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ENERGY SAVING LAMP

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Date : 17 NOVEMBER 2008

DEDICATION

This thesis is dedicated to my beloved father, mother and my family who always support me all the way every time. Thanks lot to them.

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Alhamdulillah thank to god for completion of my project. Also fully thank to all people around me who always help me to complete the project, especially to my mother and siblings for their financial and moral support. I also express my sincere appreciation to my supervisor, En. Ruhaizad b Ishak for his encouragement and guidance in completing the project.

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ABSTRACT

In our daily life, lamp is very synonym with us. Lamp is very useful especially when in the dark environment. In the modern era, there are many types of lamp. First lamp that had been used is filament lamp. After that pendarflour lamp had been used due to the low cost and it’s brighter than filament lamp. Even, another type of lamp had been introduced, that is LED lamp. This type of lamp is having longer life span compared to filament lamp and the pendarflour lamp. Besides that, this lamp is more economical compared to the pendarflour lamp. One of the problem about this lamp, it is hard to find this type of lamp in market. Due to this, the price also expensive. In my project, I use LED as my lamp. To make my project more applicable, I used 9V rechargeable battery. Usually all the battery charger have controller to control the flow of charging process. For my project, I used op-amp as the controller. This controller will cut off the charging process when the battery achieves 9.2V. Besides that, to make the lamp more efficient, one more controller circuit had been developing. This circuit acts as the automatic switch which only will allow the lamp ON when there are no falling light on the Light Dependent Resistor, LDR. With this switching method it will make the use of the lamp is more efficient and economical.

ABSTRAK

Dalam kehidupan harian kita, lampu merupakan sesuatu yang amat rapat dengan kita. Lampu amat berguna apatah lagi apabila kita berada di dalam suasana yang gelap. Di zaman yang serba moden ini terdapat pelbagai jenis lampu. Pada asalnya lampu berfilamen merupakan pilihan yang selalu digunakan. Tetapi setelah kemajuan dalam bidang sains, lampu berpendarflour menjadi pilihan ramai pengguna kerana ianya dapat mengurangkan kos elektrik dan juga lebih terang dari lampu filament. Namun begitu, satu lagi teknologi lampu yang cuba diketengahkan iaitu lampu LED. Lampu ini lebih tahan lama jika hendak dibandingkan dengan lampu filament dan lampu pendarflour. Selain itu lampu ini juga lebih jimat dari segi penggunaan elektrik jika dibandingkan dengan lampu pendarflour. Tetapi masalahnya lampu ini jarang didapati dipasaran dan harganya juga agak mahal. Dalam projek yang saya lakukan, saya menggunakan LED sebagai lampu. Untuk membolehkan penggunaan lampu lebih berleluasa, bateri digunakan bagi membuatkan ianya mudah dibawa ke mana sahaja. Selain itu bateri yang digunakan juga adalah bateri yang boleh dicas semula bagi menjimatkan kos pembelian bateri. Di dalam projek yang saya buat, saya menggunakan bateri 9V yang boleh dicas semula. Pengecas bateri biasanya terdapat satu unit pengawal yang akan menentukan samada bateri itu sudah penuh atau tidak. Dalam projek yang saya buat, pengawal tersebut adalah Op-amp. Pengawal ini akan menghentikan proses mengecas apabila bateri mencapai voltan 9.2 volt. Selain itu, bagi membuatkankan penggunaan lampu lebih efisien, satu litar pengawal yang hanya membenarkan lampu menyala ketika gelap telah dibuat. Ianya menggunakan konsep iaitu lampu hanya akan menyala jika tiada cahaya yang dikesan oleh Light Dependent Resistor, LDR. Dengan adanya system pensuisan sebegini, ia akan membuatkan penggunaan lampu lebih efisien dan menjimatkan.

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CHAPTER 1

INTRODUCTION

1.1 Overview

This project comprises three sections, power supply, charging circuit and lamp control. The output voltage of the power supply is 12V. It used to charge the battery and power the lamp control circuit. For the charging circuit, it charges the 9V rechargeable battery. The function of the rechargeable battery is to make this device portable.

Lamp controlling circuit is the switching circuits which only allow the lamp ON when there are no light falling on LDR. Leaving the lights on when no one is in the room is a huge waste of energy and money. The less time you spend with the lights on, the more energy you save.

To minimize the energy used by the lamp, LED lamp had been used. When compared, incandescent bulbs (1000 hours of life) can't beat LEDs (up to 60,000 hours.). It could save some energy, and some money. Furthermore LED bulbs are closer to the color of daylight which new studies suggest is good for staying alert. LEDs not only produce light more efficiently, they also have a tiny mirror that reflects light in one direction. A more directed light means less wasted light. With LED light bulbs and just a bit of planning we can create a more interesting lighting environment while cutting down on your electric bill.

1.2 Objectives

The main objectives are:

I. To apply theoretical knowledge that has been learn into the real situation.

II. Learn how to use the simulation software before using the components in the hardware.

III. To analyze the using of the LED light in the daily life.

1.3 Scope of Project

The scopes of this project are to develop 12Vdc power supply circuit, charging circuit and lamp controller circuit only based on theoretical knowledge that had been learn. By using the simulation software, the circuit which had been developed has been testing before install it in the actual circuit. After all hardware fully install, the theoretical value from the simulation and the actual value from the hardware is been compared. Analysis will be done based on the data that had been collected.

1.4 Problem Statement

In power supply project, the major problems occur when designing the circuit is the supply is not stabilizing. When this kind of supply use for sensitive equipment like controller, usually the output from that device is not stable. For battery charger, the most important things to design it is the method to cut-off the supply to stop the charging process. This is to make sure the life time of the battery longer. Besides that, there are a few things that we must consider, that are temperature and charging time. The switching method is the important requirement to make sure we use the lamp efficiency. Good switching make more saving in term of energy and money.

1.5 Thesis Organization

This thesis consists of five chapters. Chapter1 is about the introduction, chapter2 about literature review, chapter3 about methodology, chapter4 about result and discussion and chapter5 for conclusion and recommendation.

CHAPTER 2

LITERATURE REVIEW

Power supply circuit:

This project power supply consists of four part, transformer, rectifier, filter and ic regulator. The transformer step down the voltage from $240V_{rms}$ to $15V_{rms}$.

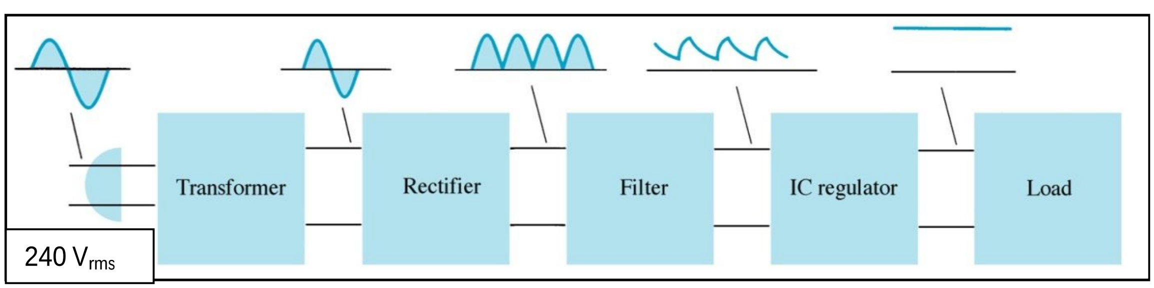


Figure 2.1: Power supply

2.1: Rectifier

A rectifier is an electrical device that converts alternating current (AC) to direct current (DC), a process known as rectification. Rectifiers have many uses including as components of power supplies and as detectors of radio signals. Rectifiers may be made of solid state diodes, vacuum tube diodes, mercury arc valves, and other components.

When only one diode is used to rectify AC (by blocking the negative or positive portion of the waveform), the difference between the term diode and the term rectifier is merely one of usage, i.e., the term rectifier describes a diode that is being used to convert AC to DC. Almost all rectifiers comprise a number of diodes in a specific arrangement for more efficiently converting AC to DC than is possible with only one diode. Before the development of silicon semiconductor rectifiers, vacuum tube diodes and copper (I) oxide or selenium rectifier stacks were used.

Early radio receivers, called crystal radios, used a "cat's whisker" of fine wire pressing on a crystal of galena (lead sulfide) to serve as a point-contact rectifier or "crystal detector". In gas heating systems flame rectification can be used to detect a flame. Two metal electrodes in the outer layer of the flame provide a current path and rectification of an applied alternating voltage, but only while the flame is present.

2.1.1: Half-wave rectification

In half wave rectification, either the positive or negative half of the AC wave is passed, while the other half is blocked. Because only one half of the input waveform reaches the output, it is very inefficient if used for power transfer. Half-wave rectification can be achieved with a single diode in a one phase supply, or with three diodes in a three-phase supply.

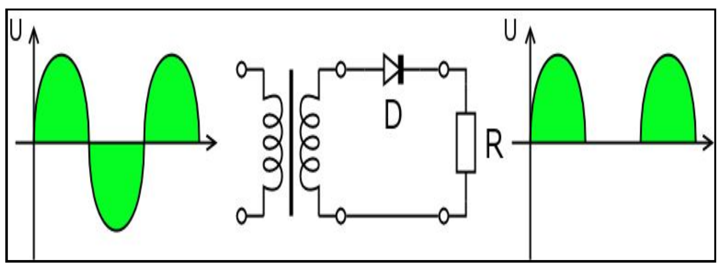


Figure 2.2: Half-wave rectification

2.1.2: Full-wave rectification

A full-wave rectifier converts the whole of the input waveform to one of constant polarity (positive or negative) at its output. Full-wave rectification converts both polarities of the input waveform to DC (direct current), and is more efficient. However, in a circuit with a non-center tapped transformer, four diodes are required instead of the one needed for half-wave rectification. Four rectifiers arranged this way are called a diode bridge or bridge rectifier:

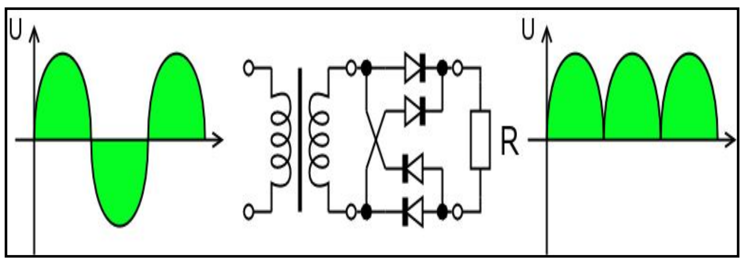


Figure 2.3: Full-wave rectification

For single-phase AC, if the transformer is center-tapped, then two diodes back-to-back (i.e. anodes-to-anode or cathode-to-cathode) form a full-wave rectifier (in this case, the voltage is half of that for the non-tapped bridge circuit above, and the diagram voltages are not to scale).

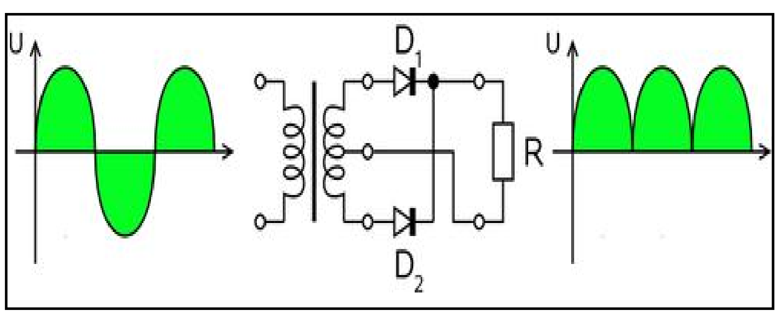


Figure 2.4: Center-tapped

2.2: Filter

2.2.1: The Capacitor Filter

The simple capacitor filter is the most basic type of power supply filter. The application of the simple capacitor filter is very limited. It is sometimes used on extremely high-voltage, low-current power supplies for cathode-ray and similar electron tubes, which require very little load current from the supply. The capacitor filter is also used where the power-supply ripple frequency is not critical, this frequency can be relatively high. The capacitor (C1) shown in figure 2.5 is a simple filter connected across the output of the rectifier in parallel with the load.

When this filter is used, the RC charge time of the filter capacitor (C1) must be short and the RC discharge time must be long to eliminate ripple action. In other words, the capacitor must charge up fast, preferably with no discharge at all. Better filtering also results when the input frequency is high; therefore, the full-wave rectifier output is easier to filter than that of the half-wave rectifier because of its higher frequency.

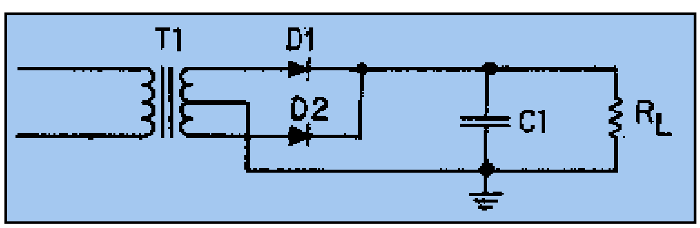


Figure 2.5: Full-wave rectifier with a capacitor filter.

For you to have a better understanding of the effect that filtering has on E_{avg}, a comparison of a rectifier circuit with a filter and one without a filter is illustrated in figure 2.6 and figure 2.7. The output waveforms in both figures represent the unfiltered and filtered outputs of the half-wave rectifier circuit. Current pulses flow through the load resistance (R_L) each time a diode conducts. The dashed line indicates the average value of output voltage. For the half-wave rectifier, E_{avg} is less than half (or approximately 0.318) of the peak output voltage. This value is still much less than that of the applied voltage. With no capacitor connected across the output of the rectifier circuit, the waveform in figure 2.6 has a large pulsating component (ripple) compared with the average or dc component. When a capacitor is connected across the output figure 2.7, the average value of output voltage (E_{avg}) is increased due to the filtering action of capacitor C1.

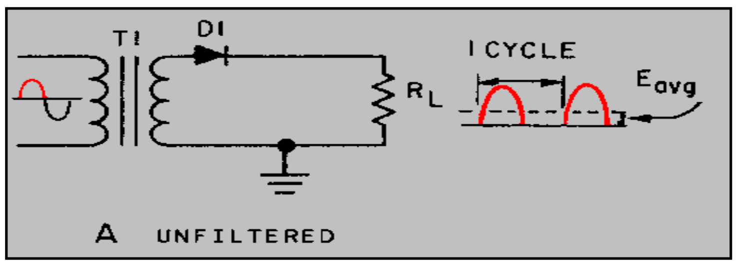


Figure 2.6 - Half-wave rectifier without filtering.

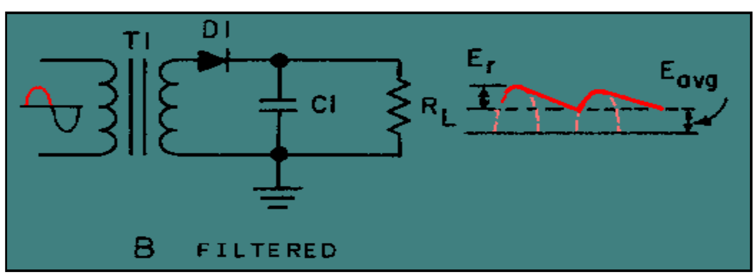


Figure 2.7 - Half-wave rectifier with filtering.

The value of the capacitor is fairly large (several microfarads), thus it presents a relatively low reactance to the pulsating current and it stores a substantial charge.

2.2.2: Resistor-Capacitor (RC) Filters

The RC capacitor-input filter is limited to applications in which the load current is small. This type of filter is used in power supplies where the load current is constant and voltage regulation is not necessary. For example, RC filters are used in high-voltage power supplies for cathode-ray tubes and in decoupling networks for multistage amplifiers.

Figure 2.8 shows an RC capacitor-input filter and associated waveforms. Both half-wave and full-wave rectifiers are used to provide the inputs. The waveform shown in view A of the figure represents the unfiltered output from a typical rectifier circuit. Note that the dashed lines in view A indicate the average value of output voltage (E_{avg}) for the half-wave rectifier. The average output voltage (E_{avg}) is less than half (approximately 0.318) the amplitude of the voltage peaks. The average value of output voltage (E_{avg}) for the full-wave rectifier is greater than half (approximately 0.637), but is still much less than, the peak amplitude of the rectifier-output waveform. With no filter circuit connected across the output of the rectifier circuit (unfiltered), the waveform has a large value of pulsating component (ripple) as compared to the average (or dc) component.

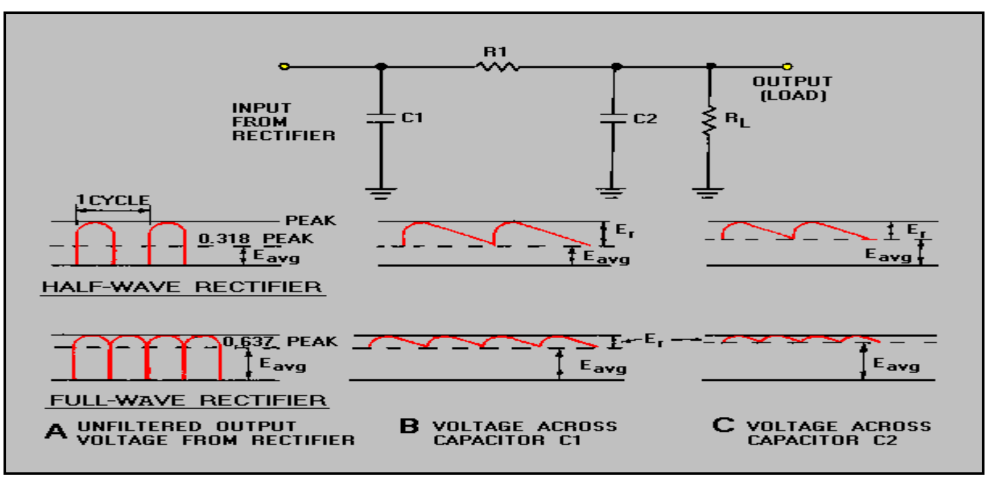


Figure 2.8 - RC filter and waveforms.

The RC filter in figure 2.8 consists of an input filter capacitor, C1, a series resistor, R1, and an output filter capacitor, C2. (This filter is sometimes referred to as an RC pi-section filter because its schematic symbol resembles the Greek letter p).

The single capacitor filter is suitable for many noncritical, low-current applications. However, when the load resistance is very low or when the percent of ripple must be held to an absolute minimum, the capacitor value required must be extremely large. While electrolytic capacitors are available in sizes up to 10,000 microfarads or greater, the large sizes are quite expensive. A more practical approach is to use a more sophisticated filter that can do the same job but that has lower capacitor values, such as the RC filter.

Views A, B, and C of figure 2.8 show the output waveforms of a half-wave and a full-wave rectifier. Each waveform is shown with an RC filter connected across the output. The following explanation of how a filter works will show you that an RC filter of this type does a much better job than the single capacitor filter.

C1 performs exactly the same function as it did in the single capacitor filter. It is used to reduce the percentage of ripple to a relatively low value. Thus, the voltage across C1 might consist of an average dc value of +100 volts with a ripple voltage of 10 volts peak-to-peak. This voltage is passed on to the R1-C2 network, which reduces the ripple even further.

C2 offers an infinite impedance (resistance) to the dc component of the output voltage. Thus, the dc voltage is passed to the load, but reduced in value by the amount of the voltage drop across R1. However, R1 is generally small compared to the load resistance. Therefore, the drop in the dc voltage by R1 is not a drawback.

Component values are designed so that the resistance of R1 is much greater than the reactance (X_C) of C2 at the ripple frequency. C2 offers very low impedance to the ac ripple frequency. Thus, the ac ripple senses a voltage divider consisting of R1 and C2 between the output of the rectifier and ground. Therefore, most of the ripple voltage is dropped across R1. Only a trace of the ripple voltage can be seen across C2 and the load. In extreme cases where the ripple must be held to an absolute minimum, a second stage of RC filtering can be added. In practice, the second stage is rarely required. The RC filter is extremely popular because smaller capacitors can be used with good results.

The RC filter has some disadvantages. First, the voltage drop across R1 takes voltage away from the load. Second, power is wasted in R1 and is dissipated in the form of unwanted heat. Finally, if the load resistance changes, the voltage across the load will change. Even so, the advantages of the RC filter overshadow these disadvantages in many cases.

- For this circuit, it used capacitor filter to reduce the peak-to-peak pulses to a small ripple voltage.

2.3: Voltage regulator

2.3.1: Series voltage regulator

The schematic for a typical series voltage regulator is shown in figure 2.9. Notice that this regulator has a transistor (Q1) in the place of the variable resistor. Because the total load current passes through this transistor, it is sometimes called a "pass transistor." Other components which make up the circuit are the current limiting resistor (R1) and the Zener diode (CR1).

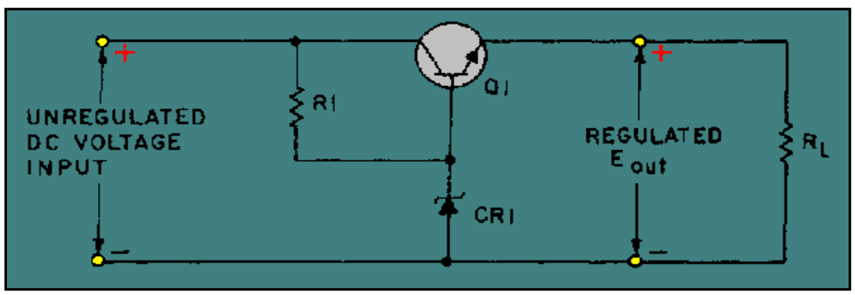


Figure 2.9 - Series voltage regulator.

Recall that a Zener diode is a diode that block current until a specified voltage is applied. Remember also that the applied voltage is called the breakdown, or Zener voltage. Zener diodes are available with different Zener voltages. When the Zener voltage is reached, the Zener diode conducts from its anode to its cathode (with the direction of the arrow).

In this voltage regulator, Q1 has a constant voltage applied to its base. This voltage is often called the reference voltage. As changes in the circuit output voltage occur, they are sensed at the emitter of Q1 producing a corresponding change in the forward bias of the transistor. In other words, Q1 compensates by increasing or decreasing its resistance in order to change the circuit voltage division.

Refer figure 2.10, voltages are shown to help you understand how the regulator operates. The Zener used in this regulator is a 15-volt Zener. In this instance the Zener or breakdown voltage is 15 volts. The Zener establishes the value of the base voltage for Q1. The output voltage will equal the Zener voltage minus a 0.7-volt drop across the forward biased base-emitter junction of Q1, or 14.3 volts. Because the output voltage is 14.3 volts, the voltage drop across Q1 must be 5.7 volts.

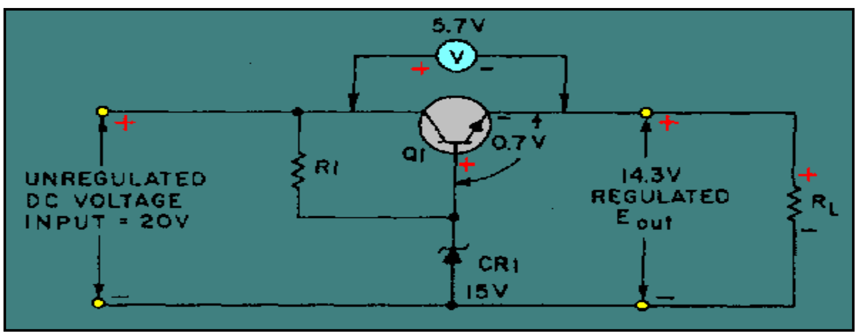


Figure 2.10 - Series voltage regulator (with voltages).

Refer figure 2.11, in order to understand what happens when the input voltage exceeds 20 volts. Notice the input and output voltages of 20.1 and 14.4 volts, respectively. The 14.4 output voltage is a momentary deviation, or variation, from the required regulated output voltage of 14.3 and is the result of a rise in the input voltage to 20.1 volts. Since the base voltage of Q1 is held at 15 volts by CR1, the forward bias of Q1 changes to 0.6 volt. Because this bias voltage is less than the normal 0.7 volt, the resistance of Q1 increases, thereby increasing the voltage drop across the transistor to 5.8 volts. This voltage drop restores the output voltage to 14.3 volts. The entire cycle takes only a fraction of a second and, therefore, the change is not visible on an oscilloscope or readily measurable with other standard test equipment.

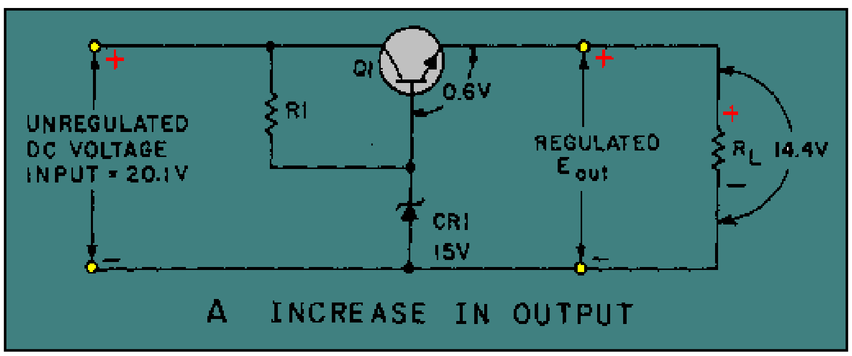


Figure 2.11 - Series voltage regulator(increase in output)

2.3.2: Shunt voltage regulator

The schematic shown in figure 2.12 is that of a shunt voltage regulator. Notice that Q1 is in parallel with the load. Components of this circuit are identical with those of the series voltage regulator except for the addition of fixed resistor R_S. As you study the schematic, you will see that this resistor is connected in series with the output load resistance. The current limiting resistor (R1) and Zener diode (CR1) provide a constant reference voltage for the base-collector junction of Q1. Notice that the bias of Q1 is determined by the voltage drop across R_S and R1. As you should know, the amount of forward bias across a transistor affects its total resistance. In this case, the voltage drop across R_S is the key to the total circuit operation.

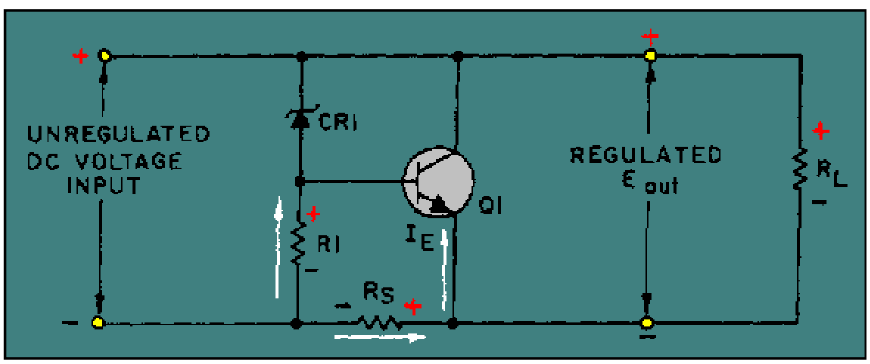


Figure 2.12 - Shunt voltage regulator.

Figure 2.13 is the schematic for a typical shunt-type regulator. Notice that the schematic is identical to the schematic shown in figure 2.12 except that voltages are shown to help you understand the functions of the various components. In the circuit shown, the voltage drop across the Zener diode (CR1) remains constant at 5.6 volts. This means that with a 20-volt input voltage, the voltage drop across R1 is 14.4 volts. With a base-emitter voltage of 0.7 volt, the output voltage is equal to the sum of the voltages across CR1 and the voltage at the base-emitter junction of Q1.

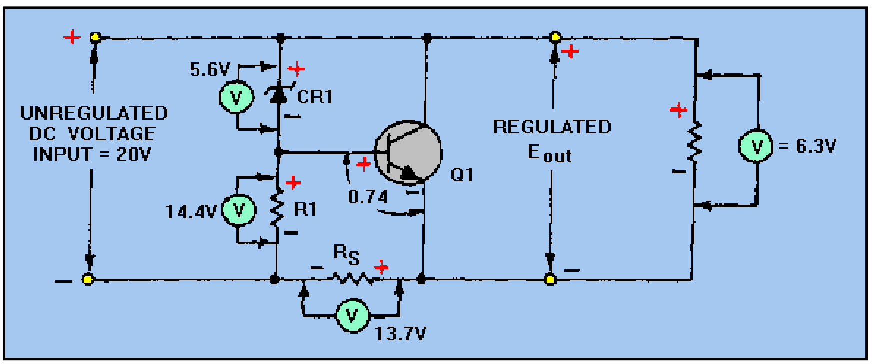


Figure 2.13 - Shunt voltage regulator (with voltages).

Now, refer figure 2.14. This figure shows the schematic diagram of the same shunt voltage regulator as that shown in figure with an increased input voltage of 20.1 volts. This increases the forward bias on Q1 to 0.8 volt. Recall that the voltage drop across CR1 remains constant at 5.6 volts. Since the output voltage is composed of the Zener voltage and the base-emitter voltage, the output voltage momentarily increases to 6.4 volts. At this time, the increase in the forward bias of Q1 lowers the resistance of the transistor allowing more current to flow through it. Since this current must also pass through R_S, there is also an increase in the voltage drop across this resistor. The voltage drop across R_S is now 13.8 volts and therefore the output voltage is reduced to 6.3 volts. Remember, this change takes place in a fraction of a second.

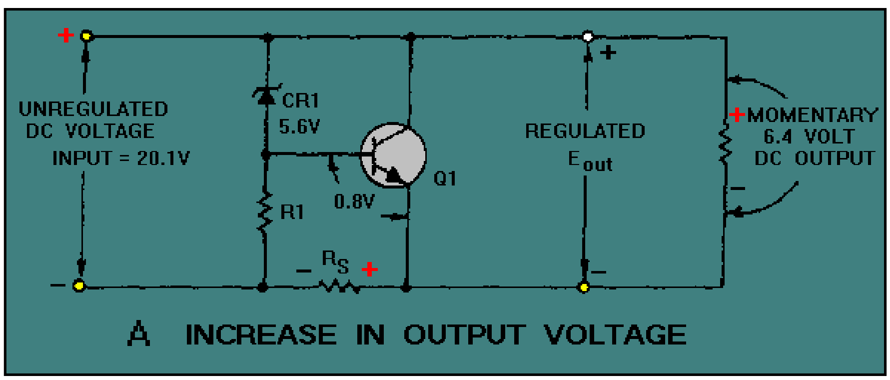


Figure 2.14 - Shunt voltage regulator(increase in output voltage)

In figure 2.15, although this schematic is identical to the other shunt voltage schematics previously illustrated and discussed, the output voltage is different. The load current has increased causing a momentary drop in voltage output to 6.2 volts. Recall that the circuit was designed to ensure a constant output voltage of 6.3 volts. Since the output voltage is less than that required, changes occur in the regulator to restore the output to 6.3 volts. Because of the 0.1 volt drop in the output voltage, the forward bias of Q1 is now 0.6 volt. This decrease in the forward bias increases the resistance of the transistor, thereby reducing the current flow through Q1 by the same amount that the load current increased. The current flow through R_S returns to its normal value and restores the output voltage to 6.3 volts.

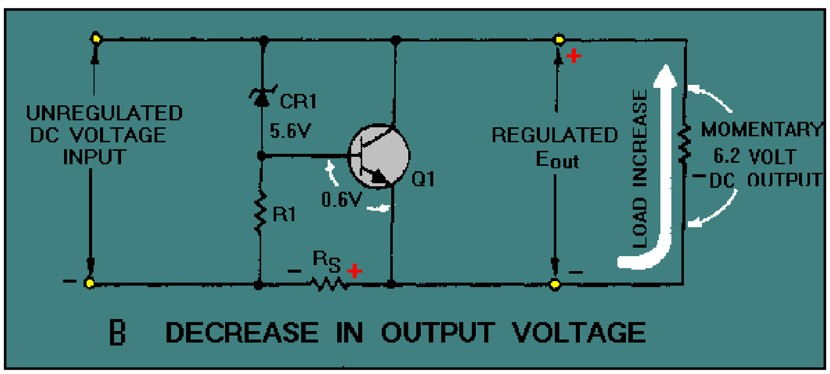


Figure 2.15 - Shunt voltage regulator(decease in output voltage)

- To provide linear and stable voltage, this circuit use regulator LM7812 to supply $12V_{dc}$ for charging circuit and lamp control circuit.

Charging circuit:

2.1: Op-Amp

Op-Amp act as the controller by use it as a comparator unit of the circuit. A comparator circuit accepts input of linear voltages and provides a digital output that indicates that one input is less than or greater than the second. If the voltage on the noninverting (+) input is greater than the voltage on the inverting (-) input, the output of the comparator goes to low impedance on for open collector / drain outputs, and high for totem pole outputs. If the voltage on the noninverting (+) input is less than the voltage on the inverting (-) input, the output of the comparator goes to high impedance off for open collector / drain outputs, and low for totem pole outputs.

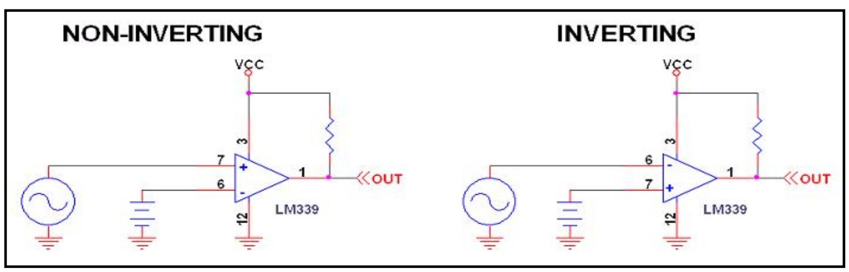


Figure 2.16: Op-amp

The inverting and noninverting stages are often combined into a window comparator stage,which only has a high output when the voltage is between the low and high limits. The high and low limits are usually produced in a 3-resistor voltage divider.

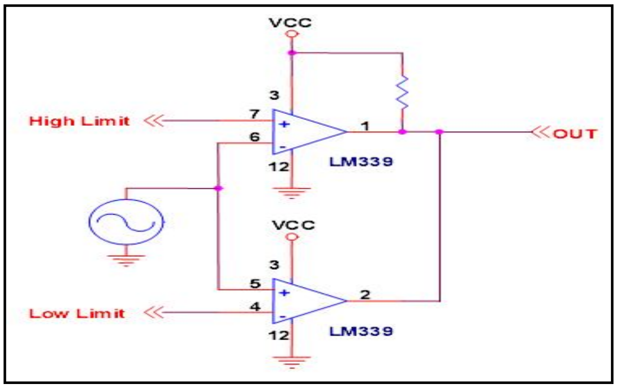


Figure 2.17: Application op-amp

2.2: Upper Limit and Lower Limit

Firstly we need to select suitable zener diodes which act as the reference voltage. After that, based on the datasheet of the battery, we need to find the lower limit and the upper limit value of the battery to prevent over-charging or deep discharge. This is to make sure that the battery has long life span. By using that value, we use the voltage divider concept to make sure the voltage drop at the resistor is higher or lower than the reference voltage.

2.3: Relay

A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. It was invented by Joseph Henry in 1835. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered to be, in a broad sense, a form of an electrical amplifier.

2.3.1 Basic design and operation

A simple electromagnetic relay, such as the one taken from a car in the first picture, is an adaptation of an electromechanical solenoid. It consists of a coil of wire surrounding a soft iron core, an iron yoke, which provides a low reluctance path for magnetic flux, a moveable iron armature, and a set, or sets, of contacts; two in the relay pictured. The armature is hinged to the yoke and mechanically linked to a moving contact or contacts. It is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. Other relays may have more or fewer sets of contacts depending on their function. The relay in the picture also has a wire connecting the armature to the yoke. This ensures continuity of the circuit between the moving contacts on the armature, and the circuit track on the Printed Circuit Board (PCB) via the yoke, which is soldered to the PCB.

When an electric current is passed through the coil, the resulting magnetic field attracts the armature and the consequent movement of the movable contact or contacts either makes or breaks a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open. When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low voltage application, this is to reduce noise. In a high voltage or high current application, this is to reduce arcing.

2.3.2 Pole and throw

Since relays are switches, the terminology applied to switches is also applied to relays. A relay will switch one or more poles, each of whose contacts can be thrown by energizing the coil in one of three ways:

- Normally-open (NO) contacts connect the circuit when the relay is activated; the circuit is disconnected when the relay is inactive. It is also called a Form A contact or "make" contact.
- Normally-closed (NC) contacts disconnect the circuit when the relay is activated; the circuit is connected when the relay is inactive. It is also called a Form B contact or "break" contact.
- Change-over (CO), or double-throw (DT), contacts control two circuits: one normally-open contact and one normally-closed contact with a common terminal. It is also called a Form C contact or "transfer" contact ("break before make"). If this type of contact utilizes”make before break" functionality, then it is called a Form D contact.

The following designations are commonly encountered:

- SPST - Single Pole Single Throw. These have two terminals which can be connected or disconnected. Including two for the coil, such a relay has four terminals in total. It is ambiguous whether the pole is normally open or normally closed. The terminology "SPNO" and "SPNC" is sometimes used to resolve the ambiguity.
- SPDT - Single Pole Double Throw. A common terminal connects to either of two others. Including two for the coil, such a relay has five terminals in total.
- DPST - Double Pole Single Throw. These have two pairs of terminals. Equivalent to two SPST switches or relays actuated by a single coil. Including two for the coil, such a relay has six terminals in total. The poles may be Form A or Form B (or one of each).
- DPDT - Double Pole Double Throw. These have two rows of change-over terminals. Equivalent to two SPDT switches or relays actuated by a single coil. Such a relay has eight terminals, including the coil.

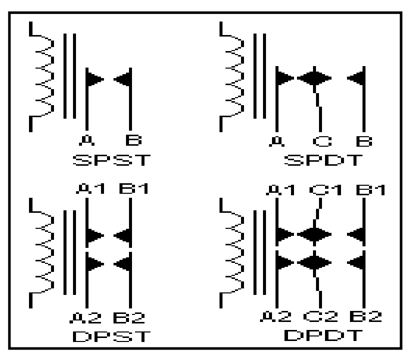


Figure 2.18: A DPDT AC coil relay and symbol of the relay

Lamp control circuit:

Lamp controlling circuit is the switching circuits which only allow the lamp ON when there are no light falling on LDR. Leaving the lights on when no one is in the room is a huge waste of energy and money. The less time you spend with the lights on, the more energy you save. A normal bulb will use 60 watts of energy an hour, meaning that you could conserve nearly 22,000 watts of energy per year by just switching off one bulb for one hour every day. That's enough energy to power one month worth of evening TV viewing.

2.1 Light Dependent Resistor(LDR)

A photoresistor or Light Dependent Resistor or CdS Cell is a resistor whose resistance decreases with increasing incident light intensity. It can also be referred to as a photoconductor.

A photoresistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance.

A photoelectric device can be either intrinsic or extrinsic. An intrinsic semiconductor has its own charge carriers and is not an efficient semiconductor, e.g. silicon. In intrinsic devices the only available electrons are in the valence band, and hence the photon must have enough energy to excite the electron across the entire bandgap. Extrinsic devices have impurities, also called dopants, added whose ground state energy is closer to the conduction band; since the electrons don't have as far to jump, lower energy photons (i.e., longer wavelengths and lower frequencies) are sufficient to trigger the device. If a sample of silicon has some of its atoms replaced by phosphorus atoms (impurities), there will be extra electrons available for conduction. This is an example of an extrinsic semiconductor.

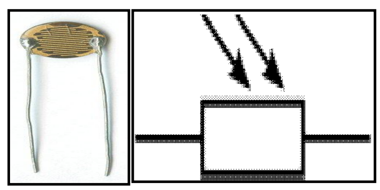


Figure 2.19: LDR and its symbol

2.2: LED lamp can minimize the energy use.

To minimize the energy used by the lamp, LED lamp had been used. When compared, incandescent bulbs (1000 hours of life) can't beat LEDs (up to 60,000 hours.). It could save some energy, and some money. Furthermore LED bulbs are closer to the color of daylight which new studies suggest is good for staying alert. LEDs not only produce light more efficiently, they also have a tiny mirror that reflects light in one direction. A more directed light means less wasted light. With LED light bulbs and just a bit of planning we can create a more interesting lighting environment while cutting down on your electric bill.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter presents the methodology of this project. It describes on how the project is organized and the flow of the steps in order to complete this project. The most difficult time during this project is to design the circuit. By just refer to the references circuit from magazine and internet the whole circuit had been developed. Software that had been used for the simulation is Pspice and Proteus.

3.2 Flowchart of the project:

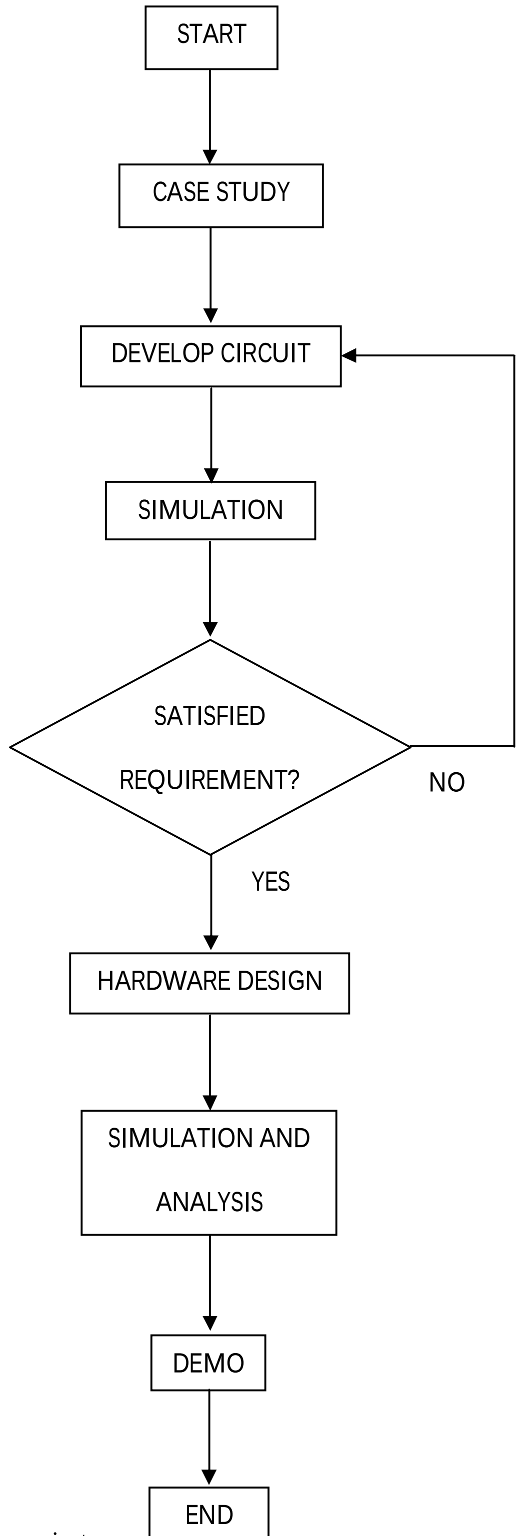


Figure 3.1: Flowchart of the project

Flow chart shows the flow of the whole project. The project begins after registering the PSM title with doing case study about the project. After referring some references like magazines, lecture note, internet and reference book, the project circuit had been develop. The project circuit consists of a few circuits like power supply circuit, charging circuit and LDR switching circuit. All of this circuit had been simulate using simulation software like Pspice and Proteus to make sure the output of the circuit satisfied the project needed.

3.3: Controller circuit

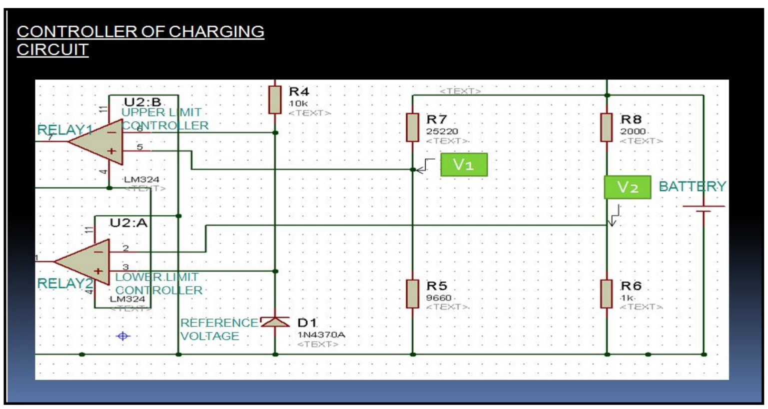


Figure 3.2: Controller circuit

For the charging circuit, if the battery voltage is 7.5V to 9.2V, main power is available. The relay1 is remaining de-energized. In this condition, the battery charges through the normally-closed contact. If the battery voltage goes below 7.5V, the voltage at its inverting pin9 goes below the reference voltage. As the result, the output of Op-Amp2 goes high and energize relay2 to prevent deep-discharge of the battery. If the battery voltage goes above 9.2V, the voltage at its non-inverting pin 12 goes above the reference voltage. As the result, the output of Op-Amp1 goes high and energize relay1 to prevent over-charge of the battery.

3.4: Project requirement.

For the power supply, it must supply 12Vdc with current 750mA. The charging circuit is for 9V rechargeable battery. Value for upper limit setting is 9.2V and for lower limit setting is 7.5V. For LDR switching circuit, it must only operated when no light falling on the LDR.

After simulation satisfied the requirement of the project, all the components had been install on the board. The troubleshooting process is done after all the components are fully installed. This is to prevent the components of the circuit from blow if any false connection happened. After finished troubleshooting, the project is been tested.

All data from the simulation and the hardware had been gathered for the analysis process. After all information and the analysis complete, my project was been presented on the seminar 2.

CHAPTER 4

RESULT DISCUSSION

This chapter consists of the discussions on the results from the hardware and the simulation software.

4.1 Power supply result:

Output from rectifier:

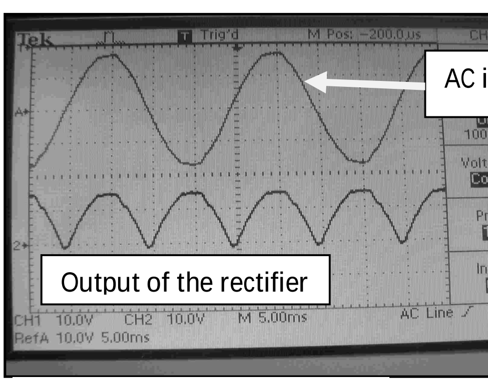


Figure 4.1: Rectifier output

Output from filter:

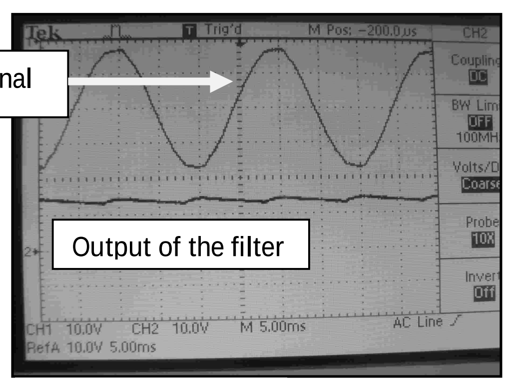


Figure 4.2: Filter

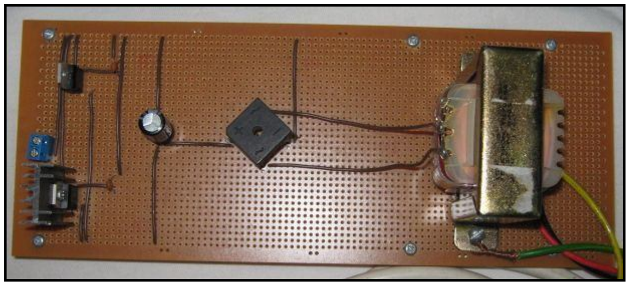
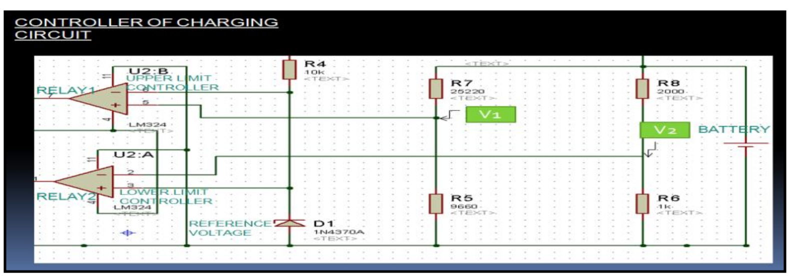


Figure 4.3: Power supply

4.2 Charging circuit data:

This circuit is the circuit that charging 9V rechargeable battery. Main components in this circuit consist of 12V relay and LM324(Op-Amp).

4.2 Circuit for charging circuit:



Hardware for charging circuit:

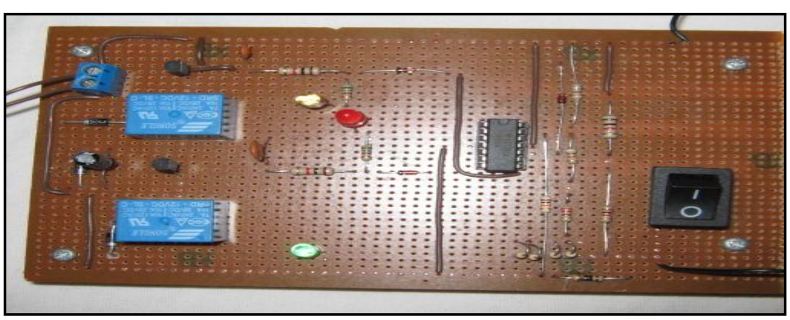


Figure 4.4: Charging circuit

Table 4.1: Hardware and simulation result

BATTERY VOLTAGE(V)	SIMULATION RESULT			HARDWARE RESULT		
	Reference voltage(V)	V1(V)	V2(V)	Reference voltage(V)	V1(V)	V2(V)
1	2.54	0.28	0.33	2.36	1.21	1.47
2	2.54	0.55	0.67	2.36	1.22	1.46
3	2.54	0.83	1.00	2.36	1.22	1.47
4	2.54	1.11	1.33	2.36	1.22	1.47
5	2.54	1.38	1.67	2.39	1.40	1.68
6	2.54	1.66	2.00	2.43	1.66	2.00
7	2.54	1.94	2.33	2.44	1.94	2.34
8	2.54	2.22	2.67	2.57	2.35	2.85
9	2.54	2.49	3.00	2.57	2.51	3.03
10	2.54	2.77	3.33	2.57	2.80	3.37

Table 4.2: Charging circuit summarization

Voltage range	**Op-amp energize**	**LED**
0 to 7.5V	Op-Amp2	Green and yellow
7.5 to 9.2v	none	Green
9.2v and above	Op-Amp1 energize	Red

Green LED shows that the battery had been charge. Yellow LED indicated that the battery is really low and cannot give the enough supply to ON the lamp (white LED). Red LED shows that the battery is fully charge and there is no charging process.

Table 4.3: Charging voltage vs time

Hours	Battery voltage(V)
0	6.71
2	7.45
4	7.45
6	7.72
8	9.37
10	8.47
12	8.52
14	8.77
16	8.82
18	9.12
20	9.20

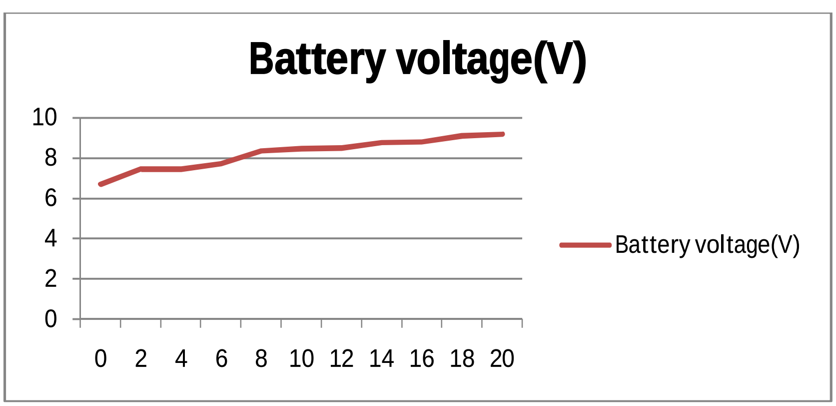


Figure 4.5: Graph charging

4.3 Controller lamp circuit:

This circuit function is to control the switching of the LED lamp. The main components on this circuit are 555 Timer, LDR and LED lamp. Its only will ON when no light falling on LDR. He number of LED used as lamp is 3-3 parallel white LED. The lamp only can be ON if the supply voltage from the battery is above 7.5V. Below from 7.5V, the LED lamp will not ON. 9V battery only can supply enough current for 3-3 parallel white LED. More LED needs more current.

Table 4.4: Lamp circuit observation

Supply Voltage	LED ON/OFF	Light condition
2	OFF	No light.
4	OFF	No light.
6	OFF	No light.
8	ON	little light
9	ON	Bright
10	ON	Very bright

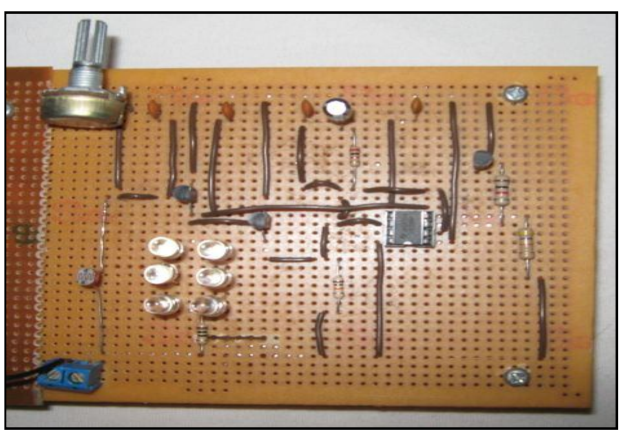


Figure 4.6: Lamp controller hardware

4.3.1: Switching method analysis.

In the real situation, if we applied this switching method which is based on light falling on LDR, we can save a lot of waste energy and money. This analysis is for the corridor lamp in kolej kediaman 2. Let's assume each house in KK2 late to switch OFF corridor lamp for one hour.

- Total house in KK2= 300
- Each house use 4ft fluorescent lamp which power about 40 watt for the corridor.
- Total power used in KK2's corridor = 300x40watt= 12Kwatt
- Electrical tariff= 21.80cent/KWh
- Total cost for 1hour= 21.80senx12= RM2.616
- For 1month= RM2.616x30= RM 78.48
- For 1year= RM78.48x12= RM 941.76

Table 4.5: Comparison between LED Light Bulbs and Incandescent Light Bulbs.

Life Span & Energy Consumption Benefits of LED Light Bulbs vs. Incandescent Light Bulbs	**Incandescent 60 Watt Light Bulb**	**CC Vivid 2 Watt LED Light Bulb**
Life Span	1000 hours	30000 hours
Number of bulbs used for 30,000 hour period	30	1
Bulb Cost for 30,000 hours	RM 67.13	RM 116.73
Electricity Usage kWh of electricity used for 30,000 hours	1800KWh	60KWh
Cost of Electricity for 30,000 hours	1800x21.80cent =RM329.40	60x21.80cent =RM13.08
Total Cost for 30,000 hours	RM 396.53	RM 129.81
Total Savings:	RM 396.53-RM 129.81= RM 266.72	

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

There are many learning process during doing this project. Not only learn about the hardware of the project but also learn how to dealing with people, how to communicate with people and also how to do the simulation. This project also makes me more clearly about the function of the basic components like Op-Amp, relay and transistor.

Do the simulation is very important process before we do the hardware. There are a few software that usually been use for simulation. That's Pspice and Proteus. The simulation software is very important to guide us design the circuit event through there are mismatch with the actual circuit.

Besides that, to choose the best type of lamp, there are a few factors we need to consider. It is depends on the situation. The factors are prices, lifespan, brightness and the power used by the lamp.

5.2 Future recommendations

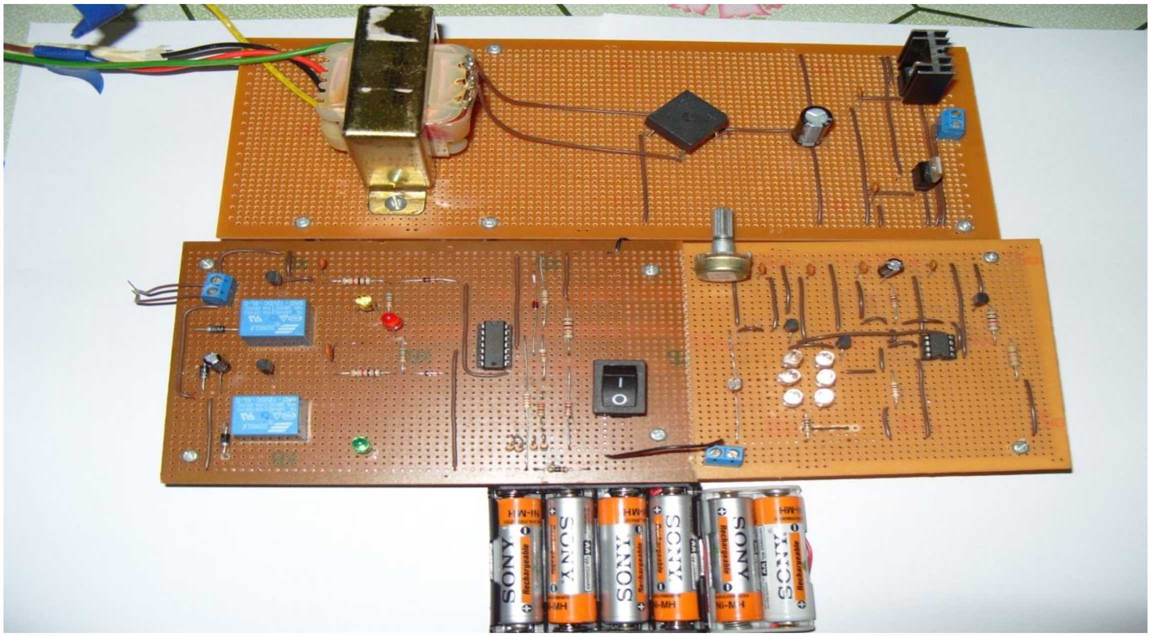
After finishing all the hardware, there are a few disadvantages I had figure out from my project. First thing is the charging time for my charger is too long. Besides that's I think I need to add current booster circuit into my charging circuit to make the charging time is about one hour or less. Due to use the high current to fast the charging process, the temperature also will increase. To control the temperature, I will add the temperature sensor to control and protect my circuit. The sensor will send the signal to the controller so that when the temperature is high, the current will go slow and if the temperature is normal, high current will be use. Based on the number of the LED lamp, the lamp is only suitable for table lamp or sleep lamp. To use it for big application like to replace fluorescent lamp, we need to add the number of LED. Based on that increase, sizes of battery also need to be enlarged. Besides that's, the rating off all my components also need to be consider again.

5.3 Costing and Commercialization

Cost for this project is only for the hardware. Power supply circuit is about RM15. Charging circuit is about RM25 and the lamp with controller circuit is about RM10. Total cost is only about RM50. A price for battery charger in the market is only about RM30 to RM50. Compared to my battery charger, the function and accessories is about same. But the disadvantage of my charger is the charging time. The market battery charger usually has 8 hours to charge the battery but my charging time is 20 hours. Its quiet hard to compete the available market battery charger. Besides that, size of my battery charger also in disadvantage side. The only thing that can be commercialized for my project is the switching method. The system can be applied in the daily life. So to conclude it, my battery charger cannot be commercialized but the switching method for the lamp can be commercialized.

APPENDIX A

HARDWARE OF THE PROJECT



APPENDIX B

DIODE 1N4007

Axial Lead Standard Recovery Rectifiers

This data sheet provides information on subminiature size, axial lead mounted rectifiers for general–purpose low–power applications.

Mechanical Characteristics

- Case: Epoxy, Molded
- Weight: 0.4 gram (approximately)
- Finish: All External Surfaces Corrosion Resistant and Terminal Leads are Readily Solderable
- Lead and Mounting Surface Temperature for Soldering Purposes: 220°C Max. for 10 Seconds, 1/16" from case
- Shipped in plastic bags, 1000 per bag.
- Available Tape and Reeled, 5000 per reel, by adding a "RL" suffix to the part number
- Polarity: Cathode Indicated by Polarity Band
- Marking: 1N4001, 1N4002, 1N4003, 1N4004, 1N4005, 1N4006, 1N4007

1N4001 thru 1N4007

1N4004 and 1N4007 are Motorola Preferred Devices

LEAD MOUNTED RECTIFIERS 50–1000 VOLTS DIFFUSED JUNCTION

CASE 59–03
DO–41

MAXIMUM RATINGS

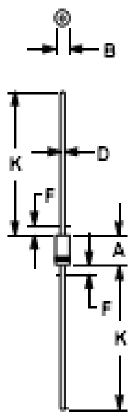
Rating	Symbol	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	Unit
*Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	Volts
*Non–Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz)	V_{RSM}	60	120	240	480	720	1000	1200	Volts
*RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	Volts
*Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 8, T_A = 75°C)	I_O	1.0							Amp
*Non–Repetitive Peak Surge Current (surge applied at rated load conditions, see Figure 2)	I_{FSM}	30 (for 1 cycle)							Amp
Operating and Storage Junction Temperature Range	T_J T_{stg}	– 65 to +175							°C

ELECTRICAL CHARACTERISTICS*

Rating	Symbol	Typ	Max	Unit
Maximum Instantaneous Forward Voltage Drop (i_F = 1.0 Amp, T_J = 25°C) Figure 1	v_F	0.93	1.1	Volts
Maximum Full–Cycle Average Forward Voltage Drop (I_O = 1.0 Amp, T_L = 75°C, 1 inch leads)	$V_{F(AV)}$	—	0.8	Volts
Maximum Reverse Current (rated dc voltage) (T_J = 25°C) (T_J = 100°C)	I_R	 0.05 1.0	 10 50	μA
Maximum Full–Cycle Average Reverse Current (I_O = 1.0 Amp, T_L = 75°C, 1 inch leads)	$I_{R(AV)}$	—	30	μA

*Indicates JEDEC Registered Data

PACKAGE DIMENSIONS



NOTES:
1. ALL RULES AND NOTES ASSOCIATED WITH JEDEC DO-41 OUTLINE SHALL APPLY.
2. POLARITY DENOTED BY CATHODE BAND.
3. LEAD DIAMETER NOT CONTROLLED WITHIN F DIMENSION.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.07	5.20	0.160	0.205
B	2.04	2.71	0.080	0.107
D	0.71	0.86	0.028	0.034
F	---	1.27	---	0.050
K	27.94	---	1.100	---

CASE 59–03
(DO–41)
ISSUE M

APPENDIX C

VOLTAGE REGULATOR LM7812

LM78XX
Series Voltage Regulators

General Description

The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and currents.

The LM78XX series is available in an aluminum TO-3 package which will allow over 1.0A load current if adequate heat sinking is provided. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistor is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating.

Considerable effort was expanded to make the LM78XX series of regulators easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response. Input bypassing is needed only if the regulator is located far from the filter capacitor of the power supply.

For output voltage other than 5V, 12V and 15V the LM117 series provides an output voltage range from 1.2V to 57V.

Features

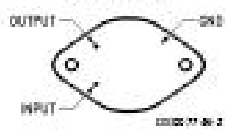
- Output current in excess of 1A
- Internal thermal overload protection
- No external components required
- Output transistor safe area protection
- Internal short circuit current limit
- Available in the aluminum TO-3 package

Voltage Range

LM7805C	5V
LM7812C	12V
LM7815C	15V

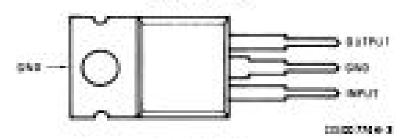
Connection Diagrams

Metal Can Package
TO-3 (K)
Aluminum



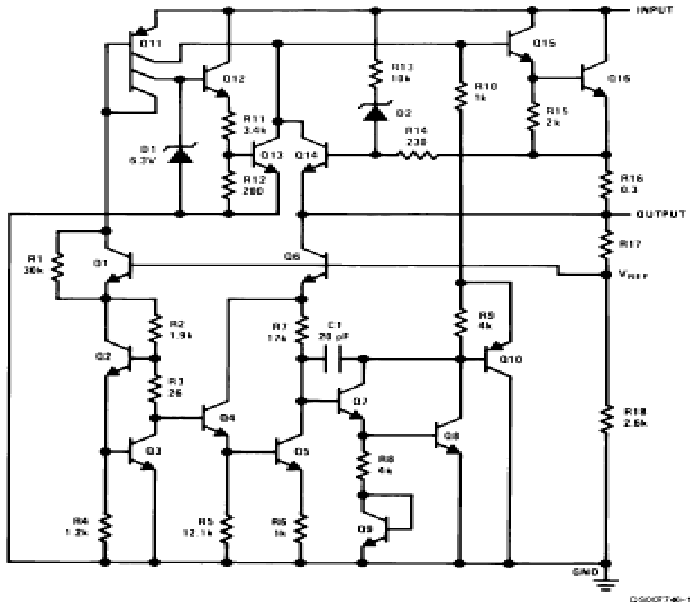
Bottom View
Order Number LM7805CK, LM7812CK or LM7815CK
See NS Package Number KC02A

Plastic Package
TO-220 (T)



Top View
Order Number LM7805CT, LM7812CT or LM7815CT
See NS Package Number T03B

Schematic




Absolute Maximum Ratings

Electrical Characteristics

Electrical Characteristics LM78XXC (Note 2) (Continued)

$0^{\circ}C \le T_J \le 125^{\circ}C$ unless otherwise noted.

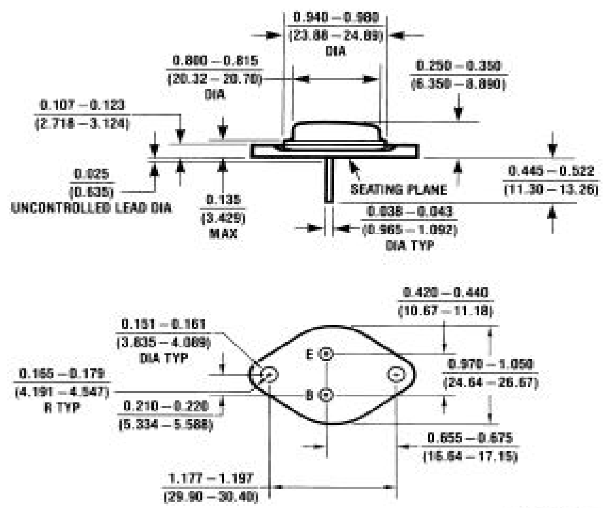
Output Voltage			5V			12V			15V			Units
Input Voltage (unless otherwise noted)			10V			19V			23V			
Symbol	Parameter	Conditions	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
	Short-Circuit Current	Tj = 25°C		2.1			1.5			1.2		A
	Peak Output Current	Tj = 25°C		2.4			2.4			2.4		A
	Average TC of V_{OUT}	0°C ≤ Tj ≤ +125°C, I_O = 5 mA		0.6			1.5			1.8		mV/°C
V_{IN}	Input Voltage Required to Maintain Line Regulation	Tj = 25°C, I_O ≤ 1A		7.5		14.6			17.7			V

Note 1: Thermal resistance of the TO-3 package (K, KC) is typically 4°C/W junction to case and 35°C/W case to ambient. Thermal resistance of the TO-220 package (T) is typically 4°C/W junction to case and 50°C/W case to ambient.

Note 2: All characteristics are measured with capacitor across the input of 0.22 µF, and a capacitor across the output of 0.1µF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

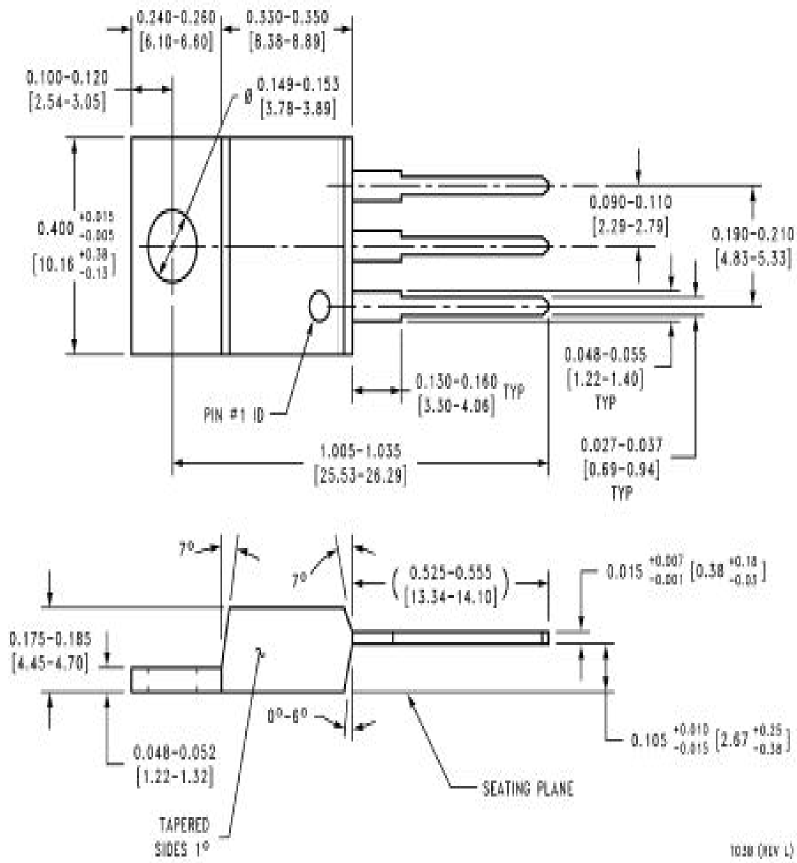
Note 3: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. For guaranteed specifications and the test conditions, see Electrical Characteristics.

Physical Dimensions inches (millimeters) unless otherwise noted



Aluminum Metal Can Package (KC)
Order Number LM7805CK, LM7812CK or LM7815CK
NS Package Number KC02A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



TO-220 Package (T)
Order Number LM7805CT, LM7812CT or LM7815CT
NS Package Number T03B

APPENDIX D

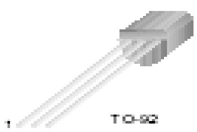
TRANSISTOR BC337

FAIRCHILD
SEMICONDUCTOR™

BC337/338

Switching and Amplifier Applications

- Suitable for AF-Driver stages and low power output stages
- Complement to BC327/BC328



1 TO-92
1. Collector 2. Base 3. Emitter

NPN Epitaxial Silicon Transistor

Absolute Maximum Ratings T_a=25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CBO}	Collector-Emitter Voltage : BC337 : BC338	 50 30	 V V
V_{CEO}	Collector-Emitter Voltage : BC337 : BC338	 45 25	 V V
V_{EBO}	Emitter-Base Voltage	5	V
I_C	Collector Current(DC)	800	mA
P_C	Collector Power Dissipation	625	mW
T_J	Junction Temperature	150	°C
T_{STG}	Storage Temperature	-55 ~ 150	°C

Electrical Characteristics T_a=25°C unless otherwise noted

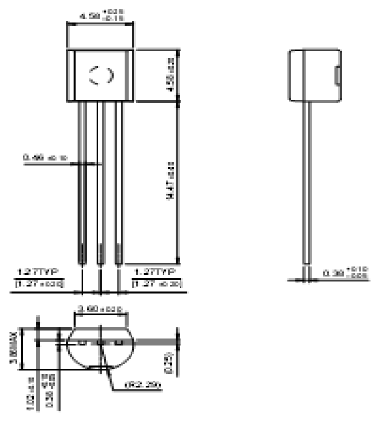
Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Units
BV_{CEO}	Collector-Emitter Breakdown Voltage : BC337 : BC338	I_C=10mA, I_B=0	 45 25			 V V
BV_{CES}	Collector-Emitter Breakdown Voltage : BC337 : BC338	I_C=0.1mA, V_{BE}=0	 50 30			 V V
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E=0.1mA, I_C=0	5			V
I_{CES}	Collector Cut-off Current : BC337 : BC338	 V_{CE}=45V, I_B=0 V_{CE}=25V, I_B=0		 2 2	 100 100	 nA nA
h_{FE1} h_{FE2}	DC Current Gain	V_{CE}=1V, I_C=100mA V_{CE}=1V, I_C=300mA	100 60		630	
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C=500mA, I_B=50mA			0.7	V
V_{BE} (on)	Base Emitter On Voltage	V_{CE}=1V, I_C=300mA			1.2	V
f_T	Current Gain Bandwidth Product	V_{CE}=5V, I_C=10mA, f=50MHz		100		MHz
C_{ob}	Output Capacitance	V_{CB}=10V, I_E=0, f=1MHz		12		pF

h_{FE} Classification

Classification	16	25	40
h_{FE1}	100 ~ 250	160 ~ 400	250 ~ 630
h_{FE2}	60-	100-	170-

Package Dimensions

TO-92



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CROSSVOLT™	FRFET™	MicroPak™	QFET™	SuperSOT™-8
DOME™	GlobalOptoisolator™	MICROWIRE™	QS™	SyncFET™
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The Power Franchise™		OPTOLOGIC®	SILENT SWITCHER®	VCX™
Programmable Active Droop™		OPTOPLANAR™	SMART START™	

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As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, or (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in significant injury to the user.

2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

APPENDIX E

TRANSISTOR BC547

NPN general purpose transistors — BC546; BC547

FEATURES

- Low current (max. 100 mA)
- Low voltage (max. 65 V).

APPLICATIONS

- General purpose switching and amplification.

DESCRIPTION

NPN transistor in a TO-92; SOT54 plastic package.
PNP complements: BC556 and BC557.

PINNING

PIN	DESCRIPTION
1	emitter
2	base
3	collector

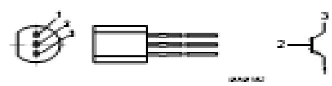


Fig. 1 Simplified outline (TO-92; SOT54) and symbol.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BC546		–	80	V
	BC547		–	50	V
V_{CEO}	collector-emitter voltage	open base			
	BC546		–	65	V
	BC547		–	45	V
V_{EBO}	emitter-base voltage	open collector			
	BC546		–	6	V
	BC547		–	6	V
I_C	collector current (DC)		–	100	mA
I_{CM}	peak collector current		–	200	mA
I_{BM}	peak base current		–	200	mA
P_{tot}	total power dissipation	$T_{amb} \leq 25\ ^\circ C$; note 1	–	500	mW
T_{stg}	storage temperature		−65	+150	°C
T_j	junction temperature		–	150	°C
T_{amb}	operating ambient temperature		−65	+150	°C

Note

1. Transistor mounted on an FR4 printed-circuit board.

Philips Semiconductors — Product specification

NPN general purpose transistors — BC546; BC547

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
$R_{th\ j-a}$	thermal resistance from junction to ambient	note 1	0.25	K/mW

Note

1. Transistor mounted on an FR4 printed-circuit board.

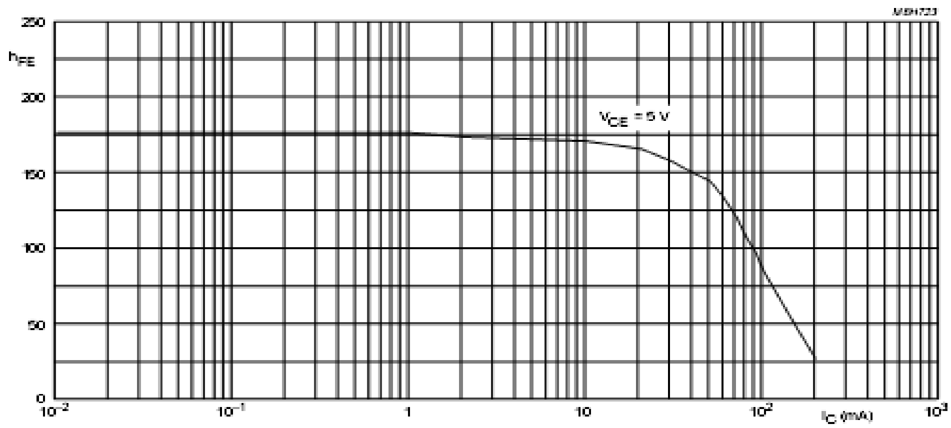
CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
I_{CBO}	collector cut-off current	I_E = 0; V_{CB} = 30 V	–	–	15	nA
		I_E = 0; V_{CB} = 30 V; T_j = 150 °C	–	–	5	μA
I_{EBO}	emitter cut-off current	I_C = 0; V_{EB} = 5 V	–	–	100	nA
h_{FE}	DC current gain	I_C = 10 μA; V_{CE} = 5 V; see Figs 2, 3 and 4				
	BC546A		–	90	–	
	BC546B; BC547B		–	150	–	
	BC547C		–	270	–	
	DC current gain	I_C = 2 mA; V_{CE} = 5 V; see Figs 2, 3 and 4				
	BC546A		110	180	220	
	BC546B; BC547B		200	290	450	
	BC547C		420	520	800	
	BC547		110	–	800	
	BC546		110	–	450	
V_{CEsat}	collector-emitter saturation voltage	I_C = 10 mA; I_B = 0.5 mA	–	90	250	mV
		I_C = 100 mA; I_B = 5 mA	–	200	600	mV
V_{BEsat}	base-emitter saturation voltage	I_C = 10 mA; I_B = 0.5 mA; note 1	–	700	–	mV
		I_C = 100 mA; I_B = 5 mA; note 1	–	900	–	mV
V_{BE}	base-emitter voltage	I_C = 2 mA; V_{CE} = 5 V; note 2	580	660	700	mV
		I_C = 10 mA; V_{CE} = 5 V	–	–	770	mV
C_c	collector capacitance	I_E = i_e = 0; V_{CB} = 10 V; f = 1 MHz	–	1.5	–	pF
C_e	emitter capacitance	I_C = i_c = 0; V_{EB} = 0.5 V; f = 1 MHz	–	11	–	pF
f_T	transition frequency	I_C = 10mA; V_{CE} = 5 V; f = 100 MHz	100	–	–	MHz
F	noise figure	I_C = 200 μA; V_{CE} = 5 V; R_S = 2 kΩ; f = 1 kHz; B = 200 Hz	–	2	10	dB

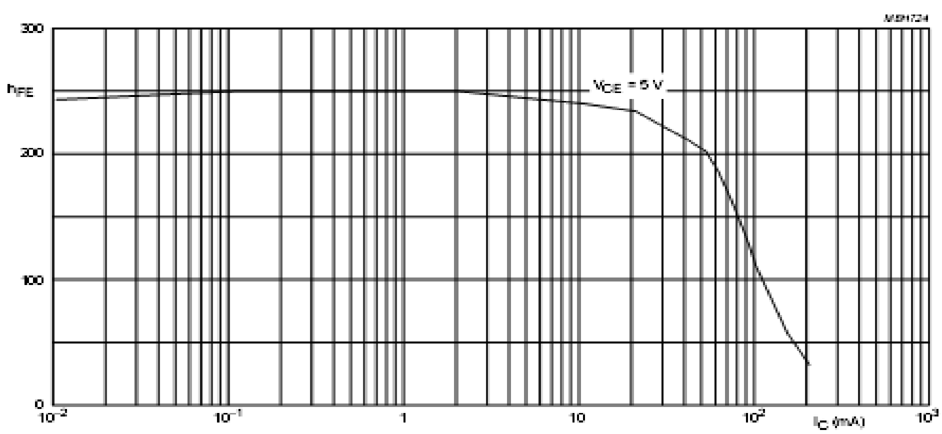
Notes

1. V_{BEsat} decreases by about 1.7 mV/K with increasing temperature.
2. V_{BE} decreases by about 2 mV/K with increasing temperature.



BC546A.

Fig.2 DC current gain; typical values.

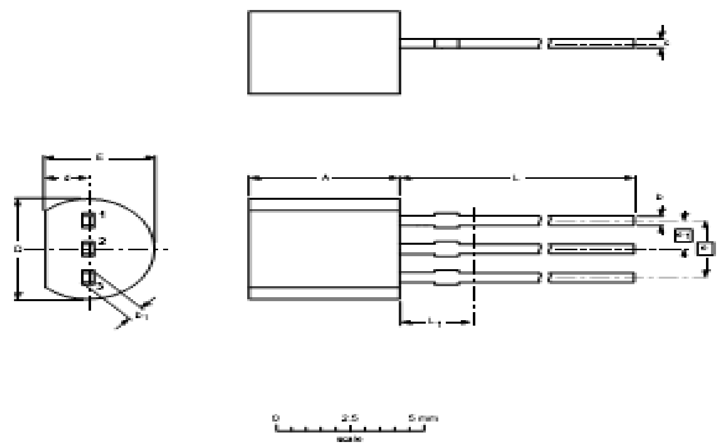


BC546B; BC547B.

Fig.3 DC current gain; typical values.

PACKAGE OUTLINE

Plastic single-ended leaded (through hole) package; 3 leads **SOT54**



DIMENSIONS (mm are the original dimensions)

UNIT	A	b	b_1	c	D	d	E	e	e_1	L	$L_1^{(1)}$
mm	5.2 5.0	0.48 0.40	0.66 0.56	0.45 0.40	4.8 4.4	1.7 1.4	4.2 3.6	2.54	1.27	14.5 12.7	2.5

Note

1. Terminal dimensions within this zone are uncontrolled to allow for flow of plastic and terminal irregularities.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT54		TO-92	SC-43			97-02-28

NPN general purpose transistors BC546; BC547

DEFINITIONS

Data Sheet Status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

LIFE SUPPORT APPLICATIONS

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APPENDIX F

OP-AMP LM324

OBSOLETE PRODUCT
NO RECOMMENDED REPLACEMENT

CA124, CA224, CA324, LM324, LM2902

Data Sheet **May 2001** **File Number 796.5**

Quad, 1MHz, Operational Amplifiers for Commercial, Industrial, and Military Applications

The CA124, CA224, CA324, LM324, and LM2902 consist of four independent, high-gain operational amplifiers on a single monolithic substrate. An on-chip capacitor in each of the amplifiers provides frequency compensation for unity gain. These devices are designed specially to operate from either single or dual supplies, and the differential voltage range is equal to the power-supply voltage. Low power drain and an input common-mode voltage range from 0V to V+ -1.5V (single-supply operation) make these devices suitable for battery operation.

Features

- Operation from Single or Dual Supplies
- Unity-Gain Bandwidth . . . . 1MHz (Typ)
- DC Voltage Gain . . . . 100dB (Typ)
- Input Bias Current . . . . 45nA (Typ)
- Input Offset Voltage . . . . 2mV (Typ)
- Input Offset Current
  - CA224, CA324, LM324, LM2902 . . . . 5nA (Typ)
  - CA124 . . . . 3nA (Typ)
- Replacement for Industry Types 124, 224, 324

Part Number Information

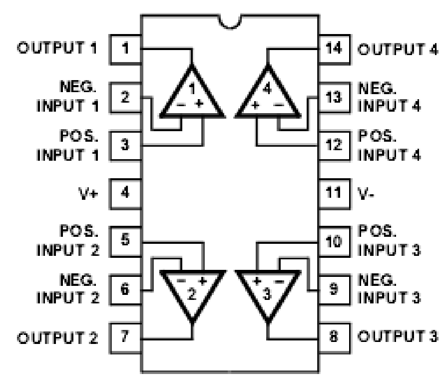
PART NUMBER (BRAND)	TEMP. RANGE (°C)	PACKAGE	PKG. NO.
CA0124E	-55 to 125	14 Ld PDIP	E14.3
CA0124M (124)	-55 to 125	14 Ld SOIC	M14.15
CA0124M96 (124)	-55 to 125	14 Ld SOIC Tape and Reel	M14.15
CA0224E	-40 to 85	14 Ld PDIP	E14.3
CA0224M (224)	-40 to 85	14 Ld SOIC	M14.15
CA0324E	0 to 70	14 Ld PDIP	E14.3
CA0324M (324)	0 to 70	14 Ld SOIC	M14.15
CA0324M96 (324)	0 to 70	14 Ld SOIC Tape and Reel	M14.15
LM324N	0 to 70	14 Ld PDIP	E14.3
LM2902N	-40 to 85	14 Ld PDIP	E14.3
LM2902M (2902)	-40 to 85	14 Ld SOIC	M14.15
LM2902M96 (2902)	-40 to 85	14 Ld SOIC Tape and Reel	M14.15

Applications

- Summing Amplifiers
- Multivibrators
- Oscillators
- Transducer Amplifiers
- DC Gain Blocks

Pinout

CA124, CA224, CA324, LM2902 (PDIP, SOIC)
LM324 (PDIP)
TOP VIEW



Absolute Maximum Ratings

Supply Voltage . . . . .32V or ±16V
Differential Input Voltage 32V
Input Voltage . . . . -0.3V to 32V
Input Current (V_I < -0.3V, Note 1) 50mA
Output Short Circuit Duration (V+ ≤ 15V, Note 2) . . . . . . Continuous

Operating Conditions

Temperature Range
CA124 . . . . -55°C to 125°C
CA224, LM2902 . . . . -40°C to 85°C
CA324, LM324 . . . . 0°C to 70°C

Thermal Information

Thermal Resistance (Typical, Note 3)	θ_{JA} (°C/W
PDIP Package	95
SOIC Package	175

Maximum Junction Temperature (Die). . . . . .175°
Maximum Junction Temperature (Plastic Package). . . . . .150°
Maximum Storage Temperature Range. . . . . -65°C to 150°
Maximum Lead Temperature (Soldering 10s) . . . . .300°
(SOIC - Lead Tips Only)

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of th device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTES:

1. This input current will only exist when the voltage at any of the input leads is driven negative. This current is due to the collector base junction of the input p-n-p transistors becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also lateral n-p-n parasitic transistor action on the IC chip. This transistor action can cause the output voltages of the amplifiers to go to the V+ voltage level (or to groun for a large overdrive) for the time duration that an input is driven negative. This transistor action is not destructive and normal output states will re-establish when the input voltage, which was negative, again returns to a value greater than -0.3V.
2. The maximum output current is approximately 40mA independent of the magnitude of V+. Continuous short circuits at V+ > 15V can cause excessive power dissipation and eventual destruction. Short circuits from the output to V+ can cause overheating and eventual destruction o the device.
3. θ_{JA} is measured with the component mounted on an evaluation PC board in free air.

Electrical Specifications Values Apply for Each Operational Amplifier. Supply Voltage V+ = 5V, V- = 0V, Unless Otherwise Specified

PARAMETER	TEST CONDITIONS	TEMP. (°C)	CA124 MIN	CA124 TYP	CA124 MAX	CA224, CA324, LM324 MIN	CA224, CA324, LM324 TYP	CA224, CA324, LM324 MAX	LM2902 MIN	LM2902 TYP	LM2902 MAX	UNITS
Input Offset Voltage (Note 6)		25	-	2	5	-	2	7	-	-	-	mV
		Full	-	-	7	-	-	9	-	-	10	mV
Average Input Offset Voltage Drift	R_S = 0	Full	-	7	-	-	7	-	-	7	-	μV/°C
Differential Input Voltage (Note 5)		Full	-	-	V+	-	-	V+	-	-	V+	V
Input Common Mode Voltage Range (Note 5)	V+ = 30V	25	0	-	V+ -1.5	0	-	V+ -1.5	-	-	-	V
	V+ = 30V	Full	0	-	V+ -2	0	-	V+ -2	-	-	-	V
	V+ = 26V	Full	-	-	-	-	-	-	0	-	V+ -2	V
Common Mode Rejection Ratio	DC	25	70	85	-	65	70	-	-	-	-	dB
Power Supply Rejection Ratio	DC	25	65	100	-	65	100	-	-	-	-	dB
Input Bias Current (Note 4)	I_I+ or I_I-	25	-	45	150	-	45	250	-	-	-	nA
	I_I+ or I_I-	Full	-	-	300	-	-	500	-	40	500	nA
Input Offset Current	I_I+ - I_I-	25	-	3	30	-	5	50	-	-	-	nA
	I_I+ - I_I-	Full	-	-	100	-	-	150	-	45	200	nA
Average Input Offset Current Drift		Full	-	10	-	-	10	-	-	10	-	pA/°C
Large Signal Voltage Gain	R_L ≥ 2k , V+ = 15V (For Large V_O Swing)	25	94	100	-	88	100	-	-	-	-	dB
	R_L ≥ 2k , V+ = 15V (For Large V_O Swing)	Full	88	-	-	83	-	-	83	-	-	dB

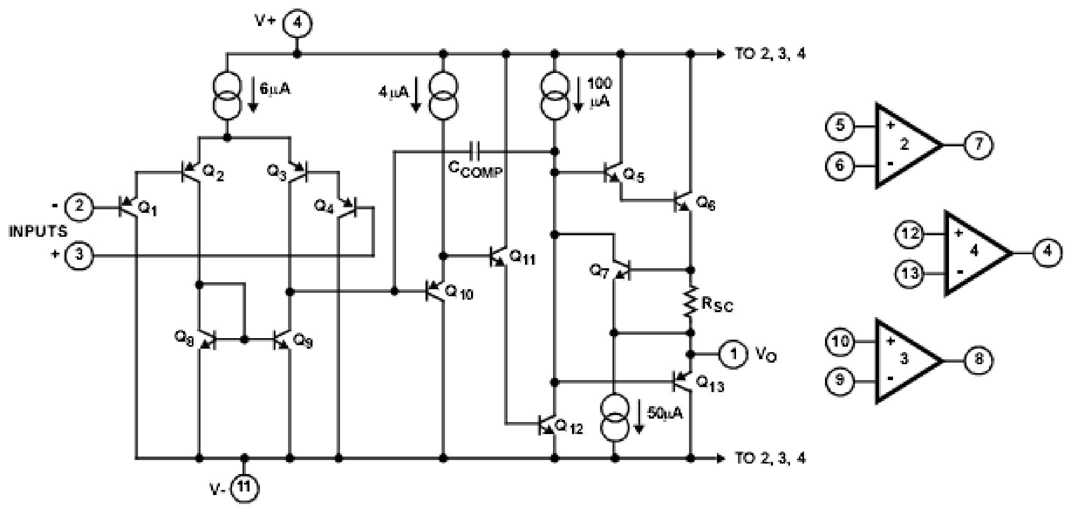
Electrical Specifications Values Apply for Each Operational Amplifier. Supply Voltage V+ = 5V, V- = 0V, Unless Otherwise Specified **(Continued)**

PARAMETER		TEST CONDITIONS	TEMP. (°C)	CA124 MIN	CA124 TYP	CA124 MAX	CA224, CA324, LM324 MIN	CA224, CA324, LM324 TYP	CA224, CA324, LM324 MAX	LM2902 MIN	LM2902 TYP	LM2902 MAX	UNITS
Output Voltage Swing		R_L = 2k	25	0	-	V+ -1.5	0	-	V+ -1.5	-	-	-	V
	High Level	R_L = 2k , V+ = 30V	Full	26	-	-	26	-	-	-	-	-	V
		R_L = 2k , V+ = 26V	Full	-	-	-	-	-	-	22	-	-	V
		R_L = 10k , V+ = 30V	Full	27	28	-	27	28	-	23	28	-	V
	Low Level	R_L = 10k	Full	-	5	20	-	5	20	-	5	100	mV
Output Current	Source	V_I+ = +1V, V_I- = 0V, V+ = 15V	25	20	40	-	20	40	-	-	-	-	mA
		V_I+ = 1V, V_I- = 0, V+ = 15V	Full	10	20	-	10	20	-	10	20	-	mA
	Sink	V_I+ = 0V, V_I- = 1V, V+ = 15V	25	10	20	-	10	20	-	-	-	-	mA
		V_I+ = 0V, V_I- = 1V, V_O = 200mV	25	12	50	-	12	50	-	-	-	-	μA
		V_I- = 1V, V_I+ = 0, V+ = 15V	Full	5	8	-	5	8	-	5	8	-	mA
Crosstalk		f = 1 to 20kHz (Input Referred)	25	-	-120	-	-	-120	-	-	-	-	dB
Total Supply Current		R_L = ∞	Full	-	0.8	2	-	0.8	2	-	0.7	1.2	mA
		R_L = ∞, V+ = 26V	Full	-	-	-	-	-	-	-	1.5	3	mA

NOTES:

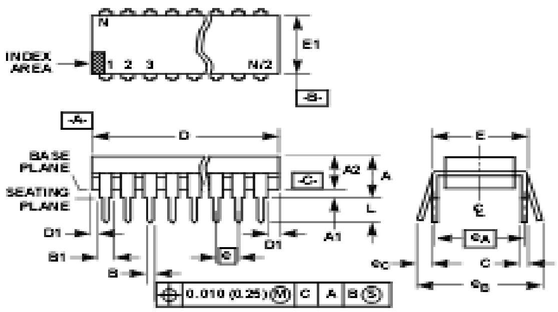
4. Due to the PNP input stage the direction of the input current is out of the IC. No loading change exists on the input lines because the current is essentially constant, independent of the state of the output.
5. The input signal voltage and the input common mode voltage should not be allowed to go negative by more than 0.3V. The positive limit of the common mode voltage range is V+ - 1.5V, but either or both inputs can go to +32V without damage.
6. V_O = 1.4V, R_S = 0 with V+ from 5V to 30V, and over the full input common mode voltage range (0V to V+ - 1.5V).

Schematic Diagram (One of Four Operational Amplifiers)



CA124, CA224, CA324, LM324, LM2902

Dual-In-Line Plastic Packages (PDIP)



NOTES:

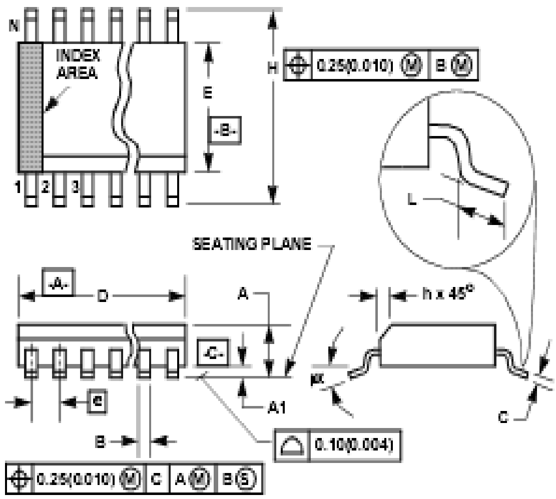
1. Controlling Dimensions: INCH. In case of conflict between English and Metric dimensions, the inch dimensions control.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication No. 95.
4. Dimensions A, A1 and L are measured with the package seated in JEDEC seating plane gauge GS-3.
5. D, D1, and E1 dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.010 inch (0.25mm).
6. E and e_A are measured with the leads constrained to be perpendicular to datum -C-.
7. e_B and e_C are measured at the lead tips with the leads unconstrained. e_C must be zero or greater.
8. B1 maximum dimensions do not include dambar protrusions. Dambar protrusions shall not exceed 0.010 inch (0.25mm).
9. N is the maximum number of terminal positions.
10. Corner leads (1, N, N/2 and N/2 + 1) for E8.3, E16.3, E18.3, E28.3, E42.6 will have a B1 dimension of 0.030 - 0.045 inch (0.76 - 1.14mm).

E14.3 (JEDEC MS-001-AA ISSUE D)
14 LEAD DUAL-IN-LINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.210	-	5.33	4
A1	0.015	-	0.39	-	4
A2	0.115	0.195	2.93	4.95	-
B	0.014	0.022	0.356	0.558	-
B1	0.045	0.070	1.15	1.77	8
C	0.008	0.014	0.204	0.355	-
D	0.735	0.775	18.66	19.68	5
D1	0.005	-	0.13	-	5
E	0.300	0.325	7.62	8.25	6
E1	0.240	0.280	6.10	7.11	5
e	0.100 BSC		2.54 BSC		-
e_A	0.300 BSC		7.62 BSC		6
e_B	-	0.430	-	10.92	7
L	0.115	0.150	2.93	3.81	4
N	14		14		9

Rev. 0 12/93

Small Outline Plastic Packages (SOIC)



NOTES:

1. Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication Number 95.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension "E" does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.25mm (0.010 inch) per side.
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
6. "L" is the length of terminal for soldering to a substrate.
7. "N" is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. The lead width "B", as measured 0.36mm (0.014 inch) or greater above the seating plane, shall not exceed a maximum value of 0.61mm (0.024 inch).
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

M14.15 (JEDEC MS-012-AB ISSUE C)
14 LEAD NARROW BODY SMALL OUTLINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.0532	0.0688	1.35	1.75	-
A1	0.0040	0.0098	0.10	0.25	-
B	0.013	0.020	0.33	0.51	9
C	0.0075	0.0098	0.19	0.25	-
D	0.3367	0.3444	8.55	8.75	3
E	0.1497	0.1574	3.80	4.00	4
e	0.050 BSC		1.27 BSC		-
H	0.2284	0.2440	5.80	6.20	-
h	0.0099	0.0196	0.25	0.50	5
L	0.016	0.050	0.40	1.27	6
N	14		14		7
α	0°	8°	0°	8°	-

Rev. 0 12/93

APPENDIX G

TIMER NE555

DESCRIPTION

The 555 monolithic timing circuit is a highly stable controller capable of producing accurate time delays, or oscillation. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output structure can source or sink up to 200 mA.

FEATURES

- Turn-off time less than 2 μs
- Max. operating frequency greater than 500 kHz
- Timing from microseconds to hours
- Operates in both astable and monostable modes
- High output current
- Adjustable duty cycle
- TTL compatible
- Temperature stability of 0.005% per °C

APPLICATIONS

- Precision timing
- Pulse generation
- Sequential timing
- Time delay generation
- Pulse width modulation

PIN CONFIGURATION

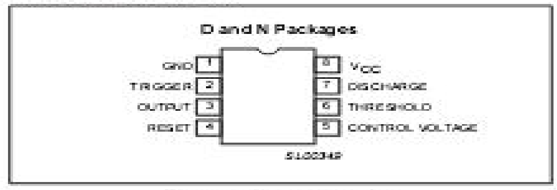


Figure 1. Pin configuration

BLOCK DIAGRAM

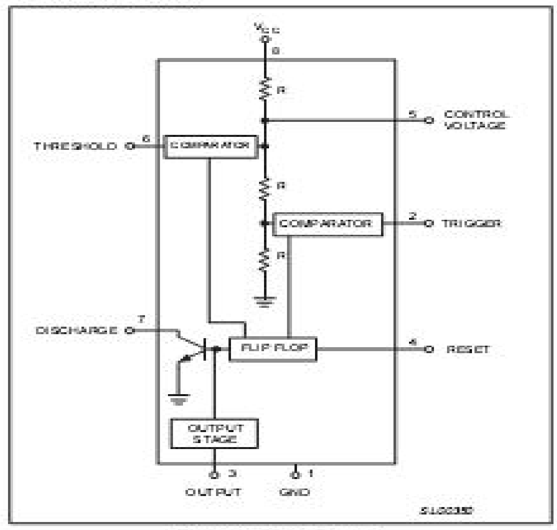


Figure 2. Block Diagram

ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
8-Pin Plastic Small Outline (SO) Package	0 to +70 °C	NE555D	SOT96-1
8-Pin Plastic Dual In-Line Package (DIP)	0 to +70 °C	NE555N	SOT97-1
8-Pin Plastic Small Outline (SO) Package	–40 °C to +85 °C	SA555D	SOT96-1
8-Pin Plastic Dual In-Line Package (DIP)	–40 °C to +85 °C	SA555N	SOT97-1
8-Pin Plastic Dual In-Line Package (DIP)	–55 °C to +125 °C	SE555CN	SOT97-1
8-Pin Plastic Dual In-Line Package (DIP)	–55 °C to +125 °C	SE555N	SOT97-1

EQUIVALENT SCHEMATIC

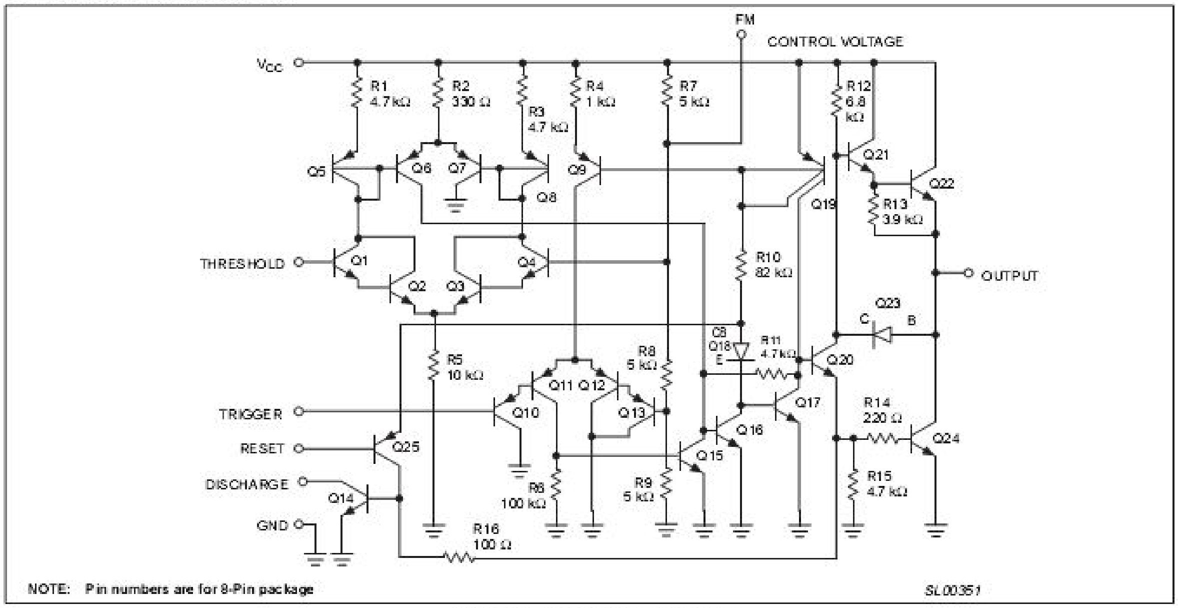


Figure 3. Equivalent schematic

ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNIT
V_{CC}	Supply voltage SE555 NE555, SE555C, SA555	 +18 +16	 V V
P_D	Maximum allowable power dissipation[1]	600	mW
T_{amb}	Operating ambient temperature range NE555 SA555 SE555, SE555C	 0 to +70 –40 to +85 –55 to +125	 °C °C °C
T_{stg}	Storage temperature range	–65 to +150	°C
T_{SOLD}	Lead soldering temperature (10 sec max)	+230	°C

NOTE:

1. The junction temperature must be kept below 125 °C for the D package and below 150°C for the N package. At ambient temperatures above 25 °C, where this limit would be derated by the following factors:
   D package 160 °C/W
   N package 100 °C/W

DC AND AC ELECTRICAL CHARACTERISTICS

T_{amb} = 25 °C, V_{CC} = +5 V to +15 V unless otherwise specified

SYMBOL	PARAMETER	TEST CONDITIONS	SE555 Min	SE555 Typ	SE555 Max	NE555/SA555/SE555C Min	NE555/SA555/SE555C Typ	NE555/SA555/SE555C Max	UNIT
V_{CC}	Supply voltage		4.5		18	4.5		16	V
I_{CC}	Supply current (low state)[1]	V_{CC} = 5 V, $R_L = \infty$ V_{CC} = 15 V, $R_L = \infty$		3 10	5 12		3 10	6 15	mA mA
t_M $\Delta t_M/\Delta T$ $\Delta t_M/\Delta V_S$	Timing error (monostable) Initial accuracy[2] Drift with temperature Drift with supply voltage	R_A = 2 kΩ to 100 kΩ C=0.1 μF		0.5 30 0.05	2.0 100 0.2		1.0 50 0.1	3.0 150 0.5	% ppm/°C %/V
t_A $\Delta t_A/\Delta T$ $\Delta t_A/\Delta V_S$	Timing error (astable) Initial accuracy[2] Drift with temperature Drift with supply voltage	R_A, R_B = 1 kΩ to 100 kΩ C = 0.1 μF V_{CC} = 15 V		4 0.15	6 500 0.6		5 0.3	13 500 1	% ppm/°C %/V
V_C	Control voltage level	V_{CC} = 15 V V_{CC} = 5 V	9.6 2.9	10.0 3.33	10.4 3.8	9.0 2.6	10.0 3.33	11.0 4.0	V V
V_{TH}	Threshold voltage	V_{CC} = 15 V V_{CC} = 5 V	9.4 2.7	10.0 3.33	10.6 4.0	8.8 2.4	10.0 3.33	11.2 4.2	V V
I_{TH}	Threshold current[3]			0.1	0.25		0.1	0.25	μA
V_{TRIG}	Trigger voltage	V_{CC} = 15 V V_{CC} = 5 V	4.8 1.45	5.0 1.67	5.2 1.9	4.5 1.1	5.0 1.67	5.6 2.2	V V
I_{TRIG}	Trigger current	V_{TRIG} = 0 V		0.5	0.9		0.5	2.0	μA
V_{RESET}	Reset voltage[4]	V_{CC} = 15 V, V_{TH} = 10.5 V	0.3		1.0	0.3		1.0	V
I_{RESET}	Reset current Reset current	V_{RESET} = 0.4 V V_{RESET} = 0 V		0.1 0.4	0.4 1.0		0.1 0.4	0.4 1.5	mA mA
V_{OL}	LOW-level output voltage	V_{CC} = 15 V I_{SINK} = 10 mA I_{SINK} = 50 mA I_{SINK} = 100 mA I_{SINK} = 200 mA		 0.1 0.4 2.0 2.5	 0.15 0.5 2.2		 0.1 0.4 2.0 2.5	 0.25 0.75 2.5	 V V V V
		V_{CC} = 5 V I_{SINK} = 8 mA I_{SINK} = 5 mA		 0.1 0.05	 0.25 0.2		 0.3 0.25	 0.4 0.35	 V V
V_{OH}	HIGH-level output voltage	V_{CC} = 15 V I_{SOURCE} = 200 mA I_{SOURCE} = 100 mA	 13.0	 12.5 13.3		 12.75	 12.5 13.3		 V V
		V_{CC} = 5 V I_{SOURCE} = 100 mA	 3.0	 3.3		 2.75	 3.3		 V
t_{OFF}	Turn-off time[5]	V_{RESET} = V_{CC}		0.5	2.0		0.5	2.0	μs
t_R	Rise time of output			100	200		100	300	ns
t_F	Fall time of output			100	200		100	300	ns
	Discharge leakage current			20	100		20	100	nA

NOTES:
1. Supply current when output high typically 1 mA less.
2. Tested at V_{CC} = 5 V and V_{CC} = 15 V.
3. This will determine the max value of R_A+R_B for 15 V operation, the max total R = 10 MΩ, and for 5 V operation, the max. total R = 3.4 MΩ.
4. Specified with trigger input HIGH.
5. Time measured from a positive-going input pulse from 0 to 0.8×V_{CC} into the threshold to the drop from HIGH to LOW of the output. Trigger is tied to threshold.

TYPICAL APPLICATIONS

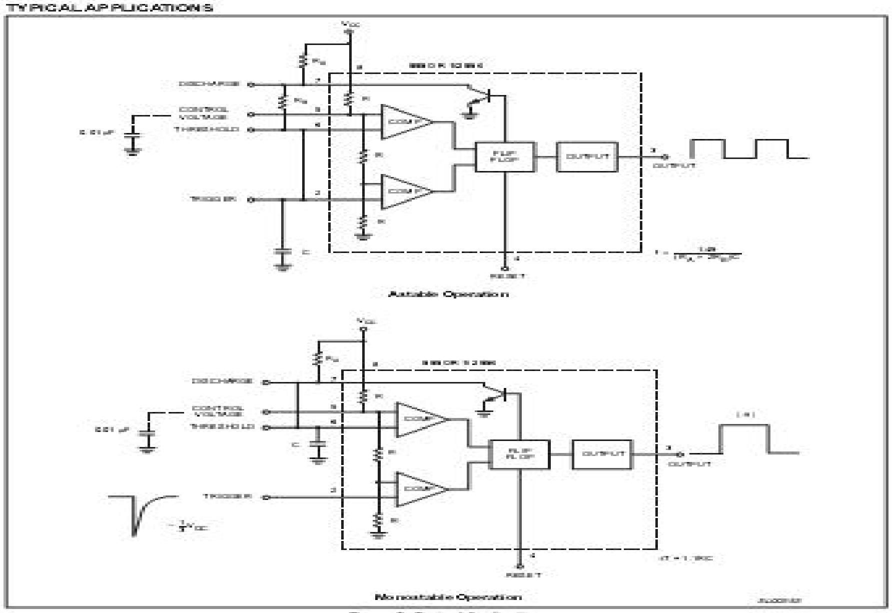
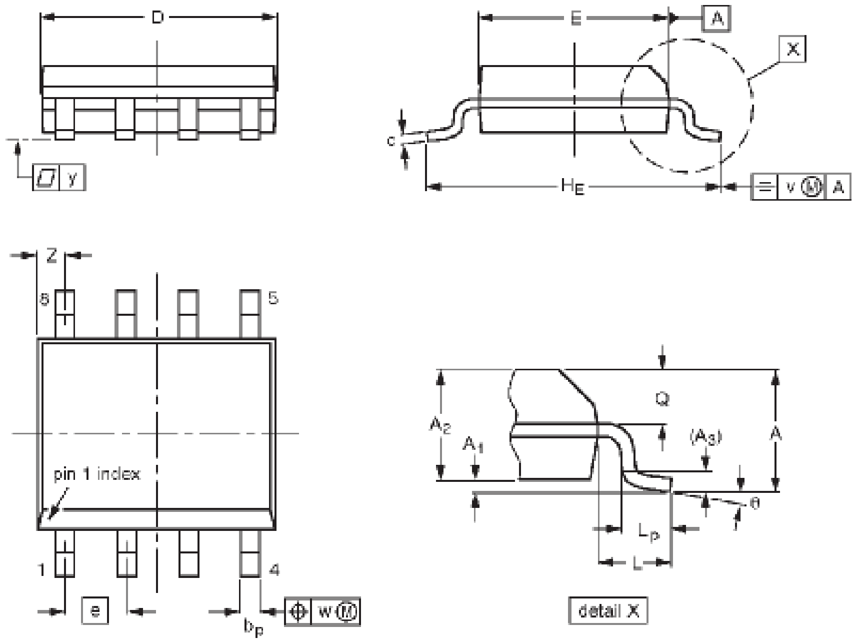


Figure 5. Typical Applications.



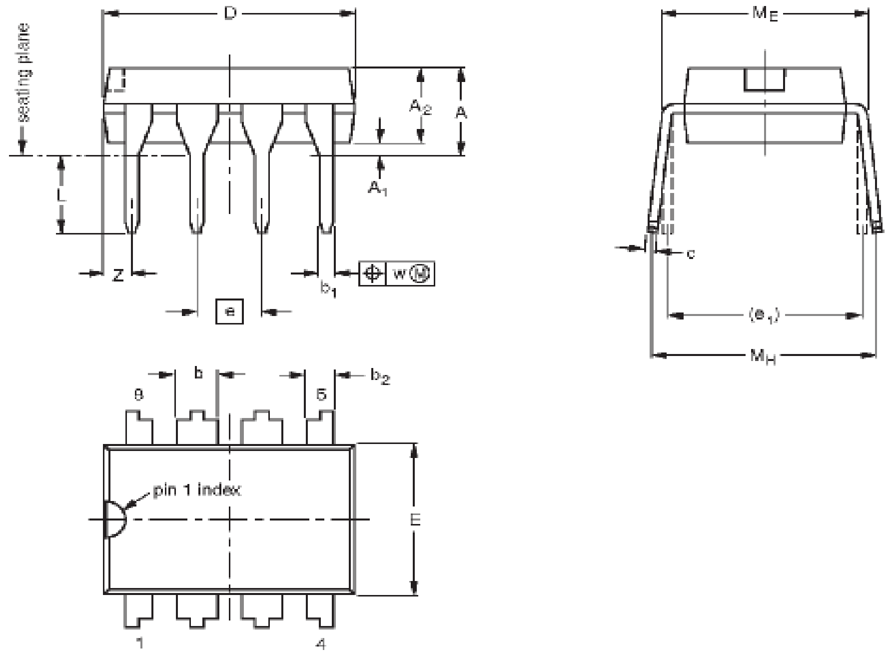
DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(2)}$	e	H_E	L	L_p	Q	v	w	y	$Z^{(1)}$	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	5.0 4.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.20 0.19	0.16 0.15	0.050	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT96-1	076E03	MS-012				~~97-05-22~~ 99-12-27



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1 min.	A_2 max.	b	b_1	b_2	c	D (1)	E (1)	e	e_1	L	M_E	M_H	w	Z (1) max.
mm	4.2	0.51	3.2	1.73 1.14	0.53 0.38	1.07 0.89	0.36 0.23	9.8 9.2	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	1.15
inches	0.17	0.020	0.13	0.068 0.045	0.021 0.015	0.042 0.035	0.014 0.009	0.39 0.36	0.26 0.24	0.10	0.30	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.045

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT97-1	050G01	MO-001	SC-504-8			~~95-02-04~~ 99-12-27

APPENDIX H

ZENER DIODE

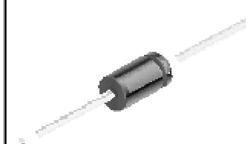
Zeners
1N5221B - 1N5279B

Absolute Maximum Ratings * T_A = 25°C unless otherwise noted

Symbol	Parameter	Value	Units
P_D	Power Dissipation Derate above 50°C	500 4.0	mW mW°C
T_{STG}	Storage Temperature Range	-65 to +200	°C
T_J	Maximum Junction Operating Temperature	+200	°C
	Lead Temperature (1/16” from case for 10 seconds)	+230	°C

* These ratings are limiting values above which the serviceability of the diode may be impaired.
** Non-recurrent square wave PW = 8.3ms, Ta = 50 degrees C.

Tolerance = 5%



DO-35 Glass case
COLOR BAND DENOTES CATHODE

Electrical Characteristics T_A=25°C unless otherwise noted

Device	V_Z (V) @ I_Z (Note 1)			Z_Z ( ) @	I_Z (mA)	Z_{ZK} ( ) @	I_{ZK} (mA)	I_R (μA) @	V_R (V)	T_C (%/°C)
	Min.	Typ.	Max.							
1N5221B	2.28	2.4	2.52	30	20	1,200	0.25	100	1.0	-0.085
1N5222B	2.375	2.5	2.625	30	20	1,250	0.25	100	1.0	-0.085
1N5223B	2.565	2.7	2.835	30	20	1,300	0.25	75	1.0	-0.080
1N5224B	2.66	2.8	2.94	30	20	1,400	0.25	75	1.0	-0.080
1N5225B	2.85	3	3.15	29	20	1,600	0.25	50	1.0	-0.075
1N5226B	3.135	3.3	3.465	28	20	1,600	0.25	25	1.0	-0.07
1N5227B	3.42	3.6	3.78	24	20	1,700	0.25	15	1.0	-0.065
1N5228B	3.705	3.9	4.095	23	20	1,900	0.25	10	1.0	-0.06
1N5229B	4.085	4.3	4.515	22	20	2,000	0.25	5.0	1.0	+/-0.055
1N5230B	4.465	4.7	4.935	19	20	1,900	0.25	2.0	1.0	+/-0.03
1N5231B	4.845	5.1	5.355	17	20	1,600	0.25	5.0	2.0	+/-0.03
1N5232B	5.32	5.6	5.88	11	20	1,600	0.25	5.0	3.0	0.038
1N5233B	5.7	6	6.3	7.0	20	1,600	0.25	5.0	3.5	0.038
1N5234B	5.89	6.2	6.51	7.0	20	1,000	0.25	5.0	4.0	0.045
1N5235B	6.46	6.8	7.14	5.0	20	750	0.25	3.0	5.0	0.05
1N5236B	7.125	7.5	7.875	6.0	20	500	0.25	3.0	6.0	0.058
1N5237B	7.79	8.2	8.61	8.0	20	500	0.25	3.0	6.5	0.062
1N5238B	8.265	8.7	9.135	8.0	20	600	0.25	3.0	6.5	0.065
1N5239B	8.645	9.1	9.555	10	20	600	0.25	3.0	7.0	0.068
1N5240B	9.5	10	10.5	17	20	600	0.25	3.0	8.0	0.075
1N5241B	10.45	11	11.55	22	20	600	0.25	2.0	8.4	0.076
1N5242B	11.4	12	12.6	30	20	600	0.25	0.1	9.1	0.077
1N5243B	12.35	13	13.65	13	9.5	600	0.25	0.1	9.9	0.079
1N5244B	13.3	14	14.7	15	9.0	600	0.25	0.1	10	0.080
1N5245B	14.25	15	15.75	16	8.5	600	0.25	0.1	11	0.082
1N5246B	15.2	16	16.8	17	7.8	600	0.25	0.1	12	0.083
1N5247B	16.15	17	17.85	19	7.4	600	0.25	0.1	13	0.084
1N5248B	17.1	18	18.9	21	7.0	600	0.25	0.1	14	0.085
1N5247B	18.05	19	19.95	23	6.6	600	0.25	0.1	14	0.085
1N5250B	19	20	21	25	6.2	600	0.25	0.1	15	0.086

Electrical Characteristics (Continued) T_A=25°C unless otherwise noted

Device	V_Z (V) @ I_Z (Note 1)			Z_Z ( )	@ I_Z (mA)	Z_{ZK} ( )	@ I_{ZK} (mA)	I_R (µA)	@ V_R (V)	T_C (%/°C)
	Min.	Typ.	Max.							
1N5251B	20.9	22	23.1	29	5.6	600	0.25	0.1	17	0.087
1N5252B	22.8	24	25.2	33	5.2	600	0.25	0.1	18	0.088
1N5253B	23.75	25	26.25	35	5.0	600	0.25	0.1	19	0.088
1N5254B	25.65	27	28.35	41	4.6	600	0.25	0.1	21	0.089
1N5255B	26.6	28	29.4	44	4.5	600	0.25	0.1	21	0.090
1N5256B	28.5	30	31.5	49	4.2	600	0.25	0.1	23	0.09
1N5257B	31.35	33	34.65	58	3.8	700	0.25	0.1	25	0.092
1N5258B	34.2	36	37.8	70	3.4	700	0.25	0.1	27	0.093
1N5259B	37.05	39	40.95	80	3.2	800	0.25	0.1	30	0.094
1N5260B	40.85	43	45.15	93	3.0	900	0.25	0.1	33	0.095
1N5261B	44.65	47	49.35	105	2.7	1000	0.25	0.1	36	0.095
1N5262B	48.45	51	53.55	125	2.5	1100	0.25	0.1	39	0.096
1N5263B	53.2	56	58.8	150	2.2	1300	0.25	0.1	43	0.096
1N5264B	57	60	63	170	2.1	1400	0.25	0.1	46	0.097
1N5265B	58.9	62	65.1	185	2.0	1400	0.25	0.1	47	0.097
1N5266B	64.6	68	71.4	230	1.8	1600	0.25	0.1	52	0.097
1N5267B	71.25	75	78.75	270	1.7	1700	0.25	0.1	56	0.098
1N5268B	80.75	85	89.25	330	1.5	2000	0.25	0.1	62	0.098
1N5269B	82.65	87	91.35	370	1.4	2200	0.25	0.1	68	0.099
1N5270B	96.45	91	95.55	400	1.4	2300	0.25	0.1	69	0.099
1N5271B	95	100	105	500	1.3	2600	0.25	0.1	76	0.099
1N5272B	104.5	110	115.5	750	1.1	3000	0.25	0.1	84	0.11
1N5273B	114	120	126	900	1.0	4000	0.25	0.1	91	0.11
1N5274B	123.5	130	136.5	1100	0.95	4500	0.25	0.1	99	0.11
1N5275B	133	140	147	1300	0.90	4500	0.25	0.1	106	0.11
1N5276B	142.5	150	157.5	1500	0.85	5000	0.25	0.1	114	0.11
1N5277B	152	160	168	1700	0.80	5500	0.25	0.1	122	0.11
1N5278B	161.5	170	178.5	1900	0.74	5500	0.25	0.1	129	0.11
1N5279B	171	180	189	2200	0.68	6000	0.25	0.1	137	0.11

V_F Forward Voltage = 1.2V Max. @ I_F = 200mA

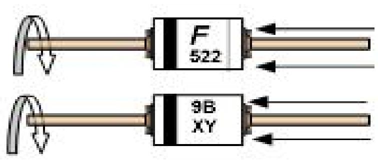
Notes:
1. Zener Voltage (V_Z)
   The zener voltage is measured with the device junction in the thermal equilibrium at the lead temperature (T_L) at 30°C ± 1°C and 3/8" lead length.

Top Mark Information

Device	Line 1	Line 2	Line 3	Line 4
1N5221B	LOGO	522	1B	XY
1N5222B	LOGO	522	2B	XY
1N5223B	LOGO	522	3B	XY
1N5224B	LOGO	522	4B	XY
1N5225B	LOGO	522	5B	XY
1N5226B	LOGO	522	6B	XY
1N5227B	LOGO	522	7B	XY
1N5228B	LOGO	522	8B	XY
1N5229B	LOGO	522	9B	XY
1N5230B	LOGO	523	0B	XY
1N5231B	LOGO	523	1B	XY
1N5232B	LOGO	523	2B	XY
1N5233B	LOGO	523	3B	XY
1N5234B	LOGO	523	4B	XY
1N5235B	LOGO	523	5B	XY
1N5236B	LOGO	523	6B	XY
1N5237B	LOGO	523	7B	XY
1N5238B	LOGO	523	8B	XY
1N5239B	LOGO	523	9B	XY
1N5240B	LOGO	524	0B	XY
1N5241B	LOGO	524	1B	XY
1N5242B	LOGO	524	2B	XY
1N5243B	LOGO	524	3B	XY
1N5244B	LOGO	524	4B	XY
1N5245B	LOGO	524	5B	XY
1N5246B	LOGO	524	6B	XY
1N5247B	LOGO	524	7B	XY
1N5248B	LOGO	524	8B	XY
1N5247B	LOGO	524	9B	XY
1N5250B	LOGO	525	0B	XY

1N5251B	LOGO	525	1B	XY
1N5252B	LOGO	525	2B	XY
1N5253B	LOGO	525	3B	XY
1N5254B	LOGO	525	4B	XY
1N5255B	LOGO	525	5B	XY
1N5256B	LOGO	525	6B	XY
1N5257B	LOGO	525	7B	XY
1N5258B	LOGO	525	8B	XY
1N5259B	LOGO	525	9B	XY
1N5260B	LOGO	526	0B	XY
1N5261B	LOGO	526	1B	XY
1N5262B	LOGO	526	2B	XY
1N5263B	LOGO	526	3B	XY
1N5264B	LOGO	526	4B	XY
1N5265B	LOGO	526	5B	XY
1N5266B	LOGO	526	6B	XY
1N5267B	LOGO	526	7B	XY
1N5268B	LOGO	526	8B	XY
1N5269B	LOGO	526	9B	XY
1N5270B	LOGO	526	0B	XY
1N5271B	LOGO	527	1B	XY
1N5272B	LOGO	527	2B	XY
1N5273B	LOGO	527	3B	XY
1N5274B	LOGO	527	4B	XY
1N5275B	LOGO	527	5B	XY
1N5276B	LOGO	527	6B	XY
1N5277B	LOGO	527	7B	XY
1N5278B	LOGO	527	8B	XY
1N5279B	LOGO	527	9B	XY

Top Mark Information (Continued)



1st line: F - Fairchild Logo
2nd line: Device Name - 3rd to 5th characters of the device name.
or 4th to 6th characters for BZXyy series
3rd line: Device Name - 6th to 7th characters of the device name.
or Voltage rating for BZXyy series
4th line: Device Code or - Two Digit - Six Weeks Date Code.
Date code plus or Two Digit - Six Weeks Date Code
Large die identification plus Large die identification, "L"

General Requirements:

1.0 Cathod Band

2.0 First Line: F - Fairchild Logo

3.0 Second Line: Device name - For 1Nxx series: 3rd to 5th characters of the device name.
For BZxx series: 4th to 6th characters of the device name.

4.0 Third Line: Device name - For 1Nxx series: 6th to 7th characters of the device name.
For BZXyy series: Voltage rating

5.0 Fourth Line: XY or XYL - Two Digit - Six Weeks Date Code
Where: X represents the last digit of the calendar year
Y represents the Six weeks numeric code
L represents the Large die identification

6.0 Devices shall be marked as required in the device specification (PID or FSC Test Spec).

7.0 Maximum no. of marking lines: 4

8.0 Maximum no. of digits per line: 3

9.0 FSC logo must be 20 % taller than the alphanumeric marking and should occupy the 2 characters of the specified line.

10.0 Marking Font: Arial (Except FSC Logo)

11.0 First character of each marking line must be aligned vertically