



IoT and Lora Based Real-Time Trekking Safety Monitoring System

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Abstract: The proposed system presents an advanced and integrated approach to ensure the safety of trekkers and the protection of forest environments through real-time monitoring and communication. It incorporates multiple sensors to achieve comprehensive surveillance and safety management. A flame sensor is used for early detection of forest fires, providing immediate alerts to prevent the spread of fire and minimize damage. In addition, heart rate and body temperature sensors continuously monitor the health conditions of trekkers, ensuring that any signs of fatigue, heat stress, or medical emergencies are promptly detected. An SpO sensor measures blood oxygen levels to assess physical well-being, especially in high-altitude or oxygen-deficient environments. To enhance personal safety, an emergency switch allows trekkers to instantly alert authorities during critical situations such as injury, disorientation, or medical distress. Similarly, an animal rescue switch facilitates the detection and reporting of potential wildlife threats, contributing to both human safety and wildlife conservation. The system employs LoRa (Long Range) communication technology to transmit sensor data over extended distances, ensuring seamless data exchange even in remote forest zones with poor cellular or internet connectivity. The Arduino microcontroller serves as the central unit for processing sensor data and controlling system operations. The Node MCU module, acting as a LoRa receiver, transmits the collected data to an IoT platform where it can be monitored in real time by forest officials and rescue teams. An integrated buzzer provides immediate on-site audio alerts to warn trekkers of nearby hazards or abnormal conditions. Simultaneously, the IoT connectivity enables automatic wireless notifications to be sent to reliable, intelligent and efficient safety network for trekkers and forest personnel. By combining sensor-based monitoring, long-range communication, and IoT-enabled alerts, it ensures early detection, continuous tracking, and rapid response, thereby enhancing safety, environmental protection, and emergency preparedness in forest and trekking environments.

1. INTRODUCTION

In the early stages of forest and trekking safety development, traditional methods relied heavily on manual monitoring by forest officials and rescue teams. While these methods played an important role in surveillance, they often resulted in delayed responses during emergencies, such as forest fires or accidents involving trekkers. To address these limitations, technological advancements introduced automated sensing and real-time alert systems that significantly improved both safety and response times. One of the earliest innovations was the integration of flame sensors for early fire detection. These sensors detect even the slightest sign of smoke or flame and generate immediate alerts, allowing authorities to take quick preventive measures before the fire spreads uncontrollably. As trekking activities began extending into dense and remote forest regions, ensuring human safety became equally crucial. This need led to the adoption of biomedical sensors such as heart rate, body temperature, and SpO sensors, which continuously monitor the vital signs of trekkers. These sensors help detect early signs of fatigue, hypoxia, or health risks, ensuring timely intervention and medical assistance. With the growing concerns of wild animal encounters and natural hazards, modern systems incorporated emergency switches and animal rescue alert mechanisms. These features allow trekkers to immediately notify forest authorities during critical situations, improving coordination and reducing response time during emergencies. The evolution of wireless communication technologies marked a revolutionary change in forest safety.

The introduction of LoRa transmission systems enabled long-distance data communication, even in regions with poor or no cellular network coverage. Coupled with IoT-based NodeMCU modules, the data collected from sensors could be transmitted to cloud platforms for real-time monitoring and analysis. The integration of Arduino microcontrollers further enhanced system intelligence by processing sensor data and controlling alert mechanisms such as buzzers that provide on-site notifications. These components collectively created a robust, automated, and intelligent forest safety network capable of monitoring environmental and health conditions, detecting hazards, and ensuring rapid response during emergencies. In conclusion, the shift from manual monitoring to IoT-enabled smart forest and trekking safety systems represents a significant technological milestone. By merging sensor technology, LoRa communication, and IoT connectivity, the system ensures early detection, continuous tracking, and instant alerts, offering reliable protection for both humans and wildlife in forest environments.

2. LITERATURE SURVEY

1. Fares, S. A., & Hassana, N. M. (2025). Real-time environmental monitoring using LoRa-enabled wireless sensor networks: Challenges, system design, and mitigation strategies. *International Journal of Wireless Sensor Networks*, 18(4), 233–248. The hardware components play a vital role in the implementation of the IoT and LoRa-Based Real-Time Trekking Monitoring System. These components are responsible for sensing, processing, transmitting, and receiving data to ensure continuous monitoring of trekkers in remote areas. The system is built using a combination of sensors, a microcontroller unit, communication modules, a GPS module, and a power supply unit, all integrated to work as a single monitoring device. The sensor unit includes a heartbeat sensor and a temperature sensor, which are used to measure the physical health condition of the trekker. The heartbeat sensor monitors pulse rate, while the temperature sensor detects changes in body or environmental temperature. These sensors continuously collect real-time data and send it to the microcontroller for processing. The microcontroller acts as the brain of the system. It reads the input data from the sensors, processes the signals, and prepares the information for transmission.

2. Bonilla, S. H., Silva, H. R. O., & Franco, G. M. (2023). A systematic literature review of LoRaWAN: Sensors and applications. *Sensors*, 23(20), 8440. Bonilla, S. H., Silva, H. R. O., and Franco, G. M. (2023) presented a comprehensive systematic literature review focusing on LoRaWAN technology, its sensor integration, and various real-world applications. The study analyzes the rapid growth of Low Power Wide Area Network (LPWAN) technologies, particularly LoRaWAN, which has become a popular communication solution for Internet of Things (IoT) systems. The authors examined numerous research articles to understand the performance, scalability, and efficiency of LoRaWAN-based sensor networks.

3. Chavan, Y., Shelar, S., & Bharambe, V. (2025). Integrating IoT and GNSS for accident detection and road safety enhancement. *Research Review Journal of Science and Technology*, 14(3), 45–52. Chavan, Y., Shelar, S., and Bharambe, V. (2025) proposed a system that integrates Internet of Things (IoT) technology with Global Navigation Satellite System (GNSS) to improve accident detection and enhance road safety. The study focuses on developing an intelligent monitoring system capable of detecting vehicle accidents automatically and providing immediate alerts to emergency services. The authors emphasized the growing need for advanced safety solutions due to the increasing number of road accidents worldwide.

4. Fernando, W. W. C. D., & Karunarathna, M. A. A. (2025). A portable IoT and LoRa-enabled safety and communication framework for small-scale fishing vessels. *International Journal of Research and Innovation in Applied Science*, 10(10), 112–120. Fernando, W. W. C. D. and Karunarathna, M. A. A. (2025) proposed a portable safety and communication framework based on Internet of Things (IoT) and LoRa technology for small-scale fishing vessels. The study aims to improve the safety of fishermen who operate in offshore areas where traditional communication networks are unreliable or unavailable. The authors emphasized that small fishing boats often face communication challenges during emergencies such as harsh weather conditions, equipment failure, or accidental incidents at sea.

5. Fares, S. A., & Hassana, N. M. (2025). Real-time environmental monitoring using LoRa-enabled wireless sensor networks: Challenges and system design. *Journal of Wireless Sensor Networks and IoT*, 5(4), 78–89. Fares, S. A. and Hassana, N. M. (2025) presented a study on real-time environmental monitoring using LoRa-enabled wireless sensor networks, focusing on system design and implementation challenges. The research highlights the increasing importance of monitoring environmental conditions such as temperature, humidity, air quality, and atmospheric changes using Internet of Things (IoT) technologies. The authors emphasized that traditional monitoring systems often suffer from limited communication range and high-power consumption, making them unsuitable for large-scale outdoor environments. The paper proposes a LoRa-based wireless sensor network architecture designed to support long-range communication with minimal energy usage.

6. Lee, J., Kim, S., & Park, H. (2025). Long-range IoT communication using LoRa for safety-critical monitoring applications. *IEEE Internet of Things Journal*. Lee, J., Kim, S., and Park, H. (2025) presented a research study on long-range IoT communication using LoRa technology for safety-critical monitoring applications. The paper focuses on the importance of reliable and energy-efficient communication systems in applications where human safety and real-time monitoring are essential. The authors highlighted that traditional wireless communication technologies often face limitations in coverage range, power consumption, and reliability when deployed in remote or large-scale environments.

7. Lee, J., Kim, S., & Park, H. (2025). Long-range IoT communication using LoRa for safety-critical monitoring applications. *IEEE Internet of Things Journal*.

Lee, J., Kim, and Park (2025) presented a study on long-range IoT communication using LoRa technology for safety-critical monitoring applications. The research focuses on improving reliable communication in systems where continuous monitoring is essential for human safety. The authors explained that LoRa provides long-distance data transmission with low power consumption, making it suitable for remote monitoring environments. The proposed system integrates sensors, LoRa modules, gateways, and cloud platforms for real-time data collection and analysis. The study highlights applications such as industrial safety monitoring, healthcare tracking, and disaster management systems. It also discusses challenges like network interference and data security. Experimental results showed stable communication performance and efficient energy usage. The paper concludes that LoRa-based IoT systems are effective solutions for reliable and scalable safety monitoring applications.

8. Luder, V., & Magno, M. (2025). Self-sustaining multi-sensor LoRa-based activity monitoring system. arXiv preprint arXiv:2506.03203. Luder, V. and Magno, M. (2025) proposed a self-sustaining multi-sensor activity monitoring system based on LoRa communication technology. The study focuses on developing an energy-efficient monitoring device capable of operating for long periods without frequent battery replacement. The system integrates multiple sensors to collect activity and environmental data in real time. LoRa technology is used to transmit data over long distances with low power consumption. The authors emphasized the use of energy harvesting techniques to support continuous operation. The system is designed for remote monitoring applications such as health tracking and environmental observation. Experimental results demonstrated reliable communication and improved energy efficiency. The research highlights the potential of self-powered LoRa systems for sustainable IoT monitoring solutions.

9. Mahesh, K., Reddy, P., & Kumar, A. (2025). Advanced IoT-based smart mining helmet with LoRa for worker safety. *International Journal for Research in Applied Science & Engineering Technology*, 13(7), 214–220.

Mahesh, K., Reddy, P., and Kumar, A. (2025) proposed an advanced IoT-based smart mining helmet integrated with LoRa technology to enhance worker safety in mining environments. The system monitors parameters such as gas levels, temperature, and worker movement in real time. Sensors collect safety-related data and transmit it through LoRa communication for long-range monitoring. The helmet provides instant alerts during hazardous conditions to prevent accidents. The study highlights low power consumption and reliable communication in underground areas. The proposed system improves emergency response and worker protection. Experimental results showed effective monitoring and stable data transmission. The research demonstrates the importance of IoT and LoRa technologies in industrial safety applications.

10. Mar, Z., Lwin, Z. M., & Hla, T. T. (2025). IoT-based environmental monitoring system with LoRa technology. *Indonesian Journal of Computer Science*, 14(2), 156–165. Mar, Z., Lwin, Z. M., and Hla, T. T. (2025) developed an IoT-based environmental monitoring system using LoRa technology for long-range data communication. The system monitors environmental parameters such as temperature, humidity, and air quality in real time. Sensors collect environmental data and transmit it through LoRa networks to a central monitoring station. The study emphasizes low power consumption and wide-area coverage suitable for remote locations. The collected data is stored and analyzed using an IoT cloud platform. The system provides continuous monitoring and alert notifications when abnormal conditions occur. Experimental results showed reliable communication and efficient performance. The research demonstrates the effectiveness of LoRa technology for smart environmental monitoring applications.

11. Mercado, R. J. M., Santos, L. P., & Cruz, J. D. (2025). Corrosion risk estimation via IoT and LoRa with machine learning. arXiv preprint arXiv:2510.02973. Mercado, R. J. M., Santos, L. P., and Cruz, J. D. (2025) proposed an IoT and LoRa-based system for corrosion risk estimation supported by machine learning techniques. The system collects environmental data such as humidity, temperature, and atmospheric conditions using sensors. LoRa communication enables long-range transmission of collected data to a monitoring platform. Machine learning algorithms analyze the data to predict corrosion risk levels accurately. The study focuses on improving infrastructure maintenance and early fault detection. The proposed system offers low power consumption and wide-area monitoring capability. Experimental results showed effective prediction accuracy and reliable communication performance. The research demonstrates the usefulness of combining IoT, LoRa, and machine learning for smart industrial monitoring applications.

12. Mohapatra, H. (2025). LoRa IoT framework with machine learning for remote livestock monitoring. arXiv preprint arXiv:2510.07322. Mohapatra, H. (2025) proposed a LoRa-based IoT framework integrated with machine learning for remote livestock monitoring. The system is designed to track animal health, movement, and environmental conditions in real time. Sensors collect data such as body temperature and activity levels, which are transmitted using LoRa communication over long distances. Machine learning algorithms analyze the collected data to detect abnormal behavior and health issues. The framework supports monitoring in rural and remote farming areas with limited network connectivity. The study emphasizes low power consumption and reliable data transmission. Experimental results showed improved monitoring accuracy and early disease detection. The research highlights the effectiveness of combining IoT, LoRa, and machine learning for smart agriculture applications.

13. Muthuselvan, S., Chandru, A., Lavanya, R., Adarsh, G. G., Venket, V. S. K., & Rajasekaran, R. (2025). Intelligent safety life jacket using LoRa technology. In *Proceedings of the International Conference on Intelligent Systems and Technology Management (ICITSM 2025)*.

13. Muthuselvan, S., Chandru, A., Lavanya, R., Adarsh, G. G., Venket, V. S. K., & Rajasekaran, R. (2025). Intelligent safety life jacket using LoRa technology.

In Proceedings of the International Conference on Intelligent Systems and Technology Management (ICITSM 2025). "Intelligent Safety Life Jacket Using LoRa Technology" (ICITSM 2025) by Muthuselvan et al. (2025) presents a smart life-saving system designed to improve water safety using LoRa communication technology. The paper focuses on preventing drowning incidents by integrating IoT-based monitoring features into a life jacket. The proposed system uses sensors to detect parameters such as body movement, water immersion, and abnormal conditions. When a person falls into water or faces distress, the system automatically triggers an alert. LoRa (Long Range) technology is used for transmitting emergency signals over long distances with low power consumption.

14.Nair, V., Joseph, A., & Menon, R. (2025). A cloud-integrated LoRa-based IoT system for environmental hazard detection. *Applied Sciences*. "A Cloud-Integrated LoRa-Based IoT System for Environmental Hazard Detection" published in *Applied Sciences* (2025) by Nair, Joseph, and Menon presents an advanced IoT framework for real-time environmental monitoring. The paper focuses on detecting environmental hazards such as air pollution, gas leaks, temperature rise, and humidity variations using sensor-based nodes. These sensor nodes collect environmental data continuously and transmit it using LoRa communication technology. LoRa enables long-range, low-power data transmission, making the system suitable for remote and large-scale monitoring areas. The collected data is sent to a centralized cloud platform for storage and analysis.

15.Pires, L. M., & Veiga, I. (2025). Design of a low-cost and low-power LoRa-based IoT system for rockfall and landslide monitoring. *Designs*, 9(6), 144 "Design of a Low-Cost and Low-Power LoRa-Based IoT System for Rockfall and Landslide Monitoring" published in *Designs*, 9(6), 144 (2025) by Pires and Veiga presents an efficient monitoring solution for geohazard detection. The study focuses on developing a cost-effective IoT system to monitor rockfalls and landslides in vulnerable areas. The system integrates vibration and tilt sensors to detect ground movement and slope instability. LoRa technology is used for long-range, low-power wireless communication, enabling data transmission from remote mountainous regions. The collected sensor data is sent to a gateway for further processing and analysis. The authors emphasize low energy consumption, making the system suitable for battery-powered and solar-powered deployments. Field tests demonstrate reliable detection of movement events and stable communication over long distances.

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3. PROPOSED SYSTEM

3.1 INTRODUCTION

An IoT and LoRa-based Real-Time Trekking Monitoring System is a smart safety solution designed to monitor trekkers in remote and mountainous regions where traditional communication networks are unreliable or unavailable. Trekking in forests, hills, and high-altitude areas often exposes individuals to risks such as getting lost, sudden weather changes, wildlife threats, or health emergencies. This proposed system leverages the power of the Internet of Things (IoT) and LoRa (Long Range) communication technology to provide continuous, real-time tracking and monitoring. The system consists of a wearable device equipped with GPS, environmental sensors, and health monitoring sensors. The collected data is transmitted using LoRa technology, which enables long-range, low-power communication without relying on cellular networks. A central LoRa gateway receives the data and forwards it to a cloud-based IoT platform for analysis and visualization. The monitoring center or trek organizers can view the real-time location, body temperature, heart rate, and environmental conditions of each trekker through a web or mobile dashboard. In case of emergencies, the system can trigger instant alerts and share precise GPS coordinates for quick rescue operations. This proposed system ensures improved safety, efficient rescue management, low power consumption, and reliable communication in remote trekking areas. It is cost-effective, scalable, and suitable for group trekking expeditions, adventure tourism, and disaster-prone regions.

3.2 BLOCK DIAGRAM

Despite providing improved safety and monitoring for trekkers, the Smart Trek Guard system has several limitations. One of the primary drawbacks is the high initial implementation cost. The system requires multiple hardware components such as microcontrollers, sensors, GPS modules, and LoRa communication devices. These components increase the overall development and deployment expenses, which may not be affordable for all trekking organizations or individual users. Another major limitation is the dependency on battery power. Since the device is designed to be portable and wearable, it relies on rechargeable batteries or power banks. Continuous monitoring of sensors and data transmission consumes significant power, which can reduce battery life during long trekking trips. In remote areas, access to charging facilities is limited, making battery management difficult. The system also faces challenges related to LoRa communication reliability. Although LoRa technology supports long-range communication, signal transmission can be affected by environmental obstacles such as dense forests, mountains, and deep valleys. These barriers may reduce signal strength and cause delays or interruptions in sending critical safety alerts. The performance of the system depends heavily on the accuracy of sensors. Environmental disturbances, sensor malfunction, or calibration errors may lead to incorrect data readings. This can result in false emergency alerts or failure to detect real danger situations. Regular maintenance and calibration are necessary to maintain system reliability. Another drawback is the need for technical maintenance and monitoring infrastructure. The system requires a base station or cloud platform to store and analyze collected data. Establishing and maintaining this infrastructure demands technical expertise and additional operational cost. The device may also face durability issues due to harsh trekking environments. Exposure to rain, dust, extreme temperatures, and physical impact can damage electronic components if proper protective casing is not used. Designing a rugged and waterproof device can increase system complexity and cost.

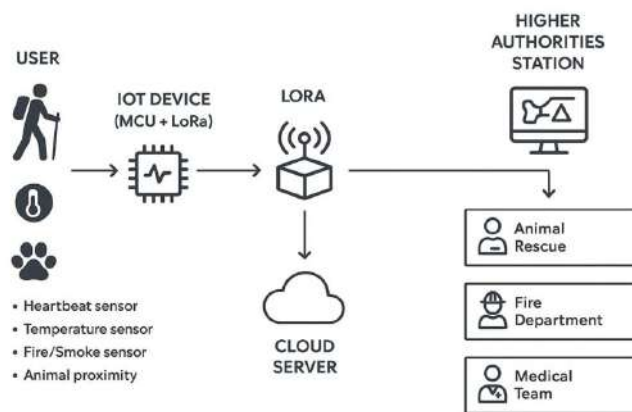


Fig 3.1 Block Diagram

Additionally, GPS tracking accuracy may decrease in dense forest areas or deep mountainous regions where satellite signals are weak. This may affect real-time location tracking during emergency situations. Overall, while Smart TrekGuard significantly enhances trekking safety, these drawbacks highlight the need for improvements in power management, communication reliability, and device durability.

3.3 APPLICATIONS

The proposed IoT and LoRa-based Real-Time Trekking Monitoring System has many practical applications in safety monitoring and remote tracking environments. The system is mainly designed to ensure the safety of trekkers by continuously monitoring their health condition and location in real time. It is highly useful in trekking and hiking activities conducted in forests, hills, and remote areas where mobile network coverage is poor or unavailable. The system helps authorities and family members track trekkers and respond quickly during emergencies.

4. HARDWARE REQUIREMENTS

4.1 INTRODUCTION:

The hardware components form the essential part of the IoT and LoRa-based Real-Time Trekking Monitoring System, enabling data collection, processing, communication, and monitoring of trekkers in real time. The system consists of various electronic modules such as sensors, microcontroller, communication modules, GPS unit, and power supply that work together to ensure efficient operation. Sensors like the heartbeat sensor and temperature sensor are used to monitor the physical condition of the trekker by continuously measuring vital parameters. A GPS module is included to obtain accurate location information such as latitude and longitude coordinates, which helps in tracking the trekker's position. The microcontroller, such as Arduino or ESP32, acts as the central processing unit of the system. It collects data from all connected sensors, processes the information, and controls the communication between different hardware modules. The LoRa module is used for long-range wireless communication, allowing data transmission over several kilometers with low power consumption, making it suitable for remote trekking environments where cellular networks are unavailable. At the receiver side, another LoRa module receives the transmitted data and forwards it to an IoT gateway or internet-enabled device for cloud storage and monitoring. A power supply unit, typically a rechargeable battery, is used to provide continuous power to all hardware components, ensuring portability and reliable operation during trekking activities. Together, these hardware components create an efficient and reliable monitoring system for enhancing trekker safety and real-time communication.

4.2 HARDWARE COMPONENTS

4.2.1 POWER SUPPLY UNIT

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others. Power supplies for electronic devices can be broadly divided into linear and switching power supplies. The linear supply is a relatively simple design that becomes increasingly bulky and heavy for high current devices; voltage regulation in a linear supply can result in low efficiency. A switched-mode supply of the same rating as a linear supply will be smaller, is usually more efficient, but will be more complex.

LINEAR POWER SUPPLY

An AC powered linear power supply usually uses a transformer to convert the voltage from the wall outlet (mains) to a different, usually a lower voltage. If it is used to produce DC, a rectifier is used. A capacitor is used to smooth the pulsating current from the rectifier. Some small periodic deviations from smooth direct current will remain, which is known as ripple. These pulsations occur at a frequency related the Power frequency (for example, a multiple of 50 or 60 Hz). The voltage produced by an unregulated power supply will vary depending on the load and on variations in the AC supply voltage. For critical electronics applications a linear Regulator will be used to stabilize and adjust the voltage. This regulator will also greatly reduce the ripple and noise in the output direct current.

Linear regulators often provide current limiting, protecting the power supply and attached circuit from over current. Adjustable linear power supplies are common laboratory and service shop test equipment, allowing the output voltage to be set over a wide range. For example, a bench power supply used by circuit designers may be adjustable up to 30 volts and up to 5 amperes output. Some can be driven by an external signal, for example, for applications requiring a pulsed output.

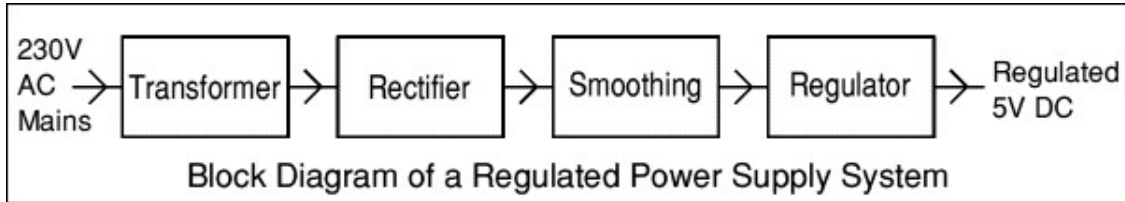


Fig: 4.2.1 Power Circuit

4.2.2 TRANSFORMER

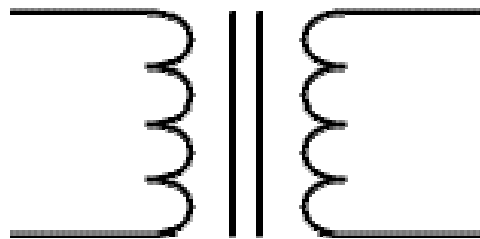


Fig 4.2.2 Transformer Symbol

Transformers convert AC electricity from one voltage to another with little loss of power. Transformers work only with AC and this is one of the reasons why mains electricity is AC. Step-up transformers increase voltage, step-down transformers reduce voltage. Most power supplies use a step-down transformer to reduce the dangerously high mains voltage (230V in UK) to a safer low voltage. The input coil is called the primary and the output coil is called the secondary. There is no electrical connection between the two coils; instead they are linked by an alternating magnetic field created in the soft-iron core of the transformer. The two lines in the middle of the circuit symbol represent the core. Transformers waste very little power so the power out is (almost) equal to the power in. Note that as voltage is stepped down current is stepped up. The ratio of the number of turns on each coil, called the turn's ratio, determines the ratio of the voltages. A step-down transformer has a large number of turns on its primary (input) coil which is connected to the high voltage mains supply, and a small number of turns on its secondary (output) coil to give a low output voltage. Turns ratio= $V_p/V_s=N_p/N_s$ and Power out=Power in $V_s \cdot I_s = V_p \cdot I_p$

V_p = primary (input) voltage , V_s = secondary (output) voltage, N_p = number of turns on primary coil

N_s = number of turns on secondary coil, I_p = primary (input) current , I_s = secondary (output) current

The low voltage AC output is suitable for lamps, heaters and special AC motors. It is not suitable for electronic circuits unless they include a rectifier and a smoothing capacitor.

4.2.3 BRIDGE RECTIFIER:

A bridge rectifier can be made using four individual diodes, but it is also available in special packages containing the four diodes required.

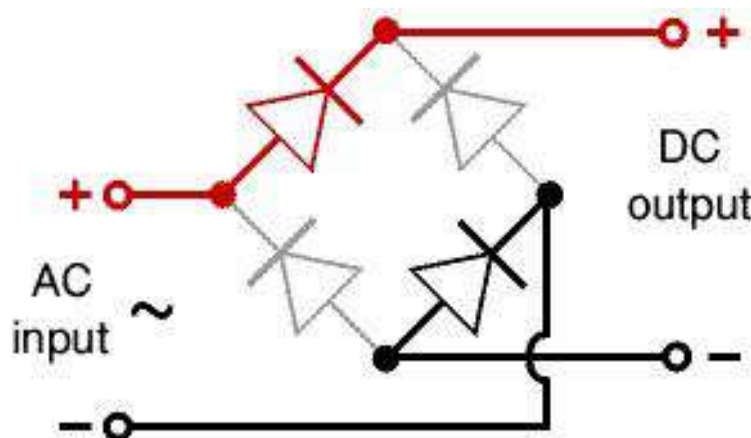


Fig:4.2.3 AC-DC CKT

It is called a full-wave rectifier because it uses the entire AC wave (both positive and negative sections). 1.4V is used up in the bridge rectifier because each diode uses 0.7V when conducting and there are always two diodes conducting, as shown in the diagram below.

Bridge rectifiers are rated by the maximum current they can pass and the maximum reverse voltage they can withstand (this must be at least three times the supply v_{RMS} I_{tage} so the rectifier can withstand the peak voltages). Please see the Diodes page for more details, including pictures of ridge rectifiers.

4.2.4 SINGLE DIODE RECTIFIER:

A single diode can be used as a rectifier but this produces half-wave varying DC which has gaps when the AC is negative. It is hard to smooth this sufficiently well to supply electronic circuits unless they require a very small current so the smoothing capacitor does not significantly discharge during the gaps. Please see the Diodes page for some examples of rectifier diodes.

SMOOTHING:

Smoothing is performed by a large value electrolytic capacitor connected across the DC supply to act as a reservoir, supplying current to the output when the varying DC voltage from the rectifier is falling. The diagram shows the unsmoothed varying DC (dotted line) and the smoothed DC (solid line). The capacitor charges quickly near the peak of the varying DC, and then discharges as it supplies current to the output. Note that smoothing significantly increases the average DC voltage to almost the peak value ($1.4 \times RMS$ value). For example 6V RMS AC is rectified to full wave DC of about 4.6V RMS (1.4V is lost in the bridge rectifier), with smoothing this increases to almost the peak value giving $1.4 \times 4.6 = 6.4V$ smooth DC. Smoothing is not perfect due to the capacitor voltage falling a little as it discharges, giving a small ripple voltage. For many circuits a ripple which is 10% of the supply voltage is satisfactory and the equation below gives the required value for the smoothing capacitor. A larger capacitor will give fewer ripples. The capacitor value must be doubled when smoothing half-wave DC.

Smoothing Capacitor for 10% ripple, $C = 5 \times I_o / v_s \times f$

C = smoothing capacitance in farads (F)

I_o = output current from the supply in amps (A)

V_s = supply voltage in volts (V), this is the peak value of the unsmoothed DC

f = frequency of the AC supply in hertz (Hz), 50Hz in the UK.

The smooth DC output has a small ripple. It is suitable for most electronic circuits.

REGULATOR:

Voltage regulator ICs are available with fixed (typically 5, 12 and 15V) or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current ('overload protection') and overheating ('thermal protection'). The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and current. Many of the fixed voltage regulator ICs has 3 leads and look like power transistors, such as the 7805 +5V 1A regulator shown on the right. They include a hole for attaching a heat sink if necessary. The regulated DC output is very smooth with no ripple. It is suitable for all electronic circuits.

4.2.5 ARDUINO CONTROLLER

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, 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 Atmega8U2 programmed as a USB-to-serial converter. "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.



Fig 4.2.5 ARDUINO CONTROLLER

4.2.6 POWER:

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

4.2.7 THE POWER PINS ARE AS FOLLOWS:

VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin. 5V. The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply. 3V3. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA. GND. Ground pins.

INPUT & OUTPUT:

Each of the 14 digital pins on the Uno can be used as an input or output, using `pinMode()`, `digitalWrite()`, and `digitalRead()` functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip .

Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach `Interrupt()` function for details. Ø PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analog `Write()` function.

SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.

LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog `Reference()` function. Additionally, some pins have specialized functionality:

I2C: 4 (SDA) and 5 (SCL). Support I2C (TWI) communication using the `Wire` library.

There are a couple of other pins on the board:

AREF. Reference voltage for the analog inputs. Used with analog `Reference()`.

Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

DIMENSION DRAWING:

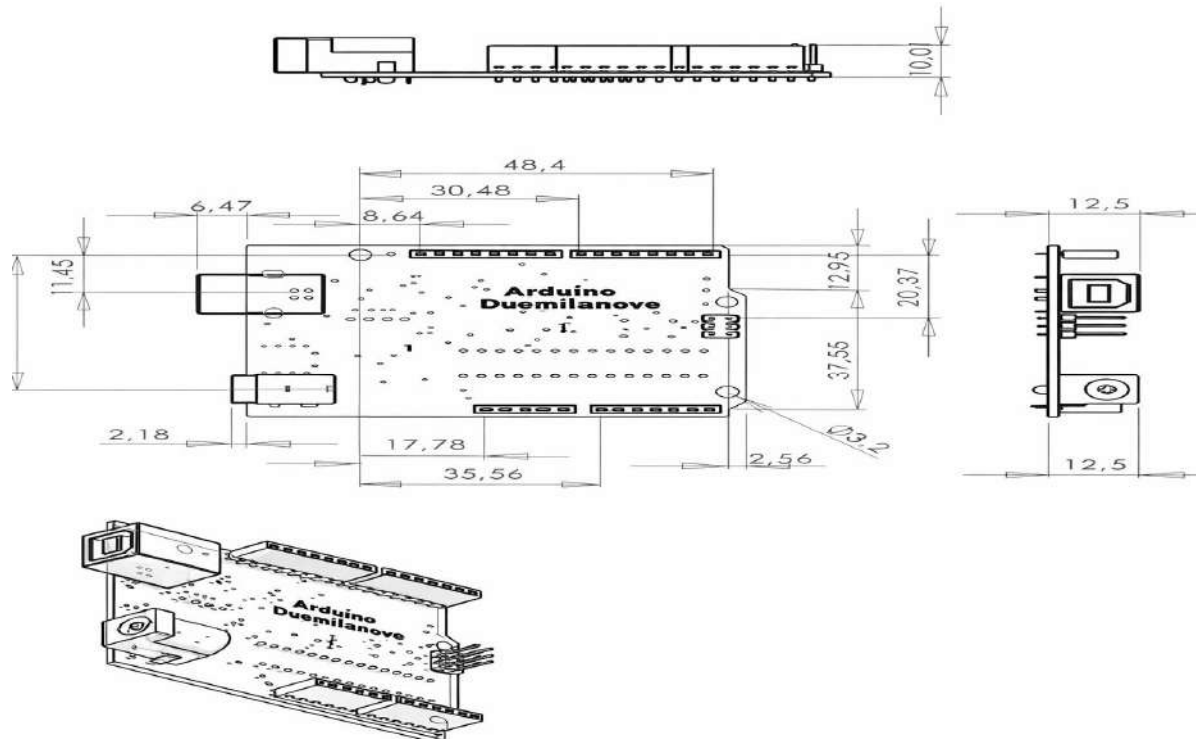


Fig: 4.2.6 Dimension Drawing



Fig 4.2.7 ARDUINO PINS

4.2.7 FLAME SENSOR

A flame detector is a Sensor designed to detect and respond to the presence of a flame or fire Responses to a detected flame depend on the installation, but can include sounding an alarm, deactivating a fuel line (such as a propane or a Natural gas line), and activating a fire suppression system. When used in applications such as industrial furnaces, their role is to provide confirmation that the furnace is properly lit; in these cases they take no direct action beyond notifying the operator or control system. A flame detector can often respond faster and more accurately than a smoke or heat detector due to the mechanisms it uses to detect the flame.

ULTRAVIOLET

Ultraviolet (UV) detectors work by detecting the UV radiation emitted at the instant of ignition. While capable of detecting fires and explosions within 3–4 milliseconds, a time delay of 2–3 seconds is often included to minimize false alarms which can be triggered by other UV sources such as Lightning ,arc Winding and Sunlight UV detectors typically operate Wave lengths. shorter than 300 nm The solar blind UV wavelength band is also easily blinded by oily contaminants.

NEAR IR ARRAY

Near Infrared (IR) array flame detectors, also known as visual flame detectors, employ flame recognition technology to confirm fire by analyzing near IR radiation using a Charge Coupled Device (CCD)

INFRARED

Infrared (IR) flame detectors monitor the infrared spectral band for specific patterns given off by hot gases. These are sensed using a specialized fire-fighting Thermal camera (TIC), a type of Thermographic Camera False alarms can be caused by other hot surfaces and background Thermal Radiation in the area. Water on the detector's lens will greatly reduce the accuracy of the detector, as will exposure to direct sunlight. A single-frequency IR flame detector is typically sensitive to wavelengths around 4.4 micrometers, which is a spectral characteristic peak of hot Carbon Dioxide as produced in a fire. The usual response time of an IR detector is 3–5 seconds.

UV/IR

These detectors are sensitive to both UV and IR wavelengths, and detect flame by comparing the threshold signal of both ranges. This helps minimize false alarms.

IR/IR FLAME DETECTION

Dual IR (IR/IR) flame detectors compare the threshold signal in two infrared ranges. Often one sensor looks at the 4.4 micrometer carbon dioxide (CO₂) emission, while the other sensor looks at a reference frequency. Sensing the CO₂ emission is appropriate for hydrocarbon fuels; for non-carbon based fuels, e.g., hydrogen, the broadband water bands are sensed.

4.2.8 IR3 FLAME DETECTION

Triple-IR flame detectors compare three specific wavelength bands within the IR spectral region and their ratio to each other. In this case one sensor looks at the 4.4 micrometer range while the other sensors look at reference wavelengths both above and below 4.4. This allows the detector to distinguish between non-flame IR sources and actual flames which emit hot CO₂ in the combustion process. As a result, both detection range and immunity to false alarms can be significantly increased. IR3 detectors can detect a 0.1m²(1 ft²) gasoline pan fire at up to 65 m (215 ft) in less than 5 seconds. Triple IRs, like other IR detector types, are susceptible to blinding by a layer of water on the detector's window. Most IR detectors are designed to ignore constant background IR radiation, which is present in all environments. Instead they are designed to detect suddenly changing or increasing sources of the radiation. When exposed to changing patterns of non-flame IR radiation, IR and UV/IR detectors become more prone to false alarms, while IR3 detectors become somewhat less sensitive but are more immune to false alarms.

4.2.9 VISIBLE SENSORS

In some detectors, a sensor for visible radiation (light) is added to the design in order to better discriminate against false alarms or to improve the detection range

VIDEO

Closed- Circuit television or a Web camera can be used for visual detection of (Wave lengths between 0.4 and 0.7 μ m). Smoke or fog can limit the effective range of these, since they operate solely in the visible spectrum.

4.3 OTHER TYPES IONIZATION CURRENT FLAME DETECTION

The intense ionization within the body of a flame can be measured by means of a current that flows when a voltage is applied by the phenomena of Flame Rectification This current can be used to verify flame presence and quality. Such detectors are used in large industrial process gas heaters and are connected to the flame control system. They usually act as both flame quality monitors and for flame failure detection.

These types of sensors are also common in a variety of household gas furnaces.

4.4 THERMOCOUPLE FLAME DETECTION

Thermocouples are used extensively for monitoring flame presence in combustion heating systems and gas cookers. A common use in these installations is to cut off the supply of fuel if the flame fails, in order to prevent unburned fuel from accumulating. These sensors measure heat and therefore are commonly used to determine the absence of a flame. This can be used to verify the presence of a pilot flame.

4.5 APPLICATIONS

UV/IR flame detectors are used in: Hydrogen stations, Gas-fueled cookers, Industrial heating and drying systems

4.5.1 TEMPERATURE SENSOR

The first slave connected to a temperature sensor LM35. This senses the temperature of an engine and provides the level of temperature.

4.5.2 GENERAL DESCRIPTION

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling.

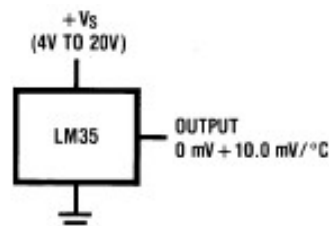


Figure 4.5.2 B TEMPERATURE SENSOR (+2°C TO +150°C)

The LM35 does not require any external calibration or trimming to provide typical accuracies of $\pm 1/4^\circ\text{C}$ at room temperature and $\pm 3/4^\circ\text{C}$ over a full -55 to $+150^\circ\text{C}$ temperature range. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only $60\ \mu\text{A}$ from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a -55° to $+150^\circ\text{C}$ temperature range, while the LM35C is rated for a -40° to $+110^\circ\text{C}$ range (-10° with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.

4.6 FEATURES

Calibrated directly in $^\circ\text{Celsius}$ (Centigrade)

Linear $+ 10.0\ \text{mV}/^\circ\text{C}$ scale factor

0.5°C accuracy guaranteeable (at $+25^\circ\text{C}$)

Rated for full -55° to $+150^\circ\text{C}$ range

Suitable for remote applications

Low cost due to wafer-level trimming

Operates from 4 to 30 volts

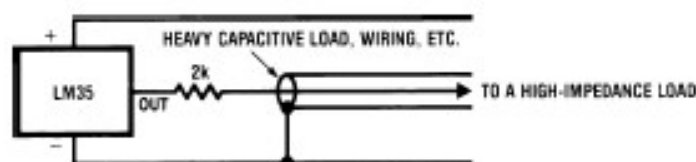
Less than $60\ \mu\text{A}$ current drain

Low self-heating, 0.08°C in still air

Nonlinearity only $\pm 1/4^\circ\text{C}$ typical

Low impedance output, $0.1\ \text{W}$ for $1\ \text{mA}$ load

CAPACITIVE LOAD



Like most micro power circuits, the LM35 has a limited ability to drive heavy capacitive loads. The LM35 by itself is able to drive 50 pf without special precautions. If heavier loads are anticipated, it is easy to isolate or decouple the load with a resistor.

4.7 HEART BEAT SENSOR

Heart beat sensor is designed to give digital output of heart beat when a finger is placed on it. When the heart beat detector is working, the beat LED flashes in unison with each heart beat. This digital output can be connected to microcontroller directly to measure the Beats Per Minute (BPM) rate. It works on the principle of light modulation by blood flow through finger at each pulse.

FEATURES:

Microcontroller based SMD design, Heart beat indication by LED, Instant output digital signal for directly connecting to microcontroller, Compact Size, Working Voltage +5V DC

APPLICATIONS:

Patient Monitoring System Bio-Feedback control of robotics and application Digital Heart Rate monitor

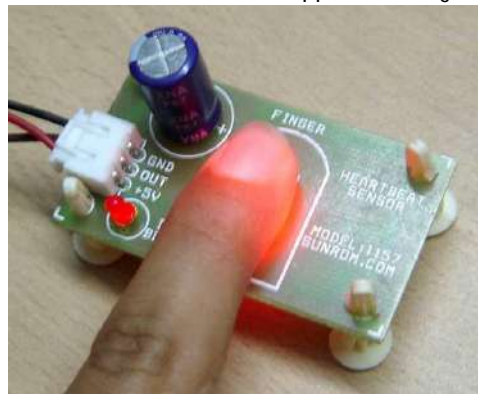


Fig: 4.7.1 Heart Beat Sensor

Medical heart sensors are capable of monitoring vascular tissue through the tip of the finger or the ear lobe. It is often used for health purposes, especially when monitoring the body after physical training. Heart beat is sensed by using a high intensity type LED and LDR. The finger is placed between the LED and LDR. As Sensor a photo diode or a photo transistor can be used. The skin may be illuminated with visible (red) using transmitted or reflected light for detection. The very small changes in reflectivity or in transmittance caused by the varying blood content of human tissue are almost invisible. Various noise sources may produce disturbance signals with amplitudes equal or even higher than the amplitude of the pulse signal. Valid pulse measurement therefore requires extensive preprocessing of the raw signal. The new signal processing approach presented here combines analog and digital signal processing in a way that both parts can be kept simple but in combination are very effective in suppressing disturbance signals. The setup described here uses a red LED for transmitted light illumination and a LDR as detector. With only slight changes in the preamplifier circuit the same hardware and software could be used with other illumination and detection concepts. The detectors photo current (AC Part) is converted to voltage and amplified by an operational amplifier (LM358).

4.7.2 NODE MCU CONTROLLER



4.7.2 NODE MCU MICROCONTROLLER

NODE MCU V3 is an open-source firmware and microcontroller that plays a vital role in designing an IoT product using a few script lines. Multiple GPIO pins on the board allow us to connect the board with other peripherals and are capable of generating PWM, I2C, SPI, and UART serial communications. Firmware and Hardware where former runs on the ESP8266 WiFi SoC and later is based on the ESP-12 module. The firmware is based on Lua A scripting language that is easy to learn, giving a simple programming environment layered with a fast scripting language that connects you with a well-known developer community. And open source firmware gives you the flexibility to edit, modify and rebuilt the existing module and keep changing the entire interface until you succeed in optimizing the module as per your requirements. Data to UART data which mainly understands the language of serial communication. Instead of the regular USB port, Micro-USB port is included in the module that connects it with the computer for dual purposes: programming and powering up the board.

Giving you the current status of the module if it is running properly when connected with the computer. The ability of module to establish a flawless Wi-Fi connection between two channels makes it an ideal choice for incorporating it with other embedded devices like NODE MCU.

NODEMCU V3 PINOUT

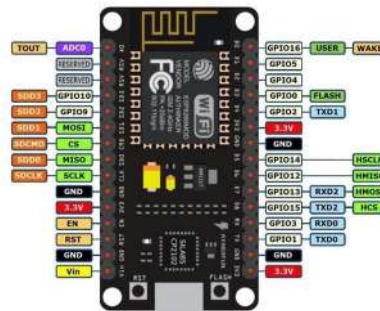


Fig: 4.7.2 NODEMCU PINS

NODEMCU V3 comes with a number of GPIO Pins. There is a candid difference between VIN and VU where former is the regulated voltage that may stand somewhere between 7 to 12 V while later is the power voltage for USB that must be kept around 5 V.

FEATURES:

Open-source.

Arduino-like hardware. o Status LED.

Micro-USB por Reset/Flash buttons. oInteractive and Programmable. Low cost oESP8266 with inbuilt Wi-Fi USB to UART converter.

GPIO pins. Arduino-like hardware IO .Advanced API for hardware IO, which can dramatically reduce the redundant work for configuring and manipulating hardware. Code like arduino, but interactively in Lua script. o Nodejs style network API.Event-driven API for network applications, which facilitates developers writing code running on a 5mm*5mm sized MCU inNodes style.Greatly speed up your IOT application developing process. o Lowest cost WI-FI.

NODEMCU Microcontroller

The NODEMCU is a powerful 32-bit dual-core microcontroller developed by Espressif Systems. It is known for its low power consumption, high processing speed, and built-in wireless capabilities (Wi-Fi + Bluetooth). In this project, ESP32 acts as the central control unit that manages all communication between GSM, GPS, LEDs, buzzer, and push buttons.

Key Features:

Dual-core Tensilica LX6 processor (up to 240 MHz).

Built-in Wi-Fi (802.11 b/g/n) and Bluetooth 4.2.

32 GPIO pins supporting UART, SPI, I2C, ADC, PWM, and DAC.

Operates at 3.3V with a deep sleep current of less than 10 μ A.

Flash memory up to 4 MB for storing firmware.



Fig 4.7.3 NODEMCU

Function in Project:

Reads input signals from emergency buttons.

Retrieves GPS data and processes coordinates.

Sends AT commands to GSM for SMS and calling.

Controls LEDs and buzzer for user feedback.

Manages power consumption and resets safely.

5. RESULT AND DISCUSSION

The proposed LoRa-based multi-node laboratory safety monitoring system demonstrated stable long-range wireless communication with low packet loss and minimal power consumption. Experimental deployment in a laboratory environment showed accurate real-time monitoring of temperature, humidity, gas concentration, and smoke levels.

The system successfully triggered early-warning alerts when abnormal thresholds were exceeded, such as gas leakage or rapid temperature rise. Data transmission remained reliable even across multiple rooms and obstructed indoor environments. The multi-node architecture proved scalable, allowing additional sensor nodes to be integrated without significant performance degradation. The results indicate that LoRa technology is highly suitable for heterogeneous indoor safety monitoring due to its extended coverage and energy efficiency. Compared to traditional wired or short-range wireless systems, the proposed framework reduces installation complexity and maintenance cost. The intelligent early-warning mechanism enhances proactive risk management, minimizing potential laboratory hazards. However, indoor signal attenuation due to walls and equipment may slightly affect signal strength, requiring optimal gateway placement. Overall, the study confirms that the system provides a reliable, scalable, and cost-effective solution for intelligent laboratory safety monitoring. The LoRa-based multi-node laboratory safety monitoring system achieved reliable real-time data acquisition from heterogeneous sensor nodes deployed across different laboratory sections. Performance evaluation showed stable communication with low latency and high data delivery success rate, even in complex indoor environments with walls and equipment interference. The system maintained consistent connectivity over extended distances within the building using a single LoRa gateway.

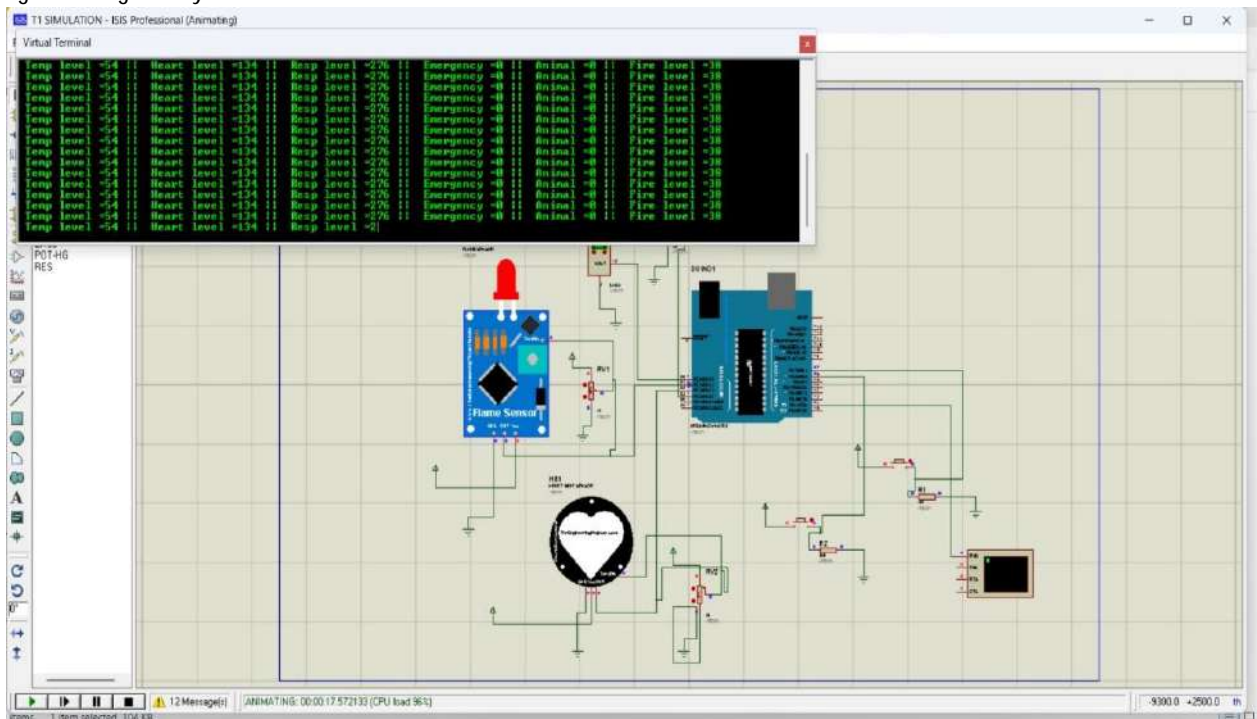


Fig 5.1 Simulation Results

The zed, and optimal gateway placement significantly improved network coverage and reliability. Different emergency scenarios such as gas leakage, rapid temperature increase, and smoke detection were simulated. In all cases, the system successfully triggered early-warning alerts once predefined safety thresholds were exceeded. The response time was minimal, demonstrating real-time monitoring capability. Power consumption modeling confirmed that LoRa nodes consumed very low energy during periodic data transmission, ensuring longer battery life. Network scalability was also tested by increasing the number of nodes, and the system maintained stable performance without major congestion issues. The simulation was conducted to evaluate the performance of the proposed LoRa-based heterogeneous safety monitoring system in a laboratory environment. A virtual indoor laboratory model was created with multiple rooms, obstacles, and equipment to replicate real-world signal conditions. Several sensor nodes were such as packet delivery ratio, latency, signal strength (RSSI), and spreading factor performance. Results showed high data reliability with minimal packet loss under normal operating conditions. Even with indoor obstructions like concrete walls and metallic equipment, the system maintained stable connectivity. Emergency scenarios such as gas leakage and sudden temperature spikes were simulated by artificially exceeding predefined safety thresholds. The system successfully generated early-warning alerts with minimal delay. The response time analysis confirmed that alerts were transmitted to the gateway and monitoring interface almost instantly. Bottom of Form. The image shows a prototype of an IoT and LoRa-based trekking safety monitoring system developed using hardware components mounted. At the center of the setup, an These sensors may include temperature, motion, gas, or heart-rate monitoring modules. Such sensors help track environmental and physiological conditions of trekkers. Toggle switches are mounted at the bottom of the board. These switches can be used to simulate emergency conditions or manually acalerts. They may also serve as ON/OFF controls for specific modules. A small communication module with an antenna is placed on the right side. This is likely the LoRa transmitter or transceiver module. The antenna helps send data over long distances to a base station. The wiring is arranged to interconnect sensors, communication modules, and power supply. Each carries signal power and components. The breadboard-style layout suggests it is a prototype model for demonstration purposes.

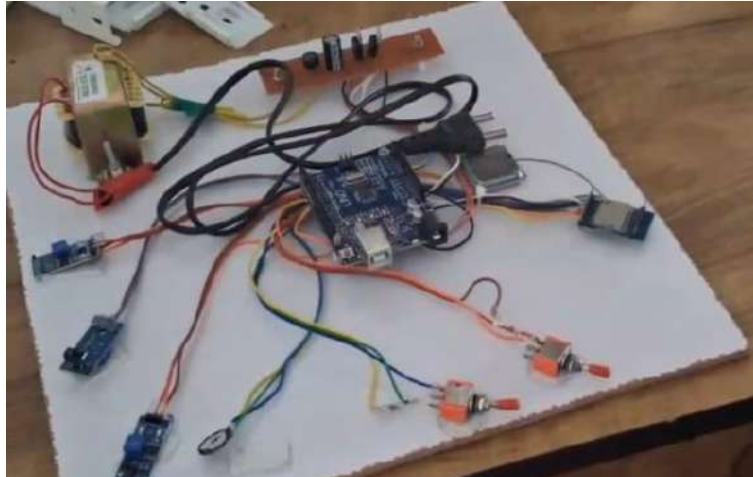


Fig 5.2 Prototype of an IoT and Lora Based Trekking Safety Monitoring System

In a real trekking scenario, this system, Would be carried about the trekker .The sensors continuously collect data such as body temperature and movement.If abnormal conditions are detected, the microcontroller processes the data. The LoRa module then transmits the alert message to a remote monitoring station. This could be a rescue team base station in control system. The system is designed to work in forest or mountain regions where cellular networks are weak.

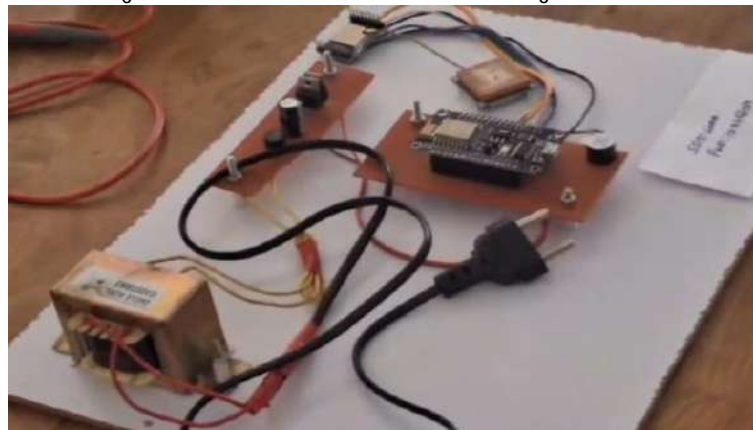


Fig 5.3 Image Shows a Hardware Prototype

This image shows a hardware prototype of an IoT and LoRa-based trekking safety monitoring system. The components are neatly mounted on a base board for demonstration purposes. At the center, a microcontroller development board is used as the main processing unit. This board controls all connected sensors and communication modules. A LoRa communication module is attached near the controller. It enables long-distance wireless data transmission. This is especially useful in remote trekking areas where mobile networks are unavailable. A GPS module is visible at the top section of the board. This module helps in tracking the real-time location of the trekker. The location data can be transmitted through LoRa to a monitoring station. On the left side, a step-down transformer is placed. It converts high AC voltage into a lower voltage suitable for electronic circuits. The connected rectifier and filter capacitors help convert AC to stable DC power. This ensures uninterrupted operation of the system. The power plug shown in the image is used to supply AC input to the transformer. Stable power is essential for accurate sensor readings and communication. Jumper wires connect all modules together. These wires carry signals and power between the components. Proper wiring ensures smooth data flow within the system. The microcontroller. It processes the data and checks for abnormal conditions. If any emergency is detected, it sends an alert signal. The LoRa module transmits this alert over long distances. A remote base station receives the information. Rescue teams can then take immediate action. This prototype demonstrates how IoT technology improves trekking safety. It combines sensing, processing, and long-range communication in one. This image shows a smartphone screen with the Mobile Hotspot feature turned ON. The hotspot network name is set as "LORA," which relates to the IoT and LoRa-based trekking safety project. The phone is sharing internet connectivity using the 2.4 GHz band. In this setup, the mobile hotspot is used to provide internet access to the IoT hardware system. The LoRa-based device connects to the internet through this hotspot. This enables cloud communication and real-time data monitoring. The system is integrated with the Blynk IoT platform for remote monitoring and control. Sensor data collected from the trekking safety device is sent to the microcontroller. The microcontroller processes the data and transmits it via LoRa. At the receiver side, the data is forwarded to the internet using Wi-Fi. Here, the smartphone hotspot acts as the Wi-Fi gateway. Through this connection, data is uploaded to the Blynk cloud server. The Blynk mobile application displays live sensor readings. Parameters like temperature, heart rate, location, and emergency status can be monitored. If abnormal conditions occur, alert notifications are sent instantly.

The screenshot also shows that one device is connected to the hotspot. This connected device may be the LoRa receiver module with Wi-Fi capability (such as ESP8266/ESP32). It uses the provided SSID and password to establish communication. Using a hotspot makes the prototype flexible for demonstration purposes. It avoids the need for a separate Wi-Fi router. This is especially useful in field testing and project presentations.

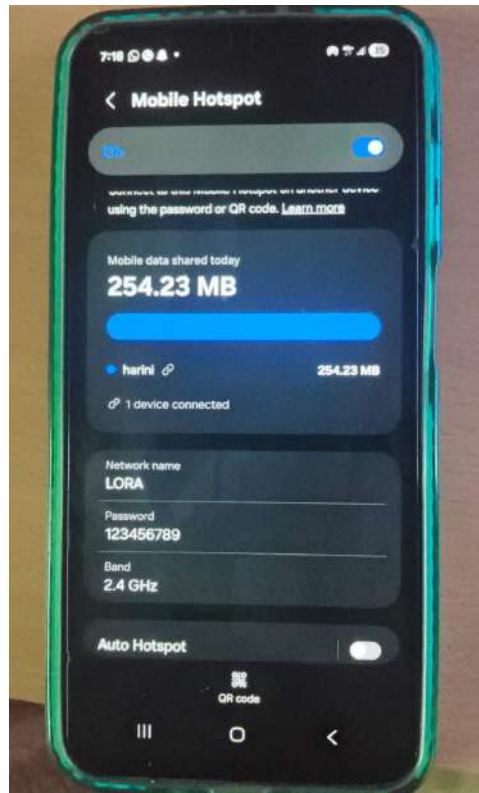


Fig 5.4 Monitoring and WIFI Access

In real trekking environments, the receiver unit can use mobile data directly. The hotspot simulates internet availability during testing. This ensures the Blynk dashboard updates in real time.



Fig 5.5 Result of Blynk IoT

Overall, the image demonstrates the cloud connectivity part of the IoT and LoRa trekking safety system. It shows how mobile internet is integrated with LoRa communication. This combination enables long-range data transmission and real-time IoT monitoring through Blynk. This image shows the Blynk IoT mobile application dashboard used for monitoring the trekking safety system. The project title displayed is "HILLY FOREST TRANSMISSION". This dashboard presents real-time data received from the IoT and LoRa-based device. The first gauge indicates fire detection status. The value "1" suggests that fire or smoke is detected in the monitored area. This helps in early warning during forest trekking. The second gauge shows heart beats. The current heart rate displayed is 77 BPM. This indicates the trekker's pulse condition in real time. Another gauge labeled Body oxidation shows a value of 91. This likely represents oxygen level (SpO₂) monitoring. It helps track the health condition of the trekker at high altitudes. The Animal movement gauge shows 0. This means no wildlife movement is detected nearby. It enhances safety by alerting trekkers about potential threats. The "need help" indicator is also 0. This suggests that no emergency button has been pressed. If activated, it would send an alert through LoRa. The body temperature gauge displays 25.61°C. This may represent ambient or body temperature readings. All sensor values are transmitted via LoRa and updated in the Blynk cloud in real time.

6. CONCLUSION

The IoT and LoRa Based Trekking Monitoring System successfully demonstrates a reliable and efficient safety solution for trekkers in remote and hilly forest regions. The system integrates environmental and physiological sensors with long-range LoRa communication technology to ensure continuous monitoring even in areas without cellular network coverage. By using various sensors such as heart rate, body temperature, fire detection, oxygen level, and motion detection, the system continuously tracks both the health condition of the trekker and surrounding environmental factors. The collected data is processed by a microcontroller and transmitted through the LoRa module over long distances with low power consumption. One of the key advantages of this system is its ability to operate in remote mountainous areas where traditional communication networks fail. LoRa technology ensures stable, long-range communication between the trekking unit and the base monitoring station. This greatly improves emergency response time in case of accidents, wildlife threats, or sudden health issues. The integration of IoT platforms enables real-time data visualization through a mobile or web dashboard. Rescue teams or forest authorities can monitor parameters instantly and receive alert notifications during abnormal conditions. The emergency help feature allows trekkers to manually send distress signals when needed. The system is cost-effective, portable, and energy-efficient, making it suitable for real-time field deployment. Its modular design also allows future expansion by adding GPS tracking, weather monitoring, or additional safety sensors.

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