Lab #6

Basic Linear Power Supply

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Lab 6: Basic Linear Power Supply

ABSTRACT

In this lab, we were to design a simple, unregulated AC-to-DC power supply. This involved designing a regulator circuit to form a regulated power supply. The parts of a regulated power supply are a transformer, rectifier, filter, and regulator. The output voltage of the circuit is dependent on the input AC voltage and the load current, as this can lead to fluctuations in the output voltage. This is the issue that the regulator circuit addresses. It is added to maintain a constant output voltage regardless of changes in the input voltage and load current. In this lab, we designed an unregulated power supply and analyzed the effects of the regulator circuit. Different load resistors were used to simulate a load and their impacts on the regulator circuit and output voltage were analyzed. The load was measured using a multimeter to evaluate the DC voltage output. An oscilloscope was used to monitor the AC Coupling through the peak-to-peak ripple.

EQUIPMENT LIST

- ➢ Function Generator
- ➢ Oscilloscope
- ➢ Multimeter
- ➢ Power Transformer
- ➢ 4 power diodes
- ➢ Electrolytic Capacitors
- ➢ Resistors for Regulator Circuit
- ➢ Power Resistors for Load

An AC power supply is needed. A wall outlet was used, which typically supplies 250V AC.

PART 1: Calculations

We used a full-wave bridge. The following calculations were made using data from Lab 5 and the equations that apply to the full-wave bridge.

1. Calculate Vmax

$$V_{max} = 1.414\,V_s - 2V_d$$
$$= 1.414(24.9923) - 2(0.7)$$
$$= 33.94V$$

2. Calculate Vdrop

$$V_{drop} = 2V$$

3. Calculate Vreg,min

$$V_{reg,min} = V_{reg,out} + V_{drop}$$
$$= 9V + 2V = 11V$$

4. Calculate Vrip

$$V_{bott} > V_{reg,min} \Rightarrow V_{bott} > 11V \Rightarrow V_{max} - V_{rip} > 11V$$
$$V_{rip} < V_{max} - 11V \Rightarrow V_{rip} < 33.94 - 11V$$
$$V_{rip} < 22.94V$$

5. Calculate Capacitance

$$V_{rip} = \frac{I_L}{2fC} \Rightarrow \frac{0.8}{2(60)C} > 22.94 \Rightarrow C > \frac{0.8}{2(60)22.94}$$
$$= 2.9 \cdot 10^{-4}$$
$$C > 290\mu F \Rightarrow \text{used } 470\mu F$$

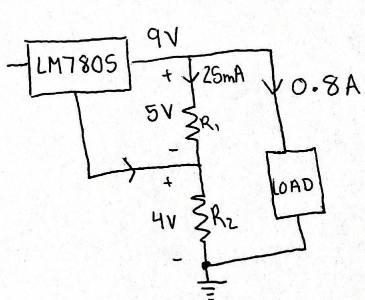
6. Calculate PRV

$$PRV = 1.414 V_s$$
$$= 1.414(24.9923)$$
$$= 39.58V$$

7. Calculate Vcap

$$V_{cap} = V_{max} = 33.94V$$

8. Calculating R1 and R2 of the Regulated Circuit:



Specs:

$V_{reg,out} = 9V$

$I_L = 0.8A$

$$R_1 = \frac{5V}{25mA} = 200\Omega$$

$$R_2 = \frac{4V}{25mA} = 160\Omega$$

PART 2: In the Lab

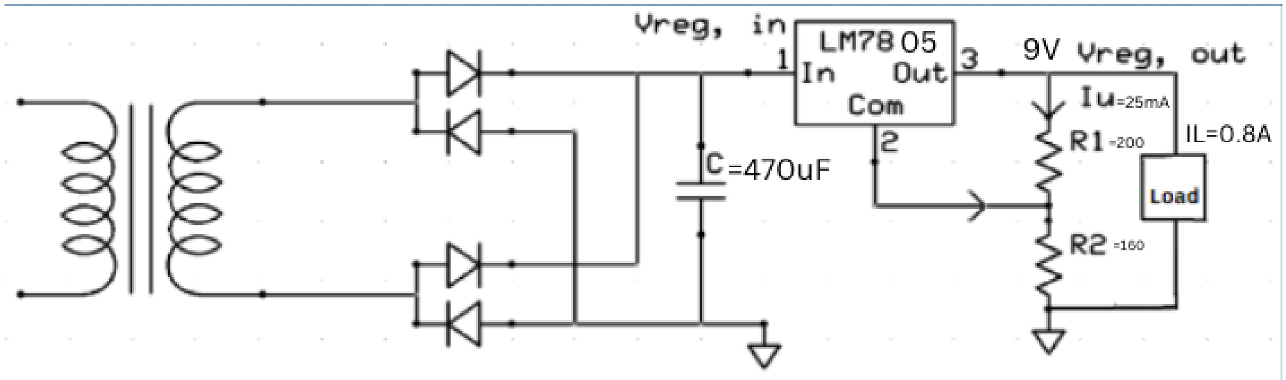


FIGURE 1: Complete Circuit Schematic

Our group was instructed to build a circuit that outputted 9V at 0.8A. This meant that Vreg,out needed to be 9V. We checked the rectifier diodes on the multimeter, as well as the capacitor on the ohmmeter, to verify their values.

We then measured the DC voltage and peak-to-peak ripple before and after the regulator under no load, 33% load, and 100% load.

No load: Open Circuit

33% Load

9V and 0.2667A

$$R_L = \frac{9V}{0.2667} = 33.746\Omega$$

100% Load

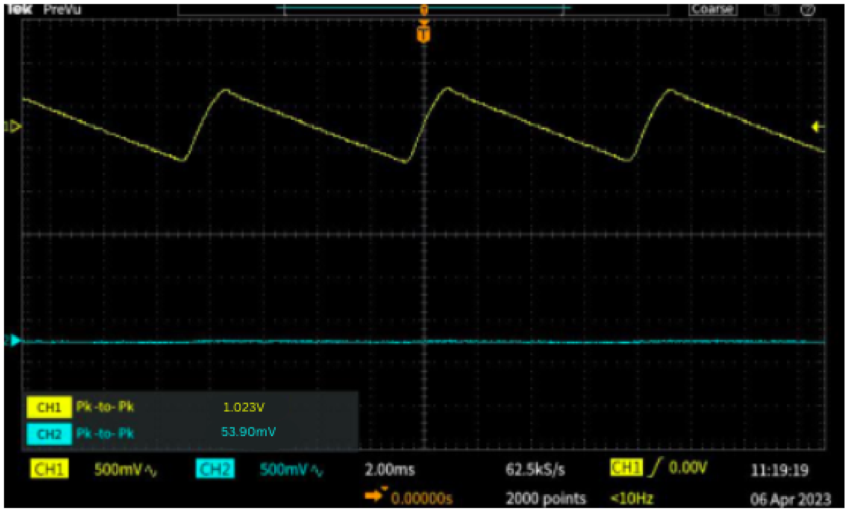
9V and 0.8A

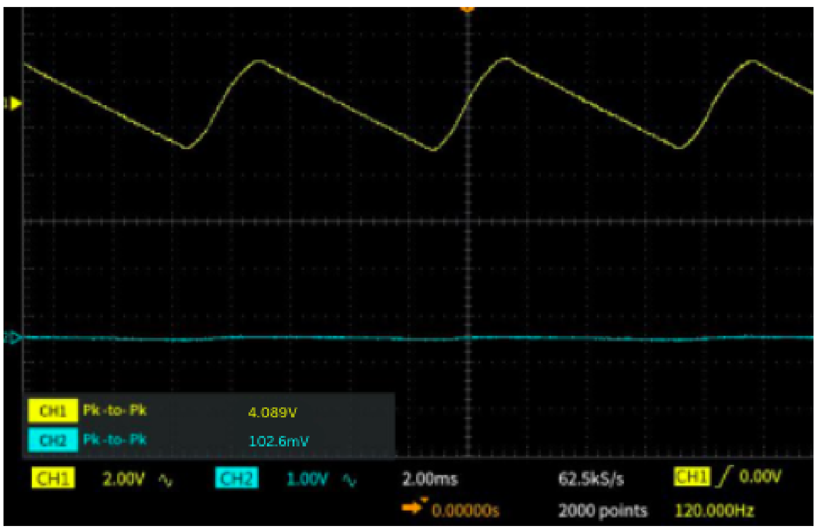
$$R_L = \frac{9V}{0.8} = 11.25\Omega$$

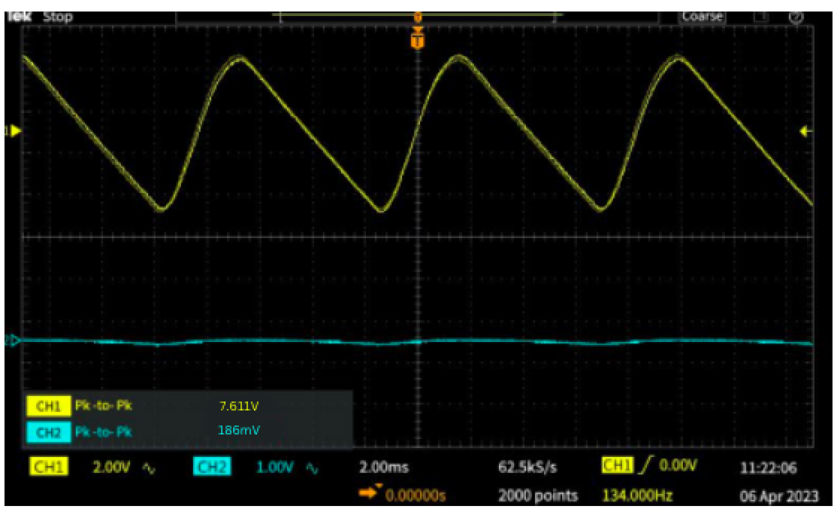
We used resistors summing to 33.65 ohms measured for the 33% load. We used resistors measuring 11.53 ohms for the 100% load.

	DC Voltage		Pk-to-Pk Ripple	
	Before Regulator	After Regulator	Before Regulator	After Regulator
NO	33.115V	9.265V	1.02V	0.0529V
33%	30.063V	9.259V	4.09V	0.1026V
100%	27.962V	9.123V	7.61V	0.1860V

TABLE 1: Measured DC voltages and peak-to-peak ripple values.







FIGURES 2-4: Scope shots for the peak-to-peak ripples.

We then were able to calculate the load regulation:

Load Regulation

$$\frac{V_{no} - V_{full}}{V_{full}} \times 100$$

Before $\frac{33.115 - 27.962}{27.962} \cdot 100 = 18.43\%$

After $\frac{9.265 - 9.123}{9.123} \cdot 100 = 1.56\%$

Using the resistors from the 33% load setup, we connected a Variac between the AC line and the power supply input. We then varied the input at 105Vrms, 115Vrms, and 125Vrms.

	DC Voltage	
	Before Regulator	After Regulator
105Vrms	27.038V	9.098V
115Vrms	29.892V	9.205V
125Vrms	32.701V	9.227V

TABLE 2: The change in DC voltage from before and after the regulator.

We then were able to calculate the line regulation:

Line Regulation

$$\frac{V_{105rms} - V_{125rms}}{V_{115rms}} \times 100$$

Before $\frac{27.038 - 32.701}{29.892} \cdot 100 = 18.94\%$

After $\frac{9.098 - 9.227}{9.205} \cdot 100 = 1.40\%$

CONCLUSION

The data recorded from measuring an unregulated power supply and its response to a regulator reveals several important observations. As the load on the power supply increases, the resistance decreases, leading to an increase in voltage due to the inverse relationship between resistance and voltage. The load regulation before the regulator is 18.43%, which improves significantly to 1.56% after the regulator is applied. Additionally, the peak-to-peak voltage ripple is substantially reduced to values under 1V after the regulator is introduced, as compared to the values recorded before the regulator. Furthermore, when a variac is used to test the effect of input voltage changes on the output, the regulator shows line regulation of 1.40%, which is significantly better than the 18.94% line regulation observed before the regulator was installed. These results suggest that the regulator effectively suppresses ripple voltage, and it is capable of regulating the power supply's output regardless of the input voltage or the size of the load.