Handheld 4-20mA +-10V current / voltage source kit

Manual

Description

General

The circuit has two outputs:

1. Voltage output

2. 0-20mA Current output

The voltage output can be wired to give either 0-10V output or +- 10V operation. A LED shows the unit is powered and a linear pot controls the output of the device. The unit isn't calibrated but is intended to be used in conjunction with a calibrated device e.g. Fluke.

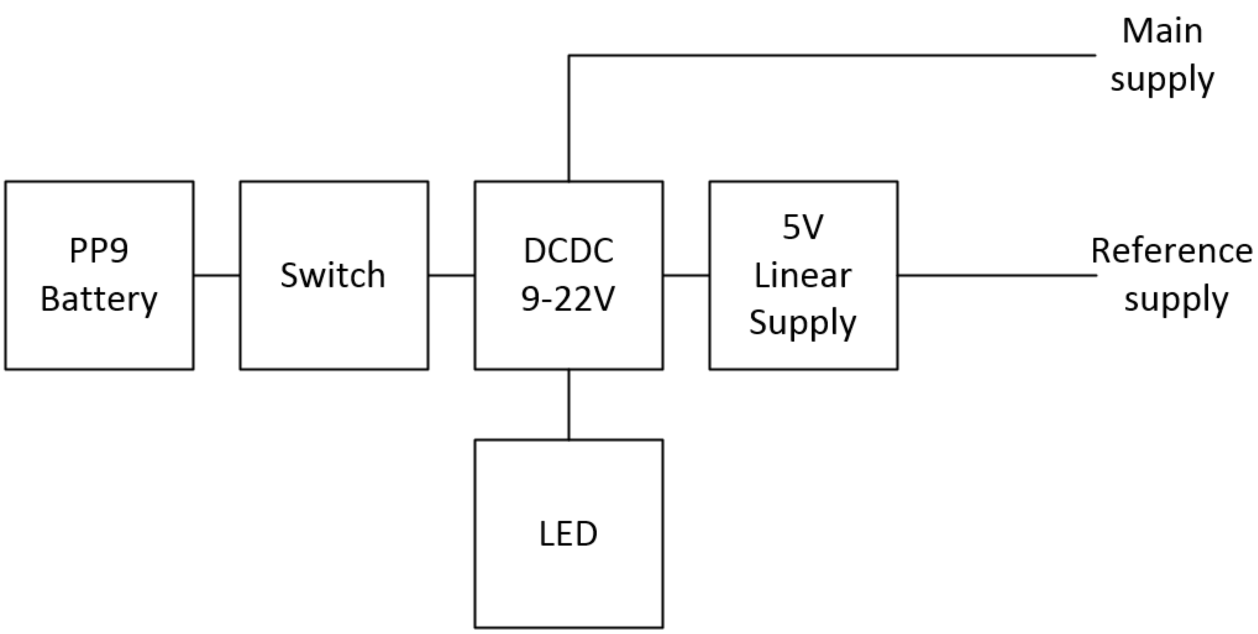
The unit is powered by a pp3 battery and will have 4 leads coming off it, one pair for current and one for voltage. It is not intended that the voltage and current modes are used simultaneously.

A LED shows when the unit is switched on.

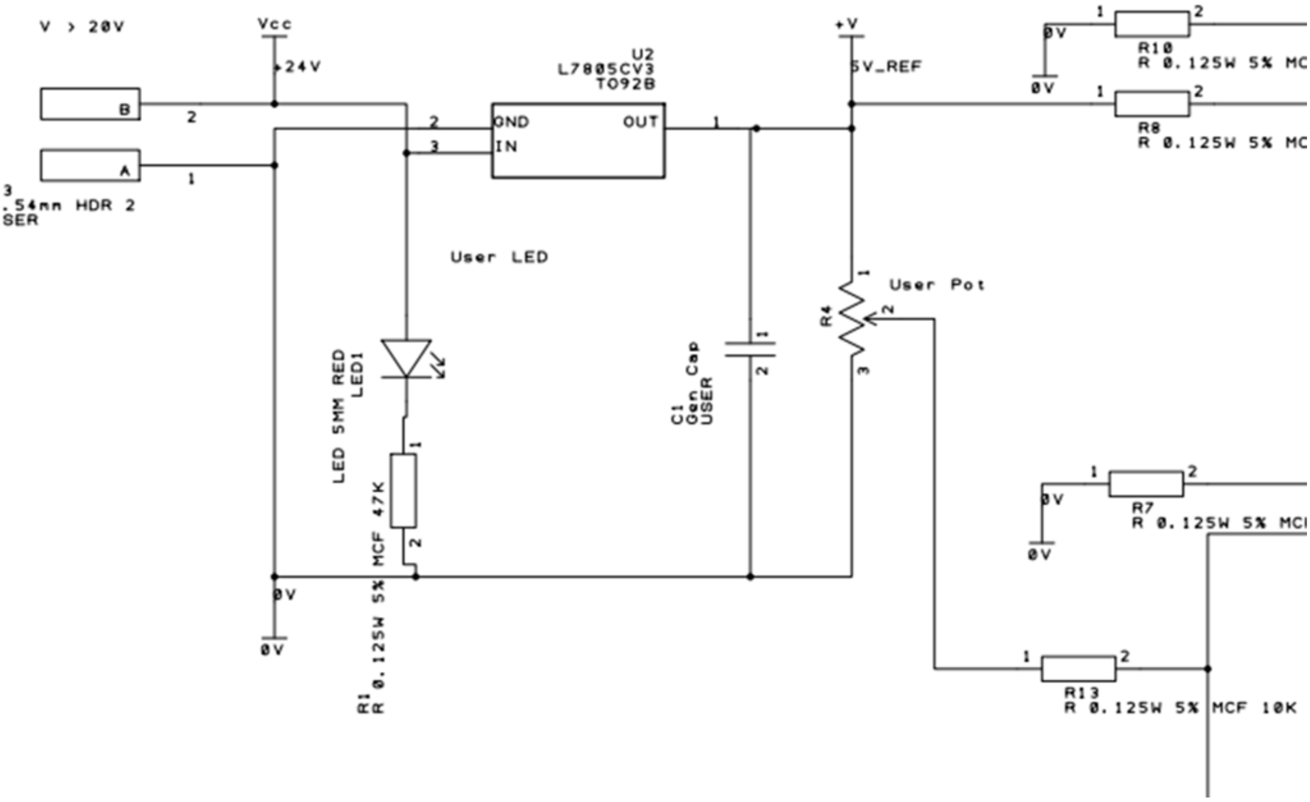
Intended Use

Hobby / Educational. Do not use on AC voltages, Do not use on high energy circuits and do not use in flammable environments.

Power supply



A 9V battery powers a DCDC switching power supply. The DCDC is fed via the side mounted switch (DCDC must go after switch), the output of this is then fed into the main PCB as shown on the schematic. On the main PCB there is a LED which is used to show when the device is turned on and will illuminate off the DCDC output voltage.

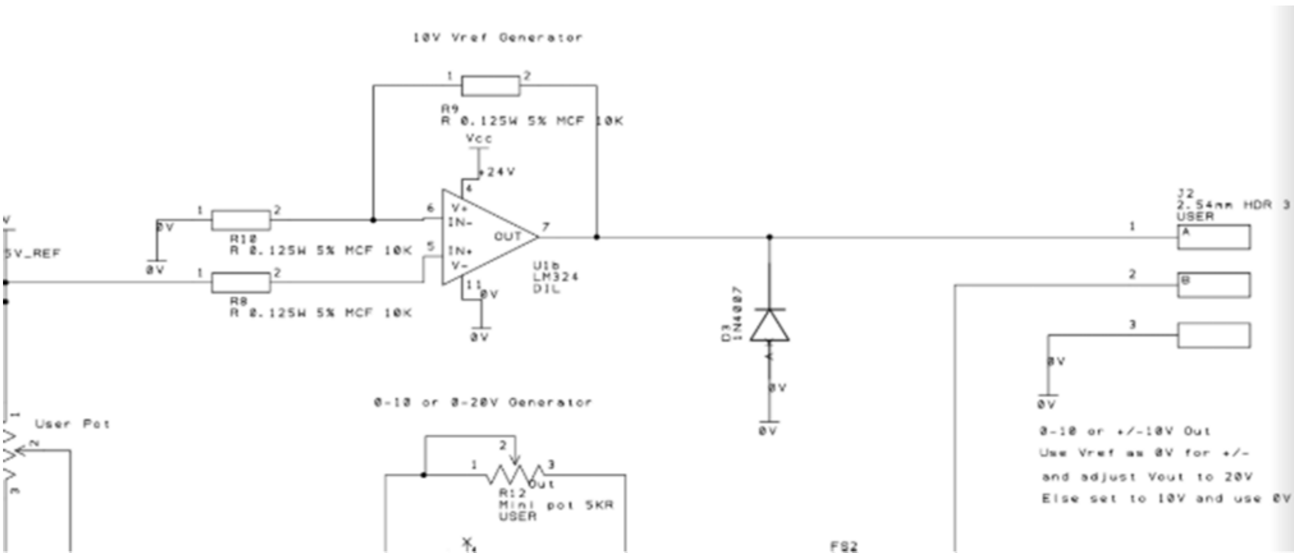


The power switch mounts to the side of the panel using two screws.

The DCDC is a MT3608, the output of which is stepped up to generate the required voltages to run the circuit. For +-/10V operation this should be set to 22V and for +10V operation this should be set to 18V. A rotating pot controls the DCDC output voltage, note - it's not very linear and you may have to turn the pot quite a bit to achieve a voltage change.

The output of the DCDC is fed into U2, a LM78L05 which generates a reference 5V on the PCB. This then feeds into the user pot which generates 0-5V, where 5V is fully clockwise on the pot.

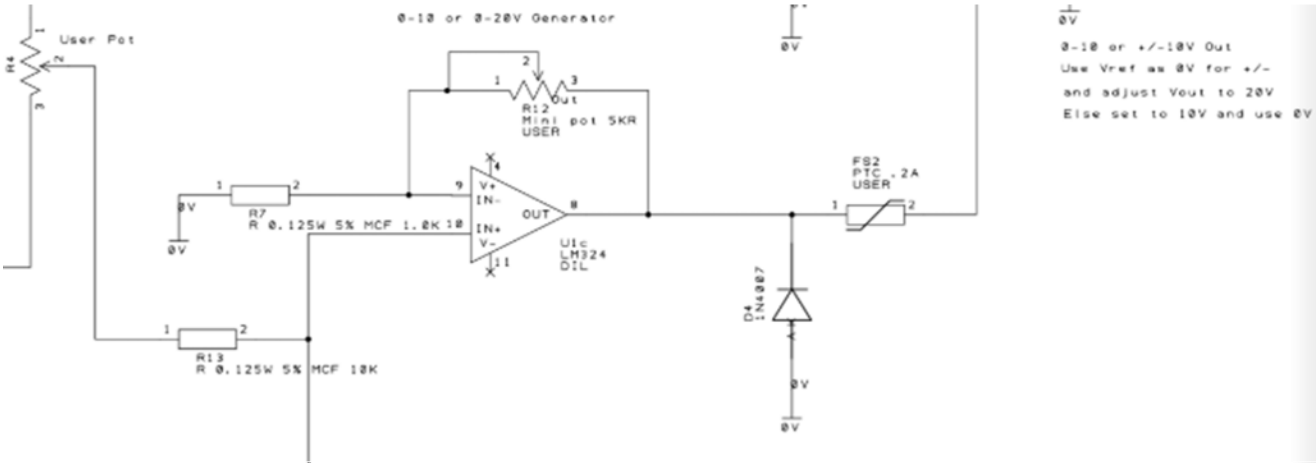
10V Reference generator



This op amp circuit generates a steady 10V output from the 5V generated by the linear regulator. It's only required when the board is configured to output +/-10V. The output goes to J2-1. The op amp is a non inverting amplifier with a gain of 2.

0-10V / 0-20V generator

This gives a variable output voltage based on the pot position. The pot outputs 5V when fully clockwise and 0V when fully counter clockwise.



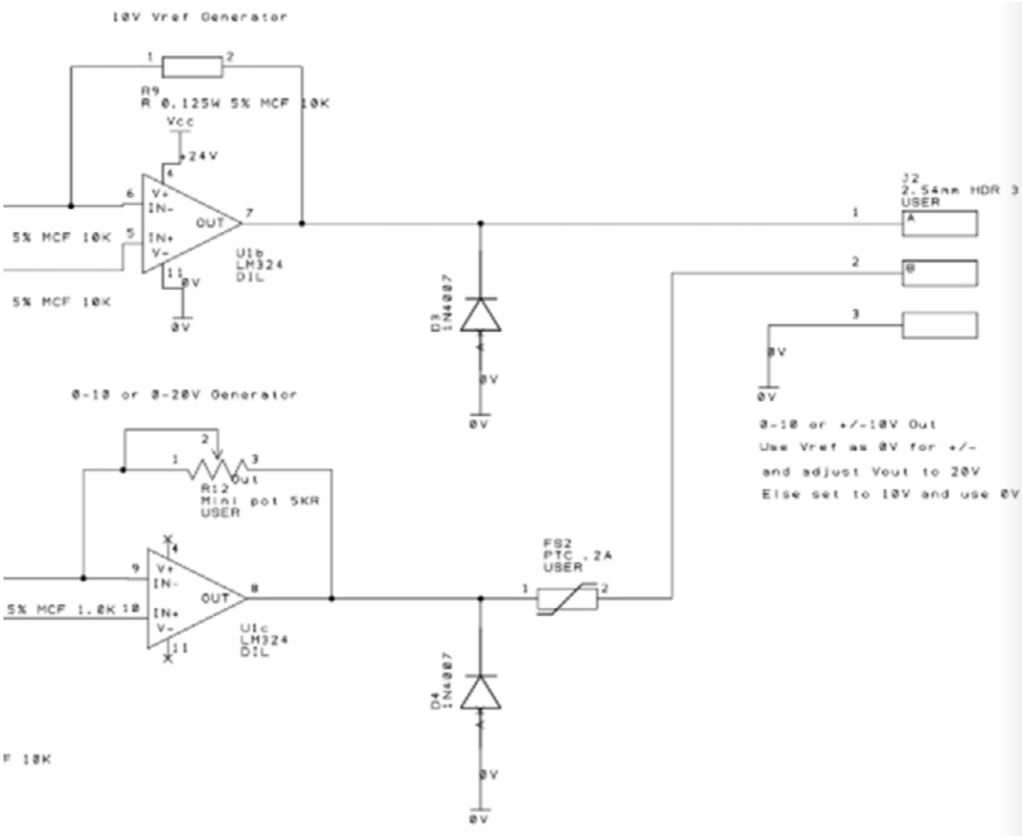
In 0-10V mode R12 is adjusted so that this circuit gives 0-10V output based on the pot position. Requires x2 gain .: R12 = 1K.

In 0-20V mode R12 is adjusted so that this circuit gives 0-20V output based on the pot position. Requires x4 gain .: R12 = 3K.

The resistance R12 sets the Gain. G = 1 + R12/1K. Or R12 = (G-1) x 1K.

Voltage output selection

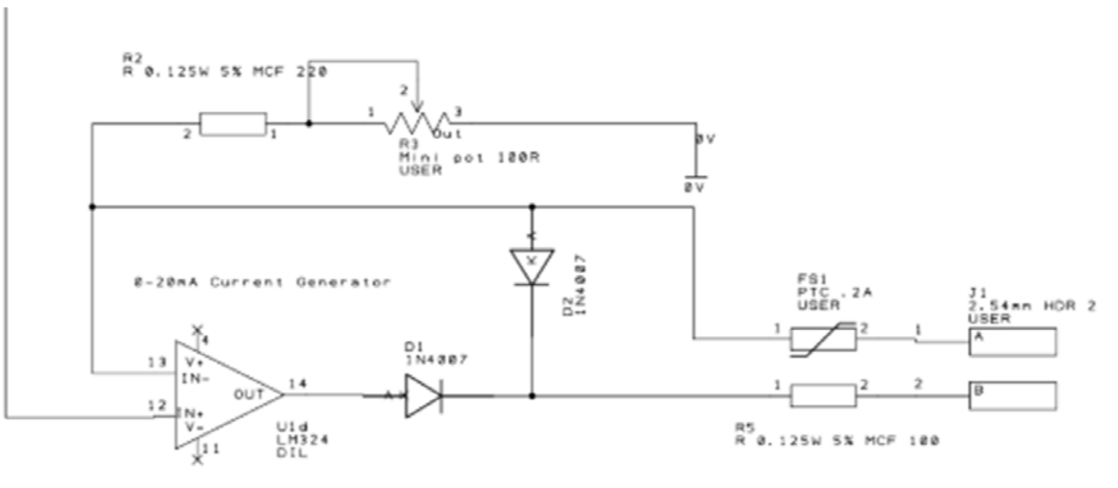
The voltage output circuit operates in either 0-10 or +/- 10V mode. Where +/-10V is used J1-1 is taken as the output reference (10V but treat as 0V) J1-2 is then taken as the voltage output (0-20V) which gives a +/- 10V output relative to J1-1.



For 0-10V operation J1-3 is taken as the reference voltage and J1-2 is taken as the voltage output to give a 0-10V range.

0-20mA Current generator circuit

Generates a variable 0-20mA through the instrument load by generating a variable voltage from op amp U1c. R2+R3 must be set to exactly 250R via adjustment pot R12. You can either calibrate the resistance (250R) or calibrate by circuit output current (20mA).



Taking the 20mA case, 5V will be fed into the IN+ terminal from the user pot. IN- must also therefore be at 5V (op amp theory), if this is at 5V then the current through R2+3 must equal 5V/250R = 20mA. Since no current can flow into the IN- terminal then that current must come from the output of the op amp J2-1 into J2-1 via whatever resistance is placed between those terminals e.g. 500R (typical in industry) or 0R if you are feeding straight into your multi-meter.

The output of the op amp will automatically increase its voltage such that the IN- terminal is at 5V, and since this is a series circuit then 20mA will always through it. The op amp will automatically correct for any volt drops so long as the voltage required to overcome that resistance does not exceed it's supply range.

So for an LM324 max output voltage is Vcc-1.5 so for the 22V case the op amp can output 20.5V max. So the maximum resistance we can drive 20mA over is R=(V-Vdiode)/I = 20 /.02 = 1000 Ohms. However on the schematic there additional resistances on our circuit so that the maximum load resistance we can drive is Rl = 1000 - 250R - 33R = 717R. If we needed to increase this we could increase the DCDC voltage or reduce the volt drop by linking out R5/D1 (although this could make the cct less robust).

R5 Is fitted for protection but can be replaced with a wire link to increase efficiency.

In industry 0-20mA sensor inputs have an input resistance of 100-500 Ohms typically, the unit has been designed to drive 500 Ohm loads, so to drive 20mA at 500 Ohm the unit needs to be able to output .02 x 500 = 10V at it's terminals.

OP AMP

A LM324 quad op amp is used as the basis of this instrument, it should be inserted using the supplied DIL header. These op amps are designed to work of a single supply and have the advantage of being cheap and readily available. The DIL socket makes replacing the unit very easy in the event of accidents.

- Max output is Vcc – 1.5V
- Max supply 32V
- Max output current 30mA

Protection

Various diodes, PTC fuses and resistors attempt to protect the device form misconnection. The diodes will either short whatever we connect to or trip PTC fuses on the main PCB. The instrument is intended for hobby/educational use though and carries no CAT rating, it is also NOT intended for use on high energy circuits.

Simultaneous use

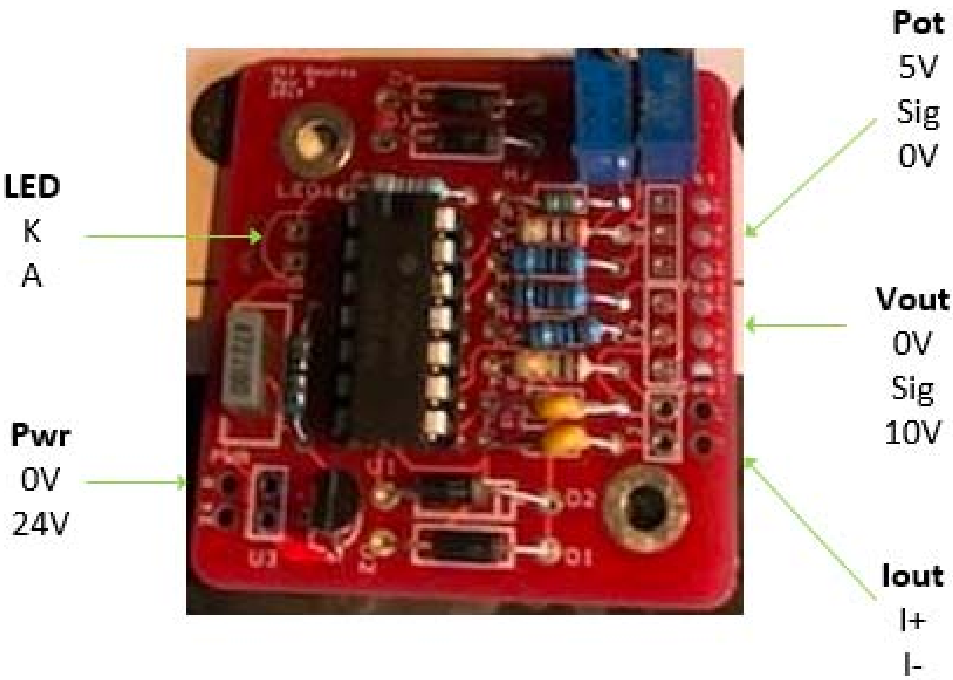
Be careful about using the voltage and current leads simultaneously. The reference wires for the current and voltage circuits are generally not 0V on the PCB therefore there is a risk of creating a short inside the instrument for example if they are both connected to a common external 0V.

Assembly suggestions

- Drill holes using sticker as a template.
- Cut sticker using scalpel and mount, use scalpel to cut holes for LED and pot.
- Cut opening for power switch using file and hacksaw, drill holes to mount switch.
- Mount the DCDC, switch and pp3 clip.
- Check operation and adjust output voltage of DCDC.
- Mount Pot, solder flying leads.
- Assemble PCB
- Commission PCB check:
    - -LED comes on
    - -Pot gives 5V when fully clockwise
    - -LM7805 regulator gives out 5V
    - -DCDC output is circa 20V
    - -Check 10V generator cct outputs 10V
    - -Check 0-10V/0-20V Outputs correct voltage by rotating user pot fully CW then check output voltage, adjust pot R12 till it's correct
    - -For 0-20mA cct rotate pot fully CW, adjust R3 to give 20mA output.
        - Check with 0R load
        - Check with 500R Load
- Mount PCB with 2x screws
- Assemble instrument

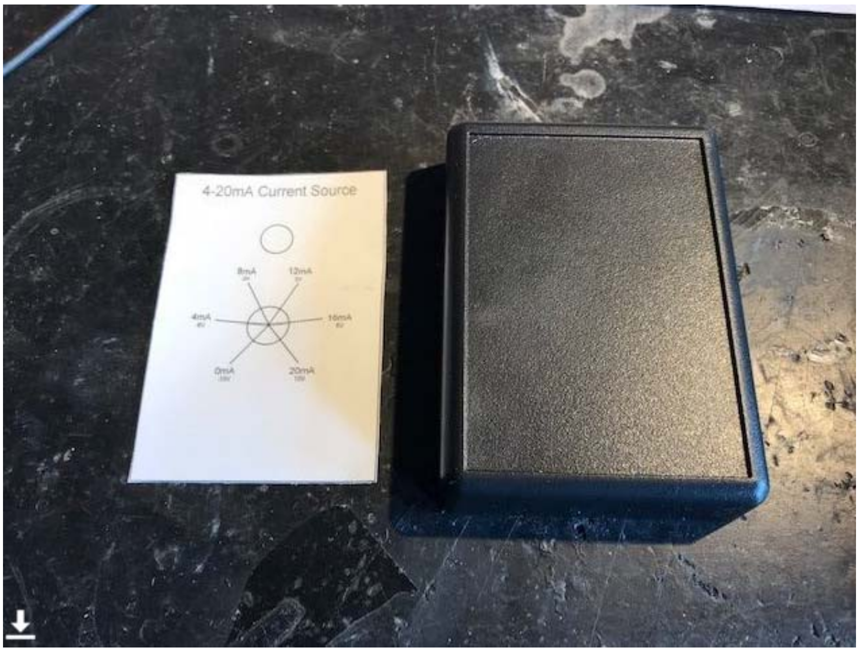
External connections

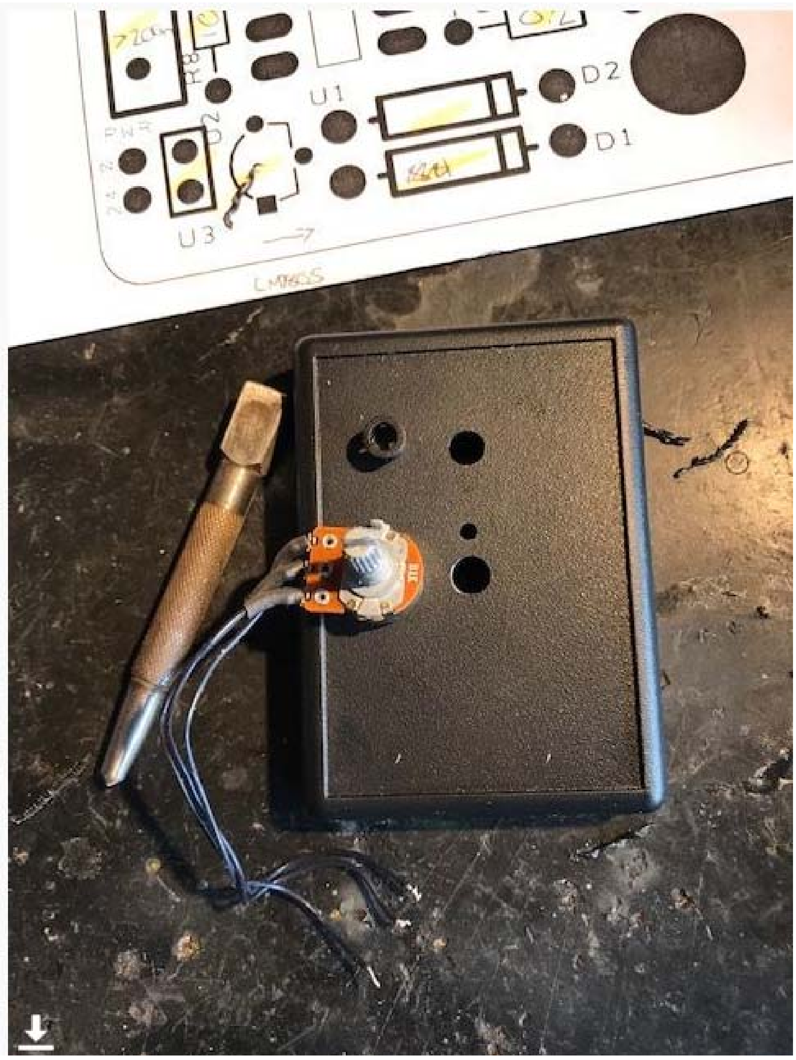
The following points have off board wiring requirements. Holes are provided for strain relief.

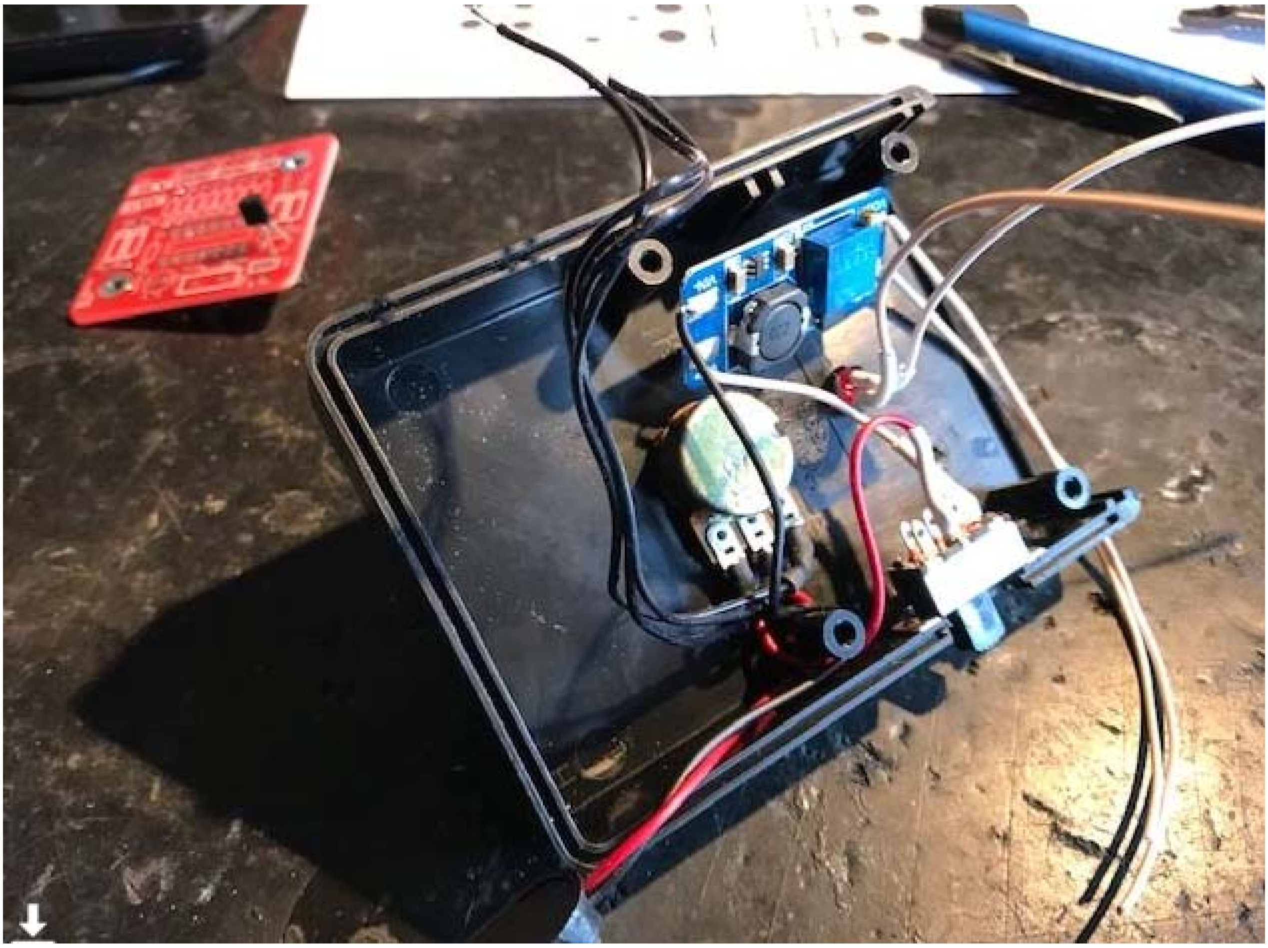


Note - 10V operation use Sig,0V   +-10V Operation use Sig,10V

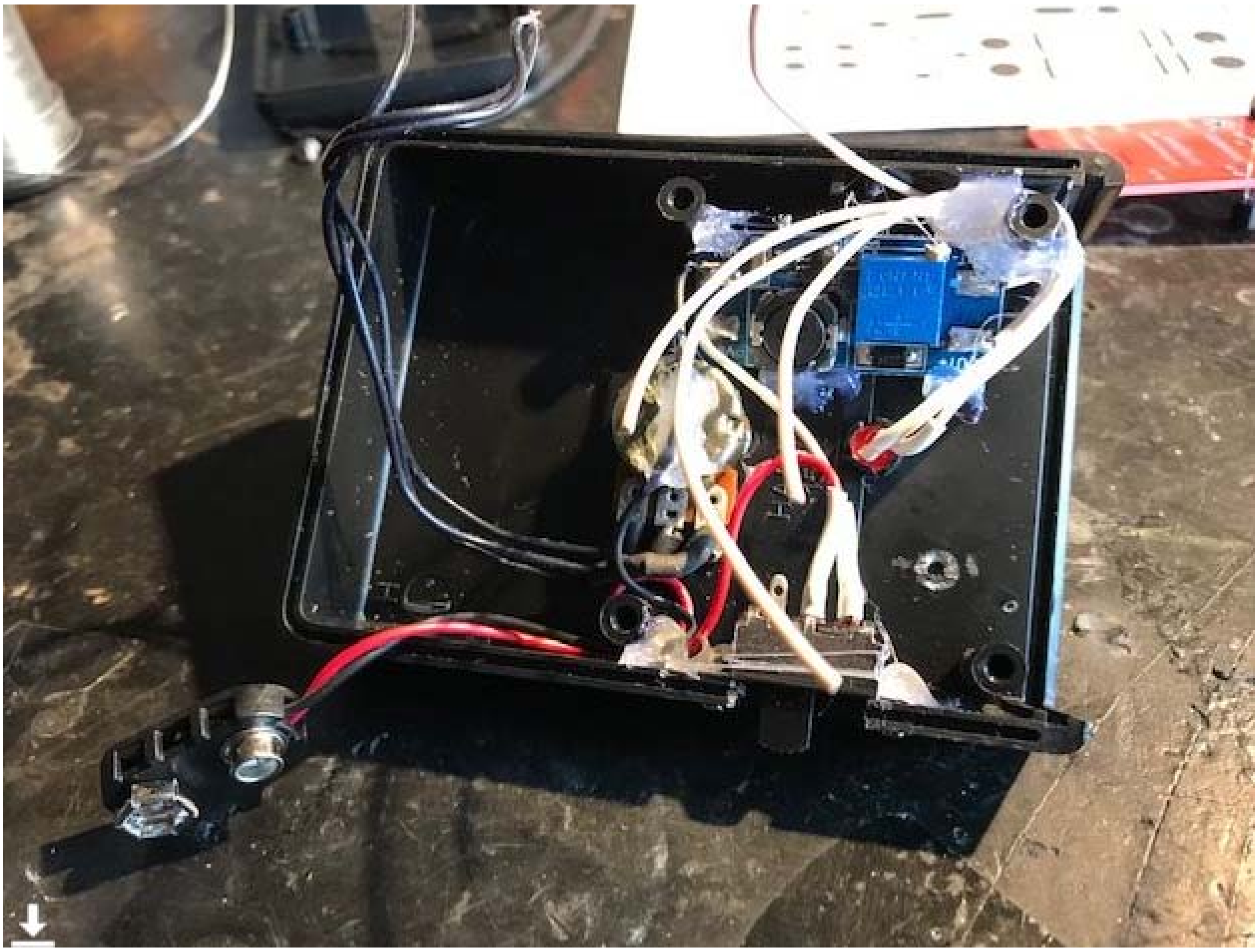
Build photos

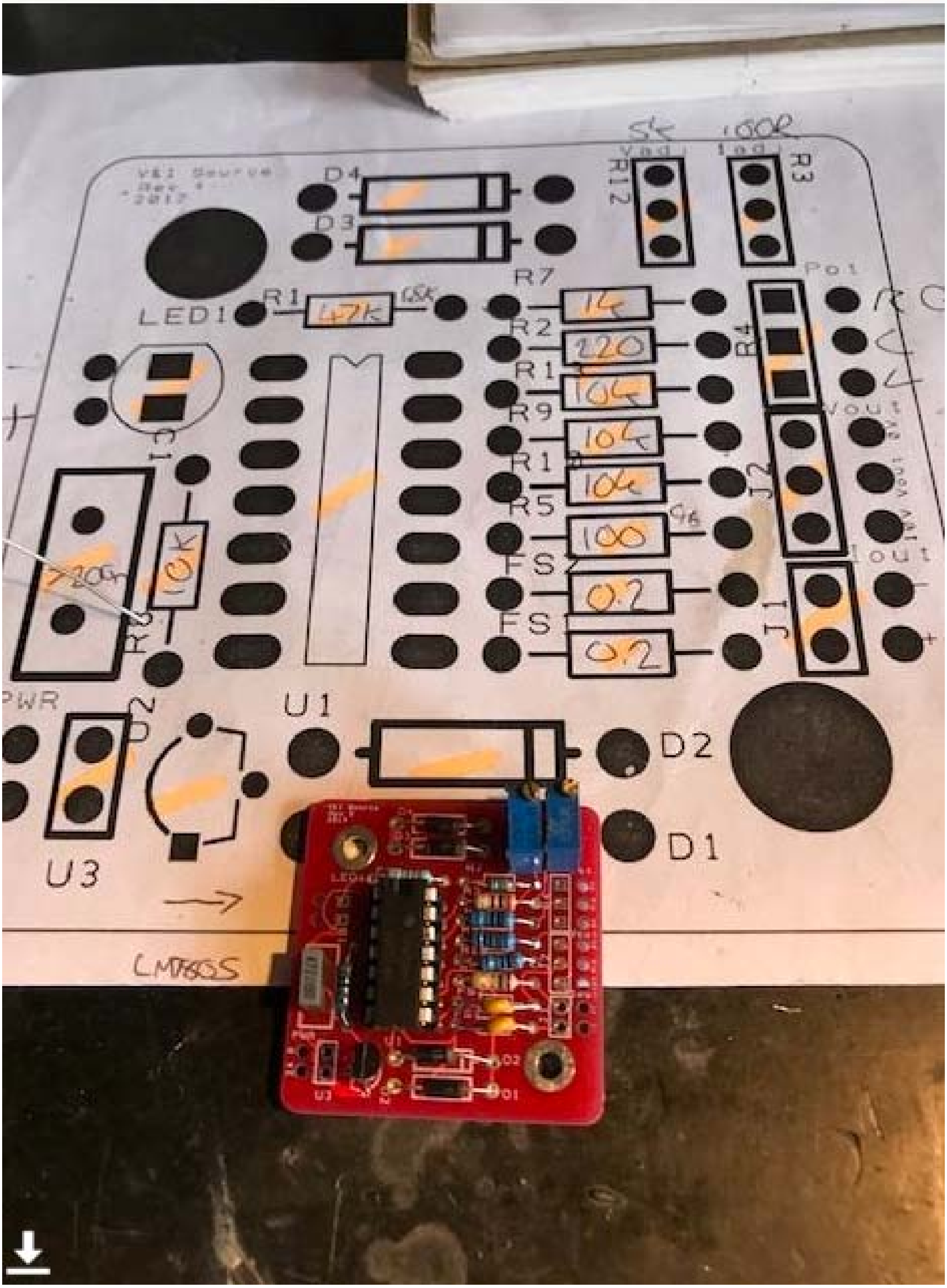


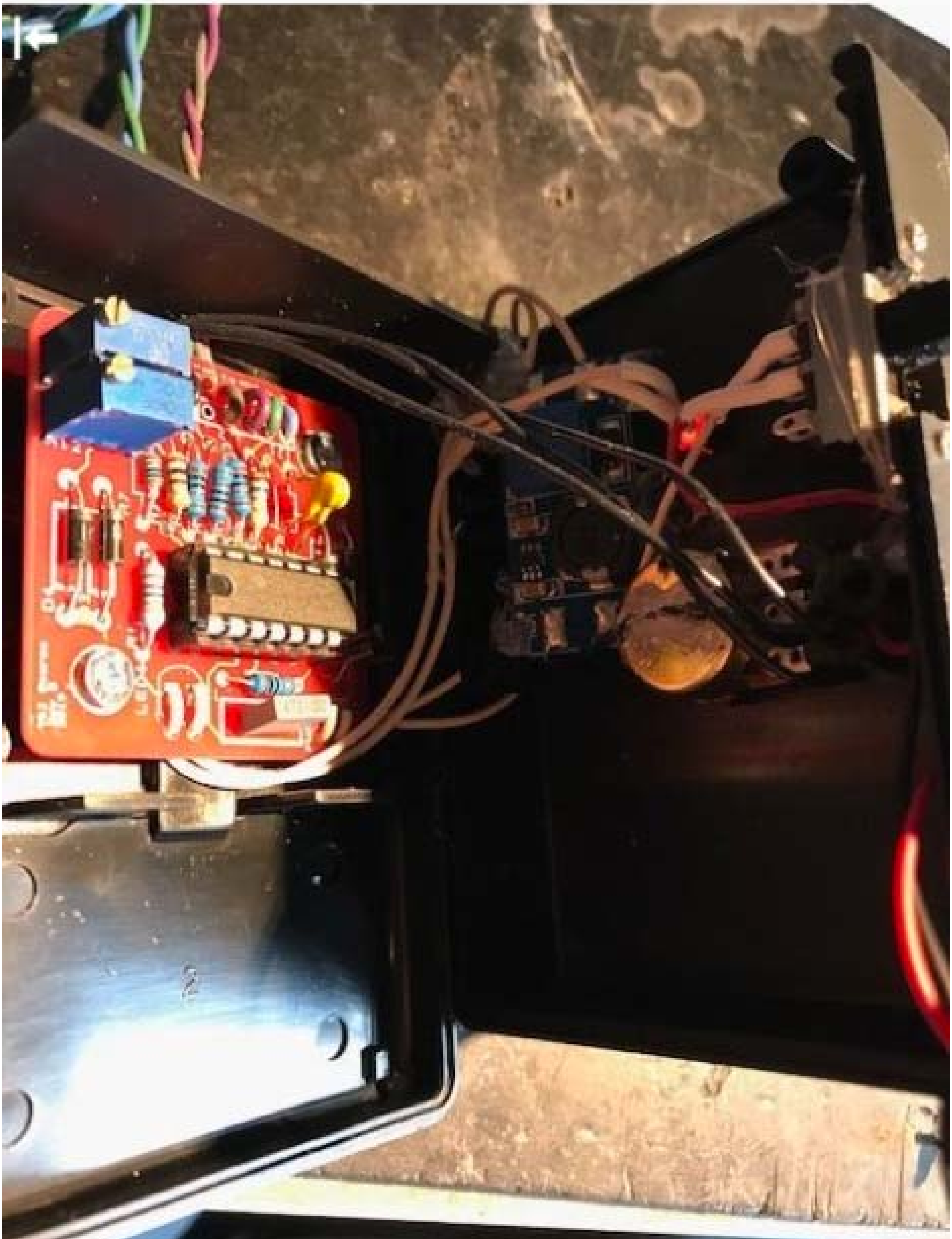





FLUKE
77 IV MULTIMETER
22.12
HOLD
MIN MAX
RANGE
OFF
400 mA
10A
FUSED
DURACELL




D4
D3
R12
R3
5K
100R
LED1
R1
47k
R7
1k
R2
220
R11
10k
R9
10k
R10
10k
R5
100
FS2
0.2
FS1
0.2
Pot
R4
Vout
J2
Iout
J1
10K
R8
PWR
U1
D2
D1
U3
LM7805



4-20mA Current Source
FLUKE
77 IV MULTIMETER
20.03
HOLD
MIN MAX
RANGE
400 mA
600V CAT III
1000V CAT II

DCDC Voltage calculations

The voltage of the DCDC converter determines bot the maximum load the 0-20mA circuit can drive as well as the maximum output voltage from the 2nd circuit. Higher voltages will tend to mean lower battery life.

If we need to drive a 500R load, then the minimum DCDC voltage the device will work at in 0-10V mode is 18V and this will be able to drive a 517R Load with the 0-20mA circuit.

DCDC Voltage for 0-10V mode		
Vd	0.3	Diode drop
Vcc	18	DCDC output
Vr	1.5	Rail voltage of op amp
Vref	5	Voltage we need at OP amp input termina;
Vout	16.2	Max Output from device to load at terminal wire
I	0.02	At 20mA
R	810	Max resistance we can drive in total broken down as....
R2	250	
R5	33	
RPTC	10	
Rl MAX	517	Max load we can drive at 20mA

Note - Removing R5 lowers this by one Volt.

If we do not need to drive a 500R load, then the minimum DCDC voltage the device will work at in 0-10V mode is 11.5V and this will only be able to drive a 192R Load with the 0-20mA circuit.

DCDC Voltage for 0-10V mode		
Vd	0.3	Diode drop
Vcc	11.5	DCDC output
Vr	1.5	Rail voltage of op amp
Vref	5	Voltage we need at OP amp input termina;
Vout	9.7	Max Output from device to load at terminal wire
I	0.02	At 20mA
R	485	Max resistance we can drive in total broken down as....
R2	250	
R5	33	
RPTC	10	
Rl MAX	192	Max load we can drive at 20mA

For the +/-10V Mode the Minimum Voltage required from the DCDC is:

DCDC Voltage for +-10V Mode		
Vmax	20	Max output voltage Required by op amp in this mode
Vr	1.5	Rail voltage of op amp.
Vcc	21.5	Volts

Which can drive a load of 692R.

DCDC Voltage for 0-10V mode		
Vd	0.3	Diode drop
Vcc	21.5	DCDC output
Vr	1.5	Rail voltage of op amp
Vref	5	Voltage we need at OP amp input termina;
Vout	19.7	Max Output from device to load at terminal wire
I	0.02	At 20mA
R	985	Max resistance we can drive in total broken down as....
R2	250	
R5	33	
RPTC	10	
Rl MAX	692	Max load we can drive at 20mA

Battery life

A PP3 Battery typically has a capacity of 120mAh. The following table illustrates how varying the DCDC converter voltage changes expected battery life. The table shows the battery current draw in different scenarios.

DCDC Voltage	20mA Load 0Ohm	0mA Load
22	130mA / 1 hr	30mA / 4 hr
12	56mA / 2 hr	15mA / 8 hr