Sistemas de microondas Lista exercicios I

Parametros S

4.9 A two-port network is driven at both ports such that the port voltages and currents have the following values ($Z_0 = 50\,\Omega$):

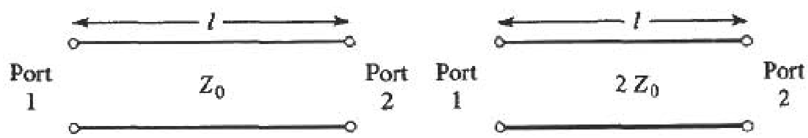
$$V_1 = 20\angle 0^\circ \qquad I_1 = 0.4\angle 90^\circ$$
$$V_2 = 4\angle -90^\circ \qquad I_2 = 0.08\angle 0^\circ$$

Determine the input impedance seen at each port, and find the incident and reflected voltages at each port.

Respostas: Zin(1)=50 ang(90°) Zin(2)=50 ang(-90°)

$V1^+$=14.1 ang(45°) $V1^-$=14.1 ang(-45°) $V2^+$=2.82 ang(-45°) $V2^-$=2.82 ang(-135°)

4.10 Derive the scattering matrix for each of the lossless transmission lines shown below, relative to a system impedance of Z_0. Verify that each matrix is unitary.



(a) S22=S11=0 S21=S12=exp(-jβl)

(b) S11=s22=-1/3 s21=s12=(8/3)*(exp(-jβl))/(3-0.333* exp(-2jβl))

4.11 Consider two two-port networks with individual scattering matrices, $[S^A]$ and $[S^B]$. Show that the overall S_{21} parameter of the cascade of these networks is given by

$$S_{21} = \frac{S_{21}^A S_{21}^B}{1 - S_{22}^A S_{11}^B}$$

4.12 Consider a lossless two-port network. (a) If the network is reciprocal, show that $|S_{21}|^2 = 1 - |S_{11}|^2$. (b) If the network is nonreciprocal, show that it is impossible to have unidirectional transmission, where $S_{12} = 0$ and $S_{21} \neq 0$.

4.15 A certain three-port network is lossless and reciprocal, and has $S_{13} = S_{23}$ and $S_{11} = S_{22}$. Show that if port 2 is terminated with a matched load, then port 1 can be matched by placing an appropriate reactance at port 3.

4.16 A four-port network has the scattering matrix shown below.

(a) Is this network lossless?
(b) Is this network reciprocal?
(c) What is the return loss at port 1 when all other ports are terminated with matched loads?
(d) What is the insertion loss and phase delay between ports 2 and 4, when all other ports are terminated with matched loads?

$$[S] = \begin{bmatrix} 0.1\angle 90^\circ & 0.8\angle -45^\circ & 0.3\angle -45^\circ & 0 \\ 0.8\angle -45^\circ & 0 & 0 & 0.4\angle 45^\circ \\ 0.3\angle -45^\circ & 0 & 0 & 0.6\angle -45^\circ \\ 0 & 0.4\angle 45^\circ & 0.6\angle -45^\circ & 0 \end{bmatrix}.$$

(e) What is the reflection coefficient seen at port 1 if a short circuit is placed at the terminal plane of port 3, and all other ports are terminated with matched loads?

Respostas: (a) Tem perdas (b) nao reciproca (c) portas 2,3 4 casadas RL=20dB (d) IL=8dB fase 45°

4.17 A four-port network has the scattering matrix shown below. If ports 3 and 4 are connected with a lossless matched transmission line with an electrical length of 60°, find the resulting insertion loss and phase delay between ports 1 and 2.

$$[S] = \begin{bmatrix} 0.3\angle -30^\circ & 0 & 0 & 0.8\angle 0 \\ 0 & 0.7\angle -30^\circ & 0.7\angle -45^\circ & 0 \\ 0 & 0.7\angle -45^\circ & 0.7\angle -30^\circ & 0 \\ 0.8\angle 0 & 0 & 0 & 0.3\angle -30^\circ \end{bmatrix}.$$

Respostas: IL=6.7dB fase 105°

Exemplo 3.17

(a) Calculate the s-parameters for the two-port network shown in Figure 3.34 for the case where $Z_0 = 50\ \Omega$.

(b) Find the return loss at the input with $Z_L = Z_0$.

(c) Determine the insertion loss for the network when the generator and the termination are both 50 Ω.

Given: Network of Figure 3.34 with $Z_0 = Z_L$.
Required: (a) s-parameters, (b) return loss, (c) insertion loss.

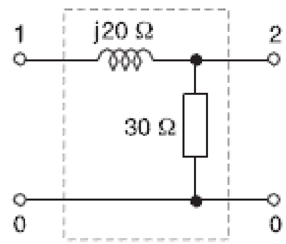


Fig. 3.34 Complex network

Respostas: s11=0.518 ang(131.16°) s22=0.442 ang(172.8°) s21=s12=0.524 ang(-16.22°)

Perda retorno =5.713dB Fwd Pwr Gain= -5.61dB

Example 3.18

A 50 Ω microwave integrated circuit (MIC) amplifier has the following s-parameters:

$$s_{11} = 0.12 \angle -10^\circ \qquad s_{12} = 0.002 \angle -78^\circ$$
$$s_{21} = 9.8 \angle 160^\circ \qquad s_{22} = 0.01 \angle -15^\circ$$

Calculate: (a) input VSWR, (b) return loss, (c) forward insertion power gain and (d) reverse insertion power loss.

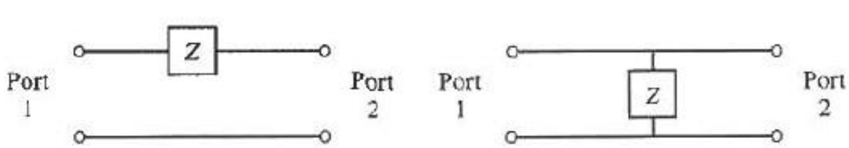
Given: $s_{11} = 0.12 \angle -10^\circ \qquad s_{12} = 0.002 \angle -78^\circ$
$s_{21} = 9.8 \angle 160^\circ \qquad s_{22} = 0.01 \angle -15^\circ$

Required: (a) Input VSWR, (b) return loss, (c) forward insertion power gain, (d) reverse insertion power loss.

Respostas: (a) VSWR = (1+0.12)/(1-0.12) (b) RL=18.42d (c) FWD Gain=19.83dB (d) REV Gain = -53.98dB

Dica: Use a descrição da topologia usando parâmetros ABCD, depois converta usando a tabela para par. S.

4.28 Find the S parameters for the series and shunt loads shown below. Show that $S_{12} = 1 - S_{11}$ for the series case, and that $S_{12} = 1 + S_{11}$ for the shunt case. Assume a characteristic impedance Z_0.

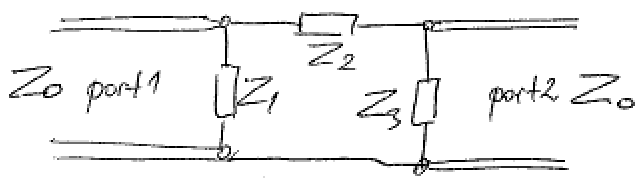


Respostas: S11= $Z/(2Z_o+Z)$ S12= $2Z_o\ /(2Z_o+Z)$ series

S11= $-Z_o/(Z_o+2Z)$ S12= $2Z\ /(Z_o+2Z)$ shunt

(5) (Homework)

Express the scattering matrix of the Π-network below in terms of its elements Z_1, Z_2, and Z_3.



Respostas: S11= Z_{in}-Z_0/ Z_{in}+Z_0

Z_{in}=(Z1 (ZoZ2+ Z3Z2+ ZoZ3)) / (Z_0Z_1+ Z_3Z_1+ Z_0Z_2+ Z_2Z_3+ Z_0Z_3)

S21=(1+S11) (Z0//Z3) / ((Z0//Z3) + Z2)

Lista Linhas transmissao

3.14 Derive the $\bar{E}$ and $\bar{H}$ fields of a coaxial line from the expression for the potential given in (3.153). Also find expressions for the voltage and current on the line and the characteristic impedance.

Respostas:

$E(\rho,\phi,z) = V_o \exp(-j\beta z) / (\rho \ln(b/a))$ na direcao ρ

$H(\rho,\phi,z) = V_o \exp(-j\beta z) / (\eta\rho \ln(b/a))$ na direcao ϕ

$Vab = V_o \exp(-j\beta z)$

$Ia = 2\pi V_o \exp(-j\beta z) / (\eta \ln(b/a))$

$Z_o = \eta \ln(b/a) / 2\pi$

3.19 Design a stripline transmission line for a 70 Ω characteristic impedance. The ground plane separation is 0.316 cm, and the dielectric constant of the filling material is 2.20. What is the guide wavelength on this transmission line if the frequency is 3.0 GHz?

Respostas:w=0.147cm e lambda_guiado=6.74cm

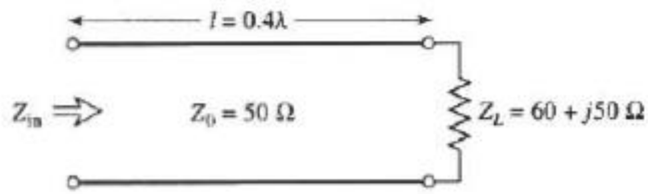
3.20 Design a microstrip transmission line for a 100 Ω characteristic impedance. The substrate thickness is 0.158 cm, with $\epsilon_r = 2.20$. What is the guide wavelength on this transmission line if the frequency is 4.0 GHz?

3.21 A 100 Ω microstrip line is printed on a substrate of thickness 0.0762 cm, with a dielectric constant of 2.2. Ignoring losses and fringing fields, find the shortest length of this line that appears at its input as a capacitor of 5 pF at 2.5 GHz. Repeat for an inductance of 5 nH. Using a microwave CAD package with a physical model for the microstrip line, compute the actual input impedance seen when losses are included (assume copper conductors and $\tan\delta = 0.001$).

Obs. Problema 3.21, deem uma olhada tambem no 2.21 (copia aqui para comodidade).

2.19 Use the Smith chart to find the following quantities for the transmission line circuit below:

(a) The SWR on the line.
(b) The reflection coefficient at the load.
(c) The load admittance.
(d) The input impedance of the line.
(e) The distance from the load to the first voltage minimum.
(f) The distance from the load to the first voltage maximum.



2.20 Repeat problem 2.19 for $Z_L = 40 - j30\ \Omega$.

2.21 Repeat problem 2.19 for $\ell = 1.8\lambda$.

Respostas 3.20 w=0.142cm lambdaGuiado=5.656cm epsEff=1.758

Respostas 3.21 β=3986.7 °/m l=3.2132cm

3.22 A microwave antenna feed network operating at 5 GHz requires a 50 Ω printed transmission line that is 16λ long. Possible choices are (1) copper microstrip, with $d = 0.16$ cm, $\epsilon_r = 2.20$, and $\tan\delta = 0.001$, or (2) copper stripline, with $b = 0.32$ cm, $\epsilon_r = 2.20$, $t = 0.01$ mm, and $\tan\delta = 0.001$. Which line should be used, if attenuation is to be minimized?

Respostas: Total Loss microlinha =0.82dB

Total Loss Stripline = 0.91dB

3.28 As discussed in the Point of Interest on the power handling capacity of transmission lines, the maximum power capacity of a coaxial line is limited by voltage breakdown, and is given by

$$P_{max} = \frac{\pi a^2 E_d^2}{\eta_0} \ln \frac{b}{a}$$

where E_d is the field strength at breakdown. Find the value of b/a that maximizes the maximum power capacity and show that the corresponding characteristic impedance is about 30 Ω.

Respostas: Zo=30 Ohms

3.A Deseja-se elaborar um sistema para medida de eps_r. Para tanto, compute (a)qual a espessura para termos 50 Ohms e (b) qual o comprimento para termos 90 graus- ou lambda/4 – na frequencia de 2GHz. O substrato é PCB comum, FR4, com eps_r=4.6 e espessura de 40mils.

Respostas: x=2cm

3B. Deseja-se, a partir de um tubo de cobre de 15cm de diâmetro, montar um cabo rígido coaxial de alta potência para broadcast. Calcule:

(a) o diâmetro do tubo interno para obter 50 Ohms.
(b) Qual a máxima potência possível de ser transmitida antes de haver um rompimento do dielétrico do ar (centelhamento).
(c) Obtenha o valor e onde ocorrerá a máxima voltagem no centelhamento.
(d) Para a frequência de 1KHz, qual seria a espessura mínima que teríamos que especificar a parede dos tubos? Pense em termos de *skin depth effect* (efeito pelicular).

Respostas: (a) 6.52cm (b) 28MW (c) 35.4kV (d) δ=2mm interessante manter aprox. 3δ de espessura

3Ca. Um cabo coaxial transmite DC? Como voce faria uma conexão de uma bateria num cabo coaxial para transporte de corrente contínua?

3Cb. Repita a questão anterior para o guia de onda. Justifique.

3Cc. Um técnico pergunta por que ele ligou o multímetro, escala de resistências, em um cabo coaxial em aberto (vermelho no inner e preto na malha) e não observou 50 Ohms. Como você explicaria a ele em termos simples?
3D. Deseja-se substituir um sistema *lumped* (com componente, ou concentrada) com um indutor de 5nH, na frequência de 1GHz. (a)Aponte qual a estrutura que será usada (stub curto ou aberto?), desenhando o final e com a dimensão da microlinha de 50 Ohms usada (espessura e comprimento). Use o substrato usado no exercício 3A. (b) Qual seria o inconveniente, baseado na sua resposta, dessa montagem distribuída em relação a concentrada? (c) O que seria possível de prever, em função da disciplina EMC, do uso da solução distribuída? Respostas: stub em curto; w=1.87mm epsEff=3.45 comprimento l=0.82m