Design Project:
Test Data

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Linear Power Supply – Parameter Test [2]

Recall the Non-Ideal Voltage Supply and DC Voltage Minimum Equation

$$V_{DC} = V_m - I_L R_O, \qquad V_{DC,\min} = V_m - I_L R_O - \frac{\Delta V_{p-p}}{2}, \qquad \Delta V_{p-p} = \frac{I_L}{2fC}$$

This test finds the values for R_O and $\frac{\Delta V_{p-p}}{I_L}$ to model this power supply.

1. Power the power supply using 12.5 V from the 120/25V CT transformer.
2. Place an Ammeter between the Unregulated Voltage Out of the Power Supply and the load.
3. Use an oscilloscope across the load to measure the average and cursors to measure the peaks.

Table 1: Linear Power Supply - Parameter Test Data

Load [Ω]	Measured I_{out} [mA]	Measured V_{DC}	Calculated R_O	Measured $V_{P(\max)}$	Measured $V_{P(\min)}$	Calculated $\Delta V_{p-p}/I_L$
∞	0	16.27	∞	16.55	15.89	∞
100	162	15.26	5.432	16.14	14.48	0.01024
50	310	14.77	3.742	15.93	13.46	0.00797

Average R_O = 4.437

Average $\Delta V_{p-p}/I_L$ = 0.009107

Notes:	Collaborated with Damon Park, Justin Tan, Data collected by Enze Xu.

Voltage Regulator – Limits Test [2]

This test collects data on the voltage and current limit ranges.

1. Power the Voltage Regulator with $V_{in} = 30$ V.
2. Place a voltmeter across the Voltage Regulator Output and an ammeter at the input.
3. Measure and record $V_{\max}$ and $V_{\min}$ by adjusting the potentiometer. Ensure the voltage regulating LED is on for both limits.
4. Measure the Quiescent current at each limit.
5. Decrease $V_{in} = 10$ V.
6. Replace the voltmeter with an ammeter. This will short the output.
7. Measure and record $I_{\max}$ and $I_{\min}$ by adjusting the potentiometer. Ensure the current regulating LED is on for both limits.

Table 2: Voltage Regulator -Limits Test Data

Measured $\boldsymbol{V}_{\min}$ [V]	Measured $\boldsymbol{V}_{\max}$ [V]	Measured $\boldsymbol{I_{Q@Vmin}}$ [mA]	Measured $\boldsymbol{I_{Q@Vmax}}$ [mA]	Measured $\boldsymbol{I}_{\min}$ [mA]	Measured $\boldsymbol{I}_{\max}$ [mA]
6.85	25.03	19.19	3.60	52.75	57.40

Notes:	Collaborated with Damon Park, Justin Tan, Data collected by Enze Xu.

Voltage Regulator - Voltage Regulation Test [2]

This test validates the operation of voltage regulation at V_{min} under varying input power.

1. Power the Voltage Regulator with $V_{in} = 30$ V.
2. Place one voltmeter across the Voltage Regulator Output and one voltmeter across the input.
3. Set $V_{out} = 15$ V using the potentiometer.
4. Record the voltage output for each voltage input target.

Table 3: Voltage Regulation Test Data at V_{min}

Target V_{in} [V]	Measured V_{in} [V]	Measured V_{out} [V]	Calculated $V_{in} - V_{out}$ [V]
30	30.38	14.98	15.4
27	27.00	14.44	12.89
24	23.96	13.97	10.02
21	20.96	13.47	7.47
18	17.97	12.92	5.06
15	14.90	12.22	2.68
12	11.92	11.03	0.87
9	9.04	8.47	0.54
6	5.97	5.42	0.51
3	3.08	2.64	0.44

Notes:	Collaborated with Damon Park, Justin Tan, Data collected by Enze Xu.

Dynamic Loading Test [4]

WARNING:
Do not let the Voltage Regulator overheat.
Take measurements quickly and turn-off between measurements .

This test validates the operation of the voltage and current regulation with varying load.

1. Power the power supply circuit with the 12.5 V from the 120/25V CT transformer.
2. Power the Voltage Regulator with the unregulated voltage and set V_{Lim}, and I_{Lim}.
3. Add a voltmeter and ammeter to the output along with one oscilloscope probe at the input and another at the output.
4. Record the voltage output, current output, and the input and output ripple.
5. Add two 470 Ω resistors in parallel to the output and repeat step 3.
6. Repeat step 3 and 4 to complete the table.

$$V_{in} = V_{\mathrm{Unreg.}}, \quad V_{Lim} = 10\text{ V}, \quad \mathrm{I_{Lim}} = 200\text{ mA}, \quad R_L = 470\ \Omega \times 16$$

Table 4: Dynamic Loading Test Data

# of parallel 470 Ω	R_L [Ω]	Measured V_{out} [V]	Measured I_{out} [A]	Measured $\Delta V_{in(p-p)}$ [V]	Measured $\Delta V_{out(p-p)}$[V]
0	∞	10.0	0	0.805	0.615
2	235	9.60	.040	1.007	0.823
4	117.5	9.33	.072	1.410	0.823
6	78.3	9.09	.110	1.410	0.823
8	58.8	9.37	.154	1.812	0.823
10	47	8.48	.180	1.811	0.823
12	39.2	7.24	.183	1.813	0.823
14	33.6	6.29	.187	2.018	0.823
16	29.4	5.60	.189	2.018	0.612

Notes:	Collaborated with Damon Park, Justin Tan, Data collected by Enze Xu.

Motor Driver Operation Test [3]

This test validates the operation of the voltage and current regulation.

1. Connect the load R_L to the motor driver output.
2. Arrange the meter such that they read positive when $D = 0$.
3. Toggle the signals B, D, and S and record the power in and out.
4. Record any observations in motor behavior.

$$V_{in} = 12\text{ V}, \quad Logic\ 0 = 0\text{ V}, \quad Logic\ 1 = 3.3\text{ V}, \quad R_L = \text{Motor}$$

Table 5: Motor Driver Operation Test Data

B[V]	D[V]	S[V]	Measured V_{in} [V]	Measured I_{in} [V]	Measured V_{out} [V]	Measured I_{out} [A]	Calculated Loss P_{Loss} [W]	Calculated Efficiency η [%]	Motor Behavior
0	0	0	12.38	1.62	0.599	0.49	19.76209	1.46%	No turning, no brake torque
0	0	1	12.36	99.50	10.29	80.38	402.7098	67.25%	Motor turns
0	1	0	12.37	1.67	0.592	-0.52	20.35006	1.49%	No turning, no brake torque
0	1	1	12.36	117.18	-9.10	-100.69	532.0658	63.26%	Motor turns in opposite direction
1	0	0	12.39	1.70	0.589	0	21.063	0.00%	Motor Stop hard to turn in one direction by hand
1	0	1	12.39	1.70	0.589	0	21.063	0.00%	Motor Stop hard to turn in one direction by hand
1	1	0	12.39	1.77	0.589	0	21.9303	0.00%	Motor Stop hard to turn in the other direction by hand
1	1	1	12.39	1.78	0.590	0	22.0542	0.00%	Motor Stop hard to turn in the other direction by hand

Notes:	For cases when the motor isn't moving. Spin the motor by hand to verify if braking torque is present. Collaborated with Damon Park, Justin Tan, Data collected by Enze Xu.

Maximum PWM Frequency Test [2]

This test validates the maximum PWM frequency.

1. Connect the load R_L to the motor driver output.
2. Use a function generator to generate a Pulse signal from 0 V to 3.3 V at 1 kHz.
3. Using an oscilloscope, measure S and either M1 or M2 (one will toggle with S).
4. Adjust the frequency to match duty cycle error.

$$V_{in} = 12\text{ V}, \quad B = 0\text{ V}, \quad D = 0\text{ V}, \quad \%\text{Duty} = 50\%, \quad R_L = 1\text{ k}\Omega$$

Table 6: Maximum PWM Frequency Test Data

Target %Duty Error	Measured $\%\text{Duty}_{in}$ [%]	Measured $\%\text{Duty}_{out}$ [%]	Measured Frequency [Hz]
1%	50.0	51.4	862
2%	50.0	52.2	1718
5%	50.0	54.8	4300
7%	50.0	57.2	6022
10%	50.0	60.0	8596

Notes:	Collaborated with Damon Park, Justin Tan, Data collected by Enze Xu.

Control Signal Current Draw Test [1]

This test measures the current draw from the control signals intended to be provided by the MSP430.

1. Connect the load R_L to the motor driver output.
2. Using an ammeter, measure the current drawn by each signal when high.
3. Have all control signals and the 3v3 input provided by one source. Place an ammeter in series.

$$V_{in} = 12\text{ V}, \quad B = 3.3\text{ V}, \quad D = 3.3\text{ V}, \quad S = 3.3\text{ V}, \quad R_L = \text{Motor}$$

$$I_B = 3.893, \quad I_D = 0.591, \quad I_S = 0.743, \quad I_{3V3} = 19.545\ , \quad I_{Total} = 24.178$$

Notes:	Collaborated with Damon Park, Justin Tan, Data collected by Enze Xu.

<u>Photo of the Power Supply [1]</u>

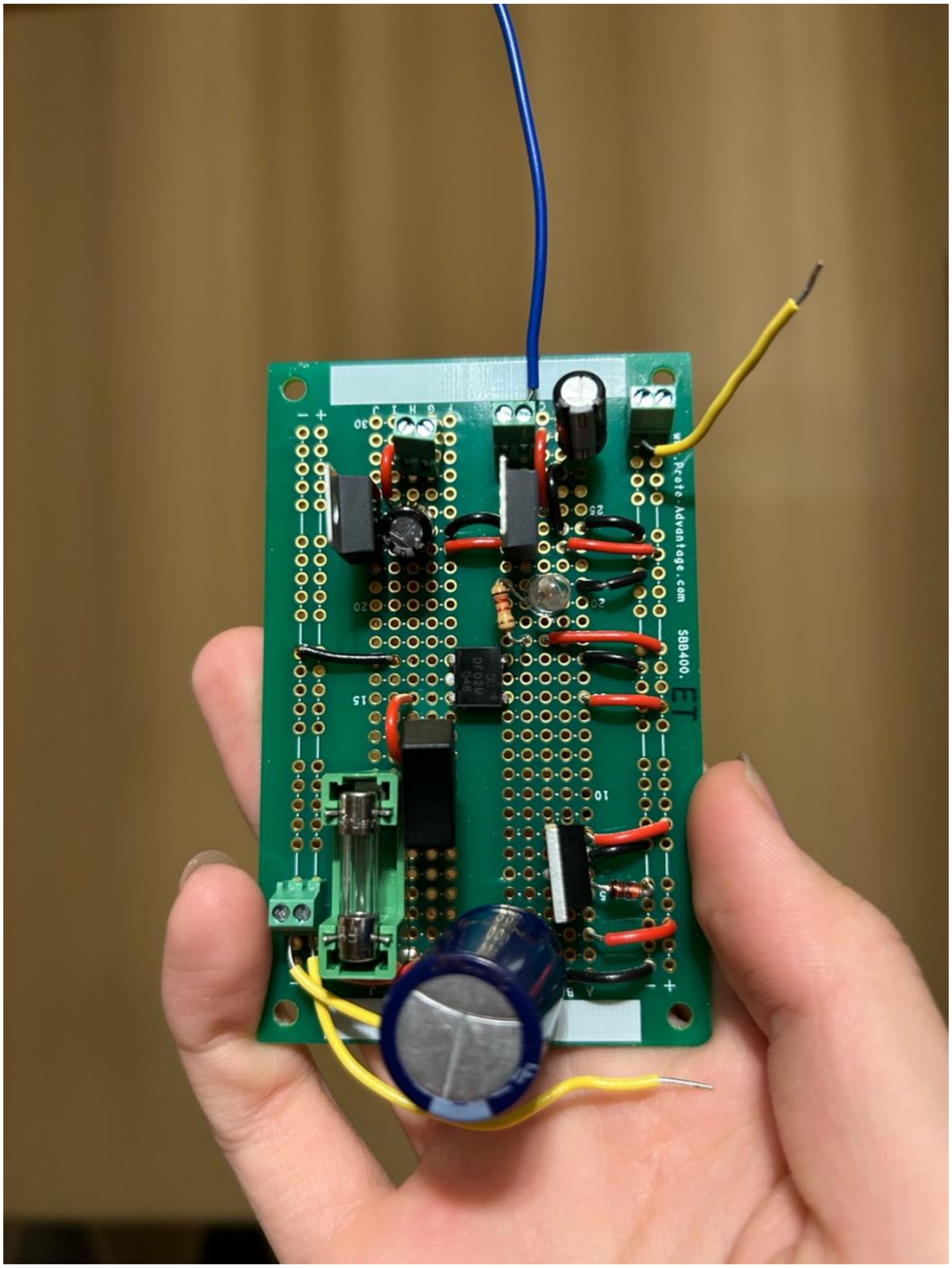


Photo of the Voltage Regulator [1]

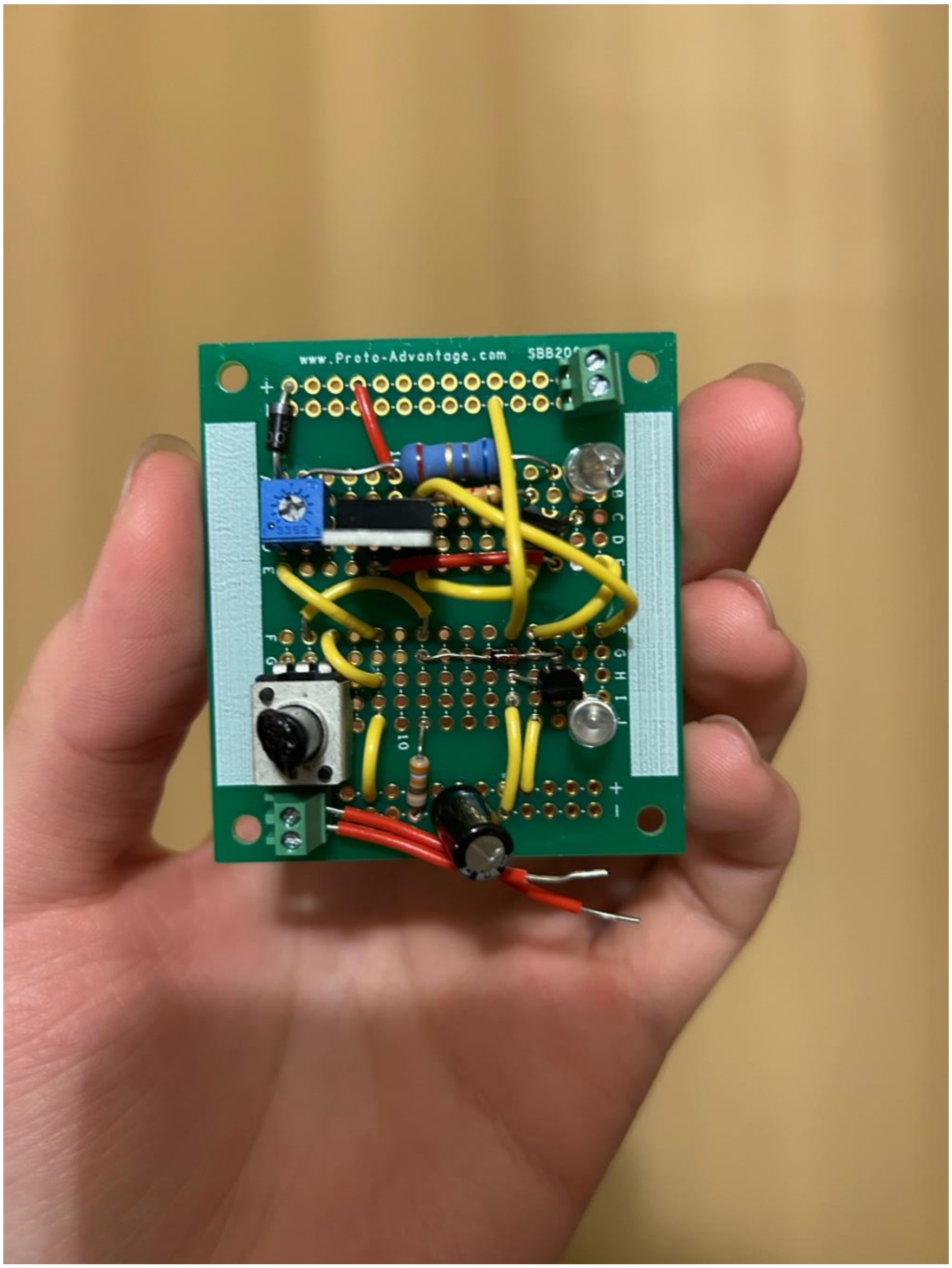


Photo of the Motor Driver [1]

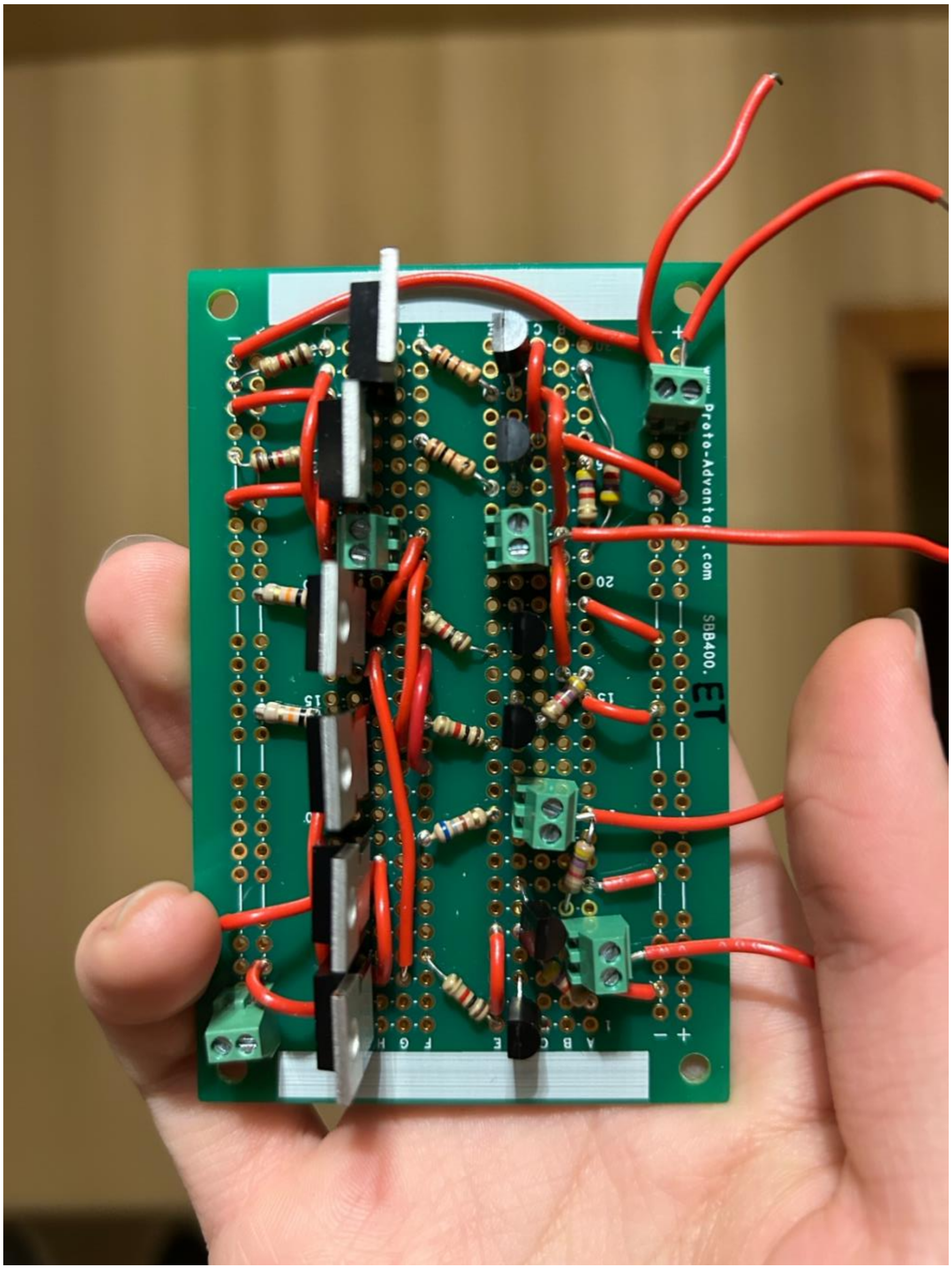
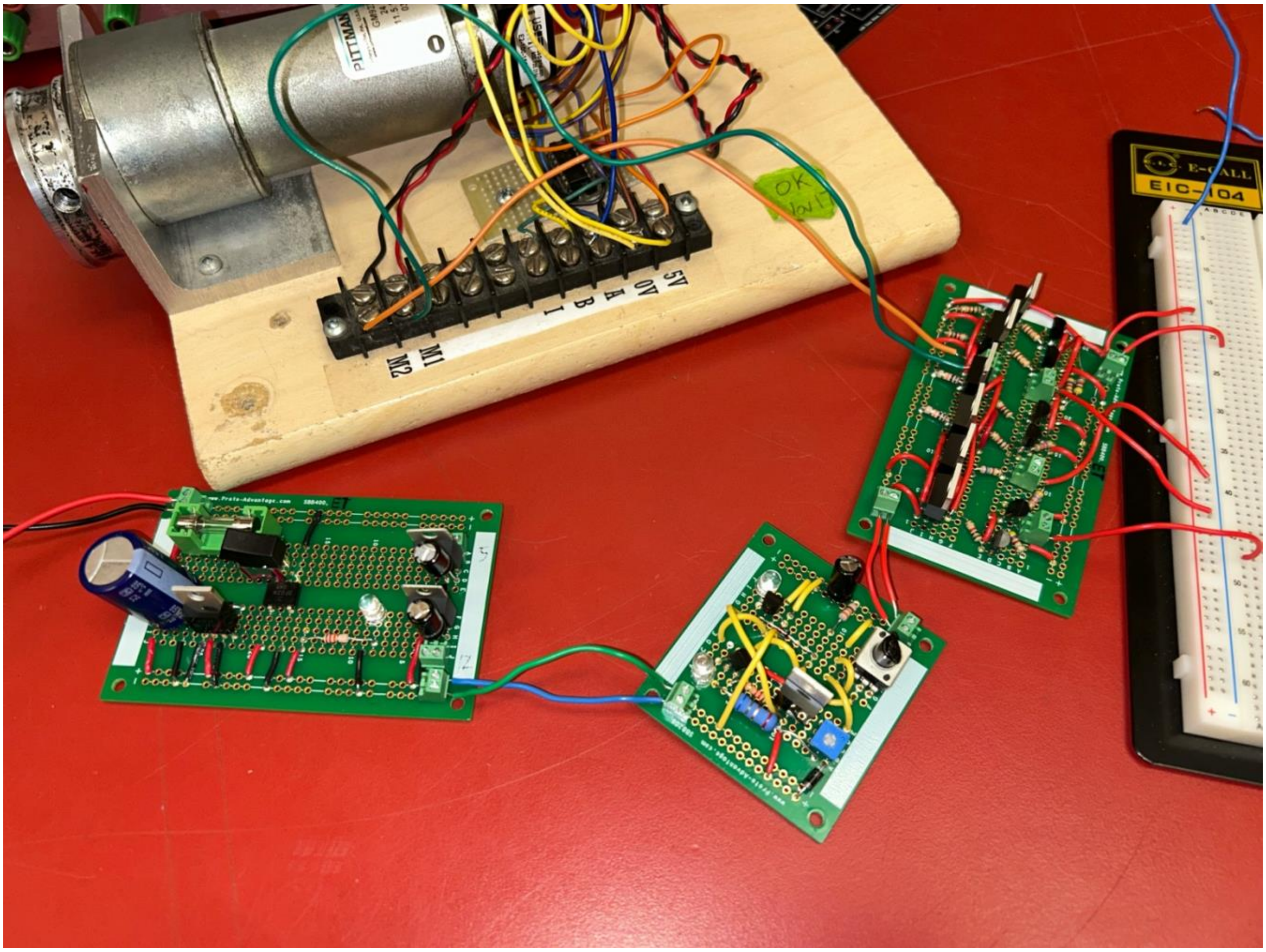


Photo of the Full System [1]



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