Matching Networks

- MNs are critical for at least two critical reasons
  - maximize power transfer: $P_t = P_i - P_r = P_i(1 - |\Gamma_{in}|^2)$
  - minimize $SWR = \frac{1 + |\Gamma_{in}|}{1 - |\Gamma_{in}|}$

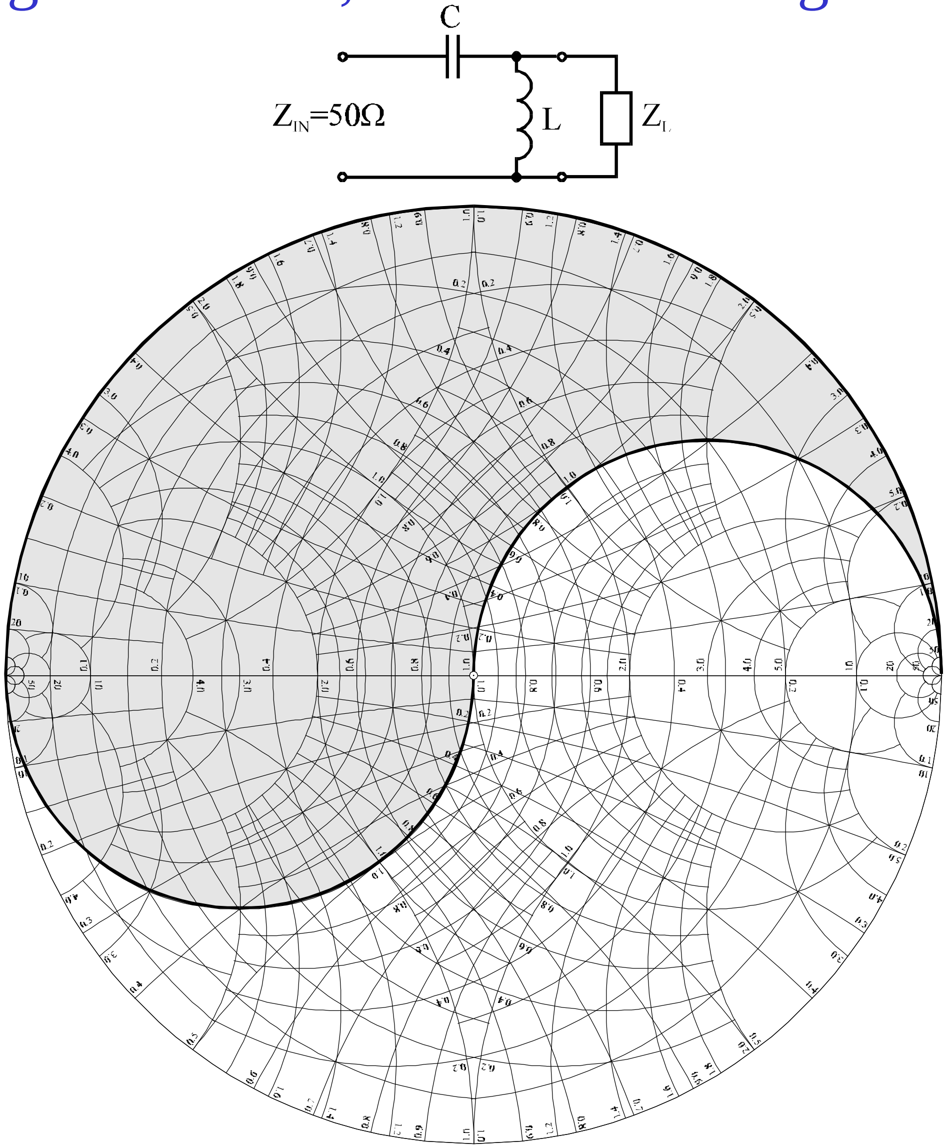
- Primary goal of a MN is to achieve

$$\Gamma_{in} = 0$$

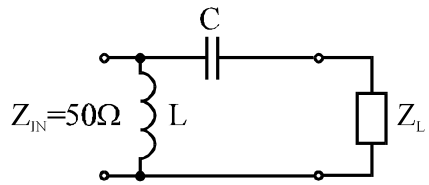
Matching Strategy

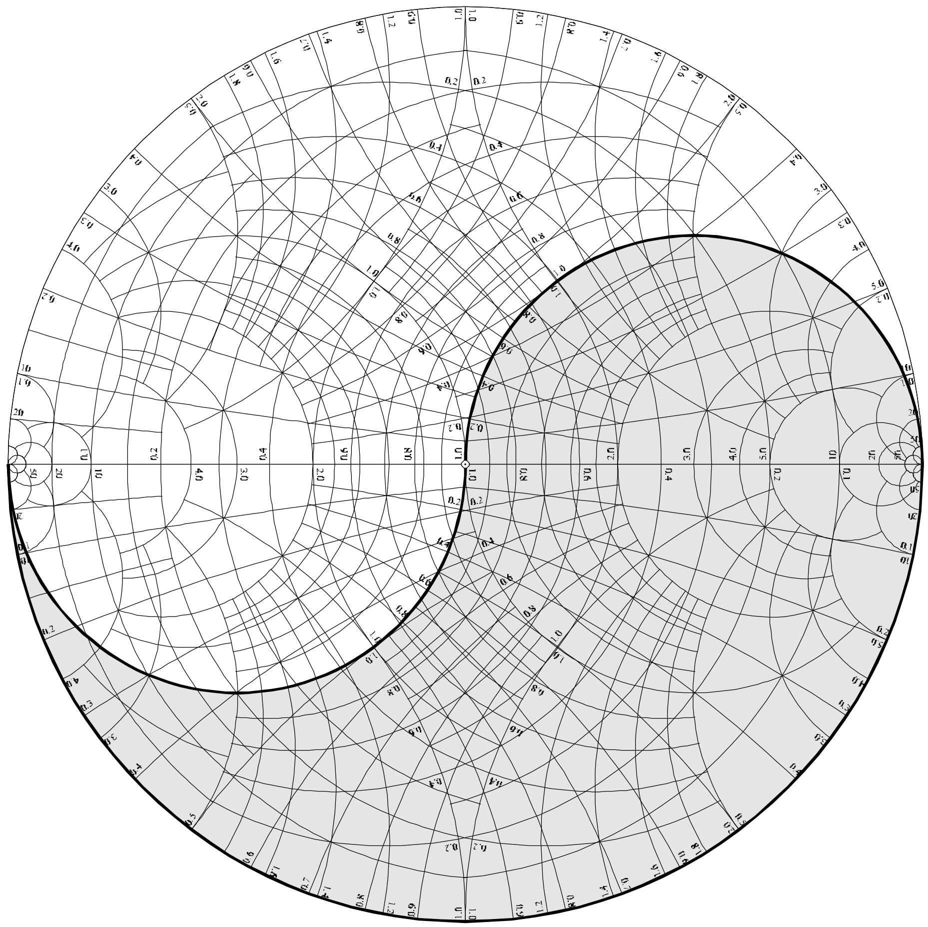
- Pick an appropriate two-element MN for which matching is possible (based on a given load impedance or S-parameter)
- Find the L, C values from the ZY Smith Chart
- Convert discrete values into equivalent microstriplines

Region of matching for shunt L, series C matching network

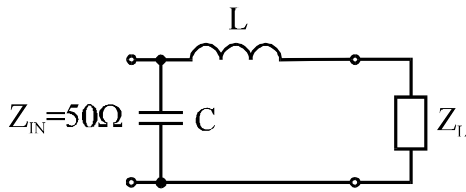


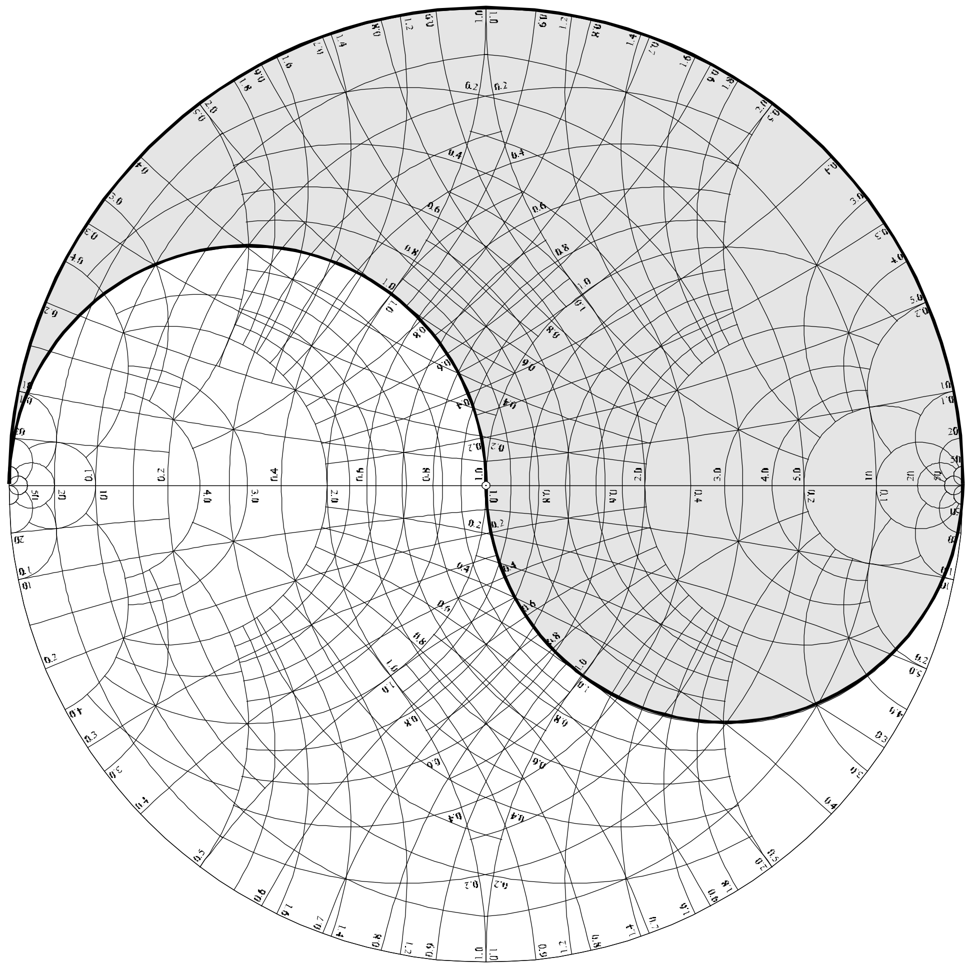
Region of matching for series C shunt L matching network



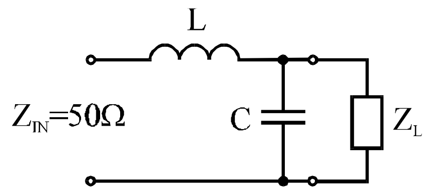


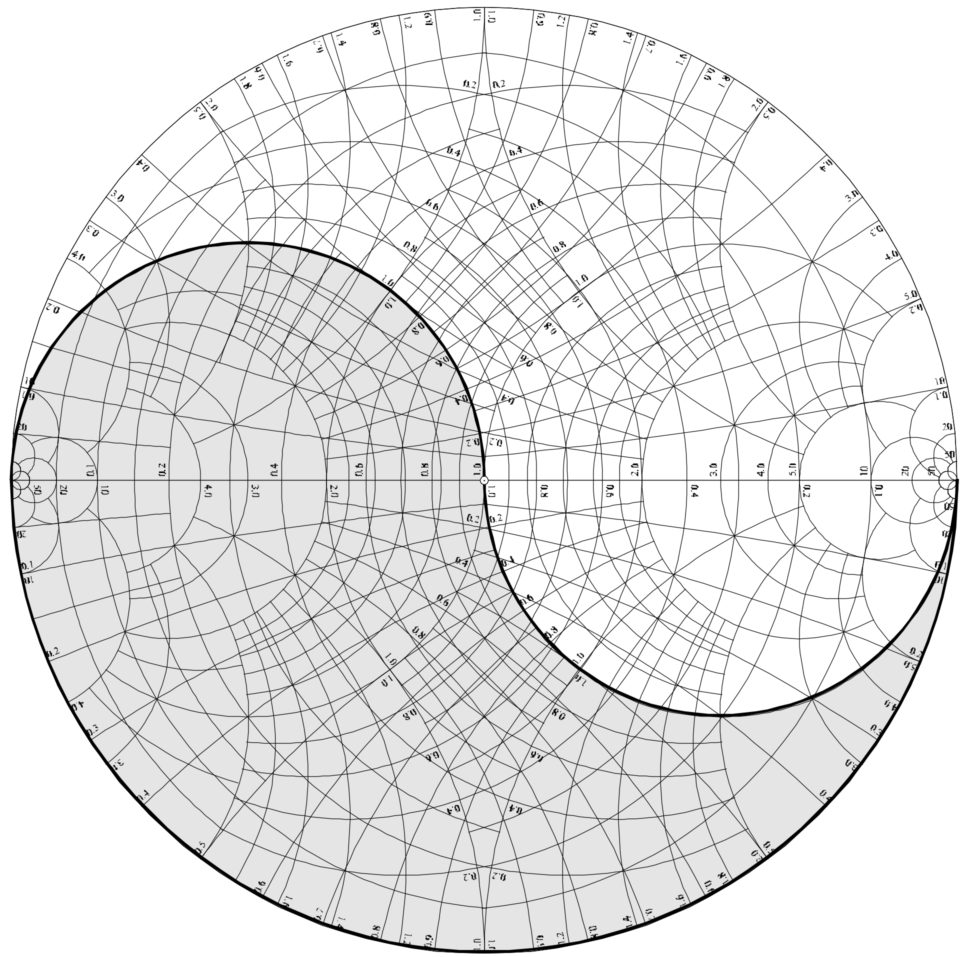
Region of matching for series L shunt C matching network





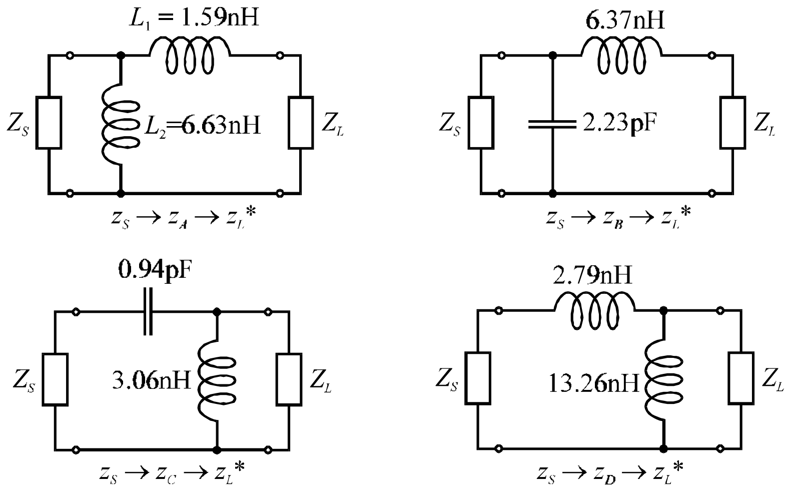
Region of matching for shunt C and series L matching network





There are two strategies

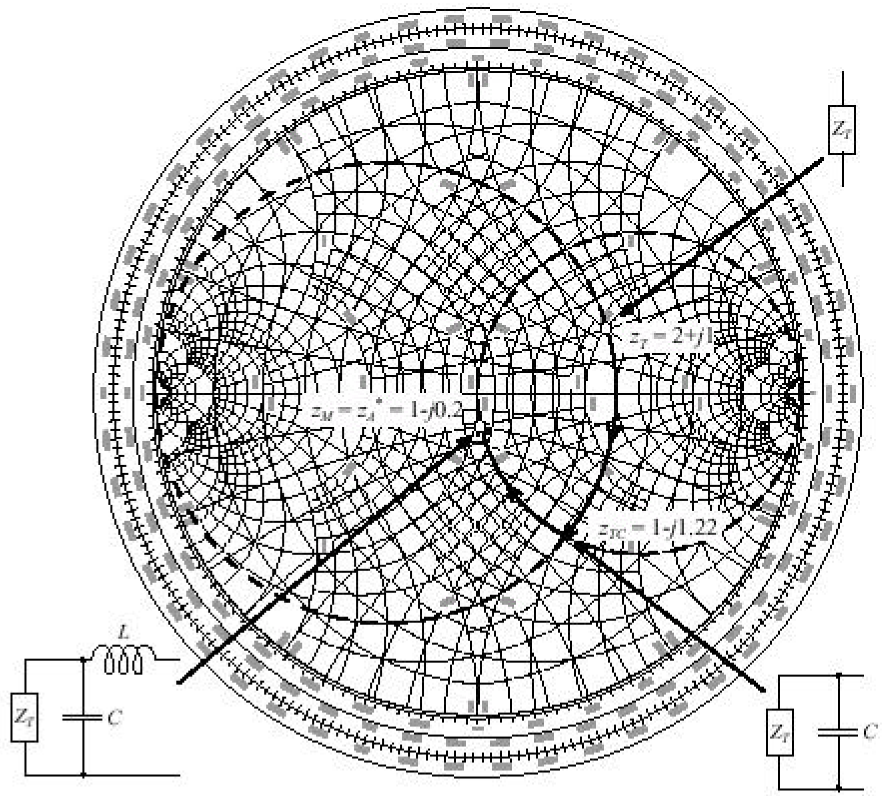
A) Source impedance -> conjugate complex load impedance



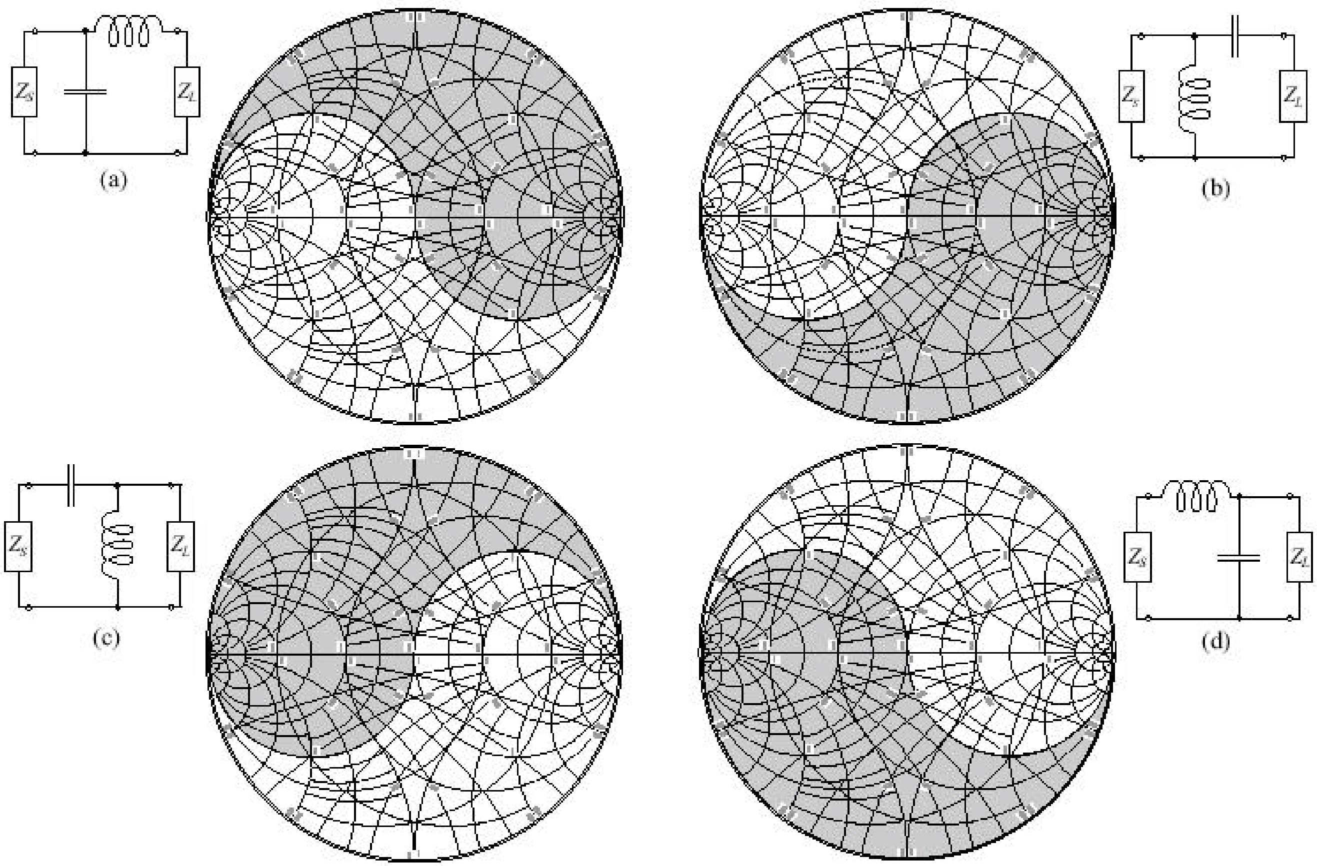
B) Load impedance -> conjugate complex source impedance

General 2 Element Approach

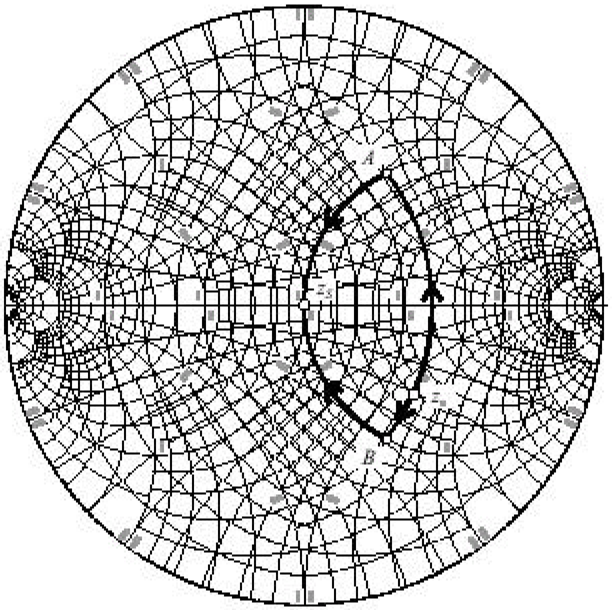
Source impedance transformation to conj. comp. load

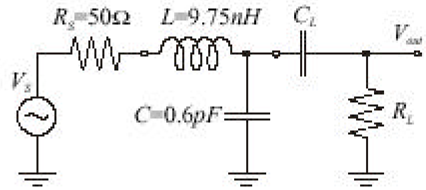


Load Impedance To Complex Conjugate Source $Z_s = Z_s^* = 50\ \Omega$



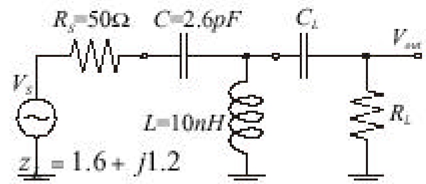
Art of Designing Matching Networks



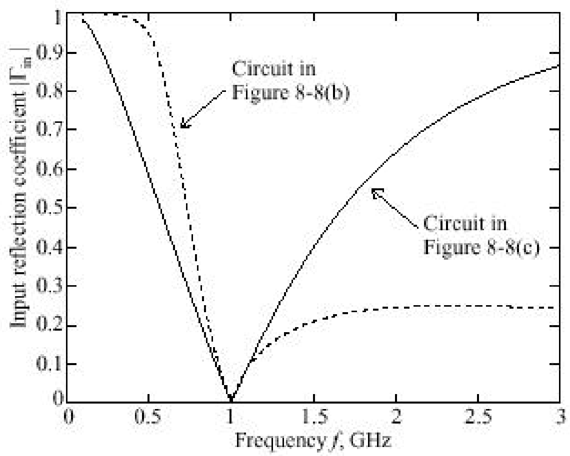


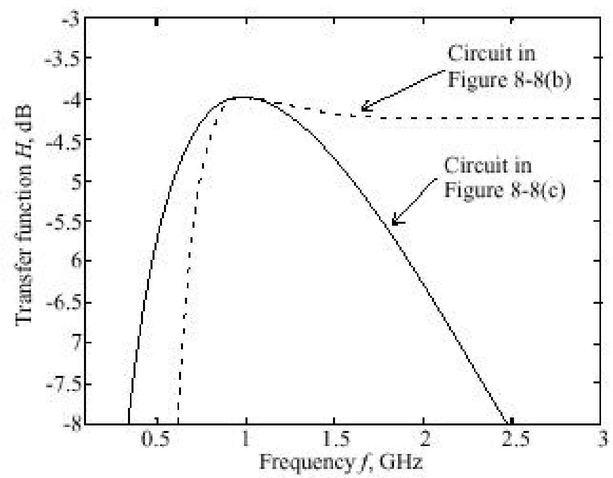
(b)

$$z_L = 1.6 + j1.2$$



(c)





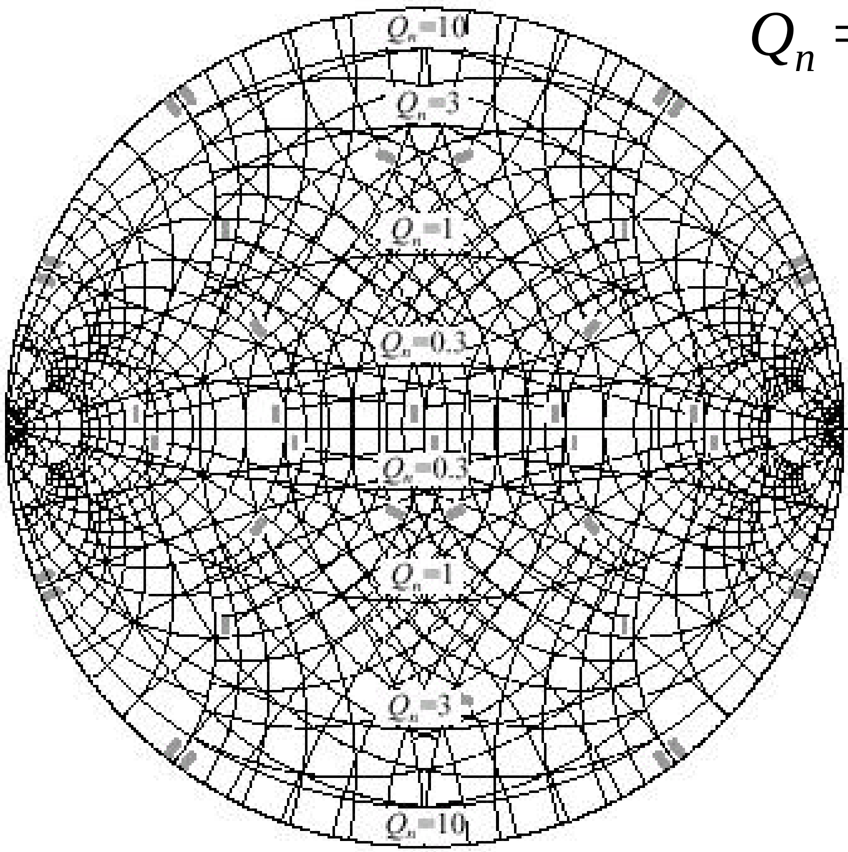
More Complicated Networks

- Three-element Pi and T networks permit the matching of almost any load conditions
- Added element has the advantage of more flexibility in the design process (fine tuning)
- Provides quality factor design (see Ex. 8.4)

Quality Factor

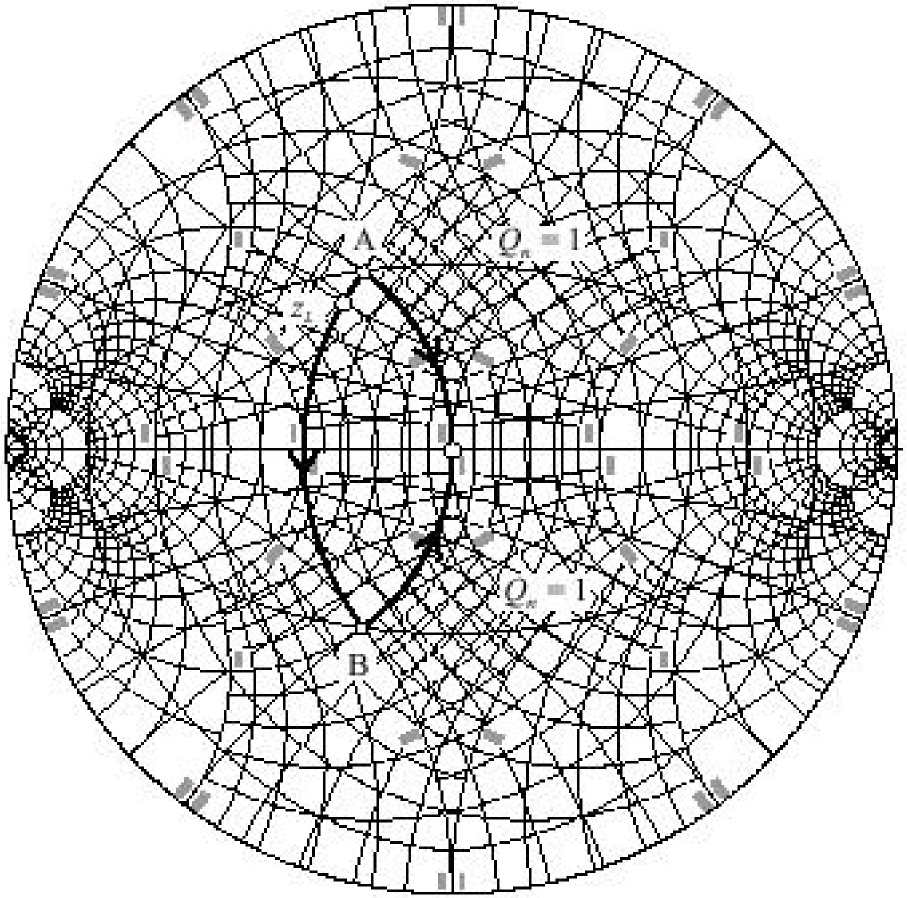
- Resonance effect has implications on design of matching network.
- Loaded Quality Factor: $Q_L = f_O/BW$
- If we know the Quality Factor Q, then we can find BW
- Estimate Q of matching network using Nodal Quality Factor Q_n
- At each circuit node can find $Q_n = |X_s|/R_s$ or $Q_n = |B_P|/G_P$ and
- $Q_L = Q_n/2$ true for any L-type Matching Network

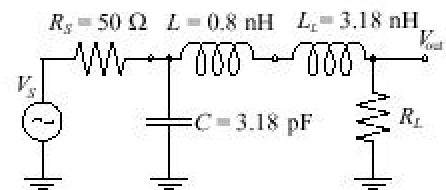
Nodal Quality Factors

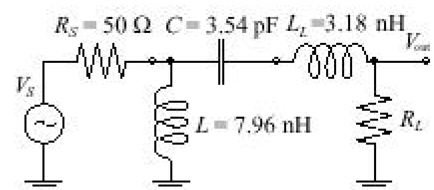


$Q_n = |x|/r = 2|\Gamma_i| / [(1-\Gamma_r)^2 + \Gamma_i^2$

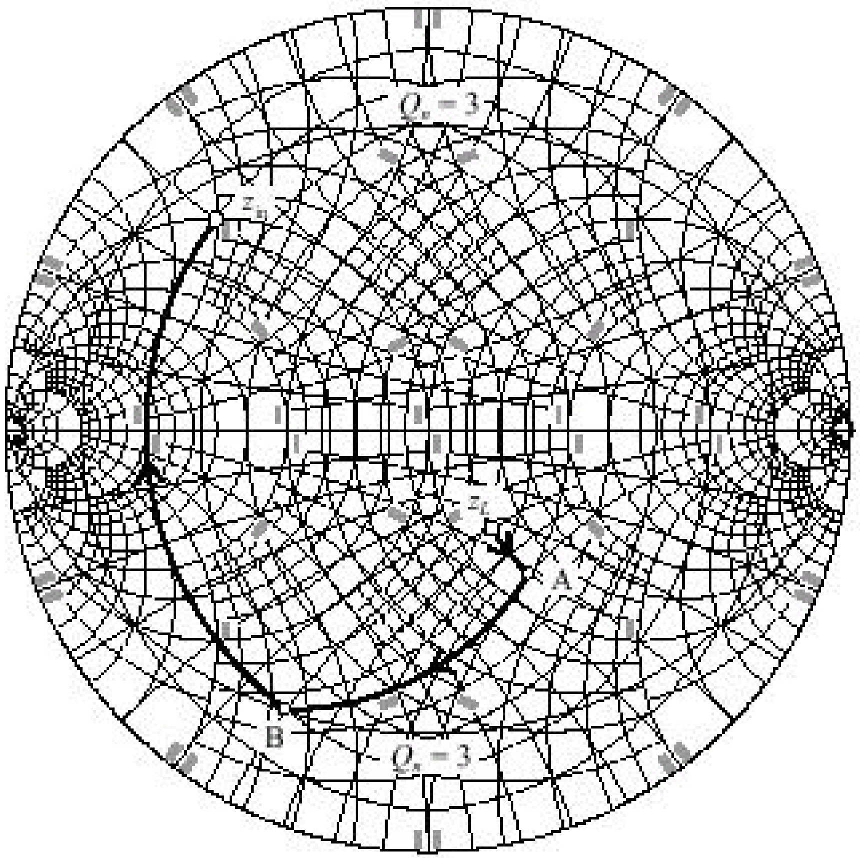
Matching Network Design Using Quality Factor

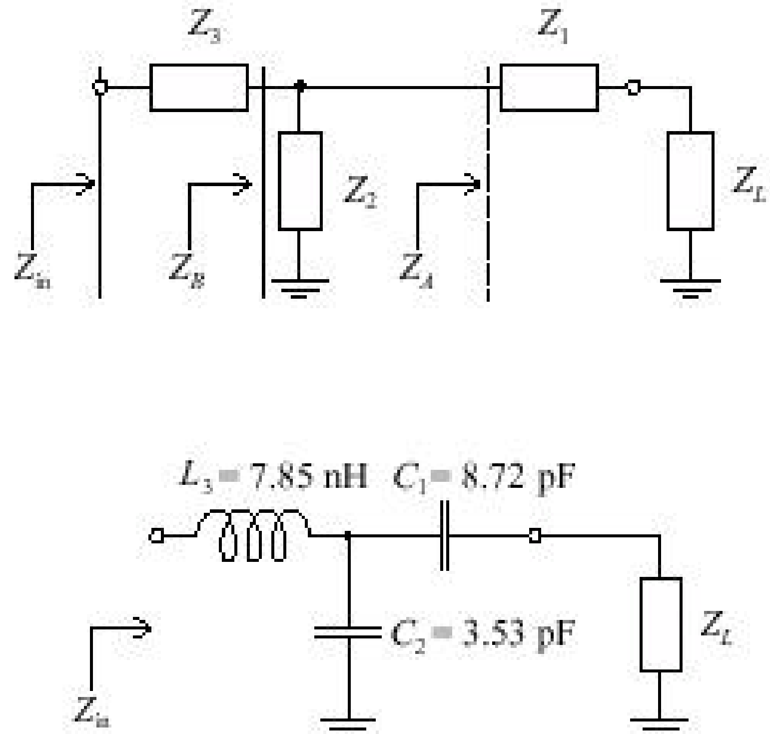




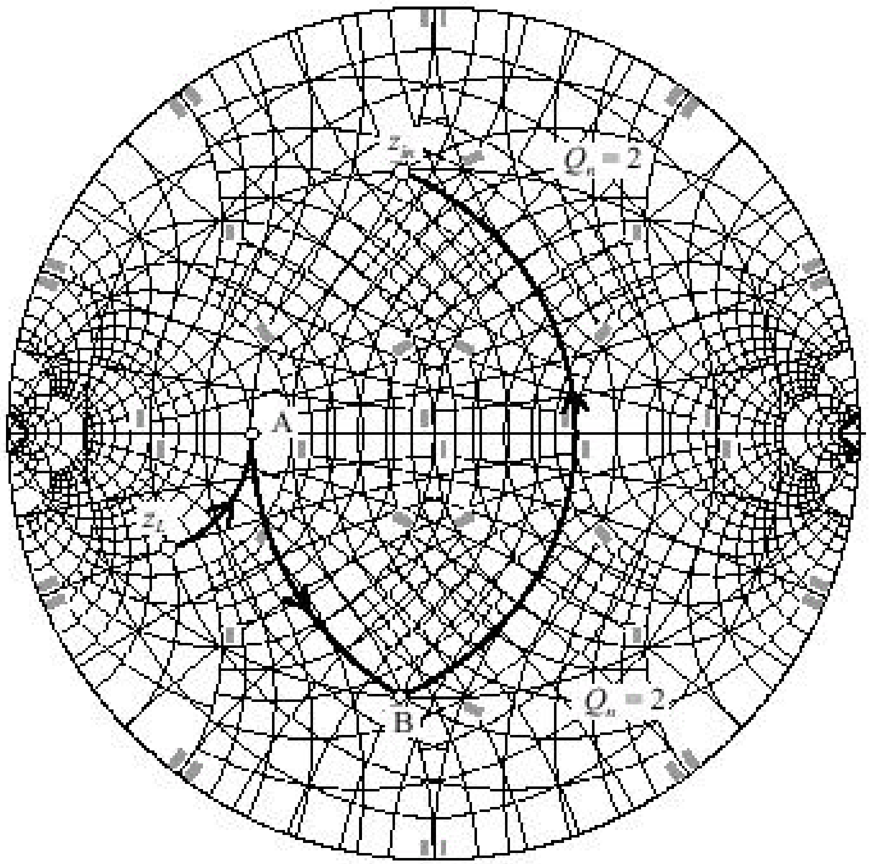


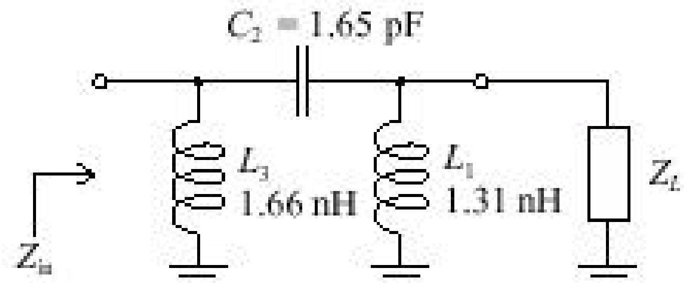
T-Type Matching Networks





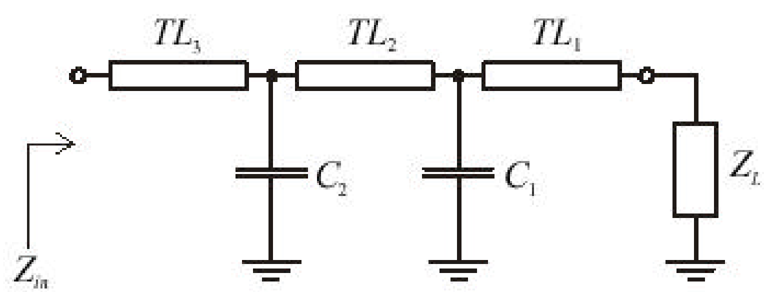
Pi-Type Matching Network



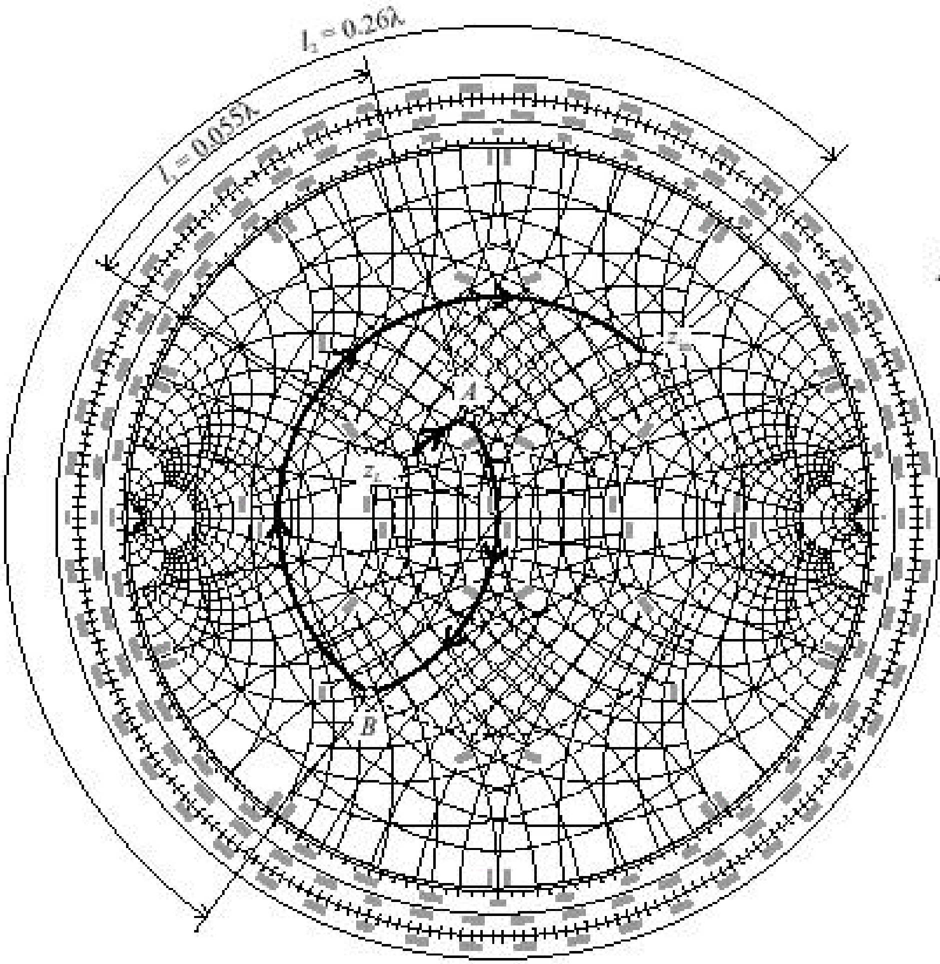


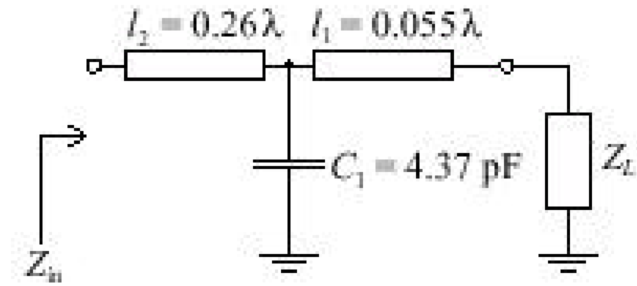
Microstripline Matching Network

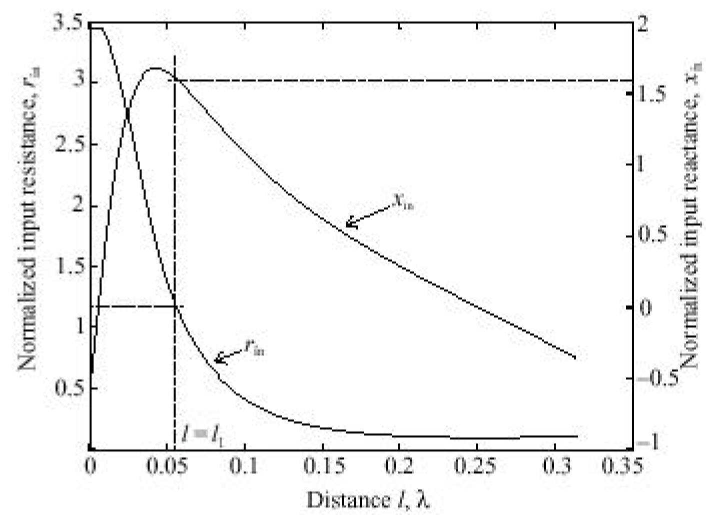
- Distributed microstip lines and lumped capacitors
- less susceptible to parasitics
- easy to tune
- efficient PCB implementation
- small size for high frequency



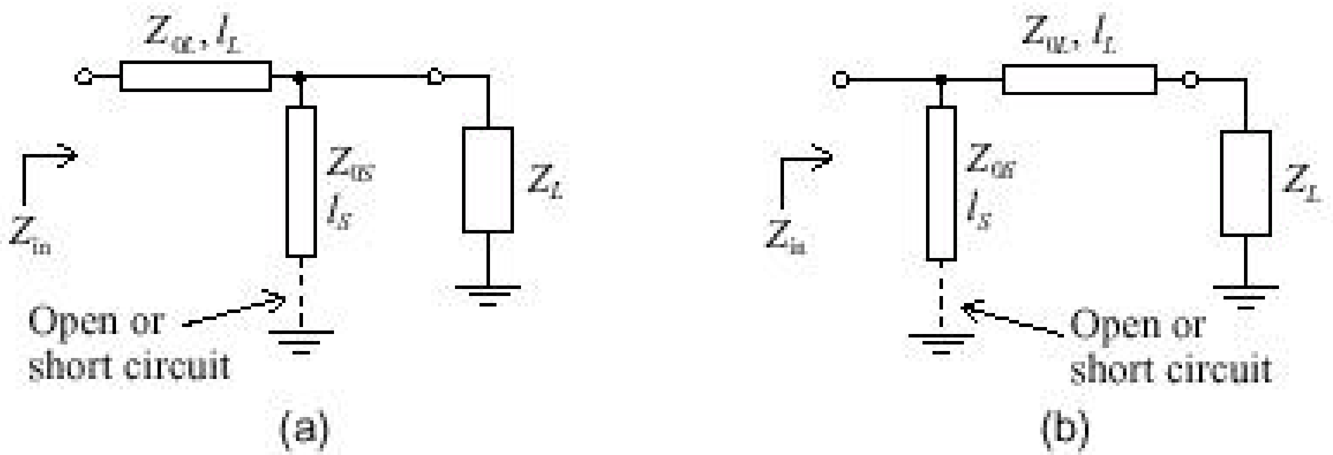
Microstripline Matching Design







Two Topologies for Single-Stub Tuners



Balanced Stubs

- Unbalanced stubs often replaced by balanced stubs

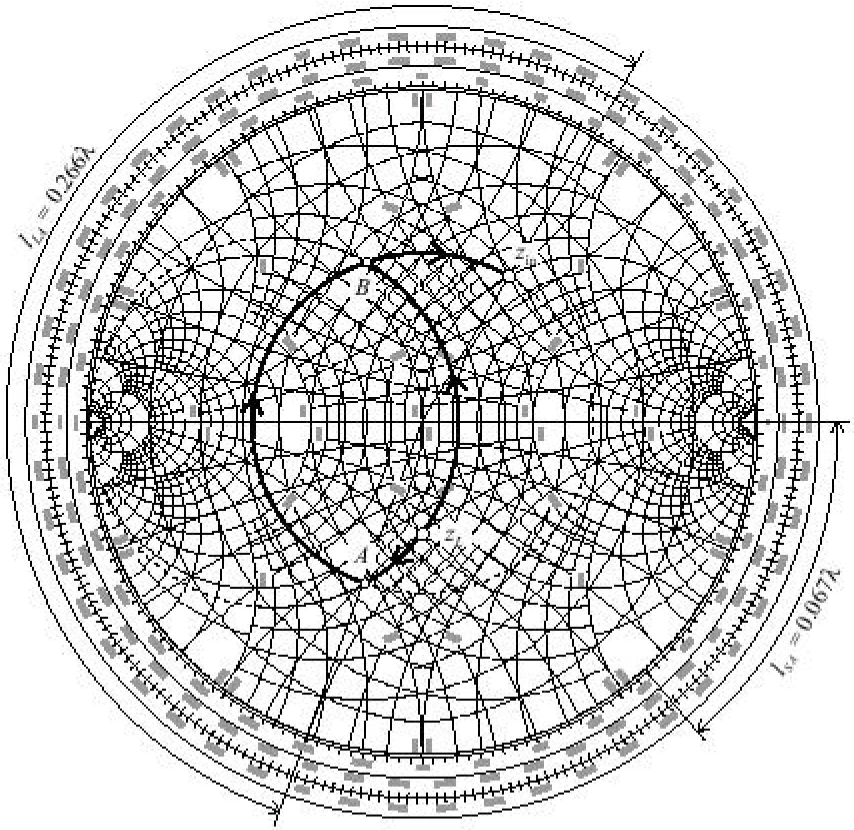
$$l_{SB} = \frac{\lambda}{2\pi} tan^{-1}\left(2\,tan\,\frac{2\pi\, l_S}{\lambda} \right) \qquad l_{SB} = \frac{\lambda}{2\pi} tan^{-1}\left(\frac{1}{2} tan\,\frac{2\pi\, l_S}{\lambda} \right)$$

<u>Open-Circuit Stub</u> <u>Short-Circuit Stub</u>

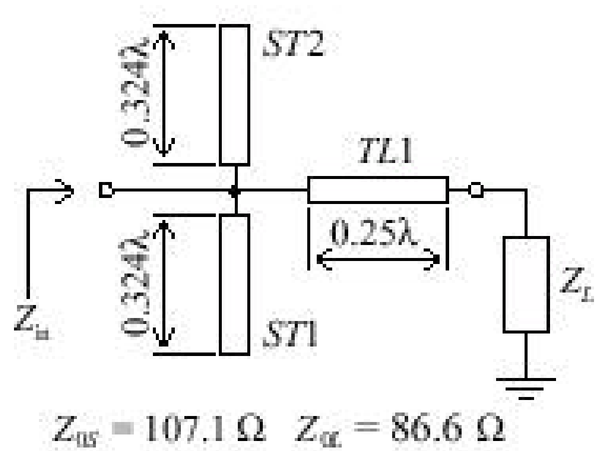
l_S is the unbalance stub length and l_{SB} is the balanced stub length.

Balanced lengths can also be found graphically using the Smith Chart

Balanced Stub Example

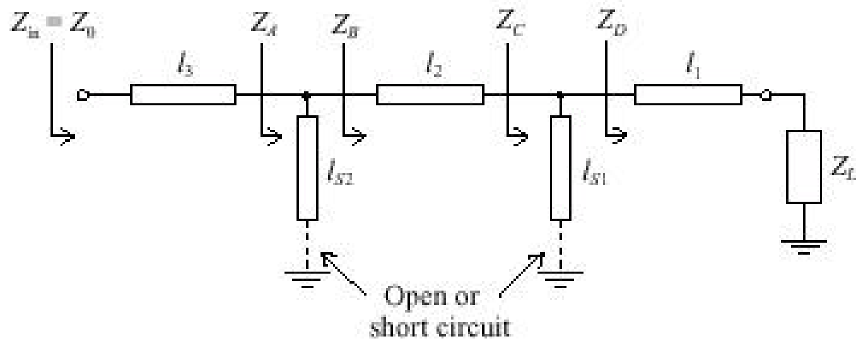


Single Stub Smith Chart



Balanced Stub Circuit

Double Stub Tuners



- Forbidden region where y_D is inside $g = 2$ circle