Lec-16

Monday, February 24, 2020 8:44 AM

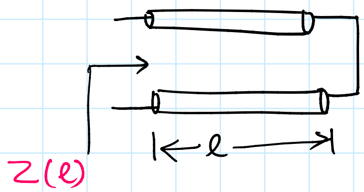
Example

$v_p = 2.07 \times 10^8 \, m/s$
Propagation Velocity

$Z_0 = 50\Omega$

- We want 15nH from a Tx line short circuited at the output
- We want this inductance @ 3GHz

Q: What is the length of the transmission line



$L_{in} = 15nH$ @ 3GHz

$$Z(l) = jZ_0 \tan(\beta l)$$

$$\beta = \frac{2\pi}{\lambda}$$

$$\cancel{j} \cdot 2\pi \times 3\times10^9 \times 15\times10^{-9} = \cancel{j} \cdot 50 \tan\left(\frac{2\pi}{\lambda} \cdot l\right)$$

$$\lambda = \frac{v_p}{f}$$

$$\frac{v_p}{f}\frac{1}{2\pi}\tan^{-1}\left(\frac{2\pi \times 3\times10^9 \times 15\times10^{-9}}{50}\right) = l$$

$$v_p = \lambda f$$

$$l = 1.53 \, cm$$

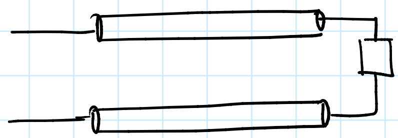
(b) If operating frequency changes to 4GHz

What is the impedance seen by 1.53cm (short circuitd) transmission line?

Case 4 VSWR on a Complex Load

1)


2)

$Z_L = R_L + jX_L$

X_L is >0 for inductance

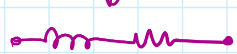
X_L is <0 for capacitance

$X_L = j\omega L$

$X_L = \dfrac{-j}{\omega C}$

$$\Gamma_L = \frac{R_L + jX_L - Z_0}{R_L + jX_L + Z_0} = \frac{R_L - Z_0 + jX_L}{R_L + Z_0 + jX_L}$$

$a + ib$ $\quad$ $a - ib$




1) Inductive + Resistive Load.

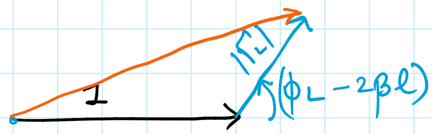
$$\Gamma_L = |\Gamma_L| e^{j\phi_L}$$

$$\frac{R_L - Z_0 + jX_L}{R_L + Z_0 + jX_L} = a + ib$$

$$\boxed{0 < \phi_L < \pi}$$

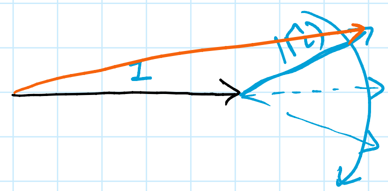
$$V(\ell) = V^{+} e^{j\beta\ell}\left(1 + \underbrace{|\Gamma_L| e^{j(\phi_L - 2\beta\ell)}}\right)$$

Phasor at $\ell = 0$
(at the load end)



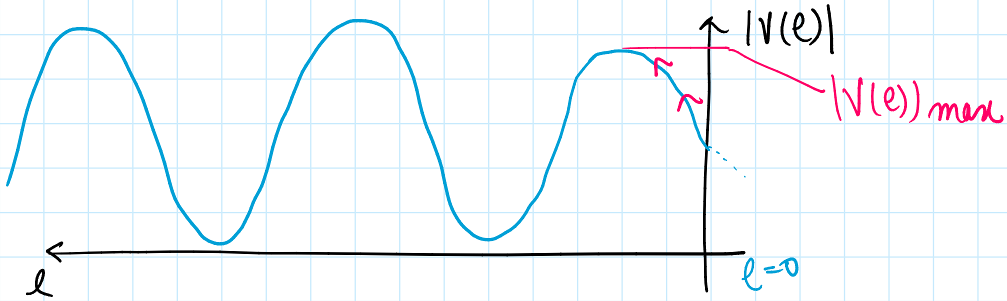
$(\beta\ell = 0)$

$\ell = 1\text{cm}$



Observation : • $|V(\ell)|$ increases as we go away from the load.

• $|V(\ell)|$ will FIRST get a maxima away from the load.



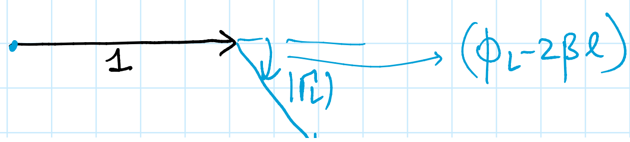
2) Capacitive + Resistive load.

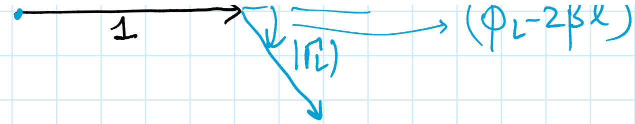
$$\Gamma_L = \frac{R_L - Z_0 + jX_L}{R_L + Z_0 + jX_L} = |\Gamma_L| e^{j\phi_L}$$

X_L: −ve

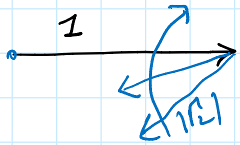
$-\pi < \phi_L < 0$

Phasor of $V(\ell)$ at $\ell = 0$



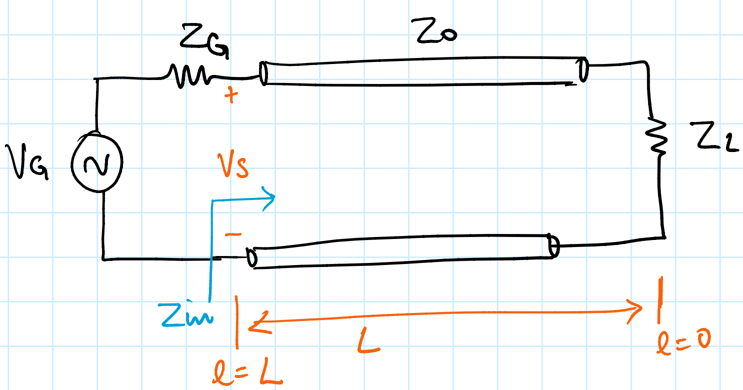


$\ell = 1$ cm



Observation : As we move away from the load $|V(\ell)|$ will FIRST hit a minima.

Derivation of V^+



$$V(\ell) = V^+ e^{j\beta\ell}\left(1 + |\Gamma_L| e^{j(\phi_L - 2\beta\ell)}\right)$$

$$V_S = V(\ell)\Big|_{\ell = L} = V^+ e^{j\beta L}\left(1 + |\Gamma_L| e^{j(\phi_L - 2\beta L)}\right) \quad \text{— (1)}$$

$$V_S = \left(\frac{Z_{in}}{Z_{in}+Z_G}\right) V_G \quad -(2) \qquad Z_{in} = Z(\ell)\Big|_{\ell=L}$$

$$\downarrow$$

$$\frac{V(\ell)}{I(\ell)}\Bigg|_{\ell=L}$$

$$Z_{in} = Z_0\left(\frac{e^{j\beta\ell} + \Gamma_L e^{-j\beta\ell}}{e^{j\beta\ell} - \Gamma_L e^{-j\beta\ell}}\right)$$

Equate (1) & (2)

$$\boxed{V^+ = \left(\frac{Z_{in}}{Z_{in}+Z_G}\right) V_G \frac{1}{e^{j\beta L}\left(1+|\Gamma_L| e^{j(\phi_L - 2\beta L)}\right)}}$$