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Noise Analysis in the Integrated System of Powerline Communication and Visible Light Communication Using Manchester and Miller Coding

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ABSTRACT*:*An integrated system of power line communication and visible light communication is proposed here. This system of communication using Light-Fidelity can be used in critical environments, such as aircrafts or hospitals. Moreover, a huge amount of unregulated bandwidth is available at infra-red and visible light frequencies. The main part of this hybrid system is visible light communication using LEDs. This system rapidly fluctuates the intensity of LEDs to create a binary code (on=1, off=0) in a way that is imperceptible to the human eye. The light then hits a sensitive photo sensor that decodes the data. This technology is known as visible light communication (VLC). Power line communication (PLC) using the existing power line as a medium for data communication. In this integrated system we can use the existing wiring infrastructure as a medium for illumination as well as communication using low cost LEDs. Broadband power line communications has been advanced through last decade and it is going to be a mature broadband access in near future. For PLC system the Discrete Multi-Tone (DMT) modulation and a simple On-Off keying (OOK) modulation scheme is employed for VLC channel.This paper aims to make a comparative evaluation of two coding techniques. The Manchester code as the code specified by the IEEE 802.15.7 standard in the case of outdoor applications using On-Off-Keying (OOK) modulation and the Miller code, as a possible alternative in Multi Input Multi Output (MIMO) applications. Better understanding of the noise effect can help us to reduce it and to improve the performance. The motivation of this work was to offer a better understanding of the modifications of the data pulse in the presence of noise.

KEYWORDS: Convolutional coding, Generalized Background Noise, Impulsive noise, Manchester coding, Miller coding, Power Line Communication, Visible Light Communication, White LED

I. INTRODUCTION

Visible Light Communication (VLC) system based on white LEDs has emerged as an eco-friendly IT green technology using THz visible light spectrum in provision of both lighting and wireless access. Installation of new communication cables between other fixed network (PC, Set-Top Box, fiber networks, etc.) and LED lights is expensive, disruptive and time consuming process. Meanwhile, the power line communications (PLC) can make it possible to use the power lines as the medium of communications. The utilities of home networking over power-lines can take advantage of the existing wiring infrastructure for provision of illumination cum communication. The integrated system of VLC and PLC is a smart way of fulfilling the premise of broadband access for home networking, while providing efficient and low-cost lighting. To achieve the higher data rates (MHz), PLC channel is simulated using DMT-QAM modulation scheme. The idea of integration of these two systems for indoor networking which was based on single carrier modulation then to improve their old system to overcome the effects of power-line noises they used multi-carrier modulation (OFDM) method. A simple on–off keying (OOK) modulation scheme is employed for IM/DD VLC channel.

On analyzing the noises in powerline communication, the powerline channel does not represent an AWGN, but it includes a superposition of five noise types: colored background noise, narrowband noise, periodic impulsive noise asynchronous to the main frequency, periodic impulsive noise synchronous to the main frequency, asynchronous

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impulsive noise. Thus, all these three can be summarized in one noise class that is seen as colored PLC background noise class and is called "Generalized Background Noise (GBN). In visible light communication AWGN noise is independent of the optical power. When little or no ambient light is present, the dominant noise source is receiver preamplifier noise, which is also signal-independent and Gaussian (though often non-white). Thus we usually model the noise as Gaussian and signal-independent. Multipath fading in VLC can be ignored because an information carrier is in the order of 10^{14} Hz. Detector dimensions are in the order of hundreds of wavelengths, which leads to efficient spectral diversity that minimizes the effects of multipath fading.

The integrated system of VLC and PLC is a smart way of fulfilling the premise of broadband access forhome networking, while providing efficient and low-cost lighting. To achieve the higher data rates (MHz), PLC channel is simulated using DMT-QAM modulation scheme. The discrete multi-tone (DMT) modulation using 16-QAM is applied for PLC and VLC channel with presence of noises. A simple on–off keying (OOK) modulation scheme is employed for IM/DD VLC channel.

Manchester code as the code specified by the IEEE 802.15.7 standard in the case of outdoor applications using On-Off-Keying (OOK) modulation and the Miller code, as a possible alternative in Multi Input Multi Output (MIMO) applications. It seems that in the case of digital signal processing (DSP), the Miller code pulse is less affected by distortions caused by noise. However, in the case of the Manchester code, the higher error tolerance compensates for the pulse distortions. the Miller coded signal was better filtered, but itwas affected by stricter tolerances limit, which was the maincause for errors. In the case of the Manchester code, the digitalfiltering was less effective but it has recovered due to its highertolerance to pulse width variations.

In this work we are analyzing the negative effects of noise on the received data signal, mainly focusing on the Bit Error Rate (BER). The analysis is performed on messages coded using the Manchester and the Miller codes. Better understanding of the noise effect on the pulse width can help mitigate it and improve the communication performances.

II. INTEGRATED SYSTEM OF PLC AND VLC

It consists of a transmitter including power-line channel, optical interface (white LED), the VLC channel which to one point at the receiving surface includes a number of lines-of sight (LOS) as well as a contribution of reflections off the walls or objects in the room and finally receiver consists of a blue filter, a concentration lens, a photo-detector (PIN type) and low noise trans-impedance amplifier (TIA) following by demodulation section. In this system, in order to bias the LED and achieve the required illumination intensity, the LED is driven by a DC current (generated by AC to DC converter). The output signal (including AC current 50Hz and information data signal) from PLC channel is passed through band pass filter to pick up data signal. The power of LED is varied according to the waveform of data signal (Intensity Modulation). A DC current level is chosen such that, ensures the device operates in a linear regime, and one which is typical of operating conditions when the device is used for illumination. In the receiver side the practical down-conversion technique is direct detection (DD), in which a photo-detector produces a current proportional to the received instantaneous power, i.e., proportional to the square of the received electric field[5].

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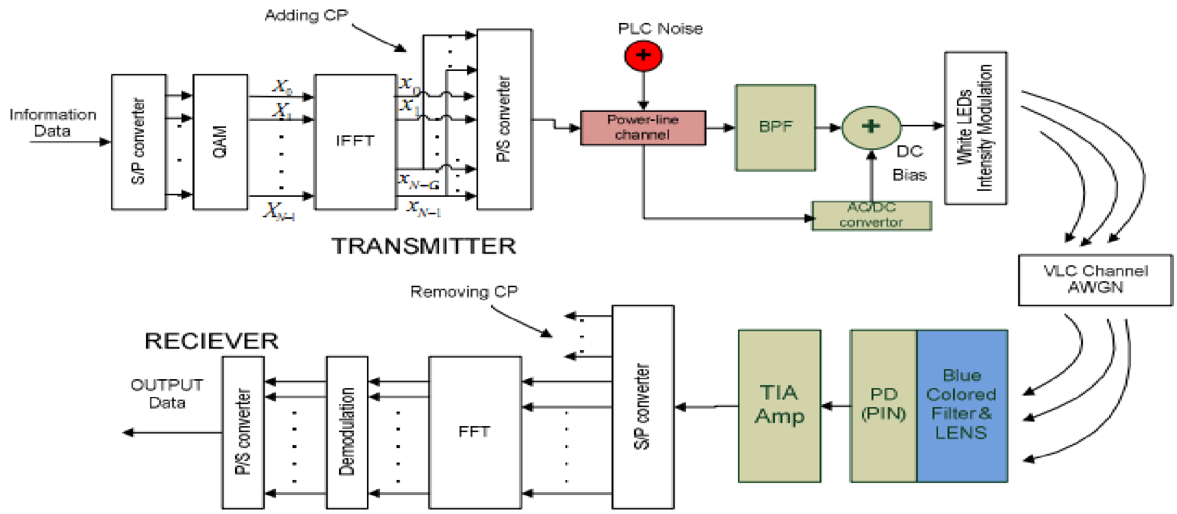

Fig 1: integrated system of power line communication and visible light communication [7]

III. NOISES AFFECTING THE INTEGRATED SYSTEM OF PLC AND VLC

The noise affecting the integrated system of power-line communication and visible light communication are

- colored background noise
- narrow band noise
- periodic impulsive noise asynchronous to the mains frequency
- periodic impulsive noise synchronous to the mains frequency
- asynchronous impulsive noise
- Shot noise
- Thermal noise

The first five types of noises are power-line channel noises and rest two are visible light communication noises.

The first three types of noise generally stay over long periods of time. Colored background noise and narrow band noises can be summarized as background noise. The next two types are time varying and can be summarized as impulsive noise. Impulsive noise has a random occurrence and its duration varies from a few microseconds to milliseconds. This periodic impulsive noise interfered with the transmitted OFDM signals affect the system performance. So these impulsive noises must be removed to improve the performance of the PLC system. The power line noises are the summation of background noise and impulsive noises.

- Coloured background noise-It is caused by summation of multiple sources of noises with low power and intensity. Its power spectral density decreases with increasing frequencies. Parameters of noise vary over time in terms of minute or hours
- Narrow band noise-consists of amplitude modulated sinusoidal signals which is caused by broadcasters, radio stations etc. This type occupies several sub-bands which are relatively small and continuous over the frequency spectrum. Amplitude generally varies over the day time and becoming higher at night when reflection properties of atmosphere becomes stronger.
- Periodic impulsive noise asynchronous to mains frequency-It is a kind of impulsive noise which is caused by switched-mode power supplies. Usually have repetition rate between 50 and 200KHz and which results in the spectrum with discrete lines with frequency spacing according to the repetition rate. Because of higher repetition rate this noise occupies frequency that are close to each other.

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- Periodic impulsive noise synchronous to mains frequency: which is mainly caused by switching actions of rectifier diodes found in many electrical appliances. Repetition rate 50 or 100KHz. These noises are of short duration in the order of micro seconds. Power spectral density decreases with frequency. Generally caused by power supply operating synchronously with the mains frequency.
- Asynchronous impulsive noise: which caused by switching transients in the power network. Have duration from of some micro seconds upto a few milliseconds. Power spectral density can reach values of more than 50dB above the background noise, making them the principle cause of error occurrence in digital communication over PLC networks.

The noise affecting the VLC channel (N_{Total}) contains a shot noise component and a thermal noise component,

$$N_{Total} = \sqrt{N_{Shot}^2 + N_{thermal}^2} \quad \text{eq. (1)}$$

The shot noise is proportional to the total optical noise power incident on the receiver. The effect of the shot noise can be minimized by using optical filters, but still this remains a perturbing noise source, limiting the communication's performances. In day-time outdoor communications, shot noise is the dominant noise component.

$$N_{Shot} = 2qIB \quad \text{eq. (2)}$$

Where q is the electronic charge (q=1.602*10^(-19)coulombs), B is the detector bandwidth and I is the produced photocurrent.

The thermal noise is represented by the preamplifier noise, and is the predominant noise source in the absence of background light.

$$N_{thermal} = \frac{4KTB\,N_{circuit}}{R} \quad \text{eq. (3)}$$

Where K is Boltzmann's constant (k=1.381*10^(-23)) , T is the temperature, $N_{circuit}$ is the circuit noise, and R is the load resistance.

Both the shot noise and the thermal noise are signal-independent and Gaussian. Under these conditions, the total noise affecting the VLC channel can be modeled as signal-independent Gaussian noise.

Background optical noises can afect the performance of VLC significantly. Scenarios may happen when the LED lamps and conventional flurescent lamps or AC-LED lamps consist in the same place. The background noise mitigated by using white LED OFDM VLC. 64 OFDM subcarriers were used (each subcarrier was in 4-QAM). The transmission data rate was12Mbps and the B.W was 6.25MHz. The OFDM carrier spacing was 97.66KHz. A flurescent lamp was used to produce different optical interference noise powers. The gas discharge lamps, like the flurescent lamps needed a ballast to operate. The ballast convert the main supply 60Hz frequency to higher frequencies for efficient lightning. The flurescent lamp had a dominant frequency tone at 90KHz, and harmonic tones at 180, 270KHz.

IV. CONVOLUTIONAL CODING

In telecommunication, a convolutional code is a type of error-correcting code that generates parity symbols via the sliding application of a boolean polynomial function to a data stream. The sliding application represents the 'convolution' of the encoder over the data, which gives rise to the term 'convolutional coding.' The sliding nature of the convolutional codes facilities trellis decoding using a time invariant trellis. Time invariant trellis decoding allows convolutional codes to be maximum likelihood soft decision decoded with reasonable complexity. The ability to perform economical maximum likelihood soft decision decoding is one of the major benefits of convolutional codes. This is in contrast to classic block codes which are generally represented by a time variant trellis and therefore are typically hard decision decoded.

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V. MANCHESTER CODING

Manchester codes were an invention that allows for timing information to be sent along with the data. In an NRZ code, if there is a long stream of ones or zeros, the receiver could conceivably suffer so much compound jitter that it would either lose or gain an entire bit time, and then be out of sync with the transmitter. This is because a long stream of 1s or 0s would not "change state" at all, but instead would simply stay at a single value. Manchester codes say that every single bittime will have a transition in the middle of the bit time, so that a receiver could find that transition, and "lock on" to the signal again, if it started to stray away from center. Because there are more transitions, however, manchester codes also require the highest bandwidth of all the line codes. In telecommunication and data storage, Manchester coding (or phase encoding) is a line code in which the encoding of each data bit has at least one transition and occupies the same time. It therefore has no Dc component, and is self-clocking, the clock signal can be recovered from the encoded data.

VI. MILLER CODING

Miller code is used internally in some computers, in which a binary 1 is represented by a transition in the middle of a bit (either up or down), and a binary 0 is represented by no transition following a binary 1; a transition between bits represented successive 0's; in this code , the longest period possible without a transition is two times. Miller code is also known as delay encoding. Delay encoding is primarily for encoding radio signals because the frequency spectrum of the encoded signal contains less low frequency energy than the conventional non-return-to-zero (NRZ) signal and less high frequency energy than a bi-phase signal. Delay encoding is an encoding using one half of the bandwidth for bi-phase encoding but features all the advantages of biphase encoding: to be rewritten: it is guaranteed to have transitions every other bit, meaning that decoding systems can adjust their clock/DC/ threshold continuously. One drawback is human reliability. The Miller code, as is used in Multi Input Multi Output (MIMO) applications. In the case of digital signal processing (DSP), the Miller code pulse is less affected by distortions caused by noise.

VII. RESULTS & DISCUSSION

Matlab 2013a is used as a simulation tool. Proper choosing of coding techniques help to improve the performance by reducing the adverse effects of noise.An efficient system is having largest SNR and lowest BER. This work analyzing which coding technique is performing better for the integrated system of power line communication and visible light communication. Considering PLC alone with noises, VLC alone with noises and integrated system of PLC and VLC with noises using the three coding techniques convolutional coding, Manchester coding and miller coding the effect is analyzed.

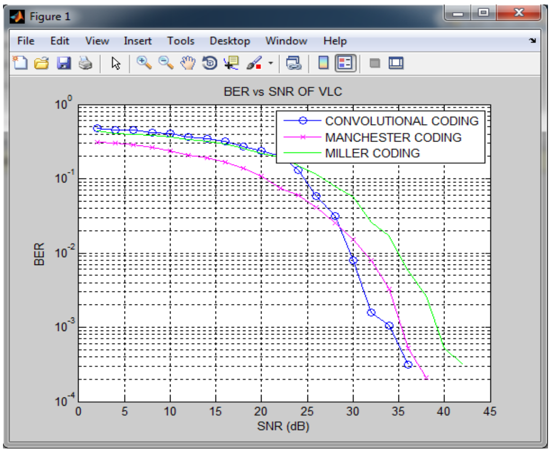

Fig 2: VLC with convolutional, Manchester and miller coding techniques

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For VLC at lower SNR Manchester coding is better performing, but when the SNR increases convolutional coding is the better coding technique for the integrated system of PLC and VLC.

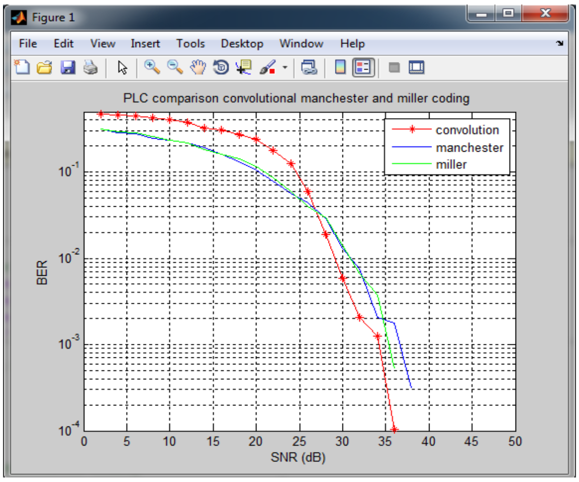

Fig 3: PLC with convolutional, Manchester and miller coding techniques

PLC is affected by a number of noises. This result tried to find out which coding techniques is better performing for PLC out of convolutional coding, Manchester coding and Miller coding. At lower SNR both Manchester and miller coding is performing almost similar, but when SNR increases convolutional coding is performing than the other two.

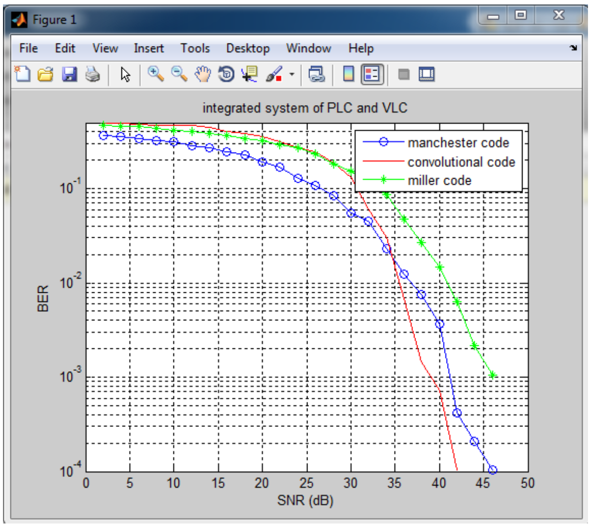

Fig 4: integrated system of PLC and VLC with convolutional, Manchester and miller coding techniques

For both PLC and VLC independently at larger SNR convolutional coding is better performing. Like this, for integrated system of PLC and VLC too convolutional coding is better performing at higher SNR. At lower SNR Manchester coding is performing well.

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VIII.CONCLUSION

The noises affecting the integrated system of power line communication and visible light communication is analysed here using the three coding techniques; convolutional coding, manchester coding and miller coding. Conclusion is made based on the SNR Vs BER curve. Depending on the Signal To Noise ratio , the coding techniques are performing differently. The impulsive noise is affecting powerline communication system severly, since it is varying over seconds or micro seconds and its amplitude is really high.. The visible light communication is mainly affected by shot noise. Shot noiseis proportional to the total optical noise power incident on the receiver. The effect of the shot noise can be minimized by using optical filters, but still this remains a perturbing noise source, limiting the communication's performances.Better understanding of the noise effectcan help mitigate it and improve the communication performances.

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BIOGRAPHY

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