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Analysis of Noises in the Digital Communication System Considering Gaussian as well as Non Gaussian Noise

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ABSTRACT: Digital communication performances are affected by noise. Amplitude Probability Distribution (APD) has been proposed within C.I.S.P.R. for characterization of the impulsive noise emitted from electrical equipment. The noise which is of impulsive nature is known to affect digital communication performances. The characteristics of noise and the bit error probability are both correlated to each other for estimation of digital communication performances. A unique noise APD pattern is obtained from each measurement of noise emission from different electrical appliances. It is important to have correct measurement set up which utilizes a programmable digitizer with analysis software to evaluate signal power level sampling rate, sample points and filter characterization in order to acquire accurate representation of the noise patterns. The APD pattern is generated by the analyzer which employs the envelope sampling technique from actual probability. The noise PDF is useful for noise modeling and simulation. The degradation on digital communication performance in terms of bit error probability can be estimated by noise PDF.

Keyword: Noise, Gaussian, APD etc.

I. INTRODUCTION

The rapid technological evolution paves the way of digital electronics system and appliances are rapidly evolving for many application. A household today consists of many more electrical and electronics appliances than it did for the past 20 years. The unintentional electromagnetic radiation from modern electronic and electrical system have becomes increasingly difficult to control. Electrical equipment generates electromagnetic emission which can degrade the quality of desired radio signal. The electromagnetic interferences will affect the communication system capacity, robustness, reliability and availability. The CISPR (the international special committee on radio interferences) is aware of their work with suitable emission of electro magnetic energy from electrical and electronic equipment [1-3] the aim is to protect the digital radio services from high interferences environment. APD is suitable for computation of the interferences effect on digital channel. APD is however not a detector because it does not give one measurement result per frequency but the probability of occurrence of certain amplitude as a function of the amplitude. APD function is used to describe the signal amplitude statistics. Traditionally when estimating impact on digital communication system interference sources have often been modeled as Gaussian noise, approach is used to characterize the amplitude statics of non Gaussian noise produced from man made electrical and electronics equipment The noise signal $s(t)$ captured by a receiver can be expressed mathematically as

$$S(t) = X(t)\cos(2\pi f_c+\theta(t))$$

Where $X(t)$ is the baseband envelope (t) is the baseband phase and fc is the carrier frequency. The amplitude is always positive considered to be a random variable with the set of sampling {Xo, X1,…Xm}. To calculate the probability of noise amplitude the percentage of the noise envelope time existence at certain threshold level, phase and frequency bandwidth will be measured as shown in the diagram.

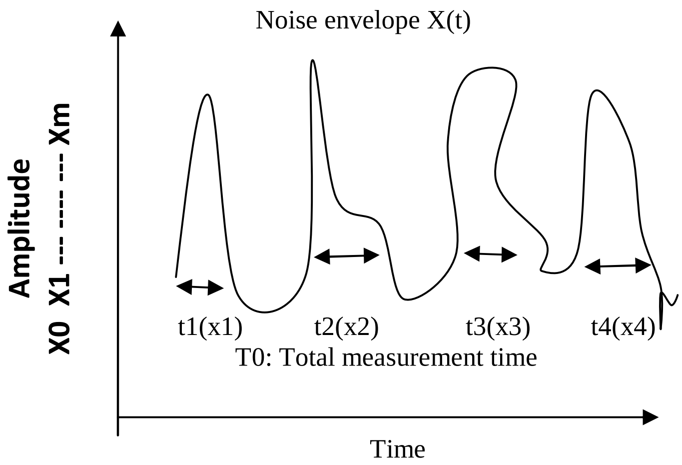


Fig. 1. The APD graph probability concept.

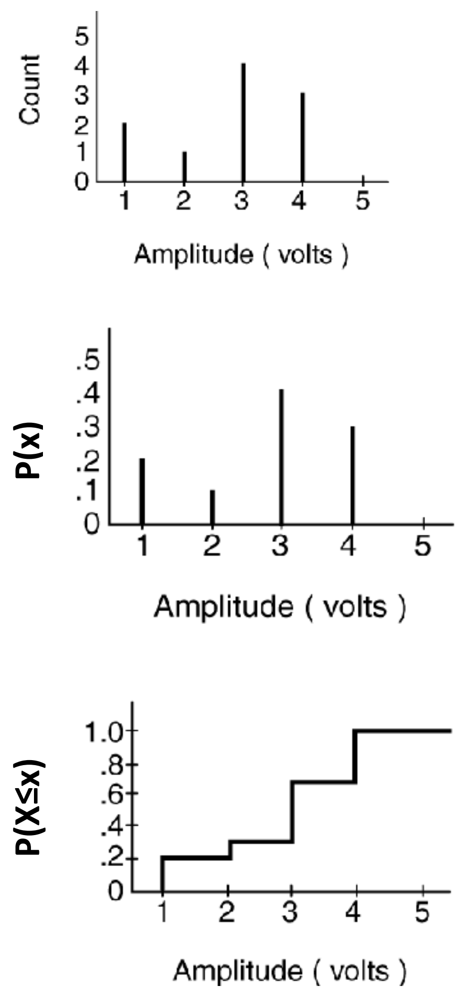
The probability density function which expresses the probability of existing random variable Xm for the m number of samples of sampling is obtained during the measurement. PDF values are positive and area under PDF graph is equal to one. The discrete PDF can be estimated from histogram plot. The discrete PDF express the probability that a random variable "X" will have realization equal to x_i . P(Xi) = p(A=x_i) where p() is the probability of its argument. The cumulative distribution function CDF expresses the probability that a random variable "X" will have a realization less than or equal to "x": C(a) = P(X#x). The discreet value of cumulative density function (CDF) is obtained by integrating the discrete PDF and vice versa for all X_i where value for *i* is less than or equal to m. CDF values ranges from 0.0 to 1.0. Since radio engineers are generally more concerned about how the noise envelope exceeds certain level they prefer to use the complementary of the cumulative distribution function (CCDF) which is known as APD. The discrete APD can be obtained by subtracting the discrete CDF value starting from value one until it becomes zero again. Fig. 1 shows the percentage of time where the noise envelope exceeds a threshold level and can be represented in APD equation

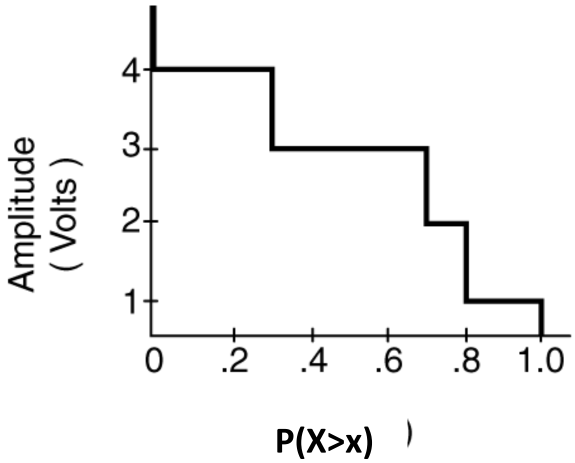
$$APD(x_m) = \sum_{i=1}^{n(x_m)} t_i(x_m)/T_0$$
$$= \int_{x_m}^{\infty} p(x)dx$$

The PDF and CDF can be obtained from measurement software. The noise pattern can be recognized by the inverse CDF. The PDF will be obtained by differentiating the result of inverse accumulative function [6].

$$f_{X_m} = -\frac{d}{dr} APD(x_m)$$

The APD function expresses the probability that a random variable "X" will have a realization greater than "x": CC(a) = P(X>x). The discrete APD is obtained by subtracting the discrete CDF from 1; CC(x) = 1-C(x). for clarification , figure shows graphs of the discrete PDF, CDF and APD.





For the random sample realizations;{X1,X2,-------X10} = {1,2,3,3,1,4,4,3,4,3} volts.

II. GAUSSIAN

The Gaussian distribution is used for continuous random variables .It is perhaps the most important PDF in the area of communication. The majority of noise processes observed in practice are Gaussian and many naturally occurring experiments are characterized by continuous random variable with Gaussian pdf. The Gaussian pdf is also known as normal PDF. The shape of Gaussian pdf is bell type.

$$f(x;\mu,\sigma^2) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(x-\mu)^2/(2\sigma^2)}$$

III. NOISE ESTIMATION BY APD

For the APD measurement the equipment is placed on a Non conducting stand. An antenna is placed on the stand beside the equipment. The equipment is placed within the antenna sensitivity area. To avoid unwanted signal the test set up is performed inside the shielded room. Data analysis software with digitizer and APD analysis software were installed in the computer for capture of signal developed by the authors. The electromagnetic interference from electrical equipments such as microwave, drill, computer, mixer is measured individually inside the shielded room. To avoid aliasing problem low pass filter is used. The sampling rate used in the measurement is 10 mb/s. The APD analyzer has software programmed to measure the frequency. The envelope of impulsive noise shows the repetitive pseudo waveforms.

The distribution of phases of noise is between 0 and 2π [4]. The distributions of the envelope component is variable which depend on the noise source.

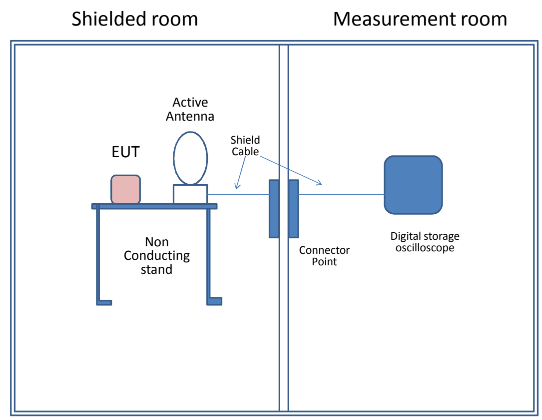


Fig .2. Experimental setup for APD measurement from electrical equipments.

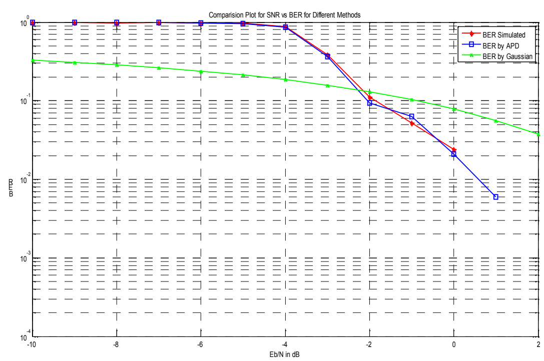
IV. BER ANALYSIS

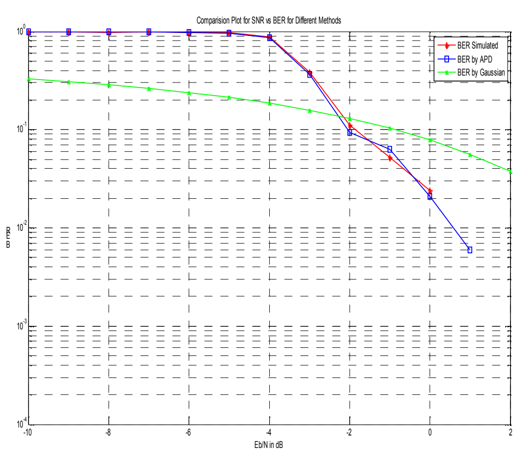
The characteristics of impulsive noise can be evaluated by the APD. The family of non Gaussian alpha stable distribution provides modeling of the impulsive noise was found by the APD analysis. The parameter are the alpha beta and gamma the alpha control the impulsiveness, beta controls the skewness and gamma controls the dispersion. The alpha is the main parameter for simulation which determines the impulse characteristics of noise. When SNR per bit is defined then the value of gamma and beta parameter are considered. The BEP is calculated for estimating the impact of the impulsive noise towards communication performances degradation [5]. The noise from mixer has increased compared to the theoretical QPSK in Gaussian noise. Fig. 2. estimated bit error probability of a OPSK signal with and without disturbing impulsive noise.

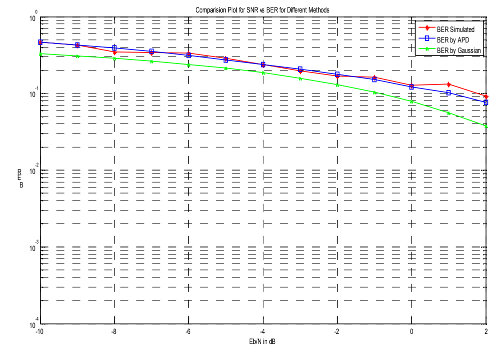
V. CONCLUSION

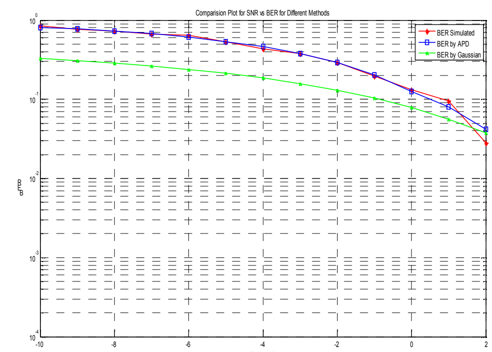
It is concluded from BER Vs SNR comparison plot that BER by Gaussian shows there is probability of occurrence of one error in 7-8 bits, while simulated BER shows probability of occurrence of error in each bits which is also shown by BER obtained by APD from the BER Vs SNR plot it is also concluded that the BER plot obtained by APD more similar to simulated BER plot as compare to BER obtained by Gaussian hence we can say that if want to design a noise free digital communication system , we have to consider the noise pattern as obtained by APD instead of Gaussian.

The project presents little method that developed an amplitude probability distribution (APD) measurement technique for electromagnetic noise radiated from electrical appliances. It is shown that a noise waveform emitted from different appliances exhibits its own distinct APD parameters. The parameters obtained from APD measurement are useful for noise modeling and simulation, from which we can estimate the performance degradation on digital communication receivers in terms of bit error probability. This work proposes a verification method to assess the performance of digital communication systems in the presence of impulsive noise and provides a basis to study complex higher-level digital modulation schemes in real electromagnetic noise environments.









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