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Design and Development of Stabilized Regulated Fixed and Variable DC Power Supply Unit (PSU) With Short Circuit Protection

Khaya Joshua Manda
Department of Engineering, School of Engineering, Information and Communications University, Lusaka, Zambia

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Corresponding Author: **Khaya Joshua Manda**

Abstract
A Fixed Regulated Power Supply, a Variable Regulated Power Supply and a Dual Regulated Power Supply are constructed by using transformers, Diodes, Capacitors, ICs and Variable resistors. Therefore, the purpose of this study is to design and develop a Variable Voltage Power Supply from Fixed Voltage Regulator that is single and dual power supply with a voltage of 5 V fixed DC, 0.25V to 15.0V variable DC, +12 V and -12V dual power supply and current range of 0 to 1Amps, power 45W with a very low output impedance of 0.010ohms with short circuit protection. This project report will be approached primarily by literature and practical research. Focusing firstly on gaining a wide and comprehensive understanding of the chosen study area, a literature review was completed. Results found also showed the load and line regulation characteristics of a constructed power supply so as to determine its stability by comparing it with standard power supply unit. Testing of constructed power supply unit to power loads (Rheostat) of 120ohms 1A and 10ohms 0.5A. The major components used include step down transformers (Input 230V AC, Output 12V AC, Output 24V AC), 1N4007 Diodes, Capacitors, ICs (7805 IC, 7812 IC, 7912 IC and LM317 IC,) and fixed & Variable resistors i.e. potentiometer, transistors. The developed power supply is tested for its functionality and the measured values are compared with nominal designed values. The designed power supply is much useful in measurements, laboratory works and general applications requiring power supply.

Keywords: FRPS; Fixed Regulated Power Supply, Variable Regulated Power Supply, Dual Regulated Power Supply

1. Introduction

1.1 Background

This Chapter will discuss introduction, Motivation and significance of this study, scope of the study, problem statement, research objectives, Organization of the thesis and the summary. Power supplies are used in all types of digital displays and cathode ray tube (CRT) colour display. Any equipment that has electronic circuits in it must have a DC supply voltage available. Since all power in the factory originates as an AC voltage, converters must be used in the power supplies to convert an AC to DC power. The regulated power supplies are typically used with circuits containing linear integrated with circuit elements. It is necessary to supply DC at various voltages to the whole or a part of electronic equipment. The power source is usually the main electricity supply of 220V AC. The voltage regulator is also used to offer fixed voltage at the output terminal and does not depend upon the input voltage supplied. Voltage regulator has three terminals. 78XX and 79XX are the two series available for the voltage regulator in the market. 78XX series of the voltage regulator is for the positive voltage supply i.e. if we have a need of +5V then 7805 voltage regulator is being used. While 79XX series is for negative supply, i.e. if there is a need of -5V then 7905 regulators are used. There is a large variety of power supplies available in the market i.e. 6V, 9V 12V etc. Voltage regulator be capable of resisting over current drawn due to short circuit or overheating. Before the damage occurs, it will cut off the circuit. But while maintaining voltage regulator in any circuit extra care is needed to be taken because if the regulator mounts in reverse polarity it will get damaged, (S Barkowitz 2003) [25].

1.2 Motivation of the study

Most power lines carry an effective AC voltage of 220V with the frequency of 50Hz. The energy from the wall outlet is practically limited, therefore, it must be converted from the alternating current (AC) to direct current (DC) and tailored to permit the right voltage suitable for electronic equipment. This can be achieved by using a DC power supply unit (Power

Supply Unit or PSU). The PSU is a device that supplies electrical power to a device or group of devices. The term is most commonly applied to units that are integrated with the devices they supply power to, such as computers and household electronics. Usually, the PSU used in the laboratory for experimental purpose is called a laboratory bench supply. It is a variable output power supply unit that can supply either a uni- or bi-polar power to the load connected.

1.3 Scope of study

This study was limited to Zambia and it focused on the role of Variable Voltage Power Supply Unit (PSU) from a fixed voltage regulator to System components, design and operation by developing a prototype.

1.4 Problem statement

In most developing countries, like Zambia, the electricity from the power grid is an alternating current (AC). Most walls outlets carry an effective AC voltage of 220V with the frequency of 50Hz. The energy from the wall outlet is practically limited, but it must be converted from the alternating current (AC) to direct current (DC) and tailored to permit the right voltage suitable for electronic equipment. This can be achieved by using a DC power supply unit (Power Supply Unit or PSU). The PSU is a device that supplies electrical power to a device or group of devices. The term is most commonly applied to units that are integrated with the devices they supply power to, such as computers and household electronics. Usually, the PSU used in the laboratory for experimental purpose is called a laboratory bench supply. It is a variable output power supply unit that can supply either a uni or bi-polar power to the load connected. The need to carry out experiments on electronic devices to ascertain their characteristics and specifications is mandatory. This makes the bench power supply important equipment in the laboratory for testing low power devices. Therefore, there is great need to undertake this research study.

1.5 Objectives of the project

1.5.1 Main objective

The main objective of this project is to design and develop a Variable Voltage Power Supply Unit from Fixed Voltage Regulator.

1.5.2 Specific objectives

1. To design the circuit for the bridge rectifier.
2. To design the for circuit for the voltage regulator
3. To install power transformer that will regulate energy levels to desired values.

1.6 Research questions

1. What is the function of the circuit for the bridge rectifier?
2. How do you assemble the circuit for the voltage regulator?
3. How do you install power transformer that will regulate energy levels to desired values?

1.7 Organization of the thesis

This thesis has five chapters organized as follows;

Chapter one discusses introduction, Motivation and significance of study, scope of study, problem statement, objectives, Organization of the thesis and the summary. Chapter two discusses introduction, Review literature and related works. Chapter three discusses introduction, Methodology and system components and summary. Chapter four discusses introduction, design, operation, calculation and summary. Finally, Chapter five has the conclusion and recommendations, references and appendix.

1.8 Summary

This Chapter has discussed introduction, Motivation and significance of this study, scope of this study, problem statement, and research objectives, Organization of the thesis and the summary of this chapter.

2. Literature Review

2.0 Introduction

This chapter will provide the literature review of a variable voltage power supply unit from a fixed voltage regulator with the following approach; voltage power supply unit background, four main renewable energy forms, Effect of climate on hydrogenation, Why solar power generation, Solar as an alternative through policy papers that analyze the effect of government policies and social-psychological, focus on consumer motivations to purchase solar systems and other related works technical papers dealing with a specific aspect of the technology, method of installment, or feasibility**.**

2.1 Review of the literature

2.1.1 Background

Ever since the start of the miniaturization era spurred on by the microelectronics revolution in the late fifties and early sixties, power conversion equipment employed in computer and telecommunication power systems has been facing continuously increasing power density and efficiency challenges. However, it was not until the introduction of high-voltage bipolar power transistors in the late sixties, which made replacing linear power supplies with high frequency switch-mode power supplies possible, that a real opportunity for decreasing the size and weight and increasing the efficiency of power conversion circuits had been created. Generally, linear power supply technology does not offer any significant opportunity for weight and size reduction because the size and weight are mainly determined by a line-frequency transformer and heatsink. Moreover, the opportunities to improve the efficiency are also very limited because the efficiency of linear power supplies is determined solely by the ratio of the output and input voltage. On the other hand, switch-mode power supply technology offers a significant size and weight reduction because it eliminates the need for bulky line frequency magnetics and also decreases the size of heatsinks due to a much-improved efficiency compared to that of linear power supplies. Generally, the efficiency and size optimization of switch-mode power supplies is based on finding a switching frequency where the trade-off between the conduction and switching losses is optimized.

Although switch-mode power supply technology has brought about dramatic power density improvements compared to linear power supply technology, further power density increases were enabled by the introduction of power MOSFET devices in the early and mid-seventies. MOSFET technology together with advancements in power magnetics made it possible to significantly increase the switching frequency and, thus, reduce the size of magnetic components. While the frequency ranges of early switch mode power supplies implemented with bipolar power devices was limited to several kilohertz, MOSFET devices have allowed for switching frequencies to be pushed into the hundred-kilohertz and even megahertz range. Because the maximum switching frequency of a power converter is related to its output power level, input voltage range, and galvanic isolation requirements, the typical switching frequency range of dc-dc converters is higher than that of off-line converters.

today's low-power, non-isolated voltage regulators (VRs) and point-of load (POL) converters whose input voltage is in the 5-V to 12-V range operate at switching frequencies in excess of 1 MHz, whereas ac-dc converters that require transformer isolation and whose rms line voltage is from 90 V to 265 V typically operate with switching frequencies in the 80-200-kHz range. Historically, the major improvements of power densities first occurred in dc-to-dc converters in the mid-eighties with the introduction of a family of high-frequency dc-dc modules by Vicor Corporation. Employing a proprietary zero current switching quasi-resonant technology that had enabled the operation in the megahertz range together with advanced packaging, Vicor managed to push the power density of 48-V input dc/dc modules, also known as "bricks," into an unprecedented power density range of 10-20 W/in3. This increasing power-density trend has been sustained ever since so that today's dc/dc "bricks" can deliver much more power from the same volume, or the same power from a much smaller volume. It should be noted that for low output-voltage bricks, specifically for those with output voltage 3.3 V and below, a more appropriate metrics for the brick capability is the maximum output current rather than the maximum output power, i.e., power density. Off-line power supplies did not see a dramatic change in power density until the beginning of the rapid growth of the Internet in the late nineties that has led to an unprecedented escalation in the employment of data-processing, networking, and storage equipment and has created strong demand for equipment and, therefore, for power supplies with much higher power densities, (D.W Smith 2002).

Until recently, efficiency increases of power conversion circuits were primarily driven by increased power density requirements since power density increases are only possible if appropriate incremental improvements in full load efficiency are achieved so that the thermal and acoustic performance are not adversely affected. As a result, maximization of the full-load efficiency has been a design focus all along. However, in the early nineties, the explosive growth of consumer electronics and data processing equipment had prompted the introduction of various, mostly voluntary, requirements aimed at minimizing the output voltage. light-load, power consumption. Meeting these ever-stringent light-load efficiency requirements, most notably those defined in German Blue Angle, U.S. Energy Star, Japan Top Runner, and ECoC (European Code of Conduct) specifications, pose major design challenges to power supply manufacturers. As a result, significant R&D resources have been dedicated by both power supply manufacturers and control IC providers to developing technologies to comply with these specifications. Today, the power supply industry is at the beginning of a major focus shift that puts efficiency improvements across the entire load range in the forefront of customers' performance requirements. This focus on efficiency has been prompted by economic reasons and environmental concerns caused by the continuous, aggressive growth of the Internet infrastructure and a relatively low energy efficiency of power delivery systems of large Internet-equipment hosting facilities.

2.2 Different types of voltage regulators with working principle

A voltage regulator is used to regulate voltage levels. When a steady, reliable voltage is needed, then the voltage regulator is the preferred device. It generates a fixed output voltage that remains constant for any changes in an input voltage or load conditions. It acts as a buffer for protecting components from damages, (P Horowitz and W Hill 1980).

A voltage regulator is a device with a simple feed-forward design and it uses negative feedback control loops. There are mainly two types of voltage regulators, Linear voltage regulators and switching voltage regulators; these are used in wider applications.

The linear voltage regulator is the easiest type of voltage regulator. It is available in two types, which are compact and used in low power, low voltage systems. Let us discuss different types of voltage regulators.

Types of Voltage Regulators and Their Working Principle

Basically, there are two types of Voltage regulators, Linear voltage regulator and Switching voltage regulator. There are two types of Linear voltage regulators that is Series and Shunt. And there are three types of Switching voltage regulators, Step up, Step down and Inverter voltage regulators.

2.2.1.1 Linear regulator

Linear regulator acts as a voltage divider. In the Ohmic region, it uses FET. The resistance of the voltage regulator varies with load resulting in constant output voltage.

Advantages of a linear voltage regulator

- Gives a low output ripple voltage
- Fast response time to load or line changes
- Low electromagnetic interference and less noise.

Disadvantages of the linear voltage regulator

- Efficiency is very low
- Requires large space – heatsink is needed
- Voltage above the input cannot be increased
- Series Voltage Regulator.

A series voltage regulator uses a variable element placed in series with the load. By changing the resistance of that series element, the voltage dropped across it can be changed. And, the voltage across the load remains constant.

The amount of current drawn is effectively used by the load, this is the main advantage of the series voltage regulator. Even when the load does not require any current, the series regulator does not draw full current. Therefore, a series regulator is considerably more efficient than shunt voltage regulator.

2.2.1.2 Shunt voltage regulator

A shunt voltage regulator works by providing a path from the supply voltage to ground through a variable resistance. The current through the shunt regulator has diverted away from the load and flows uselessly to the ground, making this form usually less efficient than the series regulator. It is, however, simpler, sometimes consisting of just a voltage-reference diode, and is used in very low-powered circuits wherein the wasted current is too small to be of concern. This form is very common for voltage reference circuits. A shunt regulator can usually only sink (absorb) current.

2.2.1.2.1 Applications of shunt regulators

- Shunt regulators are used in;
- Low Output Voltage Switching Power Supplies
- Current Source and Sink Circuits
- Error Amplifiers.
- Adjustable Voltage or Current Linear and Switching Power Supplies Voltage Monitoring
- Analog and Digital Circuits that require precision references Precision current limiters.

2.2.1.3 Switching voltage regulator

A switching regulator rapidly switches a series device on and off. The switch's duty cycle sets the amount of charge transferred to the load. This is controlled by a feedback mechanism similar to that of a linear regulator. Switching regulators are efficient because the series element is either fully conducting or switched off because it dissipates almost no power. Switching regulators are able to generate output voltages that are higher than the input voltage or of opposite polarity, unlike linear regulators. The switching voltage regulator switches on and off rapidly to alter the output. It requires a control oscillator and also charges storage components.

In a switching regulator with Pulse Rate Modulation varying frequency, constant duty cycle and noise spectrum imposed by PRM vary; it is more difficult to filter out that noise. A switching regulator with Pulse Width Modulation, constant frequency, varying duty cycle, is efficient and easy to filter out noise.

In a switching regulator, continuous mode current through an inductor never drops to zero. It allows the highest output power. It gives better performance. In a switching regulator, discontinuous mode current through the inductor drops to zero. It gives better performance when the output current is low.

2.2.1.3.1 Switching topologies

It has two types of topologies, Dielectric isolation and non-isolation.

2.2.1.3.2 Non-isolation

It is based on small changes in Vout/ Vin. Examples are Step Up voltage regulator (Boost), Raises input voltage, Step Down (Buck) lowers input voltage, step up/ Step Down (boost/ buck) Voltage regulator Lowers or raises or inverts the input voltage depending on the controller. Charge pump It provides multiples of input without using inductor on the other hand Williams, B.W. 2002.

2.2.1.3.3 Dielectric isolation

It is based on radiation and intense environments.

Advantages of switching topologies

- Efficiency
- Size
- Weight
- More complex design, capable of handling higher power efficiency.
- Switching voltage regulator can provide output, which is greater than or less than or that inverts the input voltage.

Disadvantages of switching topologies

- Higher output ripple voltage.
- Slower transient recovery time.
- EMI produces very noisy output.
- Very expensive.

2.2.1.4 Step-up voltage regulator

Step-up switching converters also called boost switching regulators, provide a higher voltage output by raising the input voltage. The output voltage is regulated, as long as the power is drawn is within the output power specification of the circuit. For driving strings of LEDs, step up Switching voltage regulator is used.

Assume Lossless in the Circuit Pin = Pout (input and output powers are same) Then Vin Iin = Vout Iout,

Iout / Iin = 1/D Therefore

- Powers remain the same
- Voltage increases
- Current decreases.

Equivalent to DC transformer

Step Down (Buck) Voltage Regulator lowers the input voltage. If input power is equal to output power, then

Pin = Pout

Vin Iin = Vout Iout,

Iout / Iin = Vin /Vout = 1/D

Step down converter is equivalent to DC transformer wherein the turns ratio is in the range of 0 to 1.

2.2.1.4.1 Step up/Step down (Boost/Buck)

It is also called Voltage inverter. By using this configuration, it is possible to raise, lower or invert the voltage as per the requirement. The output voltage is of opposite polarity of the input. This is achieved by VL forward- biasing reverse-biased diode during the off times, producing current and charging the capacitor for voltage production during the off times by using this type of switching regulator, 90% efficiency can be achieved.

2.2.1.5 Alternator voltage regulator

Alternators produce the current that is required to meet a vehicle's electrical demands when the engine runs. It also replenishes the energy which is used to start the vehicle. An alternator has the ability to produce more current at lower speeds than the DC generators that were once used by most of the vehicles. The alternator has two parts

- Stator – This is a stationary component, which does not move. It contains a set of electrical conductors wound in coils over an iron core.
- Rotor / Armature – This is the moving component that produces a rotating magnetic field by anyone of the following three ways: (i) induction (ii) permanent magnets (iii) using an exciter.

2.2.1.6 Electronic voltage regulator

A simple voltage regulator can be made from a resistor in series with a diode (or series of diodes). Due to the logarithmic shape of diode V-I curves, the voltage across the diode changes only slightly due to changes in current drawn or changes in the input. When precise voltage control and efficiency are not important, this design may work fine.

2.2.1.7 Transistor voltage regulator

Electronic voltage regulators have an astable voltage reference source that is provided by the Zener diode, which is also known as reverse breakdown voltage operating diode. It maintains a constant DC output voltage. The AC ripple voltage is blocked, but the filter cannot be blocked. Voltage regulator also has an extra circuit for short circuit protection, and current limiting circuit, over-voltage protection, and thermal shutdown (R, Penfold 2007) [13].

2.3 Bridge rectifier: Rectifier working and their types

An electrical device that is used to convert alternating current into direct current is called as rectifier. Every embedded system-based circuit or project consists of micro-controller as major component. We know that, most of the micro-controllers operate at voltage range of 5V DC. Especially, 8051 micro-controller that is frequently used for maximum number of embedded systems-based applications works at 5V DC. But, in general, the power supply available is 230V AC. So, we need to convert this 230V AC into 5V DC or required DC voltage level. This process of conversion of AC into DC is called as rectification.

The electrical and electronic circuit, which is used for rectification process is called as rectifier. There are different types of rectifiers such as half-wave rectifier, full-wave rectifier and bridge rectifier. The half-wave rectifier converts or rectifies only half cycle of input waveform. The full-wave rectifier converts or rectifies full cycle or entire input waveform. Bridge rectifier also converts or rectifies entire input waveform. But, mostly bridge wave rectifier is used for maximum number of applications as it is more efficient and advantageous than the half-wave rectifier and full-wave rectifier. Every micro-controller-based power electronics project requires rectifier, as most of the components need power supply of around 5V DC voltage.

2.3.1 Bridge wave rectifier

Bridge rectifier consists of four diodes, which are connected in the form of bridge; hence, these types of rectifiers are termed as bridge-wave rectifiers or bridge rectifiers. Different types of diodes are used for designing bride-wave rectifier. These diodes are classified based on the voltage and current ratings of the diodes. Thus, bridge-wave rectifiers can be classified into different types based on the types of diodes used. Similarly, bridge wave rectifiers designed using diodes are called as uncontrolled rectifiers and rectifiers designed using thyristors are called as controlled rectifiers. Let us start with diodes 1N4007 that are typically used to implement bridge-wave rectifier.

2.3.2 Types of bridge wave rectifiers

There are different types of bridge rectifiers that are classified based on different criteria. Consider different types of bridge rectifiers, which are classified based on the types of rectifiers such as uncontrolled rectifiers and controlled rectifiers. Diodes are called as uncontrolled rectifiers as diodes start conduction whenever the anode voltage is greater than the cathode voltage. But, in case of controlled rectifiers known as thyristors, even though the anode voltage is greater than cathode voltage, thyristors start conduction only when the gate terminal is triggered. Thus, we can trigger the gate terminal as per the requirement; hence, we can control the operation of the rectifier.

Bridge-wave rectifiers that are designed using thyristors are called as controlled bridge wave rectifiers. The operation of the rectification can be controlled by triggering the thyristors gate terminal whenever it is required. We know that the diode is a semiconductor device consisting of two layers (P-N) and thyristors is also a semiconductor device consisting of four layers (P-N-P-N). It can be used as open-circuit switch and also as a rectifier based on how the gate terminal of the thyristors is triggered.

2.3.3 Types of bridge rectifier diodes

There are series of didoes form 1N4001 to 1N4007 with different current and voltage ratings, but frequently 1N4007 is used for designing bridge-wave rectifiers. 1N4007 diode has absolute maximum ratings including voltage rating as 1000V peak repetitive reverse voltage VRPM, 1A average rectified output current IF(AV), 30A non-repetitive peak forward surge current IFSM, which can be operated at -55 degrees to +175 degrees temperature. Thermal characteristics as 3W power dissipation, junction to ambient thermal resistance 50 degrees/W. The didoes that are occasionally used to design rectifiers are series of didoes from 1N5400 to 1N5408 and 6A4. 1N5408 bridge rectifier didoes are also used for some special applications and these are having ratings as maximum repetitive peak reverse voltage 1000V, maximum RMS voltage 700V, maximum DC blocking voltage of 1000V, maximum average forward rectified current 3A, operating junction and storage temperature range -50 to +150 degrees centigrade. ACPWM control for induction motor is a practical example in which a bridge wave rectifier designed using 1N5408 diodes.

These 6A4 bridge rectifier diodes have maximum ratings and electrical characteristics as maximum recurrent peak reverse voltage of 400V, maximum reverse voltage of 280V, maximum DC breaking voltage of 400V and maximum average forward rectified current of 6A. 6A4 diodes are used for bridge rectifiers in some special applications, an example is propeller display of message by virtual LEDs. Working of bridge rectifier circuit is similar irrespective of the diodes used to design rectifier, so let us consider the bridge wave rectifier circuit designed using diodes 1N4007, as it is used for bridge rectifiers in some special applications for example a propeller display of message by virtual LEDs.

2.3.3.1 Working of the bridge rectifier used to convert 230V AC to 5V DC

Step-down transformers are used to convert 230V AC (high voltage) into 12V AC (low voltage). This 12V output is an RMS value and its peak value is given by the product of square root of two with RMS value of the output of step-down transformer, which is approximately 17V. The working principle of transformers is based on Faraday's laws of electromagnetic induction.

2.3.3.2 Uncontrolled bridge wave rectifiers

230V AC power is converted into RMS value of 12V AC or peak value of 17V (approx.), but 5V DC is the required power; for this purpose, 17V AC (peak value) power is converted into DC power, then it is stepped down to 5V DC. The 17V AC is converted into DC using a bridge-wave rectifier that consists of four diodes, which are called as uncontrolled rectifiers. Diode will conduct only in forward bias and will not conduct during the reverse bias. If anode voltage of diode is greater than cathode, then the diode is said to be in forward bias. Diodes D2 and D4 conducts during positive half cycle and diodes D1 and D3 conduct during negative half cycle. This charging and discharging of the capacitor make the pulsating DC into pure DC, as shown in figure. A step-down converter namely IC 7805 voltage regulator is used to convert 15V DC to 5V DC, (O.A Williams 1995).

In general, 7.2V to 35V is the operating voltage range of IC7805 regulator. If the input voltage is 7.2V, then it gives maximum efficiency and, as the voltage exceeds 7.2V efficiency will decrease as there will be loss of energy in the form of heat. So, heat sinks are used to protect the regulator from over heat. Even without using transformer, we can directly convert 230V AC into 5V DC using high-rating diodes. If we have 230V DC power supply, then we can directly convert the 230V DC into 5V DC using a DC-DC buck converter, (A.N Donald 1996). Feel free to post your comments in the comment section below and encourage other readers to learn the basics about rectifiers.

2.4 Related works

2.4.1 "Understanding low drop out (LDO) regulators"

By Michael Day

Low dropout regulators (LDOs) are a simple inexpensive way to regulate an output voltage that is powered from a higher voltage input. They are easy to design with and use. For most applications, the parameters in an LDO datasheet are usually very clear and easy to understand. However, other applications require the designer to examine the datasheet more closely to determine whether or not the LDO is suitable for the specific circuit conditions. Unfortunately, datasheets can't provide all parameters under all possible operating conditions. To the designer must interpret and extrapolate the available information to determine the performance under non-specified conditions.

2.4.1.1 Linear regulators

There are two types of linear regulators standard linear regulators and low dropout linear regulators (LDOs). The difference between the two is in the pass element and the amount of headroom, or dropout voltage, required to maintain a regulated output voltage. The dropout voltage is the minimum voltage required across the regulator to maintain regulation. A 3.3 V regulator that has 1 V of dropout requires the input voltage to be at least 4.3 V. The dropout voltage is the minimum voltage required across the regulator to maintain regulation. A 3.3 V regulator that has 1 V of dropout requires the input voltage to be at least 4.3 V. The input voltage minus the voltage drops across the pass element equals the output voltage. This brings up the question, "What is the minimum voltage drop across the pass element?" The answer to this question depends upon several factors.

2.4.1.2 LDO

For standard regulators, the pass element is either a Darlington NPN or PNP output stage. Standard linear regulators have voltage drops as high as 2 V which are acceptable for applications with large input-to-output voltage difference such as generating 2.5 V from a 5 V input. A typical application such as generating 3.3 V from a 3.6 V Li-Ion battery requires a much lower dropout voltage (less than 300 mV). These applications require the use of an LDO to achieve the lower dropout voltage. Most LDOs use an N-channel or P-channel FET pass element and can have dropout voltages less than 100 mV. This voltage drop is a function of the RDS (on) of the FET.

2.4.2 "Electronic eye-controlled security system using LDR"

Mr. Raj Kumar Mistri1, Mr. Kunal Kumar Singh

Electronic eye describes the design and implementation of LDR bases Security system homes, banks, malls etc. Where in security is a major concern. The proposed system uses a light dependent resistor (LDR) to sense the light intensity. The LDR sensor, sense the light intensity and generates an alarm for indicating thefts, and also turns on the lights. LDR, Electronic eye, security system. Security is a primary concern with day-to-day life and properties in our environment. This Project describes effective security alarm system that can sense the intensity light with the help of LDR. This system is placed inside cash boxes and lockers in such a way that if a burglar tries to open the locker and uses a torch light to find the valuables, then the light that falls on the electronic eye (LDR) directs a signal to the buzzer and LED for indicating thefts. Robbery has become common in our day-to-day life. Counting it, security system is also commercially available. The Security system available in market are too costly. So, this project provides security system for cash boxes and lockers at a very low cost.

2.4.2.1 Concept

The main concept of the project is to sense the intensity of Light through the LDR sensor. This system is placed inside the cash boxes and lockers. If the cash box is in closed condition the interior will be dark. Hence in the dark, the LDR will not activate. Neither the buzzer sounds, nor the LED glows, indicating that the cash box is closed. If someone tries to open the door of the cash box, light most probably from the burglar's torch falls on the LDR and the LDR directs a signal to the buzzer and LDR for indicating thefts.

2.4.3 "Design and construction of a remote-controlled fan regulator"

By Mahmud Shehu AHMED

Remote control facilitates the operation of fan regulators around the home or office from a distance. It provides a system that is simple to understand and also to operate, a system that would be cheap and affordable, a reliable and easy to maintain system of remote control and durable system irrespective of usage. It adds more comfort to everyday living by removing the inconvenience of having to move around to operate a fan regulator. The system seeks to develop a system that is cost effective while not under mining the need for efficiency. The first remote control, called "lazy bones" was developed in 1950 by Zenith Electronics Corporation (then known as Zenith Radio Corporation). The device was developed quickly, and it was called "Zenith space command", the remote went into production in the fall of 1956, becoming the first practical wireless remote-control device. Today, remote control is a standard on other consumer electronic products, including VCRs, cable and satellite boxes, digital video disc players and home audio players. And the most sophisticated TV sets have remote with as many as 50 buttons. In year 2000, more than 99 percent of all TV set and 100 percent of all VCR and DVD players sold are equipped with remote controls. The average individual these days probably picks up a remote control at least once or twice a day. Basically, a remote control works in the following manner. A button is pressed. This completes a specific connection which produces a Morse code line signal specific to that button. The transistor amplifies the signal and sends it to the LED which translates the signal into infrared light. The sensor on the appliance detects the infrared light and reacts appropriately. The remote control's function is to wait for the user to press a key and then translate that into infrared light signals that are received by the receiving appliance. The carrier frequency of such infrared signals is typically around 36 kHz. Usually, the transmitter part is constructed so that the transmitter oscillator which drives the infrared transmitter LED can be turned on/off by applying a TTL (transistor-transistor logic) voltage on the modulation-controlled input. On the receiver side, a photo transistor or photodiode takes up the signals.

2.4.4 "Development of a light dependent automatic- off timer for households electronics."

By Jonathan Gana KOLO

A switch can simply be defined as a device operated to turn electric current ON or OFF. Switches are important devices in electrical and electronics circuit design. They are hence widely used components today serving as control devices in modern electrical systems and circuits. Switches can also be defined as devices by which a circuit parameter or signal such as electrical current can be either linked to or cut off from another part of a circuit manually or automatically. The major aim of this paper was to effectively design and fabricate an electronic system that will be capable of switching off AC power supply automatically from electronic appliances connected to its output interface at night in dark environments. This device therefore makes it possible for persons to use electronic appliances such as the television set and CD players as they await sleep leisurely late at night. Furthermore, this device finds use not only in homes but as a precautionary and protective interface in industries and offices; serving as a switch to turn off at night AC power supply from electronic appliances left on carelessly or by workers negligently during the day. A key feature of this device is that its operation is light dependent, that is, the device is activated only when it is powered ON in the absence of ambient light or in a sufficiently dark environment making it a light dependent automatic-off timer for electrical appliances. The light dependent automatic-off timer uses a light dependent resistor (LDR) as its light sensor. It has the following key components 555-timer integrated circuit (IC) based Schmitt trigger with the light sensor (LDR) at its input. 4060 IC which is a 14-stage binary ripple counter with a built-in oscillator Normally closed (N/C) relay at the output interface of the device. The above- mentioned components give the device its peculiar function. The presence of the LDR makes the device light sensitive and when the room is sufficiently dark, the sensor will have high impedance, which will in turn pass a high voltage into the input of the Schmitt trigger. The Schmitt trigger being a logic inverter will pass a low signal to the RESET pin of the 4060 IC, activating the timer sub-circuit of the device. After the pre-set time period is over, the device cuts off AC power supply from its output interface via the relay action. Fig.1 shows the generalized block diagram of the system. The input voltage at the input of the 555 timer-based trigger is controlled by the voltage divider circuit consisting of the LDR (the light sensor) and the parallel combination of two resistors- 47kΩ and 100kΩ. The effective resistance of the parallel combination is given by Ω = K3210047 10047 The LDR is connected directly to the input of the Schmitt trigger.

The LDR has a light dependent resistance characteristic with its resistance increasing with decreasing light intensity. In dark environments, the resistance of the light sensor is very large, in the range of mega ohms (MΩ). Hence in the dark, the LDR divides a greater percentage of the voltage because of its large value of resistance when compared to the effective resistance of 32kΩ. Development of a light dependent automatic- off timer for households' electronics Jonathan G. KOLO ambient light and the absence of ambient light. In the first case, the value of RLDR would be very low because of the presence of ambient light and hence the 32kΩ equivalent resistance would divide a greater proportion of the 12V voltage signal as the resistance of the LDR is very small and negligible when compared to the 32kΩ resistance. Therefore, a low voltage will appear at the input of the Schmitt trigger. In the second case, the value of RLDR would be very large since there is an absence of ambient light. As a result, a greater percentage of the 12volts is divided across the LDR presenting a high voltage input at the input of the Schmitt trigger. An effective resistance value of 32kΩ was chosen in preference over the 100kΩ resistance values to ensure that the device had great sensitivity to the transition from light to darkness and vice versa.

The Schmitt trigger is used to provide a clean switching of the time delay circuit (timer unit) ON or OFF since the resistance of the LDR shows a gradual increase in encroaching darkness and similarly also, a gradual decrease in resistance as light intensity increases (in the presence of ambient light). The change in resistance of the LDR is conditioned to generate an oscillation free output with a 555 timer-based Schmitt trigger which provides the enable/ disable control needed to switch the timer unit ON (in the dark) or OFF (in bright light). The switching threshold for the inverter (Schmitt trigger) is fixed at 3ccV -required for a low to high logic state switching, and 32ccVfor a high to low logic state switching. For the 12V DC supply, the thresholds are: 3122312 and this yields 4V and 8V respectively. Hence, whenever the voltage across the LDR is less than 4V the Schmitt trigger would place a high (12V) logic state at pin 3 of the 555 timer (Timer unit disable condition) and when the input voltage exceeds 8V, a low logic state (0V) at the output of the trigger (Timer unit enable condition). Summarily, VIN would be less than 4V in the presence of light and VIN would be between 8V and 12V in dark environments. The capacitor connected to pin5 of the 555-timer eliminates noise in the circuit.

2.5 Summary

This Chapter has covered introduction, Review of the Literature, Related Works and Summary of this chapter.

3. Methodology

3.0 Introduction

This chapter gives the detail of methodology regard to study base line, system design and each major component used in this project with regard to system design requirements, types and operational conditions of each component.

3.1 Baseline study

This project report has been approached primarily by literature and practical research. Focusing firstly on gaining a wide and comprehensive understanding of the chosen subject area, a literature review was completed. The literature review included the reading of a range of textbooks along with credible internet sources journals and practical experience. Relevant aspects of these sources were then used to formulate notes, which were then used in their relevant section of the report. The knowledge gained from the literature review was then applied to design and develop solar power plant and transmission line. Materials listed below were procured and arranged as the required by the designed and developed system. Below are the hardware specification and system block diagram.

3.2 Components

- 230V to 12V Step Down Transformer
- Bridge Rectifier
- 7805 Regulator IC
- 1000µF Capacitor
- 0.22µF Capacitor
- 0.1µF Capacitor
- 470Ω Resistor x 2
- 100Ω Resistor
- 220Ω Resistor
- 330Ω Resistor
- Mini Breadboard.

System diagram

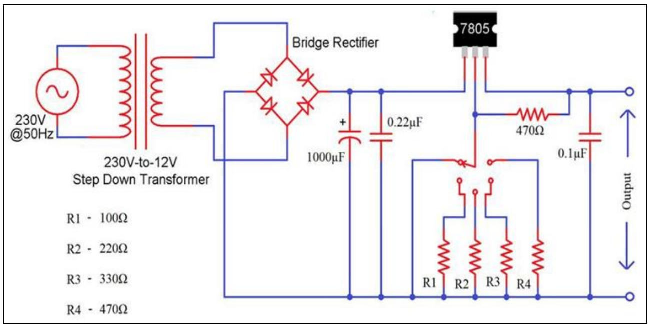

Fig 1: Circuit Diagram of Variable Voltage Power Supply

3.2.1 System components

3.2.1.1 Transformer

A transformer can be defined as a static device which helps in the transformation of electric power in one circuit to electric power of the same frequency in another circuit. The voltage can be raised or lowered in a circuit, but with a proportional increase or decrease in the current ratings, (M Fredko 2000).

3.2.1.1.1 Transformer working principle

The main principle of operation of a transformer is mutual inductance between two circuits which is linked by a common magnetic flux. A basic transformer consists of two coils that are electrically separate and inductive, but are magnetically linked through a path of reluctance. The working principle of the transformer can be understood from the figure below.

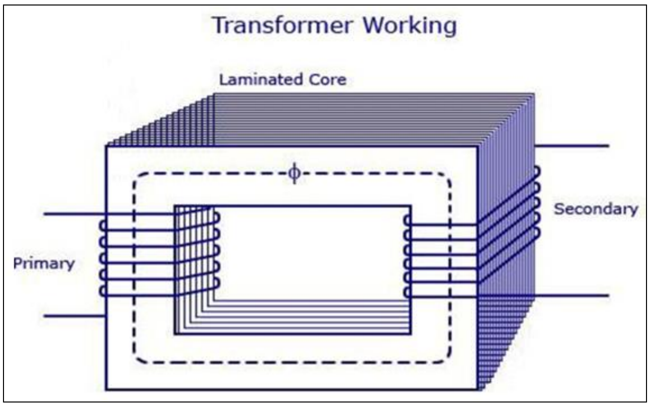

Fig 2: Transformer working

As shown above the electrical transformer has primary and secondary windings. The core laminations are joined in the form of strips in between the strips you can see that there are some narrow gaps right through the cross-section of the core. These staggered joints are said to be 'imbricated'. Both the coils have high mutual inductance, (R.A Penfold 1997). A mutual electro-motive force is induced in the transformer from the alternating flux that is set up in the laminated core, due to the coil that is connected to a source of alternating voltage. Most of the alternating flux developed by this coil is linked with the other coil and thus produces the mutual induced electro-motive force. The so produced electro-motive force can be explained with the help of Faraday's laws of Electromagnetic Induction as

$$e=M*[dI/dt]$$

If the second coil circuit is closed, a current flows in it and thus electrical energy is transferred magnetically from the first to the second coil.

According to (B. L Theraja 2002), the alternating current supply is given to the first coil and hence it can be called as the primary winding. The energy is drawn out from the second coil and thus can be called as the secondary winding. In short, a transformer carries the operations shown below:

- Transfer of electric power from one circuit to another.
- Transfer of electric power without any change in frequency.
- Transfer with the principle of electromagnetic induction.
- The two electrical circuits are linked by mutual induction.

3.2.1.1.2 Transformer construction

For the construction of a transformer, two coils are needed having mutual inductance and a laminated steel core. The two coils are insulated from each other and from the steel core. The device will also need some suitable container for the assembled core and windings, a medium with which the core and its windings from its container can be insulated. In order to insulate and to bring out the terminals of the winding from the tank, apt bushings that are made from either porcelain or capacitor type must be used.

In all transformers that are used commercially, the core is made out of transformer sheet steel laminations assembled to provide a continuous magnetic path with minimum of air-gap included. The steel should have high permeability and low hysteresis loss. For this to happen, the steel should be made of high silicon content and must also be heat treated. By effectively laminating the core, the eddy-current losses can be reduced. The lamination can be done with the help of a light coat of core plate varnish or lay an oxide layer on the surface. For a frequency of 50 Hertz, the thickness of the lamination varies from 0.35mm to 0.5mm for a frequency of 25 Hertz, (M Bates 2000).

3.2.2 Types of transformers

The types of transformers differ in the manner in which the primary and secondary coils are provided around the laminated steel core. According to the design, transformers can be classified into two,

3.2.2.1 Core- type transformer

According to (J.T Ronald 2004) [9], In core-type transformer, the windings are given to a considerable part of the core. The coils used for this transformer are form-wound and are of cylindrical type. Such a type of transformer can be applicable for small sized and large sized transformers. In the small sized type, the core will be rectangular in shape and the coils used are cylindrical. The figure below shows the large sized type. You can see that the round or cylindrical coils are wound in such a way as to fit over a cruciform core section. In the case of circular cylindrical coils, they have a fair advantage of having good mechanical strength. The cylindrical coils will have different layers and each layer will be insulated from the other with the help of materials like paper, cloth, micarta board and so on. The general arrangement of the core-type transformer with respect to the core is shown below. Both low-voltage (LV) and high voltage (HV) windings are shown.

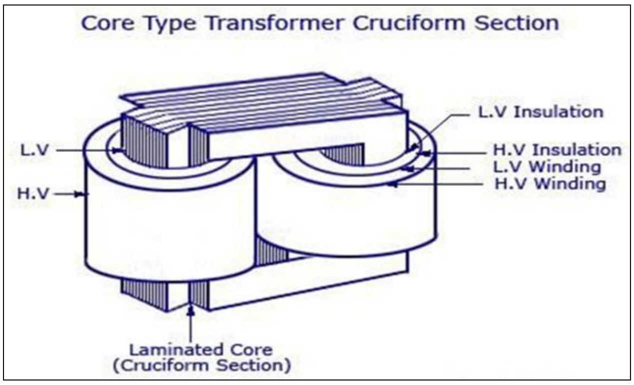

Fig 3: Core type cruciform section

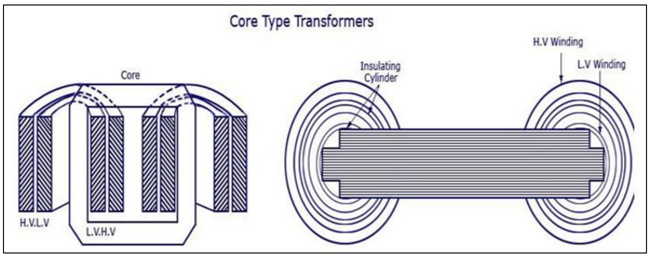

Fig 4: Core type transformers

The low voltage windings are placed nearer to the core as it is the easiest to insulate. The effective core area of the transformer can be reduced with the use of laminations and insulation.

3.2.2.2 Shell-type transformer

In shell-type transformers, the core surrounds a considerable portion of the windings. The comparison is shown in the figure below.

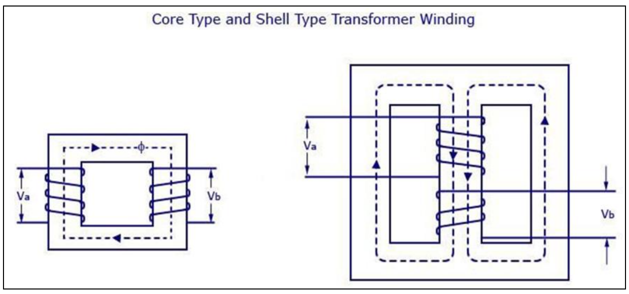

Fig 5: Core type and shell transformer winding

The coils are form-wound but are multilayer disc type usually wound in the form of pancakes. Paper is used to insulate the different layers of the multi-layer discs. The whole winding consists of discs stacked with insulation spaces between the coils. These insulation spaces form the horizontal cooling and insulating ducts (B.W Williams 2002). Such a transformer may have the shape of a simple rectangle or may also have a distributed form. Both designs are shown in the figure below:

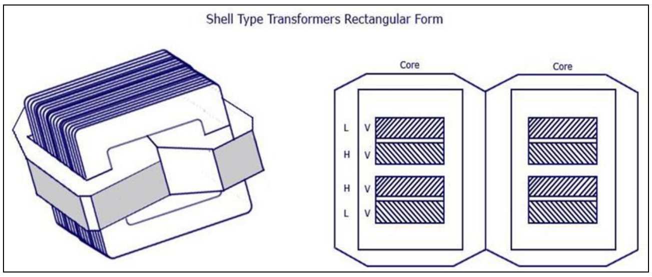

Fig 6: Shell type transformer rectangular form

A strong rigid mechanical bracing must be given to the cores and coils of the transformers. This will help in minimizing the movement of the device and also prevents the device from getting any insulation damage. A transformer with good bracing will not produce any humming noise during its working and will also reduce vibration.

A special housing platform must be provided for transformers. Usually, the device is placed in tightly-fitted sheet- metal tanks filled with special insulating oil. This oil is needed to circulate through the device and cool the coils. It is also responsible for providing the additional insulation for the device when it is left in the air. There may be cases when the smooth tank surface will not be able to provide the needed cooling area. In such cases, the sides of the tank are corrugated or assembled with radiators on the sides of the device. The oil used for cooling purpose must be absolutely free from alkalis, Sulphur and most importantly moisture. Even a small amount of moisture in the oil will cause a significant change in the insulating property of the device, as it lessens the dielectric strength of the oil to a great extent, (S Berkowitz 2003).

Mathematically speaking, the presence of about 8 parts of water in 1 million reduces the insulating quality of the oil to a value that is not considered standard for use. Thus, the tanks are protected by sealing them air-tight in smaller units. When large transformers are used, the airtight method is practically difficult to implement. In such cases, chambers are provided for the oil to expand and contract as its temperature increases and decreases. These breathers form a barrier and resist the atmospheric moisture from contact with oil. Special care must also be taken to avoid sledging. Sledging occurs when oil decomposes due to overexposure to oxygen during heating. It results in the formation of large deposits of dark and heavy matter that clogs the cooling ducts in the transformer.

The quality, durability and handling of these insulating materials decide the life of the transformer. All the transformer leads are brought out of their cases through suitable bushings. There are many designs of these, their size and construction depending on the voltage of the leads. Porcelain bushings may be used to insulate the leads, for transformers that are used in moderate voltages. Oil-filled or capacitive-type bushings are used for high voltage transformers, (J.C Osuwa 2007).

The selection between the core and shell type is made by comparing the cost because similar characteristics can be obtained from both types. Most manufacturers prefer to use shell-type transformers for high-voltage applications or for multi-winding design. When compared to a core type, the shell type has a longer mean length of coil turn. Other parameters that are compared for the selection of transformer type are voltage rating, kilo-volt ampere rating, weight, insulation stress, heat distribution and so on.

3.2.2.3 Types of transformers based on cooling method
Transformers can also be classified according to the type of cooling employed. The different types according to these classifications are:

3.2.2.3.1 Oil filled self-cooled type
Oil filled self-cooled type uses small and medium-sized distribution transformers. The assembled windings and core of such transformers are mounted in a welded, oil-tight steel tanks provided with a steel cover. The tank is filled with purified, high quality insulating oil as soon as the core is put back at its proper place. The oil helps in transferring the heat from the core and the windings to the case from where it is radiated out to the surroundings. For smaller sized transformers the tanks are usually smooth surfaced, but for large size transformers a greater heat radiation area is needed, and that too without disturbing the cubical capacity of the tank. This is achieved by frequently corrugating the cases. Still larger sizes are provided with radiation or pipes.

3.2.2.3.2 Oil filled water cooled type
This type is used for much more economic construction of large transformers, as the above-told self-cooled method is very expensive. The same method is used here as well- the windings and the core are immersed in the oil. The only difference is that a cooling coil is mounted near the surface of the oil, through which cold water keeps circulating. This water carries the heat from the device. This design is usually implemented on transformers that are used in high voltage transmission lines. The biggest advantage of such a design is that such transformers do not require housing other than their own. This reduces the costs by a huge amount. Another advantage is that the maintenance and inspection of this type is only needed once or twice in a year.

3.2.2.3.3 Air blast type
This type is used for transformers that use voltages below 25,000 volts. The transformer is housed in a thin sheet metal box open at both ends through which air is blown from the bottom to the top.

3.2.2.3.4 E.M.F equation of a transformer

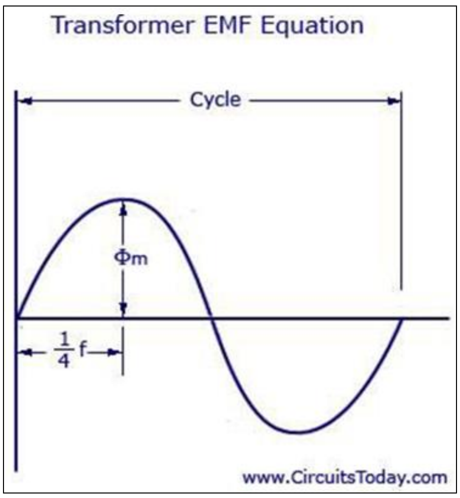

Fig 7: Transformer EMF equation

Let,
NA = Number of turns in primary NB = Number of turns in secondary
Ømax = Maximum flux in the core in webers = Bmax X A f = Frequency of alternating current input in hertz (HZ)
As shown in figure above, the core flux increases from its zero value to maximum value Ømax in one quarter of the cycle, that is in ¼ frequency second.
Therefore, average rate of change of flux = Ømax/ ¼ f = 4f ØmaxWb/s
Now, rate of change of flux per turn means induced electro motive force in volts. Therefore, average electro-motive force induced/turn = 4f Ømaxvolt
If flux Ø varies sinusoidally, then r.m.s value of induced e.m.f is obtained by multiplying the average value with form factor.
Form Factor = r.m.s. value/average value = 1.11
Therefore, r.m.s value of e.m.f/turn = 1.11 X 4f Ømax = 4.44f Ømax
Now, r.m.s value of induced e.m.f in the whole of primary winding = (induced e.m.f./turn) X Number of primary turns

Therefore,
E-A = 4.44f NAØmax = 4.44fNABmA
Similarly, r.m.s value of induced e.m.f in secondary is E-B = 4.44f NB Ømax = 4.44fNBBmA
In an ideal transformer on no load,
VA = EA and VB = EB, where VB is the terminal voltage
Voltage Transformation Ratio (K)
From the above equations we get

EB/ EA = VB/ VA = NB/NA = K

This constant K is known as voltage transformation ratio.

(1) If NB>NA, that is K>1, then transformer is called step-up transformer.
(2) If NB<1, that is K<1, then transformer is known as step-down transformer.

Again, for an ideal transformer, Input VA = output VA
VAIA = VBIB

Or, IB/IA = VA/VB = 1/K

Hence, currents are in the inverse ratio of the (voltage) transformation ratio.
Applications of a transformer
Transformers are used in most electronic circuits. A transformer has only 3 applications;

1. To step up voltage and current.
2. To Step down voltage and current
3. To prevent DC – transformers can pass only Alternating Currents so they totally prevent DC from passing to the next circuit.

But the application of these 3 applications is endless which is why they have a place in lots of circuits.

3.2.3 Bridge rectifier
According to (D Austender 1998) [12], Bridge Rectifiers are the circuits which convert alternating current (AC) into direct current (DC) using the diodes arranged in the bridge circuit configuration. They usually comprise of four or more number of diodes which cause the output generated to be of

the same polarity irrespective of the polarity at the input. Bridge rectifiers are in the same class of electronics as half-wave rectifiers and full-wave rectifiers. Bridge Rectifiers are widely used in power supplies that provide necessary DC voltage for the electronic components or devices. They can be constructed with four or more diodes or any other controlled solid-state switches.

Depending on the load current requirements, a proper bridge rectifier is selected. Components' ratings and specifications, breakdown voltage, temperature ranges, transient current rating, forward current rating, mounting requirements and other considerations are taken into account while selecting a rectifier power supply for an appropriate electronic circuit's application.

3.2.3.1 Types of bridge rectifiers

Bride rectifiers are classified into several types based on these factors: Type of supply, controlling capability, bride circuit's configurations, etc. Bridge rectifiers are mainly classified into single and three phase rectifiers (Hill 1980). Both these types are further classified into uncontrolled, half controlled and full controlled rectifiers. Some of these types of rectifiers are described below.

3.2.3.1.1 Single phase and three phase rectifiers

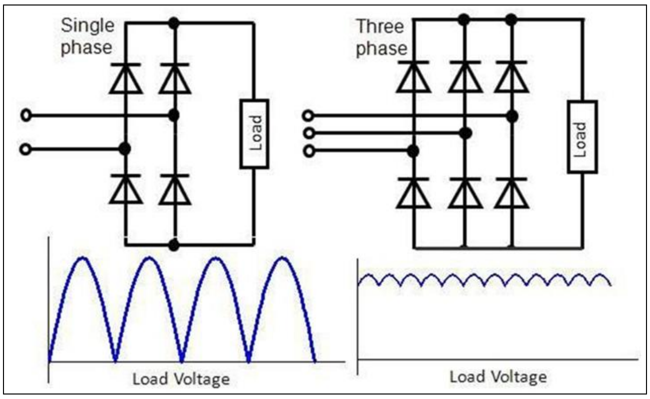

Fig 8: Single phase and three phase rectifiers

Single Phase and Three Phase Rectifiers

The nature of supply, i.e., a single phase or three-phase supply decides these rectifiers. The Single-phase bridge rectifier consists of four diodes for converting AC into DC, whereas a three-phase rectifier uses six diodes, as shown in the figure. These can be again uncontrolled or controlled rectifiers depending on the circuit components such as diodes, thyristors, and so on.

3.2.3.1.2 Uncontrolled bridge rectifiers

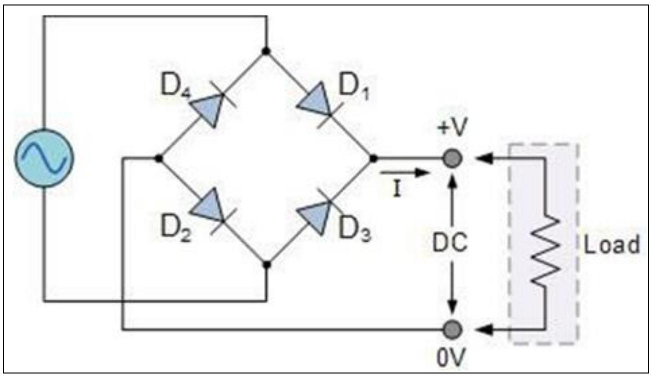

Fig 9: Uncontrolled bridge rectifiers

This bridge rectifier uses diodes for rectifying the input as shown in the figure. Since the diode is a unidirectional device that allows the current flow in one direction only. With this configuration of diodes in the rectifier, it doesn't allow the power to vary depending on the load requirement. So, this type of rectifier is used in constant or fixed power supplies.

3.2.3.1.3 Controlled bridge rectifier

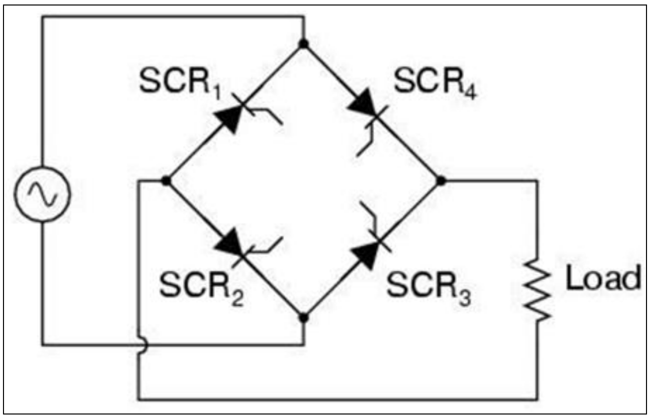

Fig 10: Controlled bridge rectifier

In this type of rectifier, AC/DC converter or rectifier – instead of uncontrolled diodes, controlled solid state devices like SCR's, MOSFET's, IGBT's, etc. are used to vary the output power at different voltages. By triggering these devices at various instants, the output power at the load is appropriately changed. The main advantage of bridge rectifier is that it produces almost double the output voltage as with the case of a full wave rectifier using center- tapped transformer. But this circuit doesn't need center tapped transformer so it resembles low-cost rectifier. The bridge rectifier circuit diagram consists of various stages of devices like transformer, Diode Bridge, filtering and regulators. Generally, all these blocks combination is called as regulated DC power supply that powers various electronic appliances, (N.S Widermer 2004).

The first stage of the circuit is a transformer, which is a step-down type that changes the amplitude of the input voltage. Most of the electronic projects uses 230/12V transformer to step-down the AC mains 230V to 12V AC supply.

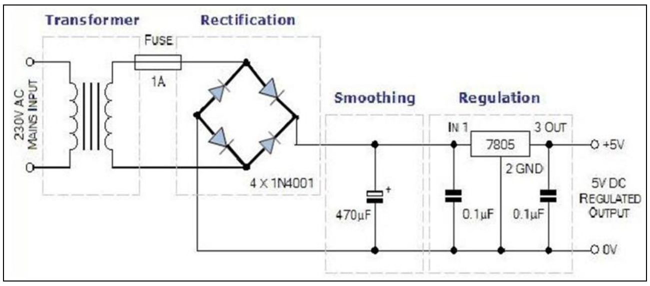

Fig 11: Rectification

Next stage is a diode-bridge rectifier which uses four or more diodes depending on the type of bridge rectifier. Choosing a particular diode or any other switching device for a corresponding rectifier needs some considerations of the device like Peak Inverse Voltage (PIV), forward current If, voltage ratings, etc. It is responsible for producing unidirectional or DC current at the load by conducting a set of diodes for every half cycle of the input signal.

Since the output after the diode bridge rectifiers is of pulsating nature, and for producing it as a pure DC, filtering is necessary. Filtering is normally performed with one or more capacitors attached across the load, as you can observe in the below figure wherein smoothing of wave is performed. This capacitor rating also depends on the output voltage.

The last stage of this regulated DC supply is a voltage regulator that maintains the output voltage to a constant level. Suppose the microcontroller works at 5V DC, but the output after the bridge rectifier is around 16V, so to reduce this voltage, and to maintain a constant level no matter voltage changes in input side a voltage regulator is necessary.

3.2.3.2 Bridge rectifier operation

A single-phase bridge rectifier consists of four diodes and this configuration is connected across the load. For understanding the bridge rectifier's working principle, consider the below circuit for demonstration purpose.

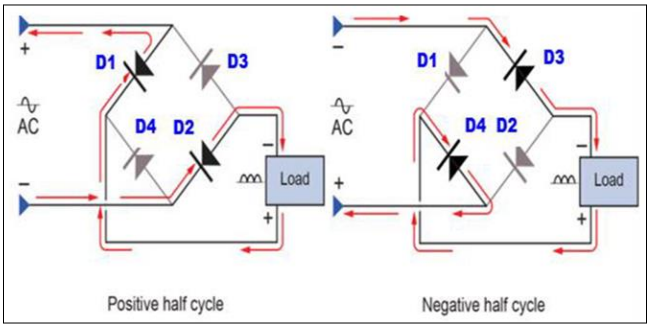

Fig 12: Bridge rectifier operation

During the Positive half cycle of the input AC waveform diodes D1 and D2 are forward biased and D3 and D4 are reverse biased. When the voltage, more than the threshold level of the diodes D1 and D2, starts conducting – the load current starts flowing through it. During the negative half cycle of the input AC waveform, the diodes D3 and D4 are forward biased, and D1 and D2 are reverse biased. Load current starts flowing through the D3 and D4 diodes when these diodes start conducting. In both the cases, the load current direction is same. unidirectional, which means DC current. Thus, by the usage of a bridge rectifier, the input AC current is converted into a DC current. The output at the load with this bridge wave rectifier is pulsating in nature, but for producing a pure DC requires additional filter like capacitor. The same operation is applicable for different bridge rectifiers, but in case of controlled rectifiers thyristors triggering is necessary to drive the current to load.

3.2.4 Voltage regulator

Voltage regulators are very common in electronic circuits. They provide a constant output voltage for a varied input voltage. In the case of a 7805 IC is an iconic regulator IC that finds its application in most of the projects, (R.J Tocci 2004) [24]. The name 7805 signifies two meaning, '78' means that it is a positive voltage regulator and '05' means that it provides 5V as output. Therefore, 7805 will provide a +5V output voltage.

The output current of this IC can go up to 1.5A. But the IC suffers from heavy heat loss hence a Heat sink is recommended for projects that consume more current. For example, if the input voltage is 12V and you are consuming 1A, then (12-5) * 1 = 7W. This 7 Watts will be dissipated as heat.

3.2.4.1 7805 as +5V voltage regulator

This is a typical application circuit of the 7805 IC. two capacitors of values 33uf and 0.1uf to get this IC working.

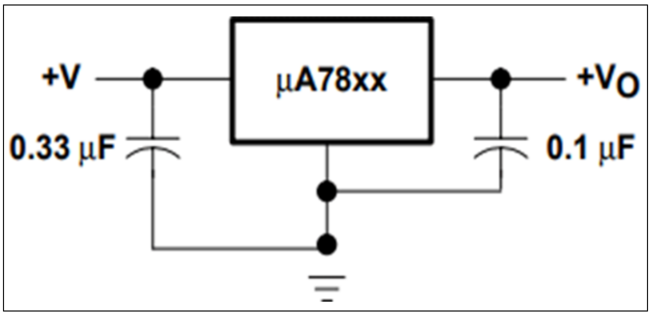

Fig 13: 7805 as +5V voltage regulator

The input capacitor 0.33uF is a ceramic capacitor that deals with input inductance problem and the output capacitor 0.1uF is also a ceramic capacitor that adds to the stability of the circuit. These capacitors should be placed close to the terminals for them to work effectively. Also, they should be of ceramic type, since ceramic capacitors are faster than electrolytic.

3.2.4.2 7805 as adjustable output regulator

This IC can also act as an adjustable output voltage regulator, meaning you can also control the output voltage for your desired value using the below circuit.

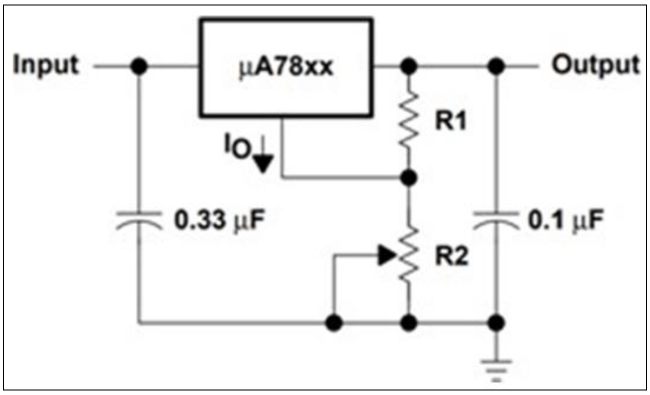

Fig 14: 7805 as adjustable output regulator

3.2.4.3 7805 as output regulator

Here, the input voltage can be anywhere between 9V to 25V, and the output voltage can be adjusted using the value of resistance R1 and R2. The value can be calculated using the below formulae.

$$V_O = V_{xx} + \left(\frac{V_{xx}}{R1} + I_Q\right)R2$$

3.2.4.4 7805 applications

- Constant +5V output regulator to power microcontrollers and sensors in most of the projects
- Adjustable Output Regulator
- Current Limiter for certain applications
- Regulated Dual Supply
- Output Polarity-Reversal-Protection Circuit.

3.2.5 Resistor

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. High-power resistors that can dissipate many watts of electrical power as heat, may be used as part of motor controls, in power distribution systems, or as test loads for generators. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity (A.H Yamin 2013).

Resistors are common elements of electrical networks and electronic circuits and are ubiquitous in electronic equipment. Practical resistors as discrete components can be composed of various compounds and forms. Resistors are also implemented within integrated circuits. The electrical function of a resistor is specified by its resistance: Common commercial resistors are manufactured over a range of more than nine orders of magnitude. The nominal value of the resistance falls within the manufacturing tolerance, indicated on the component.

3.2.6 Capacitor

A capacitor is a device that stores electrical energy in an electric field. It is a passive electronic component with two terminals. The effect of a capacitor is known as capacitance. While some capacitance exists between any two electrical conductors in proximity in a circuit, a capacitor is a component designed to add capacitance to a circuit. The capacitor was originally known as a condenser or capacitor. This name and its cognates are still widely used in many languages, but rarely in English, one notable exception being condenser microphones, also called capacitor microphones.

According to (R Kumar and M Rosen 2011), the physical form and construction of practical capacitors vary widely and many types of capacitors are in common use. Most capacitors contain at least two electrical conductors often in the form of metallic plates or surfaces separated by a dielectric medium. A conductor may be a foil, thin film, sintered bead of metal, or an electrolyte. The non-conducting dielectric acts to increase the capacitor's charge capacity. Materials commonly used as dielectrics include glass, ceramic, plastic film, paper, mica, air, and oxide layers. Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, an ideal capacitor does not dissipate energy, although real-life capacitors do dissipate a small amount. When an electric potential, a voltage, is applied across the terminals of a capacitor, for example when a capacitor is connected across a battery, an electric field develops across the dielectric, causing a net positive charge to collect on one plate and net negative charge to collect on the other plate. No current actually flows through the dielectric. However, there is a flow of charge through the source circuit. If the condition is maintained sufficiently long, the current through the source circuit ceases. If a time-varying voltage is applied across the leads of the capacitor, the source experiences an ongoing current due to the charging and discharging cycles of the capacitor.

3.3 Summary

This Chapter has covered methodology, introduction, baseline study, system design project system components and Summary of this chapter.

4. Results

4.0 Introduction

The outline for this chapter is as follows introduction, Design, operation, protection and earthing and chapter summary. This chapter gives detail to the operation requirement of the system and assembling of the components as discussed in the previous chapter.

4.1 Design

This project, shows design of a Variable Voltage Power Supply from Fixed Voltage Regulator like 7805 IC. 78XX and 79XX are the two series of three pin voltage regulator available in the market. 78XX series of the voltage regulator is for the positive voltage supply that is, if a +5V supply is to be achieved, then 7805 voltage regulator can be used. While 79XX series is for negative supply, i.e. if a -5V supply is to obtained, then 7905 regulators is used.

According to, (M. Bates 2000), Voltage regulators like 7805 are used to offer fixed voltage at the output terminal and does not depend on the variations at input voltage supplied as long as it is greater than the required voltage. LM317 is a Variable Voltage Regulator IC that can be used to produce voltages in the range of 1.5V to 37V. But the same can be produced from a fixed voltage regulator like 7805 as well although not the same range. This can be achieved by adding two resistors. Initially, the primary of the 230V to 12V Step Down Transformer is connected to the AC Mains supply while the secondary is connected to a bridge rectifier. The output of the bridge rectifier is filtered out using a capacitor and is given to the 7805 Voltage Regulator IC. A 0.22µF Capacitor is connected between INPUT and COMM (GND of 7805) while a 0.1µF Capacitor is connected between OUTPUT and COMM.

A 470Ω Resistor is connected between the COM and OUT. A rotary switch is used to switch between output resistors and the following resistors are connected to the switch 100Ω, 220Ω, 330Ω and 470Ω.

Note

- If an AC Mains Supply is used as the source, care has to be made when making connections.

4.2 Operation

The main principle behind the working of this project is as follows. Connect two resistors R1 and R2 as shown in the circuit diagram below, one between the output and GND Pin and the other between GND Pin and GND of power supply.

The amount of current flowing through R2 is a combination of current through R1 and the standby current of 7805. Depending on the output voltage requirement, we can calculate the value of this resistor and finally the output voltage can be calculated as follows.

Vout = Vreg + R2 * (Vreg/R1 + IS) were

Vreg = 5V (for 7805) and

IS = standby current of 7805 (≈2.5mA).

Based on the above calculations, you can get anywhere between 5V and 12V using a 7805 Regulator from a 12V Supply.

Calculating the Value of Resistance for the Different Voltages.

Assume that the resistor which is attached between the common terminal and the output terminal of regulator has a value of 470Ω. This implies that the value of current is 10.6 mA as V =5V furthermore V=IR.

Among the rotary switch and ground there is some amount of standby current of 2.5 mA approx. Hence about 13.1 mA of overall current is available.

Now assume that from the circuit we need 5V to 12V. With the regulator output we directly got 5V minimum. While if there is a need of 12V, then between COM and output 5V is available and for the rest 7V we need to select the appropriate value of the resistor.

Calculating for R

Here R =? V = 7V

I =13.1mA

Therefore, using ohms' law V =I*R

R = 543ohm

Hence, attaching resistor of 543 Ω with 470 Ω so to obtain the wanted output i.e. 12V. While it is difficult to get such a value of the resistor as it is not standard, the need to use the nearby value of the resistor i.e. 560 Ω.

Now if we wish to have some other voltage from 5V to 12V then we have to attach some other value of the resistor. Suppose we need 6V, then

V =6V

I = 10.6mA

Using ohms' law R = 6V/10.6mA R = 566 Ω

But the resistor R1 is already on 470Ω which is already connected in the circuit, hence for 6V value of the resistor will be 100 Ω approximately (566 - 470=96).

In the same manner for different voltages different value of resistance will calculated. In spite of the different values of resistors available, a variable resistor can be used in the circuit to get different values of voltage.

Important Notes

When switching from one resistor to other, the load will get 12V So, before switching, make sure that the load is disconnected or completely switch off the power supply, make a switch and then switch on the power supply.

4.3 Summary

This chapter covered results, introduction, design, operation and summary of this chapter

5. Conclussion and Recommendation

5.0 Introduction

This is the final chapter and it is approached as follows Introduction, Discussion which covers the baseline study, Use of technology, Development of the system as a solution and possible application. Furthermore, this chapter will look at Summary, Conclusion and recommendations / Future works. Finally, the references and appendix are given at the end of the chapter.

5.1 Discussion

5.1.1 The baseline study

This project report has been approached mainly by literature and practical research. Focusing firstly on gaining a wide and comprehensive understanding of the chosen subject area, a literature review was completed. The literature review included the reading of a range of textbooks along with credible internet sources journals and practical experience. Related aspects of these sources were then used to formulate notes, which were then used in their relevant section of the report. The knowledge gained from the literature review was then applied to design and develop a variable Voltage Power Supply from Fixed Voltage Regulator.

5.1.2 Use of technology

Power supply is used in most of the domestic and the laboratory equipment in order to power the smaller system or the devices. The developed multi-output power supply consists of four segmental outputs, Fixed DC 5 V output, variable DC output 0-15 V, regulated dual rectified DC output +12 V and – 12V. The variable DC output produced values ranging from 0-15V and regulated dual outputs produced ±12V and regulated DC will produce the 5V. The developed system is cheap, robust and very useful for domestic application and laboratory experimental purposes.

5.1.3 Development of the system as a solution

Power supplies are used in all types of digital displays and cathode ray tube (CRT) colour display. Any equipment that has electronic circuits in it must have a DC supply voltage available. Since all power in the factory originates as an AC voltage, converters must be used in the power supplies to convert an AC to DC power. The regulated power supplies are typically used with circuits containing linear integrated with circuit elements. It is necessary to supply DC at various voltages to the whole or a part of electronic equipment. The power source is usually the main electricity supply of 220V AC, (D.W, Smith 2002).

According to (M. Fredko 2000), the regulated power supply can also be used with circuits containing linear integrated circuit elements and it is constructed to get necessary voltage of 5V to supply DC at electronic equipment. The power source is usually the main electricity supply 220V AC.

5.1.4 Possible application

The variable regulated power supply can be easily constructed with an adjustable positive voltage regulator (LM 317 IC). The output voltage can be varied from 2V (DC) to 24V (DC) depending on the resistor values. This dual regulated power supply produces the maximum DC output voltage 6.8 V and the minimum DC voltage 1.2V. Modern electronic equipment needs a wide variety of DC voltage for its operation. The purpose of a power supply is to provide the primary source. The basic element of this power supply is the AC to DC converter, which consists of a transformer that converts the standard 220V, 50Hz AC. It is suitable for using in any low power electronic circuits, especially the most of the circuit using op-amp ICs. A dual polarity power supply is used for FM receiver. Two regulators, one positive and the other negative, provide the positive voltage required for the receiver circuits and the dual-polarity voltage for the operational amplifier (op-amp) circuits.

5.2 Summary

This chapter has covered Introduction, Discussion of which under Discussion the following were covered the baseline study, Use of technology, Development of the system as a solution and possible application. Furthermore, this chapter has looked at Summary, Conclusion and recommendations / Future works. Finally, the references and appendix were given at the end of the chapter.

5.3 Conclusion

From the results obtained and comparing with other related works. It can be concluded that, the generator requires very little monitoring its normal operation. The output voltage, currents, field voltage and current, stator temperatures and perhaps bearing temperature and oil level would be about the extent of the required monitoring. However, there is one item that is required by NRC regulations that must not only be monitored but if such a fault is detected, the unit must be immediately shutdown, not only the generator but the engine as well. A system is set up to monitor the currents into the generator on the neutral side and also the currents in each phase on the output (load) side of the generator. If one of the phases were to go to ground or if a phase-to-phase fault developed, the input and output currents would not match, indicating a problem exists within the protected area of the generator. In normal service, the currents in each phase of the generator are balanced.

5.4 Recommendation / Future works

The researcher is recommending that this project should be improved on the voltage variation of the output. Also, the voltage variation could be made to vary in fractions of voltage in order to make it more sensitive.

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7. Glossary

Abbreviations	Description
AC	Alternating current
VFD	Variable frequency drive
AIEE	American Institute of Electrical Engineers
DC	Direct current
RPM	Raves per minute
KVA	Kilovolt Amperes
KW	Kilowatt
SCR	Silicone controlled Rectifier
ADC	Analogue Digital counter
NC	Normally closed
MOSEFET	Metal oxide semiconductor field effect transistor
IGBT	Insulated gate bipolar transistor
LCD	Liquid crystal display
GSM	Global system for Mobile
NEMA	National Electrical Manufacturers Association
IEC	International Electrotechnical commission

8. References

1. Smith DW. PIC in Practice. Burlington: Newness publishers, 2002.
2. Horowitz P, Hill W. Art of Electronics. Cambridge: Cambridge Press, 1980.
3. Donald AN. Electronic Circuit Analysis and Design. Osborne: McGraw-Hill Company Inc, 1996.
4. Williams OA. Design and Construction of a regulated Power Supply Unit. Cambridge: Cambridge Press, 1995.
5. Fredko M. Customizing PIC Microcontrollers. Osborne: McGraw- Hill Company, 2000.
6. Theraja BL, Theraja AK. A Textbook of Electrical Technology, S. Chand, New Delhi, 2002.
7. Penfold RA. An Introduction to PIC Microcontrollers. Babani Electronic Books Publishers, 1997.
8. Bates M. Introduction to Microelectronic Systems: The PIC16F84A Microcontroller. London: Arnold Publishers, 2000.
9. Ronald JT, Neal SW. Digital Systems: Principles And Applications. Bombay: Prentice Hall Publishers, 2004.
10. Berkowitz S. Powering Digital Circuits and Systems. Toronto, Canada: Orbit Educational Book Publishers, 2003.
11. Williams BW. Power Electronics, Devices, Applications and Passive Components. Toronto, Canada: Orbit Educational Books Publishers, 2002.
12. Austender D, Saues P. Microprocessors For Measurement and Control. New Jersey: Prentice- Hall International, 1998.
13. Penfold R. Everyday Practical Electronics Magazine, February 2007. Dorset, U.K: Wimborne Publishing Ltd. 16. Proteus Software, 2007. Retrieved October 2009 from: www.Labcenter.com.
14. Osuwa JC. Logic Indicating Device for Trouble hooting Non-Pulsed Output Signals of Integrated Circuits (ICs). Pacific Journal of Science and Technology, 2008.
15. Hammed OS, Ademola AK. Design and Construction of an Emergency Rechargeable Lamp Incorporated with a Battery Overcharging Preventer Circuit. Medwell Journal of Engineering and Applied Sciences, 2008.
16. Smith DW. PIC in Practice Newness Publishers: Burlington, VT, 2002.
17. Horowitz P, Hill W. Art of Electronics. Cambridge Press Cambridge, UK, 1980.
18. Donald AN. Electronic Circuit Analysis and Design McGraw-Hill: New York, NY.4, 1996.
19. Williams OA. Design and Construction of a Regulated Power Supply Unit Cambridge Press, Cambridge, UK, 1995.

20. Fredko M. Customizing PIC Microcontrollers McGraw-Hill: New York, NY, 2000.
21. Theraja BL, Theraja AK. A Textbook of Electrical Technology, 2002.
22. Penfold RA. An Introduction to PIC Microcontrollers Babani Electronic, 1997.
23. Bates M. Introduction to Microelectronic Systems: The PIC16F84A Microcontroller Arnold Publishers: London, UK, 2000.
24. Tocci RJ, Widemer NS. Digital Systems: Principles and Applications Prentice Hall Publishers: Bombay, India, 2004.
25. Berkowitz S. Powering Digital Circuits and Systems Orbit Educational Book Publishers, Toronto, Canada, 2003.
26. Williams BW. Power Electronics, Devices, Applications and Passive Components Orbit Educational Book Publaishers: Toronto, Canadaurrent document, 2002.