$(2n-1)\frac{\pi}{2} < \beta l < n\pi$

$(2n-1)\frac{\lambda}{4} < l < \frac{n\lambda}{2}$ ← for this length it will act like a capacitor

for open circuited line.

$Z_{oc} = Z_0 \coth \gamma l.$

$Z_{oc} = -jZ_0 \cot \beta l.$

$(2n-1)\frac{\pi}{2} < \beta l < n\pi$

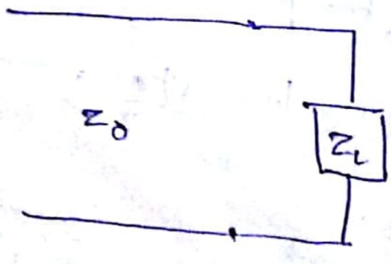
$(2n-1)\frac{\lambda}{4} < l < \frac{n\lambda}{2}$ ← Acts as inductor.

also;

$(n-1)\pi < \beta l < (2n-1)\pi/2$

$(n-1)\frac{\lambda}{2} < l < (2n-1)\frac{\lambda}{4}$ ← Acts like capacitor.

Q. The characteristic impedance of a transmission line working at 300 MHz is 50Ω and is connected to a load impedance of $(50+j50)\,\Omega$. Calculate reflection coefficient and VSWR.



$Z_0 = 50\,\Omega$

$Z_L = 50 + j50\,\Omega$

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0}$$

$$\Gamma_L = \frac{\cancel{50} + j50 - \cancel{50}}{50 + j50 + 50}$$

$$\Gamma_L = \frac{j50}{100 + j50}$$

$$= 0.2 + j0.4$$

$$= 0.45 \angle 63^\circ$$

$$VSWR = \frac{1 + |\Gamma|}{1 - |\Gamma|} = \frac{1 + 0.45}{1 - 0.45}$$

$$= \frac{1.45}{0.55} = 2.64$$

$$Z_{in} = Z_0 \left\{ \frac{Z_L + Z_0 \tanh \gamma l}{Z_0 + Z_L \tanh \gamma l} \right\}$$

$$Z_0 = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

$$\gamma = \alpha + j\beta = \sqrt{ZY} = \sqrt{(R + j\omega L)(G + j\omega C)}$$

$$v_p = \frac{\omega}{\beta}$$

$$\Gamma = \frac{V_{ref}}{V_{inc}} = \frac{Z_L - Z_0}{Z_L + Z_0}$$

$$VSWR = \frac{V_{max}}{V_{min}} = \frac{|V_1| + |V_2|}{|V_1| - |V_2|} = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

* Return loss $\rightarrow$ $R.L = -20 \log |\Gamma|$

for loss less lines

$(R=0 \; ; \; G=0)$

$$Z_{in} = Z_0 \left\{ \frac{Z_L + jZ_0 \tan \beta l}{Z_0 + jZ_L \tan \beta l} \right\}$$

$$Z_0 = \sqrt{\frac{L}{C}}$$

$$\gamma = j\omega\sqrt{LC} \; ; \; \alpha = 0 \; ; \; \beta = \omega\sqrt{LC}.$$

$$v_p = \frac{1}{\sqrt{LC}}$$

$$Z_{sc} = jZ_0 \tan\beta l \; ; \; Z_{oc} = -jZ_0 \cot\beta l.$$

Q. A $50\,\Omega$ lossless transmission line has a phase constant of 4 rad/m, at a frequency of 10 MHz. Calculate the inductance & capacitance of the line.

→. $\beta = 4\text{rad/m} \; ; \; Z_0 = 50\,\Omega$.

$f = 10\text{MHz} \quad \omega = 2\pi f = 20\pi \times 10^6 \text{ rad/s}$.

$\beta = \omega\sqrt{LC}$

$\Rightarrow \cancel{4} = \cancel{20}^{5}\pi \times 10^6 \sqrt{LC}$

$\Rightarrow LC = \left(\frac{1}{5\pi \times 10^6}\right)^2$

$\Rightarrow 2500C^2 = \left(\frac{1}{5\pi \times 10^6}\right)^2$

$\Rightarrow 50C = \frac{1}{5\pi \times 10^6}$

$C = 1.27\,nF$

$Z_0 = \sqrt{\frac{L}{C}}$

$\Rightarrow 50 = \sqrt{\frac{L}{C}}$

$\Rightarrow 2500 = \frac{L}{C}$

$\Rightarrow L = 2500C.$

$L = 3.2\,\mu H$

Q. A lossless transmission line has a series inductor of 0.4 mH/km and capacitance of 0.2 μF/ calculate characteristic impedance & phase velocity.

$\Rightarrow$ $Z_0 \sqrt{\frac{L}{C}} = \sqrt{\frac{0.4 \times 10^{-3}}{0.2 \times 10^{-9}}} = \sqrt{2 \times 10^{6}}$

$= 1.414 \times 10\ \Omega$

$$V_p = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{0.4 \times 10^{-3} \times 10^{-3} \times 0.2 \times 10^{-12}}}$$

$$= \frac{1}{\sqrt{0.08 \times 10^{-18}}}$$

$$= \frac{1}{\sqrt{8 \times 10^{-20}}}$$

$$= \frac{10^{10}}{2.82}$$

$$= 0.35 \times 10^{10}\ m/sec.$$

Q. A 30Ω transmission lossless t.L is connected to a load impedance of $(30+j30)\Omega$ what is the input impedance of the transmission line at a point $\lambda/8$ away from the load.

$\rightarrow$ $Z_0 = 30\ \Omega$; $Z_L = 30+30j\ \Omega$

$$Z_{in} = Z_0 \left\{ \frac{Z_L + jZ_0 \tan \beta l}{Z_0 + jZ_L \tan \beta l} \right\}$$

$$= Z_0 \left\{ \frac{Z_L + jZ_0 \tan\left(\frac{2\pi}{\cancel{\lambda}} \cdot \frac{\cancel{\lambda}}{8}\right)}{Z_0 + jZ_L \tan\left(\frac{2\pi}{\cancel{\lambda}} \cdot \frac{\cancel{\lambda}}{8}\right)} \right\}$$

$$= Z_0 \left(\frac{Z_L + jZ_0}{Z_0 + jZ_L} \right) = \cancel{30} \left\{ \frac{30 + j60}{\cancel{30}j} \right\}$$

$= (60 - j30)\ \Omega.$

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Q. The s.c & o.c impedances of T.L are $80\angle -20°$ and $20\angle -30°$ respectively. Determine the characteristic impedance of transmission.

$$Z_{sc} = 80\angle -20° \;;\; Z_{oc} = 20\angle -30.$$

$$Z_{sc} \cdot Z_{oc} = Z_0^2$$

$$\Rightarrow 1600\angle -50° = Z_0^2$$

$$\Rightarrow Z_0 = 40\angle -25° \;\Omega.$$

Q. A 40Ω ~~to~~ T.L is terminated with a load impedance of $j25\Omega$ and the line is operating at 150MHz. Calculate the input impedance of the line at a distance of 50 cm away from the load. (lossless).

→

$$Z_0 = 40\Omega \;;\; Z_L = j25\,\Omega.$$

$$f = 150\,MHz \Rightarrow \omega = 300\pi \times 10^6 \text{ rad/sec.}$$

$$l = 50\,cm = 0.05\,m. \qquad \lambda = \frac{c}{f} = \frac{3\times10^8}{150\times10^6} = 2m$$

$$= \lambda/4$$

$$Z_{in} = Z_0 \left\{ \frac{Z_L + Z_0 \tan \beta l}{Z_0 + Z_L \tan \beta l} \right\}$$

$$= 40 \left\{ \frac{j25 + Z_0 \tan\left(\frac{2\pi}{\lambda}\cdot\frac{\lambda}{4}\right)}{40 + j25 \tan\left(\frac{2\pi}{\lambda}\cdot\frac{\lambda}{4}\right)} \right\}$$

$$= \cancel{40 \left\{ \frac{40^2}{j20} \right\} = -80}$$

$$= 40 \times \frac{40}{j25}$$

$$= \frac{1600}{\ldots} = -64j\,\Omega.$$

Q. A purely resistive load $Z_0 = 60\,\Omega$. minimum & maximum voltages on T.L are $6\,\mu V$ and $9\,\mu V$ determine the load impedance

$V_{max} = 9\,\mu V$

~~9~~ $V_{min} = 6\,\mu V$

$$VSWR = \frac{9}{6} = 1.5.$$

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$$

$$\Rightarrow 1.5\,(1-|\Gamma|) = 1+|\Gamma|$$

$$\Rightarrow 1.5 - 1.5|\Gamma| = 1+|\Gamma|$$

$$\Rightarrow 2.5|\Gamma| = 0.5$$

$$|\Gamma| = 0.2.$$

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$$

$$\Rightarrow 0.2 = \frac{Z_L - 60}{Z_L + 60}$$

$$\Rightarrow 0.2 Z_L + 12 = Z_L - 60$$

$$\Rightarrow 0.8 Z_L = 72$$

$$Z_L = 90\,\Omega.$$

Q. A distortionless line has $Z_0 = 70\Omega$; $\alpha = 15$ mNeper/ and ~~phe~~ $v_p = 0.5 \times c$. Find the primary ~~of~~ constants of transmission line.

→

$$Z_0 = 70 \Rightarrow \sqrt{\frac{L}{C}} = 70 \Rightarrow \frac{L}{C} = 4900.$$

$$\alpha = 15 \text{ mNeper/m} \Rightarrow R\sqrt{\frac{C}{L}} = 15.$$

$$\Rightarrow R^2 \cdot \frac{C}{L} = 15$$

$$v_p = 0.5 \times c$$

$$\Rightarrow R^2 = 15 \times 4900$$

$$\Rightarrow \frac{1}{\sqrt{LC}} = 0.5 \times 3 \times 10^8$$

$$\Rightarrow R = \cancel{70}\sqrt{\frac{15}{70}}\ \Omega = 1.05\ \Omega$$

$$= \cancel{271.1}\ \Omega = \cancel{0.0053}\ \Omega$$

$$\Rightarrow \frac{1}{LC} = 2.25 \times 10^{16}$$

$$\Rightarrow LC = 0.44 \times 10^{-16}.$$

$$L = 4900 \times 95.2 \times 10^{-12}$$

$$= 0.46\ \mu H/m.$$

$$\Rightarrow 4900 C^2 = 0.44 \times 10^{-16}$$

$$C^2 = 9.07 \times 10^{-21} = 90.7 \times 10^{-22},\ C = 9.52 \times 10^{-11}$$

$$= 95.2\ pF/m$$

Q The attenth. of a 50 Ω distortionless line is 0.01 dB/m. Th line has a capacitance of 0.1 pF/m.

i) Find primary constants.

ii) Find velocity of propagation

iii) Determine %. to which the amplitude the travelling wave decreases in 1 km & 5 km

→ i)

$Z_0 = 50.$ $\alpha = 0.01\ dB/m.$

$= 1.152 \times 10^{-3}\ Np/m.$

$C = 0.1\ pF/m.$

$\alpha = R\sqrt{\frac{C}{L}}$ $Z_0 = \sqrt{\frac{L}{C}}$

$\Rightarrow (1.152 \times 10^{-3})^2 = R^2 . \frac{0.1 \times 10^{-12}}{2.5 \times 10^{-10}}$ $\Rightarrow (50)^2 = \frac{L}{0.1 \times 10^{-12}}$

$\Rightarrow L = 2500 \times 0.1 \times 10^{-12}$

$\Rightarrow 1.327 \times 10^{-6} = R^2 \times \frac{10^{-3}}{2.5}$ $= 0.25\ nH$

$\Rightarrow R^2 = \sqrt{1.327 \times 2.5 \times 10^{-3}}$

$= \sqrt{3.3175 \times 10^{-3}}$

$= 0.57 \times 10^{-1}\ \Omega$

$= 0.057\ \Omega.$

$v_p = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{0.025 \times 10^{-9} \times 0.1 \times 10^{-12}}}$

$= \frac{1}{\sqrt{25 \times 10^{-24}}}$

$= \cancel{0.2 \times 10^{11}}\ 0.2 \times 10^{12}$

$= 2 \times 10^{11}$

iii)

$$\cancel{\frac{R}{L}} = \cancel{\frac{G}{C}}$$

$\Rightarrow \cancel{G} =$

We have,

for amplitude $\longrightarrow V_1 e^{-\gamma l}$

where $\gamma = (\alpha + j\beta)$

α Amplitude, β phase.

$\therefore \quad V_1 e^{-\alpha l}$.

αl

for 1 Km :— $\alpha l = 1.152 \times \cancel{10^{-3}} \times \cancel{1000}$

$= 1.152$

$\therefore \quad V_1 e^{-\alpha l} = 0.316 V_1$

% age decrease $= \dfrac{V_1 - V_1 e^{-\alpha l}}{V_1} \times 100$

$= \dfrac{0.684 \cancel{V_1}}{\cancel{V_1}} \times 100$

$= 68.4\%$.

for 5 Km :— $\alpha l = 5.76$

$\therefore \quad V_1 e^{-\alpha l} = 3.15 \times 10^{-3} V_1$

% age decrease $= \dfrac{V_1 - V_1 e^{-\alpha l}}{V_1} \times 100$

$= \cancel{99.68}\ \dfrac{0.9968 \cancel{V_1}}{\cancel{V_1}} \times 100$

$= 99.68\%$.

Q. Calculate the maximum and minimum impedances from a transmission line and their locations for $Z_L = 100$ and $Z_0 = 50$.

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{50}{150} = 1/3.$$

$$Z_{max} = Z_0\,(VSWR)$$

$$= Z_0 \cdot \left\{ \frac{1+|\Gamma|}{1-|\Gamma|} \right\}$$

$$= 50 \left\{ \frac{1+1/3}{1-1/3} \right\}$$

$$= 50 \cdot \frac{\cancel{4}\,2}{\cancel{2}} = 100.$$

$$Z_{min} = \frac{Z_0}{VSWR} = \frac{50}{2} = 25.$$