



Texas Instruments
WiSH 2025



WanderWatch

DISTRACTION MONITORING WRISTBAND

TEAM:

BATCHU ISHITHA
BHUVANESWARI CHINNAKONDU
MEHER NARULA
VAIDEHI BHAT
KEERTHI VASUKHI KAMARAJU

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PROBLEM STATEMENT



WHY?



Increase Productivity



Improve Learning Outcomes



A Wristband

WHAT IT DOES?



Monitors Distraction

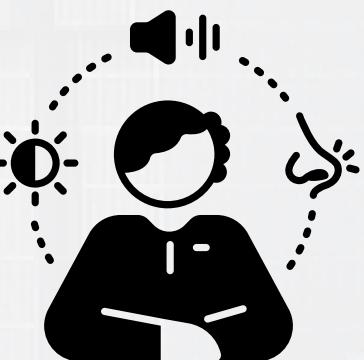


Smartphones



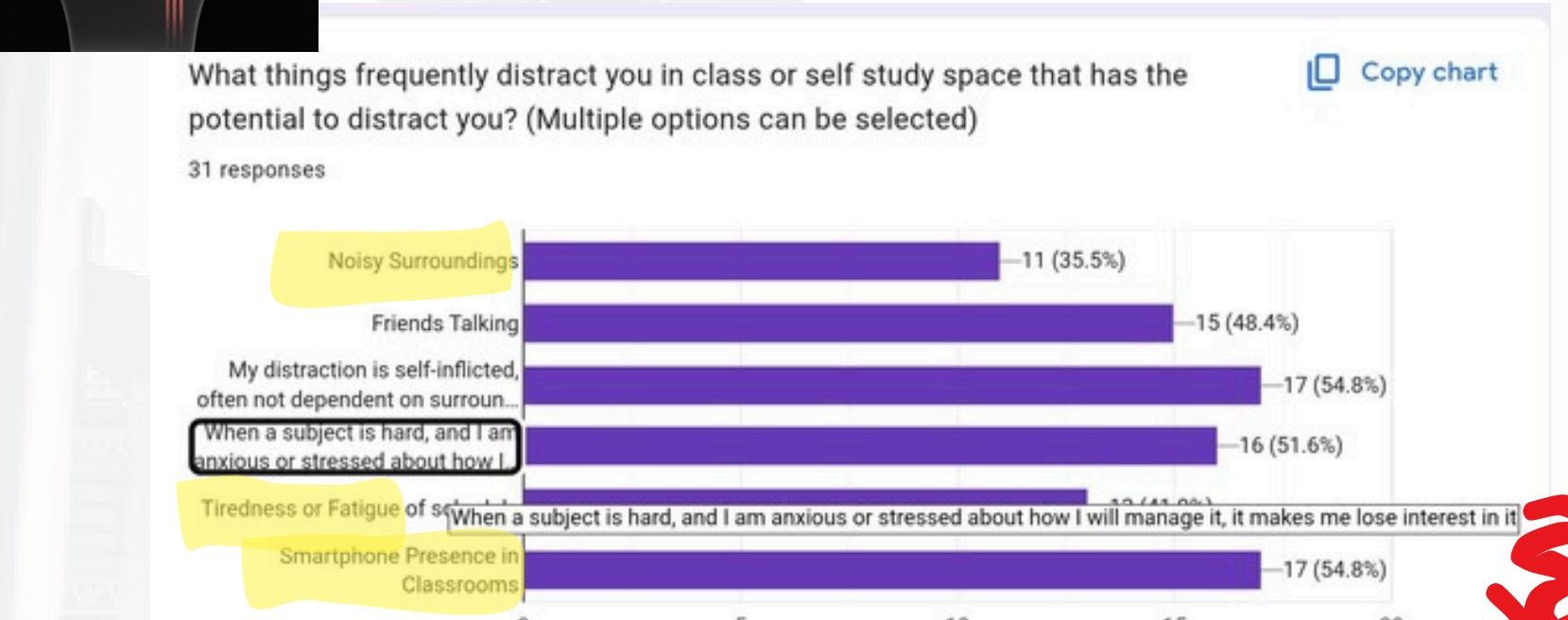
Surroundings

Social Media



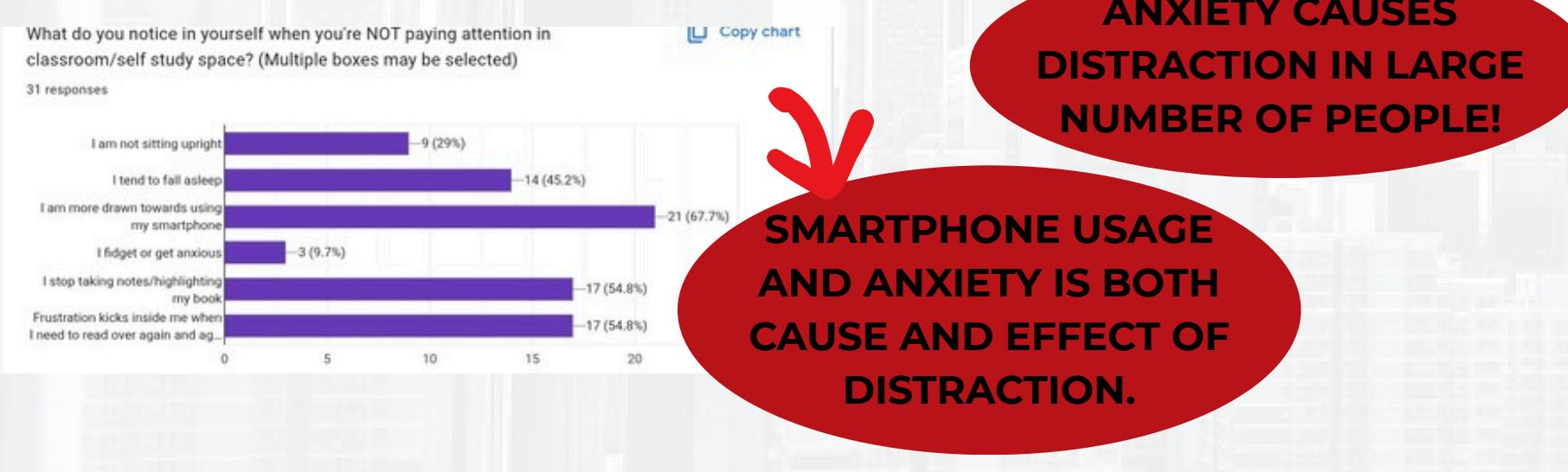


31 RESPONSES

[Copy chart](#)

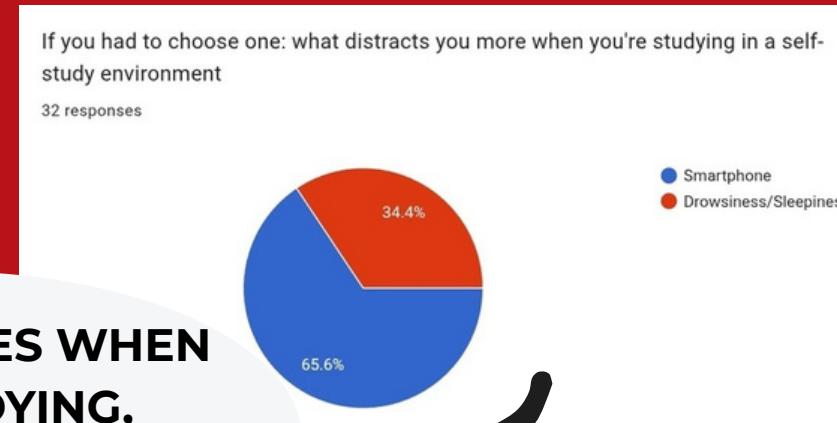
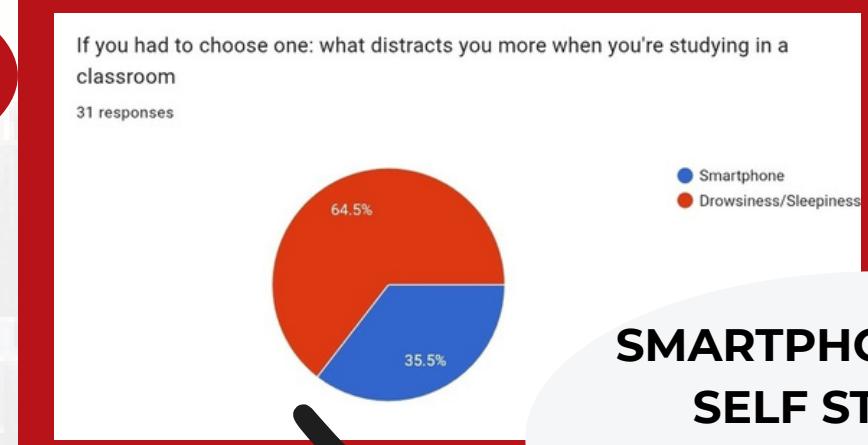
EMPATHIZING

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.



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

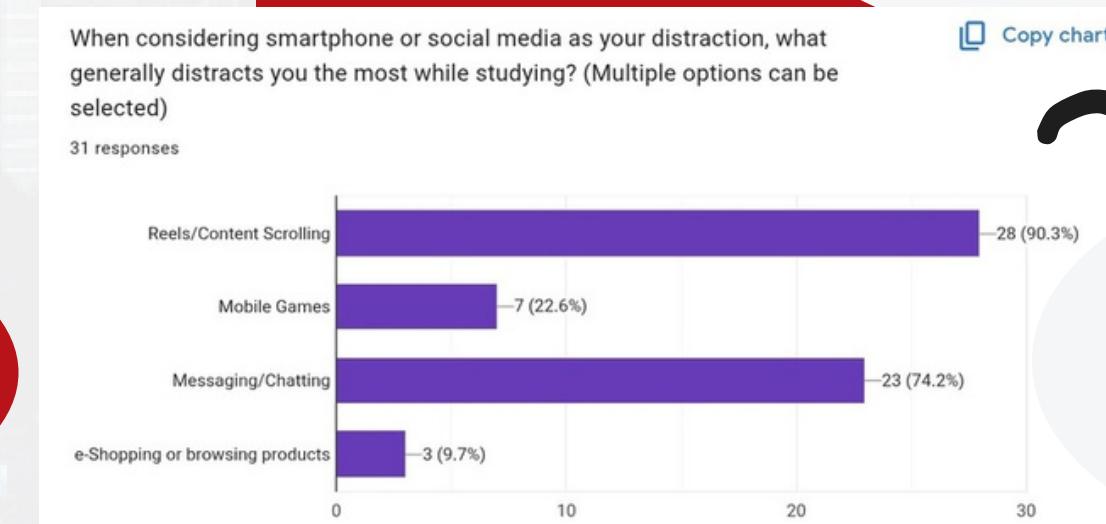
ANXIETY CAUSES DISTRACTION IN LARGE NUMBER OF PEOPLE!



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



WHAT CAUSES DISTRACTION?

NOISY SURROUNDINGS

ANXIETY AND STRESS

SMARTPHONE PRESENCE

DROWSINESS OR TIREDNESS

Issues to target

Sensors/ sensory inputs to be selected

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

WHERE DOES DISTRACTION DIFFER?

DIFFERENT IN CLASSROOM AND SELF STUDY AREA

Simultaenous Requirements:

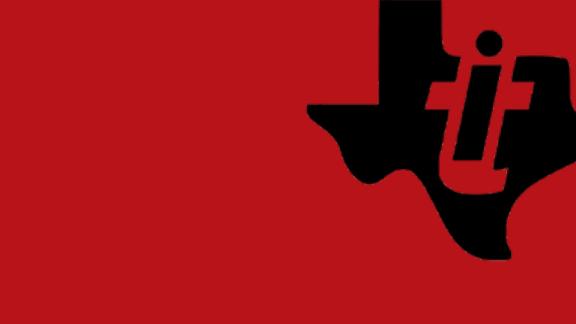
Wearable device

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

For drowsiness and anxiety detection

Skin Conductance

Inertial Measurement Unit

Hand writing motion detection

sEMG sensor activated camera

Thumb swiping motion detection

Microphone for external sound capture

Surrounding monitoring

MICROCONTROLLER

CLASSROOM SELECT MODE

BUZZER OUTPUT TO SNAP BACK INTO ATTENTION

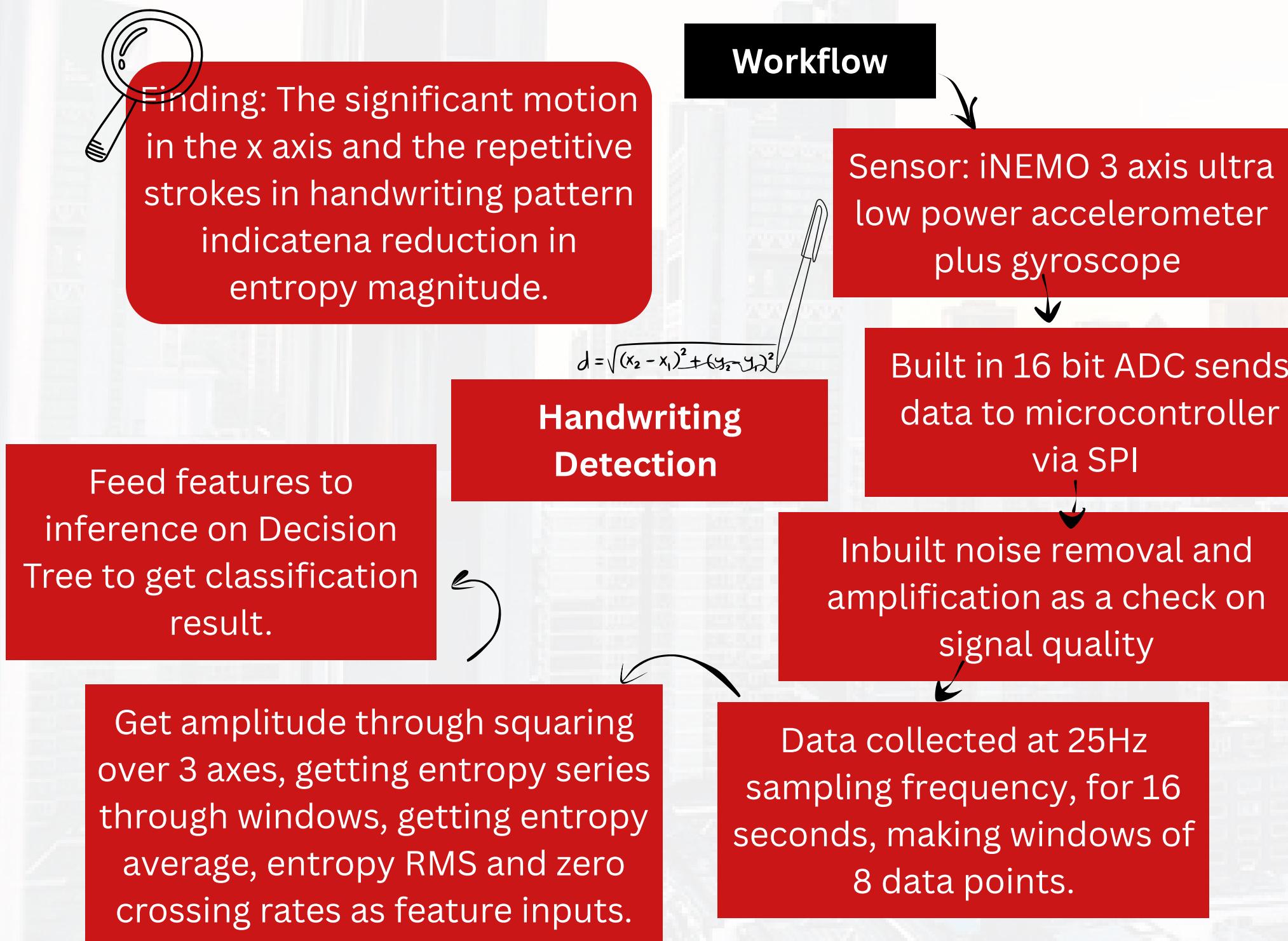
STUDY ROOM SELECT MODE

HIGHER PRIORITY WEIGHTS TO DECISIONS FROM THUMB SWIPE SENSORS

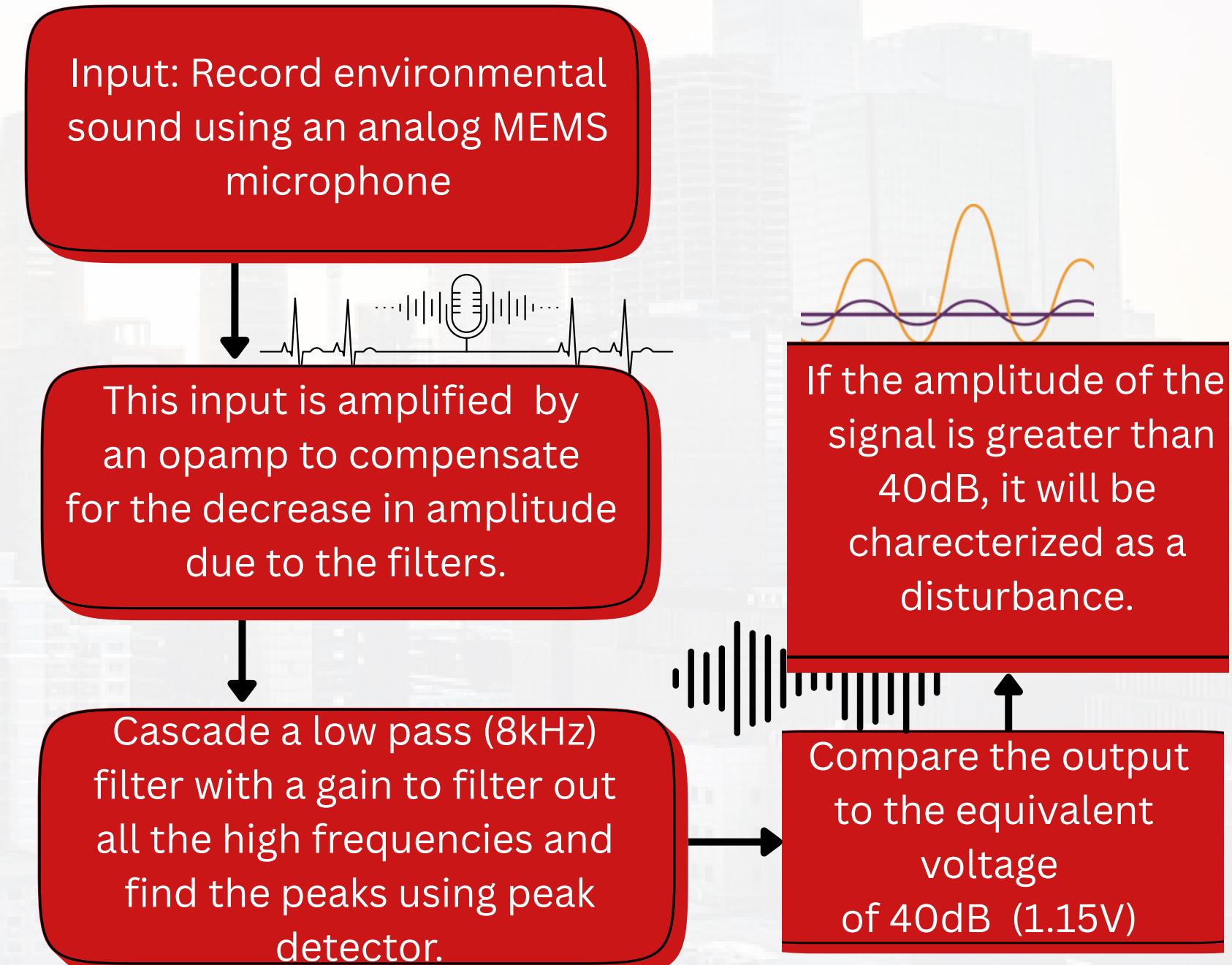
HIGHER PRIORITY WEIGHTS TO DECISIONS FROM PHYSIOLOGICAL SENSORS

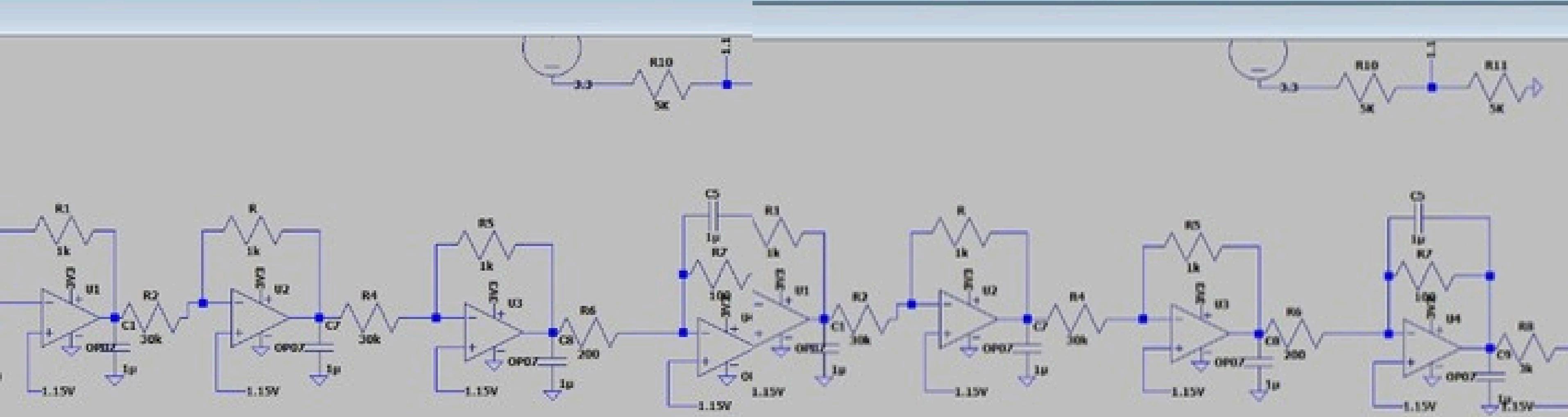
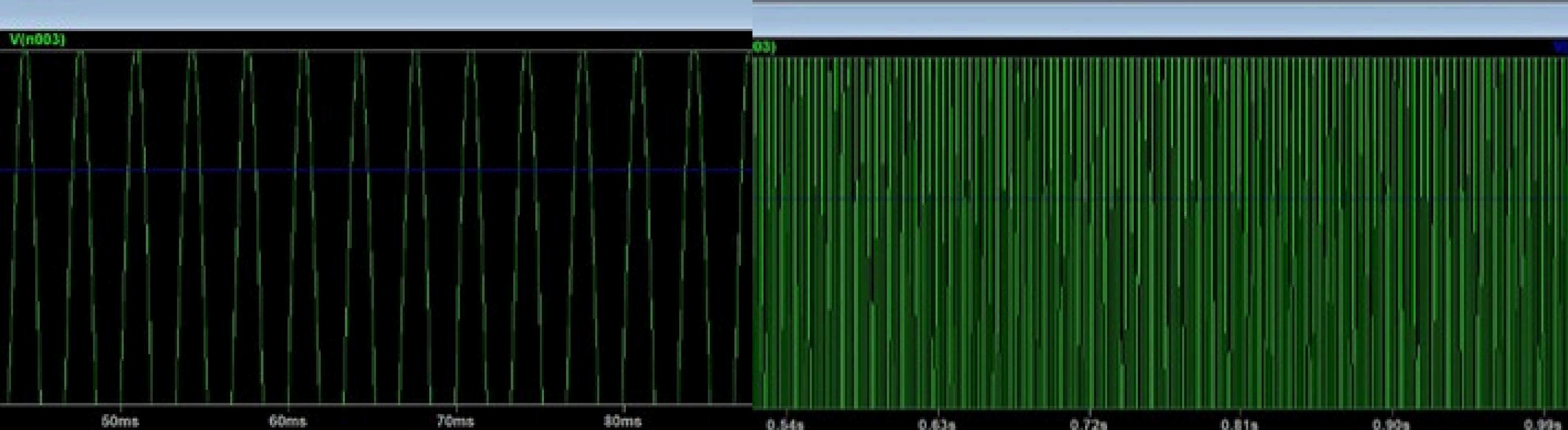


HANDWRITING DETECTION



AUDIO MONITORING







SKIN CONDUCTANCE

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

Skin conductance ($2.22\mu\text{S}$ to $100\mu\text{S}$) to Voltage conversion

Signal is sampled and stored at 200 samples per second, which is appropriate for a signal bandwidth of nearly 100 Hz.



GSR sensing

INA333 instrumentation amplifier is used to amplify the small voltages.

ADC conversion in Microcontroller.

Comparator is used for peak difference measurement with a threshold voltage

HEART RATE VARIATION

INSIDE MCU

Threshold comparision

HRV Processing
• RMSDD
• SDNN
• LF/HF



HRV Sensor

I2C PROTOCOL

ADC sampling at 12Hz

Noise cancellation of DC component and 50-60 Hz noise

IR Light Emission to penetrate into tissue

Photodiode to capture varying light intensity

Amplification using Trans-Impedance Amplifier

WITHIN THE SENSOR





EMG SIGNAL PROCESSING THROUGH AFE4404

PGA boosts signal by 1000x

24 bit ADC - 0.1KHz

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

Distracted/Not Distracted

EMG and Camera Based Gesture Detection

In Deep Sleep unless triggered

CAMERA PROCESSING VIA Himax HM01BO

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

Images captured and sent to MCU RAM which is then preprocessed

In Deep Sleep unless triggered

WIIFI MODULE -ESP8285 Wi-Fi module

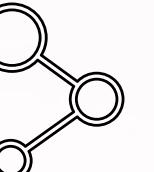
Sends the HTTP post of the JSON string containing the data

Tiny Decision Tree Model

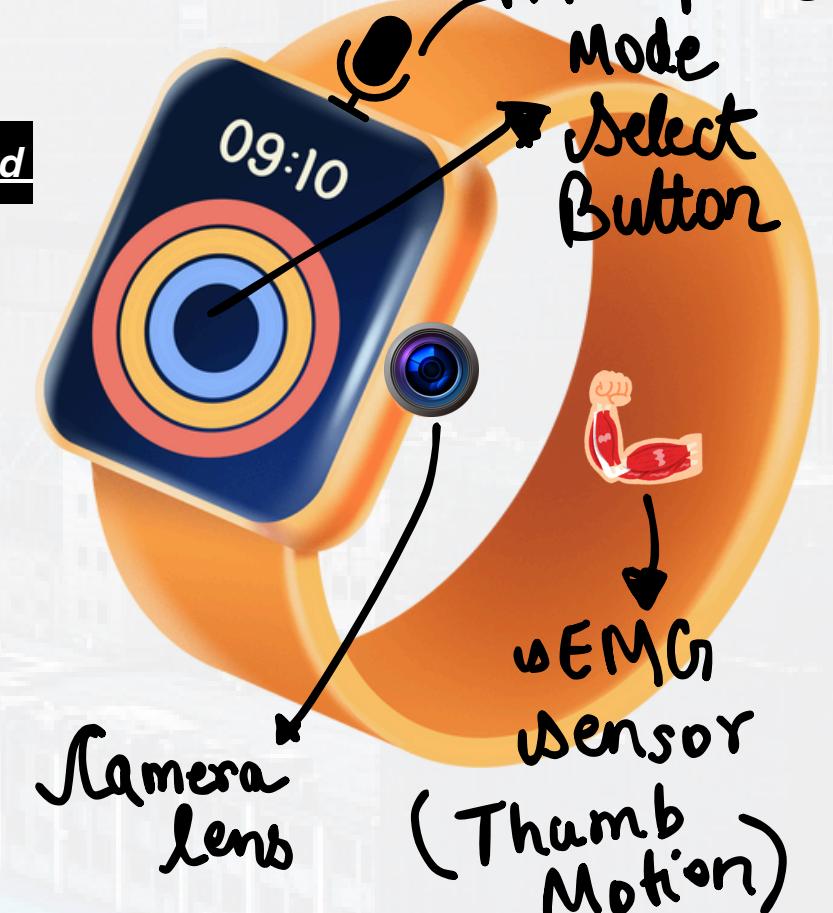
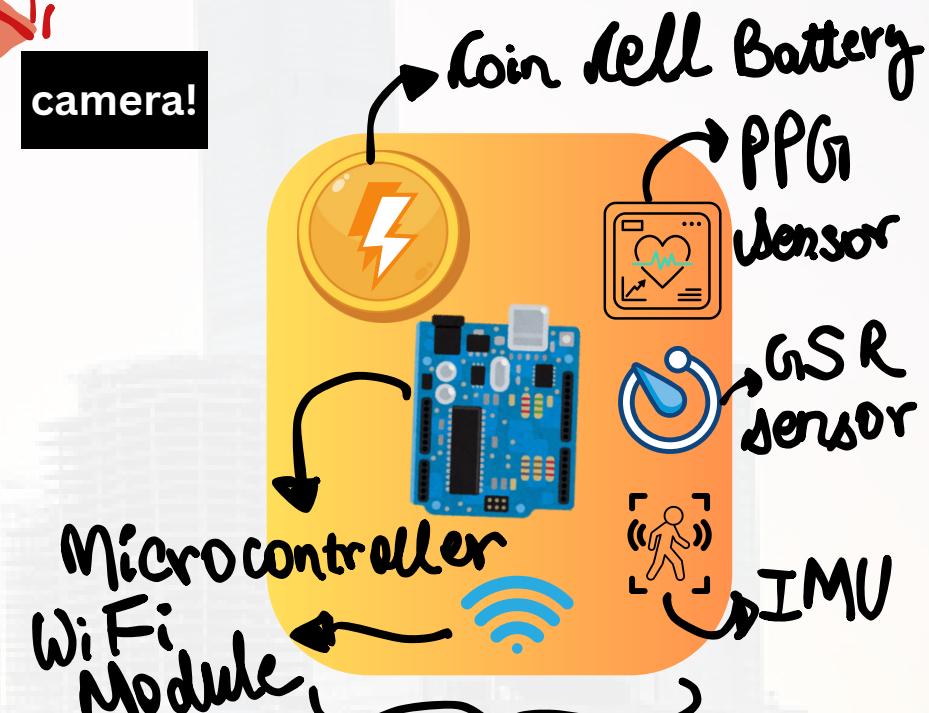
```
if(MAV > threshold1 && Sign Change > threshold2)trigger_camera = true;
```

Send Inference

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



camera!





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 HM01BO	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 . comptable with I2C . Allows Frame Buffering with 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 HMO1B0(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	Analog Circuit to analyze sound	Power Consumption
Inertial Measurement Unit		0.2	16uW		
EMG (AFE4404) - Scrolling		0.4	32uW		
Camera (Himax HMO1B0)+Wi-Fi (ESP8285 WiFi Module)	80 μ A/MHz	7.5	600uW		
PPG (AFE4404) - HRV		0.74	60uW		
Grove GSR		0.001	0.08uW		
		8.84	708.08uW		

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 microcontroller, 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





COST ANALYSIS

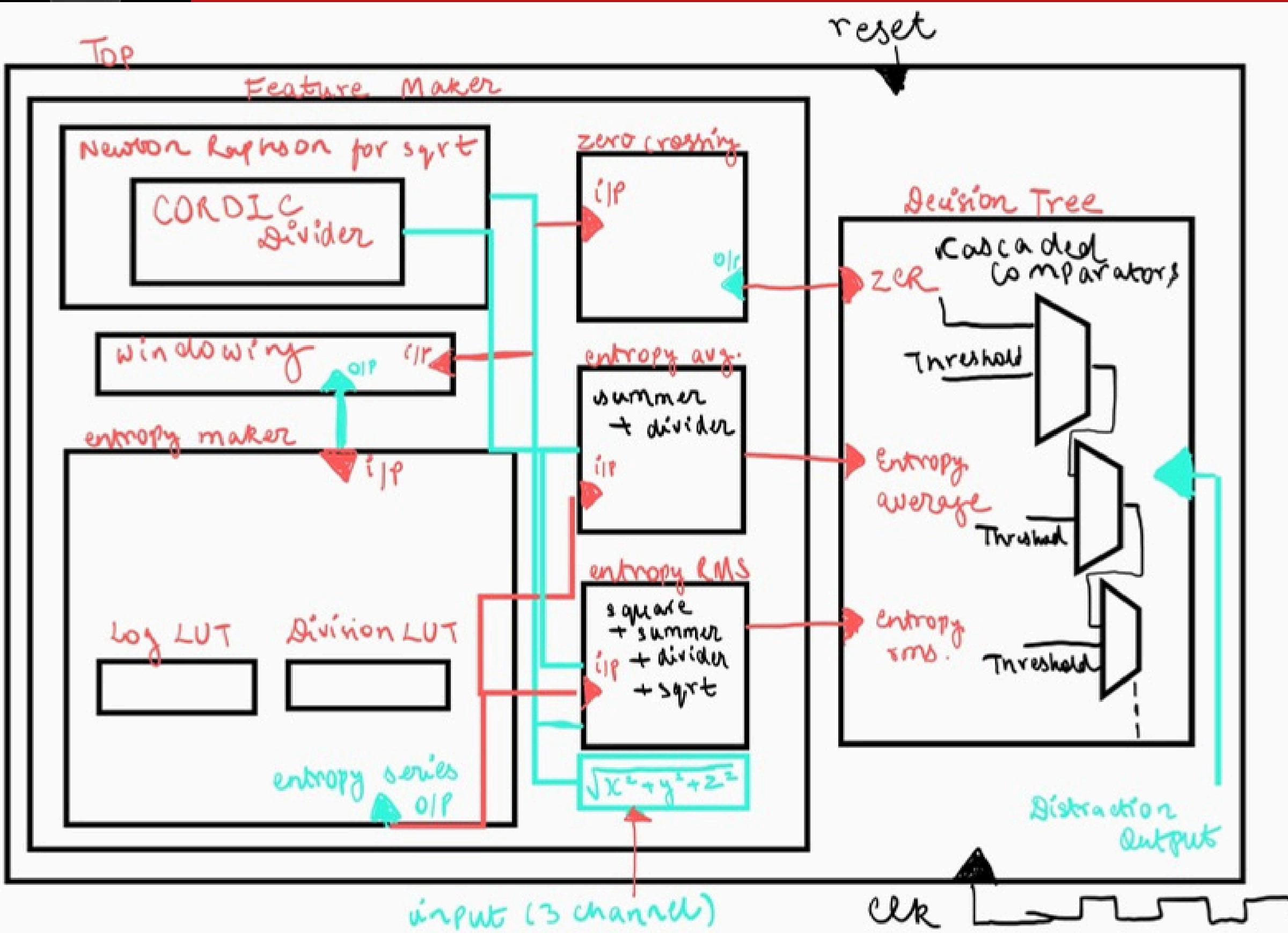


Component	Price
IR led (SFH4059)	Rs.10
Photodiode(BPW34)	Rs.20
INA333	Rs.300
Grove GSR sensor	Rs.700
Camera(HM01B0 QVGA)	Rs.980

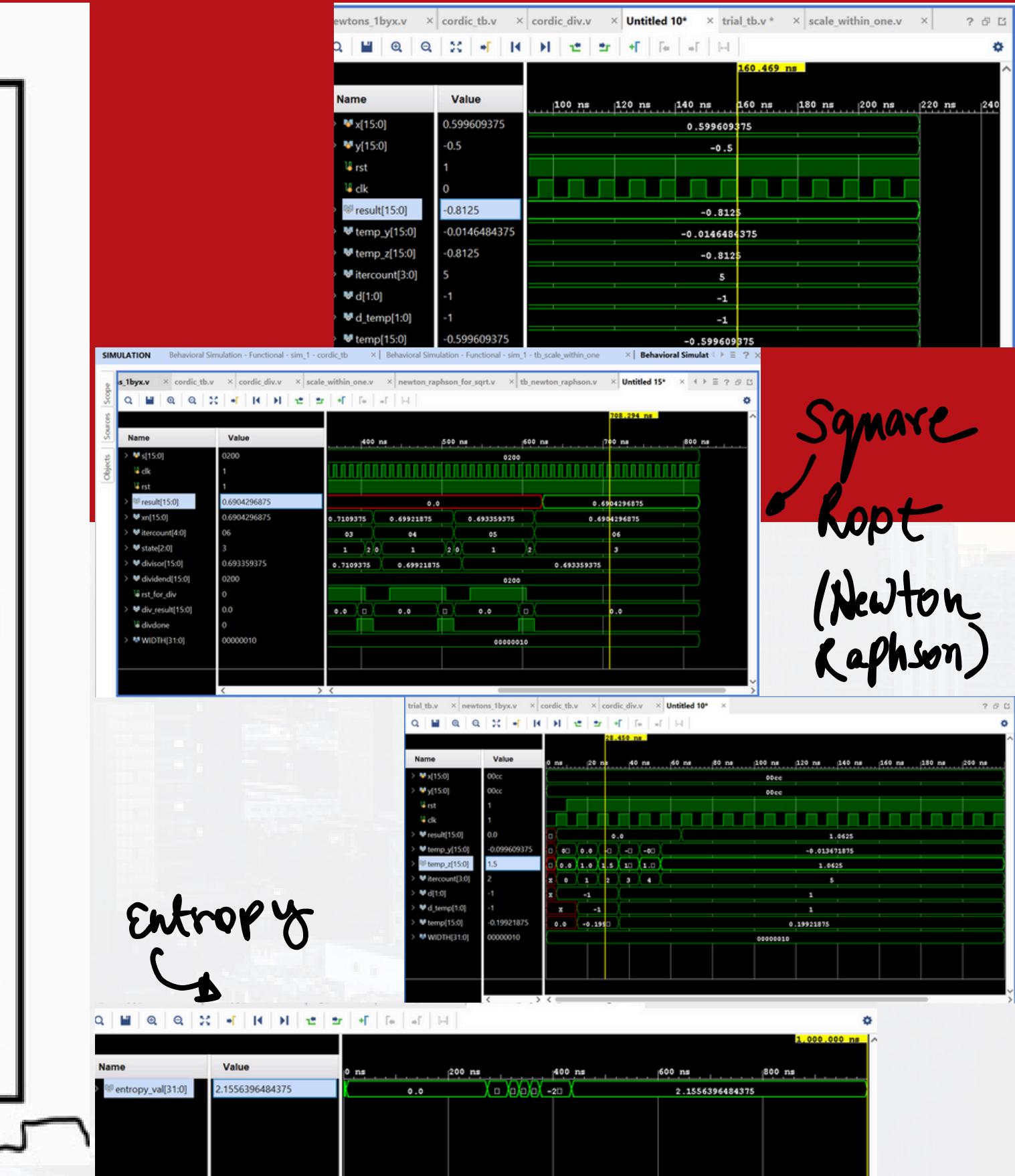
Component	Price
OPA1688(5)	Rs.700
LMV225TL	Rs.150
LSM6DSLTR(IMU)	Rs.359
MSP432(microcontroller)	Rs.300
AFE4404(PPG,EMG sensor)	Rs.1200

Total Cost ~Rs.4,700

ASIC IMPLEMENTATION OF ONE SENSORY INPUT

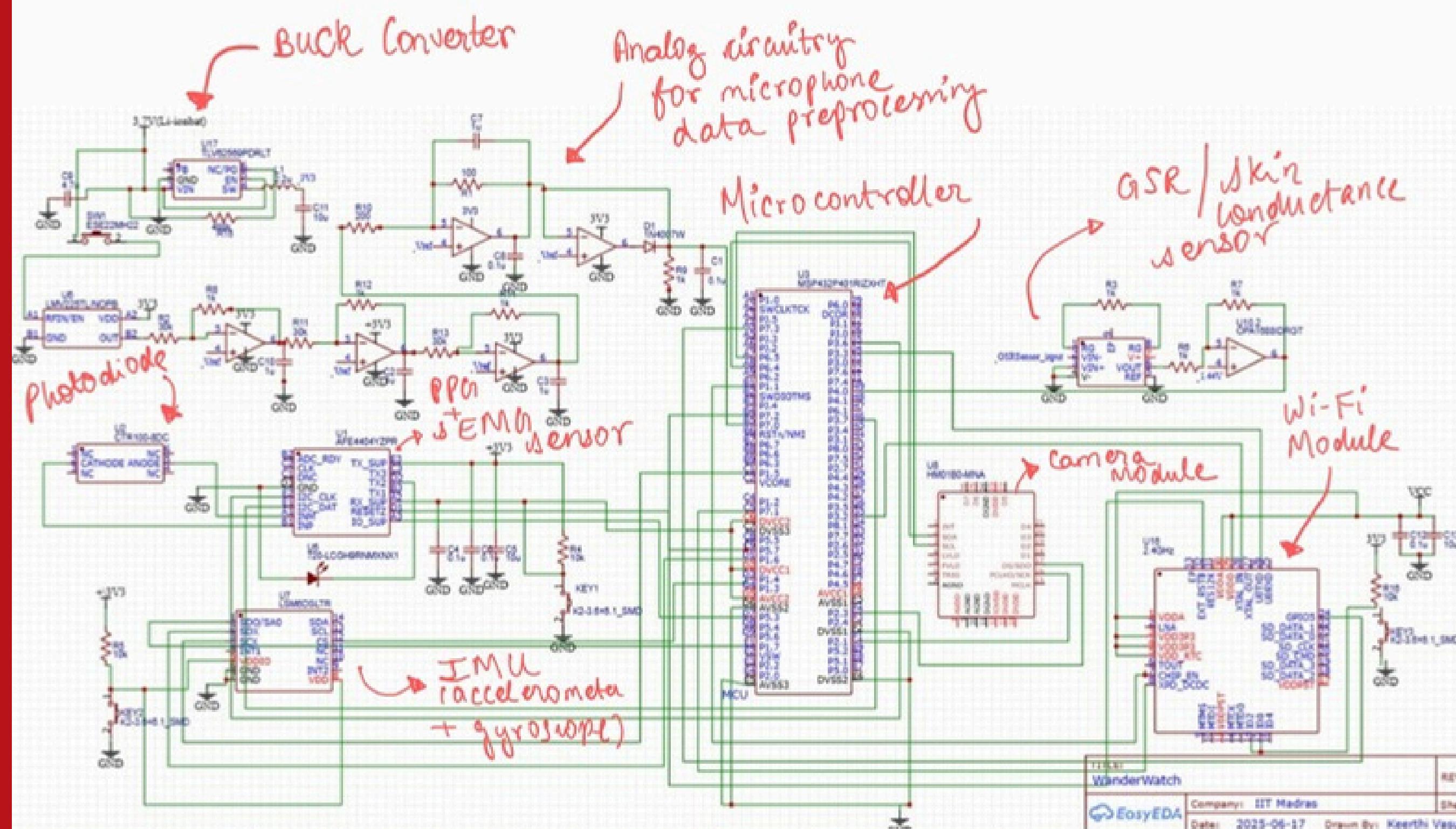


CORDIC division





PROTOTYPE WITH MICROCONTROLLER APPROACH





REFERENCES

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- 2) Stress Detector Supported Galvanic Skin Response System with IoT and LabVIEW GUI** Rajesh Singh, Anita Gehlot, Ritika Saxena, Khalid Alsubhi, Divya Anand, Irene Delgado Noya, Shaik Vaseem Akram, Sushabhan Choudhury
- 3) Gesture Recognition System Using Micro Controller** Anurup Salokhe , 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**

