STRESS METER

A REPORT

on **GSR-Powered Stress Meter**

B. Tech 3rd semester Mini Project-I (EE2191)

BY

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December, 2024

DECLARATION BY THE CANDIDATES

We certify that to the best of our knowledge

i) The work contained in the report has been done by ourselves.

ii) We have conformed to the norms and guidelines given in the Ethical Code of Conduct of the Institute.

iii) Whenever we have used materials (data, theoretical analysis and text) from other sources, we have given due credit to them by citing them in the text of the report and giving their details in the references.

iv) Whenever we have quoted written materials from other sources, we have put them under quotation marks and given due credit to the sources by citing them and giving details in the references.

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<u>CERTIFICATE OF APPROVAL</u>

We hereby approve the B. Tech 3rd semester mini project-I (EE2191) report titled, **'Title of mini project'** prepared by **Names of students with their enrolment numbers inside bracket** in partial fulfillment of the requirements for the third semester B.Tech. curriculum in the Dept. of Electrical Engineering at IIEST, Shibpur.

Dated: 03.12.2024

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Acknowledgement

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Abstract

This project explores the development and implementation of a stress monitoring device based on Galvanic Skin Response (GSR) to measure emotional stress levels. GSR, which reflects changes in skin resistance due to physiological and emotional states, is used as the core parameter for stress analysis. The proposed system uses a touch-based sensor connected to a circuit designed to amplify and process skin resistance variations.

The circuit integrates a BC548 transistor for signal amplification and the LM3915 IC for visualizing stress levels through a sequence of LEDs. The LEDs, ranging from green to red, indicate varying levels of stress, from relaxed to high stress. A piezo buzzer is activated at the highest stress levels, providing an audible warning. A regulated 5.1V Zener diode ensures stable operation across the circuit.

The device's portability, simplicity, and low power consumption make it a practical solution for real-time stress measurement. This research highlights the effectiveness of using GSR for non-invasive stress assessment and demonstrates how electronic circuits can be utilized to create affordable healthcare tools. Experimental results validate the correlation between GSR and stress levels, providing a foundation for further applications in mental health monitoring and early stress intervention systems.

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Introduction

We hope to achieve the measurement of stress levels and fluctuations in the human body to determine whether it is at any point harmful for the human body. This is necessary as overstress can lead to multiple health problems such as increased risk of heart disease, sleep apnea, insomnia and generally reduced productivity.

This is done by measuring the change of resistance on the epidermal layer of the skin, which is a direct consequence of the constriction of blood vessels below the skin. This is converted into voltage and the change in voltage is used to activate LEDs (light emitting diodes) of different colours based on the obtained stress level. The data for what is considered as “normal” stress and is not a cause for medical concern is obtained from previous studies in the area.

The stress is inversely proportional to resistance. If the skin offers low resistance, stress is high (due to increased blood supply to skin, permeability of skin rises, hence conductivity also increases). The opposite applies, less blood supply equaling less permeability and conductivity during low stress situations. The resistance is measured by passing a low voltage through the skin. This gives what is known as Galvanic Skin Response (GSR). The stress meter essentially gives a quantified reading of the GSR. A detailed look at the circuit to achieve this measurement is discussed below.

Circuit Diagram and brief discussion on the components used to integrate the Stress Meter Circuit

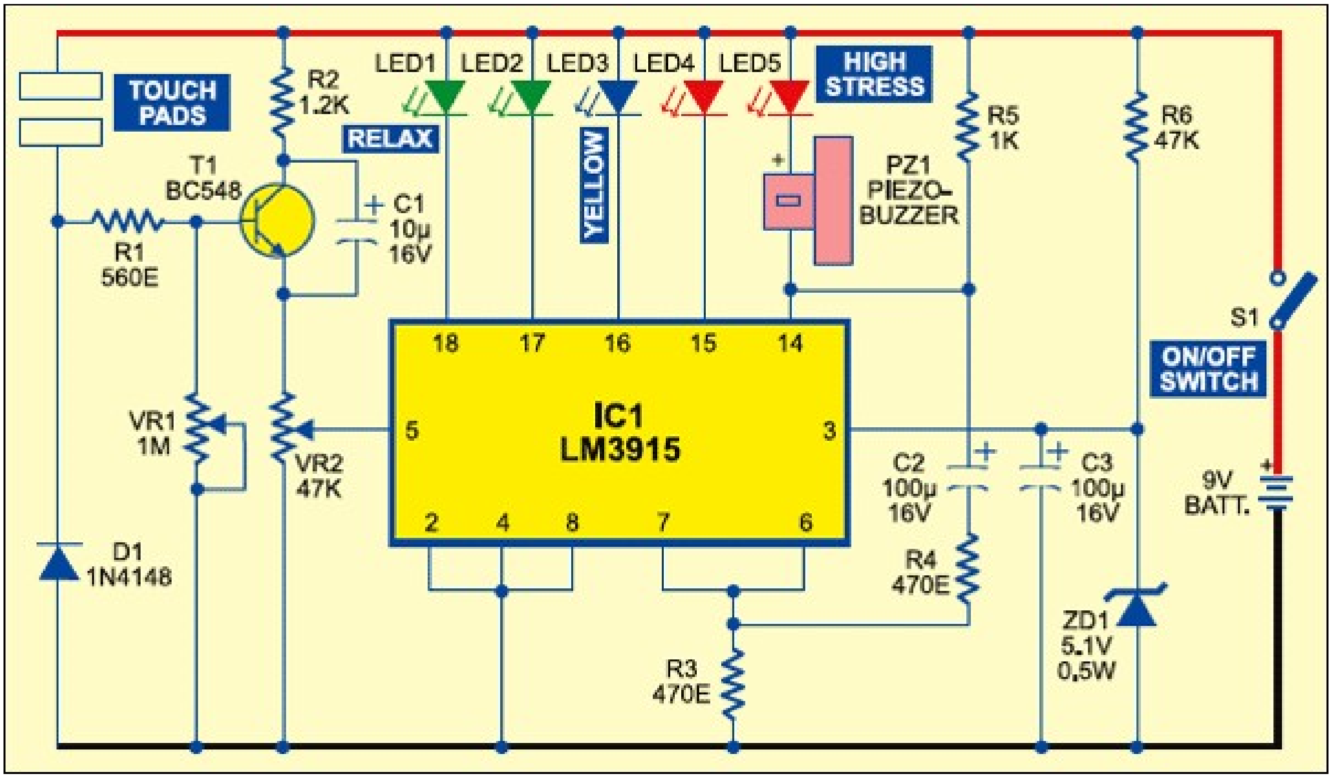

Figure 1. Circuit Diagram for Stress Meter

There are several components used to integrate the circuit, their specifications and purpose is discussed below:

LM3915 IC

LM3915 is a monolithic dot/bar display driver integrated circuit (IC), which drives the LEDs in a logarithmic manner based on the input signal voltage. It translates stress-related signal levels into visual output via LEDs, by sensing the analogue voltage at pin 5 obtained from the BC 548 transistor.

Figure 2. LM3915 IC

Resistors

Resistors are used to limit current, set levels of bias and control gain in component switching. They also fix the time constant of the circuit. This protects LEDs from burning out.

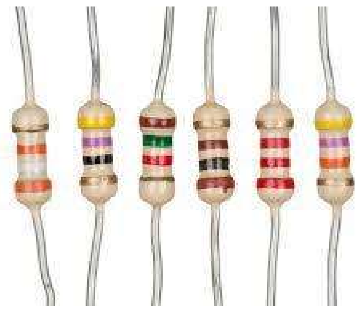

Figure 3. Resistors

Variable Resistors

Variable Resistors are used as potentiometers to divide the voltage going to the IC and adjusting the circuit sensitivity.

Capacitors

Capacitors are used to store charges as elements of frequency and filters for AC signals, as well as shunting unwanted signals to ground.

Figure 4. Capacitors

BC 548 Transistor

BC 548 is an all-purpose NPN bipolar junction transistor. It is a very elementary transistor and is widely used by hobbyists and students. It amplifies the signal produced at skin surface from touchpad.

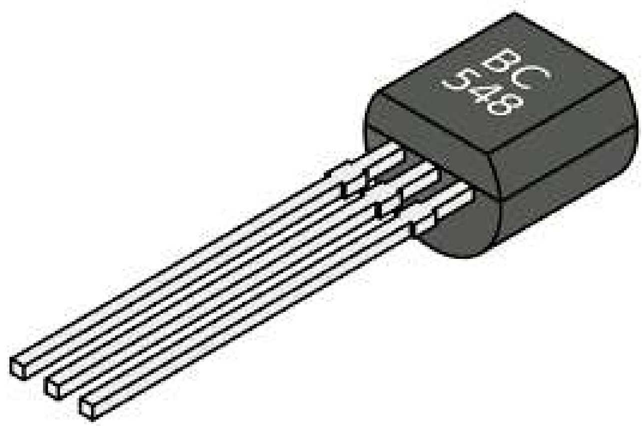

Figure 5. BC 548 Transistor

Diodes

A Zener Diode ensure the flow of a constant unidirectional voltage to the IC chip (5.1 V for this particular case).

Touch pad

A touchpad is a piezo-electric substance [2, Section 1.2.3.6] that measures the skin resistance and acts as an input to the circuit.

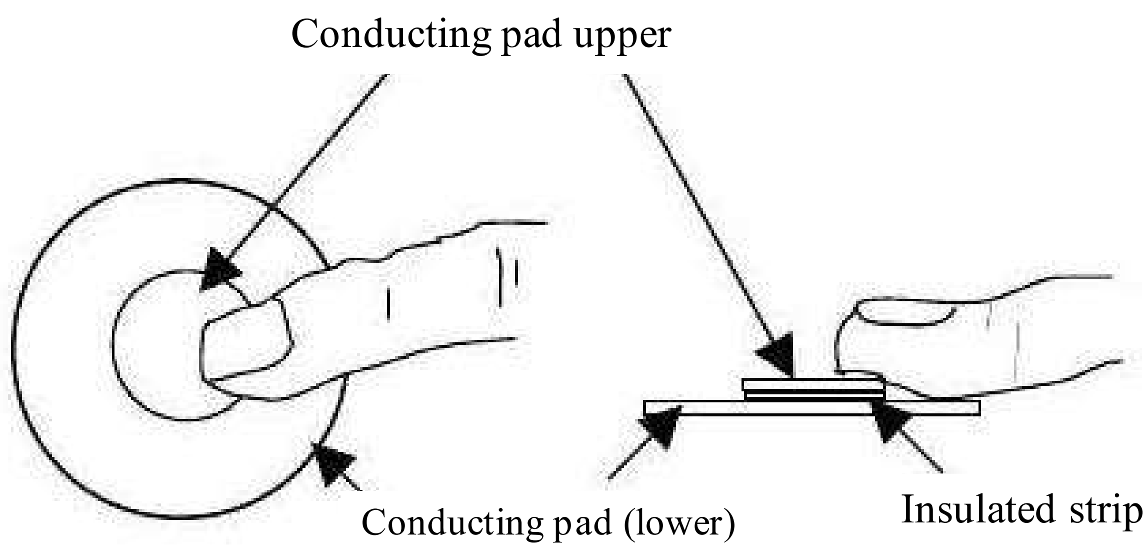

Figure 6. Working of Touch Pad

Light emitting diode display

The display consists of 5 LEDs, each representing a different level of stress

LED 1, LED 2 (Green colour): Low stress (Relaxed condition)

LED 3 (Yellow colour): Moderately stressed

LED 4, LED 5 (Red colour): High stress condition. LED 5 additionally triggers the piezo buzzer for a critically high stress warning

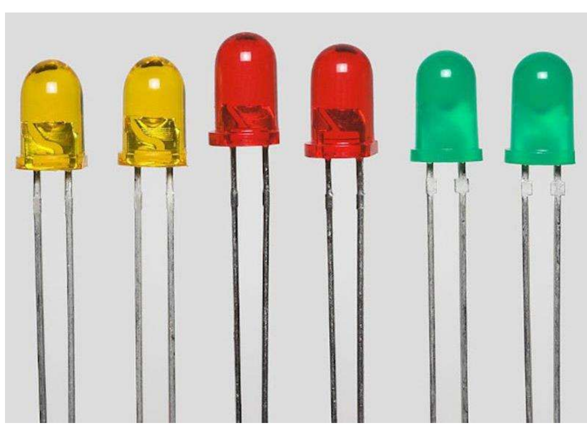

Figure 7: LEDs

Piezo-buzzer

A piezo-buzzer is a device which produces an audible warning, when the stress level reaches a critical, high stress state, as indicated by the glowing of LED 5.

Battery

The circuit is powered by a stable DC Supply of 9 volts, with a switch to control ON/OFF state

Working of the Circuit

1. **Power Supply**
    - ZD1 (5.1V Zener diode) ensures that the IC and other components operate at a stable 5.1V.
    - Capacitors C2 (100 µF, 16V) and C3 (100 µF, 16V) filter out noise from the power supply.

2. **Input Stage (Touch Pads)**
    - Touch pads serve as the input sensor. When a user places their fingers on the touch pads, their skin resistance affects the circuit.
    - Transistor T_1 (BC548) amplifies the signal generated due to variations in skin resistance.
    - R_1 (560Ω) limits the base current to T_1, preventing damage.
    - C_1 (10 µF, 16V) smoothens any noise or fluctuations from the touch pads.

3. **Voltage Divider for Signal Conditioning**
    - VR_1 (100kΩ variable resistor) adjusts the sensitivity of the circuit.
    - VR_2 (47kΩ variable resistor) further refines the signal for calibration purposes.
    - D_1 (1N4148) ensures unidirectional current flow, protecting the circuit.

4. **LM3915 IC (LED Driver)**
    - Pins 15 and 9 are connected to ground (0V).
    - Pin 16 is connected to a stabilized 5.1V reference voltage via the Zener diode ZD1 and capacitor C2 for stable operation.
    - The input signal from T1 is fed to pin 5 of the IC.
    - Resistors R3 (470Ω) and R4 (1kΩ) set the LED brightness and reference voltage scaling.

5. LED Display

LED1 to LED5 indicate different levels of stress:

- Green LEDs (Relax) light up for low stress levels.
- Yellow LEDs indicate moderate stress.
- Red LEDs (High Stress) represent high stress levels.

The LEDs are connected to the output pins of the LM3915 (pins 10 to 18), which light up sequentially based on the input voltage.

6. High-Stress Alarm

When the input reaches a "high stress" level: LED5 (High Stress) turns on. This activates the piezo buzzer PZ1 via the current-limiting resistor R5 (1kΩ), producing a warning sound.

Summary of Working

- Touch Input: Fingers on the touch pads create a resistance signal proportional to stress.
- Signal Amplification: T1 amplifies the signal, and VR1/VR2 calibrate sensitivity.
- Stress Indication: LM3915 lights LEDs to indicate stress levels (Green -> Yellow -> Red).
- High Stress Alert: When stress reaches the highest level, the buzzer sounds a warning.
- Power Control: The circuit is powered by a 9V battery with voltage regulation by ZD1.

Historical Data and Sample Calculations

A study by Mehmet A. Karaman and colleagues [2] explored factors predicting academic stress among 307 diploma students (179 males, 128 females). Results indicated that female students experienced higher academic stress than males. Bivariate correlations and multiple regression analyses identified life satisfaction, locus of control, and gender as key predictors of academic stress. The study also provided mean values, standard deviations (SD), and sample sizes (n).

Table 1: Average Stress Values for Men & Women, [2]

Dependent variables	Gender	M (mean value)	SD (standard deviation)	n (sample size)
Frustrations	Men	19.47	4.68	179
	Women	19.03	4.65	128
Conflict	Men	12.36	2.71	179
	Women	12.19	2.90	128
Pressures	Men	15.27	3.00	179
	Women	16.38	2.76	128
Changes	Men	8.64	2.84	179
	Women	9.15	2.94	128
Self-imposed	Men	21.41	3.87	179
	Women	22.45	3.63	128
Physiological	Men	31.73	10.31	179
	Women	38.01	10.64	128
Emotional	Men	11.67	3.93	179
	Women	13.63	4.21	128
Behavioral	Men	15.22	5.51	179
	Women	18.19	5.67	128
Appraisal	Men	9.45	1.77	179
	Women	9.34	1.74	128

From this, we can estimate the average stress and use it to validate readings obtained using the developed stress meter circuit

A few more data obtained from compiled searches across the internet are listed below

Table 2: Skin Conductance (GSR), Unit: microsiemens (µS)

Scenario	GSR for male (µS)	GSR for female (µS)
Resting state	2-4	3-5
Mild stress (e.g., watching suspenseful video)	5-8	6-10
Acute stress (e.g., sudden loud noise)	10-20	15-25
High stress (e.g., argument)	20-30	25-40

Table 3: Cortisol Levels, Unit: Micrograms per deciliter (µg/dL)

Scenario	Male Cortisol (µg/dL)	Female Cortisol (µg/dL)
Resting state	5-10	5-12
Mild stress (e.g., exams)	10-15	12-18
Acute stress (e.g., public speaking)	15-20	18-25
Chronic stress (e.g., long-term workload)	20-30	25-35

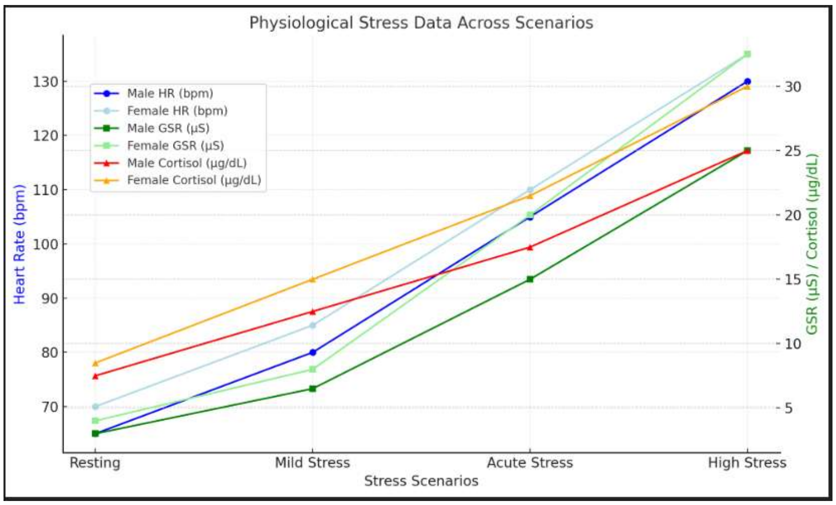

Figure 8: Stress level and their variation with respect to gender under different stress scenarios

Experimental Data

By performing various inputs in the developed simulation, we have come to a conclusion that this circuit have two parameters based on which it responds by glowing the LED – bias and amplitude. Under stressed condition human body provides these two parameters that helps to measure the stress. We have got a table of data by experimenting the simulation keeping the amplitude = 6 (constant) and varying the bias accordingly.

Table 4: No. of LEDs Glowing vs Signal Range

LEDs Glowing	Bias	Signal Range	Explanation
1 LED	4	[-2,10]	Crosses only Threshold 1 (>2), stays below 4.
2 LEDs	6	[0,12]	Crosses Thresholds 1 and 2 (>2, >4), stays

			below 8.
3 LEDs	8	[2,14]	Crosses Thresholds 1, 2, and 3 (>2, >4, >6), stays below 10.
4 LEDs	10	[4,16]	Crosses Thresholds 1, 2, 3, and 4 (>2, >4, >6, >8).
5 LEDS	12	[6,18]	Crosses all thresholds (>2, >4, >6, >8, >10).

Here the X component of signal range is Minimum signal and the Y component of signal range is Maximum signal where these are defined by following formulas:

minimum signal= (-) amplitude + bias

maximum signal= amplitude + bias

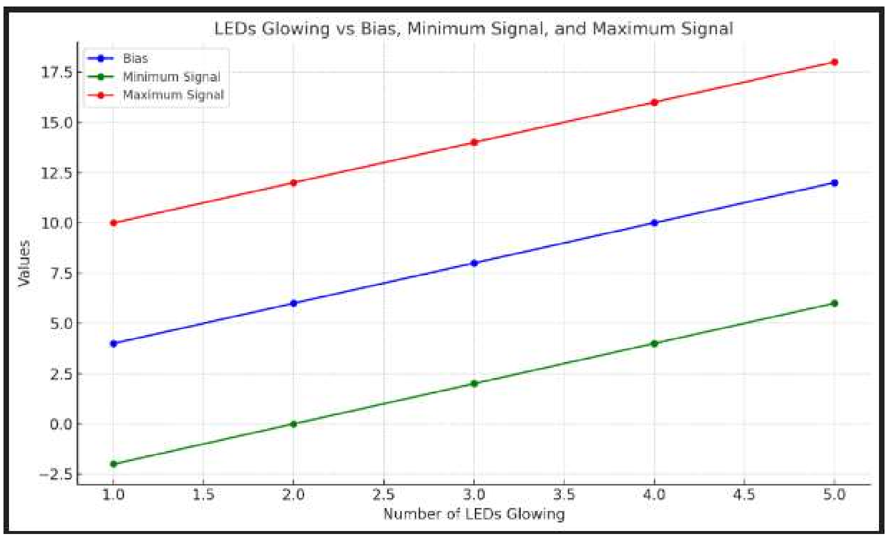

Figure 9: Graphical representation of signal range and bias with respect to number of glowed LEDs keeping amplitude constant

Sample calculations

To analyse the circuit diagram and compute sample values for the following components:

- Voltage Divider Network: Calculating voltage across the potentiometer.
- LED Threshold Voltages: Calculating the LED activation voltages.
- Buzzer Trigger Threshold: Calculating when the piezo buzzer is activated.

1. **Voltage Divider Network:**
   - Components: R1=560 Ω, R1=560Ω, VR1=1 MΩ

- Input voltage: Vin=9 V (battery).
- Formula: $V_{out} = V_{in} \times V_{R1} / (R_1 + V_{R1})$
- Assume a value for V_{R1} (e.g., V_{R1}=500 kΩ) and compute V_{out}

2. **LED Threshold Voltages (using LM3915):**
   - The IC is a dot/bar display driver with logarithmic response.
   - Assuming a reference voltage of $V_{ref} = 5$ V

     $V_{threshold} = (V_{ref} \times \text{Level}) / 10$

   - Calculate $V_{threshold}$ for LED 1 to LED 5.

3. **Buzzer Trigger Voltage:**
   - Buzzer turns on when "High Stress" LED is lit.
   - Assume a trigger voltage V_{buzzer}=3 V at the corresponding pin of LM3915.
   - Verify if $V_{threshold}$ of the last LED exceeds V_{buzzer}.

4. **Capacitor charging discharging (optional):**
   - For capacitors C_1, C_2, and C_3:
     - Formula for charging time constant: $\tau = R \cdot C$
     - Assume R and compute τ for each capacitor

Here are the sample calculations for your stress meter:

1. Voltage Divider Output:
   Using R_1=560 Ω , V_{R1}=500 kΩ , and V_{in}=9 V:
   $$V_{out} = V_{in} \times V_{R1} / (R1 + V_{R1}) = 9 \times 500000 / (560 + 500000) \approx 8.99V$$

2. LED Threshold Voltages:
   Assuming the LM3915's reference voltage $V_{ref} = 5$ V:
   $V_{threshold} = (V_{ref} \times \text{Level}) / 10$
   - For LEDs 1 to 5:
   - LED 1: 0.5 V
   - LED 2: 1.0 V
   - LED 3: 1.5 V
   - LED 4: 2.0 V
   - LED 5: 2.5 V

3. Buzzer Trigger Voltage:
   The piezo buzzer is triggered at the voltage threshold of the last LED (LED5):
   $V_{buzzer} = V_{threshold}$ (LED5) = 2.5 V

4. Capacitor Charging / Discharging:
   For C_1=10 μF and R_2=1.2 kΩ:
   $$\tau = R \cdot C = 1.2 \times 103 \times 10 \times 10^{-6} = 0.012 \text{ seconds}$$
   The time constant τ determines how quickly the capacitor charges or discharges.

Comparison to other Stress Measurement Techniques

Feature	Traditional Methods	**Stress Meter (GSR-based)**
Measurement Technique	Based on **subjective reports** (questionnaires, interviews) or **physical examination** (heart rate, blood pressure).	Measures **skin conductivity** via **Galvanic Skin Response (GSR)**, providing real-time data..00000
Real-time Feedback	**No real-time data**; stress levels are evaluated periodically or through self-reports.	**Immediate feedback** on stress levels based on electrical skin changes.
Ease of Use	Requires professional supervision, equipment, and subject cooperation.	**Easy to use**, can be applied individually with minimal training.
Accuracy	Often dependent on **subjective feelings** and stress reports, leading to variability.	Provides **quantitative, objective data** based on physiological changes.
Non-invasive	Some methods involve physical interventions like blood pressure cuffs or heart rate monitors.	**Completely non-invasive**, using only skin contact through touchpads.
Cost and Equipment	May require **expensive medical equipment** (e.g., heart monitors, blood pressure cuffs).	**Low-cost** components such as touchpads, resistors, and an IC.
Applications	Typically used in **clinical environments** or research labs.	Can be used for **personal stress monitoring**, wellness programs, and education.

Conclusions and Scope for Future Work

The stress meter created indicates the stress measured on the skin on a scale of 5 . Critically high stress also gives an audible warning. It has several advantages, namely:

- It is quite economical to put together (estimated at INR 250 per meter, further reduced at scale)
- It is very easy to assemble
- Most parts are easy to procure
- It has a low power consumption and is not taxing on the supply

The project has got definite room for expansion, the most relevant of which are discussed in further detail below:

- To reduce the size and overall footprint of the package so it can be widely marketed or used in mainstream health organisations
- Develop techniques to advise the user on methods to reduce stress, driven by Machine Learning algorithms. Such as exercising in case of stress due to fragile health
- Reduction of error due to losses in the circuit and the randomness of human skins. Accounting for factors such as time of day and season (skin contracts more in winter)
- An optical sensor can be used along with surface contact touchpad. By comparing the data and readings from the optical sensor and the touchpad, we can get a more accurate understanding of the stress levels, as well as prevent erroneous detections due to momentary rises or falls in the instrument. For example, the touchpad can activate erroneously
- Expansion to a more feature rich health monitor with features such as heartrate tracking, SpO_2 (blood oxygen) measurement and other metrics.

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Appendices:

Table 5: List of item specifications

Component	Specification	Purpose
R_1, R_5, R_6	560 ohm, 1kΩ, 47kΩ resistors (fixed)	Set biasing and control current flow in the circuit.
VR_1, VR_2	Variable resistors (47 kΩ)	Adjust sensitivity and calibration for input signals.
D_1	1 N4148	Ensures unidirectional current flow
T_1	BC548 (NPN Transistor)	Amplifies the weak GSR Signal
IC_1	LM3915 (LED Driver IC)	Drives LED array to display stress levels
LED 1 to 5	LEDs (Operating voltage: 2V, Current: 20mA)	Visual indication of stress level
PZ_1	Piezo buzzer (Operating Voltage 5-9V)	Provides an audible warning when high stress is detected.
C1, C2, C3	Capacitors (10 uF,100uF, 10uF; 16V)	Used for signal filtering and decoupling to stabilize the circuit
ZD1	Zener diode (5.1 V, 0.5W)	Provides voltage regulation to the circuit
Touch Pads	Conductive plates or skin electrodes	Detect GSR by measuring skin conductivity
9V battery	Power Source	Provides the required DC power supply for the circuit operation
S1	ON/OFF Switch	Allows the circuit to be powered on or off

Further Research on Stress Meters

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