

# 1. ESP32 Microcontroller (Core of the System)

## Overview

The **ESP32** (by Espressif Systems) is a low-cost, low-power microcontroller with **Wi-Fi + Bluetooth** connectivity.

It serves as the **main processing unit** in your wearable watch — collecting data from sensors, running logic, and sending data to the cloud.

## Key Features

- Dual-core Tensilica Xtensa CPU (~240 MHz)
- Built-in Wi-Fi (802.11 b/g/n) and Bluetooth (v4.2 BLE)
- 30–36 GPIO pins
- ADC (Analog to Digital Converter) for analog sensors
- I<sup>2</sup>C, SPI, UART communication protocols

## Role in SafeSchool

- ✓ Reads sensor data (HR, GSR, temperature, motion, GPS)
- ✓ Computes stress index locally
- ✓ Sends packets via Wi-Fi to cloud API
- ✓ Triggers alerts (SOS, vibration motor)

## Power & Integration

- 3.3 V operating voltage
  - Works with Li-ion battery + charging module (e.g., TP4056)
  - Typical current draw: 80 mA (idle) to 240 mA (Wi-Fi active)
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## ♥ 2. MAX30102 – Heart Rate and SpO<sub>2</sub> Sensor

### Working Principle

MAX30102 uses **photoplethysmography (PPG)** — shines red and IR light through skin and measures light absorption changes caused by blood volume variations.

### Output Data

- **Heart rate (BPM)**
- **Pulse waveform**
- **Heart Rate Variability (HRV)** (after algorithmic processing)

### Why It's Important

- Heart rate ↑ → excitement or stress
- HRV ↓ → mental stress or fear
- HR + HRV together help differentiate emotional vs. physical exertion

### Interfacing

- I<sup>2</sup>C communication (SDA, SCL)
- Works at 3.3 V
- Requires pull-up resistors on I<sup>2</sup>C lines

### Advantages

- ✓ Compact & low-power (1.8–3.3 V)
  - ✓ High accuracy even through wrist
  - ✓ Integrated LEDs & photodiode
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## ⚡ 3. GSR Sensor (Galvanic Skin Response)

### Working Principle

Measures **skin conductance** (electrical resistance between two electrodes).

When a person is stressed or emotional → sweat gland activity increases → skin becomes more conductive → lower resistance.

### Output Data

- Analog voltage proportional to skin conductance

### Why It's Important

- GSR ↑ indicates **stress, fear, anxiety, excitement**
- When combined with HR & HRV → gives emotional context

### Interfacing

- Analog output connected to ESP32 ADC pin
- Requires 5 V or 3.3 V power depending on module

### Example Range

- Calm skin: ~200–500 kΩ
- Stressed skin: ~10–100 kΩ

### Advantages

- ✓ Simple, inexpensive (~₹150–₹250)
  - ✓ Excellent emotional arousal detector
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## 4. MPU6050 – Accelerometer + Gyroscope

### Working Principle

- **Accelerometer:** measures linear acceleration (x, y, z) in g (gravity).
- **Gyroscope:** measures angular rotation ( $^{\circ}/s$ ).  
Both help detect motion, orientation, and sudden changes.

### Output Data

- Acceleration:  $\pm 2g$ ,  $\pm 4g$ ,  $\pm 8g$ ,  $\pm 16g$
- Gyro:  $\pm 250^{\circ}/s$  to  $\pm 2000^{\circ}/s$

### Role in SafeSchool

- Detects **falls, inactivity, tremors, unusual motion**
- Helps differentiate “running happily” vs “panicking”
- Triggers alert when large spike  $\rightarrow$  stillness  $\rightarrow$  distress

### Interfacing

- I<sup>2</sup>C communication
- Operates at 3.3 V
- Use pull-up resistors on SDA/SCL

### Example Logic

```
if (accel > 2.0g && motionStoppedFor > 3s)
    sendFallAlert();
```

### Advantages

- ✓ Compact 6-axis motion unit
  - ✓ Low cost (~₹150–₹200)
  - ✓ High sampling rate (1 kHz)
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## 5. LM35 – Temperature Sensor

### Working Principle

LM35 produces an analog voltage linearly proportional to temperature.  
 $1^{\circ}\text{C} = 10 \text{ mV}$  output.

### Why It's Useful

- Monitors **skin temperature changes**:
  - Slight rise → stress or fever
  - Drop → cold exposure or shock
- Helps validate emotional or physical distress readings

### Interfacing

- Analog output → ESP32 ADC
- Power: 5 V or 3.3 V

### Example

At  $30^{\circ}\text{C}$  → Output = 300 mV

### Advantages

- ✓ Simple linear output
  - ✓ Low cost (<₹100)
  - ✓ Stable and easy to calibrate
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## 6. GPS Module (NEO-6M)

### Working Principle

Receives signals from at least 4 satellites → calculates geographic coordinates (latitude, longitude, altitude).

### Output Data

- Latitude, Longitude, Speed, Time, Date
- Uses **NMEA protocol** (via UART)

## Role in SafeSchool

- Tracks child's route to/from school
- Detects route deviation
- Helps visualize child location on dashboard (via Leaflet map)

## Interfacing

- UART (TX/RX) to ESP32
- 3.3 V logic compatible (5 V tolerant with regulator)

## Advantages

- ✓ Global coverage
  - ✓ High accuracy ( $\pm 2\text{--}3$  m)
  - ✓ Widely supported with Arduino libraries
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## 7. SOS Button & Vibration Motor

### SOS Button

- Simple push-button connected to GPIO input (with pull-down resistor).
- When pressed, firmware triggers **immediate distress alert** to the cloud.
- Also logs timestamp & GPS coordinates.

### Vibration Motor

- Small DC motor with eccentric weight.
- Used to give **haptic feedback** (e.g., calming buzz during stress).

- Controlled via **transistor + GPIO output pin**.

## Power

- 3.3–5 V, <100 mA draw
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## 8. Power & Battery Module

### Components

- **Li-ion Battery (3.7 V, 500–1000 mAh)** → main supply
- **TP4056 Charger Board** → recharges via USB
- **Boost converter (MT3608)** → steps up to 5 V if needed

### Features

- Safe charging & cutoff protection
  - Enables ~6–10 hours battery life (depending on sensor usage)
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## 9. Other Supporting Hardware

Component	Purpose
OLED Display (0.96")	Optional – shows heart rate, alerts
Buzzer	Optional audible alarm for SOS
Enclosure	Protects electronics (wearable shell or wristband)
Breadboard/PCB	Prototype circuit mounting
Wi-Fi Router / Hotspot	Enables cloud connection during demo

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## 10. How Everything Connects (Summary)

Sensor	Communication	Function
MAX30102	I <sup>2</sup> C	HR & HRV
GSR	Analog	Skin conductance (stress)
MPU6050	I <sup>2</sup> C	Motion & fall detection
LM35	Analog	Temperature
GPS NEO-6M	UART	Location tracking
SOS Button	Digital Input	Manual emergency alert
Vibration Motor	Digital Output	Calming / feedback
ESP32	Central MCU	Data collection, transmission, decision
Cloud Server	Wi-Fi	Data storage & alert management

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## 11. Estimated Hardware Cost (Prototype Level)

Component	Approx. Cost (₹)
ESP32 Dev Board	250–400
MAX30102	300–400
GSR Sensor	200
MPU6050	180
LM35	80
GPS Module (NEO-6M)	450–550
SOS Button + Motor	60
Battery + Charger	250
Misc. (Wires, PCB, Case)	200
<b>Total</b>	<b>≈ ₹1,800 – ₹2,100</b>