Texas Instruments
WiSH 2025

WanderWatch

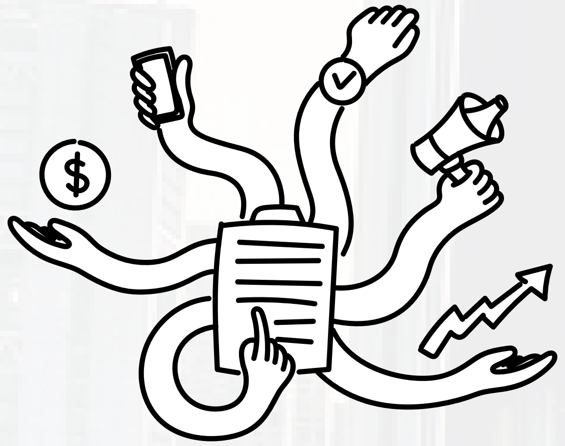
DISTRACTION MONITORING WRISTBAND

TEAM:
BATCHU ISHITHA
BHUVANESWARI CHINNAKONDU
MEHER NARULA
VAIDEHI BHAT
KEERTHI KAMARAJU

MENTORED BY:
SUBHA SARKAR
LOKESH KUMAR BOTCHA
NIKHIL GOYAL

PROBLEM STATEMENT

WHY?



Increase Productivity

Improve Learning Outcomes

A Wristband

WHAT IT DOES?

Monitors Distraction

Smartphones

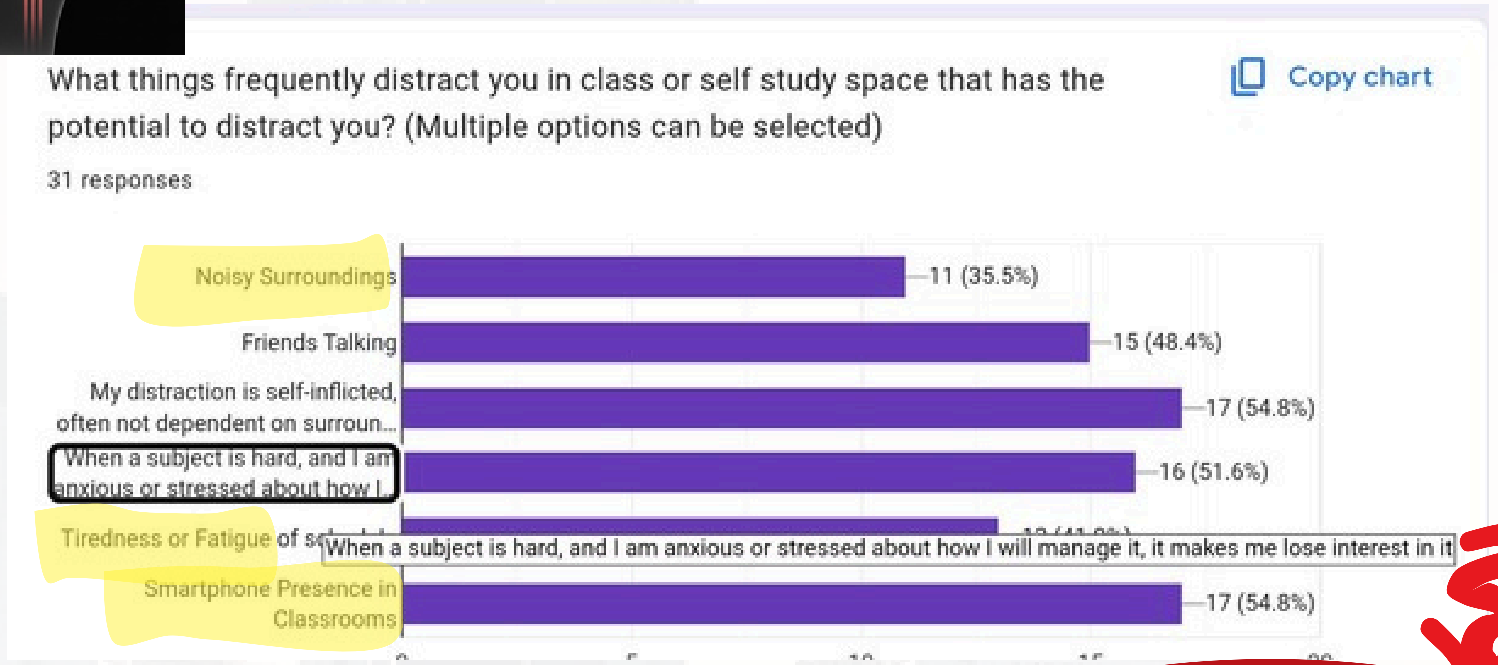
Social Media

Surroundings

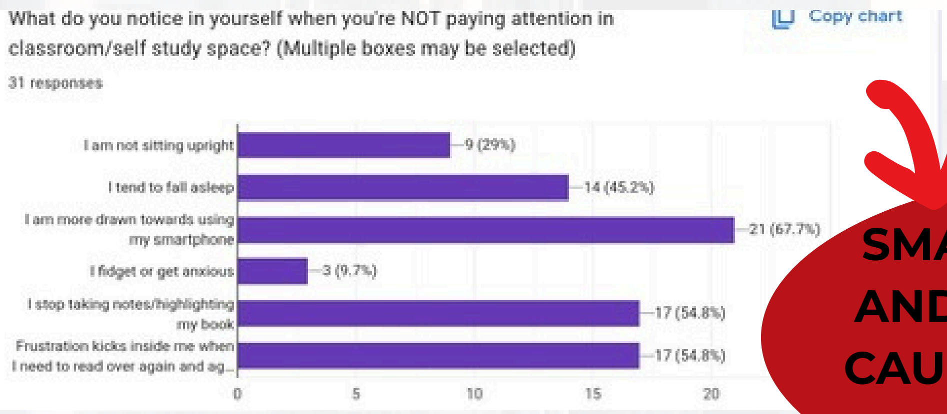
EMPATHIZING

31 RESPONSES

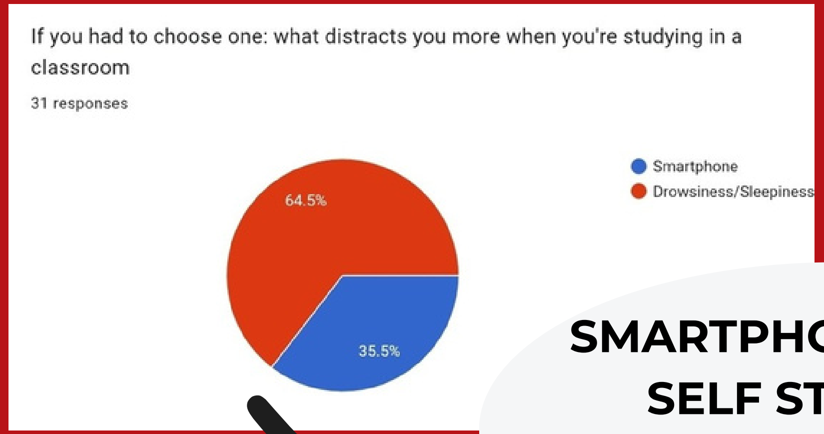
We went ahead and took survey responses from our friends and colleagues to understand the nature of distraction, what causes it, what happens when a distraction is caused, and how would people like to snap back into attention mode, trying to understand how distraction and attention mean different things to different people.

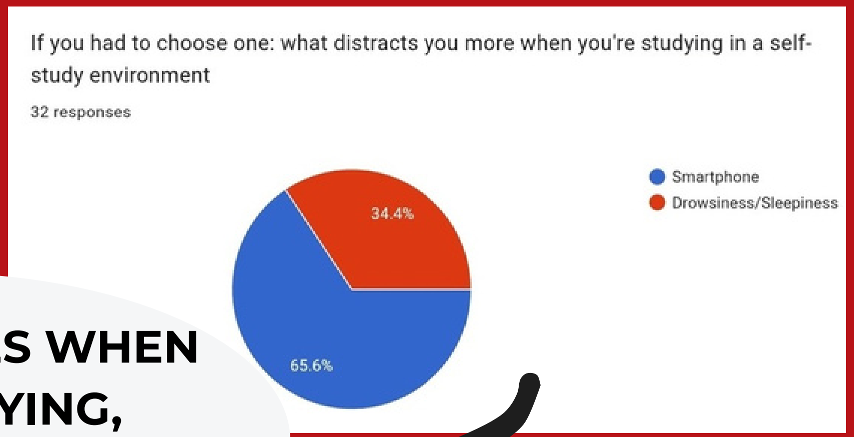


ANXIETY CAUSES DISTRACTION IN LARGE NUMBER OF PEOPLE!

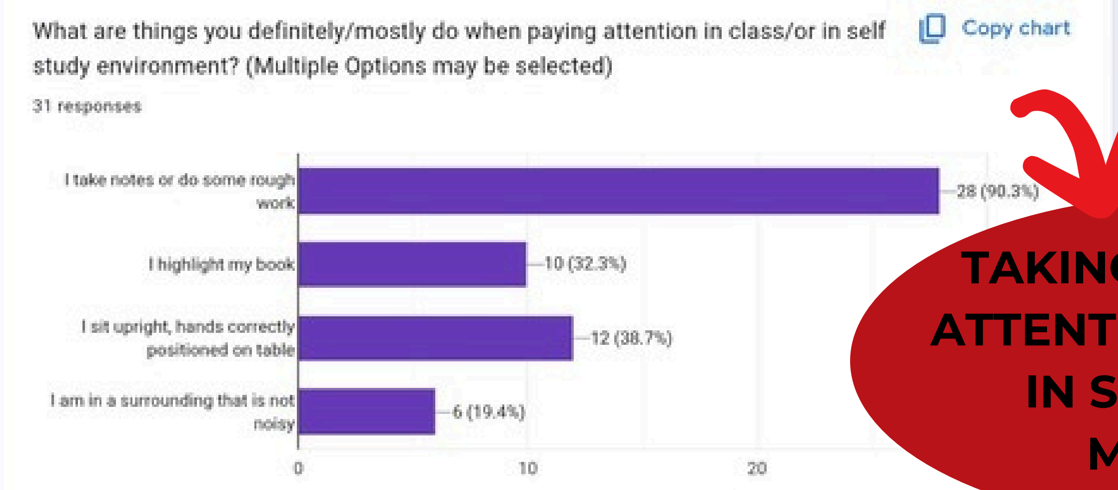


SMARTPHONE USAGE AND ANXIETY IS BOTH CAUSE AND EFFECT OF DISTRACTION.

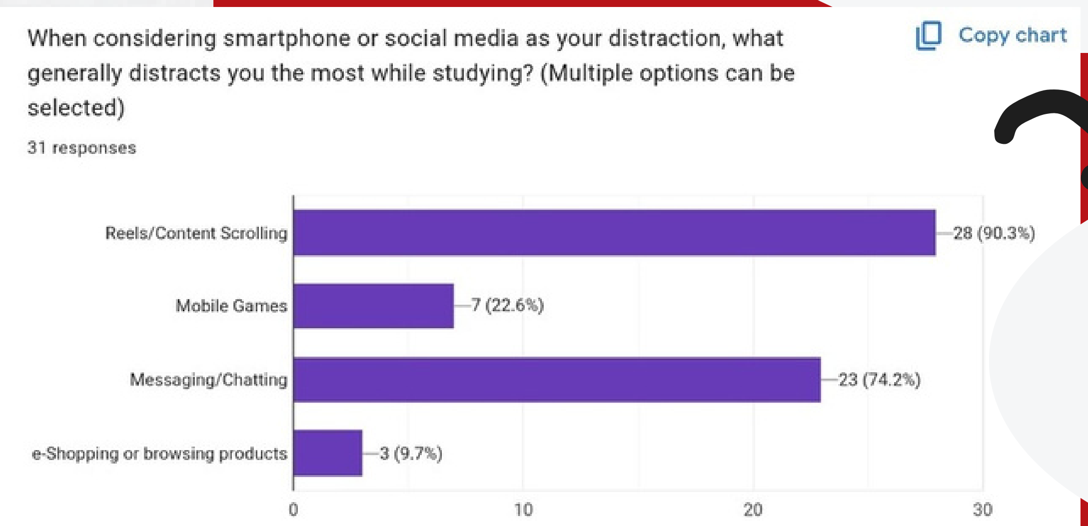




SMARTPHONES WHEN SELF STUDYING, SLEEPY WHEN IN CLASS



TAKING NOTES IS AN ATTENTION INDICATOR IN SIGNIFICANT MAJORITY



THUMB MOTION IS PROMINENT IN ALL MOBILE PHONE RELATED DISTRACTIONS

IDEATION

WANDERWATCH

WHAT CAUSES DISTRACTION?

NOISY SURROUNDINGS

ANXIETY AND STRESS

SMARTPHONE PRESENCE

DROWSINESS OR TIREDNESS

Issues to target

EVENTS TO MONITOR

INCREASED PHONE (AND HENCE THUMB SCROLLING) ACTIVITY

CHANGE IN PHYSIOLOGICAL PARAMETERS IN EVENTS OF STRESS AND ANXIETY

CHANGE IN PHYSIOLOGICAL PARAMETERS IN DRWOSY STATE

STOPPING OF TAKING NOTES:HANDWRITING DETECTION

A NOISY ENVIRONMENT

Sensors/ sensory inputs to be selected

WHERE DOES DISTRACTION DIFFER?

Configuration according to surrounding

DIFFERENT IN CLASSROOM AND SELF STUDY AREA

Simultaenous Requirements:
Wearable device
Low Power device with long battery life
Unobstrusive

DISTRACTION EVALUATION IS A MULTI - INPUT DEPENDENT PROCESS

METHODOLOGY

SENSORS ARE ACTIVATED TURN BY TURN IN EVERY CYCLE EVERY 5 MINUTES.

SENSORY INPUTS

PPG Sensor

Skin Conductance

For drowsiness and anxiety detection

Inertial Measurement Unit

Hand writing motion detection

sEMG sensor activated camera

Thumb swiping motion detection

Microphone for external sound captiure

Surrounding monitoring

MICROCONTROLLER

CLASSROOM SELECT MODE

HIGHER PRIORITY WEIGHTS TO DECISIONS FROM PHYSIOLOGICAL SENSORS

BUZZER OUPUT TO SNAP BACK INTO ATTENTION

STUDY ROOM SELECT MODE

HIGHER PRIORITY WEIGHTS TO DECISIONS FROM THUMB SWIPE SENSORS

WANDERWATCH

HANDWRITING DETECTION

Workflow

Sensor: iNEMO 3 axis ultra low power accelerometer plus gyroscope

Built in 16 bit ADC sends data to microcontroller via SPI

Inbuilt noise removal and amplification as a check on signal quality

Data collected at 25Hz sampling frequency, for 16 seconds, making windows of 8 data points.

Get amplitude through squaring over 3 axes, getting entropy series through windows, getting entropy average, entropy RMS and zero crossing rates as feature inputs.

Feed features to inference on Decision Tree to get classification result.

Handwriting Detection

$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$

Finding: The significant motion in the x axis and the repetitive strokes in handwriting pattern indicatena reduction in entropy magnitude.

AUDIO MONITORING

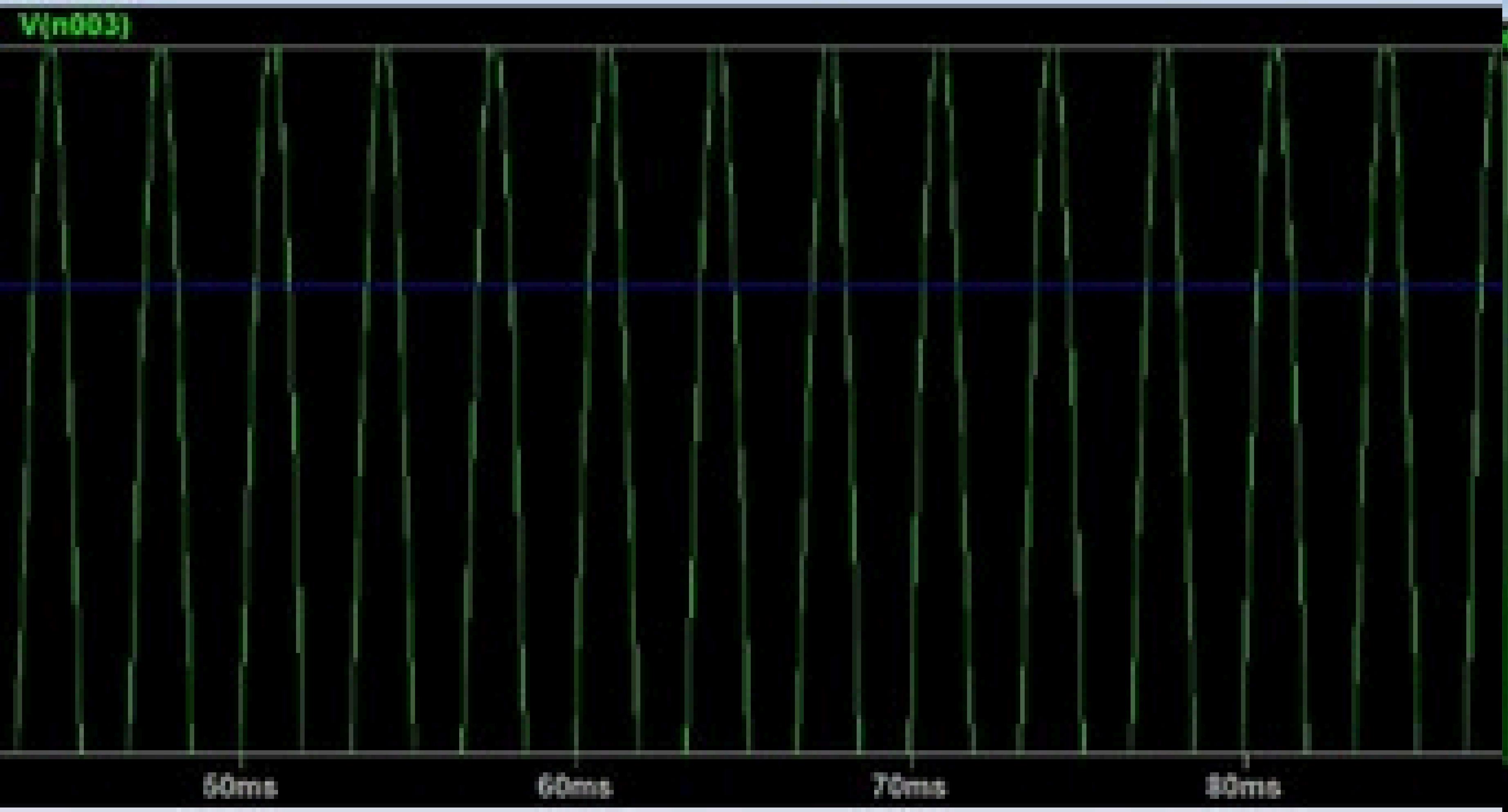
Input: Record environmental sound using an analog MEMS microphone

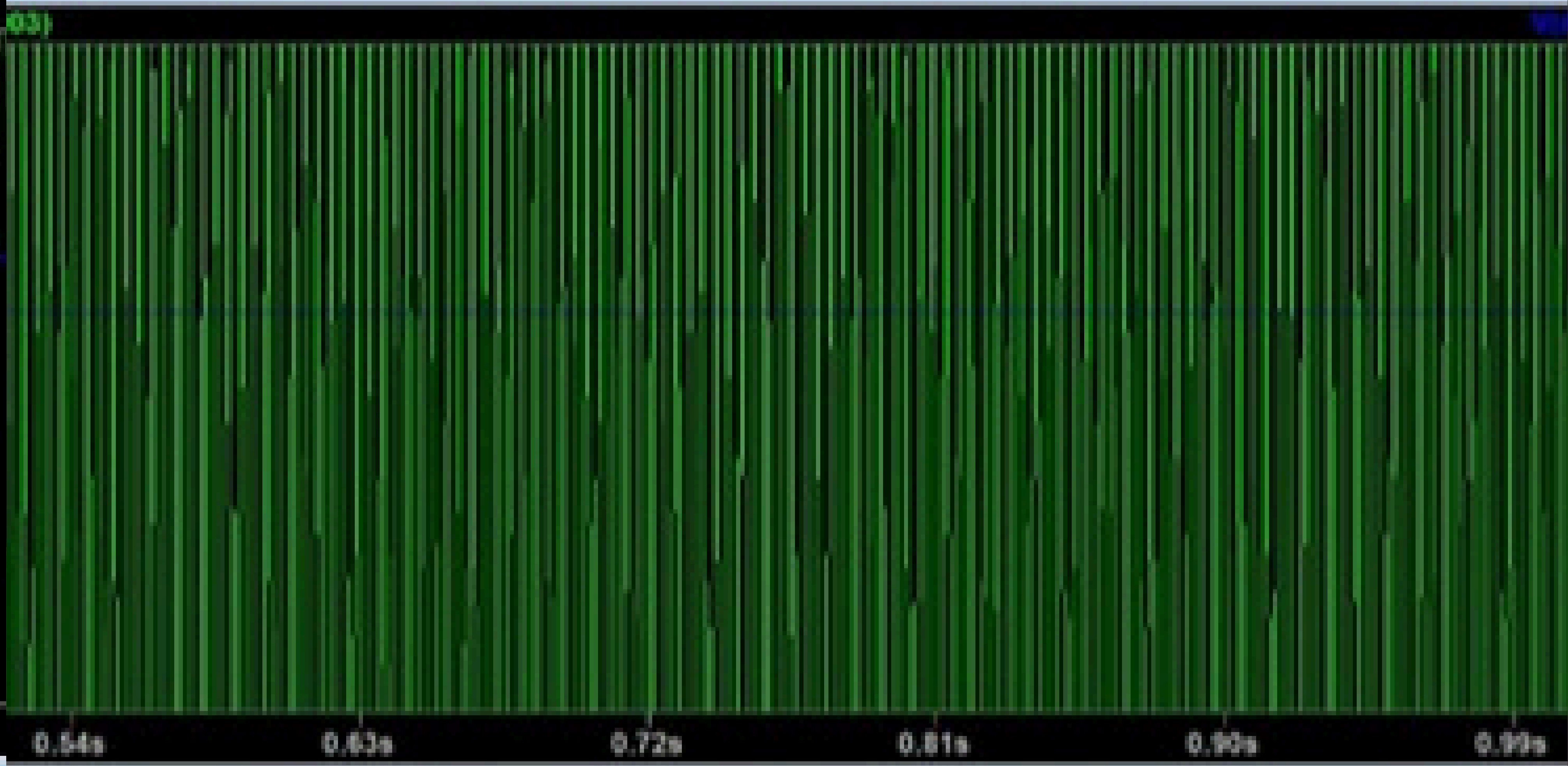
This input is amplified by an opamp to compensate for the decrease in amplitude due to the filters.

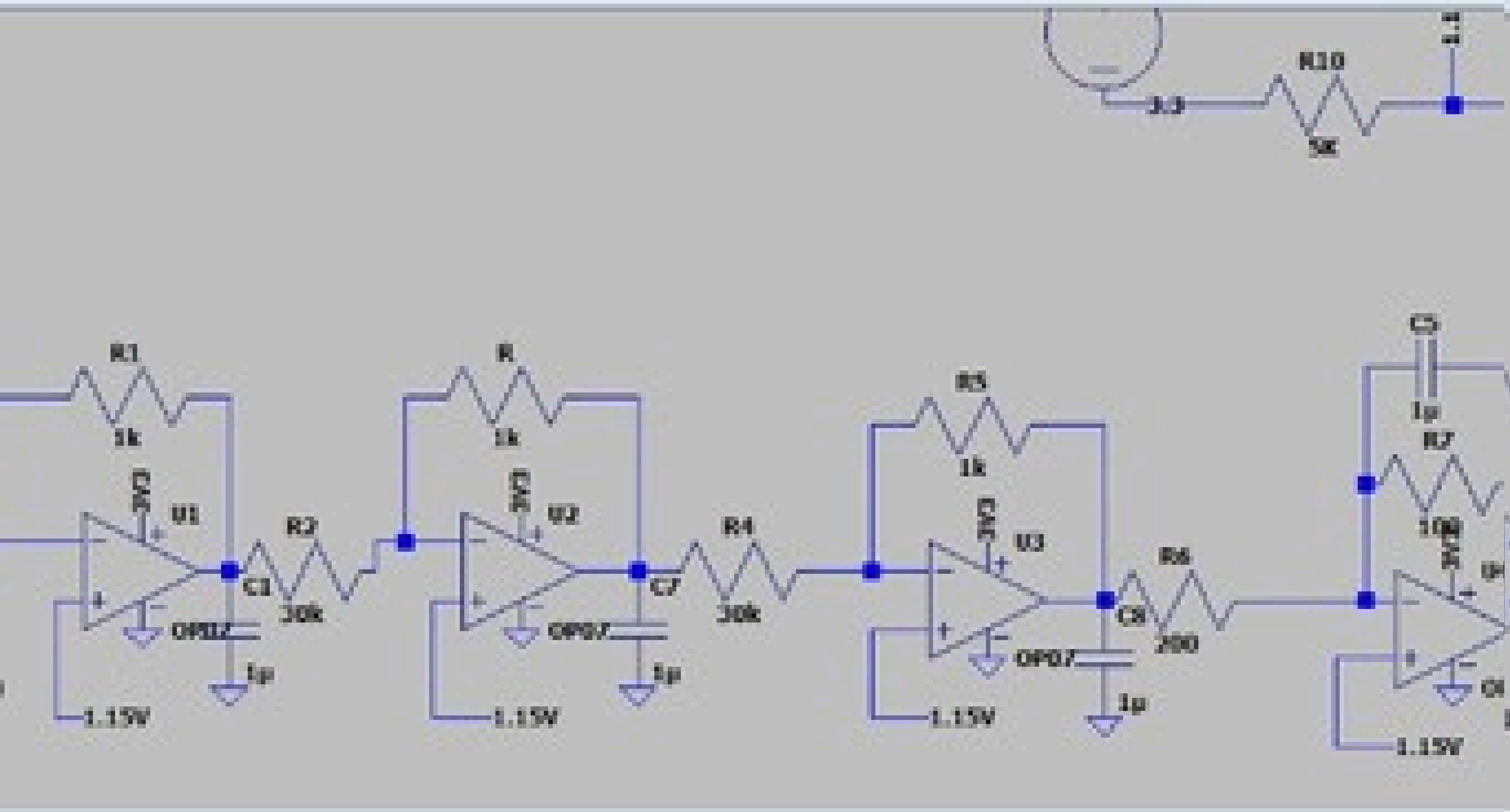
Cascade a low pass (8kHz) filter with a gain to filter out all the high frequencies and find the peaks using peak detector.

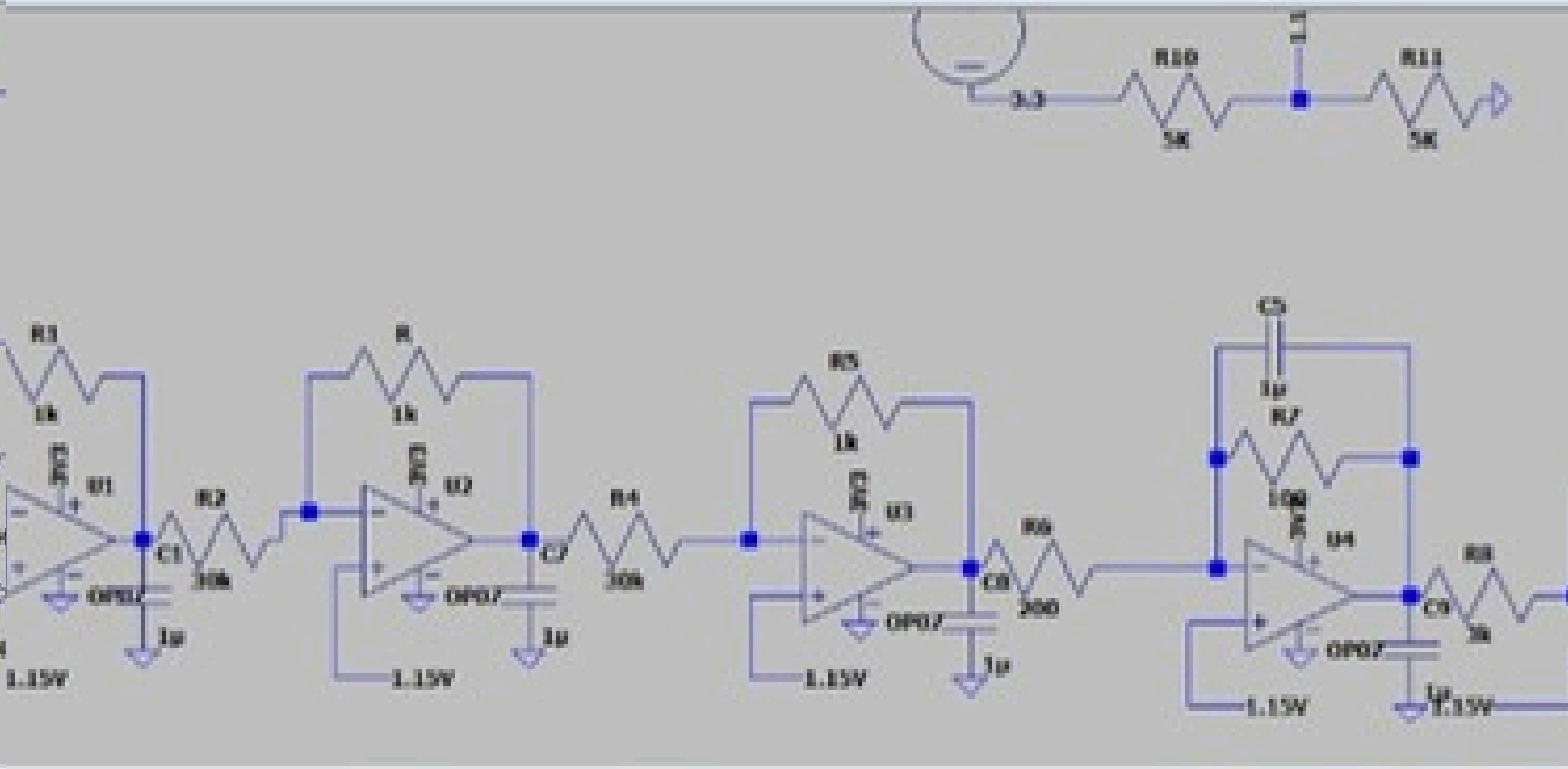
Compare the output to the equivalent voltage of 40dB (1.15V)

If the amplitude of the signal is greater than 40dB, it will be charecterized as a disturbance.


V(n003)
50ms
60ms
70ms
80ms


0.54s
0.63s
0.72s
0.81s
0.90s
0.99s


R10
5K
3.3
R1
1k
R
1k
R5
1k
C5
1μ
R7
100
U1
U2
U3
R2
30k
R4
30k
R6
200
C1
C7
C8
1μ
OP07
1.15V


R10
5K
R11
5K
3.3
C5
1μ
R1
1k
R
1k
R5
1k
R7
100
U1
U2
U3
U4
R2
30k
R4
30k
R6
200
R8
C1
C7
C8
C9
1μ
OP07
1.15V

SKIN CONDUCTANCE

Two Ag/AgCl Electrodes present in grove GSR sensor on wrist for skin conductance measurement

Skin conductance (2.22μS to 100μS) to Voltage conversion

INA333 instrumentation amplifier is used to amplify the small voltages.

Comparator is used for peak difference measurement with a threshold voltage

ADC conversion in Microcontroller.

Signal sampled at 5 Hz and Data is stored in 200 samples per second with signal bandwidth of nearly 100Hz

GSR sensing

HEART RATE VARIATION

IR Light Emission to penetrate into tissue

Photodiode to capture varying light intensity

Amplification using Trans-Impedance Amplifier

Noise cancellation of DC component and 50-60 Hz noise

WITHIN THE SENSOR

ADC sampling at 12Hz

I2C PROTOCOL

HRV Processing
- RMSSD
- SDNN
- LF/HF

Threshold comparision

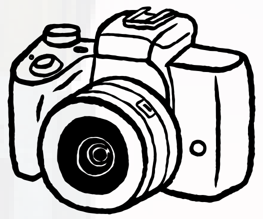
INSIDE MCU

HRV Sensor

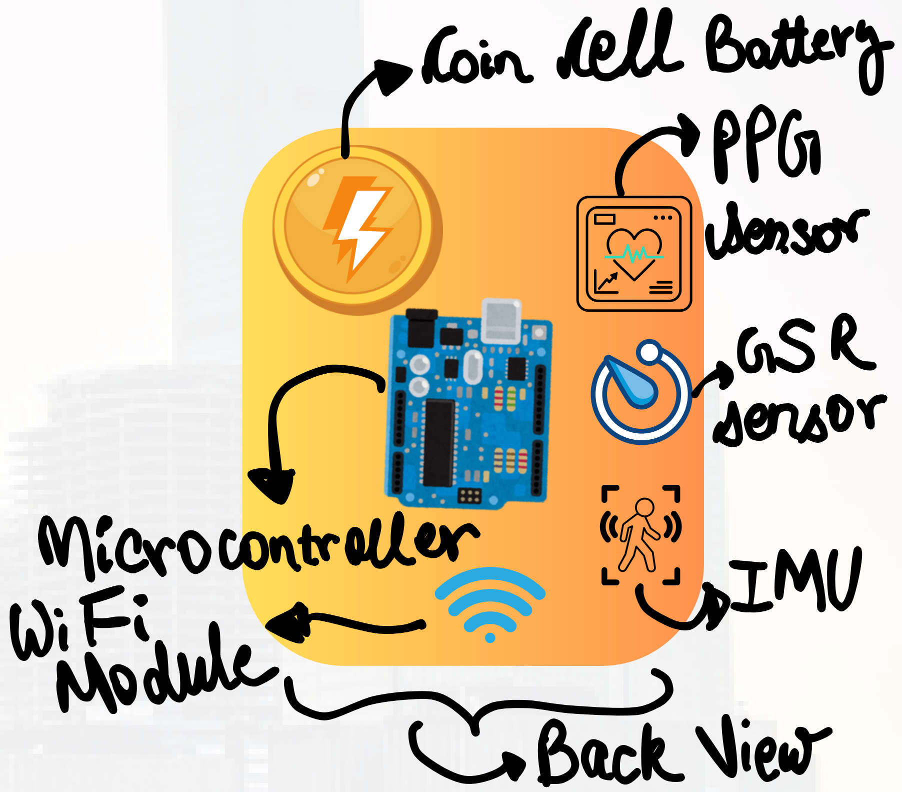
WANDERWATCH

Whole setup takes input only every 5 minutes reducing power consumption drastically

EMG and Camera Based Gesture Detection



This is a watch for a right handed person !



EMG SIGNAL PROCESSING THROUGH AFE4404

↓

PGA boosts signal

↓

24 bit ADC - 1KHz

↓

MCU reads data via I²C and samples and stores it into a FIFO queue

↓

MCU extracts features using Slope Sign Change , MAV after which it does thresholding

if (MAV > threshold1 && Sign Change > threshold2)trigger_camera = true;}

In Deep Sleep unless triggered

CAMERA PROCESSING VIA Himax HM01B0

↓

MCU initialises the DCMI interface for the camera and sends config commands through I2C

↓

Images captured and sent to MCU RAM

↓

In Deep Sleep unless triggered

WIIFI MODULE -ESP8285 Wi-Fi module

↓

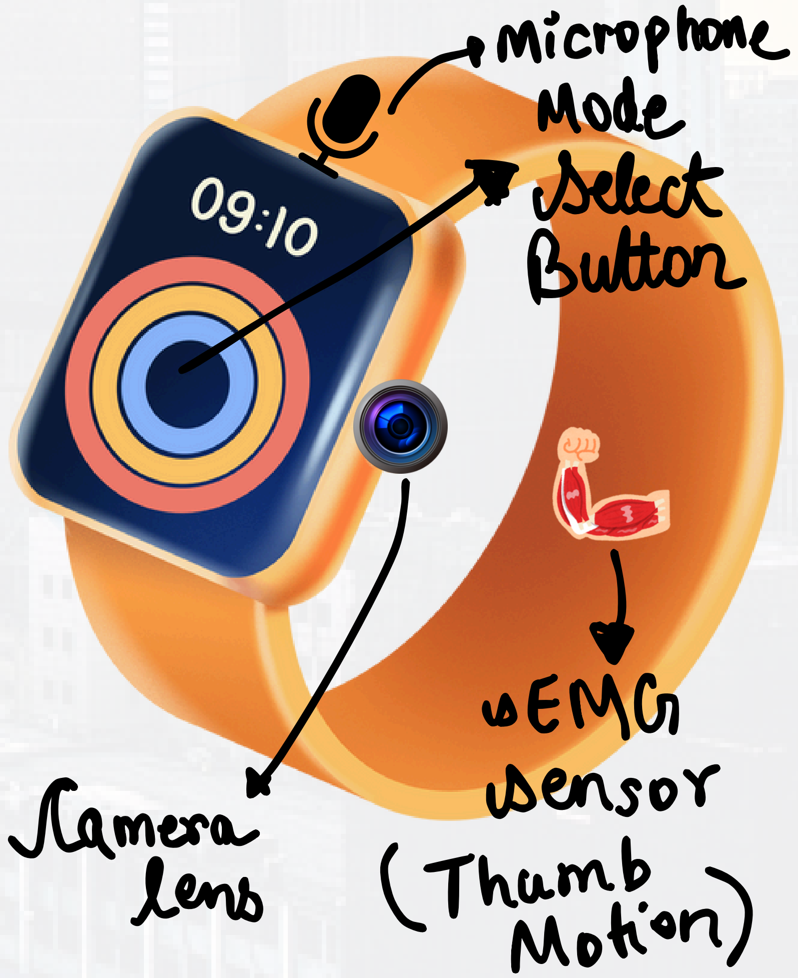
Sends the HTTP post of the JSON string containing the data

↓

Tiny Decision Tree Model

Send Inference

Distracted/Not Distracted



The Wifi and the Camera Module are only activated when they receive the necessary triggers, otherwise they are in deep sleep and consume current in uA, thus reducing power consumption

JUSTIFYING CHOICE OF SENSORS

Sensor Type	Sensor Name	Features and Specifications
Inertial Measurement Unit	LSM6DSL iNEMO inertial module	3D digital accelerometer+gyroscope, ultra low power with low current drawing, (max:0.4mA), built in 16 bit ADC, full scale acceleration range to 16g and angular scale of 2000dps, SPI and I2C interface.
EMG & PPG Sensor	AFE4404	TI sensor specifically designed for bio potential measurements . Low power , operates in the uW to mW range ideal for wearables . Integrated low noise amplifiers and ADC interface. Compatible with most MCU'S with minimal pin connections as has I2C interface .
Camera	Himax HM01B0	One of the lowest power image sensors available(1.1mw) . Small and fits into smartwatches easily(6*6 mm$^{2)}$) . Monochrome , low power , ideal for gesture detection , not overkill . comptaible with I2C . Allows Frame Buffering wit low CPU usage
Wi-Fi Module	ESP8285 WiFi Module	Compact design (5*5mm) perfect for wearables , Simple UART Interface , Low power and high efficiency , integrated flash memory , can go to deep sleep between transmissions. Does exactly what we need , no more no less .
GSR sensor	Grove GSR sensor	4-pin (VCC, GND, SIG, NC). **SIG pin** outputs analog voage proportional to skin conductance. output is clean analog signal (0-3.3V).
Microphone	LMV225TL/NOPB	TI microphone compact, accurate RF power detector IC that provides a linear output voltage proportional to input signal strength, ideal for signal monitoring in wearable and embedded devices. Output voltage is from 0.2-2V.

ENERGY CONSUMPTION OF SENSORS

Sensor Type	Current Drawn	Operating Voltage	Time Operational	Energy Consumption(each cycle)/Power Consumption
Inertial Measurement Unit	0.4mA	1.8V	16 s	11.52mJ/0.72mW
AFE4404 (EMG)	1.0 mA	3.3	2ms	6.6mJ/3.3mW
LMV225TL (Mic)	7-7.5mA	3.3	16s	23.1mW/369mJ
Himax HM01B0(Camera)	1.1 mA	1.8V	10s	19.8mJ/1.98W
ESP8285 Wi-Fi Module (Wi-Fi)	75 mA	3.3V	100ms	24.75mJ/247.5mW
AFE4404 (PPG)	1.0 mA	3.3V	1 min	3.3mJ/198mW
Grove GSR sensor	1.5mA	3.3V	3s	4.95mJ/14.85mW

ENERGY CONSUMPTION OF MICROCONTROLLER

Sensor Type	Microcontroller Mode	MIPS	Power Consumption
Inertial Measurement Unit	80 µA/MHz	0.2	16uW
EMG (AFE4404) - Scrolling		0.4	32uW
Camera (Himax HM01B0)+Wi-Fi (ESP8285 WiFi Module)		7.5	600uW
PPG (AFE4404) - HRV		0.74	60uW
Grove GSR		0.001	0.08uW
		8.84	708.08uW

Analog Circuit to analyze sound	Power Consumption
5 OPA1688 opamps	33mW

Battery used: 3.7V coin cell battery with 150mAh.
The watch would last for approximately 20.7 hrs.

NOTE: This calculation doesn't take into account the baseline power of micrcontroller, we assume that it works in its ultra low power mode.

JUSTIFICATION FOR CHOICE OF MICROCONTROLLER

Sensor	Memory Requirement
Inertial Measurement Unit	20KB
PPG(EMG)	25KB
GSR	3KB
EMG(Gesture Detection)	5KB
Camera	50KB
WIFI	4KB

1.1 Features

- Core
  - ARM® 32-Bit Cortex®-M4F CPU With Floating-Point Unit and Memory Protection Unit
  - Frequency up to 48 MHz
  - ULPBench™ Benchmark:
    - 192.3 ULPMark™-CP
  - Performance Benchmark:
    - 3.41 CoreMark/MHz
    - 1.22 DMIPS/MHz (Dhrystone 2.1)

Maximum RAM Requirement : 60KB which is still lesser than 64KB SRAM

Maximum MIPS requirement: 8.84 MIPS, provided by microcontroller : (1.22 DMIPS/MHZ, assuming 48Mhz of operating frequency its close to 58.9 MIPS

- Memories
  - Up to 256KB of Flash Main Memory (Organized Into Two Banks Enabling Simultaneous Read/Execute During Erase)
  - 16KB of Flash Information Memory (Used for BSL, TLV, and Flash Mailbox)
  - Up to 64KB of SRAM (Including 6KB of Backup Memory)
  - 32KB of ROM With MSP432™ Peripheral Driver Libraries

WANDERWATCH

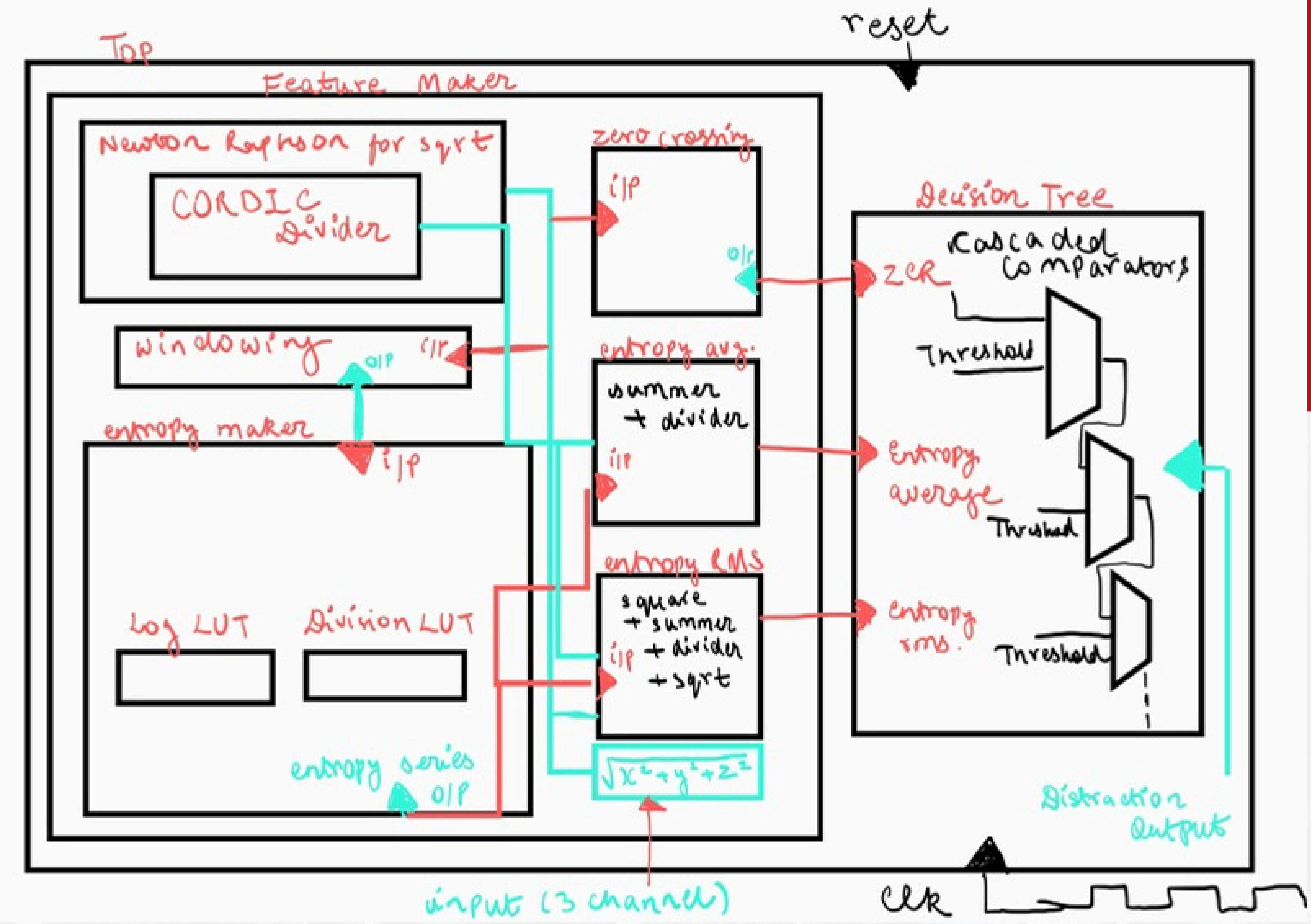
COST ANALYSIS

Component	Price
IR led (SFH4059)	Rs.10
Photodiode(BPW34)	Rs.20
INA333	Rs.300
Grove GSR sensor	Rs.700
Camera(HM01B0 QVGA)	Rs.980

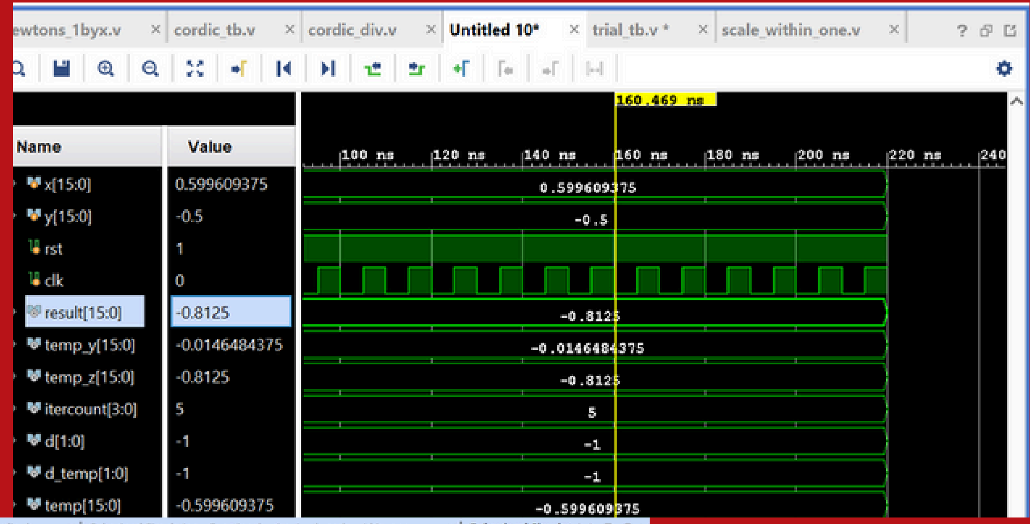
Component	Price
OPA1688(5)	Rs.700
LMV225TL	Rs.150
LSM6DSLTR(IMU)	Rs.359
MSP432(microcontroller)	Rs.300
AFE4404(PPG,EMG sensor)	Rs.1200

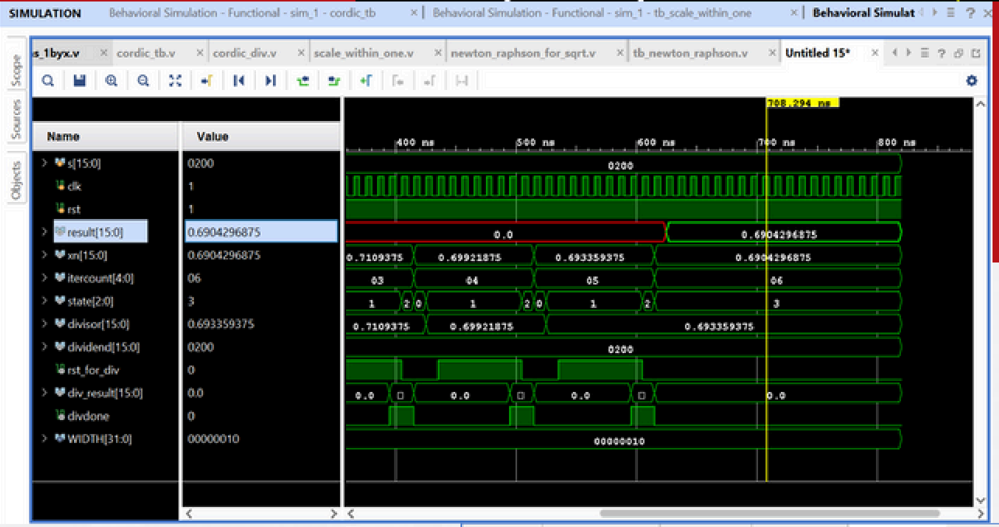
Total Cost ~Rs.4,700

ASIC IMPLEMENTATION OF ONE SENSORY INPUT

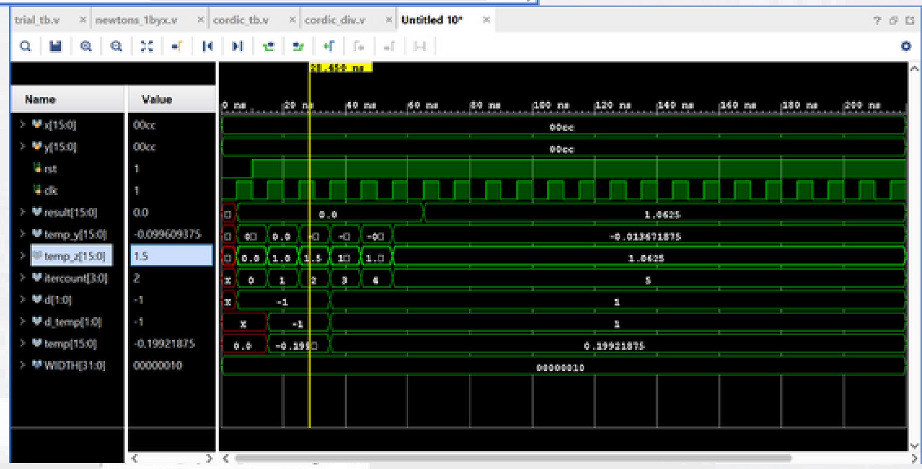


CORDIC division

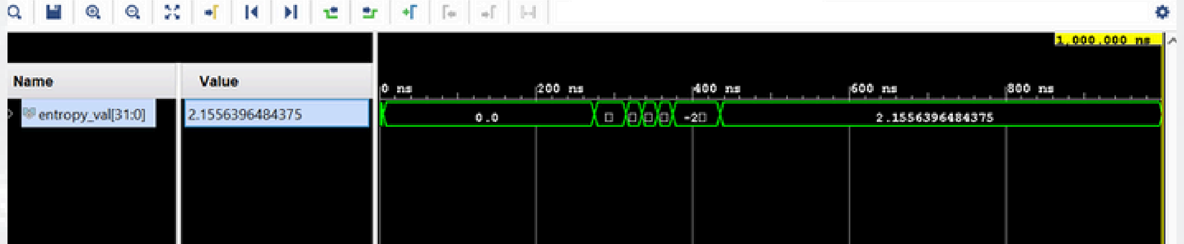




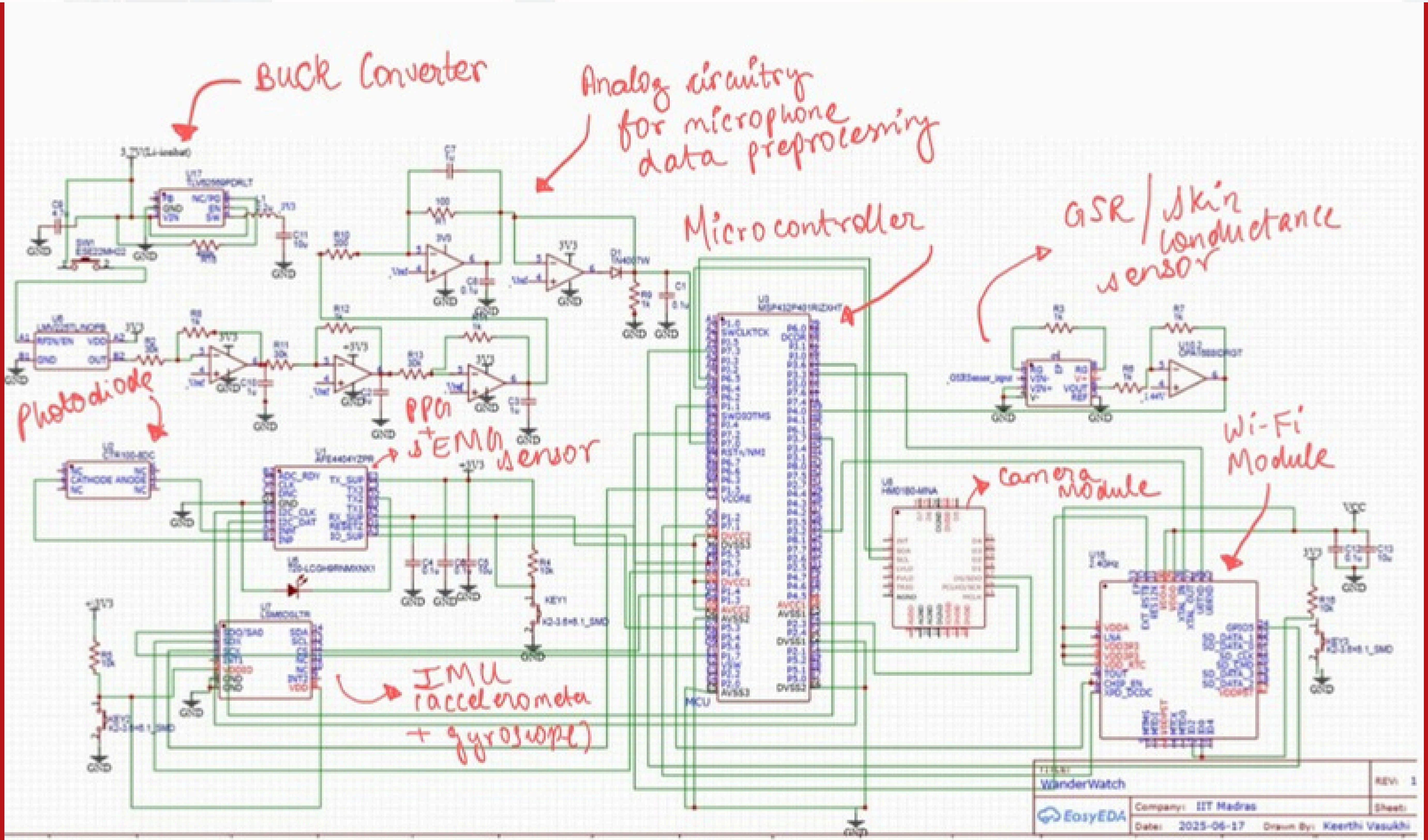
Square Root (Newton Raphson)



Entropy



PROTOTYPE WITH MICROCONTROLLER APPROACH



REFERENCES

1)Modeling and Detecting Student Attention and Interest Level using Wearable Computers Ziwei Zhu, Sebastian Ober, Roozbeh Jafari

2) Stress Detector Supported Galvanic Skin Response System with IoT and LabVIEW GUIRajesh Singh, Anita Gehlot, Ritika Saxena, KhalidAlsubhi, Divya Anand, Irene Delgado Noya, Shaik Vaseem Akram, Sushabhan Choudhury

3) Gesture Recognition System Using Micro Controller Anurup Salokhe1 , Sridhar A

4) Design and Prototyping of a Wristband-Type Wireless Photoplethysmographic Device for Heart Rate Variability Signal Analysis
M Ghamari , C Soltanpur , S Cabrera , R Romero , R Martinek , H Nazeran

5) RE-vibe in the Real World: A Case Study

6) Noise: Fact Sheet by WHO

THANK YOU