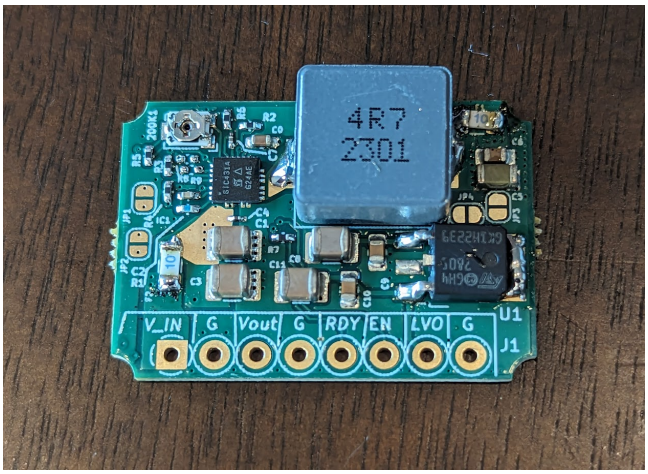
HAPTIC SOLUTIONS

Micro PSU V0.0

Open Source For Non-Commercial Use
https://github.com/Haptic-Solutions/MicroPSU

Dual output adjustable power supply based off of the SIC431 chip for high current output in a very small form factor and end-user choice of linear side regulator for low ripple output or standby power.



Applications:

- Robotics.
- Portable and wearable electronics.
- Low or high power applications.
- Battery powered electronics.
- Custom built small compute devices.

Features:

- Dual output, switching and linear.
- SIC431 based switching side.
- End-user choice of linear regulator.
- Tuneable or programmable switching side voltage output via potentiometer or bypass jumper.
- Daisy-chain or fully separate supply to linear regulator configured by solderable jumpers.
- Enable/Disable pin for switching side with optional pull up/down resistor pads.
- VReady pin from switching side for sensitive electronics.

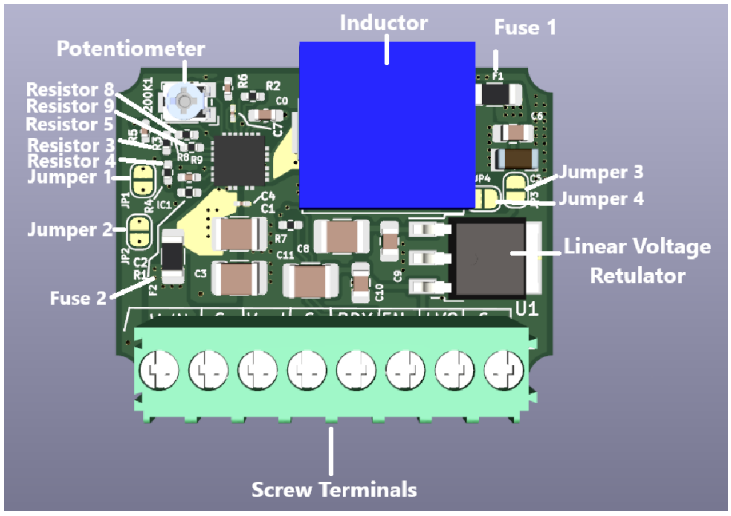
Warning: Higher Amperage draw will cause the board to reach temperatures not suitable for direct skin contact. An enclosure to prevent direct contact and a heatsink with sufficient cooling air should be used to reduce working temperature.

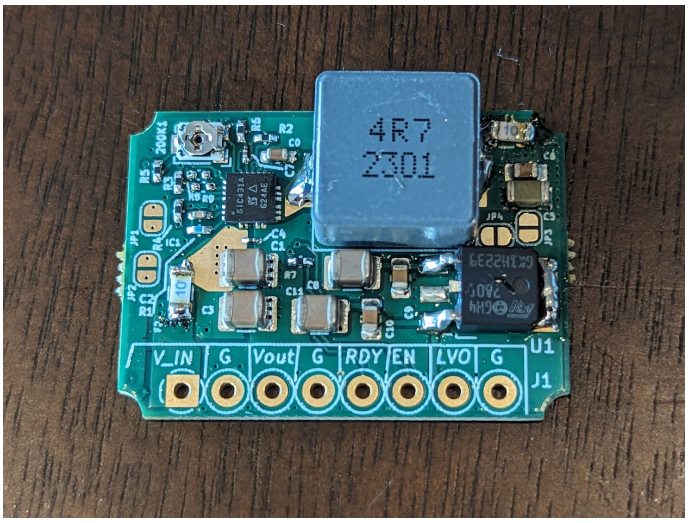
Important Notes: This kit is recommended for those who are comfortable with soldering as some assembly is required. It is also recommended to have a basic electronics understanding.
Make sure to read the document carefully as this product is not plug and play.
Make sure to use the correct wire gauge for the power you are drawing.

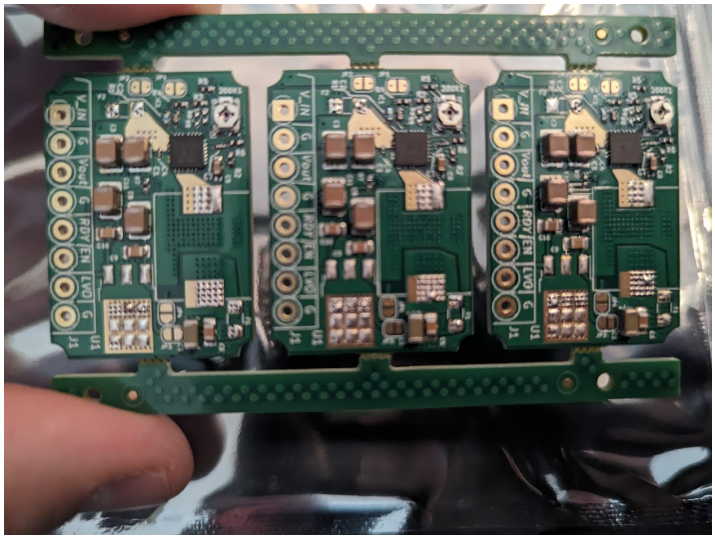
Contact: Please feel free to reach-out with comments, questions, and suggestions!
Our team would love to keep developing the board to make improvements over time in future versions and variants. This document is a living document and may be updated over time.
peter@hapticsol.com

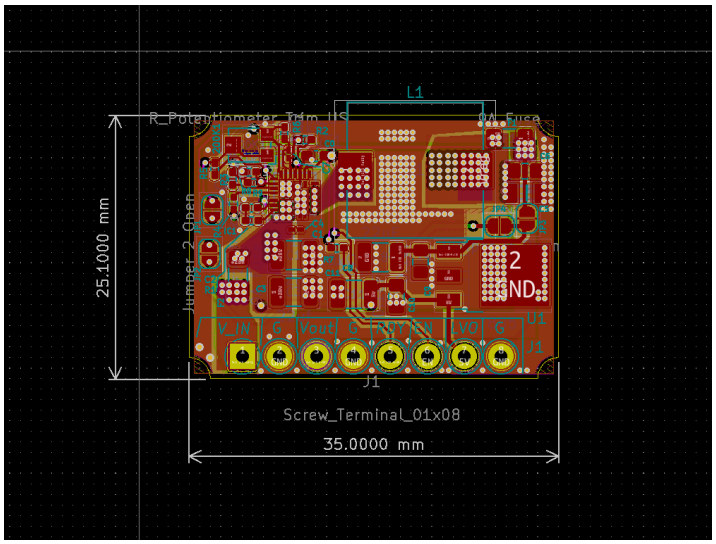
Index

1.0 Micro PSU Board Layout









- **Potentiometer** - Switching side voltage adjust.
- **Inductor (Not Populated)**- A 4.7 uH Inductor (included in kit). An inductor is required for the switching side of the Micro PSU to operate. However, we have left it unpopulated as the end user may wish to pick a different inductor value.
- **Fuse 1** - 10 Amp C1H10 for output of Micro PSU.
- **Fuse 2** - 10 Amp C1H10 for input of Micro PSU.
- **Resistor 3** - Mode 2 resistor. Pulled high for 6 ms start time. Resistor value chosen for 30% of 32 Amps Current Limit (~9.6A) (SIC431 output max is 24 Amps even though 32 Amps is used in calculation). This resistor could be replaced for a higher or lower current limit. This is not recommended and we are not responsible for any damage that may occur:
    - 51k 30%
    - 100k 54%
    - 200k 78%
    - 499K 100%

- **Resistor 4** - Mode 1 resistor. Resistor value chosen for output frequency of 300 kHz. Values chosen for 11.1 volts out with 20 volts in at 8 amps out with included inductor. Setting the frequency too high or too low will reduce efficiency and could overheat the board.
    - 51k 300kHz
    - 100k 500kHz
    - 200k 760kHz
    - 499k 1000kHz
- **Resistor 5** - If potentiometer bypass Jumper 1 is bridged, the value of this resistor sets a fixed output voltage from the SIC431. Recommend a value between 0 and 200K ohms.
- **Resistor 8** (Not Populated) Populating a 10K ohm resistor (included) here will set the board to be off by default.
- **Resistor 9** (Note Populated) Populating a 10K ohm resistor (included) here will set the board to be on by default.
  -Note: Only one resistor should be populated. Leaving both unpopulated or populating both will result in undefined behavior.
- **Jumper 1** - 200k ohm potentiometer bypass for fixed output voltage from the SIC431. In this case Resistor 5 value should be changed to the preferred value for the required voltage output.
- **Jumper 2** - Linear supply to SIC431. If using a SIC431 variant that does not have a built-in 5 volt supply for itself, this jumper may be bridged to use the linear side (with a 5v linear regulator) to power the SIC431. Jumper 4 (Power into linear regulator) would need to be closed and Jumper 3 (Switching supply into linear regulator) should be left open.
- **Jumper 3** Switching output to Linear input select.
- **Jumper 4** Power input to Linear input select.
  With Jumper 3 closed and Jumper 4 open, the linear regulator is powered by the switching linear for daisy-chain operation. This is ideal for situations where a higher current is requested from the linear side but the supply voltage is too high for the linear regulator to safely dissipate heat. This allows the switching regulator to drop the voltage down before the linear regulator so that the voltage drop across the linear regulator will be lower.
  -Note: Only one jumper shall be closed or damage may occur to the power supply and any circuits connected. Bridging both connections will cause FULL supply voltage on the switching supply output.
- **Linear Voltage Regulator (Left unpopulated)** - An L7805 is included in the kit. Other linear regulators with matching pinouts may be used such as a 3.3 volt regulator. (Board designed for 1.23 Amps). See Jumper 3 and 4 for more information.

- **Screw Terminal (Not Populated)** - A screw terminal is included in the kit if the user wishes to use it. Can be mounted on the top or bottom of the board. Alternatively wires can be soldered directly to the PCB instead.
    - **V_IN** - Supply voltage input to the Micro PSU
        - Minimum Input Voltage 3.7 volts. (SIC431 limited)
        - Maximum Input Voltage 24 volts, or max of linear regulator chosen. Whichever is lower.
    - **G** - Ground connections.
    - **Vout** - Output of the variable switching regulator (SIC431).
    - **RDY**- Power good signal output.
      -Note: If V_IN is from 3.7 volts to 5 volts, RDY will output a voltage slightly less than the input voltage if the input voltage is at or greater than the requested output voltage for Vout. If V_In is from 5 volts to 24 volts, RDY will output 5 volts if the voltage in is greater than the requested output voltage for Vout.
    - **Enable**- Used to turn on or off the switching supply side of the Micro PSU. Please see info on Resistor 8 and 9.
    - **LVO**- Output of the linear voltage regulator.

2.0 Operating Parameters

V_In Min Voltage In	3.7 Volts (SIC431)
V_In Max Voltage In	24 Volts (SIC431)
V_In Max Current In	10 Amps
Vout Max Voltage Out	~ 13 volts
Vout Min Voltage Out	1.2 volts
Vout Recommended Max Current Draw	8 Amps (Limited by config resistors. Auto shutdown at 9.6Amps)
Vout Soft Current Dropout	Just over 9.6 Amps
Vout Max Fused Current Draw	10 Amps
LVO Voltage Out	Linear Regulator Dependent.
LVO Current Out Linear Side Max	1.23 Amps limited by trace width or selected Linear Regulator and its input voltage.
Enable Input Voltage Max	24 Volts
Enable Input Voltage Min	3.7 Volts
RDY Logic Level	If V_IN is from 3.7 volts to 5 volts, RDY will output a voltage slightly less than the input voltage if the input voltage is at or greater than the requested output voltage on Vout. If V_In is from 5 volts to 24 volts, RDY will output 5 volts if the voltage in is greater than the requested output voltage.
Thermal Cutoff	120°C or 248°F
Recommended Wire Guage	20 Gauge or higher at max current.
Board Length	35 mm
Board Width	25.1mm + 1-2mm with inductor.

3.0 Testing

3.1 Burn In

The first test that was performed was running the Micro PSU for 24 hours at max current output of 8 amps and switching output voltage set to 10 volts. The voltage drop measured at the programmable load was around 9 volts.

Equipment

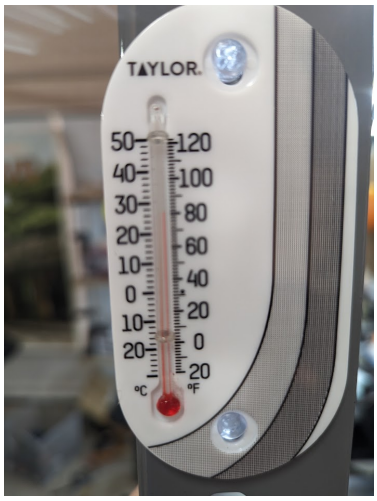
- Alitove DC 24V 15A 360W Power Supply, like would be used in a 3D printer.
- An HP6060A Programmable Load.
- A thermal camera was used to observe temperature on various parts of the board.

Parameters

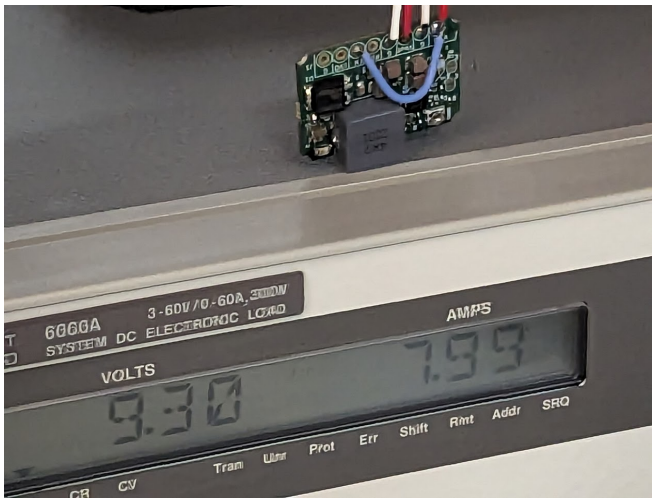
- Input Voltage: 20 Volts (tuned down with trim on PSU)
- Output Voltage: 10 Volts
- Current Draw: ~8 Amps
- Ambient Temperature around: 26.7°C or 80°F as measured by an alcohol thermometer
- Heatsinks: Two 8mm x 8mm x 5mm heat-sinks placed beneath SIC431 and the 4.7 uH Inductor.
- 20 gauge solid core wire for connections.

Results

- We observed a voltage drop of .7 Volts.
- The temperature of the board was at 94.4°C or 201.92°F
- The Hottest points observed were the Inductor and the SIC431



Temperature in Garage



Observed Output Voltage and Current Draw

Front of Board observed through Thermal Camera

Back of Board observed through Thermal Camera

Jarret testing board

Heatsinks on back of Micro PSU

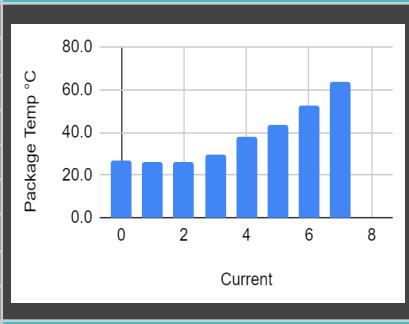
3.2 Testing Various Input and Output Voltages.

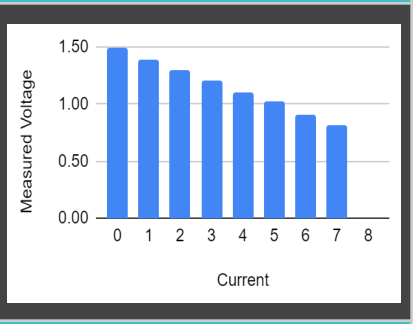
Methodology

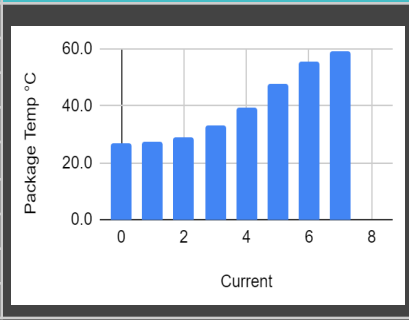
For this testing a OWON SPE6103 Programmable Lab Power Supply (0-60V 0-10A) rated for 300w was used. The power supply would be tuned to a specified input voltage, the Micro PSU would be tuned to the required output voltage. Then the programmable load would be set to increasingly higher loads every five minutes in order to take the package temperature of the SIC431, and a piece of cardboard for ambient, with a CEN-TECH Infrared Thermometer ITEM 60725. This testing was repeated for the whole range of required input and output voltages.

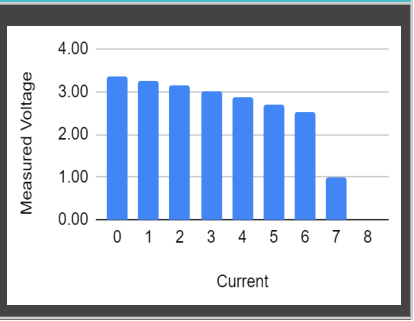
Results

Input Voltage	**3.7 Volts**	V Out No Load:	1.2-3.51 Volts
Output Voltage	1.5		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	26.8	24.1	1.49
1	26.0	23.9	1.39
2	26.3	24.1	1.30
3	29.3	23.0	1.20
4	37.6	24.1	1.10
5	43.6	24.6	1.02
6	52.7	23.9	0.91
7	63.6	24.8	0.81
8	OC	OC	OC
Output Voltage	3.3		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	27.0	24.2	3.34
1	27.2	24.1	3.24
2	28.7	23.9	3.16
3	33.1	23.5	3.01
4	39.2	24.1	2.86
5	47.7	24.1	2.70
6	55.6	23.5	2.53
7	59.0	23.7	1.00
8	OC	OC	OC

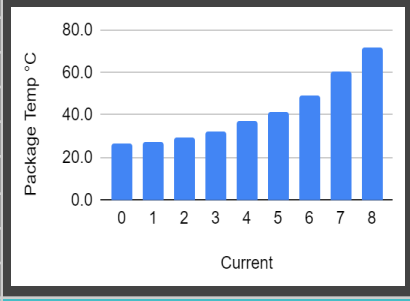


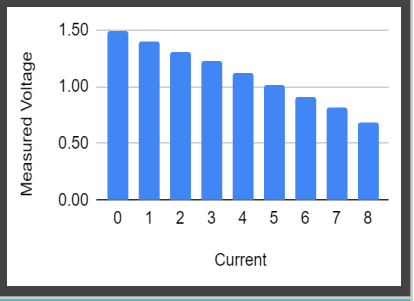




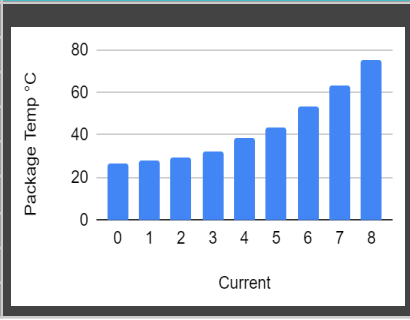


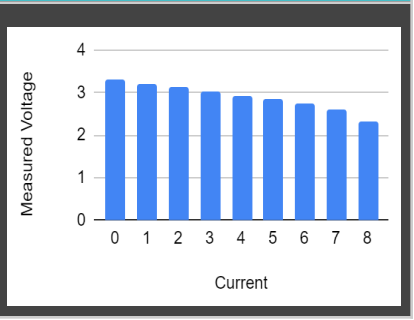
Input Voltage	**5 Volts**	V Out No Load:	1.2-4.66 Volts
Output Voltage	1.5		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	26.3	24.2	1.49
1	27.2	24.2	1.40
2	29.3	24.2	1.30
3	32.0	23.9	1.22
4	37.1	24.1	1.12
5	41.2	24.1	1.02
6	49.5	23.9	0.91
7	60.4	24.4	0.81
8	71.8	24.1	0.69



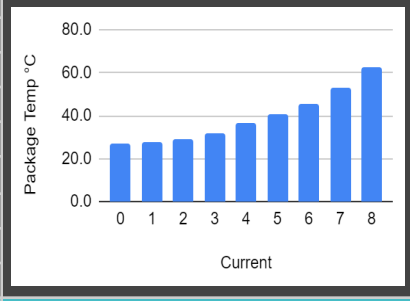


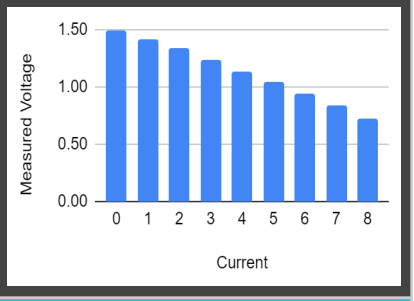
Output Voltage	3.3		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	26.8	24.7	3.31
1	27.9	24.1	3.21
2	29.3	23.5	3.13
3	32.5	23.7	3.01
4	38.5	23.3	2.93
5	43.7	23.5	2.83
6	53.5	23.3	2.73
7	63.6	24.1	2.61
8	75.6	24.1	2.32



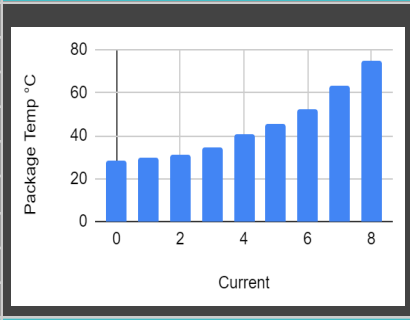


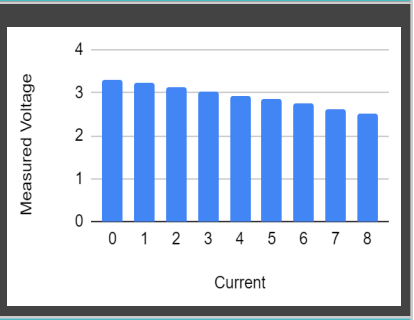
Input Voltage	**9 Volts**	V Out No Load:	1.2-8.35 Volts
Output Voltage	1.5		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	26.8	25.0	1.50
1	27.4	25.0	1.42
2	29.3	24.8	1.34
3	32.0	24.8	1.24
4	36.7	24.8	1.14
5	40.9	24.8	1.04
6	45.4	25.3	0.94
7	52.8	24.6	0.84
8	62.5	23.7	0.72



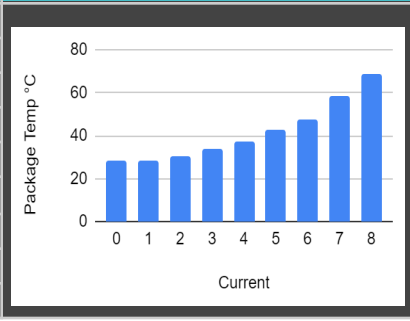


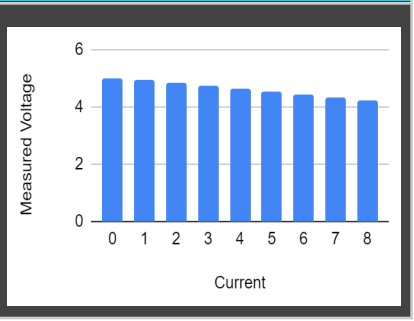
Output Voltage	3.3		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	28.7	24.2	3.31
1	29.6	24.2	3.23
2	31.3	23.9	3.13
3	34.3	23.7	3.03
4	40.7	23.9	2.93
5	45.4	23.9	2.85
6	52.2	23.7	2.74
7	63.1	24.8	2.63
8	74.6	24.1	2.51



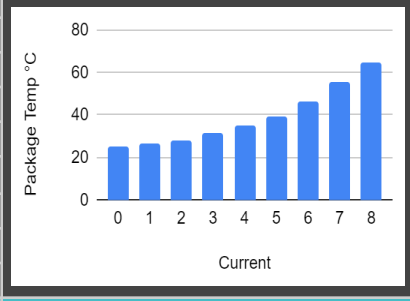


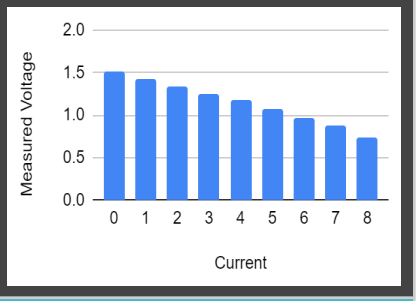
Output Voltage	5		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	28.7	23.3	5.02
1	28.7	23.7	4.94
2	30.3	24.1	4.85
3	33.6	23.7	4.75
4	37.1	23.9	4.66
5	42.4	24.1	4.56
6	47.6	24.2	4.46
7	58.3	24.8	4.34
8	68.4	24.2	4.22



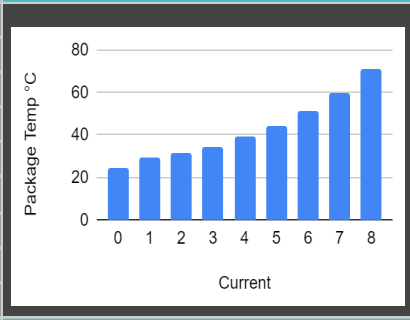


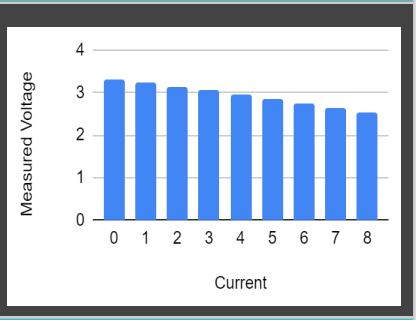
Input Voltage	**12 Volts**	V Out No Load:	1.2-11.13 Volts
Output Voltage	1.5		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	25.3	23.7	1.52
1	26.7	23.7	1.42
2	28.2	23.3	1.34
3	31.5	23.5	1.24
4	34.8	23.0	1.17
5	39.5	23.0	1.07
6	46.6	23.5	0.97
7	55.4	23.9	0.87
8	64.4	23.5	0.74



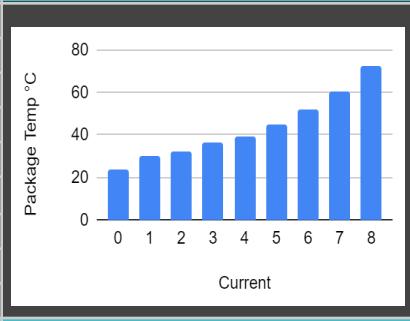


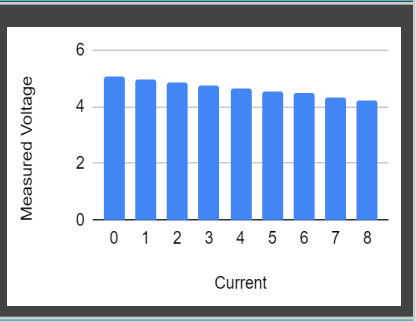
Output Voltage	3.3		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	24.4	23.5	3.31
1	29.3	23.5	3.23
2	31.3	23.3	3.13
3	34.3	23.3	3.05
4	39.5	23.7	2.95
5	44.3	24.1	2.85
6	51.2	23.5	2.75
7	59.7	23.7	2.65
8	70.8	23.3	2.53



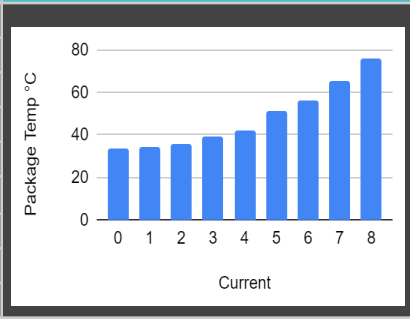


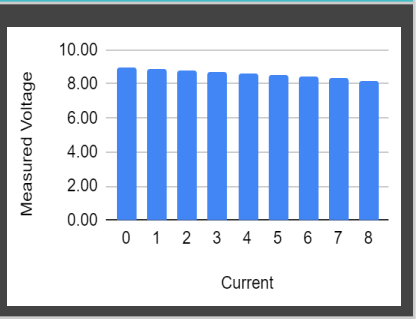
Output Voltage	5		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	24.1	24.1	5.04
1	29.8	24.8	4.94
2	32.5	24.6	4.85
3	36.2	24.8	4.75
4	39.5	24.8	4.66
5	45.2	24.8	4.56
6	51.7	24.6	4.46
7	60.8	24.6	4.34
8	72.3	24.8	4.22



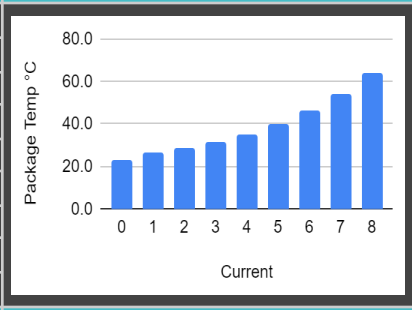


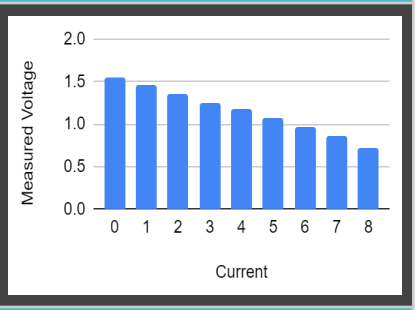
Output Voltage	9		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	33.5	25.1	9.00
1	34.5	24.8	8.90
2	35.9	24.6	8.82
3	39.0	24.8	8.74
4	42.4	24.8	8.64
5	51.2	24.6	8.54
6	55.9	24.8	8.44
7	65.2	25.3	8.32
8	76.1	25.6	8.21



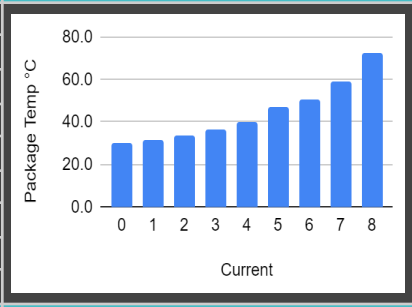


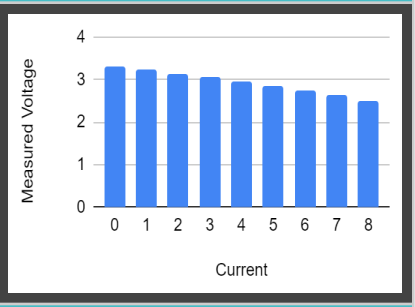
Input Voltage	**15 Volts**	V Out No Load:	1.2-13.1 Volts
Output Voltage	1.5		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	23.0	23.2	1.54
1	26.3	23.3	1.45
2	28.6	23.3	1.35
3	31.6	23.3	1.25
4	35.0	23.7	1.17
5	40.3	23.2	1.07
6	46.4	23.2	0.97
7	54.4	23.5	0.86
8	63.9	23.7	0.72



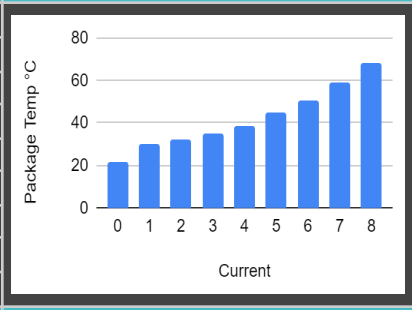


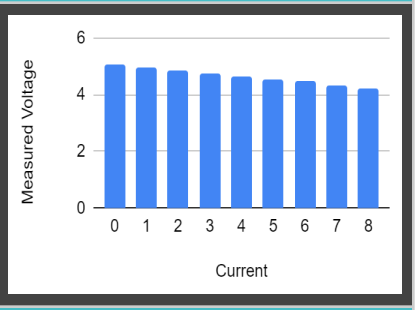
Output Voltage	3.3		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	30.3	24.4	3.31
1	31.8	24.8	3.23
2	33.5	24.8	3.13
3	36.7	25.0	3.05
4	40.0	25.0	2.95
5	47.0	25.1	2.85
6	50.8	25.0	2.75
7	58.8	24.2	2.65
8	72.3	25.3	2.51



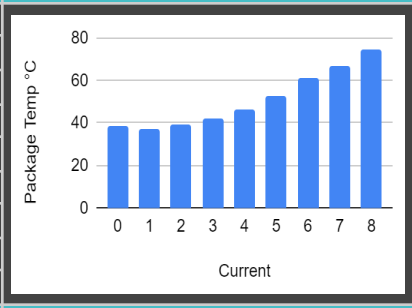


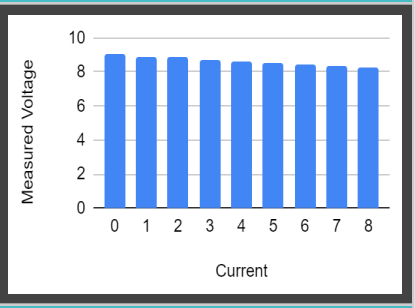
Output Voltage	5		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	21.7	21.7	5.04
1	29.8	21.9	4.94
2	32.5	22.5	4.84
3	35.4	22.5	4.75
4	38.5	22.5	4.66
5	44.8	22.5	4.56
6	50.4	22.8	4.46
7	59.4	23.3	4.34
8	68.3	23.0	4.22



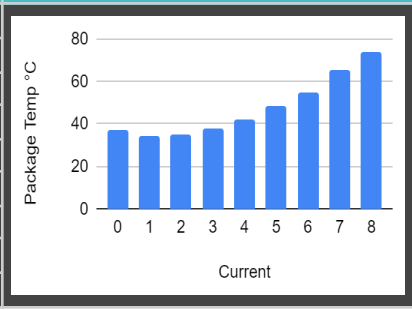


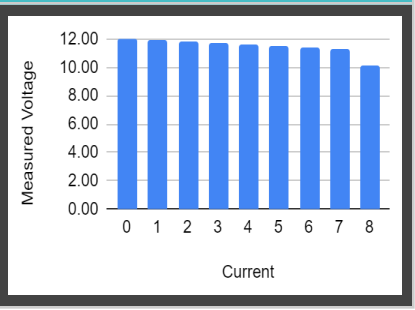
Output Voltage	9		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	38.5	21.6	9.02
1	37.1	21.6	8.92
2	39.3	22.3	8.84
3	41.8	22.5	8.74
4	46.4	22.5	8.65
5	52.7	22.3	8.55
6	61.4	22.1	8.45
7	67.0	22.3	8.34
8	74.3	22.6	8.22



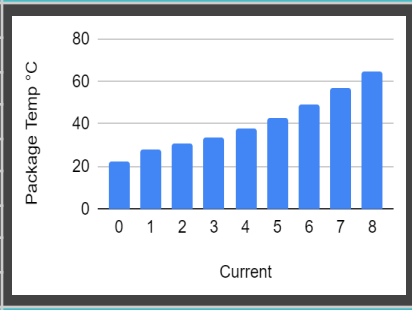


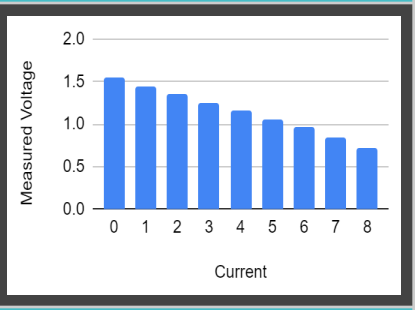
Output Voltage	12		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	37.3	23.2	12.00
1	34.3	22.5	11.92
2	35.3	22.8	11.81
3	38.1	22.1	11.72
4	42.2	22.1	11.62
5	48.5	22.6	11.52
6	55.1	22.6	11.42
7	65.3	22.8	11.31
8	74.0	22.6	10.11



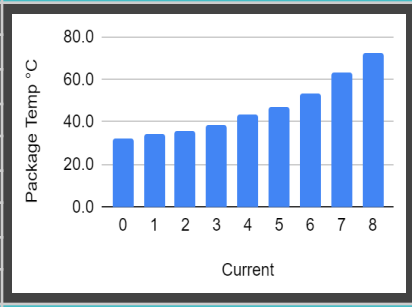


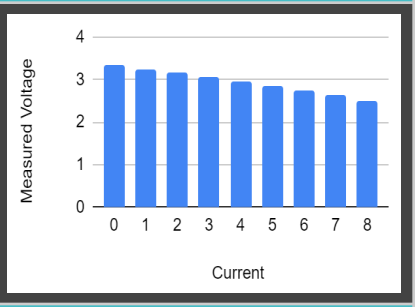
Input Voltage	**20 Volts**	V Out No Load:	1.2-13.13 Volts
Output Voltage	1.5		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	22.6	22.3	1.54
1	28.1	22.8	1.44
2	30.8	22.8	1.35
3	33.3	23.5	1.25
4	37.6	23.5	1.15
5	42.7	24.1	1.05
6	49.4	23.9	0.96
7	56.8	23.9	0.84
8	64.4	23.5	0.72



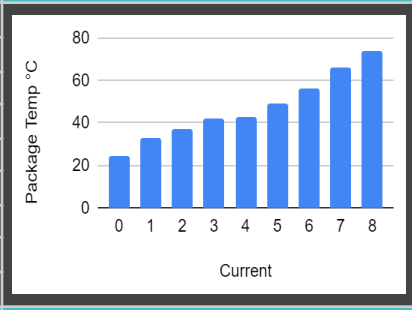


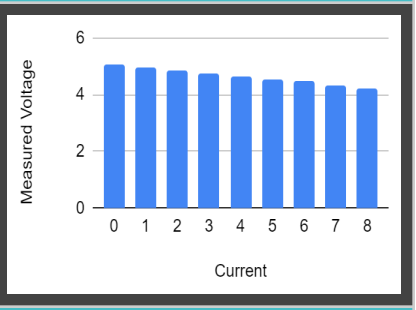
Output Voltage	3.3		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	32.0	25.3	3.33
1	34.1	25.3	3.23
2	36.0	25.0	3.15
3	38.7	24.8	3.05
4	43.3	24.4	2.95
5	47.2	23.9	2.85
6	53.7	24.2	2.75
7	63.6	24.8	2.65
8	72.5	25.5	2.51



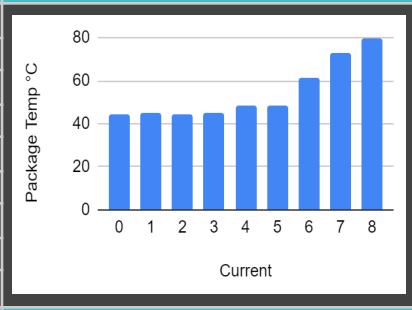


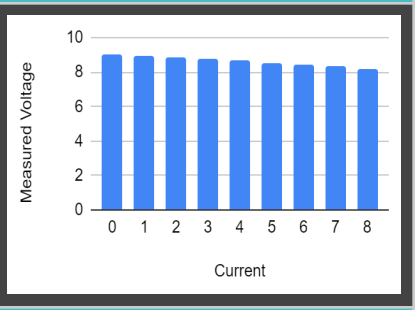
Output Voltage	5		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	24.6	23.7	5.04
1	33.0	23.7	4.94
2	37.5	23.7	4.85
3	41.8	24.1	4.75
4	42.8	24.1	4.66
5	49.4	24.2	4.56
6	56.3	23.7	4.46
7	66.1	24.4	4.34
8	74.2	24.2	4.24



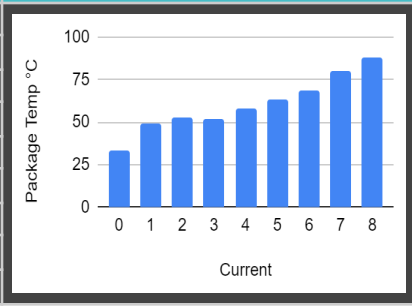


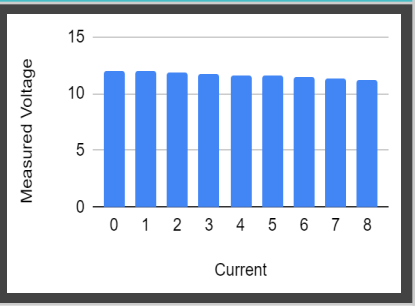
Output Voltage	9		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	44.5	23.9	9.02
1	45.2	23.9	8.92
2	44.3	23.2	8.84
3	45.0	23.7	8.75
4	48.6	23.2	8.65
5	48.5	23.2	8.55
6	61.6	23.5	8.45
7	73.0	23.5	8.34
8	79.4	23.3	8.21



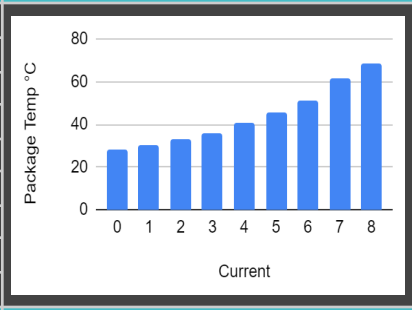


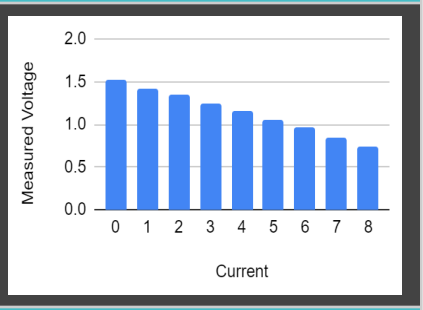
Output Voltage	12		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	33.5	22.6	12.04
1	49.1	22.5	11.94
2	52.5	22.6	11.84
3	51.7	21.6	11.71
4	58.3	22.5	11.61
5	63.6	22.5	11.59
6	68.9	22.5	11.47
7	80.2	23.0	11.37
8	87.6	23.0	11.26

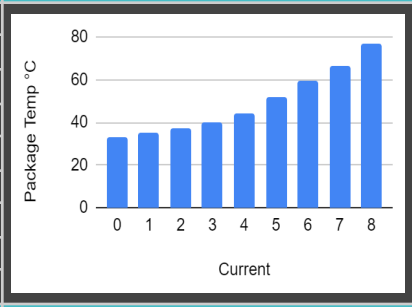


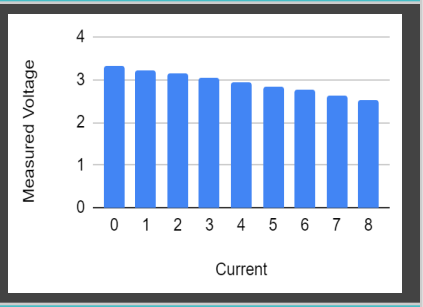


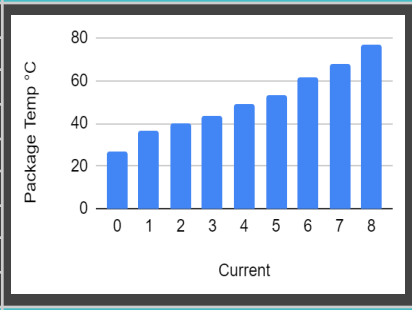
Input Voltage	**24 Volts**	V Out No Load:	1.2-13.25 Volts
Output Voltage	1.5		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	28.1	23.5	1.52
1	30.6	23.9	1.42
2	33.1	24.1	1.34
3	35.6	23.9	1.24
4	40.4	23.9	1.15
5	45.8	24.1	1.05
6	51.4	24.1	0.96
7	61.6	24.2	0.84
8	68.5	23.7	0.74
Output Voltage	3.3		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	33.3	25.1	3.31
1	35.3	24.8	3.23
2	37.5	24.6	3.13
3	40.3	24.4	3.05
4	44.3	24.6	2.95
5	51.8	24.8	2.85
6	59.3	25.0	2.75
7	66.6	24.6	2.63
8	76.9	24.6	2.51
Output Voltage	5		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	26.5	25.1	5.04
1	36.7	25.3	4.94
2	40.3	25.3	4.84
3	43.6	24.6	4.75
4	48.8	25.0	4.66
5	53.4	24.8	4.56
6	61.4	25.1	4.46
7	67.9	25.3	4.36
8	76.8	25.1	4.22
Output Voltage	9		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	43.0	24.1	9.02
1	45.0	24.1	8.94
2	47.0	24.1	8.84
3	51.8	23.7	8.75
4	55.6	23.5	8.64
5	60.0	23.5	8.54
6	67.4	23.5	8.44
7	74.6	23.7	8.32
8	85.3	23.0	8.21
Output Voltage	12		
Current	Package Temp °C	Ambient Temp °C	Output Voltage Measured
0	56.9	22.8	12.15
1	62.9	23.0	12.02
2	60.5	23.3	11.92
3	60.4	23.3	11.82
4	62.4	22.8	11.64
5	64.0	23.0	11.54
6	70.8	23.2	11.44
7	78.8	23.2	11.32
8	88.0	23.0	11.21

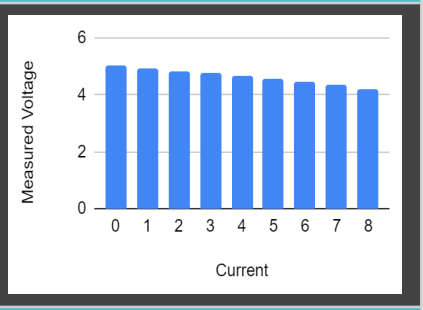


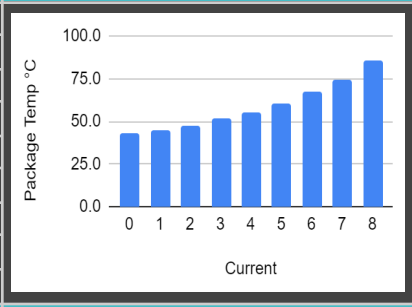


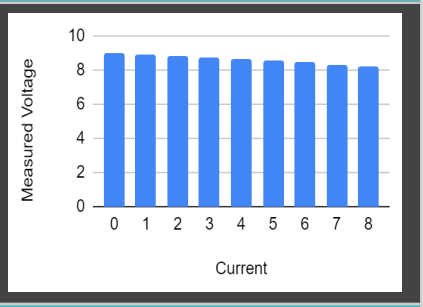


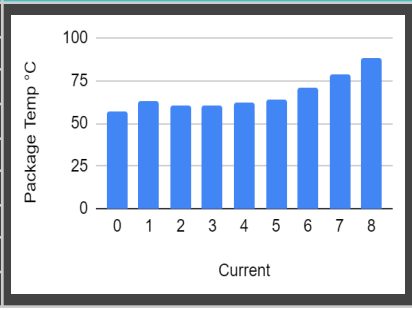


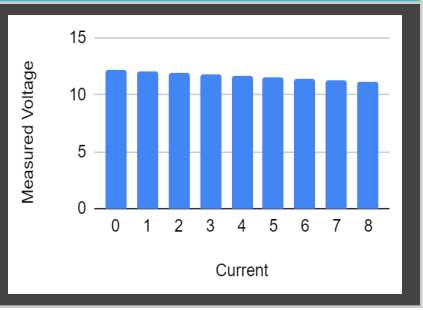




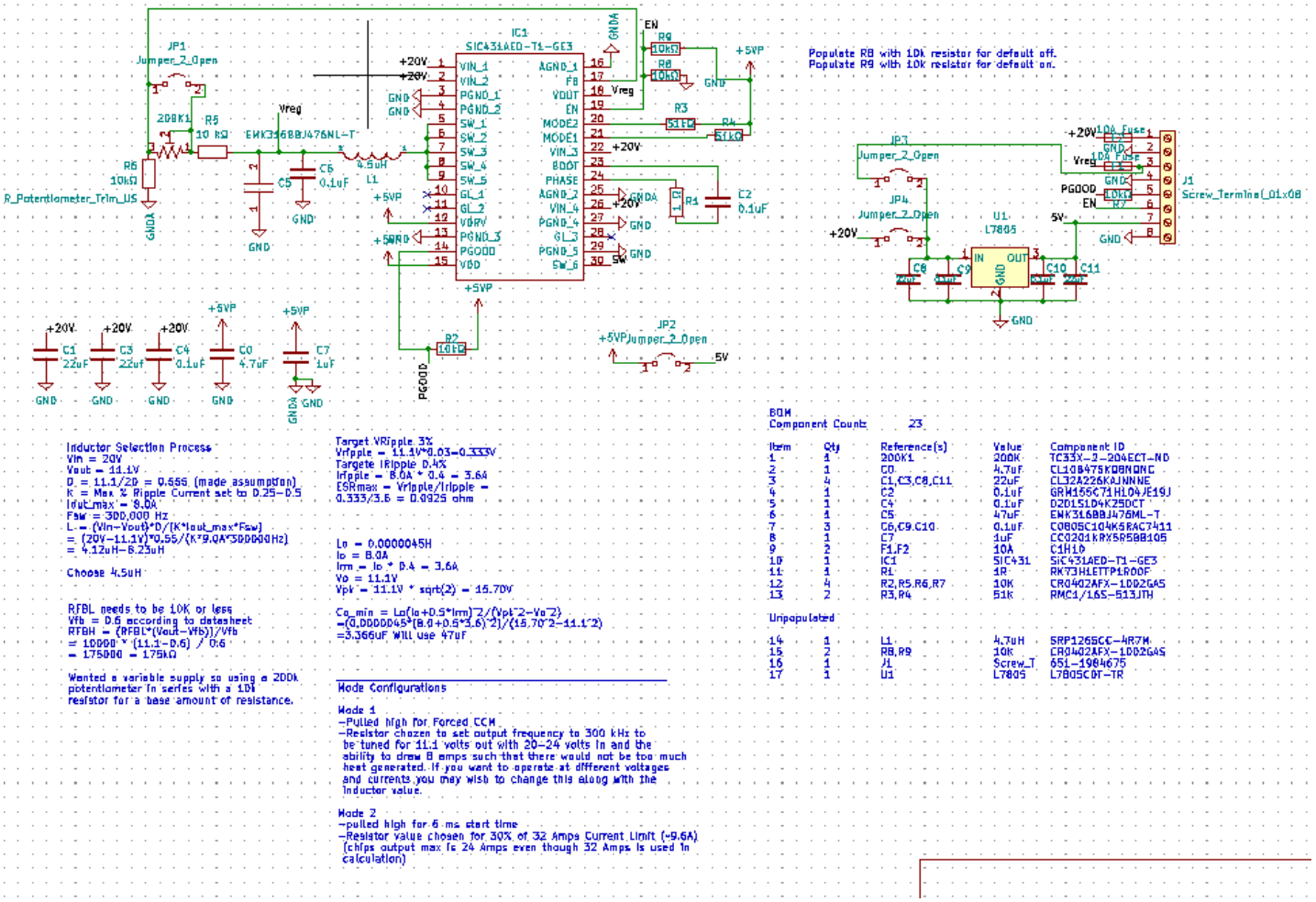








4.0 Circuit Schematic



Circuit diagram of Micro PSU. For better view download the project from Github here:
https://github.com/Haptic-Solutions/MicroPSU

5.0 Credits

Electrical Design by Peter Sasaman
Board Designed by Jarrett Cigainero

Peer Reviewers:
pyr0ball
PeterTheTinker