Miller Encoder for Outdoor MIMO VLC Application

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Abstract

Visible Light Communication (VLC) is an emerging field in Optical Wireless Communication (OWC) which utilizes the superior modulation bandwidth of Light Emitting Diodes (LEDs) to transmit data. The VLC application generally adopts Manchester and miller codes to reach dc-balance, enhancing signal reliability. So the Manchester and Miller encoder is an important part of VLC emitter section. In this paper, we have presented the architecture of VLC and designed the combined Manchester and Miller encoder. The behavior of Manchester and Miller encoder is realized by derivation of VHDL code in Xilinx ISE 13.1 software. The paper also aims to make comparative study of two coding technics used for outdoor VLC. The synthesis result shows that integrated Manchester and Miller encoder indicates successful function.

Keywords: VLC, MIMO, LED, Manchester code, miller code

I. INTRODUCTION

A. Background

The demand for wireless access is rapidly growing which resulted in heavily congested spectrum which reduces spectrum efficiency, The available radio-frequency (RF) bandwidth will not be sufficient to meet the increasing demand for wireless access. Visible light communication (VLC) is an alternative method to reduce the burden of RF-based communication. 70% of the communication is indoors, and light emitting diode (LED) arrays are used for illumination purposes because of their low energy and higher lifetime. VLC can be realized as a secondary application in LED arrays that are placed for lighting. To be able to meet this demand, the research community began looking for solutions that target alternative portions of the spectrum. VLC is one of the promising alternative that aims to provide a communication medium by using the existing illuminating devices. VLC using LEDs comprises OWC links using visible light spectrum, in which LEDs are applied with two functions, illumination and communication, simultaneously [1-2]. For these reasons, VLC attracts significant research interests. With the improvements in LED technologies, it is possible to modulate light in high frequencies. Due to their lower cost, higher lifetime and lower power consumption, LEDs are expected to replace conventional incandescent and fluorescent lamps in the near future. This enables the use of LEDs for both illumination and communication, making VLC an economic and ubiquitous data transmission solution. In these systems, light-emitting diodes blink at a rapid rate such that the human eye will not notice the change in light intensity, but a sensitive photodiode can detect the on-off behavior and decode the information embedded within it. In general, the FM0, Manchester and Miller codes can be applied to telecommunication and are often used as encoding scheme. Generally, the waveform of transmitted signal is expected to have zero mean for robustness issue and this is also referred to as dc-balance. The above mentioned codes can provide the transmitted signal with dc-balance.

B. Motivation

As societal dependence upon wireless systems continues to grow, wireless technology needs to expand to meet the demand. The availability of current forms of wireless is very limited, and it is not necessarily safe to implement wireless radio, making it necessary to explore other alternatives to wireless communication to allow continued expansion upon communication systems and to ensure safe use. In addition to the crowding of the frequency spectrum, interference is also a concern for many existing wireless systems. Any simultaneous use of a frequency band will cause interference due to the electromagnetic nature of most wireless devices, which could result in incorrect or loss of information for those users involved. A prime example of this is the use of mobile devices on planes, which directly affects safety. VLC with miller encoding scheme have more flexibility and integrity than other communication systems in many regards. Since the medium for transmission in VLC systems is visible light and not RF waves that can penetrate walls, the issue of security is inherently solved because light cannot leave the room, containing data and information in one location. There is no way to retrieve and access the information unless a user is in a direct path of the light being used to transmit the data. The paper aims to develop miller coding for outdoor VLC application as it is more suitable for external noise using Xilinx as possible encoding scheme and integrate it with Manchester code. So for indoor application, manchester coding and for outdoor application, miller coding can be used by selecting appropriate mode.

C. *Paper Organization*

The paper is organized as follows: The description about line coding, Manchester and miller encoding technique is Section II. In Section III, we describe the proposed system for outdoor MIMO VLC application. In Section IV, we give the results of a simulation of integrated miller and manchester encoders using VHDL. Finally, in Section V we give a conclusion and talk about future work.

II. LINE ENCODING TECHNIQUE

In telecommunication a line code is a code chosen for use within a communication system for transmission purpose. For digital data transport line coding is often used. Line coding consists of representing the digital signal to be transported, by an amplitude- and time-discrete signal that is optimally tuned for the specific properties of the physical channel (and of the receiving equipment). The waveform pattern of voltage or current used to represent the 1s and 0s of a digital signal on a transmission link is called line encoding. There are many ways to encode the data such as Miller encoding, Manchester encoding, FM0, NRZ, FM1, RZ, etc. Manchester and Miller codes can provide the transmitted signal with dc-balance. , the waveform of transmitted signal is expected to have zero mean for robustness issue and this is also referred to as dc-balance. For this reason, VLC prefers Manchester and Miller encoding techniques.

A. *Manchester Encoding*

Manchester code is first developed by G.E.Thomas at 1949. It is also called as phase encoding scheme. Manchester encoding is also called phase encoding. It can be used for a higher operating frequency. Manchester encoding is a very common method and is probably the most commonly used. The signals can be transmitted serially. In Manchester encoding the average power is always the same, no matter what data is transmitted. Compared to all other encoding methods, Manchester code follows an algorithm to encode the data. It always produces a transition at the center of the bit. It contains sufficient information to recover a clock. So if the data rate is twice, sufficient clock information can be recovered from the data stream so that separate clocks are not needed. Therefore, while transmitting the data, the number of wires is minimized, which is used to reduce the noise and transmission power. In Manchester encoding, the signal to be transmitted and done according (Figure 1) to the following rules,

- A ‘1’ is noted, when low to high transition occurs.
- A ‘0’ is noted, when high to low transition occurs.

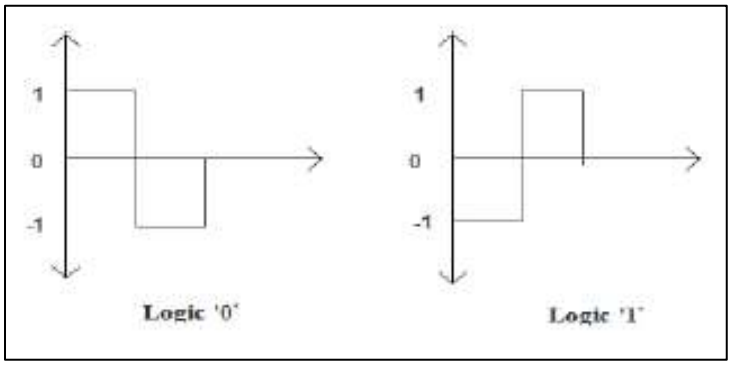

Fig. 1: Manchester Basic Functions

B. *Miller Encoding*

Miller encoding is also known as delay encoding. It can be used for higher operating frequency and is similar to Manchester encoding except that the transition occurs in the middle of an interval when the bit is 1. While using the Miller delay, noise interference can be reduced. In Manchester encoding, the signal to be transmitted and done according (Figure 7) to the following rules,

- Phase inversion occurs at data ‘1’ symbol.
- Phase changes when the logic ‘1’ data appears after the long continuous logic ‘0’ data.

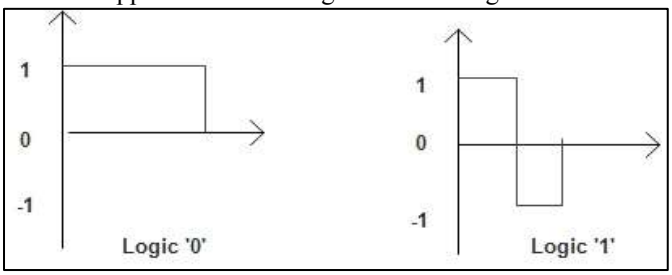

Fig. 2: Miller Basic Functions

III. PROPOSED SYSTEM

The proposed circuit is combination of Manchester and Miller encoder shown in Fig.3 which mainly consist of two types of flip-flop (D flip flop, T flip flop), two logic gates(Xor and not) and one multiplexer to combine above mentioned codes. The circuit takes the input signal as data (which is to be transmitted), clk and clk1and the output is taken at the output of multiplexer. The output of multiplexer is depends on select line, here call it as "mode". If mode = 0, the output will be Manchester code and if mode = 1, then the output will be miller code. Both the encoding scheme is available depending upon the application whether it is SISO or MIMO. In order to integrate two timing signals of clk and clk1 (double frequency of clk), an extra T-type flip-flop can be utilized to achieve the frequency division by 2.

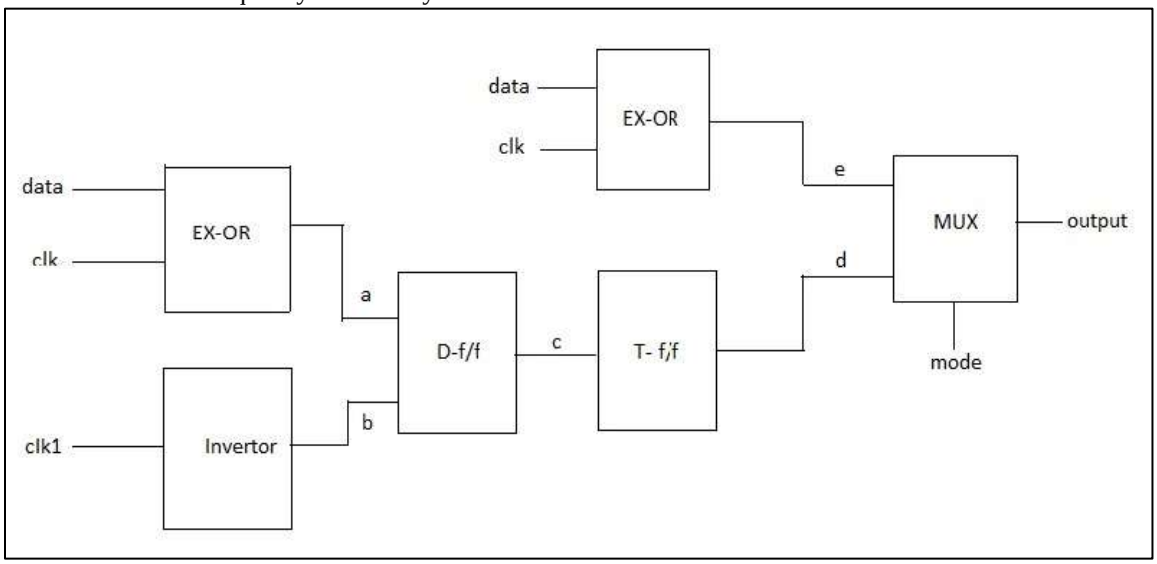

Fig. 3: Prototype Manchester and Miller encoder circuit structure

Miller encoder has a d flip flop, t flip flop, NOT gate, and XOR gate. Where the input is data and clk, then the output is a Miller output. For example, if the input is 0 and the clock, given the XOR operation has done that, therefore 0 plus a positive edge clock produces the output as 0. Given to d flip flop, the clock has inverted, and after that output is given to t flip flop it inputs as d flip flop output, which is 0. Then the TFF is toggle FF, which produces the Miller output as 1.

IV. RESULTS AND DISCUSSION

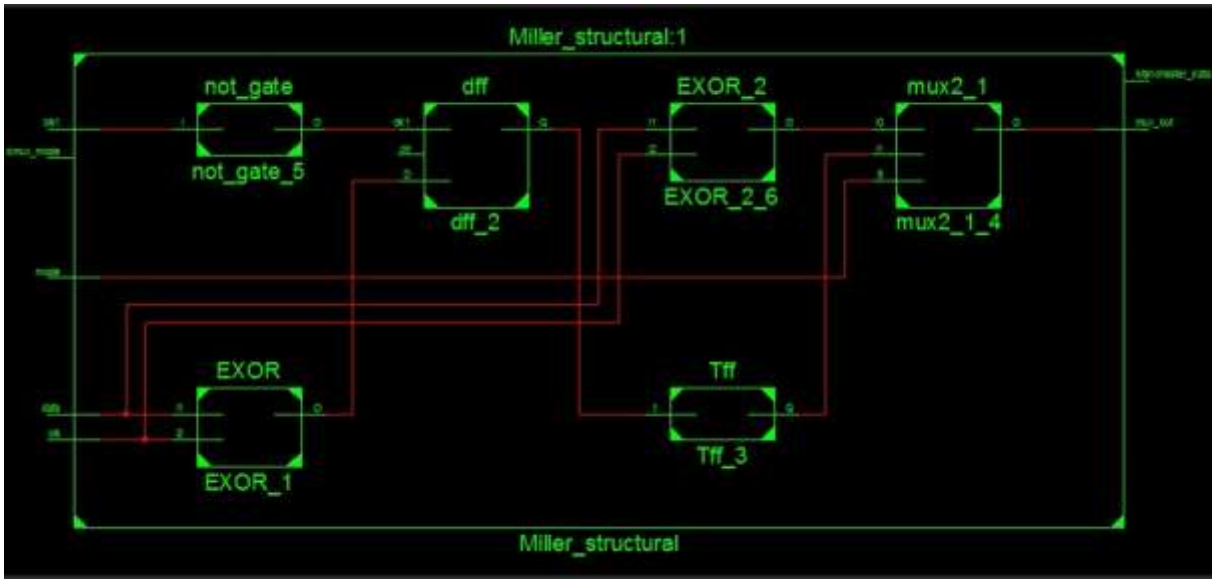

Fig. 4: RTL view of proposed Manchester and Miller encoder

Fig.4. is proposed for combined Manchester and Miller encoder. Here the output of the proposed system is depends on select line "mode".
Manchester code : Mode = 0,

Miller code : Mode = 1.

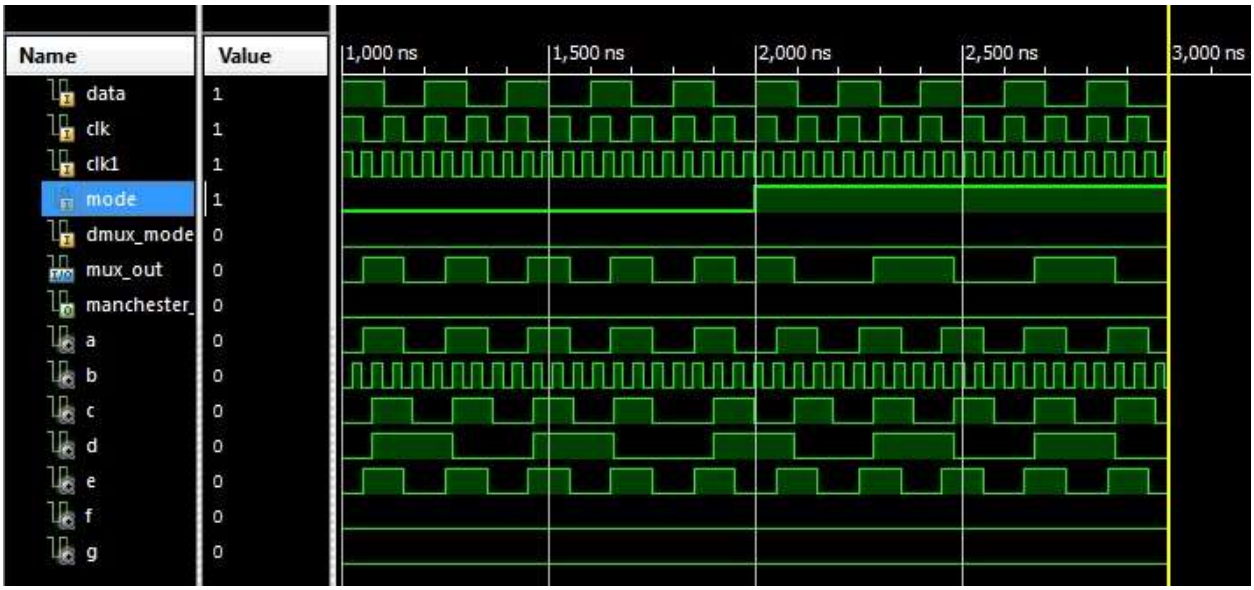

Fig. 5: Simulation result for proposed Manchester and Miller encoder.

The above mentioned codes are written in VHDL language and simulated on Xilinx ISE 13.1. The simulation result for proposed system is shown in Fig.5. The Manchester and Miller codes are written in Structural modeling style which gives the better device utilization compared to behavioral modeling style and FSM based.
The device utilization table for proposed one and previous one are shown below.

Table – 1
Device Utilization Summary

Parameter	*Previous Method*	*Proposed Method*
No of Slices	*7/2352*	*1/4656*
No of Slice Flipflop	*4/4704*	*1/9312*
No of 4 i/p LUT	*14/4704*	*4/9312*
No of Bonded IOBs	*6/144*	*5/232*
No of GClks	*1/4*	*1/24*

V. CONCLUSIONS

In this paper, miller encoding is integrated with Manchester encoding for outdoor MIMO VLC application. The entire design is done using VHDL in Xilinx ISE software. The proposed paper's result is compared with previous FSM based miller encoder. The result outperforms FSM based miller encoder in terms of physical space. Also the integrated Manchester and miller encoder offers the flexibility to select the appropriate encoding scheme depending on whether application is indoor or outdoor.

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