

DESIGN NOTES

More Notes from History

For the past 15 years, I've been collecting interesting older books on radio technology. Some are well-known (by Kraus, Terman, Jasik, etc.), and some not so well known. One interesting book is a 1945 volume, Transmission Lines, Antennas and Waveguides, by three professors in the Harvard School of Engineering: Ronold W. P. King, Harry Rowe Mimno, and Alexander H. Wing. The book is the collection of class notes for a graduate-level course taught to military officers during World War II. Each chapter of this book includes descriptions presented with exceptional clarity, especially to new graduate students who have some familiarity with the subjects. I've selected some of these to present in this column. The availability of this book is unknown. I've not seen a copy other than the one I purchased at a used book store.

—Gary Breed, Editorial Director

Transmission Lines

Chapter 1, "Transmission Lines," begins, "The transmission of power over long distances by means of wires or 'lines' is well known. There are in use transmission lines several hundred miles long transmitting power from generators of commercial power frequencies, 25 to 60 cps. Long as these lines are, they are relatively short when compared to the electrical wavelength. Since electromagnetic disturbances on open-wire transmission lines travel approximately with the speed of light (186,000 miles per second), the wavelength at 60 cps is 3,100 miles. Thus a 310-mile 60-cycle transmission line is only 0.1 wavelength long. At radio frequencies, the wavelength may be measured in a few inches or in a few centimeters."

Distributed behavior is described later in this chapter: "The transmission line cannot be analyzed as a simple series circuit, because the current in the wires is not everywhere the same. The variations in current and voltage must be examined inch by inch, centimeter by centimeter, meter by meter, etc., depending upon the wavelength and the unit of length chosen. The factors of fundamental importance are the series resistance and inductance per unit length, and the shunt capacitance per unit length. . . . A line is said to be uniform when these "distributed constants" are the same over the whole line.

Antennas

Chapter 2, "Antennas," begins with this reminder: "In order to understand the behavior of antennas and electric currents at ultra-high frequencies, it is essential to recognize that phenomena of a vastly more gen-

eral nature are involved than encountered in conventional electric networks. Attention is seldom called to the fact that electric-circuit theory which proceeds from Kirchoff's laws is a highly specialized form of a more general theory."

Other descriptions from this chapter include the following:

"It is difficult to understand the structure of general electromagnetism without first learning the appropriate symbolism, that of mathematics. But if one is willing to accept some things on faith and to meet others with an open, perhaps even an adventurous mind, a degree of familiarity with many electromagnetic phenomena can be acquired from a qualitative discussion." And,

"Every effective antenna is by its very nature coupled to all surrounding matter in the sense that work done to maintain periodic motion of charges in the antenna is largely work that will be done on charges that can ultimately be set in motion throughout the universe. . . . Only a small part of the energy supplied to an antenna is used to heat it. Most of the energy is transferred away from the antenna, presumably to be used eventually in heating all the innumerable imperfect conductors and imperfect dielectrics in which currents however small are maintained."

UHF Circuits

Ultra-high frequency circuits are defined as those with dimensions of the same order as the wavelength. Assuming they are not intended to be antennas, "its radiation can be kept small either by arranging equal and opposite currents close to together, as in open-wire lines, or by enclosing the entire circuit in a metal shield."

This chapter continues with a discussion of the "three dimensional problem" of delivering power from a generator to a load, the three dimensions being the axial component and two transverse variables.

Wave Propagation

The final chapter covers the basics of propagation, including line-of-sight, refraction and ionospheric reflection, including the description, "a radio wave originates in a systematic movement of many millions of electrons, all guided in the same general path and executing related motions. By the cumulative effect of such related disturbances one may hope to produce a planned force, of practical engineering magnitude, at a great distance. The simplest periodic movement that can be guided and controlled is the surge of electrons, to and fro, on a wire or other conductor."