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REAL-TIME STRESS DETECTION BAND USING GALVANIC SKIN RESPONSE (GSR)

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ABSTRACT

The Real-Time Stress Detection Band using Galvanic Skin Response (GSR) is a wearable physiological monitoring system designed to continuously analyze a user's emotional and mental state by examining variations in skin conductivity, which is strongly influenced by sweat gland activity controlled by the autonomic nervous system. Stress has increasingly become a major global health concern, affecting productivity, emotional stability, and long-term well-being, and conventional stress assessment methods such as questionnaires or periodic medical checkups fail to provide continuous and accurate real-time insights. This project aims to bridge this gap by integrating sensor technology, embedded computing, and intelligent data analysis into a compact wrist-worn device that measures real-time electrodermal activity. When a person experiences stress, the sympathetic nervous system activates, causing an increase in sweat secretion even in small amounts, and this physiological change results in measurable shifts in skin resistance; the GSR sensor accurately detects these subtle variations and sends them to a microcontroller, which processes the signals and applies calibrated thresholding or machine learning techniques to determine the stress level. The band continuously monitors user data, classifies stress states, and displays or transmits the results through wireless communication to smartphones or cloud dashboards for visualization and long-term trend analysis. The system also provides notifications or alerts whenever stress crosses a predefined threshold, allowing early intervention through relaxation routines, mindfulness techniques, or behavior adjustments. The primary objective of this system is to offer an affordable, non-invasive, and real-time approach to mental wellness monitoring, suitable for students, professionals, patients, or individuals dealing with high-pressure lifestyles. Unlike medical-grade equipment, this wearable solution is portable and cost-effective, making stress monitoring accessible to the general public without the need for hospital visits. The embedded algorithms ensure fast and accurate readings by filtering noise, stabilizing baseline fluctuations, and adjusting sensitivity according to environmental conditions. The device can also integrate additional sensors such as heart rate, skin temperature, or accelerometers to enable multi-parametric stress analysis for even higher accuracy. Practical applications include workplace stress evaluation, student examination anxiety tracking, early burnout detection, fitness and workout stress monitoring, and therapeutic psychological assessments. The overall system is designed for long battery life, comfortable wearing experience, and consistent performance. The project thus contributes to the growing field of wearable health technology by offering a reliable solution that identifies stress in real time through biometric changes, enabling users to take better control of their emotional health and lifestyle choices while providing researchers and clinicians with valuable physiological data for detailed behavioral modeling and medical insights.

I. INTRODUCTION

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1.1. Overview

In today's fast-paced and highly competitive world, stress has become an unavoidable part of daily life. Academic pressure, professional responsibilities, financial challenges, social expectations, and lifestyle imbalances contribute significantly to mental strain. While a moderate level of stress can enhance motivation and performance, chronic and unmanaged stress can lead to serious physical and psychological disorders, including anxiety, depression, cardiovascular diseases, sleep disturbances, and weakened immunity. According to global health reports, stress-related illnesses are steadily increasing, especially among students, working professionals, and individuals living in urban environments.

Despite its widespread impact, stress remains difficult to measure objectively. Traditional stress assessment methods primarily rely on psychological questionnaires, interviews, or self-reported surveys. Although useful, these approaches are subjective and often fail to capture real-time physiological changes. Furthermore, individuals may underreport or misinterpret their stress levels due to lack of awareness or social stigma. Clinical evaluation methods such as laboratory-based physiological monitoring are accurate but expensive, time-consuming, and impractical for continuous everyday use.

Recent advancements in wearable health technology have opened new possibilities for real-time physiological monitoring. Wearable devices such as smartwatches and fitness trackers already monitor heart rate, oxygen levels, and physical activity. However, dedicated stress monitoring systems with accurate real-time analysis remain limited in affordability and accessibility. This creates a strong need for a compact, cost-effective, and continuous stress monitoring solution.

The Real-Time Stress Detection Band using Galvanic Skin Response (GSR) is designed to address this need. The system utilizes the principle of electrodermal activity (EDA), also known as Galvanic Skin Response, to measure changes in skin conductivity. When an individual experiences stress, the sympathetic nervous system is activated, causing increased sweat gland activity—even in small, imperceptible amounts. This change reduces skin resistance and increases electrical conductivity, which can be accurately detected using a GSR sensor.

The wearable band integrates a GSR sensor with an Arduino-based microcontroller, regulated power supply, LCD display, buzzer, and Wi-Fi module. The sensor captures skin conductivity variations and sends analog signals to the microcontroller. The Arduino processes these signals using filtering and threshold algorithms to determine stress levels. The results are displayed on an LCD screen in real time and can also be transmitted wirelessly to a smartphone or cloud dashboard via the Wi-Fi module.

The system provides instant alerts through a buzzer whenever stress exceeds a predefined threshold, enabling users to take immediate corrective actions such as deep breathing exercises or relaxation techniques. Additionally, long-term data logging allows trend analysis for behavioral insights and preventive healthcare strategies.

The Real-Time Stress Detection Band represents a significant advancement in wearable health monitoring. It bridges the gap between subjective psychological assessment and objective physiological measurement by offering a non-invasive, continuous, and affordable solution. The system is designed for comfort, portability, low power consumption, and real-time processing, making it suitable for daily use.

By combining sensor technology, embedded systems, and wireless communication, this project contributes to the emerging field of smart healthcare and emotional wellness

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monitoring. It empowers users to better understand their emotional states, improve mental resilience, and make informed lifestyle decisions.

1.2. NEED FOR THE SYSTEM

The need for a real-time stress detection band arises from several societal, medical, and technological challenges.

1.2.1 Increasing Stress Levels Globally

Modern lifestyles have significantly increased mental workload and emotional pressure. Students face academic competition, professionals manage deadlines and job insecurity, and individuals cope with social and financial responsibilities. Chronic stress has become a major public health concern requiring continuous monitoring and early detection.

1.2.2 Limitations of Traditional Stress Assessment

Conventional methods such as questionnaires and interviews:

- Are subjective and self-reported
- Do not provide continuous monitoring
- Fail to detect sudden stress spikes
- Require clinical supervision

There is a need for objective physiological measurement methods.

1.2.3 Lack of Continuous Monitoring

Medical-grade stress monitoring systems are expensive and limited to clinical settings. Everyday stress fluctuations during work, study, or travel remain untracked.

1.2.4 Early Detection for Preventive Care

Chronic stress often leads to serious health issues such as hypertension, heart disease, anxiety disorders, and burnout. Early identification allows preventive action before severe complications arise.

1.2.5 Affordable Mental Health Technology

Advanced wearable devices are often costly. A low-cost Arduino-based solution makes stress monitoring accessible to students and the general population.

1.3. PROBLEM STATEMENT

Although stress significantly affects mental and physical health, there is currently no widely accessible, affordable, and real-time wearable solution for continuous stress monitoring based on physiological signals. Existing systems suffer from several limitations:

1. **Subjective Measurement** – Most stress assessments rely on self-reporting, which lacks accuracy.
2. **High Cost** – Clinical monitoring equipment is expensive and not portable.
3. **Limited Accessibility** – Continuous monitoring devices are not affordable for common users.
4. **Delayed Detection** – Traditional checkups do not capture real-time stress spikes.
5. **Lack of Immediate Alerts** – Users are unaware when stress crosses critical thresholds.

Therefore, there is a need for a wearable, real-time, low-cost, and non-invasive stress detection system capable of measuring physiological signals continuously and providing instant alerts and wireless data monitoring.

1.4. OBJECTIVES

The primary objective of this project is to design and implement a wearable real-time stress detection band using GSR technology integrated with Arduino and Wi-Fi communication.

1.4.1 General Objectives

- To measure electrodermal activity (GSR) accurately.
- To analyze stress levels in real time.
- To display stress data on an LCD.
- To send data wirelessly via Wi-Fi.
- To provide alert notifications during high stress.

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1.4.2 Specific Objectives

1. Interface GSR sensor with Arduino microcontroller.
2. Implement signal filtering to reduce noise.
3. Develop algorithm for stress classification.
4. Display stress levels (Low, Medium, High) on LCD.
5. Activate buzzer when stress exceeds threshold.
6. Transmit data to cloud/server using Wi-Fi module.
7. Log long-term stress data for trend analysis.
8. Ensure low power consumption and wearable comfort.
9. Calibrate sensor for different skin types.
10. Integrate optional multi-sensor support (heart rate, temperature).

1.4.3 Performance Objectives

- Fast response time (<2 seconds).
- Accurate stress detection.
- Stable wireless communication.
- Long battery life.
- Consistent baseline calibration.

1.5. SCOPE OF THE PROJECT

1.5.1 Technical Scope

The system includes:

- Arduino microcontroller
- GSR sensor
- Wi-Fi module (ESP8266/ESP32)
- 16x2 LCD display
- Buzzer
- Regulated power supply

The device measures electrodermal activity, processes data, and transmits stress information wirelessly.

1.5.2 Functional Scope

- Continuous stress monitoring
- Real-time stress level display
- Threshold-based alerts
- Cloud-based data visualization
- Long-term trend tracking

1.5.3 Application Scope

Applicable in:

- Workplace stress evaluation
- Student examination anxiety monitoring
- Fitness and workout stress tracking
- Psychological therapy support
- Remote patient monitoring
- Research in behavioral science

1.5.4 Limitations

- GSR alone may not capture all emotional states.
- Environmental temperature may affect readings.
- Requires proper calibration.
- Not a substitute for medical diagnosis.

II. LITERATURE SURVEY

1. Literature Review on GSR-Based Stress Monitoring

Galvanic Skin Response has long been studied as a key physiological indicator of emotional arousal and stress, and numerous research studies validate its accuracy in detecting sympathetic nervous system activation. Early work in psychophysiology demonstrated that skin conductance is highly responsive to stress triggers such as cognitive workload, emotional pressure, anxiety, and fear. Researchers established standardized measurement techniques for electrodermal activity, including tonic levels indicating baseline conductivity and phasic responses showing momentary changes. Over the years, advancements in biosensor technology have enabled the development of compact and highly sensitive GSR modules capable of measuring conductivity through simple electrodes placed on the skin. Modern studies compare GSR-based stress detection with traditional methods like cortisol measurement, EEG analysis, and heart rate variability, concluding that GSR offers a reliable, non-invasive, and low-cost alternative suitable for continuous monitoring. Wearable devices incorporating GSR sensing, such as smartwatches and stress-monitoring

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wristbands, have shown strong correlation between real-life stress events and sensor-derived data, making them highly useful for daily monitoring. Recent research also integrates machine learning classification techniques such as SVM, Random Forest, and neural networks to interpret GSR signals more accurately, allowing reliable differentiation between stress, excitement, and relaxation. Studies confirm that stress patterns vary from individual to individual, and adaptive threshold techniques improve accuracy significantly. Research also highlights that environmental factors, hydration levels, and skin dryness can influence readings, emphasizing the need for noise reduction algorithms and sensor calibration. Several clinical studies have validated GSR-based systems in scenarios such as workplace stress assessment, emotional response detection, cognitive load measurement in students, and mental health monitoring in patients. The integration of IoT technologies in recent years has further expanded the usability of GSR-based stress monitoring systems by enabling remote health tracking, cloud data analytics, and real-time alert systems. Overall, the literature strongly supports the use of GSR as a primary biomarker for stress monitoring in real-life conditions and highlights its suitability for wearable embedded systems.

2. Literature Review on Wearable Stress Detection Systems

Wearable health monitoring technologies have transformed the landscape of personal wellness and medical diagnostics by providing continuous, real-time physiological data. Several studies explore wearable stress detection systems integrating GSR, heart rate sensors, temperature sensors, and motion detectors to build a multi-modal evaluation of mental and physical stress. Research demonstrates that combining multiple biosignals significantly enhances accuracy, as stress manifests differently across individuals. Wearable devices such as fitness bands, smartwatches, and chest straps have been studied extensively, and findings indicate that comfort, battery efficiency, and signal stability are critical for user adoption. Academic research on smart bands emphasizes that GSR sensors are particularly effective because they require minimal power, small electrodes, and can be worn conveniently on the wrist. Wearable stress detection systems have been tested in diverse environments, including academic settings, industrial workplaces, driving scenarios, and clinical therapy sessions. Studies indicate that wearable bands can accurately detect anomalies in stress levels caused by fatigue, emotional disturbances, physical exertion, or external stimuli. Several projects highlight the role of embedded microcontrollers like Arduino, ESP32, and STM32 in wearable manufacturing due to their small size, low energy consumption, and wireless communication capabilities. Modern literature also highlights the integration of IoT and mobile applications for visualization, allowing users to track their stress patterns, generate reports, and receive alerts. With the rise of machine learning, many researchers have experimented with time-series analysis and classification models for stress prediction. The literature also discusses limitations such as sensor drift, noise interference, motion artifacts, and the need for periodic calibration. Nonetheless, wearable stress detection technology continues to evolve rapidly with improvements in flexible electronics, biocompatible materials, and energy-efficient computing. The strong foundation in wearable research supports the relevance and feasibility of developing a real-time stress detection band using GSR technology.

3. Literature Review on Real-Time Embedded Health Monitoring Systems

Embedded systems play a vital role in modern healthcare devices, enabling portable, real-time monitoring of vital signs and emotional states. Research in embedded health systems emphasizes low-power operation, high-speed signal processing, and reliable data transmission. Numerous studies demonstrate the use of microcontrollers and SoC platforms such as Arduino, ESP32, ARM Cortex, and Raspberry Pi for biomedical signal acquisition and processing. In stress monitoring applications, GSR sensors are widely used due to their responsiveness and ease of integration with embedded platforms. Literature on real-time systems highlights challenges in data accuracy, sensor noise, environmental stability, and power consumption. Researchers propose various signal conditioning and filtering techniques such as Kalman filtering, moving average smoothing, and adaptive thresholding to enhance reliability. Several studies explore the integration of Bluetooth, Wi-Fi, and MQTT communication for transmitting stress data to smartphones or cloud dashboards. Embedded systems also support machine learning inference, enabling on-device classification without relying on cloud processing. Research highlights the importance of ergonomic design and user comfort, especially for wrist-worn devices that must accommodate motion and sweat while ensuring consistent sensor-to-skin contact. Real-time embedded monitoring systems have been increasingly adopted in mental health care, elderly care, fitness assessment, human–computer interaction, and emotion prediction research. Studies conclude that integrating intelligent algorithms with physiological sensors in embedded devices significantly improves early detection of stress and emotional disturbances. This literature supports the development of a real-time stress detection band using GSR, validating the choice of embedded hardware, algorithms, and communication methods.

Galvanic Skin Response (GSR) — also called electrodermal activity (EDA) — has a long history as a physiological correlate of sympathetic nervous system activity. Classic psychophysiology established that sweat gland activity, even in minute amounts not perceptible to the user, changes skin conductance and that these conductance shifts reliably co-vary with arousal, emotional states, and stress. Early laboratory studies used bulky equipment to record skin conductance responses (SCRs) during controlled stimuli and demonstrated robust within-subject changes tied to cognitive load, anxiety, and stressors. That body of work established GSR's value as an objective, non-invasive marker of autonomic arousal and laid the conceptual foundation for wearable stress monitoring. Modern wearable implementations repurpose the same physiological principle in miniaturized sensor form factors and focus on continuous, ambulatory measurement rather than episodic laboratory testing.

A large stream of engineering literature covers the design and optimization of GSR sensors for wearables. Early wearable sensors emphasized simple two-electrode resistive measurements; subsequent research refined electrode materials and placement (e.g., palmar vs. wrist locations), electrode spacing, and contact mechanics to reduce motion artifacts and baseline drift. Many studies show that wrist and forearm placements (most convenient for a wristband) produce smaller amplitude signals than palmar placements but are still useful when combined with careful analog front-end design (high input impedance amplifiers, driven right leg or bias rejection circuits) and robust calibration. Advances in dry and polymer electrodes have helped wearable comfort, but the trade-off between comfort and signal fidelity remains a recurring theme in the literature.

III. SYSTEM ANALYSIS

EXISTING METHOD

Existing stress detection methods primarily rely on manual assessments such as psychological questionnaires, mood self-reporting apps, or periodic visits to therapists or clinicians. These approaches, while valuable, do not provide continuous monitoring and often depend heavily on user awareness and willingness to report stress levels accurately. Other existing systems use bulky medical devices like polygraphs, EEG machines, or multi-sensor clinical setups that are expensive, stationary, and unsuitable for daily wear. Traditional smartwatches provide heart rate tracking but lack accurate stress identification since heart rate alone is easily influenced by physical activity. Existing consumer GSR-based devices may offer basic stress indications but usually do not provide real-time precision, adaptive calibration, or continuous physiological data streaming. Many older systems fail to account for environmental factors such as temperature changes, skin dryness, or motion artifacts, which reduces reliability. Furthermore, existing methods rarely integrate intelligent data processing techniques or machine learning models for accurate classification. Limited battery life, lack of wireless communication, and absence of user alerts further restrict the effectiveness of traditional stress monitoring solutions. These gaps highlight the need for a compact, intelligent, and wearable device that can continuously monitor stress levels using GSR and provide timely feedback.

The existing stress detection systems primarily rely on psychological questionnaires, clinical interviews, or hospital-based physiological monitoring equipment such as ECG, EEG, and laboratory-grade biofeedback devices. While these methods provide useful insights, they are either subjective or limited to controlled environments. Many wearable devices currently available in the market estimate stress indirectly using heart rate variability without specifically measuring electrodermal activity. Moreover, traditional systems do not provide continuous real-time monitoring and are often expensive and inaccessible to the general population.

Disadvantages:

1. Stress assessment is often subjective and based on self-reporting.
2. Clinical monitoring equipment is expensive and not portable.
3. No continuous real-time monitoring in daily life environments.
4. Limited accessibility for students and working professionals.
5. Lack of immediate alerts when stress levels rise suddenly.

PROPOSED METHOD

The proposed Real-Time Stress Detection Band introduces a highly reliable, wearable embedded system that uses a GSR sensor to continuously measure electrodermal activity and detect stress in real time. The system includes a microcontroller that processes data, filters noise, applies threshold or machine learning-based classification, and determines accurate stress levels instantly. The band is designed to be lightweight, energy-efficient, and comfortable for long-term usage. The processed stress data is displayed on an onboard screen or transmitted wirelessly via Bluetooth or Wi-Fi to a user’s smartphone for visualization and historical analysis. Users receive alerts when elevated stress levels are detected, enabling immediate action to manage emotional strain. The proposed method overcomes limitations of existing systems by offering continuous monitoring, dynamic calibration, and intelligent analytics. The integration of IoT-based dashboards and mobile apps enhances accessibility and usability, making the system applicable for students, professionals, elderly individuals, patients, and fitness users. Its cost-effective design, compact hardware, and advanced processing make it suitable for large-scale deployment and long-term mental health monitoring.

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The proposed system, Real-Time Stress Detection Band using Galvanic Skin Response (GSR), is a wearable embedded device that continuously monitors electrodermal activity to detect stress levels in real time. The GSR sensor measures skin conductivity changes, and the Arduino microcontroller processes the signals using filtering and threshold algorithms. The stress level is displayed on an LCD screen, and alerts are generated using a buzzer when stress exceeds predefined limits. The Wi-Fi module enables wireless transmission of data to smartphones or cloud dashboards for remote monitoring and long-term analysis. This system provides a non-invasive, portable, and affordable stress monitoring solution suitable for everyday use.

Advantages:

1. Provides continuous real-time stress monitoring.
2. Affordable and portable wearable design.
3. Immediate alerts when stress crosses threshold levels.
4. Wireless data transmission for remote monitoring and analysis.
5. Objective physiological measurement using GSR technology.

IV. HARDWARE

4.1 ARDUINO UNO

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.Arduino board has the following new features:

- 1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin, that is reserved for future purposes.
- Stronger RESET circuit.
- Atmega 16U2 replace the 8U2.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

Fig: ARDUINO UNO

4.2. POWER SUPPLY

The power supplies are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. A power supply can by broken down into a series of blocks, each of which performs a particular function. A d.c power supply which maintains the output voltage constant irrespective of a.c mains fluctuations or load variations is known as "Regulated D.C Power Supply".

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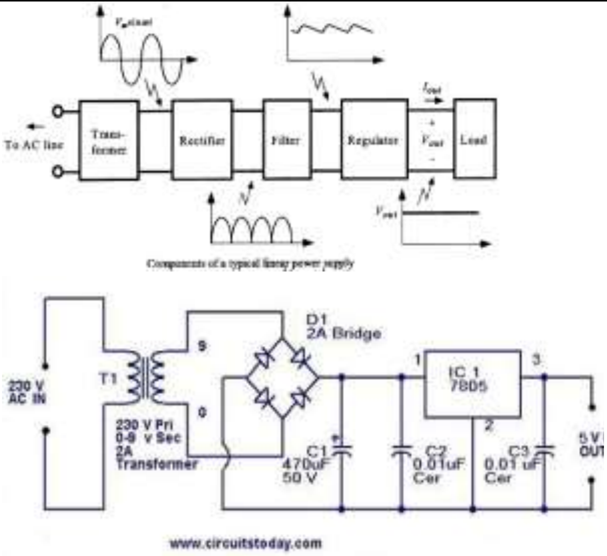


Fig: Schematic Diagram of Power Supply

4.2.1. TRANSFORMER:

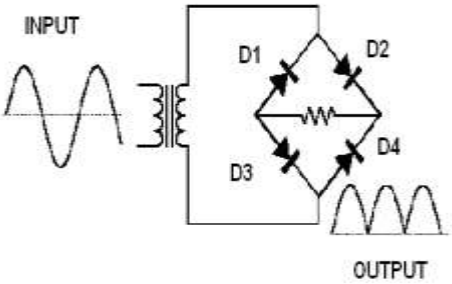
A transformer is an electrical device which is used to convert electrical power from one Electrical circuit to another without change in frequency.

When AC is applied to the primary winding of the power transformer it can either be stepped down or up depending on the value of DC needed. In our circuit the transformer of 230v/12-0-12v is used to perform the step down operation where a 230V AC appears as 12V AC across the secondary winding.

4.2.2. RECTIFIER:

A circuit which is used to convert a.c to dc is known as RECTIFIER. The process of conversion a.c to d.c is called "rectification.

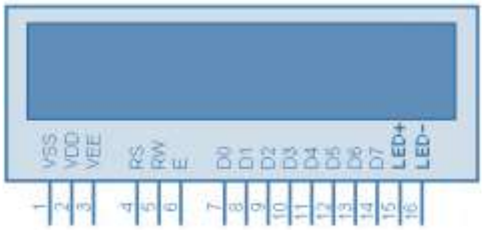
Bridge Rectifier:



Alphanumeric LCD

Liquid Crystal Display also called as LCD is very helpful in providing user interface as well as for debugging purpose. The most commonly used Character based LCDs are based on Hitachi's HD44780 controller or other which are compatible with HD44580. The most commonly used LCDs found in the market today are 1 Line, 2 Line or 4 Line LCDs which have only 1 controller and support at most of 80 characters, whereas LCDs supporting more than 80 characters make use of 2 HD44780 controllers.

Pin Description



4.3 BUZZER

What is a Buzzer: Working & Its Applications

There are many ways to communicate between the user and a product. One of the best ways is audio communication using a buzzer IC. So during the design process, understanding some technologies with configurations is very helpful. So, this article discusses an overview of an audio signaling device like a beeper or a buzzer and its working with applications.

What is a Buzzer?

An audio signaling device like a beeper or buzzer may be electromechanical or piezoelectric or mechanical type. The main function of this is to convert the signal from audio to sound. Generally, it is powered through DC voltage and used in timers, alarm devices, printers, alarms, computers, etc. Based on the various designs, it can generate different sounds like alarm, music, bell & siren.

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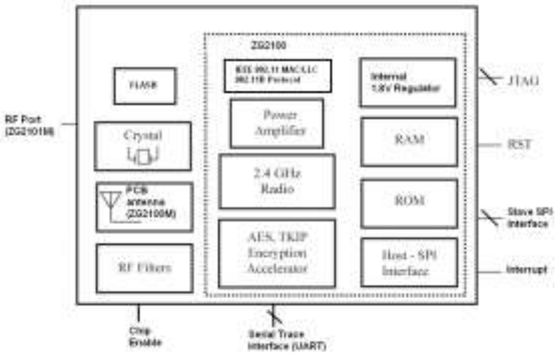
WIFI:

Description

The ZG2100M & ZG2101M modules are low-power 802.11b implementations. All RF components, the baseband and the entirety of the 802.11 MAC reside on-module, creating a simple and cost-effective means to add Wi-Fi connectivity for embedded devices. The module(s) implement a high-level API, simplifying design implementation and allowing the ZG2100M or ZG2101M to be integrated with 8- and 16-bit host microcontrollers.

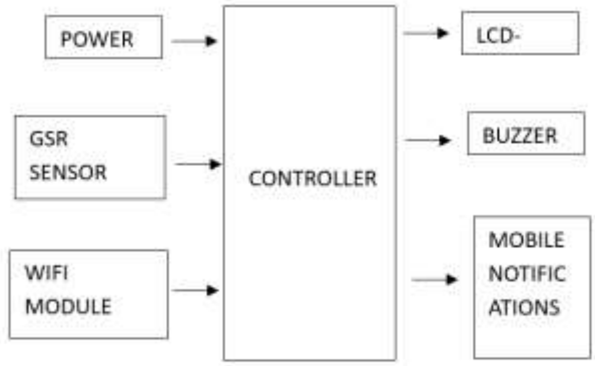
Features

• Single-chip 802.11b including MAC, baseband, RF and power amplifier
• Data Rate: 1 & 2 Mbps
• 802.11b/g/n compatible
• Low power operation
• API for embedded markets, no OS required
• PCB or external antenna options
• Hardware support for AES and RC4 based ciphers (WEP, WPA, WPA2 security)
• SPI slave interface with interrupt
• Single 3.3V supply, operates from 2.7V to 3.6V (see section 5)
• 21mm x 31mm 36-pin Dual Flat pack PCB SM Package
• Wi-Fi Certified, RoHS and CE compliant
• FCC Certified (USA, FCC ID: W7O-ZG2100-ZG2101)
• IC Certified (IC: 8248A-G21ZEROG)
• Fully compliant with EU & meets the R&TTE Directive for Radio Spectrum



V. METHODOLOGY & IMPLEMENTATIONS

BLOCK DIAGRAM



WORKING:

1. Power Supply

The power supply provides regulated DC voltage (typically 5V) to all system components.

- Ensures stable operation of the Arduino controller.
- Supplies power to the GSR sensor and Wi-Fi module.
- Maintains consistent voltage for LCD and buzzer operation.
- In wearable applications, this may be a rechargeable battery.

A stable power source is essential to avoid signal fluctuation and inaccurate stress readings.

2. GSR Sensor

The GSR (Galvanic Skin Response) sensor measures the electrical conductivity of the skin.

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Working Principle:

- When a person experiences stress, the sympathetic nervous system activates.
- Sweat gland activity increases, even in small amounts.
- This reduces skin resistance and increases conductivity.
- The GSR sensor detects these conductivity changes.
- It outputs an analog voltage signal proportional to skin resistance.

The analog signal is then sent to the controller for processing.

3. Controller (Arduino – Main Processing Unit)

The controller acts as the brain of the system.

Functions of the Controller:

1. Reads analog input from the GSR sensor.
2. Applies signal filtering (e.g., moving average or low-pass filter) to remove noise.
3. Compares processed values with predefined threshold levels.
4. Classifies stress level as:
   - Low
   - Moderate
   - High
5. Controls output devices (LCD, buzzer, Wi-Fi module).

The decision-making algorithm determines whether stress is within normal limits or exceeds the threshold.

4. LCD Display

The 16x2 LCD provides real-time feedback to the user.

It displays:

- Current GSR value
- Stress level (Low / Medium / High)
- System status messages such as “Monitoring…” or “High Stress Alert”

This allows users to instantly observe their stress condition.

5. Buzzer

The buzzer provides audible alerts when stress crosses a predefined threshold.

- Short beep → Moderate stress.
- Continuous or long beep → High stress.
- No sound → Normal condition.

This immediate alert helps the user take corrective actions such as relaxation exercises or breathing techniques.

6. Wi-Fi Module

The Wi-Fi module (ESP8266 / ESP32) enables wireless communication.

Working:

- The controller sends processed stress data to the Wi-Fi module.
- The module transmits data to:
  - Smartphone application
  - Cloud server
  - IoT dashboard (e.g., ThingSpeak, Blynk)

This allows:

- Remote monitoring
- Long-term stress trend analysis
- Mobile notifications

7. Mobile Notifications

When stress exceeds threshold levels:

- The system sends alert notifications to the user’s smartphone.
- Notifications may include:
  - “High Stress Detected”
  - “Please Relax”
  - Stress graph visualization

This feature enhances preventive healthcare and behavioral awareness.

Flow chart

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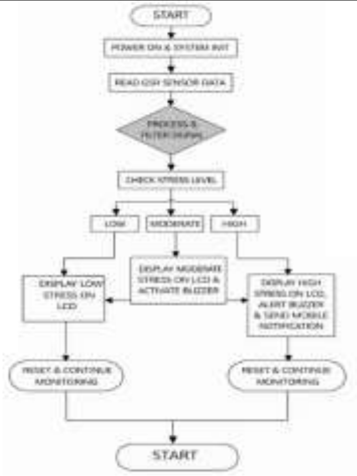

1. Start

The process begins when the system is powered ON. This indicates the activation of the wearable device.

2. Power ON & System Initialization

- The Arduino controller initializes all connected components:
    - GSR Sensor
    - LCD Display
    - Buzzer
    - Wi-Fi Module
- The system checks whether all modules are functioning properly.
- LCD may display "System Ready" or "Monitoring Started."

This stage ensures proper hardware and software setup before data collection begins.

3. Read GSR Sensor Data

- The GSR sensor continuously measures skin conductivity.
- When a person experiences stress, sweat gland activity increases.
- This reduces skin resistance and increases conductivity.
- The sensor sends an analog voltage signal to the controller.

This step collects real-time physiological data from the user.

4. Process & Filter Signal

- The raw analog signal may contain noise due to:
    - Hand movement
    - Environmental temperature
    - Sensor instability
- The controller applies filtering techniques such as:
    - Moving average filter
    - Low-pass filter
- The system stabilizes the baseline value for accurate analysis.

This step ensures clean and reliable data before classification.

5. Check Stress Level

The processed signal is compared with predefined threshold values.

The system classifies stress into three levels:

- **Low Stress**
- **Moderate Stress**
- **High Stress**

Threshold values are calibrated based on baseline readings.

6. Low Stress Condition

If the detected value falls within the normal range:

- LCD displays: "Low Stress"
- No buzzer alert
- System continues monitoring

This indicates a calm or relaxed physiological state.

7. Moderate Stress Condition

If stress level increases slightly above baseline:

- LCD displays: "Moderate Stress"
- Short buzzer alert (optional)
- System continues monitoring

This warns the user of rising stress levels.

8. High Stress Condition

If stress exceeds the predefined high threshold:

- LCD displays: "High Stress"
- Buzzer activates as alert
- Wi-Fi module sends mobile notification
- Data may be uploaded to cloud dashboard

This enables immediate intervention such as relaxation or breathing exercises.

9. Reset & Continue Monitoring

After each cycle:

- The system resets internal flags.
- Returns to continuous monitoring mode.
- Loops back to read new GSR data.

VI. CONCLUSION & FUTURE SCOPE

CONCLUSION

The Real-Time Stress Detection Band using Galvanic Skin Response (GSR) successfully demonstrates a practical, affordable, and wearable solution for continuous stress monitoring based on physiological signals. By utilizing electrodermal activity as a primary indicator of sympathetic nervous system activation, the system provides objective measurement of stress rather than relying on subjective self-reporting methods. The integration of a GSR sensor with an Arduino-based microcontroller ensures accurate signal acquisition, processing, and classification of stress levels in real time.

The system effectively filters raw sensor data, compares it with predefined thresholds, and categorizes stress into levels such as low, moderate, or high. Real-time feedback through the LCD display enhances user awareness, while buzzer alerts provide immediate notification during elevated stress conditions. Additionally, the Wi-Fi module enables wireless data transmission to smartphones or cloud dashboards, supporting remote monitoring and long-term trend analysis.

One of the key strengths of this project is its portability and cost-effectiveness. Unlike hospital-based equipment or expensive wearable devices, this system offers a compact and affordable solution suitable for students, professionals, and individuals facing high-pressure environments. The continuous monitoring feature allows early detection of stress spikes, enabling timely intervention and preventive healthcare strategies.

The device contributes significantly to the field of wearable health technology by combining embedded systems, sensor technology, and wireless communication into a unified platform. While it is not intended to replace clinical diagnosis, it serves as a valuable support tool for emotional wellness tracking, behavioral awareness, and stress management. Overall, the project successfully fulfills its objective of developing a real-time, non-invasive, and user-friendly stress detection system.

FUTURE SCOPE

Although the current system performs effectively, several improvements and enhancements can further increase its accuracy, functionality, and real-world applicability.

1. Multi-Sensor Integration

Future versions can integrate additional sensors such as:

- Heart rate sensor (PPG)
- Skin temperature sensor
- Respiration sensor
- Accelerometer

Multi-parametric analysis will significantly improve stress detection accuracy.

2. Machine Learning-Based Classification

Instead of simple threshold-based detection, advanced machine learning algorithms (SVM, Random Forest, Neural Networks) can be implemented for personalized stress prediction and improved classification accuracy.

3. Smartphone Application Development

A dedicated mobile application can:

- Display stress graphs and trends
- Provide relaxation recommendations
- Send personalized notifications
- Store long-term data securely

4. AI-Based Predictive Analytics

Artificial Intelligence can analyze long-term patterns and predict potential burnout or anxiety disorders before symptoms become severe.

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5. Battery Optimization & Miniaturization

Future designs can focus on:

- Smaller PCB design
- Low-power microcontrollers
- Improved battery backup
- Enhanced wearable comfort

6. Cloud & IoT Integration

Integration with IoT platforms can enable:

- Remote monitoring by doctors
- Workplace stress analytics
- Group-level emotional wellness evaluation

7. Clinical Validation Studies

Conducting clinical trials and calibration studies will improve system reliability and credibility for medical support applications.

8. Biofeedback & Intervention System

The device can automatically suggest or trigger:

- Guided breathing exercises
- Meditation audio
- Relaxation prompts

9. Secure Data Encryption

Future models can implement secure encryption and privacy protection mechanisms for transmitted health data.

10. Smartwatch Integration

The system can be integrated into existing smartwatch ecosystems for seamless user experience.

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