WARNING

You are dealing with very high energy levels when using this system, which may result in personal injury or fire when handled improperly. Take appropriate safety measures and use this system with great caution. Never leave it unattended while being powered.

This product contains small parts; keep out of reach of children!

This system produces significant magnet fields, do not use it when you have a cardiac pacemaker!

Always apply appropriate safety precautions when following this guide – they will not be explicitly mentioned in the following. If you are unsure how a specific step is properly and safely executed, don't do it!

DISCLAIMER

This product is provided as is without any guarantees or warranty, except where obliged by national law. In association with the product, keenlab UG (haftungsbeschraenkt) makes no warranties of any kind, either express or implied, including but not limited to warranties of merchantability, fitness for a particular purpose, of title, or of noninfringement of third party rights. Use of the product by a user is at the user's risk.

In no event shall keenlab UG (haftungsbeschraenkt) be liable for any direct, indirect, punitive, incidental, special, or consequential damages whatsoever arising out of or connected with the use or misuse of any product purchased herein. You agree and acknowledge that any product purchased should be used at your own risk and you should assess the risks before purchasing any product or using any product. You agree that in the event that keenlab UG (haftungsbeschraenkt) is deemed liable for any harm caused, the amount which it shall be liable to you shall be limited to the cost of the product.

NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A SPECIFIC PURPOSE, THE PRODUCTS TO WHICH THE INFORMATION MENTIONS MAY BE USED WITHOUT INFRINGING THE INTELLECTUAL PROPERTY RIGHTS OF OTHERS, OR OF ANY OTHER NATURE ARE MADE WITH RESPECT TO INFORMATION OR THE PRODUCT TO WHICH INFORMATION MENTIONS. IN NO CASE SHALL THE INFORMATION BE CONSIDERED A PART OF OUR TERMS AND CONDITIONS OF SALE.

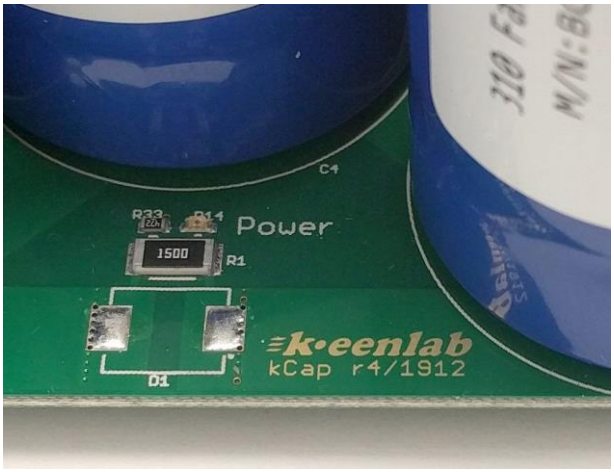
kCap User Guide

The *kCap* ultracapacitor module has been designed to allow the creation of a stationery power supply for the *kWeld* spot welder system. It provides the low output resistance that the welder asks for, in order to achieve a welding current in excess of 1000 amperes.

At the same time, the storage capacity is large enough to deliver enough energy for multiple consecutive welding pulses, without requiring recharging them. This allows for more productive work when welding larger battery packs.

As the module is basically a DC power supply with a very high pulse output power capability of up to 5000W, there are countless other applications in which it can be used.

This guide refers to *kCap* revision 4. The revision number of your module is printed on the circuit board close to the power LED:



To complete a stationery power supply for kWeld using this module, a suitable charger needs to be added. The section “Charger requirements” discusses the requirements for that and gives recommendations.

IMPORTANT: the above section also provides important installation details - incorrect wiring may defeat the built-in protection for the ultracapacitors and can lead to their destruction and possible personal harm.

As you are dealing with electronic components when building the kit, this advice is a must as well:

ESD damage is caused by a build-up of static electricity that is released into the circuitry when you accidentally touch a conductor on the circuit board. The build-up can come from either the board, or from you, or both. I package all the kits in an ESD-safe environment and ship all units in metallic ESD safe bags, eliminating static during production. During assembly and open-frame use, please take precautions to reduce ESD:

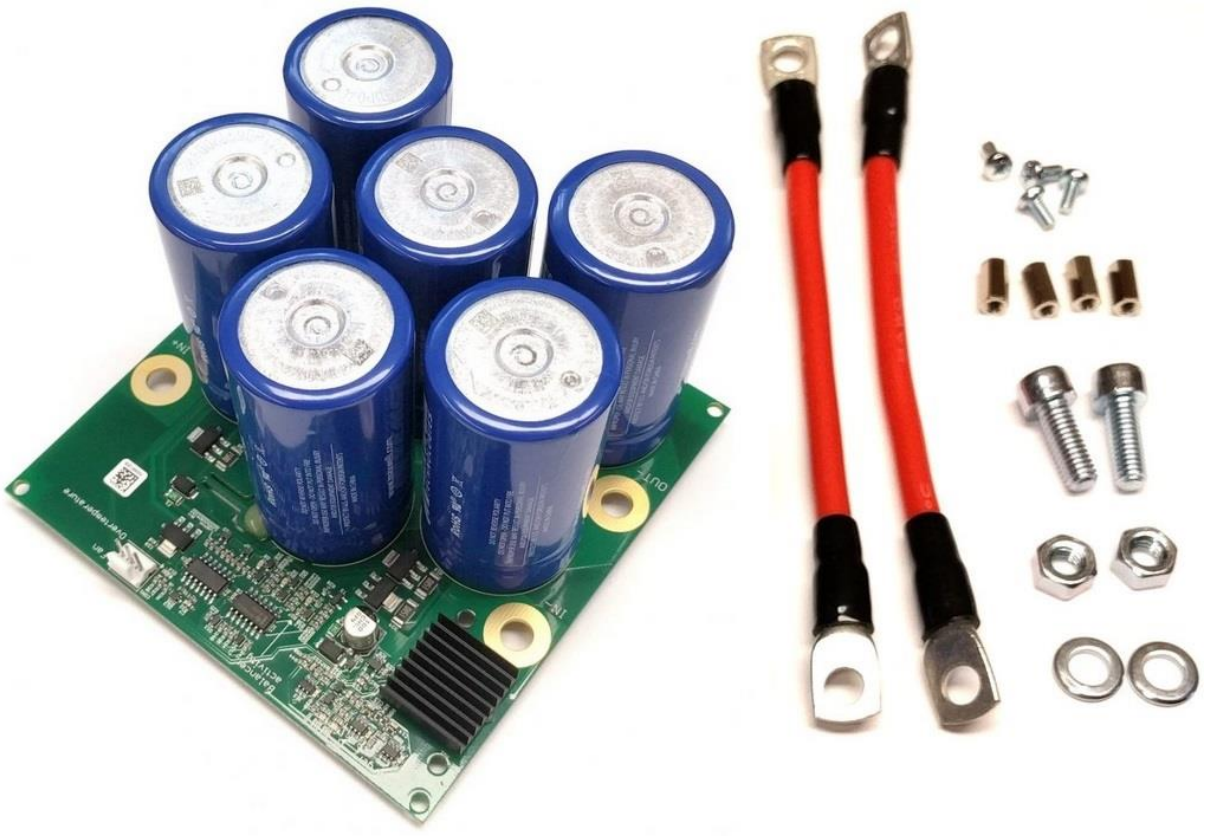
- Avoid conditions that result in high static electricity. For example, don't unpack or handle the unit while standing on carpet. Cool and dry air is very conducive to ESD. If you're in an area or season with a lot of lightning storms, you're probably more susceptible to ESD and require more caution.
- Ground yourself immediately prior to handling by touching a metal object that is connected to mains earth. Examples of these are desktop computers, all electric devices that have a metal housing, your professional soldering station, and of course the exposed ground contact of your electrical outlet.
- Notice that your body will only sense electrostatic discharge at voltages greater that approximately 1000 volts, but electronic components will already break at voltages well below that. This means that, if you don’t recognize ESD, this doesn’t mean that it does not happen. The mentioned precautions are even more important now!

ASSEMBLY GUIDE - MODULE

REQUIRED EQUIPMENT

Allen key 5mm	
Wrench 10mm	
Philips head screwdriver PH1	

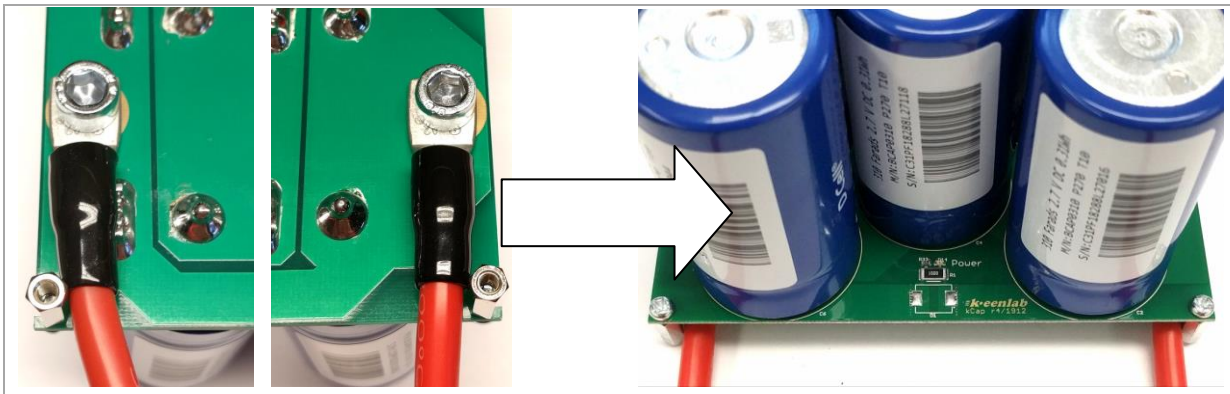
REQUIRED PARTS



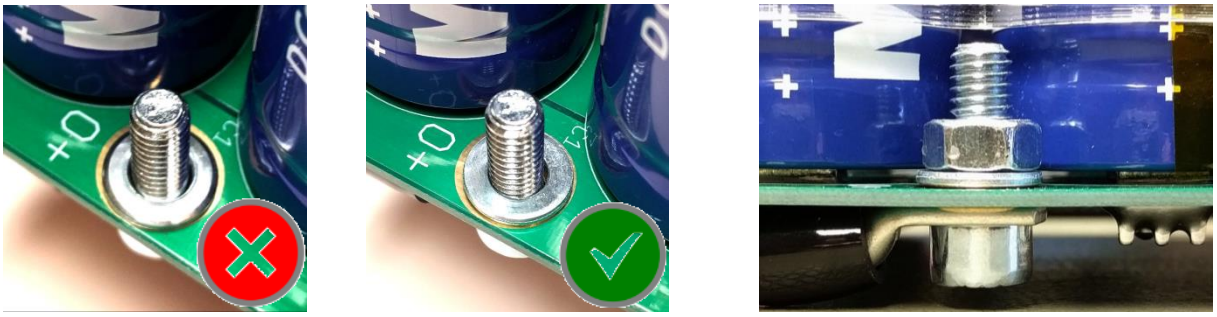
1	Assembled *kCap* electronics module
2	Cable assembly
2	Screw DIN912, M6 x 16mm, steel galvanic
2	Nut DIN934, M6, steel galvanic
2	Washer DIN125, M6 x 12mm x 1.6mm, steel galvanic
4	Standoff M3 x 10mm, female-female, brass galvanic
4	Screw DIN7985, M3 x 6mm, steel galvanic

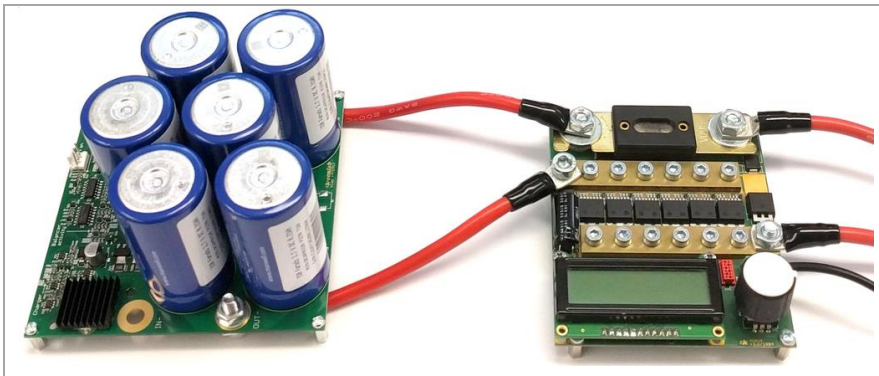
Fasten all four standoffs with their M3 screws.

NOTE: if you plan to enclose the module with the laser-cut *kCap* housing, then these parts must be mounted in a different way. Please see the next section for details.



Use the M6 screws, washers and nuts to attach the cable assemblies to the module's underside. Tighten the nuts with securely. Observe correct orientation of the washers, you may damage the circuit board otherwise. Use the stacking scheme as shown below on the right.





Attach the *kWeld* system as shown.

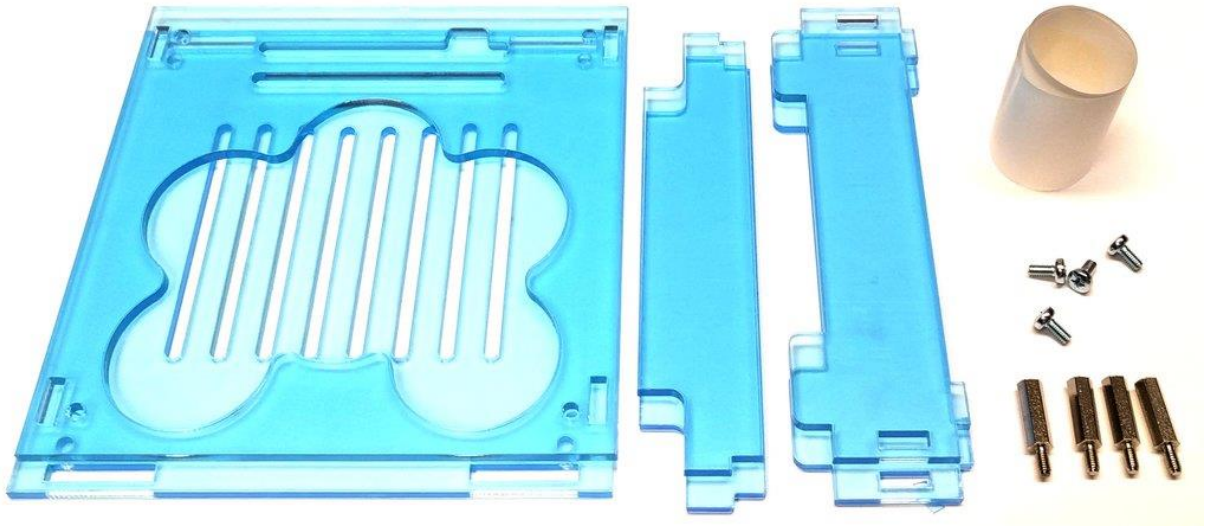
ASSEMBLY GUIDE – HOUSING

IMPORTANT: The housing is an optional accessory and sold separately, but it is highly recommended to enclose the *kCap* module as a safety measure, as short-circuiting it is dangerous due to its very high power delivery capacity.

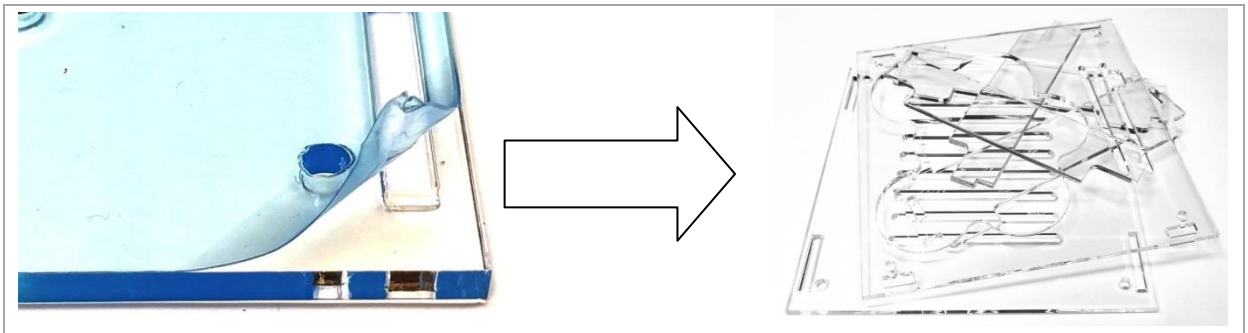
REQUIRED EQUIPMENT

Philips head screwdriver PH1	

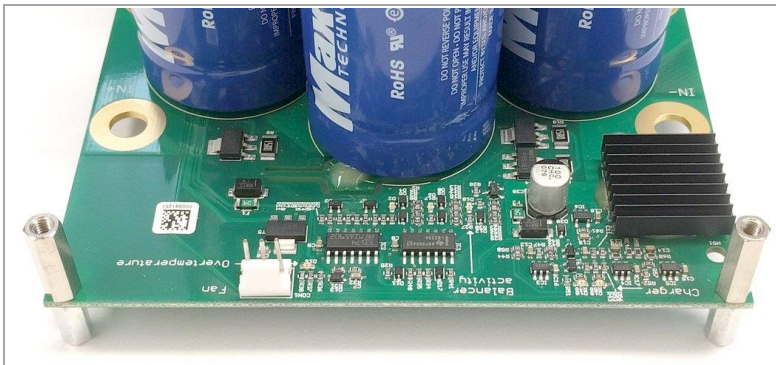
REQUIRED PARTS



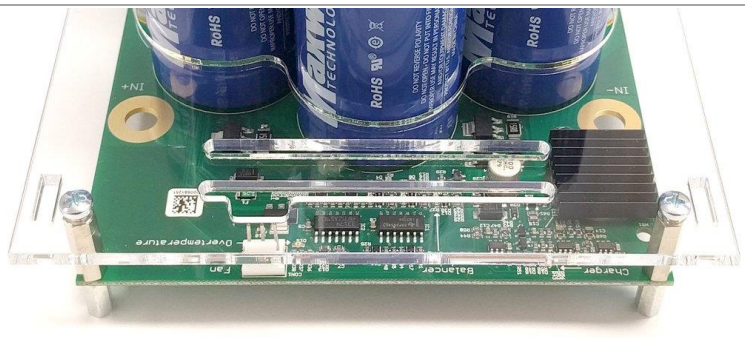
1	Acrylic glass housing part set as shown above
6	Transparent adhesive stickers on paper roll
4	Standoff M3 x 15mm, female-male, brass galvanic
4	Screw DIN7985, M3 x 6mm, steel galvanic



Peel off the protective foils from both sides of all acrylic glass parts.

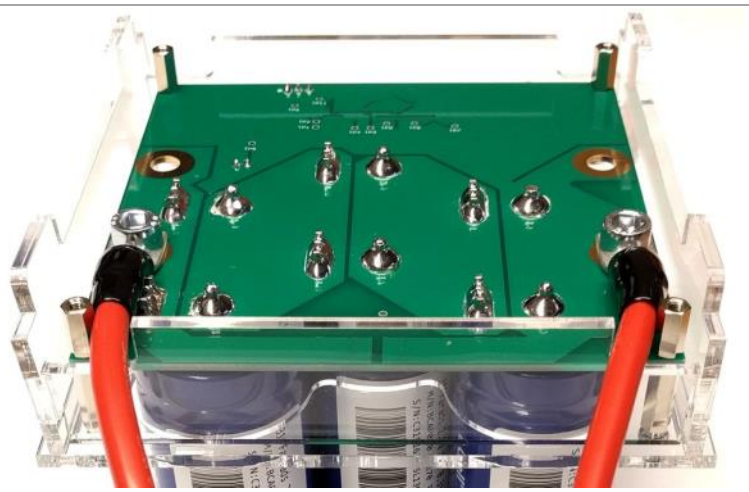


Mount the four 15mm standoffs from the housing kit to the top side of the module as shown, using the existing 10mm standoffs from the *kCap* kit.

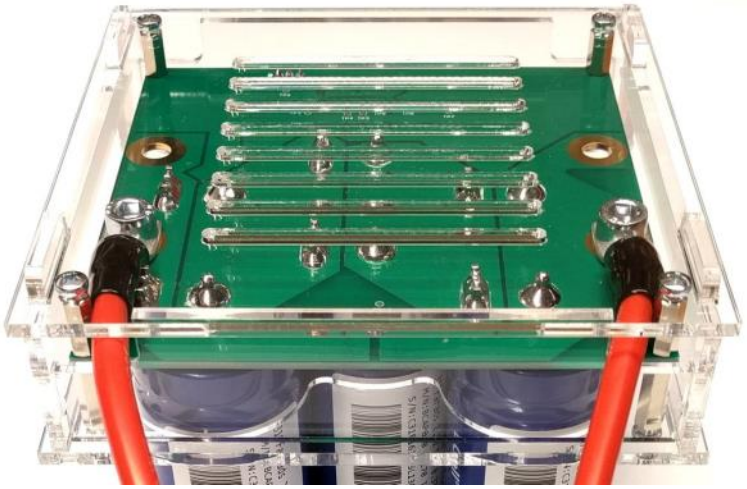


Attach the top cover using four M3 screws.

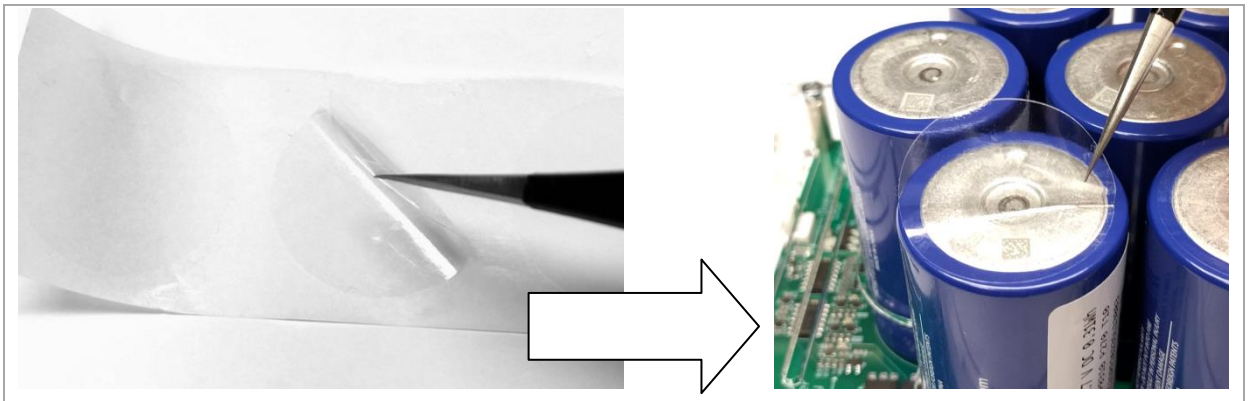
NOTE: fasten the screws gently; acrylic glass may crack when applying too much torque.



Flip the module upside down, and slide the four side wall parts into place as shown above. The parts are symmetrical.



Attach the bottom cover (this part is also symmetrical) using the remaining four M3 screws. Again, fasten the screws gently.

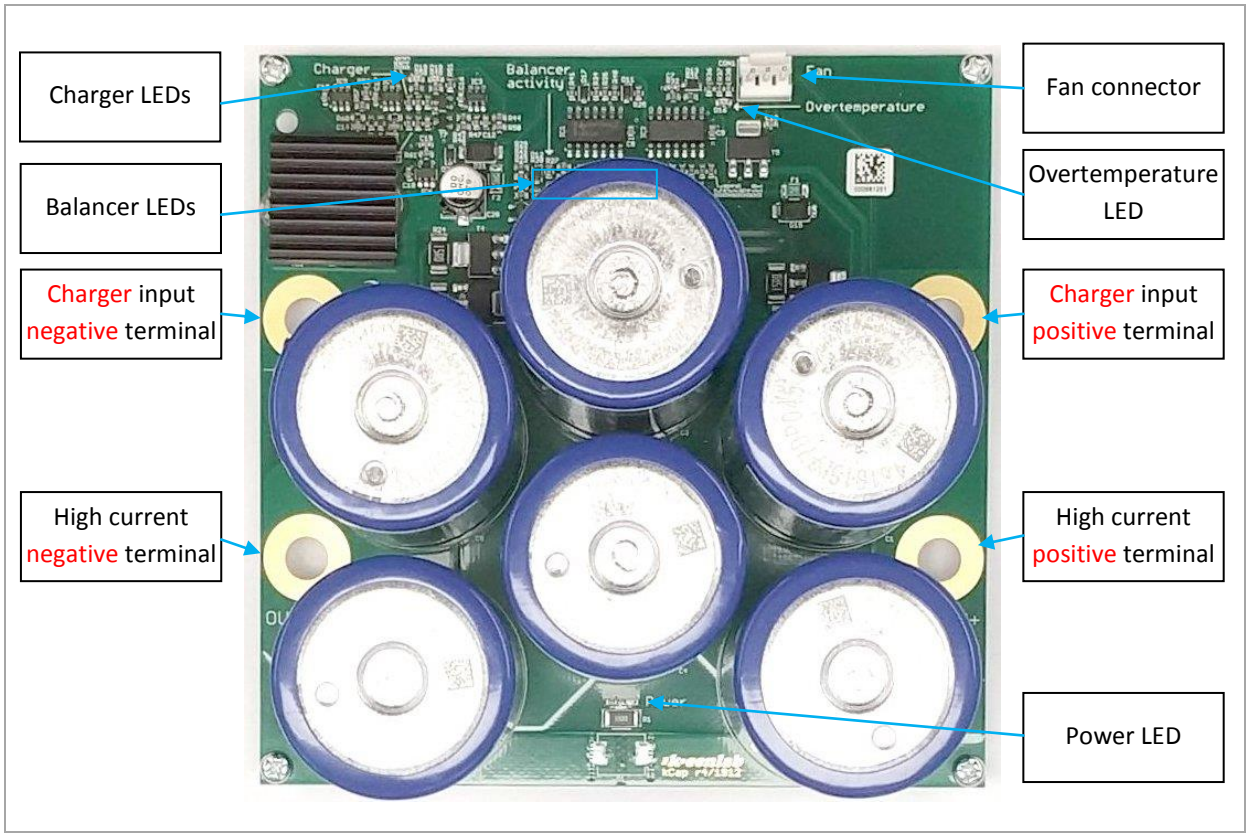


Fix the transparent stickers to the six supercapacitor cans as shown.

IMPORTANT: this is required for electrical insulation, as the aluminum cans carry voltage!

OPERATION GUIDE

OVERVIEW



Element	Description
Charger terminals	Connect a suitable charger to these terminals.
High current output terminals	Connect the *kWeld* spot welder or any other desired load to these terminals. **IMPORTANT**: make sure to closely follow the instructions in section “Charger requirements”.
Power LED	When lit, the capacitors have at least 2V across their terminals. **NOTE:** the module incorporates a discharge resistor, but due to the very high amount of energy that the capacitors store, it takes several hours to fully discharge them.
Balancer LEDs	When any of them are lit, the corresponding balancer has detected a voltage imbalance between the individual capacitors, and it is actively discharging those with excessive voltage.
Overtemperature LED	Lit whenever the capacitor temperature has exceeded 40°C. **IMPORTANT**: use this indication to reduce power demand from the capacitors, or schedule a cooling break. The capacitors are rated for 70°C, but operating them well below that limit will significantly extend their working lifetime.
Fan connector	Connect an optional 120mm / 12VDC fan here. The fan is temperature controlled by the module, and is started at 40°C. Recommended fan model: Scythe SY1225SL12SH. **NOTE**: maximum supported fan current draw is 500mA.
Charger LEDs	Both LEDs lit with gaps: initial charging; a clicking noise is normal during this time. Both LEDs lit: module is being topped up. Only left LED lit: insufficient voltage or current from charger. Only right LED lit: module is fully charged. Both LEDs off: no or insufficient voltage from charger.

SPECIFICATIONS

Electrical characteristics (typical values):

- Six Maxwell BCAP0310-P270-T10 cells in a 3S2P configuration
- Module capacity: 206 F
- Stored energy: 6780 Ws
- Input voltage 8.1V - 14.0V
- Charging current: 0 - 80 A
- Internal resistance: 3.3 milliOhms
- Short circuit current: 2400 A
- Peak output power: 5000 W (into a 3.3 milliOhm load)
- Input protected from reverse powering the supply (ideal diode circuit)
- Output voltage is automatically kept in 8.0V - 8.3V range (power supply disconnect)
- Advanced balancing circuit: +/- 50 mV voltage leveling between cells, independent from charge state
- Temperature monitoring and control of an optional 120mm fan
- Separate input and output terminals
- LED indication for balancer activity, temperature sensor, and charging state
- Dimensions: 110 x 110 x 47mm
- Modules connected in parallel: unlimited (only one charger needed for all)
- Modules connected in series: possible, but requires additional balancing between modules (e.g. power resistors), as well as electrically isolated chargers for each module

Principle of operation:

The *kCap* module will automatically disconnect its charger from the ultracapacitors when full, and will continue trickle charging them as necessary in order to keep them topped up. When turning off the charger while leaving the module connected, the built-in protection will also prevent back feeding the charger from the charged ultracapacitors, which may otherwise cause damage to it.

Performance in combination with *kWeld:*

- Repetition rate (10 J pulses): unlimited
- Repetition rate (50 J pulses[1]): once every 4 seconds
- Repetition rate (50 J pulses[1], with SY1225SL12SH cooling fan): once every 2 seconds
- Welding current[2]: 1100 A
- Maximum usable welding pulse energy[2]: 100 J

These numbers allow reliable welding of pure nickel strips of up to 0.2mm thickness.

[1] Averaged over 10 minutes - quicker bursts are allowed when staying within temperature limits.
[2] Weld spot resistance: 1 milliOhm

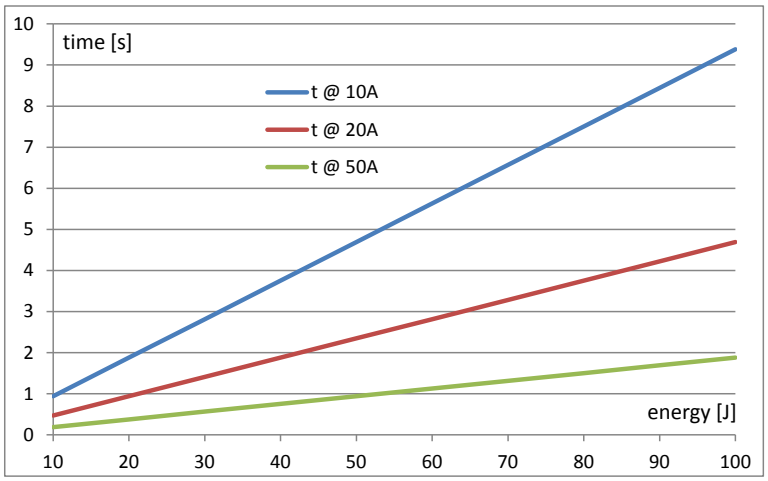
CHARGER REQUIREMENTS

In order to weld with quick repetition rates, the *kSupply* module is recommended to power this module as it provides 70A of charging current. The welder consumes up to 500W of average input power during intense use. However, when a slower recharging speed can be accepted, the following options may offer a more affordable solution.

- Meanwell RSP-150-7.5 (available from Digikey: 1866-4228-ND - use the adjustment trimmer to raise the output voltage to 8.2V) - **WARNING**: protect the AC input side against risk of electrical shocks!
- Any lead acid battery charger with 13.8V output voltage
- Any bench power supply with voltage and current regulation

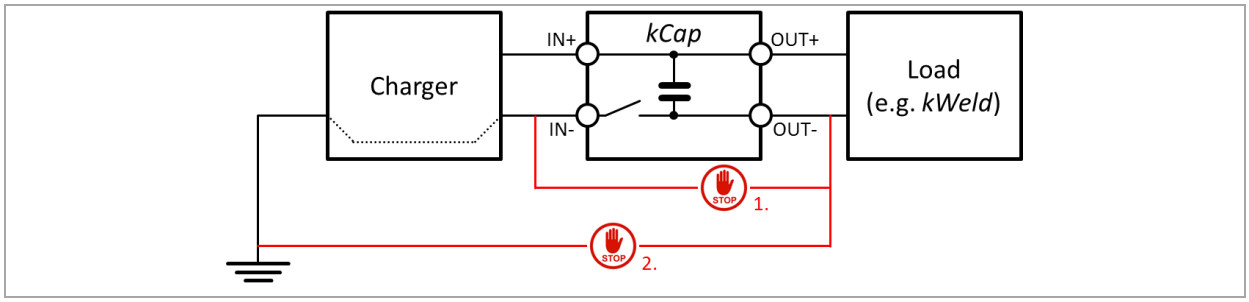
IMPORTANT: incorrect polarity or voltages in excess of 14V may damage the unit.

The following graph estimates the required recharging time in relation to the welding pulse energy. The weld spot resistance is assumed to be 1 milliOhm. For example, a 10A charger would be able to recharge the capacitor module after a 30J pulse in approximately three seconds.



Similarly to modern batteries, the ultracapacitors on the *kCap* module are very sensitive to overvoltage and would heat up when being permanently kept in this state. As they are filled with a liquid electrolyte, this would cause pressure to build up internally, which can eventually lead to their destruction. For this reason, the module features a MOSFET based high current switch that disconnects the ultracapacitors from the charger when full. It is very important that this switch is not accidentally bridged externally. The following drawing shows this switch, and points out areas that need special attention.

1. The charger may not be connected directly to the negative high current terminal.
2. The connected load must be kept isolated from the charger. There might be a direct connection from mains protective earth to the negative terminal of the charger (dashed line in drawing). This is true for the server power supplies recommended for the *kSupply* charger! For this reason, never connect the load to any grounded potential.



REVISION HISTORY

1.0	2018-08-06	First published version
2.0	2020-04-08	Updated for *kCap* revision 4