Delta-Sigma Heart Rate Monitor

Joe Griffin
Hugo Malpica
Motivation

• Use pulse oximetry and a FPGA to display heart rate visually.
• Implement 6.341 methods to process signals.
• Use 6.111 material to do cool things.
Analog Circuitry

- Anti-aliasing filter
- Comparator
- TTL level shifter
Delta Sigma Analog to Digital Converter (ADC)

• Take Nyquist frequency
• Oversample by factor M
• Apply sharp cutoff digital filter
• Decimate by factor M
Digital Signal Processing (DSP)

• Implement built in FFT
• Identify primary frequency component
• Pass waveform and heartrate data to graphics module
Graphics

- Plot waveform data points
- Use interpolation to connect pixel data
- Manage memory calls to memory buffer for heartrate printing
- Generate control signals for VGA module
Character Storage

- ROM storing transparency bits for pixels in character space
- Indexed by pixel location

- Use Matlab to generate characters FPGA can use
Video Graphics Array (VGA)

• Similar to Lab 3
• Use ADV7125 control module
• Control signals for lab 3 module generated by graphics module
# Timeline

<table>
<thead>
<tr>
<th>Week of November 2</th>
<th>Design finalized, parts ordered, begin building and Testing Blocks.</th>
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<tbody>
<tr>
<td>Week of November 9</td>
<td>Continue Building and Testing Blocks</td>
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<tr>
<td>Week of November 16</td>
<td>Continue Building and Testing Blocks, Start integrating blocks</td>
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<td>Week of November 23</td>
<td>Debugging Block interconnect</td>
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<tr>
<td>Week of November 30</td>
<td>Add finishing touches</td>
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<tr>
<td>Week of December 7</td>
<td>Demonstrate Completed Project</td>
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If time permits...

- Implement noise shaping for Delta Sigma ADC.
- Implement better interpolation method for data point plotting.
Anti Aliasing Filter

• Restricts the bandwidth of a signal.
• Implemented with a bandpass filter, low pass filter.

• Our idea: 2\textsuperscript{nd} order low pass filter.
Delta Sigma Analog to Digital Converter

- System assumes signal is bandlimited.
- Sample at low precision well above target frequency.
- Pass through high precision digital filter
- Down sample to low frequency. (Decimator)
- High precision coefficients allow trading
  - Sampling frequency for high precision
  - Generation of bits depend on oversampling rate.
Noise Shaping

• Increase the signal to noise ratio of a signal.

• No noise shaping means quadrupling sampling frequency adds 1 bit of precision

• 1\textsuperscript{st} order noise shaping means quadrupling sampling frequency adds 3 bits of precision.

• There is a limit: Don’t go over 3\textsuperscript{rd} order noise shaping.
Interpolation

• Method of constructing new data points within range of discrete data points.
• Activate pixels needed in graphics module

• Method here: Manhattan style
• Eventually: Linear