NBS MONOGRAPH 23

Amplitude-Probability Distributions for Atmospheric Radio Noise

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Families of amplitude-probability distribution curves are presented in a form such that by using three statistical parameters of atmospheric radio noise, of the type published by the National Bureau of Standards, the corresponding amplitude-probability distribution may be readily chosen. Typical values of these parameters are given.

1. Introduction

A knowledge of the detailed characteristics of atmospheric radio noise is essential to the design of radio communication systems operating at frequencies up to about 30 Mc/s. These characteristics can conveniently be expressed in terms of an amplitude-probability distribution which has been found to be an extremely useful tool in the analysis of the expected interference to a communication system [1].[1] However, since the measurement of the complete amplitude-probability distribution on a continuous basis for many frequencies and locations is prohibitive in both manpower and equipment needs, a method of obtaining this distribution from three easily measured statistical moments has been developed at the National Bureau of Standards [2]. The three moments are the average power, the average envelope voltage, and the average logarithm of the envelope voltage, and are expressed, respectively, as:

F_a=the effective antenna noise figure,
=the external noise power available from an equivalent, short, lossless, vertical antenna in decibels above ktb (the thermal noise power in a passive resistance at room temperature, t, in a bandwidth, b),
V_d=the voltage deviation in decibels below F_a,
L_d=the log deviation in decibels below F_a.

F_a can be expressed in terms of the root mean square field strength by means of the nomogram in figure 1. It should be noted that although F_a is independent of bandwidth, the root mean square field strength is proportional to the square root of the bandwidth used.

The shape of the distribution curve is dependent only on V_d and L_d, and since they have been normalized to F_a, it is possible to construct [2] distribution curves for various combinations of these parameters, independently of the value of F_a. Such curves are given in figures 2 through 21 for the range of values of V_d and L_d for which the distribution is valid. These curves give the percentage of time the ordinate is exceeded. In order to minimize the number of graphs required, several curves have been drawn on each graph at arbitrary levels. The circle on each curve corresponds to the value of F_a (the root mean square voltage for the distribution) and by shifting the ordinate scale so that zero decibel corresponds to the circle on the proper curve, the ordinate can be determined in decibels above F_a.

Values of F_a, V_d, and L_d are recorded continuously at ten of the stations in the worldwide network established by NBS [3]. These recordings are made at eight fixed frequencies between 13 kc/s and 20 Mc/s, using a bandwidth of about 200 c/s, and the data are published [4, 5] in tabular form. Values of F_a only are recorded at six additional stations in the network and are included in the publications. In addition, predictions of worldwide values of F_a have been published by C.C.I.R. [6].

Typical values of the three parameters are shown in figures 22 and 23. Figure 22 gives F_a versus frequency for summer nighttime and winter daytime, which are the periods of highest and lowest atmospheric noise levels, respectively. Curves are shown for the estimated values of F_a for each type of noise (atmospheric, galactic, and manmade) by taking into account propagation conditions as well as the recorded values.

Figure 23 gives V_d and L_d versus frequency for summer nighttime and winter daytime. The curves were not drawn through all of the measured points, since some signal contamination has been encountered and the smoothed curves are considered more representative of true conditions. The portions of the V_d and L_d curves that result from each of the three noise sources will be the same as shown for F_a in figure 22.

Although the distribution curves given in figures 2 through 21 are considered valid for a wide range of bandwidths, the values of V_d and L_d used in determining the distribution must correspond to the bandwidth to be used. The values given in figure 23 are for a 200 c/s bandwidth and must be adjusted for any other bandwidth. Methods of converting these statistical moments from one bandwidth to another are under development at NBS and will be published in the near future.

[1] Figures in brackets indicate the literature references on page 2.

2. References

[1] A. D. Watt, R. M. Coon, E. L. Maxwell, and R. W. Plush, Performance of some radio systems in the presence of thermal and atmospheric noise, Proc. IRE **46, 12,** 1914 (1958).

[2] W. Q. Crichlow, C. J. Roubique, A. D. Spaulding, and W. M. Beery, Determination of the amplitude-probability distribution of atmospheric radio noise from statistical moments, J. Research NBS **64D,** 49 (1960). (See appendix.)

[3] W. Q. Crichlow, C. A. Samson, R. T. Disney, and M. A. Jenkins, Radio noise data for the International Geophysical Year July 1, 1957–December 31, 1958, NBS Tech. Note 18 (PB 151377) (July 27, 1959).

[4] W. Q. Crichlow, C. A. Samson, R. T. Disney, and M. A. Jenkins, Radio Noise Data for the Season March, April, May 1959, NBS Tech. Note 18–2 (PB 151377–2) (March 14, 1960).

[5] W. Q. Crichlow, Noise investigation at VLF by the National Bureau of Standards, Proc. IRE **45, 6,** 778 (1957).

[6] Report on Revision of Atmospheric Radio Noise Data, C.C.I.R. Rept. No. 65, VIIIth Plenary Assembly, Warsaw (Intern. Radio Consultative Comm., Secretariat, Geneva, Switzerland) (1956).