IC BASED HEART BEAT MONITOR

Project report submitted in partial fulfillment of the requirement for the degree of

Bachelor of Technology

in

Electronics and Communication Engineering

By

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Under the supervision of

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MAY – 2010

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CERTIFICATE

This is to certify that project report entitled "IC – Based HEART BEAT RATE MONITOR", submitted by Kanav Davesar in partial fulfillment for the award of Bachelor of Technology in Electronics and Communication Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

Date:

Dr. Vivek Sehgal
(Dept. of Electronics and Communication)

Certified that this work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

Kanav Davesar
(051098)

ACKNOWLEDGEMENT

It gives me great pleasure in acknowledging the invaluable assistance extended to us by various personalities in the successful completion of this project. This project is the result of the pieces of advice of many people.

I am highly thankful to my mentor Dr. Vivek Sehgal for his guidance and constructive criticism all during the making of this project. He pacified my intense times with his creative and innovative ideas, reinforcing my interest in the work.

Finally, I would like to thank all my friends for the support they gave me form time to time.

DATE:

Kanav Davesar

(051098)

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1. CHAPTER-1

INTRODUCTION

Biomedical engineering is a discipline that advances knowledge in engineering, biology and medicine, and improves human health through cross-disciplinary activities that integrate the engineering sciences with the biomedical sciences and clinical practice.

There are a wide variety of methods to measure beats of the heart, from feeling the pulse in one's wrist to monitoring the differences in electrical potential through the body using an electrocardiograph. Such methods have their advantages and disadvantages.

The primary disadvantage of all these methods is that they involve direct contacts to the body and consequently impose a safety hazard if any mains operated electrical equipment is associated with the heart beat measurement. In this particular design of a heart beat monitor, IR light from a IR-LED is shone through the finger onto a photodiode.

1.1 Description

As there are no electrical contacts to the body, this method of pulse detection is inherently very safe. Each time the heart beats; a surge of blood is sent through the body, which increases the density of the small fleshy parts of the body, particularly the fingers. Consequently the light passing through fingers a finger will vary at each heartbeat, and this variation is detected by the photodiode. The output from the photodiode is amplified in a detector circuit to provide a CMOS compatible pulse each time the heart beats.

In this particular design, the photodiode and IR-LED are mounted on opposite sides of a 1inch diameter plastic tube which is secured in a instrument case. For measurements to be taken, the finger is inserted into the plastic tube until in covers the photodiode and is held steady.

As a digital readout of preferred to an analog one, the time between successive pulses from the detector is accurately measured and digitally converted into beats per minute, which are subsequently displayed on a 7-segment display.

When resting, the average adult human heart beats at about 70 bpm (males) and 75 bpm (females).

Transducer/Sensor

It is the device that converts one form of energy to another. For example: a photodiode converts mechanical vibrations into an electrical signal.

Signal Conditioner

It converts the output of the transducer into an electrical quantity suitable for display or recording. It usually include functions such as amplification, signal transmission circuitry.

Amplifier

Energy of signals is amplified to drive the pulse generator section.

Pulse Generator

Its generates square pulse according to heart beats or pulse rate of blood which feed to 7-segment decoder.

7-Segment Decoder It works as counter according to input pulse from pulse generator which conversion binary to decimal. decimal DATA display on display.

7-Segment Display

It display Pulse Rate of heart beats on the display

1.2 Home Use

The simple design and easy operation allows individuals to monitor the heartbeat during exercise and workouts. The device provides great safety to individuals with known heart problems.

The readings of pulse meters are accurate enough when they count from your finger or ear lobe at normal body temp.

A normal, healthy, human heart beats about 72 times per minute. A lower heart rate can result from being a consistent exerciser, from some medications for heart or blood pressure problems, or simply because of your genetic order.

Your heart rate at resting position can be measured by recording your pulse before arising in the morning on two or three different days and averaging the figures. If your rate is less than 50, or more than 90, please consult your doctor.

Your maximum heart rate is related with your age. Take 220 and subtract your age. This is rate as fast as your heart can safely be allowed to beat . Target heart rate should be 50 to 80 percent of your maximum heart rate. Target heart rate is required to estimate the useful intensity of exercise , by measuring heartbeats per minute. To begin a healthy activity program, aim for 50 to 60 percent of maximum heart rate. For a moderate exerciser, try 60 to 70 percent. If you are in great fitness condition then you may go for 70 to 80 percent of your max heart rate. Your pulse rate should come back to normal within 10 minutes after stopping the exercises or activity, if it does not - it means you are over exercising .

1.3 Pulse

In medicine, a person's **pulse** is the throbbing of their arteries as an effect of the heart beat. It can be felt in any place that allows for an artery to be compressed against a bone, such as at the neck (carotid artery), at the wrist (radial artery), behind the knee (popliteal artery), on the inside of the elbow (brachial artery), and near the ankle joint (posterior tibial artery). The pulse rate can also be measured by measuring the heart beats directly (the apical pulse).

Pressure waves move the artery walls, which are pliable; these waves are not caused by the forward movement of the blood. When the heart contracts, blood is ejected into the aorta and the aorta stretches. At this point, the wave of distention (**pulse wave**) is pronounced but relatively slow-moving (3–6 m/s). As it travels towards the peripheral blood vessels, it gradually diminishes and becomes faster. In the large arterial branches, its velocity is 7–10 m/s; in the small arteries, it is 15–35 m/s. The pressure pulse is transmitted fifteen or more times more rapidly than the blood flow.

Pulse is also used, although incorrectly, to denote the frequency of the heart beat, usually measured in beats per minute. In most people, the pulse is an accurate measure of heart rate.

Reading a pulse

Pulses are manually palpated with fingers. When palpating the carotid artery, the femoral artery or the brachial artery, the thumb may be used. However, the thumb has its own pulse which can interfere with detecting the patient's pulse at other points, where two or three fingers should be used. Fingers or the thumb must be placed near an artery and pressed gently against a firm structure, usually a bone, in order to feel the pulse.

Make sure the person is calm and has been resting for 5 minutes before reading the pulse. Put the fingers on index and middle finger over the pulse count, and count for 30 seconds, and afterwards multiply by 2, to get the pulse rate. If the person's pulse rate is irregular, count for a full minute, and do not multiply. Averaging multiple readings may give a more representative figure.

Cheap home blood pressure measurement devices also typically give a pulse reading.

1.4 OPERATION OF HEART

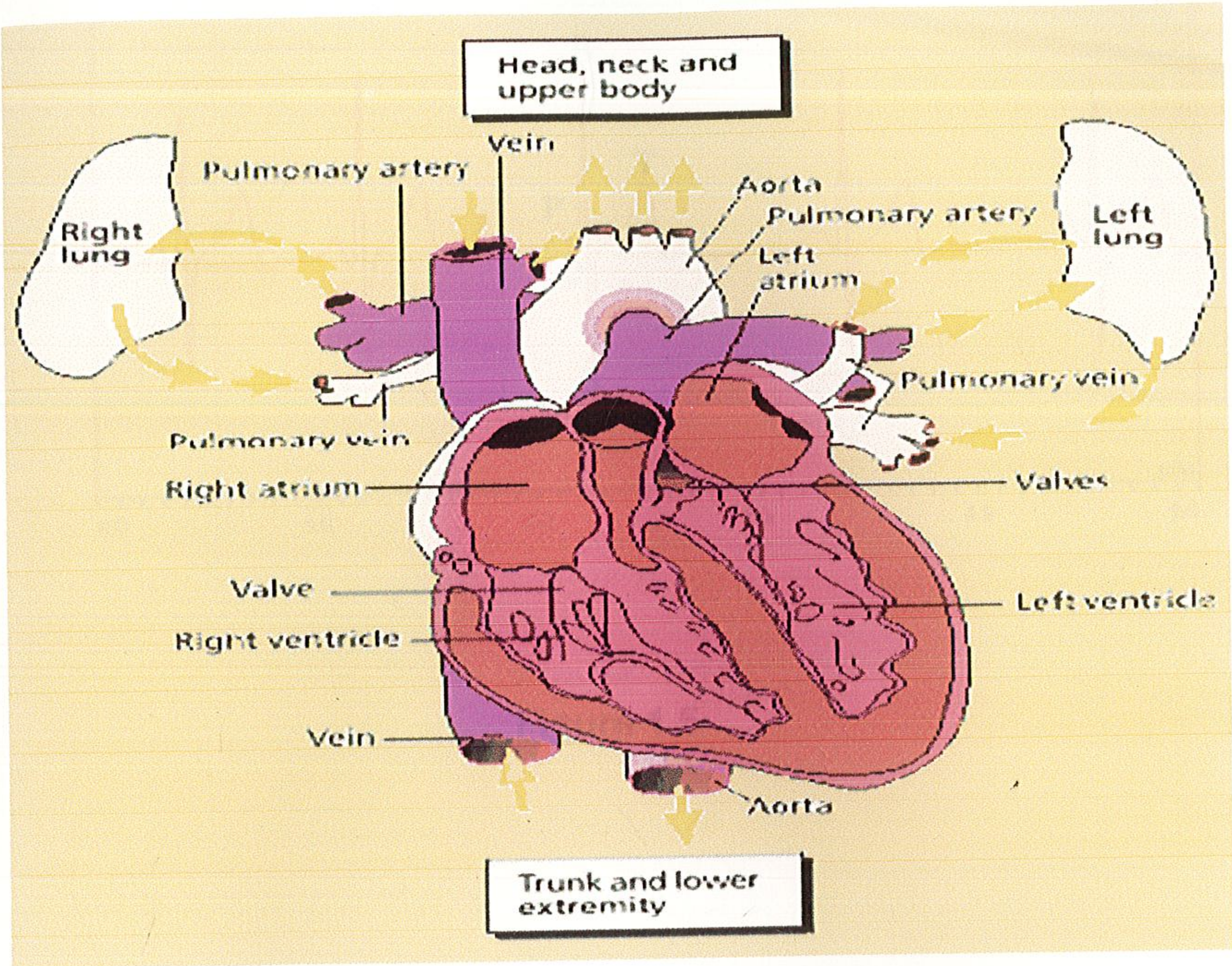


Figure 1.4

1.5 HEART RATE DURING REST

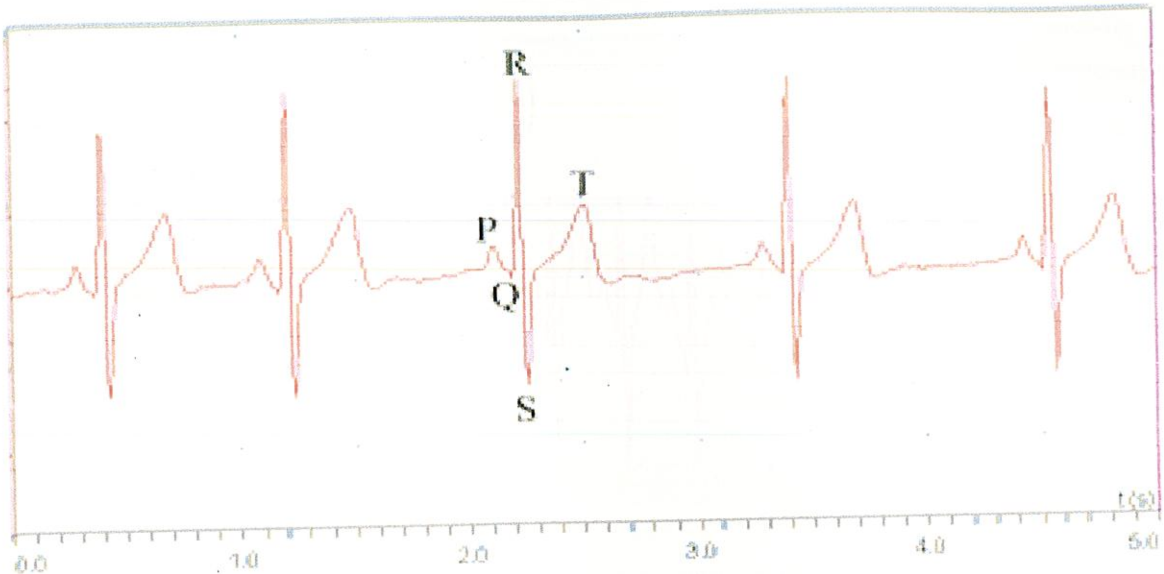


Figure 1.5

HEART RATE DURING EXERCISE

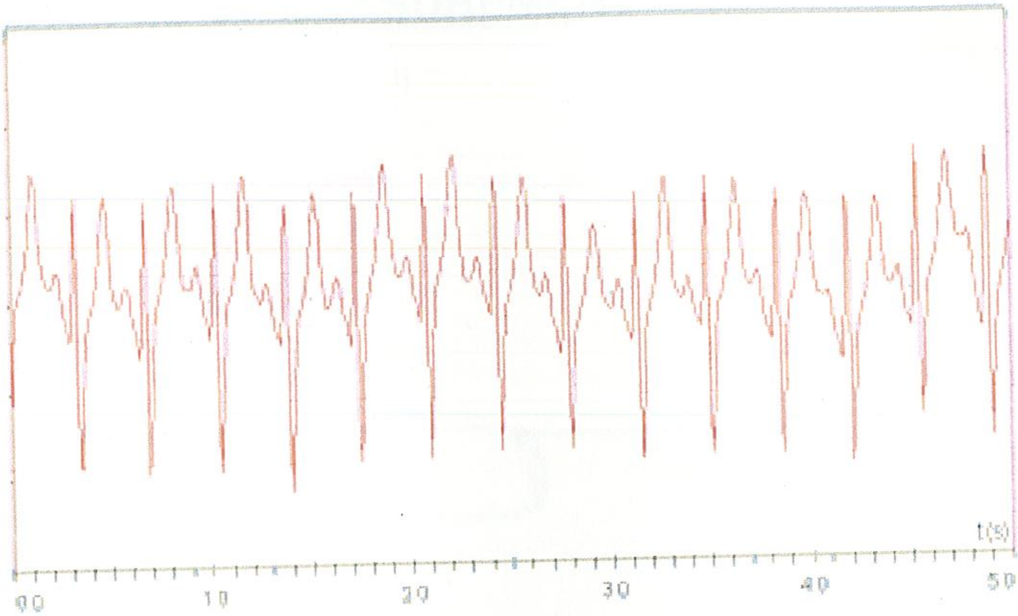


Figure 1.6

2. CHAPTER-2

2.1 PRINCIPLE OF MEASUREMENT

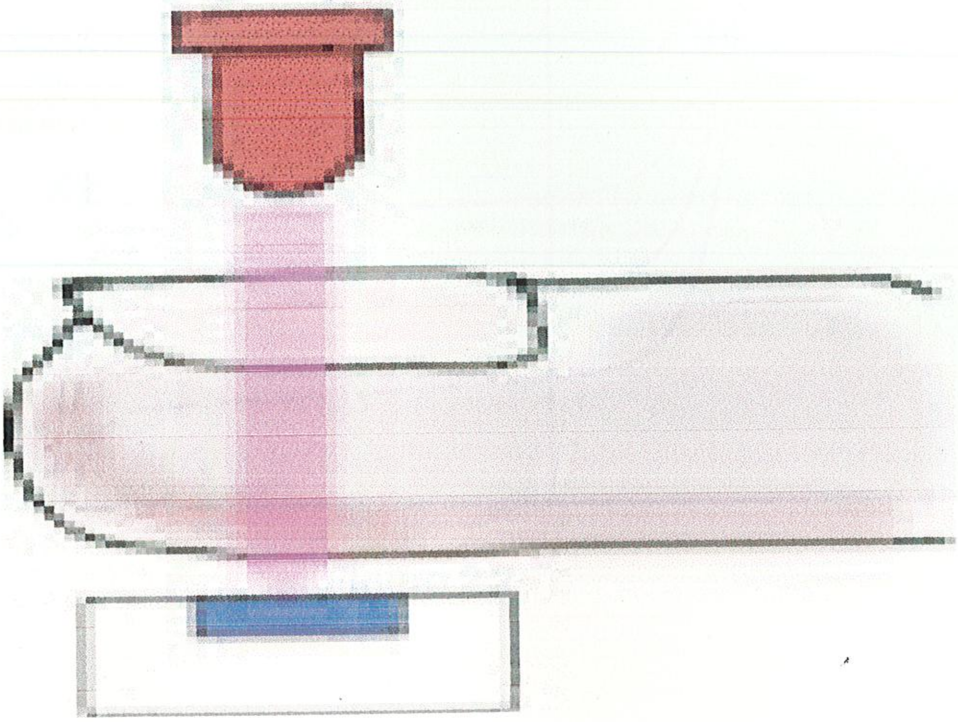


Figure 2.1

2.2 PHOTODIODE

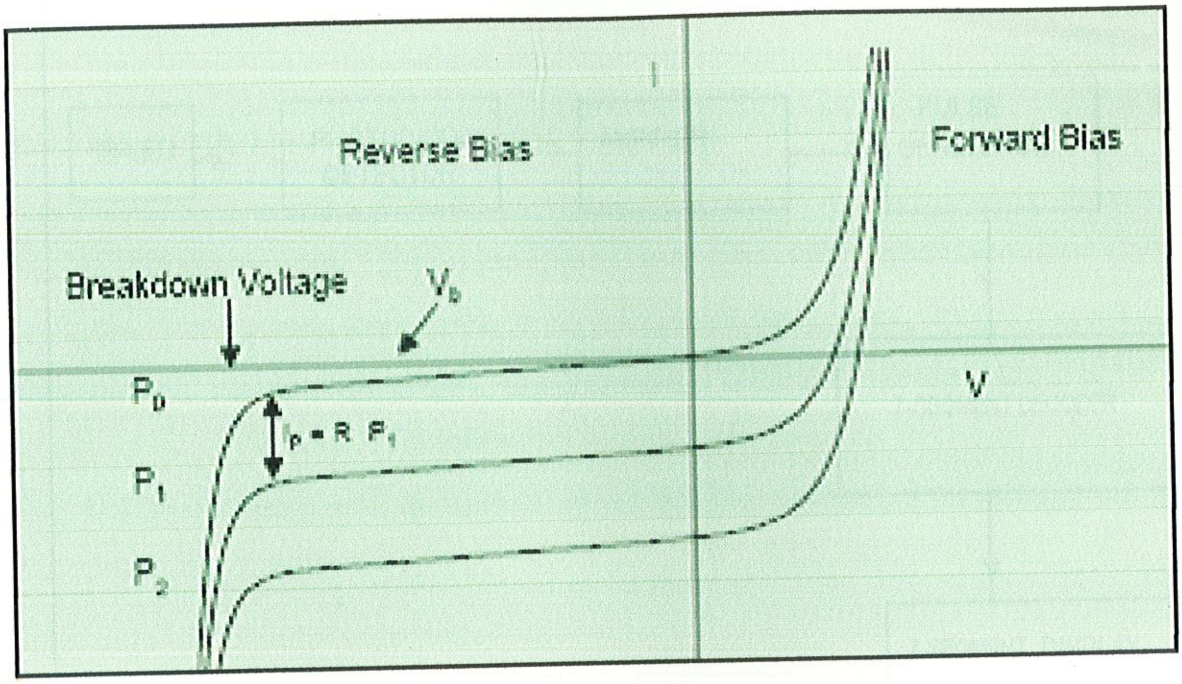


Figure 2.2

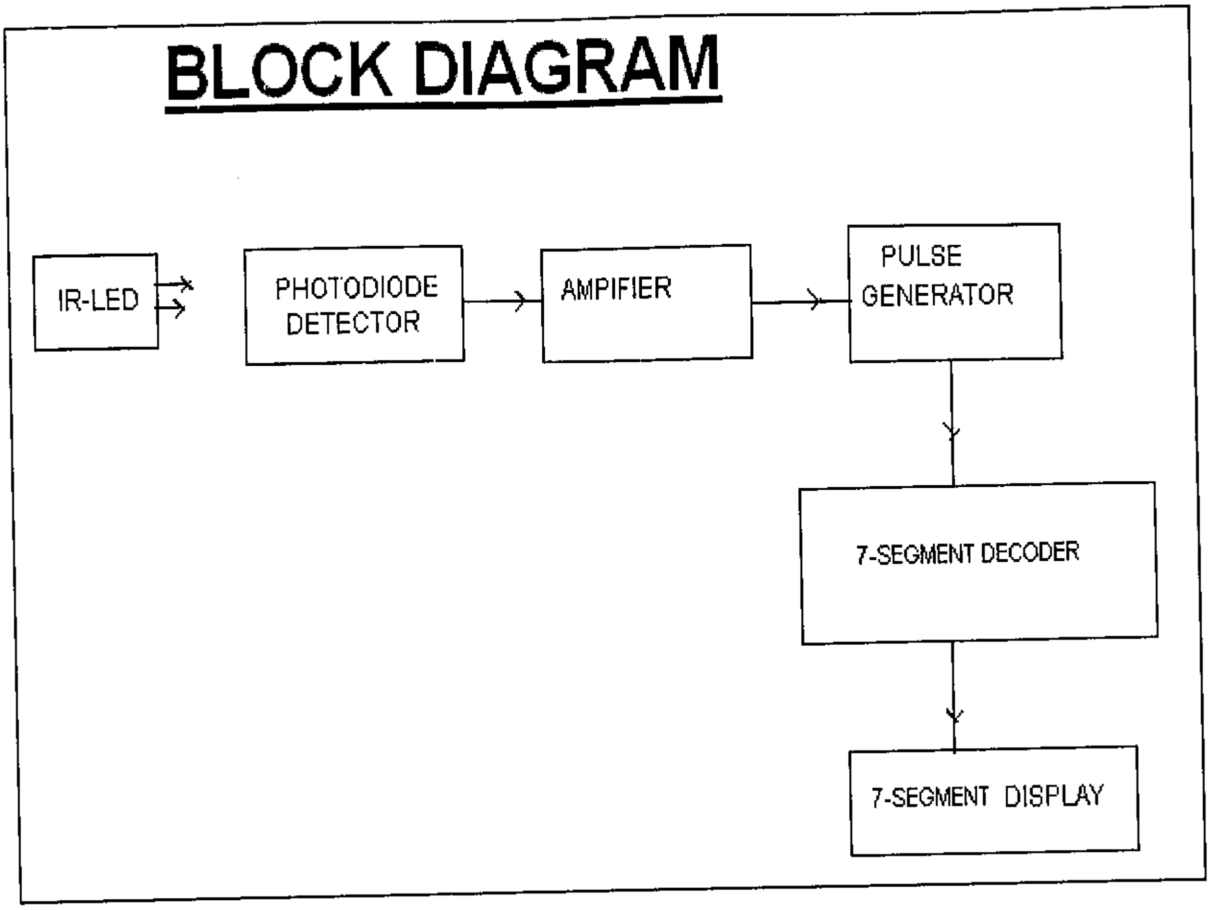

BLOCK DIAGRAM
IR-LED
PHOTODIODE DETECTOR
AMPIFIER
PULSE GENERATOR
7-SEGMENT DECODER
7-SEGMENT DISPLAY

Figure 2.3

3. CHAPTER-3

CIRCUIT WORKING

3.1 Description of Power Supply

This circuit is a small + 5 volts power supply which is useful when experimenting with digital electronics. Small inexpensive battery with variable output voltage are available, but usually their voltage regulation is very poor, which makes them not very usable for digital circuit experimenter unless a better regulation can be achieved in some way. The following circuit is the answer to the problem.

This circuit can give +5V output at about 500mA current. The circuit has overload and terminal protection.

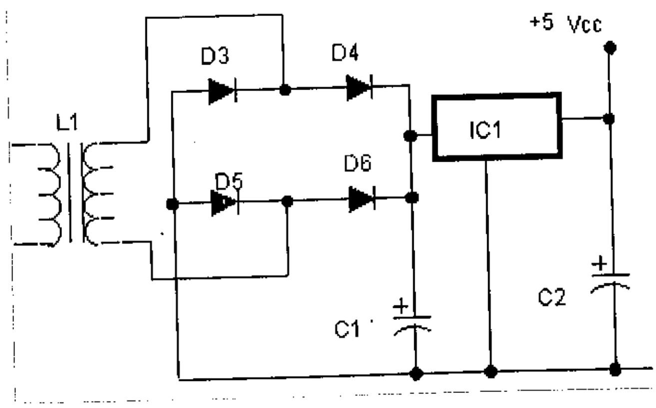


Figure 3.1 IR Light Emitter

3.1.1 Principle of Operation

Because they emit at wavelengths which provide a close match to the peak spectral response of silicon photodetectors, both GaAs and GaAlAs. There are many off-the-shelf, commercially available, IR LED emitters that can be used for a discrete infrared transceiver circuit design. It should be mentioned here that there are also a number of integrated transceivers that the designer can choose as well. In general, there are four characteristics of IR emitters that designers have to be wary of:

- Rise and Fall Time
- Emitter Wavelength
- Emitter Power
- Emitter Half-angle

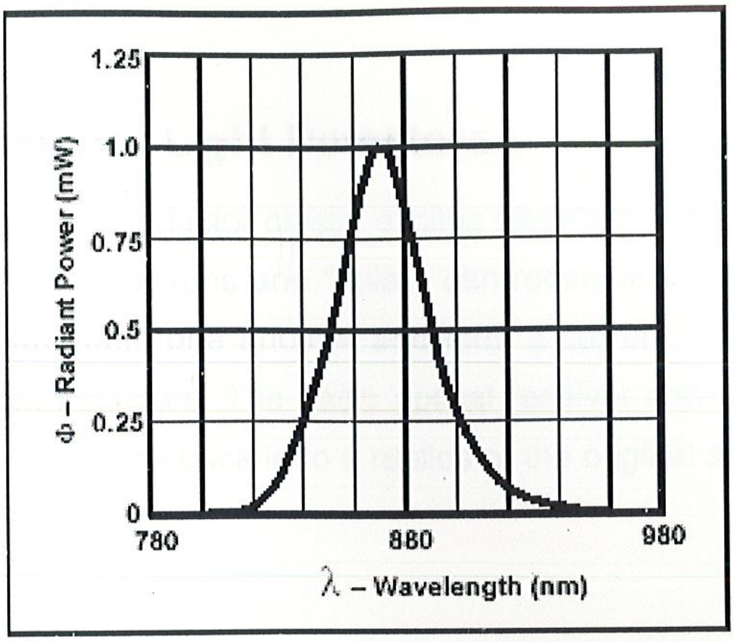
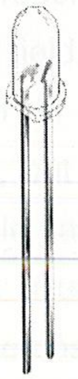
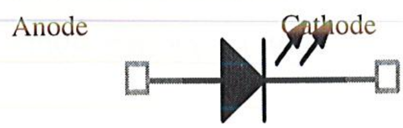


Figure 3.1.1 Wavelength vs. Radiant Power

3.1.2 Description

In this system IR LED used is The QED233 / QED234 which is a 940 nm GaAs / AlGaAs LED encapsulated in a clear untinted, plastic T-1 3/4 package.





3.2 Semiconductor Light Detectors

Energy entering a semiconductor crystal excites electrons to higher levels, leaving behind "holes". These electrons and "holes" can recombine and emit photons, or they can move away from one another and form a current. This is the basics of semiconductor light detectors. The basic optical receiver converts the modulated light coming from the space back in to a replica of the original signal applied to the transmitter.

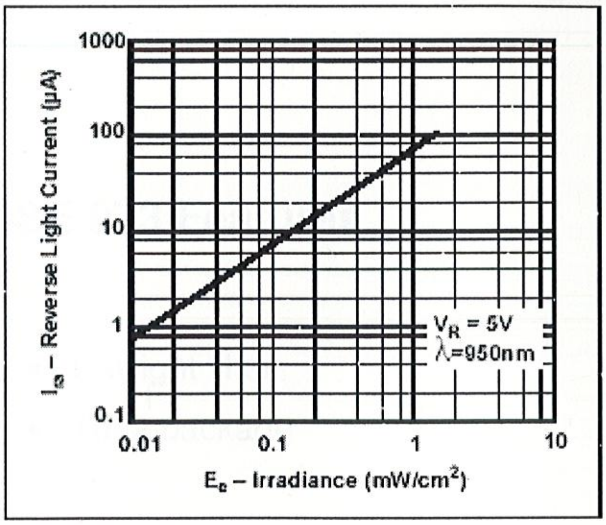
Types of optical detector

- P-N photodiode
- P-I-N photodiode
- Avalanche photodiode

In P-N photodiode, electron hole pairs are created in the depletion region of a p-n junction in proportion to the optical power. Electrons and holes are swept out by the electric field, leading to a current. In P-I-N photodiode, electric field is concentrated in a thin intrinsic layer. In avalanche photodiode, like P-I-N photodiodes, but have an additional layer in which an average of M secondary electron –hole pairs are generated through impact ionization for each primary pair. Photodiodes usually have a large sensitive detecting area that can be several hundreds microns in diameter.

3.2.1 IR Light Detector

The most common device used for detecting light energy in the standard data stream is a photodiode, Photo transistors are not typically used in IrDA standard-compatible systems because of their slow speed. Photo transistors typically have ton/toff of 2 µs or more. A photo transistor may be used, however, if the data rate is limited to 9.6 kb with a pulse width of 19.5 µs. A photodiode is packaged in such a way as to allow light to strike the PN junction.

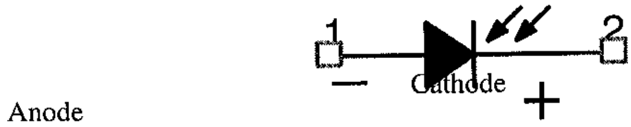


Characteristic Curve of a Reverse Biased Photodiode

In infrared applications, it is common practice to apply a reverse bias to the device. Refer to Figure 3.17 for a characteristic curve of a reverse biased photodiode. There will be a reverse current that will vary with the light level. Like all diodes, there is an intrinsic capacitance that varies with the reverse bias voltage. This capacitance is an important factor in speed.

3.2.2 Description

The QSE973 is a silicon PIN photodiode encapsulated in an infrared transparent, black, plastic T092 package.



QSE 973 Features

- Daylight filter
- T092 package

3.3 LM 358 Op Amp

The LM358/LM358A, LM258/LM258A consist of two independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltage. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage. Application areas include transducer amplifier, DC gain blocks and all the conventional OP-AMP circuits which now can be easily implemented in single power supply systems.

In this schematic, a photodiode is the sensor. photodiode generate voltage when physically bent or deformed, the the foltage is in the millivolt range. The direction that the photodiode is deformed determines the polarity: bend it one way, get a positive voltage. Bend it the other way, get a negative voltage.

In this circuit, the photodiode is put through a full-wave rectifier bridge (the four diodes) to make its voltage always positive. The output of the bridge is sent into one of the LM358's amplifiers that's configured as a voltage summing amp. The output of that amp is then fed into the other amp on the LM358 that's configured as a DC voltage gain amp. The output from the second amp is approximately 0.2 - 3.0 V DC.

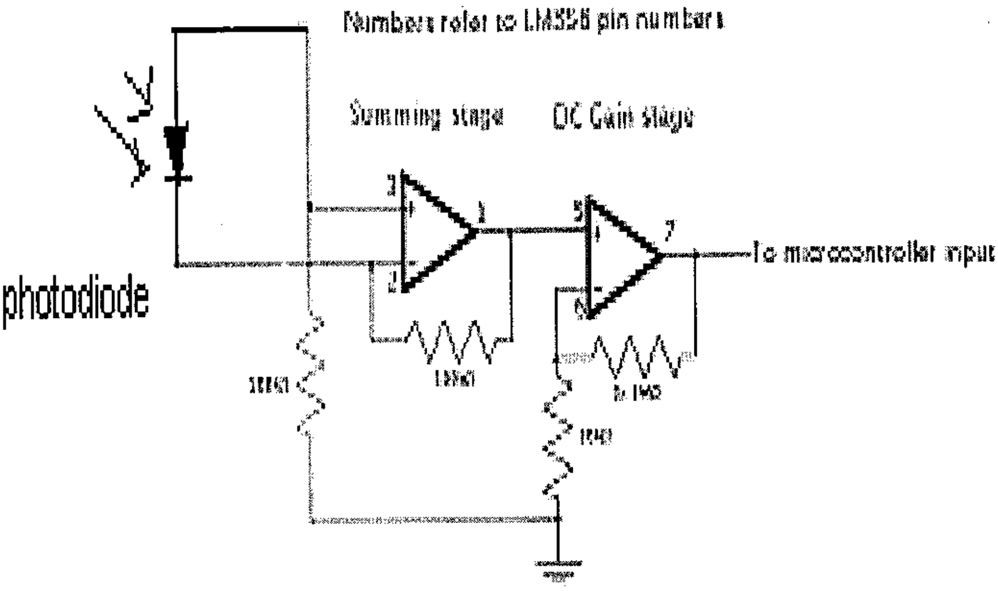
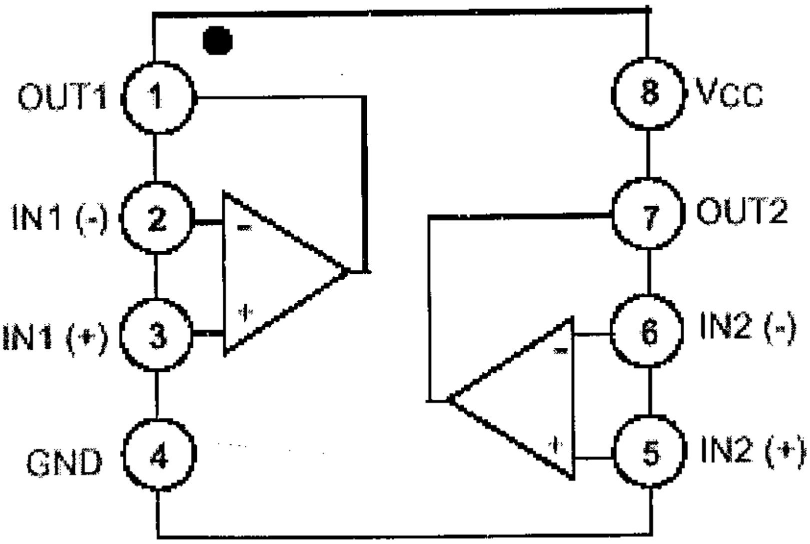


Figure 3.3 Internal Block Diagram



Advantages

- Two internally compensated op amps
- Eliminates need for dual supplies
- Allows direct sensing near GND and VOUT also goes to GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

Features

- Available in 8-Bump micro SMD chip sized package,
- Internally frequency compensated for unity gain
- Large dc voltage gain: 100 dB
- Wide bandwidth (unity gain): 1 MHz
- (temperature compensated)
- Wide power supply range:
  - — Single supply: 3V to 32V
  - — or dual supplies: ±1.5V to ±16V
- Very low supply current drain (500 μA) —essentially
- independent of supply voltage
- Low input offset voltage: 2 mV
- Input common-mode voltage range includes ground

3.4 CD4033 Decade Counter/Divider

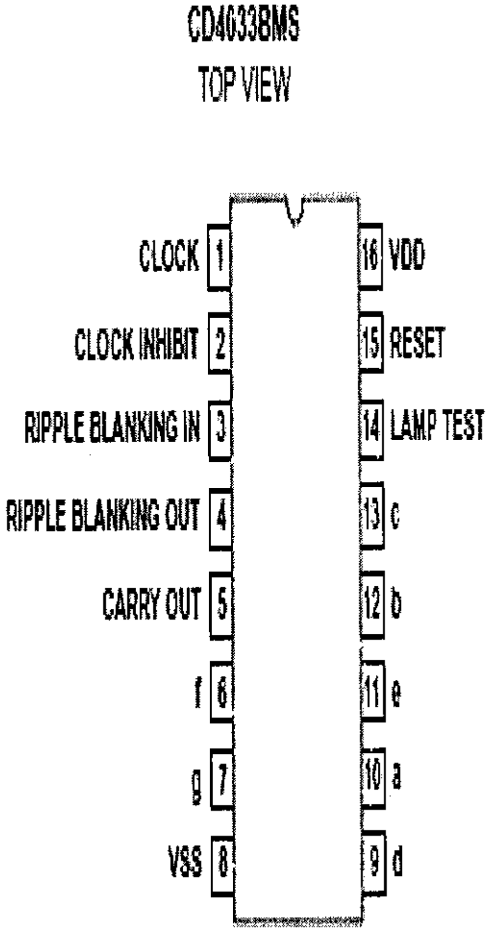
Features

- High Voltage Types (20V Rating)
- Decoded 7 Segment Display Outputs and Ripple Blanking
- Counter and 7 Segment Decoding in One Package
- Easily Interfaced with 7 Segment Display Types
- Fully Static Counter Operation DC to 6MHz (typ.) at VDD =10V
- Ideal for Low-Power Displays
- "Ripple Blanking" and Lamp Test
- 100% Tested for Quiescent Current at 20V
- Standardized Symmetrical Output Characteristics
- 5V, 10V and 15V Parametric Ratings
- Schmitt-Triggered Clock Inputs
- Meets All Requirements of JEDEC Tentative Standards No. 13B, "Standard Specifications for Description of "B" Series CMOS Device's

Applications

- Decade Counting 7 Segment Decimal Display
- Frequency Division 7 Segment Decimal Displays
- Clocks, Watches, Timers (e.g. ÷60, ÷60, ÷12 Counter/ Display
- Counter/Display Driver For Meter Applications

Pinout



Functional Diagram

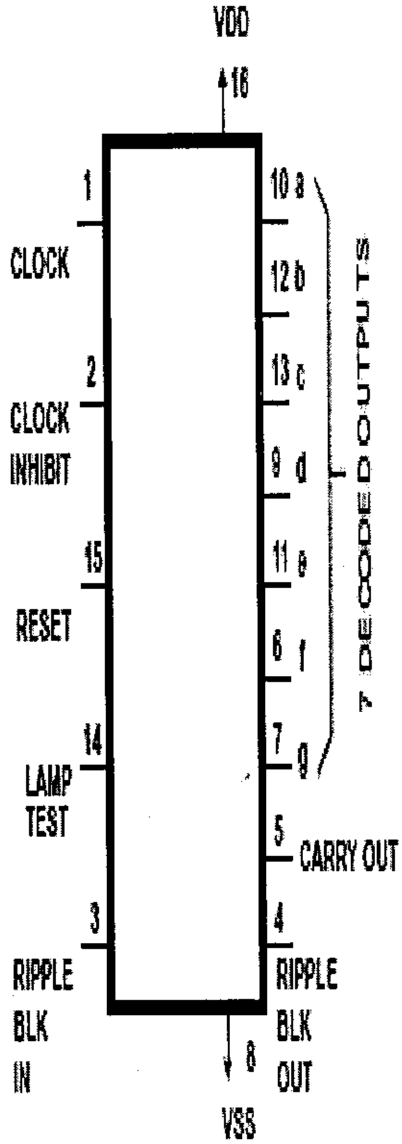


Figure 3.4

4 . CHAPTER 4

4.1 Timer 555

The 555 timer is one of the most remarkable integrated circuits ever developed. It comes in a single or dual package and even low power cmos versions exist - ICM7555. Common part numbers are LM555, NE555, LM556, NE556. The 555 timer consists of two voltage comparators, a bi-stable flip flop, a discharge transistor, and a resistor divider network.

I am particularly indebted to Philips Components and Semiconductors Australia for their most generous assistance in giving me access to material presented on this page.

Philips describe their 555 monlithic timing circuit as 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 200mA."

Applications

Applications include precision timing, pulse generation, sequential timing, time delay generation and pulse width modulation (PWM).

Pin configurations of the 555 timer

Here are the pin configurations of the 555 timer in figure 1 below.

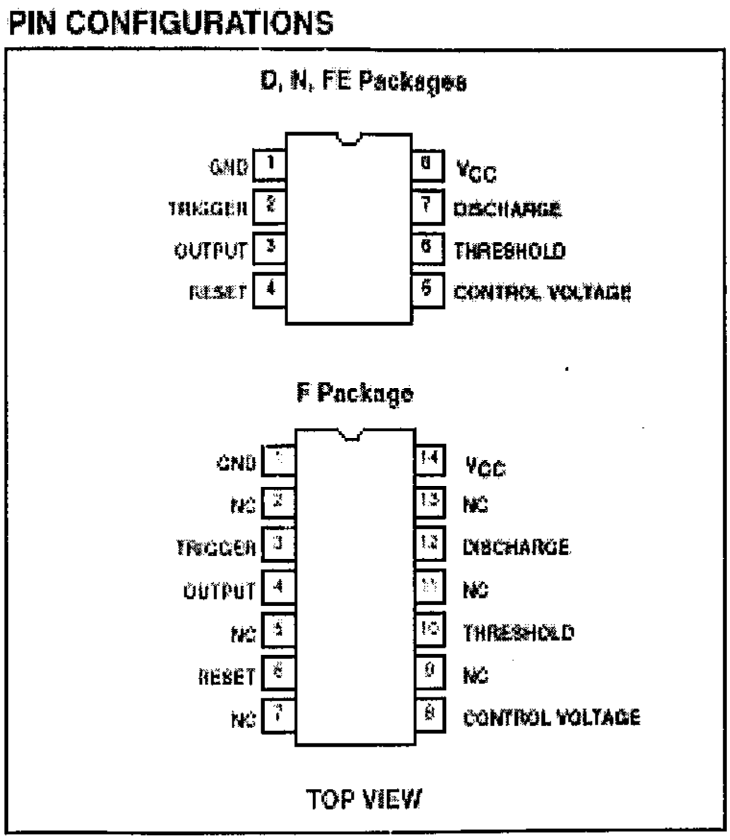
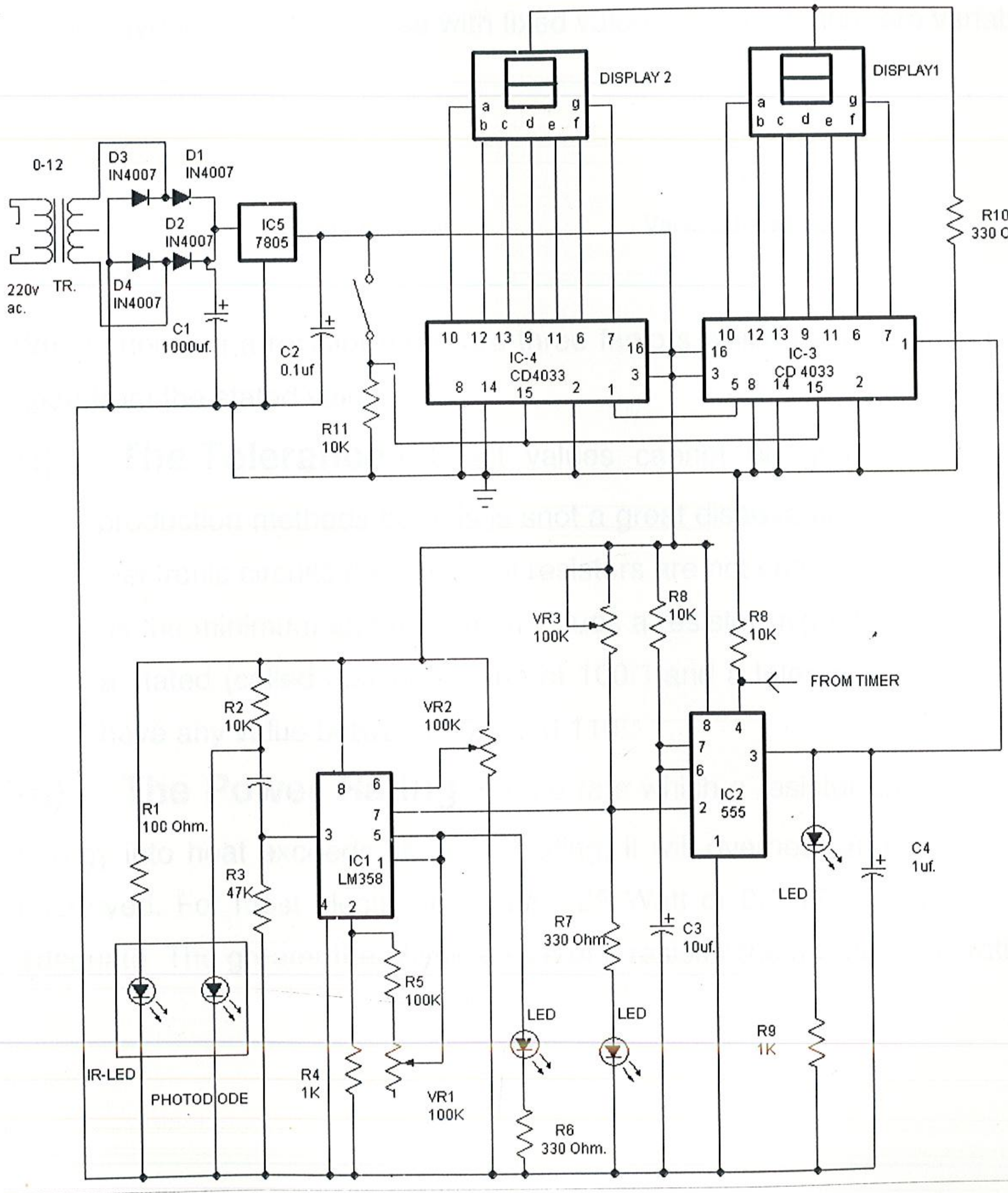


Figure 4.1 - 555 timer pin configurations

4.2 CIRCUIT DIAGRAM



4.3 Resistors

The jobs done by resistors include directing and controlling current, making changing current produce changing voltage (as in a voltage amplifier) and obtaining variable voltages from fixed ones (as in a potential divider). There are two main types of resistor-those with fixed values and those that are variable.

Fixed Resistance　　Variable Resistance

When choosing a resistor there are three factors which have to be considered, apart from the stated value.

(i) The Tolerance - Exact values cannot be guaranteed by mass-production methods but this is snot a great disadvantage because in most electronic circuits the values of resistors are not critical. The tolerance tells us the minimum and maximum values a resistor might have, e.g. one with a stated (called nominal) value of 100□ and a tolerance of +-10% could have any value between 90□ and 110□

(ii) The Power Rating - If the rate which a resistor changes electrical energy into heat exceeds its power rating, it will overheat and be damaged or destroyed. For most electronic circuit 0.25 Watt or 0.5 Watt power ratings are adequate. The greater the physical size of a resistor the greater is its rating.

(iii) The Stability - This is the ability of a component to keep the same value as it 'ages' despite changes of temperature and other physical conditions. In some circuits this is an important factor.

4.3.1 Resistor Markings

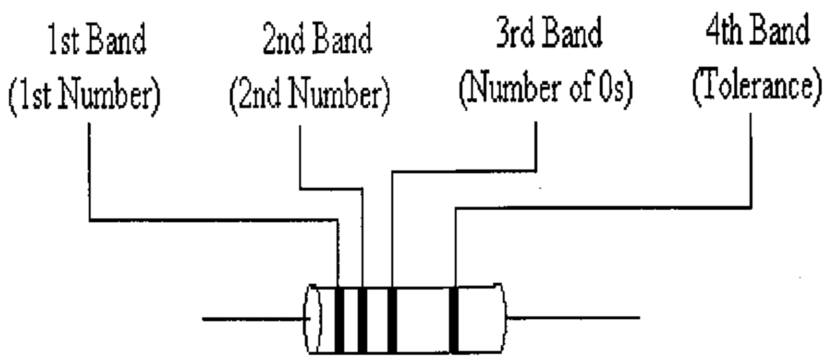
The value and tolerance of a fixed resistor is marked on it using codes. The resistor has four coloured bands painted on it towards one end. The first three from the end give the value and the fourth the tolerance. Sometimes it is not clear which is the first band but deciding where to start should not be difficult if you remember that the fourth band (which is not always present) will be either gold or silver, these being colours not used for the first band.
The first band gives the first number, the second band gives the second number and the third band tells how many noughts (0) come after the first two numbers.

4.3.2 VALUE CODE

NUMBER	COLOUR
0	Black
1	Brown
2	Red
3	Orange
4	Yellow
5	Green
6	Blue
7	Violet
8	Gray
9	White

4.3.3 TOLERANCE CODE

PERCENTAGE	COLOUR
+-5%	Gold
+-10%	Silver
+-20%	no 4th band



RESISTANCE

4.4 Capacitor

A capacitor stores electric charge. It does not allow direct current to flow through it and it behaves as if alternating current does flow through. In its simplest form it consists of two parallel metal plates separated by an insulator called the dielectric. The symbols for fixed and variable capacitors are given in fig. Polarized types must be connected so that conventional current enters their positive terminal. Non-polarized types can be connected either way round.

The capacitance (C) of a capacitor measures its ability to store charge and is stated in farads (f). The farad is sub-divided into smaller, more convenient units.

1 microfarad (1 uF) = 1 millionth of a farad = 10^{-6} F

1 nanofarad (1 nF) = 1 thousand- millionth of a farad = 10^{-9} F

1 picofarad (1pF) = 1 million-millionth of a farad = 10^{-12} F

In practice, capacitances range from 1 pF to about 150 000 uF: they depend on the area A of the plates (large A gives large C), the separation d of the plates (small d gives large C) and the material of the dielectric (e.g. certain plastics give large C).

When selecting a particular job, the factors to be considered are the value (again this is not critical in many electronic circuits), the tolerance and the stability. There are two additional factors.

(i) The working voltage. The is the largest voltage (d.c.or pead a.c.) which can be applied across the capacitor and is often marked on it, e.g. 30V wkg. It is exceeded, the dielectric breaks down and permanent damage may result.

(ii) The leakage current. No dielectric is a perfect insulator but the loss of charge through it as leakage current' should be small.

4.5 Transistors

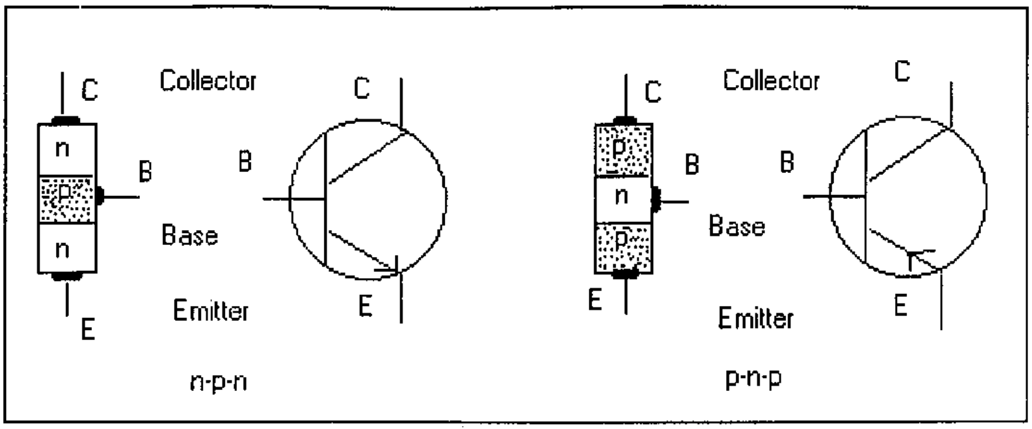


Figure 4.5

Transistors are the most important devices in electronics today. Not only are they made as discrete (separate) components but integrated circuits (Ics) may contain several thousands on a tiny slice of silicon. They are three-terminal devices, used as amplifiers and as switches. Non-amplifying components such as resistors, capacitors, inductors and diodes are said to be 'passive'; transistors are 'active' capacitors, inductors and diodes are said to be 'passive'; transistors are 'active' components.

The two basic types of transistor are:

(a) the bipolar or junction transistor (usually called the transistor) ; its operation depends on the flow of both majority and minority carriers;

(b) the unipolar or field effect transistor (called the FET) in which the current is due to majority carriers only (either electrons or holes).

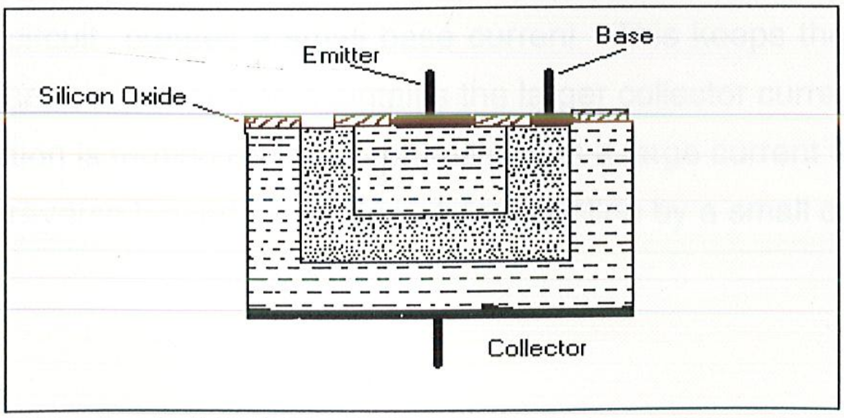
4.5.1 Junction Transistor

(i) Construction. The bipolar or junction transistor consists of two p-n junctions in the same crystal. A very thin slice of lightly doped p-or n-type semiconductor (the base B) is sandwiched between two thicker, heavily doped materials of the opposite type (the collector C and emitter E).

The two possible arrangements are shown diagrammatically in fig with their symbols. The arrow gives the direction in which conventional (positive) current flows; in the n-p-n type it points from B to E and in the p-n-p type it points from B to E and in the p-n-p type from E to B.

As with diodes, silicon transistors are in general preferred to germanium ones because they withstand higher temperatures (up to about 175 ^{0}C compared with 75 ^{0}C) and higher voltages, have lower leakage currents and are better suited to high frequency circuits. silicon n-p-n types, are more easily mass-produced than p-n-p type, the opposite is true of germanium.

A simplified section of an n-p-n silicon transistor made by the planar *planar* process in which the transistor is in effect created on one face (plane) of a piece of semiconducting material; fig. Shows a transistor complete with case (called the 'encapsulation') and three wire leads.



(ii) Action - An n-p-n silicon transistor is represented and is connected in a common emitter circuit; the emitter is joined (via batteries B1 and B2) to both the base and the collector . For transistor action to occur the base emitter junction must be forward biased, i.e. positive terminal of B1 to p- type base, and the collector base junction reverse biased , i.e. positive terminal of B2 to n- type collector .

When the base emitter bias is about +0.6 V, electrons (the majority carriers in the heavily doped n –type emitter) cross the junction (as they would in any junction diode) into the base . Their loss is made good by electrons entering the emitter from the external circuit to form the emitter current . At the same time holes from the base to the emitter but , since the p- type base is lightly doped , this is small compared with the electron flow in the opposite direction , i.e. electrons are the majority carriers in an n-p-n transistor .

In the base , only a small proportion (about 1%) of the electrons from the emitter combine with the holes in the base because the base is very thin (less than millionth of a meter) and is lightly doped . Most of the electrons are swept through the base , because they are attracted by the positive voltage on the collector , and the cross base – collector junction to become the collector current in the circuit .

The small amount of electron – hole recombination which occurs in the base gives it a momentary negative charge which is immediately compensated by battery B1 supplying it with (positive) holes . The flow of holes to the base from the external circuit creates a small base current . This keeps the base emitter junction forward biased and so maintains the larger collector current .

Transistor action is turning on (and controlling) of a large current through the high resistance (reverse biased) collector – base junction by a small current through the low – resistance (forward biased) base – emitter junction . the term transistor refers to this

effect and comes from the two words ' transfer resistor ' . Physically the collector is larger than the emitter and if one is used in place of the other the action is inefficient .

The behavior of a p-n-p transistor is similar to that of the n-p-n type but it is holes that are the majority carriers which flow from the emitter to the collector and electrons are injected into the base to compensate for recombination . To obtain correct biasing the polarities of both batteries must be reversed .

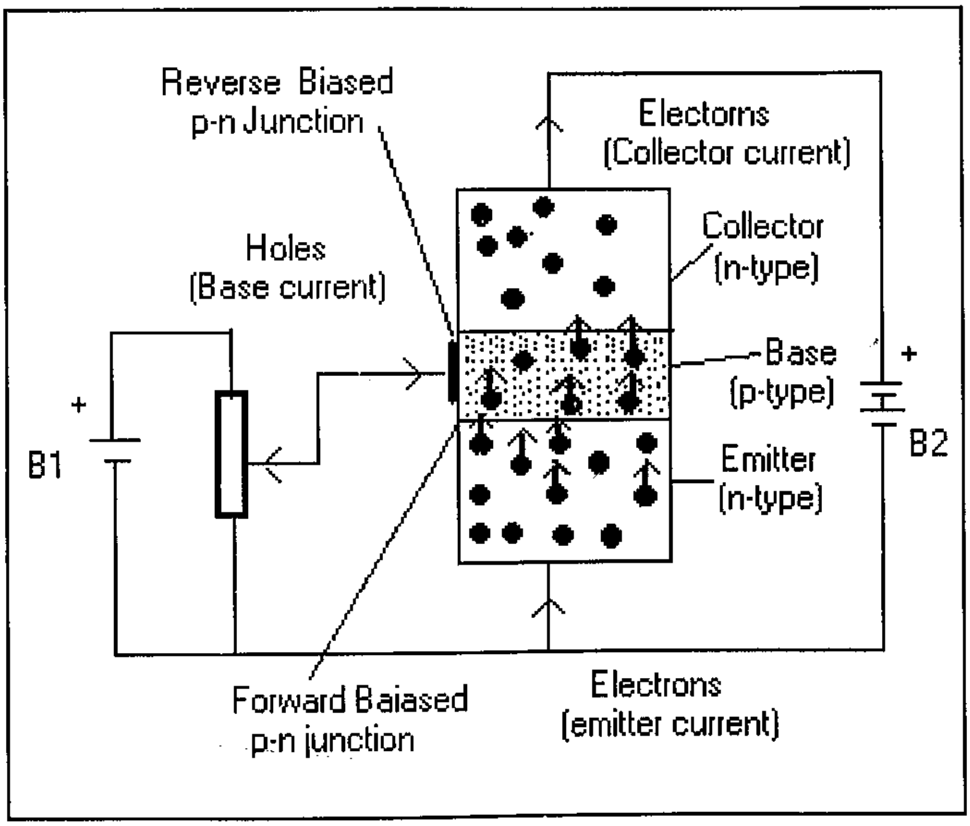


Figure 4.5.1

4.6 Diode

The simplest semiconductor device is made up of a sandwich of P-type semiconducting material, with contacts provided to connect the P-and n-type layers to an external circuit, this is a junction Diode. If the positive terminal of the battery is connected to the p-type material (cathode) and the negative terminal to the N-type material (Anode), a large current will flow. This is called forward current or forward biased.

If the connection are reversed, a very little current will flow. This is because under this condition, the p-type material will accept the electrons from the negative terminal of the battery and the N-type material will give up its free electrons to the battery, resulting in the state of electrical equilibrium since the N-type material has no more electrons. Thus there will be a small current to flow and the diode is called Reverse biased.

Thus the Diode allows direct current to pass only in one direction while blocking it in the other direction. Power diodes are used in concerting AC into DC. In this, current will flow freely during the first half cycle (forward biased) and practically not at all during the other half cycle (reverse biased). This makes the diode an effective rectifier, which convert ac into pulsating dc. Signal diodes are used in radio circuits fro detection, Zener diodes are used in the circuit to control the voltage.

A diode allows current to flow easily in one direction but not in the other, i.e. its resistance is low in the conducting or 'forward' direction but very high in the opposing or 'reverse' direction. Most semiconductor diodes are made from silicon or germanium.

A diode has two leads, the anode and the cathode: its symbol is given in fig (a). The cathode is often marked by a band at one end fig.(b); it is the lead by which conventional current leaves the diode when forward biased – as the arrow on the symbol shown. In some cases the arrow is marked on the diode fig.(c) or the shape is different (d), (e)

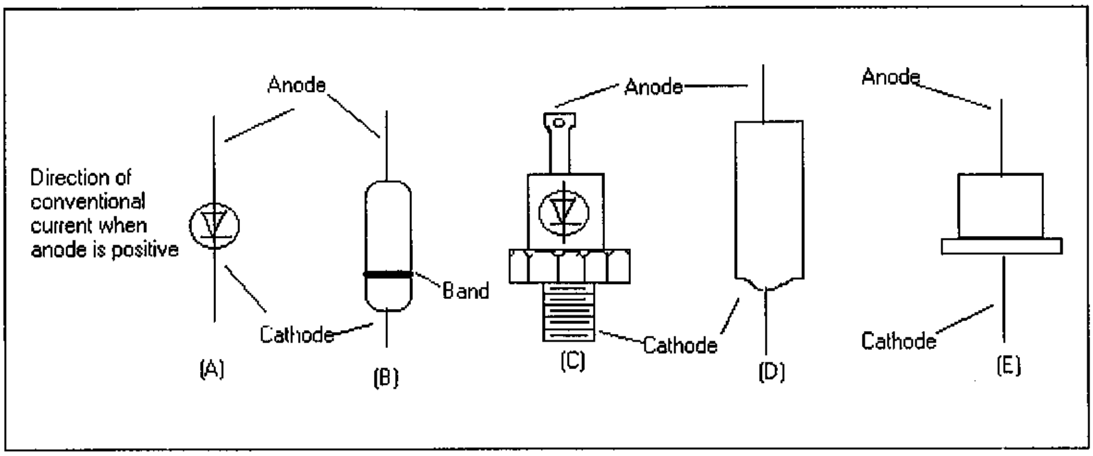


Figure 4.6

There are several kinds of diode, each with features that suit it for a particular job. Three of the main types are:

(a) The junction diode,

(b) The point-contact diode and

(c) The zener diode

Two identification codes are used for diodes. In the American system the code always starts with 1N and is followed by a serial number, e.g. IN 4001. in the continental system the first letter gives the semiconductor material (A=germanium, B= silicon) and the second letter gives the use. (A=signal diode, Y=rectifier diode, Z=Zener diode.). for example, AA119 is a germanium signal diode.

4.6.1 Zener Diode

Zener diodes are very important because they are the key to voltage regulation. The chapter also includes optoelectronic diodes, Schottky diodes, varactors, and other diodes.

A Zener diode is specially designed junction diode which can operate continuously without being damaged in the region of reverse breakdown voltage. One of the most important application of zener diode is the design of constant voltage power supply. The zener diode is joined in reverse bias to D.C. through a resistance of suitable value.

A zener diode is different; it is a silicon diode hat the manufacturer has optimized for operation in the breakdown region, zener diodes work best in the breakdown region. Sometimes called a breakdown diode, the zener diode is the backbone of voltage regulators, circuits that hold the load voltage almost constant despite large changes in line voltage and load resistance.

Figure shows the schematic symbol of a zener diode; another figure is an alternate symbol. In the either symbol, the lines resemble a "z", which stands for zener. By varying the doping level of silicon diodes, a manufacturer can produce zener diodes with breakdown voltage from about 2 to 200V. These diodes can operate in any of three regions: forward, leakage, or breakdown.

Figure shows the I-V graph of a zener diode. In the forward region, it starts conduction around 0.7V, just like a ordinary silicon diode, In the leakage region (between zero and breakdown), it has only a small leakage or reverse current. In a zener diode, the breakdown has a very sharp knee, followed by an almost vertical Vz over most of breakdown region.

4.6.2 L.E.D. (Light Emitting Diode)

Light emitting diode (LED) is basically a P-N junction semiconductor diode particularly designed to emit visible light. There are infra-red emitting LEDs which emit invisible light. The LEDs are now available in many colour red, green and yellow,. A normal LED emit at 2.4V and consumes MA of current. The LEDs are made in the form of flat tiny P-N junction enclosed enclosed in a semi-spherical dome made up of clear colured epoxy resin. The dome of a LED acts as a lens and diffuser of light. The diameter of the base is less than a quarter of an inch. The actual diameter varies somewhat with different makes. The common circuit symbols for the LED are shown in fig. 1. It is similar to the conventional rectifier diode symbol with two arrows pointing out. There are two leads- one for anode and the other for cathode.

LEDs often have leads of dissimilar length and the shorter one is the cathode. This is not strictly adhered to by all manufacturers. Sometimes the cathode side has a flat base. If there is doubt, the polarity of the diode should be identified. A simple bench method is to use the ohmmeter incorporating 3-volt cells for ohmmeter function. When connected with the ohmmeter: one way there will be no deflection and when connected the other way round there will be a large deflection of a pointer.

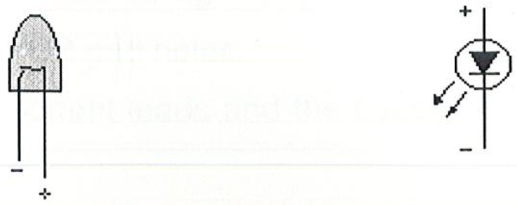
When this occurs the anode lead is connected to the negative of test lead and cathode to the positive test lead of the ohmmeter.

(ii) External resistor. Unless an LED is of the 'constant-current type' (incorporating an integrated circuit regulator—see Unit 20.4—for use on a 2 to 18 V d.c. or a. c. supply), it must have an external resistor R connected in series to limit the forward current which, typically, may be 10 mA (0.01 A). Taking the voltage drop (Vf) across a conducting LED to be about 107 V, R can be calculated approximately from:

$$R = \frac{(\text{supply voltage} - 1.7)\ \text{V}}{0.01\text{A}}$$

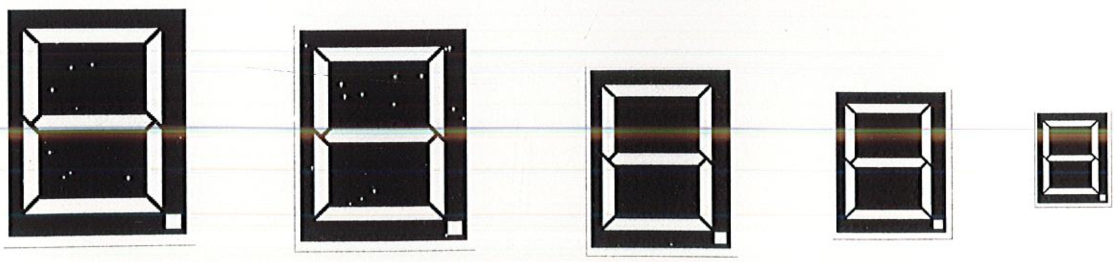
For example, on a 5 V supply, R = 3.3/0.01 = 330 Ohm.

(i) Action. An LED consists of a junction diode made form the semiconducting compound gallium arsenide phosphide. It emits light when forward biased, the colour depending on the composition and impurity content of the compound. At present red, yellow and green LEDs are available. When a p-n junction diode is forward biased, electrons move across the junction from the n-type side to the p-type side where they recombine with holes near the junction. The same occurs with holes going across the junction from the p-type side. Every recombination results in the release of a certain amount of energy, causing, in most semiconductors, a temperature rise. In gallium arsenide phosphide some of the energy is emitted as light which gets out of the LED because the junction is formed very close to the surface of the material. An LED does not light when reverse biased and if the bias is 5 V or more it may be damaged.



(iii) Decimal display. Many electronic calculators, clocks, cash registers and measuring instruments have seven-segment red or green LED displays as numerical indicators (Fig. 9.18(a)). Each segment is an LED and depending on which segments are energized, the display lights up the numbers 0 to 9 as in Fig. 9.18(b). Such displays are usually designed to work on a 5 V supply. Each segment needs a separate current-limiting resistor and all the cathodes (or anodes) are joined together to form a common connection.

The advantages of LEDs are small size, reliability, long life, small current requirement and high operating speed.



4.7 SOLDERING COMPONENTS INTO THE PCB

- Bend the component leads at right angles with both bends at the same distance apart as the PCB pad holes.
- Ensure that both component leads and the copper PCB pads are clean and free of oxidization.
- Insert component leads into holes and bend leads at about 30 degrees from vertical.
- Using small angle cutters, cut the leads at about 0.1 - 0.2 of an inch (about 2 - 4 mm) above copper pad.
- Bring tinned soldering iron tip into contact with both the component lead and the PCB pad. This ensures that both surfaces undergo the same temperature rise.
- Bring resin cored solder in contact with the lead and the copper pad. Feed just enough solder to flow freely over the pad and the lead without a 'blobbing' effect. The final solder joint should be shiny and concave indicating good 'wetting' of both the copper pad and the component lead. If a crack appears at the solder to metal interface then the potential for forming a dry joint exists.

PRECAUTIONS

1. Mount the components at the apron places before soldering. Follow the circuit description and components details, leads identification etc. Do not start soldering before making it confirm that all the components are mounted at the right place.
2. Do not use a spread solder on the board, it may cause short circuit.
3. Do not sit under the fan while soldering.
4. Position the board so that gravity tends to keep the solder where you want it.
5. Do not over heat the components at the board. Excess heat may damage the components or board.
6. The board should not vibrate while soldering otherwise you have a dry or a cold joint.
7. Do not put the kit under or over voltage source. Be sirę about the voltage either is d.c. or a.c. while operating the gadget.
8. Do spare the bare ends of the components leads otherwise it may short circuit with the other components. To prevent this use sleeves at the component leads or use sleeved wire for connections.
9. Do not use old dark colour solder. It may give dry joint. Be sure that all the joints are clean and well shiny.
10. Do make loose wire connections specially with cell holder, speaker, probes etc. Put knots while connections to the circuit board, otherwise it may get loose.

REFERENCES

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