MODULE 06

POWER SUPPLIES

PREREQUISITES: MODULE 02: INTRODUCTION.

OUTLINE OF MODULE 06:

What you will learn about in this Module:

- Linear power supplies
- Switching power supplies
- Batteries
- Solar power
- Generators & alternators
- Regulators & voltage references
- Grounding
- Fuses (standard, slow-blow, resettable)
- Circuit Breakers

What you will build in the lab:

You will use a voltage regulator to provide both a fixed (+5.0) and an adjustable (+1.2 to +14) voltage on your circuit board. You will then build a linear power supply to provide power from "line voltage" (115 VAC, the standard power plug in the wall) by using a transformer to reduce the voltage, then rectifying the voltage using a diode bridge, smoothing out the power with capacitors, then regulating it to the final desired voltage using a +5.0 Volt regulator chip.

INTRODUCTION:

Unfortunately one of the most critical yet least interesting parts of any electronic circuit is the power supply. Often, the power supply and associated hardware will be the bulkiest and most expensive element of the system that you design. Though it is not generally as interesting as the primary device that you are designing, nonetheless, an improperly designed or improperly assembled power source will almost always lead to malfunction or failure of any circuit that you build. In this module, you will read about several different types of power supplies, including batteries and solar cells, then you will build a "linear D.C. power supply": you will take power from the wall socket, transform it to a save voltage, rectify it, smooth it out, then regulate it to a nice clean +5.0 volts, for use in any circuit that you like.

READINGS FROM HOROWITZ AND HILL (H&H): *ART OF ELECTRONICS*

1.17, 1.25-1.29
Chapter 6: Introduction, 6.01-6.07, 6.10-6.19, 6.21-6.25
Chapter 14: Introduction.
14.01 (micropower)
14.02 (batteries)
14.03 (wall-plug-in units)
14.04 (solar cells)

ADDITIONAL READINGS & INTERNET RESEARCH:

Locate the Data Sheet for the following integrated circuit: LM2940T. It is a +5.0 Volt regulator manufactured by National Semiconductor. Read the page description of how this device functions.

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SELF QUIZ

You may base your answers to the following questions on the assigned readings or on additional internet research.

1: All things being equal (such as output power), why do switching power supplies weigh so much less than (and are also physically smaller than) an equivalently-rated "linear" power supply? Assume both supplies plug into the wall, and convert 115 VAC to a low voltage such as +5VDC.

2: Of the following sources of electrical power, which is the "cleanest" (i.e., which introduces the least amount of electrical noise?): Linear power supplies, switching power supplies, DC generators, batteries.

3: List as many design considerations as you can that you would take into account when attempting to design a micro-power circuit.

4: For the linear voltage regulator that you read about (the LM2940T), what range of inputs are acceptable for you to expect this device to operate properly? Describe the inputs as thoroughly as you can, not just the range of input voltages.

5: You can use a transformer to convert 60 Hz AC (alternating current) power at 115 V to other voltages, both lower and higher than the voltage supplied. Can you use a transformer to convert DC (direct current) voltages to higher or lower voltages? Explain why you can or can not do this.

6: What does a "rectifier" do?

PLEASE ANSWER THE ABOVE QUESTIONS AND E-MAIL TO THE INSTRUCTOR
"I have neither given nor received aid on this examination, nor have I concealed any violation of the Honor Code"

X_____

MODULE 06

LABORATORY PROJECTS

There are many types of power available for electronics: batteries are the cleanest and most portable, solar power is nice but not very space efficient or useful indoors or at night, and of course power is also available directly from the common household wall outlet, also known as “line power”. The main problem with line power is that the voltage is dangerously high for most electronics (about 120 Volts), and the power is in the form of “alternating current”, a sine wave that cycles 60 times each second (thus, line power is said to be at 60 Hz). So, unlike the convenient and safe low voltage direct current (D.C.) that we get from batteries, in order to use A.C. power from a wall outlet to power an electronic device we need to do two things: reduce the voltage, and turn the A.C. waveform into a steady D.C. voltage level. Both of these things are surprisingly easy to do. We reduce the voltage using a transformer, and then we convert the A.C. current to D.C. using a bridge configuration of four diodes, known as a “full-wave rectifier bridge”. You can use only one or two diodes to build what is known as a “half-bridge”. Full-wave bridges are so common that you can buy them integrated into a single package. You should be sure to review the readings in H&H to become familiar with this terminology. **Pay special attention to sections 1.25 - 1.29.** This is only 5 pages, so please review the information thoroughly. For this project, we will use four individual diodes to build a bridge to rectify the transformed alternating current to build a useful power supply.

1- Find the transformer power module. It is built into a small clear plastic box and labeled “Module-06”. It is only in a plastic box to protect you from exposure to electrical shock while working on your circuit. Normally, you would just mount the transformer directly to your PC board. If the transformer or any other parts for this module are unavailable, you can order them from Digi-Key using the part numbers provided on the schematic below.
2- You may wish to take a close look at the example circuit that I have provided in the parts cabinet. I have already built the circuit shown below so that you could test it before building one of your own. Note that the transformer connects to the circuit board using a 2-pin connector. This is called a “Molex” header. These come in all sizes and shapes, and are commonly used in electronics to connect cables to boards.
3- Once you have tested the example circuit, you can build one on your P.C. board. Do not use the “optional switch”. It is just there for you to see the effect of the 470 µF capacitor in the circuit (it removes the big ripples after the rectifier bridge). Just temporarily plug the transformer into your circuit when it is done so you can test your regulated power supply circuit.

NOTES: The main source of problems in these circuits is having the diodes in backwards. Be sure to note the cathode mark on each diode and be sure to put each diode into the circuit in the correct orientation. BE SURE TO PUT THE 470 µF CAPACITOR IN WITH THE CORRECT POLARITY OR IT WILL EXPLODE (note the “-“ sign on the side of the capacitor; this goes to the lowest voltage: ground).

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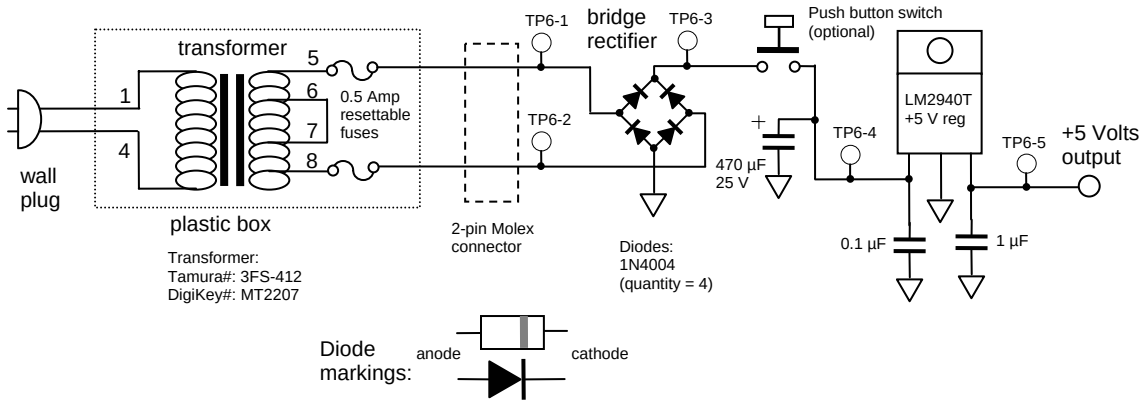
Linear Regulated Power Supply:



Put a small wire loop at each of the test points (TP6-X).
Use the oscilloscope to look at the waveforms at each of the test points (TP6-X).
Set the oscilloscope up as follows: 5V/division, time base = 5 ms, autotrigger with the threshold set at ~ 2 V.
Draw the waveforms and note the peak voltages that you see at each Test Point:

TP6-1:

TP6-2:

TP6-3 (switch NOT pressed):

TP6-3 (switch PRESSED):

TP6-4 (switch PRESSED):

TP6-5 (switch PRESSED):

Notes:

TP6-1 and TP6-2 should look like figure 1.69 in H&H. They should be 180 out of phase. TP3 should look like figure 1.71 when the switch is NOT pressed, and like the dashed line in figure 1.73 when you press the switch (this adds in the filter capacitor so the bumps get smoothed out. With the switch pressed, TP6-3 = TP6-4 = 21V (approximately). With the switch pressed, you should get a nice clean +5.0 Volts at TP6-5. You could use this to power any of your logic circuits (in later Modules).

FEEDBACK

Was this Module useful and informative?

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Is there a topic that should get more or better coverage?

_____

In what way can this Module be improved:

Content: _____

Depth of Coverage: _____

Style: _____

Any additional comments that will help us to improve this course:

_____

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If you prefer, you may e-mail comments directly to Bob Dennis: yoda@umich.edu