Introduction of Antenna & Wave Propagation

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Transducer

ANTENNA

- An antenna is an electrical device which converts electric energy into radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver.
- An antenna is a device for sending or receiving electromagnetic waves.

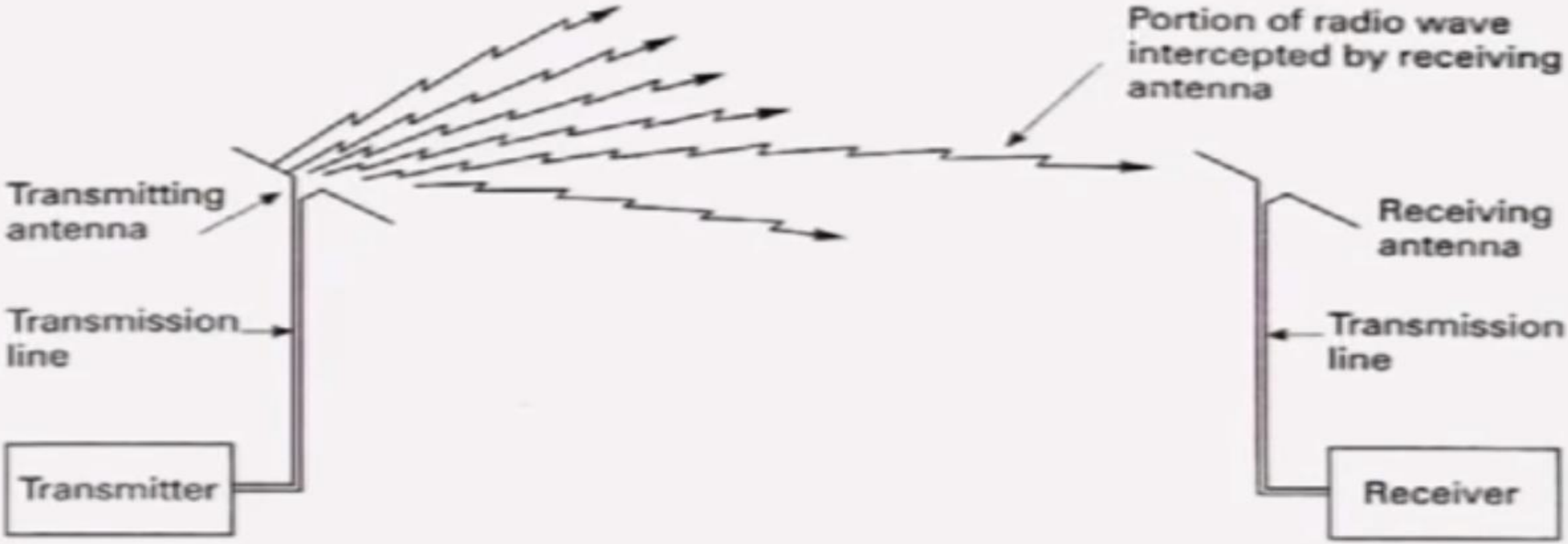
What is an Antenna

Antenna is a

1. Metallic piece or Conductor
2. Radiating and receiving electromagnetic waves / energy
3. Transition Structure linking guided waves and unguided free space waves

Radio

Wireless Communication



Radio Signal

Electro magnetic wave

Electro magnetic fields

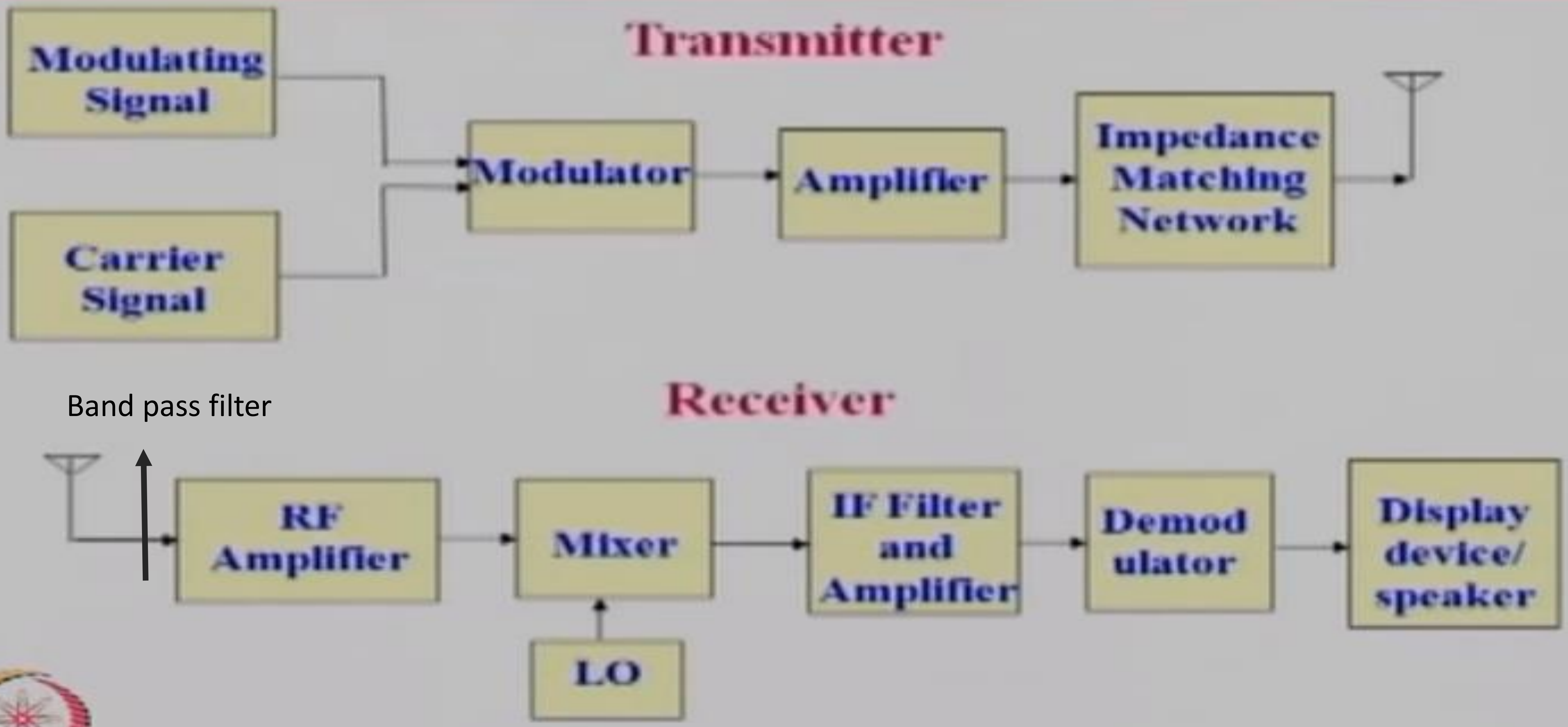
Waves

Electromagnetic field = Electric field +
Magnetic field

Electric field = Electric Charge

Magnetic field = Flow of charge = Current

Antennas in Wireless Communication Systems

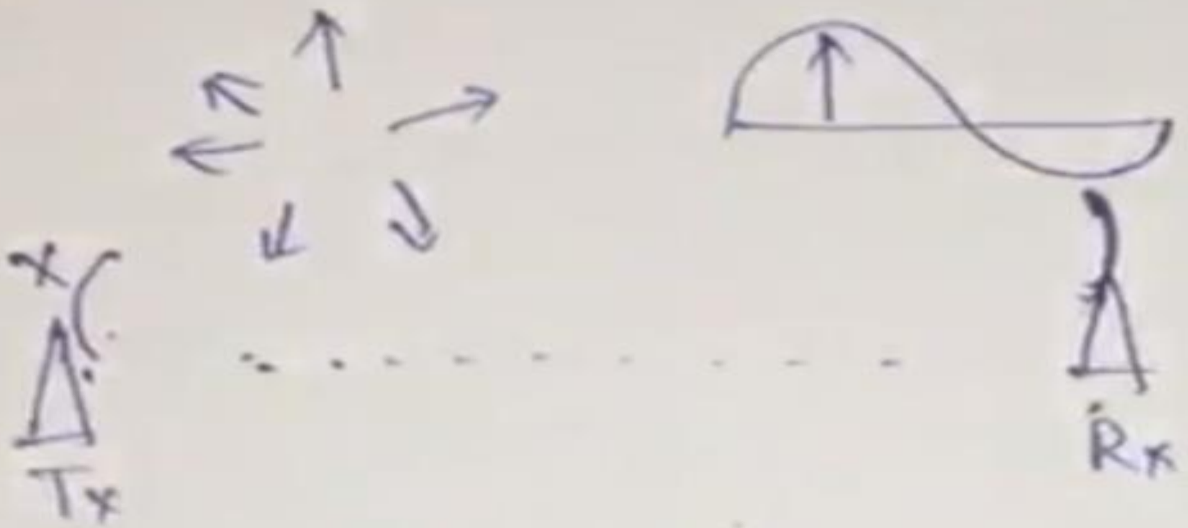


Antennas for Various Applications

- MW Radio – Frequency: 530 to 1620 kHz (use λ/4 monopole antenna)
- Cell Phones – CDMA, GSM900, GSM1800, 3G, 4G, Wi-Fi/Bluetooth (use monopole, normal mode helical, microstrip antenna, etc.)
- Cell Towers (use monopole, dipole, microstrip antenna arrays, etc.)
- Satellite and Defense Communications (use microstrip, horn, spiral, helical, reflector, Yagi-Uda, log-periodic antennas, etc.)

ANTENNA & WAVE PROPAGATION

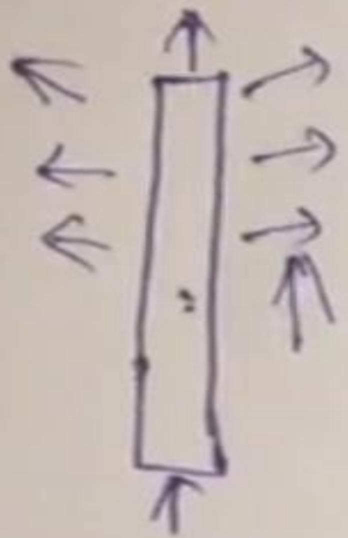
RADIO WAVE PROPAGATION



Path choosen by EM wave

- → the time of day
- → frequency of signal.
- → atmospheric condition

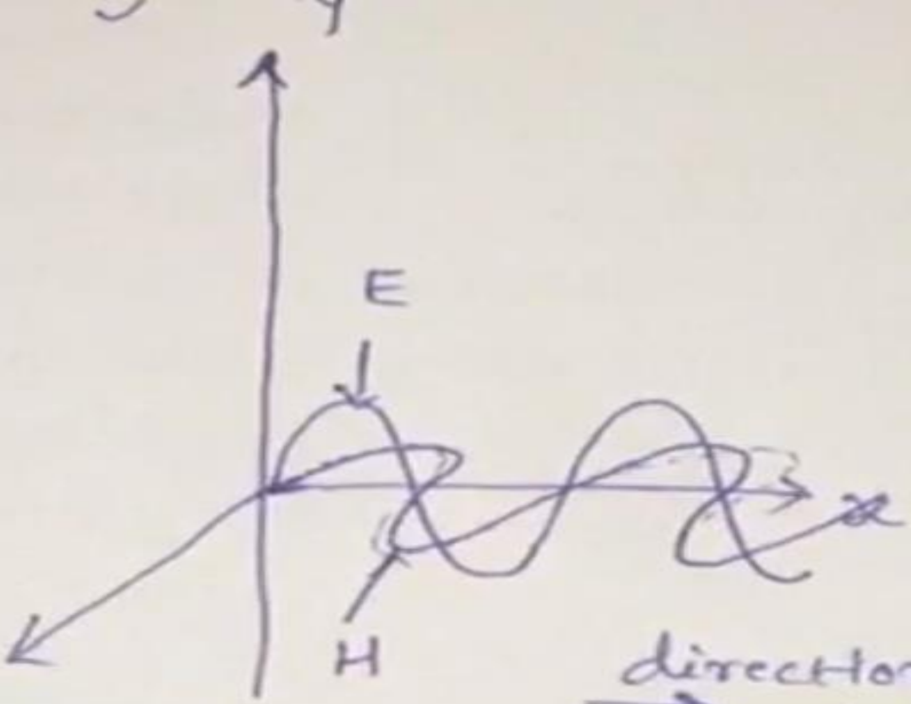
* WHAT IS RADIATION?



conductor

→ high freq.

EM waves

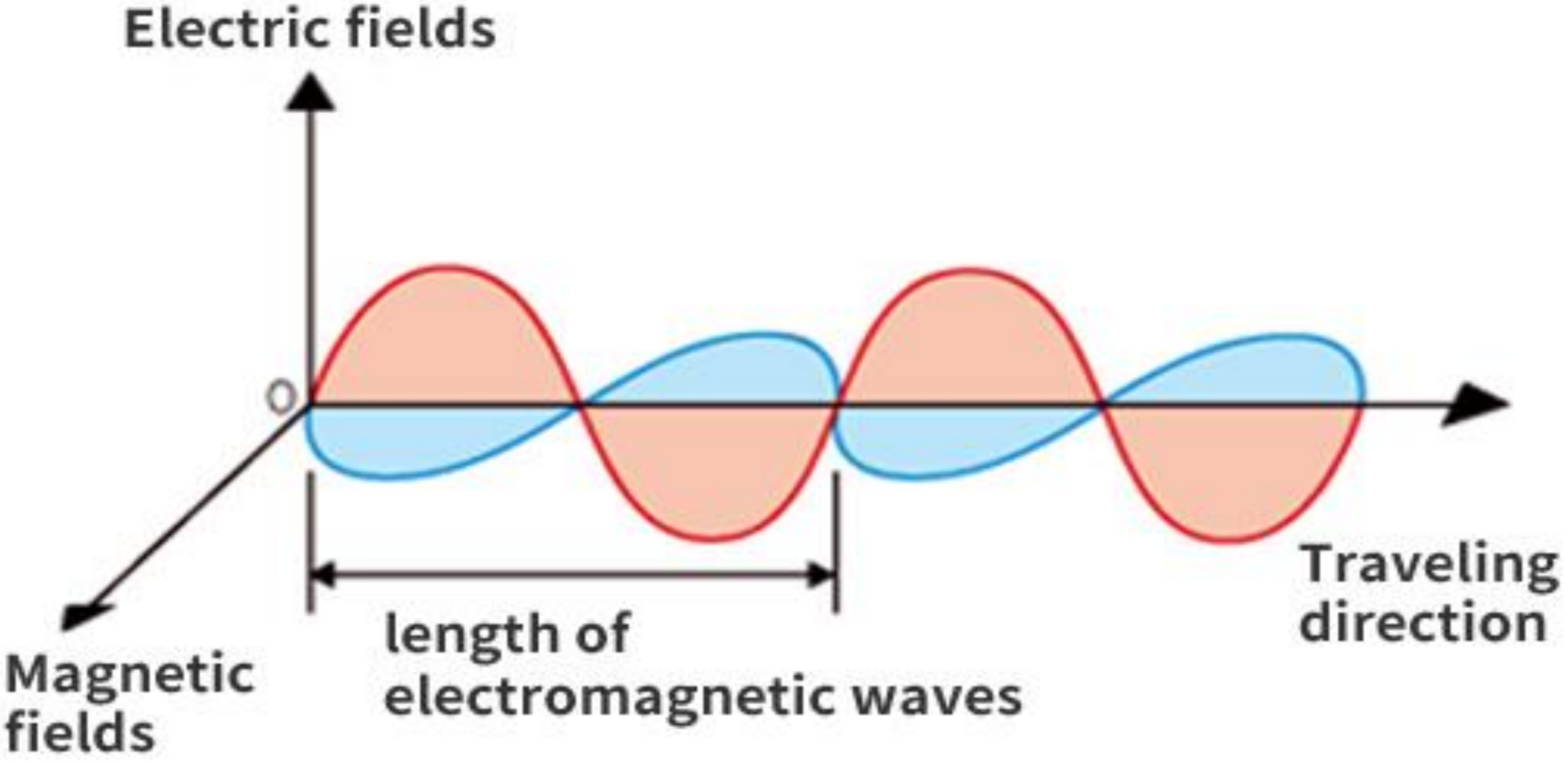


* What is the requirement of EM wave?

→ All kind of wireless comm. is done with the help of EM waves

E → seawave

H → snake


Electric fields
O
Traveling direction
Magnetic fields
length of electromagnetic waves

Electric field E
magnetic field H
* the direction of propagation are orthogonal to each other.

→ TEM waves

Transverse electromagnetic wave,

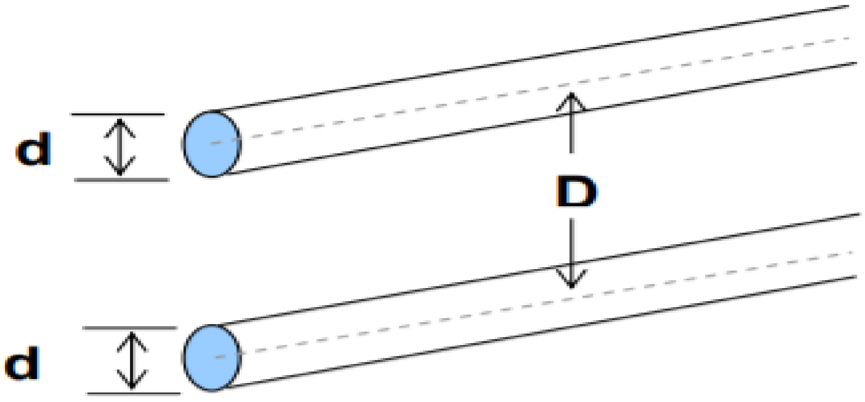
$c = 3 \times 10^8$ m/s in free space.

* properties of electromagnetic wave.

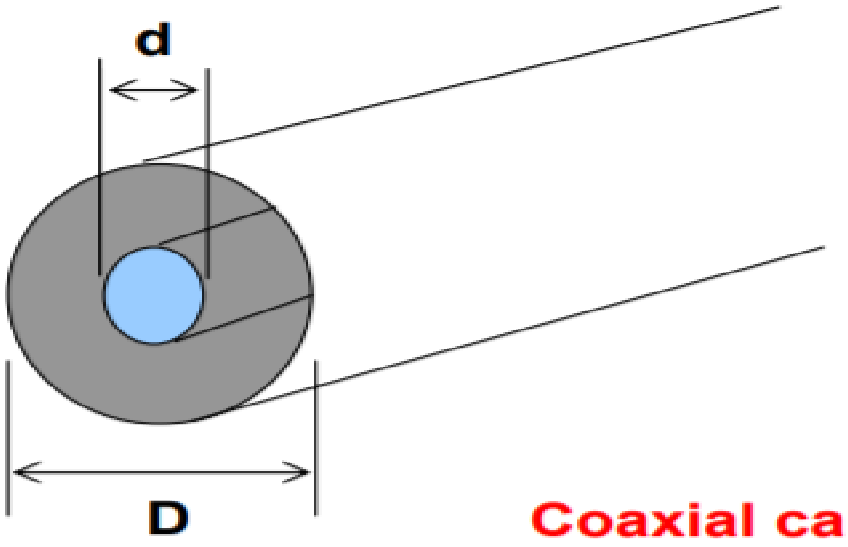
1. time varing field.
2. any physical medium. (Doesn't require)
3. seawater → lossy conductor (Cannot travel)
4. reflected from good conductors
5. refracted by some other mediums

Examples of transmission lines

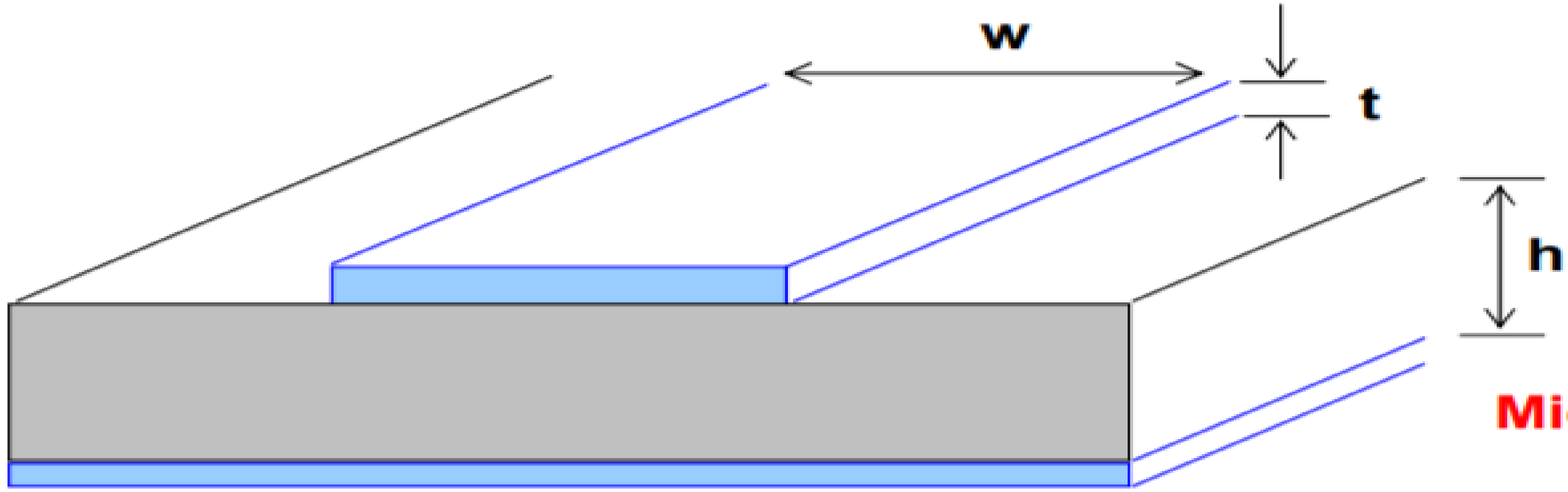
Transmission of power from one point to another



Two-wire line



Coaxial cable

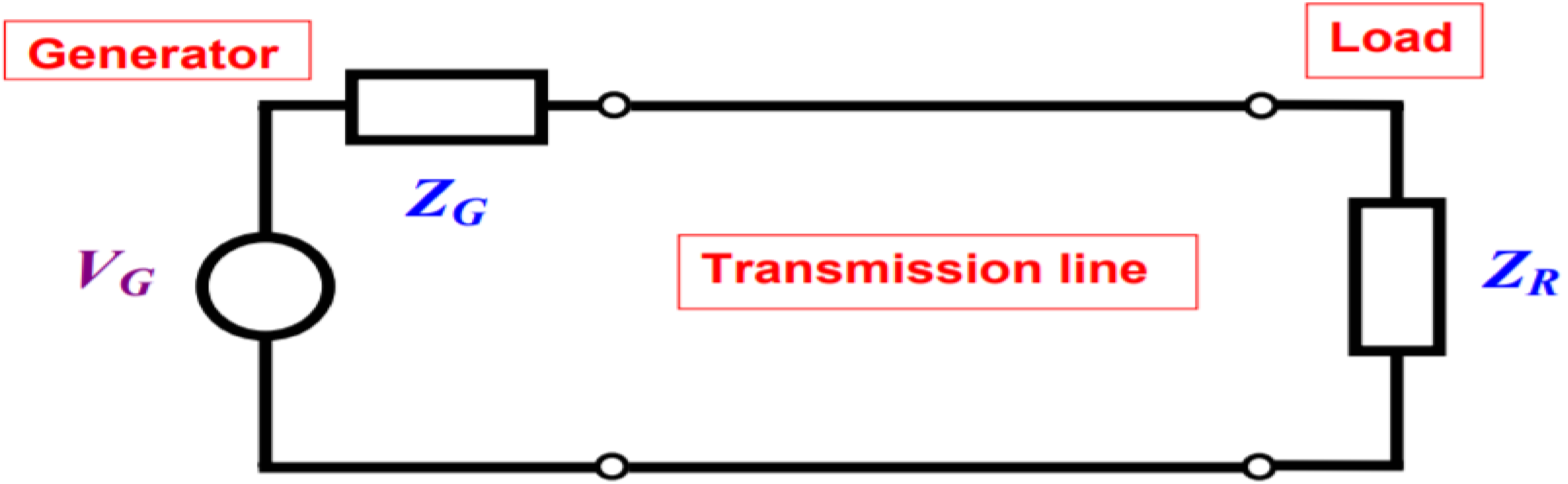


Microstrip

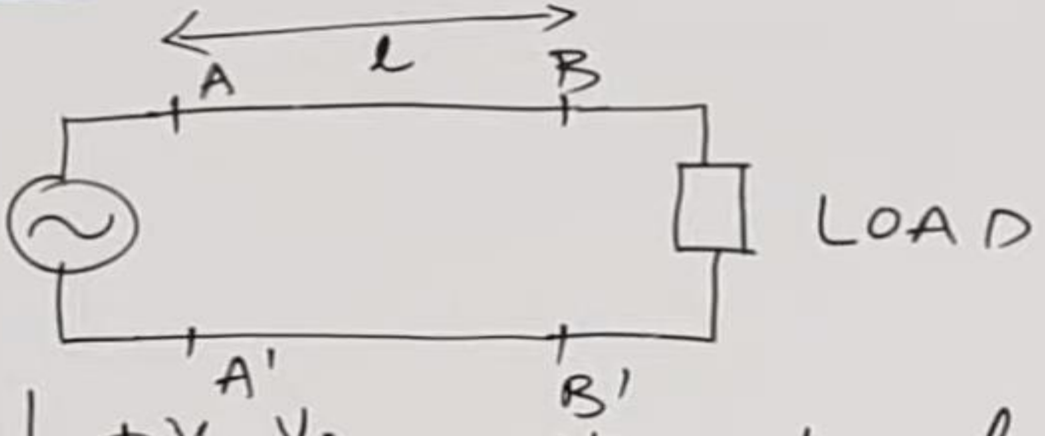
Transmission Line Equations

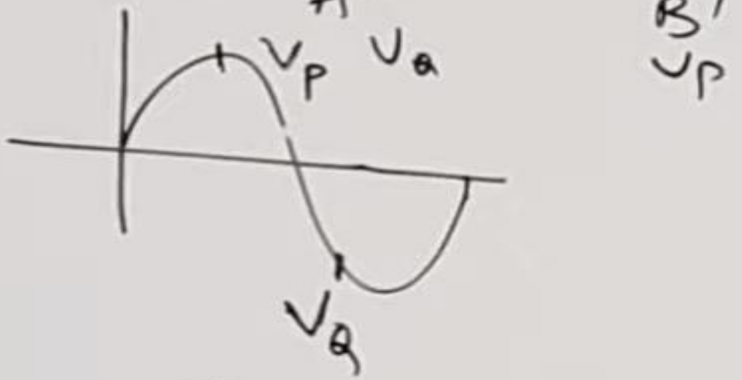
A typical engineering problem involves the transmission of a signal from a generator to a load. A transmission line is the part of the circuit that provides the direct link between generator and load.

Transmission lines can be realized in a number of ways. Common examples are the parallel-wire line and the coaxial cable. For simplicity, we use in most diagrams the parallel-wire line to represent circuit connections, but the theory applies to all types of transmission lines.



TRANSIT TIME EFFECT





$$T >> t_r$$

$$T >> \frac{l}{v}$$

$$\frac{1}{f} >> \frac{l}{v}$$

$$\frac{v}{f} >> l$$

$$\boxed{\lambda >> l}$$

Transit time effect Not applicable

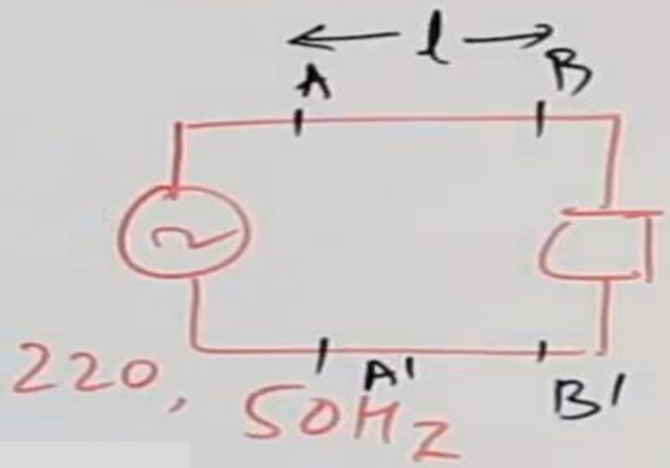
$$t_r = \frac{l}{v}$$

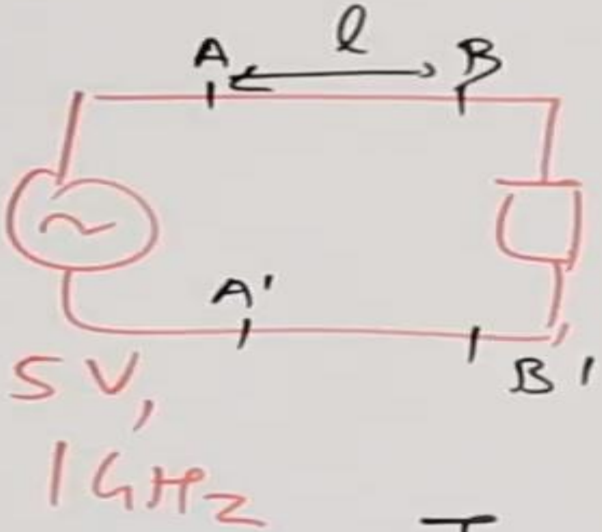
$l \rightarrow$ length
$v \rightarrow$ velocity
$t \rightarrow$ transit time

Voltage at BB' – V_P
Voltage at AA' → V_Q

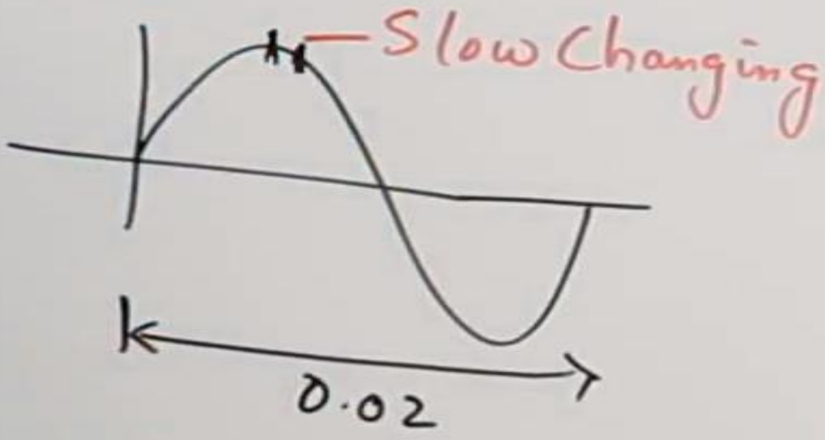
T → Time Period of Signal

TRANSIT TIME EFFECT



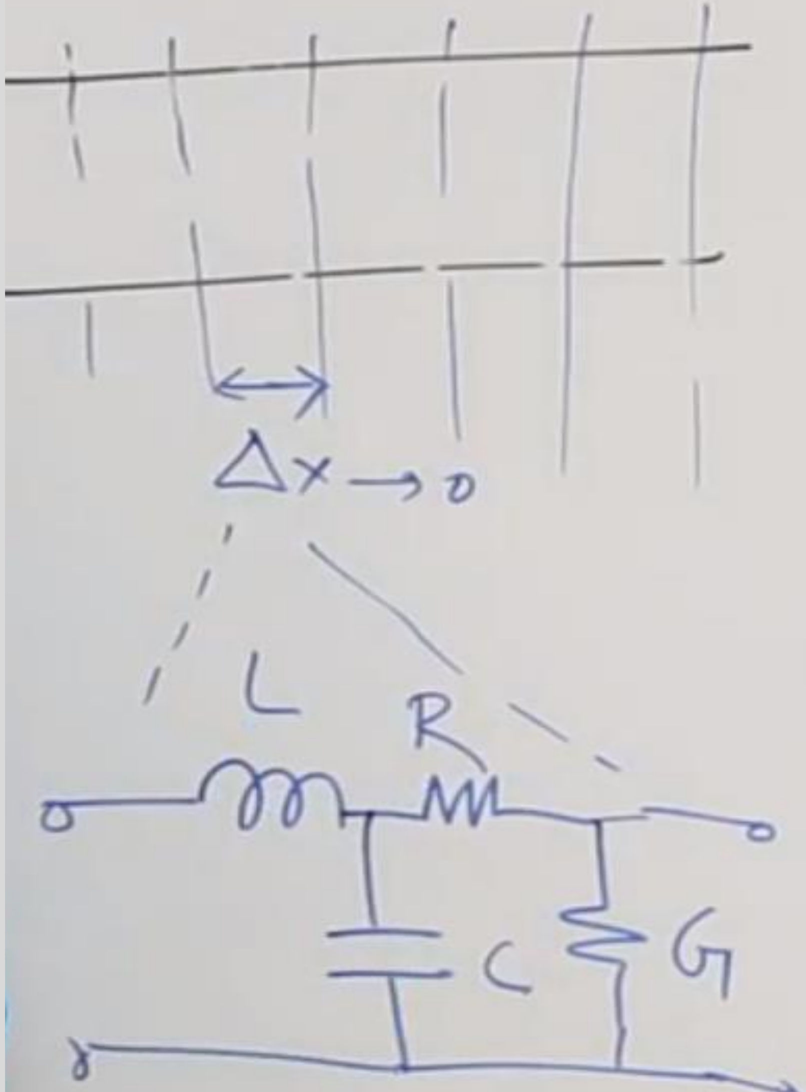


$$T = \frac{1}{50} = 0.02\,Sec$$



$$T = \frac{1}{f} = \frac{1}{1 \times 10^{9}} = 10^{-9}\,Sec$$

PRIMARY CONSTANT OF TRANSMISSION LINE:



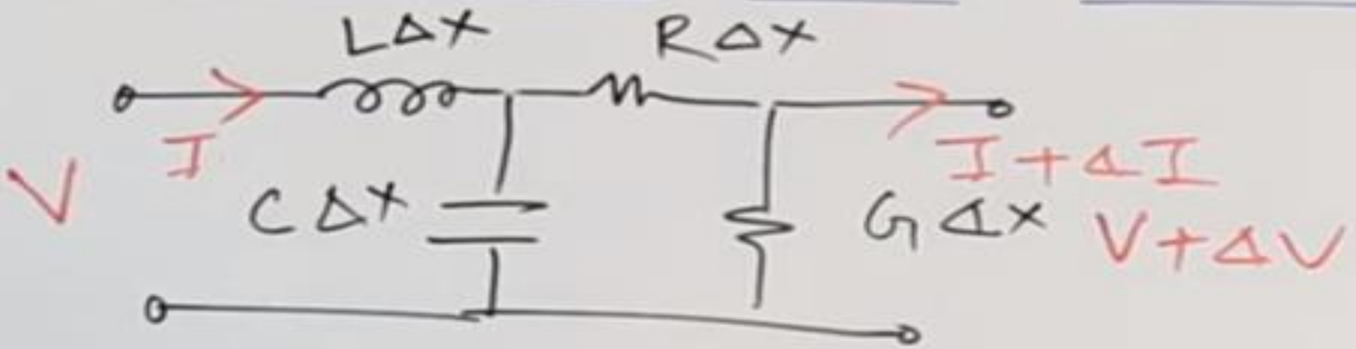
$L \to H/m$

$C \to F/m$

$R \to \Omega/m$

$G \to ℧/m$

TRANSMISSION LINE EQUATION



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

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

$$\frac{dV}{dx} = -(R + j\omega L) I \quad \text{— (1)}$$

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

$$\lim_{\Delta x \to 0} \frac{\Delta I}{\Delta x} = -(G + j\omega C) V$$

$$\frac{dI}{dx} = -(G + j\omega C) V \quad \text{— (2)}$$

After diff.

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

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

γ^2 (sigma)

$$\boxed{\frac{d^2V}{dx^2} = \gamma^2 V}$$

TRANSMISSION LINE EQUATION

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

$$V(x,t) = \left(V^+ e^{-\gamma x} + V^- e^{+\gamma x}\right) e^{j\omega t}$$

$\gamma \rightarrow$ Propogation Const.

$\gamma = \alpha + j\beta$

$\alpha \rightarrow$ attenuation Const.

$\beta \rightarrow$ Phase Const.

for Lossless Medium $(\alpha = 0)$

Transmission Line Equation

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

$$V(x,t) = \left(V^+ e^{-\gamma x} + V^- e^{+\gamma x}\right) e^{j\omega t}$$

$$= V^+ e^{-j\beta x} e^{j\omega t} + V^- e^{j\beta x} e^{j\omega t}$$

$$= V^+ e^{j(\omega t - \beta x)} + V^- e^{j(\omega t + \beta x)}$$

$$V(x,t) = \underline{V^+ e}^{-(\alpha + j\beta)x} e^{j\omega t} + \underline{V^- e}^{+(\alpha + j\beta)x} \cdot e^{j\omega t}$$

TRANSMISSION LINE EQUATION

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

$$V(x,t) = \left(V^+ e^{-\gamma x} + V^- e^{+\gamma x}\right) e^{j\omega t}$$

$$= V^+ e^{-j\beta x} e^{j\omega t} + V^- e^{j\beta x} e^{j\omega t}$$

$$= V^+ e^{j(\omega t - \beta x)} + V^- e^{j(\omega t + \beta x)}$$

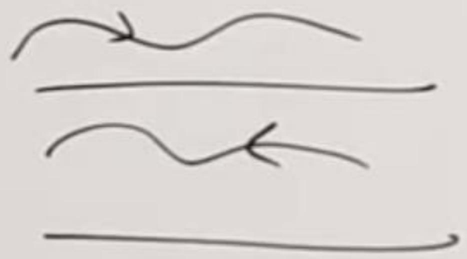
$$V(x,t) = V^+ \cos(\omega t - \beta x) + V^- \cos(\omega t + \beta x)$$

travelling +x dir

travelling −x dir

$$\vec{E} = E_0 e^{-\alpha z} \cos(\omega t - \beta z)\,\hat{x}$$

$$\vec{E} = E_0 \cos(\omega t - \beta z)\,\hat{x}$$ {lossless cond



Wave equation

Voltage travelling in the TL behaves like a wave

Reference Books

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