Wireless EKG

EECS 452 Design Project

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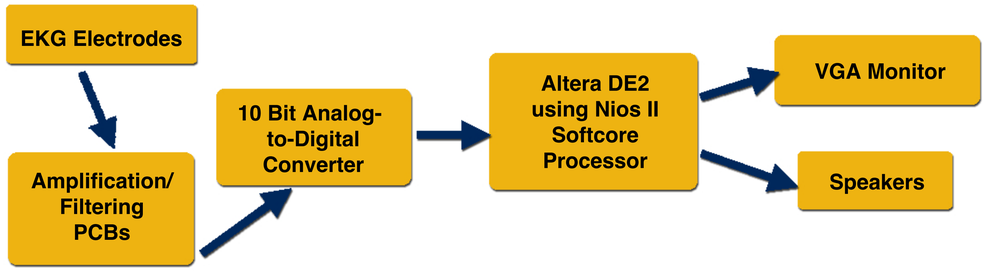
Introduction

This project is a proof of concept design for a more reasonably priced and portable EKG Device. Our device allows users to both visually and aurally monitor their heart rate. Similar to a conventional EKG device, the user's heartbeat is displayed. However, our device has a relatively low production cost and is easier to use. While many clinical EKG devices use up to 12 electrodes, our device requires only three electrodes, which can be easily placed on both wrists and on one leg.

Additionally, the heart rate display of our device changes color based on the user's heart rate and a sound is emitted each time the user's heart beats. The pitch of this sound changes with the user's heart rate. Cool colors and low pitches correspond to a relaxed or resting heart rate, while warm colors and higher pitches correspond to an anxious or active heart rate.

Block Diagram



Block Diagram Explanation

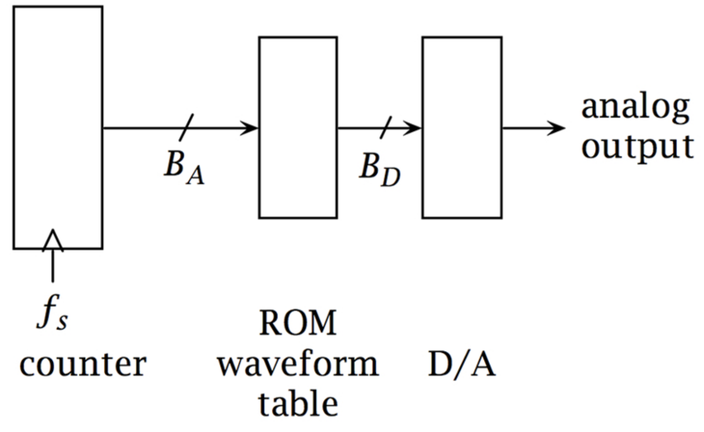
The raw EKG signals when obtained from the user are less than 5 mV in amplitude. As such, the signals need to be amplified to be usable by our equipment. The PCBs we have designed amplify the signals by a factor of 1000 and filter high frequency noise with a 4th order Butterworth filter (cutoff frequency: ~30Hz)

We have implemented a Nios II Softcore Processor on the Altera DE2 for our digital signal processing algorithms (explained on the right panel). The DE2 receives the digital versions of the EKG signals via a serial connection to the Wireless Tool receiver. Once the signals are processed, they are used to determine the outputs to both the VGA monitor and the speakers.

EKG Background

EKG machines are designed to monitor and output a visual interpretation of a heartbeat. They utilize the electrical changes created by a beating heart. When the heart is at rest there is a voltage across it, but when the heart contracts, that voltage is reduced to zero. The electrodes of the EKG machine detect the change in voltage. There are many variations of EKG designs with various numbers of electrodes. For our design, we decided to use 3 electrodes. Two of the electrodes will be attached to the user's wrists, and the third will be attached to the leg to provide a reference voltage.

Digital Signal Processing

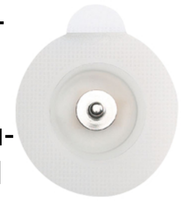


In order to output a sine tone, we implemented direct digital synthesis. We determine the frequency of the output sine tone changes with the frequency of the heartbeat. If the heartbeat increases in frequency, the frequency at which the counter increments is increased. This causes the sine wave to be read from the sine table at a higher frequency, and thus the sine tone produced is a higher pitch.

Component Background Info

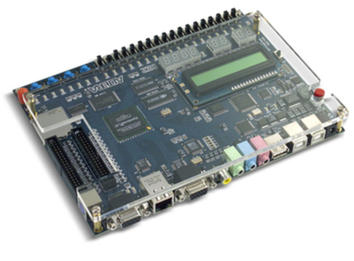
Cleartrace REF 1700-005 EKG Electrodes

Recommended to us based on successes of students from a previous semester. These low-cost, high-efficacy elecrodes were easily implementable.



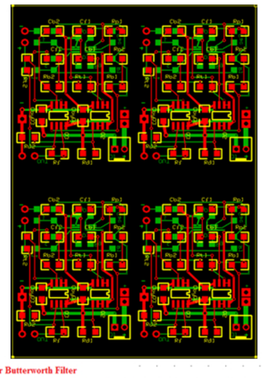
Altera DE2 Development Board

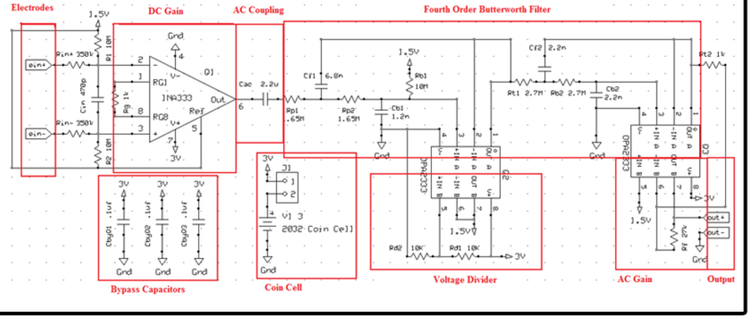
We used the Altera DE2 because of its superior VGA output capabilities, speed and processing power. Since we needed to draw to the screen and change color based on input, the 16-bit color output of the DE2 gave us more color possibilities than the 8-bit color output of other Development boards available to us. We implemented a Nios II softcore processor on the Altera DE2 so that we could design our algorithms in C rather than VHDL or Verilog.



Custom Printed Circuit Boards

Due to the nature of EKG signals, we needed to design custom PCBs to ensure that the signal-to-noise ratio would be as low as possible. These PCBs were used to layout amplification circuits and a 4th order Butterworth low pass filter. More information about the design of the PCBs and the circuits built on them can be found in the center and on the right side of the poster.





Acknowledgements

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