Digital Braille Watch

Client: Colton and Holly Albrecht

Advisor: Professor Walter Block

Team members:
Team leader – Joel Gaston
BSAC – Ryan Kimmel
BWIG – Robert Bjerregaard
Communications – Allison McArton

Date: October 22, 2008

Table of Contents

Abstract

Currently the only portable devices that allow for the visually impaired to tell time are audible watches that "speak" the time and an analog watches that have different dots at the 3, 6, 9, and 12 positions in which the individual uses touch discrimination to determine the time. While these methods work, audible watches can be disruptive and tactile analog watches can easily be misread. Digital Braille clocks that exhibit Braille numerals do exist, yet these are not portable and are meant to stay at a stationary location. Last semester, a Biomedical Engineering design team undertook a project to create a digital Braille watch for a blind client. Utilizing four vibrotactile motors, the team created a device that displayed the time in Braille using a computer and a personal measurement device. While this design was a good start, the system was not contained into a portable unit and it proved hard for a visually impaired person to distinguish between the different vibrations. Thus, the goal for this project improve upon a digital Braille design and compact it into a small, portable system that can be read with minimal error. Future work for this semester includes calibrating the distance between motors, writing code in Basic STAMP for microcontroller functions, and determining the optimal power source for the system.

Problem Statement

The visually impaired currently rely on watches that audibly announce the time or tactile analog watches that must be carefully examined to tell time. These options can be disruptive, fragile, or prone or misreading. Our goal is to create a digital Braille watch that employs 24-hour notation to tell time, does not cause disruptions, and is robust enough to have a long service life. The Braille display must be sized so that the user can accurately and reliably distinguish the different digits displayed.

Background

Problem Motivation

Colton Albrecht, who is visually impaired, currently has a watch that audibly announces the time. Since he is in school, he has noticed that his watch can be a distraction to the class. Thus, Colton has requested a watch that is not audible and that he can use without any outside assistance. With this device, Colton can gain the independence he wants while at school and around the house. This device would benefit all children who are visually impaired that have trouble with reading analog Braille watches.

Braille

As the client is visually impaired, he is very practiced at reading the Braille alphabet.   Ideally the design will display the time using Braille representations of the digits zero through nine. A shown by figure 1, Braille numbers only use the top four units of a Braille cell, as opposed to the traditional six units.

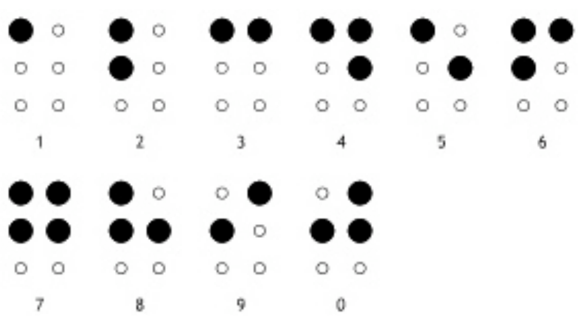

Figure 1: The Braille representation of digits zero through nine

http://www.pharmabraille.co.uk/images/braille-alphabet/braille-alphabet-numbers.gif

Competing/current products

There are a number of ways in which a visually impaired individual can determine the current time. The four most common methods include asking another person, reading analog Braille watches, audible watches, and digital Braille clocks. Though each of these methods allows the individual to ascertain the time, all have serious drawbacks.

If a visually impaired person needs to know the time, but does not own a device to aid in telling time, he or she can usually ask another person. This method of telling time may be sufficient in a few cases, but has obvious shortcomings. There are many instances during a normal day in which it would be both inconvenient and disruptive to inquire about the current time. Therefore, this method alone is not commonly used as the only way to establish the current time.

Two popular devices that are already available on the commercial market are the analog Braille watch and the audible watch. Analog Braille watches are often chosen because of the relatively simple design and the relatively inexpensive cost. The design's major flaw becomes evident once the person tries to read the time, however. These watches are easily misread, as one must be able to accurately orientate the two differently sized hands on the watch face that already contains an arrangement of bumps signifying the hour.

Figure 2: An Analog Braille Watch

http://www.geocities.com/Eureka/Concourse/3294/cortblind.jpg

The other popular device is the audible watch. Most audible watches appear very similar to popular digital watches, but contain a button that activates an audio output of the current time. The advantage of this design is that it is almost impossible to misread the time, because it is read aloud to the user. The disadvantage is that the sound that enables the user to tell time can also be distracting to others, especially in a quiet setting.

The final method for a visually impaired person to tell time is to use a digital Braille clock. The Kentucky Department for the Blind has already designed and built a "Braille Digital Clock Calendar" that displays the current time using six Braille cells – two for hours, two for minutes, and two for seconds. This design has two advantages, but one major disadvantage. The Braille Digital Clock Calendar is easy to read and is not distracting to others but is most definitely a clock, not a watch. The product measures 7x5 inches, and is one 1.5 inches thick. This is definitely not watch size. The parts for the device cost around $600, not including labor, a cost well out of our price range.

Design Constraints

The following requirements must be met throughout the design process:

1. The watch display must utilize traditional Braille numbering.
2. This must be able to fit on the wrist or in the pocket, so it must be small, and all of the components must be internalized.
3. Military time must be used – hours are to be displayed based on from 0 to 24 throughout the day.
4. The dots that are on the watch face must be positioned appropriately so the user can distinguish between them to be able to tell the time.

5. The watch must be quiet – there must not be a system that the watch announces the time, and all components must not make disruptive noise.
6. SAFE – the watch must not cause any harm to the user.
7. Aesthetics – The watch must be comfortable to the user.

Previous Design

Last semester, a BME 301 design team started this project. They came up with several different designs but ultimately decided upon a vibro-motor design. By using four small motors (as shown in Figure 3), the team had the ability to create a Braille representation time by turning on and off the motors in accordance the number desired. For example, the Braille portrayal of the number one is a single dot in the upper left, so to display this number; the upper left motor would vibrate while the others remain off.

Figure 3: A shaftless vibrating motor that draws small amounts of power in order to vibrate.
http://www.sparkfun.com/commerce/product_info.php?produ cts_id=8449

In order to keep track of time and convert this digital time into a Braille depiction, the previous team developed a program in the language Delphi 5, similar to Pascal (Tang et al., 2008). To depict the computer program output on the vibrating motors, the team used a personal measurement device (PMD). A PMD has the ability to take in either digital or analog signals and create output with varying voltages (2008). They were able to successfully output digits to the vibrating motors using military time as to not confuse AM and PM times. They used two digit outputs for the hour and two for the minutes. In order to distinguish the four numbers, the team also incorporated a one second pause between the different displays. The final output of 7:35am would produce zero, pause, seven pause, three, pause, five through the different vibrations.

This project will continue with the vibro-motor design. While last semester's team had numerous breakthroughs, there are many things that should be improved upon this semester. First of all, the client had problems distinguishing some numbers from others due to poor calibration of the vibrating motors. This will ultimately need to be fixed in order to continue with the project. Without a functioning output system, there is no use creating the device behind it. Lastly, the entire infrastructure needs to be incorporated into a small and portable device, to make the system available for everyday use.

Alternative Design Descriptions

Flip Cover

For this design, a flip cover would be placed over the face of the watch. This cover would serve a dual purpose; it would protect the face of the watch from outside forces such as rain, and it would also activate the vibro-motors. To activate the circuit, the cover would, in effect, act as a switch. When it is flipped open, it would simply closed circuit, allowing current to flow. The major advantage of this design is that a flip cover is already incorporated in the final product, and few other supplies would need to be added. In addition to this, the user would know that once the flip cover is open, no other stimulus is needed to display the time. However, there are a few disadvantages to this design. The flip cover could be susceptible to being caught and broken off, leaving no way to turn on the motors. Also, this could be a difficult switch to construct, and it may not always function appropriately. Finally, there would be a time delay between the cover opening and the user placing his or her fingers on the watch face, so this issue would need to be incorporated into the programming.

Button Underneath the Watch Face

In this design, a button would be placed underneath the watch face. When the user wants to know what the time is, all he or she would have to do is press down on the watch face. There are many advantages to this design. First and foremost, the used would not need to remember any special location or technique for activating the motors; the button would be conveniently located under the location of the motors, so the user would undoubtedly know how to read the time. There would also be no need to incorporate a time delay between activation and display into the programming. This is because the user will already have his or her finger on the face of the watch, so the finger would not have to be moved from a different location to the motors. However, if the protecting flip cover is open, the button could get inadvertently pressed, which would deplete the battery life.

Button on the Side of the Watch Face

This design incorporates a button placed on the side of the watch face. When the user wants to know what the time is, he or she would have to press the button and then place the finger over the vibro-motors. This would be a very easy system to implement, because it would only require a simple button switch. There are several disadvantages to this design, however. The user would have to remember where the button is located, which could be inconvenient. Also, as this the button under the watch face design, the button could get inadvertently pressed, which would deplete the battery life. Finally, as with the flip cover design, a time delay would have to be incorporated into the programming, since the user would have to move his or her finger from the button to the watch face.

Design Matrix

We chose to make our design matrix about methods for activation, because the previous team working on this product already determined most of the other elements of the design. The method of activation is a very important aspect of our design, mostly because this is how the client will interact with our product. If our product is not user friendly, the client, and anyone else interested in purchasing a digital Braille watch, will not stay interested and that particular design will not be marketable.

Table 1: Design Matrix

Criteria		***Possible Designs***		
Considerations	Weight	Flip Cover	Button Under	Separate Button
Safety	**5**	*5*	*4*	*4*
Cost	**5**	*3*	*4*	*4*
Durability	**25**	*18*	*22*	*22*
Feasibility	**35**	*25*	*30*	*32*
Ergonomics / Human Factors	**30**	*20*	*27*	*15*
TOTAL	**100**	*71*	*87*	*77*

The three design possibilities were analyzed based on safety, cost, durability, feasibility, and ergonomics / human factors (Table 1). Safety and cost were chosen to be weighed out of 5 points, because they are very small characteristics of this design aspect, and all three designs would have results that are very similar. Next, durability was weighed out of 25 points. The designs for the button under the face and the button on the side scored equally high, because these simply button designs should not pose much of a issue. However, the flip cover design scored less, because since it could get broken off, a main component of the circuit would be lost.

Next, feasibility was scored out of 35 points. The button on the side design seemed to be the most feasible, since it involves only a simple button switch. The design for the button under the face scored slightly less, because it too involves a simple button, but it could be more difficult to mount the face on top of the button. The flip cover design scored last, because although this is a good design, it may be very difficult set up a reliable switch with this method. Finally, the designs were analyzed based on ergonomics / human factors for a total of 30 points. The button under the motors is the best design ergonomically, because it is extremely easy for the user. The flip cover design is next, because a cover already has to be used in the design, so it would be very useful in the design. However, there would be an issue with a time delay and placing the finger over the motors in the set time in order to ready the current time. The button on the side design was last, because this would be difficult, because the user would have to remember its location.

Based on these factors, it was decided that using a button underneath the watch display would be the best design as a method for activating the vibro-motors.

Proposed Design

The difficulty and time constraints, as well as client requirements, necessitated that the vibro-motor design from the previous design team would be implemented, but improved in several distinct ways. First and foremost, a clock chip will be used as the time counter. This allows for extremely accurate time readings, as well as drastically reducing the size of the components, making the device a true wrist/pocket watch. Secondly, a microcontroller will be used to implement a program that will activate the correct vibro-motor sequence. Finally, when the vibro-dots are pressed down a switch will activate the microcontroller process of displaying the correct time.

The basic circuit to display the time consists of five circuit components: a clock chip, a ROM chip, a microcontroller, and a field-effect transistor, and the vibro-motors (Figure 4).

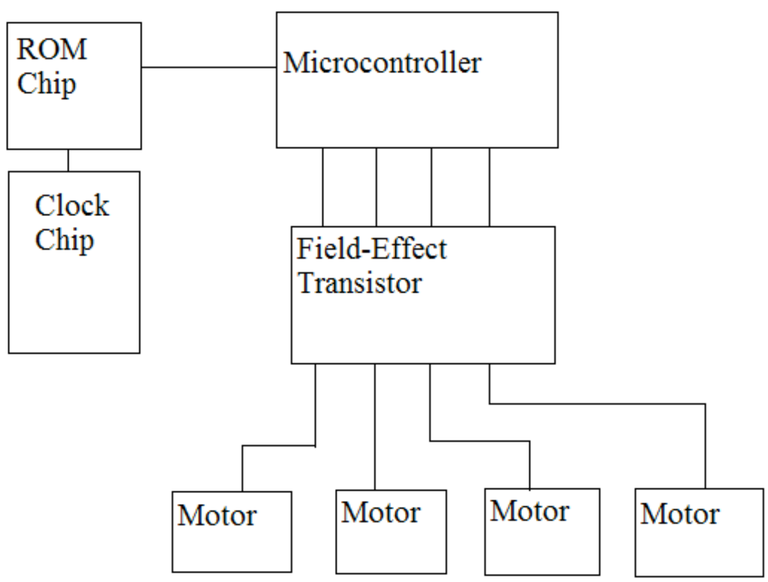

Figure 4: Potential layout for watch components

The clock chip to be implemented is a Dallas Semiconductor DS1315-5+, an integrated 16-pin time chip ("DS1315 Phantom Clock Chip"). Though many clock chips contain a quartz crystal oscillator to count the time, the chosen model does not. A crystal oscillator works by oscillating at a specific frequency when an electric current is applied to it. In the case of a clock chip, this frequency corresponds to 1/100 of a second, which allows the clock chip to increment the present time each hundredth of a second. The crystal oscillator, which must have a load capacitance of 6 pf and oscillate at 32.768 kHz, will be attached to two input pins on the clock chip. Though the clock chip lacks an internal crystal oscillator, it was chosen for several important reasons. This chip already has a preloaded program that takes the input from the crystal oscillator and increments the existing time, making it unnecessary to write a new program to do this. The chip is also inexpensive (~$15), and one can be obtained as a free sample. Lastly, the chip is completely lead-free, making it non-toxic to the wearer. The ROM chip will be used to store the current time, and will greatly facilitate interfacing the microcontroller with the clock chip. The ROM chip will also store the correct time in the event that power flow to the clock chip is interrupted (i.e. the battery runs out of power). Though not a necessary component, the ROM chip will massively improve the ease of writing the microcontroller program.

The microcontroller program will be written in the Basic Stamp programming language, and will convert the time from the ROM chip into a form that can be displayed with the vibro-motors. When activated, the microcontroller will receive a single time string from the ROM chip containing the time of activation (Block, W). This time string will be broken down into hour and minute values, which will be compared to the Braille numbering system. The microcontroller will then use this data to construct an analog output to send to the vibro-motors, forcing them to vibrate in accordance with the Braille digit being displayed. A field-effect transistor will be placed between the microcontroller and each vibro-motor, preventing current from flowing to the motors when not in use (Morrow, M).

As indicated by the design matrix, the microcontroller program will be activated when the user pushes down on the vibro-motors. The vibro-motors will be mounted in a platform, which will be placed above a push-switch. When the user pushes down on the vibro-motors the platform will lower, causing the switch to be depressed and the program to be activated.

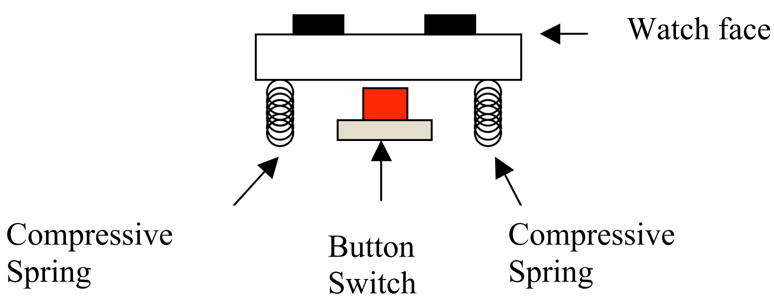

Figure 5: Method of Activation – button underneath watch face

Future Work and Testing:

Basic Stamp has been chosen for the programming language due to its ease of use and compatibility with microcontrollers. In the near future, a program must be written and tested to instruct the microcontroller to grab the time from the ROM chip/clock chip and convert this bit stream into a digital time.

As previously mentioned, the point discrimination between the four motors will have to be precisely calibrated through testing with the client. A happy medium must be found so that the dots are not too far apart in which the client cannot read the entire digit in one quick sweep of the finger; yet the motors cannot be too close together as they were in the previous design so that the vibrations are indistinguishable. Using the client to carefully assess the best possible distance between the vibrating motors will allow for minimal human error while reading the device.

Once all the components are obtained, power consumption will have to be thoroughly tested. With the combination of the vibro-motors, the clock chip, and the microcontroller, there power consumption could vary greatly. The maximum power drawn at any one time during use will have to be determined as well as the "resting" power consumption. A graph will easily illustrate the different power consumptions on a day-to-day basis with variable amounts of usage taken into account.

Once the power consumption model is successfully illustrated, a battery size and type will have to be selected. Once the battery is chosen, more testing will have to be utilized. By using an estimation for daily checking of the watch and the resulting average power consumption, it can be determined the battery's life span before replacement is needed. This will help ultimately figure out how many changes will need to occur during the client's desired 10-year shelf life.

Appendix A: Product Design Specifications

Product Design Specification for BME 300 Group 33: Digital Braille Watch (As of October 22, 2008)

Group Members: Joel Gaston, Robert Bjerregaard, Alison McArton, Ryan Kimmel

Problem Statement:

The visually impaired currently rely on watches that audibly announce the time, or tactile analog watches that must be carefully examined to tell time. These options can be disruptive, fragile, and prone to misreading. Our goal is to create a digital Braille watch that employs 24-hour notation to tell the time, does not cause disruptions, and is robust enough to have a long service-life. The Braille display must be sized so that the user can accurately and reliably distinguish the different digits displayed.

Client Requirements:

- Digital military time watch
- Watch must fit on the wrist, or in a typical pocket
- Silent system
- Braille numbering must be used to display the time

1. Design Requirements

The device must meet all of the client requirements

a. *Performance requirements:* Audible noises must not be emitted from the watch

b. Safety: The watch cannot contain toxic materials, and all wires must be internal

c. *Accuracy and Reliability*: The watch must tell time to an accuracy of one minute

d. *Life in Service*: The watch must have a life-span of several years

e. *Shelf Life*: The watch must have a shelf life of 10 years

f. *Operating Environment*: The device must be able to operate in a dry environment and be able to endure water, humidity, and temperatures between -30 and 50 degrees Celsius

g. *Ergonomics*: The device must be able to be worn or carried as a pocket watch, and should not have any rough edges or loose electrical components

h. *Size*: The watch must fit in a typical pocket

i. *Weight*: The device must weigh at most .2 kilograms

j. *Materials*: The device must be comprised of non-toxic components

k. *Aesthetics*, *Appearance, and Finish*: The watch must be aesthetically pleasing

2. Product Characteristics

a. *Quantity*: Only one working prototype. Could be mass produced based on demand and performance.

b. *Target Product Cost*: Unknown at this time

3. Miscellaneous

a. *Standards and Specifications*: The client has a patent pending
b. *Customer*: The customer would like a device that physically displays the time using Braille digits. Possible functions include a power-saving function and a flip cover
c. *Patient Related Concerns*: None
d. *Competition*: Watches for the visually-impaired are commercially available, in both audible and analog Braille varieties

References

Block, W. Personal Interview. 10 Oct. 2008.

"DS1315 Phantom Clock Chip." 21 Oct. 2008. <http://www.maximic.com/quick_view2.cfm/qv_pk/2692/t/al>

Morrow, M. Personal Interview. 10 Oct. 2008.

Tang, A., Raju, V., Boumeester, A., & Loherentz, A. (2008) "Digital Braille Watch."

Wayne D. Thompson, Kentucky Department for the Blind, <http://www.blind.ky.gov/Technology/BrailleClock/clock_description.txt> Retrieved 24 Sep. 2008