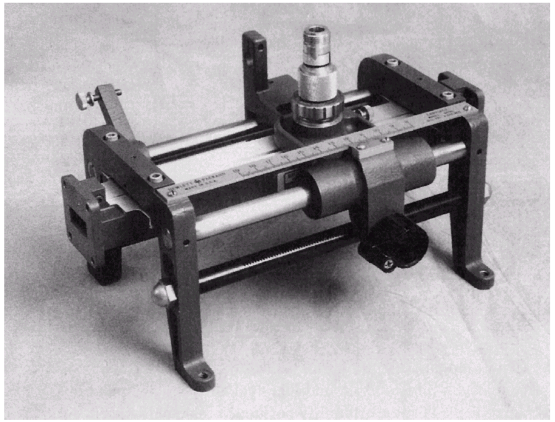
The Slotted Line

- Transmission line configuration that allows the sampling of the electric field amplitude of a standing wave on a terminated line.
- With this device
  - SWR
  - the distance of the first voltage minimum (d_{min})

  from the load can be measured.
- From this data the load impedance can be determined.



An X-band waveguide slotted line

Given SWR, d_{min} → Find the load impedance (Z_L)

- The magnitude of the reflection coefficent on the line is found from the standing wave ratio as

$$|\Gamma| = \frac{SWR - 1}{SWR + 1}$$

- Voltage minimum occurs when $e^{j(\theta-2\beta d)} = -1$

  θ- phase angle of the reflection coefficient

$$\Gamma = |\Gamma| e^{j\theta}$$

- $\theta = \pi + 2\beta d_{min}$

  d_{min}- the distance from the load to the first voltage minimum.

- Voltage minimums repeat every $\lambda/2$ (λ is the wavelength on the line)
- Any multiple of $\lambda/2$ can be added to d_{min} without changing the result in $\theta=\pi+2\beta d_{min}$($\Gamma$ will not change)
- Thus, complex reflection coefficent Γ can be found using
  - SWR
  - d_{min}

$$Z_{in} = Z_o \frac{1+\Gamma_L e^{-2j\beta d}}{1-\Gamma_L e^{-2j\beta d}}$$

- Load impedance can be found at d=0

$$Z_L = Z_o \frac{1+\Gamma_L}{1-\Gamma_L}$$

- This problem also can be solved using the Smith Chart

Example:Impedance measurement with a slotted line

The following two-step procedure has been carried out with a 50Ω coaxial slotted line to determine an unknown load impedance:

1. A short circuit is placed at the load plane resulting in a standing wave on the line with infinite SWR, and sharply defined voltage minima, as shown in figure 1a. On the arbitrarily positioned scale on the slotted line, voltage minima recorded at

   z=0.2 cm, 2.2 cm, 4.2 cm.

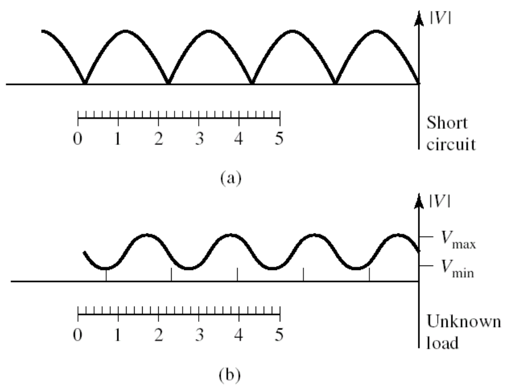


Figure 1 Voltage standing wave patterns for Example (*a*) Standing wave for short-circuit load. (*b*) Standing wave for unknown load.

2. The short circuit is removed, and replaced with the unknown load. The standing wave ratio is measured as SWR=1.5, and voltage minima, which are not as sharply defined as those in step 1, are recorded at

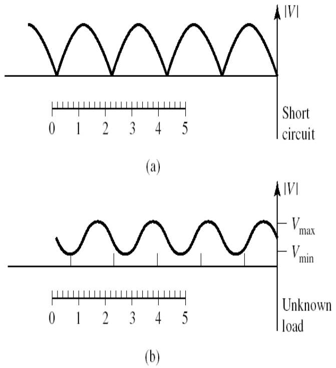
   z=0.72 cm, 2.72 cm, 4.72 cm

   as shown in Figure 1b. **Find the load impedance**.

- Voltage minimums repeat every $\lambda/2$.
- The data of step 1:

  z=0.2 cm, 2.2 cm, 4.2 cm

  λ=4 cm



- The reflection coefficient and input impedance also repeat every $\lambda/2$.
- We can consider the load terminals to be effectively located at any of the voltage minima locations in listed in step1 (z=0.2 cm, 2.2 cm, 4.2 cm).
- If we say the load is at 4.2 cm, then the data from step 2, next voltage minumum away from the load occurs at

  z=2.72 cm

  d_{min}=4.2-2.72=1.48 cm=0.37 λ

$$|\Gamma| = \frac{SWR-1}{SWR+1} = \frac{1.5-1}{1.5+1} = 0.2$$

$\theta=\pi+2\beta d_{min} = \pi+(4\pi/4).(1.48)$=86.4 degree

$$\Gamma = |\Gamma| e^{j\theta} = 0.2 e^{j86.4^0}$$

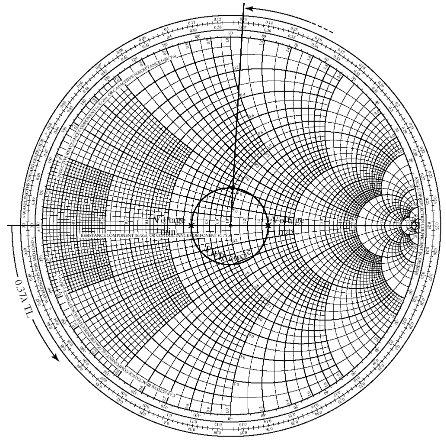
- So the load impedance is then

$$Z_L = Z_o \frac{1+\Gamma_L}{1-\Gamma_L}$$

- Z_L=47.3+j19.7

Smith chart version of the solution

- SWR=1.5
- The load is 0.37 λ away from the first voltage minimum



- The normalized load impedance is

  z_L=0.95+j0.4
- The actual load impedance is

  Z_L=47.5+j20