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IEEE Standard Test Procedure for Antennas

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Corrected Edition

When IEEE Std 149-1965 was originally approved, it included Section 11 — Definitions. That section was superseded by IEEE Std 145-1969, IEEE Standard Definitions of Terms for Antennas. This edition has been published without the superseded definitions, as reaffirmed in 1971 by the IEEE Standards Committee and approved by the American National Standards Institute.

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This publication was prepared by the Subcommittee on Methods of Testing Antennas of the IEEE Antennas and Waveguides Committee.

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CONTENTS

Test Procedure for
ANTENNAS

1. INTRODUCTION

1.1 Foreword

This Test Procedure, which supersedes the previous issue, "Standards on Antennas—Methods of Testing" 48 IRE 2S2, is concerned with measurements of the properties which characterize antennas.

In Section 1.2, symbols and units to be used in this Test Procedure are defined. The effect of the environment on the antenna and its characteristics is discussed in Section 1.3, and certain precautions to be taken during the measurements are suggested. In Section 1.4, the usefulness of the reciprocity theorem in antenna measurements is cited, along with examples of situations in which this theorem does not apply. The characteristics of electromagnetic wave polarization are outlined in Section 1.5, with emphasis on those aspects which are important in the measurement of antennas. Section 1.6 treats those electromagnetic field regions which are of particular interest in antenna measurements. In Section 1.7, the features and limitations of scale models for antenna measurements are discussed.

In Sections 2 through 10, those antenna characteristics which may require measurement are considered. The techniques associated with the measurement of each are discussed, but no attempt is made to furnish step-by-step procedural descriptions. References which are illustrative of measurement techniques are provided in which details may be found. Since measurement techniques undergo continuing refinement, the reader should be alert to references on the subject of antenna measurement which appear after this Test Procedure was prepared.

Throughout this document, certain terms are italicized where they first appear in each section. Definitions of these terms are given in IEEE Std 145-1969, IEEE Standard Definitions of Terms for Antennas, and supersede those which appeared as Section 11 of the 1965 edition of IEEE Std 149-1965.

1.2 Symbols and Units

The basic symbols used in this Test Procedure are given in the following list. Rationalized MKS units are employed, and are listed for each symbol.

BW = half-power beamwidth, degrees
D = diameter or maximum dimension of an antenna aperture, meters
E = electric field strength, volts per meter
f = frequency, cycles per second
G_{max} = maximum power gain of an antenna
$G_{d\,max}$ = directivity of an antenna
I = current, amperes
L = loss factor (ratio of power input to output)
n = ratio of full-scale dimensions to scale-model dimensions
P = power, watts
R = distance from antenna to observation point, meters
S = standing wave ratio (voltage or current)
T = noise temperature, degrees Kelvin
V = voltage, volts
Z = impedance, ohms
θ = co-latitude angle (see Figure 3)
λ = free-space wavelength, meters
ρ = voltage reflection coefficient
Φ = azimuthal angle (see Figure 3)
Ψ = antenna rotation angle

1.3 Environmental Factors

An *antenna* can be considered adequately tested only when the tests have recognized the environmental conditions of operation affecting antenna performance. Many of these environmental factors are of a specialized nature, and it is impractical to include the appropriate tests in this Test Procedure. Instead, a few cases will be briefly mentioned as examples of interest to the reader.

One category of environmental factors may be defined as directly affecting the material properties or structure of an antenna, and thus indirectly affecting the electrical characteristics. Mechanical loading of the antenna structure by wind and ice is a common, but nevertheless important, effect to be considered in the testing of many antennas. Vibration and shock tests are often made to assure that an antenna subject to severe accelerations will maintain its structural integrity, as well as to determine whether dynamic deformations are within allowable electrical limits. Antennas in exposed locations are often provided with lightning protection and anti-icing devices; the effect of such devices on the electrical characteristic must be evaluated.

Various natural or man-made environments may impose special requirements: for example, shipborne antennas may have to withstand water-wave impact and salt-water corrosion. Antennas on hypersonic vehicles must withstand very high temperatures and pressures, and antennas designed for satellite or space-probe application must withstand intense ionizing radiation, hard vacuum, and extreme temperatures. Those ground-based antennas which are intended to operate in the vicinity of a nuclear blast should maintain their essential properties in the wake of seismic waves, atmospheric shock waves, thermal radiation, ionizing radiation, blast-product erosion, and radioactive debris.

Certain antenna applications necessitate unusual attention to tests involving quite ordinary aspects of the physical