

| What          | Item                                          | Value                | Unit               | Remark                                                                                             |
|---------------|-----------------------------------------------|----------------------|--------------------|----------------------------------------------------------------------------------------------------|
| Specs         | Supply voltage                                | 5-15                 | V                  | V+                                                                                                 |
|               | Supply type                                   | Battery              |                    | NiMH, Lithium/LiPo, Lead Acid (also rechargeable)                                                  |
|               | Hardware low voltage det.                     | 4                    | V                  | Under voltage lock out H-bridge driver IC                                                          |
|               | Motor current                                 | 15 & 30              | A                  | Respectively nominal and peak (peak max 10 seconds)                                                |
|               | BEMF current                                  | 5                    | A                  | Max continue                                                                                       |
|               | External back EMF resistor <sup>1</sup>       | ?                    | $\Omega$           | To be determined empirical (if needed)                                                             |
|               | Ambient temperature                           | 0-50                 | $^{\circ}\text{C}$ |                                                                                                    |
|               | Motor type                                    | DC brushed           |                    |                                                                                                    |
|               | Control                                       | Proportional         |                    | Servo pulse                                                                                        |
|               | Directions                                    | CW/CCW               |                    |                                                                                                    |
|               | Dimensions                                    | 47x47x10             | mm                 | Without capacitor at the back                                                                      |
|               | Number of motors                              | 1                    |                    | Propeller, pistons tanks, pumps etc.                                                               |
|               | Weak dynamic braking                          | 110                  | $\Omega$           | Resistor from M1 and M2 to GND                                                                     |
|               | Thermal losses H-bridge                       | 3.5 + 0.5            | W                  | P-ch + N-ch MOSFET                                                                                 |
|               | PCB cooling area                              | 833 + 765            | mm <sup>2</sup>    | Respectively M1 and M2 (bottom and top side PCB)                                                   |
|               | Visual feedback                               | green                |                    | Status LED                                                                                         |
| NOT included  | Motor filter                                  |                      |                    | See mandatory                                                                                      |
|               | Reverse polarity protection                   |                      |                    | Limited (only 3.3V circuitry, not the H-bridge & MOSFET drivers)                                   |
|               | Over voltage protection <sup>2</sup>          |                      |                    | Limited (TVS only, consider using a back EMF resistor)                                             |
| NOT Supported | Over temperature protection                   |                      |                    | Left out (better an overheated ESC than a sunken model submarine)                                  |
|               | Short circuit protection                      |                      |                    | Consider installing a fuse in series with the V+ wire.                                             |
|               | Motor over current shut off                   |                      |                    | Left out for maximum operational reliability.                                                      |
| Does NOT have | On board fuse V+                              |                      |                    | Consider installing a fuse in series with the V+ wire.                                             |
|               | Strong dynamic braking                        |                      |                    | H-bridge shorting motor terminals (fast motor stop)                                                |
|               | Heatsink                                      |                      |                    | Designed to operate without                                                                        |
|               | Low battery detection                         |                      |                    | Only hardware under voltage lock out at 4V (MOSFET driver IC)                                      |
|               | Mounting holes                                |                      |                    |                                                                                                    |
|               | Audible feedback                              |                      |                    |                                                                                                    |
|               | Temperature protection external BEMF resistor |                      |                    | Ensure the back EMF resistor(s) has enough wattage                                                 |
| Options       | Supply decoupling capacitor                   | 1000                 | $\mu\text{F}$      | Recommended, mounted on the back of the PCB (includes a discharge resistor on the PCB).            |
|               | External back EMF output                      |                      |                    | BEMF terminal, switches to GND (NPN)                                                               |
|               | Shielded motor cable                          |                      |                    | Uses extra GND connection                                                                          |
|               | Heat shrink tubing                            | 60 (width)           | mm                 | As packaging/housing/electrical isolation                                                          |
|               | Coating of the PCB                            | Plastic 70           |                    | To protect against moisture.                                                                       |
|               | Stackable (max 3)                             | Y                    |                    | 4x solid copper wire through V+ and GND holes (common decoupling capacitor at the back of one PCB) |
| Mandatory     | Motor filter                                  |                      |                    | Attach directly to or close to the motor connections.                                              |
| Jumpers       | 1 Dead band and hysteresis                    | 5/2 or 10/4          | %                  | No jumper = 5/2 (relative to PWM range of -100...+100%)                                            |
|               | 2 PWM frequency                               | 2 or 16              | kHz                | No jumper = 2kHz                                                                                   |
|               | 3 Length servo pulse                          | 1-2 or 0.8-2.2       | ms                 | No jumper = 1.0-2.0ms                                                                              |
|               | 4 Transfer function                           | LIN/SQR <sup>3</sup> |                    | No jumper = LIN (LIN = Linear, SQR = Square root)                                                  |

### BEMF terminal

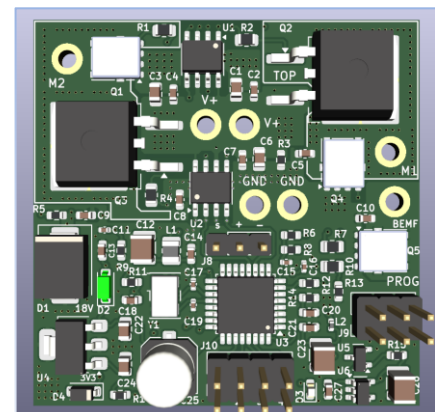
If the supply voltage gets too high due to back EMF (e.g. motor acting as generator), the BEMF terminal switches to GND. When connecting an external power resistor between the V+ and the BEMF terminal, back EMF energy can be converted into heat.

There are two types of supply voltage measurements. One with slow averaging (20.0s) and one with fast averaging (0.2s). If the difference between both is more than 1V uninterrupted for 0.2s then the BEMF output is activated (10% hysteresis).

If no external back EMF resistor is used and D1 (18V TVS) gets hot during normal motor operation then most likely a BEMF resistor is needed.

### Notes

- At 2kHz PWM frequency, a soft whistling sound may come from the motor.
- On board status LED (on = PON<sup>4</sup> & no servo signal, flashing = PON & servo signal)

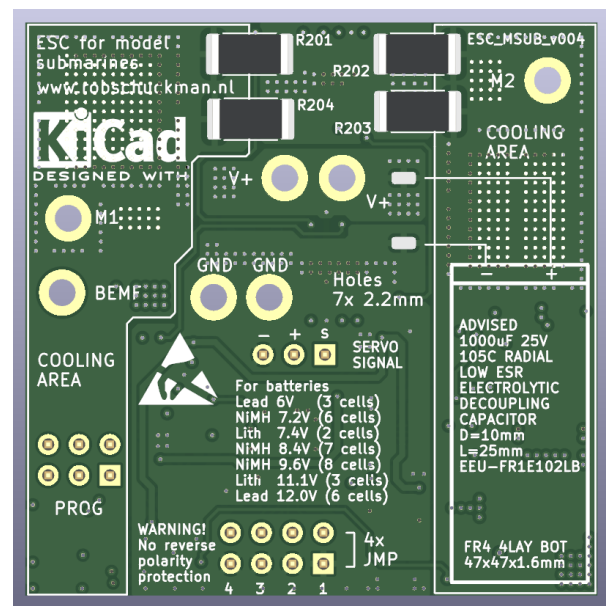
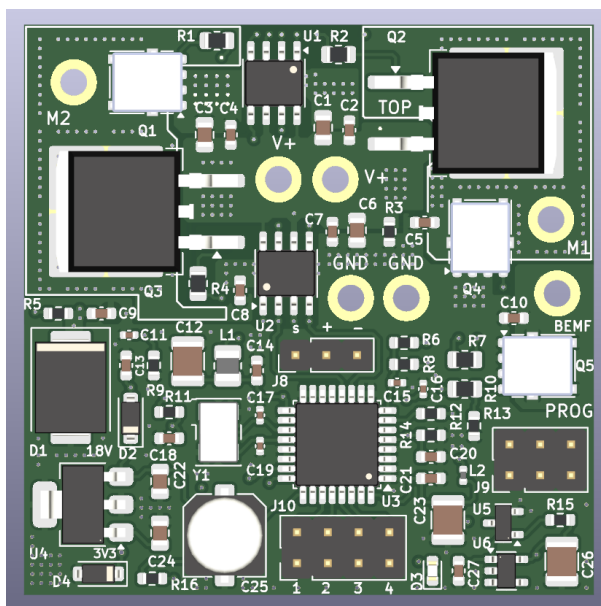
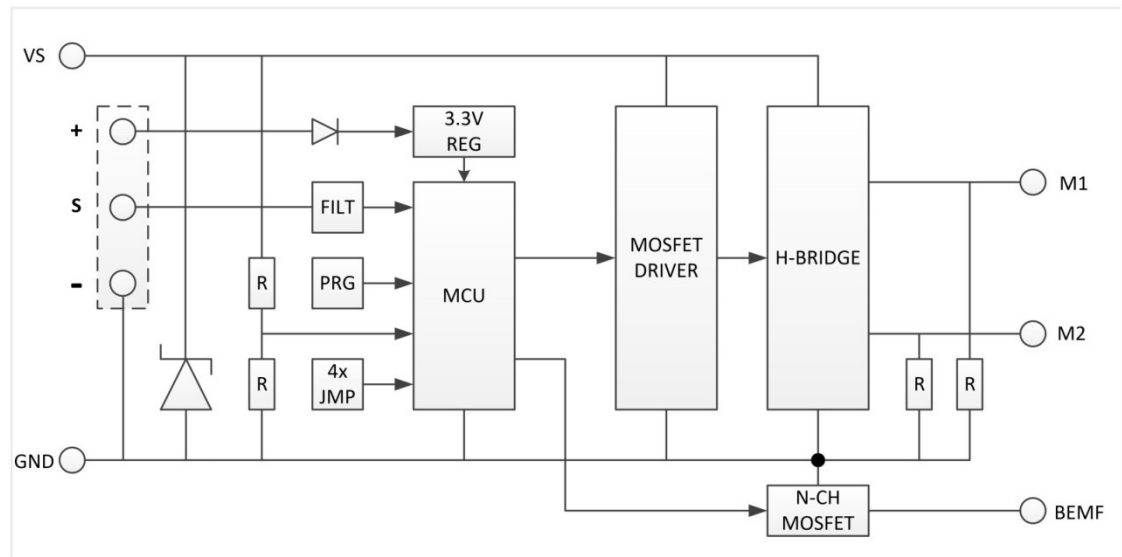


<sup>1</sup> Ensure the external back EMF resistor has enough wattage.

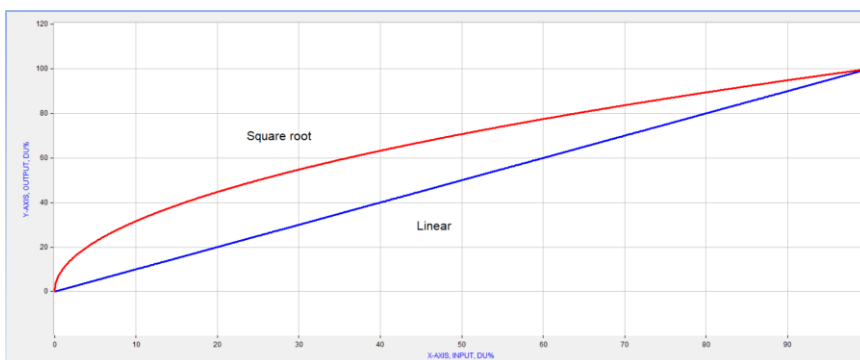
<sup>2</sup> 18V TVS connected parallel with H-bridge supply voltage.

<sup>3</sup> Use the SQR transfer function for more linear joystick behaviour if the electric motor encounters a lot of resistance when turning (e.g. due to propeller shaft grease or mechanical friction piston tanks).

<sup>4</sup> Power on

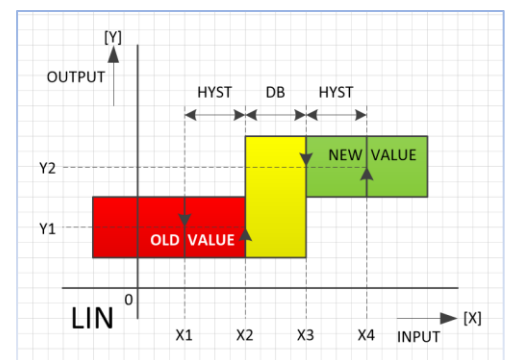


LIN/SQRT transfer function



X-axis = input = 0-100%, Y-axis = output = 0-100%

Hysteresis and dead-band



For Y to transfer from Y1 to Y2,  $(X4 - X2) > (DB + HYST)$