IRE Transactions on ELECTRONIC COMPUTERS

Volume EC-11 **April, 1962** **Number 2**

Published Bimonthly

Ch on 319

5.30.336

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IRE Transactions

on ANTENNAS and PROPAGATION

Volume AP-10 JULY, 1962 Number 4

Published Bimonthly

In This Issue

Radiation Fields from a Horizontal Electric Dipole

Near-Field Radiation Patterns Measured with Large Antennas

Space Tapering of Linear and Planar Arrays

A Quasi-"Isotropic" Antenna

Dipole Antenna in a Homogeneous Medium

Half-Wave Dipole in a Stratified Medium

Properties of Focused Apertures

Wire-Grid Lens Antenna

Pattern Limitations in Multiple-Beam Antennas

Excitation of Slots in a Conducting Screen

Geodesic Luneberg Lenses

Horizontal Polarization Reflection Coefficients

Wave Propagation in Magneto-Plasma Slabs

Magneto-Ionic Theory for Drifting Plasma

Radiation in a Gyro-Electric-Magnetic Medium

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Second-class postage paid at MENASHA, WISCONSIN, under the act of August 24, 1912. Acceptance for mailing at a special rate of postage is provided for in the act of February 28, 1925, embodied in Paragraph 4, Section 412, P. L. & R., authorized October 26, 1927.

IRE Transactions on Antennas and Propagation

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contributions

Radiation Fields from a Horizontal Electric Dipole in a Semi-Infinite Conducting Medium*

ALBERT W. BIGGS†, MEMBER, IRE

Summary—**The radiation fields of a horizontal electric dipole in a semi-infinite conducting medium are developed to yield a ground wave near the surface and a space wave above it. Previous work for points of observation slightly above the conducting medium is extended to the entire region by including the height of the observation point in the evaluation of the integral by the saddle point method. The effect of burying a horizontal electric dipole is to modify the field intensity by exp $(-h/\delta)$, where h is the depth of burial and δ is the skin depth of the medium. As h approaches zero, the expressions for radiation fields are identical with those developed by Norton.**

Introduction

THE GROUND WAVE of a horizontal electric dipole is the term used to describe the total wave which would exist along the surface of the conducting medium if the ionosphere were absent.[1] It attenuates at a rate slightly greater than inverse distance from the dipole because of the finite conductivity of the medium. The space wave is that part of the total wave above the surface which attenuates at a rate equal to the inverse distance. If the ionosphere were present, the space wave might be reflected therefrom and appear at the surface as a skywave.

The ground and space waves in the radiation field of the dipole located in air or at the surface of a flat earth have been investigated by Norton [2], Wait [3], [4], Sommerfeld [5], and King [6]. When the soil parameters are known, the field strength of the ground wave can be evaluated from equations and curves developed by Norton [7] and Millington [8]. The effect of submerging the horizontal electric dipole in a finitely conducting medium was investigated by Moore [9], Von Aulock [10], Wait [11], Kraichman [12], Saran and Held [13]. Powers and Ross [14], and Baños and Wesley [15]. Moore analyzed the effect of submerging a horizontal electric dipole in the ocean for very low frequencies. Baños and Wesley extended their investigation of buried dipoles to higher frequencies. Their results yielded the field intensities for points of observation slightly above and below the surface of the conducting medium. The purpose of this paper is to extend Baños and Wesley's results to include the space wave as well as the ground wave for a buried antenna.

Integral Formulation of Radiation Fields

The semi-infinite conducting medium is represented by a flat earth with a conductivity σ and a dielectric constant ϵ. Above this medium is nonconducting air with a dielectric constant ϵ_0. The permeability of both media is μ_0, which is the same as free space. Propagation is limited to low frequency radio waves. The fields have a time dependence exp $(-i\omega t)$.

The coordinate system for the buried dipole is shown in Fig. 1. The air is described by the region $z \geq 0$. The dipole is oriented in the x direction and is located at

* Received, July 10, 1961; revised manuscript received, January 29, 1962.
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IRE Transactions on CIRCUIT THEORY

Volume CT-9 JUNE, 1962 Number 2

Published Quarterly

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