3. DC Power Supply

Warning: Be very careful not to exceed the power limit of the load resistor. You may burn your finger if you touch an overheated resistor.

Learning Objectives

Learn how linear power supply functions. Build and characterize a simple dc power supply.

Assignments Before the Laboratory Session

Search the web for "dc power supply circuit." Read at least: http://en.wikipedia.org/wiki/Power_supply. A good dc power supply should have very little ac ripple, constant output voltage nearly independent of load current, and high efficiency.

Parts needed include four rectifying diodes, two electrolytic capacitors, and resistors. Pre-build the full wave rectifier on the circuit board.

Activities During the Laboratory Session

Verify the integrity of the oscilloscope probe by connecting it to the internal square wave source. Verify the integrity of the multimeter test lead by measuring its resistance.

Diode is the most fundamental semiconductor device with two terminals providing one-way conduction. Rectifying diodes can handle high current and convert ac power to dc. Build a full-wave bridge rectifier with four 1N4001 diodes as shown in Fig. 1. R_1 is the load resistor. Pick your own value below 10 kΩ. The resistance can be as low as ***1-W***, 100-Ω. Power rating of the load resistor is an important consideration otherwise the load resistor may overheat and burn. Pay close attention to how four diodes are arranged and where the signal ground is located. Set the dial of the large variac to 0. Make sure that the switch is at off position. Connect it to the wall plug. Connect the small isolation transformer to the variac. Adjust the variac to get a 9-V ac signal (RMS). Measure and confirm the ac voltage with a multimeter in the ac voltage mode. Please note that the output of the transformer is not connected to ground. Short circuit often results from error in configuring the transformer and the full-wave rectifier. If short circuit happens, you need to correct errors in the circuit first. Reset the circuit breaker or request the technician to replace the fuse. Record the waveform of the full-wave rectifier.

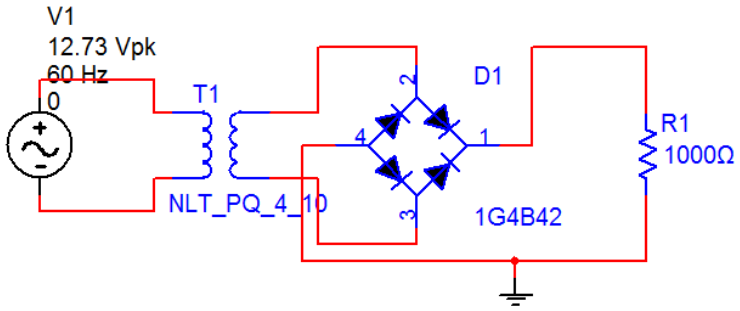

Fig. 1. The full-wave rectifier.

The output waveform of the full-wave rectifier contains a dc component but is still very much time varying. To reduce the time variation, one can use low-pass filters. Attach the π-filter consisting of C_1, R_1, and C_2 as shown in Fig. 2 to the output of the full-wave rectifier. The capacitance should be at least 100 μF. Pick your own value. Pay attention to the polarity and maximum voltage rating of electrolytic capacitors. Over voltage can cause the electrolytic capacitor to explode. The resistance in the π filter, R_1, should be small, e.g., <10 Ω. Pick your own value. It is in series with the load. There is a voltage drop. The voltage drop increases as the load current increases. This loading effect makes the output voltage current dependent. The larger the current, the smaller is the output voltage. While displaying the output waveform on the oscilloscope, you will observe the ac ripple. AC ripple results from the charging of capacitors by the rectifying diode and discharging by the load resistor. The amount of ac ripple also correlates with the load current, the higher the current the larger the ac ripple. A large capacitance can reduce the ripple more than a small capacitance can. A larger resistance in the π filter also yields lower ripple but the output voltage varies more with the load current.

Measure the dc voltage with a multimeter. Measure the peak-to-peak ac ripple with the oscilloscope. The ripple can be very small, therefore, choose the ac line trigger and use ac coupling. After getting a stable display, use averaging if needed. Create an Excel file with four columns to record load resistance, dc voltage, calculated load current, and ac ripple. Vary the load resistance from 10 kΩ, 4.7 kΩ, 1 kΩ, 470 Ω, 330 Ω, 220 Ω, to 100 Ω. Before attaching the load resistor, measure the preliminary dc voltage first. From the voltage and resistance calculate the expected power dissipation. Make sure that the power rating of the resistor is sufficient. You can always put resistors in parallel to increase the overall power handling capability. Enter measured dc voltage and ac ripple in the Excel spread sheet. Enter the calculated dc current. Generate a plot showing the dependence of dc voltage as a function of load current. Generate a similar plot for the ripple. You should see lower dc output voltage, i.e., the effect of loading, and higher ripple as the load current increases. After creating two plots, save the Excel file.

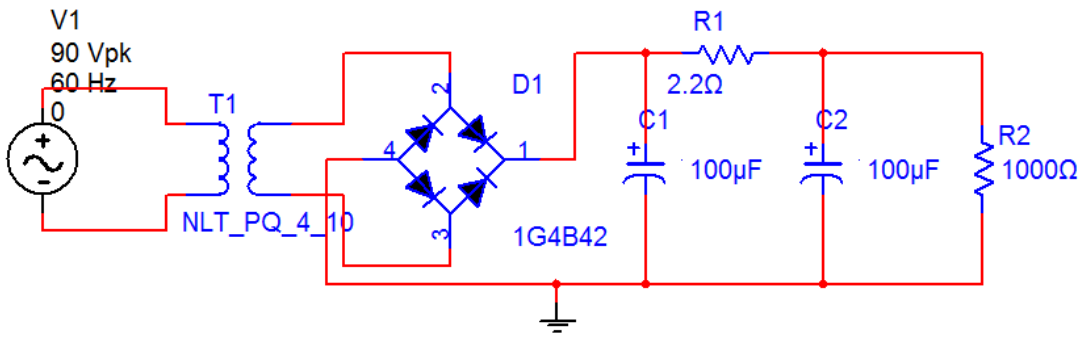

Fig. 2. Simple dc power supply circuit consisting of the full-wave rectifier and the π filter.

Linear power supply circuits have significant internal power dissipation. Therefore, their efficiency is not high. They are fine for low power applications. The efficiency is defined as power dissipated by the load divided by the input power to the power supply. For high power applications, it is better to use a switching power supply. The switching power supply is compact in size and has a much higher efficiency, i.e., above 90%. All personal computers use the switching power supply.

Activities After the Laboratory Session

Search the web for "efficiency switching power supply." Explain in your own words why switching power supply can be very compact and efficient. Are you satisfied with your own explanation? Try to convince your partner. Please note that simply copying information from other sources is not acceptable. You must explain in your own words.

Prepare a short summary with data and conclusion.

Self Study

1. How does the capacitance affect the ac ripple?
2. How does the ripple change as the load current is increased?
3. How does the dc output voltage vary as the load current is increased?

Cover and Score Sheet

Experiment 3 - DC Power Supply

Author:_____ Partner:_____

Score

Item	Credit	Score
Data	4	
Full-Wave Rectifier		
Waveform		
π-Filter		
Waveform		
Voltage Versus Load Current Plot		
Ripple Versus Load Current Plot		
Conclusion	1	
Total	**5**	

TA Signature:_____ Date:_____