The TouchType

A Mobile Communication Device for the Blind and Deaf-Blind
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ABSTRACT
The TouchType is a Braille texting device that will be able to send and receive text messages from any other mobile device that implements the Global System for Mobile Communications (GSM) standard. The user will be able to read a message through a single-character solenoid system. Along with reading messages, this device will also be able to send messages through a Braille keypad. The user interface will also allow for other common mobile phone operating functions, including speed dial, volume control, headphone input, and notification through vibration.

INTRODUCTION
In the United States, approximately 2.5 million people are legally blind [1], and of those, 70,000-100,000 are also deaf [2]. Worldwide, 314 million people are visually impaired, 87% of whom live in developing countries [3]. In a world that uses the senses of sight and sound to communicate, having neither can make living an independent life an enormous challenge. The methods and devices currently available to deaf-blind people for communication often lack in versatility and fall short of what is required by the users. Communication methods not involving technology are only applicable and effective when the conversation is face-to-face, and when all participants in the conversation know the method being used. Also, much of the technology that is available for communication for the deaf-blind community is prohibitively expensive [4] and not very portable. All of these factors limit the independence and productivity of people who are blind and deaf-blind. Many of the devices used by the deaf-blind are the same, or have been adapted from devices used by the blind for communication. While the blind certainly have more options for effective technological communication, the blind community still faces challenges with technology; much of which is still too expensive.
The TouchType proposes a new solution to the problem of non face-to-face communication for people who are deaf-blind, while providing another option for communication for those who are blind. This device is a mobile GSM device that allows for deaf-blind people to communicate via Short Message Service (SMS) or Teletype (TTY) by sending and receiving text messages. Worldwide, mobile subscriptions have reached the equivalent of 50 percent of the population [5], which shows that this technology is becoming more and more affordable to people everywhere.

The TouchType would have an impact on the overall ability for people who are blind and deaf-blind to communicate clearly with people who are not familiar with methods of communication used by blind and deaf-blind people. The cost to manufacture this device would be much lower than the options on the market today, which goes hand in hand with mobile technology. The technological implementations described below would improve the quality of life for those who use it by allowing them to be more independent and mobile.

**HARDWARE REQUIREMENTS**
The TouchType will be a battery powered device with physical dimensions that will not exceed 6”×3.5”×1.5”. Since this is a mobile device, size is of great importance to the user. With maximum dimensions such as these, the user will be able to charge the device whenever they need and wherever they go. *Figure 1* illustrates the device’s rendered physical design.
The TouchType implements a microcontroller (MCU) that is in constant interaction with a GSM quad band module, a Braille keypad, a Braille display system, a headphone jack, a text-to-voice module, a speed/volume control, a vibrating motor, and a dual power supply. While the GSM module provides the device with a communication gateway, the other hardware features allow the user to interact with the device in an efficient and effective manner. This device also utilizes a rechargeable battery in conjunction with a dual power supply integrated circuit (IC).

The TouchType will employ the Freescale MC9S12DP512 MCU for every realizable feature within this design. The MCU has a 16-bit bus system that operates at a maximum frequency of 25 MHz, and also contains 512K bytes of Flash EEPROM, 14K bytes of RAM, and 2K bytes of EEPROM. The important features that come along with this particular MCU are the three serial peripheral interface (SPI) ports, the two asynchronous serial communication interface (SCI)
ports, and the 49 general purpose input/output (GPIO) ports. There are other available features on the MCU; however they are of little importance to the device’s design. *Figure 2* illustrates the device’s general functional diagram.

![General Functional Diagram](image)

*Figure 2: General Functional Diagram*

The GSM quad band module will allow communication between both the TouchType and any mobile device that utilizes the GSM standard. The general packet radio service (GPRS) standard is the most up-to-date subgroup of GSM implementation; therefore this module would also have to support GPRS. Since 3\(^{rd}\) generation (3G) telephony has become a standard among cellular phone providers, this enables the user to take advantage of these newly acquired data rates. This module will communicate with the MCU through a set of SPI ports and will utilize only one GPIO port.

The custom Braille keypad, illustrated by *Figure 1*, will allow easy functionality between the user and the device. This keypad will include 14 buttons that will serve as alpha-numeric
buttons, one of which will serve as punctuation for the message to be sent. While these buttons allow the user to enter messages for a transmission, the three smaller buttons serve as function buttons. The button with a face on it serves as a “contacts” button, while the two in the upper left-hand corner of the device from left to right serve as “yes” and “no” buttons, respectively. These buttons will interface with the MCU using matrix connections, which cut the need for GPIOs down from seventeen to nine.

The custom Braille display system will allow the user to read the message received using a system of six solenoids that will spell out the message by means of the Braille language. An octal solenoid driver will be used to produce enough power to elevate the solenoids to display the corresponding characters embedded in the received message. This driver will allow each separate solenoid to be powered by the +5 V source, and the power required for each solenoid is less than 1 W per elevation. Since the driver is powered by +5 V, the solenoid power requirements have been added to what is needed at the dual power supply’s +5 V output. This display system will communicate with the MCU through a set of serial peripheral interface (SPI) ports and will utilize two GPIO ports.

The headphone jack will allow the user to plug in a pair of 50 Ohm headphones with a standard 3.5 mm plug-in jack. The MCU will monitor the load characteristic of this part of the device so that it may choose when it is appropriate to change the device’s state from deaf-blind mode to blind mode. With a standard voltage divider circuit, this application is easily realizable. This headphone jack system will communicate with the MCU by utilizing only one GPIO port.
Unlike the other modules and systems of the TouchType, this system will also cooperate with the voice-to-text module which is described in the following paragraph.

The text-to-voice module works in cooperation with not only the MCU, but also the headphone jack. The only time this module is enabled is when there is a realizable load at the headphone jack. If there is no load at the headphone jack, this module is in standby mode for minimal power consumption. The main purpose of this module is to convert incoming text messages, via GSM, GPRS, or TTY, and to convert those characters into phonetic tones. These phonetic tones must be understandable to the user; therefore a library of common words will be used in conjunction with this module. To increase recognition of these sounds, a low-pass filter will be implemented at the module’s output. This text-to-voice module will communicate with the MCU through a set of serial communication interface (SCI) ports.

The speed/volume control will control the speed at which the solenoids elevate between alphanumeric characters during deaf-blind mode and control the volume at which the phonetic tones are transmitted to the headphones during blind mode. The MCU will be in direct communication with this simple potentiometer circuit, and will decide whether the TouchType is in blind or deaf-blind mode. This speed/volume control will communicate with the MCU by utilizing only one GPIO port.

The vibrating motor will use simply to notify the user of different states which he or she has entered, such as sending, receiving, and enter contacts to name a few. The pattern of vibration will indicate different functions. One pulse indicates a button-press confirmation, three pulses
indicate an entry to a unique state, a long pulse indicates the end of a state, and a poly-pulse indicates an alert. This vibrating motor will be powered by a motor driver IC. The vibrating motor together with the motor driver IC will communicate with the MCU by utilizing only one GPIO port.

The dual power supply will provide a +3.3 V and +5 V potential for the modules and systems described above that will connect to a rechargeable battery. This particular dual power supply will allow for a standard 120 V-AC wall socket or a rechargeable battery to power the two separate potential outputs. When the device is plugged into a wall socket, it will not only draw its power from the wall socket, but it will also use the wall socket’s energy to recharge whatever power has dissipated from the battery. This dual power supply will communicate with the MCU by utilizing two GPIO ports.

For further understanding of the system functionality see Figure 4 in the Appendices.

SOFTWARE REQUIREMENTS
The MC9S12DP512 will be programmed using the C programming language. The MicroC/OS-II pre-emptive real-time kernel will be implemented in conjunction to appropriately segment the software modules embedded in the TouchType. Table I illustrates several of the device’s software functions.

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Function Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSM Receive</td>
<td>Monitors air for incoming messages and retrieves incoming messages. This occurs always in Idle mode, and occasionally in other modes.</td>
</tr>
<tr>
<td>GSM Transmit</td>
<td>Sends message when prompted.</td>
</tr>
<tr>
<td>Braille Input</td>
<td>Follows user’s typing by determining correct alpha-</td>
</tr>
</tbody>
</table>
**USER INTERFACE**

The TouchType’s user interface is a very important part of the device’s overall design because the buttons presented will serve multiple purposes. Therefore, the user must be able to understand the device’s functionality with minimal difficulty because the device is aimed toward blind and deaf-blind users. *Figure 3* illustrates the device’s general user interface.

![User Interface Diagram](image-url)

*Figure 3: User Interface Diagram*
Depending on what alpha-numeric character the user would like to use on the keypad, they must press either press the button once, twice, or three times. The kernel will differentiate between these options by measuring the time in between presses as well as how long the button is being pressed for. For example, if the user wishes to message “AB1” they must press the “AB” button once for the letter ‘A’, wait some time, then press the “AB” button twice for the letter ‘B’, wait some time, then press the “AB” button three times for the number ‘1’. Table II illustrates the device’s button functionality.

<table>
<thead>
<tr>
<th>Button</th>
<th>Function (1 press, 2 press, 3 press)</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Button Image]</td>
<td>Affirmative</td>
</tr>
<tr>
<td>![Button Image]</td>
<td>Negative</td>
</tr>
<tr>
<td>“AB1”</td>
<td>‘A’, ‘B’, ‘1’</td>
</tr>
<tr>
<td>“CD2”</td>
<td>‘C’, ‘D’, ‘2’</td>
</tr>
<tr>
<td>“EF3”</td>
<td>‘E’, ‘F’, ‘3’</td>
</tr>
<tr>
<td>“GH4”</td>
<td>‘G’, ‘H’, ‘4’</td>
</tr>
<tr>
<td>“IJ5”</td>
<td>‘I’, ‘J’, ‘5’</td>
</tr>
<tr>
<td>“KL6”</td>
<td>‘K’, ‘L’, ‘6’</td>
</tr>
<tr>
<td>“MN7”</td>
<td>‘M’, ‘N’, ‘7’</td>
</tr>
<tr>
<td>“OP8”</td>
<td>‘O’, ‘P’, ‘8’</td>
</tr>
<tr>
<td>“QR9”</td>
<td>‘Q’, ‘R’, ‘9’</td>
</tr>
<tr>
<td>“ST0”</td>
<td>‘S’, ‘T’, ‘0’</td>
</tr>
<tr>
<td>“UV”</td>
<td>‘U’, ‘V’, ‘ ‘ (space)</td>
</tr>
<tr>
<td>“WX”</td>
<td>‘W’, ‘X’</td>
</tr>
<tr>
<td>“YZ”</td>
<td>‘Y’, ‘Z’</td>
</tr>
</tbody>
</table>
When a message has been received by the TouchType, the user will be notified by a vibration. As Figure 3 shows, this can occur when the device is in the idle state as well as the typing message state so the user may be notified of an incoming message. This gives the user the option to cancel the current message being typed so that they may read the newly received message. Since the GSM module can operate in receive mode while the user types, a message can still be received during this time.

Regarding the user actually reading the message, they must communicate to the TouchType that they are ready to receive before this occurs. Once they are ready, the Braille display will spell out the message through the lifting and lowering of the solenoids, which will provide an adequate speed for the user to read the message efficiently. The message will be spelled out in a single-character fashion with sufficient time delays between words. The user may re-read the message as many times as they wish until a new message has been received.

For further understanding of the “sending,” “receiving,” and “enter contact” functions see Figures 5, 6, and 7 in the Appendices, respectively.

**DEVELOPMENT PLAN**

The TouchType will be implemented as a prototype using a MC9S12DP512 MCU development board, and will be enclosed in a case that will not exceed the dimensions specified in the

<table>
<thead>
<tr>
<th>“.”, “?”</th>
<th>“.”, “,”, “?”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Contacts</td>
</tr>
</tbody>
</table>

*Table II: Button Functionality. The buttons correspond to Figure 1; left to right.*
hardware requirements. Soldering and right-angle headers will be needed for certain, if not all, hardware modules. If necessary, printed circuit boards (PCBs) will be used to allow full functionality of certain hardware modules. PCBs can be custom built by several online vendors, including www.batchpcd.com and www.ezpcb.com. The solenoids and buttons will be required to be stationary as well, so they will be mounted appropriately to the TouchType’s enclosure.

Equipment required to develop the TouchType will include not only soldering tools, but a digital oscilloscope, a digital multi-meter (DMM), a DC power supply, and various tools such as screwdrivers and wire clippers. In regards to software, the CodeWright IDE and Metrowerks’ Hi-Wave will be used for programming and debugging, respectively.

For further understanding of the development plan through preliminary parts see Table III in the Appendices.

SUSTAINABILITY
The TouchType will be fully Restriction of Hazardous Substances (RoHS) compliant due to the overwhelming need to address environmental issues. The power required for the device is largest when the user reads a message; therefore it is important the device uses as little power as possible by spending most of its time in other modes. This will be achieved by staying in the idle state as much as possible, which can be further understood by Figure 3.

CONCLUSION
Within the past decade, text messaging has become an important form of communication for instant, voiceless messages at the palm of one’s hand. By improving our global communications network, we allow people all over the world to become more independent and enterprising.
Expanding communication networks among people from all walks of life is essential, and the implementation of a text messaging device for the blind and deaf-blind would further expand our global network. This device takes a complex problem shaped by limited faculties and enables an elegant solution through means of simple electronic systems.

The development of a high-tech product often leads to the user becoming heavily dependent on such a product, which in turn has its advantages and disadvantages. The TouchType brings on a new and progressive idea of technology dependence by producing immensely high advantages to the world community.
APPENDICES

Figure 4: System Functional Diagram
Choose contact from hotlist

Spell out contact name on Braille display

User presses button

Place character into message

Send message via TTY

Send message via GSM

Message sent?

Sending Message state

Contact Button

Affirmative Button

Negative Button

Figure 5: Sending Functional Diagram
Receive Message state

- Contact Button
- Affirmative Button
- Negative Button

- Poly-Pulse

- Message received

- Known contact?

- Spell out contact name on Braille display

- Key Press?

- Affirmative, Negative, or Contact?

- Enter “Enter Contact State”

- Read message on Braille display

- Reply?

- Enter “Sending Message State”

- Spell out unknown number on Braille display

Figure 6: Receiving Functional Diagram
NOTE: To enter this state, the Contact button must be held down.
<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Part Name</th>
<th>Amount</th>
<th>V (V)</th>
<th>I_{\text{max}} (mA)</th>
<th>P_{\text{max}} (W)</th>
<th>Price ($USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ElectroMechanics Online</td>
<td>Tubular Push Solenoid</td>
<td>6</td>
<td>24</td>
<td>250</td>
<td>6</td>
<td>109.80</td>
</tr>
<tr>
<td>ElectroMechanics Online</td>
<td>Solenoid Spring Return</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6.48</td>
</tr>
<tr>
<td>Freescale Semiconductor</td>
<td>MC9S12DP512</td>
<td>1</td>
<td>5</td>
<td>65</td>
<td>0.325</td>
<td>13.65</td>
</tr>
<tr>
<td>KOA Speer</td>
<td>100k Resistor, 5%, 0.25W</td>
<td>1</td>
<td>-</td>
<td>0.0025</td>
<td>0.25</td>
<td>0.19</td>
</tr>
<tr>
<td>KOA Speer</td>
<td>10k Resistor, 5%, 0.25W</td>
<td>20</td>
<td>-</td>
<td>0.525</td>
<td>5</td>
<td>3.15</td>
</tr>
<tr>
<td>Magnevation</td>
<td>SpeakJet Speech and Sound Synthesizer</td>
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<td>3.3</td>
<td>5</td>
<td>0.0165</td>
<td>24.99</td>
</tr>
<tr>
<td>Maxim Electronics</td>
<td>Vibrating Motor Driver MAX1749EUK</td>
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<td>3.3</td>
<td>0.2</td>
<td>0.0007</td>
<td>1.52</td>
</tr>
<tr>
<td>Mountain Switch</td>
<td>SPST Pushbutton</td>
<td>17</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>36.00</td>
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<tr>
<td>Precision Microdrives</td>
<td>Shaftless Vibration Motor</td>
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<td>3</td>
<td>75</td>
<td>0.225</td>
<td>4.95</td>
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<tr>
<td>SparkFun Electronics</td>
<td>GM862 Cellular Quad Band Module</td>
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<td>370</td>
<td>1.406</td>
<td>99.95</td>
</tr>
<tr>
<td>SparkFun Electronics</td>
<td>3.5 mm Audio Jack</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.50</td>
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<tr>
<td>ST-Microelectronics</td>
<td>Octal Solenoid Driver</td>
<td>1</td>
<td>5</td>
<td>10</td>
<td>0.05</td>
<td>8.68</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>775.7 mA</strong></td>
<td><strong>13.27 W</strong></td>
<td><strong>$310.86</strong></td>
</tr>
</tbody>
</table>

*Table III: Preliminary Parts List*
REFERENCES


