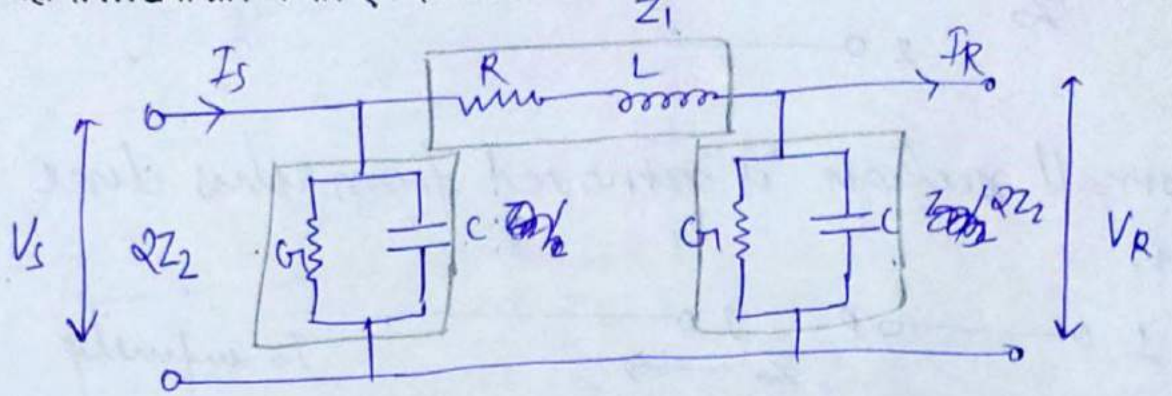
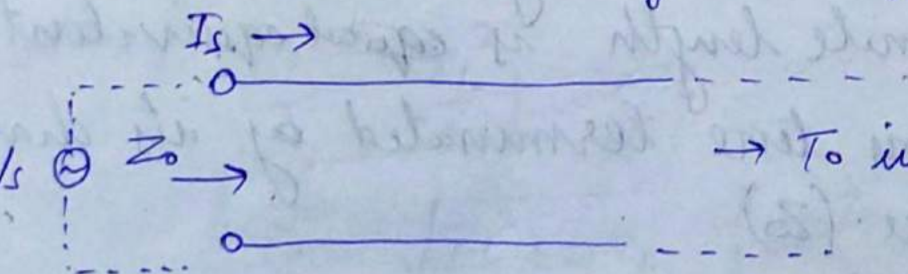


π-section representation of a transmission line section.

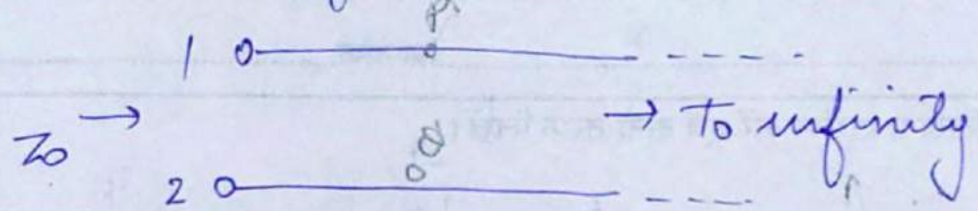
Concept of Infinite Line

→ When a transmission line is considered to be of infinite length, then there will be no possibility of reflection of signal. As the conductor ~~of~~ is of infinite length, so ~~the~~ no electrical signal will reach its end.

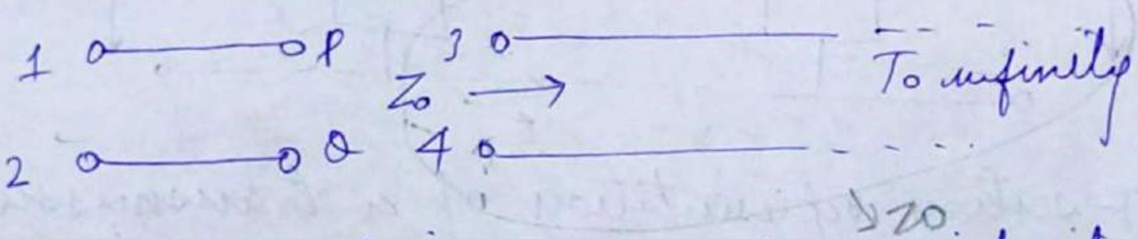


In above figure, a transmission line of infinite length is considered. V_s is the input voltage and I_s is the flow of current in the line due to V_s.

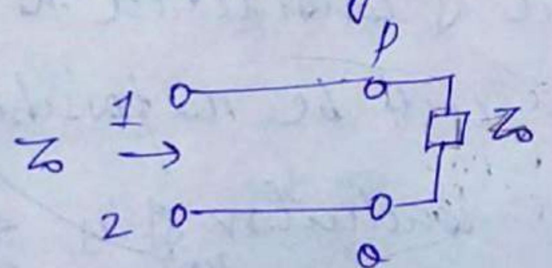
The ratio of V_s and I_s will be the input impedance of the line.
Let Z_0 is the ~~..~~ input impedance of a transmission line of infinite length.



If a small section is removed from this line PQ, then

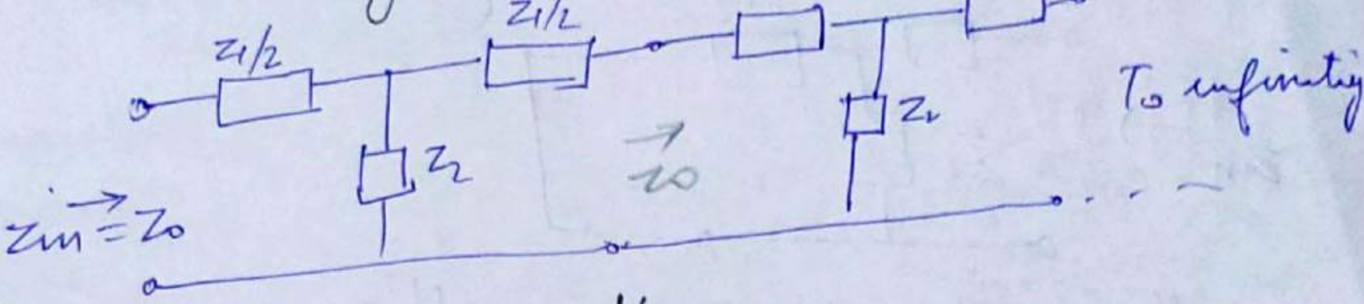


→ The remaining section ~~..~~ 3-4, is of infinite length, hence input impedance of 3-4 will be Z_0.
Thus we ~~a~~ can say the impedance b/w PQ will Z_0.

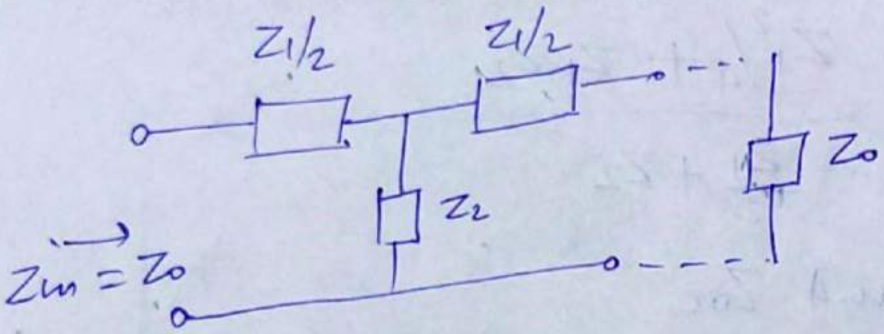


→ Thus from this we can say that a transmission line of ~~a~~ infinite length is ~~equal~~ equivalent to a transmission line terminated by its characteristic impedance. (Z_0)
→ And so, if a ~~..~~ transmission line is terminated by the characteristic impedance (Z_0), then there will be <u>no reflection of signal</u>.

T-section analysis



$$\Downarrow$$



solving $\quad Z_{in} = Z_1/2 + Z_2 \,||\, (Z_1/2 + Z_0)$

$$Z_{in} = \frac{Z_1}{2} + \frac{Z_2\left(\frac{Z_1}{2} + Z_0\right)}{Z_2 + \frac{Z_1}{2} + Z_0}$$

For ~~or~~ transmission line of infinite length

$$Z_{in} = Z_0$$

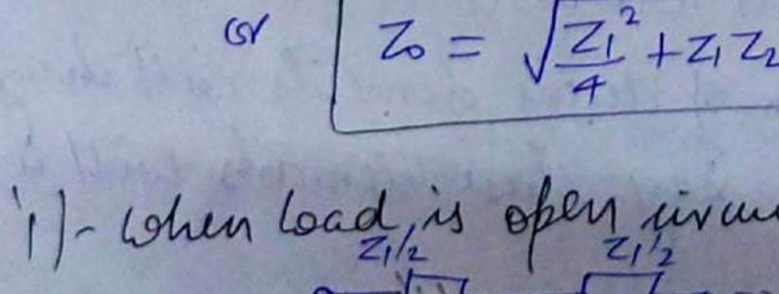
thus

$$Z_0 = \frac{Z_1}{2} + \frac{\frac{Z_1 Z_2}{2} + Z_0 Z_2}{\frac{Z_1}{2} + Z_2 + Z_0}$$

on solving $\quad Z_0^2 = \frac{Z_1^2}{4} + Z_1 Z_2$

or $\quad \boxed{Z_0 = \sqrt{\frac{Z_1^2}{4} + Z_1 Z_2}}$

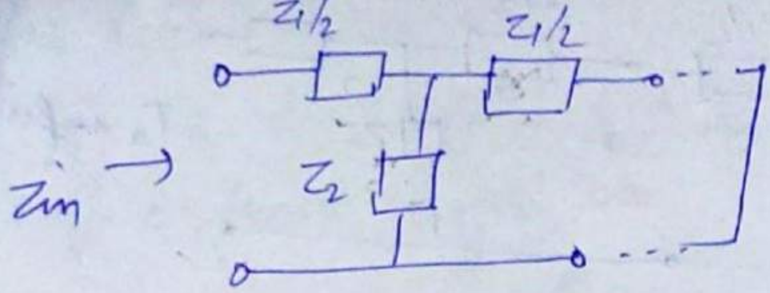
1)- When load is open circuited



then

$$Z_{in} = Z_{oc} = \frac{Z_1}{2} + Z_2$$

ii) wheeen load is short-circuited



then $Z_{in} = Z_{sc} = \frac{Z_1}{2} + Z_2 \,||\, \frac{Z_1}{2}$

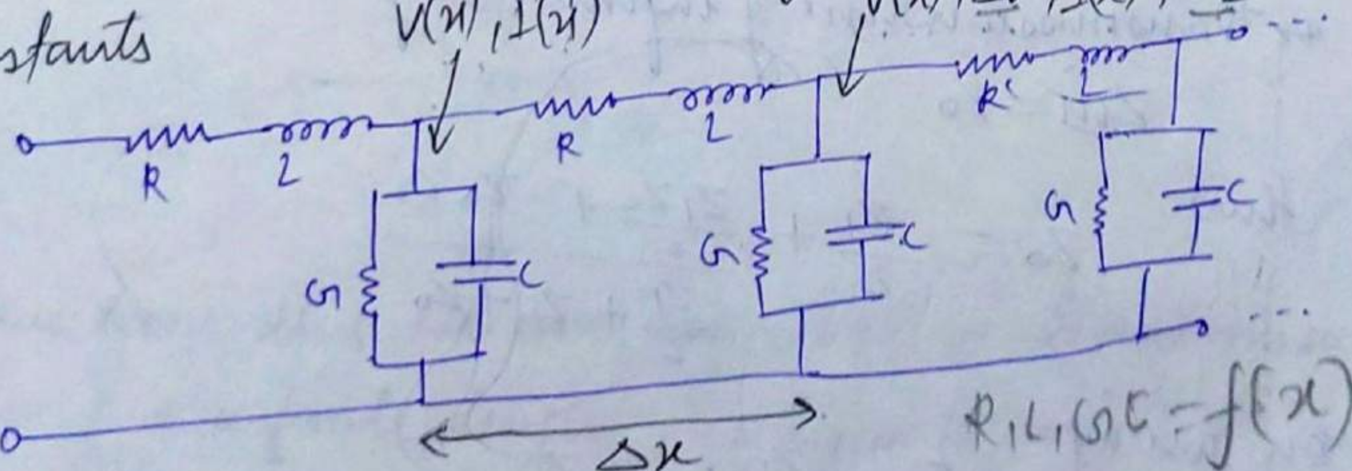
$$Z_{sc} = \frac{Z_1^2/4 + Z_1 Z_2}{\frac{Z_1}{2} + Z_2}$$

multiplying Z_{sc} and Z_{oc}

$$Z_{sc} \cdot Z_{oc} = \frac{Z_1^2}{4} + Z_1 Z_2 = Z_0^2$$

$$\Rightarrow \boxed{Z_0 = \sqrt{Z_{sc} \cdot Z_{oc}}}$$

~~If a~~ Relation b/w primary and secondary constants

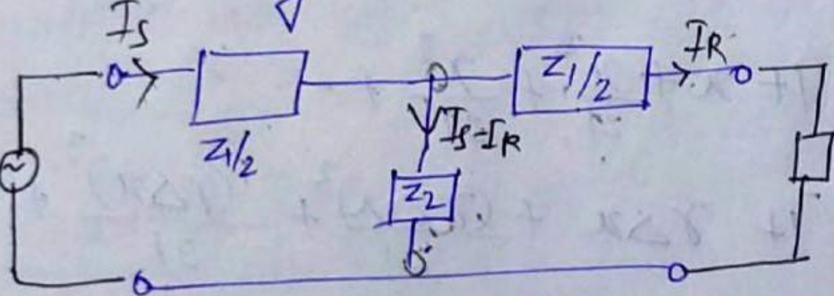


→ Since primary constants are distributed elements, so the net value of these elements will change with distance. or to say these elements will a as function of distance.

6

For a small distance Δx, the voltage and current will change by ΔV and ΔI, due to change in the primary constants (R, L, G, C) in Δx length. So let ~~in~~ the primary constant in the small length Δx will be $R\Delta x$, $L\Delta x$, $G\Delta x$, $C\Delta x$.

For a T-section of transmission line of length Δx given as -



$Y/2 = (G + j\omega C)\Delta x$

where $\frac{Z_1}{2} = \frac{1}{2}(R + j\omega L)\Delta x$, $Z_2 = \frac{1}{(G + j\omega C)\Delta x}$

$$Z_0 = \sqrt{\frac{Z_1^2}{4} + Z_1 Z_2} \quad \frac{Z_1^2}{4} \to 0$$

$$Z_0 = \sqrt{\cancel{\frac{(R + j\omega L)^2 (\Delta x)^2}{4}} + \frac{(R + j\omega L)\cancel{\Delta x}}{(G + j\omega C)\cancel{\Delta x}}}$$

For a ~~o~~ very small section of transmission line $\Delta x \to 0$

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

Propagation constant

$$e^{\gamma} = \frac{I_S}{I_R}$$

$$e^{\gamma} = \frac{Z_1/2 + Z_0 + Z_2}{Z_2}$$

$$= 1 + \frac{Z_1}{2Z_2} + \frac{Z_0}{Z_2}$$

→ For Δx

$$e^{\gamma \Delta x} = 1 + \frac{(R+j\omega L)\Delta x \times (G+j\omega C)\Delta x}{2} + \sqrt{\frac{R+j\omega L}{G+j\omega C}}(G+j\omega C)\Delta x$$

$$= 1 + \frac{(R+j\omega L)(G+j\omega C)(\Delta x)^2}{2} + \sqrt{(R+j\omega L)(G+j\omega C)}(\Delta x)$$

$$e^{\gamma \Delta x} = 1 + \sqrt{(R+j\omega L)(G+j\omega C)}\,\Delta x + (R+j\omega L)(G+j\omega C)(\Delta x)^2$$

Now $e^{x} = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots \infty$

$$e^{\gamma \Delta x} = 1 + \gamma \Delta x + \frac{(\gamma \Delta x)^2}{2!} + \boxed{\frac{(\gamma \Delta x)^3}{3!} + \dots \infty}$$

For $\Delta x \to 0$, high order terms can be neglected.

So $$e^{\gamma \Delta x} = 1 + \gamma \Delta x + \frac{(\gamma \Delta x)^2}{2!}$$

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

Also $$\gamma = \underset{\substack{\downarrow \\ \text{attenuation}}}{\alpha} + j\beta \to \text{phase constant}$$