Holter Monitor

Group 4
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Introduction

- A **Holter monitor** is a continuous tape recording of a patient's EKG for 24 hours.
- Since it can be worn during the patient's regular daily activities, it helps the physician correlate symptoms of dizziness, palpitations (a sensation of fast or irregular heart rhythm) or black outs.
- The electrocardiogram (**ECG** or EKG) is a diagnostic tool that is routinely used to assess the electrical and muscular functions of the heart.

Requirements

- Should record the ECG waveforms of the patient for the entire day(24 hours) meaning long battery life support.
- Records the discrete values along with time stamp for accuracy.
- Minimizing the risk of missing out any deviation from normal rhythm, which may go undetected in a clinical setting.

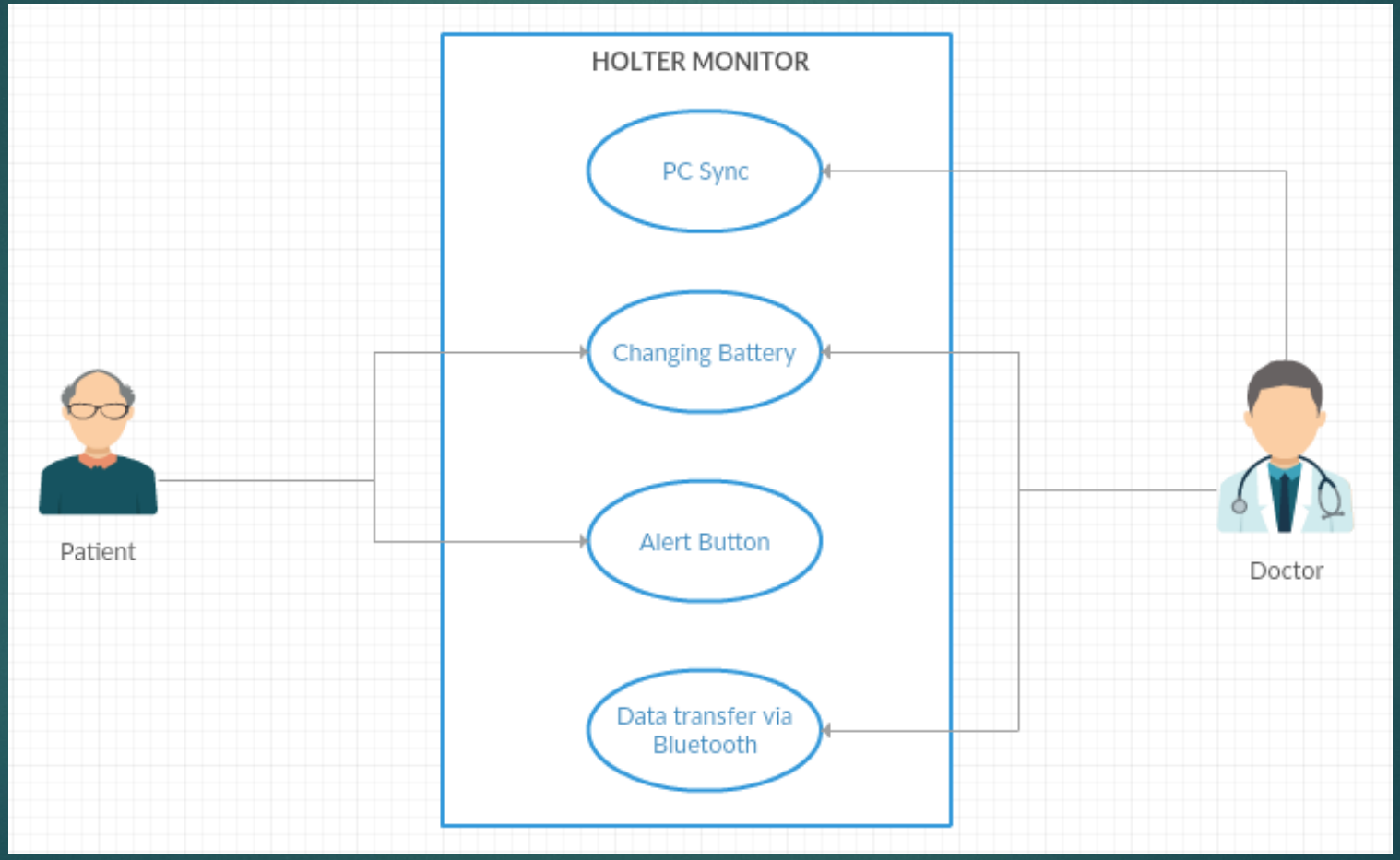
Classes and Verbs

- Initialize_I2C_sub_system()
- Initialize_RTC()
- Boot_system()

- Fetch_data_ECG
- Fetch_RTC

- Write_to_SD
- Plot_graph

Use Case Diagram



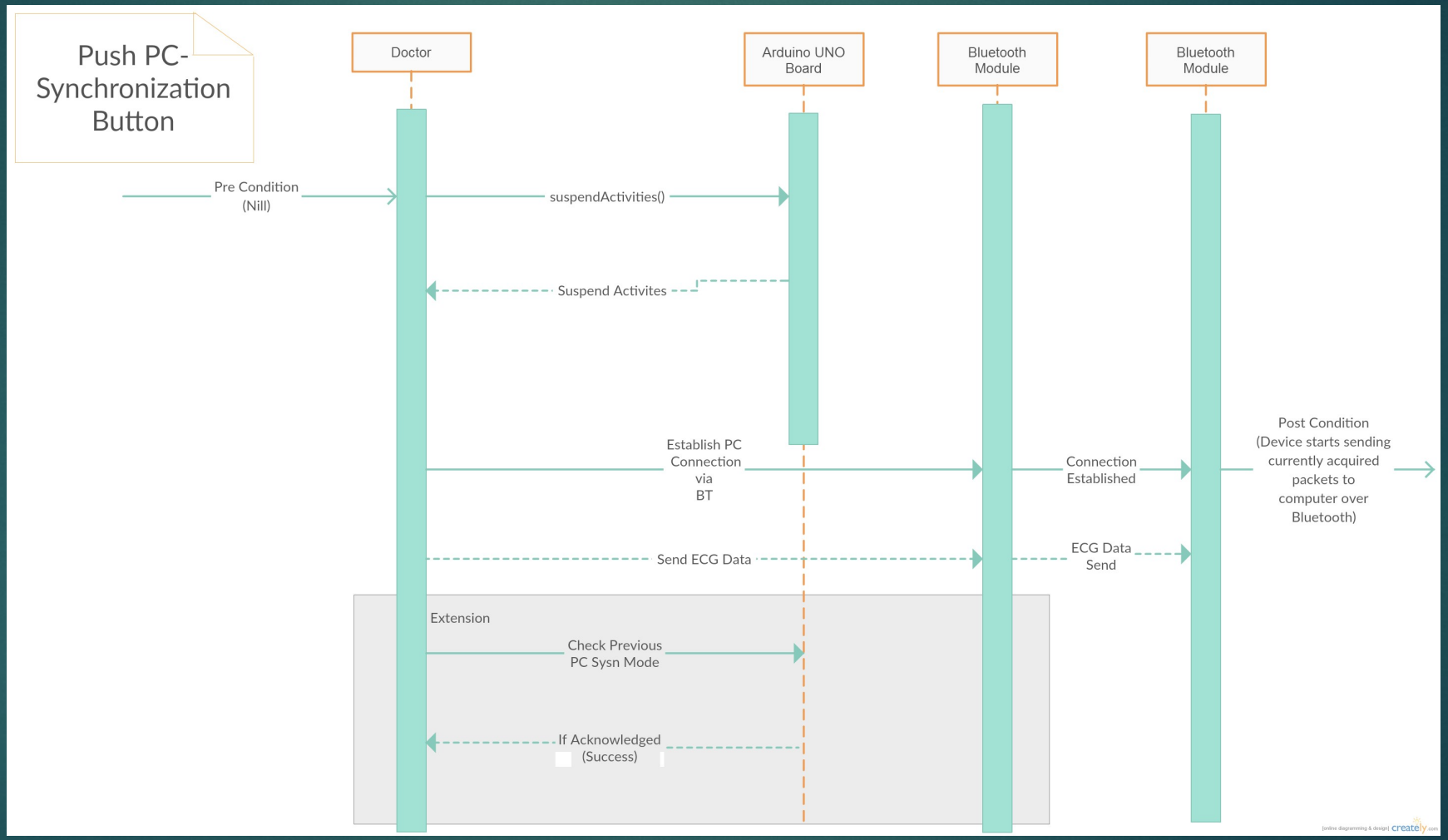
Use Case Diagram (Contd.)

1.

Number	1	
Name	Push PC-sync button	
Summary	Sends ECG packets to PC	
Priority	1	
Preconditions	Nil	
Postconditions	Device starts sending currently acquired packets to computer over Bluetooth	
Primary Actor	Doctor	
Secondary Actor	-	
Trigger	-	
Main Scenario	Step	Action
	1	Suspend all recording activities, and close currently open file on SD card.
	2	Establish connection with PC over BT
	3	Send ECG data over BT
Extensions	Step	Branching Action
	1	Exit from PC-sync mode to previous mode, if no acknowledgement is received from PC, or if connection phase is a failure.
Open Issues	Whether any PC-sync indication is to be provided by the device(?)	

System Sequence Diagram

1.



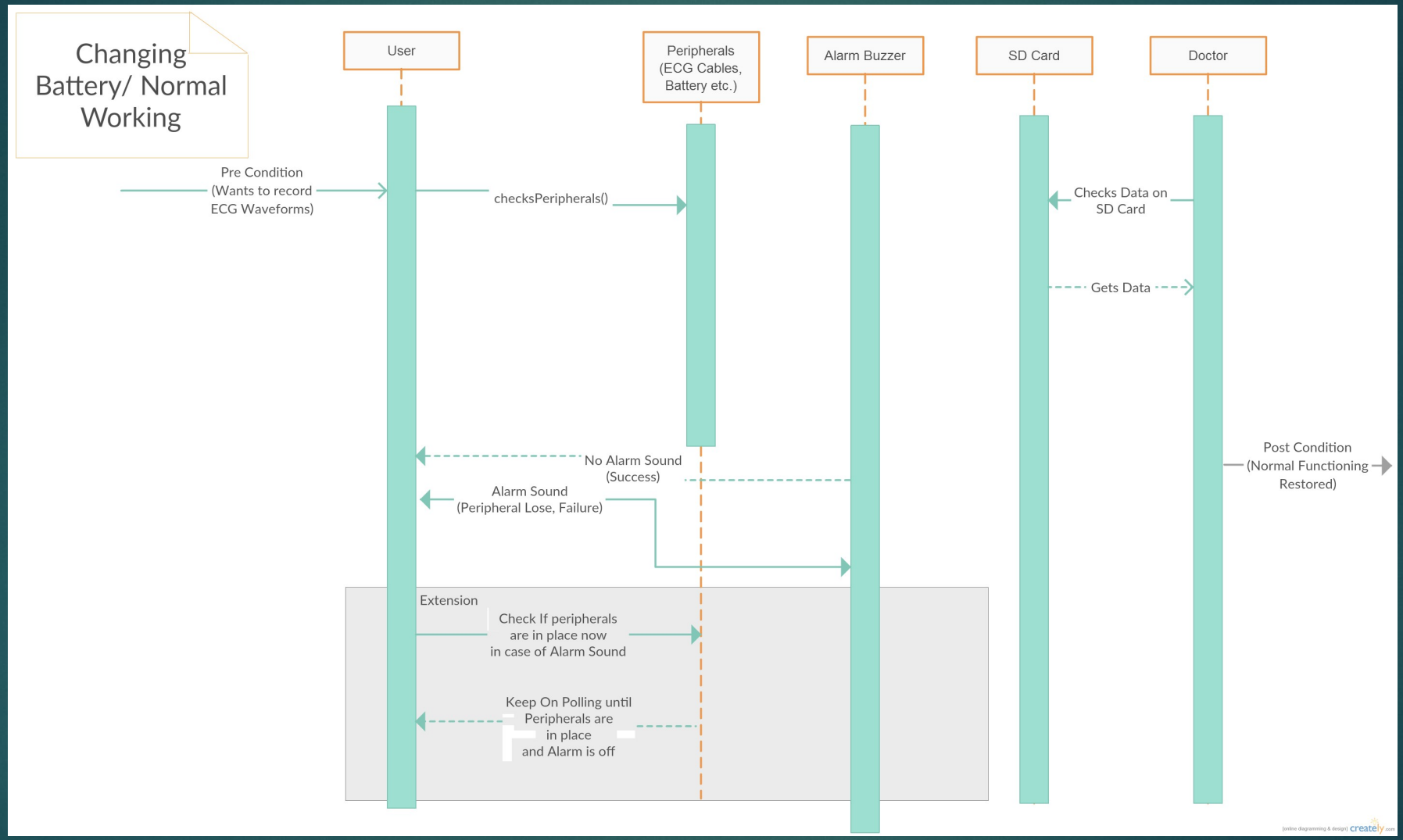
Use Case Diagram (Contd.)

2.

Number	2	
Name	Changing Battery	
Summary	System boots up	
Priority	2	
Preconditions	Nil	
Postconditions	System boot successful	
Primary Actor	Doctor	
Secondary Actor	User	
Trigger	Restoring power to device by a new pair of batteries	
Main Scenario	Step	Action
	1	Checks peripherals – RTC, accelerometer, Bluetooth and ADC
	2	Check file system on SD card
	3	Change mode to recording
Extensions	Step	Branching Action
	1	If any peripheral fails, audible alarm is generated.
Open Issues	-	

System Sequence Diagram

2.



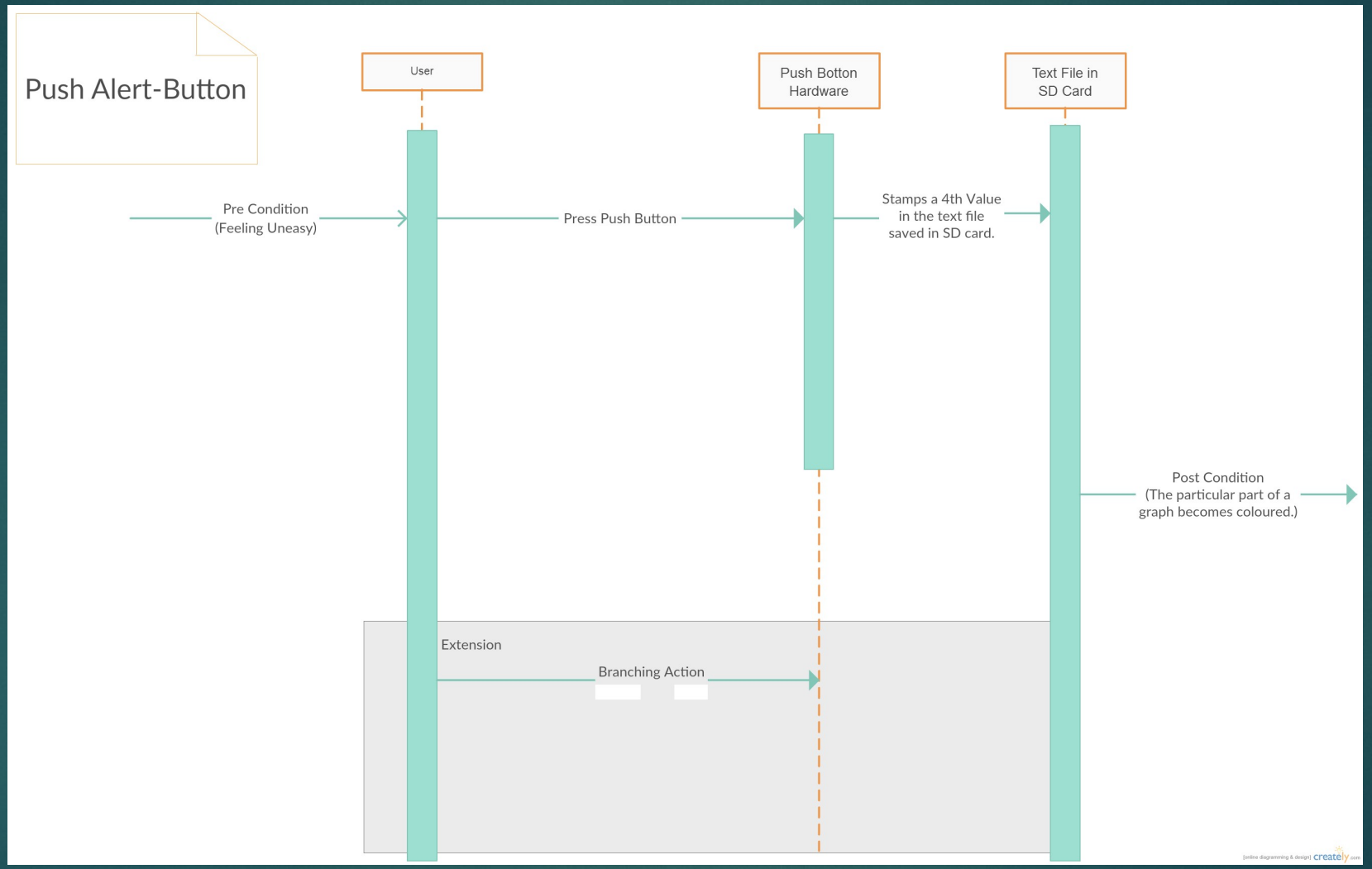
Use Case Diagram (Contd.)

3.

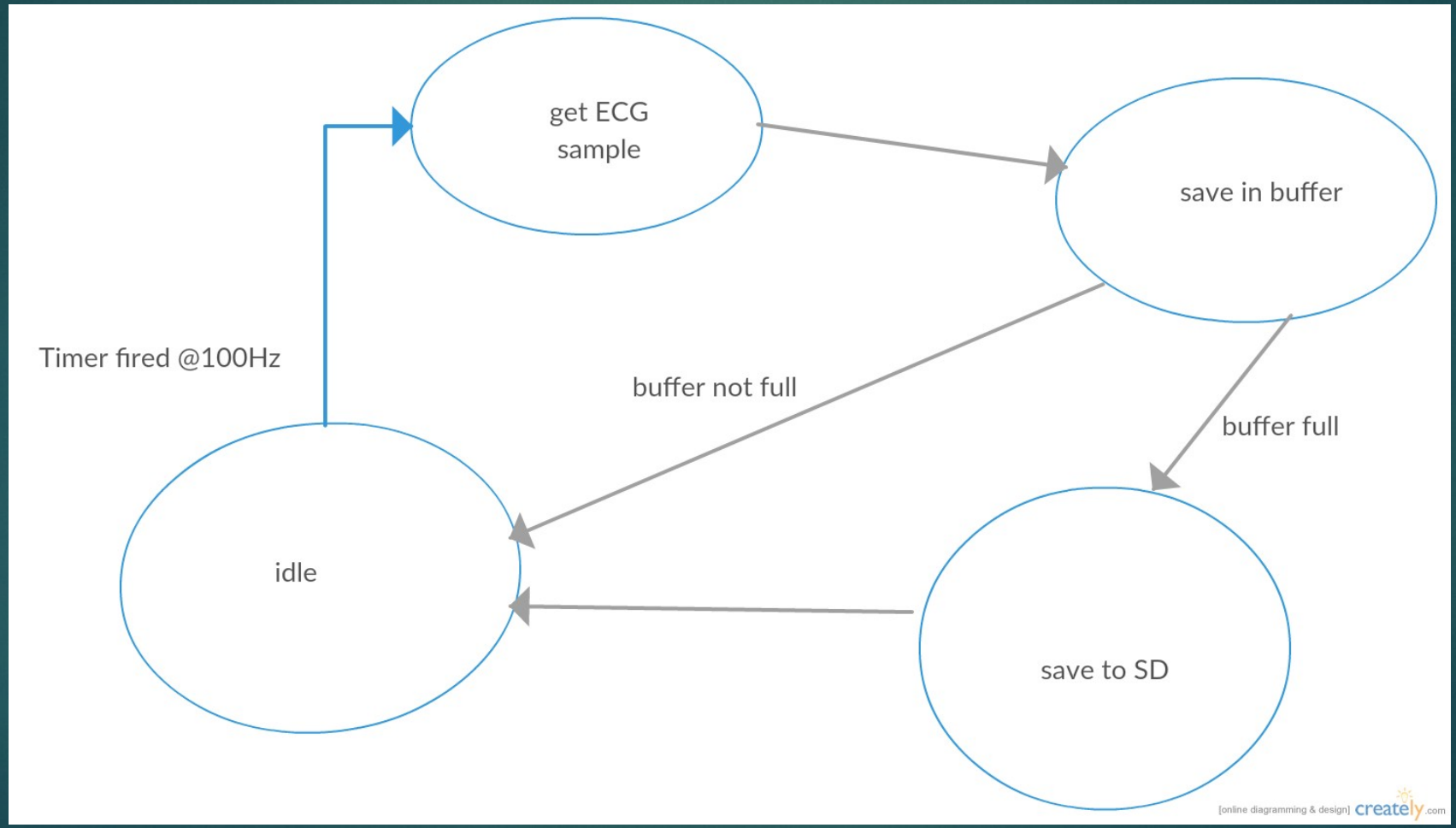
Number	3	
Name	Push Alert-Button	
Summary	Adds a marker to the currently recording packet	
Priority	4	
Preconditions	Nil	
Postconditions	Marker Added to currently recording packet	
Primary Actor	User	
Secondary Actor	-	
Trigger	-	
Main Scenario	Step	Action
	1	Add a marker to the currently recording packet
Extensions	Step	Branching Action
	-	-
Open Issues	-	

System Sequence Diagram

3.

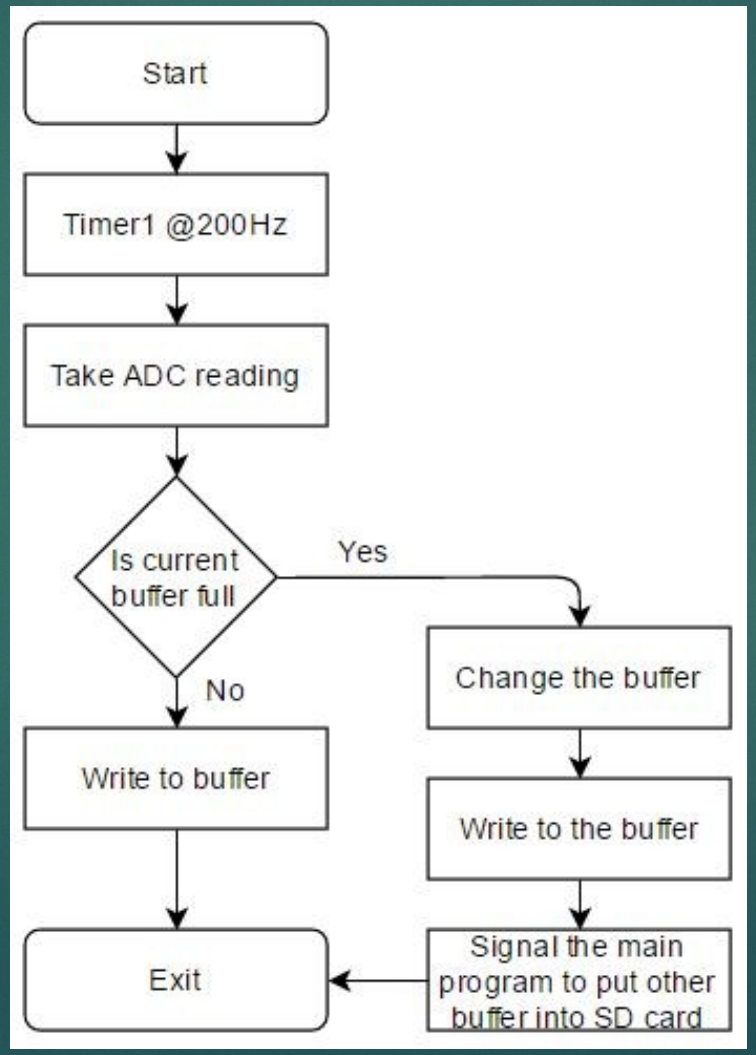


State Diagram



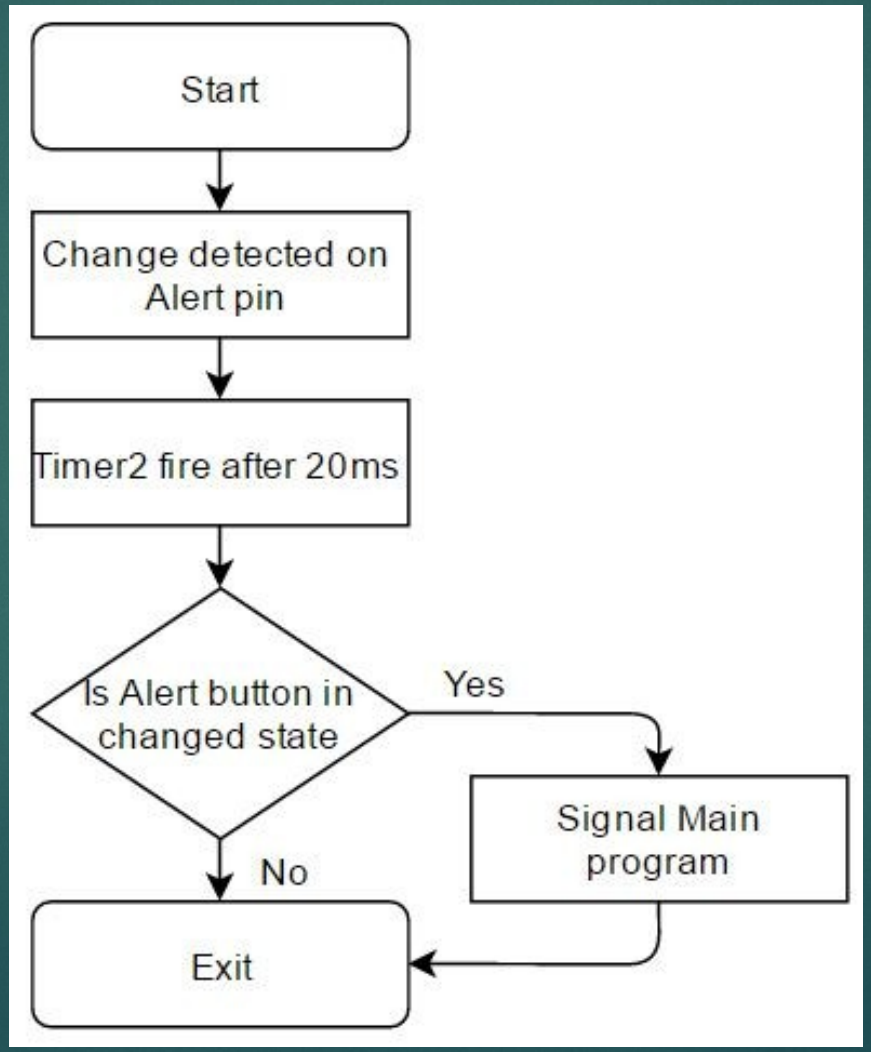
Activity Diagram:

Interrupt Service Routine 1 (ISR 1)



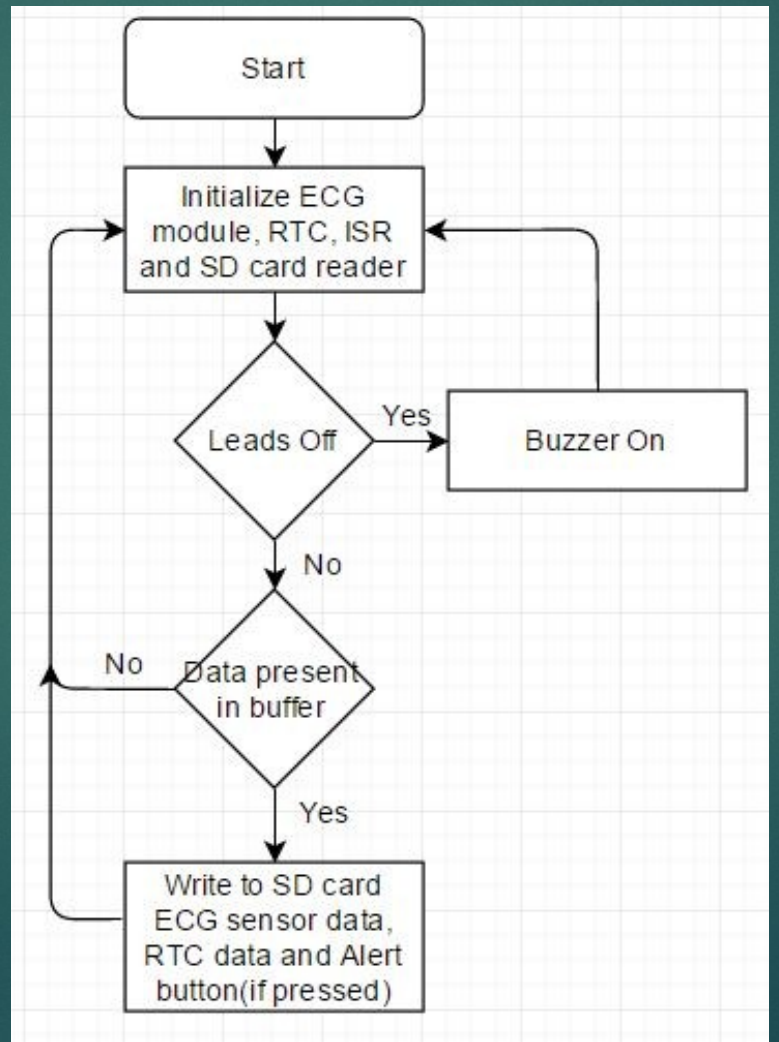
Activity Diagram:

Interrupt Service Routine 2 (ISR 2)



Activity Diagram:

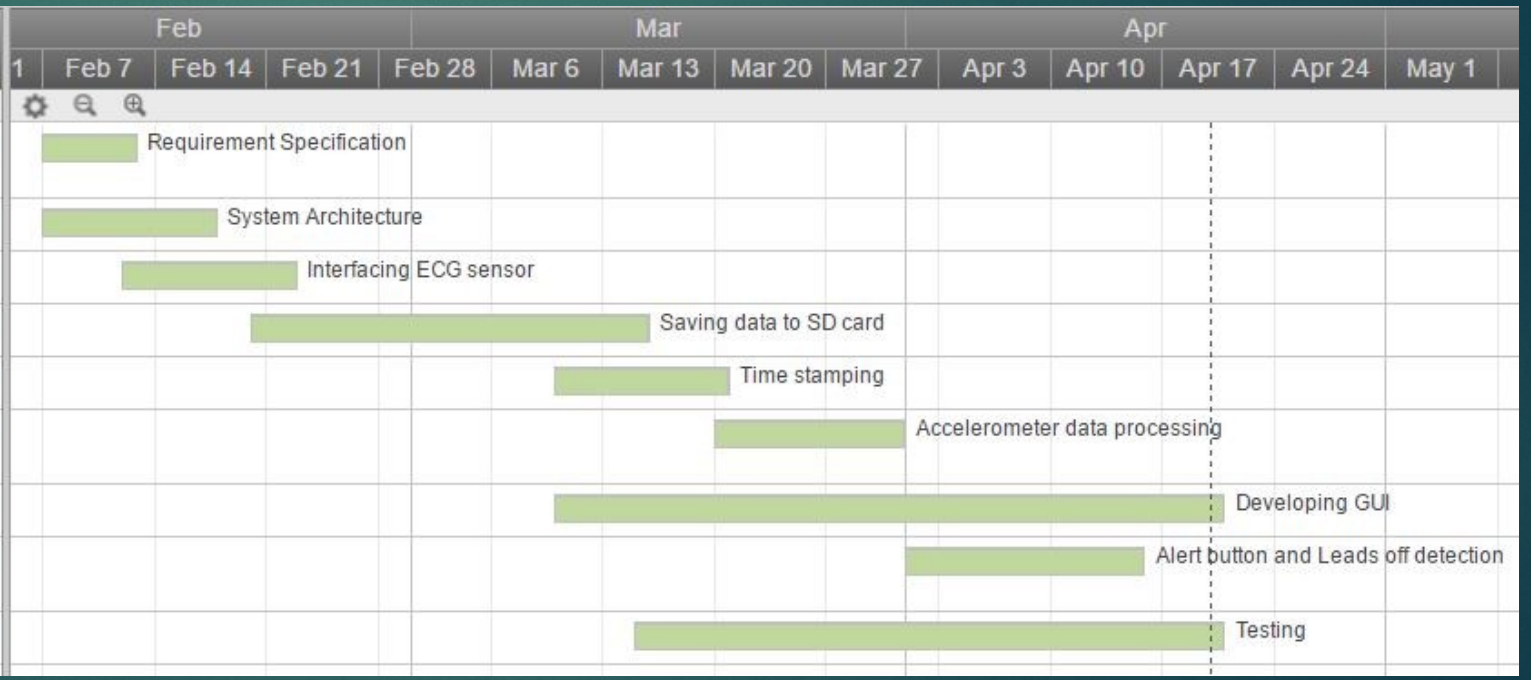
Main Program.



Timeline

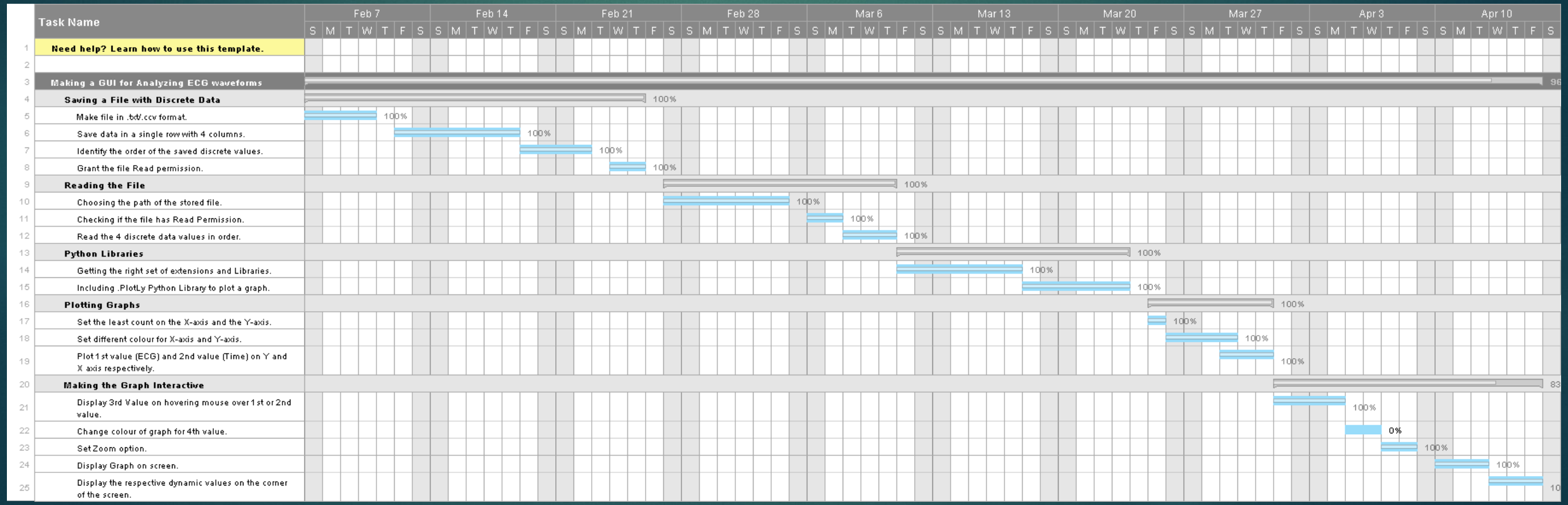
Complete Project

ID	Task Name	Start Date	End Date
1	Requirement Specification	02/07/16	02/12/16
2	System Architecture	02/07/16	02/17/16
3	Interfacing ECG sensor	02/12/16	02/22/16
4	Saving data to SD card	02/20/16	03/15/16
5	Time stamping	03/10/16	03/20/16
6	Accelerometer data processing	03/20/16	03/31/16
7	Developing GUI	03/10/16	04/20/16
8	Alert button and Leads off detection	04/01/16	04/15/16
9	Testing	03/15/16	04/20/16



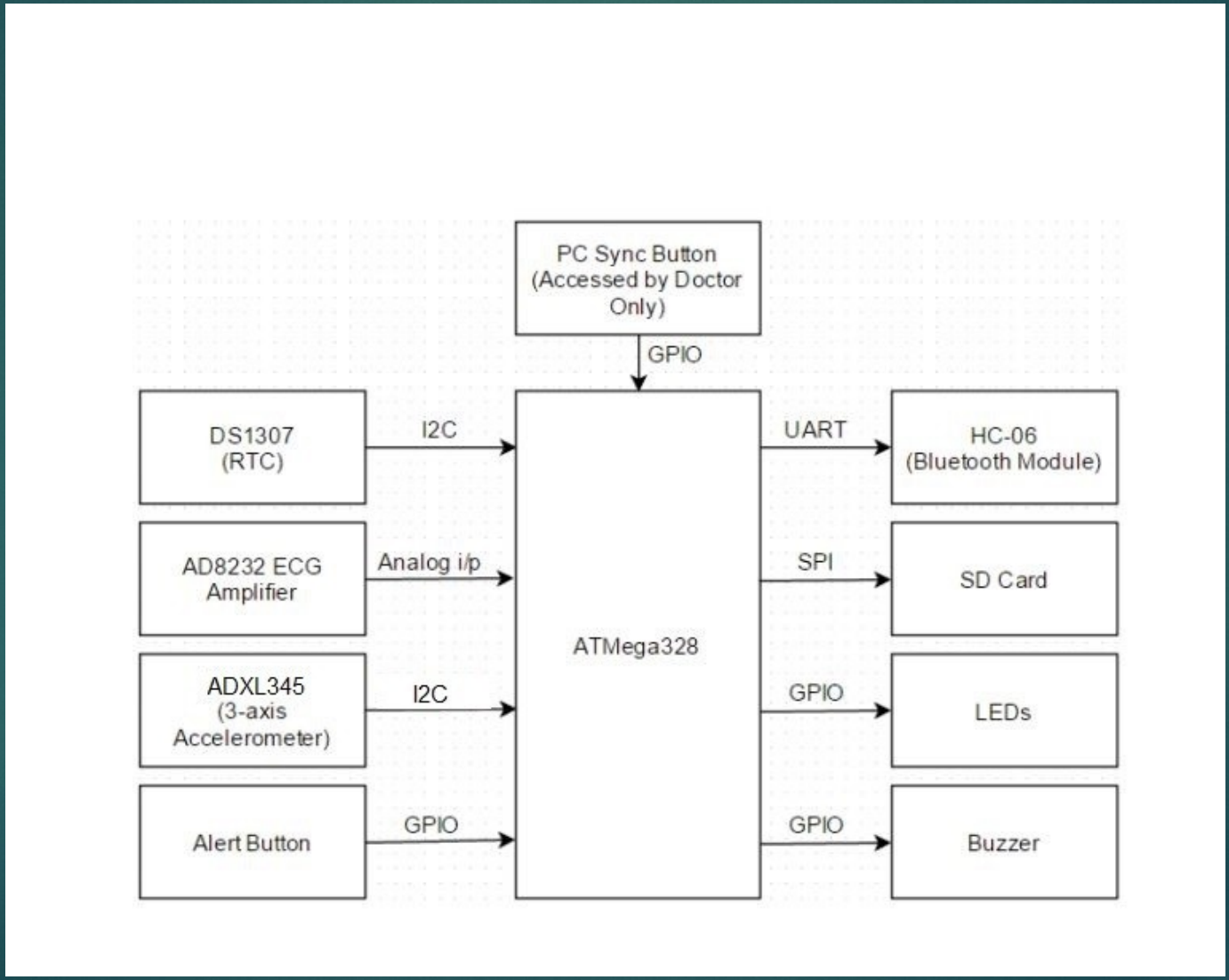
Timeline

Graphical User Interface

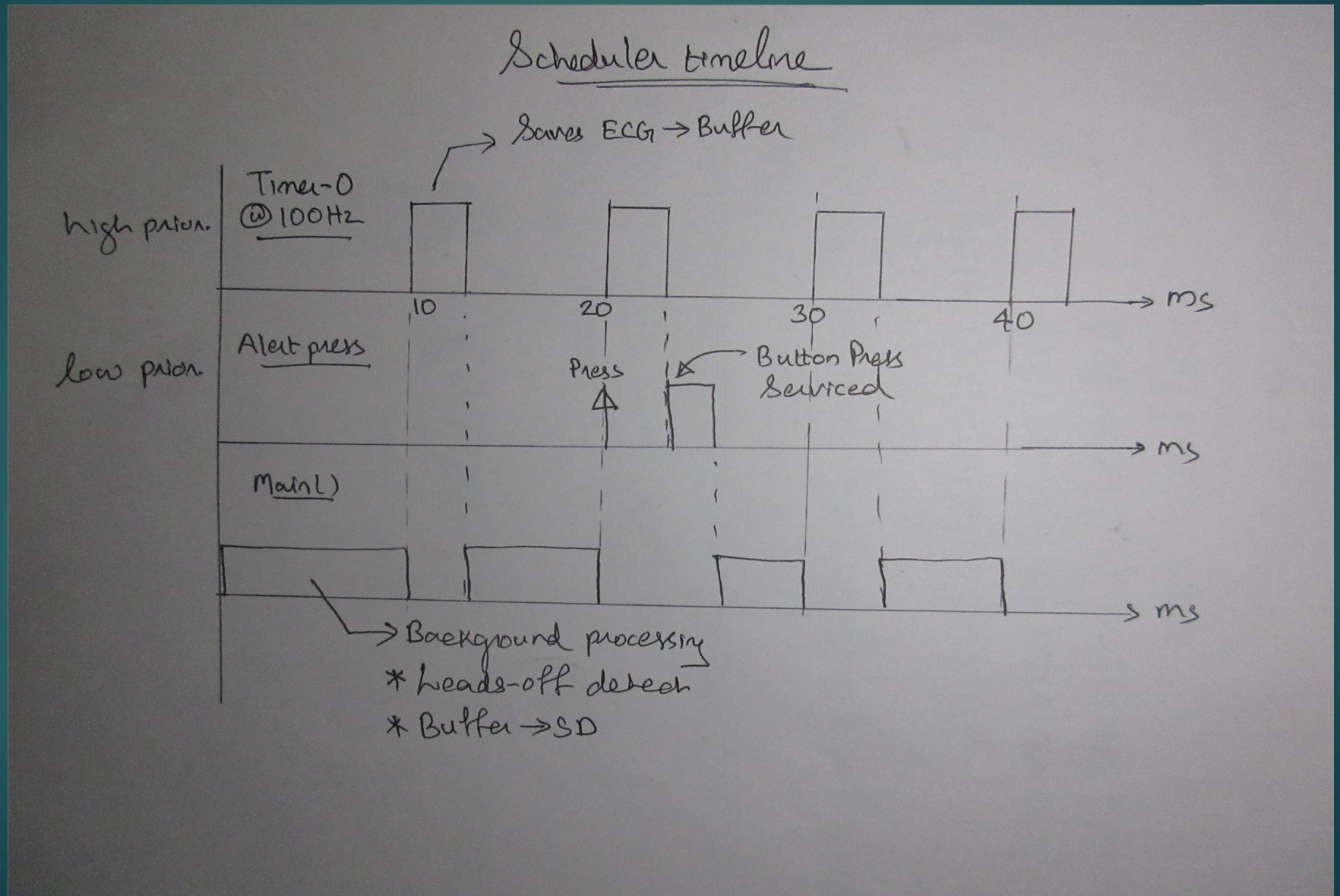


Priority	Task Name	Start Date	End Date	Status	% Done	Duration
	Need help? Learn how to use this template.					
	Making a GUI for Analyzing ECG waveforms	**02/07/16**	**04/15/16**		**96%**	**51d**
1	**Saving a File with Discrete Data**	02/07/16	02/25/16		100%	15d
	Make file in .txt/.ccv format.	02/07/16	02/10/16	Complete	100%	4d
	Save data in a single row with 4 columns.	02/12/16	02/18/16	Complete	100%	5d
	Identify the order of the saved discrete values.	02/19/16	02/22/16	Complete	100%	2d
	Grant the file Read permission.	02/24/16	02/25/16	Complete	100%	2d
2	**Reading the File**	02/27/16	03/10/16		100%	10d
	Choosing the path of the stored file.	02/27/16	03/04/16	Complete	100%	6d
	Checking if the file has Read Permission.	03/06/16	03/07/16	Complete	100%	2d
	Read the 4 discrete data values in order.	03/08/16	03/10/16	Complete	100%	3d
3	**Python Libraries**	03/11/16	03/23/16	Complete	100%	9d
	Getting the right set of extensions and Libraries.	03/11/16	03/17/16	Complete	100%	5d
	Including .PlotLy Python Library to plot a graph.	03/18/16	03/23/16	Complete	100%	4d
4	**Plotting Graphs**	03/25/16	03/31/16		100%	5d
	Set the least count on the X-axis and the Y-axis.	03/25/16	03/25/16	Complete	100%	1d
	Set different colour for X-axis and Y-axis.	03/26/16	03/29/16	Complete	100%	3d
	Plot 1st value (ECG) and 2nd value (Time) on Y and X axis respectively.	03/29/16	03/31/16	Complete	100%	3d
5	**Making the Graph Interactive**	04/01/16	04/15/16		83%	11d
	Display 3rd Value on hovering mouse over 1st or 2nd value.	04/01/16	04/04/16	Complete	100%	2d
	Change colour of graph for 4th value.	04/05/16	04/06/16	In Progress	0%	2d
	Set Zoom option.	04/07/16	04/08/16	Complete	100%	2d
	Display Graph on screen.	04/10/16	04/12/16	Complete	100%	3d
	Display the respective dynamic values on the corner of the screen.	04/13/16	04/15/16	Complete	100%	3d

Deployment Diagram



Timing Diagram



Real Time constraints

- Saving data into SD card takes 15ms/sample - By the time the current sample is saved the next sample would be missed out (a sample arrives every 10ms)

Solution – Use two buffers 128 integers each. (taking a total of 512 bytes)

- ISR writes to the buffers alternatively.

Solution - Once a buffer is full, that buffer is written into SD Card(in main()). This allows 1.28seconds to write into SD card before the second buffer is full.

Graphical User Interface

- Sample .txt/.ccv File

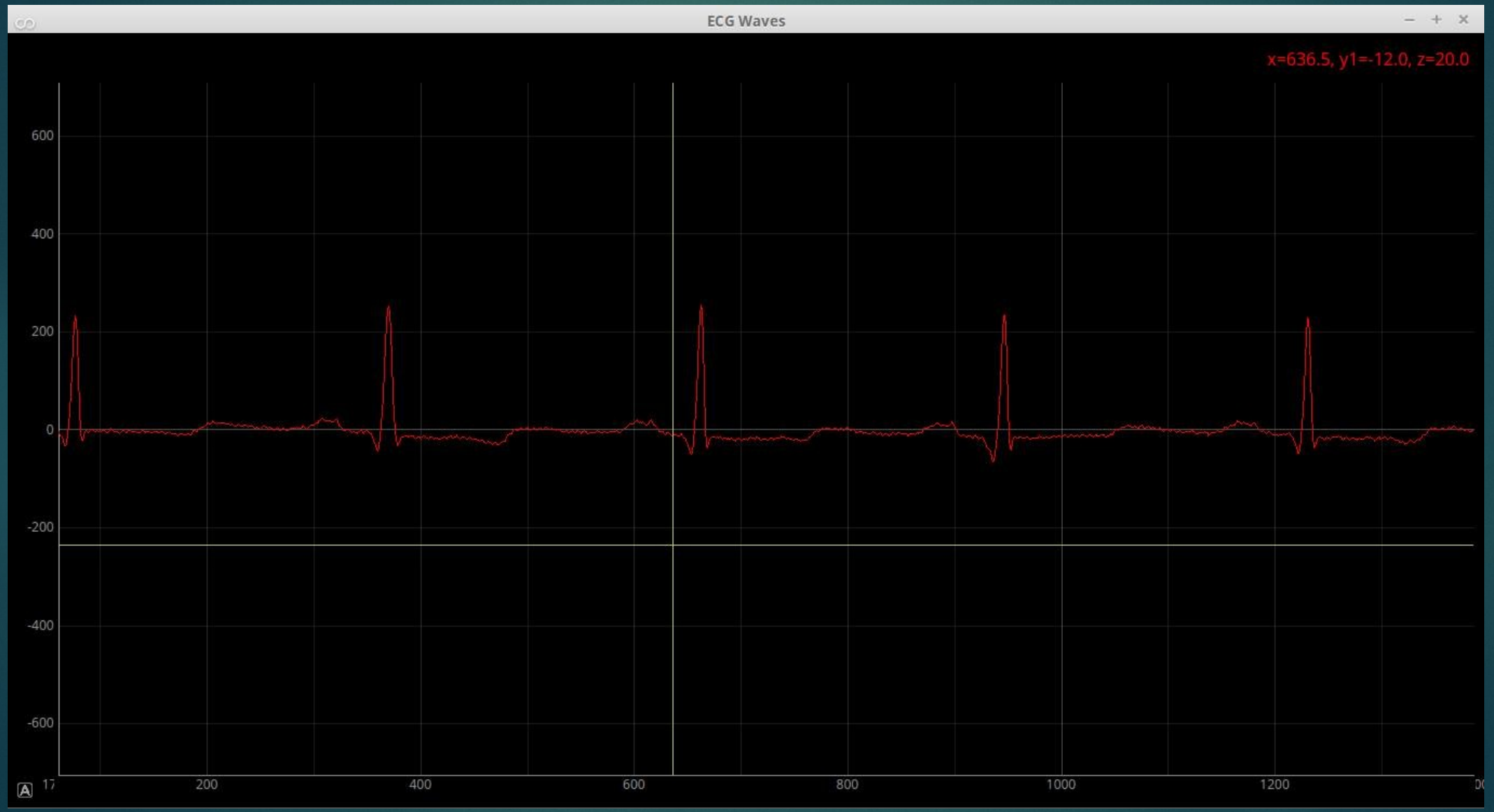
123	10:42:12	312.43	
432		123.43	
321		123.54	
434		311.3	
321		309.56	
123		329	
334		212.98	
234		320.6	
432		321.7	
546		300.01	
231		213.42	
234		345.8	
321	10:43:12	321.5	1
324		342.6	1
321		311.3	1
422		421.5	1
231		311.3	1
313		234.5	1
312		213.4	1
124		121.6	1
312		143.7	1
212		312.4	1
311		124.6	1
333		423.6	1
123	10:44:12	414.4	1

Steps to follow :

- Select Path where the file is kept in SD card.
- Run the Python Code with the given file passed as Parameter.
- The screen is displayed with an interactive graph.
- Graph has the provision of Zoom in and Zoom out.

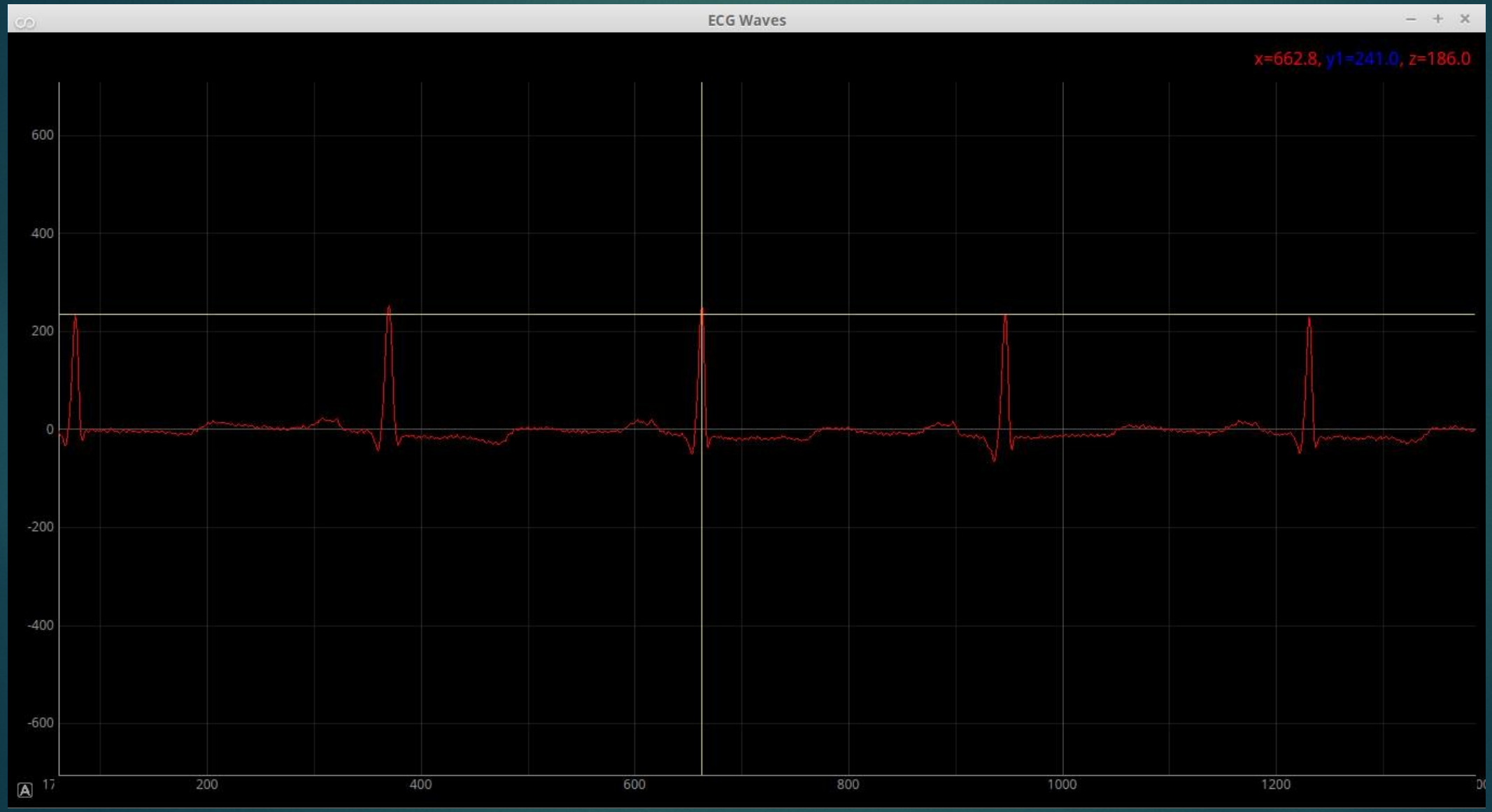
Graph Displayed

- Graph 1 (With Alarm Button Off)



Graph Displayed

- Graph 2 (With Alarm Button On)



Comparison

- Existing Solution :

CardioScope 3-Channel Holter Monitor:

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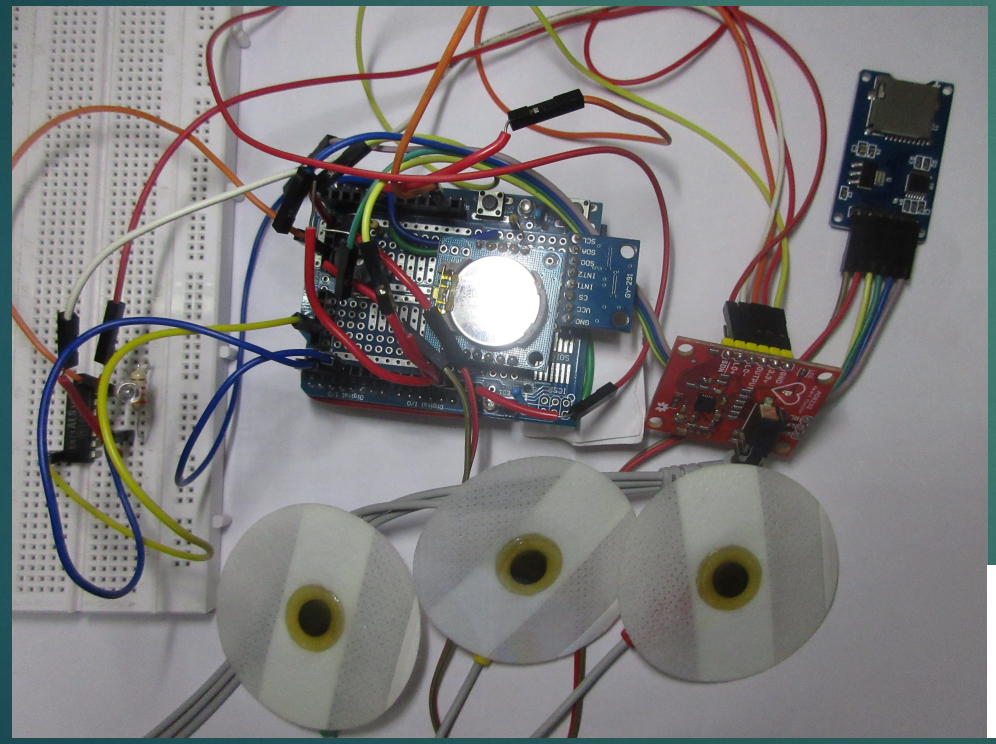
Our Prototype.

- Holter Monitor.



$ 100.00

Cost of Prototype

Cost of prototype

Sl. No.	Component	Cost (Approx.) Rs.
1	AD8232 ECG Instrumentation amplifier	1500/-
2	ADXL335 3-axis accelerometer	200/-
3	DS1307 RTC	200/-
4	4GB Micro-SD card	200/-
5	HC-06 Bluetooth Module	200/-
6	Arduino Development Board	500/-
7	3-lead ECG cable	500/-
TOTAL		3300/-

Some Additional Things

- While working on the Prototype we realized that at times the Chest Leads can get lose and leave contact from chest, resulting in an erroneous results.

Solution : We have implemented a combinational logic which will set the Buzzer on resulting in a “beep” sound and the glowing of the led. Also until the error is fixed, there will be no writing into the SD card.

The further development of GUI includes an option of selecting a time range in which the data needs to be analyzed instead of showing the complete timeline of data for further accuracy.

Thank You