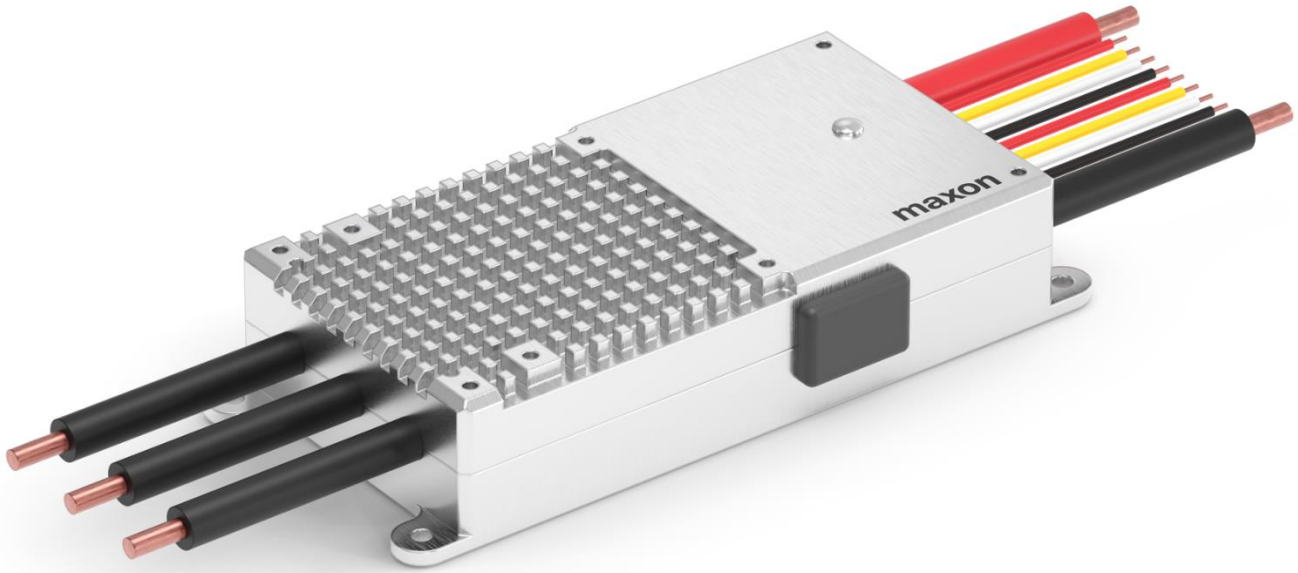
Quick Start Guide
UAV-ESC 52/30

I/O – Version (P/N: 654541)
CAN – Version (P/N: 654538)



Read this first:

- *The maxon UAV-ESC **uses closed loop speed control** with **sinusoidal commutation** (**FOC**)*
- ***Extensive** parameter tuning is needed for best performance with specific motors and propellers*
- *Maxon provides tested parameter sets for the maxon motors including recommended catalogue propellers*
- *Tests without propellers require separate parameter files → **no-load files***
- *There are **no parameters pre-loaded** to the UAV-ESC*

Additional documentation:

- *User Manual UAV-ESC 52/30:* *Comprehensive documentation with detailed information.*
- *UAV-ESC Firmware specification:* *Detailed description of the firmware and its objectives.*
- *UAV-ESC Communication Guide:* *Description of communication interfaces.*

***Danger:** Imminent hazardous situation, which could lead to serious injuries or death*

***Note**: Additional information*

***Material damage:** Possible damage of equipment*

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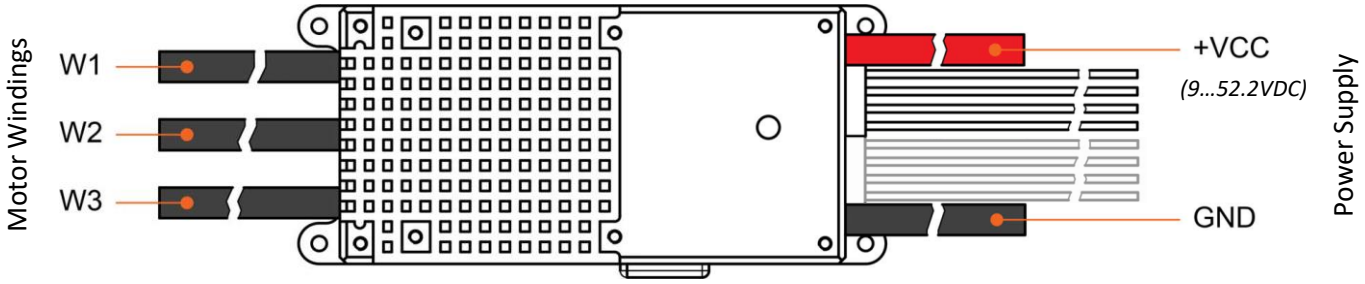
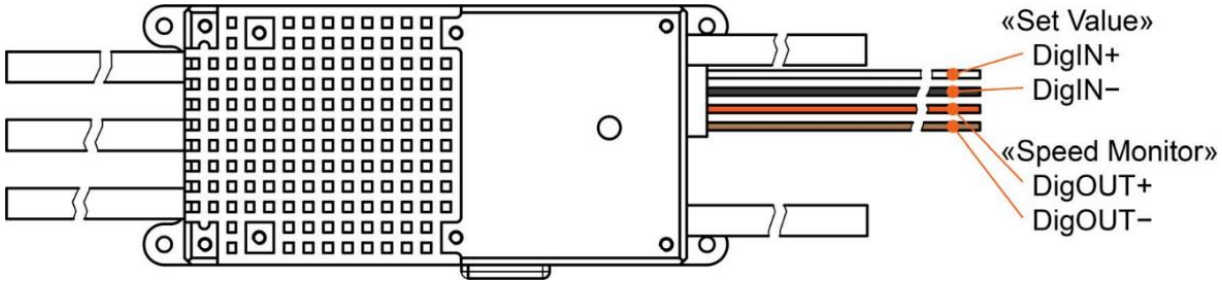
1 Interfaces / Wiring



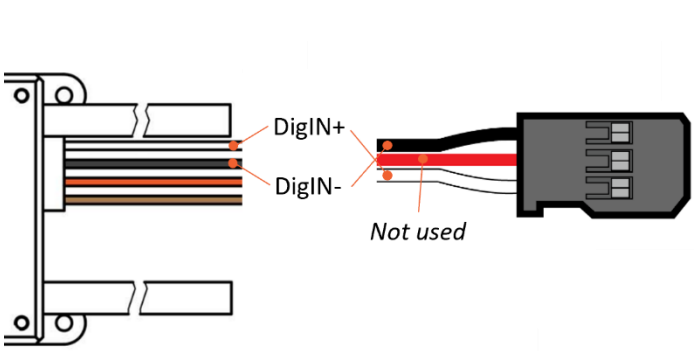
1.1 I/O – Version (P/N: 654541)

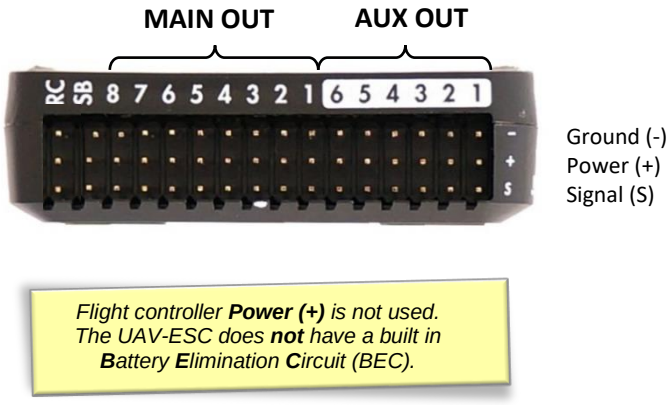
The UAV-ESC I/O version is being commanded over **P**ulse-**W**idth **M**odulation (PWM) signal (***"Set Value")*** and can output frequency dependent speed monitoring (***"Speed Monitor").***



1.1.1 Pixhawk Digital Input Wiring

UAV-ESC **DigIN+** (white) and **DigIN-** (black) cables shall be connected to flight controller **Ground (-)** and **Signal (S)** of **MAIN OUT** (motors 1 to 8).





*Flight controller **Power (+)** is not used.*
*The UAV-ESC does **not** have a built in **B**attery **E**limination **C**ircuit (BEC).*

1.1.2 UAV-ESC I/O parameter configuration

DO NOT change PWM settings, when UAV-ESC is armed, and propellers are attached!
(Indicated by continuous green light (status LED) → see section 3.1)

Index	Name	Recommended values		Notes
[3142sub01]	Digital input 1 configuration	RC-PWM velocity set value		**RC-PWM velocity set value:** Set values are received over RC PWM (standard) **None** or **General purpose A:** Set values are received from EPOS Studio via micro-USB.
[3148sub01]	Pulse width zero throttle	1050	us	
[3148sub02]	Pulse width full throttle	2000	us	
[3148sub03]	Pulse width center	= Pulse width zero throttle	us	For unidirectional control (→ see user manual section 4.5)
[3148sub04]	Pulse deadband	0	us	
[3000sub04]	Axis configuration miscellaneous	0		1: **CW** motor rotation for positive demanded values. 0: **CCW** motor rotation for positive demanded values.

113 Pixhawk configuration

No throttle calibration is needed for the maxon UAV-ESC.

The maxon UAV-ESC was tested with the Pixhawk flight controller hardware and firmware.
The following parameters are recommended for **initial setup** and **testing** (unidirectional control).

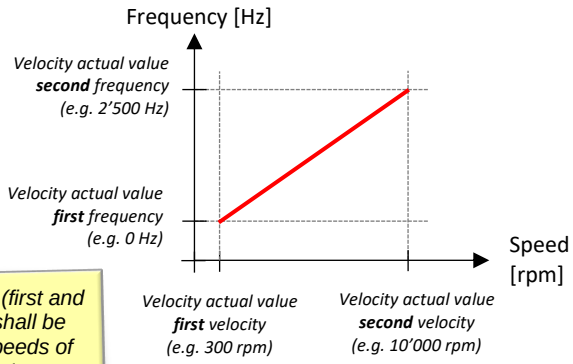
Parameter Name	Recommended values		Notes
PWM_MAIN_DISARM	1000	us	$= Pulse\ width\ zero\ throttle\ -\ 50u$
PWM_MAIN_MIN	$950 \times \frac{Synchronous\ minimum\ velocity}{max\ profile\ velocity} + 1050$		The following formula should be used to derive the optimal PWM parameter values (→ see section 3.6 and 3.7): $= \frac{Synchronous\ minimum\ velocity}{rate} + Pulse\ width\ zero\ throttle + Pulse\ deadband$ $rate = \frac{Max\ profile\ velocity}{(Pulse\ width\ full\ throttle - Pulse\ width\ zero\ throttle - 2\times Pulse\ deadband)}$
PWM_MAIN_MAX	2000	us	Chose value equal to UAV-ESC parameter: [3148sub02] **Pulse width full throttle** (→ see section 1.1.2)

114 Digital Output – Speed Monitor

The motor speed can be monitored over frequency to velocity mapping with e.g. an external micro controller unit (MCU).

Connect UAV-ESC **DigOUT-** to **GND** and the **DigOUT+** to the **digital input** of the MCU.
Additional capacity between **DigOUT-** and **DigOUT+** reduces noise.
An external power supply of max. 12VDC is required
(→ see user manual section 3.2.3.3; Figure 3-17).

With the configuration below, 0 Hz is mapped to 0 rpm,
and 2'500 Hz to 10'000 rpm (linear interpolation in between).
(→ see firmware specification section 6.3.28)



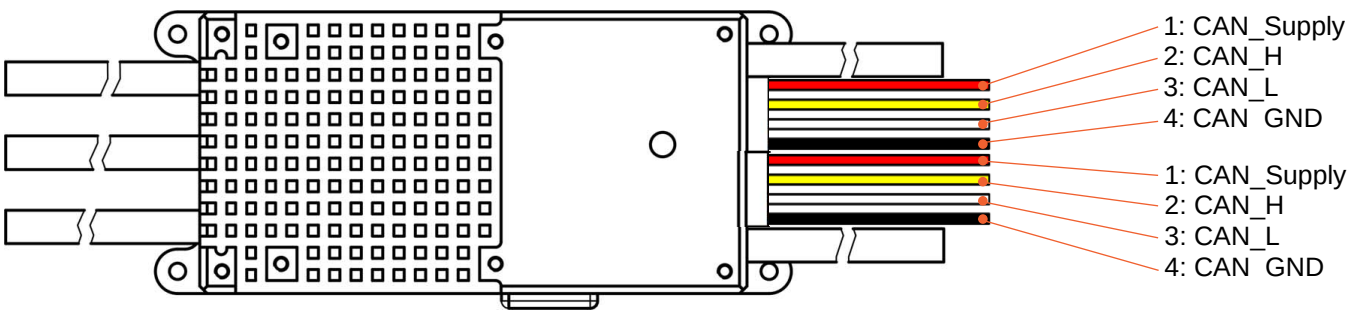
Start and end point (first and second velocity) shall be chosen close to speeds of the actual application to maximize resolution.

Index	Name	Example values		Notes
[3151sub01]	Digital output 1 configuration	35		
[3157sub01]	Velocity actual value first velocity	0	rpm	velocity starting point
[3157sub02]	Velocity actual value first frequency	0	Hz	frequency starting point
[3157sub03]	Velocity actual value second velocity	10'000	rpm	velocity end point
[3157sub04]	Velocity actual value second frequency	2'500	Hz	frequency end point

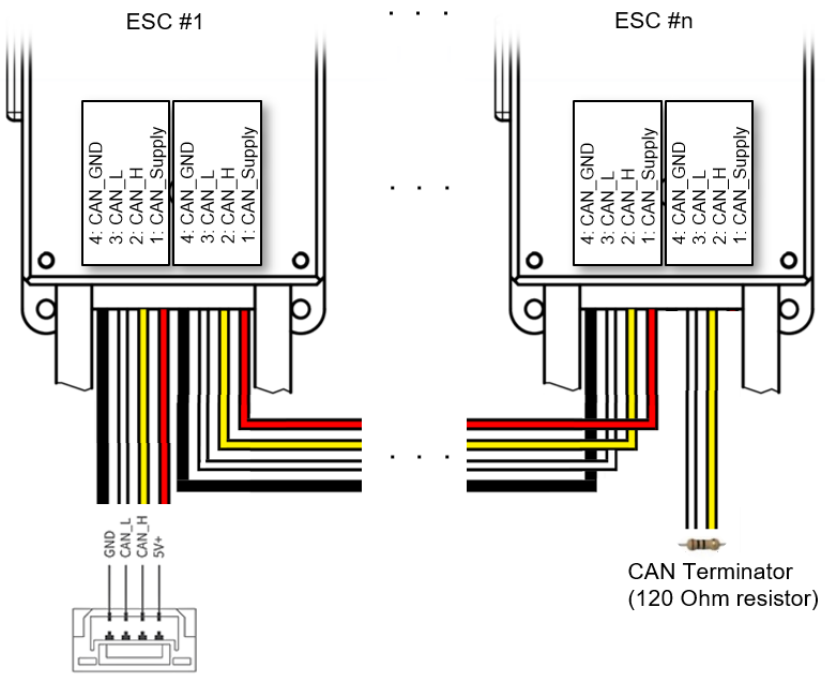
1.2 CAN – Version (P/N: 654538)

The UAV-ESC CAN version supports DroneCAN v1 bus protocol.

dronecan.
github.io



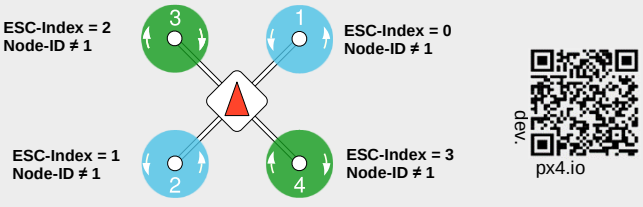
121 Pixhawk CAN Bus Wiring



*It is recommended to **twist CAN_H** and **CAN_L** wires to improve signal quality.*

***CAN_Supply** is not required for UAV-ESC but can be used to power additional sensors on the CAN bus.*

122 UAV-ESC CAN parameter configuration

Index	Name	Recommended values	Notes
[3142sub01]	Digital input 1 configuration	None	Set values can be received over micro-USB and CAN bus simultaneously.
[2000sub00]	Node-ID	1 … 127	Each UAV-ESC must have a separate Node-ID on the CAN Bus and it must be different from the Flight computer Node-ID (Default Pixhawk Node-ID: 1). Restart required after change
[3000sub04]	Axis configuration miscellaneous	0	1: **CW** motor rotation for positive demanded values. 0: **CCW** motor rotation for positive demanded values.
[2020sub00]	ESC-Index	0 … 15	The UAV-ESC index must match/map to the Airframe Reference for the vehicle type. (→ see Pixhawk configuration: ESC indexes from 0…7 map to MAIN 1-8 output on the Pixhawk) Setup example for quad copter configuration:  Restart required after change
[30F0sub02]	Set value velocity minimum	0 rpm	Shall be equal to 0 for unidirectional control (recommended).
[30F0sub03]	Set value velocity maximum	= Max profile velocity	Chose value equal to UAV-ESC parameter: [607Fsub00] **Max profile velocity** (→ see section 3.7)

123 Pixhawk configuration

Power the vehicle and all CAN system using the battery/power supply.

docs.px4.io

Parameter Name	Recommended values	Notes
UAVCAN_ENABLE	3	3: Sensors and Actuators (ESCs) Automatic Config
UAVCAN_ESC_IDLT	$\frac{Synchronous\ minimum\ velocity}{Set\ value\ velocity\ maximum} \times 8191$	Defines idle speed in UAVCAN Raw command format [0, 8191] (→ see firmware specification section 7.3.32) Chose value equal to formula with UAV-ESC parameters: [30AFsub09] **Synchronous minimum velocity** (→ see section 3.6) and [30F0sub03] **Set value velocity maximum** (→ see section 1.2.2)

2 Start-up and Arming sequence

The UAV-ESC features a defined arming procedure (→ see user manual section 4.7):

1.) Power up the system → UAV-ESC switches to **initialization** state
(Status LED: white blinking → see section 3.1)
2.) **Arm** Pixhawk flight computer → UAV-ESC switches from **initialization** to **arming timeout** state
(Status LED: continuous red light → see section 3.1)
3.) **Disarm** Pixhawk flight computer → UAV-ESC switches from **arming timeout** to **armed** state
(Status LED: continuous green light → see section 3.1)
4.) **Arm** Pixhawk flight computer again to send throttle commands

*Once the UAV-ESC is **armed**, it cannot be **disarmed** with throttle commands.*

Power cycling or disable over EPOS Studio is required.

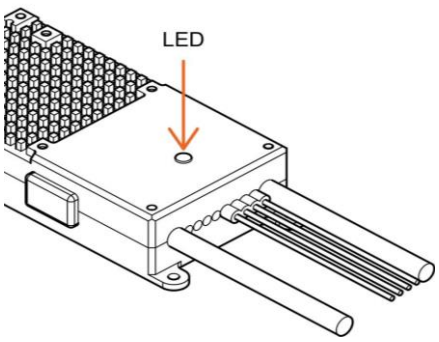
3 Protection Functions, Error Behavior & Debugging

There are 3 types of error behaviors (not every error allows every error behavior):

Disable	The motor is shutting down.
Auto fault reset	The motor is shutting down. System restarts automatically.
Warning only	The error event is displayed as warning in the status window. No failure reaction.

Carefully consider, which error leads to what UAV-ESC action.
Motor shut down (Disable, Auto fault reset) in flight is not a desired behavior.

3.1 System Status Indication

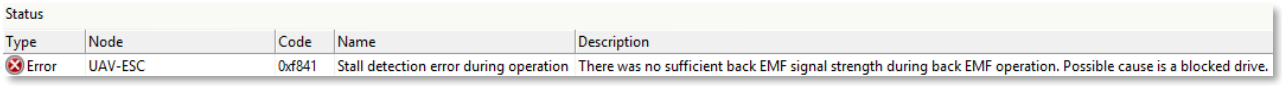


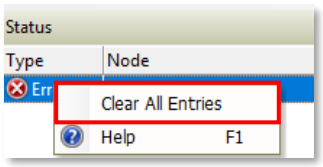
*The **blue** flashing LED "interrupts" the other colors (e.g., if green is continuously lit, it will be interrupted by the blue flashing LED).*

LED Color	Meaning	Error behavior options
White	**Initialization in progress**	N/A
Blue	**Communication in progress** - Data are being transmitted/received via CAN	N/A
Green	**Normal operation** - Blinking: Wait for arming, system is ready - Continuous: Armed, motor is powered	N/A
Yellow	**Warning** - Flying is still possible, landing upon next possible occasion is suggested	**Disable** **Auto fault reset** **Warning only**
Red	**Error** - Take-off is not possible - Flying is no longer possible	**Disable** **Auto fault reset**

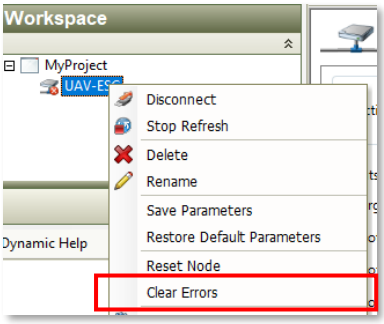
3.2 EPOS Studio - Error Handling

Errors/Warnings are displayed in the **Status** bar in the EPOS Studio as depicted below (→ see section 4):





If the error list is not cleared, the entire error/warning history is displayed. Power cycling the UAV-ESC clears the complete error history.



If **Disable** is selected as error behavior, the error must be cleared in the Workspace to enable the UAV-ESC again.

3.3 List of common critical errors

For the following errors, only **Disable** or **Auto fault reset** can be selected as error behavior (motor shutdown).

Name	Description / Cause	Recommended actions
Overcurrent error	- Short circuit in motor winding. - Controller gains too high and/or deceleration too high. - Damaged power stage. UAV-ESC parameter: [3001sub02] **Output current limit** (default: 90A) (→ see section 3.4.1)	*Reduce parameter **Profile deceleration** if error comes up while decelerating or reduce **Max motor speed** if error comes up while accelerating.*
Power stage protection error	- Short circuit of motor winding against ground. - Short circuit of motor winding against operating voltage V_{cc}. - Damaged power stage.	
Overvoltage error	- Supply voltage too high. - Deceleration too high (active breaking).	*If derating is disabled, reduce parameter **Profile deceleration** (→ see section 3.7)*
Undervoltage error	- Supply voltage too low. - Required acceleration current cannot be supplied. ***Switch-off threshold:*** ***7.3 V*** ***Recovery threshold:*** ***7.7 V***	*Reduce parameter **Profile acceleration***
Stall detection error during synchronous startup.	- Blocked motor (stall condition) during startup.	
Stall detection error during operation	- Blocked motor (stall condition) during normal operation.	
Thermal motor supervision error	- I2t level exceeds limit defined in UAV-ESC parameter [3200Fsub03] **I2t level motor error limit** (→ see section 3.4.1)	

3.4 Thermal motor protection

The UAV-ESC will limit the output current according to **I2t method** (→ see firmware specification section 3.6.2) or dependent on actual **measured motor winding temperature** (NTC sensor).

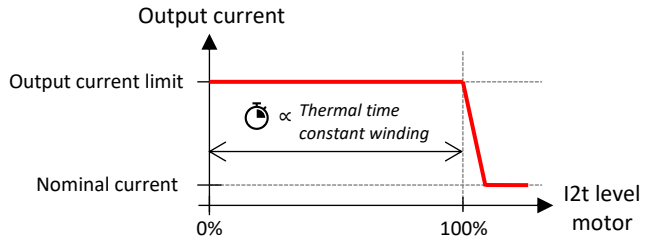
3.4.1 I2t - Method

With properly setup motor data, the motors are protected from overheating in the application.

*To access the **full performance potential** of the motor, the thermal motor protection can be adjusted or disabled by increasing **Nominal current** and/or the **Thermal time constant winding.***

Disabling motor protection in the UAV-ESC could lead to damage of motors.
*Motor **winding temperature** should be **monitored carefully**.*

Index	Name	Recommended values		Notes
[3201subA]	Motor temperature NTC type	0		**0:** motor protection via I2t model enabled (NTC disabled)
[3001sub01]	Nominal current	*See propulsion system specific values on datasheet*		The winding temperature will reach its maximum value during continuous operation at 20°C ambient temperature.
[3001sub02]	Output current limit	90'000	mA	Limited by UAV-ESC hardware.
[3001sub04]	Thermal time constant winding	*See propulsion system specific values on datasheet*		Basis for calculation of duration the max output current (**Output current limit**) can be supplied to the motor. Output current is reduced to **Nominal current** afterwards.
[3200sub01]	I2t level motor	only monitoring		≥100%: I2t motor protection is enabled, and output current is derated to **Nominal current**. 0…99%: I2t motor protection is disabled.
[3200sub03]	I2t level motor error limit	120	%	Should not be changed. If the **I2t level motor** exceeds this value, a **Thermal motor supervision error** will be triggered, and the UAV-ESC will be shut down. It means, that all measures to reduce motor winding temperature have failed and **I2t level motor** could not be decreased.



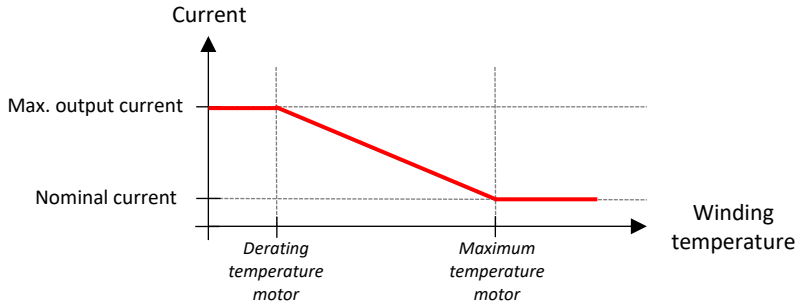
*Increasing **Nominal current** may require re-tuning of startup parameters → see section 3.6*

3.4.2 NTC Sensor

Index	Name	Recommended values		Notes
[3201subA]	Motor temperature NTC type	3435 (for NTC in maxon UAV motors)		**3435, 3490, 3610, 4000 und 4480 (all 10 kOhm):** motor protection via NTC sensor reading enabled
[3201sub09]	Warning temperature motor	135	°C	If motor temperature exceeds this value, a warning will be displayed.
[3201subC]	Derating temperature motor	145	°C	Threshold to start linear decrease in output current from max output current to **Nominal current.**
[3201subB]	Maximum temperature motor	155	°C	Threshold, where only nominal current will be fed to motor.
[3200sub01]	I2t level motor	only monitoring		I2t level has no effect on motor protection, when NTC sensor is enabled but will be displayed for reference.

*When using the preinstalled maxon NTCs, the derating ranges **shall be reduced by 35°C** (experimentally tested by maxon).*

Exact calibration with additional temperature sensors on winding is highly recommended.



3.5 Thermal UAV-ESC protection

The UAV-ESC is safeguarded by self-regulating the output power (limit I_{max}) to prevent overheating according to the following scheme:

@ -30…+85 °C: I_{max} *= 90A*
@ +85…+95 °C: I_{max} *= linearly decreased from 90A to 15A*
@ +95 °C: I_{max} *= 15A*

Index	Name	Recommended values		Notes
[3201sub08]	Warning temperature power stage	85	°C	If the UAV ESC power stage temperature exceeds this value, a warning will be displayed.

3.6 Motor startup sequence

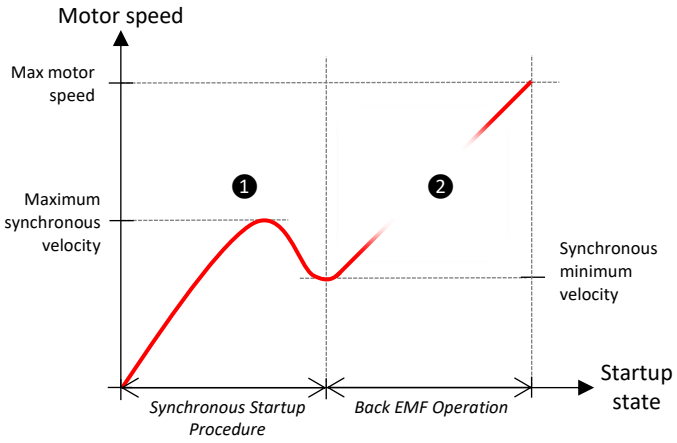
The UAV-ESC has two operational states:

❶ **Synchronous Startup Procedure:**
No reliable back-EMF signal of the motor is available at low speeds.

❷ **Back-EMF Operation:**
The UAV-ESC switches to back-EMF operation for all speeds > **Synchronous minimum velocity**.

No advanced startup tuning should be required, when using the maxon propulsion system portfolio with the corresponding parameter sets.

*For advanced tuning of **non-maxon products***
→ see user manual section 4.6.3



Index	Name	Recommended values		Notes
[30AFsub0A]	Maximum synchronous restart trials	5		Total number of failed start trials before error is triggered: ***Stall detection error during synchronous startup***
[30AFsub03]	Maximum synchronous velocity	900	rpm	If transition to back-EMF was not possible before reaching maximum synchronous velocity, an error is triggered: ***Stall detection error during synchronous startup***
[30AFsub09]	Synchronous minimum velocity	720	rpm	Defines minimum speed (idle speed) for back-EMF operation. Too small **Synchronous minimum velocity** may lead to unstable back-EMF operation and could damage the motor.

*Select **Synchronous minimum velocity** as large as possible, without generating siginifcant thrust or impose any danger to the suroundings. If **Maximum synchronous velocity** < **Synchronous minimum velocity**, increase it to 125% of **Synchronous minimum velocity**.*

3.7 Definition of motor speed, slew rate & active braking parameter

***Max acceleration**, **Profile deceleration** (and **Profile acceleration**) need to be chosen carefully to prevent overvoltage error (and derating / shut down of motors).*

Speed limit of the UAV-ESC:
$$= \frac{150'000}{number\ of\ pole\ pairs}\ rpm$$

Index	Name	Recommended values	Notes
[6080]	Max motor speed	*See propulsion system specific values on datasheet*	Set to max speed that motor and propeller in combination with given supply voltage is still able to reach.
[607Fsub00]	Max profile velocity	= Max motor speed	
[60C5sub00]	Max acceleration	= 2 x Max motor speed	Value should be as large as possible to enable full control dynamic.
[6083sub00]	Profile acceleration	= Max acceleration	
[6084sub00]	Profile deceleration	= Max acceleration	

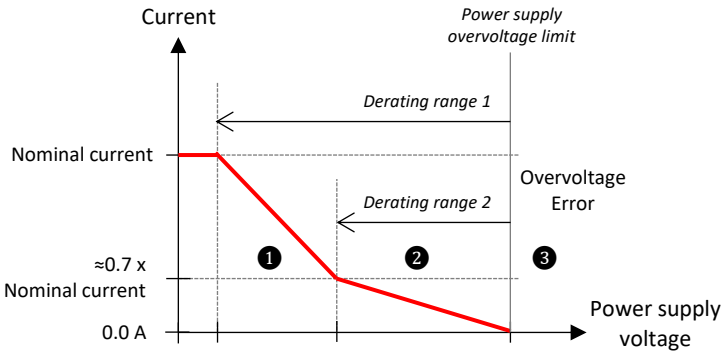
3.7.1 Active/regenerative braking:

Active braking feeds back energy to the power supply.
The power supply voltage can rise to undesired levels and even cause damage. To prevent this, the current will be derated in two steps (❶, ❷) and eventually an overvoltage error will be triggered that **disables** the UAV-ESC (❸):

❶ Voltage increase above **Derating range 1**:
Reduction of current and destruction of excess energy in the motor winding.

❷ Voltage increase above **Derating range 2**:
Further reduction of current.

❸ Voltage increase above **Power supply overvoltage limit**:
Overvoltage Error is triggered, and the UAV-ESC will be disabled (motor shut down)



Index	Name	Default		Notes
[2201sub02]	Power supply overvoltage limit	58'000	mV	*Hysteresis voltage: 400 mV* Check the battery specification and set **the Power supply overvoltage limit** to a value, that the battery can handle before being damaged.
[2202sub01]	Derating range 1	2000	mV	$= Power\ Supply\ Overvoltage\ Limit - Derating\ Range\ 1$ **Value cannot be changed!**
[2202sub02]	Derating range 2	1000	mV	$= Power\ Supply\ Overvoltage\ Limit - Derating\ Range\ 2$ **Value cannot be changed!**

Ensure, that the power supply can handle the excess energy and select the profile deceleration accordingly, so no error occurs in flight.

4 Quick Start Setup

(→ see user manual section 4.3 for further information)

1.) Run EPOS Studio.exe (no installation needed)

2.) Open the maxon predefined projects in the pop-up window

4.1 UAV-ESC connection

1.) Connect the micro-USB to the UAV-ESC.

*The UAV-ESC is **not powered** via the micro USB cable.*

2.) Connect VCC and Ground to your power supply (9…52.2 VDC) to power up the UAV-ESC.

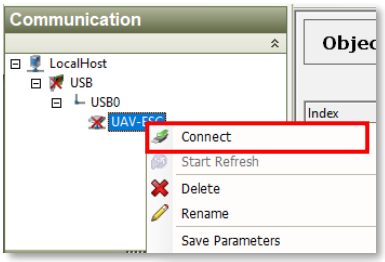
*If the power supply allows, select a **low** voltage level for comissioning.*

3.) Connect the EPOS Studio to the UAV-ESC

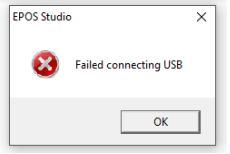
a. Open the Communication pan in EPOS Studio

b. Select the UAV-ESC (LocalHost / USB / USB0 / UAV-ESC)

c. Right click and select **Connect**



If the following error message appears, the UAV-ESC might not be powered correctly:



4.2 Load firmware and parameters

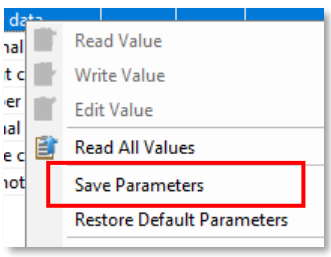
1.) Open Wizards pan

2.) Select **Firmware Update** and import firmware from file

Parameter files are provided in the maxon UAV-ESC bundle

3.) Select **Parameter Export/Import** to import parameters from file.

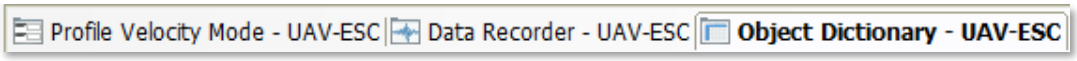
*Parameters in the **Object Dictionary** are **not** saved automatically.*
They are lost after power cycling the UAV-ESC.
*To save the parameters, right click into the window and select **Save Parameters***



4.) Save parameters

4.3 EPOS Studio tabs

The predefined project automatically opens 3 tabs in the EPOS Studio:



Profile Velocity Mode

(→ see user manual section 4.3.4.3 for further information)

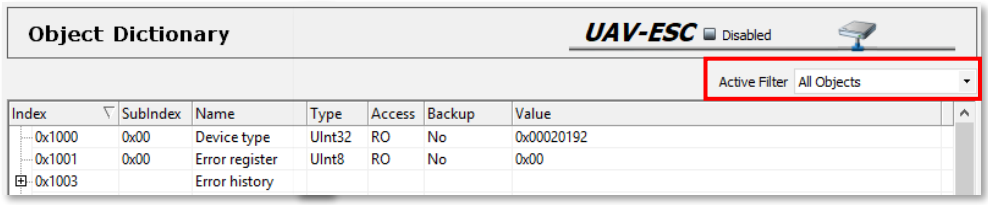
Data Recorder

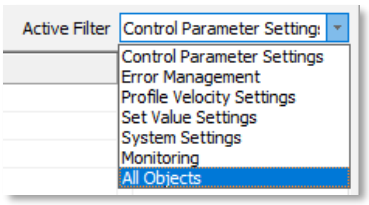
(→ see user manual section 4.3.4.2 for further information)

Object Dictionary

(→ see user manual section 4.3.4.1 for further information)

The Object dictionary tab is a complete list of all the parameter which can be adjusted to setup the UAV-ESC.
Recommended parameter settings are predefined for maxon UAV catalogue propulsion system combinations (conservative).
A set of filters has been defined, which allow user friendly access to the relevant parameters:





Disclaimer

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 and fulfills 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!*
- *Check on applicable local rules and regulations in respect to flight permissions, no-fly zones, restricted areas, and other flight restrictions.*

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