Equivalent circuit of a transmission line :-

→ Consider a 2-wire transmission line as shown in fig ① :

- When a voltage is applied across the two conducting wires, current flows through the line.

(i) The voltage produces an electric field lines between the conductors, contain shunt capacitance (C) & shunt conductance (G).

(ii) The current produces magnetic field lines around the conductors and voltage drop along them, indicates series resistance (R) and inductance (L).

→ A unit section of the line may be represented by fig ② : an equivalent circuit shown below :

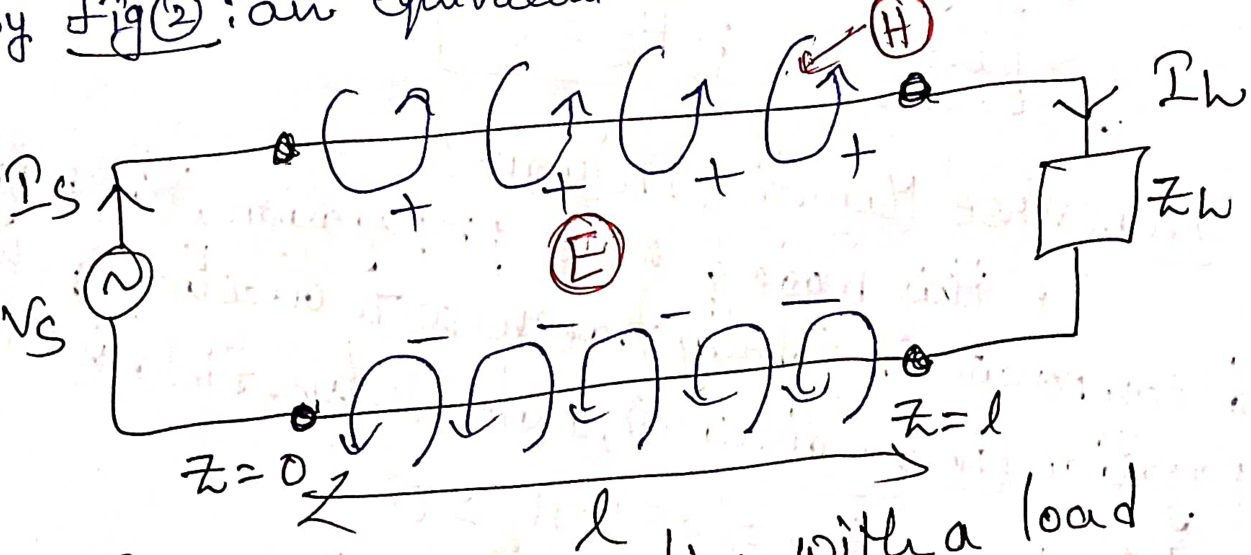

fig ① : Transmission line with a load.

Equivalent circuit of 2-wire Tx line :-

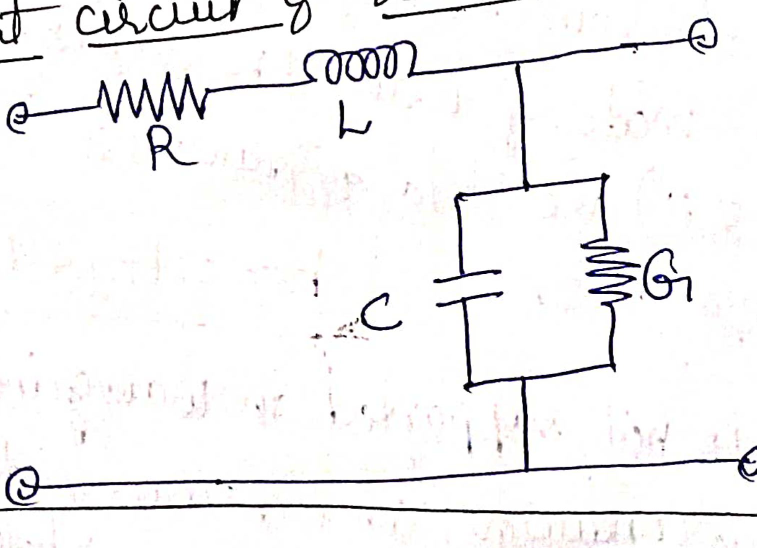

fig ② : equivalent circuit of 2-wire Tx line.

Transmission Line Parameters:- (primary constants)

→ The performance of the transmission line depends on the line parameters,

• Also, It is essential and convenient to describe a transmission line in terms of its line parameters, which are:

(i) Resistance (R):-

→ A transmission line is made up of conductors, each conductor has certain length & diameter.

→ when the current is flowing through the conductor, it must have resistance, uniformly distributed all along the length of the conductors.

∴ Resistance per unit length of the transmission line is given by $\boxed{R = \frac{\rho l}{a} \text{ ohms/km}}$

where l — length of the conductor/wire.
a — radius of the wire.

(ii) Inductance (L):-

→ when the current flows through the conductor, it induces magnetic flux surrounding to it.

→ when the current changes, magnetic flux also varies due to which an electro-magnetic force (emf) induces in the transmission line.

→ This induced emf in the transmission line resists the flow of current, measured as the inductance of the line.

→ The flux linkage per unit current is called as inductance, distributed all along the length of the line.

∴ Inductance per unit length of the transmission line is given by $\boxed{L = \frac{N\phi}{I} \ H/km}$

where N — Number of turns of coil

ϕ — Magnetic flux.

• Also, $\boxed{L = \frac{\psi}{I} \ H/km}$ where $\boxed{\psi = N\phi}$

(iii) Capacitance (C):-

→ Two metal conductors separated through some distance by dielectric material (eg:- air) and maintained at some potential difference results in capacitance.

• Hence, effect of capacitance distributed along the entire length of lines.

∴ Capacitance associated with the transmission line per unit length is given by,

$$\boxed{C = \frac{\varepsilon A}{d} \ F/km}$$

where ε — dielectric constant
A — Area of cross-section
d — distance between the 2 conductors

• Also, $\boxed{C = \frac{q}{V} \ F/km}$; q – charge
V – applied voltage.

(iv) Conductance (G):-

→ Due to the imperfections of the dielectric medium, also as capacitance being lossy always, a small amount of current flows through the dielectric medium [called leakage current].

• This gives rise to a leakage conductance associated with the Transmission line.

• Also, each capacitance has some shunt conductance, distributed all along the entire length of the transmission line.

∴ conductance per unit length is measured in mhos/km.

Important Points regarding transmission line parameters that:

① The line parameters R, L, C and G are the primary constants of the transmission line.

- All these constants are assumed to be independent of frequency.

② The line parameters are not discrete (or) lumped. Rather, they are distributed elements since these are uniformly distributed along the entire length of the line as shown below:

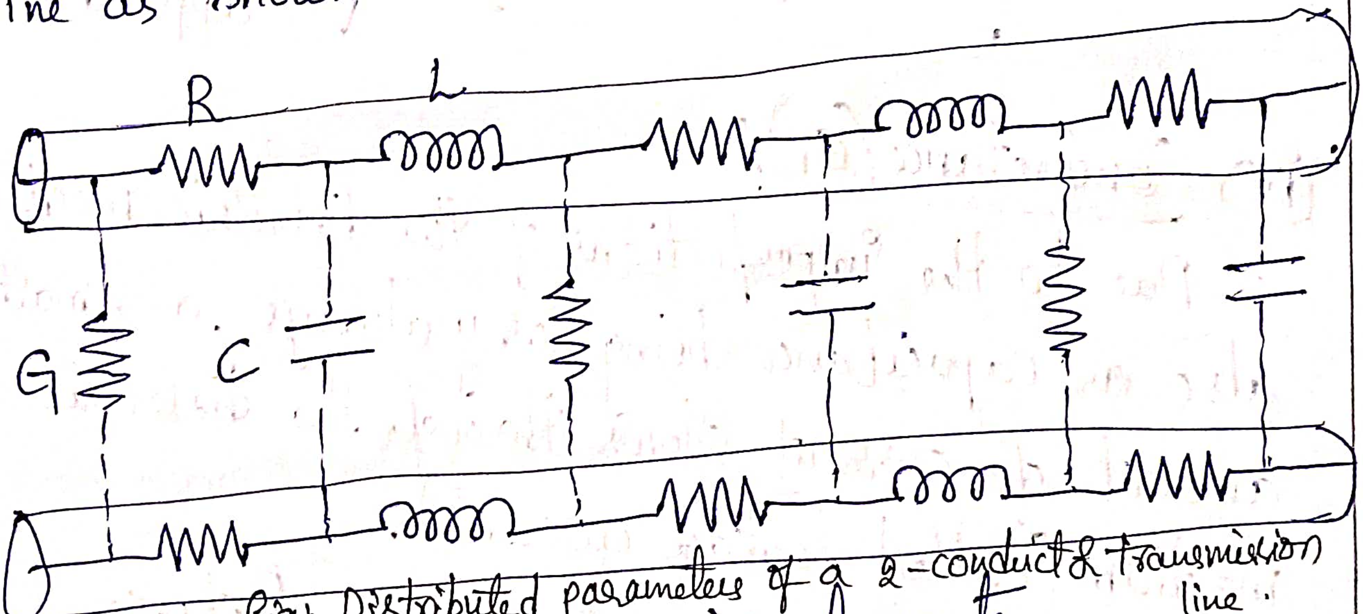

fig: Distributed parameters of a 2-conductor transmission line.

here, R and L — series elements

G and C — shunt elements

i.e series elements form series impedance

$$\boxed{Z = R + j\omega L}$$

and shunt elements form shunt admittance

$$\boxed{Y = G + j\omega C}$$