THE AMPLITUDE PROBABILITY DISTRIBUTION OF THE ATMOSPHERIC RADIO NOISE AT SOURCE

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The Amplitude Probability Distribution (A.P.D) in the origin of atmospherics has been investigated.

The received atmospheric noise structure depends on so many factors, that is, the geographycal area of thunderstorms, the noise structure of ground and cloud discharge, the character of propagation of electromagnetic waves, the distance of propagation, and the receiver responce and so on. Because of complexity of these factors, a complete and precise description of the noise structure are thought still to be not possible. Various methods of measurement have been exploited to solve the atmospheric noise problem in many countries till to the present. In our Institute, the elaborate investigations of atmospheric noises have been made by means of statistical method in relation with interference of noise on wireless communication system.

As the study abvances, it has brought us the desire to have the information of statistical characteristics of atmospheric radio noise at the source. Williams (1959) found that probability distribution of waveform amplitudes has the same characteristics as that of current peaks in cloud-to-ground discharges. Volland (1966) showed that the measured A. P. D of VLF noise is related to the geophysical distribution of lightning sources, to the transfer function of an original waveform, which is determined by the nature of earth-ionosphere wave guide and to lightning waveforms. Galejs (1966, 1967) calculated A.P.D based on amplitude distribution of lightning current to ground for the lower and higher amplitude current levels.

When the atmospheric radio noise is received at a long distance exceeding several hundred Kilo-meters from a thunderstorm center, A.P.D of the atmospheric radio noise can be represented apploximately by two or three sections of a curve on log-normal graph paper (Clarke 1962).

In the tropics, the number of local and nearby thunderstorm are usually appreciable. Ibukun (1966) limited his consideration to the tropical sources within distances less than several hundred Kilo-meters and showed that A.P.D of atmospheric noise in this case can closely be approximated by two log-normal characteristics within the limit of occupation time rate from 90 % to 0.001 %, the two log-normals have a different median and a different standard deviation, and they intersect at 3 % occupation time.

An observation of atmospheric radio noise close to their source has been carried out in this summer season at IMAICHI, TOCHIGI Prefecture, one of the most active thunderstorm districts in Japan. We concerned the noise at frequency 10 KHz under the condition of thunderstorm taking place within the distance of 30 km from the observing point.

The block diagram of the equipment is shown in Fig. 1.

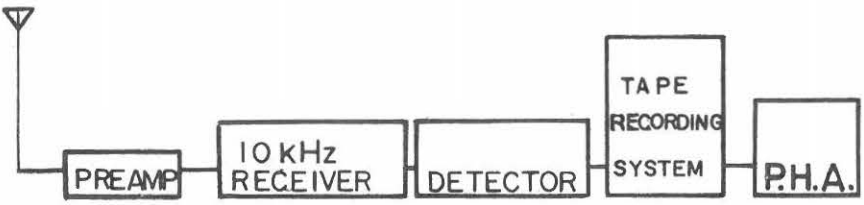

Fig. 1 Block Diagram of The Instrument

The measurement were made with a receiver tuned to 10 KHz with 3-db bandwidth of 900 Hz and a vertical antenna of 3.5 m long. After the atmospheric noise induced on the antenna has passed through the receiver system, i. e. the pre-amplifier, the HF amplifier, the mixer and the IF amplifier, the IF output is detected and recorded on a magnetic tape recorder. The A.P.D of the atmospheric noise is measured with a Pulse Height Analyzer through a reproduction process of the magnetic tape.

Generally, the higher half voltage section of a A.P.D obtained near to the source fluctuates appreciably according as how we choose the sampling time. Therefore, to provide a stasticaly significant data, the sampling duration is so arranged that the fluctuation could be reduced as small as possible.

Shown in Fig. 2 are the mearsured typical A.P.D curves at the source and the dashed curves is that obtained for a long distance. The thundercloud on Aug. 12, 1967 was observed to break out and to grow over the city of IMAICHI, and the cloud was seen to extinguish as it leaved there.

In this case, active time of the thundercloud was estimated to be about one hour. It was checked by watching a P.P.I radar echo that the received signals of large amplitude actually orginated from lightning flashes which occured within the range of 30 km from observing point.

Here 80 db indicates 1.5 v/m. At higher amplitudes, the probability distribution of atmospheric noise envelope has been found to be well represented by a straight line between 10 % and 0.005 % occupation time rate on log-normal graph paper.

If the noise amplitude is expressed in logarithmic units, the distribution is found approximately to follow a normal law over a range of probability. Using a coordinate system based on log-normal scales, a linear plot is obtained as,

$$Q(v) = \frac{0.4343}{\sigma\sqrt{2\pi}} \int_{v}^{\infty} \frac{1}{v} \exp\left[-\frac{(\log v - \log M)^2}{2\sigma^2}\right] dv$$

Where M is the median value of v and σ is the standard deviation of log v. The distribution is completely defined by M and σ. The straight line of a slope is characterized inversely propotional relation to the standard deviation.

In Fig. 2 the slope is presumed to be $\sigma \approx 16 \sim 19$ db, but this value is variable from a thunderstorm to another. It has been found that M and σ varying simultaneously in association with thunderstorm developement, but this calls for further study of atmospheric noise structure in a thunderstorm. The lower probability section of the noise distribution, which corresponds to higher voltage levels, is, in general, composed of many non-overlapping large pulses occuring in frequently, while the higher probability section which corresponds to lower voltage is mainly composed of many random overlapping events, such as the noises from distant storm centers and the set noise. Upper most value of the noise amplitude is limited, in this case, by the saturation of pre-amplifier, and plus 20 db or so higher voltage level would be expected.

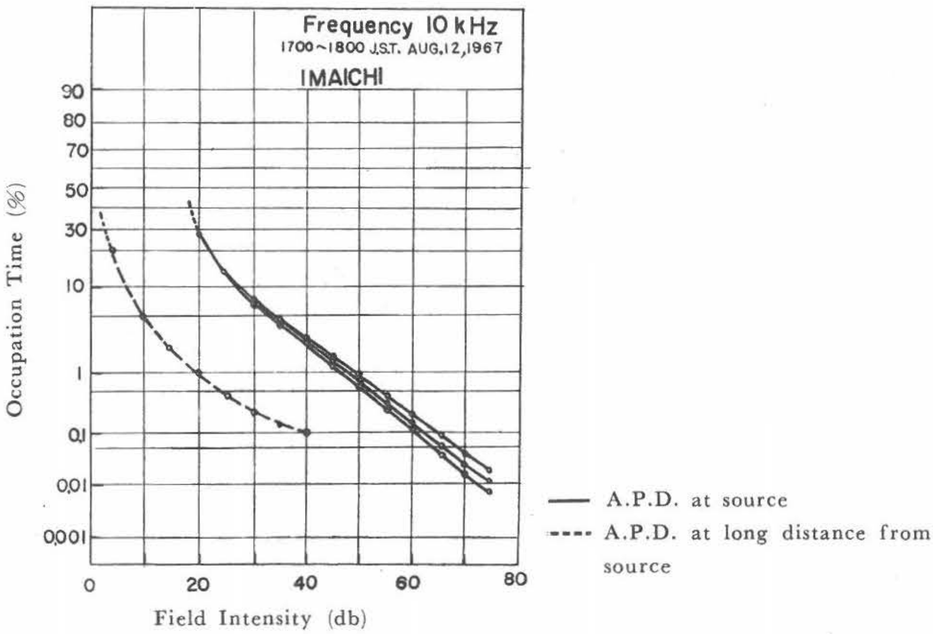

Fig. 2 Amplitude Probability Distribution of Atmospheric Radio Noise at Source.

Further information about the amplitude structure will be obtained by counting the number of crossings of the noise envelope above a series of threshoulds and measuring the probability distributions of pulse width or pulse to pulse width.

Conclusion As compared with the A.P.D of atmospheric radio noise of long distant origin, which can be represented by two or three log-normal distribution, the A.P.D at the souree has been found well fits for the representation of one log-normal distribution in the wide range of higher voltages.

Acknowledgement The authors wish to express their sincere thanks to Ishikawa's Research group for their valuable discussions and kindly supplying their data during this study.

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