CELL PHONE AUDIO CONTROLLED POINT OF SALE
TECHNOLOGY REVIEW REPORT

Alana Sweat
Group 9
October 18, 2008
1. REVISION HISTORY

2. INTRODUCTION

2.1 CUSTOMER REQUIREMENTS & PROJECT BACKGROUND
2.2 PROJECT RESEARCH
2.2.1 TECHNOLOGY REVIEW ANALYSIS – SYSTEMS
2.3 FEATURE SET
2.3.1 ABSOLUTE MINIMUM REQUIREMENTS
2.3.2 DESIRED FEATURE SET

APPENDIX A. REFERENCES

APPENDIX B. NAMING CONVENTIONS AND GLOSSARY
## 1. REVISION HISTORY

<table>
<thead>
<tr>
<th>Revision Number</th>
<th>Date</th>
<th>Description</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10-18-08</td>
<td>Created Document</td>
<td>Alana Sweat</td>
</tr>
<tr>
<td>2</td>
<td>10-19-08</td>
<td>Added encoding algorithms to review, finished introduction</td>
<td>Alana Sweat</td>
</tr>
<tr>
<td>3</td>
<td>10-21-08</td>
<td>Changed intro based on discussion with mentor</td>
<td>Alana Sweat</td>
</tr>
<tr>
<td>4</td>
<td>11-2-08</td>
<td>Added formatting</td>
<td>Alana Sweat</td>
</tr>
</tbody>
</table>
2. INTRODUCTION
   Picture this: you’ve been searching forever to find a parking place downtown, and you
finally see one. You park the car and get out to add money to the parking meter, only to realize
that you don’t have any change. However, you do have your cell phone. You dial an 800
number, enter a few codes at the prompt of the voice on the phone, and hold your cell phone up
to the parking meter. In no time at all, a tone comes out of the phone, the parking meter hears it
and adds the amount of money you specified to the meter, and you’re free to go about your
business.

   That is our project: to design a system that will transmit a tone of some sort through the
phone system into your cell phone, and be picked up by a microphone attached to a
microcontroller which will decode the tone and use it to perform the desired action. A large part
of our project, and the part that is of most interest to our sponsor, GE Security, will be coming up
with successful encoding and decoding algorithms to transmit data with a 99% success rate. In
addition to research into data transmission, we will be looking into the possibility of setting up a
simple IVR system, and also doing some microcontroller programming to process the data once
it leaves the cell phone.

2.1 CUSTOMER REQUIREMENTS & PROJECT BACKGROUND
   GE Security, our sponsor, is interested in how the core of our project, the encoding and
decoding algorithms we come up with, can be applied in the future to their products. For GE
Security, a secondary goal would be to make the design environmentally rugged, since all of
their products are rated for extreme temperatures and conditions.

   There are a lot of other applications of our project as well. Parking meters, DVD
dispensers, buying mass transit tickets at kiosks, the list is endless. Basically, any kiosk or meter
that currently requires a credit card or cash could be adapted to be paid for using a cell phone. Whether or not it is economically feasible to implement our design depends on the application, but trying to make the design as inexpensive as possible without sacrificing quality widens the range of applications.
## 2.2 Project Research

<table>
<thead>
<tr>
<th>Encoding Algorithms</th>
<th>What is it?</th>
<th>Current Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTMF (dual-tone multi-frequency)</td>
<td>Combining two frequencies to produce a different, distinct frequency</td>
<td>Mostly telephones/keypads: 3 frequencies on top, 4 on side, when you press a button the two frequencies at that button are summed and outputted as a distinct frequency</td>
</tr>
<tr>
<td>FSK (frequency-shift keying)</td>
<td>Uses one frequency sine wave to transmit a “1”, and another frequency sine wave to transmit a “0”</td>
<td>Most common form = audible Used by telephone modems, US Emergency Alert System, amateur radio</td>
</tr>
<tr>
<td>OOK (on-off keying)</td>
<td>A “1” is signaled by the presence of a sinusoidal carrier wave, a “0” is signaled by the absence of that wave</td>
<td>Morse code, optical communication systems Most effective at lower-speed transmissions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Microphones</th>
<th>Manufacturer</th>
<th>Frequency Response</th>
<th>Signal-to-Noise Ration</th>
<th>Supply Voltage</th>
<th>Supply Current</th>
<th>Impedance</th>
<th>Other Features</th>
<th>Dimensions</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>WM-63PRT</td>
<td>Panasonic-ECG</td>
<td>20-16k Hz</td>
<td>58dB</td>
<td>2V</td>
<td>0.5 mA</td>
<td>2200 ohms</td>
<td>Omni-directional</td>
<td>6mm diam. x 1.3mm</td>
<td>$3.47</td>
</tr>
<tr>
<td>WP-23502-P16</td>
<td>Knowles Acoustics</td>
<td>100-6k Hz</td>
<td>Unknown</td>
<td>1.3V</td>
<td>0.05 mA</td>
<td>4400 ohms</td>
<td>Waterproof</td>
<td>5.59mm x 4.01mm x 2.26mm</td>
<td>$37.22</td>
</tr>
<tr>
<td>Behringer C2 Condenser Microphone</td>
<td>Behringer</td>
<td>20-20k Hz</td>
<td>75dB</td>
<td>48 VDC</td>
<td>3 mA</td>
<td>75 ohms</td>
<td>Studio-quality</td>
<td>1” x 4”</td>
<td>$59.95</td>
</tr>
<tr>
<td>Microcontrollers &amp; DSPs</td>
<td>Manufacturer</td>
<td>Performance</td>
<td>Voltage</td>
<td>A/D</td>
<td>D/A</td>
<td>Flash Memory</td>
<td>SRAM</td>
<td>I/O Pins</td>
<td>Price</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>--------------------</td>
<td>-------------</td>
<td>----------</td>
<td>-------------------</td>
<td>-----</td>
<td>--------------</td>
<td>--------</td>
<td>----------</td>
<td>--------</td>
</tr>
<tr>
<td>ATmega128</td>
<td>Atmel</td>
<td>16 MHz</td>
<td>4.5-5.5 V</td>
<td>8-channel, 10-bit</td>
<td>No</td>
<td>128K Bytes</td>
<td>4K Bytes</td>
<td>53</td>
<td>$15.00</td>
</tr>
<tr>
<td>ATmega48</td>
<td>Atmel</td>
<td>20 MHz</td>
<td>2.7-5.5 V</td>
<td>8-channel, 10-bit</td>
<td>No</td>
<td>4K Bytes</td>
<td>512 Bytes</td>
<td>23</td>
<td>$2.73</td>
</tr>
<tr>
<td>STM32 (F101RB)</td>
<td>STMicroelectronics</td>
<td>36 MHz</td>
<td>2.0-3.6 V</td>
<td>10-channel, 12-bit</td>
<td>2-channel, 12-bit</td>
<td>128K Bytes</td>
<td>16K Bytes</td>
<td>36</td>
<td>$11.94</td>
</tr>
<tr>
<td>AT32AP7000</td>
<td>Atmel</td>
<td>150 MHz</td>
<td>3.0-3.6 V</td>
<td>16-bit</td>
<td>16-bit</td>
<td>External</td>
<td>32K Bytes</td>
<td>160</td>
<td>$20.00</td>
</tr>
<tr>
<td>PIC24F MCU</td>
<td>Microchip</td>
<td>32 MHz</td>
<td>2.0-3.6 V</td>
<td>13-channel, 10-bit</td>
<td>No</td>
<td>16K Bytes</td>
<td>4K Bytes</td>
<td>21</td>
<td>$1.66</td>
</tr>
<tr>
<td>MAXQ3212</td>
<td>Maxim/Dallas</td>
<td>3.58 MHz</td>
<td>5.0 V</td>
<td>No</td>
<td>No</td>
<td>1k Word</td>
<td>64 Bytes</td>
<td>15</td>
<td>$4.48</td>
</tr>
</tbody>
</table>
2.2.1 Technology Review Analysis – Systems

I did some basic research into different types of encoding algorithms, just to get a feel for the different types being used today. While the simplest form looked to be OOK, since it only requires transmitting one frequency, trying to figure out when there is no frequency being transmitted in a noisy environment could be difficult. There are forms of both DTMF and FSK currently in use over the phone lines today, which could be very helpful when determining what frequencies will come through the phone system without being distorted into something unrecognizable.

When researching microcontrollers, I realized there were two types that would possibly suit our application: general purpose microcontrollers and DSP microcontrollers. The DSP microcontrollers in general have more specialized instructions sets that make it easier to handle digital signal processing. They also usually have not only an A/D converter, but a D/A converter as well, which could come in handy if we decide to include a confirmation tone in the system to play a sound back to the cell phone confirming the data transmission. I only looked at 2 DSP microcontrollers, the STM32 and the Atmel AT32AP7000. The Atmel looked like it would meet our requirements, but it also seemed to be considerably larger than we would need. The STM32 is one of my top choices overall, as it is fast, has A/D and D/A, and runs off of a fairly low voltage.

Of the other four microcontrollers I researched, the two I liked the most were the ATmegas. The main problem with the Microchip controller is that it is still in production, and so would not be practical for our design because we will need a controller that we know works well and is readily available. The Maxim controller is a very small, limited function microcontroller, and to use it we would have to have at least an external A/D converter, and possibly an external
D/A converter. The two ATmega microcontrollers are fast, have an A/D converter, and would be the easiest for us to program, as we have prior experience using the ATmega128 from class.

I also did some preliminary research into some of the different types of microphones available. The microphone is going to be an important part of our system, as it has to be able to accurately pick up a sound coming from a cell phone speaker. I looked briefly at quite a few microphones, and decided on the three above as a fairly good representation of the different types available. The Behringer, which was by far the nicest small microphone I saw, was also completely unpractical for our application. It is designed for a studio, and we are going to need one that runs off of a low voltage (preferably a battery), and that will be simple to attach to a circuit. Either of the other two would probably work, depending on the specific frequencies we end up using, but I thought the Knowles Acoustics microphone was interesting as it is waterproof, and one of the lower-priority objectives for our project is that the design be environmentally rugged. Once we decide on frequencies and audio levels, we will better be able to choose a good microphone for our project.
2.3 Feature Set

2.3.1 Absolute Minimum Requirements

• Demonstrate tone decoding at a distance to be determined from cell phone speaker with a 99% success rate
• Research and prototype various command tone encoding and decoding algorithms
• Research and prototype confirmation tone encoding and decoding algorithms
• Research ways to address security concerns that would apply to this medium
• Determine and demonstrate optimal baud rate in clean environments and noisy environments
• Working prototype for senior expo where anyone can demonstrate system using their own cell phone
• System must be cost effective and usable by technologically challenged

2.3.2 Desired Feature Set

• “Point of Sale” device
• Microcontroller with DSP algorithms for audio filtering, tone decoding, audio noise rejection
• Display (and optionally an actuator to add credit to an imaginary meter, strike a relay, turn on an LED, etc.)
• Real time clock time
• Speaker for confirmation tone or tones
• Microphone to record sounds from cell phone speaker
• Battery
• Environmentally rugged (dust, water)
• IVR application
• Tone generation in same range as voice
• Receives confirmation tone
APPENDIX A. REFERENCES


http://www.zzounds.com/item--BEHC2


APPENDIX B. NAMING CONVENTIONS AND GLOSSARY

A/D: analog to digital

D/A: digital to analog

DSP: digital signal processing

DTMF: dual-tone multi-frequency

FSK: frequency-shift keying

IVR: interactive voice response

OOK: on-off keying