Designing and Development of combined +-5V and +-12V Regulated Power Supply

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Abstract—This is a simple approach to obtain a 12V and 5V DC power supply using a single circuit. The circuit uses two ICs 7812(IC1) and 7805 (IC2) for obtaining the required voltages. The AC mains voltage will be stepped down by the transformer T1, rectified by bridge B1 and filtered by capacitor C1 to obtain a steady DC level .The IC1 regulates this voltage to obtain a steady 12V DC. The output of the IC1 will be regulated by the IC2 to obtain a steady 5V DC at its output. In this way both 12V and 5V DC are obtained.
Such a circuit is very useful in cases when we need two DC voltages for the operation of a circuit. By varying the type number of the IC1 and IC2, various combinations of output voltages can be obtained. If 7806 is used for IC2, we will get 6V instead of 5V.Same way if 7809 is used for IC1 we get 9V instead of 12V.
The project ”Designing and development of combined +- 5v and +- 12v regulated power supply” can be used to power up TTL and CMOS based projects, it provides 5 VDC & 12 VDC outputs with an onboard mains transformer. The project is based on the industry popular 7800 series voltage regulator in TO220 packages

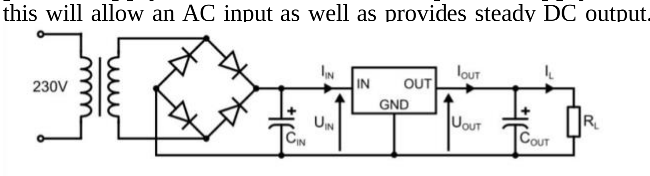
Keywords— Transformer, regulated power supply, rectifier, filter

I. Introduction

We know that there are different types of electrical & electronic circuits which use a DC power supply. Universally, we cannot use the DC batteries due to expensive as well as require replacement when discharged. In this situation, we require a circuit which can change AC supply to DC supply. A rectifier filter circuit includes a normal **DC power supply**. The normal DC power supply o/p remains stable if the load is contrast. Although in several electronic circuits it is extremely significant to maintain the DC power supply constant irrespective of alternative AC supply. Otherwise, the circuit will get damage. To overcome this problem, voltage regulating devices can be used. So the blend of the voltage regulating devices by the normal dc power supply is named as **DC regulated power supply**. This is an electrical device, used to generate the steady DC supply irrespective of alternative AC supply.

II. Regulated Power Supply

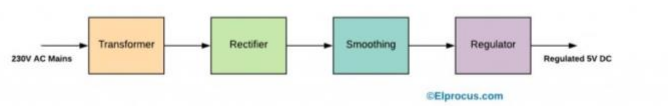
The **IC Regulated power supply (RPS)** is one kind of electronic circuit, designed to provide the stable DC voltage of fixed value across load terminals irrespective of load variations. The main function of the regulated power supply is to convert an unregulated alternating current (AC) to a steady direct current (DC). The RPS is used to confirm that if the input changes then the output will be stable. This power supply is also called a linear power supply, and this will allow an AC input as well as provides steady DC output.



Regulated Power Supply Circuit

Block diagram for Regulated Power Supply

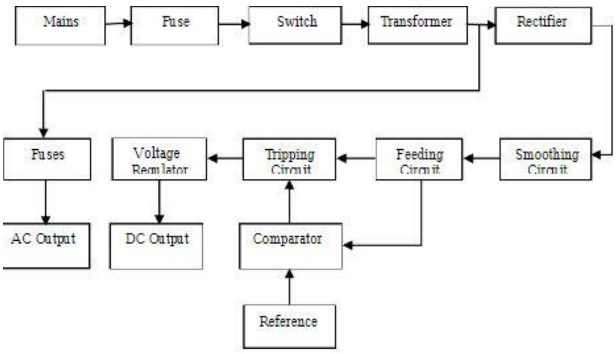
The **block diagram of a regulated power supply** mainly includes a **step-down transformer**, a rectifier, a DC filter, and a regulator. The **Construction & working of a regulated power supply** is discussed below.



Regulated Power Supply Block Diagram

III. BASIC OVERVIEW OF THE DEVELOPMENT POWER SUPPLY

The requirement of regulated DC and AC power supplies differ widely among the various electrical and electronic devices. The main characteristics that need to be considered in the design of a regulated power supply are the output DC voltage (V_{dc}), maximum current (I_{max}) required by the load, the tolerance level and the percentage regulation(%Reg) allowable [1,2,4,5]. In addition, the AC output level needed by the load must also be considered for the case of a multi-output power supply. Figure 1 shows the generalized block diagram of the designed multi-output power supply unit. Each block in the diagram represents a section of the circuit that carries out a specific function. The functional block diagram of figure 1 also shows the interconnection between these blocks.



The basic and integral components of the block diagram in figure 1 above are briefly described below.

- **The Transformer**-The centre-tap transformer initially takes the input supply from AC mains voltage of 220Vand steps it down to a lower voltage level of 30V (15V-0-15V). However, after construction, the desired voltage range was obtained at the output. When it comes to the operation voltage, the step-up transformer application can be roughly divided into two groups: LV (voltages up to 1kV) and HV application (voltages above 1 kV).Just as transformers can step down the voltage – going from a higher primary side voltage to a lower secondary side voltage they can also step up the voltage, going from a lower primary side voltage to a higher secondary side voltage. These are known as step-up transformers.The transformer turns ratio (n) for a step down transformer is approximately proportional to the voltage ratio:

$$n = \frac{V_P}{V_S} = \frac{N_P}{N_S}$$

- **The Rectifier** In electronics, Rectifier circuit is the most used circuit because almost every electronic appliance operates on DC (Direct Current) but the availability of the DC Sources are limited such as electrical outlets in our homes provide AC (Alternating current)**.** The rectifier is the perfect candidate for this job in industries & Home to convert AC into DC. Even our cell phone chargers use rectifiers to convert the AC from our home outlets to DC**.** Different types of Rectifiers are used for specific applications.

  We mainly have two types of voltage types present that are widely used these days. They are alternating and direct voltage types. These voltage types can be converted from one type to another using special circuits designed for that particular conversion. These conversions happen everywhere.

  Our main supply which we get from power grids are alternating in nature and the appliances we use in our homes generally require a small DC voltage. This process of converting alternating current into direct current is given the name rectification. Converting AC to DC is preceded by further process which can involve filtering, DC-DC conversion and so on. One of the most common part of an electronic power supply is a bridge rectifier.

  Many electronic circuits require rectified DC power supply for powering various electronic basic components from available AC mains supply. The simple bridge rectifier is used in a variety of electronic AC based power devices.

  Another way to look at the rectifier circuit is that, it can be said to convert currents instead of voltages. This makes more intuitive sense, because we are more accustomed to using current to define a component's nature. Concisely, a rectifier take a current which has both negative and positive components and rectifies it such that only the positive component of the current remains.

- **The Filter-** The ripple in the signal denotes the presence of some AC component. This ac component has to be completely removed in order to get pure dc output. So, we need a circuit that smoothens the rectified output into a pure dc signal.A filter circuit is one which removes the ac component present in the rectified output and allows the dc component to reach the load.The following figure shows the functionality of a filter circuit.

- **The voltage Regulator-** This is the stage that delivers a stabilized DC voltage to the output as set by the control unit. The regulator circuit provides a fixed voltage for stable calibrated DC output voltages. Usually zener diodes and transistors are used for voltage regulation purposes Electronic voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and other elements. In automobile alternators and central power station generator plants, voltage regulators control the output of the plant. In an electric power distribution system, voltage regulators may be installed at a substation or along distribution lines so that all

IV. Characteristics of RPS

The quality of the power supply can be decided by the several factors namely load current, voltage, source and voltage regulation, ripple rejection, o/p impedance, etc. Some of the factors are explained below.

- **Load Regulation**

The load regulation is also known as a load effect. This can be defined as whenever the load current alters from lowest to highest value then the output of the regulated voltage will be changed. This can be calculated by using the following equation.

Load regulation = Vno load – Vfull load

From the above load regulation equation, we can conclude that whenever no-load voltage happens then the load resistance will be unlimited. Similarly, whenever full load voltage happens then the load resistance will be the lowest value. So the voltage regulation will be lost.

% of Load Regulation = (Vno load – Vfull load)/(Vfull-load) X 100

- **Lowest Load Regulation**

The load-resistance on which a current supply supplies its full-load charged current by rated voltage can be called as the lowest load resistance.

Lowest Load Resistance = Voltage full load / Current full-load

- **Line our Source Regulations**

In the power supply block diagram, the input voltage is 230 Volts however in practice; there are significant differences within the AC supply mains voltage. As this mains supply voltage is i/p to the normal power supply, the bridge rectifier's filtered o/p is approximately directly proportional toward the AC mains voltage. The source regulation can be defined as the modify in regulated o/p voltage for a particular range of low voltage.

- **Output Impedance**

The output resistance of the regulated power supply is very small. Although the exterior load resistance can be changed, approximately no change can be seen within the load voltage. The o/p impedance of a perfect voltage source is zero

- **Ripple Rejection**

The voltage regulators fix the o/p voltage against the input voltage variations. Ripple is equal to a periodic difference within the i/p voltage. Thus, a voltage regulator satisfies the ripple that approaches with the unregulated i/p voltage. Because a voltage regulator utilizes -ve feedback, the distortion can be decreased with a similar factor as the gain.

V. Designing of 5v regulated DC

The major sections of the regulated dc supply are rectification, smoothing, control and voltage regulation as shown in the block of figure (1) above. This applies to all the regulated power supplies that are designed in this work.

The rectification section employs bridge rectification that comprises of four (4) diodes IN4007 while the smoothing was carried out using two 1000μF 50V capacitors. Since the desired regulated output voltage is 5V, input of 10V was used in the design to cater for instance of low voltage in the 5V output design since at least 7V is required for the LM7805 regulator according to data sheet. Using equation (2) adapted from [7], we obtain the root mean square value of the maximum possible rectified voltage after smoothing as shown in equation

$$Vms = V\sqrt{2} - Va \qquad (2)$$

Where V = Input voltage to the rectifier

Vd = Forward voltage of the diode

In this case V=10V and V_d = 2 X 0.7 =1.4 (since there are two diodes involved in each cycle).

Therefore,

$$Vrms = 10\sqrt{2} - 1.4 = 12.47\ v$$

At 220V ac supply into the transformer, the maximum possible rectified voltage after smoothing is 12.78V. The limit of the input for maximum input voltage is 35V.

At the comparator section, R3 is the voltage dropper or current limiter. D5 is a zener diode = $5V_1$ as a reference.
When the comparator input is high then, the output voltage of the comparator ($V_{control}$) is low and the switch is ON.
When $V_{control}$ is high, the switch is OFF.
As shown in figure 3, a Darlington pair was used in the switching to boost the current R4 and R6 are the bias

resistors. It turns ON if the V_{BE} is -0.6V at Q2 since PNP transistors were used.

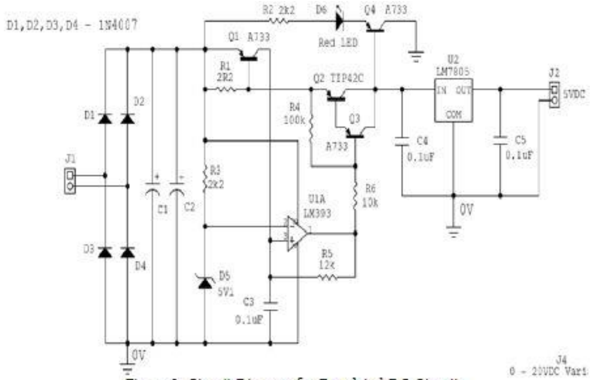


Figure 3: Circuit Diagram for Regulated DC Circuit

V. Tripping Circuit

The tripping circuit is incorporated in figure 3. The resistor R1(2R2) develops a voltage proportional to the amount of current flowing through it. This voltage is sensed by the comparator U1A(LM393) through transistor Q1(A733) and compared to the 5.1V zener voltage reference of D5. When the reference voltage is exceeded the output of the
consequently appears at the collector of the Darlington pair switches on transistor Q4(A733) and thus, there is a current path through its emitter to its collector which results in the glowing of the indicator LED D6. The LED turns ON only when the switch is off that is, when the supply has tripped. R2 was used as current limiter for the LED. C4 and C5 were used to suppress transient effects on the input and the output respectively of the regulator. This tripping circuit is also incorporated in each of the DC segment of figures 4 and 5

VI. Designing of Circuit

- **Step 1: The selection of Regulator IC-** The selection of a regulator IC depends on your output voltage. In our case, we are designing for the 5V output voltage, we will select the LM7805 linear regulator IC.Next thing is, we need to know voltage, current and power ratings of selected regulator IC.This is done by using the datasheet of regulator IC. Following are the ratings, pin diagram for LM7805.

Datasheet of 7805 also prescribes to use a 0.1μF capacitor at the output side to
avoid transient changes in the voltages due to changes in load.And a 0.1μF at the input side of the regulator to avoid ripples if the filtering is far away from the regulator

- **Step 2 : The selection of Transformer**

The right transformer selection means saving a lot of money. We got to know, the minimum input to our selected regulator IC is 7V. So, we need a transformer to step down the main AC to at least this value.But, between the regulator and transformer, there is a diode bridge rectifier too. The rectifier has its own voltage drop across it, i.e. 1.4V. We need to compensate for this value as well.

- **Step 3 : Selection of Diodes for brigde**

You see, the rectifier is made by arranging diodes in some pattern. To make rectifier we need to select proper diodes for it. When selecting a diode for the bridge circuit.Keep in mind the output load current, and maximum peak secondary voltage of the transformer i-e 9V in our case. Instead of individual diodes, you can also use one individual bridge that comes in the IC package.But I don't want you to use here, just for purpose of learning and playing with individual diodes.

- **Step 4: The Selection of Smoothing capacitor and Calculations**

Things we need to keep in mind while selecting a proper capacitor filter are, its voltage, power rating, and capacitance value. T
he voltage rating is calculated from the secondary voltage of a transformer. Rule of thumb is, the capacitor voltage rating must be at least 20% more than the secondary voltage.So, if the secondary voltage is 17 V (Peak value), then your capacitor voltage rating must be at least 50V.Second, we need to calculate the proper capacitance value. It depends upon the output voltage and the output current. To find the proper value of capacitance, use the formula below:

$$C = \frac{I_o}{2\Pi f V_o}$$

Where,

Io = Load current i-e 500mA in our design, Vo = Output voltage i-e in our case 5V, *f = Frequency*

In our case:

$$C = \frac{500mA}{2\times\Pi\times50\times5} = 3.1847\times10^{-4}$$

Frequency is 50Hz because in our country mains AC is 220 @ 50Hz. You might have 120V @ 60Hz mains AC. If so then put the values accordingly. Then by using capacitor formula, the practical standard close to this value i-e 3.1847E-4 is 470uF.

Another important formula from the book "Electronic Devices by Thomas L. Floyd" is listed below. This can also be used to calculate the capacitor value.

$$C = \frac{2+(Rf)}{2(Rf)fR}$$

In this case, R is load resistance. And Rf is ripple factor, which should be less than 10% for a good design. And with this, we just finish designing 5V power supply.

VII. Advantages

A supply with regulated output has many advantages. Following are of the key importance.

- • low noise levels
- • low-cost
- • simplicity
- • reliability

Regulated power supply are very simple to design, you might have felt it. Simple design makes it very cost effective. These power supplies have low cost and are very reliable.

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VII..Conclusion

The project "**Development and Designing of combined +-5v and +-12v regulated Power Source"** is successfully tested and implanted

VIII. Reference

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