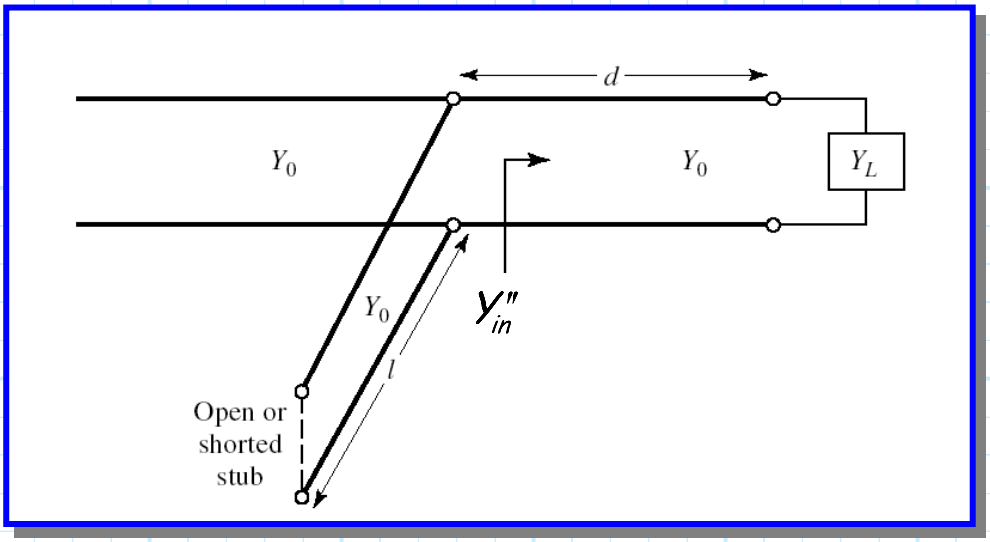
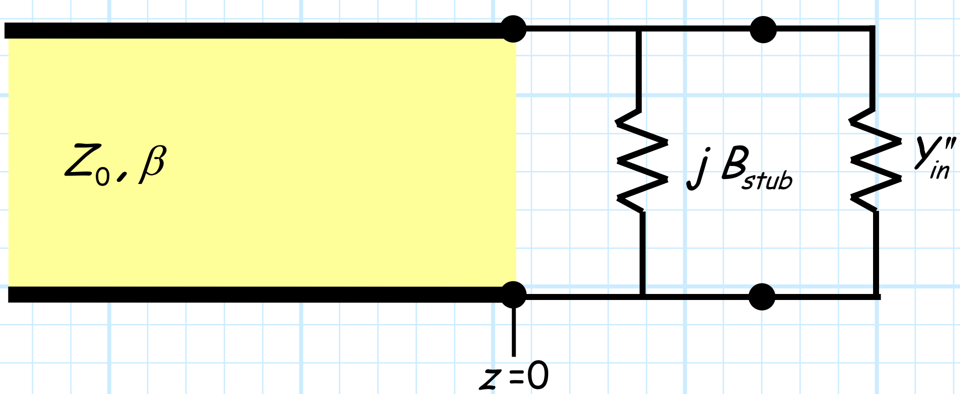
Shunt Stub Tuning

Consider the follow transmission line structure, with a **shunt stub**:



The two **design parameters** of this matching network are lengths ℓ and d.

An equivalent circuit is:



where of course:

$$Y_{in}'' = Y_0 \left(\frac{Y_L + j\, Y_0 \tan \beta d}{Y_0 + j\, Y_L \tan \beta d} \right)$$

and the reactance jB_{stub} of transmission line stub of length ℓ is either:

$$jB_{stub} = \begin{cases} jY_0 \tan \beta \ell & \text{for an } \textbf{open}\text{-circuit stub} \\ -jY_0 \cot \beta \ell & \text{for an } \textbf{short}\text{-circuit stub} \end{cases}$$

Therefore, for a matched circuit, we require:

$$jB_{stub} + Y_{in}'' = Y_0$$

Note this complex equation is actually **two real equations**!

i.e.,

$$\text{Re}\{Y_{in}''\} = Y_0$$

and

$$\text{Im}\{jB_{stub} + Y_{in}''\} = 0 \quad \Rightarrow \quad B_{stub} = -B_{in}''$$

where

$$B_{in}'' \doteq \text{Im}\{Y_{in}''\}$$

Since Y''_{in} is dependent on d only, our **design procedure** is:

1) Set d such that $\text{Re}\{Y''_{in}\} = Y_0$.

2) Then set ℓ such that $B_{stub} = -B''_{in}$.

We have **two choices** for determining the lengths d and ℓ. We **can** use the design equations (5.9, 5.10, 5.11) on p. 232,

OR

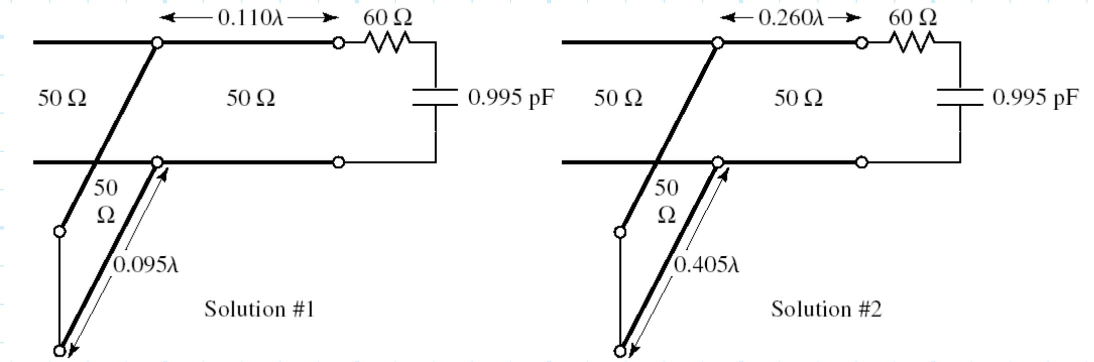
we can use the **Smith Chart** to determine the lengths!

1) Rotate **clockwise** around the Smith Chart from y_L until you intersect the **g =1 circle**. The "length" of this rotation determines the value d. Recall there are **two** possible solutions!

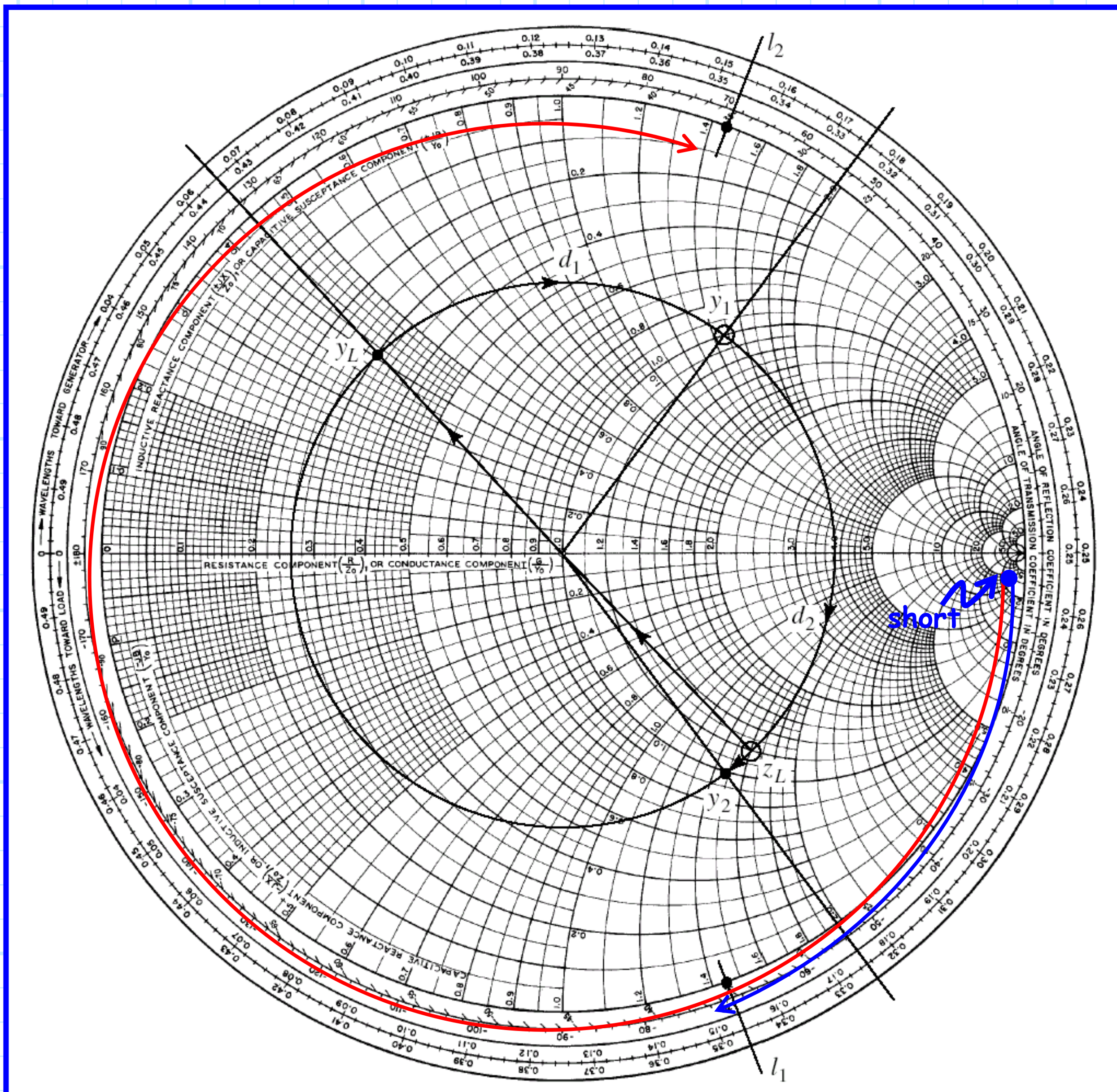
2) Rotate **clockwise** from the short/open circuit point around the **g = 0 circle**, until b_{stub} equals $-b''_{in}$. The "length" of this rotation determines the stub length ℓ.

For example, your **book** describes the case where we want to match a load of $Z_L = 60 - j80$ (at 2 GHz) to a transmission line of $Z_0 = 50\Omega$.

Using **shorted** stubs, we find **two** solutions to this problem:



Whose length values d and ℓ where determined from a Smith Chart:



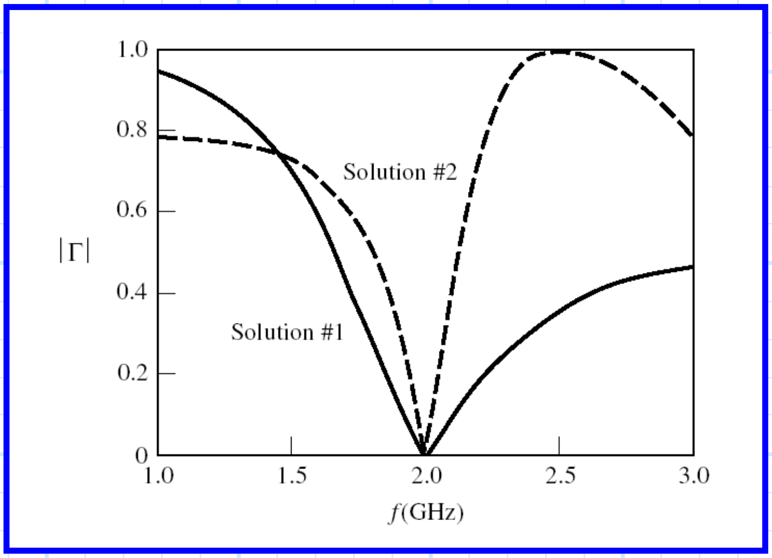
Q: ***Two*** *solutions! Which one do we use?*

A: The one with the **shortest** lengths of transmission line!

Q: *Oh, I see! Shorter transmission lines provide* ***smaller*** *and (slightly) cheaper matching networks.*

A: True! But there is a more **fundamental** reason why we select the solution with the **shortest** lines—the matching **bandwidth** is **larger**!

For example, consider the **frequency response** of the two examples:



Clearly, solution 1 provides a **wider** bandwidth!