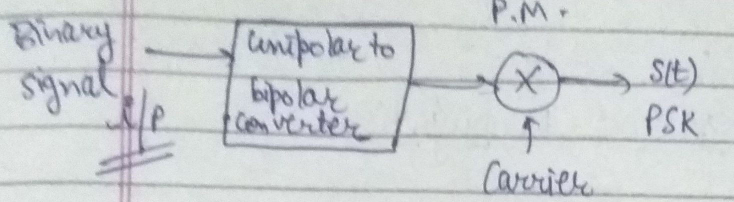
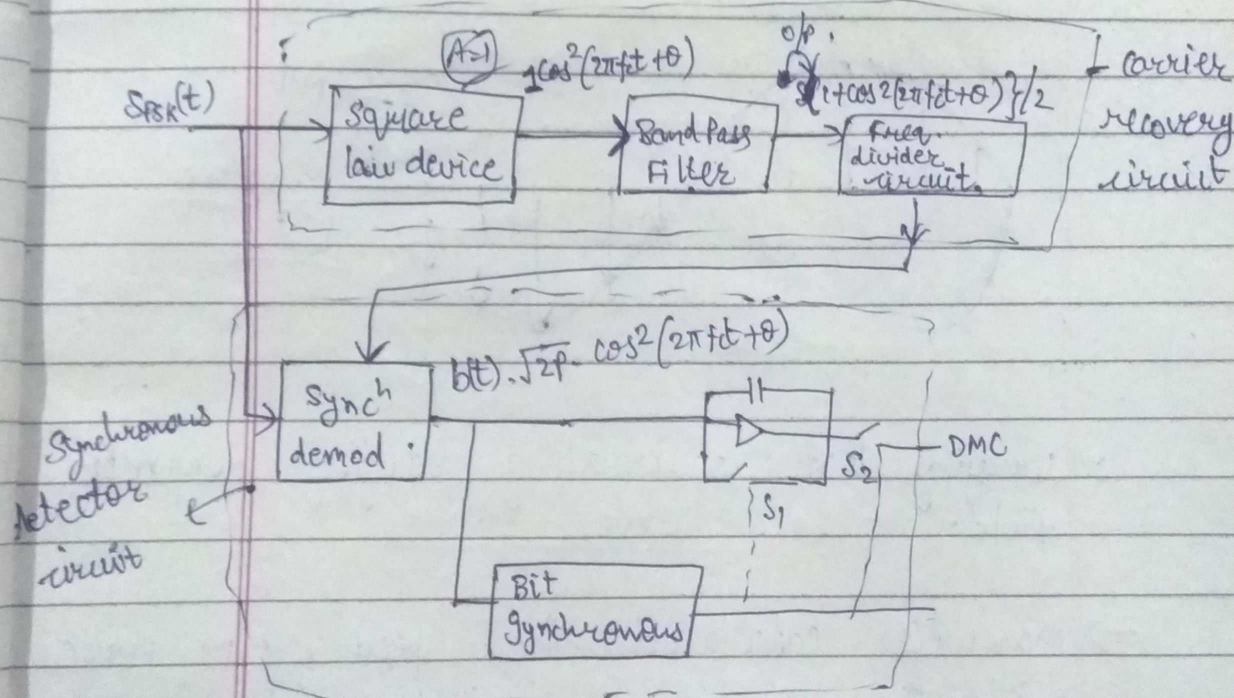
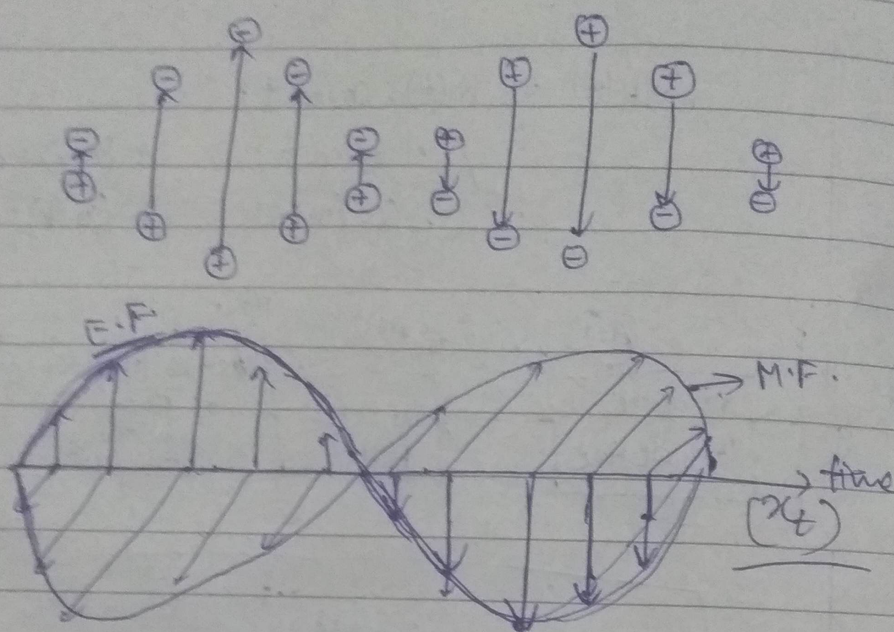


$$S_{PSK}(t) = m(t) \cdot \cos(\omega_c t)$$

$$= \begin{cases} A\cos(\omega_c t) & m(nT_b) = A(\text{"1"}). \\ A\cos(\omega_c t + \pi) & m(nT_b) = A(\text{"0"}). \end{cases}$$

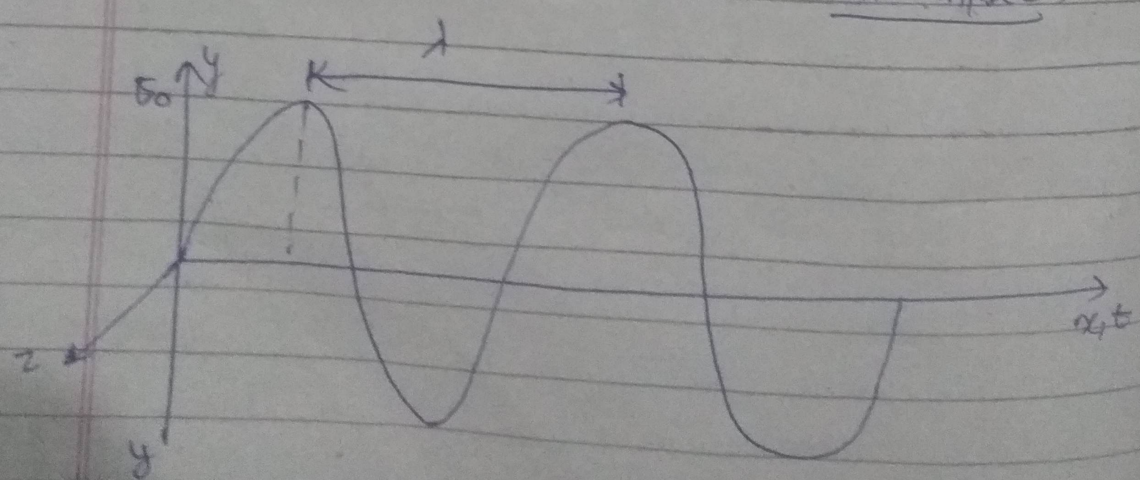


EM waves and Propagation



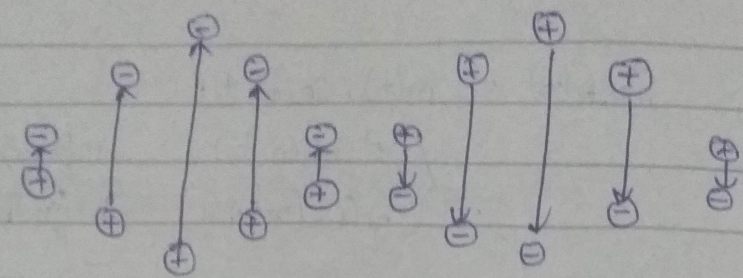
→ varying E.F. is creating varying magnetic field.

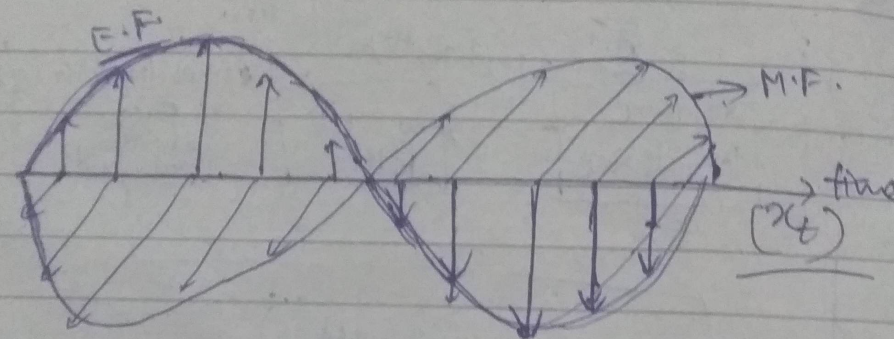
→ Maxwell calculated the speed of EM waves with the help of permittivity and permeability and it came out to be 3×10^8 m/sec.



$\vec{E_y} = E_0 \cos(kx - \omega t + \phi)$ E_0 = max value

EM Waves and Propagation





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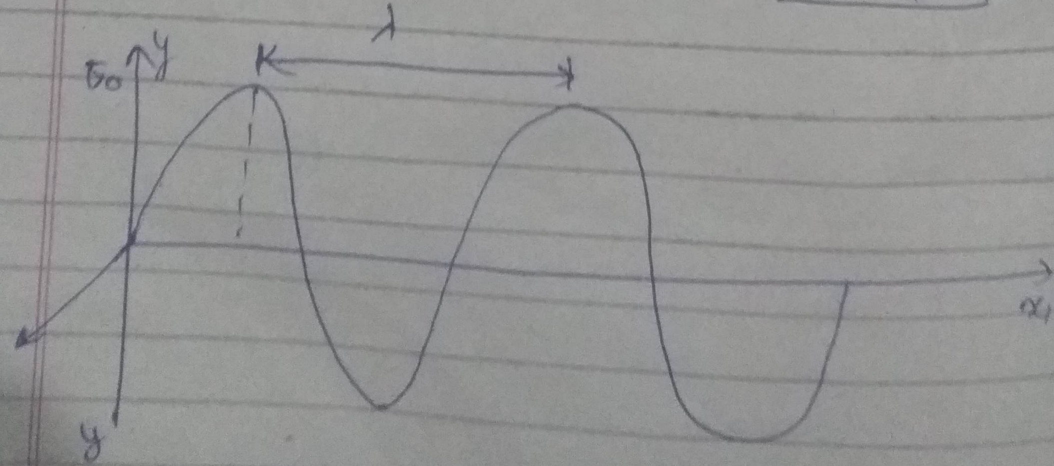

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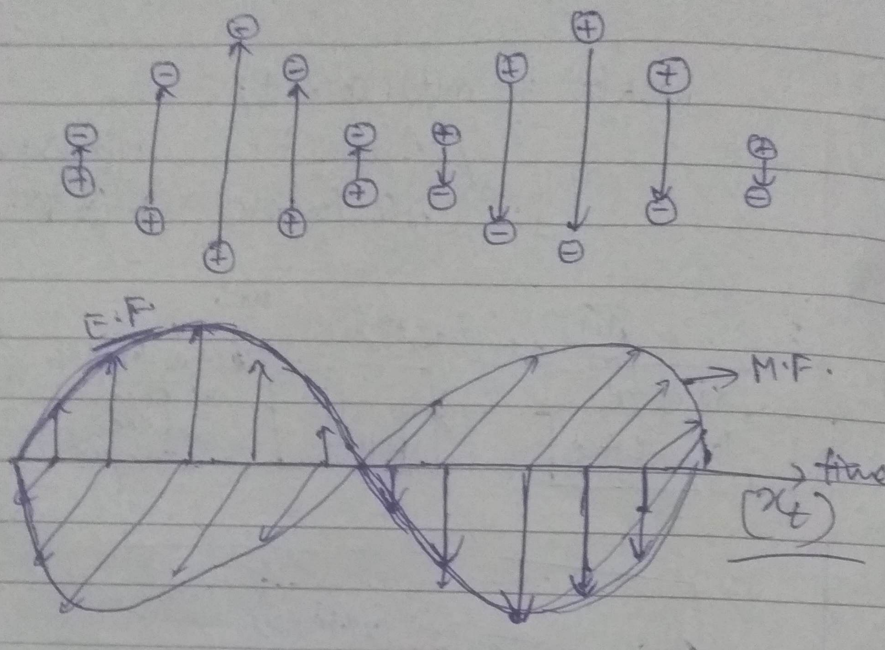
EM waves and Propagation



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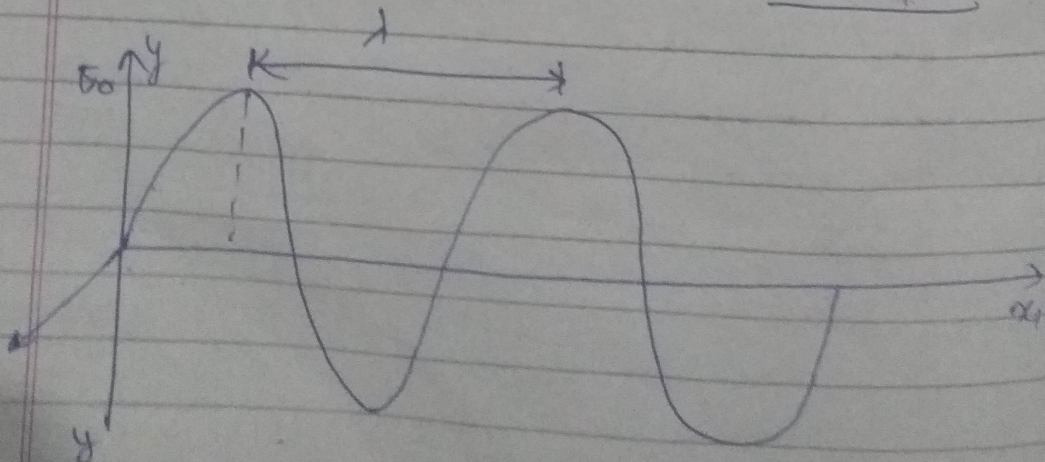

$$\vec{E_y} = E_0 \cos(kx - \omega t + \phi)$$

E_0 = max value

$k = \frac{2\pi}{\lambda}$ = propagation constant.

ω = angular frequency = $2\pi\nu$

$$B_z = B_0\{\cos(kx - \omega t + \phi)\}$$

ϕ = leading / lagging angle.

~~Eg~~ $E_y = 200\cos(6x - \underset{\uparrow\ 25}{\omega t} + \underset{\uparrow\ \pi/6}{\phi})$

$k = 6$

$\lambda = \frac{\pi}{3}$

$\omega = \cancel{2\pi}\,25$, $\nu = \cancel{2\pi}\ \frac{25}{2\pi}$

$v = \frac{\omega}{k} = \frac{25}{6}$ ~~= 4m~~/sec

$\vec{E} \times \vec{H}$ = ~~poynting~~ pontying vector

<u>Types of propagation</u>

1. Ground wave ~~Proga~~ Propagation.
2. Sky ~~wave~~ wave
3. Space (Satellite) Communication.

P.T.O.

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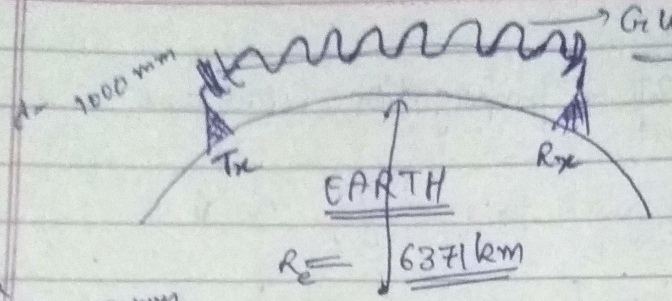
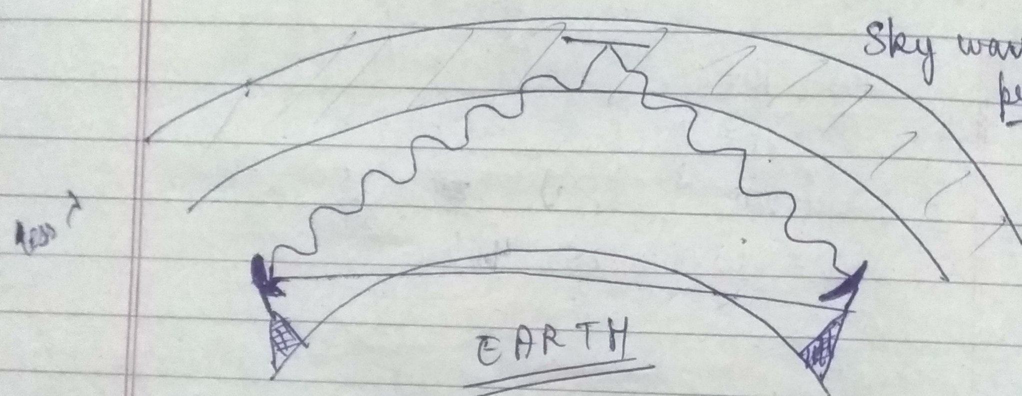
GW propagation



size of antenna $= \frac{\lambda}{4} = \frac{1000}{4} = 250mm$

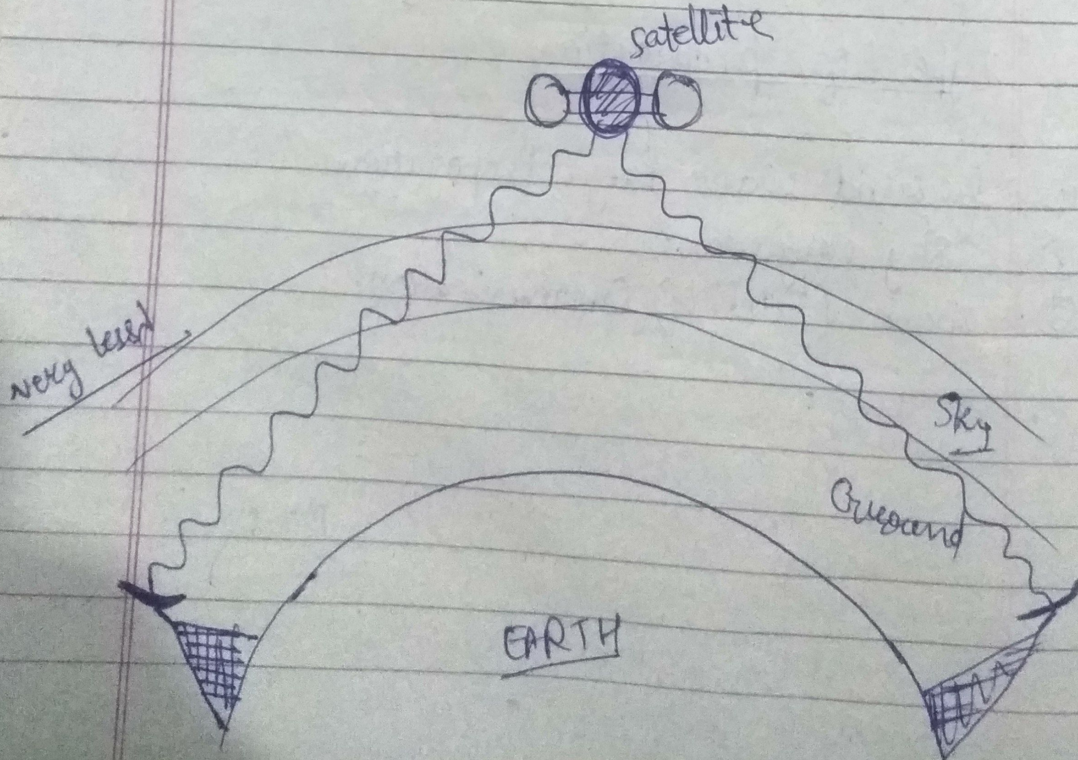
① When EM is travelling ~~pallel~~ parallel to earth surface, then it is called ground wave propagation. (freq. few kHz to 5MHz)

Sky wave propagation



(freq. → 3MHz – 32MHz)

&



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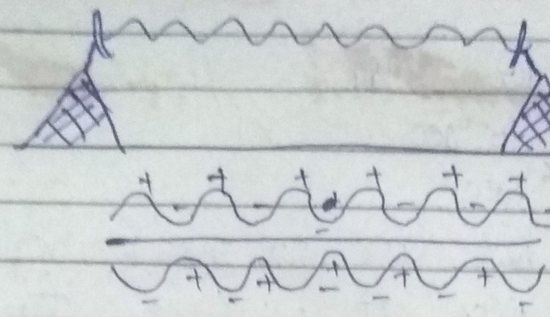
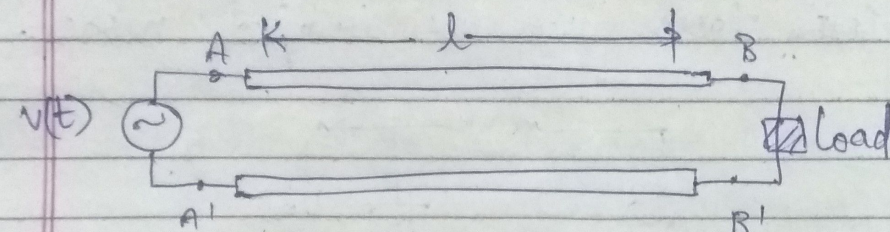
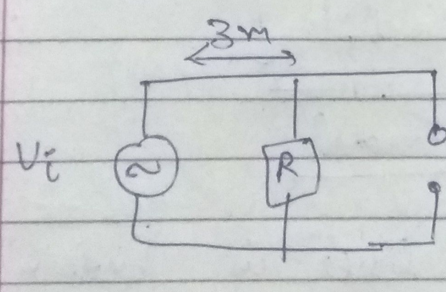


leakage
change of ~~shunting~~
due to induction.

Waveguide:-

Generally we use transmission lines to transfer our signals (except space ~~wave~~ communication). In those transmission lines, waves incur a huge power loss. To reduce those losses we use waveguide.





$v_o = v_i$ (for low freq.)

(for high freq.) $\underline{(v_o \neq v_i)}$.

$$t_r = \frac{l}{V} = \frac{3m}{3\times10^8} \Rightarrow \underline{10^{-8}\,sec}$$

$f = 100\,Hz$

$T = 0.01\,sec$

$\Rightarrow$ ~~$T >>> T_r$~~ $T >> t_r$

(we can neglect t_r here).

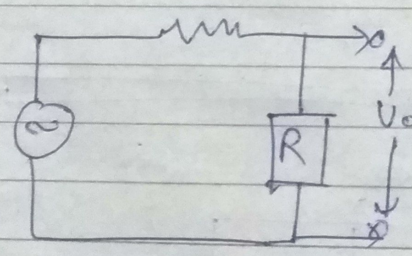
P.T.O.

$f = 1MHz$, 5 Vpp
$t_r = 10^{-8}$ sec
$T = 10^{-6}$ sec

★ but here we can't neglect t_r since it is close to the T.

⇒ for freq. >= 1GHz, $t_r > T$ and losses are very high, hence in these cases we use waveguides.

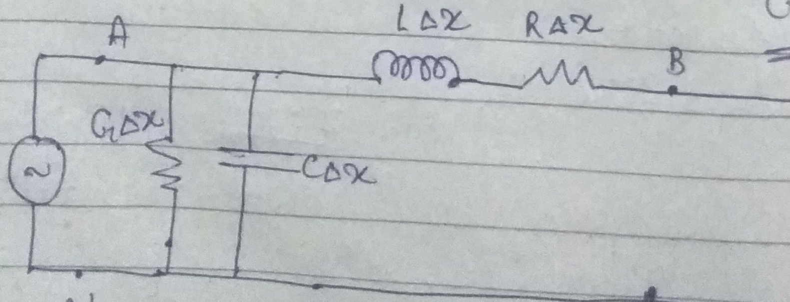
To model the entire transmission line ~~losses~~ losses, we use lumped model.



Lumped model

γ = propagation constant

The transmission line is broken into smaller lumped model, so that their transient time is very less.



$G = \frac{1}{R}$

$\omega = 2\pi f$

Halogen

$$\Delta V = -(R\Delta x + j\omega L\Delta x) I$$
$$\Delta I = -(G\Delta x + j\omega C\Delta x) V$$

$$\frac{\Delta V}{\Delta x} = -(R + j\omega L) I$$

$$\frac{\Delta I}{\Delta x} = -(G + j\omega C) V$$

$$\lim_{\Delta x \to 0} \frac{\Delta V}{\Delta x} = \frac{dV}{dx} = -(R + j\omega L) I$$

$$\frac{dI}{dx} = -(G + j\omega C) V$$

$$\frac{d^2 V}{dx^2} = -(R + j\omega L) \frac{dI}{dx}$$

$$\frac{d^2 V}{dx^2} = -(R + j\omega L) \left(-(G + j\omega C) V\right)$$

$$\frac{d^2 V}{dx^2} = +(R + j\omega L)(G + j\omega C) V$$

γ = propagation constant

$$\frac{d^2 I}{dx^2} = \underbrace{(R + j\omega L)(G + j\omega C)}_{\gamma^2} I$$

$$\frac{d^2 V}{dx^2} = \gamma^2 V \quad , \quad \frac{d^2 I}{dx^2} = \gamma^2 I$$

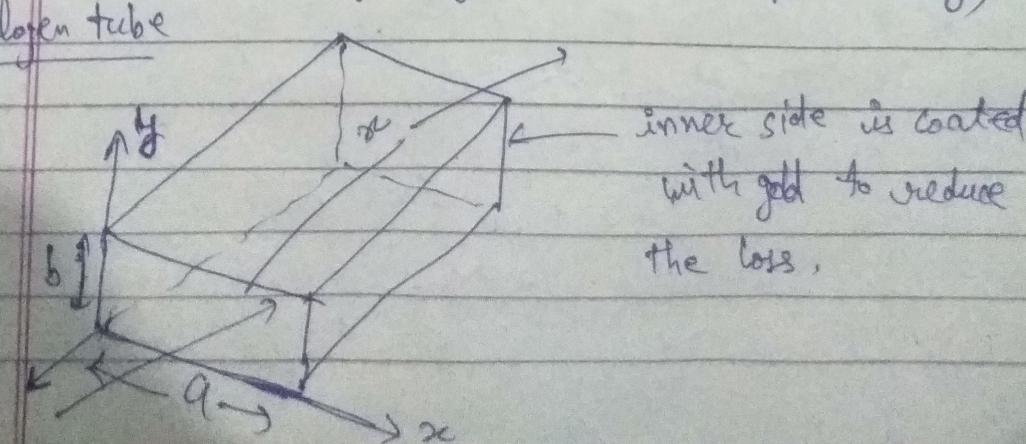
$$V = V^+ e^{-\gamma x} + V^- e^{+\gamma x}$$

$$I = I^+ e^{-\gamma x} + I^- e^{\gamma x}$$

$f_s > f_c$ ~~above~~ critical freq.

(Propagation will take place only)

Halogen tube



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wave propagating in z- direction:

$$\nabla^2 E_z = \mu\epsilon \frac{\partial^2 E_x}{\partial t^2}$$

$$H_z = 0$$

TM (transfer magnetic)

$$\nabla^2 H_z = \mu\epsilon \frac{\partial^2 H_z}{\partial t^2}$$

$$E_z = 0$$

TE

$$E_z = E_{0z}\, e^{j\omega t} \cdot e^{-\gamma z}$$

$$\omega = 2\pi f$$

$$\frac{\partial E_z}{\partial t} = E_{0z}\, e^{j\omega t} \cdot e^{-\gamma z} (j\omega)$$

$$= (j\omega) E_z$$

$$\boxed{\frac{\partial}{\partial t} = (j\omega)}$$

$$\frac{\partial^2 E_z}{\partial t^2} = (j\omega)(j\omega) E_z$$

$$= -\omega^2 E_z$$

$$\frac{\partial^2}{\partial t^2} = -\omega^2$$

$$E_z = E_{0z}\, e^{j\omega t}\, e^{-\gamma t}$$

$$\frac{\partial E_z}{\partial z} = (-\gamma) E_z \quad , \quad \boxed{\frac{\partial}{\partial z} = -\gamma}$$

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$$\boxed{\frac{\partial^2}{\partial z^2} = -\gamma^2}$$

$$\frac{\partial^2 E_z}{\partial z^2} = \gamma^2 E_z$$

$$\nabla^2 E_z = \mu\epsilon \frac{\partial^2 E_z}{\partial t^2} \quad \& \quad H_z = 0 \ (TM)$$

$$\frac{\partial^2 E_z}{\partial x^2} + \frac{\partial^2 E_z}{\partial y^2} + \frac{\partial^2 E_z}{\partial z^2} = \mu\epsilon \frac{\partial^2 E_z}{\partial t^2}$$

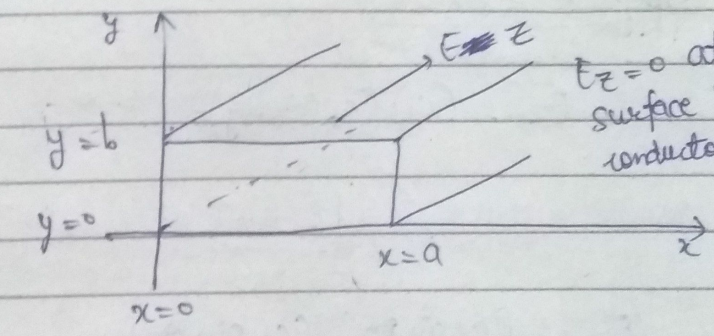
h

$$\frac{\partial^2 E_z}{\partial x^2} + \frac{\partial^2 E_z}{\partial y^2} + (\gamma^2 + \omega^2\mu\epsilon) E_z = 0$$

$$+ h^2 E_z = 0$$

P.D.E. (Partial differential equation).

$$E_z = (C_1 \cos Bx + C_2 \sin Bx)(C_3 \cos Ay + C_4 \sin Ay).$$



$E_z = 0$ at the surface of the conductor

TM:- $H_z = 0$, E_z

$$E_z = (C_1 \cos Bx + C_2 \sin Bx)(C_3 \cos Ay + C_4 \sin Ay)$$

1.) $E_z = 0$ at $y = 0$ and for all values of x from 0 to a.

2.) $E_z = 0$ at $x = 0$ for all values of y from 0 to b.

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(3) $E_z = 0$ at $x = a$ for all ~~valy~~ values of y from 0 to b.

(4) $E_z = 0$ at $y = b$, for all values of x from 0 to a.

Apply (1) boundary condition:-

$$E_z = (C_1 \cos Bx + C_2 \sin Bx) C_3 = 0$$

~~Apply (2) BC~~ $\Rightarrow$ $\boxed{C_3 = 0}$

~~$E_z =$~~

~~Apply~~ $E_z = (C_1 \cos Bx + C_2 \sin Bx)(C_4 \sin Ay)$

Apply 2nd B.C.:-

$$E_z = (C_1)(C_4 \sin Ay) = 0$$

$$\boxed{C_1 = 0}$$

$$E_z = (C_2 \sin Bx)(C_4 \sin Ay).$$

Apply (3):

$$E_z = \underset{\neq 0}{C_2 C_4} \sin B \underset{a}{x} \underset{\neq 0}{\sin Ay} = 0$$

$$\Downarrow$$

$$\sin Ba = 0$$

$Ba =$ multiples of π

$$Ba = m\pi$$

$$B = \frac{m\pi}{a}.$$

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Apply ④ :-

$$E_z = \underbrace{C_2 C_4}_{\neq 0} \underbrace{\sin Bx}_{\neq 0} \, \sin Ab = 0$$

$$\sin Ab = 0$$

$$Ab = \text{multiples of } \pi$$

$$Ab = n\pi$$

$$\boxed{A = \frac{n\pi}{b}}$$

$$\boxed{A = \frac{n\pi}{b}}$$

$$\Rightarrow \boxed{E_z = C_2 C_4 \sin\left(\frac{m\pi}{a}\right) x \ \sin\left(\frac{n\pi}{b}\right) y}$$

let, $h^2 = A^2 + B^2$

as assumed :- $h^2 = \gamma^2 + \omega^2 \mu \epsilon$

$$A^2 + B^2 = \gamma^2 + \omega^2 \mu \epsilon$$

$$\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 = \gamma^2 + \omega^2 \mu \epsilon$$

$$\gamma^2 = \left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 - \omega^2 \mu \epsilon$$

$$\gamma = \sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 - \omega^2 \mu \epsilon}$$

$$\gamma = \alpha + j\beta$$

if $\omega^2 \mu \epsilon > \left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2$

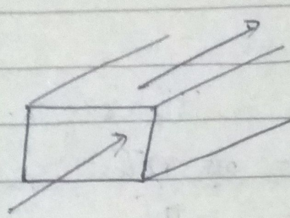
$$\gamma = \cancel{\alpha}^{\,0} + j\beta$$

α = attenuation factor

β = propagation factor

if $\omega^2 \mu \epsilon < \left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2$

$\gamma = \alpha + \cancel{j\beta} \rightarrow 0$



Ez

for ~~pot~~ better propagation, $\alpha \to 0$ and $\beta \neq 0$,

so that coated with gold and silver.

(TM) transfer magnetic

Cut-off Freq. (fc)

It is a freq. at ~~cutt~~ ~~cut~~ which propagation of ~~electromagti~~ electromagnetic wave propagates through the waveguide by assuming input freq. greater than this freq. (fc).

At cut off freq. $\gamma = 0$ and $f = f_c$.

$$\gamma^2 = \left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 - \omega^2 \mu \epsilon = 0$$

$$\omega^2 = \frac{1}{\mu\epsilon}\left(\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2\right)$$

$\omega = 2\pi f$, $\omega_c = 2\pi f_c$

$$\omega_c = \frac{1}{\sqrt{\mu\epsilon}}\left[\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2}\right]$$

$$f_c = \frac{1}{2\pi\sqrt{\mu\epsilon}}\left[\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2}\right]$$

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$n, m = 0, 1, 2, \ldots \infty$.

Air $\epsilon_r = 1$

& $\epsilon = \epsilon_0 \epsilon_r$

$\mu = \mu_0 \mu_r$.

$$f_c = \frac{1 \times \pi}{2\pi\sqrt{\mu_0 \epsilon_0}} \left[\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2} \right]$$

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$$

TM

transfer magnetic

$$f_c = \frac{c}{2} \left[\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2} \right]$$

$H_z = 0$, E_z,

m	n
0	0
0	1
1	0
1	1

$$E_z = \overset{C_2 C_4}{C'} \sin\left(\frac{m\pi}{a}\right) x \cdot \sin\left(\frac{n\pi}{b}\right) y.$$

$TM_{mn} \longrightarrow TM_{11}$ = minimum mode of propagation in rectangular TM propagation

$\lambda_c = c/f_c$ (cutoff wavelength).

$$\lambda_c = \frac{c}{\frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}}$$

Dominant mode:-

It is that mode for wh[illegible] the cut off wavelength achieves highest value.

TM_{11} , $m=1$, $n=1$

$$\lambda_c = \frac{2ab}{\sqrt{a^2+b^2}}$$

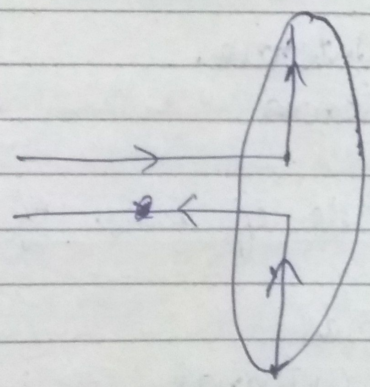
		TM	TE
①	lowest	TM_{11}	TE_{01}
②	Dominant	TM_{11}	TE_{10}
③	Dominant (λ_c)	$\frac{2ab}{\sqrt{a^2+b^2}}$	$2a$

Antenna

→ It is a specific device for sending or receiving an electromagnetic wave.

→ Antenna converts electrical signals into the EM waves and vice-versa.

→ Antennas are connected to the transmission lines. A particular structure is needed for the radiation of EM waves.



dipole antenna

Need of antennas

① To access the remote locations, cost effective.

Types of antennas :-

1. Physical structure.
2. Freq. range of operation.
3. Mode of applications.

On the basis of structure

a) Wire Antenna.
b) Aperture Antenna.
c) Reflector Antenna.
d) lens Antenna.
e) Micro strip Antenna.
f) Array Antenna.

On the basis of freq. of opr^n :-

1. VLF Antennas
2. Low freq. antennas.
3. Medium freq.
4. High f.
5. Very high.
6. ~~Ulter~~ Ultra high.
7. Super ultra.
8. Microwave
9. Radiowave.

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On the basis of Mode of Application:-
1. Point to point $comm^n$ antennas.
2. Broadcasting application.
3. Radar communication.
4. satellite communication.

Basic terminology in Antennas

1. Frequency.
2. wavelength.
3. Impedance Matching.
4. VSWR and Reflected Power.
5. BW.
6. Percentage of BW.
7. Radiation Intensity.

Frequency:-
The rate of repetition of a wave over a ~~pero~~ period of time is called frequency.

wavelength:-
Distance b/w two maximas.

Impedance Matching:-
The impedance of transmitter and receiver is same so that effective radiation will take place.

K.D. Prasad Antenna and wave propagation

USWR :-

Voltage Standing wave ratio. The ratio of maximum voltage to the minimum voltage.
If USWR varies higher then lots of losses will takes place.

Bandwidth :-

A ~~s~~ range of frequency over ~~each~~ which communication will take place.

Precentage of BW :-

Absolute bandwidth by central freq. It gives the % of deviation.

Radiation Intensity :-

Power per unit solid angle. The direction in which max. power transmission would take place.

Directivity :-

The ratio of max. radiation intensity of the subject antenna to the radiation intensity of an isotropic or reference antenna. is called directivity.