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Regulated Power Supply

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ABSTRACT

A dc power supply that maintains the output voltage constant irrespective of the fluctuations in ac mains or variations in load is known as s regulated power supply. A regulated power supply generally consists of a step down transformer, rectifier circuit, and filter circuit and some voltage devise connected to the input.

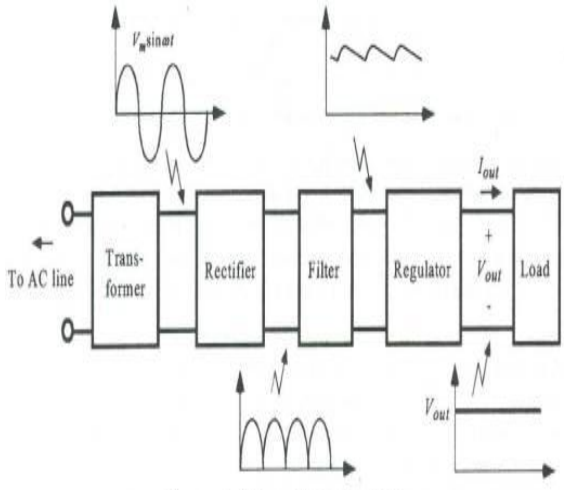
I.INTRODUCTION

Almost all electronic devices used in electronic circuits need a dc source of power to operate. The source of dc power is used to establish the dc operating points (Q-points) for the passive and active electronic devices incorporated in the system [1-2].

The dc power supply is typically connected to each and every stage in an electronic system. It means that the single requirement common to all phases of electronics is the need for a supply of dc power. For portable low-power systems batteries [3-4] may be used, but their operating period is limited. Thus for long time operation frequent recharging or replacement of batteries become much costlier and complicated [5-6].

More frequently, however, electronic equipment is energized by a power supply, derived from the standard industrial or domestic ac supply by transformation, rectification, and filtering [7-8].(The combination of a transformer, a rectifier and a filter constitutes an ordinary dc power supply, also called an unregulated power supply).

(i) Block Diagram



Components of a typical linear power supply

The block diagram of an ordinary power supply is depicted in the figure. Usually, a small dc voltage, in the range of 2—24 volts is required for the operation of different electronic circuits, while in India, single-phase ac supply is available at 230 V. So a small step-down transformer is used at the beginning which reduces the voltage level according to the needs. Next block is a rectifier which converts the sinusoidal ac voltage into pulsating dc [9-10]. In the last there is. a filter block which reduces the ripples (ac components) from the rectifier output voltage. The filter is a device which passes dc component to the load and blocks ac components of the rectifier output.

For many applications in electronics, unregulated power supply is not good enough because of the following reasons.

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1. Poor regulation. The output voltage is far from constant as the load varies. The internal resistance of an ordinary power supply is relatively large (more than 30 ohms). So output voltage is significantly affected by the magnitude of current drawn from the supply. The voltage drop in the internal resistance of the supply increases directly with an increase in load current.

2. Variations in the ac supply mains. The permissible variation in the ac supply mains voltage as per Electricity Rules is 6% of its rated value. But in some countries, the variations in ac mains voltage is much more than this (sometimes it may vary from 180 V to 260 V). The dc output voltage being proportional to the input ac voltage, therefore, varies largely.

3. Variations in temperature. The dc output voltage varies with temperature, particularly if semiconductor devices are employed.

These variations in dc output voltage may cause inaccurate or erratic operation or even malfunctioning of many electronic circuits. For instance, in oscillators the frequency will shift, in transmitters output will get distorted, and in amplifiers the operating point will shift causing bias instability.

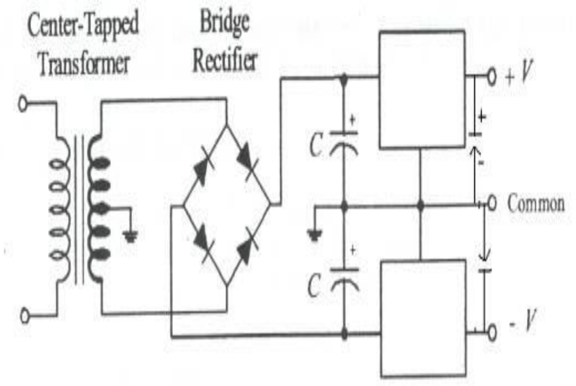
Some feedback arrangement (acting as a voltage regulator) is employed in conjunction with an unregulated power supply to overcome the above mentioned three shortcomings and also to reduce the ripple voltage. Such a system is called a regulated power supply.

In many applications, it is important to protect the power supply output against inadvertent short-circuits that might destroy either the circuit under test or operation of the supply itself. Thus current-limiting circuits are often incorporated into the regulator design.

Power supplies are becoming steadily more sophisticated in terms of performance objectives and application strategies. A commercial power supply is typically a complex system that makes use of ICs to reduce ripple, improve regulation, and widen control options. Programmable power supplies are also available to allow remote operation that is useful in many settings.

(ii) Circuit

Regulated power supply is an electronic circuit that is designed to provide a constant dc voltage of predetermined value across load terminals irrespective of ac mains fluctuations or load variations.



A regulated power supply essentially consists of an ordinary power supply and a voltage regulating device, as illustrated in the figure. The output from an ordinary power supply is fed to the voltage regulating device that provides the final output. The output voltage remains constant irrespective of variations in the ac input voltage or variations in output (or load) current.

Figure given below shows the complete circuit of a regulated power supply with a transistor series regulator as a regulating device. The ac voltage, typically 230 V_{rms} is connected to a transformer which transforms that ac voltage to the level for the desired dc output. A bridge rectifier then provides a full-wave rectified voltage that is initially filtered by a ∏ (or C-L-C) filter to produce a dc voltage. The resulting dc voltage usually has some ripple or ac voltage variation. A regulating circuit use this dc input to provide a dc voltage that not only has much less ripple voltage but also remains constant even if the input dc voltage varies somewhat or the load connected to the output dc voltage changes. The regulated dc supply is available across a voltage divider.

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CALCULATIONS

V_0= 0 to 30 V

I_0 = 1.0 A

I_{adj} = 100µA max

If we use R_1=240 ohm, then for V_0 of 1.2 volt, the value of R_2 from equation

$V_0=1.25(1+R_2/R_1)+(I_{adj})(R_2)$

$1.2=1.25(1+R_2/240)+(10^{-4})R_2$ R_2=2.02 KΩ

If V_0=30V

$30=1.25(1+R_2/240)+(10^{-4})R_2$ R_2 =5.4 KΩ

The main parts required for the construction of the variable regulated power supply are listed below along with their specifications:-

BR1 = Bridge Rectifier, 100V - 3A

IC1 = LM317, adjustable regulator

V = Meter, 30V, RI = 85 ohm

Plug = 3-wire plug & cord

TR1 = Transformer, 30V, 2A

R1 = 240 ohm, 5%

D1 = 1N4002

D2 = 1N4002

C= 1000 µF, 1 63V

C2 = 0.1 µF

C3 = 1µF

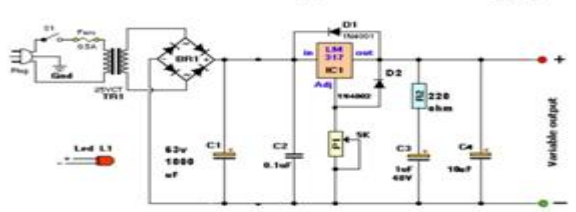
C4 = 10µF

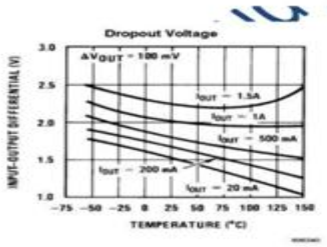
P1 = 5K, potentiometer

Fuse = 110V, 500mA, slow-blow, Fuse Holder, wire, solder, case, knob for P1 Red & Black Banana Jacks

CIRCUIT DIAGRAM & GRAPH

Variable Regulated Power Supply





II. WORKING PRINCIPLE

This is a simple, but low-ripple power supply and an excellent project if you're starting out in electronics. It will suit your needs for most of your bench testing and prototype applications.

The output is adjustable from 1.2 volts to about 30 volts. Maximum current is about 1.5 amps which is also sufficient for most of your tinkering. It is relatively easy to build and can be pretty cheap if you have some or all the required parts. A printed circuit board is not included and I'm not planning on adding one since the whole thing can easily be built on perforated or Vero board. Or buy one of Radio Shack/Tandy's experimenters' boards (#276-150). Suit yourself. The meter and the transformer are the money suckers, but if you can scrounge them up from somewhere it will reduce the cost significantly. BR1 is a full-wave bridge rectifier. The two '~' denotes 'AC' and are connected to the 25vac output coming from the transformer.

IC1 is a 3-pin, TO-220 model. Be sure to put a cooling rib on IC1, at its max 1.5 a current it quickly becomes very hot. All the parts can be obtained from your local Radio Shack or Tandy store. The physical size of the power supply case depends largely on the size of the meter & transformer. But almost anything will do. Go wild.

III. CIRCUIT DESCRIPTION

For any circuit to study or construct, first of all we need to have a translucent picture of our required circuit. We must have all the details of the inputs and outputs of the circuit so that there must be no error while constructing the given circuit. So in the following paragraph there is a detailed description of the circuit to be done**.**

The 110V-AC coming from the power cord is fed to the transformer TR1 via the on-off switch and the 500mA fuse. The 30vac output (approximately) from the transformer is presented to the BR1, the bridge-rectifier, and here rectified from AC (Alternating Current) to DC (Direct Current). If you don't want to spend the money for a Bridge Rectifier, you can easily use four general purpose 1N4004 diodes. The pulsating DC output is filtered via the 2200µF capacitor (to make it more manageable for the regulator) and fed to 'IN'-put of the adjustable LM317 regulator (IC1). The output of this regulator is your adjustable voltage of 1.2 to 30volts varied via the 'Adj' pin and the 5K pot meter P1. The large value of C1 makes for a good, low ripple output voltage.

Why exactly 1.2V and not 0-volt? Very basic, the job of the regulator is two-fold; first, it compares the output voltage to an internal reference and controls the output voltage so that it remains constant, and second, it provides a method for adjusting the output voltage to the level you want by using a potentiometer. Internally the regulator uses a zener diode to provide a fixed reference voltage of 1.2 volt across the external resistor R2. (This resistor is usually around 240 ohms, but 220 ohms will work fine without any problems). Because of this the voltage at the output can never decrease below 1.2 volts, but as the potentiometer (P1) increases in resistance the voltage across it, due to current from the regulator plus current from R2, its voltage increases. This increases the output voltage.

D1 is a general purpose 1N4001 diode, used as a feedback blocker. It steers any current that might be coming from the device under power around the regulator to prevent the regulator from being damaged. Such reverse currents usually occur when devices are powered down.

The 'ON' Led will be lit via the 18K resistor R1. The current through the led will be between 12 - 20mA @ 2V depending on the type and color Led you are using. C2 is a 0.1µF (100nF) de-coupler capacitor to filter out the transient noise which can be induced into the supply by stray magnetic fields. Under normal conditions this capacitor is only required if the regulator is far away from the filter cap, but I added it anyway. C3 improves transient response. This means that while the regulator may perform perfectly at DC and at low frequencies, (regulating the voltage regardless of the load current), at higher frequencies it may be less effective. Adding this 1 µF capacitor should improve the response at those frequencies.

R3 and the trimmer pot (P2) allows you to 'zero' your meter to a set voltage. The meter is a 30Volt type with an internal resistance of 85 ohms. I you have or obtained a meter with a different Ri (internal resistance) you will have to adjust R3 to keep the current of meter to 1mA.

Just another note in regards this meter, use the reading as a guideline. The reading may or may not be off by about 0.75volts at full scale, meaning if your meter indicates 30 volts it may be in reality almost 31 volts or 29 volts.

If you need a more precise voltage, then use your multi meter.

IV. CONSTRUCTION

Construction has always been the most essential segment for any circuit to be done. All the theoretical knowledge that we possess are implemented in the construction of the circuit. Like, I said earlier we have to be very clear about all the nuances of the circuit, and then only we will be successful in making a flawless circuit. So in following paragraph there is a detailed description of the construction of our circuit.

Because of the few components we can use a small case but use whatever we have available. We used a power cord from a computer and cut the computer end off. All computer power cords are three-prong. The ground wire, which is connected to the middle pin of the power plug is connected to the chassis. The color of the ground-wire is either green or green/yellow. It is there for your protection if the 110vac accidentally comes in contact with the supply housing (case). BE CAREFUL always to disconnect the power plug when you working inside the chassis. If we choose to use an in-line, or clip-type fuse holder be sure to isolate it with heat shrink or something to minimize accidental touching.

I use perf-board (or Vero board) as a circuit board. This stuff is widely available and comes relatively cheap. It is either made of some sort of fiber material or Phenolic or Bakelite pcb. They all work great. Some Phenolic boards come with copper tracks already on them which will make soldering the project together easier.

I mounted the LM 317(T) regulator on a heat sink. If you use a metal/aluminum case you can mount it right to the metal case, insulated with the mica insulator and the nylon washer around the mounting screw. Note that the metal tab of the LM317 is connected internally to the 'Output' pin. So it has to be insulated when mounting directly to the case. Use heat sink compound (comes in transparent or white color) on the metal tab and mica insulator to maximize proper heat transfer between LM317 and case/ or heat sink.

Drill the holes for the banana jacks, on/off switch, and LED and make the cut-out for the meter. It is best to mount everything in such a way that you are able to trouble-shoot your circuit board with ease if needed. One more note about the on-off switch S1, this switch has 110VAC power to it. After soldering, insulate the bare spots with a bit of silicon gel. Works great and prevents electrical shock through accidental touching.

If all is well, and we are finished assembling and soldering everything, then we must check all the connections. After checking the connections, checking of the capacitors C1 & C3 for proper polarity (especially for C1, polarity reversal may cause explosion) should be done. Hookup a multi meter to the power supply output jacks.

Set the meter for DC volts. Switch on S1 (led will light, no smoke or sparks?) and watch the meter movement. Adjust the potentiometer until it reads on your multi meter 15Volts. Adjust trim pot P2 until the meter also reads 15volts. When done, note any discrepancies between your multi meter and the power supply meter at full scale (max output). Maybe there is none, maybe there is a little, but you will be aware of it.

V. CONCLUSION

For many, power supplies are unfortunately still not considered an important component, but this attitude is definitively a mistake. Power supplies deliver the voltage to each and every single component in the PC and make them work. It is the heart of the system and the provided electricity works like blood in the human body. If the delivered electricity is faulty or unstable it can ruin even the greatest high-end rig instantly. It is important that readers understand the importance of power supplies in today's PCs and we will do our part from now on to deliver the necessary tests. In addition we will explore the manufacturers themselves; good quality starts with a good engineering team that develops upcoming power supplies. We will visit the offices and factories of the manufacturers to show how and where power supplies are made.

VI. FUTURE SCOPE

LM 317 has many future prospects. By using LM 317 we can easily overcome the noise effect of the circuit and by changing the load resistance and voltage the noise effect can further be diminished. So that we get an error free output voltage. In other words LM 317 is highly proficient in making a circuit error free and flawless.

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