

REPORT ITU-R P.2089

The analysis of radio noise data

(Question ITU-R 214/3)

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Scope

Impulsive noise is an important aspect of man-made noise in particular. This Report describes a method of analysing noise measurements so as to characterize both the impulsive and the Gaussian parts of the noise distribution.

1 Sources of radio noise

Radio noise external to the radio receiving system derives from the following causes:

- radiation from lightning discharges (atmospheric noise due to lightning);
- aggregated unintended radiation from electrical machinery, electrical and electronic equipments, power transmission lines, or from internal combustion engine ignition (man-made noise);
- emissions from atmospheric gases and hydrometeors;
- the ground or other obstructions within the antenna beam;
- radiation from celestial radio sources.

NOTE 1 – Radio noise comprises the background noise level in the absence of other signals, whether intentionally or unintentionally radiated, so that noise or signals due to unwanted co-channel transmissions or due to spurious emissions from individual transmitting or receiving systems are not considered. In addition, noise due to local or identifiable specific sources is not included.

Of these sources atmospheric noise due to lightning and man-made noise may include impulsive contributions, whereas the other sources are likely to have entirely Gaussian characteristics.

2 Terms for the specification of noise intensity and their interrelationship

External radio noise comprises two main components: White Gaussian noise (WGN) and impulsive noise (IN).

Impulsive disturbances to a receiver system may be considered in two classes:

Impulsive noise – Where the disturbance is broadband compared to the IF filter bandwidth of the receiver being considered. Impulsive noise is typically made up of an aggregate of very short impulses that are very wideband and are frequently man-made in origin. The class includes impulses from automotive ignition circuits, thermostats, lighting, etc.

Other impulsive disturbances – Where the disturbance has a bandwidth which is spectrally comparable to, or less than, the IF filter bandwidth of the receiver being considered. Such a disturbance is likely to be structured, possibly generated by telecommunication systems, and is probably not of interest to the receiver being considered. Such disturbances are not taken into account as a component of radio noise.

2.1 Noise representations

A noise voltage is a function of time that can be described statistically with the use of random variables. The time-varying noise voltage $v(t)$ is represented as a passband signal modulated on a carrier frequency f_c thus:

$$v(t) = \text{Re} \left\{ \hat{v}(t) e^{j2\pi f_c t} \right\} \quad (1)$$

where $\hat{v}(t)$ is the noise voltage complex baseband signal centred about 0 Hz that can be represented in Cartesian or polar form as:

$$\hat{v}(t) = x(t) + jy(t) = \sqrt{x(t)^2 + y(t)^2} e^{j \arctan(y(t)/x(t))} \quad (2)$$

where $x(t)$ and $y(t)$ are the baseband signal real and imaginary components respectively.

The instantaneous noise power is defined as:

$$w = |\hat{v}(t)|^2 \quad (3)$$

The mean noise power is defined as:

$$w_0 = E\{w\} \quad (4)$$

where $E\{\}$ denotes the expected value of its argument.

The noise power is normalized by the average noise power due to black body radiation and thermal noise that is present in all radio systems. This average noise power is defined by the formula:

$$k T_0 b$$

where:

$k = 1.38 \times 10^{-23}$, Boltzmann's constant, given in Joules per Kelvin

$T_0 = 290$ K, absolute temperature

b : receiver noise equivalent bandwidth.

Furthermore, the standard convention is used that variables in upper case are the decibel equivalents of those in lower case, e.g. $W = \log_{10}(w)$. In this format W is known as a *figure* and w is known as a *factor*.

2.2 White Gaussian noise statistics

A random statistical process can be characterized in terms of a probability density function (PDF). In the case of WGN, by definition, the voltage is modelled by a Gaussian distribution with zero mean and a uniform power spectral density (PSD). In terms of polar coordinates, the WGN amplitude is Rayleigh distributed and the phase is uniformly distributed. If a long enough measurement is made, then an amplitude histogram will approximate to the PDF.

Assuming a mean power level of w_{0g} and a random noise variable, w_{RV} , the power PDF for WGN is:

$$p_g(w_{RV}) = \frac{1}{w_{0g}} e^{\frac{-w_{RV}}{w_{0g}}} \quad (5)$$