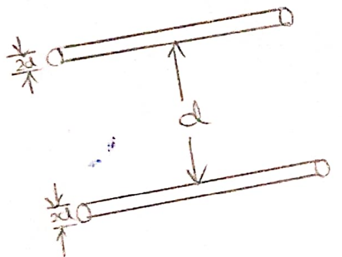
1. Explain different types of Transmission lines with neat sketches.

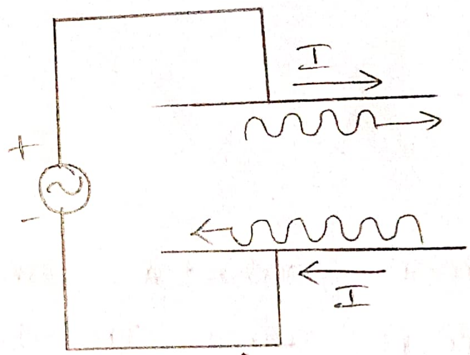
Types:

1. Parallel wireline (or) open wireline.
2. Parallel plate (or) Planar transmission line.
3. Twisted wires
4. Wire above conducting plane
5. co-axial able
6. wave guides
7. optical fibres
8. Microstrip lines
9. Strip lines

1. Parallel wireline (or) open wireline:-



Two wire parallel line



Potential difference

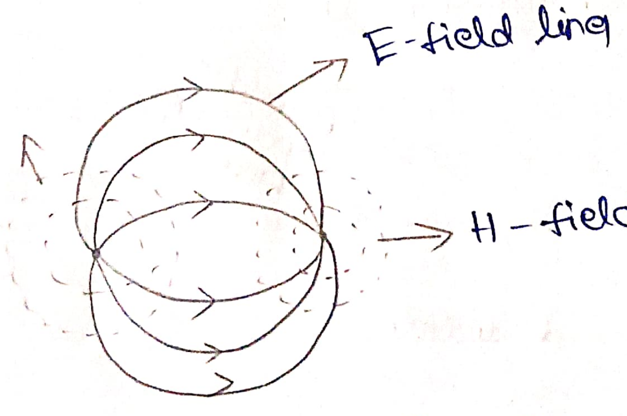


fig: Field lines [E&H]

⇒ Most commonly used transmission line.

⇒ Two parallel are seperated by uniform distance 2a (or) a.

⇒ the current flows from one tranimission wire to another tranimission line.

⇒ Electric field and magnetic field are perpendicular to Each other.

Advantages:

1. simple structure.

2. Easy to contruct.

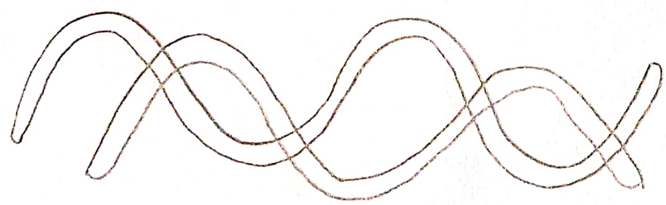
3. Low cost.

Disadvantages:

1. As it is open tranimission line structure It is capable of getting EM interferences.

2. Above 100MHz there will be more Radiation losses.

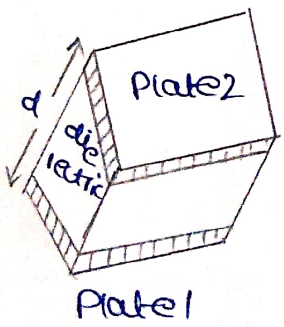
2. Twisted pair of tranimission line:-

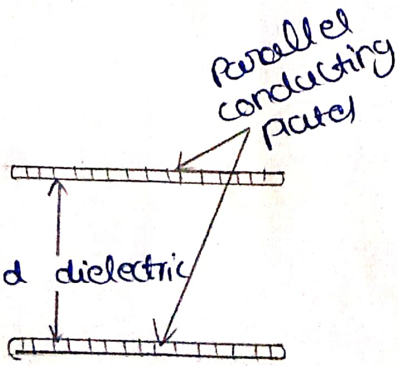


Two or more conductors are used.

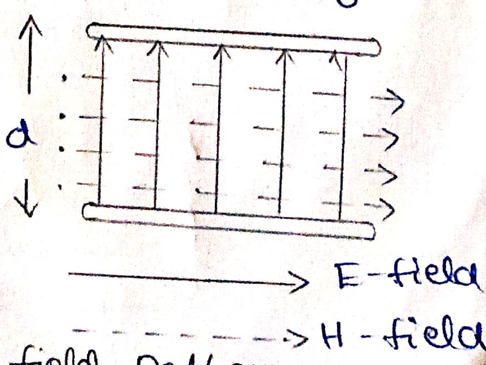
Two or more wires are twisted and protected by insulator.

3. Parallel Plate Tranimission line:





direction of propagation

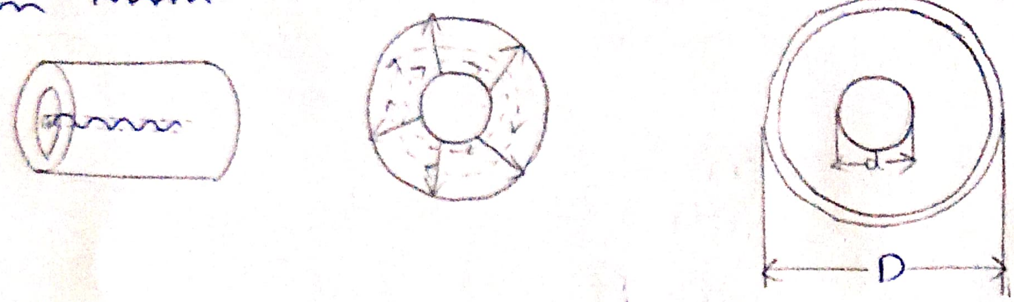


field pattern

⇒ This transmission is used in PCB technology.

⇒ This plates are used for the closing of Transmission and a nnae.

4. coxial cable:



⇒ In this two conductors are used.

⇒ Signal is transmissted in Hollow space

Advantage:

1. Radiation losses are less they replace parallel plates.

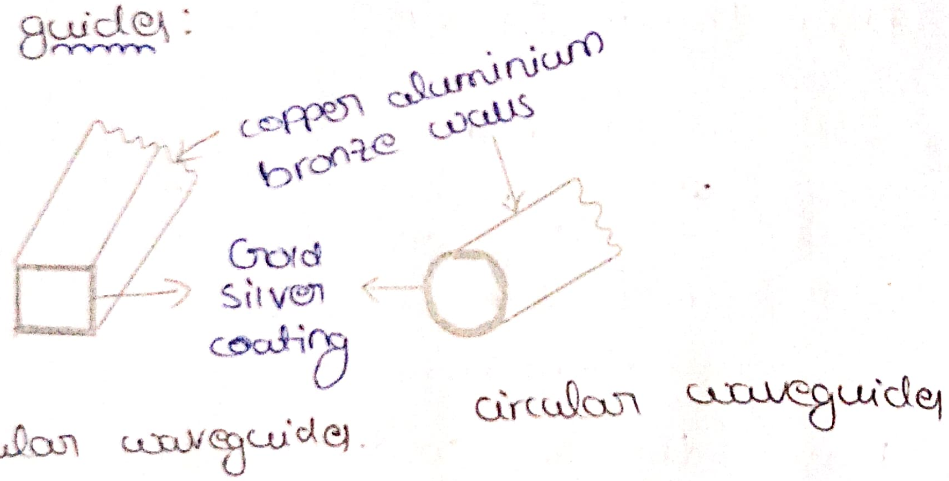
Disadvantage:

1. Beyond 1GHz this becomes onstable.

Application:

TV cables

5. wave guides:



⇒ The wave guides are used in Microwave frequencies.

⇒ Frequency is 300MHz to 300GHz.

⇒ Mode of propagation are TE, TM because of two conductor.

Advantages:

1. power loss during propagation is negligible.

2. Large power handling capable.

3. As it is simple structure installation is easy.

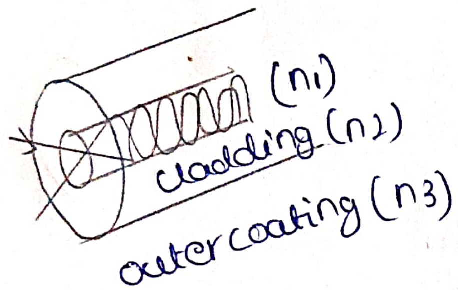
Disadvantages:

1. Installation cost is high.

2. Not flexible.

3. large in size.

6. optical fibre:



⇒ In this information in the form of light is travelled through it.

⇒ $n_1 > n_2$

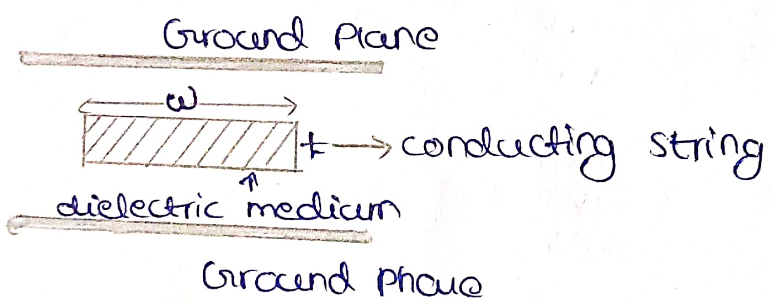
Advantages:

1. very High band width.

2. More efficiency

3. small size.

7. Strip lines: (Planar transmission lines)



⇒ The signal travel through conducting strip.

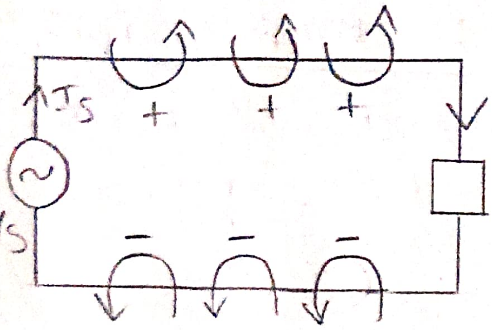
⇒ the frequency range 100M to 100 GHz.

⇒ In this we cannot tune the frequency range it is overcome in Microstrip lines.

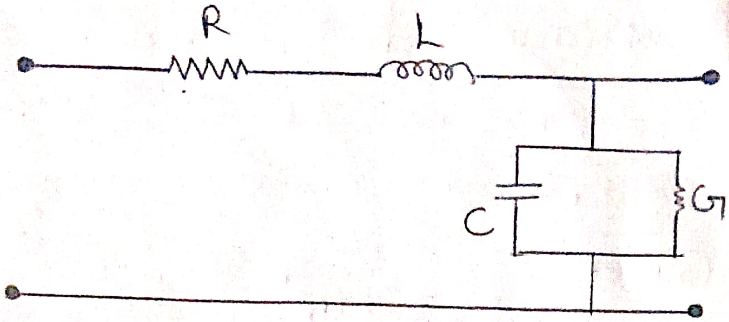
⇒ The Ground Phase and Ground Phase we are separated by dielectric medium.

2. Draw the Equivalent circuit for an open wire transmission line and Define primary constants of transmission line?

Equivalent circuit of Transmission lines:



Transmission line with Load



Equivalent circuit of two wire Transmission line.

Primary constants of Transmission line:

1. Resistance: When current is flowing through the conductor it must have resistance uniformly distributed all along the length of conductor.

$$\boxed{R = \frac{\rho l}{a} \text{ ohms/km}}$$

ρ = Resistivity
l = length of conductor
a = Radius of wire

2. Inductance:

The Induced EMF in the transmission line resist the flow of current measured as inductance of wire.

$$\boxed{L = \frac{N\phi}{I} \text{ H/km}}$$

N = no. of turns of coil.
ϕ = magnetic field.
I = current.

3. Capacitance:

capacitance per unit length is given as

$$\boxed{C = \frac{\epsilon A}{d} \text{ f/km}}$$

ϵ = dielectric constant
A = area of cross section
d = distance between conductor.

4. Conductance:

It is measured as shunt conductance per unit length

units = Mhos/km.

3. A transmission line has $R = 3\,\Omega/m$, $L = 1\,\mu H/m$, $C = 1\,pF/m$ and $G = 0$ operated at $f = 500\,MHz$. Find the attenuation constant of line.

Given,

$R = 3\,\Omega/m$

$L = 1\,\mu H/m = 1 \times 10^{-6}$

$C = 1\,pF/m = 1 \times 10^{-12}$

$G = 0$

$f = 500\,MHz$, $\omega = 2\pi f$

$= 2 \times \pi \times 500 \times 10^{6}$

$= 1000\pi \times 10^{6} = 10^{9}\pi$ rad/s

$\gamma = \sqrt{(R + j\omega L)(G + j\omega C)}$

$\gamma = \sqrt{(3 + j\pi \times 10^{9} \times 10^{-6})(0 + j\pi \times 10^{9} \times 10^{-12})}$

$\gamma = \sqrt{(3 + j\pi \times 10^{3})(j\pi \times 10^{-3})}$

$\gamma = \sqrt{(3 + j3141.6)(j0.0031416)}$

$\gamma = \sqrt{-9.87 + j0.0094}$

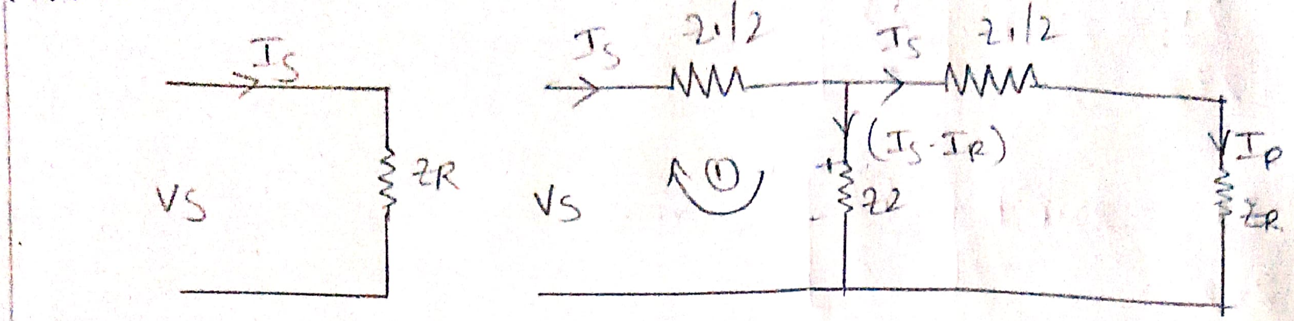
$\gamma = 0.07 + j3.14$

Attenuation constant $\alpha = 0.07$ NP/m

Phase constant $\beta = 3.14$ (or) π rad/m

4. Derive T-Equivalent circuit of a Transmission line?

T-Equivalent circuit:



$$V_S = \frac{I_S Z_1}{2} - I_S (I_S - I_R) Z_2 = 0$$

$$V_S = \frac{I_S Z_1}{2} + I_S (I_S - I_R) Z_2$$

$$V_S = \frac{I_S Z_1}{2} + I_S Z_2 - I_R Z_2$$

$$I_R Z_2 = \frac{I_S Z_1}{2} + I_S Z_2 - V_S$$

$$I_R = \frac{I_S Z_1}{2Z_2} + I_S - \frac{V_S}{Z_2}$$

$$I_R = I_S \left[1 + \frac{Z_1}{2Z_2}\right] - \frac{V_S}{Z_2} \longrightarrow ①$$

At $x = l$ current Equation,

$$I_R = I_S \cosh \beta l - \frac{V_S}{Z_0} \sinh \beta l \longrightarrow ②$$

compare Eq ① & ②

$$\cosh \beta l = 1 + \frac{Z_1}{2Z_2} \longrightarrow ③$$

$$\frac{\sinh \beta l}{Z_0} = \frac{1}{Z_2}$$

$$\boxed{Z_2 = \frac{Z_0}{\sinh \beta l}} \longrightarrow ④$$

from Eq ③

$$\frac{Z_1}{2Z_2} = \cosh \beta l - 1$$

$$= 1 + 2\sinh^2\left(\frac{\gamma l}{2}\right) - 1$$

$$\frac{Z_1}{2Z_2} = 2\sinh^2\left[\frac{\gamma l}{2}\right]$$

$$\frac{Z_1}{2Z_2} = 2\sinh^2\left[\frac{\gamma l}{2}\right]$$

$$\frac{Z_1}{2} = 2\sinh^2\left[\frac{\gamma l}{2}\right] \cdot Z_2$$

$$= 2\sinh^2\left(\frac{\gamma l}{2}\right) \cdot Z_2$$

$$= 2\sinh^2\left(\frac{\gamma l}{2}\right)\left(\frac{Z_0}{\sinh \gamma l}\right)$$

$$\frac{Z_1}{2} = \frac{2\sinh^2\left(\frac{\gamma l}{2}\right) Z_0}{\sinh \gamma l}$$

$$\frac{Z_1}{2} = \frac{2\sinh^2\left(\frac{\gamma l}{2}\right) Z_0}{\sinh \gamma l}$$

$$\frac{Z_1}{2} = \frac{2\sinh^2\left(\frac{\gamma l}{2}\right) \cdot Z_0}{2\sinh\left(\frac{\gamma l}{2}\right)\cosh\left(\frac{\gamma l}{2}\right)}$$

$$\frac{Z_1}{2} = Z_0 \cdot \tanh\left(\frac{\gamma l}{2}\right)$$

5. Define and explain both loss less and distortion less line in terms of transmission line parameters.

Loss less transmission line:

$$R = G = 0$$

$$\gamma = \sqrt{(R + j\omega L)(G + j\omega C)}$$

Real part:

$$\alpha = \sqrt{LC}\left[\frac{R}{L}\right] = \sqrt{L}\cdot\sqrt{C}\left[\frac{R}{L}\right]\cdot\sqrt{L}$$

$$\boxed{\alpha = R\sqrt{\frac{C}{L}}}$$

$$\boxed{\beta = \omega\sqrt{LC}}$$

$$Z_0 = \sqrt{\frac{R+j\omega L}{G+j\omega C}} = \sqrt{\frac{L(R/L+j\omega)}{C(G/C+j\omega)}}$$

$$= \sqrt{\frac{L}{C}}\sqrt{\frac{R/L+j\omega}{R/L+j\omega}}$$

$$Z_0 = \sqrt{\frac{L}{C}}$$

Phase velocity $V_p = \omega/\beta = \frac{\omega}{\omega\sqrt{LC}}$

$$\boxed{V_p = \frac{1}{\sqrt{LC}}}$$

6. Define wavelength, phase velocity and Group velocity. Derive the relation between Group velocity & phase velocity.

Wavelength:

It is the distance that wave ~~length~~ travels along the line to have phase of 2π Radians.

$$\beta\lambda = 2\pi$$

$$\boxed{\lambda = \frac{2\pi}{\beta} \text{ meters}}$$

2. Phase velocity:

The velocity with which a wave of constant phase is propagating in transmission line is called phase velocity.

$$\boxed{V_p = \omega/\beta \text{ km/sec}}$$

$$= \sqrt{(j\omega L)(j\omega C)}$$

$$\alpha + j\beta = j\omega\sqrt{LC}$$

$$\alpha = 0;\ \beta = \omega\sqrt{LC}$$

$$Z_0 = \sqrt{\frac{R+j\omega L}{G+j\omega C}}$$

$$= \sqrt{\frac{j\omega L}{j\omega C}}$$

$$Z_0 = \sqrt{\frac{L}{C}}$$

Phase velocity: $V_p = \frac{\omega}{\beta}$

$$= \frac{\omega}{\omega\sqrt{LC}}$$

$$V_p = \frac{1}{\sqrt{LC}}$$

since $V_p = \frac{1}{\sqrt{\mu\epsilon}}$

$$\sqrt{\mu\epsilon} = \sqrt{LC}$$

Distortionless transmission:

$$\frac{R}{L} = \frac{G}{C}$$

$$\gamma = \sqrt{(R+j\omega L)(G+j\omega C)}$$

$$= \sqrt{L\left(\frac{R}{L}+j\omega\right)C\left(\frac{G}{C}+j\omega\right)}$$

$$= \sqrt{LC}\sqrt{\left(\frac{R}{L}+j\omega\right)\left(\frac{G}{C}+j\omega\right)}$$

$$\gamma = \sqrt{LC}\sqrt{\left(\frac{R}{L}+j\omega\right)\left(\frac{G}{C}+j\omega\right)}$$

$$= \sqrt{LC}\sqrt{\left(\frac{R}{L}+j\omega\right)\left(\frac{R}{L}+j\omega\right)}$$

$$\gamma = \sqrt{LC}\left(R/L+j\omega\right)$$

$$\gamma = \alpha + j\beta = \sqrt{LC}\left(\frac{R}{L}\right) + j\sqrt{LC}\cdot\omega$$

Group Velocity:

It is defined as the ratio of ratio of changing angular frequency to the changing phase constant.

$$V_g = \frac{\omega_2 - \omega_1}{\beta_2 - \beta_1} = \frac{d\omega}{d\beta} \text{ m/s}$$

Relation between Group velocity & Group velocity:

$$V_p = \frac{\omega}{\beta}$$

differentiate both side w.r.t ω,

$$\frac{dV_p}{d\omega} = \frac{\beta \cdot \frac{d\omega}{d\omega} - \omega \cdot \frac{d\beta}{d\omega}}{\beta^2}$$

$$= \frac{\beta\left[1 - \frac{\omega}{\beta} \cdot \frac{d\beta}{d\omega}\right]}{\beta^2}$$

$$= \beta\left[1 - \frac{\omega}{\beta} \cdot \frac{d\beta}{d\omega}\right]$$

$$\frac{dV_p}{d\omega} = \frac{1 - V_p \cdot \frac{d\beta}{d\omega}}{\beta}$$

$$\beta \cdot \frac{dV_p}{d\omega} = 1 - V_p\left[\frac{1}{V_g}\right]$$

$$\frac{V_p}{V_g} = 1 - \beta \cdot \frac{dV_p}{d\omega}$$

$$V_g = \frac{V_p}{1 - \beta\left(\frac{dV_p}{d\omega}\right)}$$

$$\boxed{V_g = \frac{V_p}{1 - \frac{\omega}{V_p}\left[\frac{dV_p}{d\omega}\right]}}$$