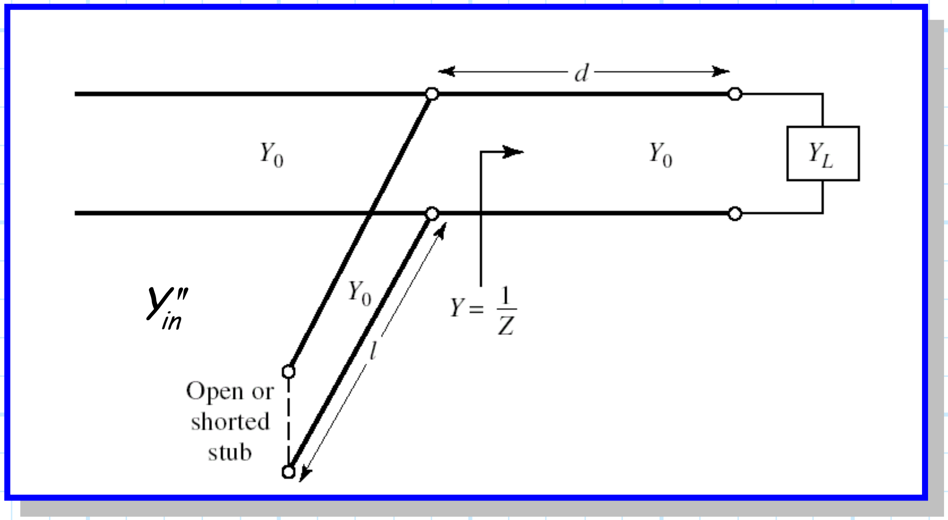
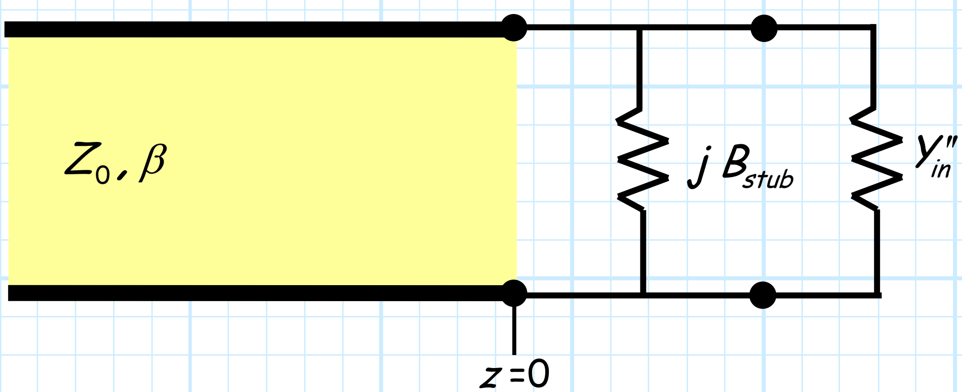
Shunt Stub Tuning

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:

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

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

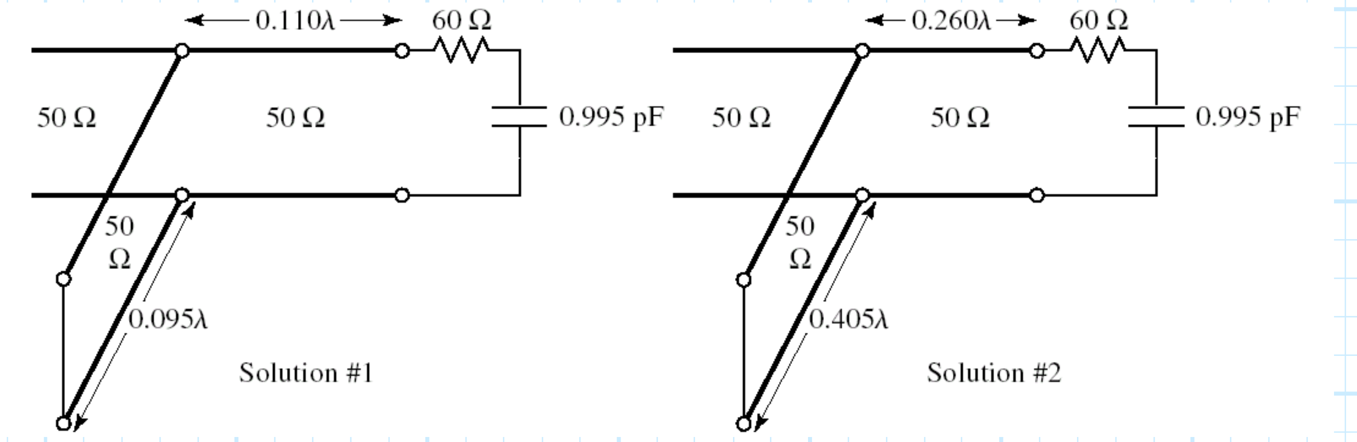
we can use the **Smith Chart** to determine the lengths!

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!

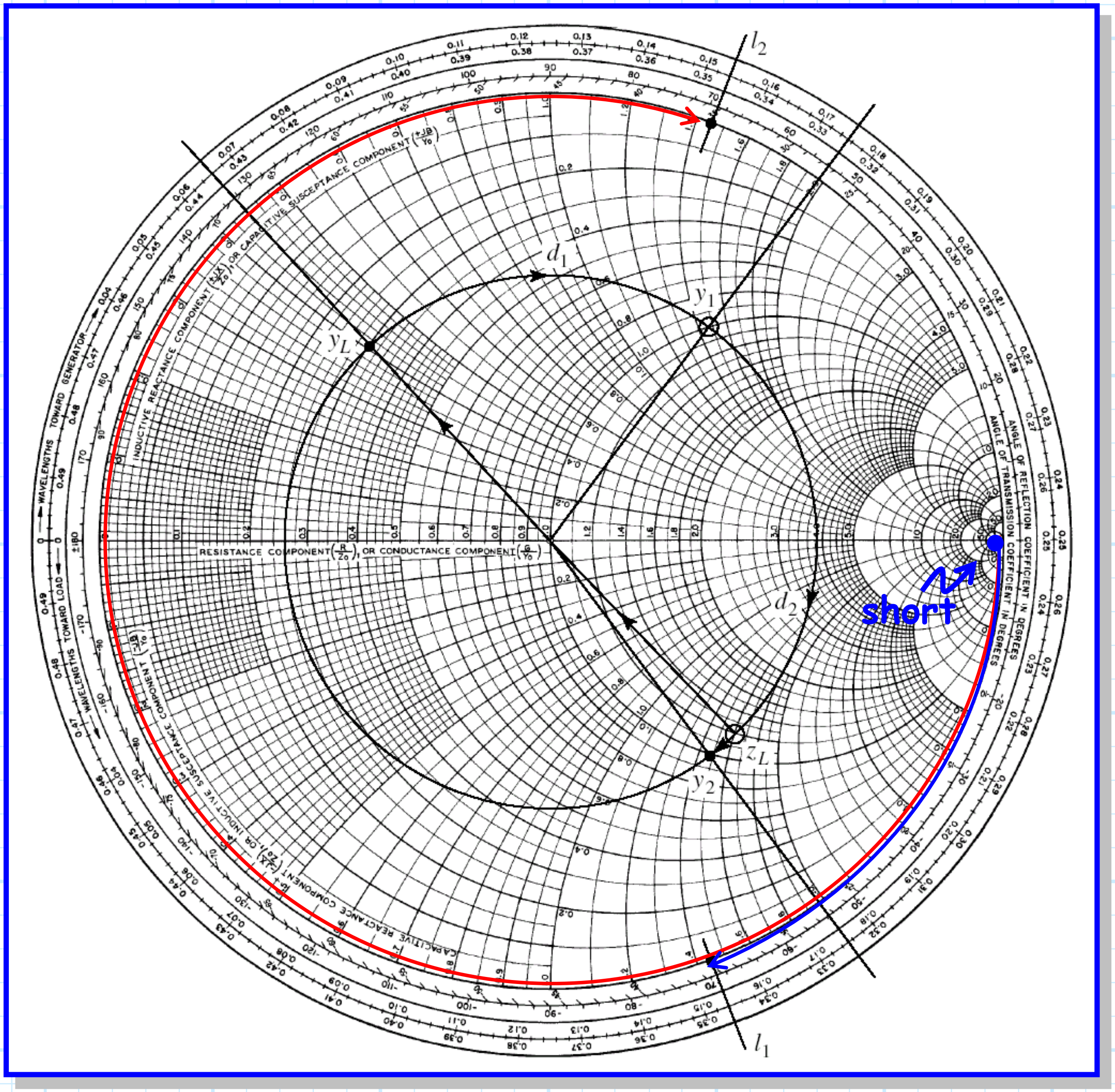
2) Rotate **clockwise** from the short/open circuit point around the ***g*** **= 0 circle**, until b_{stub} equals $-b_{in}''$. The "length" of this rotation determines the stub length ℓ.

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 were determined from a Smith Chart:



l_2
d_1
y_1
y_L
d_2
z_L
y_2
l_1
short
RESISTANCE COMPONENT, OR CONDUCTANCE COMPONENT
ANGLE OF REFLECTION COEFFICIENT IN DEGREES
ANGLE OF TRANSMISSION COEFFICIENT IN DEGREES
WAVELENGTHS TOWARD GENERATOR
WAVELENGTHS TOWARD LOAD
INDUCTIVE REACTANCE COMPONENT, OR CAPACITIVE SUSCEPTANCE COMPONENT
CAPACITIVE REACTANCE COMPONENT, OR INDUCTIVE SUSCEPTANCE COMPONENT

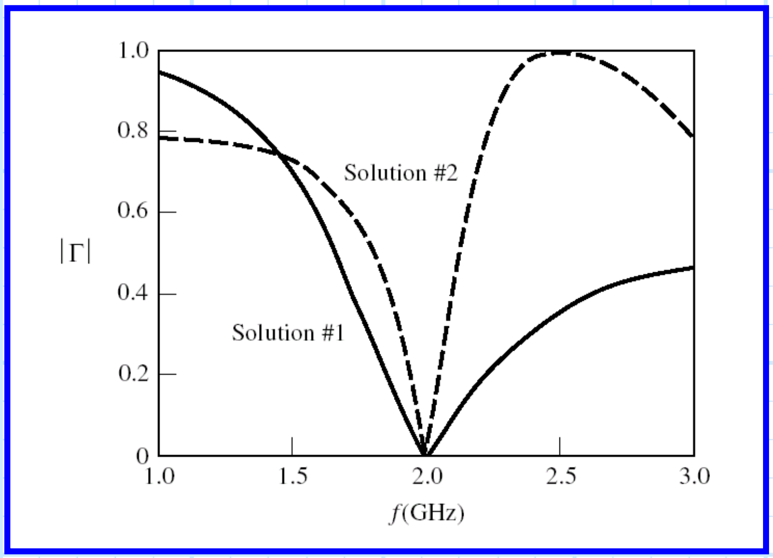
Q: ***Two** solutions! Which one do we use?*

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!