Optical wireless communication using LED and improvement in noise parameter

**Mr. Prajwalsingh C. Parihar[1], Ms. Prerna R. Katre[2] , Ms. Veena S. Urade[3], Mr. Amey V. Nerkar[4]
Ms. Bhagyashree D. Gudadhe[5], Mr. Ankit Bhoyar[6]**

[1]Assistant Professor, ECE department, DBACER Nagpur, Maharashtra, India
[23456]B.E.Student, ECE department, DBACER Nagpur, Maharashtra, India

Abstract- *There are many challenges which come across during wireless optical communication. Optical noise is the factor which leads to deterioration of signal during light emitting diode optical wireless communication. For this reason, here we first experimentally studied, characterize and demonstrated the effect of optical background noise on the performance of the wireless communication channel. By using Manchester coding, we demonstrate the mitigation of optical noise. Here, no optical filtering, feedback or adaptive monitoring is required. Along with that, theoretical and numerical analysis of mitigation of the optical background noise using Manchester decoding process is also provided. Our experimental results shows that for the AC-LED operating at <500 KHz and fluorescent light, Manchester coding can significantly eliminate optical noise.*

Key Words: *Free-space communication, optical communications, light-emitting diode (LED), noise mitigation.*

1.INTRODUCTION

The light emitting diodes passes the properties such as high power efficiency, compact size and prolonged durability. This makes them suitable to be used for many applications like displays, signboards, lamps, light, automobile indicates, traffic signal lights.All these featureshave encouraged the intrgration or use of general lightning system with communication, which can provide a cost effective optical wireless communication [1]-[5]. This system provides highly secure and electromagnetic interference (EMI) free comunication. On the other hand there are several challenges in the practical implementation of this system. Limited direct modulation speed of the white LED is one of the challenges for which several techniques have been proposed, including the use of pre or post equalization [6],[7]. One of technique is pre

or post equalization [6],[7],or various modulation formats

like discretemultitone (DMT) [8]. communication is the optical noise generated by the AC-LEDs or conventional fluorescent lamps. Various techniques have be proposed to mitigate this generated optical noise. One of technique is the adaptive filtering in which interference signal and channel characteristics needs to be estimated, which further equalizes the received signal, using linear prediction coefficient.

Another challenge which come across during LED optical wireless technique, for which continous adaptive monitoring and feedback are required.

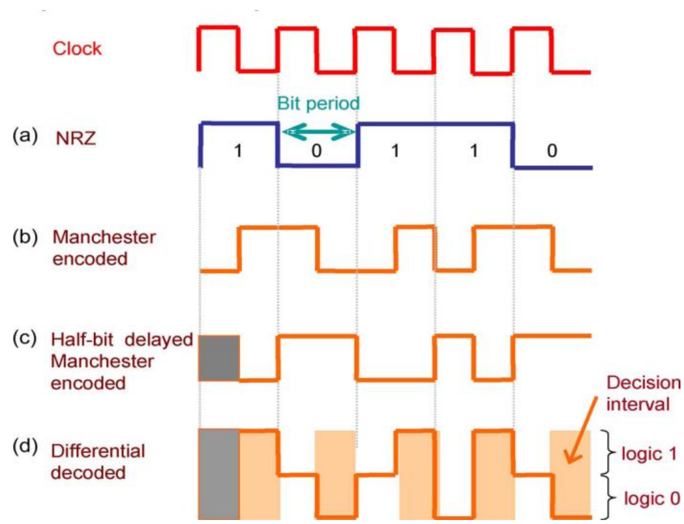

Fig.(1). Schematic bit pattern. (a) NRZ signal, (b) Manchester signal, (c) half-bit delayed Manchester signal, and (d) decoded Manchester signal.

In these paper, the manchester coding for the LED to mitigate the optical noise is demonstrated. In this adaptive monitoring, feedback or optical filtering not required. The advantages of manchester coding is that it can provide signal synchronization and enhance the clock recovery. Some experiments are carried out to evaluate the performance of manchester coded optical wireless communication. Signal using different noise frequencies and experimental result shows that manchester coding is efficient than the conventional non return to zero (NRZ) when the optical noise frequency is <500KHz.

2. PRINCIPLE

In this section the encoding and decoding of Manchester signal are discussed. The schematic bit pattern for Manchester coding and decoding is shown in fig (1). In Manchester coded signal, the signal transition from low to high represents logic "1", while the signal transition from high to low represents logic "0". By using exclusive-or (XOR) operation of the original NRZ data (blue curve in fig (1) the Manchester signal is generated. This signal is provided to LED source. The received Manchester signal is provided into two parts at the receiver (Rx). As shown in fig. 1(c) one part will be half-bit delayed using offline digital signal processing (DSP) or using commercially available different amplifier for decoding the received Manchester signal will then subtract its half-bit delayed signal. Further as shown in fig.1(d) bit-error-rate (BER) decision can be made at the time interval which indicates that the received signal can be correctly decoded when it is compared with the original NRZ signal logic, as shown in Fig. 1(a).

3. EXPERIMENT

The experimental setup is shown in fig (2).A pseudorandom binary sequence (PRBS) 2^{10} - 1 of NRZ and Manchester electrical signals with peak-to-peak voltage of 1 V is generated by an arbitrary waveform generator (AWG) (Agilent 33220A).The bandwidth and the resolution of the AWG are 20 MHz and 14 bits, respectively. The sampling rate is 50 MSa/s. These signals were then directly applied to a LED light (Cree, XLamp XR-E LED), which was DC biased at 2V. The AWG provides the DC bias. The LED has a 3-dB direct modulation bandwidth of about 1 MHz. The white light was transmitted across 1.65-m free space via a pair of focusing lens. This isthen received by a silicon based PIN Rx (Thorlabs PDA36A). The PIN Rx has the wavelength range of 350–1100 nm for detection with responsivity of 0.65 A/W and active area of 13 mm^2. It has a bandwidth of 17 MHz and the root mean square (rms) noise of 530 μV. Then, the received electrical signal was amplified by an amplifier (Mini-CircuitZHL-6A) and recorded by a real-time oscilloscope (Tektronix TDS2022B). The real-time oscilloscope has bandwidth of 100 MHz with vertical resolution of 9 bits and sample rate

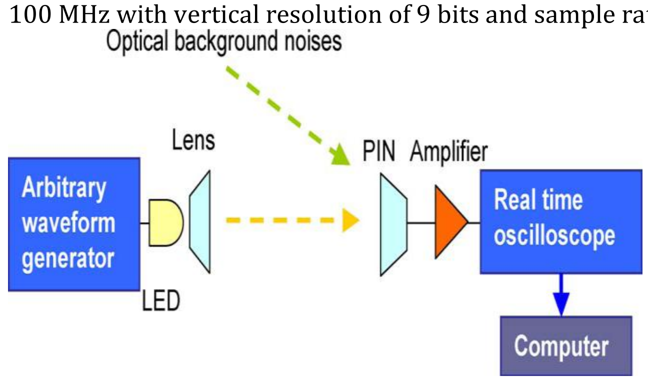

Fig (2): LED optical wireless communication experiment setup with the effect of optical background noise.

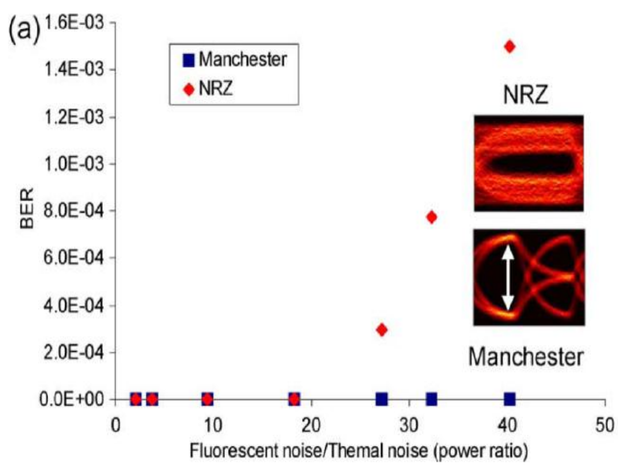

Fig. 3(a): BER and eye diagrams of NRZ- and Manchester-coded optical wireless communication signal at 1.25 Mb/s.

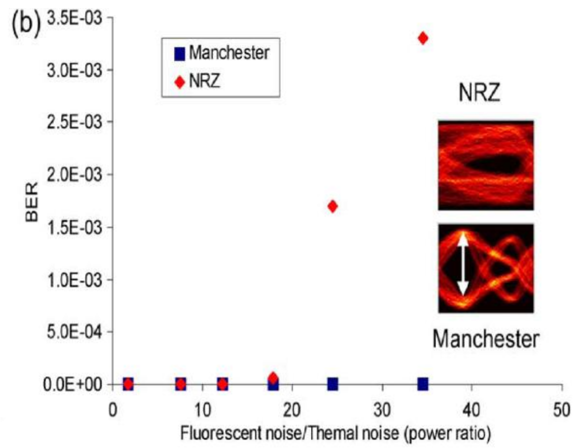

Fig. 3(b): BER and eye diagrams of NRZ- and Manchester-coded optical wireless communication signal at 2.5 Mb/s.

of 1.25 GSa/s. In the experiment of using a single LED, an illumination level of 300 lx was maintained (measured by a lux meter), and the transmission distance was about 1.65 m. According to [11], in a standard room size of 5 m × 5 m × 3 m, the LED lights were installed at a height of 2.5 m from the floor. The height of the desk was about 0.85 m. Hence, the distance between the LED lights and the user device that was put on the desk was about 1.65 m. A conventional fluorescent light from a desk lamp was purposely located near the Rx, which deteriorated the optical signal quality from LED optical wireless communication link.

4. CONCLUSION

Here we have successfully demonstrated the mitigation of optical background noise using the Manchester coding for the LED. Under the interference in particular band, the Manchester coding has significant effect for improvement in signal quality. The Manchester is also a line code that provides synchronization. To enhance the transmission performance further, other forward error correction (FEC) techniques can also be used. In this experiment no optical filtering, feedback or adaptive monitoring are required. At the bit rate of 1.25 Mb/s, the BER of Manchester coded optical wireless communication was error-free (Q>14) in all the measurements, while the transmission of the NRZ-coded optical wireless communication produced error even at low F/T or 10 dB. When the F/T increases to 40 dB, the BER of the NRZ-coded optical wireless communication is only 1.5×10^{-3}. At the bit rate of 2.5 Mb/s (in this case we over modulated the LED light) hence, the Q-Factor of both Manchester and NRZ –coded signals decreased due to ISI generated by the limited modulation bandwidth. However , we have observed that Manchester –coded signal performs better since the differential decoding of the Manchester signal can reduce the ISI and enhance the eye opening of the received signal. The further experiments are carried out to evaluated the performance of Manchester –coded optical wireless communication signal using different optical noise frequencies generated by AC-LEDs, and the experiment results showed that Manchester coding performed better than the conventional NRZ when the noise frequency was <500kHz.

5. REFERENCES

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