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EMPOWERING COMMUNICATION : FPGA – based Morse Code system for differently - abled individuals

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***Abstract*— Patients with neuromuscular diseases like Amyotrophic Lateral Sclerosis (ALS), Multiple Sclerosis, or Muscular Dystrophy usually experience severe communication difficulties. This paper introduces an FPGA-based Morse code communication system that can be used to support differently-abled people. The system uses a switch input for Morse code input, which is decoded by an FPGA-based decoder and displayed on a seven-segment display. The system is developed in Verilog HDL on the Xilinx Vivado tool and runs on a Boolean board. Results show the utility of the presented system in creating an accessible, portable, and efficient communication alternative for people with disabilities.**

Keywords—Field Programmable Gate Array (FPGA), Morse Code, Verilog HDL , Xilinx Vivado, Seven-segment display

I. INTRODUCTION

Depending on the causes of their combined visual and hearing impairment, their education, and upbringing, a large number of people with deaf-blindness express themselves in a variety of ways. Differently-abled individuals express themselves in a variety of ways. Generally, the below mentioned methods are largely utilized.

- Modified signs
- Signed languages
- Tactile Sign language
- Tracing things, etc.

Dashes, dots, and spaces replace alphabetic characters, numbers, and punctuation marks in Morse code. Electrical pulses of different durations, or mechanical or visual signals, like flashing lights, can be transmitted based on the code. The aim of this project is to make the morse decoder as portable as possible by taking into account the fact that an individual with vision impairment will need encoders while communicating. Deaf or blind individuals tend to communicate solely in braille, so that there are lesser chances that their conversation partner will understand them. In such cases, a portable morse encoder may be greatly beneficial. Due to Boolean board's strong performance, the morse inputs can be assembled, deciphered, and displayed at a best-fit speed in the seven segment display, thus enabling effective communication.

This paper has numerous characteristics for visually and speech impaired individuals such as easily communicable and comprehensible to normal individuals and caretakers. Further they are also lightweight, trustworthy and can be carried to any location at any time

II. METHODS AND MATERIALS

A. *Proposed Method*

A simple-to-identify and simple-to-operate switch is provided for the challenged individual. The method suggested is depicted in Figure 1. From the proposed system diagram, it is evident that the switch input is used. On activation of the Morse sequence buttons, the user inputs to the system (challenged individual). Switch inputs and a clock signal offer DOT, DASH signals to the Boolean board. Morse code can be constructed and conveyed from this information. The message constructed is decoded afterwards using Vivado and the Verilog Morse decoder tool. Next, a Morse decoder is utilized, which converts state codes into hexadecimal values that appear on a seven-segment display. The program flow of the Morse Code Communicator using a Boolean board is illustrated in a flow chart (Fig 2.1).

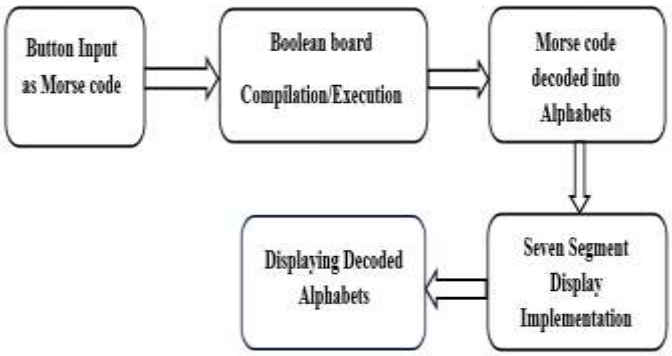


Fig.2.1 Proposed Method

B. *Morse Code*

Rather than alphabetic letters, numbers and punctuation marks, dots, dashes, and spaces are employed in Morse Code. Depending upon the code, electrical pulses of varying length or mechanical or visual signals, e.g., flashing lights, can be sent.

Table 2.1 Morse code representation of Numbers

NUMBERS	SYMBOLS
0	-----
1	.----
2	..---
3	...--
4	....-
5	.....
6	-....
7	--...
8	---..
9	----.

Table 2.2 Morse code representation of Alphabets

ALPHABETS	SYMBOLS	ALPHABETS	SYMBOLS
A	.-	N	-.
B	-...	O	---
C	-.-.	P	.--.
D	-..	Q	--.-
E	.	R	.-.
F	..-.	S	...
G	--.	T	-
H	....	U	..-
I	..	V	...-
J	.---	W	.--
K	-.-	X	-..-
L	.-..	Y	-.--
M	--	Z	--..

C. *Components*

The Boolean board of Figure 3 facilitates it to be an easy to embed hardware design. It supports many I/O ports, switches, LEDs, and seven-segment displays, which distinguish it from other boards. To embed the hardware design, Xilinx employs either HDL to construct the software. Boolean board enables the designer to easily design their hardware module. Short circuits, open circuits, and incorrect wire connections are all options in hardware design. Consequently, we can fail to get the expected outcome and can even fail to determine where the problem is. Still, with Xilinx Boolean board, errors are immediately observed and information can be processed faster. The output is displayed with a seven-segment display and, and input is accomplished through buttons. Code dumps are available via I/O ports. Due to the above-mentioned features, Boolean board is our project's choice. Everything can be packed into one component so that deaf or vision-impaired individuals as well as their caretakers may better understand. It's easy to carry with you,and it's not hard to keep up with what they're trying to say.

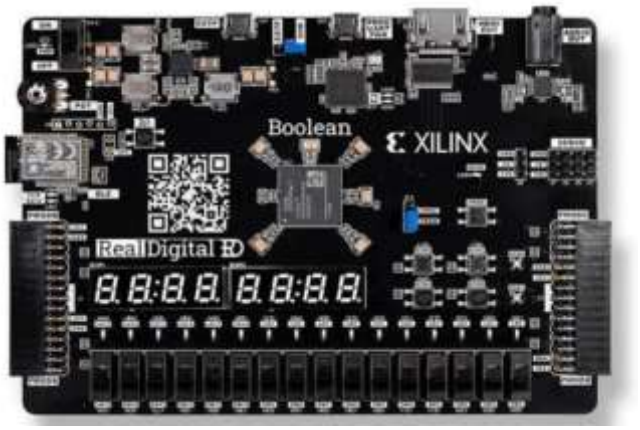


Fig. 2.2. Boolean board

The Boolean board that are being illustrated in Fig. 2.2, consist of seven segment display. The segments are capable of getting arranged to shape a rectangular form. With four seven segment screens we can show integers and alphabets with a decimal point.

It will be useful to both speech and vision impaired individuals as well as their caregivers. In order to show the alphabet one at a time, we only used one seven-segment display. Certain characters, like the letters m, k, and g, are not possible to display. Items like tea, ice, and oats, however, can be displayed very easily.

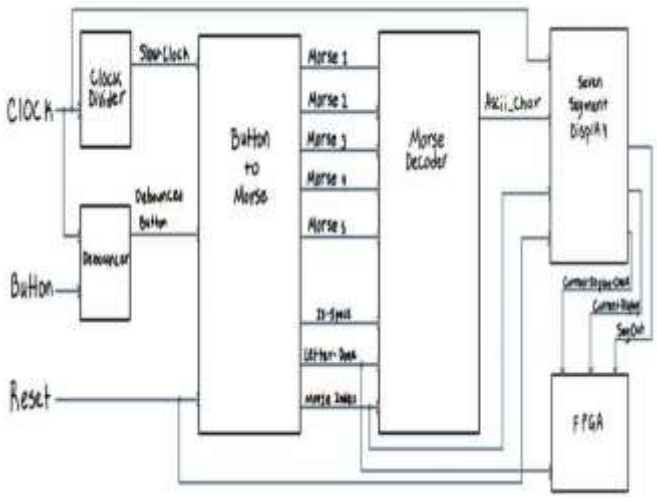


Fig. 2.3. Block Diagram

D. Proposed Algorithm

The flow chart above illustrates program flow of Morse Code Communicator embedded on Boolean board Short presses which equal to 1 clock cycle, represent dots, while longer presses which equal to 3 clock cycles represent dashes.

1. Button Press:

oWhile the button is pressed:
▪ The counter increments.
▪ The inactivity_counter resets.
o When the button is released (button transitions from high to low):
▪ If the press duration (counter) is:
▪ Short: Register as a dot (2'b01).
▪ Long: Register as a dash (2'b10).
▪ The Morse symbol is stored in the current morse_index position, which then
increments.

2. Button Inactivity:

o If the button remains unpressed for a sufficient time (inactivity_counter >= three_time_units):
▪ The current Morse sequence (up to 5 symbols) is finalized and transferred to
the morse_one to morse_five outputs.
▪ The letter_done signal is asserted to indicate the letter is complete.
▪ The morse_index resets for the next letter.

3. Reset:

o All signals, counters, and registers are cleared when reset is asserted.

E. Code Analysis

a) Clock Divider:

The given Verilog code implements a clock divider module, which takes a high-frequency input clock (100 MHz) and produces a lower-frequency output clock based on selectable frequency options. Here's a breakdown:

1. clock: The 100 MHz input clock signal.

2. one_sec_unit: Signal to select a 2 Hz output clock (1-second period).

3. half_sec_unit: Signal to select a 4 Hz output clock (0.5-second period).

4. quarter_sec_unit: Signal to select an 8 Hz output clock (0.25-second period).

b) Debouncer:

The Debouncer module cleans up any noise from the button input to ensure stable signals are sent to the next stage.

1.Button to Morse:

The button_to_morse module converts the button press durations into Morse code symbols. Short presses which equal to 1 clock cycle, represent dots, while longer presses which equal to 3 clock cycles represent dashes. This module also detects when a letter is completed (letter_done). The morse_index signal tracks the position of each Morse code symbol within a letter. You can also reset the display using the reset button.

2.Morse Decoder:

The morse_decoder takes the Morse code symbols (morse_one to morse_five) and converts them into their corresponding ASCII character. It uses a binary tree traversal logic to match the sequence of dots and dashes to letters, numbers, or special characters. When a valid character is decoded, it is sent to the next stage.

3.7 Segment Display:

The seven_seg_disp module takes the ASCII character output from the decoder and translates it into a pattern for a seven-segment display. It cycles through multiple displays to show characters sequentially, supporting up to eight characters at a time. The module shifts the active display with each new character or reset signal

III. RESULTS AND DISCUSSION

A. Vivado Schematic Diagram

Due to successful compilation of HDL codes, schematic diagram in Fig.3.1. was created by the vivado simulation tool. Synthesis, implementation, and bitstream were created successfully. To program the Boolean board, first, the bitstream is generated and then hooked up with the system. The hexadecimal output is sent to the seven-segment display.

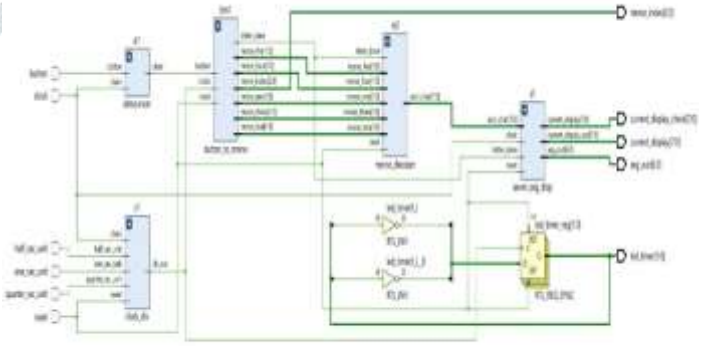


Fig. 3.1. Vivado Schematic diagram

B. Morse Code As An Effective Communication Medium

Individuals with impairments and those whose communications skills have been damaged due to strokes,

heart attacks, or paralysis have employed Morse Code as an alternative means of communication. Eyelids of some individuals have been used to create dots and dashes in Morse Code through a sequence of long and rapid blinks.

Morse code is one of the most critical forms of radiocommunication in aviation, with individual codes for every aircraft and every base. Morse Code is widely used for more important and more humane purposes than a communication tool for the deaf and blind . Morse Code is a viable alternative for most communication devices for the disabled due to its seamless operation and simple syntax. Project hardware can be easily transferred and modified. After we program it, we can employ it and produce as much output as desired until it terminates. The chief drawback is in Boolean board , some letters like k, q, l and m are unable to display in seven segment display.

C. Sample Output Letters

If the visually and speech impaired individual desires ”EAT”, he tells the caretaker via the Boolean board Morse code communicator. The visually and speech impaired individual performs the following steps to type “EAT”. First, he/she inputs the Morse code for “e” which is a Single dash (“.”). Then he/she inputs the Morse code for “A” is a Single dot (“.”). Lastly, he/she inputs the Morse code for “t” that is dash (“-“).The caretaker now knows that the person desires to EAT

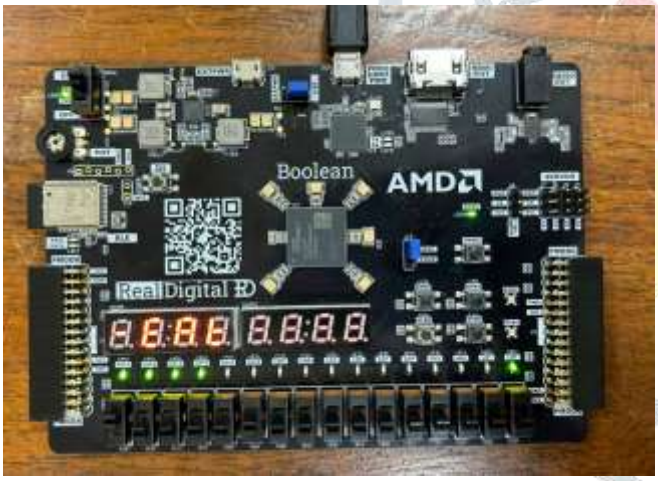


Fig.3.2 Sample Output

D. Project Discussion

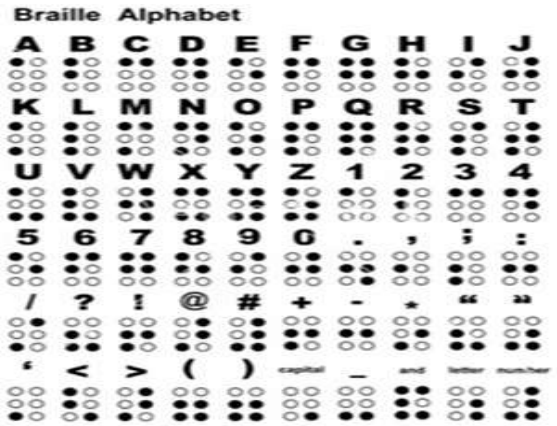
This paper has been prepared keeping in mind the contribution to be done back to the society as an electronics engineer. Therefore, under the VLSI category, while keeping in view the boards, traditional and efficient boards such as Arduino,Basys-3,PYNQ board were all taken into account because of their efficiency and perfect structure for our decoder project. But finally Boolean board was determined to be the ideal board for our project. Boolean board was chosen over the cheaper and very efficient Arduino board because Arduino is more code-oriented microprocessor domain related implementing protocol board which has more focus towards IT subjects like Internet of Things and also tending more towards micro controller domain. Even during examining the code, Arduino codes were more IT oriented than a Basys3/Boolean board. Hence keeping these points on mind, Boolean board was chosen as the primary board for the implementation of our project despite the fact that Arduino has more advantages. We wanted the project to be purely electronics based and delivering a pathway of opportunity as a steppingstone for advancements in this portable communication domain and hence decided to take up the challenge of coding and implementing entirely through Boolean board.

We took the decision of utilizing the inbuilt seven segment display of the Boolean board which is built into the board and therefore can save plenty of time during execution and can be very effective in translating the morse inputs and displaying it as a binary alphabet output .The built-in seven segment display will be utilized to show the binary output which may save time and confusion for the challenged individual and the individual they attempt to communicate with. Here efficiency of the model and the challenged individual’s need for quick and instant communication is given higher importance over the opposite individual’s ease of reading. Braille is touch-based system since we discussed previously.

Not everybody visually people's fingers are sensitive enough to track the matrix patterns to recognize a long word or a sentence. With the eruption of World War 1 and World War 2, lots of people especially soldiers lost not only eyesight but also for the most part because of their greeting of grenades and landmines. Individuals used to lose limbs, vision and get affected due to hearing imparities. So, examining the challenging character of the Braille system, it can be assumed that visually impaired individuals may not be comfortable learning completely with the Braille system.

E. The Need For Alternatives To Braille System

Braille system is among the most popular and employed system in the world by people who are blind to learn and comprehend alphabets through the strong sense of touch. Braille has been used extensively since it was discovered in the almost 1820s. Although Braille could be imagined to the visually impaired individuals, it also possessed some of its own drawbacks. Braille Alphabet Chart Braille alphabet (Figure. 9)chart illustrates how each alphabet/number can be represented by a 3x2 matrix where 64 combinations are possible using any of the 6 dot spaces available.



. Fig.3.3. Braille Alphabet

IV. CONCLUSION

As a result, we were successful in designing and implementing an FPGA-based Morse code communicator for blind or deaf individuals. We chose to utilize the integrated seven-segment display and Boolean board over a more standard and efficient Arduino board. HDL code is loaded onto the Boolean board by utilizing Vivado

software.For the purposes of this project, the outcome of this project is that the Boolean board reads the button inputs, processes and stores them in hexadecimal arrays, and then encodes them into binary inputs that are displayed on the seven-segment display.The primary objective of our project was to show the positive contribution an electronic model communicator can have on society. Due to being a universal language with a common morse table, there are numerous communication models that have already been created for disabled people.These days, individuals are travelling extensively and exchanging with new and familiar people wherever they go.

Morse code has proven to be a good communication tool for individuals who find reading or speaking difficult. It can also be employed to communicate with individuals who cannot speak, write or type because medical problems. The system described in this research facilitates communication. Since every character can be translated into a pre-specified series of dots and dashes, Morse code has been shown to be the most efficient way to convey alphanumeric data to a third party. The output message of the simulation is shown on a seven-segment display.

The simulation was coded using the Boolean board kit. It is an easy and versatile method to transmit text messages via wireless media .In this method, the individuals who find it

hard to communicate simply has to enter the dots or dashes, and the decoding program on Boolean board will show verbal output on a seven-segment display once it is executed. When every character is mapped, Morse code has been demonstrated to be the most effective technique of communicating with a third person. As a result, the Boolean board kit was used to create a very effective and portable morse code decoder.

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