

# **MULTIFUNCTION 48-PIN I/O CONTROLLER**

With CANopen®

## **USER MANUAL**

**P/N: AX031201**

## ACRONYMS

|                 |                                                                        |
|-----------------|------------------------------------------------------------------------|
| <b>AI</b>       | Analog Input                                                           |
| <b>AO</b>       | Analog Output                                                          |
| <b>CAN</b>      | Controller Area Network                                                |
| <b>CANopen®</b> | CANopen® is a registered community trademark of CAN in Automation e.V. |
| <b>CAN-ID</b>   | CAN 11-bit Identifier                                                  |
| <b>COB</b>      | Communication Object                                                   |
| <b>CTRL</b>     | Control                                                                |
| <b>DI</b>       | Digital Input                                                          |
| <b>DO</b>       | Digital Output                                                         |
| <b>EDS</b>      | Electronic Data Sheet                                                  |
| <b>EMCY</b>     | Emergency                                                              |
| <b>LSB</b>      | Least Significant Byte (or Bit)                                        |
| <b>LSS</b>      | Layer Settling Service                                                 |
| <b>LUT</b>      | Lookup Table                                                           |
| <b>MI</b>       | Magnetic Input                                                         |
| <b>MSB</b>      | Most Significant Byte (or Bit)                                         |
| <b>NMT</b>      | Network Management                                                     |
| <b>PID</b>      | Proportional-Integral-Derivative Control                               |
| <b>RLYO</b>     | Relay Output                                                           |
| <b>RO</b>       | Read Only Object                                                       |
| <b>RPDO</b>     | Received Process Data Object                                           |
| <b>RW</b>       | Read/Write Object                                                      |
| <b>SDO</b>      | Service Data Object                                                    |
| <b>TPDO</b>     | Transmitted Process Data Object                                        |
| <b>UI</b>       | Universal Input                                                        |
| <b>VO</b>       | Valve Output (Universal)                                               |
| <b>WO</b>       | Write Only Object                                                      |

## REFERENCES

- [DS-301]            CiA DS-301 V4.1 – CANopen Application Layer and Communication Profile. CAN in Automation 2005
- [DS-305]            CiA DS-305 V2.0 – Layer Setting Service (LSS) and Protocols. CAN in Automation 2006
- [DS-404]            CiA DS-404 V1.2 – CANopen profile for Measurement Devices and Closed Loop Controllers. CAN in Automation 2002

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## 1. OVERVIEW OF CONTROLLER

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### 1.1. Description of Multifunction I/O Controller

This User Manual describes the architecture and functionality of a 48-pin Multifunction I/O controller with CANopen®.

The Multifunction I/O Controller (MF-I/O) is designed for extremely versatile control of 2 isolated digital, 4 universal, 1 magnetic, and 4 isolated analog inputs as well as 1 proportional valve, 4 relay, and 4 isolated analog outputs. Its flexible circuit design gives the user a wide range of configurable input and output types. The sophisticated control algorithms allow the user to program the controller for a wide range of applications without the need for custom software.

On the input side of the MF-I/O, the four universal inputs can be configured to measure: voltage (0-1V, 0-2.5V, 0-5V, 0-10V), current (0-20mA, 4-20mA), resistive (25Ohms – 250kOhm), frequency (up to 10kHz), PWM (up to 10kHz), and digital (ON/OFF). The four isolated analog inputs can be configured to measure: voltage (0-5V, 0-10V), current (0-20mA, 4-20mA), and digital (ON/OFF). There are 2 designated isolated digital inputs as well as 1 magnetic pickup input.

On the output side, the 1 proportional valve output can be configured to drive: proportional current (up to 2.0A); hotshot digital current; proportional voltage (up to supply); proportional PWM; or straight on/off digital loads. The 4 isolated analog outputs can be configured to drive: proportional analog voltage (0-5V, 0-10V), proportional current (0-20mA, 4-20mA). The 4 relay outputs have digital on/off behaviour.

The MF-I/O also supports two CAN interfaces which are isolated from one another. This extends the versatility of the controller which allows it to be used in two separate CANopen® networks and considered as two separate modules. Therefore, the controller supports different Node IDs and different Baud Rates on each CAN.

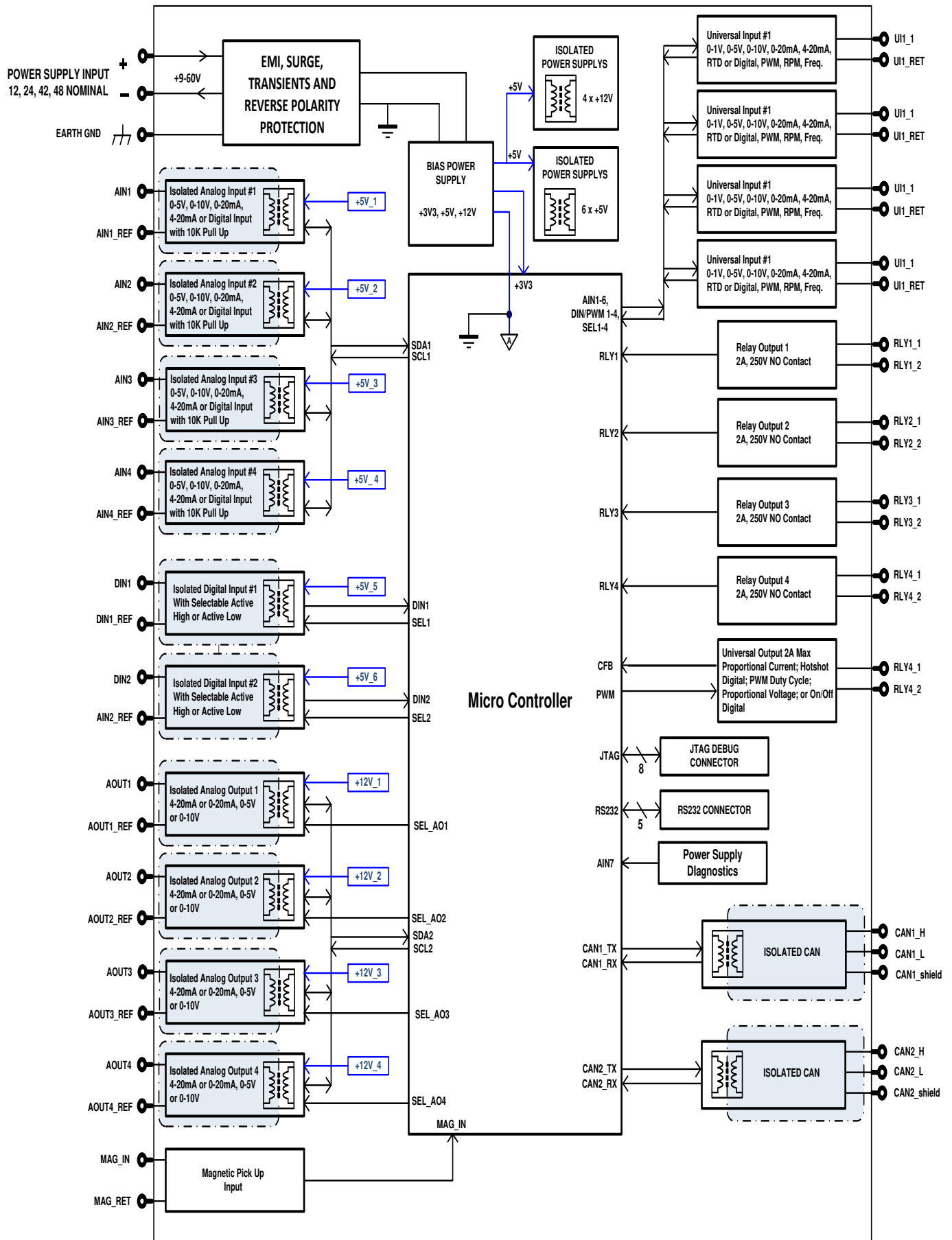


Figure 1A – Hardware Functional Block Diagram

The MF-I/O is a highly programmable controller, allowing the user to configure it for their application. Its sophisticated control algorithms allow for open or closed loop drive of the proportional output. It can be operated as either a self-contained control system, driving the outputs directly from the on-board logical function blocks, and/or it can be integrated into one or two CANopen ® network of controllers. All outputs and logical function blocks on the unit are inherently independent from one another, but can be programmed to interact in a large number of ways. While Figure 1A shows the hardware features, Figure 1B shows the logical function blocks (software) available on the MF-I/O.

The MF-I/O has a number of built-in protection features that can shutoff the outputs in adverse conditions. These features are described in detail in subsequent sections, and they include hardware shutoffs to protect the circuits from being damaged as well as software shutdown features that can be enabled in safety critical systems when an input or CAN fault is detected.

The various function blocks supported by the MF-I/O are outlined in the following sections. All objects are user-configurable using standard commercially available tools that can interact with a CANopen ® Object Dictionary via an .EDS file.

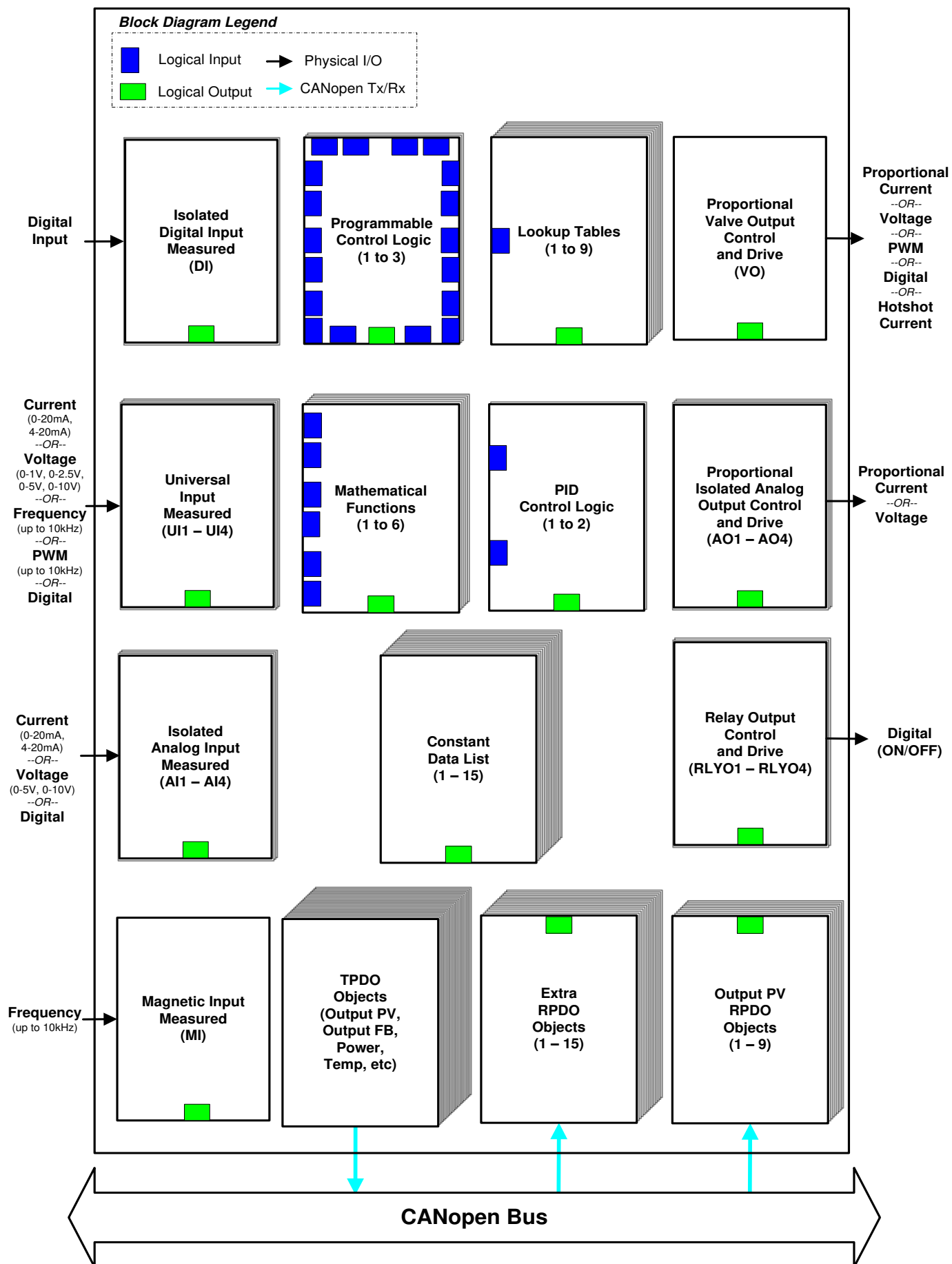
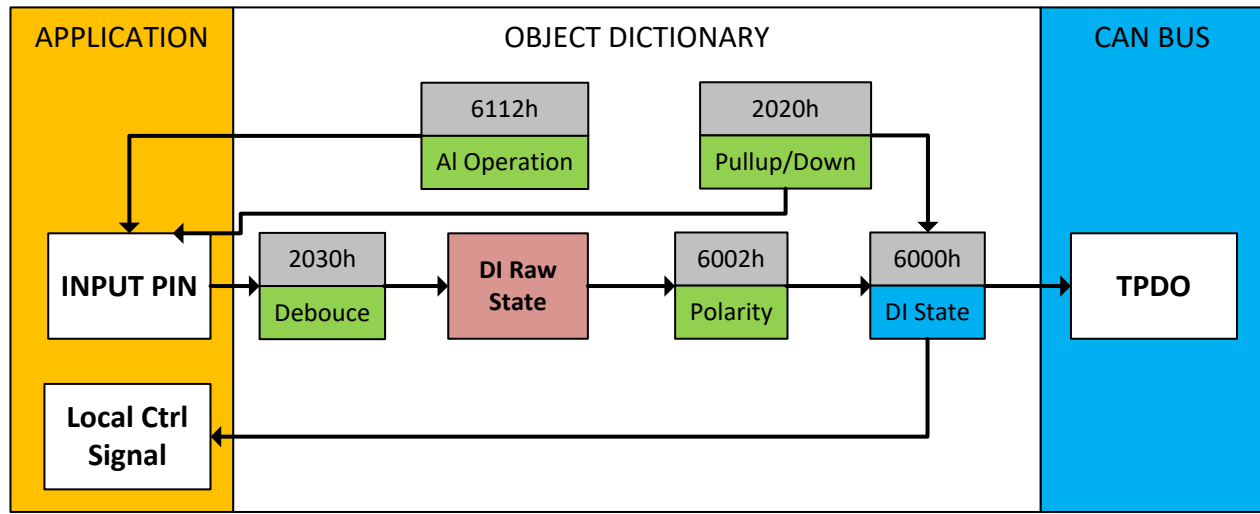


Figure 1B –Logic Functional Block Diagram

## 1.2. Digital Input Function Block

The digital input (DI) function block only becomes applicable on the input when object 6112h, **AI Operation**, is set to a digital input response.



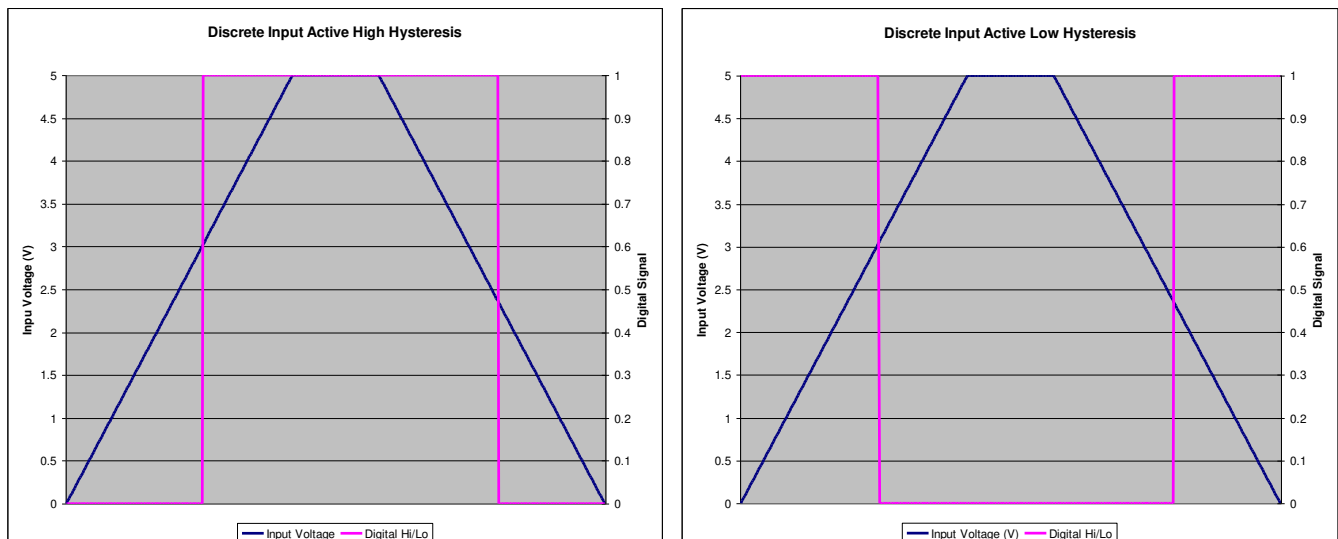
**Figure 2 – Digital Input Objects**

When object 6112h is set to *10 = Digital Input*, object 2020h **DI Pull-up/Pull-down Mode** will determine the configuration of the internal Pull-up/Pull-down resistors. The options for object 2020h are shown in Table 1, with the default **bolded**.

| Value | Meaning                                                          |
|-------|------------------------------------------------------------------|
| 0     | Pullup/Down Disabled (high impedance input)                      |
| 1     | 22k $\Omega$ Pullup Resistor Enabled (to 5V)                     |
| 2     | <b>22k<math>\Omega</math> Pulldown Resistor Enabled (to GND)</b> |

**Table 1 – DI Pullup/Down Options**

Figure 3 shows the hysteresis on the input when switching a discrete signal. A digital input can be switched up to +Vcc (42Vmax.)

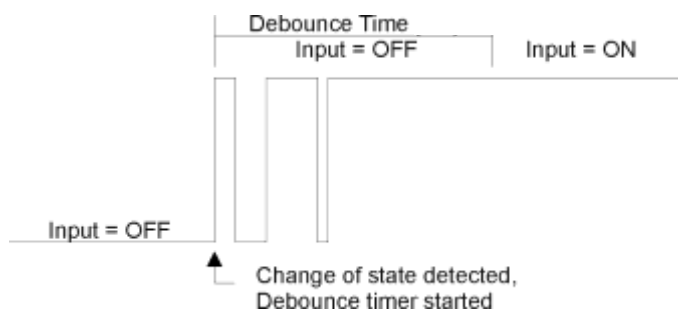


**Figure 3 – Discrete Input Hysteresis**

Object 2030h **DI Debounce Filter** is applied to the input before the state is read by the processor. The options for object 2030h are shown in Table 2, with the default bolded.

| Value | Meaning               |
|-------|-----------------------|
| 0     | Filter Disabled       |
| 1     | Filter 111ns          |
| 2     | <b>Filter 1.78 us</b> |
| 3     | Filter 14.22 us       |

**Table 2 – DI Debounce Filter Options**



**Figure 4 – Digital Input Debouncing**

Once the raw state has been evaluated, the logical state of the input is determined by **object 6002h DI\_Polarity\_8\_Input\_Lines**. The options for object 6002h are shown in Table 3. The state of the DI will be written to read-only object 6000h **DI\_Read\_state\_8\_Input\_Lines**. By default, normal on/off logic is used.

| Value | Meaning              |
|-------|----------------------|
| 0     | <b>Normal On/Off</b> |
| 1     | Inverse On/Off       |

**Table 3 – Object 6002h DI\_Polarity\_8\_Input\_Lines options**

The format to write to object 6002h is as follows:

Sub-index 1 will determine the following inputs' polarities:

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| AI2   | AI1   | UI4   | UI3   | UI2   | UI1   | DI2   | DI1   |

Sub-index 2 will determine the following inputs' polarities:

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
|       |       |       |       |       |       | AI4   | AI3   |

The rest of the bits in sub-index 2 will be ignored.

As per the format of object 6002h, the bits in object 6000h **DI\_Read\_state\_8\_Input\_Lines** will be written to represent the same inputs' states.

There is another type of 'digital' input that can be selected when 6112h is set to 20 = Analog On/Off. However, in this case, the input is still configured as an analog input, and therefore the objects from the Analog Input (AI) block are applied instead of those discussed above. Here, objects 2020h, 2030h and 6030h are ignored, and 6000h is written as per the logic shown in Figure 5. In this case, the MIN parameter is set by object 7120h **AI Scaling 1 FV**, and the MAX is set by 7122h **AI Scaling 2 FV**.

For all other operating modes, object 6000h will always be zero.

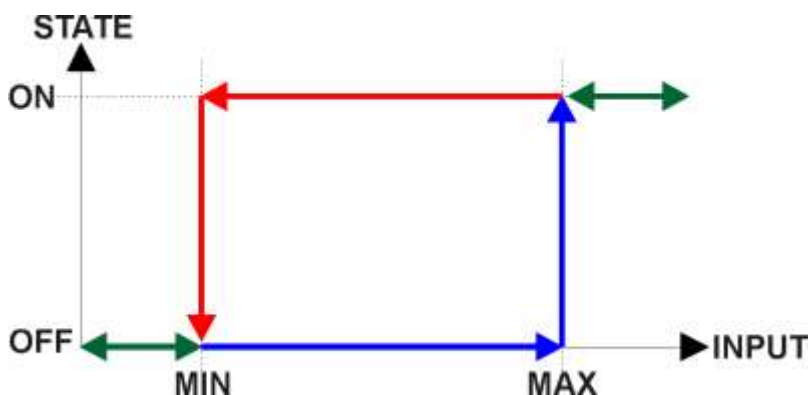


Figure 5 – Analog Input Read as Digital

### 1.3. Analog Input Function Block

The analog input (AI) function block is the default logic associate with the universal inputs.

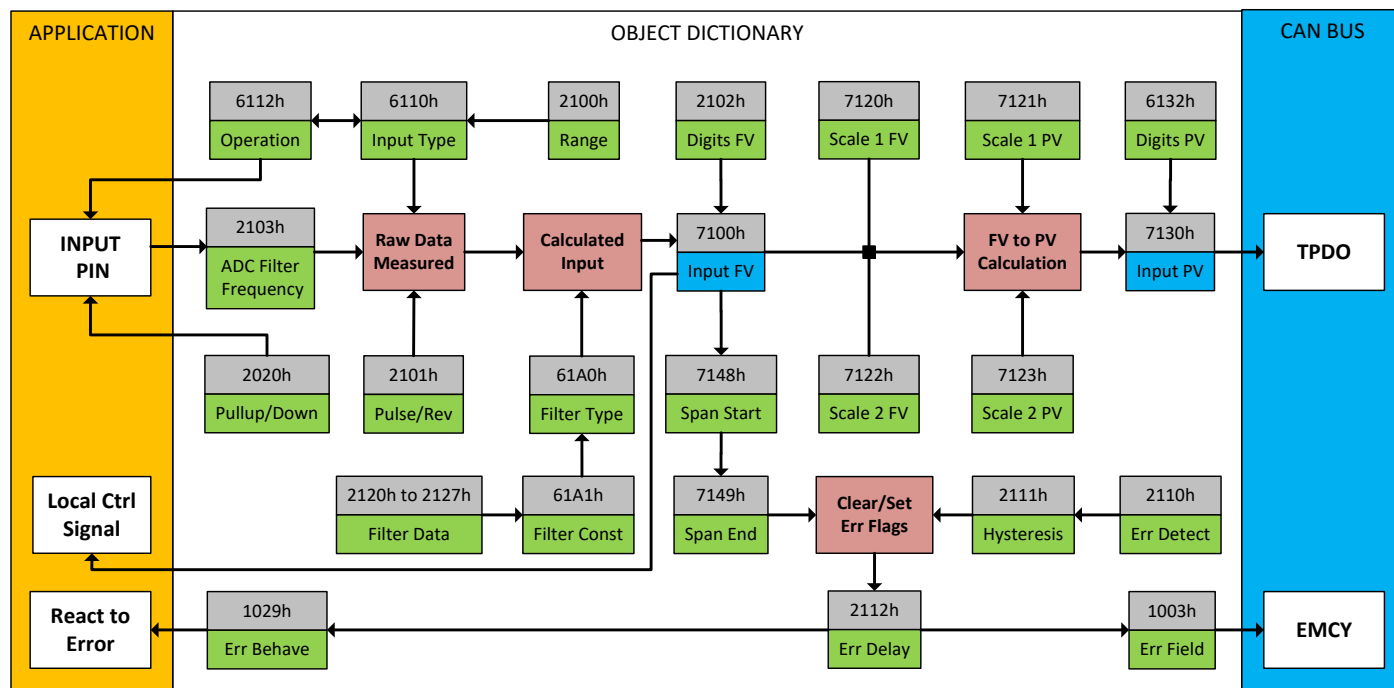


Figure 6 – Analog Input Objects

Object 6112h, **AI Operating Mode** determines whether the UI, AI, MI or DI function block is associated with an input. The options for object 6112h are shown in Table 4. No values other than what are shown here will be accepted.

| Value    | Meaning                          |
|----------|----------------------------------|
| 0        | Channel Off                      |
| <b>1</b> | <b>Normal Operation (analog)</b> |
| 10       | Digital Input (On/Off)           |
| 20       | Analog and On/Off                |

**Table 4 – Object 6112h - AI Operating Mode Options**

However, due to the specific functionality of some of the inputs of the MF-I/O, some of the AI Operating Modes cannot be accomplished. DI1 and DI2 **can only be configured to 0 (Channel Off) or 20 (Digital Input (On/Off))**. Likewise, MI **cannot be configured to 10 (Digital Input (On/Off))**.

The most important object associate with the AI function block is object 6110h **AI Sensor Type**. By changing this value, and associated with it object 2100h **AI Input Range**, other objects will be automatically updated by the controller. The options for object 6110h are shown in Table 5, and no values other than what are shown here will be accepted. The inputs are setup to measure voltage by default.

| Value     | Meaning                  |
|-----------|--------------------------|
| <b>40</b> | <b>Voltage Input</b>     |
| 50        | Current Input            |
| 60        | Frequency Input (or RPM) |
| 100       | Resistive Input          |
| 10000     | PWM Input                |

**Table 5 – Object 6110h - AI Sensor Type Options**

The allowable ranges will depend on the input selected and input sensor type selected. Table 6 shows the relationship between the sensor type, and the associated range options. The default value for each range is bolded, and object 2100h **AI Range** will automatically be updated with this value when 6110h is changed. The grayed-out cells mean that the associated value is not allowed for the range object when that sensor type has been selected.

| Value | Voltage        | Current          | Frequency            | Resistive           | PWM                          |
|-------|----------------|------------------|----------------------|---------------------|------------------------------|
| 0     | 0 to 1V*       | 0 to 20mA        | <b>0.5Hz to 50Hz</b> | <b>25Ω to 250kΩ</b> | Low Freq (<1kHz)             |
| 1     | 0 to 2.5V*     | <b>4 to 20mA</b> | 10Hz to 1kHz         |                     | <b>High Freq (&gt;100Hz)</b> |
| 2     | <b>0 to 5V</b> |                  | 100Hz to 10kHz       |                     |                              |
| 3     | 0 to 10V       |                  |                      |                     |                              |

**Table 6 – Object 2100h - AI Input Range Options Depending on Sensor Type**

\* Note: this range is possible for **Universal Inputs**, only

Not all objects apply to all input types. For example, object 2103h **AI Filter Frequency for ADC** is only applicable with a voltage, current or resistive input is being measured. In these cases, the ADC will automatically filter as per Table 7, and is set for 50Hz noise rejection by default.

| Value    | Meaning            |
|----------|--------------------|
| 0        | Input Filter Off   |
| <b>1</b> | <b>Filter 50Hz</b> |

|   |                      |
|---|----------------------|
| 2 | Filter 60Hz          |
| 3 | Filter 50Hz and 60Hz |

**Table 7 – Object 2103h - ADC Filter Frequency Options**

Conversely, frequency and PWM inputs use object 2020h **DI Pull-up/Pull-down Mode** (see Table 1) while voltage, current and resistive inputs set this object to zero. Also, a frequency input can be automatically turned into an RPM measurement instead simply by setting object 2101h **AI Number of Pulses Per Revolution** to a non-zero value. All other input types ignore this object. Regardless of type, however, all analog inputs can be further filtered once the raw data has been measured (either from ADC or Timer.) Object 61A0h **AI Filter Type** determines what kind of filter is used per Table 8. By default, additional software filtering is disabled.

| Value | Meaning              |
|-------|----------------------|
| 0     | No Filter            |
| 1     | Moving Average       |
| 2     | Repeating Average    |
| 3     | Third-Order Low Pass |

**Table 8 – Object 61A0h - AI Filter Type Options**

Object 61A1h **AI Filter Constant** is used with all three types of filters as per the formulas below:

Calculation with no filter:

Value = Input

The data is simply a ‘snapshot’ of the latest value measured by the ADC or timer.

Calculation with the moving average filter:

$$\text{Value}_N = \text{Value}_{N-1} + \frac{(\text{Input} - \text{Value}_{N-1})}{\text{FilterConstant}}$$

This filter is called every 1ms. The value FilterConstant stored in object 61A1h is 10 by default.

Calculation with the repeating average filter:

$$\text{Value} = \frac{\sum \text{Input}_N}{N}$$

At every reading of the input value, it is added to the sum. At every N<sup>th</sup> read, the sum is divided by N, and the result is the new input value. The value and counter will be set to zero for the next read. The value of N is stored in object 61A1h, and is 10 by default. This filter is called every 1ms.

Calculation with the 3<sup>rd</sup> Order Low Pass filter:

$$\text{Value}_N = \frac{[\text{C}_{IN0} * \text{Input}_N + \text{C}_{IN1} * \text{Input}_{N-1} + \text{C}_{IN2} * \text{Input}_{N-2} + \text{C}_{IN3} * \text{Input}_{N-3} + \text{C}_{OUT1} * \text{Value}_{N-1} + \text{C}_{OUT2} * \text{Value}_{N-2} + \text{C}_{OUT3} * \text{Value}_{N-3}]}{2^{\text{Power}}}$$

C<sub>IN0</sub> Coefficient for Input(n)

C<sub>IN1</sub> Coefficient for Input(n-1)

C<sub>IN2</sub> Coefficient for Input(n-2)

C<sub>IN3</sub> Coefficient for Input(n-3)

C<sub>OUT1</sub> Coefficient for Output(n-1)

C<sub>OUT2</sub> Coefficient for Output(n-2)

C<sub>OUT3</sub> Coefficient for Output(n-3)

This filter uses 16-bit fixed point math. Object 2120h **AI Third-Order Filter Power** tells the controller the shift value used when the coefficients were selected.

The value of object 61A1h determines how often the filter is called (in ms), and is set to 10 by default. In between calls, the data of the input signal is the value which was calculated the last time the filter was called. The filter coefficients are stored in objects 2121h to 2127h.

The value from the filter is shifted according to read-only object 2102h **AI Decimal Digits FV** and then written to read-only object 7100h **AI Input Field Value**.

The value of 2102h will depend on the AI Sensor Type and Input Range selected, and will be automatically updated per Table 9 when either 6110h or 2100h are changed. All other objects associated with the input field value also apply this object. These objects are 7120h **AI Scaling 1 FV**, 7122h **AI Scaling 2 FV**, 7148h **AI Span Start**, 7149h **AI Span End**, and 2111h **AI Error Clear Hysteresis**. These objects are also automatically updated when the Type or Range is changed.

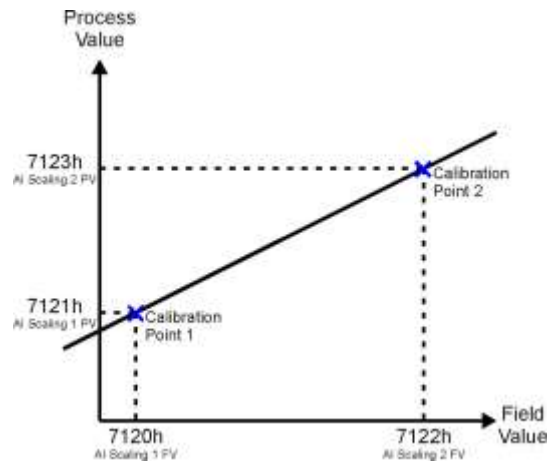
| Sensor Type and Range     | Decimal Digits |
|---------------------------|----------------|
| Voltage: All Ranges       | 3 [mV]         |
| Current: All Ranges       | 3 [uA]         |
| Resistive: Full Range     | 2 [0.01 kΩ]    |
| Frequency: 0.5Hz to 50Hz  | 2 [0.01 Hz]    |
| Frequency: 10Hz to 1kHz   | 1 [0.1 Hz]     |
| Frequency: 100Hz to 10kHz | 0 [Hz]         |
| Frequency: RPM Mode       | 1 [0.1 RPM]    |
| PWM: All Ranges           | 1 [0.1 %]      |
| Digital Input             | 0 [On/Off]     |

**Table 9 – Object 2102h - AI Decimal Digits FV Depending on Sensor Type**

It is the **AI Input FV** which is used by the application for error detection, and as a control signal for other logic blocks (i.e. output control.) Object 7100h is mappable to a TPDO, and is mapped to TPDO1 by default.

Read-only object 7130h **AI Input Process Value** is also mappable . However, the default values for objects 7121h **AI Scaling 1 PV** and 7123h **AI Scaling 2 PV** are set to equal 7120h and 7122h respectively, while object 6132h **AI Decimal Digits PV** is automatically initialize to equal 2102h. This means that the default relationship between the FV and PV is one-to-one, so object 7130h is not mapped to a TPDO by default.

Should a different linear relationship between what is measured versus what is sent to the CANopen bus be desired, objects 6132h, 7121h and 7123h can be changed. The linear relationship profile is shown in Figure 7 below. Should a non-linear response be desired, the lookup table function block can be used instead, as described in section 1.7.



**Figure 7 – Analog Input Linear Scaling FV to PV**

As stated earlier, the FV scaling objects are automatically updated with the Sensor Type or Range changes. This is because objects 7120h and 7122h are not only used in a linear conversion from FV to PV as described above, but also as the minimum and maximum limits when the input is used to control another logic block. Therefore, the values in these objects are important, even when the AI Input PV object is not being used.

The AI Span Start and AI Span End objects are used for fault detection, so they too are automatically updated for sensible values as the Type/Range changes. The Error Clear Hysteresis object is also updated, as it too is measured in the same unit as the AI Input FV object.

Table 10 lists the default values that are loaded into objects 7120h, 7122h, 7148h, 7149h, and 2111h for each Sensor Type and Input Range combination. Recall that these objects all have the decimal digits applied to them as outlined in Table 9.

| Sensor Type/<br>Input Range | 7148h<br>AI Span Start<br>(i.e. Error Min) | 7120h<br>AI Scaling 1 FV<br>(i.e. Input Min) | 7122h<br>AI Scaling 2 FV<br>(i.e. Input Max) | 7149h<br>AI Span End<br>(i.e. Error Max) | 2111h<br>Error Clear<br>Hysteresis |
|-----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|------------------------------------------|------------------------------------|
| Voltage: 0 to 1V            | 50 [mV]                                    | 100 [mV]                                     | 1000 [mV]                                    | 1050 [mV]                                | 25 [mV]                            |
| Voltage: 0 to 2.5V          | 100 [mV]                                   | 250 [mV]                                     | 2500 [mV]                                    | 2600 [mV]                                | 50 [mV]                            |
| Voltage: 0 to 5V            | 200 [mV]                                   | 500 [mV]                                     | 4500 [mV]                                    | 4800 [mV]                                | 100 [mV]                           |
| Voltage: 0 to 10V           | 200 [mV]                                   | 500 [mV]                                     | 9500 [mV]                                    | 9800 [mV]                                | 200 [mV]                           |
| Current: 0 to 20mA          | 0 [uA]                                     | 0 [uA]                                       | 20000 [uA]                                   | 20000 [uA]                               | 250 [uA]                           |
| Current: 4 to 20mA          | 1000 [uA]                                  | 4000 [uA]                                    | 20000 [uA]                                   | 21000 [uA]                               | 250 [uA]                           |
| Resistive: 0.025 to 250kΩ   | 2 [0.01kΩ]                                 | 10 [0.01kΩ]                                  | 20000 [0.01kΩ]                               | 25000 [0.01kΩ]                           | 1 [0.01kΩ]                         |
| Freq: 0.5Hz to 50Hz         | 100 [0.01Hz]                               | 500 [0.01Hz]                                 | 5000 [0.01Hz]                                | 5500 [0.01Hz]                            | 20 [0.01Hz]                        |
| Freq: 10Hz to 1kHz          | 50 [0.1Hz]                                 | 100 [0.1Hz]                                  | 10000 [0.1Hz]                                | 11000 [0.1Hz]                            | 50 [0.1Hz]                         |
| Freq: 100Hz to 10kHz        | 50 [Hz]                                    | 100 [Hz]                                     | 10000 [Hz]                                   | 10500 [Hz]                               | 10 [Hz]                            |
| Freq: RPM Mode              | 500 [0.1RPM]                               | 1000 [0.1RPM]                                | 30000 [0.1RPM]                               | 33000 [0.1RPM]                           | 100 [0.1RPM]                       |
| PWM: 0 to 100%              | 10 [0.1%]                                  | 50 [0.1%]                                    | 950 [0.1%]                                   | 990 [0.1%]                               | 10 [0.1%]                          |
| Digital Input               | OFF                                        | OFF                                          | ON                                           | ON                                       | 0                                  |

**Table 10 – AI Object Defaults Based on Sensor Type and Input Range**

It might not be desired in a particular application for the automatic updating of objects when a key object is changed, i.e. AI Sensor Type. In this case, object 5550h **Enable Automatic Updates** can be set to FALSE (true by default) in which case changing an object will have no impact on any other objects. In this mode, the user must manually change all the objects for sensible values or the controller will not work as expected.

When changing these objects, Table 11 outlines the range constraints places on each based on the Sensor Type and Input Range combination selected. In all cases, the MAX value is the upper

end of the range (i.e. 5V or ) Object 7122h cannot be set higher than MAX, whereas 7149h can be set up to 110% of MAX. Object 2111h on the other hand can only be set up to maximum value of 10% of MAX. Table 11 uses the base unit of the input, but recall the limits will also have object 2102h apply to them as per Table 9.

| Sensor Type/<br>Input Range                                                                                    | 7148h          | 7120h                                            | 7122h                                           | 7149h                | 2111h      |
|----------------------------------------------------------------------------------------------------------------|----------------|--------------------------------------------------|-------------------------------------------------|----------------------|------------|
| Voltage: 0 to 1V, 0 to 2.5V, 0 to 5V and 0 to 10V<br>Current: 0 to 20mA<br>RPM: 0 to 6000RPM<br>PWM: 0 to 100% | 0 to 7120h     | 7148h to 7122h                                   | 7120h to 7149h<br>If(7149h>MAX)<br>7120h to MAX | 7122h to 110% of MAX | 10% of MAX |
| Current: 4 to 20mA                                                                                             | 0 to 7120h     | 7148h to 7122h<br>If(7148h<4mA) 4mA to 7122h     |                                                 |                      |            |
| Resistive: 0.025 to 250kΩ                                                                                      | 25Ω to 7120h   | 7148h to 7122h                                   |                                                 |                      |            |
| Freq: 0.5Hz to 50Hz                                                                                            | 0.1Hz to 7120h | 7148h to 7122h<br>If(7148h<0.5Hz) 0.5Hz to 7122h |                                                 |                      |            |
| Freq: 10Hz to 1kHz                                                                                             | 5Hz to 7120h   | 7148h to 7122h<br>If(7148h<10Hz) 10Hz to 7122h   |                                                 |                      |            |
| Freq: 100Hz to 10kHz                                                                                           | 50Hz to 7120h  | 7148h to 7122h<br>If(7148h<100Hz) 100Hz to 7122h |                                                 |                      |            |

**Table 11 – AI Object Ranges Based on Sensor Type and Input Range**

The last objects associated with the analog input block left to discuss are those associated with fault detection. Should the calculated input (after measuring and filtering) fall outside of the allowable range, as defined by the AI Span Start and AI Span End objects, an error flag will be set in the application if and only if object 2110h **AI Error Detect Enabled** is set to TRUE (1).

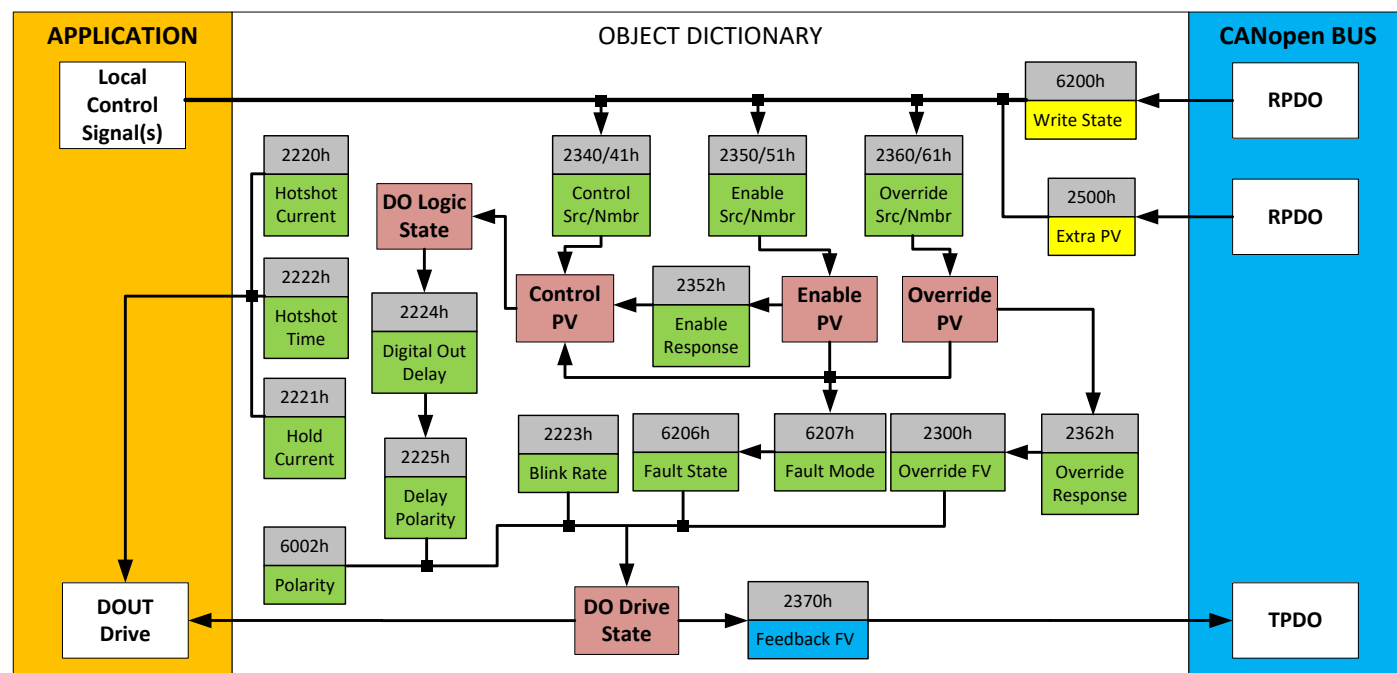
When (7100h AI Input FV < 7148h AI Span Start), an “Out of Range Low” flag is set. If the flag stays active for the 2112h **AI Error Reaction Delay** time, an Input Overload Emergency (EMCY) message will be added to object 1003h **Pre-Defined Error Field**. Similarly, when (7100h AI Input FV > 7149h AI Span End), an “Out of Range High” flag is set, and will create an EMCY message should it stay active throughout the delay period. In either case, the application will react to the EMCY message as defined by object 1029h **Error Behaviour** at the sub-index corresponding to an Input Fault. Refer to section 3.2.4 and 3.2.13 for more information about objects 1003h and 1029h.

Once the fault has been detected, the associate flag will be cleared only once the input comes back into range. Object 2111h **AI Error Clear Hysteresis** is used here so that the error flag will not be set/cleared continuously while the AI Input FV hovers around the AI Span Start/End value.

To clear an “Out of Range Low” flag, AI Input FV >= (AI Span Start + AI Error Clear Hysteresis)  
To clear an “Out of Range High” flag, AI Input FV <= (AI Span End - AI Error Clear Hysteresis)  
Both flags cannot be active at once. Setting either one of these flags automatically clears the other.

#### 1.4. Digital Output Function Block

The digital output (DO) function block only becomes applicable on the output when object 6310h, **AO Output Type**, is set to a digital output type (Output type = 1000 or 1020).



### Figure 8 – Digital Output Objects

Several of the objects shown in the above diagram are in fact associated with the Analog Output function block, and are explained in detail in Section 1.5. Therefore, this section will only elaborate on the objects unique to the DO function block.

An output can be controlled either by an on-board control signal (such the result from a lookup table or a math function) or a CANopen object that has been mapped to an RPDO. In the case of an output configured for a digital response, when a CANopen Message has been selected as the 2340h **AO Control Input Source** (see Table 15), then data from the appropriate bit within the sub-index from write-mappable object 6200h **DO\_Write\_state\_8\_output\_lines** will be used as the control signal. The format of object 6200h will be as follows:

| D7 | D6 | D5 | D4    | D3    | D2    | D1    | D0 |
|----|----|----|-------|-------|-------|-------|----|
| -  | -  | -  | RLYO4 | RLYO3 | RLYO2 | RLYO1 | PO |

For digital outputs DO1 to DO5 (Proportional Valve and Relay Outputs), the Enable and Override Inputs and Responses in the digital mode are the same as for an Analog Output, and are evaluated in the same order. Therefore, what is described in Section 1.5 for these also applied for the DO function block for all outputs.

As with the AO function, the DO1 to DO5 will respond to the Control Input if and only if the following conditions have been met:

- a) No fault is detected for any of the control signals
- b) The override command is either ignored or false (Override Input)
- c) The output has not been disabled by a secondary signal (Enable Input)

The resulting **DO\_Write\_state\_8\_output\_lines** will depend on the object 6202h **DO\_Polarity\_8\_output\_lines**, as per Table 12. By default, normal on/off output logic is used.

| Value | Meaning        | DO Logic State | DO Drive State |
|-------|----------------|----------------|----------------|
| 0     | Normal On/Off  | OFF            | OFF            |
|       |                | ON             | ON             |
| 1     | Inverse On/Off | OFF            | ON             |
|       |                | ON             | OFF            |

**Table 12 – Object 6202h - DO Polarity Options**

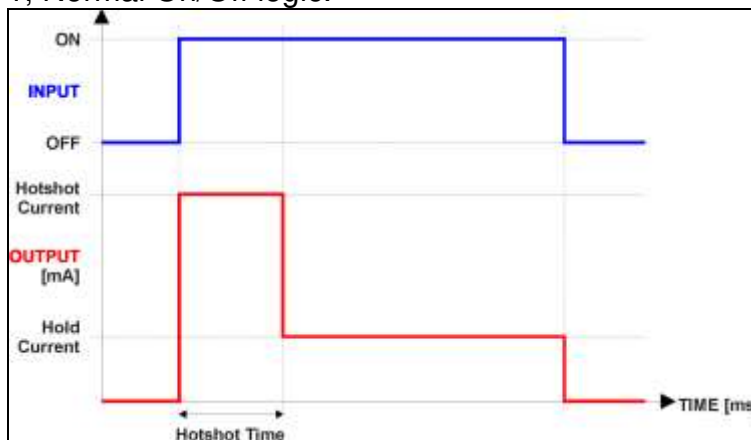
When the regular on/off output logic is used, objects 2224h **Digital Out Delay** and 2225h **Delay Polarity** come to effect. When this object is >0ms, however, this value will determine how long after the output will react once it is commanded has been driven will the output react. Object 2225h **Delay Polarity** determines on which edge the delay will affect. By default, **Digital Out Delay** is set to 0ms (no delay) and **Delay Polarity** is set to rising edge – in which case the output will react as soon as it is commanded.

Depending output polarity configured - when set, the Relay outputs will close – thereby connecting 'Relay Out x+' to 'Relay Out x-', where x is 1-4. The Relay outputs are Normally Open by default.

The read-only mappable object 2370h **AO Feedback FV** will be loaded with the **DO Drive State** (0=OFF, 1=ON) when the output is setup for a digital type. This only applies for Proportional Valve Output.

With the Proportional Valve output, outside of a straight ON/OFF digital output (where ON = +Vps applied to output pin), there is a second type of digital output called a "Hotshot." This output is designed to work with inductive loads (i.e. a hydraulic valve) that can be hotshot with a high current for a short period of time to fully open the load. Then, the current is dropped back to a lower holding value to keep it open until the **DO Drive State** turns off as shown in Figure 9.

Objects 2220h **DO Hotshot Current**, 2221h **DO Hold Current**, and 2222h **DO Hotshot Time** are used with this output type to drive the load. Since the output timer is used for the hotshot time, DO Polarity option 3, Blinking Logic does not apply with this output type. The response in this case will be the same as option 1, Normal On/Off logic.



**Figure 9 – Hotshot Digital Profile**

As mentioned in the Controller Overview, any digital output can be setup to react to a fault detected on any of the **inputs** to the function block (control, enable or override.) Should any one of these inputs be showing an error condition, object 6250h **DO Fault Mode** determines how the output will respond, per Table 13. By default, the output will revert to the state defined in object 6260h **DO Fault State**.

| Value | Meaning                        |
|-------|--------------------------------|
| 0     | Maintain Last State            |
| 1     | <b>Apply Pre-Defined State</b> |

Table 13 – Object 6250h - DO Fault Mode Options

## 1.5. Analog Output Function Block

The analog output (AO) function block is the default logic associate with outputs 1 thru 10.

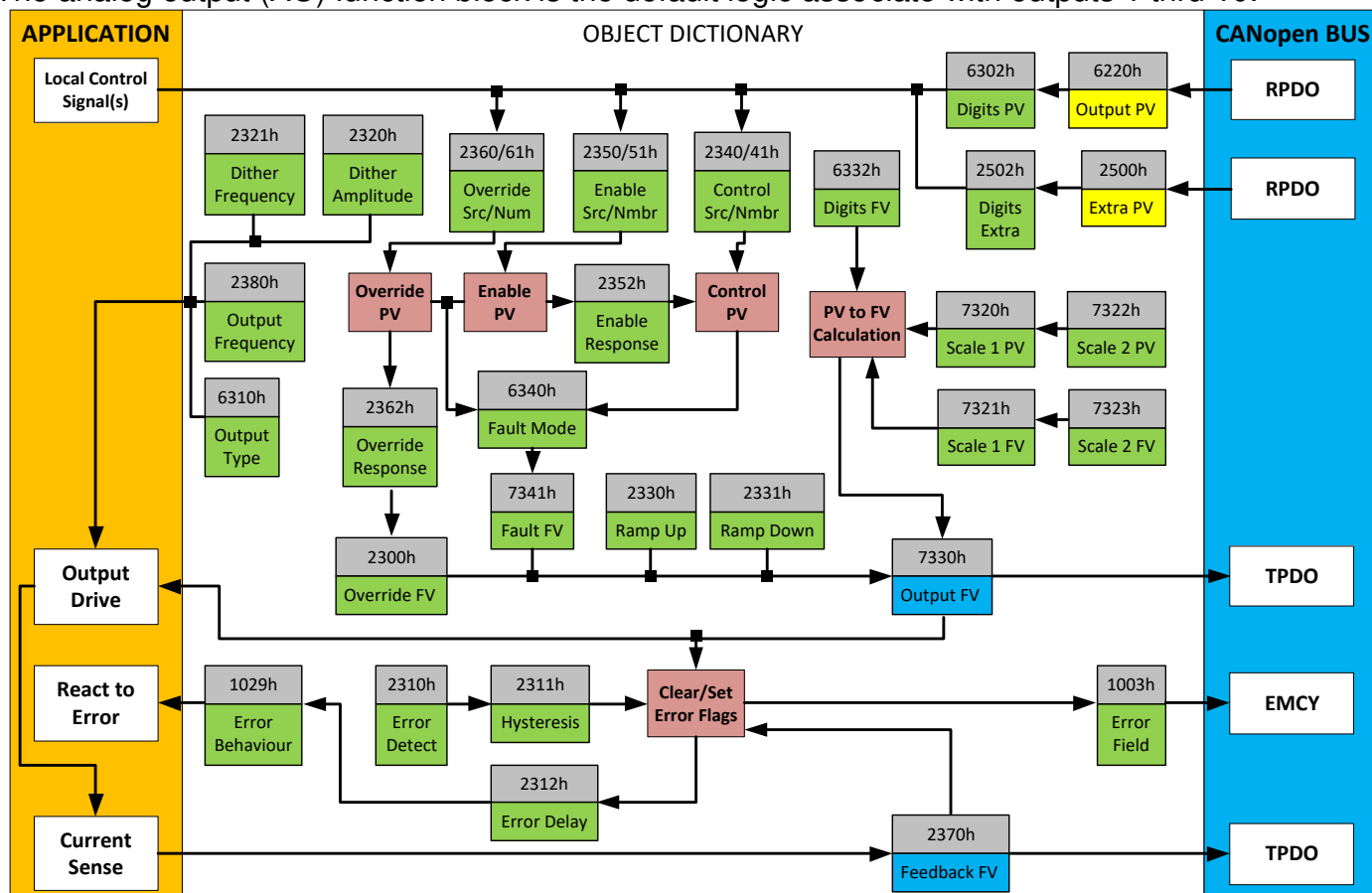


Figure 10 – Analog Output Objects

There are many objects associated with the analog output function block, but not all of them apply to all output types or control conditions. To start with, object 6310h **AO Output Type** defines how the output drive circuitry will be configured as per Table 14. This table also shows the output unit and range for each type. By default, analog outputs are configured as proportional current types.

| Value     | Meaning                | Range [Unit]          |
|-----------|------------------------|-----------------------|
| 0         | Output Disabled        | N/A                   |
| 10        | Output Voltage         | 0 to 48 [V]*          |
| <b>20</b> | <b>Output Current</b>  | <b>0 to 2000 [mA]</b> |
| 21        | Current (4-20mA)       | 0 to 20 [mA]          |
| 40        | Output PWM             | 0 to 100 [%]          |
| 1000      | Output Digital On/Off  | 0 (OFF) or 1 (ON)**   |
| 1020      | Output Digital Hotshot | 0 (OFF) or 1 (ON)     |

**Table 14 – Object 6310h - AO Output Type Options**

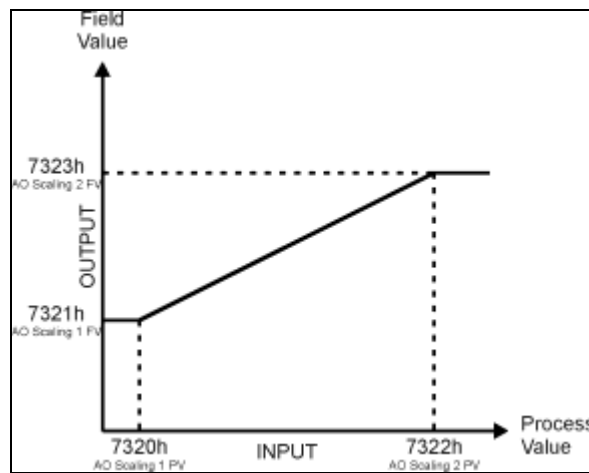
\*Note: This is the Output Type selected for **AOs**

\*\*Note: This is the Output Type selected for **RLYOs**

When the output type is changed, all objects related to the output (scaling PV, Decimal Digits PV, etc) are automatically updated by default. Object 5550h enables/disables automatic updates. When disabled (set to False), the objects are to be manually configured.

In regards to Proportional Valve output, the Current output controlled by a close-loop PID control, and these objects should not be changed without proper consideration. In Voltage mode, the output is actually a high frequency PWM signal that is being adjusted by the processor such that the average voltage would match the target FV, up to the supply voltage. *External filtering of the signal would have to be applied to get a true DC voltage.* In PWM mode, the FV represents the output duty cycle. The digital output types have been covered in Section 1.2

The relationship between the Process Value (input) and the Field Value (output) is a linear one, as shown in Figure 11. However, the output will actually use the AO Scaling FV objects as limits to the drive, such that the output will hold at the minimum and maximum FV points, as shown in the figure.



**Figure 11 – Analog Output Linear Scaling PV to FV**

The MF-I/O controller allows for the PV input can be selected from the list of the logical function blocks supported by the controller as shown in Figure 1B. As a result, any output from one function block can be selected as the control source for another. Keep in mind that not all options make sense in all cases, but the complete list of control sources is shown in Table 15. By default, analog outputs are setup to respond to the corresponding CANopen RPDO message.

| Value | Meaning                           |
|-------|-----------------------------------|
| 0     | Control Source Not Used (Ignored) |
| 1     | CANopen Message (RPDO)            |
| 2     | Analog Input Function Block       |
| 3     | Constant Function Block           |
| 4     | PID Control Function Block        |
| 5     | Lookup Table Function Block       |
| 6     | Mathematical Function Block       |
| 7     | Programmable Logic Function Block |
| 8     | Output Commanded Field Value      |
| 9     | Output Feedback Field Value       |
| 10    | Power Supply Measured             |
| 11    | Processor Temperature Measured    |

**Table 15 – Control Source Options**

In addition to a source, each control also has a number which corresponds to the sub-index of the function block in question. Table 16 outlines the ranges supported for the number objects, depending on the source that had been selected.

| Control Source                     | Range | Object (Meaning)                             |
|------------------------------------|-------|----------------------------------------------|
| <b>Control Source Not Used</b>     | 0     | Ignored                                      |
| <b>CANopen Message (RPDO)</b>      | 1     | 7300h sub-index 1 or 6200h sub-index 1 bit 0 |
|                                    | 2     | 7300h sub-index 2 or 6200h sub-index 1 bit 1 |
|                                    | 3     | 7300h sub-index 3 or 6200h sub-index 1 bit 2 |
|                                    | 4     | 7300h sub-index 4 or 6200h sub-index 1 bit 3 |
|                                    | 5     | 7300h sub-index 5 or 6200h sub-index 1 bit 4 |
|                                    | 6     | 7300h sub-index 6                            |
|                                    | 7     | 7300h sub-index 7                            |
|                                    | 8     | 7300h sub-index 8                            |
|                                    | 9     | 7300h sub-index 9                            |
|                                    | 10    | 2500h sub-index 1 (Extra Received PV 1)      |
|                                    | 11    | 2500h sub-index 2 (Extra Received PV 2)      |
|                                    | 12    | 2500h sub-index 3 (Extra Received PV 3)      |
|                                    | 13    | 2500h sub-index 4 (Extra Received PV 4)      |
|                                    | 14    | 2500h sub-index 5 (Extra Received PV 5 )     |
|                                    | 15    | 2500h sub-index 6 (Extra Received PV 6)      |
|                                    | 16    | 2500h sub-index 7 (Extra Received PV 7)      |
|                                    | 17    | 2500h sub-index 8 (Extra Received PV 8 )     |
|                                    | 18    | 2500h sub-index 9 (Extra Received PV 9)      |
|                                    | 19    | 2500h sub-index 10 (Extra Received PV 10)    |
|                                    | 20    | 2500h sub-index 11 (Extra Received PV 11)    |
|                                    | 21    | 2500h sub-index 12 (Extra Received PV 12)    |
|                                    | 22    | 2500h sub-index 13 (Extra Received PV 13)    |
|                                    | 23    | 2500h sub-index 14 (Extra Received PV 14)    |
|                                    | 24    | 2500h sub-index 15 (Extra Received PV 15)    |
| <b>Analog Input Function Block</b> | 1     | 7100h sub-index 1 or 6000h sub-index 1 bit 0 |
|                                    | 2     | 7100h sub-index 2 or 6000h sub-index 1 bit 1 |
|                                    | 3     | 7100h sub-index 3 or 6000h sub-index 1 bit 2 |
|                                    | 4     | 7100h sub-index 4 or 6000h sub-index 1 bit 3 |

|                                                                                                                                                                                               |    |                                               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|-----------------------------------------------|
|                                                                                                                                                                                               | 5  | 7100h sub-index 5 or 6000h sub-index 1 bit 4  |
|                                                                                                                                                                                               | 6  | 7100h sub-index 6 or 6000h sub-index 1 bit 5  |
|                                                                                                                                                                                               | 7  | 7100h sub-index 7 or 6000h sub-index 1 bit 6  |
|                                                                                                                                                                                               | 8  | 7100h sub-index 8 or 6000h sub-index 1 bit 7  |
|                                                                                                                                                                                               | 9  | 7100h sub-index 9 or 6000h sub-index 2 bit 0  |
|                                                                                                                                                                                               | 10 | 7100h sub-index 10 or 6000h sub-index 2 bit 1 |
|                                                                                                                                                                                               | 11 | 7100h sub-index 11                            |
| <b>Constant Function Block</b>                                                                                                                                                                | 1  | 5010h sub-index 1 (always FALSE)              |
|                                                                                                                                                                                               | 2  | 5010h sub-index 2 (always TRUE)               |
|                                                                                                                                                                                               | 3  | 5010h sub-index 3 (Constant FV 3)             |
|                                                                                                                                                                                               | 4  | 5010h sub-index 4 (Constant FV 4)             |
|                                                                                                                                                                                               | 5  | 5010h sub-index 5 (Constant FV 5)             |
|                                                                                                                                                                                               | 6  | 5010h sub-index 6 (Constant FV 6)             |
|                                                                                                                                                                                               | 7  | 5010h sub-index 7 (Constant FV 7)             |
|                                                                                                                                                                                               | 8  | 5010h sub-index 8 (Constant FV 8)             |
|                                                                                                                                                                                               | 9  | 5010h sub-index 9 (Constant FV 9)             |
|                                                                                                                                                                                               | 10 | 5010h sub-index 10 (Constant FV 10)           |
|                                                                                                                                                                                               | 11 | 5010h sub-index 11 (Constant FV 11)           |
|                                                                                                                                                                                               | 12 | 5010h sub-index 12 (Constant FV 12)           |
|                                                                                                                                                                                               | 13 | 5010h sub-index 13 (Constant FV 13)           |
|                                                                                                                                                                                               | 14 | 5010h sub-index 14 (Constant FV 14)           |
|                                                                                                                                                                                               | 15 | 5010h sub-index 15 (Constant FV 15)           |
| <b>PID Control Function Block</b>                                                                                                                                                             | 1  | 2460h sub-index 1 (PID Output FV 1)           |
|                                                                                                                                                                                               | 2  | 2460h sub-index 2 (PID Output FV 2)           |
| <b>Lookup Table Function Block</b>                                                                                                                                                            | 1  | 3017h (Lookup Table 1 Output Y-Axis PV)       |
|                                                                                                                                                                                               | 2  | 3027h (Lookup Table 2 Output Y-Axis PV)       |
|                                                                                                                                                                                               | 3  | 3037h (Lookup Table 3 Output Y-Axis PV)       |
|                                                                                                                                                                                               | 4  | 3047h (Lookup Table 4 Output Y-Axis PV)       |
|                                                                                                                                                                                               | 5  | 3057h (Lookup Table 5 Output Y-Axis PV)       |
|                                                                                                                                                                                               | 6  | 3067h (Lookup Table 6 Output Y-Axis PV)       |
|                                                                                                                                                                                               | 7  | 3077h (Lookup Table 7 Output Y-Axis PV)       |
|                                                                                                                                                                                               | 8  | 3087h (Lookup Table 8 Output Y-Axis PV)       |
|                                                                                                                                                                                               | 9  | 3097h (Lookup Table 9 Output Y-Axis PV)       |
| <b>Mathematical Function Block</b>                                                                                                                                                            | 1  | 4350h sub-index 1 (Math Output PV 1)          |
|                                                                                                                                                                                               | 2  | 4350h sub-index 2 (Math Output PV 2)          |
|                                                                                                                                                                                               | 3  | 4350h sub-index 3 (Math Output PV 3)          |
|                                                                                                                                                                                               | 4  | 4350h sub-index 4 (Math Output PV 4)          |
|                                                                                                                                                                                               | 5  | 4350h sub-index 5 (Math Output PV 5)          |
|                                                                                                                                                                                               | 6  | 4350h sub-index 6 (Math Output PV 6)          |
| <b>Programmable Logic Function Block</b>                                                                                                                                                      | 1  | 3xy7h (Lookup Table Selected by Logic 1)      |
|                                                                                                                                                                                               | 2  | 3xy7h (Lookup Table Selected by Logic 2)      |
|                                                                                                                                                                                               | 3  | 3xy7h (Lookup Table Selected by Logic 3)      |
| <b>NOTE:</b> The following options should be considered for diagnostic feedback, and should not be selected as a control source for logic inputs (i.e. output control or lookup table X-Axis) |    |                                               |
| <b>Output Commanded Field Value</b>                                                                                                                                                           | 1  | 7330h sub-index 1 or 6000h sub-index 1 bit 0  |
|                                                                                                                                                                                               | 2  | 7330h sub-index 2 or 6000h sub-index 1 bit 1  |
|                                                                                                                                                                                               | 3  | 7330h sub-index 3 or 6000h sub-index 1 bit 2  |
|                                                                                                                                                                                               | 4  | 7330h sub-index 4 or 6000h sub-index 1 bit 3  |

|                                       |     |                                              |
|---------------------------------------|-----|----------------------------------------------|
|                                       | 5   | 7330h sub-index 5 or 6000h sub-index 1 bit 4 |
|                                       | 6   | 7330h sub-index 6                            |
|                                       | 7   | 7330h sub-index 7                            |
|                                       | 8   | 7330h sub-index 8                            |
|                                       | 9   | 7330h sub-index 9                            |
| <b>Output Feedback Field Value</b>    | 1   | 2370h sub-index 1 (PO1 FB)                   |
| <b>Processor Temperature Measured</b> | N/A | 5040h (Power Supply FV) sub-index 1          |
| <b>Power Supply Measured</b>          | N/A | 5040h (Temperature FV) sub-index 2           |

**Table 16 – Control Number Options Depending on Source Selected**

There are three inputs to the output function block, each one with a unique source and number object. For the control function (PV axis in Figure 11), objects 2340h **AO Control Input Source** and 2341h **AO Control Input Number** are used. For the enable function, objects 2350h **AO Enable Input Source** and 2351h **AO Enable Input Number** are used. Lastly, for the override function, objects 2360h **AO Override Input Source** and 2361h **AO Override Input Number** are used.

When using any control source as the X-Axis input to a function block, the corresponding scaling limits are defined as per Table 17. It is the responsibility of the user to make sure that the scaling objects for any function block are setup appropriately depending on the source selected for the X-Axis input.

Note that for the Outputs, the actual objects for the scaling (6302h, 7320h, 7322h) should be edited to match the objects defined in this table when the control source is changed.

| <b>Control Source</b>                                  | <b>Scaling 1</b>                         | <b>Scaling 2</b>                             | <b>Dec Digits</b> |
|--------------------------------------------------------|------------------------------------------|----------------------------------------------|-------------------|
| CANopen Message – Num 1 to 10                          | 7230h                                    | 7322h                                        | 6302h             |
| CANopen Message – Num 11 to 25                         | 2520h                                    | 2522h                                        | 2502h             |
| Constant Function Block                                | N/A                                      | N/A                                          | N/A (float)       |
| PID Control Function Block                             | 0%                                       | 100%                                         | 1 (fixed)         |
| Lookup Table yz Function Block<br>(where yz = 01 to 9) | 0 or lowest<br>from 3yz6h <sup>(*)</sup> | 100 or highest<br>from 3yz6h <sup>(**)</sup> | 3yz3h             |
| Mathematical Function                                  | 4021h                                    | 4023h                                        | 4032h             |
| Programmable Logic Function                            | 0%                                       | 100%                                         | 1 (fixed)         |
| Output Commanded Field Value                           | 7230h                                    | 7322h                                        | 6302h             |
| Output Feedback Field Value                            | 7230h                                    | 7322h                                        | 6302h             |
| Power Supply Measured                                  | N/A                                      | N/A                                          | 1 (fixed)         |
| Processor Temperature Measured                         | N/A                                      | N/A                                          | 1 (fixed)         |

(\*) - Whichever value is smaller; (\*\*) - Whichever value is larger

**Table 17 – Scaling Limits per Control Source**

As shown in Figure 11, the Output FV will be calculated based on the FV scaling selected. Since 7321h represents the value at or below the lowest control input received, it represents the minimum field value that will be applied at the output. Similarly, 7323h represents the maximum FV that will be applied.

While (7320h < 7322h) must always hold true, in order to get an inverse response (i.e. output decreases as the input increased), simply set 7321h higher than 7323h.

In general, the profile shown in Figure 11 holds true. However, in some cases it may be desired that the minimum offset not be applied when the value is outside of the range, i.e. when using a joystick profile with a deadband. For this reason, object 2342h **AO Control Response** has the options shown in Table 18.

| Value | Meaning                              |
|-------|--------------------------------------|
| 0     | Single Output Profile (Figure 11)    |
| 1     | <b>Output OFF below Scaling 1 PV</b> |
| 2     | Output OFF above Scaling 2 PV        |

**Table 18 – Object 2342 - AO Control Response Options**

Enable and Override inputs have been mentioned several times already. By default, neither inputs are used (control sources are set to 0=Ignore), but they can be activated for safety interlocks or other more complex applications. Table 19 shows the options for object 2352h **AO Enable Response**.

| Value | Meaning                               |
|-------|---------------------------------------|
| 0     | Enable When ON, Else Shut OFF         |
| 1     | Enable When ON, Else Ramp OFF         |
| 2     | Enable When ON, Else Keep Last Value  |
| 3     | <b>Enable When OFF, Else Shut OFF</b> |
| 4     | Enable When OFF, Else Ramp OFF        |
| 5     | Enable When OFF, Else Keep Last Value |

**Table 19 – Object 2352h - AO Enable Response Options**

Table 20 shows options for object 2362h **AO Override Response** respectively. In both cases, the default responses are bolded. When the override is applied, the output is driven to the value defined in object 2300h, **AO Override FV**.

| Value | Meaning                 |
|-------|-------------------------|
| 0     | <b>Override When ON</b> |
| 1     | Override When OFF       |

**Table 20 – Object 2362h - AO Override Response Options**

When an input to the output block goes into an error condition, object 6340 **AO Fault Mode** determines how the output will respond, per Table 21. By default, the output will be driven to the value defined in object 7341h **AO Fault FV**.

| Value | Meaning                     |
|-------|-----------------------------|
| 0     | Maintain Last State         |
| 1     | <b>Apply Pre-Defined FV</b> |

**Table 21 – Object 6340 - AO Fault Mode Options**

The controller applies the logic shown in Figure 6 when evaluating what output FV to apply. Under normal conditions, i.e. when the control input is driving the output as shown in the green box, there are ramping objects that can be applied to soften the output response. Object 2330h **AO Ramp Up** and object 2331 **AO Ramp Down** are both millisecond numbers that define how long it will take to ramp from AO Scaling 1 FV to AO Scaling 2 FV.

There are three 'Timer Banks' in the MF-I/O that drive all ten outputs. bank 1 is shared between outputs 1-4, bank 2 is shared between outputs 5-8, and bank 3 is shared between outputs 9-10.

Object 2380h **AO Output Frequency** allows for adjusting the frequency of the outputs. However, since the outputs do not have an independent timer driving each output, if any output in its respective bank is set to Current and/or Hotshot Current types - the output frequency is defaulted to 25kHz and cannot be adjusted. **AO Output Frequency** can be adjusted as long as none of the outputs are set to Current and/or Hotshot Current types in their respective bank.

Object 2320h **AO Dither Frequency** and object 2321h **AO Dither Amplitude** are only applicable with current output types. The dither is a low frequency signal that is superimposed on-top of the high frequency output. While the dither frequency will match exactly what is in object 2320h, the exact amplitude of the dither will depend on the properties of the coil. When adjusting 2321h, select a value that is high enough to ensure an immediate response to the coil to small changes in the control inputs, but not so large as to effect the accuracy or stability of the output. ***If 2321h is set to zero, dithering is disabled.*** The dither frequency, as for the output frequency, is shared between the outputs in each bank. The dither amplitude, however, is independent of one another.

There are three other objects associated with the close-loop PID control of the current through an inductive load. These objects have been factory calibrated, and ***should not be changed.*** However, the user does have access to these objects in the unlikely case that they should be adjusted. These objects are 2382h, **AO Current PID Proportional Gain**, 2383h **AO Current PID Integral Time**, and 2384h **AO Current PID Derivative Time**. *These objects must not be confused with PID objects in the PID function block which operates independently of the close-loop current control.*

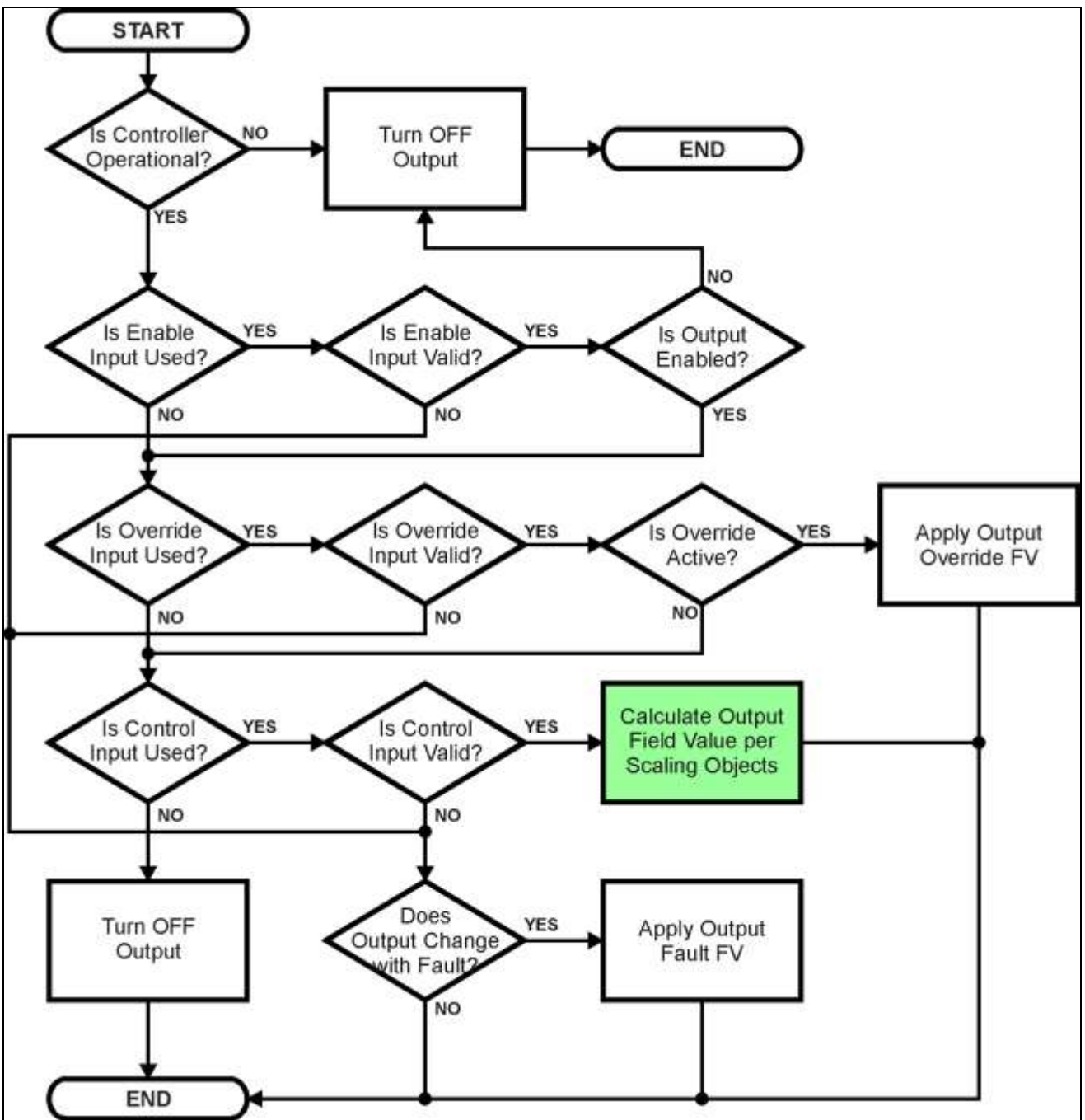


Figure 12 – Analog Output Logic Flowchart

In addition to the read-only mappable object 7330h **AO Output Field Value** (as represented by the green box above), there is another object 2370h **AO Feedback FV**, also read-only mappable. This object reflects the actual measured value at the output. It is also used to detect and flag an error if there is an open or short circuit at the output.

If object 2310h **AO Error Detect Enable** is set to TRUE, then the absolute value between the desired output FV (7330h) and the measured feedback (2370h) is compared to 2311h **AO Error Clear Hysteresis**. If the difference between the target and the actual exceeds the hysteresis value, then a fault is present. Since both open and short circuits read close to zero feedback, a signal is also sent to the processor whenever a short (to either GND or +Vcc) has occurred. The controller will then flag an “Open Circuit” fault. If the flag stays active for the 2312h **AO Error Reaction Delay** time, then an appropriate EMCY message will be added to object 1003h **Pre-Defined Error Field**. The application will react to the EMCY message as defined by object 1029h

**Error Behaviour** at the sub-index corresponding to an Input Fault. Refer to section 2.2.4 and 3.2.13 for more information about objects 1003h and 1029h, including the complete list of EMCY messages.

Once the absolute difference between the target and feedback FV comes back with the tolerance defined in 2311h, the error flag is cleared. This means that when the output is commanded off, the flags are automatically reset, since the target and feedback are now both zero.

## 1.6. PID Control Function Block

The PID control (PID) function blocks are not used by default.

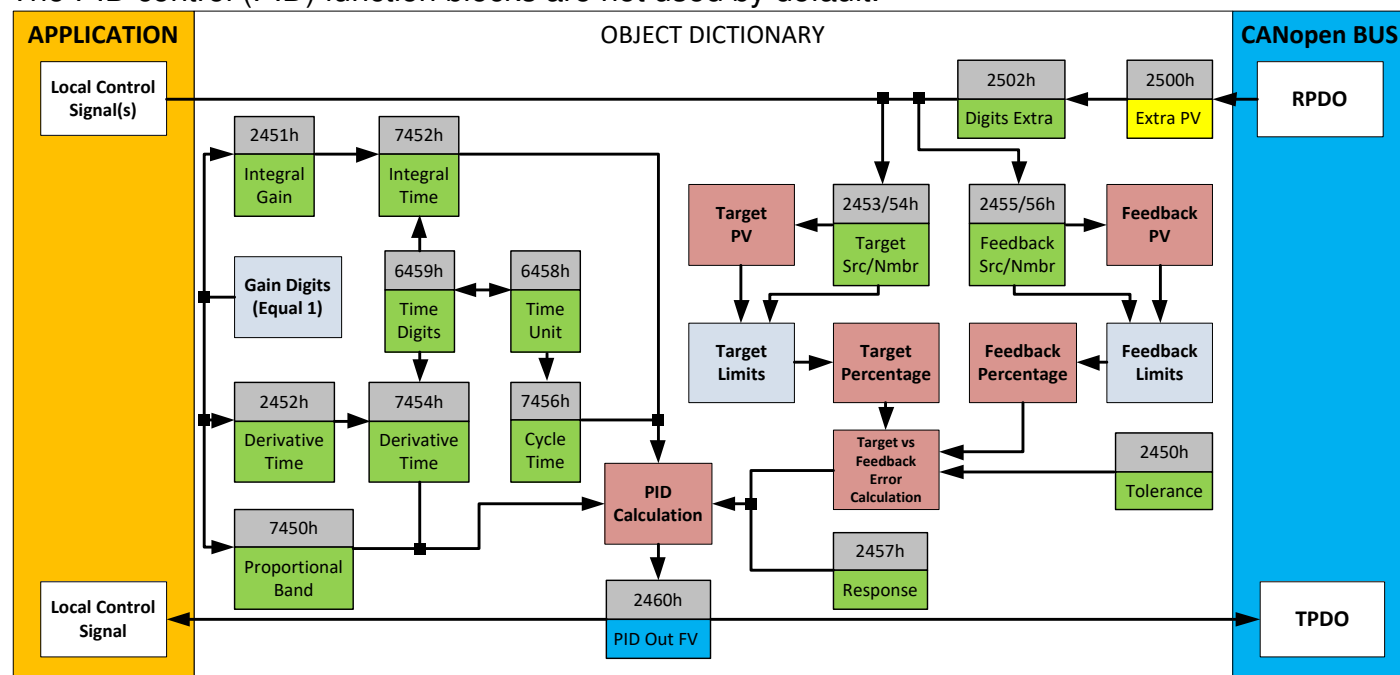


Figure 13 – PID Control Objects

As with the output function block, the PID control function has control inputs associate with it that can be mapped to the output from any other function block. Objects 2453h **PID Target Source** and 2454h **PID Target Number** define what value the PID loop will attempt to maintain. For example, in the case of a setpoint (fixed) control application, this input can be mapped to one of object 5010h, a Constant FV. In this case, since there is no pre-defined range associated with a constant (see Table 17), the scaling limits will be set equal to those of the feedback input. Otherwise, the target input units do not have to match the feedback units, so long as they are scaled relative to one another.

Objects 2355h **PID Feedback Source** and 2356h **PID Feedback Number** define the close-loop input. Both the target and feedback use Tables 15 and 16 as the available options. Both inputs are normalized to a percentage based on the associated scaling limits as defined in Table 17.

Object 2450h **PID Tolerance** defines the acceptable difference between the target and feedback, as a percentage, whereby an absolute difference smaller than this is treated as a 0% error.

Unless both the target and feedback inputs have legitimate control sources selected, the PID loop is disabled. When active, however, the PID algorithm will be called every 7456h **PID Cycle Time**, the default being every 10ms.

Object 6458h **PID Physical Unit Timing** is a read-only value and is defined in Seconds. The default value for object 6459h **PID Decimal Digits Timing** is 3, which means the object 7456h, along with other PID timing objects, are interpreted in milliseconds. Other time objects associated with the PID control are 7452h **PID Integral Action Time (Ti)** and 7454h **PID Derivative Action Time (Td)**.

None time related objects use a fixed resolution of 1 decimal digit. These objects include 7450h **PID Proportional Band (G)**, 2450h **PID Tolerance**, 2451h **PID Integral Gain (Ki)**, and 2454h **PID Derivative Gain (Kd)**.

By default, the PID loop is assumed to be controlling a single output which will increase/decrease as the feedback over/undershoots the target. However, some systems may require a push-pull response where one output comes on when over target, and the other when under. Object 2457h **PID Control Response** allows the user to select the response profile as needed from Table 22.

| Value | Meaning              |
|-------|----------------------|
| 0     | Single Output        |
| 1     | On When Over Target  |
| 2     | On When Below Target |

**Table 22 – PID Control Response Options**

The PID algorithm used is shown below, with names in red being the object variables. The result PIDOutput<sub>k</sub> is written to the read-only mappable object 2460h **PID Output Field Value**, and is interpreted as a percentage value with 1 decimal place resolution. It can be used as the control source for another function block, i.e. one of the analog outputs.

```

T = Loop_Update_Rate*0.001

P_Gain = G
I_Gain = G*Ki*T/Ti
D_Gain = G*Kd*Td/T
Note: If Ti is zero, I_Gain = 0

Errork      = Target - Feedback
ErrorSumk = ErrorSumk-1 + Errork

Pk = Errork * P_Gain

Ik = ErrorSumk * I_Gain

Dk = (Errork-Errork-1) * D_Gain

PIDOutputk = Pk + Ik + Dk

```

**Figure 14 – PID Control Algorithm**

Each system will have to be tuned for the optimum output response. Response times, overshoots and other variables will have to be decided by the customer using an appropriate PID tuning strategy.

## 1.7. Lookup Table Function Block

The lookup table (LTz) function blocks are not used by default.

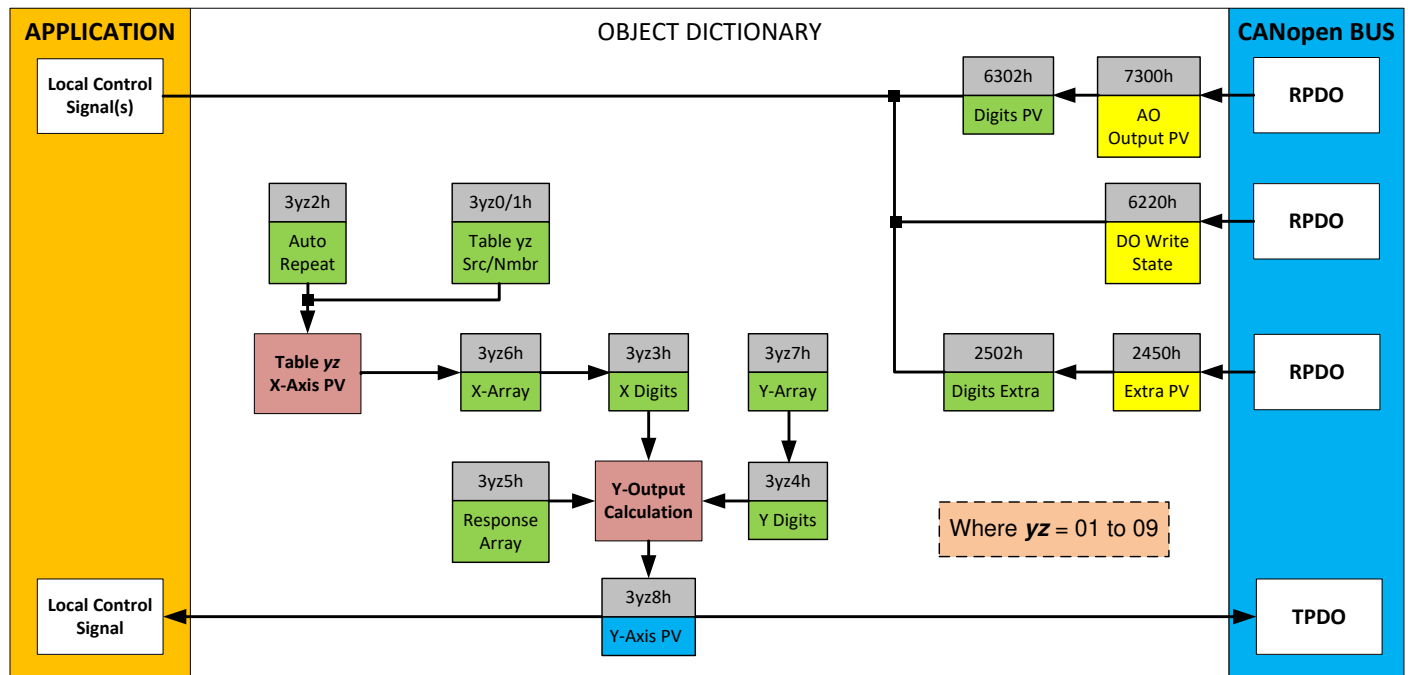


Figure 15 – Lookup Table Objects

**Lookup tables are used to give an output response of up to 10 slopes per input.** The array size of the objects 3yz5h **LTyz Point Response**, 3yz6h **LTyz Point X-Axis PV** and 3yz7h **Point Y-Axis PV** shown in the block diagram above is therefore 11.

Note: If more than 10 slopes are required, a Programmable Logic Block can be used to combine up to three tables to get 30 slopes, as is described in Section 1.8.

A parameter that will affect the function block is object **3yz5h sub-index 1** which defines the “**X-Axis Type**”. By default, the tables have a ‘*Data Response*’ output (0). Alternatively, it can be selected as a ‘*Time Response*’ (1). ,

There are two (or three) other key parameters that will affect how this function block will behave depending on the “**X-Axis Type**” chosen. If chosen ‘*Data Response*’, then the objects 3yz0h **Lookup Table yz Input X-Axis Source** and 3yz1h **Lookup Table yz Input X-Axis Number** together define the control source for the function block. When it is changed, the table values in object 3yz6h need to be updated with new defaults based on the X-Axis source selected as described in Tables 15 and 16. If however, the “**X-Axis Type**” is chosen to be ‘*Time Response*’, an additional parameter is taken into consideration - object 3yz2h, **Lookup Table yz Auto Repeat**. These will be described in more detail in Section 1.7.4.

### 1.7.1. X-Axis, Input Data Response

In the case where the “**X-Axis Type**” = ‘*Data Response*’, the points on the X-Axis represents the data of the control source.

However, should the minimum input be less than zero, for example a resistive input that is reflecting temperature in the range of -40°C to 210°C, then the “**LTz Point X-Axis PV sub-index 1**” will be set to the minimum instead, in this case -40°C.

The constraint on the X-Axis data is that the next index value is greater than or equal to the one below it, as shown in the equation below. Therefore, when adjusting the X-Axis data, it is recommended that  $X_{11}$  is changed first, then lower indexes in descending order.

$$\text{MinInputRange} \leq X_1 \leq X_2 \leq X_3 \leq X_4 \leq X_5 \leq X_6 \leq X_7 \leq X_8 \leq X_9 \leq X_{10} \leq X_{11} \leq \text{MaxInputRange}$$

As stated earlier, MinInputRange and MaxInputRange will be determined by the scaling objects associated with X-Axis Source that has been selected, as outlined in Table 17.

### 1.7.2. Y-Axis, Lookup Table Output

**By default, it is assumed that the output from the lookup table function block will be a percentage value in the range of 0 to 100.**

In fact, so long as all the data in the Y-Axis is  $0 \leq Y[i] \leq 100$  (where  $i = 1$  to 11) then other function blocks using the lookup table as a control source will have 0 and 100 as the Scaling 1 and Scaling 2 values used in linear calculations shown in Table 17.

However, the Y-Axis has no constraints on the data that it represents. This means that inverse, or increasing/decreasing or other responses can be easily established. **The Y-Axis does not have to be a percentage output, but could represent full scale process values instead.**

In all cases, the controller looks at the **entire range** of the data in the Y-Axis sub-indexes, and selects the lowest value as the MinOutRange and the highest value as the MaxOutRange. So long as they are not both within the 0 to 100 range, they are passed directly to other function blocks as the limits on the lookup table output. (i.e. Scaling 1 and Scaling 2 values in linear calculations.)

Even if some of the data points are ‘*Ignored*’ as described in Section 1.7.3, they are still used in the Y-Axis range determination. If not all the data points are going to be used, it is recommended that Y10 be set to the minimum end of the range, and Y11 to the maximum first. This way, the user can get predictable results when using the table to drive another function block, such as an analog output.

### 1.7.3. Point To Point Response

By default, all six lookup tables have a simple linear response from 0 to 100 in steps of 10 for both the X and Y axes. For a smooth linear response, each point in the 30z5h **LTz Point Response** array is setup for a ‘*Ramp To*’ output.

Alternatively, the user could select a ‘*Step To*’ response for 30z4h, where  $N = 2$  to 11. In this case, any input value between  $X_{N-1}$  to  $X_N$  will result in an output from the lookup table function block of  $Y_N$ . (Recall: *LTz Point Response sub-index 1 defines the X-Axis type*)

Figure 16 shows the difference between these two response profiles with the default settings.

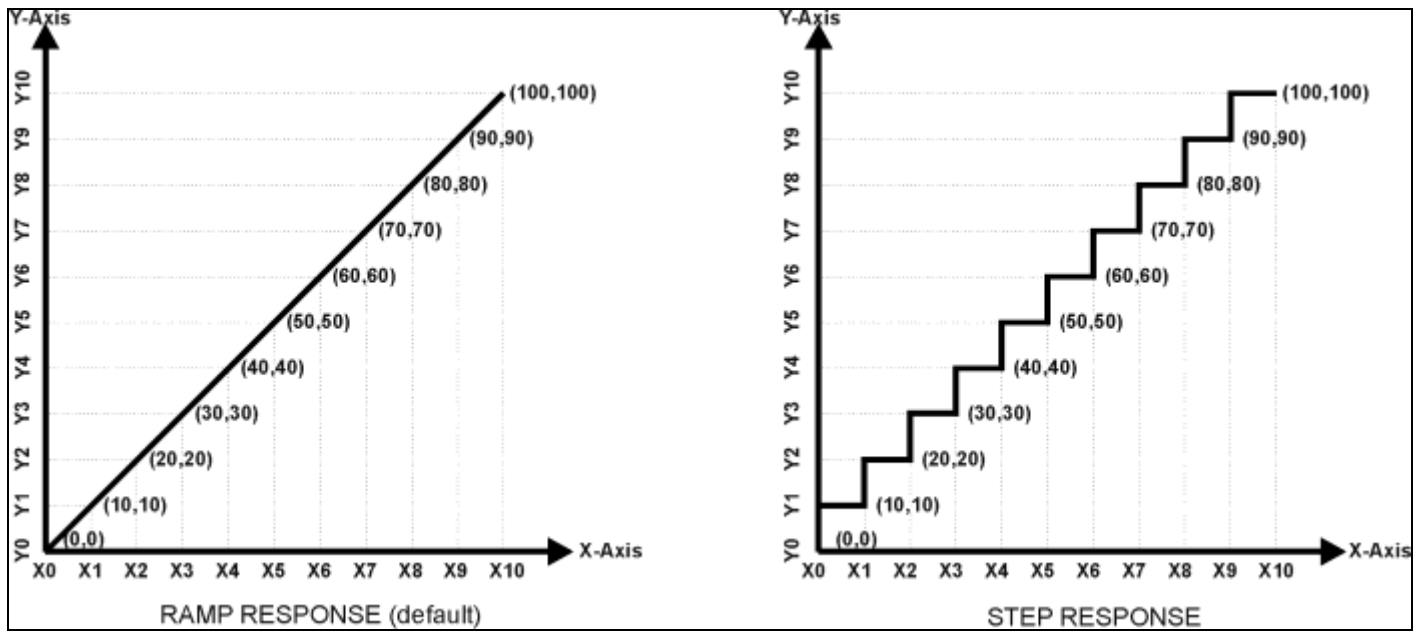


Figure 16 – Lookup Table Defaults with Ramp and Step Responses

Lastly, any point except (1,1) can be selected for an 'Ignore' response. If **LTz Point Response sub-index N** is set to ignore, then all points from (X<sub>N</sub>, Y<sub>N</sub>) to (X<sub>11</sub>, Y<sub>11</sub>) will also be ignored. For all data greater than X<sub>N-1</sub>, the output from the lookup table function block will be Y<sub>N-1</sub>.

A combination of 'Ramp To', 'Jump To' and 'Ignore' responses can be used to create an application specific output profile. An example of where the same input is used as the X-Axis for two tables, but where the output profiles 'mirror' each other for a deadband joystick response is shown in Figure 17. The example shows a dual slope percentage output response for each side of the deadband, but additional slopes can be easily added as needed. *(Note: In this case, since the analog outputs are responding directly to the profile from the lookup tables, both would have object 2342h AO Control Response set to a 'Single Output Profile.')*

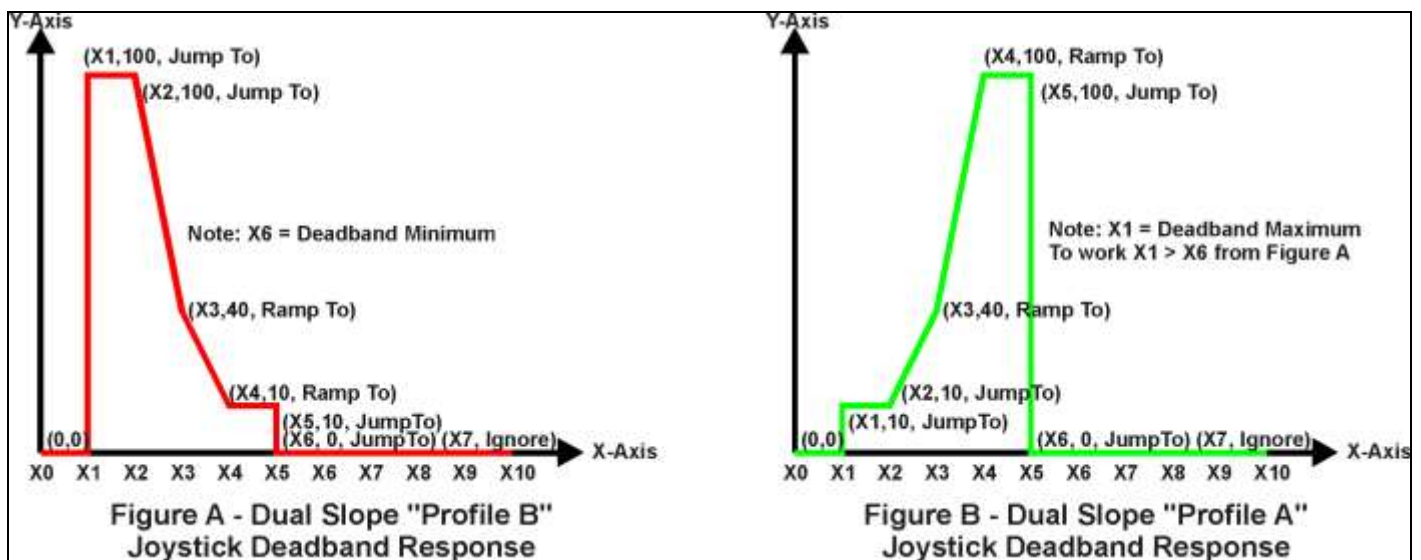


Figure 17 – Lookup Table Examples to Setup for Dual-Slope Joystick Deadband Response

To summarize, Table 23 outlines the different responses that can be selected for object 30z4h, both for the X-Axis type and for each point in the table.

| Sub-Index | Value | Meaning                                  |
|-----------|-------|------------------------------------------|
| 1         | 0     | Data Response (X-Axis Type)              |
| 2 to 11   |       | Ignore (this point and all following it) |
| 1         | 1     | Time Response (X-Axis Type)              |
| 2 to 11   |       | Ramp To (this point)                     |
| 1         | 2     | N/A (not an allowed option)              |
| 2 to 11   |       | Jump To (this point)                     |

**Table 23 – LTyz Point Response Options**

#### 1.7.4. X-Axis, Time Response

As mentioned in Section 1.5, a lookup table can also be used to get a custom output response where the “**X-Axis Type**” is a ‘*Time Response*’. When this is selected, the X-Axis now represents time, in units of milliseconds, while the Y-Axis still represents the output of the function block.

With this response, the sequence will start depending on two parameters:

- **Lookup Table yz Input X-Axis Source** Object 3yz0h and;
- **Lookup Table yz Auto Repeat** Object 3yz2h

By default, the “Auto Repeat” object is set to FALSE (0). In this case, the lookup table will react in the following way:

The X-Axis control source is treated as a digital input. When the control input is ON, the output will be changed over a period of time based on the profile in the lookup table. Once the profile has finished (i.e. reached index 11, or an ‘Ignored’ response), the output will remain at the last output at the end of the profile until the control input turns OFF.

**However**, when the “Auto Repeat” object is set to TRUE (1), the lookup table will react in the following way:

When the control input is ON, the output will be changed over a period of time based on the profile in the lookup table. Once the profile has finished (i.e. reached index 11, or an ‘Ignored’ response), the lookup table will revert back to the first point in the table and Auto Repeat the sequence. This will continue for as long as the input remains ON. Once the input turns OFF, the lookup table sequence will stop and the output of the lookup table is zero.

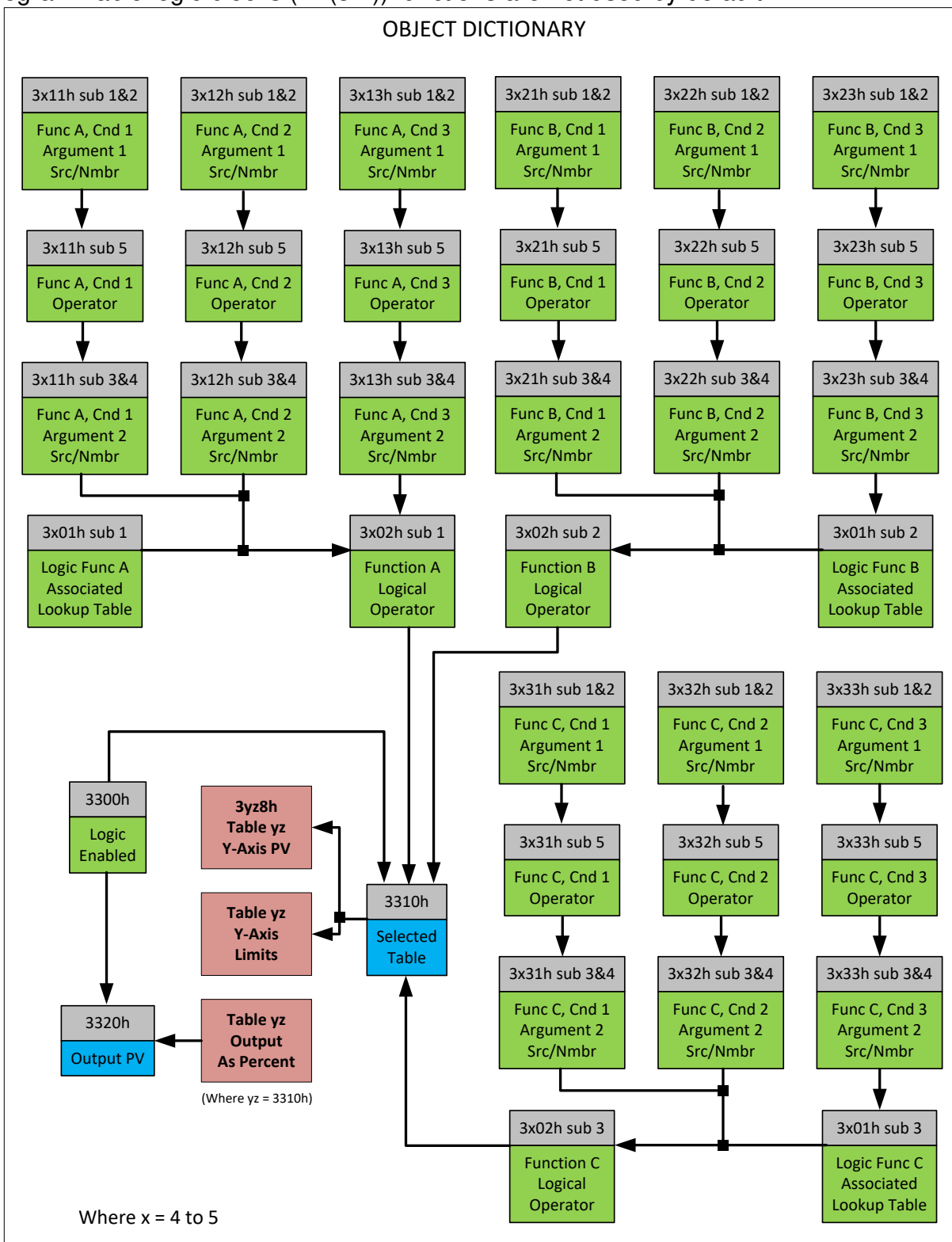
**Note:** When the control input is OFF, the output is always at zero. When the input comes ON, the profile will **ALWAYS** start at position (X<sub>1</sub>, Y<sub>1</sub>) which is 0 output for 0ms.

When using the lookup table to drive an output based on **time**, it is mandatory that objects 2330h **Ramp Up** and 2331h **Ramp Down** in the analog output function block be set to **zero**. Otherwise, the output result will not match the profile as expected. Recall, also, that the AO scaling should be set to match the Y-Axis scaling of the table in order to get a 1:1 response of AO Output FV versus LTyz Output Y-Axis PV.

In a time response, the data in object 30z6h **LTyz Point X-Axis PV** is measured in milliseconds, and object 3yz3h **LTyz X-Axis Decimal Digits PV** is automatically set to 0. A minimum value of 1ms must be selected for all points other than sub-index 1 which is automatically set to [0,0]. The interval time between each point on the X-axis can be set anywhere from 1ms to 24 hours. [86,400,000 ms]

## 1.8. Programmable Logic Function Block

The programmable logic blocks (LB(3-x)) functions are not used by default.



**Figure 18 – Logic Block Objects**

This function block is obviously the most complicated of them all, but very powerful. Any LB<sub>x</sub> (where X= 4 to 7) can be linked with up to three lookup tables, any one of which would be selected only under given conditions. Any three tables (of the available 12) can be associated with the logic, and which ones are used is fully configurable on object 3x01 **LB(3-x) Lookup Table Number**.

Should the conditions be such that a particular table (A, B or C) has been selected as described in Section 1.8.2, then the output from the selected table, at any given time, will be passed directly to LB(3-x)'s corresponding sub-index X in read-only mappable object 3320h **Logic Block Output PV**. The active table number can read from read-only object 3310h **Logic Block Selected Table**.

**Note:** In this document, the term *LB(3-x)* refers to Logic Blocks 1 to 4. Due to the CANopen Object indices, Logic Block 1 begins at 3401h where x, in this case, is 4.

Therefore, an LBx allows up to three different responses to the same input, or three different responses to different inputs, to become the control for another function block, such as an analog output. Here, the “**Control Source**” for the reactive block would be selected to be the ‘*Programmable Logic Function Block*,’ as described in Section 1.5.

In order to enable any one of logic blocks, the corresponding sub-index in object 3300h **Logic Block Enable** must be set to TRUE. They are all disabled by default.

Logic is evaluated in the order shown in Figure 19. Only if a lower indexed table (A, B, C) has not been selected will the conditions for the next table be looked at. **The default table is always selected as soon as it is evaluated. It is therefore required that the default table always be the highest index in any configuration.**

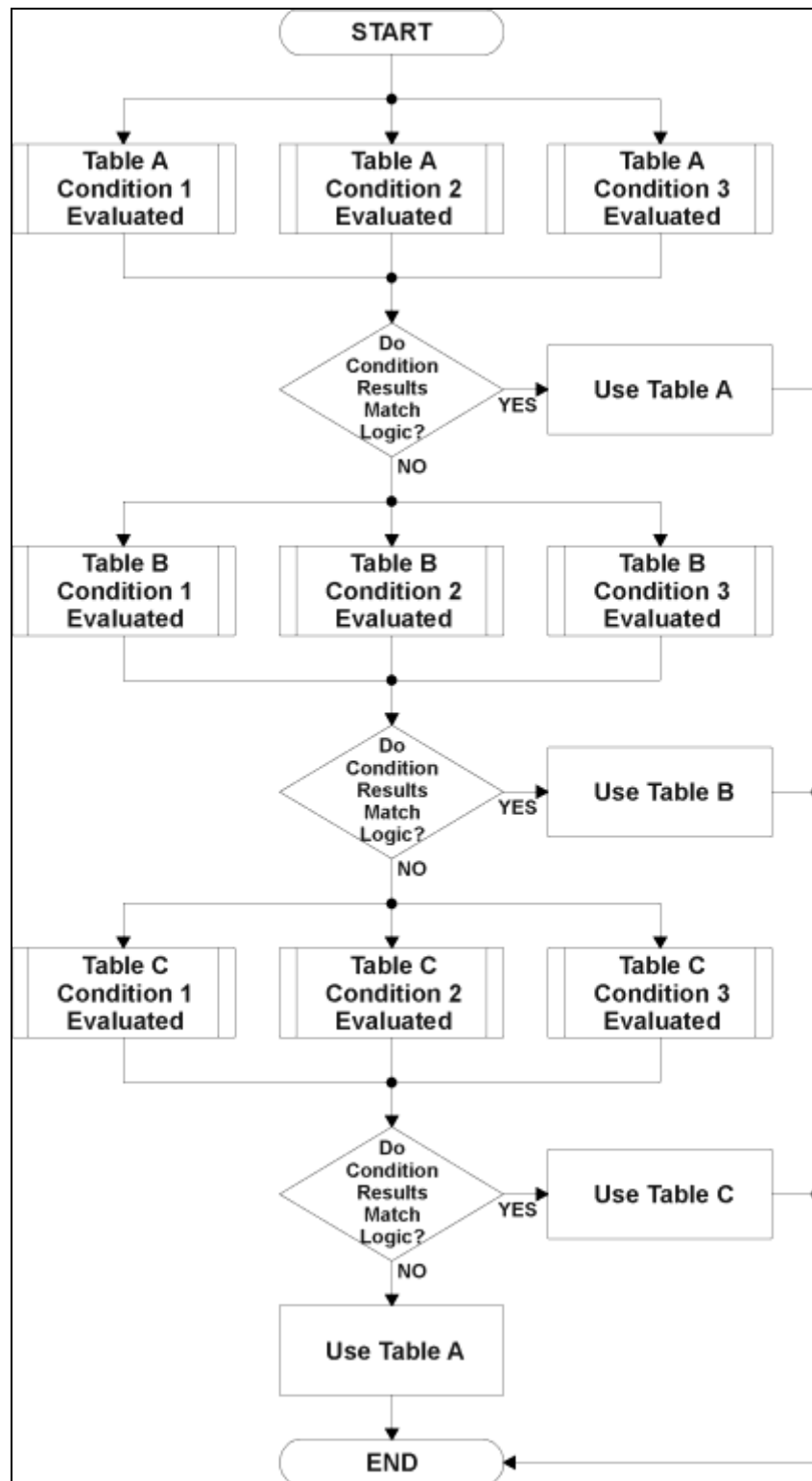


Figure 19 – Logic Block Flowchart

### 1.8.1. Conditions Evaluation

The first step in determining which table will be selected as the active table is to first evaluate the conditions associated with a given table. Each table has associated with it up to three conditions that can be evaluated. Conditional objects are custom DEFSTRUCT objects defined as shown in Table 24.

| Index | Sub-Index | Name                        | Data Type |
|-------|-----------|-----------------------------|-----------|
| 3xyz* | 0         | Highest sub-index supported | UNSIGNED8 |
|       | 1         | Argument 1 Source           | UNSIGNED8 |
|       | 2         | Argument 1 Number           | UNSIGNED8 |
|       | 3         | Argument 2 Source           | UNSIGNED8 |
|       | 4         | Argument 2 Number           | UNSIGNED8 |
|       | 5         | Operator                    | UNSIGNED8 |

\* Logic Block X Function Y Condition Z, where X = 4 to 7, Y = A, B or C, and Z = 1 to 3

**Table 24 – LB(3-x) Condition Structure Definition**

Objects 3x11h, 3x12h and 3x13h are the conditions evaluated for selecting Table A.  
Objects 3x21h, 3x22h and 3x23h are the conditions evaluated for selecting Table B.  
Objects 3x31h, 3x32h and 3x33h are the conditions evaluated for selecting Table C.

Argument 1 is always a logical output from another function block, as listed in Table 26. As always, the input is a combination of the functional block objects 3xyzh sub-index 1 **“Argument 1 Source”** and **“Argument 1 Number.”**

Argument 2 on the other hand, could either be another logical output such as with Argument 1, OR a constant value set by the user. To use a constant as the second argument in the operation, set **“Argument 2 Source”** to *‘Constant Function Block’*, and **“Argument 2 Number”** to the desired sub-index. When defining the constant, make sure it uses the same resolution (decimal digits) as the Argument 1 input.

Argument 1 is evaluated against Argument 2 based on the **“Operator”** selected in sub-index 5 of the condition object. The options for the operator are listed in Table 25, and the default value is always *‘Equal’* for all condition objects.

| Value | Meaning                   |
|-------|---------------------------|
| 0     | =, Equal                  |
| 1     | !=, Not Equal             |
| 2     | >, Greater Than           |
| 3     | >=, Greater Than or Equal |
| 4     | <, Less Than              |
| 5     | <=, Less Than or Equal    |

**Table 25 – LB(3-x) Condition Operator Options**

By default, both arguments are set to *‘Control Source Not Used’* which disables the condition, and automatically results in a value of N/A as the result. Although is generally considered that each condition will be evaluated as either TRUE or FALSE, the reality is that there could be four possible results, as described in Table 26.

| Value | Meaning        | Reason                                                                   |
|-------|----------------|--------------------------------------------------------------------------|
| 0     | False          | (Argument 1) Operator (Argument 2) = False                               |
| 1     | True           | (Argument 1) Operator (Argument 2) = True                                |
| 2     | Error          | Argument 1 or 2 output was reported as being in an error state           |
| 3     | Not Applicable | Argument 1 or 2 is not available (i.e. set to 'Control Source Not Used') |

**Table 26 – LB(3-x) Condition Evaluation Results**

### 1.8.2. Table Selection

In order to determine if a particular table will be selected, logical operations are performed on the results of the conditions as determined by the logic in Section 1.8.1. There are several logical combinations that can be selected, as listed in Table 27. The default value for object 3x02h **LB(3-x) Function Logical Operator** is dependent on the sub-index. For sub-index 1 (Table A) and 2 (Table B), the 'Cnd1 And Cnd2 And Cnd3' operator is used, whereas sub-index 3 (Table C) is setup as the 'Default Table' response.

| Value | Meaning                 |
|-------|-------------------------|
| 0     | Default Table           |
| 1     | Cnd1 And Cnd2 And Cnd3  |
| 2     | Cnd1 Or Cnd2 Or Cnd3    |
| 3     | (Cnd1 And Cnd2) Or Cnd3 |
| 4     | (Cnd1 Or Cnd2) And Cnd3 |

**Table 27 – LB(3-x) Function Logical Operator Options**

Not every evaluation is going to need all three conditions. The case given in the earlier section, for example, only has one condition listed, i.e. that the Engine RPM be below a certain value. Therefore, it is important to understand how the logical operators would evaluate an Error or N/A result for a condition, as outlined in Table 28.

| Logical Operator       | Select Conditions Criteria                                                                                                                                                                                                                                                                                                                                                               |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Default Table          | Associated table is automatically selected as soon as it is evaluated.                                                                                                                                                                                                                                                                                                                   |
| Cnd1 And Cnd2 And Cnd3 | <p><b>Should be used when two or three conditions are relevant, and all must be True to select the table.</b></p> <p>If any condition equals False or Error, the table is not selected.<br/>An N/A is treated like a True.<br/>If all three conditions are True (or N/A), the table is selected.</p> <p>If((Cnd1==True) &amp;&amp;(Cnd2==True)&amp;&amp;(Cnd3==True)) Then Use Table</p> |
| Cnd1 Or Cnd2 Or Cnd3   | <p><b>Should be used when only one condition is relevant. Can also be used with two or three relevant conditions.</b></p> <p>If any condition is evaluated as True, the table is selected.<br/>Error or N/A results are treated as False</p> <p>If((Cnd1==True)    (Cnd2==True)    (Cnd3==True)) Then Use Table</p>                                                                      |

|                         |                                                                                                                                                                                                                                                                                                                   |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (Cnd1 And Cnd2) Or Cnd3 | <p><b>To be used only when all three conditions are relevant.</b></p> <p>If both Condition 1 and Condition 2 are True, OR Condition 3 is True, the table is selected. Error or N/A results are treated as False</p> <p>If( ((Cnd1==True)&amp;&amp;(Cnd2==True))    (Cnd3==True) ) Then Use Table</p>              |
| (Cnd1 Or Cnd2) And Cnd3 | <p><b>To be used only when all three conditions are relevant.</b></p> <p>If Condition 1 And Condition 3 are True, OR Condition 2 And Condition 3 are True, the table is selected. Error or N/A results are treated as False</p> <p>If( ((Cnd1==True)   (Cnd2==True)) &amp;&amp; (Cnd3==True) ) Then Use Table</p> |

**Table 28 – LB(3-x) Conditions Evaluation Based on Selected Logical Operator**

If the result of the function logic is TRUE, then the associated lookup table (see object 4x01h) is immediately selected as the source for the logic output. No further conditions for other tables are evaluated. For this reason, the *Default Table* should always be setup as the highest letter table being used (A, B or C) If no default response has been setup, the Table A automatically becomes the default when no conditions are true for any table to be selected. This scenario should be avoided whenever possible so as to not result in unpredictable output responses.

The table number that has been selected as the output source is written to sub-index X of read-only object 4010h **Logic Block Selected Table**. This will change as different conditions result in different tables being used.

### 1.8.3. Logic Block Output

Recall that Table Y, where Y = A, B or C in the LB(3-x) function block does NOT mean lookup table 1 to 3. Each table has object 3x01h LB(3-x) **Lookup Table Number** which allows the user to select which lookup tables they want associated with a particular logic block. The default tables associated with each logic block are listed in Table 29.

| Programmable<br>Logic Block Number | Table A – Lookup<br>Table Block Number | Table B – Lookup<br>Table Block Number | Table C – Lookup<br>Table Block Number |
|------------------------------------|----------------------------------------|----------------------------------------|----------------------------------------|
| 1                                  | 1                                      | 2                                      | 3                                      |
| 2                                  | 4                                      | 5                                      | 6                                      |
| 3                                  | 7                                      | 8                                      | 9                                      |
| 4                                  | 10                                     | 11                                     | 12                                     |

**Table 29 – LB(3-x) Default Lookup Tables**

If the associated Lookup Table YZ (where YZ equals 3310h sub-index X) does not have an **“X-Axis Source”** selected, then the output of LB(3-x) will always be “Not Available” so long as that table is selected. However, should LTyz be configured for a valid response to an input, be it Data or Time, the output of the LTyz function block (i.e. the Y-Axis data that has been selected based on the X-Axis value) will become the output of the LB(3-x) function block so long as that table is selected.

The LB(3-x) output is always setup as a percentage, based on the range of the Y-Axis for the associated table (see Section 1.7.2) It is written to sub-index X of read-only object 3320h **Logic Block Output PV** with a resolution of 1 decimal place.

## 1.9. Math Function Block

There are six mathematic function blocks that allow the user to define basic algorithms. Math function block Z = 1 to 6 will be enabled based on sub-index Z in object 4000h **Math Enable**.

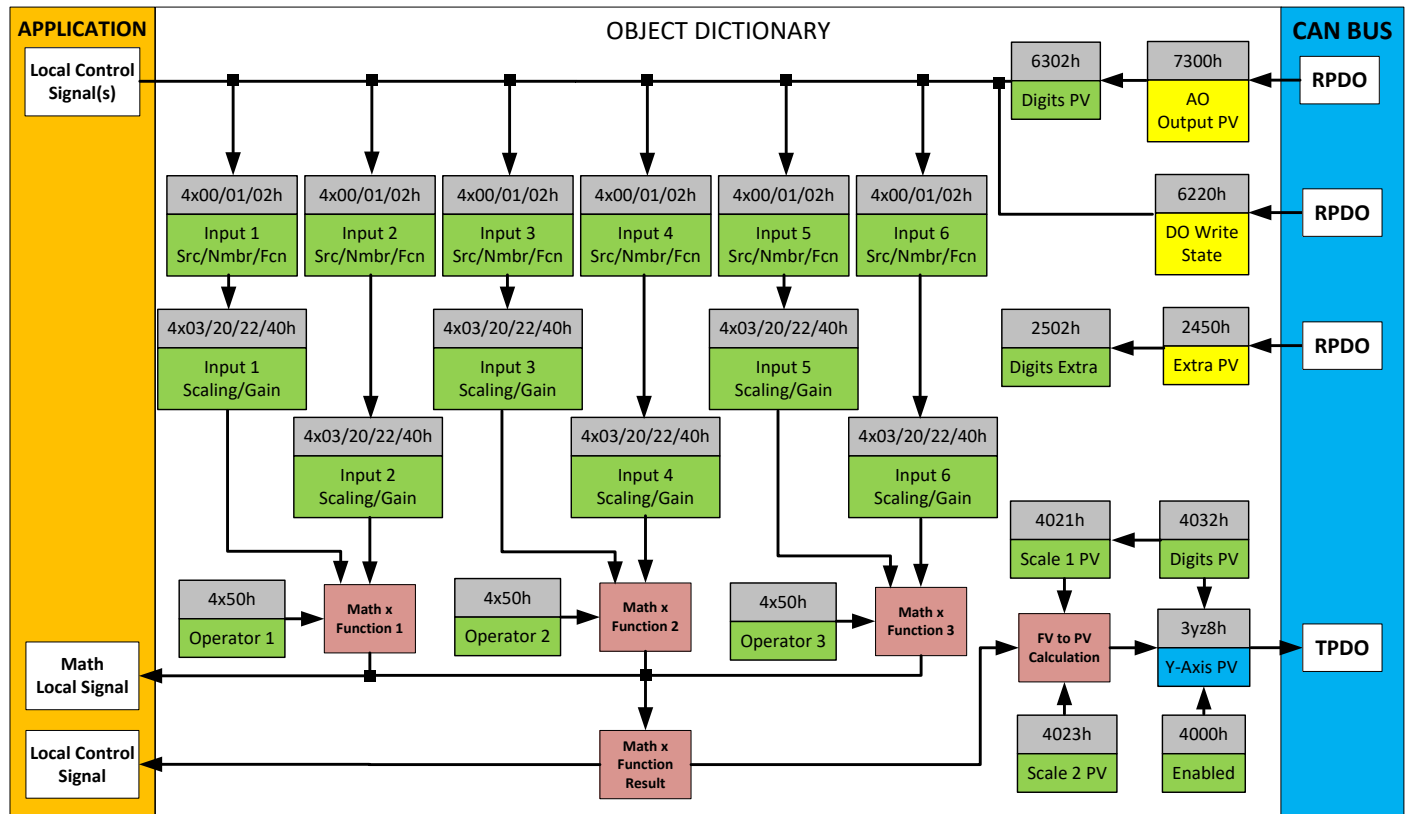


Figure 20 – Math Function Block Objects

A math function block can take up to six input signals, as listed in Table 15 in Section 1.5. Each input is then scaled according the associated scaling and gain objects. A “Math Input X” is determined by the corresponding sub-index X = 1 to 6 of the objects 4y00h **Math Y Input Source** and 4y01h **Math Y Input Number**. Here, y = 1 to 6; corresponding the Math 1- Math 6.

Inputs are converted into a percentage value based on objects 4y20h **Math Y Scaling 1 FV** and 4y22h **Math Y Scaling 2 FV**. Before being used in the calculation, these objects apply the resolution shift defined by object 4y02h **Math Y Decimal Digits FV**. As with any other function block using a control source for the X-Axis in a conversion, the scaling objects should be selected to match the values in the control’s corresponding objects as per Table 17.

For additional flexibility, the user can also adjust object 4y40h **Math Y Input Gain**. This object has a fixed decimal digit resolution of 2, and a range of -100 to 100. By default, each input has a gain of 1.0.

For example, in the case where the user may want to combine two inputs such that a joystick (Input 1) is the primary control of an output, but the speed can be incremented or decremented based on a potentiometer (Input 2), it may be desired that 75% of the scale is controlled by the joystick position, while the potentiometer can increase or decrease the min/max output by up to 25%. In this case, Input 1 would have a gain of 0.75, while Input 2 uses 0.25. The resulting addition will give a command from 0 to 100% based on the combined positions of both inputs.

For each input pair, the appropriate arithmetic or logical operation is performed on the two inputs, InA and InB, according the associated function in sub-index of InB in object 4y50h **Math Y Operator**. The list of selectable function operations is defined in Table 30.

|    |      |                                              |
|----|------|----------------------------------------------|
| 0  | =    | True when InA Equals InB                     |
| 1  | !=   | True when InA Not Equal InB                  |
| 2  | >    | True when InA Greater Than InB               |
| 3  | >=   | True when InA Greater Than or Equal InB      |
| 4  | <    | True when InA Less Than InB                  |
| 5  | <=   | True when InA Less Than or Equal InB         |
| 6  | OR   | True when InA or InB is True                 |
| 7  | NOR  | True when InA and InB are False              |
| 8  | AND  | True when InA and InB are True               |
| 9  | NAND | True when InA and InB are not both True      |
| 10 | XOR  | True when InA/InB is True, but not both      |
| 11 | XNOR | True when InA and InB are both True or False |
| 12 | +    | Result = InA plus InB                        |
| 13 | -    | Result = InA minus InB                       |
| 14 | x    | Result = InA times InB                       |
| 15 | /    | Result = InA divided by InB                  |
| 16 | MIN  | Result = Smallest of InA and InB             |
| 17 | MAX  | Result = Largest of InA and InB              |

**Table 30 – Object 4y50h Math Function Operators**

For Function 1, InA and InB are Math Inputs 1 and 2, respectively.

For Function 2, InA and InB are Math Inputs 3 and 4, respectively.

For Function 3, InA and InB are Math Inputs 5 and 6, respectively.

Exclusively within a Math Block, there is a third control parameter: Object 4y02h, **Math Y Function Number**. This parameter allows for the result of any Function (1, 2 or 3) to be the input to any **Math Input Y** within the same Math Block. Therefore, **Math Y Input Source** must be a Math Block and **Math Y Input Number** must be the same number as being configured. When these four parameters match, if **Math Y Function Number** is set to 1, 2, or 3, the respective input will be the result of the Function selected. By default, **Math Y Function Number** is set to 0 – in which case this parameter is ignored and uses the Math Block output result. These functions can only be used within the Math Block. They can not be used for other Math Blocks or logic blocks.

This allows for more versatility within the Math Block. For a valid result in each Function, both inputs must be non-zero value (other than '*Control Source Not Used*'). Otherwise, the corresponding Function is ignored. Furthermore, for a valid/expected output result in each Math Block, it is necessary to keep in mind how the Functions link to one another within the Math Block. As an example, consider all 6 inputs to be CANopen Messages 1 to 6 (thus using all 3 Functions). Since all 3 functions are used but Function 3 has no relation to Function 1 or 2, the result of the Math Block will be the result of Function 3, thus, ignoring Functions 1 and 2.

For logical operators (6 to 11), any SCALED input greater than or equal to 0.5 is treated as a TRUE input. For logic output operators (0 to 11), the result of the calculation for the function will always be 0 (FALSE) or 1 (TRUE).

Error data (i.e. input measured out of range) is always treated as a 0.0 input into the function.

For the arithmetic functions (12 to 17), it is recommended to scale the data such that the resulting operation will not exceed full scale (0 to 100%) and saturate the output result.

When dividing, a zero InB value will always result is a zero output value for the associated function. When subtracting, a negative result will always be treated as a zero, unless the function is multiplied by a negative one, or the inputs are scaled with a negative coefficient first.

The resulting final mathematical output calculation is in the appropriate physical units using object 4021h **Math Output Scaling 1 PV** and 4023h **Math Output Scaling 2 PV**. These objects are also considered the Min and Max values of the Math Block output and apply the resolution shift defined by object 4032h **Math Output Decimal Digits PV**. The result is written to read-only object 4030h **Math Output PV**. These scaling objects should also be taken into account when the Math Function is selected as the input source for another function block, as outlined in Table 17.

## 1.10. Miscellaneous Function Block

There are some other objects available which have not yet been discussed, or mentioned briefly in passing (i.e. constants.) These objects are not necessarily associated with one another, but are all discussed here.

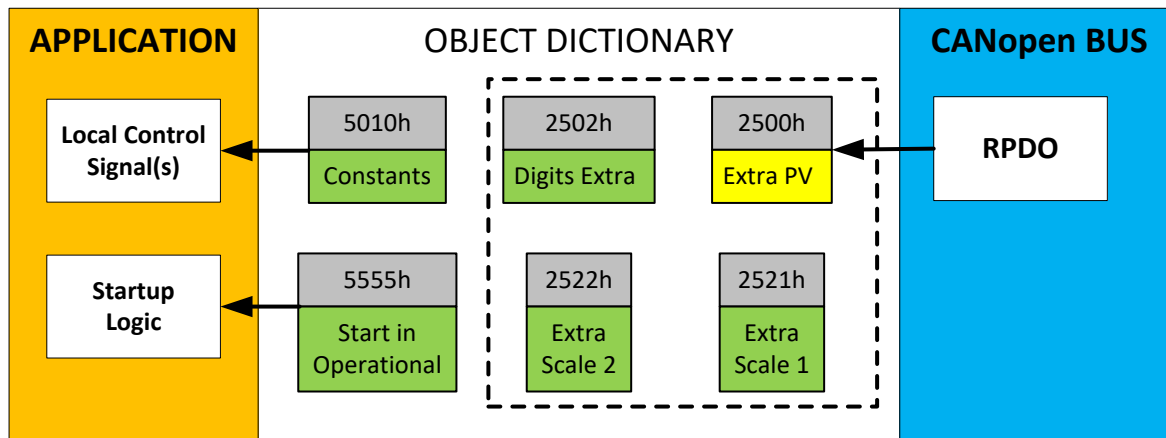


Figure 21 – Miscellaneous Objects

### Extra RPDO Messages

Objects 2500h **Extra Control Received PV**, 2502h **EC Decimal Digits PV**, 2502h **EC Scaling 1 PV** and **EC Scaling 2 PV** have been mentioned in Section 1.3, Table 16. These objects allow for additional data received on a CANopen ® RPDO to be mapped independently to various function blocks as a control source. For example, a PID loop must have two inputs (target and feedback), so one of them has to come from the CAN bus. The scaling objects are provided to define the limits of the data when it is used by another function block, as shown in Table 17.

### Constant Values

Object 5010h **Constant Field Value** is provided to give the user the option for a fixed value that can be used by other function blocks. Sub-index 1 is fixed as FALSE (0) and sub-index 2 is always TRUE (1). There are 13 other sub-indexes provided for user selectable values.

The constants are read as 32-bit real (float) data, so no decimal digit object is provided. When setting up the constant, make sure to do it with the resolution of the object that will be compared with it.

The False/True constants are provided primarily to be used with the logic block. The variable constants are also useful with the logic or math blocks, and they can also be used as a setpoint target for a PID control block.

### Fault Detection Objects

Object 5040h **FD Field Value** is a read only object containing the field values of the over temperature, over and under voltage. Object 5041h **FD Set Threshold** sets the limit values for which the faults occur when reached. When any of these thresholds are reached, the faults will clear when the values have lowered to values set in object 5042h **FD Clear Threshold**.

For the MF I/O controller to begin monitoring fault detections, object 5050h **Error Check Detection** determines which Fault Detection is enabled through 1 byte data as bits. Once a fault is detected, object 5051h **Error Response Delay** will determine how long the fault needs to be present to flag and error.

### Automatic Update of Objects

Object 5550h **Enable Automatic Updates** allows for the controller to automatically update the objects related to the output to defaults when it is changed. By default, this object is set to TRUE, in which case the objects are set to their default values depending on the type selected.

On the other hand, when this object is FALSE, the objects are not set to defaults and are left with the same values previous to changing the type. In this case, these are to be configured manually.

### Startup

The last object 5555h **Start in Operational** is provided as a 'cheat' when the unit is not intended to work with a CANopen network (i.e. a stand-alone control), or is working on a network comprised solely as slaves so the OPERATION command will never be received from a master. By default this object is disabled (FALSE).

When using the MF-I/O as a stand-alone controller where 5555h is set to TRUE, it is recommended to disable all TPDOs (set the Event Timer to zero) so that it does not run with a continuous CAN error when not connected to a bus.

## 1.11. Dimensions and Pinout

The Ten Output Valve Controller is packaged in a plastic housing from Deutsch IPD. The assembly carries an IP67 rating.

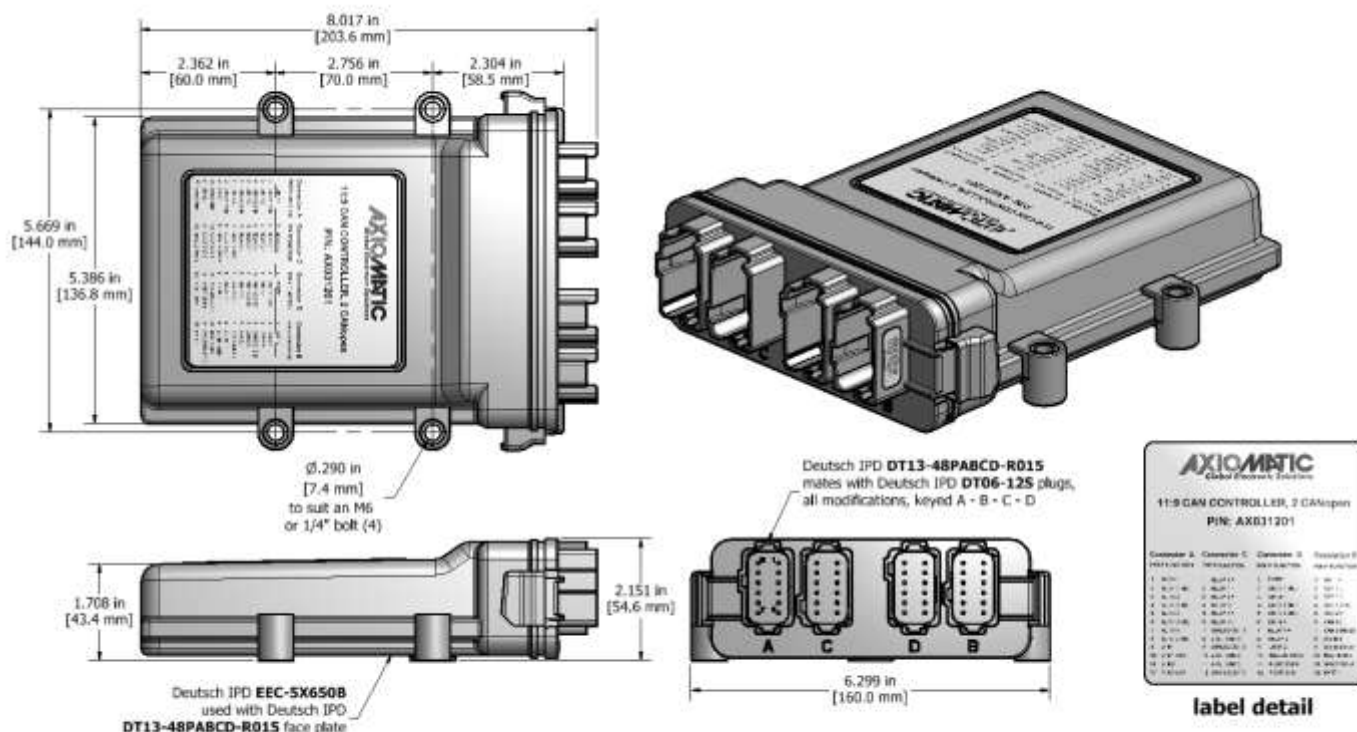


Figure 16 – Housing Dimensions

| Connector A |              | Connector C |             | Connector D |              | Connector B |                |
|-------------|--------------|-------------|-------------|-------------|--------------|-------------|----------------|
| Pin #       | Function     | Pin #       | Function    | Pin #       | Function     | Pin #       | Function       |
| 1           | A/D IN 1     | 1           | RELAY 1 +   | 1           | P OUT        | 1           | BATT +         |
| 2           | A/D IN 1 GND | 2           | RELAY 1 -   | 2           | UNI IN 1 RTN | 2           | CAN 1 L        |
| 3           | A/D IN 2     | 3           | RELAY 2 +   | 3           | UNI IN 1     | 3           | CAN 1 H        |
| 4           | A/D IN 2 GND | 4           | RELAY 2 -   | 4           | UNI IN 2 RTN | 4           | CAN 1 SH       |
| 5           | A/D IN 3     | 5           | RELAY 3 +   | 5           | UNI IN 3 RTN | 5           | CAN 2 H        |
| 6           | A/D IN 3 GND | 6           | RELAY 3 -   | 6           | UNI IN 3     | 6           | CAN 2 L        |
| 7           | A/D IN 4     | 7           | A OUT 1     | 7           | RELAY 4 +    | 7           | CAN 2 SH       |
| 8           | A/D IN 4 GND | 8           | A OUT GND 1 | 8           | RELAY 4 -    | 8           | UNI IN 4       |
| 9           | D IN 1       | 9           | A OUT 2     | 9           | UNI IN 2     | 9           | UNI IN 4 RTN   |
| 10          | D IN 1 GND   | 10          | A OUT GND 2 | 10          | A OUT 4      | 10          | MAG IN GND     |
| 11          | D IN 2       | 11          | A OUT GND 3 | 11          | A OUT GND 4  | 11          | MAG PICK-UP IN |
| 12          | D IN 2 GND   | 12          | A OUT 3     | 12          | P OUT GND    | 12          | BATT -         |

Table 31 – Connector Pinout

## 2. CANOPEN ® OBJECT DICTIONARY

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The CANopen ® object dictionary of the MF-I/O Controller is based on CiA device profile DS-404 V1.2 (device profile for Closed Loop Controllers). The object dictionary includes Communication Objects beyond the minimum requirements in the profile, as well as several manufacturer-specific objects for extended functionality. The MF-I/O Controller supports 2 CAN interfaces which share manufacturer-specific objects but have separate Communication Objects.

### 2.1. NODE ID and BAUDRATE

By default, the MF-I/O Controller ships factory programmed with a Node ID = 127 (0x7F) and with Baudrate = 125 kbps.

#### 2.1.1. LSS Protocol to Update

The only means by which the Node-ID and Baudrate can be changed is to use Layer Settling Services (LSS) and protocols as defined by CANopen ® standard DS-305.

Follow the steps below to configure either variable using LSS protocol. If required, please refer to the standard for more detailed information about how to use the protocol.

##### 2.1.1.1. Setting Node-ID

- Set the module state to LSS-configuration by **sending** the following message:

| <i>Item</i> | <i>Value</i>                           |
|-------------|----------------------------------------|
| COB-ID      | 0x7E5                                  |
| Length      | 2                                      |
| Data 0      | 0x04 (cs=4 for switch state global)    |
| Data 1      | 0x01 (switches to configuration state) |

- Set the Node-ID by **sending** the following message:

| <i>Item</i> | <i>Value</i>                                      |
|-------------|---------------------------------------------------|
| COB-ID      | 0x7E5                                             |
| Length      | 2                                                 |
| Data 0      | 0x11 (cs=17 for configure node-id)                |
| Data 1      | Node-ID (set new Node-ID as a hexadecimal number) |

- The module will send the following response (any other response is a failure).

| <i>Item</i> | <i>Value</i>                       |
|-------------|------------------------------------|
| COB-ID      | 0x7E4                              |
| Length      | 3                                  |
| Data 0      | 0x11 (cs=17 for configure node-id) |
| Data 1      | 0x00                               |
| Data 2      | 0x00                               |

- Save the configuration by **sending** the following message:

| <i>Item</i> | <i>Value</i>                         |
|-------------|--------------------------------------|
| COB-ID      | 0x7E5                                |
| Length      | 1                                    |
| Data 0      | 0x17 (cs=23 for store configuration) |

- The module will send the following response (any other response is a failure):

| <i>Item</i> | <i>Value</i>                         |
|-------------|--------------------------------------|
| COB-ID      | 0x7E4                                |
| Length      | 3                                    |
| Data 0      | 0x17 (cs=23 for store configuration) |
| Data 1      | 0x00                                 |
| Data 2      | 0x00                                 |

- Set the module state to LSS-operation by **sending** the following message:  
(Note, the module will reset itself back to the pre-operational state)

| <i>Item</i> | <i>Value</i>                        |
|-------------|-------------------------------------|
| COB-ID      | 0x7E5                               |
| Length      | 2                                   |
| Data 0      | 0x04 (cs=4 for switch state global) |
| Data 1      | 0x00 (switches to waiting state)    |

#### 2.1.1.2. Setting Baudrate

- Set the module state to LSS-configuration by **sending** the following message:

| <i>Item</i> | <i>Value</i>                           |
|-------------|----------------------------------------|
| COB-ID      | 0x7E5                                  |
| Length      | 2                                      |
| Data 0      | 0x04 (cs=4 for switch state global)    |
| Data 1      | 0x01 (switches to configuration state) |

- Set the baudrate by **sending** the following message:

| <i>Item</i> | <i>Value</i>                                     |
|-------------|--------------------------------------------------|
| COB-ID      | 0x7E5                                            |
| Length      | 3                                                |
| Data 0      | 0x13 (cs=19 for configure bit timing parameters) |
| Data 1      | 0x00 (switches to waiting state)                 |
| Data 2      | Index (select baudrate index per Table 32)       |

| <i>Index</i> | <i>Bit Rate</i>       |
|--------------|-----------------------|
| <b>0</b>     | 1 Mbit/s              |
| <b>1</b>     | 800 kbit/s            |
| <b>2</b>     | 500 kbit/s            |
| <b>3</b>     | 250 kbit/s            |
| <b>4</b>     | 125 kbit/s (default)  |
| <b>5</b>     | reserved (100 kbit/s) |

|          |           |
|----------|-----------|
| <b>6</b> | 50 kbit/s |
| <b>7</b> | 20 kbit/s |
| <b>8</b> | 10 kbit/s |

**Table 32 – LSS Baudrate Indices**

- The module will send the following response (any other response is a failure):

| <i><b>Item</b></i> | <i><b>Value</b></i>                              |
|--------------------|--------------------------------------------------|
| COB-ID             | 0x7E4                                            |
| Length             | 3                                                |
| Data 0             | 0x13 (cs=19 for configure bit timing parameters) |
| Data 1             | 0x00                                             |
| Data 2             | 0x00                                             |

- Activate bit timing parameters by **sending** the following message:

| <i><b>Item</b></i> | <i><b>Value</b></i>                             |
|--------------------|-------------------------------------------------|
| COB-ID             | 0x7E5                                           |
| Length             | 3                                               |
| Data 0             | 0x15 (cs=19 for activate bit timing parameters) |
| Data 1             | <delay_lsb>                                     |
| Data 2             | <delay_msb>                                     |

The delay individually defines the duration of the two periods of time to wait until the bit timing parameters switch is done (first period) and before transmitting any CAN message with the new bit timing parameters after performing the switch (second period). The time unit of switch delay is 1 ms.

- Save the configuration by **sending** the following message (on the NEW baudrate):

| <i><b>Item</b></i> | <i><b>Value</b></i>                  |
|--------------------|--------------------------------------|
| COB-ID             | 0x7E5                                |
| Length             | 1                                    |
| Data 0             | 0x17 (cs=23 for store configuration) |

- The module will send the following response (any other response is a failure):

| <i><b>Item</b></i> | <i><b>Value</b></i>                  |
|--------------------|--------------------------------------|
| COB-ID             | 0x7E4                                |
| Length             | 3                                    |
| Data 0             | 0x17 (cs=23 for store configuration) |
| Data 1             | 0x00                                 |
| Data 2             | 0x00                                 |

- Set the module state to LSS-operation by **sending** the following message:  
(Note, the module will reset itself back to the pre-operational state)

| <i><b>Item</b></i> | <i><b>Value</b></i> |
|--------------------|---------------------|
| COB-ID             | 0x7E5               |
| Length             | 2                   |

|        |      |                                |
|--------|------|--------------------------------|
| Data 0 | 0x04 | (cs=4 for switch state global) |
| Data 1 | 0x00 | (switches to waiting state)    |

The following screen capture (left) shows the CAN data was sent (7E5h) and received (7E4h) by the tool when the baudrate was changed to 250 kbps using the LSS protocol. The other image (right) shows what was printed on an example debug RS-232 menu while the operation took place.

Between CAN Frame 98 and 99, the baudrate on the CAN Scope tool was changed from 125 to 250 kbps.

## 2.2. COMMUNICATION OBJECTS (DS-301 and DS-404)

The communication objects supported by the MF-I/O Controller are listed in the following table. A more detailed description of some of the objects is given in the following subchapters. Only those objects that have device-profile specific information are described. For more information on the other objects, refer to the generic CANopen protocol specification DS-301.

| <b>Index<br/>(hex)</b> | <b>Object</b>                 | <b>Object Type</b> | <b>Data Type</b> | <b>Access</b> | <b>PDO<br/>Mapping</b> |
|------------------------|-------------------------------|--------------------|------------------|---------------|------------------------|
| 1000                   | Device Type                   | VAR                | UNSIGNED32       | RO            | No                     |
| 1001                   | Error Register                | VAR                | UNSIGNED8        | RO            | No                     |
| 1002                   | Manufacturer Status Register  | VAR                | UNSIGNED32       | RO            | No                     |
| 1003                   | Pre-Defined Error Field       | ARRAY              | UNSIGNED32       | RO            | No                     |
| 100C                   | Guard Time                    | VAR                | UNSIGNED16       | RW            | No                     |
| 100D                   | Life Time Factor              | VAR                | UNSIGNED8        | RW            | No                     |
| 1010                   | Store Parameters              | ARRAY              | UNSIGNED32       | RW            | No                     |
| 1011                   | Restore Default Parameters    | ARRAY              | UNSIGNED32       | RW            | No                     |
| 1016                   | Consumer Heartbeat Time       | ARRAY              | UNSIGNED32       | RW            | No                     |
| 1017                   | Producer Heartbeat Time       | VAR                | UNSIGNED16       | RW            | No                     |
| 1018                   | Identity Object               | RECORD             |                  | RO            | No                     |
| 1020                   | Verify Configuration          | ARRAY              | UNSIGNED32       | RO            | No                     |
| 1029                   | Error Behaviour               | ARRAY              | UNSIGNED8        | RW            | No                     |
| 1400                   | RPDO1 Communication Parameter | RECORD             |                  | RW            | No                     |
| 1401                   | RPDO2 Communication Parameter | RECORD             |                  | RW            | No                     |
| 1402                   | RPDO3 Communication Parameter | RECORD             |                  | RW            | No                     |
| 1403                   | RPDO4 Communication Parameter | RECORD             |                  | RW            | No                     |
| 1404                   | RPDO5 Communication Parameter | RECORD             |                  | RW            | No                     |
| 1405                   | RPDO6 Communication Parameter | RECORD             |                  | RW            | No                     |
| 1600                   | RPDO1 Mapping Parameter       | RECORD             |                  | RO            | No                     |
| 1601                   | RPDO2 Mapping Parameter       | RECORD             |                  | RO            | No                     |
| 1602                   | RPDO3 Mapping Parameter       | RECORD             |                  | RO            | No                     |
| 1603                   | RPDO4 Mapping Parameter       | RECORD             |                  | RO            | No                     |
| 1604                   | RPDO5 Mapping Parameter       | RECORD             |                  | RO            | No                     |
| 1605                   | RPDO6 Mapping Parameter       | RECORD             |                  | RO            | No                     |
| 1800                   | TPDO1 Communication Parameter | RECORD             |                  | RW            | No                     |
| 1801                   | TPDO2 Communication Parameter | RECORD             |                  | RW            | No                     |
| 1802                   | TPDO3 Communication Parameter | RECORD             |                  | RW            | No                     |
| 1803                   | TPDO4 Communication Parameter | RECORD             |                  | RW            | No                     |
| 1804                   | TPDO5 Communication Parameter | RECORD             |                  | RW            | No                     |
| 1805                   | TPDO6 Communication Parameter | RECORD             |                  | RW            | No                     |
| 1A00                   | TPDO1 Mapping Parameter       | RECORD             |                  | RW            | No                     |
| 1A01                   | TPDO2 Mapping Parameter       | RECORD             |                  | RW            | No                     |
| 1A02                   | TPDO3 Mapping Parameter       | RECORD             |                  | RW            | No                     |
| 1A03                   | TPDO4 Mapping Parameter       | RECORD             |                  | RW            | No                     |
| 1A04                   | TPDO5 Mapping Parameter       | RECORD             |                  | RW            | No                     |
| 1A05                   | TPDO6 Mapping Parameter       | RECORD             |                  | RW            | No                     |

### 2.2.1. Object 1000h: Device Type

This object contains information about the device type as per device profile DS-404. The 32-bit parameter is divided into two 16-bit values, showing General and Additional information as shown below.

MSB

LSB

|                                        |                                           |
|----------------------------------------|-------------------------------------------|
| <b>Additional Information</b> = 0xE01C | <b>General Information</b> = 0x0194 (404) |
|----------------------------------------|-------------------------------------------|

DS-404 defines the Additional Information field in the following manner:

0000h = reserved

0001h = digital input block

0002h = analog input block

0004h = digital output block

0008h = analog output block

0010h = controller block (aka PID)

0020h = alarm block

0040h ... 0800h = reserved

1000h = reserved

2000h = lookup table block (manufacturer-specific)

4000h = programmable logic block (manufacturer-specific)

8000h = miscellaneous block (manufacturer-specific)

#### ***Object Description***

|             |             |
|-------------|-------------|
| Index       | 1000h       |
| Name        | Device Type |
| Object Type | VAR         |
| Data Type   | UNSIGNED32  |

#### ***Entry Description***

|               |            |
|---------------|------------|
| Access        | RO         |
| PDO Mapping   | No         |
| Value Range   | 0xE01F0194 |
| Default Value | 0xE01F0194 |

### 2.2.2. Object 1001h: Error Register

This object is an error register for the device. Any time there is an error detected by the MF-I/O Controller, the Generic Error Bit (bit 0) is set. Only if there is no errors in the module will this bit will be cleared. No other bits in this register are used by the MF-I/O Controller.

#### ***Object Description***

|             |                |
|-------------|----------------|
| Index       | 1001h          |
| Name        | Error Register |
| Object Type | VAR            |
| Data Type   | UNSIGNED8      |

#### ***Entry Description***

|               |            |
|---------------|------------|
| Access        | RO         |
| PDO Mapping   | No         |
| Value Range   | 00h or 01h |
| Default Value | 0          |

### 2.2.3. Object 1002h: Manufacturer Status Register

This object is used for manufacturer debug purposes.

### 2.2.4. Object 1003h: Pre-Defined Error Field

This object provides an error history by listing the errors in the order that they have occurred. An error is added to the top of the list when it occurs, and is immediately removed when the error condition has been cleared. The latest error is always at sub-index 1, with sub-index 0 containing the number of errors currently in the list. When the device is in an error-free state, the value of sub-index 0 is zero.

The error list may be cleared by writing a zero to sub-index 0, which will clear all errors from the list, regardless of whether or not they are still present. Clearing the list does NOT mean that the module will return to the error-free behaviour state if at least one error is still active.

The MF-I/O Controller has a limitation of a maximum of 4 errors in the list. If the device registers more errors, the list will be truncated, and the oldest entries will be lost.

The error codes stored in the list are 32-bit unsigned numbers, consisting of two 16-bit fields. The lower 16-bit field is the EMCY error code, and the higher 16-bit field is a manufacturer-specific code. The manufacturer-specific code is divided into two 8-bit fields, with the higher byte indicating the error description, and the lower byte indicating the channel on which the error occurred.

MSB

LSB

| Error Description | Channel-ID | EMCY Error Code |
|-------------------|------------|-----------------|
|-------------------|------------|-----------------|

If node-guarding is used (not recommended per the latest standard) and a lifeguard event occurs, the manufacturer-specific field will be set to 0x1000. On the other hand, if a heartbeat consumer fails to be received within the expected timeframe, the Error Description will be set to 0x80 and the Channel-ID (nn) will reflect the Node-ID of the consumer channel that was not producing. In this case, the manufacturer-specific field will therefore be 0x80nn. In both cases, the corresponding EMCY Error Code will be the Guard Error 0x8130.

When an analog output is not working as described in Section 1.5, then the Error Description will reflect what channel(s) is at fault using the following table. Also, if an RPDO is not received within the expected “Event Timer” period, an RPDO timeout will be flagged. Table 33 outlines the resulting Error Field Codes and their meanings.

| Error Field Code | Error Description                         | Meaning                               | ID  | Meaning               | EMCY Code | Meaning                   |
|------------------|-------------------------------------------|---------------------------------------|-----|-----------------------|-----------|---------------------------|
| 00000000h        | EMCY Error Reset (fault no longer active) |                                       |     |                       |           |                           |
| 4003F001h        | 40h                                       | Positive Overload (Out-of-range High) | 03h | Universal Input 1     | F001h     | Input Overload            |
| 5003F001h        | 50h                                       | Negative Overload (Out-of-range Low)  | 03h | Universal Input 1     | F001h     | Input Overload            |
| 4004F001h        | 40h                                       | Positive Overload (Out-of-range High) | 04h | Universal Input 2     | F001h     | Input Overload            |
| 5004F001h        | 50h                                       | Negative Overload (Out-of-range Low)  | 04h | Universal Input 2     | F001h     | Input Overload            |
| 4005F001h        | 40h                                       | Positive Overload (Out-of-range High) | 05h | Universal Input 3     | F001h     | Input Overload            |
| 5005F001h        | 50h                                       | Negative Overload (Out-of-range Low)  | 05h | Universal Input 3     | F001h     | Input Overload            |
| 4006F001h        | 40h                                       | Positive Overload (Out-of-range High) | 06h | Universal Input 4     | F001h     | Input Overload            |
| 5006F001h        | 50h                                       | Negative Overload (Out-of-range Low)  | 06h | Universal Input 4     | F001h     | Input Overload            |
| 4007F001h        | 40h                                       | Positive Overload (Out-of-range High) | 07h | Analog Input 1        | F001h     | Input Overload            |
| 5007F001h        | 50h                                       | Negative Overload (Out-of-range Low)  | 07h | Analog Input 1        | F001h     | Input Overload            |
| 4008F001h        | 40h                                       | Positive Overload (Out-of-range High) | 08h | Analog Input 2        | F001h     | Input Overload            |
| 5008F001h        | 50h                                       | Negative Overload (Out-of-range Low)  | 08h | Analog Input 2        | F001h     | Input Overload            |
| 4009F001h        | 40h                                       | Positive Overload (Out-of-range High) | 09h | Analog Input 3        | F001h     | Input Overload            |
| 5009F001h        | 50h                                       | Negative Overload (Out-of-range Low)  | 09h | Analog Input 3        | F001h     | Input Overload            |
| 400AF001h        | 40h                                       | Positive Overload (Out-of-range High) | 0Ah | Analog Input 4        | F001h     | Input Overload            |
| 500AF001h        | 50h                                       | Negative Overload (Out-of-range Low)  | 0Ah | Analog Input 4        | F001h     | Input Overload            |
| 400BF001h        | 40h                                       | Positive Overload (Out-of-range High) | 0Bh | Magnetic Pickup       | F001h     | Input Overload            |
| 500BF001h        | 50h                                       | Negative Overload (Out-of-range Low)  | 0Bh | Magnetic Pickup       | F001h     | Input Overload            |
| 1001F002h        | 10h                                       | Sensor Break (Open Circuit on AO)     | 01h | Proportional Output 1 | F002h     | Output Overload           |
| 40003100h        | 40h                                       | Positive Overload (Vps Overvoltage)   | 00h | Unspecified           | 3100h     | Device Voltage            |
| 50003100h        | 50h                                       | Negative Overload (Vps Undervoltage)  | 00h | Unspecified           | 3100h     | Device Voltage            |
| 40004200h        | 40h                                       | Positive Overload (Over Temp)         | 00h | Unspecified           | 4200h     | Device Temperature        |
| 00008100h        | 00h                                       | RPDO Timeout                          | 00h | Unspecified           | 8100h     | Communication - generic   |
| 10008130h        | 10h                                       | Lifeguard Event                       | 00h | Unspecified           | 8130h     | Lifeguard/Heartbeat Error |
| 80nn8130h        | 80h                                       | Heartbeat Timeout                     | nn  | Node-ID               | 8130h     | Lifeguard/Heartbeat Error |
| 00008140h        | 00h                                       | Bus OFF Event                         | 00h | Unspecified           | 8400h     | Bus OFF Recovery          |

**Table 33 – Pre-Defined Error Field Codes**

**Object Description**

|             |                         |
|-------------|-------------------------|
| Index       | 1003h                   |
| Name        | Pre-Defined Error Field |
| Object Type | ARRAY                   |
| Data Type   | UNSIGNED32              |

**Entry Description**

|               |                   |
|---------------|-------------------|
| Sub-Index     | 0h                |
| Description   | Number of entries |
| Access        | RW                |
| PDO Mapping   | No                |
| Value Range   | 0 to 15           |
| Default Value | 0                 |

|               |                      |
|---------------|----------------------|
| Sub-Index     | 1h to 15             |
| Description   | Standard error field |
| Access        | RO                   |
| PDO Mapping   | No                   |
| Value Range   | UNSIGNED32           |
| Default Value | 0                    |

**2.2.5. Object 100Ch: Guard Time**

The objects at index 100Ch and 100Dh shall indicate the configured guard time respective to the life time factor. The life time factor multiplied with the guard time gives the life time for the life guarding protocol described in DS-301. The Guard Time value shall be given in multiples of ms, and a value of 0000h shall disable the life guarding.

It should be noted that this object, and that of 100Dh are only supported for backwards compatibility. The standard recommends that newer networks do not use the life guarding protocol, but rather heartbeat monitoring instead. Both life guarding and heartbeats can NOT be active simultaneously.

**Object Description**

|             |            |
|-------------|------------|
| Index       | 100Ch      |
| Name        | Guard Time |
| Object Type | VAR        |
| Data Type   | UNSIGNED16 |

**Entry Description**

|               |            |
|---------------|------------|
| Sub-Index     | 0h         |
| Access        | RW         |
| PDO Mapping   | No         |
| Value Range   | 0 to 65535 |
| Default Value | 0          |

**2.2.6. Object 100Dh: Lifetime Factor**

The life time factor multiplied with the guard time gives the life time for the life guarding protocol. A value of 00h shall disable life guarding.

***Object Description***

|             |                  |
|-------------|------------------|
| Index       | 100Dh            |
| Name        | Life time factor |
| Object Type | VAR              |
| Data Type   | UNSIGNED8        |

***Entry Description***

|               |          |
|---------------|----------|
| Sub-Index     | 0h       |
| Access        | RW       |
| PDO Mapping   | No       |
| Value Range   | 0 to 255 |
| Default Value | 0        |

### 2.2.7. Object 1010h: Store Parameters

This object supports the saving of parameters in non-volatile memory. In order to avoid storage of parameters by mistake, storage is only executed when a specific signature is written to the appropriate sub-index. The signature is “save”.

The signature is a 32-bit unsigned number, composed of the ASCII codes of the signature characters, according to the following table:

| MSB |     | LSB |     |
|-----|-----|-----|-----|
| e   | v   | a   | s   |
| 65h | 76h | 61h | 73h |

On reception of the correct signature to an appropriate sub-index, the MF-I/O Controller will store the parameters in non-volatile memory, and then confirm the SDO transmission.

By read access, the object provides information about the module’s saving capabilities. For all sub-indexes, this value is 1h, indicating that the MF-I/O Controller saves parameters on command. **This means that if power is removed before the Store object is written, changes to the Object Dictionary will NOT have been saved in the non-volatile memory, and will be lost on the next power cycle.**

#### ***Object Description***

|             |                  |
|-------------|------------------|
| Index       | 1010h            |
| Name        | Store Parameters |
| Object Type | ARRAY            |
| Data Type   | UNSIGNED32       |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 8                           |
| Default Value | 8                           |

|               |                                               |
|---------------|-----------------------------------------------|
| Sub-Index     | 1h                                            |
| Description   | Save all parameters                           |
| Access        | RW                                            |
| PDO Mapping   | No                                            |
| Value Range   | 0x65766173 (write access)<br>1h (read access) |
| Default Value | 1h                                            |

|               |                                               |
|---------------|-----------------------------------------------|
| Sub-Index     | 2h                                            |
| Description   | Save communication parameters                 |
| Access        | RW                                            |
| PDO Mapping   | No                                            |
| Value Range   | 0x65766173 (write access)<br>1h (read access) |
| Default Value | 1h                                            |

|               |                                               |
|---------------|-----------------------------------------------|
| Sub-Index     | 3h                                            |
| Description   | Save application parameters                   |
| Access        | RW                                            |
| PDO Mapping   | No                                            |
| Value Range   | 0x65766173 (write access)<br>1h (read access) |
| Default Value | 1h                                            |

|               |                                               |
|---------------|-----------------------------------------------|
| Sub-Index     | 4h                                            |
| Description   | Save manufacturer parameters                  |
| Access        | RW                                            |
| PDO Mapping   | No                                            |
| Value Range   | 0x65766173 (write access)<br>1h (read access) |
| Default Value | 1h                                            |

### 2.2.8. Object 1011h: Restore Parameters

This object supports the restoring of the default values for the object dictionary in non-volatile memory. In order to avoid restoring of parameters by mistake, the device restores the defaults only when a specific signature is written to the appropriate sub-index. The signature is “load”.

The signature is a 32-bit unsigned number, composed of the ASCII codes of the signature characters, according to the following table:

| MSB |     | LSB |     |
|-----|-----|-----|-----|
| d   | a   | o   | l   |
| 64h | 61h | 6Fh | 6Ch |

On reception of the correct signature to an appropriate sub-index, the MF-I/O Controller will restore the defaults in non-volatile memory, and then confirm the SDO transmission. **The default values are set valid only after the device is reset or power-cycled.** This means that the MF-I/O Controller will NOT start using the default values right away, but rather continue to run from whatever values were in the Object Dictionary prior to the restore operation.

By read access, the object provides information about the module’s default parameter restoring capabilities. For all sub-indexes, this value is 1h, indicating that the MF-I/O Controller restores defaults on command.

#### ***Object Description***

|             |                            |
|-------------|----------------------------|
| Index       | 1011h                      |
| Name        | Restore Default Parameters |
| Object Type | ARRAY                      |
| Data Type   | UNSIGNED32                 |

#### ***Entry Description***

|             |                             |
|-------------|-----------------------------|
| Sub-Index   | 0h                          |
| Description | Largest sub-index supported |
| Access      | RO                          |
| PDO Mapping | No                          |

|               |   |
|---------------|---|
| Value Range   | 4 |
| Default Value | 4 |

|               |                                             |
|---------------|---------------------------------------------|
| Sub-Index     | 1h                                          |
| Description   | Restore all default parameters              |
| Access        | RW                                          |
| PDO Mapping   | No                                          |
| Value Range   | 0x64616F6C (write access), 1h (read access) |
| Default Value | 1h                                          |

|               |                                             |
|---------------|---------------------------------------------|
| Sub-Index     | 2h                                          |
| Description   | Restore default communication parameters    |
| Access        | RW                                          |
| PDO Mapping   | No                                          |
| Value Range   | 0x64616F6C (write access), 1h (read access) |
| Default Value | 1h                                          |

|               |                                             |
|---------------|---------------------------------------------|
| Sub-Index     | 3h                                          |
| Description   | Restore default application parameters      |
| Access        | RW                                          |
| PDO Mapping   | No                                          |
| Value Range   | 0x64616F6C (write access), 1h (read access) |
| Default Value | 1h                                          |

|               |                                             |
|---------------|---------------------------------------------|
| Sub-Index     | 4h                                          |
| Description   | Restore default manufacturer parameters     |
| Access        | RW                                          |
| PDO Mapping   | No                                          |
| Value Range   | 0x64616F6C (write access), 1h (read access) |
| Default Value | 1h                                          |

### 2.2.9. Object 1016h: Consumer Heartbeat Time

The MF-I/O Controller can be a consumer of heartbeat objects for a single module. This object defines the expected heartbeat cycle time for that module, and if set to zero, it is not used. When the object is non-zero, the time is a multiple of 1ms, and monitoring will start after the reception of the first heartbeat from the module. If the MF-I/O Controller fails to receive a heartbeat from a node in the expected timeframe, it will indicate a communication error, and respond as per object 1029h.

|            |              |           |                |
|------------|--------------|-----------|----------------|
| Bits       | 31-24        | 23-16     | 15-0           |
| Value      | Reserved 00h | Node-ID   | Heartbeat time |
| Encoded as |              | UNSIGNED8 | UNSIGNED16     |

#### **Object Description**

|             |                         |
|-------------|-------------------------|
| Index       | 1016h                   |
| Name        | Consumer heartbeat time |
| Object Type | ARRAY                   |
| Data Type   | UNSIGNED32              |

#### **Entry Description**

|               |                   |
|---------------|-------------------|
| Sub-Index     | 0h                |
| Description   | Number of entries |
| Access        | RO                |
| PDO Mapping   | No                |
| Value Range   | 1                 |
| Default Value | 1                 |

|               |                         |
|---------------|-------------------------|
| Sub-Index     | 1h                      |
| Description   | Consumer heartbeat time |
| Access        | RW                      |
| PDO Mapping   | No                      |
| Value Range   | UNSIGNED32              |
| Default Value | 0                       |

### 2.2.10. Object 1017h: Producer Heartbeat Time

The MF-I/O Controller could be configured to produce a cyclical heartbeat by writing a non-zero value to this object. The value will be given in multiples of 1ms, and a value of 0 shall disable the heartbeat.

#### ***Object Description***

|             |                         |
|-------------|-------------------------|
| Index       | 1017h                   |
| Name        | Producer heartbeat time |
| Object Type | VAR                     |
| Data Type   | UNSIGNED16              |

#### ***Entry Description***

|               |             |
|---------------|-------------|
| Sub-Index     | 0h          |
| Access        | RW          |
| PDO Mapping   | No          |
| Value Range   | 10 to 65535 |
| Default Value | 0           |

### 2.2.11. Object 1018h: Identity Object

The identity object indicates the data of the MF-I/O Controller, including vendor id, device id, software and hardware version numbers, and the serial number.

In the Revision Number entry at sub-index 3, the format of the data is as shown below

|                                           |  |                   |                  |
|-------------------------------------------|--|-------------------|------------------|
| MSB                                       |  |                   | LSB              |
| Major revision number (object dictionary) |  | Hardware Revision | Software Version |

#### ***Object Description***

|             |                 |
|-------------|-----------------|
| Index       | 1018h           |
| Name        | Identity Object |
| Object Type | RECORD          |
| Data Type   | Identity Record |

#### ***Entry Description***

|               |                   |
|---------------|-------------------|
| Sub-Index     | 0h                |
| Description   | Number of entries |
| Access        | RO                |
| PDO Mapping   | No                |
| Value Range   | 4                 |
| Default Value | 4                 |

|               |                        |
|---------------|------------------------|
| Sub-Index     | 1h                     |
| Description   | Vendor ID              |
| Access        | RO                     |
| PDO Mapping   | No                     |
| Value Range   | 0x00000055             |
| Default Value | 0x00000055 (Axiomatic) |

|               |              |
|---------------|--------------|
| Sub-Index     | 2h           |
| Description   | Product Code |
| Access        | RO           |
| PDO Mapping   | No           |
| Value Range   | 0xAA031201   |
| Default Value | 0xAA031201   |

|               |                 |
|---------------|-----------------|
| Sub-Index     | 3h              |
| Description   | Revision Number |
| Access        | RO              |
| PDO Mapping   | No              |
| Value Range   | UNSIGNED32      |
| Default Value | 0x00010301      |

|               |               |
|---------------|---------------|
| Sub-Index     | 4h            |
| Description   | Serial Number |
| Access        | RO            |
| PDO Mapping   | No            |
| Value Range   | UNSIGNED32    |
| Default Value | No            |

### 2.2.12. Object 1020h: Verify Configuration

This object can be read to see what date the software (version identified in object 1018h) was compiled. The date is represented as a hexadecimal value showing day/month/year as per the format below. The time value at sub-index 2 is a hexadecimal value showing the time in a 24 hour clock

MSB

LSB

|                     |                       |                      |
|---------------------|-----------------------|----------------------|
| Day (in 1-Byte Hex) | Month (in 1-Byte Hex) | Year (in 2-Byte Hex) |
| 00                  | 00                    | Time (in 2-Byte Hex) |

For example, a value of 0x30042014 would indicate that the software was compiled on April 30<sup>th</sup>, 2014. A time value of 0x00001842 would indicate it was compiled at 6:42pm.

#### **Object Description**

|             |                      |
|-------------|----------------------|
| Index       | 1020h                |
| Name        | Verify configuration |
| Object Type | ARRAY                |
| Data Type   | UNSIGNED32           |

#### ***Entry Description***

|               |                   |
|---------------|-------------------|
| Sub-Index     | 0h                |
| Description   | Number of entries |
| Access        | RO                |
| PDO Mapping   | No                |
| Value Range   | 2                 |
| Default Value | 2                 |

|               |                    |
|---------------|--------------------|
| Sub-Index     | 1h                 |
| Description   | Configuration date |
| Access        | RO                 |
| PDO Mapping   | No                 |
| Value Range   | UNSIGNED32         |
| Default Value | No                 |

|               |                    |
|---------------|--------------------|
| Sub-Index     | 2h                 |
| Description   | Configuration time |
| Access        | RO                 |
| PDO Mapping   | No                 |
| Value Range   | UNSIGNED32         |
| Default Value | No                 |

### **2.2.13. Object 1029h: Error Behaviour**

This object controls the state that the MF-I/O Controller will be set into in case of an error of the type associated with the sub-index.

A network fault is flagged when an RPDO is not received within the expected time period defined in the “Event Timer” of the associated communication objects, (see Section 2.2.14 for more information) or if a lifeguard or heartbeat message is not received as expected. Input faults are defined in Section 1.3, and output faults are defined in Section 1.5. Power Supply faults are described in Section 1.10.

For all sub-indexes, the following definitions hold true:

- 0 = Pre-Operational (node reverts to a pre-operational state when this fault is detected)
- 1 = No State Change (node remains in the same state it was in when the fault occurred)
- 2 = Stopped (node goes into stopped mode when the fault occurs)

#### ***Object Description***

|             |                 |
|-------------|-----------------|
| Index       | 1029h           |
| Name        | Error Behaviour |
| Object Type | ARRAY           |
| Data Type   | UNSIGNED8       |

#### ***Entry Description***

|               |                   |
|---------------|-------------------|
| Sub-Index     | 0h                |
| Description   | Number of entries |
| Access        | RO                |
| PDO Mapping   | No                |
| Value Range   | 5                 |
| Default Value | 5                 |

|               |                     |
|---------------|---------------------|
| Sub-Index     | 1h                  |
| Description   | Communication Fault |
| Access        | RW                  |
| PDO Mapping   | No                  |
| Value Range   | See above           |
| Default Value | 0 (Pre-Operational) |

|               |                     |
|---------------|---------------------|
| Sub-Index     | 2h                  |
| Description   | Digital Input Error |
| Access        | RW                  |
| PDO Mapping   | No                  |
| Value Range   | See above           |
| Default Value | 1 (No State Change) |

|               |                     |
|---------------|---------------------|
| Sub-Index     | 3h                  |
| Description   | Analog Input Error  |
| Access        | RW                  |
| PDO Mapping   | No                  |
| Value Range   | See above           |
| Default Value | 1 (No State Change) |

|               |                      |
|---------------|----------------------|
| Sub-Index     | 4h                   |
| Description   | Digital Output Error |
| Access        | RW                   |
| PDO Mapping   | No                   |
| Value Range   | See above            |
| Default Value | 1 (No State Change)  |

|               |                     |
|---------------|---------------------|
| Sub-Index     | 5h                  |
| Description   | Analog Output Error |
| Access        | RW                  |
| PDO Mapping   | No                  |
| Value Range   | See above           |
| Default Value | 1 (No State Change) |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 6h                    |
| Description   | Fault Detection Error |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | See above             |
| Default Value | 1 (No State Change)   |

## 2.2.14. RPDO Behaviour

Per the CANopen ® standard DS-301, the following procedure shall be used for re-mapping, and is the same for both RPDOs and TPDOs.

- Destroy the PDO by setting bit **exists** (most significant bit) of sub-index 01h of the according PDO communication parameter to 1b
- Disable mapping by setting sub-index 00h of the corresponding mapping object to 0
- Modify the mapping by changing the values of the corresponding sub-indices
- Enable mapping by setting sub-index 00h to the number of mapped objects
- Create the PDO by setting bit **exists** (most significant bit) of sub-index 01h of the according PDO communication parameter to 0b

The MF-I/O Controller can support up to six RPDO messages. All RPDOs on the MF-I/O Controller use the similar default communication parameters, with the PDO IDs set according to the pre-defined connection set described in DS-301. Most RPDOs do not exist, there is no RTR allowed, they use 11-bit CAN-IDs (base frame valid) and they are all event-driven. While all six have valid default mappings defined (see below) only RPDO1 is enabled by default (i.e. RPDO exists).

### ***RPDO1 Mapping at Object 1600h: Default ID 0x200 + Node ID***

| <b>Sub-Index</b> | <b>Value</b> | <b>Object</b>                               |
|------------------|--------------|---------------------------------------------|
| 0                | 4            | Number of mapped application objects in PDO |
| 1                | 0x73000110   | Proportional Output Process Value           |
| 2                | 0x73000610   | Analog Output 1 Process Value               |
| 3                | 0x73000710   | Analog Output 2 Process Value               |
| 4                | 0x73000810   | Analog Output 3 Process Value               |

### ***RTPDO2 Mapping at Object 1601h: Default ID 0x300 + Node ID***

| <b>Sub-Index</b> | <b>Value</b> | <b>Object</b>                               |
|------------------|--------------|---------------------------------------------|
| 0                | 4            | Number of mapped application objects in PDO |
| 1                | 0x73000910   | Analog Output 4 Process Value               |
| 2                | 0x62000108   | Digital Write 8 Output Lines                |
| 3                | 0            |                                             |
| 4                | 0            |                                             |

### ***RPDO3 Mapping at Object 1602h: Default ID 0x400 + Node ID***

| <b>Sub-Index</b> | <b>Value</b> | <b>Object</b>                               |
|------------------|--------------|---------------------------------------------|
| 0                | 4            | Number of mapped application objects in PDO |
| 1                | 0x25000110   | Extra Received 1 PV                         |
| 2                | 0x25000210   | Extra Received 2 PV                         |
| 3                | 0x25000310   | Extra Received 3 PV                         |
| 4                | 0x25000410   | Extra Received 4 PV                         |

### ***RPDO4 Mapping at Object 1603h: Default ID 0x500 + Node ID***

| <b>Sub-Index</b> | <b>Value</b> | <b>Object</b>                               |
|------------------|--------------|---------------------------------------------|
| 0                | 4            | Number of mapped application objects in PDO |
| 1                | 0x25000510   | Extra Received 5 PV                         |
| 2                | 0x25000610   | Extra Received 6 PV                         |
| 3                | 0x25000710   | Extra Received 7 PV                         |
| 4                | 0x25000810   | Extra Received 8 PV                         |

**RPDO5 Mapping at Object 1604h: Default ID 0x200 + Node ID + 1**

| <b>Sub-Index</b> | <b>Value</b> | <b>Object</b>                               |
|------------------|--------------|---------------------------------------------|
| 0                | 4            | Number of mapped application objects in PDO |
| 1                | 0x25000910   | Extra Received 9 PV                         |
| 2                | 0x25000A10   | Extra Received 10 PV                        |
| 3                | 0x25000B10   | Extra Received 11 PV                        |
| 4                | 0x25000C10   | Extra Received 12 PV                        |

**RPDO6 Mapping at Object 1605h: Default ID 0x300 + Node ID + 1**

| <b>Sub-Index</b> | <b>Value</b> | <b>Object</b>                               |
|------------------|--------------|---------------------------------------------|
| 0                | 4            | Number of mapped application objects in PDO |
| 1                | 0x25000D10   | Extra Received 13 PV                        |
| 2                | 0x25000E10   | Extra Received 14 PV                        |
| 3                | 0x25000F10   | Extra Received 15 PV                        |
| 4                | 0            |                                             |

None of them have the timeout feature enabled, i.e. the “Event Timer” on sub-index 5 is set to zero. When this is changed to a non-zero value, if the RPDO has not been received from another node within the time period defined (while in Operational mode), a network fault is activated, and the controller will go to the operational state define in Object 1029h sub-index 4.

**Object Description**

|             |                              |
|-------------|------------------------------|
| Index       | 1400h to 1405h               |
| Name        | RPDO communication parameter |
| Object Type | RECORD                       |
| Data Type   | PDO Communication Record     |

**Entry Description**

|               |                   |
|---------------|-------------------|
| Sub-Index     | 0h                |
| Description   | Number of entries |
| Access        | RO                |
| PDO Mapping   | No                |
| Value Range   | 5                 |
| Default Value | 5                 |

|               |                                                            |
|---------------|------------------------------------------------------------|
| Sub-Index     | 1h                                                         |
| Description   | COB-ID used by RPDO                                        |
| Access        | RW                                                         |
| PDO Mapping   | No                                                         |
| Value Range   | See value definition in DS-301                             |
| Default Value | 40000000h + RPDO1 + Node ID<br>C0000000h + RPDOx + Node-ID |

| <b>X</b> | <b>RPDOx ID</b> |
|----------|-----------------|
| 1        | 0200h           |
| 2        | 0300h           |
| 3        | 0400h           |
| 4        | 0500h           |
| 5        | 0201h           |
| 6        | 0301h           |

Node-ID = Node-ID of the module. The RPDO COB-IDs are automatically updated if the Node-ID is changed by LSS protocol.

80000000h in the COB-ID indicates that the PDO does not exist (destroyed)

04000000h in the COB-ID indicates that there is no RTR allowed on the PDO

|               |                                |
|---------------|--------------------------------|
| Sub-Index     | 2h                             |
| Description   | Transmission type              |
| Access        | RO                             |
| PDO Mapping   | No                             |
| Value Range   | See value definition in DS-301 |
| Default Value | 255 (FFh) = Event Driven       |

|               |                                |
|---------------|--------------------------------|
| Sub-Index     | 3h                             |
| Description   | Inhibit Time                   |
| Access        | RW                             |
| PDO Mapping   | No                             |
| Value Range   | See value definition in DS-301 |
| Default Value | 0                              |

|               |                     |
|---------------|---------------------|
| Sub-Index     | 4h                  |
| Description   | Compatibility entry |
| Access        | RW                  |
| PDO Mapping   | No                  |
| Value Range   | UNSIGNED8           |
| Default Value | 0                   |

|               |                                |
|---------------|--------------------------------|
| Sub-Index     | 5                              |
| Description   | Event-timer                    |
| Access        | RW                             |
| PDO Mapping   | No                             |
| Value Range   | See value definition in DS-301 |
| Default Value | 0                              |

*Recall: A non-zero event timer for an RPDO means that it will result in a network fault being flagged if it has not been received within this timeframe while in Operational mode.*

### 2.2.15. TPDO Behaviour

The MF-I/O Controller can support up to eight TPDO messages. All TPDOs on the MF-I/O Controller use the similar default communication parameters, with the PDO IDs set according to the pre-defined connection set described in DS-301. Most TPDOs do not exist, there is no RTR allowed, they use 11-bit CAN-IDs (base frame valid) and they are all time-driven. While all have valid default mappings defined (see below) only TPDO1 to TPDO3 are enabled by default (i.e. TPDO exists).

#### ***TPDO1 Mapping at Object 1A00h: Default ID 0x180 + Node ID***

| <b><i>Sub-Index</i></b> | <b><i>Value</i></b> | <b><i>Object</i></b>                        |
|-------------------------|---------------------|---------------------------------------------|
| 0                       | 4                   | Number of mapped application objects in PDO |
| 1                       | 0x71000310          | Universal Input 1 Field Value               |
| 2                       | 0x71000410          | Universal Input 2 Field Value               |
| 3                       | 0x71000510          | Universal Input 3 Field Value               |
| 4                       | 0x71000610          | Universal Input 4 Field Value               |

#### ***TPDO2 Mapping at Object 1A01h: Default ID 0x280 + Node ID***

| <b><i>Sub-Index</i></b> | <b><i>Value</i></b> | <b><i>Object</i></b>                        |
|-------------------------|---------------------|---------------------------------------------|
| 0                       | 4                   | Number of mapped application objects in PDO |
| 1                       | 0x71000710          | Analog Input 1 Field Value                  |

|   |            |                            |
|---|------------|----------------------------|
| 2 | 0x71000810 | Analog Input 2 Field Value |
| 3 | 0x71000910 | Analog Input 3 Field Value |
| 4 | 0x71000A10 | Analog Input 4 Field Value |

**TPDO3 Mapping at Object 1A02h: Default ID 0x380 + Node ID**

| Sub-Index | Value      | Object                                      |
|-----------|------------|---------------------------------------------|
| 0         | 1          | Number of mapped application objects in PDO |
| 1         | 0x71000A10 | Magnetic Input Field Value                  |
| 2         | 0          |                                             |
| 3         | 0          |                                             |
| 4         | 0          |                                             |

**TPDO4 Mapping at Object 1A03h: Default ID 0x480 + Node ID**

| Sub-Index | Value      | Object                                         |
|-----------|------------|------------------------------------------------|
| 0         | 2          | Number of mapped application objects in PDO    |
| 1         | 0x60000108 | Digital Read 8 Input Lines DI1-2, UI1-4, AI1-2 |
| 2         | 0x60000208 | Digital Read 8 Input Lines AI3-4               |
| 3         | 0          |                                                |
| 4         | 0          |                                                |

**TPDO5 Mapping at Object 1A04h: Default ID 0x180 + Node ID + 1**

| Sub-Index | Value      | Object                                      |
|-----------|------------|---------------------------------------------|
| 0         | 1          | Number of mapped application objects in PDO |
| 1         | 0x23700110 | Proportional Output 1 Feedback Field Value  |
| 2         |            |                                             |
| 3         |            |                                             |
| 4         |            |                                             |

**TPDO6 Mapping at Object 1A05h: Default ID 0x280 + Node ID + 1**

| Sub-Index | Value      | Object                                       |
|-----------|------------|----------------------------------------------|
| 0         | 2          | Number of mapped application objects in PDO  |
| 1         | 0x50400120 | Processor Temperature Field Value (measured) |
| 2         | 0x50400220 | Power Supply Field Value (measured)          |
| 3         | 0          | Not used by default                          |
| 4         | 0          | Not used by default                          |

Since only TPDO1 to TPDO3 have a non-zero value transmission rate (i.e. Event Timer in sub-index 5 of communication object), only these TPDOs will be automatically broadcasted when the unit goes into OPERATIONAL mode.

**Object Description**

|             |                              |
|-------------|------------------------------|
| Index       | 1800h to 1805h               |
| Name        | TPDO communication parameter |
| Object Type | RECORD                       |
| Data Type   | PDO Communication Record     |

**Entry Description**

|           |    |
|-----------|----|
| Sub-Index | 0h |
|-----------|----|

|               |                   |
|---------------|-------------------|
| Description   | Number of entries |
| Access        | RO                |
| PDO Mapping   | No                |
| Value Range   | 5                 |
| Default Value | 5                 |

|               |                                                            |
|---------------|------------------------------------------------------------|
| Sub-Index     | 1h                                                         |
| Description   | COB-ID used by TPDO                                        |
| Access        | RW                                                         |
| PDO Mapping   | No                                                         |
| Value Range   | See value definition in DS-301                             |
| Default Value | 40000000h + TPDOx + Node-ID<br>C0000000h + TPDOy + Node-ID |

| <i>X</i> | <i>TPDOx ID</i> | <i>Y</i> | <i>TPDOy ID</i> |
|----------|-----------------|----------|-----------------|
| 1        | 0180h           | 4        | 0480h           |
| 2        | 0280h           | 5        | 0181h           |
| 3        | 0380h           | 6        | 0281h           |
|          |                 | 7        | 0381h           |
|          |                 | 8        | 0481h           |

Node-ID = Node-ID of the module. The TPDO COB-IDs are automatically updated if the Node-ID is changed by LSS protocol.

80000000h in the COB-ID indicates that the PDO does not exist (destroyed)

04000000h in the COB-ID indicates that there is no RTR allowed on the PDO

|               |                                |
|---------------|--------------------------------|
| Sub-Index     | 2h                             |
| Description   | Transmission type              |
| Access        | RO                             |
| PDO Mapping   | No                             |
| Value Range   | See value definition in DS-301 |
| Default Value | 254 (FEh) = Event Driven       |

|               |                                |
|---------------|--------------------------------|
| Sub-Index     | 3h                             |
| Description   | Inhibit Time                   |
| Access        | RW                             |
| PDO Mapping   | No                             |
| Value Range   | See value definition in DS-301 |
| Default Value | 0                              |

|               |                     |
|---------------|---------------------|
| Sub-Index     | 4h                  |
| Description   | Compatibility entry |
| Access        | RW                  |
| PDO Mapping   | No                  |
| Value Range   | UNSIGNED8           |
| Default Value | 0                   |

|               |                                                          |
|---------------|----------------------------------------------------------|
| Sub-Index     | 5                                                        |
| Description   | Event-timer                                              |
| Access        | RW                                                       |
| PDO Mapping   | No                                                       |
| Value Range   | See value definition in DS-301                           |
| Default Value | 100ms (on TPDO1,TPDO2, TPDO3)<br>0ms (on TPDO4 to TPDO8) |

### 2.3. APPLICATION OBJECTS (DS-404)

| <b>Index<br/>(hex)</b> | <b>Object</b>                 | <b>Object<br/>Type</b> | <b>Data Type</b> | <b>Access</b> | <b>PDO<br/>Mapping</b> |
|------------------------|-------------------------------|------------------------|------------------|---------------|------------------------|
| 6000                   | DI Read State 8 Input Lines   | ARRAY                  | BOOLEAN          | RO            | Yes                    |
| 6002                   | DI Polarity 8 Input Lines     | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 7100                   | AI Input Field Value          | ARRAY                  | INTEGER16        | RO            | Yes                    |
| 6110                   | AI Sensor Type                | ARRAY                  | UNSIGNED16       | RW            | No                     |
| 6112                   | AI Operating Mode             | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 7120                   | AI Input Scaling 1 FV         | ARRAY                  | INTEGER16        | RW            | No                     |
| 7121                   | AI Input Scaling 1 PV         | ARRAY                  | INTEGER16        | RW            | No                     |
| 7122                   | AI Input Scaling 2 FV         | ARRAY                  | INTEGER16        | RW            | No                     |
| 7123                   | AI Input Scaling 2 PV         | ARRAY                  | INTEGER16        | RW            | No                     |
| 7130                   | AI Input Process Value        | ARRAY                  | INTEGER16        | RO            | Yes                    |
| 6132                   | AI Decimal Digits PV          | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 7148                   | AI Input Span Start           | ARRAY                  | INTEGER16        | RW            | No                     |
| 7149                   | AI Input Span End             | ARRAY                  | INTEGER16        | RW            | No                     |
| 61A0                   | AI Filter Type                | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 61A1                   | AI Filter Constant            | ARRAY                  | UNSIGNED16       | RW            | No                     |
| 6200                   | DO Write state 8 Output lines | ARRAY                  | BOOLEAN          | RW            | Yes                    |
| 6202                   | DO Polarity 8 Output Lines    | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 6250                   | DO Fault Mode 8 Output Lines  | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 6260                   | DO Fault State 8 Output Lines | ARRAY                  | BOOLEAN          | RW            | No                     |
| 7300                   | AO Output Process Value       | ARRAY                  | INTEGER16        | RW            | Yes                    |
| 6302                   | AO Decimal Digits PV          | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 6310                   | AO Output Type                | ARRAY                  | UNSIGNED16       | RW            | No                     |
| 7320                   | AO Output Scaling 1 PV        | ARRAY                  | INTEGER16        | RW            | No                     |
| 7321                   | AO Output Scaling 1 FV        | ARRAY                  | INTEGER16        | RW            | No                     |
| 7322                   | AO Output Scaling 2 PV        | ARRAY                  | INTEGER16        | RW            | No                     |
| 7323                   | AO Output Scaling 2 FV        | ARRAY                  | INTEGER16        | RW            | No                     |
| 7330                   | AO Output Field Value         | ARRAY                  | INTEGER16        | RO            | Yes                    |
| 6332                   | AO Decimal Digits FV          | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 6340                   | AO Fault Mode                 | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 7341                   | AO Fault Field Value          | ARRAY                  | INTEGER16        | RW            | No                     |
| 7450                   | PID Proportional Band         | ARRAY                  | INTEGER16        | RW            | No                     |
| 7452                   | PID Integral Action Time      | ARRAY                  | INTEGER16        | RW            | No                     |
| 7454                   | PID Derivative Action Time    | ARRAY                  | INTEGER16        | RW            | No                     |
| 7456                   | PID Cycle Time                | ARRAY                  | INTEGER16        | RW            | No                     |
| 6458                   | PID Physical Unit Timing      | ARRAY                  | UNSIGNED32       | RO            | No                     |
| 6459                   | PID Decimal Digits Timing     | ARRAY                  | UNSIGNED8        | RW            | No                     |

### 2.3.1. Object 6000h: DI Read State 8 Input Lines

This read-only object shall read group of 8 input lines as 8-bit information. Refer to Section 1.2 for more information

#### ***Object Description***

|             |                            |
|-------------|----------------------------|
| Index       | 6000h                      |
| Name        | DI Read State 8 Input Line |
| Object Type | ARRAY                      |
| Data Type   | BOOLEAN                    |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|               |                                  |
|---------------|----------------------------------|
| Sub-Index     | 1h                               |
| Description   | Digital Input State Bitmap D1-D8 |
| Access        | RO                               |
| PDO Mapping   | Yes                              |
| Value Range   | 0 (OFF) or 1 (ON)                |
| Default Value | 0                                |

|               |                                   |
|---------------|-----------------------------------|
| Sub-Index     | 2h                                |
| Description   | Digital Input State Bitmap D9-D10 |
| Access        | RO                                |
| PDO Mapping   | Yes                               |
| Value Range   | 0 (OFF) or 1 (ON)                 |
| Default Value | 0                                 |

### 2.3.2. Object 6002h: DI Polarity 8 Input Lines

This object shall define the polarity of a group of 8 input lines. This object determines how the state read on the input pin corresponds to the logic state, in conjunction with manufacturer object 2020h, as defined in Table 3.

#### ***Object Description***

|             |                          |
|-------------|--------------------------|
| Index       | 6002h                    |
| Name        | DI Polarity 1 Input Line |
| Object Type | ARRAY                    |
| Data Type   | UNSIGNED8                |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|                     |                                     |
|---------------------|-------------------------------------|
| Sub-Index           | 1h                                  |
| Description         | Digital Input Polarity Bitmap D1-D8 |
| Access              | RW                                  |
| Section PDO Mapping | No                                  |
| Value Range         | See Table 3                         |
| Default Value       | 0 (Normal On/Off)                   |

|               |                                      |
|---------------|--------------------------------------|
| Sub-Index     | 2h                                   |
| Description   | Digital Input Polarity Bitmap D9-D10 |
| Access        | RW                                   |
| PDO Mapping   | No                                   |
| Value Range   | See Table 3                          |
| Default Value | 0 (Normal On/Off)                    |

### 2.3.3. Object 7100h: AI Input Field Value

This object represents the measured value of an analog input that has been scaled as per manufacturer object 2102h AI Decimal Digits PV. The base unit for each type of input is defined in Table 9, as well as the read-only resolution (decimal digits) associated with the FV.

#### ***Object Description***

|             |                      |
|-------------|----------------------|
| Index       | 7100h                |
| Name        | AI Input Field Value |
| Object Type | ARRAY                |
| Data Type   | INTEGER16            |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                                  |
|---------------|----------------------------------|
| Sub-Index     | 1h to 1h (x = 1 to 11)           |
| Description   | Analog Input X FV                |
| Access        | RO                               |
| PDO Mapping   | Yes                              |
| Value Range   | Data Type Specific, see Table 11 |
| Default Value | No                               |

### 2.3.4. Object 6110h: AI Sensor Type

This object defines the type of sensor (input) which is connected to the analog input pin.

#### ***Object Description***

|             |                |
|-------------|----------------|
| Index       | 6110h          |
| Name        | AI Sensor Type |
| Object Type | ARRAY          |

|           |            |
|-----------|------------|
| Data Type | UNSIGNED16 |
|-----------|------------|

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                        |
|---------------|------------------------|
| Sub-Index     | 1h to Ah (x = 1 to 10) |
| Description   | AIx Sensor Type        |
| Access        | RW                     |
| PDO Mapping   | No                     |
| Value Range   | See Table 5            |
| Default Value | 40 (voltage)           |

|               |                  |
|---------------|------------------|
| Sub-Index     | Bh               |
| Description   | AI11 Sensor Type |
| Access        | RW               |
| PDO Mapping   | No               |
| Value Range   | See Table 5      |
| Default Value | 60 (frequency)   |

### **2.3.5. Object 6112h: AI Operating Mode**

This object enables special operating modes for the input.

#### ***Object Description***

|             |                   |
|-------------|-------------------|
| Index       | 6112h             |
| Name        | AI Operating Mode |
| Object Type | ARRAY             |
| Data Type   | UNSIGNED8         |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 1h to 2h (x = 1 to 2) |
| Description   | AIx Operating Mode    |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | See Table 4           |
| Default Value | 10 (digital mode)     |

|             |                        |
|-------------|------------------------|
| Sub-Index   | 3h to Bh (x = 3 to 11) |
| Description | AIx Operating Mode     |

|               |                       |
|---------------|-----------------------|
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | See Table 4           |
| Default Value | 10 (normal operation) |

### 2.3.6. Object 7120h: AI Input Scaling 1 FV

This object describes the field value of the first calibration point for the analog input channel, as shown in Figure 7. It also defines the “minimum” value of the analog input range when using this input as a control source for another function block, as described in Table 17 in Section 1.5. It is scaled in the physical unit of the FV, i.e. object 2102h applies to this object.

#### **Object Description**

|             |                       |
|-------------|-----------------------|
| Index       | 7120h                 |
| Name        | AI Input Scaling 1 FV |
| Object Type | ARRAY                 |
| Data Type   | INTEGER16             |

#### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                        |
|---------------|------------------------|
| Sub-Index     | 1h to Ah (x = 1 to 10) |
| Description   | AIx Scaling 1 FV       |
| Access        | RW                     |
| PDO Mapping   | No                     |
| Value Range   | See Table 11           |
| Default Value | 500 [mV]               |

|               |                   |
|---------------|-------------------|
| Sub-Index     | Bh                |
| Description   | AI11 Scaling 1 FV |
| Access        | RW                |
| PDO Mapping   | No                |
| Value Range   | See Table 11      |
| Default Value | 1000 [0.1 RPM]    |

### 2.3.7. Object 7121h: AI Input Scaling 1 PV

This object defines the process value of the first calibration point for the analog input channel, as shown in Figure 7. It is scaled in the physical unit of the PV, i.e. object 6132h applies to this object.

#### **Object Description**

|             |                       |
|-------------|-----------------------|
| Index       | 7121h                 |
| Name        | AI Input Scaling 1 PV |
| Object Type | ARRAY                 |
| Data Type   | INTEGER16             |

#### **Entry Description**

|           |    |
|-----------|----|
| Sub-Index | 0h |
|-----------|----|

|               |                             |
|---------------|-----------------------------|
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                         |
|---------------|-------------------------|
| Sub-Index     | 1h to 10h (x = 1 or 10) |
| Description   | AIx Scaling 1 PV        |
| Access        | RW                      |
| PDO Mapping   | No                      |
| Value Range   | Integer16               |
| Default Value | 500 [same as 7120h]     |

|               |                      |
|---------------|----------------------|
| Sub-Index     | Bh                   |
| Description   | AI11 Scaling 1 PV    |
| Access        | RW                   |
| PDO Mapping   | No                   |
| Value Range   | Integer16            |
| Default Value | 1000 [same as 7120h] |

### 2.3.8. Object 7122h: AI Input Scaling 2 FV

This object describes the field value of the second calibration point for the analog input channel, as shown in Figure 7. It also defines the “maximum” value of the analog input range when using this input as a control source for another function block, as described in Table 17 in Section 1.5. It is scaled in the physical unit of the FV, i.e. object 2102h applies to this object.

#### **Object Description**

|             |                       |
|-------------|-----------------------|
| Index       | 7122h                 |
| Name        | AI Input Scaling 2 FV |
| Object Type | ARRAY                 |
| Data Type   | INTEGER16             |

#### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                         |
|---------------|-------------------------|
| Sub-Index     | 1h to 10h (x = 1 or 10) |
| Description   | AIx Scaling 2 FV        |
| Access        | RW                      |
| PDO Mapping   | No                      |
| Value Range   | See Table 11            |
| Default Value | 4500 [mV]               |

|             |                   |
|-------------|-------------------|
| Sub-Index   | Bh                |
| Description | AI11 Scaling 2 FV |
| Access      | RW                |

|               |                 |
|---------------|-----------------|
| PDO Mapping   | No              |
| Value Range   | See Table 11    |
| Default Value | 30000 [0.1 RPM] |

### 2.3.9. Object 7123h: AI Input Scaling 2 PV

This object defines the process value of the second calibration point for the analog input channel, as shown in Figure 7. It is scaled in the physical unit of the PV, i.e. object 6132h applies to this object.

#### **Object Description**

|             |                       |
|-------------|-----------------------|
| Index       | 7123h                 |
| Name        | AI Input Scaling 2 PV |
| Object Type | ARRAY                 |
| Data Type   | INTEGER16             |

#### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                        |
|---------------|------------------------|
| Sub-Index     | 1h to Ah (x = 1 to 10) |
| Description   | AIx Scaling 2 PV       |
| Access        | RW                     |
| PDO Mapping   | No                     |
| Value Range   | Integer16              |
| Default Value | 4500 [same as 7122h]   |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | Bh                    |
| Description   | AI11 Scaling 2 PV     |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | Integer16             |
| Default Value | 30000 [same as 7122h] |

### 2.3.10. Object 7130h: AI Input Process Value

This object represents the result of the input scaling applied per Figure 7, and gives the measured quantity scaled in the physical unit of the process value (i.e. °C, PSI, RPM, etc) with the resolution defined in object 6132h AI Decimal Digits PV.

#### **Object Description**

|             |                        |
|-------------|------------------------|
| Index       | 7130h                  |
| Name        | AI Input Process Value |
| Object Type | ARRAY                  |
| Data Type   | INTEGER16              |

#### **Entry Description**

|             |                             |
|-------------|-----------------------------|
| Sub-Index   | 0h                          |
| Description | Largest sub-index supported |

|               |    |
|---------------|----|
| Access        | RO |
| PDO Mapping   | No |
| Value Range   | 11 |
| Default Value | 11 |

|               |                        |
|---------------|------------------------|
| Sub-Index     | 1h to Bh (x = 1 to 11) |
| Description   | AIx Process Value      |
| Access        | RO                     |
| PDO Mapping   | Yes                    |
| Value Range   | Integer16              |
| Default Value | No                     |

### 2.3.11. Object 6132h: AI Decimal Digits PV

This object describes the number of digits following the decimal point (i.e. resolution) of the input data, which is interpreted with data type Integer16 in the process value object.

Example: A process value of 1.230 (Float) will be coded as 1230 in Integer16 format if the number of decimal digits is set to 3.

#### ***Object Description***

|             |                      |
|-------------|----------------------|
| Index       | 6123h                |
| Name        | AI Decimal Digits PV |
| Object Type | ARRAY                |
| Data Type   | UNSIGNED8            |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                        |
|---------------|------------------------|
| Sub-Index     | 1h to Ah (x = 1 to 10) |
| Description   | AIx Decimal Digits PV  |
| Access        | RW                     |
| PDO Mapping   | No                     |
| Value Range   | 0 to 4                 |
| Default Value | 3 [Volt to mV]         |

|               |                        |
|---------------|------------------------|
| Sub-Index     | Bh                     |
| Description   | AI11 Decimal Digits PV |
| Access        | RW                     |
| PDO Mapping   | No                     |
| Value Range   | 0 to 4                 |
| Default Value | 1 [RPM to 0.1 RPM]     |

### 2.3.12. Object 7148h: AI Span Start

This value specifies the lower limit where field values are expected. Field values which are lower than this limit are marked as negative overload. It is scaled in the physical unit of the FV, i.e. object 2102h applies to this object.

#### **Object Description**

|             |               |
|-------------|---------------|
| Index       | 7148h         |
| Name        | AI Span Start |
| Object Type | ARRAY         |
| Data Type   | INTEGER16     |

#### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                            |
|---------------|----------------------------|
| Sub-Index     | 1h to Ah (x = 1 to 10)     |
| Description   | AIx Span Start (Error Min) |
| Access        | RW                         |
| PDO Mapping   | No                         |
| Value Range   | See Table 11               |
| Default Value | 200 [mV]                   |

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | Bh                          |
| Description   | AI11 Span Start (Error Min) |
| Access        | RW                          |
| PDO Mapping   | No                          |
| Value Range   | See Table 11                |
| Default Value | 500 [0.1 RPM]               |

### 2.3.13. Object 7149h: AI Span End

This value specifies the upper limit where field values are expected. Field values which are higher than this limit are marked as positive overload. It is scaled in the physical unit of the FV, i.e. object 2102h applies to this object.

#### **Object Description**

|             |             |
|-------------|-------------|
| Index       | 7149h       |
| Name        | AI Span End |
| Object Type | ARRAY       |
| Data Type   | INTEGER16   |

#### **Entry Description**

|             |                             |
|-------------|-----------------------------|
| Sub-Index   | 0h                          |
| Description | Largest sub-index supported |
| Access      | RO                          |

|               |    |
|---------------|----|
| PDO Mapping   | No |
| Value Range   | 11 |
| Default Value | 11 |

|               |                          |
|---------------|--------------------------|
| Sub-Index     | 1h to Ah (x = 1 to 10)   |
| Description   | AIx Span End (Error Max) |
| Access        | RW                       |
| PDO Mapping   | No                       |
| Value Range   | See Table 11             |
| Default Value | 4800 [mV]                |

|               |                           |
|---------------|---------------------------|
| Sub-Index     | Bh                        |
| Description   | AI11 Span End (Error Max) |
| Access        | RW                        |
| PDO Mapping   | No                        |
| Value Range   | See Table 11              |
| Default Value | 33000 [0.1 RPM]           |

#### 2.3.14. Object 61A0h: AI Filter Type

This object defines the type of data filter that will be applied to the raw input data, as read from the ADC or Timer, before it is passed to the field value object. The types of data filters are defined in Table 8, and how they are used is outlined in Section 1.3.

##### **Object Description**

|             |                |
|-------------|----------------|
| Index       | 61A0h          |
| Name        | AI Filter Type |
| Object Type | ARRAY          |
| Data Type   | UNSIGNED8      |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                        |
|---------------|------------------------|
| Sub-Index     | 1h to Bh (x = 1 to 11) |
| Description   | AIx Filter Type        |
| Access        | RW                     |
| PDO Mapping   | No                     |
| Value Range   | See Table 8            |
| Default Value | 0 (no filter)          |

### 2.3.15. Object 61A1h: AI Filter Constant

This object defines the number of steps used in the various filters, as defined in Section 1.3

#### ***Object Description***

|             |                    |
|-------------|--------------------|
| Index       | 61A0h              |
| Name        | AI Filter Constant |
| Object Type | ARRAY              |
| Data Type   | UNSIGNED16         |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                        |
|---------------|------------------------|
| Sub-Index     | 1h to Bh (x = 1 to 11) |
| Description   | AIx Filter Constant    |
| Access        | RW                     |
| PDO Mapping   | No                     |
| Value Range   | 1 to 1000              |
| Default Value | 10                     |

### 2.3.16. Object 6200h: DO Write State 8 Output Lines

This object shall set a group of 8 output lines as a byte of information.

#### ***Object Description***

|             |                              |
|-------------|------------------------------|
| Index       | 6200h                        |
| Name        | DO Write State 8 Output Line |
| Object Type | ARRAY                        |
| Data Type   | BOOLEAN                      |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 1                           |
| Default Value | 1                           |

|               |                     |
|---------------|---------------------|
| Sub-Index     | 1h                  |
| Description   | DO1-DO5 Write State |
| Access        | RW                  |
| PDO Mapping   | Yes                 |
| Value Range   | 0 (OFF) or 1 (ON)   |
| Default Value | 0 (OFF)             |

### 2.3.17. Object 6202h: DO Polarity 8 Output Lines

This object defines the polarity of a group of 8 output lines.

#### ***Object Description***

|             |                            |
|-------------|----------------------------|
| Index       | 6202h                      |
| Name        | DO Polarity 8 Output Lines |
| Object Type | ARRAY                      |
| Data Type   | UNSIGNED8                  |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 1                           |
| Default Value | 1                           |

|               |                   |
|---------------|-------------------|
| Sub-Index     | 1h                |
| Description   | DO1-DO5 Polarity  |
| Access        | RW                |
| PDO Mapping   | No                |
| Value Range   | See Table 12      |
| Default Value | 0 (normal on/off) |

### 2.3.18. Object 6206h: DO Fault Mode 1 Output Line

This object defines the fault mode of a group of 8 output lines (1 bit per line). The object determines the how each line shall respond when a fault condition is detected on any control input, as described in Table 13.

#### ***Object Description***

|             |                             |
|-------------|-----------------------------|
| Index       | 6206h                       |
| Name        | DO Fault Mode 1 Output Line |
| Object Type | ARRAY                       |
| Data Type   | UNSIGNED8                   |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 1                           |
| Default Value | 1                           |

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 1h                          |
| Description   | DO1-DO5 Fault Mode          |
| Access        | RW                          |
| PDO Mapping   | No                          |
| Value Range   | See Table 13                |
| Default Value | 1 (apply pre-defined state) |

### 2.3.19. Object 6207h: DO Fault State 1 Output Line

This object defines the pre-defined state on detecting a fault condition. It is defined for a group of 8 output lines. The corresponding bit must be set in the default output line mode (Object 6206).

#### ***Object Description***

|             |                              |
|-------------|------------------------------|
| Index       | 6207h                        |
| Name        | DO Fault State 1 Output Line |
| Object Type | ARRAY                        |
| Data Type   | BOOLEAN                      |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 1                           |
| Default Value | 1                           |

|               |                     |
|---------------|---------------------|
| Sub-Index     | 1h                  |
| Description   | DO1-DO5 Fault State |
| Access        | RW                  |
| PDO Mapping   | No                  |
| Value Range   | 0 (OFF) or 1 (ON)   |
| Default Value | 1 (ON)              |

### 2.3.20. Object 7300h: AO Output Process Value

This object represents the process value of the output. It can be used as an input to the analog output function block when the input has been selected as controlled by a CANopen Message (per Table 15 in Section 1.5).

#### ***Object Description***

|             |                             |
|-------------|-----------------------------|
| Index       | 7300h                       |
| Name        | Analog Output Process Value |
| Object Type | ARRAY                       |
| Data Type   | INTEGER16                   |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 1h to 9h (x = 1 to 9) |
| Description   | Outx Process Value    |
| Access        | RW                    |
| PDO Mapping   | Yes                   |
| Value Range   | Integer16             |
| Default Value | No                    |

### 2.3.21. Object 6302h: AO Decimal Digits PV

This object describes the number of digits following the decimal point (i.e. resolution) of the output control data, which is interpreted with data type Integer16 in the process value object.

#### **Object Description**

|             |                      |
|-------------|----------------------|
| Index       | 6302h                |
| Name        | AO Decimal Digits PV |
| Object Type | ARRAY                |
| Data Type   | UNSIGNED8            |

#### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                      |
|---------------|----------------------|
| Sub-Index     | 1h                   |
| Description   | PO Decimal Digits PV |
| Access        | RW                   |
| PDO Mapping   | No                   |
| Value Range   | 0 to 4               |
| Default Value | 0 [A to mA]          |

|               |                         |
|---------------|-------------------------|
| Sub-Index     | 2h to 5h (x = 1 to 4)   |
| Description   | RLYOx Decimal Digits PV |
| Access        | RW                      |
| PDO Mapping   | No                      |
| Value Range   | 0 to 4                  |
| Default Value | 0 [Digital on/off]      |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 6h to 9h (x = 1 to 4) |
| Description   | AOx Decimal Digits PV |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | 0 to 4                |
| Default Value | 3 [Volt to mV]        |

### 2.3.22. Object 6310h: AO Output Type

This object specifies the type of analog output, as defined in Table 14.

#### **Object Description**

|             |                |
|-------------|----------------|
| Index       | 6310h          |
| Name        | AO Output Type |
| Object Type | ARRAY          |
| Data Type   | UNSIGNED16     |

#### **Entry Description**

|           |    |
|-----------|----|
| Sub-Index | 0h |
|-----------|----|

|               |                             |
|---------------|-----------------------------|
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |              |
|---------------|--------------|
| Sub-Index     | 1h           |
| Description   | PO Type      |
| Access        | RW           |
| PDO Mapping   | No           |
| Value Range   | See Table 14 |
| Default Value | 20 (current) |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 2h to 5h (x = 1 to 4) |
| Description   | RLYOx Type            |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | See Table 14          |
| Default Value | 1000 (digital)        |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 6h to 9h (x = 1 to 4) |
| Description   | AOx Type              |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | See Table 14          |
| Default Value | 10 (voltage)          |

### 2.3.23. Object 7320h: AO Output Scaling 1 PV

This object defines the minimum value of the input, and should be specified to equal the corresponding scaling object of the control source, as outlined in Table 17. It will be scaled in the physical unit of the control source. The resolution will ALWAYS be dependent on object 6302h AO Decimal Digits PV, even when the output is not being controlled directly by the AO Output PV object 7300h. This object must always be smaller than object 7322h AO Output Scaling 2 PV.

#### ***Object Description***

|             |                        |
|-------------|------------------------|
| Index       | 7320h                  |
| Name        | AO Output Scaling 1 PV |
| Object Type | ARRAY                  |
| Data Type   | INTEGER16              |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|             |                 |
|-------------|-----------------|
| Sub-Index   | 1h              |
| Description | PO Scaling 1 PV |

|               |              |
|---------------|--------------|
| Access        | RW           |
| PDO Mapping   | No           |
| Value Range   | See Table 17 |
| Default Value | 300 [mA]     |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 2h to 5h (x = 1 to 4) |
| Description   | RLYOx Scaling 1 PV    |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | See Table 17          |
| Default Value | 0 [off]               |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 6h to 9h (x = 1 to 4) |
| Description   | AOx Scaling 1 PV      |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | See Table 17          |
| Default Value | 0 [mV]                |

#### 2.3.24. Object 7321h: AO Output Scaling 1 FV

This object defines the output field value when the input data is at or below the AO Output Scaling 1 PV value as shown in Figure 11. It will be scaled in the physical unit of the output, dependent on type, with the resolution defined in object 6332h AO Decimal Digits FV. The value can be set anywhere within the allowable output range as outlined in Table 14. This value can be set higher than object 7323h AO Output Scaling 2 FV for an inverse response (i.e. decreasing) to an increasing input.

##### ***Object Description***

|             |                        |
|-------------|------------------------|
| Index       | 7321h                  |
| Name        | AO Output Scaling 1 FV |
| Object Type | ARRAY                  |
| Data Type   | INTEGER16              |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                                  |
|---------------|----------------------------------|
| Sub-Index     | 1h                               |
| Description   | PO Scaling 1 FV                  |
| Access        | RW                               |
| PDO Mapping   | No                               |
| Value Range   | Dependent on type (see Table 14) |
| Default Value | 300 [mA]                         |

|             |                       |
|-------------|-----------------------|
| Sub-Index   | 2h to 5h (x = 1 to 4) |
| Description | RLYOx Scaling 1 FV    |

|               |                                  |
|---------------|----------------------------------|
| Access        | RW                               |
| PDO Mapping   | No                               |
| Value Range   | Dependent on type (see Table 14) |
| Default Value | 0 [off]                          |

|               |                                  |
|---------------|----------------------------------|
| Sub-Index     | 6h to 9h (x = 1 to 4)            |
| Description   | AOx Scaling 1 FV                 |
| Access        | RW                               |
| PDO Mapping   | No                               |
| Value Range   | Dependent on type (see Table 14) |
| Default Value | 0 [mV]                           |

### 2.3.25. Object 7322h: AO Output Scaling 2 PV

This object defines the maximum value of the input, and should be specified to equal the corresponding scaling object of the control source, as outlined in Table 17. It will be scaled in the physical unit of the control source. The resolution will ALWAYS be dependent on object 6302h AO Decimal Digits PV, even when the output is not being controlled directly by the AO Output PV object 7300h. This object must always be larger than object 7322h AO Output Scaling 2 PV.

#### ***Object Description***

|             |                        |
|-------------|------------------------|
| Index       | 7322h                  |
| Name        | AO Output Scaling 2 PV |
| Object Type | ARRAY                  |
| Data Type   | INTEGER16              |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                 |
|---------------|-----------------|
| Sub-Index     | 1h              |
| Description   | PO Scaling 2 PV |
| Access        | RW              |
| PDO Mapping   | No              |
| Value Range   | See Table 17    |
| Default Value | 1500 [mA]       |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 2h to 5h (x = 1 to 4) |
| Description   | RLYOx Scaling 2 PV    |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | See Table 17          |
| Default Value | 1 [on]                |

|             |                       |
|-------------|-----------------------|
| Sub-Index   | 6h to 9h (x = 1 to 4) |
| Description | AOx Scaling 2 PV      |

|               |              |
|---------------|--------------|
| Access        | RW           |
| PDO Mapping   | No           |
| Value Range   | See Table 17 |
| Default Value | 5000 [mV]    |

### 2.3.26. Object 7323h: AO Output Scaling 2 FV

This object defines the output field value when the input data is at or above the AO Output Scaling 2 PV value as shown in Figure 11. It will be scaled in the physical unit of the output, dependent on type, with the resolution defined in object 6332h AO Decimal Digits FV. The value can be set anywhere within the allowable output range as outlined in Table 14. This value can be set lower than object 7321h AO Output Scaling 1 FV for an inverse response (i.e. decreasing) to an increasing input.

#### **Object Description**

|             |                        |
|-------------|------------------------|
| Index       | 7323h                  |
| Name        | AO Output Scaling 2 FV |
| Object Type | ARRAY                  |
| Data Type   | INTEGER16              |

#### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                                  |
|---------------|----------------------------------|
| Sub-Index     | 1h                               |
| Description   | PO Scaling 2 FV                  |
| Access        | RW                               |
| PDO Mapping   | No                               |
| Value Range   | Dependent on type (see Table 14) |
| Default Value | 1500 [mA]                        |

|               |                                  |
|---------------|----------------------------------|
| Sub-Index     | 2h to 5h (x = 1 to 4)            |
| Description   | RLYOx Scaling 2 FV               |
| Access        | RW                               |
| PDO Mapping   | No                               |
| Value Range   | Dependent on type (see Table 14) |
| Default Value | 1 [on]                           |

|               |                                  |
|---------------|----------------------------------|
| Sub-Index     | 6h to 9h (x = 1 to 4)            |
| Description   | AOx Scaling 2 FV                 |
| Access        | RW                               |
| PDO Mapping   | No                               |
| Value Range   | Dependent on type (see Table 14) |
| Default Value | 5000 [mV]                        |

### 2.3.27. Object 7330h: AO Output Field Value

This object represents the target output drive field value as a result of the output logic described in Section 1.5, and the scaling applied as shown in Figure 11. It is defined in the physical unit of the output dependent on type, as outlined in Table 14. The resolution of the object is defined in object 6332h AO Decimal Digits FV.

#### ***Object Description***

|             |                           |
|-------------|---------------------------|
| Index       | 7330h                     |
| Name        | Analog Output Field Value |
| Object Type | ARRAY                     |
| Data Type   | INTEGER16                 |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 1h to 9h (x = 1 to 9) |
| Description   | Outx Field Value      |
| Access        | RO                    |
| PDO Mapping   | Yes                   |
| Value Range   | Integer16             |
| Default Value | No                    |

### **2.3.28. Object 6332h: AO Decimal Digits FV**

This object describes the number of digits following the decimal point (i.e. resolution) of the output data, which is interpreted with data type Integer16 in the field value object.

#### ***Object Description***

|             |                      |
|-------------|----------------------|
| Index       | 6332h                |
| Name        | AO Decimal Digits FV |
| Object Type | ARRAY                |
| Data Type   | UNSIGNED8            |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                      |
|---------------|----------------------|
| Sub-Index     | 1h                   |
| Description   | PO Decimal Digits FV |
| Access        | RW                   |
| PDO Mapping   | No                   |
| Value Range   | 0 to 4               |
| Default Value | 0 [mA]               |

|               |                         |
|---------------|-------------------------|
| Sub-Index     | 2h to 5h (x = 1 to 4)   |
| Description   | RLYOx Decimal Digits FV |
| Access        | RW                      |
| PDO Mapping   | No                      |
| Value Range   | 0 to 4                  |
| Default Value | 0 [digital on/off]      |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 6h to 9h (x = 1 to 4) |
| Description   | AOx Decimal Digits FV |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | 0 to 4                |
| Default Value | 3 [mV]                |

### 2.3.29. Object 6340h: AO Fault Mode

This object defines how an output shall response when a fault condition is detected on any control input, as described in Table 21.

#### ***Object Description***

|             |               |
|-------------|---------------|
| Index       | 6340h         |
| Name        | AO Fault Mode |
| Object Type | ARRAY         |
| Data Type   | UNSIGNED8     |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                          |
|---------------|--------------------------|
| Sub-Index     | 1h to 9h (x = 1 to 9)    |
| Description   | Outx Fault Mode          |
| Access        | RW                       |
| PDO Mapping   | No                       |
| Value Range   | See Table 21             |
| Default Value | 1 (apply pre-defined FV) |

### 2.3.30. Object 7341h: AO Fault Field Value

This object contains the pre-defined field value of an analog output when a fault condition is present, and the corresponding sub-index in object 7341h is enabled. It will be scaled in the physical unit of the output, dependent on type, with the resolution defined in object 6332h AO Decimal Digits FV.

#### ***Object Description***

|             |                      |
|-------------|----------------------|
| Index       | 7341h                |
| Name        | AO Fault Field Value |
| Object Type | ARRAY                |

|           |           |
|-----------|-----------|
| Data Type | INTEGER16 |
|-----------|-----------|

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                                  |
|---------------|----------------------------------|
| Sub-Index     | 1h                               |
| Description   | PO Fault Field Value             |
| Access        | RW                               |
| PDO Mapping   | No                               |
| Value Range   | Dependent on type (see Table 14) |
| Default Value | 500 [mA]                         |

|               |                         |
|---------------|-------------------------|
| Sub-Index     | 2h to 5h (x = 1 to 4)   |
| Description   | RLYOx Fault Field Value |
| Access        | RW                      |
| PDO Mapping   | No                      |
| Value Range   | -                       |
| Default Value | 1 [on]                  |

|               |                                  |
|---------------|----------------------------------|
| Sub-Index     | 6h to 9h (x = 1 to 4)            |
| Description   | AOx Fault Field Value            |
| Access        | RW                               |
| PDO Mapping   | No                               |
| Value Range   | Dependent on type (see Table 14) |
| Default Value | 1000 [mV]                        |

### **2.3.31. Object 7450h: PID Proportional Band**

This object describes the proportional band gain (G in Figure 14) of the PID algorithm. The value is always interpreted as having a resolution of one digit after the decimal place.

#### ***Object Description***

|             |                       |
|-------------|-----------------------|
| Index       | 7450h                 |
| Name        | PID Proportional Band |
| Object Type | ARRAY                 |
| Data Type   | INTEGER16             |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|             |                        |
|-------------|------------------------|
| Sub-Index   | 1h to 2h (x = 1 to 2)  |
| Description | PIDx Proportional Gain |

|               |                      |
|---------------|----------------------|
| Access        | RW                   |
| PDO Mapping   | No                   |
| Value Range   | 0 to 100 (0 to 10.0) |
| Default Value | 5 [0.5]              |

### 2.3.32. Object 7452h: PID Integral Action Time

This object describes the integral time ( $T_i$  in Figure 14) of the PID algorithm. The physical unit is always seconds, as defined in object 6458h, with the decimal digits (resolution) given in object 6459h. To prevent instability, it is recommended to never set this less than three times higher than object 7454h ( $T_d$  in Figure 14).

#### **Object Description**

|             |                          |
|-------------|--------------------------|
| Index       | 7452h                    |
| Name        | PID Integral Action Time |
| Object Type | ARRAY                    |
| Data Type   | INTEGER16                |

#### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|               |                              |
|---------------|------------------------------|
| Sub-Index     | 1h to 2h ( $x = 1$ to 2)     |
| Description   | PID $x$ Integral Time        |
| Access        | RW                           |
| PDO Mapping   | No                           |
| Value Range   | 0.001 [sec] to 1000.00 [sec] |
| Default Value | 5 [ms or 0.005sec]           |

### 2.3.33. Object 7454h: PID Derivative Action Time

This object describes the derivative time ( $T_d$  in Figure 14) of the PID algorithm. The physical unit is always seconds, as defined in object 6458h, with the decimal digits (resolution) given in object 6459h. To prevent instability, it is recommended to never set this more than three times smaller than object 7452h ( $T_i$  in Figure 14).

#### **Object Description**

|             |                            |
|-------------|----------------------------|
| Index       | 7454h                      |
| Name        | PID Derivative Action Time |
| Object Type | ARRAY                      |
| Data Type   | INTEGER16                  |

#### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|               |                              |
|---------------|------------------------------|
| Sub-Index     | 1h to 2h (x = 1 to 2)        |
| Description   | PIDx Derivative Time         |
| Access        | RW                           |
| PDO Mapping   | No                           |
| Value Range   | 0.001 [sec] to 1000.00 [sec] |
| Default Value | 1 [ms or 0.001sec]           |

### 2.3.34. Object 7456h: PID Cycle Time

This object defines how frequently the PID loop is called. The physical unit is always seconds, as defined in object 6458h, with the decimal digits (resolution) given in object 6459h.

#### **Object Description**

|             |                |
|-------------|----------------|
| Index       | 7456h          |
| Name        | PID Cycle Time |
| Object Type | ARRAY          |
| Data Type   | INTEGER16      |

#### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|               |                              |
|---------------|------------------------------|
| Sub-Index     | 1h to 2h (x = 1 to 2)        |
| Description   | PIDx Cycle Time              |
| Access        | RW                           |
| PDO Mapping   | No                           |
| Value Range   | 0.001 [sec] to 1000.00 [sec] |
| Default Value | 10 [ms or 0.010sec]          |

### 2.3.35. Object 6458h: PID Physical Unit Timing

This read-only object defines the physical unit of objects 7452h, 7454h and 7456h. It represents “seconds” as the unit used in all cases.

#### **Object Description**

|             |                          |
|-------------|--------------------------|
| Index       | 6458h                    |
| Name        | PID Physical Unit Timing |
| Object Type | ARRAY                    |
| Data Type   | UNSIGNED32               |

#### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|           |                       |
|-----------|-----------------------|
| Sub-Index | 1h to 2h (x = 1 to 2) |
|-----------|-----------------------|

|               |                           |
|---------------|---------------------------|
| Description   | PIDx Physical Unit Timing |
| Access        | RO                        |
| PDO Mapping   | No                        |
| Value Range   | 0003 0000h                |
| Default Value | 0003 0000h (seconds)      |

### 2.3.36. Object 6459h: PID Decimal Digits Timing

This object describes the number of digits following the decimal point (i.e. resolution) of the PID timing data, which is interpreted with data type Integer16 in objects 7452h, 7454h and 7456h.

#### ***Object Description***

|             |                           |
|-------------|---------------------------|
| Index       | 6459h                     |
| Name        | PID Decimal Digits Timing |
| Object Type | ARRAY                     |
| Data Type   | UNSIGNED8                 |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|               |                            |
|---------------|----------------------------|
| Sub-Index     | 1h to 2h (x = 1 to 2)      |
| Description   | PIDx Decimal Digits Timing |
| Access        | RW                         |
| PDO Mapping   | No                         |
| Value Range   | 0 to 4                     |
| Default Value | 3 [default ms]             |

## 2.4. MANUFACTURER OBJECTS

| <b>Index<br/>(hex)</b> | <b>Object</b>                               | <b>Object<br/>Type</b> | <b>Data Type</b> | <b>Access</b> | <b>PDO<br/>Mapping</b> |
|------------------------|---------------------------------------------|------------------------|------------------|---------------|------------------------|
| 2020                   | DI Pull Up/Down Mode 1 Input Line           | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 2030                   | DI Debounce Filter 1 Input Line             | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 2100                   | AI Input Range                              | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 2101                   | AI Number of Pulses Per Revolution          | ARRAY                  | UNSIGNED16       | RW            | No                     |
| 2102                   | AI Decimal Digits FV                        | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 2103                   | AI Filter Frequency for ADC                 | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 2110                   | AI Error Detect Enable                      | ARRAY                  | BOOLEAN          | RW            | No                     |
| 2111                   | AI Error Clear Hysteresis                   | ARRAY                  | INTEGER16        | RW            | No                     |
| 2112                   | AI Error Reaction Delay                     | ARRAY                  | UNSIGNED16       | RW            | No                     |
| 2120                   | AI Third-Order Filter Power                 | ARRAY                  | UNSIGNED16       | RW            | No                     |
| 2121                   | AI Third-Order Filter Input Coefficient N0  | ARRAY                  | INTEGER16        | RW            | No                     |
| 2122                   | AI Third-Order Filter Input Coefficient N1  | ARRAY                  | INTEGER16        | RW            | No                     |
| 2123                   | AI Third-Order Filter Input Coefficient N2  | ARRAY                  | INTEGER16        | RW            | No                     |
| 2124                   | AI Third-Order Filter Input Coefficient N3  | ARRAY                  | INTEGER16        | RW            | No                     |
| 2125                   | AI Third-Order Filter Output Coefficient N1 | ARRAY                  | INTEGER16        | RW            | No                     |
| 2126                   | AI Third-Order Filter Output Coefficient N2 | ARRAY                  | INTEGER16        | RW            | No                     |
| 2127                   | AI Third-Order Filter Output Coefficient N3 | ARRAY                  | INTEGER16        | RW            | No                     |
| 2220                   | DO Hotshot Current 1 Output Line            | ARRAY                  | INTEGER16        | RW            | No                     |
| 2221                   | DO Hold Current 1 Output Line               | ARRAY                  | INTEGER16        | RW            | No                     |
| 2222                   | DO Hotshot Time 1 Output Line               | ARRAY                  | UNSIGNED16       | RW            | No                     |
| 2223                   | DO Blink Rate 1 Output Line                 | ARRAY                  | UNSIGNED16       | RW            | No                     |
| 2224                   | DO Delay Time 1 Output Line                 | ARRAY                  | UNSIGNED16       | RW            | No                     |
| 2225                   | DO Delay Polarity 1 Output Line             | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 2300                   | AO Override Field Value                     | ARRAY                  | INTEGER16        | RW            | No                     |
| 2310                   | AO Error Detect Enable                      | ARRAY                  | BOOLEAN          | RW            | No                     |
| 2311                   | AO Error Clear Hysteresis                   | ARRAY                  | INTEGER16        | RW            | No                     |
| 2312                   | AO Error Reaction Delay                     | ARRAY                  | UNSIGNED16       | RW            | No                     |
| 2320                   | AO Dither Frequency                         | ARRAY                  | UNSIGNED16       | RW            | No                     |
| 2321                   | AO Dither Amplitude                         | ARRAY                  | UNSIGNED16       | RW            | No                     |
| 2330                   | AO Ramp Up                                  | ARRAY                  | UNSIGNED16       | RW            | No                     |
| 2331                   | AO Ramp Down                                | ARRAY                  | UNSIGNED16       | RW            | No                     |
| 2340                   | AO Control Input Source                     | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 2341                   | AO Control Input Number                     | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 2342                   | AO Control Response                         | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 2350                   | AO Enable Input Source                      | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 2351                   | AO Enable Input Number                      | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 2352                   | AO Enable Response                          | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 2360                   | AO Override Input Source                    | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 2361                   | AO Override Input Number                    | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 2362                   | AO Override Response                        | ARRAY                  | UNSIGNED8        | RW            | No                     |
| 2370                   | AO Feedback Field Value                     | ARRAY                  | INTEGER16        | RO            | Yes                    |
| 2380                   | AO Output Frequency                         | ARRAY                  | UNSIGNED16       | RW            | No                     |
| 2382                   | AO Current PID Proportional Gain            | ARRAY                  | FLOAT32          | RW            | No                     |
| 2383                   | AO Current PID Integral Time                | ARRAY                  | FLOAT32          | RW            | No                     |
| 2384                   | AO Current PID Derivative Time              | ARRAY                  | FLOAT32          | RW            | No                     |
| 2450                   | PID Tolerance                               | ARRAY                  | INTEGER16        | RW            | No                     |
| 2451                   | PID Integral Gain                           | ARRAY                  | INTEGER16        | RW            | No                     |
| 2452                   | PID Derivative Gain                         | ARRAY                  | INTEGER16        | RW            | No                     |
| 2453                   | PID Target Source                           | ARRAY                  | UNSIGNED8        | RW            | No                     |

|      |                                           |        |            |    |     |
|------|-------------------------------------------|--------|------------|----|-----|
| 2454 | PID Target Number                         | ARRAY  | UNSIGNED8  | RW | No  |
| 2455 | PID Feedback Source                       | ARRAY  | UNSIGNED8  | RW | No  |
| 2456 | PID Feedback Number                       | ARRAY  | UNSIGNED8  | RW | No  |
| 2457 | PID Control Response                      | ARRAY  | UNSIGNED8  | RW | No  |
| 2460 | PID Output Field Value                    | ARRAY  | INTEGER16  | RO | Yes |
| 2500 | EC Extra Received Process Value           | ARRAY  | INTEGER16  | RW | Yes |
| 2502 | EC Decimal Digits PV                      | ARRAY  | UNSIGNED8  | RW | No  |
| 2520 | EC Scaling 1 PV                           | ARRAY  | INTEGER16  | RW | No  |
| 2522 | EC Scaling 2 PV                           | ARRAY  | INTEGER16  | RW | No  |
| 3yz0 | LTyz Input X-Axis Source                  | VAR    | UNSIGNED8  | RW | No  |
| 3yz1 | LTyz Input X-Axis Number                  | VAR    | UNSIGNED8  | RW | No  |
| 3yz2 | LTyz Auto Repeat                          | VAR    | UNSIGNED8  | RW | No  |
| 3yz3 | LTyz X-Axis Decimal Digits PV             | VAR    | UNSIGNED8  | RW | No  |
| 3yz4 | LTyz Y-Axis Decimal Digits PV             | VAR    | UNSIGNED8  | RW | No  |
| 3yz5 | LTyz Point Response                       | ARRAY  | UNSIGNED8  | RW | No  |
| 3yz6 | LTyz Point X-Axis PV                      | ARRAY  | INTEGER32  | RW | No  |
| 3yz7 | LTyz Point Y-Axis PV                      | ARRAY  | INTEGER16  | RW | No  |
| 3yz8 | LTyz Output Y-Axis PV                     | VAR    | INTEGER16  | RO | Yes |
| 3300 | Logic Block Enable                        | ARRAY  | BOOLEAN    | RW | No  |
| 3310 | Logic Block Selected Table                | ARRAY  | UNSIGNED8  | RO | Yes |
| 3320 | Logic Output Process Value                | ARRAY  | INTEGER16  | RO | Yes |
| 3x01 | LB(3-x) Lookup Table Number               | ARRAY  | UNSIGNED8  | RW | No  |
| 3x02 | LB(3-x) Function Logical Operator         | ARRAY  | UNSIGNED8  | RW | No  |
| 3x11 | LB(3-x) Function A Condition 1            | RECORD | UNSIGNED8  | RW | No  |
| 3x12 | LB(3-x) Function A Condition 2            | RECORD | UNSIGNED8  | RW | No  |
| 3x13 | LB(3-x) Function A Condition 3            | RECORD | UNSIGNED8  | RW | No  |
| 3x21 | LB(3-x) Function B Condition 1            | RECORD | UNSIGNED8  | RW | No  |
| 3x22 | LB(3-x) Function B Condition 2            | RECORD | UNSIGNED8  | RW | No  |
| 3x23 | LB(3-x) Function B Condition 3            | RECORD | UNSIGNED8  | RW | No  |
| 3x31 | LB(3-x) Function C Condition 1            | RECORD | UNSIGNED8  | RW | No  |
| 3x32 | LB(3-x) Function C Condition 2            | RECORD | UNSIGNED8  | RW | No  |
| 3x33 | LB(3-x) Function C Condition 3            | RECORD | UNSIGNED8  | RW | No  |
| 4500 | Math Block Enable                         | ARRAY  | BOOLEAN    | RW | No  |
| 4521 | Math Output Scaling 1 PV                  | ARRAY  | INTEGER16  | RW | No  |
| 4523 | Math Output Scaling 2 PV                  | ARRAY  | INTEGER16  | RW | No  |
| 4530 | Math Output Process Value                 | ARRAY  | INTEGER16  | RO | Yes |
| 4532 | Math Output Decimal Digits PV             | ARRAY  | UNSIGNED8  | RW | No  |
| 4y00 | Math Y Input Source                       | ARRAY  | UNSIGNED8  | RW | No  |
| 4y01 | Math Y Input Number                       | ARRAY  | UNSIGNED8  | RW | No  |
| 4y02 | Math Y Function Number                    | ARRAY  | UNSIGNED8  | RW | No  |
| 4y03 | Math Y Input Decimal Digits FV            | ARRAY  | UNSIGNED8  | RW | No  |
| 4y20 | Math Y Input Scaling 1 FV                 | ARRAY  | INTEGER16  | RW | No  |
| 4y22 | Math Y Input Scaling 2 FV                 | ARRAY  | INTEGER16  | RW | No  |
| 4y40 | Math Y Input Gain                         | ARRAY  | INTEGER8   | RW | No  |
| 4y50 | Math Y Operator                           | ARRAY  | UNSIGNED8  | RW | No  |
| 5010 | Constant Field Value                      | ARRAY  | FLOAT32    | RW | No  |
| 5040 | Fault Detection Field Value               | ARRAY  | UNSIGNED16 | RO | Yes |
| 5041 | Fault Detection Set Threshold             | ARRAY  | UNSIGNED16 | RW | No  |
| 5042 | Fault Detection Clear Threshold           | ARRAY  | UNSIGNED16 | RW | No  |
| 5050 | Fault Detection Enable Err Check 8 Faults | ARRAY  | UNSIGNED8  | RW | No  |
| 5041 | Fault Detection Error Response Delay      | ARRAY  | UNSIGNED16 | RW | No  |
| 5555 | Start in Operational Mode                 | VAR    | BOOLEAN    | RW | No  |

Where **yz** = 01 to 09 (LUT 1 to 09) and **x** = 4 to 5 (Logic 1 to 2) and **y** = 1 to 6 (Math 1 to 6)

#### 2.4.1. Object 2020h: DI Pullup/Down Mode 1 Input Line

This object determines how the state read on the input pin corresponds to the logic state, in conjunction with application object 6020h, as defined in Table 3. The options for this object are listed in Table 1, and the controller will adjust the input hardware according to what is specified.

##### **Object Description**

|             |                                  |
|-------------|----------------------------------|
| Index       | 2020h                            |
| Name        | DI Pullup/Down Mode 1 Input Line |
| Object Type | ARRAY                            |
| Data Type   | UNSIGNED8                        |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 1h to Bh (x = 1 or 11)      |
| Description   | Digital Input X Pullup/Down |
| Access        | RW                          |
| PDO Mapping   | No                          |
| Value Range   | See Table 1                 |
| Default Value | 0 (pullup/down disabled)    |

#### 2.4.2. Object 2030h: DI Debounce Filter 1 Input Line

This object will debounce the input signal applied on a single digital input as shown in Figure 4. The options for this object are listed in Table 2.

##### **Object Description**

|             |                                 |
|-------------|---------------------------------|
| Index       | 2020h                           |
| Name        | DI Debounce Filter 1 Input Line |
| Object Type | ARRAY                           |
| Data Type   | UNSIGNED8                       |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 1h to Bh (x = 1 to 11)      |
| Description   | Digital Input X Pullup/Down |
| Access        | RW                          |
| PDO Mapping   | No                          |
| Value Range   | See Table 2                 |
| Default Value | 2 [Filter 1.78 us]          |

### 2.4.3. Object 2100h: AI Input Range

This object, in conjunction with 6110h AI Sensor Type, defines the analog input defaults (Table 10) and allowable ranges (Table 11) for objects 2111h, 7120h, 7122h, 7148h and 7149h. The number and types of ranges will vary according to what type of sensor is connected to the input, as described in Table 17.

#### ***Object Description***

|             |                |
|-------------|----------------|
| Index       | 2100h          |
| Name        | AI Input Range |
| Object Type | ARRAY          |
| Data Type   | UNSIGNED8      |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                        |
|---------------|------------------------|
| Sub-Index     | 1h to Ah (x = 1 to 10) |
| Description   | Input X Range          |
| Access        | RW                     |
| PDO Mapping   | No                     |
| Value Range   | See Table 17           |
| Default Value | 2 [0-5V]               |

|               |                      |
|---------------|----------------------|
| Sub-Index     | Bh                   |
| Description   | Magnetic Input Range |
| Access        | RW                   |
| PDO Mapping   | No                   |
| Value Range   | See Table 17         |
| Default Value | 1 [100Hz to 1kHz]    |

### 2.4.4. Object 2101h: AI Number of Pulses Per Revolution

This object is only used when a “Frequency” input type has been selected by object 6110h. The controller will automatically convert frequency measurement from Hz to RPM when a non-zero value is specified. In this case, objects 2111h, 7120h, 7122h, 7148h and 7149h will be interpreted as RPM data. Object 2100h AI Input Range must still be specified in Hertz, and should be selected according to the expected frequencies that the RPM sensor will operate in.

#### ***Object Description***

|             |                                    |
|-------------|------------------------------------|
| Index       | 2101h                              |
| Name        | AI Number of Pulses Per Revolution |
| Object Type | ARRAY                              |
| Data Type   | UNSIGNED16                         |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                               |
|---------------|-------------------------------|
| Sub-Index     | 1h to Bh (x = 1 to 11)        |
| Description   | Input x Pulses per Revolution |
| Access        | RW                            |
| PDO Mapping   | No                            |
| Value Range   | 0 to 1000                     |
| Default Value | 1                             |

#### 2.4.5. Object 2102h: AI Decimal Digits FV

This object describes the number of digits following the decimal point (i.e. resolution) of the input data, which is interpreted with data type Integer16 in the field value object.

Example: A field value of 1.230 (Float) will be coded as 1230 in Integer16 format if the number of decimal digits is set to 3.

In addition to the FV object 7100h, objects 2111h, 7120h, 7122h, 7148h and 7149h will also be specified with this resolution. This object is normally read-only, and will be automatically adjusted by the controller as per Table 9 depending on the analog input type and range that has been selected. When object 5550h is set to FALSE (disables automatic updates), this object becomes writeable.

##### ***Object Description***

|             |                      |
|-------------|----------------------|
| Index       | 2102h                |
| Name        | AI Decimal Digits FV |
| Object Type | ARRAY                |
| Data Type   | UNSIGNED8            |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                                      |
|---------------|--------------------------------------|
| Sub-Index     | 1h to Ah (x = 1 to 10)               |
| Description   | Inputx Decimal Digits FV             |
| Access        | RW (only when object 5550h is false) |
| PDO Mapping   | No                                   |
| Value Range   | See Table 9                          |
| Default Value | 3 [Volt to mV]                       |

|           |    |
|-----------|----|
| Sub-Index | Bh |
|-----------|----|

|               |                                      |
|---------------|--------------------------------------|
| Description   | MI Decimal Digits FV                 |
| Access        | RW (only when object 5550h is false) |
| PDO Mapping   | No                                   |
| Value Range   | See Table 9                          |
| Default Value | 1 [0.1 RPM]                          |

#### 2.4.6. Object 2103h: AI Filter Frequency for ADC

This object is used to specify the cutoff filter frequency for the ADC peripheral on the processor. The analog-to-digital converter is used with analog input types: voltage; current; and resistive. It is also used to measure: analog output current feedback; power supply voltage, and processor temperature. The available filters are listed in Table 7.

##### ***Object Description***

|             |                             |
|-------------|-----------------------------|
| Index       | 2104h                       |
| Name        | AI Filter Frequency for ADC |
| Object Type | ARRAY                       |
| Data Type   | UNSIGNED8                   |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                          |
|---------------|--------------------------|
| Sub-Index     | 1h to Bh (x = 1 to 11)   |
| Description   | AIx ADC Filter Frequency |
| Access        | RW                       |
| PDO Mapping   | No                       |
| Value Range   | See Table 7              |
| Default Value | 1 [Filter 50Hz]          |

#### 2.4.7. Object 2110h: AI Error Detect Enable

This object enables error detection and reaction associated with the analog input function block. When disabled, the input will not generate an EMCY code in object 1003h Pre-Defined Error Field, nor will it disable any output controlled by the input should the input go out of range as defined by the objects 7148h AI Span Start and 7149h AI Span End.

##### ***Object Description***

|             |                        |
|-------------|------------------------|
| Index       | 2110h                  |
| Name        | AI Error Detect Enable |
| Object Type | ARRAY                  |
| Data Type   | BOOLEAN                |

##### ***Entry Description***

|             |                             |
|-------------|-----------------------------|
| Sub-Index   | 0h                          |
| Description | Largest sub-index supported |

|               |    |
|---------------|----|
| Access        | RO |
| PDO Mapping   | No |
| Value Range   | 11 |
| Default Value | 11 |

|               |                            |
|---------------|----------------------------|
| Sub-Index     | 1h to Bh (x = 1 to 11)     |
| Description   | Inputx Error Detect Enable |
| Access        | RW                         |
| PDO Mapping   | No                         |
| Value Range   | 0 (FALSE) or 1 (TRUE)      |
| Default Value | 1 [TRUE]                   |

#### 2.4.8. Object 2111h: AI Error Clear Hysteresis

This object is used to prevent rapid activation/clearing of an input fault flag, and sending of object 1003h to the CANopen ® network. Once the input has gone above/below the thresholds that define the valid operating range, it must come back into range minus/plus this value to clear the fault. It is scaled in the physical unit of the FV, i.e. object 2102h applies to this object.

##### **Object Description**

|             |                           |
|-------------|---------------------------|
| Index       | 2111h                     |
| Name        | AI Error Clear Hysteresis |
| Object Type | ARRAY                     |
| Data Type   | INTEGER16                 |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                               |
|---------------|-------------------------------|
| Sub-Index     | 1h to Ah (x = 1 to 10)        |
| Description   | Inputx Error Clear Hysteresis |
| Access        | RW                            |
| PDO Mapping   | No                            |
| Value Range   | See Table 11                  |
| Default Value | 100 [mV]                      |

|               |                           |
|---------------|---------------------------|
| Sub-Index     | Bh                        |
| Description   | MI Error Clear Hysteresis |
| Access        | RW                        |
| PDO Mapping   | No                        |
| Value Range   | See Table 11              |
| Default Value | 100 [0.1 RPM]             |

#### 2.4.9. Object 2112h: AI Error Reaction Delay

This object is used to filter out spurious signals and to prevent saturating the CANopen ® network with broadcasts of object 1003h as the fault is set/cleared. Before the fault is recognized (i.e. the EMCY code is added to the pre-defined error field list), it must remain active throughout the period of time defined in this object. The physical unit for this object is milliseconds.

##### **Object Description**

|             |                         |
|-------------|-------------------------|
| Index       | 2112h                   |
| Name        | AI Error Reaction Delay |
| Object Type | ARRAY                   |
| Data Type   | UNSIGNED16              |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                          |
|---------------|--------------------------|
| Sub-Index     | 1h to Bh (x = 1 to 11)   |
| Description   | AIx Error Reaction Delay |
| Access        | RW                       |
| PDO Mapping   | No                       |
| Value Range   | 0 to 60,000              |
| Default Value | 1000 [ms]                |

#### 2.4.10. Object 2120h: AI Third-Order Filter Power

Third order filtering of the input data is done using 16-bit fixed point math. This object tells the controller the shift value (i.e.  $2^x$ ) that was used when the coefficients were selected. See Section 1.3 for more information on the third-order low pass filter.

##### **Object Description**

|             |                             |
|-------------|-----------------------------|
| Index       | 2120h                       |
| Name        | AI Third-Order Filter Power |
| Object Type | ARRAY                       |
| Data Type   | UNSIGNED16                  |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|             |                                 |
|-------------|---------------------------------|
| Sub-Index   | 1h to Bh (x = 1 to 11)          |
| Description | Inputx Third-Order Filter Power |

|               |                        |
|---------------|------------------------|
| Access        | RW                     |
| PDO Mapping   | No                     |
| Value Range   | 0 to 16                |
| Default Value | 10 [ $2^{10} = 1024$ ] |

**2.4.11. Object 2121h: AI Third-Order Filter Input Coefficient N0**

**2.4.12. Object 2122h: AI Third-Order Filter Input Coefficient N1**

**2.4.13. Object 2123h: AI Third-Order Filter Input Coefficient N2**

**2.4.14. Object 2124h: AI Third-Order Filter Input Coefficient N3**

These objects specify the 16-bit shifted input co-efficient values used in the third-order low pass filter calculation described in Section 1.3. They are all defined with a right shift value of  $2^{10}$ . Since coefficient N3 is set to zero, the default filter is a second-order low pass.

***Object Description***

|             |                                                      |
|-------------|------------------------------------------------------|
| Index       | 2121h to 2124h (x = 0 to 3)                          |
| Name        | AI 3 <sup>rd</sup> Order Filter Input Coefficient Nx |
| Object Type | ARRAY                                                |
| Data Type   | INTEGER16                                            |

***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                                                 |
|---------------|-------------------------------------------------|
| Sub-Index     | 1h to Bh (y = 1 to 11)                          |
| Description   | AIy 3 <sup>rd</sup> Order Filter Input Coeff Nx |
| Access        | RW                                              |
| PDO Mapping   | No                                              |
| Value Range   | -10000 to 10000                                 |
| Default Value | N0=120, N1=241, N2=120, N3=0                    |

**2.4.15. Object 2125h: AI Third-Order Filter Output Coefficient N1**

**2.4.16. Object 2126h: AI Third-Order Filter Output Coefficient N2**

**2.4.17. Object 2127h: AI Third-Order Filter Output Coefficient N3**

These objects specify the 16-bit shifted output co-efficient values used in the third-order low pass filter calculation described in Section 1.3. They are all defined with a right shift value of  $2^{10}$ . Since coefficient N3 is set to zero, the default filter is a second-order low pass.

***Object Description***

|             |                                                       |
|-------------|-------------------------------------------------------|
| Index       | 2125h to 2127h (x = 1 to 3)                           |
| Name        | AI 3 <sup>rd</sup> Order Filter Output Coefficient Nx |
| Object Type | ARRAY                                                 |
| Data Type   | INTEGER16                                             |

**Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                                                  |
|---------------|--------------------------------------------------|
| Sub-Index     | 1h to Bh (y = 1 to 11)                           |
| Description   | Aly 3 <sup>rd</sup> Order Filter Output Coeff Nx |
| Access        | RW                                               |
| PDO Mapping   | No                                               |
| Value Range   | -10000 to 10000                                  |
| Default Value | N1=704, N2=-164, N3=0                            |

**2.4.18. Object 2220h: DO Hotshot Current 1 Output Line**

This object is used to define the hotshot current that will be applied for the hotshot time when an output configured as a digital hotshot is turned ON. See Figure 9 for more information. The physical unit is mA, and it uses the same resolution as the AO Output FV, so object 6332 AO Decimal Digits FV applies.

**Object Description**

|             |                                  |
|-------------|----------------------------------|
| Index       | 2220h                            |
| Name        | DO Hotshot Current 1 Output Line |
| Object Type | ARRAY                            |
| Data Type   | INTEGER16                        |

**Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                                                 |
|---------------|-------------------------------------------------|
| Sub-Index     | 1h                                              |
| Description   | DO1 Hotshot Current                             |
| Access        | RW                                              |
| PDO Mapping   | No                                              |
| Value Range   | 2221h (Hold Current) to I <sub>max</sub> (2.5A) |
| Default Value | 2000 [mA]                                       |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 2h to 5h (x = 1 to 4) |
| Description   | RLYOx Hotshot Current |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | NA                    |
| Default Value | 0                     |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 6h to 9h (x = 1 to 4) |
| Description   | AOx Hotshot Current   |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | NA                    |
| Default Value | 0                     |

#### 2.4.19. Object 2221h: DO Hold Current 1 Output Line

This object is used to define the hold current that will be maintained after the hotshot time while an output configured as a digital hotshot is ON. See Figure 9 for more information. The physical unit is mA, and it uses the same resolution as the AO Output FV, so object 6332 AO Decimal Digits FV applies.

##### **Object Description**

|             |                               |
|-------------|-------------------------------|
| Index       | 2221h                         |
| Name        | DO Hold Current 1 Output Line |
| Object Type | ARRAY                         |
| Data Type   | INTEGER16                     |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                              |
|---------------|------------------------------|
| Sub-Index     | 1h                           |
| Description   | DO Hold Current              |
| Access        | RW                           |
| PDO Mapping   | No                           |
| Value Range   | 0 to 2220h (Hotshot Current) |
| Default Value | 500 [mA]                     |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 2h to 5h (x = 1 to 4) |
| Description   | RLYOx Hold Current    |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | NA                    |
| Default Value | 0                     |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 6h to 9h (x = 1 to 4) |
| Description   | AOx Hold Current      |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | NA                    |
| Default Value | 0                     |

#### 2.4.20. Object 2222h: DO Hold Time 1 Output Line

This object is used to define the time that the hotshot current will be applied when an output configured as a digital hotshot is turned ON. See Figure 9 for more information. The physical unit is milliseconds.

##### ***Object Description***

|             |                               |
|-------------|-------------------------------|
| Index       | 2222h                         |
| Name        | DO Hotshot Time 1 Output Line |
| Object Type | ARRAY                         |
| Data Type   | UNSIGNED16                    |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                  |
|---------------|------------------|
| Sub-Index     | 1h               |
| Description   | DOx Hotshot Time |
| Access        | RW               |
| PDO Mapping   | No               |
| Value Range   | 0 to 60,000      |
| Default Value | 1000 [ms]        |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 2h to 5h (x = 1 to 4) |
| Description   | RLYOx Hotshot Time    |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | NA                    |
| Default Value | 0                     |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 6h to 9h (x = 1 to 4) |
| Description   | AOx Hotshot Time      |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | NA                    |
| Default Value | 0                     |

#### 2.4.21. Object 2224h: DO Delay Time 1 Output Line

This object is used only when an ON/OFF digital output has been specified for a normal ON/OFF response by object 6202h DO Polarity (only applies to Normal ON/OFF). While the DO is commanded, the output will remain in the previous state until the time specified in this object has elapsed prior to changing to the commanded state. The physical unit is milliseconds. The polarity for which the delay will take effect is specified by object 2225h.

**Object Description**

|             |                           |
|-------------|---------------------------|
| Index       | 2225h                     |
| Name        | DO Delay Time Output Line |
| Object Type | ARRAY                     |
| Data Type   | UNSIGNED16                |

**Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 1h to 9h (x = 1 to 9) |
| Description   | Outx Delay Time       |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | 0 to 60,000           |
| Default Value | 0 [ms]                |

**2.4.22. Object 2225h: DO Delay Polarity 1 Output Line**

This object is used only when an ON/OFF digital output has been specified for a normal ON/OFF response by object 6240h DO Polarity (only applies to Normal ON/OFF). While the DO is commanded to the state specified by this object, the output will remain in the previous state until the time specified by object 2224h has elapsed prior to driving the output to the commanded state.

**Object Description**

|             |                           |
|-------------|---------------------------|
| Index       | 2225h                     |
| Name        | DO Delay Time Output Line |
| Object Type | ARRAY                     |
| Data Type   | UNSIGNED8                 |

**Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 1h to 9h (x = 1 to 9) |
| Description   | Outx Delay Time       |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | 0 (OFF) to 1 (ON)     |
| Default Value | 1 [ON]                |

#### 2.4.23. Object 2300h: AO Override Field Value

This object contains the pre-defined field value of an analog output when an override condition is active. It will be scaled in the physical unit of the output, dependent on type, with the resolution defined in object 6332h AO Decimal Digits FV.

##### **Object Description**

|             |                |
|-------------|----------------|
| Index       | 2300h          |
| Name        | AO Override FV |
| Object Type | ARRAY          |
| Data Type   | INTEGER16      |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                                  |
|---------------|----------------------------------|
| Sub-Index     | 1h                               |
| Description   | PO Override FV                   |
| Access        | RW                               |
| PDO Mapping   | No                               |
| Value Range   | Dependent on type (see Table 14) |
| Default Value | 750 [mA]                         |

|               |                                  |
|---------------|----------------------------------|
| Sub-Index     | 2h to 5h (x = 1 to 4)            |
| Description   | RLYOx Override FV                |
| Access        | RW                               |
| PDO Mapping   | No                               |
| Value Range   | Dependent on type (see Table 14) |
| Default Value | 1 [on]                           |

|               |                                  |
|---------------|----------------------------------|
| Sub-Index     | 6h to 9h (x = 1 to 4)            |
| Description   | AOx Override FV                  |
| Access        | RW                               |
| PDO Mapping   | No                               |
| Value Range   | Dependent on type (see Table 14) |
| Default Value | 0 [mV]                           |

#### 2.4.24. Object 2310h: AO Error Detect Enable

This object enables error detection and reaction associated with the analog output function block. When disabled, the input will not generate an EMCY code in object 1003h Pre-Defined Error Field should the control detect an open/short circuit at the load.

##### **Object Description**

|       |                        |
|-------|------------------------|
| Index | 2310h                  |
| Name  | AO Error Detect Enable |

|             |         |
|-------------|---------|
| Object Type | ARRAY   |
| Data Type   | BOOLEAN |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                        |
|---------------|------------------------|
| Sub-Index     | 1h                     |
| Description   | PO Error Detect Enable |
| Access        | RW                     |
| PDO Mapping   | No                     |
| Value Range   | 0 (FALSE) or 1 (TRUE)  |
| Default Value | 1 [TRUE]               |

|               |                           |
|---------------|---------------------------|
| Sub-Index     | 2h to 5h (x = 1 to 4)     |
| Description   | RLYOx Error Detect Enable |
| Access        | RW                        |
| PDO Mapping   | No                        |
| Value Range   | 0 (FALSE) or 1 (TRUE)     |
| Default Value | 0 [FALSE]                 |

|               |                         |
|---------------|-------------------------|
| Sub-Index     | 6h to 9h (x = 1 to 4)   |
| Description   | AOx Error Detect Enable |
| Access        | RW                      |
| PDO Mapping   | No                      |
| Value Range   | 0 (FALSE) or 1 (TRUE)   |
| Default Value | 1 [TRUE]                |

### **2.4.25. Object 2311h: AO Error Clear Hysteresis**

This object is used to define the absolute difference that can be tolerated between the target output (as commanded by the control input) and the measured feedback. Any difference outside of the value will flag an open or short circuit fault. It is scaled in the physical unit of the output FV, i.e. object 6332h applies to this object.

#### ***Object Description***

|             |                           |
|-------------|---------------------------|
| Index       | 2311h                     |
| Name        | AO Error Clear Hysteresis |
| Object Type | ARRAY                     |
| Data Type   | INTEGER16                 |

#### ***Entry Description***

|             |                             |
|-------------|-----------------------------|
| Sub-Index   | 0h                          |
| Description | Largest sub-index supported |
| Access      | RO                          |
| PDO Mapping | No                          |

|               |    |
|---------------|----|
| Value Range   | 10 |
| Default Value | 10 |

|               |                                                    |
|---------------|----------------------------------------------------|
| Sub-Index     | 1h to 0h (x = 1 to 10)                             |
| Description   | AOx Error Clear Hysteresis                         |
| Access        | RW                                                 |
| PDO Mapping   | No                                                 |
| Value Range   | 0 to 10% of 7321h or 7323h,<br>whichever is larger |
| Default Value | 100 [mA]                                           |

|               |                            |
|---------------|----------------------------|
| Sub-Index     | 1h to 0h (x = 1 to 10)     |
| Description   | AOx Error Clear Hysteresis |
| Access        | RW                         |
| PDO Mapping   | No                         |
| Value Range   | NA                         |
| Default Value | 0 [off]                    |

|               |                                                    |
|---------------|----------------------------------------------------|
| Sub-Index     | 1h to 0h (x = 1 to 10)                             |
| Description   | AOx Error Clear Hysteresis                         |
| Access        | RW                                                 |
| PDO Mapping   | No                                                 |
| Value Range   | 0 to 10% of 7321h or 7323h,<br>whichever is larger |
| Default Value | 200 [mV]                                           |

#### 2.4.26. Object 2312h: AO Error Reaction Delay

This object is used to filter out spurious signals and to prevent saturating the CANopen ® network with broadcasts of object 1003h as the fault is set/cleared. Before the fault is recognized (i.e. the EMCY code is added to the pre-defined error field list), it must remain active throughout the period of time defined in this object. The physical unit for this object is milliseconds.

##### **Object Description**

|             |                         |
|-------------|-------------------------|
| Index       | 2312h                   |
| Name        | AO Error Reaction Delay |
| Object Type | ARRAY                   |
| Data Type   | UNSIGNED16              |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|             |                         |
|-------------|-------------------------|
| Sub-Index   | 1h                      |
| Description | PO Error Reaction Delay |
| Access      | RW                      |
| PDO Mapping | No                      |

|               |             |
|---------------|-------------|
| Value Range   | 0 to 60,000 |
| Default Value | 1000 [ms]   |

|               |                            |
|---------------|----------------------------|
| Sub-Index     | 2h to 5h (x = 1 to 4)      |
| Description   | RLYOx Error Reaction Delay |
| Access        | RW                         |
| PDO Mapping   | No                         |
| Value Range   | 0 to 60,000                |
| Default Value | 0 [ms]                     |

|               |                          |
|---------------|--------------------------|
| Sub-Index     | 6h to 9h (x = 1 to 4)    |
| Description   | AOx Error Reaction Delay |
| Access        | RW                       |
| PDO Mapping   | No                       |
| Value Range   | 0 to 60,000              |
| Default Value | 1000 [ms]                |

#### 2.4.27. Object 2320h: AO Dither Frequency

This object defines the low frequency that is superimposed on the high output frequency (object 2380h) when an AO is configured as a current output. The dither frequency should be selected such that the valve will respond immediately to small changes in current. The physical unit for this object is Hertz.

##### ***Object Description***

|             |                     |
|-------------|---------------------|
| Index       | 2320h               |
| Name        | AO Dither Frequency |
| Object Type | ARRAY               |
| Data Type   | UNSIGNED16          |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                     |
|---------------|---------------------|
| Sub-Index     | 1h                  |
| Description   | PO Dither Frequency |
| Access        | RW                  |
| PDO Mapping   | No                  |
| Value Range   | 50 to 400           |
| Default Value | 250 [Hz]            |

|             |                            |
|-------------|----------------------------|
| Sub-Index   | 2h to 9h                   |
| Description | RLYO & AO Dither Frequency |
| Access      | RW                         |
| PDO Mapping | No                         |
| Value Range | NA                         |

|               |   |
|---------------|---|
| Default Value | 0 |
|---------------|---|

#### 2.4.28. Object 2321h: AO Dither Amplitude

This object defines the amplitude of the low frequency signal that is superimposed on the output when an AO is configured as a current output. A zero value in this object disables the dithering feature. Note, the actual dither amplitude will not match exactly what is defined in this object, as it will be dependent on the inductance of the coil. Rather, this object should be adjusted such that the valve will respond immediately to small changes in current. The physical unit for this object is milliamps. Object 6332h does NOT apply.

##### ***Object Description***

|             |                     |
|-------------|---------------------|
| Index       | 2321h               |
| Name        | AO Dither Amplitude |
| Object Type | ARRAY               |
| Data Type   | UNSIGNED16          |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 1h                          |
| Description   | AOx Dither Amplitude        |
| Access        | RW                          |
| PDO Mapping   | No                          |
| Value Range   | 0 to 500                    |
| Default Value | 0 [mA] (dithering disabled) |

|               |                            |
|---------------|----------------------------|
| Sub-Index     | 2h to 9h                   |
| Description   | RLYO & AO Dither Amplitude |
| Access        | RW                         |
| PDO Mapping   | No                         |
| Value Range   | NA                         |
| Default Value | 0                          |

#### 2.4.29. Object 2330h: AO Ramp Up

This object defines the time it will take to ramp from the minimum output PV to the maximum as defined by objects 7321h and 7323h. It can be used to soften the response to a step change at the input. The physical unit for this object is milliseconds.

##### ***Object Description***

|             |            |
|-------------|------------|
| Index       | 2330h      |
| Name        | AO Ramp Up |
| Object Type | ARRAY      |
| Data Type   | UNSIGNED16 |

**Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |             |
|---------------|-------------|
| Sub-Index     | 1h          |
| Description   | PO Ramp Up  |
| Access        | RW          |
| PDO Mapping   | No          |
| Value Range   | 0 to 60,000 |
| Default Value | 1000 [ms]   |

|               |                   |
|---------------|-------------------|
| Sub-Index     | 2h to 9h          |
| Description   | RLYO & AO Ramp Up |
| Access        | RW                |
| PDO Mapping   | No                |
| Value Range   | 0 to 60,000       |
| Default Value | 0 [ms]            |

**2.4.30. Object 2331h: AO Ramp Down**

This object defines the time it will take to ramp from the maximum output PV to the minimum as defined by objects 7321h and 7323h. It can be used to soften the response to a step change at the input. The physical unit for this object is milliseconds.

**Object Description**

|             |              |
|-------------|--------------|
| Index       | 2331h        |
| Name        | AO Ramp Down |
| Object Type | ARRAY        |
| Data Type   | UNSIGNED16   |

**Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 10                          |
| Default Value | 10                          |

|               |              |
|---------------|--------------|
| Sub-Index     | 1h           |
| Description   | PO Ramp Down |
| Access        | RW           |
| PDO Mapping   | No           |
| Value Range   | 0 to 60,000  |
| Default Value | 1000 [ms]    |

|               |                     |
|---------------|---------------------|
| Sub-Index     | 2h to 9h            |
| Description   | RLYO & AO Ramp Down |
| Access        | RW                  |
| PDO Mapping   | No                  |
| Value Range   | 0 to 60,000         |
| Default Value | 0 [ms]              |

#### 2.4.31. Object 2340h: AO Control Input Source

This object defines the type of input that will be used to control the analog (or digital) output as shown in the logic flowchart in Figure 6. The available control sources on the MF-I/O controller are listed in Table 15. Not all sources would make sense to control the AO, and it is the user's responsibility to select a source that makes sense for the application.

##### ***Object Description***

|             |                         |
|-------------|-------------------------|
| Index       | 2340h                   |
| Name        | AO Control Input Source |
| Object Type | ARRAY                   |
| Data Type   | UNSIGNED8               |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                           |
|---------------|---------------------------|
| Sub-Index     | 1h to 9h (x = 1 to 9)     |
| Description   | Outx Control Input Source |
| Access        | RW                        |
| PDO Mapping   | No                        |
| Value Range   | See Table 15              |
| Default Value | 1 (CANopen RPDO)          |

#### 2.4.32. Object 2341h: AO Control Input Number

This object defines the number of the source that will be used to control the analog (or digital) output as shown in the logic flowchart in Figure 6. The available control numbers are dependent on the source selected, as shown in Table 16. Once selected, the control represents the process value (X-Axis input) in Figure 11. Objects 6302h, 7320h, 7322h should therefore be updated to match the scaling limits defined by the control source/number, as listed in Table 17.

##### ***Object Description***

|             |                         |
|-------------|-------------------------|
| Index       | 2341h                   |
| Name        | AO Control Input Number |
| Object Type | ARRAY                   |
| Data Type   | UNSIGNED8               |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                           |
|---------------|---------------------------|
| Sub-Index     | 1h to 9h (x = 1 to 9)     |
| Description   | Outx Control Input Number |
| Access        | RW                        |
| PDO Mapping   | No                        |
| Value Range   | See Table 16              |
| Default Value | x (CANopen Message x)     |

#### 2.4.33. Object 2342h: AO Control Response

This object defines the response profile of the analog output FV with respect to the input PV (as selected by objects 2340h/2341h.) Normally it will follow the profile shown in Figure 11. However, in some cases the offset will be disabled (i.e. output at 0) when the PV is below 7320h Scaling 1 PV or alternatively above the 7322h Scaling 2 PV. The options for this object are listed in Table 18. When an output is configured as a digital output using object 6310h then this object is ignored, and object 6240h, DO Polarity, is used instead.

##### ***Object Description***

|             |                     |
|-------------|---------------------|
| Index       | 2342h               |
| Name        | AO Control Response |
| Object Type | ARRAY               |
| Data Type   | UNSIGNED8           |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                                   |
|---------------|-----------------------------------|
| Sub-Index     | 1h to 9h (x = 1 to 9)             |
| Description   | Outx Control Response             |
| Access        | RW                                |
| PDO Mapping   | No                                |
| Value Range   | See Table 18                      |
| Default Value | 1 (Output OFF below Scaling 1 PV) |

#### 2.4.34. Object 2350h: AO Enable Input Source

This object defines the type of input that will be used to enable/disable the analog (or digital) output as shown in the logic flowchart in Figure 6. The available control sources on the MF-I/O controller are listed in Table 15. Not all sources would make sense to enable the AO, and it is the user's responsibility to select a source that makes sense for the application.

**Object Description**

|             |                        |
|-------------|------------------------|
| Index       | 2350h                  |
| Name        | AO Enable Input Source |
| Object Type | ARRAY                  |
| Data Type   | UNSIGNED8              |

**Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                          |
|---------------|--------------------------|
| Sub-Index     | 1h to 9h (x = 1 to 9)    |
| Description   | Outx Enable Input Source |
| Access        | RW                       |
| PDO Mapping   | No                       |
| Value Range   | See Table 15             |
| Default Value | 0 (control not used)     |

**2.4.35. Object 2351h: AO Enable Input Number**

This object defines the number of the source that will be used to enable/disable the analog (or digital) output as shown in the logic flowchart in Figure 6. The available control numbers are dependent on the source selected, as shown in Table 16.

**Object Description**

|             |                        |
|-------------|------------------------|
| Index       | 2351h                  |
| Name        | AO Enable Input Number |
| Object Type | ARRAY                  |
| Data Type   | UNSIGNED8              |

**Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                          |
|---------------|--------------------------|
| Sub-Index     | 1h to 9h (x = 1 to 9)    |
| Description   | Outx Enable Input Number |
| Access        | RW                       |
| PDO Mapping   | No                       |
| Value Range   | See Table 16             |
| Default Value | 0 (null control source)  |

#### 2.4.36. Object 2352h: AO Enable Response

This object determines if the input will act as an enable or safety interlock (i.e. input must be ON to engage the output) or a disable signal (i.e. the output will shutoff when the input is ON.) The options for this object for analog output 1 to 4 are listed in Table 19.

##### ***Object Description***

|             |                    |
|-------------|--------------------|
| Index       | 2352h              |
| Name        | AO Enable Response |
| Object Type | ARRAY              |
| Data Type   | UNSIGNED8          |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                                     |
|---------------|-------------------------------------|
| Sub-Index     | 1h to 9h (x = 1 to 9)               |
| Description   | Outx Enable Response                |
| Access        | RW                                  |
| PDO Mapping   | No                                  |
| Value Range   | See Table 19                        |
| Default Value | 3 (Enable When Off, Else Shut Off ) |

#### 2.4.37. Object 2360h: AO Override Input Source

This object defines the type of input that will be used to active the override value for the analog outputs as shown in the logic flowchart in Figure 6. The available control sources on the MF-I/O controller are listed in Table 15. Not all sources would make sense to enable the AO, and it is the user's responsibility to select a source that makes sense for the application.

##### ***Object Description***

|             |                          |
|-------------|--------------------------|
| Index       | 2360h                    |
| Name        | AO Override Input Source |
| Object Type | ARRAY                    |
| Data Type   | UNSIGNED8                |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|             |                            |
|-------------|----------------------------|
| Sub-Index   | 1h to 9h (x = 1 to 9)      |
| Description | Outx Override Input Source |

|               |                      |
|---------------|----------------------|
| Access        | RW                   |
| PDO Mapping   | No                   |
| Value Range   | See Table 15         |
| Default Value | 0 (control not used) |

#### 2.4.38. Object 2361h: AO Override Input Number

This object defines the number of the source that will be used to override the analog outputs as shown in the logic flowchart in Figure 6. The available control numbers are dependent on the source selected, as shown in Table 16.

##### **Object Description**

|             |                          |
|-------------|--------------------------|
| Index       | 2361h                    |
| Name        | AO Override Input Number |
| Object Type | ARRAY                    |
| Data Type   | UNSIGNED8                |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                            |
|---------------|----------------------------|
| Sub-Index     | 1h to 9h (x = 1 to 9)      |
| Description   | Outx Override Input Number |
| Access        | RW                         |
| PDO Mapping   | No                         |
| Value Range   | See Table 16               |
| Default Value | 0 (null control source)    |

#### 2.4.39. Object 2362h: AO Override Response

This object determines how the override command will respond to the input state. The options for this object are listed in Table 20.

##### **Object Description**

|             |                      |
|-------------|----------------------|
| Index       | 2362h                |
| Name        | AO Override Response |
| Object Type | ARRAY                |
| Data Type   | UNSIGNED8            |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                        |
|---------------|------------------------|
| Sub-Index     | 1h to 9h (x = 1 to 9)  |
| Description   | Outx Override Response |
| Access        | RW                     |
| PDO Mapping   | No                     |
| Value Range   | See Table 20           |
| Default Value | 0 (Override When On)   |

#### 2.4.40. Object 2370h: AO Feedback Field Value

This read-only object reflects the actual measured current feedback of an output. For other output types (i.e. voltage, PWM or digital,) it will reflect the target Output FV or State (for DO type) based on PV vs. FV calculations (see Figure 11) and applied ramps. It can be mapped to a PDO for diagnostic purposes. It will be scaled in the physical unit of the output, dependent on type, with the resolution defined in object 6332h AO Decimal Digits FV.

##### ***Object Description***

|             |                         |
|-------------|-------------------------|
| Index       | 2370h                   |
| Name        | AO Feedback Field Value |
| Object Type | ARRAY                   |
| Data Type   | INTEGER16               |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                                  |
|---------------|----------------------------------|
| Sub-Index     | 1h to 9h (x = 1 to 9)            |
| Description   | Outx Feedback Field Value        |
| Access        | RO                               |
| PDO Mapping   | Yes                              |
| Value Range   | Dependent on type (see Table 14) |
| Default Value | No                               |

#### 2.4.41. Object 2380h: AO Output Frequency

This object is used to set the frequency of the outputs. However, because some outputs share the same timers, if any output in its respective bank is configured as a Current or Hotshot type, the output frequency will remain 25kHz. For the controller to change the output frequency of the bank, none of the outputs (in their bank) can be configured as any of these two types.

##### ***Object Description***

|             |                     |
|-------------|---------------------|
| Index       | 2380h               |
| Name        | AO Output Frequency |
| Object Type | ARRAY               |
| Data Type   | INTEGER16           |

**Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                |
|---------------|----------------|
| Sub-Index     | 1h             |
| Description   | PO Frequency   |
| Access        | RW             |
| PDO Mapping   | No             |
| Value Range   | 1-25,000 Hertz |
| Default Value | 25,000 [Hz]    |

|               |                     |
|---------------|---------------------|
| Sub-Index     | 2h to 9h            |
| Description   | RLYO & AO Frequency |
| Access        | RW                  |
| PDO Mapping   | No                  |
| Value Range   | NA                  |
| Default Value | 0                   |

**2.4.42. Object 2382h: AO Current PID Proportional Gain**

This object has been factory calibrated, and should be changed with caution. Axiomatic will no longer guarantee the accuracy or responsiveness of the current output when this value is changed. It is provided as a writeable object in case the output frequency is changed and the user wants to try and optimize the current PID loop. Axiomatic does not recommend this.

**Object Description**

|             |                                  |
|-------------|----------------------------------|
| Index       | 2382h                            |
| Name        | AO Current PID Proportional Gain |
| Object Type | ARRAY                            |
| Data Type   | FLOAT32                          |

**Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                                  |
|---------------|----------------------------------|
| Sub-Index     | 1h                               |
| Description   | PO Current PID Proportional Gain |
| Access        | RW                               |
| PDO Mapping   | No                               |
| Value Range   | FLOAT32                          |
| Default Value | 0.60                             |

|               |                                        |
|---------------|----------------------------------------|
| Sub-Index     | 2h to 9h                               |
| Description   | RLYO &AO Current PID Proportional Gain |
| Access        | RW                                     |
| PDO Mapping   | No                                     |
| Value Range   | FLOAT32                                |
| Default Value | 0                                      |

#### 2.4.43. Object 2383h: AO Current PID Integral Time

This object has been factory calibrated, and should be changed with caution. Axiomatic will no longer guarantee the accuracy or responsiveness of the current output when this value is changed. It is provided as a writeable object in case the output frequency is changed and the user wants to try and optimize the current PID loop. Axiomatic does not recommend this.

##### ***Object Description***

|             |                              |
|-------------|------------------------------|
| Index       | 2383h                        |
| Name        | AO Current PID Integral Time |
| Object Type | ARRAY                        |
| Data Type   | FLOAT32                      |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                              |
|---------------|------------------------------|
| Sub-Index     | 1h                           |
| Description   | PO Current PID Integral Time |
| Access        | RW                           |
| PDO Mapping   | No                           |
| Value Range   | FLOAT32                      |
| Default Value | 0.0015                       |

|               |                                     |
|---------------|-------------------------------------|
| Sub-Index     | 2h to 9h                            |
| Description   | RLYO & AO Current PID Integral Time |
| Access        | RW                                  |
| PDO Mapping   | No                                  |
| Value Range   | FLOAT32                             |
| Default Value | 0                                   |

#### 2.4.44. Object 2384h: AO Current PID Derivative Time

This object has been factory calibrated, and should be changed with caution. Axiomatic will no longer guarantee the accuracy or responsiveness of the current output when this value is changed. It is provided as a writeable object in case the output frequency is changed and the user wants to try and optimize the current PID loop. Axiomatic does not recommend this.

**Object Description**

|             |                                |
|-------------|--------------------------------|
| Index       | 2384h                          |
| Name        | AO Current PID Derivative Time |
| Object Type | ARRAY                          |
| Data Type   | FLOAT32                        |

**Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 9                           |
| Default Value | 9                           |

|               |                                |
|---------------|--------------------------------|
| Sub-Index     | 1h                             |
| Description   | PO Current PID Derivative Time |
| Access        | RW                             |
| PDO Mapping   | No                             |
| Value Range   | FLOAT32                        |
| Default Value | 0.0000                         |

|               |                                       |
|---------------|---------------------------------------|
| Sub-Index     | 2h to 9h                              |
| Description   | RLYO & AO Current PID Derivative Time |
| Access        | RW                                    |
| PDO Mapping   | No                                    |
| Value Range   | FLOAT32                               |
| Default Value | 0.0000                                |

**2.4.45. Object 2450h: PID Tolerance**

This object defines the allowable absolute difference between the target and the feedback, below which the error will be interpreted as zero (i.e. PID output stops changing). The physical unit for this object is percentage, and the value is always interpreted as having a resolution of one digit after the decimal place.

**Object Description**

|             |               |
|-------------|---------------|
| Index       | 2450h         |
| Name        | PID Tolerance |
| Object Type | ARRAY         |
| Data Type   | INTEGER16     |

**Entry Description**

|               |                            |
|---------------|----------------------------|
| Sub-Index     | 0h                         |
| Description   | argest sub-index supported |
| Access        | RO                         |
| PDO Mapping   | No                         |
| Value Range   | 2                          |
| Default Value | 2                          |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 1h to 2h (x = 1 to 2) |
| Description   | PIDx Tolerance        |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | 0 to 100 (0% to 10%)  |
| Default Value | 10 [1%]               |

#### 2.4.46. Object 2451h: PID Integral Gain

This object describes the integral gain ( $K_i$  in Figure 14) of the PID algorithm. The value is always interpreted as having a resolution of one digit after the decimal place.

##### **Object Description**

|             |                   |
|-------------|-------------------|
| Index       | 2451h             |
| Name        | PID Integral Gain |
| Object Type | ARRAY             |
| Data Type   | INTEGER16         |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 1h to 2h (x = 1 to 2) |
| Description   | PIDx Integral Gain    |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | 0 to 100              |
| Default Value | 10 [1.0]              |

#### 2.4.47. Object 2452h: PID Derivative Gain

This object describes the derivative gain ( $K_d$  in Figure 14) of the PID algorithm. The value is always interpreted as having a resolution of one digit after the decimal place.

##### **Object Description**

|             |                     |
|-------------|---------------------|
| Index       | 2452h               |
| Name        | PID Derivative Gain |
| Object Type | ARRAY               |
| Data Type   | INTEGER16           |

##### **Entry Description**

|             |                             |
|-------------|-----------------------------|
| Sub-Index   | 0h                          |
| Description | Largest sub-index supported |
| Access      | RO                          |
| PDO Mapping | No                          |
| Value Range | 2                           |

|               |   |
|---------------|---|
| Default Value | 2 |
|---------------|---|

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 1h to 2h (x = 1 to 2) |
| Description   | PIDx Derivative Gain  |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | 0 to 100              |
| Default Value | 10 [1.0]              |

#### 2.4.48. Object 2453h: PID Target Source

This object defines the type of input that will be used to determine the target process value for the PID control loop. The available control sources on the MF-I/O controller are listed in Table 15. Not all sources would make sense to use as a PID target source, and it is the user's responsibility to select a source that makes sense for the application. A selection of "Control Source Not Used" disables the associated PID control function block.

##### ***Object Description***

|             |                   |
|-------------|-------------------|
| Index       | 2453h             |
| Name        | PID Target Source |
| Object Type | ARRAY             |
| Data Type   | UNSIGNED8         |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|               |                                    |
|---------------|------------------------------------|
| Sub-Index     | 1h to 2h (x = 1 to 2)              |
| Description   | PIDx Target Source                 |
| Access        | RW                                 |
| PDO Mapping   | No                                 |
| Value Range   | See Table 15                       |
| Default Value | 0 (control not used, PID disabled) |

#### 2.4.49. Object 2454h: PID Target Number

This object defines the number of the source that will be used as the target PV for the PID control loop. The available control numbers are dependent on the source selected, as shown in Table 16. Once selected, the control will convert the commanded target into a percentage value using the scaling limits of the control source/number as defined in Table 17.

##### ***Object Description***

|             |                   |
|-------------|-------------------|
| Index       | 2454h             |
| Name        | PID Target Number |
| Object Type | ARRAY             |
| Data Type   | UNSIGNED8         |

**Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|               |                                |
|---------------|--------------------------------|
| Sub-Index     | 1h to 2h (x = 1 to 2)          |
| Description   | PID <sub>x</sub> Target Number |
| Access        | RW                             |
| PDO Mapping   | No                             |
| Value Range   | See Table 16                   |
| Default Value | <b>x</b>                       |

**2.4.50. Object 2455h: PID Feedback Source**

This object defines the type of input that will be used to determine the feedback process value for the PID control loop. The available control sources on the MF-I/O controller are listed in Table 15. Not all sources would make sense to use as a PID feedback source, and it is the user's responsibility to select a source that makes sense for the application. A selection of "Control Source Not Used" disables the associated PID control function block.

**Object Description**

|             |                     |
|-------------|---------------------|
| Index       | 2455h               |
| Name        | PID Feedback Source |
| Object Type | ARRAY               |
| Data Type   | UNSIGNED8           |

**Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|               |                                    |
|---------------|------------------------------------|
| Sub-Index     | 1h to 2h (x = 1 to 2)              |
| Description   | PID <sub>x</sub> Feedback Source   |
| Access        | RW                                 |
| PDO Mapping   | No                                 |
| Value Range   | See Table 15                       |
| Default Value | 0 (control not used, PID disabled) |

**2.4.51. Object 2456h: PID Feedback Number**

This object defines the number of the source that will be used as the feedback PV for the PID control loop. The available control numbers are dependent on the source selected, as shown in Table 16. Once selected, the control will convert the measured/received feedback into a percentage value using the scaling limits of the control source/number as defined in Table 17.

#### ***Object Description***

|             |                     |
|-------------|---------------------|
| Index       | 2456h               |
| Name        | PID Feedback Number |
| Object Type | ARRAY               |
| Data Type   | UNSIGNED8           |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 1h to 2h (x = 1 to 2) |
| Description   | PIDx Feedback Number  |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | See Table 16          |
| Default Value | x                     |

### **2.4.52. Object 2457h: PID Control Response**

This object defines the output profile for the PID control function block in a push-pull dual output system. The options for this object are listed in Table 22.

#### ***Object Description***

|             |                      |
|-------------|----------------------|
| Index       | 2457h                |
| Name        | PID Control Response |
| Object Type | ARRAY                |
| Data Type   | UNSIGNED8            |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|             |                       |
|-------------|-----------------------|
| Sub-Index   | 1h to 2h (x = 1 to 2) |
| Description | PIDx Control Response |
| Access      | RW                    |
| PDO Mapping | No                    |
| Value Range | See Table 22          |

|               |                   |
|---------------|-------------------|
| Default Value | 0 (single output) |
|---------------|-------------------|

#### 2.4.53. Object 2460h: PID Output Field Value

This read-only output contains the PID control function block FV (as a percentage) that can be used as the input source for another function block (i.e. analog output.) It will be a value between 0 to 100% as per the algorithm defined in Figure 14. The physical unit for this object is percentage, and the value is always interpreted as having a resolution of one digit after the decimal place.

##### ***Object Description***

|             |               |
|-------------|---------------|
| Index       | 2460h         |
| Name        | PID Output FV |
| Object Type | ARRAY         |
| Data Type   | INTEGER16     |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 1h to 2h (x = 1 to 2) |
| Description   | PIDx Output FV        |
| Access        | RO                    |
| PDO Mapping   | Yes                   |
| Value Range   | 0 to 1000 (0 to 100%) |
| Default Value | No                    |

#### 2.4.54. Object 2500h: EC Extra Received Process Value

This object provides an extra control source in order to allow other function blocks to be controlled by data received from a CANopen ® RPDO. It functions similarly to any other writeable, mappable PV object, such as 7300h AO Output PV.

##### ***Object Description***

|             |                                 |
|-------------|---------------------------------|
| Index       | 2500h                           |
| Name        | EC Extra Received Process Value |
| Object Type | ARRAY                           |
| Data Type   | INTEGER16                       |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 15                          |
| Default Value | 15                          |

|               |                            |
|---------------|----------------------------|
| Sub-Index     | 1h to 15h (x = 1 to 15)    |
| Description   | ECx Received Process Value |
| Access        | RW                         |
| PDO Mapping   | Yes                        |
| Value Range   | Integer16                  |
| Default Value | No                         |

#### 2.4.55. Object 2502h: EC Decimal Digits PV

This object describes the number of digits following the decimal point (i.e. resolution) of the extra control data, which is interpreted with data type Integer16 in the process value object.

##### **Object Description**

|             |                      |
|-------------|----------------------|
| Index       | 2502h                |
| Name        | EC Decimal Digits PV |
| Object Type | ARRAY                |
| Data Type   | UNSIGNED8            |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 15                          |
| Default Value | 15                          |

|               |                         |
|---------------|-------------------------|
| Sub-Index     | 1h to 15h (x = 1 to 15) |
| Description   | ECx Decimal Digits PV   |
| Access        | RW                      |
| PDO Mapping   | No                      |
| Value Range   | 0 to 4                  |
| Default Value | 1 (0.1 resolution)      |

#### 2.4.56. Object 2520h: EC Scaling 1 PV

This object defines the minimum value of the extra control source. It used as the Scaling 1 value by other functions blocks when the EC has been selected as the source for the X-Axis data, i.e. as seen in Figure 11. There is no physical unit associate with the data, but it uses the same resolution as the received PV as defined in object 2502h, EC Decimal Digits PV. This object must always be smaller than object 2522h EC Scaling 2 PV.

##### **Object Description**

|             |                 |
|-------------|-----------------|
| Index       | 2520h           |
| Name        | EC Scaling 1 PV |
| Object Type | ARRAY           |
| Data Type   | INTEGER16       |

##### **Entry Description**

|             |                             |
|-------------|-----------------------------|
| Sub-Index   | 0h                          |
| Description | Largest sub-index supported |
| Access      | RO                          |

|               |    |
|---------------|----|
| PDO Mapping   | No |
| Value Range   | 15 |
| Default Value | 15 |

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 1h to 15h (x = 1 to 15)     |
| Description   | ECx Scaling 1 PV            |
| Access        | RW                          |
| PDO Mapping   | No                          |
| Value Range   | -32768 to 2522h sub-index X |
| Default Value | 0                           |

#### 2.4.57. Object 2522h: EC Scaling 2 PV

This object defines the maximum value of the extra control source. It used as the Scaling 2 value by other functions blocks when the EC has been selected as the source for the X-Axis data, i.e. as seen in Figure 11. There is no physical unit associate with the data, but it uses the same resolution as the received PV as defined in object 2502h, EC Decimal Digits PV. This object must always be larger than object 2520h EC Scaling 1 PV.

##### **Object Description**

|             |                 |
|-------------|-----------------|
| Index       | 2522h           |
| Name        | EC Scaling 2 PV |
| Object Type | ARRAY           |
| Data Type   | INTEGER16       |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 15                          |
| Default Value | 15                          |

|               |                            |
|---------------|----------------------------|
| Sub-Index     | 1h to 15h (x = 1 to 15)    |
| Description   | ECx Scaling 2 PV           |
| Access        | RW                         |
| PDO Mapping   | No                         |
| Value Range   | 2520h sub-index X to 32767 |
| Default Value | 1000 (100.0)               |

#### 2.4.58. Object 3yz0h: LTyz Input X-Axis Source

This object defines the type of input that will be used to determine the X-Axis input process value for the lookup table function. The available control sources on the MF-I/O controller are listed in Table 15. Not all sources would make sense to use as an X-Axis input, and it is the user's responsibility to select a source that makes sense for the application. A selection of "Control Source Not Used" disables the associated lookup table function block.

##### **Object Description**

|       |                             |
|-------|-----------------------------|
| Index | 3yz0h (where yz = 01 to 09) |
|-------|-----------------------------|

|             |                          |
|-------------|--------------------------|
| Name        | LTyz Input X-Axis Source |
| Object Type | VARIABLE                 |
| Data Type   | UNSIGNED8                |

#### ***Entry Description***

|               |                      |
|---------------|----------------------|
| Sub-Index     | 0h                   |
| Access        | RW                   |
| PDO Mapping   | No                   |
| Value Range   | See Table 15         |
| Default Value | 0 (control not used) |

### **2.4.59. Object 3yz1h: LTyz Input X-Axis Number**

This object defines the number of the source that will be used as the X-Axis input PV for the lookup table function. The available control numbers are dependent on the source selected, as shown in Table 16. Once selected, the limits for the points on the X-Axis will be constrained by the scaling objects of the control source/number as defined in Table 17.

#### ***Object Description***

|             |                             |
|-------------|-----------------------------|
| Index       | 3yz1h (where yz = 01 to 09) |
| Name        | LTyz Input X-Axis Number    |
| Object Type | VARIABLE                    |
| Data Type   | UNSIGNED8                   |

#### ***Entry Description***

|               |                         |
|---------------|-------------------------|
| Sub-Index     | 0h                      |
| Access        | RW                      |
| PDO Mapping   | No                      |
| Value Range   | See Table 16            |
| Default Value | 0 (null control source) |

### **2.4.60. Object 3yz2h: LTyz Auto Repeat**

This object determines whether the lookup table sequence will repeat automatically once the last point in the lookup table has been completed. This object is only taken into effect when the response is set to '*Time Response*'. For more details on the functionality of this object and its effect on the lookup table, please refer to section 1.7.4

#### ***Object Description***

|             |                               |
|-------------|-------------------------------|
| Index       | 3yz2h (where yz = 01 to 09)   |
| Name        | LTyz X-Axis Decimal Digits PV |
| Object Type | VARIABLE                      |
| Data Type   | UNSIGNED8                     |

#### ***Entry Description***

|             |                   |
|-------------|-------------------|
| Sub-Index   | 0h                |
| Access      | RW                |
| PDO Mapping | No                |
| Value Range | 0 (OFF) to 1 (ON) |

|               |         |
|---------------|---------|
| Default Value | 0 [OFF] |
|---------------|---------|

#### 2.4.61. Object 3yz3h: LTyz X-Axis Decimal Digits PV

This object describes the number of digits following the decimal point (i.e. resolution) of the X-Axis input data and the points in the lookup table. It should be set equal to the decimal digits used by the PV from the control source/number as defined in Table 17.

##### ***Object Description***

|             |                               |
|-------------|-------------------------------|
| Index       | 3yz3h (where yz = 01 to 09)   |
| Name        | LTyz X-Axis Decimal Digits PV |
| Object Type | VARIABLE                      |
| Data Type   | UNSIGNED8                     |

##### ***Entry Description***

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 0h                    |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | 0 to 4 (see Table 17) |
| Default Value | 0                     |

#### 2.4.62. Object 3yz4h: LTyz Y-Axis Decimal Digits PV

This object describes the number of digits following the decimal point (i.e. resolution) of the Y-Axis points in the lookup table. When the Y-Axis output is going to be the input to another function block (i.e. an analog output), it is recommended that this value be set equal to the decimal digits used by the block that is using the lookup table as the control source/number.

##### ***Object Description***

|             |                               |
|-------------|-------------------------------|
| Index       | 3yz4h (where yz = 01 to 09)   |
| Name        | LTyz Y-Axis Decimal Digits PV |
| Object Type | VARIABLE                      |
| Data Type   | UNSIGNED8                     |

##### ***Entry Description***

|               |        |
|---------------|--------|
| Sub-Index     | 0h     |
| Access        | RW     |
| PDO Mapping   | No     |
| Value Range   | 0 to 4 |
| Default Value | 0      |

#### 2.4.63. Object 3yz5h: LTyz Point Response

This object determines the Y-Axis output response to changes in the X-Axis input. The value set in sub-index 1 determines the X-Axis type (i.e. data or time), while all other sub-indexes determine the response (ramp, step, ignore) between two points on the curve. The options for this object are listed in Table 23. See Figure 16 for an example of the difference between a step and ramp response.

##### ***Object Description***

|             |                             |
|-------------|-----------------------------|
| Index       | 3yz5h (where yz = 01 to 12) |
| Name        | LTyz Point Response         |
| Object Type | ARRAY                       |
| Data Type   | UNSIGNED8                   |

#### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                          |
|---------------|--------------------------|
| Sub-Index     | 1h                       |
| Description   | X-Axis Type              |
| Access        | RW                       |
| PDO Mapping   | No                       |
| Value Range   | See Table 23 (0 or 1)    |
| Default Value | 0 (x-axis data response) |

|               |                          |
|---------------|--------------------------|
| Sub-Index     | 2h to Bh (x = 2 to 11)   |
| Description   | LTyz Point X Response    |
| Access        | RW                       |
| PDO Mapping   | No                       |
| Value Range   | See Table 23 (0, 1 or 2) |
| Default Value | 1 (ramp to response)     |

#### **2.4.64. Object 3yz6h: LTyz Point X-Axis PV**

This object defines the X-Axis data for the 11 calibration points on the lookup table, resulting in 10 different output slopes.

When a data response is selected for the X-Axis type (sub-index 1 of object 3yz5), this object is constrained such that X1 cannot be less than the Scaling 1 value of the selected control source/number, and X11 cannot be more than the Scaling 2 value. The rest of the points are constrained by the formula below. The physical unit associate with the data will be that of the selected input, and it will use the resolution defined in object 3yz3h, LTz X-Axis Decimal Digits PV.

$$\text{MinInt16} \leq X_1 \leq X_2 \leq X_3 \leq X_4 \leq X_5 \leq X_6 \leq X_7 \leq X_8 \leq X_9 \leq X_{10} \leq X_{11} \leq \text{MaxInt16}$$

When a time response has been selected, each point on the X-Axis can be set anywhere from 1 to 86,400,000ms.

#### **Object Description**

|             |                             |
|-------------|-----------------------------|
| Index       | 3yz6h (where yz = 01 to 12) |
| Name        | LTyz Point X-Axis PV        |
| Object Type | ARRAY                       |
| Data Type   | INTEGER32                   |

#### **Entry Description**

|             |                             |
|-------------|-----------------------------|
| Sub-Index   | 0h                          |
| Description | Largest sub-index supported |

|               |    |
|---------------|----|
| Access        | RO |
| PDO Mapping   | No |
| Value Range   | 11 |
| Default Value | 11 |

|               |                        |                      |
|---------------|------------------------|----------------------|
| Sub-Index     | 1h to Bh (x = 1 to 11) |                      |
| Description   | LTyz Point X-Axis PVx  |                      |
| Access        | RW                     |                      |
| PDO Mapping   | No                     |                      |
| Value Range   | See above (data)       | 1 to 86400000 (time) |
| Default Value | $10^{*(x-1)}$          | No                   |

#### 2.4.65. Object 3yz7h: LTyz Point Y-Axis PV

This object defines the Y-Axis data for the 11 calibration points on the lookup table, resulting in 10 different output slopes. The data is unconstrained and has no physical unit associate with it. It will use the resolution defined in object 3yz4h, LTyz Y-Axis Decimal Digits PV.

##### **Object Description**

|             |                             |
|-------------|-----------------------------|
| Index       | 3yz7h (where yz = 01 to 12) |
| Name        | LTz Point Y-Axis PV         |
| Object Type | ARRAY                       |
| Data Type   | INTEGER16                   |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 11                          |
| Default Value | 11                          |

|               |                                             |  |
|---------------|---------------------------------------------|--|
| Sub-Index     | 1h to Bh (x = 1 to 11)                      |  |
| Description   | LTyz Point Y-Axis PVx                       |  |
| Access        | RW                                          |  |
| PDO Mapping   | No                                          |  |
| Value Range   | Integer16                                   |  |
| Default Value | $10^{*(x-1)}$ [i.e. 0, 10, 20, 30, ... 100] |  |

#### 2.4.66. Object 3yz8h: LTyz Output Y-Axis PV

This read-only object contains the lookup table function block PV that can be used as the input source for another function block (i.e. analog output.) The physical unit for this object is undefined, and it will use the resolution defined in object 3yz4h, LTz Y-Axis Decimal Digits PV.

##### **Object Description**

|             |                             |
|-------------|-----------------------------|
| Index       | 3yz8h (where yz = 01 to 09) |
| Name        | LTyz Output Y-Axis PV       |
| Object Type | VARIABLE                    |
| Data Type   | INTEGER16                   |

**Entry Description**

|               |           |
|---------------|-----------|
| Sub-Index     | 0h        |
| Access        | RO        |
| PDO Mapping   | Yes       |
| Value Range   | Integer16 |
| Default Value | No        |

**2.4.67. Object 3300h: Logic Block Enable**

This object defines whether or not the logic shown in Figure 19 will be evaluated.

**Object Description**

|             |                    |
|-------------|--------------------|
| Index       | 3300h              |
| Name        | Logic Block Enable |
| Object Type | ARRAY              |
| Data Type   | BOOLEAN            |

**Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 4                           |
| Default Value | 4                           |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 1h to 2h (x = 1 to 2) |
| Description   | LBx Enable            |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | 0 (FALSE) or 1 (TRUE) |
| Default Value | 0 [FALSE]             |

**2.4.68. Object 3310h: Logic Block Selected Table**

This read-only object reflects what table has been selected as the output source for the logic block after the evaluation shown in Figure 19 has been performed.

**Object Description**

|             |                            |
|-------------|----------------------------|
| Index       | 3310h                      |
| Name        | Logic Block Selected Table |
| Object Type | ARRAY                      |
| Data Type   | UNSIGNED8                  |

**Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 4                           |
| Default Value | 4                           |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 1h to 3h (x = 1 to 3) |
| Description   | LBx Selected Table    |
| Access        | RO                    |
| PDO Mapping   | Yes                   |
| Value Range   | 1 to 12               |
| Default Value | No                    |

#### 2.4.69. Object 3320h: Logic Block Output PV

This read-only object reflects the output from the selected table, interpreted as a percentage. The limits for the percentage conversion are based on the range of the lookup tables Y-Axis Output PV as shown in Table 28. This value has a fixed decimal digit value of 1 giving a resolution of 0.1%.

##### ***Object Description***

|             |                       |
|-------------|-----------------------|
| Index       | 3320h                 |
| Name        | Logic Block Output PV |
| Object Type | ARRAY                 |
| Data Type   | UNSIGNED8             |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 4                           |
| Default Value | 4                           |

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 1h to 3h (x = 1 to 3)       |
| Description   | LBx Output PV               |
| Access        | RO                          |
| PDO Mapping   | Yes                         |
| Value Range   | Dependent on Selected Table |
| Default Value | No                          |

#### 2.4.70. Object 3x01h: LB(3-x) Lookup Table Numbers

This object determines which of the six lookup tables supports on the MF-I/O are associated with a particular function within the given logic block. Up to three tables can be linked to each logic function.

##### ***Object Description***

|             |                              |
|-------------|------------------------------|
| Index       | 3x01h (where x = 4 to 5)     |
| Name        | LB(3-x) Lookup Table Numbers |
| Object Type | ARRAY                        |
| Data Type   | UNSIGNED8                    |

##### ***Entry Description***

|             |                             |
|-------------|-----------------------------|
| Sub-Index   | 0h                          |
| Description | Largest sub-index supported |
| Access      | RO                          |
| PDO Mapping | No                          |
| Value Range | 4                           |

|               |                               |
|---------------|-------------------------------|
| Default Value | 4                             |
| Sub-Index     | 1h to 4h (y = A to C)         |
| Description   | LB(3-x) Lookup Table Y Number |
| Access        | RW                            |
| PDO Mapping   | No                            |
| Value Range   | 1 to 12                       |
| Default Value | See Table 18                  |

#### 2.4.71. Object 3x02h: LB(3-x) Function Logical Operator

This object determines how the results of the three conditions for each function are to be compared to one another to determine the overall state of the function output. There are up to three functions that can be evaluated in each logic block. The options for this object are defined in Table 27. See Section 1.8 for more information about how this object is used.

##### **Object Description**

|             |                                   |
|-------------|-----------------------------------|
| Index       | 3x02h (where x = 4 to 5)          |
| Name        | LB(3-x) Function Logical Operator |
| Object Type | ARRAY                             |
| Data Type   | UNSIGNED8                         |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 4                           |
| Default Value | 4                           |

|               |                                                                                  |
|---------------|----------------------------------------------------------------------------------|
| Sub-Index     | 1h to 4h (y = A to C)                                                            |
| Description   | LB(3-x) Function Y Logical Operator                                              |
| Access        | RW                                                                               |
| PDO Mapping   | No                                                                               |
| Value Range   | See Table 27                                                                     |
| Default Value | Function A = 1 (and all)<br>Function B = 1 (and all)<br>Function C = 0 (default) |

#### 2.4.72. Object 3x11h: LB(3-x) Function A Condition 1

#### 2.4.73. Object 3x12h: LB(3-x) Function A Condition 2

#### 2.4.74. Object 3x13h: LB(3-x) Function A Condition 3

#### 2.4.75. Object 3x21h: LB(3-x) Function B Condition 1

#### 2.4.76. Object 3x22h: LB(3-x) Function B Condition 2

#### 2.4.77. Object 3x23h: LB(3-x) Function B Condition 3

#### 2.4.78. Object 3x31h: LB(3-x) Function C Condition 1

#### 2.4.79. Object 3x32h: LB(3-x) Function C Condition 2

#### 2.4.80. Object 3x33h: LB(3-x) Function C Condition 3

These objects, 3xyzh, represent Logic Block z, Function y, Condition z, where x = 4 to 7, y = 1 (A) to 3 (C), and z = 1 to 3. All of these objects are a special type of record, defined in Table 24. Information on how to use these objects is defined in Section 1.8.

### **Object Description**

|             |                                |
|-------------|--------------------------------|
| Index       | 3xyzh                          |
| Name        | LB(3-x) Function y Condition z |
| Object Type | RECORD                         |
| Data Type   | UNSIGNED8                      |

### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 5                           |
| Default Value | 5                           |

|               |                     |
|---------------|---------------------|
| Sub-Index     | 1h                  |
| Description   | Argument 1 Source   |
| Access        | RW                  |
| PDO Mapping   | No                  |
| Value Range   | See Table 15        |
| Default Value | 1 (CANopen Message) |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 2h                    |
| Description   | Argument 1 Number     |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | See Table 16          |
| Default Value | 11 (EC Received PV 1) |

|               |                   |
|---------------|-------------------|
| Sub-Index     | 3h                |
| Description   | Argument 2 Source |
| Access        | RW                |
| PDO Mapping   | No                |
| Value Range   | See Table 15      |
| Default Value | 5 (Constant PV)   |

|               |                   |
|---------------|-------------------|
| Sub-Index     | 4h                |
| Description   | Argument 2 Number |
| Access        | RW                |
| PDO Mapping   | No                |
| Value Range   | See Table 16      |
| Default Value | 3 (Constant FV 3) |

|             |          |
|-------------|----------|
| Sub-Index   | 5h       |
| Description | Operator |
| Access      | RW       |

|               |              |
|---------------|--------------|
| PDO Mapping   | No           |
| Value Range   | See Table 14 |
| Default Value | 0 (Equals)   |

#### 2.4.81. Object 4000h: Math Function Enable

The corresponding sub-index of object must be set TRUE in order for a math function block to be enabled. Otherwise, the output will always be at 0.

##### **Object Description**

|             |                      |
|-------------|----------------------|
| Index       | 4000h                |
| Name        | Math Function Enable |
| Object Type | ARRAY                |
| Data Type   | BOOLEAN              |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 2                           |
| Default Value | 2                           |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 1h to 6h (Y = 1 to 6) |
| Description   | Math Y Enable         |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | 0 (FALSE) or 1 (TRUE) |
| Default Value | 0 [FALSE]             |

#### 2.4.82. Object 4021h: Math Output Scaling 1 PV

This object defines the process value that would correspond to 0% output from the math calculation. The object would apply the resolution defined in object 4532h Math Output Decimal Digits PV. The physical unit is undefined.

##### **Object Description**

|             |                          |
|-------------|--------------------------|
| Index       | 4021h                    |
| Name        | Math Output Scaling 1 PV |
| Object Type | ARRAY                    |
| Data Type   | INTEGER16                |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 6                           |
| Default Value | 6                           |

|             |                            |
|-------------|----------------------------|
| Sub-Index   | 1h to 6h (Y = 1 to 6)      |
| Description | Math Y Output Scaling 1 PV |

|               |                 |
|---------------|-----------------|
| Access        | RW              |
| PDO Mapping   | No              |
| Value Range   | -32768 to 32767 |
| Default Value | 0               |

#### 2.4.83. Object 4023h: Math Output Scaling 2 PV

This object defines the process value that would correspond to 100% output from the math calculation. The object would apply the resolution defined in object 4532h Math Output Decimal Digits PV. The physical unit is undefined.

##### **Object Description**

|             |                          |
|-------------|--------------------------|
| Index       | 4023h                    |
| Name        | Math Output Scaling 2 PV |
| Object Type | ARRAY                    |
| Data Type   | INTEGER16                |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 6                           |
| Default Value | 6                           |

|               |                            |
|---------------|----------------------------|
| Sub-Index     | 1h to 6h (Y = 1 to 6)      |
| Description   | Math Y Output Scaling 2 PV |
| Access        | RW                         |
| PDO Mapping   | No                         |
| Value Range   | -32768 to 32767            |
| Default Value | 10000 (100.00)             |

#### 2.4.84. Object 4030h: Math Output Process Value

This read-only object reflects the output from the math function block after it has been scaled by objects 4021h and 4023h. The object would apply the resolution defined in object 4032h Math Output Decimal Digits PV. The physical unit is undefined.

##### **Object Description**

|             |                           |
|-------------|---------------------------|
| Index       | 4030h                     |
| Name        | Math Output Process Value |
| Object Type | ARRAY                     |
| Data Type   | INTEGER16                 |

##### **Entry Description**

|             |                             |
|-------------|-----------------------------|
| Sub-Index   | 0h                          |
| Description | Largest sub-index supported |
| Access      | RO                          |

|               |    |
|---------------|----|
| PDO Mapping   | No |
| Value Range   | 6  |
| Default Value | 6  |

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 1h to 6h (Y = 1 to 6)       |
| Description   | Math Y Output Process Value |
| Access        | RO                          |
| PDO Mapping   | Yes                         |
| Value Range   | -32768 to 32767             |
| Default Value | No                          |

#### 2.4.85. Object 4032h: Math Output Decimal Digits PV

This object describes the number of digits following the decimal point (i.e. resolution) of the output data, which is interpreted with data type Integer16 in the process value object.

##### ***Object Description***

|             |                               |
|-------------|-------------------------------|
| Index       | 4032h                         |
| Name        | Math Output Decimal Digits PV |
| Object Type | ARRAY                         |
| Data Type   | UNSIGNED8                     |

##### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 6                           |
| Default Value | 6                           |

|               |                          |
|---------------|--------------------------|
| Sub-Index     | 1h to 6h (Y = 1 to 6)    |
| Description   | Math Y Decimal Digits PV |
| Access        | RW                       |
| PDO Mapping   | No                       |
| Value Range   | 0 to 4                   |
| Default Value | 2 (0.01)                 |

#### 2.4.86. Object 4y00h: Math Y Input Source

This object defines the input sources that will be used in the mathematical calculations. Here, y = 1 to 6 – representing Math Block 1 to Math Block 6. If a control source is not used, the associate mathematical calculation would be ignored. The available control sources on the MF-I/O controller are listed in Table 15.

##### ***Object Description***

|             |                     |
|-------------|---------------------|
| Index       | 4y00h (y = 1 to 6)  |
| Name        | Math Y Input Source |
| Object Type | ARRAY               |

|           |           |
|-----------|-----------|
| Data Type | UNSIGNED8 |
|-----------|-----------|

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 6                           |
| Default Value | 6                           |

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 1h to 6h (X = 1 to 6)       |
| Description   | Math Y Input X Source       |
| Access        | RW                          |
| PDO Mapping   | No                          |
| Value Range   | See Table 15                |
| Default Value | 0 (control source not used) |

### **2.4.87. Object 4y01h: Math Y Input Number**

This object defines the number of the input source that will be used in the math calculation. The available control numbers are dependent on the source selected, as shown in Table 16. Once selected, the input value will be used in the corresponding calculation as described in Section 1.9.

#### ***Object Description***

|             |                     |
|-------------|---------------------|
| Index       | 4y01h (y = 1 to 6)  |
| Name        | Math Y Input Number |
| Object Type | ARRAY               |
| Data Type   | UNSIGNED8           |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 6                           |
| Default Value | 6                           |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 1h to 6h (X = 1 to 6) |
| Description   | Math Y Input X Number |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | See Table 16          |
| Default Value | 0 (null input)        |

### **2.4.88. Object 4y02h: Math Y Input Function Number**

This object defines the number of the function within the Math Block will be used in the math calculation. This object is applicable when the Input Source together with the Input Number match the Math Block that is being configured. If Input Source and Input Number match the Math Block

being configured and the Function Number is 0, this object is ignored. For more details, refer to Section 1.9.

#### ***Object Description***

|             |                     |
|-------------|---------------------|
| Index       | 4y01h (y = 1 to 6)  |
| Name        | Math Y Input Number |
| Object Type | ARRAY               |
| Data Type   | UNSIGNED8           |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 6                           |
| Default Value | 6                           |

|               |                                |
|---------------|--------------------------------|
| Sub-Index     | 1h to 6h (X = 1 to 6)          |
| Description   | Math Y Input X Function Number |
| Access        | RW                             |
| PDO Mapping   | No                             |
| Value Range   | See Table 16                   |
| Default Value | 0 (null input)                 |

### **2.4.89. Object 4y03h: Math Y Input Decimal Digits FV**

This object describes the number of digits following the decimal point (i.e. resolution) of the input data, which is interpreted with data type Integer16 in the field value object.

#### ***Object Description***

|             |                                |
|-------------|--------------------------------|
| Index       | 4y03h (y = 1 to 6)             |
| Name        | Math Y Input Decimal Digits FV |
| Object Type | ARRAY                          |
| Data Type   | UNSIGNED8                      |

#### ***Entry Description***

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 6                           |
| Default Value | 6                           |

|               |                                  |
|---------------|----------------------------------|
| Sub-Index     | 1h to 6h (X = 1 to 6)            |
| Description   | Math Y Input X Decimal Digits PV |
| Access        | RW                               |
| PDO Mapping   | No                               |
| Value Range   | 0 to 4                           |
| Default Value | 2 (0.01)                         |

#### 2.4.90. Object 4y20h: Math Y Input Scaling 1 FV

This object defines the input field value that would correspond to 0% when scaling the input for use in the math calculation. All inputs are normalized to a percentage before being used by the math function block. The object would apply the resolution defined in object 4y03h Math Y Input Decimal Digits FV. The physical unit would match that of the input source.

##### **Object Description**

|             |                           |
|-------------|---------------------------|
| Index       | 4y20h (y = 1 to 6)        |
| Name        | Math Y Input Scaling 1 FV |
| Object Type | ARRAY                     |
| Data Type   | INTEGER16                 |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 6                           |
| Default Value | 6                           |

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 1h to 6h (X = 1 to 6)       |
| Description   | Math Y Input X Scaling 1 FV |
| Access        | RW                          |
| PDO Mapping   | No                          |
| Value Range   | INTEGER16                   |
| Default Value | 0                           |

#### 2.4.91. Object 4y22h: Math Y Input Scaling 2 FV

This object defines the input field value that would correspond to 100% when scaling the input for use in the math calculation. All inputs are normalized to a percentage before being used by the math function block. The object would apply the resolution defined in object 4y03h Math Y Input Decimal Digits FV. The physical unit would match that of the input source.

##### **Object Description**

|             |                           |
|-------------|---------------------------|
| Index       | 4y22h (y = 1 to 6)        |
| Name        | Math Y Input Scaling 2 FV |
| Object Type | ARRAY                     |
| Data Type   | INTEGER16                 |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 6                           |
| Default Value | 6                           |

|           |                       |
|-----------|-----------------------|
| Sub-Index | 1h to 6h (X = 1 to 6) |
|-----------|-----------------------|

|               |                             |
|---------------|-----------------------------|
| Description   | Math Y Input X Scaling 2 FV |
| Access        | RW                          |
| PDO Mapping   | No                          |
| Value Range   | INTEGER16                   |
| Default Value | 10000 (100.00%)             |

#### 2.4.92. Object 4y40h: Math Y Input Gain

This object can be used to adjust the ‘weight’ of the input in the math calculation. It is a multiplier of the input after it has been converted into a percentage, before it is used in the math calculation. This object has a fixed resolution of 2 decimal digits.

##### **Object Description**

|             |                    |
|-------------|--------------------|
| Index       | 4y40h (y = 1 to 6) |
| Name        | Math Y Input Gain  |
| Object Type | ARRAY              |
| Data Type   | INTEGER8           |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0h                          |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 6                           |
| Default Value | 6                           |

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 1h to 6h (X = 1 to 6) |
| Description   | Math Y Input X Gain   |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | -100 to 100           |
| Default Value | 100 (1.0)             |

#### 2.4.93. Object 4y50h: Math Y Operator

This object defines the actual operators that will be used in each stage of a math calculation, as described in Section 1.9. The options for this object are listed in Table 30.

##### **Object Description**

|             |                    |
|-------------|--------------------|
| Index       | 4y50h (y = 1 to 6) |
| Name        | Math Y Operator    |
| Object Type | ARRAY              |
| Data Type   | UNSIGNED8          |

##### **Entry Description**

|             |                             |
|-------------|-----------------------------|
| Sub-Index   | 0h                          |
| Description | Largest sub-index supported |
| Access      | RO                          |

|               |    |
|---------------|----|
| PDO Mapping   | No |
| Value Range   | 3  |
| Default Value | 3  |

|               |                            |
|---------------|----------------------------|
| Sub-Index     | 1h to 3h (X = 1 to 3)      |
| Description   | Math Y Function X Operator |
| Access        | RW                         |
| PDO Mapping   | No                         |
| Value Range   | See Table 30               |
| Default Value | 12 (Plus)                  |

#### 2.4.94. Object 5010h: Constant Field Value

This object is provided to allow the user to compare against a fixed value, i.e. for setpoint control in a PID loop, or in a conditional evaluation for a logic block. The first two values in this object are fixed at FALSE (0) and TRUE (1). There are ten other sub-indexes provide for other unconstrained data.

##### **Object Description**

|             |                      |
|-------------|----------------------|
| Index       | 5010h                |
| Name        | Constant Field Value |
| Object Type | ARRAY                |
| Data Type   | FLOAT32              |

##### **Entry Description**

|               |                             |
|---------------|-----------------------------|
| Sub-Index     | 0                           |
| Description   | Largest sub-index supported |
| Access        | RO                          |
| PDO Mapping   | No                          |
| Value Range   | 15                          |
| Default Value | 15                          |

|               |                |
|---------------|----------------|
| Sub-Index     | 1              |
| Description   | Constant False |
| Access        | RO             |
| PDO Mapping   | No             |
| Value Range   | 0              |
| Default Value | 0 (false)      |

|               |               |
|---------------|---------------|
| Sub-Index     | 2             |
| Description   | Constant True |
| Access        | RO            |
| PDO Mapping   | No            |
| Value Range   | 1             |
| Default Value | 1 (true)      |

|               |               |
|---------------|---------------|
| Sub-Index     | 3             |
| Description   | Constant FV 3 |
| Access        | RW            |
| PDO Mapping   | No            |
| Value Range   | Float32       |
| Default Value | 3.141593      |

|               |               |
|---------------|---------------|
| Sub-Index     | 4             |
| Description   | Constant FV 4 |
| Access        | RW            |
| PDO Mapping   | No            |
| Value Range   | Float32       |
| Default Value | 2.718282      |

|               |               |
|---------------|---------------|
| Sub-Index     | 5             |
| Description   | Constant FV 5 |
| Access        | RW            |
| PDO Mapping   | No            |
| Value Range   | Float32       |
| Default Value | 1.414214      |

|               |               |
|---------------|---------------|
| Sub-Index     | 6             |
| Description   | Constant FV 6 |
| Access        | RW            |
| PDO Mapping   | No            |
| Value Range   | Float32       |
| Default Value | 1.732051      |

|               |               |
|---------------|---------------|
| Sub-Index     | 7             |
| Description   | Constant FV 7 |
| Access        | RW            |
| PDO Mapping   | No            |
| Value Range   | Float32       |
| Default Value | 2.236068      |

|               |               |
|---------------|---------------|
| Sub-Index     | 8             |
| Description   | Constant FV 8 |
| Access        | RW            |
| PDO Mapping   | No            |
| Value Range   | Float32       |
| Default Value | 2.50          |

|               |               |
|---------------|---------------|
| Sub-Index     | 9             |
| Description   | Constant FV 9 |
| Access        | RW            |
| PDO Mapping   | No            |
| Value Range   | Float32       |
| Default Value | 5.00          |

|               |                |
|---------------|----------------|
| Sub-Index     | 10             |
| Description   | Constant FV 10 |
| Access        | RW             |
| PDO Mapping   | No             |
| Value Range   | Float32        |
| Default Value | 10.00          |

|             |                |
|-------------|----------------|
| Sub-Index   | 11             |
| Description | Constant FV 11 |

|               |         |
|---------------|---------|
| Access        | RW      |
| PDO Mapping   | No      |
| Value Range   | Float32 |
| Default Value | 20.00   |

|               |                |
|---------------|----------------|
| Sub-Index     | 12             |
| Description   | Constant FV 12 |
| Access        | RW             |
| PDO Mapping   | No             |
| Value Range   | Float32        |
| Default Value | 40.00          |

|               |                |
|---------------|----------------|
| Sub-Index     | 13             |
| Description   | Constant FV 13 |
| Access        | RW             |
| PDO Mapping   | No             |
| Value Range   | Float32        |
| Default Value | 60.00          |

|               |                |
|---------------|----------------|
| Sub-Index     | 14             |
| Description   | Constant FV 14 |
| Access        | RW             |
| PDO Mapping   | No             |
| Value Range   | Float32        |
| Default Value | 80.00          |

|               |                |
|---------------|----------------|
| Sub-Index     | 15             |
| Description   | Constant FV 15 |
| Access        | RW             |
| PDO Mapping   | No             |
| Value Range   | Float32        |
| Default Value | 1000.00        |

#### 2.4.95. Object 5040h: Fault Detection Field Value

This read-only object is available for diagnostic feedback purposes. It reflects the measured over/under voltage powering the controller as well as the internal microcontroller temperature. The physical unit for this object is volts and °C, respectively.

##### ***Object Description***

|             |                          |
|-------------|--------------------------|
| Index       | 5040h                    |
| Name        | Power Supply Field Value |
| Object Type | VARIABLE                 |
| Data Type   | FLOAT32                  |

##### ***Entry Description***

|             |     |
|-------------|-----|
| Sub-Index   | 0h  |
| Access      | RO  |
| PDO Mapping | Yes |

|               |   |
|---------------|---|
| Value Range   | 3 |
| Default Value | 3 |

|               |                              |
|---------------|------------------------------|
| Sub-Index     | 1h                           |
| Description   | Over Temperature Field Value |
| Access        | RO                           |
| PDO Mapping   | Yes                          |
| Value Range   | 0 to 1250 [°C x 10]          |
| Default Value | 0                            |

|               |                          |
|---------------|--------------------------|
| Sub-Index     | 2h                       |
| Description   | Over Voltage Field Value |
| Access        | RO                       |
| PDO Mapping   | Yes                      |
| Value Range   | 0 to 500 [V x 10]        |
| Default Value | 0                        |

|               |                           |
|---------------|---------------------------|
| Sub-Index     | 3h                        |
| Description   | Under Voltage Field Value |
| Access        | RO                        |
| PDO Mapping   | Yes                       |
| Value Range   | 0 to 500 [V x 10]         |
| Default Value | 0                         |

#### 2.4.96. Object 5041h: FD Set Threshold

This object sets the value that will flag a fault detection error in the 10 Analog Input if the measured field value (5040h) goes above (FD 1 and FD 2) or below (FD 3) this limit. If error checking on the fault is enabled by object 5050h, then the module will flag an appropriate error on that channel. This value must be in the same units as the field value for the fault, as determined by the sub-index.

##### **Object Description**

|             |                  |
|-------------|------------------|
| Index       | 5041h            |
| Name        | FD Set Threshold |
| Object Type | ARRAY            |
| Data Type   | UNSIGNED16       |

##### **Entry Description**

|               |                   |
|---------------|-------------------|
| Subindex      | 0h                |
| Description   | Number of entries |
| Access        | RO                |
| PDO Mapping   | No                |
| Value Range   | 3                 |
| Default Value | 3                 |

|               |                                        |
|---------------|----------------------------------------|
| Sub-index     | 1h                                     |
| Description   | Over Temperature Set Threshold         |
| Access        | RW                                     |
| PDO Mapping   | No                                     |
| Value Range   | 5042h at sub-index 1 to 1250 [°C x 10] |
| Default Value | 1100 (110.0°C)                         |

|               |                                       |
|---------------|---------------------------------------|
| Sub-index     | 2h                                    |
| Description   | Over Voltage Set Threshold            |
| Access        | RW                                    |
| PDO Mapping   | No                                    |
| Value Range   | 5042h at sub-index 2 to 1000 [V x 10] |
| Default Value | 500 (50.0V)                           |

|               |                                     |
|---------------|-------------------------------------|
| Sub-index     | 3h                                  |
| Description   | Under Voltage Set Threshold         |
| Access        | RW                                  |
| PDO Mapping   | No                                  |
| Value Range   | 80 to 5042h at sub-index 3 [V x 10] |
| Default Value | 90 (9.0V)                           |

#### 2.4.97. Object 5042h: FD Clear Threshold

This object sets the value that will clear a fault detection error in the 10 Analog Input if the measured field value (5040h) goes below (FD 1 and FD 2) or above (FD 3) this threshold. This value must be in the same units as the field value for the fault, as determined by the sub-index.

##### **Object Description**

|             |                    |
|-------------|--------------------|
| Index       | 5042h              |
| Name        | FD Clear Threshold |
| Object Type | ARRAY              |
| Data Type   | UNSIGNED16         |

##### **Entry Description**

|               |                   |
|---------------|-------------------|
| Subindex      | 0h                |
| Description   | Number of entries |
| Access        | RO                |
| PDO Mapping   | No                |
| Value Range   | 3                 |
| Default Value | 3                 |

|               |                                      |
|---------------|--------------------------------------|
| Subindex      | 1h                                   |
| Description   | Over Temperature Clear Threshold     |
| Access        | RW                                   |
| PDO Mapping   | No                                   |
| Value Range   | 500 to 4001h at subindex 1 [°C x 10] |
| Default Value | 850 (85.0°C)                         |

|               |                                                        |
|---------------|--------------------------------------------------------|
| Subindex      | 2h                                                     |
| Description   | Over Voltage Clear Threshold                           |
| Access        | RW                                                     |
| PDO Mapping   | No                                                     |
| Value Range   | 4002h at subindex 3 to<br>4001h at subindex 2 [V x 10] |
| Default Value | 480 (48.0V)                                            |

|             |                               |
|-------------|-------------------------------|
| Subindex    | 3h                            |
| Description | Under Voltage Clear Threshold |
| Access      | RW                            |
| PDO Mapping | No                            |

|               |                                                        |
|---------------|--------------------------------------------------------|
| Value Range   | 4001h at subindex 3 to<br>4002h at subindex 2 [V x 10] |
| Default Value | 120 (12.0V)                                            |

#### 2.4.98. Object 5050h: FD Enable Error Check 8 Faults

This object enables or disables the fault detection error-checking feature for each fault detectable by the MF I/O controller. The bitmap for this object at sub-index 1 is:

- Bit 0: Over Temperature Detection
- Bit 1: Over Voltage Detection
- Bit 2: Under Voltage Detection

##### **Object Description**

|             |                                   |
|-------------|-----------------------------------|
| Index       | 5050h                             |
| Name        | FD Enable Error Checking 8 Faults |
| Object Type | ARRAY                             |
| Data Type   | UNSIGNED8                         |

##### **Entry Description**

|               |                   |
|---------------|-------------------|
| Sub-index     | 0h                |
| Description   | Number of entries |
| Access        | RO                |
| PDO Mapping   | No                |
| Value Range   | 1                 |
| Default Value | 1                 |

|               |                                                                         |
|---------------|-------------------------------------------------------------------------|
| Sub-index     | 1h                                                                      |
| Description   | Error Check for FD 1 to FD 3                                            |
| Access        | RW                                                                      |
| PDO Mapping   | No                                                                      |
| Value Range   | Bit Value 0 = Error Check Disabled<br>Bit Value 1 = Error Check Enabled |
| Default Value | 00h (all error check disabled)                                          |

#### 2.4.99. Object 5051h: FD Error Response Delay

This object is used to prevent intermittent faults from overloading the bus with error messages. The value is defined as a multiple of 1ms. If a fault has been present during the entirety of the delay time, the MF I/O Controller will flag an error of the detected fault once the timer has expired. The object can be set to zero, in which case a fault will immediately trigger an error response.

##### **Object Description**

|             |                         |
|-------------|-------------------------|
| Index       | 5051h                   |
| Name        | FD Error Response Delay |
| Object Type | ARRAY                   |
| Data Type   | UNSIGNED16              |

##### **Entry Description**

|               |                   |
|---------------|-------------------|
| Subindex      | 0h                |
| Description   | Number of entries |
| Access        | RO                |
| PDO Mapping   | No                |
| Value Range   | 3                 |
| Default Value | 3                 |

|               |                           |
|---------------|---------------------------|
| Subindex      | 1h to 3h                  |
| Description   | Error Delay, FD 1 to FD 3 |
| Access        | RW                        |
| PDO Mapping   | No                        |
| Value Range   | 0 to 10000 [ms]           |
| Default Value | 5000 [ms]                 |

#### 2.4.100. Object 5550h: Enable Automatic Updates

This object allows the controller to update objects to defaults automatically when an output type is changed. By default this object is TRUE.

##### ***Object Description***

|             |                     |
|-------------|---------------------|
| Index       | 5550h               |
| Name        | Enable Auto Updates |
| Object Type | VARIABLE            |
| Data Type   | BOOLEAN             |

##### ***Entry Description***

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 0h                    |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | 0 (FALSE) or 1 (TRUE) |
| Default Value | 1 [TRUE]              |

#### 2.4.101. Object 5555h: Start in Operational Mode

This object allows the unit to start in Operational mode without requiring the presence of a CANopen ® Master on the network. It is intended to be used only when running the MF-I/O controller as a stand-alone module. This should always be set FALSE whenever it is connected to a standard master/slave network.

##### ***Object Description***

|             |                           |
|-------------|---------------------------|
| Index       | 5555h                     |
| Name        | Start in Operational Mode |
| Object Type | VARIABLE                  |
| Data Type   | BOOLEAN                   |

##### ***Entry Description***

|               |                       |
|---------------|-----------------------|
| Sub-Index     | 0h                    |
| Access        | RW                    |
| PDO Mapping   | No                    |
| Value Range   | 0 (FALSE) or 1 (TRUE) |
| Default Value | 0 [FALSE]             |

### 3. Technical Specifications

#### 3.1. Power Supply

|                    |                                                                                                                                                           |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Power Supply Input | 12, 24, 48VDC nominal                                                                                                                                     |
| Supply Current     | Contact Axiomatic                                                                                                                                         |
| Protection         | Reverse polarity protection is provided.<br>Power supply input section protects against transient surges and shorts.<br>Software protection also provided |

#### 3.2. Outputs

|                               |                                                                                                                                                                                                                            |
|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Proportional Output Functions | Current [mA], Voltage [V], PWM [%], Digital On/Off, Hotshot On/Off                                                                                                                                                         |
| Output Type                   | High side switching (sourcing output up to 2.0 A), Grounded Load<br>Current sensing for close-loop control, current feedback on object 2370h<br>High frequency output drive at 25kHz (fixed for current and Hotshot types) |
| Current PID Loop              | User configurable (use with caution)                                                                                                                                                                                       |
| Protection for Output+        | The unit is fully protected against short circuit to ground. Unit will fail safe in the case of a short circuit condition, self-recovering when the short is removed.                                                      |
| Error Detection/Reaction      | EMCY code generation (object 1003h) and fault reaction is possible (1029h) when an open or short circuit is detected at the output (current mode only).                                                                    |
| Output Accuracy               | Output Current mode +/-2% full scale error<br>Output Voltage mode +/-5% full scale error<br>Output PWM Duty Cycle mode +/-1% full scale error                                                                              |
| Output Resolution             | Current: 1mA, Voltage: 0.1V, PWM: 0.1%                                                                                                                                                                                     |
| Ramp Times                    | Ramp Up: 0 to 60000 ms<br>Ramp Down: 0 to 60000 ms                                                                                                                                                                         |
| Output Frequency              | Frequency configurable from 1Hz to 25000Hz                                                                                                                                                                                 |
| Dither Frequency              | Fully configurable from 50Hz to 400Hz                                                                                                                                                                                      |
| Dither Amplitude              | Adjustable amplitude up to 400mA                                                                                                                                                                                           |

|                        |                           |
|------------------------|---------------------------|
| Relay Output Functions | Digital On/Off – 5A rated |
|------------------------|---------------------------|

|                          |                                                                                                                                                         |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| Analog Output Functions  | Current [uA], Voltage [mV]                                                                                                                              |
| Error Detection/Reaction | EMCY code generation (object 1003h) and fault reaction is possible (1029h) when an open or short circuit is detected at the output (current mode only). |
| Output Accuracy          | Output Current mode +/-2% full scale error<br>Output Voltage mode +/-5% full scale error                                                                |
| Output Resolution        | Current: 1mA, Voltage: 0.1V                                                                                                                             |
| Ramp Times               | Ramp Up: 0 to 60000 ms<br>Ramp Down: 0 to 60000 ms                                                                                                      |

#### 3.3. Communication

|                     |                                                                                                                                                                                                                                                                         |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CAN                 | 2 independent CAN 2.0B port, protocol CiA CANopen ®                                                                                                                                                                                                                     |
| Network Termination | According to the CAN standard, it is necessary to terminate the network with external termination resistors. The resistors are 120 Ohm, 0.25W minimum, metal film or similar type. They should be placed between CAN_H and CAN_L terminals at both ends of the network. |

### 3.4. General Specifications

|                      |                                                                                                                                  |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Microprocessor       | STM32F207ZGT7, 16-bit, 1024 KByte flash program memory                                                                           |
| Control Logic        | User programmable functionality using SDO object access, per CiA DS-301                                                          |
| User Interface       | .EDS provided to interface to standard CANopen ® tools                                                                           |
| Operating Conditions | -40 to 85 °C (-40 to 185 °F)                                                                                                     |
| Storage              | -50 to 105 °C (-58 to 221 °F)                                                                                                    |
| Packaging            | Refer to Figure 16 for dimensions.<br>IP67 rating for product assembly<br>Can be mounted directly on the valve block or remotely |
| Vibration Compliance | Random Vibration: 7.68 Grms peak<br>Sinusoidal Component: 10 g peak<br>Based on MIL-STD-202G, Methods 204G, 214A and 213B        |

#### 4. VERSION HISTORY

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| Version | Date                              | Author            | Modifications                                                                                                                                             |
|---------|-----------------------------------|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1       | July 7 <sup>th</sup> , 2014       | Gustavo Del Valle | Initial Draft                                                                                                                                             |
| 1A      | September 11 <sup>th</sup> , 2014 | Gustavo Del Valle | Updated CANopen index ranges as some COB dictionary descriptions were out of bounds.                                                                      |
| 1B      | November 2 <sup>nd</sup> , 2014   | Gustavo Del Valle | Updated Table 33 (Pre-Defined Error Field Codes) on page 53 to include missing input error field codes and to remove unsupported output error field codes |
| --      | April 16, 2015                    | Amanda Wilkins    | Added vibration compliance                                                                                                                                |
| 1C      | October 6, 2021                   | Amanda Wilkins    | Updated pinout                                                                                                                                            |

## OUR PRODUCTS

AC/DC Power Supplies  
Actuator Controls/Interfaces  
Automotive Ethernet Converters  
Battery Chargers  
CAN Controls, Routers, Repeaters  
CAN/WiFi, CAN/Bluetooth  
Current/Voltage Converters  
DC/DC Power Converters  
Engine Temperature Scanners  
Ethernet/CAN Converters,  
Gateways, Switches  
Fan Drive Controllers  
Gateways, CAN/Modbus Protocols  
Gyroscope Inclinometers  
Hydraulic Valve Controllers  
Inclinometers, Triaxial  
I/O Controls  
LVDT Signal Converters  
Machine Controls  
Modbus Controls  
Motor Controls  
Power Supplies, DC/DC, AC/DC  
PWM Signal Converters/Isolators  
Resolver Signal Conditioners  
Service Tools  
Signal Conditioners, Converters  
Strain Gauge CAN Controls  
Surge Suppressors

## OUR COMPANY

Axiomatic provides electronic machine control components to the off-highway, commercial vehicle, electric vehicle, power generator set, material handling, renewable energy and industrial OEM markets. ***We innovate with engineered and off-the-shelf machine controls that add value for our customers.***

## QUALITY DESIGN AND MANUFACTURING

Axiomatic in Canada has an ISO 9001:2015 design and manufacturing facility.

## SERVICE

All products to be returned to Axiomatic require a Return Materials Authorization Number (RMA#) from [sales@axiomatic.com](mailto:sales@axiomatic.com). Please provide the following information when requesting an RMA number:

- Serial number, part number
- Hours of operation, description of problem
- Wiring set up diagram, application and other comments as needed

## SAFE USE

All products should be serviced by Axiomatic. Do not open the product and perform the service yourself.



This product can expose you to chemicals which are known in the State of California, USA to cause cancer and reproductive harm. For more information go to [www.P65Warnings.ca.gov](http://www.P65Warnings.ca.gov).

## DISPOSAL

Axiomatic products are electronic waste. Please follow your local environmental waste and recycling laws, regulations and policies for safe disposal or recycling of electronic waste.

## WARRANTY, APPLICATION APPROVALS/LIMITATIONS

Axiomatic Technologies Corporation reserves the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. Users should satisfy themselves that the product is suitable for use in the intended application. All our products carry a limited warranty against defects in material and workmanship. Please refer to our Warranty, Application Approvals/Limitations and Return Materials Process as described on [www.axiomatic.com/service.html](http://www.axiomatic.com/service.html).

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