5. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The current information on worldwide atmospheric noise levels and other characteristics is contained in CCIR Report 322 (1964). Since the publication of this report, additional measurements and other investigations have identified some main areas where the current atmospheric noise estimates could be improved. These areas are summarized below.

A great deal of additional measurements have become available and more locations on the earth's surface, making it possible to improve the estimates of atmospheric noise levels (field strength) worldwide. In this report, the analysis of this additional data (as well as the original data) has been presented and new improved estimates obtained, both in graphical and numerical form. These two forms are "identical," which is not the situation currently. Also, the new results are substantially different (on the order of 20 dB in some cases) from the current CCIR estimates for some areas, especially around the "new" measurement locations.

In order to determine the effects of the non-Gaussian atmospheric noise on system performance, the APD (cumulative exceedance distribution of the received noise envelope) is always required information (but sometimes not sufficient). The APD is a function of the receiver bandwidth and the present method of converting from the CCIR Report 322 bandwidth (200 Hz) to the required bandwidth has been shown since the publication of CCIR Report 322 to be greatly in need of modification. This report presents a new bandwidth conversion procedure based on a very extensive analysis (Herman and De Angelis, 1983). While this procedure is strictly valid only at MF, its use in place of the current method should be a substantial improvement. Also, preliminary analysis of wideband noise measurements at HF tend to indicate that the MF results will also be valid at HF. This report also presents numerical algorithms for the bandwidth conversion and for the APD itself. Care should be exercised when applying this new procedure to lower frequencies (i.e., LF, VLF, and ELF) as the pulse time structure of the atmospheric noise is different at these lower frequencies and, therefore, perhaps affected differently by the receiver bandpass. Also, the original analysis that led to the current CCIR Report 322 bandwidth conversion relationships assumed Gaussian-shaped receiver filters (i.e., no ringing), whereas the study by Herman and De Angelis (1983) used essentially rectangular shaped bandpasses (thus better representing modern communications receivers). The bandwidth conversion of the APD, is, therefore, in need of further study and refinement, both with measurements (especially at the lower frequencies) and with analytical investigations.

Previously, numerical representation (coefficients) were available for only a few of the noise parameters given by CCIR Report 322. Here, we have given the numerical representation of all these parameters. We have also done this for parameters that were not explicitly included before in Report 322 (i.e., σ_{V_d}, L_d, and σ_{L_d}).

The CCIR Report 322 presents estimates for average background atmospheric radio noise, with any effects caused by local thunderstorm activity removed from the data. In various areas of the world, local thunderstorm activity is present enough of the time to be an important factor. Also, noise from this local activity can be important at frequencies above HF. Information concerning the effects of local thunderstorm activity is given in the report by Hagn and Shepherd (1985). However, additional information on the effects of local thunderstorm activity is required and should be obtained by measurements, perhaps coupled with satellite observations (Kotaki, 1984). The report by Hagn and Shepherd (1985) also gives the relationships between F_a and rms field strength for antennas other than a short vertical monopole (the only antenna treated by CCIR Report 322), along with recommendations for additional needed efforts in this area.

The above should remove the main drawbacks present in the current atmospheric radio noise estimates. There are, however, other areas that still have not been treated in any systematic way. These include noise directionality and polarization. Also, measurements exist at only a very few locations in the Southern Hemisphere, so additional information is needed here to further improve the estimates there. It is possible that data from satellites can supplement ground-based observations to improve the estimates for these regions (Kotaki and Katoh, 1983 and Kotaki, 1984). The results of Kotaki (1984) (and any similar results) should be compared with the new estimates obtained here to define areas where additional measurements would be fruitful. In addition to measurements (e.g., Hagn et al., 1968), the procedures developed for obtaining atmospheric noise directionality and polarization results from thunderstorm distributions (Maxwell et al., 1970, Kelly et al., 1981, and Ortenburger et al., 1971) can be used to develop worldwide "directivity factors" to use in conjunction with the current omnidirectional estimates. These techniques can also be used, of course, to generate omnidirectional noise "data" for areas of the world where measurements do not exist.

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