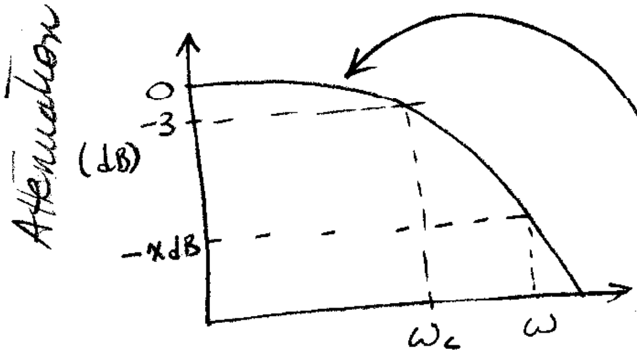
FILTER DESIGN HANDBOOK –

LUMPED ELEMENT FILTER DESIGN

STEP 1: DETERMINE 'g' PARAMETERS FOR LP DESIGN

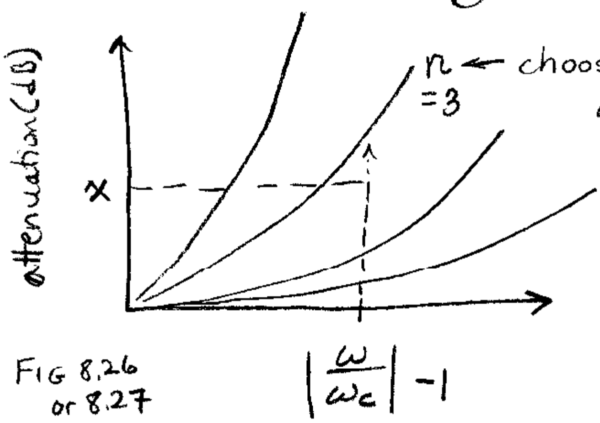


$$P_{LR} = \frac{P_{inc}}{P_{load}} = \frac{1}{1 - |\Gamma(\omega)|^2}$$

BINOMIAL– MAXFLAT
FIG 8.26
TABLE 8.3

CHEBYSHEV (0.5 or 3dB RIPPLE)
FIG 8.27
TABLE 8.4

"Design a binomial filter with a cutoff frequency ω_c that is x dB down at frequency ω."



← choose n curve that is above x at $\left|\frac{\omega}{\omega_c}\right| - 1$

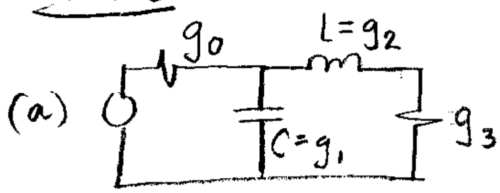
FIG 8.26 or 8.27

Read g values from Table 8.3 or 8.4; $g_0 = 1$

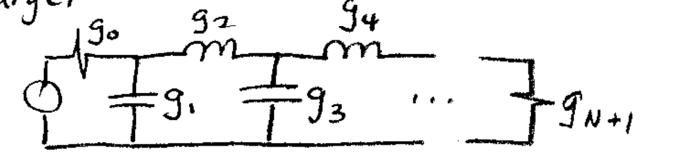
$N = n-1$	g_1	g_2	g_3	g_4
1	2.0	1.0		
2	1.41	1.41	1.0	
3	1.0	2.0	1.0	1.0

$N = n - 1$

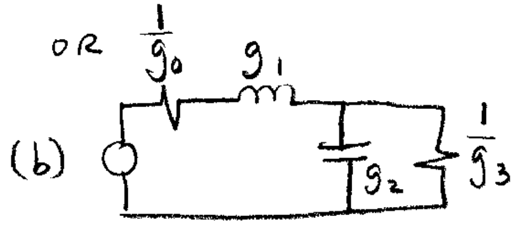
STEP 2: Draw LP Filter

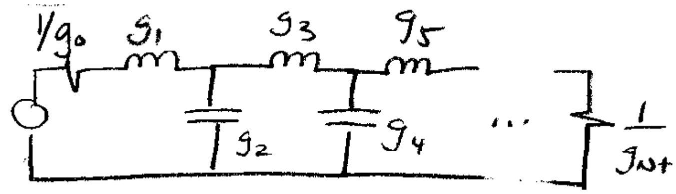


Larger Filter:



OR





THESE DESIGNS ASSUME $\omega = 1$ AND $Z_0 = 1$

STEP 3(a) DENORMALIZE LOW PASS

FILTER (a): $R_g = Z_0 g_0$

$C = g/(Z_0 \omega_c)$

$L = Z_0 g/\omega_c$

$R_L = Z_0 g_{N+1}$

FILTER (b): $R_g = 1/(Z_0 g_0)$

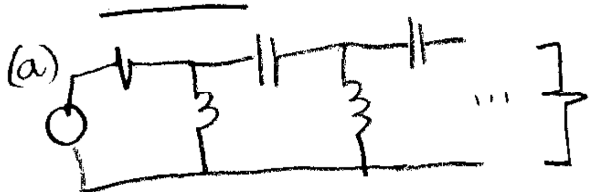
$C = g/(Z_0 \omega_c)$

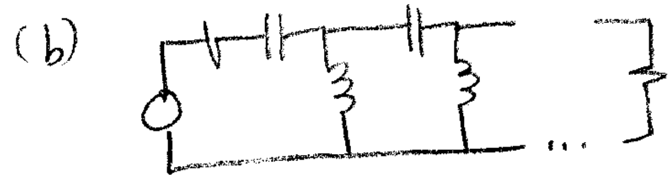
$L = Z_0 g/\omega_c$

$R_L = 1/(Z_0 g_{N+1})$

* IF R_L NOT MATCHED, USE $\lambda/4$ TX to MATCH

STEP 3b: CONVERT FROM LP to HP & Denormalize





FILTER (a) $R_g = Z_0 g_0$

$C = 1/(Z_0 \omega_c g)$

$L = Z_0/(\omega_c g)$

$R_L = Z_0 \ g_{N+1}$

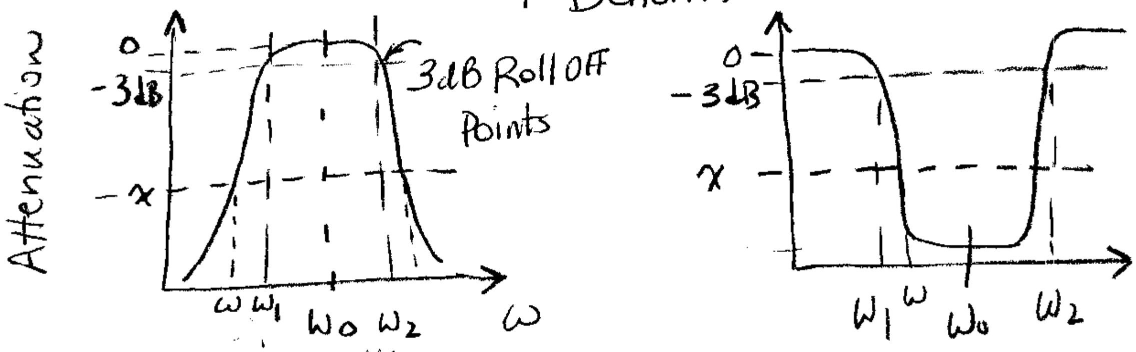
FILTER (b) $R_g = 1/(Z_0 g_0)$

$C = 1/(Z_0 \omega_c g)$

$L = Z_0/(\omega_c g)$

$R_L = Z_0 g_{N+1}$

Step #5: Convert LP to BP or Band Stop & Denormalize



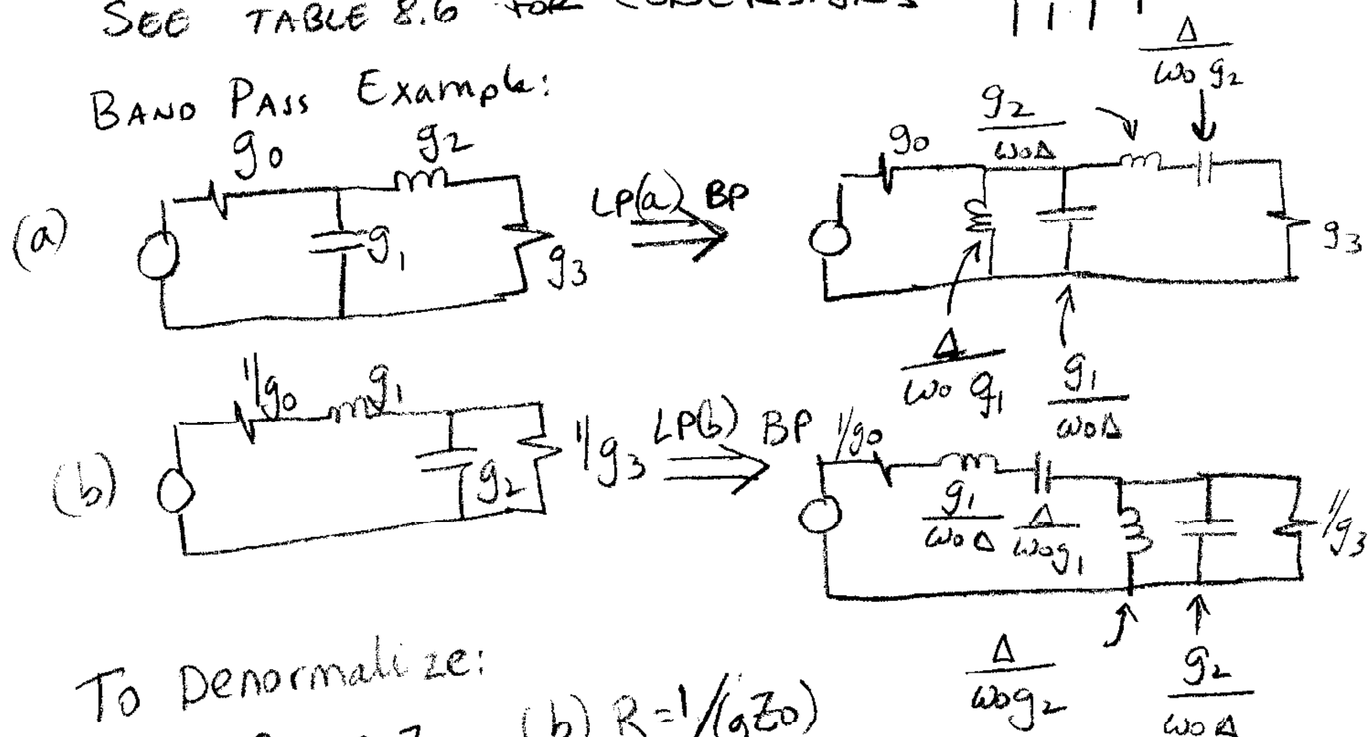
Fractional Bandwidth

$\Delta = \dfrac{\omega_2 - \omega_1}{\omega_0}$; $\omega_0 = \sqrt{\omega_1 \omega_2}$; $\omega_{LP} = \dfrac{1}{\Delta}\left(\dfrac{\omega}{\omega_0} - \dfrac{\omega_0}{\omega}\right)$

Often given in % (multiply Δ by 100) Look at Fig 8.26 or 8.27 using $\left|\dfrac{\omega_{LP}}{1}\right| - 1$

SEE TABLE 8.6 FOR CONVERSIONS

Band Pass Example:



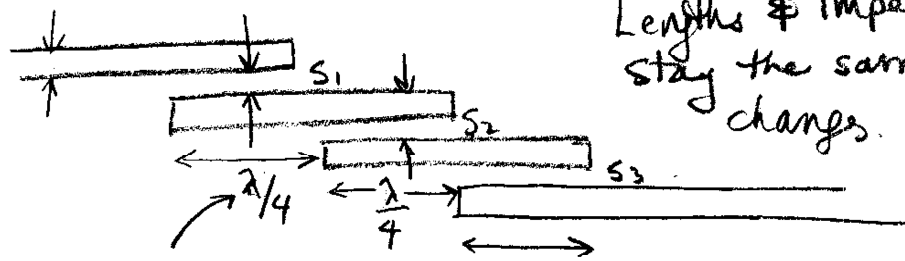
To Denormalize:

(a) $R = g Z_0$
$L = L Z_0$
$C = C / Z_0$

(b) $R = 1/(g Z_0)$
$L = L Z_0$
$C = C / Z_0$

Coupled Line Filter (CLF)

width of all lines gives Z_0



Lengths & impedance stay the same. Spacing changes.

Remember to calculate $\frac{\lambda}{4}$ for μstrip: $\lambda_\varepsilon = \frac{c_0}{f\sqrt{\varepsilon_{reff}}}$

↑ eqⁿ (3.195)

Steps (1, ~~2,4~~, 6): same as for lumped element

But – Do NOT Denormalize

Step 5 – CLF

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

$$Z_0 J_i = \frac{\pi \Delta}{2\sqrt{g_{i-1} g_i}} \quad \text{for } i = 2, 3, \ldots, \overset{n-1}{N}$$

$$\underset{Z(n)}{Z_0 J_{N+1}} = \sqrt{\frac{\pi \Delta}{2 g_N g_{N+1}}}$$

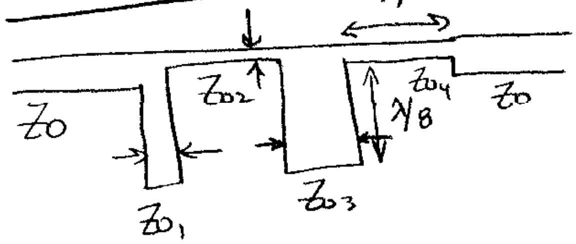
Step 6 – CLF – Find Even & Odd Impedances

$$Z_{oe} = Z_0\left[1 + J Z_0 + (J Z_0)^2\right]$$

$$Z_{oo} = Z_0\left[1 - J Z_0 + (J Z_0)^2\right]$$

Find s with Fig 7.30 or linecalc

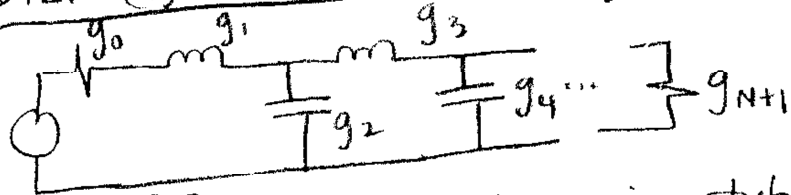
STUB FILTER (SF)



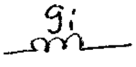
Note: λ is $\lambda_\varepsilon = \dfrac{c_0}{f\sqrt{\varepsilon_{reff}}}$ ← Eq. (3.195)

Lengths stay the same (λ/8), impedances (widths) change

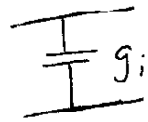
STEPS (1, 2, ~~4a~~) Same as for lumped elements, Do NOT Denormalize



STEP 5 - SF Replace

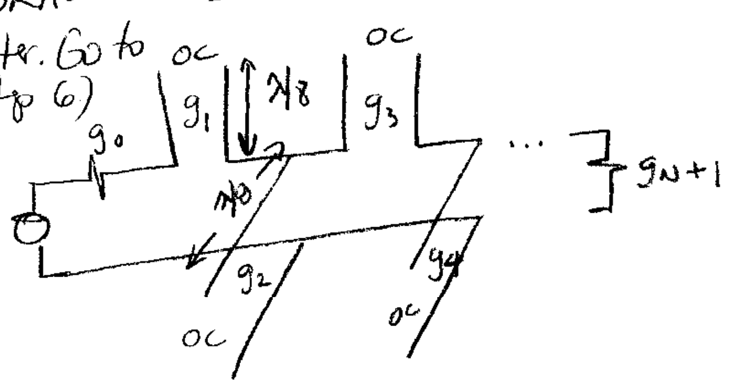


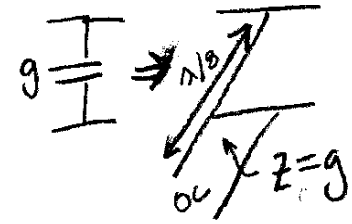
with series stub with impedance $Z_i = g_i$



with parallel stub w/ impedance $Z_i = g_i$

(Not critical to DRAW filter. Go to step 6)

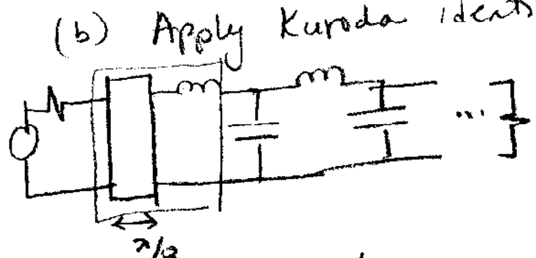


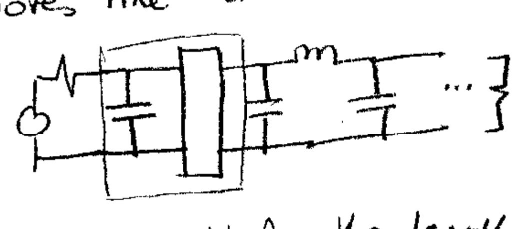


STEP 6 - SF Use Kuroda Identities (Table 8.7) to convert to all parallel stubs

(a) Add λ/8 line to front (or front & back of filter).

(b) Apply Kuroda identity - moves line "inside"



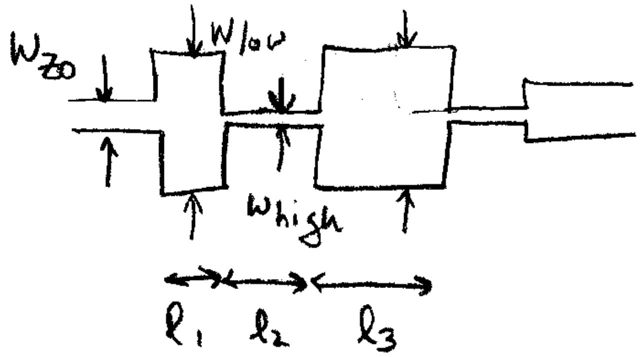


Add line & repeat

Add Another length & Repeat until done, all

Multiply impedances of all lines by Zo.

STEPPED IMPEDANCE FILTER (SIF)



Impedance stays the same, Lengths change

Calculate widths for Z_{low} & Z_{high} using

Calc $\beta = \frac{2\pi}{\lambda_\varepsilon}$ $\lambda_\varepsilon = \frac{c_0}{f\sqrt{\varepsilon_{reff}}}$ 3.195

Steps (1, ~~2, 4a~~) Same as lumped element Design.

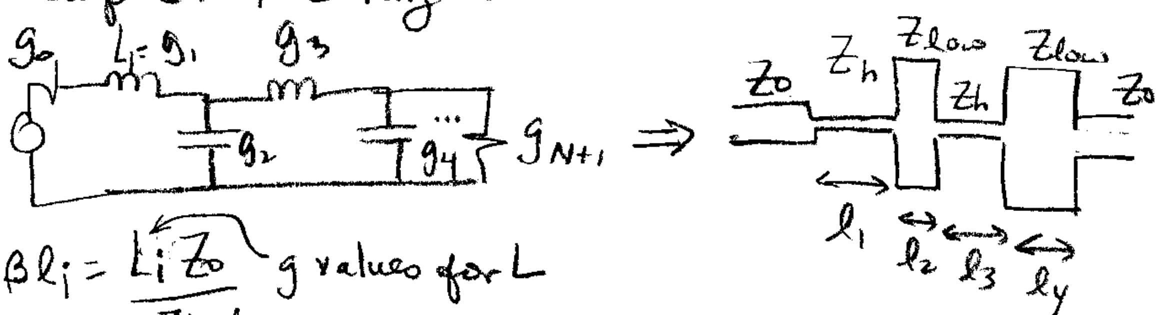
DO NOT denormalize.

Step 5 - SIF

Choose Z_0 high (thin line) depending on how thin a line can be manufactured

Z_0 low (fat line) depending on available space

Step 6: Find lengths



$\beta l_i = \frac{L_i Z_0}{Z_{high}}$ g values for L

$\beta l_i = \frac{C_i Z_{low}}{Z_0}$ g values for C

Values given in RADIANS : $\lambda_\varepsilon = 360° = 2\pi$ radians

Line calc in Degrees