

IDENTIFICATION OF BASIC ELECTRONIC COMPONENTS THEIR CHARACTERISTICS & TESTING

1.0.0 INTRODUCTION

An electronic circuit is composed of various types of components. Some of these components are termed as active components because they take part in the transformation of the energy while other components, which only dissipate or store energy, are called as passive elements. The vacuum tubes, rectifier, transistors are some of the common active while the resistances, which dissipate the power and energy storing elements such as capacitances and inductances are known as passive elements. The transformers may be regarded as a matching device. The success of any electronic circuit depends not only on proper selection of the active elements but on the passive and matching elements too. The proper function, of an active device is decided by the proper values of these passive elements. Hence the selection of these elements such as resistances, inductances, capacitance, and transformers not only require the proper attention, but also decide the proper function of the active devices as well as the circuit as a whole.

Here we shall discuss about some important electronic components and their characteristics, particularly used in Biomedical instruments.

1.1.0 ELECTRONIC COMPONENTS :

These can be classified into

1.1.1 Passive Components : Components like resistance, capacitance inductance, and fall in this class.

1.1.2 Active Components : They can be further classified as

Semiconductor Devices : Semiconductor diode, zener diode, and varactor diode etc. Uni-junction transistor, Bipolar junction transistor (BJT), FET, silicon, Controlled rectifier etc.

Vacuum Tube Devices : Vacuum tube diode, triode, Tetrode, Pentode, Hexode, Heptode etc.

Gas Tube Devices : Gas diodes, Thyratrons etc.

Photo Sensitivity Devices : Gas photodiodes, photo multiplier tubes, photodiodes, light emitting diode, photosensitive transistor etc.

Though there are devices, which are specific to particular frequency range and applications like microwave devices etc.

1.1.3 PASSIVE DEVICES:

1.1.4 RESISTANCES: Resistors can be made to control the flow of current, to work as Voltage dividers, to dissipate power and it can shape electrical waves when used in combination of other components. **Basic unit is ohms, (Ω)**

1.1.5 RESISTIVE ELEMENTS:

Metal alloys, carbon and graphite used with binders etc. are the, usual resistive materials. The alloys used as resistance wire usually have higher specific resistances than the base metals and have lower temperature coefficient of resistance. The three most common types of resistance wire used are nickel-copper, nickel. Chromium-aluminum and nickel-chromium. Carbon and graphite are used as the basic resistance materials when they are mixed and heated with proper variety of resin binders. These types of resistances are generally known as composition carbon type's resistors. The resistive element may be either in the form of a film or a solid slug, which consists of a number of conducting particles held together by resin. In the film type the base materials may be glass, ceramic and plastics.

Resistors can be (i) fixed resistors with two ends, (ii) variable resistor or potentiometers. Resistors are specified by the value of resistance, in ohms maximum power dissipation in watts, and precision in %.

Types: Resistors can be designed in many ways by usage, shape, physical construction tolerances, resistances are of the following three types i.e.

1.1.6 FIXED RESISTORS:

1.1.7 SEMIVARIABLE RESISTORS:

1.1.8 VARIABLE RESISTORS:

The fixed resistances are those whose values cannot be changed. In case of semi variable types of resistances their values can be changed with help of a screwdriver. Semi variable types resistances are known as preset. In case of the variable resistances their values can be changed from zero to maximum with the help of a movable arm.

Types include : Metal oxide, non inductive, carbon composition, carbon film, metal film, deposited film, ceramic, chip fixed, variable, trimmer, carmet, miniature, PC Board SPST combination, wire wound fixed and variable units, dual potentiometers, power resistors, precision, conductive plastic, hybrid and surface mount.

Resistances in series $R = R_1 + R_2 + R$

Resistances in parallel $1/R = 1/R_1 + 1/R_2 + 1/R_3 + \dots$

Voltage drop $V = I.R$ I is current,

Power dissipation $P = I^2.R = V^2/R$

1.1.9 RHEOSTATE :

A wire wound pot that can dissipate 5 and more watts is often referred to as a rheostat. The resistance wire is wound on an open ring of ceramic which is covered with vitreous enamel, except for the track of the wiper arm. Rheostats are used to control motor speeds, x-ray tube voltages, ovens and many other high power applications.

2.0.0 THERMISTORS:

A Thermistor is non-linear resistance made of semiconductor material that is extremely sensitive to change in temperature. For a small change in body temperature of a Thermistor, there is an appreciable change in its resistance, where as most conductors have a positive temperature coefficient, the thermistor can exhibits a positive or negative temperature coefficient, (NTC). The thermistor is mostly negative temperature coefficient resistances. The resistances of thermistor decreases rapidly for increased temperature.

The thermistor are used in wide variety of applications. They can be used in measurement and control of temperatures, time delay, temperature compensation and liquid level indicators. The thermistor is available in the form of a disk, bead, or bolted assembly packages.

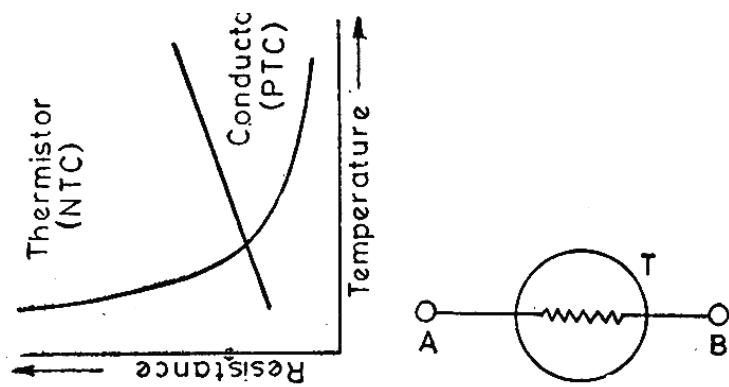


Fig.-1
shows the temperature-resistance characteristics of thermistor.

2.1.0 VARISTORS

These are voltage dependent resistances. They also fall under the category of non-linear resistors. According to the Ohm's Law the current is directly proportional to the impressed voltage but in case of varistors the current is proportional to the n th power of the impressed voltage i.e.

$$I \propto V^n$$

where I is the current in Amperes and V is the impressed voltage on the Varistors. Figure-2 shows the V-I characteristics of the Varistors.

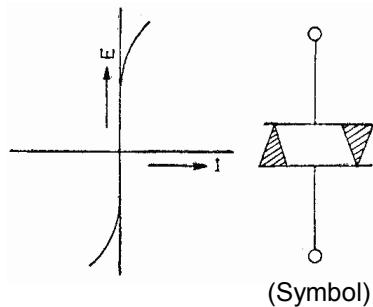


Figure-2
V-I characteristic of varistors

Application of the Varistor include voltage surge and protective circuits and the generation of non-sinusoidal waveform. The varistors are made out of silicon carbide and is available in the form of disk, rod or washers. They can withstand d.c. voltage upto 10 kV or so. Fig.-3. Show the V-I characteristics of Varistors.

2.2.0 CAPACITORS :

It stores the charge across its two plates. Capacitor opposes the change of voltage across its plates; the electric field developed across the plate opposes the rapid change in voltages. It produces phase difference between voltage applied to it and the current, which passes through it. The current leads the voltage by 90° in the ideal capacitance with infinite resistance across the plates. (Fig. 3)

Design of capacitor is connected with relation of the proper electric material for particular type of application. The dielectric material used for capacitors may be grouped in the various classes. The dielectric coverage for different value of capacitor is shown in fig.-4.

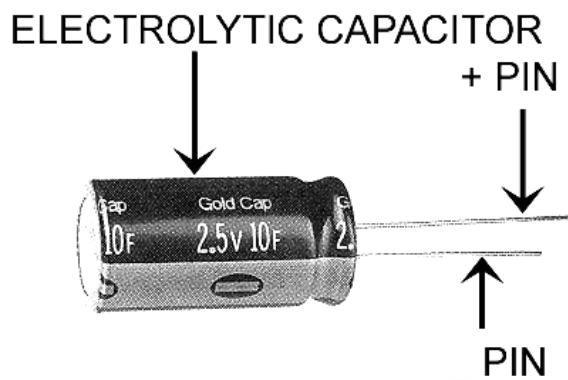


Figure -3

The value of capacitor never remains constant except under certain fixed conditions. It changes with temperature, frequency and ageing. The capacitance value marked on the capacitor strictly applies only at specified room temperature and at low frequencies. The behavior of capacitor at various frequencies may be grouped into the following seven classes.

Mica, glass, air, and low loss ceramic capacitors are used from few kHz to few hundreds MHz.

Paper and metalized paper capacitor cover the frequency range from few Hz to few hundred kHz.

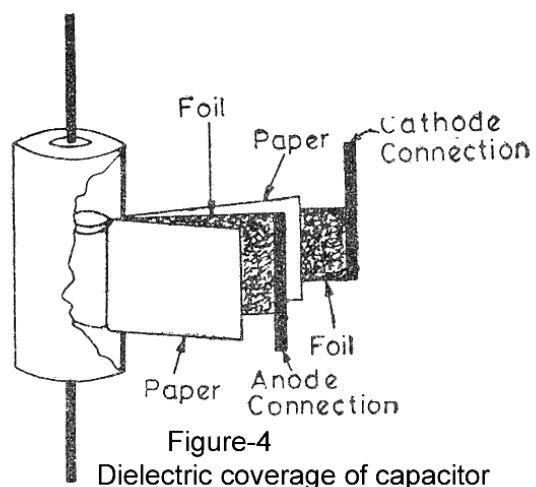


Figure-4
Dielectric coverage of capacitor

High dielectric constant ceramic capacitor can only be used between the frequency ranges from few kHz to few, hundred of kHz however, they can find use from very low frequency to 1000 kHz.

Aluminum electrolytic capacitor can find use at power frequency from 10Hz to 1000Hz but can be used up to 10 kHz.

Tantalum electrolytic capacitor may be used from dc to few hundred Hz.

Polyethylene, tere-phthalate (Mylar), cellulose acetate capacitor may find use from few hundred Hz to few MHz.

Polystyrene, polyethylene, poly-tetra-fluoro-ethylene (Teflon) capacitors are used from dc to 1000 MHz range. They are reported to give satisfactory performance even at higher frequencies.

The capacitance units in farads, μ F, pF, nF

Value of the capacitance is given by Its value and the max specify. Voltage which can be safely applied to its

When capacitor is put in parallel the over all capacitance C is

$$C = C_1 + C_2 + C_3 + \dots$$

and in series $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots$

2.2.1 VARIABLE: Air variable capacitors are supplied as single or multi gauge type, and trimmers.

2.2.2 VARACTORS:

(voltage variable capacitors)
When a p-n diode is reversed biased the depletion region becomes devoid of free electrons and holes. Thus in such a situation the depletion layer may be considered to be layer of dielectric while the p and n regions as the plates of capacitors.

When the reversed biased increased the width of the depletion layer will increase, hence the capacitance will decrease. While with reduction of reverse bias the capacitance will increase as shown in figure-5.

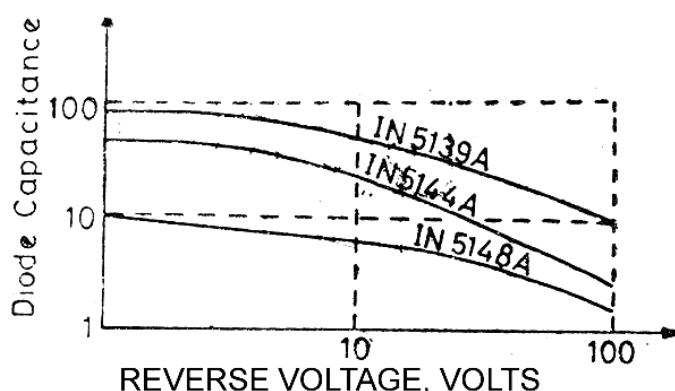


Figure-5

Such types of diodes are also known as voltage variable capacitors or varactors. The symbol of the varactors diodes is shown in Fig.-6.

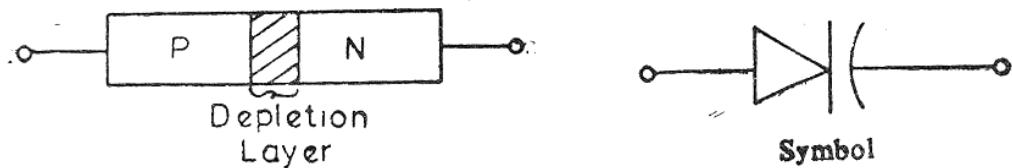


Figure 6
symbol of the varactors

Capacitors are named in a number of ways : after the dielectric they use, or their application or some physical attribute.

3.0.0 TRANSFORMERS :

The transformers used in electronic circuits may be classified into three classes depending on their application.

Power transformers used with power supplies.

Audio transformers cover the input and output transformers and isolation transformers.

Pulse transformers used in various types of pulse circuits.

Table given below shows various types of symbols of transformers.

S. No.	Type	Symbol
1	Transformer with magnetic core	
2	Shielded, transformer with magnetic core	
3	Magnetic core with a shield between windows	
4	Air cored transformer	

5	One winding transformer with adjustable inductance	
6	Transformer with tapings	
7	Autotransformer	
8	Single phase three winding transformer	
9	Three phase with 1-phase two winding transformer	

4.0.0 INDUCTORS: Like capacitors, inductors also store energy in one part of AC cycle and return it during the next part of the cycle.

Inductance is that property of a device that reacts against a change in current through the device. Inductors are components designed for use in circuits to resist changes in current and thus serve important control functions.

Inductor designed is based on the principle that a varying magnetic field induces a voltage in any conductor in that field. Thus, a practical inductor may simply be a coil wire. The current in each loop of the coil produces a magnetic field that passes through neighboring loops. If the current through the coil is constant the magnetic field is constant and no action takes place. A change in the current, however,

produces a change in the magnetic field. The energy absorbed or released from the changing magnetic field reacts against the change in current, and this is exhibited as an induced voltage (electromotive force, emf), which is counter to the change in applied voltage. The inductor thus behaves as an impedance to ac current.

The counter emf is directly proportional to the rate of change of current through the coil ($V_L = L[\frac{di}{dt}]$). The proportionality constant is the inductance L , which has the unit of henrys (H). In an ac circuit, as shown in, the inductor offers reactance to alternating current. The inductive reactance X_L has the units of ohms and is given by

$$X_L = \omega L = 2\pi f L$$

Total inductance

$$L = L_1 + L_2 + L_3 \dots$$

Inductances in parallel :

$$\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$$

5.0.0 SEMICONDUCTORS DEVICES :

It is not easy to define a semiconductor if we want to take into account all its physical characteristics. However, a semiconductor is defined on the basis of electrical conductivity as under A semiconductor is a substance which has resistivity (10^{-4} to $0.5 \Omega m$) in between conductors and insulators e.g. germanium, silicon, carbon etc. When a semiconductor is neither a good conductor nor an insulator, then why not to classify it as a resistance material? The answer shall be readily available if we study the following table :

Sr. No.	Substance	Nature	Resistivity
1	Copper	Good conductor	$1.7 \times 10^{-8} \Omega m$
2	Germanium	Semiconductor	$0.6 \Omega m$
3	Glass	Insulator	$9 \times 10^{11} \Omega m$
4	Nichrome	resistance material	$10^{-4} \Omega m$

Comparing the resistivity of above materials, it is apparent that the resistivity of germanium (semiconductor) is quite high as compared to copper (conductor) but it is quite low when compared with glass (insulator). This shows that resistivity of a semiconductor lies in between conductor and insulators. However, it will be wrong to consider the semiconductor as a resistance material. For example, nichrome, which is one of the highest resistance material, has resistivity much lower than germanium. This shows that electrically germanium cannot be regarded as conductor or insulator or a resistance material. This gave a such substances like germanium the name of semiconductors.

It is interesting to note that it not the resistivity alone that decide whether a substance is a semiconductor or not. For example it is just possible to prepare an alloy

whose resistivity falls within the range of semiconductors but the alloy cannot be regarded as a semiconductor. In fact, semiconductors have a number of peculiar properties which distinguish them from conductors, insulators and resistance materials.

5.1.0 PROPERTIES OF SEMICONDUCTORS:

The resistivity of semiconductor is less than an insulator but more than a conductor. The semiconductors have negative temperature coefficient of resistance i.e. the resistance of semiconductor decreases with the increase in temperature and vice-versa. For example germanium is actually an insulator at low temperatures but it becomes a good conductor at high temperatures.

When a suitable metallic impurity (e.g. arsenic, gallium etc.) is added to a semiconductor, its current conducting properties change appreciably. This property is most important.

5.1.1 Two type of semiconductor material known as P - type and N - type such as silicon and germanium.

p-type : Impurity Of lower group, it contain excess of holes or deficiency of electrons.

n-type : impurity of higher group, contains excess of electrons or deficiency of holes.

5.2.0 DIODES :

By forming a junction of n & p type material. Barrier potential is formed across the junction due to crossing of holes to n side and crossing of electron to p side.

This property of current flow in only one direction i.e. when the diode is forward biased is used in rectification. Though, theoretically the forward resistance of the diode is zero but practically it is not. The voltage drop in forward direction is $v = i R_d$.

5.2.1 CHARACTERISTICS :

Where R_d is dynamic forward resistance. The junction drop is 0.3V in Germanium. And 0.7V in silicon diode.

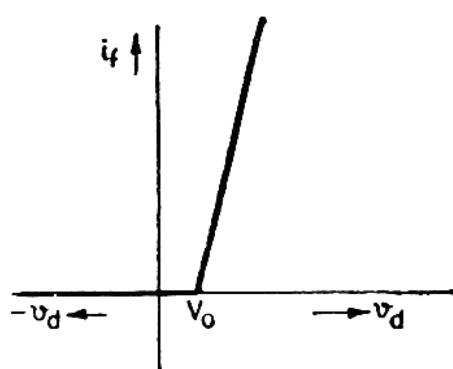


Figure-6
Characteristic of Diode

Diodes are specified by max reverse voltage, and forward voltage and maximum current capacity maximum frequency of operation.

Diodes are used in power supplies, for rectification, and in pulse shaping applications.

5.3.0 ZENER DIODE:

These diodes are operated in reverse bias mode, as the reverse bias is increased the resistance remains constant until a certain value known as avalanche point is reached due to avalanche effect the current suddenly increases and the voltage across it becomes almost constant.

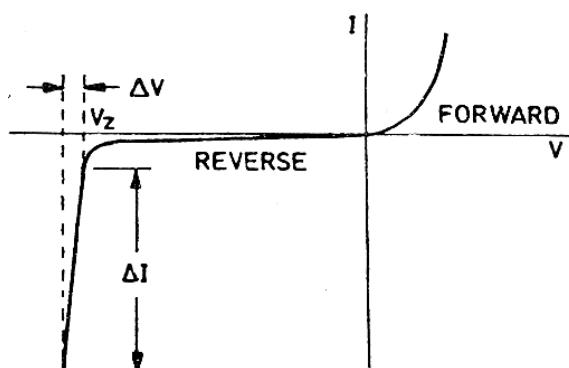


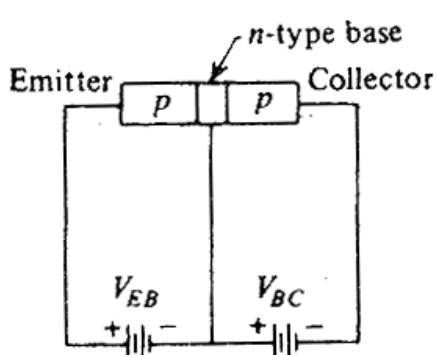
Figure - 7
Characteristic of Zenor Diode

Zener voltage may vary from as little as 3 volt to 150 volts depending on the way the Zener is manufactured used as the voltage regulator.

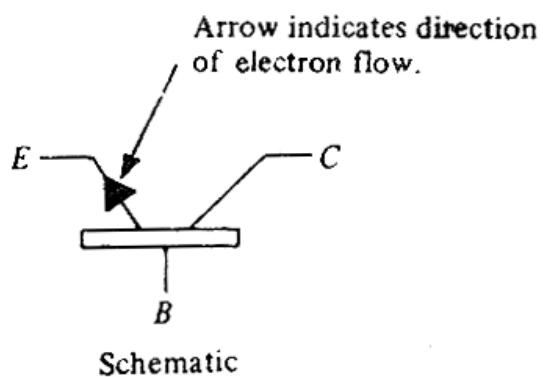
5.4.0 TRANSISTORS :

Bipolar junction Transistors (BJT) :

It is a three-layer device having two junctions npn and pnp transistors are possible.



(a)



(b)

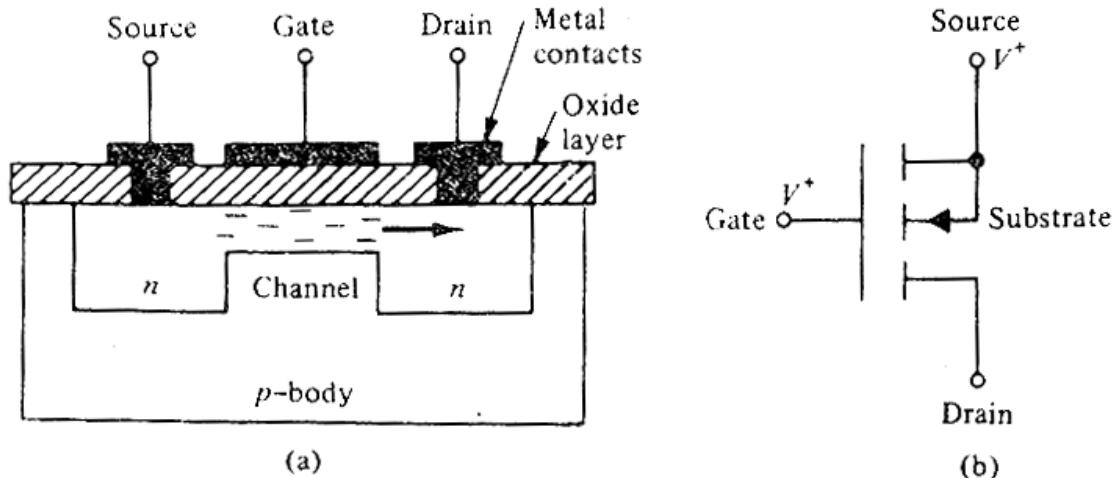


Figure - 8

Base of emitter junction is forward biased. Therefore having low resistance. Base to collector junction is reverse biased offering very high resistance. The order of collector current and emitter current is same but the collector circuit resistance is very high therefore resulting in voltage or power amplification. It works in three configurations

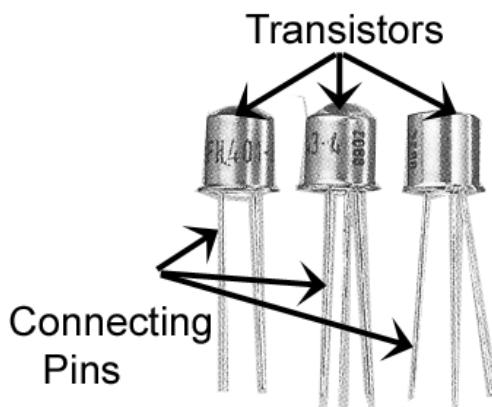


Figure 9

5.5.0 INTEGRATED CIRCUITS (I.C'S)

Transistors may be used as discrete units or as components of a microelectronic circuit. The advent of microelectronics has not affected the functions of the basic components-namely, transistors, resistors, and so on. The major difference is that all these components are available as an electrical functional unit fabricated on a single small IC chip. Many problems of circuit design are solved with the IC, thus simplifying the design, operation, and maintenance of instrumentation.

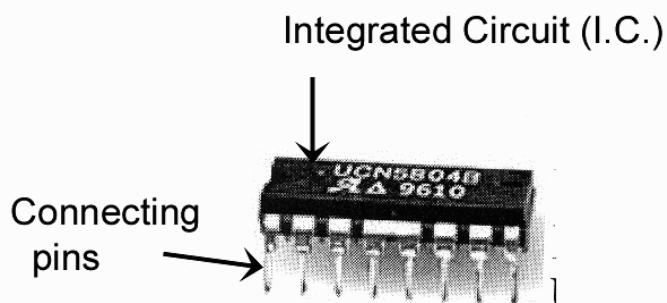


Figure 10
Integrated Circuit

ICs may function in a linear or nonlinear manner. The output of a linear IC is directly proportional to the input. Linear IC applications include many types of amplification, modulation, and voltage regulation. The operational amplifier is the most important type of linear IC. Nonlinear ICs include all digital ICs and other circuits where there is not a linear relationship between the input and output signals. Digital ICs, the most important type of a nonlinear ICs, usually use some form of bi-stable (on/off) operation. These ICs are common in computer circuits and in other digital applications such as counters, calculators, and digital data communication equipment.

ICs must be placed in a protective housing and have connections to the outside world. There are three methods of packaging ICs in containers (figure-11); the TO-5 glass metal can, the ceramic flat pack, and the dual-in-line ceramic or plastic flat packs known as dual-in-line packages (DIPs). The popular, less expensive plastic (DIP packages can have 14,16,18,24 or 40 connecting pins. A minimum of two pins is required for connecting the IC to the power supply. The remaining connections are available for use as terminals for input and output signals.

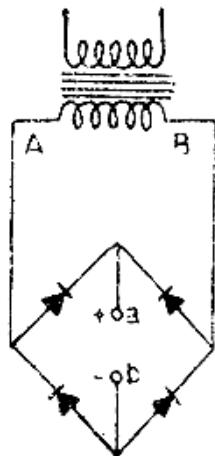
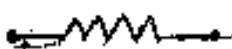


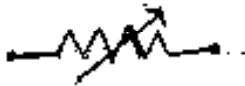
Figure-11 Full Wave Bridge Rectifier

6.0.0 ELECTRONICS COMPONENTS AND SYMBOLS

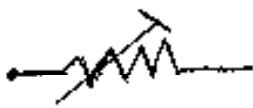
1. RESISTOR



2. VARIABLE RESISTOR (POTENTIOMETER)



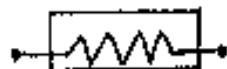
3. PRESET.



4. NTC RESISTOR (THERMISTOR)



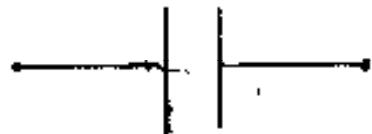
5. PTC RESISTOR (POSISTOR)



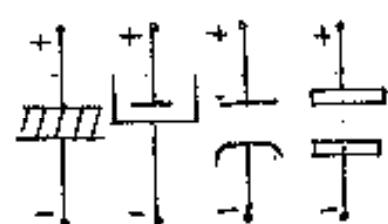
6. FUSIBLE RESISTOR



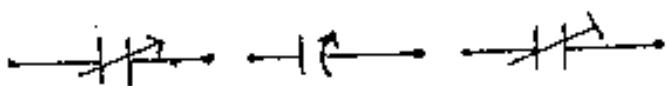
7. LDR (LIGHT DEPENDENT RESISTOR)



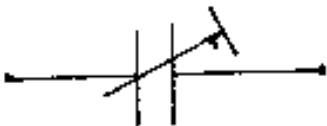
8. CAPACITOR. (NON-ELECTROLYTIC)



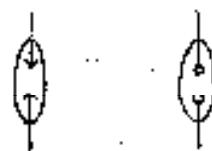
9. ELECTROLYTIC CAPICTOR.



10. VARIABLE CAPACITOR.



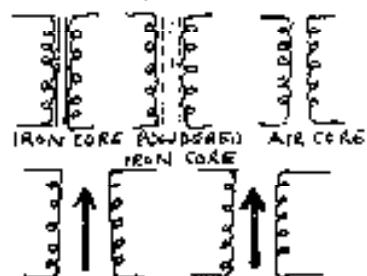
12. SPARK GAP CAPACITOR.



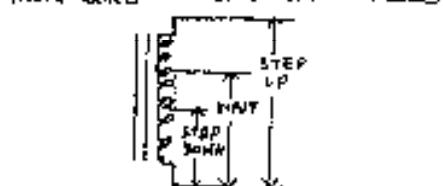
13. FUSE.



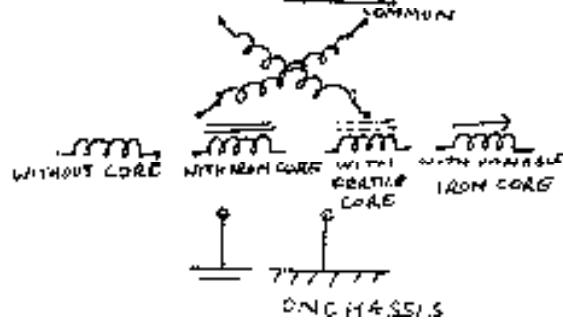
14. TRANSFORMER (ISOLATION.)



15. TUNING COILS



16. AUTO TRANSFORMER.



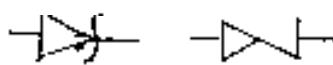
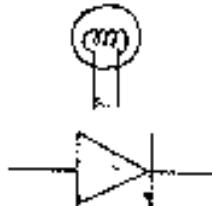
17. DEFLECTION COIL

18. INDUCTOR

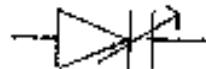
19. EARTH

20. BULB.

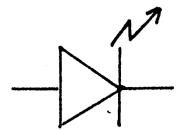
21. DIODE.



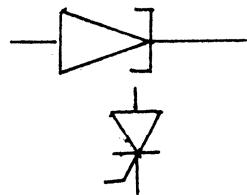
22. ZENER DIODE.



23. VARACTOR DIODE.



24. LED (LIGHT EMITTING DIODE)



25. TUNNEL DIODE.

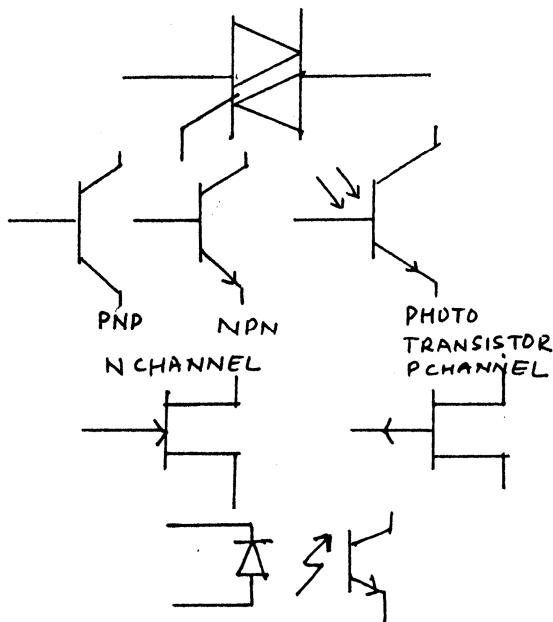
26. SCR (SILICON CONTROLLED RECTIFIER)



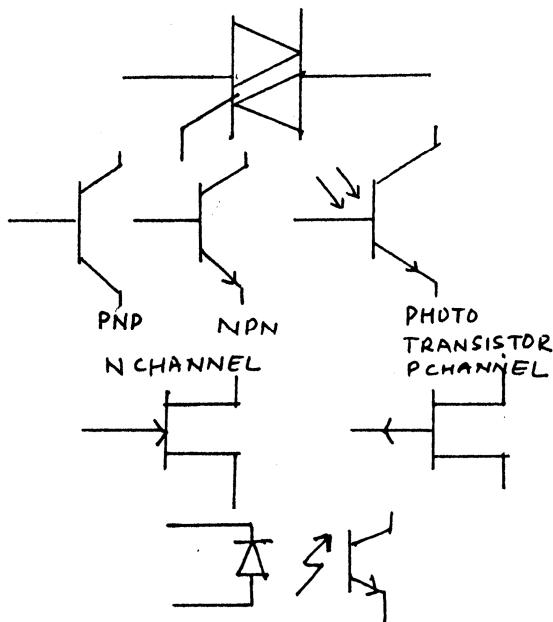
27. DIAC



28. TRIAC.

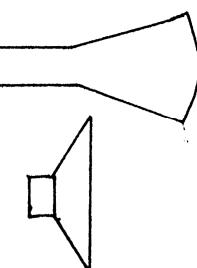


29. TRANSISTOR.



30. FIELD EFFECT TRANSISTOR (FET)

32 .INTEGRATED CIRCUIT (OP AMP.)



33 .CRT.

34. SPEAKER.



35. MICROPHONE.

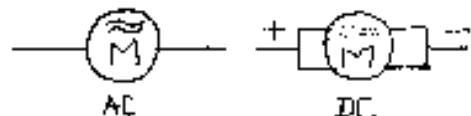
36. SWITCH.



37. BATTERY.



38. MOTOR.



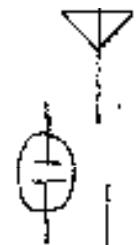
39VOL T METER



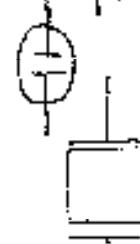
40. AMMETER.



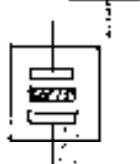
41. AERIAL (ANTENNA)



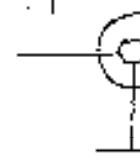
42. NEON LAMP.



43. PEIZO ELECTRIC CRYSTAL



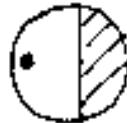
44. PEIZO BUZZER



45. SHIELDED CONNECTOR.

ON PCB

R - RESISTOR



ELECTROLYTIC
NEGATIVE
LEAD

L- INDUCTANCE



C-CAPACITANCE

D-DIODE

T-TRANSFORMER

F-FUSE



← TRANSISTOR

Q-TRANSISTOR

TP-TEST PIONTS



← PRESET

8.0.0 Colour code for Resistances

Colour	I Band	II Band	III Band	IV Band
	1st Digit	2nd Digit	Multiplier	Tolerance
Black	0	0	100	
Brown	1	1	10 ¹	1%
Red	2	2	10 ²	2%
Orange	3	3	10 ³	
Yellow	4	4	10 ⁴	
Green	5	5	10 ⁵	
Blue	6	6	10 ⁶	
Violet	7	7	10 ⁷	
Grey	8	8	10 ⁸	
White	9	9	10 ⁹	
Gold	--	--	10-1	5%
Silver	--	--	10-2	10%
No Colour	--	--	--	20%
