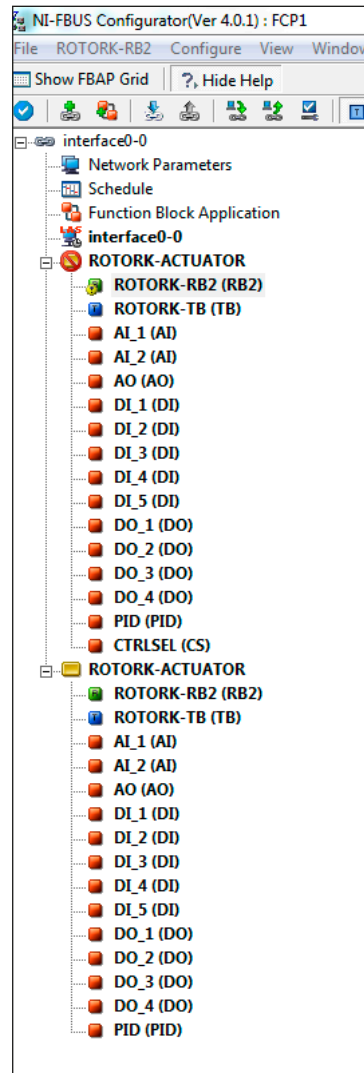


Fig F.5: Device view following a processor restart

Appendix G – DTM

Rotork has a DTM which can be downloaded from via the following link:

<http://www.rotork.com/document/index/versions/masterID/55353/>

This link also contains the DTM user manual PUB089-004.

Note: Rotork does not supply a Comm DTM nor does it supply an FDT. These must be purchased from another vendor.

The DTM provides read / write access to the key Transducer Block parameters and can be used with Rotork's ITK4.6, 5.1 and 6.1 FF cards.

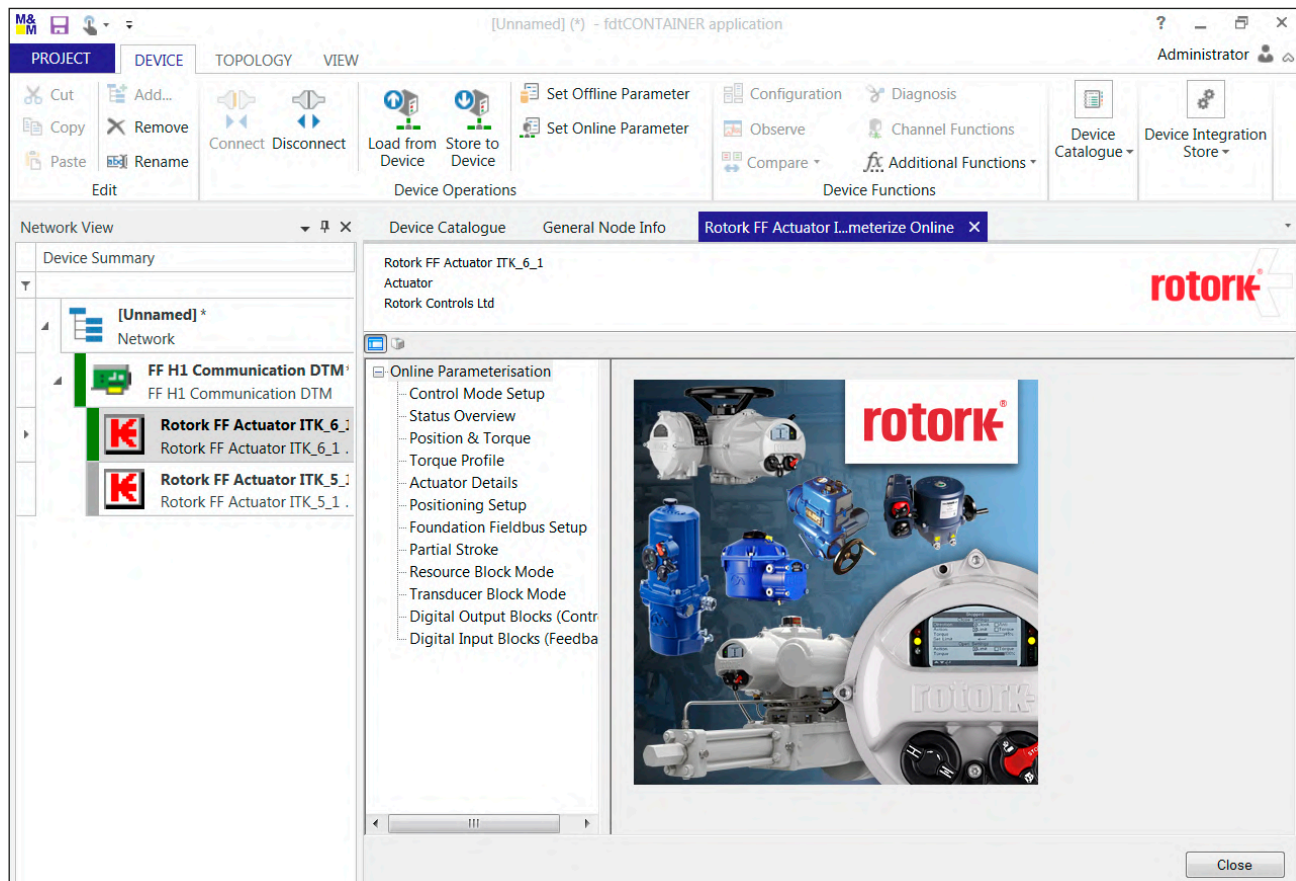


Fig G.1: DTM opening screen

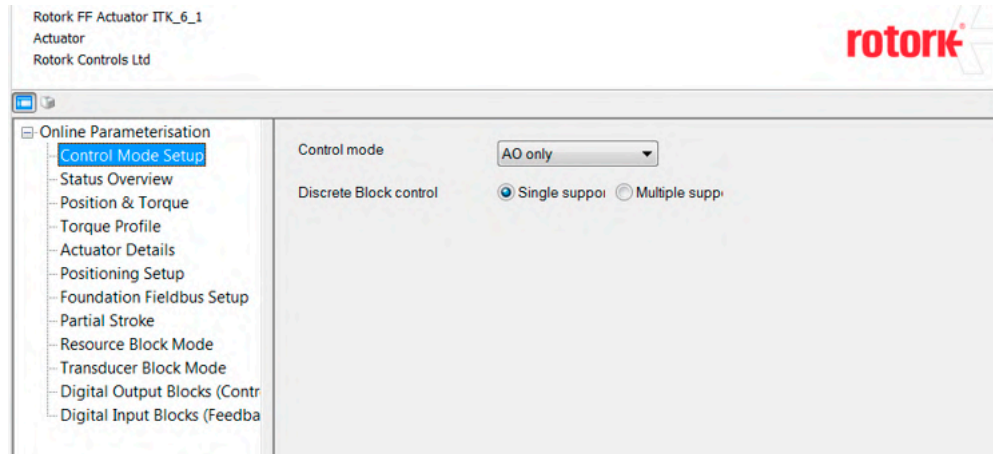


Fig G.2: Setting the control mode and discrete block control

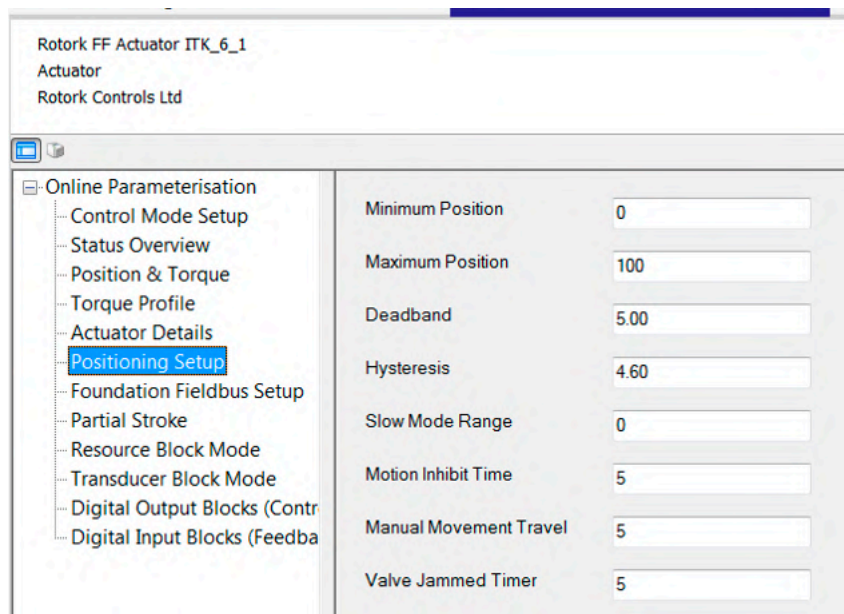


Fig G.3: Setting the actuator positioning parameters

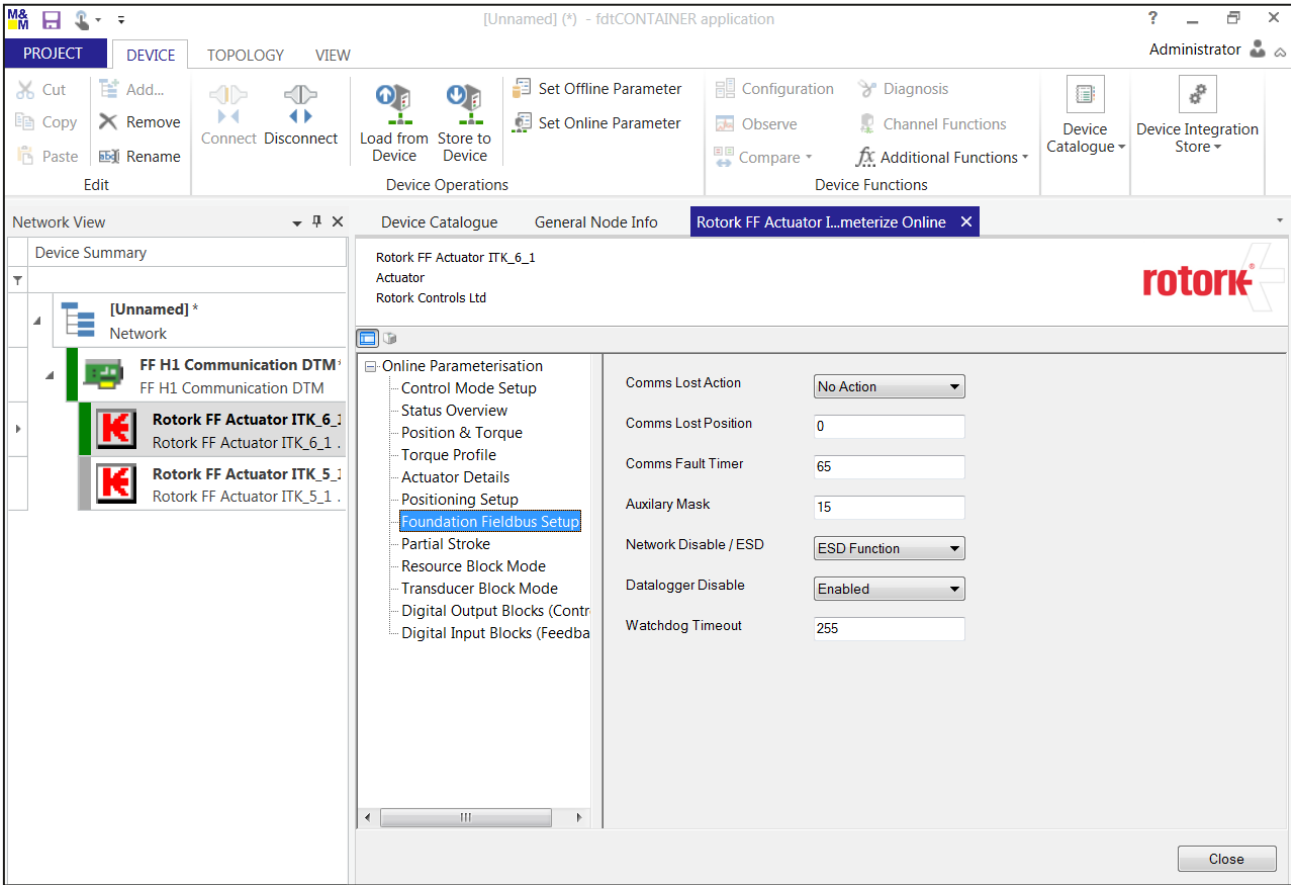


Fig G.4: Setting the FF card's operational parameters

Appendix H – Host Interoperability Support Test (HIST)

Like all responsible field device vendors, Rotork has successfully passed the rigorous ITK testing at the Fieldbus Foundation's test lab in Austin, Texas. For most other bus systems this would be sufficient, but the Foundation Fieldbus protocol is very complex and interpretations on its use can differ slightly between various DCS vendors.

This means it is strongly recommended to obtain HIST approval prior to the on-site commissioning of an FF system. This HIST should cover not only the field devices to be used but also the particular make and model of DCS and the firmware revision used. A HIST is a service that DCS vendors provide, possibly for a small charge. It is not a service that Rotork can offer.

Rotork has deposited FF actuators at all the major DCS vendors test labs to enable them to test our cards when required. For specific projects, Rotork can provide a list of HIST approvals.

1. Configuration Settings

a. Setting the FF card's address beyond the usable address range configured in the DCS.

The factory default setting for FF cards supplied inside a Rotork actuator is 34. If the DCS's useable address range is set to 33 or lower the actuator will not be detected by the DCS. FF cards supplied as spares will be despatched with an un-configured address. If the FF card is not visible on the DCS configurator screens, try using a hand held configurator tool, such as the Emerson 475, to check the FF card's settings.

b. Changing the channel numbers for the function blocks.

Changing the channel numbers of the function blocks will result in the actuator not functioning correctly. The channel numbers listed in the CFF file (and shown below) must be adhered to:

| | |
|-------------------|------------|
| AI 1 (Position %) | Channel 1 |
| AI 2 (Torque %) | Channel 2 |
| DI 1 | Channel 3 |
| DI 2 | Channel 4 |
| DI 3 | Channel 5 |
| DI 4 | Channel 6 |
| DI 5 | Channel 7 |
| AO | Channel 8 |
| DO 1 | Channel 9 |
| DO 2 | Channel 10 |
| DO 3 | Channel 11 |
| DO 4 | Channel 12 |

c. Changing the FF card's timing parameters

Changing the channel numbers of the function blocks will result in the actuator either not responding at all or else having an intermittent response. Use the timing parameters as listed in the CFF file:

```
MaximumResponseDelaySlotTime = 0x50
```

```
MinimumInterPduDelay = 0x10
```

```
SlotTime = 0x08
```


2. Output Blocks

a. Setting the “Discrete Block Control” mode in the Transducer Block to multiple support and downloading more than one DO in the schedule.

Whilst all five DI blocks can be used in multiple support mode to give 40 DI states, only one DO can be used. Downloading two or more DOs from the same actuator will result in the actuator failing to respond to DO commands.

b. Setting the “Discrete Block Control” mode in the Transducer Block to multiple support and writing more than one actuator control command.

It is possible to send multiple DO commands to the actuator’s output relays via a DO block, but it is not possible to send more than one actuator control command, e.g. open, close or stop. Sending two commands at the same time will result in the actuator failing to respond to either.

c. Setting the “Discrete Block Control” mode in the Transducer Block to single bit support and writing more than one actuator control command.

Sending more than one actuator control command, e.g. open, close or stop at the same time will result in the actuator failing to respond to either. Sending a command and then sending another counter command, without cancelling the first, will result in the actuator continuing with the first command.

d. Trying to operate the output relays with an LO alarm status present.

If the actuator has a monitor relay fault, any of its control blocks (AO or DO) being used in the schedule will be put into an LO state and all commands via this block will be inhibited. This means not just the actuator control but also the output relays which may be used for controlling other equipment outside of the actuator. The same control inhibit function is true if the block is in an IMAN state.

e. Action on loss of comms settings.

There is a series of actuator parameters, accessible via the TB that, if enabled, can drive the actuator to an end of travel limit, mid-travel position, or stop the actuator when host comms are lost. These are parameters 56 to 58 in the TB.

There is also a standard FF parameter within the DO and AO blocks known as “Fault state to value”. If this is selected and the FF block goes into fault state, the value in the “fault state value register” will be used by the function block. As an example, if the upstream block connected to the AO block has problem this will put the AO block in fault state – if the fault state value is 50, then the actuator will be sent to 50%.

If both of these features are enabled, make sure they are set to perform the same function.

f. Fault state on restart.

This is another FF feature. If this is selected, any time the block restarts it will take the fault state value and use that until the block itself reaches CAS mode. This is NOT a fault state, it is just using the Fault State value.

A grayscale world map is centered in the background of the lower half of the page. The map is overlaid with a series of concentric, wavy lines that radiate from the center, creating a sense of global connectivity or signal transmission.

www.rotork.com

A full listing of our worldwide sales and service network is available on our website.

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