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10/25/18

2559-2971

Power Supply Design and Construction

Introduction

This module utilizes two different methods for constructing a power supply, a Zener diode regulator, or a regulator IC. The goal of the module is to take 120V rms voltage and output either 5.1V at 25mA with the Zener diode, or 5.0V at 25mA using the regulator IC. A DC power supply from an 120V Ac circuit is implemented as follows: The AC voltage is stepped down using a transformer, to about 20V AC. This is then full wave rectified using four diodes in a bridge configuration. The output of this circuit goes to a filter, i.e. a large capacitor to make the voltage linear. This then goes to a regulator, either a Zener diode or a regulator IC. The Zener diode can operate in breakdown, meaning that it will maintain 5V for low current.

Design

The block diagrams for the two circuits are provided in Figure 1. The LTSpice circuits are given in Figures 2 and 3. In both designs, the 120 AC voltage is fed to a transformer that steps the voltage down to 20V AC. The diode rectifier is used to generate a full wave rectified 20V voltage. This is then sent to a filter, consisting of a 1470 uF capacitor in parallel with a 22k resistor. This network is connected to a 1K resistor, which then goes to either a Zener diode or a regulator IC. In the case of the Zener diode, the Zener diode is in parallel with the load. For the regulator IC, a 47 uF capacitor is connected to the input of the IC, and the output is connected to a 22uF capacitor in parallel with the load. The bill of materials is shown in Table 1, with the total cost coming to $122.15.

Conclusion

For the first circuit, the 5.1 Zener diode was able to meet the requirements for 25mA, as shown in Figure 4. However, for 100mA, the voltage was no longer 5.1V. This is due to limitations of using the Zener diode. The Zener diode is not able to support 100mA of current while operating in breakdown due to power limitations, as shown in Figure 5. This results in a loss of voltage. With the regulator IC, the voltage can remain at a constant 5V for 25mA and 100mA output current, as shown in Figures 6 and 7. This is due to the regulator IC utilizing an operational amplifier; the op-amp is able to output at a constant voltage for a wide range of currents. The largest difficulty in implementing the design is ensuring that the proper resistance is used as the load. If the resistance is too small, the Zener diode can cease functionality due to exceeding the power specifications.

Appendix

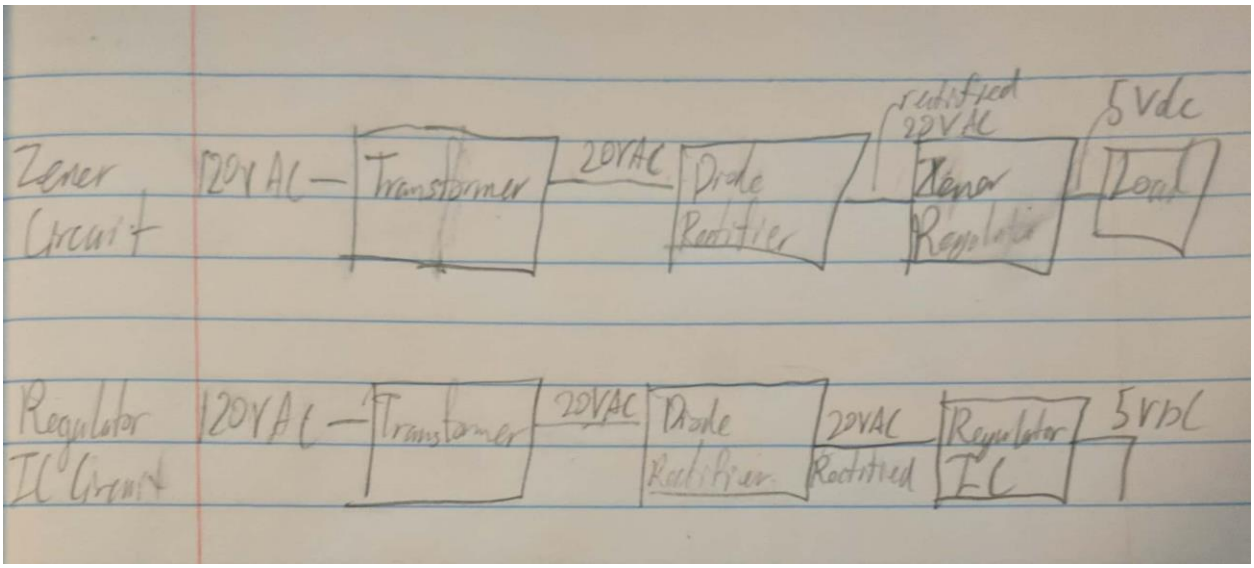

Figure 1: Block Diagram of Power Supply Circuits

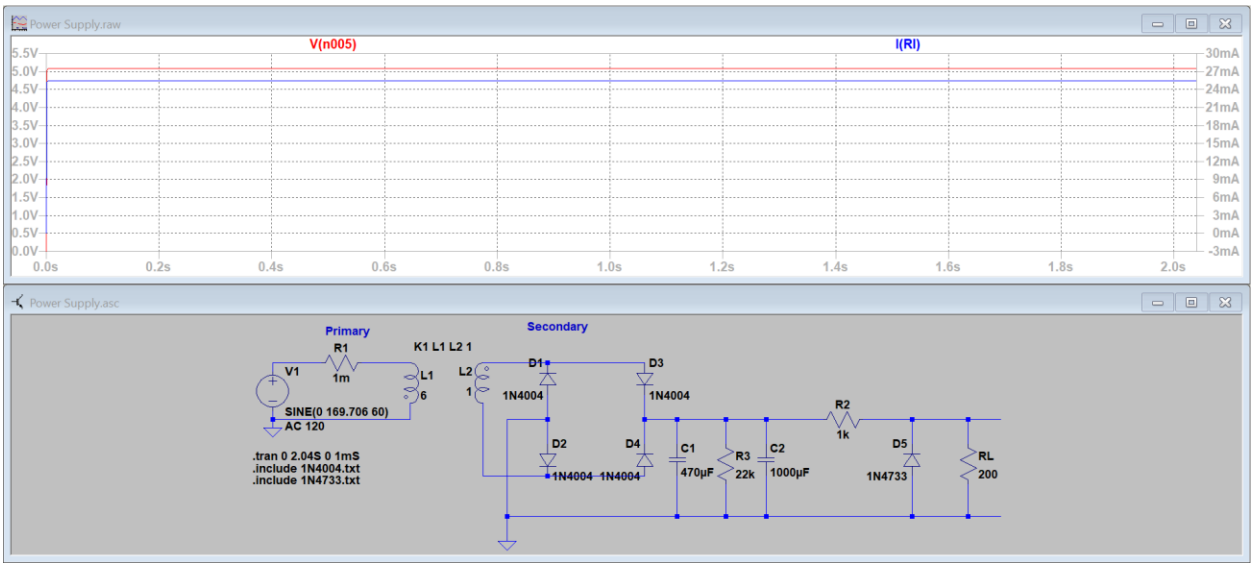

Figure 2: LTSpice Schematic of Zener Diode Power Supply, with Simulation

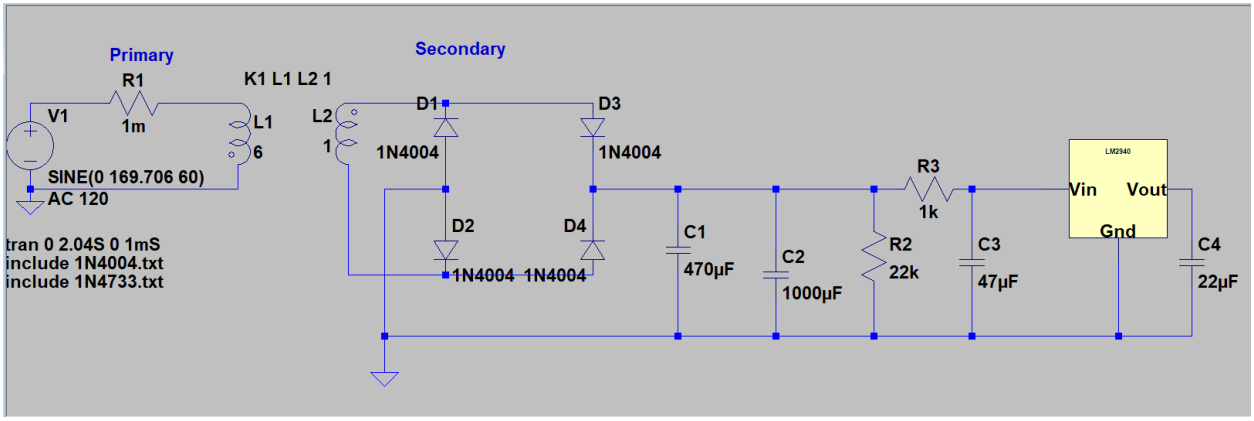

Figure 3: LTSpice Schematic of Regulator IC Power Supply

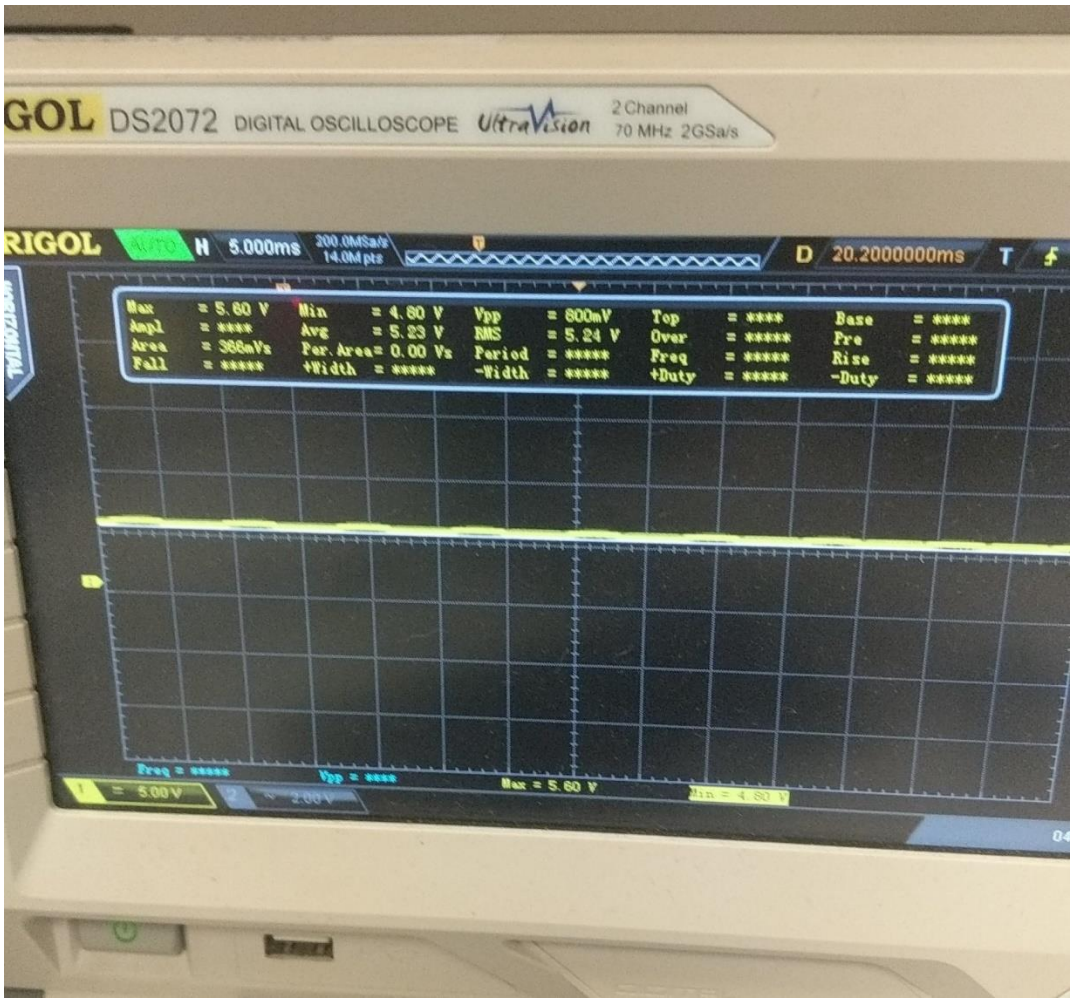

Figure 4: Output from Zener Diode Circuit, 25mA Output Current

Figure 5: Output from Zener Diode Circuit, 100mA Output Current

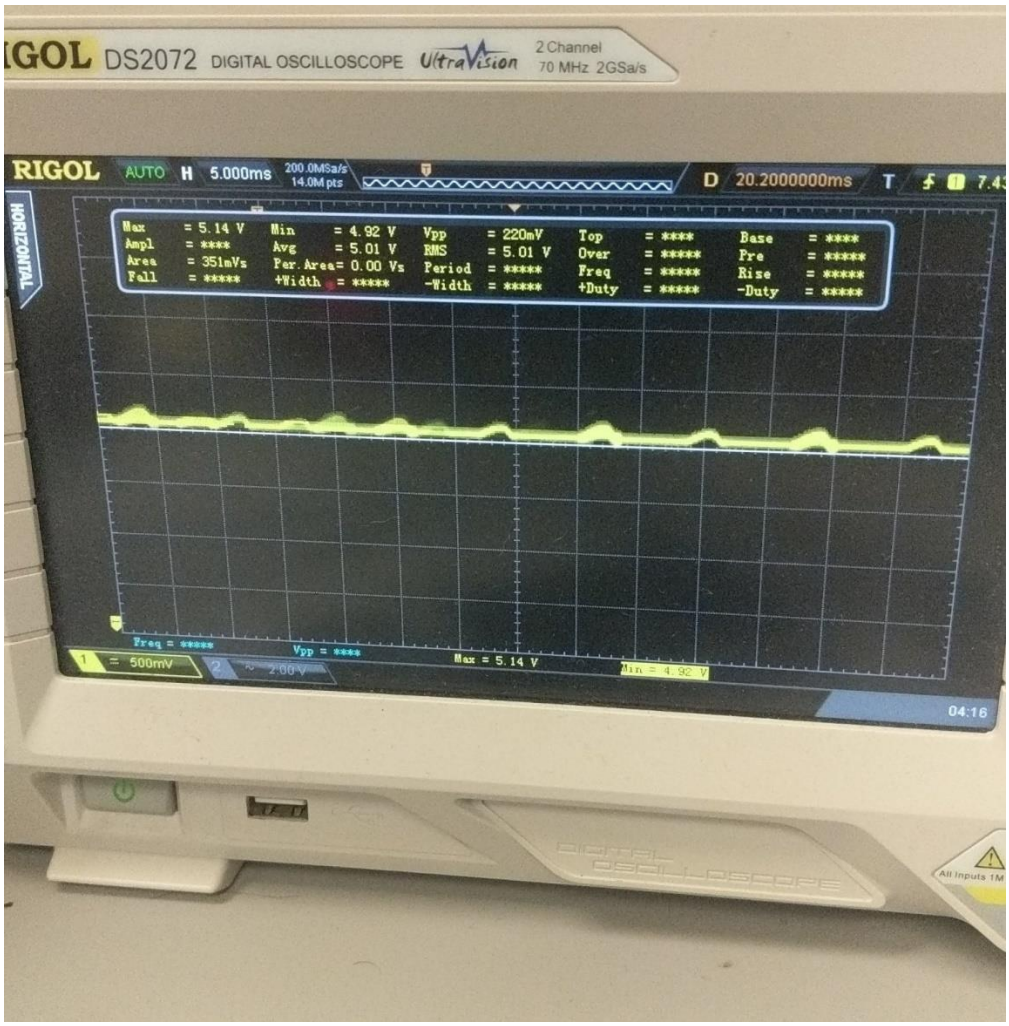

Figure 6: Output from Regulator IC Circuit, 25mA Output Current

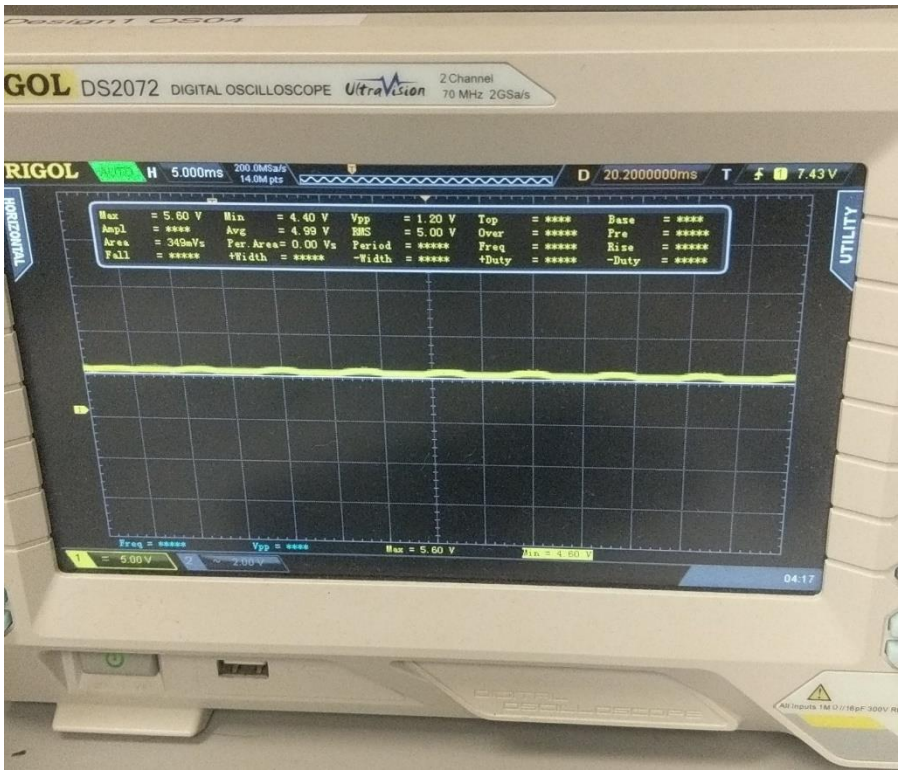

Figure 7: Output from Regulator IC Circuit, 100mA Output Current

Part Number	Part Name	Cost per Part	Volume Discount (Price per unit for 100 units)	Source
1	Breadboard with Wires	$3.59	N/A	Amazon
2	22K Resistor	$0.19	$0.15	Jameco Electronics
3	120 VAC to 20VAC Transformer	$2.65	$1.90	Mouser Electronics
4	1N4004 Diode (x4)	$0.76	$0.10	DigiKey
5	470uF Capacitor	$0.61	$0.28	Mouser Electronics
6	1000uF Capacitor	$1.94	$1.03	Mouser Electronics
7	1k Resistor	$0.10	$0.09	Allied Electronics
8	1N4733 Zener Diode	$0.25	$0.07	Mouser Electronics
9	Decade Box	$110	$11000	Grainger
10	LM2940 5V Regulator IC	$0.99	N/A	Ebay
11	47uF Capacitor	$0.38	$0.34	Allied Electronics
12	22uF Capacitor	$0.69	$0.49	Jameco Electronics
Total		$122.15		

Table 1: Bill of Materials