EE 481/581 Microwave Engineering Quiz #10 (Fall 2025)

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 30 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 which starts with an inductor. The filter is to be implemented using a stepped-impedance design in a 60 Ω (R_0) system where the lowest and highest practical impedances are 25 Ω (Z_ℓ) and 120 Ω (Z_h). 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.]

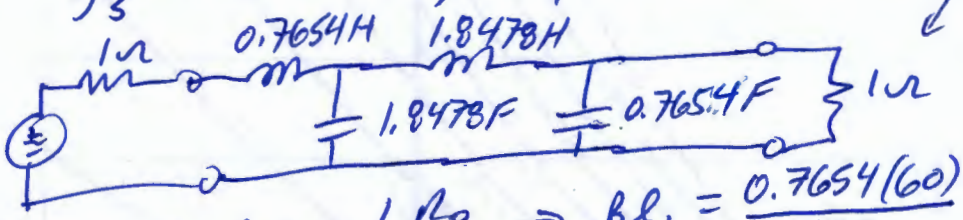
$\left|\frac{\omega}{\omega_c}\right| - 1 = \left|\frac{3\omega_c}{\omega_c}\right| - 1 = 2$ → plot on Fig 8.26.

Read $N = 4$, as first trace above 30dB.

$g_0 = g_5 = 1$ are for source & load resistances.

$g_1 = 0.7654 = L_1$, $g_2 = 1.8478 = C_2$,

$g_3 = 1.8478 = L_3$, & $g_4 = 0.7654 = C_4$ } Filter Prototype



(8.86a) $\beta\ell = \frac{L R_0}{Z_h}$ (inductor) $\Rightarrow \beta\ell_1 = \frac{0.7654(60)}{120} = 0.3827 = 21.927^\circ$

$\Rightarrow \beta\ell_3 = \frac{1.8478(60)}{120} = 0.9239 = 52.936^\circ$ ∴

(8.86b) $\beta\ell = \frac{C Z_\ell}{R_0}$ (capacitor) $\Rightarrow \beta\ell_2 = \frac{1.8478(25)}{60} = 0.7699 = 44.113^\circ$

$\Rightarrow \beta\ell_4 = \frac{0.7654(25)}{60} = 0.3189 = 18.273^\circ$

Prototype: $N =$ 4

Section	Prototype immittance	Characteristic Impedance (Ω)	$\beta\ell_i$ (rad)	$\beta\ell_i$ (deg)
1	0.7654 H	120	0.3827	21.93
2	1.8478 F	25	0.7699	44.11
3	1.8478 H	120	0.9239	52.94
4	0.7654 F	25	0.3189	18.27

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.

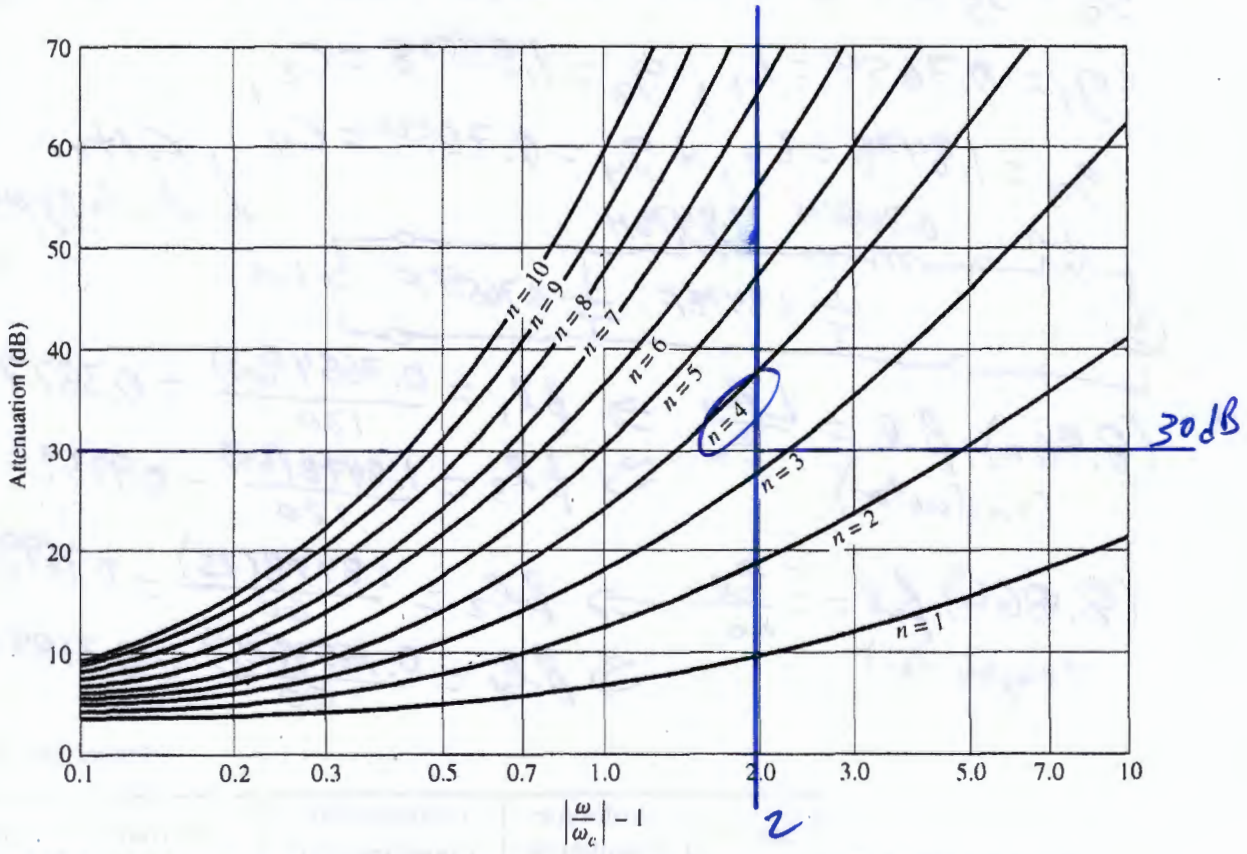


FIGURE 8.26 Attenuation versus normalized frequency for maximally flat filter prototypes.

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 #10 (Fall 2025)

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 40 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 which starts with an inductor. The filter is to be implemented using a stepped-impedance design in a 55 Ω system (R_0) where the lowest and highest practical impedances are 20 Ω (Z_ℓ) and 110 Ω (Z_h). 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.]

$\left|\frac{\omega}{\omega_c}\right| - 1 = \left|\frac{4\omega_c}{\omega_c}\right| - 1 = 3 \Rightarrow$ Plot on Fig 8.26

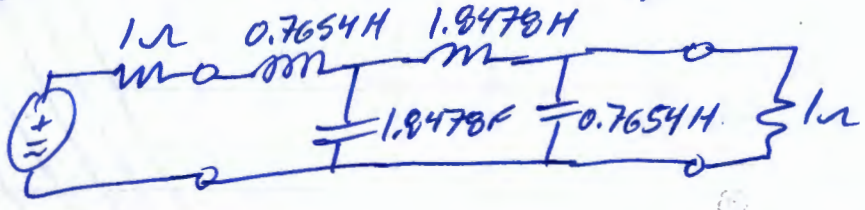
Read $N = 4$, as first trace above 40 dB.

$g_0 = g_5 = 1$ are for source & load resistances,

$g_1 = 0.7654 = L_1$, $g_2 = 1.8478 = C_2$, $g_3 = 1.8478 = L_3$, &

$g_4 = 0.7654 = C_4$.

LPF prototype



(8.86a) (Inductor) $\beta\ell = \frac{L R_0}{Z_h} \Rightarrow \frac{0.7654(55)}{110} = 0.3827 = 21.927^\circ = \beta\ell_1$

$\Rightarrow \frac{1.8478(55)}{110} = 0.9239 = 52.936^\circ = \beta\ell_3$

(8.86b) (capacitor) $\beta\ell = \frac{C Z_\ell}{R_0} \Rightarrow \frac{1.8478(20)}{55} = 0.6719 = 38.4986^\circ = \beta\ell_2$

$\Rightarrow \frac{0.7654(20)}{55} = 0.2783 = 15.947^\circ = \beta\ell_4$

Prototype: $N =$ 4

Section	Prototype immittance	Characteristic Impedance (Ω)	$\beta\ell_i$ (rad)	$\beta\ell_i$ (deg)
1	0.7654H	110	0.3827	21.93
2	1.8478F	20	0.6719	38.50
3	1.8478H	110	0.9239	52.94
4	0.7654 F	20	0.2783	15.95

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}
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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

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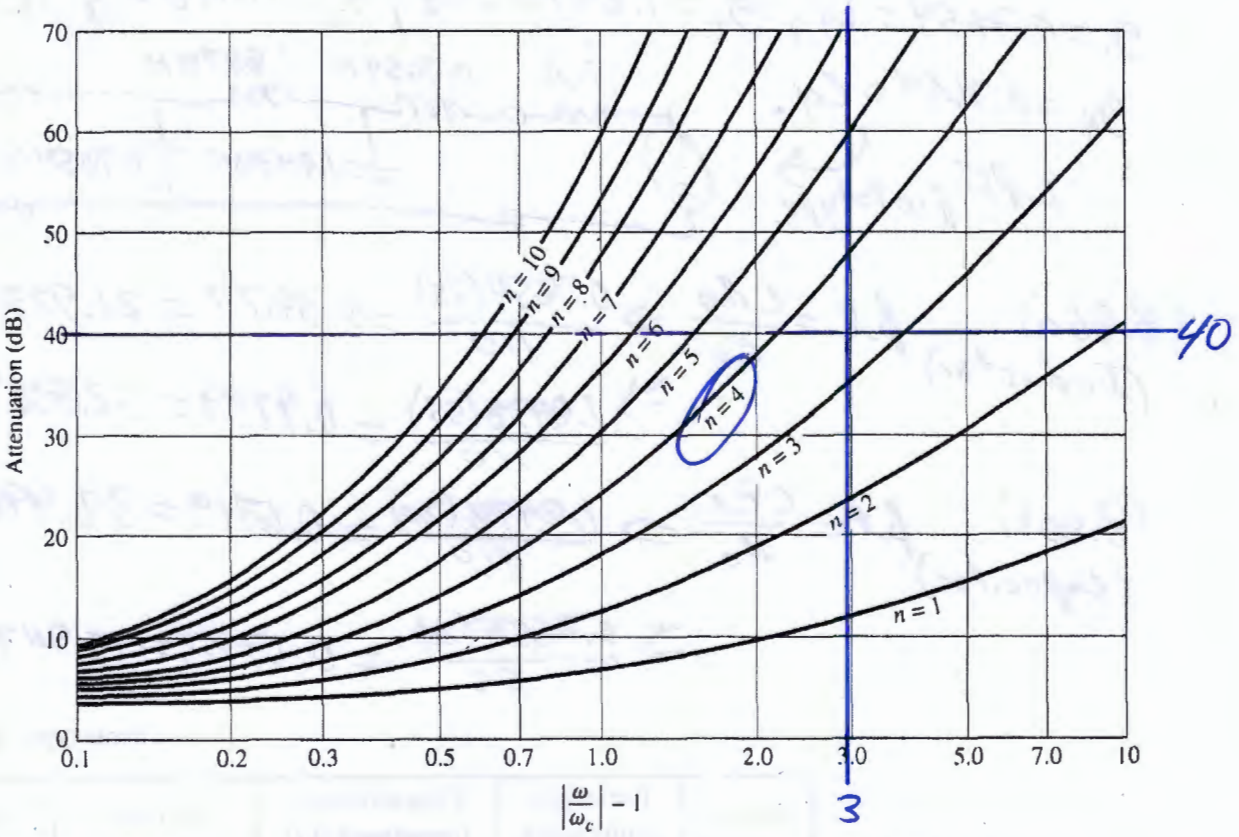

FIGURE 8.26 Attenuation versus normalized frequency for maximally flat filter prototypes.

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