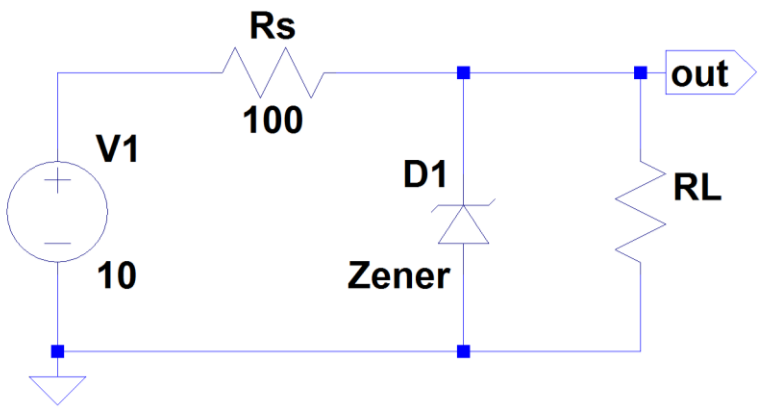
REPORT

註：模板檔案僅提供最簡報告內容

註：請用三用電表與材料包的電阻，自行測量實驗數值

註：本結報所需量測照片皆需包含電路、電阻及電表顯示數值

Part 1: Zener shunt regulator

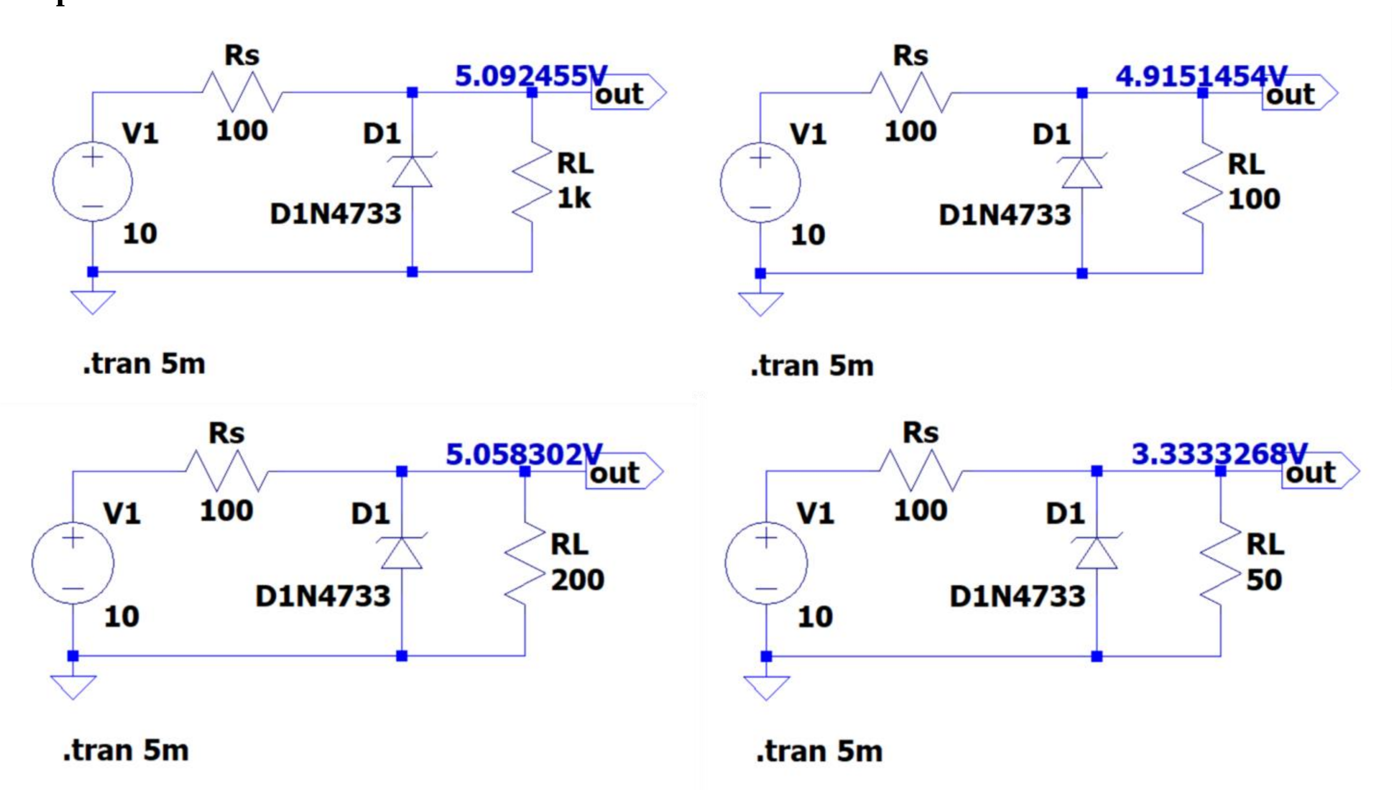


V1: 實驗室電源供應器
D1: Lab05 使用的 Zener diode
此為麵包板電路，不用焊接
RL 不接，表示電路開路。

$$LOR = \frac{\Delta V_{out}}{\Delta I_{out}} = \frac{V_x - V_{no\ loading}}{I_x - I_{no\ loading}}$$

RL (Ω)	open (no loading)	1k	200	100	50
V_{out} (V)	5.02	5.01	4.92	4.65	3.33
I_{out} (A)	0	0.005	0.02	0.04	0.06
ΔVout (V)		-0.01	-0.1	-0.37	-1.69
ΔI_{out} (A)		0.005	0.02	0.04	0.06
LOR (Ω)		-2	-5	-9.25	-28.167

LTspice Simulation:



Observation:

If the Zener diode weren't present, the voltage at "Out" would be:

1kΩ: $10 \times \frac{1000}{100+1000} = 9.091$

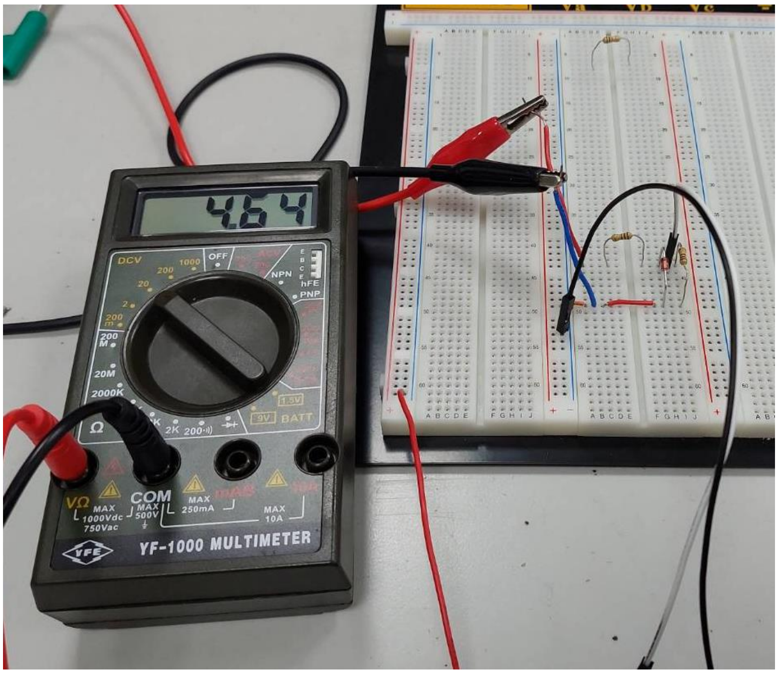
200Ω: $10 \times \frac{200}{100+200} = 6.67$

100Ω: $10 \times \frac{100}{100+100} = 5$

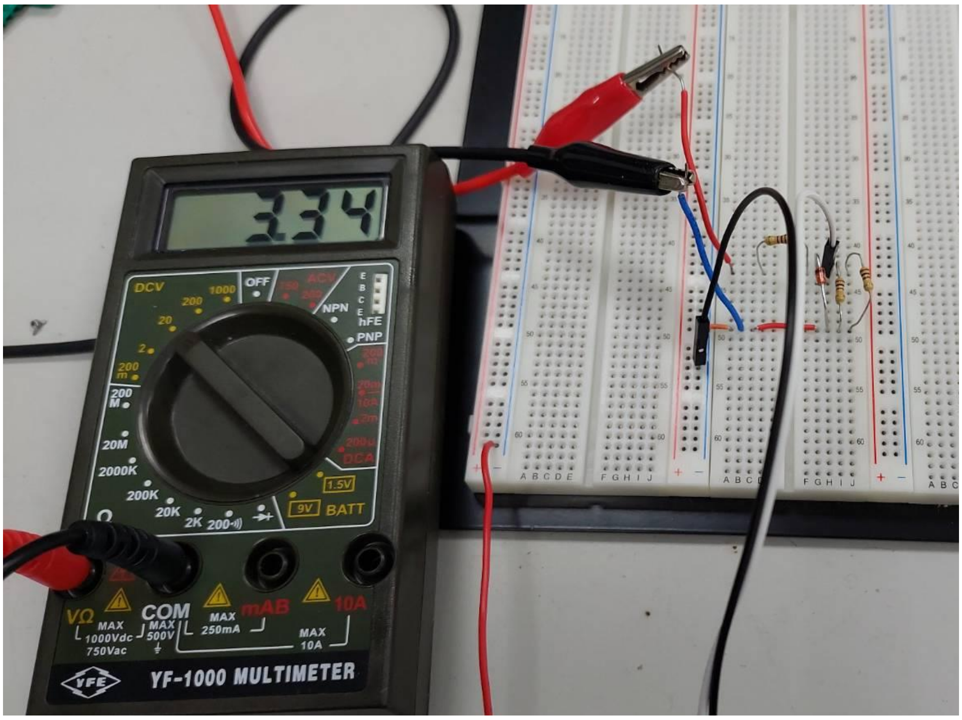
50Ω: $10 \times \frac{50}{100+50} = 3.333$

When the load is 50Ω, there isn't enough voltage to trigger a breakdown in the Zener diode, therefore there is no regulation and the circuit behaves as if the Zener diode weren't there.

Record picture of DC voltage value on the multimeter when RL = 1k ohm



Record picture of DC voltage value on the multimeter when RL = 50 ohm



Part 2: 78/79 Series regulator (soldered on perfboard)

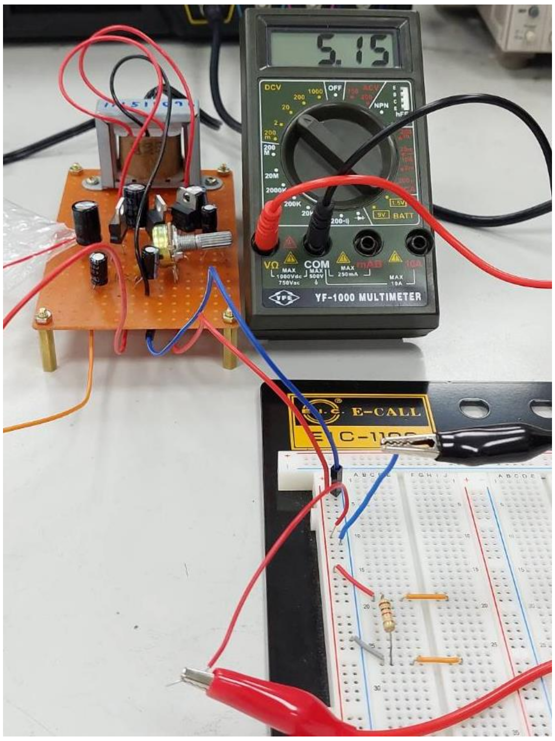
$$LOR = \frac{\Delta V_{out}}{\Delta I_{out}} = \frac{V_x - V_{no\ loading}}{I_x - I_{no\ loading}}$$

7805 IC (**+5 V output**) 可變電壓請調整至大約 5 Volt 的輸出

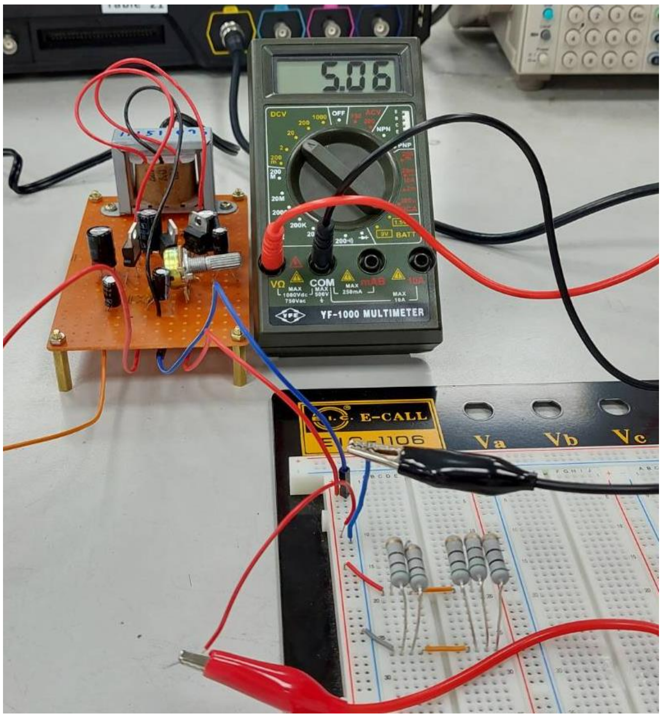
RL (Ω)	open (no loading)	1k	100 (**high power Resistor**)	25 (**high power Resistor**)	10 (**high power Resistor**)
V_{out} (V)	5.13	5.13	5.12	5.07	4.76
I_{out} (A)	0	0	0.05	0.20	0.47
ΔVout (V)		0	-0.01	-0.06	-0.37
ΔI_{out} (A)		0	0.05	0.20	0.47
LOR (Ω)		0	-0.2	-0.3	-0.7872

You may notice that the values in the chart are different from the ones measured in the pictures below. This is because I modified my power supply on demo day, switching out the capacitors(This will be explained further in the report). The measuring done for the chart is done prior to that. I don't want to do it all over again so I left it like so.

Record picture of DC voltage value on the multimeter when RL = 1k ohm



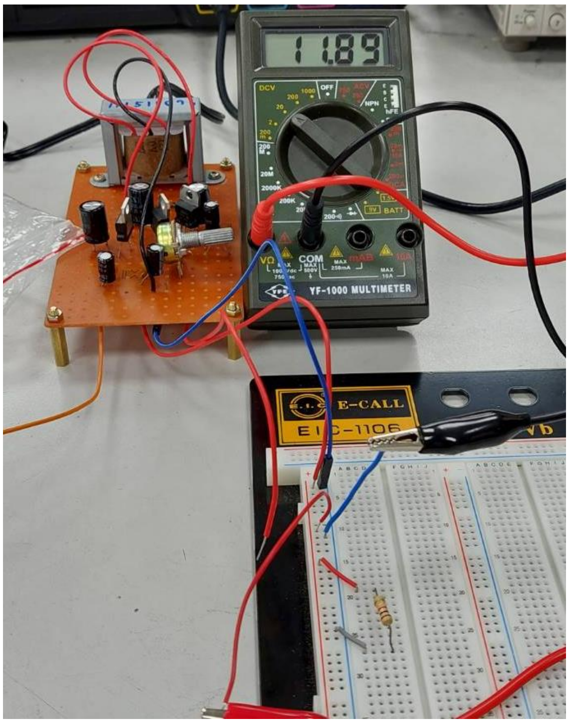
Record picture of DC voltage value on the multimeter when RL = 10 ohm



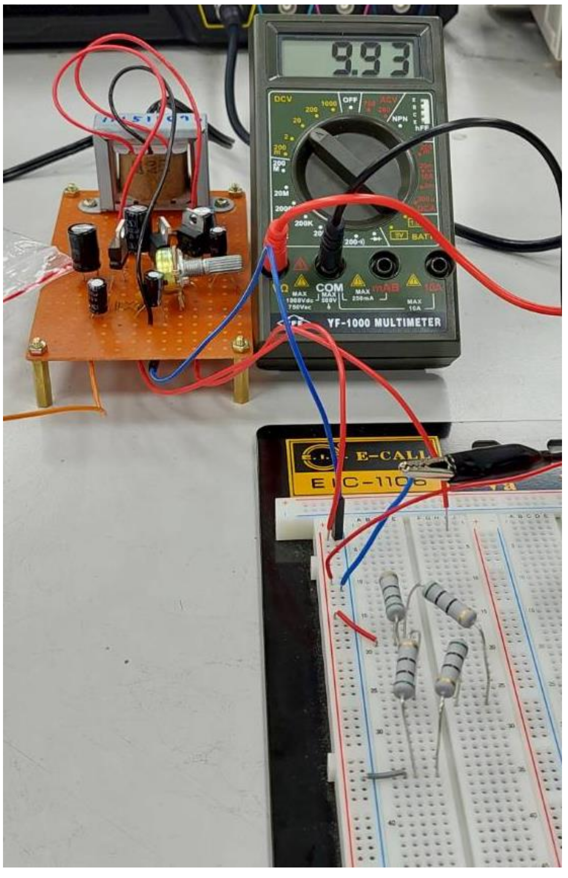
7812 IC 輸出電壓接近 +12V

RL (Ω)	open (no loading)	1k	200 (**high power Resistor**)	100 (**high power Resistor**)	50 (**high power Resistor**)
V_{out} (V)	11.90	11.89	11.76	11.31	10.01
I_{out} (A)	0	0.01	0.05	0.10	0.19
ΔVout (V)		-0.01	-0.14	-0.59	-1.89
ΔI_{out} (A)		0.01	0.05	0.10	0.19
LOR (Ω)		-1	-2.8	-5.9	-9.9474

Record picture of DC voltage value on the multimeter when RL = 1k ohm



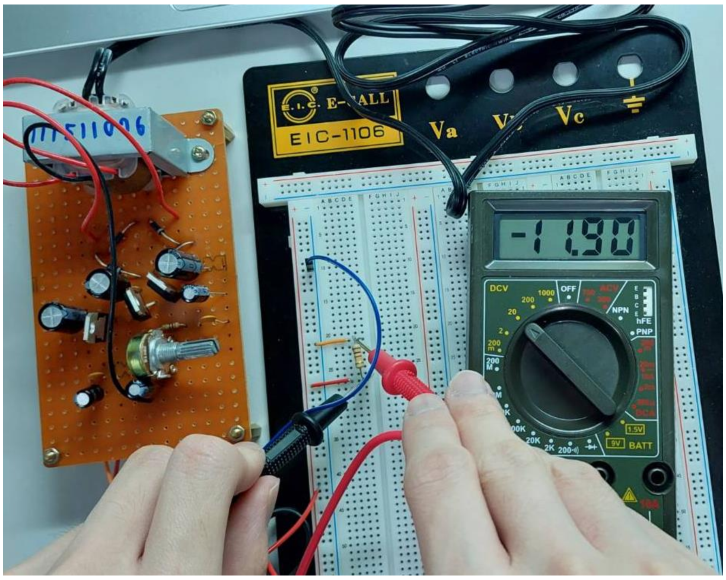
Record picture of DC voltage value on the multimeter when RL = 50 ohm



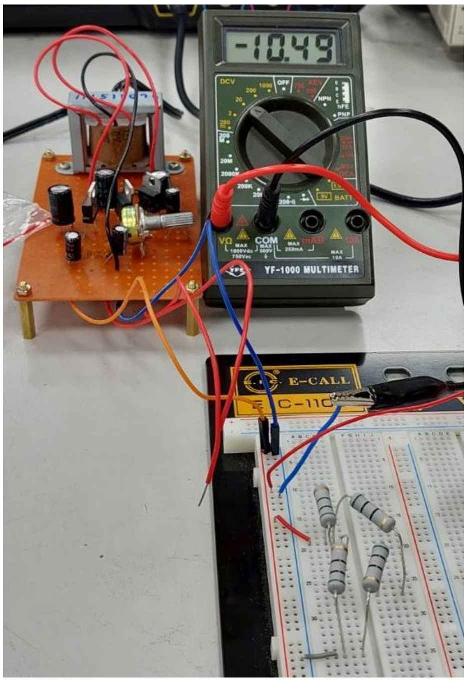
7912 IC 輸出電壓接近 -12V

RL (Ω)	open (no loading)	1k	200 (**high power Resistor**)	100 (**high power Resistor**)	50 (**high power Resistor**)
V_{out} (V)	-12.01	-11.99	-11.95	-11.79	-10.72
I_{out} (A)	0	-0.01	-0.06	-0.11	-0.21
ΔVout (V)		0.02	0.06	0.22	1.29
ΔI_{out} (A)		-0.01	-0.06	-0.11	-0.21
LOR (Ω)		-2	-1	-2	-6.1429

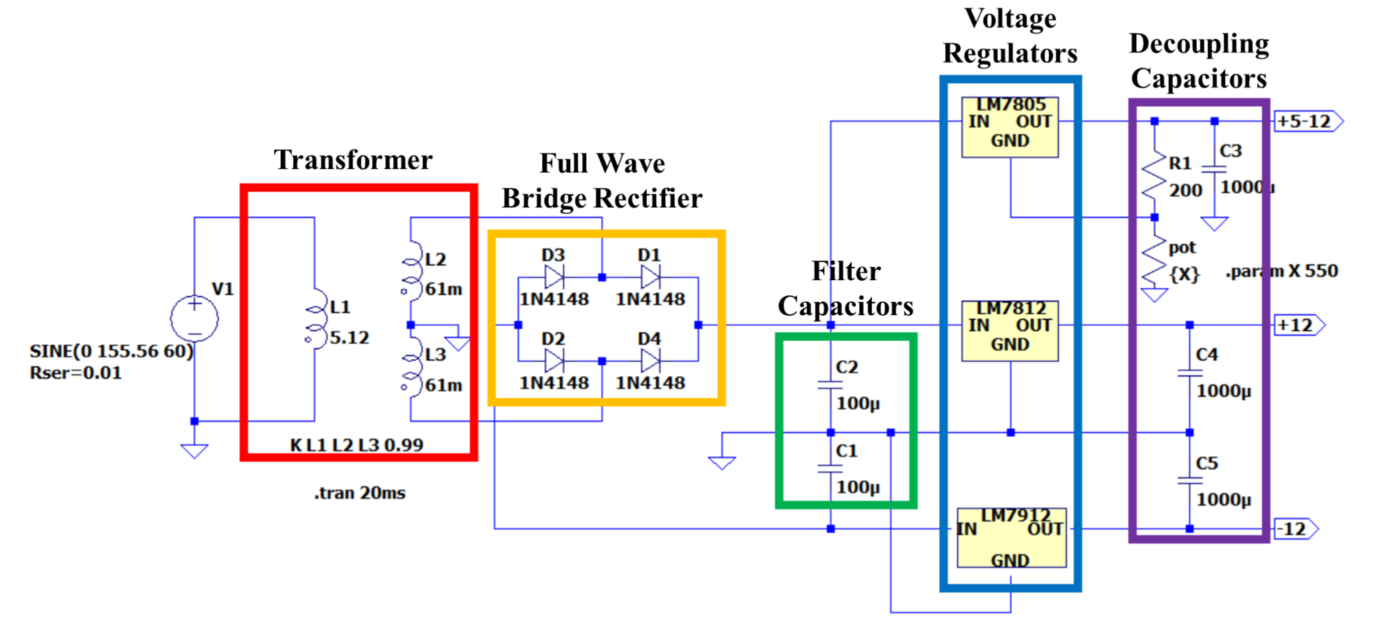
Record picture of DC voltage value on the multimeter when RL = 1k ohm



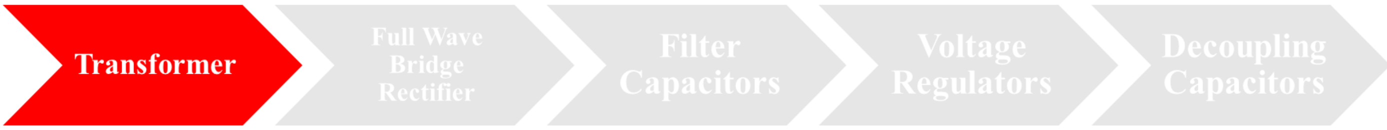
Record picture of DC voltage value on the multimeter when RL = 50 ohm



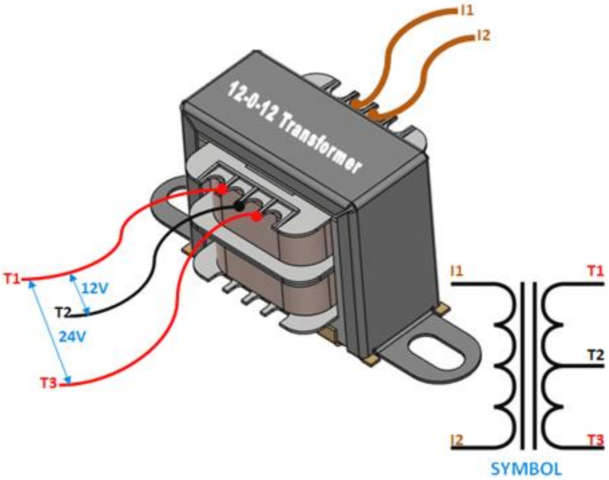
Implemented Circuit schematic (i.e. the practical circuit you show to TA):
手繪或 LTSpice 繪製電路圖(含各元件數值)、照片紀錄（包含但不限於：焊接完成電路、各系統說明等）



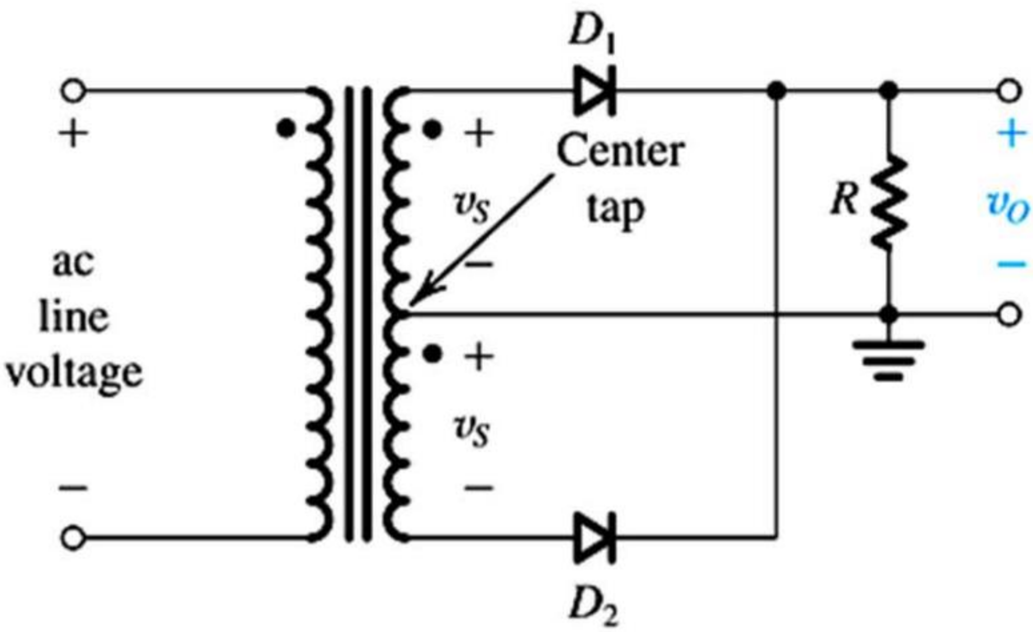
I have separated the power supply into 5 sections, each with their own purpose. I will explain each marked section in detail further below.



A normal transformer only has 2 output ports. However, the one given to us is a center-tapped transformer, which has 3 outputs, 1 positive port on either end, and a ground port in the center.

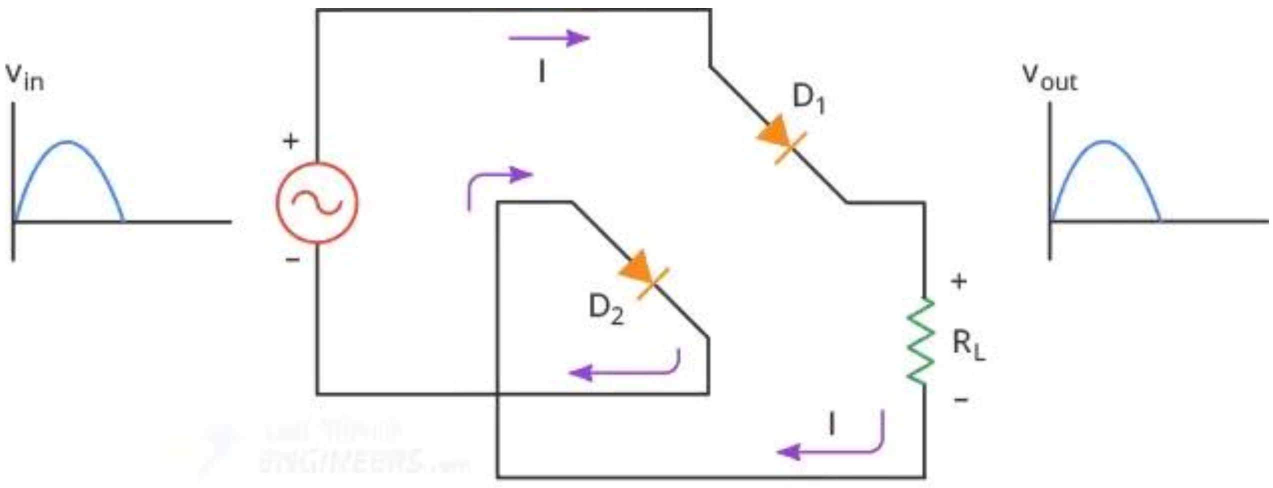


A key advantage that this should have provided(I didn't know this when I soldered my board) is that we can use only 2 diodes to accomplish full-wave rectification, which I learned on Monday in professor Yi-Ming's Electronics lecture. A traditional 2-port transformer would require 4 diodes. It's a pity that I learned this after I soldered my board, otherwise I would have implemented a more efficient circuit.



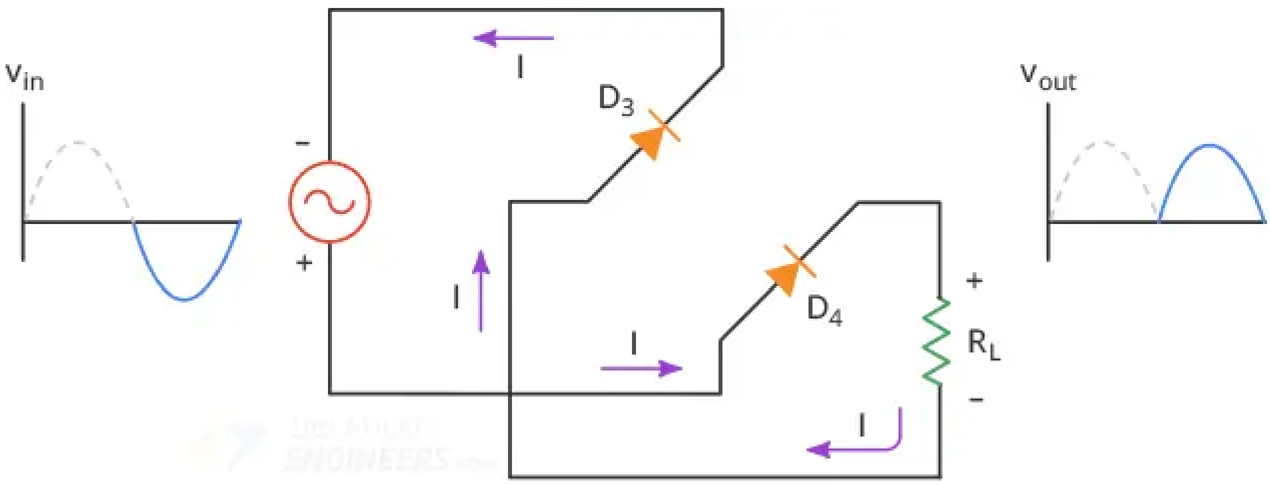
What is a full-wave bridge rectifier?

A full-wave bridge rectifier is an electronic circuit consisted of 4 diodes that converts an AC voltage into a pulsating DC voltage.



During positive half-cycle

During the positive half-cycle of the AC input voltage, the diodes connected in the bridge allow the current to flow through them in the forward bias direction. Diodes D1 and D2 conduct during this period, allowing the positive half-cycle of the AC voltage to pass through and reach the load.



During negative half-cycle

During the negative half-cycle of the AC input voltage, diodes D3 and D4 conduct, allowing the current to flow through them in the forward bias direction. This allows the negative half-cycle of the AC voltage to pass through and reach the load. As a result, the negative half-cycle is also rectified, and a pulsating DC voltage is generated.

However, the combination of the two positive and negative half-cycles creates a pulsating DC voltage across the load. The output voltage still exhibits a ripple or pulsation because it periodically drops to zero, as the diodes switch between conducting and non-conducting states with the change in the AC input voltage polarity. To obtain a more stable DC voltage, a filter capacitor is often connected in parallel with the load.

What do the large capacitors in the middle do?

To “smooth out” the ripple, filter capacitors are connected in parallel with the load, and they smooth out this ripple by storing energy during voltage peaks and releasing it during voltage troughs.

Capacitors act as a reservoir of energy that can be used to counteract fluctuations in the supply voltage. When there is a sudden drop in the supply voltage, the capacitor releases its stored energy to compensate for the voltage drop, helping to maintain a more constant output voltage. Conversely, when the supply voltage increases, the excess energy is absorbed by the capacitor. Naturally, the higher the capacitance, the better the smoothing.

What do the three ICs do?

The 3 ICs we used, 7805, 7812, 7912, produce the same result as the Zener shunt regulator we tested in Part 1. They maintain a stable and constant output voltage even when provided with a varying input. However, the job is not quite done yet. There still remains some imperfections with our power supply.

What purpose does the capacitors at the very end serve?

Variations in current demand (for example, connecting a 555 timer to our power supply) can cause fluctuations in the voltage supplied to the load. Decoupling capacitors can negate this problem. They are used in electronic circuits to reduce noise, stabilize voltage levels.

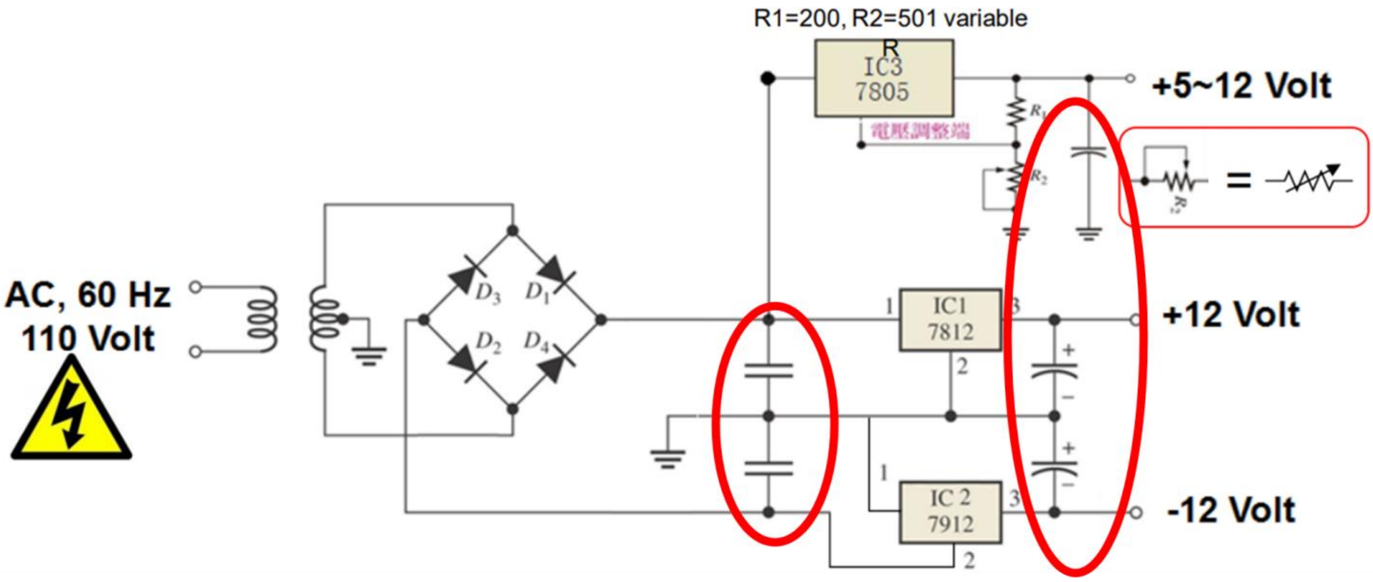
Why do we need two different capacitors?

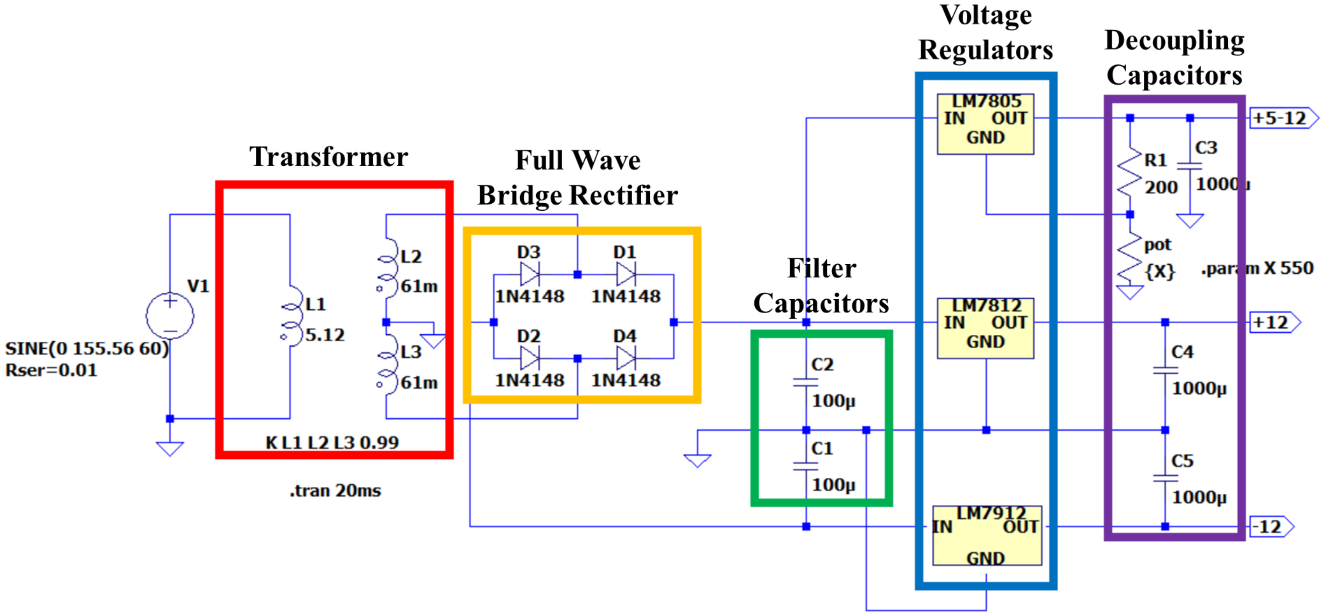
The smaller capacitor (0.1uF) is better at filtering high-frequency noise and providing a low-impedance path for noise at higher frequencies. It can respond quickly to fast voltage changes and attenuate(weaken) noise caused by rapid switching of digital signals.

The larger capacitor (100uF) can store more energy and is better suited for providing energy during transient current demands or for smoothing out low-frequency and more significant voltage fluctuations. It helps maintain stable voltage levels over longer periods.

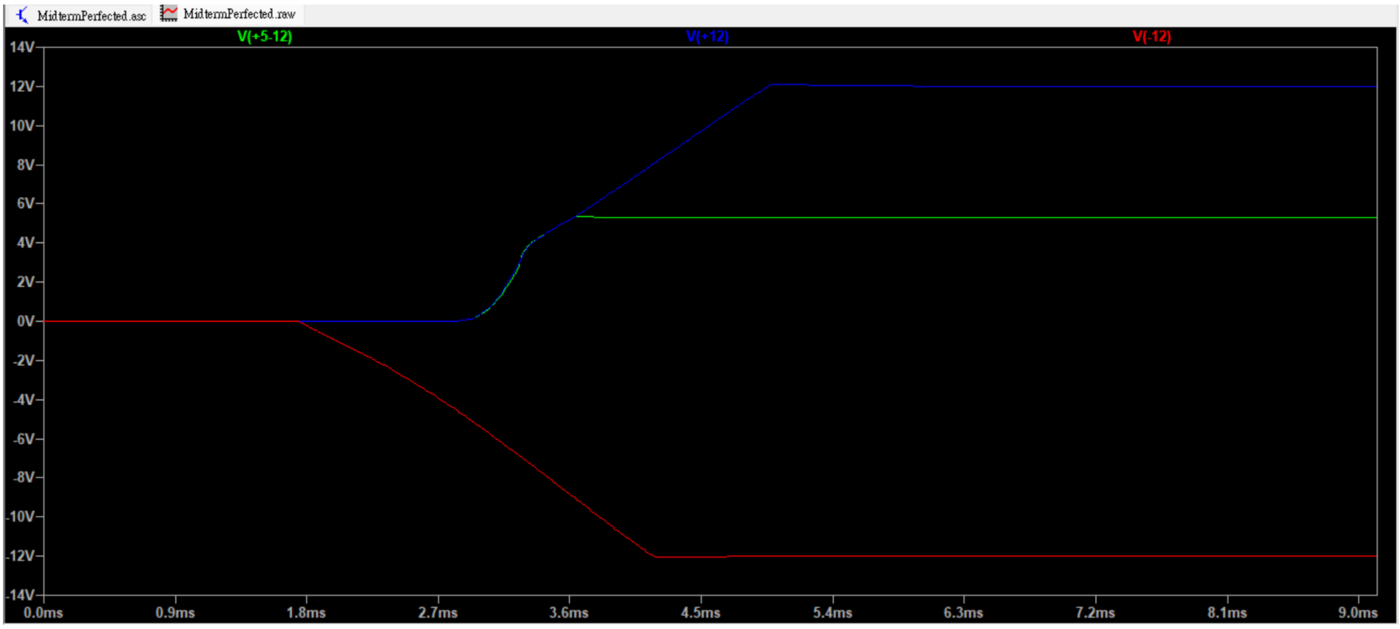
Design Process:

This is the "basic" power supply design provided to us. I implemented this on my breadboard and tested the output, which looked mostly correct. At this point, I thought that this was a good enough power supply so I soldered the design onto my perfboard. (I actually used the 100uF capacitors as filter capacitors and the 1000uF as decoupling capacitors, I later realized that I should have done the opposite.)



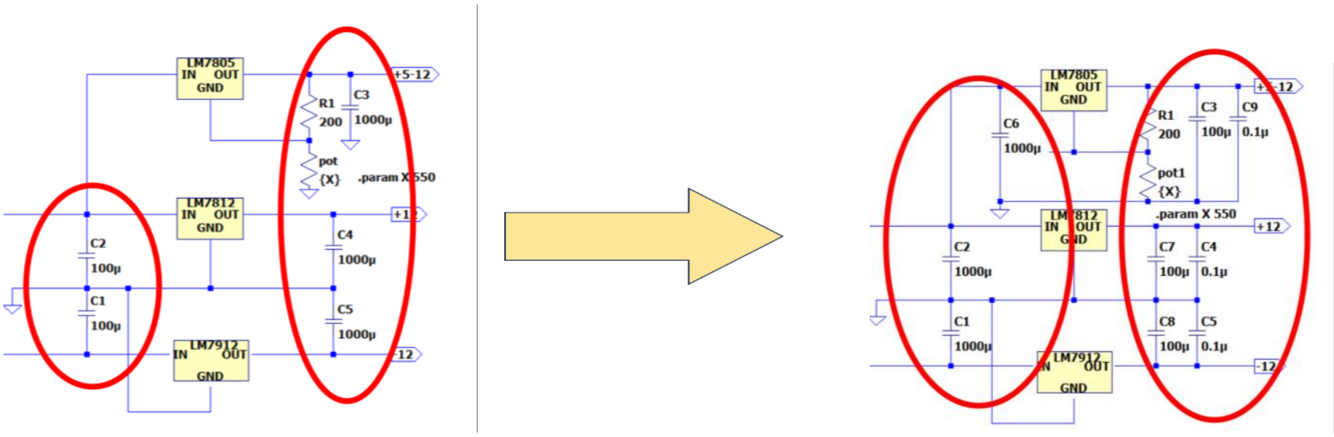


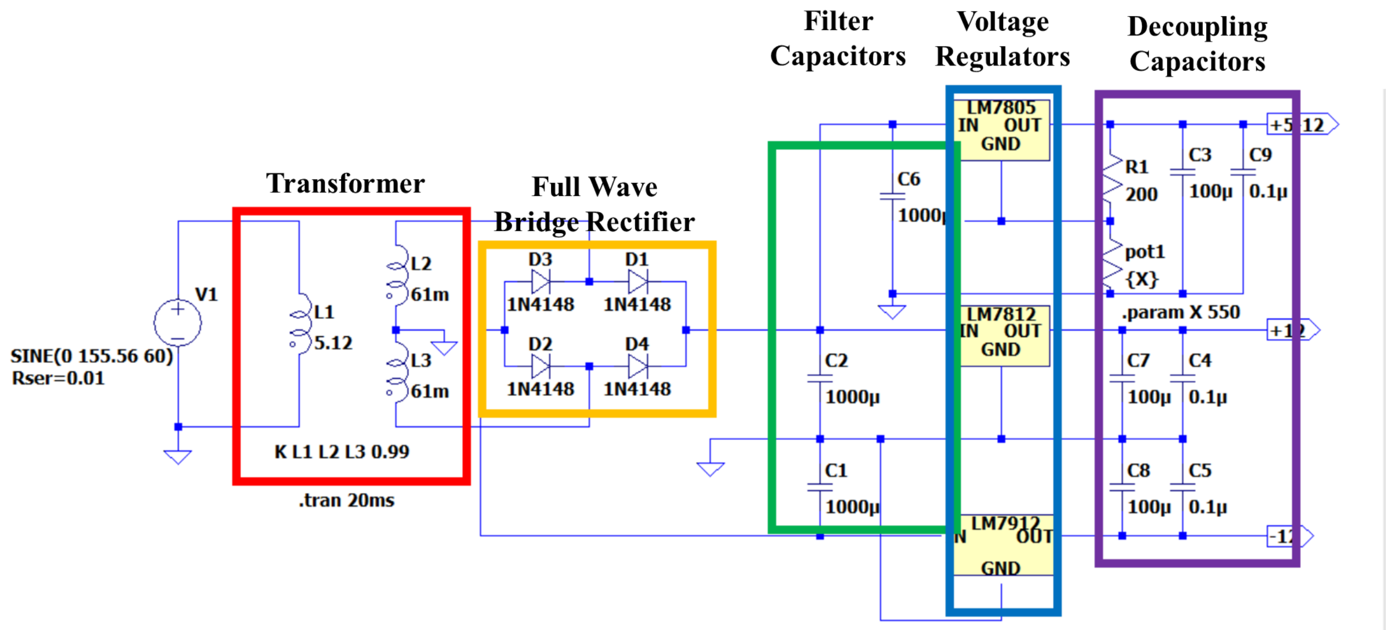
LTspice Simulation:



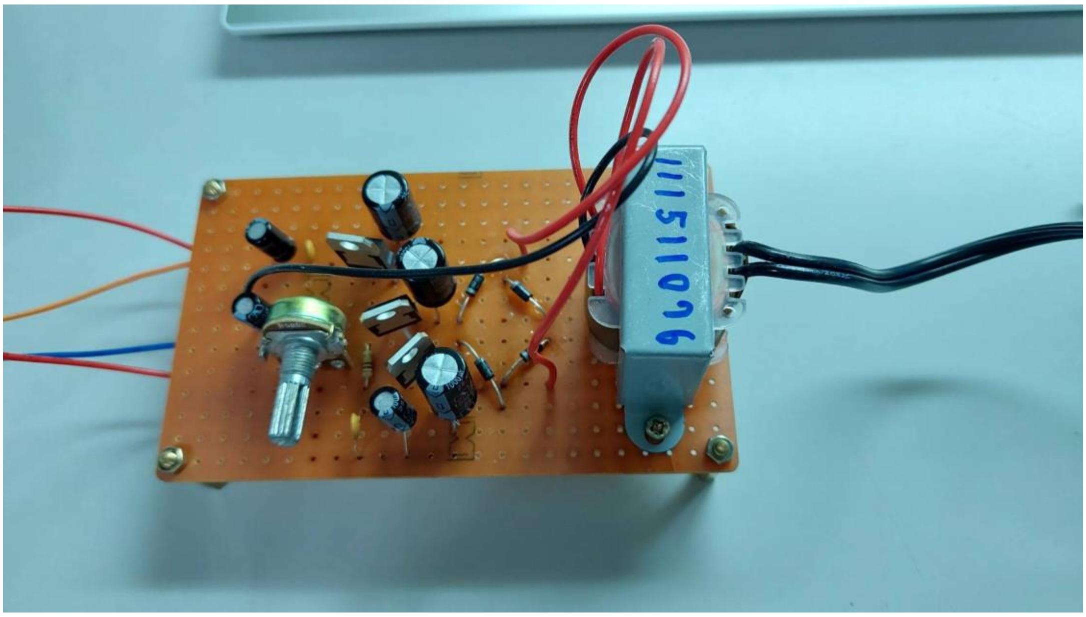
However, when working on this report, I asked myself the question, “What are the capacitors at the end for?”. After looking it up, I learned that they were decoupling capacitors, and that small capacitance capacitors and large capacitance capacitors are often used together for decoupling. While the simulated voltage may look stable, this power supply design is not suitable for a load with varying current demand.

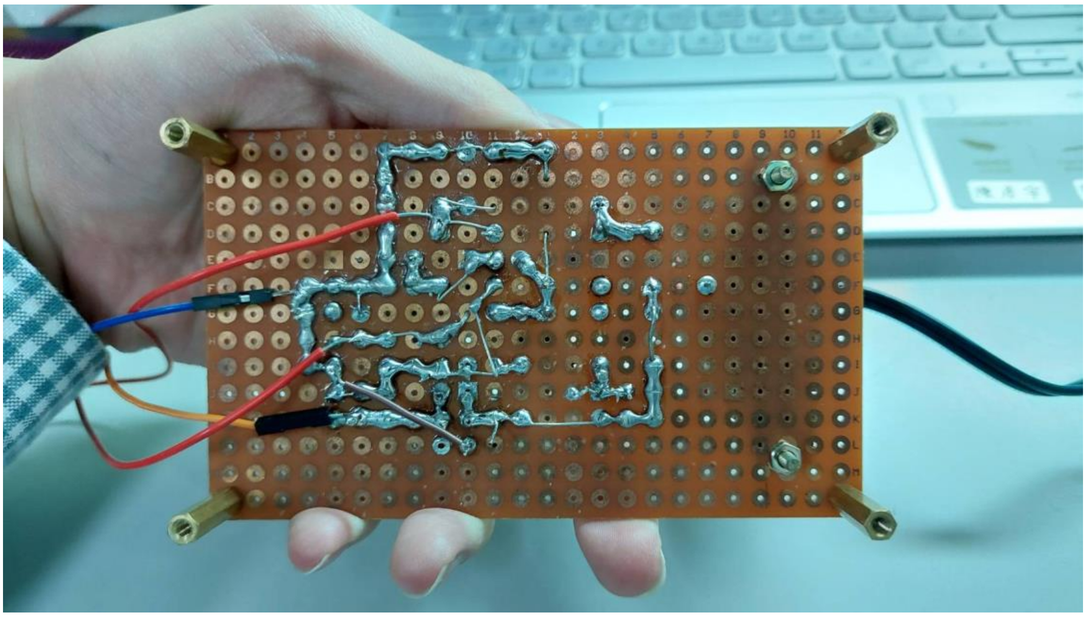
After realizing this, I redesigned my power supply and implemented the following circuit on my perfboard. Additionally, LM7805 previously had to share a filter capacitor with 7812, making the output less stable so I added an extra dedicated capacitor in front of it.





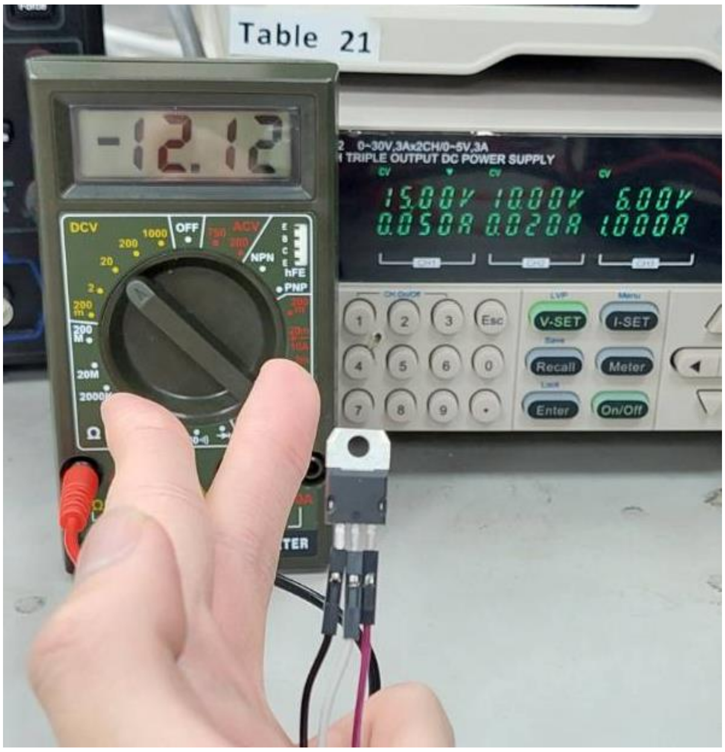
Perfboard Implementation:





Circuit Debug:

Difference in good and damaged voltage regulator ICs:



I have assisted several classmates with their projects. I noticed that if their measured output voltage is slightly higher than the nominal value (ex: getting 13.06V instead of around 12V from 7812), then there's a high likelihood that the regulator IC has been damaged. A way to test this (using 7912 as an example) is to remove the IC and supply it with a higher voltage (-15 in this case) than its designated output and see if it reduces the voltage to a correct value. The 7912 I tested in this picture works fine. A faulty one may have an output larger than -13V.

Damaged Capacitors:

It was demonstrated in a video during a previous experiment that electrolytic capacitors will explode if connected in reverse. Several classmates have made this mistake. Thankfully, they were stopped before their capacitors exploded.

Electrolytic capacitors contain a liquid electrolyte that can break down(electrolysis 電解) when exposed to reverse voltage. When the electrolyte breaks down due to reverse voltage, it can lead to the formation of hydrogen gas within the capacitor. Since electrolytic capacitors are typically sealed, this pressure has nowhere to go, causing the capacitor to swell and, in extreme cases, rupture or explode.

Damaged potentiometer:

Resistors and potentiometers are made using carbon composite. While they are usually pretty robust, the high heat from soldering can damage the carbon if done incorrectly. In one extreme case, someone damaged their potentiometer which should have a resistance of 10 ~ 500Ω, and the value went up to 1000~1400Ω.