1) A beam of light moves from one medium to another medium with less density. The critical angle is 60°. Do we have reflection for each of the following incident angles? Show the bending of the light rays in each case.

Sum 18 | 7M

(i) 40°
(ii) 60°
(iii) 80°

Sol^n → Given :- Critical angle = 60°.

(i) 40° degrees :-

- The incident angle (40°) is smaller than the critical angle (60°).
- We have the refraction
- The light rays enters into the less dense medium as shown in the figure below:-

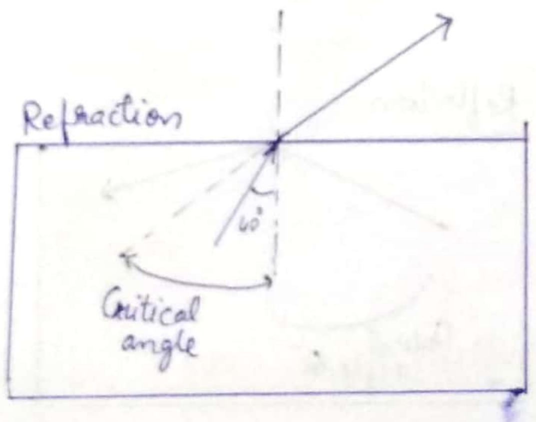


Fig a: 40 degrees

(ii) 60° degree :-

- The incident angle (60°) is the same as the critical angle.
- We have the refraction.
- The light ray ~~on returns back to the more~~ travels along the surface. ~~dense medium~~.

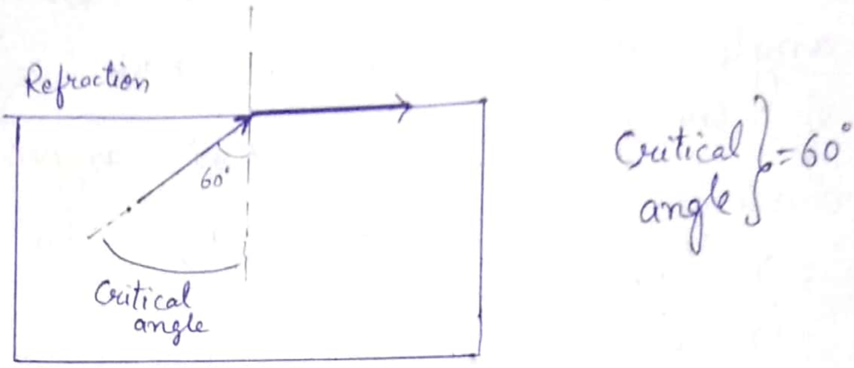


Fig b: 60 degrees

(iii) 80° degree :-

- The incident angle (80°) is greater than the critical angle (60° degrees).
- We have reflection.
- The light ray returns back to the more dense medium.

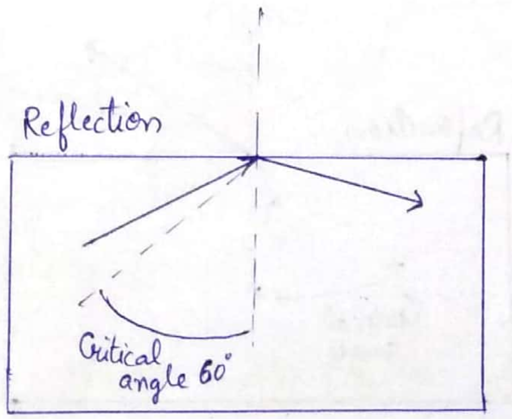


Fig c: 80° degrees

2) Two channels one with bit rate of 190 kbps and another with bit rate of 180 kbps are to be multiplexed using pulse stuffing TDM with no synchronization bits.

(i) What is the frame rate? [Sum 18]

(ii) What is the size of frames in bits?

(iii) What is the duration of a frame? [7M]

(iv) What is the data rate?

Sol:→

- Given: First source bit rate = 190 kbps
  & Second source bit rate = 180 kbps.
- The following figure shows the pulse stuffing in TDM.

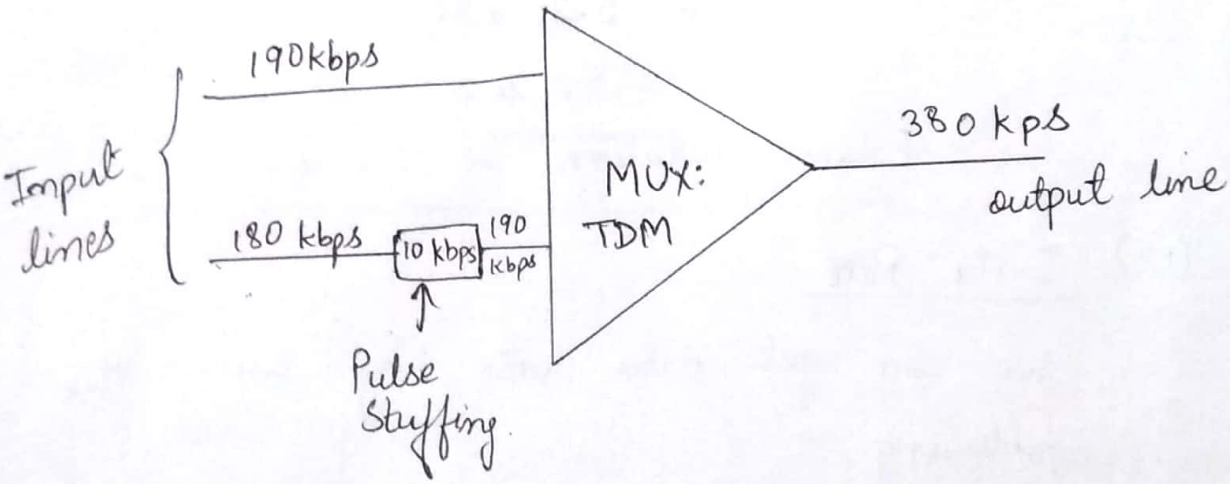


Fig:- TDM with pulse stuffing.

- Extra bits are added to the second source to make both rates = 190 kbps

(i) Frame rate: Each frame carries 1 bit from each source (190 kbps).

∴ Frame rate = ~~190 kbps~~ 190 kbps = 190 x 1000 bps
⇒ 190000 frames/s.

(ii) Size of ~~the~~ a frame :-

- The frame carries one bit from each source.
- ∴ Frame size = 1 + 1 = 2 bits.

(iii) Duration of a Frame :-

- We can get frame duration by using the formula :-

$$\text{Frame duration} = \frac{1}{\text{frame rate}}$$

$$= \frac{1}{190000}$$

$$= 5.2 \times 10^{-6} s$$

$$= 5.2 \mu s$$

∴ Frame duration is 5.2 μs.

(iv) Data Rate :-

We can get data rate by using the following :-

$$\text{Output data rate} = \text{frame rate} \times \text{frame size}$$

$$= 190000 \times 2 = 380000$$

∴ Data Rate ⇒ 380 kbps

Here the output bit rate is greater than the sum of input rates (370 kbps) because of extra bits added to the second source.

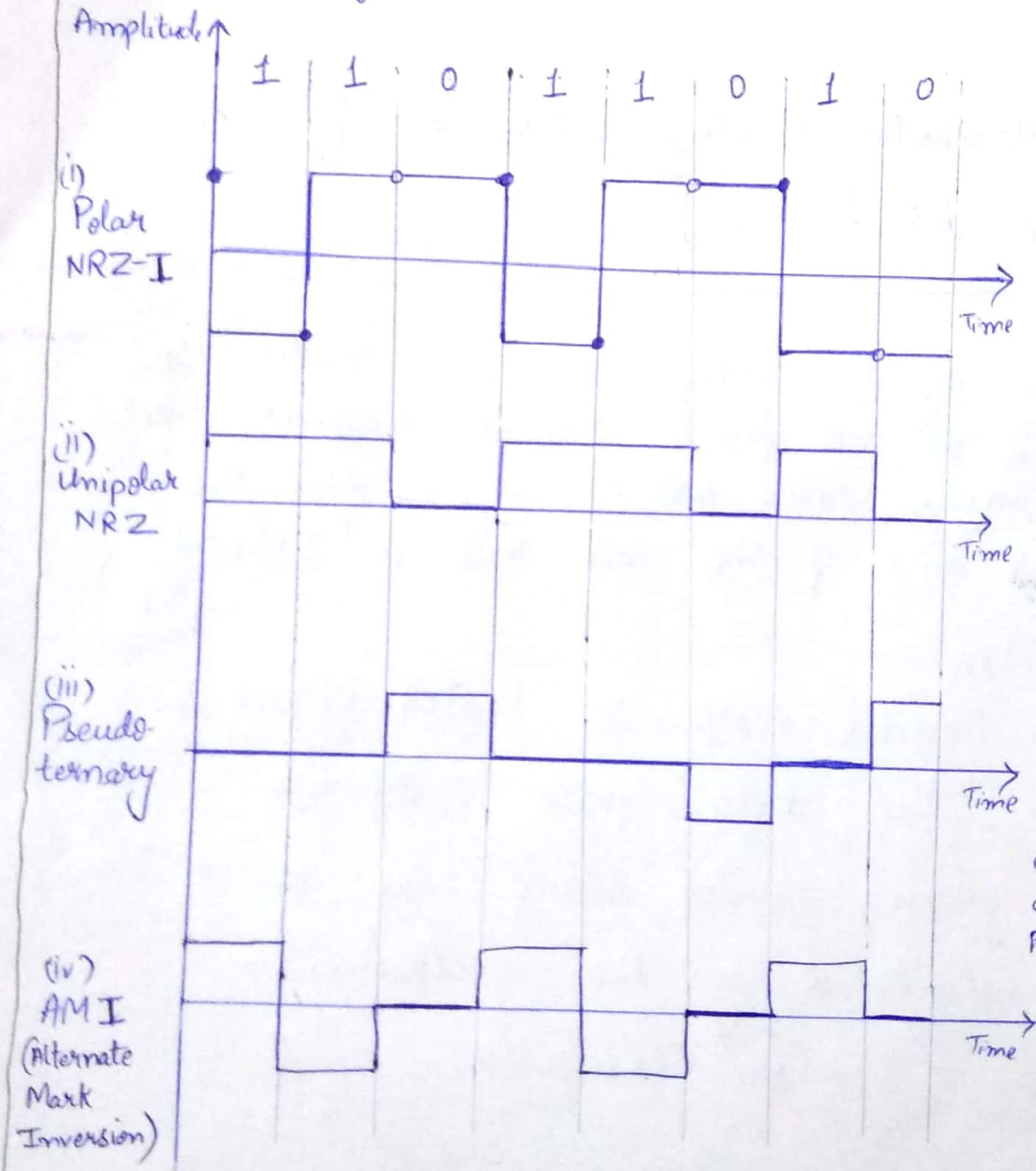
3) Digital data 11011010 is to be transmitted. Draw resulting wave forms of the following method.

(i) Polar NRL - I (ii) Unipolar NRZ
(iii) Pseudoternary (iv) AMI
(v) Manchester.

Win 17 | 7M

Sol^n:-

Given digital data = 1 1 0 1 1 0 1 0



The change or lack of change determines the bit.
o No Inversion: Bit 0
• Inversion: Bit 1

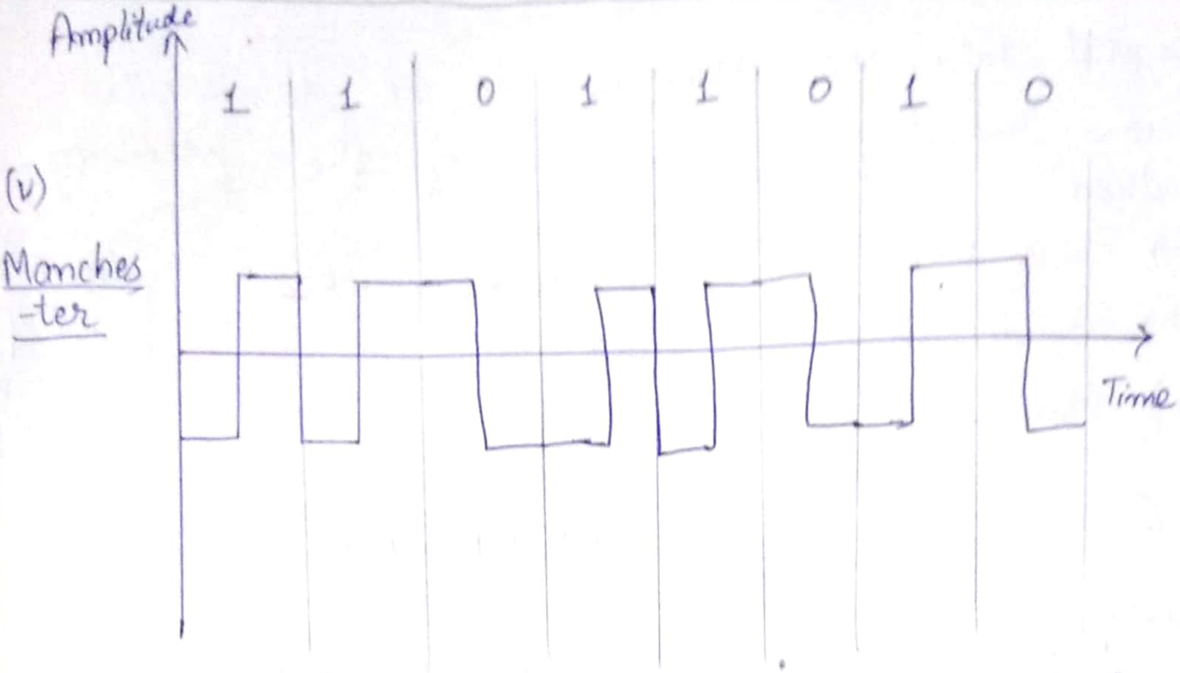
Positive voltage defines bit 1 & zero voltage defines bit 0

Bit 1 is encoded as zero voltage & Bit 0 is encoded as alternating positive & negative voltages

Bit 1 is encoded as alternating positive & negative voltages & Bit 0 as zero voltage.

P.T.O

(v) Manchester



In Manchester encoding 0 bit is ⎿ & the bit 1 is ⏌.

4) In a digital transmission, the sender clock is 0.2 percent faster than the receiver clock. How many extra bits per second does the sender send if the data rate is 1 Mbps? [7M]

Solⁿ:-

Given :-

- Sender Clock is faster by 0.2 %.
- The data rate = 1 Mbps.

By given, sender clock can be calculated by the following :-

∴ Sender Clock faster = 0.2 %

$$= \frac{0.2}{100}$$

$= 0.002$

- The data rate in seconds can be calculated by :→ 1 Mbps

$= 1 \times 10^6$ bps

$= 10^6$ bps ($\cancel{1000000}$

∴ Data Rate = 1000000 bps

- Now, we can calculate extra bits per second that the sender sends.
- The extra bits can be obtained by the following :-

Extra bits $= 0.002 \times 1000000$

$= 2000$ bits.

- Therefore, the extra bits send per second are 2000 bits.

5) The telephone line has 4 kHz bandwidth. What is the maximum number of bits we can send using each of the following techniques? **8M**
let $d = 0$.
(i) ASK (ii) PSK (iii) QAM (iv) FSK.

Sol:

Given, ~~tel~~ The telephone line has the bandwidth $(B) = 4\,kHz$,
and $d = 0$.

No. of bits can be found by the following formula:-

$$B = (1+d) \cdot \frac{N}{r}$$

$$\therefore \boxed{N = \frac{B \times r}{(1+d)}}$$

where, B (the bandwidth) & d are given and r needs to be find out.
& N is the data rate

(i) <u>ASK</u>.

For ASK, $r = \log_2 2 = \log_2 2$

$\therefore r = 1$

$$\therefore N = \frac{B \times r}{(1+d)} = \frac{4 \times 1}{1+0}$$

$$= \frac{4}{1} = 4$$

$$\therefore \boxed{N = 4\,kbps}$$

(ii) **PSK :-**

For PSK, $r = \log_2 L = \log_2 2$

$\therefore r = 1$

$\therefore N = \frac{B \times r}{(1+d)} = \frac{4 \times 1}{1+0} = \frac{4}{1} = 4$

$\therefore \boxed{N = 4 \text{ kbps}}$

(iii) **QAM :-**

For QAM, $r = \log_2 L \Rightarrow \log_2 4$

$= \log_2 2^4$

$= 4 \cdot \log_2 2$

$= 4 \times 1$

$\therefore r = 4$

$\therefore N = \frac{B \times r}{(1+d)} = \frac{4 \times 4}{1+0} = \frac{16}{1} = 16$

$\therefore \boxed{N = 16 \text{ kbps}}$

(iv) **FSK :-**

For FSK, $r = \log_2 L = \log_2 2$

$\therefore r = 1$

$\therefore N = \frac{B \times r}{(1+d)} = \frac{4 \times 1}{1+0} = \frac{4}{1} = 4$

$\therefore \boxed{N = 4 \text{ kbps}}$

5) What is the number of bits per baud for the following techniques?

(i) ASK with four different amplitudes
(ii) FSK with 8 different frequencies
(iii) PSK with 4 different phases
(iv) QAM with a constellation of 128 points

Soln:-

- For the number of bits per baud is denoted by r.
- We can use the formula:

$$\boxed{r = \log_2 L}$$

where, L is the level which indicates type signal element.

(i) ASK with 4 different amplitudes:-

For ASK, $r = \log_2 4$
$= \log_2 2^2$
$= 2 \cdot \log_2 2$
$= 2 \cdot 1$
$\therefore r = 2$

$\therefore$ Here, the no. of bits per baud for ASK is 2.

(ii) FSK with 8 different frequencies:-

For FSK, $r = \log_2 8$
$= \log_2 2^3$
$= 3 \cdot \log_2 2$
$= 3 \cdot 1$
$\therefore r = 3$

$\therefore$ Here, the no. of bits per baud for FSK is 3.

(iii) PSK with 4 different phases :—

For PSK, $r = \log_2 4$

$= \log_2 2^2$

$= 2 \cdot \log_2 2$

$= 2 \cdot 1$

$\therefore r = 2$

$\therefore$ Here, No. of bits per baud for PSK is 2.

(iv) For QAM :—

$r = \log_2 128$

$= \log_2 2^7$

$= 7 \cdot \log_2 2$

$= 7 \cdot 1$

$\therefore r = 7$

$\therefore$ Here, the no. of bits for QAM is 7.

6) A non-periodic composite signal has a bandwidth of 200kHz with a middle frequency of 150 kHz. and peak amplitude 20V. Draw the frequency domain of signal.

Sol^n → Given: Total Bandwidth = 200 kHz

& Middle frequency = 150 kHz.

Peak amplitude = 20 V.

- First, we have to calculate the lowest and highest frequency.
- The frequencies on both sides of middle freq (150 kHz) can be obtained by :—

Frequencies on both sides of middle frequency $\Big\} = \frac{200}{2} = 100$

$\therefore$ Lowest frequency = middle frequency − 100
= 150 − 100
= 50 kHz.

& Highest frequency = middle frequency + 100
= 150 + 100
= 250 kHz.

- ~~As~~ The signal is a non-periodic composite signal with peak amplitude 20 V.
- Consider two extreme frequencies has 0 V.
- The frequency domain of the signal with 50 kHz (lowest frequency) and 250 kHz (highest frequency) is as follows :—

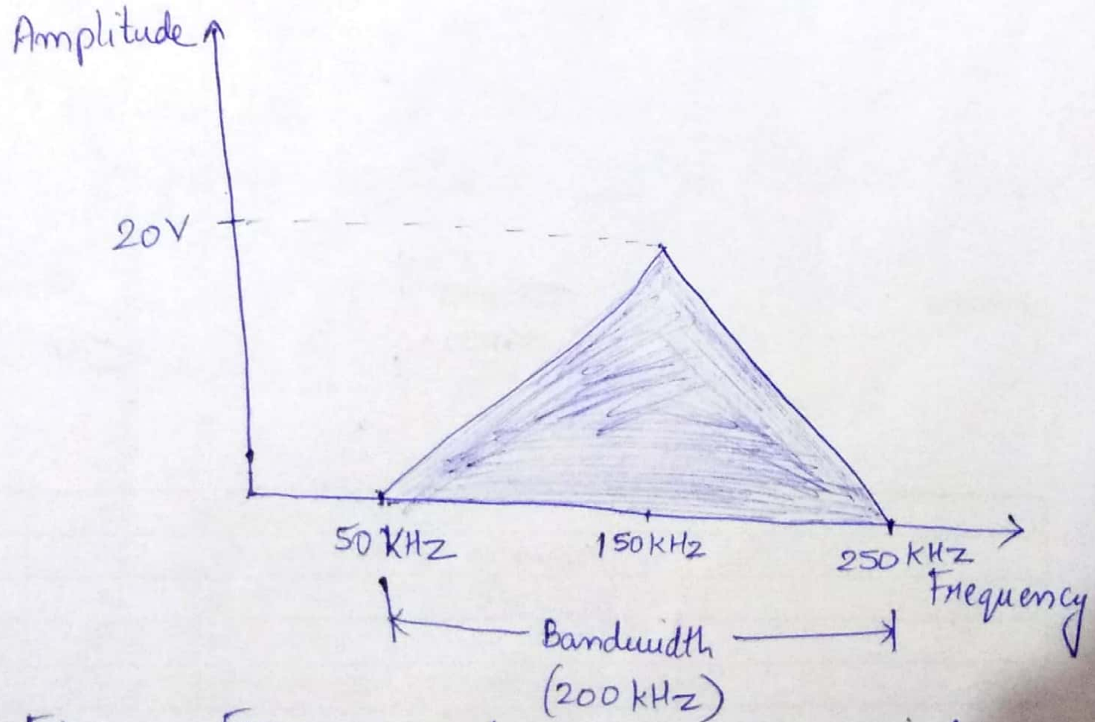


Fig:— Frequency domain of nonperiodic composite signal

7) Two periodic signals has bandwidth of 800 Hz with lowest frequency 100 Hz. Find the highest frequency & draw frequency spectrum. The peak amplitude is 10 V for lowest & highest frequency.

Sol.^{n} ⇒

Let f_h be the highest frequency,
f_l be the lowest frequency &
B the bandwidth.

Then, $\boxed{B = f_h - f_l}$

~~= 800~~

$\therefore f_h = B + f_l$

$f_h = 800 + 100$

$\therefore f_h = 900$ Hz.

∴ The highest frequency is 900 Hz,
lowest frequency is 100 Hz &
Bandwidth is 800 Hz.

∴ The frequency spectrum is as shown below:—

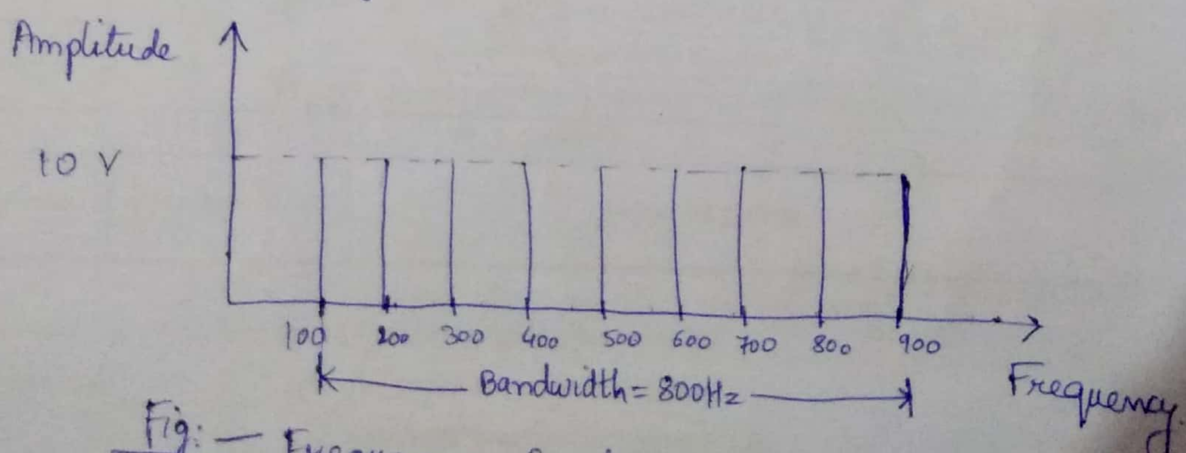


Fig:— Frequency Spectrum.

8) What is bandwidth of signal that can be decomposed into five sine waves with frequency at 0, 30, 40, 120 & 300 Hz ? All peak values are same. Draw bandwidth.

Sol^n :⇒

Given: Five sine waves with frequencies of 0, 30, 40, 120 & 300 Hz.

Let $f_h = 300$ Hz, $f_l = 0$ Hz

Bandwidth, $B = f_h - f_l$

$= 300 - 0$

$= 300$ Hz.

∴ The spectrum has five spikes for each frequency.

The bandwidth (or frequency spectrum) is shown below:—

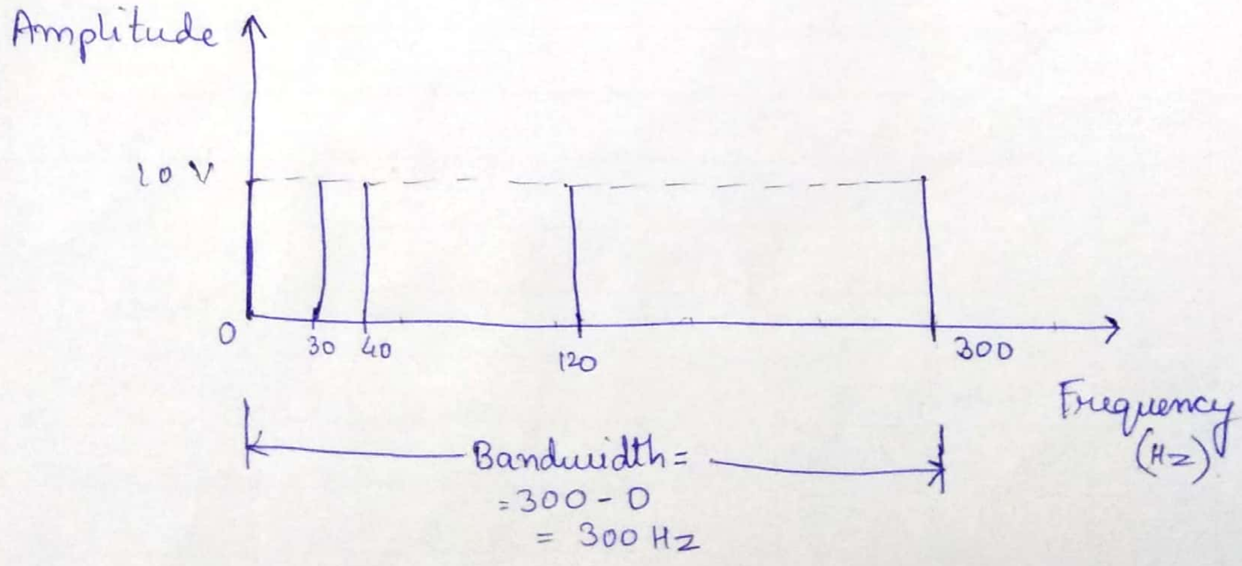


Fig: Bandwidth with peak amplitude 10 V

9) A non periodic composite signal contains frequency from 10 to 40KHz. The peak amplitude is 12V for the lowest and the highest signals and 30V for the 20 kHz signal. Assuming that the amplitudes change gradually from minimum to maximum, draw frequency spectrum.

Sol:→

The signal is non periodic, hence the frequency domain is made of a continuous spectrum as shown in figure below:→

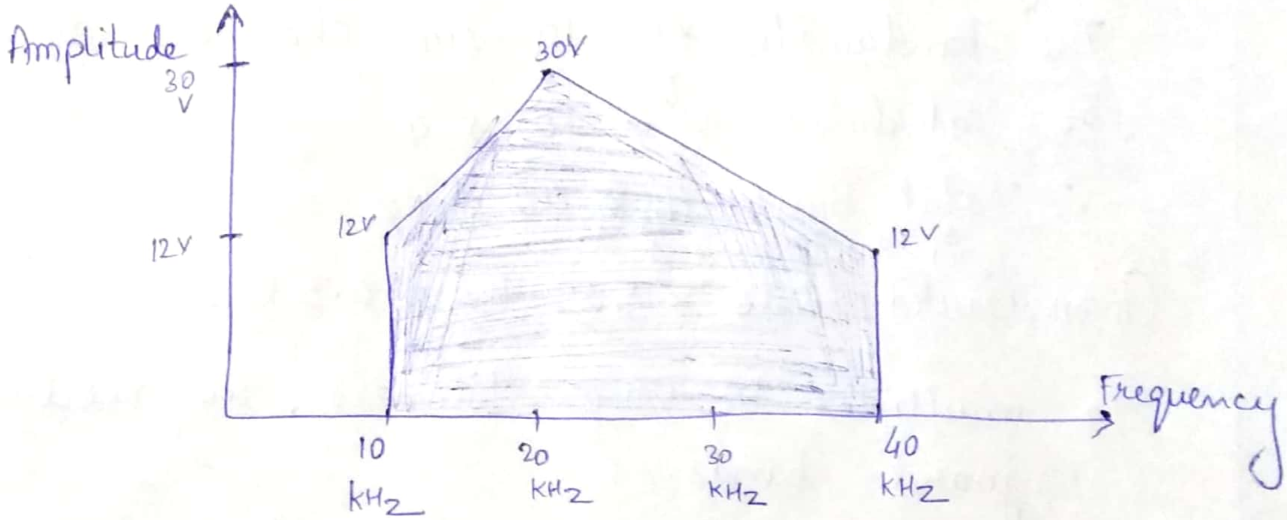


Fig:- Required Frequency Spectrum.

- The ~~peak~~ amplitude is 12 V for lowest & highest frequencies.
- The peak amplitude is 30 V for 20 kHz.
- The amplitude is changing gradually because the signal is non-periodic.
- And the non-periodic signals are continuous.

10) Assume the voice channel occupies a bandwidth of 4kHz. We need to multiplex 10 voice channels with guard bands of 500 Hz. Using FDM calculate the required bandwidth.

Sol:→ Given:- Bandwidth = 4 KHz
& 10 voice channels with guard bands of 500 Hz.

Using FDM,
The bandwidth of 10 voice channels can be calculated as = 10 x 4

∴ Total Bandwidth of 10 channels ⇒ 40 kHz.

Given, Gaurd bands = 500 Hz = 0.5 kHz

To multiplex 10 voice channels, we need 9 guard bands.

∴ Required bandwidth, B ⇒

~~B = 4x10 + 0.5~~

$\boxed{\text{B = Bandwidth of 10 voice channels + 9 guards bands}}$

$\therefore B = 40 + (0.5 \times 9)$

$= 40 + 4.5$

$= 44.5 \text{ KHz}$

∴ The required bandwidth for 10 voice channels with guard bands is 44.5 kHz