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!

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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* revisions 2 and 3. The revision number of your module is printed on the circuit board close to the positive input terminal:

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.

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:

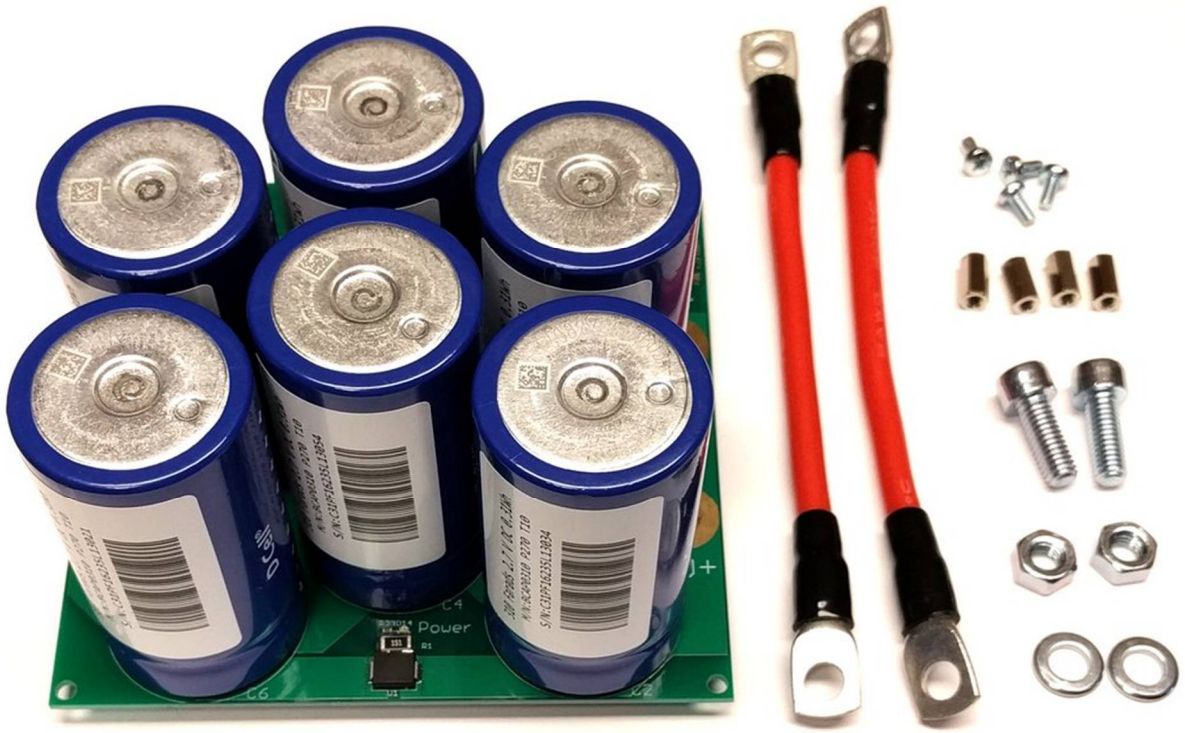
- Avoid conditions that result in high static electricity. For example, don't unpack or handle the unit while standing on carpet. Cool and dry air is very conducive to ESD. If you're in an area or season with a lot of lightning storms, you're probably more susceptible to ESD and require more caution.
- 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

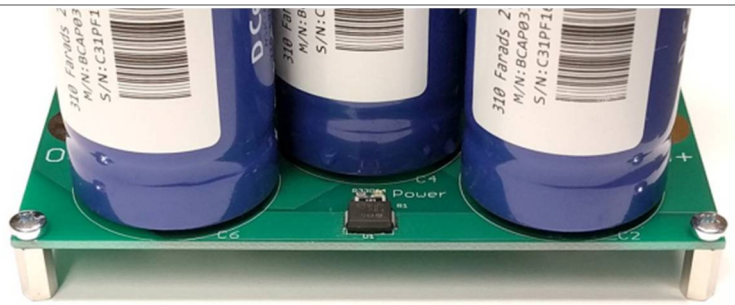
REQUIRED EQUIPMENT

Allen key 5mm	
Wrench 10mm	
Philips head screwdriver PH1	

REQUIRED PARTS

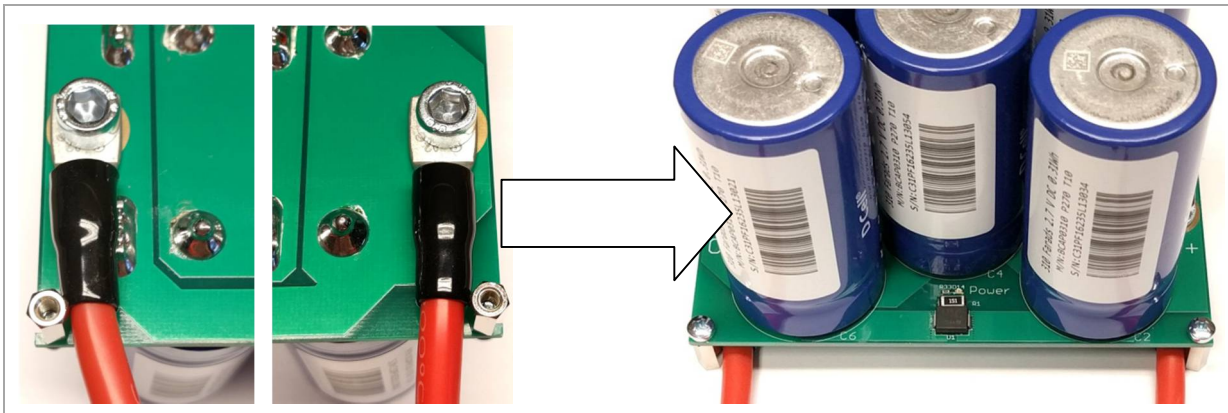


1	Assembled *kCap* electronics module
2	Cable assembly
2	Screw DIN912, M6 x 16mm, steel galvanic
2	Nut DIN934, M6, steel galvanic
2	Washer DIN125, M6 x 12mm x 1.6mm, steel galvanic
4	Standoff M3 x 10mm, female-female, brass galvanic
4	Screw DIN7985, M3 x 6mm, steel galvanic

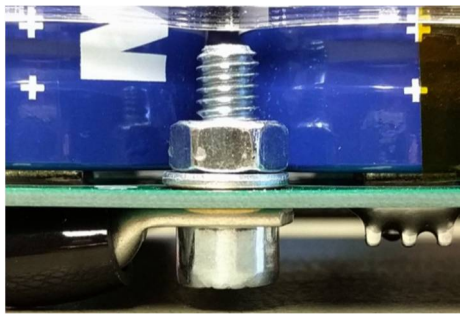


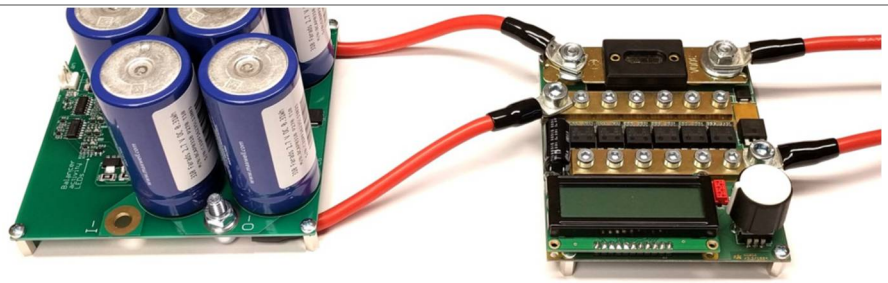
Fasten all four standoffs with their M3 screws.

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.

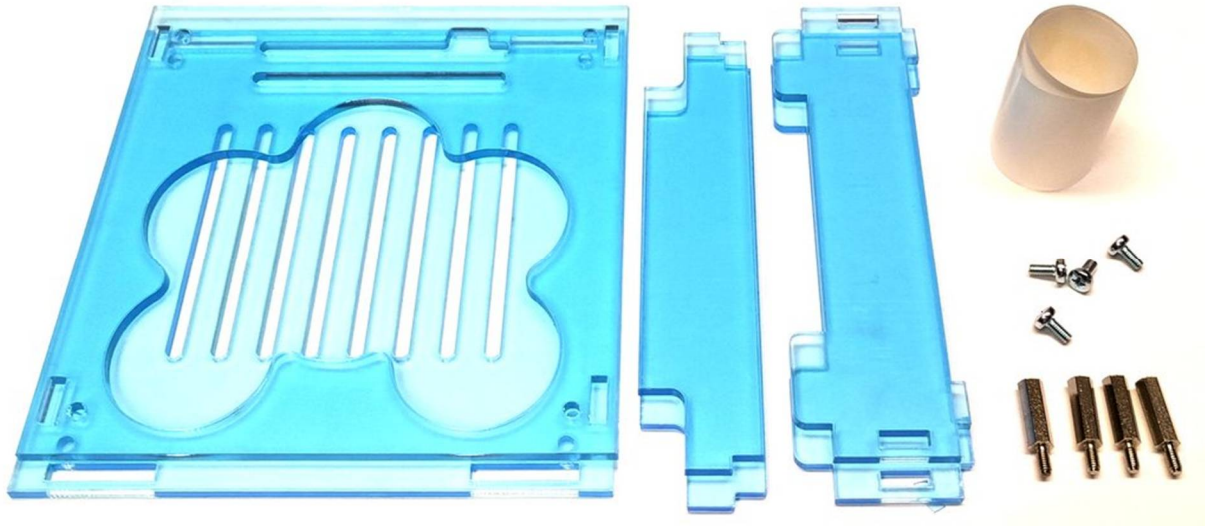
ASSEMBLY GUIDE – HOUSING

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.

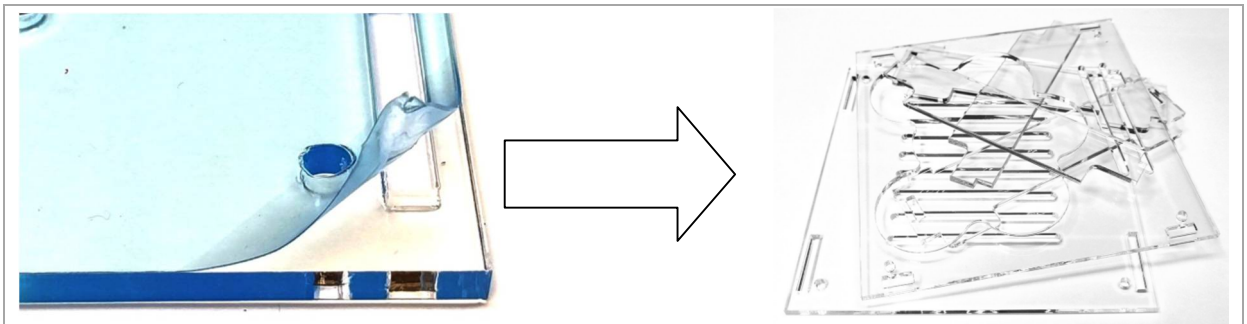
REQUIRED EQUIPMENT

Philips head screwdriver PH1	

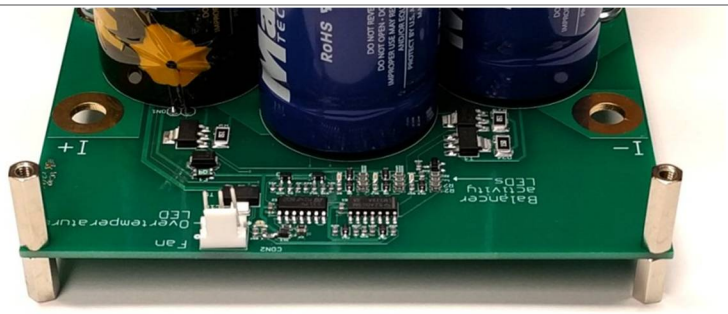
REQUIRED PARTS



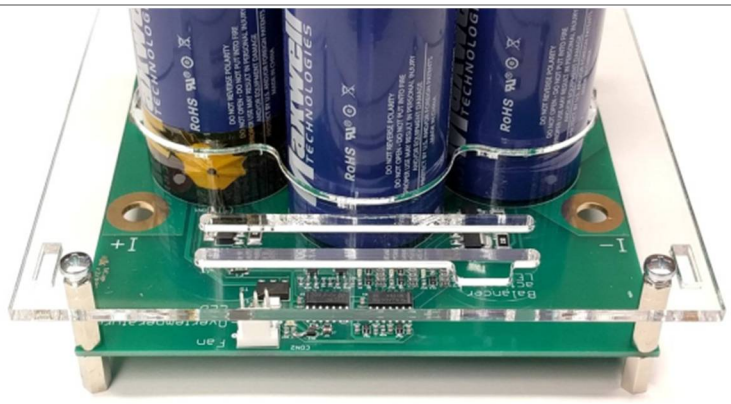
1	Acrylic glass housing part set as shown above
6	Transparent adhesive stickers on paper roll
4	Standoff M3 x 15mm, female-male, brass galvanic
4	Screw DIN7985, M3 x 6mm, steel galvanic



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

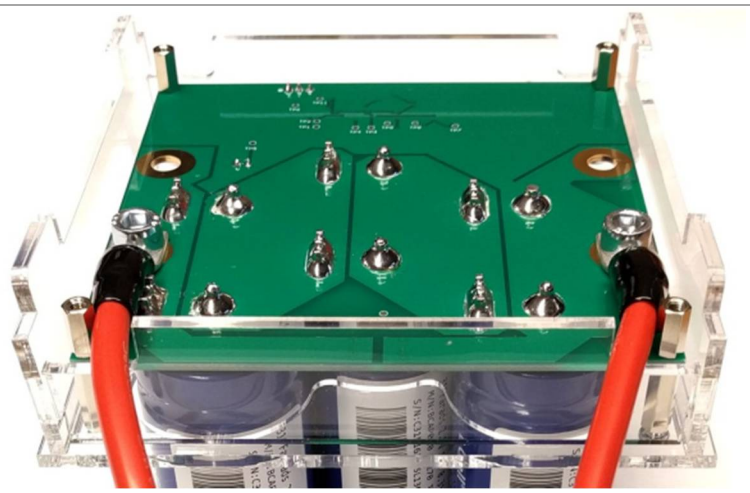


Mount the four 15mm standoffs from the housing kit to the top side of the module as shown, using the existing 10mm standoffs from the *kCap* kit.

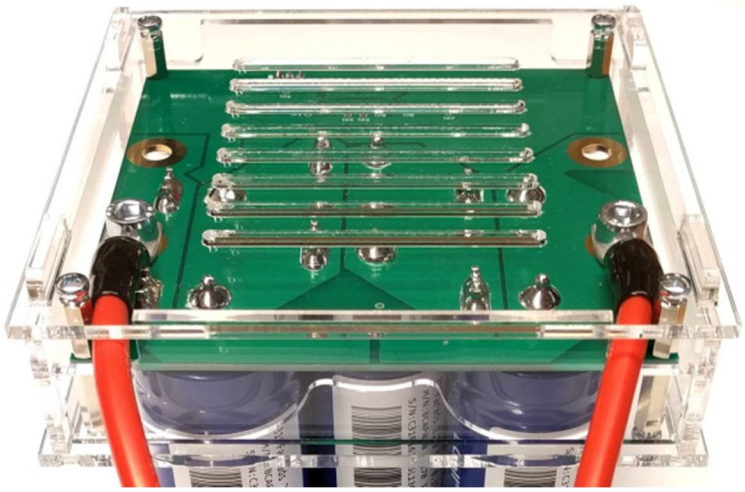


Attach the top cover using four M3 screws.

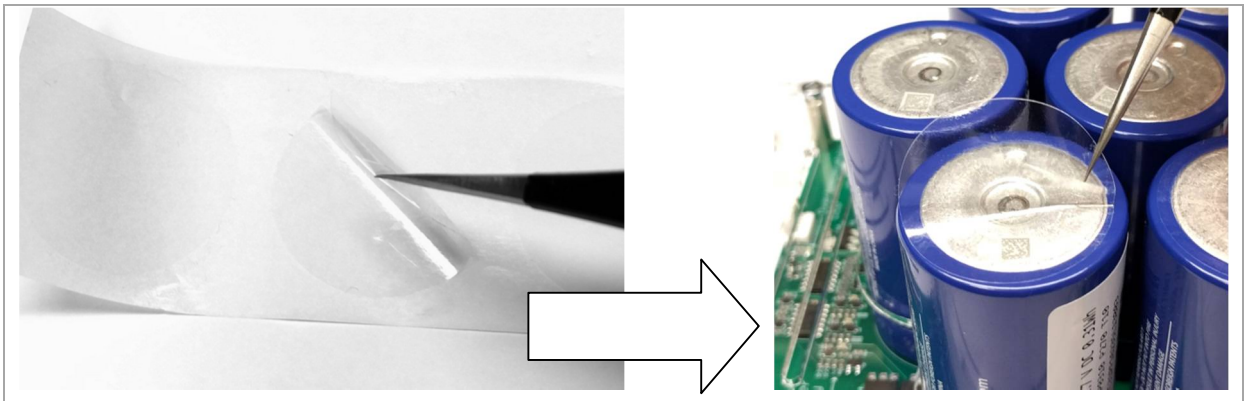
NOTE: fasten the screws gently; acrylic glass may crack when applying too much torque.



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.

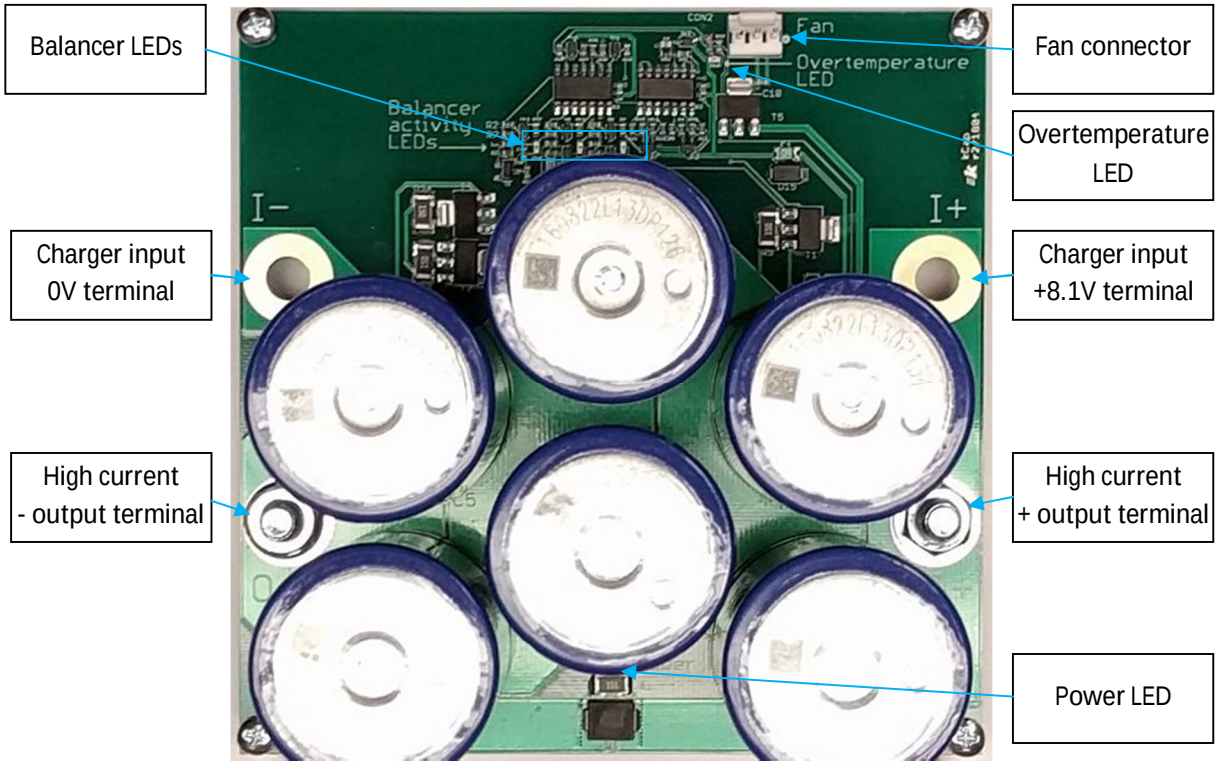


Fix the transparent stickers to the six supercapacitor cans as shown.

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. **IMPORTANT**: incorrect polarity or a higher voltage will damage the capacitors. **IMPORTANT**: these terminals have a limited current carrying capability, do not use them as output terminals.
High current output terminals	Connect the *kWeld* spot welder or any other desired load to these terminals.
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 fan current draw is 500mA.

SPECIFICATIONS

Electrical characteristics (typical values):

- Six Maxwell BCAP0310-P270-T10 cells in a 3S2P configuration
- Module capacity: 206 F
- Stored energy: 6780 Ws
- Operating voltage: 0 - 8.1 V
- 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)
- 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 and temperature sensor
- Dimensions: 110 x 110 x 47mm
- Modules connected in parallel: unlimited
- Modules connected in series: possible, but requires additional balancing between modules (e.g. power resistors)

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

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

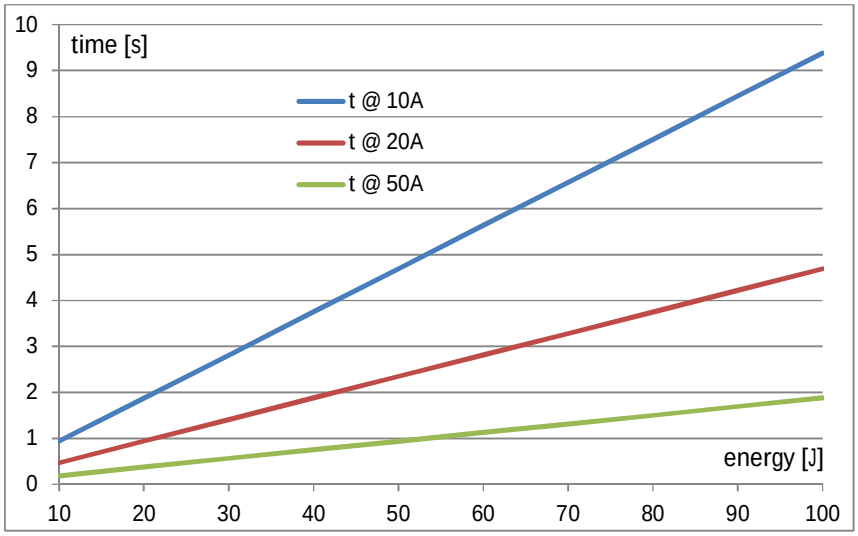
CHARGER REQUIREMENTS

An empty supercapacitor basically presents a short circuit to the power supply that it is connected to. Most switch-mode power supplies are not suitable for such a load, because they will react on this by shutting down their output (and typically periodically attempt to restart, in order to recover from this situation).

Because of their large storage capacity, these capacitors need to be treated rather like a rechargeable battery, and consequently require a charger that delivers a controlled current to them, until the maximum operating voltage is reached and held. This is called CC/CV (constant-current / constant-voltage) charging.

The constant-voltage set point of such a charger should match the *kCap* operating voltage of 8.1V.

The amount of needed current depends on the actual use, however. The following graph estimates the required recharging time in relation to the welding pulse energy, when used with *kWeld*. 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.



Such a charger can be built in a cost efficient way: A standard ATX power supply can easily be converted into a high current 12VDC power supply (https://www.instructables.com/id/How-to-power-up-an-ATX-Power-Supply-without-a-PC/). The required CC/CV charger functionality can be implemented with a current-limited adjustable DC/DC converter module; these are available with various output current capabilities. For light duty welding tasks, the following module has been successfully tested together with a 500W ATX power supply and the *kCap / kWeld* system. These are sold as "*300W 20A DC-DC 3.3V 5V 12V Adjustable CC CV Buck Step Down Regulator LED Driver*" for less than 10€ (e.g. https://www.ebay.com/itm/323178504725). Connect the module to the prepared ATX power supply, adjust its output voltage to 8.1V and its current to maximum, and connect it to the *kCap* charging input (while being shut down).

REVISION HISTORY

1.0	2018-08-06	First published version