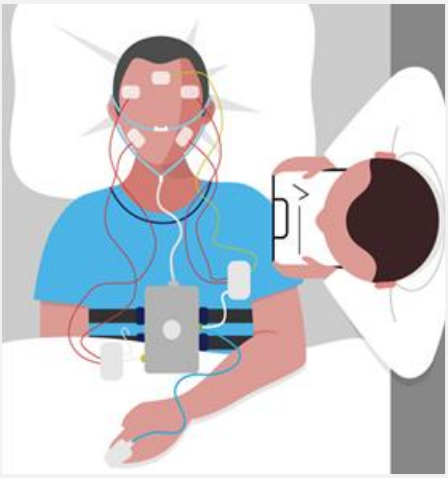
APNEMETER:

(Sleeping Apnea Detector)

Don’t let the inconvenience kill you



Module EN1190: Engineering Design Project
Product Design Proposal

Project Name: Apnemeter (Sleeping Apnea Detector)
Group EN-13
Due Date: 17th July 2022
Date of Submission: 17th July 2022

Liyanaarachchi D.S.G.L.S.	200345N
Liyanage P.H.S.	**200352H**
Lokugeegana D.L.	**200356A**
Lukshan G.W.C.M.	**200358G**

Content

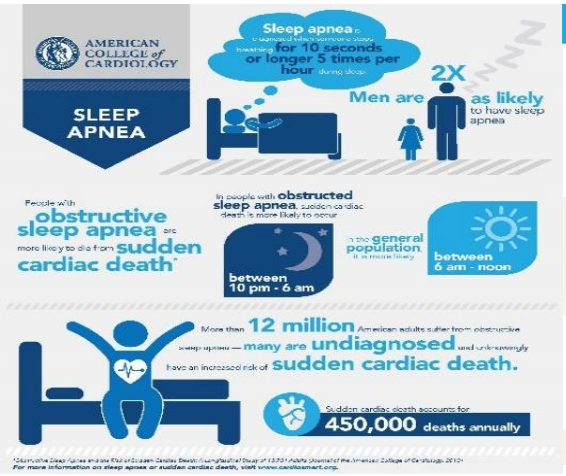
Contents

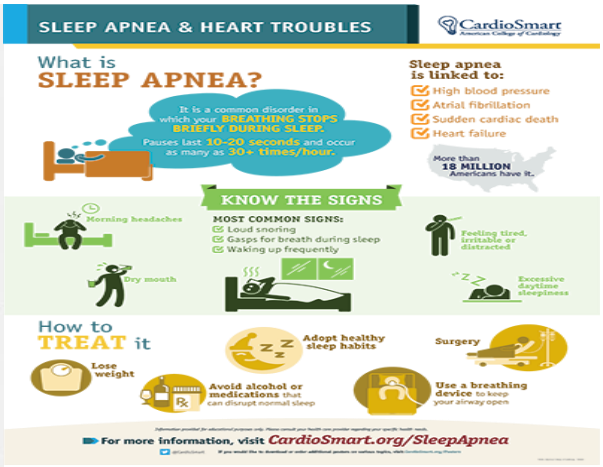
1 Problem description

1.1 Problem

Snoring while sleeping is a common condition that we see in the society. Sleeping apnea is a condition that occurs due to blockage of airways to the lungs and the body is deprived of oxygen during sleep.

Statistics show that nearly **25 million people** in USA suffers from obstructive sleep apnea. (**American Academy of sleeping Medicine**) https://aasm.org/rising-prevalence-of-sleep-apnea-in-u-s-threatens-public-health/





Sleep apnea is a serious condition even though people usually neglect it. This would have a serious effects ranging from depression & anxiety, hypertension, cardiac arrhythmia, strokes or even to a sudden cardiac death if undiagnosed. (**Journal of the American college of cardiology**) https://pubmed.ncbi.nlm.nih.gov/23770166/

The current diagnostic method for this condition is **sleep polysomnography** which is a **bulky device** and requires to be admitted to a hospital or a place with a trained technician. The **high cost** of the device makes could not be used to personally collect data for a longer period of time. https://www.newchoicehealth.com/procedures/sleep-study-polysomnography

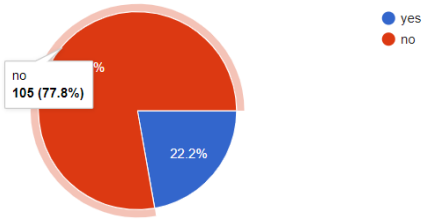
These **inconveniences make people reluctant to be tested** hospitalized, so there is a **vacancy for a smaller easy to use device at home** that could be used as an initial test and then decide whether the severity of the condition requires further testing.

1.2 Solution validation

Sleep Apnea is a serious disease effects ranging from depression & anxiety, hypertension, cardiac arrhythmia, strokes or even to a sudden cardiac death if undiagnosed. This is caused as oxygen level decrement in body due to snoring while in sleep. Statistics show that nearly **25 million people** in USA suffers from obstructive sleep apnea.

Have you ever heard about sleep apnea?

135 responses



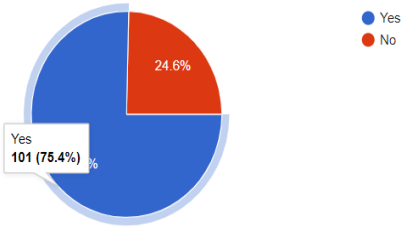
We have conducted a research whether people of Sri Lanka is aware about the diseases. Also whether this device is affordable for them to get an initial diagnosis. The conclusions from the results are as follows,

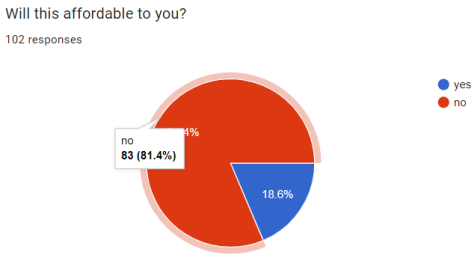
From the 135 sample we conducted the survey, 108 of them were not aware of Sleep Apnea. This shows that most of the people doesn't know about the disease.

In the survey we conducted we gave a brief description about how much serious this disease is, then most of people in the sample are willing to get diagnosed. This shows us that if people were aware of the disease they might get diagnosed. For marketing purpose, we might be able to put some videos about sleep apnea to YouTube for people to get informed.

Are you willing to get diagnosed?

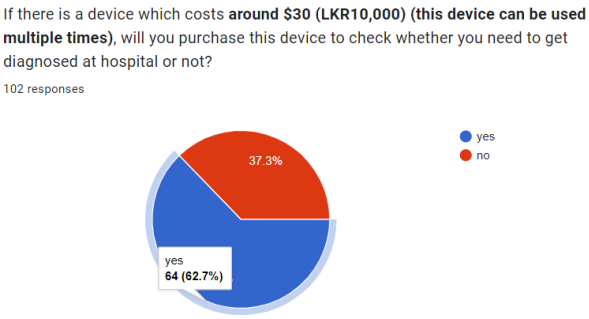
134 responses

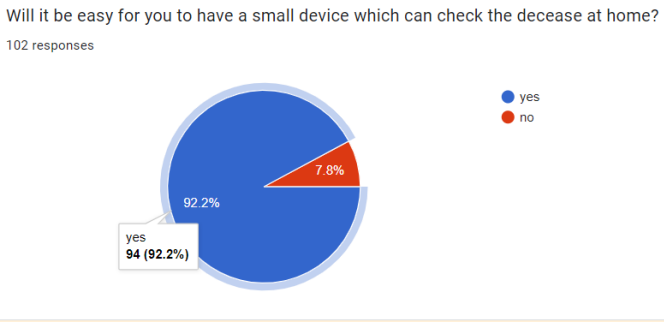




From the sample of people who are willing to get diagnosed (108), 81% of them cannot afford the current diagnosis method of Sleeping Polysomnography. Therefore, only 83 from the sample may consider whether or not to buy our product.

The device which we are making will cost around than LKR 10,000 ($30) and 62.7% of the people who are not able to diagnose Sleep Polysomnography will but our product. This means our product will save about 64 more lives from a sample of 135. This means market for our product will be automatically created if we informed the people in a proper method.





From the sample of 102 (people who cannot afford the Sleep Polysomnography), 94% thinks our product will be so much easy to use. But there were only 62.7% who will but our product for LKR 10,000. May be some people cannot afford 10,000 for this due to current financial difficult situation. We will try our best to reduce the cost so that this device will be even more affordable.

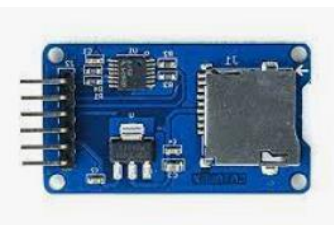
2 Technical feasibility

2.1 Equipment feasibility

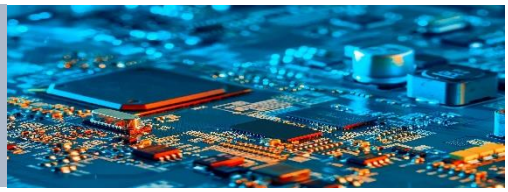
The main technical equipments are the ATMega328P (micro controller), MAX4466 (mic sensor with pre amplifier), MAX30102 (Oxygen level and heart beat sensor), SD card module, TP4056 (charger control) and Display. We have already purchased most of the main components except the display and battery. Therefore, resources requirement is fine up to now.

2.2 Performance feasibility

We are currently doing trials on recording the required sound by using an Arduino board, where up to now we were successfully conducting the tests. Enclosure design is being done step wise such that it will be suitable to our design. Except the mic sensor other circuits and sensors will be inside the main enclosure which is to be wear near the wrist. Mic sensor will be kept somewhat near to the mouth to get more accurate sound. Currently we are ongoing with designing the PCB and it seems to be meeting all the performance targets.



3 Technical specification



3.1 Key features

- From this device, O_2 saturation level in blood and heart beat are measured and recorded as csv files meanwhile snoring sound is recorded and saved in wav format in SD card. Device does not record sound throughout the night continuously even though it records heart beat and oxygen level. It records sound when snoring detects. The file size of sound recording will be reduced as an advantage of recording sounds when only snoring detects.
- Physical dimensions are 8.5x4.5x2.5 in centimetres, due to the current electricity crisis in Sri Lanka certain thin Lipo batteries are hard to find on the market if we could find such a battery device height will reduce to 1.5cm.

3.2 Power consumption

Equipment	Power Supply		Normal Power Consumption
ATmega328p(micro controller)	$5\ V$		$70\ mW$
Max 4466	$5\ V$		$0.3\ mW$
Max 30102	$3.3\ V$		$3\ mW$
SD card module	$5\ V$		$250\ mW$
OLED	$5\ V$		$50\ mW$
Total			$\mathbf{373.3\ mW}$

- Power is supplied to ATmega328p micro controller and the mic module MAX 4466 during the sleeping time continuously. Atmega328p micro controller with 16Mhz clock circuit and 5V supply voltage typically draws 46mW and maximum power consumption is 70mW as the device is bit computer intensive higher value was selected for the safe margin. SD card module consumes more power but it does not keep on every moment therefore actual power consumption is **less than** 373.3mW.
- In the OLED display each pixel is illuminated separately, therefore power consumption would depend on the amount of pixels illuminated.

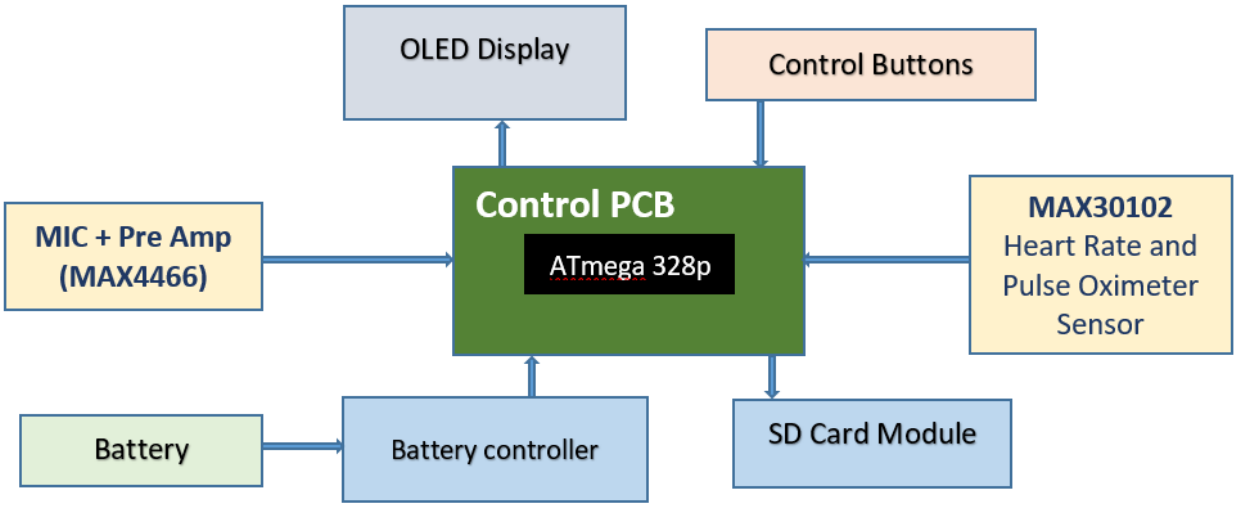
3.3 Weight

- We estimate enclosure and belt will be about 100g, PCB and electronic components will be about 20g and batteries will be about 42 x 2 g. Then total mass will be about 204g. 3.7V thin Lipo batteries were hard to find due to the current situation, but if we use them weight will be reduced by 60g and final weight would be 144g.

3.4 Interfaces

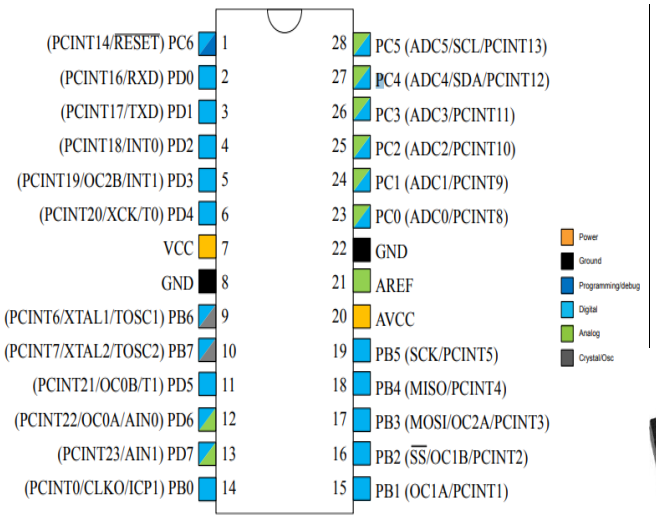
- An immediate feedback would be given to the consumer via the OLED display, after a time period SD card could be ejected and inserted into a laptop for analysis.

4 Product Architecture



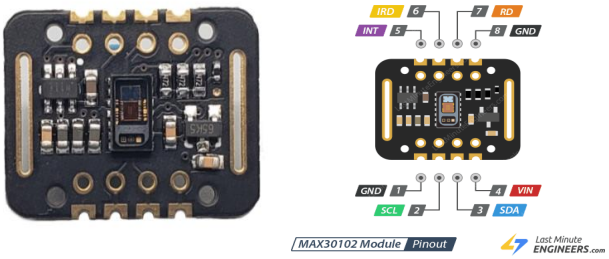
4.1 Control PCB with ATmega328p Micro controller

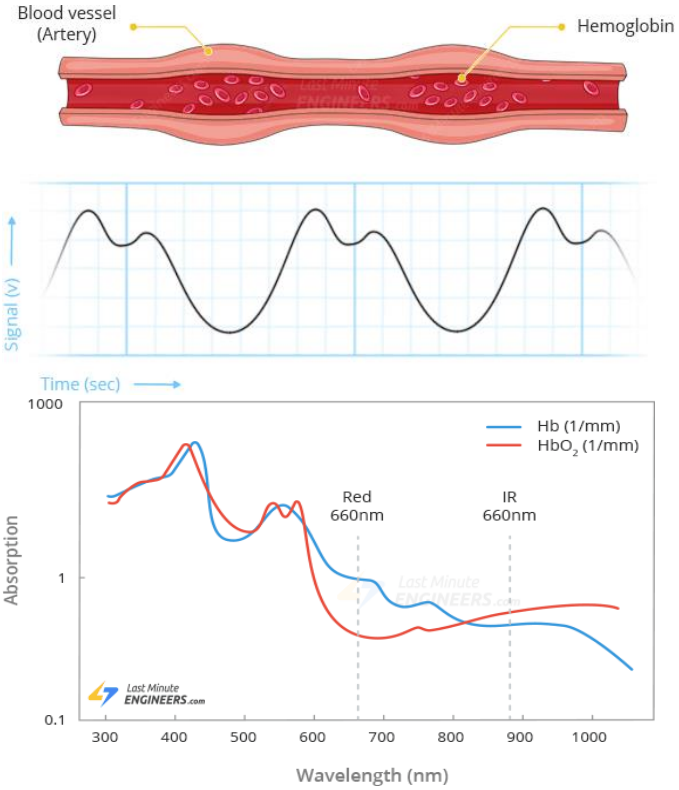
Atmel ATmega328p is a 8bit Microcontroller with very low power consumption. A clock circuit of 16Mhz is suggested to use with it. The microcontroller is equipped with 32KB of Flash memory, 1KB of EEPROM, 2KB of internal SPRAM. The PCB also comes with power management components as some modules run on different voltages.



4.2 MAX30102 (Heart Rate and Pulse Oximeter Sensor)

MAX30102 is a sensor that could be used to measure Heart Rate and Blood Oxygen Saturation. The module comes with two LEDs of IR and red, specialized optical elements, and filters. Heart rate is measured by the changing waveform of refracted IR light due to pulses. Oxygen saturation is measured by the relative intensities of refracted IR and Red lights as IR light is more absorbed by oxygenated blood red light is more absorbed by deoxygenated blood.



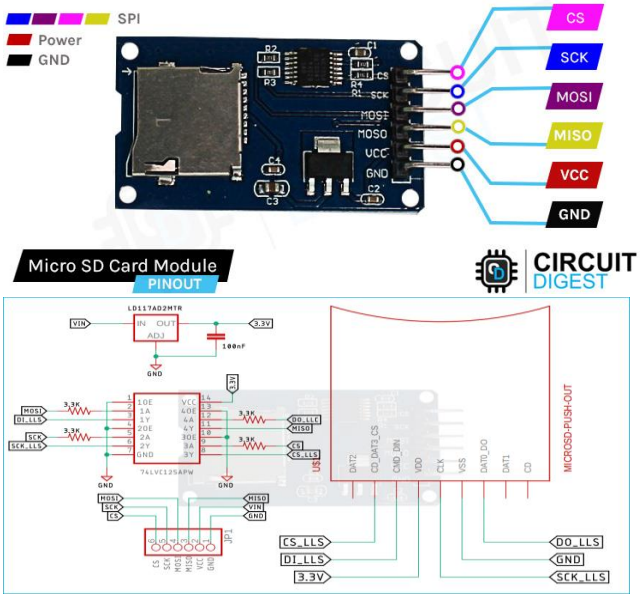


4.3 MAX4466 (MIC + Pre Amp Module)

MAX4466 is a module with inbuilt microphone and max4466 op amp IC based pre amplifier. Despite the very low power consumption and the extremely small package size the device is capable of giving adjustable gain up to A_{VOL}=125dB max.

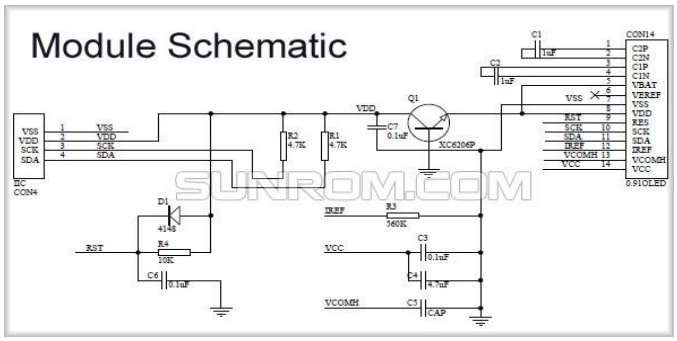
4.4 SD Card Module

This module facilitates the microcontroller to communicate with a SD card up to 32GB and read and write files. The module needs to be synced with the same clock circuit that the microcontroller runs on.



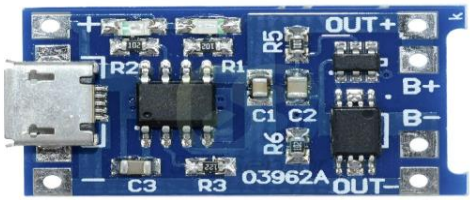
4.5 OLED Display

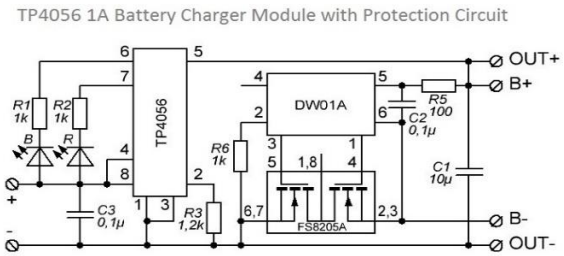
A 128x32 monochrome OLED display is suggested for the design. The display has a viewing angle of 160 degrees and communicates via a I2C serial interface hence only 2 IO pins from the microcontroller is required. OLED displays have a low power consumption relative to LCD displays.



4.6 Battery Controller (TP4056)

A lithium ion battery charger protection circuit is to be implemented. The protection circuit module gives protection for over charging, over discharging with short circuit protection. The device support type C USB chargin





4.7 Battery

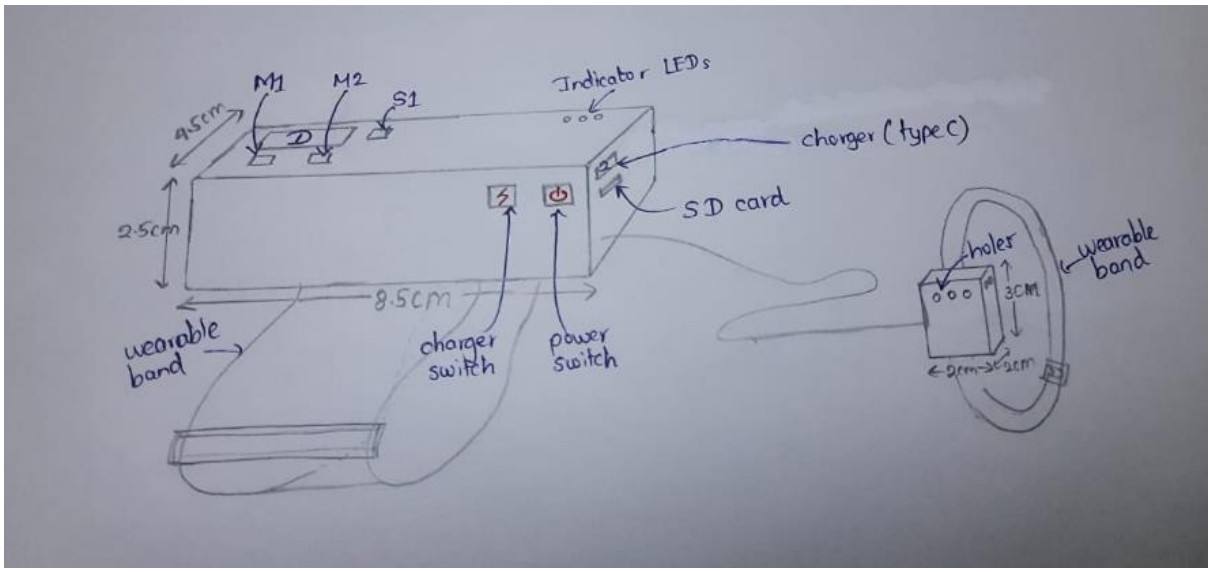
Two 3.7V Lithium polymer batteries are to be used but thin Lipo battery is hard to find in the market and we are using 18650 batteries as alternative, if thin Lipo battery is found device height and weight will reduce in a significant amount.

5 Initial and Finalized Sketches of the Product Enclosures

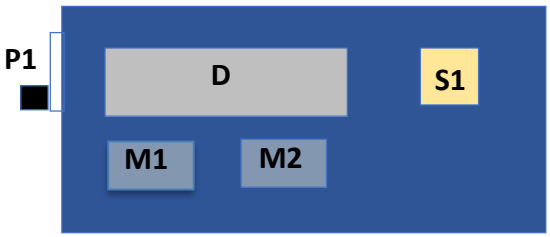
Initial sketch is same as the final sketch; the main difference is the place of wearing the device.

We decided to place the device near the wrist so that there will be no wires. Then a new problem occurred that the mic module may not recognise the snoring sound.

Finally, we decided to keep the mic module near to the mouth at shoulder and the other main part at the wrist.



6 UI Design



D → Display

M1 → Menu Button1

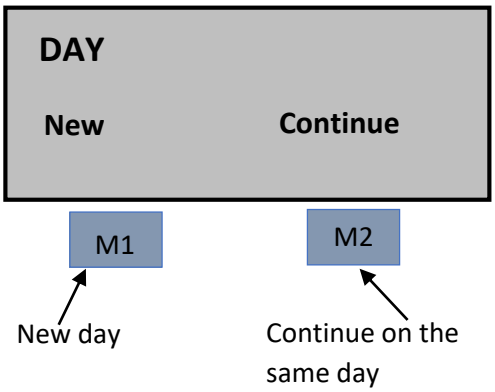
M2 → Menu Button2

P1 → Power Button

S1 → Start/Stop Switch

There are 3 buttons and one switch in the user interface. Power button is used to on or off power supply. Menu button1 is used to choose left item on the display and Menu button2 is used to choose right item. Start/Stop switch is used to start or stop the function.

6.1 Initiation



To initiate the device, first you have to choose whether you start the function on a new date or continue last date.

6.2 Functioning

(When Not -Recording)

DAY	H/B	O_2	n
02	75	96	2

DAY- Current day

H/B- Heart beat

O_2 - Oxygen Saturation

n - number of instances that O_2 saturation drops

(When recording)

DAY	H/B	O_2	n	Rec
02	75	96	2	3

DAY- Current day

H/B- Heart beat

O_2 - Oxygen Saturation

n - number of instances that O_2 saturation drops

Rec- number of hours of recording

Display will show above facts and under Oxygen saturation it displays minimum value during the total hours of recording.

7 Marketing, Sales and Beyond

7.1 Marketing techniques

The current diagnostic method for sleep apnea is sleep polysomnography. The cost of sleep polysomnography ranges for $1250-$6700. Average cost is around $2925. This cost is equal to the average monthly salary of an American citizen (it is about 5-month salary of a Sri Lankan employee). Our product which detects whether we need to diagnose sleep apnea, this is significantly cheaper than sleep polysomnography. Therefore, the price of the product is affordable to normal people also.

Working people have a tight schedule and they are busy with their work. So, most of the people don't have enough time to admit to hospital and spend 4 or 5 days on a hospital bed. They can easily use our apnemeter and check whether they have affected or not at home.

Sleeping polysomnography is a bulky device which is difficult to wear while sleeping but our device is simple and small which makes it convenient to the person.

We are going to go-ahead with above three marketing points majorly.

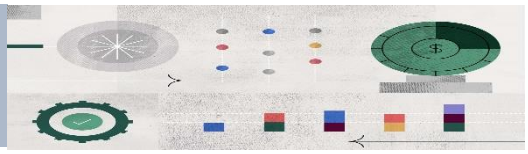
7.2 Product Packing

Product packaging is quite normal. Simple cardboard box is used and there is a user manual guide which is easily understandable.

Since components are placed in separate from each other, repairing can be done unless there is a damage in PCB.

If user is going to dispose the device, sensors or other electronic components which are working properly can be used to make other products as well as to make a new apnemeter. This would be a great help to reduce E-waste in the environment also.

8 Product Budget



Equipment	LKR
Main Technical Equipment: *[price in SL (as on June 2022)]*	
Atmega328p(micro controller)	1200.00
Max 4466	450.00
Max 30102	425.00
SD card module	150.00
TP 4056 battery charger	230.00
OLED display	960.00
18650 rechargeable battery 3.7v (2 equipment)	2000.00
Other equipment: (estimated prices)	
Capacitors, resistors, etc…	200.00
Enclosure (estimated budget)	1500.00
Total	**7115.00**

9 Task allocation for the group members

- Team is led by **Dulan Lokugeegana** by having a great support from **Pabadhi Liyanage, Shanaka Liyanarachchi and Chanula Maduwantha**.

- The **main idea** was from **Shanaka Liyanarachchi**. Design thinking was done by collaboration of all 4 members.

- **PCB** design part is to be done by **Chanula, Shanaka and Dulan**.

- **Enclosure and documentation** will be done by **Pabadhi and Dulan**.

- **Electronic circuit design** is done by **Shanaka, Chanula and Dulan**.

- **ATMega328p is programmed** by **Shanaka**.

- **If possible we are going to build an extra software** which will be run in Laptop for further detailed report which will be done by **Shanaka**