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# Curves of Ground Proximity Loss for Dipole Antennas (a Digest)

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A brief description is given of a recently published atlas of curves showing dipole antenna loss due to the presence of a conducting ground.

This note describes a recent paper [Vogler and Noble, 1963],[1] in which ground proximity loss, defined as the decibel ratio of the antenna input resistance to its free space resistance, is presented in graphical form for four types of antennas: vertical and horizontal electric and magnetic elementary dipoles. Curves are given showing the ground proximity loss for a wide range of values of ground constants, antenna height above the ground surface, and frequency.

The paper contains a brief discussion of the importance of a knowledge of ground proximity loss in the design and evaluation of radio communication systems, the factors which affect the ground loss of an actual antenna, and the restrictions and assumptions that were made in formulating the problem. Relationships for obtaining the antenna input resistance $r$ and formulas used for the calculation of the resistance ratio $r/r_f$ for each of the four antennas are presented, and the method of evaluating the integrals involved is discussed. Explicit expressions are included for the resistance ratio over a perfectly conducting ground.

The numerical results, as shown by the graphs, indicate the considerable effect that ground proximity loss can have on the design of some radio communication systems. The curves presented may be used in the evaluation of radio systems through the concept of system loss [Norton, 1959].[2]

The accompanying figures show examples from the atlas of each of the four different antennas: vertical electric dipole (VED), horizontal electric

[1] Vogler, L. E., and J. L. Noble (1963), Curves of ground proximity loss for dipole antennas, NBS Tech. Note No. 175.

[2] Norton, K. A. (July–Aug. 1959), System loss in radio wave propagation, J. Research NBS **63D** (Radio Prop.), No. 1, 53–73.

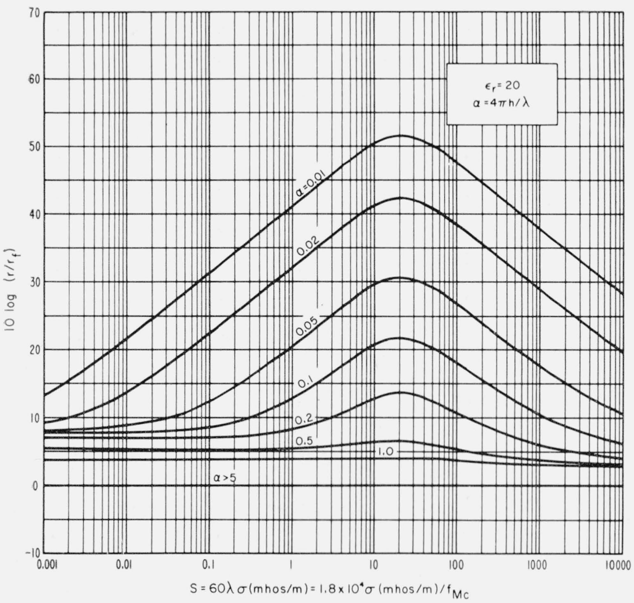


FIGURE 1. *Ground proximity loss for VED, $\epsilon_r=20$.*

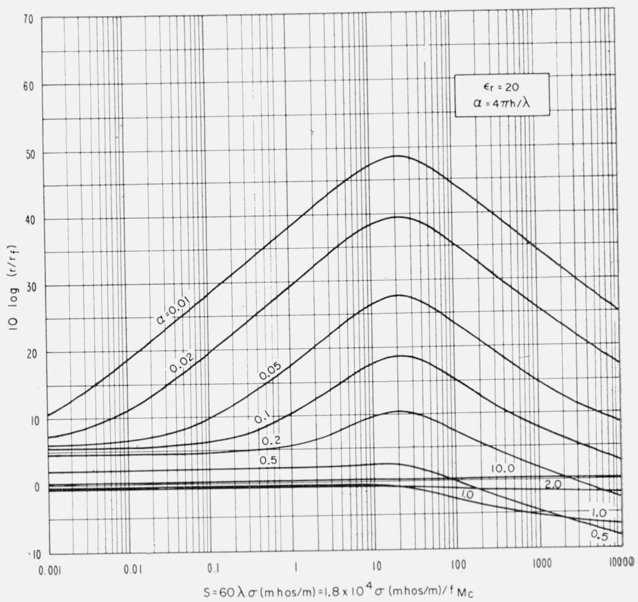


FIGURE 2. *Ground proximity loss for HED, $\epsilon_r=20$.*

687-416—63——9

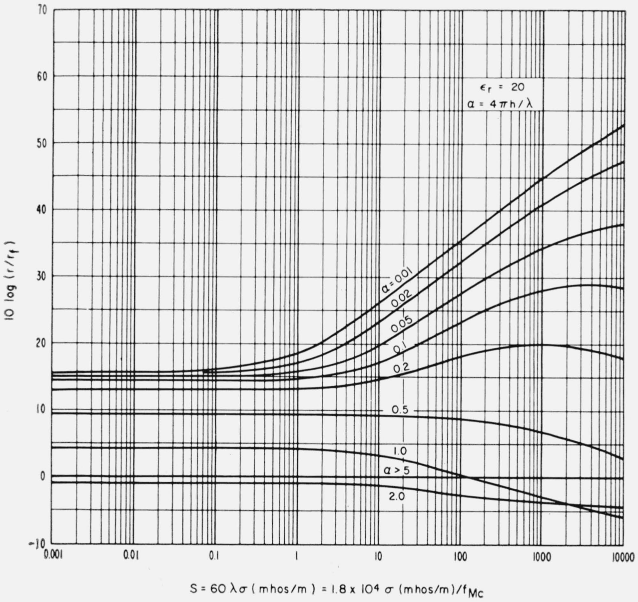


FIGURE 3. *Ground proximity loss for VMD, $\epsilon_r=20$.*

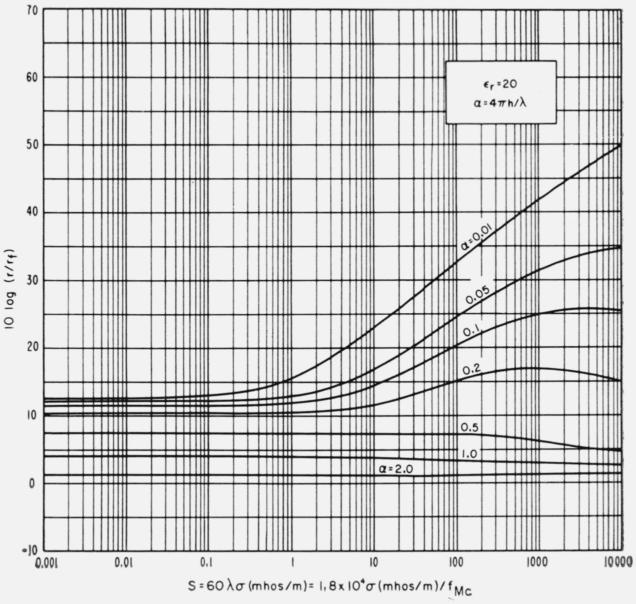


FIGURE 4. *Ground proximity loss for HMD, $\epsilon_r=20$.*

dipole (HED), vertical magnetic dipole (VMD), and horizontal magnetic dipole (HMD). The symbol $\epsilon_r$ denotes the relative dielectric constant and $\sigma$(mhos/m) the conductivity of the ground; $h$ is the height of the antenna above the ground, and $\lambda$ is the free space wavelength, both measured in meters. Similar curves in the atlas show ground proximity loss for values of $\epsilon_r$ ranging from 1.1 to 80.

The loss may become quite large for certain combinations of ground conductivity and frequency as the antenna height is decreased ($\alpha \to 0$). On the other hand as the ratio $h/\lambda$ is increased, the effect of the ground becomes negligible and the loss approaches zero for all conductivities and frequencies. For very poorly conducting soils the loss approaches a limiting value that depends on both the dielectric constant of the ground and the antenna height in wavelengths. For highly conducting grounds such that the quantity $\lambda\sigma \to \infty$, the loss is a function only of the ratio $h/\lambda$.

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