COMPOSITE VEDEO SIGNAL :-

BASICS :- ↳ In TV, picture signal is a combination of multiple signals.

(i) camera signal :- corresponding to the variation of light of given picture.

(ii) Synchronization pulse :- To provide synchronization

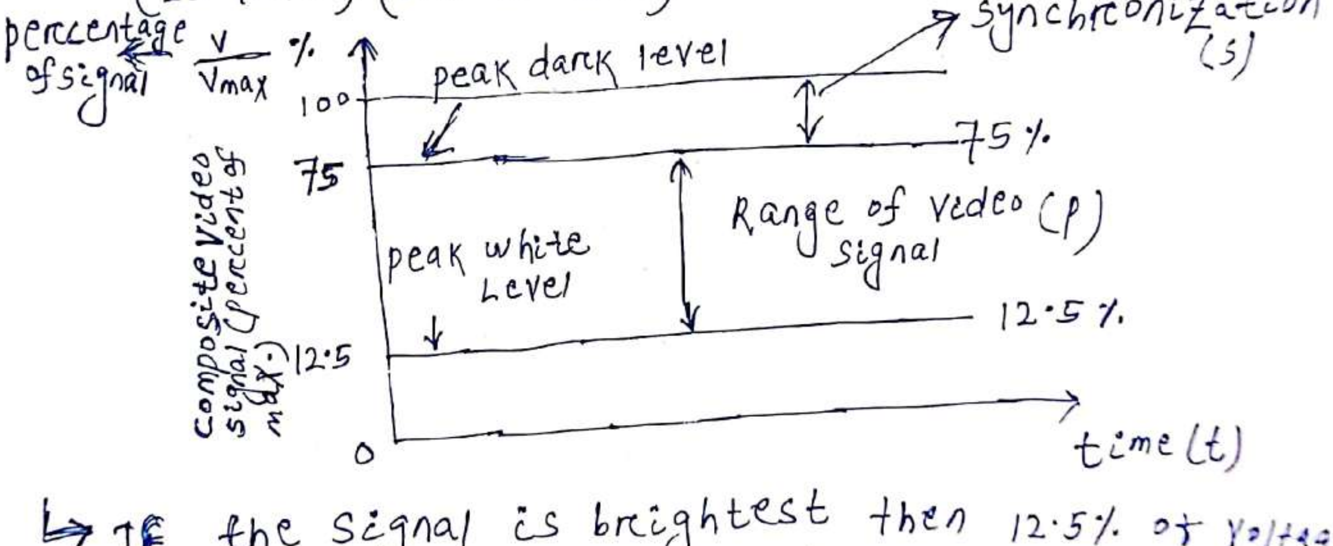
(iii) Blanking pulse :- To make retraces invincible.

↳ In TV, There are 625 lines in one frame.

↳ one frame is divided in two fields, 1 to 312.5 lines and 312.5 to 625 lines.

↳ In 1st field from 1 to 312.5 again divided into trace (292.5 lines) (1 to 292.5) and Retrace (20 lines) (292.5 to 312.5).

↳ In 2nd field from 312.5 to 625 lines again divided in to trace (292.5 lines) (312.5 to 605) and retrace (20 lines) (605 to 625).



↳ If the signal is brightest then 12.5% of voltage available similarly for darkest signal maximum 75% of voltage available. In between 12.5% to 75% of voltage Level video signal voltage range exist.

↳ In camera video signal we sent blanking pulse and synchronization pulse. synchronization is always provided in between 75 to 100%.

↳ $\frac{P}{S}$ ratio should be maintained to $\frac{10}{4}$. ($\frac{\text{Video signal voltage}}{\text{synchronization signal voltage}}$)

If P/S ratio > $\frac{10}{4}$ then cost of synchronization occurs.

If $\frac{P}{S}$ ratio < $\frac{10}{4}$ then it will be cost of picture data.

Camera signal :- ↳ Lowest Amplitude at 12.5%, shows whitest part of the picture. ↳ Highest Amplitude at 75%, shows darkest part of the picture.

↳ Signal Transmission is done by Negative polarity Transmission.

Horizontal Blanking pulse :- ↳ Horizontal Blanking pulse (12 μsec) has 3 portion.

(i) Front porch (1.5 μsec) [Fly back initiated with black level.]

(ii) Horizontal synchronization pulse (4.7 μsec) [synchronization is done to Transmitter to Receiver by pulse.]

(iii) Back porch (5.8 μsec) [Fly back completed with black level.]

Vertical sync pulse :- (i) It is of 2.5 line duration.

(ii) so its Time period is $2.5 \times 64 \mu s = 160 \mu s$.

(iii) At the end of first field vertical synch pulse is added at (312.5 to 315) (2.5 lines).

(iv) At the end of second field again vertical sync pulse is added at (1 to 2.5) (2.5 lines).

(v) one vertical sync pulse ends at half line period and one ends at full line period.

Vertical Blanking period :- (i) It is the period during which picture information is completely suppressed and flyback retrace of field is initiated and completed.

(ii) It is of 20 lines duration. so Time will be $20 \times 64 \mu sec = 1.28$ msecond

↳ composite video signal is formed by (i) Electrical signal corresponding to the picture information.

(ii) Lines scanned in TV camera pickup Tube.

(iii) Introduced sync signals.

↳ Three components of composite video signal. (i) camera signal. (ii) synchronizing pulses. (iii) Blanking pulses.

Horizontal Blanking period :- ↳ It is part of each line during which line sync pulse is inserted.
↳ During This period :- (i) Flyback is initiated and completed. (ii) Beam cutoff by the black level amplitude of video signal.
↳ Horizontal Blanking period $= 0.19H$, Here $H = 64\mu s$

$= 0.19 \times 64\mu s$

$= 12\mu s$

Horizontal sync pulse :- ↳ short pulse sent from Transmitter to Receiver. ↳ sync pulse is used to synchronize Transmitter and receiver. ↳ width $= 0.07 \times H = 0.07 \times 64\mu sec$

$= \boxed{4.7\mu second}$

Front porch :- ↳ sync pulse does not coincide with blanking pulse but it follows after about 2% of the line period. This short period is called front porch.
↳ Front porch $= 2.5\%$ width $H = 1.5\mu second$

Back porch :- ↳ At the blanking level allows plenty of time for retrace to be completed.
↳ Back porch period is $5.8\mu second$.
↳ permits time for the horizontal time base circuit to reverse direction of current for the initialization of scanning for next time. ↳ It provides amplitude and enables to preserve the DC content of picture information at Transmitter.

↳ Amplitude = Blanking Level.
↳ At Receiver Blanking Level is independent of the picture details. This picture details is utilized in Automatic Gain control (AGC) circuits. AGC circuits develop AGC voltage proportional to the signal strength picked up at the antenna.

<u>Details of Horizontal scaning</u>

Total line period (H) → 64 μsecond.
Horizontal Blanking → 12 μsecond.
Horizontal sync pulse → 4.7 μsecond.
Front porch → 1.5 μsecond.
Back porch → 5.8 μsecond.

~~Vertical sync pulse~~ :-

— x —

BASICS OF PIXELS IN TV :- ↳ converscion of light beam in to video is done by scanning process.
↳ smallest part of picture element covered by light beam is referenced as pixel.
↳ for aspect ratio 4:3 [Number of pixels in horizontal lines are $\left(\frac{4}{3}\right)$th times compared to pixels in vertical lines.]
↳ for aspect ratio 16:9 [Number of pixels in horizontal lines are $\left(\frac{16}{9}\right)$th times compared to pixels in vertical lines.]

pixels lost in vertical Blanking :-
↳ As we have seen in interlaced scanning, in first field of vertical trace 292.5 Active lines are there and in first field of vertical retrace 20 inactive lines are there. similarly for second field of vertical trace another 292.5 active lines are there and in second field of vertical of retrace 20 inactive lines are there.
↳ So in one frame, 585 Active lines are there with vertical trace and 40 inactive lines are there with vertical retrace.
↳ So during vertical retrace, pixels are lost due to screen is blank.
↳ So number of active lines are given by

$$N_a = \text{Total no. of lines } (N_t) - \text{Inactive Lines } (N_I)$$
$$= 625 - 40 = 585$$

pixels lost due to Kell effect :- (i) Arrangement of pixels is uneven and random in nature. (ii) During scanning process, scanning beam may miss some pixels. (iii) In General, 70% of pixels are reproduced during scaning process, so 30% of pixels may get lost during scanning. This effect is referred as Kell effect.

↳ so, The number of active lines actually reproducing pixels can be calculated by multiplying active lines by a Kell factor (K), whose value is choosen (0.7):

↳ Total pixels in vertical direction = $N_a \times K$

$= 585 \times 0.7 = 410$

Active Lines

RESOLUTION :- (i) Resolution means ability to differentiate between nearly spaced pixels.

(ii) In Gross structure of TV, we have already discussed that horizontal resolution is always higher than vertical resolution in TV. Because, horizontal dimension is greater than that of vertical dimension.

(iii) Vertical resolution is given by $R_V = N_a \times K$

$= 585 \times 0.7 = 410$

(iv) Horizontal resolution is given by $R_H = R_V \times a$

a = Aspect Ratio (4/3)

$\Rightarrow R_H = 410 \times 4/3$

$= 546$

(v) Resolution is always expressed by vertical resolution. Example :- 1080p, 720p, 144p, 240p.

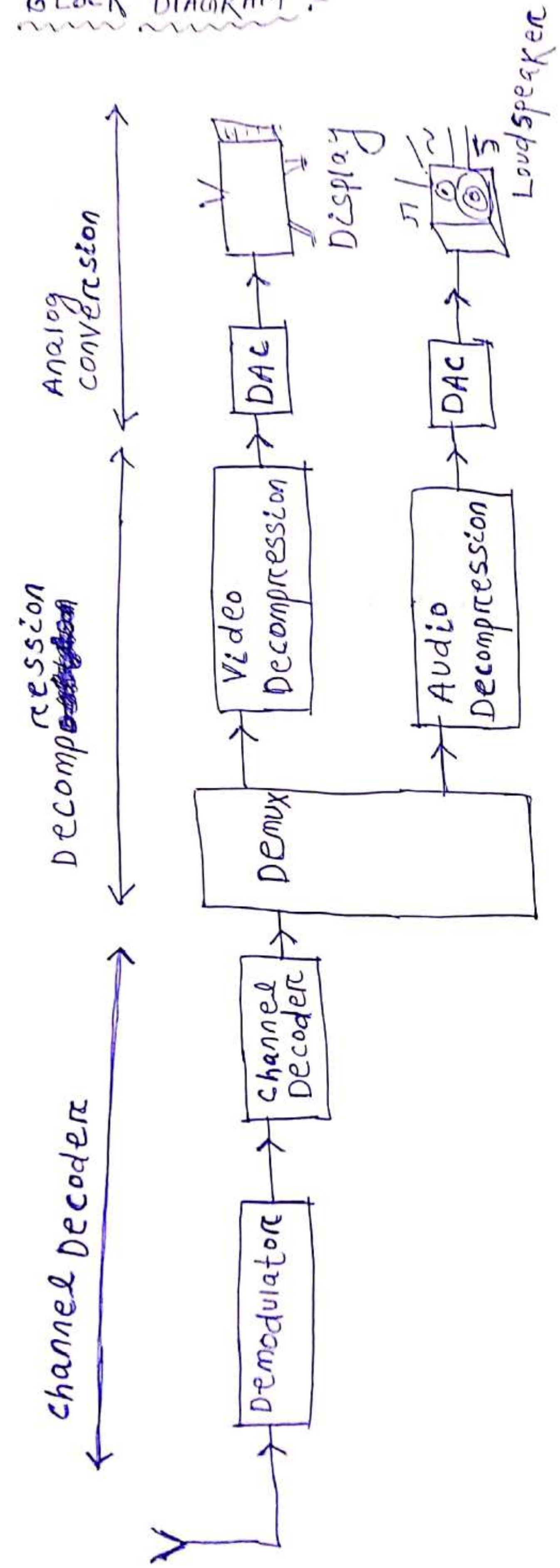
BANDWIDTH :- Bandwidth means the highest video frequency related to the time taken in scanning two nearly spaced pixels.

Let R_H pixels scanned in t second. so 2 pixels are scanned in $\boxed{T = \frac{2 \cdot t}{R_H} \text{ second}}$. Bandwidth $= \frac{1}{T} = \frac{R_H}{2 \cdot t}$

As smaller is the size pixels, less would be the time taken in scanning two adjacent pixels, better will be the resolution and hence higher will be the bandwidth.

DIGITAL TV RECEIVER :-

BLOCK DIAGRAM :-



Basics of Digital TV Receiver :-

↳ Digital TV signal Receiver can be sub divided in-to three (3) parts.

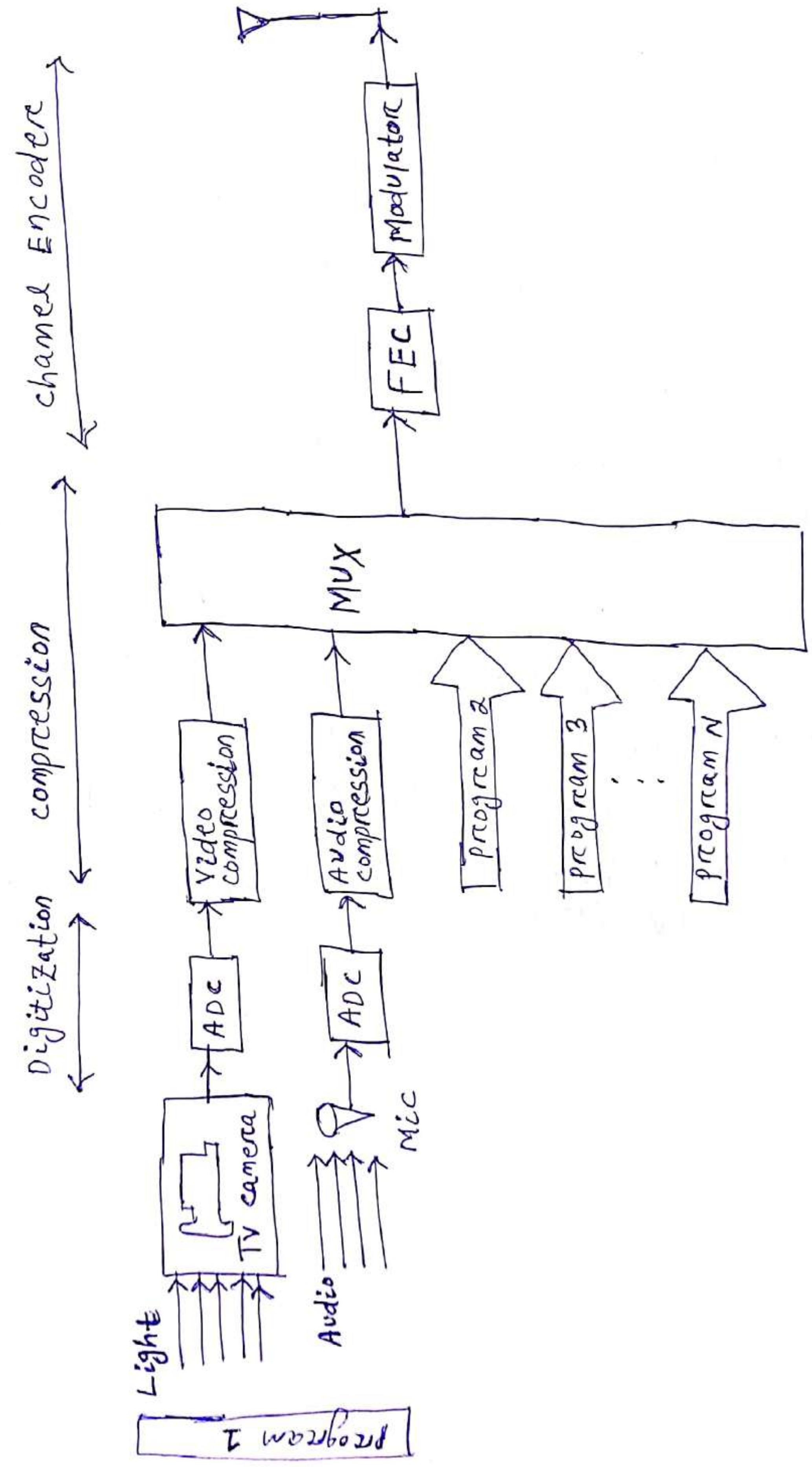
1. Channel Decoding :- (i) Demodulation of received signal. (ii) Error Detection and correction.
2. Digital Decompression :- (i) Video and Audio Decompression. (ii) MPEG decoder decompress digital video. (iii) Expanding (Non Linear Dequantization) to decompress audio.
3. Analog Conversion :- (i) Digital data converted into analog signal to display TV program on Television.

↳ At Receiver side we use QPSK demodulator.

↳ Channel Decoder corrects the digital error which occurs in the channel.

DIGITAL TV TRANSMITTER :-

BLOCK DIAGRAM :-



Basics of Digital TV Transmitter :-

↳ Digital TV signal Transmission can be sub divided into three (3) parts.

① Digitization :- (i) conversion of Analog signal in-to digital signal. (ii) ADC converter has sampling, quantization and encoding process.

② Digital compression :- (i) Video and Audio compression digitally. (ii) MPEG encoder compress digital Video. (iii) Nonlinear quantization used to compress audio (companding)

③ Channel Encoding :- (i) It has forward error correction and Modulation. (ii) For HDTV broadcasting QPSK Modulator is used.

↳ ~~ad~~ The output signal of TV camera is available in Three formats. i.e. YUV format, YIQ format, $YC_b r_b$ format.

↳ In YUV format signal :- Y represents Luminance Signal, UV represents Color signal.

$Y = 0.299R + 0.587G + 0.11G\,B$, $U = 0.492(B-Y)$,

$V = 0.877(R-Y)$.

↳ In digital TV transmission system we use YUV format only.

—— x —— x —— x —— x ——

LIQUID CRYSTAL DISPLAY (LCD) :-

↳ Liquid crystal refers to compounds which are in crystalline arrangement, but can flow like liquid. The light source passes through a liquid-crystal material that can be aligned to either block (or) transmit the light. 2 glass plates, each containing a light polarizer at right angles to the other, sandwich a liquid crystal material. Rows of horizontal transparent conductors are built into one glass page. columns of vertical conductors are put in to the other plate.

↳ The intersection of 2 conductors define a pixel position. passive Matrix LCD in the "on" state, polarized light passing through the material is twisted so that it will pass through the opposite polarizer. Different materials can display different colors. By placing thin film transistors at pixel locations, voltage at each pixel can be controlled. Active-Matrix LCD.

MONOCHROME TV TRANSMITTER :-

Basics :- → Monochrome TV means Black and White TV.

→ Elementary area of picture is broken in to "picture Element" (or) "pixels". There are almost infinite elements/pixels in any picture, so information of picture is very complex. Each element/pixel has different level of brightness.

→ Information is given as a function of two variables space and time.

→ Ideally, There is infinite elements/pixels of information in optical domain.

→ practically, conversion of optical elements in to electrical form is done and its Transmission is carried out element by element.

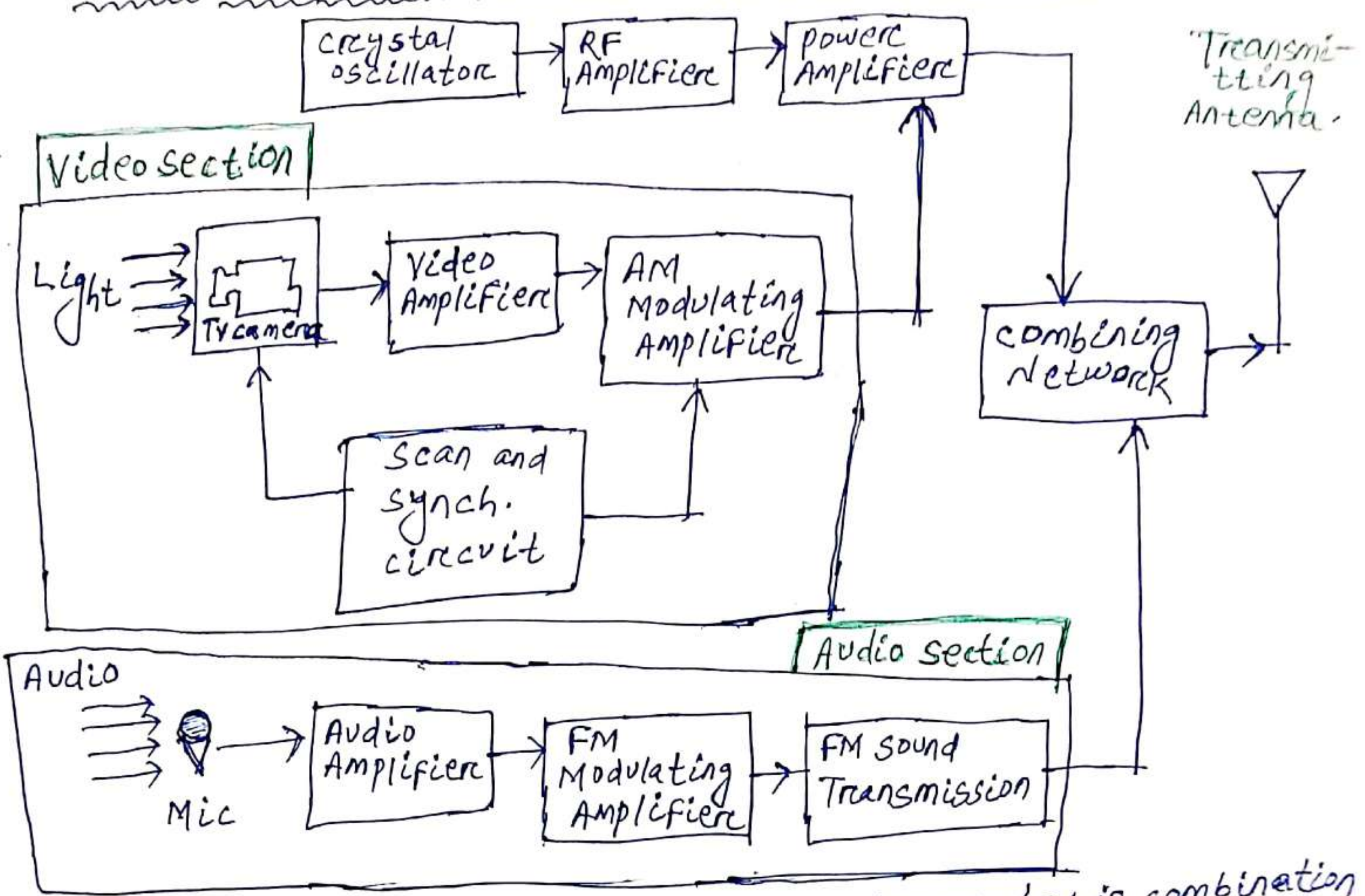
→ Scanning of elements is done at a very fast rate and this process is repeated a large number of times per second to create an illusion of simultaneous pick up and transmission of picture details.

parameters of Monochrome TV Transmitter :-

→ It has a video information, in between black and white with the shades of gray. → It transmits on channels in the VHF (Very High Frequency) and UHF (Ultra High Frequency). → picture and sound signals are modulated on RF carrier to reduce antenna size.

BLOCK DIAGRAM EXPLANATION :- (i) In Monochrome TV transmitter there are Two sections, video section and Audio section. (ii) TV camera will capture the video which is in optical domain. TV camera again translate video information to Electrical signal. (iii) After that electrical domain of video will be given to Video Amplifier and then

BLOCK DIAGRAM OF MONOCHROME TV TRANSMITTER :-



we will give it to AM Modulating Amplifier. (It is combination of AM Modulator and Amplifier). (iv) Scan & synch. circuit is used to provide synchronisation of video information in proper sequence.

(v) Bandwidth of Monochrome TV transmitter for video section is about 5MHZ. (vi) In Audio section we will having Mic first that convert Audio signal to Electrical signal of sound then it is given to Audio Amplifier and then it is given to FM Modulating Amplifier. In Audio section Available bandwidth is about 20KHZ.

→ our aim is to transmit both video section and Audio section through same antenna. ~~So~~ Since Audio section Frequency is very low (20KHZ) so it is very difficult to transmit low Frequency signal through Antenna. so we will convert Low Frequency signal to High Frequency signal. For that we will have crystal oscillator first and then it is given to RF Amplifier. RF Frequency is there in VHF & UHF Band. combining Network will combine both video section and Audio section signal and ~~it is given~~ ~~trans~~ both signal is transmitted through transmitting Antenna.

Scanned by CamScanner

MONOCHROME TV RECEIVER

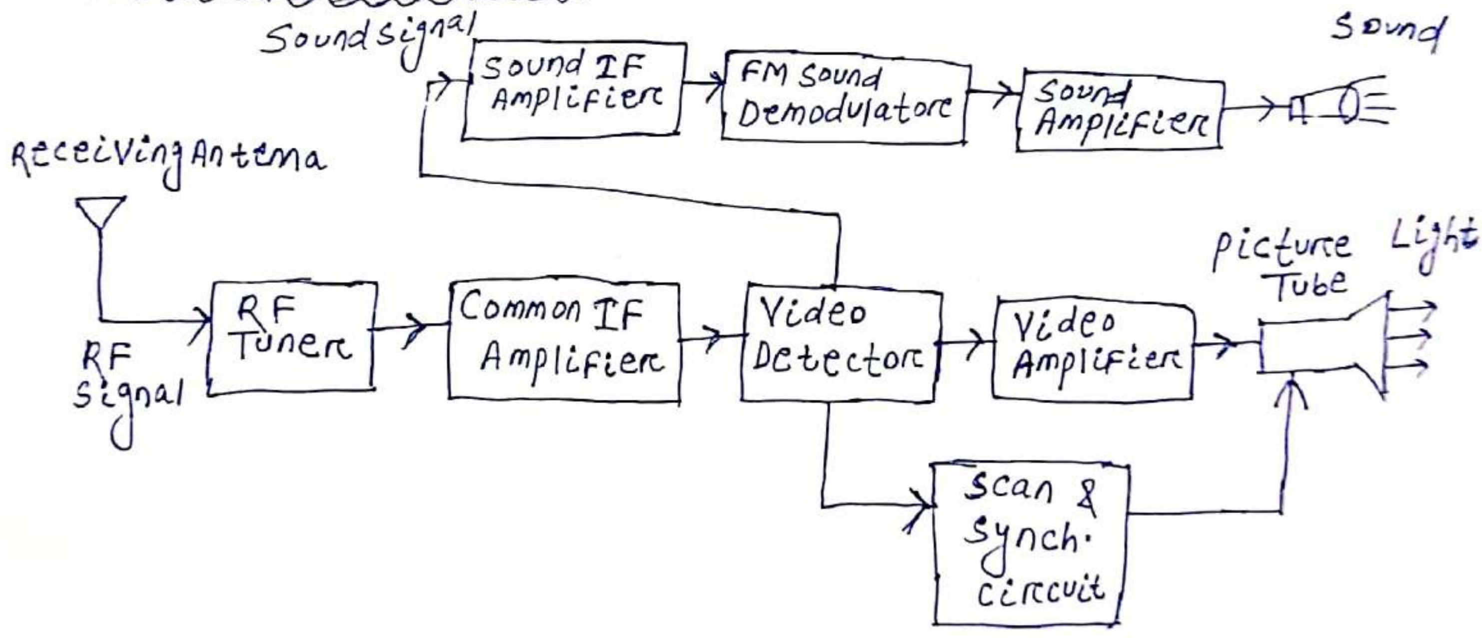
Basics :- (i) Data Transmitted by Monochrome TV transmitter antenna will be received by Monochrome TV receiver.

(ii) Here, our agenda is

↳ Receive Electromagnetic (EM) signal by Antenna at Receiver.
↳ convert that signal in to Electrical signal.
↳ Separate sound and video signals.
↳ play Sound by Speaker and play Video by tube.

(iii) In Monochrome TV, display will be black and white with the shades of gray (brightness).

BLOCKDIAGRAM :-



↳ Receiving Antenna receives EM Signal. so Antenna converts EM signal in RF electrical signal.

↳ RF Tuner translates RF Frequency to Intermediate Frequency (IF frequency). As per basic standard of Monochrome TV, IF Frequency for sound is 33.4MHZ, IF frequency for video = 38.9 MHZ

↳ common IF Amplifier picture commonly amplifying picture IF Frequency as well as sound IF frequency.

↳ Video Detector having AM Demodulator in video side.

↳ In picture Tube Two types of scanning is done ① Vertical scanning ② Horizontal scanning.

↳ In Audio side we are having FM Demodulator.

↳ picture Bandwidth over here around 5MHZ (megahertz) and sound Bandwidth over here around 20 KHZ (kilo hertz.)

parameters of Monochrome TV Receiver :- ① It has a video information, in between black and white with the shades of gray. i.e. Brightness will justify video information.

(ii) It Receives channels in the VHF and UHF. (iii) picture and sound signals are demodulated from RF carrier received from antenna.

FLICKER (OR) INTERLACED SCANNING :- ①

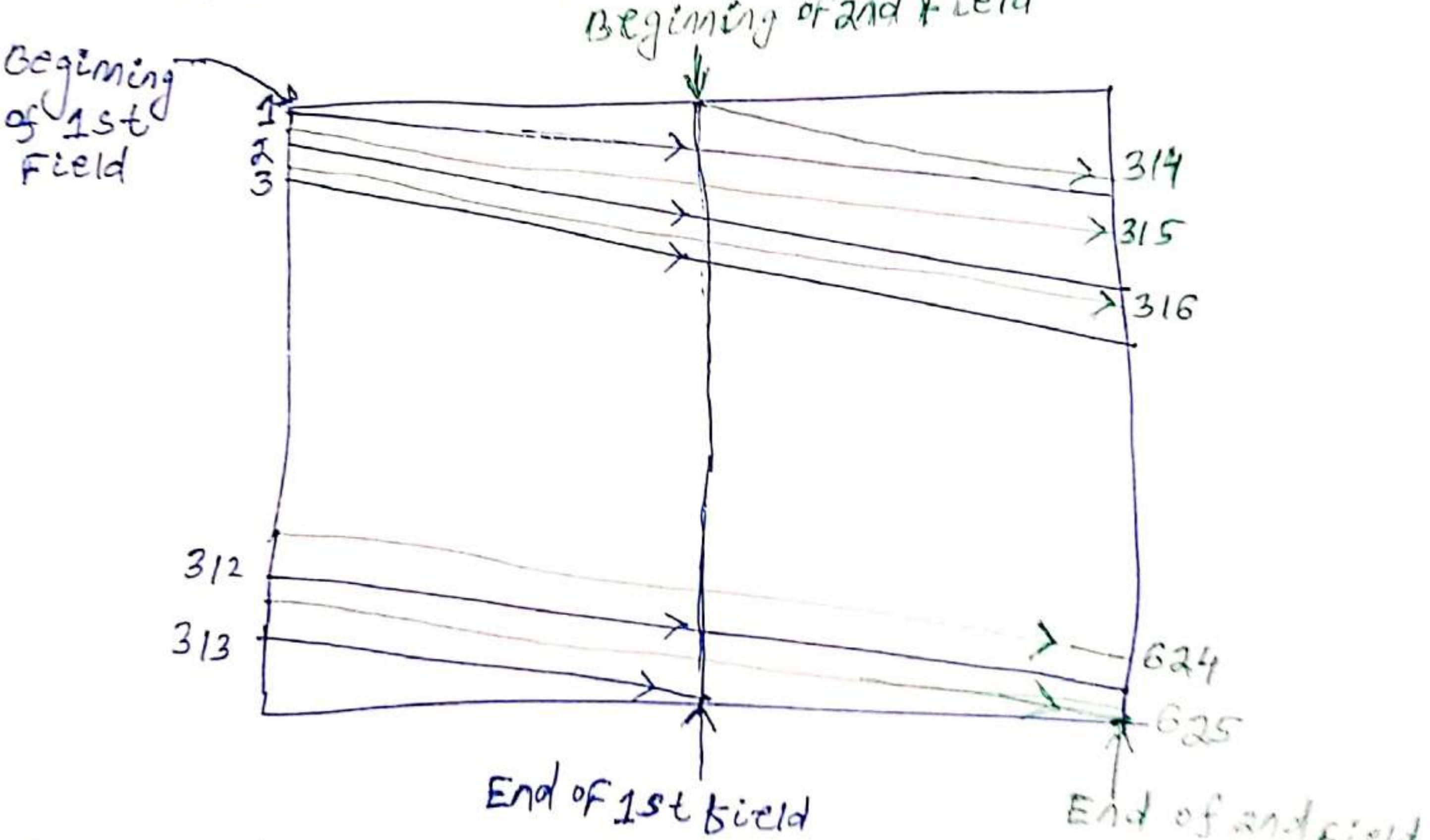
→ In TV picture, 24 pictures per second we can see and 25 frames are scanned per second.

→ But some time they are not rapid and blank screen produce some successful frames. This is called Flicker.

→ To solve flicker problem each picture show twice i.e. 48 view of the scene show together per second. Each picture is scanned twice.

→ In Interlaced scanning, 50 vertical scanning per second is done to reduce flicker.

→ Each picture has 625 lines that is divided in to set of 312.5 line in two field.



→ To achieve horizontal sweep oscillator work frequency 15625 HZ ($312.5 \times 50 = 15625$)

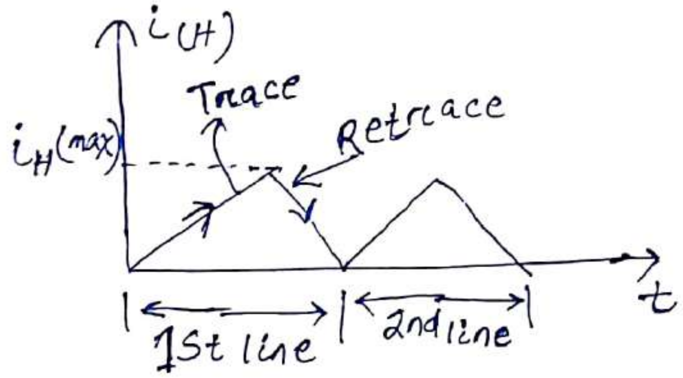
50 → Frequency of Electrical Home Supply 50 HZ in INDIA.

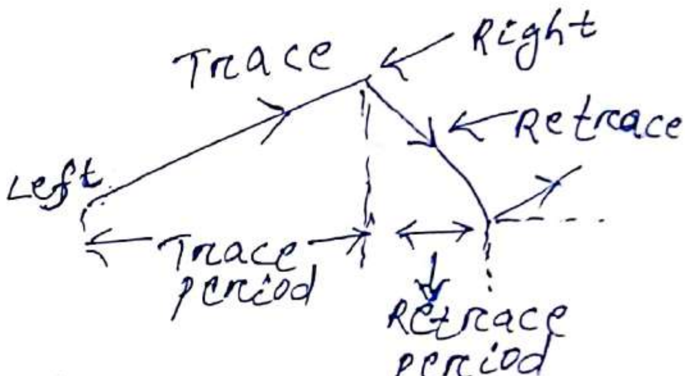
Scan no. of Line per frame $\left(\frac{15625}{25} = 625 \text{ lines}\right)$

→ Vertical sweep oscillator run frequency 50HZ (312×50 = 15625)

→ The division of picture in to many horizontal lines is called scanning. The flickering effect can be minimized by using interlaced scanning. From the point of view of flicker, it is observed that 50 picture frames per second is the minimum requirement in Television scanning.

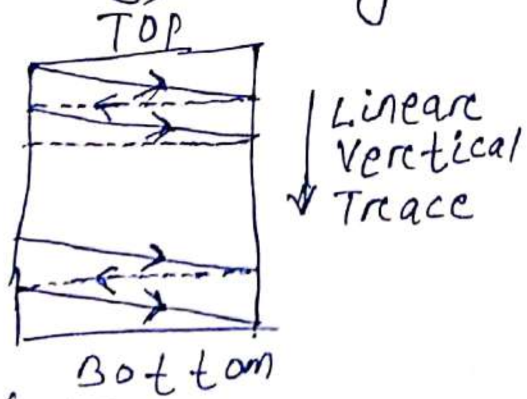
→ Horizontal line scanning frequency of (15625+15625 = 31625 HZ) is required for a 625 line system with a period of ($64\mu s/2 = 32\mu s$).



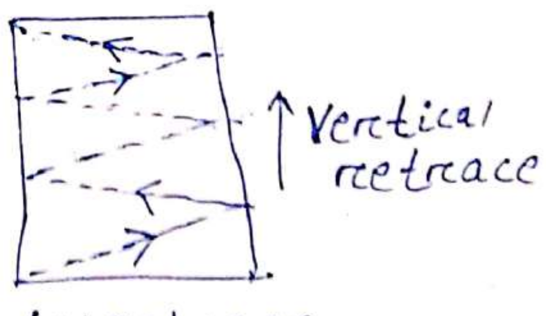


[waveform of current in the horizontal deflection coils producing linear (constant velocity) scanning in the horizontal direction.]

| ← one cycle of Deflection current → |

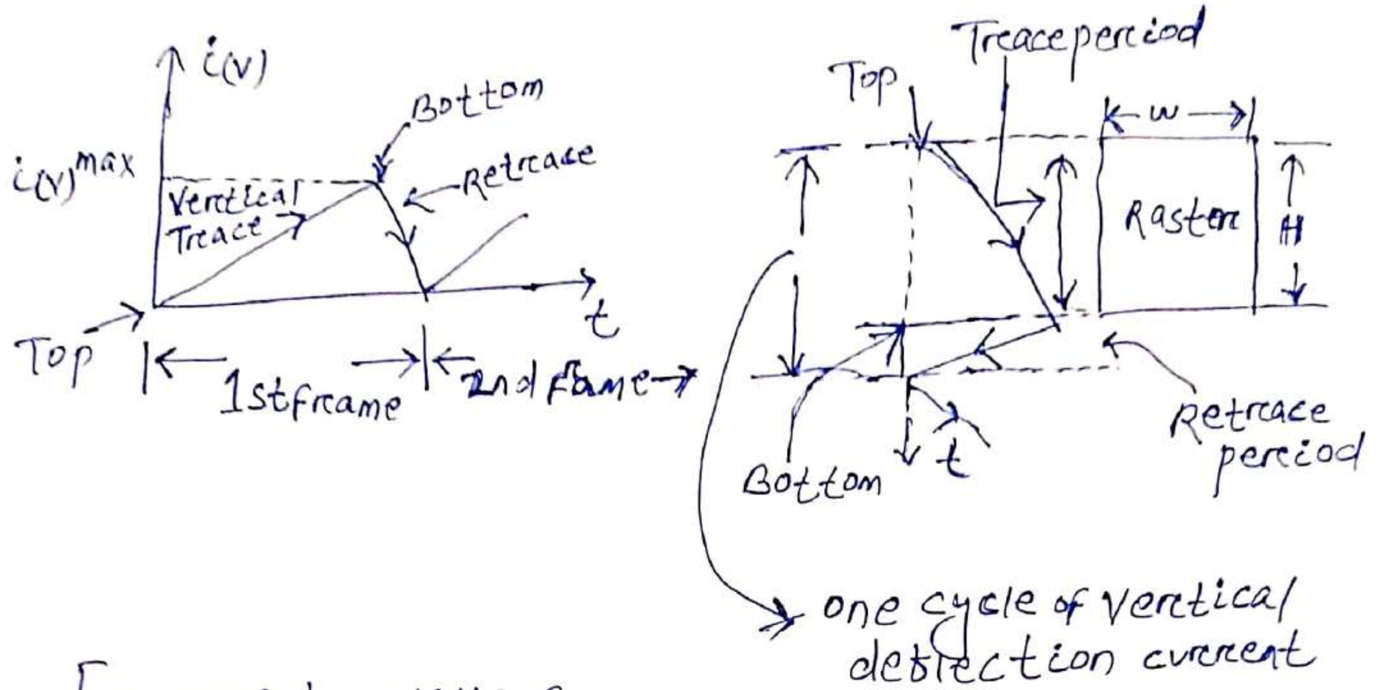


(a) Trace



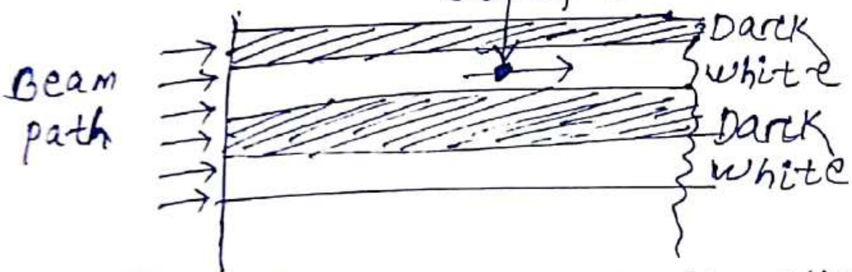
(b) Retrace

[VERTICAL SCANNING]



[current wave form in vertical deflection coils.]

Number of Scanning Lines :-



[Scanning spot perfectly aligned with black and white lines]

↳ Alternate lines are black and white. The electrical information corresponding to the brightness of each bar will be correctly reproduced during the scanning process.

↳ If ① Thickness of scanning beam = width of each white and black bar.

② Number of scanning lines = Number of bars.

↳ The maximum number of alternate light and dark elements (lines) which can be resolved by the eye is given by

$$N_V = \frac{1}{\alpha \cdot \rho} \quad \text{——— (1)}$$

where,

N_V = Total number of lines (elements) to be resolved in the vertical direction.

α = Minimum resolving angle of the eye expressed in radians $\left(\frac{\pi}{180} \times \frac{1}{60}\right)$.

$\rho = \frac{D}{H}$ = viewing distance / picture Height = (standard Value = 4)

putting These Values in eqn-①

$$N_v = \frac{1}{(\pi/180 \times \frac{1}{60}) \times 4} = 860$$

↳ A distinct pickup of the picture information results

(i) Total number of scanning lines = 860.

(ii) The scanning beam just passes over each bar (line)

Interlaced scanning :-

↳ In Television pictures an effective rate of 50 vertical scans per second is utilized to reduce flicker. This is accomplished by increasing the downward rate of travel of the scanning electron beam. so that every alternate line gets scanned instead of every successive line. Thus the total number of lines are divided in to two groups called 'fields'. Each field is scanned alternately this method of scanning is known as interlaced scanning.

↳ For successful interlaced scanning, the 625 lines of each frame (or) picture are divided in to sets of 312.5 lines.

↳ To achieve this the horizontal sweep oscillator is made to work at a frequency of 15625 HZ. (312.5 X 50 = 15625)

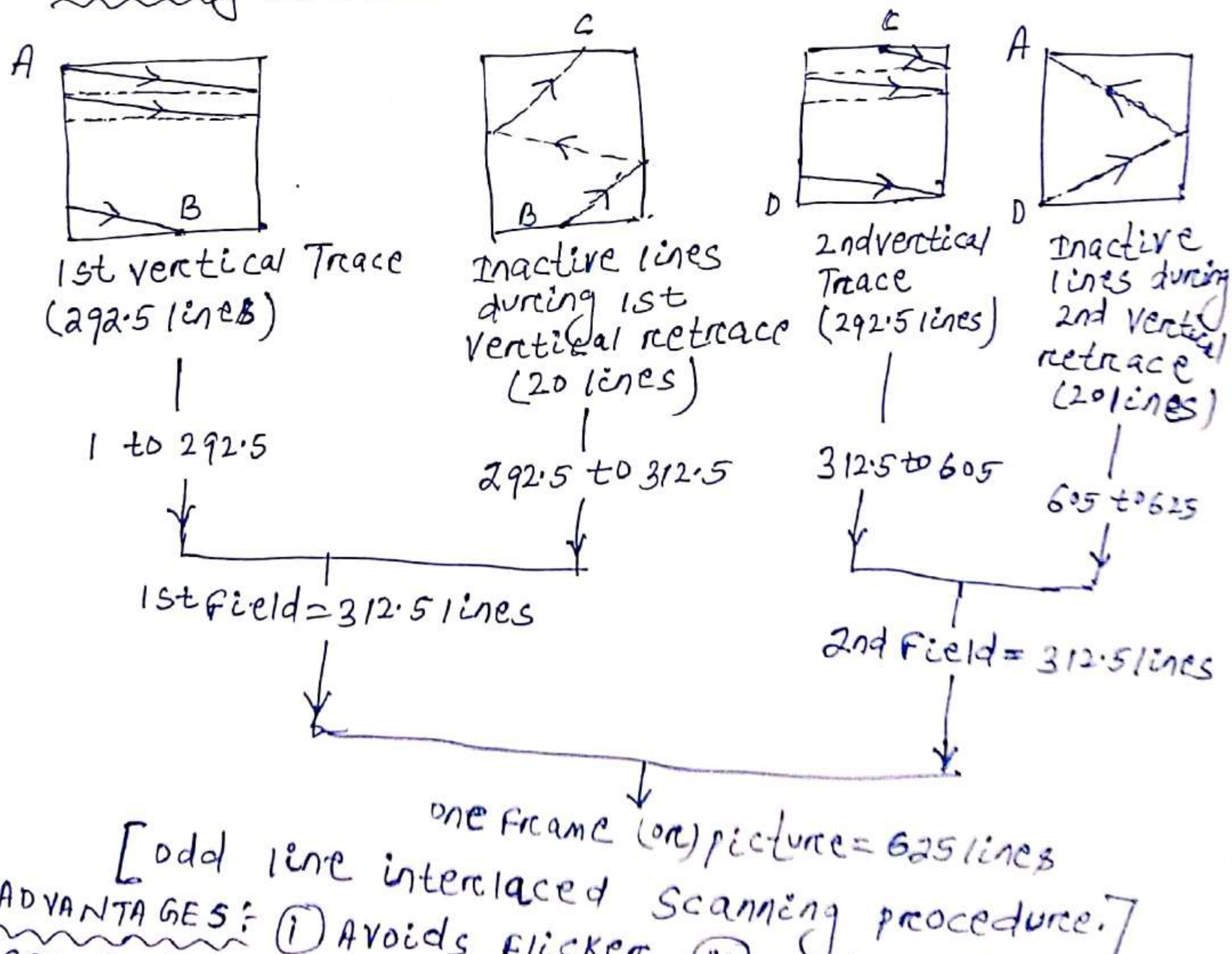
↳ Two scanning periods are available i.e For Horizontal deflection current and For vertical deflection current. For Horizontal deflection current Time period (Trace Time + Retrace Time) is 64 MS and having frequency 15625 HZ.

For vertical deflection current Total Time period (Trace Time + Retrace Time) is 20ms and having frequency 50HZ.

↳ The horizontal and vertical sweep oscillators operate continuously to achieve the fast sequence of interlaced scanning $20\left(\frac{1280\mu s}{64\mu s}\right)$ horizontal lines.

↳ This leaves the active number of lines, N_a, for scanning the picture details equal to $625 - 40 = 585$, instead of the 625 lines actually scanned per frame.

Scanning sequence



[odd line interlaced scanning procedure.]

ADVANTAGES: (i) Avoids flicker (ii) It is better than sequential scaning. (iii) Conserves Bandwidth.

Progressive Scanning	Interlaced Scanning
(1) In this every successive line is being scanned.	(1) In this the electron beam first scans odd lines from top to bottom and then it scans the lines those are skipped in the previous scanning.
(2) The effective no. of pictures scaned per second are 25 frames/second.	(2) The effect no. of fields scanned per second are 50 frames/second.
(3) Flicker problem will occur.	(3) Flicker problem is avoided.
(4) Total no. of lines scanned at a time from top to bottom are 625 lines.	(4) Total no. of lines scanned at a time from top to bottom are 312.5 lines.

—xx— xx—

INTRODUCTION TO TELEVISION SYSTEM:-

↳ The word television has its origin in two Greek words 'tele' and 'vision'. Tele means 'at distance' and vision means 'seeing'.

↳ Earlier selenium photosensitive cells were used for converting light from pictures into electrical signals. (i.e. conversion of optical signal to electrical signal.)

↳ First camera tube is iconoscope. In 1935 TV broadcasting started. In 1959 TV came to India.

Evolution of TV :-

① Black and white TV → ② color TV → ③ plasma TV → ④ 3D TV → ⑤ HD TV

Intensity of Light in a picture :- The intensity of illumination can vary from darkness (light of faint stars in the universe, which is taken as reference = 0dB) to light of bright. sun on snow is 110dB.

ASPECT RATIO :- width to Height ratio of a picture frame is called Aspect ratio. width is kept longer than height because of the following facts:-

① Horizontal dimension of a scene is generally more than its vertical dimension.

(2) Eyes can move with more ease and comfort in the horizontal plane than in the vertical.

(3) The fovea, the surface of maximum sensitivity and resolution at the centre of the retina in the eye has greater width than height. Hence, the Longer width of the image ensures more efficient use at the fovea.

(4) As a result of intensive subjective tests by the cinema people, aspect ratio of 4:3 was found to be most pleasing aesthetically and less fatiguing to the eyes. The same ratio was accepted by the television engineers as the cinema films formed a major part of the TV programmes. This enabled direct transmission of films without wastage of any film area.

↳ Dimension of a TV receiver are specified by the diagonal length of the screen, when the width is $4x$ and height is $3x$ and the diagonal Length would be $5x$.

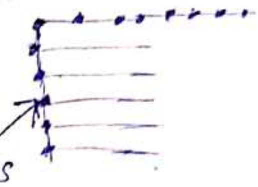
ex:- If TV screen of size 30 cm

$\Rightarrow 5x = 30\text{ cm} \Rightarrow x = 6\text{ cm}$

Hence height $= 3x = 18$ cm and

width $= 4x = 24$ cm

Picture Elements :- For analysis and processing, an image can be considered to be consisting of tiny areas (dots), called picture elements (PELS) (or) more popularly pixels.



(pixels on a vertical Line and on a Horizontal Line on a screen.)

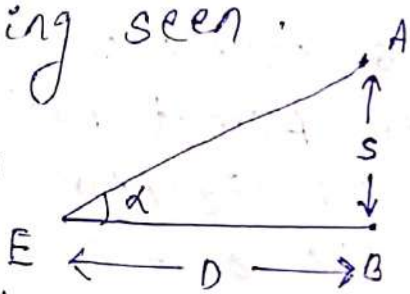
→ The maximum number of pixels that can appear on a vertical line on the screen will be equal to number of Horizontal Lines. Here in given figure 6 horizontal Lines.
So 6 pixels on a vertical Line.
As the Aspect Ratio is 4:3 so $6 \times \frac{4}{3} = 8$ pixels on a horizontal Line. Total number of pixels on the screen is $6 \times 8 = 48$

Details and Resolution :- closely spaced small objects (or) small distinct features in a picture form details. Smaller the objects (or) features visible distinctly, higher is the resolution of the details (or) finer are the details being seen. The ability to see the fine details in a picture is called Resolution.
Example :- wrinkles on a face, hair of the eye brows, veins on a leaf and similar closely spaced but distinct features should be clearly visible in a reproduced picture for good resolution. A pixel in a picture represents a very small area (almost point size) which possesses the characteristics brightness and color at that point.

Visual Acuteness and Viewing Distance :-

Human eye has resolution of 1 minute (or $\frac{1}{60}$ degree). It means that if two closely spaced objects form a minimum angle of 1 minute at the eye, they would be distinctly visible. For smaller angles, the two objects would appear as merged with each other. The angle subtended at the eye will depend on two factors.

1. The space, S, between the objects.
2. The distance, D, from which the objects are being seen.



Let the two closely spaced but distinct objects be A and B. Angle α subtended by A and B at the eye E = S/D radians

As 1 radian = $\frac{180}{\pi}$ degrees, angle $\alpha = \frac{180}{\pi} \times \frac{S}{D}$ degrees

For clear resolution, this angle should be $= \frac{1}{60}$ degree. Hence $\frac{180 \times S}{\pi \times D} = \frac{1}{60}$ (or)

$$\frac{S}{D} = \frac{\pi}{180 \times 60}$$

Example-1 :- calculate the minimum distance between adjacent pixels for the viewing distance equal to 2.5 mtr.

Soln :- $S = \frac{2.5 \times \pi}{180 \times 60} = 73 \times 10^{-5}\,m = 0.073\,cm$

— x —

Example-2:- Calculate the number of pixels in 50 cm size TV Screen for Example-1.

Soln:- For 50 cm size screen, width = 40 cm, height = 30 cm

Therefore No. of pixels in width = $\frac{40}{0.073}$

and No. of pixels in height = $\frac{30}{0.073}$

Hence Total number of pixels = $\frac{40}{0.073} \times \frac{30}{0.073}$

$= 225000$

—x—x—xx—

Persistence of Vision and Flicker:-

When the eye sees light, it continues to see it for about 60ms after the light source is removed. This property of eye is called persistence of vision. It has been possible to see movie picture because of this property.

FLICKER:- Time of persistence of vision is more for darkness than for bright light. This results in a phenomenon called flicker. It means dark intervals between bright pictures become visible for a very short time and appear as a flicker.

BRIGHTNESS:- Brightness in TV pictures is the average intensity of light. It determines the background level of illumination in the reproduced picture. The eye adapts itself to the average prevailing brightness and sees all variations with respect to this adapted value.

ELEMENTS OF A TV SYSTEM :-

↳ picture Transmission. ↳ Sound Transmission,
↳ picture Reception. ↳ Sound Reception.
↳ synchronization. ↳ Receiver controls.
↳ Colour Television.

PICTURE TRANSMISSION :-

Fundamental Aim :- To extend the sense of sight beyond its natural limit along with the sound associated with the scene. → (Black and white TV)

↳ In 625 line monochrome system :- picture signal is Amplitude modulated and sound signal is frequency modulated, carrier frequencies are suitably spaced and modulated outputs radiated through a common antenna.

↳ picture information is optical in nature. It assembly of a large number of bright and dark areas, each representing a picture element. Infinite number of pieces existing simultaneously.

↳ Information is a function of two variables Time and space.

↳ Instead of using infinite number of channels simultaneously, we use scanning.

Scanning :- optical information is converted in to electrical form and transmitted element by element, one at a time in a sequential manner to cover the entire scene to be televised.

↳ scanning is done at very fast rate. It is repeated a number of times per second to create an illusion of simultaneous pick up.

TV camera :- ① Heart of a TV camera is a Camera tube.

② Camera Tube converts optical information in to corresponding electrical signal.

③ ~~Amp~~ Here Amplitude is proportional to brightness.

④ optical image is focused by a lens assembly to a rectangular glass face plate.

⑤ Transparent conductive coating at the inner side of the glass is face plate, on which a thin Layer of photoconductive material is coated and it is having a very high resistance when no light falls on it.

⑥ Resistance decreases when the intensity increases.

⑦ Electron Beam is used to pick up the picture information available on the target plate interms of varying resistance.

⑧ Beam is formed by an electron gun and the beam is deflected by a pair of deflection coils kept mutually perpendicular on the glass plate to achieve scanning of the entire target area.

↳ ⑨ Video signal is amplified. Amplitude Modulated with channel picture carrier frequency. It is fed to the transmitter antenna for radiation along with the sound signal.

Advantages :- (i) structure is very simple. (ii) It is economical. (iii) It is effective in the medium ~~fre~~ frequency MF (300K - 3MHz) and HF (3-30 MHz.) (iv) properties of radiation can enhance when used in array.

Disadvantages :- (i) Major lobe is little inclined at an angle and controlled by its length. (ii) poor directivity. (iii) power density in minor lobes.

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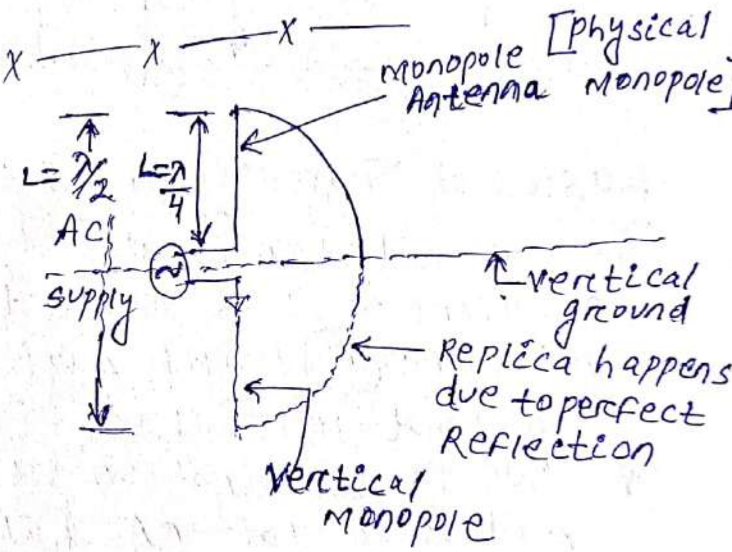
MONOPOLE ANTENNA :-



- Physical Length of monopole antenna is $\frac{\lambda}{4}$.
- Dipole Antenna having length is $\lambda/2$.
- Monopole Antenna has lower radiation efficiency with respect to Dipole Antenna.

—x—

BASICS OF ANTENNA ARRAY :-

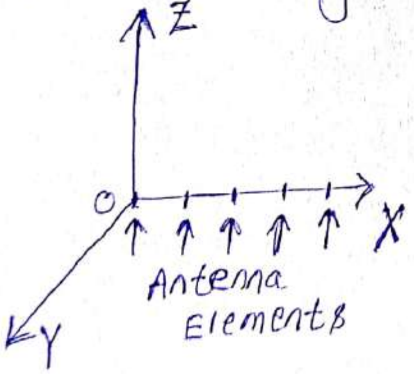
↳ In some wireless communication applications, we need to have narrow beam for large distance communication. So it is possible by 2 ways. ① Increasing the size of Antenna. ② Using Antenna array. These are used (i) To increase gain of Antenna. (ii) To have narrow beam.

ANTENNA ARRAY :- ↳ Antenna formed by multiple elements of Antenna is antenna array.

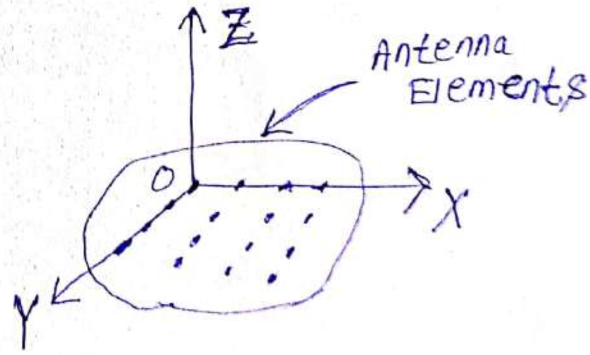
↳ In most cases elements of an array are identical. This is not necessary but it is convenient, simpler and more practical.

↳ If array arranged in one axis (X, Y or Z) then it is said to be single dimensional array (or) Linear array.

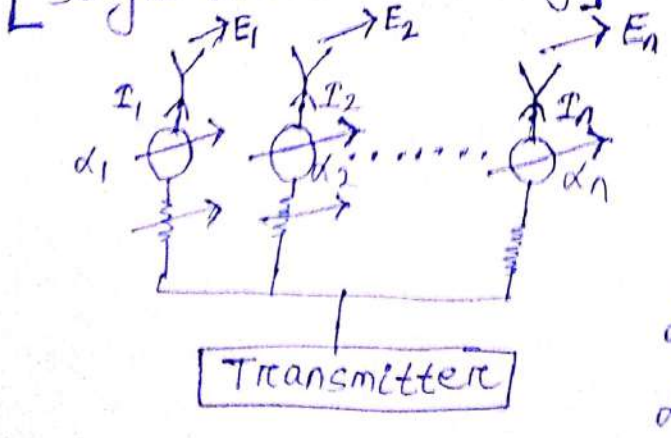
↳ If Array arranged in plane (XY, YZ or XZ) then it is said to be two dimensional array (or) plannar array.



[Single Dimensional Array.]



[Plannar Array.]



Y → Antennas, → phase shifter

→ Attenuator

α_1 = Phase Difference of 1st element.

α_2 = ,, ,, ,, 2nd ,, .

. . . . . .

α_n = ,, ,, ,, nth ,, .

↳ Electric field by different element is given by

$$\vec{E_1} = E_1 \cdot e^{j\psi_1}, \quad \vec{E_2} = E_2 \cdot e^{j\psi_2}, \quad \dots, \quad \vec{E_n} = E_n \cdot e^{j\psi_n}$$

ψ_1 = phase Angle of 1st element, ψ_2 = Phase Angle of 2nd element

ψ_n = phase Angle of nth element.

↳ current supplied to different element is given by

$$I_1 = I_1 \cdot e^{j\alpha_1}, \quad I_2 = I_2 \cdot e^{j\alpha_2} \quad \dots \quad I_n = I_n \cdot e^{j\alpha_n}$$

↳ So, Total Electric field is

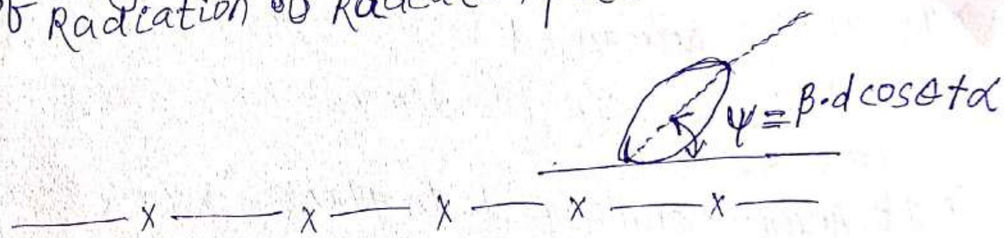
$$\vec{E} = \vec{E_1} + \vec{E_2} + \dots + \vec{E_n} = E_1 \cdot e^{j\psi_1} + E_2 \cdot e^{j\psi_2} + \dots + E_n \cdot e^{j\psi_n}$$

where $\psi = \beta \cdot d + \alpha = \left(\frac{2\pi}{\lambda}\right) \cdot d + \alpha$

d = Spacing between Elements, α = Initial phase

λ = wavelength.

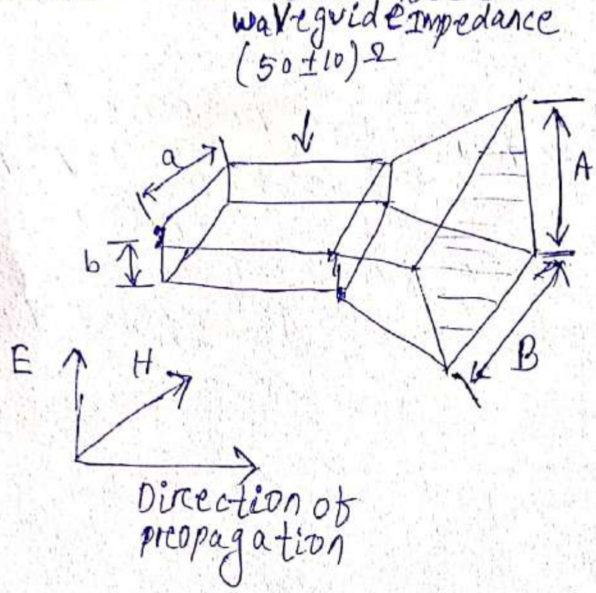
ψ = Angle of Radiation of Radiation pattern.

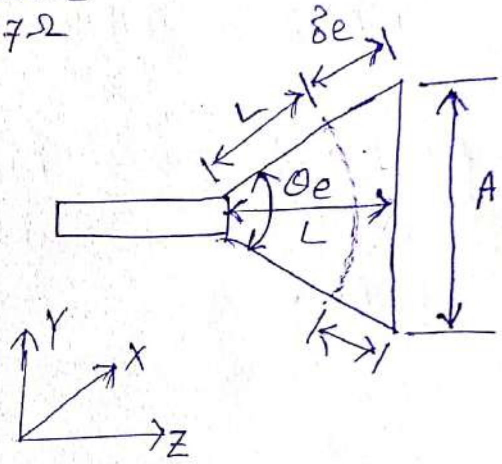


HORN ANTENNA :-

Basics :- (i) Horn Antennas are constructed by flaring of waveguide. (ii) It increases the directivity. (iii) It improves the impedance Matching. (iv) It is directional Antenna, so it can be utilized for long distance communications.

Structure of Horn Antenna :-





L = Flaring Length
θ_e = flaring angle with E-plane.
δe = E-plane flaring Difference.

↳ By Pythagores Theorem

$$(L+\delta e)^2 = L^2 + (A/2)^2$$

$$\Rightarrow L^2 + 2\cdot\delta e\cdot L + (\delta e)^2 = L^2 + \frac{A^2}{4}$$

$$\Rightarrow 2\cdot\delta e\cdot L + (\delta e)^2 = A^2/4$$

↳ By neglecting $(\delta e)^2$ we have

$$\Rightarrow \boxed{L = \frac{A^2}{8\cdot\delta e}} \qquad \left(\begin{matrix}\delta_E < 0.25\lambda \\ \delta_H < 0.4\lambda\end{matrix}\right)$$

Types of Horn Antenna :- (i) sectoral E-plane Horn. (Flaring is done along E-field) (ii) sectoral H-plane Horn. (Flaring is done along H-field). (iii) pyramidal Horn (Flaring is done along both E-field and H-field). (iv) In circular wave guide flaring is done in circular dimension that is called Conical Horn.

Designing of Horn Antenna :-

$$HPBW(E\text{-plane}) = \frac{56^\circ}{A_\lambda}(deg) \quad \left(A_\lambda = \frac{A}{\lambda}\right)$$

$$HPBW(H\text{-plane}) = \frac{67^\circ}{B_\lambda}(deg) \quad \left(B_\lambda = B/\lambda\right)$$

$$FNBW(E\text{-plane}) = \frac{115^\circ}{A_\lambda}(deg)$$

$$FNBW(H\text{-plane}) = \frac{170^\circ}{B_\lambda}(deg)$$

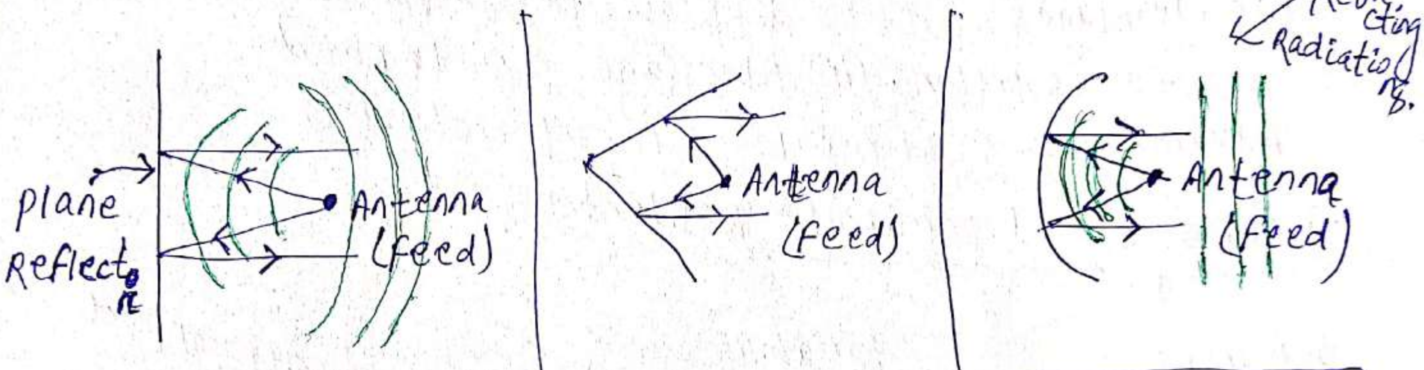
Gain $G = \frac{4\pi A_e}{\lambda^2} \times \eta$, where η = Antenna Efficiency
A_e = Effective Aperature Area.

Applications :- (i) Microwave Engineering. (ii) Feed for parabolic Reflector. (iii) Short Range RADAR.

REFLECTOR ANTENNA :-

Basics :- (i) It is highly directional Antenna. (ii) It is used to very long distance communication, such as satellite communications. (iii) It is applicable to Microwave frequency range (1-100 GHz) and beyond that. (iv) It consists of Two types of elements.
↳ Active Element (Feed Antenna). ↳ parasitic Element (Reflector)

Types of Reflector Antenna :-

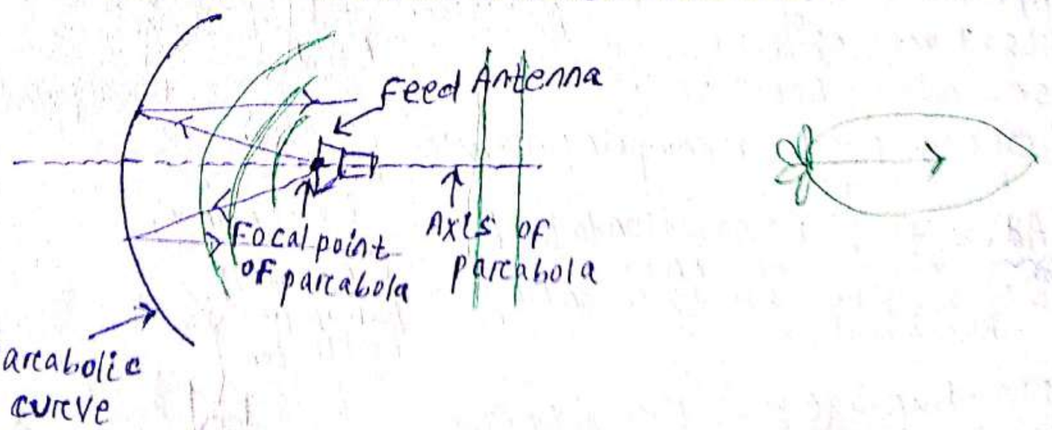


plane Reflector
↳ plane Reflector has less directivity.

corner Reflector
↳ Here Directivity is little more than plane Reflector.

curved Reflector (or) parabolic Reflector.
↳ Here Directivity is ~~more~~ High.

working of parabolic curved Reflector :-



↳ parabolic Reflector antenna converts spherical wavefronts into planar wavefronts. Due to this it is highly directive antenna.

Applications:- (i) Radio Astronomy. (ii) Microwave communication. (iii) Satellite communication. (iv) Deep space communication.

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Feeding Mechanism of parabolic Reflector :- Types of Feeding. (i) center feed parabolic Reflector. (ii) offset Feed parabolic Reflector. (iii) cassergain feed (center) (iv) cassergain offset feed.

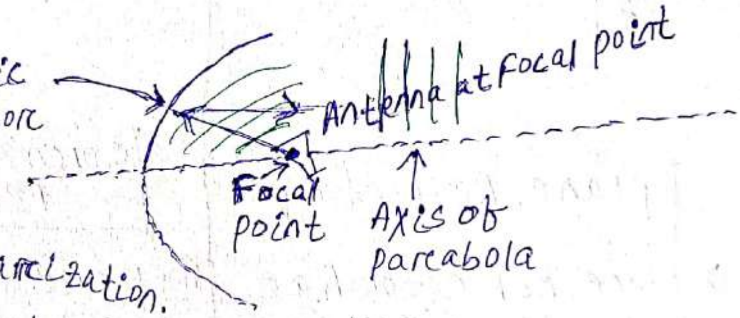
(1) center feed parabolic Reflector:-

Disadvantages:- (i) It is difficult to use for Low noise application due to isolation. (ii) Blockage due to feed.

Advantages:- (i) It has less cross polarization.

(2) offset Fed parabolic Reflector:-

Advantage:-
(i) No blockage due to Feed.

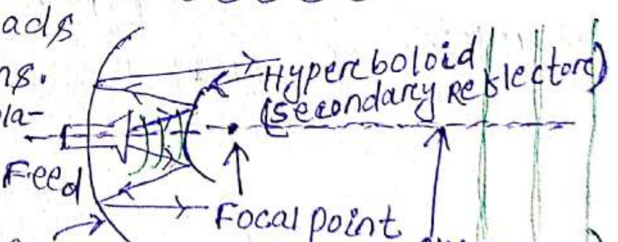


Disadvantages:- (i) cross polarization.

(3) center Feed cassergain parabolic Reflector:-

Advantage:- (i) Isolation of Feed Leads it's use in Low noise applications. (ii) Directivity is high. (iii) Low crosspolarization.

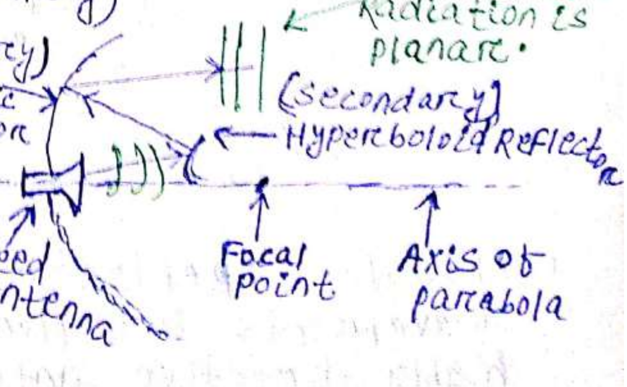
Disadvantage:- (i) Blockage due to secondary Reflector.



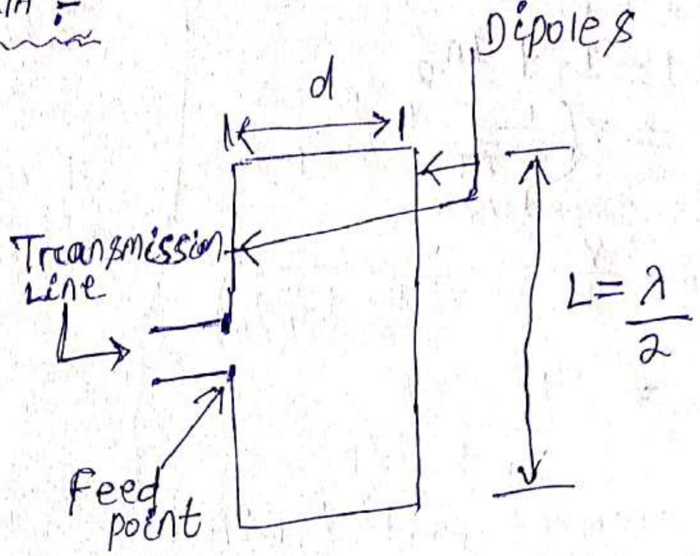
(4) offset feed cassergain parabolic Reflector:-

Advantage:- (i) Isolation to feed Antenna. (ii) No blockage due to secondary Reflector.

Disadvantage:- (i) crosspolarization occurs. Because not symmetric with respect to Axis of parabola.



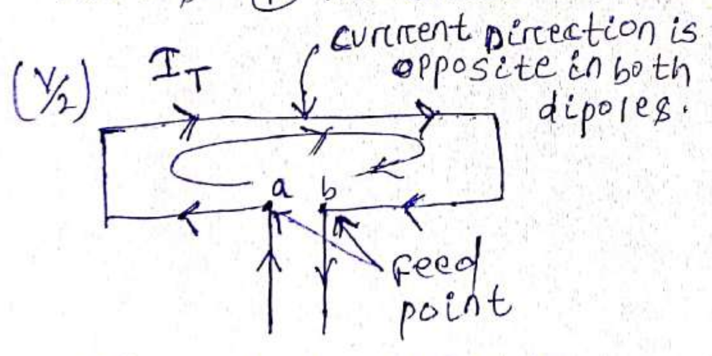
FOLDED DIPOLE ANTENNA :-



Basics :-

- It consists of two parallel dipoles connected at the ends forming a narrow wire loop.
- Length of dipole $L = \frac{\lambda}{2}$ and separation between two dipole is d which is very smaller than λ and L.
- It has high input impedance than half wave dipole.
- It has high bandwidth than half wave dipole antenna. It is utilized for 300Ω Transmission Line.

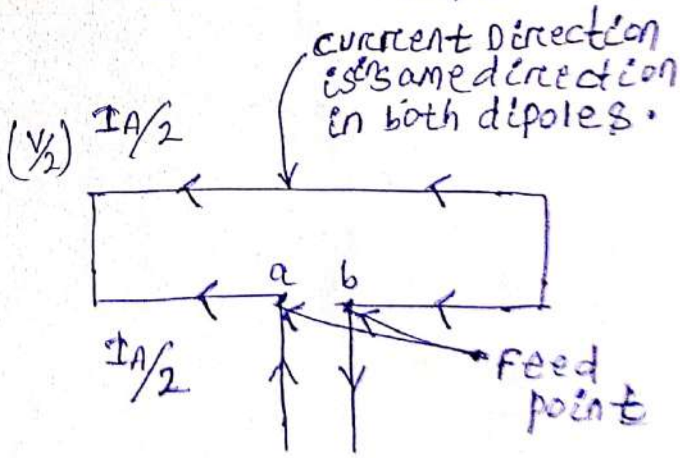
Operation of Folded Dipole :- It is operated in two different modes. (i) Transmission Line Mode. (ii) Antenna Mode.



Transmission Line Mode

↓

It does not radiates because current direction is opposite in both dipoles. So Electric field cancels.



Antenna Mode

↓

It does Radiates.

Derivation of Input Impedance

- current in Transmission Line

$$I_T = \frac{V/2}{Z_T} = \frac{V}{2 \cdot Z_T}$$

- current in Antenna Mode

$$I_A = \frac{V/2}{Z_D} = \frac{V}{2 \cdot Z_D}$$

- For Dipole Length $L = \lambda/2$

$$Z_T = jZ_0 \cdot \tan\left(\beta \cdot (L/2)\right)$$

$$= jZ_0 \cdot \tan\left[\frac{2\pi}{\lambda} \cdot \frac{\lambda}{4}\right]$$

$$= jZ_0 \cdot \tan(\pi/2) = \boxed{\infty}$$

↳ Total current through single Dipole

$$I = I_T + I_A/2$$
$$= V\left(\frac{1}{2 \cdot Z_T} + \frac{1}{4 \cdot Z_D}\right)$$

↳ Input Impedance

$$Z_{in} = \frac{V}{I} = \frac{V}{V\left(\frac{1}{2Z_T} + \frac{1}{4 \cdot Z_D}\right)}$$

$$\Rightarrow Z_{in} = \frac{4Z_T \cdot Z_D}{Z_T + 2 \cdot Z_D}$$

↳ So input Impedance

$$Z_{in} = \frac{4 \cdot Z_D}{1 + \left(\frac{2 \cdot Z_D}{Z_T}\right)} = \frac{4 \cdot Z_D}{1+0} = 4 \cdot Z_D$$

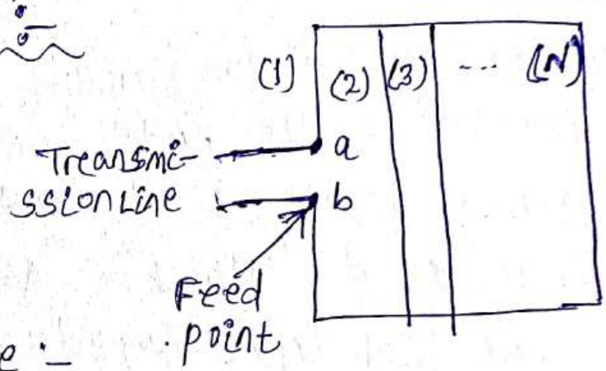
Here $Z_D \approx 73\ \Omega$

$$\Rightarrow \boxed{Z_{in} \approx 300\ \Omega}$$

N-element folded Dipole :-

For N-elements

$$\boxed{Z_{in} = N^2 \cdot Z_D}$$



Applications of Folded Dipole :-

↳ FM broadcast band receiving Antenna.
↳ TV Antenna.
↳ Driving element in Yagi-uda Antenna.
↳ Matching Network of Antenna.

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Scanned by CamScanner

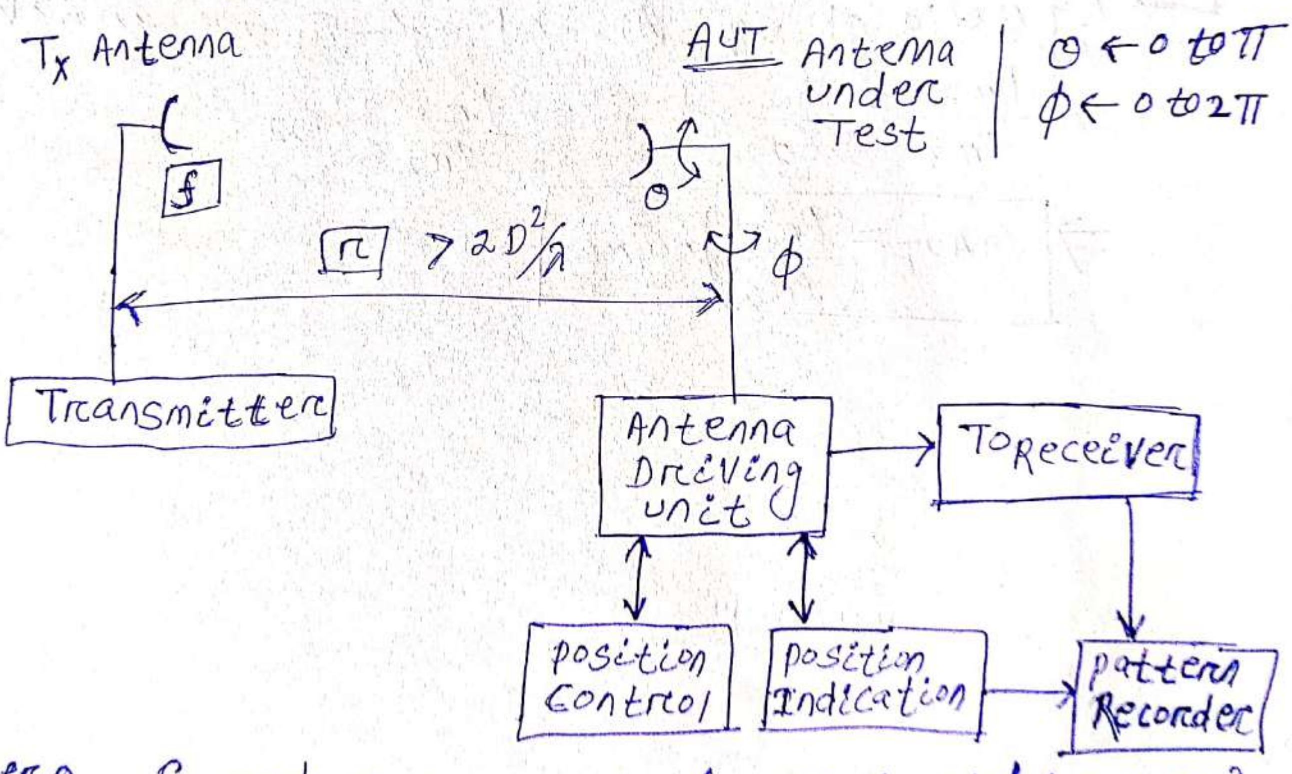
RADIATION PATTERN MEASUREMENT :-

Basics: (i) It is measured at fix distance r and at fixed frequency f. (ii) Here angle θ varies from 0 to π. (iii) Here angle ϕ varies from 0 to 2π.

Definition:- (i) A plot of radiation characteristics of Antenna as a function of θ and ϕ for constant radial distance r and frequency f is called as the Radiation pattern of the Antenna.

parameteres of Radiation patteren :-

↳ First Null Beam width (FNBW). ↳ Half power Beam width (HPBW). ↳ Major Lobe. ↳ side Lobes. ↳ Nulls. ↳ Maxima. ↳ front to back ratio.



↳ Here f and r is constant. r should be $> \frac{2D^2}{\lambda}$.

↳ pattern Recorder ~~measures~~ stores Amplitude and Angle.

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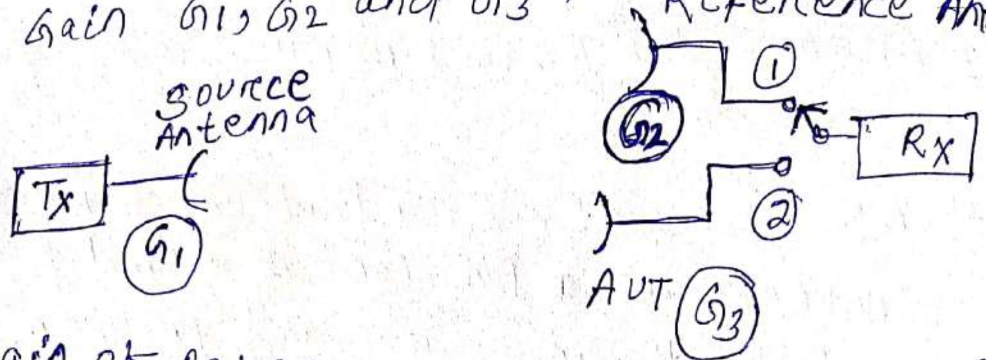
GAIN MEASUREMENT (continued) :-

(2) Comparision Method :- ↳ It requires three antenna of Gain G_1, G_2 and G_3.



↳ Gain of Reference antenna is known gain G_2.

↳ By keeping switch at position (1)

$$P_{r2} = P_T \cdot G_1 \cdot G_2 \cdot \left(\frac{\lambda}{4\pi R}\right)^2 \quad \text{—— (A)}$$

↳ By keeping switch at position —(2)

$$P_{r3} = P_T \cdot G_1 \cdot G_3 \cdot \left(\frac{\lambda}{4\pi R}\right)^2 \quad \text{—— (B)}$$

↳ By ratio of eqn—(A) and eqn—(B) we can have

$$\frac{P_{r2}}{P_{r3}} = \frac{G_2}{G_3} \Rightarrow G_3 = \left(\frac{P_{r3}}{P_{r2}}\right) \cdot G_2$$

$$\Rightarrow \boxed{G_{AUT} = \left(\frac{P_{r3}}{P_{r2}}\right) \cdot G_{ref}}$$

—— x ——

ANTENNA FIELD ZONES :-

↳ Field zone means how antenna radiates with respect to its position. There are three antenna field zone (1) Reactive near field region. (2) Radiating near field region. (3) Far field region

(1) Reactive Near Field Region :-

↳ It is that portion of the near field region immediately surrounding the antenna where in the reactive field predominates.

↳ For most of the antennas, The outer boundary of this region is $\boxed{R = 0.62\sqrt{\frac{L^3}{\lambda}}}$

↳ But for a very short dipole radiator, the outer boundary is $\boxed{R < \frac{\lambda}{2\pi}}$

↳ In general, objects within this region will result in coupling with the antenna and distortion of the ultimate far field antenna pattern.

↳ Large conductor within this distance will couple with the antenna and "detune" it. The result can be an altered resonant frequency, radiation resistance and Radiation pattern.

(2) Radiating Near field Region :-

↳ It is that region of the field of an antenna between the Reactive near field region and the far field region. ↳ For This region, the distance from the antenna R is $\boxed{0.62\sqrt{\frac{L^3}{\lambda}} < R < \frac{2 \cdot L^2}{\lambda}}$.

↳ This region is also called the Transition region.

↳ properties of this region are :- (i) The Antenna pattern is taking shape but it is not completely formed.

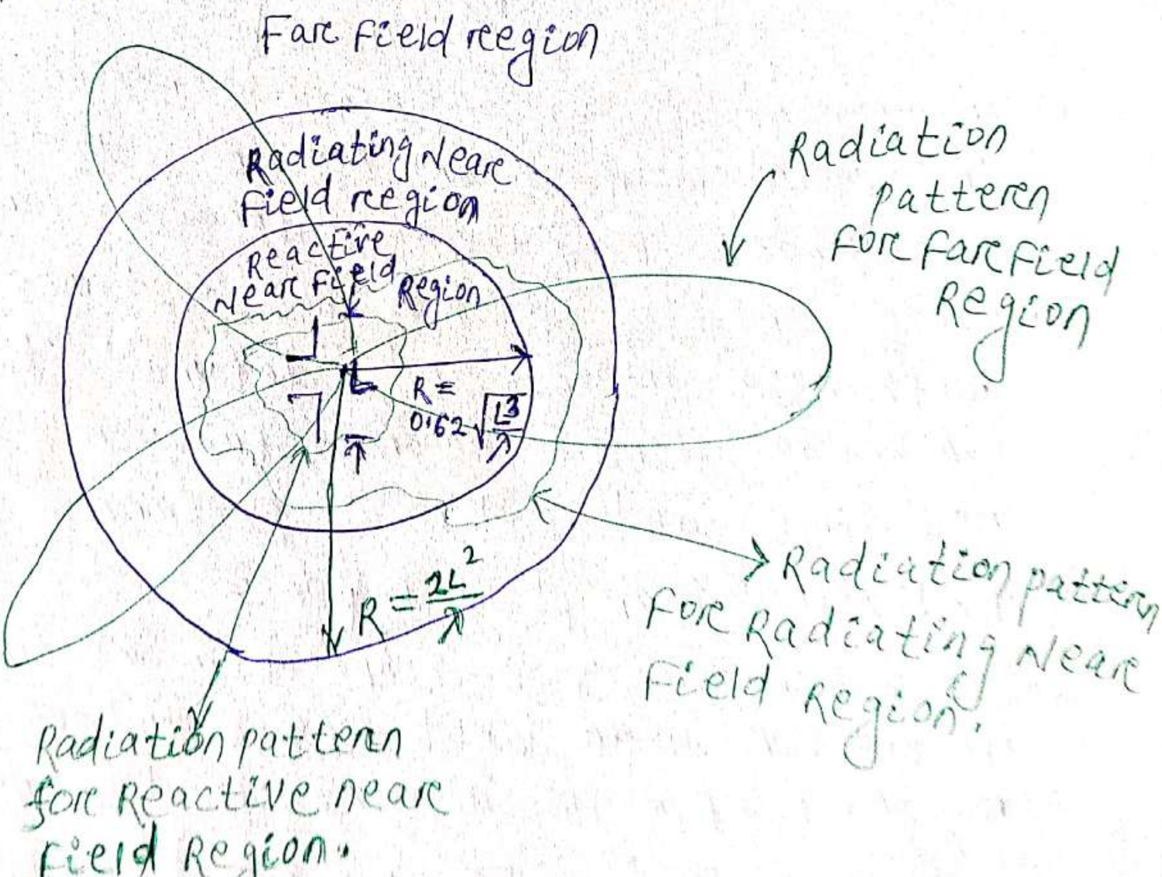
(ii) The radiation field predominates the reactive field. (iii) The radiated wave front is still clearly curved. (iv) The Electric and Magnetic field vectors are not orthogonal.

(3) Far-Field Region :- ↳ It is that region of the field of an Antenna where the angular field distribution is essentially independent of the distance from the antenna.

↳ For this region, the distance from the antenna R is

$$\boxed{R > \frac{2L^2}{\lambda}}$$

↳ properties of this region are :- (i) The wavefront becomes approximately plannere. (ii) The Radiation pattern is completely formed and does not vary with distance. (iii) E-field and H-field vectors are orthogonal to each other.



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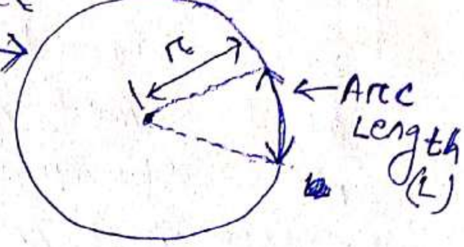
Angle [Radian] :-



It is arc Length per unit radius.

$$\theta = \frac{\text{Arc Length}}{\text{Radius}} = \frac{L}{r} \text{ [in radian]}$$

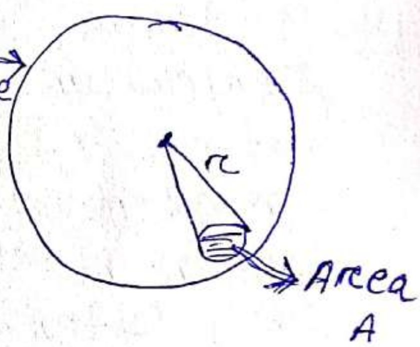
↳ For complete circle, Arc Length $= 2\pi r$

$$\theta = \frac{2\pi r}{r} = 2\pi \text{ (Radian)}$$

↳ Radian is measured in 2-Dimension (2D).

Solid Angle [steradian] :-

↳ It is amount of area per square of radius.



$$\text{solid Angle}(\phi) = \frac{\text{Area}}{(\text{radius})^2} \text{ (in sr)}$$

↳ for complete sphere, surface area is $= 4\pi r^2$

Now solid Angle $\phi = \frac{4\pi r^2}{r^2} = 4\pi$ sr (in steradian)

↳ solid angle is angle measurement in 3D.

Relation between Radian and steradian :-

↳ 1 steradian $= 1 \text{ rad} \times 1 \text{ rad} = 1 \text{ rad}^2$

$$= \left(\frac{180}{\pi}\right)^2 (\text{deg})^2 = 3286.13 \,(\text{degree})^2$$

↳ For complete sphere

Solid angle $= 4\pi$ (So) $= 4\pi \times 3286.13$

$= 41273.88 \,(\text{degree})^2$

—— x —— x —— xx ——

ANTENNA TEMPERATURE :-

Basics :- (i) Antenna Temperature T_a is a parameter that describes how much noise an antenna produces in a given environment.

(ii) This Temperature is not the physical temperature of the antenna. (iii) Moreover, an antenna does not have an intrinsic "antenna Temperature" associated with it; rather the temperature depends on its gain pattern and the thermal environment that it is placed in. (iv) Antenna Temperature is also sometimes referred to as Antenna Noise Temperature.

Definition of Antenna Temperature :- (i) The noise Temperature is mathematically defined as

$$T_A = \frac{1}{4\pi}\int_0^{2\pi}\int_0^{\pi} R(\theta,\phi)\cdot T(\theta,\phi)\cdot \sin\theta\cdot d\theta\cdot d\phi$$

(ii) where, $R(\theta,\phi)$ is Radiation pattern of Antenna. $T(\theta,\phi)$ is Temperature distribution.

(iii) To define the environment, we will introduce a Temperature distribution - This is the Temperature in every direction away from the antenna in spherical co-ordinates. For instance, the night sky is roughly 4 Kelvin; The value of the temperature pattern in the direction of the Earth's ground is the physical temperature of the Earth's ground.

Noise power By Antenna as per Antenna Temperature :-

→ Noise power $\boxed{P_{TA} = K\cdot T_A\cdot B}$, where T_A is Antenna Temperature, (in Kelvin) K is Boltzmann's constant, B is Bandwidth.

Gain with Respect to Temperature :-

↳ A parameter often encountered in specification sheets for antennas that operate in certain environments is the ratio of gain of the antenna divided by the antenna temperature (or system temperature if a receiver is specified). This parameter is written as G/T, and has units of dB/Kelvin.

———x——— x ——— x ———x———

RADIATION RESISTANCE IN ANTENNA :- (R_r)

↳ The antenna is a radiating device, which radiates Electromagnetic wave (EM wave) in the space.

↳ If we supply I current to antenna, then power dissipated by antenna is $\boxed{P = I^2 \cdot R}$.

↳ The energy supplied to antenna is dissipated in two ways.
① Radiated power (P_{rad}) ② Due to ohmic Loss (P_{Loss})

↳ So, Total power $P = P_{rad} + P_{Loss} = I^2 \cdot R_r + I^2 \cdot R_L$

$$= I^2 \cdot (R_r + R_L)$$

R_r = Radiation Resistance

↳ Radiation efficiency $\epsilon_{rad} = \frac{R_r}{R_r + R_L}$

If R_r is high then ϵ_{rad} is high.

↳ Radiation resistance depends upon following parameters.
① Configuration Antenna. ② Ratio of Length to Diameter of conductor used in antenna. ③ It depends upon point where radiation resistance is considered. ④ Location of antenna with respect to ground and other objects. ⑤ Corona discharge.

↳ Basically Radiation Resistance is associated with amount of power radiated by antenna in the space as Electromagnetic waves. So higher the Radiation Resistance, indicates higher the radiated power by antenna. And higher the Radiation Resistance, highere the Radiation efficiency of antenna.

DIRECTIVITY OF ANTENNA :-

① The directivity of an antenna is defined as the ratio of radiation intensity in a given direction from the antenna to the radiation intensity average over all direction.

$$D = \frac{U_{given\ direction}}{U_{avg.}}, \quad U = \text{Radiation Intensity}$$

↳ Average radiation Intensity $U_{avg} = \frac{P_{rad}}{4\pi}$

$$\Rightarrow \boxed{D = \frac{4\pi \cdot U}{P_{rad}}}$$

↳ Maimum Directivity has to be calculated in case of direction is not given. So Maximum Directivity is defined as the ratio of radiation Intensity in maximum direction to the readiation Intensity of Isotropic Source. Isotropic source radiates equally in all direction.

↳ Approximated Directivity $(D) = \frac{4\pi}{\theta_{HP} \cdot \phi_{HP}}$

Here θ_{HP} = Half power Beamwidth (HPBW) in E-plane.

ϕ_{HP} = Half power Beamwidth (HPBW) in H-plane.

—x— x—

Example:- The radiation Intensity of a unidirectional Antena is given by $U = U_m \cdot \cos\theta$, where $0 \leq \theta \leq \frac{\pi}{2}$, $0 \leq \phi \leq 2\pi$. Find Directivity.

Soln:- Directivity $D = \frac{4\pi \cdot U_m}{P_{rad}} = \frac{4\pi \cdot U_m}{U_m \cdot \pi} = 4$

Radiated power $P_{rad} = \int U \cdot d\Omega = \int_{\theta=0}^{\pi/2} \int_{\phi=0}^{2\pi} (U_m \cdot \cos\theta) . \sin\theta \cdot d\theta \cdot d\phi$

$$= \frac{U_m}{2} \cdot \int_{\phi=0}^{2\pi} d\phi \cdot \int_{\theta=0}^{\pi/2} 2 \cdot \cos\theta \cdot \sin\theta \cdot d\theta = \frac{U_m (2\pi)}{2} \cdot \int_{\theta=0}^{\pi/2} \sin 2\theta \cdot d\theta$$

$$= U_m \pi \left[-\frac{\cos 2\theta}{2} \right]_0^{\pi/2} = \frac{U_m \pi}{2} \cdot [-\cos\pi + \cos 0]$$

$$= \frac{U_m \pi}{2} \cdot [1+1] = \boxed{U_m \cdot \pi}$$

put ~~these~~ This value in above equation.

—x— x—

RADIATION DENSITY AND RADIATED POWER :-

↳ when Electromagnetic wave travels in space, The power density of radiation by antenna related to Electric and Magnetic field is given by

$$\vec{w} = \vec{E} \times \vec{H} \quad (\text{watt}/\text{metre}^2)$$

↳ so, for Instantaneous power $P_{int} = \oint \vec{w} \cdot \vec{ds}$

↳ Average power density $w_{avg.} = \frac{1}{2} Re [\vec{E} \times \vec{H}]$

↳ so, radiated power / Average power by Antenna is

$$\boxed{P_{rad} = \oint_S \vec{w}_{avg} \cdot \vec{ds}} = \oint_S \left[\frac{1}{2} Re(\vec{E} \times \vec{H})\right] \cdot \vec{ds}$$

$$= \frac{1}{2} \oint_S Re(\vec{E} \times \vec{H}) \cdot ds$$

↳ Relationship between $\vec{E}$ and $\vec{H}$ is $H = \frac{E}{\eta}$ (or)

$$\vec{E} = \eta \cdot \vec{H}$$

$$\Rightarrow \vec{w}_{avg} = \frac{E^2}{2\eta} \cdot \vec{a_r} = \frac{\eta H^2}{2} \cdot \vec{a_r}$$

$$P_{rad} = \frac{1}{2\eta} \oint_S E^2 \, \vec{a_r} \cdot \vec{ds}$$

—xx— x —x—

Example on Radiated power :-

Que:- The power density of an antena is expressed as

$$\vec{W}_{rad} = \frac{A_0 \cdot \sin\theta}{r^2} \cdot \hat{a}_r \quad (\text{watt}/\text{metre}^2)$$

Find the Radiated power

In Intensity we don't multiply r^2.

Sol:- $P_{rad} = \oint W_{rad} \cdot \vec{ds} = \iint_{\phi\ \theta} W_{rad} \cdot r^2 \cdot \sin\theta \cdot d\theta \cdot d\phi$

we multiply with r^2 only in case of power Density.

$$= \int_{\phi=0}^{2\pi} \int_{\theta=0}^{\pi} \frac{A_0 \cdot \sin\theta}{r^2} \cdot r^2 \cdot \sin\theta \cdot d\theta \cdot d\phi$$

$$= \int_{\phi=0}^{2\pi} \int_{\theta=0}^{\pi} A_0 \sin^2\theta \cdot d\theta \cdot d\phi = A_0 \cdot \int_{\phi=0}^{2\pi} d\phi \cdot \int_{\theta=0}^{\pi} \sin^2\theta \cdot d\theta$$

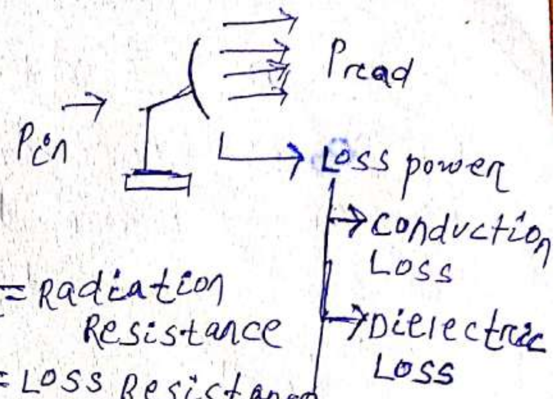
$$= A_0 \cdot (2\pi) \cdot \int_{\theta=0}^{\pi} \left(\frac{1-\cos 2\theta}{2}\right) \cdot d\theta$$

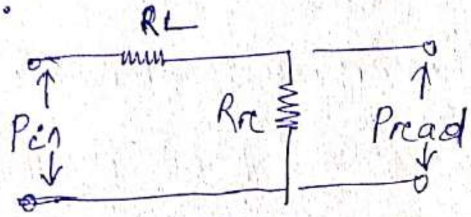
$$= A_0 \pi \int_{\theta=0}^{\pi} (1-\cos 2\theta)\cdot d\theta = A_0 \cdot \pi \left[\theta - \frac{\sin 2\theta}{2}\right]_{\theta=0}^{\pi}$$

$$= A_0 \pi \left[(\pi - 0) - (0-0)\right] = \boxed{A_0 \cdot \pi^2} \text{ watt.}$$

ANTENNA RADIATION EFFICIENCY :-

↳ If loss power is more then Radiated power (P_{rad}) will be less.





R_r = Radiation Resistance
R_L = Loss Resistance

↳ Radiation Efficiency $= \dfrac{P_{rad}}{P_{in}} = \dfrac{R_r}{R_r + R_L} = \epsilon_{rad}$

↳ By increasing Radiation Resistance, we can increase radiation efficiency.

Example :- If $R_L = 10\Omega$, $R_r = 10\Omega$

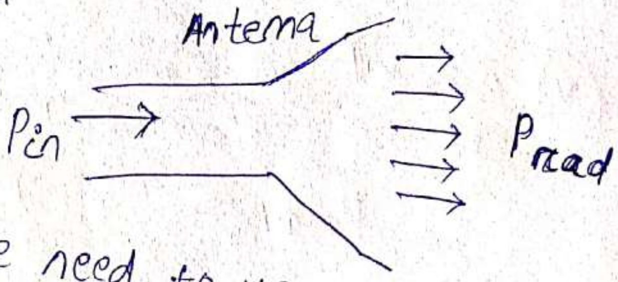
$$\epsilon_{rad} = \frac{R_r}{R_r + R_L} = \frac{10}{20} = 0.5$$

If $R_L = 10\Omega$, $R_r = 40\Omega$

$$\epsilon_{rad} = \frac{40}{50} = 0.8$$

ANTENNA GAIN :-

(i) we have seen Directivity of Antenna is $D = \frac{4\pi \cdot U_m}{P_{rad}}$ —— (1)



(ii) For Gain of Antenna we need to use Pin instead of Prad in directivity.

$G = \frac{4\pi U_m}{P_{in}}$ —— (2)

(iii) Efficiency of Antenna $K = \frac{P_{rad}}{P_{in}}$

(iv) Equation-(2)/Equation-(1) is $\frac{G}{D} = \frac{4\pi U_m/P_{in}}{4\pi U_m/P_{rad}} = \frac{P_{rad}}{P_{in}} = K$

$\Rightarrow \boxed{G = K \cdot D}$

(v) Gain of Antenna can be measured by Antenna under Test with respect to reference antenna.

$\Rightarrow \boxed{G = \frac{U_{AUT}}{U_{Ref.}}} = \frac{\text{Radiation Intensity of Antenna under Test}}{\text{Radiation Intensity of reference Antenna}}$

reference Antenna → (Isotropic Antenna)

$U_{Ref.} = \frac{P_{in}}{4\pi}$

So, $G = \frac{U_{AUT}}{P_{in}/4\pi} = \boxed{\frac{4\pi \cdot U_{AUT}}{P_{in}}}$

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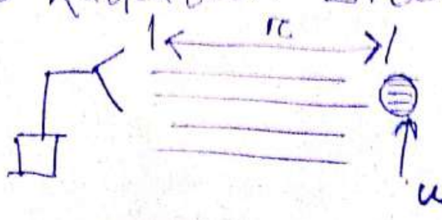
RADIATION INTENSITY :-

(i) Radiation Intensity is amount of power radiated by antenna per unit solid angle.

(ii) unit of Radiation Intensity is watt/steradian.



$U = w \cdot r^2$

(iii) w (power density) $= \frac{E^2}{2 \cdot \eta}$

(iv) So, Radiation Intensity $= \frac{r^2 \cdot E^2}{2 \cdot \eta}$

(v) Based on Radiation Intensity, Radiated power can be calculated by

$$P_{rad} = \int U \cdot d\Omega = \oint_S \vec{W} \cdot d\vec{s}$$

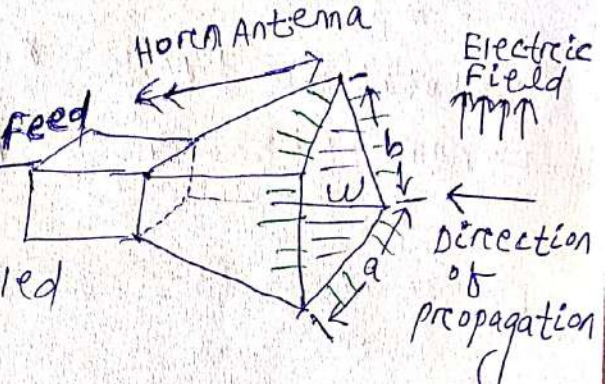
$$= \int_\theta \int_\phi U \cdot \underline{\sin\theta \cdot d\theta \cdot d\phi}$$

—— x —— x ——

ANTENNA APERATURES :-

↳ Aperature means Area. With each Antenna, we can associate a number of equivalent areas. These are used to describe the power capturing characteristics of antenna. Different aperatures are
① Physical Apereature, ② Effective Aperature
③ Scattering Aperature ④ Loss Aperature
⑤ Collecting Aperature.

① Physical Aperature :-



↳ Rectangular horn antenna with dimensions a and b is given. The area of opening called as Physical aperature A_p.

$$\boxed{A_p = a \times b}$$

↳ If Incident wave has power density W. Then Received power $\boxed{P = W \cdot A_p \text{ (in watts.)}}$.

② Effective Aperature :- ↳ when we receive power, it is less than we calculate. It is happening due to following reasons. (i) Horn is not uniform over opening.
(ii) Electric field ($\vec{E}$ field) at wall must be zero but practically not.
(iii) Due to teppering loss. (iv) Due to conduction loss.

↳ So to understand effective aperature we need to calculate aperature efficiency.

$$\epsilon_{ap} = \frac{A_e}{A_p} = \frac{\text{Effective Aperature}}{\text{Physical Apereature}}$$

↳ Sattering Aperature occurs due to edges of Antenna. If edges are not proper then there will be scattering from edges of any antenna.

↳ Loss will occure due to conductive material as a horn, so E-field is not zero at the wall.

↳ collecting Aperature will indicate how much ElectroMagnetic wave it will collect at the opening of Antenna.

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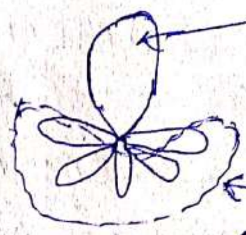
BEAM EFFICIENCY



Ω_M = Solid Angle for Major lobes

Ω_m = Solid Angle for Minor lobes

↳ Total Solid Angle $\Omega_A = \Omega_M + \Omega_m$

↳ Beam Efficiency $\epsilon_M = \frac{\Omega_M}{\Omega_A} = \frac{\Omega_M}{\Omega_M + \Omega_m}$

↳ stray factor $\epsilon_m = \frac{\Omega_m}{\Omega_A} = \frac{\Omega_m}{\Omega_M + \Omega_m}$

↳ Beam Efficiency + stray Factor = 1

— x —

BASICS OF RADIATION PATTERN :-

① HPBW (Half power Beam width) :-

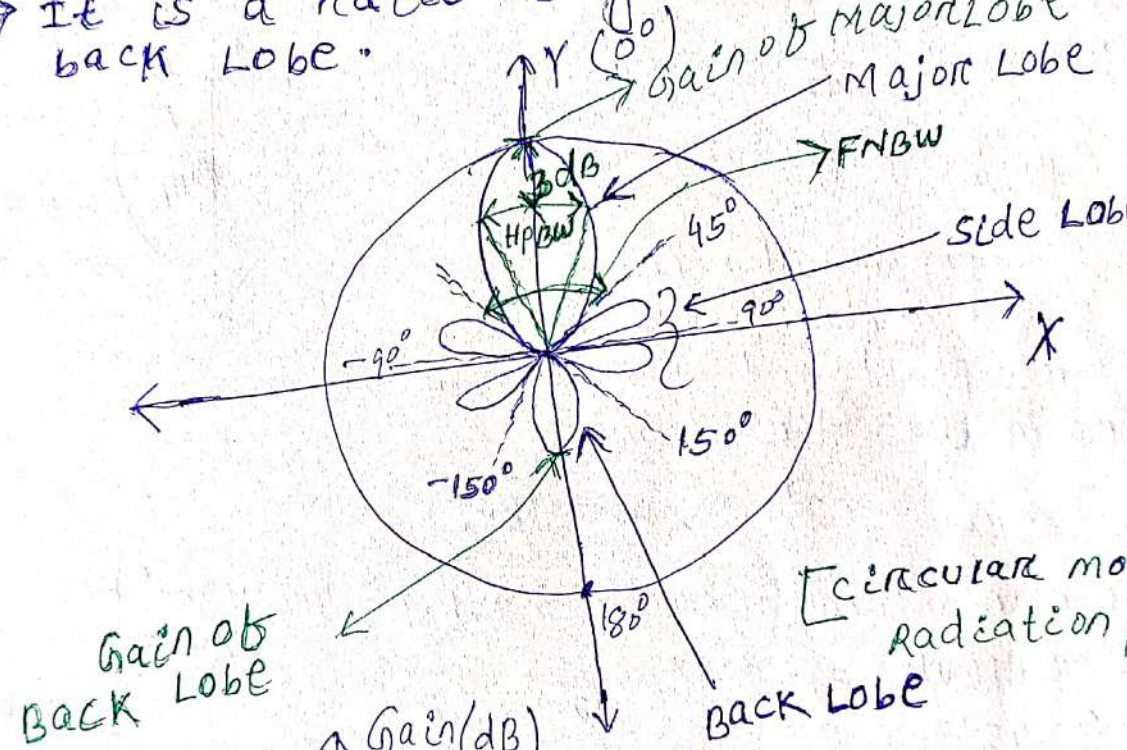
↳ It is a angular width of major lobe, from maximum to 3-dB down.

② FNBW (First Null Beam width) :-

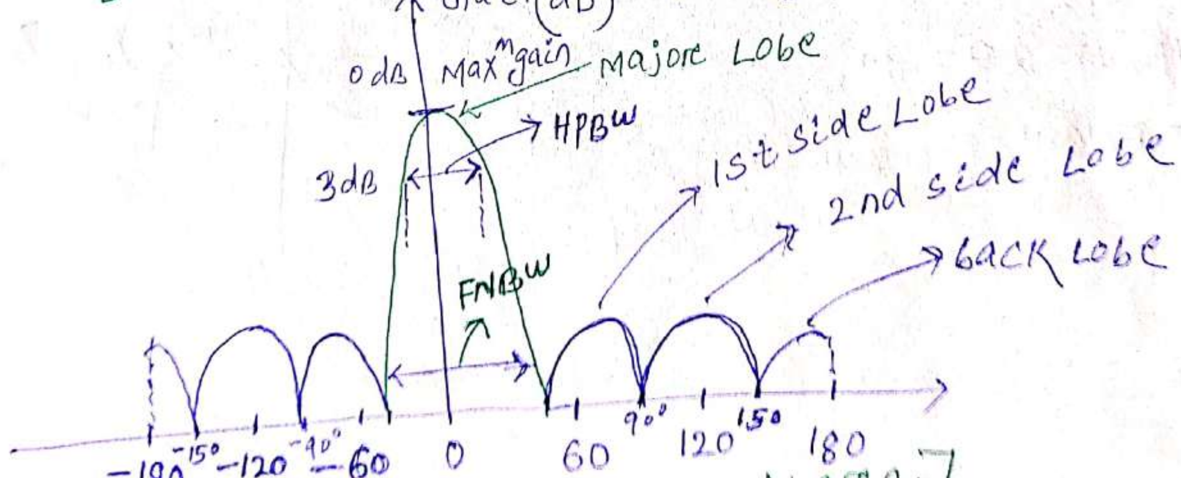
↳ It is a width of Major lobe.

③ Front to Back ratio :-

↳ It is a ratio of gain from major Lobe to back Lobe.



[circular mode of Radiation pattern.]



[Axial Mode of Radiation pattern.]

↳ In above diagram An Antenna is radiating in X-Y plane.

↳ Major Lobe Angle with X-axis is 45° and with Y-axis is 0°.

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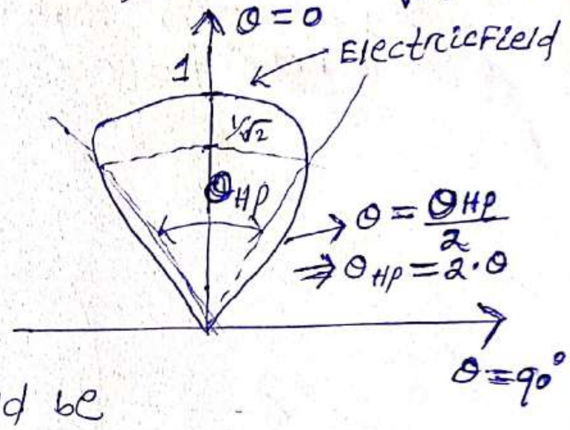
Examples on HPBW and FNBW :-

Que :- An Antenna is having a field patteren given by $E(\theta) = \cos\theta$, for $0 \leq \theta \leq 90^\circ$. Find Half power Beam width and FNBW.

Ans :- HPBW is width of beam of major lobe and power is half. We know power (P) $\propto E^2$ (square of Electric Field.)

$\Rightarrow E \propto \sqrt{P}$

↳ At Half power Beam width power is half, and at the same time Electric field (E-field) should be $\frac{1}{\sqrt{2}}$ of maximum E-field.



↳ $E(\theta) = \cos\theta = \frac{1}{\sqrt{2}} \Rightarrow \theta = 45^\circ$

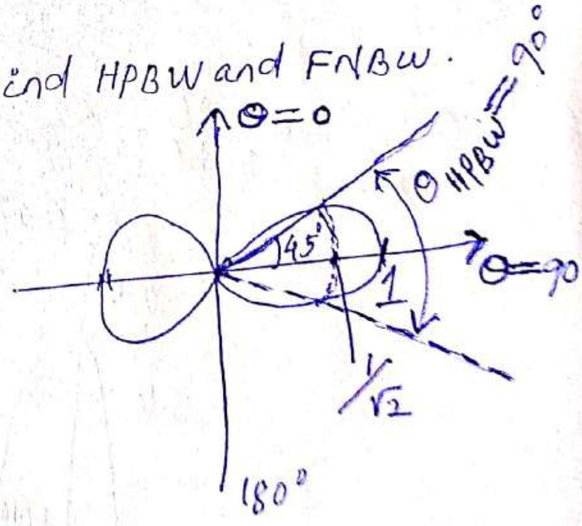
$\Rightarrow \theta_{HPBW} = 2 \cdot \theta = 90^\circ$

↳ First Null Beamwidth (FNBW) is based on Null. Null means Electric field and power should be zero in that direction.

$\Rightarrow \theta_{FNBW} = 2\theta' = 2 \times 90 = 180^\circ$

—— x ——

Que-2 For an antenna $E(\theta) = \sin\theta$. Find HPBW and FNBW.



Ans :- For HPBW, $E(\theta) = \sin\theta = \frac{1}{\sqrt{2}}$

$\Rightarrow \theta = 45^\circ$

$\Rightarrow \theta_{HPBW} = 2\theta = 90^\circ$

↳ For FNBW, $\theta_{FNBW} = 180^\circ - 0^\circ$

$= \boxed{180^\circ}$

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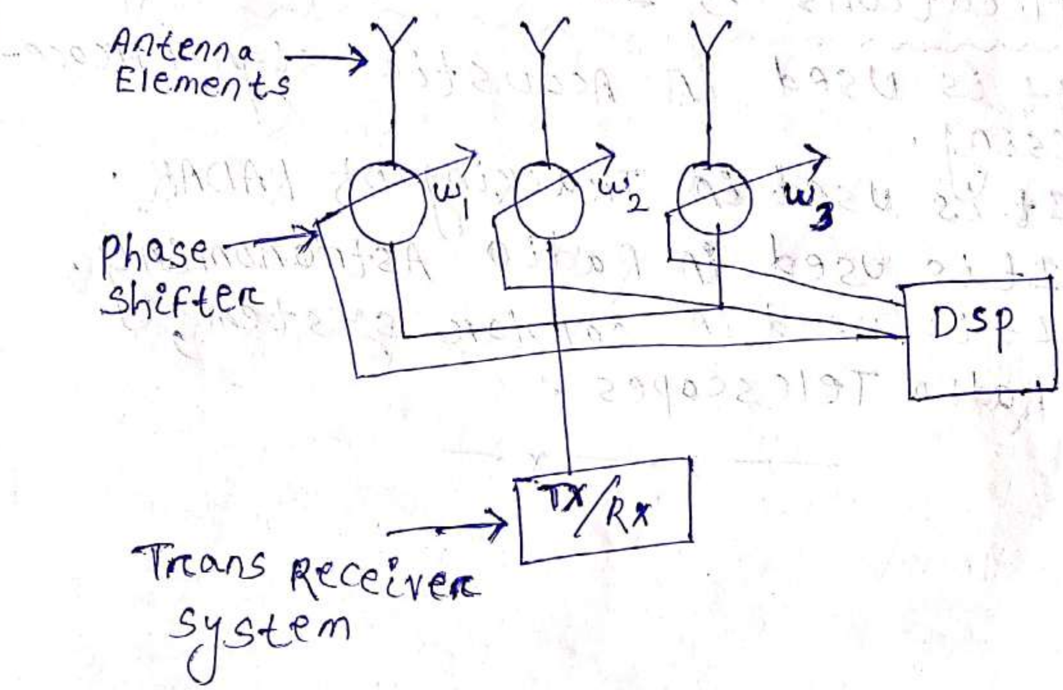
SMART ANTENNA :-

↳ It is the combination of Antenna phased Array and DSP processors.

STRUCTURE OF SMART ANTENNA :-



↳ phase of the phase shifter is controlled by DSP processor. By controlling the phase of phase shifter Antenna is steered.

↳ Antenna Elements radiates in desired direction only. It has minimum intereference. Each Antenna element is connected with phase shifter and then it is connected with Trans-Receiver system. smart Antenna has higher gain in desired direction.

Definition :- A smart Antenna system combines multiple antenna elements with signal processing capability to optimize the radiation and/or reception pattern automatically in response to the signal environment

Smart Antenna Benefits :- ① It has higher gain for the desired signal.
② Intereference Rejection.
③ Increase system capacity.

Applications of smart Antenna :-

① It is used in Acoustic signal processing.
② It is used in Tracking of RADAR.
③ It is used in Radio Astronominy.
④ It is used in cellular system, Radio Telescopes.

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e

ZERO MODE and PI MODE IN MAGNETRON:-

→ If ϕ represents the relative phase change of the AC electric field across adjacent cavities then

$$\phi = \frac{2\pi n}{N}, \text{ where } n = 0, \pm 1, \pm 2, \ldots \pm \frac{N}{2}$$

→ It means $\frac{N}{2}$ number of modes of resonance can exist if N is an even number.

If $n=0$, $\phi = 0$, so it is zero mode

If $n = \frac{N}{2}$ then $\phi = \pi$, so it is called PI MODE magnetron.

Pi MODE in MAGNETRON :-

→ In this mode, adjacent anode cavity have 180° phase difference. pi mode is most commonly used more in magnetron.

→ A Magnetron when operated under pi mode, it gives maximum output power and desired frequency.

→ Since Magnetron has 8 coupling cavity resonators, several different modes of oscillation is possible.

→ The oscillation frequency corresponding to the different modes are quite close to one another, so that a pi mode oscillation which is normal for magnetron.

→ The modes which are close to pi mode, switching occurs between ~~thes~~ modes. This is called mode jumping.

strapping in MAGNETRON :-

→ In order to avoid mode jumping strapping is used.

→ strapping consists of two rings of heavy gauge wire connecting alternate anode poles. These are the poles that should be in phase with each other for pi mode. phase other than pi is rejected.

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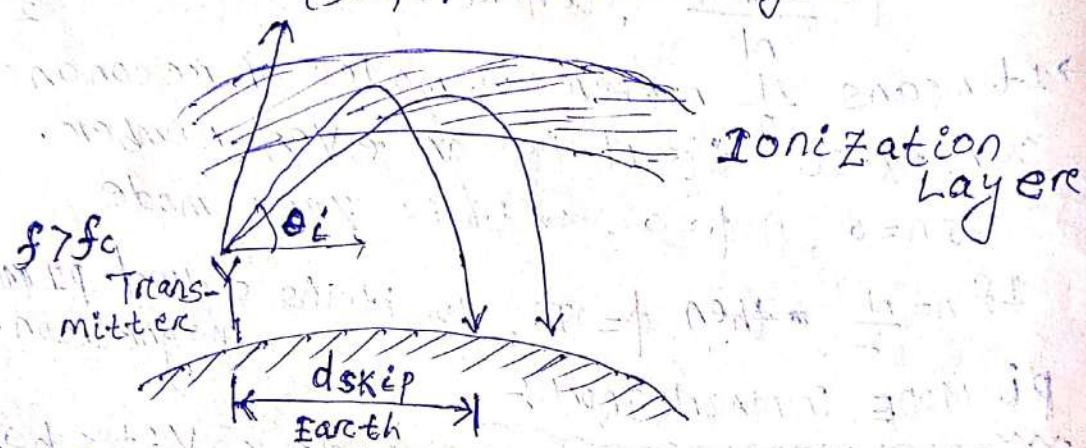
SKIP DISTANCE :- The skip Distance is the shortest distance from a Transmitter measured along earth's surface at which sky wave at fixed frequency ($f > f_c$) will be returned to the earth.



↳ A θ_i Angle of Radiation the signal comes to the earth by reflecting in Ionization Layer.

↳ So we can say the sky wave propagation is possible for greater than skip distance.

↳ Equation of Maximum usable frequency (f_{muf}) and critical frequency (f_c) is

$$\Rightarrow f_{MUF} = f_c \cdot \sqrt{1+\left(\frac{d}{2H}\right)^2}$$

$$\boxed{\Rightarrow d_{skip} = 2H \cdot \sqrt{\left(\frac{f_{MUF}}{f_c}\right)^2 - 1}}$$

xx — xx — xx

CRITICAL FREQUENCY :- For any given time, each Ionospheric Layer has a maximum frequency at which radio waves can be transmitted vertically and reflected back to the earth. This frequency is known as critical frequency.

↳ For Ionosphere Layer $\mu = \sqrt{1 - \frac{81N}{f^2}}$, where

μ = Refractive Index of Ionospheric Layer.

N = Number of Electron Density.

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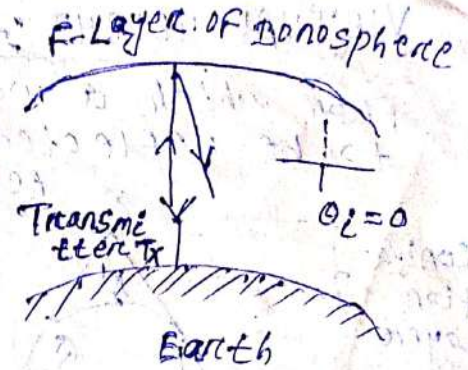
From Snell's Law,

$$\mu = \frac{\sin\theta_i}{\sin\theta_t} = \sqrt{1-\frac{81N}{f^2}}$$



↳ For $f = f_c$ (critical frequency), $\theta_i = 0$

$$\Rightarrow 0 = \sqrt{1-\frac{81N}{f^2}}$$

$$\Rightarrow \boxed{f_c = 9\sqrt{N}}$$

↳ For D-Layer in Ionosphere critical frequency $f_c = 100$ KHZ.

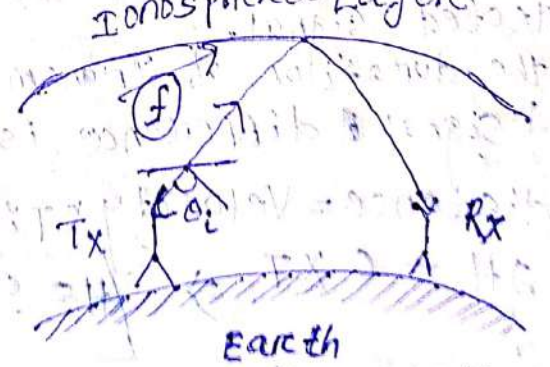
For E-Layer → $f_c = 3$ to 5 MHZ

For F_1-Layer → $f_c = 5$ to 7 MHZ

For F_2-Layer → $f_c = 10$ MHZ

MAXIMUM USABLE FREQUENCY (MUF) :-

↳ In sky wave propagation the maximum usable frequency is defined as the highest frequency that can be used for sky wave communication between two given points on earth.



CASE-1 :-

↳ for $\theta_i = 90^\circ$,

$f = f_c = f_{MUF}$

$$\boxed{f_{MUF} = 9\sqrt{N}}$$

CASE-2 :-

for $\theta_i < 90^\circ$, $\mu = \sin\theta_i = \sqrt{1-\frac{81N}{f^2}}$

↳ After the range of maximum usable frequency, the signal is penetrated into ionosphere.

↳ Here frequency is variable.

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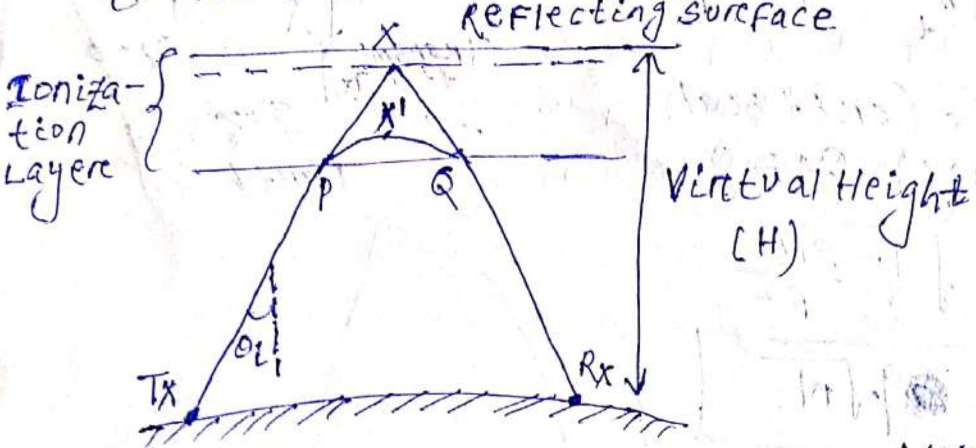
VIRTUAL HEIGHT :- The Virtual height is that height from which a wave sent up at an angle appears to be reflected.



↳ Due to Gradual change in Refractive Index actual path is $T_x - P - X' - Q - R_x$. And virtual path is $T_x - P - X - Q - R_x$.

↳ The height associated with virtual path is virtual height.

↳ To measure the virtual height, the instrument used is ionospheric sound is also called as IONOSONDE.

↳ The Transmitter Antenna sends vertically upward radio wave of pulse duration 150 micro second (MS).

↳ The Receiver Antenna (Rx) is placed closed to Transmitter Antenna (T_x) and receives ~~reflected~~ reflected signal.

↳ If the duration of Transmitter (T_x) and Receiver (R_x) signal difference is T. Then,

distance = Velocity × Time

$$\Rightarrow 2H = c \times T \Rightarrow \boxed{H = \frac{c \times T}{2}}$$

(Sending Distance H, Receiving distance is H by Reflection. So Total Distance is 2H)

↳ The height associated with Actual path is Actual height.