Integrated Miller – Manchester Encoder and Decoder for Outdoor MIMO VLC Application

R. M. Gharat
Department of Electronics Engineering
Government College of Engineering, Amravati India

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 designed the combined Manchester- Miller encoder and decoder in VHDL code. The behavior of Manchester- Miller encoder and decoder is realized by using structural modeling style 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.

Key words: LED, VLC, Manchester Coding, Miller Coding

I. INTRODUCTION

The demand for wireless access is rapidly growing which resulted in heavily congested spectrum which reduces spectrum efficiency and making quality of service provided to the user is poor. The available radio-frequency (RF) bandwidth will not be sufficient to meet the increasing demand for wireless access. In order to share the load over RF, the alternative method is Visible light communication (VLC). 70% of the communication is indoors, and light emitting diode (LED) arrays are used for illumination purposes because of their low energy, higher lifetime and high efficiency. 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. VLC with Manchester and Miller encoding scheme have more flexibility and integrity than other communication systems. 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. The paper aims to develop miller coding for outdoor VLC application using Xilinx ISE 13.1 software 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.

A. 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.

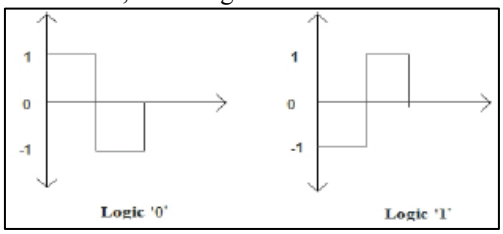

Fig. 1: Manchester Basic Functions

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.

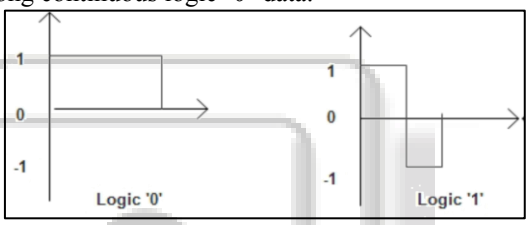

Fig. 2: Miller Basic Functions

III. PROPOSED SYSTEM

The structural modeling style is similar to schematic entry. The structural modeling style uses the modular design i.e while designing a complex project, the whole project should be split in two or more simple design or modules or components in order to easy handle the complexity. This approach allows a design reuse without the need to reinvent and re-test the design every time. Structural Modeling Style shows the Graphical Representation of components with their Interconnection. It defines that how each of these components are coded separately and are connected to each other using wires.

The proposed circuit is combination of Manchester and Miller encoder shown in Fig.3 which mainly consist of transmitter made up 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. The receiver made up of demultiplexer to separate out Manchester and Miller signal. The demux_mode is used to pass the Manchester code (when demux_mode =0) and Miller code (when demux_mode =1). Miller data gets when the demultiplexed Miller signal is explored with the delayed demultiplexed Miller signal. Both the encoding scheme is available depending upon the application whether it is indoor or outdoor. 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.

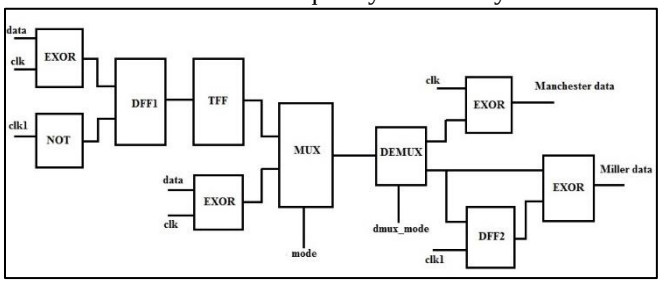

Fig. 3: Prototype for Integrated Manchester- Miller encoder and decoder circuit structure

IV. RESULTS AND DISCUSSION

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.

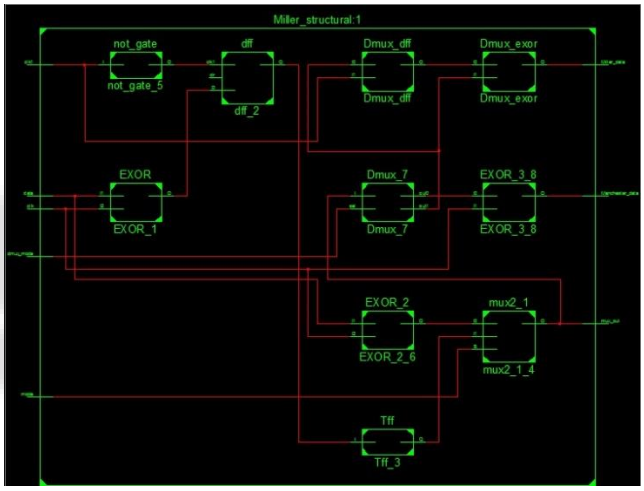

Fig. 4: RTL view of proposed Manchester and Miller encoder

A. Manchester Code

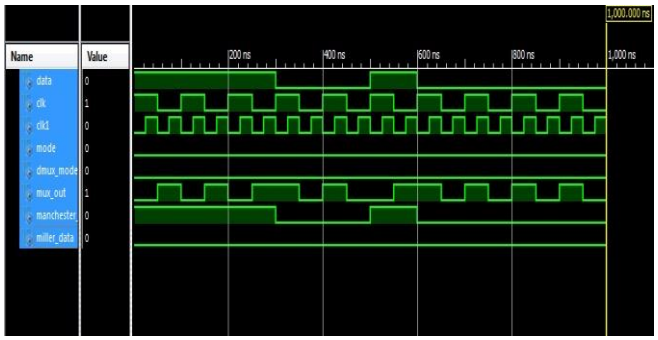

Fig. 5: Manchester code

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.

Miller code

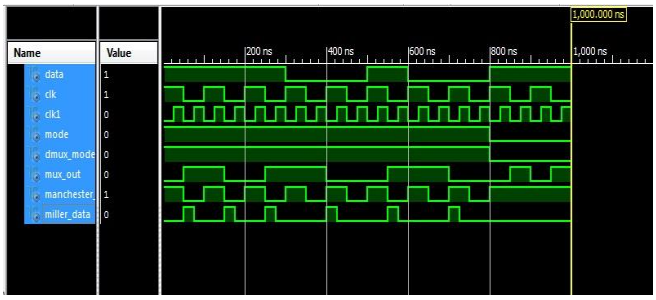

Fig. 6: Simulation result for proposed a) Manchester and b) Miller encoder.

The device utilization summary and timing summary for proposed one and previous FSM based method are shown below.

Parameter	FSM based Method (for encoder only)	Proposed Method
No of Slices	7/2352	3/4656
No of Slice Flipflop	4/4704	5/9312
No of 4 i/p LUT	14/4704	6/9312
No of Bonded IOBs	6/144	8/232
No of GClks	1/4	2/24

Table 1: Device Utilization Summary

Parameter	FSM based Method (for encoder only)	Proposed Method
Maximum frequency	188.644MHz	391.389 MHz
Min i/p arrival time before clk	4.380ns	2.936 ns
Max o/p required time after clk	12.305ns	5.694 ns
Max combinational path delay	12.137ns	6.335 ns

Table 2: Timing Summary

V. CONCLUSIONS

In this paper, miller encoding is integrated with Manchester encoding for outdoor MIMO VLC application and successfully decoded too. The entire design is done in VHDL language using structural modeling style in Xilinx ISE 13.1 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 and timing parameters. 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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