HADAMARD Coded Modulation for Optical Wireless Communication and Performance Analysis

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Abstract — A new method is proposed for optimizing the performance of Hadamard coded modulation (HCM)based systems in visible light communication. Prior to HCM, PSK was used in Wireless Optical Communication (WOC) for data modulation whereas HCM was used as precoder in PSK systems. But the constraint of optical sources used lead to signal distortion at the output. Hence HCM is used as an alternative technique for systems that require high average power. Here data is modulated using Fast Walsh Hadamard Transform. On-off keying (OOK) along with thresholding method is applied to the HCM system for improving its performance. Both the existing and modified system performance is evaluated in terms of various performance parameters. There are numerous modulation methods appropriate for optical wi-fi verbal exchange. OOK, PPM are adopted widely in optical wireless conversation foe its high average-strength-performance. DPPM, DPIM are new modulation techniques for optical wireless verbal exchange, which may be the substitutes of PPM due to their better performance in strength performance and bandwidth performance. On this system in mixture of the feature of the atmospheric optical VLC channel, the bandwidth efficiency, transmission capability, power efficiency and slot errors fee of the everyday modulation schemes as OOK, PPM, DPPM and DPIM for atmospheric optical wi-fi communications are analyzed. Theoretical evaluation and simulation outcomes by using MATLAB display that DPPM, DPIM and DH-PIM are extra relevant for the destiny optical wireless verbal exchange.

Keywords: Hadamard Code, Modulation Technique, Visible Light Communication, Performance Analysis, BER (Bit Error Rate), SNR (Signal-To-Noise Ratio), Channel Capacity, Coding Gain, Optical Wireless Communication, Optical Intensity Modulation.

I. INTRODUCTION

A 5G technology as they say, LIFI is coined as a huge MIMO visible light communication community which uses LEDs. A future technology that ensures to replace the 2G, 2.5G, 3G and the latest 4G systems of communication. The current technologies which employ WIFI define it as any “wireless local area network (WLAN) products that are based on the Institute of Electrical and Electronics Engineers' (IEEE) 802.11 standards”. LIFI is thought of as an alternative or an exchange to the currently used WIFI. With an exhausted and congested network, it was necessary to articulate our minds into a technology which not only is ubiquitous but also a resourceful quantity. Professor Harald Haas during his TED global talk rightfully coined LIFI as the future upcoming technology. This technology further has the quintessential advantage of not needing any base stations and primarily requiring unlicensed services. Very high facts rates may be finished due to low interference, high device bandwidths and excessive depth optical output. Moreover, it is non-hazardous and a safe technology which can even be employed in riverbeds and is cost effective. These pros of LIFI outshine it from other technologies.

II. LITERATURE SURVEY

The minimum distance of Hadamard codes, which are a class of error-correcting codes used in digital communications. The authors analyze the properties of Hadamard codes and derive a lower bound on their minimum distance, which is a measure of their error-correcting capability. An improved Hadamard code-based M-ary PSK modulation scheme for power line communication systems, which provides higher spectral efficiency and better error performance compared to traditional modulation schemes. New Hadamard code-based PSK modulation scheme for IoT communications, which provides a good trade-off between BER performance and spectral efficiency. The proposed method involves a modified decoding algorithm that utilizes a "maximum likelihood decoding" approach. This method considers the probability of all possible transmitted code words and selects the most probable one. The authors claim that this approach can improve the error correction capability of Hadamard codes by up to 2-3 dB, which is significant in practical communication systems.

III. EXISTING METHODS

Wireless communication is nothing but a mobile communication which plays vital role in the world. Wireless communication has much greater impact on the communication networks in present as well as future. But, still the total availability of bandwidth is note efficiently used. It is difficult to find the availability of unused spectrum. Using an efficient method, the unused spectrum can be found and given to multiple users. The Encoder block is mostly introduced in a communique block so one can combat the above effect. For efficient transmission, comparing and locating the excellent encoding technique is performed the usage of MATLAB stimulator.

A. Different encoding techniques:

It is the process to convert original data into a transmittable format. This can be done using words, symbols and pictures. There are many encoding techniques. The commonly used techniques are Convolution coding linear block coding.

B. Convolutional coding:

In an error detecting code that generate parity symbols and used to transmit digital data over communication channel.

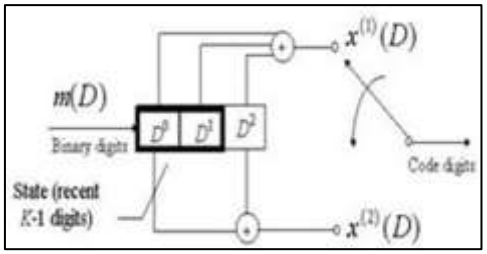

Fig-3.1. Block Diagram of Convolutional Encoder

The new values of x (1) and x (2) is generated depending upon Do, D1and D2 when the message bit is shifted to position "Do", D1 and D2 stores the previous two message bits. The current bit is present in Do.

In this way we can give it as

X(1)=Do+D1+D2andX(2)=D0+D2

- The output moves the first samples x (1) and x (2).
- Shift register then shift the contents of D1 and D2.
- Input bit is then taken and stored in D0.
- X(1) and X(2) are generated a gain according to the new combination of Do, D1 and D2.
- The output then moves first samples x (1) and x (2).

Then the output bit stream for successive input bits will be,

X=x (1)x(2)x(1)x(2)x(1)x(2)……

And soon

For a single message bit, the encoded code word is two bits. Here in convolution codes, the information bits are followed by the parity bits.

C. Hamming codes:

Hamming codes (n, k) are linear block codes. The following conditions can be satisfied by this code, Number of check bits q>=3Block length n=2q-1 Message bits k=n-q Minimum distance d min is 3.

Since the minimum distance d min of is 3, it can be used to sense the correct single errors.

This can also be obtained from the generalized. We know that the codes rate for hamming codes is given as,

D. Effect of Coding Techniques in Matlab

MATLAB stands for Laboratory Virtual Instrument Engineering Workbench. The system- designed platform and program development environment. MATLAB compiler gives a code to the CPU platform. By changing the syntax and by compilation the graphical code is translated into machine code. The MATLAB syntax cannot be changed during the editing process to compile into an executable machine code in the execute process. In MATLAB we have compared convolutional and hamming code and calculated the BER for both.

1) Channel Noise

Here we have used two different channels to compare the encoding techniques in MATLAB. They are:

a) AWGN (adaptive white Gaussian noise)
b) Rayleigh

2) Additive White Gaussian Noise (AWGN)

Its miles one of the primary noise models. On this additive model when it is added to any noise that can be essential to the data machine. White refers to an idea, that it has unvarying power across the frequency band within the facts godet. It has an analogy to the color white where it has uniform emission at all frequencies. It has a normal distribution in time domain with an average time domain value of zero.

3) Rayleigh

The Rayleigh model is a statistical model that can be utilized by Wi-Fi devices to account for the effects of radio signal propagation. The model is based on the assumption that the magnitude of a signal transmitted through a medium will vary randomly, following a Rayleigh distribution. In other words, the magnitude of the resultant signal can be described as the square root of the sum of the squares of two independent Gaussian random variables.

4) Convolutional and Hamming Codes in Matlab

In MATLAB we have made a coding for convolutional and hamming codes and obtained the BER graph for AWGN channel.

The table is given below with Eb/No and BER ratio:

Channel	EB/No	Convolutional Codes (BER)	Hamming Codes (BER)
AWGN	5	0.0031057	0.0113715
	6	0.000595134	0.00465063
	7		
		0.000145033	0.00141019
	8	0.000005001	0.000250034
	9	0.000005001	0.000100014

Table 3.1. Comparison Table of Convolution and Hamming Codes.

From the table above we can clearly say that a convolutional code has the lowest BER and it is the best coding technique. Most students understand parity bits. A parity bit is an additional bit, either 0 or 1, that is added to a byte or a larger block of data to assist in detecting errors. With even parity, the byte and its parity bit will contain an even number of 1s. If the byte itself contains an odd number of 1s, parity bit is set to 1 to make the total number even. If the byte contains an even number of 1s, the parity bit is set to 0. If any of the bits are flipped, the total number of 1s will be odd, and we can determine that the byte contains an error.

IV. PROPOSED SYSTEM

It is an rising technology that uses light as an alternative of radio frequency signals for data transmission in visible light communication. The unregulated bandwidth available in VLC reduces the traffic on the RF spectrum. It is also known as short range optical wireless communication. The objective of VLC is to increase data rates in wireless communication and to have better performance of networks especially for indoor networks using light emitting diode (LED) lamps. LED has many benefits such as low power consumption, small size long life, low heat, low heat radiation So they are used in numerous applications like traffic lights, advertisement displays, indoor lighting equipment and so on.

However, using LEDs as sources add limitations on the modulation schemes and codes is used. Therefore modulation and coding schemes with high spectral efficiencies are required with high spectral efficiencies are required to provide high data rate connection.

OFDM (Orthogonal frequency division multiplexing) is an efficient modulation technique for high data rate communications and has been adapted to work in

energy efficient optical communications. But the peak power constraint of the optical sources limits the high peaks of the output signal resulting in signal distortion. PAPR (Peak to average power ratio) reduction techniques can alleviate this problem. Hadamard modulation was thus proposed because of their based VLC systems.

A. HADAMARD CODED MODULATION

Hadamard coded modulation uses a binary Hadamard matrix to modulate the input data. Suppose HN be an N^{th} order binary Hadamard matrix, obtained by replacing -1 by 0 in the original {−1, 1} Hadamard matrix [5]. The components of u are assumed to be modulated (PAM). i.e.…

$$Un \in \{0,1/M\text{-}1\ ,2/M\text{-}1,...1\} \text{for } n = 0,1\ldots N\text{-}1. \quad (1)$$

The HCM symbols generated are sent to an amplitude modulator that then modulates the optical source. This structure, which we call the single-source structure, can be used with power-line communication (PLC) integrated VLC networks, where the data is send to the LED bulbs via the power lines and each component of the LED array cannot be modulated separately. In the single-source structure, the nonlinear transfer function of the optical source causes unequal spacing between the transmitted power levels, which makes the symbols more susceptible to noise, and therefore, a pre-distorter is required to make the power levels equal. A control circuit is also needed to compensate for the drift due to the thermal changes, which leads to an increased complexity of the transmitter.

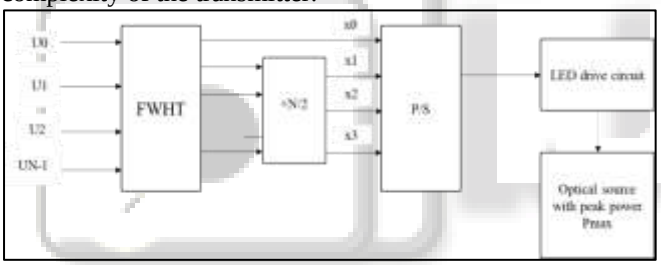

Fig. 4.1: Block diagram of HCM transmitter

The transmitted vector x is obtained from the data vector as

$$x = uHN + (1\text{-}u)\,\bar{H}N \quad (2)$$

The equation can be rewritten as

$$x = u\,(HN - \bar{H}N) + N/2[0\ .....1] \quad (3)$$

where the second term is obtained from the product of a 1 N vector of all ones and $\bar{H}N$. The matrix $(HN - \bar{H}N)$ is the bipolar Hadamard matrix, and hence, the first term in eq (3) is the Walsh-Hadamard transform of the vector u.

Using an FWHT of size N, the Hadamard transform, which has a complexity of N log2 N, and then a constant value of N/2 is added to elements to generate x. Here N − 1 rows of HN are only used that have a weight of N/2 to modulate the Hadamard matrix which has all ones are ignored. Hence the first component of u gets set to zero, and the rate of M-PAM HCM therefore is (N − 1)/N log2M. There exists a fixed the remaining N − 1 rows, which helps in removing the interference of the Hadamard codewords among each other side.

The decoded vector v is obtained from the received vector y

$$v = 1/N(yHN\ T \quad \bar{T}) + 1/2[1\text{-}N\ ,1,1....1] \quad (4)$$

which can be realized by an opposite FWHT (IFWHT)

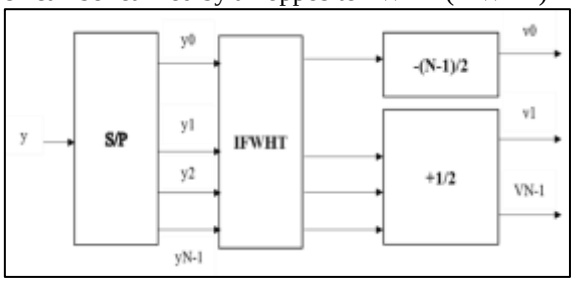

Fig. 4.2: Block diagram of HCM receiver

The noise payable to the channel, n and the output signal is given by y = h * x + n, where h = {h(k)} is the discrete-time equivalent impulse response of the channel and * denotes the convolution operation. For an ideal non-dispersive channel with impulse response.

$$h(k)=\{1,\text{for } k = 0 = \{0, \text{ for } k \neq 0 \quad (5)$$

the decoded data can be rewritten as

$$v = (u+1/2[1\text{-}N,1,1....1]) + \tilde{n} \quad (6)$$

where ñ is a 1*N noise vector with independent components

For average power levels less than P0/2, the HCM signals are not distorted by the LED nonlinearity and the performance of HCM is only limited by the noise.

B. Modified HCM System

The high average optical powers are required for illumination in VLC system, some forms of OFDM can suffer from signal clipping. This problem can be alleviated by using that trade-off complexity and energy inefficiency Hadamard matrices is used as precoders in OFDM systems to reduce BER and increase the resistance of the signals against frequency selective fading. A multilevel modulation technique named HCM (Hadamard Coded Modulation) that uses the Hadamard matrices as a modulation technique rather than a precoder. In this system the data is modulated using a fast Walsh-Hadamard transform (FWHT) and the receiver uses an inverse fast Walsh-Hadamard transform (IFWHT) to decode the received signals. The proposed system uses OOK (on-off keying) to modulate the input data and at the receiver an integrate and dump method is used to recover the demodulated signal.

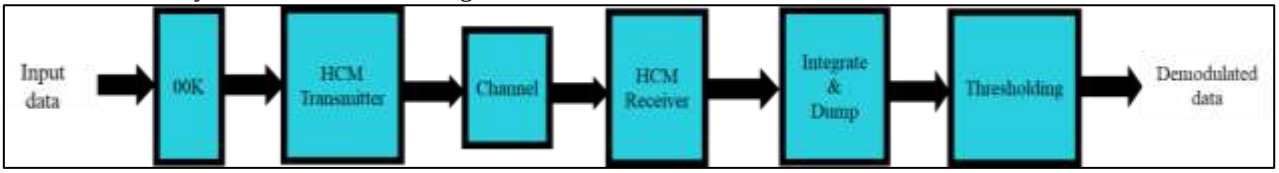

Fig.4.3 Block diagram of proposed system

1) On-off keying

It is the simplest form of amplitude shift keying(ASK) modulation scheme in which digital data is represented at the presence or absence of a carrier wave. Presence of a carrier for a period represents a binary one whereas its absence indicates a binary zero. Since a series of logical ones and zeros are represented by simply switching on and off the carrier, it is referred to as on-off keying. The frequency shift keying. Mathematically we can represent it as a wave form consisting of a signal

$$S(t)=A\sin\{2\pi ft+\phi\} \quad (7)$$

Where we set a=A, ϕ = 0 when the bit is '1'and a = 0,ϕ = 0 when it is '0'On-off keying have been primarily adopted that conveys in sequence in the intensity, in either NRZ (non- return- to- zero) or RZ (return-to -zero) format. The advantage of OOK modulation to transmitter goes to 'idle' state during transmission of logic 'zero' thereby help in conserving battery.

2) VLC channel model

The impulse-response of a VLC channel consists of line of-sight (LOS) and non-line-of-sight (NLOS) parts. In VLC systems, the NLOS impulse response to reflections of the light from the walls and other objects and usually causes inter-symbol interference at symbol-rates higher than 50 Msps. Given the sampling period, which is assumed to be the same as the length of the time-slots in this work, an equivalent discrete impulse response of the VLC channel, $\alpha = \alpha l$, can be calculated from the continuous impulse-response. In the model the noise in the system is modeled as an additive white Gaussian noise (AWGN) source, which is a good approximation for high background light scenarios. The front-end of our VLC system model is depicted in Fig.4

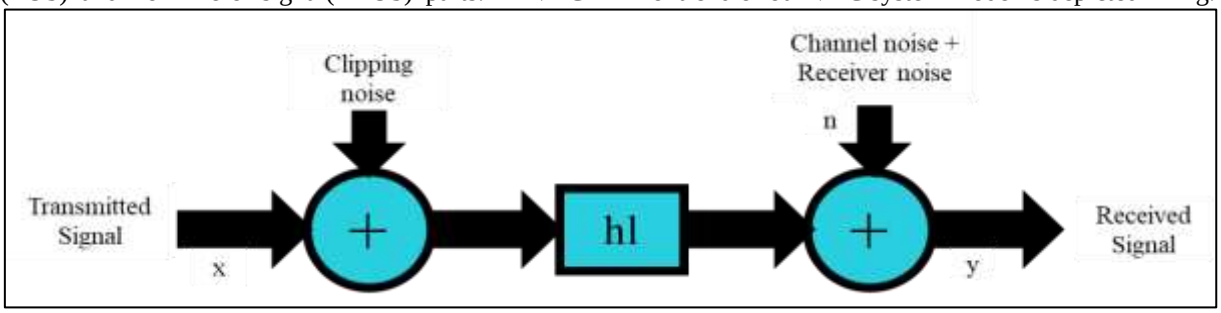

Fig. 4.4: VLC system front end

3) Integrate and dump

The integrate and Dump block creates a cumulative sum of the discrete time input signal, while resetting the sum to zero according to a fixed schedule. The input parameters for the process are the signal to be integrated along with the number of samples taken.ie the signal is integrated for one symbol period and its averaged value is stored to a variable. The process continues for the no of samples taken.

Receiver models often use integrate and dump operation when the system's transmitter uses a square pulse input. This operation is also used in fiber optics and in spread spectrum communication (CDMA) The block accepts a scalar, matrix input signal or a column vector. When the intermediate output values are cleared, The output of the block gets delayed relative to its input throughout simulation. However, the receiver inherently rejects all inter symbol interference due to the integrator resetting between bits.

In this method we specify the mixing period in samples as a positive, integer scalar greater than one. It defines the length of the sample blocks that is integrated between resets. In digital communication the filter is used as a matched filter for the detection of signals under additive white gaussian noise (AWGN).

4) Thresholding

It is subjected to thresholding to retrieve the demodulated signal. We find the maximum of the signal output. Then we find a signal 'x' such that

$$x = y/\max(y) \quad (8)$$

This signal is compared against a fixed threshold of 0.1 and the decision is made as follows

x < = 0.1 means logic 0

x > 0.1 means logic 1

This data is transmitted data for analyzing error and various performance parameters are calculated namely bit error rate, energy efficiency.

C. Performance Analysis and Comparison of Error Rate

The direct detection in the system of optical wireless communication were adopted. At the same time the bandwidth of receiver is very wide. Then the x (t) which is gotten in sample decision device are S n(t) t + when pulse "1" is sent, or x (t) is n (t) without pulse. The decision device are St. Decision threshold is supposed b, P1/0 is e "1" are misjudged "0"and P0/1 is "0" are misjudged "1", they respectively are as follows:

$$P_{01}=(1/2)\{1+erf[(b-\sqrt{S_t})/\sqrt{2\sigma_n^2}]\}$$

$$P_{10}=(1/2)\{1-erf[b/\sqrt{2\sigma_n^2}]\}$$

$$erf(x)=\frac{2}{\sqrt{\pi}}\int_0^x \exp(-u^2)du=1-erfc(x)$$

V. RESULTS AND COMPARISON

A. Signal to Noise Ratio

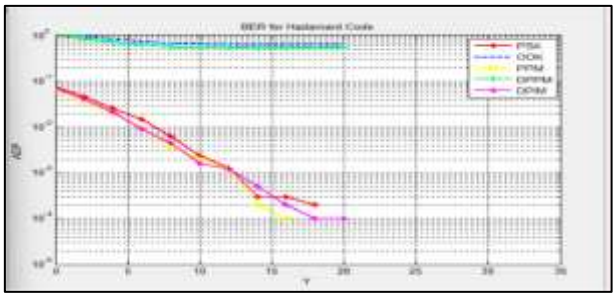

Fig. 5.1:

PSK	ASK	PPM	DPPM	DIPM
0.008	1.2	0.06	1.09	0.94

The results for all the modulation techniques OOK, PPM, DPPM and DPIM using Hadamard code shows that the Bit Error Rate for PPM using Hadamard code is low when compared to the existing PSK modulation with Hamming code

B. Bit Error Rate

The results shows that when compared to all four modulation techniques OOK, PPM, DPPM and DPIM, PPM modulation using Hadamard code gives lower Bit Error Rate when

compared to the existing PSK methodology using Hamming code.

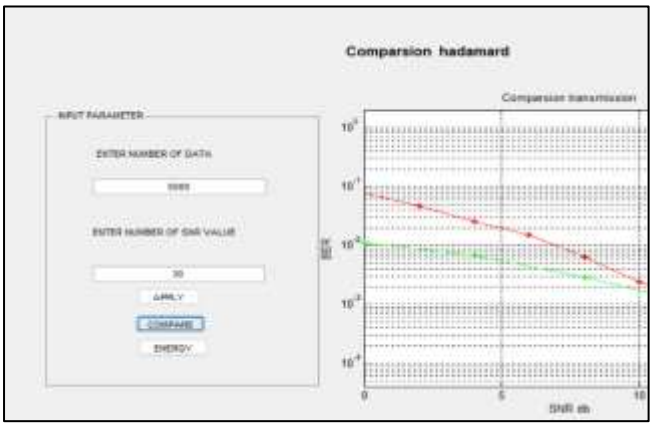

Fig. 5.2:

PSK	OOK	PPM	DPPM	DPIM
0.0793	0.079	0.0674	0.0678	0.0711

C. Energy Detection and Accuracy

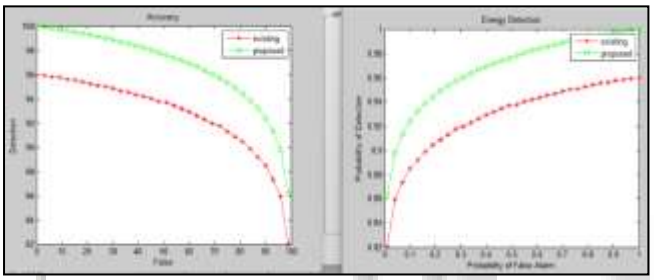

Fig. 5.3:

Probability of false alarm	Existing method (PSK with Hamming Code)	Proposed method (PPM with Hadamard code)
0	0.01	0.86
0.1	0.87	0.90
0.2	0.91	0.94
0.3	0.92	0.96
0.4	0.93	0.97
0.5	0.94	098

Probability of false alarm	Existing method (PSK with Hamming Code)	Proposed method (PPM with Hadamard code)
0	96	100
10	95.7	99.7
20	95.2	99.3
30	95	99
40	94.5	98.6
50	94	98

From the graph and tabulation PPM modulation using Hadamard Code gives higher efficiency and accuracy when the existing PSK modulation technique using Hamming code.

VI. CONCLUSION

With the results and discussion, it is finally concluded that Hadamard coded technique with pulse position modulation reduces bit error rate and signals to noise ratio. It increases efficiency and accuracy with deference to the comparison made OOK, DPPM and DPIM modulation techniques. So, the results of PPM using Hadamard code is better for transmission as it provides distortion less signal and the reception when compared to PSK modulation technique with hamming code.

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