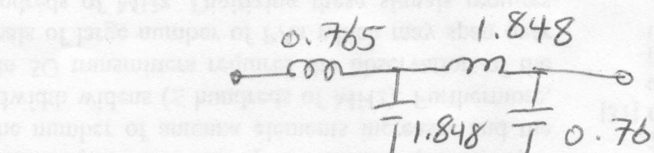
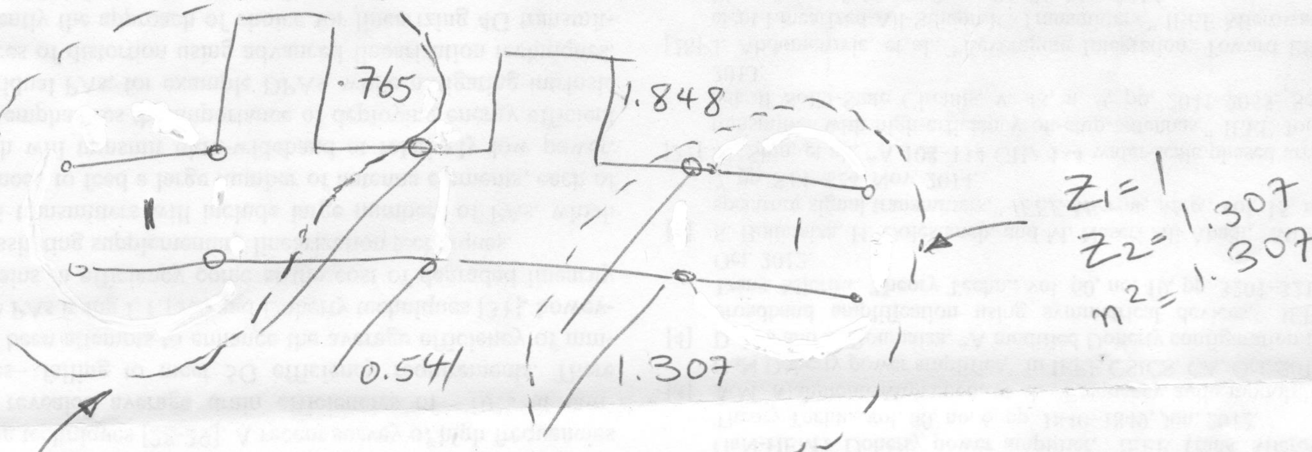
Q1) From Fig. 8.26 → N = 4 $\left|\frac{13.6}{8.0}\right| - 1 = 0.7$

From Table 8.3 → LP Prototype:

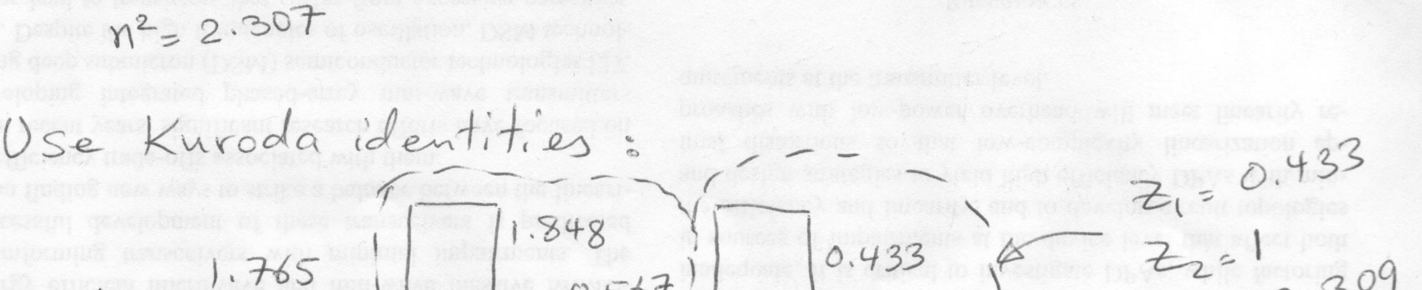


a) Applying Richard Transformation and add U.E.s



$Z_1 = 0.765$
$Z_2 = 1$
$n^2 = 2.307$

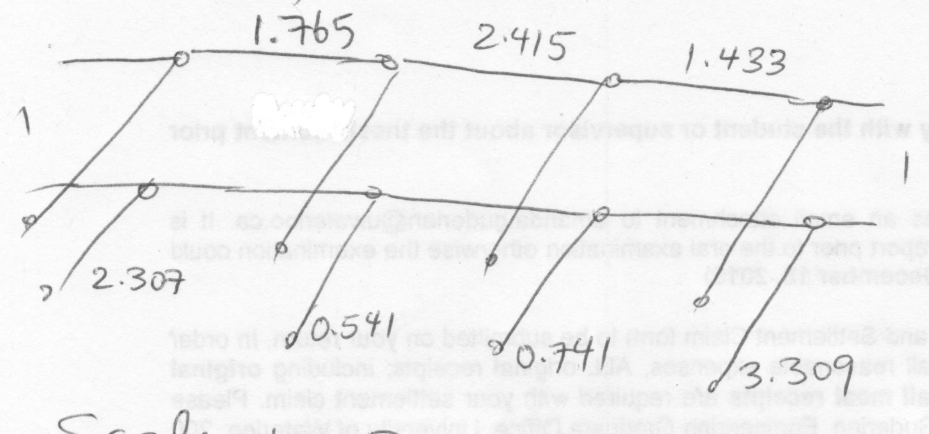
Use Kuroda identities:



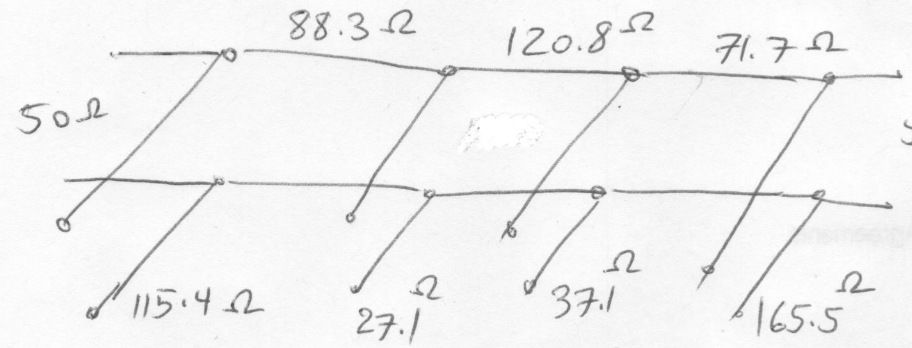
$Z_1 = .848$
$Z_2 = 0.507$
$n^2 = 1.307$

#1

Q1) (Continue)



Scale to $50\,\Omega$:



(all lines are $\lambda/8$ long @ 8GHz)

$l \cong 135$ mil

b) $Z_l = 10\,\Omega$, $\theta_l = \dfrac{L Z_0}{Z_h}$ (inductor)

$Z_h = 130\,\Omega$

$\theta_c = \dfrac{C Z_l}{Z_0}$ (capacitor)

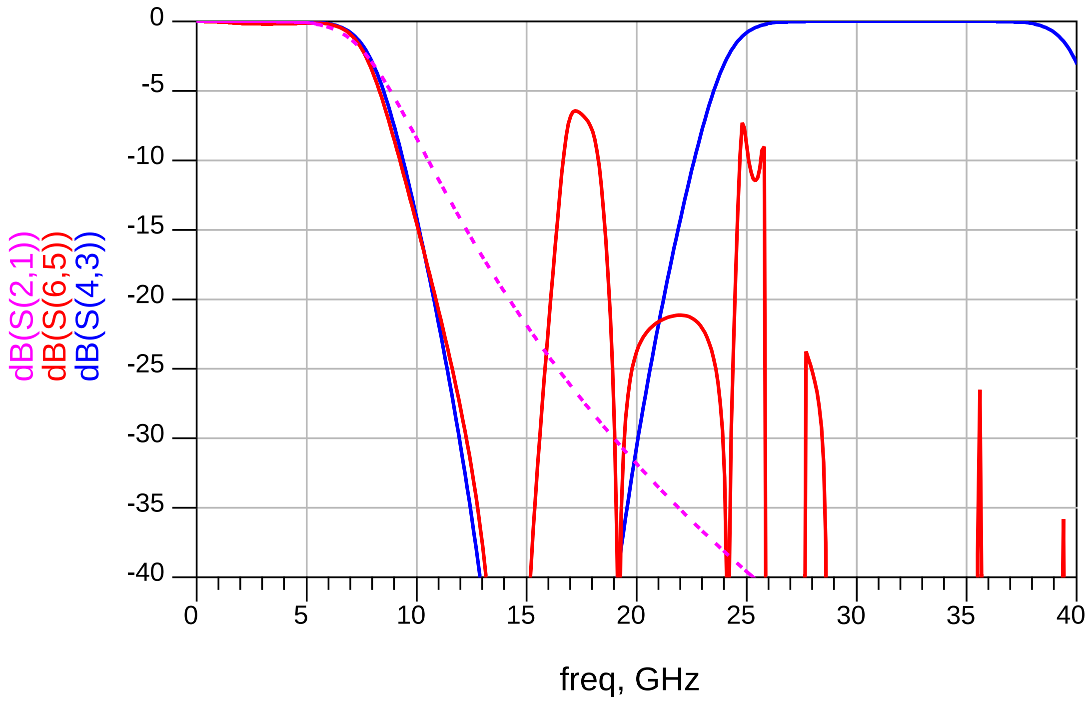
[L, C are g_k values]

$Z_0 = 50\,\Omega$

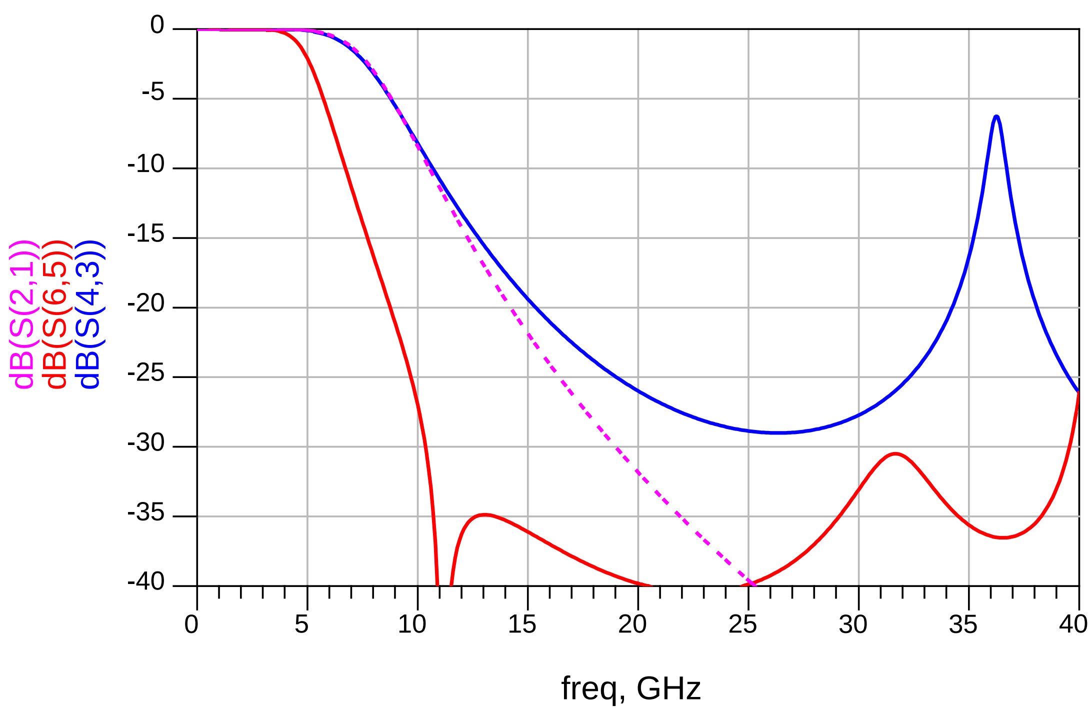
Section	$Z_i(\Omega)$	$\theta_i(^\circ)$	W_i (mil)	l_i (mil)
1	130	16.9°	12	53
2	10	21.2°	692	60
3	130	40.7°	12	128
4	10	8.8°	692	25

blue: Ideal TLs, red: MLINs w/ discontinuities, magenta: original LC

(a)



(b)



Q2. a) $f_0 = 3\,\text{GHz}$, $Z_0 = 75\,\Omega$, $N = 3$, B.S., 0.5 dB E.R.

First use (8.75) to transform 3.1 GHz to a L.P. prototype response frequency:

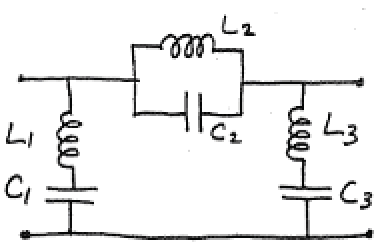
$$\omega \leftarrow \Delta\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)^{-1} = 0.1\left(\frac{3.1}{3} - \frac{3}{3.1}\right)^{-1} = 1.52$$

So, $\left|\frac{\omega}{\omega_c}\right| - 1 = 0.52$, and Figure 8.27a gives an attenuation of 11 dB for $N=3$. From Table 8.4, the prototype values are,

$g_1 = 1.5963$

$g_2 = 1.0967$

$g_3 = 1.5963$



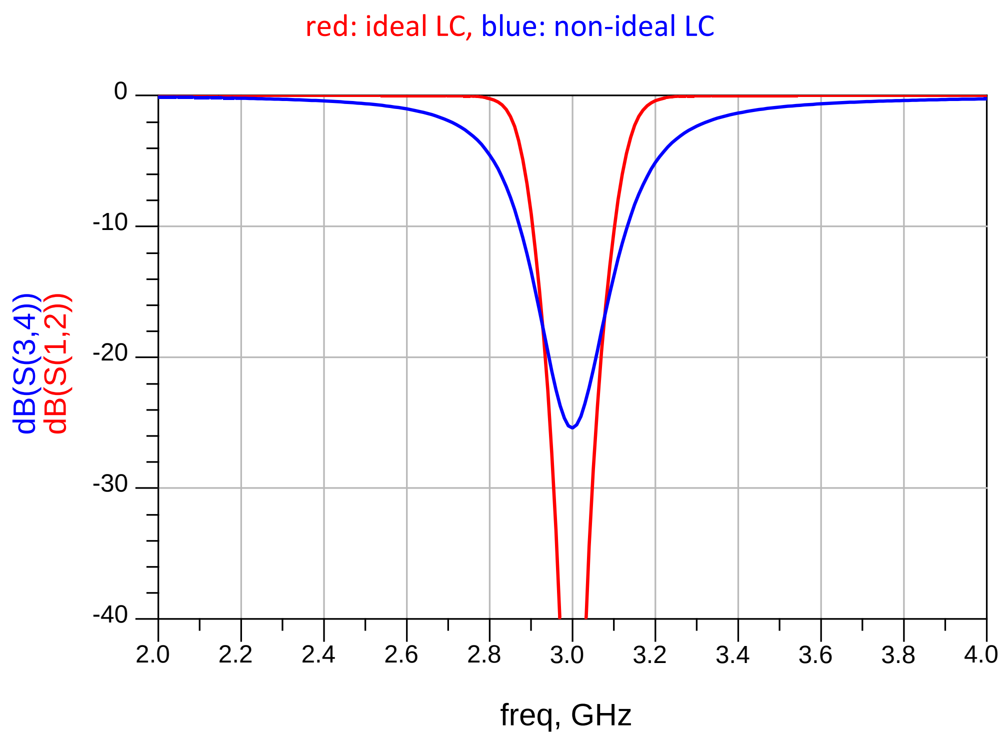
From Table 8.6 and (8.64) the scaled element values are,

$L_1 = \frac{Z_0}{\omega_0 g_1 \Delta} = 24.9\,\text{nH}$ ✓ $\qquad C_1 = \frac{g_1 \Delta}{\omega_0 Z_0} = 0.113\,\text{pF}$ ✓

$L_2 = \frac{g_2 \Delta Z_0}{\omega_0} = 0.436\,\text{nH}$ ✓ $\qquad C_2 = \frac{1}{Z_0 \omega_0 g_2 \Delta} = 6.45\,\text{pF}$ ✓

$L_3 = \frac{Z_0}{\omega_0 g_3 \Delta} = 24.9\,\text{nH}$ ✓ $\qquad C_3 = \frac{g_3 \Delta}{Z_0 \omega_0} = 0.113\,\text{pF}$ ✓

The calculated response for this filter is shown on the following page. Note that the insertion loss at 3.1 GHz is about 10 dB.



red: ideal LC, blue: non-ideal LC
dB(S(3,4))
dB(S(1,2))
0
-10
-20
-30
-40
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
4.0
freq, GHz

Q3.

$$[S] = \frac{-1}{\sqrt{2}}\begin{bmatrix} 0 & j & 1 & 0 \\ j & 0 & 0 & 1 \\ 1 & 0 & 0 & j \\ 0 & 1 & j & 0 \end{bmatrix}$$ for hybrid

a) let $b = \lambda/4$ at $f_o \Rightarrow \beta b = \pi/2$

Assume V_o^+ incident at T-junction. Then,

$$V_1^+ = V_o^+ e^{-j\beta(b-a)} = e^{-j\pi/2} e^{j\beta a}$$

$$V_4^+ = V_o^+ e^{-j\beta a}$$

$$V_2^- = \frac{-V_o^+}{\sqrt{2}}(jV_1^+ + V_4^+) = \frac{-V_o^+}{\sqrt{2}}(e^{j\beta a} + e^{-j\beta a}) = -\sqrt{2}\, V_o^+ \cos\beta a$$

$$P_2 = \tfrac{1}{2}|V_2^-|^2 = |V_o^+|^2 \cos^2\beta a$$

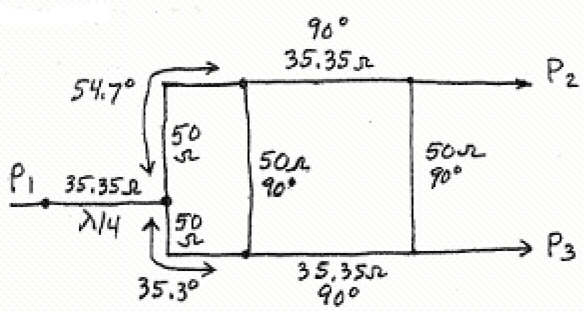
$$V_3^- = \frac{-V_o^+}{\sqrt{2}}(V_1^+ + jV_4^+) = \frac{-V_o^+}{\sqrt{2}}(-je^{j\beta a} + je^{-j\beta a}) = -\sqrt{2}\, V_o^+ \sin\beta a$$

$$P_3 = \tfrac{1}{2}|V_3^-|^2 = |V_o^+|^2 \sin^2\beta a$$

So $\frac{P_3}{P_2} = \tan^2\beta a = \tan^2\frac{\pi a}{2b}$ ✓ (since $\beta = \frac{2\pi}{\lambda} = \frac{2\pi}{4b} = \frac{\pi}{2b}$)

b) For $\frac{P_3}{P_2} = 0.5$, $a = 0.098\lambda = 35.3°$; $(b-a) = 0.152\lambda = 54.7°$

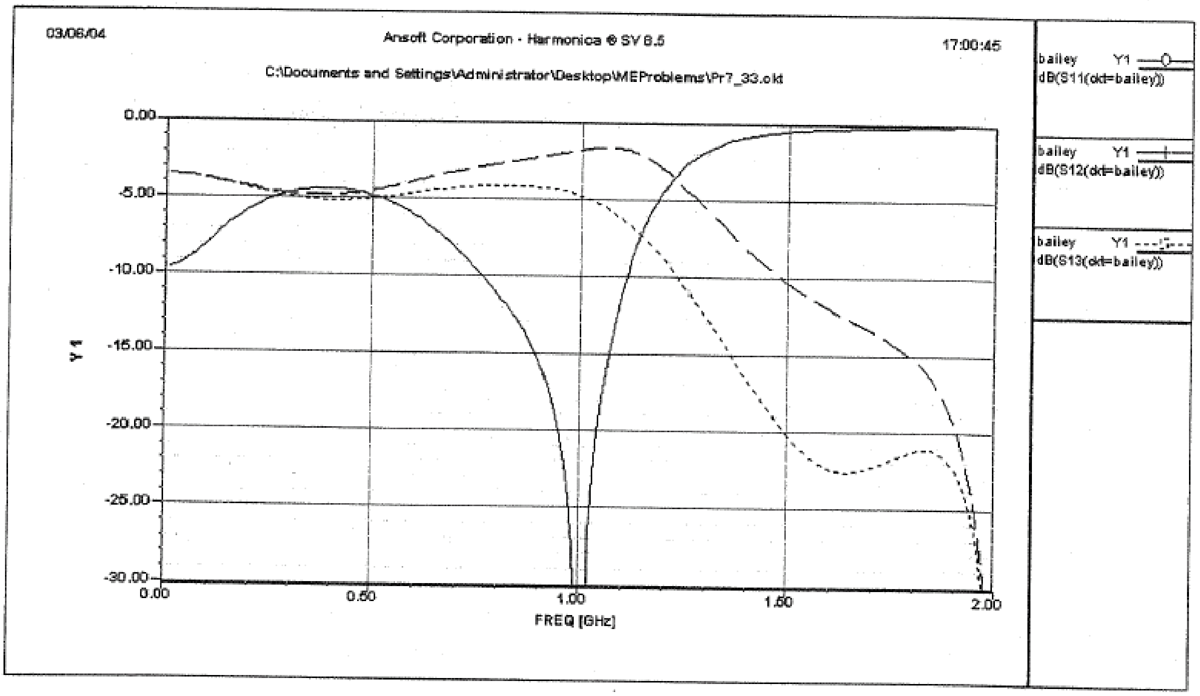
CIRCUIT:



The S-parameters are plotted on the following page, for a center frequency of 1 GHz. Note that the power output ratios,

$$\frac{P_2}{P_1} = \frac{2}{3} = -1.76\text{dB} \quad \text{and} \quad \frac{P_3}{P_1} = \frac{1}{3} = -4.77\text{dB}$$

are verified.



03/06/04
Ansoft Corporation - Harmonica ® SV 8.5
17:00:45
C:\Documents and Settings\Administrator\Desktop\MEProblems\Pr7_33.ckt
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
Y1
0.00
0.50
1.00
1.50
2.00
FREQ [GHz]
bailey Y1
dB(S11(ckt=bailey))
bailey Y1
dB(S12(ckt=bailey))
bailey Y1
dB(S13(ckt=bailey))

Q4. First, note that $[S]_{coupler} = \frac{-j}{\sqrt{2}}\begin{bmatrix} 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & -1 \\ 1 & 0 & 0 & 1 \\ 0 & -1 & 1 & 0 \end{bmatrix}$

a)

$$RF_7 = S_{42}RF_3 + S_{43}RF_5 = \frac{j}{\sqrt{2}}(RF_3 - RF_5)$$

$$\frac{RF_2}{RF_1} = 0.93 \equiv -0.63\ dB, \qquad \frac{RF_5}{RF_2} = 0.03 \equiv -30.46\ dB$$

Hence,

$$\frac{RF_5}{RF_1} = 0.93 \times 0.03 = 0.0279 = -31.09dB$$

Also,

$$\frac{RF_3}{RF_1} = S_{13}^{CRLTR} \cdot S_{12}^{CRLTR} = 0.03 \times 0.93 = 0.0279 = -31.09dB$$

$$\frac{RF_7}{RF_1} = \frac{j}{\sqrt{2}}\left(\frac{RF_3}{RF_1} - \frac{RF_5}{RF_1}\right) = 0$$

b) We have built an ideal circulator using non-ideal circulators and a 180° hybrid coupler