Lecture No: 08

TRANSMISSION LINE MODELING

Long Line (contd.)

γ = Propagation constant of transmission line
$= (\alpha + j\beta)\ m^{-1}$

$$e^{\gamma l} = e^{\alpha l} \cdot e^{j\beta l} = e^{\alpha l} \angle \beta l$$

α = Attenuation constant of line

β = Phase constant of line

Now,

$$\cosh \gamma l = \frac{e^{\gamma l} + e^{-\gamma l}}{2} = \frac{1}{2}\left(e^{\alpha l} \angle \beta l + e^{-\alpha l} \angle -\beta l\right)$$

$$\sinh \gamma l = \frac{1}{2}\left(e^{\alpha l} \angle \beta l - e^{-\alpha l} \angle -\beta l\right)$$

In this way, if we know α & β, we can calculate $\sinh \gamma l$ & $\cosh \gamma l$. and therefore we can calculate V_s, I_s in terms of V_R, I_R.

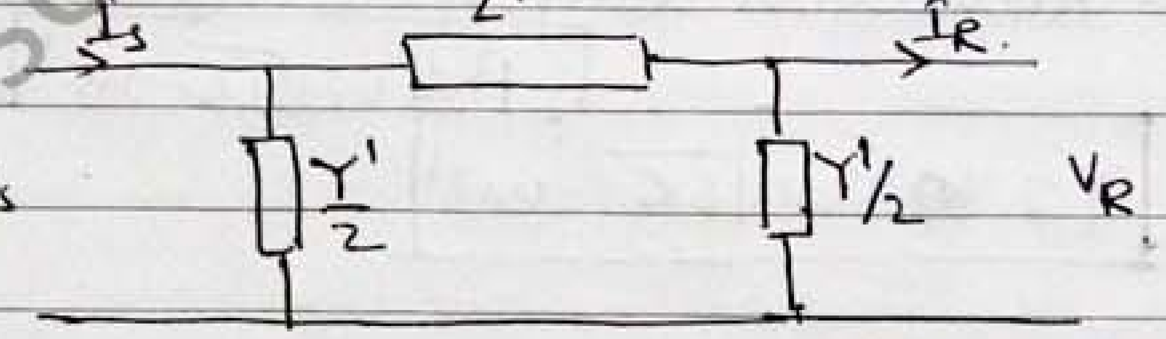
Now,

$$\cosh(\alpha l + j\beta l) = \cosh(\alpha l)\cos(\beta l) + j\sinh(\alpha l)\sin(\beta l)$$

$$\sinh(\alpha l + j\beta l) = \sinh(\alpha l)\cos(\beta l) + j\cosh(\alpha l)\sin(\beta l)$$

→

EQUIVALENT π-MODEL (Long Line)



Z' is the modified value of Z.
Y' is Modified value of Y.

$$A = D = 1 + \frac{Y'Z'}{2} \text{ per unit}$$

$$B = Z'\ \Omega$$

$$C = Y'\left(1 + \frac{Y'Z'}{4}\right) S.$$

$$Z' = Z_c \sinh(\gamma l) = Z l \frac{\sinh(\gamma l)}{\gamma l} = Z F_1 \quad \left\{ \because Z_c = \frac{Z}{\sqrt{ZY}} \right\}. \qquad Z = z \cdot l.$$

$$\frac{Y'}{2} = \frac{\tanh(\gamma l/2)}{Z_c} = \frac{Y}{2} \frac{\tanh(\gamma l/2)}{\gamma l/2} = \frac{Y}{2} F_2.$$

LOSSLESS LINE

→ A transmission line in which the series impedance consists of only inductance part (resistance is neglected) and shunt admittance consists of only capacitance part (conductance is neglected) is known as Lossless line.

→ In case of Lossless line,

$$Z = j\omega l \ \Omega/m.$$

$$Y = j\omega C \ S/m$$

$$Z_S = \sqrt{\frac{Z}{Y}} = \text{surge impedance of line}$$

For lossless line, charac. Imp. is called surge Impedance.

$$\boxed{Z_S = \sqrt{\frac{L}{C}} \ \Omega}$$ (Pure real number) or (Pure resistive in nature)

"But Z_C is a complex no."

Similarly,

$$\gamma = \sqrt{ZY} = j\omega\sqrt{LC} = j\beta \ m^{-1}$$

(Purely imaginary term)

Here Attenuation const. $\alpha = 0$ (for Lossless line)

$$\boxed{\beta = \omega\sqrt{LC} \ m^{-1}} = \text{Phase constant}.$$

$$\therefore \boxed{\gamma = j\omega\sqrt{LC} \ m^{-1}}$$

ABCD PARAMETER (lossless line)

$$A(x) = D(x) = \cosh(\gamma x) = \cosh(j\beta x) = \frac{e^{j\beta x} + e^{-j\beta x}}{2} = \cos\beta x$$

$$A(x) = D(x) = \cos\beta x \text{ per unit.}$$

$$B(x) = Z_C \sinh(\gamma x) = jZ_C \sin(\beta x) = j\sqrt{\frac{L}{C}} \sin(\beta x) \ \Omega$$

$$C(x) = \frac{\sinh(\gamma x)}{Z_C} = \frac{j\sin(\beta x)}{\sqrt{L/C}} \ S.$$

$$Z' = jZ_C \sin\beta l = jX' \ \Omega.$$

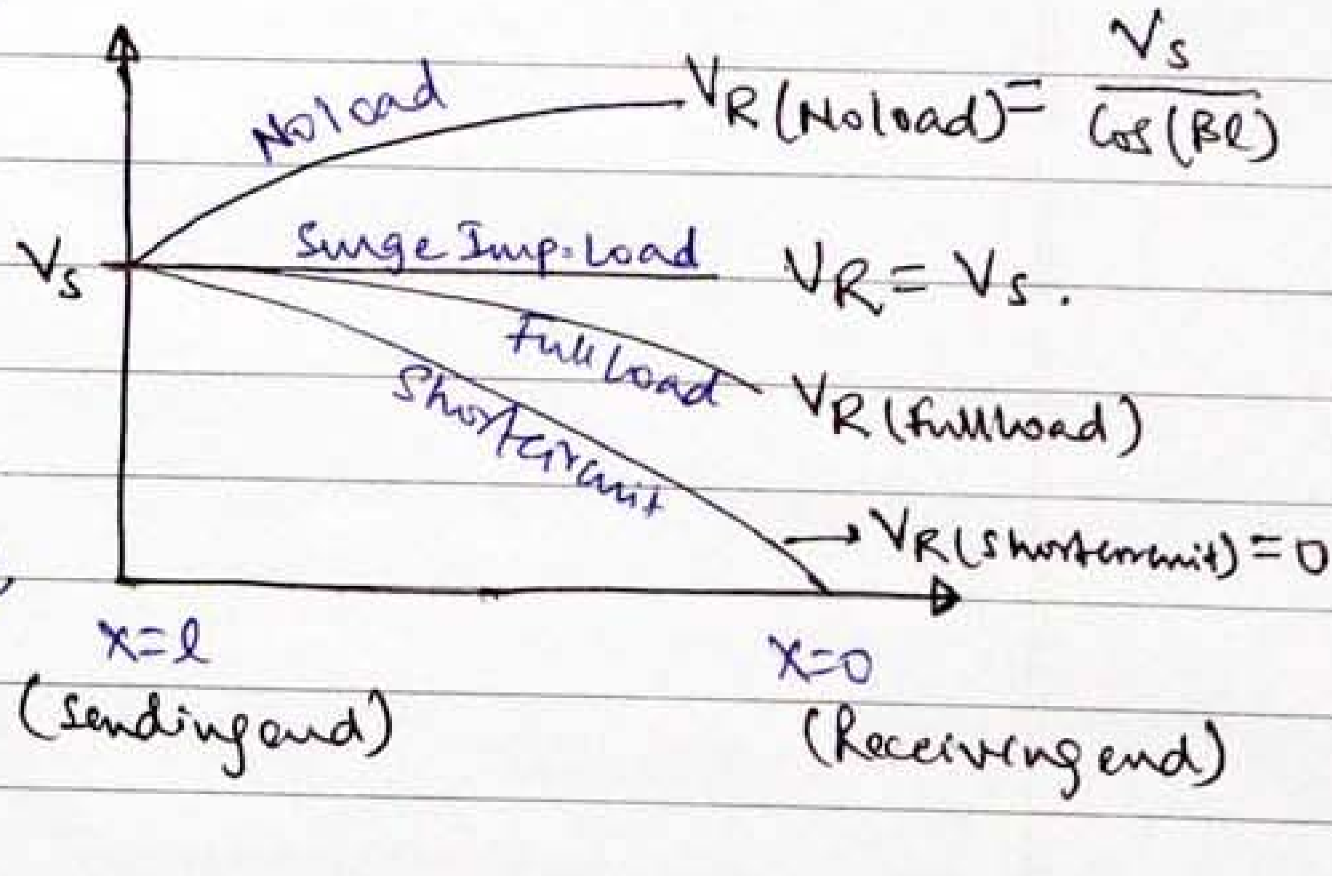
Now, If we talk in terms of power flowing in lossless line through surge impedance loading i.e.

$$S(x) = P(x) + jQ(x) = V(x)\, I^*(x)$$
$$= \left(e^{j\beta x} V_R\right)\left(e^{j\beta x}\frac{V_R}{Z_c}\right)^*$$
$$S(x) = \frac{|V_R|^2}{Z_c}$$

<u>Conclusion:</u> Real Power flow along the line is constant & reactive power flow is zero.

→ Since there is no losses in the T.L. so whatever power we are sending from sending end ~~we are r.~~ is being received at the receiving end & real power along the line is constant.

→ Also whatever reactive power losses takes place in T.L. bcoz of the series reactance of the line is being produced by the shunt capacitance of the line. so, ~~reactive~~ there is no any reactive power flow in the T.L..



For lossless line

<u>At No Load</u>, $I_R = 0$

$$V_{R(\text{No load})} = \frac{V_s}{\cos\beta l}$$

When surge Impedance Loading is done then

~~$V_{R(SIL)}$~~ $\boxed{V_R = V_s}$

When short circuited then

$$\boxed{V_R = 0}, \quad \& \quad V_{s(\text{short circuit})} = I_{R(SC)}\,(Z_c \sin\beta l)$$