



USER MANUAL UMAX100251

40A BLDC MOTOR CONTROLLER with CANOpen®

USER MANUAL

P/N: AX100251

VERSION HISTORY

Version	Date	Author	Modification
1.0.0	April 5, 2023	Jordan Wilbur	Initial version. Based on v1.01 of UMAX100250
1.0.1	February 29, 2024	M Ejaz	Legacy changes Marketing review Added dimensional drawing Updated technical specifications

ACRONYMS

ACK	Positive Acknowledgement (from SAE J1939 standard)
BATT +/-	Battery positive (a.k.a. Vps) or Battery Negative (a.k.a. GND)
BEMF	Back Electromotive Force / Counter-electromotive Force
DM	Diagnostic Message (from SAE J1939 standard)
DTC	Diagnostic Trouble Code (from SAE J1939 standard)
ECU	Electronic Control Unit (from SAE J1939 standard)
GND	Ground reference (a.k.a. BATT-)
I/O	Inputs and Outputs
MAP	Memory Access Protocol
NAK	Negative Acknowledgement (from SAE J1939 standard)
PDU1	A format for messages that are to be sent to a destination address, either specific or global (from SAE J1939 standard)
PDU2	A format used to send information that has been labeled using the Group Extension technique, and does not contain a destination address.
PGN	Parameter Group Number (from SAE J1939 standard)
PropA	Message that uses the Proprietary A PGN for peer-to-peer communication
PropB	Message that uses a Proprietary B PGN for broadcast communication
PWM	Pulse Width Modulation
RPM	Rotations per Minute
SPN	Suspect Parameter Number (from SAE J1939 standard)
TP	Transport Protocol
Vps	Voltage Power Supply (a.k.a. BATT+)
%dc	Percent Duty Cycle (Measured from a PWM input)

TABLE OF CONTENTS

1. OVERVIEW OF CONTROLLER	12
1.1. Motor Control Functionality.....	13
1.1.1. Sensorless Control	14
1.2. Digital Input Function Block.....	16
1.3. Input Function Block	18
1.4. Output Function Block	22
1.4.1. Digital Output Modes	29
1.5. Lookup Tables	31
1.5.1. X-Axis, Input Data Response	32
1.5.2. Y-Axis, Lookup Table Output.....	33
1.5.3. Point To Point Response	33
1.5.4. X-Axis, Time Response	35
1.6. PID Function Blocks	36
1.7. Math Function Blocks	37
1.8. Miscellaneous Function Block	39
1.9. Available Control Sources	41
2. INSTALLATION INSTRUCTIONS	44
2.1. Dimensions and Pinout.....	44
3. CANOPEN® OBJECT DICTIONARY	45
3.1. Node ID and Baudrate	45
3.1.1. LSS Protocol to Update	45
3.1.1.1. Setting Node ID	45
3.1.1.2. Setting Baudrate	46
3.2. Communication Objects (DS 301 and DS-404).....	49
3.2.1. Object 1000h: Device Type	50
3.2.2. Object 1001h: Error Register	50
3.2.3. Object 1003h: Pre-Defined Error Field	51
3.2.4. Object 100Ch: Guard Time.....	52
3.2.5. Object 100Dh: Lifetime Factor	53
3.2.6. Object 1010h: Store Parameters	53
3.2.7. Object 1011h: Restore Parameters	55
3.2.8. Object 1016h: Consumer Heartbeat Time.....	56
3.2.9. Object 1017h: Producer Heartbeat Time.....	57
3.2.10. Object 1018h: Identity Object	57
3.2.11. Object 1020h: Verify Configuration.....	58
3.2.12. Object 1029h: Error Behaviour	59
3.2.13. RPDO Behaviour	60
3.2.14. TPDO Behaviour.....	63
3.3. Application Objects (DS-402 and DS-404).....	66
3.3.1. Object 6000h: DI Read State 8 Input Lines	67

3.3.2.	Object 6002h: DI Polarity 8 Input Lines	67
3.3.3.	Object 7100h: AI Input Field Value	68
3.3.4.	Object 6110h: AI Sensor Type	68
3.3.5.	Object 6112h: AI Operating Mode	69
3.3.6.	Object 7120h: AI Input Scaling 1 FV	69
3.3.7.	Object 7121h: AI Input Scaling 1 PV	70
3.3.8.	Object 7122h: AI Input Scaling 2 FV	71
3.3.9.	Object 7123h: AI Input Scaling 2 PV	71
3.3.10.	Object 7130h: AI Input Process Value.....	72
3.3.11.	Object 6132h: AI Decimal Digits PV	72
3.3.12.	Object 7148h: AI Span Start.....	73
3.3.13.	Object 7149h: AI Span End	73
3.3.14.	Object 61A0h: AI Filter Type.....	74
3.3.15.	Object 61A1h: AI Filter Constant	74
3.3.16.	Object 606Ch: MC Actual Motor Velocity	75
3.3.17.	Object 6075h: MC Rated Motor Current.....	75
3.3.18.	Object 60FFh: MC Target Velocity	76
3.3.19.	Object 607Eh: MC Polarity	76
3.3.20.	Object 6080h: MC Max Motor Speed	76
3.3.21.	Object 6200h: DO Write State 8 Output Lines	77
3.3.22.	Object 6002h: DO Polarity 8 Output Lines	77
3.3.23.	Object 7300h: AO Output Process Value	78
3.3.24.	Object 6302h: AO Decimal Digits PV	78
3.3.25.	Object 6310h: AO Output Type	79
3.3.26.	Object 7320h: AO Output Scaling 1 PV.....	79
3.3.27.	Object 7321h: AO Output Scaling 1 FV.....	80
3.3.28.	Object 7322h: AO Output Scaling 2 PV.....	81
3.3.29.	Object 7323h: AO Output Scaling 2 FV.....	82
3.3.30.	Object 7330h: AO Output Field Value	82
3.3.31.	Object 6332h: AO Decimal Digits FV	83
3.3.32.	Object 6340h: AO Fault Mode	83
3.3.33.	Object 7341h: AO Fault Field Value	84
3.3.34.	Object 7450h: PID Proportional Band	85
3.3.35.	Object 7452h: PID Integral Action Time	85
3.3.36.	Object 7454h: PID Derivative Action Time	86
3.3.37.	Object 7456h: PID Cycle Time	86
3.3.38.	Object 6458h: PID Physical Unit Timing.....	87
3.3.39.	Object 6459h: PID Decimal Digits Timing	87
3.4.	Manufacturer Objects	89
3.4.1.	Object 2020h: DI Pullup/Down Mode 1 Input Line	92

3.4.2.	Object 2030h: DI Debounce Filter 1 Input Line	92
3.4.3.	Object 2100h: AI Input Range	93
3.4.4.	Object 2101h: AI Number of Pulses Per Revolution	93
3.4.5.	Object 2102h: AI Decimal Digits FV	94
3.4.6.	Object 2103h: AI Filter Frequency for ADC	94
3.4.7.	Object 2110h: AI Error Detect Enable	95
3.4.8.	Object 2111h: AI Error Clear Hysteresis	96
3.4.9.	Object 2112h: AI Error Reaction Delay	96
3.4.10.	Object 2220h: DO Hotshot Current 1 Output Line	97
3.4.11.	Object 2221h: DO Hold Current 1 Output Line	97
3.4.12.	Object 2222h: DO Hold Time 1 Output Line	98
3.4.13.	Object 2224h: DO Delay Time 1 Output Line	99
3.4.14.	Object 2225h: DO Delay Polarity 1 Output Line	99
3.4.15.	Object 2300h: AO Override Field Value	100
3.4.16.	Object 2310h: AO Error Detect Enable	101
3.4.17.	Object 2311h: AO Error Clear Hysteresis.....	101
3.4.18.	Object 2312h: AO Error Reaction Delay.....	102
3.4.19.	Object 2320h: AO Dither Frequency	103
3.4.20.	Object 2321h: AO Dither Amplitude	104
3.4.21.	Object 2330h: AO Ramp Up	104
3.4.22.	Object 2331h: AO Ramp Down	105
3.4.23.	Object 2340h: AO Control Input Source	106
3.4.24.	Object 2341h: AO Control Input Number.....	106
3.4.25.	Object 2342h: AO Control Response	107
3.4.26.	Object 2350h: AO Enable Input Source	107
3.4.27.	Object 2351h: AO Enable Input Number	108
3.4.28.	Object 2352h: AO Enable Response.....	109
3.4.29.	Object 2360h: AO Override Input Source.....	109
3.4.30.	Object 2361h: AO Override Input Number	110
3.4.31.	Object 2362h: AO Override Response	110
3.4.32.	Object 2370h: AO Feedback Field Value	111
3.4.33.	Object 2380h: AO Output Frequency	111
3.4.34.	Object 2382h: AO Current PID Proportional Gain	112
3.4.35.	Object 2383h: AO Current PID Integral Time	113
3.4.36.	Object 2384h: AO Current PID Derivative Time	114
3.4.37.	Object 2450h: PID Tolerance	114
3.4.38.	Object 2451h: PID Integral Gain.....	115
3.4.39.	Object 2452h: PID Derivative Gain.....	115
3.4.40.	Object 2453h: PID Target Source	116
3.4.41.	Object 2454h: PID Target Number	117

3.4.42.	Object 2455h: PID Feedback Source	117
3.4.43.	Object 2456h: PID Feedback Number.....	118
3.4.44.	Object 2457h: PID Control Response	118
3.4.45.	Object 2460h: PID Output Field Value	119
3.4.46.	Object 2500h: EC Extra Received Process Value	119
3.4.47.	Object 2502h: EC Decimal Digits PV	120
3.4.48.	Object 2520h: EC Scaling 1 PV.....	120
3.4.49.	Object 2522h: EC Scaling 2 PV.....	121
3.4.50.	Object 3340h: MC Control Input Source.....	122
3.4.51.	Object 3341h: MC Control Input Number	122
3.4.52.	Object 3350h: MC Direction Input Source	122
3.4.53.	Object 3351h: MC Direction Input Number.....	123
3.4.54.	Object 3360h: MC Enable Input Source	123
3.4.55.	Object 3361h: MC Enable Input Number.....	124
3.4.56.	Object 3510h: MC Number of Pole Pairs	124
3.4.57.	Object 3511h: MC Rotor Position Detection.....	124
3.4.58.	Object 3512h: MC Commutation Sequence	125
3.4.59.	Object 3513h: MC Overcurrent Clear Time	125
3.4.60.	Object 3515h: MC PWM Frequency	125
3.4.61.	Object 3516h: MC Rated RPM	126
3.4.62.	Object 3518h: MC Overtemperature Threshold	126
3.4.63.	Object 3610h: MC Speed Control Mode.....	126
3.4.64.	Object 3611h: MC Speed P Gain	127
3.4.65.	Object 3612h: MC Speed I Gain.....	127
3.4.66.	Object 3620h: MC Current Control Mode	127
3.4.67.	Object 3621h: MC Current P Gain.....	128
3.4.68.	Object 3622h: MC Current I Gain	128
3.4.69.	Object 3710h: MC Ramp Up Time	128
3.4.70.	Object 3711h: MC Ramp Down Time	129
3.4.71.	Object 3yz0h: LTyz Input X-Axis Source	129
3.4.72.	Object 3yz1h: LTyz Input X-Axis Number.....	129
3.4.73.	Object 3yz2h: LTyz Auto Repeat.....	130
3.4.74.	Object 3yz3h: LTyz X-Axis Decimal Digits PV.....	130
3.4.75.	Object 3yz4h: LTyz Y-Axis Decimal Digits PV.....	131
3.4.76.	Object 3yz5h: LTyz Point Response	131
3.4.77.	Object 3yz6h: LTyz Point X-Axis PV	132
3.4.78.	Object 3yz7h: LTyz Point Y-Axis PV	132
3.4.79.	Object 3yz8h: LTyz Output Y-Axis PV	133
3.4.80.	Object 4000h: Math Function Enable	133
3.4.81.	Object 4021h: Math Output Scaling 1 PV.....	134

3.4.82.	Object 4023h: Math Output Scaling 2 PV	134
3.4.83.	Object 4030h: Math Output Process Value	135
3.4.84.	Object 4032h: Math Output Decimal Digits PV	136
3.4.85.	Object 4y00h: Math Y Input Source.....	136
3.4.86.	Object 4y01h: Math Y Input Number	137
3.4.87.	Object 4y03h: Math Y Input Decimal Digits FV	137
3.4.88.	Object 4y20h: Math Y Input Scaling 1 FV.....	138
3.4.89.	Object 4y22h: Math Y Input Scaling 2 FV.....	138
3.4.90.	Object 4y40h: Math Y Input Gain	139
3.4.91.	Object 4y50h: Math Y Operator	139
3.4.92.	Object 5010h: Constant Field Value.....	140
3.4.93.	Object 5040h: Fault Detection Field Value	143
3.4.94.	Object 5041h: FD Set Threshold	143
3.4.95.	Object 5042h: FD Clear Threshold.....	144
3.4.96.	Object 5050h: FD Enable Error Check 8 Faults	145
3.4.97.	Object 5051h: FD Error Response Delay	146
3.4.98.	Object 5550h: Enable Automatic Updates.....	146
3.4.99.	Object 5555h: Start in Operational Mode	146

4. REFLASHING OVER CAN WITH EA BOOTLOADER ERROR! BOOKMARK NOT DEFINED.

APPENDIX A - TECHNICAL SPECIFICATION.....A-1

Table 1 – Default commutation sequence.....	13
Table 2 – DI Pullup/Down Options	16
Table 3 – DI Debounce Filter Options	17
Table 3 – Object 6002h DI Polarity 8 Input Lines Options	17
Table 3 – Object 6112h AI Operating Mode Options	19
Table 6 – Input Object Subindices.....	19
Table 7 – Universal Input Sensor Type Options.....	19
Table 8 – Object 2100h - AI Input Range Options Depending on Sensor Type	19
Table 9 – Object 2103h - ADC Filter Frequency Options.....	19
Table 10 – Object 2102h – AI Decimal Digits FV Depending on Sensor Type	20
Table 11 – AI Object Defaults Based on Sensor Type and Input Range	21
Table 12 – AI Object Ranges Based on Sensor Type and Input Range	22
Table 13 – Output Type Options	23
Table 14 – Output Object Subindices.....	24
Table 15 – Scaling Limits per Control Source	25
Table 16 – Object 2342 - AO Control Response Options	26
Table 17 – Object 2352h - AO Enable Response Options.....	26
Table 18 – Object 2362h - AO Override Response Options	26
Table 19 – Object 6340 - AO Fault Mode Options	26
Table 19 – Object 6202h - DO Polarity Options	30
Table 19 – Object 6206h - DO Fault Mode Options	31
Table 22 – LTyz Point Response Options.....	35
Table 23 – PID Control Response Options	37
Table 24 – Object 4y50h Math Function Operators	39
Table 25 – Available Control Sources and Numbers	42
Table 26 – Control Number Options Depending on Source Selected.....	43
Table 22 – AX100250 Connectors’ Pinouts	44

Table 28 – LSS Baudrate Indices..... 47
Table 18 – Pre-Defined Error Field Codes 52

Figure 1 – AX100251 Block Diagram 12

Figure 2 – Sensorless drive startup steps 15

Figure 3 – Discrete Input Hysteresis 16

Figure 4 – Digital Input Debouncing 17

Figure 5 – Analog Input Read as Digital..... 18

Figure 5 – Input Objects 18

Figure 7 – Analog Input Linear Scaling FV to PV 21

Figure 8 – Output Objects 23

Figure 9 – Analog Output Linear Scaling PV to FV 24

Figure 9 – Analog Output Logic Flowchart 28

Figure 11 – Digital Output Objects 29

Figure 12 – Hotshot Digital Profile 31

Figure 12 – Lookup Table Objects 32

Figure 14 – Lookup Table Defaults with Ramp and Step Responses..... 34

Figure 15 – Lookup Table Examples to Setup for Dual-Slope Joystick Deadband Response 34

Figure 16 – PID Control Objects..... 36

Figure 17 – PID Control Algorithm..... 37

Figure 18 – Math Function Block Objects 38

Figure 19 – Miscellaneous Objects 40

Figure 5 – AX100250 Dimensional Drawing 44

REFERENCES

TDAX100251 Technical Datasheet, 40A BLDC Motor Controller with CANOpen®, Axiomatic Technologies

1. OVERVIEW OF CONTROLLER

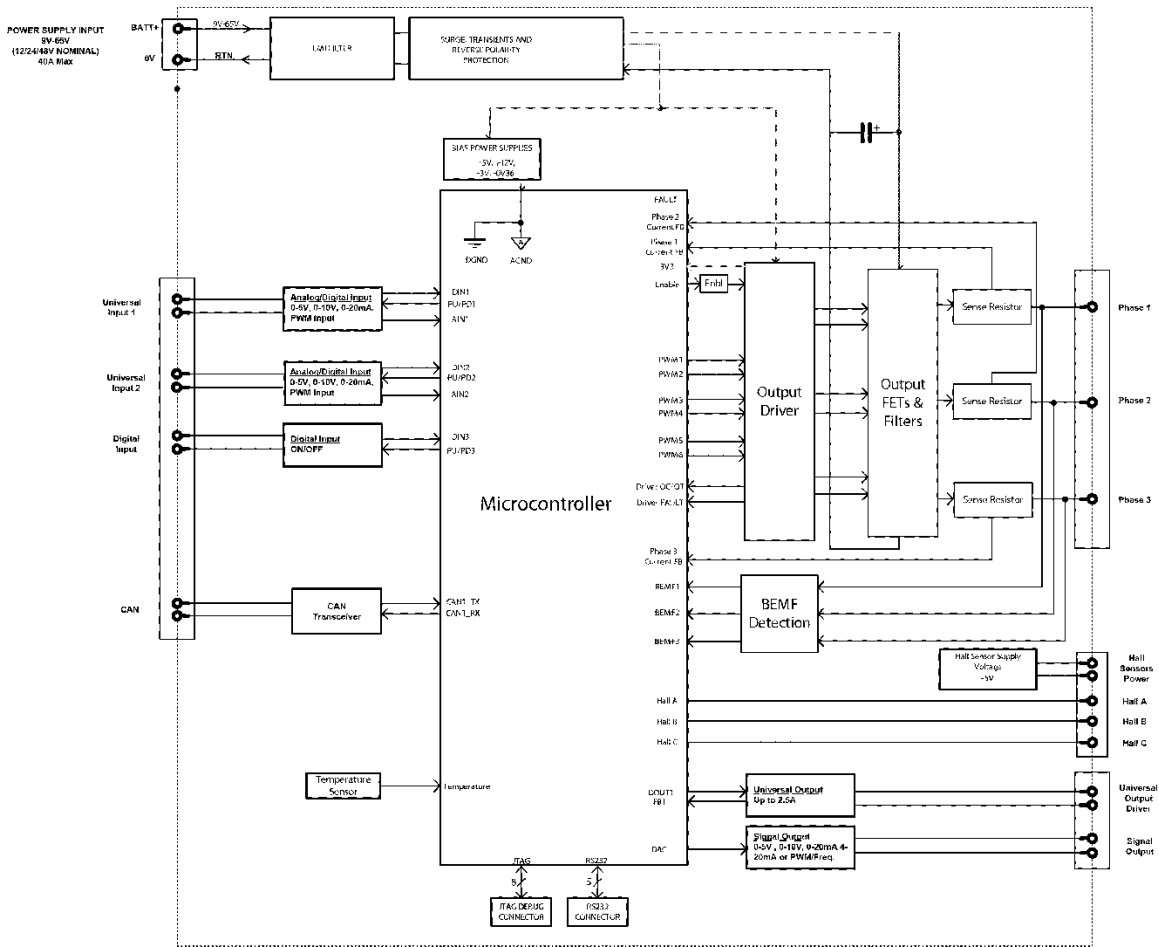


Figure 1 – AX100251 Block Diagram

The AX100251 BLDC motor controller implements the 6 step sensorless BLDC commutation algorithm, it supports controlling a BLDC motor with Hall sensors or using sensorless motor control. In addition to the CAN bus interface, the BLDC controller has three inputs (two universal and one digital) and two outputs (one proportional current and one analog signal) that can be used for interfacing the controller.

The controller can be configured through PDO and SDO protocol, using appropriate software. Setpoint configuration can be saved in an eds file which can be used to easily program the same configuration into another BLDC Controller. Throughout this document object names are referred with bolded text in double-quotes and the setpoint option is referred with italicized text in single-quotes. For example, “**Object 3511h Rotor position detection**” set to option ‘*0-Sensorless*’.

The BLDC Motor Controller can be ordered using the following part numbers depending on the application.

AX100251	Controller with CANOpen® support
AX100250	Controller with the default J1939 baud rate (250kbits/s).
AX100250-01	Controller with the 500kbits/s J1939 baud rate.
AX100250-02	Controller with a custom 1Mbits/s J1939 baud rate.

1.1. Motor Control Functionality

There are multiple objects that allow the user to configure the 40A BLDC controller to drive a variety of different BLDC motors.

The Motor Parameters Objects support the configuration of the main motor parameters, such as number of pole pairs, rated RPM of the motor and PWM frequency to use in motor drive.

“**Object 3510h - Number of pole pairs**” has direct influence on how the 40A BLDC controller picks up the motor RPM, this parameter should be always set to correspond the motor driven by the controller.

“**Object 3511h - Rotor position detection**” selects the algorithm for position detection, the options are ‘1-Hall sensors’ and ‘0-Sensorless’.

“**Object 3516h - Rated RPM**” setpoint is used for normalizing the RPM data in the function blocks. It does not have other influence how the motor is driven by the controller.

“**Object 6075h - Rated motor current**” defines the max current to use when driving the motor. This current limit is used together with the PI Current Controller current limit to define the hardware over current limit to use (the smaller one of the two is used).

“**Object 3515h - PWM Frequency**” sets the frequency to use in the Phase outputs’ PWM signal in kHz. This also sets the ISR tick time used in sensorless startup parameters (see section 1.1.1), 1 tick time = 1k * PWM Frequency⁻¹

“**Object 3512h - Commutation sequence**” sets the offset to the Hall sensor states vs. phase drive sequence. Most motors will work with the default setting, ‘0 – Version 1’. This setting offsets the ‘Hall, combined’ values in Table 1.

The Hall sensor states have the following default values and the phase outputs are driven like shown in Table 1. The column “Hall, combined” shows the value programmed in the object. The combined Hall state is calculated using:

$$Hall, combined = (Hall_A) \ll 2 + (Hall_B) \ll 1 + Hall_C$$

Hall, combined	Hall C	Hall B	Hall A	Phase A	Phase B	Phase C
2	0	1	0	PWM	OFF	LOW
3	1	1	0	OFF	PWM	LOW
1	1	0	0	LOW	PWM	OFF
5	1	0	1	LOW	OFF	PWM
4	0	0	1	OFF	LOW	PWM
6	0	1	1	PWM	LOW	OFF

Table 1 – Default commutation sequence

In case the over current protection gets triggered, the “**Object 3513h - Over current event clear time**” specifies the time in milliseconds after which the controller clears the over current status and

resumes normal operation. If the event clear time is set to 0ms, the over current status won't be cleared (a power cycle is required to resume normal operation).

“**Object 3518h - Over temperature threshold**” defines the max drive stage temperature. If the temperature rises above this limit, motor driving is derated and a diagnostic status can be flagged using the Diagnostics Blocks.

“**Object 351Ah - Motor Current Filter Constant**” and “**Object 3519h - Motor RPM Filter Constant**” define filter coefficients for repeating average filters used in motor current and motor rpm measurements.

The motor is controlled using Control (RPM), Enable, and Direction signals. These signals can be configured using the following objects to specify the control source (see Table 25 for a list of control sources). Note that the Motor RPM Control can be controlled by the CAN Message control source (RPDO mapped to **Object 60FFh - Target Velocity**), and the Direction/Enable signals can be controlled by CAN Message, or the Input Control Source.

Signal	Control Source Object	Control Number Object
Control (RPM)	3340h	3341h
Direction	3350h	3351h
Enable	3360h	3361h

The motor Control (RPM), and Direction are configured by default to use RPDO1, which is mapped to “**Object 607Eh – Motor Polarity**” and “**Object 60FFh – Target Velocity**”. This allows the motor speed and direction to be controlled through a single CAN message. If a different control scheme is desired, the RPDO mapping parameters can be changed to fit the application.

In order to prevent abrupt changes at the output due to sudden changes in the command input, the user can choose to use the independent up or down ramps to smooth out the coil's response. The “**Object 3710h - Ramp Up**” and “**Object 3711 - Ramp Down**” are in milliseconds, and the step size of the output change will be determined by taking the absolute value of the output range (**Object 3516h - Rated RPM**) and dividing it by the ramp time given in object 3710h/3711h. In other words, these objects define the time it takes the motor to reach the max RPM, not the target RPM.

1.1.1. Sensorless Control

The sensorless motor control is based on detecting the back emf voltage on the free phase while the motor is running. While this voltage is available only when the motor is running, the startup procedure is carried out without knowing whether the rotor actually rotates or not. Depending on the motor in question, the user has to tune the startup parameters through the objects mentioned below.

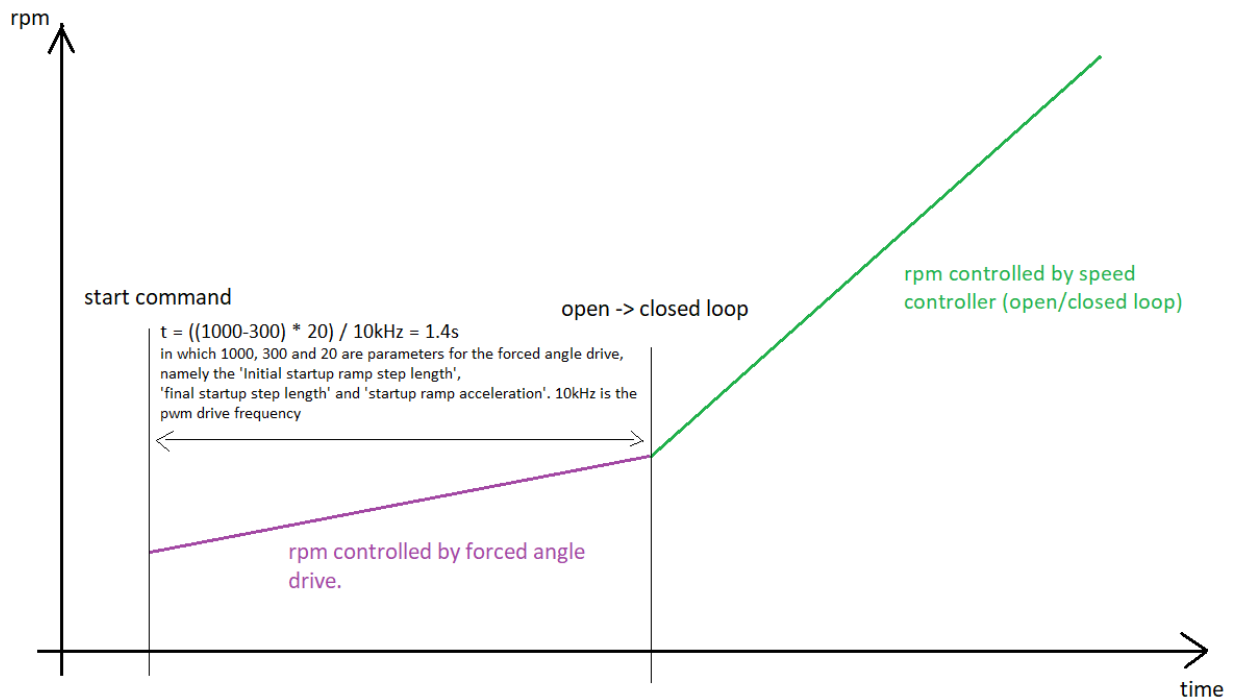


Figure 2 – Sensorless drive startup steps

The sensorless startup is carried out like this:

1. Forced angle drive

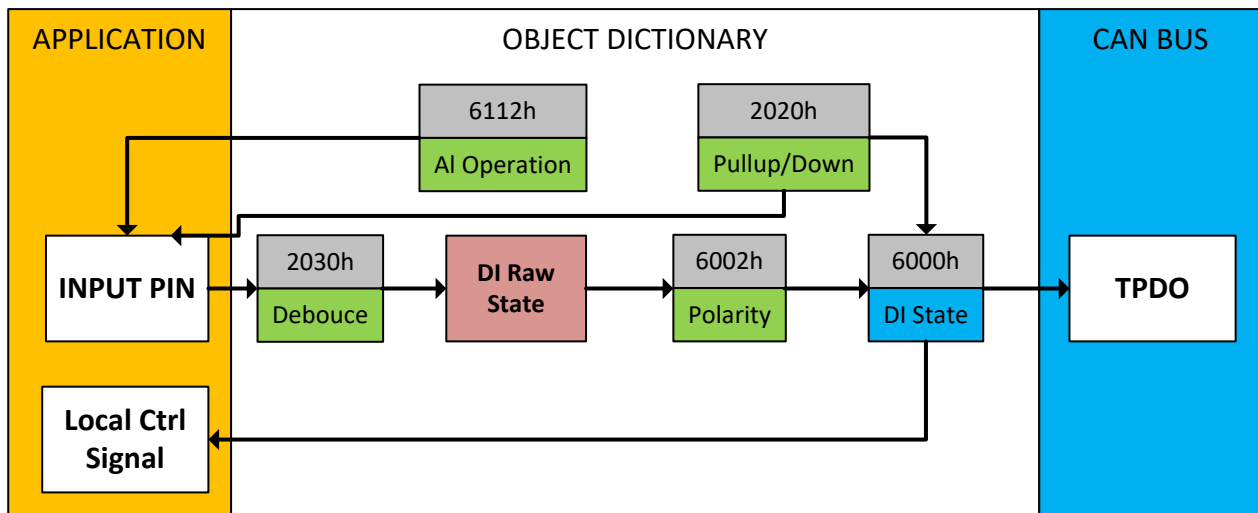
During the initial forced angle drive period, the motor is driven in open loop configuration for picking up speed and for making the back emf signals available for the sensorless control. The speed of the forced angle drive is dependent on the ramp up time specified in “**Object 3710h – Motor Ramp Up Time**”. The forced angle drive takes place over 10% of the full ramp up time. When the motor is driven in sensorless mode, the minimum ramp up time is 1000ms to ensure smooth operation.

2. Normal Operation

After the forced angle drive is done, the rotor should be rotating. At this point the controller switches over to normal operation in which the rotor position is picked up by the back emf algorithm and the PWM drive signals are applied accordingly. In this mode the motor driving signals’ PWM duty cycle is determined by the Speed and/or Current controller, as configured.

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.



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 2 with the default **bolded**.

Value	Meaning
0	Pullup/Down Disabled (high impedance input)
1	22kΩ Pullup Resistor Enabled (to 5V)
2	22kΩ Pulldown Resistor Enabled (to GND)

Table 2 – 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.)

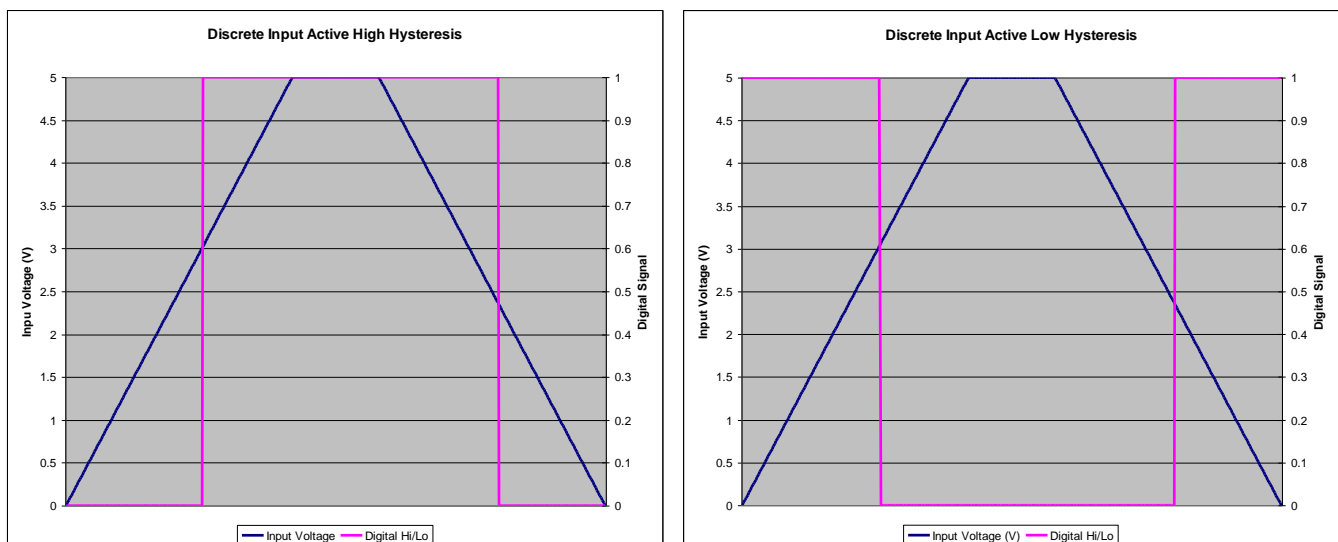


Figure 3 – Discrete Input Hysteresis

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 3, with the default bolded.

Value	Meaning
0	Filter Disabled
1	Filter 10ms
2	Filter 20ms
3	Filter 40ms
4	Filter 100ms
5	Filter 200ms
6	Filter 400ms
7	Filter 1000ms

Table 3 – DI Debounce Filter Options

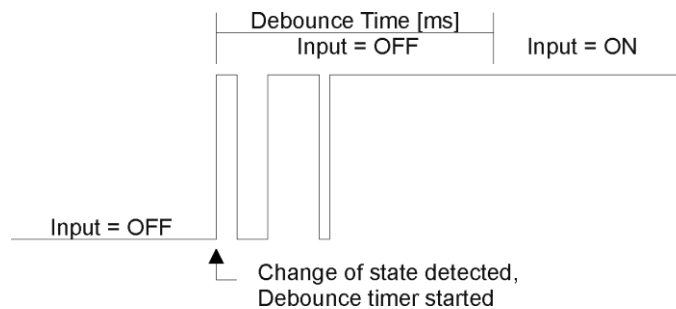


Figure 4 – Digital Input Debouncing

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 4. 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	Normal On/Off
1	Inverse On/Off

Table 4 – Object 6002h DI Polarity 8 Input Lines Options

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

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
					DI1	UI2	UI1

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, and 2030h 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.

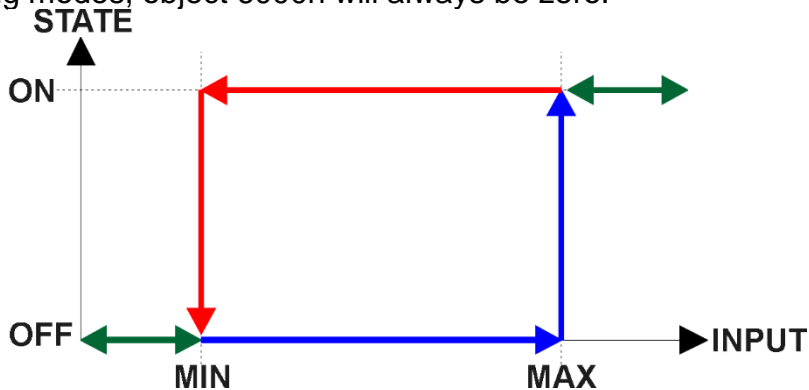


Figure 5 – Analog Input Read as Digital

1.3. Input Function Block

The Input Function Block is the default logic associated with the universal and digital inputs.

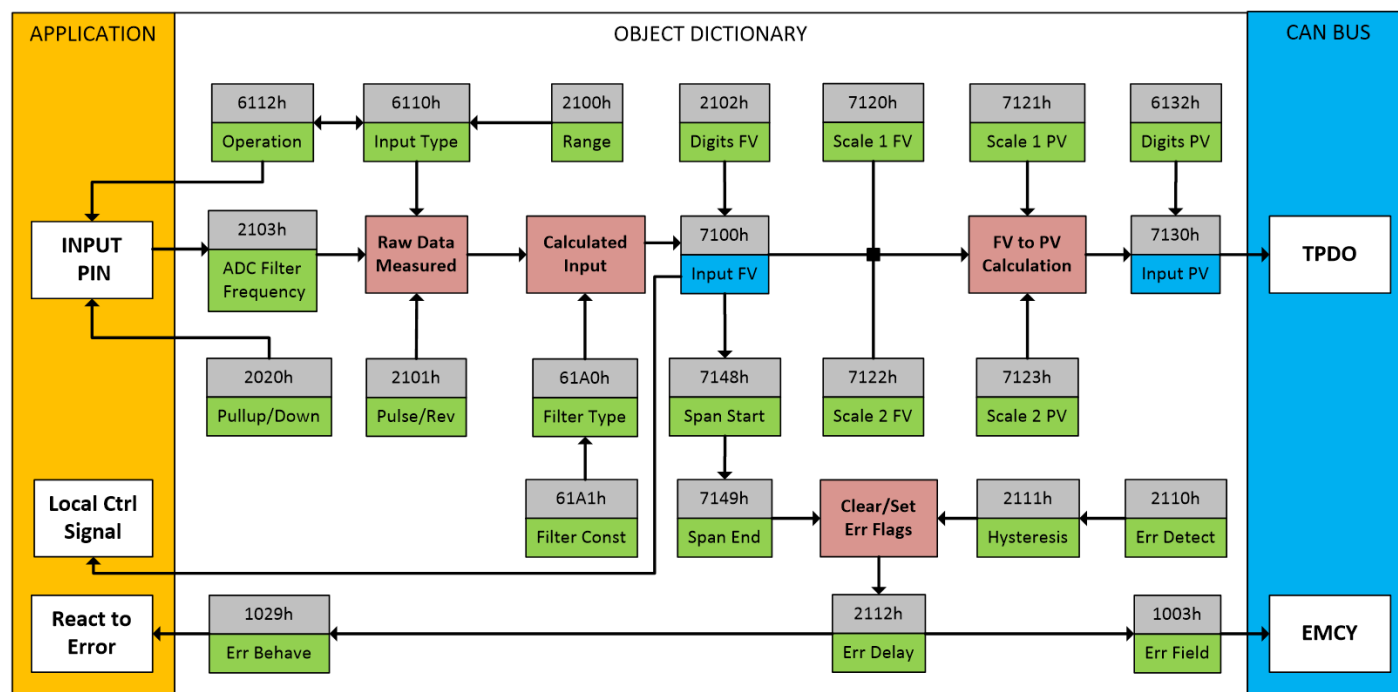


Figure 6 – Input Objects

Object 6112h, **AI Operating Mode** determines whether the AI, or DI function block is associated with an input. The options for object 6112h are shown in Table 5. No values other than what are shown here will be accepted.

Value	Meaning	Notes
0	Channel Off	
1	Normal Operation (analog)	Default for Universal Inputs
10	Digital Input (On/Off)	Default for Digital Input

20	Analog and On/Off	
----	-------------------	--

Table 5 – Object 6112h AI Operating Mode Options

Note that the Digital Input subindex can only be configured to **0 (Channel Off)** or **10 (Digital On/Off)**. The subindices for the Input objects correspond to the ECU inputs as shown below:

Sub-Index	Corresponding Input
1	Universal Input 1
2	Universal Input 2
3	Digital Input 1

Table 6 – Input Object Subindices

Selecting input type using the “**Object 6110h - Input Sensor Type**” influences other objects (assuming auto-updates are enabled through “**Object 5550h – Enable Auto-Updates**”) and how they are interpreted, and should thus be selected first on this block. The input sensor types for Universal Inputs are listed in Table 7.

Value	Meaning
40	Voltage
50	Current
60	Frequency
100	Resistive
10000	PWM

Table 7 – Universal Input Sensor Type Options

The allowable ranges will depend on the input selected and input sensor type selected. Table 8 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 5V	0 to 20mA	0.5Hz to 50Hz	30Ω to 250kΩ	Low (<100Hz)
1	0 to 10V	4 to 20mA	10Hz to 1kHz		High (>100Hz)
2			100Hz to 10kHz		

Table 8 – Object 2100h - AI Input Range Options Depending on Sensor Type

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 9, and is off by default.

Value	Meaning
0	Input Filter Off
1	Filter 50Hz
2	Filter 60Hz
3	Filter 50Hz and 60Hz

Table 9 – Object 2103h - ADC Filter Frequency Options

Conversely, frequency and inputs use object 2020h **DI Pull-up/Pull-down Mode** (see Table 2) while voltage, current, PWM, and resistive inputs set this object to zero. Note that **Pull-up** can only be selected for a frequency input, or a voltage input in digital mode. 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.

The value read by an input is shifted 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 10 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 10 – 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 1.5.

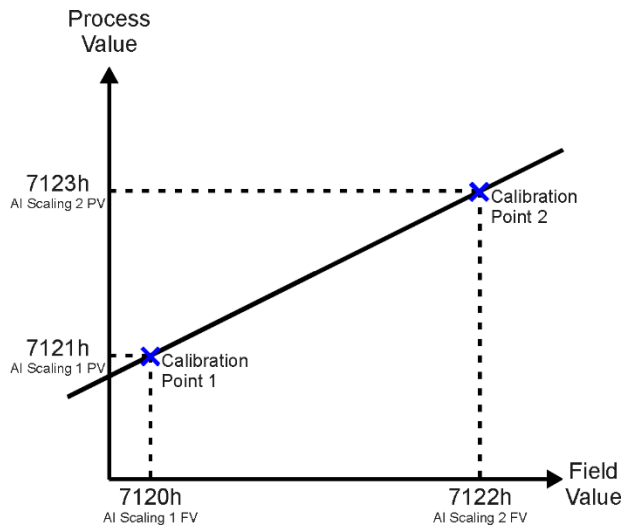


Figure 7 – Analog Input Linear Scaling FV to PV

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 11 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 10.

Sensor Type/ Input Range	7148h AI Span Start (i.e. Error Min)	7120h AI Scaling 1 FV (i.e. Input Min)	7122h AI Scaling 2 FV (i.e. Input Max)	7149h AI Span End (i.e. Error Max)	2111h Error Clear Hysteresis
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 11 – 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 12 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 12uses the base unit of the input, but recall the limits will also have object 2102h apply to them as per Table 10.

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

Table 12 – 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 \geq (AI Span Start + AI Error Clear Hysteresis)
 To clear an “Out of Range High” flag, AI Input FV \leq (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. Output Function Block

The BLDC Controller contains a Signal (Analog) Output capable of Voltage output up to 10V, and current up to 20mA, and a Proportional Output Capable of various output types.

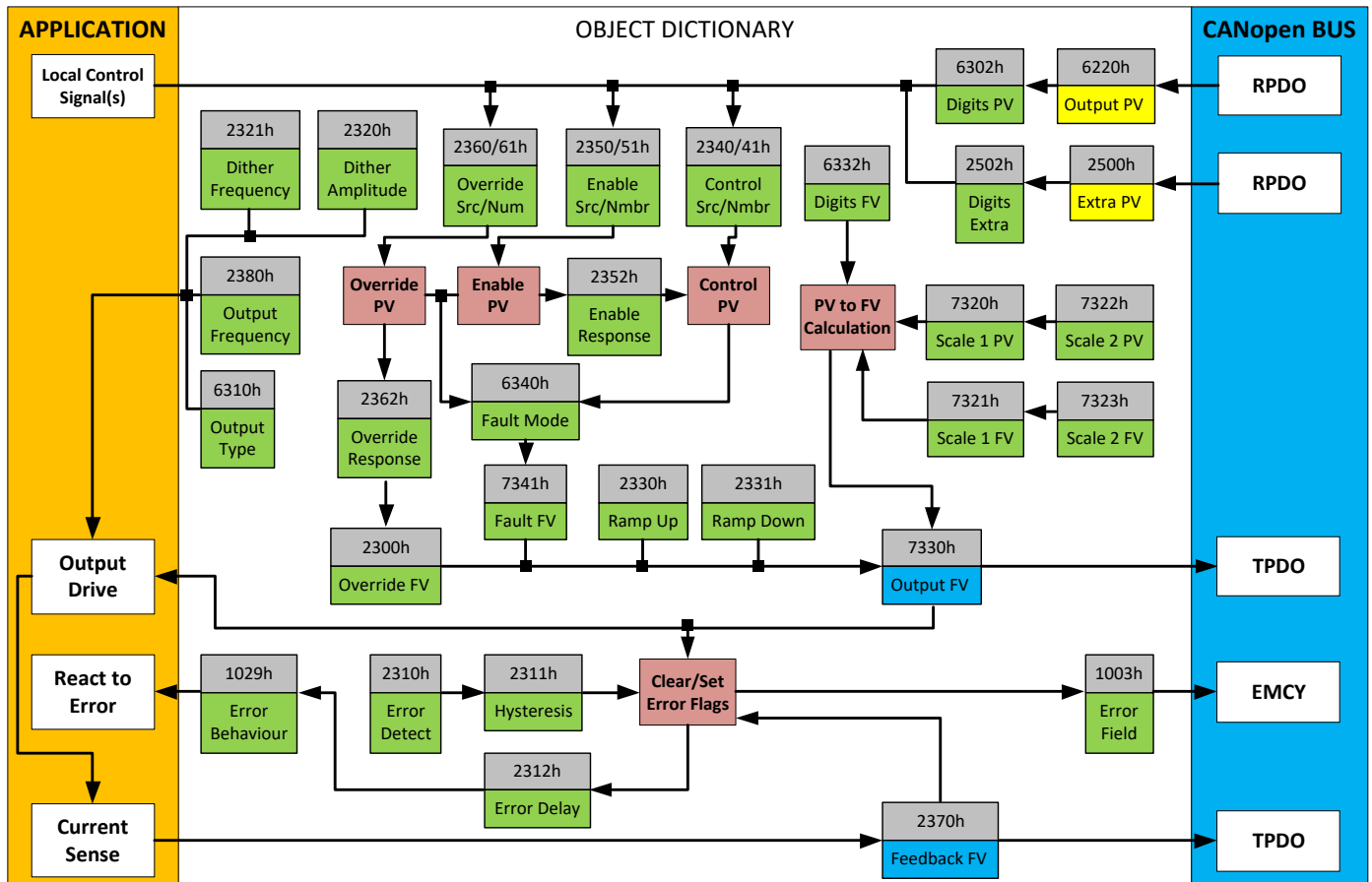


Figure 8 – Output Objects

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 13. This table also shows the output unit and range for each type. By default, analog output is configured as output voltage types, and the Proportional Output is configured as proportional current type.

Value	Meaning	Proportional Output Range [Unit]	Analog Output Range
0	Output Disabled	N/A	N/A
10	Output Voltage	0 to 48 [V]	0 to 10[V]*
20	Output Current	0 to 2500 [mA]	N/A
21	Current (4-20mA)	0 to 20 [mA]	0 to 20 [mA]
40	Output PWM	0 to 100 [%]	N/A
1000	Output Digital On/Off	0 (OFF) or 1 (ON)	N/A
1020	Output Digital Hotshot	0 (OFF) or 1 (ON)	N/A

Table 13 – Output Type Options

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

Note that the objects relating to the Output Functional Block have sub-indices corresponding to the different outputs on this ECU as follows:

Sub-Index	Corresponding Input
1	Proportional Output
2	Analog (Signal) Output

Table 14 – Output Object Subindices

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 1.4.1.

The relationship between the Process Value (input) and the Field Value (output) is a linear one, as shown in Figure 9. However, the output will 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.

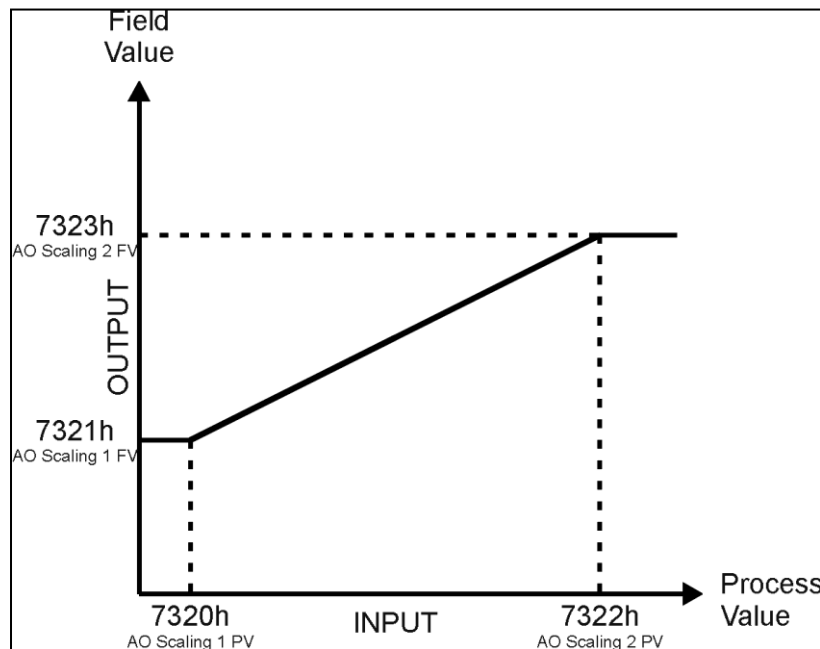


Figure 9 – Analog Output Linear Scaling PV to FV

The BLDC controller allows for the PV input to be selected from the list of the logical function blocks supported by the controller as shown in Figure 1. 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 25. By default, analog outputs are setup to respond to the corresponding CANopen RPDO message.

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 9), 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 15. 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.

Control Source	Scaling 1	Scaling 2	Dec Digits
CANopen Message – Num 1 to 2 (Motor Polarity & Motor Target RPM)	N/A	N/A	N/A
*CANopen Message – Num 3 to 4 (Signal/Proportional Output PV)	7320h	7322h	6302h
CANopen Message – Num 5 to 16	2520h	2522h	2502h
Input Block	7120h	7122h	2102h
PID Control Function Block	0%	100%	1 (fixed)
Lookup Table yz Function Block (where yz = 01 to 9)	0 or lowest from 3yz6h(**)	100 or highest from 3yz6h(***)	3yz3h
Mathematical Function	4021h	4023h	4032h
Motor RPM Value	N/A	N/A	0 (fixed)
Motor Current Feedback	N/A	N/A	N/A
Constant Function Block	N/A	N/A	N/A (float)
Output Commanded Field Value	7320h	7322h	6302h
Output Feedback Field Value	7320h	7322h	6302h
Power Supply Measured	N/A	N/A	1 (fixed)
Board Temperature	N/A	N/A	1 (fixed)
Processor Temperature Measured	N/A	N/A	1 (fixed)

(*) – Applies to **Analog** Output modes only. See **Digital Output modes** section for CANOpen Message Control information

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

Table 15 – Scaling Limits per Control Source

As shown in Figure 9, 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 9 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 16.

Value	Meaning
0	Single Output Profile (Figure 11)*
1	Output OFF below Scaling 1 PV
2	Output OFF above Scaling 2 PV

Table 16 – Object 2342 - AO Control Response Options

*Note that if the output control source (**2340h**) or output type (**6310h**) are changed, and auto-updates are enabled (**5550h**) the output control response will revert back to 0 – Single Output Profile by default.

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 17 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	Enable When OFF, Else Shut OFF
4	Enable When OFF, Else Ramp OFF
5	Enable When OFF, Else Keep Last Value

Table 17 – Object 2352h - AO Enable Response Options

Table 18 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	Override When ON
1	Override When OFF

Table 18 – 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 19. By default, the output will be driven to the value defined in object 7341h **AO Fault FV**.

Value	Meaning
0	Shutoff
1	Apply Pre-Defined FV
2	Maintain Last State

Table 19 – Object 6340 - AO Fault Mode Options

The controller applies the logic shown in Figure 10 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.

Object 2380h **AO Output Frequency** allows for adjusting the frequency of the output.

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.*

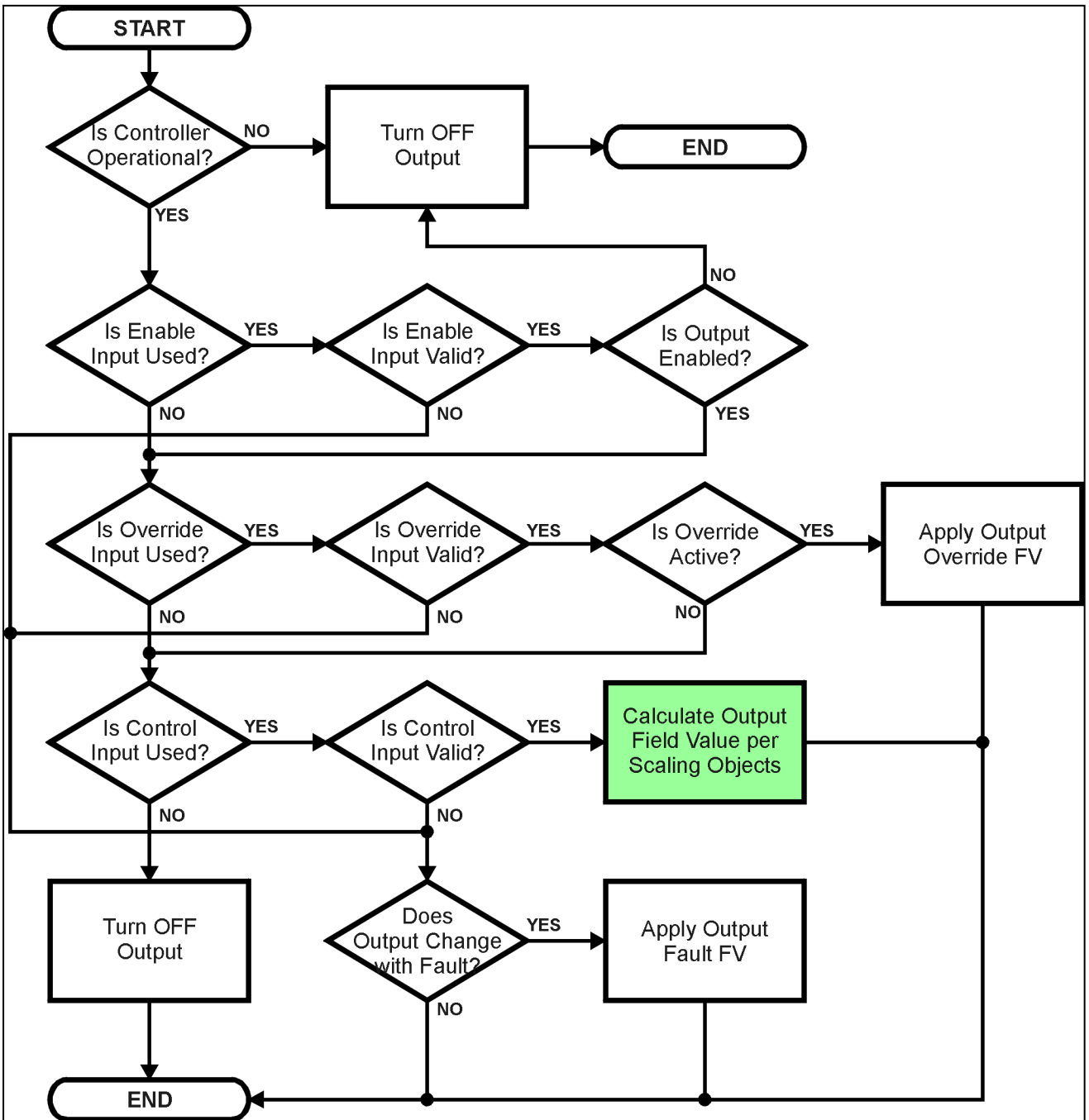


Figure 10 – Analog Output Logic Flowchart

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.

1.4.1. Digital Output Modes

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). The Proportional Output is the only output on the BLDC controller which supports digital modes.

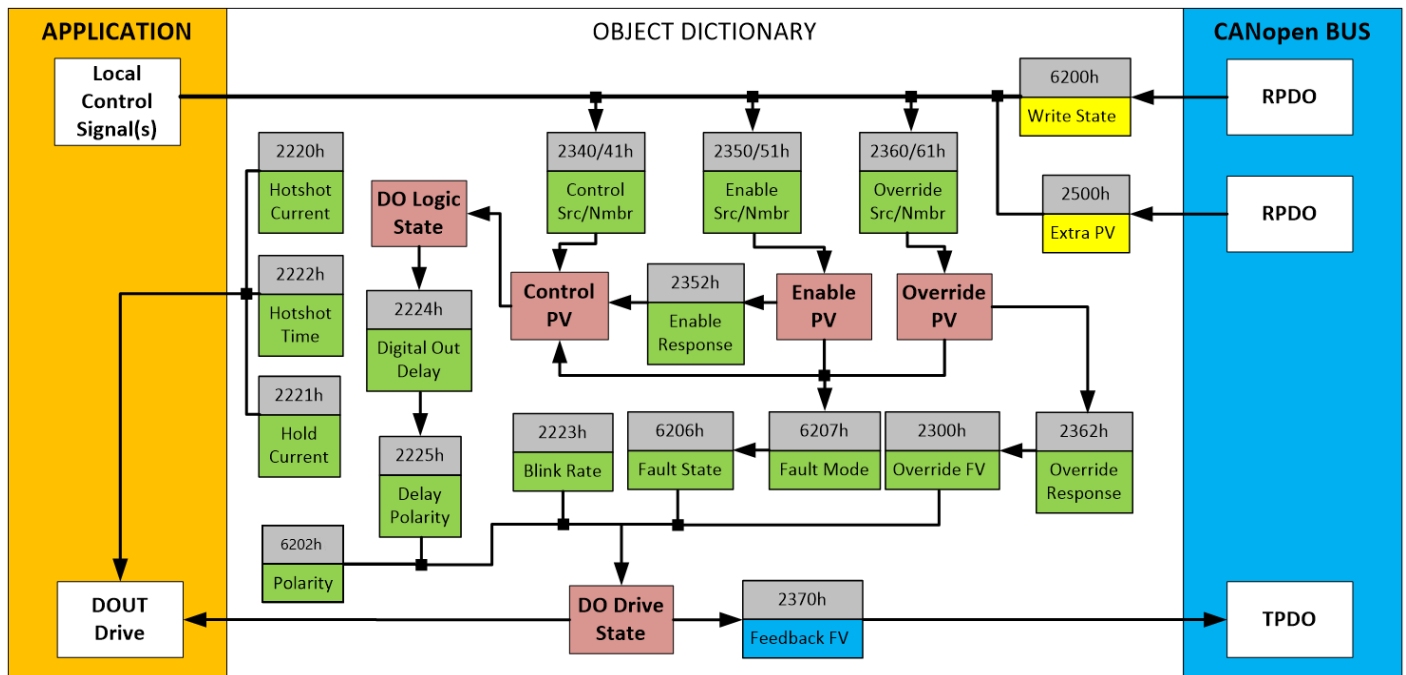


Figure 11 – Digital Output Objects

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 1.4. 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 25), 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 number specified in 2341h **AO Control Input Number** is ignored.

The format of object 6200h will be as follows:

D7	D6	D5	D4	D3	D2	D1	D0
-	-	-	-	-	-	-	PO

For digital 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 1.4 for these also applied for the DO function block for all outputs.

As with the AO function, the DO 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 20 – 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.

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 12.

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.

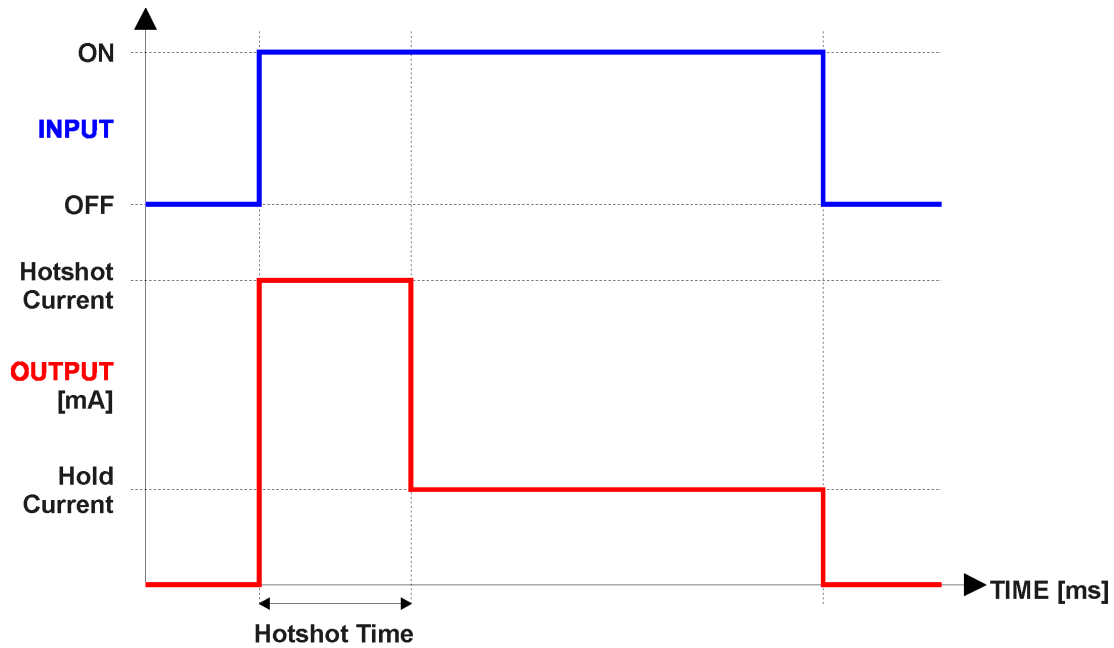


Figure 12 – Hotshot Digital Profile

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 6206h **DO Fault Mode** determines how the output will respond, per Table 21. By default, the output will revert to the state defined in object 6207h **DO Fault State**.

Value	Meaning
0	Maintain Last State
1	Apply Pre-Defined State

Table 21 – Object 6206h - DO Fault Mode Options

1.5. Lookup Tables

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

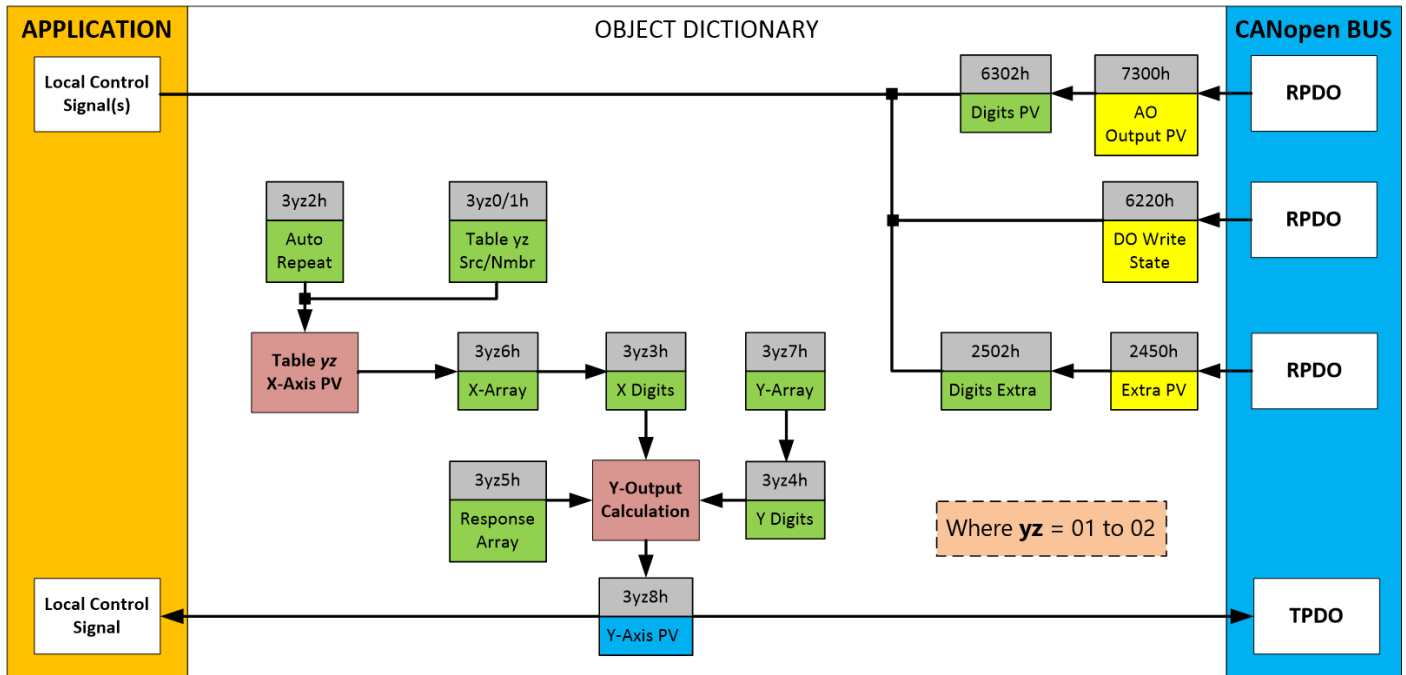


Figure 13 – Lookup Table Objects

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.

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 1.5.4.

1.5.1. 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 X₁₁ is changed first, then lower indexes in descending order.

MinInputRange <= X₁<= X₂<= X₃<= X₄<= X₅<= X₆<= X₇<= X₈<= X₉<= X₁₀<= X₁₁<= 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 15.

1.5.2. 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 15.

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 1.5.3, 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.

1.5.3. 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 14 shows the difference between these two response profiles with the default settings.

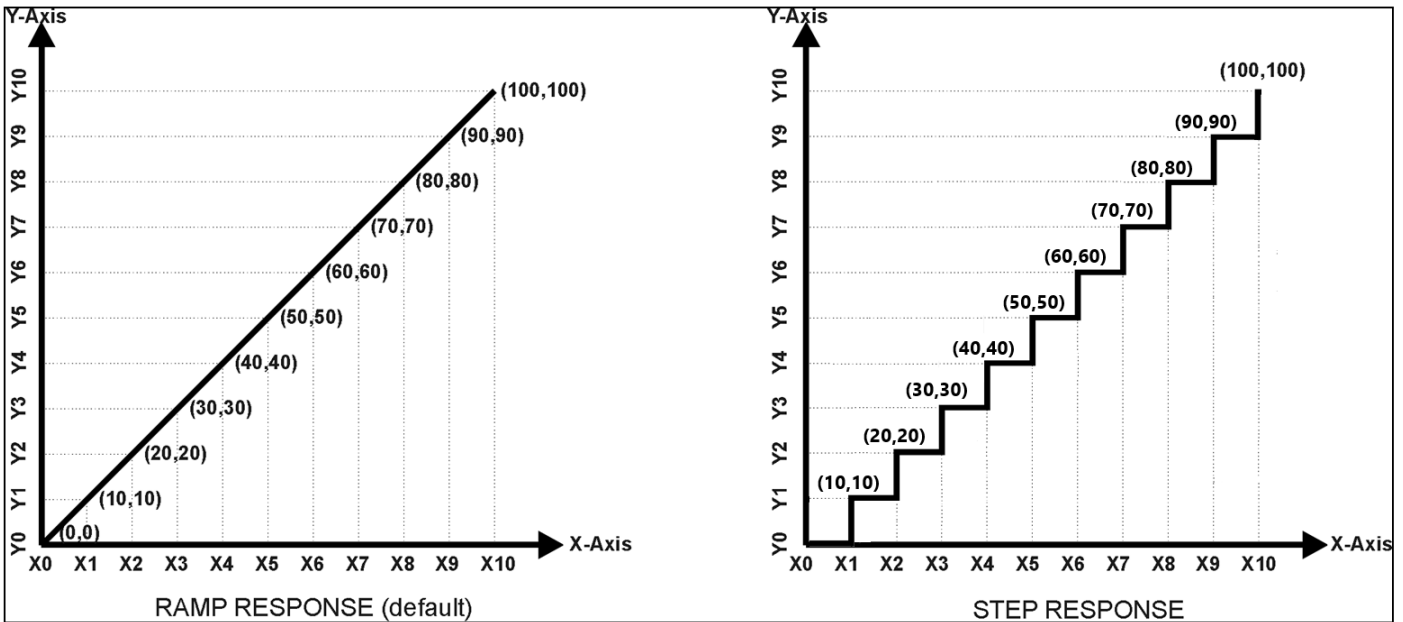


Figure 14 – Lookup Table Defaults with Ramp and Step Responses

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_N, Y_N) to (X_{11}, Y_{11}) will also be ignored. For all data greater than X_{N-1} , the output from the lookup table function block will be Y_{N-1} .

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 15. 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.’)

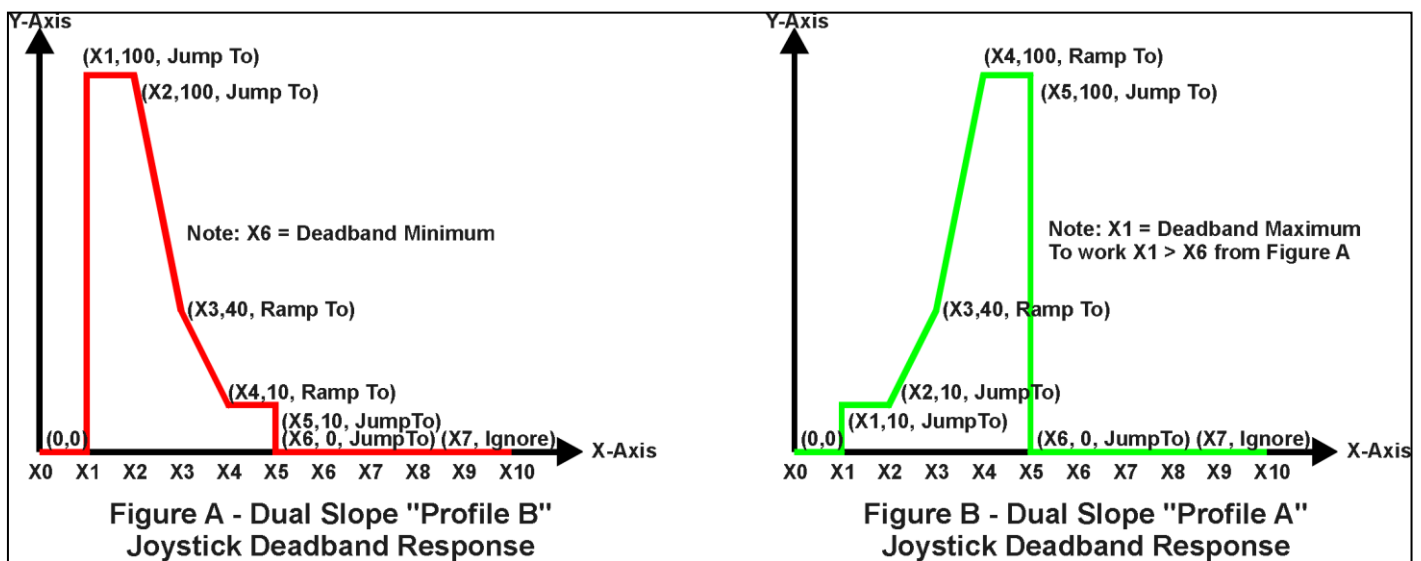


Figure 15 – Lookup Table Examples to Setup for Dual-Slope Joystick Deadband Response

To summarize, Table 22 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 22 – LTyz Point Response Options

1.5.4. 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 (X₁, Y₁) 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]

1.6. PID Function Blocks

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

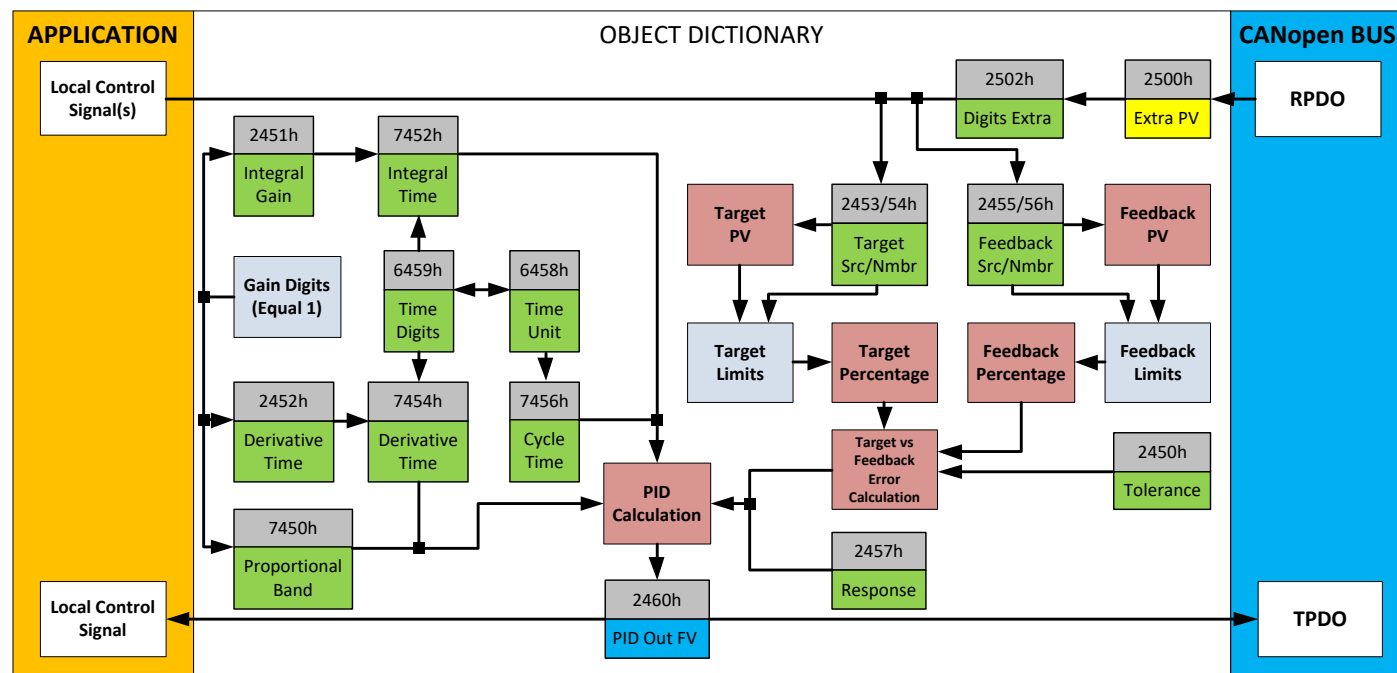


Figure 16 – PID Control Objects

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 15), 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 Table 25 and Table 26 as the available options. Both inputs are normalized to a percentage based on the associated scaling limits as defined in Table 15.

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 23.

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

Table 23 – PID Control Response Options

The PID algorithm used is shown below, with names in red being the object variables. The result $PIDOutput_k$ 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 17 – 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. Math Function Blocks

There are two mathematic function blocks that allow the user to define basic algorithms. Math function block Z = 1 to 2 will be enabled based on sub-index Z in object 4000h **Math Enable**.

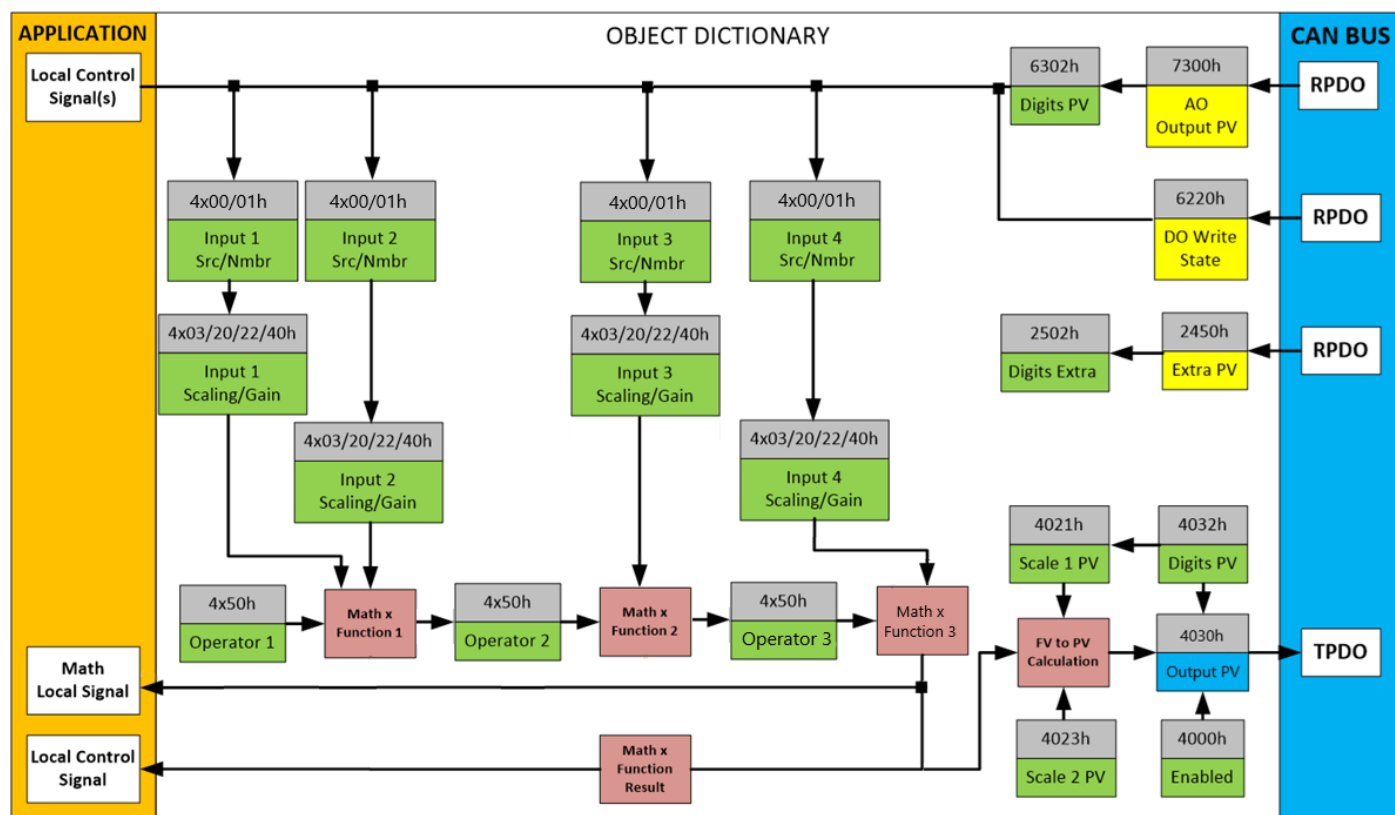


Figure 18 – Math Function Block Objects

A math function block can take up to four input signals, as listed in Table 25. 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 2 of the objects 4y00h **Math Y Input Source** and 4y01h **Math Y Input Number**. Here, y = 1 to 2; corresponding the Math 1 - Math 2.

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 4y03h **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 15.

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 (resulting in a gain of -1.0 to 1.0, respectively). 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 to the associated function in sub-index of InB in object 4y50h **Math Y Operator**. The list of selectable function operations is defined in Table 24.

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 24 – 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 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 in 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 15.

1.8. 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.

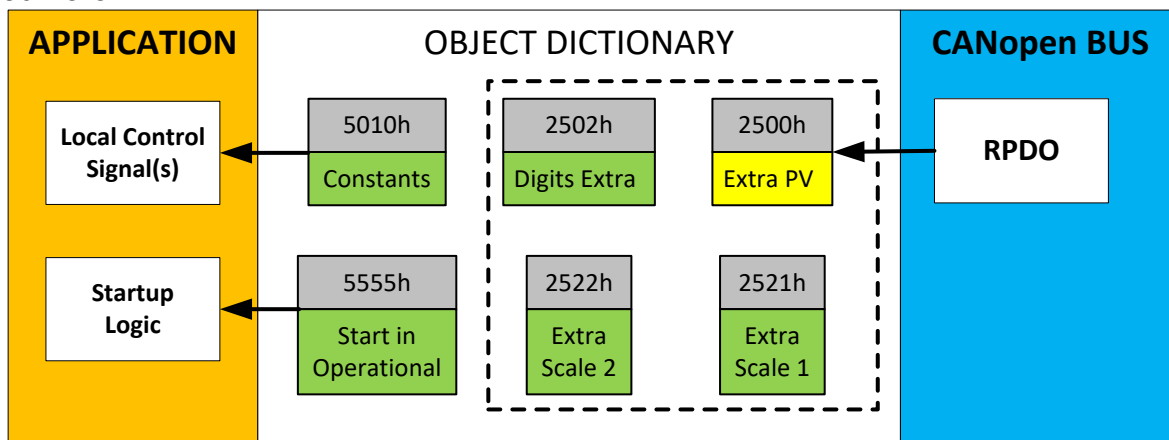


Figure 19 – Miscellaneous Objects

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 Table 15. 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 15.

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.

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 BLDC 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.

1.9. Available Control Sources

Many of the Function Blocks have selectable input signals, which are determined with “[Name] Source” and “[Name] Number” objects. Together, these objects uniquely select how the I/O of the various function blocks are linked together. “[Name] Source” setpoint determines the type of the source and “[Name] Number” selects the actual source if there is more than one of the same type. Available “[Name] Source” options and associated “[Name] Number” ranges are listed in Table 25. All sources are available for all blocks. Though input Sources are freely selectable, it must be remembered that not all options would make sense in all cases, and it is up to the user to program the controller in a logical and functional manner.

Value	Meaning
0	Control Not Used
1	Received CAN Message (RPDO)
2	Universal/Digital Input Measured
3	PID Function Block
4	Lookup Table
5	Math Function Block
6	Motor RPM Value
7	Motor Current Feedback
8	Control Constant Data
9	Output Target Drive
10	Measured Prop. Output Current
11	Power Supply Voltage
12	Board Temperature
13	CPU Temperature

Table 25 – Available Control Sources and Numbers

In addition to a source, each control also has a number which corresponds to the sub-index of the function block in question. Table 26 outlines the ranges supported for the number objects, depending on the source that had been selected.

Control Source	Range	Object (Meaning)
Control Source Not Used	0	Ignored
CANopen Message (RPDO)	1	607Eh – Motor Polarity
	2	60FFh – Motor Target RPM Command
	3	7300h sub-index 1 or 6200h sub-index 1 bit 1
	4	7300h sub-index 2 or 6200h sub-index 1 bit 2
	5	2500h sub-index 1 (Extra Received PV 1)
	6	2500h sub-index 2 (Extra Received PV 2)
	7	2500h sub-index 3 (Extra Received PV 3)
	8	2500h sub-index 4 (Extra Received PV 4)
	9	2500h sub-index 5 (Extra Received PV 5)
	10	2500h sub-index 6 (Extra Received PV 6)
	11	2500h sub-index 7 (Extra Received PV 7)
	12	2500h sub-index 8 (Extra Received PV 8)
Analog Input Function Block	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	6000h sub-index 1 bit 2
Constant Function Block	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)
PID Control Function Block	1	2460h sub-index 1 (PID Output FV 1)
	2	2460h sub-index 2 (PID Output FV 2)
Lookup Table Function Block	1	3017h (Lookup Table 1 Output Y-Axis PV)
	2	3027h (Lookup Table 2 Output Y-Axis PV)
Mathematical Function Block	1	4350h sub-index 1 (Math Output PV 1)
	2	4350h sub-index 2 (Math Output PV 2)
<i>NOTE: 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)</i>		
Output Commanded Field Value	1	7330h sub-index 1 or 6000h sub-index 1 bit 0
	2	7330h sub-index 2 or 6000h sub-index 1 bit 1
Output Feedback Field Value	1	2370h sub-index 1 (PO1 FB)
Processor Temperature Measured	N/A	5020h (Power Supply FV) sub-index 1
Power Supply Measured	N/A	5030h (Temperature FV) sub-index 2

Table 26 – Control Number Options Depending on Source Selected

2. INSTALLATION INSTRUCTIONS

2.1. Dimensions and Pinout

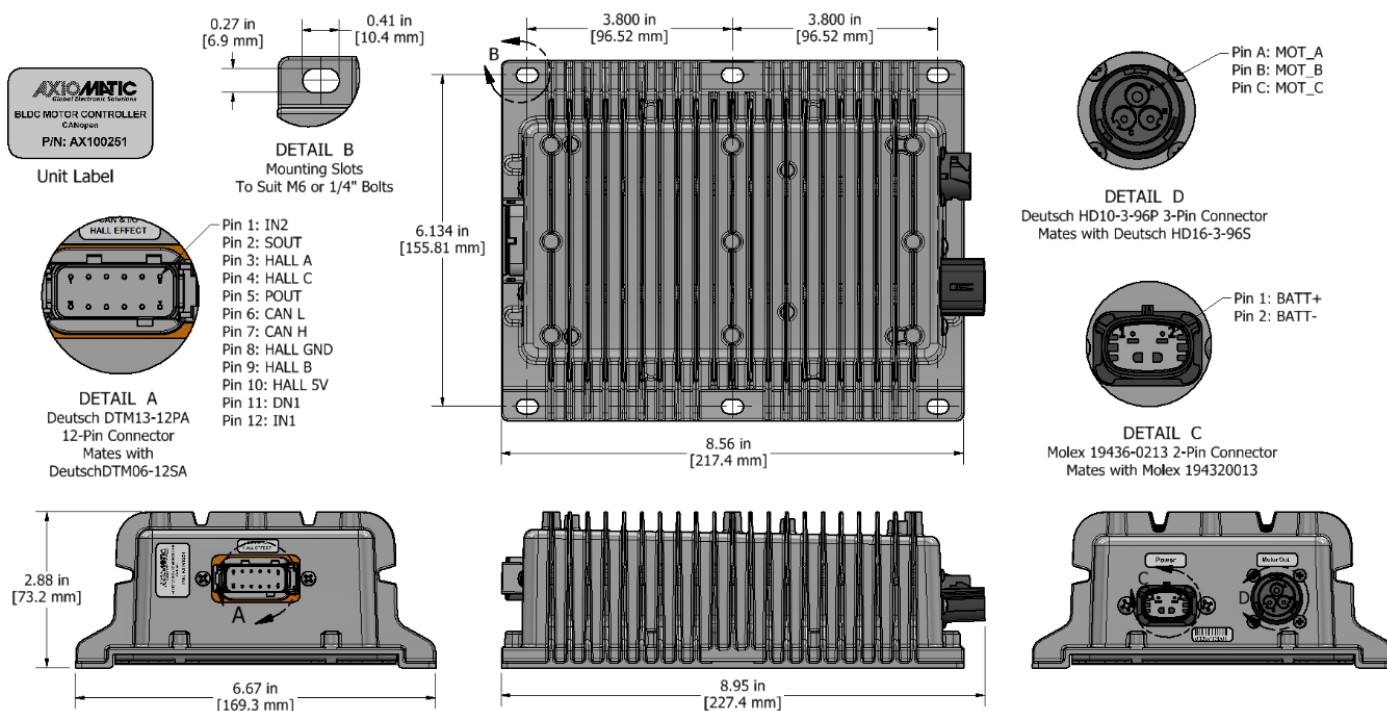


Figure 20 – AX100251 Dimensional Drawing

<p>Power Connector: Molex P/N: 19436-0213</p> <table border="1"> <thead> <tr> <th>Pin#</th> <th>Function</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Batt+</td> </tr> <tr> <td>2</td> <td>Batt-</td> </tr> </tbody> </table>	Pin#	Function	1	Batt+	2	Batt-	<p>Signal, Hall Effect and CAN Connector: TE Deutsch DTM13-12PA</p> <table border="1"> <thead> <tr> <th>Pin#</th> <th>Function</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>INPUT 2</td> </tr> <tr> <td>2</td> <td>SIGNAL OUT</td> </tr> <tr> <td>3</td> <td>HALL A</td> </tr> <tr> <td>4</td> <td>HALL C</td> </tr> <tr> <td>5</td> <td>POUT</td> </tr> <tr> <td>6</td> <td>CAN L</td> </tr> <tr> <td>7</td> <td>CAN H</td> </tr> <tr> <td>8</td> <td>HALL GND</td> </tr> <tr> <td>9</td> <td>HALL B</td> </tr> <tr> <td>10</td> <td>HALL 5V</td> </tr> <tr> <td>11</td> <td>DIGITAL IN1</td> </tr> <tr> <td>12</td> <td>INPUT 1</td> </tr> </tbody> </table>	Pin#	Function	1	INPUT 2	2	SIGNAL OUT	3	HALL A	4	HALL C	5	POUT	6	CAN L	7	CAN H	8	HALL GND	9	HALL B	10	HALL 5V	11	DIGITAL IN1	12	INPUT 1
Pin#	Function																																
1	Batt+																																
2	Batt-																																
Pin#	Function																																
1	INPUT 2																																
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4	HALL C																																
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6	CAN L																																
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<p>Motor Connector: TE Deutsch P/N: HD10-3-96P</p> <table border="1"> <thead> <tr> <th>Pin#</th> <th>Function</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Motor A Out</td> </tr> <tr> <td>2</td> <td>Motor B Out</td> </tr> <tr> <td>3</td> <td>Motor C Out</td> </tr> </tbody> </table>	Pin#	Function	1	Motor A Out	2	Motor B Out	3	Motor C Out																									
Pin#	Function																																
1	Motor A Out																																
2	Motor B Out																																
3	Motor C Out																																

Table 27 – AX100250 Connectors' Pinouts

3. CANOPEN® OBJECT DICTIONARY

The CANopen ® object dictionary of the BLDC Controller is based on CiA device profile DS-402 V4.0 (Drives and Motion Control Device Profile) and 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.

3.1. Node ID and Baudrate

By default, the BLDC Controller ships factory programmed with a Node ID = 127 (0x7F) and with Baudrate = 125 kbps.

3.1.1. 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.

3.1.1.1. 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)

3.1.1.2. 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 28)

Index	Bit Rate
0	1 Mbit/s
1	800 kbit/s
2	500 kbit/s
3	250 kbit/s
4	125 kbit/s (default)
5	reserved (100 kbit/s)
6	50 kbit/s
7	20 kbit/s
8	10 kbit/s

Table 28 – LSS Baudrate Indices

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

Item	Value
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:

Item	Value
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):

Item	Value
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):

Item	Value
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)

3.2. Communication Objects (DS 301 and DS-404)

The communication objects supported by the BLDC 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.

Index (hex)	Object	Object Type	Data Type	Access	PDO Mapping
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
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
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
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

3.2.1. 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

Additional Information = 0x0002	General Information = 0x0192 (402)
--	---

DS-402 defines the Additional Information field for generic PDO mapping in the following manner:

Device	Additional information															
	Mode bits								Type							
	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Frequency converter	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	1
Servo drive	*	*	*	*	*	*	*	*	0	0	0	0	0	0	1	0
Stepper motor	*	*	*	*	*	*	*	*	0	0	0	0	0	1	0	0
Multiple device module	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Object Description

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

Entry Description

Access	RO
PDO Mapping	No
Value Range	0x00020192
Default Value	0x00020192

3.2.2. Object 1001h: Error Register

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

3.2.3. 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 BLDC 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)					
4001F001h	40h	Positive Overload (Out-of-range High)	01h	Universal Input 1	F001h	Input Overload
5001F001h	50h	Negative Overload (Out-of-range Low)	01h	Universal Input 1	F001h	Input Overload
4002F001h	40h	Positive Overload (Out-of-range High)	02h	Universal Input 2	F001h	Input Overload
5002F001h	50h	Negative Overload (Out-of-range Low)	02h	Universal Input 2	F001h	Input Overload
1001F002h	10h	Sensor Break (Open Circuit on AO)	01h	Proportional Output 1	F002h	Output Overload

00012310h	00h	Short Circuit on AO	01h	Proportional Output 1	2310h	Current at Output too High (short to GND or Vcc)
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
40004000h	40h	Positive Overload (Over Temp)	00h	Unspecified	4000h	Motor 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 29 – 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

3.2.4. 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

3.2.5. 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

3.2.6. 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 BLDC 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 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) 1h (read access)
Default Value	1h

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

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

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

3.2.7. 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 BLDC 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 BLDC 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 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

3.2.8. Object 1016h: Consumer Heartbeat Time

The BLDC 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 BLDC 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

3.2.9. Object 1017h: Producer Heartbeat Time

The BLDC 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

3.2.10. Object 1018h: Identity Object

The identity object indicates the data of the BLDC 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)	Major Software Version	Minor 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	0xAA100251
Default Value	0xAA100251

Sub-Index	3h
Description	Revision Number
Access	RO
PDO Mapping	No
Value Range	UNSIGNED32
Default Value	0x00010100

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

3.2.11. 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 30th, 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

3.2.12. Object 1029h: Error Behaviour

This object controls the state that the 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)

3.2.13. 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.

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

- d) Enable mapping by setting sub-index 00h to the number of mapped objects
- e) Create the PDO by setting bit **exists** (most significant bit) of sub-index 01h of the according PDO communication parameter to 0b

The BLDC Controller can support up to four RPDO messages. All RPDOs on the Controller use 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 four 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

Sub-Index	Value	Object
0	4	Number of mapped application objects in PDO
1	0x607E0008	Motor Polarity (Direction)
2	0x60FF0020	Motor Target Velocity (RPM)
3	0x0	
4	0x0	

RPDO2 Mapping at Object 1601h: Default ID 0x300 + Node ID

Sub-Index	Value	Object
0	4	Number of mapped application objects in PDO
1	0x73000110	Proportional Output Target
2	0x73000210	Signal Output Target
3	0x62000108	Digital Output ON/OFF (Prop Out in digital modes)
4	0x0	

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

Sub-Index	Value	Object
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

Sub-Index	Value	Object
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

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 1403h
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 C0000000h + RPDOx + Node-ID

X	RPDOx ID
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.

3.2.14. TPDO Behaviour

The BLDC Controller can support up to four TPDO messages. All TPDOs on the Controller use 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 is enabled by default (i.e. TPDO exists).

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

Sub-Index	Value	Object
0	4	Number of mapped application objects in PDO
1	0x71000110	Universal Input 1 Field Value
2	0x71000210	Universal Input 2 Field Value
3	0x71000310	Digital Input 1 Field Value
4	0x23700110	Proportional Output Feedback Field Value

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

Sub-Index	Value	Object
0	4	Number of mapped application objects in PDO
1	0x606C0020	Motor Velocity [RPM]
2	0x60770020	Motor Torque [mA]
3	0x0	
4	0x0	

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

Sub-Index	Value	Object
0	1	Number of mapped application objects in PDO
1	0	
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	0	
2	0	
3	0	
4	0	

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

Object Description

Index	1800h to 1803h
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 C0000000h + TPDOy + Node-ID

X	TPDOx ID	Y	TPDOy ID
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	250ms (on TPDO1) 0ms (on TPDO2 to TPDO4)

3.3. Application Objects (DS-402 and DS-404)

Index (hex)	Object	Object Type	Data Type	Access	PDO Mapping
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
606C	MC Actual Motor Velocity	VAR	INTEGER32	RO	Yes
6075	MC Rated Motor Current	VAR	UNSIGNED32	RW	No
60FF	MC Target Velocity	VAR	INTEGER32	RW	Yes
607E	MC Polarity	VAR	UNSIGNED8	RW	Yes
6080	MC Max Motor Speed	VAR	UNSIGNED32	RW	No
6200	DO Write state 8 Output lines	ARRAY	BOOLEAN	RW	Yes
6202	DO Polarity 8 Output Lines	ARRAY	UNSIGNED8	RW	No
6206	DO Fault Mode 8 Output Lines	ARRAY	UNSIGNED8	RW	No
6207	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

3.3.1. 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 1.4.1 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	1
Default Value	1

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

3.3.2. 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 20.

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	1
Default Value	1

Sub-Index	1h
Description	Digital Input Polarity Bitmap D1-D8
Access	RW
Section PDO Mapping	No
Value Range	See Table 20
Default Value	0 (Normal On/Off)

3.3.3. 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 10, 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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 to 3)
Description	Analog Input x FV
Access	RO
PDO Mapping	Yes
Value Range	Data Type Specific
Default Value	No

3.3.4. 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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 to 3)
Description	AIx Sensor Type
Access	RW
PDO Mapping	No
Value Range	See Table 7
Default Value	40 (voltage)

3.3.5. 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	3
Default Value	3

Sub-Index	1h to 2h (x = 1 to 2)
Description	AIx Operating Mode
Access	RW
PDO Mapping	No
Value Range	See Table 5
Default Value	1 (Normal Operation)

Sub-Index	3h
Description	AI3 Operating Mode
Access	RW
PDO Mapping	No
Value Range	See Table 5
Default Value	10 (Digital On/Off)

3.3.6. 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 25. 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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 to 3)
Description	AIx Scaling 1 FV
Access	RW
PDO Mapping	No
Value Range	See Table 12
Default Value	500 [mV]

3.3.7. 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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 or 3)
Description	AIx Scaling 1 PV
Access	RW
PDO Mapping	No
Value Range	Integer16
Default Value	500 [same as 7120h]

3.3.8. 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 25. 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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 or 3)
Description	AIx Scaling 2 FV
Access	RW
PDO Mapping	No
Value Range	See Table 12
Default Value	4500 [mV]

3.3.9. 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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 to 3)
Description	AIx Scaling 2 PV
Access	RW
PDO Mapping	No

Value Range	Integer16
Default Value	4500 [same as 7122h]

3.3.10. 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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 to 3)
Description	AIx Process Value
Access	RO
PDO Mapping	Yes
Value Range	Integer16
Default Value	No

3.3.11. 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	3

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

3.3.12. 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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 to 3)
Description	Alx Span Start (Error Min)
Access	RW
PDO Mapping	No
Value Range	See Table 12
Default Value	200 [mV]

3.3.13. 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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 to 3)
Description	AIx Span End (Error Max)
Access	RW
PDO Mapping	No
Value Range	See Table 12
Default Value	4800 [mV]

3.3.14. 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.

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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 to 3)
Description	AIx Filter Type
Access	RW
PDO Mapping	No
Value Range	See Table 9
Default Value	0 (no filter)

3.3.15. 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
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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	Alx Filter Constant
Access	RW
PDO Mapping	No
Value Range	1 to 1000
Default Value	10

3.3.16. Object 606Ch: MC Actual Motor Velocity

This read-mappable object contains the Measured Motor velocity in RPM.

Object Description

Index	606Ch
Name	MC Actual Motor Velocity
Object Type	VAR
Data Type	INTEGER32

Entry Description

Sub-Index	0h
Description	Measured Motor Velocity [RPM]
Access	RO
PDO Mapping	Yes
Value Range	INTEGER32
Default Value	0

3.3.17. Object 6075h: MC Rated Motor Current

Object Description

Index	6075h
Name	MC Rated Motor Current
Object Type	VAR
Data Type	UNSIGNED32

Entry Description

Sub-Index	0h
Description	Rated Motor Current [mA]
Access	RW
PDO Mapping	No

Value Range	UNSIGNED32
Default Value	7000

3.3.18. Object 60FFh: MC Target Velocity

This write-mappable object contains the Motor Target Velocity. The CANOpen Message RPDO 2 Control Source is configured to this mapped object.

Object Description

Index	60FFh
Name	MC Target Velocity
Object Type	VAR
Data Type	INTEGER32

Entry Description

Sub-Index	0h
Description	Target Velocity [RPM]
Access	RW
PDO Mapping	Yes
Value Range	INTEGER32
Default Value	0

3.3.19. Object 607Eh: MC Polarity

Object Description

Index	607Eh
Name	MC Polarity
Object Type	VAR
Data Type	UNSIGNED8

Entry Description

Sub-Index	0h
Description	Polarity [CW/CCW]
Access	RW
PDO Mapping	No
Value Range	0 - 1
Default Value	0 [CW]

3.3.20. Object 6080h: MC Max Motor Speed

Object Description

Index	6080h
Name	MC Target Velocity
Object Type	VAR
Data Type	UNSIGNED32

Entry Description

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

Description	Max Motor Speed [RPM]
Access	RW
PDO Mapping	No
Value Range	UNSIGNED32
Default Value	0

3.3.21. 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-DO3 Write State
Access	RW
PDO Mapping	Yes
Value Range	0 (OFF) or 1 (ON)
Default Value	0 (OFF)

3.3.22. Object 6002h: DO Polarity 8 Output Lines

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

Object Description

Index	6002h
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-DO3 Polarity

Access	RW
PDO Mapping	No
Value Range	See Table 20
Default Value	0 (normal on/off)

3.3.23. 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 26).

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	2
Default Value	2

Sub-Index	1h to 2h (x = 1 to 2)
Description	Outx Process Value
Access	RW
PDO Mapping	Yes
Value Range	Integer16
Default Value	No

3.3.24. 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	2
Default Value	2

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
Description	AO Decimal Digits PV
Access	RW
PDO Mapping	No
Value Range	0 to 4
Default Value	3 [Volt to mV]

3.3.25. Object 6310h: AO Output Type

This object specifies the type of analog output, as defined in Table 13.

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	2
Default Value	2

Sub-Index	1h
Description	PO Type
Access	RW
PDO Mapping	No
Value Range	See Table 13
Default Value	20 (current)

Sub-Index	2h
Description	AO Type
Access	RW
PDO Mapping	No
Value Range	See Table 13
Default Value	10 (voltage)

3.3.26. 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 15. 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	2
Default Value	2

Sub-Index	1h
Description	PO Scaling 1 PV
Access	RW
PDO Mapping	No
Value Range	See Table 15
Default Value	300 [mA]

Sub-Index	2h
Description	AO Scaling 1 PV
Access	RW
PDO Mapping	No
Value Range	See Table 15
Default Value	0 [mV]

3.3.27. 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 9. 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 13. 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 13)
Default Value	300 [mA]

Sub-Index	2h
Description	AO Scaling 1 FV
Access	RW
PDO Mapping	No
Value Range	Dependent on type (see Table 13)
Default Value	0 [mV]

3.3.28. 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 15. 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	2
Default Value	2

Sub-Index	1h
Description	PO Scaling 2 PV
Access	RW
PDO Mapping	No
Value Range	See Table 15
Default Value	1500 [mA]

Sub-Index	2h
-----------	----

Description	AO Scaling 2 PV
Access	RW
PDO Mapping	No
Value Range	See Table 15
Default Value	5000 [mV]

3.3.29. 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 9. 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 13. 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	2
Default Value	2

Sub-Index	1h
Description	PO Scaling 2 FV
Access	RW
PDO Mapping	No
Value Range	Dependent on type (see Table 13)
Default Value	1500 [mA]

Sub-Index	2h
Description	AOx Scaling 2 FV
Access	RW
PDO Mapping	No
Value Range	Dependent on type (see Table 13)
Default Value	5000 [mV]

3.3.30. 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 1.4, and the scaling applied as shown in Figure 9. It is defined in the physical unit of the output dependent on type, as outlined in Table 13. 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	2
Default Value	2

Sub-Index	1h to 2h (x = 1 to 2)
Description	Outx Field Value
Access	RO
PDO Mapping	Yes
Value Range	Integer16
Default Value	No

3.3.31. 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	2
Default Value	2

Sub-Index	1h to 2h (x = 1 to 2)
Description	AOx Decimal Digits FV
Access	RW
PDO Mapping	No
Value Range	0 to 4
Default Value	3 [mV]

3.3.32. 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 19.

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	2
Default Value	2

Sub-Index	1h to 2h (x = 1 to 2)
Description	Outx Fault Mode
Access	RW
PDO Mapping	No
Value Range	See Table 19
Default Value	1 (apply pre-defined FV)

3.3.33. 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	2
Default Value	2

Sub-Index	1h
Description	PO Fault Field Value
Access	RW
PDO Mapping	No
Value Range	Dependent on type (see Table 13)
Default Value	500 [mA]

Sub-Index	2h
Description	AOx Fault Field Value
Access	RW
PDO Mapping	No
Value Range	Dependent on type (see Table 13)
Default Value	1000 [mV]

3.3.34. Object 7450h: PID Proportional Band

This object describes the proportional band gain (G in Figure 17) 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]

3.3.35. Object 7452h: PID Integral Action Time

This object describes the integral time (Ti in Figure 17) 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 (Td in Figure 17).

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	PIDx Integral Time
Access	RW
PDO Mapping	No
Value Range	0.001 [sec] to 1000.00 [sec]
Default Value	5 [ms or 0.005sec]

3.3.36. Object 7454h: PID Derivative Action Time

This object describes the derivative time (Td in Figure 17) 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 (Ti in Figure 17).

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]

3.3.37. 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]

3.3.38. 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)

3.3.39. 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]

3.4. Manufacturer Objects

Index (hex)	Object	Object Type	Data Type	Access	PDO Mapping
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
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
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
3340	MC Control Input Source	VAR	UNSIGNED8	RW	No
3341	MC Control Input Number	VAR	UNSIGNED8	RW	No
3350	MC Direction Input Source	VAR	UNSIGNED8	RW	No
3351	MC Direction Input Number	VAR	UNSIGNED8	RW	No
3360	MC Enable Input Source	VAR	UNSIGNED8	RW	No
3361	MC Enable Input Number	VAR	UNSIGNED8	RW	No
3510	MC Number of Pole Pairs	VAR	UNSIGNED16	RW	No
3511	MC Motor Position Detection	VAR	UNSIGNED8	RW	No
3512	MC Commutation Sequence	VAR	UNSIGNED8	RW	No
3513	MC Overcurrent Clear Time	VAR	UNSIGNED16	RW	No
3515	MC PWM Frequency	VAR	UNSIGNED16	RW	No
3516	MC Rated RPM	VAR	UNSIGNED16	RW	No
3518	MC Overtemperature Threshold	VAR	UNSIGNED8	RW	No
3610	MC Speed Control Mode	VAR	UNSIGNED8	RW	No
3611	MC Speed P Gain	VAR	REAL32	RW	No
3612	MC Speed I Gain	VAR	REAL32	RW	No
3620	MC Current Control Mode	VAR	UNSIGNED8	RW	No
3621	MC Current P Gain	VAR	REAL32	RW	No
3622	MC Current I Gain	VAR	REAL32	RW	No
3710	MC Ramp Up Time	VAR	UNSIGNED16	RW	No
3711	MC Ramp Down Time	VAR	UNSIGNED16	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
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
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
5051	Fault Detection Error Response Delay	ARRAY	UNSIGNED16	RW	No
5555	Start in Operational Mode	VAR	BOOLEAN	RW	No

Where $yz = 01$ to 02 (LUT 1 to 02) and $y = 1$ to 2 (Math 1 to 2)

3.4.1. 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 4. The options for this object are listed in Table 2, 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	3
Default Value	3

Sub-Index	1h to 3h (x = 3 to 11)
Description	Digital Input X Pullup/Down
Access	RW
PDO Mapping	No
Value Range	See Table 2
Default Value	0 (pullup/down disabled)

3.4.2. 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 3.

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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 to 3)
Description	Dlx Debounce Filter
Access	RW
PDO Mapping	No
Value Range	See Table 3
Default Value	0 [Debounce Filter OFF]

3.4.3. Object 2100h: AI Input Range

This object, in conjunction with 6110h AI Sensor Type, defines the analog input defaults (Table 11) and allowable ranges (Table 12) 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 25.

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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 to 3)
Description	Input X Range
Access	RW
PDO Mapping	No
Value Range	See Table 25
Default Value	2 [0-5V]

3.4.4. 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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 to 3)
Description	Input x Pulses per Revolution
Access	RW
PDO Mapping	No
Value Range	0 to 1000
Default Value	1

3.4.5. 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 10 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	3
Default Value	3

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

3.4.6. 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 9.

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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 to 3)
Description	AIx ADC Filter Frequency
Access	RW
PDO Mapping	No
Value Range	See Table 9
Default Value	1 [Filter 50Hz]

3.4.7. 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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 to 3)
Description	Inputx Error Detect Enable
Access	RW
PDO Mapping	No
Value Range	0 (FALSE) or 1 (TRUE)
Default Value	1 [TRUE]

3.4.8. 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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 to 3)
Description	Inputx Error Clear Hysteresis
Access	RW
PDO Mapping	No
Value Range	See Table 12
Default Value	100 [mV]

3.4.9. 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	3
Default Value	3

Sub-Index	1h to 3h (x = 1 to 3)
Description	AIx Error Reaction Delay
Access	RW
PDO Mapping	No
Value Range	0 to 60,000
Default Value	1000 [ms]

3.4.10. 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 12 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	2
Default Value	2

Sub-Index	1h
Description	PO1 Hotshot Current
Access	RW
PDO Mapping	No
Value Range	2221h (Hold Current) to I _{max} (2.5A)
Default Value	2000 [mA]

Sub-Index	2h
Description	AO Hotshot Current
Access	RW
PDO Mapping	No
Value Range	NA
Default Value	0

3.4.11. 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 12 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	2
Default Value	2

Sub-Index	1h
Description	POut Hold Current
Access	RW
PDO Mapping	No
Value Range	0 to 2220h (Hotshot Current)
Default Value	500 [mA]

Sub-Index	2h
Description	AOut2 Hold Current
Access	RW
PDO Mapping	No
Value Range	NA
Default Value	0

3.4.12. 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 12 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	2

Default Value	2
---------------	---

Sub-Index	1h
Description	POut Hotshot Time
Access	RW
PDO Mapping	No
Value Range	0 to 60,000
Default Value	1000 [ms]

Sub-Index	2h
Description	AOut Hotshot Time
Access	RW
PDO Mapping	No
Value Range	NA
Default Value	0

3.4.13. 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	2
Default Value	2

Sub-Index	1h to 2h
Description	Outx Delay Time
Access	RW
PDO Mapping	No
Value Range	0 to 60,000
Default Value	0 [ms]

3.4.14. 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	2
Default Value	2

Sub-Index	1h to 2h (x = 1 to 2)
Description	Outx Delay Time
Access	RW
PDO Mapping	No
Value Range	0 (OFF) to 1 (ON)
Default Value	1 [ON]

3.4.15. 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	2
Default Value	2

Sub-Index	1h
Description	POut Override FV
Access	RW

PDO Mapping	No
Value Range	Dependent on type (see Table 13)
Default Value	750 [mA]

Sub-Index	2h
Description	AOut Override FV
Access	RW
PDO Mapping	No
Value Range	Dependent on type (see Table 13)
Default Value	0 [mV]

3.4.16. 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	2
Default Value	2

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
Description	AO Error Detect Enable
Access	RW
PDO Mapping	No
Value Range	0 (FALSE) or 1 (TRUE)
Default Value	1 [TRUE]

3.4.17. 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	2
Default Value	2

Sub-Index	1h
Description	PO Error Clear Hysteresis
Access	RW
PDO Mapping	No
Value Range	0 to 10% of 7321h or 7323h, whichever is larger
Default Value	100 [mA]

Sub-Index	2h
Description	AO Error Clear Hysteresis
Access	RW
PDO Mapping	No
Value Range	NA
Default Value	0 [off]

3.4.18. 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	2
Default Value	2

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
Description	AO Error Reaction Delay
Access	RW
PDO Mapping	No
Value Range	0 to 60,000
Default Value	1000 [ms]

3.4.19. 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	2
Default Value	2

Sub-Index	1h
Description	PO Dither Frequency
Access	RW
PDO Mapping	No
Value Range	50 to 400
Default Value	250 [Hz]

Sub-Index	2h
Description	AO Dither Frequency
Access	RW
PDO Mapping	No

Value Range	NA
Default Value	0

3.4.20. 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	2
Default Value	2

Sub-Index	1h
Description	PO Dither Amplitude
Access	RW
PDO Mapping	No
Value Range	0 to 500
Default Value	0 [mA] (dithering disabled)

Sub-Index	2h
Description	AO Dither Amplitude
Access	RW
PDO Mapping	No
Value Range	NA
Default Value	0

3.4.21. 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	2
Default Value	2

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
Description	AO Ramp Up
Access	RW
PDO Mapping	No
Value Range	0 to 60,000
Default Value	0 [ms]

3.4.22. 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	2
Default Value	2

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
Description	AO Ramp Down
Access	RW
PDO Mapping	No
Value Range	0 to 60,000
Default Value	0 [ms]

3.4.23. 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 8. The available control sources on the BLDC controller are listed in Table 25. 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	2
Default Value	2

Sub-Index	1h to 2h (x = 1 to 2)
Description	Outx Control Input Source
Access	RW
PDO Mapping	No
Value Range	See Table 25
Default Value	1 (CANopen RPDO)

3.4.24. 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 8. The available control numbers are dependent on the source selected, as shown in Table 25. Once selected, the control represents the process value (X-Axis input) in Figure 9. Objects 6302h, 7320h, 7322h should therefore be updated to match the scaling limits defined by the control source/number, as listed in Table 25.

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	2
Default Value	2

Sub-Index	1h to 2h (x = 1 to 2)
Description	Outx Control Input Number
Access	RW
PDO Mapping	No
Value Range	See Table 26
Default Value	x (CANopen Message x)

3.4.25. 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 9. 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 16. 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	2
Default Value	2

Sub-Index	1h to 2h (x = 1 to 2)
Description	Outx Control Response
Access	RW
PDO Mapping	No
Value Range	See Table 16
Default Value	1 (Output OFF below Scaling 1 PV)

3.4.26. 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 8. The available control sources on the BLDC controller are listed in Table 25. 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	2
Default Value	2

Sub-Index	1h to 2h (x = 1 to 2)
Description	Outx Enable Input Source
Access	RW
PDO Mapping	No
Value Range	See Table 25
Default Value	0 (control not used)

3.4.27. 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 8. The available control numbers are dependent on the source selected, as shown in Table 26.

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	2
Default Value	2

Sub-Index	1h to 2h (x = 1 to 2)
Description	Outx Enable Input Number

Access	RW
PDO Mapping	No
Value Range	See Table 26
Default Value	0 (null control source)

3.4.28. 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 the analog output are listed in Table 17.

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	2
Default Value	2

Sub-Index	1h to 2h (x = 1 to 2)
Description	Outx Enable Response
Access	RW
PDO Mapping	No
Value Range	See Table 17
Default Value	3 (Enable When Off, Else Shut Off)

3.4.29. 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 8. The available control sources on the BLDC controller are listed in Table 25. 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	2
Default Value	2

Sub-Index	1h to 2h (x = 1 to 2)
Description	Outx Override Input Source
Access	RW
PDO Mapping	No
Value Range	See Table 25
Default Value	0 (control not used)

3.4.30. 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 8. The available control numbers are dependent on the source selected, as shown in Table 26.

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	2
Default Value	2

Sub-Index	1h to 2h (x = 1 to 2)
Description	Outx Override Input Number
Access	RW
PDO Mapping	No
Value Range	See Table 26
Default Value	0 (null control source)

3.4.31. 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 18.

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	2
Default Value	2

Sub-Index	1h to 2h (x = 1 to 2)
Description	Outx Override Response
Access	RW
PDO Mapping	No
Value Range	See Table 18
Default Value	0 (Override When On)

3.4.32. 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 9) 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	2
Default Value	2

Sub-Index	1h to 2h (x = 1 to 2)
Description	Outx Feedback Field Value
Access	RO
PDO Mapping	Yes
Value Range	Dependent on type (see Table 13)
Default Value	No

3.4.33. 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	2
Default Value	2

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
Description	AO Frequency
Access	RW
PDO Mapping	No
Value Range	NA
Default Value	0

3.4.34. 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 writable 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	2
Default Value	2

Sub-Index	1h
Description	PO Current PID Proportional Gain
Access	RW
PDO Mapping	No
Value Range	FLOAT32
Default Value	0.60

Sub-Index	2h
Description	AO Current PID Proportional Gain
Access	RW
PDO Mapping	No
Value Range	FLOAT32
Default Value	0

3.4.35. 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	2
Default Value	2

Sub-Index	1h
Description	PO Current PID Integral Time
Access	RW
PDO Mapping	No
Value Range	FLOAT32
Default Value	0.0015

Sub-Index	2h
Description	AO Current PID Integral Time
Access	RW
PDO Mapping	No

Value Range	FLOAT32
Default Value	0

3.4.36. 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	2
Default Value	2

Sub-Index	1h
Description	PO Current PID Derivative Time
Access	RW
PDO Mapping	No
Value Range	FLOAT32
Default Value	0.0000

Sub-Index	2h
Description	AO Current PID Derivative Time
Access	RW
PDO Mapping	No
Value Range	FLOAT32
Default Value	0.0000

3.4.37. 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	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 Tolerance
Access	RW
PDO Mapping	No
Value Range	0 to 100 (0% to 10%)
Default Value	10 [1%]

3.4.38. Object 2451h: PID Integral Gain

This object describes the integral gain (K_i in Figure 17) 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]

3.4.39. Object 2452h: PID Derivative Gain

This object describes the derivative gain (K_d in Figure 17) 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]

3.4.40. 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 BLDC controller are listed in Table 25. 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 25
Default Value	0 (control not used, PID disabled)

3.4.41. 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 26. 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 25.

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 _x Target Number
Access	RW
PDO Mapping	No
Value Range	See Table 26
Default Value	x

3.4.42. 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 BLDC controller are listed in Table 25. 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	PIDx Feedback Source
Access	RW
PDO Mapping	No
Value Range	See Table 25
Default Value	0 (control not used, PID disabled)

3.4.43. 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 26. 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 25.

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 26
Default Value	x

3.4.44. 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 23.

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 23
Default Value	0 (single output)

3.4.45. 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 17. 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

3.4.46. 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

3.4.47. 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)

3.4.48. 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 9. 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

3.4.49. 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 9. 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)

3.4.50. Object 3340h: MC Control Input Source

This object defines the type of input that will be used to determine the target process value for the Motor Target Velocity. The only control source allowed for motor RPM is 1 – Received CANOpen Message [RPDO].

Object Description

Index	3340h
Name	MC Control Input Source
Object Type	VAR
Data Type	UNSIGNED8

Entry Description

Sub-Index	0h
Description	MC Control Source
Access	RW
PDO Mapping	No
Value Range	See Table 25
Default Value	1 (Received CANOpen Message [RPDO])

3.4.51. Object 3341h: MC Control Input Number

Object Description

Index	3341h
Name	MC Control Input Number
Object Type	VAR
Data Type	UNSIGNED8

Entry Description

Sub-Index	0h
Description	MC Control Number
Access	RW
PDO Mapping	No
Value Range	See Table 25
Default Value	2

3.4.52. Object 3350h: MC Direction Input Source

This object defines the type of input that will be used to determine the target process value for the Motor Direction. The available control sources on the controller are listed in Table 25. A selection of “Control Source Not Used” disables the associated control function block.

Object Description

Index	3350h
Name	MC Direction Input Source
Object Type	VAR
Data Type	UNSIGNED8

Entry Description

Sub-Index	0h
Description	MC Direction Source
Access	RW
PDO Mapping	No
Value Range	See Table 25
Default Value	1 (Received CANOpen Message [RPDO])

3.4.53. Object 3351h: MC Direction Input Number**Object Description**

Index	3351h
Name	MC Direction Input Number
Object Type	VAR
Data Type	UNSIGNED8

Entry Description

Sub-Index	0h
Description	MC Direction Input Number
Access	RW
PDO Mapping	No
Value Range	See Table 25
Default Value	1

3.4.54. Object 3360h: MC Enable Input Source

This object defines the type of input that will be used to Enable the Motor. The available control sources on the controller are listed in Table 25. A selection of “Control Source Not Used” disables the associated control function block.

Object Description

Index	3360h
Name	MC Enable Input Source
Object Type	VAR
Data Type	UNSIGNED8

Entry Description

Sub-Index	0h
Description	MC Enable Source
Access	RW
PDO Mapping	No
Value Range	See Table 25
Default Value	1 (Received CANOpen Message [RPDO])

3.4.55. Object 3361h: MC Enable Input Number

Object Description

Index	3361h
Name	MC Enable Input Number
Object Type	VAR
Data Type	UNSIGNED8

Entry Description

Sub-Index	0h
Description	MC Enable Input Number
Access	RW
PDO Mapping	No
Value Range	See Table 25
Default Value	5

3.4.56. Object 3510h: MC Number of Pole Pairs

This object holds the number of pole pairs of the target motor. For example, a four pole BLDC motor would have 2 Pole Pairs.

Object Description

Index	3510h
Name	MC Number of Pole Pairs
Object Type	VAR
Data Type	UNSIGNED8

Entry Description

Sub-Index	0h
Description	Number of Pole Pairs
Access	RW
PDO Mapping	No
Value Range	UNSIGNED8
Default Value	2

3.4.57. Object 3511h: MC Rotor Position Detection

This object determines whether Hall Sensors are used in controlling the motor.

Object Description

Index	3511h
Name	MC Rotor Position Detection
Object Type	VAR
Data Type	UNSIGNED8

Entry Description

Sub-Index	0h
Description	MC Rotor Position Detection

Access	RW
PDO Mapping	No
Value Range	0 (sensorless) – 1 (hall sensors)
Default Value	0

3.4.58. Object 3512h: MC Commutation Sequence

The Motor Commutation Sequence is described in more detail in Section 1.1.

Object Description

Index	3512h
Name	MC Commutation Sequence
Object Type	VAR
Data Type	UNSIGNED8

Entry Description

Sub-Index	0h
Description	Commutation Sequence
Access	RW
PDO Mapping	No
Value Range	0 – 5
Default Value	0

3.4.59. Object 3513h: MC Overcurrent Clear Time

Object Description

Index	3513h
Name	MC Overcurrent Clear Time
Object Type	VAR
Data Type	UNSIGNED16

Entry Description

Sub-Index	0h
Description	Overcurrent Clear Time [ms]
Access	RW
PDO Mapping	No
Value Range	UNSIGNED16
Default Value	5000

3.4.60. Object 3515h: MC PWM Frequency

Object Description

Index	3515h
Name	MC PWM Frequency
Object Type	VAR
Data Type	UNSIGNED16

Entry Description

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

Description	PWM Frequency [kHz]
Access	RW
PDO Mapping	No
Value Range	UNSIGNED16
Default Value	16

3.4.61. Object 3516h: MC Rated RPM

Object Description

Index	3516h
Name	MC Rated RPM
Object Type	VAR
Data Type	UNSIGNED16

Entry Description

Sub-Index	0h
Description	MC Rated RPM
Access	RW
PDO Mapping	No
Value Range	UNSIGNED16
Default Value	3000

3.4.62. Object 3518h: MC Overtemperature Threshold

Object Description

Index	3518h
Name	MC Overtemperature Threshold
Object Type	VAR
Data Type	UNSIGNED8

Entry Description

Sub-Index	0h
Description	Overtmp Threshold [deg C]
Access	RW
PDO Mapping	No
Value Range	UNSIGNED8
Default Value	130

3.4.63. Object 3610h: MC Speed Control Mode

Object Description

Index	3610h
Name	MC Speed Control Mode
Object Type	VAR
Data Type	UNSIGNED8

Entry Description

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

Description	Speed Control Mode
Access	RW
PDO Mapping	No
Value Range	See Section 1.1
Default Value	0

3.4.64. Object 3611h: MC Speed P Gain

Object Description

Index	3611h
Name	MC Speed P Gain
Object Type	VAR
Data Type	REAL32

Entry Description

Sub-Index	0h
Description	Speed P Gain
Access	RW
PDO Mapping	No
Value Range	REAL32
Default Value	0.800

3.4.65. Object 3612h: MC Speed I Gain

Object Description

Index	3612h
Name	MC Speed I Gain
Object Type	VAR
Data Type	REAL32

Entry Description

Sub-Index	0h
Description	Speed I Gain
Access	RW
PDO Mapping	No
Value Range	REAL32
Default Value	0.008

3.4.66. Object 3620h: MC Current Control Mode

Object Description

Index	3620h
Name	MC Current Control Mode
Object Type	VAR
Data Type	UNSIGNED8

Entry Description

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

Description	Current Control Mode
Access	RW
PDO Mapping	No
Value Range	See Section 1.1
Default Value	0

3.4.67. Object 3621h: MC Current P Gain

Object Description

Index	3621h
Name	MC Current P Gain
Object Type	VAR
Data Type	REAL32

Entry Description

Sub-Index	0h
Description	Current P Gain
Access	RW
PDO Mapping	No
Value Range	REAL32
Default Value	0.600

3.4.68. Object 3622h: MC Current I Gain

Object Description

Index	3622h
Name	MC Current I Gain
Object Type	VAR
Data Type	REAL32

Entry Description

Sub-Index	0h
Description	Current I Gain
Access	RW
PDO Mapping	No
Value Range	REAL32
Default Value	0.006

3.4.69. Object 3710h: MC Ramp Up Time

Object Description

Index	3710h
Name	MC Ramp Up Time
Object Type	VAR
Data Type	UNSIGNED16

Entry Description

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

Description	Ramp Up Time [ms]
Access	RW
PDO Mapping	No
Value Range	100 - 30000
Default Value	2000

3.4.70. Object 3711h: MC Ramp Down Time

Object Description

Index	3711h
Name	MC Ramp Down Time
Object Type	VAR
Data Type	UNSIGNED16

Entry Description

Sub-Index	0h
Description	Ramp Down Time [ms]
Access	RW
PDO Mapping	No
Value Range	100 - 30000
Default Value	2000

3.4.71. 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 BLDC controller are listed in Table 25. 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 02)
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 25
Default Value	0 (control not used)

3.4.72. 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 26. 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 25.

Object Description

Index	3yz1h (where yz = 01 to 02)
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 26
Default Value	0 (null control source)

3.4.73. 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 02)
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]

3.4.74. 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 25.

Object Description

Index	3yz3h (where yz = 01 to 02)
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 25)
Default Value	0

3.4.75. 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 02)
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

3.4.76. 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 22. See Figure 14 for an example of the difference between a step and ramp response.

Object Description

Index	3yz5h (where yz = 01 to 02)
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 22 (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 22 (0, 1 or 2)
Default Value	1 (ramp to response)

3.4.77. 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 02)
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

3.4.78. 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 02)
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]

3.4.79. 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 02)
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

3.4.80. 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 2h (Y = 1 to 2)
Description	Math Y Enable
Access	RW
PDO Mapping	No
Value Range	0 (FALSE) or 1 (TRUE)
Default Value	0 [FALSE]

3.4.81. 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	2
Default Value	2

Sub-Index	1h to 2h (Y = 1 to 2)
Description	Math Y Output Scaling 1 PV
Access	RW
PDO Mapping	No
Value Range	-32768 to 32767
Default Value	0

3.4.82. 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	2
Default Value	2

Sub-Index	1h to 2h (Y = 1 to 2)
Description	Math Y Output Scaling 2 PV
Access	RW
PDO Mapping	No
Value Range	-32768 to 32767
Default Value	10000 (100.00)

3.4.83. 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	2
Default Value	2

Sub-Index	1h to 2h (Y = 1 to)
Description	Math Y Output Process Value
Access	RO

PDO Mapping	Yes
Value Range	-32768 to 32767
Default Value	No

3.4.84. 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	2
Default Value	2

Sub-Index	1h to 2h (Y = 1 to 2)
Description	Math Y Decimal Digits PV
Access	RW
PDO Mapping	No
Value Range	0 to 4
Default Value	2 (0.01)

3.4.85. Object 4y00h: Math Y Input Source

This object defines the input sources that will be used in the mathematical calculations. Here, y = 1 to 2 – representing Math Block 1 to Math Block 2. If a control source is not used, the associate mathematical calculation would be ignored. The available control sources on the BLDC controller are listed in Table 25.

Object Description

Index	4y00h (y = 1 to 2)
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	2

Default Value	2
---------------	---

Sub-Index	1h to 2h (X = 1 to 2)
Description	Math Y Input X Source
Access	RW
PDO Mapping	No
Value Range	See Table 25
Default Value	0 (control source not used)

3.4.86. 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 26. Once selected, the input value will be used in the corresponding calculation as described in Section 1.7.

Object Description

Index	4y01h (y = 1 to 2)
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	2
Default Value	2

Sub-Index	1h to 2h (X = 1 to 2)
Description	Math Y Input X Number
Access	RW
PDO Mapping	No
Value Range	See Table 26
Default Value	0 (null input)

3.4.87. 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 2)
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	2
Default Value	2

Sub-Index	1h to 2h (X = 1 to 2)
Description	Math Y Input X Decimal Digits PV
Access	RW
PDO Mapping	No
Value Range	0 to 4
Default Value	2 (0.01)

3.4.88. 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 2)
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	2
Default Value	2

Sub-Index	1h to 2h (X = 1 to 2)
Description	Math Y Input X Scaling 1 FV
Access	RW
PDO Mapping	No
Value Range	INTEGER16
Default Value	0

3.4.89. 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 2)
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	2
Default Value	2

Sub-Index	1h to 2h (X = 1 to 2)
Description	Math Y Input X Scaling 2 FV
Access	RW
PDO Mapping	No
Value Range	INTEGER16
Default Value	10000 (100.00%)

3.4.90. 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 2)
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	2
Default Value	2

Sub-Index	1h to 2h (X = 1 to 2)
Description	Math Y Input X Gain
Access	RW
PDO Mapping	No
Value Range	-100 to 100
Default Value	100 (1.0)

3.4.91. 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 1.7. The options for this object are listed in Table 24.

Object Description

Index	4y50h (y = 1 to 2)
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	1
Default Value	1

Sub-Index	1h to 3h (X = 1 to 3)
Description	Math Y Function X Operator
Access	RW
PDO Mapping	No
Value Range	See Table 24
Default Value	12 (Plus)

3.4.92. 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

3.4.93. 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

3.4.94. 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)

3.4.95. 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 [$^{\circ}\text{C} \times 10$]
Default Value	850 (85.0 $^{\circ}\text{C}$)

Subindex	2h
Description	Over Voltage Clear Threshold
Access	RW
PDO Mapping	No
Value Range	4002h at subindex 3 to 4001h at subindex 2 [$\text{V} \times 10$]
Default Value	480 (48.0V)

Subindex	3h
Description	Under Voltage Clear Threshold
Access	RW
PDO Mapping	No
Value Range	4001h at subindex 3 to 4002h at subindex 2 [$\text{V} \times 10$]
Default Value	120 (12.0V)

3.4.96. 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 Bit Value 1 = Error Check Enabled

Default Value	00h (all error check disabled)
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3.4.97. 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]

3.4.98. 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]

3.4.99. 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 BLDC 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]

APPENDIX A - TECHNICAL SPECIFICATION

Specifications are indicative and subject to change. Actual performance will vary depending on the application and operating conditions. 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 <https://www.axiomatic.com/service/>.

All specifications are typical at nominal input voltage and 25°C unless otherwise specified.

Power

Power Supply Input	12, 24, or 48 VDC nominal (9 to 65 VDC)
Quiescent Current	70.2 mA @ 12 V; 37.3 mA @ 24 V; 18 mA @ 48 V typical
Surge Protection	120 VDC

Input

Universal Signal Inputs	<p>2 universal signal input properties are user configurable. Refer to the block diagram and information below.</p> <p>Any input on the controller can be coded into a Proprietary B message that can be sent to the CAN network.</p> <p>12-bit analog to digital resolution Protected against shorts</p> <p><u>Voltage Input:</u> Range: 0-5 VDC or 0-10 VDC Resolution: 1 mV Accuracy: ±1%</p> <p><u>Current Input:</u> Range: 4-20 mA or 0-20 mA Resolution: 1 µA Accuracy: ±1% Current sense resistor: 249 Ω</p> <p><u>Frequency Input:</u> Auto-Ranging: 0.1-10,000 Hz Resolution: 0.01% Accuracy: ±1%</p> <p><u>PWM Signal:</u> Range: 0.5-10,000 Hz Duty Cycle : 0 to 100% Resolution: 0.01% Accuracy: ±1%</p> <p><u>Digital Input:</u> Active high with 10 KΩ pull-up resistor or active low with 10 KΩ pull-down resistor Amplitude: up to +Vps</p> <p>These can be configured to act as an encoder input. Input 1 is the Encoder A and input 2 is the Encoder B interface. (Encoder inputs are not yet supported. Contact Axiomatic.)</p>
Digital / PWM / Frequency Inputs	<p>1 input is provided</p> <p><u>Frequency Input:</u> Auto-Ranging: 0.1-10,000 Hz Resolution: 0.01% Accuracy: ±1%</p> <p><u>PWM Signal:</u> Range: 0.1-10,000 Hz Duty Cycle : 0 to 100% Resolution: 0.01% Accuracy: ±1%</p> <p><u>Digital Input:</u> Active high with 10 KΩ pull-up resistor or active low with 10 KΩ pull-down resistor Amplitude: up to +Vps</p> <p>These inputs can be used as an enable or direction command for the controller.</p>

Motor Feedback	<p>Hall effect sensor 10 KΩ pull-up to +5 V per input A +5 V supply and ground connection is provided.</p> <p>Sensorless control using back EMF is also available in the standard model.</p>
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Output

Output to BLDC Motor	<p>H-bridge 40 A @ 48 VDC nominal continuous 40 A @ 24 VDC nominal continuous 40 A @ 12 VDC nominal continuous</p> <p>Overcurrent protection is provided at 50 A. Short circuit protection is provided. The maximum rated speed and motor rated current are configurable to suit individual motor specifications.</p>
Motor Stop	Shut off with or without ramping
Motor Direction	Motor direction command can be mapped to any input or come from the CAN bus.
Motor Control Mode	Flexible control is provided by user configurable parameters for speed and torque control loops. The control input to drive the motor can be mapped to either of the 2 universal inputs or the controller can respond to messages from a CAN bus.
Thermal Protection	Thermal protection is built-in and configurable.
Universal Output	<p>1 output is selectable as:</p> <p><u>Proportional Current:</u> Range: 0-2.5 A Resolution: 1 mA Accuracy: $\pm 1\%$</p> <p><u>Hotshot Digital:</u> Current: 2.5 A</p> <p><u>PWM Duty Cycle:</u> Current: 2.5 A Resolution: 0.01% Accuracy: $\pm 1\%$</p> <p><u>On/Off Digital:</u> Current: 2.5 A Sourcing from power supply or output off</p> <p><u>Half-Bridge Output:</u> Current sensing, grounded load. High side sourcing up to 2.5 A High frequency drive</p> <p>Load at supply voltage must not draw more than 2.5A Ramp and dither setpoints are configurable.</p> <p>Overcurrent protection Short circuit protection</p> <p>Hotshot Coil Saver Output: The output is on/off with a hotshot current which keeps the load ON with a holding current. This is used as an energy saving method of load control. The output is configurable to send a feedback message to the CAN bus. The feedback is always sent as a word with a resolution of 1 mA/bit and 0 mA offset. Refer to Proportional Output Hotshot Digital Profile.</p>
Signal Output	<p>1 voltage or current output is provided to follow the rotation speed of the motor.</p> <p>12-bit digital to analog (voltage, current) Protected against short to GND or +Vcc 1 signal output GND is provided.</p> <p><u>Voltage Output:</u> Range: 0-5 VDC or 0-10 VDC Resolution: 1 mV Accuracy: $\pm 1\%$</p> <p><u>Current Output:</u> Range: 4-20 mA or 0-20 mA Resolution: 1 μA Accuracy: $\pm 1\%$ Current sense resistor: 249 Ω</p>

General Specifications

Microcontroller	TMS320F280049
Motor Control	<p>Standard embedded software is provided.</p> <p>The following parameters are user configurable.</p> <p><u>Motor Direction:</u> Uni-directional or bi-directional control from an input or the CAN bus. The direction is also configurable.</p> <p><u>Enable:</u> A universal input can be configured to enable the motor when on. A CAN message can also be used as an enable input.</p> <p><u>Control Mode:</u> Open loop speed or closed loop speed, open loop torque or closed loop torque</p> <p><u>CAN:</u> CAN bus messages control the motor and/or auxiliary outputs instead of the analog or digital inputs</p>
Communication	1 CAN port (CANopen® compliant)
User Interface	EDS File Standard CANopen® tools (not supplied)
Software Flashing	Axiomatic Electronic Assistant, P/N: AX070502 or AX070506K
Operating Conditions	-40°C to 85°C (-40°F to 185°F)
Storage Temperature	-50°C to 125°C (-58°F to 257°F)
Weight	3.75 lb. (1.695 kg)
Protection	IP67
Enclosure and Dimensions	Encapsulated in an anodized aluminum extrusion with gasket 8.95 in x 6.67 in x 2.88 in (227.4 mm x 169.3 mm x 73.2 mm) (W x L x H including connectors, excluding mating connectors) Refer to Dimensional Drawing.
Electrical Connections	<p><u>Power Connector:</u> Molex equivalent P/N: 19436-0213 Mates with Molex P/N: 19432-0013</p> <p><u>Motor Connector:</u> TE Deutsch equivalent P/N: HD10-3-96P Mates with TE Deutsch equivalent P/N: HD16-3-96S</p> <p><u>Signal, Hall Effect and CAN Connector:</u> TE Deutsch equivalent P/N: DTM13-12PA Mates with TE Deutsch equivalent P/N: DTM06-12SA</p> <p>Wires should be of the appropriate gauge to meet requirements of applicable electrical codes and suit the specifications of the connector(s).</p>
Mating Cables	A mating plug kit comprised of all mating connectors is available as P/N: AX070450 (includes 1 plug DTM06-12SA, 1 socket HD16-3-96S, 1 wedgelock WM12S, 12 contacts 0462-201-20141, 3 contacts 0462-201-16141, 1 wedgelock 19432-0013, 2 terminals 19434-0003).
Mounting	The motor controller should be mounted as close to the battery and/or the motor as possible. Install the unit with appropriate space available for servicing and for adequate wire harness access and strain relief. Mounting ledges include holes sized for M6 or 1/4 inch bolts. The bolt length will be determined by the end-user's mounting plate thickness. Typically, 20 mm (3/4 inch) is adequate.

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OUR PRODUCTS

AC/DC Power Supplies
Actuator Controls/Interfaces
Automotive Ethernet Interfaces
Battery Chargers
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CAN/WiFi, CAN/Bluetooth, Routers
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Engine Temperature Scanners
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Gateways, Switches
Fan Drive Controllers
Gateways, CAN/Modbus, RS-232
Gyroscopes, Inclinometers
Hydraulic Valve Controllers
Inclinometers, Triaxial
I/O Controls
LVDT Signal Converters
Machine Controls
Modbus, RS-422, RS-485 Controls
Motor Controls, Inverters
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

We have an ISO9001:2015 registered design/manufacturing facility in Canada.

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 at <https://www.axiomatic.com/service/>.

COMPLIANCE

Product compliance details can be found in the product literature and/or on axiomatic.com. Any inquiries should be sent to sales@axiomatic.com.

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.

SERVICE

All products to be returned to Axiomatic require a Return Materials Authorization Number (RMA#) from rma@axiomatic.com. Please provide the following information when requesting an RMA number:

- Serial number, part number
- Runtime hours, description of problem
- Wiring set up diagram, application and other comments as needed

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.

CONTACTS

Axiomatic Technologies Corporation
1445 Courtneypark Drive E.
Mississauga, ON
CANADA L5T 2E3
TEL: +1 905 602 9270
FAX: +1 905 602 9279
www.axiomatic.com
sales@axiomatic.com

Axiomatic Technologies Oy
Höytämöntie 6
33880 Lempäälä
FINLAND
TEL: +358 103 375 750
www.axiomatic.com
salesfinland@axiomatic.com