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Pulse Spacing Distribution of VHF Rural Wideband Radio Noise

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Abstract

VHF radio noise has been studied in a rural environment with a large bandwidth. The pulse spacing distribution is similar to that of random Poisson-distributed pulses over periods of a few minutes, but over longer periods the mean pulse rate changes causing the long-term pulse spacing distribution to exhibit a more complex form.

The specification of radio noise properties requires the determination of both the amplitude and time statistics of the noise. The amplitude probability distribution function (APD) is preferred for describing the noise amplitude, while time statistics are usually specified by the pulse duration distribution (PDD) and the pulse spacing distribution (PSD) (Spaulding *et al.* 1971). As larger bandwidths are used, the noise becomes more obviously impulsive in its form and the PSD becomes a more natural parameter for measurement than the PDD, although the latter can be important due to its intimate connection with the radiofrequency spectrum of the noise. In contrast to the APD, the PSD has proved difficult to model theoretically (Disney and Spaulding 1970) and simple noise models invariably fail to describe observed structure in the PSD.

In principle, the noise PSD should be very simple. If the occurrence of noise pulses is a Poisson process and a pulse is accepted as such when the observed field strength exceeds some predetermined value, then the PSD should be exponential in form with the (negative) exponent being proportional to the mean pulse rate. No matter how many noise sources are considered, provided that each process produces uncorrelated random noise, the distribution should remain exponential. When measurements have been made, however, an exponential distribution has rarely been reported, the general indication being that some correlation can exist between one pulse and the next. This idea fits in well with the concept of the occurrence of noise bursts: non-stationary noise generating processes might be, for example, thunderstorms with discharges consisting of a number of strokes or, in urban areas, sources of man-made noise with intermittent usage. However, measurements at our laboratory have shown that the correlation can extend to many seconds in a rural location and can depend on the time of day or time in the week. In order to investigate the problem further, the PSD of rural wideband noise at 50 MHz has been observed on a regular basis for several months and an account of some of the results is presented below.

Measurements have been made at the Buckland Park field station of the University of Adelaide, which is situated in a rural location 25 km from the city limits. The antenna used was a half-wave folded dipole, one-quarter of a wavelength above ground and feeding a 50 MHz receiver with 10 MHz bandwidth. As described in a previous paper (Clay *et al.* 1973), this large bandwidth allows the use of pulse techniques, and the PSD was determined by feeding the detected receiver output into a nuclear physics discriminator and using the discriminator output with suitable

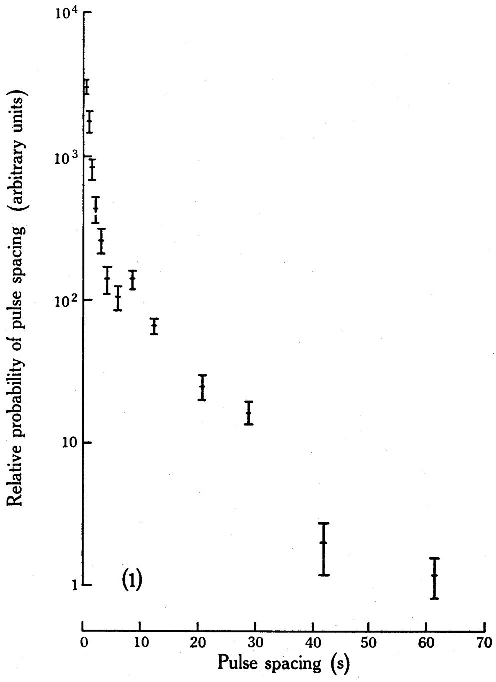
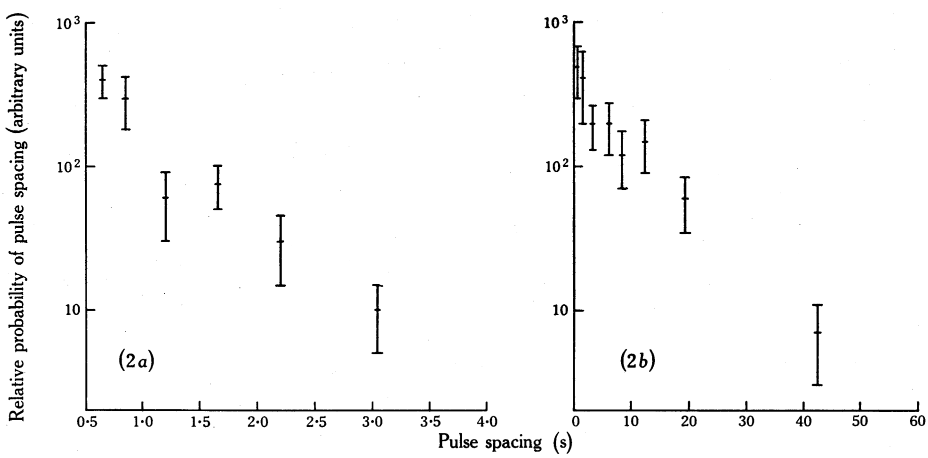


Fig. 1 (*left*). Typical example of a daytime noise pulse spacing distribution as observed in the present experiment.

Fig. 2 (*below*). Pulse spacing distributions (*a*) and (*b*) obtained from two 5-min periods of the experimental run from which Fig. 1 was obtained.



amplification to put pulse markers on to a fast-moving (10 mm s^{-1}) chart. This means that, in principle, spacings can be measured down to 100 ms, although measurements are not normally made below 600 ms in order to retain acceptable accuracy.

For convenience, most of the PSD measurements were made in the daytime. However, television transmissions limit the measurement of other noise parameters at these times and some work was done at night. Local television broadcasting includes a 57–63 MHz channel, the receiver response being only 6 dB below its maximum at the lower frequency (the broadcast antenna is visible at a distance of about 50 km). The pulse amplitudes normally observed are about 20 dB above the television background. A typical daytime PSD, such as that shown in Fig. 1, would give a straight line of slope related to the mean pulse rate for a Poisson noise source.

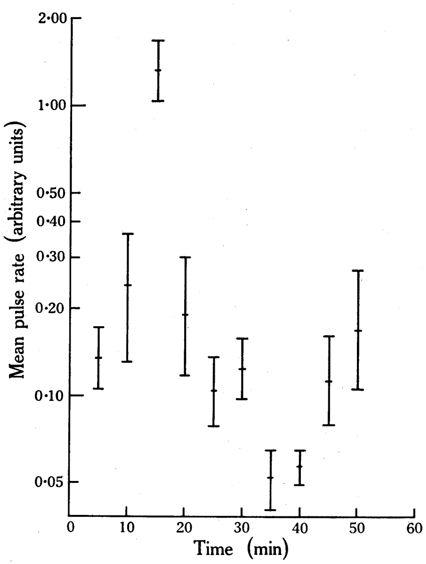


Fig. 3. Long-term variation of the mean pulse rate for 5-min subsets of the data plotted in Fig. 1. The values were obtained from distributions such as those shown in Fig. 2.

As discussed above, it is possible to interpret these curves as being the result of correlations between the observed pulses, although here correlations would be necessary between pulses with spacings of the order of seconds. It is not clear what physical processes are involved in producing these noise bursts, and an alternative interpretation could be that there is no direct correlation between successive pulses but that the mean rate of pulses changes with time. As an analogy, one can picture the counting of decays in a radioactive source. The decays are random and an exponential spacing distribution is observed. If, within the period of measurement, the original sample is replaced by another, a different random spacing distribution will be found and the result for the whole run will be the sum of two exponentials, giving a distribution rather like that found in the radio data. The two interpretations then are: (1) correlations between successive pulses or (2) a non-stationary noise generating process.

In order to test the two hypotheses, the runs were split into shorter time sections and PSD's were obtained for each section. If the hypothesis (2) is correct, a number of distributions will be obtained which approach exponential in form; if the hypothesis (1) is correct, each individual distribution will be a random sample from the total distribution in Fig. 1. Representative data obtained in this way are shown in Fig. 2. Only two 5-min subsets are presented but they are typical of the others. It is clear that these subsets would not be likely to be obtained from the data in Fig. 1 by random sampling and that each is much more like a simple exponential than the parent distribution. For random pulses, the slopes of the distributions are inversely proportional to the mean pulse rates and the variation of the inverse of the e-folding times for the distributions is a measure of the variation in the mean pulse rates. A plot of the resulting variation is shown in Fig. 3, where it is seen that considerable changes in rate can occur within quite short times. Similar results have been found at all times of day and night for these large background pulses.

At night, other noise parameters can be measured for comparison with the mean rates for the bigger pulses. In particular, the mean rate for smaller pulses ($\sim 50\ \mathrm{s}^{-1}$) and the total integrated noise level have been used. Despite the large difference (~ 50 times) between the mean rates for large and small pulses, strong correlation in their variation has been found. The correlation between the mean rate for large pulses and the integrated noise level was rather weaker.

In conclusion, it appears that it is possible to obtain a PSD similar to those found in the literature by assuming a slow variation in the mean pulse rate for 50 MHz rural noise. This mean pulse rate appears to be closely related to rather more easily measured parameters such as the rate of observation of smaller pulses or the integrated noise level.

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