EE 481/581 Microwave Engineering Quiz #11 (Fall 2024)

Name Key A

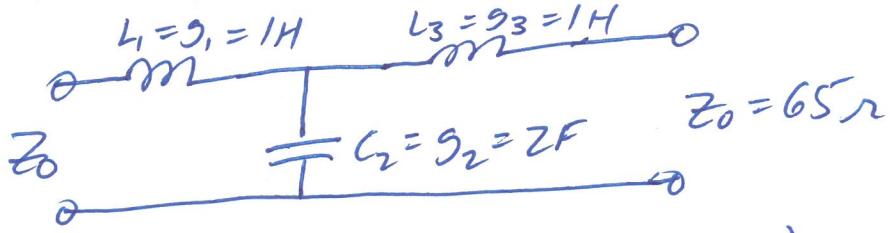
Instructions: Open notes/text. Place answers in indicated spaces. **Show** & **clearly label** *all* work for partial credit.

Design a maximally flat low-pass filter prototype with an attenuation of at least 25 dB at three times the cutoff frequency of the minimum order N. and the immittance values g_0 to g_{N+1}. Assume a prototype design with the use of inductors maximized. The filter is to be implemented using a stepped-impedance design in a 65 Ω system where the lowest and highest practical impedances are 25 Ω and 120 Ω. Fill out the table provided with the immittance (F or H), impedance (highest or lowest practical value), and electrical length $\beta\ell_i$ (rad and degrees) of each section going from 1 to N. [Rows may be added or skipped as necessary.]

$\left|\frac{\omega}{\omega_c}\right| - 1 = \left|\frac{3\omega_c}{\omega_c}\right| - 1 = 2 \rightarrow$ Mark on Fig 8.26 along w/ 25 dB $\Rightarrow$ Need 3rd order filter. (3 sections)

Per Table 8.3, $g_1 = 1$, $g_2 = 2$, & $g_3 = 1$

Per Fig 8.25,



Inductors $\beta\ell$ (8.86a), (use $Z_h = 120\Omega$)

$$\beta\ell_1 = \beta\ell_3 = \frac{LR_0}{Z_h} = \frac{1(65)}{120} = 0.541\overline{6}\ \text{rad} = 31.035^\circ$$

Capacitor $\beta\ell$ (8.86b), (use $Z_\ell = 25\Omega$)

$$\beta\ell_2 = \frac{CZ_\ell}{R_0} = \frac{2(25)}{65} = 0.76923\ \text{rad} = 44.074^\circ$$

Prototype: $N =$ 3

Section	Prototype immittance	Characteristic Impedance (Ω)	$\beta\ell_i$ (rad)	$\beta\ell_i$ (deg)
1	1H	120	$0.541\overline{6}$	31.035
2	2F	25	0.76923	44.074
3	1H	120	$0.541\overline{6}$	31.035

TABLE 8.3 Element Values for Maximally Flat Low-Pass Filter Prototypes ($g_0 = 1$, $\omega_c = 1$, $N = 1$ to 10)

N	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9	g_{10}	g_{11}
1	2.0000	1.0000									
2	1.4142	1.4142	1.0000								
3	1.0000	2.0000	1.0000	1.0000							
4	0.7654	1.8478	1.8478	0.7654	1.0000						
5	0.6180	1.6180	2.0000	1.6180	0.6180	1.0000					
6	0.5176	1.4142	1.9318	1.9318	1.4142	0.5176	1.0000				
7	0.4450	1.2470	1.8019	2.0000	1.8019	1.2470	0.4450	1.0000			
8	0.3902	1.1111	1.6629	1.9615	1.9615	1.6629	1.1111	0.3902	1.0000		
9	0.3473	1.0000	1.5321	1.8794	2.0000	1.8794	1.5321	1.0000	0.3473	1.0000	
10	0.3129	0.9080	1.4142	1.7820	1.9754	1.9754	1.7820	1.4142	0.9080	0.3129	1.0000

Source: Reprinted from G. L. Matthaei, L. Young, and E. M. T. Jones, *Microwave Filters, Impedance-Matching Networks, and Coupling Structures*, Artech House, Dedham, Mass., 1980, with permission.

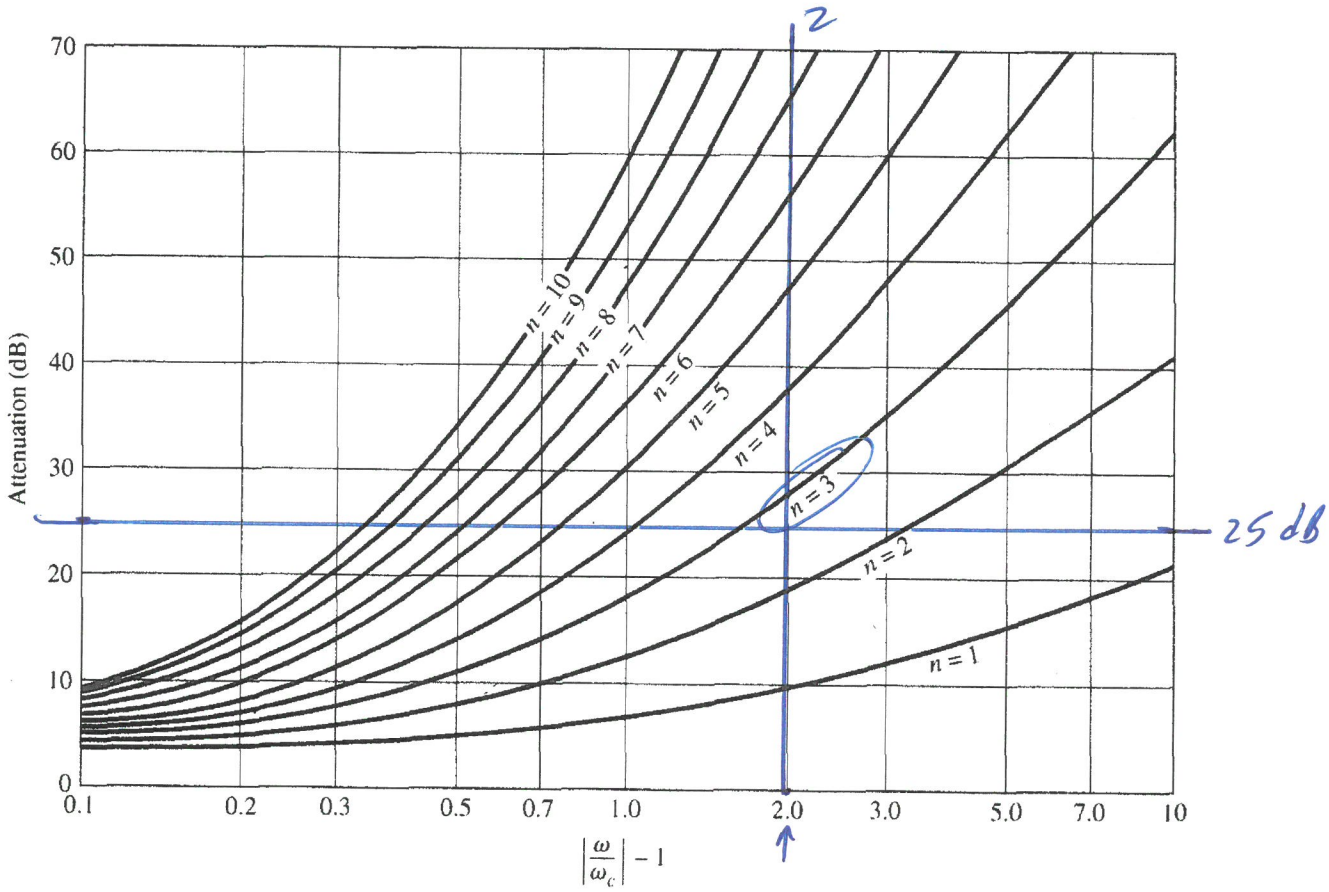


FIGURE 8.26 Attenuation versus normalized frequency for maximally flat filter prototypes.

Adapted from G. L. Matthaei, L. Young, and E. M. T. Jones, *Microwave Filters, Impedance-Matching Networks, and Coupling Structures*, Artech House, Dedham, Mass., 1980, with permission.

EE 481/581 Microwave Engineering Quiz #11 (Fall 2024)

Name Key B

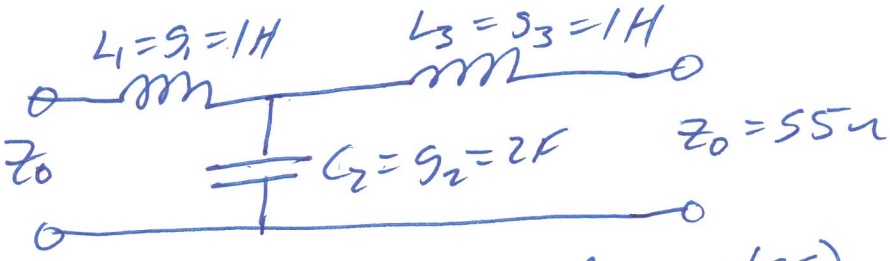
Instructions: Open notes/text. Place answers in indicated spaces. **Show** & **clearly label** *all* work for partial credit.

Design a maximally flat low-pass filter prototype with an attenuation of at least 32 dB at four times the cutoff frequency of the minimum order N. and the immittance values g_0 to g_{N+1}. Assume a prototype design with the use of inductors maximized. The filter is to be implemented using a stepped-impedance design in a 55 Ω system where the lowest and highest practical impedances are 20 Ω and 100 Ω. Fill out the table provided with the immittance (F or H), impedance (highest or lowest practical value), and electrical length $\beta\ell_i$ (rad and degrees) of each section going from 1 to N. [Rows may be added or skipped as necessary.]

$\left|\frac{\omega}{\omega_c}\right| - 1 = \left|\frac{4\omega_c}{\omega_c}\right| - 1 = 3 \Rightarrow$ Mark on Fig 8.26 along w/ 32 dB $\Rightarrow$ Need 3rd order filter (3 sections)

Per Table 8.3, $g_1 = 1$, $g_2 = 2$, & $g_3 = 1$

Per Fig 8.25



Inductors $\beta\ell$ (8.86a), $\beta\ell_1 = \beta\ell_3 = \frac{L R_0}{Z_h} = \frac{1(55)}{100}$
(use $Z_h = 100\Omega$) $= 0.55$ rad $= 31.513°$

Capacitor (8.86b), $\beta\ell_2 = \frac{C Z_e}{R_0} = \frac{2(20)}{55}$
(use $Z_e = 20\Omega$) $= 0.72$ rad $= 41.66966°$

Prototype: $N =$ 3

Section	Prototype immittance	Characteristic Impedance (Ω)	$\beta\ell_i$ (rad)	$\beta\ell_i$ (deg)
1	1H	100	0.55	31.513
2	2F	20	0.72	41.67
3	1H	100	0.55	31.513

TABLE 8.3 Element Values for Maximally Flat Low-Pass Filter Prototypes ($g_0 = 1$, $\omega_c = 1$, $N = 1$ to 10)

N	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9	g_{10}	g_{11}
1	2.0000	1.0000									
2	1.4142	1.4142	1.0000								
3	1.0000	2.0000	1.0000	1.0000							
4	0.7654	1.8478	1.8478	0.7654	1.0000						
5	0.6180	1.6180	2.0000	1.6180	0.6180	1.0000					
6	0.5176	1.4142	1.9318	1.9318	1.4142	0.5176	1.0000				
7	0.4450	1.2470	1.8019	2.0000	1.8019	1.2470	0.4450	1.0000			
8	0.3902	1.1111	1.6629	1.9615	1.9615	1.6629	1.1111	0.3902	1.0000		
9	0.3473	1.0000	1.5321	1.8794	2.0000	1.8794	1.5321	1.0000	0.3473	1.0000	
10	0.3129	0.9080	1.4142	1.7820	1.9754	1.9754	1.7820	1.4142	0.9080	0.3129	1.0000

Source: Reprinted from G. L. Matthaei, L. Young, and E. M. T. Jones, *Microwave Filters, Impedance-Matching Networks, and Coupling Structures*, Artech House, Dedham, Mass., 1980, with permission.

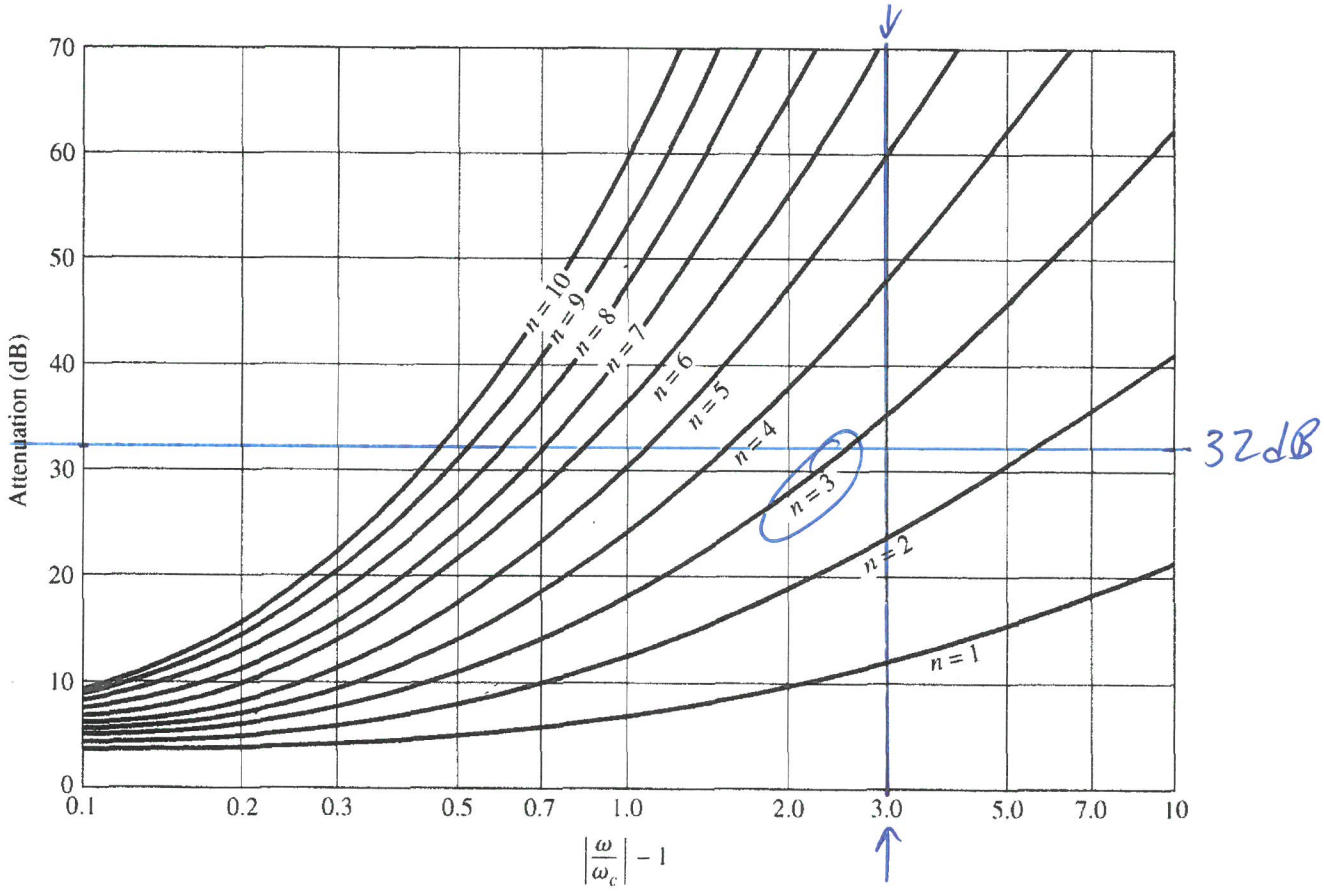


FIGURE 8.26 Attenuation versus normalized frequency for maximally flat filter prototypes.

Adapted from G. L. Matthaei, L. Young, and E. M. T. Jones, *Microwave Filters, Impedance-Matching Networks, and Coupling Structures*, Artech House, Dedham, Mass., 1980, with permission.