IEEE 802.4L

Through-the Air Physical Media, Radio

CHAPTER 3

NOISE STATISTICS

The noise source used in testing and theoretical work is gaussian. It can be described by its RMS voltage, and its bandwidth. It cannot be described by a peak voltage, however. Any observed peak voltage may eventually be exceeded. The probability that an observed value will be some factor, K, greater than the RMS value is plotted in figure 3-1 and figure 3-2. The odds that an observed value will be 10 times the RMS value is very small: at 1,000,000 observations per second, there is a good chance of seeing it once in the age of the universe.

The function plotted in figure 3-2 is defined as 2*Q(K). The probability that the magnitude of the peak observed value in N samples will be in the range K to K+d is:

P(K,d,N) = (1-2*Q(K+d))**N-(1-2*Q(K))**N

The likelihood that the peak voltage will be at value K is a probability density function, equal to P(K,d,N)/d as d approaches zero. This function is plotted in figure 3-3 and figure 3-4. It can be seen from figure 3-4 that in 1,000,000,000 samples the expected value of K in a peak hold measurement is 15.8 dB above the RMS value. (The maximum rate that a continuous system can provide independent samples is two times the bandwidth of the system.)

The ratio of signal RMS voltage to Noise RMS voltage is signal to noise ratio. Errors occur when the occasional peaks in noise obliterate the signal. If the noise has the same bandwidth as the signal, and the signal has an error rate of 1/1,000,000,000 at a signal to noise ratio of 20 dB, then the signal must be at least 20.0-15.8 dB or 4.2 dB above the peak noise to be detected without error.

Precise understanding of the effect that peak noise has on the network requires knowledge about the receiver used for the given signalling technique. The design of certain types of receivers is proprietary, and subject to patent application. Ultimate performance of one such design, developed at Inland, is shown in figures 3-5 and figure 3-6.

Actual measurements of noise on cable shows behavior that is not gaussian. The central limit theorem used in statistics would seem to indicate that all sources contributing to noise on the cable should combine to produce a gaussian normal curve. In fact, this does not happen, the theorem doesn't apply. In many real installations, some sources completely dominate the others. Measurement is made difficult, since many of these sources are off most of the time. For this reason, peak holding measurements over long periods of time are needed to obtain a valid estimate of the challange that noise will present to the network.

Assume that a 2 dimensional plane is covered with gaussian noise transmitters that have a high RMS output when they are on, but are usually off. The number of transmitters at a given distance from a receiver is proportional to the distance. The voltage, (not power), at the receiver is inversely proportional to that distance. A family of curves for equal power transmitters is plotted in figure 3-7. The envelope of the curves has a slope inversely proportional to voltage. For cases where this is a good model of the noise driving the cable, it is unlikely that the actual noise on the cable will have a gaussian distribution.