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INST 120
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Regulated DC Power Supply

Introduction:

Our project this quarter was to modify a previously built AC-DC power supply to provide a regulated output voltage. This report details and diagrams the finished circuit, and its operation.

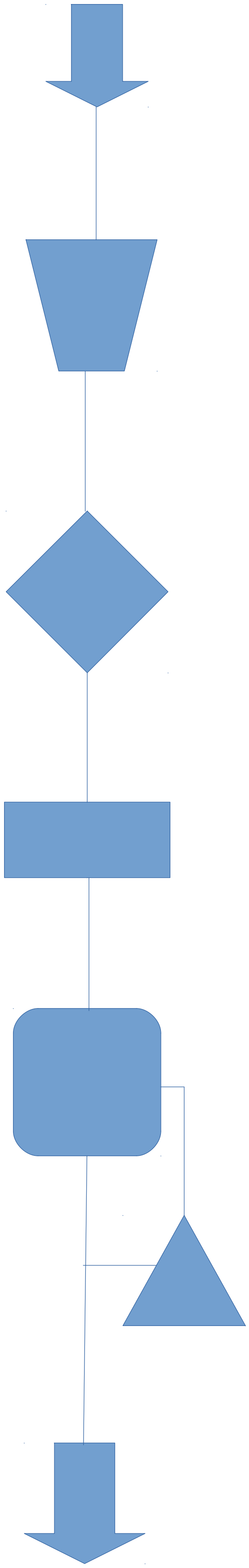
Contents:

Objectives:

Design and implement a modification to the unregulated AC-DC power supply constructed last quarter.

This modification should:

- Regulate the DC voltage to a stable output voltage
- Be unlikely to burn down my house, or electrocute my cat
- Earn a high grade on this project



AC In – AC power from the wall enters the Power Supply

Step-down Transformer – Reduces voltage from ~120 VAC to ~18 VAC

Bridge Rectifier – Conducts (+) alternations to one output, (-) to the other, Outputs rippled DC

Filter Capacitor – Stores Charge at peak voltage and releases it as the Bridge Rectifier output varies

Voltage Regulator – Maintains a steady voltage across its V(out) and Ground legs, even as the load varies

Voltage Adjustment – Lifts the Ground leg of the voltage regulator, can be adjusted to vary output voltage

Regulated DC Out – DC power exits the power supply to the load

Circuit Description:

AC Power from the wall enters the supply through the back of the case. It travels to the primary side of the transformer, where current through the coils builds a magnetic field; this magnetic field alternates as the current does. Through mutual inductance, this alternating magnetic field induces voltage across the coils in the secondary side of the transformer. The magnitude of the induced voltage is proportional to the voltage across the primary coils and the coil ratio of secondary to primary. With this supply 120 Volts AC across the primary is stepped down to about 18 Volts AC across the transformer secondary.

From the secondary side of the transformer, power travels to the AC input of the bridge rectifier. The bridge rectifier is a set of four diodes arranged to maintain consistent polarity across its outputs, even as the input polarity alternates.

While the polarity of the output voltage is consistent, its magnitude is not. It peaks when the voltage from the transformer secondary is at a (+)/(-) peak, and goes to zero when the voltage from the transformer secondary does. To stabilize the voltage a large 2.2mF capacitor is wired across the rectifier output. As the rectifier output ripples, the capacitor stores charge at peak voltage, and can release it as the voltage drops; in effect stabilizing the voltage near the peak voltage. Resistor 'R1' provides the filter capacitor with a low current discharge path, allowing the capacitor to discharge to a safe state when power is disconnected. The resistor is sized for an RC time constant of about three minutes.

While the circuit described thus far is sufficient for light, voltage insensitive loads, heavier or more sensitive loads would find the voltage stability unacceptable. Therefore, a voltage regulator is needed. The voltage regulator used (LM7805) has internal circuitry to feed a precise current through a reverse biased zener diode, producing a precise 5 volt zener voltage across the diode. This voltage is seen across the output and ground legs of the voltage regulator. The capacitor added across those legs filters out high frequency feedback from the internal circuitry.

The voltage regulator only regulates the voltage across its output and ground legs, not between the output leg and circuit ground. Therefore raising the voltage from the ground leg to the circuit ground, the voltage from the regulator's output leg to circuit ground is equally increased. The regulator also has a steady load state (quiescent) current of about 5mA out of the ground leg, passing that current through a resistor raises the voltage of the ground leg. However, as the load on the output is varied the ground leg current may fluctuate, and with it the regulator’s effective voltage. The resistor ‘R2’ provides a steady 25mA current from the regulator’s output leg to its ground leg; adding to, and washing out fluctuations in, the ground leg current, stabilizing the ground leg voltage. This voltage with the regulator’s voltage added on top is passed to the supply’s output.

Conclusion:

A modification to last quarter’s AC-DC power supply has been designed and implemented. It does regulate a stable output voltage. It is constructed such that it is unlikely to burn down my cat or electrocute my house. I am confident that it will also meet the final goal of earning a high grade.

Event Log:

10JAN – 15JAN2018	Research into LM78xx series regulators and variable regulators.
16JAN2018	Part Ordering
26JAN2018	Circuit assembly
27JAN2018	Part arrangement and case modification
28JAN2018	Final assembly and operation testing

Parts & Cost List:

ABS Project Case	$7.51
NEMA 5-15P IEC C13 Power Cord	$6.95
IEC C14 AC Power Jack	$0.86
16A 125Vac Rocker Switch	$0.52
Fuse & Fuse Holder	$0.36/KIT
110Vac – 12.6Vac Transformer	KIT
BTC Protoboard	$7.89
KBP2005G Bridge Rectifier	$0.51
2.2 mF Capacitor	KIT
82kOhm 1/4W resistor	KIT
LM7805CT Voltage Regulator	$0.95
100nF Capacitor	KIT
200Ohm 1/2W Resistor	$0.16
233Ohm 1/2W Resistor	$0.16
470OHM 1/2W Resistor	$0.13
1kOhm 1/2W Linear Potentiometer	$1.94
SP3T Toggle Switch	$6.85
Red & Black Output Terminals	$0.98
Connector Wires	KIT
TOTAL	$35.74