# III. ELECTRODYNAMICS OF MEDIA

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## A. SUBSURFACE PROBING AND COMMUNICATION WITH A MAGNETIC DIPOLE

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In geophysical subsurface probing and communication, the source is sometimes a current loop. At frequencies with the radius of the loop small compared with a wavelength, the current loop can be regarded as a magnetic dipole. We first want to find the radiation pattern with a magnetic dipole on the ground. We consider the ground to be anisotropic. In Fig. III-1 we show radiation patterns corresponding to anisotropy in permeability as compared with an isotropic case. It can be seen that increasing anisotropy in the positive direction increases the power coupled into the ground. This diagram is not plotted against the real observation angle from transmitter to observer, but against the angle at which the outflow of power is normal. We must appreciate that at an observation point, the power received may not come from the direction joining the observer and the transmitter, but instead from a different angle. The angle can be

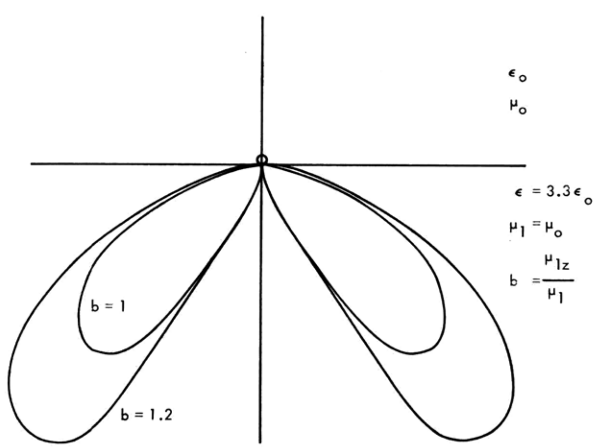


Fig. III-1. Radiation patterns.

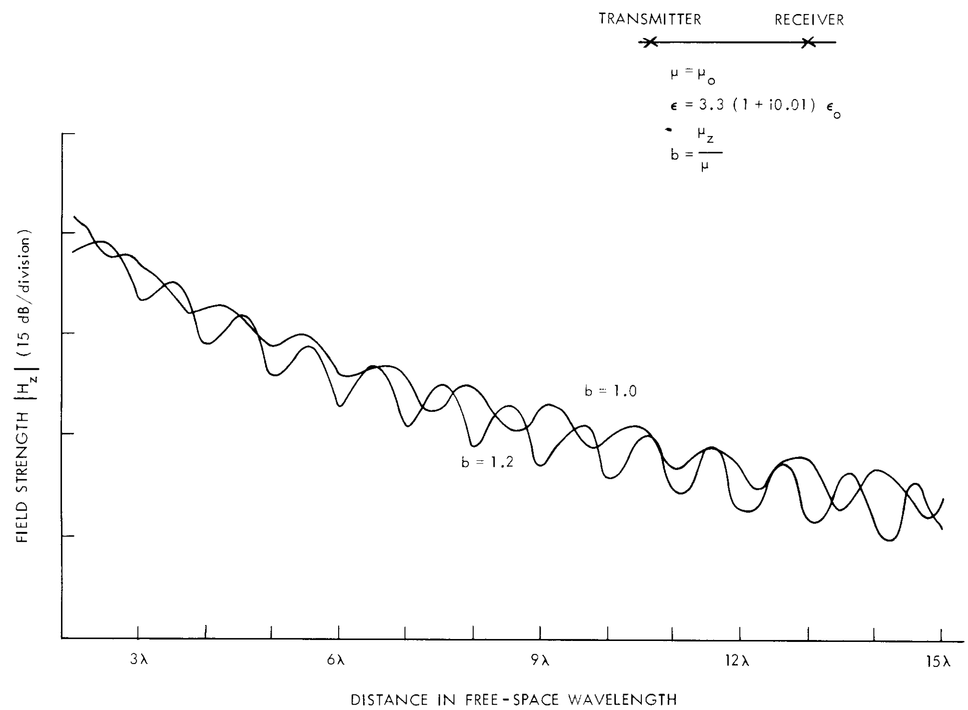


Fig. III-2. Interference patterns for half-space media.

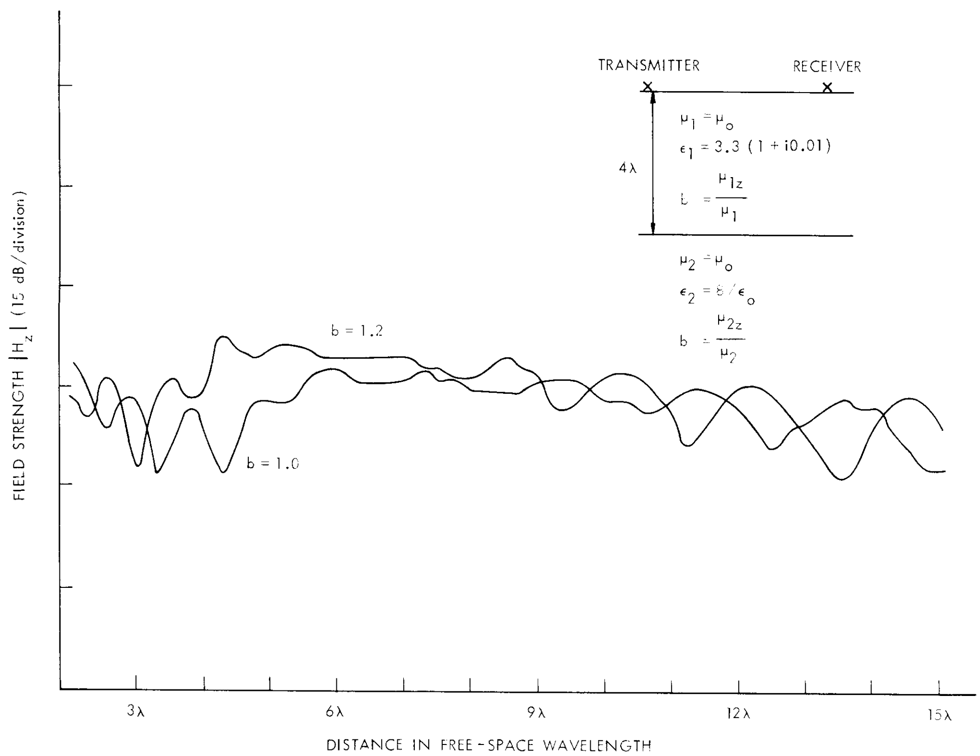


Fig. III-3. Interference patterns for two-layer media.

determined from the normal to the wave surface of the anisotropic medium.

When both transmitter and receiver are on the ground, we are interested in finding the field strength as a function of distance from the transmitter. The fields are TE waves with components $H_z$, $H_\rho$, and $E_\phi$. First, we assume that there is no subsurface reflector. Then the field strength $H_z$ for anisotropic and isotropic cases would be as plotted in Fig. III-2.

Second, we assume that there is a subsurface reflector and in Fig. III-3 we illustrate interference patterns of $|H_z|$. The reflector is assumed to be a dense dielectric medium with relative dielectric constant 81. It can be seen that the field strength does not decrease as fast as in the half-space case, mainly because of reflections from the subsurface.

These calculations were carried out with a formulation previously outlined by Kong[1] and with techniques applied elsewhere[2] by Tsang, Kong, and Simmons.

References

1. J. A. Kong, Geophys. 37, 985-996 (1972).
2. L. Tsang, J. A. Kong, and G. Simmons, J. Geophys. Res. 78, 3287-3300 (1973).