Design of a Higher Order Modulator/ Demodulator for VLC by Combining ASK and FSK

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Abstract - Visible light communication is a famous data communications variant which uses visible light between 380nm and 750nm. Here, the modulation used is a form in which the light signal varies in order to represent various symbols of a message signal. In order to achieve higher order modulation; in frequency shift keying, the number of frequencies are required to be increased and in amplitude shift keying, the number of amplitude levels are needed to be increased. In this paper, a new higher order modulator is proposed by combining the above modulation schemes which can be used in visible light communication. The proposed model is expected to reduce bit error rates at any given signal to noise ratios targeting better quality of service. The performance of the proposed model is validated through the simulations.

Keywords: Amplitude shift keying, Bit error rate, Frequency shift keying, Modulation, Signal to noise ratio, Visible light communication

I. INTRODUCTION

Modulation is the process of encoding information from a message signal in a way that is suitable for transmission. Modulations in visible light communication (VLC), are the forms in which the light signal varies in order to represent various symbols of the message signal. Quadratic amplitude modulation (QAM) is identified as a higher order modulation scheme with good performance [1]. It can be considered as a combination of amplitude shift keying (ASK) and phase shift keying (PSK) modulations. But such modulation schemes are ideally not to be used in VLC as they need accurate detection of the phasor. Hence, ASK and frequency shift keying (FSK) [2] would be the modulation options that can be used for such communications.

Bit error rate (BER) is a critical parameter for evaluating systems that transmit message information from one place to another. Signal to noise ratio (SNR) is a well-known measure of how the signal and noise power compare. It has a direct impact on a system's error probability and performance. The combination of ASK and FSK modulations together to prove that it has a reasonably low BER relative to SNR [3-5].

II. METHODOLOGY

We have used two methods to measure the performance of this new modulation scheme. BER of the new modulation scheme has been found by theoretical calculations and MATLAB simulations are done to determine the BER relative to SNR of ASK/FSK modulation.

The below model shows the physical implementation of combined ASK/ FSK modulator and demodulator.

A. System Model

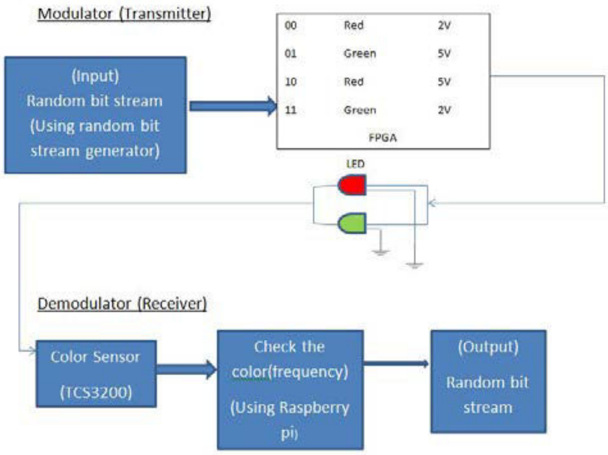

Fig. 1 System implementation of combining ASK/FSK

Two frequencies and two amplitudes are used in this system. The two frequencies are red and green respectively. And the amplitudes are assigned as 5V and 2V. In the transmitter's side, a random bit stream is input to a programmable device (FPGA/ Raspberry pi) and then two bits at a time will be considered according to the table below,

Table 1: Symbol assigning for LEDs

Symbol	Colour of LED	Amplitude
10	G	A1
11	G	A2
00	R	A1
01	R	A2

According to Table 1, the symbol assignment of LEDs and respective amplitudes can be identified, as an example, if the received symbol is 01, then the red LED will on with a voltage of 2V.

In the demodulator's side, the received colour intensities will be identified using a TCS3200 colour sensor and a programmable device, and it will be decoded back to a bit stream. This output bit stream is expected to have a less number of errors.

B. BER Analysis

Here, both the signals of ASK and FSK have been combined to achieve four different coding levels. The resultant message signal of the combined ASK/FSK would be then

00 – $A_1 \cos(2\pi f_1 t)$

01 – $A_1 \cos(2\pi f_2 t)$

10 – $A_2 \cos(2\pi f_1 t)$

11 – $A_2 \cos(2\pi f_2 t)$

Accordingly, the basis functions (ϕ) were evaluated using the Gram-Schmidt orthogonalization process, for M=4, N<= 4 where M refers to the number of signals and N for number of basis functions.

Assume that f_1 and f_2 are sets of orthogonal frequencies.

$$\Phi_1 = \frac{\sqrt{2}}{Tb} \cos\ (2\pi f_1 t)$$

$$\Phi_2 = \frac{\sqrt{2}}{Tb} \cos\ (2\pi f_2 t)$$

C. BER simulation.

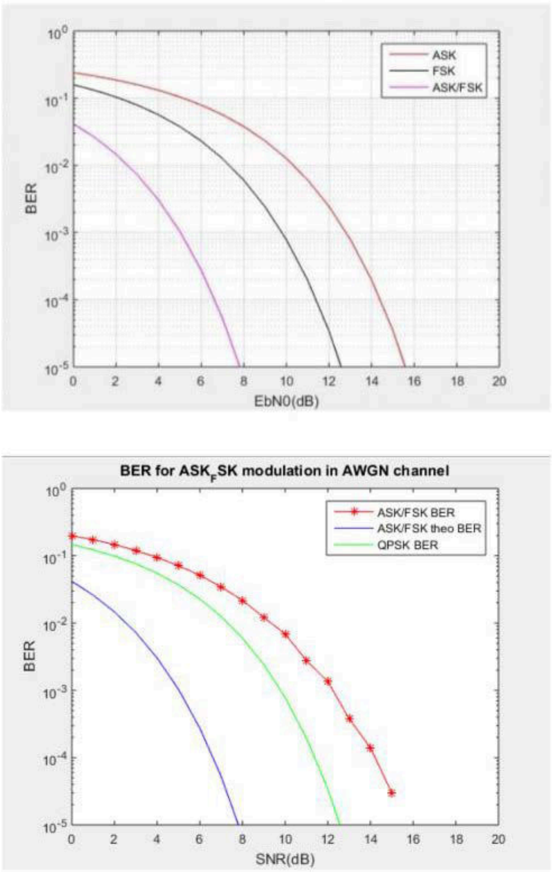

Fig. 2 BER comparison of ASK, FSK, QPSK and ASK/FSK

III. RESULTS AND DISCUSSIONS

The BER relative to SNR in AWGN channel are plotted in figure 2. According to above figure 2, 1st graph, we can observe that SNR (E_bN_0) vs BER curve of ASK modulation is on top of the graph and below that, the curve of SNR vs BER graph of FSK modulation can be observed. From these observations, it is clear that the BER is lower and efficiency of FSK modulation is greater than efficiency of ASK modulation which has a high BER because error probability of ASK is high according to Figure 1.

In this research, our aim was to combine ASK modulation and FSK modulation and to prove that the combination is more efficient. Hence, we can observe the curve of SNR vs BER of ASK/FSK modulation is underneath ASK and FSK curves. We can identify that ASK/FSK modulation has higher efficiency than FSK modulation because error probability is less in its modulation according to the graph. As a summary, when considering the BER of the three modulation schemes, it can be seen that, *ASK < FSK < ASK/FSK.*

According to the 2nd graph we have compared the theoretical and simulation results of QPSK and combined ASK/FSK modulation. QPSK's theoretical BER shows lesser performance than ASK/ FSK theoretical BER performance, but since it cannot be adapted into VLC, it can be observed that combined ASK/FSK might be a better solution. Accordingly, we have proved that combined ASK/FSK modulation has a low BER and has a better performance for VLC.

IV. CONCLUSION

BER performance of the proposed modulation scheme for VLC is evaluated and verified with the simulation. According to the simulations, combined ASK/FSK digital modulation scheme shows better performance compared to individual modulations. In future, the physical implementation of the modulator and demodulator of combined ASK/ FSK modulation will be done and the practical BER will be compared with the simulated BER.

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