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DESIGN OF A MANCHESTER ENCODER FOR MIL-STD-1553 APPLICATIONS

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Abstract: MIL-STD-1553 is a data bus protocol mainly used in the avionic systems like spacecrafts, helicopters, missiles, fighter planes etc. for data transfer. It is a bidirectional, time division multiplexed and serial data bus. The bit coding scheme used in the data bus standard is Manchester Encoding. In this paper, the design of a Manchester encoder for MIL-STD-1553 data bus using Verilog HDL is proposed which is designed for the coding the data words of the bus protocol.

Key Words: MIL-STD-1553, Manchester Encoding, logical transitions, Verilog HDL.

I. INTRODUCTION

In the 1950s and 1960s, avionics systems were analogue, simple, stand-alone systems made up of various subsystems connected using point to point wiring. The wiring used increased the complexity of the system design increasing the overall weight of the aircraft systems. Hence there was a need to eliminate the same. With the inception of the digital technology in 1970s, the concept of digitalization was also introduced in the avionics systems. Transfer of digital data could be done bidirectionally and serially reducing the number of interconnections became the major advantage of the digitalization. But there also was a necessity of a data transmission medium which would allow the subsystems to share a single set of wires for the data transfer. Hence, the concept of data bus was introduced and MIL-STD-1553 (Military Standard 1553) is one such data bus standard used in avionics systems till date due to its high reliability. The first draft of serial MIL-STD-1553 data bus was released in 1970 by a subcommittee A2-K of Society of Automotive Engineers (SAF) and was first published as a U.S Airforce Standard in 1973. The primary user of this standard is F-16 Falcon Fighter aircraft.

The important characteristics of MIL-STD-1553 bus standard that supports its usage in avionics include: the use of twisted shielded pair wire which provides noise cancelling; eliminates point to point wiring there by reducing the overall size of the space craft. The bus protocol uses the Manchester encoding to transfer data through the bus though the coding scheme requires more bandwidth (more bits than the original data bits is required) is because it can synchronize itself which minimizes the error rate. Manchester encoder being an inescapable part of the bus standard also plays a very important role in avionics industry.

II. OVERVIEW OF MIL-STD-1553 BUS

A. ARCHITECTURE OF MIL-STD-1553

The physical medium of the data bus consists of four hardware elements: a pair of twisted shielded wire providing the medium for the data exchange/transfer on the data bus; a bus controller which acts as a master controlling the entire operation/protocol of the data bus; a bus monitor which monitors the data exchange taking place on the data bus and 31 remote terminals acting as interfaces between the bus and the subsystems (sender or user of the data exchanged). Figure 1 depicts a simple architecture of the bus system.

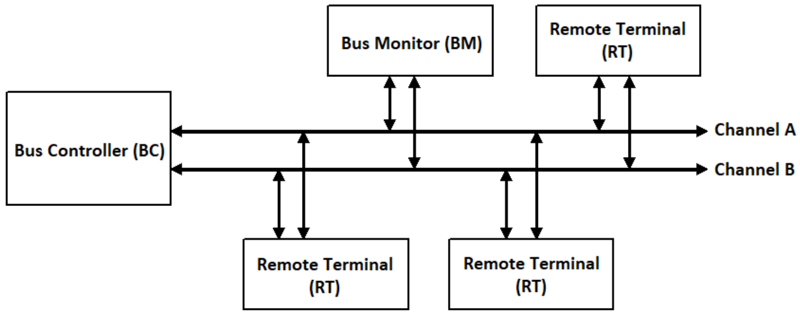

Fig 1: Architecture of MIL-STD-1553 Bus

Figure 2 shows the block diagram of the 1553 bus system which consists of a bus controller (BC) protocol controller, remote terminal (RT) protocol controller and Manchester encoder and decoder which is common to both the protocol controllers because the data transfer takes place in a Manchester coded format.

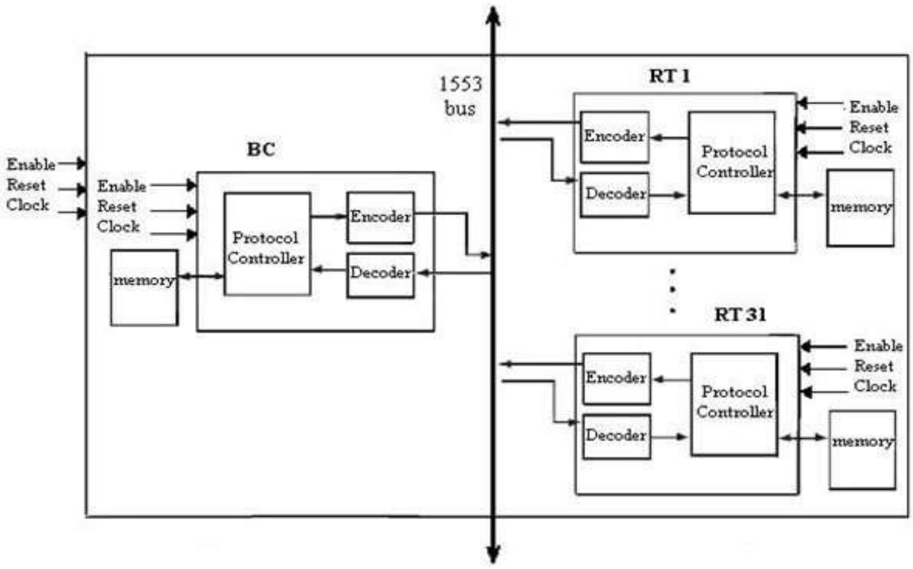

Fig 2: Block Diagram of MIL-STD-1553 Bus

B. FORMAT of WORDS

The data bus protocol provides three types of word format namely: Command Word (CW), Data Word (DW) and Status Word (SW). Command word and Status word are called the control words because they control the entire operation of transmission and reception on the data bus; Command word always being generated by the bus controller specifies the function of the remote terminal as to whether the remote terminal should transfer the information to the bus controller or receive the information from the bus controller; Status word specifies the status or health of the remote terminal acknowledging the data transfer. Data word consists of the actual information that needs to be transferred. Figure 3 describes the three types of word format.

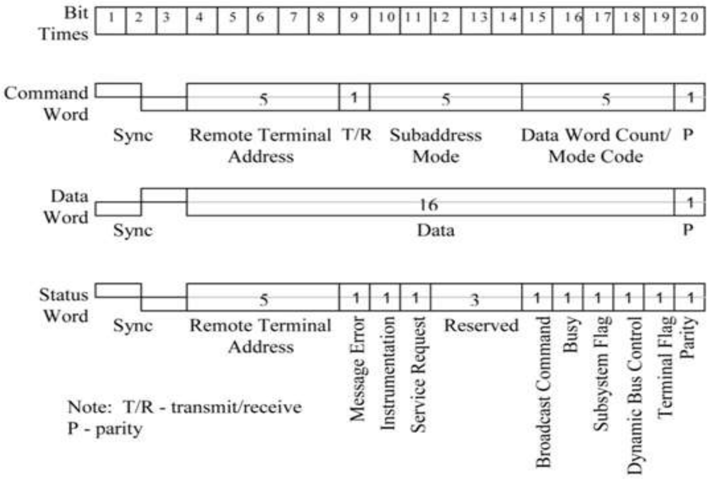

Fig 3: Word Formats

Each word is a 20-bit word. The first 3-bits are used as sync bits, next 16 bits are used as data bits and last bit is the parity bit. The sync bits help in differentiating the control words from data words and also indicates the start of a new word. There are two types of synchronization fields namely command/status sync and data sync. The command/status sync has a high voltage for first one and a half bit times and low voltage for the next one and a half bit times. The data sync is inverse of the command/status sync. Figures 4 describes the conventional sync fields and 5 describes the practical sync fields used in the design of the Manchester Encoder.

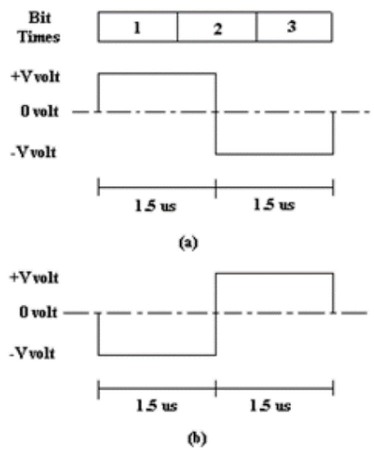

Fig 4: (a)Sync Bits of Control Words (b) Sync Bits of Data Word

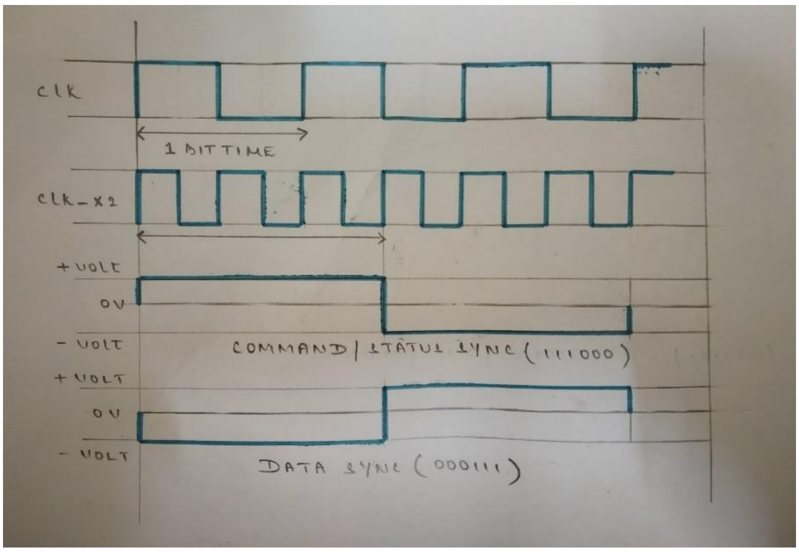

Fig 5: Practical Coding of the Sync Bits

C. PRINCIPLE OF MANCHESTER CODING

There are two conventions for representing data in a Manchester coded form. The first convention given by G.E. Thomas specifies that '0' is represented as a low to high logical transition and '1' is represented as a high to low transition. The second convention followed by IEEE 802.3 states that '0' is represented as a high to low logical transition and '1' is represented as a low to high transition. In the present design, convention given by Thomas is considered. Figure 6 shows the Manchester coding scheme.

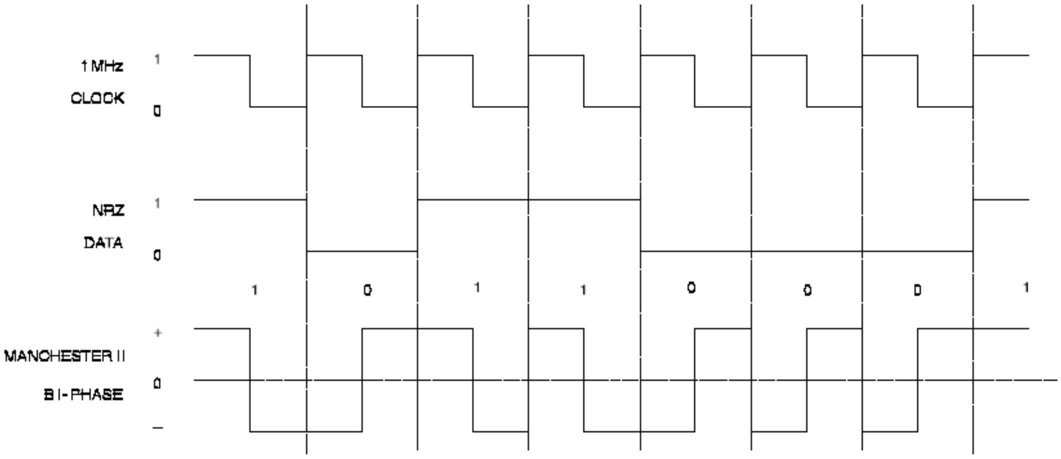

Fig 6: Principle of Manchester Coding

III. DESIGN OF A MANCHESTER ENCODER

The encoder requires a single clock with a frequency (2 MHz) of twice the desired data rate (1 Mbps). The input signals to the encoder are **enc_clk, rst_n, tx_dword (**Input Data Word (16 bits)**), tx_csw** and **tx_dw.** The output signals from the encoder are **tx_data, tx_dval** and **tx_busy.** The encoder cycle begins with either **tx_csw** or **tx_dw** pulse along with the command-status or data word to be transmitted. Then the encoder asserts **tx_busy** until it transmits this word serially through all the encoder functions and then de-asserts **tx_busy** to accept the next word. Figure 7 shows the block diagram of the Manchester encoder and Table 1 represents the signal description of the Manchester encoder.

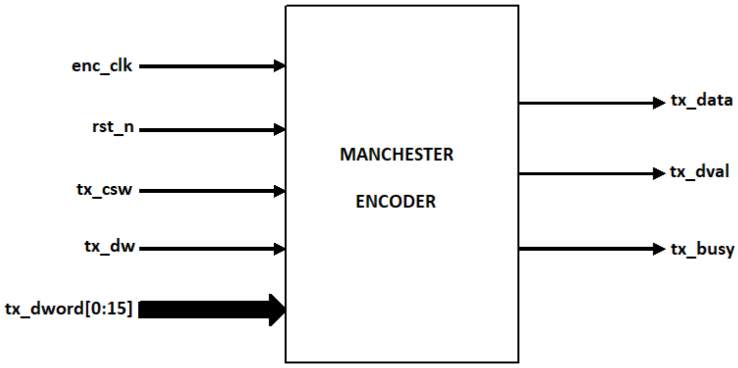

Fig 7: Block Diagram of Manchester Encoder

SIGNAL NAME	ACTIVE STATE	I/O	SIGNAL DESCRIPTION
enc_clk	-	In	Encoder clock of 2MHz
rst_n	Low	In	Asynchronous Reset
tx_dword [15:0]	-	In	Data word from user for transmission
tx_csw	High	In	Indicates tx_dword has command or status word
tx_dw	High	In	Indicates tx_dword has data word
tx_data	-	Out	Serial Data Output
tx_dval	High	Out	Data valid indication for tx_data
tx_busy	High	Out	Indicates encoder is not ready to accept next word

Table 1: Signal Description of Manchester Encoder

IV. RESULTS:

The proposed Verilog design for Manchester encoder has been simulated using EDA Playground. The simulation outputs are shown for the data "5555" and "1347" in figures 9 and 10 respectively. The simulation output for the entire Manchester encoder is shown figure 8.

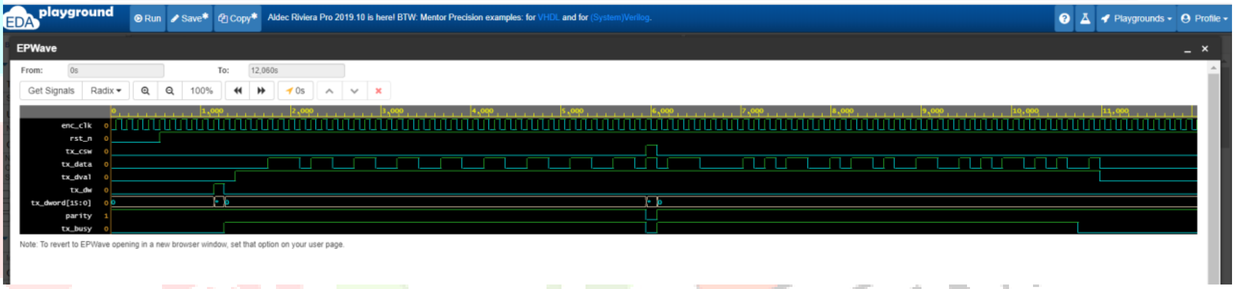

Fig 8: Simulation output of Manchester Encoder

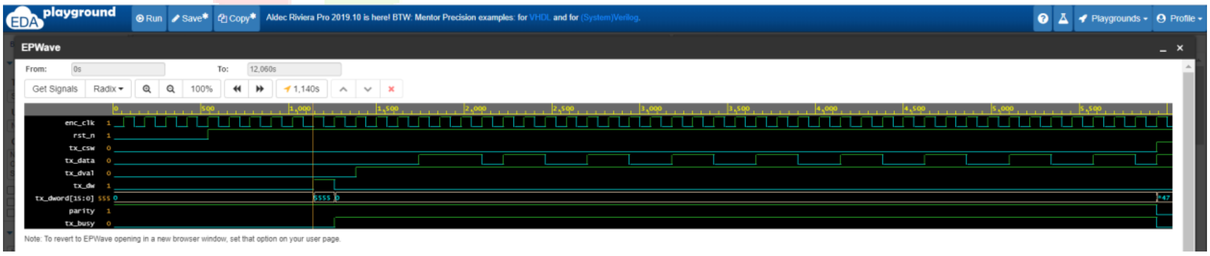

Fig 9: Simulation output of Manchester Encoder for "5555"

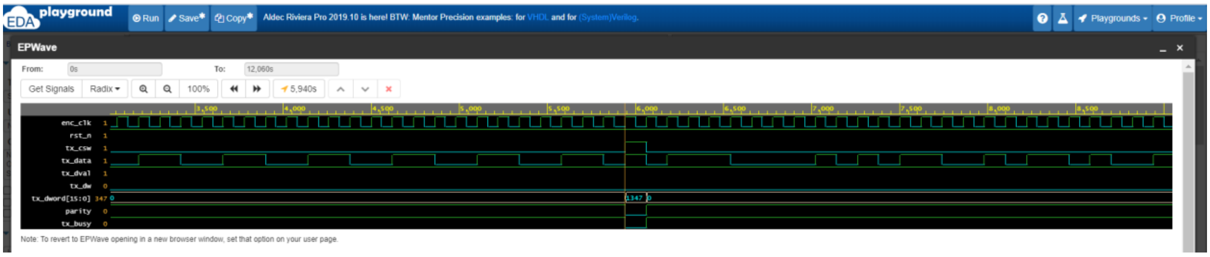

Fig 10: Simulation output of Manchester Encoder for "1347"

V. CONCLUSION

The design of the Manchester encoder for the data bus MIL-STD-1553 proposed in the paper holds an inevitable place in the avionics industry due to its decreased error rate and high reliability.

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