Group assignment

TL and Waveguides

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Assignment

a). Standing wave ratio(SWR) and the reflection coefficient

$$S = \frac{V_{max}}{V_{min}} = \frac{I_{max}}{I_{min}} = \frac{1+T_L}{1-T_L}$$

$$I_{max} = \frac{V_{max}}{Z_0}$$

$$I_{min} = \frac{V_{min}}{Z_0}$$

The voltage reflection coefficient at any point on the line is the ratio of the magnitude of the reflected voltage to that of the incident voltage waves. That is;

$$T(z) = \frac{V_0^- e^\gamma z}{V_0^+ e - \gamma z} = \frac{V_0^- e^2 \gamma z}{V_0^T}$$

But, $Z = l - l^1$

$$T(z) = \frac{V_0^- e^2 \gamma l e^- 2\gamma l}{V_0^+} = T_L e^- 2\gamma l$$

The current reflection coefficient at any point on the line is negative of the voltage reflection coefficient at that point. Thsat is,

$$\frac{I_0^- e^\gamma l}{I_0^+ e^- \gamma l} = -T_L$$

b). Short circuit, open circuit and matched line characteristics

For short circuit, $Z_L = 0$,

$$Z_{sc} = Z_{in} for Z_L = 0$$

$$Z_{sc} = jZ_0 tan\beta l$$

Transmission coefficient=-1, s=infinity

For open circuit,

$$Z_{os} = -jZ_0 cot\beta l$$

For matched line,

$Z_{in} = Z_0$

Transmission coefficient=0, s=1

c). Transmission lines impedance matching(including the quarter wave transformers)

Quarter wave transformer matching

Z_0 cannot be equal to Z_L as the load is mismatched and a reflected wave exists. Maximum power transfer cannot take place

We recall that,

$l = \frac{\lambda}{4} or \beta l = \frac{2\pi}{\lambda} x \frac{\lambda}{4} = \frac{\pi}{2}$

$Z_{in} = Z_0 \frac{Z_L + jZ_0 tan\frac{\pi}{2}}{Z_0 + jZ_L tan\frac{\pi}{2}} = \frac{Z_0^2}{Z_L}$

that is,

$\frac{Z_{in}}{Z_0} = \frac{Z_0}{Z_L}$

or, $Z_{in} = \frac{1}{Z_L}, y_{in} = Z_L$

thus by adding a $\frac{\lambda}{4}$ line on our smith chart, we obtain the input admittance corresponding to a given load impedance.

$Z_0 = \sqrt{Z_0 Z_L}$

The main disadvantage of the quarter wave transformer is that it is a narrow band or frequency sensitive device.

Single stub turner(Matching)

It eliminates the major drawback of using a quarter wave transformer.

$Z_0 = Z_{in} = 1$

First, we draw the locus $y = 1 + jb(r = 1 circle)$ on the smith chart. If a shunt stub of admittance $y_s = -jb$ is introduced at A, then, $y_{in} = 1 + jb + y_s = 1 + jb - jb = 1 + j0$

1. A 100Ω transmission line is connected to a load consisting of 50ohm resistors in series with a 10pF capacitor. Find the reflection coefficient at the load for a 100mHz signal

Reflection coefficient, $T_L = \frac{Z_L - Z_0}{Z_L + Z0}$

$T_L = \frac{50 - j1590 - 100}{50 - j159 + 100}$

$= 0.76\angle -60.70$

Find the impedance at the input end of the transmission line if its length is 0.125 $Z_{in} = Z_0 \frac{Z_L + jZ_0 tan\beta l}{Z_0 + jZ_L tan\beta l}$

$\beta(l) = \frac{2\pi}{\lambda} 1.25\lambda$

$= \frac{\pi}{4}$

$Z_{in} = 100 \frac{50 - j159 + j100}{100 + j150 - j159}$

$Z_{in} = 29.32\angle -60.65\Omega$

2. A lossless transmission line with $Z_0 = 50\Omega$ and $d = 1.5m$ connects a voltage source to a terminal load of $Z_L = (50 + j50)ohm$. If $V_g = 60V$, operating frequency f=100mHz, and $Z_g = 50\Omega$ and assuming that the speed of the wave along the transmission line equalt to the speed of light, C, find the distance of the first voltage maximum from the load.

$\lambda = \frac{c}{f} = \frac{3 * 10^8}{10^8} = 3m$

$T_L = \frac{Z_L - Z_0}{Z_L = Z_0}$

$T_L = \frac{50 + j50 - 50}{50 + j50 + 50} = 0.45\angle 1.11 radians$

$l_m = \frac{\theta_L \lambda}{4\pi} + \frac{n\lambda}{2}$

when n=0,

$l_m = \frac{1.11}{4\pi}\lambda = 0.09\lambda$

$l_m = 0.09 * 3 = 0.27$ (from one load)

What is the power delivered to the load P_L?

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

$\beta = \frac{2\pi}{3}$

$l = 1.5$

$Z_{in} = 50 + j50\Omega$

$I_{in} = \frac{V_g}{Z_g + Z_{in}} = \frac{6}{50+50+j50} = 0.536656\angle{-26.56}$

$P_L = P_{in} = 0.5 * 0.536656^2 * 50 = 7.2W$

3. A 40m long transmission line has $V_g = 15\angle 0 V_{rms}$, $Z_0 = 30 + j60\Omega$, and $V_L = 5\angle{-48} V_{rms}$. If the lin eis matched to the load, calculate: The input impedance Z_{in}

Hints: $Z_0 = 30 + j60\Omega, b).0.112\angle{-63.43}A, 7.5\angle 0 V_{rms}, c).0.0101 + j0.2094$

$Z_{in} = 30 + j60$

The sending end current and voltage

$V_{in} = \frac{Z_{in} V_g}{Z_{in} + Z_0} = \frac{V_g}{2} as Z_{in} = Z_0$

$V_{in} = 7.5\angle 0 V_{rms}$

$I_{in} = \frac{V_g}{2Z_0} = \frac{15\angle 0}{2(30+j60)}$

$I_{in} = 0.112\angle{-63.43}$

The propagation constant, γ

$e^{\alpha} l e^{j} \beta l = 1.5\angle 48$

$e^{-} \gamma l = \frac{V_0^+}{V_L} = \frac{7.5\angle 0}{5\angle{-48}} = 1.5\angle 48$

$ln[e^{\alpha} l e^{j} \beta l] = ln[1.5\angle 48]$

$\alpha l + j\beta l = ln[1.5\angle 48$

$\alpha + j\beta = \frac{ln[1.5\angle 48]}{l}$

$\alpha = \frac{ln1.5}{40} = 0.0101 N_p/m$

$\beta = \frac{pi}{150} = 0.02094 rad/m$

$\gamma = \alpha + j\beta = 0.0101 + j0.02094/m$