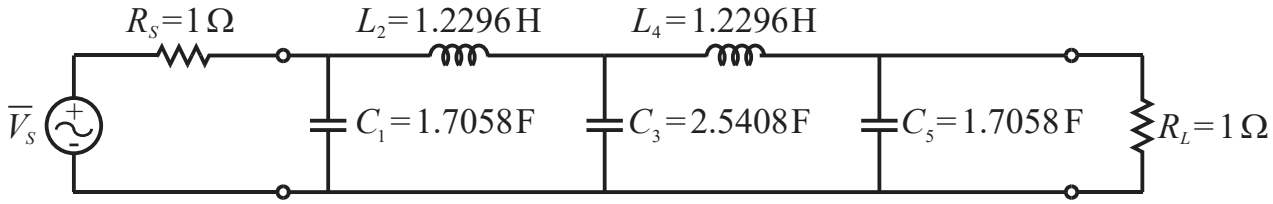
8.16 Design a stepped-impedance low-pass filter having a cutoff frequency of 3 GHz and a fifth-order 0.5 dB equal-ripple response. Assume $R_0 = 50\ \Omega$, $Z_\ell = 15\ \Omega$, and $Z_h = 120\ \Omega$. (a) Find the required electrical lengths of the five sections

- First, find and draw fully-labeled sketch of low-pass filter prototype circuit (use form shown in Fig. 8.25a). Also, specify the impedance associated with each section. CAD part is not required.
- From Table 8.4, we get immittances: **$g_0 = 1$, $g_1 = g_5 = 1.7058$, $g_2 = g_4 = 1.2296$, $g_3 = 2.5408$** and **$g_6 = 1$** (matched).

TABLE 8.4 Element Values for Equal-Ripple Low-Pass Filter Prototypes ($g_0 = 1$, $\omega_c = 1$, $N = 1$ to 10, 0.5 dB ripple)

	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	1.0000			
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

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



- Using the immittances, Z_0, Z_ℓ, & Z_h, & eq'ns (8.86a) & (8.86b), the electrical lengths are:

For $C_1 = C_5 = 1.7058$ F, use **$Z_\ell = 15\ \Omega$** and sections with electrical length $\Rightarrow$

$$\beta\ell_1 = \beta\ell_5 = \frac{C Z_\ell}{R_0} = \frac{g_1 Z_\ell}{R_0} = \frac{1.7058(15)}{50} \Rightarrow \beta\ell_1 = \beta\ell_5 = 0.51174\ \text{rad} = 29.32^\circ$$

For $L_2 = L_4 = 1.2296$ H, use **$Z_h = 120\ \Omega$** and sections with electrical length $\Rightarrow$

$$\beta\ell_2 = \beta\ell_4 = \frac{L R_0}{Z_h} = \frac{g_2 R_0}{Z_h} = \frac{1.2296(50)}{120} \Rightarrow \beta\ell_2 = \beta\ell_4 = 0.5123\ \text{rad} = 29.35^\circ$$

For $C_3 = 2.5408$ F, use **$Z_\ell = 15\ \Omega$** and a section with electrical length $\Rightarrow$

$$\beta\ell_3 = \frac{C Z_\ell}{R_0} = \frac{g_3 Z_\ell}{R_0} = \frac{2.5408(15)}{50} \Rightarrow \beta\ell_3 = 0.76224\ \text{rad} = 43.67^\circ$$

All are less than 45 degrees!