E-music Performance System

Team #6:
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TA: Kevin Bassett

ECE 445 Senior Design
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Purpose

- Eliminate printing costs for marching bands by making electronic flipfolder at a reasonable price
- Make managing large repertoires of music easier by making music easier to add, delete, and organize
- Facilitate conductor-performer communication by enhancing visual cues
- Cut down on time between switching songs
Features

- TFT screen displays electronic sheet music
- MicroSD card memory to store electronic music files
- Wireless remote to allow conductor to transmit visual cues and/or sheet music to performers
- Push-button interface for page turning in-performance
- LED Metronome for practicing
- AA Rechargeable Battery powered
- Central controller interface with PC
Top Level Block Diagram

- Laptop and Wireless Transmitter
- SD Memory
- User Input
- LED Metronome
- Power Supply
- Receiver
- TFT Display
- PSoC
Display Hardware

• Original Plan: Use E-Ink Display
  – Sunlight Readable
  – Low Power Usage
  – Holds state when powered off

• Problems
  – Expensive ($100+)
  – Displays and Development Tools not made available to students
Display Hardware

• Solution: TFT Display
  – Hantronix HDA700L-2S ($55)
  – 7” diagonal, comparable to flipfolder
  – Sufficient Resolution (800 x 480)
  – Simple 40 pin TTL interface

• Display software still programmed as if slower E-ink display was used
Display Hardware

• Drawbacks of TFT display
  – Loss of Sunlight Readability
  – Consumes more power
  – Backlighting is essential, requires higher voltage than digital components
  – 18-bit RGB Color Display is unnecessary, only used grayscale
Memory Hardware

- 4GB MicroSD card and surface mount PCB connector ($7)
  - 1 page of music = 1-bit 800 x 480 bitmap = 47 KB
  - Easily connected to computer to load music
  - Simple interfacing to microcontroller via SPI interface
Wireless TX/RX

- Receiver: XB24 ($19)
- Transmitter: XBP24 ($32) connected to PC via FTDI
- Transmitter has listed range of 1 mile
- Transmitter can send packets of up to 100 bytes at a time to receiver via UART
User Input and LED Metronome

- **User Input**
  - 6 tactile switches located on left side of device, plus main power switch on back
  - Used to change pages, bring up music selection menu, and toggle metronome

- **LED metronome**
  - LED on right side of device flashes at adjustable number of beats per minute
  - Operated in current sink mode, tied to high current pin on microprocessor
Power Supply

- 4 AA batteries and 3.3 V linear regulator supply power to all digital components
- Boost Converter provides 10 V to display backlight
# Power Budget

<table>
<thead>
<tr>
<th>3.3 V Component</th>
<th>Typical Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display</td>
<td>200 mA</td>
</tr>
<tr>
<td>Receiver</td>
<td>50 mA</td>
</tr>
<tr>
<td>Memory</td>
<td>30 mA</td>
</tr>
<tr>
<td>Processor</td>
<td>10 mA</td>
</tr>
<tr>
<td>User Input and LED</td>
<td>20 mA</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>310 mA</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10 V Component</th>
<th>Typical Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backlight</td>
<td>160 mA</td>
</tr>
</tbody>
</table>

Energy Input = 1.2 V * 2500 mAh  
= 3000 mWh per battery  
= 12000 mWh

Power Usage = 2623 mW

Battery Life = 4.57 hours
Cypress PSoC

- Expensive as a microprocessor, cheap as system ($10)
- Capable microprocessor
- Digital blocks
  - Fast hardware prototyping
  - Adaptable to different display methodologies
Display Blocks
Display Blocks
Display Blocks
Software

- **Init**
  - **Menu idle**
    - **Receive data**
    - **Display Interrupt**
      - **Handle DMA For display**
    - **Handle button/received cmd**
  - **Display music**
    - **SD card**
Cypress DevBoard Interface

- Simple PCB to connect display, SD card, and Xbee to PSoC 5 Development kit
- Kit provides power to components, user I/O, and can be programmed via USB input
- Provided a way to test display and memory software before migration to final hardware

Source: cypress.com
Cypress DevBoard Interface

Port E Schematic

Hardware Interface Schematic

Picture
Dev Board Testing

- Easy debugging with LCD character display
- Character display made menu easier to make
- Platform usable for spring football game
Sample Sheet Music
Hardware Design Decisions

- Make 2-bit grayscale possible
  - Improves image quality, especially with scanned music
- Remove boost converter
  - Small, hard to solder, leads underneath IC
  - Inefficient conversion
  - Display backlight tolerates 8-12 Volts
  - Solution: Use 9 V battery
New Power Budget

### 3.3 V Component

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<tr>
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<td>20 mA</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>310 mA</strong></td>
</tr>
</tbody>
</table>

**Energy Input** = $1.2 \text{ V} \times 2500 \text{ mAh}
= 3000 \text{ mWh per battery}
= 12000 \text{ mWh}

**Power Usage** = 1023 mW

**Battery Life** = 11.7 hours

### 9 V Component

<table>
<thead>
<tr>
<th>Component</th>
<th>Typical Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backlight</td>
<td>160 mA</td>
</tr>
</tbody>
</table>

**Energy Input** = $9 \text{ V} \times 600 \text{ mAh}
= 5400 \text{ mWh}

**Power Usage** = 1440 mW

**Battery Life** = 3.75 hours
Hardware Design Decisions

- Send Final PCB to Sunstone for fabrication
  - Lots of fine pitch components (PSoC, display connector, JTAG connector)
  - Plated vias and through holes

- Casing is necessary
  - Added protection and neatness worth the extra time
Casing

- Serpac Clear Case: 6.88” x 4.88” x 1.40”
- Display mounted on front panel, batteries and PCB on back
- 5 panel mount buttons and 1 toggle switch (backlight) on left
- 1 red LED on right
Final Schematic
Final Board
Finished Reader Device
# Final Unit Cost

<table>
<thead>
<tr>
<th>Reader Components</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFT Display, ribbon cable, and board connector</td>
<td>$60.00</td>
</tr>
<tr>
<td>MicroSD card and socket</td>
<td>$7.00</td>
</tr>
<tr>
<td>XB24</td>
<td>$19.00</td>
</tr>
<tr>
<td>PSoC 5 and programming conn.</td>
<td>$12.00</td>
</tr>
<tr>
<td>PCB</td>
<td>$35.00</td>
</tr>
<tr>
<td>Case</td>
<td>$10.00</td>
</tr>
<tr>
<td>Batteries, holders, and voltage reg.</td>
<td>$8.00</td>
</tr>
<tr>
<td>Buttons, LED, resistors, capacitors</td>
<td>$5.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$160.00</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transmitter Components</th>
<th>Cost</th>
</tr>
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<tbody>
<tr>
<td>XBP24</td>
<td>$32.00</td>
</tr>
<tr>
<td>FTDI cable</td>
<td>$20.00</td>
</tr>
<tr>
<td>Voltage regulator and capacitors</td>
<td>$2.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$54.00</strong></td>
</tr>
</tbody>
</table>
Testing the Final Device

• Successes
  – Clear Stable Image on Display
  – Memory Read/Write functions as intended
  – Menu displays on screen, and is navigable by buttons
  – Metronome blinks correctly, and rate can be changed

• Failures
  – Wireless capability

• Possible Explanations
  – PC communicates with transmitter and transmits correct signal
  – Receiver and transmitter hardware/firmware functional
  – Probable Cause: Software interface with microprocessor
Summary

• E-Reader device successfully built, with some modification to original design
• Transmitter hardware successfully built
• Core software functions properly
  – Music display, menu navigation
• Wireless not functioning, due to software interface with PSoC
Future Work

• Improve Battery Life
  – Implement Boost Converter
  – Add variable resistor, so backlight can be dimmed
  – Get E-Ink display

• Improve Case
  – Lighter, thinner casing
  – Make battery easier to replace
  – Anti-reflective coating

• Include music education tools (e.g. tuner)
Acknowledgements

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• ECE Machine Shop Staff
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• Professor Carney
• Kevin Bassett, and all the ECE 445 TA’s
Questions?