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Braill-e-Book: An Innovative Idea for an Economical, User-Friendly and Portable eBook Reader for the Visually Impaired

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Abstract- This paper aims at presenting the prototype for Braill-e-Book, a portable and user-friendly device that converts the large ocean of e-knowledge into the Braille format for the blind to access easily. The Braill-e-Book makes use of USB flash drives that contain several books in text format. It has a speech recognition system using which the user can search for the file name or its author, which when selected will be displayed on a refreshable display. Furthermore, the Braill-e-Book is equipped with the audio notifications to enable the user to navigate through the entire process easily. It is an innovative upgrade to the presently available electronic Braille display devices which are either not portable or have a PC dependency.

***Index Terms*-** Braille literacy, Braille eBook reader, speech recognition, text to Braille conversion, USB flash drive

I. Introduction

The visually impaired, who make up a large section of the population [1], face many problems when it comes to accessing one of the most widespread means of knowledge - books. There are a very few books that exist in the Braille format for the visually impaired to read. And with one page in a normal book taking up to three pages in a Braille book [2], they are very large and heavy. If this medium of access to knowledge and entertainment could be made less cumbersome, cheaper and simpler, a large section of the blind population would have an easier access to education, thus increasing their currently poor literacy rate [3]. The best way to tackle this would be to take the help of technology [4].

Owing to this, several companies came up with the solution of audio books, text-to-speech converters, Braille displays and printers [5]. There are a very few audio books available in the market, and though text-to-speech converters can solve this problem, by converting any book into an audio format, the resulting audio can be extremely monotonous and devoid of expressions. The Braille displays are very expensive (a few thousand USD) [6] and have a PC dependency. 'TactoBook' [7] is one such example of a portable Braille eBook reader, however it requires a software on the PC to convert normal books into a Braille format. Braille printers also cannot work without a PC and as the paper used for printing is similar to that used in normal Braille books, these printed books are not at all portable. This problem, thus, sparked the idea of creating a stand-alone, portable, cheaper and lighter device that will be more accessible by the visually impaired, acting as a medium of education and entertainment for them.

Braill-e-Book aims at overcoming the drawbacks of the existing solutions by integrating the Braille conversion, the file selection process and the display unit together. Thus, it enables the user to read any book or even some notes in the pen drive which are in the text format on the tactile Braille display, by just speaking its name, or that of its author. This will open the gates for the visually impaired to an immense wealth of e-knowledge.

II. Module Definition and Operation

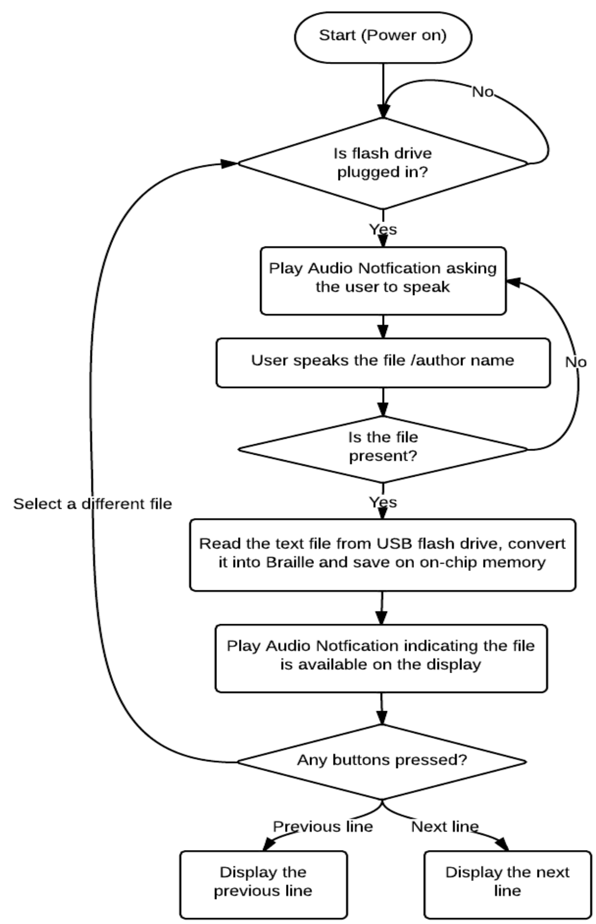

Figure 1: Flowchart of working of device

The Braill-e-Book comprises of different modules, which deal with the functioning of its different features. The device has a

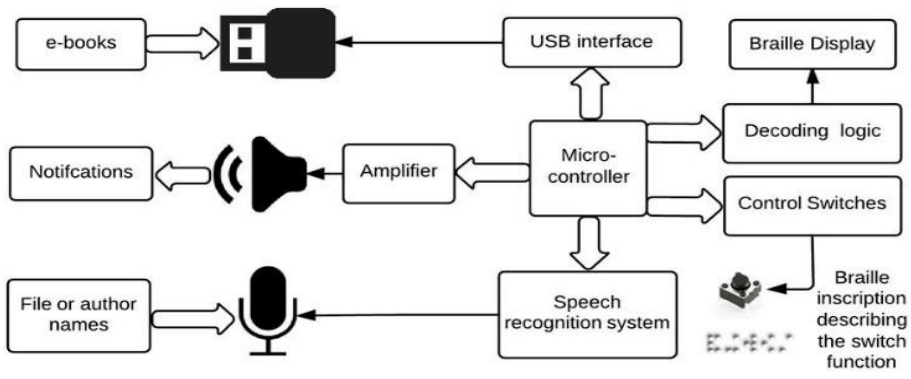

Figure 2: Block diagram of different modules on the device

USB host port, which enables the user to insert a USB flash drive containing eBook files. Once detected, the device plays an audio notification and then, the user can speak the name of either the file or the author. The speech input, when recognized, is used to search for the file in the pen drive. If a file is found, which has the same name as what the user spoke, it is said to be 'match' and the device plays another tone indicating that the file has been found successfully and the display is now active for the user to access. This file is also saved onto the device memory, so that it can be read even with the pen drive removed. If though, the speech input does not match any file present in the pen drive, a notification will be played indicating that the user should repeat the query, or that the file is not available in the memory. The user is also provided with three buttons having a text inscribed in Braille near them to indicate their functionality: one for choosing another file to read, one for reading the previous line and another for reading the next line. If the visually impaired user wishes to read another file, it can be done so at any point of time by using the button provided and repeating the entire process again. Figure 1 shows the basic flow of the device operation. The different modules are illustrated in Figure 2.

III. Hardware Design and Demonstration

A. Control

A prototype of the system was made on a smaller scale [8]. This prototype was based on the Texas Instruments Ultra Low Power MSP430F5659 microcontroller [9] which was programmed using the Code Composer Studio software by TI. The same microcontroller can be used further during the actual implementation of the system.

B. Braille Display

A dynamic Braille display can be implemented using shape memory alloy (SMA) actuator coils [10] that moves the pins up or down depending on the input signal. Each Braille character comprises of 6 dots, and for driving each dot, one actuator is required. Hence for a 10-character display, 60 actuators are required. Thus, this means that 60 pins of the controller would be utilized for displaying the ten characters.

However, a decoding logic has been designed, as shown in Figure 3, which reduces the number of pins from 60 to just 10, thereby drastically reducing the required data lines from the controller. As each character is of 6 dots, 6 data lines are used for carrying the data required to display each character and the remaining 4 lines are used for selecting a particular character out of the 10 characters on the display.

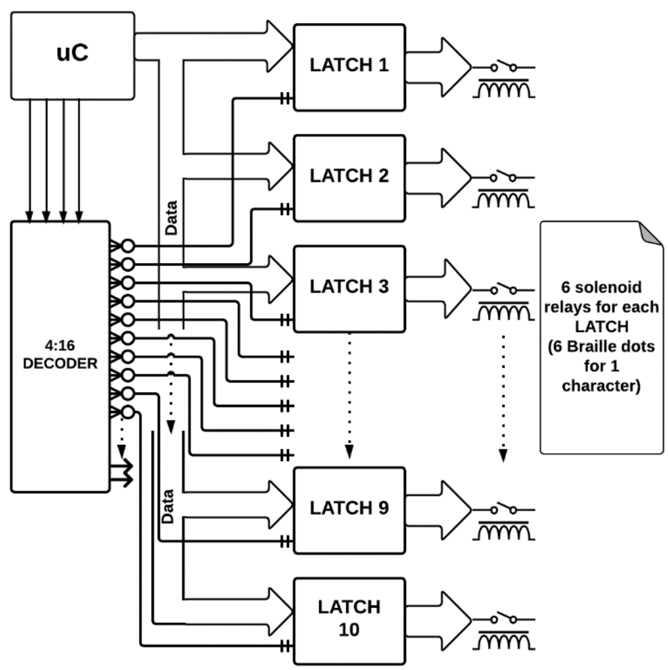

Figure 3: Decoding logic for the refreshable display

While testing the display logic prototype, a five character LED Matrix was used. The decoding logic comprised of CMOS to TTL logic level converter ICs HCF4050, a 3:8 Decoder IC 74138 to select the character, latch ICs 74LS573 to hold the character values and buffer ICs 74LS245 to drive the LED display (see Appendix).

For the actual implementation, the LED matrix will have to be replaced by the SMA coil actuators. Also, the logic will be slightly modified to accommodate 10 characters instead of the currently 5 characters. Figure 4 shows the display showing a file from the pen drive.

C. Speech recognition and audio notifications

The device has a speech recognition system, in which the user speech input is used in an intelligent search algorithm which compares the recognized terms with the names of the books, or its authors to give the best match.

In this prototype, the HM2007 IC by HMC [11] was used for speech recognition. Though this decreased the complexity of the circuit, in the final implementation, a DSP can be used for a better voice recognition system [12].

To aid the user in the process, Braill-e-Book can have several audio notifications. For this purpose, the microcontroller generated monotones, which were then given to a speaker driven by the audio amplifier IC LM386 [13] (see Appendix). The notifications had different combinations of monotones to make them sound distinct. In the final implementation, prerecorded voice notifications will replace the monotones.

D. USB Interface

The Braill-e-Book is equipped with a USB host slot wherein the user can insert the USB flash drive containing books in text (.txt) format. The USB flash drive was chosen for this purpose as it is one of the most commonly used mass storage devices. The selected file is then converted to the Braille format and given to the decoding logic for displaying.

For reading the files from a USB flash drive, the VDrive2 Module unit by FTDI [14], which is based on the Vinculum VNC1L chip [15], was used for converting the USB protocol into UART. In the final implementation, the printed circuit board can incorporate the VNC1L IC circuit instead of using VDrive2. This will enable us to use the SPI protocol instead of UART to make it faster and also reduce the size and cost of the system.

E. DC Distribution Box (DCDB)

The various components of Braill-e-Book need to be powered as per their voltage and current requirements, and being a portable device, this is accomplished by using a battery as a voltage source. For this, a DCDB was used that took unregulated supply from the battery and supplied regulated voltages.

Though Braill-e-Book utilizes a battery as its power source, while implementing the prototype, a 12V DC power supply was used. In the final circuit, it will be replaced with Lithium ion batteries along with the same DCDB circuit. For a good efficiency, instead of linear voltage regulator IC, switching voltage regulator IC LM2575 [16], which has an efficiency of up to 70%, was used for designing (see Appendix) regulated voltage supplies of 3.3V and 5V outputs.

IV. CONCLUSION

It was observed that the prototype produced the expected outputs as illustrated herein in Figure 4. Braill-e-Book was tested by taking five eBooks in a pen drive, and after selecting the file, the contents of the file were displayed correctly. Hence it can be said that the complete system, with the aforementioned technical improvements, which will enhance the system performance, is realizable. Besides, as the materials used for building the prototype were inexpensive, it can be said that the final product will be affordable.

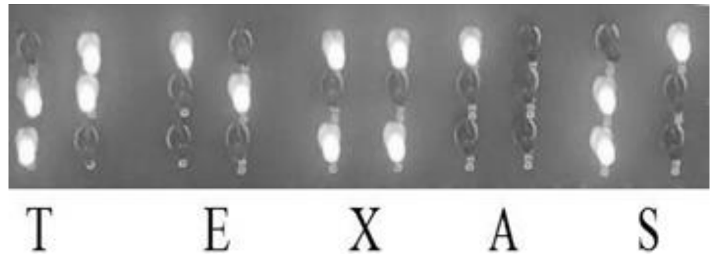

Figure 4: Picture of the LED display of the prototype displaying Braille text along with the converted normal text shown below

APPENDIX

The following figures show the schematics and the printed circuit board layout for the circuits built:

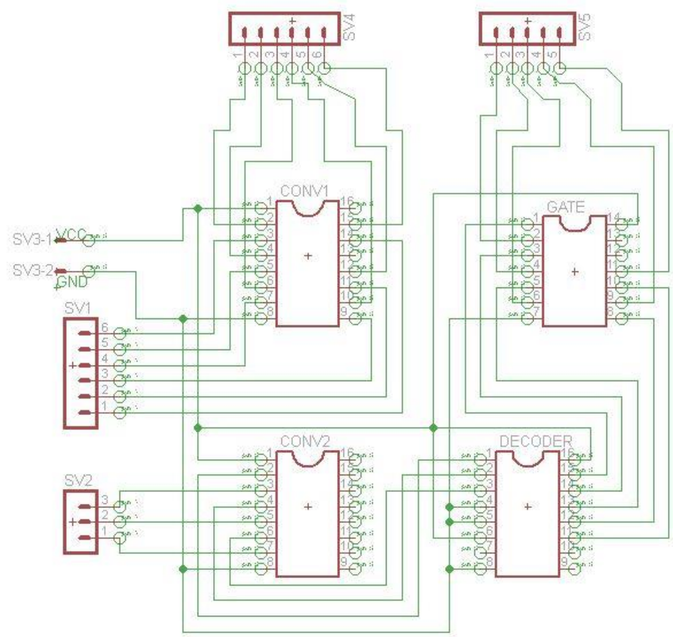

Figure 5: Schematic for display - decoder circuit

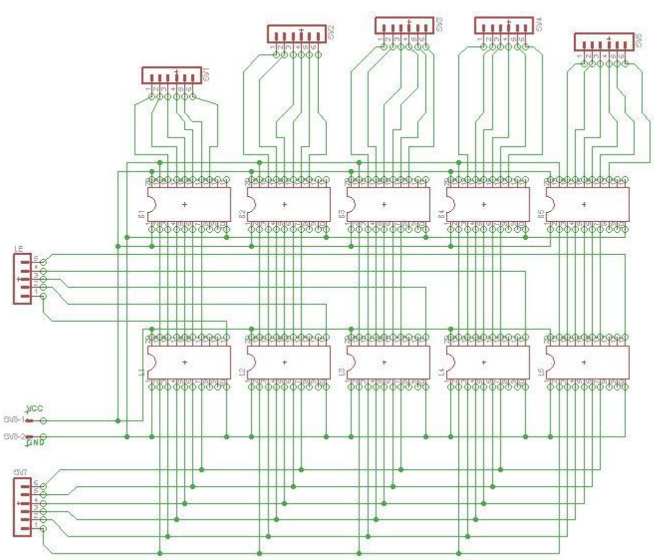

Figure 6: Schematic for display - latch and buffer circuit

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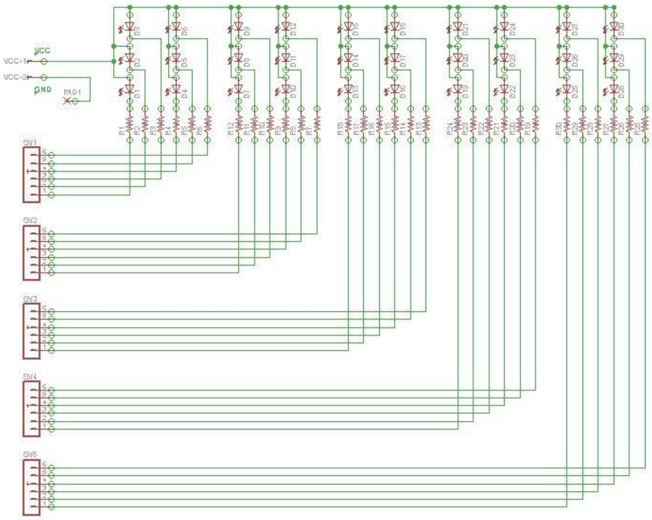

Figure 7: Schematic for display - LED matrix circuit

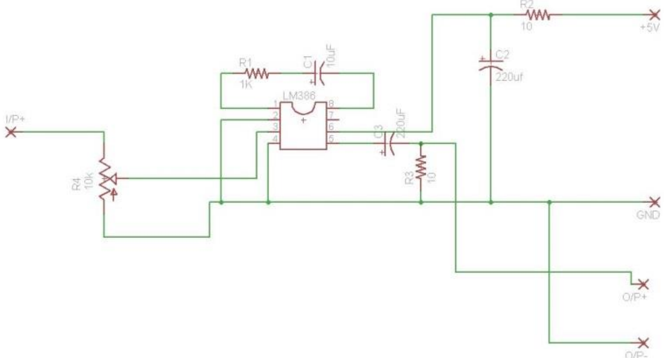

Figure 8: Schematic for audio amplifier

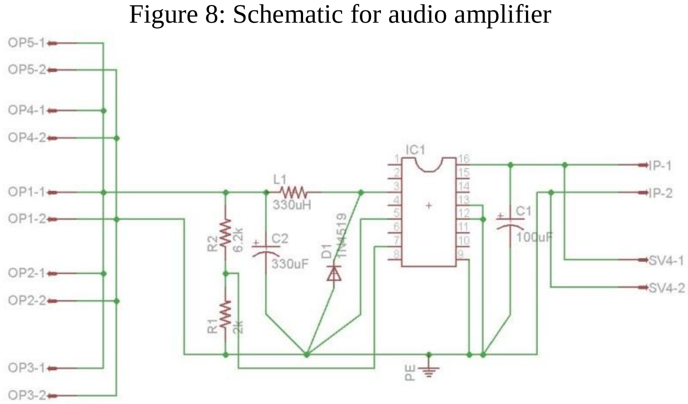

Figure 9: Schematic for 5V power supply

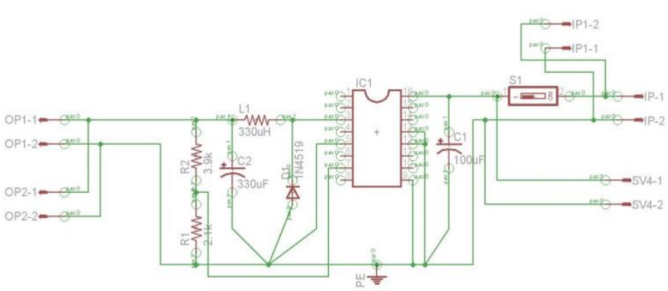

Figure 10: Schematic for 3.3V power supply

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