

## B.TECH.

Second Semester Examination, May-2011

### BASICS OF ELECTRONICS

**Note :** Attempt five questions in total, at least one question from each section. Question No. 1. is compulsory.

**Q. 1. (a) What is diffusion current?**

**Ans Drift Current :** The steady flow of electrons in are direction caused by the applied electron field constitutes a electric current called the drift current.

**Diffusion Current :** It occurs when charge carrier diffuse from a point of conc. to spread uniformly through out the volume of a piece of material.

**Q. 1. (b) What is Barkhausen criteria for oscillations?**

**Ans. Barkhausen Criteria :**

- The loop gain of the circuit must be equal to (or slightly greater than) unity and
- The phase shift around the circuit must be zero. These two conditions for sustained oscillations are called Barkhouses criteria.

**Q. 1. (c) What is breakdown of PN-diode?**

**Ans.**  $(11011)_2 = (27)_{10}$

A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0

**Q. 1. (d) Why we need amplification?**

**Ans.** Amplification is the process of adding strength to the input signal or it is a process of magnifying. the input signal without changing its shape.

The circuit which amplifies a small input signal is called an amplifier. It is important that the magnified

output signal must have the same shape as that of the input signal i.e., if the input wave is a sine wave then the magnitude output signal must also be a sinewave

**Q. 1. (e) Give truth table of S-R flip-flop.**

**Ans. Truth table of SR flip-flop :**

S	R	$Q_n$	$Q_{n+1}$
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	X can't be determined
1	1	1	

**Section-A**

**Q. 2. (a) Write short note on Wein bridge oscillator.**

**Ans. Wien Bridge Oscillator :**

- Like the phase shift oscillator discussed in section, this is also an RC oscillator, because it uses a feedback network which consists of resistors and capacitors.
- The major difference between Wein bridge and RC-phase shift oscillator is that, in Wein bridge oscillator, the amplifier used does not introduce any phase shift (in other words it is a non-inverting amplifier), therefore the feedback network also does not have to introduce any phase shift. It has to introduce adequate attenuation only.
- The feedback network used for this type of oscillator is called as "Wein bridge." Therefore the name Wein bridge oscillator.
- Before we start analyzing various circuits for the Wein bridge oscillator, let us analyze the Wein bridge circuit.

**The Wein Bridge Circuit :**

The "Wein bridge" which is used as the feedback network in Wein bridge oscillator is shown in fig. (a) and shows the basic Wein Bridge oscillator.

The amplifier in fig. (b) can use a transistor or FET or an OP-AMP as amplifying device.

The wein bridge of fig. (a) has four arms. The arm AD which consists of the series combination of

$R_1$  and  $C_1$  and the arm CD which consists of the parallel combination of  $R_2$  and  $C_2$  are called as the frequency sensitive arms. This is because the components connected in these arms decide the oscillator frequency.

The resistor  $R_3$  and  $R_4$  are used to generate a reference voltage which remains constant independent of frequency.

The ac input voltage is applied between points "A" and "C" of the bridge. When the wein bridge is used in the oscillator circuit, the feedback voltage is applied between these points as shown in fig. (b).

Wein bridge circuit of fig. (a) is used as a feedback network in the wein bridge oscillator circuit as shown in fig. (b). It is also called as the "Lead-Lag Network." At low frequencies it acts like a lead network whereas at high frequencies it acts like a lag network. But the phase shift introduced at the output frequency is  $0^\circ$ .

#### Expressions for Feedback Factor (b) and Frequency (f):

- In order to obtain the expressions for the feedback factor " $\beta$ " and the oscillator frequency " $f$ " we will consider only the frequency sensitive arms AD and CD as shown in fig.
- Note that  $V_{in}$  of fig. is actually the output and the voltage across  $R_2$   $C_2$  acts as a feedback voltage  $V_F$ .
- The feedback factor or gain of the feedback network ( $\beta$ ) is defined as;

$$\beta = V_F / V_{in}$$

- But  $V_F$  is the voltage across the parallel combination of  $R_2$  and  $C_2$ . Let the impedance of the arm AD which has  $R_1$ ,  $C_1$  in series be  $Z_1$  and that of the arm DC which has  $R_2$ ,  $C_2$  in parallel be  $Z_2$ .

$$V_F = \frac{Z_2}{(Z_1 + Z_2)} \times V_{in}$$

and

$$\beta = \frac{V_F}{V_{in}} = \frac{Z_2}{(Z_1 + Z_2)}$$

- Now let us obtain the expression for  $Z_1$  and  $Z_2$

$$Z_1 = R_1 + \frac{1}{j\omega C_1} = \frac{1 + j\omega R_1 C_1}{j\omega C_1}$$

and

$$Z_2 = R_2 \parallel X_{C2} = R_2 \parallel \frac{1}{j\omega C_2}$$

$$Z_2 = \frac{R_2 \times (1/j\omega C_2)}{R_2 + (1/j\omega C_2)} = \frac{R_2}{1 + j\omega R_2 C_2}$$

- Substituting equations (a) and (b) equation (c), we get

$$\beta = \frac{[R_2 / (1 + j\omega R_2 C_2)]}{\left[ \frac{1 + j\omega R_1}{j\omega C_1} \right] + [R_2 / (1 + j\omega R_2 C_2)]}$$

- Substitute  $j\omega = s$ , in the above expression to get,

$$\beta = \frac{[R_2 / (1 + sR_2 C_2)]}{\left[ \frac{1 + sR_1}{sC_1} \right] + [R_2 / (1 + sR_2 C_2)]}$$

- Multiply numerator and denominator by  $(1 + sR_2 C_2)$

$$\beta = \frac{sC_1 R_2}{[(1 + sR_1 C_1)(1 + sR_2 C_2)] + sR_2 C_1}$$

$$= \frac{sC_1 R_2}{1 + s(R_1 C_1 + R_2 C_2) + s^2 R_1 R_2 C_1 C_2}$$

$$\beta = \frac{sC_1 R_2}{1 + s(R_1 C_1 + R_2 C_2 + R_2 C_1) + s^2 R_1 R_2 C_1 C_2}$$

- Resubstitutes  $s = j\omega$  and  $s^2 = j^2 \omega^2 = -\omega^2$  into equation, we get,

$$\beta = \frac{j\omega C_1 R_2}{1 + j\omega(R_1 C_1 + R_2 C_2 + R_2 C_1) - \omega^2 R_1 R_2 C_1 C_2}$$

- Grouping the real and in imaginary parts in the denominator, we get



$$\therefore \beta = \frac{j\omega C_1 R_2}{(1 - \omega^2 R_1 R_2 C_1 C_2) + j\omega (R_1 C_1 + R_2 C_2 + R_2 C_1)}$$

Rationalize the equation, to get

$$\beta = \frac{j\omega C_1 R_2 \left[ (1 - \omega^2 R_1 R_2 C_1 C_2) - j\omega (R_1 C_1 + R_2 C_2 + R_2 C_1) \right]}{(1 - \omega^2 R_1 R_2 C_1 C_2)^2 + \omega^2 (R_1 C_1 + R_2 C_2 + R_2 C_1)^2}$$

- As mentioned earlier, the phase shift introduced by the Wein bridge circuit at the desired output frequency should be  $0^\circ$ . For that the imaginary part of equation should have a zero value.

$$\therefore \omega_1 C_1 R_2 (1 - \omega^2 R_1 R_2 C_1 C_2) = 0$$

$$\therefore \omega^2 R_1 R_2 C_1 C_2 = 1$$

$$\text{Or } \omega^2 = \frac{1}{R_1 R_2 C_1 C_2}$$

$$\therefore \omega = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}$$

$$\text{And frequency, } f = \frac{1}{2\pi \sqrt{R_1 R_2 C_1 C_2}}$$

This is the expression for the oscillator frequency.

- If we substitute  $R_1 = R_2 = R$  and  $C_1 = C_2 = C$  in the expression for the oscillator frequency, then equation gets modified as follows :

$$\text{Oscillator frequency, } f = \frac{1}{2\pi RC}$$

- Similarly if we substitute  $R_1 = R_2 = R$  and  $C_1 = C_2 = C$  into the expression for  $\beta$  equation then we get

$$\text{Feedback factor } \beta = \frac{3}{0 + \frac{1}{C^2 R^2} (3RC)^2} = \frac{3}{9}$$

$$\beta = 1/3$$

- Thus, at the oscillator frequency "f" the value of the feedback factor  $\beta$  is "1/3".

#### Gain of the amplifier for sustained oscillations :

- According to Barkhausen criteria, the loop gain should be greater than 1 and phase shift around the loop should be zero.

- The positive sign of  $\beta$  in equation shows that the phase shift introduced at frequency "f" is zero. The satisfy the other condition, i.e.,

$$|A\beta| \geq 1$$

Substituting  $\beta = 1/3$  we get,

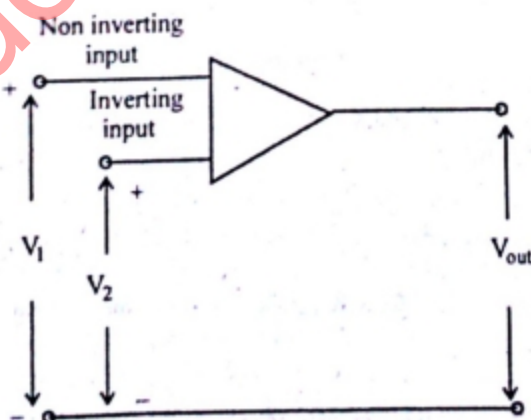
- Thus the amplifier gain should be at least equal to 3 to ensure sustained oscillations.

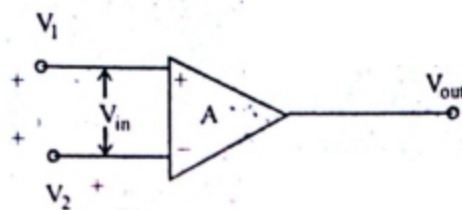
#### Q. 2. (b) Explain Op-amp with its block diagram.

**Ans. Operational Amplifier :** Abbreviated as op-amp, is basically a multistage amplifier, very high gain, direct coupled amplifier. -ve feedback amplifier that has high input impedance and low output impedance and has capability of amplifying signals having frequency ranging from 0 Hz to 1 MHz.

**Symbol of op-amp :** The schematic symbol of op-am is shown in fig. A is the voltage gain,  $V_1$  is the non-inverting input and  $V_2$  is the inverting input. The differential input is

$$V_{in} \text{ or } V_d = V_1 - V_2 \text{ \& output voltage } V_{out} = AV_{in} = A(V_1 - V_2)$$





(b)

Note that voltages,  $V_1$ ,  $V_2$  and  $V_{out}$  are node voltages. This means that they are always measured w.r.t. ground. The differential input voltage  $V_{in}$  is the difference of two node voltages  $V_1$  and  $V_2$ .

It consists of two input terminals and one output terminal. Here the inputs are marked with plus (+) and minus (-) to indicate non-inverting and inverting inputs respectively. A signal applied to the plus input appears with the same polarity and is amplified at the output, while an input applied to the minus terminal appears amplified but inverted at the output.

**Q. 3. Write short note on ;**

(a) Inverter

(b) SMPS

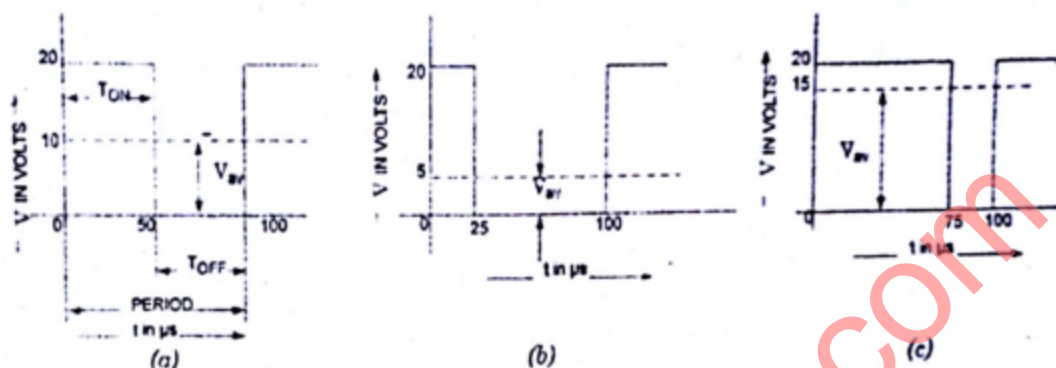
**Ans. (a) Inverter :**

**(b) SMPS :**

**Switch Mode Power Supplies (SMPS) or Switching Regulators :**

The regulated power supplies described earlier were basically linear voltage regulators. A linear voltage regulator possesses many limitations :

- (i) The input transformer is bulky and is a very expensive component in the whole regulated power supply since it is used at low line frequency (50 Hz).
- (ii) As the ac frequency is 50 Hz, filter capacitors of large values are required to minimize the ripples introduced.
- (iii) The series regulators exhibit 50% efficiency and hence input voltage should be more than output voltage. If efficiency is less, then that part (difference in input-output voltage) of voltage will be dissipated in the form of power in series pass transistor ( $Q_1$ ) which is always in active region. A TTL system regulator ( $V_{out} = 5V$ ) when operated at 10V ac input provides 50% efficiency and only 25% for 20 V dc input.
- (iv) Two dc supply voltages are required, +5 V for TTL and  $\pm 15$  V for op-amp, which is not economically and practically feasible.



### Pulse Width Modulation and Average Value

Switch mode power supply (SMPS) overcomes the limitations of regulated power supplies. Here in SMPS (or sometimes called switching regulator), the pass transistor ( $Q_1$ ) is used as a controlled switch and is operated either in cutoff region or saturation region which makes the power transfer via the pass transistor in the form of discrete pulses.

As in the case with other digital switching devices, this mode of operation results in very low power consumption.

SMPS are used in modern digital equipment such as telephone exchange, PCs, robotics etc., battery powered equipment, space vehicles etc. Such systems need very compact, light weight and highly energy efficient supplies. SMPS utilizes pulse width modulation to control the average value of output voltage. The average value of the waveform depends on the area of waveform. If the  $T_{ON}$  time (or say, duty cycle

$\frac{T_{ON}}{T_{ON} + T_{OFF}}$  is varied, the average value of voltage changes proportionately.

In the PWM switching at constant switching frequency, the switch control signal is generated by comparing  $V_{control}$  and repetitive waveform, as shown in fig.

SMPS or switching regulators can provide large load currents at low voltage precisely what is required in PCs (personal computers).

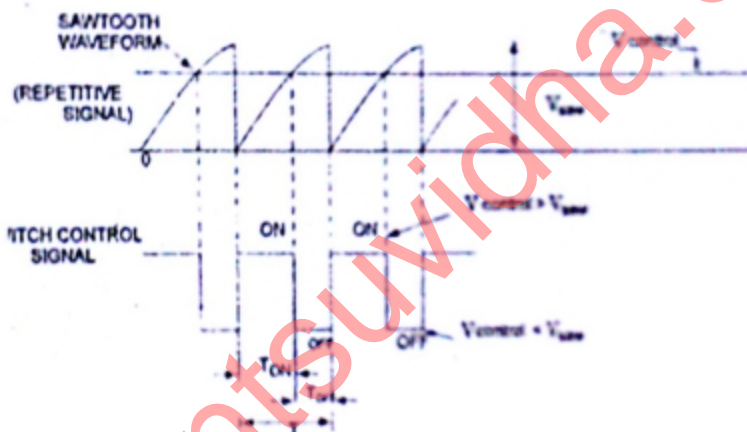
Switching regulators are available in three basic configurations viz. step-down, step-up and polarity inverting configurations.

Step-down version is shown in fig. (a). The rectangular pulses on the base saturate and cut off the pass transistor during each cycle. This generates a rectangular voltage at the input to LC filter. This filter blocks the ac component and allows the dc component to pass to the output. Because of the on-off switching, the average value is always less than the input voltage. This is why the circuit is called the step-down version.





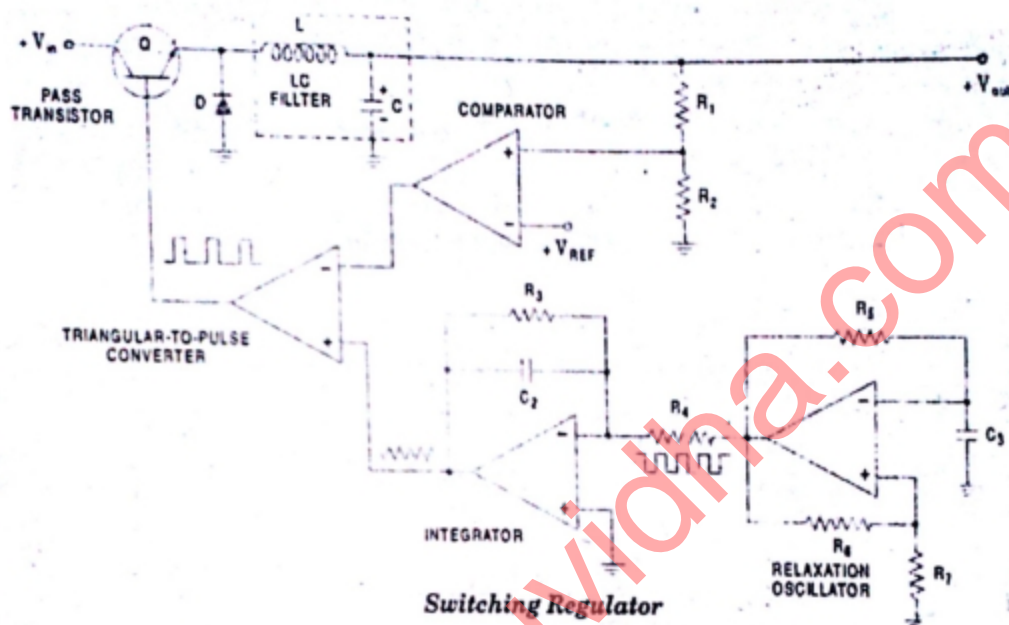
(a) Pulse Width Modulator



(b) Comparator Signals

Step-up version of the switching regulator is shown in fig. (b). Again, the transistor is alternately saturated and cut off. When the transistor is saturated, current flows through the inductor. When the transistor suddenly cuts off, the magnetic field around the coil collapses and induces a large voltage across the coil of opposite polarity. This keeps the current flowing in the same direction. Furthermore, the inductive kickback voltage is larger than the input voltage. This is why the circuit is called step-up configuration.

Polarity Inverting regulator is shown in fig. (c). When the transistor is saturated, current flows through the inductor. When the transistor cuts off, the magnetic field collapses, and the inductive kickback keeps current flowing in the same direction. Since the transistor is off, the only path is through the capacitor. If the direction of charging current through the capacitor is checked, output voltage is found to be negative.



A low-power design, using circuits that we are already familiar with, is illustrated in Fig. The relaxation oscillator generates a square wave whose frequency is determined by  $R_5$  and  $C_3$ . The square-wave is integrated to provide a triangular wave, which is used to drive the noninverting (+) input of a triangular-to-pulse converter. The pulses of this circuit then drive the pass transistor. The duty cycle of these pulses will determine the output voltage.

The duty cycle  $D$  is the ratio of the on time  $T_{ON}$  to the time period  $T$ . By controlling the duty cycle of the pulse generator, the duty cycle of the input voltage to the LC filter is controlled. The output of the LC filter is a dc voltage with only a small ripple. This output voltage is directly proportional to the duty cycle and is given as

$$V_{out} = DV_{in}$$

Since  $D$  can vary from 0 to 1,  $V_{out}$  can vary from 0 to  $V_{in}$ .

The output of the LC filter is sampled by a voltage divider, which returns a feedback voltage to the comparator. The feedback voltage is compared with a reference voltage  $V_{REF}$  from a zener diode or other source. The output of the comparator then drives the inverting input of the triangular-to-pulse generator.

**Q. 4. (a) Write a short note on function generator.**

**Ans.** A function generator is a signal source that has the capability of producing different types of waveforms as its output signal. The most common output waveforms are sine-waves, triangular-waves, square-waves, and sawtooth-waves. The frequencies of such waveforms may be adjusted from a fraction of a hertz to several hundred kHz.

Actually the function generators are very versatile instruments as they are capable of producing a wide variety of waveforms and frequencies. In fact, each of the waveform they generate are particularly suitable for a different group of applications. The uses of sinusoidal outputs and square-wave outputs have already been described in the earlier article. The triangular-wave and sawtooth-wave outputs of function generators are commonly used for those applications which need a signal that increases (or reduces) at a specific linear rate. They are also used in driving sweep oscillators in oscilloscopes and the X-axis of X-Y recorders.

Many function generators are also capable of generating two different waveforms simultaneously (from different output terminals, of course). This can be a useful feature when two generated signals are required for particular application. For instance, by providing a square wave for linearity measurements in an audio-system, a simultaneous sawtooth output may be used to drive the horizontal deflection amplifier of an oscilloscope, providing a visual display of the measurement result. For another example, a triangular-wave and a sine-wave of equal frequencies can be produced simultaneously. If the zero-crossings of both the waves are made to occur at the same time, a linearly varying waveform is available which can be started at the point of zero phase of a sine-wave.

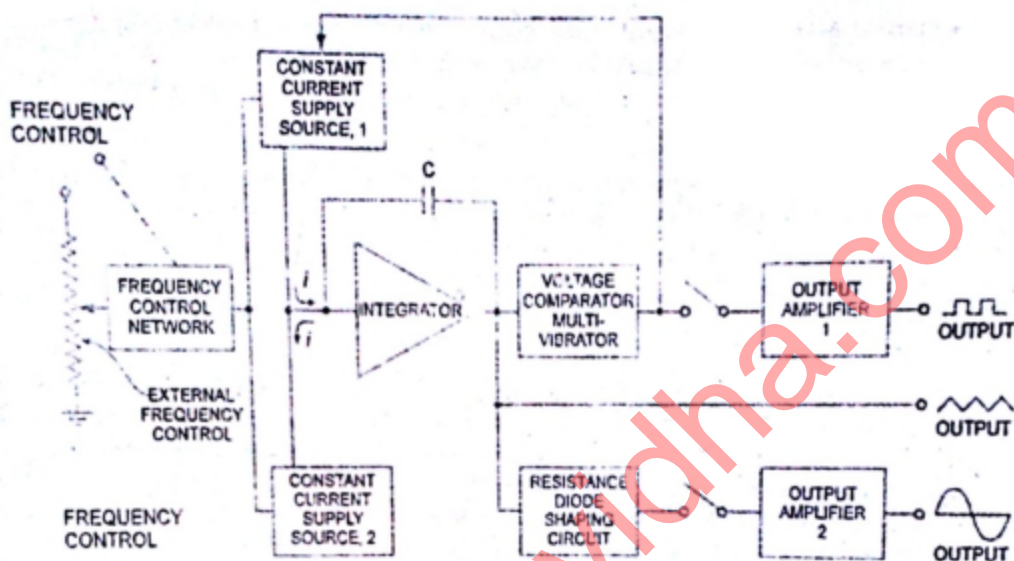
Another important feature of some function generators is their capability of phase-locking to an external signal source. One function generator may be used to phase lock a second function generator, and the two output signals can be displaced in phase by an adjustable amount. In addition, one function generator may be phase locked to a harmonic of the sine-wave of another function generator. By adjustment of the phase and the amplitude of the harmonics, almost any waveform may be produced by the summation of the fundamental frequency generated by one function generator and the harmonic generated by the other function generator. The function generator can also be phase locked to an accurate frequency standard, and all its output wave-forms will have the same frequency, stability, and accuracy as the standard.

The block diagram of a function generator is given in Fig. 9.47. In this instrument the frequency is controlled by varying the magnitude of current that drives the integrator. This instrument provides different types of waveforms (such as sinusoidal, triangular and square waves) as its output signal with a frequency range of 0.01 Hz to 100 kHz.

The frequency controlled voltage regulates two current supply sources. Current supply source 1 supplies constant current to the integrator whose output voltage rises linearly with time according to output signal

voltage equation  $v_{out} = \frac{-1}{C} \int i dt$ . An increase or decrease in the current increases or reduces the slope of the output voltage and thus controls the frequency.





**Block Diagram of Function Generator**

The voltage comparator multi-vibrator changes state at a predetermined maximum level, of the integrator output voltage. This change cuts-off the current supply from supply source 1 and switches to the supply source 2. The current supply source 2 supplies a reverse current to the integrator so that its output drops linearly with time. When the output attains a predetermined level, the voltage comparator again changes state and switches on to the current supply source 1.

The output of the integrator is a triangular-wave whose frequency depends on the current supplied by the constant current supply sources.

The comparator output provides a square-wave of the same frequency as output.

The resistance diode network changes the slope of the triangular-wave as its amplitude changes and produces a sinusoidal wave with less than 1% distortion.

**Q. 4. (b) What are universal gates? Why they are so called?**

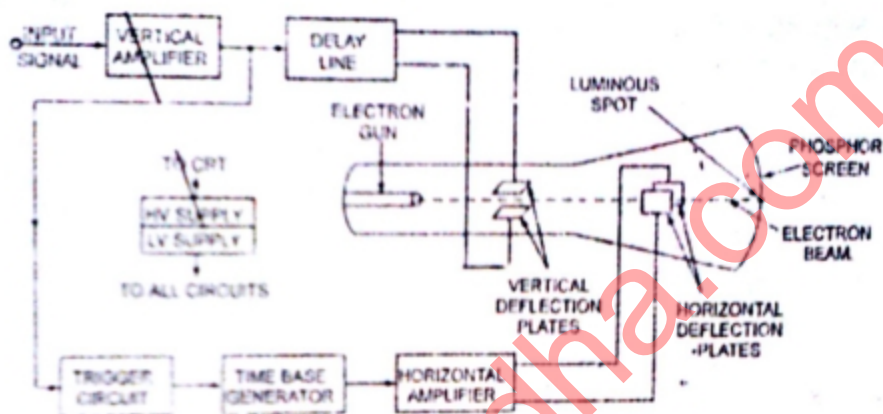
**Ans. Universal Gate :** Nand and NOR gates are said to be universal gates because any digital system can be implemented by using these gates. Any boolean or logic expression can be realized with AND, OR or NOT gates but the Nand and NOR gates are more common from the hardware point of view because they are readily available in IC form. Sequential and combinational circuits can be constructed with these gates because the flip-flop circuit can be constructed from two Nand gate connected back to back.



## Basics of Electronics

**Q. 5. (a) Write short note on CRO.**

**Ans. Block Diagram of a General Purpose CRO :**



**Block Diagram of a General Purpose CRO**

The instrument employs a cathode ray tube (usually abbreviated as CRT), which is the heart of the oscilloscope. It generates the electron beam, accelerates the beam to a high velocity, deflects the beam to create the image, and contains a phosphor screen where the electron beam eventually becomes visible. For accomplishing these tasks various electrical signals and voltages are required, which are provided by the power supply circuit of the oscilloscope. Low voltage supply is required for the heater of the electron gun for generation of electron beam and high voltage, of the order of few thousand volts, is required for cathode ray tube to accelerate the beam. Normal voltage supply, say a few hundred volts, is required for other control circuits of the oscilloscope.

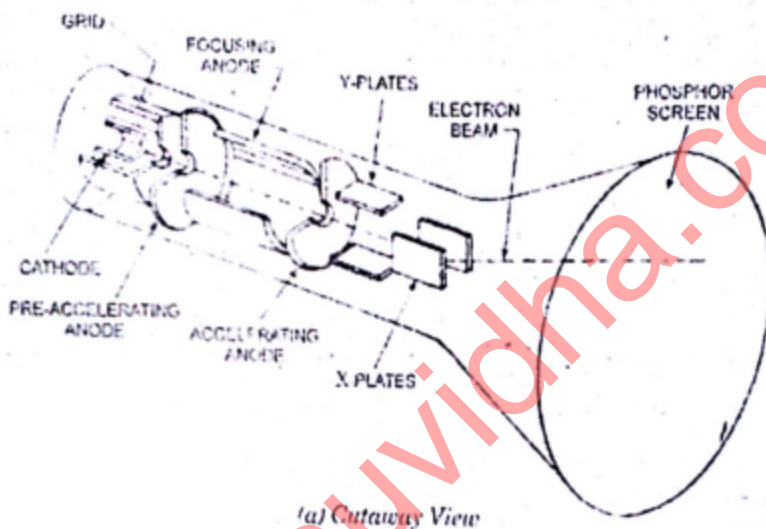
Horizontal and vertical deflection plates are fitted between electron gun and screen to deflect the beam according to input signal. Electron beam strikes the screen and creates a visible spot. This spot is deflected on the screen in horizontal direction (X-axis) with constant time dependent rate. This is accomplished by a time base circuit provided in the oscilloscope. The signal to be viewed is supplied to the vertical deflection plates through the vertical amplifier, which raises the potential of the input signal to a level that will provide usable deflection of the electron beam. Now electron beam deflects in two directions, horizontal on X-axis and vertical on Y-axis. A triggering circuit is provided for synchronizing two types of deflections so that horizontal deflection starts at the same point of the input vertical signal each time it sweeps. A basic block diagram of a general purpose oscilloscope is shown in fig. Cathode ray tube and its various components will be discussed in the following articles.

The cathode ray tube (CRT) is the heart of a cathode ray oscilloscope (CRO). The remaining part of the CRO consists of circuit to operate the CRT.

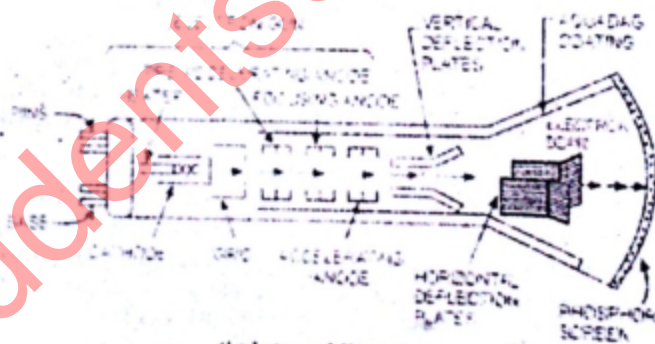
Cathode ray tube essentially consists of an electron gun for producing a stream of electrons, focusing and accelerating anodes for producing a narrow and sharply focused electron beam, horizontal and vertical

deflection plates for controlling the beam path and an evacuated glass envelope with phosphor screen giving bright spot when struck by a high velocity electron beam, and base through which connections are made to different components.

### 1. Electron Gun Assembly :



(a) Cutaway View



(b) Internal Structure

### Cathode Ray Tube

The electron gun assembly consists of an indirectly heated cathode, a control grid surrounding the cathode, a focusing anode and an accelerating anode. The sole function of the electron gun assembly is to provide a focused electron beam which is accelerated towards the phosphor screen. The cathode is a nickel cylinder coated with an oxide coating of barium and strontium and emits plenty of electrons, when heated. The emitting surface of the cathode should be as small as possible, theoretically a point. Rate of emission of electrons or say the intensity of electron beam depends on the magnitude of cathode current, which can be



controlled by the control grid in a manner similar to a conventional vacuum tube. The typical values of current and voltage required by an indirectly heated cathode are 600 mA at 6.8 V (ac or dc). The special low power designs use 140 mA at 1.5 V. The control grid is usually a metal cylinder covered at one end but with a small hole in the cover. This is usually a metal cup of low permeability steel, about 15 mm in diameter and 15 mm long. An aperture of approximate 0.25 mm is drilled in the grid cap for the passage of electrons through it. The grid is kept at negative potential (variable) with respect to cathode and its function is to vary the electron emission and so the brilliancy of the spot on the phosphor screen. The hole in the grid is provided to allow passage for electrons through it and concentrate the beam of electrons along the axis of tube. Electron beam comes out from the control grid through a small hole in it and enters a pre-accelerating anode, which is a hollow cylinder in shape and is at a potential of few hundred volts more positive than the cathode so as to accelerate the electron beam in the electric field. This accelerated beam would be scattered now because of variations in energy and would produce a broad ill-defined spot on the screen. This electron beam is focused on the screen by an electrostatic lens consisting of two more cylindrical anodes called the focusing anode and accelerating anode apart from the pre-accelerating anode. The focusing and accelerating anodes may be open or close at both ends and if covered, holes must be provided in the anode cover for the passage of electrons. The function of these anodes is to concentrate and focus the beam on the screen and also to accelerate the speed of electrons.

The pre-accelerating anode and the accelerating anode are connected to a common positive high voltage of about 1,500 V. The focusing anode is connected to a lower adjustable voltage of 500 V.

## 2. Deflection Plate Assembly :

Electron beam, after leaving the electron gun, passes through the two pairs of deflection plates. One pair of deflection plates is mounted vertically and deflects the beam in horizontal or X-direction and so called the horizontal or X-plates and the other pair is mounted horizontally and deflects the beam in vertical or Y-direction and called the vertical or Y-plates. These plates are to deflect the beam according to the voltage applied across them. For example if a constant pd is applied to the set of Y-plates, the electron beam will be deflected upward if the upper plate is +ve. In case the lower plate is + ve then the beam will be deflected downward. Similarly if a constant pd is applied to the set of X-plates, the electron beam will be deflected to the left or right of the tube axis according to the condition whether the left or right plate is + ve. When a sinusoidal voltage is applied to Y-plates, the beam will be moved up and down according to the variation of plate potential. If the frequency of variation is more than 16 Hz the deflection will be a vertical line in the centre of the screen. In case the sinusoidal voltage is applied to X-plates and frequency of variation is more than 16 Hz the deflection will be a horizontal line. If potentials are applied to both sets of plates simultaneously, the deflection will be an oblique line. The amount of deflection is in proportion to the voltage applied to the pair of plates.

## 3. Screen For CRT :

As we know that some crystal line materials, such as phosphor, have property of emitting light when exposed to radiation. This is called the fluorescence characteristic of the materials. These fluorescent materials continue to emit light even after radiation exposure is cut off. This is called the phosphorescence characteristic of the materials. The length of time during which phosphorescence occurs is called the persistence of the phosphor.

Persistence is usually measured in terms of the time required for the CRT image to decay to a certain percentage (usually 10 per cent) of the original light output. It is expressed as short, medium and long. Persistence is called short if it lasts for microseconds, medium if it lasts for milliseconds and long in case it lasts for

seconds to several minutes. Short persistence is required, for externally high speed phenomena, to avoid smearing and interference caused when one image persists and overlaps with the next one. Medium persistence traces are mostly used for general purpose applications. Long persistence traces are used for transients as they keep the fast transient on the screen for observation after the transient has disappeared.

The end wall of the CRT, called the screen, is coated with phosphor. When electron beam strikes the CRT screen, a spot of light is produced on the screen. The phosphor absorbs the kinetic energy of the bombarding electrons and emits energy at a lower frequency in a visual spectrum. Among the fluorescent materials used are zinc orthosilicate giving a green trace very suitable for visual observations; calcium tungstate giving blue and ultraviolet radiations very suitable for photography and zinc sulphide with other materials giving a white light suitable for TV. Zinc phosphate gives a pronounced after glow and is useful when studying transient phenomena because the trace persists for short while after the transient has disappeared.

The intensity of light emitted from the screen of CRT, known as luminance, depends upon several factors such as (i) on the number of bombarding electrons striking the screen per second (ii) on the energy with which the bombarding electrons strike the screen which is determined by the accelerating potential (more the accelerating potential more the luminance) (iii) on the time the beam strikes a given area of the phosphor i.e. sweep speed and (iv) on the physical characteristics of the phosphor itself. Almost all manufacturers provide their customers with a choice of phosphor materials. Table 9.1 summarizes the characteristics of the some of the commonly used phosphors.

Phosphor Type	Fluorescence	Phosphorescence	Relative Luminance*	Decay To 0.1% (ms)	Remarks
P <sub>1</sub>	Yellow-green	Yellow-green	50%	95	P <sub>31</sub> in most applications.
P <sub>2</sub>	Blue-green	Yellow-green	55%	120	Good compromise for high and low-speed applications.
P <sub>4</sub>	White	White	50%	20	Television displays.
P <sub>7</sub>	Blue	Yellow-green	35%	1,500	Long decay; Observation of low-speed phenomena.
P <sub>11</sub>	Purple-blue	Purple-blue	15%	20	Photographic applications.
P <sub>31</sub>	Yellow-green	Yellow-green	100%	32	General purpose-brightest available phosphor.



#### 4. Glass Body and Base :

The whole assembly is protected in a conical highly evacuated glass housing through suitable supports. The inner walls of CRT between neck and screen are usually coated with a conducting material known as aquadag and this coating is electrically connected to the accelerating anode. The coating is provided in order to accelerate the electron beam after passing between the deflecting plates and to collect the electrons produced by secondary emission when electron beam strikes the screen. Thus the coating prevents the formation of -ve charge on the screen and state of equilibrium of screen is maintained.

In some tubes, particularly CRTs with magnetic focusing (such as TV picture tubes), the accelerating anode is dispensed with entirely and the conductive coating is used as the final accelerating anode.

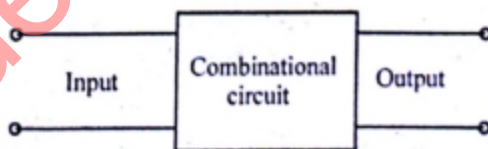
In small CRTs, connections to various electrodes are brought out through pins in the base of the tube, as shown in Fig. (6). Larger type and medium sized high performance tubes operate at very high voltages and these leads are brought out through the sides of the glass envelope.

Horizontal and vertical marks are marked on the screen of the CRT to provide user a correct measurement. These marks, usually in rectangular form, are called graticule.

**Size :** Size refers to the screen diameter. CRTs for oscilloscopes are available in sizes 1, 2, 3, 5 and 7 inches. 3 inch is most common for portable instruments. For example, a CRT having a number 5G<sub>P1</sub> is 5 inch tube with a medium persistence green trace. The first number indicates that it is a 5 inch tube and P<sub>1</sub> indicates a medium persistence green trace. Both round and rectangular CRTs are found in oscilloscopes. The vertical viewing size is 8 cm and horizontal is 10 cm.

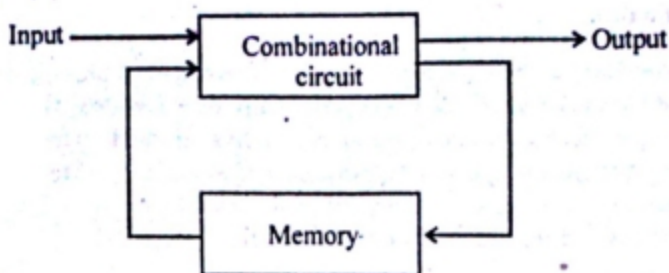
**Q. 5. (b) Give difference between combinational circuits and sequential circuits.**

**Ans. Combinational Circuits :** Are those circuits in which output at any instant of time depend upon the present input at that instant of time.



e.g., are adder, subtractor, multiplexer, demultiplexer etc.

**Sequential circuits :** Are those circuits in which the output at any instant of time not only depend upon the present input but also on the past state of the circuit. It consist of a combinational circuit and a memory element.



e.g., are flip-flop, counters, registers.

**Q. 6. (a) Explain Dot-matrix display with example.**

**Ans.  $5 \times 7$  Dot matrix display :**

- This display is as shown in fig.

- Here 5 columns and 7 rows of LED's are arranged as shown in fig. (b). The writing patterns of dot-matrix display is of two types :

1. Common anode and common cathode.
2. X-Y array connection.

**(a) Basic format of dot matrix display**

- Due to a large number of LEDs used, it is not practical to use a separate driver for each LED. Therefore multiplexing technique is used to lit the LEDs in a sequential manner. Techniques like dynamic display system can be used to improve the brightness of the display.
- In dynamic display systems all the required LEDs are not turned on simultaneously. But they are turned on sequential at a fast speed.
- Due to the "persistence of vision" the displayed character appears to be stable. Due sequentially illuminating the LEDs, current drawn from the dc supply reduces and brightness can be improved.

**Applications of LED displays :**

Following are some of the important applications of LED displays :

1. 1-segment displays are used to display token numbers in banks.
2. To display temperature, humidity outside the observatory.
3. Digital wall clocks.
4. Rolling displays for advertising, at public places such as bus stations, railways stations etc.

**Q. 6. (b) Write advantages of LED in electronics display.**

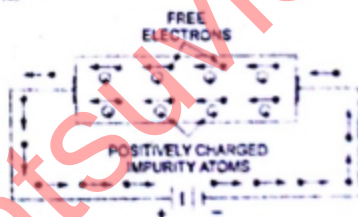
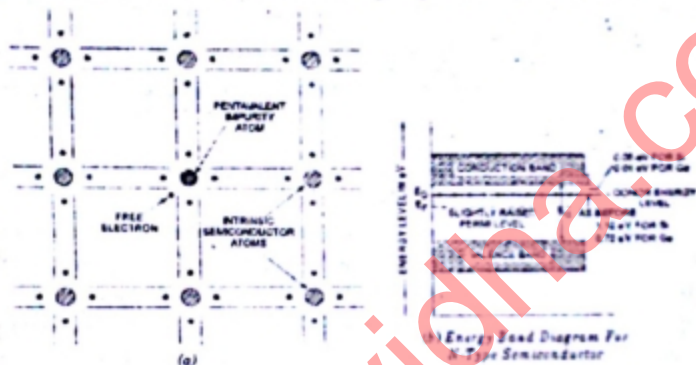
**Ans. Advantage of LED :**

1. They are miniature in size and can be stacked together to form numeric and alphanumeric displays

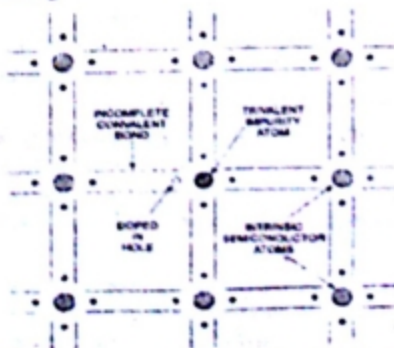
such an impurity is also called the N-type impurity.

Since current flowing through the crystal is primarily due to free electrons (negatively charged particles), such a conductor is called the N-type semiconductor.

In an N-type semiconductor material, the number of holes is small in comparison to parent intrinsic semiconductor because the larger number of electrons present increase the rate of recombination of electrons with the holes. Thus, the number of free electrons becomes far greater than the number of holes. That is why it is said that an N-type semiconductor has electrons as majority carriers, and the holes as minority carriers.



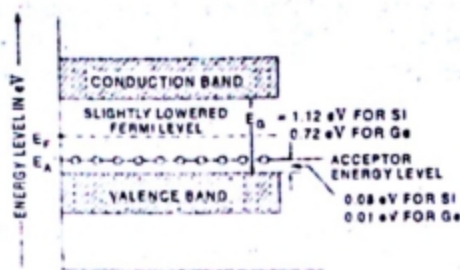
**2. P-type extrinsic semiconductors :** When a small amount of trivalent impurity, such as boron, gallium, indium or aluminium, is added to a pure semiconductor crystal during the crystal growth, the resulting crystal is called the P-type extrinsic semiconductor, where P stands for positive. The effect of adding one of these impurities in Si or Ge is illustrated in Fig.



When a trivalent impurity is added to silicon (or germanium), these impurity atoms form covalent bonds with four surrounding intrinsic semiconductor (silicon or germanium) atoms but one bond is left incomplete and gives rise to a hole, as illustrated in Fig. Such impurities make available positive carriers because they



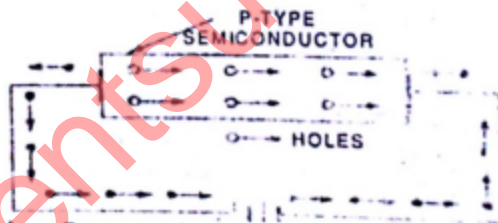
create holes which can accept electrons. These impurities are consequently known as acceptor or P-type impurities. The amount of impurity which is required to be added to have an appreciable effect on the conductivity is very small.



**Energy Band Diagram For P-Type Semiconductor**

The effect of this doping process on the relative conductivity can best be explained by energy band diagram shown in Fig. When acceptor or P-type impurities are added to the intrinsic semiconductor, they produce an allowable discrete energy level which is just above the valence band, as shown in Fig. Since a very small amount of energy ( $0.08 \text{ eV}$  in case of silicon and  $0.01 \text{ eV}$  in case of germanium) is required for an electron to leave the valence band and occupy the acceptor energy level, holes are created in the valence band by these electrons. The holes so created constitute the larger number of carriers in the semiconductor material.

Since holes can be said to have a positive charge, acceptor-doped semiconductor material is referred to as P-type semiconductor. The resulting P-type material is electrically neutral for the same reasons as for the N-type material.



The worthnoting points about P-type semiconductors are:

- In P-type semiconductors, the majority carriers are holes while the minority carriers are electrons.
- P-type semiconductor remains electrically neutral as the number of mobile holes under all conditions remains equal to the number of acceptors.
- When an electric field is applied across a P-type semiconductor, as shown in Fig. 1.21, the current conduction is primarily due to holes. Here the holes are shifted from one covalent bond to another and constitute the hole current. The hole current flows more slowly than electron current in N-type semiconductor.
- In P-type conductivity, the valence electrons move from one covalent bond to another covalent bond unlike N-type where conduction is by electrons.

Since the current flowing through the crystal is primarily due to holes, which have positive charge, such a semiconductor is called the P-type semiconductor and the conductivity is called the P-type conductivity. The impurity making P-type semiconductor is also called the P-type impurity.