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Palestine Polytechnic University

Mechanical & Computer Engineering Departments

Graduation Project

Mechatronics Braille Display

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كلية الهندسة

دائرة الهندسة الميكانيكية

Mechatronics Braille Display

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بناء على نظام كلية الهندسة والتكنولوجيا واشراف ومتابعة المشرف المباشر على المشروع ومتابعة أعضاء اللجنة الممتحنة، تم تقديم هذا المشروع الى دائرة الهندسة الكهربائية والحاسوب ، وذلك استكمالا لمتطلبات درجة البكالوريوس في تخصص هندسة الاتصالات والالكترونيات.

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Abstract

Mechatronics Braille display is a device that displays Braille characters for blind and visually impaired to read by touching. A Braille character consists of six or eight dots in a rectangular array 3×2 or 4×2. The height of the dot is controlled by a piezoelectric bimorph underneath. Electrical signals stimulate the piezoelectric bimorphs to bend up or down, consequently causing the dots to rise or fall, creating the Braille characters.USB port used to get the data from PC, and send it to Microcontroller. Mbed Microcontroller is used to process the entered text and convert it to Braille code, then it used as a controller of the system for controlling the piezoelectric Braille cell. The device is built and tested with number of blind and visually impaired. The results prove the performance, applicability of the device functions with blind/visually impaired need of the device.

Acknowledgment

We would like to express our gratitude to our parents, our families and our friends, whom we admire very much and have brought love, warmth, patience, and understanding to our lives, without whom we would be unable to complete our project. We want to thank Eng. Hussein Amro, our supervisor, for his patience, help and guidance through the entire project who appreciated us for our work and motivated us and before all of them to God who made all the things possible. Special thanks to Palestine Polytechnic university Mechanical and Computer Engineering departments, Mr. Mustafa Abu Tair , Eng. Hani Ghosheh , JDECO electricity lab team, Alsalam school, Alaaia school and al shurooq school for their support and help. This graduation project has been supported by JDECO Fund.

CHAPTER 1

Introduction

1.1 Introduction

Proceeding from our deep faith that every human being on this planet has the right to learn and to have an honorable life based on our full conviction of the importance of making the tools of learning easily accessible for all the groups of learners even for the people of special needs. Based on our experience of the difficult situation in which the blind live and from which the suffer, we decided to focus on this marginalized social group on the way at promoting its scientific acquisition and enhancing its cultural level. It is practically noted that this group did not find the easy available instrument or method to learn so far. After a comprehensive study of the available instruments, either old and modern and getting a feedback about their advantages, disadvantages and their prices, we managed to have a frame work for a device or apparatus in order to read easily and quickly. This device helps the blind to read and go through any electronic book without exerting himself to look for the old and limited printed books or their recordings.

1.2 Project objectives

❖ General Objectives :

1. To bring new technology for blind people in the Middle East and Palestine, which enriches and increases their educational and economic level.
2. To build a Mechatronics device that will help blind people to read any text file they want.

❖ Private Objectives :

1. To develop a project that combines mechanical and computer engineering.
2. To build a graduation project that takes us from the level of undergraduates to engineers prepared for the real world.

1.3 Recognition of the Need

The problem needed to be solved is an important one for the blind people suffer from it; that is how to spare the easy practical device suitable for learning. The researcher has paid a visit to the blind school in Hebron and other related institutions. The researcher found out that every student carries a big tool with a weight of approximately five kilograms. When asked about this tool and its function, found that it represents the pencil which the student can do nothing without it. They also carry a group of books, printed in Braille language in so they can read the material and revise it as well. They also complain that about the lack of the books needed in Braille language, not to forget the unavailability of the quality paper.

Another method used in reading is sound reading programs which require a computer set. The program is downloaded only once. All these devices, old or modern are not cost-effective as it starts from 1000$. Even the cost of a single copy of the simple sound program exceeds 3000$. This is for devices commonly used by blind users. In addition to that, as we previously mentioned, we found through our introduction, to the latest modern technology regarding the blind ,- that there are some newly-invented devices that are operating using different techniques for the purpose of aiding the blind. For reading, there is what so-called (refreshable Braille display). There is also more developed devices, considered as Laptop designed especially for the blind to enable them read the electronic texts, writing, use internet, send the emails and receive the messages, but we found that these devices – in spite of their excellent qualities- do not meet the user's needs for simple stationary which are easy to use and possess. The main reason for this is the cost of these technologies to a great extent. So buying and possessing them is very difficult and is only restricted to a certain group of rich users who could afford to buy them.

The result of all is that in spite of the tremendous scientific and technological development, there is nothing to meet and satisfy the need of the blind users to possess the simple stationary with moderate cost. And that what we try to solve by our project.

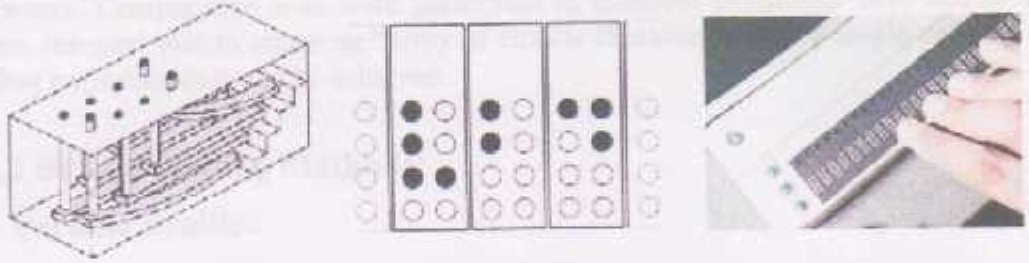
1.4 Previous Studies

Louis Braille's reading and writing system has given the blind access to the written word since the early 19th century. Braille characters replace the sighted written letters with tactile equivalents. In Braille alphabet, each character consists of an array of two columns and three rows of raised, or absent dots. Traditionally embossed on paper, more recently Braille also has been provided by refreshable Braille displays that generally add a fourth row of dots. Refreshable Braille displays were initially the only type of computer interface available for the blind. Despite the growing popularity of more affordable speech synthesis hardware and software, refreshable Braille remains a primary or secondary access medium for many blind computer users. Commercially available refreshable Braille displays have a little changes in the past 25 years. There are several methods used for writing/ reading Braille. Writing methods include the Perkins Braille writer, slate & stylus, and Braille embossers used with specialized computer software, the reading methods also include Braille displays and electronic Braille note takers. These shall be described in more details way as the following:

1.4.1 Braille Reading Methods:

- **Braille Displays**

A Braille display is a device that has a row of special "soft" cells made of plastic or metal pins. The pins are controlled by a computer and move up or down to display, in Braille, the characters that appear on the computer screen. This type of Braille is said to be "refreshable," because it changes as the user moves around on the screen. The Braille display usually sits under the computer keyboard. Typical systems use cantilevered bimorph piezoactuators (reeds) supporting vertical pins at their free end. Upon activation, a reed bends, lifting the pin upward. Braille characters are displayed by assembling six or eight of these mechanisms inside a package called a cell (see Figure 1.1(a)). A basic system includes 40 or 80 cells to display a line of text (Figure 1.1(b)), plus switches to navigate in a page (Figure 1.1(c)) [1]



(a) (b) (c)

Fig. 1.1 Conventional Braille display: (a) cell actuation mechanism, (b) array of cells, and (c) Picture of a commercially available Braille display

Typical Braille displays cost much more than a personal computer.-price start from $1,295.00 and up-

❖ Electronic Braille Notetakers

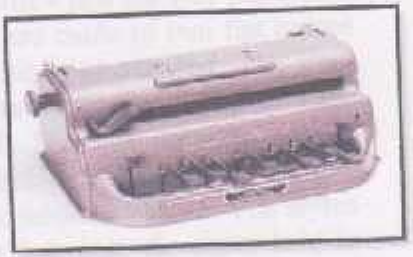
Electronic Braille note takers are portable devices with Braille keyboards that Braille readers can use to enter information. The text stored in these devices could be read with a built-in Braille display or the device can read aloud with a synthesized voice. These devices are handy for taking notes in class, and often have built-in address books, calculators, and calendars. –price starts from $1,995.00 and up-[2]

❖ Alternative Technologies

In recent years many alternative designs have been proposed, all sharing the principle of raising individual pins, or dome shapes, out of a surface [3]. In 2004 alone, no less than six U.S. patents related to Braille cells have been granted, and many others are pending (e.g., [4, 5, 6]). While most of the research focuses on reducing the cost of actuation, very little work is concerned with new approaches to the display of Braille. Of note is a system proposed by Tang and Beebe [7] who sandwiched discrete electrodes in a dielectric. The application of high voltage to these electrodes causes the skin to adhere locally to a glassy surface, thereby creating small tactile objects. Patterns resembling Braille characters could presumably be displayed with this method, however it appears to suffer from sensitivity to environmental factors such as humidity or skin condition. Several investigators proposed the idea of a single display moving with the scanning finger rather than the finger scanning over an array of cells. Fricke [8] mounted a single Braille cell on a rail and activated its pins with waveforms resembling "pink noise" in an attempt to imitate the effect of friction of the skin with a pin. Ramstein [9] designed an experiment with a Braille cell used in conjunction with a planar "Pantograph" haptic device in an attempt to dissociate character localization from character recognition. The haptic device was programmed to indicate the location of the characters in a page, while the cell was used to read individual characters. Comparative tests were performed in different conditions with one or two hands. Again, the goal was to create an "array of Braille characters" with a single cell and reasonable reading performance could be achieved.

1.4.2 Braille Writing Methods:

❖ Perkins Braille:



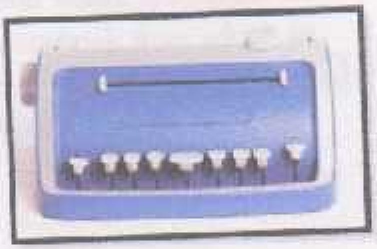
The **Perkins Braille** is a "Braille typewriter" with a key corresponding to each of the six dots of the Braille code, a space key, a backspace key, and a line space key. Like a manual typewriter, it has two side knobs to advance paper through the machine and a carriage return lever above the keys. The rollers that hold and advance the paper have grooves designed to avoid crushing the raised dots the Braille creates.

Perkins brailler is the most widely used brailler in the world. Invented in 1951 by David Abraham, a teacher at Perkins School for the Blind. It has withstood the test of time, owing to its great durability, reliability and ease of use. The Perkins Brailler has undergone changes over the years with improvements and new functionality. The following is a list of available Perkins braillers:

➢ **Perkins SMART Brailler**

The SMART Brailler is an upgraded version of the Next Generation brailler and features a video screen and audio feedback which displays and speaks letters and words in real-time as they are being brailled. This makes it easier for people who don't know Braille to learn. Also, sighted teachers and parents can see and follow along with what their students and children are brailling.

➢ **Next Generation® Perkins Brailler**



The Next Generation brailler is based on the Standard Brailler so it has the same functionality but is smaller, lighter and sturdier. This makes it easier to carry and use for brailler users.

➢ **Standard Perkins Brailler**

The Standard brailler is the classic version of the brailler that is widely used by brailler users throughout the world. In addition to those braillers there are also electric braillers that make it possible to braille with increased speed and with less effort. A unimanual brailler is for those who can only use one hand and a large cell brailler for those who have tactile problems.

But as we see that all of these devices uses heavyweight paper to write on them, also they are heavy, and expensive –the price start from 700$-

❖ Slate and stylus

The slate and stylus are inexpensive, portable tools used to write Braille - just the way paper and

pencil are used for writing print. Slates are made of two flat pieces of metal or plastic held together by a hinge at one end. The slate opens up to hold paper. The top part has rows of openings that are the same shape and size as a Braille cell. The back part has rows of indentations in the size and shape of Braille cells. The stylus is a pointed piece of metal with a plastic or wooden handle. The stylus is used to punch or emboss the Braille dots onto the paper held in the slate. The indentations in the slate prevent the stylus from punching a hole in the paper when the dots are embossed. Slates and styluses come in many shapes and sizes. - Price: $32.95- [11]

❖ Braille Printers (Embossers)

Braille printers are devices connected to a computer that do the actual embossing of Braille onto thick (heavyweight) paper. They work like a regular computer printer does, in that the user can print out letters, reports, and other files from the computer. -Small-volume Braille printers cost between $1,800 and $5,000 and large-volume ones may cost between $10,000 and $80,000. -

Our project is the next generation of electronic Braille notetaker; we build whole system device that includes the main tools needed by the blind such as a book and a copybook from which he can read easily and quickly. We glad that the project time and the financial aids serve us such that we build complete device with piezoelectric Braille cell to let the blinds read the book they want and we test it.

1.5 Mechatronics Braille Display Features

After a long study of the available instruments, old and modern, getting information about their advantages, disadvantages and their prices, we found that all these devices cannot be available in the poor countries due to its high price which hasn't been changed in the last 10 to 20 years, due to the limit number of companies take control of all the market to supply this devices, also these devices come with full options so that makes its price high. So we decided to bring this important and useful technology to these countries affordable the basic needs that the blind look for.

CHAPTER 2

Braille System

2.1 Introduction

The Braille system is a method used by blind people to read and write; raised dots represent the letters of the alphabet. It also contains equivalents for punctuation marks and provides symbols to show letter groupings. It is read by moving one or two hands from left to right along each line. Both hands are usually involved in the reading process, and reading is generally done with the index fingers character by character. The average reading speed is about 125 words per minute, but greater speeds of up to 200 words per minute are possible.

Braille characters consist of six-dot cells; two wide by three tall. These dots are numbered downward 1, 2, 3 on the left, and 4, 5, and 6 on the right (see Fig.2.1). Any of the dots may be raised, giving 2^6 or 64 possible characters. Although Braille cells are used world-wide, the meaning of each of the 64 cells depends on the language being used to depict. Different languages have their own Braille codes: mapping the alphabets, numbers and punctuation symbols to Braille cells according to need. Braille characters can also be used to represent whole words or groups of letters. [11]

1 O O 4
2 O O 5
3 O O 6

Fig. 2.1 The Dot that represents Braille symbols

2.2 Braille History

An eleven-year-old blind boy took a secret code used by for the French Army and managed to modify it to create the basis for written communication for blind individuals. Louis Braille spent nine years in developing and refining the system of raised dots to be later used after his name. [12]

The original military code was called "night writing" and was used by soldiers to communicate at night without subjecting themselves to danger when using any light. It was based on twelve-dot cells: (two dots wide by six dots high). Each dot or combination of dots within the cell stood for a letter or a phonetic sound. The problem with the military code was that the human fingertip could not feel all the dots with one touch, because it was so large. Louis Braille refined the code to be based on a cell of six dots in a 3 x 2 configuration. The dimensions of the Braille cells are also standardized, but these may vary slightly depending on the country. Braille gradually came to be accepted throughout the world as the fundamental form of written communication for blind individuals, and today remains basically invented.

There have been some modifications on the Braille system, particularly the addition of contractions representing groups of letters or whole words that appear frequently in a language. These modifications permit faster Braille reading, and hence helping reduce the size of Braille books and making them less cumbersome.

2.3 Braille Cell Dimensions

When Braille cells are embossed on paper, certain rules must be applied for the mutual distances between dots, cells and lines of cells. Almost every country has its own specification(s), but the differences are minor. The dimensions of a Braille cell, as printed on an embosser. (See Figure 2.2).

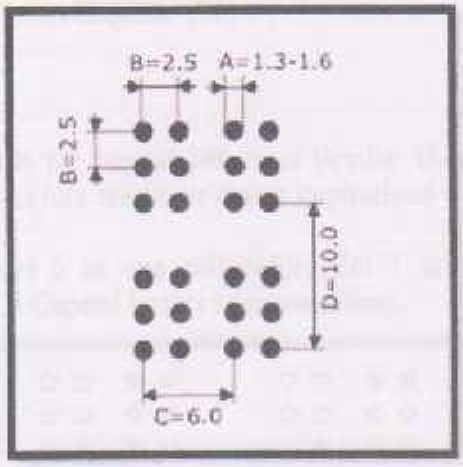


Fig. 2.2 - Braille cell dimensions
A = Dot base diameter, B = Dot to dot distance,
C = Cell to cell distance, D = Line to line distance (mm).

2.4 Braille System

As we said before Braille is a tactile approach to reading and writing. The basic Braille symbol is called the Braille cell. It consists of six dots arranged in the formation of a rectangle, three dots high and two dots wide or arranged in two columns and three rows. Each dot has an assigned number between one and six, (see Fig.2.1).

2.4.1 English Braille

Figure 2.3 show the representation of English language in Braille, (see Fig. 2.3 English Braille).

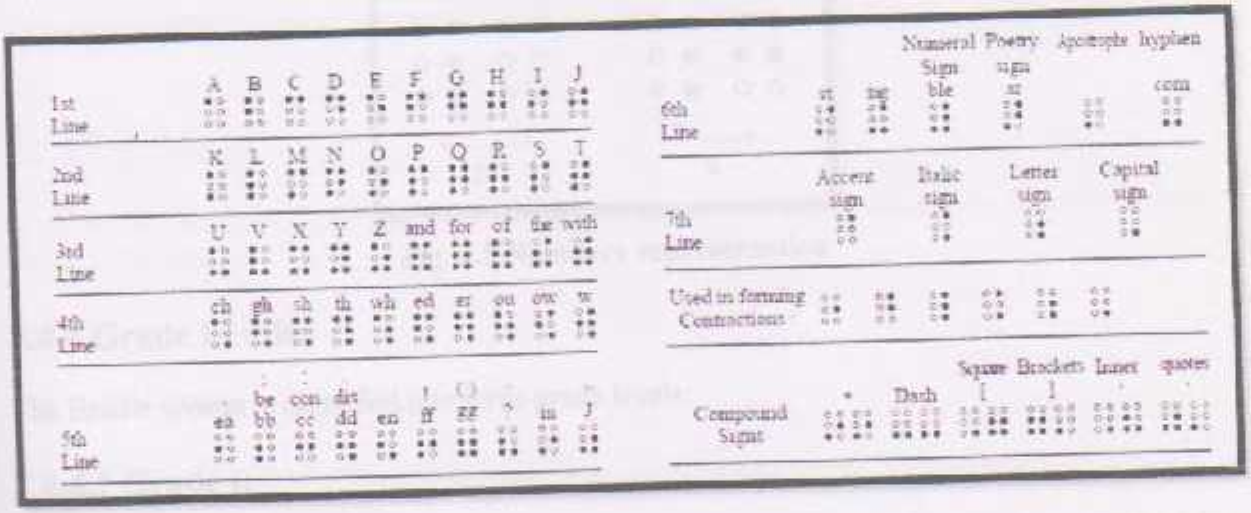


Fig. 2.3 English Braille

The beauty of Braille is that it is based on phonetics. Thus be it any language, Hindi, Japanese, German or Chinese, the same sounding letters will have the same Braille sign. For example, "ba" in Hindi has the same dot as "b" in English. [13]

2.4.2 Capital Letters

There are no different symbols for capital letters in Braille. Capitalization is accomplished by placing a dot 6 in the cell just before the letter that is capitalized.

Illustration: For example, dot 6 in one cell before dot 1 in the next cell would make the combination "A", (See Fig. 2.4 Capital letters representation).

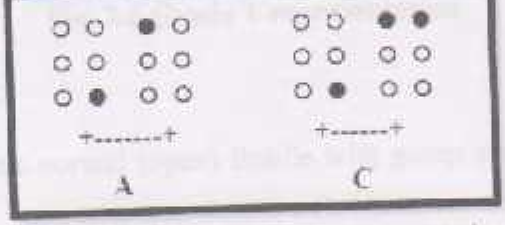


Fig. 2.4 Capital letters representation

2.4.3 Numbers

The first ten letters of the alphabet are used to make numbers. These are expressed by the letters 'a' to 'j' preceded by the numeric indicator which is dots 3-4-5-6.

Illustration: The numeric indicator, dots 3-4-5-6 in one cell, before dots 1 in the next cell, which is letter 'a' would make the combination as numeral '1'. Similarly the letter 'b' preceded by numeric indicator would represent numeral '2'. In the same sequence the letter 'j' preceded by numeric indicator would represent numeral '0', (See Fig. 2.5 Numbers representation).

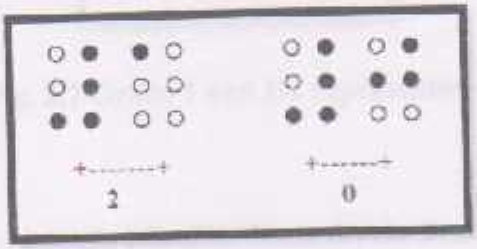


Fig. 2.5 Numbers representation

2.4.4 Grade Levels:

The Braille system is classified into three grade levels:

2.4.4.1 Grade I:

Each letter of the Braille word is fully spelled out. It is generally sufficient to learn Grade I for those who do not read and write Braille extensively.

Illustration: The word "STAND" can be represented by dots 2-3-4 in one cell, dots 2-3-4-5 in the second cell, dot 1 in the third cell, dots 1-3-4-5 in the fourth cell and dots 1-4-5 in the fifth cell, (See Fig. 2.6 Grade 1 representation).

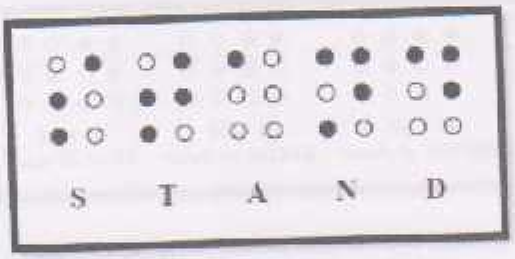


Fig. 2.6 Grade 1 representation

2.4.4.2 Grade I and 1/2:

Grade I and 1/2: It represents normal (open) Braille with group symbols which are moderately contracted.

Illustration: The group symbol for 'THE' is dots 2-3-4-6. Thus if dots 2-3-4-6 in one cell are followed by dots 1-3-4 in the second cell, the combination is read as 'THEM', (See Fig. 2.7 Grade 1and 1/2 representation).

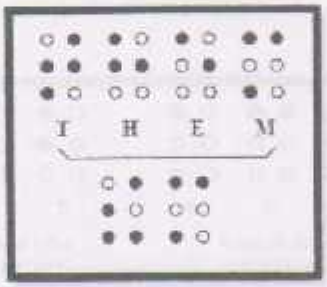


Fig. 2.7 Grade 1 and 1/2 representation

2.4.4.3 Grade II:

It represents contracted form of Grade I Braille. Generally the Braille books for children contain Grade II Braille.

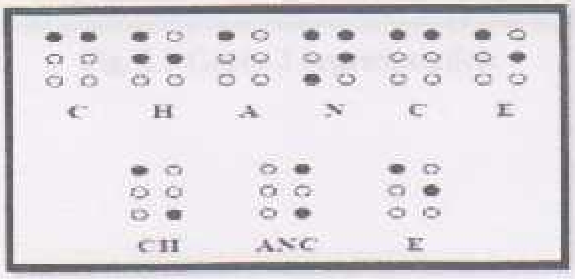
Illustrations

I. Contractions With One Cell Only

B in Braille stands for BUT
C in Braille stands for CAN
D in Braille stands for DO
E in Braille stands for EVERY
K in Braille stands for KNOWLEDGE
P in Braille stands for PEOPLE, etc.

II. Contractions With Two Cells

III. Group Symbols with Three Cells



Thus dots 4 and 6 in one cell which is a second cell in a group symbol stands for ANCE. Similarly, dots 5 and 6 in one cell in this position stands for ENC e.g. in PENCE.

IV. Abbreviation

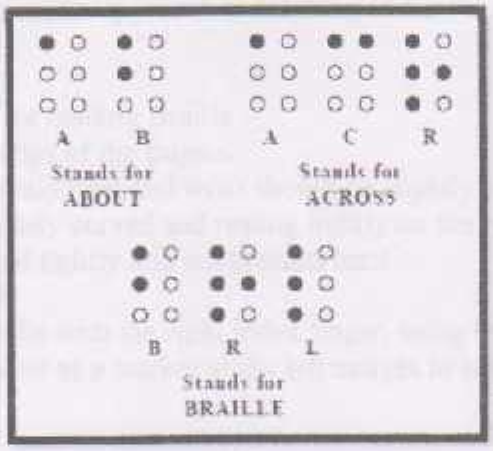


Fig. 2.8 Grade 2 representation

NOTE:
In our project we will use Braille Grade 1 which is used from the beginning of reading and writing instructions.

2.4.4.4 Grade III:

It is a complicated form of Braille, mostly used as short-hand.

Illustrations:

Contractions

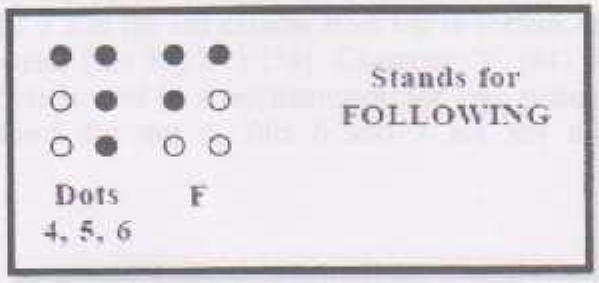


Fig. 2.9 Grade 3 representation

2.5 Reading of Braille

Wolfgang Stein advocates scientific approach to teaching of Braille and recommends the following sequence:

- Use both forefingers for reading Braille
- Read Braille with the tips of the fingers
- Fingers should be slightly bent and wrist should be slightly elevated
- Fingers should be slightly curved and resting lightly on the reading material
- Dots should be touched lightly and not pressed hard
- Read from left to right
- Most people read Braille with the right index finger, using the left index finger to read part of the Braille line or as a marker at the left margin to help find the next line.[13]

2.6 Braille Computer Code

The basic purpose of the Braille computer code is to represent characters or expressions used in texts relating to computers, and for material input to or output by a computer. It consists of a scheme for precisely representing a wide range of print characters used in such contexts, and is designed so that the most frequently occurring print characters have a single Braille cell representation. This last feature leads to differences between the computer code and Standard English Braille and Mathematics notation. The most significant departure from these codes is the way numbers are coded.

ASCII code is one of Braille computes codes. Louis Braille mapped ASCII characters 32 to 95 to 'Braille' cells. There are 2^6=64 possible combinations with 6 dots, so this explains the selection of 64 ASCII characters. They are listed in table 1 (see table 1.1 –Braille ASCII 6-Dot Table-). A Braille character is usually expressed in a sequence of numbers for the positions of the dots. Dots in the cell are numbered 1 2 3 in the left column from top to bottom, and dots 4 5 6 in the right column from top to bottom, (see Fig.2.1) [14]. Character "t" (84) for example has dots on positions 2-3-4-5. One byte is used as a representation for each pattern ("t" > 00011110), with bit=0 for dot 1 and bit=5 for dot 6. Bits 6 and 7 are not used; they are always=0.

Braille ASCII 6-Dot Table 1.1

1	2	3	4	5	6	7
ASCII dec	ASCII hex	ASCII char	Braille dots (dec)	Braille dots (bin)	Braille cell	Braille meaning
32	20	(space)	(none)	00000000	⠀	(space)
33	21	!	2-3-4-6	00101110	⠮	the
34	22	"	5	00010000	⠐	(contraction)
35	23	#	3-4-5-6	00111100	⠼	(number prefix)
36	24	$	1-2-4-6	00101011	⠫	ed
37	25	%	1-4-6	00101001	⠩	sh
38	26	&	1-2-3-4-6	00101111	⠯	and
39	27	'	3	00000100	⠄	'
40	28	(	1-2-3-5-6	00110111	⠷	of
41	29	)	2-3-4-5-6	00111110	⠾	with
42	2A	*	1-6	00100001	⠡	ch
43	2B	+	3-4-6	00101100	⠬	ing
44	2C	,	6	00100000	⠠	(uppercase prefix)

1 ASCII dec	2 ASCII hex	3 ASCII char	4 Braille dots (dec)	5 Braille dots (bin)	6 Braille cell	7 Braille meaning
47	2F	/	3-4	00001100	⠌	**st**
48	30	0	3-5-6	00110100	⠴	**"**
49	31	1	2	00000010	⠂	**,**
50	32	2	2-3	00000110	⠆	**;**
51	33	3	2-5	00010010	⠒	**:**
52	34	4	2-5-6	00110010	⠲	**.**
53	35	5	2-6	00100010	⠢	**en**
54	36	6	2-3-5	00010110	⠖	**!**
55	37	7	2-3-5-6	00110110	⠶	**(or)**
56	38	8	2-3-6	00100110	⠦	**" or ?**
57	39	9	3-5	00010100	⠔	**in**
58	3A	:	1-5-6	00110001	⠱	**wh**
59	3B	;	5-6	00110000	⠰	**(letter prefix)**
60	3C	<	1-2-6	00100011	⠣	**gh**
61	3D	=	1-2-3-4-5-6	00111111	⠿	**for**

1 ASCII dec	2 ASCII hex	3 ASCII char	4 Braille dots (dec)	5 Braille dots (bin)	6 Braille cell	7 Braille meaning
64	40	@	4	00001000	⠈	(accent prefix)
65	41	A	1	00000001	⠁	a
66	42	B	1-2	00000011	⠃	b
67	43	C	1-4	00001001	⠉	c
68	44	D	1-4-5	00011001	⠙	d
69	45	E	1-5	00010001	⠑	e
70	46	F	1-2-4	00001011	⠋	f
71	47	G	1-2-4-5	00011011	⠛	g
72	48	H	1-2-5	00010011	⠓	h
73	49	I	2-4	00001010	⠊	i
74	4A	J	2-4-5	00011010	⠚	j
75	4B	K	1-3	00000101	⠅	k
76	4C	L	1-2-3	00000111	⠇	l
77	4D	M	1-3-4	00001101	⠍	m
78	4E	N	1-3-4-5	00011101	⠝	n

1 ASCII dec	2 ASCII hex	3 ASCII char	4 Braille dots (dec)	5 Braille dots (bin)	6 Braille cell	7 Braille meaning
81	51	Q	1-2-3-4-5	00011111	⠟	q
82	52	R	1-2-3-5	00010111	⠗	r
83	53	S	2-3-4	00001110	⠎	s
84	54	T	2-3-4-5	00011110	⠞	t
85	55	U	1-3-6	00100101	⠥	u
86	56	V	1-2-3-6	00100111	⠧	v
87	57	W	2-4-5-6	00111010	⠺	w
88	58	X	1-3-4-6	00101101	⠭	x
89	59	Y	1-3-4-5-6	00111101	⠽	y
90	5A	Z	1-3-5-6	00110101	⠵	z
91	5B	[	2-4-6	00101010	⠪	ow
92	5C	\	1-2-5-6	00110011	⠳	ou
93	5D	]	1-2-4-5-6	00111011	⠻	er
94	5E	^	4-5	00011000	⠘	(contraction)
95	5F	_	4-5-6	00111000	⠸	(contraction)

CHAPTER 3

Conceptual Design and Functional Specification

3.1 Introduction

Mechatronics Braille Display is divided into integrated electronic components in which they are connected with each other. Each component has a specific function, to achieve the required shape and performance of the device. To build such a device, a set of parameters must be considered, such as: safety, portability, cost, design simplicity and volume occupied by the device.

3.2 Conceptual Design

The purpose of the project was producing a Mechatronics display with interface keys that can be use by blind people without affecting them. The process starts when the blind turns on the device and puts his SD card in the device, then the microcontroller asks for all data inside the SD card, and starts read these data, and displays character by character on the piezoelectric cell. The blind starts read the characters, also he can use next/previous key to get the next/previous character, or use next/previous page key to get the next/previous page. Microcontroller is used to control all operation of the system including data input from SD card and data output to the piezoelectric cell.

The block diagram of the whole system is shown in Figure 3.1.

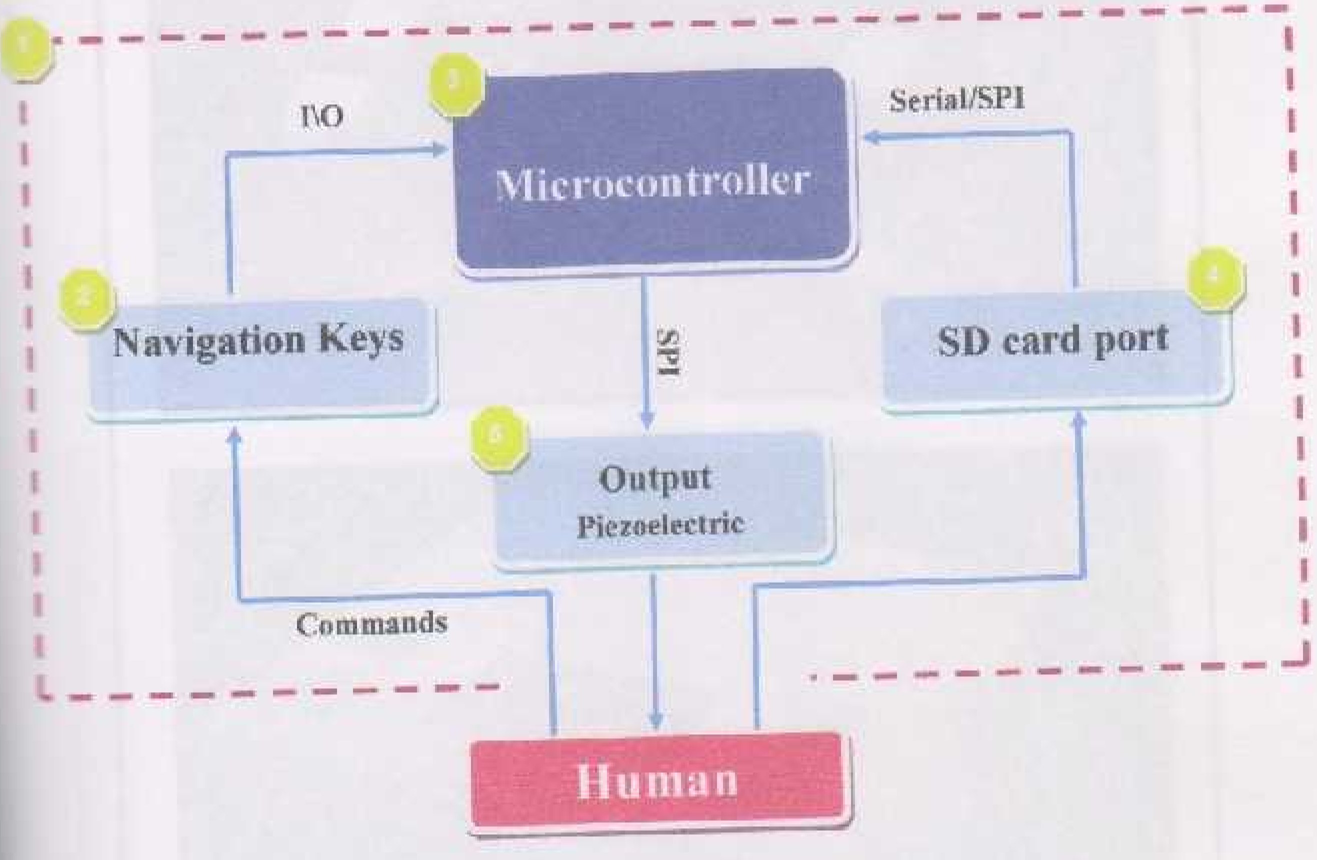


Fig. 3.1 Block diagram of Mechatronics Braille Display

3.3 Functional Specification

In this section, more details are given for each component with its related blocks in Figure 3.1.

3.3.1 Design of the Device (block 1)

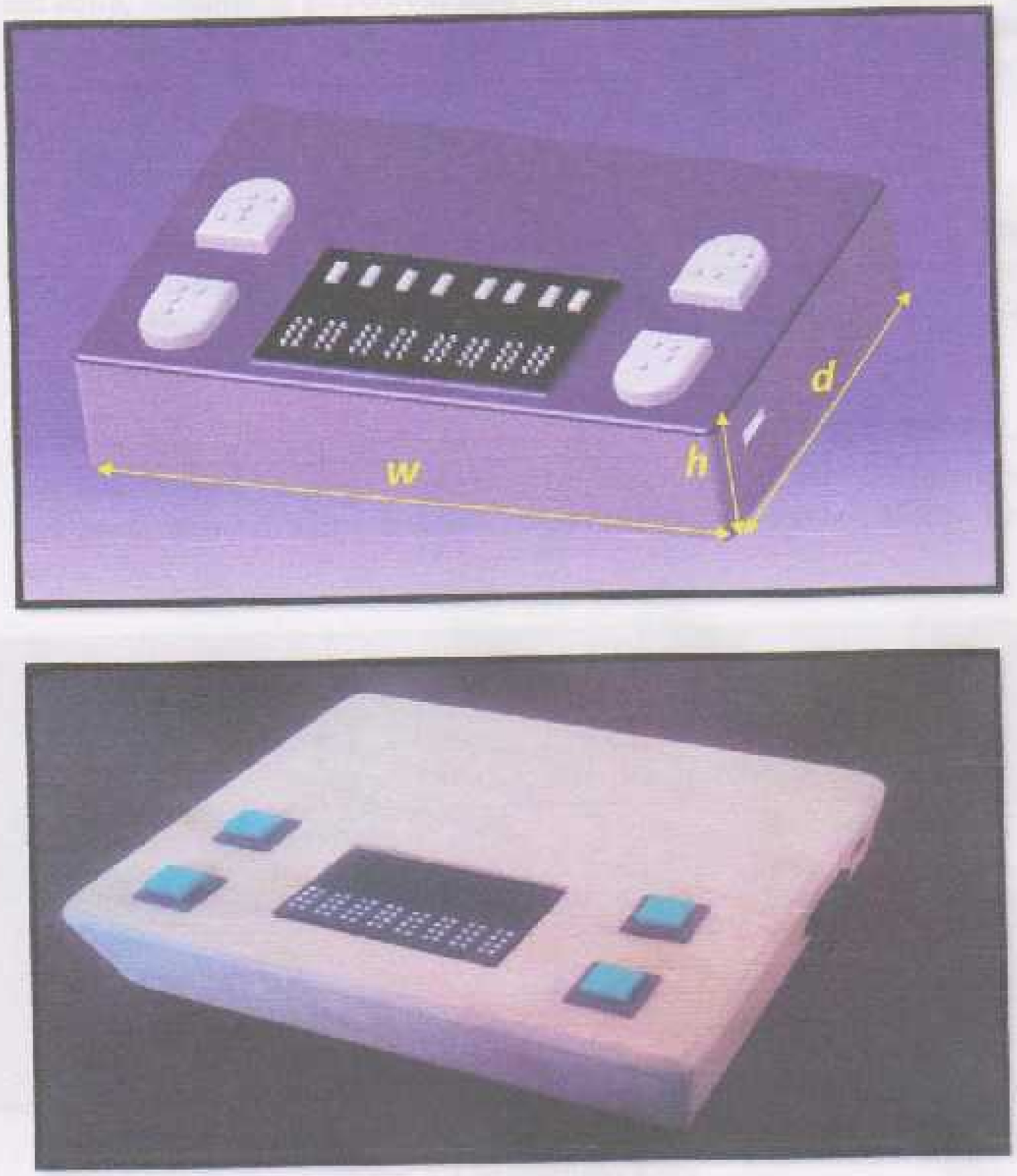


Fig. 3.2 Mechatronics Braille Display

Here in our project, we believe that the interaction between the user and the product is one of the primary concerns of the product design process. So we focused on four aspects of **ergonomics design** to develop and design our device (See Figure 3.2), which are: safety, comfort, ease of use and low cost:

I. **Safety:** there is a direct interacts between the blind and the device; in order to switch it on/off, also to make the blind able to read the text, they must touch the pins that go up and down, moreover to go between lines they need to click on the navigation keys. All these interactions will be considered in our design of the device. For these reasons the edges of the device, navigations buttons and the head of the pins are designed to be not sharp, to guarantee the safety of the blind.

II. **Comfort:** it expected that blinds may use the device for one or two hours per a day at least, blind comfort must be assured in the designing of the display So we focus on making the surface of the device smooth and appropriate to the average sizes of the hands, the dimensions of the device are (width (w) =12cm x height (h) =3cm x depth (d) = 8cm), see figure 3.2.

III. **Ease of use:** in order to make the device suitable for blinds, it must be simple , and that what we did in our device, we put four navigation keys each one achieve one job, also each one marked with a letter in Braille code to show its function as shown in figure 3.3 below:

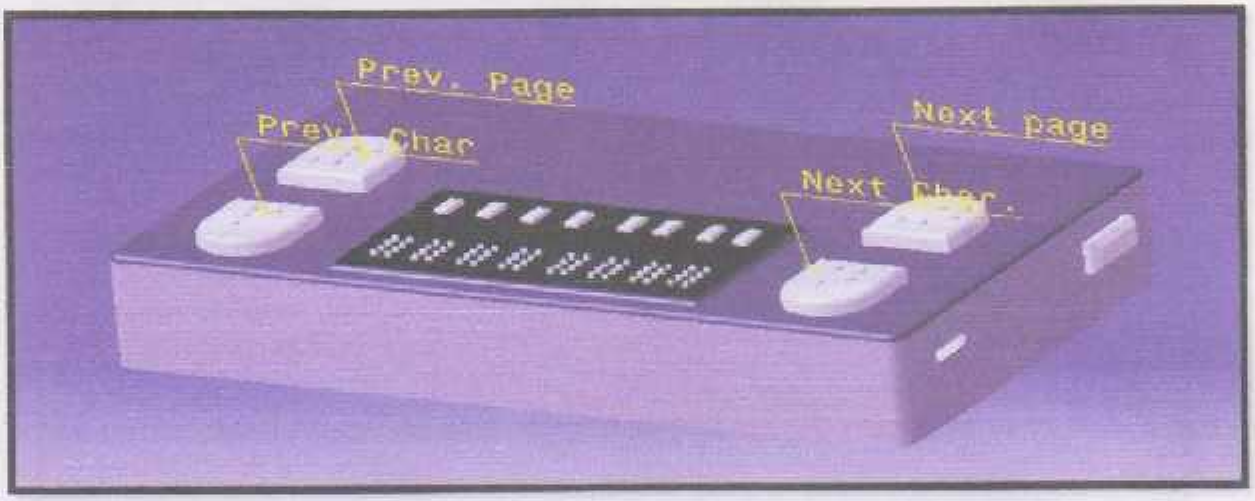


Fig. 3.3 Navigations Keys

Blind can put his SC Card in the device, and move easily and intuitively through texts, characters and pages by using the navigation keys, and start reading.

IV. **Low cost:** we built the device with cost around 700$.

3.3.2 Navigation keys

The navigation keys (see figure 3.4), which are located on the front of the Mechatronics Braille display, enable the user to read without interruption, as the reading fingers can remain on the Braille display. The navigation keys can be simply operated with ring finder. The navigation keys allow the user to move easily and intuitively through texts, characters and pages. In our device there are five navigation keys, each key has a specific function as show in table 3.1 below:

Fig. 3.4 Marks on navigations keys

On/Off button
if the device run on the button shut it down , if the device off the button turn it on
Next button
the current character disappear and the next character show up
Previous button
the current character disappear and the previous character show up
Next page button
the current page disappear and the first character from the next page show up
Previous page button
the current page disappear and the first character from the previous page show up

Table 3.1 Navigation Keys Functions

3.3.3 Microcontroller

Microcontrollers are one of the most important devices implementing communication and electronic control systems. A microcontroller is a type of microprocessor furnished in a single integrated circuit and needs a minimum of support chips. The microcontroller is capable of storing and running programs. It contains a CPU (central processing unit), RAM (random-access memory, ROM (read- only memory), I/O (input-output) lines, serial, parallel and Ethernet ports, Serial communication peripheral, sometimes other built-in peripheral such as A/D (analog to digital) and D/A (digital to analog) converter. Microcontroller will be used as a controller for the system. It used to control every single dot at each Braille cell depending on input data from SD card. In our project we have four options to use for microcontrollers, which are: **ARDUINO, MBED NXP LPC1768** and **BEAGLEBONE** all these microcontrollers achieve our requirement in the project like number of Input/output pins, voltage needed to run microcontroller, processor performance .

- **Arduino:**

Arduino as shown in figure 3.5 is an open source microcontroller system that is a very popular and easy to use, flexible, and fast to develop. Microcontrollers are tiny computers that do specific jobs, receive inputs from sensors and control the loads. The Arduino Uno is one type of the microcontrollers. It has 14 digital input/output pins, a 16 MHz crystal oscillator, a USB connection, and a reset button. The Arduino board contains everything needed to support the microcontroller. The Arduino Uno can be programmed with the Arduino software [١٥]. The Arduino hardware and software are both open source, which means the code, and the schematics, design, etc. are all open for anyone to take freely.

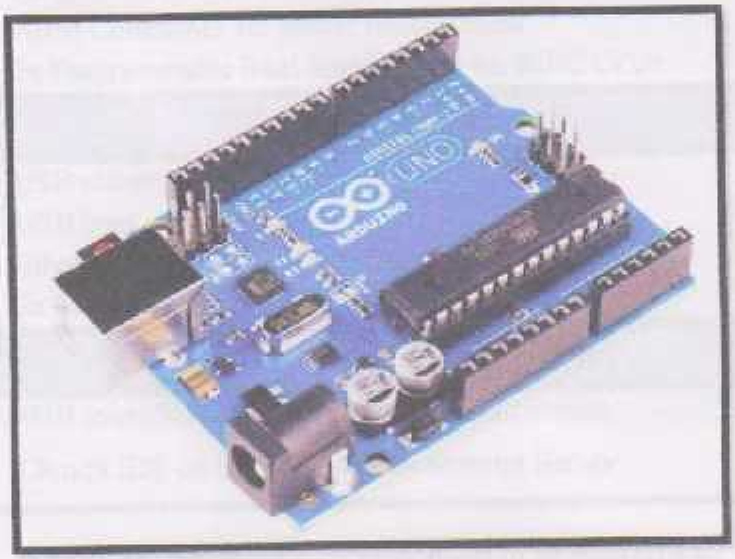


Fig. 3.5 Arduino board

➢ BeagleBone:

BeagleBone is a credit-card-sized Linux computer that connects with the Internet and runs software such as Android 4.0. With plenty of I/O and processing power for real-time analysis provided by the TI Sitara processor, BeagleBone can be complemented with boards which augment BeagleBone's functionality (See Figure 3.6). The hardware specifications shown in table 3.2 [16]

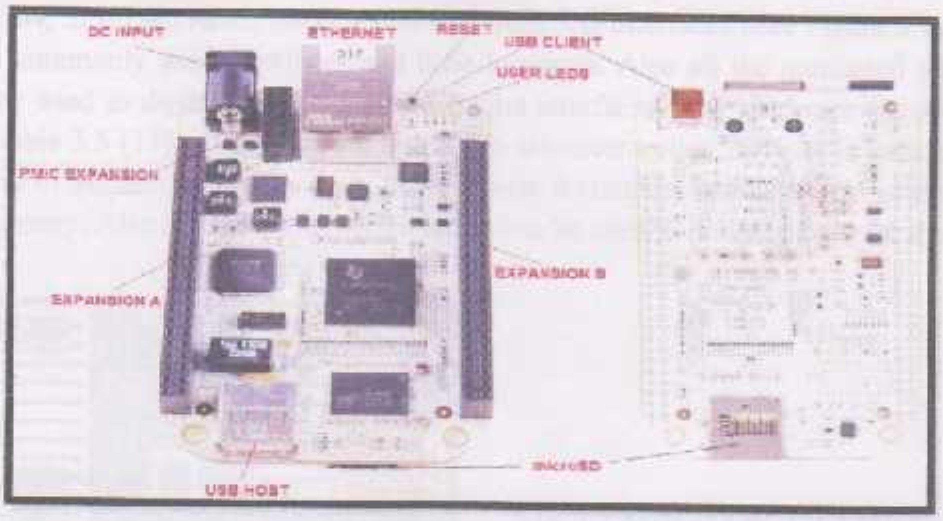


Fig. 3.6 BegaleBone board

Processor
➢ 720MHz super-scalar ARM Cortex-A8 (armv7a) ➢ 3D graphics accelerator ➢ ARM Cortex-M3 for power management ➢ 2x Programmable Real time Unit 32-bit RISC CPUs
Connectivity
➢ USB client: power, debug and device ➢ USB host ➢ Ethernet ➢ 2x 46 pin headers
Software
➢ 4GB microSD card with Angstrom Distribution ➢ Cloud9 IDE on Node.JS with Bonescript library

Table 3.2 Hardware specification of BegaleBone

➢ MBED NXP LPC1768 :

The mbed NXP LPC1768 Microcontroller is designed for prototyping all sorts of devices, especially those including Ethernet, USB, and the flexibility of lots of peripheral interfaces and FLASH memory. It is packaged as a small DIP form-factor for prototyping with through-hole PCBs, stripboard and breadboard, and includes a built-in USB FLASH programmer. It is based on the NXP LPC1768, with a 32-bit ARM Cortex-M3 core running at 96MHz. It includes 512KB FLASH, 32KB RAM and lots of interfaces including built-in Ethernet, USB Host and Device, CAN, SPI, I2C, ADC, DAC, PWM and other I/O interfaces (See Figure 3.7). Figure 3.7 shows the commonly used interfaces and their locations. Also all the numbered pins (p5-p30) can also be used as digital input and digital output interfaces. The hardware specifications are shown in table 3.3 [17]. At the end we chose this microcontroller, because it has more features like number of digital input and output, also because it contains internal RAM so it can be used as flash memory. Also it is easy to program and it can be used as power supply for the device.

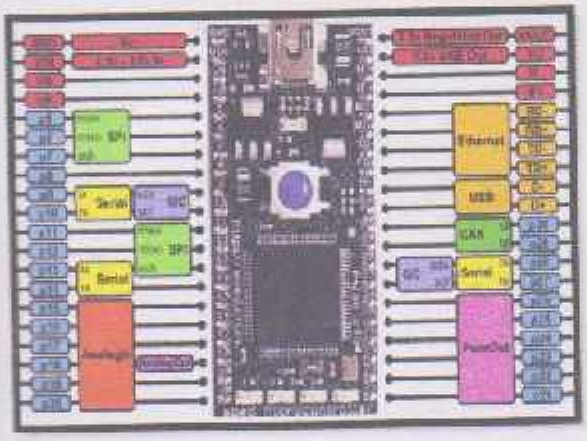


Fig. 3.7 MBED LPC1768 Microcontroller

Processor
➢ High performance ARM® Cortex™-M3 Core ➢ 96MHz, 32KB RAM, 512KB FLASH
Connectivity
➢ 40-pin 0.1" pitch DIP package, 54x26mm ➢ 5V USB or 4.5-9V supply ➢ Built-in USB drag 'n' drop FLASH programmer
Software
➢ Lightweight Online Compiler ➢ High level C/C++ SDK ➢ Cookbook of published libraries and projects

Table 3.٣ Hardware specification of MBED NXP LPC11768

3.3.4 SD Card Port

In order to enter the text form SD card to the device, there must be a SD card port that can let the data transfer from SD card memory to the microcontroller. In the device we use the internal memory of the mbed microcontroller, user can download any text file using mini USB cable directly from PC to the SD card of mbed .The device permits to use SD card port to get the files form evternal SD card that contains the required text (See Figure 3.8).

Fig. 3.8 SD card port

3.3.5 The Piezoelectric Cell

Piezoelectric Braille cell represents a single unit of a Braille character that can be displayed and refreshes itself to any Braille character depending on a command input. It consists of a structural base, piezoelectric bimorphs, and a printed circuit board (PCB), a cap and pins or white dots, (See Fig. 3.9 Assembly drawing of the Piezoelectric Braille Cell). Each cell has eight dots in a rectangular array 4x2 and is controlled by piezoelectric bimorph.

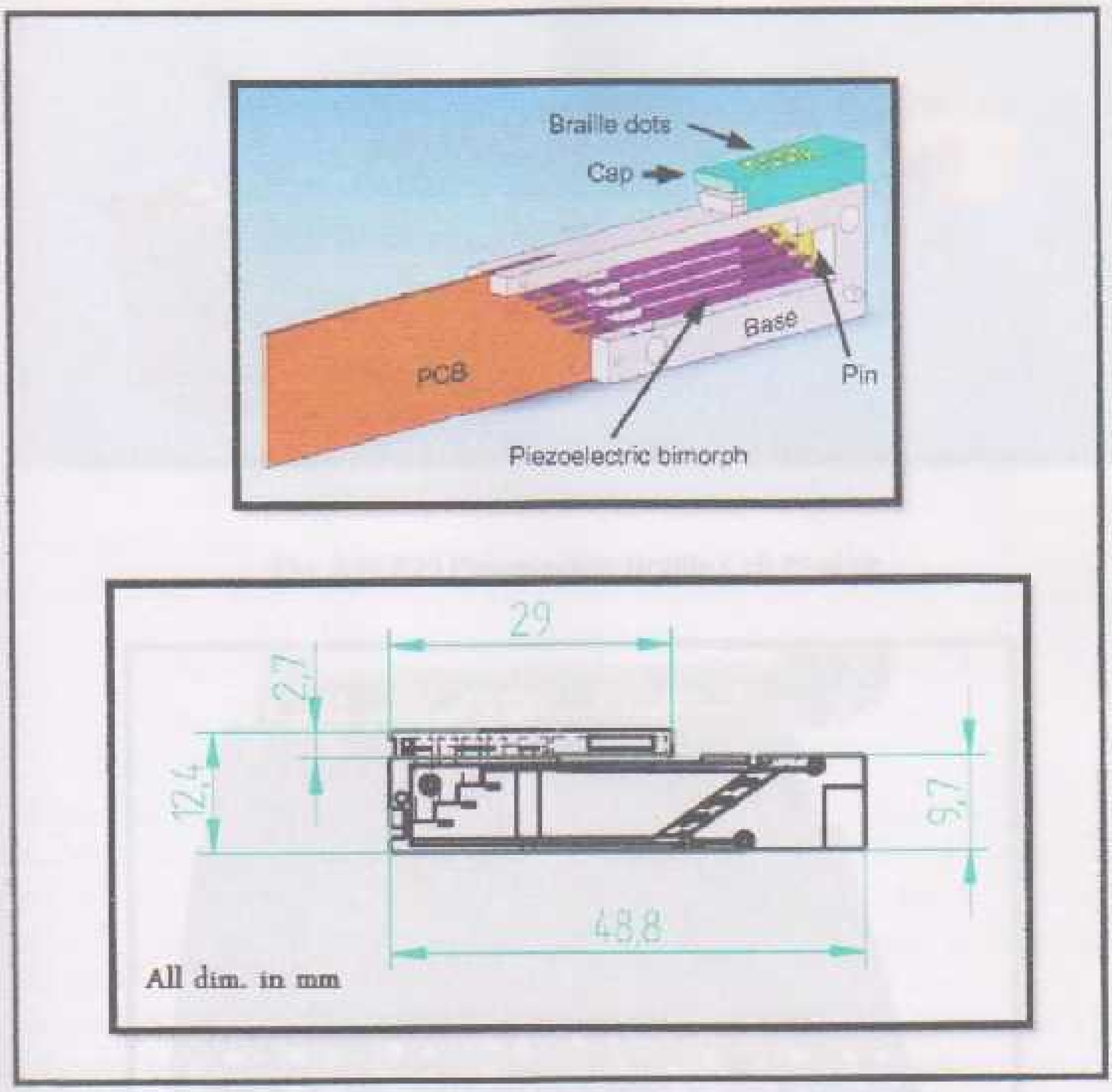


Fig. 3.9 Assembly drawing of the Piezoelectric Braille Cell

The piezoelectric bimorph is located inside piezoelectric Braille cell and attached to every single dot. Those dots will represent a Braille character or alphabet. Piezoelectric bimorph will bend up or down depending on the value of voltage applied. Figure 3.10 shows P20 piezoelectric Braille cell module from Metec Company which is used as Braille actuator. (See Fig. 3.11, 8 Piezoelectric Braille Cells). We have been used 8 piezoelectric Braille cells to represent 8 characters of Braille at each time.

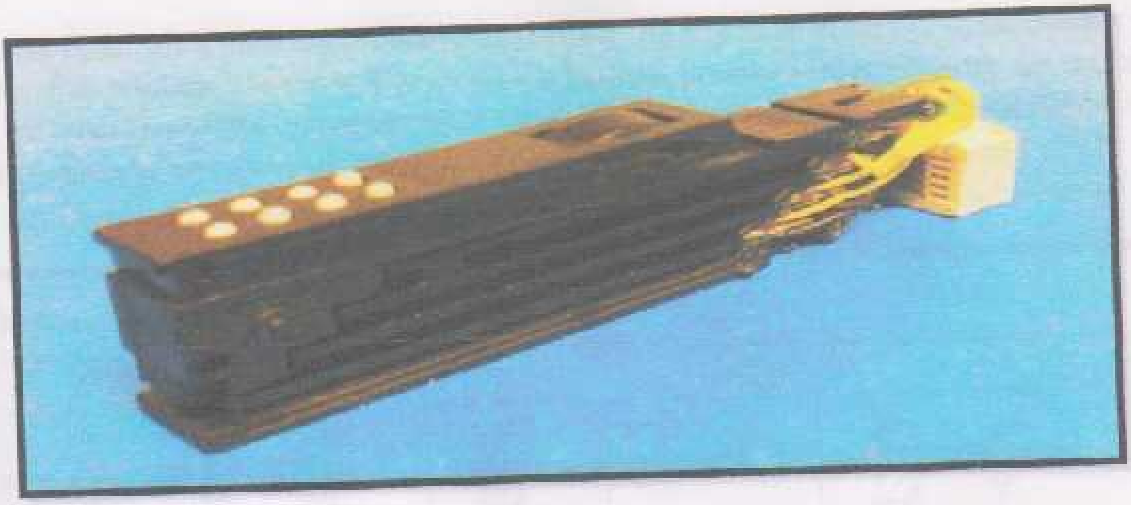


Fig. 3.10 P20 Piezoelectric Braille Cell Module

Fig. 3.11, 8 Piezoelectric Braille Cells

Figure 3.12 shows the driving mechanism of piezoelectric Braille cell, the pins are supported and controlled by the piezoelectric bimorph, and the other end of the bimorph is fixed to the base. The free length of the bimorph is L, d is the tip displacement. Normal position of bimorph is a straight beam when there is no electrical excitation .If there is an electrical signal causing the bimorph to bend up. The dot will be raised up. This rise position is used when the dot is active. On the other hand, if there is an electrical signal causing the bimorph to bend down, the dot will fall down under the reference surface[18].

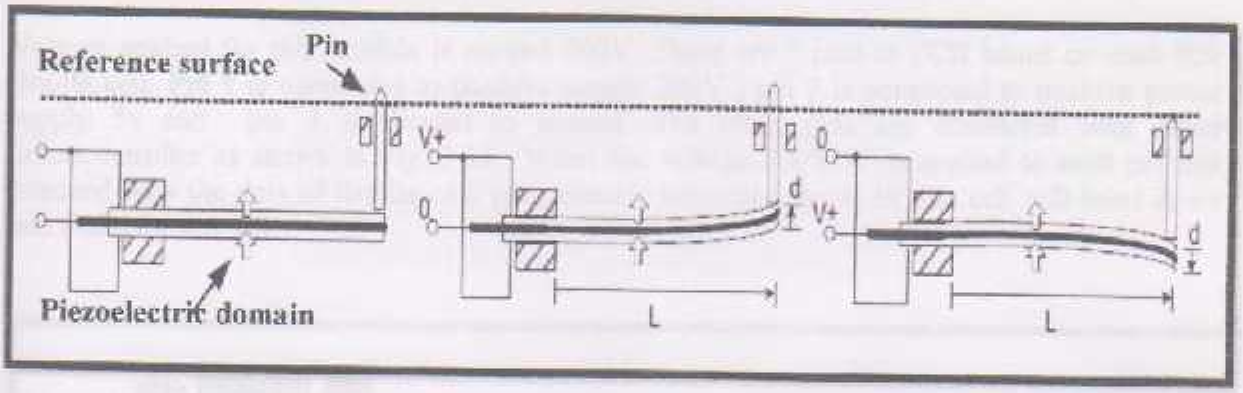


Fig. 3.12 Actuation mechanism of the Piezoelectric Braille Cell

While touching the active Braille character, the underneath Piezoelectric beam is simultaneously subject to both touching force and applied voltage which are mechanical and electrical excitations, respectively. The response of the Braille dots is investigated when the touching force is varied from **0-0.32 N** which is common range for Braille readers based on survey made at Tammasakon Schiil of visually impaired people in Hat Yai, Songkhla, Thailand [19] .In the survey, touching force of blind people when sensing Braille Note is measured. In addition, preference of the blind people roundness of the Braille dots is studied by letting them read the same character but different dot shapes. The result implies that the tip displacement decrease as the touching force increase. The dot is able to maintain its positive above the normal position for certain amount of force depend on the applied voltage.

The survey data provides primary information showing that **the touching forces are in the range of .05-.39 N** and the preference of dot roundness is 0.75mm fillet. Along with these usage conditions, dimension of the piezoelectric bimorph and material was selected to meet the requirement of the device.

The designed piezoelectric bimorph has a settling time of 150 ms. Dot rising time= 50ms, tactile force = 17Cn minimum. The relationship between the Braille dot height and applied voltage is linear. After we did experiment on piezoelectric to find the relationship between force applied and the height of pin we noticed that the behavior of the piezoelectric Braille dot when it is touched is the dot height decreased as the force increases. The height of the pins can reach 3mm.

Also the minimum dot cycling rate: As high as 10 Hertz for most applications, but 1 Hz may be tolerable for some applications with limited interaction, such as continuous reading of long pages of text on multiple-line or full-page displays. Piezoelectric Braille cell has high reliability; Lifetime is10^7 cycles for single-line displays and correspondingly less for larger, multiple-line or full-page displays that are updated less frequently [20].

Voltage applied for this module is around 200V. There are 7 pins at PCB board on each P20 Braille cell. Pin 1 is connected to positive supply 200V , pin 7 is connected to positive power supply 5v and pin 3 is shorted to ground. The other pins are connected with mbed microcontroller as shown in Fig. 3.13 . When the voltage 200VDC is applied to each pin that attached with the dots of Braille cell, piezoelectric bimorphs inside Braille cell will bend down and make the dot fall.

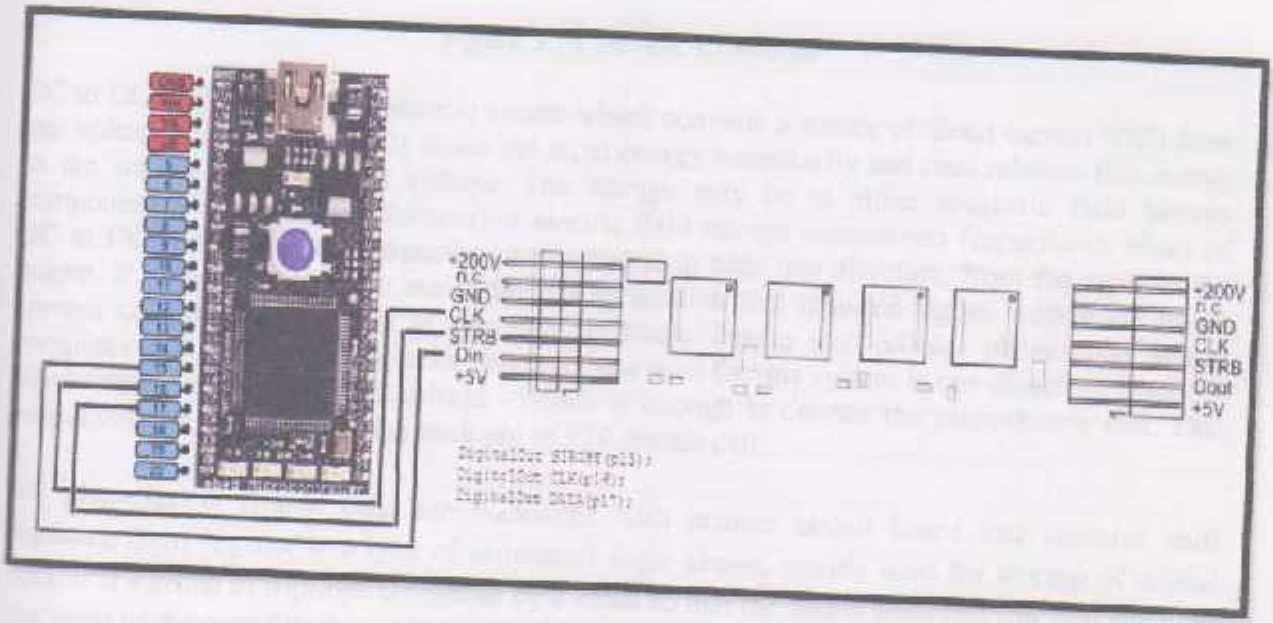


Fig. 3.13 PCB Connection with mbed microcontroller

As we mentioned before, piezoelectric Braille cell needs 200V DC to operate, a DC to DC converter shown in figure 3.14 was used in our project.

Figure 3.14 DC-DC Converter

DC to DC converter is an electronic circuit which converts a source of direct current (DC) from one voltage level to another. It stores the input energy temporarily and then releases that energy to the output at a different voltage. The storage may be in either magnetic field storage components (inductors, transformers) or electric field storage components (capacitors). Many of DC to DC converters are designed to move power in only one direction, from the input to the output. It is has been used in many devices application that required higher voltage but lower current consumption such as in portable electronic device like cellular phones and laptop computer [20]. DC to DC converter that has been used for this system is one direction, from 5V input voltage to 185V output voltage –Which is enough to operate the piezoelectric cell. This output voltage will be applied at each pin of P20 Braille cell.

All piezoelectric Braille cells are connected with printed circuit board that contains shift registers, Shift register is a type of sequential logic circuit, mainly used for storage of digital data. It is a group of flipflops connected by a chain so that the output from one flip-flop becomes the input of the next flip-flop. All the flip-flops are driven by a common clock, and all are set or reset simultaneously. One of the most common uses of a shift register is to convert between serial to parallel data interfaces[21].

The shift register is used to convert the serial data from mbed microcontroller to parallel data which can be spread to every single dot at Braille cell. As we know, each Braille cell has eight pins that representing each dot for one Braille cell. All pins need to be triggered by some voltage value whether 200V to rise up the dots or 0V to fall the dots under reference surface. HV509 chip has been used as a shift register for this system. The HV509 is a 200V, 16-channel serial to parallel converter. The high voltage outputs and the backplane driver are designed to source and sink ±1.0mA. By combining high voltage and low voltage devices in one IC, it replaces a large number of discrete components including multiple high voltage N-channel and Pchannel

MOSFETs in applications such as driving piezoelectric transducers and flat panel displays in push-pull mode. The HV509 can be used in any application that requiring multiple output, high voltage, low current sourcing and sinking capabilities [21]. The input voltage for this shift register is around 0.5V to 6.0V and it can produce output voltage on each pin up to 200V.

The HV509 can be controlled by some peripheral in mbed microcontroller called serial peripheral interface (SPI). Each time when we send data we send 8 bits serially, Data is shifted through the shift registers during the low to high clock transition , we use internal clock from mbed and connect it with PCB that contains shift register. Shift register can handle up to 500KHz clock speed , also its transition time can reach 125ns. For this shift register the data sequence is [7 8 3 2 1 6 5 4], so when we want to operant pin 1 in Braille cell we send array consists of these bits [1 1 1 0 1 1 1], table 3.4 shows the sequence of all English alphabet and numbers.

Character	sequence	Character	sequence
A/a	11101111	Y/y	00001011
B/b	11100111	Z/z	10001011
C/c	01101111	0	00110111
D/d	00101111	1	11101111
E/e	10101111	2	11100111
F/f	01100111	3	01101111
G/g	00100111	4	00101111
H/h	10100111	5	10101111
I/i	01110111	6	01100111
J/j	00110111	7	00100111
K/k	11101011	8	10100111
L/l	11100011	9	01110111
M/m	01101011	Number sign	11000011
N/n	00101011	Null	11111111
O/o	10101011	X/x	01001011
P/p	01100011	W/w	00010111
Q/q	00100011	Capital sign	10111111
R/r	10100011	Letter sign	00111111
S/s	01100111	Inner ,	10110011
T/t	00110011		
U/u	11001011		
V/v	11000011		

Table 3.4 Characters sequence in piezoelectric Braille cell

3.4 Design of Schematic Circuit

Fig. 3.15 below shows the schematic diagram of the system. Piezoelectric connected directly with mbed through PCB .PCB consists of 7 pins, pin 1 is connected to positive supply 185V from DC-DC converter, pin 4 is connected with pin 16 –digital output- in mbed, pin 5 is connected with pin 17 –digital output- in mbed, pin 6 is connected with pin 15 –digital output- in mbed, pin 7 is connected to positive power supply 5v and pin 3 is shorted to ground. 5 volt is needed to operate DC-DC converter and mbed, we take 5 volt directly from 5 volt power supply. SD card port and navigation keys need 3.3 volt, so we take 3.3 volt directly from mbed pin (Vout). All the components of the device are connected on breadboard, see Fig 3.16. The outer box is under printing, it will be build from wood, it will be exactly the same as it mentioned before in the design.

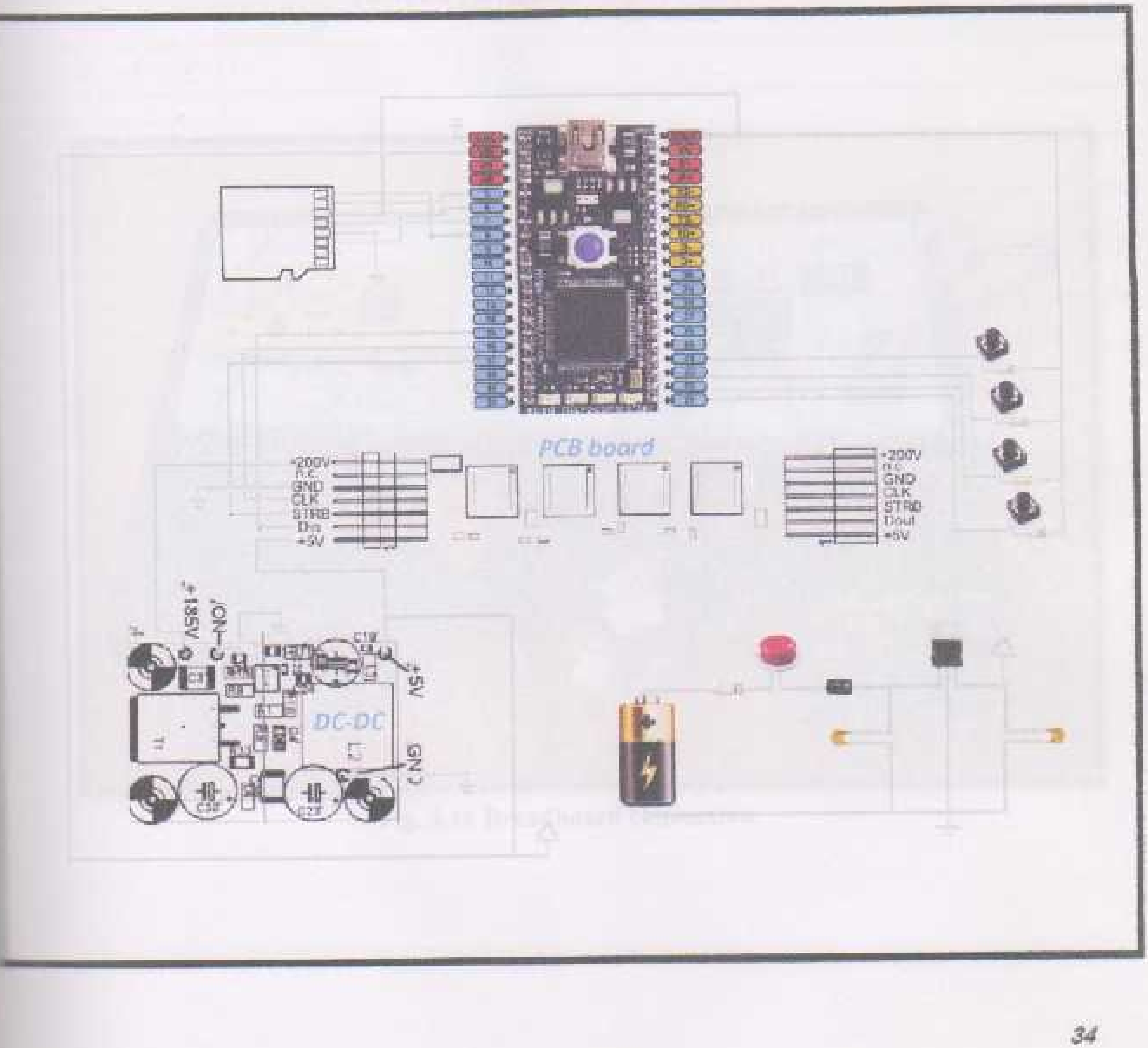


Fig. 3.15 Schematic diagram of the system

The navigation keys attached with digital I/O of Microcontroller as shown in the table 3.5 below:

navigation keys	Digital Input
Next button	P21
Previous button	P23
Previous page button	P24
Next page button	p22

Table 3.5 Navigation Keys Connections

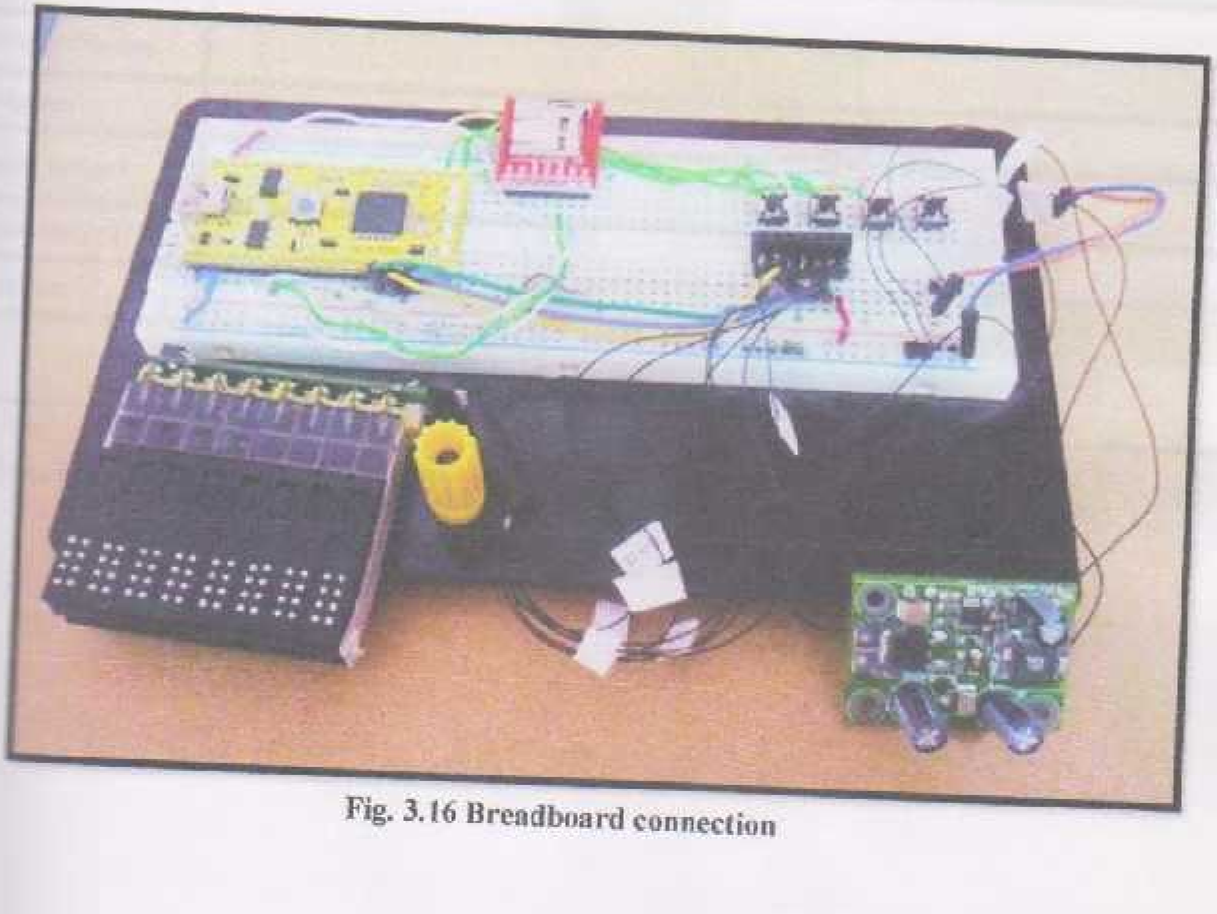


Fig. 3.16 Breadboard connection

3.5 Time Schedule

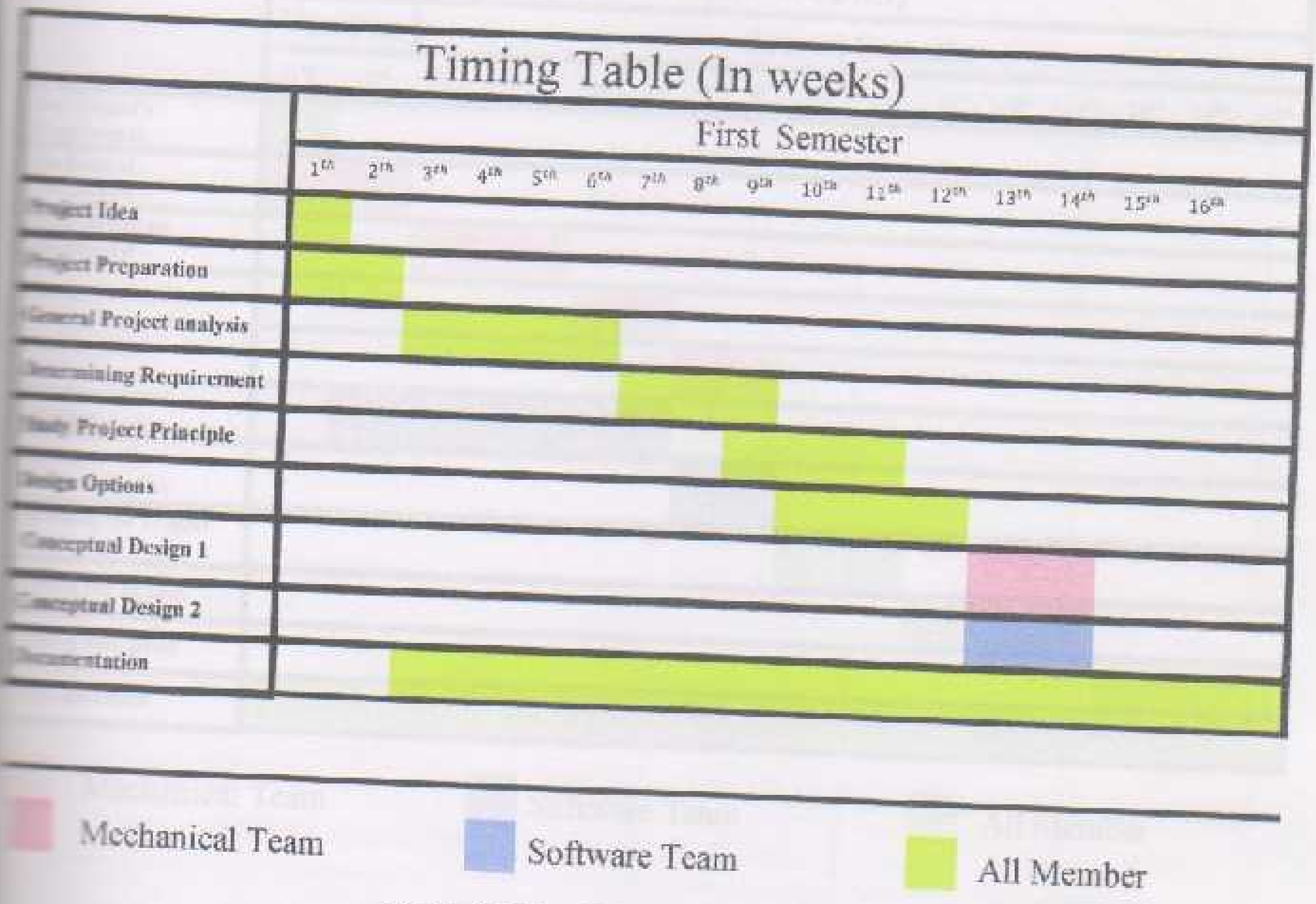


Table 3.6 Time Schedule -First Semester-

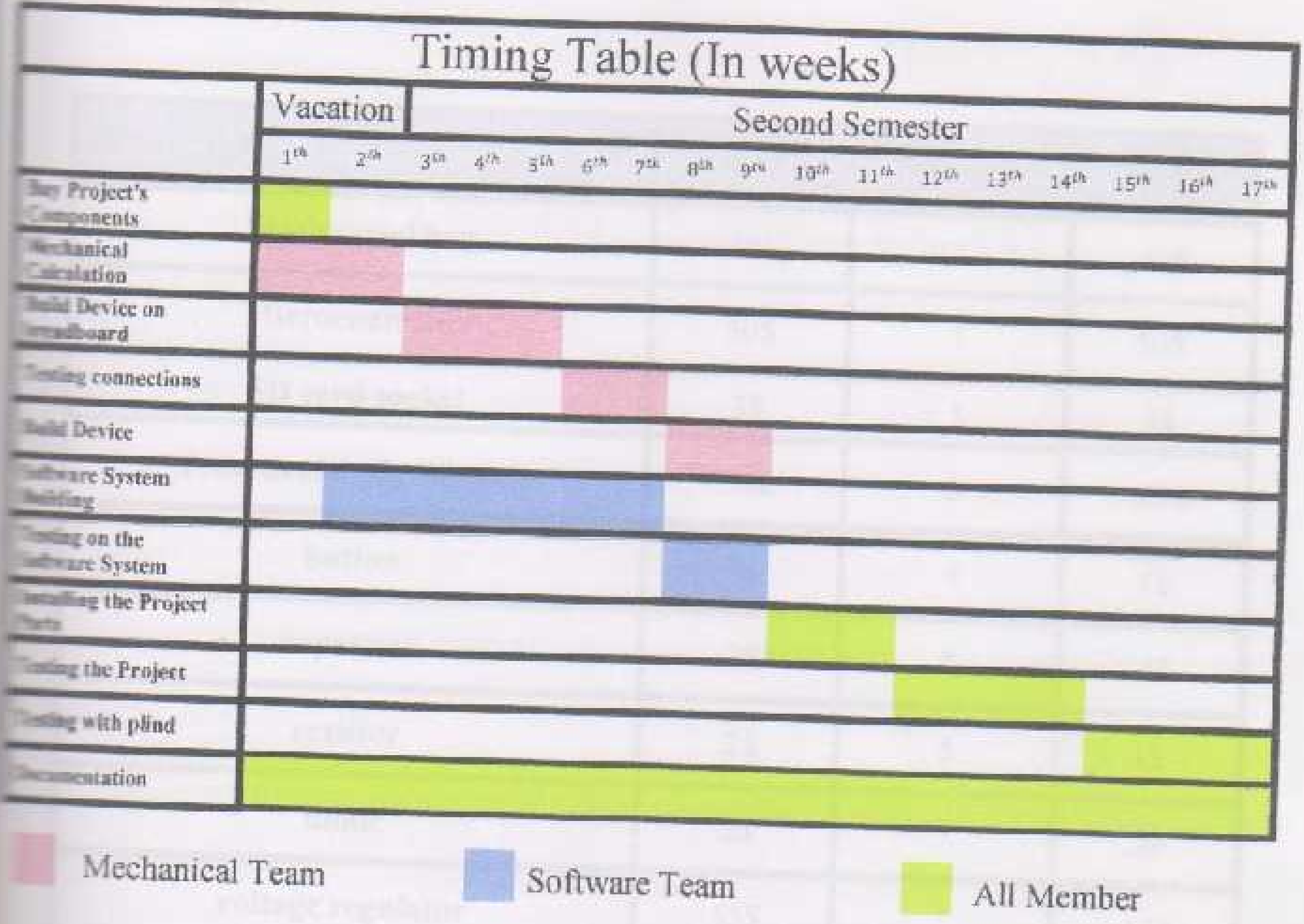


Table 3.7 Time Schedule -Second Semester-

3.6 Budget

Component	Price $	Quantity	Total
Mechanical box	40$	١	40$
Microcontroller	50$	١	50$
SD card socket	3$	١	3$
Piezoelectric Braille cell	50$	8	400$
button	1$	٥	5$
capacitor	.2$	٢	.4$
resistor	.2$	5	1$
diode	.2$	١	.2$
voltage regulator	.55$	١	.55$
Breakout Board	10$	١	10$
battery	3$	١	3$
Software (VS)	100$	١	100$
Dc-Dc converter	70$	1	70$
			683.15

Table 3.7 Budget

CHAPTER 4

Software System

4.1 Introduction

We certainly know that is not enough just to connect the microcontroller to other components and turn the power supply on to make it works. There is something else must be done. The microcontroller needs to be programmed to be capable of performing anything useful, therefore the project has two major subsystems, the hardware system and the software system, which they completely integrated to have an improved embedded system.

The device built includes an improved hardware supported with a complete high performance software tools. There were two main choices for microcontrollers that can be used in the implementation of the project. The MBED NXP LPC1768 and BEAGLEBONE; both of them are capable to deserve the features of the device. But we used MBED as our controller as mentioned in chapter three.

It manages to use the microcontroller as a part of the device connected to the USB port without any external supports. MBED NXP LPC1768 supported with C and C++ languages. mbed does a lot of optimizations on the software side and offers the ability to easy add high-level features to the device. Software system deals with the file entered to the device through the SC card port, and converting the contents characters to the ASCII Braille code which would be printed on the device.

4.2 Software System Implementation

In the software implementation process, initialization processing, data input processing from SD card or on the local file itself and data output to leads as Braille cell processing are considered.

4.2.1 Use Cases template

As shown in the Use-Case diagram in **Figure4.1**, the software programming would be in 3 phases. Preparation the text file, processing the file and printing in ASCII code.

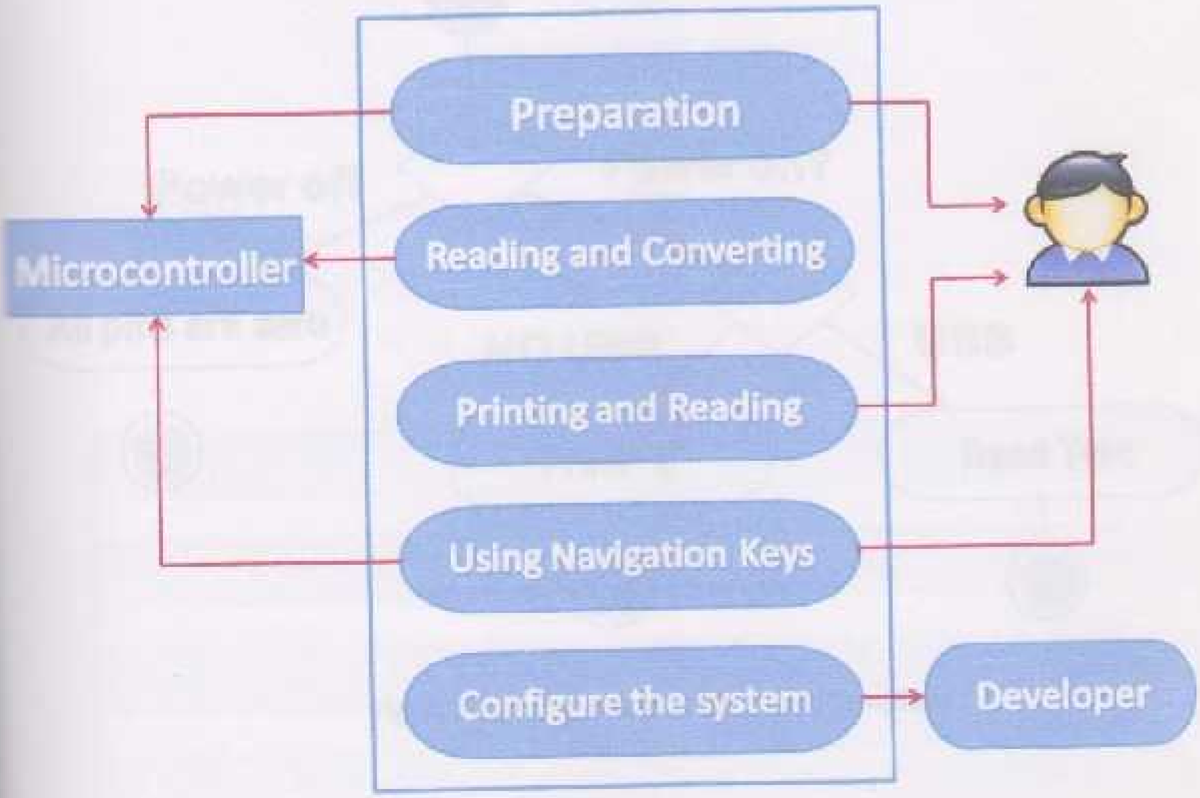


Figure4.1

Use-case:
preparing
Primary actor:
microcontroller
Secondary actor:
user

Preconditions:
power , existing SD card , exiting text file
Scenario:
User should turn the device ON, microcontroller check if the text files are exist in order to start processing.

Table 4.1 Use 1 Template

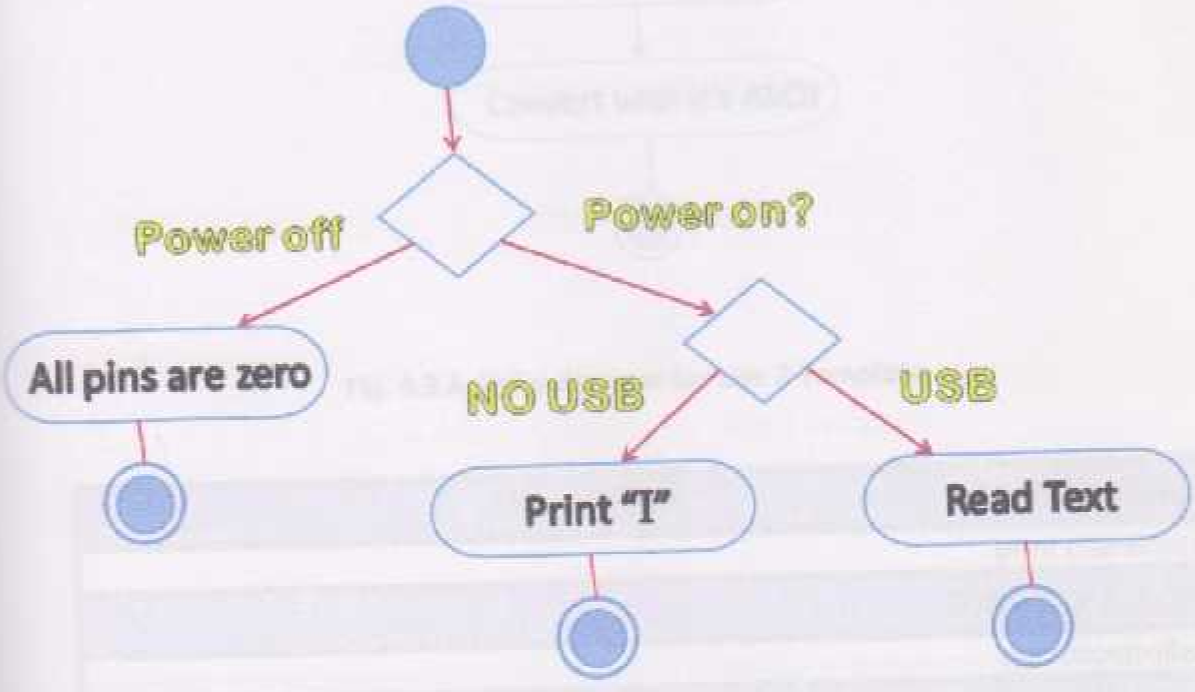


Fig. 4.2 Activity diagram for Use 1 Template

Use-case:
process the text file
Primary actor:
microcontroller
Preconditions:
Device in Ready status
Scenario:
microcontroller would read the first character in the text file and convert it to Braille ASCII code

Table 4.2 Use 2 Template

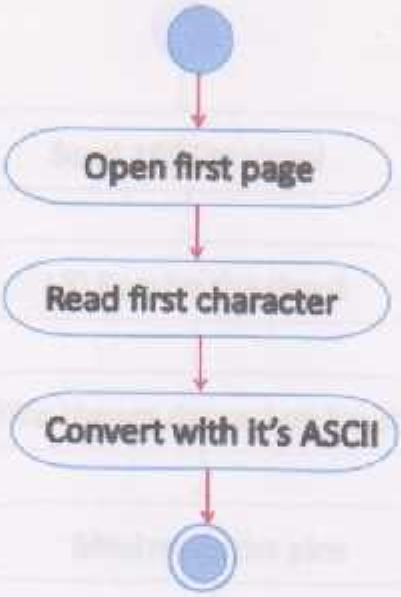


Fig. 4.3 Activity diagram for Use 2 Template

Use-case:
print characters
Primary actor:
microcontroller
Preconditions:
Read character
Scenario:
microcontroller would read the first character in the text file and convert it to Braille ASCII code and move the Piezoelectric cells

Table 4.3 Use 3 Template

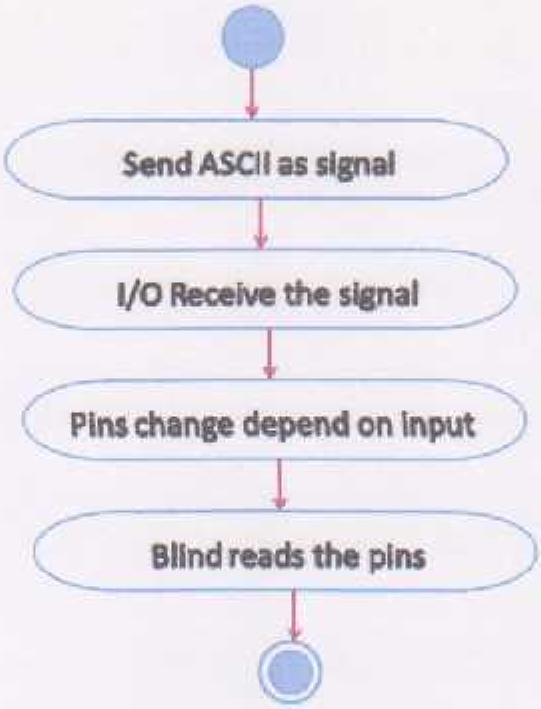
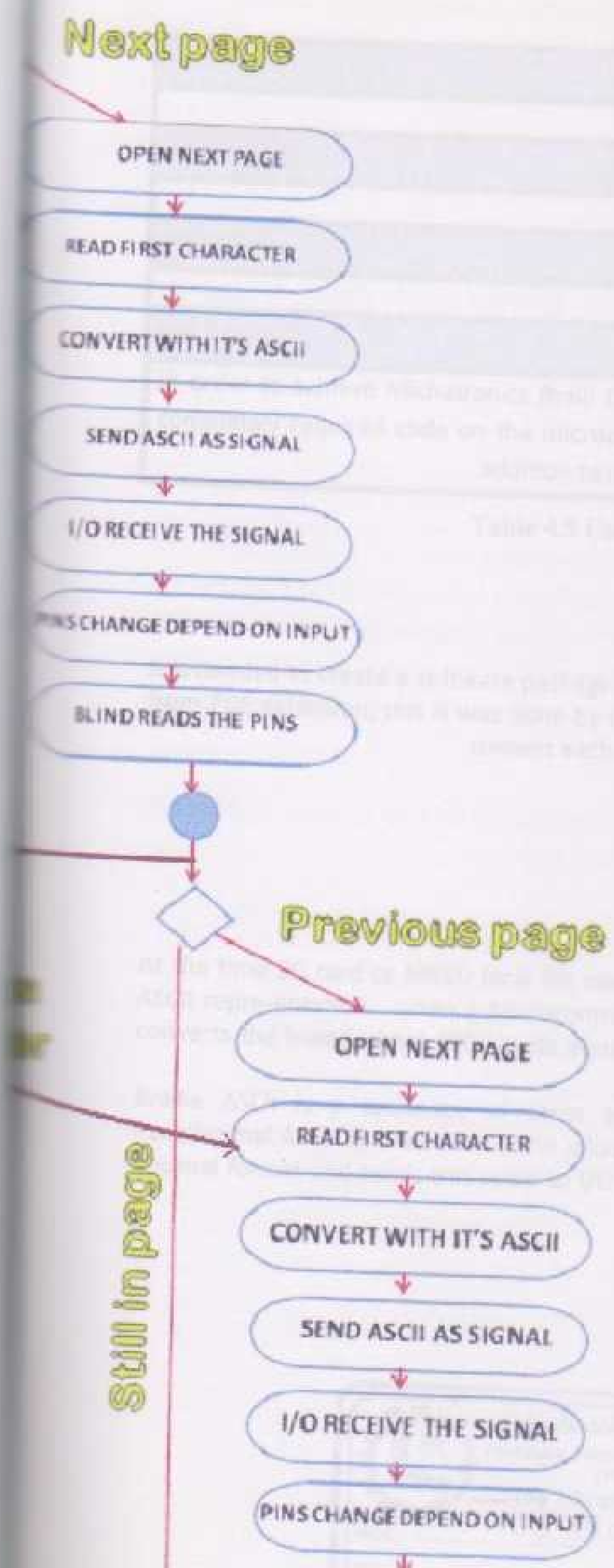


Fig. 4.4 Activity diagram for Use 3 Template

Use-case:
Use navigations Key
Primary actor:
User
Preconditions:
Reading first character
Scenario:
when user read the first character, he could move to any of Navigation Keys (previous/next character) and (previous/Next page)

Table 4.4 Use 4 Template



Next page
OPEN NEXT PAGE
READ FIRST CHARACTER
CONVERT WITH IT'S ASCII
SEND ASCII AS SIGNAL
I/O RECEIVE THE SIGNAL
PINS CHANGE DEPEND ON INPUT
BLIND READS THE PINS
Previous page
Still in page
OPEN NEXT PAGE
READ FIRST CHARACTER
CONVERT WITH IT'S ASCII
SEND ASCII AS SIGNAL
I/O RECEIVE THE SIGNAL
PINS CHANGE DEPEND ON INPUT

Fig. 4.5 Activity diagram for Use 4 Template

Use-case:
Configure the system
Primary actor:
Team of work on the project
Preconditions:
processing
Scenario:
In order to achieve Michatronics Braill Display, the software system should do the completely required code on the microcontroller, and force the predicted risks. In addition to improve other future features to the device.

Table 4.5 Use 5 Template

4.2.2 PDF Files Converting

It is needed to create a software package that contains a text file after converting it from PDF extension, this is was done by using a converter software program which convert each page in the PDF file to a separate text file.

4.2.3 Software Configuration

At the time SD card or MBED local file read a characters, it stores it`s hexadecimal ASCII representation. when a Microcontroller reads USB, it reads this ASCII then converts the hexadecimal ASCII to its equal binary Braille ASCII as shown in **Braille ASCII 6-Dot Table in chapter2.**

Braille ASCII is a sequence of zeros and ones, so after a converting from hexadecimal ASCII to Braille ASCII the microcontroller convert it to its equivalent in decimal format and sends this value to I/O ports in order to move the Piezoelectric up and down.

4.3 Microcontrollers

In the Previous semester we had multiple choices with using the suitable microcontroller, the choices were **BegaleBone** and **Mbed Board.** Each of them was have its facilities, but after the searching, we considered to use MBED NXP LPC1768 with C programming language online compiler.

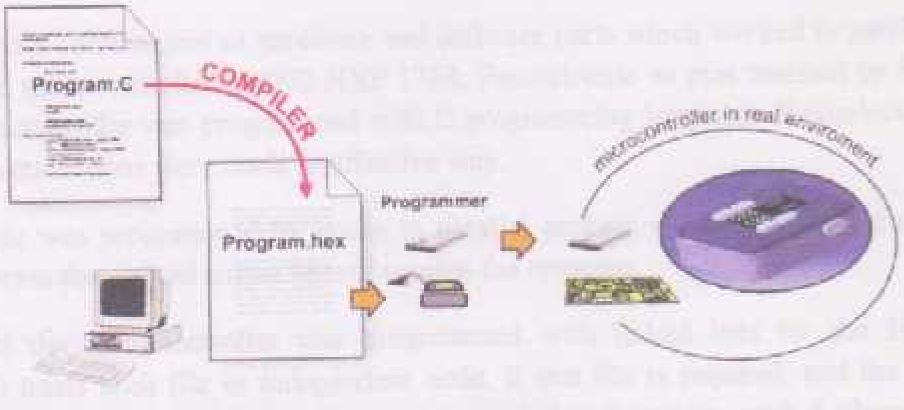
4.3.1 Mbed Board

The mbed NXP LPC1768 Microcontroller is designed for prototyping all sorts of devices, especially those including Ethernet, USB, and the flexibility of lots of peripheral interfaces and FLASH memory[17]

- **C Software Platform**

The Mbed Compiler provides a lightweight online C/C++ IDE that is pre-configured to let quickly writing programs, compiling and download them to run on the Mbed Microcontroller. The compiler uses the professional ARMC C compiler engine, so it produces efficient code that can be used free-of-charge. The IDE includes workspace version control, code formatting and auto-generation of documentation for published libraries.

We worked in our project on C language; it is far from complexity which is wanted in our work and it offers the required facilities in the code.



CHAPTER 5

Software Implementation

5.1 Introduction

We considered the importance of this project is coming from the depth of importance of the reading right to all humans even whose don't have eyes to read books and study.

We aimed from this project to design a device which permit blind student read any electronic text file they want. By that we have extracted our facilities in order to achieve our goal.

This device is a combination of hardware and software parts which worked in parallel process, we have used microcontroller MBED NXP 1768, Piezoelectric as pins touched by blind hands. MBED microcontroller was programmed with C programming language, Piezoelectric also. All the required connections were made in effective way.

Software code was programmed to works in parallel process with the hardware components. Once blind press the wanted button he will receive the response.

The code of the microcontroller was programmed with linked lists for the files and the characters, it treats each file as independent node, if this file is required, and the pointer was pointed to it. The other linked list was used to read the characters, each 8 characters are an independent node pointed by a pointer. On the other hand the response time of the piezoelectric was processed by the wait with the push buttons.

5.2 Software Parts

1. **Process on PC**

   The device will be provided with a software program which is a converter program from PDF format to text file formats, each page in the PDF file would be converted to a separate text file and saved it in an ascending order on the SD card or on the local file, local file is the storage space with mbed itself.

2. **Reading text files**

   Text file is read page by page and character by character, according to the received command such that, the programmed code receives commands from push buttons activated by device user , analyze them and send signals (presented characterizes) to piezoelectric. There are 4 choices in reading stage:

   - Next Page; if the blind want to move to the next page in his book
   - Previous Page; if the blind want to move to the previous page in his book.
   - Next Character; in this mode, piezoelectric represents each 8avharacters in parallel so that if the blind want to move to next 8 characters in the current page, he should press the button.
   - Previous Character; if the blind want to move to the previous 8 characters.

   If the button specialized to previous page was pressed, the code will call the responsible function and send signal to the piezoelectric pins and so on.

5.3 Structural Code

Pseudo code

```
Build a struct to store all text file a linked list;

Build a struct to store all text file a linked list;

Create a headFile pointer to points to the current chapter;

Create a headFileChar pointer to points to the current character;

Check file for"TXT" type
```

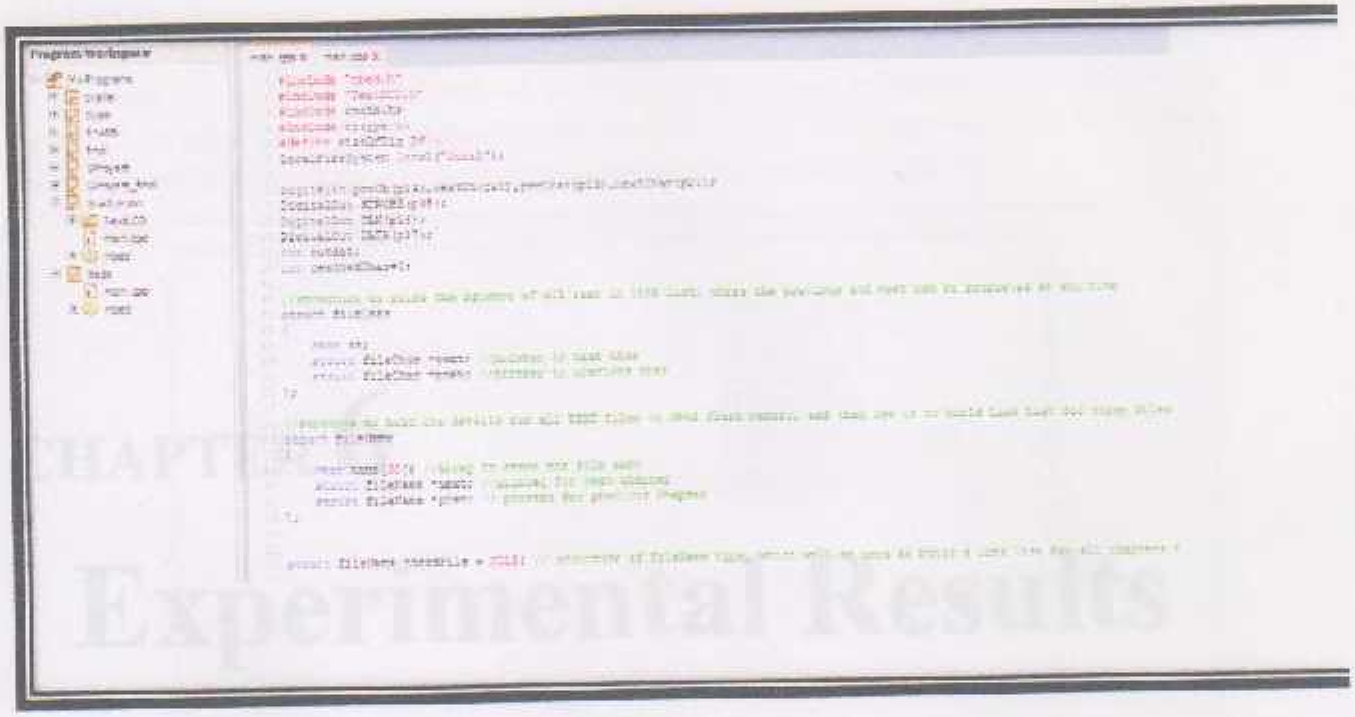
```
{
IF the end of the file name is with ".txt"
return file;
}
To Get all files Names
{ build a struct to hold details of retrieve file.
filename struct to build a linked list for file names
WHILE Files=1
{
IF file end with ".txt" and file != "DICTIONARY.txt"
Continue;
HeadFile pointer = first File;
} // End While

Create temporarily pointer; // temp
Set NextFile = Null;
temp->prev=ptr; // Set PreviousFile = temp pointer;
ptr->next=temp; // set Next chapter to next.
ptr=temp; // set the pointer to the last file.

Read File
{ create pointer;
Open the first file;
Pointer read the header
```

```
WHILE ( read != EndOfFile)
{
 read character;
headFileChar->prev=NULL;      //set the previous for the head pointer to NULL
temp->ch=ch; // set the read character to temporarly pointer.
temp->next=NULL; // set Next character to null.
temp->prev=ptr; // set next char for PTR to temp
ptr=temp; // set ptr to point to the last char
} END WHILE

Read Dictionary File
{
Open Dictionary file ; //  it`s a dictionary of binary aschii code to each character .
Read file
}
Get the binary value to a read character
{
Read character;
Search in the dictionary
Return binary value;
}
Store Data
```

```
{ convert binary value of character to decimal
}


Main ()
{
Read the Dictionary;
Read first file;
Read first character;
Call store data function [ current character];
Store in Data Array;

WHILE (1)
Call Piezo Function;
headFileChar=headFileChar->next;
IF (Next char ==1)
headFileChar=headFileChar->next;
getChar;
store current character in Data array;
END IF;

IF (Previous char ==1)
headFileChar=headFileChar-previous;
getChar;
```

```
store current character in Data array;

END IF;


IF (nect chapter ==1)

headFile=headFile->next;

END IF;


IF (previous chapter ==1)

headFile=headFile->previous;

END IF;

END WHILE;


Piezo Function

{

Set STROBE to pin 15;

Set CLK to pin 16;

Set DATA to pin 17;


STROBE =1;

For each Module; // Module = 8cells in paralle.
```

```
outdata =data[j];



FOR each Pin

{

CLK=0;

      { IF (outdata & 1)

        DATA=1;

      else

        DATA=0 ;

        }

END FOR


      Wait for 10 microsecond

   CLK=1;   }

END FOR.
```



CHAPTER 6

Experimental Results

6.1 Introduction

This chapter provides all the experimental stages for the system and its results, starting with stage 1 which we used leds as an output in the device representing one Braille cell, stage 2 which we used leds as an output in the device representing two Braille cells, stage 3 that includes testing Dc to Dc converter, stage 4 includes operating piezoelectric Braille cell and stage 5 which the whole device is tested as a complete system

6.2 Stage -1-

In this stage, we connect all the parts of the system as it shown in Figure 6.1,the system was consist of six leds as an output , that represent one Braille cell . This stage was made to check the logic of the software system, which presenting one Braille character on six leds.

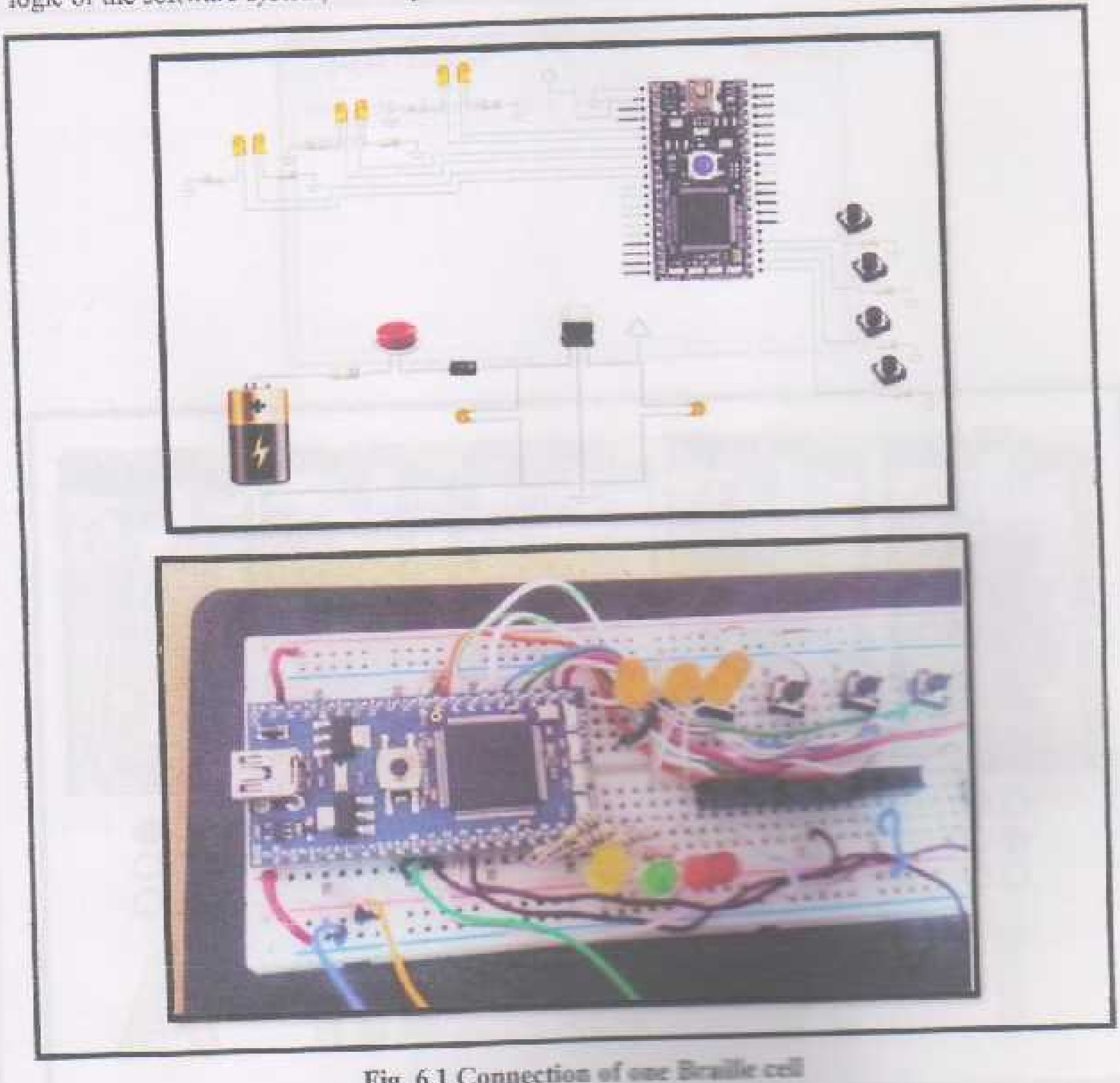


Fig. 6.1 Connection of one Braille cell

This stage starts with reading one character from text file located inside mbed internal memory, then the code converts the character to its representation in Braille ASCII,and send it to the mbed digital output pins.

After connecting the circuit and downloading the code in mbed, the test was made, and the results were applicable to our requirements form the code. As shown in figure 6.2, we write inside the page 1- text file located in mbed internal memory- name "Amani", so the first character was shown in the leds was "A" , then after clicking on NEXT button , the leds shows the next character which is "m" . Also we tested PREVIOUS button, which also run successfully.

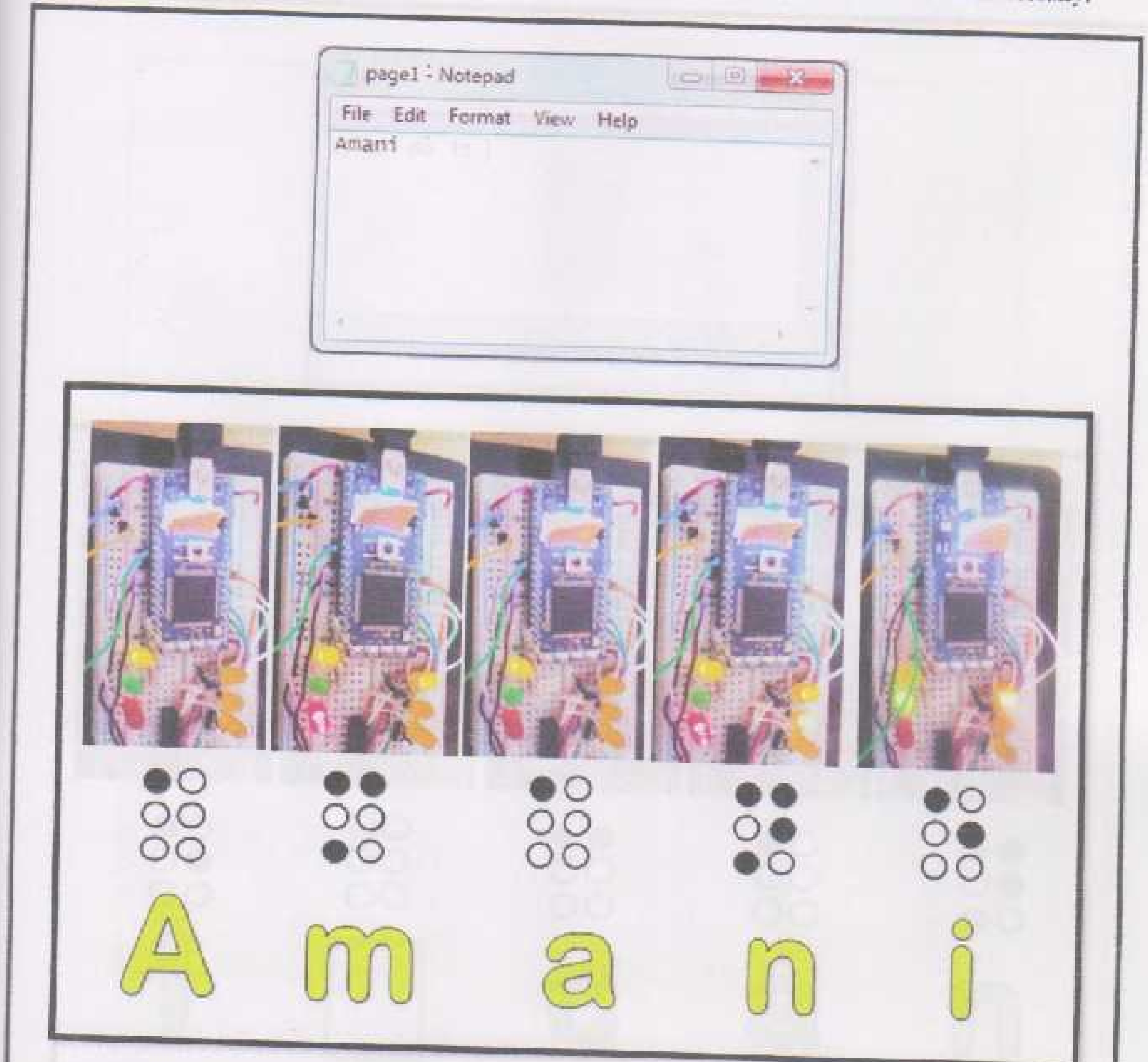


Fig. 6.2 Testing the code using six leds as one Braille cell –page 1-

Also we tested NEXT PAGE button, to go from page 1 to page two - text files located in mbed internal memory- , the page was contain " I can " characters , so the leds first represented alphabet "I" , then when we clicked on NEXT button , the leds represent null " " , figure 6.3 shows the representation. Also we tested BREVIOUS PAGE button, which also run successfully.

Fig. 6.3 Testing the code using six leds as one Braille cell –page 2-

6.3 Stage -2-

In this stage, we connect all the parts of the system as it shown in Figure 6.4,the system was consist of twelve leds as an output , that represent two Braille cell . This stage was made to check the logic of the software system, which presenting two Braille character at the same time.

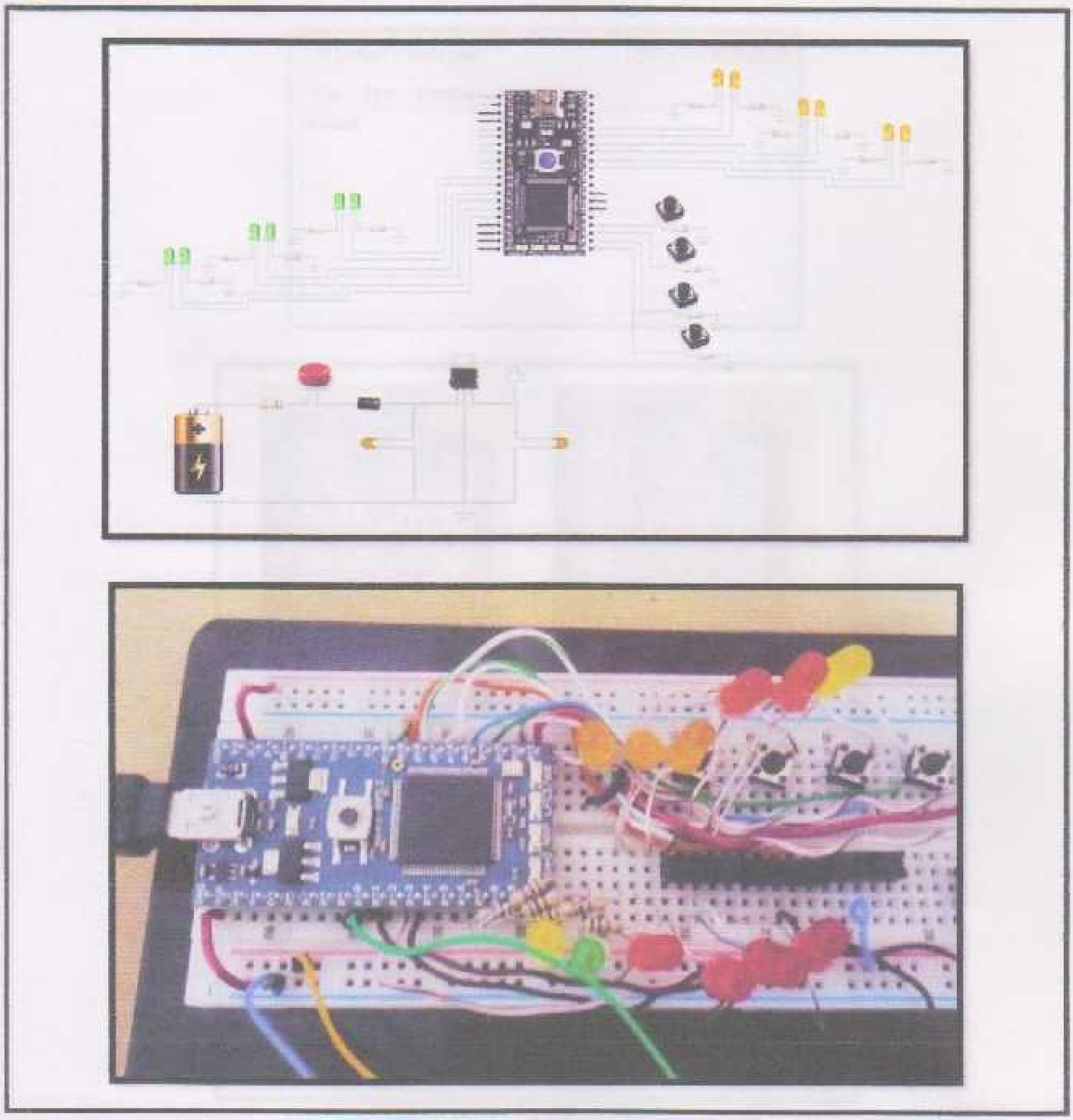


Fig. 6.4 Connection of two Braille cells

After connecting the circuit and downloading the code in mbed, the test was made, and the results were applicable to our requirements form the code. As shown in figure 6.5, we write inside the page 1- text file located in mbed internal memory- four characters "Aaba", so the first character was shown in the first six leds was "A" , and the anther six leds represent second character which is "a" After clicking on NEXT button , the leds shows the next characters which are "ba" . Also we tested PREVIOUS button, which also run successfully.

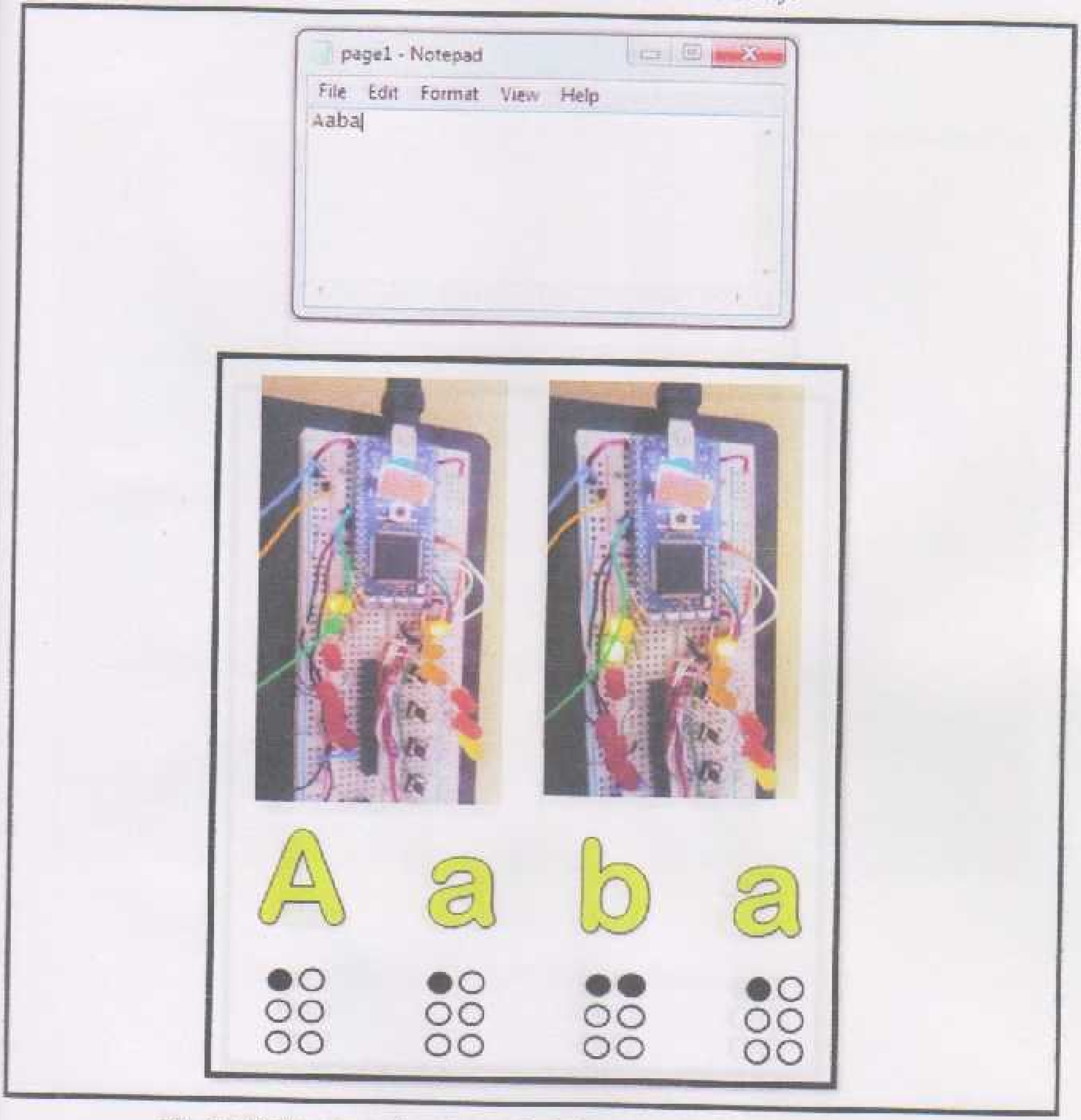


Fig. 6.5 Testing the code using twelve leds as two Braille cells –page 1-

Also we tested NEXT PAGE button, to go from page 1 to page two - text files located in mbed internal memory- , the page was contain " Bala " characters , so the first character was shown in figure 6.6, the first six leds was "B" , and the anther six leds represent second character which is "a" .After clicking on NEXT button , the leds shows the next characters which are "la" . Also we tested BREVIOUS PAGE button, which also run successfully.

Fig. 6.6 Testing the code using twelve leds as two Braille cells –page 2-

6.4 Stage -3-

After long waiting from January to last week in April we finally get the DC to Dc converter. In this stage, we connect DC- DC converter -that convert 5 Volt DC to 185 Volt dc- directly with power supply 5 Volt DC , to check the exactly output voltage for the converter before connecting it with piezoelectric Braille cells . from the test we see that the Dc to Dc converter convert from 5V to 186.4 V.See figure 6.7.

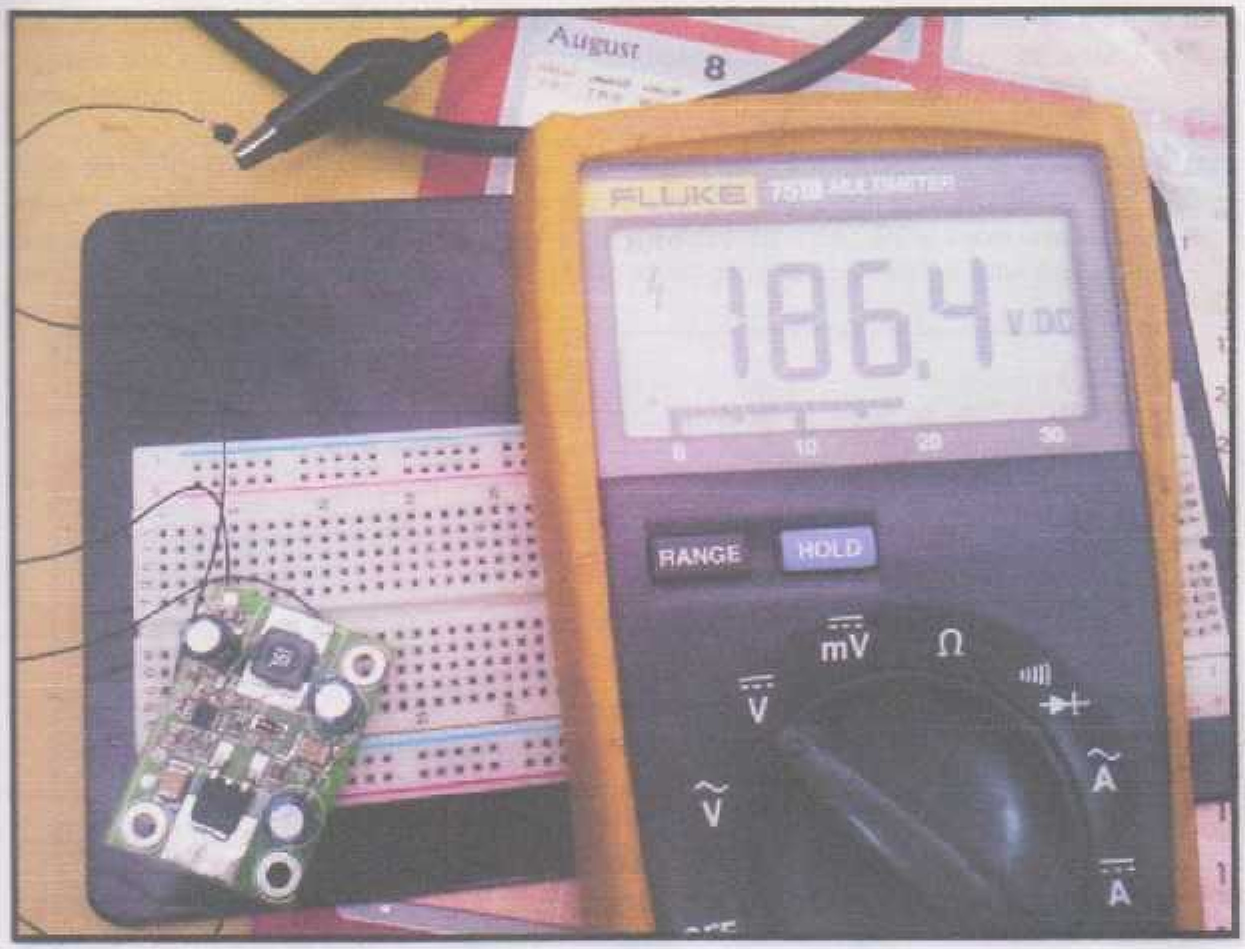


Fig. 6.7 Testing DC – DC converter

6.5 Stage -4-

This stage was the most difficult stage, because we were needed to operate and test piezoelectric Braille cells without having data sheet for the cells. All what we get from the manufacturing company was: the piezoelectric needs 200 volt to operate.

After connecting the piezoelectric with mbed, we start thinking how to program it. we noticed that the piezoelectric contain seven pins, three pins connected with microcontroller .The first pin called STRP which gives commands to the piezoelectric to start receiving data from the microcontroller, the second pin is CLK which represent the clock that control the time between sending the data as bits, third pin called Din which is transfer data from microcontroller to the piezoelectric cells. According on the names of these pins we start writing the code for the piezoelectric.

After finishing the first code, we were able to operate the piezoelectric but it give us random values , for example, when we send the representation of alphabet A in Braille ASCII to the piezoelectric ,the pins that raise up give us unknown representation . So to solve this problem we start sending 8 bits as shown in table 6.1, and see which pin rise up when we send these data.

01111111	○● ○○ ○○ ○○	11110111	○○ ●○ ○○ ○○
10111111	○○ ○● ○○ ○○	11111011	○○ ○○ ○○ ●○
11011111	○○ ○○ ○● ○○	11111101	○○ ○○ ○○ ○●
11101111	●○ ○○ ○○ ○○	11111110	○○ ○○ ○○ ●○

Table 6.1 Serial commands and its representation

Depending on the table 6.1, we make a relation between the serial commands and the pins that rise up , and then we find the relation between these commands with Braille ASCII code , as in table 3.4 also as in figure 6.8

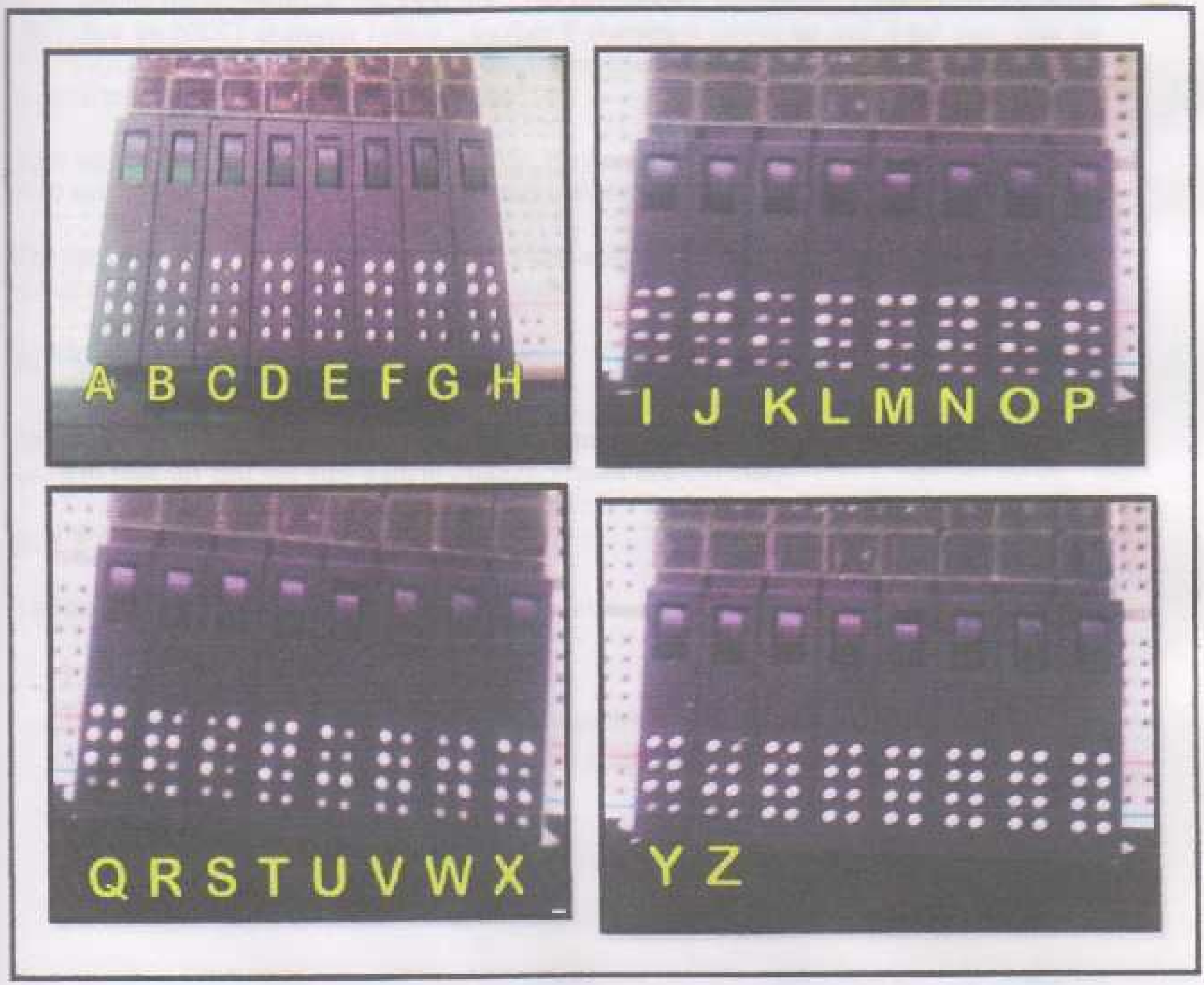


Fig. 6.8 Alphabet representation in piezoelectric cell

6.6 Stage -5-

In this stage we tested the whole system, starting from converting the PDF file to text files using easy PDF to text converter . Then downloading the text file to the mbed internal memory, and start reading the pages inside the local file . The device each time shows 8 characters .Once the user click on NEXT character button , another 8 characters shown up and if the user click on PREVIOUS character button , the previous 8 characters shown up . The same process will be applied to NEXT / PREVIOUS page buttons.

Also we tested the device with blind students , they respond positively , the device matches with their needs , and they were able to read the text inside the memory using the device .

The attached video in the CD shows the real experiment of the device with blind student , who tested the device and give us the feedback about it

6.7 Conclusion

The device is proved to be safe , easy for use , comfort , and suitable for blind people, they can use it to read any text file they want in English, French and Germany.

6.8 Future work

The following three tasks are suggested as future works:

1. Add Arabic language to the device
2. Add audio reader , to give the user voice command , and read the text option
3. Add writing option , and improve the device to be a note taker

References

[1] B. Stöger and K. Miesenberger. The conventional braille display - state of the art and future perspectives. In Computers Helping People with Special Needs (LNCS 860), pages 447–454, 1994.

[2] D. Blazie. Refreshable braille now and in the years ahead. Braille Monitor, 43(1), 2000.

[3] J. Roberts, O. Slattery, and D. Kardos. Rotating-wheel braille display for continuous refreshable Braille. In Digest of Technical Papers, Society for Information Display International Symposium , Vol. XXXI, pages 1130–1133, 2000.

[4] R. C. Petersen. Tactile display system. U.S. Patent No. 6,734,785, 2004.

[5] P. Yang. Electroactive polymer actuator braille cell and braille display. U.S. Patent No. 6,881,063, 2005.

[6] D. K. Biegelsen, W. B. Jackson, L.-E. Swartz, A. A. Berlin, and P. C. Cheung. Pneumatic actuator with elastomeric membrane and low-power electrostatic flap valve arrangement. U.S. Patent No. 6,807,892, 2004.

[7] H. Tang and D. Beebe. A microfabricated electrostatic haptic display for persons with visual impairments. IEEE Transactions on Rehabilitation Engineering, 6(3), 1998.

[8] J. Fricke. Substituting friction by weak vibration on a tactile pin array. In IEE Colloquium on Developments in Tactile Displays (Digest No. 1997/012), pages 3/1–3/3, 1997.

[9] C. Ramstein. Combining haptic and Braille technologies: Design issues and pilot study. In Proc. 2nd ACM Conference on Assistive Technologies (ASSETS '96), pages 37–44, 1996.

[10] American Foundation for blind, http://www.braillebug.org/braille_technology.asp

[11] A.Abualkishik, and K.Omar.The Quranic Braille System –Introduction-, page 1, 2009.

[12] J.Dixon Ph.D. , World Braille Usage –The Braille System : An Evolution of Literacy- page 7,1990 .

[13] H. Joshi, Braille –The Braille System : An Evolution of Literacy- page 7,1990 .

[14] http://wrb.home.xs4all.nl/Articles_2011/Article_WPFBraille6Dot_01.htm

[15] Arduino Uno
http://arduino.cc/en/Main/ArduinoBoardUno

[16] BegalBoard
http://beagleboard.org/bone

[17] MBED Microcontrollers
http://mbed.org/handbook/mbed-Microcontrollers

[18] P.Smithmaitire, Analysis and Designing of Piezoelectric Braille Display , 2009
[19] P.Smithmaitire, Analysis and Designing of Piezoelectric Braille Display , 2009
[20] Miniature high voltage dc-dc converters series GMA datasheet. Printed by Hitex Power Ltd Littlehampton West Sussex, in the United States of America.
[21] 16-channel serial to parallel converter with high voltage push-pull outputs. Hv509 data sheet. Printed by Supertex Technology, inc Sunnyvale, California in the United States of America.