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UAV-ESC

Firmware Specification

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UAV-ESC Electronic Speed Controllers
Firmware Specification
CCMC | Edition 2022-11 | DocID rel10894

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READ THIS FIRST

THESE INSTRUCTIONS ARE INTENDED FOR QUALIFIED TECHNICAL PERSONNEL.

IMPORTANT NOTICE: PREREQUISITES FOR PERMISSION TO COMMENCE COMMISSIONING
The UAV-ESC is considered as partly completed machinery according to EU Directive 2006/42/EC, Article 2, Clause (g) and **is intended to be incorporated into or assembled with other machinery or other partly completed machinery or equipment**.

WARNING
RISK OF INJURY
OPERATING THE DEVICE WITHOUT THE FULL COMPLIANCE OF THE SURROUNDING SYSTEM WITH THE EU DIRECTIVE 2006/42/EC MAY CAUSE SERIOUS INJURIES!

- Do not operate the device, unless you have made completely sure that the other machinery fully complies with the EU directive's requirements!
- Do not operate the device, unless the other machinery fulfills all relevant health and safety aspects!
- Do not operate the device, unless all respective interfaces have been established and fulfill the requirements stated in this document!

PRIOR COMMENCING WITH ANY ACTIVITIES YOU MUST CAREFULLY READ AND UNDERSTAND THIS MANUAL AND YOU MUST FOLLOW THE INSTRUCTIONS GIVEN THEREIN.

YOU MUST NOT PUT THE DEVICE INTO SERVICE UNLESS YOU HAVE MADE COMPLETELY SURE ABOUT THE FOLLOWING:

- You must make sure that the surrounding system with all involved components (such as motor, propeller, flight controller, other connected electronics or devices) does fully comply with any applicable law as well as local rules and regulations!
- You must make sure that the surrounding system does fulfill all relevant health and safety aspects!
- You must make sure that all respective interfaces have been correctly established and that they fulfill the herein stated requirements!

OBSERVE THE FOLLOWING BEFORE TAKE-OFF AND KEEP IN MIND DURING THE ENTIRE FLIGHT:

- Check on applicable local rules and regulations in respect to flight permissions, no-fly zones, restricted areas, and other flight restrictions.
- Check for airworthiness and full operational condition of your aircraft.
- Check all components for tight fit before every flight. Make sure that all motors, propellers, and other parts are installed correctly. Do not attempt to fly the aircraft with worn or damaged components.
- DO NOT approach or touch the aircraft while the motors or propellers are running or while the aircraft is powered.

USE THIS PRODUCT STRICTLY ACCORDING TO THE INFORMATION GIVEN IN THE PRESENT DOCUMENT.
MAXON DOES NOT ASSUME ANY LIABILITY FOR LOSS, DAMAGE, CLAIMS, OR COSTS OF ANY KIND (INCLUDING, BUT NOT EXCLUDED TO) CONSEQUENTIAL, DIRECT, INDIRECT, OR INCIDENTAL DAMAGES, LOST PROFITS OR LOST SAVINGS, PERSONAL INJURY OR LACK OF CARE, OR CLAIMS OF THIRD PARTIES, EVEN IF MAXON WAS INFORMED OF SUCH LOSS, DAMAGE, CLAIMS, OR COSTS THAT MAY DIRECTLY OR INDIRECTLY ARISE FROM USING THIS PRODUCT IN AN IMPROPER OR UNSUITABLE WAY.

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TABLE OF CONTENTS

1 ABOUT

The present document provides you with information on the UAV-ESC firmware specification.

Find the latest edition on the present document as well as additional documentation and software for UAV-ESC unmanned aerial vehicle electronic speed controllers on the Internet
➔http://uav.maxongroup.com

1.1 About this Document

1.1.1 Intended Purpose

The purpose of the present document is to familiarize you with the UAV-ESC Electronic Speed Controllers. It will highlight the tasks for safe and adequate installation and commissioning. Follow the described instructions…

- to avoid dangerous situations,
- to keep installation and/or commissioning time at a minimum,
- to increase reliability and service life of the described equipment

The present document is part of a documentation set and contains performance data and specifications, information on fulfilled standards, details on connections and pin assignment, and wiring examples. The below overview shows the documentation hierarchy and the interrelationship of its individual parts:

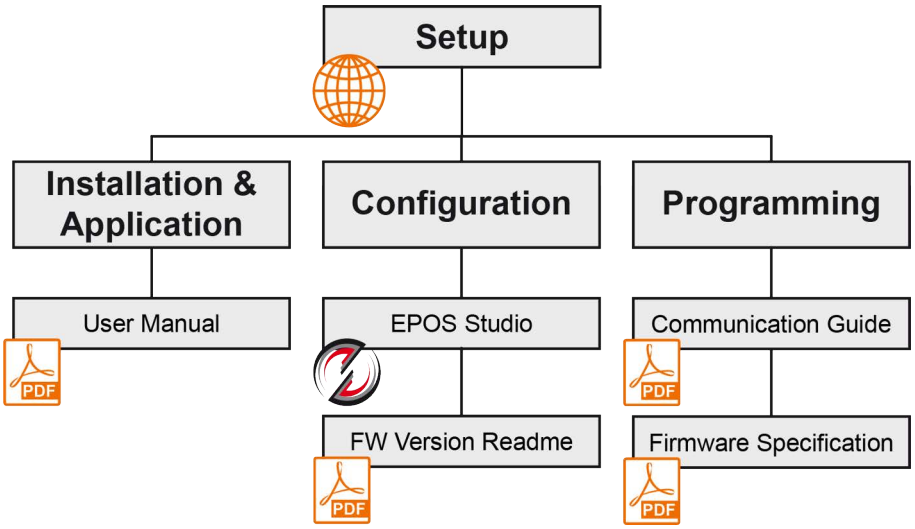

Figure 1-1 Documentation structure

1.1.2 Target Audience

The present document is intended for trained and skilled personnel. It conveys information on how to understand and fulfill the respective work and duties.

The present document is a reference book. It does require particular knowledge and expertise specific to the equipment described.

1.1.3 How to use

Take note of the following notations and codes which will be used throughout the document.

Notation	Explanation
UAV-ESC	stands for all supported sensorless controller types of the UAV-ESC family
«Abcd»	indicating a title or a name (such as of document, product, mode, etc.)
(n)	referring to an item (such as order number, list item, etc.)
*	referring to an internal value
➔	denotes “see”, “see also”, “take note of”, or “go to”

Table 1-1 Notations used

In the later course of the present document, the following abbreviations and acronyms will be used:

Short	Description
Back EMF	Back Electromotive Force
BLDC motor	Brushless direct current motor
BOPD	Back EMF only Position Detection
CCW	Counterclockwise
CST	Cyclic Synchronous Torque Mode
CSTCA	Cyclic Synchronous Torque Mode with Commutation Angle
CW	Clockwise
ESBT	Electrical System Back EMF Tuning Mode
ESC	Electronic speed controller
ESHOC	Electrical System Harmonic Offset Calibration Mode
EST	Electrical System Tuning Mode
FOC	Field-oriented control
GPIO	General Purpose Input/Output
LiPo	Lithium-ion polymer battery
NTC	Negative temperature coefficient thermistor (thermally-sensitive resistor)
OBD	Object Dictionary
PMSM	Permanent magnet synchronous motor
PVM	Profile Velocity Mode
SDO	Service Data Object
SLPD	Sensorless Position Detection
UAV	Unmanned aerial vehicle

Table 1-2 Abbreviations & acronyms used

1.1.4 Symbols and Signs

Requirement / Note / Remark
Indicates an action you must perform prior continuing or refers to information on a particular item.

Best Practice
Gives advice on the easiest and best way to proceed.

Material Damage
Points out information particular to potential damage of equipment.

1.1.5 Trademarks and Brand Names

For easier legibility, registered brand names are listed below and will not be further tagged with their respective trademark. It must be understood that the brands (the below list is not necessarily completely) are protected by copyright and/or other intellectual property rights even if their legal trademarks are omitted in the later course of this document.

Brand name	Trademark owner
CANopen® CiA®	© CiA CAN in Automation e.V, DE-Nuremberg
DroneCAN	by open source community «DroneCAN Development Team»

Table 1-3 Brand names and trademark owners

1.1.6 Sources for additional Information

uav.maxongroup.com

Find the latest edition of the present document and other information here:
➔https://uav.maxongroup.com/

If you should encounter any problems or if you have any questions, feel free to contact the maxon Support Center:
➔https://support.maxongroup.com/hc/en-us/

support.maxongroup.com

For further details and additional information, please refer to below listed sources:

#	Reference
[1]	USB Implementers Forum: Universal Serial Bus Revision 2.0 Specification www.usb.org/developers/docs
[2]	CiA 301 CANopen application layer and communication profile www.can-cia.org
[3]	CiA 306 CANopen electronic data sheet specification www.can-cia.org
[4]	CiA 402 CANopen device profile for drives and motion control www.can-cia.org
[5]	IEC 61158-x-12: Industrial communication networks – Fieldbus specifications (CPF 12)
[6]	IEC 61800-7: Adjustable speed electrical power drives systems (Profile type 1)
[7]	EN 5325-4 Industrial communications subsystem based on ISO 11898 (CAN) for controller device interfaces Part4: CANopen
[8]	DroneCAN protocol https://dronecan.github.io/

Table 1-4 Sources for additional information

1.1.7 Copyright

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1.2 About the Devices

maxon's «UAV-ESC Electronic Speed Controllers» are high-performance, sensorless, small-sized, fully digital, smart control units. They feature field oriented control (FOC) for brushless EC (BLDC) motors and drive systems without Hall sensors.

1.3 About the Safety Precautions

IMPORTANT NOTICE: PREREQUISITES FOR PERMISSION TO COMMENCE INSTALLATION

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WARNING

Risk of Injury
Operating the device without the full compliance of the surrounding system with the EU directive 2006/42/EC may cause serious injuries!

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- *Do not operate the device, unless all respective interfaces have been established and fulfill the stated requirements!*

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2 SYSTEM OVERVIEW

2.1 Device Control

The state machine describes the axis state and the possible control sequence of the axis. An axis state represents a special internal or external behavior. The state of the axis also determines the commands that will be accepted.

States may be changed using the ➔Controlword and/or according to internal events. The actual state can be read using the ➔Statusword. A new state transition must not be initiated before the previous one is completed and the ➔Statusword is changed accordingly.

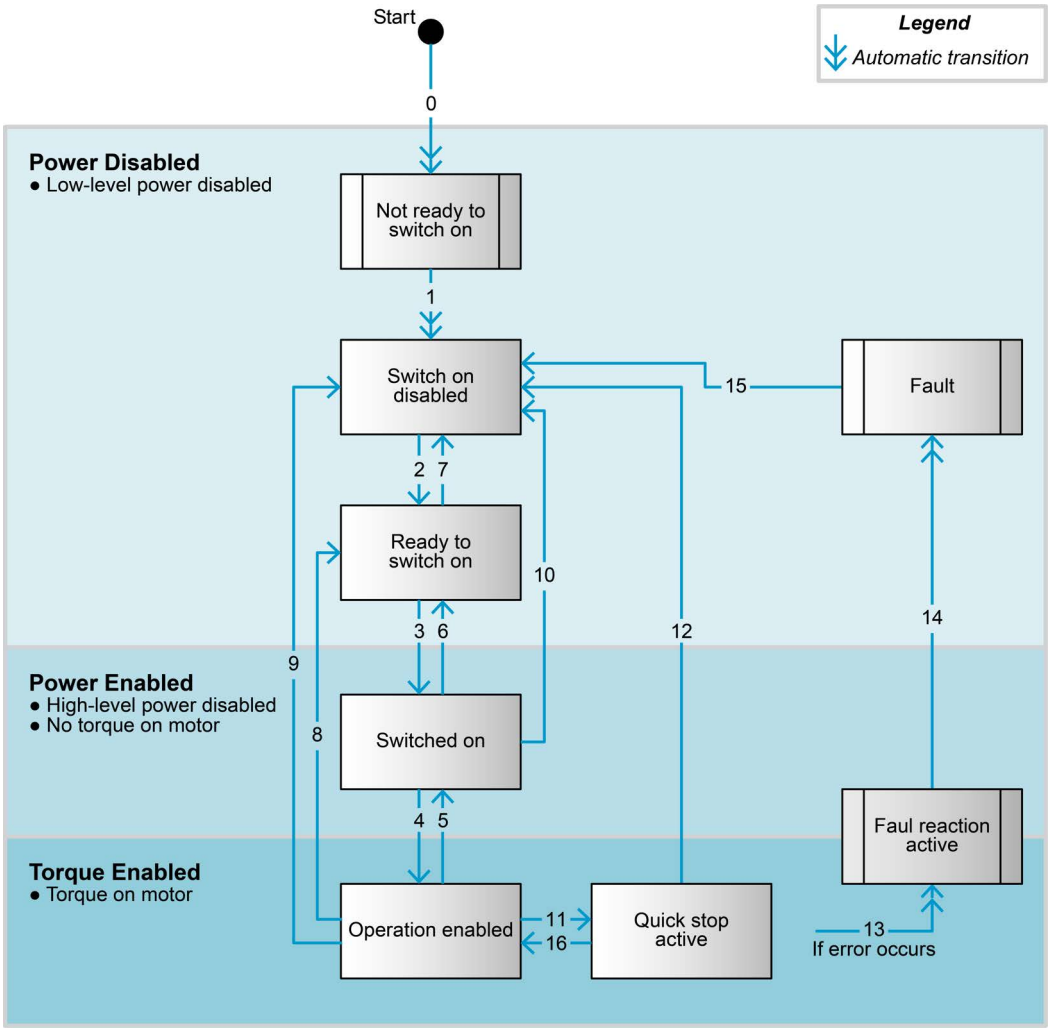


Figure 2-2 Device State Machine

2.1.1 State of the Drive

The following ➔Statusword bits indicate the actual state of the drive.

State	Statusword [binary]	Description
Not ready to switch on	xxxx xxxx x00x 0000	Drive function is disabled
Switch on disabled	xxxx xxxx x10x 0000	Drive initialization is complete. Drive parameters may be changed. Drive function is disabled.

State	Statusword [binary]	Description
Ready to switch on	xxxx xxxx x01x 0001	Drive parameters may be changed. Drive function is disabled.
Switched on	xxxx xxxx x01x 0011	Drive function is disabled. Current offset calibration done.
Operation enabled	xxxx xxxx x01x 0111	No faults have been detected. Drive function is enabled and power is applied to the motor.
Quick stop active	xxxx xxxx x00x 0111	«Quick stop» function is being executed. Drive function is enabled and power is applied to the motor.
Fault reaction active	xxxx xxxx x00x 1111	A fault has occurred in the drive. Selected fault reaction is being executed.
Fault	xxxx xxxx x00x 1000	A fault has occurred in the drive. Drive parameters may have changed. Drive function is disabled.

Table 2-5 Device state bits

2.1.2 State Transitions

State transitions are caused by internal events in the drive or by commands from the host via the ➔Control-word.

State transition during change of state

If a command is received which causes a change of state, this command will be processed completely and the new state attained before the next command can be processed.

Transition	Event	Action
0	Reset	Initialize drive
1	Drive has initialized successfully	Activate communication
2	«Shutdown» command received	
3	«Switched on» command received	Initialize current sensor. Current offset calibration.
4	«Enable operation» command received	Enable drive function (enable current controller and, if needed, position or velocity controller)
5	«Disable operation» command received	Stop movement according to «Disable operation option code». Disable drive function.
6	«Shutdown» command received	Disable power section
7	«Quick stop» or «Disable voltage» command received	
9	«Disable voltage» command received	Stop movement according to «Shutdown option code». Disable drive function and power section.
10	«Quick stop» or «Disable voltage» command received	
11	«Quick stop» command received	Stop movement according to «Quick stop option code»
12	«Disable voltage» command received	Disable drive function and power section
13	A fault has occurred	Start fault reaction

Transition	Event	Action
14	The fault reaction is completed or «Fault Reset» command received	Disable drive function and power section
15	«Fault reset» command received	Reset fault condition if no fault is present. Note that the ➔Error history is not cleared.
16	«Enable operation» command received	

Table 2-6 Device state transitions

2.1.3 Device Control Commands

Axis control commands are triggered by the following bit patterns in the ➔Controlword.

Command	LowByte of controlword [binary]	State transition
Shutdown	0xxx x110	2, 6, 8
Switch on	0xxx x111	3
Switch on & Enable operation	0xxx 1111	3, 4 [a]
Disable voltage	0xxx xx0x	7, 9, 10, 12
Quick stop	0xxx x01x	11
Disable operation	0xxx 0111	5
Enable operation	0xxx 1111	4, 16
Fault reset	0xxx xxxx → 1xxx xxxx	14, 15

[a] Automatic transition to state «Operation enabled» after execution of command «Switch on»

Table 2-7 Axis control commands

2.2 System Units

The units for the device are as follows:

- Velocity units are in revolutions/minute [rpm]
- Acceleration units are in revolutions/minute/second [rpm/s]

2.2.1 SI Units

Description	Name	Symbol	Notation index
Dimensionless	–	–	0x00
Length	Meter	m	0x01
Mass	Kilogram	kg	0x02
Time	Second	s	0x03
Electric current	Ampere	A	0x04
Time	Minute	min	0x47
Square second	Square second	s^2	0x57

Table 2-8 SI units – Notation index

2.2.2 CiA 402 Application Profile-specific Units

Description	Name	Symbol	Notation index
Revolutions	revolutions	rev	0xB4
Increments	increments	inc	0xB5
Steps	steps	steps	0xAC
Velocity (manufacturer-specific)	revolutions/minute	rpm	0xC0

Table 2-9 CiA 402 Application profile-specific units – Notation index

2.2.3 Unit Prefixes

Prefix	Factor	Symbol	Notation index
Mega	10^6	M	0x06
Kilo	10^3	k	0x03
Hecta	10^2	h	0x02
Deca	10^1	da	0x01
–	10^0	–	0x00
Deci	10^{-1}	d	0xFF
Centi	10^{-2}	c	0xFE
Milli	10^{-3}	m	0xFD
—	10^{-4}	—	0xFC
—	10^{-5}	—	0xFB
Micro	10^{-6}	µ	0xFA

Table 2-10 Unit prefixes – Notation index

2.3 USB Bus Powering

Powering the controller for configuration via USB only is not possible. To use a communication interface, the power supply must be connected.

3 OPERATING MODES

3.1 Operating Mode Selection Guide

The device behavior depends on the currently activated mode of operation.

- Choose desired mode (➔“Overview” on page 3-19).
- Select mode using (➔“Modes of operation” on page 7-96).
- Read currently active mode from ➔“Modes of operation display” on page 7-96.

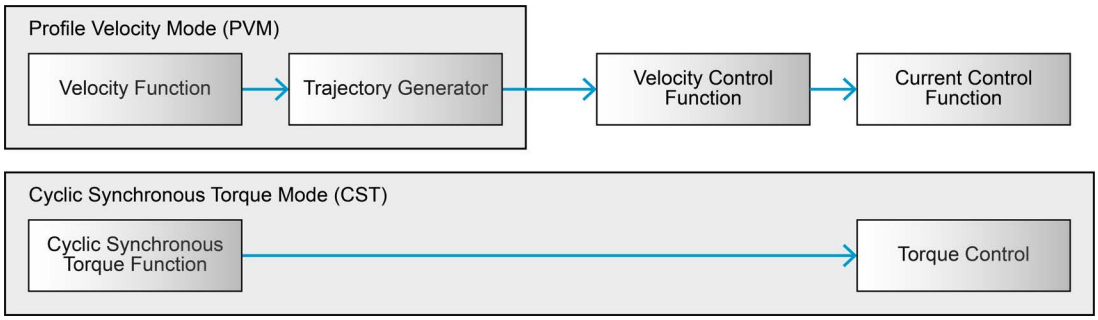


Figure 3-3 Functional architecture

3.2 Overview

PROFILE VELOCITY MODE (PVM)

Controls the drive's velocity. It supplies limit functions and Trajectory Generation (➔page 3-19).

CYCLIC SYNCHRONOUS TORQUE MODE (CST)

The trajectory generator is located in the control device (not in the drive device). In cyclic synchronous manner, it provides a target torque to the drive device, which then performs torque control (➔page 3-21).

3.3 Profile Velocity Mode (PVM)

The «Profile Velocity Mode» includes a velocity trajectory generator and a velocity control function.

Annotation

Items marked with an asterisk (*) refer to internal values.

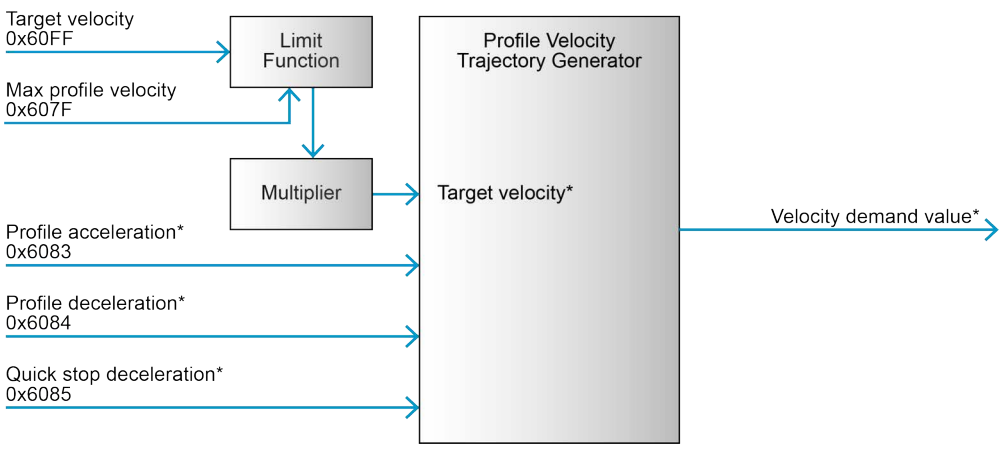


Figure 3-4 PVM – Block diagram

3.3.1 Profile Velocity Trajectory Generator

The trajectory generator supports the following motion profiles.

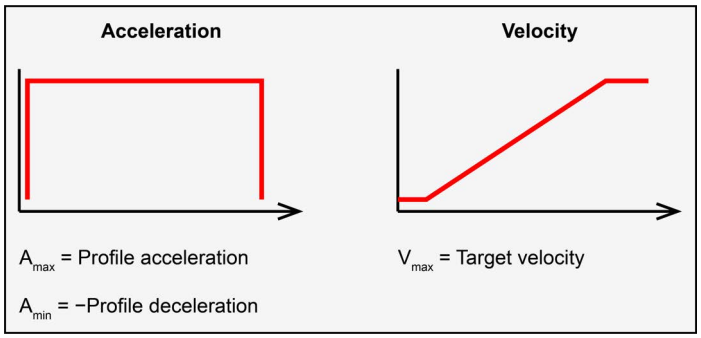


Figure 3-5 Profile velocity trajectory – Linear ramp (trapezoidal profile)

3.3.2 How to use «PVM»

CONFIGURATION PARAMETERS

Parameter	Index	Description
➔Max profile velocity	0x607F	Defines the maximum permitted speed
➔Max motor speed	0x6080	Indicates the configured maximum permitted speed for the motor. It serves as protection of the motor and is taken from the motor data sheet.
➔Quick stop deceleration	0x6085	Defines the deceleration ramp during a «Quick stop»
➔Max acceleration	0x60C5	Defines the maximum allowed acceleration and deceleration

Table 3-11 PVM – Configuration parameters

COMMANDING PARAMETERS

Parameter	Index	Description
➔Controlword	0x6040	The mode will be controlled by a write access to the controlword's mode-dependent bits. A new target velocity is not assumed before the controlword is written.
➔Target velocity	0x60FF	The speed that the drive is supposed to reach
➔Profile acceleration	0x6083	Defines the acceleration ramp during a movement
➔Profile deceleration	0x6084	Defines the deceleration ramp during a movement
➔Motion profile type	0x6086	Selects the type of motion profile used for the movement: 0 = linear ramp (trapezoidal profile)

Table 3-12 PVM – Commanding parameters

CONTROLWORD (PVM-SPECIFIC BITS)

Bit 15…9	Bit 8	Bit 7	Bit 6…4	Bit 3…0
➔Table 7-55	Halt	➔Table 7-55	reserved	➔Table 7-55

Table 3-13 PVM – Controlword

Name	Value	Description
Halt	0	Execute or continue motion
	1	Stop axis

Table 3-14 PVM – Controlword bits

OUTPUT PARAMETERS

Parameter	Index	Description
➔Statusword	0x6041	Mode state can be observed by the statusword bits
➔Velocity demand value	0x606B	The output of the trajectory generator. It is used as input for the velocity control function.

Table 3-15 PVM – Output parameters

STATUSWORD (PVM-SPECIFIC BITS)

Bit 15, 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9…0
➔Table 7-56	Not used	Speed	➔Table 7-56	Target reached	➔Table 7-56

Table 3-16 PVM – Statusword

Name	Value	Description
Target reached	0	Halt = 0: Target velocity not (yet) reached Halt = 1: Axis decelerates
	1	Halt = 0: Target velocity reached Halt = 1: Axis has velocity “0” (zero)
Speed	0	Speed is not equal “0” (zero)
	1	Speed is equal “0” (zero)

Table 3-17 PVM – Statusword bits

3.4 Cyclic Synchronous Torque Mode (CST)

With «Cyclic Synchronous Torque Mode», the trajectory generator is located in the control device (not in the drive device). It provides a target torque to the drive device in cyclic synchronous manner, thus the drive performs torque control.

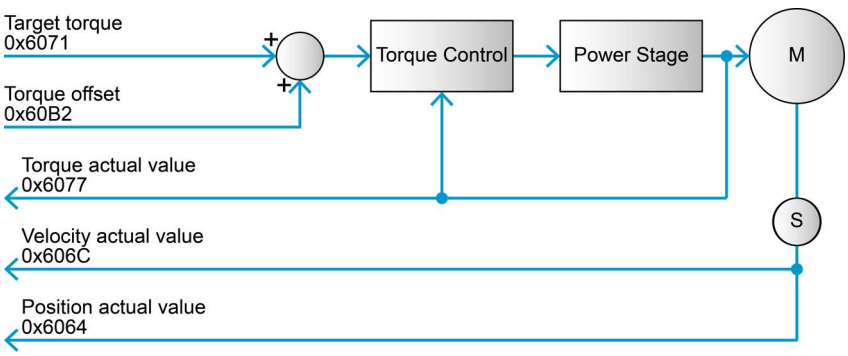


Figure 3-6 CST – Overview

CST is based on the current control function. The inputs are ➔Target torque and (optionally) ➔Torque offset. The input ➔Motor data is used to define limitations for velocity and current values. Actual values for position, velocity, and torque are used as output to the control device.

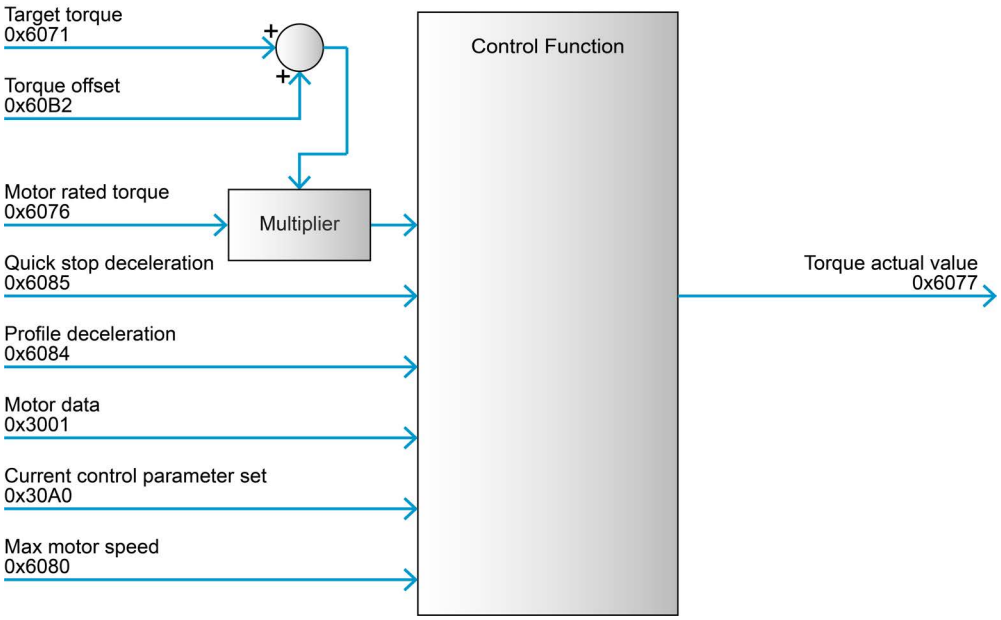


Figure 3-7 CST – Block diagram

3.4.1 How to use «CST»

CONFIGURATION PARAMETERS

Parameter	Index	Description
Nominal current (➔Motor data)	0x3001	The maximum permissible continuous current of the motor
Motor torque constant (➔Motor data)	0x3001	The torque constant of the motor
➔Max motor speed	0x6080	Indicates the configured maximum allowed speed for the motor. It serves as protection for the motor and is taken from the motor data sheet.
➔Current control parameter set	0x30A0	Configuration of the current controller gains
➔Quick stop deceleration	0x6085	Defines the deceleration for the quick stop ramp
➔Profile deceleration	0x6084	Defines the deceleration for the slowdown ramp
➔Motor rated torque	0x6076	Reference value for all torque related objects.

Table 3-18 CST – Configuration parameters

COMMANDING PARAMETERS

Parameter	Index	Description
➔Target torque	0x6071	Torque input value for the torque controller
➔Torque offset	0x60B2	Optional torque offset which is added to the target torque value

Table 3-19 CST – Commanding parameters

CONTROLWORD

CST does not use mode-specific control word bits.

OUTPUT PARAMETERS

Parameter	Index	Description
➔Torque actual value	0x6077	Actual motor torque value
➔Velocity actual value	0x606C	Actual velocity value
➔Current demand value	0x30D0	Holds the set value for the current controller
➔Current actual values	0x30D1	The averaged and the actual current value

Table 3-20 CST – Output parameters

STATUSWORD (CST-SPECIFIC BITS)

Bit 15, 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9…0
➔Table 7-56	reserved	drive follows command value	➔Table 7-56	reserved	➔Table 7-56

Table 3-21 CST – Statusword

Name	Value	Description
drive follows command value	0	Drive does not follow the target value
	1	Drive is in state operation enabled and follows the target and setpoint values of the control device

Table 3-22 CST – Statusword bits

3.5 Velocity Control Function

Used for velocity-based modes, such as «Profile Velocity Mode».

The control loop is fed with the «Velocity demand value» and «Position actual value» (the output of the position detection unit) like an encoder as input parameters. The behavior of the control may be influenced by externally applicable control parameters. The output of the controller is a current demand value, which serves as input for the current controller.

Annotation

Items marked with an asterisk (*) refer to internal values.

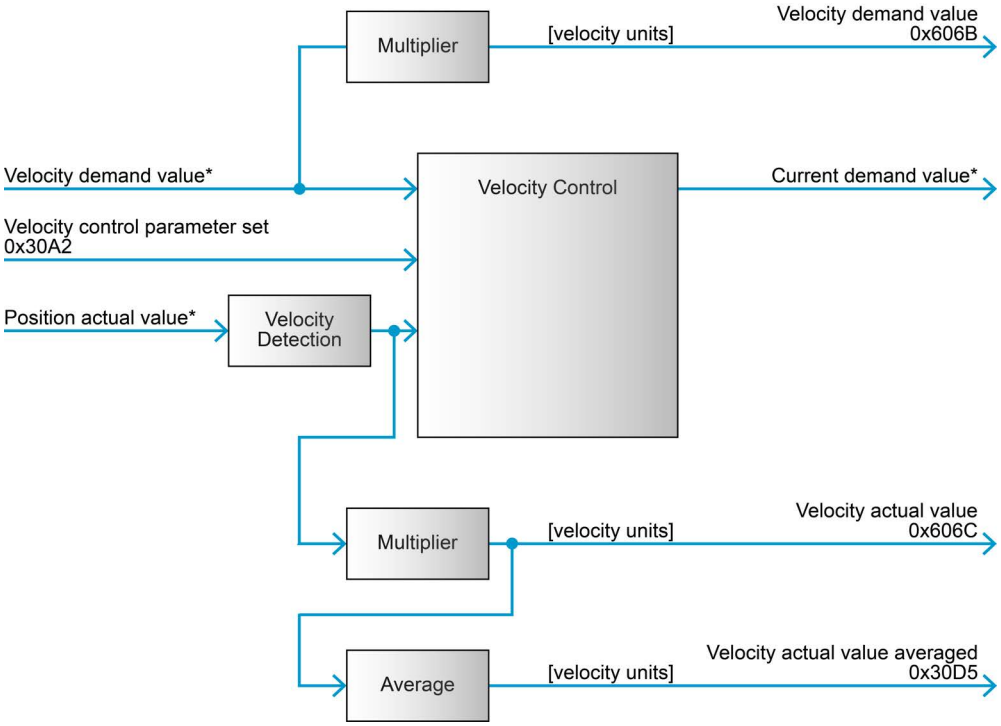


Figure 3-8 Velocity Control Function – Block diagram

3.5.1 How to use «Velocity Control Function»

CONFIGURATION PARAMETERS

Parameter	Index	Description
➔Velocity control parameter set	0x30A2	Configuration of the velocity controller gains

Table 3-23 Velocity Control Function – Configuration parameters

COMMANDING PARAMETERS

There are no commanding parameters. The Velocity Control Function is directly commanded by velocity-based operating modes (such as Profile Velocity Mode).

OUTPUT PARAMETERS

Parameter	Index	Description
➔Velocity demand value	0x606B	The operation mode's output. It is used as input for the velocity control function. Generally, the value is the output of the trajectory generator.
➔Velocity actual value	0x606C	The actual velocity value
➔Velocity actual value averaged	0x30D5	The averaged actual velocity value

Table 3-24 Velocity Control Function – Output Parameters

3.6 Current Control Function

All operating modes are based on the current control function. The «Current demand value» is received from the velocity controller.

Annotation
Items marked with an asterisk (*) refer to internal values.

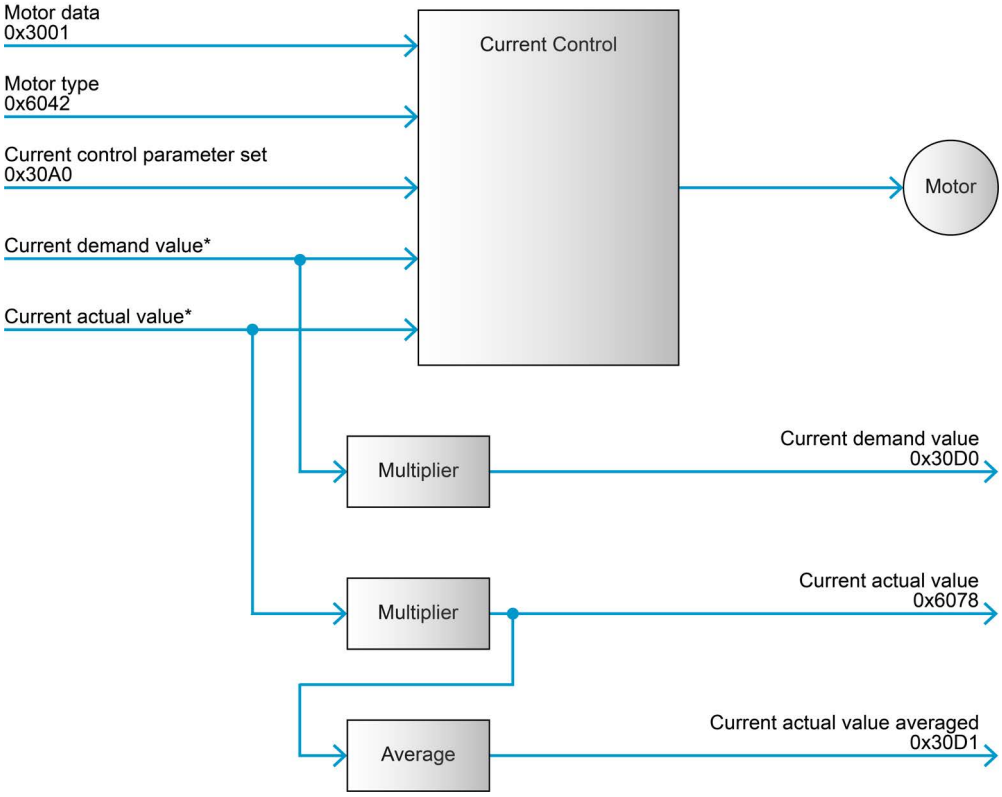


Figure 3-9 Current Control Function – Block diagram

3.6.1 How to use «Current Control Function»

CONFIGURATION PARAMETERS

Parameter	Index	Description
➔Current control parameter set	0x30A0	Configuration of the current controller gains
➔Motor data	0x3001	Used for configuration of motor-dependent parameters

Table 3-25 Current Control Function – Configuration parameters

COMMANDING PARAMETERS

There are no commanding parameters. The Current Control Function is commanded by the control loop «Velocity control function» or directly by operating mode «Cyclic Synchronous Torque Mode».

OUTPUT PARAMETERS

Parameter	Index	Description
➔Current demand value	0x30D0	Set value for current controller
➔Current actual values	0x30D1	The averaged and actual current value

Table 3-26 Current Control Function – Output parameters

3.6.2 Output Current Limitation according to analog input «Motor winding temperature»

With properly setup ➔Motor data and ➔Thermal overload protection, the device will limit the output current according to analog input «Motor winding temperature» with parameters «Nominal current», «Output current limit», «Maximum temperature motor» and «Derating temperature motor».

The current derating principle based on the «Maximum temperature motor» is depicted in ➔Figure 7-19.

3.6.3 Output Current Limitation according to I²t Method

If the analog input «Motor winding temperature» is not used, the ouput current can be limited according to I²t method. With properly setup ➔Motor data, the device will limit the output current according to I2t method with the parameters «Nominal current», «Output current limit», and «Thermal time constant winding». The I2t method assumes an ambient temperature of 25 °C. If this condition is not fulfilled, the output current must be reduced by adjusting the above mentioned parameters to the actual ambient temperature.

The motor winding temperature is calculated as follows:

$$\vartheta = P_V \cdot R_{th} \cdot \left(1 - e^{-\frac{t}{\tau_{th}}}\right) + \vartheta_a \cdot e^{-\frac{t}{\tau_{th}}}$$

ϑ calculated actual winding temperature

P_V thermal dissipation loss

R_{th} thermal resistance

ϑ_a temperature at beginning of measuring period

τ_{th} thermal time constant winding

Use the scale to determine the time during which the device can source a current (➔Figure 3-10).

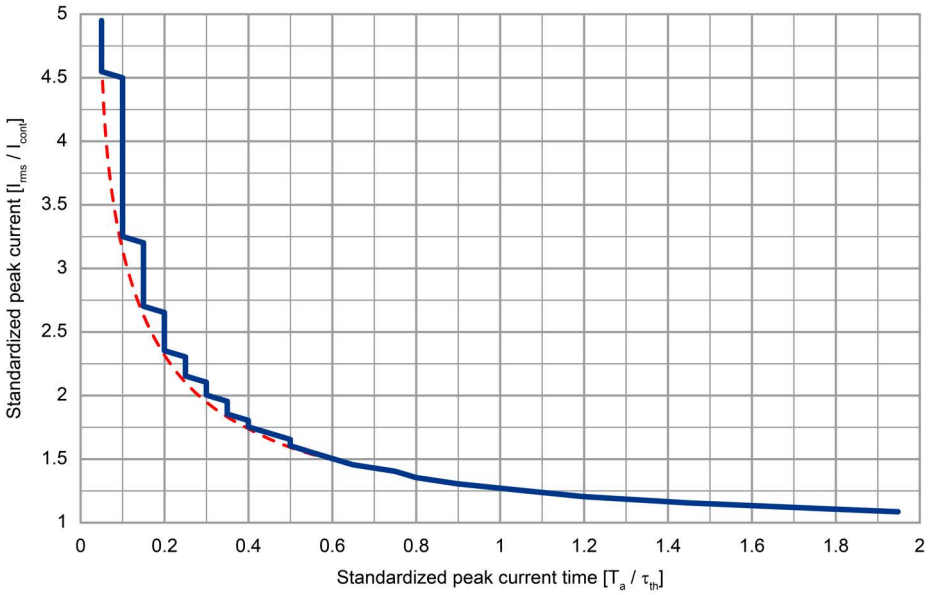


Figure 3-10 Standardized peak current vs. standardized peak current time

EXAMPLE:

Given configuration (for details ➔"Motor data" on page 7-60):

- Current limit: 1470 mA
- Output current limit: 2940 mA
- Thermal time constant winding [τ_{th}]: 2.8

At acceleration time [T_a], the motor needs a higher acceleration current [I_a]. The UAV-ESC's current limiting method according to I2t fulfills this need.

For how long (max.) does the device source the higher acceleration current [I_a] = 2940 mA?

- Standardized peak current = 2940 mA / 1470 mA = 2
- Standardized peak current time > 0.3
- The resulting acceleration time T_P = 0.3 · thermal time constant winding = 0.3 · 2.8 s = 840 ms.

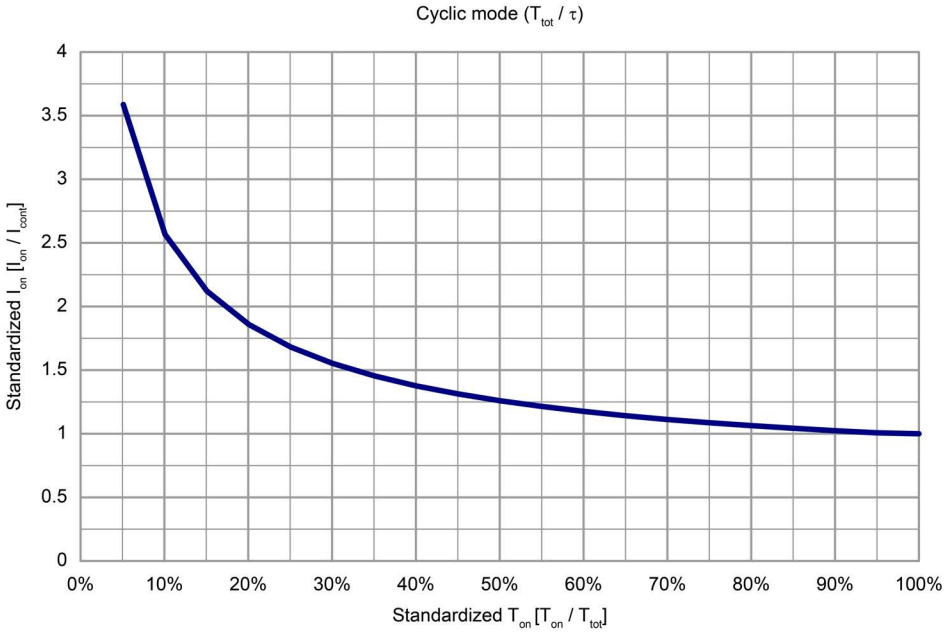


Figure 3-11 Cyclic mode standardized vs. standardized “ON time”

- standardized T_{on} ratio of “ON time” vs. total time
- standardized I_{on} current at “ON time” standardized with «Continuous current limit»

EXAMPLE:

Given configuration (for details ➔“Motor data” on page 7-60):

- Application in “cyclic mode” – the current is switched on/off every 2.8 s.
- Thermal time constant winding: 2.8 s
- Continuous current limit: 1470 mA

For the “ON time” of 280 ms (10%), a standardized output current of 2.6 is possible. Therefore, the possible output current I_{on} = 2.6 · Continuous current limit = 2.6 · 1470 mA = 3822 mA.

4 INPUTS AND OUTPUTS

4.1 Digital Inputs

Available are predefined functions and general purpose inputs for process control. Number and assignment of the inputs are hardware-dependent (for details ➔separate document «User Manual» of respective controller).

Configuration of the digital input functions is done with ➔“Configuration of digital inputs” on page 7-81, the polarity is set with ➔“Digital input properties” on page 7-80.

The input logic state is read with ➔“Digital input properties” on page 7-80 while the functionality state is read with ➔“Digital inputs” on page 7-103.

DigIn1 is not available with «UAV-ESC 52/30 CAN».

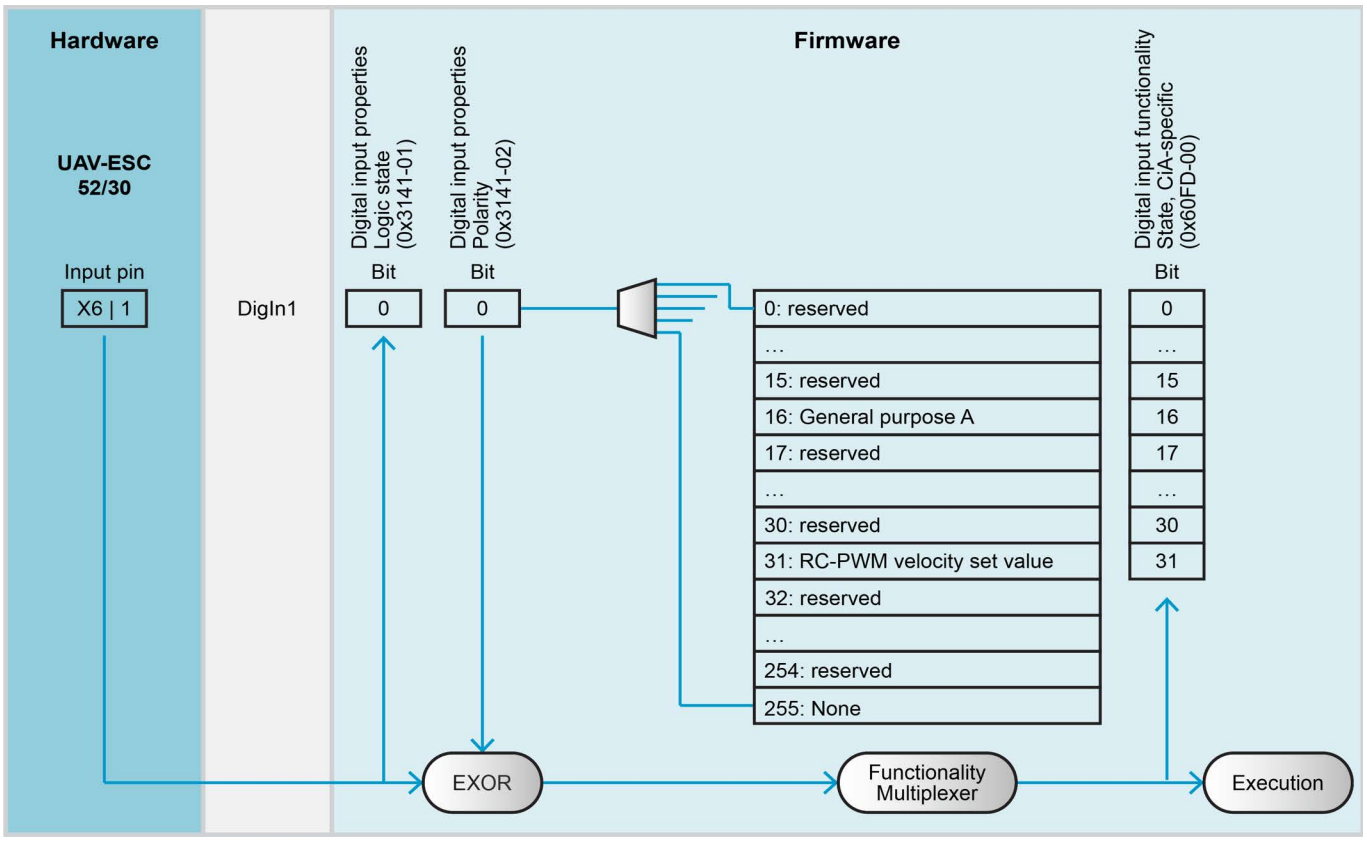


Figure 4-12 Digital input functionality – UAV-ESC 52/30

DIGITAL INPUT TIMING BEHAVIOR

- **Hardware**
  For details on voltage levels and switching delays ➔separate document «User Manual» of respective controller.
- **Software filter**
  The digital inputs are filtered to suppress spikes. The filter has a length of 1 ms. Therefore, to detect a state change (edge), the input level must be stable for more than 1 ms.
- **Update rates**
  The digital input functionality states (➔Digital inputs) and the ➔Digital input properties are updated at 1 kHz.

4.2 Digital Outputs

Available are predefined functions and general purpose outputs for process control. Number and assignment of the outputs are hardware-dependent (for details ➔separate document «User Manual» of respective controller).

Configuration of the digital output functions is done with ➔“Configuration of digital outputs” on page 7-86, the polarity is set with ➔“Digital output properties” on page 7-85.

The functionality state can be set with ➔“Digital outputs” on page 7-104, the logic state of the corresponding pin can be read with ➔“Digital output properties” on page 7-85.

DigOut1 is not available with «UAV-ESC 52/30 CAN».

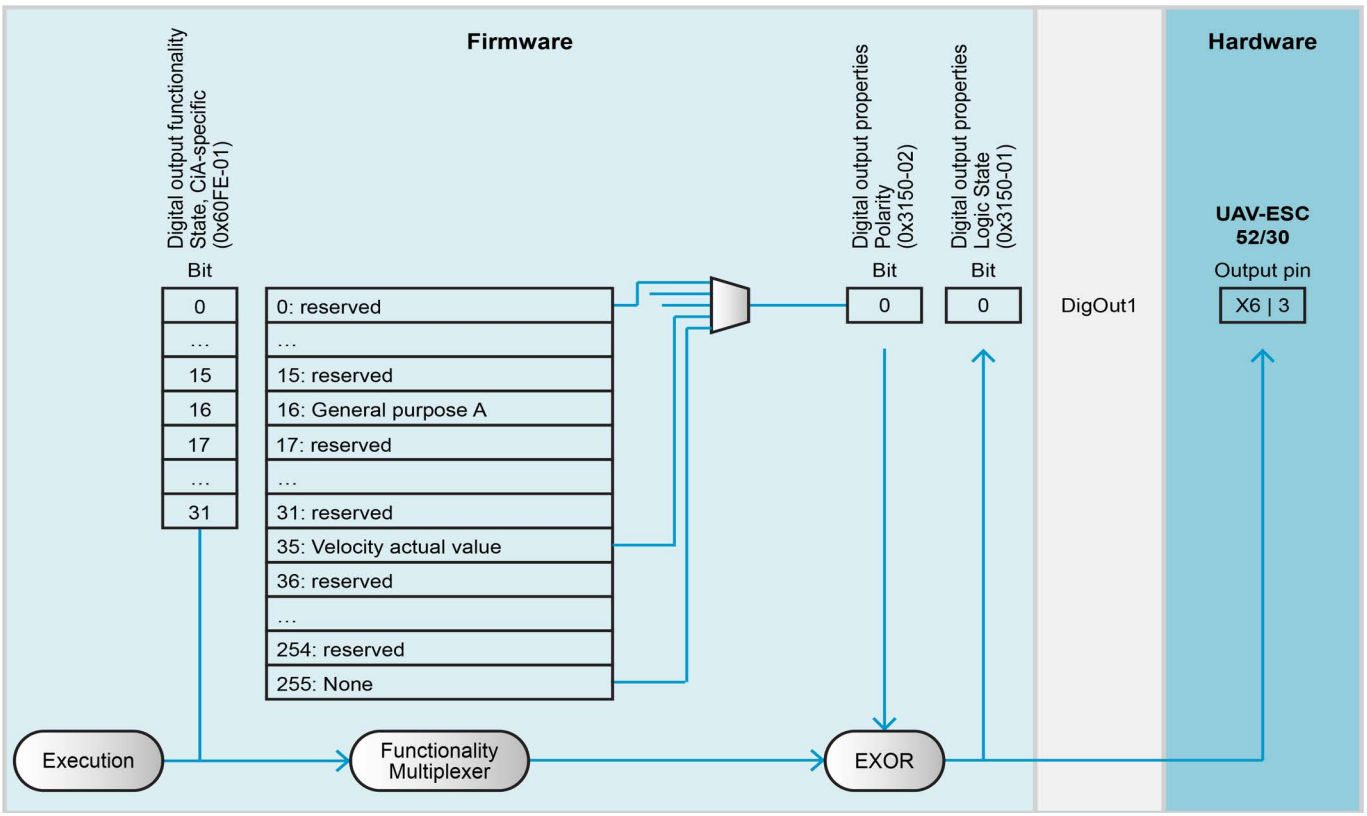


Figure 4-13 Digital output functionality – UAV-ESC 52/30

DIGITAL OUTPUT TIMING BEHAVIOR

- **Hardware**
  For details on voltage levels and switching delays ➔separate document «User Manual» of respective controller.
- **Update rates**
  Digital outputs (➔Digital outputs) are updated when the object is written, no update rate applies. The same applies for the logic state (➔Digital output properties).

5 SENSORLESS SYNCHRONOUS STARTUP

The UAV-ESC provides Sensorless position detection with the Back EMF only Position Detection (BOPD) method.

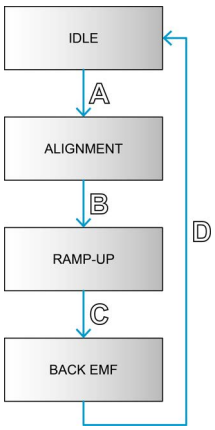
The BOPD identifies the actual velocity only above a certain minimum velocity. Therefore, a synchronous startup phase is needed when using BOPD.

Synchronous startup is **always active in BOPD**. It is active in both modes PVM and CST.

During the synchronous startup phase, the parameters of the object ➔Synchronous startup parameter set are in use.

If the direction of rotation is changed, the velocity decreases until the ➔Transition lower threshold is reached. Then the rotation in the opposite direction is started immediately with a new alignment phase.

5.1 Synchronous Startup States



State / Transition	Description
Idle	The drive is enabled, current is controlled to “0” (zero)
“A”	Set target velocity or target torque
Alignment	The rotor rapidly accelerates to the configured alignment angle, transient oscillation
“B”	Alignment time expired
Ramp-up	The rotor accelerates with synchronous open loop control
“C”	Back EMF magnitude is sufficient
Back EMF	As soon as the Back EMF observer magnitude allows the measurement of the actual velocity, the drive is switched to Back EMF state. In this state, “normal” closed loop control is possible. If the velocity – and along with it the Back EMF observer magnitude – falls below a certain limit, the actual velocity can no longer be identified and the drive switches back to Idle state.
“D”	Set target velocity or target torque to “0” (zero)

Table 5-27 Synchronous startup states

5.2 Parameters

CONFIGURATION PARAMETERS

Parameter	Index	Description
➔Synchronous startup parameter set	0x30AF	Defines the behavior of the synchronous startup
➔Current control parameter set	0x30A0	Current controller gains
➔Velocity control parameter set	0x30A2	Velocity controller gains (Parameter Set 1 is used only)
➔Back EMF observer parameter set	0x30A5	Back EMF Observer Parameters
➔Angle fusion parameter set	0x30A9 0x07…0x0C	Back EMF Observer Parameters

Table 5-28 Synchronous startup – Configuration parameters

COMMANDING PARAMETERS & OUTPUT PARAMETERS

Synchronous startup is active in ➔“Profile Velocity Mode (PVM)” on page 3-19 and ➔“Cyclic Synchronous Torque Mode (CST)” on page 3-21.

5.2.1 Behavior of Operation Mode-specific Status Bits

The behavior of the status bits is similar to the normal startup. The target reached bit is set during synchronous startup Idle state, even though no closed loop control is possible at this stage.

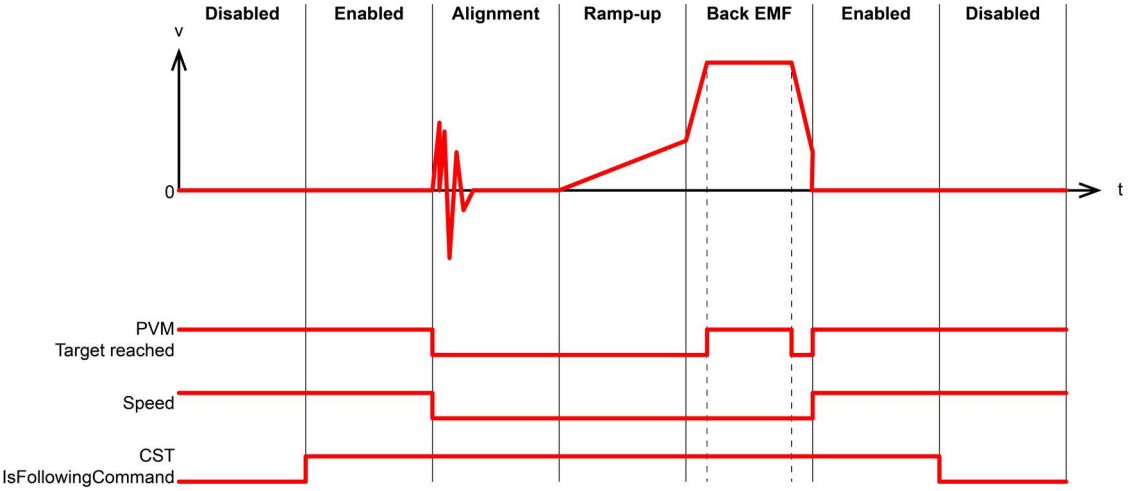


Table 5-29 Behavior of operation mode-specific status bits

5.2.2 Actual and Demand Values

The BOPD position and velocity actual values are displayed in BEMF state only. In other states 0 is displayed, because the actual position is not known.

The velocity demand value also shows the startup ramp (even though open loop control is used in this state). The movement within the alignment phase is not displayed because it is not known

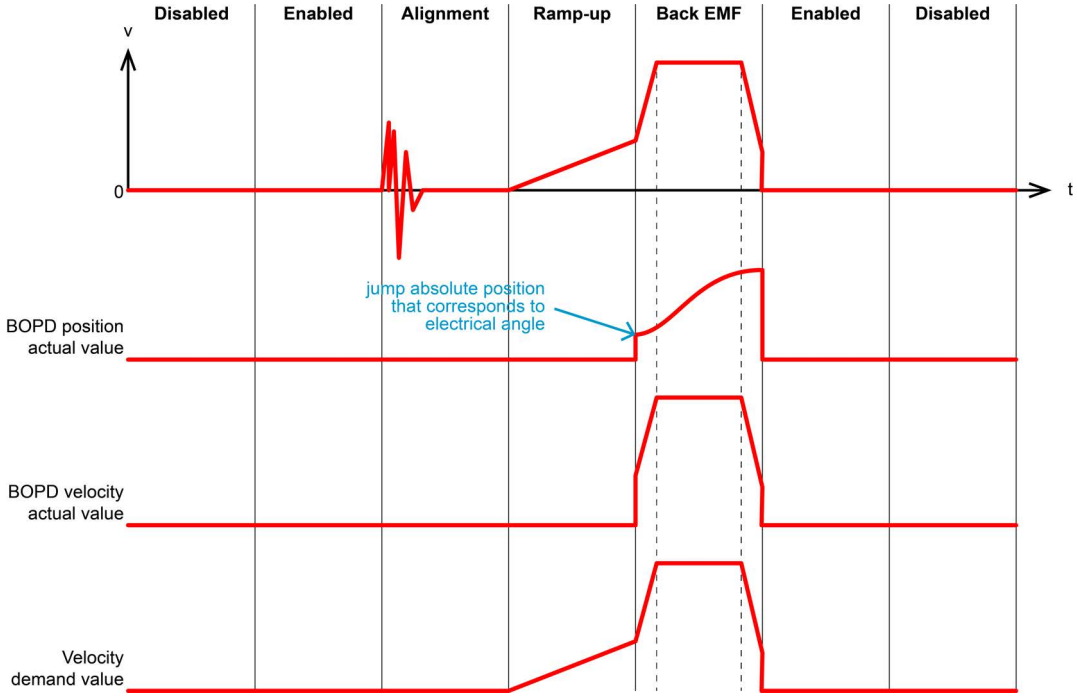


Table 5-30 Actual and demand values

5.2.3 Errors

For details see ➔“Stall detection error during synchronous startup” on page 8-117 and ➔“Stall detection error during operation” on page 8-117.

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6 COMMUNICATION

The device supports communication profiles for USB amd CANopen. You can find detailed information on the subject in the separate document ➔«UAV-ESC Communication Guide». For sources of supply see ➔chapter “1.1.6 Sources for additional Information” on page 1-11.

6.1 USB Communication

The device’s USB interface follows the «Universal Serial Bus Specification Revision 2.0».

The device always communicates as a slave and uses the «maxon Serial V2» protocol.

Find details here:
➔«UAV-ESC Communication Guide», chapter “2 USB Communication”

6.2 CAN Communication

The UAV-ESC’s CAN interface follows the CiA CANopen specifications:

- CiA 301 V4.2; CANopen application layer and communication profile
- CiA 306 V1.3; CANopen electronic data sheet specification
- CiA 402 V4.0; CANopen drives and motion control device profile

Find details here:
➔«UAV-ESC Communication Guide», chapter “3 CAN Communication”

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7 OBJECT DICTIONARY (OBD)

7.1 Overview

7.1.1 Object Data types

Index	Name	Base type	Description	Size [Bits]	Range
0x0001	BOOLEAN	BOOL	False/True	1	0.1
0x0002	INTEGER8	SINT	Short Integer	8	$-2^7 \ldots 2^7-1$
0x0003	INTEGER16	INT	Integer	16	$-2^{15} \ldots 2^{15}-1$
0x0004	INTEGER32	DINT	Double Integer	32	$-2^{31} \ldots 2^{31}-1$
0x0015	INTEGER64	LINT	Long Integer	64	$-2^{63} \ldots 2^{63}-1$
0x0005	UNSIGNED8	USINT	Unsigned Short Integer	8	$0 \ldots 2^8-1$
0x0006	UNSIGNED16	UINT	Unsigned Integer	16	$0 \ldots 2^{16}-1$
0x0007	UNSIGNED32	UDINT	Unsigned Double Integer	32	$0 \ldots 2^{32}-1$
0x001B	UNSIGNED64	ULINT	Unsigned Long Integer	64	$0 \ldots 2^{64}-1$
0x0009	VISIBLE_STRING	STRING(n)	Visible String (1 octet per character)	8*n	–
0x000A	OCTET_STRING	ARRAY[0…n] of USINT	Sequence of octets (data type USINT)	8*(n+1)	–
0x0021	PDO_MAPPING	–	PDO Mapping Parameter Record	–	–
0x0023	IDENTITY	–	Identity Parameter Record	–	–

Table 7-31 Object data types

7.1.2 Object Codes

Object code	Object name
0x0007	VAR
0x0008	ARRAY
0x0009	RECORD

Table 7-32 Object codes

7.1.3 Object Access Types

Access type	Description
RW	read and write access
RO	read only access
WO	write only access
CONST	read only access value is constant

Table 7-33 Object access types

7.1.4 Object Flags

Flag	Code	Description
Backup	YES/NO	Entry can be stored/not stored in non-volatile memory

Table 7-34 Object flags

7.2 Entries Overview

Index	Name	Object code
0x1000	➔Device type	VAR
0x1001	➔Error register	VAR
0x1003	➔Error history	ARRAY
0x1008	➔Manufacturer device name	VAR
0x1010	➔Store parameters	ARRAY
0x1011	➔Restore default parameters	ARRAY
0x1018	➔Identity object	RECORD
0x2000	➔Node-ID	VAR
0x2001	➔CAN bit rate	VAR
0x2006	➔USB frame timeout	VAR
0x200A	➔CAN bit rate display	VAR
0x2020	➔ESC index	VAR
0x2021	➔Node status configuration	ARRAY
0x2022	➔ESC status configuration	ARRAY
0x2024	➔Raw command configuration	ARRAY
0x2025	➔RPM command configuration	ARRAY
0x2040	➔Error behavior	ARRAY
0x2200	➔Power supply	RECORD
0x2201	➔Power supply supervision	ARRAY
0x3000	➔Axis configuration	RECORD
0x3001	➔Motor data	RECORD
0x3002	➔Electrical system parameters	RECORD
0x30A0	➔Current control parameter set	RECORD
0x30A2	➔Velocity control parameter set	RECORD
0x30A5	➔Back EMF observer parameter set	RECORD
0x30A9	➔Angle fusion parameter set	RECORD
0x30AF	➔Synchronous startup parameter set	RECORD
0x30D0	➔Current demand value	VAR
0x30D1	➔Current actual values	ARRAY
0x30D2	➔Torque actual values	ARRAY
0x30D3	➔Velocity actual values	ARRAY
0x30F0	➔Set value command	ARRAY
0x3141	➔Digital input properties	ARRAY
0x3142	➔Configuration of digital inputs	ARRAY
0x3148	➔RC-PWM input set value properties	RECORD

Continued on next page.

Index	Name	Object code
0x3150	➔Digital output properties	ARRAY
0x3151	➔Configuration of digital outputs	ARRAY
0x3157	➔Digital output velocity actual value properties	ARRAY
0x3200	➔Motor protection	RECORD
0x3201	➔Thermal overload protection	RECORD
0x3203	➔Motor control	RECORD
0x603F	➔Error code	VAR
0x6040	➔Controlword	VAR
0x6041	➔Statusword	VAR
0x6060	➔Modes of operation	VAR
0x6061	➔Modes of operation display	VAR
0x606B	➔Velocity demand value	VAR
0x606C	➔Velocity actual value	VAR
0x6071	➔Target torque	VAR
0x6076	➔Motor rated torque	VAR
0x6077	➔Torque actual value	VAR
0x607F	➔Max profile velocity	VAR
0x6080	➔Max motor speed	VAR
0x6083	➔Profile acceleration	VAR
0x6084	➔Profile deceleration	VAR
0x6085	➔Quick stop deceleration	VAR
0x6086	➔Motion profile type	VAR
0x60A9	➔SI unit velocity	VAR
0x60AA	➔SI unit acceleration	VAR
0x60B2	➔Torque offset	VAR
0x60C5	➔Max acceleration	VAR
0x60FD	➔Digital inputs	VAR
0x60FE	➔Digital outputs	ARRAY
0x60FF	➔Target velocity	VAR
0x6502	➔Supported drive modes	VAR

Table 7-35 OBD – Object overview

7.3 Objects

Annotation
Items marked with an asterisk (*) refer to internal values.

7.3.1 Device type

Describes the device type. The lower word stands for the supported device profile number. The value 0x0192 (402) means that the device follows CiA 402 “CANopen device profile for drives and motion control”. The higher word holds information on the drive type. The value 0x0002 means that the drive is a servo drive.

Name	Device type	
Index	0x1000	
Subindex	0x00	
Data type	UNSIGNED32	
Access type	RO	
Default value	0x00020192	
Value range	–	–
Backup	NO	

7.3.2 Error register

The error register for the device. The device maps internal errors into this byte.

Name	Error register	
Index	0x1001	
Subindex	0x00	
Data type	UNSIGNED8	
Access type	RO	
Default value	0	
Value range	–	–
Backup	NO	

Bit	Description
7	Manufacturer-specific
6	reserved (always 0; zero)
5	Device profile-specific
4	Communication error
3	Temperature error
2	Voltage error
1	Current error
0	Generic error

Table 7-36 Error register bits

7.3.3 Error history

Holds errors that have occurred on the device ➔ chapter “8 Error Handling” on page 8-107.

Name	Error history
Index	0x1003
Object code	ARRAY
Highest subindex supported	5

7.3.3.1 Number of errors

Contains the number of actual errors that are recorded in the array starting at subindex 1. Writing a “0” (zero) deletes the error history (empties the array).

Name	Number of errors	
Index	0x1003	
Subindex	0x00	
Data type	UNSIGNED8	
Access type	RW	
Default value	0	
Value range	0	5
Backup	NO	

7.3.3.2 Error history

Every new error code is stored at subindex 1, earlier error codes move down the list. The error numbers are comprised of a 16-bit error code and 16-bit additional error information. In the case of additional information, the most significant bit is set in the event of a warning.

Names	Error history 1 Error history 2 Error history 3 Error history 4 Error history 5	
Index	0x1003	
Subindex	0x01…0x05	
Data type	UNSIGNED32	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.4 Manufacturer device name

Holds the manufacturer device name.

Name	Manufacturer device name	
Index	0x1008	
Subindex	0x00	
Data type	VISIBLE_STRING	
Access type	RO	
Default value	UAV-ESC	
Value range	–	–
Backup	NO	

7.3.5 Store parameters

Controls saving of configuration parameters in a non-volatile memory.

Name	Store parameters
Index	0x1010
Object code	ARRAY
Highest subindex supported	1

In order to avoid storage of parameters by mistake, storage will only be executed when a specific signature is written to the respective subindex.

BYTE	**MSB**			**LSB**
Character	'e'	'v'	'a'	's'
Hex value	0x65	0x76	0x61	0x73

Table 7-37 Store parameters signature

On read access to the appropriate subindex, the value provides information on its storage functionality (for format ➔Table 7-38).

On read access, the device will always return the value 0x00000001 since the device can only store the parameters on command.

Bit	**Value**	**Description**
31…2	X	reserved
1 (auto)	1	The device saves parameters autonomously
	0	The device does not save parameters autonomously
0 (cmd)	1	The device saves parameters on command
	0	The device does not save parameters on command

Table 7-38 Store parameters state

7.3.5.1 Save all parameters

All controller parameters will be stored in a non-volatile memory if the code “save” is written to the object.

Name	Save all parameters
Index	0x1010
Subindex	0x01
Data type	UNSIGNED32
Access type	RW
Default value	0x00000001
Value range	write access ➔Table 7-37 read access ➔Table 7-38
Backup	NO

7.3.6 Restore default parameters

Configuration parameters are restored to the default values.

Restoring the default parameters is permitted in NMT state «Pre-Operational» and device state «Power Disable», only. The default values are only set valid after the device is reset or power cycled.

Name	Restore default parameters
Index	0x1011
Object code	ARRAY
Highest subindex supported	4

In order to avoid restoring of default parameters by mistake, restoring will only be executed when a specific signature is written to the respective subindex.

BYTE	MSB			LSB
Character	‘d’	‘a’	‘o’	‘l’
Hex value	0x64	0x61	0x6F	0x6C

Table 7-39 Restore default parameters signature

On read access to the appropriate subindex, the value provides information on its storage functionality (for format ➔Table 7-40).

On read access, the device will always return the value 0x00000001 since the device can only restore the parameters on command.

Bit	Value	Description
31…1	X	reserved
0 (cmd)	1	The device restores parameters on command
	0	The device does not restore parameters on command

Table 7-40 Store default parameters state

7.3.6.1 Restore all default parameters

All controller parameters will be restored to default values in a non-volatile memory if the code “load” is written to the object. Only permitted if all axes of the controller are in device state «Power Disable».

Name	Restore all default parameters
Index	0x1011
Subindex	0x01
Data type	UNSIGNED32
Access type	RW
Default value	0x00000001
Value range	write access ➔Table 7-39 read access ➔Table 7-40
Backup	NO

7.3.7 Identity object

Provides general identification information on the device.

Name	Identity object
Index	0x1018
Object code	RECORD
Highest subindex supported	4

7.3.7.1 Vendor-ID

Unique “maxon motor ag” vendor identification defined by CiA.

Name	Vendor-ID	
Index	0x1018	
Subindex	0x01	
Data type	UNSIGNED32	
Access type	RO	
Default value	0x000000FB	
Value range	–	–
Backup	NO	

7.3.7.2 Product code

The high word contains the hardware version. The low word contains the application number.

Name	Product code	
Index	0x1018	
Subindex	0x02	
Data type	UNSIGNED32	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

Hardware version	Hardware
0xA400	UAV-ESC 52/30 Digital I/O
0xA401	UAV-ESC 52/30 CAN

Table 7-41 Definition of hardware version

7.3.7.3 Revision number

The high word contains the software version. The low word contains the application version.

Name	Revision number	
Index	0x1018	
Subindex	0x03	
Data type	UNSIGNED32	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.7.4 Serial number

Contains the last 8 digits of the device serial number.

Name	Serial number	
Index	0x1018	
Subindex	0x04	
Data type	UNSIGNED32	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

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7.3.8 Node-ID

Identifies the node. Changes to this object only come into effect after restart. Therefore, storing all parameters after a change is required, then restart.

Name	Node-ID	
Index	0x2000	
Subindex	0x00	
Data type	UNSIGNED8	
Access type	RW	
Default value	➔Table 7-42	
Value range	➔Table 7-42	➔Table 7-42
Backup	YES	

Hardware	Default	Min	Max
UAV-ESC 52/30 Digital I/O	1	1	1
UAV-ESC 52/30 CAN	1	1	127

Table 7-42 Definition of Node-ID

7.3.9 CAN bit rate

Note: This object is available with UAV-ESC 52/30 CAN only

Holds the desired bit rate of the CAN interface.

Changes applied to this object come into effect after restart. After a change in the settings, store all parameters and restart.

Name	CAN bit rate
Index	0x2001
Subindex	0x00
Data type	UNSIGNED8
Access type	RW
Default value	0
Value range	➔Table 7-43
Backup	YES

Value	Description
0	1 Mbit/s
1	reserved
2	500 kbit/s
3	250 kbit/s
4	125 kbit/s
5 ... 9	reserved

Table 7-43 CAN bit rate

7.3.10 USB frame timeout

Defines the timeout over a USB communication frame. Scaled in [ms].

Name	USB frame timeout	
Index	0x2006	
Subindex	0x00	
Data type	UNSIGNED16	
Access type	RW	
Default value	500	
Value range	50	20'000
Backup	YES	

7.3.11 CAN bit rate display

Note: This object is available with UAV-ESC 52/30 CAN only

Represents the actual configured bit rate of the CAN interface.

Name	CAN bit rate display
Index	0x200A
Subindex	0x00
Data type	UNSIGNED8
Access type	RO
Default value	-
Value range	➔Table 7-43
Backup	NO

7.3.12 ESC index

Note: This object is available with UAV-ESC 52/30 CAN only

The enumeration ID of this UAV-ESC device is within the set of attached UAV-ESC devices on the bus.

Changes applied to this object come into effect after restart. After a change in the settings, store all parameters and restart.

Name	ESC index	
Index	0x2020	
Subindex	0x00	
Data type	UNSIGNED8	
Access type	RW	
Default value	0	
Value range	0	15
Backup	YES	

7.3.13 Node status configuration

Note: This object is available with UAV-ESC 52/30 CAN only

Name	Node status configuration
Index	0x2021
Object code	RECORD
Highest subindex supported	2

7.3.13.1 Node status data type ID

The DroneCAN data type Identifier for the node status message.

Name	Node status data type ID	
Index	0x2021	
Subindex	0x01	
Data type	UNSIGNED16	
Access type	RW	
Default value	341	
Value range	0	21000
Backup	YES	

7.3.13.2 Node status rate

The transmission rate for the Node status messages [ms].

Name	Node status rate	
Index	0x2021	
Subindex	0x02	
Data type	UNSIGNED16	
Access type	RW	
Default value	100	
Value range	0	1000
Backup	YES	

7.3.14 ESC status configuration

Note: This object is available with UAV-ESC 52/30 CAN only

Name	ESC status configuration
Index	0x2022
Object code	RECORD
Highest subindex supported	2

7.3.14.1 ESC status data type ID

The DroneCAN data type Identifier for the ESC status message.

Name	ESC status data type ID	
Index	0x2022	
Subindex	0x01	
Data type	UNSIGNED16	
Access type	RW	
Default value	1034	
Value range	0	21000
Backup	YES	

7.3.14.2 ESC status rate

The transmission rate for the ESC status messages [ms].

Name	ESC status rate	
Index	0x2022	
Subindex	0x02	
Data type	UNSIGNED16	
Access type	RW	
Default value	100	
Value range	0	1000
Backup	YES	

7.3.15 Raw command configuration

Note: This object is available with UAV-ESC 52/30 CAN only

Name	Raw command configuration
Index	0x2024
Object code	RECORD
Highest subindex supported	2

7.3.15.1 Raw command data type ID

The DroneCAN data type Identifier for the raw command message.

Name	Raw command data type ID	
Index	0x2024	
Subindex	0x01	
Data type	UNSIGNED16	
Access type	RW	
Default value	1030	
Value range	0	21000
Backup	YES	

7.3.15.2 Raw command minimum rate

The minimum allowed transmission rate of the received raw command messages [ms].

Name	Raw command minimum rate	
Index	0x2024	
Subindex	0x02	
Data type	UNSIGNED16	
Access type	RW	
Default value	1000	
Value range	0	10000
Backup	YES	

7.3.16 RPM command configuration

Note: This object is available with UAV-ESC 52/30 CAN only

Name	RPM command configuration
Index	0x2025
Object code	RECORD
Highest subindex supported	2

7.3.16.1 RPM command data type ID

The DroneCAN data type Identifier for the RPM command message.

Name	RPM command data type ID	
Index	0x2025	
Subindex	0x01	
Data type	UNSIGNED16	
Access type	RW	
Default value	1031	
Value range	0	21000
Backup	YES	

7.3.16.2 RPM command minimum rate

The minimum allowed transmission rate of the received RPM command messages [ms].

Name	RPM command minimum rate	
Index	0x2025	
Subindex	0x02	
Data type	UNSIGNED16	
Access type	RW	
Default value	1000	
Value range	1	10000
Backup	YES	

7.3.17 Error behavior

Allows configuration of the device behavior for individual errors. Write access is only permitted in device state «Disabled».

Name	Error behavior
Index	0x2040
Object code	ARRAY
Highest subindex supported	24

Value	Description
0x00	Disable
0x01	Auto fault reset (disable and change to previous state)

Table 7-44 Error behavior values

Value	Description
0x00	Disable
0x02	Warning only (entry in error history only, no reaction)

Table 7-45 Disable value with warning option

Value	Description
0x00	Disable
0x01	Auto fault reset (disable and change to previous state)
0x02	Warning only (entry in error history only, no reaction)

Table 7-46 Error behavior values with warning option

7.3.17.1 Overcurrent error (0x2310)

Name	Overcurrent error (0x2310)
Index	0x2040
Subindex	0x01
Data type	UNSIGNED8
Access type	RW
Default value	0x01
Value range	➔Table 7-44
Backup	YES

7.3.17.2 Power stage protection error (0x2320)

Name	Power stage protection error (0x2320)
Index	0x2040
Subindex	0x02
Data type	UNSIGNED8
Access type	RW
Default value	0x00
Value range	➔Table 7-44
Backup	YES

7.3.17.3 Overvoltage error (0x3210)

Name	Overvoltage error (0x3210)
Index	0x2040
Subindex	0x03
Data type	UNSIGNED8
Access type	RW
Default value	0x01
Value range	➔Table 7-44
Backup	YES

7.3.17.4 Undervoltage error (0x3220)

Name	Undervoltage error (0x3220)
Index	0x2040
Subindex	0x04
Data type	UNSIGNED8
Access type	RW
Default value	0x00
Value range	➔Table 7-44
Backup	YES

7.3.17.5 RC-PWM set value input error (0x8A89)

Name	RC-PWM set value input error (0x8A89)
Index	0x2040
Subindex	0x06
Data type	UNSIGNED8
Access type	RW
Default value	0x02
Value range	➔Table 7-46
Backup	YES

7.3.17.6 Process control message queue full error (0xF000)

Name	Process control message queue full error (0xF000)
Index	0x2040
Subindex	0x07
Data type	UNSIGNED8
Access type	RW
Default value	0x02
Value range	➔Table 7-46
Backup	YES

7.3.17.7 Process control busy switching error (0xF001)

Name	Process control busy switching error (0xF001)
Index	0x2040
Subindex	0x08
Data type	UNSIGNED8
Access type	RW
Default value	0x02
Value range	➔Table 7-46
Backup	YES

7.3.17.8 Process initialization timeout error (0xF002)

Name	Process initialization timeout error (0xF002)
Index	0x2040
Subindex	0x09
Data type	UNSIGNED8
Access type	RW
Default value	0x00
Value range	➔Table 7-46
Backup	YES

7.3.17.9 Stall detection error during synchronous startup (0xF840)

Name	Stall detection error during synchronous startup (0xF840)
Index	0x2040
Subindex	0x0C
Data type	UNSIGNED8
Access type	RW
Default value	0x00
Value range	➔Table 7-44
Backup	YES

7.3.17.10 System overload error (0xFF01)

Name	System overload error (0xFF01)
Index	0x2040
Subindex	0x0D
Data type	UNSIGNED8
Access type	RW
Default value	0x02
Value range	➔Table 7-46
Backup	YES

7.3.17.11 Watchdog error (0xFF02)

Name	Watchdog error (0xFF02)
Index	0x2040
Subindex	0x0E
Data type	UNSIGNED8
Access type	RW
Default value	0x00
Value range	➔Table 7-46
Backup	YES

7.3.17.12 System peak overloaded error (0xFF0B)

Name	System peak overloaded error (0xFF0B)
Index	0x2040
Subindex	0x0F
Data type	UNSIGNED8
Access type	RW
Default value	0x02
Value range	➔Table 7-46
Backup	YES

7.3.17.13 Stall detection error during operation (0xF841)

Name	Stall detection error during operation (0xF841)
Index	0x2040
Subindex	0x10
Data type	UNSIGNED8
Access type	RW
Default value	0x01
Value range	➔Table 7-44
Backup	YES

7.3.17.14 CAN overrun error (0x8110)

Note: This object is available with UAV-ESC 52/30 CAN only

Name	CAN overrun error (0x8110)
Index	0x2040
Subindex	0x11
Data type	UNSIGNED8
Access type	RW
Default value	0x02
Value range	➔Table 7-46
Backup	YES

7.3.17.15 CAN passive mode error (0x8120)

Note: This object is available with UAV-ESC 52/30 CAN only

Name	CAN passive mode error (0x8120)
Index	0x2040
Subindex	0x12
Data type	UNSIGNED8
Access type	RW
Default value	0x02
Value range	➔Table 7-46
Backup	YES

7.3.17.16 CAN bus turned off (0x81FD)

Note: This object is available with UAV-ESC 52/30 CAN only

Name	CAN bus turned off (0x81FD)
Index	0x2040
Subindex	0x13
Data type	UNSIGNED8
Access type	RW
Default value	0x02
Value range	➔Table 7-46
Backup	YES

7.3.17.17 CAN Rx queue overflow (0x81FE)

Note: This object is available with UAV-ESC 52/30 CAN only

Name	CAN Rx queue overflow (0x81FE)
Index	0x2040
Subindex	0x14
Data type	UNSIGNED8
Access type	RW
Default value	0x02
Value range	➔Table 7-45
Backup	YES

7.3.17.18 CAN Tx queue overflow (0x81FF)

Note: This object is available with UAV-ESC 52/30 CAN only

Name	CAN Tx queue overflow (0x81FF)
Index	0x2040
Subindex	0x15
Data type	UNSIGNED8
Access type	RW
Default value	0x02
Value range	➔Table 7-45
Backup	YES

7.3.17.19 DroneCAN message error (0x8290)

Note: This object is available with UAV-ESC 52/30 CAN only

Name	DroneCAN message error (0x8290)
Index	0x2040
Subindex	0x16
Data type	UNSIGNED8
Access type	RW
Default value	0x02
Value range	➔Table 7-45
Backup	YES

7.3.17.20 DroneCAN receive message timeout (0x8291)

Note: This object is available with UAV-ESC 52/30 CAN only

Name	DroneCAN receive message timeout (0x8291)
Index	0x2040
Subindex	0x17
Data type	UNSIGNED8
Access type	RW
Default value	0x02
Value range	➔Table 7-45
Backup	YES

7.3.17.21 Thermal motor supervision error (0x4382)

Name	Thermal motor supervision error (0x4382)
Index	0x2040
Subindex	0x18
Data type	UNSIGNED8
Access type	RW
Default value	0x01
Value range	➔Table 7-44
Backup	YES

7.3.18 Power supply

Used to display the power supply parameters.

Name	Power supply
Index	0x2200
Object code	ARRAY
Highest subindex supported	1

7.3.18.1 Power supply voltage

Represents the actual power supply voltage. Given in [0.1 V].

Name	Power supply voltage	
Index	0x2200	
Subindex	0x01	
Data type	UNSIGNED16	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.19 Power supply supervision

Used to customize power supervision.

Name	Power supply supervision
Index	0x2201
Object code	ARRAY
Highest subindex supported	2

7.3.19.1 Power supply overvoltage limit

If the supply voltage raises above this overvoltage limit, the over-voltage error will be set. The error can only be cleared if the supply voltage falls below the overvoltage limit minus the overvoltage hysteresis (0.4 V). The value is given in [0.001 V].

Name	Power supply overvoltage limit	
Index	0x2201	
Subindex	0x02	
Data type	UNSIGNED32	
Access type	RW	
Default value	58’000	
Value range	8’100	58’000
Backup	NO	

7.3.20 Axis configuration

Used to setup the main components of the axis by configuring the sensors and the control structure. Write access is only permitted in device state «Power Disable».

Name	Axis configuration
Index	0x3000
Object code	ARRAY
Highest subindex supported	5

7.3.20.1 Axis configuration miscellaneous

Used to define various options regarding the axis configuration.

Name	Axis configuration miscellaneous
Index	0x3000
Subindex	0x04
Data type	UNSIGNED32
Access type	RW
Default value	0
Value range	➔Table 7-47
Backup	Yes

Bit	Name	Value	Description
31...1	reserved	0	–
0	Axis polarity	1	Inverse polarity – rotational direction of the axis is CW when demanded values are positive
		0	Normal polarity – rotational direction of the axis is CCW when demanded values are positive

Table 7-47 Axis configuration miscellaneous – Bits

7.3.21 Motor data

Used to configure the parameters of the motor.

Some parameters are used to limit the output current according to the I2t method. For detailed motor specifications ➔maxon catalog.

Name	Motor data
Index	0x3001
Object code	RECORD
Highest subindex supported	5

7.3.21.1 Nominal current

Represents the nominal current of the motor [mA]. Continuous operation of the motor at this current level and at 25 °C ambient will cause the winding to ultimately reach the specified maximum winding temperature. This assumes no heat sinking. The value can be substantially increased if the motor mount is made of heat-dissipating materials.

Related objects: ➔"Motor rated torque" on page 7-98

Name	Nominal current	
Index	0x3001	
Subindex	0x01	
Data type	UNSIGNED32	
Access type	RW	
Default value	35'000	
Value range	0	90'000
Backup	YES	

7.3.21.2 Output current limit

Represents the maximum permissible current of the motor [mA]. We recommend to set the value to double of ➔Nominal current.

Related objects: ➔"Thermal time constant winding" on page 7-62

Name	Output current limit	
Index	0x3001	
Subindex	0x02	
Data type	UNSIGNED32	
Access type	RW	
Default value	0	
Value range	0	90'000
Backup	YES	

7.3.21.3 Number of pole pairs

Represents the number of magnetic pole pairs (number of poles divided by 2) of the rotor of a brushless DC motor (maxon EC motor/BLDC motor).

Write access is only permitted in device state «Power Disable».

Related objects: ➔"Max motor speed" on page 7-99

Name	Number of pole pairs	
Index	0x3001	
Subindex	0x03	
Data type	UNSIGNED8	
Access type	RW	
Default value	21	
Value range	1	255
Backup	YES	

7.3.21.4 Thermal time constant winding

Represents the thermal time constant of the motor winding. It is used to calculate the length of time the ➔Output current limit (subindex 0x02) is permitted to be connected to the motor. Given in [0.1 s].
Example: For a time constant of 4 seconds, set the value “40”.

Name	Thermal time constant winding	
Index	0x3001	
Subindex	0x04	
Data type	UNSIGNED16	
Access type	RW	
Default value	160	
Value range	1	10'000
Backup	YES	

7.3.21.5 Torque constant

Represents the motor’s torque constant. Given in [µNm/A].

Related objects: ➔“Motor rated torque” on page 7-98

Name	Torque constant	
Index	0x3001	
Subindex	0x05	
Data type	UNSIGNED32	
Access type	RW	
Default value	66'400	
Value range	0	10'000'000
Backup	YES	

7.3.22 Electrical system parameters

Used to configure the parameters of the motor model.

Name	Electrical system parameters
Index	0x3002
Object code	ARRAY
Highest subindex supported	2

7.3.22.1 Transition parameter (a)

The value has no unit and a resolution of 1/1000.

Name	Transition parameter (a)	
Index	0x3002	
Subindex	0x03	
Data type	UNSIGNED32	
Access type	RW	
Default value	900	
Value range	0	1'000'000
Backup	YES	

7.3.22.2 Input parameter (b)

Given in [µV/mA].

Name	Input parameter (b)	
Index	0x3002	
Subindex	0x04	
Data type	UNSIGNED32	
Access type	RW	
Default value	1'600	
Value range	0	1'000'000
Backup	YES	

7.3.23 Current control parameter set

Holds the current controller parameters. The current controller is realized with a digital PI controller.

Name	Current control parameter set
Index	0x30A0
Object code	RECORD
Highest subindex supported	2

7.3.23.1 Current controller P gain

Represents the proportional gain of the current controller. Given in $[\frac{\mu V}{A}]$.

Name	Current controller P gain	
Index	0x30A0	
Subindex	0x01	
Data type	UNSIGNED32	
Access type	RW	
Default value	30'000	
Value range	–	–
Backup	YES	

7.3.23.2 Current controller I gain

Represents the integral gain of the current controller. Given in $[\frac{\mu V}{A \cdot s}]$.

Name	Current controller I gain	
Index	0x30A0	
Subindex	0x02	
Data type	UNSIGNED32	
Access type	RW	
Default value	130'000	
Value range	–	–
Backup	YES	

7.3.24 Velocity control parameter set

Velocity regulation is implemented with a digital PI controller. The object holds all parameters of the velocity controller.

Name	Velocity control parameter set
Index	0x30A2
Object code	RECORD
Highest subindex supported	4

7.3.24.1 Velocity controller P gain [1]

Represents the proportional gain of the velocity controller 1. Given in $[\frac{\mu A \cdot s}{rad}]$.

Name	Velocity controller P gain [1]	
Index	0x30A2	
Subindex	0x01	
Data type	UNSIGNED32	
Access type	RW	
Default value	500'000	
Value range	–	–
Backup	YES	

7.3.24.2 Velocity controller I gain [1]

Represents the integral gain of the velocity controller 1. Given in $[\frac{\mu A}{rad}]$.

Name	Velocity controller I gain [1]	
Index	0x30A2	
Subindex	0x02	
Data type	UNSIGNED32	
Access type	RW	
Default value	1'500'000	
Value range	–	–
Backup	YES	

7.3.24.3 Velocity controller FF velocity gain [1]

Represents the speed feedforward gain of the velocity controller 1. Given in $[\frac{\mu A \cdot s}{rad}]$.

Name	Velocity controller FF velocity gain [1]
Index	0x30A2
Subindex	0x03
Data type	UNSIGNED32
Access type	RW
Default value	0

Value range	–	–
Backup	YES	

7.3.24.4 Velocity controller FF acceleration gain [1]

Represents the acceleration feedforward gain of the velocity controller 1. Given in $[\frac{\mu A \cdot s^2}{rad}]$.

Name	Velocity controller FF acceleration gain [1]	
Index	0x30A2	
Subindex	0x04	
Data type	UNSIGNED32	
Access type	RW	
Default value	0	
Value range	–	–
Backup	YES	

7.3.25 Back EMF observer parameter set

Holds the Back EMF observer parameters.

Name	Back EMF observer parameter set
Index	0x30A5
Object code	ARRAY
Highest subindex supported	4

7.3.25.1 Kalman current gain [1]

The value has no unit and a resolution of 1/1000.

Name	Kalman current gain [1]	
Index	0x30A5	
Subindex	0x01	
Data type	UNSIGNED32	
Access type	RW	
Default value	698	
Value range	0	1'000'000
Backup	YES	

7.3.25.2 Kalman Back EMF gain [1]

Given in $[\frac{\mu V}{mA}]$.

Name	Kalman Back EMF gain [1]	
Index	0x30A5	
Subindex	0x02	
Data type	UNSIGNED32	
Access type	RW	
Default value	339	
Value range	0	1'000'000
Backup	YES	

7.3.25.3 Kalman current gain [2]

The value has no unit and a resolution of 1/1000.

Name	Kalman current gain [2]	
Index	0x30A5	
Subindex	0x03	
Data type	UNSIGNED32	
Access type	RW	
Default value	698	
Value range	0	1'000'000
Backup	YES	

7.3.25.4 Kalman Back EMF gain [2]

Given in $[\frac{\mu V}{mA}]$.

Name	Kalman Back EMF gain [2]	
Index	0x30A5	
Subindex	0x04	
Data type	UNSIGNED32	
Access type	RW	
Default value	460	
Value range	0	1'000'000
Backup	YES	

7.3.26 Angle fusion parameter set

Holds the angle fusion and mode switch parameters.

Name	Angle fusion parameter set
Index	0x30A9
Object code	RECORD
Highest subindex supported	12

7.3.26.1 Back EMF magnitude

The magnitude based on the estimated Back EMF voltage.Given in [mV] as per the following calculation:

$$Bemf_{Magnitude} = \sqrt[2]{Bemf_{Alpha}{}^{2} + Bemf_{Beta}{}^{2}} - (OffsetScale \cdot CurrentDemand)$$

Name	Back EMF magnitude	
Index	0x30A9	
Subindex	0x05	
Data type	UNSIGNED32	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.26.2 Back EMF magnitude filter

The cutoff frequency of the Back EMF magnitude low-pass filter. Given in [0.1 Hz].

The displayed value is the value used internally. It may differ slightly from the entered value due to rounding differences.

Name	Back EMF magnitude filter	
Index	0x30A9	
Subindex	0x07	
Data type	UNSIGNED16	
Access type	RW	
Default value	3'000	
Value range	1	65'535
Backup	YES	

7.3.26.3 Back EMF rotation sign filter

The cutoff frequency of a low-pass filter used on the actual Back EMF rotation direction. It is configured according to the desired dynamic behavior (maximum acceleration at low velocities). Given in [0.1 Hz].

Name	Back EMF rotation sign filter	
Index	0x30A9	
Subindex	0x08	
Data type	UNSIGNED16	
Access type	RW	
Default value	100	
Value range	1	65'535
Backup	YES	

7.3.26.4 Back EMF rotation sign indicator filtered

The rotation sign is evaluated based on the Back EMF voltage. The corresponding value is filtered with ➔Back EMF rotation sign filter. A positive sign indicates a positive rotation direction (CCW).

Name	Back EMF rotation sign indicator filtered	
Index	0x30A9	
Subindex	0x09	
Data type	INTEGER32	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.26.5 Back EMF magnitude offset current factor 1

Factor for current-dependent Back EMF magnitude offset. Given in [mV/A].

The factor is active at low current values (current actual value below ➔Back EMF magnitude offset current threshold).

Name	Back EMF magnitude offset current factor 1	
Index	0x30A9	
Subindex	0x0A	
Data type	UNSIGNED16	
Access type	RW	
Default value	0	
Value range	0	10'000
Backup	YES	

7.3.26.6 Back EMF magnitude offset current factor 2

Factor for current-dependent Back EMF magnitude offset. Given in [mV/A].

The factor is active at high current values (current actual value above ➔Back EMF magnitude offset current threshold).

Name	Back EMF magnitude offset current factor 2	
Index	0x30A9	
Subindex	0x0B	
Data type	UNSIGNED16	
Access type	RW	
Default value	0	
Value range	0	10'000
Backup	YES	

7.3.26.7 Back EMF magnitude offset current threshold

Below this threshold, the ➔Back EMF magnitude offset current factor 1 is active, above this threshold ➔Back EMF magnitude offset current factor 2 is active. Given in [mA].

Name	Back EMF magnitude offset current threshold	
Index	0x30A9	
Subindex	0x0C	
Data type	UNSIGNED16	
Access type	RW	
Default value	0	
Value range	0	10'000
Backup	YES	

7.3.27 Synchronous startup parameter set

Controls the synchronous startup behavior.

Name	Synchronous startup parameter set
Index	0x30AF
Object code	RECORD
Highest subindex supported	16

7.3.27.1 Synchronous angular acceleration

The acceleration during synchronous startup ramp. Given in [rpm/s].

Name	Synchronous angular acceleration	
Index	0x30AF	
Subindex	0x01	
Data type	UNSIGNED16	
Access type	RW	
Default value	1'000	
Value range	1	20'000
Backup	YES	

7.3.27.2 Synchronous acceleration current ratio

The current amplitude during synchronous startup ramp in percent of nominal motor current. Given in [‰].

Name	Synchronous acceleration current ratio	
Index	0x30AF	
Subindex	0x02	
Data type	UNSIGNED16	
Access type	RW	
Default value	1'000	
Value range	1	1'000
Backup	YES	

7.3.27.3 Maximum synchronous velocity

The maximum velocity during synchronous operation. A ➔Stall detection error during synchronous startup is thrown if the maximum synchronous velocity is reached while the ➔Back EMF magnitude is still below ➔Transition upper threshold. Given in [rpm].

Name	Maximum synchronous velocity	
Index	0x30AF	
Subindex	0x03	
Data type	UNSIGNED32	
Access type	RW	
Default value	900	
Value range	1	72'000 per number of pole pairs
Backup	YES	

7.3.27.4 Startup alignment angle

The alignment angle as initial angle for synchronous startup. Given in [multiplies of 360°/2^{16}; electrical angle].

Name	Startup alignment angle	
Index	0x30AF	
Subindex	0x04	
Data type	UNSIGNED16	
Access type	RW	
Default value	0	
Value range	0	65'536
Backup	YES	

7.3.27.5 Startup alignment time

Defines the duration of the alignment phase. Given in [ms].

Name	Startup alignment time	
Index	0x30AF	
Subindex	0x05	
Data type	UNSIGNED16	
Access type	RW	
Default value	50	
Value range	1	10'000
Backup	YES	

7.3.27.6 Startup alignment current ratio

The current amplitude during startup alignment in percent of nominal motor current. Given in [‰].

Name	Startup alignment current ratio	
Index	0x30AF	
Subindex	0x06	
Data type	UNSIGNED16	
Access type	RW	
Default value	200	
Value range	1	1'000
Backup	YES	

7.3.27.7 Transition upper threshold

The upper threshold of the state switch hysteresis. It determines when to switch from open loop synchronous startup to closed loop control with Back EMF observer rotor frame for commutation. The value should be greater than ➔Transition lower threshold. Given in [mV].

Name	Transition upper threshold	
Index	0x30AF	
Subindex	0x07	
Data type	UNSIGNED32	
Access type	RW	
Default value	8'000	
Value range	0	50'000
Backup	YES	

7.3.27.8 Transition lower threshold

The lower threshold of the state switch hysteresis. It determines when to switch from Back EMF observer rotor frame for commutation back to controlled shutdown of the rotating axis. Value should be smaller than ➔Transition upper threshold. Given in [mV].

Name	Transition lower threshold	
Index	0x30AF	
Subindex	0x08	
Data type	UNSIGNED32	
Access type	RW	
Default value	1'000	
Value range	0	50'000
Backup	YES	

7.3.27.9 Synchronous minimum velocity

Defines the minimum target velocity if synchronous startup is in use. If the ➔Target velocity is lower than ½ synchronous minimum velocity, it is rounded down to 0 rpm. If it is higher than ½ synchronous minimum velocity, it is rounded up to synchronous minimum velocity. However, if the velocity is decreased, the ➔Target velocity is rounded down to 0 at ¼ synchronous minimum velocity. Given in [velocity unit].

The object is active for all modes that use the object ➔Target velocity.

Name	Synchronous minimum velocity	
Index	0x30AF	
Subindex	0x09	
Data type	UNSIGNED32	
Access type	RW	
Default value	300	
Value range	0	5'000
Backup	YES	

Synchronous startup state	Target value	Velocity setpoint
Back EMF state	<½ synchronous minimum velocity	0
	≥½ synchronous minimum velocity	Synchronous minimum velocity
	≥synchronous minimum velocity	Target velocity
Other states	<¼ synchronous minimum velocity	0
	≥¼ synchronous minimum velocity	Synchronous minimum velocity
	≥synchronous minimum velocity	Target velocity

Table 7-48 Synchronous minimum velocity

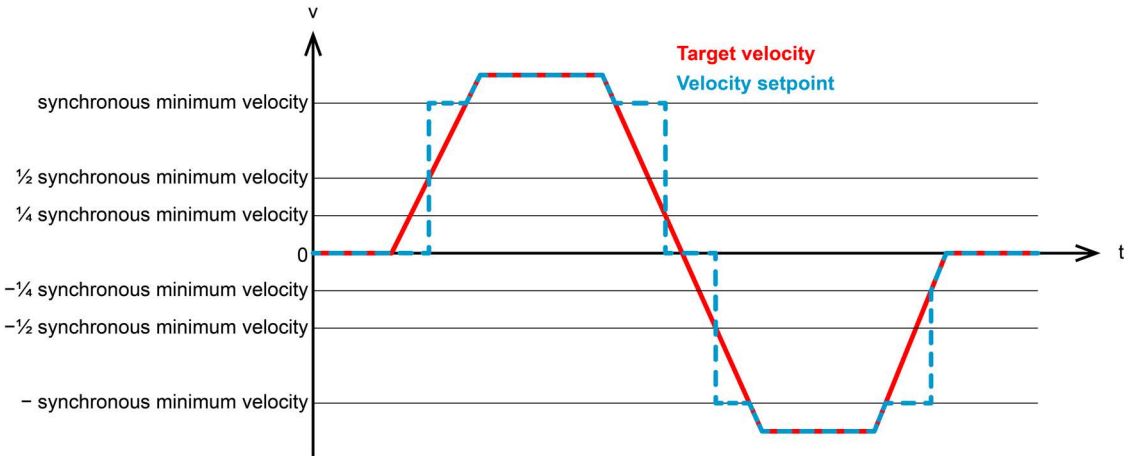

Figure 7-14 Velocity setpoint for a continuously changing target velocity

7.3.27.10 Maximum synchronous startup trials

If a stall error occurs during synchronous startup, the device automatically tries to restart. This object specifies the total number of start trials before an error is thrown.

Name	Maximum synchronous startup trials	
Index	0x30AF	
Subindex	0x0A	
Data type	UNSIGNED8	
Access type	RW	
Default value	5	
Value range	1	5
Backup	YES	

7.3.27.11 Synchronous startup state

Represents the internal state of synchronous startup state machine.

Name	Synchronous startup state
Index	0x30AF
Subindex	0x10
Data type	UNSIGNED8
Access type	RO
Default value	–
Value range	➔Table 7-49
Backup	NO

Value	Enumeration
0	Idle
1	Start alignment
2	Alignment
3	Ramp up
4	Back EMF operation
255	No synchronous startup

Table 7-49 Synchronous startup state – Enumeration

7.3.28 Current demand value

The set value for the current controller. Given in [mA].

Name	Current demand value	
Index	0x30D0	
Subindex	0x00	
Data type	INTEGER32	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.29 Current actual values

Provides the actual current values.

Name	Current actual values
Index	0x30D1
Object code	ARRAY
Highest subindex supported	2

maxon

7.3.29.1 Current actual value averaged

Represents the ➔Current actual value filtered by 1st order digital low-pass filter with a cut-off frequency of 50 Hz. Given in [mA].

Name	Current actual value averaged	
Index	0x30D1	
Subindex	0x01	
Data type	INTEGER32	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.29.2 Current actual value

Provides the actual value of the motor's current. Given in [mA].

Name	Current actual value	
Index	0x30D1	
Subindex	0x02	
Data type	INTEGER32	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.30 Torque actual values

Provides the actual torque values.

Name	Torque actual values
Index	0x30D2
Object code	ARRAY
Highest subindex supported	1

7.3.30.1 Torque actual value averaged

Represents the ➔Torque actual value filtered by 1st order digital low-pass filter with a cut-off frequency of 50 Hz. Given in $[\frac{MotorRatedTorque}{1000}]$.

Related objects: ➔“Torque actual value” on page 7-98

Name	Torque actual value averaged	
Index	0x30D2	
Subindex	0x01	
Data type	INTEGER16	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.31 Velocity actual values

Provides the actual velocity values.

Name	Velocity actual values
Index	0x30D3
Object code	ARRAY
Highest subindex supported	1

7.3.31.1 Velocity actual value averaged

Represents the ➔Velocity actual value filtered by 1st order digital low-pass filter with a cut-off frequency of 5 Hz.

Related objects: ➔“Velocity actual value” on page 7-97

Name	Velocity actual value averaged	
Index	0x30D3	
Subindex	0x01	
Data type	INTEGER32	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.32 Set value command

Note: This object is available with UAV-ESC 52/30 CAN only

Name	Set value command
Index	0x30F0
Object code	RECCORD
Highest subindex supported	5

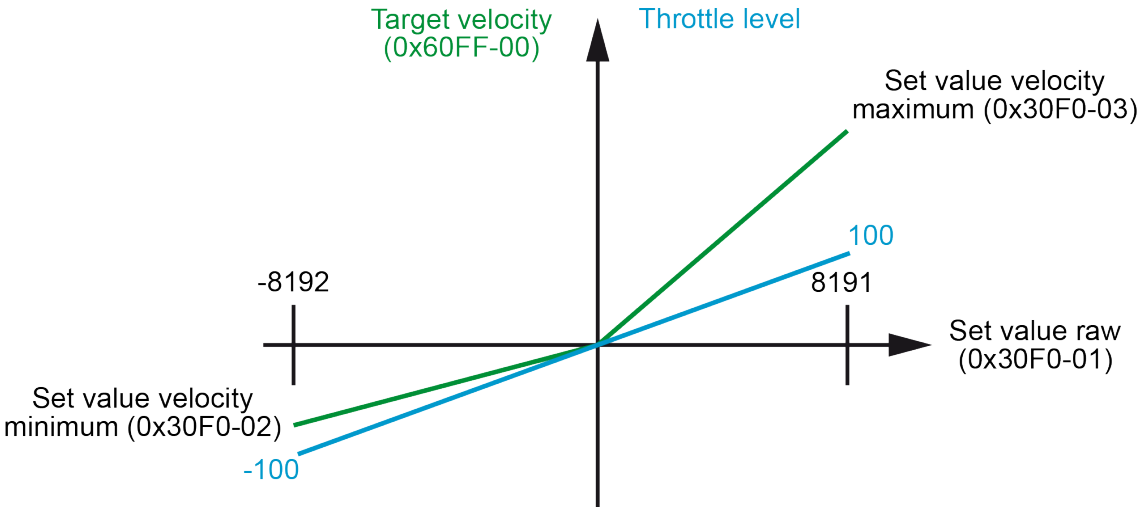

Figure 7-15 Set value raw conversion

7.3.32.1 Set value raw

The raw value of the set value is scaled in parts of the related maximum value [1 / 8191].

Name	Set value raw	
Index	0x30F0	
Subindex	0x01	
Data type	INTEGER16	
Access type	RW	
Default value	0	
Value range	-8192	8191
Backup	NO	

7.3.32.2 Set value velocity minimum

The set value velocity minimum [velocity units].

Name	Set value velocity minimum	
Index	0x30F0	
Subindex	0x02	
Data type	INTEGER32	
Access type	RW	
Default value	0	
Value range	- max. motor speed	0
Backup	YES	

7.3.32.3 Set value velocity maximum

The set value velocity maximum [velocity units].

Name	Set value velocity maximum	
Index	0x30F0	
Subindex	0x03	
Data type	INTEGER32	
Access type	RW	
Default value	1000	
Value range	0	max. motor speed
Backup	YES	

7.3.32.4 Set value throttle level actual

Displays the actual throttle level calculated from set value raw. A value of -32768% represents an invalid throttle state. Otherwise the value is between -100% and +100%.

Name	Set value throttle level actual	
Index	0x30F0	
Subindex	0x04	
Data type	INTEGER16	
Access type	RO	
Default value	-	
Value range	-	-
Backup	NO	

7.3.32.5 Set value rpm

The set value is given in [velocity units].

Name	Set value rpm	
Index	0x30F0	
Subindex	0x05	
Data type	INTEGER32	
Access type	RW	
Default value	0	
Value range	-	-
Backup	NO	

7.3.33 Digital input properties

Number and assignment of the inputs are hardware-dependent (for details ➔separate document «User Manual» of respective controller).

Related objects: ➔“Configuration of digital inputs” on page 7-81 / ➔“Digital inputs” on page 7-103

Name	Digital input properties
Index	0x3141
Object code	ARRAY
Highest subindex supported	2

7.3.33.1 Digital inputs logic state

Displays the state of the digital input logic signal (before polarity correction). A bit is read as “1” if the signal at the corresponding pin is high.

Name	Digital inputs logic state
Index	0x3141
Subindex	0x01
Data type	UNSIGNED16
Access type	RO
Default value	➔Table 7-50
Value range	➔Table 7-50
Backup	NO

Bit	Functionality
31…1	reserved
0	DigIn1

Table 7-50 Digital input bits

7.3.33.2 Digital inputs polarity

Used to set the polarity of the digital input functionalities. If a bit is set to “0” (zero), the associated pin is high active. For bit description ➔Table 7-50.

Name	Digital inputs polarity	
Index	0x3141	
Subindex	0x02	
Data type	UNSIGNED16	
Access type	RW	
Default value	0x0000	
Value range	–	–
Backup	YES	

7.3.34 Configuration of digital inputs

Configures the functionality that will be assigned to digital inputs. Number and assignment of the inputs are hardware-dependent (for details ➔separate document «User Manual» of respective controller).

Related objects: ➔“Digital input properties” on page 7-80 / ➔“Digital inputs” on page 7-103

Name	Configuration of digital inputs
Index	0x3142
Object code	ARRAY
Highest subindex supported	1

7.3.34.1 Digital input 1 configuration

Maps functions to digital inputs. Each function can only be mapped once, each digital input can only hold one function.

Names	Digital input 1 configuration
Index	0x3142
Subindex	0x01
Data type	UNSIGNED8
Access type	RW
Default value	31: UAV-ESC 52/30 Digital I/O 255: UAV-ESC 5230 CAN
Value range	➔Table 7-51
Backup	YES

Value	Functionality	Description
255	None	No functionality assigned
254…32	reserved	–
31 [a]	RC-PWM velocity set value	Set velocity over PWM input signal
30…17	reserved	–
16 [a]	General purpose A	State can be read
15…0	reserved	–

Table 7-51 Digital inputs – Configuration

[a] Value only settable for UAV-ESC 52/30 Digital I/O

7.3.35 RC-PWM input set value properties

Note: This object is available with UAV-ESC 52/30 Digital-I/O only

A setpoint function for the digital input. It configures the velocity set value which is set by a PWM pulse input. The functionality is supported in ➔Profile Velocity Mode (PVM).

Best practice
The setpoint specification always refers to +/- ➔Max motor speed symmetrical around «Pulse width center throttle».

- *If «Pulse width center» (0x03) is set to «Pulse width zero throttle» (0x01) or «Pulse width full throttle» (0x02), the setpoint is unidirectional only.*
- *If «Pulse width center» (0x03) is between the two "throttle values" (0x01, 0x02), the setpoint is bidirectional.*

Name	RC-PWM input set value properties
Index	0x3148
Object code	RECORD
Highest subindex supported	7

7.3.35.1 Pulse width zero throttle

Displays the pulse width zero throttle. Given in [µs].

Name	Pulse width zero throttle	
Index	0x3148	
Subindex	0x01	
Data type	UNSIGNED16	
Access type	RW	
Default value	1'100	
Value range	800	1'250
Backup	YES	

7.3.35.2 Pulse width full throttle

Displays the pulse width full throttle. Given in [µs].

Name	Pulse width full throttle	
Index	0x3148	
Subindex	0x02	
Data type	UNSIGNED16	
Access type	RW	
Default value	1'940	
Value range	1'750	2'200
Backup	YES	

7.3.35.3 Pulse width center

Displays the pulse width center. Given in [µs].

Name	Pulse width center	
Index	0x3148	
Subindex	0x03	
Data type	UNSIGNED16	
Access type	RW	
Default value	1'100	
Value range	800	2'200
Backup	YES	

7.3.35.4 Pulse deadband

Displays the pulse deadband. Given in [µs].

Name	Pulse deadband	
Index	0x3148	
Subindex	0x04	
Data type	UNSIGNED16	
Access type	RW	
Default value	20	
Value range	0	200
Backup	YES	

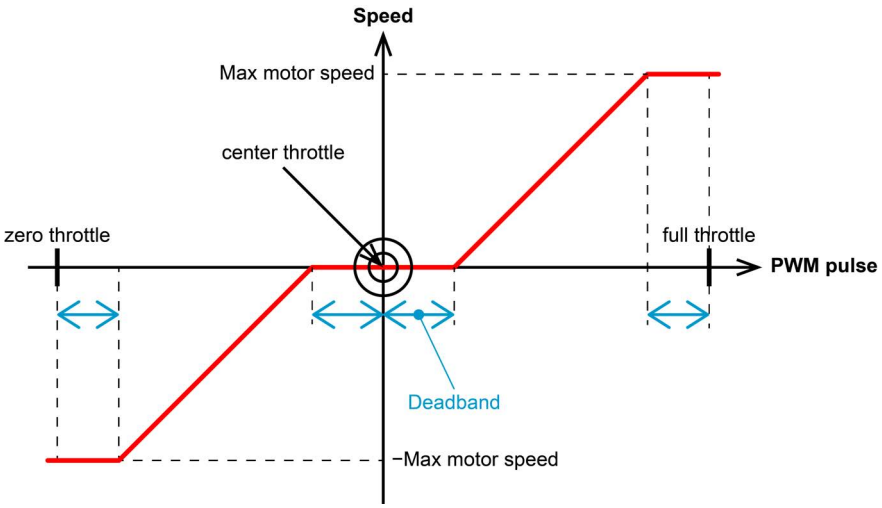

Figure 7-16 Pulse deadband

7.3.35.5 Frequency actual value

Displays the actual PWM frequency and represents the PWM signal measured at the configured digital input. Given in [Hz].

If the PWM input rate is outside the range of 30…800 Hz, the error 0x8A89 (RC-PWM set value input error) is triggered.

Name	Frequency actual value	
Index	0x3148	
Subindex	0x05	
Data type	UNSIGNED16	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.35.6 Pulse width actual value

Displays the PWM input high pulse length and represents the PWM signal measured at the configured digital input. Given in [µs].

If the pulse width is outside the range of 500…2'500 µs, the error 0x8A89 (RC-PWM set value input error) is triggered.

Name	Pulse width actual value	
Index	0x3148	
Subindex	0x06	
Data type	UNSIGNED16	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.35.7 Throttle level actual value

Displays the actual throttle level in percent. A value of -32768% represents an invalid throttle state. Otherwise the value is between -100% and +100%. Given in [%].

Name	Throttle level actual value	
Index	0x3148	
Subindex	0x07	
Data type	INTEGER16	
Access type	RO	
Default value	0	
Value range	-100	+100
Backup	NO	

7.3.36 Digital output properties

Number and assignment of the outputs are hardware-dependent (for details ➔separate document «User Manual» of respective controller).

Related objects: ➔“Configuration of digital outputs” on page 7-86 / ➔“Digital outputs” on page 7-104

Name	Digital output properties
Index	0x3150
Object code	ARRAY
Highest subindex supported	2

7.3.36.1 Digital outputs logic state

Displays the digital output logic state (after polarity correction). A bit is read as “1” if the signal at the corresponding pin is high.

Name	Digital outputs logic state
Index	0x3150
Subindex	0x01
Data type	UNSIGNED16
Access type	RO
Default value	0x0000
Value range	➔Table 7-52
Backup	NO

Bit	Functionality
31…1	reserved
0	DigOut1

Table 7-52 Digital output bits

7.3.36.2 Digital outputs polarity

Used to set the polarity of the digital outputs. If a bit is set to “1”, the associated output will be inverted, thus “1” in ➔Digital outputs will set the output pin low.

For bit description ➔Table 7-52.

Name	Digital outputs polarity	
Index	0x3150	
Subindex	0x02	
Data type	UNSIGNED16	
Access type	RW	
Default value	0x0000	
Value range	–	–
Backup	YES	

7.3.37 Configuration of digital outputs

Note: This object is available with UAV-ESC 52/30 Digital-I/O only

Configures the functionality that will be assigned to digital outputs 1 to 3. Number and assignment of the outputs are hardware-dependent (for details ➔separate document «User Manual» of respective controller).

Related objects: ➔“Digital output properties” on page 7-85 / ➔“Digital outputs” on page 7-104

Name	Configuration of digital outputs
Index	0x3151
Object code	ARRAY
Highest subindex supported	1

7.3.37.1 Digital output 1 configuration

Names	Digital output 1 configuration
Index	0x3151
Subindex	0x01
Data type	UNSIGNED8
Access type	RW
Default value	16: General purpose A
Value range	➔Table 7-53
Backup	YES

Value	Functionality	Description
255	None	No functionality assigned
254…36	reserved	–
35	Velocity actual value	Outputs frequency proportional to the mechanical motor rotation
34…17	reserved	–
16	General purpose A	State can be read/written by the host
15…0	reserved	–

Table 7-53 Digital outputs – Configuration

7.3.38 Digital output velocity actual value properties

Note: This object is available with UAV-ESC 52/30 Digital-I/O only

Configures the velocity actual value which is assigned to a digital output.

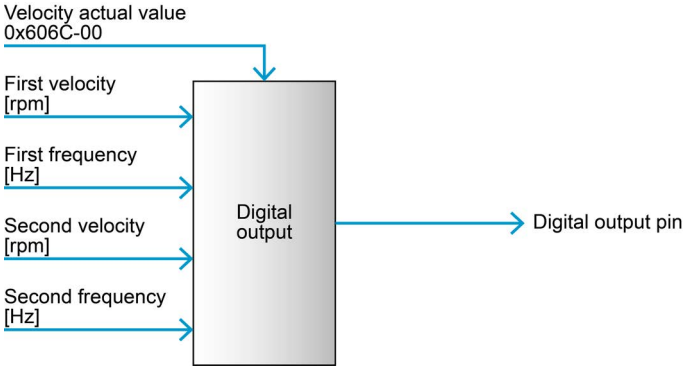

Figure 7-17 Digital output velocity actual value properties

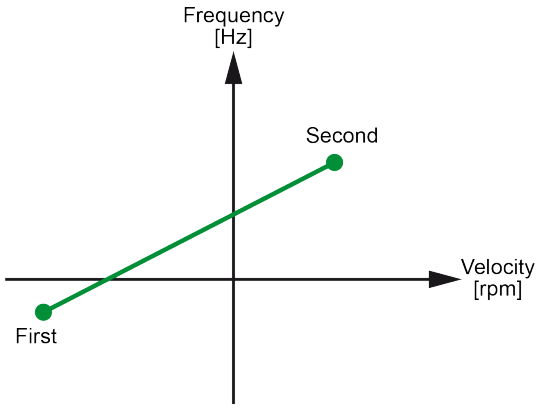

Figure 7-18 Digital output velocity set value properties – Set value

Name	Digital output velocity actual value properties
Index	0x3157
Object code	ARRAY
Highest subindex supported	4

7.3.38.1 Velocity actual value first velocity

Given in [rpm].

Name	Velocity actual value first velocity	
Index	0x3157	
Subindex	0x01	
Data type	INTEGER32	
Access type	RW	
Default value	0	
Value range	−150'000	+150'000
Backup	YES	

7.3.38.2 Velocity actual value first frequency

Given in [Hz].

Name	Velocity actual value first frequency	
Index	0x3157	
Subindex	0x02	
Data type	UNSIGNED16	
Access type	RW	
Default value	0	
Value range	0	2'500
Backup	YES	

7.3.38.3 Velocity actual value second velocity

Given in [rpm].

Name	Velocity actual value second velocity	
Index	0x3157	
Subindex	0x03	
Data type	INTEGER32	
Access type	RW	
Default value	0	
Value range	−150'000	+150'000
Backup	YES	

7.3.38.4 Velocity actual value second frequency

Given in [Hz].

Name	Velocity actual value second frequency	
Index	0x3157	
Subindex	0x04	
Data type	UNSIGNED16	
Access type	RW	
Default value	0	
Value range	0	2'500
Backup	YES	

7.3.39 Motor protection

Represents the motor protection parameters.

Name	Motor protection
Index	0x3200
Object code	RECORD
Highest subindex supported	3

7.3.39.1 I2t level motor

Provides the actual thermal state of the internal i2t motor protection feature. The number is given in percent but values higher than 100% are possible.

Name	I2t level motor	
Index	0x3200	
Subindex	0x01	
Data type	UNSIGNED16	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.39.2 I2t level motor error limit

Configures the i2t level motor error limit. The number is given in percent but values higher than 100% are possible.

Name	I2t level motor error limit	
Index	0x3200	
Subindex	0x03	
Data type	UNSIGNED16	
Access type	RW	
Default value	120	
Value range	–	–
Backup	NO	

7.3.40 Thermal overload protection

Handles the thermal overload protection.

Name	Thermal overload protection
Index	0x3201
Object code	RECORD
Highest subindex supported	12

7.3.40.1 Temperature power stage

Displays the power stage temperature. Given in [0.1 C°].

Name	Temperature power stage	
Index	0x3201	
Subindex	0x01	
Data type	INTEGER16	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.40.2 Temperature motor

Displays the motor temperature. Given in [0.1 C°]. If a valid motor NTC temperature sensor is selected and no NTC is connected the error (0x43B0) will be set and the value ‘’9999’’ will be displayed.

Name	Temperature motor	
Index	0x3201	
Subindex	0x02	
Data type	INTEGER16	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.40.3 Warning temperature power stage

Displays the warning temperature for the power stage. The value is given in [0.1 C°]. If the power stage temperature exceeds this value, the thermal overload warning (0x4210) will be set.

Name	Warning temperature power stage	
Index	0x3201	
Subindex	0x08	
Data type	UNSIGNED16	
Access type	RW	
Default value	1’000	
Value range	0	1’000
Backup	NO	

7.3.40.4 Warning temperature motor

Displays the warning temperature for the motor. The value is given in [0.1 C°]. If the motor temperature exceeds this value, the thermal motor overload warning (0x4380) will be set.

Name	Warning temperature motor	
Index	0x3201	
Subindex	0x09	
Data type	UNSIGNED16	
Access type	RW	
Default value	1’350	
Value range	1’000	2’000
Backup	NO	

7.3.40.5 Motor temperature NTC type

Selects the desired motor temperature sensor type (NTC 10kΩ). If “NONE” is selected, the current derating based on the motor temperature is turned off and only I2t limitation is active.

Name	Motor temperature NTC type
Index	0x3201
Subindex	0x0A
Data type	UNSIGNED16
Access type	RW
Default value	0
Value range	➔Table 7-54
Backup	YES

Value	NTC Type (B25/85)	I2t limitation
0	None (Temperature motor = 0.0°)	YES
3435	B25/85: 3435	NO
3490	B25/85: 3490	NO
3610	B25/85: 3610	NO
4000	B25/85: 4000	NO
4480	B25/85: 4480	NO

Table 7-54 Motor winding temperature sensor – Type

7.3.40.6 Maximum temperature motor

Represents the maximum temperature of motor. Given in [0.1 °C].

Together with “Derating temperature motor” the following behavior is defined.

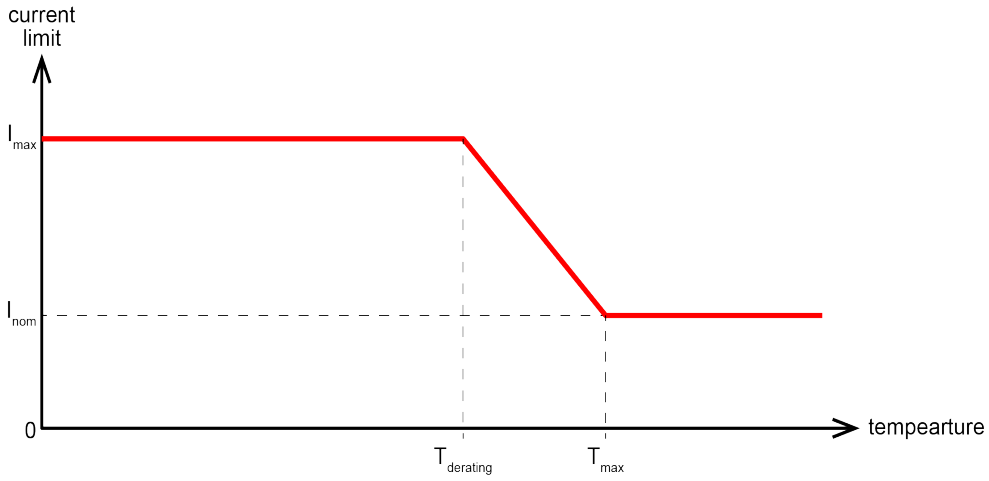

Figure 7-19 Current derating principle

Name	Maximum temperature motor	
Index	0x3201	
Subindex	0x0B	
Data type	UNSIGNED16	
Access type	RW	
Default value	1’550	
Value range	1’000	2’000
Backup	YES	

7.3.40.7 Derating temperature motor

Represents the derating temperature of motor. Given in [0.1 °C].

Name	Derating temperature motor	
Index	0x3201	
Subindex	0x0C	
Data type	UNSIGNED16	
Access type	RW	
Default value	1’450	
Value range	1’000	2’000
Backup	YES	

7.3.41 Motor control

Handles the motor control.

Name	Motor control
Index	0x3203
Object code	RECORD
Highest subindex supported	1

7.3.41.1 PWM duty cycle actual value

Displays the duty cycle of a PWM signal that is applied to the motor. The value is given in thousandth parts of the supply voltage.

Name	PWM duty cycle actual value	
Index	0x3203	
Subindex	0x01	
Data type	UNSIGNED16	
Access type	RO	
Default value	–	
Value range	–	–
PDO mapping	YES	
Backup	NO	

maxon

7.3.42 Error code

Provides the error code of the last error that occurred in the device. This value differs from the value in object ➔Error register. The value also appear in object ➔Error history.

Name	Error code	
Index	0x603F	
Subindex	0x00	
Data type	UNSIGNED16	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.43 Controlword

Comprises bits for the following items:

- ➔"Device Control Commands" on page 2-17 (bits 0…3, 7)
- Supervision of operating modes (bits 4…6, 8):
  ➔"Controlword (PVM-specific Bits)" on page 3-20
  ➔"Statusword (CST-specific Bits)" on page 3-23

For bit patterns of triggered commands ➔"Device Control Commands" on page 2-17.

Related objects: ➔"Statusword" on page 7-95

Name	Controlword	
Index	0x6040	
Subindex	0x00	
Data type	UNSIGNED16	
Access type	RW	
Default value	–	
Value range	–	–
Backup	NO	

Bit	Description	PVM	CST
15	Operating mode-specific	reserved	reserved
14…9	reserved		
8	Operating mode-specific	Halt	
7	Fault reset		
6…4	Operating mode-specific	reserved	
3	Enable operation		
2	Quick stop		
1	Enable voltage		
0	Switched on		

Table 7-55 Controlword bits

7.3.44 Statusword

Comprises bits for the following items:

- ➔“State of the Drive” on page 2-16 (bits 0…6)
- Operating state of the mode (bits 10, 12 and 13):
  ➔“Statusword (PVM-specific Bits)” on page 3-21
  ➔“Statusword (CST-specific Bits)” on page 3-23
- Internal limit active (bit 11: signals according to I2t method)
- Remote (bit 9: indicates NMT state is «Operational»)
- Warning (bit 7: indicates the presence of a warning condition)

Related objects: ➔“Controlword” on page 7-94

Name	Statusword	
Index	0x6041	
Subindex	0x00	
Data type	UNSIGNED16	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

Bit	Description	PVM	CST
15…14	reserved (0)		
13	Operating mode-specific	Not used	
12	Operating mode-specific	Speed	Drive follows command value
11	Internal limit active	max. speed I2t, current OV derating	
10	Operating mode-specific	Target reached	
9	Remote		
8	reserved (0)		
7	Warning		
6	Switch on disabled		
5	Quick stop		
4	Voltage enabled (power stage on)		
3	Fault		
2	Operation enabled		
1	Switched on		
0	Ready to switch on		

Table 7-56 Statusword bits

7.3.45 Modes of operation

Switches the operating mode. We recommend to use ➔Modes of operation display after changing the operation mode.

Related objects: ➔“Modes of operation display” on page 7-96

Name	Modes of operation
Index	0x6060
Subindex	0x00
Data type	INTEGER8
Access type	RW
Default value	3
Value range	➔Table 7-57
Backup	YES

Operation mode	Description
3	➔Profile Velocity Mode (PVM)
10	➔Cyclic Synchronous Torque Mode (CST)

Table 7-57 Modes of operation

7.3.46 Modes of operation display

Displays the actual mode of operation. The meaning of the returned value corresponds to the code in ➔Table 7-57.

Related objects: ➔“Modes of operation” on page 7-96

Name	Modes of operation display
Index	0x6061
Subindex	0x00
Data type	INTEGER8
Access type	RO
Default value	–
Value range	➔Table 7-57
Backup	NO

7.3.47 Velocity demand value

Used as input for the position controller. For profiled moves, the value is generated by the profile generator. Given in [velocity units] (➔page 2-18).

Name	Velocity demand value	
Index	0x606B	
Subindex	0x00	
Data type	INTEGER32	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.48 Velocity actual value

Provides the actual velocity value of the axis. If no main sensor is configured, the value is “0” (zero). Given in [velocity units] (➔page 2-18).

Related objects: ➔“Velocity actual value averaged” on page 7-77

Name	Velocity actual value	
Index	0x606C	
Subindex	0x00	
Data type	INTEGER32	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.49 Target torque

Indicates the configured input value for the torque controller in Cyclic Synchronous Torque Mode. Given in per thousand of ➔Motor rated torque).

Related objects: ➔“Motor rated torque” on page 7-98

Name	Target torque	
Index	0x6071	
Subindex	0x00	
Data type	INTEGER16	
Access type	RW	
Default value	0	
Value range	–	–
Backup	NO	

7.3.50 Motor rated torque

Reference value for all torque related objects. The value is defined as «Nominal current» multiplied by the «Torque constant». Given in [µNm].

Write access is permitted but has no effect.

Related objects: ➔“Motor data” on page 7-60

Name	Motor rated torque	
Index	0x6076	
Subindex	0x00	
Data type	UNSIGNED32	
Access type	RW	
Default value	0	
Value range	–	–
Backup	NO	

7.3.51 Torque actual value

Provides the actual torque and corresponds to the motor’s instantaneous torque. Given in per thousand of ➔Motor rated torque).

Related objects: ➔“Motor rated torque” on page 7-98

Name	Torque actual value	
Index	0x6077	
Subindex	0x00	
Data type	INTEGER16	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

7.3.52 Max profile velocity

Used as velocity limit in a PVM move. Given in [velocity units] (➔page 2-18).

Related objects: ➔“Max motor speed” on page 7-99 / ➔“Target velocity” on page 7-104

Name	Max profile velocity	
Index	0x607F	
Subindex	0x00	
Data type	UNSIGNED32	
Access type	RW	
Default value	5'000	
Value range	1	➔Max motor speed
Backup	YES	

7.3.53 Max motor speed

Indicates the configured maximum allowed speed for the motor. It serves as protection for the motor. Given in [rpm].

For detailed motor specifications ➔maxon catalog.

Related objects: ➔“Number of pole pairs” on page 7-61 / ➔“Max profile velocity” on page 7-98 / ➔“Target velocity” on page 7-104

Name	Max motor speed	
Index	0x6080	
Subindex	0x00	
Data type	UNSIGNED32	
Access type	RW	
Default value	5'000	
Value range	1	150’000 / number of pole pairs
Backup	YES	

7.3.54 Profile acceleration

Defines the acceleration value used during a profiled move. Given in [acceleration units] (➔page 2-18).

Name	Profile acceleration	
Index	0x6083	
Subindex	0x00	
Data type	UNSIGNED32	
Access type	RW	
Default value	4'000	
Value range	1	➔Max acceleration
Backup	YES	

7.3.55 Profile deceleration

Defines the deceleration value used during a profiled move. Given in [acceleration units] (➔page 2-18).

Name	Profile deceleration	
Index	0x6084	
Subindex	0x00	
Data type	UNSIGNED32	
Access type	RW	
Default value	2'000	
Value range	1	➔Max acceleration
Backup	YES	

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7.3.56 Quick stop deceleration

Used with a «Quick stop» command to determine the deceleration of the quick stop profile. Given in [acceleration units] (➔page 2-18).

Related objects: ➔“Controlword” on page 7-94

Name	Quick stop deceleration	
Index	0x6085	
Subindex	0x00	
Data type	UNSIGNED32	
Access type	RW	
Default value	2'000	
Value range	1	➔Max acceleration
Backup	YES	

7.3.57 Motion profile type

Selects the type of motion profile trajectory used in ➔“Profile Velocity Mode (PVM)” on page 3-19.

Name	Motion profile type	
Index	0x6086	
Subindex	0x00	
Data type	UNSIGNED16	
Access type	RW	
Default value	0	
Value range	➔Table 7-58	–
Backup	YES	

Value	Description
0	linear ramp (trapezoidal profile)

Table 7-58 Motion profile types

7.3.58 SI unit velocity

Defines the velocity units. Coding of the user-defined units and prefixes follows ➔chapter “2.2.1 SI Units” on page 2-18.

Write access is only permitted in device state «Power Disable».

Name	SI unit velocity
Index	0x60A9
Subindex	0x00
Data type	UNSIGNED32
Access type	RW
Default value	0x00B44700
Value range	➔Table 7-60
Backup	YES

Bit 31…24	Bit 23…16	Bit 15…8	Bit 7…0
Prefix	Numerator	Denominator	reserved (0)

Table 7-59 SI units velocity – Bits

Value	Description	Symbol
0x00B44700	Revolutions/minute	rev/min (rpm)

Table 7-60 SI units velocity – Value range

7.3.59 SI unit acceleration

Defines the acceleration units. Coding of the user-defined units and prefixes follows ➔chapter “2.2.1 SI Units” on page 2-18.

Write access is only permitted in device state «Power Disable».

Name	SI unit acceleration
Index	0x60AA
Subindex	0x00
Data type	UNSIGNED32
Access type	RW
Default value	0x00C00300
Value range	➔Table 7-62
Backup	YES

Bit 31…24	Bit 23…16	Bit 15…8	Bit 7…0
Prefix	Numerator	Denominator	reserved (0)

Table 7-61 SI units acceleration – Bits

Value	Description	Symbol
0x00C00300	(Revolutions/minute)/second	rpm/s

Table 7-62 SI units acceleration – Value range

7.3.60 Torque offset

Provides the offset of the torque. Given in per thousand of ➔Motor rated torque.

In CST, the given offset is added to the ➔Target torque.

Related objects: ➔“Target torque” on page 7-97

Name	Torque offset	
Index	0x60B2	
Subindex	0x00	
Data type	INTEGER16	
Access type	RW	
Default value	0	
Value range	–	–
Backup	NO	

7.3.61 Max acceleration

Used to limit the maximum allowed acceleration to prevent mechanical damage. It represents the limit of all other acceleration/deceleration objects of the axis. Given in [acceleration units] (➔page 2-18).

Related objects: ➔“Profile acceleration” on page 7-99 / ➔“Profile deceleration” on page 7-99 / ➔“Quick stop deceleration” on page 7-100

Name	Max acceleration	
Index	0x60C5	
Subindex	0x00	
Data type	UNSIGNED32	
Access type	RW	
Default value	100'000	
Value range	1	4'294'967'295
Backup	YES	

7.3.62 Digital inputs

Displays the state of the digital input functionalities (after polarity correction by ➔Digital input properties; Polarity). Number and assignment of the inputs are hardware-dependent (for details ➔separate document «User Manual» of respective controller).

Related objects: ➔“Digital input properties” on page 7-80 / ➔“Configuration of digital inputs” on page 7-81

Name	Digital inputs	
Index	0x60FD	
Subindex	0x00	
Data type	UNSIGNED32	
Access type	RO	
Default value	–	
Value range	–	–
Backup	NO	

Bit	Functionality	Description
31…17	reserved	–
16	General purpose A	State can be read
15…0	reserved	–

Table 7-63 Digital inputs

7.3.63 Digital outputs

Configures the state of the digital output functionalities (before polarity correction by ➔Digital output properties; Polarity). If a bit is set to “1” and the polarity bit is set to “0” (zero), the signal at the corresponding pin is high. Number and assignment of the outputs are hardware-dependent (for details ➔separate document «User Manual» of respective controller).

Related objects: ➔“Digital output properties” on page 7-85 / ➔“Configuration of digital outputs” on page 7-86

Name	Digital outputs	
Index	0x60FE	
Object code	ARRAY	
Highest subindex supported	1	

7.3.63.1 Physical outputs

Name	Physical outputs	
Index	0x60FE	
Subindex	0x01	
Data type	UNSIGNED32	
Access type	Bit 0…23: RW / Bit 24…31: RO	
Default value	0	
Value range	–	–
Backup	NO	

Bit	Functionality	Description
31…17	reserved	–
16	General purpose A	State can be read/written by the host
15…0	reserved	–

Table 7-64 Digital outputs

7.3.64 Target velocity

In Profile Velocity Mode (PVM), the object indicates the configured target velocity and is used as input for the trajectory generator. Given in [velocity units] (➔page 2-18).

Related objects: ➔“Max profile velocity” on page 7-98 / ➔“Max motor speed” on page 7-99 / ➔“Profile acceleration” on page 7-99 / ➔“Profile deceleration” on page 7-99

Name	Target velocity	
Index	0x60FF	
Subindex	0x00	
Data type	INTEGER32	
Access type	RW	
Default value	0	
Value range	−150'000	+150'000
Backup	NO	

7.3.65 Supported drive modes

Provides an overview of the implemented operating modes in the device. Supported are the following modes:

- ➔Profile Velocity Mode (PVM)
- ➔Cyclic Synchronous Torque Mode (CST)

Name	Supported drive modes	
Index	0x6502	
Subindex	0x00	
Data type	UNSIGNED32	
Access type	RO	
Default value	0x00000204	
Value range	–	–
Backup	NO	

Bit		Description
31…10	0	reserved
9	1	Cyclic Synchronous Torque Mode (CST)
8…3	0	reserved
2	1	Profile Velocity Mode (PVM)
1…0	0	reserved

Table 7-65 Supported drive modes – Bits

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8 ERROR HANDLING

8.1 Entries Overview

The controller can detect a variety of device errors. The reaction to an error depends on error type and fault reaction code. After execution of the fault reaction, the device changes to fault state and the drive will be disabled.
The ➔“Error history” on page 7-41 holds the error codes that occurred. The ➔“Error register” on page 7-40 holds a set of flags which provide a summary of the type of errors that have occurred. The flags remain set until all errors are explicitly cleared via the "Error History" or the "Controlword".

For fault reaction codes, the following notations will be used:

- d: A secure movement is no longer possible.
- w: No effect on device status (warning).
- c: Depends on the configuration in the error behavior object 0x2040.

Error code	Error register	Name	Fault reaction code
0x0000	0000 0000b	No Error	
0x1000	0000 0001b	➔Generic error	d
0x1080 0x1082	0000 0001b	➔Generic initialization error	d
0x2310	0000 0010b	➔Overcurrent error	c
0x2320	0000 0010b	➔Power stage protection error	c
0x3210	0000 0100b	➔Overvoltage error	c
0x3220	0000 0100b	➔Undervoltage error	c
0x4210	0000 1000b	➔Thermal power stage overload error	w
0x4380	0000 1000b	➔Thermal motor overload error	w
0x4381	0000 1000b	➔Thermal motor sensor error	d
0x4382	0000 1000b	➔Thermal motor supervision error	c
0x5280	0000 0001b	➔Hardware defect error	d
0x5281	0000 0001b	➔Hardware incompatibility error	d
0x5480	0000 0001b	➔Hardware MPA handler 1 error	d
0x5481	0000 0001b	➔Hardware MPA handler 2 error	d
0x6180 … 0x61FF	0000 0001b	➔Internal software error	d
0x6380	0000 0001b	➔CRC check failed error	d
0x8110	0001 0000b	➔CAN overrun error (object lost)	c
0x8120	0001 0000b	➔CAN passive mode error	c
0x81FD	0001 0000b	➔CAN bus turned off error	c
0x81FE	0001 0000b	➔CAN Rx queue overflow	c
0x81FF	0001 0000b	➔CAN Tx queue overflow	c
0x8290	0001 0000b	➔DroneCAN message error	c
0x8291	0001 0000b	➔DroneCAN receive message timeout	c
0x8A89	0000 0001b	➔RC-PWM set value input error	c
0xF000	0000 0001b	➔Process control message queue full error	c

Continued on next page.

Error code	Error register	Name	Fault reaction code
0xF001	0000 0001b	➔Process control busy switching error	c
0xF002	0000 0001b	➔Process initialization time-out error	c
0xF840	0000 0001b	➔Stall detection error during synchronous startup	c
0xF841	0000 0001b	➔Stall detection error during operation	c
0xFF01	0000 0001b	➔System overloaded error	c
0xFF02	0000 0001b	➔Watchdog error	c
0xFF0B	0000 0001b	➔System peak overloaded error	c

Table 8-66 Device error codes

8.2 Device Errors

8.2.1 Generic error

Error code	0x1000
Error register	0000 0001b
Cause	Unspecific error occurred
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error recovery	Reset fault with ➔Controlword

8.2.2 Generic initialization error

Error code	0x1080, 0x1082
Error register	0000 0001b
Cause	Unspecific critical error occurred during boot-up
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error recovery	Reset device. If the problem persists, contact your supplier.

8.2.3 Overcurrent error

Error code	0x2310
Error register	0000 0010b
Cause	Short circuit in motor winding. Controller gains too high and/or deceleration too high. Damaged power stage.
Effect	Depends on the settings in Error behavior object 0x2040-01
Error recovery	Reset fault with ➔Controlword

8.2.4 Power stage protection error

Error code	0x2320
Error register	0000 0010b
Cause	Short circuit of motor winding against ground. Short circuit of motor winding against operating voltage Vcc. Damaged power stage.
Effect	Depends on the settings in Error behavior object 0x2040-02
Error recovery	Reset fault with ➔Controlword

8.2.5 Overvoltage error

Error code	0x3210
Error register	0000 0100b
Cause	Power supply voltage too high
Effect	Depends on the settings in Error behavior object 0x2040-03
Error recovery	In most cases this error occurs at deceleration where the motor works as a generator and the energy flows from motor to power supply (resulting in an increased voltage). Usually, a capacitor (for example 2200 µF) close to the device will solve the problem. If not, a shunt regulator will be necessary to dissipate brake energy. Reset fault with ➔Controlword (only possible if supply voltage is in valid range).

8.2.6 Undervoltage error

Error code	0x3220
Error register	0000 0100b
Cause	Supply voltage is too low for operation. Power supply cannot supply required acceleration current.
Effect	Depends on the settings in Error behavior object 0x2040-04
Error recovery	Reset fault with ➔Controlword (only possible if supply voltage is in valid range)

8.2.7 Thermal power stage overload error

Error code	0x4210
Error register	0000 1000b
Cause	Temperature at device’s power stage too high
Effect	Warning only
Error recovery	Reset fault with ➔Controlword (only possible if temperature is in valid range)

8.2.8 Thermal motor overload error

Error code	0x4380
Error register	0000 1000b
Cause	Temperature at motor too high
Effect	Warning only
Error recovery	Reset fault with ➔Controlword (only possible if supply voltage is in valid range)

8.2.9 Thermal motor sensor error

Error code	0x4381
Error register	0000 1000b
Cause	Temperature at motor not measurable due to: • wrong/broken wiring of NTC temperature sensor • defective NTC temperature sensor • incompatible temperature sensor type
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error recovery	Reset fault with ➔Controlword (only possible if supply voltage is in valid range)

8.2.10 Thermal motor supervision error

Error code	0x4382
Error register	0000 1000b
Cause	I2t level motor limit exceeded. Specification object ➔ 0x3200-03
Effect	Depends on the settings in Error behavior object 0x2040-0D
Error recovery	Reset fault with ➔Controlword (only possible if supply voltage is in valid range)

8.2.11 Hardware defect error

Error code	0x5280
Error register	0000 0001b
Cause	Hardware problem detected
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error recovery	Reset device. If the problem persists, contact your supplier.

8.2.12 Hardware incompatibility error

Error code	0x5281
Error register	0000 0001b
Cause	An incompatible hardware combination was detected
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error recovery	Reset device. If the problem persists, contact your supplier.

8.2.13 Hardware MPA handler 1 error

Error code	0x5480
Error register	0000 0001b
Cause	A hardware problem was detected in the MPA handler
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error recovery	Reset device. If the problem persists, contact your supplier.

8.2.14 Hardware MPA handler 2 error

Error code	0x5481
Error register	0000 0001b
Cause	A hardware problem was detected in the MPA handler
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error recovery	Reset device. If the problem persists, contact your supplier.

8.2.15 Internal software error

Error codes	0x6180…0x61FF
Error register	0000 0001b
Cause	Internal software error occurred
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error recovery	Reset fault with ➔Controlword

8.2.16 CRC check failed error

Error code	0x6380
Error register	0000 0001b
Cause	Persistent parameters are corrupt and could not be loaded
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error recovery	Set parameters correctly by parameter import or in object dictionary. Store parameters and reset the device.

8.2.17 Hall sensor error

Error code	0x7388
Error register	0010 0000b
Cause	Motor Hall sensors report an impossible signal combination due to_ • incorrect wiring of Hall sensors • incorrect wiring of Hall sensors supply voltage • damage Hall sensors • big Hall sensors signal noise
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error recovery	Reset fault with ➔Controlword

8.2.18 CAN overrun error (object lost)

Error code	0x8110
Error register	0001 0000b
Cause	One of the CAN mailboxes experienced an overflow caused by too high communication rate
Effect	Depends on the settings in error behavior object 0x2040-11
Error recovery	Reset fault by clearing ➔Error history

8.2.19 CAN passive mode error

Error code	0x8120
Error register	0001 0000b
Cause	Device changed to CAN passive mode due to… • CAN bit rate of one CAN node in network wrong • CAN network not connected • hardware wiring of CAN bus not correct
Effect	Depends on the settings in error behavior object 0x2040-12
Error recovery	Reset fault by clearing ➔Error history

8.2.20 CAN bus turned off

Error code	0x81FD
Error register	0001 0000b
Cause	CAN controller has entered CAN bus off state
Effect	Depends on the settings in error behavior object 0x2040-13
Error recovery	Reset fault by clearing ➔Error history

8.2.21 CAN Rx queue overflow

Error code	0x81FE
Error register	0001 0000b
Cause	One of the CAN receive queues had an overrun caused by too high communication rate
Effect	Depends on the settings in error behavior object 0x2040-14
Error recovery	Reset fault by clearing ➔Error history

8.2.22 CAN Tx queue overflow

Error code	0x81FF
Error register	0001 0000b
Cause	The CAN transmit queue had an overrun caused by too high communication rate due to… • load on CAN bus too high • time triggered PDOs defined with too small rate • CAN bus inactive
Effect	Depends on the settings in error behavior object 0x2040-15
Error recovery	Reset fault by clearing ➔Error history

8.2.23 DroneCAN message error

Error code	0x8290
Error register	0001 0000b
Cause	Invalid DroneCAN message received due to for example: • Invalid crc • Short or incompatible frame • Wrong toggle bit • Wrong address
Effect	Depends on the settings in error behavior object 0x2040-16
Error recovery	Reset fault by clearing ➔Error history

8.2.24 DroneCAN receive message timeout

Error code	0x8291
Error register	0001 0000b
Cause	One of the expected receive messages was not received within the defined minimum rate
Effect	Depends on the settings in error behavior object 0x2040-17
Error recovery	Reset fault by clearing ➔Error history

8.2.25 RC-PWM set value input error

Error code	0x8A89
Error register	0000 0001b
Cause	RC-PWM pulse or frequency is out of specified range. For details see Firmware Specification object ➔0x3148-05 Frequency actual value and object ➔0x3148-06 Pulse width actual value.
Effect	Depends on the settings in Error behavior object 0x2040-06
Error recovery	Reset fault with ➔Controlword

8.2.26 Process control message queue full error

Error code	0xF000
Error register	0000 0001b
Cause	Internal communication message queues are full
Effect	Depends on the settings in Error behavior object 0x2040-07
Error recovery	Reset fault with ➔Controlword

8.2.27 Process control busy switching error

Error code	0xF001
Error register	0000 0001b
Cause	Busy switching process
Effect	Depends on the settings in Error behavior object 0x2040-08
Error recovery	Reset fault with ➔Controlword

8.2.28 Process initialization time-out error

Error code	0xF002
Error register	0000 0001b
Cause	A process was not able to finish its initialization in time
Effect	Depends on the settings in Error behavior object 0x2040-09
Error recovery	Reset fault with ➔Controlword

8.2.29 Gain calibration ramp-up timeout error

Error code	0xF800
Error register	0000 0001b
Cause	Unable to reach nominal current level during ramp-up phase
Effect	Warning Warning flag set in ➔Statusword
Error recovery	Reset fault with ➔Controlword

8.2.30 Gain calibration residual current timeout error

Error code	0xF801
Error register	0000 0001b
Cause	Residual current did not fall below noise threshold after gain measurement
Effect	Warning Warning flag set in ➔Statusword
Error recovery	Reset fault with ➔Controlword

8.2.31 Gain/offset calibration skipped error

Error code	0xF802
Error register	0000 0001b
Cause	Rotation on motor detected, gain/offset calibration has been skipped, using previous values.
Effect	Warning Warning flag set in ➔Statusword
Error recovery	Reset fault with ➔Controlword

8.2.32 Offset calibration results faulty error

Error code	0xF803
Error register	0000 0001b
Cause	Offsets exceed limits, gain/offset calibration has been skipped, using previous values.
Effect	Warning Warning flag set in ➔Statusword
Error recovery	Reset fault with ➔Controlword

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8.2.33 Polarity correction timeout error

Error code	0xF810
Error register	0000 0001b
Cause	Back EMF signal integral has not reached specified threshold within defined time
Effect	Device disabled Red LED «ON» Error flag set in ➔Statusword
Error recovery	Reset fault with ➔Controlword

8.2.34 Polarity correction PWM distortion error

Error code	0xF811
Error register	0000 0001b
Cause	PWM modulator reports PWM distortion
Effect	Device disabled Red LED «ON» Error flag set in ➔Statusword
Error recovery	Reset fault with ➔Controlword

8.2.35 Back EMF identification resistance value error

Error code	0xF820
Error register	0000 0001b
Cause	Back EMF identification reports an invalid resistance input value, please run electrical identification first.
Effect	Device disabled Red LED «ON» Error flag set in ➔Statusword
Error recovery	Reset fault with ➔Controlword

8.2.36 Harmonic offset calibration verification error

Error code	0xF830
Error register	0000 0001b
Cause	Harmonic offset calibration result quality out of tolerance.
Effect	Device disabled Red LED «ON» Error flag set in ➔Statusword
Error recovery	Reset fault with ➔Controlword

8.2.37 Stall detection error during synchronous startup

Error code	0xF840
Error register	0000 0001b
Cause	There was no switch from synchronous startup to back EMF state before the ➔Maximum synchronous velocity was reached. Possible cause is a blocked drive (stall condition).
Effect	Depends on the settings in error behavior object 0x2040-0C
Error recovery	Reset fault with ➔Controlword

8.2.38 Stall detection error during operation

Error code	0xF841
Error register	0000 0001b
Cause	There was not sufficient back EMF signal strength during operation in back EMF state. Possible cause is a blocked drive (stall condition).
Effect	Depends on the settings in error behavior object 0x2040-10
Error recovery	Reset fault with ➔Controlword

8.2.39 Arming timeout occurred during startup

Error code	0xF842
Error register	0000 0001b
Cause	Set value process data for arming is incorrect or missing.
Effect	Red LED “ON” Warning flag set in ➔Statusword
Error recovery	Automatic when ‘PWM velocity set value’ signal is present.

8.2.40 System overloaded error

Error code	0xFF01
Error register	0000 0001b
Cause	Device has not enough free resources to process new commands
Effect	Depends on the settings in Error behavior object 0x2040-0D
Error recovery	Reset fault with ➔Controlword

8.2.41 Watchdog error

Error code	0xFF02
Error register	0000 0001b
Cause	Cyclic monitoring has detected an invalid device status
Effect	Depends on the settings in Error behavior object 0x2040-0E
Error recovery	Reset fault with ➔Controlword

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8.2.42 System peak overloaded error

Error code	0xFF0B
Error register	0000 0001b
Cause	Device has not enough free resources to provide proper regulation
Effect	Depends on the settings in Error behavior object 0x2040-0F
Error recovery	Reset fault with ➔Controlword

9 FIRMWARE VERSION HISTORY

9.1 Version Overview

Date [yyyy-mm]	Version		Application		Description
	Software	Hardware	#	Version	
2022-11	0130h	A400h, A401h	0000h	0000h	New hardware, new features, bug fixing
2020-09	0120h	A400h	0000h	0000h	First official release

Table 9-67 Version overview

9.2 Version History

UAVESC_0130h_Axxxh_0000h_0000h (Release 2022-11)		
Binary Files	UAV-ESC 52/30 Digital I/O	UAVESC_0130h_A400h_0000h_0000h.bin
	UAV-ESC 52/30 CAN	UAVESC_0130h_A401h_0000h_0000h.bin
Features	Introduction	UAV-ESC 52/30 CAN
	Communication	New DroneCAN communication for UAV_ESC 50/30 CAN
	Parameter	New axis polarity object
	Motor thermal protection	Support of motor temperature sensor
	Over voltage protection	New over voltage derating functionality
Changes	Bugfix	General minor bug fixing and improvements

UAVESC_0120h_A400h_0000h_0000h (Release 2020-09)		
Binary Files	UAV-ESC 52/30 Digital I/O	UAVESC_0120h_A400h_0000h_0000h.bin
Features	Full range	First official release

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