

Correspondence

Optimum Bandwidth for Waveguide-to-Coaxial Transducers

Mumford¹ 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:

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

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:

$R = Z_0$ at center frequency, and achieves bandwidths of the order of 20 per cent for a vswr of 1.10.

Since Z_0 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. λ_g/λ increases with decreasing frequency, but at a much slower rate than the decrease of $\sin^2 2\pi l/\lambda_g$;

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

λ_g/λ also decreases with increasing frequency.

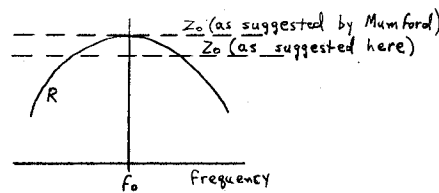


Fig. 1.

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 Z_0 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:

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

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

$$\cos^2 \frac{\pi d}{a} = \frac{Z_0}{240\pi g/a} \left[\left(\frac{\lambda_g}{\lambda} \sin^2 \frac{2\pi l}{\lambda_g}\right)_{at f_L} \cdot \left(\frac{\lambda_g}{\lambda} \sin^2 \frac{2\pi l}{\lambda_g}\right)_{at f_0} \right]^{-\frac{1}{2}} \quad (3)$$

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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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

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

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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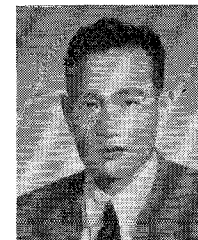
search associate of the Spanish Council of Scientific Research in Madrid and he worked in electroacoustics.

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.

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