Developer Guide

System Overview:

BER LLC made a variable power supply that supplies 2-14V that can be changed through a laptop and control knobs. An Arduino Due is used to program the power supply. Our goal was to design a versatile and portable power supply that can be used in any lab setup. The maximum current rating is 1.5A which is powerful enough for any benchtop lab power supply. It has many redundant safety features including a current warning display and voltage setting lock button. To promote clean voltage signal, a linear topology with voltage regulators were used to mitigate any voltage ripple behavior. Voltage ripple causes heat and circuit inefficiencies which is undesirable in any testing or prototyping assignment. All of these features make a powerful, safe, and highly applicable benchtop power supply.

Electrical Specifications:

Characteristics	**Rating**
Maximum input voltage	120 VAC, 60Hz (wall power)
Outputs	2-14V output; 1.5A maximum
Power Rating	21W max
Operating temperature	100°C

User Guide:

Set the power supply on a stable surface and plug a standard wall plug into the back of the power supply (120 V). Plug the cables into the front jacks to use that channel. Use the buttons on the front panel to adjust output voltage or change the channel selected. Press the lock button to prevent any changes to the output voltage. Press the lock button a second time to enable changes to the output voltage. The warning system will display how close you are to reaching the current limit of the power supply. When all 9 LEDs are lit up, you are about to blow the internal fuse.

Design Artifacts:

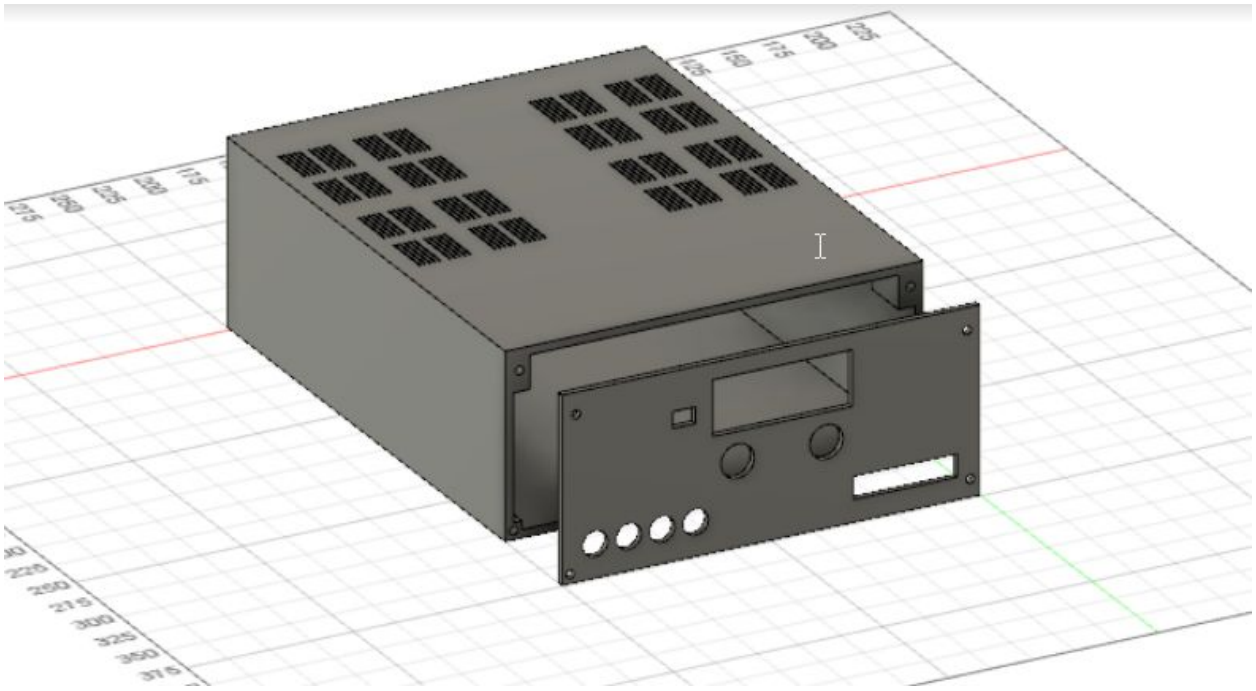

Figure 1: Enclosure

This enclosure has dimensions of 4.5” x 9.8” x 12”. There are cooling vents in the top and the back where fans will move cool air to prevent overheating. The front panel is held by 4 screws which allows access to the inside of the enclosure. The front panel holds the screen, knobs/buttons, channel output connectors, and warning system.

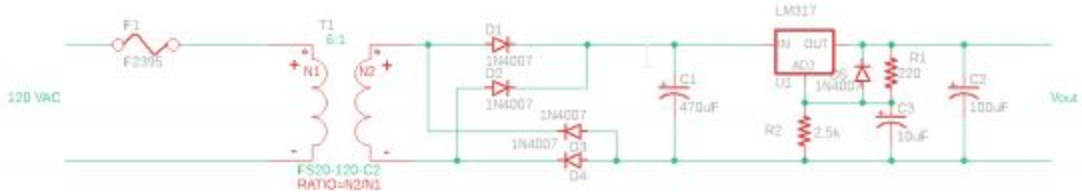

Figure 2: Full Bridge Rectifier

The rectifier circuit provides a conversion from AC to DC which allows the user to apply the outputs in their circuits. It takes in 120VAC from wall power and converts it to 16V at the output. It uses a step down transformer to output ~20VAC then rectified and sent through the linear regulator. This output is then used to power the Arduino Due and channeled to the output. This voltage then can be changed in the output stage block.

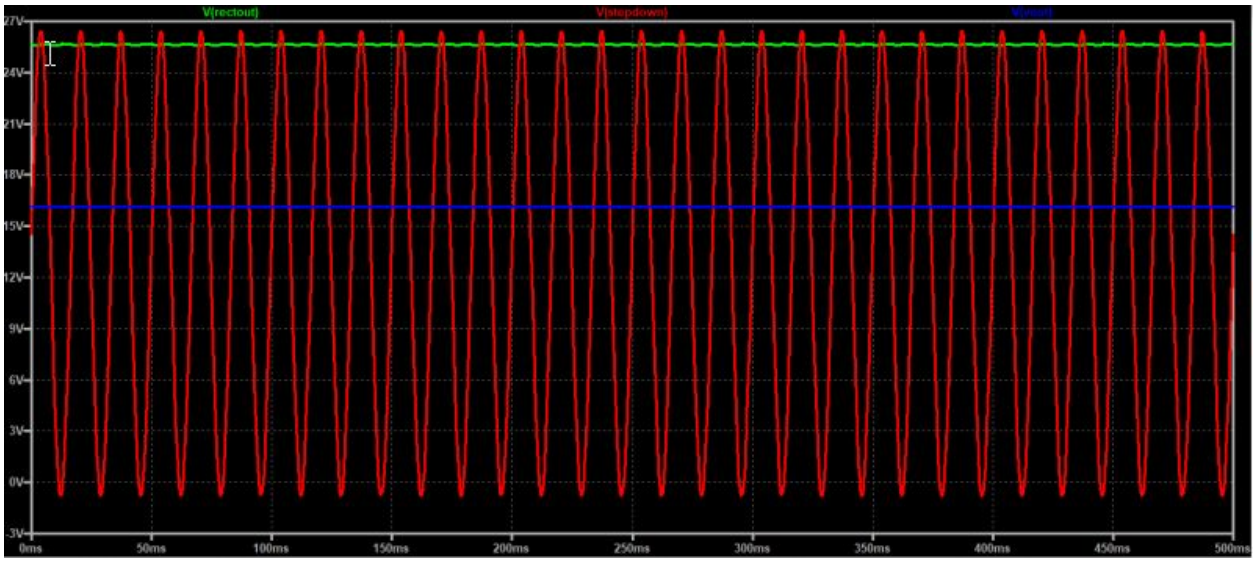

Figure 3: No Load

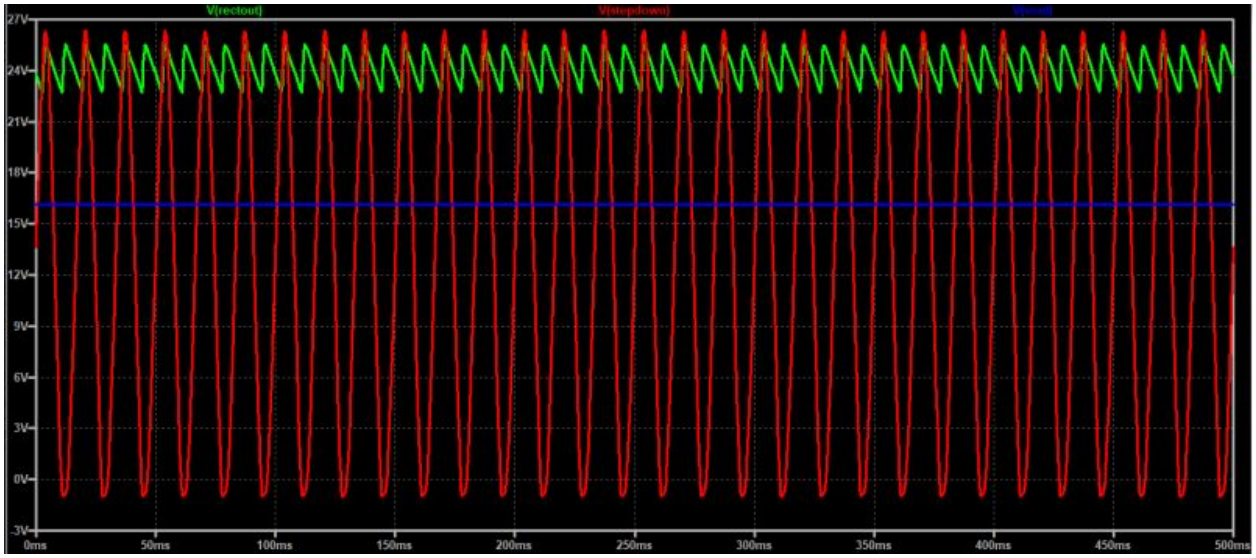

Figure 4: Medium Load

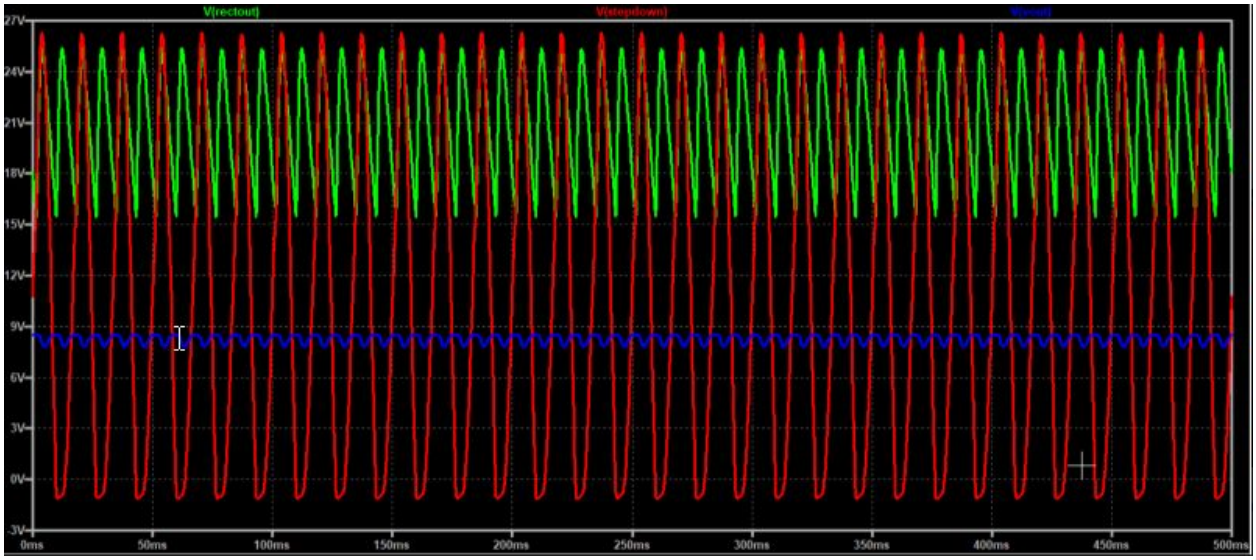

Figure 5: Maximum Load

Figures 3-5 show the load characteristics as current approaches the 1.5A limit. Since the power supply uses a linear topology, under medium loads the power supply has very low voltage ripple behavior. As for the maximum load, the power supply then begins to fail and loses a reliable 16V output. The purpose of the visual current warning system helps prevent this from happening.

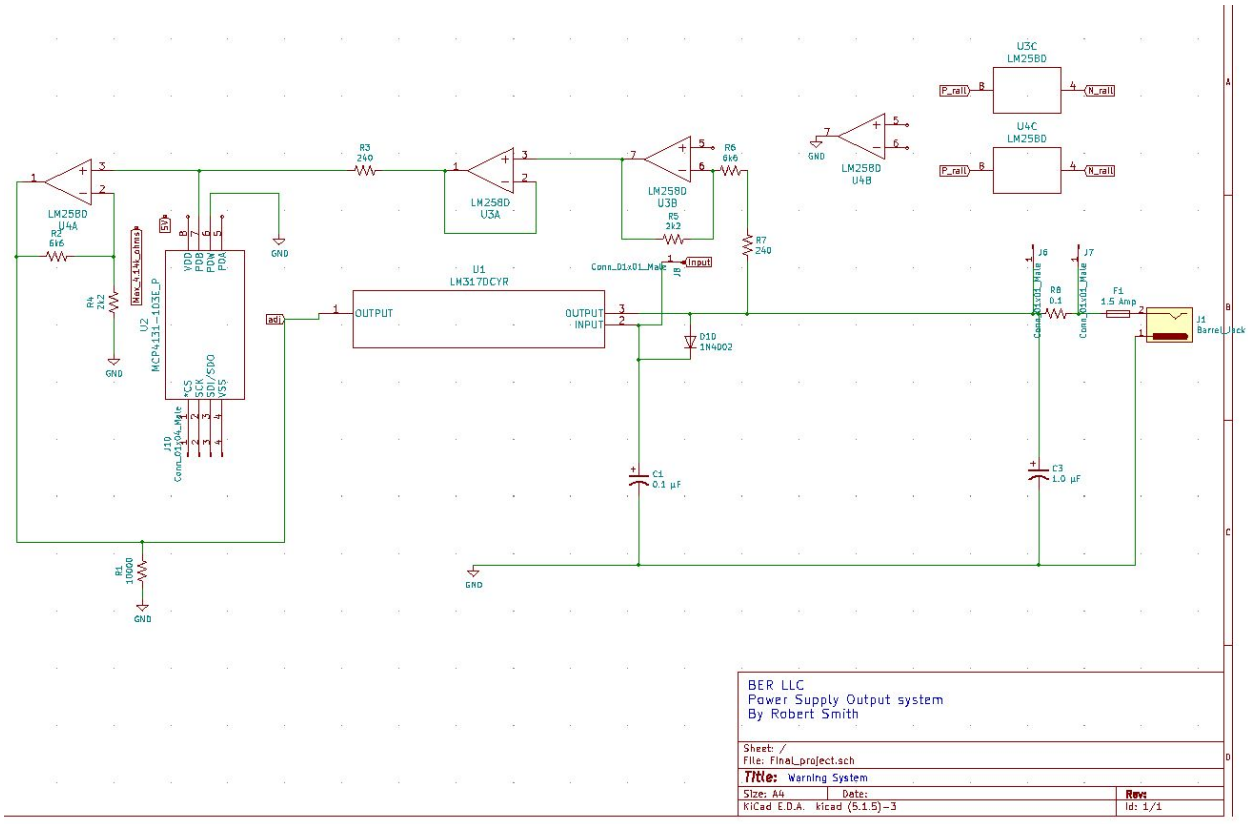

Figure 6: Output schematic

The output takes in a 16 volt DC signal and outputs from 2 to 14 volts with a maximum of 1.5 amps. The adjustment pin on the voltage regulator is controlled through an SPI settable digital potentiometer. The digi-pot takes in an 8-bit value to choose a resistance between 0 and 5 K ohms. To use the digi-pot, a ⅓ amplifier is used to drop the voltage before the voltage divider and then amplified with a 3 times amplifier after to be sent to the adjustment pin of the regulator.

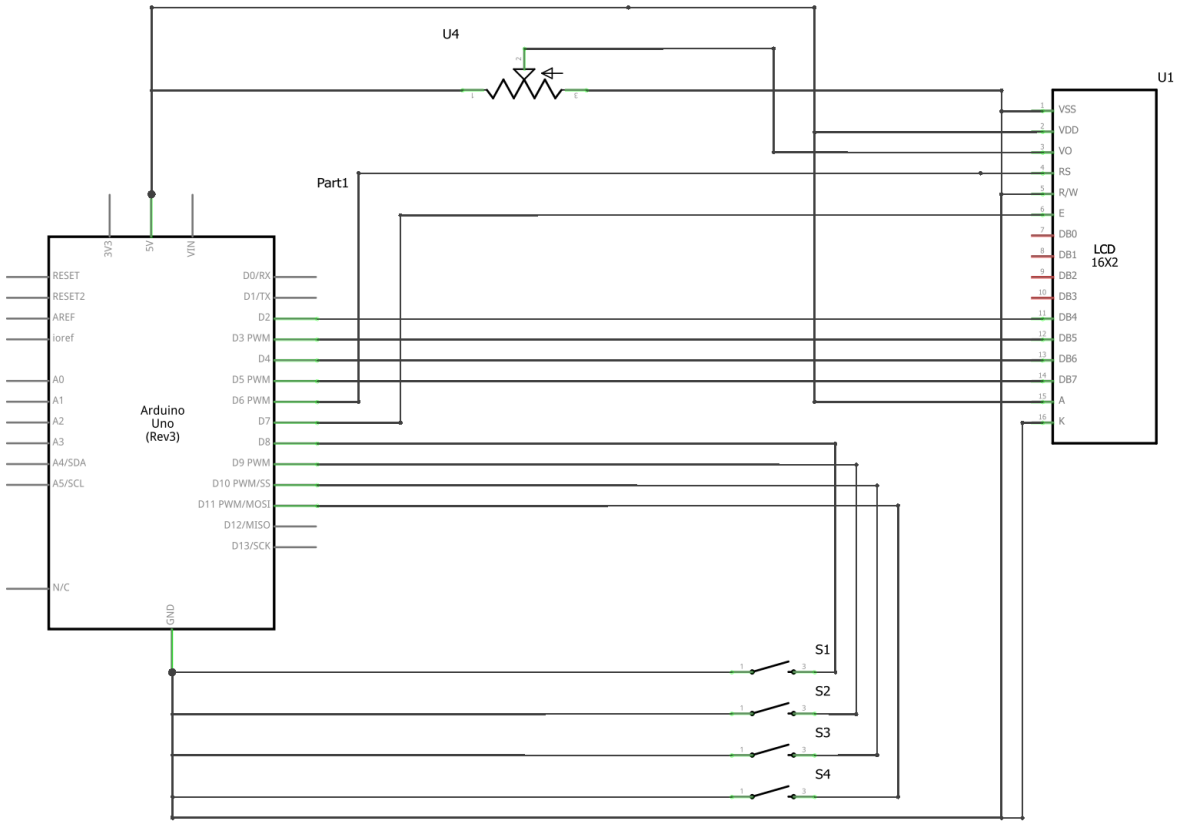

Figure 7: LCD-Control interface

The LCD display takes in 5v for the VDD and to power the Back light. The 10k Ohm potentiometer is set to 2.4k Ohms for best contrast on the LCD display. Data is sent from the arduino to the LCD using a 4-bit signal. The buttons are connected to digitals pins and ground. The buttons are set initially low and set high whenever the buttons are pressed. The buttons are used to change the voltages displayed on the LCD screen or change the state of the safety lock.

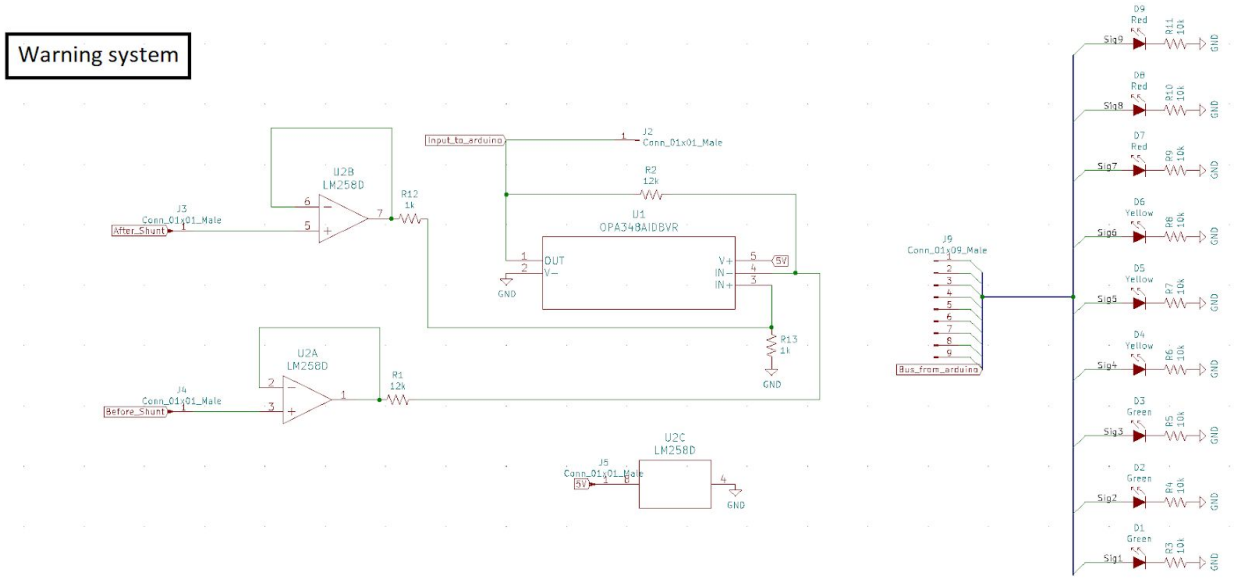

Figure 8: Warning system schematic

The warning system takes a reading across a shunt resistor from the output block and determines the current through the output. Then the arduino lights up the LEDs based on how close the output is to the 1.5 amps limit. When all nine LEDs are lit up, the internal fuse is close to blowing on the output block.

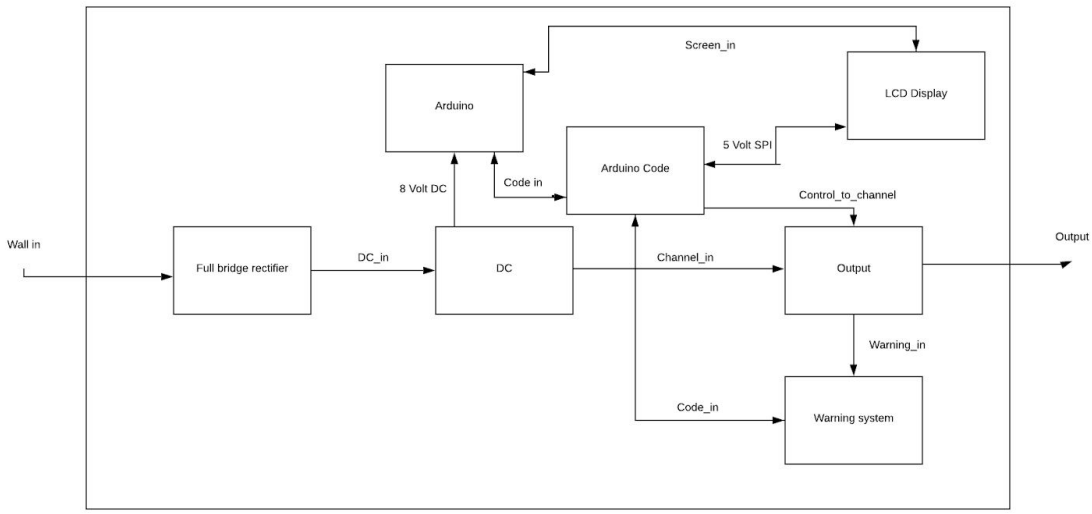

Figure 9: Block diagram for system

Our power supply takes power from a standard US wall plug (120 volts @ 60 Hz) and outputs 2 to 14 volts at up to 1.5 amps. An arduino controls the LCD display and sets the output voltage by the front panel or connecting a laptop.

PCB:

The PCB is a 106x65 mm board encompassing mostly ports and connections for the LCD control interface. There are two main layers with the ground connections being on one layer and the PWM and power connections on another. The PCB allows for more organized internals when in the enclosure. It gives the wires coming from the PCB more length so the LCD screen and buttons can be placed in the correct spots.

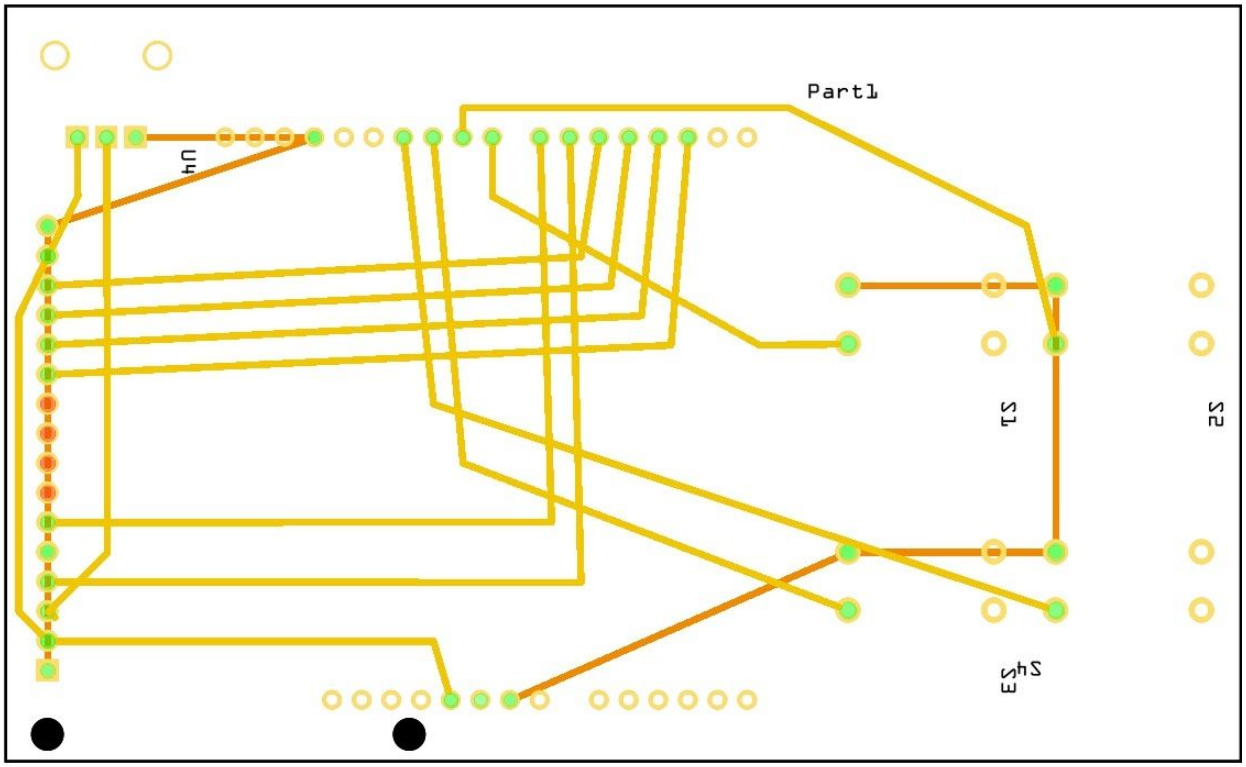

Figure 10: PCB layout

Part Information:

	A	B	C	D	E	F	G	H	I	J	K	L
1	Output circuit											
2	Part Name	Reference	Manufacturer Part Number	Qty	Description	Foot Print						
3	Resistor	R3 - R11	RC0603JR-0710KL	9	10k 0603	,0603						
4	Resistor	R12, R13	RC0603JR-071KL	2	1k 0603	,0603						
5	Resistor	R1, R2	CRCW020112K0FKED	2	12k 0201	,0201						
6	LED	D1, D2, D3	151031VS06000	3	Green LED	TH 3mm						
7	LED	D4, D5, D6	151031YS05900	3	Yellow LED	TH 3mm						
8	LED	D7, D8, D9	C5SMF-RJF-CT0W0BB1	3	Red LED	TH 5mm						
9	Op amp	U1	OPA348AIDBVR	1	OPA348IDBVR	8pin DIP						
10	Op amp	U2	LM258D	1	LM258D	8pin DIP						
11	Op amp	U3, U4	LM258DR	2	Dual op amp	8-SOIC (0.154", 3.90mm Width)						
12	Digital potentiometer	U2	MCP4151T-502E/MS	1	0-5k 257 steps	8-TSSOP, 8-MSOP (0.118", 3.00mm Width)						
13	Fuse	F1	SST 1.5	1	1.5A	0.240" L x 0.100" W x 0.100" H (6.10mm x 2.54mm x 2.54mm)						
14	Jack	J1	PJ-075CH-SMT-TR	1	Barrel Jack	1.00mm ID (0.039"), 3.40mm OD (0.134")						
15	Diode	D1	1N4002G	1	General diode	Through hole						
16												
17	Warning System											
18	Resistor	R3 - R11	RC0603JR-0710KL	9	10k 0603	,0603						
19	Resistor	R12, R13	RC0603JR-071KL	2	1k 0603	,0603						
20	Resistor	R1, R2	CRCW020112K0FKED	2	12k 0201	,0201						
21	LED	D1, D2, D3	151031VS06000	3	Green LED	TH 3mm						
22	LED	D4, D5, D6	151031YS05900	3	Yellow LED	TH 3mm						
23	LED	D7, D8, D9	C5SMF-RJF-CT0W0BB1	3	Red LED	TH 5mm						
24	Op amp	U1	OPA348AIDBVR	1	OPA348IDBVR	8pin DIP						
25	Op amp	U2	LM258D	1	LM258D	8pin DIP						
26												
27	Full Bridge Rectifier											
28	Component	Description	Part	Refrence	Value	Footprint	Quantity	MPN				
29	1	Transformer	T	T1	6:1	Hand soldern	1	FS20-120-C2				
30	2	Diode	D	D1-D5	N/A	Hand soldern	4	1N4007				
31	3	Resistor	R	R1	220 ohm	Hand soldern	1	oo resistor kits				
32	4	Resistor	R	R2	2.5k ohm	Hand soldern	1	oo resistor kits				
33	5	Voltage Reg	U	U1	N/A	Hand soldern	1	LM317T				
34	6	Polarized Capacitor	C	C1	470uF	Hand soldern	1	5938-1044773				
35	7	Polarized Capacitor	C	C2	100uF	Hand soldern	1	5938-1044773				
36	8	Polarized Capacitor	C	C3	10uF	Hand soldern	1	5938-1044774				
37	9	Fuse w/fuseholder	F	F1	5A	Cartridge/Hand soldern	1	F2395				
38								Total:				
39	LCD Display											
40	Component	Description	Part	Referenc	Value	Quantity	Datasheet					
41	1	Microcontroller	Arduino Uno Clone	Part 1	ATMEGA328p	1	https://eecs.oregonstate.edu/education/inventory_datasheets/P1468522442.pdf					
42	2	16x2 LCD Scren	LCD Display	U1	Qapass 1602A	1	https://resi.store/datasheets/16x2lcd.pdf					
43	3	Contrast Knob	Potentiometer	U4	10k Ohm	1	https://resi.store/datasheets/linearpot.pdf					
44	4	Menu Buttons	Tactile SPST Switchj	S1-S4	KSMC6	4	https://resi.store/datasheets/spst.pdf					
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