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Estimation of Noises Due to Electromagnetic Induction in Digital Communication

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ABSTRACT: This paper presents a technique to estimate the noise due to electromagnetic waves emitted from electrical appliances working nearby the digital communication system and study their impact towards digital communication systems by using the amplitude probability distribution (APD). A unique noise APD pattern is obtained from each measurement of noise due to electromagnetic induction from electrical appliances. The noise envelope and its APD is useful for noise modeling and simulation, from which we can estimate the degradation on digital communication performance

Keywords: Noise, digital communication, Bit error rate and APD

I. INTRODUCTON

Noise sounds like an irritating word, everybody try to be free from it. But a very interesting fact is that there is no existence of noise. It is a relative word. There is limited way of interchanging of the information or messages. When various people want to communicate in the same way then due to similarity in the pattern of information, one information interfere the others, these interferences are actually called Noise if this interference increases, it may destroy the original information. Now to send the information in original form, from sender to receiver either we change the way and search for a unique way or exclusive way of communication, in which way there is no communication at least nearby you. It needs a new scientific research and it will defiantly expensive too. Another solution is ignoring all the interferences which are less affecting your communication, and concentrate on the pattern of the interferences which is significantly affecting the required signals i.e. our original information. We are here more concern with digital communication system due the advantages of it i.e. improved efficiency, better transmission accuracy, and better noise immunity, requirement of lesser bandwidth, secrecy, and standardization of transmission/reception equipment.

There is a need for a new measuring method and new requirements on maximum emitted electromagnetic energy to protect digital communication system. It is important that the new method fulfils requirement of correlation between the impact on a digital communication system and the measured value of the noise due to electromagnetic inductions

In this paper we are analyzing the pattern of noises which degrade the performance of the digital communication system.

II. NOISES IN DIGTAL COMMUNICATION SYSTEM

According to very basic principle of electrical engineering there is always an induction of electromagnetic field around a current carrying conductor. Hence if any electrical device working nearby any part of communication system there will be induction of electromagnetic field which will affect the communication system.

In wireless handsets and mobile devices, such as cellular phones, electromagnetic compatibility issues continue to grow in significance. We are seeing more issue such as auto-jamming which is caused by self-generated noise, reception and sensitivity issues, among others, degrading device performance-largely due to self generated noise from the device itself, as well as due to other electrical and electronic devices working around.

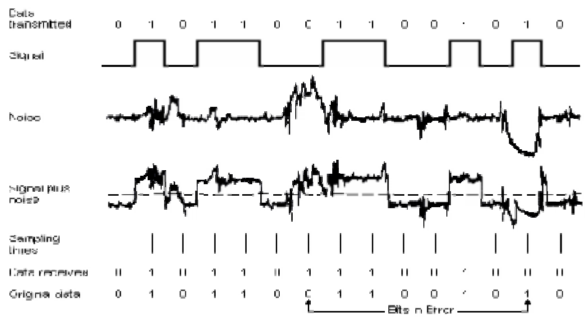

Fig.1. Effects of noise in digital communication.

Fig. 1. shows the digital information to be transmitted in bits as well as in the pulse form. third row of this figure shows noises while next row shows the information signal affected by noise, the last two rows of this figure shows that 7^{th} and 14^{th} bits of the original information signal has been changed due to noise. In this way the performance of the digital communication system is degraded due to noise impulses introduces in the system by electrical appliances shown in Fig. 2.

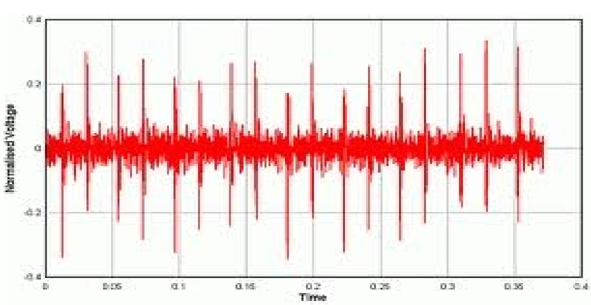

Fig. 2. Noise impulses.

III. AMPLITUDE PROBABILITY DISTRIBUTION

One method of measuring and evaluating noise fluctuation is through APD Mapping. Noise measurement technology referred to as Amplitude probability distribution (APD) is an effective method of analyzing the noise, which can cause electromagnetic compatibility issues.

The APD technique is useful for two reasons. First, the APD technique identifies noise emission from various sources of electromagnetic waves. Second, the PDF $f(x)$ can be obtained from the APD which can then be used for noise modeling and simulation. This then allows us to estimate the performance degradation in terms of BER [5].

Amplitude probability distribution is based on probability theory and mathematical statistics. The main purpose of statistical measurement is to get probability density function of noise.

Electrical equipments and industrial process radiate electromagnetic interferences, which can degrade the performance of digital communication system. An example, radiated emission Mixer, Drill and Computer is today presents in several frequency bands These electromagnetic interferences often has a different behavior, which often result in a worse degradation than Gaussian noise. The APD measurement function is a way to characterize this kind of interferences [6].

APD provides study of issues related to noise values of digital communication. For example, a strong correlation can be shown to exist between the APD noise in the band frequency of a digital communication system like GSM and the influence of that noise on the system [2,3]. That is why measurements by ADP are a reliable indicator of interference for wireless handsets using digital communications.

The amplitude probability distribution, APD, is defined as the part of time the measured envelope of a disturbance exceeds a certain level, [1]. The relation between the APD estimate, APD_R (r), and the estimate of the probability density function of the envelope is basically

$$APD_R(r) = 1-F_R(r)$$

And

$$f_R(r) = \frac{d}{dr}F_R(r) = -\frac{d}{dr}APD_R(r)$$

Where F_R and f_R denote the cumulative density function (CDF) and probability density function (PDF), respectively, of the envelope *R*.

The APD can be estimated by a spectrum analyzer, where the signal is first converted to an intermediate frequency and band limited by a resolution bandwidth filter.

The signal can then be compressed by a log amplifier, after which the envelope is extracted by an envelope detector.

The practical advantage with the APD is that the interference impact in terms of bit error rate (BER) for a system exposed to the interference in the APD can easily be determined directly from the APD.

For binary modulation the maximum BER is the APD at the point where the exposed system has its received signal level [4].

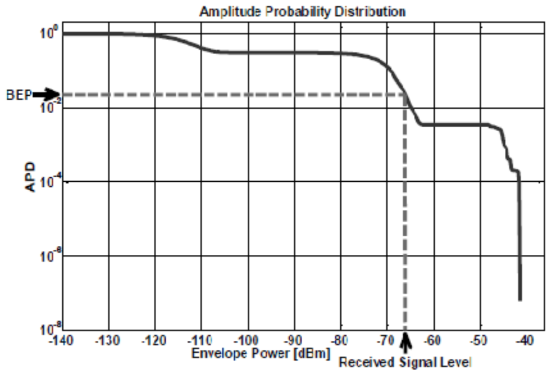

Fig. 3. The relation between APD and BER.

For the APD measurement, the measured signal is passed through an A/D converter after which the data samples are collected and the APD is determined. The resolution bandwidth for the spectrum analyzer should ideally be the same as the receiver bandwidth of the wireless systems to be analyzed. The sampling rate *f*s for the A/D conversion must satisfy the Nyquist criterion. It is also important to collect as many samples so that the APD is stationary the peak detector was used to detect the envelope of the IF signal. One 12 bit A/D converter was used. As a complement to the APD measurements, conventional electric field measurements were done both with peak and average detectors. The antenna used is a wideband antenna complying emission measurements.[5]

IV. DETERMINATION OF PERFORMANCE DEGRADATION BY USING APD

The traditional way of determining the error probability of a digital radio receiver is to assume that the interference can be modeled as Gaussian noise. For that kind of noise, error probability expressions are often quite easily derived for different kinds of receivers. On the other hand, for other types of noise, there are no general and simple methods. But, as we will see, with information provided by an APD detector, it is possible to incorporate also noise of non-Gaussian nature to the conventional error probability expressions. The key issue when determining the impact from a disturbing signal or the plain performance of a coherent digital radio receiver is mainly to have information of the envelope and phase at the decision moment in the detector. For example, the performance of a coherent BPSK receiver in thermal receiver noise is determined by [7].

$$P_b = Q\left(\sqrt{\frac{E_b}{N_0/2}}\right),$$

Where E*b* is the bit energy and N0 *is* the single-sided power spectral density of the thermal receiver noise and

$$Q(v) = \frac{1}{2\pi}\int_v^\infty \exp\left(-\frac{x^2}{2}\right)dx\,.$$

The method can be concluded into the following steps:
1. Estimate $f_R(r)$ out of measured $APD_R(r)$.
2. Adjust the decision variable with respect of the disturbance, e.g. substitute square root of E*b* with Square root of $Eb + r\cos\phi$ for coherent BPSK.
3. Use conventional error formula for Gaussian noise and average for r and ϕ.

The symbol error probability of a QPSK modulated signal can be derived with the same approach. In order to evaluate the influence on a two dimensional modulation scheme like e.g. coherent QPSK, the contribution from the disturbing signal also has to be described in two dimensions.

V. CONCLUSION

The paper presents error expressions for the performance of digital communication system when they are subjected to a electromagnetic inferences due electrical appliances. It shows the possibility to use the information provided by the measured APD of the electrical appliances, in order to estimate the degradation of a digital communication system. The method assumes that the measurement parameters are relatively equivalent to the ones in the analyzed system, in terms of e.g. bandwidth. Fulfilling these assumptions, the method incorporates a impulsive noise and provides a simple way to consider the effect of electromagnetic interferences from electrical equipment, which often is of non-Gaussian nature. This opens the possibility to determine the impact on digital communication system of complex electromagnetic environments.

It is shown in the waveform that a noise waveform emitted from different electrical appliance 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 system.

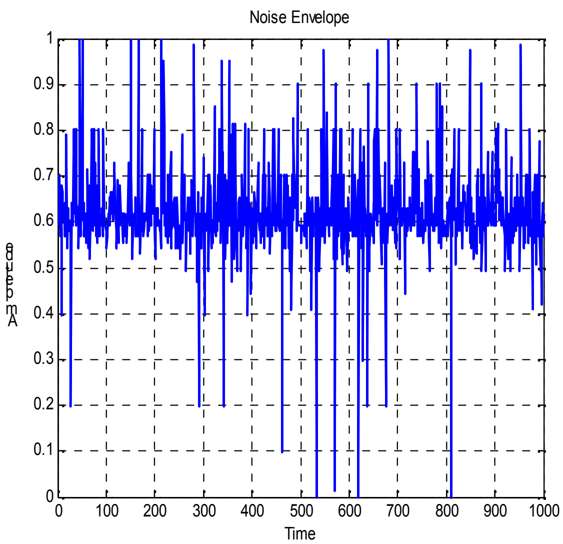

Fig. 4. Envelope of noise due to Mixer.

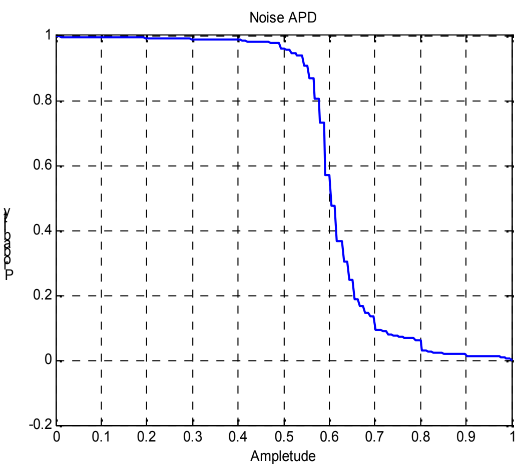

Fig. 5. APD of noise due to Mixer.

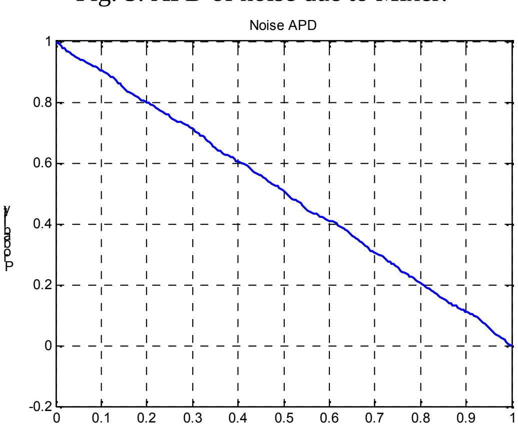

Fig. 6. APD of noise due to Drill.

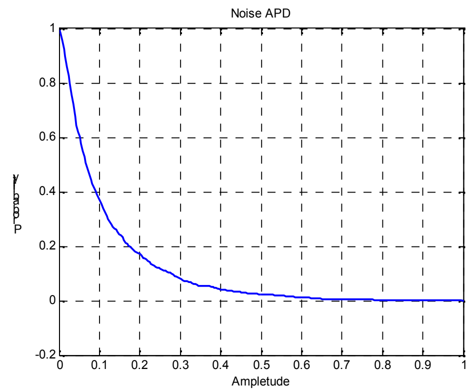

Fig.7 APD of noise due to Computer

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