## **BMEN 428/ECEN 489 CSCE 489/BMEN 689**

ECG Signal Processing – Part #1

## Please **SIGN IN** at the front!

# Turn in all **POST LABS** at the front!





## Safety

If you have any questions at all, or feel uncomfortable performing the experiments please let the TA know!

Make sure that whenever you have electrodes connected to your body, your device is connected to a portable battery or personal computer (unplugged laptop), **NOT TO THE OUTLET**.

In other words, there should **NEVER** be an electrical path from your body to the wall outlet. If any of the TAs see you not complying with these guidelines, you will get an

#### AUTOMATIC <u>F</u> GRADE





## **Project Description**

#### Part #1

Collect and wirelessly transmit your ECG data, in addition to reporting the heart rate (in bpm) as well.

#### Part #2

Read data from the computer (wirelessly) that contains an ECG signal corrupted by noise, apply digital filters and filter out noise (in MSP430), and then send "filtered" data back to computer.





## **Project Goal**

In addition to applying filtering algorithms in the MSP430, you have to explore the limitations of the microcontroller.

#### **Major Limitations:**

- 1) Computational Power
- 2) Precision and Accuracy
- 3) Available Memory





## **Project Gantt Chart**

#### 1<sup>st</sup> Week

Design algorithm to detect heart rate. Implement in MSP430.

#### 2<sup>nd</sup> Week

Finish heart rate detection algorithm. Design filters and test out with MATLAB. Begin to implement in MSP430.

#### 3<sup>rd</sup> Week

Finish filter designs and implementation in MSP430. Submit results to Kaggle.com.





## **Project Gantt Chart**

#### 4<sup>th</sup> Week ???

There should be no 4<sup>th</sup> week. "Buffer" time to debug/troubleshoot any problems arising in previous parts of the lab.

If you don't set strict deadlines for each part of the project you might run the risk of not finishing on time! Remember that the project is <u>16%</u> of your grade.





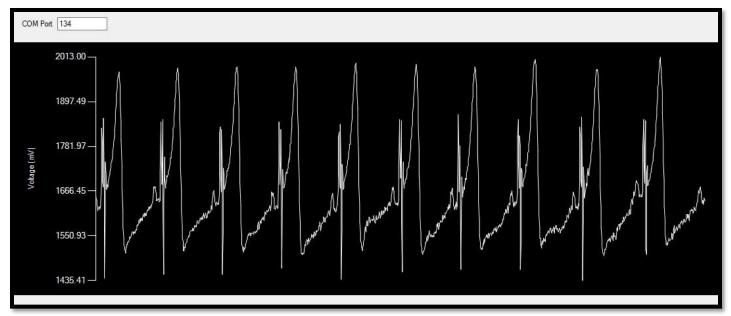
## **Part #1**





This part of the project constitutes an extension of Lab #6.

You are expected to output the same ECG signal from your body, in addition to your heart rate.



No time dependence on x - axis. Need to define an algorithm that "counts" the number of beats per period, and use that to calculate "bpm".





You are free to develop and implement whatever heart rate algorithm you like, as long as it works and you are able to explain how the algorithm works to the TAs.

You are also free to employ any digital signal processing on the MSP430 if you feel it would help your algorithm. You cannot however use any additional hardware other than what we provide in the lab.

For every beat after the first heartbeat, you need to calculate the time since the last heartbeat and report this as a heart rate in bpm.





In addition to the two bytes you will be sending for the digitized ECG data like you did in Lab 6, you will also need to send a <u>third byte</u> that encodes the heart rate in bpm.

So for every sample, you need to <u>first send 2 bytes of the ADC-converted</u> <u>ECG data, and then 1 byte of a heart rate value.</u>

You will not get a new heart rate every sample, so just send the number '0' whenever a new heart rate is not available. In other words, the only time you will not send the number '0' is when your algorithm has detected a new heartbeat and can calculate an updated heart rate.

When the GUI receives a "0" it will output the heart beat previously calculated. In other words, the GUI will only "update" the heart rate when it does not receive a "0".





The overall flow will be initiated by the PC GUI, details of which will be explained further in the next subsection. <u>The GUI will send the letter 'a' to initiate the data transfer.</u>

Therefore you must set up a UART receive ISR that looks for the letter 'a' and only then starts sending out the converted ADC results as well as the heart rate to the PC.

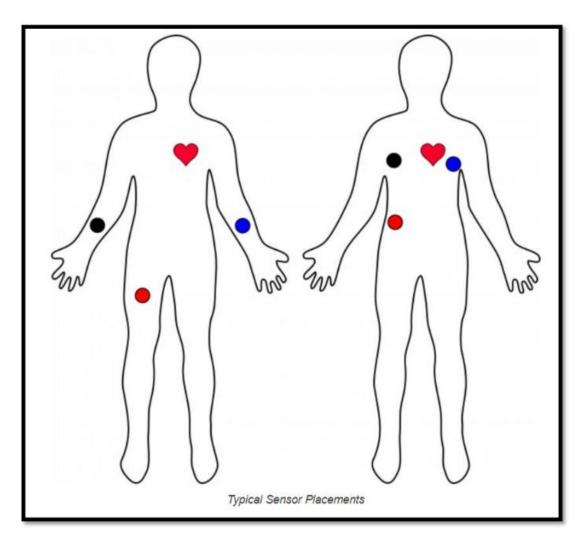
Once the transfer is initiated in this manner, the MSP430 must continuously send the samples to the PC at the predetermined sampling rate. The PC GUI will automatically handle receiving the incoming packets and plotting the signal on a graph. The heart rates that you send will also be plotted on a second graph.





#### **Sensor Placement**

Pay attention to where the **RIGHT** and **LEFT** sides are! Your signal may be inverted!







#### "SimpleSerial\_ECG+HR\_Voltage.exe"

| 🖳 ESP Lab Data Visualization Tool            |                   |                   |  | _ | × |
|--|-------------------|-------------------|--|---|---|
| Start Stop                                   | Start Saving Data | Save Data to File |  |   |   |
| COM Port                                     |                   |                   |  |   |   |
|  |                   |                   |  |   |   |
| 250.00 —                                     |                   |                   |  |   |   |
| 200.00 —                                     |                   |                   |  |   |   |
| [변화] 150.00 —<br>왕왕 150.00 —<br>임이 100.00 —  |                   |                   |  |   |   |
| ử<br>100.00 —<br>표                           |                   |                   |  |   |   |
| 50.00 —                                      |                   |                   |  |   |   |
| 0.00 —                                       |                   |                   |  |   |   |
|  |                   |                   |  |   |   |
| 3300.00 —                                    |                   |                   |  |   |   |
| 1980.00 —                                    |                   |                   |  |   |   |
| الم 660.00 –<br>الم 660.00 –<br>الم 660.00 – |                   |                   |  |   |   |
| File<br>-660.00 —                            |                   |                   |  |   |   |
| -1980.00 —                                   |                   |                   |  |   |   |
| -3300.00                                     |                   |                   |  |   |   |





#### Setting up the Bluetooth module (1)



Connect the USB to your computer.





### Setting up the Bluetooth module (2)

|                        | ← Settings          |  | - 0            | × |
|------------------------|---------------------|--|----------------|---|
|                        | 🐯 DEVICES           |  | Find a setting | P |
|                        | Printers & scanners | Add devices  |                | Â |
|                        | Connected devices   | , Add a device   |                | 1 |
|                        | Bluetooth           | + Add a device   |                | 1 |
| Click on the           | Mouse & touchpad    | Other devices  |                |   |
|                        | Typing              | BCM20702A0   |                | 1 |
| Windows icon and type: | AutoPlay            | DELL P2211H  |                |   |
| ()por                  |                     | Dell USB Laser Mouse   |                |   |
| "Add or remove         |                     | Dell USB QuietKey Keyboard   |                | 1 |
| devices"               |                     | Texas Instruments MSP-FET430UIF  |                |   |
| Click on the           |                     | Download over metered connections  |                |   |
| Bluetooth tab          |                     | To help prevent extra charges, keep this off so device software<br>(drivers, info, and apps) for new devices won't download while<br>you're on metered Internet connections. |                |   |
| Bradtooth tab          |                     | • Off  |                |   |
|                        |                     | Related settings   |                |   |
|                        |                     | Bluetooth settings   |                |   |
|                        |                     | Devices and printers   |                |   |
|                        |                     | Device manager   |                | ~ |





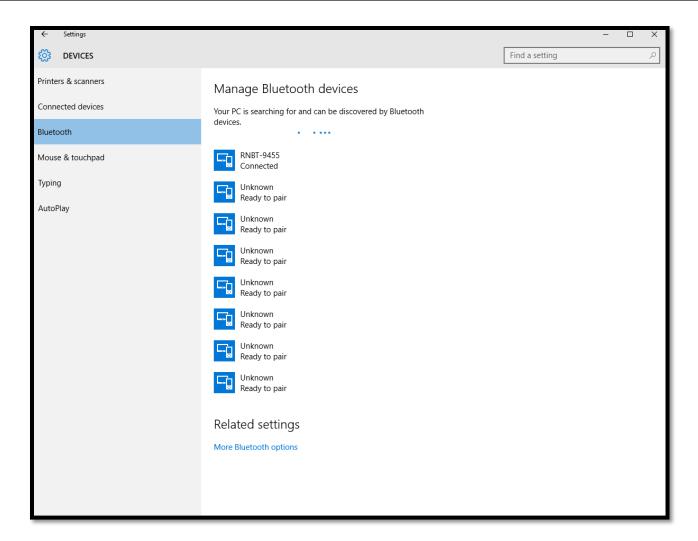
## Setting up the Bluetooth module (3)

Look up your device!

Your device name should be:

RNBT – XXXX

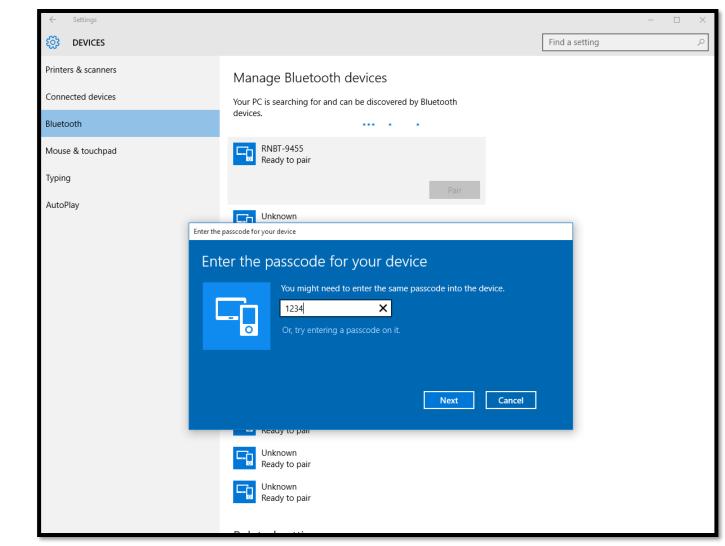
Where the XXXX correspond to the last 4 digits of the MAC ID in your Bluetooth module.







#### Setting up the Bluetooth module (4)





**Password:** 

"1234"



### Setting up the Bluetooth module (5)

#### Once you've paired your device, click below on the

"More Bluetooth Settings"

And the window on the right should pop-up.

| 8 Bluetooth Settings                                  | $\times$ |
|---|----------|
| Options COM Ports Hardware                            |          |
| Discovery   |          |
| Allow Bluetooth devices to find this PC               |          |
| Bluetooth devices will see the name of this PC.       |          |
| Notifications   |          |
| Alert me when a new Bluetooth device wants to connect |          |
| Show the Bluetooth icon in the notification area      |          |
|   |          |
|   |          |
|   |          |
|   |          |
|   |          |
| Restore Defaults                                      |          |
| OK Cancel Apply                                       |          |





### Setting up the Bluetooth module (6)

#### Search for the COM port of your device and write it down.

Look for the "Outgoing" direction.

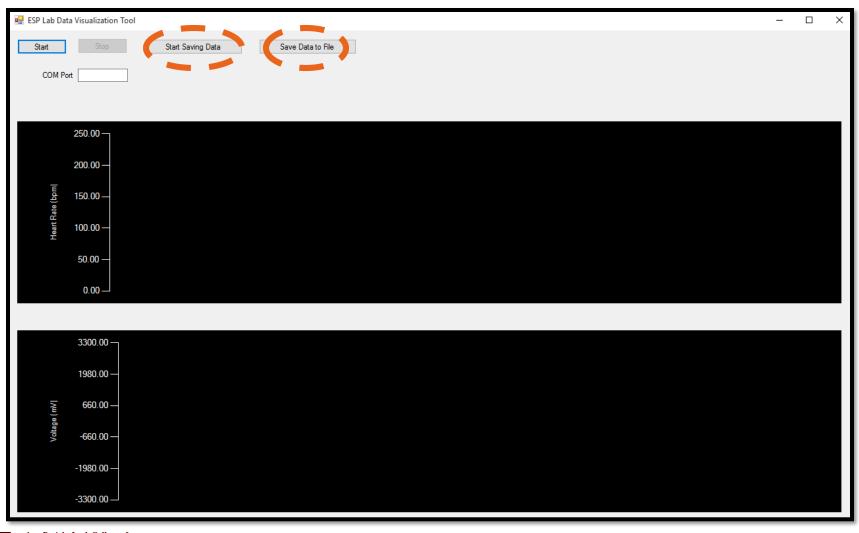
The name of the device may have a "RNI-SPP" embedded to it after the device name.

| 8 | Bluetooth Se  | ettings       |  | × |
|---|---------------|---------------|--|---|
| 0 | ption: COM P  | orts Hardware | 2  |   |
|   | whether you r |               | erial) ports listed below. To determine<br>ort, read the documentation that came |   |
| ( | Port          | Direction     | Name ^   |   |
|   | COMOL         | inserning.    |  |   |
|   | COM33         | Incoming      |  |   |
|   | COM34         | Incoming      | RNBT-93C0  |   |
|   | COM35         | Incoming      |  |   |
|   | COM36         | Incoming      |  |   |
|   | COM37         | Incoming      | RNBT-9455  |   |
|   | COM40         | Incoming      |  |   |
|   | COM41         | Outgoing      | RNBT-93C0 'RNI-SPP'  |   |
|   | COM42         | Incoming      |  |   |
|   | COM43         | Incoming      | RNBT-9455  |   |
|   | COM44         | Outgoing      | RNBT-9455 'RNI-SPP'  |   |
|   | <             |               | >  |   |
|   |               |               | Add Remove   |   |
|   |               |               |  |   |
|   |               |               |  |   |
|   |               |               | OK Cancel Apply  |   |
|   |               |               | OK Cancel Apply  |   |





#### **Take some measurements!**







#### **ECG + Heart Rate**

|                 | ta Visualization Tool  | - 🗌                                       |
|-----------------|--|---|
| COM P           |  | Relatively constant line around 60-70 bpm |
|                 | 250.00   |   |
| te (bpm         | 150.00 —   |   |
| Heart Rate (bpm | 100.00 —   |   |
|                 | 50.00 —<br>0.00 —  |   |
| Voltage (mVI    | 1951.71<br>1785.23<br>1618.75<br>1452.26<br>1285.78<br>1119.30 |   |





#### **Expected Results**

