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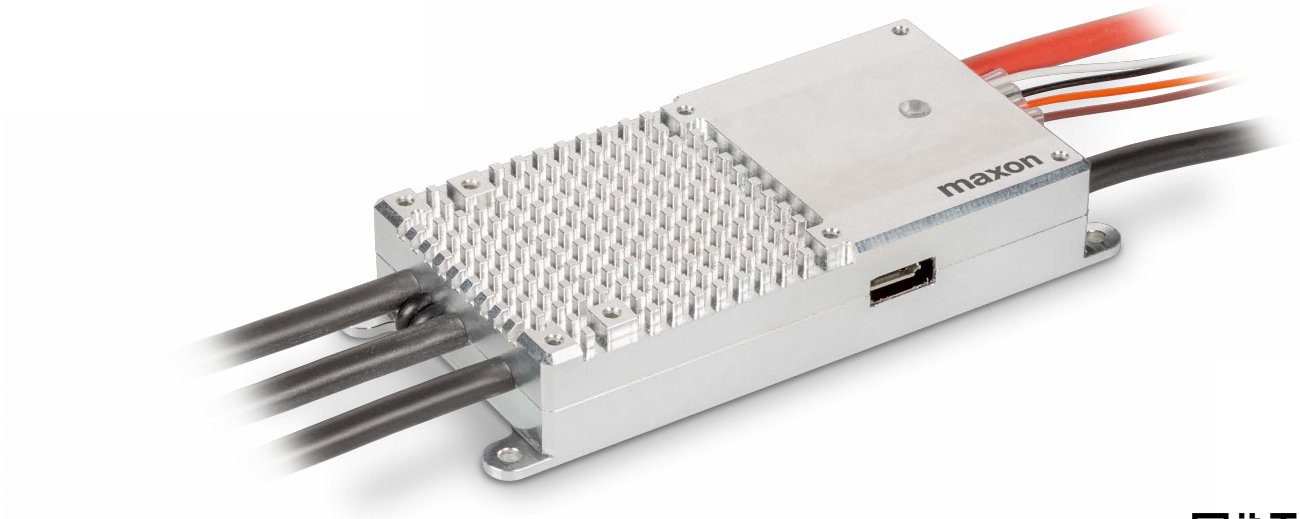
UAV-ESC 52/30

User Manual



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UAV-ESC 52/30 Electronic Speed Controller | P/N's 654541 / 654538
User Manual
CCMC | Edition 2022-11 | DocID rel10924

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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 52/30 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.

TABLE OF CONTENTS

1 ABOUT

The «UAV-ESC 52/30» must be installed in a particular and specific way. Therefore, closely follow the described information in given order to achieve both safe and easy installation as well as reliable operational service.

The easiest and safest way of doing

- *Do not engage with any task unless you have the knowledge to do so.*
- *Make sure that you have read and understood the safety precautions. Observe them, keep them in mind, and follow them at all times.*
- *Follow the description in given order. Work your way through the document. Do not skip nor cut short any sections.*
- *Read the «General Rules» at the beginning of a chapter closely. Observe them, keep them in mind, and follow them at all times.*

1.1 About this Document

Use the document to…
–stay safe,
–be fast,
–end up with set up and ready-to-go equipment.

1.1.1 Intended Purpose

The purpose of the present document is to familiarize you with the UAV-ESC 52/30 Electronic Speed Controller. 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:

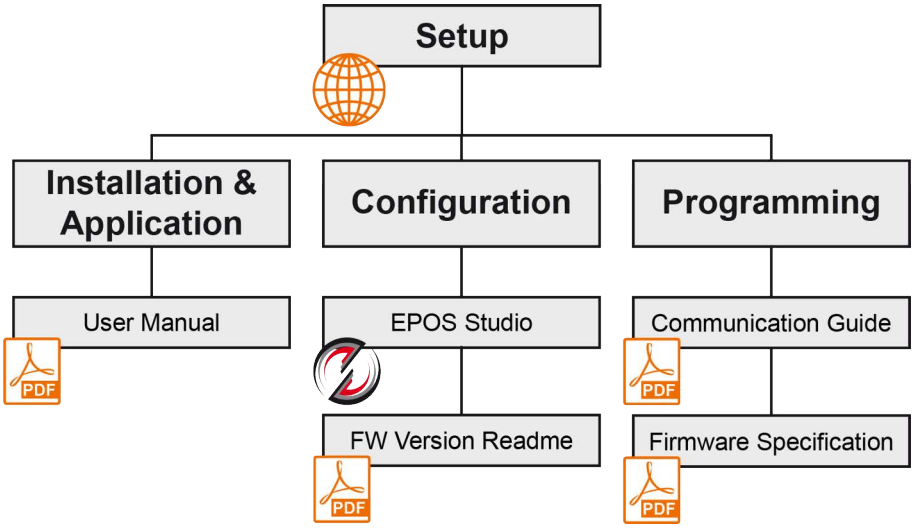

Figure 1-1 Documentation structure

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.

1.1.3 How to use

Throughout the document, the following notations and codes will be used.

Notation	Meaning
(n)	refers to an item (such as part numbers, list items, etc.)
➔	denotes “see”, “see also”, “take note of” or “go to”

Table 1-1 Notation used

1.1.4 Symbols & Signs

In the course of the present document, the following symbols and signs will be used.

Type	Symbol	Meaning	
Safety alert		DANGER	Indicates an **imminent hazardous situation**. If not avoided, it **will result in death or serious injury**.
		WARNING	Indicates a **potential hazardous situation**. If not avoided, it **can result in death or serious injury**.
		CAUTION	Indicates a **probable hazardous situation** or calls the attention to unsafe practices. If not avoided, it **may result in injury**.
Prohibited action	 (typical)	Indicates a dangerous action. Hence, **you must not**!	
Mandatory action	 (typical)	Indicates a mandatory action. Hence, **you must**!	
Information		Requirement / Note / Remark	Indicates an activity you must perform prior continuing, or gives information on a particular item you need to observe.
		Best practice	Indicates an advice or recommendation on the easiest and best way to further proceed.
		Material damage	Indicates information particular to possible damage of the equipment.

Table 1-2 Symbols and signs

1.1.5 Trademarks & 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 list below is not necessarily concluding) are pro-

tected 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
Pico-SPOX	© Molex, USA-Lisle, IL
CANopen® CiA®	© CiA CAN in Automation e.v, DE-Nuernberg
Vimeo®	© Vimeo.com, Inc., USA-New York, NY

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

1.1.7 Copyright

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1.2 About the Device

Capabilities of the device, included features.

maxon's «UAV-ESC 52/30 Digital-I/O» and «UAV-ESC 52/30 CAN» are high-performance sensorless electronic speed controller (ESC) for PMSM/BLDC motors designed for use in propulsion systems of electric unmanned aerial vehicles (UAVs). This document covers both products, if not explicitly mentioned the expression «UAV-ESC 52/30» covers both variants. They are designed for applications, in which both high reliability and high performance are of importance.

The «Digital-I/O» version with opto-isolated input and output is particularly suitable for classic RC servo signals and is fully configurable. The «CAN» version is made for system integration based on the DroneCAN protocol.

Latest technology, such as field-oriented control (FOC) combined with a very dynamic closed-loop speed controller capable of up to 150'000 rpm electrical speed create new opportunities in regard to system design and performance.

An intuitive PC-based EPOS studio software allows commissioning, configuration, and monitoring of functions and parameters, such as set value input, speed, current, temperature, and many more. Via USB, settings can easily been performed, verified, and duplicated.

Find the latest edition of the present document as well as additional documentation and software for UAV electronic speed controllers also on the internet: ➔https://uav.maxongroup.com

In addition, you may wish to browse the EPOS video library. It features video tutorials that provide easy to follow instructions on how to get started with «EPOS Studio» and shows you tip and tricks on how to set up communication interfaces, and so on. Explore on Vimeo: ➔https://vimeo.com/album/4646388

The aluminum housing seals the capsuled electronics against dust and humidity. In addition, the housing features excellent heat dissipation capabilities, which allow stable, reliable, and long-term operation even during highly intense operational periods.

Active protective functions prevent both ESC and motor from operating in dangerous conditions. Thereby, the error behavior can be configured and adjusted as required.

For easier legibility, in the later course of this document naming of components will be as follows:

Short form	Meaning
BLDC motor	Brushless direct current motor
ESC	Electronic speed controller
FOC	Field-oriented control
LiPo	Lithium-ion polymer battery
NTC	Negative temperature coefficient thermistor (thermally-sensitive resistor)
PMSM	Permanent magnet synchronous motor
UAV	Unmanned aerial vehicle

Table 1-4 Abbreviations

1.3 About the Safety Precautions

Keep in mind: Safety first!

- Make sure to read and understand the note “READ THIS FIRST” on page A-2.
- Do not engage with any work unless you possess the stated skills (➔chapter “1.1.2 Target Audience” on page 1-5).
- Refer to ➔chapter “1.1.4 Symbols & Signs” on page 1-6 to understand the subsequently used indicators.
- Make sure that you observe any regulation with regard to health, safety, and accident prevention as well as to environmental protection applicable in your country and at the site of implementation.
- Make sure to closely read and understand the «General Rules» at the beginning of a chapter. Observe them, keep them in mind, and follow them at all times.

DANGER

High voltage and/or electrical shock
Touching live wires causes death or serious injuries!

- *Consider any power cable as connected to live power, unless having proven the opposite!*
- *Make sure that neither end of cable is connected to live power!*
- *Make sure that power source cannot be engaged while work is in process!*
- *Obey lock-out/tag-out procedures!*
- *Make sure to securely lock any power engaging equipment against unintentional engagement and tag it with your name!*

Requirements

- *Make sure that all associated devices and components are installed according to local regulations.*
- *Be aware that, by principle, an electronic apparatus can not be considered fail-safe. Therefore, you must make sure that any machine/apparatus has been fitted with independent monitoring and safety equipment. If the machine/apparatus should break down, if it is operated incorrectly, if the control unit breaks down or if the cables break or get disconnected, etc., the complete drive system must return and be kept in a safe operating mode.*
- *Be aware that you are not entitled to perform any repair on components supplied by maxon.*

Electrostatic sensitive device (ESD)

- *Wear working cloth and use equipment in compliance with ESD protective measures.*
- *Handle device with extra care.*

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2 SPECIFICATIONS

2.1 Technical data

Parameter		UAV-ESC 52/30 Digital-I/O (654541)	UAV-ESC 52/30 CAN (654538)
Electrical data	Nominal power supply voltage $+V_{CC}$	9…52.2 VDC (3S…12S LiPo)	
	Absolute supply voltage $+V_{min}$ / $+V_{max}$	8 VDC / 56 VDC	
	Output voltage (max.)	0.95 x $+V_{CC}$	
	Output current I_{cont} Airflow 0 m/s; no additional heat sink; T_A 20 °C; $+V_{CC}$ 52.2 V	30 A	
	Output current I_{max} Airflow 0 m/s; no additional heat sink; T_A 20 °C; $+V_{CC}$ 52.2 V; t < 25 s	90 A	
	Pulse width modulation frequency	25 kHz	
	Commutation	Sensorless, FOC	
	Sampling rate PI current controller	25 kHz (40 µs)	
	Sampling rate PI speed controller (closed loop)	2.5 kHz (400 µs)	
	Max. efficiency	>99%	
	Max. speed EC motor (sinusoidal)	150'000 rpm (1 pole pair)	
	Built-in motor choke	none	
Inputs & Outputs	Digital input «Set Value»	+2.50…+5.25 VDC (optically isolated); pulse width distortion max. 50 ns	–
	Digital output «Speed Monitor e-rpm»	max. 12 VDC / I_L ≤15 mA (optically isolated); max. 2.5 kHz	–
	Analog input «Motor winding temperature»	for use with NTC resistors 10 kΩ; B25/85 = 3435 K, 3490 K, 3610 K, 4000 K and 4480 K	
Motor connections	BLDC motor	Motor winding 1, 2, 3	
Interfaces	USB	USB 2.0, Full Speed	
	CAN	–	max. 1 Mbit/s
Status indicators	Device status	multi color LED (see chapter “System Status Indication” on page 4-32)	

Continued on next page.

Parameter			UAV-ESC 52/30 Digital-I/O (654541)	UAV-ESC 52/30 CAN (654538)
Physical	Dimensions (L x W x H)		86.0 x 38.0 x 17.0 mm	
	Weight	ESC with housing/with cables	approx. 102 g	
		ESC with housing/without cables	approx. 53 g	
		ESC without housing/with cables	approx. 66 g	
		ESC without housing/cables	approx. 18 g	
	Mounting		4 mounting holes for M2 screws	
Environmental conditions	Temperature [a]	Operation	−30…+20 °C	
		Extended range [b]	+20…+72 °C Derating ➔Figure 2-2	
		Storage	−40…+85 °C	
	Altitude	Operation [c]	0…6'000 m MSL	
	Humidity		5…90% [d]	

[a] Without additional heat sink or airflow. For details see ➔chapter “Derating of output current” on page 2-13.

[b] Operation within the extended range (temperature) is permitted. However, a respective derating (declination of output current I_{cont}) as to the stated values will apply.

[c] Operating altitude in meters above Mean Sea Level, AMSL

[d] Condensation over extended periods or water immersion are not permitted

Table 2-5 Technical data

2.2 Thermal data

2.2.1 Derating of output current

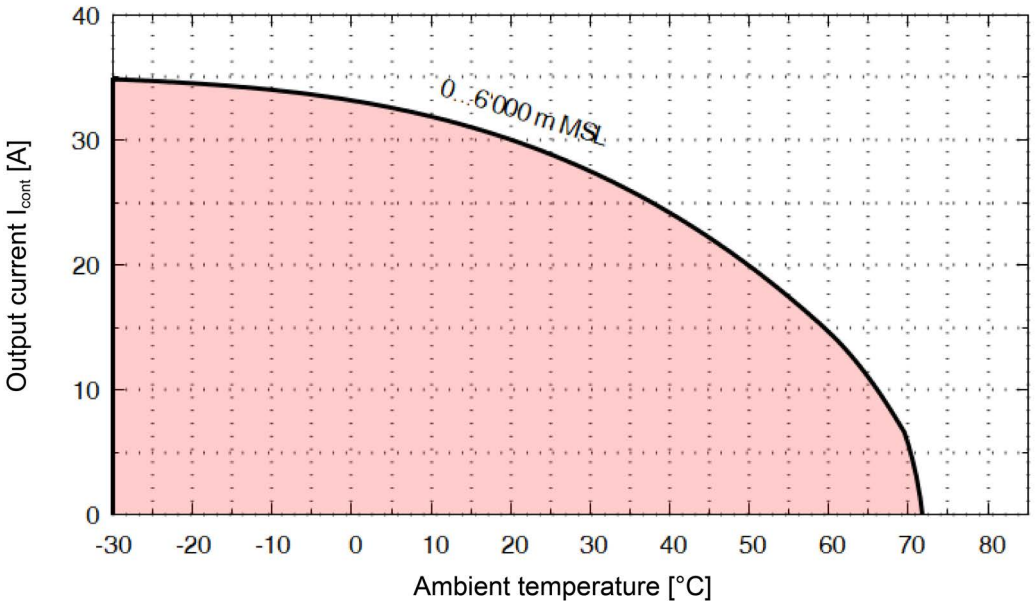

Figure 2-2 Derating of output current

2.2.2 Increase of output current

The following diagram shows the permissible continuous output current under additional airflow without causing the controller to overheat. The graph shows the permitted additional output current in relation to the continuous output current as determined according to the previous chapter “2.2.1 Derating of output current” on page 2-13.

Conditions: 0 (zero) m AMSL; dry air

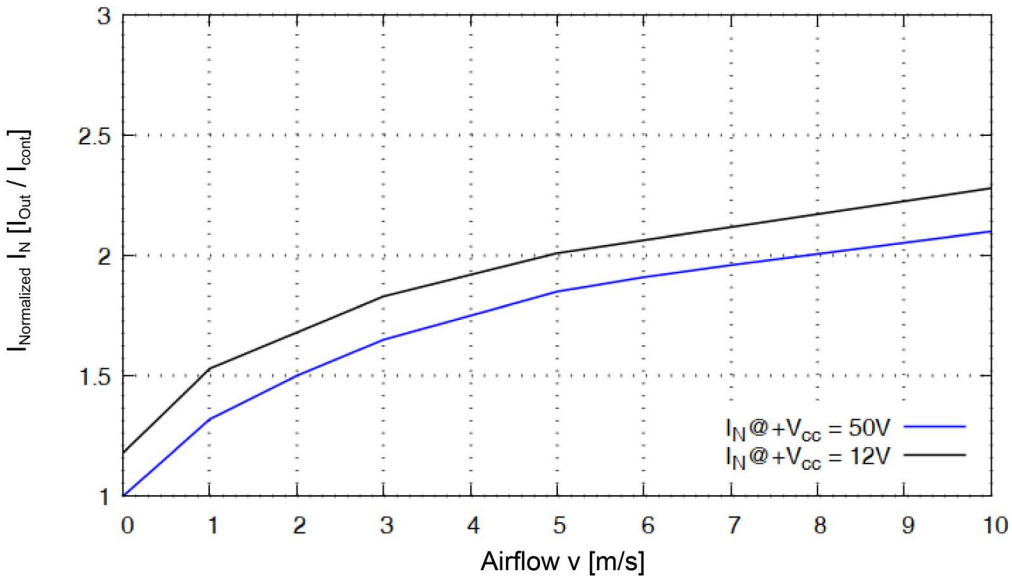

Figure 2-3 Increase of output current

2.3 Limitations

Protection functionality	Switch-off threshold	Recovery threshold
Undervoltage	7.3 V	7.7 V
Overvoltage	58.0 V	57.6 V
Overcurrent	160 A	—
Thermal overload	Safeguarded by self-regulating output power limitation; the maximum output current I_{max} is linearly decreased between an electronics temperature of +85…+95 °C: I_{max} @ −30…+85 °C: 90 A I_{max} @ +95 °C: 15 A	

Table 2-6 Limitations

2.4 Dimensional drawing

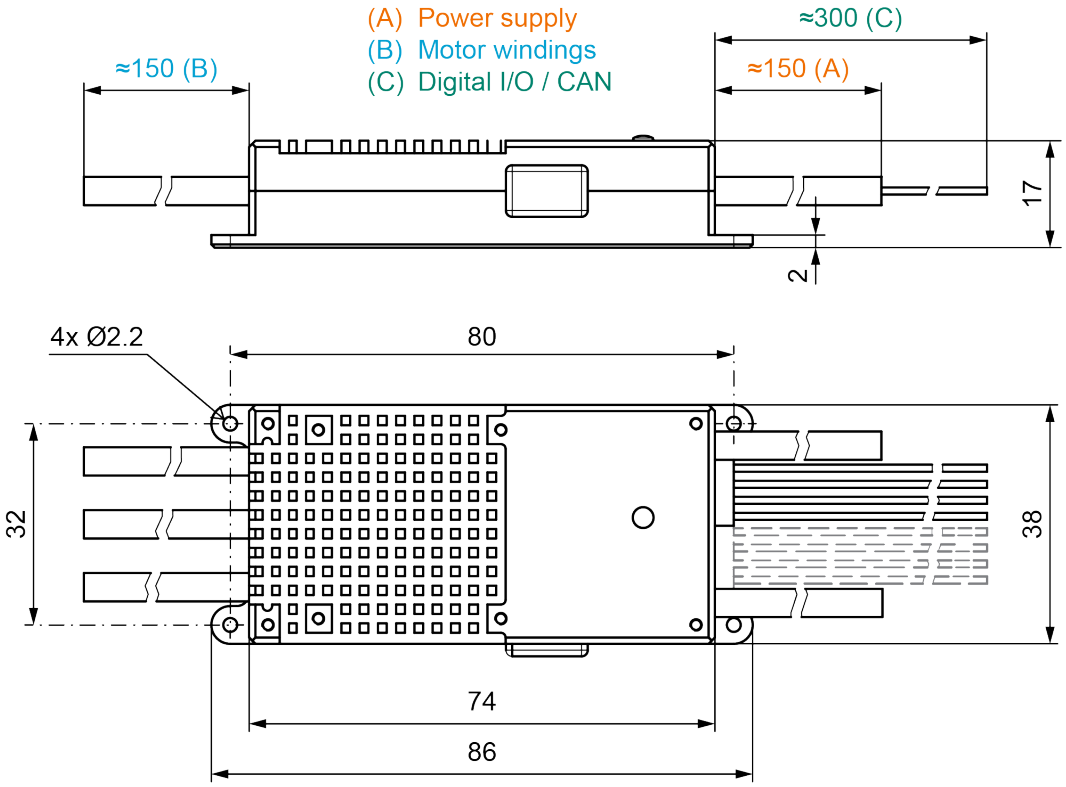

Figure 2-4 UAV-ESC 52/30 | Dimensional drawing [mm]

2.5 Standards & directives

The described device has been successfully tested for compliance with the below listed standards.
Only the complete system (the fully operational equipment comprising all individual components, such as motor, controller, power supply unit, EMC filter, cabling etc.) can undergo an EMC test to ensure interference-free operation.

Others		
Environment	IEC/EN 60068-2-6	Environmental testing – Test Fc: Vibration (sinusoidal, 10…500 Hz, 20 m/s^2)
	MIL-STD-810F	Random transport (10…500 Hz up to 2.53 g_{rms})
Safety	UL File Number	Unassembled printed circuit board E214297

Table 2-7 Standards

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3 ELECTRICAL INSTALLATION

3.1 General rules

WARNING

Risk of injury
Unintentional or automatic operation can lead to serious injury
- *Make sure that the surrounding system is protected from automatic start-up.*
- *Make sure to apply all necessary safeguards against unintentional operation.*

Improper handling can cause irreversible hardware damage
- *Handle all components with care.*
- *Pay special attention to cleanliness.*
- *Handle connectors and cables with special care; do not kink, bend, strain, or route around sharp edges.*

Maximal permitted supply voltage
- *Make sure that supply power is between 9…52.2 VDC.*
- *Supply voltages above 58 VDC, or wrong polarity will destroy the unit.*
- *Note that the necessary output current is depending on the load torque. Yet, the output current limits are as follows:*
  – continuous 30 A, without additional heat sink or airflow
  – short-time (acceleration) max. 90 A

Hot plugging the USB interface may cause hardware damage
If the USB interface is being hot-plugged (connecting while the power supply is on), the possibly high potential differences of the two power supplies of controller and PC/Notebook can lead to damaged hardware.
- *Avoid potential differences between the power supply of controller and PC/Notebook or, if possible, balance them.*
- *Insert the USB connector first, then switch on the power supply of the controller.*

3.2 Connections

You may connect the controller in two different ways:

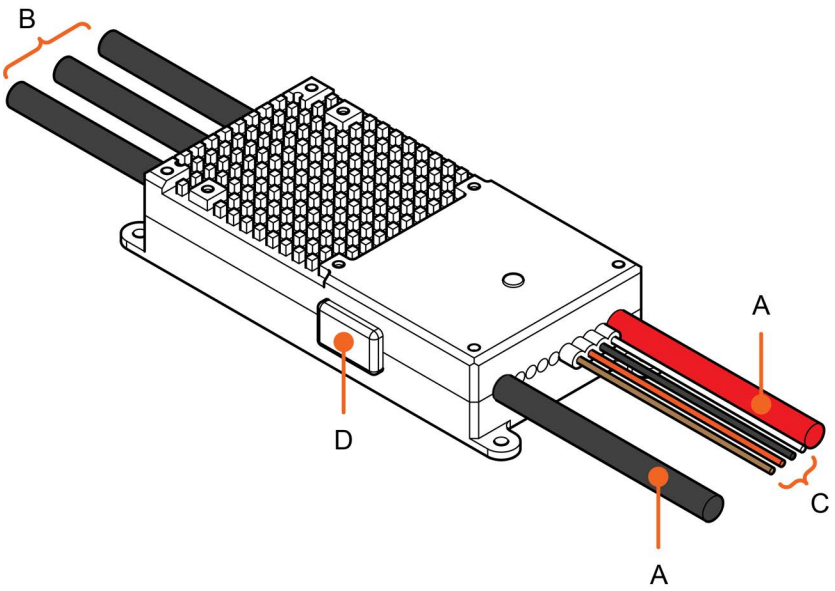
a) Either use the prefab wires and cables (➔chapter “3.2.1 Prefab cables and wires” on page 3-18).

b) Or directly solder your cables to the controller’s printed circuit board (➔chapter “3.2.2 Connection to solder pads” on page 3-21).

3.2.1 Prefab cables and wires

3.2.1.1 UAV-ESC 52/30 Digital-I/O (654541)

UAV-ESC 52/30 with opto-isolated Digital-I/Os



A Power supply (X1, X2) ➔page 3-22

B Motor (X3, X4, X5) ➔page 3-22

C Digital-I/Os (X6) ➔page 3-23

D USB (X9) ➔page 3-27

Figure 3-5 Prefab cables and wires

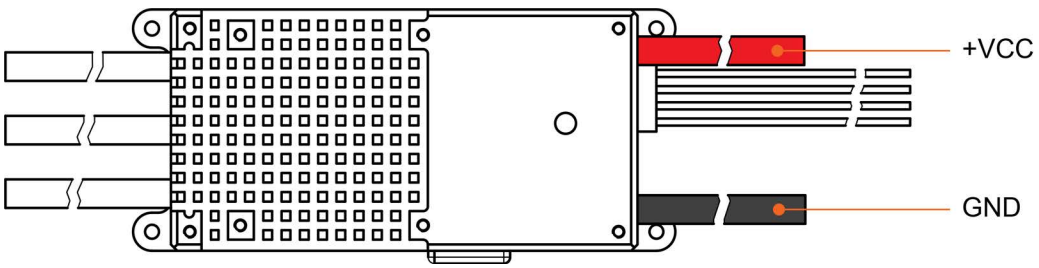


Figure 3-6 Cables & wires: Power supply

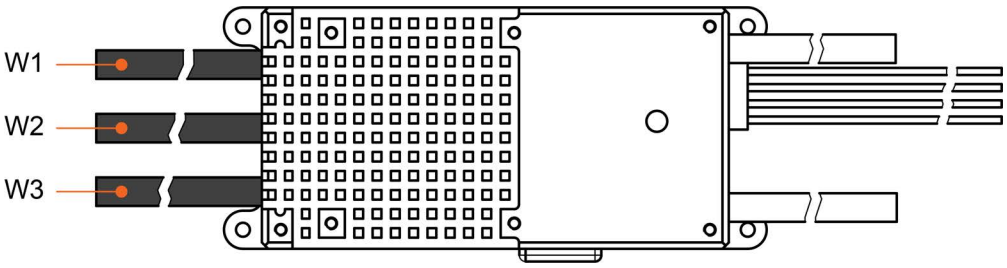


Figure 3-7 Cables & wires: Motor

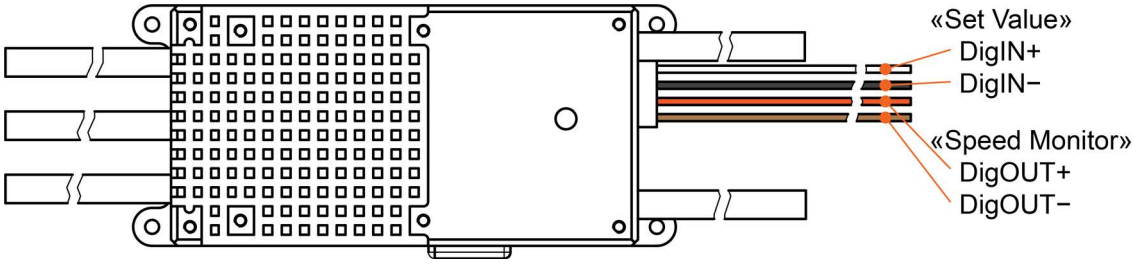
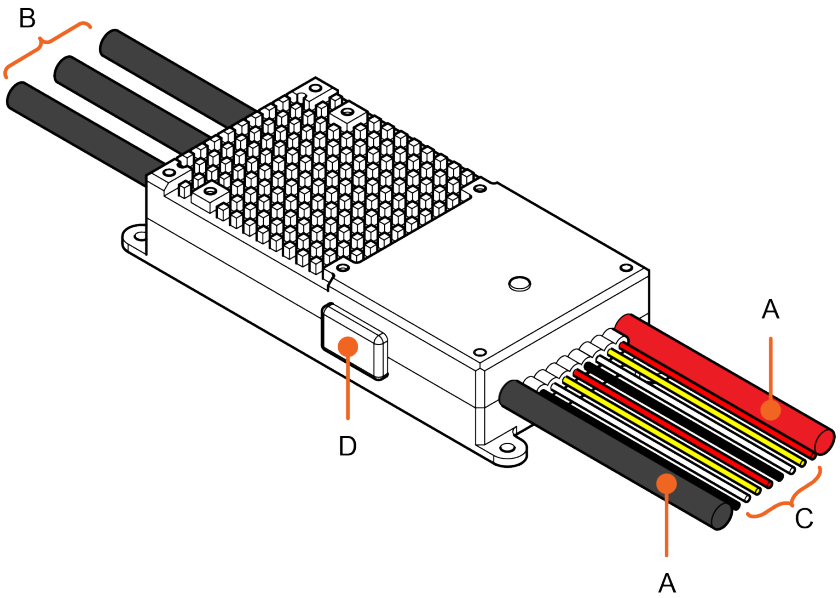


Figure 3-8 Cables & wires: Digital-I/Os

3.2.1.2 UAV-ESC 52/30 CAN (654541)

UAV-ESC 52/30 with opto-isolated CAN



A Power supply (X1, X2) ➔page 3-22

B Motor (X3, X4, X5) ➔page 3-22

C CAN (X6, X7) ➔page 3-25

D USB (X9) ➔page 3-27

Figure 3-9 Prefab cables and wires

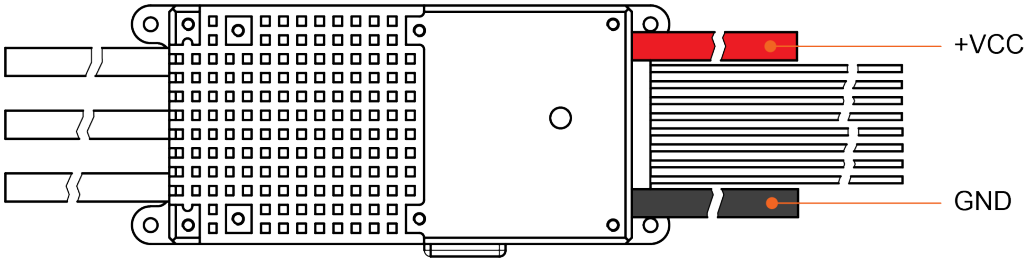


Figure 3-10 Cables & wires: Power supply

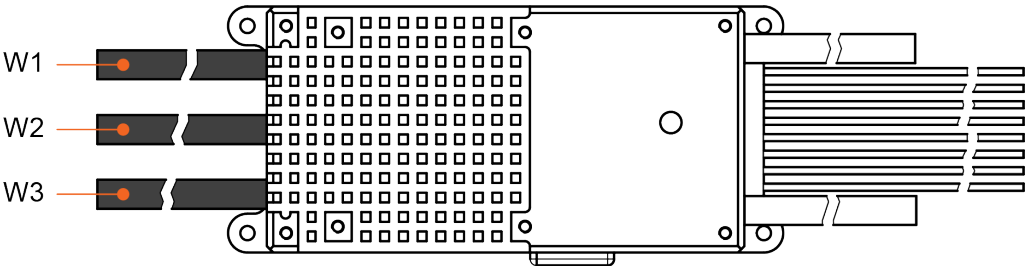


Figure 3-11 Cables & wires: Motor

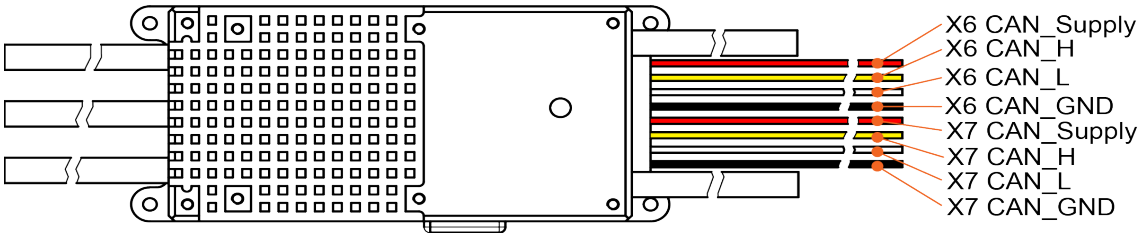
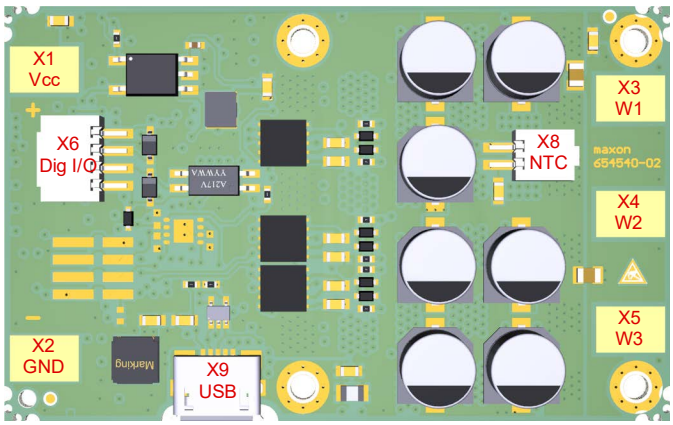


Figure 3-12 Cables & wires: CAN

3.2.2 Connection to solder pads

The UAV-ESC 52/30 might be used without housing and prefab cables. If doing so, the installer must ensure proper cooling/thermal connection of the device and usage of electrical cables/wires with appropriate size. All specifications given in this document are related to the UAV-ESC 52/30 with housing and prefab cables.

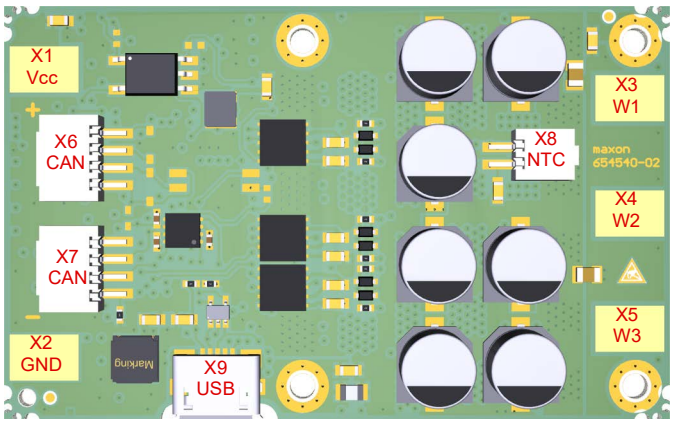
UAV-ESC 52/30 Digital-I/O (654541), without housing and prefab cables



X1 **Power supply (X1, X2)**
X2 **➔page 3-22**
X3
X4 **Motor (X3, X4, X5) ➔page 3-22**
X5
X6 **Digital-I/Os (X6) ➔page 3-23**
X8 **Analog Input (X8) ➔page 3-26**
X9 **USB (X9) ➔page 3-27**

Figure 3-13 Connections to solder pads - UAV-ESC 52/30 Digital-I/O

UAV-ESC 52/30 CAN (654538), without housing and prefab cables



X1 **Power supply (X1, X2)**
X2 **➔page 3-22**
X3
X4 **Motor (X3, X4, X5) ➔page 3-22**
X5
X6 **CAN (X6, X7) ➔page 3-25**
X7
X8 **Analog Input (X8) ➔page 3-26**
X9 **USB (X9) ➔page 3-27**

Figure 3-14 Connections to solder pads - UAV-ESC 52/30 CAN

3.2.3 Connection specifications

3.2.3.1 Power supply (X1, X2)

Solder pad	Cable color	Signal	Description
X1	red	+VCC	Power supply voltage (9…52.2 VDC)
X2	black	GND	GND

Table 3-8 Power supply connection X1 & X2 – Pin assignment

Cable	
Type	AWG12, silicone, highly flexible, high-temperature resistant (>150 °C)
Outer diameter	approximately 4.4 mm
Length	150 mm

Table 3-9 Power supply connection X1 & X2 – Cable specifications

3.2.3.2 Motor (X3, X4, X5)

Solder pad	Cable color	Signal	Description
X3	black	W1	Motor winding 1
X4	black	W2	Motor winding 2
X5	black	W3	Motor winding 3

Table 3-10 Motor connection X3, X4 & X5 – Pin assignment

Cable	
Type	AWG12, silicone, highly flexible, high-temperature resistant (>150 °C)
Outer diameter	approximately 4.4 mm
Length	150 mm

Table 3-11 Motor connection X3, X4 & X5 – Cable specifications

3.2.3.3 Digital-I/Os (X6)

Note: This object is available with UAV-ESC 52/30 Digital-I/O (654541) only

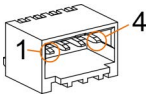


Figure 3-15 Digital-I/Os connector X6

Pin	Cable color	Signal	Description
X6 | 1	white	DigIN+	Digital input «Set Value» plus
X6 | 2	black	DigIN−	Digital input «Set Value» minus
X6 | 3	orange	DigOUT+	Digital output «Speed Monitor» plus
X6 | 4	brown	DigOUT−	Digital output «Speed Monitor» minus

Table 3-12 Digital-I/Os connector X6 – Pin assignment

Cable	
Type	AWG24, PTFE, flexible, high-temperature resistant (200 °C)
Outer diameter	approximately 1 mm
Length	300 mm

Table 3-13 Digital-I/Os connector X6 – Cable specifications

Connector		
On board	Header	Molex (874380443)
Suitable plug	Housing	Molex (874390400)
	Crimp terminal	Molex (874210000), AWG 24-26, Tin Molex (874210002), AWG 24-26, Gold
Recommended tool	Hand crimp tool	Molex (2002183900)

Table 3-14 Digital-I/Os connector X6 – Connector specifications

Continued on next page.

Digital input	
Circuit type	Optically isolated input
Input voltage	0…5 VDC
Max. input voltage	−5.0…+5.25 VDC
Logic 0	<0.8 V
Logic 1	>2.5 V
Input current	<8 mA @ 5.25 VDC
Pulse width distortion	<50 ns

Table 3-15 Digital input specification

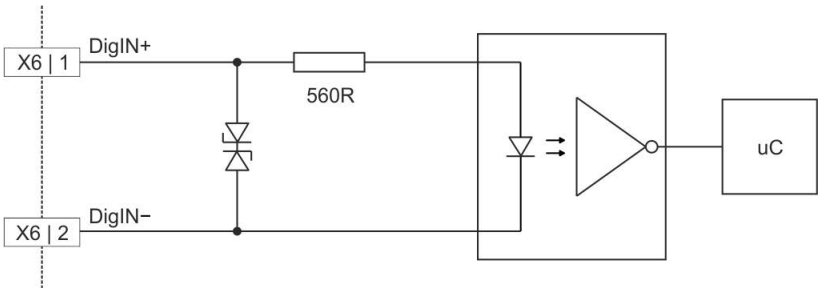


Figure 3-16 Digital input «Set Value» circuit

Digital output		
Circuit type		Optically isolated output
Max. input voltage		12 VDC
Max. load current		15 mA
Leakage current @ OFF state		<10 µA
Voltage drop @ ON state		<0.4 V
Max. output frequency		2.5 kHz
Optocoupler On/Off state transition delay		typically 25 µs @ $R_{Pull-Up}$ 1 kΩ; C_L 470 pF typically 70 µs @ $R_{Pull-Up}$ 10 kΩ; C_L 470 pF
Optocoupler Off/On state transition delay		typically 1.1 µs @ $R_{Pull-Up}$ 1…10 kΩ; C_L 470 pF
Pull-up resistor R_{PullUp} (external, not included)	Minimum	$R_{PullUpMin} \geq \frac{V_{DD}}{0.015A}$
	Maximum	$R_{PullUpMax} \leq \frac{t \approx 4000000ps}{C_L + 50pF}$
	Recommended	$R_{PullUp} = 1\ldots10k\Omega$

Table 3-16 Digital output specification

Continued on next page.

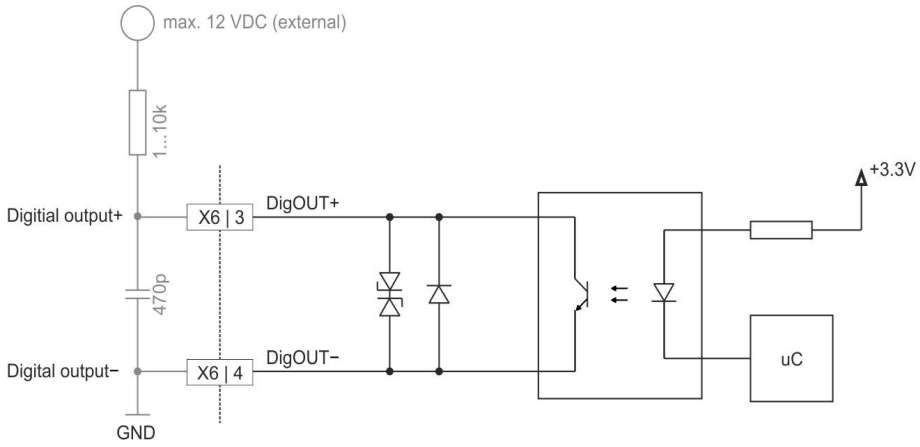


Figure 3-17 Digital output «Speed Monitor» circuit

3.2.3.4 CAN (X6, X7)

Note: This object is available with UAV-ESC 52/30 CAN (654538) only

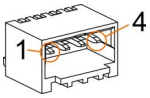


Figure 3-18 CAN connector X6 & X7

Pin	Cable color	Signal	Description
X6 | 1 X7 | 1	red	CAN_Supply	CAN external supply
X6 | 2 X7 | 2	yellow	CAN_H	CAN high bus line
X6 | 3 X7 | 3	white	CAN_L	CAN low bus line
X6 | 4 X7 | 4	black	CAN_GND	Ground

Table 3-17 CAN connector X6 & X7 – Pin assignment

Connector		
On board	Header	Molex (874380443)
Suitable plug	Housing	Molex (874390400)
	Crimp terminal	Molex (874210000), AWG 24-26, Tin Molex (874210002), AWG 24-26, Gold
Recommended tool	Hand crimp tool	Molex (2002183900)

Table 3-18 CAN connector X6 & X7 – specifications

CAN interface	
Standard	ISO 11898-2:2003
Max. CAN power supply voltage	52.2 VDC (12S LiPo)
Max. CAN power supply current	1A
Max. bit rate	1 Mbit/s
Max. number of CAN nodes	127
Protocol	DroneCAN v1
Node-ID setting	by software

Table 3-19 CAN interface specification

Note:
- *Consider the CAN master's maximal bit rate.*
- *The standard Node-ID setting (factory setting) is 1.*
- *The standard bit rate setting (factory setting) is 1 Mbit/s.*
- *Use 120 Ω Termination resistors at both ends of the CAN bus.*
- *The «CAN_Supply»* signal is not in use by the UAV-ESC 52/30 but just looped in between the CAN connectors X6 and X7.

3.2.3.5 Analog Input (X8)

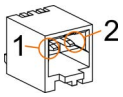


Figure 3-19 Analog input connector X8

Pin	Signal	Description
X8 | 1	AnIN	Analog input «Motor winding temperature»
X8 | 2	GND	Ground

Table 3-20 Analog input connector X8 – Pin assignment

Connector		
On board	Header	Molex (874380243)
Suitable plug	Housing	Molex (874390400)
	Crimp terminal	Molex (874210000), AWG 24-26, Tin
Recommended tool	Hand crimp tool	Molex (2002188900)

Table 3-21 Analog input connector X8 – specifications

For connecting a suitable cable assembly to the analog input, the controllers housing must be disassembled. When the housing is assembled again, make sure that all cables and wires are positioned properly in the cutouts. The screws shall be secured with appropriate thread locking adhesives.

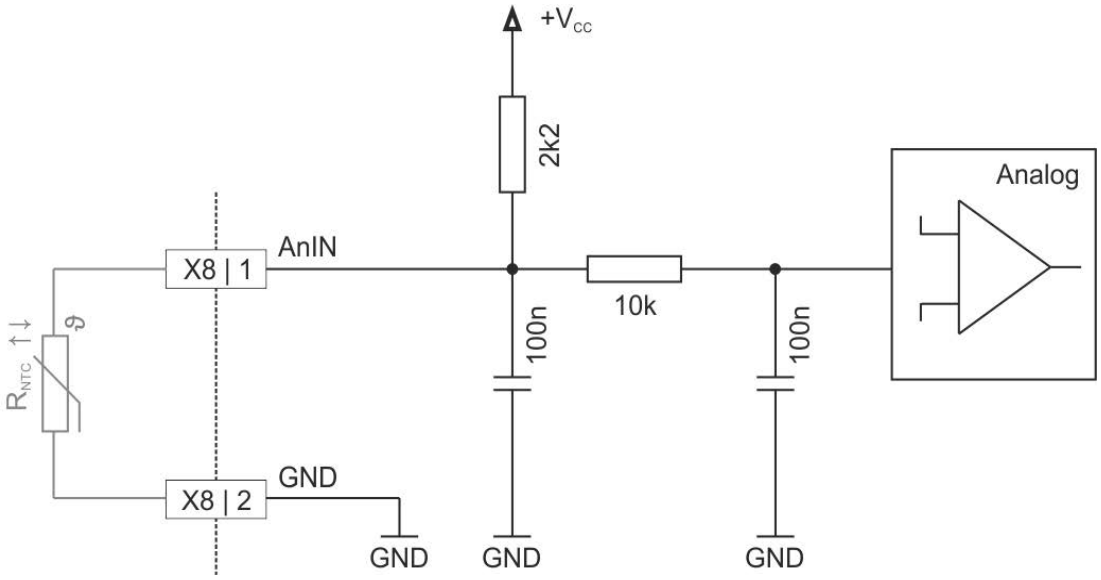


Figure 3-20 Analog input «Motor winding temperature» – circuit

3.2.3.6 USB (X9)

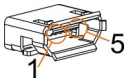


Figure 3-21 USB connector X9

Hot plugging the USB interface may cause hardware damage

If the USB interface is being hot-plugged (connecting while the power supply is on), the possibly high potential differences of the two power supplies of controller and PC/Notebook can lead to damaged hardware.

- *Avoid potential differences between the power supply of controller and PC/Notebook or, if possible, balance them.*
- *Insert the USB connector first, then switch on the power supply of the controller.*

Pin	PC's USB Terminal	Signal	Description
X9 | 1	1	USB_V_{BUS}	USB bus supply voltage input +5 VDC
X9 | 2	2	USB_D−	USB Data− (twisted pair with Data+)
X9 | 3	3	USB_D+	USB Data+ (twisted pair with Data−)
X9 | 4	–	ID	not connected
X9 | 5	4	USB_GND	USB ground

Table 3-22 USB connector X9 – Pin assignment

USB	
USB Standard	USB 2.0 (full speed)
Max. bus supply voltage	+5.25 VDC
Max. DC data input voltage	−0.5…+3.8 VDC

Table 3-23 USB interface specification

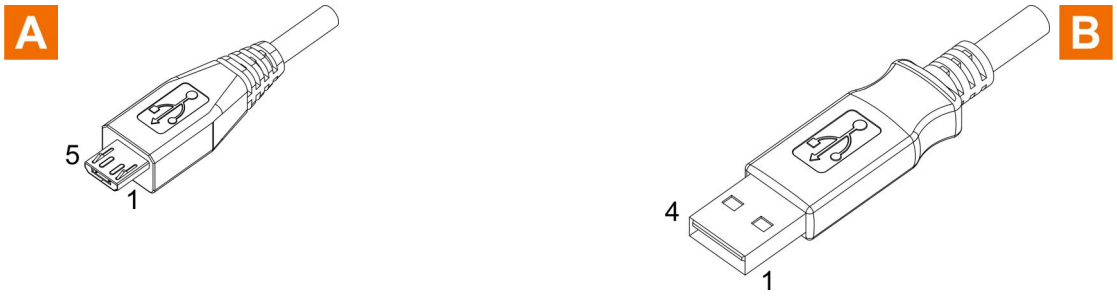
USB Type A - micro B Cable (403968)	
	
Cross-section	According to USB 2.0 / USB 3.0 specification
Length	1.5 m
Head A	USB Type “micro B”, male
Head B	USB Type “A”, male

Table 3-24 USB Type A - micro B Cable

3.3 Wiring diagrams

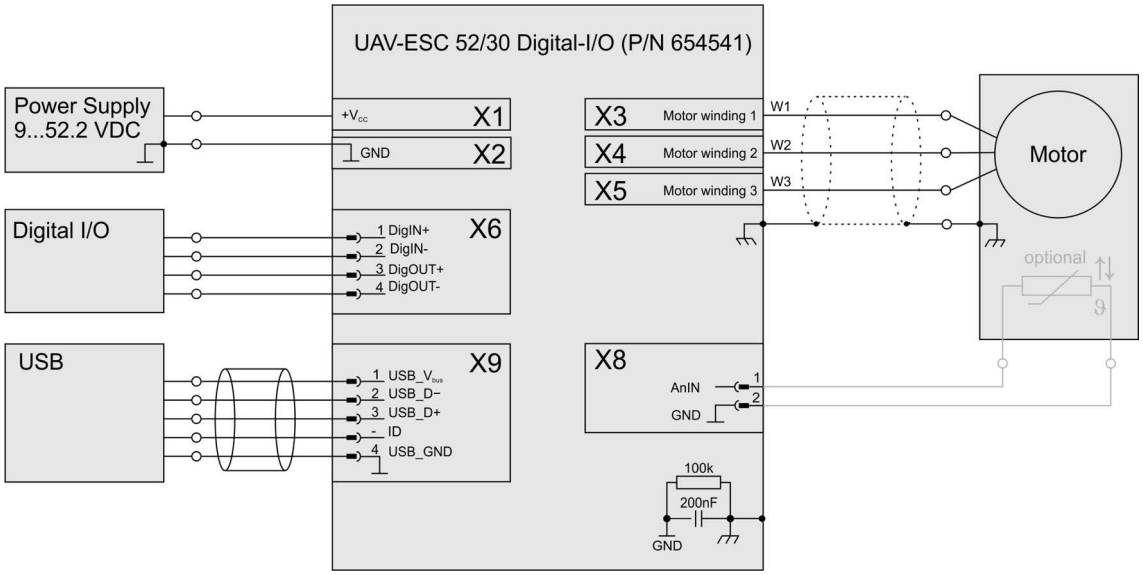


Figure 3-22 UAV-ESC 52/30 Digital-I/O | Wiring diagram

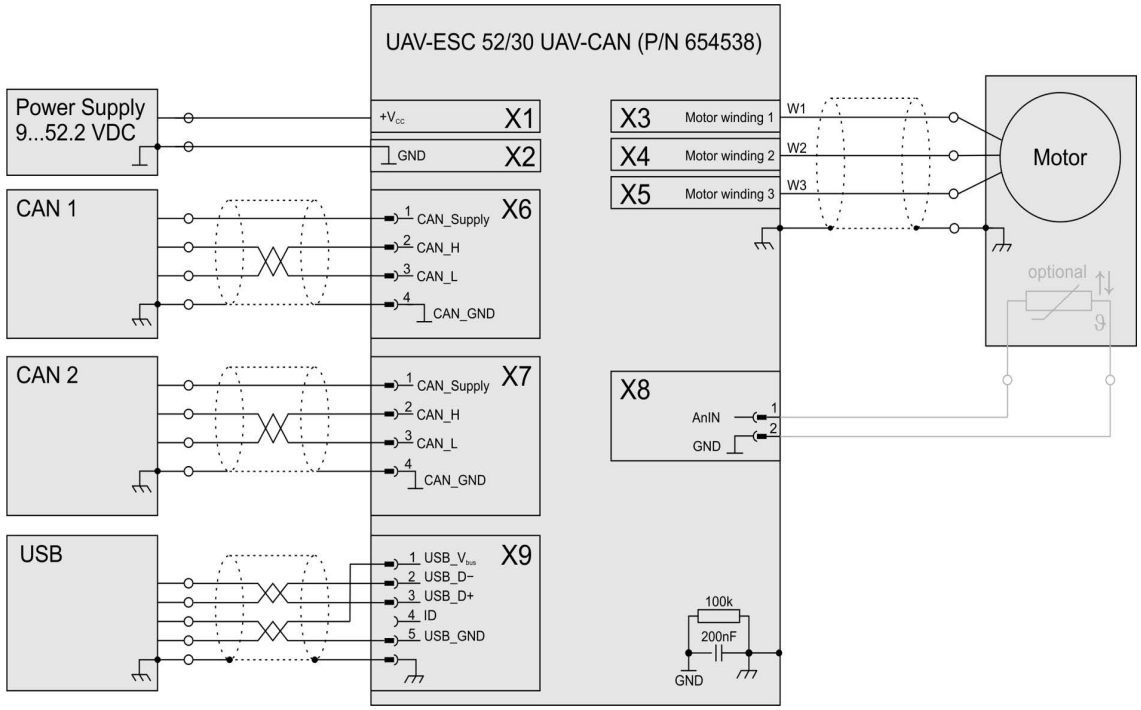


Figure 3-23 UAV-ESC 52/30 UAV-CAN | Wiring diagram

maxon

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4 COMMISSIONING

Best Practice
The most common way to commission the controller is to use the USB interface as the set value input. The corresponding digital input shall be configured to ***None*** *as depicted in* ➔*Figure 4-37 on page 4-38*

4.1 General Rules

IMPORTANT NOTICE: PREREQUISITES FOR FLIGHT PERMISSION

DANGER

Risk of severe injury
Unreasonable or inappropriate operation can cause death or serious injuries!
- *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.*

IMPORTANT NOTICE: PREREQUISITES FOR PERMISSION TO COMMENCE COMMISSIONING

The UAV-ESC 52/30 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!*

Maximal permitted supply voltage
- *Make sure that supply voltage is between 9…52.2 VDC.*
- *Supply voltages above 58 VDC, or wrong polarity will destroy the unit.*

Hot plugging the USB interface may cause hardware damage
If the USB interface is being hot-plugged (connecting while the power supply is on), the possibly high potential differences of the two power supplies of controller and PC/Notebook can lead to damaged hardware.
- *Avoid potential differences between the power supply of controller and PC/Notebook or, if possible, balance them.*
- *Insert the USB connector first, then switch on the power supply of the controller.*

4.2 System Status Indication

The system status is indicated by optical signals.

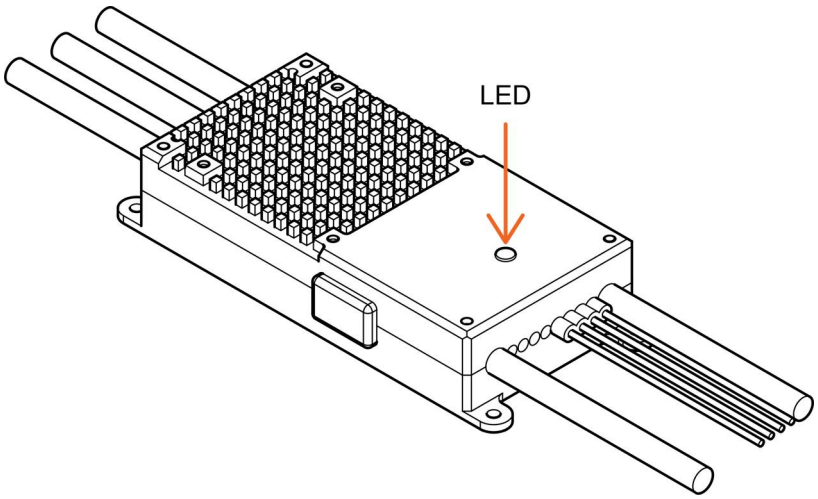

Figure 4-24 Status LEDs

Color	Meaning
White	**Initialization in progress**
Blue [a]	**Communication in progress** • Data are being transmitted/received via CAN
Green	**Normal operation** • Blinking: Wait for arming, system is ready • Continuous: Armed, motor is powered
Yellow	**Warning** • Flying is still possible, landing upon next possible occasion is suggested
Red	**Error** • Take-off is not possible • Flying is no longer possible

Table 4-25 Visual signals

[a] If the blue LED is blinking/flashing, it “interrupts” the other colors;
for example if green is continuously lit, it will be interrupted by the blue blinking/flashing.

The start-up and arming sequence is described in detail in ➔chapter “4.7 Start-up and Arming” on page 4-50.

4.3 Quick Start Guide

This chapter provides a brief description on the first steps to setup and run the UAV-ESC. It does not claim to be a complete and concluding step-by-step instruction with in-depth explanations. It solely describes the installation and use of the maxon «EPOS Studio», a software used to commission and control various types of motion controllers, such as the UAV-ESC.

You will need the following:

- Personal computer (PC)
- Power supply
- USB cable
- UAV-ESC software & documentation package available here: ➔https://uav.maxongroup.com/

In addition, you may wish to browse the EPOS video library. It features video tutorials that provide easy to follow instructions on how to get started with «EPOS Studio» and shows you tips and tricks on how to setup communication interfaces, and so on. Explore on Vimeo: ➔https://vimeo.com/album/4646388

4.3.1 Running «EPOS Studio»

1) Access the software and documentation package available on ➔https://uav.maxongroup.com and open the folder named **EPOS Studio**.
2) Double-click the application file **EPOS Studio.exe** which will be run without installation.

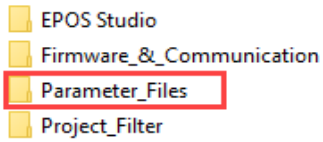

Figure 4-25 EPOS Studio – Start application file

4.3.2 Setting up «EPOS Studio»

3) After the startup process of the «EPOS Studio» is completed, the pop-up window **New Project** will appear.
Select **UAV-ESC Project** and click **Next** to continue.

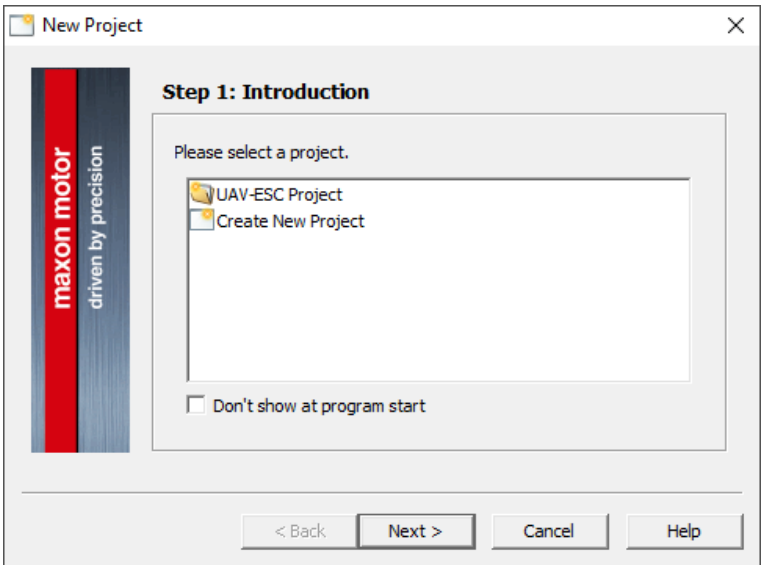

Figure 4-26 EPOS Studio – Select project

4) Choose the path where you want the project to save, then click **Finish** to complete.

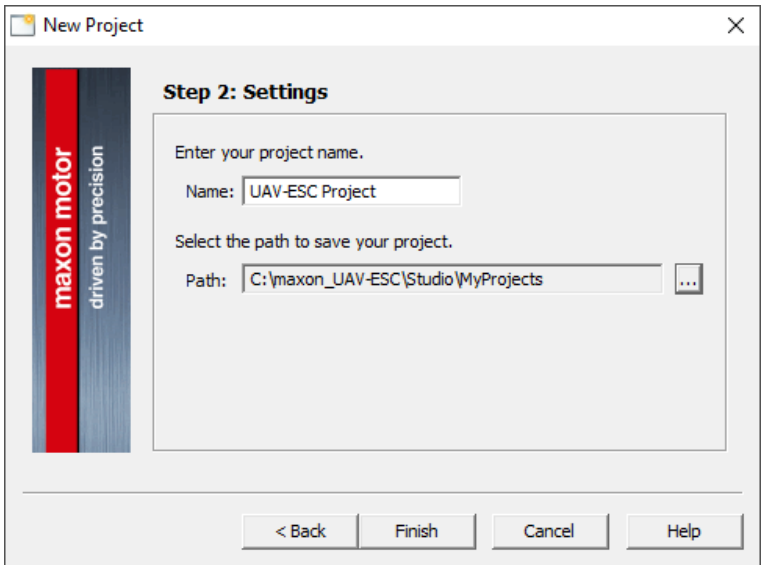

Figure 4-27 EPOS Studio – Select path to save

A connection failure message will appear as the UAV-ESC is not yet powered. Confirm the failure message and proceed with the following section 4.3.3.

4.3.3 Connecting the UAV-ESC

5) Remove the plastic lid if installed (➔Figure 4-28; “D”) from the UAV-ESC housing to access the USB connector X9.

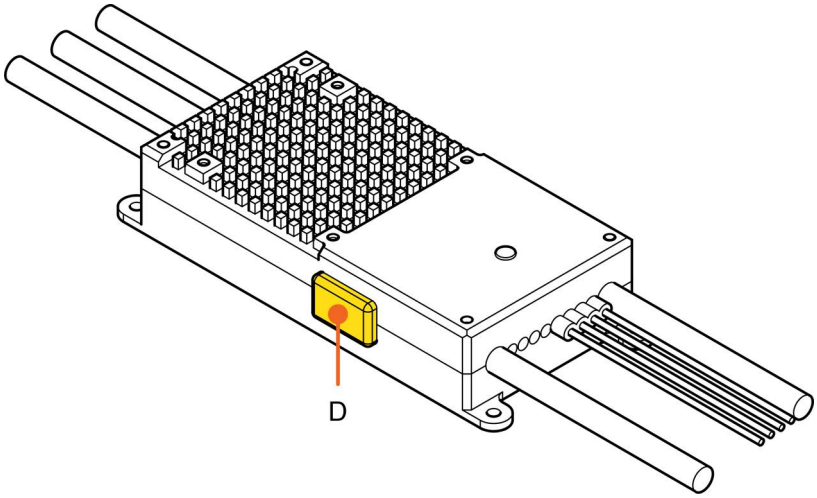

Figure 4-28 Removal of USB connector cover

6) Connect the UAV-ESC’s USB port with your PC using an USB micro B cable (➔page 3-28).

Non-powered device
The UAV-ESC is not powered while connected via USB. Thus, do not expect the LEDs to be blinking as during operation.

7) Power up the UAV-ESC as follows (➔chapter “3.2.1 Prefab cables and wires” on page 3-18):
– Connect the power cable (red) to a power source delivering a supply voltage of 9…52.2 VDC.
– Connect the ground cable (black) to ground (resp. the battery’s “-” pole).
The status LEDs will now indicate the actual state (➔chapter “4.2 System Status Indication” on page 4-32).

8) In «EPOS Studio», select the pane **Communication**. Then click right on **UAV-ESC** and click **Connect** to establish the connection.

Figure 4-29 Connection to the controller

9) If the UAV-ESC should not be powered correctly, an error message will appear. If the case, check for correct connections and the specified supply voltage as described in above ➔step 7.

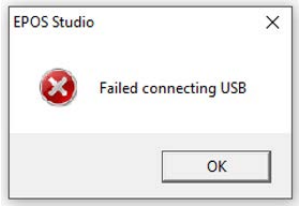

Figure 4-30 Connection failure message

4.3.4 Using «EPOS Studio»

If you have loaded the predefined project and have connected the UAV-ESC as described above, the following three tabs are automatically opened:

- Profile Velocity Mode
- Object Dictionary
- Data Recorder

4.3.4.1 Object Dictionary and Parameter Settings

The object dictionary is a list comprising all parameters that can be read or adjusted in order to setup the UAV-ESC.

Changes are not automatically saved
*After you have altered a parameter, you are required to execute the command to save the change. Do so by click right into the window, then select **Save Parameters**.*

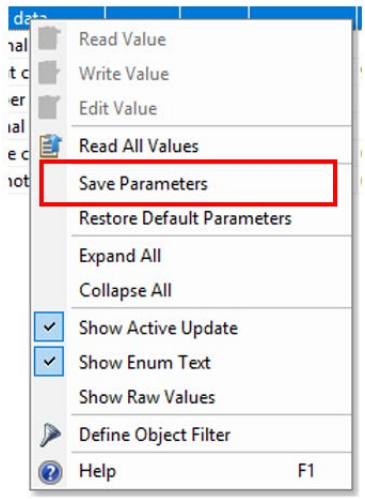

Figure 4-31 Save parameters

For ease of use, a number of preset filters can be selected to access the relevant parameters.

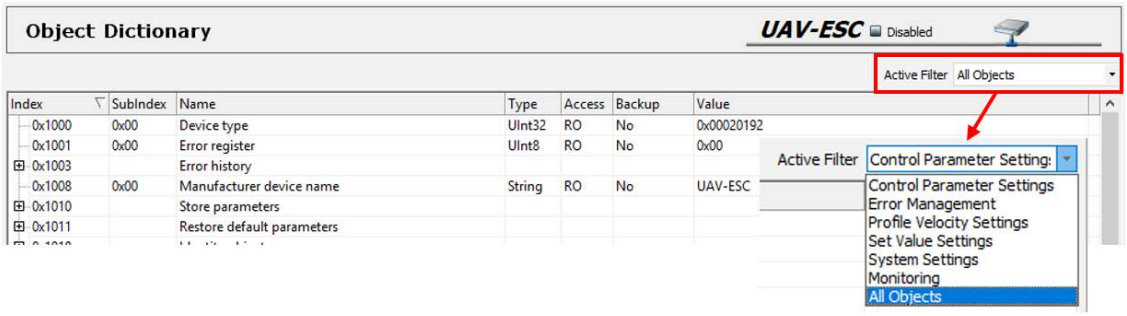

Figure 4-32 Object dictionary – predefined filters

a) **Control Parameter Settings**
Contains a list of all parameters relevant for adjustment of startup and motion control behavior and performance.

b) **Error Management**
The behavior for every error can be defined here as follows: ➔“Error behavior” on page 4-41

Disable	The motor is shutting down
Auto fault reset	The motor is shutting down, but system restarts automatically.
Warning only	The error event is displayed as warning in the status window. The ESC is not performing any failure reaction.

Carefully consider the effect and possible consequences an error might have on the UAV-ESC
For example, shutting down the motor in flight is most probably not an appropriate or desired behavior.

Errors and warnings are displayed in the **Status pane** located at the bottom of the display. The list displays the entire error/warning history until cleared.

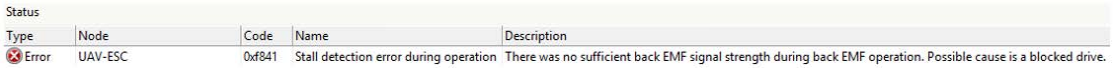

Figure 4-33 Errors and warnings display

To clear the list, right click into the **Status pane** and select **Clear All Entries**.

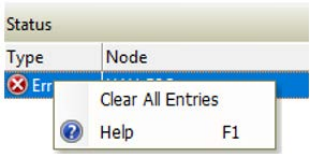

Figure 4-34 Clearing error/warning history

If **Disable** is selected as error behavior, a manual action is required to restart the motor. In this case, the error must be cleared either in «EPOS Studio» with right click in the navigation pane **Workspace** on **UAV-ESC** or by a set value transition back to zero before a new set value is accepted.

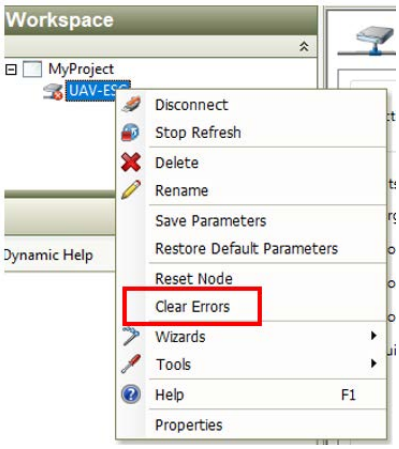

Figure 4-35 Clearing errors and warnings

Clearing an error in workspace does not clear the error in the status pane
*It is therefore possible to reconstruct the error history, even if **auto fault reset** is selected.*

c) **Profile Velocity Settings**
Contains a list of parameters to set the velocity profiles, for example max. speed, acceleration, deceleration/braking, etc.).

d) **Set Value Settings**
There are two ways the UAV-ESC can receive set values, which are defined by the parameter **Configuration of digital inputs**.

PWM velocity set value (default)

The set values are received from the RC-PWM interface. This is used in normal UAV flight mode.

In addition, the parameters in this section define how the PWM signal is interpreted and mapped to the motor speed (➔page 4-43).

⊟ 0x3142		Configuration of digital inputs				
0x3142	0x01	Digital input 1 configuration	Enum	RW	Yes	PWM velocity set value

Figure 4-36 Digital input configuration by RC-PWM

None

The set values are received from EPOS Studio via micro USB. This is mainly used to setup and test the UAV-ESC's functionality.

Index	SubIndex	Name	Type	Access	Backup	Value
0x3142		Configuration of digital inputs				
0x3142	0x01	Digital input 1 configuration	Enum	RW	Yes	None

Figure 4-37 Digital input configuration via EPOS Studio

If the digital input configuration from above has changed, the UAV-ESC must be reset so that the change comes into effect.

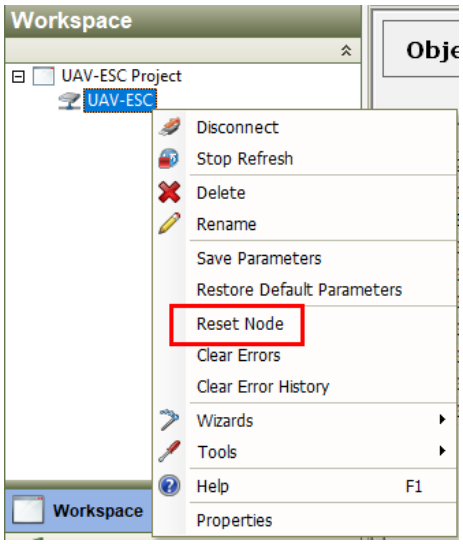

Figure 4-38 Reset node

e) **System Settings**
They define physical and electrical limitations as well as characteristics of the motor and the overall system.

f) **Monitoring**
Contains a list of objects to monitor system values (e.g. supply voltage, current, temperature, etc.).

4.3.4.2 Data Recorder

For debugging, setup, monitoring, and testing the UAV-ESC, the «EPOS Studio» features a fully configurable data recorder. Four different data channels can be recorded at the same time and the resulting data set can be saved to a file.

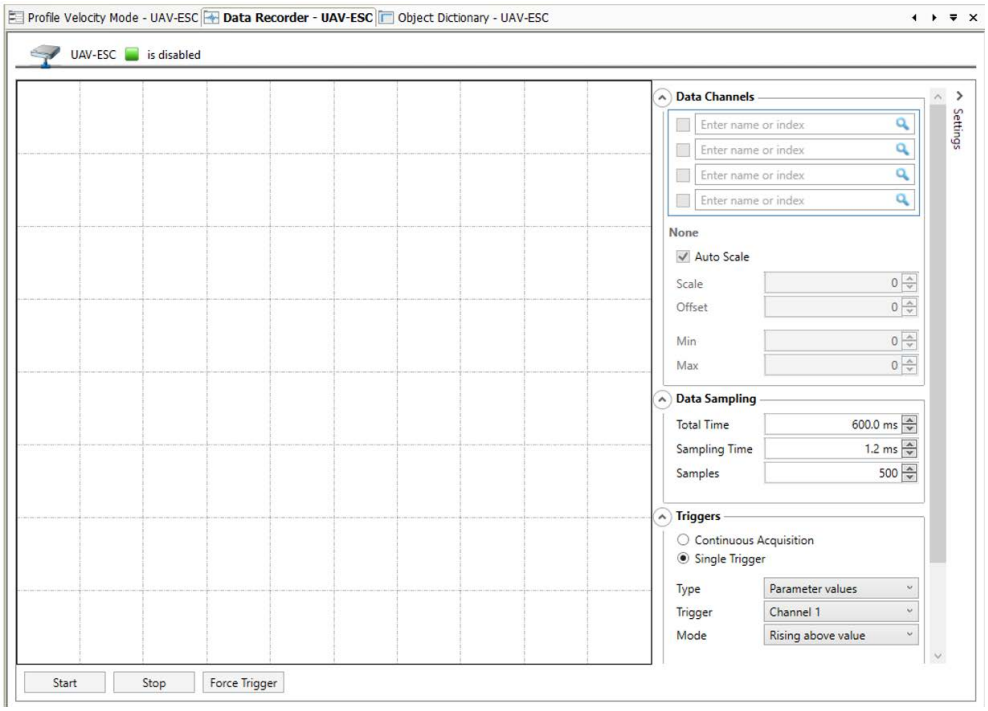

Figure 4-39 Data recorder

4.3.4.3 Profile Velocity Mode

In this tab, the set values for the UAV-ESC are defined and the actual values can be monitored. Thereby, consider that the range of parameter settings is given by the limits set in **Profile Velocity Settings** (➔“Set Value Settings There are two ways the UAV-ESC can receive set values, which are defined by the parameter Configuration of digital inputs.” on page 4-37).

In the **Inputs** section, the desired **Target velocity** can be adjusted manually. In addition, **Profile acceleration** and **Profile deceleration** are also accessible.

The **Outputs** section displays the motors response to the selected input settings.

In the **Control** section, the system can be put in different states (similar as with RC Radio).

Enable	Arms the system
Disable	Disarms the system. The motor coasts down and will come to a standstill due to friction.
Set velocity	The **Target velocity** from Inputs section is considered as set value and the motor tries to reach the desired speed
Halt	Deceleration with **Profile deceleration** until the motor stops
Quick stop	Deceleration with **Quick stop deceleration** until the motor stops

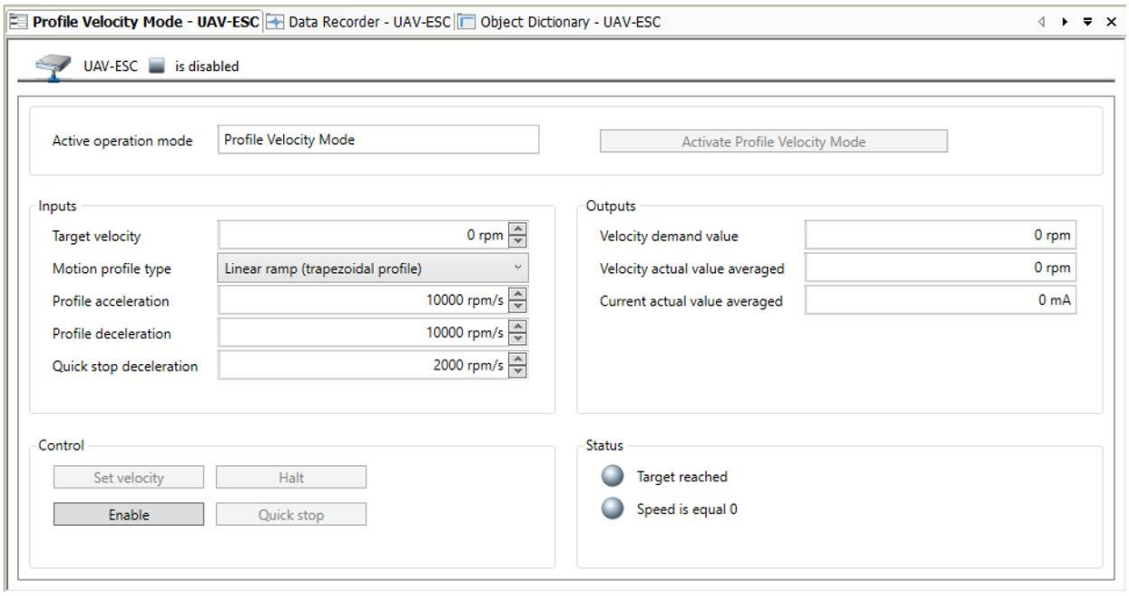

Figure 4-40 Profile velocity mode

4.3.5 Using EPOS Studio support functions

Beside the described main functions, there are two wizards available for extended functions.

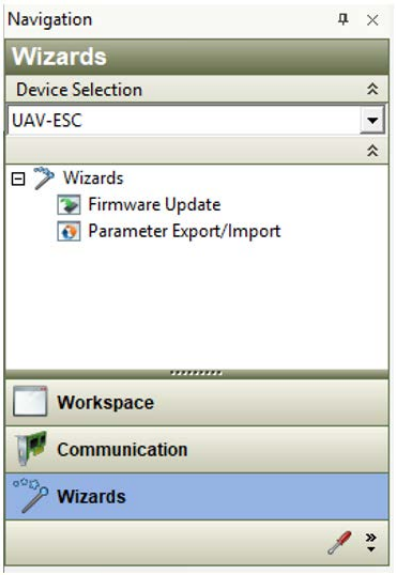

Figure 4-41 Support functions

Firmware Update	Handles download and installation of new firmware files to the UAV-ESC
Parameter Export/Import	Handles the process to store the actual parameters of the UAV-ESC into a file (export) or load an existing parameter file to the UAV-ESC (import)

The controller's firmware – the internal operating system – is subject to continuous development and may receive add-ons and extensions, or may contain features especially designed for your application.

4.4 Active protection functions & error behavior

Detailed information regarding the protection functions & error behavior is provided in ➔ «UAV-ESC Firmware Specification»

4.4.1 Active protection functions

Active protective functions prevent both UAV-ESC and motor from operating in dangerous conditions.

1) UAV-ESC self-protection.
The under-/overvoltage protection, overcurrent protection and thermal overload protection will prevent the UAV-ESC from damage up to a certain limit (➔ chapter “2.3 Limitations” on page 2-14).
2) Output current limitation according analog input «Motor winding temperature».
If the analog input «Motor winding temperature» is used, i.e. NTC is mounted on the motor winding and providing the respective signal to the UAV-ESC. The output current to the motor is limited basically considering the parameters «Nominal current», «Output current limit», «Maximum temperature motor» and «Derating temperature motor».
3) Output current limitation according to I2t method.
If the analog input «Motor winding temperature» is not used, the output current to the motor is limited according the I2t method, basically considering the parameters «Nominal current», «Output current limit», and «Thermal time constant winding». This limitation will prevent the motor from operation outside the maximum allowed winding temperature.
4) Overvoltage derating.
The overvoltage derating is active when the motor is in regenerative state and reduces the probability of an overvoltage error, resulting from current flowing back to the power supply and thus increasing the power supply voltage.

4.4.2 Error behavior

The error behavior of specific device errors (➔chapter “Table 4-26 Errors” on page 4-42) can be configured and adjusted as required.

Recommended setting: When bench testing is performed, configure an error behavior so that the device is disabled / reset and protected. When the device is installed in a drone, the error behavior could be set to «Warning only».

Disable	The motor is shutting down
Auto fault reset	The motor is shutting down, but system restarts automatically.
Warning only	The error event is displayed as warning in the status window. The ESC is not performing any failure reaction.

Index	SubIndex	Name	Description / Cause
0x2040	0x01 *	Overcurrent error	Short circuit in motor winding. Controller gains too high and/or deceleration too high. Damaged power stage.
0x2040	0x02 *	Power stage protection error	Short circuit of motor winding against ground. Short circuit of motor winding against operating voltage Vcc. Damaged power stage.
0x2040	0x03 *	Overvoltage error	Supply voltage too high. Deceleration too high.
0x2040	0x04 *	Undervoltage error	Supply voltage too low. Required acceleration current cannot be supplied.

Index	SubIndex	Name	Description / Cause
0x2040	0x06	RC-PWM set value input error	PWM signal is out of allowed range
0x2040	0x07	Process control message queue full error	Internal firmware error
0x2040	0x08	Process control busy switching error	Internal firmware error
0x2040	0x09	Process initialization timeout error	Internal firmware error
0x2040	0x0C *	Stall detection error during synchronous startup	Blocked motor (stall condition) during startup
0x2040	0x0D	System overloaded error	Internal firmware error
0x2040	0x0E	Watchdog error	Internal firmware error
0x2040	0x0F	System peak overloaded error	Internal firmware error
0x2040	0x10 *	Stall detection error during operation	Blocked motor (stall condition) during normal operation
0x2040	0x11	CAN overrun error	Too high communication rate
0x2040	0x12	CAN passive mode error	CAN bit rate of one CAN node in network wrong. CAN network not connected. Hardware wiring of CAN bus not correct.
0x2040	0x13	CAN bus turned off	CAN controller has entered CAN bus off state
0x2040	0x14	CAN Rx queue overflow	Too high communication rate
0x2040	0x15	CAN Tx queue overflow	Too high communication rate due to… - load on CAN bus too high - time triggered PDOs defined with too small rate - CAN bus inactive
0x2040	0x16	DroneCAN message error	Invalid DroneCAN message received due to for example: - Invalid crc - Short or incompatible frame - Wrong toggle bit - Wrong address
0x2040	0x17	DroneCAN receive message timeout	One of the expected receive messages was not received within the defined minimum rate
0x2040	0x18*	Thermal motor supervision error	I2t level motor limit exceeded.

Table 4-26 Errors

* The error behavior setting «Warning only» is not available for these indexes.
Additional errors are pre-configured and the error behavior cannot be changed by the user.

4.5 RC-PWM Set Value Input

Note: This object is available with UAV-ESC 52/30 Digital-I/O (654541) only

The set value interface supports classic RC-PWM signals and is fully configurable.

Parameter	Default value	Range
Update rate		50…600 Hz
Max motor speed	5'000 rpm	$1\ldots\frac{150000}{\text{number of pole pairs}}$ rpm
Pulse width zero throttle	1'100 µs	800…1'250 µs
Pulse width center	1'100 µs	800…2'200 µs
Pulse width full throttle	1'940 µs	1'750…2'200 µs
Pulse dead band	20 µs	0…200 µs

Table 4-27 Signal range and configuration of PWM signal

The set value range refers to ± «Max motor speed» symmetrically around «Pulse width center».

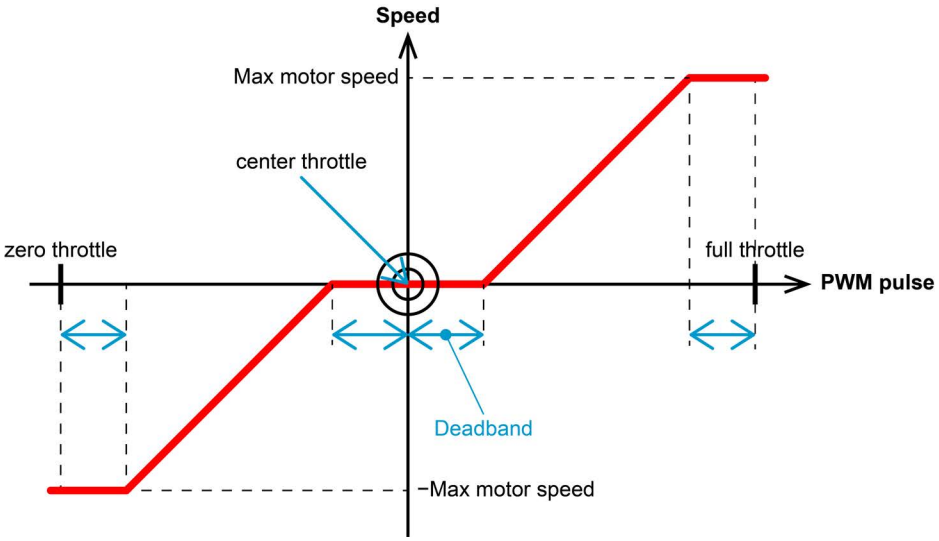

Figure 4-42 Set value scaling

- If «Pulse width center» and «Pulse width zero throttle» are equal, the set value range is distributed only unidirectional (➔Example 1 (default values)).
- If «Pulse width center» lies between «Pulse width zero throttle» and «Pulse width full throttle», the set value range is distributed bidirectional (➔Example 2).

4.5.1 Example 1 (default values)

For default values and value range ➔Table 4-27 on page 4-43.

PWM signal	Speed set value
0…1'120 µs	0 rpm
1'120…1'920 µs	0…+5'000 rpm (6.25 rpm/µs)
1'920 µs…∞	+5'000 rpm

Table 4-28 PWM set value | Example 1

4.5.2 Example 2

Parameter	Value
Pulse width zero throttle	1'100 µs
Pulse width center	1'500 µs
Pulse width full throttle	1'900 µs
Pulse deadband	20 µs
PWM signal	**Speed set value**
0…1'120 µs	−5'000 rpm
1'120…1'480 µs	−5'000…0 rpm (13.89 rpm/µs)
1'480…1'520 µs	0 rpm
1'520…1'880 µs	0…+5'000 rpm (13.89 rpm/µs)
1'880 µs…∞	+5'000 rpm

Table 4-29 PWM set value | Example 2

4.6 Parametrization

Best Practice
The most common way to commission the controller is to use the USB interface as the set value input. The corresponding digital input shall be configured to ***None*** *as depicted in* ➔*Figure 4-37 on page 4-38*

For proper operation of the UAV-ESC and the complete propulsion system, the UAV-ESC must be parametrized correctly. If the UAV-ESC controls a maxon UAV motor with a suitable propeller, a predefined parameter file can be chosen and imported to the UAV-ESC. If a third-party motor is controlled, or a propeller not recommended by maxon is used the UAV-ESC must be parametrized manually to allow proper operation.

4.6.1 Configuration of Profile Velocity Parameters

The parameters for the profile velocity indirectly define the flight characteristics of the drone. The following table lists all objects associated with the profile velocity mode.

Index	SubIndex	Name
0x607F	0x00	Max profile velocity
0x6083	0x00	Profile acceleration
0x6084	0x00	Profile deceleration
0x60C5	0x00	Max acceleration

Table 4-30 Profile velocity parameters

4.6.2 Import of maxon parameter file (for maxon UAV motors with suitable propellers)

maxon provides a variety of predefined parameter files for the maxon UAV motors used with suitable propellers. These parameter files are part of the UAV-ESC software & documentation package available here: https://uav.maxongroup.com/ and can be imported to the UAV-ESC to configure the controller for the specific motor/propeller combination. After import, only the profile velocity parameters, which define the flight characteristic, must be adjusted.

- Import the applicable parameter file (➔chapter “4.3.5 Using EPOS Studio support functions” on page 4-40)
- Adjust the profile velocity parameters as required (➔chapter “4.6.1 Configuration of Profile Velocity Parameters” on page 4-45)

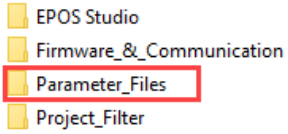

Figure 4-43 EPOS Studio – Start application file

4.6.3 Configuration and parametrization of UAV-ESC (for third-party motors and/or propellers not recommended by maxon)

If the UAV-ESC is driving a third-party motor or a propeller not recommended by maxon, the UAV-ESC must be fully configured and parametrized. The following sections provide guidance for configuration and parametrization.

Basically, four steps are required:

- Calculation of control system parameters
- Configuration of motor parameters (for proper operation and motor protection)
- Configuration of synchronous startup parameters (for proper starting of the system)
- Configuration of profile velocity parameters (to configure parameters for flight)

For detailed information about the discussed objects see separate document ➔ «UAV-ESC Firmware Specification».

4.6.3.1 Calculation of control system parameters

For the calculation of specific control system parameters, the motors resistance, inductance and speed constant are required. These values shall be taken from the motor's data sheet.

Enter these values into the ➔ «UAV-ESC Calculation Sheet» and copy the resulting output values to the respective objects/indexes in EPOS Studio as indicated below.

Index	SubIndex	Name	Value / Source
0x3002		Electrical system parameter	from UAV-ESC calculation sheet
0x3002	0x03	Transition parameter (a)	from UAV-ESC calculation sheet
0x3002	0x04	Input parameter (b)	from UAV-ESC calculation sheet
0x30A0		Current control parameter set	from UAV-ESC calculation sheet
0x30A0	0x01	Current controller P gain	from UAV-ESC calculation sheet
0x30A0	0x02	Current controller I gain	from UAV-ESC calculation sheet
0x30A5		Back EMF observer parameter set	from UAV-ESC calculation sheet
0x30A5	0x01	Kalman current gain [1]	from UAV-ESC calculation sheet
0x30A5	0x02	Kalman Back EMF gain [1]	from UAV-ESC calculation sheet
0x30A5	0x03	Kalman current gain [2]	from UAV-ESC calculation sheet
0x30A5	0x04	Kalman Back EMF gain [2]	from UAV-ESC calculation sheet
0x30AF		Synchronous startup parameter set	from UAV-ESC calculation sheet
0x30AF	0x07	Transition upper threshold	from UAV-ESC calculation sheet
0x30AF	0x08	Transition lower threshold	from UAV-ESC calculation sheet

Table 4-31 Control system parameters

4.6.3.2 Configuration of motor parameters

Before driving a motor, a couple of parameters must be adjusted in the Object Dictionary for proper operation and motor protection. The motor data can be found on its data sheet.

Index	SubIndex	Name	Value / Source
0x3001		Motor data	
0x3001	0x01	Nominal current	acc. motor data sheet
0x3001	0x02	Output current limit	if unknown, set to double of Nominal current
0x3001	0x03	Number of pole pairs	acc. motor data sheet
0x3001	0x04	Thermal time constant winding	acc. motor data sheet
0x3001	0x05	Torque constant	acc. motor data sheet
0x6080	0x00	Max motor speed	acc. motor data sheet

Table 4-32 Motor parameters

4.6.3.3 Configuration of synchronous startup parameters

These parameters define the startup behavior of the system. maxon recommends starting with the default parameters and to adjust these parameters only if the system cannot startup properly. Particularly if the motor does not turn at all, and/or unusual noise is present, or the motor stops during the startup phase (which lasts for a couple of seconds).

By default, the UAV-ESC will run maximum five startup trial. It might be that the first attempt(s) are not successful, but one of the five attempts is. If the first attempt is not successful, maxon recommends to adjust the startup parameters.

Index	SubIndex	Name
0x30AF		
0x30AF	0x01	Synchronous angular acceleration
0x30AF	0x02	Synchronous acceleration current ratio
0x30AF	0x03	Maximum synchronous velocity
0x30AF	0x04	Startup alignment angle
0x30AF	0x05	Startup alignment time
0x30AF	0x06	Startup alignment current ratio
0x30AF	0x07	Transition upper threshold
0x30AF	0x08	Transition lower threshold
0x30AF	0x09	Synchronous minimum velocity
0x30AF	0x0A	Maximum synchronous startup trials

Table 4-33 Synchronous startup parameters

The adjustment of the startup parameters shall be done according the following instructions if the startup is not successful with the default parameters.

Set 0x30AF 0x0A «Maximum synchronous startup trials» to 1 so that an error is displayed by the EPOS Studio.

Material damage: During the following procedures the motor is performing several startup trials. Make sure that the motor does not overheat to avoid damage.

Startup behavior is «normal» but UAV-ESC does not change to Back EMF (Operational) Mode

«Normal» startup behavior means the motor is doing the alignment first and then accelerates constantly. The motor does not oscillate and no «unusual» noise is present. Finally, the startup procedure is canceled, and the motor stops. The EPOS Studio should show a «Stall detection error during synchronous startup».

1) Note down the value of 0x30AF 0x08 «Transition lower threshold» and set to 50 mV
2) Reduce 0x30AF 0x07 «Transition upper threshold» by 10%
3) Perform startup
4) If not successful, reduce 0x30AF 0x07 «Transition upper threshold» by another 10% (from initial value, same reduction as before)
5) Repeat steps 3 and 4 until startup is successful
6) Once startup is successful, set 0x30AF 0x08 «Transition lower threshold» to a value that is the initial value noted in step 1, reduced by the same percentage as the 0x30AF 0x07 «Transition upper threshold»

Example:

	Initial values **1. Startup** ***Not successful***	**2. Startup** ***Not successful***	**3. Startup** ***Not successful***	**4. Startup** ***Successful***	***Final values***
0x30AF 0x07 Transition upper threshold [mV]	500	450 (=500 reduced by 10%)	400 (=500 reduced by 20%)	350 (=500 reduced by 30%)	350
0x30AF 0x08 Transition lower threshold [mV]	150	50	50	50	105 (=150 reduced by 30%)

Table 4-34 Example synchronous startup parameters

Startup behavior is «unusual»

An «unusual» behavior means the motor does not turn at all, is oscillating during the alignment and not at rest before accelerating, not accelerating constantly, and/or noise of the motor is loud and/or sounds «not good». A «Stall detection error during synchronous startup» might appear in the EPOS Studio in addition. The following procedure will resolve the «unusual» startup behavior initially, and then will ensure that the change to Back EMF (Operational) Mode will function properly.

Resolving «unusual» behavior

1) Set 0x30AF 0x05 «Startup alignment time» to 1’000 ms
2) Note down the value of 0x30AF 0x07 «Transition upper threshold» and set to 20’000 mV
3) Perform startup
4) If the behavior is still «unusual», reduce 0x30AF 0x01 «Synchronous angular acceleration» by 100 rpm/s (absolute minimum value for 0x30AF 0x01 «Synchronous angular acceleration» is 100 rpm/s)
5) Repeat steps 3 and 4 until startup behavior is «good»
   the EPOS Studio might show a «Stall detection error during synchronous startup»

Ensuring change to Back EMF (Operational) Mode

6) Once the startup behavior is «normal», set 0x30AF 0x07 «Transition upper threshold» to the initial value, noted in step 2 (the startup behavior might be worse again)
7) Increase 0x30AF 0x07 «Transition upper threshold» by 10%
8) Perform startup
9) Repeat steps 7 and 8 until startup is successful and the UAV-ESC changes to Back EMF (Operational) Mode
10) Finally the «Startup alignment time» can be reduced as long as the startup is successful

Example:

	Initial values **1. Startup** ***Behavior unusual***	**2. Startup** ***Behavior unusual***	**3. Startup** ***Behavior unusual***	**4. Startup** ***Behavior unusual***	**5. Startup** ***Not successful***	**6. Startup** ***Successful***
0x30AF 0x01 Synchronous angular acceleration [rpm/s]	1'000	1'000	900 (=1'000 reduced by 10%)	800 (=1'000 reduced by 20%)	800	800
0x30AF 0x05 Startup alignment time [ms]	50	1'000	1'000	1'000	1'000	1'000
0x30AF 0x07 Transition upper threshold [mV]	500	20'000	20'000	20'000	550 (=500 increased by 10%)	600 (=500 increased by 20%)

Table 4-35 Example synchronous startup parameters

4.7 Start-up and Arming

For safety reasons, the UAV-ESC 52/30 Digital-I/O features a rigid arming procedure to prevent the motor from unintentional starting. The following steps are required to arm the controller after power up:

1) Power up the system.
2) Signalization of initialization sequence (LED white blinking, continuous red after few seconds depending on set value input).
3) If set value = "0 rpm" (zero speed): Wait for arming (LED green blinking, yellow blinking if warning is present).
4) If set value ≠ "0 rpm" (zero speed): Arming timeout (LED continuous red).
   Once set value = "0 rpm" (zero speed): Wait for arming (LED green blinking, yellow blinking if warning is present).
5) When controller in status Wait for arming and set value ≠ "0 rpm" (zero speed): Armed (LED continuous green, continuous yellow if warning is present). Motor is powered.

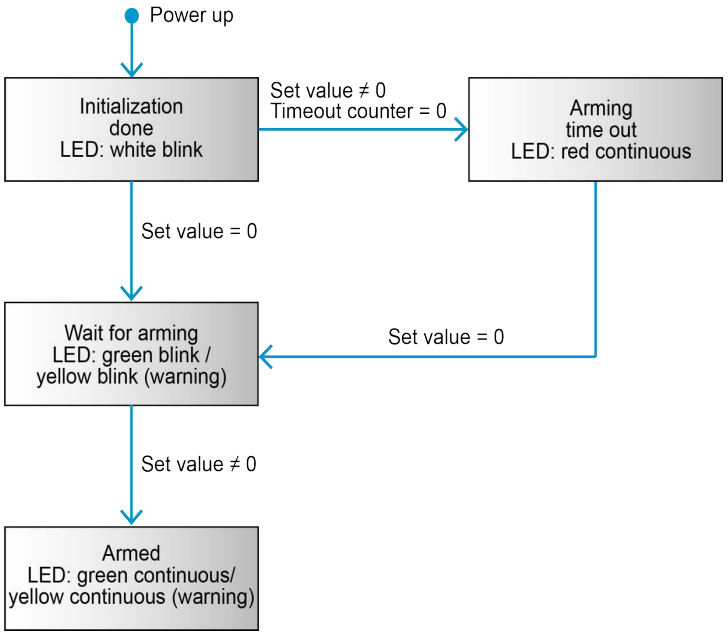

Figure 4-44 Start-up and arming

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