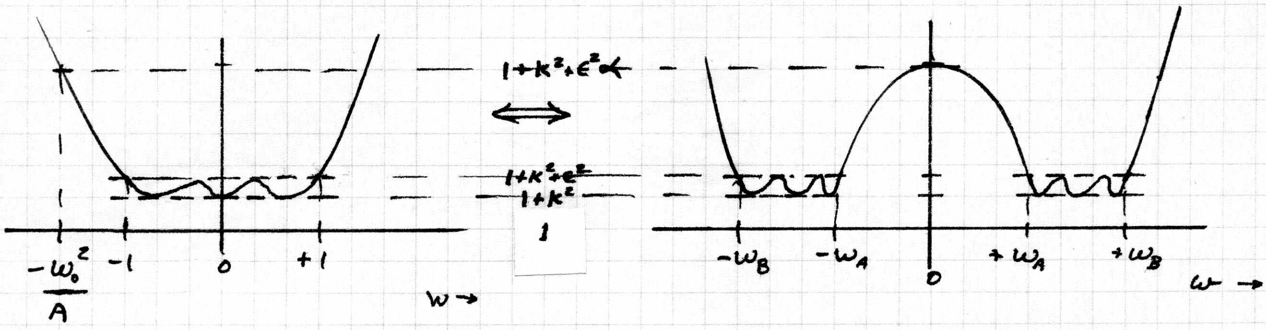
PSEUDO-BANDPASS : QUASI-LOWPASS / QUASI-HIGHPASS

CONSIDER THE MAPPING : $S = -j\left(\dfrac{s^2 + \omega_0^2}{A}\right)$



LP	⇔	PSEUDO-BANDPASS (QUASI-LOWPASS CASE)
-1	⇔	$\pm\omega_A$
$+1$	⇔	$\pm\omega_B$
0	⇔	ω_0
$-\frac{\omega_0^2}{A}$	⇔	0

$s = \pm j\omega_A$

$$-j = -j\left(\frac{-\omega_A^2 + \omega_0^2}{A}\right)$$

$$A - \omega_0^2 = -\omega_A^2$$

$$\omega_A^2 = \omega_0^2 - A \qquad \text{eq. 1.}$$

$s = \pm j\omega_B$

$$+j = -j\left(\frac{-\omega_B^2 + \omega_0^2}{A}\right)$$

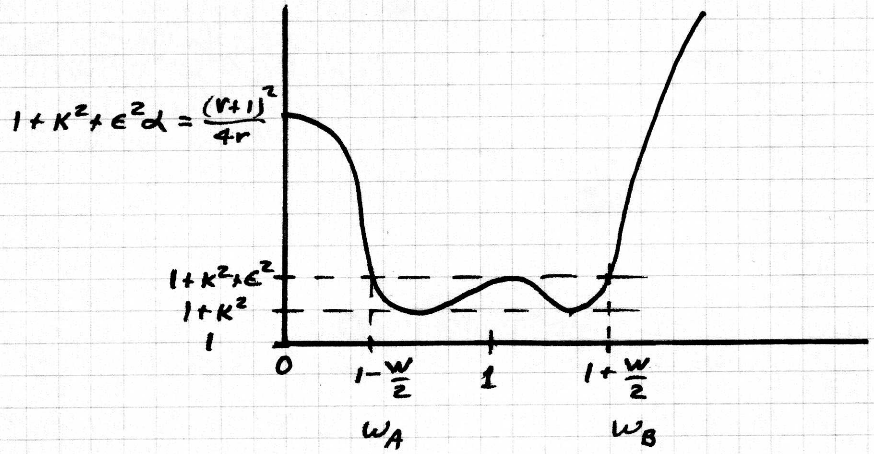
$$-A - \omega_0^2 = -\omega_B^2$$

$$\omega_B^2 = \omega_0^2 + A \qquad \text{eq 2.}$$

eq 1 + eq. 2 $\Rightarrow$ $\omega_0^2 = \dfrac{\omega_A^2 + \omega_B^2}{2}$

eq. 2 − eq 1 $\Rightarrow$ $A = \dfrac{\omega_B^2 - \omega_A^2}{2}$

$$\frac{\omega_A+\omega_B}{2} = 1 \quad \Rightarrow \quad \omega_A = 1-\frac{W}{2}\,, \qquad \omega_B = 1+\frac{W}{2}\,, \qquad \text{WHERE } W = \frac{f_b-f_a}{\bar{f}}\,, \quad \bar{f} = \frac{f_a+f_b}{2}\,.$$

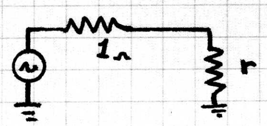


DC MISMATCH LOSS $\quad \lambda=0$

$$S = -j\,\frac{\omega_0^2}{A}$$

$$1+K^2+\epsilon^2\alpha = \left|IL_{LP}\left(\frac{-\omega_0^2}{A}\right)\right|^2 \underset{\text{MUST}}{=} \left|IL_{P.BP}(0)\right|^2$$

@ $\lambda=0$



$$\rho_{P.BP} = \frac{r-1}{r+1} \Rightarrow |\rho_{P.BP}|^2 = \frac{r^2-2r+1}{r^2+2r+1}\,.$$

$$|IL_{P.BP}|^2 = \frac{1}{1-|\rho|^2} = \frac{r^2+2r+1}{r^2+2r+1-r^2+2r-1} = \frac{r^2+2r+1}{4r}$$

$$|IL_{P.BP}|^2 = \frac{(r+1)^2}{4r}$$

$$1+K^2+\epsilon^2\alpha = \frac{(r+1)^2}{4r}$$

$$\epsilon^2\alpha = \frac{(r+1)^2}{4r} - K^2 - 1 = \frac{(r+1)^2-4r-4K^2r}{4r}$$

$$\epsilon^2 = \frac{(r-1)^2}{\alpha 4r} - \frac{K^2}{\alpha} \Rightarrow \epsilon \text{ is a function of } K.$$

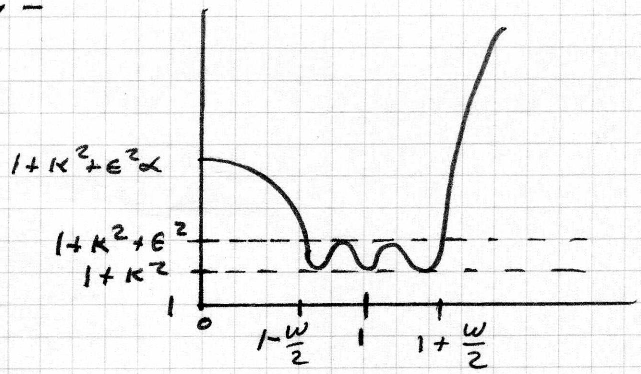
(ie offset AND RIPPLE ARE NOT INDEPENDENT.)

NOTE THAT $\quad \alpha = T_N^2\left(\frac{\omega_0^2}{A}\right) = \cosh^2\left(N\cosh^{-1}\left(\frac{\omega_0^2}{A}\right)\right).$

So, $\quad \epsilon = \sqrt{\left[\frac{(r-1)^2}{4r} - K^2\right] \Big/ \cosh^2\left(N\cosh^{-1}\left(\frac{\omega_0^2}{A}\right)\right)}\,.$

QUASI·LOWPASS RESPONSE – SUMMARY –

MAPPING : $$S = -j\left(\frac{s^2 + \omega_0^2}{A}\right)$$



$$A = \frac{\omega_B^2 - \omega_A^2}{2}$$

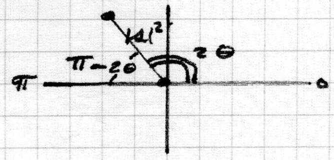
$$\omega_0 = \sqrt{\frac{\omega_A^2 + \omega_B^2}{2}}$$

$$W = \frac{f_b - f_a}{\bar{f}}, \quad \bar{f} = \frac{f_b + f_a}{2} \Rightarrow W = \frac{2(f_b - f_a)}{f_b + f_a}$$

$$\left.\begin{aligned} \omega_A &= 1 - \frac{W}{2} \\ \omega_B &= 1 + \frac{W}{2} \end{aligned}\right\} \quad \omega_{MEAN} = \frac{\omega_A + \omega_B}{2} = 1$$

$\Rightarrow$ DENORMALIZE WRT $2\pi\dfrac{(f_b + f_a)}{2} = \pi(f_b$

INVERSE MAPPING :



$$AjS = s^2 + \omega_0^2$$

$$Aj(\sigma + j\omega) = s^2 + \omega_0^2$$

$$jA\sigma - A\omega - \omega_0^2 = s^2$$

$$s^2 = jA\sigma - (A\omega + \omega_0^2)$$

NOTE: SECOND QUADRAN

$$|s^2| = \sqrt{(A\sigma)^2 + (A\omega + \omega_0^2)^2}$$

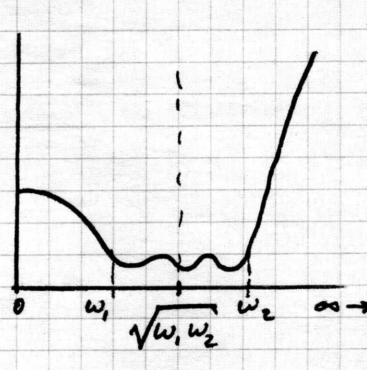
$$|s| = \sqrt[4]{(A\sigma)^2 + (A\omega + \omega_0^2)^2}$$

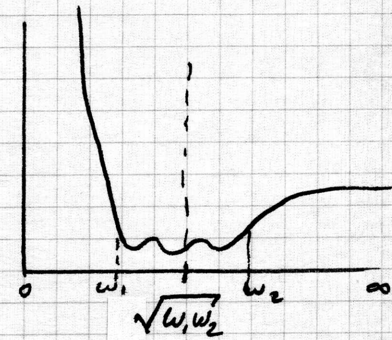
$$2\theta = \tan^{-1}\left[\frac{A\sigma}{-(A\omega + \omega_0^2)}\right] + \pi$$

$$\theta = -\frac{1}{2}\tan^{-1}\left(\frac{A\sigma}{A\omega + \omega_0^2}\right) + \frac{\pi}{2}$$

QUASI-LOWPASS — QUASI-HIGHPASS

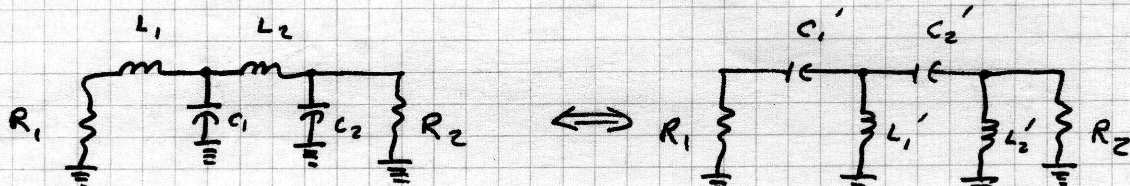
CONSIDER THE MAPPING: $$S = \frac{\omega_1 \omega_2}{s}$$





$$Z = SL = \frac{\omega_1 \omega_2 L}{s} \Rightarrow C' = \frac{1}{\omega_1 \omega_2 L}$$

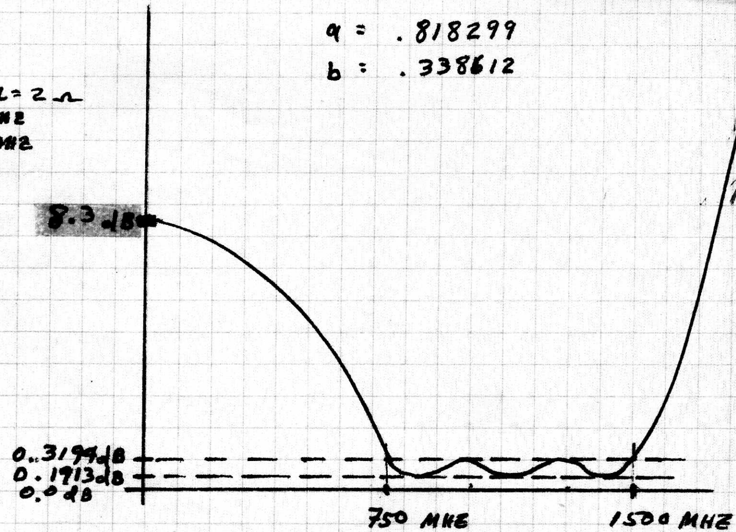
$$Y = SC = \frac{\omega_1 \omega_2 C}{s} \Rightarrow L' = \frac{1}{\omega_1 \omega_2 C}$$



PSEUDO-BANDPASS MATCH EXAMPLE

$Q = 2.5$
$N = 6$
$TR = 25$, $RL = 2\ \Omega$
$f_1 = 750$ MHz
$f_2 = 1500$ MHz

a = .818299
b = .338612



PASSBAND VSWR = 1.725:1
(RIPPLE + OFFSET)

LP POLES (REFLECTION)

$S_1 = -.912815136 + j\,0.$
$S_2 = -.456407568 + j\,1.17257136$
$S_3 = -.456407568 - j\,1.17257136$

LP ZEROS (REFLECTION)

$S_1 = -.35172301 + j\,0.$
$S_2 = -.17258615 + j\,.916164798$
$S_3 = -.17258615 - j\,.916164798$

PSEUDO-BP POLES (REFLECTION)

$s_1, s_1^* = -.279045342 \pm j\,1.09040241$
$s_2, s_2^* = -.110226727 \pm j\,1.38020842$
$s_3, s_3^* = -.243953438 \pm j\,.623626611$

$W = .6666$
$W_A = .6666$
$W_B = 1.3333$
$A = .6666$
$W_0 = 1.054$

PSEUDO-BP ZEROS (REFLECTION)

$s_1, s_1^* = -.108578556 \pm j\,1.05966996$
$s_2, s_2^* = -.0438167638 \pm j\,1.31293852$
$s_3, s_3^* = -.0808051311 \pm j\,.711943853$

ALL LHP FOR MAX REACTANCE ABSORBTION AT LOAD.

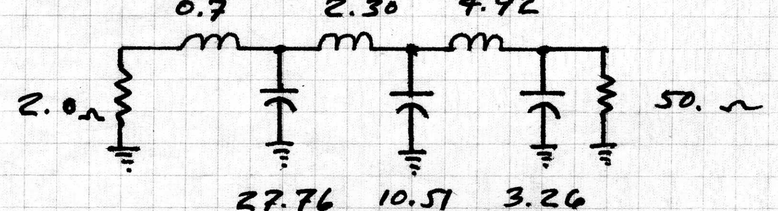
$$\mathrm{Num}\left[\rho(s)\right] = s^6 + .466400902\,s^5 + 3.44209824\,s^4 + 1.09601665\,s^3 + 3.51308897\,s^2 + .559906105\,s + 1.00530933$$

$$\mathrm{DENom}\left[\rho(s)\right] = s^6 + 1.26645101\,s^5 + 4.13528243\,s^4 + 3.31183623\,s^3 + 4.56992394\,s^2 + 1.78999576\,s + 1.08908511$$

$$\frac{Z_{LP}(s)}{R_0} = \frac{2s^6 + 1.7329\,s^5 + 7.5774\,s^4 + 4.4079\,s^3 + 8.083\,s^2 + 2.35\,s + 2.0944}{.8\,s^5 + .6932\,s^4 + 2.216\,s^3 + 1.057\,s^2 + 1.23\,s + .083776}$$

$g(0) = 1.00000$
$g(1) = 2.50000$
$g(2) = 0.39253$
$g(3) = 8.15183$
$g(4) = 0.14863$
$g(5) = 17.39823$
$g(6) = 0.046167$
$g(7) = 25.00000$

$\Rightarrow$



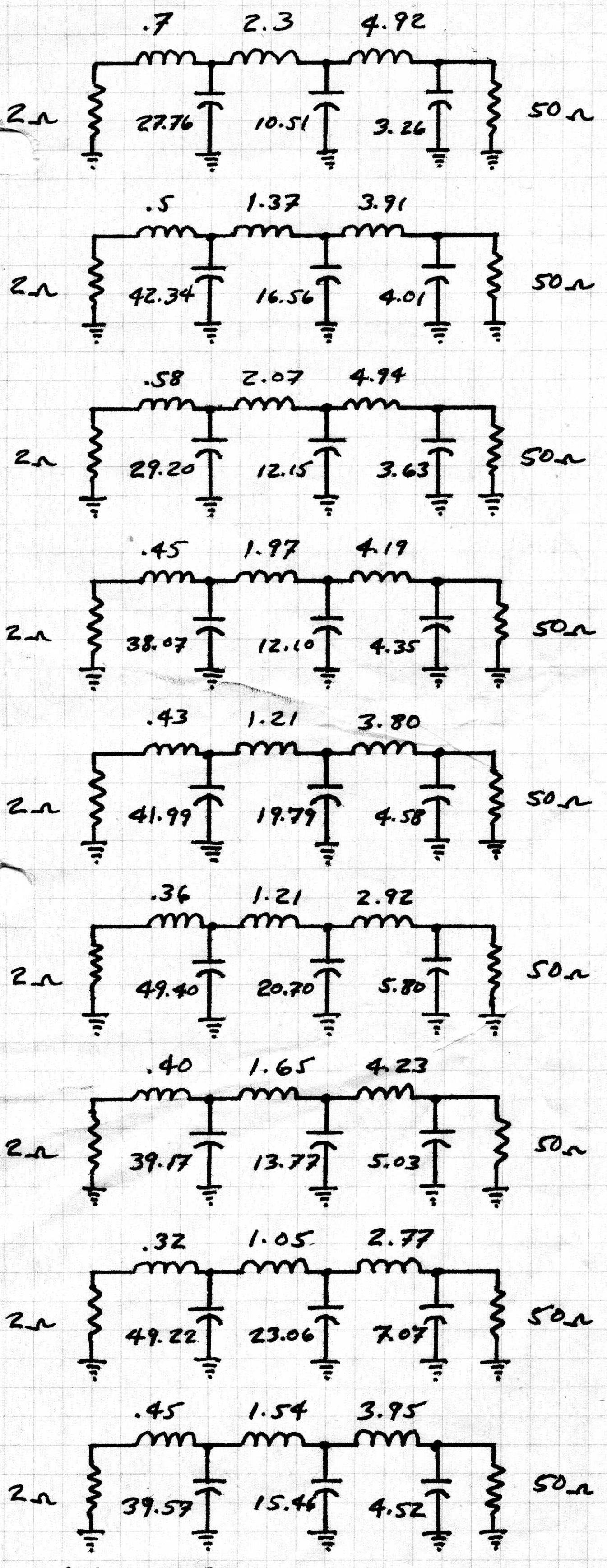
NOTE: .7nH 2Ω

$\Rightarrow Q = 2.5$ @ $f_0 = 1125$ MHz

PSEUDO-BANDPASS MATCH EXAMPLES

$f_1 = 750$ MHZ
$f_2 = 1500$ MHZ

$R_L = 2\,\Omega \Rightarrow TR = 25:1$



OFFSET (dB)	RIPPLE (dB)	RESL. ZERO PLACEMENT
.1913	.12805	$S_1, S_1^* \Rightarrow$ LHP $S_2, S_2^* \Rightarrow$ LHP $S_3, S_3^* \Rightarrow$ LHP
.1913	.12805	$S_1, S_1^* \Rightarrow$ LHP $S_2, S_2^* \Rightarrow$ LHP $S_3, S_3^* \Rightarrow$ RHP
.1913	.12805	$S_1, S_1^* \Rightarrow$ LHP $S_2, S_2^* \Rightarrow$ RHP $S_3, S_3^* \Rightarrow$ LHP
.1913	.12805	$S_1, S_1^* \Rightarrow$ RHP $S_2, S_2^* \Rightarrow$ LHP $S_3, S_3^* \Rightarrow$ LHP
.1913	.12805	$S_1, S_1^* \Rightarrow$ LHP $S_2, S_2^* \Rightarrow$ RHP $S_3, S_3^* \Rightarrow$ RHP
.1913	.12805	$S_1, S_1^* \Rightarrow$ RHP $S_2, S_2^* \Rightarrow$ LHP $S_3, S_3^* \Rightarrow$ RHP
.1913	.12805	$S_1, S_1^* \Rightarrow$ RHP $S_2, S_2^* \Rightarrow$ RHP $S_3, S_3^* \Rightarrow$ LHP
.1913	.12805	$S_1, S_1^* \Rightarrow$ RHP $S_2, S_2^* \Rightarrow$ RHP $S_3, S_3^* \Rightarrow$ RHP
0.0	.13476	$S_1, S_1^* \Rightarrow$ $j\omega$ AXIS $S_2, S_2^* \Rightarrow$ $j\omega$ AXIS $S_3, S_3^* \Rightarrow$ $j\omega$ AXIS

REFLECTION ZEROS:

$|\sigma_1| = .108578556$
$|\omega_1| = 1.05966996$
$|\sigma_2| = 0.0438167638$
$|\omega_2| = 1.31293852$
$|\sigma_3| = 0.0808051311$
$|\omega_3| = 0.711943853$

NOTE THAT EACH OF THE FIRST EIGHT NETWORKS YIELD IDENTICAL INSERTION LOSS (MAGNITUDE) RESPONSES. YET, BY MOVING THE REFLECTION ZEROS, THE REACTANCE DISTRIBUTION THROUGHOUT THE NETWORK IS CHANGED.
ALL LHP ZEROS ⇒ MAX REACT. AT LOW Z SIDE.
ALL RHP ZEROS ⇒ MAX REACT. AT HI Z SIDE.
NO OFFSET LOSS ($j\omega$ AXIS ZEROS) YIELDS THE LAST NETWORK.

PSEUDO-BANDPASS EXAMPLE – DETAILS of 1st N=6 EXAMPLE (All LHP ZERO

$$\text{OFFSET} = 0.1913\ dB \Rightarrow 1+K^2 = 10^{.01913}$$

$$K^2 = .045046$$

$$K = .21224$$

$$f_a = 750$$

$$f_b = 1500$$

$$\Rightarrow W = \frac{2(1500-750)}{1500+750} = 0.66667$$

$$W_A = 1 - \frac{W}{2} = .66667$$

$$W_B = 1 + \frac{W}{2} = 1.3333$$

$$A = \frac{W_B^2 - W_A^2}{2} = .66667$$

$$W_0 = \sqrt{\frac{W_B^2 + W_A^2}{2}} = 1.05409$$

$$r = 25$$

$$N_{PSEUDO\cdot BP} = 6 \Rightarrow N_{LP} = 3$$

$$\epsilon = \sqrt{\left(\frac{(r-1)^2}{4r} - K^2\right) \Big/ \cosh^2\left[N \cosh^{-1}\left(\frac{W_0^2}{A}\right)\right]} = .1768$$

RECALL,

$$a = \frac{1}{N} \sinh^{-1} \sqrt{\frac{1+K^2}{\epsilon^2}} = .8184$$

$$b = \frac{1}{N} \sinh^{-1}\left(\frac{K}{\epsilon}\right) = .3387$$

- FANO'S a and b ALLOW POLES AND ZEROS of LP ρ TO BE OBTAINED.
- PSEUDO-BANDPASS REFLECTION POLES AND ZEROS ARE THEN OBTAINED VIA LP – PBP MAPPING.
- DRIVING-POINT IMPEDANCE FUNCTION IS FORMED.
- CONTINUED FRACTION EXPANSION IS PERFORMED
- DENORMALIZATION COMPLETES THE SYNTHESIS

$$\begin{array}{r|l} & 2.5s \\ \hline .8s^5 + .6932s^4 + 2.216s^3 + 1.057s^2 + 1.23s + .083776 & 2s^6 + 1.7329s^5 + 7.5774s^4 + 4.4079s^3 + 8.083s^2 + 2.35s + 2.0944 \\ & \underline{2s^6 + 1.733s^5 + 5.54s^4 + 2.6425s^3 + 3.075s^2 + .209s} \\ & 2.0374s^4 + 1.7654s^3 + 5.008s^2 + 2.141s + 2.0944 \end{array}$$

$$\begin{array}{r|l} & .3926s \\ \hline 2.0374s^4 + 1.7654s^3 + 5.008s^2 + 2.141s + 2.0944 & .8s^5 + .6932s^4 + 2.216s^3 + 1.057s^2 + 1.23s + .083776 \\ & \underline{.8s^5 + .6932s^4 + 1.966s^3 + .8407s^2 + .822s} \\ & .25s^3 + .2163s^2 + .408s + .083776 \end{array}$$

$$\begin{array}{r|l} & 8.15s \\ \hline .25s^3 + .2163s^2 + .408s + .083776 & 2.0374s^4 + 1.7654s^3 + 5.008s^2 + 2.141s + 2.0944 \\ & \underline{2.0374s^4 + 1.763s^3 + 3.325s^2 + .6828s} \\ & 1.683s^2 + 1.4582s + 2.0944 \end{array}$$

$$\begin{array}{r|l} & .1486s \\ \hline 1.683s^2 + 1.4582s + 2.0944 & .25s^3 + .2163s^2 + .408s + .083776 \\ & \underline{.25s^3 + .2167s^2 + .311s} \\ & .097s + .083776 \end{array}$$

$$\begin{array}{r|l} & 17.35s \\ \hline .097s + .083776 & 1.683s^2 + 1.4582s + 2.0944 \\ & \underline{1.683s^2 + 1.454s} \\ & 2.0944 \end{array}$$

$$\begin{array}{r|l} & .0463s \\ \hline 2.0944 & .097s + .083776 \\ & \underline{.097s} \\ & .083776 \end{array}$$

$$\frac{2.0944}{.083776} = 25.0$$

$g_0 = 1.0000$
$g_1 = 2.5000$
$g_2 = 0.3926$
$g_3 = 8.1500$
$g_4 = 0.1486$
$g_5 = 17.3500$
$g_6 = 0.0463$
$g_7 = 25.0000$

SYMMETRIC — DISCUSS PHYSICAL AND ELECTRICAL SYMMETRY

eg. NO OFFSET, ODD ORDER LP PROTOTYPE

$$g_0 = g_{N+1}$$
$$g_1 = g_N$$
$$g_2 = g_{N-1}$$
$$\vdots$$
$$g_{\frac{N+1}{2}} = g_{\frac{N+1}{2}}$$

2nd HALF NETWORK EQUIVALENT TO 1st.

ANTIMETRIC — DISCUSS PHYSICAL AND ELECTRICAL ANTI-SYMMETRY

eg. NO OFFSET, EVEN ORDER LP OR QUASI-LP PROTOTYPE

$$g_0 = 1 \Rightarrow g_{N+1} = r\,g_0 = r$$
$$g_1 \Rightarrow g_N = \frac{g_1}{r}$$
$$g_2 \Rightarrow g_{N-1} = r\,g_2$$
$$\vdots$$
$$g_{\frac{N}{2}} \Rightarrow g_{\frac{N}{2}+1} = r\,g_{N/2} \quad \text{for } \tfrac{N}{2} \text{ EVEN.}$$
$$= \frac{g_{N/2}}{r} \quad \text{for } \tfrac{N}{2} \text{ ODD.}$$

SIGNIFICANCE OF OFFSET

$$K = 0 \Rightarrow b = 0$$

$$\therefore \quad g_k\, g_{k+1} = \frac{4 \sin\left(\frac{2k-1}{2N}\pi\right) \sin\left(\frac{2k+1}{2N}\pi\right)}{\sinh^2(a) + \sin^2\left(\frac{k\pi}{N}\right)}$$

$$g_0\, g_1 = \frac{2 \sin\left(\frac{\pi}{2N}\right)}{\sinh(a)} = g_N\, g_{N+1}$$

IE SYMMETRY / ANTISYMMETRY ; SAME SOURCE AND LOAD Q.