Correspondence

Optimum Bandwidth for Waveguide-to-Coaxial Transducers

Mumford[1] has determined a method for optimizing the bandwidth of waveguide-to-coaxial transducers. His equivalent circuit is a coaxial line, of characteristic impedance Z_0, terminated in a resistance R, such that:

$$R = 240\pi \frac{b}{a} \frac{\lambda g}{\lambda} \sin^2 \frac{2\pi l}{\lambda g} \cos^2 \frac{\pi d}{a} \qquad (1)$$

where each of the terms in (1) are as defined by Mumford. After determining the value of l, at center frequency, he adjusts d so that: $R = Zo$ at center frequency, and achieves bandwidths of the order of 20 per cent for a vswr of 1.10.

Since Zo is invariant with frequency, the vswr varies as the product

$$\frac{\lambda g}{\lambda} \sin^2 \frac{2\pi l}{\lambda}$$

which has a maximum value at center frequency (Fig. 1), for reasons listed here.

$2\pi l/\lambda g$ is usually about 80°, so that $\sin^2 2\pi l/\lambda g$ remains fairly constant for large increases in frequency, but decreases rapidly as frequency is decreased. $\lambda g/\lambda$ increases with decreasing frequency, but at a much slower rate than the decrease of $\sin^2 2\pi l/\lambda g$; $\lambda g/\lambda$ also decreases with increasing frequency.

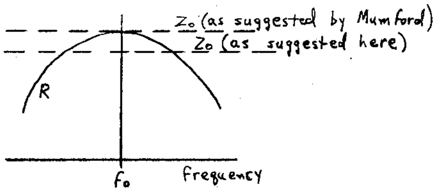

Fig. 1.

From the foregoing, it can readily be seen that even wider bandwidths than those achieved by Mumford are obtainable if R is made greater than Zo at center frequency. In order to determine how much greater than Z_0, R should be, I have found the following equations very useful:

$1.10 = R/Z_0$ at center frequency, f_0, which is obtained by setting vswr at center frequency equal to 1.10, and leads to:

$$\cos^2 \frac{\pi d}{a} = \frac{Z_0}{240\pi b/a} \cdot \frac{1.10}{\left(\frac{\lambda g}{\lambda} \sin^2 \frac{2\pi l}{\lambda g}\right)_{at\, f_0}} \qquad (2)$$

and

$$\left(\frac{R}{Z_0}\right)_{at\, f_0} = \left(\frac{Z_0}{R}\right)_{at\, f_L}$$

where f_L is the low frequency end of the desired band. This yields

$$\cos^2 \frac{\pi d}{a} = \frac{Z_0}{240\pi g/a} \left[\left(\frac{\lambda g}{\lambda} \sin^2 \frac{2\pi l}{\lambda g}\right)_{at\, f_L} \cdot \left(\frac{\lambda g}{\lambda} \sin^2 \frac{2\pi l}{\lambda g}\right)_{at\, f_L}\right]^{-\frac{1}{2}}. \qquad (3)$$

Use of (3) has led me to a design which has a calculated vswr of 1.10 or better over a frequency band in excess of 30 per cent.

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[1] W. W. Mumford, "The optimum piston position for wide-band coaxial-to-waveguide transducers," PROC. IRE, vol. 41, p. 256; February, 1953.

Addendum to Planar Transmission Lines—I*

If it is desired to use fine wires of diameter a instead of these flat strips, an elementary argument shows that the characteristic impedance is given very closely by

$$Z = \frac{120}{Vk} \ln\left(\frac{4h}{\pi a} \tanh \frac{\pi d}{2h}\right).$$

The attenuation is given to sufficient accuracy by the relevant formulas of the paper referred to above.

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* David Park, "Planar transmission lines," vol MTT-3, pp. 8–12; April, 1955.

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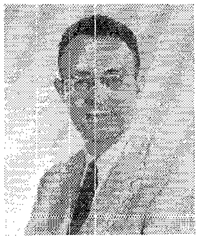

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Carlos M. Angulo (S'50–A'52–M'52–SM'56) was born in Pinto (Madrid) Spain, in 1921. He received the degree of Ingeniero de Telecomunicacion from the Escuela Oficial de Telecomunicacion in Madrid, Spain, in 1946; the M.E.E. degree in communication engineering in 1951 and the D.E.E. in electrophysics in 1955, both from the Polytechnic Institute of Brooklyn.

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Dr. Angulo joined the Polytechnic Institute of Brooklyn as a research associate in 1949 and as instructor of electrical engineering in 1950; his research during this period was in microwaves. He became an assistant professor of engineering in 1952 and associate professor in 1955, at Brown University, Providence, R. I., where he is at present doing research in antennas and propagation, and teaching.

During the summer of 1956, Dr. Angulo was a visiting research associate professor at the Control Systems Laboratory of the University of Illinois working in propagation problems.

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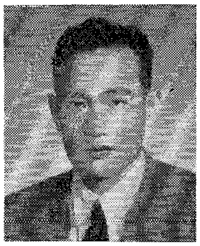

T. S. CHEN

Tsung-Shan Chen (A'48–M'55) was born in Hopei, China, on February 2, 1913. He received the B.S. from Tangshan Chiao-Tung University, China, in 1933, and the M.S. from Purdue University in 1934. He attended M.I.T. and received the S.M. in 1935 and the Sc.D. in 1938, both in electrical engineering.

He was professor of electrical engineering at the National Central University, China, until 1947. He joined RCA in 1951, and has been working in the Microwave Tube Advanced Development Section of the Tube Division at Harrison, N. J.