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Optimized Soil Communication In Remote Areas

Ms.*V.Remya*
Department of Electronics and Communication Engineering
Sri Sairam Engineering College
Chennai, India
remya.ece@sairam.edu.in

Ms.*K.Suruthipriya*
Department of Electronics and Communication Engineering Sri Sairam Engineering College
Chennai, India
suruthipriyakamalakannan6@gmail.com

Ms.*S.Shanmugapriya*
Department of Electronics and Communication Engineering
Sri Sairam Engineering College
Chennai, India
priyasethuraman0606@gmail.com

Ms.*B.Shwethaa*
Department of Electronics and Communication Engineering Sri Sairam Engineering College
Chennai, India
shwethaabalaji@gmail.com

***Abstract*—Wireless Underground Sensor Networks (WUSN) is a commonly used wireless sensor network, which mainly deploys its sensors in the underground region of the soil. It is a network of sensor nodes deployed in the subterranean region. There are numerous perks when it comes to using WUSN for the deployment of sensor nodes which includes security, reliability, deployment range, etc. The group of sensors buried underground gathers data on various environmental parameters like temperature, humidity, soil moisture, etc. One of the main challenges in WUSNs is to develop efficient communication protocols that can cope with the unique characteristics of the underground environment. The soil can cause signal attenuation and reflection, making it difficult to establish reliable communication links. Magnetic induction is one of the wireless communication technologies used in WUSNs. It involves the use of electromagnetic waves to transmit data between sensors buried underground. Magnetic induction is ideal for WUSNs because it can penetrate the soil and rocks, and is less susceptible to signal attenuation and reflection compared to other wireless communication technologies. Hence both MI(Magnetic Induction) and the Internet Of Underground Things (IOUT) are incorporated into the WUSN to collect and transmit data in the most reliable manner.**

Keywords*—WUSN, Electromagnetic waves, Magnetic Induction, IOUT.

I. Introduction

The sensors in a WUSN communicate with each other using wireless communication technologies such as radio frequency (RF), acoustic, or magnetic waves. These signals can penetrate the soil and transmit data to a base station or a sink node, which acts as a gateway between the underground network and the outside world.The use of magnetic induction in WUSNs has the potential to improve the efficiency and safety of various underground operations and infrastructure, enabling better resource management and environmental protection[1].WUSNs have the potential to revolutionize various applications, including infrastructure monitoring, seismic warning systems, and agricultural automation.The use of magnetic induction technology in WUSNs can help in realtime processing of data, eliminating data loss and attenuation caused by moisture content, and enabling the retrieval of soil parameters such as temperature and moisture[3].In addition to this, WUSNs can also be utilized in remote areas for the security of human life, as you mentioned.

The deployment of emergency buttons and GPS tracking can help in tracking intruders and providing precise latitude and longitude information to the authorities. Overall, the use of WUSNs and magnetic induction-based communication has the potential to revolutionize various applications and improve safety, efficiency, and environmental protection.

Data collection in WUSNs is done through sensors that are buried underground. These sensors are designed to measure various environmental parameters such as temperature, humidity, soil moisture, and pressure[6]. The collected data is then stored in the sensor node's memory.

Data transfer in WUSNs is typically done through wireless communication between the buried sensors and a gateway node, which acts as a bridge between the underground sensors and the above-ground network infrastructure. The gateway node can be connected to the internet, allowing the collected data to be transmitted to a remote location for further processing and analysis.

Magnetic induction is used in WUSNs for communication between the sensors and the base station[3]. The use of magnetic induction waves is advantageous because they can penetrate the soil, allowing communication between underground sensors and the surface.There are several types of electromagnetic waves that can be used in WUSNs, including radio waves, microwaves, and infrared waves.

Magnetic induction waves are used because they have the longest range and can penetrate most types of soil[4].The sensors in a WUSN use electromagnetic waves to communicate with each other and with the base station. Each sensor is equipped with a transceiver that sends and receives electromagnetic signals. The signals are modulated to carry data and then transmitted to other sensors or the base station.

To improve the reliability of communication in WUSNs, multiple frequencies and channels can be used. This allows for better signal quality and reduces the chances of interference from other wireless devices.

II. WIRELESS UNDERGROUND SENSOR NETWORK

WUSN is a specific type of WSN that focuses on using sensors in the soil's subsurface area. They offer effective subterranean communication. Connection is accomplished by positioning the transmitter and reception modules below ground and coupling the ground of the two modules to enable communication.

Senors are placed and connected to a transmitter based on our needs to communicate with a transmitter using the soil as a medium. The qualities of the sand, its composition, and the water content all affect how waves travel underground. Up to 30% of the soil's water content can be used for communication.WUSN submits the application in the monitoring, surveillance, and detection fields.

A. *Soil Composition:*

The components that interact with soil underground impact the communication as the burial depth of the wusn module, the distance between the transmitter and receiver, soil porosity, and moisture content are considered major factors for underground communication.Components of soil include organic matter, minerals, water, and air.

B. *Volumetric Water Content:*

Compared to the typical composition (30%), the soil's increased water composition results in significant data loss. Data loss is referred to by attenuation. Attenuation a vital phenomenon that limits the transmission of data over a wide range

C. *Depth Intensity:*

The layers of soil include topsoil and subsoil. The data transfer can be done through either of the layers. Underground- to-underground communication(UG2UG) needs to deploy the sensors of transmitting and receiving mediums in the soil layers. The Underground to aboveground(UG2AG) requires placing either of the sensors of the medium in the soil layers

D. *Frequency Fluctuation:*

Due to the effects of several parameters including, attenuation and multipath propagation Electromagnetic waves are replaced by magnetic induction through which signals are transmitted. The porosity and humus in soil will certainly reduce the EM waves.

III. MAGNETIC INDUCTION-BASED COMMUNICATION

The limitations of electromagnetic waves are addressed by using MI-based communication. Rather than underground-to-aboveground or aboveground-to-subterranean communication, magnetic induction-based communication is employed when underground-to-underground communication is necessary. This depends on the induction coupled between the two coils of the transmitter and receiver. Knowing that soil, water, and slit are all components of the underground communication medium and as well as the parameters of soil density and volumetric water content, the (UG-UG) needs an effective communication method. The difficulties with EM include the signal being absorbed by subterranean materials like dirt and water, the creation of highly shifting channels, and the necessity of larger antennas. The aforementioned issues can be solved with MI, which also offers less attenuation, better channel conditions, reliability, and lower path loss. The factors of the subsurface, have no effect on the MI channels since the magnetic permeability (4 x 10-7 H/m) is the same for soil, water, and air.

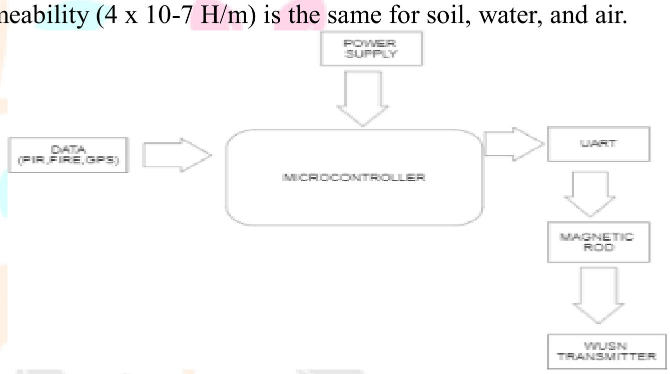

Fig.1.WUSN transmitter

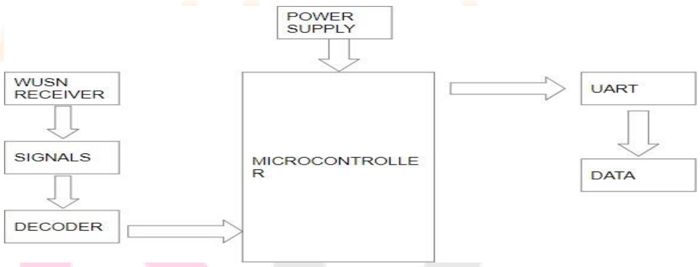

Fig.2.WUSN Receiver

IV. RELATED WORKS

For agricultural field monitoring, WUSN is implanted beneath a 4-inch diameter and transmits data up to 50 meters.[1]

To successfully transfer data over long distances, a magnetic rod that is circular in shape and functions as an inductor is used rather than electromagnetic waves, which experience propagation delay while passing through the soil.[4]

WUSN can be utilized to transfer data for monitoring soil conditions for irrigation land, earthquake prediction, and the detection of hazardous gases in coal mines.[5]

For effective data transmission in the MI-WUSN module, the radius of the transmitting coil must be less than the radius of the reception coil.[10]

V. PROPOSED SYSTEM

The proposed system includes a GPS tracker, PIR sensor, flame sensor, and emergency button. The aforementioned devices are placed because the proposed system focuses on monitoring forest fires,animal or human activity,and safeguarding the tribal people and woodcutters in the forest.

GPS tracker:

The provision of a GPS tracker gives the latitude and longitude value of the location in order to take immediate action at the time of need at the particular location.

PIR sensor:

In the monitoring area, PIR sensors are utilized. It serves as a motion detector. The system has a 5-meter detecting range. The output pin turns high when the PIR sensor detects the motion of an item by sensing a change in heat, and the object is thus detected.

Flame sensor:

The risk of forest fire is very high, especially in the summer. The forest fire is therefore identified by the flame sensor.

Emergency button:

The intended system also includes an emergency button that users may push to request assistance in case of an animal attack or other dangerous circumstances.

In the proposed methodology, a circular magnetic rod is used in place of a rectangular one to form a magnetic pattern and serve as an inductor. A near-field magnetic induction allows for the transmission of data through the soil without attenuation or data propagation.Unlike electromagnetic waves, data is sent without delay over a very long distance of up to 50 meters using a magnetic rod. It operates in the 300–700 MHz range of low frequency. Up to 8–10 cm of the rod is buried in the topsoil. Faster communication occurs when soil is in good moisture condition.The WUSN transmitter module[Fig.1.] has TTL UART which is used to encode the input data. Secondly, the Attiny 13 controller with an internal oscillation clock frequency of 9.6MHz and frequency generator are used to produce electronic signals. The frequency Shift Keying modulator produces the carrier signal and impedance matching circuit for designing the input impedance for a desired value. In the receiver module[Fig.2.], a similar process takes place in reverse order to retrieve the data.

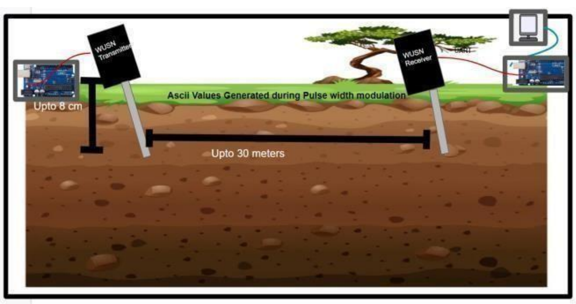

Fig.3.System Model

The data is sent through the soil as a medium using the pulse wave modulation technique and data is sent in ASCII code format to the receiver. Then the received data are displayed on the monitor by applying the IOT technique.Fig.3.depicts the total system model.

Fig.4.Monitoring Window

VI. CONCLUSION

The magnetic induction, which is produced by the magnetic flux created by the nodes in the transmitting region, induces a voltage on the receiver and allows the data to be sent through the soils. The suggested device intends to keep an eye on life on earth by detecting environmental factors like mobility and fire.The Global positioning system can be used to track objects' locations.Thus in the face of danger, defending forest workers and members of tribal groups.In Fig.4. depicts the monitoring screen at the receiver side that has a fire field where the result is empty since no fire is detected and in the animal field it shows detected,as it is surrounded by human interactions. Similarly when the emergency button is pressed "Emergency" is notified and for tracking the location (latitude and longitude) are shown.

VII. REFERENCES

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