DIELECTRIC POLARIZATION

The behavior of any dielectric as the frequency is varied depends upon the polarization existing in that dielectric. There are two distinct kinds of polarization, dipole and interfacial. Dipole polarization, as first described by Debye, occurs in dielectrics having polar molecules. In an alternating electric field these dipoles tend to oscillate with the field and the degree with which they succeed determines the increase in dielectric constant and capacitance. The way in which this increase occurs as the frequency is decreased is shown in Figure 1.[1] Dissipation factor also increases at first but reaches a maximum and then decreases in a symmetrical curve. Interfacial polarization, first described by Maxwell, occurs in composite dielectrics. The heaping up of the charged carriers, ions or electrons, at the interfaces of the components during each alternation of the electric field, serves to increase the dielectric constant and capacitance just as effectively as the oscillation of the dipoles. In fact the two types of polarization cannot be distinguished by the way either dielectric constant or dissipation factor varies with frequency. In that respect they differ only in the frequency ranges in which they occur, as indicated roughly in Figure 2. Interfacial polarization has also been called dielectric absorption and volume charge, these names being particularly appropriate when referring to the fact that the total charge stored in such a dielectric by the long-time application of a steady voltage can be several times that expected from the audio-frequency dielectric constant.

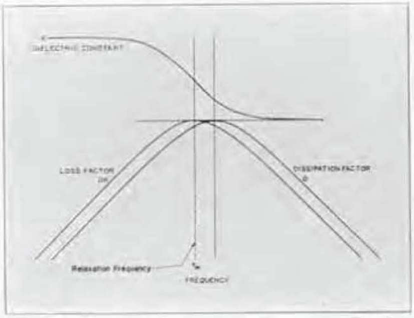

FIGURE 3. Change of dielectric constant, loss factor, and dissipation factor with frequency for a single polarization.

The frequency at which maximum loss factor [2] occurs, called the relaxation frequency, and the rates at which both loss factor and dielectric constant change with frequency depend on the kind of polarization, the kind of dielectric, and the temperature. For mica there is no dipole polarization and the relaxation frequency for its interfacial polarization is well below 1 cycle. The interfacial relaxation frequency for paper is also well below 1 cycle. Paper has also a dipole polarization in the neighborhood of 100 Mc, which is of little consequence be-

[1]E. J. Murphy and S. O. Morgan, The Dielectric Properties of Insulating Materials, *Bell System Technical Journal*, Vol. 16, Oct. 1937, pp. 493–512.

[2]Dissipation factor $D = \frac{R}{X}$; loss factor $= DK$, where K is the dielectric constant.

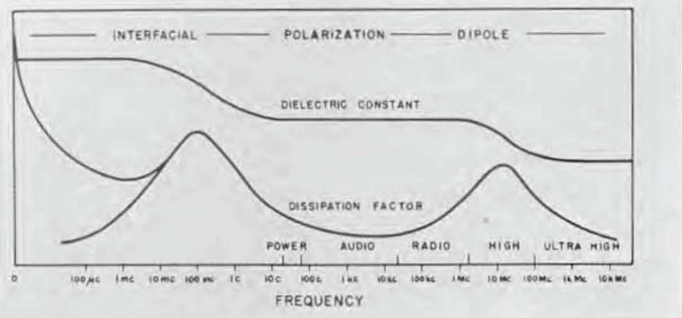

FIGURE 2. Typical curves showing how dielectric constant and dissipation factor change with frequency due to dielectric polarization (after Murphy and Morgan). The upper branch of the dissipation factor curve shows the effect of d-c conductivity.