GENERAL RADIO COMPANY

engineering department

INSTRUMENT NOTES

IN-112 1967

Measurement of the Phase Shift and Electrical Length of Two-Port Unknowns

The rf phase shift of reasonably low-loss, two-port unknowns or connectors can be measured accurately with a slotted line by an indirect method. The electrical length of the unknown is measured both with short- and with open-circuit terminations as the average of these two values is simply related to the rf phase shift of the unknown in a matched 50-Ω system. Here is the procedure:

a. Connect the unknown to the slotted line and the output of the unknown. Measure the position of the first minimum on the slotted line with the main scale and vernier.

b. Remove the unknown, short-circuit the end of the slotted line, and measure the new position of the minimum, which will have shifted to the left by an amount equal to the electrical length of the unknown. At the higher frequencies, the shift may be several wavelengths, so that the minimum in question will no longer be the first one. To resolve the ambiguity, calculate a rough figure for the electrical length. To the over-all physical length of the unknown, add the physical length of any dielectric-filled sections of line multiplied by $(1-\sqrt{\epsilon})$. Look for a minimum at this approximate distance to the left of the original minimum.

c. Reinstall the unknown, and terminate it with the open-circuit termination. Measure the position of the first minimum on the slotted line.

d. Remove the unknown, place the open circuit on the end of the slotted line, and measure the new position of the minimum. It will have shifted to the left by approximately the same amount as in the short-circuit case.

e. Subtract the scale reading of step (a) from that of step (b) to determine the short-circuit electrical length of the unknown, L_{sc}. Similarly determine the open-circuit electrical length, L_{oc}.

f. Average the short- and open-circuit electrical lengths to obtain the electrical length for a matched 50-Ω system, L_m.

$$L_m = \frac{L_{sc} - L_{oc}}{2}$$

g. Calculate the rf phase shift of the unknown from the electrical length by either of the following formulas:

$$\phi = \frac{2\pi L_m}{\lambda} \text{ radians}$$

or

$$\phi = \frac{360\, L_m}{\lambda} \text{ degrees,}$$

Where λ = wavelength of the test frequency

ϕ = rf phase shift.

– John Zorzy

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parison to that of the unknown connector that it may be neglected in most cases. The insertion VSWR of such a test section represents closely the insertion VSWR of a single connector with respect to the characteristic impedance of the transmission line.

J. Zorzy

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WEST CONCORD, MASSACHUSETTS 01781

*NEW ENGLAND: 22 Baker Avenue
West Concord, Massachusetts 01781

*METROPOLITAN NEW YORK: 845 Broad Avenue
Ridgefield, New Jersey 07657

PHILADELPHIA: Fort Washington Industrial Park
Fort Washington, Pennsylvania 19034

*WASHINGTON and BALTIMORE: 11420 Rockville Pike
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CLEVELAND: 5579 Pearl Road
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Dallas, Texas 75207

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SAN FRANCISCO: 626 San Antonio Road
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MONTREAL: 1255 Laird Boulevard
Town of Mount Royal, Quebec, Canada

*TORONTO: 99 Floral Parkway
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*Repair services are available at these offices.

GENERAL RADIO COMPANY (Overseas), 8008 Zurich, Switzerland

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