Attenuation Measurements

- Will use the RF substitution method to measure attenuation (i.e., insertion loss) for a device.
- Will use a detector connected to SWR meter. SWR meter is calibrated for use with a detector operating in its square-law region.

Step 1:

- Device → V.A. set to 0 mm
- Set to reference value (e.g., -2 dB) using GAIN knob.

Step 2: Remove device → input power to V.A. Increases. Then, adjust V.A. blade position to get reference value on SWR back. Go to calibration curve of V.A. & determine attenuation.
• Assuming $A_1$, attenuation in step (1) & $A_2$, in (2):

$$\text{I.L.} = A_2 - A_1 \quad (\text{dB})$$

• The device you will use is the 6-dB fixed attenuator. So, what do you expect the I.L. will be??

• RF sub. method eliminates errors due to detector.

• Main source of error is the calibration curve of the V.A.

• Will use the SWR meter to make relative power measurements, not absolute power.
Standing Waves

- The sum of two waves traveling in opposite directions \( \Rightarrow \) standing wave.

\[
\begin{align*}
Z_0 &\quad \Rightarrow \quad Z_L \\
\end{align*}
\]

If \( Z_L \neq Z_0 \) \( \Rightarrow \) mismatch \( \Rightarrow \) reflections

\( \Rightarrow \) S.W. on the line

![Diagram of standing wave with max and min voltages and wavelength](image)

Standing wave ratio \( = \frac{V_{\max}}{V_{\min}} = \frac{1 + |\Pi|}{1 - |\Pi|} \)

- \( Z_L = 0 \Rightarrow V_{\min} = 0 \), \( |\Pi| = 1 \), \( SWR = \infty \)
- \( Z_L = \infty \Rightarrow \) "", "", ", ""
- \( Z_L = jX \Rightarrow \) "", "", ", ""

recall, \( \Pi = \frac{Z_L - Z_0}{Z_L + Z_0} \)
• Distance between two successive minima (or maxima) = \( \frac{A_g}{2} \)

• From \( A_g \), one can get frequency of operation. Recall,

\[
\lambda_g = \frac{\lambda}{\sqrt{1 - \left(\frac{f_c}{f}\right)^2}} \quad , \quad \lambda = \frac{c}{f} \quad , \quad f_c = \frac{c}{2a}
\]

\[ \Rightarrow \quad \lambda_g = \frac{c}{\sqrt{f^2 - f_c^2}} \]

\[ \Rightarrow \quad \left( \frac{1}{\lambda_g} \right)^2 = \frac{f^2 - f_c^2}{c^2} = \frac{f^2}{c^2} - \left( \frac{1}{2a} \right)^2 \]

\[ \Rightarrow \quad f = c \sqrt{\left( \frac{1}{\lambda_g} \right)^2 + \left( \frac{1}{2a} \right)^2} \quad \text{(as in manual)} \]

3 \times 10^8 \text{ since air-filled waveguide.}

• Will use the slotted line to measure the S.W. in this experiment for 3 loads:
  
  - Short-Ckt load
  - Matched load
  - (6 dB att. + short ckt) load
Short-CR T Load:

\[
\frac{|V|}{V_{\text{max}}} \quad k \quad \lambda_{3/4}
\]

Will locate a max. first, then move the slotted line in steps of 2 mm, and record readings till hit another max.

Matched Load:

No S.W. → if perfect match.

6 dB + Short CR T:

\[
\frac{V}{V_{\text{max}}} \quad 6 \text{ dB} \quad 0.6 \quad \text{(why ??)}
\]
Return loss = 12 dB = -20 \log |P| \\

\Rightarrow |P| = 0.2512 \\

\Rightarrow \text{SWR} = 1.671 = \frac{V_{\text{max}}}{V_{\text{min}}} \\

\Rightarrow \frac{V_{\text{min}}}{V_{\text{max}}} = 0.6