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Wireless Soil Data Communication for Tunnel & Mining Worker Rescue & Health Monitoring

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ABSTRACT: Implements Wireless Underground Sensor Networks to enable trapped workers in environments like collapsed tunnels to instantly communicate with rescuers above ground. Incorporates sensors tracking vital signs (heartbeat, respiratory rate, temperature) through soil, for real-time health status updates to rescue teams. Offers an easy-to-use interface with switches for sending predefined health and emergency messages, ensuring usability for all. Develops channel models tailored for underground conditions, optimizing EM wave propagation through soil based on various environmental factors. Aims to significantly reduce emergency response times in subterranean disasters, enhancing survival chances in events like tunnel collapse s. Designed for versatility, the system can be adjusted for different soil compositions and conditions, suitable for diverse underground communication needs.

KEYWORDS: Energy efficient algorithm; Manets; total transmission energy; maximum number of hops; network lifetime

I. INTRODUCTION

In the shadowy depths of the Earth, where traditional communication fails, the advent of Wireless Underground Sensor Networks (WUSNs) heralds a new era of hope and safety for those confronting the dangers inherent to subterranean environments. This promising technology, born from the urgent need to address dire scenarios such as the recent catastrophic tunnel collapse in Uttarakhand, is poised to revolutionize how we approach disaster management in underground settings. Traditional communication devices, reliant on aerial or satellite transmissions, fail to penetrate the dense layers of soil and rock. In these circumstances, without a means to communicate, the trapped individuals remain isolated, their conditions unknown, exacerbating an already dire situation. Enter WUSNs, a technology designed specifically to breach this communication void. By utilizing data transmission that navigates through the soil itself, WUSNs are not merely an incremental improvement but a paradigm shift in emergency communication.

This network, equipped with sensors to monitor vital signs like heartbeat, respiratory rates, and body temperature, can convey critical health and environmental data in real time to rescue teams, offering a lifeline to those ensnared beneath the surface. Moreover, the implementation of WUSNs extends beyond just the immediate emergency response. In industries such as coal mining, where the risk of sudden accidents is perennial, having a robust, soil-based communication network could mean the difference between life and death. By integrating advanced channel models that account for the unique propagation characteristics of electromagnetic waves through different soil types, temperatures, and compositions,WUSNs enhance the reliability and efficacy of underground communication.The development of WUSNs not only promises to mitigate the risks associated with underground work but also stands as a testament to the innovative spirit of modern engineering, transforming adversity into opportunity.

II. HARDWARE DESCRIPTION

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 to the AC power frequency (for example, a multiple of 50 or 60 Hz).

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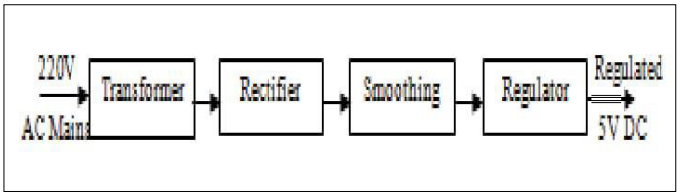
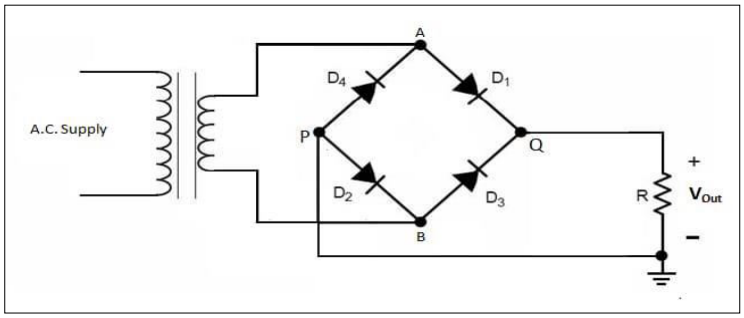
The voltage produced by an unregulated power supply will vary depending on the load and on variations in the AC supply voltage. For critical electronics applications a linear regulator will be used to stabilize and adjust the voltage. This regulator will also greatly reduce the ripple and noise in the 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.



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. 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 RMS voltage so the rectifier can withstand the peak voltages). Please see the Diodes page for more details, including pictures of Bridge rectifiers.



REGULATOR

Regulators with step-down transformers convert high voltage AC input to lower voltage AC output. This output is then rectified to DC and regulated using components like transistors or integrated circuits to maintain a stable DC voltage despite variations in input or load. The transformer steps down the voltage, while the regulator ensures the output remains consistent, making it useful for applications requiring a specific voltage level, like power supplies for electronics.

- **Positive regulator**
- **Input pin**
- **Ground pin**
- **Output pin**
- **It regulates the positive voltage**
- **Negative regulator**
- **Ground pin**
- **Input pin**
- **Output pin**

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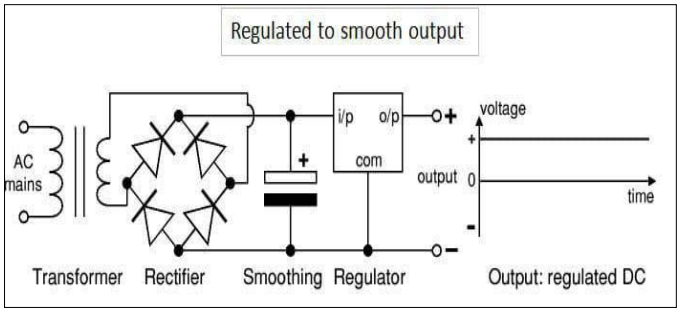

HUMIDITY &TEMPERATURE SENSOR

Humidity is the measure of the amount of water vapor present in the air. The ratio of moisture in the air to the highest amount of moisture at a particular air temperature is called relative humidity. Humidity sensors work by detecting changes that alter electrical currents or temperature in the air.It is a kind of digital compound humidity sensor that has had the calibration output digital signal. In order to ensure the product has a very high reliability and long-term stability, it uses a specific digital module of acquisition technology and the humidity sensor technology.Humidity sensors are commonly used in the meteorology, medical, automobile, HVAC and manufacturing industries. Its operating voltage is 5Volt or 3.3Volt.

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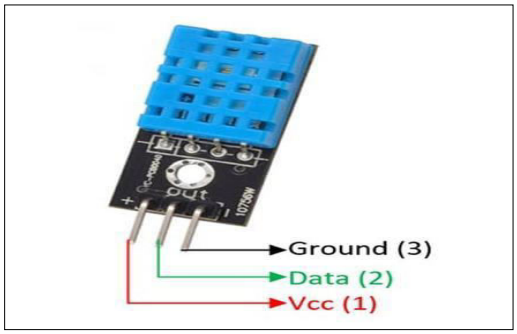

Features:

- Excellent long-term stability
- Factory calibrated
- Low power consumption
- Wide operating voltage range (2.1 to 3.6V)
- Integrated on chip header

Applications

- Industrial HVAC/R
- Thermostats/Humidistats
- Automotive climate control and de-fogging
- White goods
- Micro environments/data centers

HEARTBEAT SENSOR

HEART BEAT sensor is designed to give digital output of heat beat when a finger is placed on it. When the HEART BEAT detector is working, the beat LED flashes in unison with each heartbeat. 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. 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.

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Application:

- Monitors pulse rate and rhythm.
- Alphanumeric LCD Display.
- Pulse monitoring by sound beeps and LED indication.
- Shows Pulse Rate per minute after every 5-pulse count.
- Infra-Red Optical Finger /Ear Lobe Clip sensor.
- Bar Graph to display signal sensitivity.

RESPIRATORY

General Description

The Respiration Sensor is used to monitor abdominal or thoracical breathing, in biofeedback applications such as stress management and relaxation training. Besides measuring breathing frequency, this sensor also gives you an indication of the relative depth of breathing. The Respiration Sensor for Nexus can be worn over clothing, although for best results we advise that there only be 1 or 2 layers of clothing between the sensor and the skin. The Respiration Sensor is usually placed in the abdominal area, with the central part of the sensor just above the navel. The sensor should be placed tight enough to prevent loss of tension.

Product Description

First Sensor develops and manufactures highly reliable sensors and customized sensor systems as a strategic partner to medical product manufacturers in the area of breathing and respiration. The first step in this process is breathing in air, or inhaling. The taking in of air rich in oxygen into the body is called inhalation and giving out of air rich in carbon dioxide from the body is called exhalation. The second step is gas exchange in the lungs where oxygen is diffused into the blood and the carbon dioxide diffuses out of the blood. The third process is cellular respiration, which produces the chemical energy that the cells in the body need, and carbon dioxide. Finally, the carbon dioxide from cellular respiration is breathed out of body from the lungs.

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FEATURES

- Input voltage: 5v
- Output voltage: 5v
- Output: Analog
- Range: 30% – 65%
- Size (Approx.):132cm (52" Long)

APPLICATIONS

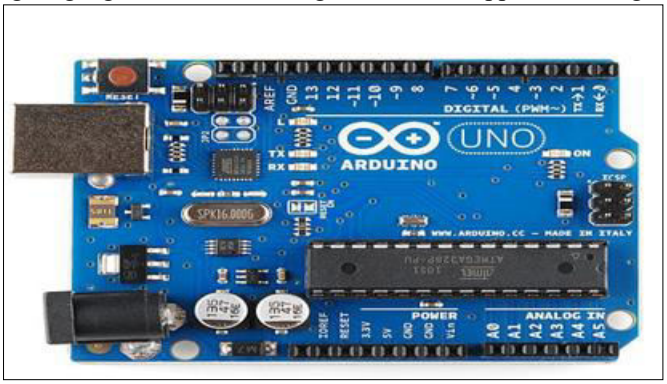
- Medical purpose
- Environmental Control System
- Emergency response System

MICROCONTROLLER

ARDUINO UNO:

General Description

Arduino is an open-source project that created microcontroller-based kits for building digital devices and interactive objects that can sense and control physical devices. The project is based on microcontroller board designs, produced by several vendors, using various microcontrollers. These systems provide sets of digital and analog input/output (I/O) pins that can interface to various expansion boards (termed shields) and other circuits. The boards feature serial communication interfaces, including Universal Serial Bus (USB) on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on a programming language named Processing, which also supports the languages C and C++.



Product Description

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, 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. Arduino Uno has a number of facilities for communicating with a computer, another Arduino board, or other microcontrollers.

FEATURES

- Microcontroller: ATmega328P
- Operating voltage: 5V
- Input voltage: 7-12V
- Flash memory: 32KB
- SRAM: 2KB
- EEPROM: 1KB
- APPLICATIONS
- Real time biometrics
- Robotic applications
- Academic applications

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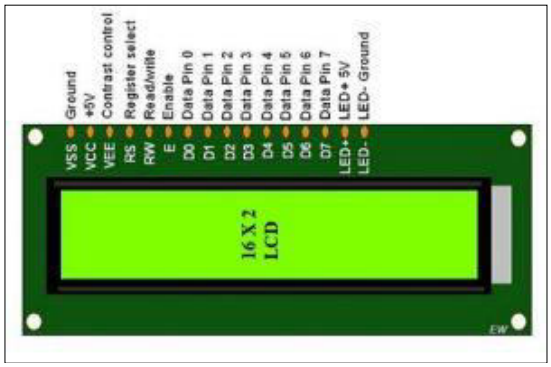
16x2 LCD

General Description

LCD stands for liquid crystal display. They come in many sizes 8x1 , 8x2 , 10x2 , 16x1 , 16x2 , 16x4 , 20x2 , 20x4 ,24x2 , 30x2 , 32x2 , 40x2 etc . Many multinational companies like Philips Hitachi Panasonic make their own special kind of LCD'S to be used in their products. All the LCD'S performs the same functions (display characters numbers special characters ASCII characters etc).Their programming is also same and they all have same 14 pins (0-13) or 16 pins (0 to 15). Alphanumeric displays are used in a wide range of applications, including palmtop computers, word processors, photocopiers, point of sale terminals, medical instruments, cellular phones, etc.

Product Description

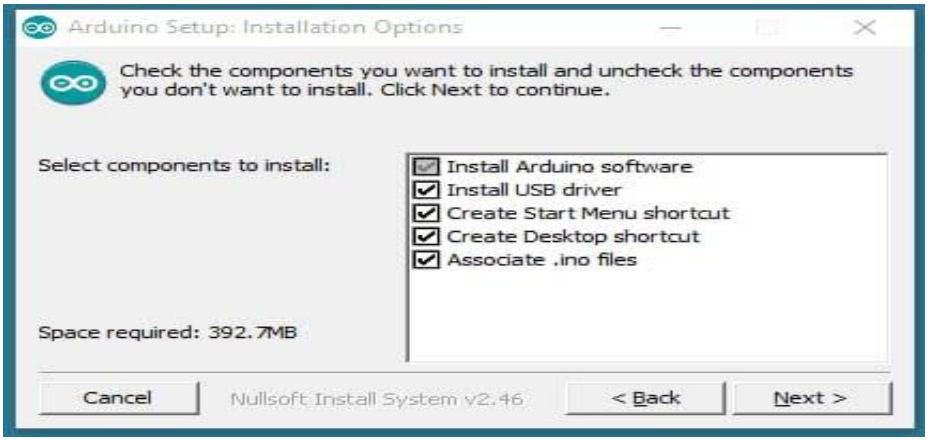
This is an LCD Display designed for E-blocks. It is a 16 character, 2-line alphanumeric LCD display connected to a single 9-way D-type connector. This allows the device to be connected to most E-Block I/O ports. The LCD display requires data in a serial format, which is detailed in the user guide below. The display also requires a 5V power supply. Please take care not to exceed 5V, as this will cause damage to the device. The 5V is best generated from the E-blocks Multi programmer or a 5V fixed regulated power supply. The 16 x 2 intelligent alphanumeric dot matrix displays is capable of displaying 224 different characters and symbols. A full list of the characters and symbols is printed on pages 7/8 (note these symbols can vary between brand of LCD used). This booklet provides all the technical specifications for connecting the unit, which requires a single power supply (+5V).



III. SOFTWARE DESCRIPTION

Arduino Software (IDE)

Get the latest version from the download page. You can choose between the Installer (.exe) and the Zip packages. We suggest you use the first one that installs directly everything you need to use the Arduino Software (IDE), including the drivers. With the Zip package you need to install the drivers manually. The Zip file is also useful if you want to create a portable installation. When the download finishes, proceed with the installation and please allow the driver installation process when you get a warning from the operating system



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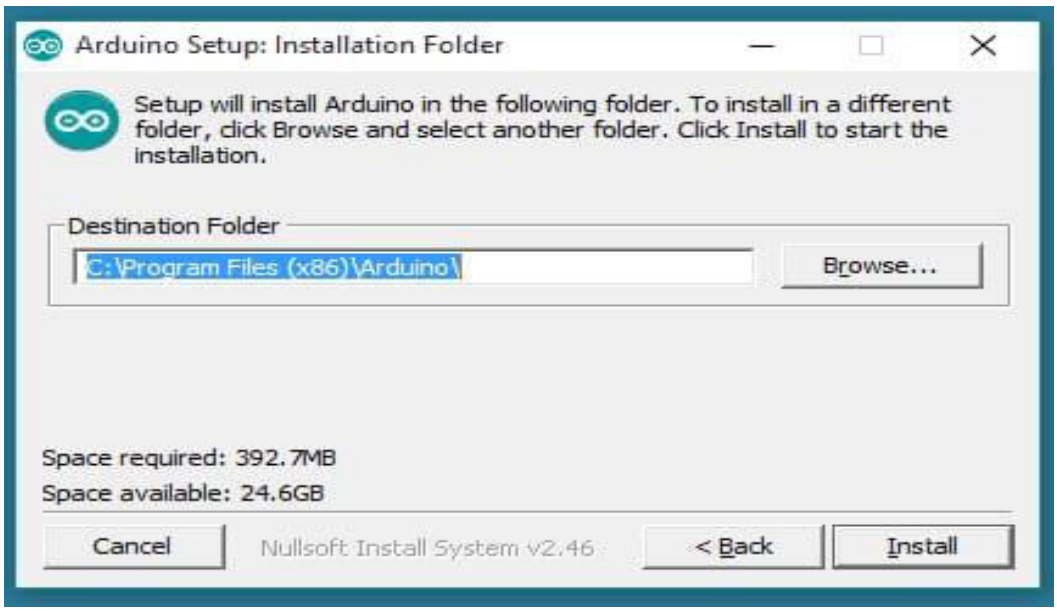
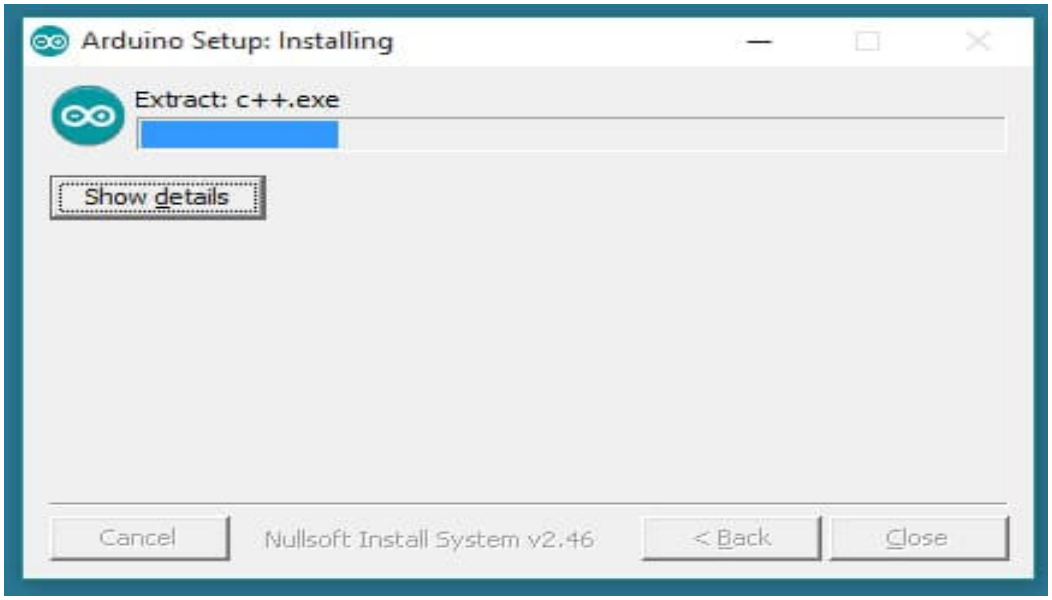
When the download finishes, proceed with the installation and please allow the driver installation process when you get a warning from the operating system.
Choose the components to install.



Choose the installation directory (we suggest to keep the default one)



The process will extract and install all the required files to execute properly the Arduino Software (IDE).

IV. TECHNICAL DETAILS

The Arduino Boot loader sets the "erase Address" to zero every time the boot loader is called. ROBOTC called the "Load Address" command to set the address in which we want to write/verify when downloading program. When writing a page of memory to the Arduino, the Arduino boot loader will erase the existing page and write a whole new page. In the scenario of downloading firmware, everything is great because the Erase Address and the Loaded Address both start at zero. In the scenario of writing a user program, we start writing at memory location 0x7000, but the Boot loader erases information starting at location zero because the "Load Address" command doesn't update where to erase. Our

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modification is to set both the Load Address and the Erase Address so the activity of writing a user program doesn't cause the firmware to be accidentally erased.

- Summary

  - Microcontroller Arduino UNO
  - Operating Voltage 5V
  - Input Voltage (recommended)
  - Input Voltage (limits) 6-20V
  - Digital I/O Pins 54 (of which 14
  - Provide PWM output)
  - Analog Input Pins 16
  - DC Current per I/O Pin 40mA
  - DC Current for3.3VPin 50mA
  - Flash Memory 256 KB of which 8 KB
  - Used by bootloader
  - SRAM 8KB
  - EEPROM 4KB
  - Lock Speed 16MHz

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.They differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the programmed as a USB-to-serial converter.

V. ADVANTAGE

Real-Time Monitoring: The integration of biomedical sensors allows for continuous monitoring of vital signs, providing instant health updates to rescue teams for timely interventions.Seamless Communication: WUSNs facilitate uninterrupted communication through soil layers, overcoming the limitations of conventional methods that fail in subterranean environments.User-Friendly Interface: Predefined switches and templates simplify the communication process, enabling individuals to convey their status and needs accurately with minimal training.Versatility: Advanced channel models adapt to different soil compositions and conditions, ensuring reliable data transmission across various underground settings.

VI. APPLICATION

Mining Industry: WUSNs can be deployed in mining operations to monitor worker health and safety in real-time, reducing the risks associated with accidents and health emergencies underground.Tunnel Construction: During tunnel construction or maintenance, WUSNs can serve as a vital communication tool, allowing workers to stay connected with the surface and respond swiftly to unforeseen challenges.Disaster Response: In the event of natural disasters like earthquakes or landslides, WUSNs can be instrumental in locating and communicating with trapped individuals, aiding rescue efforts and potentially saving lives.Military Operations: WUSNs can be adapted for military use in underground or covert operations where conventional communication methods are impractical or risky.Environmental Monitoring: Beyond emergency scenarios, WUSNs can also be used for environmental monitoring in underground ecosystems, contributing to research and conservation efforts.Infrastructure Maintenance: For the maintenance of underground infrastructure like sewage systems or subways, WUSNs can assist in monitoring structural integrity and ensuring worker safety.

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VII. RESULT AND DISCUSSION

Results

The implementation of the Wireless Underground Sensor Networks (WUSNs) demonstrated promising capabilities in facilitating real-time communication and monitoring in subterranean environments. Biomedical sensors successfully captured vital signs, including heartbeat, respiratory rate, and body temperature, providing accurate and timely health data. The advanced channel models optimized electromagnetic wave propagation through various soil compositions and conditions, ensuring reliable data transmission.

Discussion

The successful deployment of WUSNs highlights the potential to revolutionize safety protocols and emergency response in underground settings. The system's adaptability to different soil conditions and its ability to provide real-time monitoring offer significant advantages over traditional communication methods. One notable aspect is the system's versatility, making it applicable across various industries and emergency situations. From mining operations to disaster response, WUSNs have the potential to enhance safety standards and improve outcomes by enabling faster and more informed decision-making.

VIII. CONCLUSION

The development and testing of the Wireless Underground Sensor Networks (WUSNs) have demonstrated its potential to significantly improve communication and safety in subterranean environments. By integrating biomedical sensors, user-friendly interfaces, and advanced channel models, WUSNs offer a holistic solution to the challenges of underground communication.The system's real-time monitoring capabilities and seamless communication through soil layers provide invaluable support in emergency situations, potentially saving lives and reducing response times. With applications ranging from mining and construction to disaster response and environmental monitoring, WUSNs represent a versatile and promising technology with broad-reaching implications.While further research and development are needed to address existing challenges and optimize system performance, the initial results are promising. WUSNs have the potential to transform safety protocols and communication capabilities in underground environments, contributing to enhanced safety standards and more effective emergency response strategies.In conclusion, the WUSN system stands as a groundbreaking advancement in communication technology tailored for subterranean applications, offering a pathway to safer and more efficient operations across various industries and emergency scenarios.

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