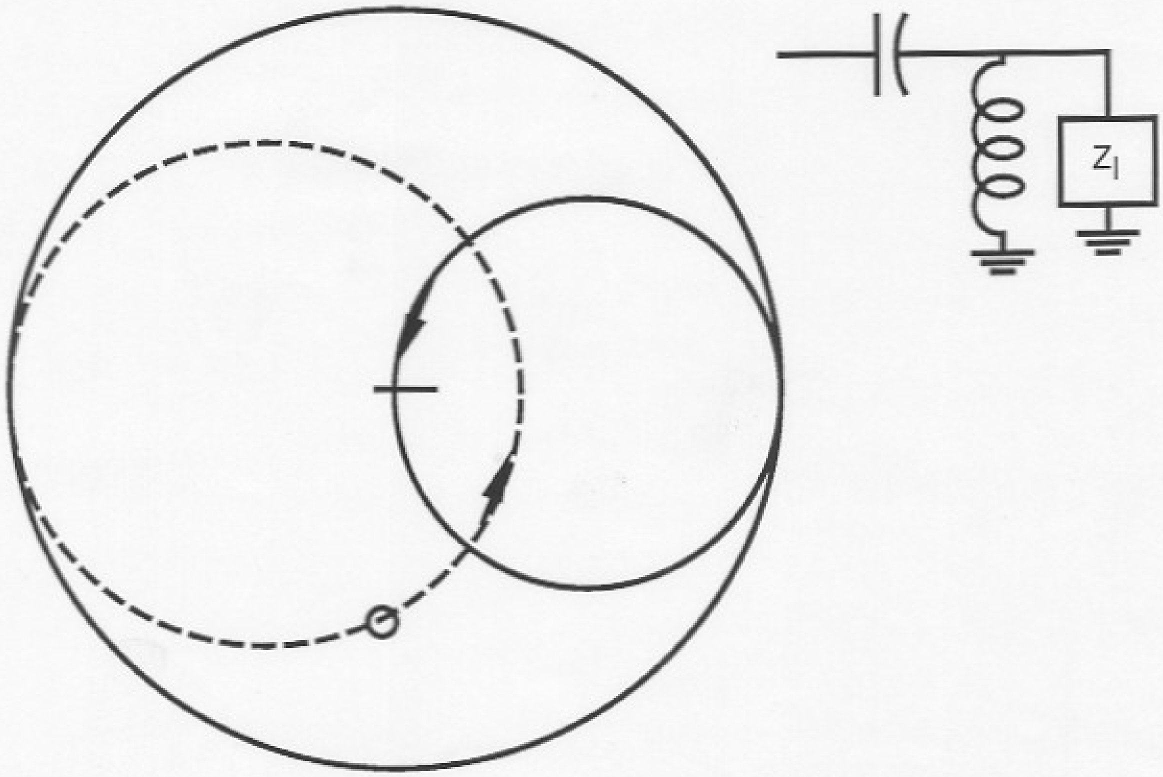
ECE 202A Notes set 5

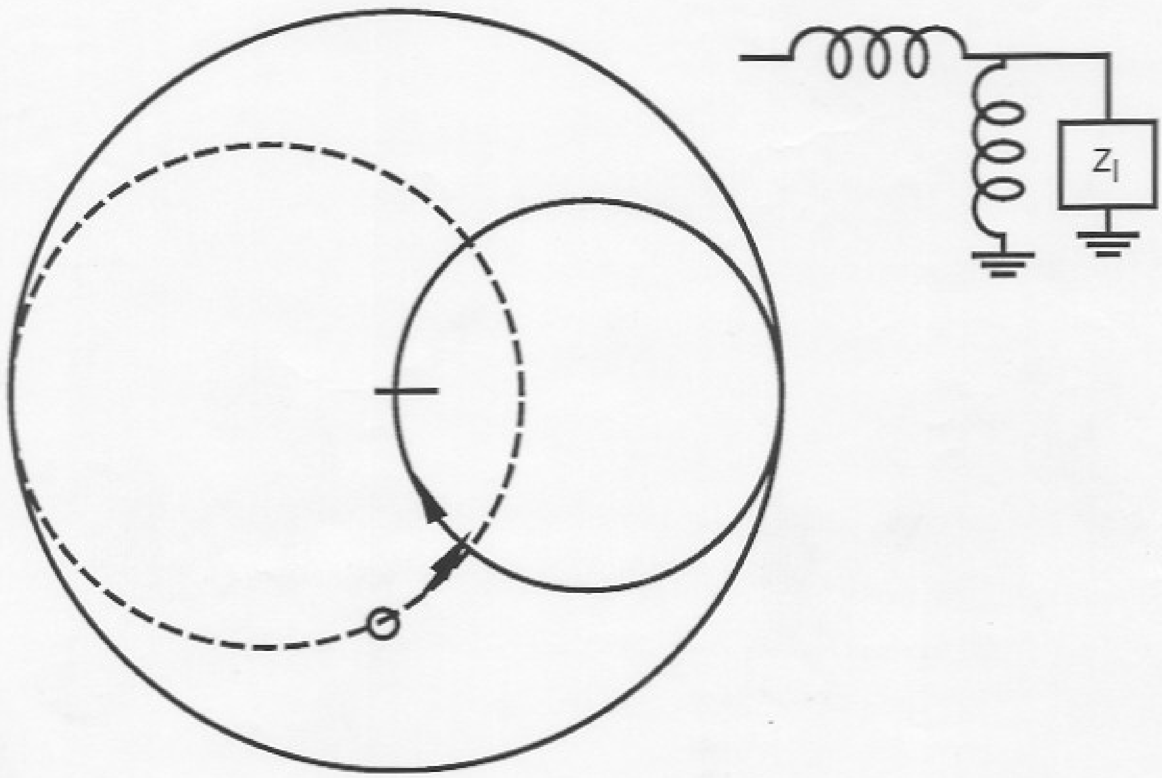
Impedance Matching Lecture.

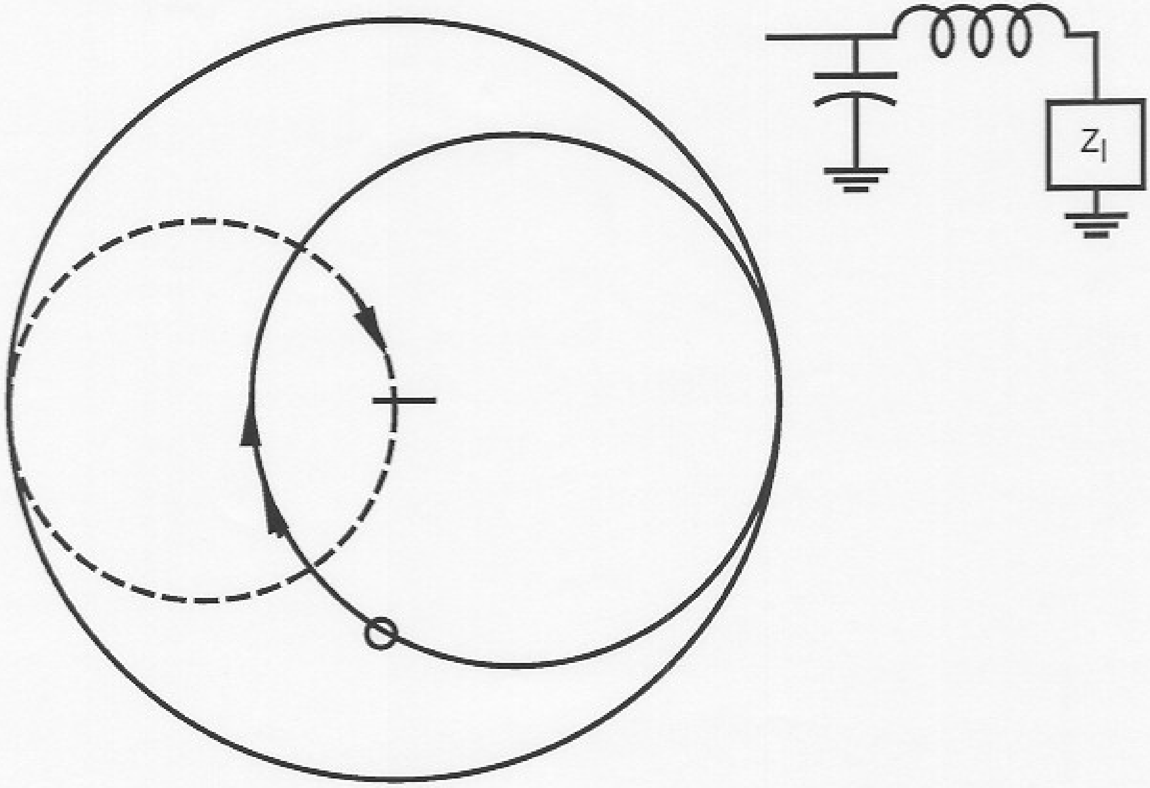
Most of what follows is best discussed (graphically) in the lecture. The following pages are intended to be used as view-graph foils in lectures. write on your copy during the discussion.

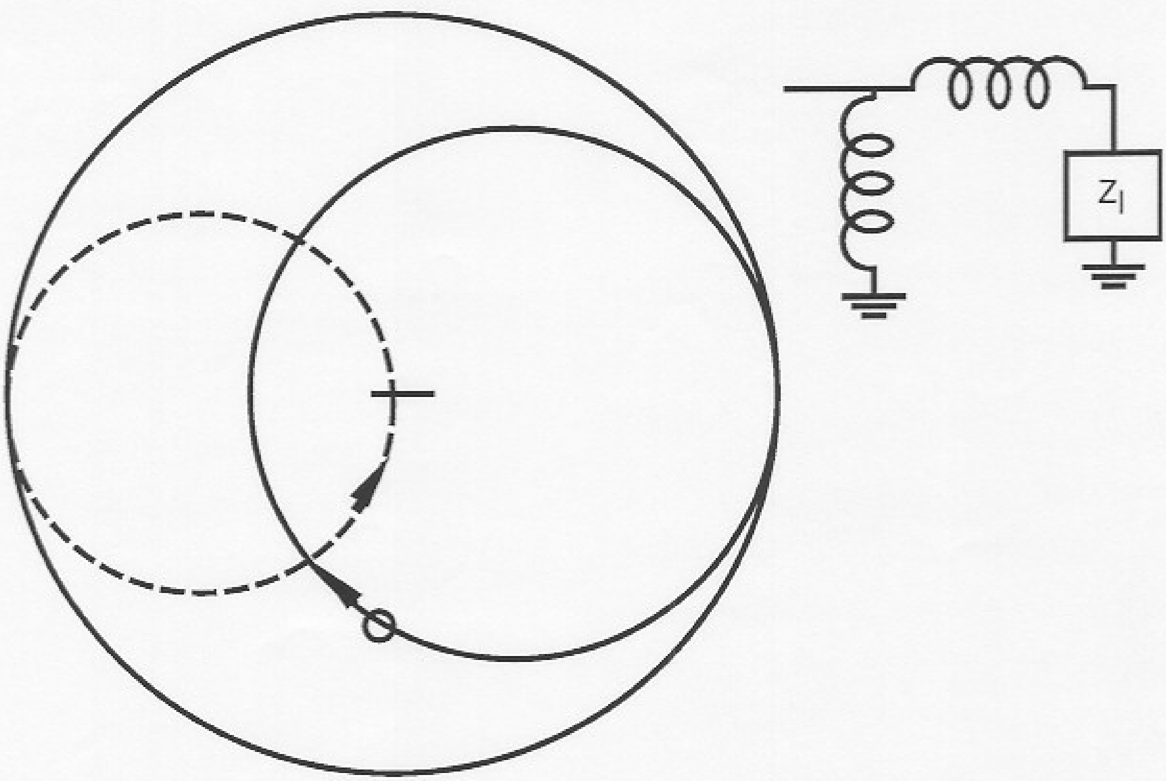
one item will be written down here: distributed realizations of lumped matching networks (next page.)

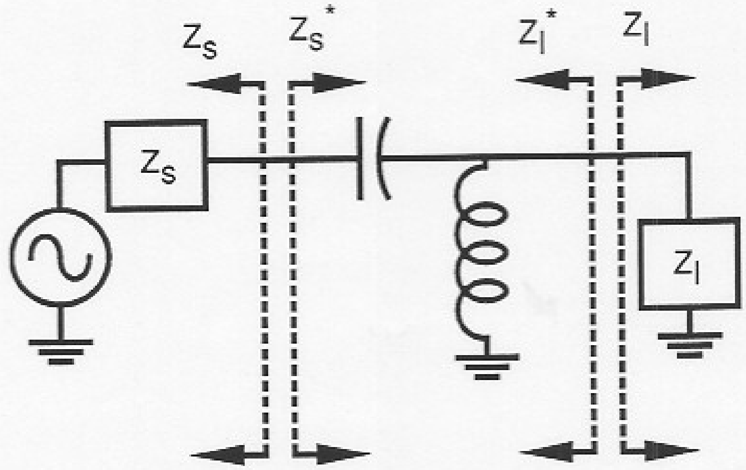
Impedance Matching Lecture.

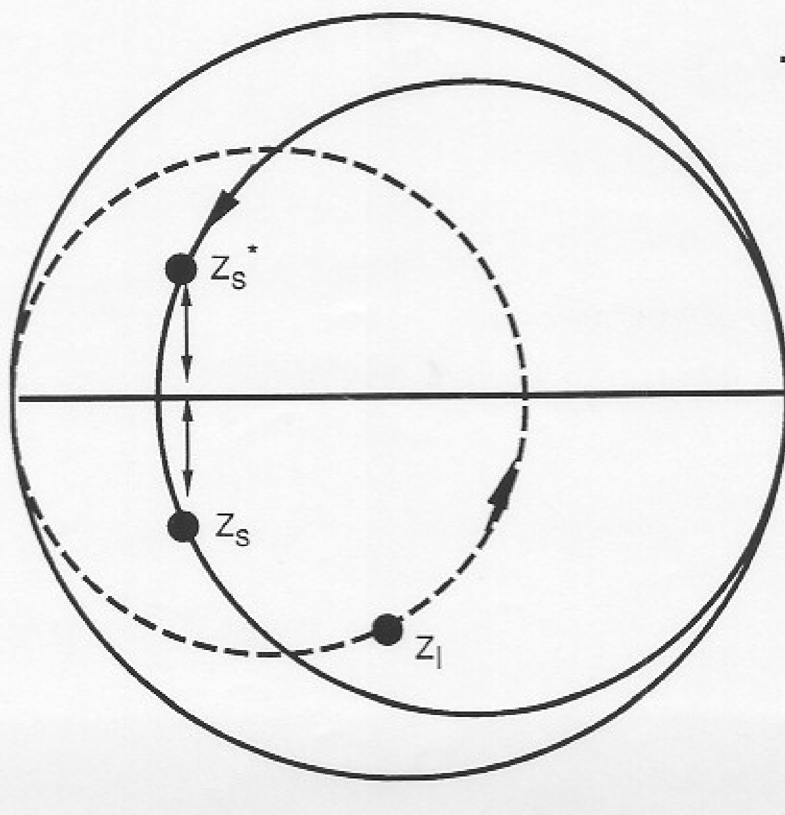


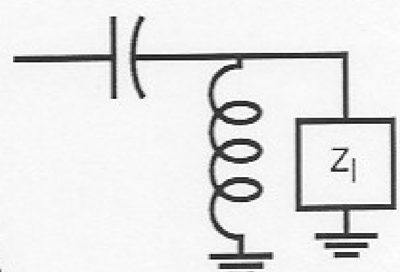



Z1

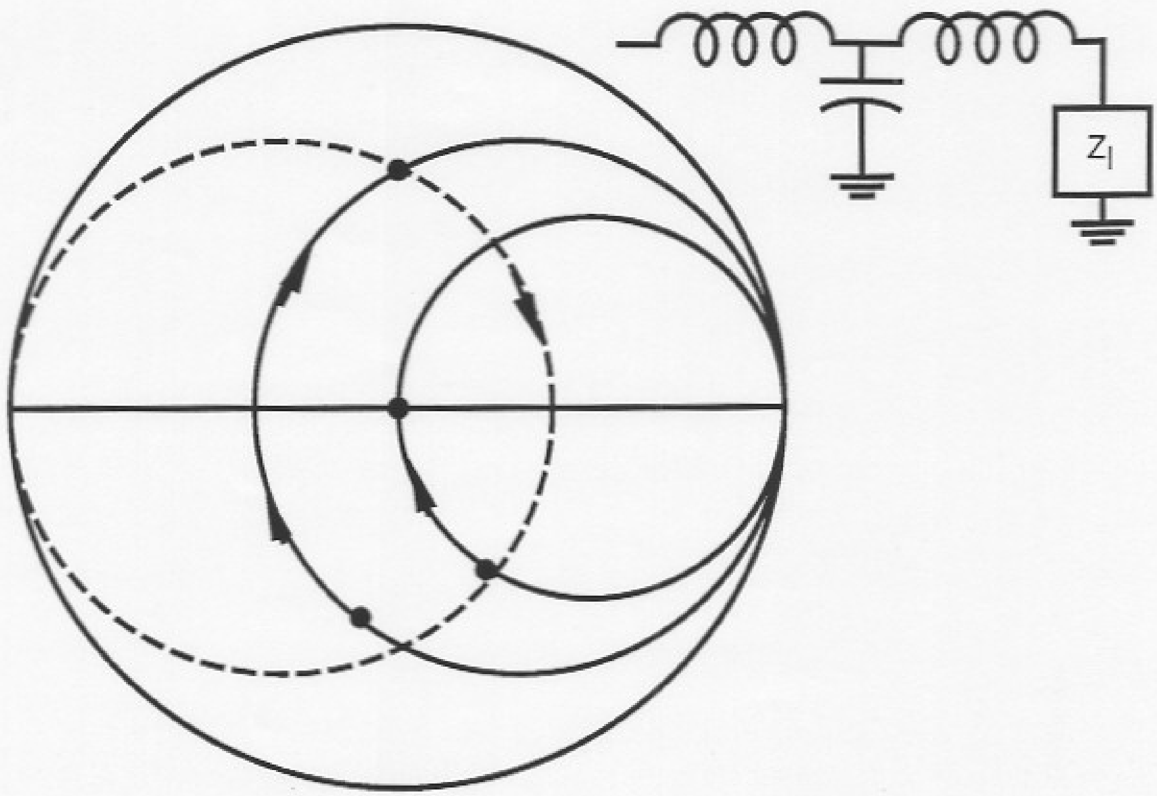

Z1

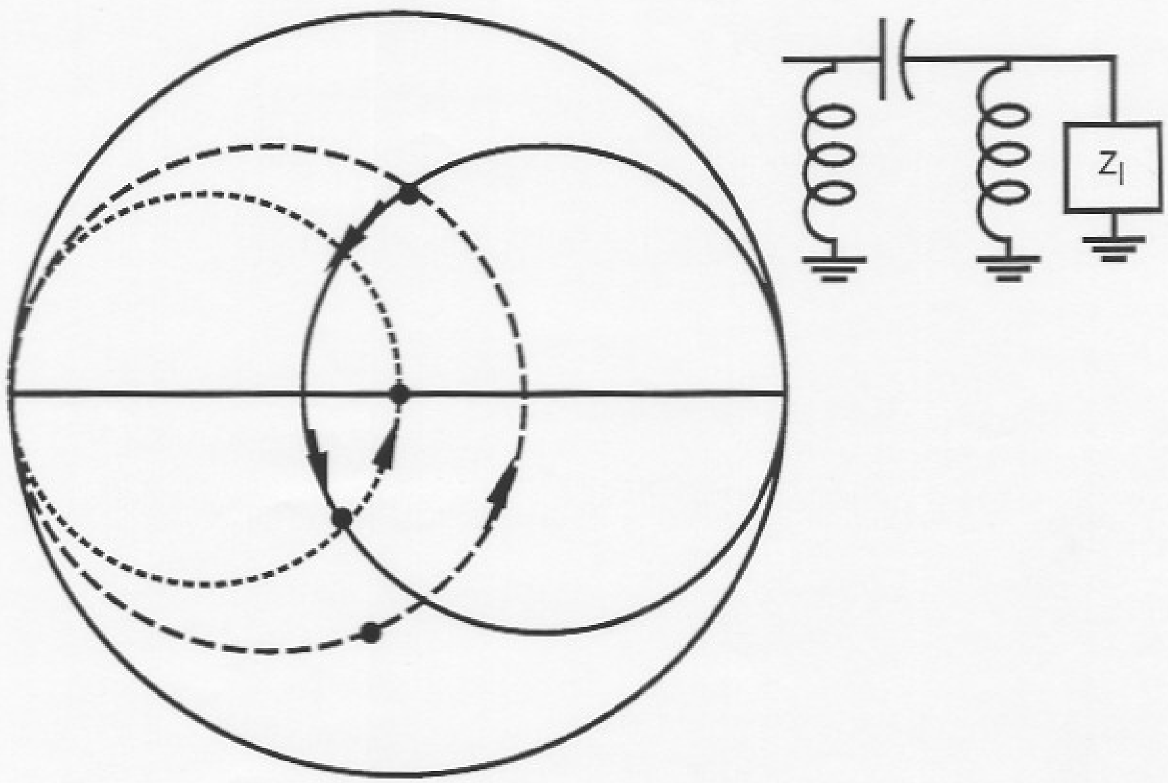

Z_s
Z_s^*
Z_l^*
Z_l
Z_s
Z_l


Z_s^*
Z_s
Z_l

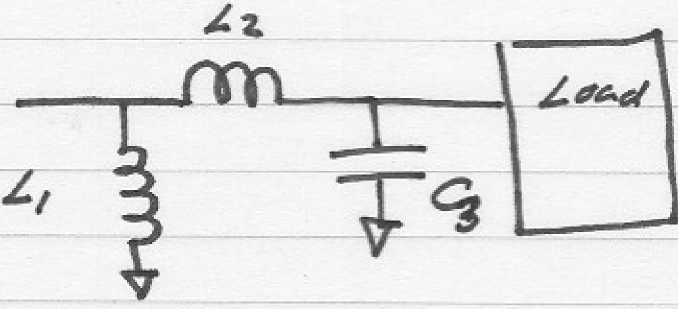

Z_l

1d

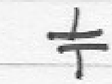
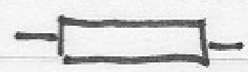




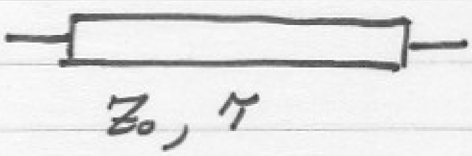
Suppose we have designed a lumped impedance-matching network, thus:

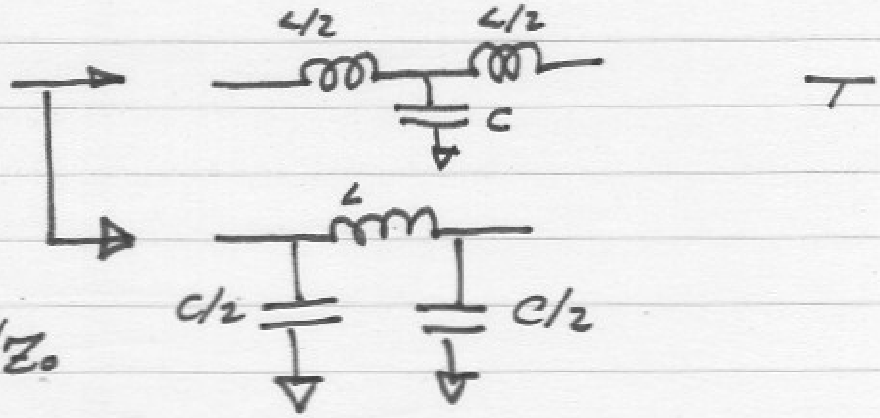


this example has shunt and series inductors and a shunt capacitor. Think for a moment as to why no series capacitor has been chosen.

we may not have  &  available to us, only  of impedances over the range Z_{min} to Z_{max}.

recall the models of <u>short</u> trans. lines:





$L = T Z_0$, $C = T / Z_0$

Comment on electrical length:

The Microwave literature will say a line is 43° long at 5 GHz (f_{ref}). what does this mean?

Electrical length $= E = \dfrac{\ell}{\lambda_{ref}} \cdot 360°$

recall $f \cdot \lambda = v$ so $f_{ref} \lambda_{ref} = v$

$$\rightarrow E = \frac{\ell}{v / f_{ref}} \cdot 360° = \frac{\ell}{v} \cdot f_{ref} \cdot 360°$$

$$\boxed{E = T \cdot f_{ref} \cdot 360°}$$

I, like the people who wrote the program SPICE, find the "electrical length" description cumbersome.

a line which is 1 ns long has an electrical length $E = 360°$ at $f_{ref} = 1$ GHz

and

an electrical length $E = 36°$ at $f_{ref} = 100$ MHz.

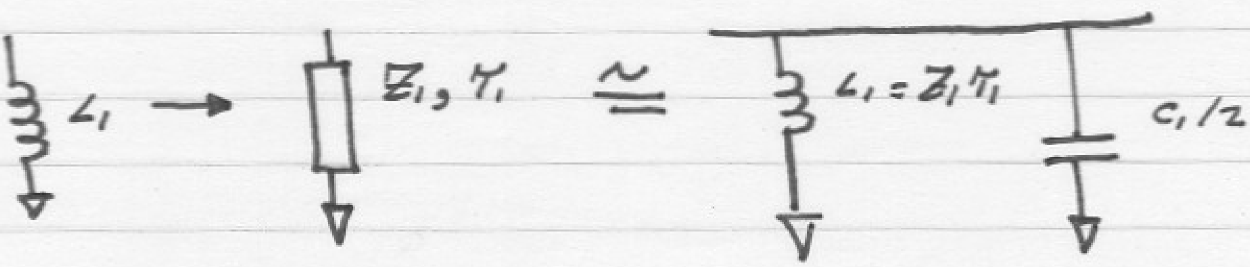
why not just say $\tau = 1$ ns ?

... you should be conversant with

<u>Both</u> terminologies.

... lets approximate our —ꟽ— & —||—

with —▭—

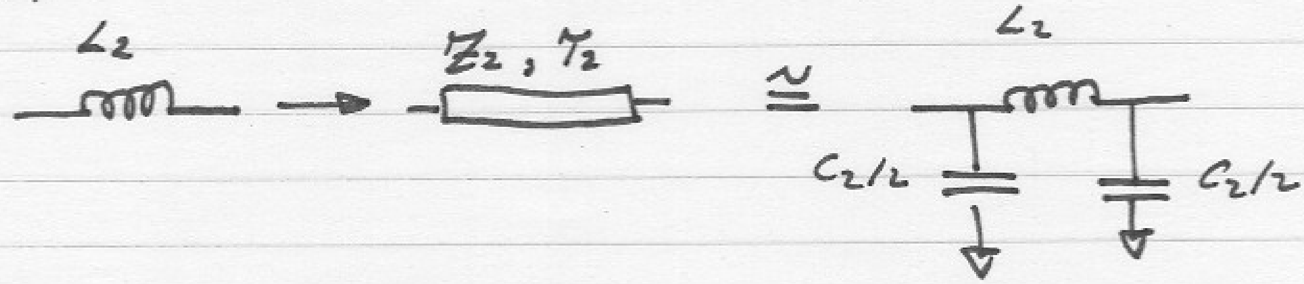


$C_1 = \tau_1 / Z_1 = L_1 / Z_1^2$

So, we have obtained the inductor L_1 we desire, together with a $C_1/2$ which we do not. C_1 does vary as $1/Z_1^2$, so using a high impedance line helps greatly in reducing C_1

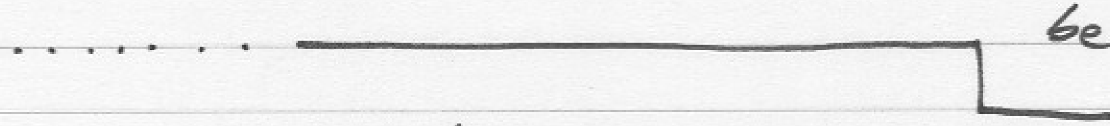
The issue will always be: is the undesired C sufficiently small?

approximate:

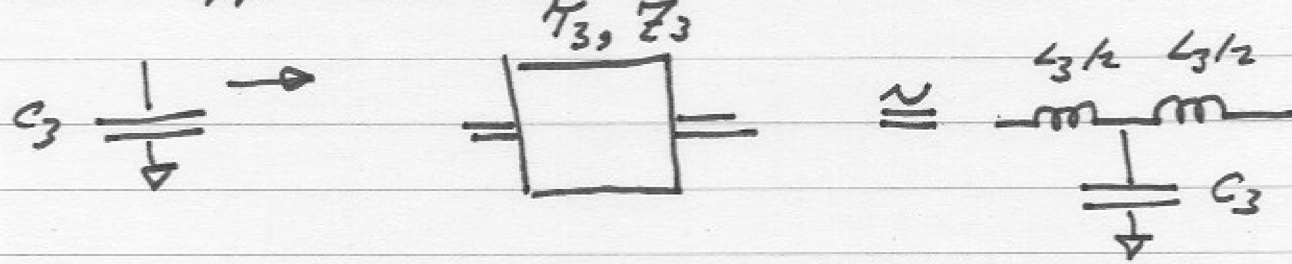


again $L_2 = Z_2 \tau_2$

$C_2 = \tau_2 / Z_2 = L_2 / Z_2^2$ $\Rightarrow$ Z_2 should be high.



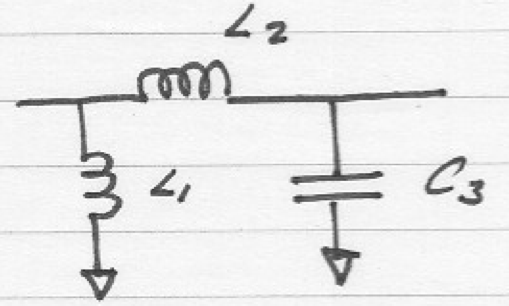
and approximate:



$$C_3 = \tau_3 / Z_3$$

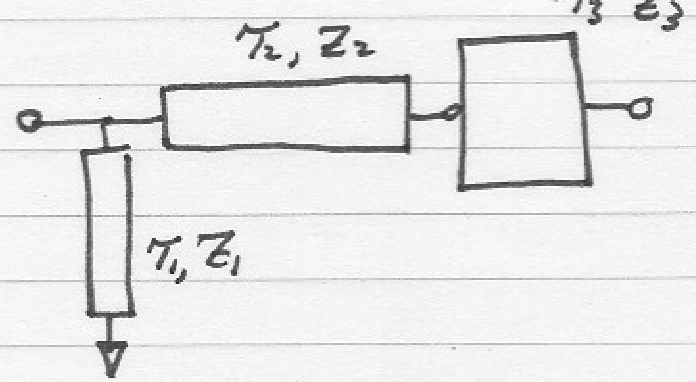
$L_3 = \tau_3 Z_3 = C_3 Z_3^2 \rightarrow$ Z_3 should be <u>low</u>.

so we started with this

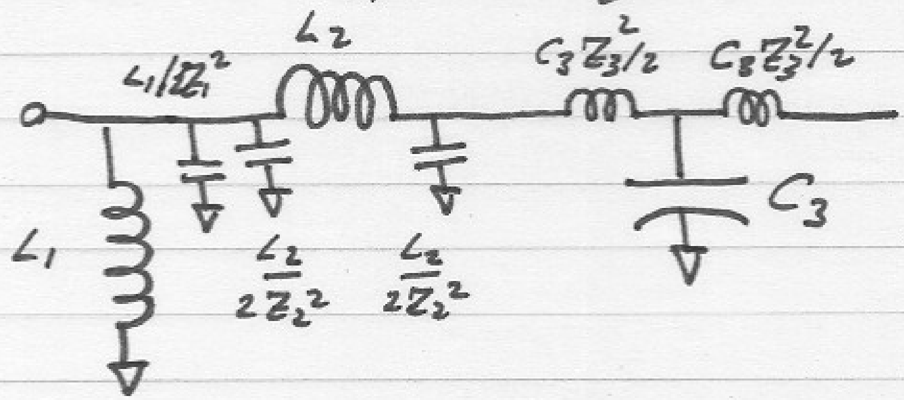


approximated it with this:

$\Longrightarrow$

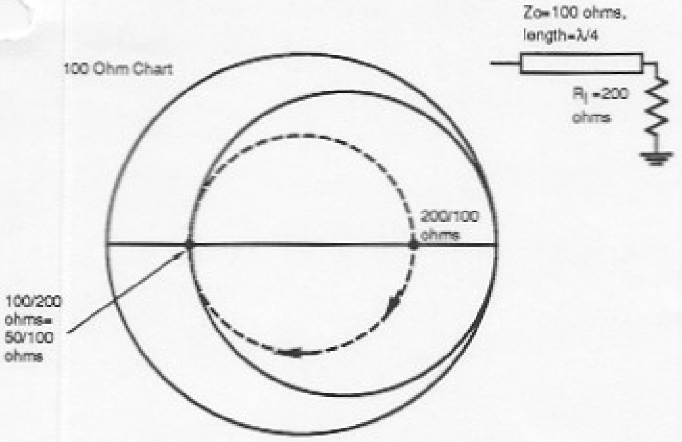


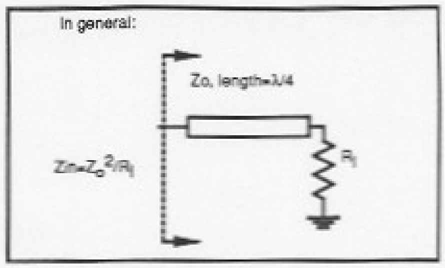
which is approximately this:



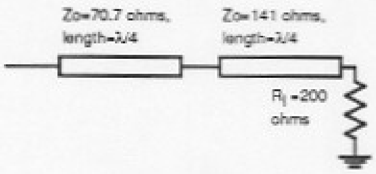
... If Z_1 and Z_2 are <u>sufficiently high</u>
and Z_3 sufficiently low
this will approximate the desired network.

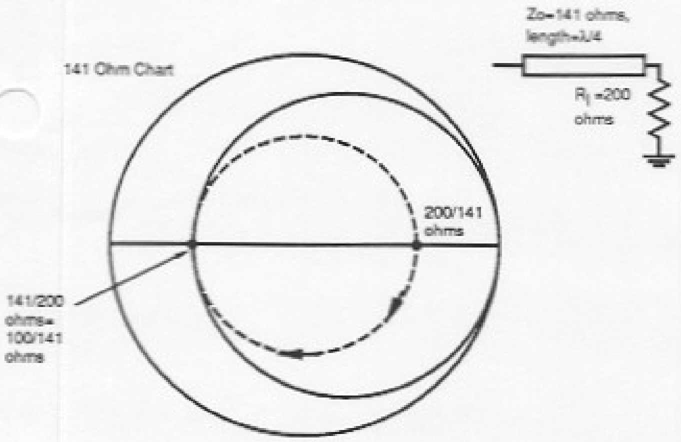
Single matching section

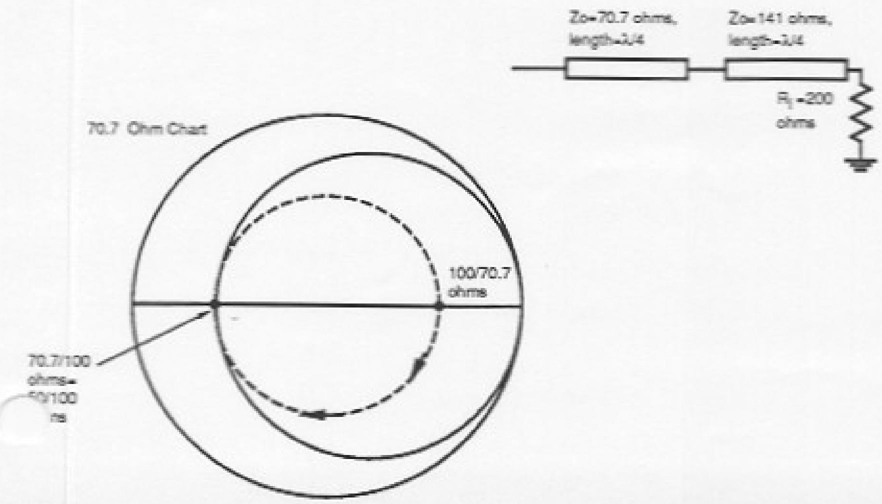




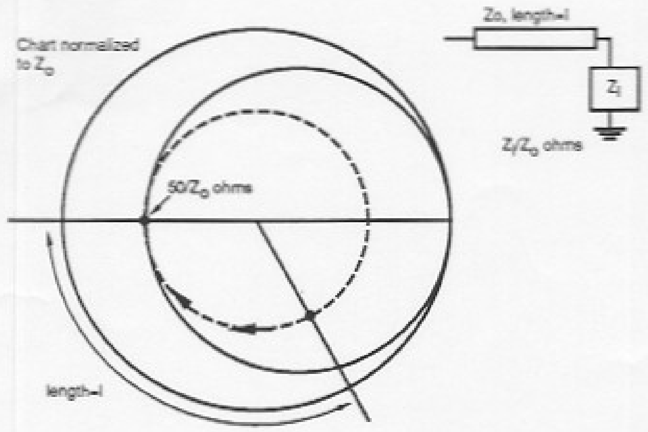
Multi-Section







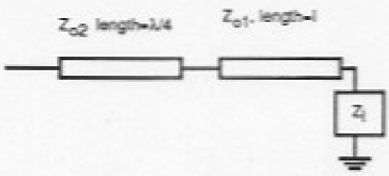
Single-section

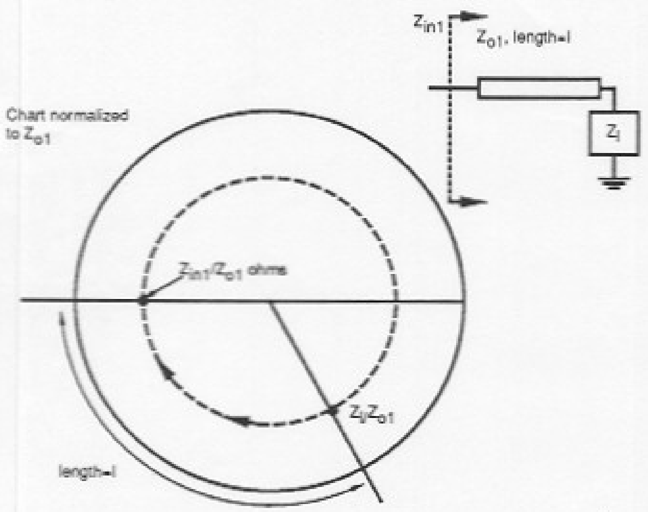


Advantage: Single element
Disadvantage: No Clear Synthesis procedure, cut-and-try design method only

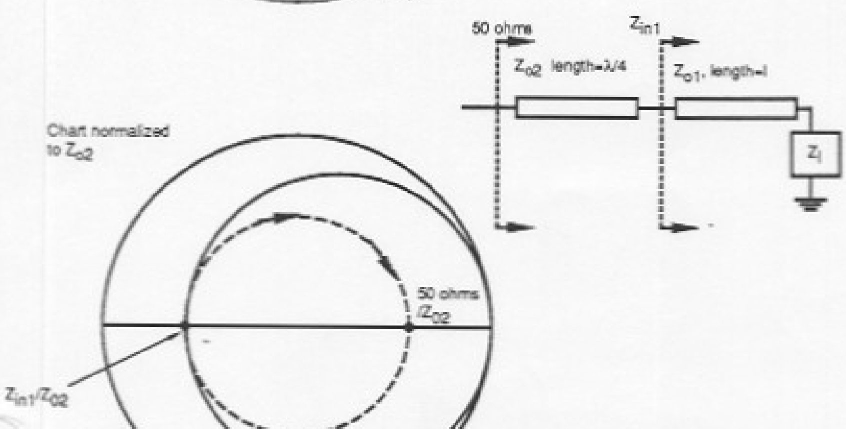
---

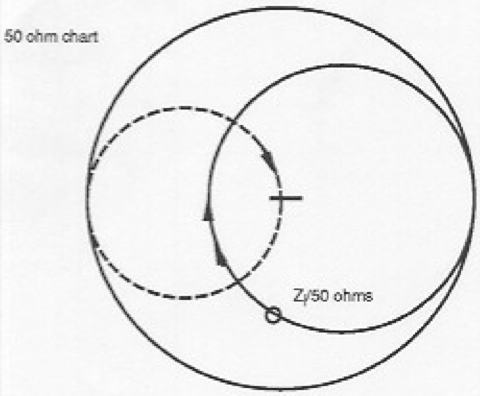
Two-Section

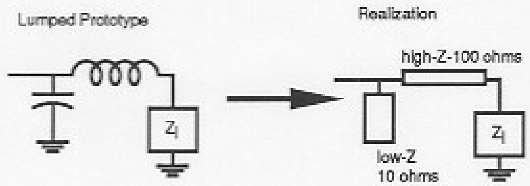


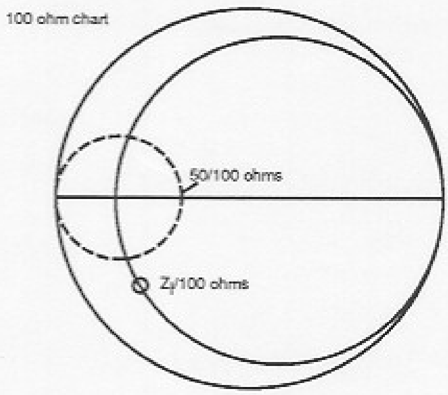


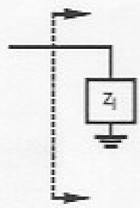
Suggestion for design:
If Zload is capacitive, make first line high-impedance,
If Zload is inductive, make first line low-impedance

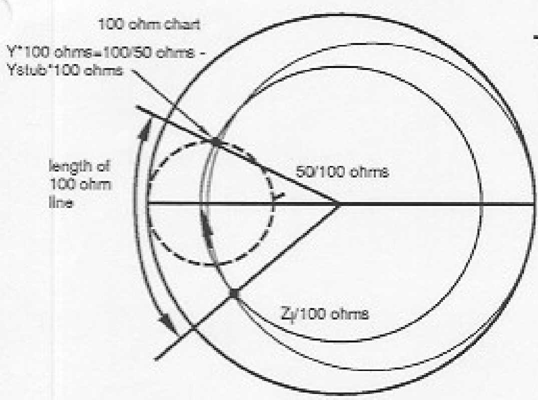


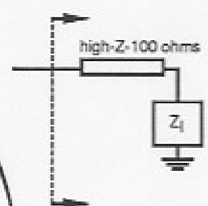

50 ohm chart
Zl/50 ohms

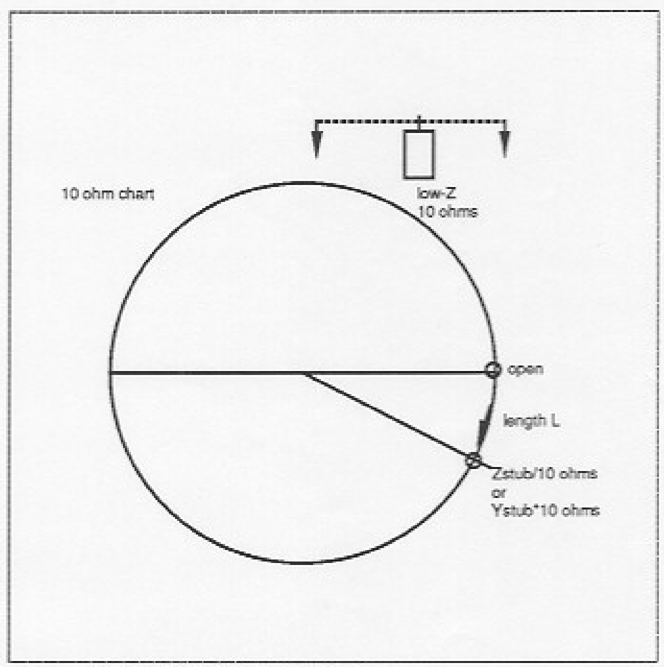

Lumped Prototype
Zl
Realization
high-Z-100 ohms
low-Z
10 ohms
Zl

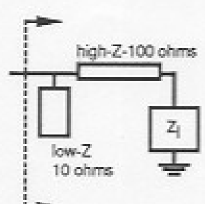

100 ohm chart
50/100 ohms
Zl/100 ohms

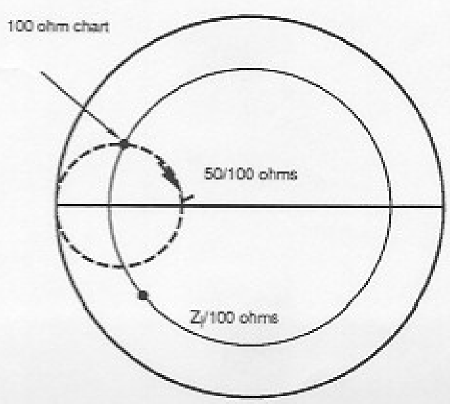

Zl

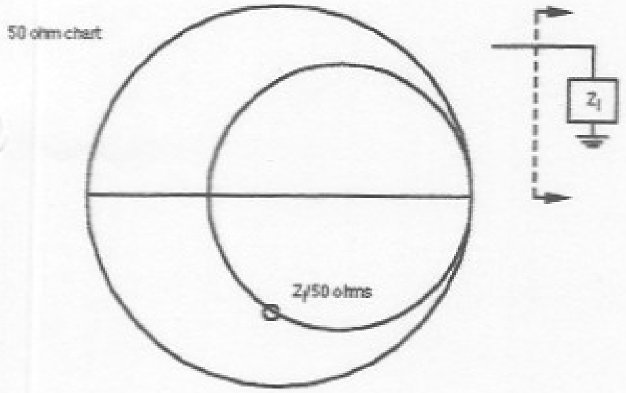

100 ohm chart
Y*100 ohms=100/50 ohms -
Ystub*100 ohms
length of
100 ohm
line
50/100 ohms
Zl/100 ohms

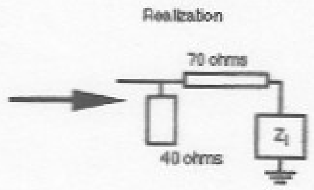

high-Z-100 ohms
Zl

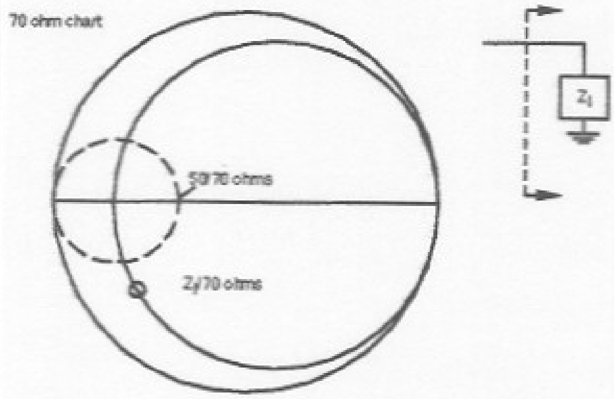

10 ohm chart
low-Z
10 ohms
open
length L
Zstub/10 ohms
or
Ystub*10 ohms

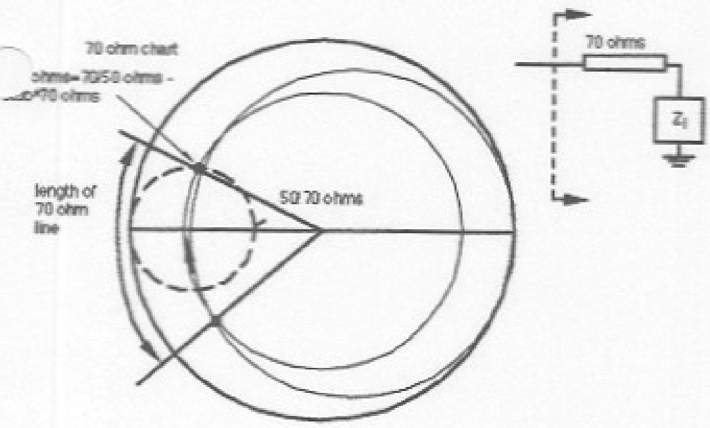

high-Z-100 ohms
low-Z
10 ohms
Zl

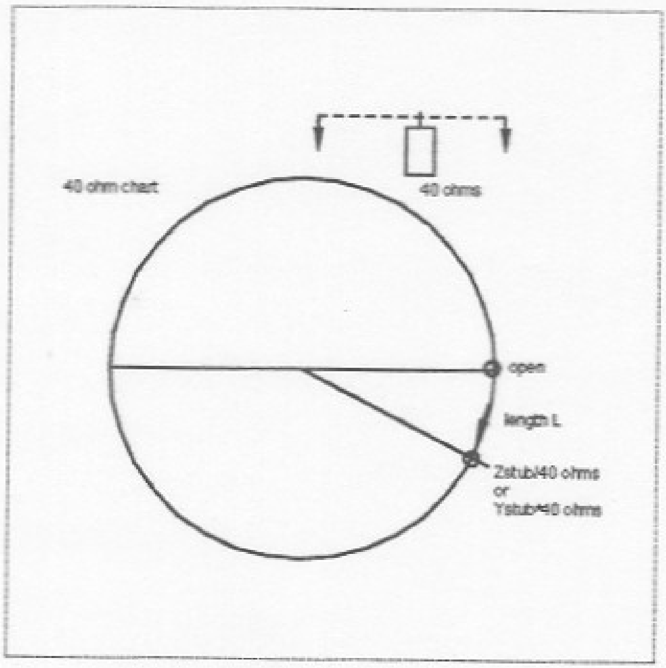

100 ohm chart
50/100 ohms
Zl/100 ohms

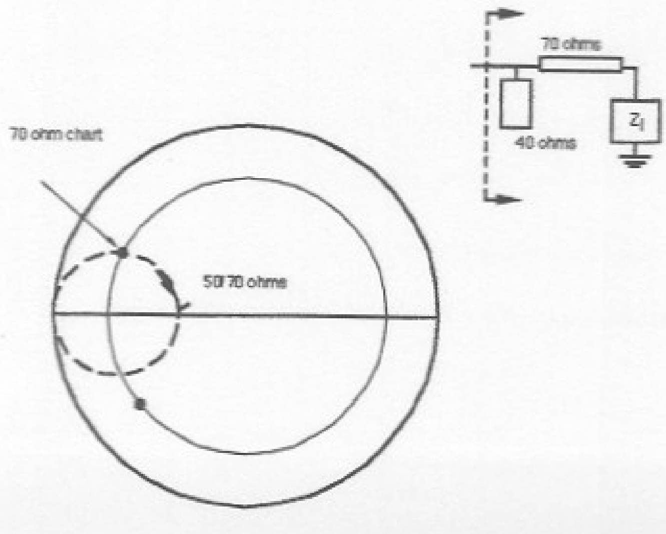

50 ohm chart
Z_l/50 ohms
Z_l

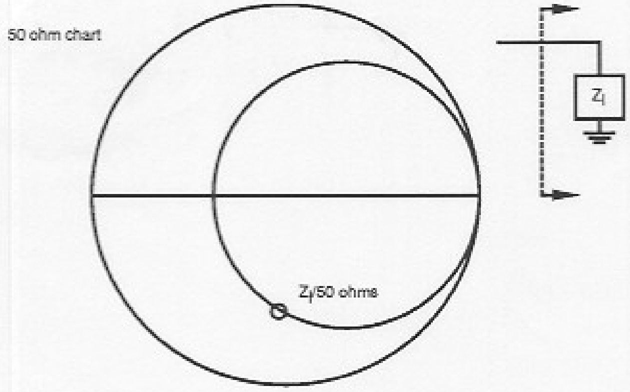

Realization
70 ohms
40 ohms
Z_l

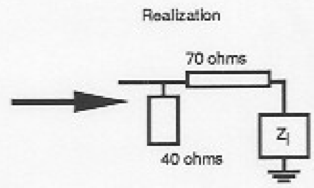

70 ohm chart
50/70 ohms
Z_l/70 ohms
Z_l

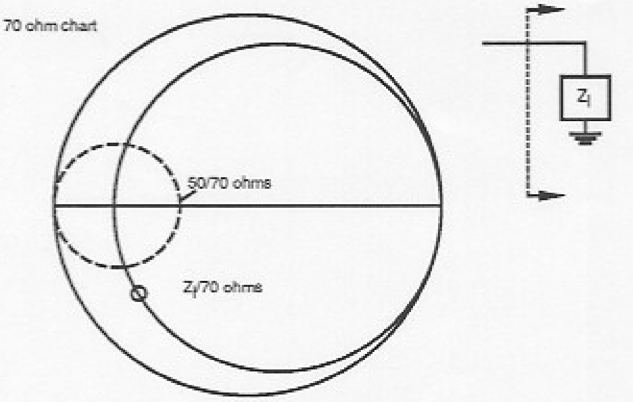

70 ohm chart
length of 70 ohm line
50/70 ohms
70 ohms
Z_l

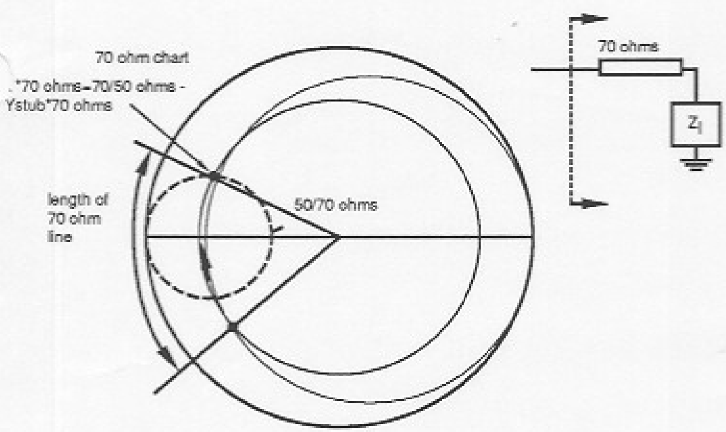

40 ohms
40 ohm chart
open
length L
Zstub/40 ohms
or
Ystub*40 ohms

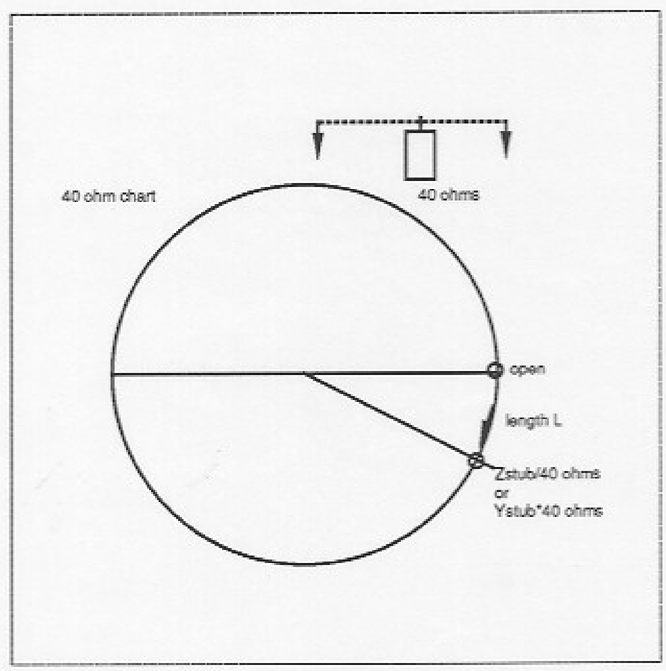

70 ohms
40 ohms
Z_l
70 ohm chart
50/70 ohms

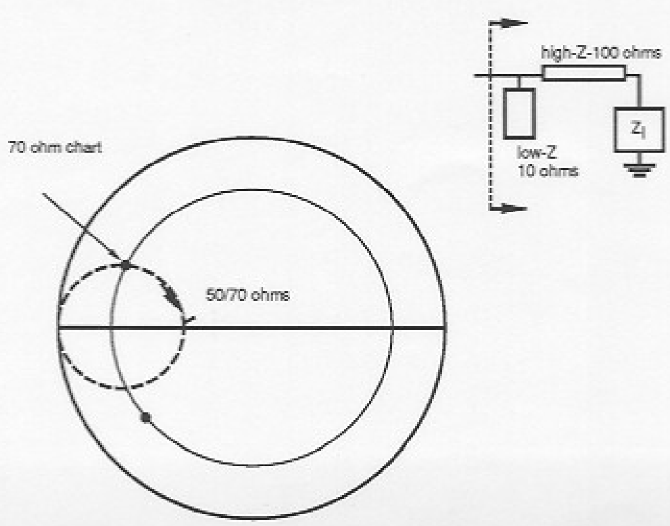

50 ohm chart
Z_l/50 ohms
Z_l


Realization
70 ohms
40 ohms
Z_l


70 ohm chart
50/70 ohms
Z_l/70 ohms
Z_l


70 ohm chart
*70 ohms=70/50 ohms -
Ystub*70 ohms
length of
70 ohm
line
50/70 ohms
70 ohms
Z_l


40 ohm chart
40 ohms
open
length L
Zstub/40 ohms
or
Ystub*40 ohms


70 ohm chart
50/70 ohms
high-Z-100 ohms
low-Z
10 ohms
Z_l