Use MWI program to design a microstrip implementation of the stepped-impedance low-pass filter designed in 8.16a on Rogers RO4003C with 1 oz. copper and 0.06" board thickness. [Hint: Use 'Dk values for characteristic impedance' option.] a) Find width w_{15}, phase velocity v_{15}, wavelength λ_{15}, and length of 15 Ω sections. b) Find width w_{120}, phase velocity v_{120}, wavelength λ_{120}, and length of 120 Ω sections. c) Find width w_{50}, phase velocity v_{50}, and wavelength λ_{50} for 50 Ω microstrip. d) Draw a fully-labeled top view sketch of design with 50 Ω microstrip traces (indefinite length) at input and output. For legibility, the sketch may be scaled.

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8.16 Design a stepped-impedance low-pass filter having a cutoff frequency of 3 GHz and a fifth-order 0.5 dB equal-ripple response. Assume $R_0 = 50\ \Omega$, $Z_\ell = 15\ \Omega$, and $Z_h = 120\ \Omega$. (a) Find the required electrical lengths of the five sections, and

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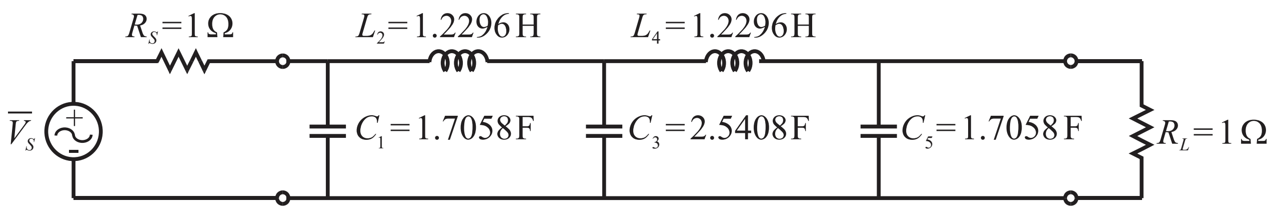
- For the filter architecture of Fig 8.25a, we have



- Using the immittances, given Z_0, Z_l & Z_h, and equations (8.86a) & (8.86b), the electrical lengths are:

For $C_1 = C_5 = 1.7058$ F $\Rightarrow$

$$\beta l_1 = \beta l_5 = \frac{CZ_l}{R_0} = \frac{g_1 Z_l}{R_0} = \frac{1.7058(15)}{50} \Rightarrow \underline{\beta l_1 = \beta l_5 = 0.51174 \text{ rad} = 29.32^\circ}$$

For $L_2 = L_4 = 1.2296$ H $\Rightarrow$

$$\beta l_2 = \beta l_4 = \frac{L R_0}{Z_h} = \frac{g_2 R_0}{Z_h} = \frac{1.2296(50)}{120} \Rightarrow \underline{\beta l_2 = \beta l_4 = 0.5123 \text{ rad} = 29.35^\circ}$$

For $C_3 = 2.5408$ F $\Rightarrow$

$$\beta l_3 = \frac{C Z_l}{R_0} = \frac{g_3 Z_l}{R_0} = \frac{2.5408(15)}{50} \Rightarrow \underline{\beta l_3 = 0.76224 \text{ rad} = 43.67^\circ}$$

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a) Find width w_{15}, phase velocity v_{15}, wavelength λ_{15}, and length of 15 Ω sections.

For $Z_\ell = 15\ \Omega$, MWI gives:

$\Rightarrow$ **$\underline{w_{15} = 17.18 \text{ mm}}$,**

with a phase velocity $\Rightarrow$ **$\underline{v_{15} = 1.65 \times 10^8 \text{ m/s}}$.**

So, the wavelength is $\lambda_\ell = \lambda_{15} = \dfrac{v_p}{f} = \dfrac{1.65\times10^8}{3\times10^9}$ $\Rightarrow$ **$\underline{\lambda_{15} = 55.0 \text{ mm}}$.**

The length for the capacitive sections C_1 and C_5 are:

$$\ell_1 = \ell_5 = \frac{\beta\ell_1}{\beta} = \frac{\beta\ell_1}{2\pi/\lambda_{15}} = \frac{\beta\ell_1(\lambda_{15})}{2\pi} = \frac{0.51174(55.4)}{2\pi} \quad \Rightarrow \quad \underline{\mathbf{\ell_1 = \ell_5 = 4.51\ mm}}.$$

The length for the capacitive section C_3 is:

$$\ell_3 = \frac{\beta\ell_3}{\beta} = \frac{\beta\ell_3}{2\pi/\lambda_{15}} = \frac{\beta\ell_3(\lambda_{15})}{2\pi} = \frac{0.76224(55.4)}{2\pi} \quad \Rightarrow \quad \underline{\mathbf{\ell_3 = 6.72\ mm}}.$$

b) Find width w_{120}, phase velocity v_{120}, wavelength λ_{120}, and length of 120 Ω sections.

For Z_h = 120 Ω, MWI gives:

$\Rightarrow$ $\underline{\mathbf{w_{120} = 0.517\ mm}}$,

with a phase velocity $\Rightarrow$ $\underline{\mathbf{v_{120} = 1.876 \times 10^8\ m/s}}$.

So, the wavelength is $\lambda_h = \lambda_{120} = \frac{v_p}{f} = \frac{1.876\times10^8}{3\times10^9}$ $\Rightarrow$ $\underline{\mathbf{\lambda_{120} = 62.533\ mm}}$.

The lengths for the inductive sections L_2 and L_4 are:

$$\ell_2 = \ell_4 = \frac{\beta\ell_2}{\beta} = \frac{\beta\ell_2}{2\pi/\lambda_{120}} = \frac{\beta\ell_2(\lambda_{120})}{2\pi} = \frac{0.5123(62.533)}{2\pi} \quad \Rightarrow \quad \underline{\mathbf{\ell_2 = \ell_4 = 5.099\ mm}}.$$

c) Find width w_{50}, phase velocity v_{50}, and wavelength λ_{50} for 50 Ω microstrip.

For Z_0 = 50 Ω, MWI gives:

$\Rightarrow$ $\underline{\mathbf{w_{50} = 3.454\ mm}}$,

with a phase velocity $\Rightarrow$ $\underline{\mathbf{v_{50} = 1.786 \times 10^8\ m/s}}$.

So, the wavelength is $\lambda_{50} = \frac{v_p}{f} = \frac{1.786\times10^8}{3\times10^9}$ $\Rightarrow$ $\underline{\mathbf{\lambda_{50} = 59.533\ mm}}$.

- The resulting **stepped-impedance lowpass** filter circuit (150% of original) is: