UNIT-I

Transmission Lines-I

→ Energy can be transmitted in 2 ways:

① **Wireless transmission:**

By the radiation of free electromagnetic (EM) waves, the energy can be transmitted from one place to another.

② **Wire transmission:**

By using various conductor arrangements known as transmission line, the energy can be transmitted from one place to another.

Definition of Transmission line:-

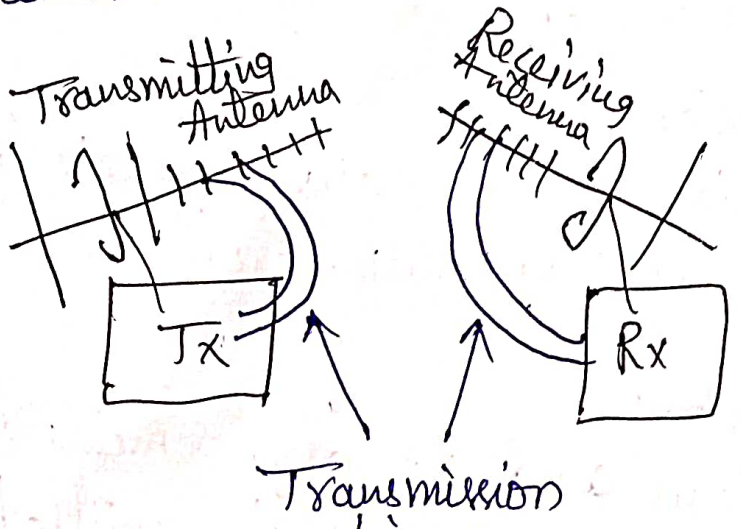
Transmission line is a conductive method for guiding Electromagnetic (EM) energy from one place (Transmitter) to another place (Receiver).

Importance of transmission lines:-

① The generation & transmission of electromagnetic (EM) radiation at low frequencies will require directive antennas of larger dimensions. It is very expensive.

② If the wave of electromagnetic is not guided, so much of power is wasted due to the radiation losses. So, for efficient transmission EM energy should be guided.

(3) Transmission lines are used as a link between the Antenna to a transmitter (or) Receiver.



(4) Transmission lines used as power distribution section at low frequencies (high power) and communications at higher frequencies (low power).

(5) Transmission lines acts as circuit elements such as Resistors, capacitors, inductors, resonators etc.

(6) Transmission lines are used for "impedance matching" for maximum power transfer.

(7) They are also used as filters, transformers and even insulators at very high frequencies.

(8) They also used as measuring devices in electrical laboratories.

2.

Types of Transmission Lines:

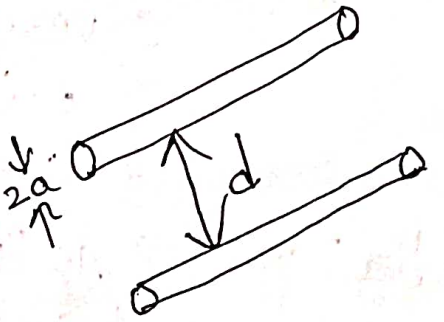
→ Various types of guiding structures are:

1. parallel wire line (or) open wire lines
2. parallel-plate (or) planar transmission lines
3. Twisted wires
4. wire above conducting plane
5. coaxial cables.
6. Waveguides
7. optical fibers
8. Microstrip lines
9. strip lines.

① parallel-wire lines (or) open-wire lines:

→ A transmission line which consists of 2-parallel conductors separated at a uniform distance of 'd', in which each wire has a radius of 'a', as shown below fig①:

→ These lines are most common form of Tx lines, are mounted on posts (or) on towers.



fig②: Two-wire parallel lines.

→ when a voltage is applied between these lines, the signal current travels down one wire and returns to the source on the other wire, as shown in fig②.

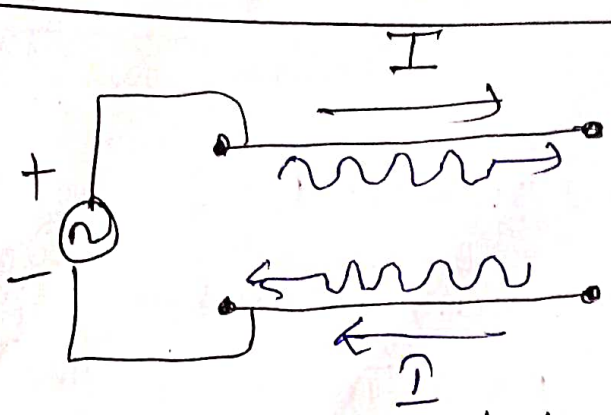


Fig ②:- potential difference (V)

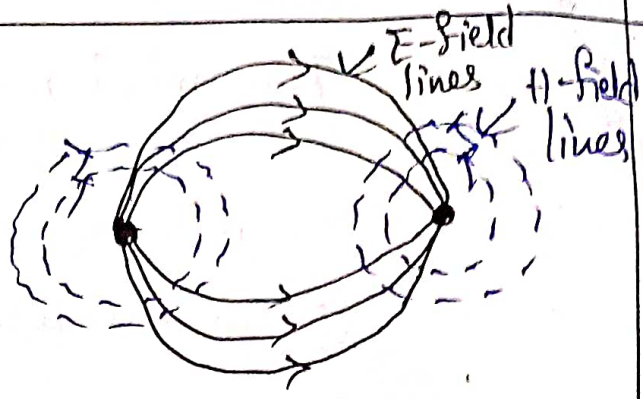


Fig ③: Field lines (E & H)

→ when electrical energy propagating through these lines setup electric field (E) between them, in turn creates magnetic field (H), as shown in fig ③.

∴ Both E and H are at right angles to each other and to the direction of propagation, known as Transverse electro-magnetic (TEM) mode of propagation.

→ These open-wire lines are suitable for frequencies upto 100MHz.

Advantages :-
① simple structure
② very easy to construct
③ easy to maintain over short distances
④ cheaper.

Disadvantages :-
① As it is open transmission line structure, it is capable of getting electromagnetic interference.
② above 100MHz, there will be more radiation losses (as Tx lines become unstable)
③ As distance increases, cost increases.

Examples / Applications :- power lines, telephone line, telegraph lines etc.

② Twisted pair of wires:-

→ These are laid underground and consists of 2 (or) more conductors, individually insulated with paper and all these conductors are periodically twisted in pairs & placed in a protective lead shield as shown in fig:

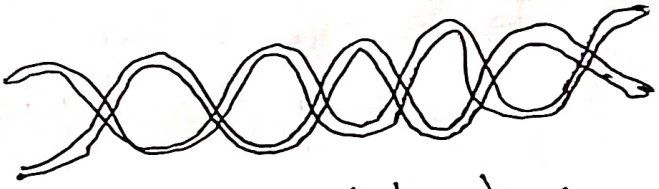


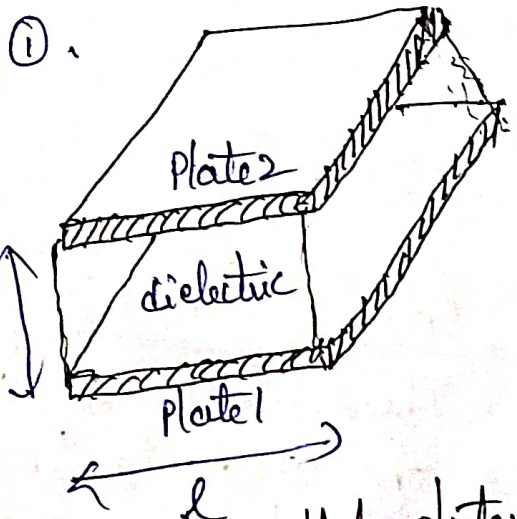
fig:- Twisted wires

Advantage:- To overcome the electromagnetic interference of open-wire lines, these wires are shielded.

example/Application:- power cables.

③ Parallel-plate transmission lines:-

→ These lines consists of two parallel conducting plates of length(l) separated by a dielectric slab of an uniform thickness (d) as shown below fig ①.



fig①: parallel-plates.

Advantage:- These lines are used at microwave frequencies, can be fabricated inexpensively using PCB technology.
(printed-circuit board)

→ Conider, the cross section view as well as the field patterns of a parallel-plate Tx line as shown in fig②.

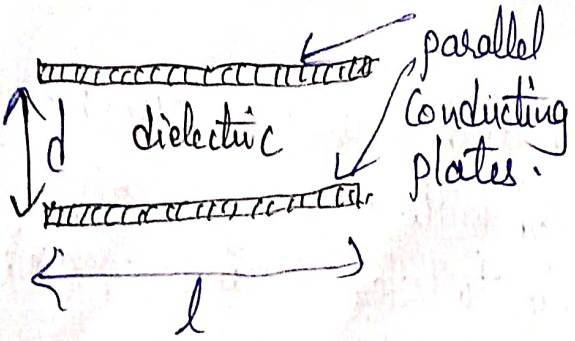
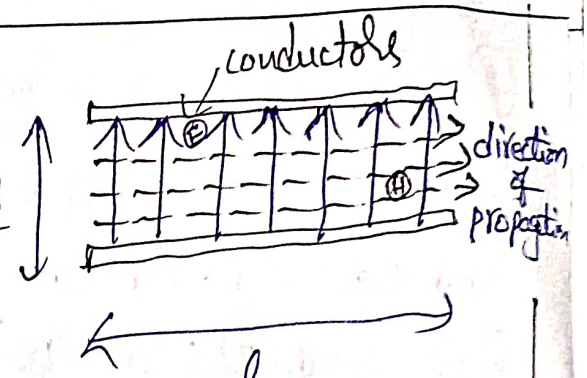


Fig (2a): cross-section view of parallel-plates



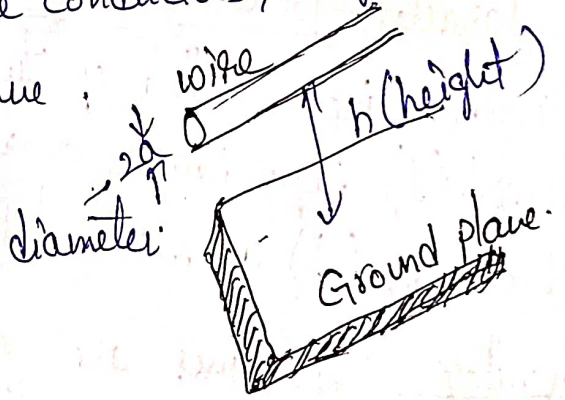
here, ——→ E-field lines
- - - - → H-field lines

Fig (2b): field patterns.

example/Application :- These plates are used to connect the transmitters & antennas.

(4) wire above the ground plane :-

→ It consists of a single conductor, is place above a conducting (ground) plane.



(5) Coaxial Cables :-

→ These cables employs 2-conductors placed coaxially i.e one conductor is placed coaxial within another hollow conductor as shown in fig:

→ The volume between these 2-conductors is filled with dielectric material (ex:- poly-ethylene)

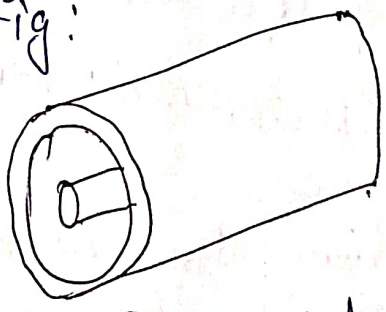


Fig: coaxial cable

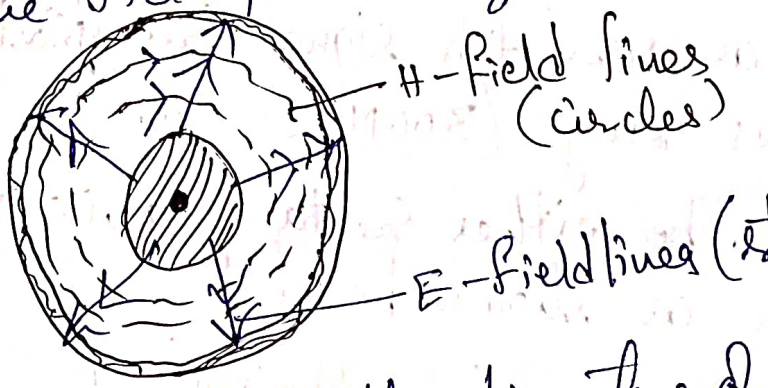
→ These cables are extensively used in the frequency range upto 1GHz.

→ These cables support either TE (or) TM mode of propagation, based on it's feeding.

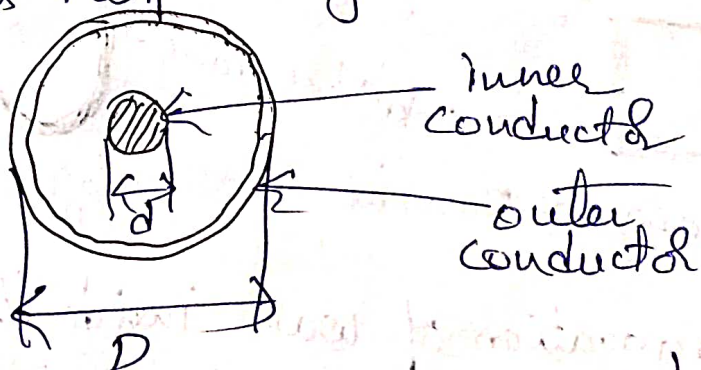
→ The electric & magnetic fields are confined within the dielectric region, cannot leak into freespace

∴ Radiation losses are eliminated.

∴ Consider, the field patterns of coaxial cable as:



→ Let 'D' and 'd' are the diameters of outer & inner conductors respectively as shown below:



Advantages:

→ Radiation losses are less, thus replaces parallel-wire lines.

Disadvantages: Beyond 1GHz, these cables become unstable.

Applications: ① TV cables, input cables to high-frequency precision measuring instruments, used in electrical laboratories

② There are widely used in applications where high voltage levels are needed.

⑥ Waveguides:

→ Waveguides are a special category of Tx lines used to guide the waves along the length of the tube.
i.e A hollow metallic tube acts as the medium to transfer EM energy (microwaves) from one end to another.

→ These are used for signal transmission at Microwave frequencies range (300MHz – 300GHz).

→ The tube can be either rectangular (or) cylindrical waveguide as shown below:

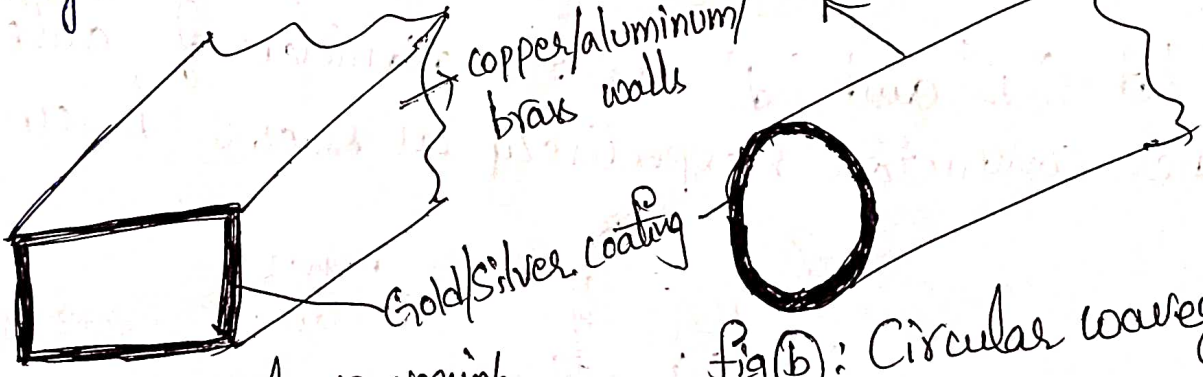


Fig ⓐ: Rectangular waveguide.

Fig ⓑ: Circular waveguide

→ The propagation of wave inside the waveguide originates basically 2 modes: either TE (or) TM mode.

Note: TEM mode is not supported in waveguides.

Advantages:- ① power loss during propagation is negligible
② Large power handling capability
↳ larger Bandwidth

③ As it is a simple structure, its installation is easy.

Disadvantages:

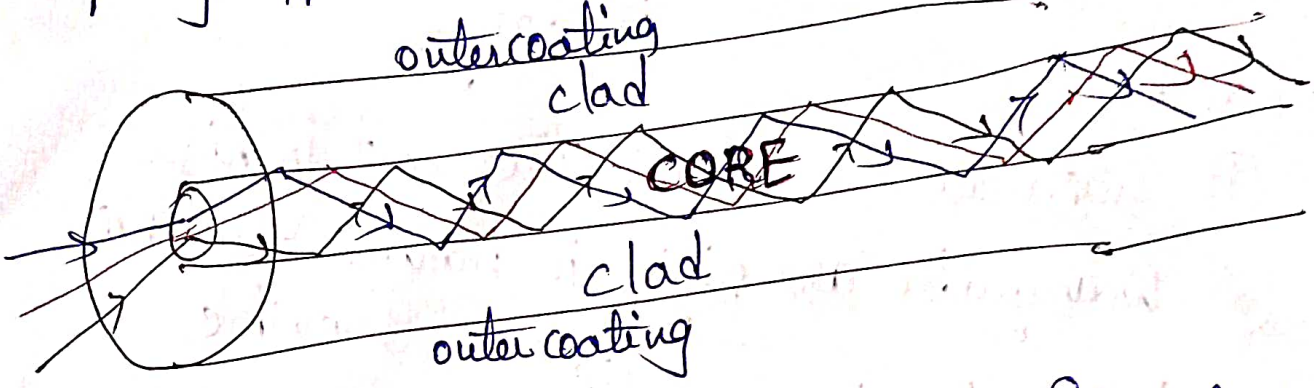
① Installation & manufacting cost is high
② Waveguides are rigid in nature, thus not flexible
④ larger in size & bulkier.

→ Waveguides can operate only above a certain frequency called cutoff frequency and acts as a high-pass filter (HPF).
∴ So, signal frequency must be greater than the cutoff frequency in order to have a proper signal transmission.

⑦ Optical fibers:

→ These are used for the communication of light signals from one point to another, over long & short distances.
→ In the optical fiber a modulated beam of light are used to carry the information from one place to another on the principle of total internal reflection.
→ Basically optical fibers consist of 2 parts:
① core and cladding: These are made from fused Silica glass (SiO_2) and are optically transparent.
② outer coating: protective layers of plastic are

uniformly applied to the entire length of the fiber.



Core :- The central portion of the optical fibers is called core, in which light rays are guided.

Clad :- The surrounding portion of core is called cladding

→ Let n_1 — refractive index of core
n_2 — refractive index of clad

. To make the light rays always kept within the core of the optical fibers, the necessary condition is

$$\boxed{n_1 > n_2}$$

Coating :- It gives protection to fibers from external influences, absorbs shear forces, also attenuates any undesirable light in the cladding. (usually colored)

. Let n_3 — refractive index of coating

and $\boxed{n_3 > n_1 > n_2}$

Advantages :- ① very high bandwidth ⇒ very high information carrying capacity.
② Small size, light weight
③ low losses ⇒ superior transmission quality ⇒ more efficient
④ Reduced cost & higher security.

(8) Microstrip lines :-

→ These lines are used to carry EM waves (or) microwave frequency signals.

→ It consists of 3 layers : conducting strip
dielectric
Ground plane.

structure: A parallel-plate transmission line consists of an open conducting strip (very thin copper sheet) and a ground plane separated by a dielectric substrate as shown below:

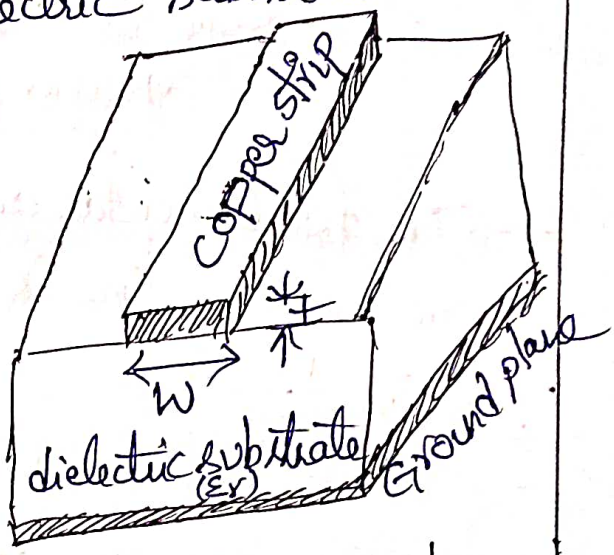


fig: Microstrip line

→ These lines are fabricated using PCB technology.

advantages:-

① used in Microwave Integrated circuits (MIC).

② used to design and fabricate RF and microwave components such as directional coupler, power divider/combiner, filter, antenna etc.

③ Support all types of modes such as TE (or) TM (or) TEM, to propagate through it.

④ These are cheaper when compared to waveguides.

(9) Strip lines :-

→ These are the planar transmission lines used at frequencies from 100MHz to 100GHz.

→ It consists of central thin conducting strip of width (W) and thickness (t) placed inside dielectric substrate between 2 wide ground plates.

here, $W > t$

t — same for strip & ground planes.

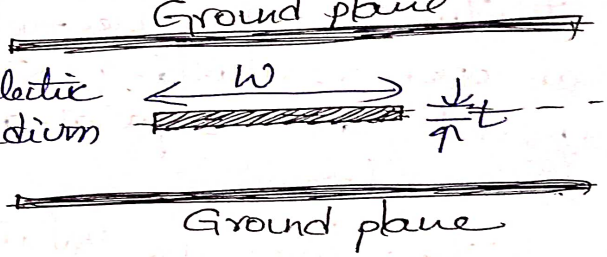


Fig :- Stripline.

→ The fundamental and dominant mode in strip line is TEM mode.

Disadvantage :-

→ It is not accessible for adjustment and tuning.

Note :- This problem is avoided in microstrip lines, which allows mounting of active & passive devices, also allows making minor adjustments after circuit fabrication.