High Resolution Version also available on my website: https://robin-h-yuan.herokuapp.com/

PCB Hardware Personal Project Portfolio

1. My First Four Layer PCB - *Christmas Tree Light*

Figure 1A: Layout

Figure 1B: Assembled PCB

Design Description:

The board was designed for my girlfriend as a Christmas gift. The entire function of the board is to blink the LEDs with a fading/breathing effect. It is a four-layer PCB with a lower power and cost-effective PIC32MM microcontroller. The fading effect was implemented using PWM on the outputs and a custom timer ISR to adjust the duty cycle written by me. I designed all the schematics, layout and routed everything on this board. The board uses USB type-C for power delivery. I also created the symbol and footprint for the u-controller. Everything on the board is assembled by using a stencil, paste, and hot air gun; the LEDs are hand soldered.

2. My First PCB with a Switching Mode Power Supply - *Square Wave Generator*

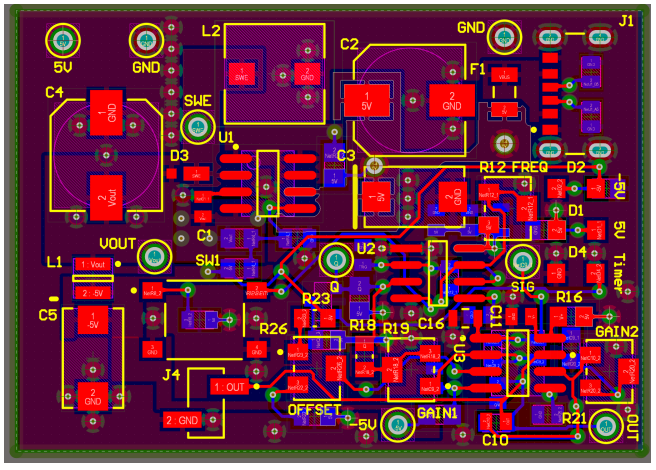

Figure 2A: Layout

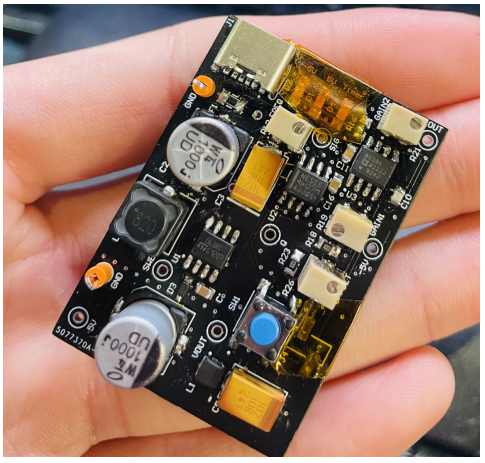

Figure 2B: Assembled PCB

High Resolution Version also available on my website: https://robin-h-yuan.herokuapp.com/

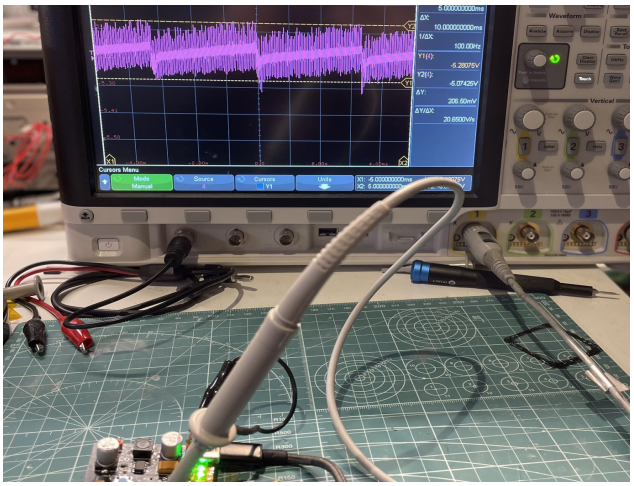

Figure 2C: Inverting SMPS -5V Ripple Measurement

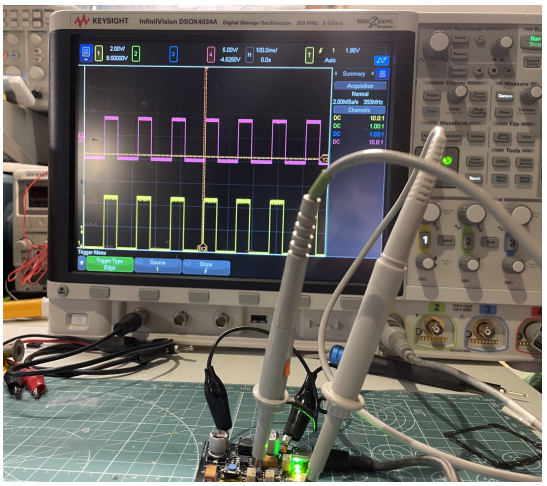

Figure 2B: Output Waveform

Design Description:

The board was created to explore the use of a DC-DC converter and a way to compete with my friends to see who could make the smallest board given the same schematics. The board can be used as a square wave generator with adjustable offset, gain and frequency. The board uses USB-C for 5V power delivery as usual but an MC34063A IC is used to create a -5V power rail for the op-amp. In addition, all high-current paths use polygons instead of traces. As of now, the ripple voltage when loaded is approximately 200mV(Vpp @ 350MHz) and 140mV when unloaded. The actual ripple will be smaller than the current measurement as the long ground lead of the probe is prone to picking up noise.

Future Improvements:

Since this is the first revision, there are various improvements that can be made to reduce the noise level. First, we can add a ferrite bead right after the output to suppress the high-frequency noise. Then, we will cascade an LDO voltage regulator. Furthermore, having a bigger board will give me more space to keep the high current/switching loops as far as possible from sensitive ICs. Finally, I will also have some additional decoupling capacitors.

Feb 27, 2023 Update:

After tweaking the switching frequency by changing the timing capacitor, the ripple was further reduced to 75mV when loaded.

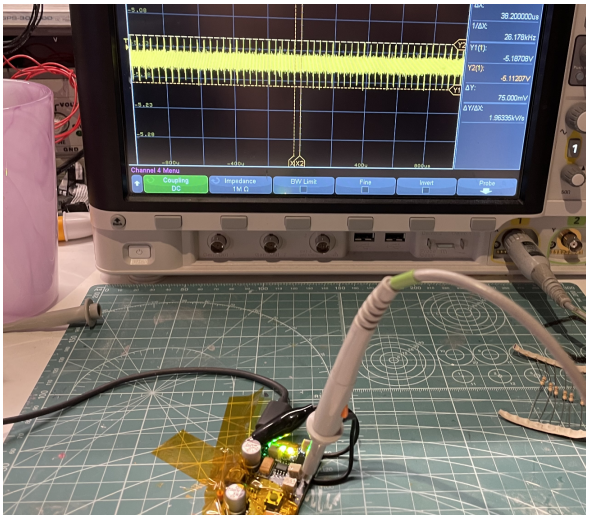

Figure 2D: Improved Inverting SMPS -5V Ripple Measurement

Figure 2E: HOME LAB

3. Open Robotics Drivetrain Power Distribution PCB

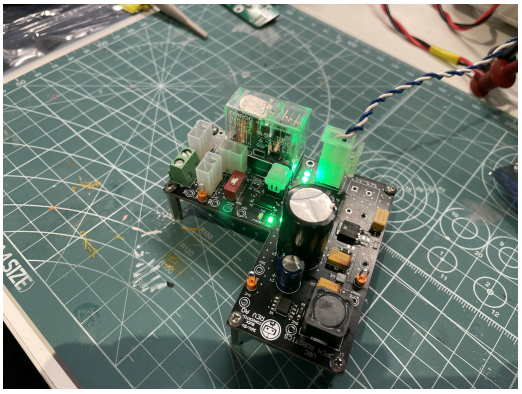

Figure 3A: Power Distribution PCB

Design Description:

This board will be responsible for delivering power to the stepper motors (36V) and all other electronics (5V). The PCB has a classic 34063 IC for stepping down the Li battery voltage from 36V to 5V. It also consists of an emergency stop system using a power relay. The emergency stop signal can be asserted by using the mechanical switch or sending a digital signal. The digital input is isolated from the high-power circuit using an optocoupler.

Noise Reduction Techniques:

The output ripple and noise level is 20mV when unloaded. I have implemented many techniques that I learned from my previous PCB. First of all, use the datasheet to calculate the appropriate inductor, timing capacitor, etc. Then, I cascade an LC filter after the output as its first stage. Afterward, I added a ferrite bead to suppress the high-frequency noise. Finally, I used an RC filter with a series pass transistor (capacitance multiplier) to minimize the voltage dropout issue. Also, no GND or Power Polygons/Planes directly under the inductor to reduce noise coupling.

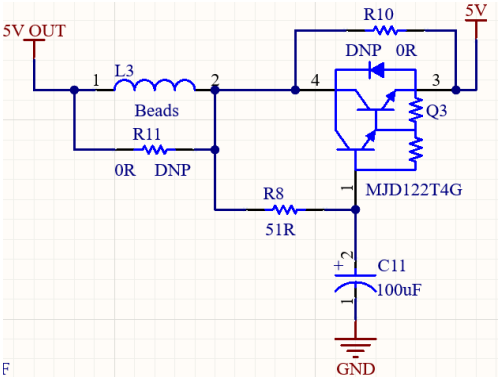

Figure 3B: Capacitance Multiplier Circuit

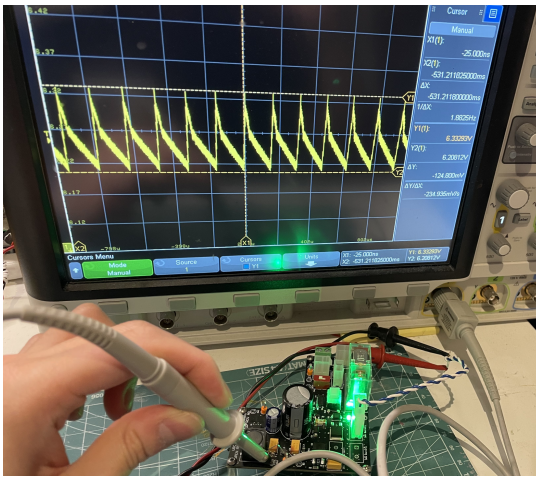

Figure 3C: Unfiltered Output (125mV Ripple)

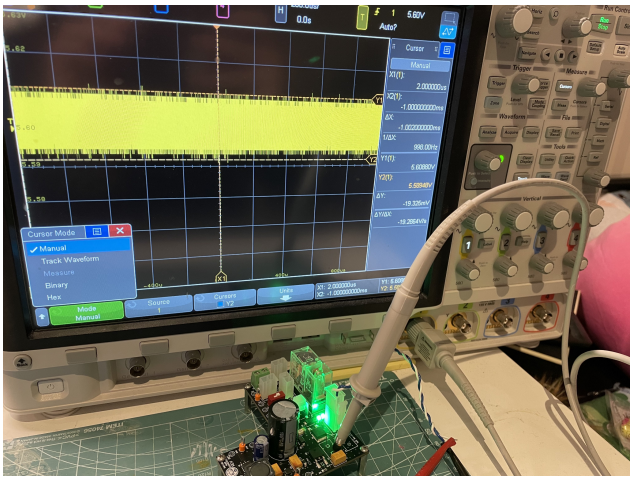

Figure 3D: Filtered Output(20mV Noise + Ripple)

Power Delivery Techniques:

- Polygons and split power planes on high current paths
- Added stitching vias to connect planes together
- Reverse Polarity Protection: PMOS
- ESD Protection: TVS Diodes

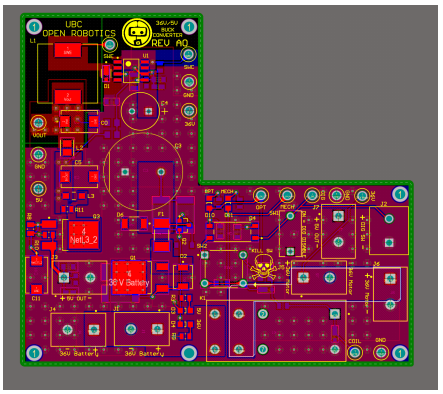

Figure 3E: PCB Layout