Design a coupled line BPF with N=3 and 0.5 dB equal response. The center frequency is 2.0 GHz, the bandwidth is 10 % and Z_o= 50 Ω.

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 and 3.0 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

① LPF prototype values : Table 8.4

$g_1 = 1.5963$
$g_2 = 1.0967$
$g_3 = 1.5963$
$g_4 = 1.000$

Remind: Coupled line BPF Example

Design a coupled line BPF with N=3 and 0.5 dB equal response. The center frequency is 2.0 GHz, the bandwidth is 10 % and Z_o= 50 Ω.

① LPF prototype values : Table 8.4

$g_1 = 1.5963$
$g_2 = 1.0967$
$g_3 = 1.5963$
$g_4 = 1.000$

$Z_0 J_1 = \sqrt{\frac{\pi\Delta}{2g_1}} = 0.3137$

$Z_0 J_2 = \frac{\pi\Delta}{2\sqrt{g_1 g_2}} = 0.1187$

$Z_0 J_3 = \frac{\pi\Delta}{2\sqrt{g_2 g_3}} = 0.1187$

$Z_0 J_4 = \sqrt{\frac{\pi\Delta}{2g_3 g_4}} = 0.3137$

$Z_{oe_1} = Z_0[1 + J_1 Z_0 + (J_1 Z_0)^2]$
$= 70.61\ \Omega$

$Z_{oe_2} = 56.64\ \Omega$

$Z_{oe_3} = \cancel{70.61}\ 56.64\ \Omega$

$Z_{oe_4} = 70.61\ \Omega$

$Z_{oo_1} = Z_0[1 - J_1 Z_0 + (J_1 Z_0)^2]$
$= 39.24\ \Omega$

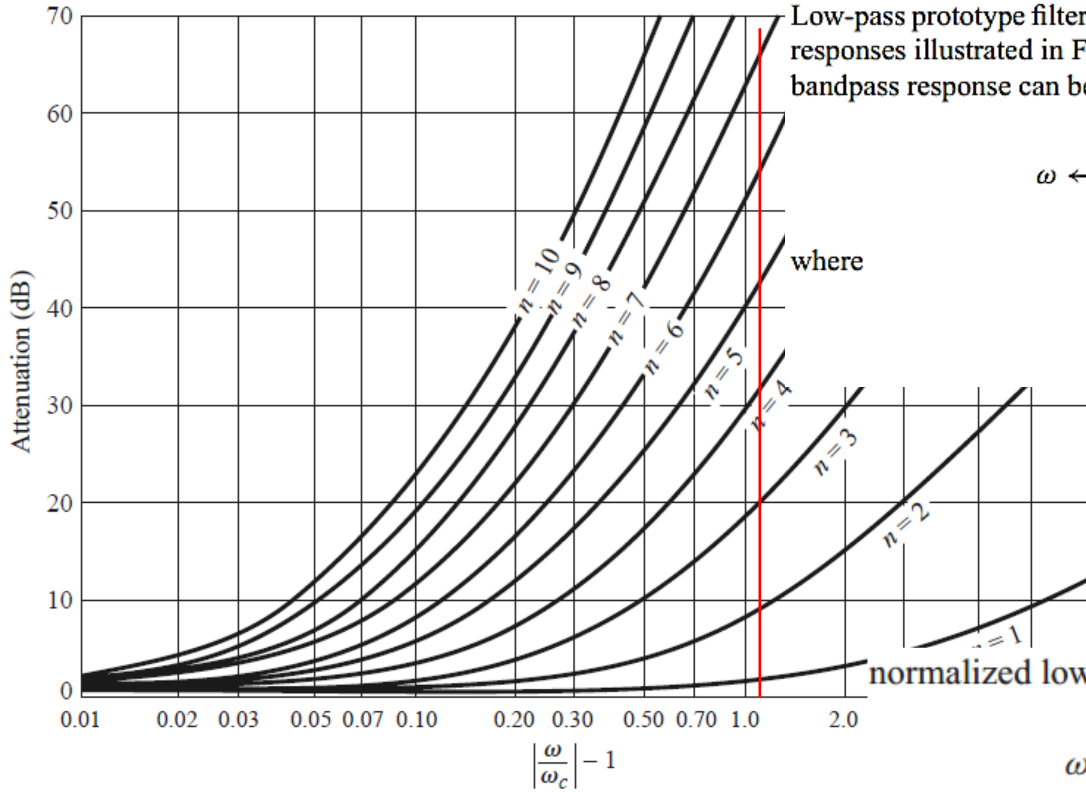
$Z_{oo_2} = 44.77\ \Omega$

$Z_{oo_3} = 44.77\ \Omega$

n	g_n	$Z_0 J_n$	$Z_{0e}(\Omega)$	$Z_{0o}(\Omega)$
1	1.5963	0.3137	70.61	39.24
2	1.0967	0.1187	56.64	44.77
3	1.5963	0.1187	56.64	44.77
4	1.0000	0.3137	70.61	39.24

Ex) Design a coupled line BPF with N=3 and 0.5 dB equal response. The center frequency is 2.0 GHz, the bandwidth is 10 % and Z_o= 50 Ω. $\Delta = 0.1$ (given)

What is the attenuation at 1.8 GHz?



Attenuation versus normalized frequency for equal-ripple (a) 0.5 dB ripple level.

Low-pass prototype filter designs can also be transformed to have the bandpass or bandstop responses illustrated in Figure 8.31. If ω_1 and ω_2 denote the edges of the passband, then a bandpass response can be obtained using the following frequency substitution:

$$\omega \leftarrow \frac{\omega_0}{\omega_2 - \omega_1}\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right) = \frac{1}{\Delta}\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right), \tag{8.71}$$

where

$$\Delta = \frac{\omega_2 - \omega_1}{\omega_0} \tag{8.72}$$

normalized low-pass form ($\omega_c = 1$):

$$\omega \leftarrow \frac{1}{\Delta}\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right) = \frac{1}{0.1}\left(\frac{1.8}{2.0} - \frac{2.0}{1.8}\right) = -2.11.$$

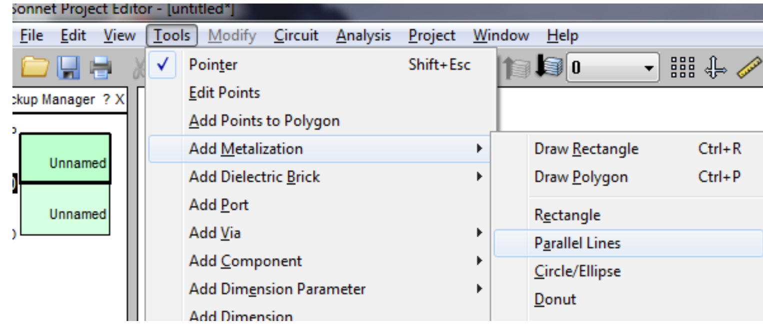
Then the value on the horizontal scale of Figure 8.27a is

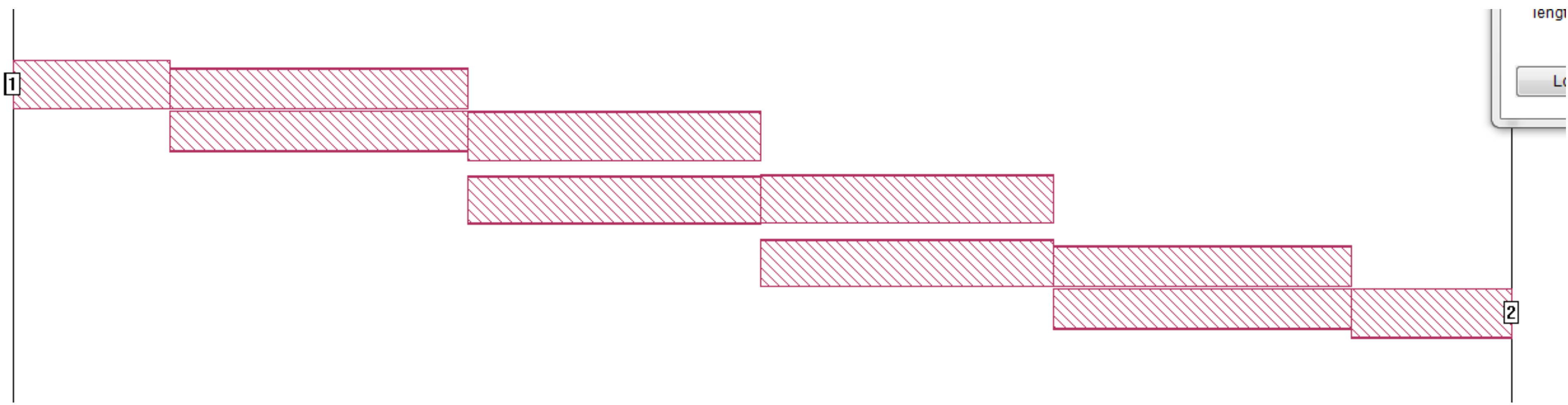
$$\left|\frac{\omega}{\omega_c}\right| - 1 = |-2.11| - 1 = 1.11,$$

which indicates an attenuation of about 20 dB for $N = 3$.

Coupled Line BPF Sonnet Assignment

- Using the geometry obtained from the insertion loss LPF example 1, plot S11 and S22
  - Cell size = 0.2 x minimum gap
  - Box size = 140 x 100
  - Use Rogers 5880 (Er=2.2 d=1.5 mm)
  - Analyze between 1.5 ~ 2.5 GHz





Coupled Line BPF Sonnet Assignment
(Due April 20th Midnight Online Submission)

- Geometry

- **Simulation Results (S11 and S21)**

Discuss the simulation results

1. How can you increase the center frequency?
2.
3.