



Currawong
ENGINEERING

VELOCITY ESC



**HIGH POWER, HIGH RELIABILITY
BRUSHLESS MOTOR CONTROL
FOR UAV POWER SYSTEMS
JULY 2021**

THE VELOCITY ESC

UNPRECEDENTED CONTROL UNMATCHED POWER AND RELIABILITY

Currawong Engineering's line of Velocity Electronic Speed Controllers (ESCs) provides high power, high reliability brushless motor control for UAV power systems.

This product fulfils the pressing need for an aerospace grade electronic speed controller (ESC) for use with 3-phase brushless DC motors. Currawong has engineered a robust device with a high level of documentation, testing and traceability.

High Power

With peak output power in excess of 20kW, the Velocity ESC supports

extreme heavy-lift applications. High voltage operation (up to 18S / 75V) reduces current losses and allows larger motors to operate more efficiently.

Industry Confidence

Currawong's Velocity ESC is being used by many major players in the heavy lift UAV sector. The ESC is not subject to ITAR restrictions.

Health Monitoring

High speed glitch-free control is provided with the fully-isolated CAN interface, which also provides high-speed real-time telemetry data. In addition

to monitoring RPM, current, voltage and temperature data, the ESC reports internal health monitoring statistics.

Runs Cooler

Extremely low impedance MOSFET switches with impedance matched drive circuitry means that the Velocity ESC runs cool, operating at partial throttle or maximum load. Reduced cooling requirements means easier airframe integration and increased flight endurance.

MODEL	VELOCITY HT	VELOCITY HC	VELOCITY HS NEW!
Voltage	75V / 18S	60V / 14S	60V / 14S
Current* (Sustained / Peak)	150 A / 300A	250A / 500A	150A / 300A
Power	10kW	15kW	7.5kW
Length	110mm (4.33 inch)	110mm (4.33 inch)	110mm (4.33 inch)
Width	60mm (2.36 inch)	60mm (2.36 inch)	60mm (2.36 inch)
Height	29mm (1.14 inch)	32mm (1.26 inch)	21mm (0.83 inch)
Weight	300g (10.58 oz)	350g (12.35 oz)	250g (8.82 oz)
Max e-RPM	250,000 electrical RPM		
Drive Frequency	5-75kHz		
Timing Advance	0 – 25°		
Operating Temperature	-20°C – 100°C		

* Continuous current rating will depend on ESC installation. ESC and motor temperature must be kept below maximum rated value.

RELIABILITY

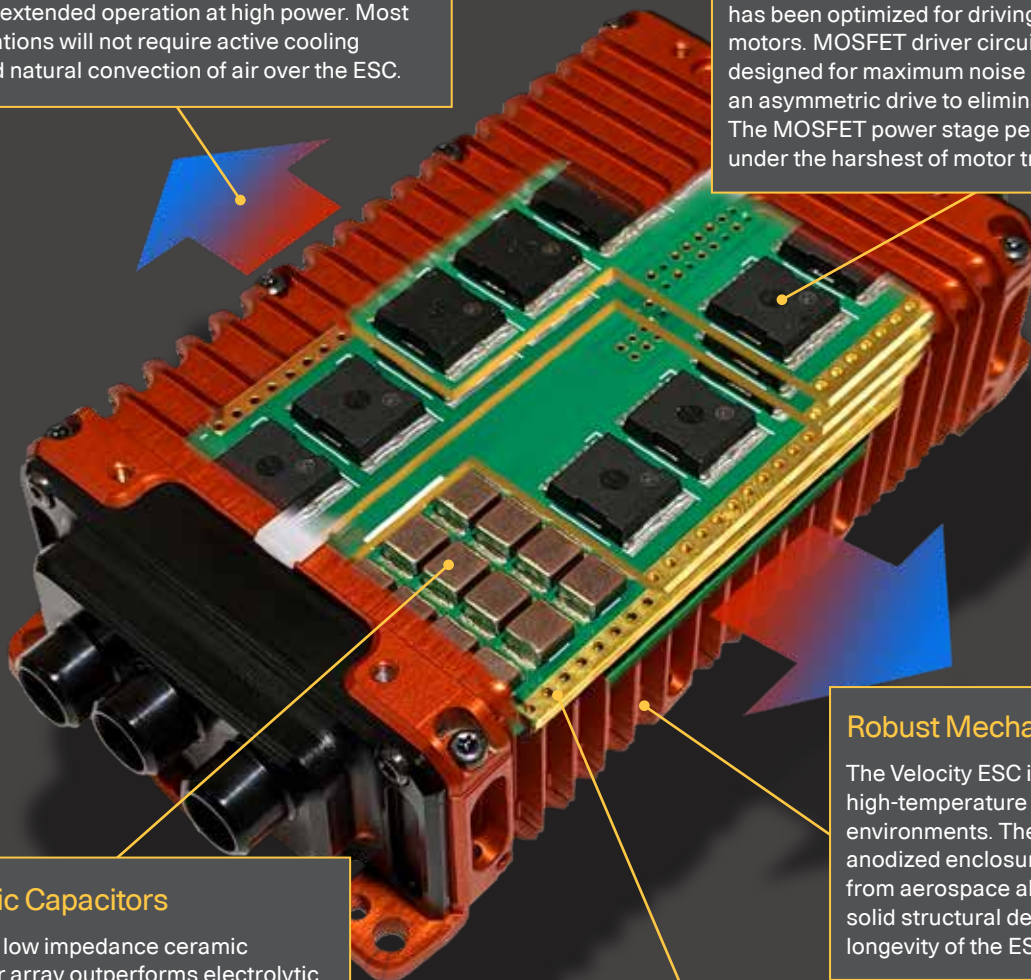
Through advanced hardware and software design, the Velocity ESC provides the high reliability required for flight-critical applications. Tight coupling between the control board and power electronics provides the level of signal integrity necessary to ensure the ESC drives large motors at continuous operation for extended periods.

Thermal Management

The Velocity ESC provides extremely high power density. A low-impedance thermal path from the switching elements to the enclosure heat-sink allows extended operation at high power. Most applications will not require active cooling beyond natural convection of air over the ESC.

Low Impedance MOSFETs

Extremely low impedance MOSFETs with impedance matched drive circuitry means the ESC runs cooler even when operating at maximum load. The power electronics design has been optimized for driving extremely large motors. MOSFET driver circuitry has been designed for maximum noise immunity, using an asymmetric drive to eliminate shoot-through. The MOSFET power stage performs well under the harshest of motor transients.



Ceramic Capacitors

A unique low impedance ceramic capacitor array outperforms electrolytic capacitors, providing better performance at altitude, long storage life and will not deteriorate over time. The ceramic capacitors provide extremely high ripple current capacity, ensuring longevity of the ESC at full power.

Robust Mechanical Design

The Velocity ESC is designed for high-temperature high-vibration environments. The lightweight anodized enclosure is machined from aerospace aluminium. The solid structural design ensures longevity of the ESC in the vehicle.

Heavy Copper PCBs

Power carrying PCBs have been designed to maximise electrical and thermal conductivity. Impedance matching of gate drivers is facilitated by custom PCB construction techniques. High quality conformal coating is applied to the electronics to ensure long life and reliability in harsh environments.

PERFORMANCE

Reliable Starting

The advanced sensorless starting algorithm provides extremely reliable motor starting, which is critical for VTOL transition. Multiple commutation algorithms run in parallel to ensure that starting is repeatable, even for high-inertia systems. Motor starting parameters can be precisely tuned for a given motor.

Active Freewheeling

Active freewheeling (synchronous rectification) provides superior performance at partial load. The ESC runs cooler and operates very efficiently. The intelligent high-speed commutation algorithm reduces switching noise (EMF) and audible motor noise.

RPM Controller

An integrated closed loop RPM controller enables tight control of motor speed which compensates for variations such as wind loading. RPM commands are sent to the ESC via the CAN interface.

Extreme Dynamics

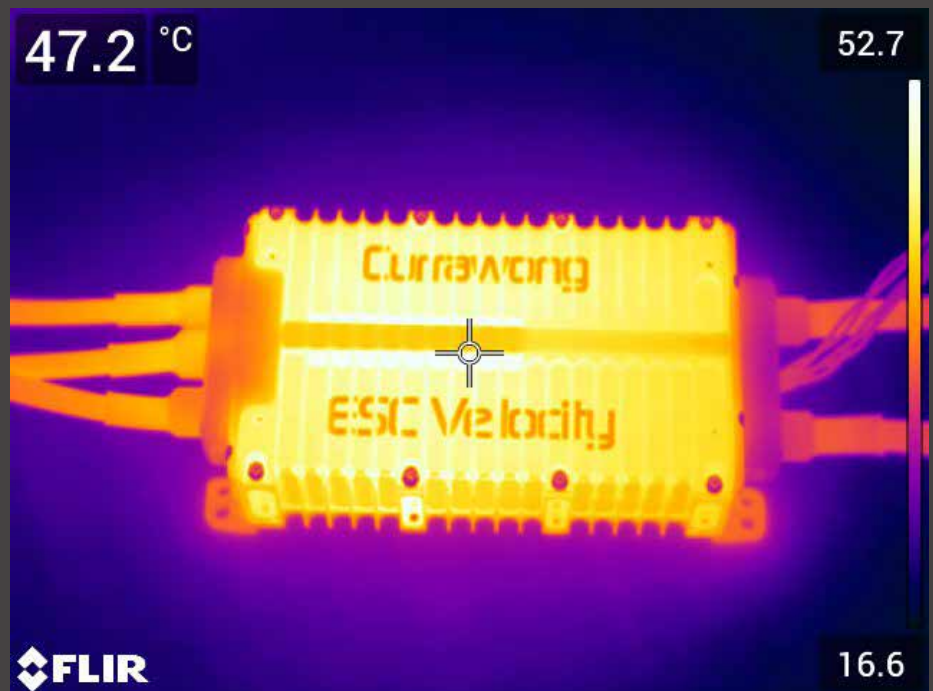
The robustness of the power electronics allows the motor to be driven with exceptionally high transients. Acceleration and deceleration rates can be configured separately, allowing system bandwidth to be tuned for a given application.

High Speed Commutation

The Velocity ESC provides superior RPM performance at both the low and high ends of motor speeds, with a maximum electrical RPM of 250,000 and a configurable drive frequency up to 75 kHz.

Power Density

By tightly integrating class-leading power electronics with a mechanical layout designed to minimize thermal impedance, the Velocity ESC provides unmatched power density.



SAFETY

Protection Features

Self-protection features ensure that the ESC does not operate outside the safe operating range. User-configurable foldback limits (on parameters such as current, voltage ripple and temperature) allow a safe operating range to be defined for a particular operation.

Depending on requirements, the ESC can be configured to automatically adjust operation, for example to track a limiting parameter such as maximum battery current.

Importantly, the safety features do not disable or stop the motor operation – the motor will continue to operate even in a protection state.

Hardware Interlock

The Velocity incorporates a true hardware interlock system which provides guaranteed motor shutdown for improved operator safety. The CAN interface remains operational when the interlock is active, allowing preflight checks while the ESC is safe. Interlock status is reported over the CAN interface.

Powerful Microcontroller

The ESC uses a powerful 32-bit microcontroller running an advanced real-time operating system. The RTOS enables high-level telemetry and safety functions to run asynchronously with motor control.

Isolated CAN

The isolated CAN interface provides for simple connection to a wide range of autopilots whilst improving signal integrity and reducing the number of connectors required by the autopilot. The CAN interface is galvanically isolated from the power inputs of the ESC, ensuring that noise due to motor transients is not reflected onto the input signals.



Advanced Telemetry

The CAN interface provides real-time reporting of ESC and motor telemetry data, such as RPM, current, voltage and temperature. Additionally the motor temperature can be reported with an optional connector for an external motor temperature sensor.

Data Logging

On-board data logging can record motor operational data, in addition to this data being recorded in the autopilot.



CONFIGURATION

Autopilot Integration

The Velocity ESC is natively integrated with Piccolo and Ardupilot.

Integration with third-party systems is simplified with provision of a fully-documented ICD and SDK.



Highly Configurable

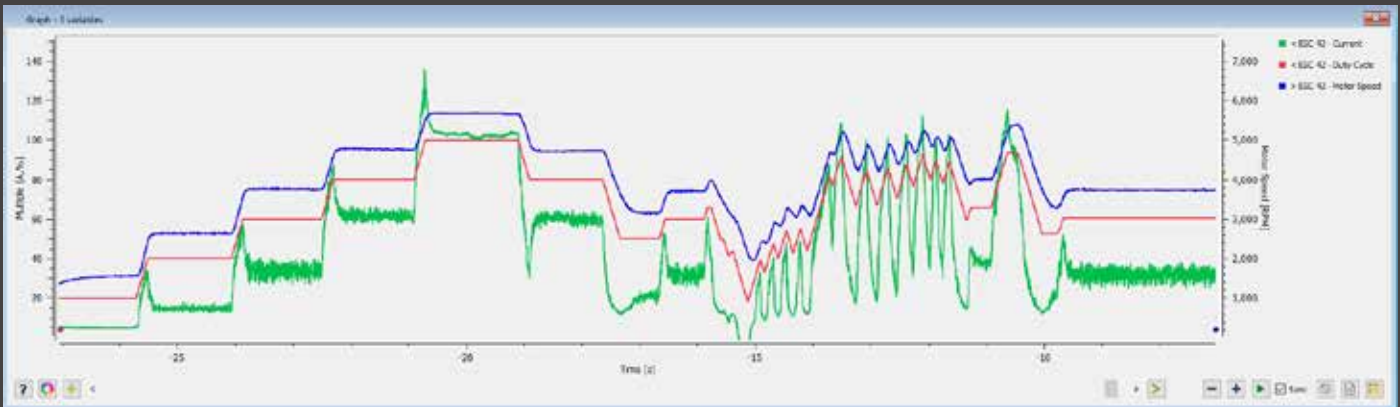
The Velocity ESC provides a wide range of configuration parameters, allowing the ESC to be tuned to a particular motor / propeller setup. A powerful PC application (CEquip) allows full configuration of the Velocity ESC. CEquip also provides real-time graphing of ESC parameters.

Configuration Management

The ESC reports its configuration over the CAN interface, allowing the operator / autopilot to validate that each ESC is configured correctly as part of a regular pre-flight check. Firmware and configuration checksum values can be queried from the ESC.

Integrated Bootloader

An integrated bootloader allows firmware updating over the CAN interface. ESC firmware can be updated in-situ, without the requirement to remove the ESC from a vehicle.



The screenshot shows the CEquip V1.0.11 software interface. The top bar indicates 'CAN connected via 5uCAM at 1000kbit/s - Connected to InvenSense'. The main interface is divided into several panels:

- ESC Status - #42:** Shows status for Hardware, Software, AIW On, Reverse Direction, Command Timeout, Spinning, Running, Starting, Foldback, Sync, Any Warnings, Any Errors, and a table of Cause/Status/Action.
- Warning Panel:** Lists various warnings like Overspeed, Overcurrent, Motor Temp, Undervoltage, Overvoltage, Invalid PWM Signal, Demag Angle, Timing Advance, Long Demag, Missed Zero Crossing, Spinning Reversed, and Max. Speed Limit.
- Error Panel:** Lists errors like Failed Start, Commutation Error, Hall Sensor Error, Overcurrent Error, Overspeed Error, and Settings Checksum.
- ESC Control - #42:** A circular control panel with a needle gauge, buttons for PWM, AIW, Start, Stop, and Current, and a 'Continue Commands' checkbox.
- ESC Settings - #42:** A table of settings including Protection Level, Max Current, Free Current, Regen Current, ESC Temp, Motor Temp, Motor Speed, Undervoltage, Overvoltage, Demag Angle, Timing Advance, and Max. Comm. Speed.
- ESC Command - #42:** A panel for sending commands like Tick (Velocity), Status (Inhibited), Duty Cycle (0 km), and ESC Pulse Width Command (Open Loop).

QUALITY ASSURANCE

Testing / Validation

Currawong performs extensive validation testing on firmware and hardware, with a wide range of representative motors and propellers in a purpose-built testing facility. Firmware quality is ensured with a continuous testing process.

Acceptance Tests

Each ESC is individually tested to ensure it passes a series of acceptance tests during the commissioning process. A high-power calibration test ensures each ESC is performing correctly under high load. Acceptance reports are provided with each ESC.

Documentation and Support

Currawong provides a high level of product documentation, in addition to ongoing engineering support. Each ESC is uniquely serialized providing product traceability from production through to the customer.

CUSTOMER SUPPORT

Integration Services

Currawong has comprehensive test facilities and can assist customers with configuring and measuring the performance of the customers motor and propeller. Currawong is able to measure motor thrust and high precision electrical parameters to optimize the ESC/motor/propeller combination.

Custom ESC Development

Currawong can work with customers to develop custom motor control hardware where off-the-shelf solutions do not meet specific design requirements. The Velocity hardware and software products are readily adaptable to custom solutions.

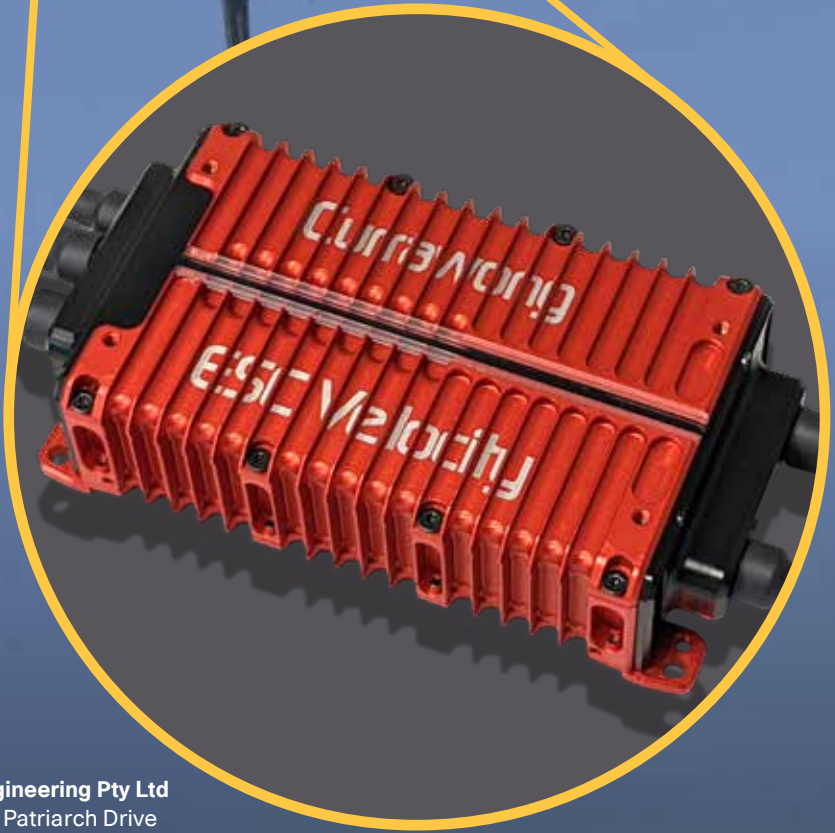
Customer Configuration Management

Currawong supports custom order codes to ensure consistency of supply against customer configuration requirements.

Custom Harnessing

Currawong can provide custom cabling and harnessing solutions, allowing customers to receive ESCs wired for their particular vehicle requirements. Currawong uses NASA standard wire wrapping to ensure high mechanical reliability.





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