University of Pennsylvania
Department of Electrical and System Engineering
Medical Devices Lab

ESE3400, Fall 2023 Project: Wireless ECG Monitor Wednesday, Nov. 15

Presentation/Demo Due: Monday, December 11, 11:59PM
Report Due: Tuesday, December 12, 11:59PM

Design Problem: Design an ECG Monitor and Heart Rate Detection with Wireless Communication. You will use the knowledge you've gained in the Labs to put together your custom designed signal conditioning board with the Adafruit nRF52 Board to acquire a noisy ECG signal from the heart rate simulator and report the heart rate as well as display the ECG signal. This may require digital filtering using python in real time and will require setting up low energy bluetooth communication to interact with a computer, tablet or other mobile device.

Minimum Functionality Specifications:

- Acquire biopotential signal from ECG Simulator (Test a variety of different signals - regular and irregular, varied amplitudes and heart rates, noisy and non-noisy - and compare performance of your device for a variety of different signals). You can also use electrodes and acquire your own ECG (as long as your device is completely battery powered and not connected to anything connected to building ground (e.g. an oscilloscope).
- Signal Conditioning: Amplify and bandpass filter signal for ADC input
- Use ADC on Adafruit nRF52 Feather Board to digitize signal
- Transmit ECG data wirelessly from periphery ECG device to central device
- Write python code to perform any signal processing (eg, filtering, upsampling, R-R detection, etc.) to detect heart rate of ECG
- Visualize ECG signal and heart rate on central device. ECG signal and heart rate must update with some periodicity you determine (I.e. It must update, but it doesn't have to be in real time).
- One additional function that you propose. Some examples might include:
  - Use LCD screen to visualize heart rate on periphery ECG device
  - Detect and notify of arrhythmia (irregular heart beat)
  - Use accelerometer data to check if low or high heart rate is expected (eg. in the case of exercise)

  - With electrode patches demonstrate mobility of a patient while still acquiring a good ECG recording
  - A real time plotting/analysis of the sensor data
  - Anything else you propose!

- Package your periphery device for mobility

Presentation/Demo on 12/11 in Lab:

- Create a 10-minute presentation describing your design operation with focus on the additional function(s) you implemented.
- Describe the performance limitations (eg, input amplitude limits, noise limits, HB limits, mobility and power limitations etc.)
- Include how you verified operation of each piece of the project as listed above
- Include any problems/difficulties you ran into and how you solved them
- Show demo of your device working

Report due 12/12: Your report should be a single, stand-alone document and should include a full design description such that your device can be repeated by anyone who reads the report. You will submit your report in Canvas by the due date. Any late submissions may be subject to a late penalty. Things you might include are listed below:

- Device functionality description and motivation
- Schematics, PCB design, and simulation for the signal conditioning design
- Full system description including any wiring between custom PCB and Adafruit nRF52 Feather board
- Description of and DSP systems designed including commented python code
- Wireless communication operation and setup including any relevant python code
- Design process writeup including design choices made and trouble shooting
- Conclusion of design functionality with design limitations
- Learning outcomes and future work

Extra Credit: Best written report will get extra credit.