EE 2010 Circuit Analysis
Lab 05: 120V AC - 5V DC Regulated Power Supply

Lab Section: **Printed Name (Last, First):**

All electronic devices require power supplies. Often, it is necessary to make available several DC voltages drawing from the same energy source. In this Lab, we will examine, simulate, and verify a very commonly-employed method of constructing a 5V DC Voltage supply suitable to use for USB standard devices.

Learning Objectives:

- Be able to simulate the operation of a regulated 5V DC power supply
- Be able to incorporate a "step-down" transformer for AC voltage reduction
- Be able to incorporate a "full-wave rectifier" to obtain a DC voltage from an AC waveform
- Understand the operation of a regulated voltage supply
- Be able to evaluate the loading characteristics of a 5V DC regulated power supply

A. Before coming to lab:

1. AD - DC Power Supply Background:

1.1 Read about the ubiquity of 5V DC supplies due, in part, to the *USB voltage standard*.

1.2 Understand the role and *operation of transformers* in "stepping-down" or "stepping-up" AC voltages

1.3 Understand the operation of *full-wave rectifiers* in producing a DC voltage source

1.4 Download and examine for pertinent parameters, a data sheet for a 7805 voltage regulator.

1.5 Watch *this video* explaining the operations of voltage regulators.

1.6 Understand the terms *Drop Out Voltage*

1.7 Read and understand *this article* on the 7805 voltage regulator.

1.8 Watch *this video* showing how to build an Arduino Power Supply using the 7805.

2. Circuit Simulation and Verification

Figure 1 shows a pluggable 120V AC to 5V DC regulated power supply as would be used for USB devices and other applications.

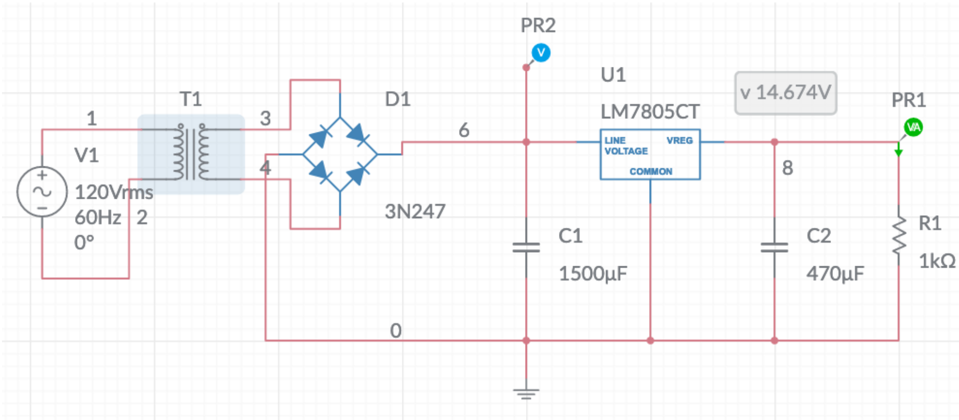


Figure 1: A simplified circuit diagram of a portable, USB voltage supply/charger.

2.1 Construct this circuit in Multisim.

2.2 Begin with a 120V 60Hz AC source to represent US residential available power.

2.3 The 10:1 “step-down” transformer changes 120V 60Hz AC to roughly 12V 60Hz AC.

2.4 Note the transformer settings in the figure below.

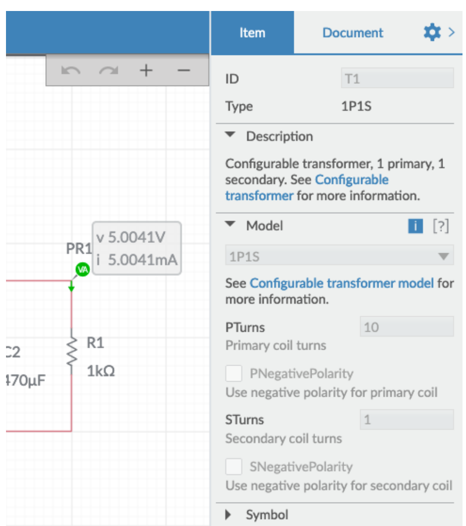


Figure 2: Multisim transformer setings.

2.5 When the simulation Verify the production of 5V DC with $R_1 = 1M\Omega$.

2.6 Make note of the voltage across and current through R_1. 5.2388v, 5.2388μA

2.7 Change the value of R_1 to $1k\Omega$.

2.8 Make note of the voltage across and current through R_1. 5.2387v, 5.2387mA

2.9 Change the value of R_1 to 100Ω.

2.10 Make note of the voltage across and current through R_1. 5.2378v, 52.378mA

2.11 Graph the 3 points on a Voltage vs Current graph using any technique you like.

2.12 Capture a picture or screenshot of your graph.

2.13 Does this circuit exhibit a Voltage vs Current graph approximating a straight line?

Yes

2.14 Calculate the **power dissipated in the voltage regulator** for $R_1 = 100\Omega$.

Power= 0.2743W

2.15 If this circuit were physically realized and in operation, do you think the voltage regulator feel warm to the touch? Why?

Yes, it has a heat sink

2.16 Use the voltage and current measurements performed in prior steps to find what is referred to as a Thevenin-equivalent resistance as:

$$R_{Th} = \frac{V_{\text{1M}} - V_{\text{LOAD}}}{I_{\text{LOAD}}} = \frac{V_{\text{1M}} - V_{\text{LOAD}}}{V_{\text{LOAD}}/R_{\text{LOAD}}}$$

Where R_{LOAD} and V_{LOAD} is the resistive value and corresponding voltage measured for the $R_1 = 1k\Omega$ and $R_1 = 100\Omega$ with one calculation done for each of these values.

We'll see later how V_{1M} and R_{Th} are useful in modeling the function of linear circuits as in:

Rth 1k = 0.0190887

Rth 100 = 0.01909

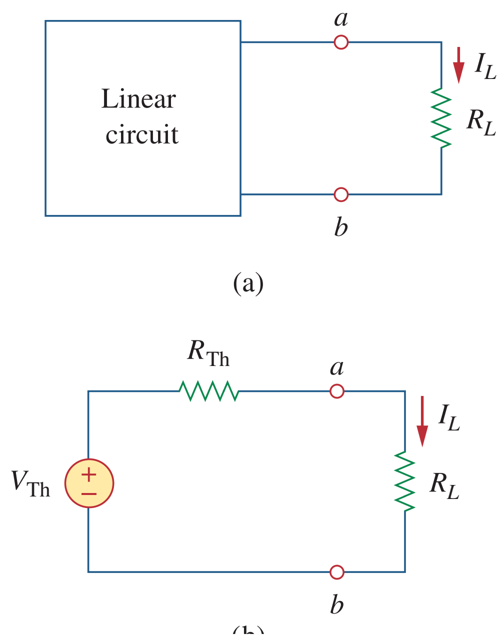
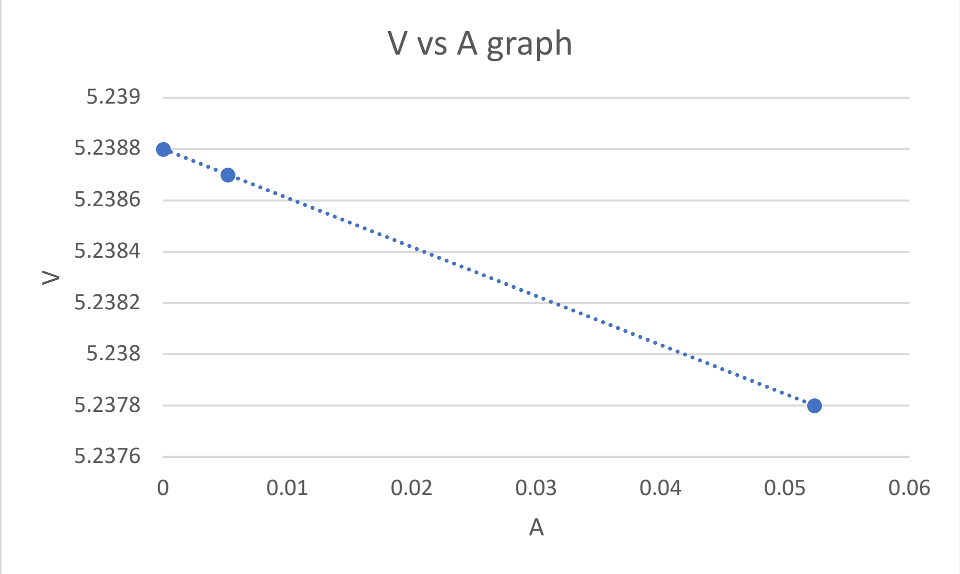


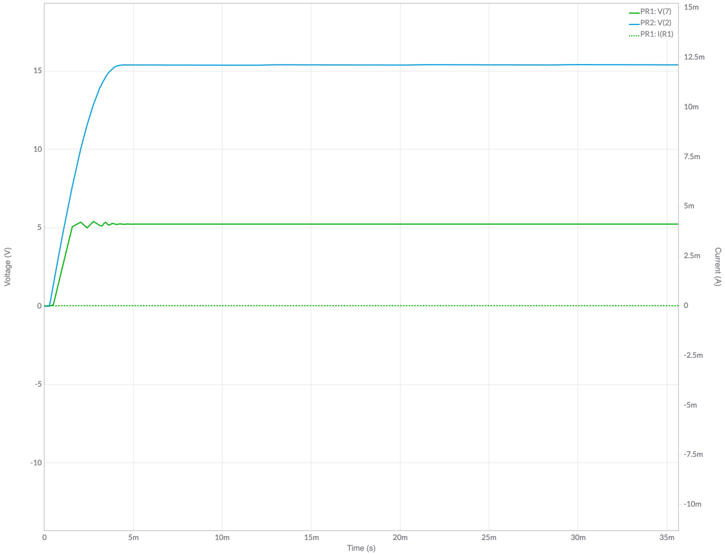
Figure 3: A Thevenin-equivalent model of a linear circuit.

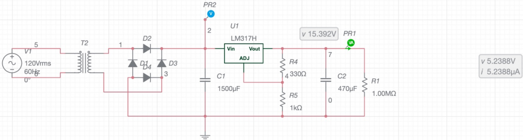
2.17 Upload your constructed circuit and Voltage-Current plot **as a single document** to Pilot. If you do not see the dropbox on Pilot or are not able to find it, please contact your TA.



V vs A graph
5.239
5.2388
5.2386
5.2384
5.2382
5.238
5.2378
5.2376
V
0
0.01
0.02
0.03
0.04
0.05
0.06
A

Interactive 1





PR2
V
2
U1
LM317H
Vin
Vout
ADJ
v 15.392V
PR1
VA
v 5.2388V
i 5.2388µA
5
T2
1
D2
V1
120Vrms
60Hz
0°
6
D1
D3
D4
3
C1
1500µF
R4
330Ω
4
R5
1kΩ
7
C2
470µF
0
R1
1.00MΩ

B. In Lab Procedures

1. Circuit Realization and Verification

Figure 4 shows a lab-safe modification of the DC (5 Volt) regulated power supply simulated in the pre-lab.

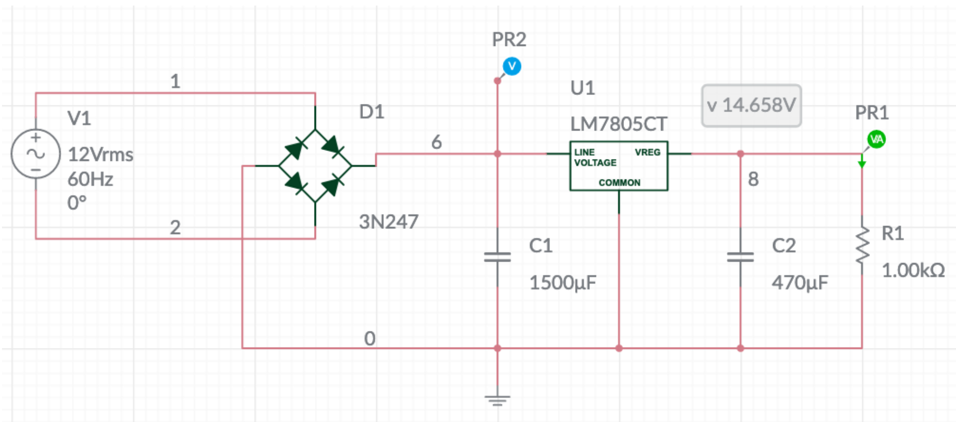
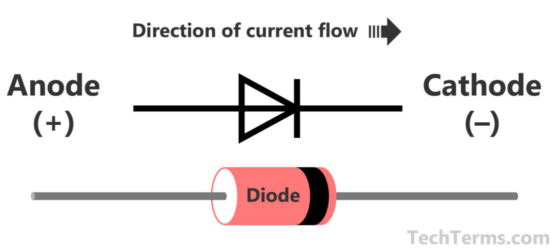


Figure 4: Simplified DC (5 Volt) regulated power supply.

1.1 Note that we are using the function generator set at 12V, 60 Hz as the input to the full-wave rectifier. (No transformer).

1.2 Select and assemble the components of the above circuit on a protoboard.

1.3 The polarities for diodes (current flow direction) and electrolytic capacitors (voltage polarity direction) are depicted below



(a) Diode current flow polarity

(b) Capacitor voltage polarity

Figure 5: Component polarity designations

1.4 The particular values of the two capacitors are not important. Use components with reasonable values you can find.

1.5 Set the function generator amplitude to 12V at 60 Hz.

1.6 Connect the function generator directly to the oscilloscope and verify the generation of a sine wave

1.7 Apply the function generator output to the full-wave rectifier circuit

1.8 Measure the voltage supplied by the voltage regulator in the absence of a load.

Voltage: 547mV

1.9 Select and connect a load resistor (or a combination of resistors designed to realize the required value) to the supply output so as to draw a current of approximately $200mA$.

1.10 Measure the supplied voltage and current at the loaded supply output.

Voltage: 202mV
Current: .2A

1.11 Explain any change in the supply voltage from the unloaded voltage.

the load resistor provides a path for the capacitor to discharge

1.12 Calculate the **power dissipated in the voltage regulator** for this particular load configuration.

Power: 202mv^2/1000=4.0804e-5W

1.13 Does the voltage regulator feel warm to the touch? Why?

no, not enough power is being dissipated

1.14 Use the voltage and current measurements performed in prior steps to find what is referred to as a Thevenin-equivalent resistance as:

$$\begin{aligned} R_{Th} &= \frac{V_{\text{OPEN}} - V_{\text{LOAD}}}{I_{\text{LOAD}}} \\ &= \frac{V_{\text{OPEN}} - V_{\text{LOAD}}}{V_{\text{LOAD}}/R_{\text{LOAD}}} \end{aligned}$$

1.15 Verify with your TA that the circuit works properly. Have your TA sign below.

TA Signature: Owen Riemer

Takeaways:

1. Linear voltage regulators are a simple and cheap stable voltage supply.
2. Linear systems may be modeled in terms of simplified parameters.