<Chapter-I>

Introduction to Electronics

→ The word electronics derives its name from 'electron' present in all material.

→ So the branch of Engineering which deals with current conduction through a vacuum or gas or semiconductor is known as 'electronics'.

Signals :-

We can define signal as

→ "Any function of one or more independent variables which contains some information is called a signal".

→ Generally signal is a time varying quantity.

→ Signals contains information about variety of things & activities of our physical world.

→ In daily life we come across several electrical signals such as Radio signal, T.V signal, Computer signal etc.

One Dimensional Signal :-

When the function depends on a single variable, the signal is said to be one-dimensional signal.

Multidimensional Signal :-

When the function depends one two or more variables, the signal is said to be multi dimensional.

Classification

In electrical sense, the signal can be voltage or current. The voltage & current is the function of time as independent variable.

Q/ Find the fundamental period of the following signals

(a) $\sin 15\pi t$ (b) $\sin 20\pi t$

(a)

$x(t) = \sin 15\pi t$

$x(t) = \sin \omega t$

$\omega = 15\pi$

$\Rightarrow 2\pi f = 15\pi$

$\Rightarrow f = \frac{15}{2} = 7.5\ Hz$

$T = \frac{1}{f} = \frac{1}{7.5} = 0.133\ sec.$

(b) $x(t) = \sin 20\pi t$.

$\omega t = 20\pi t$

$\Rightarrow \omega = 20\pi$

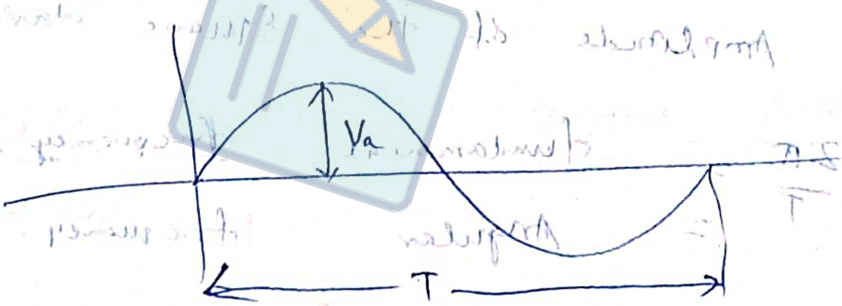
$\Rightarrow 2\pi f = 20\pi$

$\Rightarrow f = 10$ Hz

$T = \frac{1}{f} = \frac{1}{10} = 0.1$ second.

Frequency Spectrum of Signal:-

1) Using Mathematical Tools like Fourier Series & Fourier Transform we can represent a voltage $V_s(t)$ or current $i_s(t)$ as sum of sine wave signals of different frequency & amplitude.



V_a = Amplitude.

ω = Angular frequency.

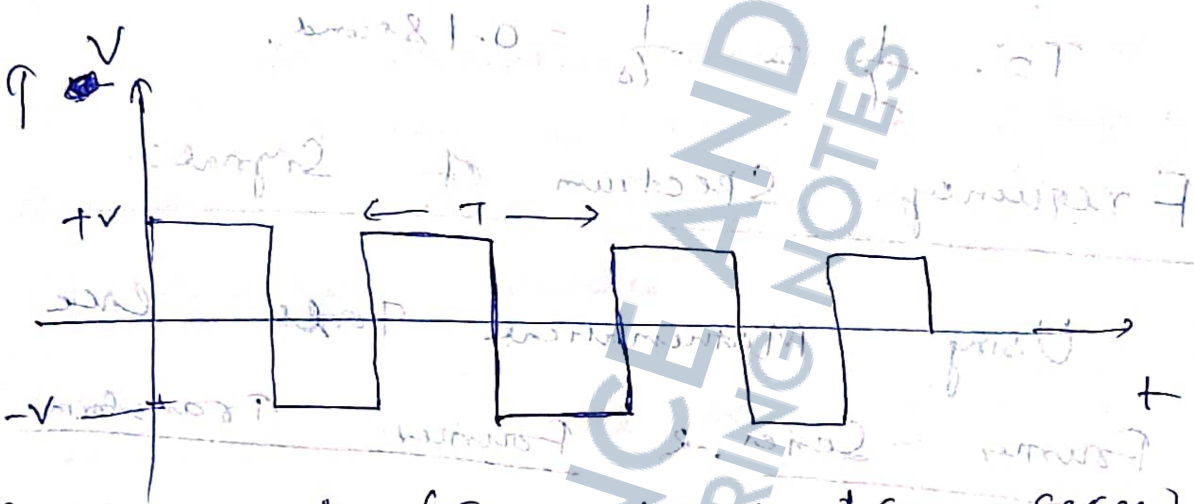
T = Time period of signal.

$\omega = 2\pi f = \frac{2\pi}{T}$. $\left(\because f = \frac{1}{T}\right)$

→ Fourier Series is for periodic signals.

→ Fourier transform is for both periodic and non periodic signals.

→ R.M.S Value = $\frac{\text{Peak value}}{\sqrt{2}} = \frac{V_a}{\sqrt{2}}$ (Here V_a = Peak Amplitude)

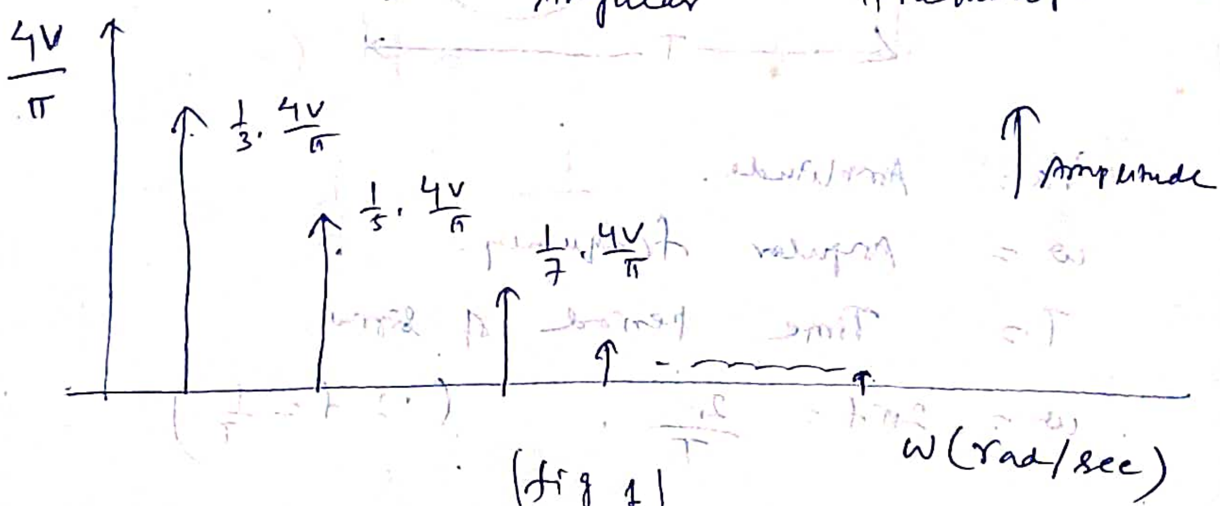


By the help of (Fourier transform / Fourier series) This symmetrical waveform can be represented as

$$v(t) = \frac{4V}{\pi}\left(\sin \omega_0 t + \frac{1}{3}\sin 3\omega_0 t + \frac{1}{5}\sin 5\omega_0 t + \cdots\right)$$

V = Amplitude of the Square wave

$\omega = \frac{2\pi}{T}$ = fundamental frequency.
= Angular frequency.



(fig 1)

(fig 1 :- The frequency spectrum of periodic square wave)

→ Fourier transform can be applied to a non periodic signal.

e.g.

BPUT Question 1) Find the frequency f & w of a sine wave signal with period of 1 ms.

Ans :- Data given, T = 1ms.

$$f = \frac{1}{T} = \frac{1}{1 \times 10^{-3}} = 10^3 = 1000 \text{ Hz}$$

$$w = 2\pi f = 2\pi \times 1000 = 2\pi \times 10^3 \text{ rad/sec.}$$

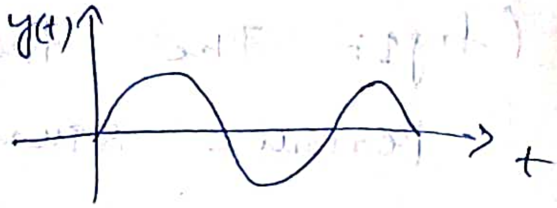
2/ Define Analog, Digital, discrete-time signal.

Ans :-

Analog Signal :-

The analog signal is that type of signal which varies continuously with certain interval of time.

e.g. $y(t) = \sin t$

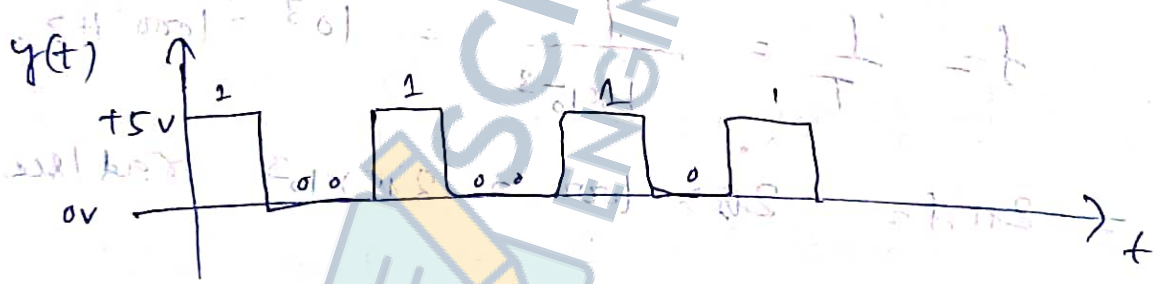


Note :- 1) The name (analog) derives from the fact that such a signal is analogous to the physical signal that is present.

2) The magnitude of amplitude of an analog signal can take any value.

Digital Signal :-

Digital signal is that type of signal which is represented a sequence of numbers i.e magnitude at an instant of time.



e.g :- Pulse train shown.

High = +5V (called logic 1)

low = 0V (called logic 0).

Discrete - Time Signal :-

If a signal is defined for certain specific interval of time, then it is called discrete-time signal.

The time instant / interval need not to be equidistant. But in practice they are usually taken at equal spaced interval for computational convenience.

e.g. $y(n) = \begin{cases} (0.2)^n, & \text{for } n \geq 0 \\ 0, & \text{otherwise} \end{cases}$

where n is an integer.

Conversion of Analog Signal to Digital Signals :-

Digital signal can be obtained from the analog signal by using an analog-to-digital converter (ADC).

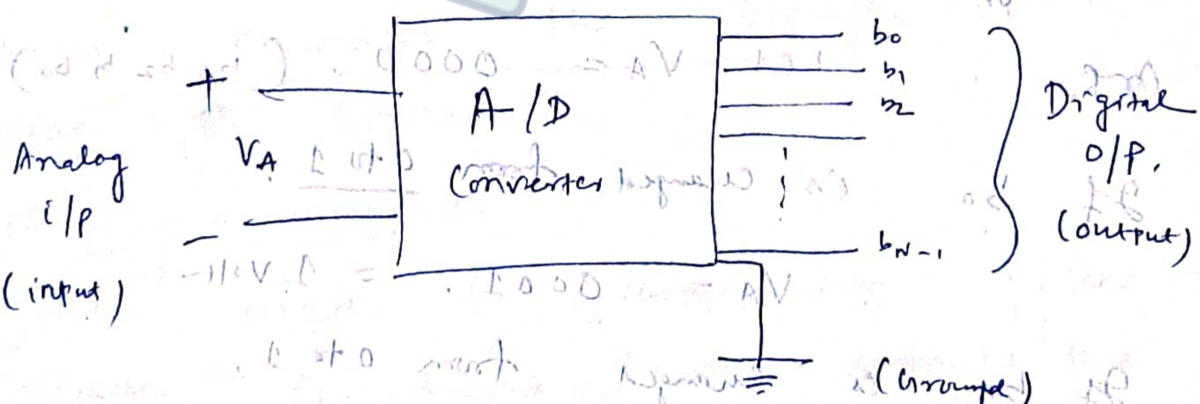


Fig:- Block diagram representation of analog-to-digital converter (ADC)

→ DAC → Digital to Analog Converter

→ DAC → It does the reverse of ADC, It converts digital signal into analog signal.

Q) Consider a 4 digit word $D = b_3 b_2 b_1 b_0$, used to represent analog signal V_A that varies betn 0 to 5V.

(a) Give D corresponding to V_A = 0V, 1V, 2V, 15V.

Ans:- 0 → 0000
1 → 0001
2 → 0010
15 → 1111

b) Which change in V_A causes a change from 0 to 1 in b_0, b_1, b_2, b_3.

Ans:- Let V_A = 0000. ($b_3 b_2 b_1 b_0$)

If b_0 is changed from 0 to 1:

V_A = 0001. = 1 Volt

If b_1 is changed from 0 to 1,

V_A = 0010 = 2 Volt.

If b_2 is changed from 0 to 1,

$V_A =$ ~~0100~~ 0100 = 4 V.

If b_3 is changed from 0 to 1,

$V_A =$ 1000 = 8 V.

(c) If $V_A = 5.2$ V, what do you expect D to be, what is the error?

Ans :- ~~D will be 5 V.~~

Let $V_A = 5$ V

D will be = 0101.

$$\text{error} = \frac{5 - 5.2}{5} = \frac{-0.2}{5} = -4\%.$$

Amplifier :-

An amplifier is an electronic device which increases the strength of a weak signal.

Need of amplification :-

The need for amplification arises because transducers provide signals that are said to be weak i.e in the micro volt (μV) or milli volt (mV) range and possessing little energy. Such signals are too small for reliable processing.

→ Linearity in the amplifier should be taken care of, so that information contained in the signal is not changed or no new information is introduced.

→ An amplifier that preserves the details of the signal waveform is characterized by the relationship,

$$V_o(t) = A \cdot V_i(t) \quad \text{--- (1)}$$

→ 'A' is a constant representing the magnitude of amplification, known as amplifier gain.

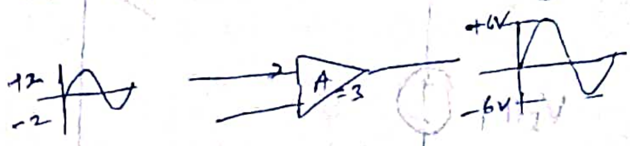
→ The equation (1) is a linear relationship, hence the amplifier describes a linear amplifier.

→ If $V_o(t) = A \cdot V_i^2(t)$

it is a non-linear amplifier.

If the power of $V_i(t)$ is 1 then it is linear else it is non linear amplifier.

Ex :- The pre-amplifier in the home stereo system is an example of voltage amplifier.

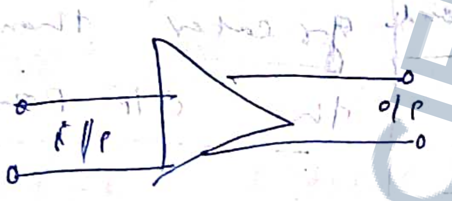


Power Amplifier :- in the home stereo system

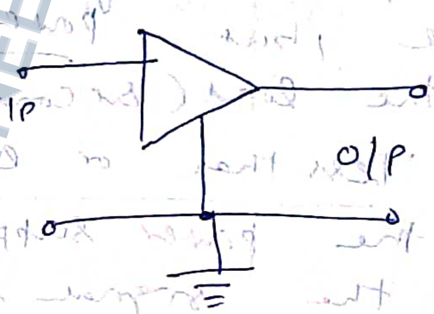
e.g. Power amplifier provides sufficient power to drive the loud speaker, which is a amplifier load.

∴ Power amplifier provide (medium) modest amount of voltage gain but substantial current gain. (i.e. High current gain).

Amplifier Ckt. Symbol:-



(a) < Ckt symbol for Amplifier >

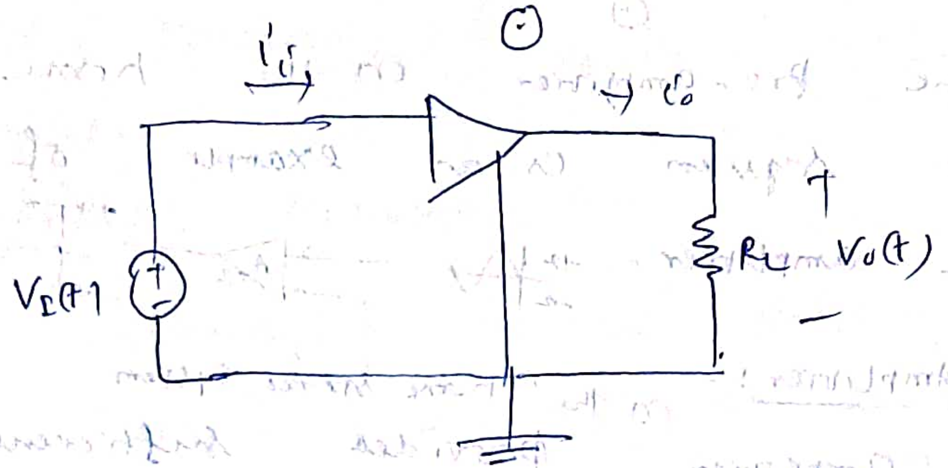


(b) < An amplifier with common terminal grounded between i/p and o/p ports >

Voltage gain :-

It is ratio of o/p voltage to the i/p voltage.

$$A_v = \frac{V_o}{V_i}$$



Difference b/w transformer / Amplifier :-

Transformer	Amplifier
1) In transformer voltage delivered to the load could be greater than voltage feeding i/p side, but power delivered to the load (secondary) is less than or equal to the power supplied by the signal source. i.e Power remains constant $V_1 I_1 = V_2 I_2$.	1) But in power amplifier, the o/p power is always greater than the i/p power.

$$\text{Power gain } (A_P) = \frac{\text{Load power}}{\text{i/p Power}}$$

$$= \frac{\text{o/p power}}{\text{i/p power}}$$

$$= \frac{V_o I_o}{V_I I_I}$$

$$A_P = \frac{V_o I_o}{V_I I_I}$$

$$= \left(\frac{V_o}{V_I}\right) \cdot \left(\frac{I_o}{I_I}\right)$$

$$A_P = A_V \cdot A_I$$

Power gain = Voltage gain × Current gain

↳ If A_P, A_V, A_I not in dB.

Expressing in dB

Voltage gain in dB = $20 \log |A_V|$ dB

Current gain in dB = $20 \log |A_I|$ dB.

power gain in dB = $10 \log |A_P|$ dB.

Amplifier efficiency:-

$$\text{efficiency } (\eta) = \frac{P_L}{P_{dc}} \times 100 = \frac{P_o}{P_{dc}} \times 100$$

P_L = ~~Load~~ ~~po~~ Power supplied to the load.

P_{dc} = DC Power supplied to the amplifier.

P_o = O/P power.

Ex:- 1.1 (Sedra/Smith)

Q) Consider an amplifier operating from ±10V power supplies. It is fed with sinusoidal voltage having 1 V peak & delivers a sinusoidal voltage o/p 9V peak to 1 kΩ load. The amplifier draws a current of 9.5 mA from each of its 2 power supplies. The i/p current of the amplifier is found to be sinusoidal with 0.1 mA peak. Find the voltage gain, current gain, power gain & power ~~delivered~~ drawn from the d/c supplies, power dissipated in the amplifier and amplifier efficiency.

Ans :-

(a) A_v = voltage gain.

$$A_v = \frac{\text{o/p voltage}}{\text{i/p voltage}} = \frac{9\,V}{1\,V} = 9.$$

$$(A_v)_{dB} = 20 \log 9 = 19.08\ dB.$$

(b) A_I = current gain $= \frac{I_o}{I_i}$

$$I_o = \frac{V_o}{R_L} = \frac{9\,V}{1\,k\Omega} = 9\ mA$$

$$I_i = 0.1\ mA$$

$$A_I = \frac{9\ mA}{0.1\ mA} = 90.$$

$$(A_I)_{dB} = 20 \log 90 = 39.1\ dB.$$

(c) A_p = Power gain.

$$A_p = \frac{P_L}{P_I} = \frac{\text{power at the load}}{\text{I/P power}}$$

$$P_L = V_{orms} \cdot I_{orms} = \frac{9}{\sqrt{2}} \cdot \frac{9\ mA}{\sqrt{2}} = 40.5\ mW$$

$$P_I = V_{I\,rms} \cdot I_{I\,rms} = \frac{1}{\sqrt{2}} \times \frac{0.1\ mA}{\sqrt{2}} = 0.05\ mW$$

$$A_p = \frac{P_L}{P_I} = \frac{40.5}{0.05} = 810$$

$$(A_p)_{dB} = 10 \log A_p = 10 \log 810 = 29.1\ dB.$$

(d) Power drawn by dc supplies

$$P_{dc} = V_1 I_1 + V_2 I_2$$

$$= 10 \times 9.5 + 10 \times 9.5$$

$$= 95 + 95$$

$$= 190\ mWatt.$$

(e) Power dissipated in the amplifier

$P_{dissipated} = P_{dc} + P_I - P_L$

$= 190 + 0.05 - 40.5$

$= 149.55$

$\simeq 149.6$ mwatt.

(f) Amplifier efficiency

$\eta = \frac{P_L}{P_{dc}} = \frac{40.5}{190} \times 100 = 21.3\%$.

B.PUT 2008

Q) An amplifier operating from ± 3 V supplies provides a 2.2 V_{p-p} sine wave across a $100\,\Omega$ load, when provided with $0.2 V_{p-p}$ input from which 1.0 mA peak is drawn. The avg. current in each supply is measured to be 20mA. Find the voltage gain, current gain, & power gain expressed in dB. Find the supply power, amplifier dissipation and amplifier efficiency.

Ans: (a) $A_V = \frac{\text{o/p voltage}}{\text{i/p voltage}}$

$\Rightarrow A_v = \dfrac{2.2}{0.2} = 11$

$(A_v)_{dB} = 20 \log 11 = \boxed{20.827 \text{ dB}}$

(b) Ans

$\text{Current gain} = \dfrac{\text{o/p current}}{\text{i/p current}}$

$I_o = \dfrac{V_o}{I_o} = \dfrac{2.2\text{V}}{100} = 22 \text{ mA}.$

$A_I = \dfrac{I_o}{I_I} = \dfrac{22 \text{ mA}}{1.0 \text{ mA}} = 22.$

$(A_I)_{dB} = 20 \log 22 = \boxed{26.848} \text{ dB}.$

(c) ~~$A_p = \dfrac{V_o I_o}{V_I \cdot I}$~~

$A_p = \dfrac{V_o I_o}{V_I \cdot I_I} = \dfrac{\text{O/P power}}{\text{i/p power}}$

$P_o = \text{O/p power} = V_{orms} \times I_{orms} = \dfrac{2.2}{\sqrt{2}} \times \dfrac{22 \text{mA}}{\sqrt{2}}$

$= 24.2 \text{ mW}$

$P_I = \text{i/p power} = V_{irms} \times I_{irms} = \dfrac{0.2}{\sqrt{2}} \times \dfrac{1 \text{mA}}{\sqrt{2}}$

$= 0.1 \text{ mWatt}$

$A_p = \dfrac{24.2}{0.1} = 242$

$(A_P)_{dB} = 10 \log 242$

$= 23.838$

(d) Supply power

$P_{dc} = V_1 I_1 + V_2 I_2$

$= 3 \times 20\,mA + 3 \times 20\,mA$

$P_{dc} = 120$ mwatt.

(e) $P_{dissipated} = P_{dc} + P_I - P_o$

$= 120 + 0.1 - 24.2$

$P_{dissipated} = 95.9$ m watt.

(f) Amplifier Efficiency

$\eta = \frac{P_L}{\text{Supply power}} = \frac{P_o}{P_{dc}}$

$= \frac{24.2}{120} \times 100$

$\eta = 20.16\ \%$.

Q) BPUT An amplifier has current gain of 60 dB & power gain of 50 dB. Find its voltage gain.

Ans :- $A_P = A_V \cdot A_I$

$20 \log A_P = 20 \log (A_V \cdot A_I)$

$\Rightarrow 20 \log A_P = 20 [\log A_V + \log A_I]$

$\Rightarrow 2 \times 10 \log A_P = 20 \log A_V + 20 \log A_I$

$\Rightarrow 2 \times (A_P)_{dB} = (A_V)_{dB} + (A_I)_{dB}$

$\Rightarrow 2 \times 50 = (A_V)_{dB} + 60$

$\Rightarrow (A_V)_{dB} = 100 - 60 = 40 \text{ dB}$ (Ans).

Q BPUT A signal of 100 mV is fed to an amplifier which produces o/p of 8.5 volt. Find its voltage gain in dB.

Ans :- $V_i = 100 \text{ mV}$

$V_o = 8.5 \text{ V}$.

$A_V = \frac{V_o}{V_i} = \frac{8.5}{100 \times 10^{-3}} = \frac{8.5 \times 1000}{100} = 85.$

$(A_V)_{dB} = 20 \log 85 = 38.6 \text{ dB}.$

Q BPUT:-

A periodic digital waveform has pulse width 25 μs & period of 150 μs. Determine freq & duty cycle.

Ans→ Duty cycle = $\frac{\text{Pulse width}}{\text{Time period}}$

$= \frac{25\,\mu s}{150\,\mu s}$

$= \frac{1}{6} = 16.66\,\%$.

$f = \frac{1}{T} = \frac{1}{150 \times 10^{-6}} = \frac{10^3 \times 10^3}{150} = 6.66\ KHZ$.

Q BPUT.

An amplifier has voltage gain 100 V/V & current gain 1000 A/A. Express current & voltage gain in dB & find the power gain.

Ans→ $(A_V)_{in\ dB} = 20 \log 100 = 20 \times 2 = 40\ dB$.

$(A_I)_{in\ dB} = 20 \log 1000 = 20 \times 3 = 60\ dB$.

~~$A_P = A$~~ $A_P = A_V \cdot A_I$

$A_P = 100 \times 1000 = 10^5$.

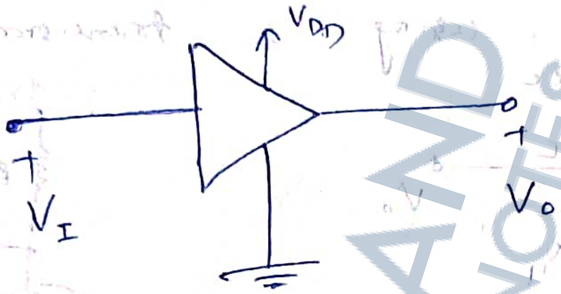
$(A_P)_{in\ dB} = 10 \log 10^5$

$= 10 \times 5$

$= 50\ dB$

Digital Inverters: -

It inverts the logic value of its input signal. For logic 0 o/p will be logic 1 & for logic 1 o/p will be logic 0.



V_I	V_o
0	1
1	0

I/P		O/P
0	→	1
1	→	0

Input: -

Q) Which of the following signals are along

(i) O/P of CE Amplifier.

(ii) O/P of NAND gate

(iii) O/P of a Flip Flop.

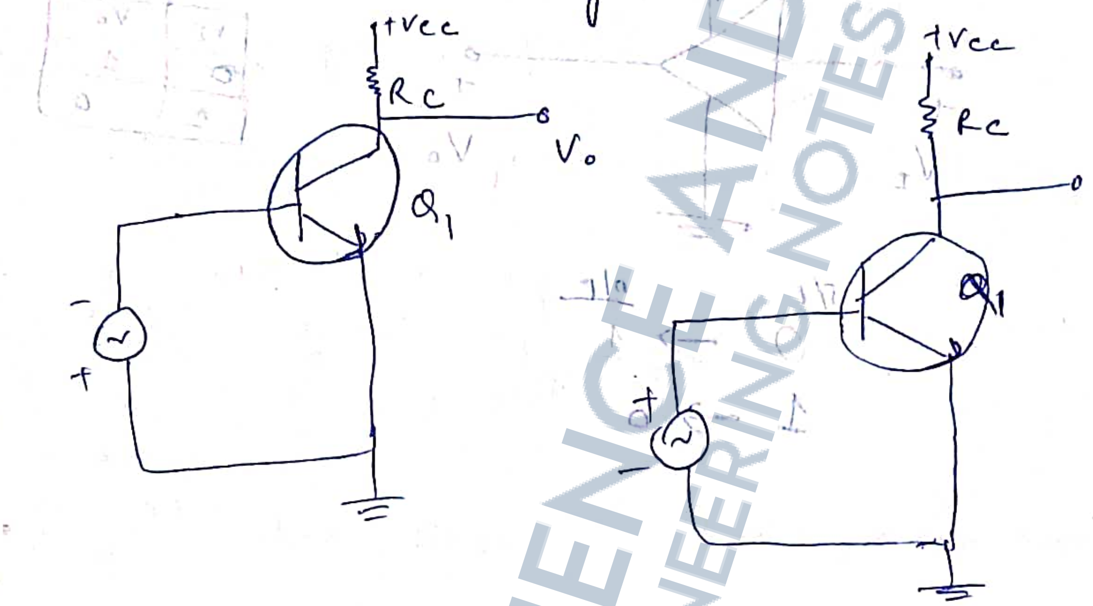
Ans ÷ (i)

P.T.O

Q BPUT

1) Can you make logic inverter using a transistor ? Justify.

Ans : Yes, we can make a logic inverter using a transistor.



(a) (b)

→ when we give i/p as low (logic 0) in fig(a), transistor Q_1 is off. $I_C = 0$ (collector current is 0)

$$I_C = 0$$

$$V_{CE} = V_{CC} - I_C R_C$$

$$\Rightarrow V_0 = V_{CC} - 0$$

$$\Rightarrow V_0 = V_{CC}$$

∴ O/P is logic 1. (V_{CC})

∴ When i/p is 0, o/p is 1 :

Refering to fig (b)

When we give high i/p logic(1), the transistor Q_1 is on. I_c (collector current) is maximum.

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

$$V_o \cong 0$$

∴ o/p is 0.

When i/p is 1, o/p is 0.

Thus the transistor can work as a logical inverter.