Correspondence

VHF Slow-Wave Slotted Line*

INTRODUCTION

A slotted line is generally used for voltage-standing-wave-ratio and impedance measurements in the microwave region. Because a slotted line operable down to 25 Mc would be from 10 to 15 feet long, it is impractical for general laboratory use, and is difficult and expensive to construct with the necessary mechanical tolerances.

A new VHF slotted line has been designed using a slow-wave structure technique; the line was developed to measure the VSWR and the impedance of components in the frequency range from 25 to 200 Mc. Because a slow-wave technique is used in the design, the new slotted line is only 3 feet long whereas a comparable conventional coaxial slotted line would be 24 feet long.

The VHF slow-wave slotted line consists of conductor bent into a serpentine configuration and placed over a conducting ground plane (Fig. 1). A fast fundamental wave travels along the serpentine line with the velocity of light and a slow wave travels along the axis of the line with a much reduced velocity. If the line is terminated with a load other than its characteristic impedance, a standing wave will exist along the line. A probe moving along the axial direction of the serpentine line will measure a voltage standing wave with a wavelength much shorter than that of free-space wavelength.

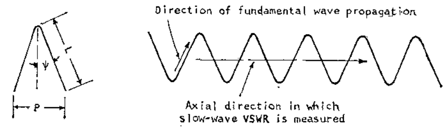

Fig. 1—Wave in a serpentine line.

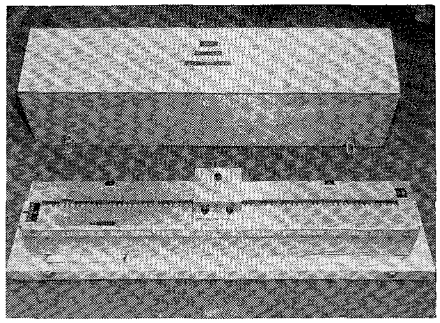
Fig. 2—VHF slow-wave slotted line.

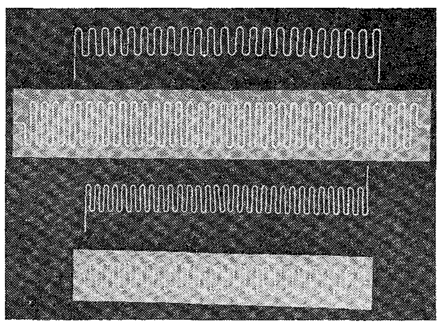
Fig. 3—Serpentine lines.

The ratio of the free-space wavelength, λ_0, and the axial serpentine line wavelength λ_s is termed the wave-retardation factor and is approximately

$$\frac{\lambda_0}{\lambda_s} = \sqrt{\epsilon}\csc\psi = \frac{2L}{P}\sqrt{\epsilon}.$$

The characteristic impedance of the serpentine line above a conducting plane can be calculated as the impedance of a straight wire over an infinite ground plane. If the spacing between the serpentine line and the plane is small compared to the spacing between adjacent legs of the line, the error due to increased distributed capacitance is negligible. Therefore, the characteristic impedance Z_0 is

$$Z_0 = \frac{60}{\sqrt{\epsilon}}\cosh^{-1}\frac{2h}{d},$$

where:

ϵ = composite dielectric constant of the materials surrounding the wire,
h = distance between the center of the wire and the ground plane,
d = diameter of the wire.

EXPERIMENTAL MODEL

The experimental model of the slow-wave slotted line is shown in Fig. 2. The serpentine line was formed with $\frac{3}{16}$-inch aluminum rod and is housed in an aluminum casing. A slow-wave with a wave retardation factor of about 8.3 was measured along the axial direction of the serpentine line. Measurements with a coaxial sliding short at the load end of the slotted line show that the slow-wave standing-wave minimum moves with that of the sliding short at the rate of the wave-retardation factor. The over-all length of the line is three feet. The specifications are as follows:

Frequency range	25 Mc to 200 Mc
Characteristic impedance	50±1 ohms
Wave-retardation factor	8.3
Residual VSWR	1.05 max
Short-circuit VSWR	100:1 min
Connectors	Type N
Detector element	1N21
Tuner	Lumped LC circuit
Dimensions	$3\frac{3}{4}\times6\times36$ inches
Weight	30 pounds

A significant advantage of the VHF slow-wave slotted line is that it is amenable to manufacture by inexpensive laminating and etching processes. The critical dimensional tolerances are the uniformity of the serpentine line and its spacing from the ground plane. The dielectric surrounding the line must be of low-loss material such as teflon or rexolite. The laminating and etching processes make it possible to construct a serpentine line with the necessary mechanical tolerances. Such a slotted line can extend the operating frequency of a 3-foot line from 25 Mc to as much as 1000 Mc. Several sizes of serpentine lines used in the slow-wave slotted line are shown in Fig. 3.

CONCLUSION

The operation of slotted lines is simple and straightforward, so that even unskilled technicians can make measurements without difficulties. With the new, compact slow-wave slotted line, VSWR and impedance measurements can now be extended down to 25 Mc. Although impedance measurements at frequencies as low as 25 Mc can be made with an impedance bridge, such null-detecting measurements are usually cumbersome and time consuming.

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Miniature Strip-Line to Waveguide Slot Adapter—Co-Linear*

An inline adapter from miniature air dielectric strip transmission line with a ground plane spacing of 0.130 in to half height X-band waveguide has been developed by the Microwave Design Group at Hycon Manufacturing Company, Monrovia, Calif. The upper wall of the waveguide was used as the lower ground plane for the strip-line. Unity coupling was accomplished through a transverse slot in the common wall. The slot was 0.066-in wide by 0.750-in long surrounded by a metal cavity 0.250 in by 1.000 in built into the ground planes. (See Fig. 1.) The slot junction was matched by use of tunable shorts both in the strip-line and the waveguide. The output of the 50-ohm stripline was terminated by a built-in strip-line load whose VSWR was 1.04.

An intermediate height waveguide section was attached to the unit since it was tested on a standard X-band waveguide slotted line. This intermediate section was 0.283-in high, 0.900-in wide, by 0.401-in long.

The slot adapter was tuned for optimum VSWR at four frequencies with the moveable shorts. Test results are tabulated in Table I and plotted in Fig. 2.

While only an X-band slot adapter has been built, similar designs for higher or lower frequency bands are feasible.

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