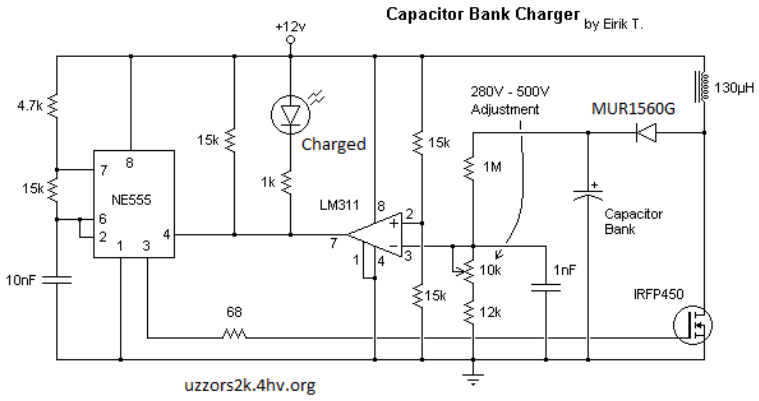
UZZORS2K



# 450V Capacitor Charger - Boost Converter

The boost converter is a DC-DC converter, which basically stores energy in an inductor and then releases it. What happens is voltage is applied to the inductor, and current starts to flow through it. When the mosfet switches off the current flowing through the inductor can't stop immediately. In most cases this would result in the voltage at the mosfet drain rising until current can flow again (avalanching of the mosfet or just a dead mosfet), however the diode provides a path for the inductor current into the capacitor bank instead. So for each period energy is stored in the inductor and then sent onward to the capacitor. The 555 is used to continuously pulse the inductor. The reason storing energy in an inductor before sending it to a capacitor can be used to boost voltage is rather simple. As stated earlier the inductor current is unstoppable and is routed into the capacitor. This current represents energy stored in the inductor which is slowly flowing out of it again (actually the current ramping up during the on-time builds up a magnetic field, the field then decreases during off-time. The inductor's energy is stored in this changing field.) Since energy is stored in a capacitor as voltage difference between the plates and results from current "flowing" in the capacitor, the voltage must increase because the capacitor is accepting current from the inductor. To keep accepting more energy from the inductor the capacitor voltage must rise. NEVER run the boost converter without a capacitor as the inductor energy has to go somewhere, and avalanching through the IRFP450 is the only option left. The power dissipated in the mosfet will (unless properly heatsunk) quickly kill it.

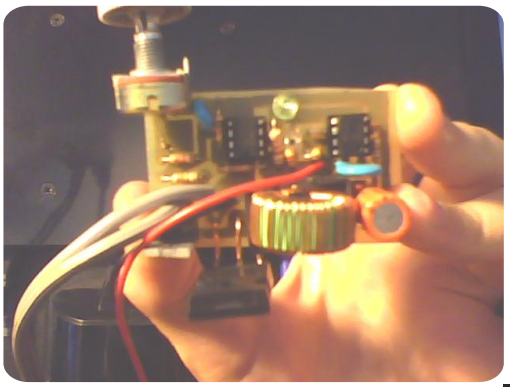


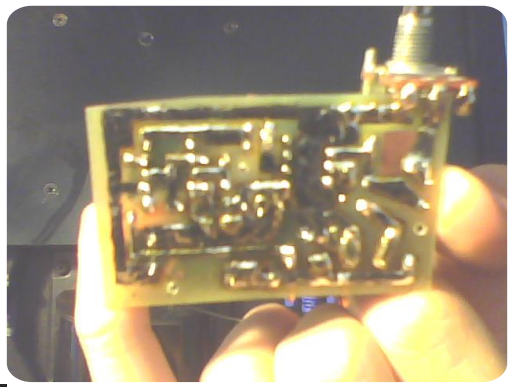

The converter consumes around 3A, and is designed for 12V use. The charge time for a 4700µF, 430V bank is 30 seconds, meaning 15W of output power. W00t, 40% efficiency. Greater efficiencies have been reported however. When the desired voltage is reached the 555 is turned off automatically, and the LED lights. The actual boost converter section of the circuit consists of the 555 + timing components, IRFP450, inductor and 500V diode. The rest is just there to stop the circuit at the target voltage. The voltage sensing is based on a LM311 voltage comparator, which as the name indicates compares the voltages at it's inputs. If the positive input is greatest the output of the comparator is positive. If the negative input is greatest the output is negative, in this case 0V or ground. A voltage divider (the two 15k resistors) is used to provide half of the supply voltage to the positive input. A 1M resistor combined with a 10k resistor and 10k potentiometer form a variable voltage divider. Look up calculators on the Internet to see how this works. The 1nF cap is there to stabilize the voltage. So with a voltage divider on the positive input providing 6V, and a variable voltage divider on the negative input, the comparator output will start high, and go low when the target voltage is reached. The comparator output is fed to the 555 reset pin, which is active low, meaning it will reset or inhibit the 555 when the target voltage is reached.

Note: All resistors are 1/4W. The inductor should have a current handling capacity of at least 2A, and are often called chokes. Any value of 100 to 200µH will work. Other values close to this will also work to some degree.

## NEW! Make your own PCB!

I've made a PCB layout for using ExpressPCB so soldering the circuit together is easier if you can make PCBs. Some assumptions were made as to the diode package and inductor size, so check whether your components will fit first. Included in the zipped folder is a .pdf file, parts list, and drawing of component layout so ExpressPCB isn't required. Download PCB files. Reader Paul McInnis bravely tried the first revision of the PCB design, which gave me some insight on what needed to be changed.





## Inductance and Frequency

If you feel a need to modify the circuit, I've made a frequency/ inductance/ power calculator. I'm no engineer, but assuming all of the inductor energy is transfered to the capacitor bank it should be correct. Download the spreadsheet here. You need to find a point where the inductor won't saturate, current can be limited by on-time or inductance. You will probably want to get the most power as possible too. Power is stored in the inductor and is released during off-time. Since an inductor's stored energy is 0.5*L*I^2 and energy is released with each off-time a high frequency combined with high inductor current will give the most power. (use a small inductance for high frequencies) I'm unsure of the tradeoff's here, but I guess the inductor's core material will be the frequency limiting factor.

## Troubleshooting / FAQ

If you have any questions, for the love of God check here before emailing me. Also, try to understand the circuit function as this makes troubleshooting vastly more simple.

- No, 9V batteries aren't good enough. If you're having problems upgrade to a bank of AAs, a motorcycle battery, an ATX supply or whatever.
- If you hear a high pitched squeal everything should be working (assuming the switching frequency is still in the audible range), check the connection to the capacitor bank if it's not charging.
- If the timer is working but nothing is happening make sure the inductor, diode and mosfet are all connected correctly. Also make sure you are using an inductor of sufficient inductance.
- Capacitor charges to 12 volts? This means the MOSFET isn't switching. Check the 555, IRFP450 gate, and drain with an oscilloscope.
- Will only charge to XXX volts, then slows down or stops? This is almost always caused by too little power. I've tested this design to 445V, so it will work up to there from 12V. See point 1.
- Where to get components? Your local components supplier, google "components" in your language, possibly "resistor" and find the first online store. If the store is any good they'll have what you need.
- If you're green in electronics then try a 555 blinker circuit and comparator/op-amp test circuit first. That way you have the 555 and 311 part down, and the rest is easy.
- If your question is not on this list email me so I can put it here. ;-)

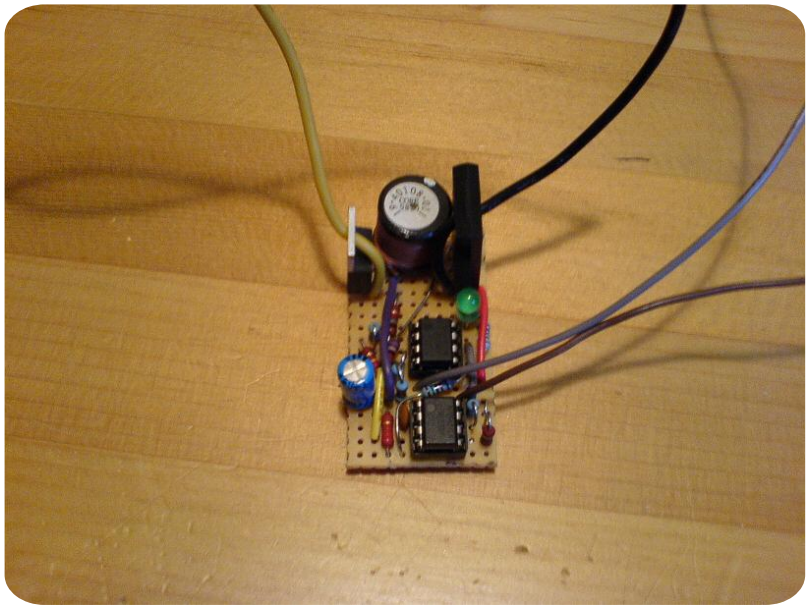
## Test point voltages:

The voltage at pin 4 on the 555 and pin 7 of the 311 should be close to 12V when the circuit starts up. When the target voltage is reached this voltage should drop to 0.6V or less.
The voltage at the positive input of the LM311 should be 6V, or half of the supply voltage (V/2).
The voltage at the negative input should approach 6V or V/2 as the capacitors approach the target voltage.

## Pictures

As you can see they can be built quite small, using surface mount components can decrease size further. Use a heatsink on the IRFP450 as it begins heating when the

capacitor voltage rises above 400V.



This circuit has been built with success by numerous others, among them Electroguns.com. Reader Edward Bennett sent in a shopping list suggestion for three major component dealers. For the heatsinks, I suggest scavenging them, or finding an old processor cooler.

**Mouser** (link leads to pre-filled shopping cart)

**Rapid Electronics**
Diode
Inductor
1M Resistor
10nF Capacitor
1nF Capacitor
MOSFET
12K Resistor
68 Ohm Resistor
Potentiometer
4.7k Resistor
15k Resistor x4
LM311
1k Resistor
8 AA Holders
Strip Board
LED
8-DIP IC Socket

**Futurlec**
Diode - MUR1560G
Inductor - PIND100
1M Resistor - R001M14W
10nF Capacitor - C010UC
1nF Capacitor - C001UC
MOSFET - IRFP450
12K Resistor - R012K14W
68 Ohm Resistor - R068R14W
Potentiometer - POT10K
4.7k Resistor - R0047K14W

15k Resistor x4 - R015K14W
LM311 - LM311N
1k Resistor - R001K14W
4 AA Holders x2
Strip Board Or Proto Board - STPBRD1 - EXPBRD
LED - LED5G
8-DIP IC Socket - ICS8
TO-220 Heatsink - Optional (The IFP450 uses a To-247 package, so it won't fit. The diode will however)

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