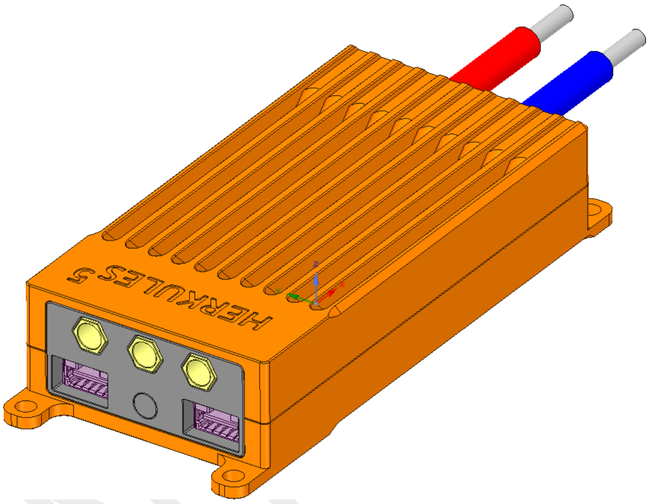
HERKULES^5 – Datasheet

Brushless Motor Controller
for Industrial and UAV application

Features

- High-End Brushless Motor Speed Controller
- Supply Voltage **9-52V** (3-12S LiPo)
- Motor current **200Apeak / 80A** continuous
- Trapezoidal (**BLDC**) or Sinus Drive (**FOC**)
- Autotiming (Phase-advance, field-weakening)
- **Sensorless** and **sensored** commutation
- Drive Modes: duty-cycle (**PWM**),
  current (**TORQUE**) and speed-control (**RPM**)
- Fully **protected** against **over-current** and over-voltage with soft-limitation
- Fully controlled acceleration and braking current (**recuperation** current control)
- Highly robust commutation in all conditions especially at fast speed changes
- Fast direction change (**reverse mode**)
- Communication interface:
  2 x CAN, **1 x USB** (galvanic coupled)
  2 x PPM, **1 x UART**, **1 x I2C** (galvanic decoupled)
- Setpoint update rate up to **1000Hz**
- Flexible configuration of all parameters with comfortable graphical user interface
- Integrated **datalogger** with microSD Card
- Optional **hall-sensor** and external FAN control
- Open diagnosis and communication protocol
- Multiple RC-telemetry protocols
  (Futaba, Graupner, Jeti, HiTec, Multiplex, etc.)



- CNC-milled aluminum case for best cooling
- Dimension (LxWxH): 83x42x20mm (basic body)
- Mass: ca. 135g (without battery cable)

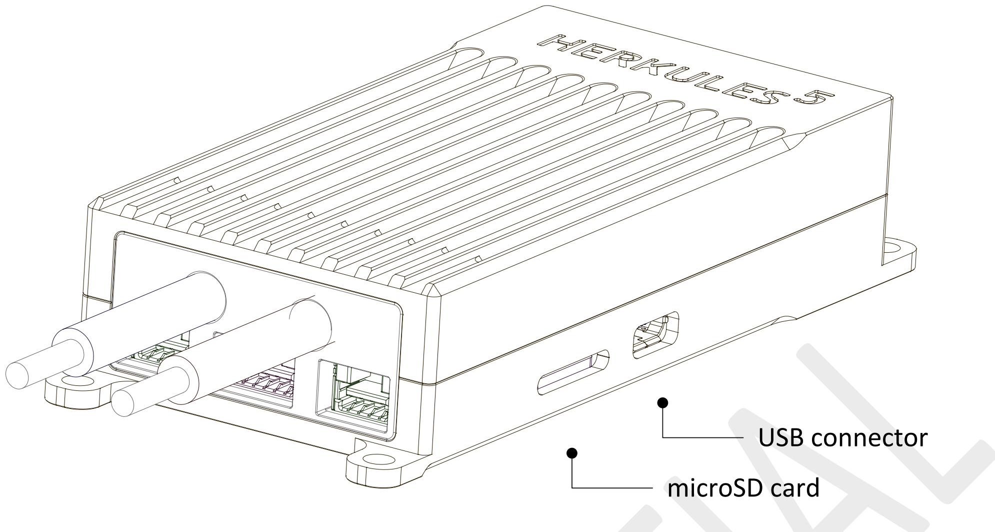
Applications

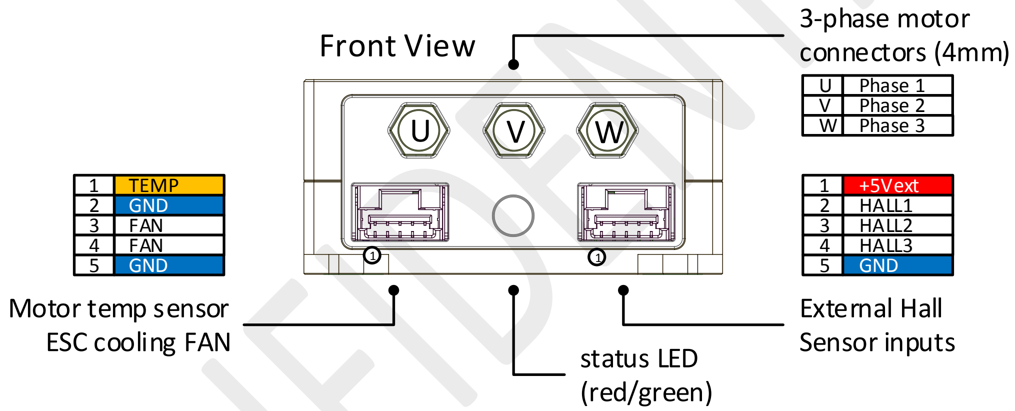
- Multicopter UAV application
  (Supports DJI, Mikrokopter, Pixhawk, etc.)
- Airplane UAV
- Industrial Vehicle Drive Sets
- Robotics

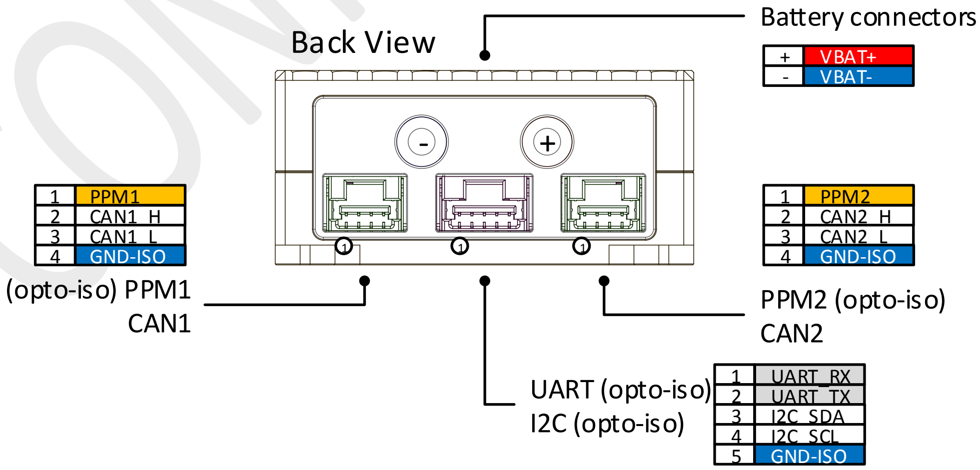
Overview

HERKULES^5 is a high performance brushless motor control electronic (ESC) for professional and industrial application. It can drive brushless DC motors (BLDC) with trapezoidal (BLDC) or sinusoidal current shape by use of field-oriented control (FOC). Application can select between control modes PWM (Duty-cycle), TORQUE (Current-control) or RPM (speed-control). The powerstage is fully protected against overvoltage and overcurrent. The currents in all motor phases and in the battery lines are measured and cycle-by-cycle limited. This allows a perfect current regulation and motor protection especially at fast speed changes and the acceleration and the recuperation current can be controlled precisely. Communication is possible via CAN, UART, I2C, PPM and USB interface with fast update rates up to 1000Hz. A graphical Windows-tool allows easy configuration of all parameters and updating the firmware.

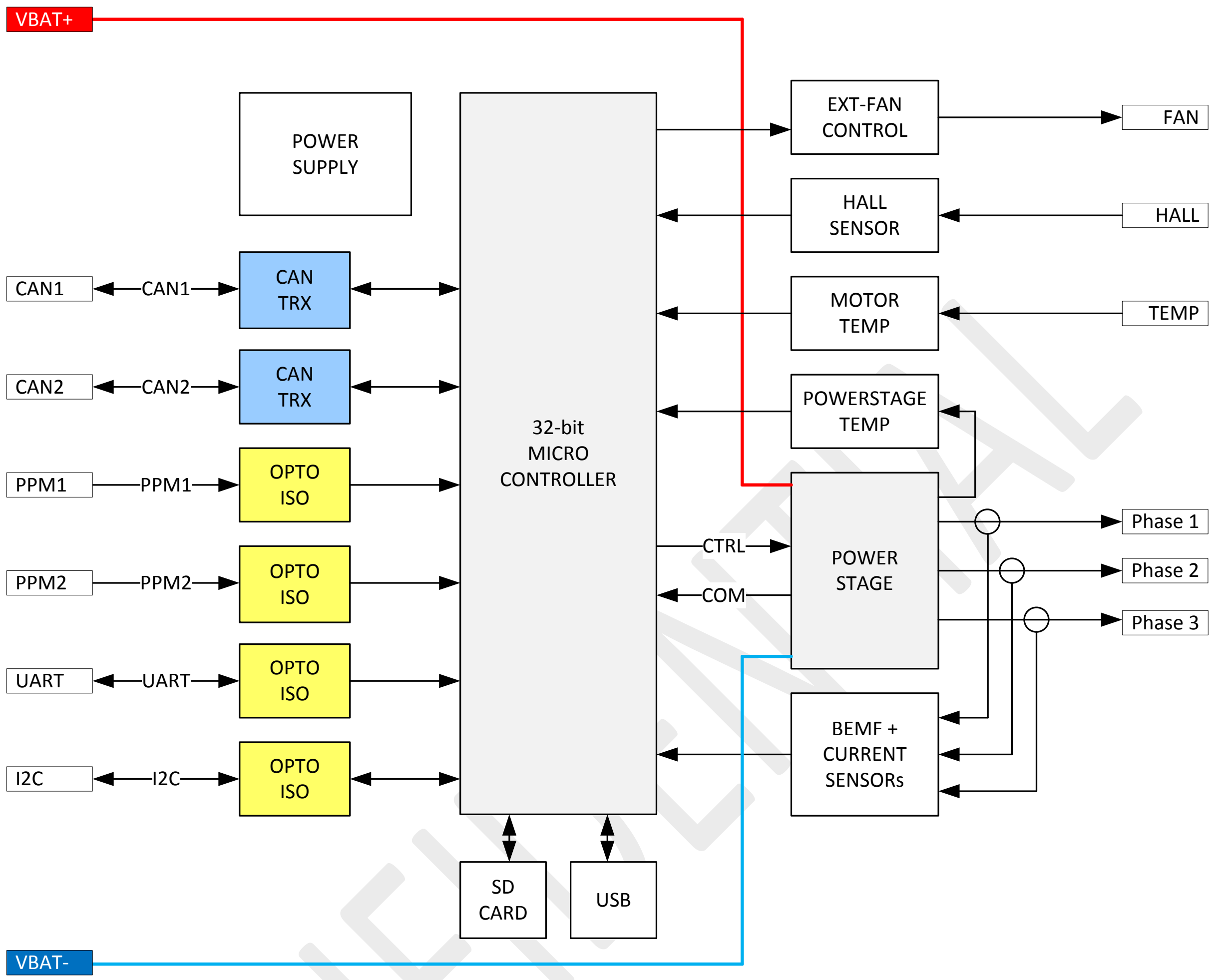
Connections







System Architecture



Communication Interface

USB
The Micro-USB socket provides a high speed communication to a host computer. The Interface is detected as virtual comport and allows via the graphical user interface to update the firmware, configure all motor control parameters and stream back and display realtime measurement data from the motor controller in the host computer.

PPM1 and PPM2
Two independent RC-standard PPM interfaces (pulse-pause-modulation) are implemented to control the ESC. Both interfaces are optically decoupled to avoid communication failures caused by ground loops. The setpoint is decoded from a pulse length of 1.0-2.0ms (configurable) with a max. repetition rate of 500Hz. User can define the detected positive range for forward and the negative range for backward operation. The setpoint update rate is optimized for high-speed reaction time which is necessary in multicopter / UAV application.

CAN1 and CAN2
Two independent CAN interfaces allow the use of a robust bidirectional communication in harsh environments. Beside of the setpoint transmission from master to the ESC, a detailed diagnosis readback from ESC to the master is possible. Via CAN all connected ESCs get a unique ID and can be configured and updated with latest firmware as with USB bus. The documentation of the communication protocol is available and allows easy implementation in customer's application. For more details please refer to the user manual.

I2C
The I2C-Bus is available to communicate with the master controller. The interface is optically decoupled to avoid communication failures caused by ground loops. The standard UAV-communication protocols from MIKROKOPTER are supported as well as a proprietary communication interface. The documentation of the communication protocol is available and allows easy implementation in customer's application. For more details please refer to the user manual.

UART
The galvanic/optical decoupled UART interface is available to communicate with the master controller via a full duplex interface. The max baudrate is 115.200bps and allows setpoint transfer from master to ESC and diagnosis information from ESC to master. Standard Mikrokopter protocol is supported as well as a proprietary communication interface. The documentation of the communication protocol is available and allows easy implementation in customer's application. For more details please refer to the user manual.

ANALOG1 and ANALOG2
Instead of a digital signal, an analog voltage between 0…5V can be applied on PPM1 or PPM2 to control setpoint and braking (recuperation) current. This makes it possible especially in electrically driven vehicles to control with one or two potentiometers (gas and break pedals) the torque and braking current. For more details please refer to the user manual.

MicroSD Card Datalogger
The integrated MicroSD-card provides a full featured Datalogger with selectable data rates up to 200Hz. All Motor Parameter like Current, RPM, ESC Temp, Diagnosis and Status-Flags and optional external CAN bus messages can be logged during operation and analysed by the graphical user interface. The data to be stored can be selected by the user interface.

Motor Control and operation modes

Basic Motor Control Mode

Motors can be driven in different control modes. The mode and it's setting can be programmed with the graphical configuration tool.

- **Trapezoidal block commutation (BLDC) (sensored or sensorless)**

In the BLDC mode, the ESC drives only two motor phases at a time with current. The third motor phase is used for sensing the right commutation time. This mode is mainly used in most standard ESCs. User can select between sensored, sensorless or mixed mode operation.

- **Field oriented Vector Control (FOC) (sensored or sensorless)**

In the FOC mode, the ESC drives the motor phases with a sinusoidal current shape, calculated by load and motor characteristics. This has very low commutation noise and high torque at low speed. User can select between sensored, sensorless or mixed mode operation.

Quadrant Operation

The ESC can drive in forward or backward direction the motor. User can program the acceleration deceleration / braking current separately and define also the recuperation current proportional relative to the setpoint.

- **Unidirectional (no reverse) without recuperation / active freewheel**
- **Unidirectional (no reverse) with recuperation / active braking**
- **Bidirectional (reverse mode possible) without recuperation / active freewheel**
- **Bidirectional (reverse mode possible) with recuperation / active braking**

For more details, please refer to the user manual.

Power control options

Depending on the application, different power control options are selectable by configuration.

- **PWM-Mode – Duty-Cycle control**

The motor setpoint received from master is translated to a PWM with variable duty-cycle proportional to the setpoint. The motor phase voltage is changed and the speed of the motor changes. The motor speed changes when the load or the battery supply voltage changes and the master control has to take care on sending new setpoints to compensate this behavior. This mode is used in most standard ESCs.

- **Torque Mode- Current Control**

The motor setpoint received from the master is translated to a motor current setpoint and controlled in a fast direct regulation loop. This mode allows a high linearity between setpoint and motor torque and gives a fast and direct control over the motor power output. This mode is often used in ground vehicle drives where user wants to control the motor torque.

- **RPM Mode – Speed Regulation**

The motor setpoint received from the master is translated to target speed setpoint and controlled in a PID regulation loop. This gives best control about the motor speed independent on the load. Depending on motor / load setup, the regulation is slower than in torque mode. User has to carefully trim PID regulation parameters to get a stable behavior.

Electrical Specification

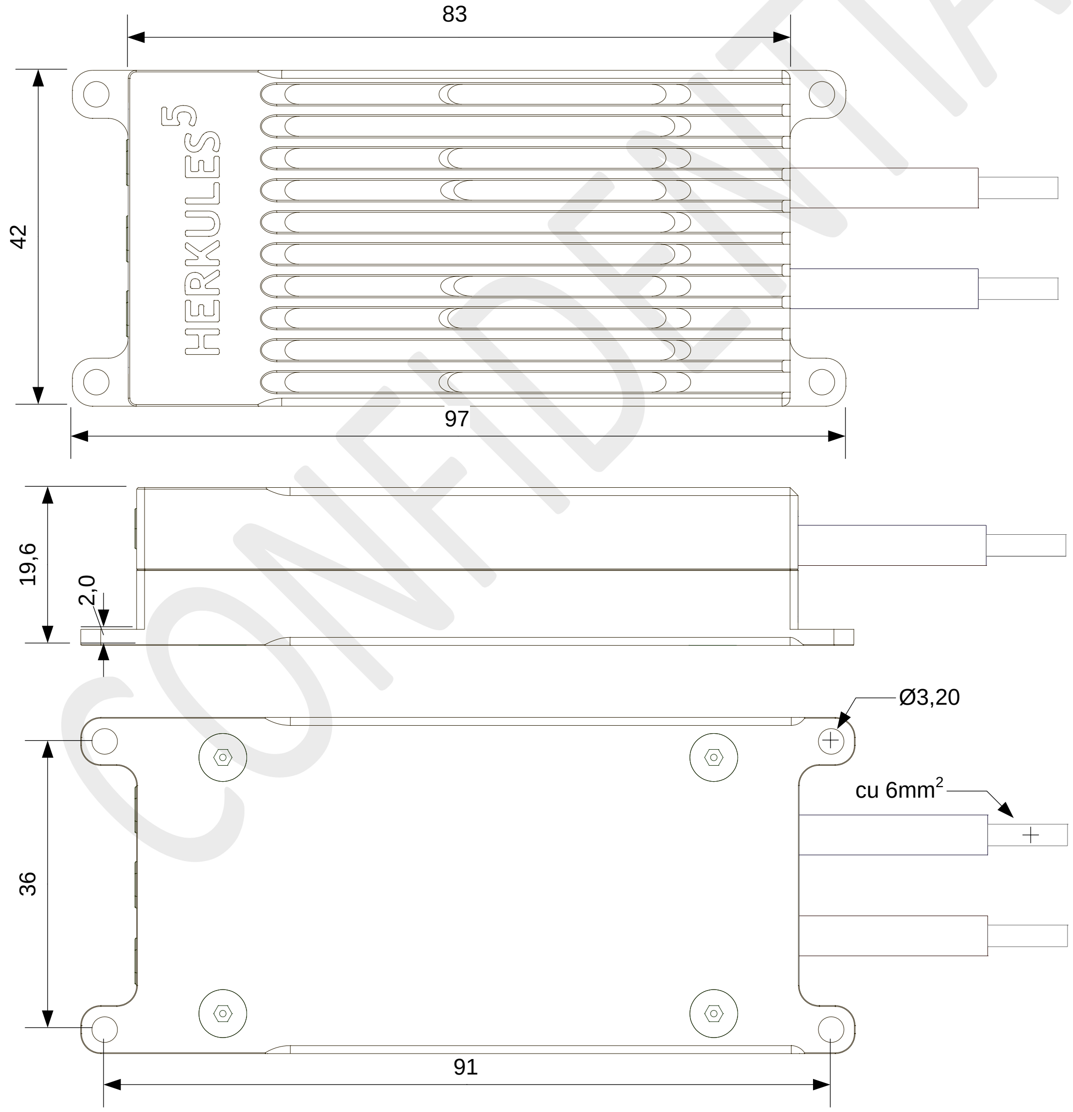
Absolute max voltage .... 9 - 60V
Recommended Supply voltage ....12 – 50V
Maximum motor current...........................200A(1)
Average motor current.................................80A(2)
Internal Impedance 5mOhm

Overcurrent limitation range................ 20 - 200A
Max ambient temperature .... -20 – 85°C
Overtemp limitation threshold.............. +110°C(3)
Overtemp switch off threshold .... +125°C(3)

(1)Motor Current limit configurable by software
(2)Good cooling with sufficient airflow required, optional with external FAN
(3)Internal temp on power PCB. Case temperature must not exceed max ambient temperature!

Mechanical Dimension

Total weight incl. alu case and bat-wire........ca. 135g



All dimensions are in mm. Drawing not to scale.