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IMPULSIVE NOISE CANCELLATION IN SINGLE-CARRIER FDMA TRANSMISSION USING DIFFERENT MODULATION SCHEMES

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ABSTRACT
Communication signals over power-line channels can be affected greatly by impulsive noise (IN). The effect of this noise is commonly reduced with the application of a nonlinear preprocessor at the receiver such as blanking or clipping that blanks and/or clips the received signal when it exceeds a certain threshold. Erroneous blanking/clipping of the unaffected signals can lead to significant performance degradations. It is found that determining the optimal blanking/clipping threshold is the key for achieving best performance. In contract to these studies, we show in this paper that the performance of the nonlinear preprocessing-based method is not only impacted by the blanking threshold but also by the transmitted signal's peak-to-average power ratio (PAPR). In light of this and for more efficient IN cancellation we, therefore, propose to implement single-carrier FDMA (SC-FDMA), which inherently has low PAPR properties, combined with a nonlinear preprocessor at the receiver.

KEYWORDS: Impulse Noise, PAPR, SCFDMA, IFDMA, LFDMA, SNR, SINR.

INTRODUCTION
POWER-LINE communication (PLC) becomes a very attractive alternative for in-home networking applications. Power line communications (PLC) technology utilize the widespread electric power infrastructure to provide high-speed broadband multimedia services within the home or office. Power line communication becomes more attractive alternatives for in-home networking applications and it provides communications at 200 Mbps [1]. The disadvantage of power grids as its characteristics presents some technical challenges for high-speed data communications. Noise at a power outlet and this noise is the sum of noises produced by different appliances connected to the line producing impulsive noise and other narrow-band interference. The eminent advantage of PLC networks is the fact that it can be easily accessed through electricity outlets in the home as they utilize an existing infrastructure of wiring networks. This technology becomes even more demanding in harsh wireless environments where propagation loss is high, such as in underground structures and buildings with metal walls [2]. However such medium does not support signal transmission at high frequency. It becomes most important to overcome the branching problem which greatly affects the signal quality due to large number of reflection points [3], noise [4-6] ,crosstalk's between the wires and high frequency dependent attenuation [7]. Power line channel respond to noise which is not additive white Gaussian noise as in case of conventional communication channels, rather it is characterized into background noise (BN) and impulsive noise (IN) [4], [8]. In power line channel, impulsive noise is more responsible for degrading communication signals. [9]. IN is considered as short duration pulse which occurs randomly having high power spectral density (PSD) [4], [10]. To analyze and evaluate the system performance in the presence of IN, Middleton class-A noise [12], [13] has been widely accepted and therefore, it will also adopt in this paper. Multicarrier modulation, such as orthogonal frequency-division multiplexing (OFDM) systems [14], have been proposed for PLC in [15] and adopted by many PLC standards [1]. Several methods have been reported in the literature on the topic of mitigating IN power line OFDM-based systems. The simplest of which is to precede the OFDM demodulator with a blanker to zero the incoming signal when it exceeds a certain threshold [16]–[20]. In these methods, the selection of the blanking threshold is the key for achieving best performance. Theoretical performance analysis and blanking threshold optimization are considered in [18] and [20] where closed-form expressions for the signal-to-noise ratio (SNR) at the output of the blanker and the optimal blanking threshold (OBT) were derived. These studies rely on the assumption that the IN characteristics, in the form of signal-to-impulsive noise ratio (SINR) and the IN probability of occurrence, can be

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made available at the receiver in order to optimally blank IN. Such assumptions, however, may be difficult to fulfill in practice because of the short-term variations of IN. In such a scenario, the estimation errors of noise parameters could lead to imperfect recognition of the IN signal. As a result, this will cause blanking uncorrupted signal samples causing blanking errors and, hence, significant performance deterioration [21]. Not only may that, but also uncorrupted signal samples with high amplitude wrongly trigger the blanker, causing errors [22].This can be the case in OFDM systems since they suffer from high peak - to-average power ratio (PAPR). Therefore, in this study, we show that the performance of the blanking-based IN mitigation technique is sensitive not only to the blanking threshold but also to the signal's PAPR. In contrast to other studies, in this paper, we give comparative study of implementing single carrier-frequency- division multiple access (SCFDMA) using QAM and PSK modulation, which inherently has a low PAPR [23], [24], and address the issue. Two SC-FDMA schemes are considered for optimizing the blanking threshold to enhance the overall performance of the system. These two schemes are-localized FDMA and interleaved FDMA. The organization of the rest of the paper is as follows. The system model is described in next section. Section III presents a comparative analysis of the PAPR for LFDMA and IFDMA systems and their relationship with the blanking threshold. The investigation over probability of blanking error for LFDMA and IFDMA systems is done in section IV, and the corresponding output SNR performance is presented in Section V. The problem of blanking threshold optimization of the two FDMA systems and the corresponding maximum-achievable output SNR are addressed in Section VI. Finally, conclusions are drawn in last section.

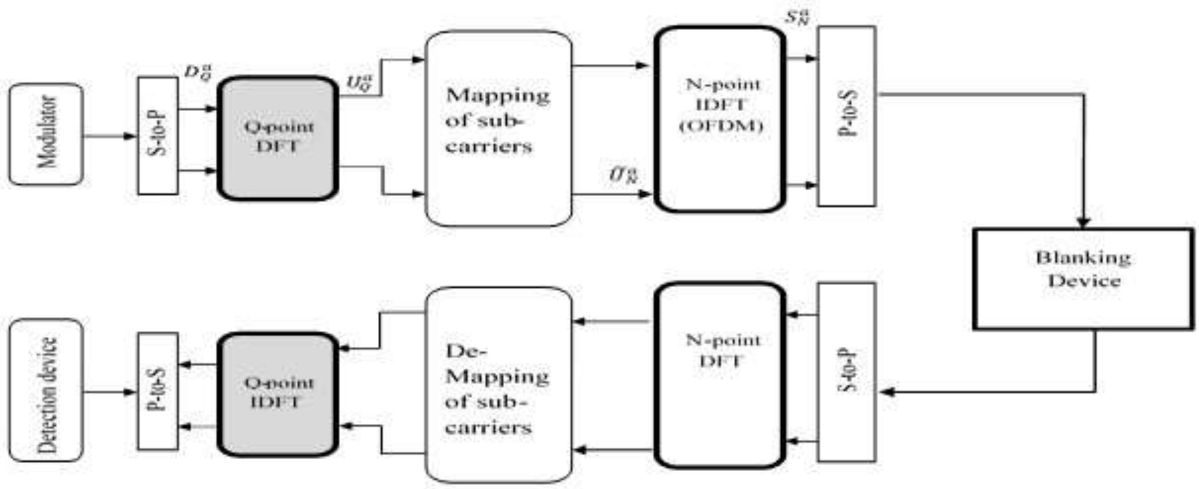

Figure1.1 Transreceiver of SC-FDMA with blanking device

Impulsive Noise

Impulsive noise is generally characterized by short voltage peaks. These short voltage peaks are rare single events which are caused mainly by switching on and off the switching events [25]. The IN noise have high impact on data transmission so it become essential to gain statistical information about the probability of impulsive width, impulsive amplitude and interarrival time.

SYSTEM MODEL TECHNIQUE

The system model used in this paper is as follows. Firstly the information bits are mapped into 16-QAM and PSK symbols and these bits are then grouped into blocks each with length N by serial to parallel converter and then these blocks are passed through DFT block to get its frequency domain analysis. The output of DFT is then fed to subcarrier mapping technique. Two mapping techniques have been used in this paper-LFDMA and IFDMA. In the first scheme, consecutive subcarriers are occupied by the DFT out-puts with zeros occupying the remaining subcarriers whereas in the IFDMA scheme, the DFT outputs are allocated over the entire bandwidth with equal distance while zero padding the unused subcarriers. The frequency-domain samples are then passed through an M-point inverse discrete Fourier transform (IDFT) modulator to produce time domain samples given by (IDFT), before going into the parallel to serial (P-to-S) convertor and then transmission is done.
The PAPR of transmitted signal is given by

$$PAPR = \frac{max_{0\le t\le T}(|x(t)^2|)}{\frac{1}{T}\int_0^T |x(t)^2|dt}$$

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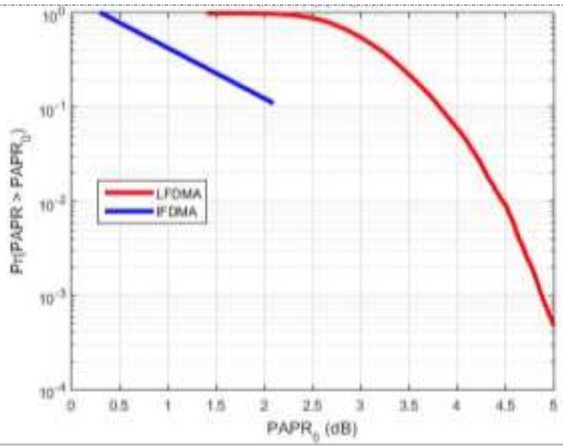

Figure 2.1 CCDF for LFDMA and IFDMA when M=64, N=16, and Q=4 for 8-QAM

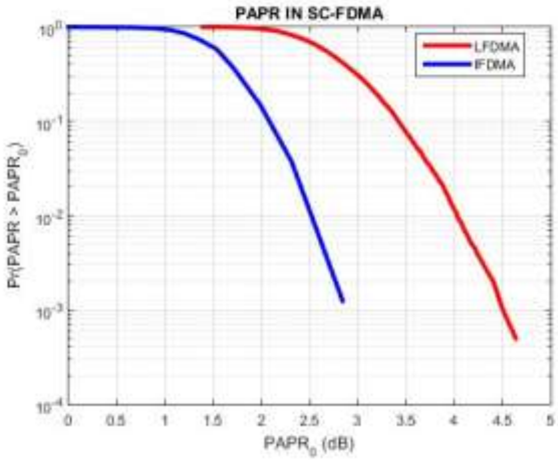

Figure 2.2 CCDF for LFDMA and IFDMA when M=64, N=16, and Q=4 for 16-QAM

For the modulation techniques 16-QAM and 8-QAM blanking error of LFDMA and IFDMA systems are shown below.

Table2.1

	16-QAM		8-QAM	
Mapping Tech.	LFDMA	IFDMA	LFDMA	IFDMA
Total Impulses	10	10	8	8
Recognized Impulses	7	8	5	6
Blanking Errors	3	2	3	2

Figure 2.3, Figure 2.4, Figure 2.5, Figure 2.6 and Table 2.1 summarize the scenario from which it is obvious that the IFDMA system provides the lower blanking errors than LFDMA since it recognizes more of the IN pulses and leaves lower blanking errors.

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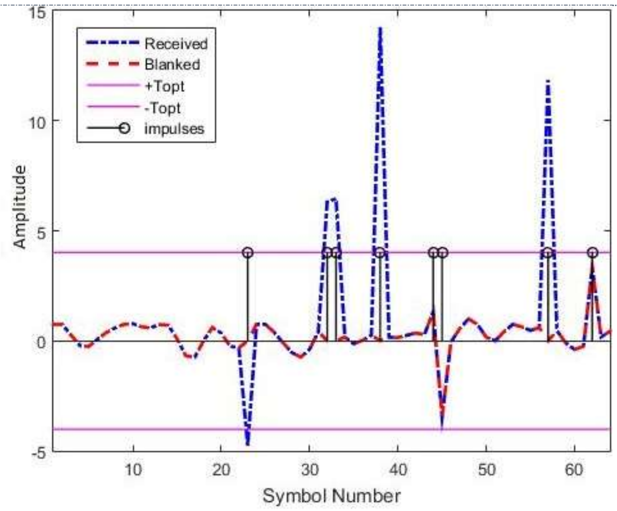

Figure 2.3 LFDMA blanking threshold for 8-QAM

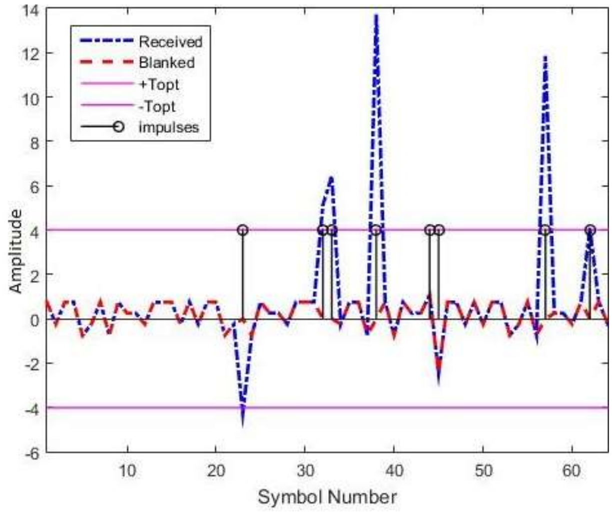

Figure 2.4 IFDMA blanking threshold for 8-QAM

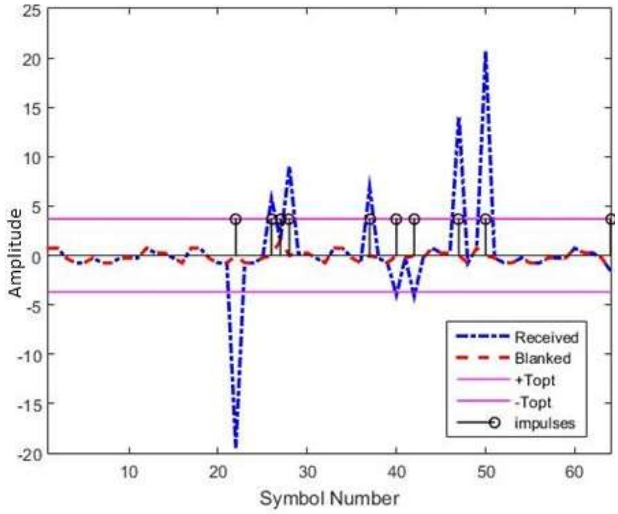

Figure 2.5 LFDMA blanking threshold for 16-QAM

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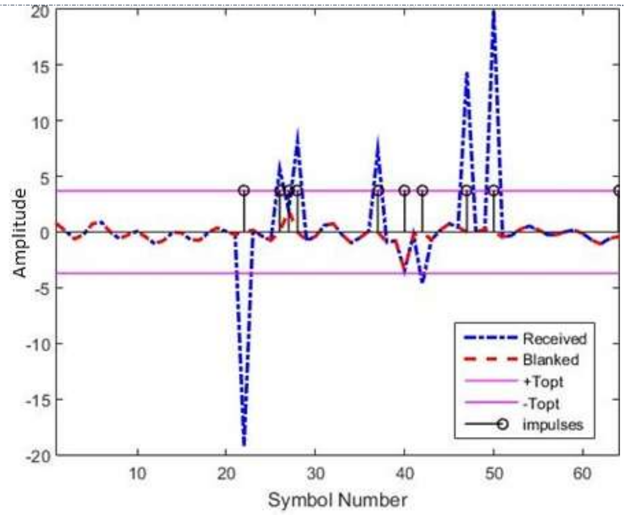

Figure 2.6 IFDMA blanking threshold for 16-QAM

PROBABILITY OF BLANKING ERROR

The probability of blanking error (Pb) is defined as the probability that the amplitude of the received sample Ar = |rm| exceeds the blanking threshold when it is unaffected by IN and it is given as Pb= P (BH0), where B is the event of blanking the received signal exceeding T. According to Bayes' theorem, P(BH0) = P(B|H0) P(H0)

Pb = P (Ar > T | H0) P (H0)

The probability of blanking error versus blanking threshold graph is shown below for 8-QAM and 16-QAM modulation technique. It is important to set the threshold level appropriate so as to optimize the blanking error efficiently. Where IFDMA is found to be best. Probability of blanking error versus blanking threshold for LFDMA, and IFDMA systems, SNR = 40 dB is shown below.

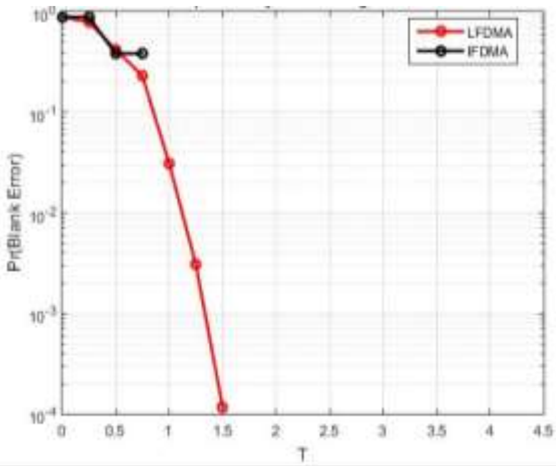

Figure 3.1 Probability of blanking error for 8-QAM

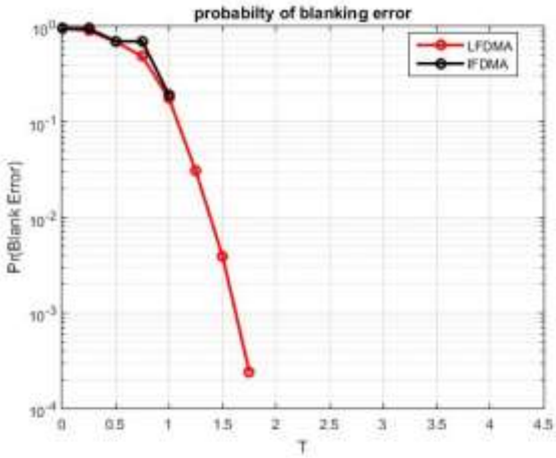

Figure 3.2 Probability of blanking error for 16-QAM

OUTPUT SNR VERSUS THE BLANKING THRESHOLD

Fig. 4.1 and Fig 4.2 shows the result obtained after MATLAB simulation done for output SNR versus optimal threshold. The matter of interest is to see that there exist an OBT for each system that maximizes the output SNR. The optimization for two techniques is investigated for the two modulation technique. The output SNR for LFDMA and IFDMA system is calculated by below equation.

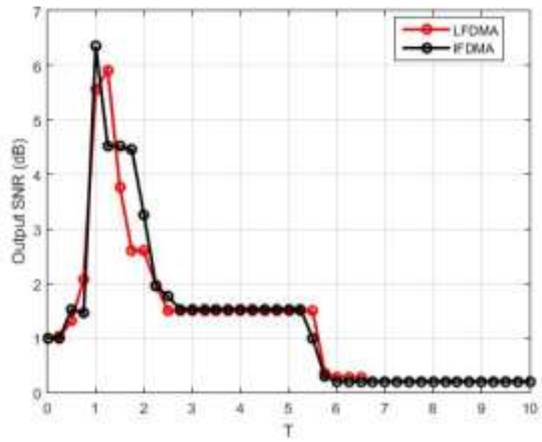

Figure 4.1 Output SNR of LFDMA, and IFDMA versus blanking threshold for 8-QAM

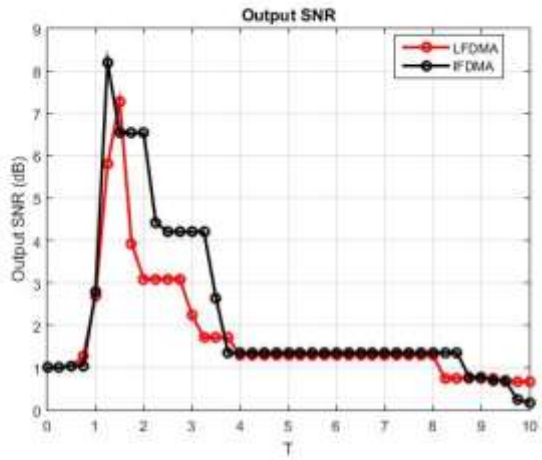

Figure 4.2 Output SNR of LFDMA, and IFDMA versus blanking threshold for 16-QAM

RESULTS AND CONCLUSIONS

In this paper we have investigated the performance of SC-FDMA with optimized blanking in the presence of impulse noise under two modulation techniques i.e. 16-Quadrature Amplitude Modulation and 8-Quadrature Amplitude Modulation. This paper presents comparative study for the detection of impulsive noise in the form of blanking error. Fig 2.3 to Fig 2.5 gives shows the number of blanking errors detected. Fig 3.1 and Fig 3.2 gives the probability of blanking error for the two case LFDMA and IFDMA. Variation of probability of blanking error decreases while increasing optimal threshold. By observing graph we observe that application of IFDMA makes it feasible to optimally blank IN without the need for prior knowledge about the noise characteristics. In our paper we have compare blanking technique for blanking error detection, SC-FDMA can also applied for nonlinear preprocessors.

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