Chapter # 18

Electronics

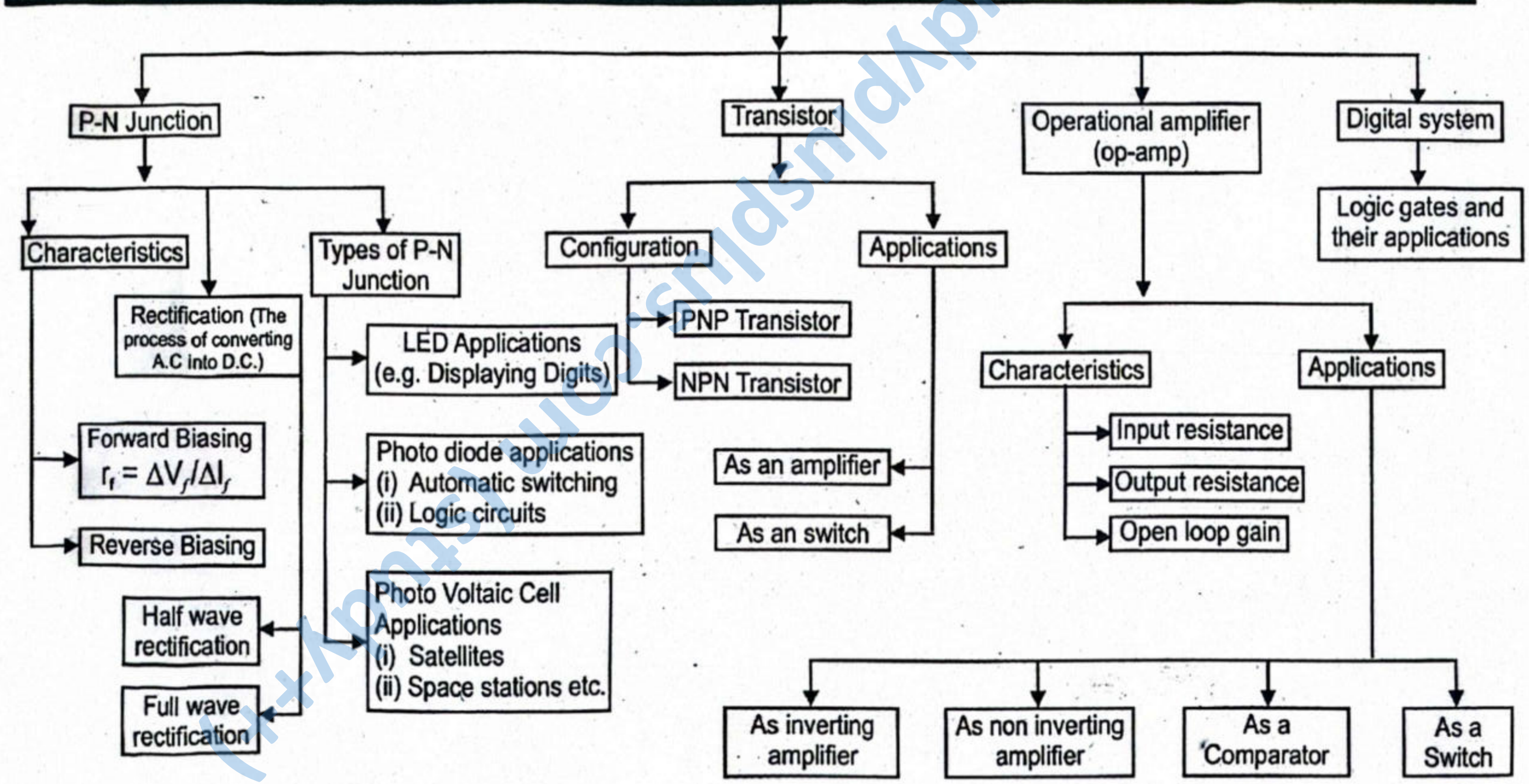
Learning Objectives

- Describe forward and reserve biasing of a p-n junction.
- Understanding half and full wave rectification.
- Know the uses of light emitting diode, photo diode and photo voltaic cell.
- Describe the operations of transistor.
- Know current equation and solve related problems.
- Understand the use of transistors as an amplifier and a switch.
- Understand operational amplifier and its characteristics.
- Know the applications of an operational amplifier as inverting and non-inverting amplifier using virtual ground concept.
- Understand the use of an operational amplifier as a comparator e.g., night switch.
- Understand the function of each of the following logic gates: AND, NOT, OR and NAND gates and represent their functions by means of truth tables (limited to a maximum of two inputs).
- Describe how to combine different gates to form XOR and XNOR gates.
- Understand combinations of logic gates to perform control functions.

CONCEPT MAP

ELECTRONICS

The branch of Physics which deals with the development of electron emitting devices, their utilization and controlling electron flow in electrical circuits



Electronics is branch of science and technology that makes use of controlled motion of electrons through different media and vacuum.

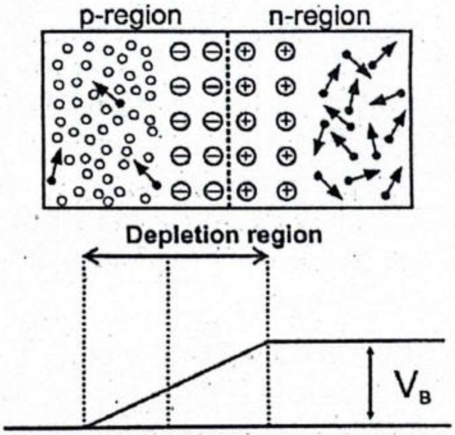
Modern electronics is principally concerned with semi-conductors devices.

Silicon is one of the most commonly used semi-conductor and the basic material from which highly sophisticated integrated circuits known as chips are made. The use of chips in analogue as well as in digital electronics is described in the form of black boxes.

Q.1 What is P-n Junction? Discuss its Characteristics in Detail?

Ans.

P-N JUNCTION



If the crystal of germanium or silicon is grown in such a way that it's one half is doped with trivalent impurity and the other half is doped with pentavalent impurity, p-n junction is formed.

In n-type material, the majority charge carriers are electrons while in p-type material, the majority charge carriers are holes.

Depletion Region:

The electrons diffuse in p-type material just after the formation of p-n junction. So a charge-less region is formed around the junction, which contains no charge carriers (i.e mobile charges). This region is known as depletion region.

In figure, dots represent the electrons and circles represent the holes. Where as the circles with +ve and –ve signs shows the positive and negative ions which constitute the depletion region.

For Your Information

For an ideal diode, its resistance in forward baised is zero and becomes infinite in case of reverse baised.

Potential Barrier:

Due to charge on the ions a potential difference develops across the depletion region, which stops the further diffusion of electrons and holes. This potential difference is called potential barrier.

The value of potential barrier for Ge is 0.3 volts while for Si is 0.7 volts.

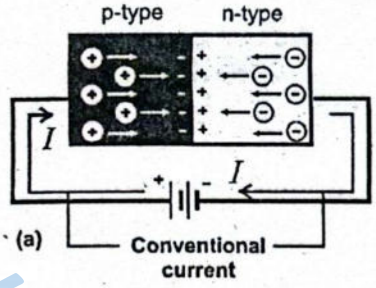
Biasing of pn-Junction:

If battery of some emf is connected across a P-N junction, then junction is said to be biased junction.

The biasing of a junction can be done into two ways:

(i) Forward biased p-n junction

(ii) Reverse biased p-n junction

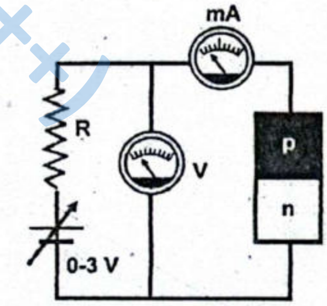


(1) Forward Biased p-n Junction:

When an external potential is applied across the pn junction in such a way that positive terminal of the battery is connected with p-type and its negative terminal is connected to the n-type, then p-n junction is said to be forward biased.

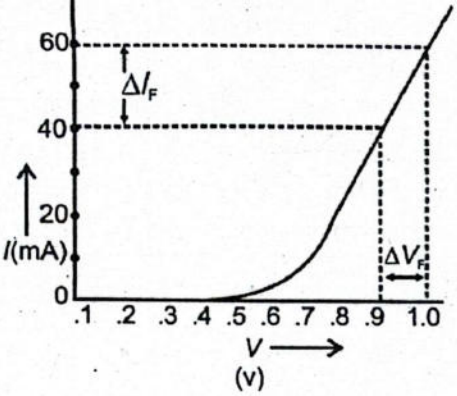
So the external potential difference supplies the energy to free the electrons in n-type region and to holes in p-type region.

When the energy is sufficient to overcome the potential barrier. The current may be of the order of few milli-amperes begins to flow across pn-junction. So the p-n junction is said to forward biased.



(b) There is an appreciable current through the diode when the diode is forward based.

We can draw the graph between current and voltage for forward biasing of Si, as shown in figure.



Forward biased Resistance / Dynamic resistance:

The reciprocal of the slope represents the forward biased resistance. It is the resistance offered by the p-n junction, when it is conducting.

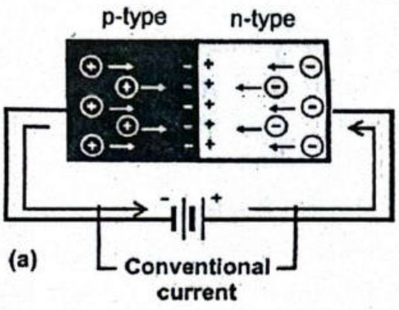
$$r_f = \frac{1}{\text{slope}}$$

$$r_f = \frac{\Delta V_f}{\Delta I_f}$$

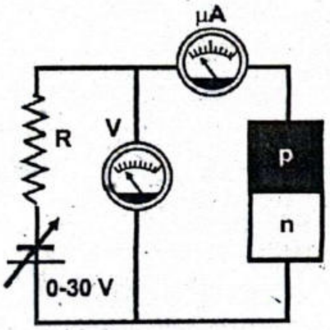
The value of forward resistance is only a few ohms.

(2) Reverse Biased p-n Junction:

When an external potential is applied across the p-n junction in such a way that positive terminal of the battery is connected with n-type while negative terminal is connected with p-type, then the p-n junction is said to be reversed biased.



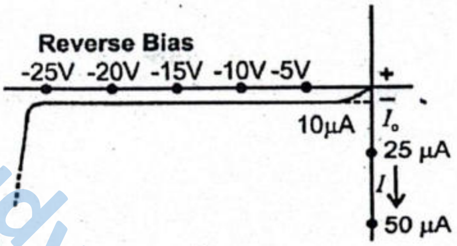
In this case, no current will flow due to majority charge. However, a very small current in micro-amperes flows across the junction due to flow of minority charge carriers, which is called reverse current or leakage current. The saturation value I_o reaches quickly with the increase of reverse voltage. As the reverse voltage is further increased, reverse current remains almost constant. At this stage, the resistance is of the order of several mega ohms.



How pn-junction breaks down:

As the reverse voltage is increased, the K.E. of minority charge carriers also increases till it is sufficient to break a covalent bond. As the covalent bond breaks more electron hole pairs are produced. So, the minority carriers begin to increase rapidly.

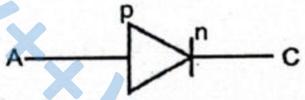
This increases the reverse current. The value of reverse voltage at which junction breaks down is called break down voltage. After the break down the reverse current increases sharply which may damage the diode.



Note:

P-N junction is also known a semi-conductor diode. It can be symbolically represented as,

The arrow head represent the p-region while vertical line represents the n-region. The current flows in the direction of arrow when a diode is forward biased.



Q.2 What is rectification? Discuss the Working of Different Rectifier Circuits?

LHR – 2017, D.G.KHAN – 2017

Ans.

RECTIFICATION

The conversion of alternating current into direct current is called rectification. The circuit used for this purpose, is called rectifier.

Commonly, we use diodes for this purpose. Rectifier circuits are of two kinds:

(1) Half wave rectifier
(2) Full wave rectifier.

For Your Information

The frequency of pulsating d.c from a full wave rectifier circuit is 100Hz if the frequency of input a.c signal is 50Hz.

(1) HALF-WAVE RECTIFICATION:

The circuit which converts half of the alternating current cycle into direct current is called as half wave rectifier circuit.

A half wave rectifier circuit is shown in figure. An alternating voltage is T is applied to a diode D connected with a resistance R in series.

During the Positive Half Cycle

During the positive half cycle ($0 \longrightarrow T/2$), of the input a.c signal, the diode is forward biased. So it offers low resistance and current flows through.

During the Negative Half Cycle

During the negative half cycle($T/2 \longrightarrow T$), of the input a.c signal, the diode is reverse biased. So it offers very high resistance and a current flow through R is almost zero.

The same process continues for next half cycles and so on for an a. c input. However the current flows in one direction, so it is direct current, which has pulses. The final output is called pulsating d. c.

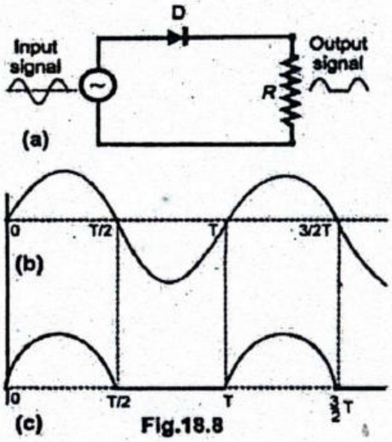


Fig.18.8

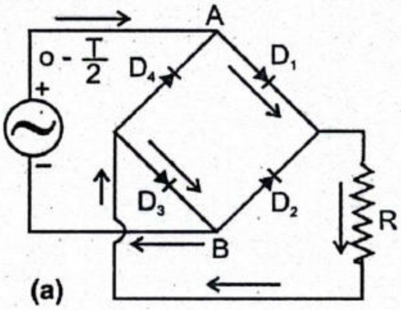
(2) FULL-WAVE RECTIFICATION:

The circuit used for obtaining the d.c signal for both the half cycles of input a.c is called full-wave rectifier circuit.

A full-wave rectifier circuit consists of four diodes in form of a bridge. That is why it is also called bridge wave rectifier circuit.

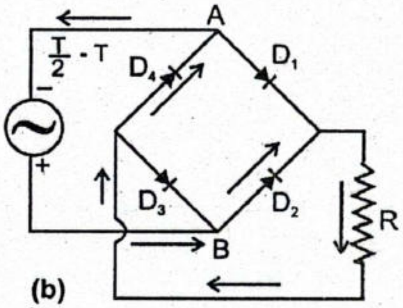
During the Positive Half Cycle

During the positive half cycle ($0 \longrightarrow T/2$) of a.c input. The terminal A of the bridge is positive with respect to B. So the diodes D_1 and D_3 become forward biased and conduct. The direction of current is shown below.

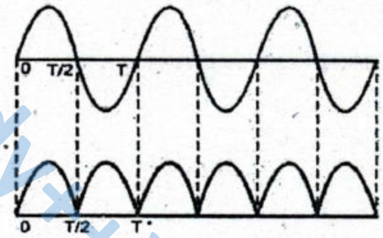


During the Negative Half Cycle

During the negative half cycle ($T/2 \longrightarrow T$) of a.c input. The terminal A of the bridge is negative with respect to B. So the diodes D_2 and D_4 become forward biased and conduct. The direction of current through R is shown in figure.



It is clear from figures a and b that the current through R flows in the same direction for both the half cycles of input a.c signal. However the output is pulsating d.c. The pulses can be removed by use of filter circuit.



Note:

Filter circuit is made from the suitable combination of capacitors and inductors.

Q.3 What are the Different Types of Especially Designed p-n Junction Diodes?

Ans.

SPECIALLY DESIGNED P-N JUNCTIONS

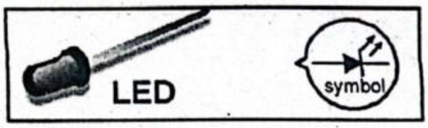
P-n junction may be developed for some special purposes in addition to rectification purpose, there most commonly used such diodes are:

(1) Light emitting diode

(2) Photo diode

(3) Photo voltaic cell

1- LIGHT EMITTING DIODE: (LED)



It is a forward biased pn-junction which emits (visible) light when energized. LED'S emits no light when reversed biased. In fact if you operate LED in reverse it will quickly damage.

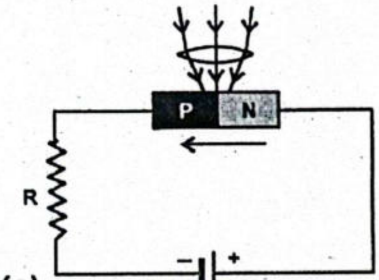
Special type of semi-conductors such as gallium arsenide and gallium arsenide phosphide are used for this purpose. In which potential barrier is such that when an electron combines with a hole during forward bias conduction, a photon of visible light is emitted. *The colour of light depends upon the nature of the semiconductor.*

A seven segment display

Uses of LED:

- i) These diodes are used as small light sources. e.g. indicators.
- ii) A specially formed array of seven LED's is used for displaying the digits etc. in electronical appliances.
- iii) LED's are used in calculators and digital watches.
- iv) LED's are used in burglar alarm system.

2- PHOTO DIODE:

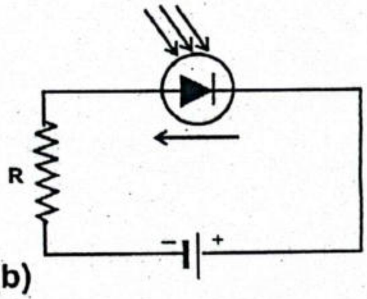


(a)

The diode which convert light energy into electrical energy is called photo diode.

Photo diode is used for detection of light, it is operated in reverse biased condition. Its symbol is shown in figure (b). When no light falls on the junction, the reverse current is almost negligible. When its pn-junction is exposed to light, the reverse current increases with the intensity of light.

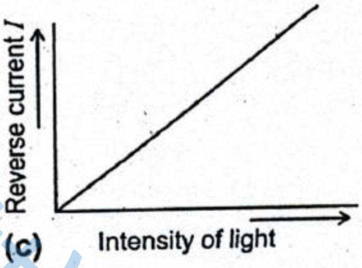
A photo-diode can switch ON and OFF in nanoseconds. So it is one of the fastest light detecting device. Response time of a photo diode is typically 250 ns,



(b)

Uses:-

- (i) Detection-both visible and invisible lights.
- (ii) Automatic switching.
- (iii) Logic circuits.
- (iv) Optical communication equipment etc.
- (v) Security systems
- (vi) T.V remote (control system)
- (vii) Burglar alarm system



(c)

PHOTOVOLTAIC CELL:

It is a transducer which converts light energy into electrical energy. It is the reverse process of LED.

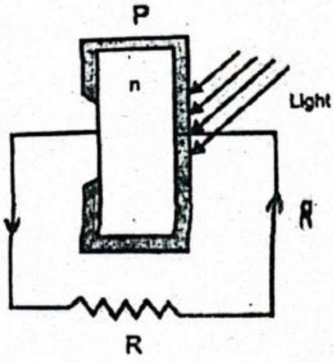
Working of Photovoltaic Cell:

When photons of light fall on / near the junction, the electron – hole pairs are produced. The electric field at the junction pushes the holes to the p-region and electrons to n-region. This displacement of free charges produces a current when load R is connected across the terminals of device. The current is directly proportional to intensity of light.

A silicon photovoltaic cell produces a small voltage of V and current is of the order of few mA.

In order to obtain the greater power, thousands of such cells are used in series.

A Si solar cell with surface area 4000 $(mm)^2$ can deliver a maximum power of 0.6 W at about 0.5V in full sun.



Uses:

i) These are commonly used in satellites to converts the solar energy into electrical power needed to operate the electronic devices on board.

ii) These are also being used for driving bikes and cars.

Note:

In **photo-diode**, we use a source of electric current, where as in **photovoltaic cell**, there is no need of electric source.

MCQ's From Past Board Papers

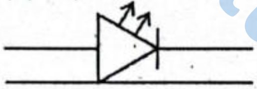
1. **In forward biasing, the value of resistance is** **(Grw 2016, Sgd 2015 G – I)**
(A) Large (B) Very large (C) Small (D) Very small

2. **For rectification we use** **(Grw 2017, D. G. Khan 2015 G – II)**
(A) Transformer (B) Diode (C) Choke (D) Generator

3. **Reverse current flows due to** **(Sgd 2017 G II) (Sgd 2017 G II, D. G. Khan 2015 G – I)**
(A) Majority charge carriers (B) Minority charge carriers (C) Electrons (D) Holes

4. **The photodiodes are used for:** **(Mir-II-14, 15)**
(A) Security system (B) Counting system (C) Automatic door system (D) All of above

5. **The potential difference develops in case of Ge is** **(Fsd 14, 15, Mirpur 2015, Swl 2016, Mirpur 2013, Bwp 2011, 14)**
(A) 0.9 V (B) 0.7 V (C) 0.5V (D) 0.3V



6. **is the electrical symbols for:** **(Lhr –12 G II, 2016)**
(A) Diode (B) Photodiode (C) photocell (D) LED

7. **Conversion of A.C. into D.C. is called:** **(Fsd 2018, Lhr 2017 G II, Grw 2013 G I, 2015, Mirpur 2009, Rwp 2011)**
(A) Modulation (B) Amplification (C) Oscillation (D) Rectification

8. **A potential barrier of 0.7 volt exist across p–n junction made from:** **(Grw 2013 G I)**
(A) Silicon (B) Germanium (C) Indium (D) Gallium

9. **When a P–N junction is reverse biased, the depletion region is:** **(Lhr 2013, 2016)**
(A) Widened (B) Narrowed (C) Normal (D) No change

10. **Universal gate is the gate which can perform the function of:** **(Grw 2013 G II)**
(A) buffer gate (B) any logic gate (C) any basic gate (D) any exclusive gate

11. **The number of terminal in a semiconductor diode are:** **(Rwp 2017)**
(A) 2 (B) 3 (C) 4 (D) 5

12. **A light emitting diode (LED) emits light only when:** **(Lhr 2014 G I)**
(A) Reverse biased (B) Forward biased (C) Unbiased (D) None of these

13. **Which factor does not affect the conductivity of PN–junction diode:** **(Lhr 2014 G II)**
(A) Doping (B) Temperature (C) Voltage (D) Pressure

14. **Light emitting diodes (LED) are made from semi-conductors:** **(Lhr 2015 G – II)**
(A) Silicon (B) Germanium (C) Carbon (D) Gallium arsenide

15. **Pulsating out put of full wave rectifier can be made smooth by using circuit called:** **(Lhr 2017, Rwp 2014)**
(A) Filter (B) Amplifier (C) Resistor (D) Transistor

16. **Specially designed p.n. junction used as indicator in electronic circuits is:** **(Mirpur 2009, 2013)**
(A) LED (B) Solar cell (C) Photo voltaic cell (D) Photodiode

17. **A PN-junction can not be used as:** **(Lhr 2016 Group II)**
(A) Rectifier (B) Amplifier (C) Detector (D) LED

18. **A diode characteristic curve is plotted between** **(Lhr 2016 Group I)**
(A) Current and time (B) Voltage and time
(C) Voltage and current (D) Forward voltage and reverse voltage

19. **The *ratio of* potential barriers of Ge to Si at room temperature is :** **(Lhr 2016 Group II)**
(A) 7 : 3 (B) 1 : 3 (C) 2 : 5 (D) 3 : 7

20. **In full wave rectification no of diodes required are equal to** **(Azad Kashmir 2017, Lhr 2010, 2016 G II, Fsd 2011, 2015, Sgd 2016 G I)**
(A) 3 (B) 4 (C) 5 (D) 1

21. ***The colour of* light emitted by a LED.depends on** **(Swl 2016)**
(A) its forward biasing (B) the type of semi conductor material used
(C) the amount of forward current (D) its reverse biasing

22. **Depletion region carries** **(D.G.Khan 2016 Group II)**
(A) –Ve charge (B) +Ve charge (C) Ions (D) No charge

23. **In photovoltaic cell, current is directly proportional to:** **(Grw 2015)**
(A) wavelength of light (B) intensity of light (C) frequency of light (D) energy

24. **Which one can be used as temperature sensor in electric circuit?** **(Sgd 2015 Group II)**
(A) Capacitor (B) Diode (C) LDR (D) Thermistor

25. **The barrier potential of Silicon Diode at room temperature is:** **(Sgd 2017 G I, Bwp 2017 G II, Rwp 2014, D.G.Khan 15 G II Lhr 2015 Group I, Bwp 2015, D.G.Khan 2015 G II, D.G.Khan 2016 G I, Mtn 2015 G I, Sgd, D.G.Khan 2018)**
(A) 0.3 V (B) 0.7 V (C) 3 V (D) 7 V

26. **A photodiode can turn its current ON and OFF in:** **(Mtn 2017 G I)**
(A) Micro seconds (B) Mega second (C) Nano seconds (D) Milli seconds

27. **Which diode works at reverse biasing?** **(D.G.Khan 2017 G II)**
(A) LED (B) Photovoltaic cell (C) Photodiode (D) Silicon diode

28. **Photodiode is used for detection of** **(Mtn 2018, Grw, Rwp 2017)**
(A) Heat (B) Magnet (C) Current (D) Light

29. **Conversion of only one half of A.C. into D.C. is called** **(Grw 2018)**
(A) half wave amplification (B) wave amplification (C) half wave electrification (D) half wave rectification

30. **The reverse current through a semiconductor diode is due to:** **(Sgd GI 2018)**
(A) Minority carriers (B) Majority carriers (C) Holes (D) Electrons

ANSWER KEY'S

1.	C	2.	B	3.	B	4.	D	5.	D	6.	D	7.	D	8.	A	9.	A	10.	C
11.	A	12.	B	13.	D	14.	D	15.	A	16.	A	17.	B	18.	C	19.	D	20.	B
21.	B	22.	C	23.	B	24.	D	25.	B	26.	C	27.	C	28.	D	29.	C	30.	A

Q.4 What is a Transistor? Discuss its Construction and Different Types?

Ans.

TRANSISTOR

It is simply a sandwich of one type of semi conductor material between two layers of the other type.

OR

A transistor consists of two back to back pn-junctions made in a signal piece of semi conductor crystal.

Combinations of Transistors:

There are two combinations of transistors:

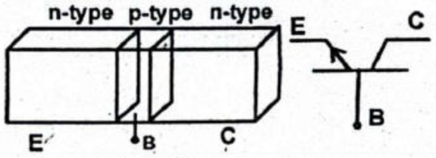
(1) p-n-p transistor
(2) n-p-n transistor

(1) p-n-p transistor:

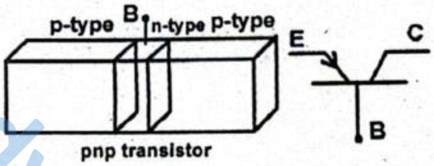
When n-type substance (Si or Ge) is sandwiched between two p-type substances, then device formed is called p-n-p transistor, Its electronic symbolic shown in figure with symbolic representation.

(2) n-p-n transistor:

When a p-type substance is sandwiched between two n-type substances, then device formed is called n-p-n transistor. Its electronic symbol is shown in figure.



npn transistor



pnp transistor

Parts (or-regions) of Transistor:

The main parts of transistor are:

(i) Emitter (ii) Base (iii) Collector

(i) Emitter:

- The emitter has greater concentration of impurity atoms as compared to collector, so it has more charge carriers than collector.
- *The* arrow on emitter terminal *shows the direction of* conventional current.
- The width of the emitter is slightly smaller in size as compared to collector.

Four your Information

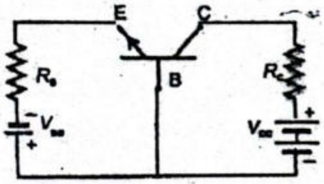
A transistor is contraction of two words, transfer and resistor. It is so became transistor is basically a resistor that amplifies electrical signals as they are transformed from its input terminals to output terminals

OR

The name transistor is derived from tans-resistor, which means that it can transfers its internal resistance from low resistance EB-circuit to much higher resistance in CB-circuit.

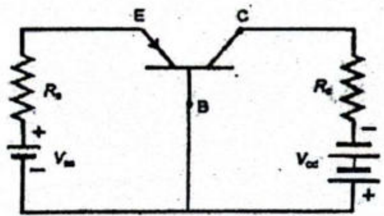
(ii) Base:

- The central region is known as base. Usually, the base is very thin of the order of 10^{-6}m.
- It has least concentration of impurity as compared to emitter and collector.
- It has key role in transistor. It controls the flow of electron from emitter to collector.



(iii) Collector:

- The collector's function is to collect majority charge carriers through base.
- The collector has less concentration of impurity as compared to emitter.
- The collector is comparatively larger in size than the emitter because it has to dissipate much greater power.



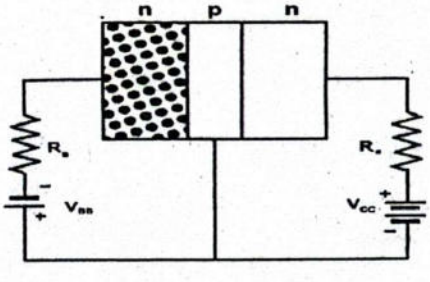
Operation or Working of a Transistor:

Emitter-base junction is forward biased by V_{BB} while base-collector junction is reversed biased by V_{cc}. For normal operation V_{cc} is greater than V_{BB}. The biasing of both the transistors is shown below;

Q.5 Write Down a Detail note on Operation of Transistor?

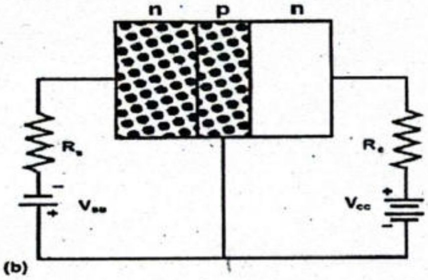
Ans.

CURRENT FLOW IN N-P-N TRANSISTOR



(a)

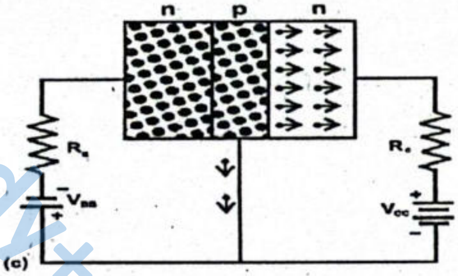
Figure (a) shows the biasing of an n-p-n transistor. Electrons in the emitter have not yet entered to base region. After the application of the biasing voltage, emitter base junction is forward biased. So emitter injects the number of electrons in the base region. fig. (b)



(b)

The electrons in the base can follow two paths. They can either flow out of base to positive terminal of V_{BB} or they can be attracted towards the collector due to V_{cc}. Since the base is extremely thin, very few electrons manage to recombine with holes and escape out of the base.

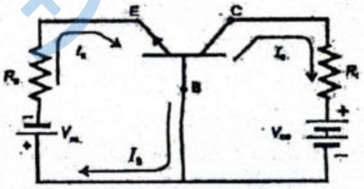
So only a few electrons recombine with holes and almost all of free electrons injected from emitter into base are attracted into collector by large positive V_{cc}. Fig. (c)



(c)

The an electronic current I_E flow from emitter to base, a very small part of it I_B flows out of the base and the rest of current I_c flows out of the collector. From figure it is found that

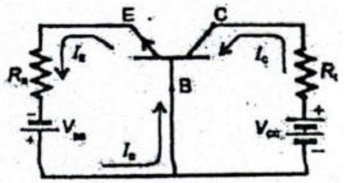
$$\boxed{I_E = I_C + I_B} \quad ......(1)$$



Current Gain:

The ratio of collector current I_c to base current I_B is a constant, known as current gain β.

So $$\boxed{\beta = \frac{I_C}{I_B}}$$



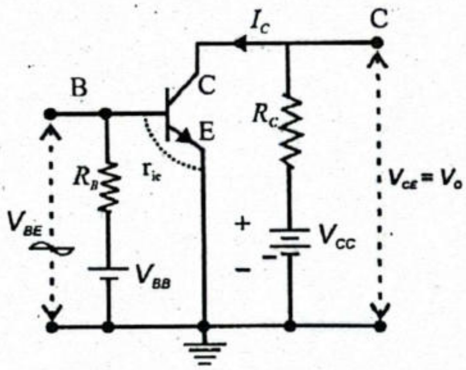
Its value ranges from 30 to 500.

Equation (1) and (2) are fundamental equations for all transistors.

Q.6 How can we Use a Transistor as an Amplifier? *LHR 2016, FSD 2017, Swl 16, Rwp 17, FEDERAL 2017*

Ans.

TRANSISTOR AS AN AMPLIFIER



A device which can amplify the input signals is called amplifier. In most electronic circuits, we use the transistor as an amplifier. It is the building block of the very complex electronic circuit. So transistor amplifier is very important to study.

A simple amplifier is shown in figure, with base-emitter as input terminals and base-collector as output terminal. V_{BB} forward biases the base-emitter junction while the V_{cc} reverse biases the base-collector junction and V_{cc} is very greater than V_{BB}. V_{BE} and V_{CE} are the input and output voltages respectively. The base current is

$$I_B = \frac{V_{BE}}{r_{ie}}$$

where r_{ie} is base emitter resistance of the transistor. The transistor amplifies the base current by β times. So

$$I_c = \beta I_B$$

$$I_c = \beta \frac{V_{BE}}{r_{ie}}$$

The output voltage $V_o = V_{CE}$ is determined by Kirchhoff's voltage law (KVL). So,

$$V_{cc} = I_c R_c + V_{CE}$$

Or $$V_{cE} = V_{cc} - I_c R_c$$

Or $$V_o = V_{cc} - I_c R_c$$

Or $$V_o = V_{cc} - \beta \frac{V_{BE}}{r_{ie}} R_c \text{ ....(i)}$$

When a small signal voltage ΔV_{in} is applied at the input terminal, then the following changes occur;

(i) V_{BE} changes to $V_{BE} + \Delta V_{in}$
(ii) I_B changes to $I_B + \Delta I_B$
(iii) I_C changes to $I_C + \Delta I_C$
(iv) V_o changes by $V_o + \Delta V_o$

For Your Information

The mobility of electrons is two - three times the mobility of holes. Therefore npn devices are fast and hence preferred.

Putting the changed values in equation (i), we get

$$V_o + \Delta V_o = V_{CC} - \beta \frac{(V_{BE} + \Delta V_{in})}{r_{ie}} R_c \text{ .... (ii)}$$

Subtracting equation (i) from (ii)

$$V_o + \Delta V_o - V_o = V_{CC} - \beta \frac{V_{BE} + \Delta V_{in}}{r_{ie}} R_C - V_{CC} + \beta \frac{V_{BE}}{r_{ie}} R_C$$

$$V_o + \Delta V_o - V_o = V_{CC} - \beta \frac{V_{BE}}{r_{ie}} R_C - \beta \frac{\Delta V_{in}}{r_{ie}} R_C - V_{CC} + \beta \frac{V_{BE}}{r_{ie}} R_C$$

or
$$\Delta V_o = -\beta \frac{\Delta V_{in}}{r_{ie}} R_C$$

$$\frac{\Delta V_o}{\Delta V_{in}} = -\beta \frac{R_C}{r_{ie}}$$

Therefore the gain of the amplifier is

$$\boxed{A = -\beta \frac{R_c}{r_{ie}}}$$

The value of the factor $\beta \frac{R_c}{r_{ie}}$ is of the order of hundreds, so the input voltage is amplified. The negative sign shows there is a phase shift of 180° between the input and the output signals.

Q.7 How can we Use a Transistor as a Switch?

Ans.

TRANSISTOR AS A SWITCH

Transistor may use as a switch in many electronic devices.

The emitter and collector behave as the terminals of the switch. The circuit in which the current is to be turned ON and OFF is connected across these terminals. So they behave like control terminals.

To Turn on:

To turn on the switch, the small potential V_B is applied across the base to emitter terminals fig a. So due to increase in base current I_B, a heavy current I_c starts to flow in common-emitter circuit. The large collector current I_c is possible only when resistance between C and E has such a small value that potential drop across CE is nearly 0.1 volt.

In fig (a) emitter is at ground, so we can assume that collector is also at ground and collector-emitter circuit of fig (a) can be drawn as shown in fig (b).

To turn off:

In order to turn OFF the switch, we will switch OFF the base current I_B by opening the base circuit (fig c). As $\beta = I_c / I_B$ and $I_c = \beta I_B$. So when I_B is zero, I_c is also zero and common emitter circuit become open (fig d). At this stage the resistance between C and E is nearly infinity.

Note:

An electronic computer is basically a vast arrangement of electronic switches which are made from transistor.

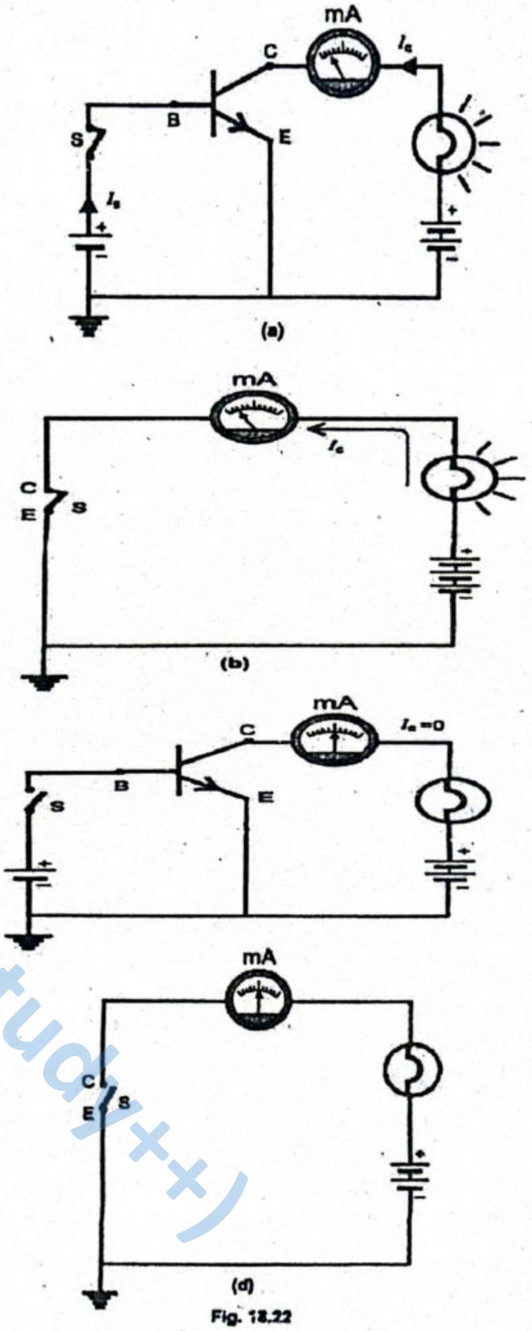


Fig. 18.22

MCQ's From Past Board Papers

1. The size of base in a transistor is: (Lhr 2017 G I) (D.G.Khan 2017 G I, Bwp 11, D.G.Khan 14, Swl 2015, Grw 13 G II, Lhr 14, 2015 G – I, 16 G II Fsd 15, Mtn 15 G – I)
(A) 10 m (B) 10^{-7}m (C) 10^{-8}m (D) 10^{-6}m

2. The ratio β in transistor is called: (Mtn 2015 GII Rwp 2015)
(A) Current gain (B) Voltage gain (C) Nuclear gain (D) Emitter gain

3. **Transistors are made from:** **(Lhr 2016 GI, Swl 2014)**
(A) Plastics (B) Metals (C) Conductors (D) Dopped semiconductors

4. **The term transistor stands for:** **(Swl 2014)**
(A) Transfer of current (B) Transfer of voltage (C) Transfer of resistance (D) Transfer of charge

5. **An expression for current gain of the transistor is given by:**
(Mtn, D.G.Khan 2017 G I, Lhr 12 G II, 2011, Mirpur 2016, Sgd, Bwp 2015)
(A) $\beta = \frac{I_B}{I_C}$ (B) $\beta = I_B + I_C$ (C) $\beta = I_C - I_B$ (D) $\beta = \frac{I_C}{I_B}$

6. **The central region of a transistor is called:** **(Sgd 2017 G I, Bwp 2017 G I) (Lhr 2013)**
(A) Base (B) Emitter (C) Collector (D) Neutral

7. **Which one has greater concentration of impurity:** **(Mir-II-13 Supp, Lhr 16, Mtn 2015 G-II, Mtn 15, Rwp, D.G.Khan 18)**
(A) Emitter (B) Base (C) Collector (D) Whole transistor

8. **In a common emitter amplifier, the phase difference between the input signal voltage and output signal voltage is:**
(Federal 2011, Fsd 2012)
(A) $\frac{\pi}{4}$ (B) π (C) 0 (D) $\frac{\pi}{2}$

9. **The gain of Amplifier is given as:** **(Swl 2014, Bwp 2015)**
(A) $-\beta R_C / r_{ie}$ (B) $\beta r_{ie} / R_C$ (C) $\frac{-R_2}{R_1}$ (D) $1 + \frac{R_2}{R_1}$

10. **The width of central region of a transistor is:** **(Swl 2015, Mtn 2016 Group I, Lhr 2015 Group I, Bwp 2018)**
(A) 10^{-4} m (B) 10^{-6} m (C) 10^{-3} m (D) 10^{-9} m

11. **SI unit of current gain is:** **(Grw 2016)**
(A) ampere (B) volt (C) coulomb (D) no unit

12. **The gain of transistor amplifier depends upon** **(Rwp 2016)**
(A) Resistance connected with collector (B) Resistance connected at base
(C) Input voltage (D) Output voltage

13. **For normal operation of a transistor, the E–B junction is always;** **(Azad Kashmir 2017)**
(A) Forward biased (B) Reverse biased (C) Not biased (D) No effect of biasing

14. **________ is the building block of every complex electronic circuit.** **(Mtn GII 2018)**
(A) Semiconductor diode (B) Resistor (C) Capacitor (D) Amplifier

ANSWER KEY'S

1.	D	2.	A	3.	D	4.	C	5.	D	6.	A	7.	A	8.	B	9.	A	10.	B
11.	D	12.	A	13.	A	14.	D												

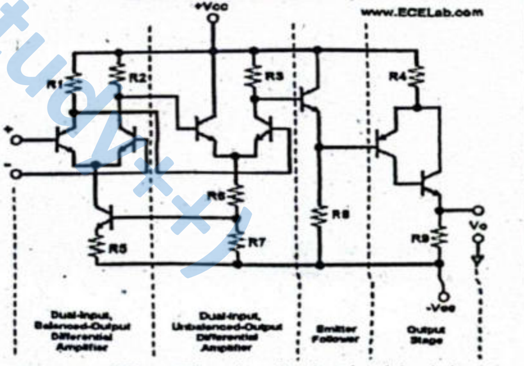
Q.8 What is an Operational Amplifier? Describe its Characteristics? ***D.G.KHAN – 2017, Mtn 2016***

Ans.

OPERATIONAL AMPLIFIER

Amplifiers are very commonly used important electronic circuit. Instead of making the amplifier by discrete component, we may use integrated amplifier silicon chip, which is enclosed in a capsule. Pins are connected with the working terminals such as input, output and power supply project outside the capsule (fig a). Such an integrated amplifier is called operational amplifier. Operational amplifier can perform the mathematical operation electronically.

For Your Information



An op amplifier: The circuits in the black box.

Symbolical Representation:

Operational amplifier is usually represented by symbol shown in figure b. It has two input terminals.

Inverting Input (-):

A signal applied at inverting input appears after amplification at output terminal with the phase difference of 180°.

Non-inverting Input (+):-

A signal applied at non-inverting input appears after amplification at output without any phase change.

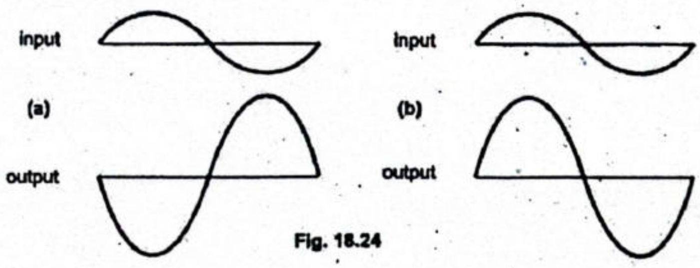
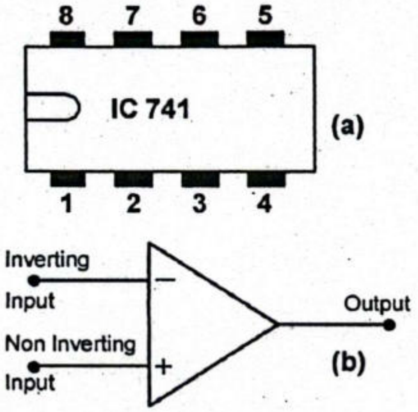


Fig. 18.24



CHARACTERISTICS OF OP-AMP

High Input Resistance:

It is the resistance between (+) and (–) inputs of amplifier whose value is of the order of several mega ohms (2MΩ or more). So due to large value of R_{in} practically no current flows between the two input terminals.

Note: In ideal case R_{in} is infinite.

Low Output Resistance:

It is the resistance between output terminal and the ground. It value is only a few ohms.

It is low about 100Ω. So, op-amp can deliver practically all its output voltage to a load of 2kΩ or more connected to amplifier, which is an advantage.

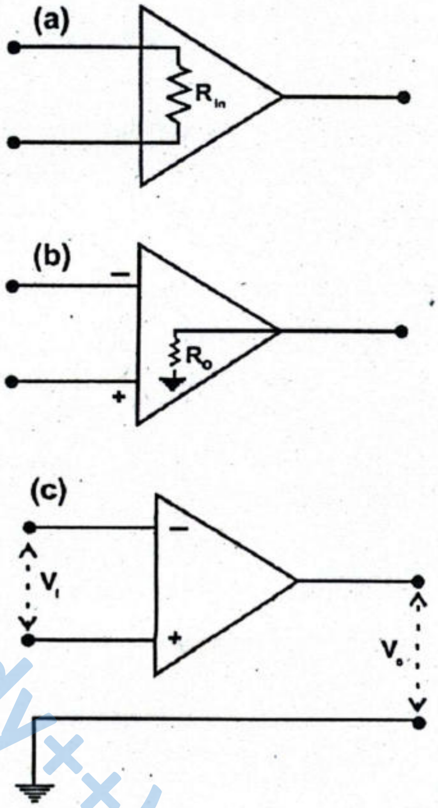
Note: Ideal op-amp has zero output resistance.

Open Loop Gain:

It is the ratio of output voltage V_o to voltage difference between inverting and non-inverting inputs, when there is no external connection between the input and output.

So $$\boxed{A_{OL} = \frac{V_o}{V_+ - V_-} = \frac{V_o}{V_i}}$$

The open loop gain of an amplifier is very high of the order of 10^5.



Q.9 Derive the Expression for Gain of an Inverting OP-AMP?

Ans. ***DG KHAN – 2009, RWP – 2010***

OP-AMP AS INVERTING AMPLIFIER

Consider an inverting amplifier as shown in figure. The input voltage V_i is applied across R_1 to the inverting terminal (-). The output voltage V_o is therefore out of phase with input. The non-inverting terminal is at ground (i.e. at zero potential). As open loop gain A_{OL} is very high of the order of 10^5. Thus V_o may have any value between $+V_{CC}$ and $-V_{CC}$. So according to equation.

For Your Information

OP-Amp has wide band width which is the range of frequencies which are amplified by op-amp without distortion.

$$A_{OL} = \frac{V_o}{V_+ - V_-} = \frac{V_o}{V_i}$$

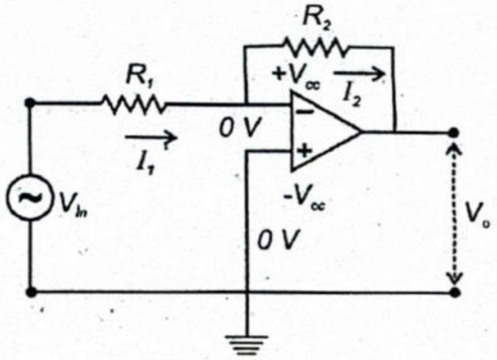
For any value of V_o,

$$V_+ - V_- \approx 0$$

Or $V_+ \approx V_-$

Since V_+ is at ground so V_- is virtually at ground (i.e. $V_- \approx 0$).

So according to fig.



$$\text{Current through } R_1 = I_1 = \frac{V_i - V_-}{R_1} = \frac{V_i - 0}{R_1} = \frac{V_i}{R_1}$$

$$\text{Current through } R_2 = I_2 = \frac{V_- - V_o}{R_2} = \frac{0 - V_o}{R_2} = -\frac{V_o}{R_2}$$

Since practically no current flows between (-) and (+).

So according to Kirchoff's rule

$$I_1 = I_2$$

$$\frac{V_i}{R_1} = -\frac{V_o}{R_2}$$

$$\frac{V_o}{V_i} = -\frac{R_2}{R_1}$$

$\frac{V_o}{V_i}$ = Gain of non – inverting amplifier = G

$$\boxed{G = -\frac{R_2}{R_1}}$$

The negative sign shows that the output signal is 180° out of phase with respect to input signal.

Note:

Closed loop gain depends upon the values of R_1 and R_2 but it is independent of what is happening inside the amplifier.

Q.10 Derive the Expression for Gain of a Non-Inverting OP-AMP?

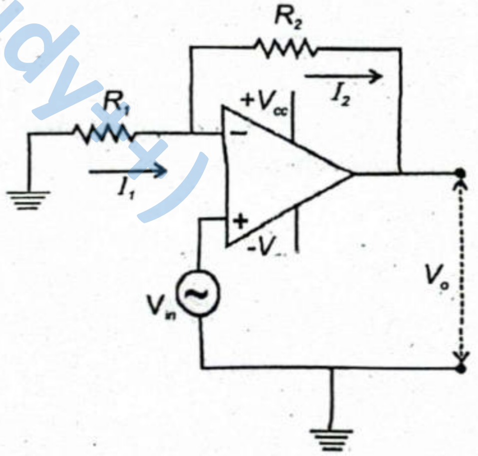
Ans.

OP-AMP AS NON-INVERTING AMPLIFIER

Consider the circuit of non-inverting amplifier. The input voltage V_i is applied across the non-inverting terminal (+). Since open loop gain is high of the order of 10^5. The inverting (–) and non inverting terminals are virtually at same potential.

So $V_- \approx V_+ = V_i$

From figure



$$\text{Current through } R_1 = I_1 = \frac{0 - V_-}{R_1} = \frac{0 - V_i}{R_1} = -\frac{V_i}{R_1}$$

$$\text{Current through } R_2 = I_2 = \frac{V_- - V_o}{R_2} = \frac{V_i - V_o}{R_2}$$

Since practically no current flows between (-) and (+) terminals

$$I_1 = I_2$$

$$-\frac{V_i}{R_1} = \frac{V_i - V_o}{R_2}$$

$$-\frac{V_i}{R_1}=\frac{V_i}{R_2}-\frac{V_o}{R_2}$$

$$\frac{V_o}{R_2}=\frac{V_i}{R_1}+\frac{V_i}{R_2}$$

$$\frac{V_o}{R_2}=V_i\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$$

$$\frac{V_o}{R_2}=V_i\left(\frac{R_1+R_2}{R_1}\right)$$

$$\frac{V_o}{V_i}=\frac{R_1}{R_1}+\frac{R_2}{R_1}$$

$$\frac{V_o}{V_i}=1+\frac{R_2}{R_1}$$

$$\frac{V_o}{V_i}=\text{Gain of amplifier}=G$$

$$G=1+\frac{R_2}{R_1}$$

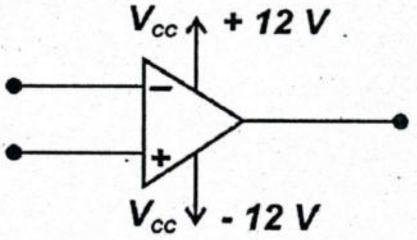
Positive sign of gain shows that input and output signals are in phase.

Note:

The gain of an inverting OP-AMP depends only upon the values of R_1 an R_2 but not depends upon the internal structure of OP-AMF.

Q.11 How operational amplifier is used as Comparator?

Ans.

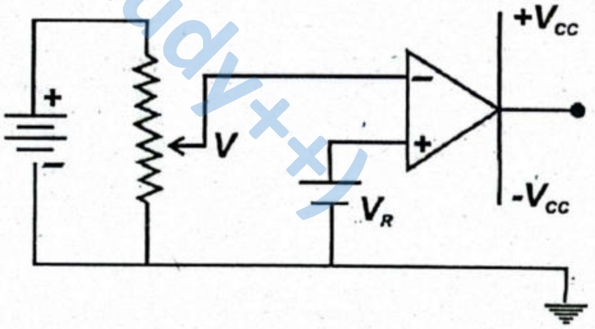


OP-AMP AS COMPARATOR

It is a circuit which is used to compare signal or voltage levels.

In an op–amp, usually two inputs of equal voltage but opposite polarity are required. Most op-amp operates with $V_{CC} = \pm 12V$.

As the open loop gain of *op*-amp is very high of the order of 10^5. So a *very small* change in potential between (-) and (+) inputs produces such a large amplified output that it get saturated. So the output will become either equal to $+V_{cc}$ or $-V_{cc}$. This feature of op-amp is used to compare two voltages.



In above figure,

V_R = reference voltage which is connected with (+) terminal.

V = voltage (to be compared) is connected with (-) terminal.

When $V_- > V_+$ or $V > V_R$

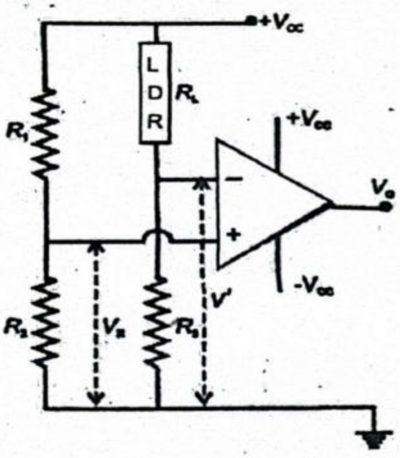
then $V_o = -V_{cc}$

And

When $V_- < V_+$ or $V < V_R$

then $V_o = +V_{cc}$

Q.12 How the comparator can be used as a Night Switch?



Ans.

COMPARATOR AS A NIGHT SWITCH

Suppose it is required that when intensity of light falls below a certain level, the street light is automatically switched on. This can be made by using op-amp as a comparator. In the figure resistances R_1 and R_2 form a potential divider circuit. The potential drop across R_2 provides the reference voltage V_R to the (+) input of op-amp

As $V_R = IR_2$

since $I = \left(\dfrac{V_{cc}}{R_1 + R_2}\right)$

therefore $V_R = \dfrac{R_2}{R_1 + R_2} V_{cc}$ ________ (1)

LDR (R_L) is a light dependent resistance. The value of resistance R_L depends upon the intensity of light falling upon it.

R_L and R_3 forms another potential divider. The potential drop across R_3 is V'. So,

$$V' = \frac{R_3}{R_L + R_3} V_{cc} \text{ ________ (2)}$$

V' provides the voltage to (-) input of op-amp V' will not a constant voltage but it changes with the intensity of light.

During day time:

During day time, when light falls on LDR, R_L is small. So from equation (2), V' will be large such that $V' > V_R$ so that $V_o = -V_{cc}$.

The output of operational amplifier is connected with a relay system system which switches on only when $V_o = +V_{cc}$.

Thus, when $V_o = -V_{cc}$, the light will not be switched ON.

During Night:

During night time, R_L become larger and V' decreases. When V' becomes just less than V_R (i.e. $V' < V_R$), the output of op-amp switches to $+V_{cc}$ which switches on the relay system and the street lights are turned ON.

For Your Information

Integrated circuit (IC) chips are manufactured on wafers of semi-conductor material.

MCQ's From Past Board Papers

1. The voltage gain of an inverting OP-Amplifier is ________ (Fed 2014) (Grw 2014, Swl 2014)
(A) $G = 1 - \frac{R_2}{R_1}$ (B) $G = 1 - \frac{-R_1}{R_2}$ (C) $G = \frac{-R_2}{R_1}$ (D) None of these

2. The magnitude of open loop gain of OP–amplifier is of the order of: (Bwp 2017 G II, D.G.Khan 15 G I, Lhr 15 G II, Rwp 2016, Grw, Sgd 2014, Bwp 2011, AJK 2018, D.G.Khan 2016)
(A) 10^3 (B) 10^5 (C) 10^7 (D) 10^9

3. For non-inverting amplifier if $R_1 = \propto$ ohm and $R_2 = 0$ ohm, then gain of amplifier is: (Lhr 2011 G-II,Bwp 2017, Lhr 2012)
(A) –1 (B) Zero (C) +1 (D) Infinite

4. The input resistance of an op-amplifier is: (Swl 2018, Fsd 2016)
(A) Zero (B) Low (C) High (D) Equal to output resistance

5. Automatic functioning of streetlight can be done by the use of:- (Fsd, D.G.Khan 17 G-II, Mtn 2016 G-II, Lhr, Bwp 2018)
(A) Inductor (B) Capacitor (C) Comparator (D) Thermistor

6. Output resistance of an op-amp is (Sgd 2016 Group I)
(A) High (B) Zero (C) Low (D) Equal to input resistance

7. The gain of non-inverting amplification factor β is given by: (Rwp 2015)
(A) $1+\frac{R_2}{R_1}$ (B) $1+\frac{R_1}{R_2}$ (C) $-\frac{R_2}{R_1}$ (D) $-\frac{R_1}{R_2}$

8. The use of LDR is in the circuit of: (Swl 2015Mirpur 2014, 2012)
(A) night switch (B) logic gate (C) rectifier (D) oscillator

9. The circuit which compares the two voltage is (Sgd 2017 G II)
(A) VDR (B) Sensor (C) Comparator (D) Logic gate

10. Find the gain if inverting, amplifier of external resistance $R_1 = 10K\Omega$ and $R_2 = 100K\Omega$ (Sgd 2018, Bwp 17 G I)
(A) −5 (B) −10 (C) −2 (D) 50

11. The Resistance between the inverting (−) and Non-Inverting (+) inputs is called input Resistance and is of the order of: (Bwp GII 2018)
(A) Ohms (B) Kilo Ohms (C) Thousands Ohms (D) Mega Ohms

12. In put resistance of op-amplifier is of the order of: (Rwp 2018)
(A) Few ohms (B) Mega ohms (C) Milli ohms (D) Micro ohms

13. In case of non-inverting op. Amplifier if $R_1 = \frac{R_2}{2}$ then: (Azad Kashmir 2018)
(A) $V_{out} = 3V_{in}$ (B) $V_{in} = 3V_{out}$ (C) $V_{out} = 2V_{in}$ (D) $V_{in} = 2V_{out}$

14. The gain of non inverting op.Amp of external resistances $k_1 = 10k\Omega$, $R_2 = 100k\Omega$ is (Sgd 2015 Group II)
(A) 0.1 (B) 10 (C) 11 (D) −10

15. A naturally occurring disintegration involving the emission of high energy electrons is called:
(A) Positron Decay (B) Beta Decay (C) Gamma Decay (D) Alpha Decay

16. By emitting β – particle and γ – Particle simultaneously the nucleus changes its charge: (Sgd 18, DGK 17, Lhr 2012)
(A) Losses by 1 (B) Increases by 1 (C) Increases by 2 (D) No change will be observed

ANSWER KEY'S

1.	C	2.	B	3.	C	4.	C	5.	C	6.	C	7.	A	8.	A	9.	C	10.	B
11.	D	12.	A	13.	A	14.	C	15.	B	16.	B								

Q.13 What do you know about Digital System? Describe it briefly?

Ans.

DIGITAL SYSTEMS

A digital system deals with quantities or variables which have only two discrete values or states.

Following are the examples of such quantities;

- A switch can open or closed
- The answer of a question is either yes or no.
- A statement can either true or false.
- A bulb can either on or off.

So

1^{st} state	True	High	1	Yes	On	Closed
2^{nd} state	False	Low	0	No	Off	Open

The mathematical treatment of these quantities can be easily described if they are represented by binary digits 1 and 0.

When we are dealing with voltages, we use the terms High and Low for their representation.

For switching process we use the terms open and closed for on and off.

Boolean algebra:

For manipulation of binary numbers (i.e. 0 and 1), we require a special type of algebra known as Boolean algebra. 1 and 0 are known as Boolean variables. Boolean algebra based upon three basic operations namely:

(i) AND operation
(ii) OR operation
(iii) NOT operation

What are Logic Gates? Discuss Fundamental as well as Exclusive Logic Gates?

LOGIC GATES

The electronic circuit implements the various logic operations are called logic gates.

OR

The electronic circuit that makes the logic decision is called logic gate. These are the basic building block of digital circuit.

In these gates high and low states. i.e. 1 and 0 states are represented by a certain voltage level. Ideally a particular voltage level represents a high (1) and another voltage level represents low (0).

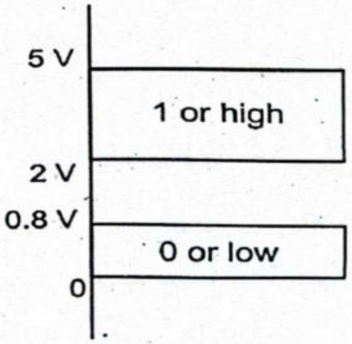
Range of High(1) and Low(0) levels

High (1)

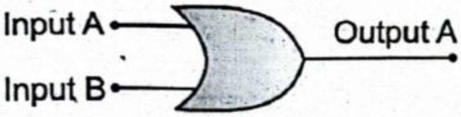
High (1) can be any voltage between specified minimum or maximum value. If voltage of 3.5V is applied to a gate, it will accept it as high or 1, as shown in figure.

Low (0)

The low (0) can be any voltage between specified minimum and maximum values. If voltage of 0.5V is applied, the gate will recognize it as 0 or low, as shown in figure.



FUNDAMENTAL LOGIC GATES



OR Gate

OR GATE: (Any or All Gate)

It is any or all gate. It gives an output 1 for either of two inputs 1 or both inputs 1.

It performs the OR operation. It has two or more than two inputs but a single output.

Let an OR gate has two inputs A and B and a single output X.

If one of the input is at 1 then output is also at 1 otherwise zero.

Mathematically,

$$X = A + B$$

Table 18.2

A	B	Out put
0	0	0
0	1	1
1	0	1
1	1	1

AND gate

AND GATE: (All Or Nothing Gate)

It is all or nothing gate.

It gives an output 1 for both two inputs 1.

If has two or more than two inputs and a single output.

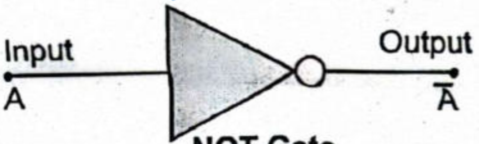
It is designed such that it performs the AND operation.

So output X is 1 only when A and B inputs are at logic 1 and for all other combinations the output X is zero. Mathematically,

$$X = A . B$$

Table 18.3

A	B	Out put
0	0	0
0	1	0
1	0	0
1	1	1



NOT Gate

NOT GATE: (Inverter)

It is called NOT gate because its output is NOT same as its output.

It gives an output of 1 for an input is zero.

It performs the operation of inversion. That is why it is also known as inverter.

It changes the logic level to its opposite level.

Its symbolical representation is shown in figure. Bar shows that the value of variable has been inverted. The bubble shows the inversion operation.

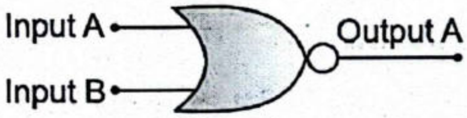
Mathematically, for an input A,

$$X = \overline{A}$$

Table 18.4

A	Out put
0	1
1	0

UNIVERSAL GATES



NOR gate

NOR GATE:

The combination of NOT and OR gate, is called NOR gate.

It performs the inverted operation of OR.

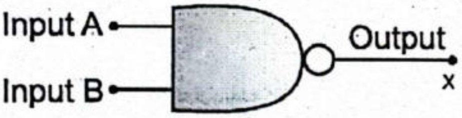
It gives an output 1 when all its inputs are 0.

Mathematically,

$$X = \overline{A+B}$$

Table 18.5

A	B	Out put
0	0	1
0	1	0
1	0	0
1	1	0



NAND gate

NAND GATE:

The combination of NOT and AND gate, is called NAND gate.

It performs the inverted operation of AND.

It gives an output 1 for either but not both of inputs 1 or both inputs are 0.

Mathematically,

$$X = \overline{A.B}$$

Table 18.6

A	B	Out put
0	0	1
0	1	1
1	0	1
1	1	0

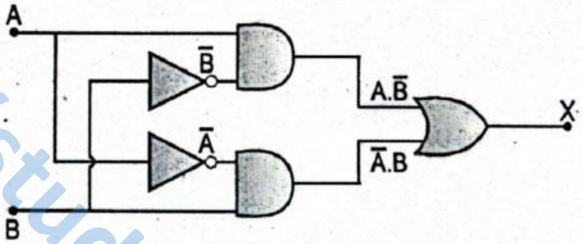
EXCLUSIVE GATES

EXCLUSIVE OR GATE: (XOR Gate)

It has an output of 1 when its inputs are different.

Consider a Boolean function X of two variables A and B such as,

$$X = A\overline{B}+\overline{A}B$$



Making an XOR gate

The first term of function X is obtained by ANDing the variable A with NOT of B.

The second term is NOT of A ANDed with B.

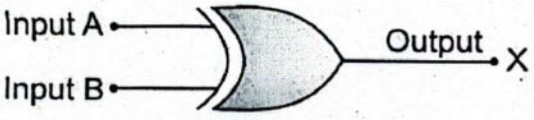
The function X is obtained by ORing these two terms.

It can be constructed by combining AND, OR and NOT gates.

Its truth table is given below.

Table 18.7

A	B	Out put
0	0	0
0	1	1
1	0	1
1	1	0



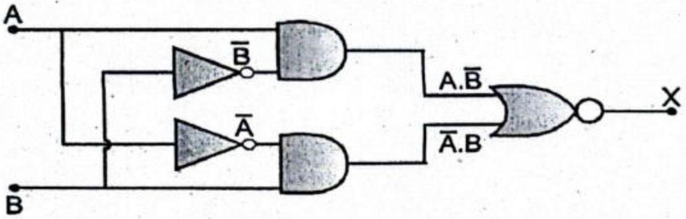
XOR gate

EXCLUSIVE NOR GATE: (XNOR Gate)

It has an output of 1 when both of its inputs are identical.

Exclusive-NOR gate is obtained by inverting the output of XOR gate.

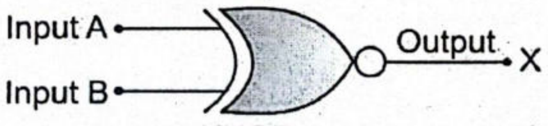
The bubble at the output of XOR gate represents the function of inversion.



$$X = \overline{A\bar{B}+\bar{A}B}$$

It can also the constructed by NOT, AND and NOR gates.

Its truth table and symbol in given below



XNOR gate

Table 18.8

A	B	Out put
0	0	1
0	1	0
1	0	0
1	1	1

Q.15 How the Combination of Logic Gates is Used in the Controlling Systems?

Ans.

APPLICATION OF GATES IN CONTROL SYSTEM

Gates are widely used in control system. These systems can monitor the physical parameters such as temperature pressure or some other physical quantities. As gates operates with electrical voltage only, so some sensors are required.

Sensors:

The device which converts various physical quantities into electric voltage is called sensor.

Examples:

- Light dependent resistance (LDR) is a sensor of light.
- Microphone is a sound sensor.
- Thermistor is a temperature sensor.
- Similarly, there are level sensors which give an electrical signal when the level of liquid in a vessel attains a certain limit.

Monitoring of Pressure and Temperature:

Sensors are used to monitor the pressure and temperature of chemical solution stored in a vat.

The sensor produces a High or 1 when either the temperature or the pressure exceeds from a certain limit.

A circuit is to be designed which will ring an alarm when either the temperature or pressure or both cross the maximum specified limit. The alarm requires a LOW for its activation. Its block diagram is shown in figure.

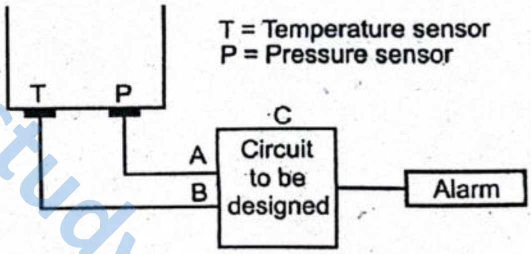


Table 18.9

A	B	Out put
0	0	1
0	1	0
1	0	0
1	1	0

Let A and B are fed by the temperature and the pressure sensor T and P filled into a vat. As soon as the limit of temperature or pressure is exceeded i.e. when A = 0, B = 1

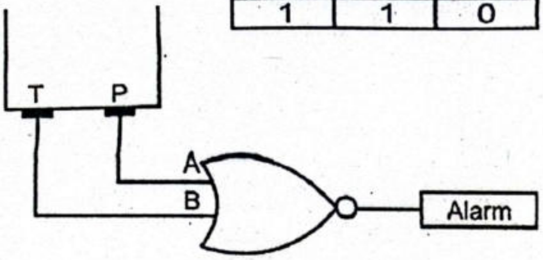
OR when B = 0, A = 1

OR when A = 1, B = 1.

The output of circuit should be 0.

Within certain limit for A = B = 0, the output should be 1.

For this purpose, we should use a NOR gate.



MCQ's From Past Board Papers

1. **Which one can be used as temperature sensor in electric circuit?** **(Mtn 2014-15, Sgd 2015 G – II Mirpur 2012)**
(A) Capacitor (B) Diode (C) LDR (D) Thermistor

2. **The Truth Table of logic function:** **(Bwp 2016)**
(A) Summarizes its output values (B) Tabulates all its input conditions only
(C) Display all its input/output possibilities (D) Is not based on logic gates

3. **In which type of logic gate, the output is one when, both inputs are zero?** **(Fed 2011)**
(A) OR gate (B) AND gate (C) NOT gate (D) NOR gate

4. **The circuit which changes input signal at output with phase difference of 180° is called:** **(Mtn 2017, Fed 12)**
(A) Amplifier (B) Inverter (C) Non-Inverter (D) Switch

5. **Which of the following is not basic operation of Boolean variables?** **(Fed 2013)**
(A) YES operation (B) NOT operation (C) AND operation (D) OR operation

6. **The mathematical relation for NOR operation is ________** **(Fed 2014)**
(A) $X = \overline{A \cdot B}$ (B) $X = \overline{A + B}$ (C) $X = \overline{A} \cdot B$ (D) $X = B \cdot \overline{A}$

7. **Mathematical notation for AND operation is:** **(D.G.Khan 2018, Lhr 2016 Sgd 2014)**
(A) $X = A - B$ (B) $X = A + B$ (C) $X = \overline{AB}$ (D) $X = \overline{A}$

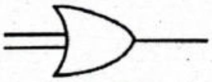
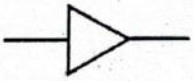
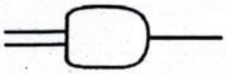
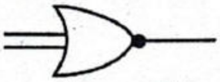
8. **If both the inputs are low, the output is high for:** **(Federal 2017, Fsd 2014 Grw 2011)**
(A) OR gate (B) AND gate (C) XOR gate (D) NOR gate

9. **Any logical expression can be realized using only?** **(Bwp 2011, 12 Grw 2010)**
(A) AND gate (B) NAND gate (C) AND, OR and NOT gate (D) NOT gate

10. **The Boolean expression of NAND Gate is:-** **(Lhr 2018, Fsd 2017, Mtn 2016 Group II)**
(A) $X = A. B$ (B) $X = \overline{A}$ (C) $X = \overline{A. B}$ (D) $X = A + B$

11. **$x = \overline{A + B}$ is the mathematical notation for** **(Sgd 2016 Group II)**
(A) OR-gate (B) NOR-gate (C) NAND gate (D) AND gate

12. **A two inputs NAND gate with inputs A and B has an output 0, if** **(Bwp 2016)**
(A) B is zero (B) A is zero (C) Both A and B are 1 (D) Both A and B are 0

13. **The symbol for AND gate is** **(D.G.Khan 2016 Group II)**
(A)  (B)  (C)  (D) 

14. **The output of two input OR gate is zero only when its:** **(Mirpur 2016)**
(A) Both inputs are zero (B) Either input is zero (C) Both inputs are one (D) Either input is one

15. **Logic gates can control some physical parameters like:-** **(Mtn 2017 G II)**
(A) Temperature, Pressure (B) Resistance, Inductance (C) Capacitance, Impedance (D) Current, Voltage

16. **The device which are required to convert various physical qualities into electric voltage are called** **(Swl 17)**
(A) filters (B) rectifiers (C) amplifiers (D) sensors

17. **The Boolean equation for exclusive OR-gate is given by** **(Bwp 2018, Sahiwal 2017)**
(A) $X = A.B + B.A$ (B) $X = A\overline{B} + \overline{A}B$ (C) $\overline{A}. \overline{B} + A.B$ (D) $X = \overline{A.B + A.B}$

18. **The Boolean equation for exclusive NOR gate is given by** **(D.G.Khan GII 2018)**
(A) $X = AB + BA$ (B) $X = A\overline{B} + \overline{B}A$ (C) $X = \overline{A\overline{B} + \overline{A}B}$ (D) $X = \overline{A+B}$

19. **Which one is not fundamental ligic gate?** **(Fsd 2018)**
(A) OR gate (B) AND gate (C) NOT gate (D) NAND gate

20. **When A = 0, B = 1, then output of 'NAND' gate is:** **(Sgd GII 2018)**
(A) 0 (B) 1 (C) 0.1 (D) 0.8

ANSWER KEY'S

1.	D	2.	C	3.	D	4.	B	5.	A	6.	B	7.	C	8.	D	9.	C	10.	C
11.	B	12.	C	13.	C	14.	A	15.	A	16.	D	17.	B	18.	C	19.	D	20.	B

IMPORTANT SHORT QUESTIONS FOR BOARD EXAMS

1. Write any two characteristics of operational amplifier. **(Fsd 2016)**

Ans. **High Input Resistance:**

It is the resistance between (+) and (–) inputs of amplifier whose value is of the order of several mega ohms (2MΩ or more). So due to large value of R_{in} practically no current flows between the two input terminals.

Note: In ideal case R_{in} is infinite.

Low Output Resistance:

It is the resistance between output terminal and the ground. It value is only a few ohms.

It is low about 100Ω. So, op-amp can deliver practically all its output voltage to a load of 2kΩ or more connected to amplifier, which is an advantage.

Note: Ideal op-amp has zero output resistance.

Open Loop Gain:

It is the ratio of output voltage V_o to voltage difference between inverting and non-inverting inputs, when there is no external connection between the input and output.

So $$\boxed{A_{OL}=\frac{V_o}{V_+-V_-}=\frac{V_o}{V_i}}$$

The open loop gain of an amplifier is very high of the order of 10^5.

2. What is the principle of virtual ground of operational amplifier?
(D.G.Khan 2015 Group I) (Sgd 2016 Group I)

Ans. **Virtual ground:**

When an op-amp is used as an inverting amplifier, input voltage is applied at inverting terminal while the non-inverting terminal is grounded as shown is fig.

As open loop gain of op-amp is very high of the order or 10^5. So $V_+ \sim V_-$ hence the input voltage (V_i) is reduced to such a small value that it may be assumed to be at ground. This is called virtual ground. (Clearly, *it is not the real ground*)

3. What is an ideal diode? **Rwp 2017, Sgd 2018, Mirpur 2018**

Ans. **Ideal diode**

Ideal diode is that which offers zero resistance when it is forward biased
And
offers infinite resistance when it is reverse biased.

4. What is reverse or leakage current in p–n junction diode? **(Rwp 2016, Sgd 2017)**

Ans. **Leakage current**

In reverse biased p-n junction, the negative terminal of the battery pulls the holes away from the junction and positive terminal attracts electrons. However, a very small current of the order of few micro amperes flows across the junction due to flow of minority charge carrier. This current is known as reverse current or leakage current in p-n junction diode.

5. What is meant by transistor? Name its three regions.

Ans. **Transistor and its different regions**

It is an electronic instrument which is formed by the combined effect of p-type and n-type substances, in such a way that the central substance is sandwiched its opposite substances at the other ends. *It is used* to amplify both current as well as voltage.

Three regions of the transistor are

(i) Emitter
(ii) Base
(iii) Collector

* * *

FORMULAE

1	**Forward resistance of pn-junction**	$r_f = \frac{\Delta V_f}{\Delta I_f}$	
2	**Transistor current equation**	$I_E = I_C + I_B$	
3	**Current gain CE-transistor**	$\beta = \frac{I_C}{I_B}$	
4	**Gain of CE-amplifier**	$A = \frac{\Delta V_o}{\Delta V_{in}}$	$A = -\beta \frac{R_C}{r_{ie}}$
5	**Voltage equation for output loop**	$V_{CC} = I_C R_C + V_{CE}$	
6	**Voltage equation for input loop**	$V_{CC} = I_B R_B + V_{BE}$	
7	**Open loop gain of an operational amplifier**	$A_{OL} = \frac{V_o}{V_+ - V_-}$	$A_{OL} = \frac{V_o}{V_{in}}$
6	**Gain of an inverting amplifier**	$G = -\frac{R_2}{R_1}$	
7	**Gain of an non-inverting amplifier**	$G = 1 + \frac{R_2}{R_1}$	
8	**OR Gate**	$X = A + B$	
10	**AND Gate**	$X = A . B$	
11	**NOT Gate**	$X = \overline{A}$	
12	**NOR Gate**	$X = \overline{A + B}$	
13	**NAND Gate**	$X = \overline{A . B}$	
14	**XOR Gate**	$X = A\overline{B} + \overline{A}B$	
15	**XNOR Gate**	$X = \overline{A\overline{B} + \overline{A}B}$	

UNITS

1	**Forward or reversed resistance**	ohm	Pa
2	**Voltage gain**	No unit	
3	**Current gain**	No unit	

CONSTANTS

1	**Current gain (β)**	$30-500$	Pa
2	**Open loop gain of an operational amplifier**	$\sim 10^5$	

SOLVED EXAMPLES

Example 18.1:

In a certain circuit, the transistor has a collector current of 10 mA and a base current of 40 μA. What is the current gain of the transistor?

Given data:

Collector current = $I_C = 10\text{ mA} = 10 \times 10^{-3}\text{ A}$

Base current = $I_B = 40\ \mu\text{A} = 40 \times 10^{-6}\text{ A}$

To find:

Current gain = β = ?

Calculations:

Using the relation

$$\beta = \frac{I_C}{I_B}$$

Putting the values, we get

$$\beta = \frac{10\times10^{-3}}{40\times10^{-6}}$$

$$\beta = \frac{1}{4}\times10^{3}$$

$$\beta = \frac{1000}{4}$$

$$\boxed{\beta = 250}$$

Example 18.2:

Find the gain of the circuit as shown in Fig. 18.30.

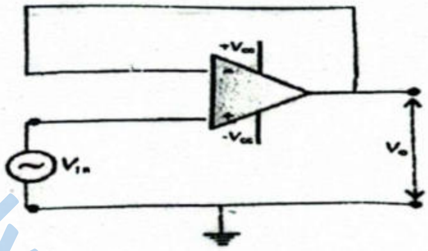


Fig. 18.30

Given data:

As the input signal V_i is connected to non-inverting input (+), so the op-amp acts as a non-inverting amplifier.

$R_1 = \infty$ (infinity)

and $R_2 = 0$

To find:

Gain = G = ?

Calculations:

Using the formula

$$G = 1+\frac{R_2}{R_1}$$

Putting the values, we get

$$G = 1+\frac{0}{\infty}$$

$$G = 1 + 0$$

$$\boxed{G = 1}$$

SHORT QUESTIONS OF THE EXERCISE

18.1 How does the motion of an electron in a n-type substance differ from the motion of holes in a p-type substance? (Grw 2017, Rwp 18, Mirpur 14, Lhr 2014, 16, Mtn 2011, Bwp 2013)

Ans. Motion of electrons in n-type and p-type substance (differences)

(1) When a battery is connected to n-type electrons (majority carriers) drift towards the ***positive end*** while in p-type material holes drift towards the ***negative ends*** of battery.

(2) Mobility of electron (in n-type) is ***greater*** than the mobility of holes in p-type.

18.2 What is the net charge on a n-type or a p-type substance? (Grw 2018, Bwp 2013, DG khan 2014)

Ans. The net charge on n-type or a p-type substance is ***zero.***

Reason

n-type substance is formed when a small amount of pentavalent impurity is added to pure semi-conductors. Similarly, p-type substance is formed when a small amount of trivalent impurity is added to pure semi-conductors. Since all the atoms in an n-type or p-type substance are ***electrically neutral*** so the proportion of negative and positive charges does not changed hence the net charge on n-type or p-type is zero.

18.3 The anode of a diode is 0.2 positive with respect to its cathode. Is it forward biased? (Rwp 2013 Grw 2010, Lhr 2011)

Ans. ***Yes,*** it is forward biased.

Reason

We know that when the anode (p-side) is positive with respect to its cathode (n-side) it is said to be forward biased. In case of Si, V_B = 0.7V and for Ge. V_B = 0.3V

So, diode will ***not*** conduct in case of Ge or Si.

18.4 Why charge carriers are not present in the depletion region? (Fsd 2013 Grw 2008, Lhr 2018 G II, Federal 2017)

Ans. This is due to the fact that when (just after the formation of pn-junction) an electron from n-region, diffuses into the p-region, it leaves behind a ***positive ion.***

When this electron recombines with hole in p-region, a ***negative ion*** is formed. So no charge carriers are available in this region, though it contains immobile positive and negative ions.

18.5 What is the effect of forward and reverse biasing of a diode on the width of depletion region? (Grw 2009, 11, Lhr 2015, Swl 2013)

Ans. (a) When the pn-junction diode is forward biased, the width of depletion region ***reduces.*** In other words, barrier potential is reduced which allows move current to flow across the junction.

(b) When the diode is reversed biased, the width of depletion region is ***increased*** because the majority carriers are pulled away from the junction.

18.6 Why ordinary silicon diodes do not emit light? (Bwp 2017, 2018 G II, Fsd 2011, Mirpur 2012)

Ans. Reason

(i) It is *opaque* to light.

(ii) The ordinary silicon diodes do not emit light because it has low value of forward bias voltage than LED. The emitted photon have

→ Energy E = 0.7ev and wavelength λ = 1770 nm

The photon emitted from Si diode lies in infrared region which is not visible.

It emits infrared invisible heat radiations.

→ That is why the ordinary Si diode do not emit visible light.

18.7 Why a photo diode is operated in reverse biased state? (Rwp 2018, 13, Sgd 2017, Lhr 2018 G II)

Ans. Reason

Basically, photo diode is used for the ***detection of light***. In reverse biased condition, photo diode has a very small (amount) reverse current. This current is due to minority carriers. The number of these minority carriers depends upon intensity of light incident on junction. So when the junction is exposed to light (visible / invisible) reverse current***IUBincreases*** and can easily be detected.

18.8 Why is the base current in a transistor very small? (Grw 2017, DG khan 2016 G II)

Ans. The base current in a transistor is very small due to the following reasons.

Reason

(i) Base is very ***thin (10^{-6} m)*** as compared to either emitter or collector.

(ii) Base is very ***lightly*** doped.

(iii) Biasing voltage between base-collector junction (V_{cc}) is ***larger*** than the voltage between base-emitter junction.

18.9 What is the biasing requirement of the junctions of a transistor for its normal operation? Explain how these requirements are met in a common emitter amplifier? (Lhr 2011, 12, Grw 2014)

Ans. Biasing requirement

For the normal operation of a transistor,

(i) Emitter base junction is ***forward biased*** and

(ii) Collector base junction is ***reversed biased.***

For CE-Amplifier

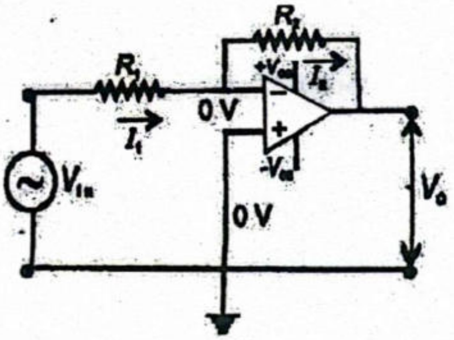
- In common emitter amplifier, input signal is applied between base and emitter and the output signal is taken across collector and emitter.
- Similarly, EB-junction is forward biased and CB-junction reverse biased.

18.10 What is the principle of virtual ground? Apply it to find the gain of an inverting amplifier? (Lhr 2018 G I, Fsd 2011, Rwp 2016)

Long

Ans. Virtual ground

When an op-amp is used as an inverting amplifier, input voltage is applied at inverting terminal while the non-inverting terminal is grounded as shown is fig.



As open loop gain of op-amp is very high of the order or 10^5. So the input voltage (V_i) is reduced to such a small value that it may be assumed to be at ground. This is called virtual ground. (Clearly, *it is not the real ground*)

Gain of an inverting amplifier:

From figure

$$\text{Currant through } R_1 = I_1 = \frac{V_i - V_-}{R_1} = \frac{V_i - 0}{R_1} = \frac{V_i}{R_1}$$

Similarly,

$$\text{Current through } R_2 = I_2 = \frac{V_- - V_o}{R_2} = \frac{0 - V_o}{R_2} = \frac{-V_o}{R_2}$$

As practically, no current flows between (-) and (+) terminals, so according to Kirchhoff's current rule

$$I_1 = I_2$$

OR

$$\frac{V_i}{R_1} = -\frac{V_o}{R_2}$$

OR

$$\frac{V_o}{V_i} = -\frac{R_2}{R_1}$$

As $\frac{V_o}{V_i}$ is defined as gain G of inverting amplifier

Therefore, $G = -\frac{R_2}{R_1}$

The negative sign indicates that output signal is ***<u>180° out of phase</u>*** with respect to input signal.

Note: Above equation shows that G depends upon the two external resistances R_1 and R_2, it is independent of what is happening inside the amplifier.

18.11 The inputs of a gate are 1 and 0.Identify the gate if its output is (a) 0, (b) 1.

(Bwp 2011, 12, D.G.Khan 2010, 14 Grw 2008,11)

Ans. (a) The gate may be AND, NOR or XNOR

Reason

If A = 1 and B = 0, then

For AND gate $X = A.B = 1.0 = 0$

For NOR gate $X = \overline{A+B} = \overline{1+0} = \overline{1} = 0$

For XNOR gate $X = \overline{A.\bar{B}+\bar{A}.B} = \overline{1.\bar{0}+\bar{1}.0} = \overline{11+0.0} = \overline{1} = 0$

(b) The gate may by OR, NAND or XOR

Reason

If A = 1 and B = 0, then

For OR gate $X = A+B = 1+0 = 1$

For NAND gate $X = \overline{A.B} = \overline{1.0} = \overline{0} = 1$

For XOR gate $X = A.\overline{B} + \overline{A}.B = 1.\overline{0} + \overline{1}.0 = 1.1 + 0.0 = 1$

18.12 Tick (√) the correct answer

(i) A diode characteristic curve is a plot between

(a) current and time (b) voltage and time

(c) voltage and current (d) forward voltage and reverse voltage

(ii) The colour of light emitted by a LED depends on

(a) its forward bias (b) its reverse bias

(c) the amount of forward curreent (d) the type of semi–conductor material used

(iii) In a half–wave rectifier the diode conducts during

(a) both halves of the input cycle (b) a portion of the +ve half of the input cycle

(c) a portion of the –ve half of the input cycle (d) one half of the input cycle

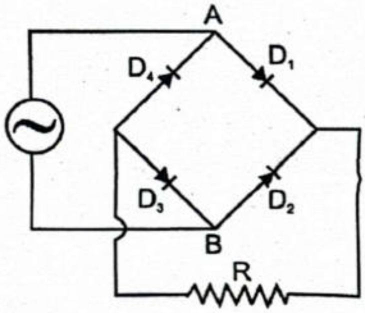
(iv) In a bridge rectifier of Fig when V_i is positive at point B with respect to point A, which diodes are ON.

(a) D_2 and D_4

(b) D_1 and D_3

(c) D_2 and D_3

(d) D_1 and D_4



(v) The common emitter current amplification factor β is given by

(a) $\frac{I_C}{I_E}$ (b) $\frac{I_C}{I_B}$ (c) $\frac{I_E}{I_B}$ (d) $\frac{I_B}{I_E}$

(vi) Truth table of logic function

(a) summarizes its output values (b) tabulates all its input conditions only

(c) display all its input/output possibilities (d) is not based on logic algebra

(vii) The output of a two inputs OR gate is 0 only when its

(a) both inputs are 0 (b) either inputs is 1

(c) both inputs are 1 (d) either inputs is 0

(viii) A two inputs NAND gate with inputs A and B has an outputs 0 if

(a) A is 0 (b) B is 0

(c) both A and B are zero (d) both A and B are 1

(ix) The truth table shown below is for

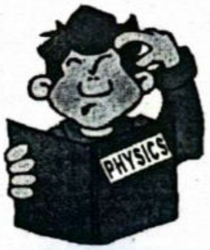
(a) XNOR gate (b) OR gate

(c) AND gate (d) NAND gate

A	B	X
0	0	1
0	1	0
1	0	0
1	1	1

ANSWERS

1. c	2. d	3. d	4. b	5. b	6. c	7. a	8. d	9. a



Exercise Problems

18.1 The current flowing into the base of a transistor is 100 μA. Find its collector current I_C, its emitter current I_E and the ratio I_C/I_E, if the value of current gain β is 100.

Given data:

Base current = $I_B = 100\ \mu A = 100 \times 10^{-6}\ A = 1 \times 10^{-4}\ A$

Current gain = $\beta = 100$

To find:

(i) Collector current = I_C = ?

(ii) Emitter current = I_E = ?

(iii) Ratio = $\frac{I_C}{I_E}$ = ?

Calculations:

(i) As $\beta = \frac{I_C}{I_B}$

or $I_C = \beta I_B$

Putting the values, we get

$$I_C = 100 \times 1 \times 10^{-4}$$

$$I_C = 1 \times 10^{-2}\ A$$

or $$I_C = 10 \times 10^{-3}\ A$$

$$\boxed{I_C = 10\ mA}$$

(ii) Now, as

$$I_E = I_B + I_C$$

Putting the values, we get

$$I_E = (1 \times 10^{-4}) + (1 \times 10^{-2})$$

$$I_E = 10.1 \times 10^{-3}\ A$$

$$\boxed{I_E = 10.1\ mA}$$

(iii) Now, the ratio $\frac{I_C}{I_E}$ is

$$\frac{I_C}{I_E} = \frac{10 \times 10^{-3}}{10.1 \times 10^{-3}}$$

$$\boxed{\frac{I_C}{I_E} = 0.99}$$

18.2 **Fig. P. 18.2 shows a transistor which operates a relay as the switch S is closed. The relay is energized by a current of 10 mA. Calculate the value R_B which will just make the relay operate. The current gain β of the transistor is 200. When the transistor conducts, its V_{BE} can be assumed to be 0.6 V.**

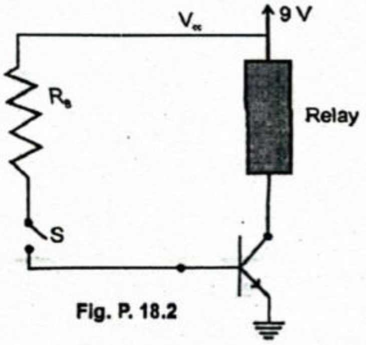


Fig. P. 18.2

Given data:

Collector current = I_C = 10 mA = 10×10^{-3} A

Current gain = β = 200

Base-emitter voltage = V_{BE} = 0.6 V

Collector voltage = V_{CC} = 9 V

To find:

Base resistance = R_B = ?

Calculations:

As $$\beta = \frac{I_C}{I_B}$$

or $$I_B = \frac{I_C}{\beta}$$

Putting the values, we get

$$I_B = \frac{10\times10^{-3}}{200} = 5\times10^{-5}\ \text{A}$$

Now applying input loop equation

$$V_{CC} = I_B R_B + V_{BE}$$

or $$R_B = \frac{V_{CC} - V_{BE}}{I_B}$$

Putting the values, we get

$$R_B = \frac{9-0.6}{5\times10^{-5}}$$

Or $$R_B = 168 \times 10^3\ \Omega \qquad (\because 10^3\Omega = 1\ \text{k}\Omega)$$

$$\boxed{R_B = 168\ \text{k}\Omega}$$

18.3 **In circuit (Fig. P. 18.3), there is negligible potential drop between B and E, if β is 100calculate**

(i) **base current**

(ii) **collector current**

(iii) ***potential* drop across R_C**

(iv) **V_{CE}**

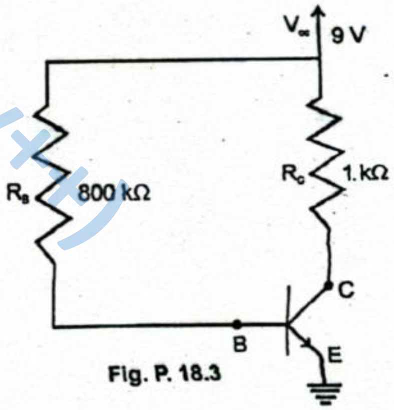


Fig. P. 18.3

Given data:

Base-emitter voltage = V_{BE} = 0

Collector Biasing voltage = V_{CC} = 9V

Collector resistance = R_C = 1 kΩ = 1000 Ω

Base resistance = R_B = 800 kΩ = 800 × 1000 = 8×10^5 Ω

Current gain = β = 100

To find:

(i) Base current = I_B = ?

(ii) Collector current = I_C = ?

(iii) Potential drop across $R_C = V_C$ = ?

(iv) V_{CE}

Calculations:

(i) As input loop equation is

$$V_{CC} = I_B R_B + V_{BE}$$

As potential drop between B and E is negligible, so $V_{BE} = 0$

$$V_{CC} = I_B R_B + 0$$

or $$I_B = \frac{V_{CC}}{R_B}$$

Putting the values, we get

$$I_B = \frac{9}{8\times10^5} = 1.125\times10^{-5} = 11.25\times10^{-6}\ \text{A}$$

$$\boxed{I_B = 11.25\ \mu\text{A}}$$

(ii) As $$\beta = \frac{I_C}{I_B}$$

or $$I_C = \beta I_B$$

Putting the values, we get

$$I_C = 100 \times 11.25 \times 10^{-6}$$

$$I_C = 1.125 \times 10^{-3}\ \text{A}$$

$$\boxed{I_C = 1.125\ \text{mA}}$$

(iii) Now $V_C = I_C R_C$

Putting the values, we get

$$V_C = 1.125 \times 10^{-3} \times 1 \times 10^3$$

$$\boxed{V_C = 1.125\ \text{V}}$$

(iv) As output loop equation is

$$V_{CC} = V_C + V_{CE}$$

or $$V_{CE} = V_{CC} - V_C$$

Putting the values, we get

$$V_{CE} = 9 - 1.125$$

$$\boxed{V_{CE} = 7.875\ \text{V}}$$

18.4 Calculate the output of the op-amp circuit shown in Fig. P. 18.4.

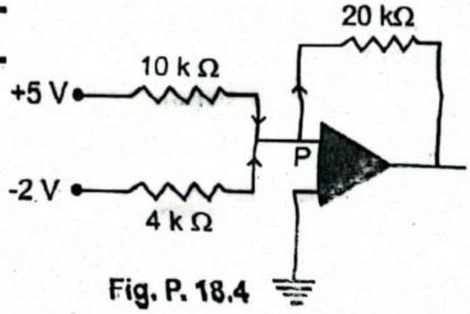


Fig. P. 18.4

Given data:

$R_1 = 10\ \text{k}\Omega = 10 \times 10^3\ \Omega$

$R_2 = 4\ \text{k}\Omega = 4 \times 10^3\ \Omega$

$R_3 = 20\ \text{k}\Omega = 20 \times 10^3\ \Omega$

$V_1 = +5$ volts, $V_2 = -2$ volts

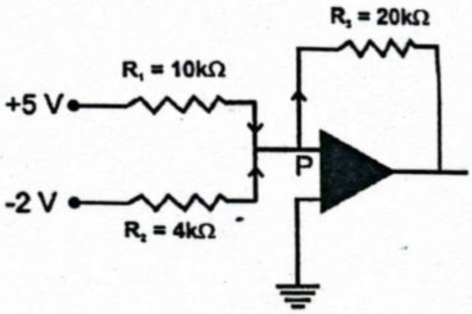
To find:

Output voltage = V_o = ?

Calculations:

$$\text{Current through } R_1 = I_1 = \frac{V_1 - 0}{R_1} = \frac{5-0}{10\times10^3} = 0.5\times10^{-3}\,\text{A}$$

$$\text{Current through } R_2 = I_2 = \frac{V_2 - 0}{R_2} = \frac{-2-0}{4\times10^3} = -0.5\times10^{-3}\,\text{A}$$



$$\text{Current through } R_3 = I_3 = \frac{V_3}{R_3} \quad I_3 = \frac{V_3}{R_3} = \frac{V_o - 0}{R_3} = \frac{V_o}{20\times10^3}$$

$$= (0.05\times10^{-3}V_o)\,\text{A}$$

Applying Kirchhoff's rule, at point P, we have

$$I_1 + I_2 = I_3$$

Putting the values, we get

$$0.5\times10^{-3} + (-0.5\times10^{-3}) = 0.05\times10^{-3}\times V_o$$

$$0 = 0.05\times10^{-3}\,V_o$$

or $\boxed{V_o = 0}$

18.5 Calculate the gain of non-inverting amplifier shown in Fig. P. 18.5.

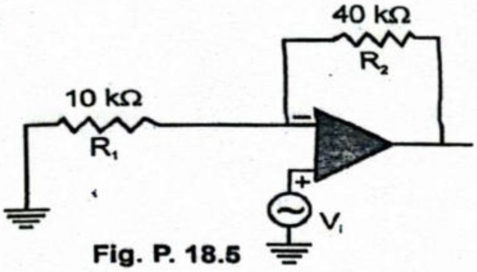


Fig. P. 18.5

Given data:

$R_1 = 10\ \text{k}\Omega = 10\times10^3\ \Omega$

$R_2 = 40\ \text{k}\Omega = 40\times10^3\ \Omega$

To find:

Gain = G = ?

Calculations:

As the gain of non-inverting amplifier is

$$G = 1 + \frac{R_2}{R_1}$$

Putting values, we get

$$G = 1 + \frac{40\times10^3}{10\times10^3}$$

$$G = 1 + 4$$

$$\boxed{G = 5}$$

18.6 Calculate the gain of an amplifier in which the collector resistance R_C is 5 kΩ. The input resistance between the base and emitter of a typical transistor is 2.5 kΩ and value of its β = 100.

Given data:

Collector resistance = 5 kΩ

$R_C = 5\times10^3\ \Omega$

The input resistance between the base and emitter = r_{ie} = 2.5 kΩ

$r_{ie} = 2.5\times10^3\ \Omega$

To find:

Gain of amplifier = A = ?

Calculations:

As gain of amplifier is

$$A = -\beta \frac{R_C}{r_{ie}}$$

Putting the values, we get

$$A = -\frac{100 \times 5 \times 10^3}{2.5 \times 10^3}$$

$$\boxed{A = -200}$$

* * *

MCQ's From Past Board Papers

1. **The colour of light emitted by a LED depends on**
(a) Its forward bias voltage (b) Its reverse bias voltage
(c) Amount of current (d) Type of semi conductor material

2. **P side is earthed and N side is given -2v then diode will**
(a) Partially conduct (b) breakdown (c) Conduct (d) not conduct

3. **The electrical circuit used to get smooth D.C output from rectifier is**
(a) Amplifier (b) oscillator (c) Filter (d) All

4. **If R_1 is infinity and R_2 is zero then gain of non inverting amplifier is**
(a) 0 (b) infinity (c) 1 (d) 2

5 **If $I_c = 4mA$ and $\beta = 95$ then I_E is**
(a) 4.1mA (b) 4.02mA (c) 4.4mA (d) 4.042mA

6. **In night switch op-amplifier is used as**
(a) Inverting amplifier (b) non inverting amplifier (c) Comparator (d) none of these

7. **When the p-n junction is forward biased, current flows through it is of the order of:**
(a) Few mono-amperes (b) Few milli-amperes (c) Few amperes (d) Few micro-amperes

8. **A diode characteristics curve is a plot between:**
(a) Current and resistance (b) Voltage and time (c) Voltage and current (d) Current and time

9. **A photo-diode can switch its current ON and OFF in:**
(a) Pico-seconds (b) micro-seconds (c) nano-seconds (d) milli-seconds

10. **Identify the sensors among the following**
(a) Microphone (b) NAND gate (c) LDR (d) all of these

11. **Ratio of I_C to I_B is nearly equal, and is known as**
(a) Reverse Bias Current (b) Forward bias current (c) Emitter Current (d) Current Gain

12. ***What is potential barrier of silicon diode at room temperature***
(a) 0.3v (b) 0.7v (c) 1v (d) 2mv

13. **What will be output value of an OR gate when both switches are open**
(a) 0 (b) 1 (c) Both a and b (d) None

14. **Common – Emitter amplification factor β is given by**
(a) $\frac{I_c}{I_E}$ (b) $\frac{I_c}{I_B}$ (c) $\frac{I_E}{I_B}$ (d) $\frac{I_B}{I_E}$

15. **In which of following gates, output is one. When both inputs are zero**
(a) OR (b) AND (c) NOT (d) NOR

16. **Mathematical relation for NOR operation**
(a) $x=\overline{A.B}$ (b) $x=\overline{A+B}$ (c) $x=\overline{A}.B$ (d) $x=A.\overline{B}$

17. **Voltage gain of no – inverting amplifier**
(a) $G=1-\frac{R_2}{R_1}$ (b) $1+\frac{R_2}{R_1}$ (c) $-\frac{R_2}{R_1}$ (d) None

18. **A single PN junction cannot be used as**
(a) Rectifier (b) Detector (c) Source of Light (d) Amplifier

Answers Key

1.	d	2.	c	3.	c	4.	c	5.	d
6.	c	7.	b	8.	c	9.	c	10.	a
11.	d	12.	b	13.	a	14.	b	15.	d
16.	b	17.	b	18.	d				

IMPORTANT PREVIOUS BOARDS SHORT QUESTIONS

1. Define open loop gain of an operational amplifier and write its formula. **(Mtn GII 2018) (Lhr GI 2018)**
2. Draw diagram of exclusive OR gate and write its formula. **(Lhr GI 2018)**
3. Why ordinary silicon diodes do not emit light? Explain.
(D.G.Khan GI 2018) (Mtn GII 2018) (Azad Kashmir 2018) (Sgd GI 2018) (Lhr GI 2018)
4. How the *current* flows in forward and reverse biased diode? **(Lhr GII 2018)**
5. The input of a gate are 1 and 0 identify the gate if its output is: **(Lhr GII 2018)**
6. What is the effect of Forward Biasing and Reverse Biasing of Diode on the width of Depletion Region?
(Rwp 2018) (Bwp GI 2018)
7. Draw the Symbol of Exclusive OR Gate and write its Truth Table. **(Bwp GI 2018)**
8. Why is a Photo - Diode operated in Reverse Biased State? **(Bwp GI 2018)**
9. What is OR Gate? **(Bwp GII 2018)**
10. Why is Base Current in a Transistor is very small? **(Bwp GII 2018) (Mtn GI 2018)**
11. Define Digital System and Logic Gates. **(Bwp GII 2018) (D.G.Khan GI 2018)**
12. What is the net charge on a n-type or a p-type substance? Explain. **(D.G.Khan GI 2018) (D.G.Khan GII 2018)**
13. Why charge carriers are not present in the depletion region?
(Rwp 2018) (Sgd GII 2018) (Swl 2018) (D.G.Khan GII 2018) (Mtn GI 2018)
14. What is meant by forward and reverse biasing of a semi-conductor diode? **(D.G.Khan GII 2018)**
15. The anode of a diode is 0.2 positive with respect to its cathode. Is it forward biased? **(Fsd 2018) (Mtn GI 2018)**
16. What is meant by forward biasing and reverse biasing of p-n junction? **(Grw 2018)**
17. Write the truth table of NAND gate. **(Mtn GII 2018)**
18. What is AND Gate. **(Sgd GI 2018)**
19. Define Forward Bias and Reversed Bias. **(Sgd GI 2018)**
20. Define rectification. Draw a circuit diagram of half wave rectifier. **(Sgd GII 2018)**
21. What do you know about Light emitting diode? **(Sgd GII 2018)**
22. What is AND gate? Write its truth table. **(Swl 2018)**

23. What is photodiode? Write down its any two applications. **(Rwp 2018)**

24. What is photovoltaic cell? How it works? **(Azad Kashmir 2018)**

25. Write down any two characteristics of operational amplifier. **(Azad Kashmir 2018) (Swl 2018)**

IMPORTANT PREVIOUS BOARDS LONG QUESTIONS

Q1. The current flowing into the base of a transistor is 100μA. Find the ratio $\frac{I_C}{I_E}$, if the value of current gain β is 100.
(Grw 2018) (Swl 2018) (Lhr GI 2018)

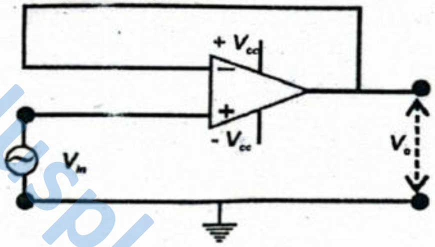
Q2. Fig Exercise Numerical 18.2. shows a transistor which operates a relay as the switch s is closed. The relay is energized by a current of 10 mA. Calculate the value R_B which will just make the relay operate. The current gain β of the transistor is 200. When the transistor conducts, its V_{BE} can be assumed to be 0.6 V. **(Lhr GII 2018)**

Q3. What are N-Type materials? How can these be obtained? Explain. **(Bwp GI 2018)**

Q4. What is an Amplifier? Discuss action of a transistor as a voltage amplifier. Also derive formula for voltage gain. **(Bwp GI 2018)**

Q.5 In the circuit shown in the fig form exercise numerical 18.3 below, there is negligible potential drop between B and E. Calculate.
(i) Base current (ii) Potential drop across R_C (iii) V_{CE} **(D.G.Khan GI 2018)**

Q6. Find the gain of the circuit as shown in given figure. **(D.G.Khan GII 2018)**



Q7. How operational amplifier can be used a inverting and non-inverting amplifier? Derive their gain. **(Fsd 2018)**

Q8. What is meant by Rectification? Explain the action of semiconductor diode as full wave rectifier. **(Mtn GI 2018)**

Q9. Calculate the gain of non-inverting amplifier shown in figure. **(Mtn GII 2018)**