International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 10 | Oct - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

5G/4G Cell Tower Radiation & Environmental Health Monitoring

Ms. Kamble.V.V
E&TC Dept.
(JSPM'S BSP)

Ms.Mhase. A.V,
E&TC Dept.
(JSPM'S BSP)

Ms.Lotke.M.M
E&TC Dept.
(JSPM'S BSP)

Ms.Raut.P.A
E&TC Dept.
(JSPM'SBSP)

Mr. Takale.V.B
E&TC Dept
(JSPM'S BSP)

Abstract -The rapid deployment of 4G and 5G mobile communication networks has increased public interest in radio frequency electromagnetic field (RF-EMF) exposure around cellular base stations. This paper presents a proposed Internet of Things (IoT) -based framework for monitoring RF exposure and selected environmental parameters near mobile towers. The system combines a calibrated RF field-strength or power-density meter, environmental sensors, a micro controller or edge gateway, a location and time-stamped data logger, and a cloud dashboard. Measurements can be collected at defined public-access locations and compared with applicable exposure limits, including the relevant Indian Department of Telecommunications (DoT) requirements. The framework is designed to show trends, identify unusual readings for verification, and communicate understandable information to communities and authorities. It does not assume that the presence of a tower causes illness: health effects must be evaluated using established epidemiological methods, and an IoT monitor alone cannot diagnose or establish causation. No field measurements are claimed in this conceptual paper; the implementation and validation plan is described for future work.

Key Words: 4G, 5G, Cell Tower, RF-EMF, Non-Ionizing Radiation, IoT, Environmental Monitoring, Exposure Assessment, Public Health.

1. INTRODUCTION

Mobile communication infrastructure is an essential part of modern life. Fourth-generation (4G) and fifth-generation (5G) networks use radiofrequency electromagnetic fields to transfer information between user devices and base-station antennas. As network coverage expands, residents sometimes express concern about exposure in homes, schools, hospitals, workplaces, and other public spaces near towers. These concerns make transparent, repeatable and technically sound exposure assessment important Radiofrequency fields used for mobile communication are non-ionizing; they do not have sufficient photon energy to ionize atoms in the way that X-rays do. The principal established interaction mechanism at sufficiently high RF exposure levels is heating of body tissue. International guidance such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) 2020 guidelines covers RF fields from 100 kHz to 300 GHz, including frequencies used by 4G and 5G.

The World Health Organization (WHO) states that, to date, no adverse health effect has been causally linked with exposure to wireless technologies when considered within established exposure guidance; ongoing research and careful monitoring remain important. A major practical challenge is that exposure varies with antenna configuration, frequency band, traffic load, beam direction, reflections, obstructions and distance. Distance alone cannot reliably determine exposure at a particular point. Therefore, measurements should be made with appropriate instruments, documented measurement geometry and calibrated procedures. This paper proposes a monitoring architecture that can support systematic data collection without overstating what the data can prove.

2. BODY OF PAPER

The proposed work focuses on three connected tasks: (i) measuring RF exposure using a suitable RF meter or isotropic probe, (ii) recording contextual environmental parameters and measurement metadata, and (iii) presenting the results through a dashboard with clear threshold and data-quality indicators. A low-cost microcontroller may coordinate environmental sensors and communication, but RF exposure readings must come from an instrument designed and calibrated for the relevant frequency range. General-purpose Wi-Fi modules, smartphone signal bars, and uncalibrated broadband sensors are not substitutes for compliance-grade RF measurement equipment

Traditional RF radiation surveys generally involve specialized instruments operated by trained personnel. Although these measurements can provide reliable information about exposure at a particular location and time, periodic surveys may not capture variations associated with changing network traffic or environmental conditions. Continuous or repeated monitoring can help identify temporal patterns and locations that require further investigation

Internet of Things (IoT) technologies provide an opportunity to develop low-cost monitoring platforms using sensors, microcontrollers, wireless communication modules, and cloud-based data storage. Such systems can support the collection, visualization, and analysis of environmental measurements. Nevertheless, the reliability of an IoT-based RF monitoring system depends on sensor calibration, measurement bandwidth, frequency response, data quality, and comparison with recognized exposure assessment methods.

2.1 PROPOSED SYSTEM

The system is organized into sensing, edge processing, communication, cloud storage, visualization and review layers. At each monitoring point, the operator records the site identifier, date and time, approximate location, measurement height, antenna orientation where known, weather conditions and nearby obstructions. The RF instrument provides electric-field strength (V/m), power density (W/m² or mW/m²), or another instrument-supported exposure metric. Where the instrument supports only broadband readings, the dashboard labels the result as broadband and does not falsely attribute it to an individual operator or frequency band.

A microcontroller or single-board computer reads environmental sensors, receives readings from a supported meter interface, applies data-quality checks and sends records through Wi-Fi, Ethernet or cellular connectivity. The cloud application stores raw readings, instrument metadata, calibration dates and threshold versions. Alerts should be described as “reading requires verification” rather than as a health-danger diagnosis. Compliance determinations should follow the prescribed DoT testing process and use appropriate calibrated equipment.

2.2 SYSTEM ARCHITECTURE / BLOCK

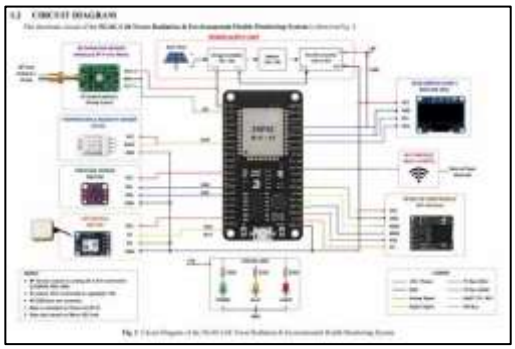


fig.2.1 Block Diagram of Proposed System

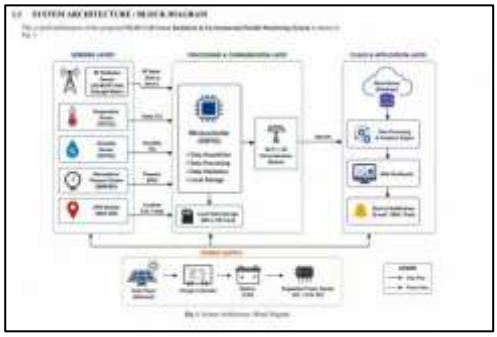


Fig -2.2: Interfacing Circuit Schematic

SOFTWARE ARCHITECTURE

The firmware periodically reads supported sensor interfaces, validates incoming values, checks timestamps and attaches site metadata. Measurements outside the instrument’s valid range, missing samples, stale calibration records and communication failures are marked rather than silently discarded. If connectivity is lost, records are buffered locally and uploaded when the link returns. The cloud service stores the original measurement, units, instrument identifier, calibration status, measurement duration and the applicable comparison limit.

The dashboard should distinguish a single spot measurement from a time-averaged result, and should identify whether a value is measured, calculated or manually entered. Limit comparisons must be frequency- and metric-appropriate. A threshold crossing prompts a repeat measurement and review by a competent person; it does not by itself demonstrate a health effect. User access should be role-based, and public-facing views should avoid exposing residents’ personal information.

3. HARDWARE-BASED SYSTEM

A. Arduino Mega 2560



Fig-3.1: Arduino Mega 2560

The Arduino Mega 2560 acts as the central embedded master controller. Providing 54 digital I/O pins, 16 analog inputs, and 4 hardware UART serial ports, it interfaces all sensory inputs, motor driver PWM signals, and external communication transceivers concurrently without bus contention.

B. Node MCU (ESP32)



Fig-3.2: ESP32

The ESP32-integrates an OV2640 2-megapixel image sensor with dual-core 2.4 GHz Wi-Fi. It streams real-time MJPEG video to the surface dashboard while bridging UART sensor packets to the Blynk cloud server over wireless TCP/IP sockets.

C. RF Radiation Sensor (EMF)



Fig-3.3: RF Radiation Sensor (EMF)

An RF radiation sensor is an electronic device used to detect radio-frequency electromagnetic signals present in the surrounding environment. In our project, 5G/4G Cell Tower Radiation & Environmental Health Monitoring, it is intended to monitor RF signals near mobile communication towers.

D. MQ-135 (Air Quality)



Fig-3.4: MQ-135 (Air Quality)

The MQ-135 is an air-quality sensor used to detect certain gases and monitor changes in the surrounding air. It produces an electrical output based on the gases present. The ESP32 processes this output and displays the readings on an LCD or IoT dashboard. This sensor helps us monitor air quality near the cell tower.

E. DHT11 Temperature & Humidity Sensor

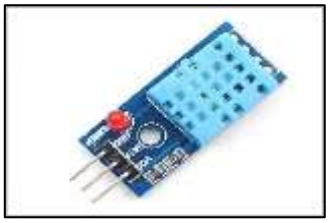


Fig-3.5: DHT11 Sensor

DHT11 and DHT22 are digital temperature and humidity sensors. They measure the surrounding environmental conditions and send digital data to the ESP32 microcontroller. The readings are displayed on an LCD or uploaded to an IoT dashboard. DHT22 generally provides better accuracy and a wider measurement range than DHT11."F.Light Sensor (LDR)

F. Light Sensor (LDR)



Fig-3.6: Light Sensor (LDR)

LDR(Light Dependent Resistor) is a light-sensitive electronic component. It is used to detect the intensity of light in the surrounding environment.

In your 5G/4G Cell Tower Radiation & Environmental Health Monitoring project, the LDR measures the surrounding light level. Its readings can be processed by a microcontroller such as ESP32.

G. LCD Display (I2C)



Fig-3.7: LCD Display (I2C)

The LCD display is used to show the readings collected by the sensors. The ESP32 processes the data and sends it to the LCD. It helps users easily monitor RF sensor output and environmental parameters such as temperature, humidity, and light intensity."

H.Water Pump (for cooling)



Fig-3.8: SG90 Servo Motor

The water pump motor is an electro mechanical device used to transfer water from one place to another. It operates using electrical energy and produces water flow through a pumping mechanism. In our project, it can be used as an optional component for water circulation or cooling demonstrations. The ESP32 can control it through a suitable motor driver or relay."SIM800L GSM Module

I.Relay Module



Fig-3.9: SIM800L GSM Module

The relay module is an electrically operated switch used to control external devices. The ESP32 sends a control signal to the relay, which switches a connected device ON or OFF according to the programmed conditions. In our project, it can be used to control an optional water pump or an alarm system."Li-Po Battery (12V, 3000 mAh)

K.Power Supply



Fig-3.10: Battery (12V)

The power supply circuit provides the electrical energy required to operate the entire monitoring system. It converts or regulates the input voltage to the levels required by the ESP32, sensors, and LCD display. A stable power supply helps the system operate reliably

Table -1: System Specifications

Parameter	Proposed specification / requirement	Parameter	Proposed specification / requirement
RF measurement	Calibrated RF meter covering target 4G/5G bands; instrument-dependent range and uncertainty	RF measurement	Calibrated RF meter covering target 4G/5G bands; instrument-dependent range and uncertainty
Reported units	V/m and/or W/m²; preserve the meter's native metric and conversion method	Reported units	V/m and/or W/m²; preserve the meter's native metric and conversion method
Environmental inputs	Temperature and relative humidity; optional PM sensor if required by the study	Environmental inputs	Temperature and relative humidity; optional PM sensor if required by the study
Sampling plan	Defined spot or time-series protocol; interval chosen based on instrument and study objective	Sampling plan	Defined spot or time-series protocol; interval chosen based on instrument and study objective
Connectivity	Wi-Fi / Ethernet / cellular, with local data buffering	Connectivity	Wi-Fi / Ethernet / cellular, with local data buffering
Data record	Timestamp, site ID, location, height, units, instrument ID, calibration status and quality flag	Data record	Timestamp, site ID, location, height, units, instrument ID, calibration status and quality flag
Dashboard	Time trends, location view, guideline comparison, export and audit history	Dashboard	Time trends, location view, guideline comparison, export and audit history
Safety and privacy	No personal health diagnosis; secure access; avoid collecting unnecessary personal data	Safety and privacy	No personal health diagnosis; secure access; avoid collecting unnecessary personal data
Parameter	**Proposed specification / requirement**	**Parameter**	**Proposed specification / requirement**

4. WORKING OF THE SYSTEM

First, the study team defines monitoring locations and a measurement plan. Points may include publicly accessible areas around a tower, nearby sensitive-use locations where access is permitted, and background comparison sites. The plan records measurement height, probe orientation, duration, antenna visibility, reflections and relevant site conditions. Measurements should not be taken by climbing towers or entering restricted areas without authorization.

Second, the calibrated RF instrument is allowed to stabilize and is operated according to its manual. Readings are collected using the chosen protocol, with repeated samples where appropriate. The edge device captures environmental parameters and metadata, then checks whether values are missing, outside the instrument range or associated with expired calibration. Each record is stored locally before upload so that network interruptions do not erase measurements.

Third, the cloud dashboard displays measurements with units, time and location. Results are compared only with the correct exposure limits and averaging conditions for the relevant frequency range and jurisdiction. If a reading appears unusually high or approaches a limit, the system flags it for repeat measurement and expert assessment. A formal compliance conclusion should be made only using the applicable DoT procedure and qualified measurement personnel.

If environmental health research is planned, it requires a separate protocol, ethical review where applicable, appropriate comparison groups and control of confounding factors.

5. ENVIRONMENTAL & HEALTH CONSIDERATION

The RF exposure assessment and health monitoring are related but distinct activities. An RF meter quantifies a physical exposure metric; it does not measure cancer, sleep quality, stress or other health outcomes. A sensor dashboard can improve transparency and identify where more careful measurement is warranted, but it cannot establish a causal relationship between tower exposure and disease.

Current scientific guidance identifies tissue heating as the established mechanism of adverse effects at sufficiently high RF levels. WHO's public information on 5G states that no adverse health effect has been causally linked with wireless technologies to date, while noting that evidence specific to some newer 5G frequencies is less extensive than for older technologies. RF exposure should therefore be evaluated against recognized limits, and public communication should avoid both unsupported alarm and absolute claims that all possible future questions have been resolved.

Environmental monitoring can also document temperature, humidity, particulate matter and noise where these are within the project scope. These measurements provide site context but should be analyzed independently from RF exposure unless a valid scientific hypothesis and study design connect them. Community engagement, transparent methods and access to measurement records can help address concern constructively.

6. ADVANTAGES & LIMITATIONS

The proposed framework supports repeatable logging, time-stamped records, remote access, easier comparison between sites and transparent reporting. It can reduce manual transcription errors and help identify readings that deserve expert follow-up. The design is modular, allowing different calibrated meters and environmental sensors to be integrated.

Its limitations include the cost of suitable RF instruments, dependence on calibration and correct measurement practice, variation in exposure over time, and possible bias from poor site selection. A broadband meter may not identify the source or frequency contribution. Environmental sensors may drift and require separate calibration. Most importantly, measured exposure data alone cannot establish a health outcome or prove that a particular tower caused it.

CONCLUSION

This paper presents an IoT-based framework for monitoring 4G/5G cell-tower radiofrequency exposure and selected environmental conditions. The system combines a calibrated RF measurement instrument, environmental sensors, an edge logger, secure communication, cloud storage and a dashboard that compares data with applicable guidance. Its principal value is to make measurements traceable, understandable and available for expert review. Successful deployment depends on appropriate instruments, documented sampling methods, calibration, data-quality checks and compliance with local rules. The framework is a monitoring aid, not a medical diagnostic tool, and it does not imply that tower proximity alone causes illness. Future work should implement the prototype, validate it against a reference instrument, conduct field measurements and publish results with uncertainty and limitations clearly stated.

ACKNOWLEDGEMENT

The authors would like to thank their project guide, department and institute for their guidance and support. This section should be updated with the actual names of contributors, facilities and funding sources before submission.

REFERENCES

[1] International Commission on Non-Ionizing Radiation Protection (ICNIRP), “Guidelines for Limiting Exposure to Electromagnetic Fields (100 kHz to 300 GHz),” Health Physics, vol. 118, no. 5, pp. 483–524, 2020. doi: 10.1097/HP.0000000000001210.

[2] World Health Organization, “Radiation: 5G mobile networks and health,” WHO Questions and Answers. Available: https://www.who.int/news-room/questions-and-answers/item/radiation-5G-mobile-networks-and-health

[3] World Health Organization, “Radiation and health: Wireless,” WHO. Available: https://www.who.int/teams/environment-climate-change-and-health/radiation-and-health/non-ionizing/wireless

[4] Department of Telecommunications, Government of India, “Public Awareness: Electromagnetic Field (EMF) emissions from mobile towers.” Available: https://dgtelecom.gov.in/public-awareness/

[5] Press Information Bureau, Government of India, Ministry of Communications, “Reduction in EMF Emissions,” 5 August 2022. Available: https://www.pib.gov.in/Pressreleaseshare.aspx?PRID=1848739

[6] International Commission on Non-Ionizing Radiation Protection, “RF EMF Guidelines 2020: 100 kHz–300 GHz.” Available: https://www.icnirp.org/en/publications/article/rf-guidelines-2020.html

AUTHOUR BIOGRAPHIES



Ms. Mhase.A.V.
Diploma student in Electronics & Telecommunication Engineering. Academic interests include AI, embedded systems, IoT and industrial automation.



Ms. Lotke.M.M
Diploma student in Electronics & Telecommunication Engineering. Academic interests include AI, embedded systems, IoT and industrial automation.



Ms.Raut.P.A
Diploma student in Electronics & Telecommunication Engineering. Academic interests include AI, embedded systems, IoT and industrial automation.



Ms.Kamble.V.V
Diploma student in Electronics & Telecommunication Engineering. Academic interests include AI, embedded systems, IoT and industrial automation.



Mr. Takale V.B
Is Diploma lecturer in Electronics and Telecommunications Engineering Department at JSPM's Bhivrabai Sawant Polytechnic, Wagholi.