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Refreshable Braille Display Device

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Abstract: Refreshable Braille displays are an absolute necessity for the visually impaired individuals, offering tactile access to digital content through dynamic pin arrays that form Braille characters. These displays connect to computers and smartphones granting users access to a wide range of information and encouraging independence and inclusion in a digital world. While speech output suffices for many materials, electronic Braille displays are preferred for technical texts, despite their high cost and limited availability of translated books. To address these challenges, a novel device is proposed, featuring a single Braille cell design. The paper involves designing a compact hardware solution with solenoid-based tactile pins controlled by an Arduino microcontroller via a Bluetooth-enabled application. This innovative approach promises cost-effectiveness, efficiency, and compatibility with various digital devices, enhancing accessibility and independence for visually impaired individuals.

Index Terms **- Braille display, grade 1 Braille, solenoid, electromagnetic actuation, visually impaired.**

I. Introduction

Braille originated from a tactile code called night writing developed by Charles Barbier. Initially the Braille script was designed for soldiers to communicate silently, it later evolved as a simpler writing system for the visually impaired. Another script, known as Barbier's system used sets of 12 embossed dots to encode sounds, but Braille identified three major issues such as symbols represented sounds rather than letters that make it inefficient, the symbols were cumbersome for the reading finger, slowing the process and it lacked symbols for numerals and punctuation. Braille addressed these by using 6-dot cells and creating specific patterns for each letter, as well as symbols for numerals and punctuation as shown in Fig.1 [1]. Over time, Braille expanded to include contractions and logograms, resembling shorthand. Today, there are Braille codes for over 133 languages, with Unified English Braille (UEB) standardizing codes among English-speaking countries since 1991 [2]. Braille serves as a vital tool for visually impaired individuals, offering tactile access to textual and graphical content. While personal devices primarily rely on visual information, Braille provides an alternative through refreshable Braille displays. These displays feature raised dots representing alphabet letters in cells of 3x2 or 4x2 dots, with the dots changing dynamically to represent different texts [3].

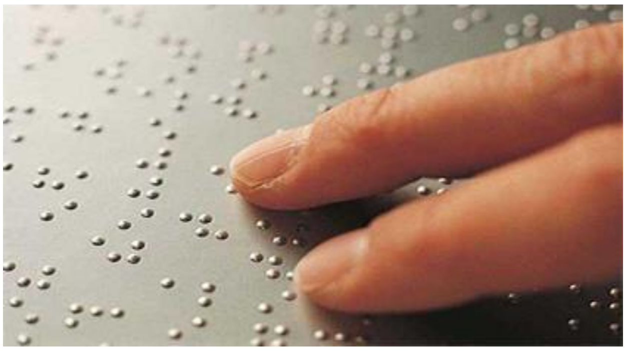


Fig. 1: 6 dot braille textbook reading for visually impaired people [3]

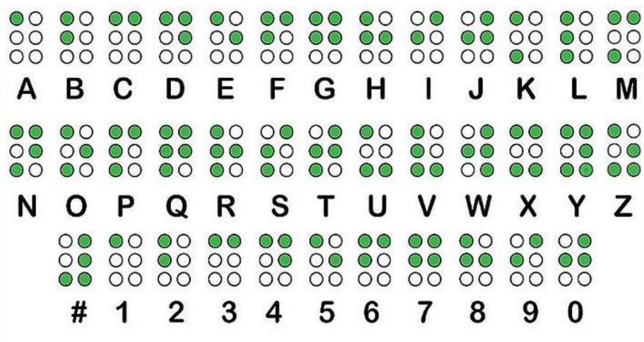


Fig. 2: grade 1 braille script

Braille script encompasses three grades, each tailored to different reading levels and purposes. grade 1Braille, also known as uncontracted Braille, represents each letter, number, and punctuation mark individually with a corresponding Braille cell. It serves as the foundational level of Braille literacy, ideal for beginners and early learners [2].

In this paper, we are considering grade 1 Braille script depicted in Fig.2 as grade 1 Braille is often considered the best option for certain situations due to reasons like foundational literacy where grade 1 Braille provides a solid foundation in Braille literacy as it represents each letter, number, and punctuation mark individually. It also provides clarity and simplicity as in grade 1 Braille, there are no contractions or abbreviations, ensuring clarity and simplicity in representation. This straightforward one-to-one correspondence between printed text and Braille characters makes it easier for beginners to understand and for educators to teach. Additionally, grade 1 Braille is often used in early education settings to introduce individuals with visual impairments to reading and writing, laying the groundwork for further literacy development [3].

II. Related Work

Actuation through electromagnetic induction via solenoids is a common method employed in various mechanical and electrical systems. Solenoids are coils of wire wound around a cylindrical core, typically made of ferromagnetic material. When an electric current flows through the coil, it generates a magnetic field, causing the solenoid to actuate. This actuation can manifest as linear motion, rotational motion, or the opening and closing of valves or switches, depending on the design and application [4].

One key advantage of solenoid actuation is its simplicity and reliability. By controlling the flow of electric current, precise control over the actuation process can be achieved, allowing for accurate positioning and timing in a wide range of applications. Solenoid actuation finds uses in various industries, including automotive, aerospace, manufacturing, and home appliances, where it is employed in mechanisms such as door locks, fuel injectors, pneumatic valves, and relay switches. Overall, electromagnetic induction via solenoids offers a versatile and efficient means of actuation in many mechanical and electrical systems [4].

The paper consists of the design and assembly of a compact hardware solution consisting of solenoid-based tactile pins that can dynamically raise and lower to form Braille characters.

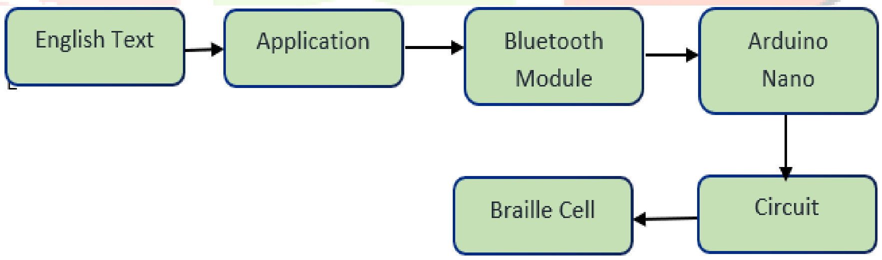


Fig. 3: block diagram of the system

As depicted in Fig.3, the system operates through three essential stages. The first step involves an application that can transmit strings via wireless connection to the Arduino nano. In the prototype model a Bluetooth module has been used considering the low cost and effectiveness of the module. Six solenoids have been used for the six-pin mechanism of the Braille module along with six npn transistors to drive the six solenoids [5]. These solenoids are than assembled and arranged in the form of a Braille cell placed inside an outer casing that holds all the components together [6].

III. Methodology

A. Software For Tactile Display

The process begins by initializing an input string, typically sourced from an application's user interface. A counter is then incremented to track the position in the string. At a decision point, the program determines if the current character is valid for translation into Braille. If valid, it proceeds to convert the character into its Braille representation and displays it on a Braille device. The program then checks if the string has ended; if so, it terminates, otherwise, it loops back to continue processing. Finally, the process ends after all characters are translated.

In the domain of assistive technology, the app acts as a link between digital text and tactile Braille language. Leveraging Bluetooth technology, users can input English text via a user-friendly interface. Upon selecting 'Convert,' the text transforms into Braille, following the Unicode standard for Braille patterns. The app sends the Braille-encoded text to the Arduino nano using the HC-05 Bluetooth module, which is known for its ease of use and integration with microcontrollers. The Arduino nano, programmed in C++, interprets the received data and actuates the corresponding solenoids to represent the Braille characters physically. Python's strong support for serial communication simplifies interaction with the HC-05 module, ensuring dependable data transfer to the Arduino nano [5].

Figure.4 represents the program flow of the software from the start to the end that is utilized by the controller to implement the features as presented in the block diagram.

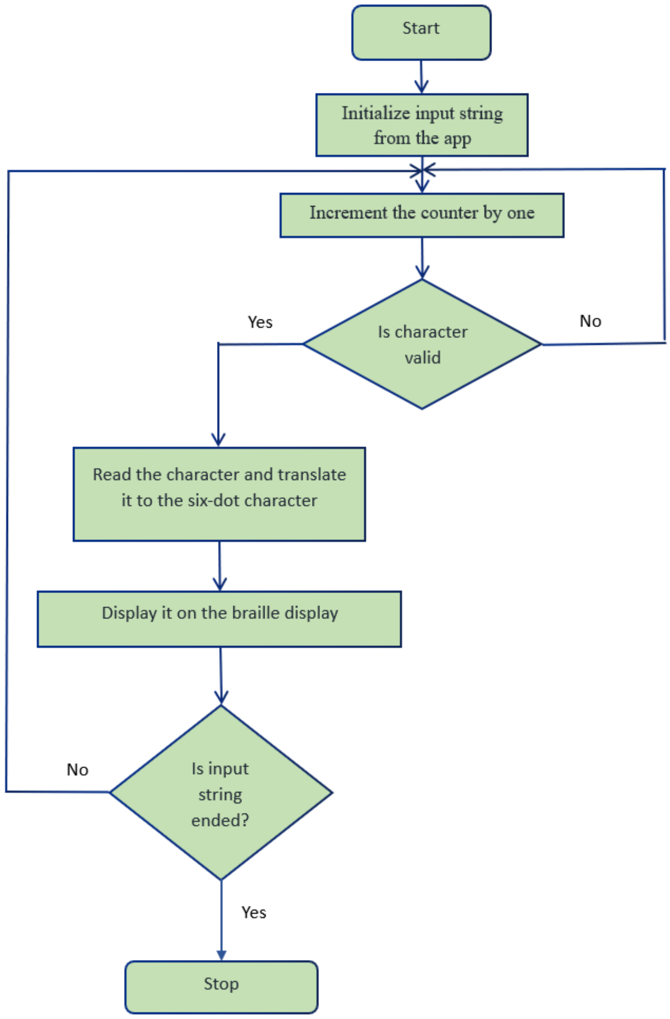


Fig. 4: flowchart for text to braille conversion

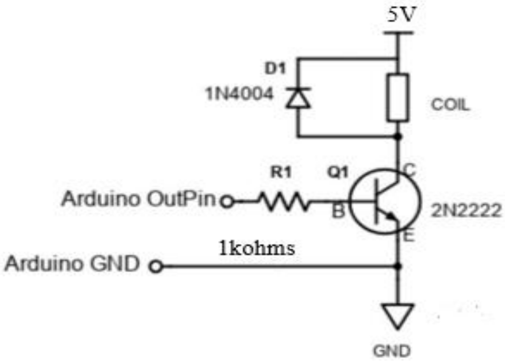
B. Tactile Display Hardware Unit

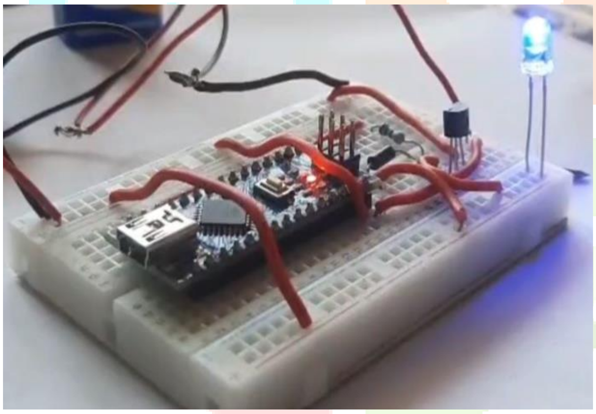
1. Solenoid Actuation Circuit

Figure.5 shows the basic circuit of actuation framework on controller. When the Arduino sends a low signal (0) to the base of the transistor, it is in the cut-off region, acting as an open switch. This prevents current flow through the transistor, and consequently, through the solenoid coil. When the Arduino sends a high signal (1) to the base of the transistor, it enters the saturation region, acting as a closed switch which actuates the solenoid. This allows current to flow from the power supply, through the transistor, through the diode. The diode is placed in parallel with the solenoid coil to protect the transistor. When the solenoid is powered off, it generates a back EMF which could damage the transistor. The diode allows this back EMF to bypass the transistor, protecting it from damage. The resistor limits the current flow to protect the components and ensure proper operation. For testing purposes, a led has been used to indicate the high and low signals. So, the actuated solenoid is indicated by the glowing of led as shown in Fig.6.

2. Circuit Detail of the proposed schematic model

The schematic model created on Proteus software as depicted in Fig.7 represents the configuration of the Arduino-based controller for a refreshable Braille display. It includes Arduino nano, six 1kohms resistors, six npn transistors, six diodes and six LEDs and a power supply circuit, which may consist of a USB connection to the board, a 9V 500mA DC wall-plug adapter, or a 9V alkaline battery.





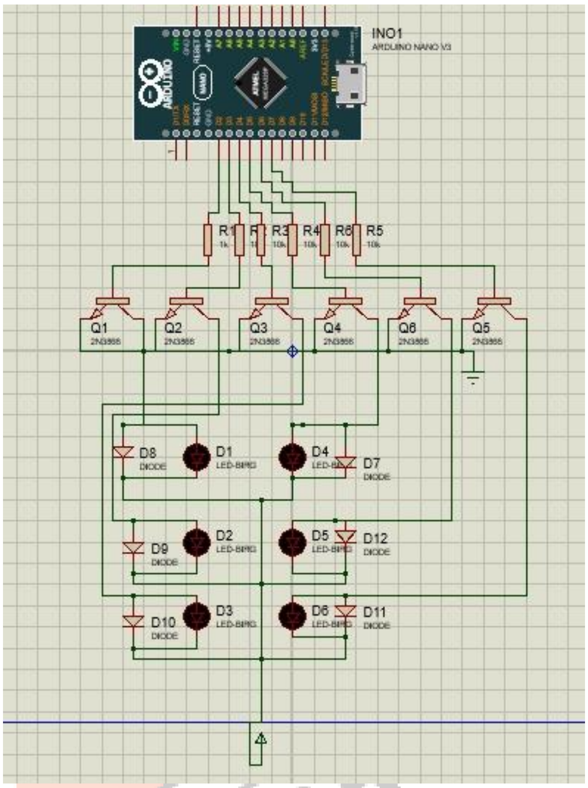


Fig.7: controller schematic model

Fig.6: hardware implementation of the circuit

IV. Experimental Results

A. Design of Solenoid

The dc push pull solenoid design features dimensions of 1cm length and 2cm width, with an inner diameter of 0.7cm and an outer diameter of 2cm. Utilizing magnetic permeability of actuation material, μ_r as 1 and its displacement required to be 0.5cm, the calculations yield the required number of turns on the solenoid to be approximately 442 turns. Figure.8 shows the completed design of solenoid.

Fig.8: solenoid coil with 442 turns of copper wire

B. Hardware Implementation

The solenoid actuation circuit, comprised of Arduino, resistor, transistor, and diode, was successfully implemented and tested on Proteus software, with LEDs serving as hardware indicators. Notably, the LEDs were utilized to form patterns of alphabets and numbers in Braille, enhancing the circuit's functionality and accessibility. Figure.9 and Fig.11 shows the alphabet Y and the number 7 respectively, which were tested using LEDs. These characters were further implemented using solenoids as shown in Fig.10 and Fig.12.

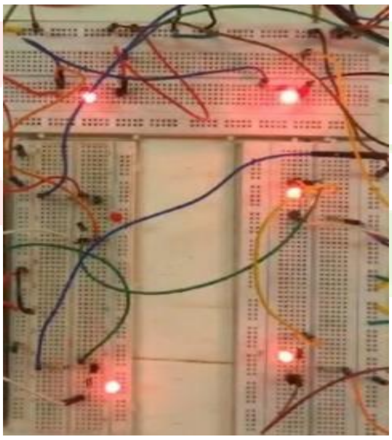


Fig.9: braille character y using leds

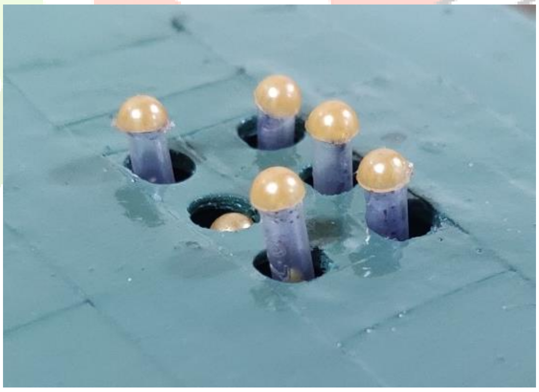


Fig.10: braille character y using solenoids

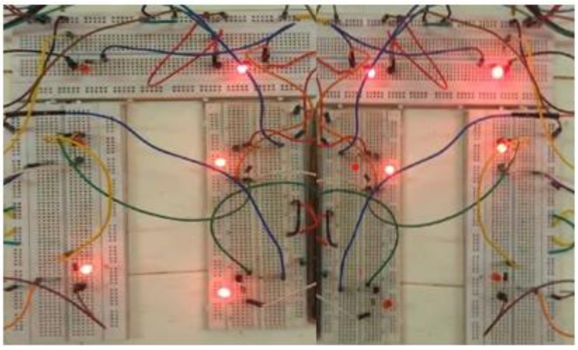


Fig.11: braille character 7 using leds

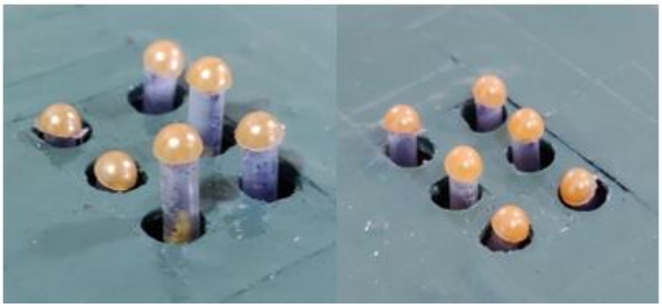


Fig.12: braille character 7 using solenoids

C. PCB Mounted Circuit

Our final design, mounted on a PCB board, presents a solution comprising all essential components. This comprehensive setup includes Bluetooth connectivity, Arduino signal processing, and precise solenoid actuation. Notably, a battery with a switch enables solenoid activation, while an external DC supply ensures optimal performance of the solenoids as shown in Fig.13.

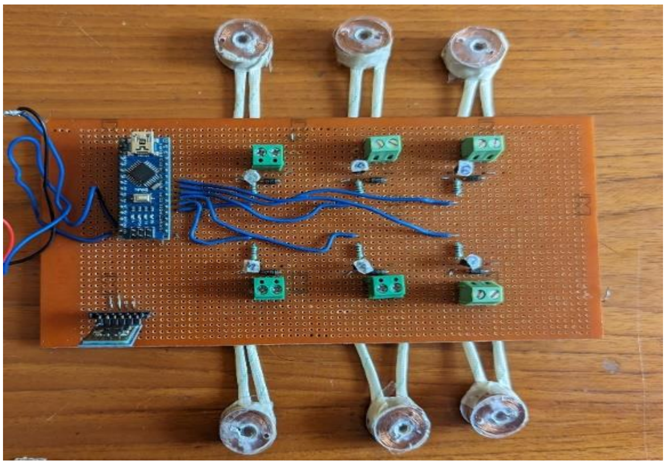


Fig.13: pcb mounted circuit

A prototype has been developed to offer a preliminary depiction of the device's appearance and functionality. With a focus on being easily transportable, the design opts for lightweight materials like cardboard. The processing unit is facilitated by Arduino nano, chosen for its efficiency and affordability. Complemented by inexpensive materials, the model ensures cost-effectiveness without compromising performance.

V. CONCLUSION

The paper discusses about the significant advancement in enhancing accessibility for individuals with visual impairments through the development of a refreshable Braille display device. The software-generated braille has been successfully tested on a hardware prototype utilizing solenoids as actuating braille patterns, achieving accurate representation of all alphabetic and numeric characters. Utilizing NPN transistors to drive solenoids, the system demonstrates a cost-effective approach to implementing Braille cells via electromagnetic actuation. Employing an Arduino nano controller, the device seamlessly converts digital text input from an app into tactile Braille format. Utilizing Bluetooth technology enables wireless communication between the app and Arduino, enhancing user interaction. The paper mainly focuses on the potential for enhanced accessibility in assistive technology provided by this innovative solution.

VI. ACKNOWLEDGEMENT

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REFERENCES

[1] Sutariya, R. D., Singh, H. S., Babariya, S. R., Kadiyar, S. A., & Modi, D. H. (2017, December). Refreshable Braille display for the visually impaired. In *2017 14th IEEE India Council International Conference (INDICON)* (pp. 1-5). IEEE.

[2] Russomanno, A., O'Modhrain, S., Gillespie, R. B., & Rodger, M. W. (2015). Refreshing refreshable Braille displays. *IEEE transactions on haptics*, *8*(3), 287-297.

[3] Kumari, S., Akole, A., Angnani, P., Bhamare, Y., & Naikwadi, Z. (2020, June). Enhanced Braille display use of OCR and solenoid to improve text to Braille conversion. In *2020 International Conference for Emerging Technology (INCET)* (pp. 1-5). IEEE.

[4] Bettelani, G. C., Averta, G., Catalano, M. G., Leporini, B., & Bianchi, M. (2020). Design and validation of the readable device: a single-cell electromagnetic refreshable Braille display. *IEEE transactions on haptics*, *13*(1), 239-245.

[5] Rahman, A. M., Khandaker, S. M., Saleheen, N. N., Afee, T. N., Afrin, N., & Alam, M. A. (2018, June). A portable Braille refreshable display using micro servos. In *2018 Joint 7th International Conference on Informatics, Electronics & Vision (ICIEV) and 2018 2nd International Conference on Imaging, Vision & Pattern Recognition (icIVPR)* (pp. 212-217). IEEE.

[6] Wu, X., Kim, S. H., Zhu, H., Ji, C. H., & Allen, M. G. (2012). A refreshable Braille cell based on pneumatic microbubble actuators. *Journal of Microelectromechanical Systems*, *21*(4), 908-916.

[7] Gupta, R., Singh, P. K., & Bhanot, S. (2016). Design and implementation of Arduino based refreshable Braille display controller. *Indian Journal of Science and Technology*.

[8] Bettelani, G. C., Averta, G., Catalano, M. G., Leporini, B., & Bianchi, M. (2020). Design and validation of the readable device: a single-cell electromagnetic refreshable Braille display. *IEEE transactions on haptics*, *13*(1), 239-245.