Curs 14

Seminar 2

Filtre – Problema 1

- Proiectaţi un filtru trece sus cu elemente concentrate cu frecventa de taiere 1GHz, un echiriplu de 3 dB, cu atenuare mai mare de 40dB la 0.6GHz care sa lucreze pe impedante rezistive de 50Ω.

$$n \geq \frac{ch^{-1}\left(\sqrt{\left\{\left[\left(10^{0,1L_{As}}\right)-1\right]/\left[\left(10^{0,1L_{Ar}}\right)-1\right]\right\}}\right)}{ch^{-1}\left(\omega'_s/\omega'_1\right)}$$

Filtre prototip de tip echi-riplu cu terminații rezistive

0.5 dB Ripple

N	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9	g_{10}	g_{11}
1	0.6986	1.0000									
2	1.4029	0.7071	1.9841								
3	1.5963	1.0967	1.5963	1.0000							
4	1.6703	1.1926	2.3661	0.8419	1.9841						
5	1.7058	1.2296	2.5408	1.2296	1.7058	1.0000					
6	1.7254	1.2479	2.6064	1.3137	2.4758	0.8696	1.9841				
7	1.7372	1.2583	2.6381	1.3444	2.6381	1.2583	1.7372	1.000			
8	1.7451	1.2647	2.6564	1.3590	2.6964	1.3389	2.5093	0.8796	1.9841		
9	1.7504	1.2690	2.6678	1.3673	2.7239	1.3673	2.6678	1.2690	1.7504	1.0000	
10	1.7543	1.2721	2.6754	1.3725	2.7392	1.3806	2.7231	1.3485	2.5239	0.8842	1.9841

Filtre prototip de tip echi-riplu cu terminații rezistive

$$g_1 = \frac{2a_1}{\gamma}$$

$$g_k = \frac{4a_{k-1}a_k}{b_{k-1}g_{k-1}}, k = 2,3,\ldots,n$$

$$g_{n+1} = \begin{cases} 1 \quad pentru \;\; n = impar \\ \coth^2\left(\frac{\beta}{4}\right) \quad pentru \;\; n = par \end{cases}$$

$$a_k = \sin\left[\frac{(2k-1)\pi}{2n}\right], k = 1,2,\ldots,n$$

$$b_k = \gamma^2 + \sin^2\left(\frac{k\pi}{n}\right), k = 1,2,\ldots,n$$

$$\beta = \ln\left(\coth\frac{L_{Ar}}{17,37}\right)$$

$$\gamma = \sinh\left(\frac{\beta}{2n}\right)$$

Scalarea in impedanta si frecventa, FTS

Scalarea in impedanta

$$L' = R_0 L$$

$$C' = \frac{C}{R_0}$$

$$R'_s = R_0$$

$$R'_L = R_0 R_L$$

Scalarea in frecventa

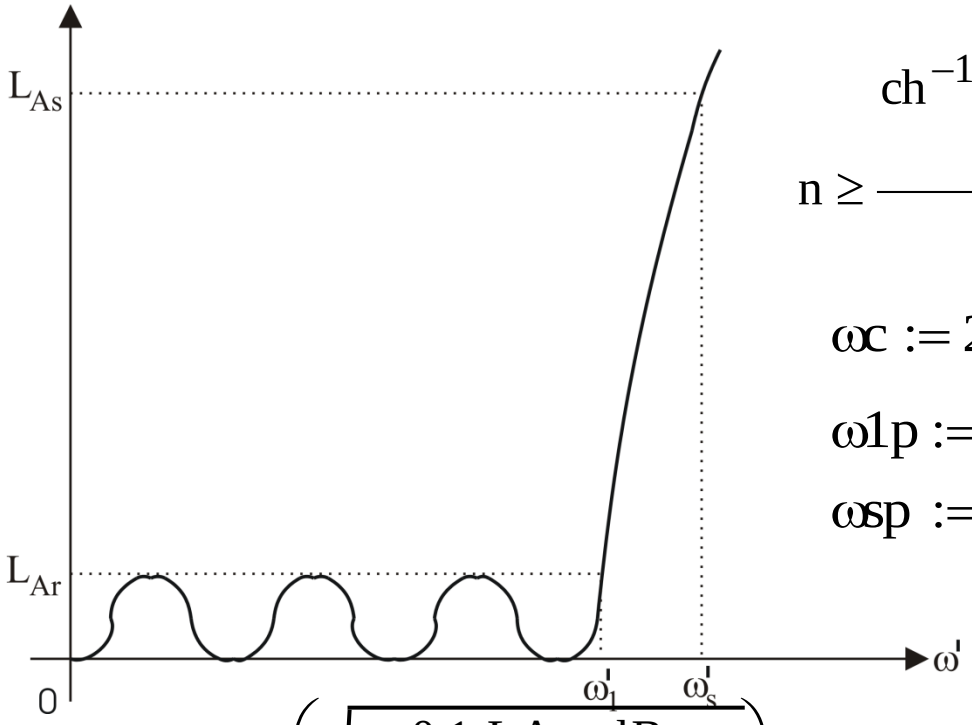
$$\omega \leftarrow -\frac{\omega_c}{\omega}$$

Valorile noi

$$C'_k = \frac{1}{R_0 \omega_c L_k}$$

$$L'_k = \frac{R_0}{\omega_c C_k}$$

Calculul ordinului filtrului echi-riplu



$$n \geq \frac{ch^{-1}\left(\sqrt{\left\{\left[\left(10^{0,1L_{As}}\right)-1\right]/\left[\left(10^{0,1L_{Ar}}\right)-1\right]\right\}}\right)}{ch^{-1}\left(\omega'_s/\omega'_1\right)}$$

$\omega c := 2\cdot\pi\cdot 1GHz$ $\quad \omega p(\omega) := \frac{\omega c}{\omega}$

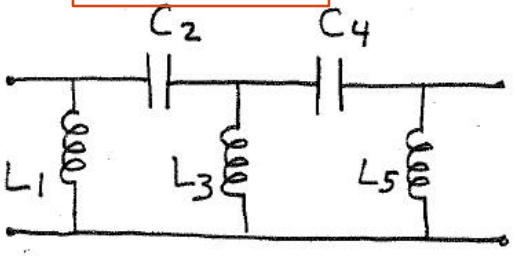
$\omega 1p := \omega p(\omega c)$ $\quad \omega 1p = 1$

$\omega sp := \omega p(2\cdot\pi\cdot 0.6GHz)$ $\quad \omega sp = 1.667$

$LAs\_dB := 40$ $\quad LAr\_dB := 3$

$$n := \frac{\operatorname{acosh}\left(\sqrt{\frac{10^{0.1\cdot LAs\_dB}-1}{10^{0.1\cdot LAr\_dB}-1}}\right)}{\operatorname{acosh}\left(\frac{\omega sp}{\omega 1p}\right)}$$

$n = 4.825$ $\quad n := 5$



Rezolvare Mathcad

$$\beta := \ln\left(\coth\left(\frac{LAr\_dB}{17.37}\right)\right) \qquad \beta = 1.766 \qquad \gamma := \sinh\left(\frac{\beta}{2\cdot n}\right) \qquad \gamma = 0.178$$

$$a(k) := \sin\left(\frac{2k-1}{2\cdot n}\cdot\pi\right) \qquad b(k) := \gamma^2 + \sin\left(\frac{k\cdot\pi}{n}\right)^2$$

$$g := \left| \begin{array}{l} g_1 \leftarrow 2\cdot\dfrac{a(1)}{\gamma} \\ \text{for } k \in 2..n \\ \quad g_k \leftarrow \dfrac{4\cdot a(k-1)\cdot a(k)}{b(k-1)\cdot g_{k-1}} \\ g \end{array} \right. \qquad g = \begin{pmatrix} 0 \\ 3.481 \\ 0.762 \\ 4.538 \\ 0.762 \\ 3.481 \end{pmatrix}$$

$$L1 := \frac{R0}{\omega c\cdot g_1} \qquad L1 = 2.286\times 10^{-9}\ H$$

$$C2 := \frac{1}{R0\cdot\omega c\cdot g_2} \qquad C2 = 4.178\times 10^{-12}\ F$$

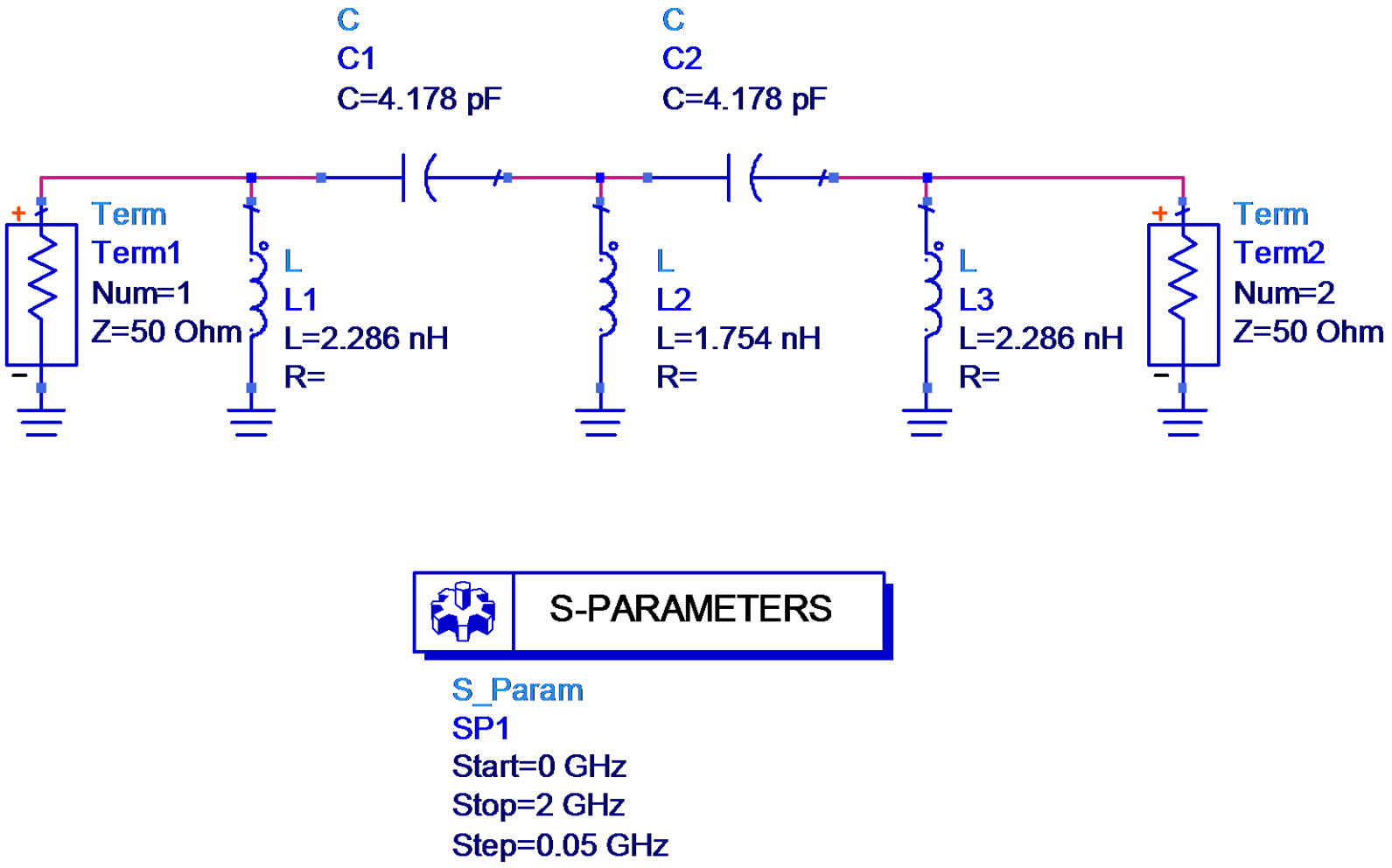
$$L3 := \frac{R0}{\omega c\cdot g_3} \qquad L3 = 1.754\times 10^{-9}\ H$$

$$C4 := \frac{1}{R0\cdot\omega c\cdot g_4} \qquad C4 = 4.178\times 10^{-12}\ F$$

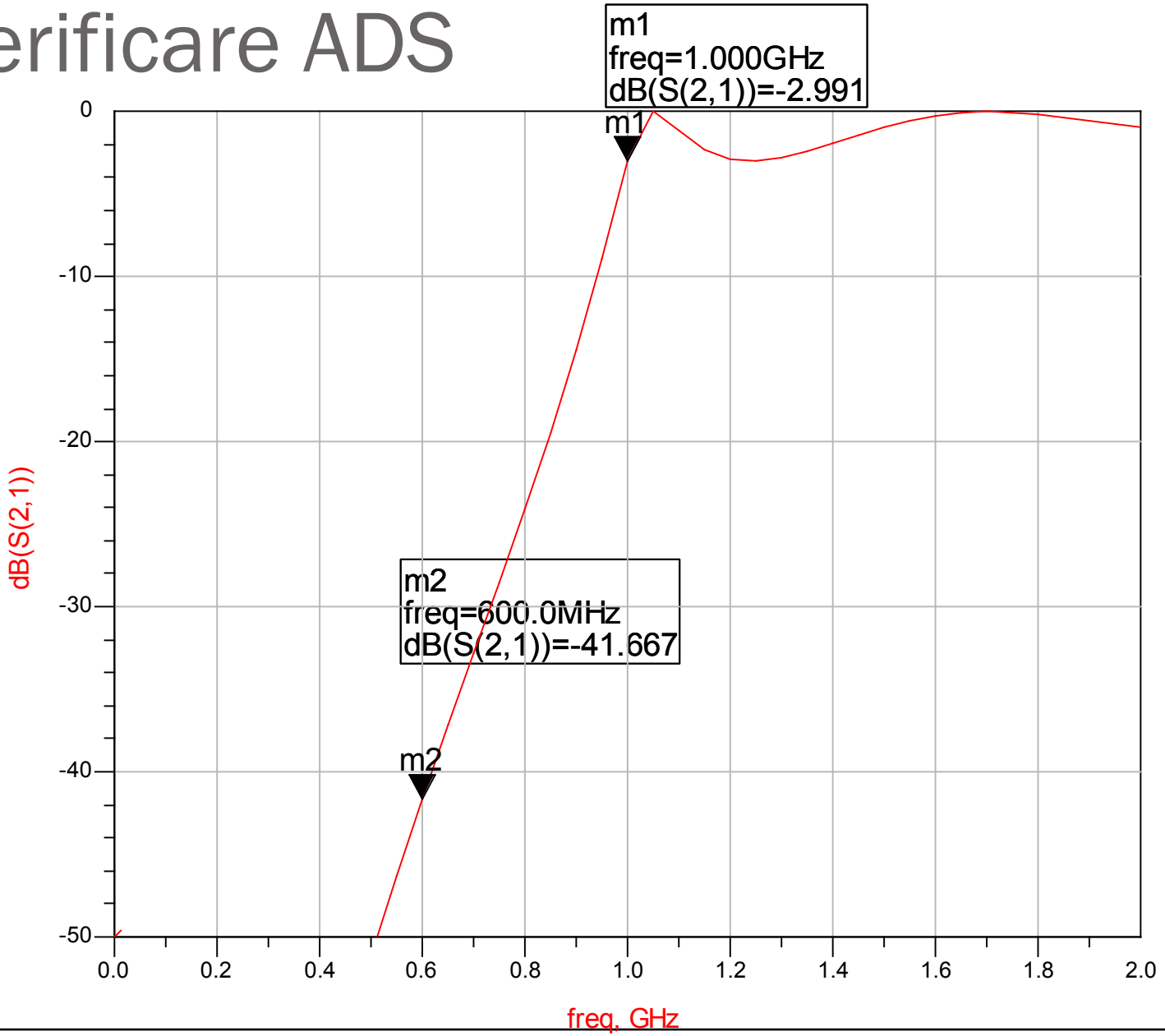
$$R0 := 50\Omega$$

$$L5 := \frac{R0}{\omega c\cdot g_5} \qquad L5 = 2.286\times 10^{-9}\ H$$

Verificare ADS



Verificare ADS



Filtre – Problema 2

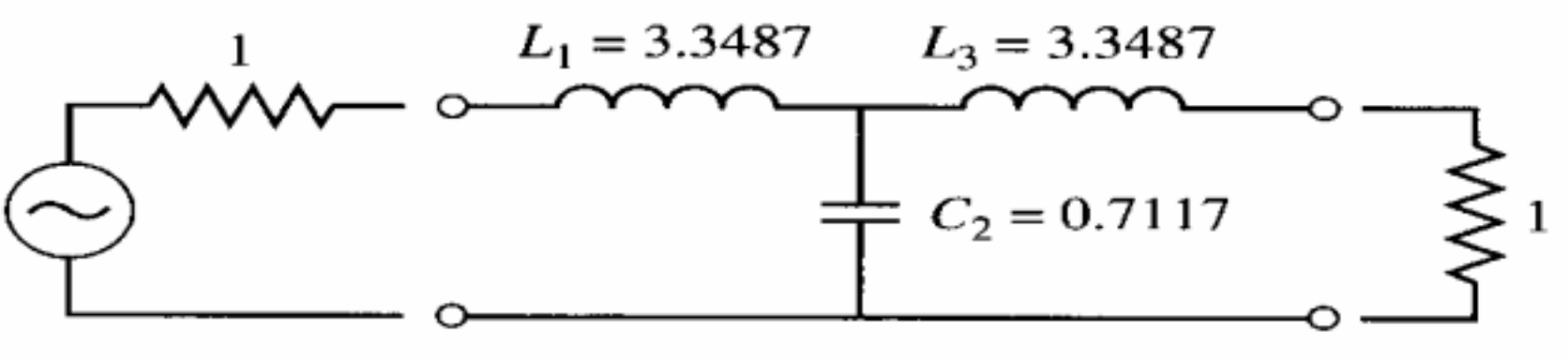
- Să se proiecteze un filtru trece-jos de tip maxim plat în tehnologie microstrip. Specificaţiile sunt: frecvenţa de tăiere 6 GHz, ordinul 3, impedanţa de 50 Ω.

EXEMPLU - Curs 9

- Să se proiecteze un filtru trece-jos în tehnologie microstrip. Specificaţiile sunt: frecvenţa de tăiere 4 GHz, ordinul 3, impedanţa de 50 Ω, şi o caracteristică echi-riplu de 3 dB.

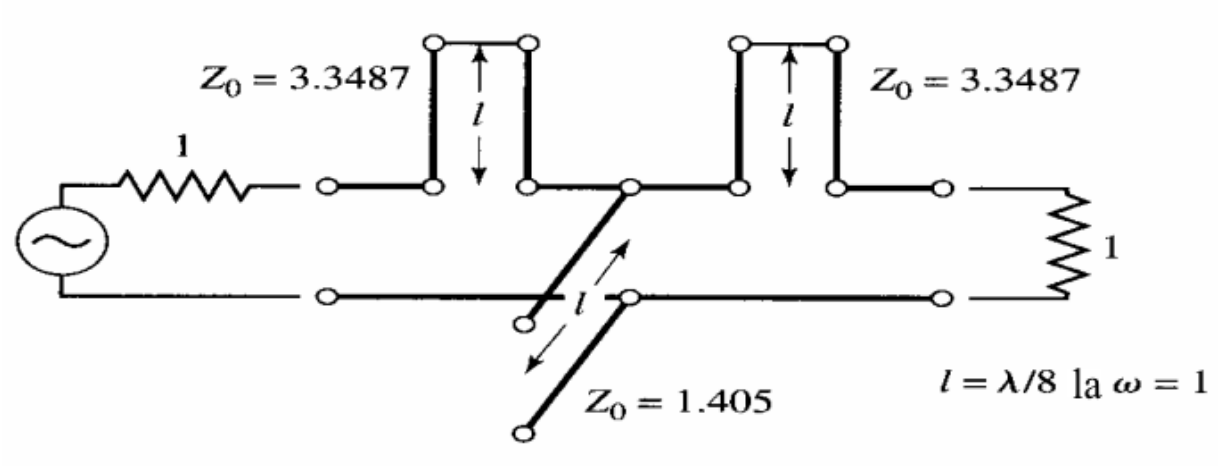
Solutie

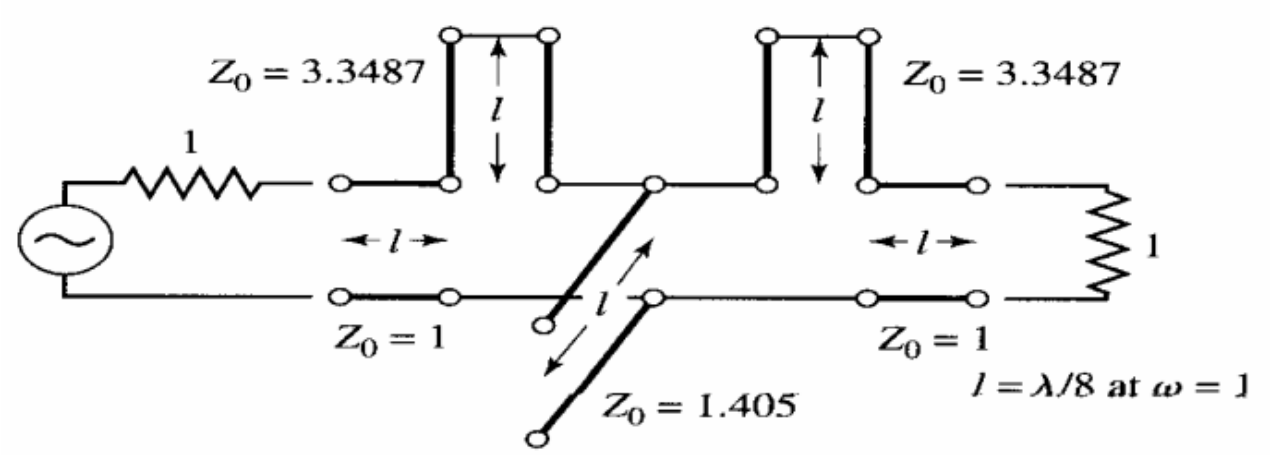
$$g_1 = 3.3487 = L_1$$
$$g_2 = 0.7117 = C_2$$
$$g_3 = 3.3487 = L_3$$
$$g_4 = 1.0000 = R_L$$



Solutie - 2

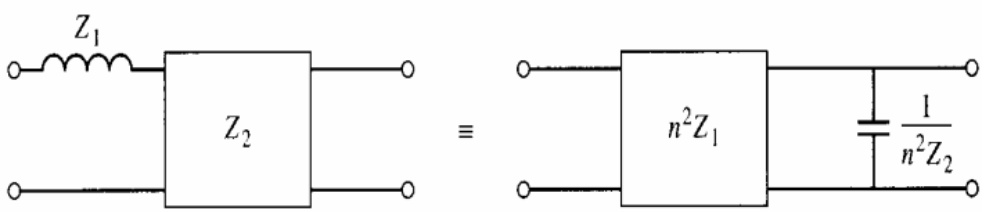
$$Z_{L1} = L_1 \qquad z_{C2} = \frac{1}{C_2} \qquad Z_{L3} = L_3$$

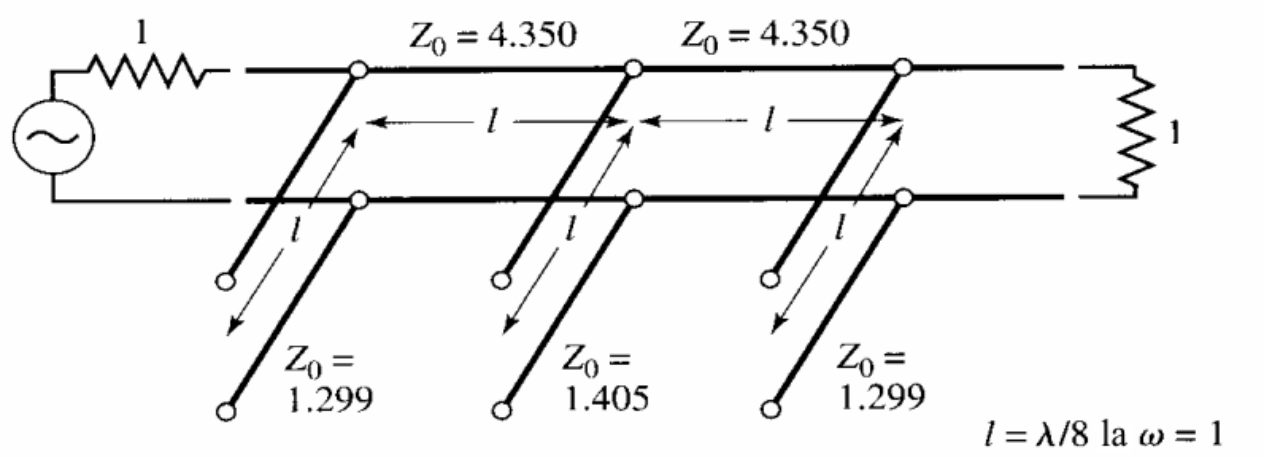




Solutie - 3

$$n = \sqrt{1 + \frac{R_L}{Z_{L1}}} \qquad n^2 = 1.299$$

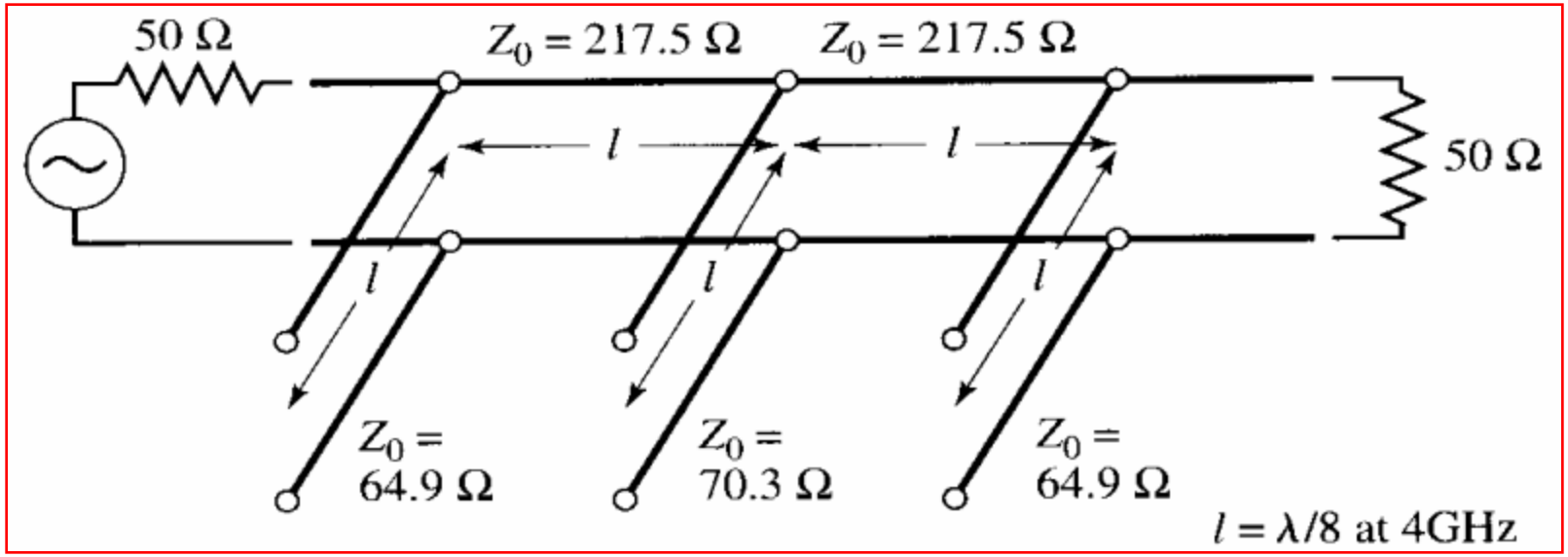




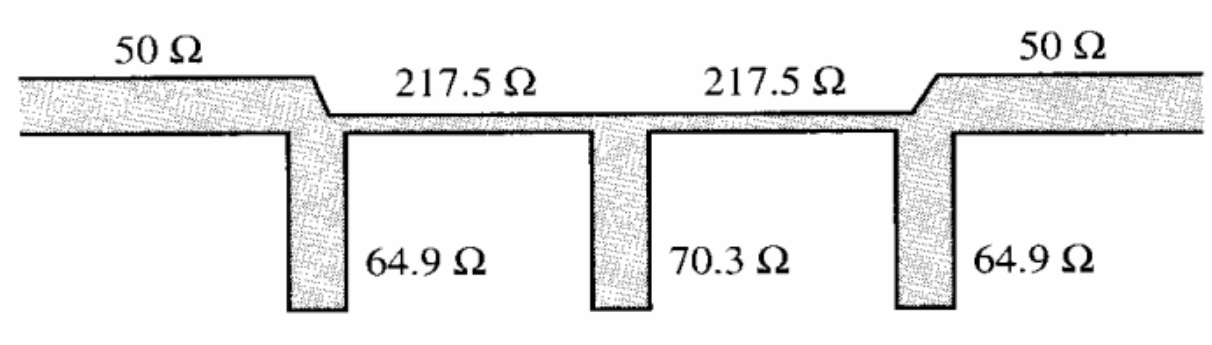
Solutie - 4

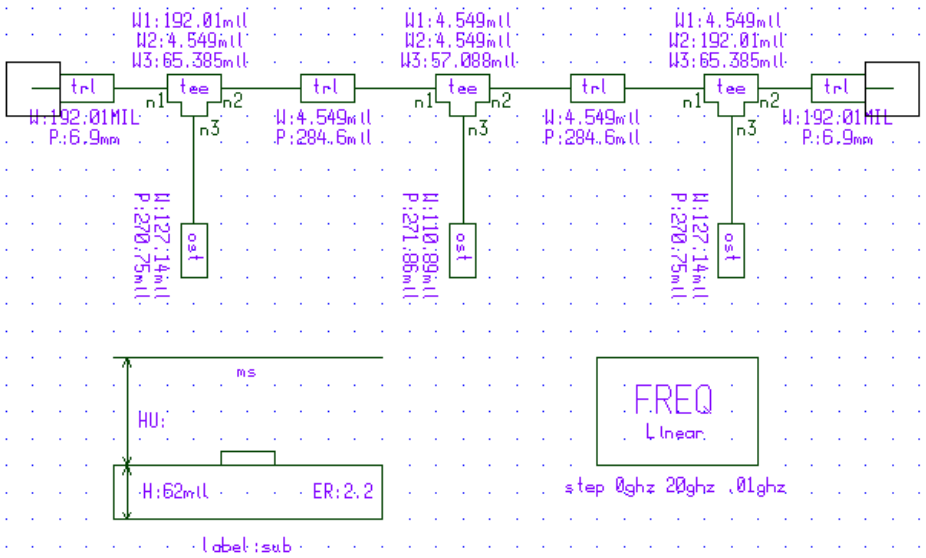
$$Z_{sh1} = n^2 Z_0 = 64.93\Omega \qquad Z_{sh2} = Z_{C2} \cdot Z_0 = 70.254\Omega \qquad Z_{sh3} = n^2 Z_0 = 64.93\Omega$$

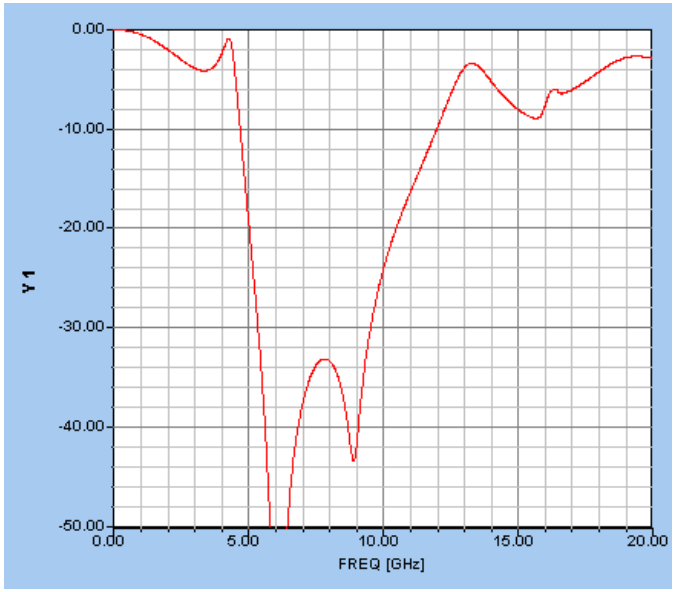
$$Z_{se1} = n^2 \cdot Z_{L1} \cdot Z_0 = 217.435\Omega \qquad Z_{se2} = n^2 \cdot Z_{L3} \cdot Z_0 = 217.435\Omega$$



Solutie – Filtrul realizat microstrip si simulat

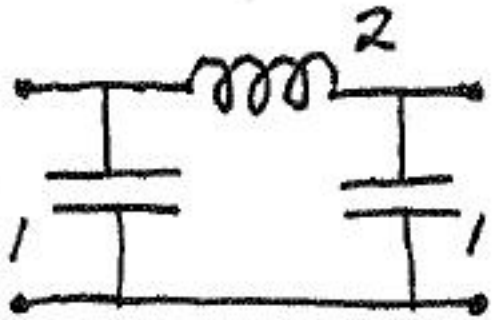


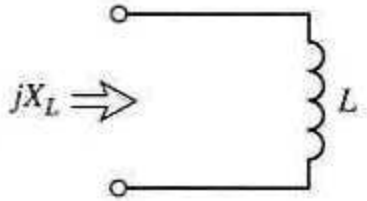


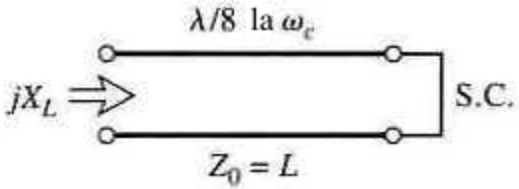


Rezolvare

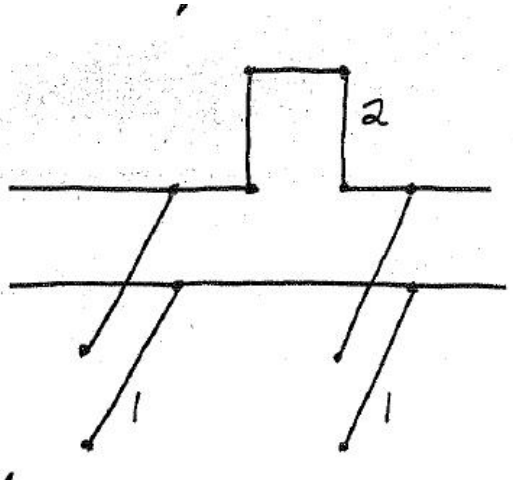
- Filtru prototip

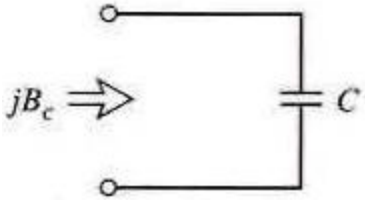


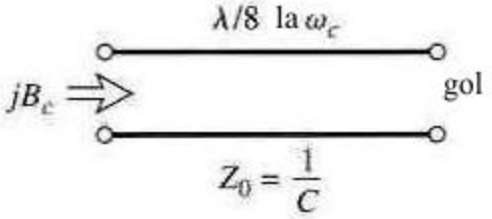




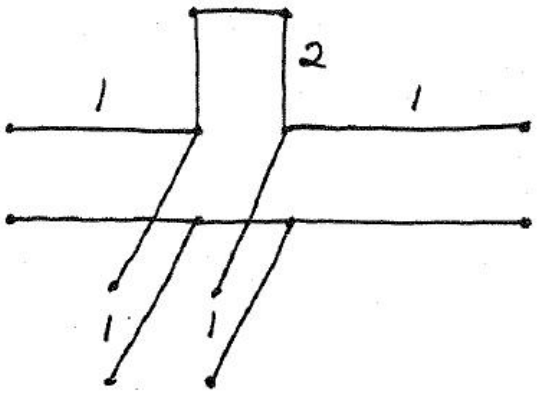
- Transformarea Richard



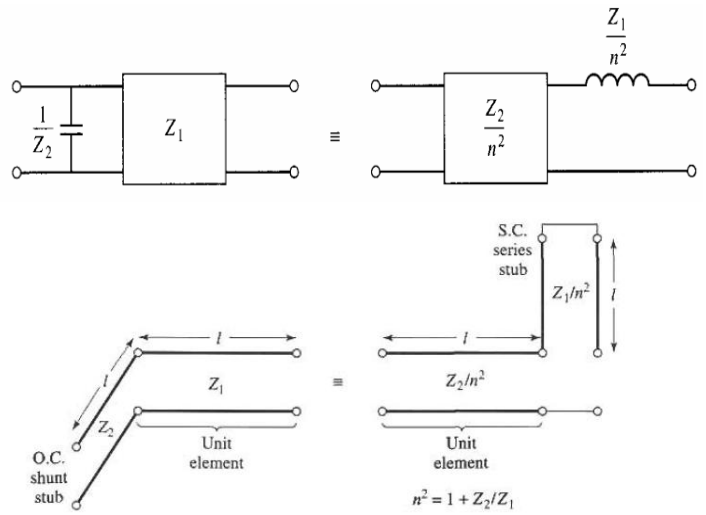




- Adaugarea elementelor unitate la capete



- Identitatile Kuroda (de 2 ori)

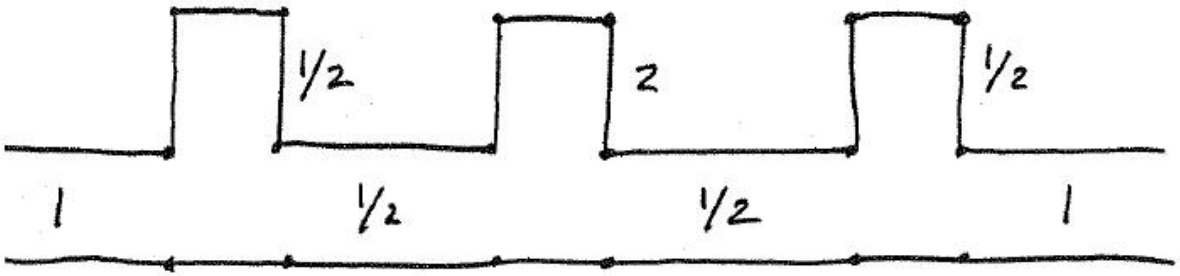


$Z_1 = 1$

$Z_2 = 1$

$n^2 = 1 + \frac{Z_2}{Z_1}$

$= 2$



- Scalare la 50Ω