RESEARCH INVENTY: International Journal of Engineering and Science
ISBN: 2319-6483, ISSN: 2278-4721, Vol. 2, Issue 1
(November 2012), PP 48-52
www.researchinventy.com

Variation of Impulsive Noise with Distance of the Noise Source from the Power Line in Power Line Communication

Anirban Sengupta, Chitrangada Roy
[1]*Department of Electrical Engineering*
Sharda University, Greater Noida, U.P, India
[2]*Associate System Engineer IBM, Kolkata, India*

Abstract: *- This paper describes the variation of impulsive noise with the distance of the noise source from the power line in power line communication. Here a rectifier has been chosen as the periodic impulsive noise source and an induction motor has been taken as aperiodic impulsive noise source. The distance of the noise source from the power line has been varied and the variation of noise magnitude has been plotted, also the variation has been modeled mathematically.*

Keywords- *power line communication, noise.*

I Introduction

The idea of sending communication signal over the same power lines (which is mainly used to distribute electrical power) is as old as telegraph itself. A channel characteristic of the power line shows a typical behavior which is briefly described here. Impedance is highly varying with frequency and ranges from a few Ohm to few kilo Ohm. At some frequencies there are peaks in the impedance characteristics. At these peaks the network behaves like a parallel resonant circuit. However, in most of the frequency ranges the impedance shows inductive or capacitive behavior. Characteristic impedance of a power line cable is typically in the range of 90 Ohm. Net impedance is not only influenced by characteristic impedance but also by network topology and connected loads which may have highly varying impedances as well.

The noise spectrum is highly varying with frequency and time. There is an overall decay of the noise level with increasing frequency. A typical example of a measured noise spectrum is shown in Fig. 1. Noise at the power line is influenced by a large number of different noise sources with different characteristics. There are broadband disturbances, e.g. universal motors, and narrowband disturbances, e.g. HF-radio signals, power supplies. The shape of the noise curve is very much dependent on location and time. Because of the frequency dependency of impedance of the power line, impedance mismatch often occurs when coupling in and out. Furthermore, the loads that are showing different impedances as well as a multitude of impedance discontinuities, e.g. by branch cables, cause reflections and echoes. These effects lead to multipath propagation and may produce narrowband notches.

To use the same power line for communication purposes, a detail analysis of the different kinds of noises is also essential which are inadvertently introduced into the signal in the process of transmission. We have limited our scope of work in this paper considering the impulsive noise only.

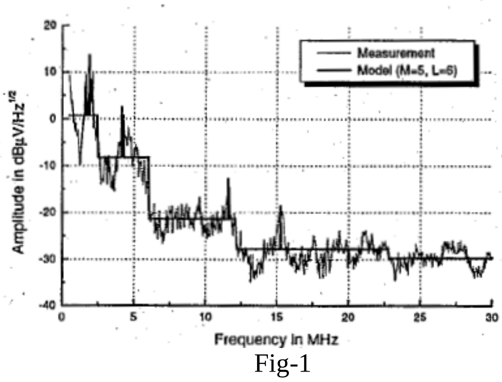


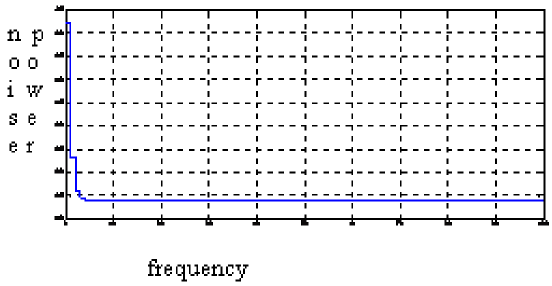
Fig-1

Next section describes all these different kinds of noises, their characteristic behavior and models. Section 3 describes the proposed filters and their design considerations. Next, in section 4 results of simulation are presented and finally the paper concludes in section 5.

II. Powerline Noises

Colored Background Noise- This type of noise is caused by overlaying of multiple sources of noise with relatively low power. Generally, power density of background noise is between -120 dB (V^2/Hz) and -140 dB (V^2/Hz) with an increasing power density towards lower frequencies (e.g. below 1 MHz) as in [1].

A typical measurement result of background noise with low power density is illustrated in Figure 2



below

Figure 2: Colour background noise pattern

Generally, we can see that power density of background noise decreases towards higher frequencies. Results of multiple measurements of noise in [2] showed that decreasing power density with increasing frequency can be approximated by an exponential decaying curve in logarithmic scale.

$$A(f)=A_{\infty}+A_0+\exp(-f/f_0) \qquad (1)$$

Narrow Band Noise- In general, noise scenarios in power line channels contain narrow-band noise, whose intensity and frequency varies over place and time. The main sources for narrow band noise are broadcasters in long, middle and short wave range as well as several radio services like amateur radio, so that almost the whole frequency range until 20 MHz is overlaid by narrow-band noise. A part of a noise spectrum with clearly visible narrow-band noise is shown Figure 3 below as in [3].

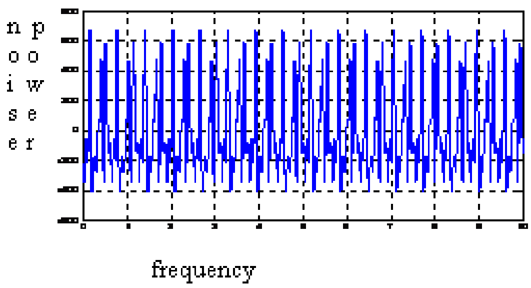


Figure 3: Narrow-band noise pattern

We can see that power density is distinctly above background noise level. Thus, narrow-band noise has to be considered separately when generating noises in a channel emulator. Obviously, narrow-band noise can be modeled as a sum of multiple sine noises with different amplitudes.

Using a deterministic model the signal results in the following equation

$$n_{narrow-band}(t)=\sum_{i=1}^{N}A_i(t).\sin(2\pi f_i t+\varphi) \qquad (2).$$

Impulsive Noise- Net-synchronous impulsive noise occurs in 50 Hz-alternating voltage current network with frequencies of 50 Hz or 100 Hz. They are caused by synchronous power converters occurring in dimmers and by all kinds of rectifiers using diodes [4].

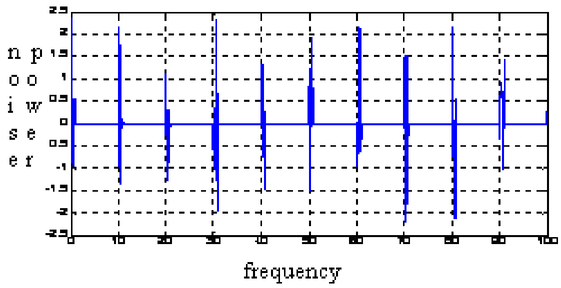


Figure .4: Periodic impulsive noise characteristics

With "aperiodic impulsive noise" we will describe this type of noise which occurs time-randomly. In literature, this noise is also known as "asynchronous impulsive noise". However, since periodic impulsive noise is also asynchronous to supply frequency, we will choose the clearer term "aperiodic impulsive noise".

This type of noise is caused by all kinds of switching operations, for example by household appliances, electric motors, or condenser discharge lamps. Aperiodic impulsive noise very often occurs in bunches (so called "burst noise"), which increases their disturbing impact. With many different sources this noise has very different properties regarding time response and spectral properties. A typical example for such noise is given in Figure 5.

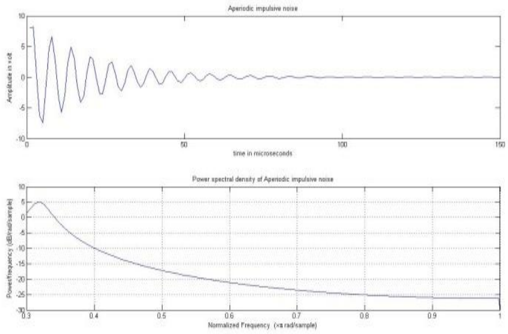


Figure 5: Time characteristics and spectral behavior of Impulsive noise

III. Proposed Technique

a) **Variation of periodic Impulsive Noise:-** In this proposed technique we have taken a controlled rectifier as the noise source and the distance of the noise source from the power line has been varied and the result of this variation has been plotted. The proposed technique is shown in Figure 6.

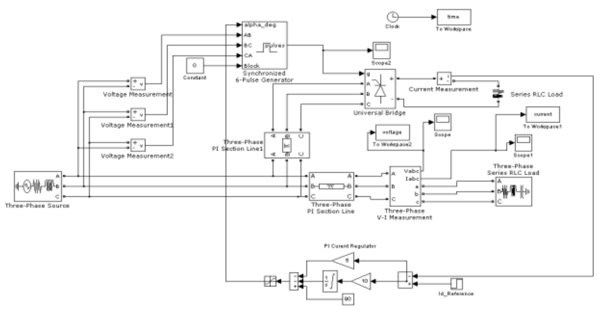


Figure 6: Proposed technique to vary the distance of the periodic impulsive noise from power line

b) Variation of Aperiodic Impulsive Noise:- Apeiodic Impulsive Noise occurs due to different kinds of switching operation, like electric motors. In this paper a three phase induction motor has been taken as the noise source and the distance of the noise source from the power line has been varied and the effect of the variation has been plotted. The proposed scheme is shown in Figure 7.

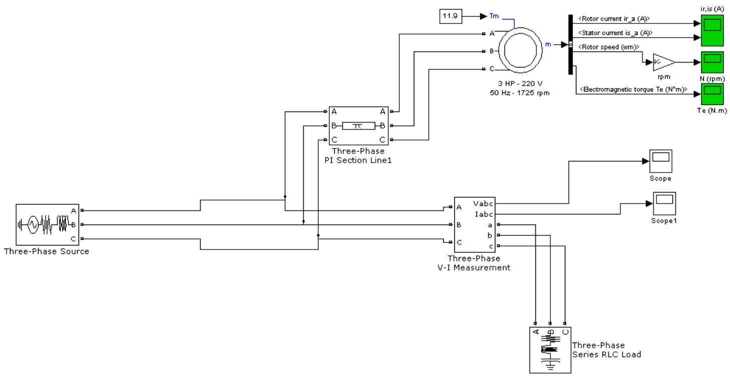


Figure 7:- Proposed technique to vary distance of the aperiodic impulsive noise source

IV. Results And Discussions

a) ***Variation of periodic Impulsive Noise***:- The proposed technique is modeled using MATLAB Simulink which is essentially a controlled rectifier set situated at a distance from the power line. The distance of the noise source from the power line has been varied gradually and the effect of this variation has been recorded and a mathematical formula has been derived. The experimented values and the mathematical values of this variation are shown in Figure 8 and Figure 9 respectively.

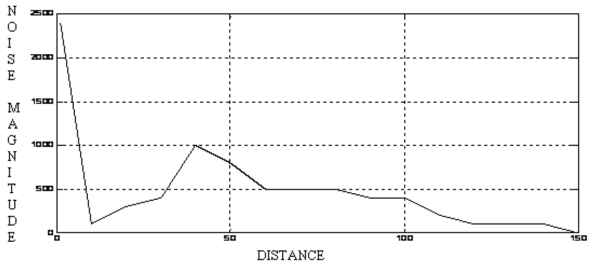


Figure 8: Experimental variation of periodic impulsive noise magnitude with distance

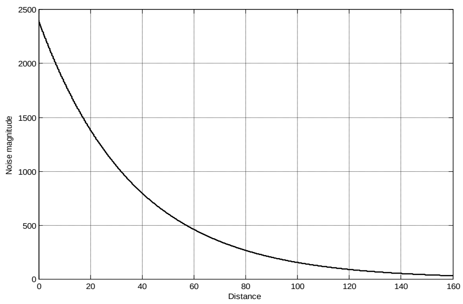


Figure 9: Generalized variation of periodic impulsive noise magnitude with distance

From this figure it can be concluded that the noise magnitude decreases exponentially with the distance of the noise source from the communication channel. Which can be expressed by the formula given below:-

$$P(d)=A_0e^{(-0.0015d)} \qquad (3)$$

Where, P(d)= Noise power at a distance d
A_0= Noise magnitude when d=0

b) Variation of Aperiodic Impulsive Noise:- The variation of the distance of the induction motor with the power line is shown in Figure 10.

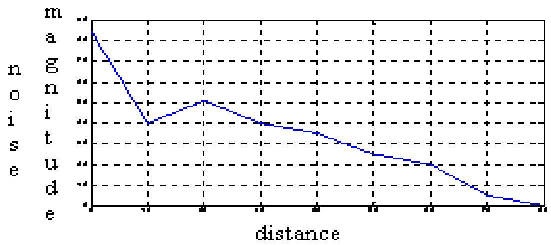


Figure 10: Variation of Aperiodic Impulsive noise with distance

This variation is almost like a straight line. Therefore, it can be concluded that aperiodic impulsive noise varies almost linearly with the distance of the noise

source from the power line. This variation can be modeled mathematically as:-

$$P(d)=P(0)-d \qquad (4)$$

Where P(d)= Noise magnitude
P(0)= Noise magnitude at d=0
d= Distance of the noise Source from the power line

Based on equation (4), a generalized variation of the noise power with the variation of the noise source from the power line can be drawn as shown in Figure (11)

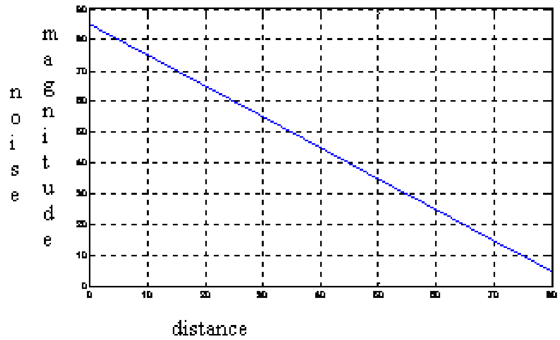


Figure 10: Generalized variation of aperiodic impulsive noise with distance

V. Conclusion

The main objective of this paper is to study and understand the variation of the noise magnitude with the variation of the distance of the power line from the noise source. Here a controlled rectifier and an induction motor are taken as the noise sources and the distance of the noise sources from the power line has been varied. Based on this variation a mathematical modeling formula has been generated to understand the variation and to model the variation for further use.

References:-

[1] Yong-tao Ma, Kai-hua Liu, Zhi-jun Zhang, Jie-xiao Yu, Xiao-lin Gong, “ Modeling the Colored Background Noise of Power Line Communication Channel Based on Artificial Neural Network.”IEEE Trans on Consumer Electronics, 2007, 45(2): 345~348

[2] H. Phillipps, “Modeling of powerline communication channels”,proc .3rd Int.symp.power line Communications and its applications, Lancaster, U.K., 1999,pp.14-21.

[3] M. Zimmermann and K. Dostert, “Analysis and modeling of impulsive noise in broad-band power-line communications,” *IEEE transactions on ELECTROMAGNETIC COMPATIBILITY*, Vol.44, pp.249-258, FEB 2002

[4] OPERA, “ Theoretical Postulation of PLC Channel Model”, version: 2 .